State of Delaware
2000 Watershed Assessment Report
(305(b))

Department of Natural Resources and Environmental Control
April 1, 2000

Preface

The 2000 Delaware Watershed Assessment Report provides a statewide assessment of surface water and groundwater resources, and highlights Delaware's initiatives in water resources management and pollution control during 1997 through 1999. The report fulfills the reporting requirements set forth under Section 305(b) of the Federal Clean water Act of 1977, as amended in 1981 and 1987. The report is organized in accordance with federal Environmental Protection Agency's (EPA) guidance documents.

This report summarizes the statewide water quality assessment and provides an overview of major initiatives and concerns on a statewide basis. Tables and charts are provided which show the result of water quality analysis and designated use support findings for data from the period of September 1997 through August 1999.

There are two appendices to the report. Appendix one is the data provided by citizen monitoring programs. Appendix two contains the completed TMDL regulations that were enacted in 1998 and 1999.

Assessments for the Delaware River and Bay are completed by the Delaware River Basin Commission (DRBC).

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Part I Executive Summary

Part I Executive Summary

As recently as 1975, Delaware routinely experienced serious water pollution and public health problems as a result of the discharge of untreated sewage and wastes. Since then, as a result of voluntary efforts, regulatory actions, and significant private and public investments in wastewater treatment facilities, localized improvements in water quality have been achieved.

The need for additional cleanup and pollution prevention continues. The focus of water quality management has shifted from point source discharges (end-of-pipe) to decreased stream flows and nonpoint source problems, such as urban and agricultural runoff, erosion, and sedimentation. Unaddressed, these problems lead to poor habitat conditions for fish and other aquatic life, decreased enjoyment of our surface waters for recreation, and unhealthy conditions for those surface waters upon which we rely for drinking water supply and other domestic uses.

I.1 Water Quality Monitoring

The DNREC recognizes the need to use its personnel and financial resources efficiently and effectively. To that end, surface water quality monitoring is conducted in a manner that focuses available resources on the Whole Basin Management concept. The Whole Basin Management Program in Delaware operates on a 5-year rotating basis. This new approach enables the DNREC to comprehensively monitor and assess the condition of the State environment with due consideration to all facets of the ecosystem.

Elements of the State's specific Surface Monitoring Program include:

- TMDL-Related Monitoring
- General Assessment Monitoring
- Toxics in Biota Monitoring
- Toxics in Sediment Monitoring
- Biological Assessment Monitoring

I.1.1 Delaware Rivers and Lakes

Delaware has more than 2509 miles of rivers and streams, and 2,954 acres of lakes and ponds that have been classified using a rating system called for in the Federal Clean Water Act. The classification system is keyed to a management program designed to protect uses of the waters (referred to as "designated uses") for such purposes as drinking water supply, recreation, and the propagation of fish aquatic life and wildlife. These designated uses serve as Delaware's water quality goals for specific watersheds. In order to protect those uses, a comprehensive set of chemical, biological, and habitat standards have been promulgated. Designated uses and standards are embodied in the State of Delaware Surface Water Quality Standards as amended on August 11, 1999.

The Department of Natural Resources and Environmental Control has found that 96% of Delaware's rivers and streams do not fully support the swimming use and 71% do not fully support the fish and wildlife use (see figures I-1 and I-2 for statewide summaries of designated use support). Most of these waters do not meet the standards because of nonpoint source pollution impacts.

Ponds and lakes in Delaware exhibit many of the same problems as rivers and streams. However, ponds and lakes also serve as "catch basins" for a variety of pollutants that are washed from the land and the air into these water bodies. Two indicators which show the tendency for lakes and ponds to accumulate pollutants are fish consumption advisories due to toxic substances in the fish, and the extent of nutrient enrichment. Nutrient enrichment can lead to excessive weed and algae growth, reduced water clarity, and decreases in population of aquatic life and wildlife. The department has found that 69% of Delaware's fresh water ponds and lakes do not fully support the swimming use and 27% do not fully support the fish and wildlife use.

I.1.2 Wetlands in Delaware

Wetlands have many important functions and values to society. They provide fish and wildlife habitat, maintain water quality, and provide indirect socioeconomic values such as flood and storm water damage protection. With the implementation of federally mandated legislation known as Total Maximum Daily Load (TMDL) to reduce pollutants into water bodies, wetland preservation is considered one of the most important strategies for achieving the pollution reduction efforts necessary to meet water quality standards.

The impetus to improve existing wetland inventories was the need by the Delaware Department of Transportation (DELDOT) and the Delaware Department of Natural Resources (DNREC), and the US Fish and Wildlife Service to have updated aerial photography to assess recent statewide wetland trends. This collaborative effort was known as the Statewide Wetlands Mapping Project (SWMP). These agencies assessed statewide wetland losses, gains, and changes in wetland type using improved higher resolution color aerial infrared photography. The improved aerial photography allowed wetland scientists greater precision and accuracy for the delineation and photo interpretation of "wetland signatures" (e.g., tonal contrasts that identify specific vegetative communities, hydrologic regimes and other miscellaneous features), than previous mapping efforts allowed. These wetland signatures were then areally tabulated and classified within the bounds prescribed by the Cowardin et al. hierarchical classification scheme. Wetland trends were then assessed as totals (i.e., statewide trends), and/or by the four individual basins (i.e., Northern Piedmont, Delaware Bay drainage, Chesapeake Bay drainage, and Inland Bays drainage)

From this assessment, it was found that 2000 acres of vegetated wetlands were lost statewide between 1981/2 and 1992. Palustrine vegetated wetlands suffered the greatest losses. Most of the destructive impacts were attributed to agricultural activities, with secondary amounts ascribed to residential activities. Individual Basins reflect similar wetland type losses and destructive impacts, with minor variations.

I.1.3 Bacteria (Pathogen Indicators)

As the name implies, "indicator bacteria" are indicators of pathogenic (disease causing) bacteria and viruses. Sources of indicator bacteria (enterococcus and coliform) are widespread. The sources of most concern are those of human origin such as raw or inadequately treated sewage. Wildlife and animal operations such as feedlots can also be significant sources of indicator bacteria, although they represent less of a risk to human health compared to human wastes.

High levels of bacteria pose an increased risk of illness to shellfish consumers, swimmers, and others who may come in contact with contaminated waters. Approximately 96% of Delaware's rivers and streams, 48% of ponds and lakes, and 59% of estuarine waters (not including the Delaware River and Bay) were found to have bacteria concentrations above the levels considered acceptable for primary contact recreation (swimming, bathing, and water skiing). Many of Delaware's estuarine and tidal waters exhibited bacteria levels above those considered safe for harvesting and consumption of shellfish. Waters most impacted include the tidal tributaries to Delaware Bay and portions of Delaware's Inland Bays.

I.1.4 Nutrient Enrichment

Nutrient enrichment of surface waters is a natural process, spanning thousands of years, resulting from natural erosion and the breakdown of organic material. Lakes and ponds in various stages of nutrient enrichment are considered a natural feature of Delaware's environment. Activities linked to soil erosion, domestic waste disposal (on-site septic systems), and runoff, can greatly increase the rate and amount of nutrients reaching lakes and ponds, accelerating the nutrient enrichment process. As previously mentioned, characteristic symptoms of nutrient enriched water bodies include murky green waters or nuisance plant growth. Delaware waters are generally considered to be impacted by nutrients (nitrogen and phosphorus). Average concentrations of total nitrogen and total phosphorus in Delaware waters are shown in figure I-3.

Figure 1.1 Use Support Charts

Figure 1.2 Use Support map

Figure I-3 Nutrient Maps

I.1.5 Fish Consumption Advisories

Toxic substances such as Polychlorinated Biphenyls (PCB's), metals and pesticides persist in the environment and accumulate in the flesh of fish. The following table lists the current fish consumption advisories (recommended limitations on the consumption of particular fish species) issued jointly by the Delaware Department of Natural Resources and Environmental Control and the Department of Health and Social Services, as of Spring, 1999.

Delaware Fish Consumption Advisories as of June 1999

Waterbody	Species	Geographical Extent	Contaminants of Concern*	Advice
Becks Pond	All Finfish	Entire Pond	PCBs, Mercury	No more than six 8-ounce meals per year
Delaware River	All Finfish	Delaware State Line to the C&D Canal	PCBs, Arsenic, Dioxin, Mercury, Chlorinated Pesticides	No Consumption
Red Lion Creek	All Finfish	Rt 13 to the Delaware River	PCBs, Dioxin	No more than three 8-ounce meals per year
Lower Delaware River and Delaware Bay	Striped Bass, Channel Catfish, White Catfish, American Eel, White Perch	C&D Canal to Delaware Bay Mouth	PCBs, Mercury, Dioxin	No more than one 8-ounce meal per year.
Tidal Brandywine River	All Finfish	River Mouth to Baynard Blvd.	PCBs	No Consumption
Non-Tidal Brandywine River	All Finfish	Baynard Blvd. To Pennsylvania Line	PCBs, Dioxin	No more than two 8-ounce meals per year
Tidal Christina River	All Finfish	River Mouth to Smalley's Dam	PCBs, Dieldrin	No Consumption
Non-tidal Christina River	All Finfish	Smalley's Dam to I-95	PCBs	No more than six 8-ounce meals per year
Little Mill Creek	All Finfish	Creek mouth to Kirkwood Highway	PCBs	No Consumption
Tidal White Clay Creek	All Finfish	River Mouth to Rte 4	PCBs	No Consumption
Non Tidal White Clay Creek	All Finfish	Rte. 4 to Paper Mill Road	PCBs	No more than one 8-ounce meal per month

Delaware Fish Consumption Advisories as of June 1999				
Waterbody	**Species**	**Geographical Extent**	**Contaminants of Concern***	**Advice**
Red Clay Creek	All Finfish	State Line to Stanton	PCBs, Dioxin, Chlorinated Pesticides	No Consumption
Chesapeake & Delaware Canal	All Finfish	Entire Canal in Delaware	PCBs	No Consumption
Appoquinimink River	All Finfish	Tidal Portions	PCBs, Dioxin	No More than one 8-ounce meal per year
Drawyers Creek	All Finfish	Tidal Portions	PCBs, DDT	No More than one 8-ounce meal per year
Silver Lake Middletown	All Finfish	Entire Lake	PCBs, Dieldrin, DDT, Dioxin	No More than one 8-ounce meal per year
St. Jones River	All Finfish	River Mouth to Silver Lake Dam	PCBs, Dioxin, Mercury, Arsenic	No More than two 8-ounce meals per year
Moores Lake	All Finfish	Entire Pond	PCBs, DDT	No More than two 8-ounce meals per year
Silver Lake Dover	All Finfish	Entire Pond	PCBs, DDT	No More than two 8-ounce meals per year
Wyoming Mill Pond	All Finfish	Entire Pond	PCBs, Dioxin, DDT	No More than two 8-ounce meals per year
* The pollutant listed first is of the greatest concern in this system.				

I.2 General Changes or Trends in Water Quality

As a result of water quality protection programs that are in place in Delaware, in general surface water quality in Delaware has remained fairly stable in spite of increasing development and population growth. Impacts to waters are generally the result of past practices or contamination events, activities that are not regulated nor otherwise managed, or changes that are occurring on a larger regional scale. For example, air pollutants from sources outside of Delaware contaminate Delaware's surface waters via rainfall.

Improvements in water quality have been documented in localized areas where a discharge was eliminated or better treatment installed. Basin-wide water quality improvements in waters that are being impacted by historical contamination yet unquantified pollution sources are very difficult to detect over a short period of time. Targeted monitoring over long time periods (years) is necessary in order to detect changes.

Although Delaware's surface water quality may not have changed significantly over the last several years, there have been many improvements made in watershed assessment approaches and methodologies. Additionally, many water quality criteria are stricter as a result of amendments to the State's Water Quality

Standards. Therefore, we have become more proficient at identifying water quality problems and, at the same time, are calling for higher quality waters.

The stability of Delaware's surface water quality is likely the result of increased efforts to control both point and nonpoint sources of pollution. In addition to the significant investments in wastewater treatment technologies previously mentioned, many private business interests are investing in practical and cost-effective nonpoint source pollution control practices (Best Management Practices) on farms, residential developments, and commercial and industrial sites. Likewise, public agencies such as the Delaware Department of Transportation are investing revenues in improved storm water management practices and wetlands creation to mitigate the impacts of maintenance and new highway construction activities.

I.2.1 Ground Water Quality

The ground water resources of Delaware are generally abundant and of high quality. Water pumped from the approximately 13 aquifers provides about two-thirds of all domestic water needs. In northern Delaware (north of the C&D Canal) ground water supplies about one-third of the domestic freshwater needs while in the remainder of the state, ground water supplies all of the domestic freshwater needs. There are approximately 1,000 public water supply wells in the state. In addition to domestic use, ground water is pumped for irrigation, industrial, agricultural and other uses. Ground water also discharges as base flow to surface water bodies and, during periods of low or no rainfall, essentially all stream flow is the result of ground water discharge.

Ground water quality can be degraded locally by both natural and man-induced causes. The most common naturally occurring problem is dissolved iron that is derived from iron-containing minerals. Chloride and high dissolved solids are also found along the coastal areas of the Delaware Bay, Inland Bays, and the Atlantic Ocean. These contaminants are also found at varying depths below the land surface within the various aquifers. Man-induced ground water quality problems occur from both point sources and non-point sources of contamination. Generally speaking, nutrient problems are most prevalent in southern Delaware while urban/industrial problems are most prevalent in northern Delaware. The shallow unconfined aquifers are the most commonly impacted but impacts have also been seen in some deeper aquifers. Dissolved iron is the most common ground water quality problem but is naturally found in various parts of aquifers. The most common man-induced contaminant found in public drinking water systems is nitrate. Nitrate is derived primarily from septic systems and the land application of fertilizer and manure. Levels above 10 milligrams per liter exceed the U.S EPA maximum contaminant level for public drinking water systems. Other contaminants found in public drinking water systems but a very low frequencies are lead (likely the result of old home plumbing), volatile organic compounds, and some pesticides. The Division of Public Health responds to exceedences of drinking water standards by requiring the supply owners reduce contaminant concentrations to below drinking water standards.

Point sources of contamination to ground water include septic systems, petroleum storage tanks, hazardous and solid waste sites, and other regulated sites. Statewide, the largest number of sites are domestic septic systems with an estimated 78,000. Over half of these are found in Sussex County. There have been approximately 2,800 leaking underground storage tank sites statewide. Of these, 60 percent were found in New Castle County. However, 80 percent of these sites have been closed and clean-ups completed.

This Watershed Assessment Report includes an assessment of the ground water resource quality in the Inland Bays Basin. Ground water resources provide all of the drinking water needs in this basin as well as other freshwater needs such as irrigation and agriculture. Other than naturally occurring dissolved iron, the most common contaminant is nitrate with the major sources being septic systems, animal operations, and application of fertilizer and manure. Chloride problems remain a concern along the coastal reaches of the Atlantic Ocean and the Inland Bays.

Both regulatory and non-regulatory means are used to address both point and non-point sources of contamination with progress seen in reducing point sources of contamination. Non-point sources are also being addressed but are more difficult to assess due to the slow nature of ground water flow and diffuse impacts of various land uses. However, some improvement has been seen in nitrate levels in public drinking water systems since the previous watershed assessment report. Additional monitoring and assessment is occurring.

I.2.2 Future Needs and Activities to Improve Environmental Quality of the State

The State of Delaware will continue to focus on nonpoint source pollution problems such as urban and agricultural runoff, erosion and sedimentation and ground water contamination. The Department of Natural Resources and Environmental Control will emphasize pollution prevention, education, and both voluntary and regulatory efforts to improve the quality of surface and ground water resources. Additional research and assessment efforts will be necessary to better understand the response of aquatic systems to certain pollutants. Additionally, because of the relationship of stream flow to ecological health, the development of a surface water withdrawal/minimum stream flow maintenance policy is a priority. Improved assessment and management of biological health and physical habitat quality are also priorities.

The health of Delaware's aquatic systems and ground water resources will be assessed and managed within the framework of the Department of Natural Resources and Environmental Control's Whole Basin Management Program. This Program calls for the Department, in partnership with other governmental entities, private interests, and all stakeholders, to focus its resources on specific watersheds and basins (groups of watersheds) within specific time frames.

Five basins and 41 watersheds have been delineated (see figure I-4 entitled "Delaware Drainage Basins and Watersheds"). The Whole Basin Management activities in the State started within the Piedmont Basin in 1996, and were followed by the Chesapeake Basin in 1997, the Inland Bays in 1998 and the Delaware Bay Drainage Basin started in 1999. Similar activities will begin soon for the Delaware Estuary.

In addition to the planning and preliminary assessment steps, Whole Basin Management will include intensive basin monitoring, comprehensive analyses, management option evaluations, and resource protection strategy development. Public participation and ongoing implementation activities will occur throughout the Whole Basin Management process. The chart entitled "Whole Basin Management Plan Process and Timeline" details the steps and milestones.

Figure I-4 Delaware Basins and Watersheds

Figure showing time line for whole basin management plan process

I.3 Programs to Correct Impairments

I.3.1 State of Delaware Total Maximum Daily Program (TMDL)

Section 303(d) of the Federal Clean Water Act (CWA) requires States to develop a list of water bodies for which existing pollution control activities are not sufficient to attain applicable water quality standards (303(d) List) and to develop Total Maximum Daily Loads (TMDLs) for pollutants of concern. A TMDL sets a limit on the amount of a pollutant that can be discharged into a waterbody such that water quality standards are met.

The State of Delaware is operating under a court-approved Consent Decree to establish TMDLs for all impaired streams on the State's 1996 303(d) list by the year 2006. So far, the State has established TMDLs for the following watersheds:

1. Appoquinimink River watershed. The TMDL for the Appoquinimink River watershed was established in January 1998. The Appoquinimink River TMDL requires reduction of nutrients and organic loads from point and nonpoint sources in the watershed.
2. Nanticoke River and Broad Creek Sub-basin. The TMDL for the Nanticoke River and Broad Creek Sub-basin was established in December 1998. The Nanticoke River and Broad Creek TMDL requires that Biological Nutrient Removal (BNR) technology be employed for wastewater treatment at four large treatment plants in the sub-basin. In addition, it requires that nonpoint sources of nutrients (nitrogen and phosphorous) be reduced by 30 to 50 percent.
3. Indian River, Indian River Bay, and Rehoboth Bay. The TMDL for Indian River, Indian River Bay, and Rehoboth Bay was established in December 1998. The TMDL requires systematic elimination of all point sources of nutrients in the sub-basin. Furthermore, it requires that nonpoint sources of nutrients (nitrogen and phosphorous) be reduced by 40 to 85 percent
4. Zinc TMDL for the White Clay Creek. The TMDL for zinc in the White Clay Creek was established in November of 1999. This TMDL specifies the maximum amount of zinc that can be released to the Creek from the now defunct NVF Newark facility.
5. Zinc TMDL for the Red Clay Creek. The TMDL for zinc in the Red Clay Creek was established in December of 1999. This TMDL specifies the maximum amount of zinc that can be discharged to the Creek from the NVF Yorklyn facility.

In addition to above established TMDLs, Delaware DNREC is planning to develop TMDLs for the following watersheds within the next two years:

- Christina River Sub-basin
- Murderkill River Watershed
- Tributaries and ponds of the Nanticoke River and Broad Creek watersheds, and
- Tributaries and ponds of Appoquinimink River watershed

I.3.2 USDA Conservation Programs:

The objective of current programs will focus on conservation of soil, water, and related resources, water quality protection and improvement, wetland restoration, protection and creation, and wildlife habitat development and protection. More detail on the programs the USDA sponsors can be obtained by contacting the appropriate USDA agency for more specific information.

I.3.3 Center for the Inland Bays Projects

The Center is involved in a number of programs that are detailed in Part III, Chapter One

Part II Background

Part II Background

This report on Delaware's water quality has been prepared pursuant to the requirement set forth in the Federal Clean Water Act of 1977 and the 1981 and 1987 amendments of Section 305(b), which require each state to prepare and submit to Congress a description of the water quality of all navigable waterways within the State on a biennial basis. The information contained herein applies to the period of September 1997 through August of 1999.

Water quality assessments contained in this report were based on information available at the time of assessment. All basin assessments were prepared by the Delaware Department of Natural Resources and Environmental Control, Division of Water Resources.

II.1 State Atlas

Table 2.1 provides a brief summary of statistics regarding population and waterbody sizes for Delaware. The waterbody sizes listed in the table are obtained from a Geographic Information System (GIS) data layer which was recently developed to index state's stream waters with the U.S. EPA's Reach File 3 network of streams.

Table 2.1 State Atlas

State Population[1]	731,210
State Surface Area	1981 square miles
Number of Basins	5
Number of Watersheds	41
Total number of Stream and River Miles	2506
Number of perennial river miles	1778
Number of intermittent stream miles	405
Number of ditches and canals	326
Number of Border Miles	87
Acres of Lakes/Reservoirs/Ponds	2954
Square Miles of Estuarine Waters[2]	841
Number of Ocean Coastal Miles	25
Acres of Freshwater Wetlands	449,626
Acres of Tidal Wetlands	190,329

1. 1997 Delaware Vital Statistics Annual Report, Delaware Health and Social Services.

2. Surface area for Delaware River Zone 5 and Delaware Bay provided by the Delaware River Basin Commission, 1994 -1995 305(b) Report.

II.2 Summary of Classified Uses

The State of Delaware Surface Water Quality Standards (as amended August 1999) contains the following Designated Use categories:

- Public Water Supply (PS)
- Industrial Water Supply (IS)
- Primary Contact Recreation (PCR)
- Secondary Contact Recreation (SCR)
- Fish, Aquatic Life, and Wildlife (FISH,WL)
- Cold Water Fish - Put and Take (CWF)
- Agricultural Water Supply (AS)
- Exceptional Recreational or Ecological Significance (ERES)
- Harvestable Shellfish Waters (SFH)

EPA recognizes that each state may have different designated use categories and definitions. In order to improve reporting consistency and interpretation of assessment information on the national level, EPA has recommended the use of the following designated use categories for reporting purposes:

- Fish Consumption
- Shellfishing
- Aquatic Life Support
- Swimming
- Secondary Contact Recreation
- Drinking Water Supply
- Agriculture

Delaware has applied EPA's categories in reporting designated use support on the following basis:

- Fish Consumption is assessed based on whether a fish advisory exists for a waterbody;
- Aquatic Life Support is equivalent to Delaware's Fish, Aquatic Life, and Wildlife designated use;
- Shellfishing is equivalent to Delaware's Harvestable Shellfish Waters designated use;
- Swimming is equivalent to Delaware's Primary Contact Recreation designated use and also includes water skiing;
- Secondary Contact is equivalent to Delaware's Secondary Contact Recreation designated use and includes activities such as boating;
- Drinking Water Supply is equivalent to Delaware's Public Water Supply designated use;
- Agriculture is equivalent to Delaware's Agricultural Water Supply designated use.

For this report, the attainment of the Clean Water Act goal of fishable waters is primarily based on Aquatic Life Support and Fish Consumption. Less than full support or attainment of either the Aquatic Life Support or Fish Consumption infers that the fishable goal of the Clean Water Act is not fully supported. Less than full support of the Swimming or Primary Contact Recreation designated use infers that the swimmable goal of the Clean Water Act is not fully supported.

Delaware's Exceptional Recreational or Ecological Significance (ERES) designation is applied to special State waters that are accorded a higher level of protection than other waters. Section 11.5 of the State of Delaware Surface Water Quality Standards (August 1999) contains specific criteria for ERES waters.

All the State's waters are designated for Primary Contact Recreation and for Fish, Aquatic Life, and Wildlife purposes.

II.3 Nonpoint Source Pollution Control Program

The Nonpoint Source Management Program is a dynamic and open-ended program intended to facilitate and promote statewide efforts to manage nonpoint source pollution. The following goals guide the program:

- The NPS Program will support the identification and quantification of those problems that are caused specifically by nonpoint source pollution through assessment updates.
- The NPS Program will be implemented and updated to realistically reduce nonpoint source pollution in a cost-effective manner.
- The NPS Program will address nonpoint source pollution through a program that balances education, research, technical assistance, financial incentives, and regulation.
- The NPS Program will follow a non-degradation policy in areas where surface and ground waters meet state water quality standards and a policy to realistically improve water quality in areas that do not meet these standards.
- The NPS Program will continue to use the coordinated approach for implementation and maintain an open-ended framework to incorporate new initiatives.

In Delaware, the lead agency for the development and implementation of the Nonpoint Source (NPS) 319 Program is the Department of Natural Resources and Environmental Control (DNREC), Division of Soil and Water Conservation. The NPS program is required to develop an annual list of Environmental Indicators and to provide yearly progress reports to EPA on the accomplishment of stated goals and objectives. Delaware's NPS Program will distribute the 1999 Annual Report in April 2000. Delaware revised the NPS Management Plan document in 1999. It was subsequently approved by EPA in November, 1999. The Management Plan provides direction for the implementation of nonpoint source initiatives for 1999 through 2004. Delaware will strive to assure effective and efficient use of financial resources by leveraging funds with other programs and by targeting NPS priority issues and areas.
The NPS Program Staff has developed program milestones/objectives that focus staff resources on critical issues and areas. These priority issues have been identified in the Management Plan,1999 and Assessment Report, 1995 as well as other assessment processes such as the 305(b) Report and the Whole Basin Preliminary Assessment process. The specific "Milestones for Implementation" that will guide the NPS Program staff for the next five years are as follows:

- Commit NPS 319 funds (20% max. allowed) to Total Maximum Daily Load (TMDL) development. Support implementation of TMDL Pollution Control Strategies in the Inland Bays and Nanticoke Watersheds.
- Commit NPS Staff Resources to Whole Basin Management Initiatives. Develop criteria for expanded uses of the State Revolving Fund. Implement new technologies and best management practices associated with expanded uses.
- Establish Environmental Indicators. Use indicators for tracking/assessing environmental improvement
- Provide input and technical support to DNREC water quality assessment prioritization such as the Unified Watershed Assessment List and 305(b) List.
- Nutrients: Agriculture - Provide technical and financial support for alternative uses of manure, distribution of manure, and on-farm conservation planning. Seek mass balance of nutrients in the state and regionally.
- Urban - Develop baseline data for urban Loadings Provide technical support for Conservation Reserve Enhancement Program (CREP), Confined Animal Feeding Operations (CAFOs), and the Coastal Nonpoint Source Pollution Program .
- Hydromodification: Agriculture - Support expanded research/implementation of Best Management Practices (BMPs) to prevent nutrient and sediment transport by agricultural drainage ways.

- Urban - Advance research and implementation of improved storm water management techniques to maintain the stability of streams and rivers and prevent further environmental degradation. Provide public education on the benefits of riparian corridors and the protection of existing corridors.

Information and Education - Promote public outreach on NPS issues by use of the DNREC web page, Annual Report, NPS display, fact sheets, presentations and public service announcements.

Part III Surface Water Assessments

Part III Surface Water Assessments

Part III Chapter 1

III.1.1 Surface Water Monitoring Programs

Water quality and biological data for Delaware's surface waters are collected under Delaware's Ambient Surface Water Quality Monitoring Program and Biological Monitoring Program within DNREC. Several active citizen monitoring programs have also been developed throughout Delaware that augment the data collected by DNREC. These programs are discussed below.

The DNREC recognizes the need to use its personnel and financial resources efficiently and effectively. To that end, surface water quality monitoring is conducted in a manner that focuses available resources on the Whole Basin Management concept. The Whole Basin Management Program in Delaware operates on a 5-year rotating basis. This new approach enables the DNREC to comprehensively monitor and assess the condition of the State environment with due consideration to all facets of the ecosystem.

Elements of the State's specific Surface Monitoring Program include:

- TMDL-Related Monitoring
- General Assessment Monitoring
- Toxics in Biota Monitoring
- Toxics in Sediment Monitoring
- Biological Assessment Monitoring

III.1.1.1 TMDL Related Monitoring

Section 303(d) of the Clean Water Act (CWA), as amended by the Water Quality Act of 1987, requires States to identify those waters within their boundaries that are water quality limited, to prioritize them, and to develop a Total Maximum Daily Load (TMDL) for pollutants of concern. A water quality limited water is a waterbody in which water quality does not meet applicable water quality standards, and/or is not expected to meet applicable standards, even after application of technology-based effluent limitations for Publicly Owned Treatment Works (POTW) and other point sources.

Delaware DNREC has developed a list of water quality limited waters (303(d) List) and is planning to complete TMDLs for all segments on the 1996 list over a ten-year period. The TMDL development schedule is coordinated with the Department's Whole Basin Management Program.

The TMDL related monitoring is designed to provide the necessary information for developing, calibrating, and verifying hydrodynamic and water quality models and/or to support the existing models. The Department uses the hydrodynamic and water quality models as management tools for establishing total maximum daily loads; for allocating loads between point and nonpoint sources of pollutants; and for monitoring progress toward achieving water quality goals and standards.

III.1.1.2 General Assessment Monitoring

The General Assessment Monitoring Network (GAMN) provides for routine water quality monitoring of surface waters throughout Delaware. Each station is monitored for conventional parameters such as nutrients, bacteria, dissolved oxygen, pH, alkalinity, hardness, and metals. The data from this monitoring is entered into the EPA's STORET database, is reviewed and then analyzed in assessing the water quality condition of each water body system. Figure III-1 is a map of active STORET stations used for this report.

Figure III-1 Storet Map

III.1.1.3 Annual Toxics in Biota Monitoring

The Annual Toxics in Biota Monitoring provides for screening level surveys and intensive surveys for toxic contaminants in fish/shellfish. Provision is also made to revisit waters where fish consumption advisories have been issued in the past to determine if contaminant levels in fish are increasing or decreasing over time. Intensive surveys are planned and conducted in areas where contamination has been detected in screening level surveys.

III.1.1.4 Toxics in Sediment Monitoring

The purpose of the Toxics in Sediment program is to obtain baseline information regarding the levels of various toxics in the sediments of waters throughout the State. The program is designed to complement the Annual Toxics in Biota Monitoring.

III.1.1.5 Biological Assessment Monitoring

The assessment of the quality of surface waters utilizes a multi disciplinary approach involving physical, chemical, and biological measures. The biological monitoring program is a major tool used by the Department to assess the conditions of surface waters. It includes the assessment of indigenous biological communities and physical habitats of streams, ponds, estuaries and wetlands. The goal of the program is to establish numeric biological criteria in State water quality standards to complement both existing chemical criteria and other assessments focused on fish tissue monitoring and bioassay testing. Standard methods have been developed and tested for assessing the biological community and habitat quality of nontidal streams, and draft numeric criteria are under development. Efforts over the next few years will focus on the development of methods for assessing estuaries and ponds and for assessing the quality and quantity of wetlands

III.1.2 Coordination/Collaboration

III.1.2.1 Delaware Center for the Inland Bays

III.1.2.1.1 Overview

The Delaware Center for the Inland Bays was established as a nonprofit organization in 1994 under the Inland Bays Watershed Enhancement Act (Chapter 76 or Del. C. S7603). The mission of the Center for the Inland Bays is to oversee the implementation of the Inland Bays Comprehensive Conservation and Management Plan and to facilitate a long-term approach for the wise use and enhancement of the Inland Bays watershed by conducting public outreach and education, developing and implementing conservation projects, and establishing a long-term process for the preservation of the Inland Bays watershed.

The goals of the Center for the Inland Bays are:

To sponsor and support educational activities, restoration efforts, and land acquisition programs that lead to the present and future preservation and enhancement of the Inland Bays watershed.

To build, maintain, and foster the partnership among the general public; the private sector; and local, state, and federal governments, which is essential for establishing and sustaining policy, programs, and the political will to preserve and restore the resources of the Inland Bays watershed.

To serve as a neutral forum where Inland Bays watershed issues may be analyzed and considered for the purposes of providing responsible officials and the public with a basis for making informed decisions concerning the management of the resources of the Inland Bays watershed.

The establishment of the Center was the culmination of more than 20 years of active public participation and investigation into the decline of the Inland Bays and the remedies for the restoration and preservation of the watershed. A key element of this progression was the publication of a Decisions for Delaware: Sea

Grant Looks at the Inland Bays (1983) and the participation by Sea Grant researchers and outreach personnel in the problem-solving process. The last six years of this work were accomplished as part of the National Estuary Program.

The National Estuary Program, established under the Clean Water Act and administered by the U.S. Environmental Protection Agency (EPA), provided approximately $2 million to study the Inland Bays, characterize and set priorities for addressing the environmental problems in the watershed, and develop a Comprehensive Conservation and Management Plan (CCMP) to protect and restore the bays. The underlying theme of the program is that a collaborative, consensus-building effort involving citizens; private interests; organized groups; and federal, state, and local governments is essential to the successful development and implementation of the CCMP. Recently completed through a highly successful participatory effort, the Inland Bays CCMP has now been approved by Governor Thomas Carper and the EPA. Funding is provided by the EPA, the State of Delaware and private donations.

III.1.2.1.2 Major Environmental Issues

The Delaware Center for the Inland Bays has joined many others in learning all it can about Pfiesteria, especially in light of recent reports of fish kills in the nearby Pocomoke River. Since this organism thrives in stressed estuaries, like the Inland Bays, the concern of nutrient over-enrichment (especially phosphorus) is bringing a new concern to our attention. The Center also knows that the ulva (sea lettuce) bloom of this year and last year is also driven by excess nitrogen and phosphorus. The sources of these loadings are both point and non-point. The loss of valuable aquatic, upland, and wetland habitat is also an important symptom of the stressed conditions of the Inland Bays. However, it is increasingly clear that public attention and concern for our Inland Bays is reaching a level perhaps never seen before in our state. News coverage and media attention of the ulva bloom and the presence of pfiesteria in the Inland Bays makes our efforts even more visible and accountable. The Center is on the forefront of taking some important leadership steps in the restoration of the Inland Bays.

III.1.2.1.3 FY 2000 Center For The Inland Bays Project Summaries (Future Opportunities)

III.1.2.1.3.1 Demonstration Project Management and Oversight

Overall administration and oversight of Center activities, coordination with cooperating agencies and organizations, communication and tracking of progress of CCMP.

III.1.2.1.3.2 Tributary Strategy Program

A citizen based program focusing the three inland bay basins; each team will assist the Delaware Department of Natural Resources and Environmental Control in developing pollution control strategies for TMDL limits

III.1.2.1.3.3 James Farm Restoration and Wetlands Buffer Restoration

A program to restore the native plant community and expand existing forest and wetland buffer at the County-owned and Center for the Inland Bays.

III.1.2.1.3.4 Citizen Science: The Inland Bays Citizen Monitoring Program

A program to support the Inland Bays Citizen Monitoring Program.

III.1.2.1.3.5 Evaluation of Bivalve Culture and Restoration Methods/Rehoboth & Indian River Bays

A program to monitor and evaluate shellfish culture.

III.1.2.1.3.6 Characterization and Development of Indicators of the Status of the Inland Bays

A program to develop a set of environmental indicators to assist managers and the public with assessments of the status and health of the Inland Bays.

III.1.2.1.3.7 Sustaining Living Resources in Delmarva's Coastal Bays

A program to sponsor a conference to convene scientists, managers, conservationists and fishermen to discuss common issues.

III.1.2.1.3.8 Bacteria as Biological Controls and Biosensors of Pfiesteria piscicida

To explain how and if bacteria can control the toxic Dinoflagellate, Pfiesteria piscicida, in the bays.

III.1.2.1.3.9 Inland Bays Education through Interactive Classroom Learning Centers

This will create two interactive learning centers for use at the first and fifth grade elementary school levels.

III.1.2.1.3.10 The Relationship between Juvenile Fishes and Dissolved Oxygen Levels

An extension of a 1998 monitoring study which will relate dissolved oxygen to the distribution, abundance and feeding of the juvenile stages of Winter Flounder, Summer Flounder, Weakfish and Atlantic Croaker.

III.1.2.1.3.11 Water Quality and Pollution Prevention Education for Inland Bays Communities

A pilot project that is an extension of Home-A-Syst program.

III.1.3 Citizen's Monitoring Programs in Delaware

In recent years, many citizens' groups have been formed nationwide in response to the growing concerns about degraded water quality. Delaware was one of the first states to initiate citizens' water quality monitoring program of streams to augment fixed monitoring by state agencies. The involvement of citizens in collecting data and making observations on their streams results in an educated public with an appreciation for their watersheds and awareness of pollution threats to vital resources. Data and observations collected by citizens with a strong sense of environmental stewardship will contribute to the long-term success of environmental strategies.

Delaware has four programs that use citizens to monitor water quality. Delaware Stream Watch was established in 1985 by the Delaware Nature Society in cooperation with DNREC. The Inland Bays Citizen Monitoring program was established in 1990 as part of the Inland Bays Estuary Program. The Nanticoke Citizen Monitoring Program was founded in 1991 by concerned citizens of the City of Seaford in cooperation with DNREC. The Adopt A Wetland Program initiated in May 1993 by the Division of Water Resources and later transferred to the division of Fish and Wildlife.

III.1.3.1 Delaware Stream Watch

Delaware Stream Watch, a grassroots volunteer water resource protection program, is a cooperative effort of the Delaware Nature Society, DNREC, and more recently, industry. Since its inception in 1985, Stream Watch has focused on pollution detection and water quality education. Three monitoring programs are presently being conducted: Stream Adoption, Technical Monitoring, and the Specialized Surveys. As part of the Stream Adoption program, some 160 sites in 24 of Delaware's 41 watersheds have been formally adopted. Technical Monitoring now includes more than 37 individuals (adults and college students) monitoring over 28 sites monthly in the greater Christina Basin. In the major Specialized Survey activity, over 120 hours of volunteer time were donated annually by 11 volunteers to conduct a quantified macro invertebrate survey on 3 sites in the Delaware portion of the White Clay Creek. Additionally, other special surveys include smaller macro invertebrate surveys and a limited enterococcus monitoring project on three Nature Society preserve properties. Also, various educational events are conducted each year to train nearly 700 persons in monitoring techniques and to increase awareness of water issues for an additional 4250 persons.

III.1.3.1.1 Stream Adoption

To reach the largest audience, the Stream Adoption Program is designed with flexibility for the volunteers. Volunteer Stream Watchers are trained in a three hour workshop to recognize and report four major water pollution problems: toxic, organic, nutrient, and sediment. They are also trained to conduct three types of water quality surveys (visual, chemical/physical and macro invertebrate) using simple methods and equipment.

The visual survey includes an inventory of pollution signs such as excess algae and unusual water color or odor, potential pollution sources such as water discharge pipes or materials stockpiled next to the water; and obvious ecological factors that may affect stream health such as bank erosion due to loss of vegetation.

The chemical/physical survey includes air and surface water temperature and the use of field test kits to determine the pH, and levels of dissolved oxygen, and occasionally, in coastal waters, salinity.

The macro invertebrate survey consists of collecting aquatic insects and other invertebrates from rocks, leaf packs, vegetation, sticks, logs and/or bottom sediments, using washing and sieving techniques or constructed nets. Volunteers are then taught to recognize four types of aquatic insect larva or nymphs that are useful indicators of pollution.

Each volunteer receives an illustrated, step by step Delaware Stream Watch Guide to reinforce and supplement the information provided during the workshop. They are encouraged to adopt a stream (or other body of water) and choose from among the survey methods according to the type of waterway and their individual interests and capabilities. They are requested to fill in data sheets and mail them to DNREC upon completion of the survey. Monitoring seasonally at least four times per year are encouraged.

Stream watchers can adopt waterway sections as individuals or as a group. See Figure 1 for location by watershed of these adopted sections. For Approximately one quarter of the 160 sites currently adopted, volunteers collect and mail in detailed visual, chemical, and/or macro invertebrate data at a minimum of three times per year. A few volunteers collect and mail in data on a monthly or bimonthly basis. The remaining volunteers visually monitor for evidence of pollution. These volunteers report any pollution problems to the appropriate agency, but are not required to record and mail in data sheets.

III.1.3.1.2 Technical Monitoring

In 1995, Stream Watch expanded the Technical Monitoring program from the original 6 sites in the Red Clay Creek Basin to more than 28 in the greater Christina Basin (which includes the Red Clay, White Clay, and Brandywine Creek sub-basins). The technical monitoring program’s monthly sampling frequency, strategic site selection, and rigorous quality control and assurance measures provide accurate baseline data and allow for subtle trend analysis. Volunteers range from persons with advanced engineering and science degrees to college students. Field test kits are used to monitor air and surface water temperature, dissolved oxygen levels, pH, nitrate nitrogen, alkalinity, and conductivity. Some visual observations are also recorded.

Stream flow data was added in 1998 to the parameters measured at monitoring sites. DNREC provided training to volunteers and Stream Watch staff in the use of electronic flow meters. DNREC also has provided loaner flow meters for use by volunteers. Flow data is measured 1 - 2 times per year.

III.1.3.1.3 Specialized Surveys

The major Specialized Survey is the White Clay Creek Macroinvertebrate Survey. In partnership with the Stroud Water Research Center, the White Clay Watershed Association, and the University of Delaware, Stream Watch conducts an annual quantified macro invertebrate survey on 3 sites in the Delaware portion of the White Clay Creek. Four surber samples are collected at each site and specimens are preserved in the field; later in the laboratory specimens are identified to family or order level and taxa tallied. Data is analyzed at Stroud.

III.1.3.1.4 Red Clay Creek Microbiological Project

Six sites are sampled monthly in the Red Clay Creek Basin and tested by a volunteer faculty member at the University of Delaware for enterococcus bacteria. The purpose of the project is to establish baseline data.

III.1.3.1.5 Education

The Stream Watch program's educational focus is extended through various avenues. The semiannual editions of "Stream Talk" reach a mailing list of over 1400 concerned citizens. Water quality monitoring and stream ecology workshops involve 100 citizens, 100 teachers, and 700 elementary through college age students per year. Other educational activities conducted Statewide include slide and video presentations, public exhibits, and seminars and conferences on water quality concerns.

Two great advances in water quality education occurred in 1998. First, a Watershed Unit for 7th grade students was developed cooperatively by the Department of Natural Resources and Environmental Control and the Department of Education. The nine-week unit explores all aspects of watershed concepts and the activities correlate with the Delaware State Content Standards for Science, Math, Social Studies, and Language Arts. Stream Watch activities are included as an integral part of assessing watershed health. Twenty-nine teachers were trained in two 5-day workshops. Trunks of monitoring equipment and items necessary for activities were provided by a grant from industry. Each year more than 4350 students will learn how to monitor the health of a stream using Stream Watch instructional materials and methods.

Secondly, the video entitled "Our Water: Who's Got the Power?" was produced by the Delaware Nature Society and the Stroud Water Research Center. The half-hour video informs viewers of watershed principles and how landscape management affects water quality. The video is an excellent outreach tool for the general public. It will also be used as an introduction to the watershed unit.

III.1.3.1.6 Advocacy

Stream Watch staff and volunteers act as advocates for water resource protection. Advocacy actions taken include correspondence and contact with key local, state and federal agency personnel and lawmakers; participation in public hearings and commentary on water quality issues including federal wetlands permitting revisions and Total Maximum Daily Loads (TMDLs); and membership in water resource committees and task forces, including the state Source Water Protection Program and the Christina Basin Task Force. Advocacy efforts on a focused, local level are also integral to Stream Watch.

Contact with Stream Watch Adopters is maintained in several ways. All Stream Watchers receive the newsletter, "Stream Talk," edited by DNS and published twice a year. Volunteers are also encouraged to attend a refresher/enrichment training session once per year. At this session, volunteers also may be retrained on chemical test kit procedures and macro invertebrate identification, are able to check the validity of their test kits and receive individual answers to their monitoring questions. Volunteers with questions or concerns call the Stream Watch office, the DNREC liaison, or their watershed cluster leader (an experienced volunteer in their local area) for assistance. The Stream Watchers List Server was piloted in 1999 as an additional means of communication. The server allows participants (volunteers and others interested in the state's water quality) to post questions and observations via an e-mail system on the Internet. A link to the server is provided in the Delaware Stream Watch web page at www.delawarenaturesociet~,.org/streamwatch.htm. In addition, the DNREC liaison maintains personal written contact with volunteers, responding to every data report submitted and answering individual questions on monitoring techniques, malfunctioning equipment or biological observations. The DNREC liaison also phones the volunteers when necessary to recommend an appropriate agency to solve a pollution problem.

Stream Watcher pollution reports have been well received by state and county officials. Telephone calls from Stream Watchers to the toll free 24 hour DNREC Environmental Complaint Hotline or through DNREC liaison are welcomed by enforcement officers because they know that the individuals have been trained to recognize signs of pollution. The detailed observations and site locations provided by Stream Watchers make responses faster and more effective. Since its inception, Stream Watch volunteers have been the first to report fish kills, illegal trash dumping, high coliform counts, failing septic systems, sewer overflows, and erosion/sedimentation problems.

The Delaware Nature Society employs one fulltime coordinator and two part-time assistants to conduct the Stream Watch program. The staff members at the Delaware Nature Society recruit, train, support, and cultivate the volunteers; plan and administer the program; serve as information resources; and provide various educational programs. The DNREC also employs Citizens Monitoring Coordinator who serves as a liaison to receive, acknowledge and direct responses to the data received from the volunteers and report regulatory problems to enforcement personnel, who respond as appropriate. The DNREC Coordinator also develops and conducts workshops and participates in some of the educational activities organized by the Delaware Nature Society.

Funding for Stream Watch is from DNREC, the Delaware Nature Society, and industry. Originally DNREC funds were obtained via a grant from the U.S. Environmental Protection Agency and later from penalty fees resulting from enforcement actions. Currently Stream Watch receives the major portion of its funding through a line-item in the DNREC budget. The Delaware Nature Society provides office space, equipment, and in-kind services in addition to contributing funds directly. The Society also receives grants for specific items in the Stream Watch budget. In particular the Technical Monitoring program is supported by funds and in-kind support from several local industries, and in-kind support and equipment from DNREC. In 1999 DNREC funding equaled approximately $72,000.

III.1.4 Data Interpretation and Communication

Delaware has converted its older Waterbody System (WBS) database to the new EPA provided Assessment Database (ADB). The ADB is a Microsoft Access© database that generated the summary Use Assessment tables in this report. Over the last several years, the Department has been using internal resources and an EPA contractor to georeference waters of the State. The Department uses the resultant products to provide data and information to its constituents

III.2 Chapter 2: Assessment Methodology and Summary Data

III.2.1 Methodology

The basis for assessment of Delaware's surface waters is provided in the State of Delaware Water Quality Standards (amended August 1999). Each water body in the state is assigned designated uses, and water quality standards are established for these designated uses. The assessments are made by comparing water quality data and related information to water quality standards for each water body. The results of each assessment will be compared to criteria provided in the EPA's Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates (EPA-841-B-97-002A, September 1997) to determine the degree of use support attained for a water body.

III.2.2 Assessment Categories

In accordance with EPA guidance, the assessments are categorized according to the amount and quality of information available. Assessments are classified as "Monitored" if site-specific water quality or biological data was available for the period of September 1, 1997 to August 31, 1999.

Assessments were classified as "Evaluated" if available data did not meet the criteria discussed above. The Evaluated assessments relied on information on land use, point and nonpoint pollution sources, citizens monitoring reports, water quality data collected on a similar water body within the drainage basin, or water quality data prior to September 1, 1997.

Table III-1 Evaluated, Monitored and Assessed Waters

Type of Waterbody	Assessment Basis		Total Assessed
	Evaluated	Monitored	
Coastal Shore Line (Miles)	0	25	25
Estuary (Square Miles)	.59	28.95	29.54
Lakes (Acres)	625.50	2328.40	2953.90
Rivers (Miles)	1817.16	688.91	2506.07

III.2.3 Data Sources

Water quality and biological data for Monitored assessments is primarily provided by the Ambient Surface Water Quality Monitoring Program. This monitoring includes fixed station monitoring and biological surveys using rapid bioassessment protocols. Physical/chemical data collected by this program is maintained and accessed through the EPA's STORET database. Other sources of information include fishery surveys and annual reports by DNREC Division of Fish and Wildlife; recreational and shellfish sanitation water quality surveys; and technical reports prepared for the Delaware Estuary and the Inland Bays Estuary Program. Information for Evaluated assessments is based on knowledge of pollutant loadings from point and nonpoint sources; information provided by citizen reports prepared under the Stream Watch Program; citizen complaints filed with DNREC; water quality data from similar water bodies; or water quality data collected prior to September 1, 1997.

III.2.4 Data Analysis

Water quality data for the assessments was retrieved for the period of September 1, 1997 through August 31, 1999. Data collected after August 31, 1999 was reviewed when available. In instances where data for a water body was not available for the 1997-1999 period, information from prior State of

Delaware Watershed Assessment Reports [305(b)] was used. The relative frequency of standard violations is used to determine the degree of use support as described in the next section.

The water quality parameter used to assess the Swimmable Water Goal of the Clean Water Act and Primary Contact Recreation designated uses was Enterococcus concentrations. Geometric mean and 90 percentile concentrations of Enterococcus data for the period were calculated and then compared to State's standard in order to determine the degree of use support. Delaware's standard with regard to Enterococcus Bacteria is 100 colonies/100mL for freshwaters and 10 colonies/100mL for marine waters. Information on bathing area closures as posted by the Division of Public Health was also used.

To establish Aquatic Life Use Support (ALUS), both physical and chemical data were used. A summary of water quality data analysis for each stream segment is provided in this report.

Delaware's Shellfish Program is based on a qualitative assessment of pollution sources. This is augmented by a quantitative measure of ambient water indicator bacteria. Semi-monthly sample results are incorporated into spreadsheets of the most recent 15 samples taken; and less than ten percent of the samples may not exceed 330 total coliform per 100mL. Delaware's Shellfish Program uses a standard of 70 total coliform bacteria per 100 mL.

In addition, waters are classified based on theoretical loading from concentrations of boats in and around marinas - mimicking the TMDL concept. Interstate Shellfish Sanitation Conference (ISSC) protocol assumes zero-fecal-coliform background water, and establishes buffers around marinas based on dilution volume required to reach 70 total coliform per 100 mL standard.

III.2.5 Decision Criteria for Determining Use Support

The decision criteria for determining the attainment of designated uses follows the EPA's Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates (EPA-841-B-97-002A, September 1997) and is presented in the flow charts shown in Figure III-2 and III-3.

Figure III-2

Decision Criteria for Aquatic Life Use Support

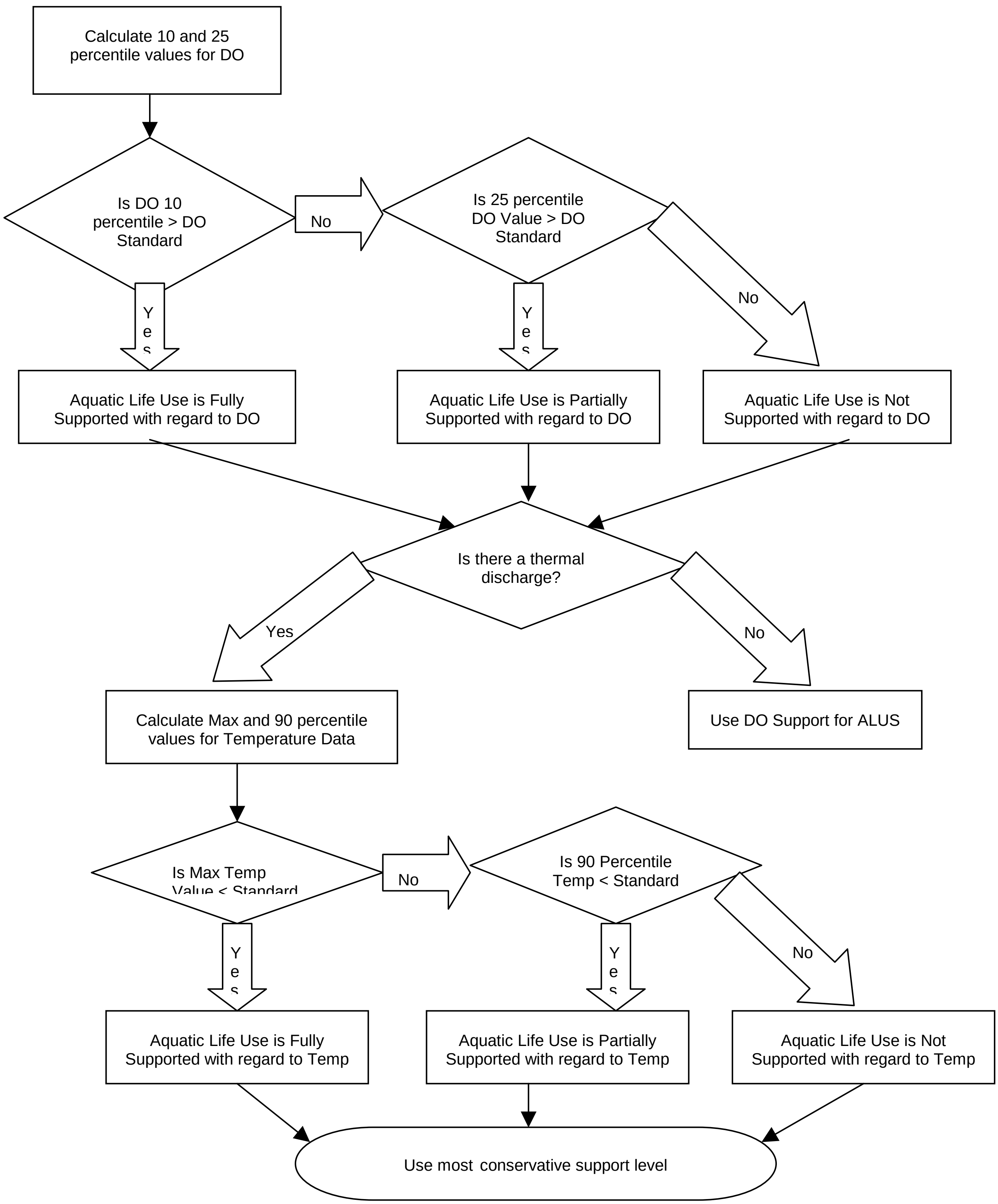
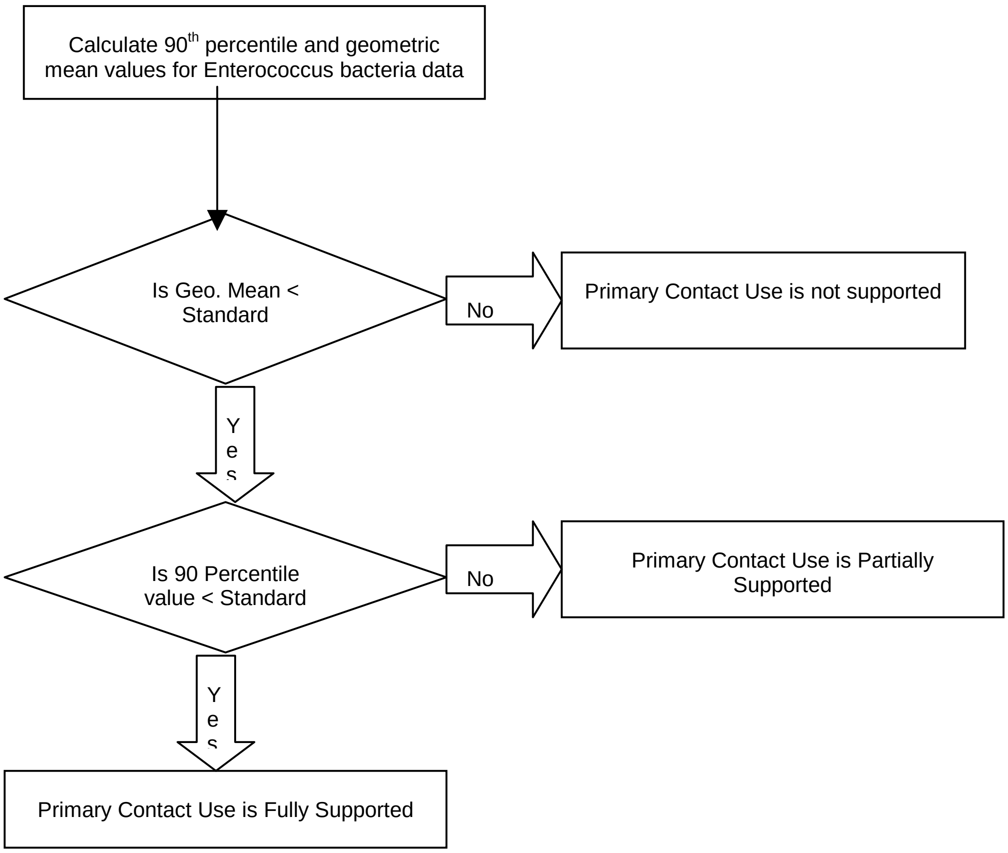


Figure III-3

Decision Criteria for Primary Contact Use Support



III.2.5.1 1. Primary Contact:

This designated use is considered fully supported when the geometric mean value and the 90 percentile value are both less than the water quality standards. If the geometric mean value is less than the standard, but the 90th percentile is greater, then the primary contact use is partially supported. In situations where both measures exceed the water quality standards, then the designated use is considered not supported.

Bathing area closure data are also taken into account when making the final use determination; fully supporting if no bathing area closures or restrictions are in effect during September 1, 1995 through August 31, 1997, partially supporting in cases where one bathing area closure per year of less than one week's duration, and not supporting if there is more than one closure per year or one closure per year of greater than one week's duration.

III.2.5.2 2. Secondary Contact:

Determination of this use support was arrived by reviewing the 1994 and 1996 305(b) Reports. The use support was similar to previous 305(b) reports.

III.2.5.3 3. Aquatic Life:

Physical/chemical data were used in making an aquatic life use support (ALUS) determination.

a. Dissolved oxygen--- According to the guidelines, when water quality standards are exceeded in less than 10 percent of measurements, the water use is considered fully supported. If violation of water quality standard is between 10 and 25 percent, it is considered partially supported. For cases that water quality standards exceeded in more than 25 percent of measurements, the use was considered not supported.

b. Temperature--- ALUS is considered fully supported when the maximum value is less than the water quality standards. If the maximum value is less than the standard, but 90 percentile is greater, then use is partially supported. In situations where both measures exceed the water quality standards then the designated use is considered not supported..

c. **Zinc** Delaware is reporting two segments as not supporting ALUS due to zinc excursions that were fully documented in TMDLs that were developed for the impaired segments.

Nutrient Characterization

In addition to the comparison of data to established water quality standards, a categorization scheme for nutrient concentrations of ambient waters was implemented. Nutrients included in the comparisons were total nitrogen, total phosphorus, and chlorophyll-a. The categories are based on the range of concentrations as described by low, moderate, and high concentrations. These categories are defined by the ranges shown in the following table (Table III-2).

Table III-2 Categories of Nutrient Concentrations

Nutrient Range	Total Nitrogen (mg/l)	Total Phosphorous (mg/l)	Chlorophyll-a (ug/l)
Low	Less than 1.0 mg/l	Less than 0.05 mg/l	Less than 10 ug/l
Moderate	1.0 mg/l - 3.0 mg/l	0.05 mg/l - 0.10 mg/l	10 ug/l - 50 ug/l
High	Greater than 3.0 mg/l	Greater than 0.10 mg/l	Greater than 50 ug/l

This comparison provides a general ranking of nutrient levels in Delaware's surface waters. High concentrations of any nutrient do not necessarily imply that water quality or biota are adversely impacted, but it does serve to highlight areas where nutrients are entering the waters.

Delaware took a conservative approach in making ALUS determinations. Both temperature and dissolved oxygen status were considered in the determinations. If one parameter was partially supporting and the other was not supporting, then the segment was listed as not supporting the use. This approach ensured that sites were listed as impaired, using all available data

III.2.5.4 4. ERES Waters (Exceptional Recreation or Ecological Significance):

This designated use is considered supported if all other designated uses for ERES water is fully supported. If one or more of the designated uses are partially supported, the ERES use is partially supported. If one or more of the designated uses are not supported, then ERES is not supported.

III.2.5.5 5. Public Water Supply:

The determination of this use was reached by consulting with the Drinking Water Program and Division of Public Health.

III.2.5.6 6. Agricultural Supply:

Generally all designated waters support this use unless there is specific information to the contrary.

III.2.5.7 7. Industrial Supply:

Generally all designated waters support this use unless there is specific information to the contrary.

III.2.5.8 8. Shellfish Waters:

Areas marked in blue color in Figures III-4 and III-.5 meet the water quality standard vis-à-vis shellfish harvesting as fully supporting. Areas marked in yellow color are partially supporting; and areas marked in red color are not supporting.

III.2.6 Summary Data Tables

The following summary table (Table III-3) was compiled using the EPA provided Assessment Database. The table summarizes Use Support determinations in Table III-5.

Figure III-4

Figure iii-5

Table III-3 Individual Use Support Summary

(National and State Uses)

Type of Waterbody: River

Note: All numbers are in Miles

Use	Size Assessed	Size Fully Supporting	Size Fully Supporting but Threatened	Size Partially Supporting	Size Not Supporting	Size Not Attainable
Aquatic Life Support	2,506.07	740.84	0.00	515.91	1,249.32	0.00
Cold Water Fishery	66.60	53.80	0.00	0.00	12.80	0.00
Shellfishing	5.20	0.00	0.00	0.00	5.20	0.00
ERES (Exc. Rec.& Eco. Sig.)	881.05	0.00	0.00	237.70	643.35	0.00
Primary Contact (Recr)	2,506.07	106.72	0.00	748.25	1,651.10	0.00
Secondary Contact (Recr)	2,506.07	2,506.07	0.00	0.00	0.00	0.00
Drinking Water Supply	204.50	198.50	0.00	0.00	6.00	0.00
Agriculture	1,959.11	1,959.11	0.00	0.00	0.00	0.00
Industrial	2,479.78	2,479.78	0.00	0.00	0.00	0.00

Table III-3 Individual Use Support Summary (continued)

(National and State Uses)

Type of Waterbody: Freshwater Lake
Note: All numbers are in Acre

Use	Size Assessed	Size Fully Supporting	Size Fully Supporting but Threatened	Size Partially Supporting	Size Not Supporting	Size Not Attainable
Aquatic Life Support	2,953.90	2,159.20	0.00	299.70	495.00	0.00
ERES (Exc. Rec.& Eco. Sig.)	757.80	123.00	0.00	495.60	139.20	0.00
Primary Contact (Recr)	2,953.90	911.00	0.00	1,136.00	906.90	0.00
Secondary Contact (Recr)	2,953.90	1,544.70	0.00	1,251.40	157.80	0.00
Drinking Water Supply	295.60	295.60	0.00	0.00	0.00	0.00
Agriculture	2,764.60	2,764.60	0.00	0.00	0.00	0.00
Industrial	2,953.90	2,953.90	0.00	0.00	0.00	0.00
Nondegradation	33.00	33.00	0.00	0.00	0.00	0.00

Table III-3 Individual Use Support Summary (continued)

(National and State Uses)

Type of Waterbody: Estuary
Note: All numbers are in Square Miles

Use	Size Assessed	Size Fully Supporting	Size Fully Supporting but Threatened	Size Partially Supporting	Size Not Supporting	Size Not Attainable
Aquatic Life Support	28.95	0.00	0.00	25.00	3.95	0.00
Shellfishing	14.54	0.59	0.00	13.95	0.00	0.00
ERES (Exc. Rec.& Eco. Sig.)	29.54	0.00	0.00	25.00	4.54	0.00
Primary Contact (Recr)	29.54	12.00	0.00	16.00	1.54	0.00
Secondary Contact (Recr)	28.95	28.95	0.00	0.00	0.00	0.00
Industrial	28.95	28.95	0.00	0.00	0.00	0.00

Table III-3 Individual Use Support Summary (continued)

(National and State Uses)

Type of Waterbody: Coastal Waters
Note: All numbers are in Miles

Use	Size Assessed	Size Fully Supporting	Size Fully Supporting but Threatened	Size Partially Supporting	Size Not Supporting	Size Not Attainable
Aquatic Life Support	25.00	25.00	0.00	0.00	0.00	0.00
Primary Contact (Recr)	25.00	25.00	0.00	0.00	0.00	0.00
Secondary Contact (Recr)	25.00	25.00	0.00	0.00	0.00	0.00
Industrial	25.00	25.00	0.00	0.00	0.00	0.00
Nondegradation	25.00	25.00	0.00	0.00	0.00	0.00

III.3 Chapter Three: Rivers/Streams, Estuaries and Lakes Water Quality Assessments

Presented on the following pages are two tables. Table III-4 is a summary of data collected by the Department in the period from September 1, 1997 through August 31, 1999. The table is organized based on Basins, Watersheds and then Delaware Waterbody Segment ID. For each segment, the table lists the STORET stations in the segment that were used in the analysis and summary statistics for the physical and chemical data used in the use support determinations that are in Table III-5.

III.3.1 Causes/Stressors and Sources of Impairment of Designated Uses

Nutrients, low dissolved oxygen, and biology and habitat degradation were the leading cause of nonsupport of Aquatic Life uses. A direct correspondence was found between the trend in biological quality and the quality of physical habitat. Habitat degradation may result in exceedences of the dissolved oxygen and temperature criteria. Sources of biological and habitat impairment are due to nonpoint source pollution mainly from urban and agricultural runoff.

Pathogenic indicators (bacteria) are the most widespread pollutants impacting designated uses. The pathogen indicator monitored by the State for primary contact recreation is Enterococcus bacteria. Other pathogen indicators, such as total coliform and fecal coliform bacteria, are monitored to regulate shellfish harvesting areas. Indicator organisms are not a threat to human health or aquatic life, but their presence in abundant numbers signals an increased probability that disease causing organisms may be present.

Although pathogenic indicators are the most widespread contaminant in the State, nutrients and toxics pose the most serious threats to water quality, aquatic life, and human health. Most of the State's estuarine waters are considered nutrient enriched. Water quality and aquatic life impacts from nutrient enrichment include eutrophication and low dissolved oxygen levels. A large portion of the nutrients are transported to the estuaries and lakes by the rivers and ground water. The presence of toxics has resulted in fish consumption advisories in three basins within Delaware, including Red Clay Creek, Red Lion Creek, St. Jones River and the Delaware Estuary. Several other basins are considered threatened by toxic contamination.

Due to the ubiquitous nature of many pollutants such as pathogen indicators, positive identification of specific sources, and their relative impact, is difficult. Hence, multiple sources are cited for most cases. Agricultural runoff, nonpoint sources, urban runoff, and municipal and industrial point sources are the primary sources of nutrients and toxics

Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Salinty (ppt) Avg	Temp (c) Max	Temp (c) 90th%tile	DO (mg/L) Min	DO (mg/L) Max	DO (mg/L) Avg	DO (mg/l) 10th %tile	DO (mg/l) 25th %tile	Ent. Bact Geo Mean	Ent. Bact 90th%tile	pH Min	pH Max	pH Avg	Total N (mg/l) Min	Total N (mg/l) Max
Piedmont Drainage Basin																		
Brandywine Creek	Lower Brandywine River	DE 040-001	104011	0.1	25.6	24.8	7.0	13.3	9.4	7.12	7.4	100	660	6.9	8.2	7.7	0.281	2.170
Brandywine Creek	Upper Brandywine Creek, From State Line To Wilmington	DE 040-002	104021 104051	0.1	26.1	24.5	6.0	13.6	9.6	7.11	8.2	39	588	7.3	8.1	7.7	0.096	1.630
Brandywine Creek	All Tributaries On Brandywine Creek From The Headwaters to the Confluence with the Christina River	DE 040-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Christina River	Lower Christina River	DE 120-001	106011 106291	0.9	27.6	27.0	5.5	11.2	8.2	6.03	6.4	102	591	6.5	7.8	7.3	0.276	2.608
Christina River	Mid Christina River, Between White Clay Creek And Brandywine	DE 120-002	106021	0.5	27.3	26.7	5.0	10.8	8.3	5.74	7.5	153	600	6.3	7.8	7.2	0.206	2.312
Christina River	Christina River, Tributaries On The Christina River Between White Clay Crrek and Brandywine River	DE 120-002-01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Christina River	Upper Christina River	DE 120-003	106031	0.1	26.0	25.2	3.5	11.5	8.1	6.22	6.5	158	690	6.3	7.7	7.2	0.283	1.656
Christina River	Nonesuch Creek	DE 120-003-01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Christina River	Christina River Tributaries From Smalleys Pond Overflow To White Clay Creek	DE 120-003-02	106321	0.3	23.3	22.1	1.5	12.6	6.6	2.70	4.6	289	2000	6.8	7.6	7.2	0.225	1.301
Christina River	Lower Christina Creek	DE 120-004-01	106111 106141 106331	0.1	25.5	23.6	3.0	12.6	7.8	4.14	5.8	175	916	6.3	7.7	7.1	0.180	1.598
Christina River	Belltown Run	DE 120-004-02	106341	0.1	23.7	22.9	3.6	11.4	6.9	3.78	4.9	311	1220	6.6	7.3	7.0	0.407	1.148
Christina River	Muddy Run	DE 120-004-03	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Christina River	West Branch Including Persimmon Run And Stine Haskell Branch	DE 120-005-01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Christina River	Upper Christina Creek	DE 120-006	106191	0.1	23.6	22.5	8.0	13.3	10.5	8.20	8.7	136	713	6.6	7.8	7.2	0.113	0.795
Christina River	Little Mill Creek	DE 120-007-01	106281	0.1	25.3	24.5	5.1	11.7	8.9	6.44	8.2	189	600	6.5	7.9	7.3	0.204	1.661
Christina River	Chestnut Run	DE 120-007-02	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Christina River	Smalleys Pond	DE 120-L01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Christina River	Becks Pond	DE 120-L02	106121 106351	0.1	27.2	25.8	6.2	11.9	8.5	6.32	6.7	36	828	6.9	8.2	7.4	0.122	1.104
Christina River	Sunset Pond	DE 120-L03	106131 106361 106371 106381	0.1	26.8	24.2	1.1	12.1	6.5	2.94	3.2	96	2000	6.4	7.6	7.0	0.161	1.963
Naamans Creek	Lower Naamans Creek Including Its Tributaries	DE 230-001-01	101041	0.2	25.0	25.0	5.7	5.7	5.7	5.70	5.7	103	103	8.7	8.7	8.7	0.156	0.156
Naamans Creek	Upper Naamans Creek Including North Br. And South Br.	DE 230-001-02	101021 101031	0.1	24.4	24.4	6.0	12.2	9.0	6.31	7.8	84	450	6.9	8.5	7.5	0.113	0.947
Red Clay Creek	Red Clay Creek From Pennsylvania State Line	DE 260-001	103011 103031 103041	0.1	24.4	23.2	5.6	13.0	9.4	7.05	7.5	167	1734	6.6	8.3	7.5	0.131	2.302

"--" = no data in the period of Sept 1, 1997 to Aug 31 1999

Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Salinty (ppt) Avg	Temp (c) Max	Temp (c) 90th%tile	DO (mg/L) Min	DO (mg/L) Max	DO (mg/L) Avg	DO (mg/l) 10th %tile	DO (mg/l) 25th %tile	Ent. Bact Geo Mean	Ent. Bact 90th%tile	pH Min	pH Max	pH Avg	Total N (mg/l) Min	Total N (mg/l) Max
Red Clay Creek	Burroughs Run From Pennsylvania State Line Run	DE 260-002	103061	0.1	21.4	21.1	8.3	14.0	10.9	8.54	9.2	83	570	6.8	7.8	7.4	0.023	3.099
Red Clay Creek	All Other Red Clay Creek Tributaries Located In The Watershed But Not On the mainstem.	DE 260-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Red Clay Creek	Hoopes Reservoir	DE 260-L01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shellpot Creek	Lower Shellpot Creek	DE 300-001-01	102041	0.6	29.7	28.2	5.5	9.5	6.9	5.70	6.0	63	250	6.5	7.2	7.0	1.096	4.890
Shellpot Creek	Upper Shellpot Creek	DE 300-001-02	102011	0.1	24.8	24.5	5.9	11.9	8.2	6.32	6.8	261	510	6.9	7.9	7.3	0.172	3.579
Shellpot Creek	All Other Tributaries To Shellpot Creek Located In The Watershed But Not On the mainstem.	DE 300-001-03	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
White Clay Creek	White Clay Creek From Pennsylvania State Line	DE 320-001	105011 105031 105151	0.1	23.9	23.1	6.0	13.2	9.9	7.03	7.8	141	1284	6.2	8.2	7.4	0.139	1.605
White Clay Creek	Mill Creek	DE 320-002	105071	0.1	23.1	21.9	6.3	12.6	9.5	6.73	7.6	283	870	6.2	7.6	7.0	0.126	1.935
White Clay Creek	Pike Creek	DE 320-003	105101	0.1	23.1	22.1	8.1	13.8	10.9	8.43	8.9	90	1232	6.8	8.1	7.5	0.028	1.670
White Clay Creek	Middle Run	DE 320-004	105131	0.1	23.1	21.8	8.5	13.4	10.8	9.20	9.3	114	810	6.6	7.9	7.3	0.057	1.529
White Clay Creek	All Tributaries to White Clay Creek From The Headwaters To The Confluence With the Christina River	DE 320-005	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inland Bays/Atlantic Ocean																		
Assawoman Bay	Assawoman Bay	DE 350-E01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Buntings Branch	Bunting's Branch	DE 070-001	311041	0.0	17.0	16.8	4.0	8.2	6.5	4.48	5.2	1005	1473	6.8	7.8	7.1	0.231	3.418
Indian River/Indian River Bay	White Creek	DE 140-001	310121 312011	15.9	27.0	26.0	2.2	8.2	4.7	3.34	3.8	67	600	5.8	8.2	7.2	0.308	2.032
Indian River/Indian River Bay	Blackwater Creek	DE 140-002	308361	0.1	19.6	19.5	6.2	6.4	6.3	6.22	6.2	542	589	6.9	7.0	7.0	0.343	0.577
Indian River/Indian River Bay	Pepper Creek And Tributaries, Including Vines Creek, Mccrays and Deep Hole Branches	DE 140-003	308091 308151 308351	0.1	21.6	20.3	0.6	9.0	6.1	3.22	4.3	111	640	3.7	7.4	6.3	0.248	3.728
Indian River/Indian River Bay	Indian River	DE 140-004	306181 306191	14.4	27.4	27.1	4.1	7.7	6.0	4.75	5.1	66	340	6.3	7.9	7.1	0.547	2.677
Indian River/Indian River Bay	Swan Creek	DE 140-005	308301 308341	0.1	17.4	17.3	6.9	9.7	8.1	7.30	7.4	88	1074	5.8	7.1	6.6	0.190	1.226
Indian River/Indian River Bay	Stockley Branch	DE 140-006	308141 308281 308321	0.1	23.9	23.3	0.9	9.4	6.6	3.26	6.0	51	390	6.0	7.6	6.5	0.259	2.242
Indian River/Indian River Bay	Eli Walls Tax Ditch	DE 140-007	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indian River/Indian River Bay	Deep Branch, Including Peterkins Br., White Oak Swamp Ditch, Socorockets Ditch, Welsh and Simpler Branches	DE 140-008	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indian River/Indian River Bay	Mirey Branch, Including Sheep Pen Ditch, And Narrow Drain	DE 140-009	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indian River/Indian River Bay	Betts Pond Branch	DE 140-010	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

"--" = no data in the period of Sept 1, 1997 to Aug 31 1999

Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Salinty (ppt) Avg	Temp (c) Max	Temp (c) 90th%tile	DO (mg/L) Min	DO (mg/L) Max	DO (mg/L) Avg	DO (mg/l) 10th %tile	DO (mg/l) 25th %tile	Ent. Bact Geo Mean	Ent. Bact 90th%tile	pH Min	pH Max	pH Avg	Total N (mg/l) Min	Total N (mg/l) Max
Indian River/Indian River Bay	Lower Indian River Bay	DE 140-E01	306121 306131 306321	27.6	25.4	23.9	3.5	9.4	6.2	4.43	5.1	3	24	6.9	8.0	7.5	0.114	2.727
Indian River/Indian River Bay	Upper Indian River Bay	DE 140-E02	306161 306331 306341	19.3	30.6	29.1	3.1	7.9	5.5	4.03	4.6	24	190	6.8	7.8	7.3	0.308	3.358
Indian River/Indian River Bay	Millsboro Pond	DE 140-L01	308071 308271 308331	0.1	27.4	25.5	6.5	12.1	8.6	7.32	7.8	7	36	6.2	8.5	6.9	0.309	1.332
Indian River/Indian River Bay	Betts Pond	DE 140-L02	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indian River/Indian River Bay	Ingram Pond	DE 140-L03	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Indian River/Indian River Bay	Morris Mill Pond	DE 140-L04	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Iron Branch	Iron Branch	DE 150-001	309021 309041	0.1	24.4	23.3	4.1	9.6	6.4	4.82	5.4	165	693	5.4	7.1	6.6	0.186	5.193
Lewes and Rehoboth Canal	Lewes-Rehoboth Canal	DE 170-001	305011 305041 305061 305081	20.7	24.9	24.4	2.8	10.9	5.3	3.02	3.5	32	422	6.9	7.9	7.2	0.093	2.162
Little Assawoman Bay	Little Assawoman Canal	DE 180-001	312041	22.5	26.2	25.9	2.8	7.8	4.6	2.80	2.9	61	324	6.0	7.5	7.2	0.278	2.361
Little Assawoman Bay	Miller Creek	DE 180-002	310101	12.7	27.4	27.1	1.8	8.1	3.8	1.94	2.2	110	600	5.8	7.3	6.5	1.278	5.440
Little Assawoman Bay	Dirickson Creek	DE 180-003	310031	14.0	26.5	26.3	2.9	6.8	4.6	3.26	3.7	68	255	6.1	8.1	7.4	1.593	3.084
Little Assawoman Bay	Jefferson Creek And Dead End Lagoons	DE 180-004	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Little Assawoman Bay	Little Assawoman Bay	DE 180-E01	310011 310071	23.9	26.5	25.4	2.5	8.8	5.4	3.35	3.8	6	43	7.1	8.2	7.6	0.494	2.206
Rehoboth Bay	From The Headwaters Of Chapel Br. To The Confluence Of Herring Creek	DE 280-001-01	308051	11.1	27.7	25.8	4.5	8.6	5.9	4.57	4.8	104	298	6.3	7.2	6.7	0.340	1.957
Rehoboth Bay	Love Creek	DE 280-002	308291 308371	0.1	24.8	24.1	5.3	9.3	7.4	5.86	6.5	10	160	5.9	7.4	6.8	0.189	1.413
Rehoboth Bay	Rehoboth Bay	DE 280-E01	306071 306091 306111	28.4	25.3	24.2	4.0	9.4	6.3	4.58	5.1	2	6	6.4	7.9	7.4	0.027	1.364
Rehoboth Bay	Burton Pond	DE 280-L01	308031	0.1	27.9	26.1	6.6	9.2	7.7	6.61	6.9	5	35	6.2	7.7	7.1	0.205	1.420
	Delaware Bay Drainage																	
Appoquinimink River	Lower Appoquinimink River	DE 010-001-01	109091 109121 109141	5.4	27.7	27.5	3.5	9.2	6.1	4.27	5.0	115	407	6.8	7.6	7.2	0.594	1.944
Appoquinimink River	Upper Appoquinimink River - Odessa	DE 010-001-02	109041 109051 109151 109171	4.0	27.8	27.6	3.5	9.5	5.9	3.73	4.7	270	1347	6.6	7.4	7.2	0.554	2.346
Appoquinimink River	Drawyer Creek and Tributaries	DE 010-001-03	109071 109201 109211	2.2	27.9	27.4	4.5	9.3	6.0	4.60	4.6	376	1743	6.3	7.5	7.1	0.094	3.451
Appoquinimink River	All Tributaries From The Headwaters Of Appoquinimink River to the Bay	DE 010-001-04	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Appoquinimink River	Upper Appoquinimink - Wiggins Mill Pond Branch	DE 010-002-01	109221 109231	0.1	27.1	26.3	1.8	8.3	5.7	2.69	4.0	585	2614	6.5	9.1	7.0	0.220	2.121
Appoquinimink River	Upper Appoquinimink, Deep Creek To Confluence With Silver Lake	DE 010-002-02	109241 109251	0.1	27.5	26.5	5.4	9.7	7.4	5.47	6.0	202	791	6.0	7.3	6.7	0.441	1.977
Appoquinimink River	Noxontown Pond	DE 010-L01	109131	0.1	28.6	28.4	5.4	11.8	7.4	5.89	6.3	20	56	7.7	8.9	8.3	1.073	4.261

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Salinty (ppt) Avg	Temp (c) Max	Temp (c) 90th%tile	DO (mg/L) Min	DO (mg/L) Max	DO (mg/L) Avg	DO (mg/l) 10th %tile	DO (mg/l) 25th %tile	Ent. Bact Geo Mean	Ent. Bact 90th%tile	pH Min	pH Max	pH Avg	Total N (mg/l) Min	Total N (mg/l) Max
Appoquinimink River	Silver Lake (Middletown)	DE 010-L02	109031	0.1	27.9	27.2	5.3	11.5	8.8	6.98	8.2	12	153	6.9	8.6	7.9	0.178	2.088
Appoquinimink River	Shallcross Lake	DE 010-L03	109191	0.1	27.4	27.2	4.8	10.5	8.5	6.42	7.6	7	23	6.6	9.1	7.7	0.510	1.739
Army Creek	Lower Army Creek	DE 020-001	114011	1.4	30.6	27.7	5.2	10.9	7.6	5.83	6.6	32	75	6.5	7.5	7.0	0.723	2.351
Army Creek	Upper Army Creek	DE 020-002	114021	0.0	22.8	22.6	7.6	11.0	9.4	7.70	8.3	128	1107	6.5	7.6	7.0	0.176	0.536
Army Creek	Tributaries to Army Creek not on the Mainstem	DE 020-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Blackbird Creek	Lower Blackbird Creek	DE 030-001	110041	5.1	28.8	28.1	3.8	7.7	6.2	4.69	5.5	104	246	6.8	7.4	7.1	0.499	2.133
Blackbird Creek	Upper Blackbird Creek	DE 030-002	110021	0.0	27.1	24.9	0.7	8.0	5.4	2.16	3.4	216	1167	6.4	7.6	7.0	0.329	1.994
Blackbird Creek	Tributaries on the mainstem of Blackbird Creek	DE 030-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Broad Kill River	Lower Broadkill River	DE 060-001	303041	1.7	26.5	25.6	4.7	8.8	6.6	5.06	5.8	276	993	6.5	7.4	7.0	0.493	2.253
Broad Kill River	Beaverdam Creek	DE 060-002	303171 303181	0.2	23.3	22.4	2.0	9.1	5.8	2.49	4.4	329	1690	6.3	8.3	6.8	0.023	1.914
Broad Kill River	Upper Broadkill River	DE 060-003	303031	0.1	26.7	25.5	7.0	10.4	8.1	7.18	7.5	23	53	6.3	9.1	7.2	0.077	0.844
Broad Kill River	Round Pole Branch	DE 060-004	303311	0.1	21.5	21.0	3.4	7.1	4.8	3.88	4.4	255	680	6.3	6.9	6.7	0.671	2.445
Broad Kill River	Ingram Branch	DE 060-005	303011 303021	0.4	23.3	22.5	3.5	10.2	6.2	3.99	5.5	273	747	6.7	7.6	7.2	0.038	4.470
Broad Kill River	Pemberton Branch	DE 060-006	303341	0.0	20.0	19.8	6.6	9.8	7.9	6.75	7.0	350	1000	6.2	7.4	7.0	0.189	1.569
Broad Kill River	Lower Red Mill Branch	DE 060-007-01	303051	0.1	27.4	27.3	5.8	12.3	8.6	6.04	6.9	25	151	7.4	9.5	8.6	1.293	5.595
Broad Kill River	Martin Branch	DE 060-007-02	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Broad Kill River	Heronwood Branch	DE 060-007-03	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Broad Kill River	Primehook Creek Including Its Tributaries	DE 060-008	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Broad Kill River	Red Mill Pond	DE 060-L01	303231	0.0	25.6	24.6	2.6	8.8	5.8	3.80	5.0	158	352	6.1	7.8	7.0	0.196	3.591
Broad Kill River	Waggamons Pond	DE 060-L02	303351	0.0	27.4	26.3	7.2	10.1	8.6	7.64	8.1	24	95	6.5	9.3	7.5	0.121	1.058
Broad Kill River	Waples Pond & Reynolds Pond	DE 060-L03	303331 303381	0.0	27.5	26.3	2.8	11.6	7.0	3.28	5.7	40	198	5.5	8.4	7.0	0.285	1.102
C&D Canal	Chesapeake And Delaware Canal From Maryland Line To Delaware River	DE 090-001	108021 108031	4.5	28.1	27.4	5.3	9.1	6.9	5.80	6.1	17	107	6.6	7.6	7.1	0.243	1.146
C&D Canal	Chesapeake And Delaware Canal Tributaries On Canal From Md line to Delaware River	DE 090-002	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C&D Canal	Chesapeake And Delaware Canal Tributaries Located In The Watershed but not on the Mainstem	DE 090-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C&D Canal	Lums Pond	DE 090-L01	108111	0.0	27.4	27.3	5.3	9.0	7.7	6.21	7.0	7	58	6.7	8.7	7.5	0.563	1.277
Cedar Creek	Lower Cedar Creek	DE 080-001	301031 301091	11.1	27.3	25.5	2.6	9.0	5.6	2.85	4.0	107	575	6.3	8.0	7.2	0.268	2.454
Cedar Creek	Upper Cedar Creek, Headwaters To Cedar Creek Mill Pond	DE 080-002	301021	0.1	28.9	27.2	7.0	11.5	9.5	7.98	8.9	7	112	6.9	9.8	8.4	0.167	0.890
Cedar Creek	Slaughter Creek	DE 080-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dragon Run Creek	Lower Dragon Run Creek	DE 130-001	111011	1.0	25.5	25.4	1.9	11.4	5.6	2.07	2.3	13	210	6.6	7.7	7.0	0.399	3.262
Dragon Run Creek	Upper Dragon Run Creek	DE 130-002	111031	0.0	21.6	18.1	2.3	7.0	4.9	2.84	3.6	216	1013	6.5	7.5	6.9	0.049	0.678
Leipsic River	Lower Leipsic River	DE 160-001	202031	7.5	24.7	24.6	1.3	6.1	4.4	2.46	4.2	266	960	6.1	7.1	6.7	1.197	2.356
Leipsic River	Upper Leipsic River	DE 160-002	202041	2.0	23.6	23.2	2.5	6.4	4.4	2.66	2.9	524	1432	6.4	7.7	7.0	0.863	2.083

"--" = no data in the period of Sept 1, 1997 to Aug 31 1999

Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Salinty (ppt) Avg	Temp (c) Max	Temp (c) 90th%tile	DO (mg/L) Min	DO (mg/L) Max	DO (mg/L) Avg	DO (mg/l) 10th %tile	DO (mg/l) 25th %tile	Ent. Bact Geo Mean	Ent. Bact 90th%tile	pH Min	pH Max	pH Avg	Total N (mg/l) Min	Total N (mg/l) Max
Leipsic River	Leipsic, Tributaries From Dam At Garrisons Lake To Mouth	DE 160-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Leipsic River	Tributaries of Liepsic River From Headwaters To Garrisons Lake	DE 160-004	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Leipsic River	Garrisons Lake	DE 160-L01	202021	0.0	26.6	25.8	1.0	9.0	6.1	2.64	5.1	119	464	6.3	8.7	7.5	1.583	4.947
Leipsic River	Masseys Mill Pond	DE 160-L02	202011	2.4	25.2	24.7	2.2	8.2	5.5	2.68	3.4	195	1493	6.5	7.5	7.0	1.040	2.883
Little River	Lower Little Creek	DE 190-001-01	204031	12.9	27.8	24.7	3.4	8.3	6.2	3.68	4.9	399	1380	6.4	8.0	7.3	0.478	3.841
Little River	Upper Little Creek	DE 190-001-02	204041	0.1	26.7	24.3	1.8	7.3	4.1	1.94	2.8	56	840	6.1	7.7	6.9	0.288	2.045
Little River	Pipe Elm Branch	DE 190-001-03	204011	0.1	21.5	19.6	4.3	7.6	5.6	4.51	4.6	110	670	6.2	7.4	6.8	0.168	1.399
Little River	Tributaries of Little River Located In The Watershed But Not On The Mainstem	DE 190-001-04	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mispillion River	Lower Mispillion River	DE 210-001	208021 208061	10.4	26.9	26.6	3.8	9.5	6.0	3.89	4.6	73	397	6.8	7.7	7.3	0.394	2.948
Mispillion River	Upper Mispillion River, Headwaters To Silver Lake	DE 210-002	98 305(b)	0.0	20.7	19.6	--	6.7	8.4	7.00	7.5	403	1900	6.7	7.5	7.1	2.385	4.084
Mispillion River	Johnson Branch Including Its Tributaries	DE 210-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mispillion River	Mispillion Tributaries From Headwaters To Silver Lake	DE 210-004	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mispillion River	Mispillion Tributaries From Dam At Silver Lake To The Mouth	DE 210-005	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mispillion River	Tub Mill Pond	DE 210-L01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mispillion River	Silver Lake (Milford)	DE 210-L02	208211	2.8	27.7	25.8	3.4	11.0	7.5	5.24	6.7	66	384	6.7	8.2	7.4	0.368	1.602
Mispillion River	Haven Lake	DE 210-L03	208011	0.0	28.0	26.1	4.5	10.2	7.3	5.39	6.3	26	68	6.8	7.5	7.2	0.277	0.777
Mispillion River	Griffith Lake	DE 210-L04	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Mispillion River	Blairs Pond	DE 210-L05	208191	0.0	27.5	25.8	6.5	10.1	8.5	7.05	7.8	19	89	6.7	9.2	7.9	0.033	5.660
Mispillion River	Abbotts Pond	DE 210-L06	208181	0.0	27.7	25.4	4.4	9.2	6.4	4.52	5.3	28	118	6.6	7.5	7.0	0.172	3.787
Murderkill River	Lower Murderkill River	DE 220-001	206091 206101 206131 206141 206231	11.8	30.2	27.9	1.8	12.6	5.3	2.75	3.4	146	665	6.5	8.1	7.1	0.497	2.814
Murderkill River	Spring Creek	DE 220-002	206081 206601 206611 206621 206631 206641	0.5	30.3	22.9	1.4	10.5	6.3	3.92	5.6	346	2000	6.3	7.3	6.9	0.092	2.752
Murderkill River	Mid Murderkill River	DE 220-003	206211	0.1	22.1	21.3	6.9	7.2	7.1	6.93	7.0	175	545	6.3	7.2	6.8	1.202	2.400
Murderkill River	Browns Branch	DE 220-004	206041 206051 206421 266651	0.1	25.2	22.1	3.4	9.0	6.1	4.14	5.2	283	1627	6.0	7.2	6.7	0.927	15.190
Murderkill River	Upper Murderkill River	DE 220-005	206011 206351 206661 206671 206681	0.0	24.6	22.5	0.8	9.7	6.3	3.80	6.1	322	2000	6.0	7.6	6.8	0.397	12.660
Murderkill River	Mcginnis Pond	DE 220-L01	206461 206561	0.1	31.7	26.3	4.0	9.8	7.2	4.80	5.0	101	2000	6.2	8.8	7.0	0.080	1.766
Murderkill River	Andrews Lake	DE 220-L02	206071	0.0	31.2	26.3	5.5	9.8	8.2	6.78	7.8	80	917	6.3	8.4	7.2	0.136	1.692
Murderkill River	Coursey Pond	DE 220-L03	206451	0.0	32.3	27.4	5.1	11.6	7.7	5.91	7.4	51	345	6.2	9.4	7.5	0.203	2.634
Murderkill River	Killen Pond	DE 220-L04	206021 206691	0.1	31.1	29.7	5.8	12.5	9.0	6.76	8.2	9	583	7.0	10.1	8.9	0.993	2.518

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Salinty (ppt) Avg	Temp (c) Max	Temp (c) 90th%tile	DO (mg/L) Min	DO (mg/L) Max	DO (mg/L) Avg	DO (mg/l) 10th %tile	DO (mg/l) 25th %tile	Ent. Bact Geo Mean	Ent. Bact 90th%tile	pH Min	pH Max	pH Avg	Total N (mg/l) Min	Total N (mg/l) Max
Murderkill River	Mccauley Pond	DE 220-L05	206361	0.0	31.8	26.9	5.0	11.8	8.7	7.16	7.9	40	523	6.3	9.2	7.5	0.422	1.749
Red Lion Creek	Lower Red Lion Creek	DE 270-001-01	107031	0.2	25.5	25.5	3.4	10.2	7.0	4.18	5.5	107	495	6.2	7.4	6.9	0.356	1.648
Red Lion Creek	Upper Red Lion Creek, Headwaters To Route 13	DE 270-001-02	107011	0.0	22.6	22.6	4.3	10.3	7.1	5.01	5.5	104	773	6.5	7.3	7.0	0.093	1.401
Red Lion Creek	Tributaries Located In The Watershed But Not On Mainstem of Red Lion Creek	DE 270-001-03	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Saint Jones River	Lower St. Jones River	DE 290-001-01	205041	10.8	27.3	25.1	3.3	8.1	6.0	3.82	4.6	90	664	6.8	7.8	7.1	1.151	3.924
Saint Jones River	Upper St. Jones River	DE 290-001-02	205091 205571	1.6	28.3	26.6	4.9	11.0	7.8	5.44	6.0	61	258	6.9	8.0	7.3	0.882	3.099
Saint Jones River	Tributaries of Saint Jones River From Old Lebanon Bridge To The Mouth Of Delaware	DE 290-001-03	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Saint Jones River	Isaac Branch	DE 290-002	205241	0.1	22.8	21.3	5.8	9.6	7.5	5.96	6.2	267	1196	6.7	7.6	7.2	0.091	1.571
Saint Jones River	Fork Branch	DE 290-003	205151	0.1	25.5	22.9	2.9	5.3	4.2	2.98	3.1	29	181	6.6	7.4	7.1	0.435	1.749
Saint Jones River	Tidbury Branch	DE 290-004	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Saint Jones River	Moores Lake	DE 290-L01	205181	0.1	28.5	25.8	5.3	11.3	9.0	6.58	8.5	57	472	6.9	8.9	7.9	0.494	1.560
Saint Jones River	Silver Lake (Dover)	DE 290-L02	205191	0.1	27.8	25.7	5.3	10.8	8.6	6.06	7.2	77	588	7.0	9.0	8.0	0.603	3.147
Saint Jones River	Derby Pond	DE 290-L03	205211	0.1	28.2	25.4	4.7	10.6	8.7	6.10	8.2	8	1202	7.1	8.6	7.7	0.392	1.187
Smyrna River	Smyrna River	DE 310-001	201041 201051	4.3	27.6	27.3	2.8	9.0	5.9	3.48	4.2	371	1353	6.3	7.5	6.9	0.594	3.381
Smyrna River	Mill Creek	DE 310-002	201021	0.1	28.8	28.3	4.9	13.8	7.4	4.96	5.4	121	888	6.4	8.2	7.0	0.343	4.658
Smyrna River	Tributaries of Smyrna River From The Headwaters To The Confluence With The Delaware River	DE 310-003	201161	0.1	23.5	23.3	5.8	9.1	6.8	5.80	6.1	260	2000	6.4	8.2	6.9	0.333	1.655
Smyrna River	Lake Como & Duck Creek Pond	DE 310-L01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Chesapeake Bay																	
Broad Creek	Lower Broad Creek, Including Collins & Culvert Ditch, Holly Ditch, Rossakatum and Cooper Branches	DE 050-001	307021 307151	0.0	23.1	22.2	0.5	12.1	6.5	2.38	5.2	69	809	6.0	7.2	6.7	0.325	1.688
Broad Creek	Tussocky Branch	DE 050-002	307061 307291 307331	0.0	29.3	25.9	5.0	12.2	8.0	5.80	6.6	26	167	5.5	7.3	6.7	0.119	4.640
Broad Creek	Little Creek	DE 050-003	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Broad Creek	Chipman Pond Branch	DE 050-004	307111 307121 307341	0.1	29.5	25.2	5.0	12.6	8.5	6.29	7.4	129	733	6.7	9.6	7.3	0.180	1.007
Broad Creek	James Branch Including Pepper Pond Br., Hitch Pond Br., Etc.	DE 050-005-01	307081 307281 307351 307361 307381 307391	0.0	29.7	23.7	1.1	13.4	6.1	1.89	3.4	190	940	6.2	7.7	6.8	0.293	2.502
Broad Creek	Trussum Pond Branch	DE 050-005-02	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Broad Creek	Trap Pond Branch	DE 050-006-01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Broad Creek	Raccoon Prong	DE 050-006-03	307221 307371	0.1	24.0	23.9	1.9	10.2	6.1	3.43	5.3	162	1250	6.4	7.5	6.8	0.347	2.145

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Salinty (ppt) Avg	Temp (c) Max	Temp (c) 90th%tile	DO (mg/L) Min	DO (mg/L) Max	DO (mg/L) Avg	DO (mg/l) 10th %tile	DO (mg/l) 25th %tile	Ent. Bact Geo Mean	Ent. Bact 90th%tile	pH Min	pH Max	pH Avg	Total N (mg/l) Min	Total N (mg/l) Max
Broad Creek	Portsville Pond	DE 050-L01	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Broad Creek	Tussock Pond	DE 050-L02	307101	0.0	30.0	28.9	7.8	11.3	8.7	7.86	7.9	29	342	6.5	8.3	7.1	0.488	1.109
Broad Creek	Horseys Pond	DE 050-L03	307171	0.1	28.5	27.9	5.9	11.4	9.1	7.30	8.1	18	204	5.9	9.9	7.7	0.535	1.601
Broad Creek	Records Pond	DE 050-L04	307011 307401	0.1	27.8	27.4	6.1	11.8	8.6	6.81	7.7	65	353	6.0	8.8	7.2	0.213	2.660
Broad Creek	Chipman Pond & Wileys Pond	DE 050-L05	307131	0.1	30.3	28.6	7.1	12.1	9.5	7.82	8.9	32	118	6.9	9.6	8.1	0.361	0.853
Broad Creek	Trussum Pond	DE 050-L06	307091	0.0	27.2	25.8	1.8	13.2	5.6	2.45	3.4	135	573	6.2	7.1	6.7	1.163	2.605
Broad Creek	Trap Pond	DE 050-L07	307181	0.0	30.4	29.6	5.0	11.3	8.1	5.49	6.2	15	67	6.6	8.9	7.4	0.987	5.152
Broad Creek	Raccoon Pond	DE 050-L08	307201	0.0	27.4	26.1	0.2	10.5	4.8	0.85	1.9	20	332	6.4	6.9	6.6	0.435	1.860
Chesapeake Drainage	Cypress Branch	DE 100-001	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chesapeake Drainage	Sewell Branch	DE 100-002	112021	0.0	22.2	21.6	2.6	6.0	4.4	3.16	4.0	162	657	6.1	7.8	6.8	0.770	1.800
Chesapeake Drainage	Gravelly Run	DE 100-003	112031	0.0	24.7	24.5	1.7	7.0	4.8	2.78	4.4	158	1285	6.2	7.6	6.9	0.551	2.897
Chesapeake Drainage	Tributaries Of Elk River	DE 100-004	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chesapeake Drainage	Tributaries Of Sassafras River	DE 100-005	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chotpank River	Tappahanna Ditch	DE 110-001	207081	0.0	23.7	20.4	4.5	10.2	6.5	4.75	5.2	56	679	6.7	7.1	7.0	0.194	1.455
Chotpank River	Culbreth Marsh Ditch	DE 110-002	207091	0.0	25.1	21.6	5.2	10.3	7.0	5.20	5.3	84	734	6.3	7.2	6.7	0.172	1.468
Chotpank River	Cow Marsh Creek	DE 110-003	207021	0.0	24.8	21.4	4.0	10.2	6.3	4.55	5.3	20	93	6.1	7.1	6.6	0.227	1.287
Chotpank River	Mud Mill Pond	DE 110-L01	207111	0.0	24.0	20.5	1.8	8.9	4.4	1.85	2.3	84	400	6.3	7.4	6.7	0.461	2.194
Marshyhope Creek	Marshyhope Creek, Headwaters To State Line	DE 200-001	302021 302031	0.0	25.3	24.4	6.1	9.7	7.7	6.80	7.2	17	210	6.2	7.6	6.8	0.113	1.158
Marshyhope Creek	Tributaries of Marshyhope CreekFrom The Headwaters To State Line	DE 200-002	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nanticoke River	Lower Nanticoke River	DE 240-001	304021 304031 304071 304091 304101 304141 304151 304171 304461 304471 304621	0.1	30.0	29.0	4.2	12.0	8.3	6.34	7.0	69	390	5.1	7.6	6.9	0.143	9.590
Nanticoke River	Upper Nanticoke River	DE 240-002	304191 304291	0.1	25.5	24.6	6.1	12.5	8.1	6.30	6.6	83	600	6.0	7.1	6.6	0.071	2.786
Nanticoke River	Clear Brook Branch	DE 240-003	304041 304371 304381 304571 304631	0.1	26.8	25.4	2.4	11.4	7.0	2.82	6.1	148	910	5.7	7.8	6.7	0.124	11.760
Nanticoke River	Deep Creek Branch	DE 240-004	304591 304601 304641	0.0	23.3	22.9	1.4	10.6	6.5	2.22	5.6	151	636	5.6	7.5	6.7	0.118	4.385
Nanticoke River	Gravelly Branch	DE 240-005	316011 316021 316031	0.0	27.9	25.8	4.1	11.2	7.5	5.30	6.0	63	362	5.8	7.2	6.5	0.099	1.514
Nanticoke River	Bridgeville Branch	DE 240-006	304051 304271 304371 304611	0.0	26.6	23.8	1.1	14.2	7.2	4.44	5.4	85	616	5.9	7.4	6.7	0.195	9.240
Nanticoke River	Gum Branch	DE 240-007	304441 304531	0.1	22.8	22.3	4.1	10.1	7.4	4.75	6.3	675	1850	5.9	7.1	6.6	0.183	2.928
Nanticoke River	Lewes Creek	DE 240-008	304421 304451 304541 304551 304561	0.1	29.1	21.2	1.1	12.3	7.4	2.70	6.7	272	2000	6.1	9.9	6.8	0.138	2.034
Nanticoke River	Dupont Gut	DE 240-009	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Salinty (ppt) Avg	Temp (c) Max	Temp (c) 90th%tile	DO (mg/L) Min	DO (mg/L) Max	DO (mg/L) Avg	DO (mg/l) 10th %tile	DO (mg/l) 25th %tile	Ent. Bact Geo Mean	Ent. Bact 90th%tile	pH Min	pH Max	pH Avg	Total N (mg/l) Min	Total N (mg/l) Max
Nanticoke River	Gum Branch, Upper Nanticoke River	DE 240-010	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nanticoke River	Craigs Pond	DE 240-L01	304301	0.1	27.3	25.9	4.4	13.0	8.1	5.41	6.2	50	1220	6.4	7.1	6.8	0.152	1.569
Nanticoke River	Concord Pond	DE 240-L02	304311 304651	0.0	29.5	27.3	6.8	11.5	9.0	7.06	7.6	29	133	5.8	9.7	7.4	0.171	1.472
Nanticoke River	Collins Pond	DE 240-L03	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nanticoke River	Williams Pond	DE 240-L04	304321 304581	0.1	30.3	28.9	6.3	11.8	9.0	6.56	7.4	49	1688	6.0	9.7	7.4	0.166	1.649
Nanticoke River	Hearns Pond	DE 240-L05	304411	0.1	29.2	27.9	4.3	12.3	9.2	6.52	8.5	158	346	6.5	10.1	7.8	0.304	3.812
Pocomoke River	Pocomoke River, Headwaters To Maryland State Line	DE 250-001	313011	0.0	21.5	20.3	4.3	7.0	5.7	4.60	4.9	331	625	6.7	7.2	7.0	0.260	1.669
Pocomoke River	Pocomoke River, Tributaries From The Headwaters To Maryland line	DE 250-002	98 305(b)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Total N (mg/l) Avg	Total P (mg/l) Min	Total P (mg/L) Avg	Total P (mg/l) Max	Chlor-A (ug/L) Avg	Chlor-A (ug/L) Max
Piedmont Drainage Basin									
Brandywine Creek	Lower Brandywine River	DE 040-001	104011	0.718	0.056	0.202	0.624	5	13
Brandywine Creek	Upper Brandywine Creek, From State Line To Wilmington	DE 040-002	104021 104051	0.655	0.066	0.215	1.180	4	11
Brandywine Creek	All Tributaries On Brandywine Creek From The Headwaters to the Confluence with the Christina River	DE 040-003	98 305(b)	--	--	--	--	--	--
Christina River	Lower Christina River	DE 120-001	106011 106291	1.086	0.025	0.161	0.449	25	96
Christina River	Mid Christina River, Between White Clay Creek And Brandywine	DE 120-002	106021	1.164	0.070	0.149	0.318	56	179
Christina River	Christina River, Tributaries On The Christina River Between White Clay Crrek and Brandywine River	DE 120-002-01	98 305(b)	--	--	--	--	--	--
Christina River	Upper Christina River	DE 120-003	106031	0.843	0.022	0.089	0.284	9	21
Christina River	Nonesuch Creek	DE 120-003-01	98 305(b)	--	--	--	--	--	--
Christina River	Christina River Tributaries From Smalleys Pond Overflow To White Clay Creek	DE 120-003-02	106321	0.739	0.021	0.082	0.113	8	21
Christina River	Lower Christina Creek	DE 120-004-01	106111 106141 106331	0.656	0.018	0.094	0.343	5	11
Christina River	Belltown Run	DE 120-004-02	106341	0.715	0.038	0.212	0.664	13	53
Christina River	Muddy Run	DE 120-004-03	98 305(b)	--	--	--	--	--	--
Christina River	West Branch Including Persimmon Run And Stine Haskell Branch	DE 120-005-01	98 305(b)	--	--	--	--	--	--
Christina River	Upper Christina Creek	DE 120-006	106191	0.437	0.008	0.066	0.447	3	11
Christina River	Little Mill Creek	DE 120-007-01	106281	0.648	0.029	0.085	0.255	9	29
Christina River	Chestnut Run	DE 120-007-02	98 305(b)	--	--	--	--	--	--
Christina River	Smalleys Pond	DE 120-L01	98 305(b)	--	--	--	--	--	--
Christina River	Becks Pond	DE 120-L02	106121 106351	0.576	0.026	0.051	0.096	11	29
Christina River	Sunset Pond	DE 120-L03	106131 106361 106371 106381	0.847	0.021	0.077	0.144	16	69
Naamans Creek	Lower Naamans Creek Including Its Tributaries	DE 230-001-01	101041	0.156	0.044	0.044	0.044	8	8
Naamans Creek	Upper Naamans Creek Including North Br. And South Br.	DE 230-001-02	101021 101031	0.355	0.010	0.046	0.094	7	37
Red Clay Creek	Red Clay Creek From Pennsylvania State Line	DE 260-001	103011 103031 103041	0.729	0.097	0.309	1.020	6	19

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Total N (mg/l) Avg	Total P (mg/l) Min	Total P (mg/L) Avg	Total P (mg/l) Max	Chlor-A (ug/L) Avg	Chlor-A (ug/L) Max
Red Clay Creek	Burroughs Run From Pennsylvania State Line Run	DE 260-002	103061	0.469	0.011	0.043	0.100	5	11
Red Clay Creek	All Other Red Clay Creek Tributaries Located In The Watershed But Not On the mainstem.	DE 260-003	98 305(b)	--	--	--	--	--	--
Red Clay Creek	Hoopes Reservoir	DE 260-L01	98 305(b)	--	--	--	--	--	--
Shellpot Creek	Lower Shellpot Creek	DE 300-001-01	102041	2.547	0.094	0.240	0.648	40	152
Shellpot Creek	Upper Shellpot Creek	DE 300-001-02	102011	0.859	0.007	0.074	0.198	5	11
Shellpot Creek	All Other Tributaries To Shellpot Creek Located In The Watershed But Not On the mainstem.	DE 300-001-03	98 305(b)	--	--	--	--	--	--
White Clay Creek	White Clay Creek From Pennsylvania State Line	DE 320-001	105011 105031 105151	0.572	0.030	0.254	0.646	5	11
White Clay Creek	Mill Creek	DE 320-002	105071	0.526	0.009	0.039	0.107	4	11
White Clay Creek	Pike Creek	DE 320-003	105101	0.427	0.004	0.057	0.335	4	8
White Clay Creek	Middle Run	DE 320-004	105131	0.511	0.003	0.066	0.299	5	13
White Clay Creek	All Tributaries to White Clay Creek From The Headwaters To The Confluence With the Christina River	DE 320-005	98 305(b)	--	--	--	--	--	--
Inland Bays/Atlantic Ocean									
Assawoman Bay	Assawoman Bay	DE 350-E01	98 305(b)	--	--	--	--	--	--
Buntings Branch	Bunting's Branch	DE 070-001	311041	1.420	0.145	0.322	0.561	5	5
Indian River/Indian River Bay	White Creek	DE 140-001	310121 312011	1.027	0.014	0.092	0.416	7	16
Indian River/Indian River Bay	Blackwater Creek	DE 140-002	308361	0.460	0.018	0.024	0.029	4	5
Indian River/Indian River Bay	Pepper Creek And Tributaries, Including Vines Creek, Mccrays and Deep Hole Branches	DE 140-003	308091 308151 308351	1.467	0.027	0.127	0.371	20	278
Indian River/Indian River Bay	Indian River	DE 140-004	306181 306191	1.454	0.023	0.157	0.442	27	67
Indian River/Indian River Bay	Swan Creek	DE 140-005	308301 308341	0.731	0.003	0.056	0.267	3	5
Indian River/Indian River Bay	Stockley Branch	DE 140-006	308141 308281 308321	0.903	0.016	0.119	0.420	17	96
Indian River/Indian River Bay	Eli Walls Tax Ditch	DE 140-007	98 305(b)	--	--	--	--	--	--
Indian River/Indian River Bay	Deep Branch, Including Peterkins Br., White Oak Swamp Ditch, Socorockets Ditch, Welsh and Simpler Branches	DE 140-008	98 305(b)	--	--	--	--	--	--
Indian River/Indian River Bay	Mirey Branch, Including Sheep Pen Ditch, And Narrow Drain	DE 140-009	98 305(b)	--	--	--	--	--	--
Indian River/Indian River Bay	Betts Pond Branch	DE 140-010	98 305(b)	--	--	--	--	--	--

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Total N (mg/l) Avg	Total P (mg/l) Min	Total P (mg/L) Avg	Total P (mg/l) Max	Chlor-A (ug/L) Avg	Chlor-A (ug/L) Max
Indian River/Indian River Bay	Lower Indian River Bay	DE 140-E01	306121 306131 306321	0.808	0.013	0.120	0.477	8	35
Indian River/Indian River Bay	Upper Indian River Bay	DE 140-E02	306161 306331 306341	1.349	0.026	0.166	0.505	24	107
Indian River/Indian River Bay	Millsboro Pond	DE 140-L01	308071 308271 308331	0.695	0.017	0.076	0.149	6	24
Indian River/Indian River Bay	Betts Pond	DE 140-L02	98 305(b)	--	--	--	--	--	--
Indian River/Indian River Bay	Ingram Pond	DE 140-L03	98 305(b)	--	--	--	--	--	--
Indian River/Indian River Bay	Morris Mill Pond	DE 140-L04	98 305(b)	--	--	--	--	--	--
Iron Branch	Iron Branch	DE 150-001	309021 309041	1.730	0.022	0.126	0.362	9	21
Lewes and Rehoboth Canal	Lewes-Rehoboth Canal	DE 170-001	305011 305041 305061 305081	0.843	0.023	0.120	0.305	9	35
Little Assawoman Bay	Little Assawoman Canal	DE 180-001	312041	1.037	0.044	0.151	0.661	11	29
Little Assawoman Bay	Miller Creek	DE 180-002	310101	2.643	0.026	0.344	0.993	60	139
Little Assawoman Bay	Dirickson Creek	DE 180-003	310031	2.268	0.115	0.726	3.060	209	1402
Little Assawoman Bay	Jefferson Creek And Dead End Lagoons	DE 180-004	98 305(b)	--	--	--	--	--	--
Little Assawoman Bay	Little Assawoman Bay	DE 180-E01	310011 310071	1.094	0.046	0.143	0.588	26	59
Rehoboth Bay	From The Headwaters Of Chapel Br. To The Confluence Of Herring Creek	DE 280-001-01	308051	1.078	0.010	0.093	0.235	16	32
Rehoboth Bay	Love Creek	DE 280-002	308291 308371	0.749	0.009	0.052	0.150	8	29
Rehoboth Bay	Rehoboth Bay	DE 280-E01	306071 306091 306111	0.495	0.011	0.119	0.696	8	35
Rehoboth Bay	Burton Pond	DE 280-L01	308031	0.593	0.008	0.027	0.078	5	13
Delaware Bay Drainage									
Appoquinimink River	Lower Appoquinimink River	DE 010-001-01	109091 109121 109141	1.078	0.145	0.256	0.729	24	88
Appoquinimink River	Upper Appoquinimink River - Odessa	DE 010-001-02	109041 109051 109151 109171	1.423	0.111	0.277	0.937	57	190
Appoquinimink River	Drawyer Creek and Tributaries	DE 010-001-03	109071 109201 109211	1.736	0.043	0.328	0.884	66	267
Appoquinimink River	All Tributaries From The Headwaters Of Appoquinimink River to the Bay	DE 010-001-04	98 305(b)	--	--	--	--	--	--
Appoquinimink River	Upper Appoquinimink - Wiggins Mill Pond Branch	DE 010-002-01	109221 109231	0.968	0.021	0.073	0.159	26	67
Appoquinimink River	Upper Appoquinimink, Deep Creek To Confluence With Silver Lake	DE 010-002-02	109241 109251	1.019	0.013	0.084	0.294	8	19
Appoquinimink River	Noxontown Pond	DE 010-L01	109131	2.047	0.057	0.097	0.269	77	117

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Total N (mg/l) Avg	Total P (mg/l) Min	Total P (mg/L) Avg	Total P (mg/l) Max	Chlor-A (ug/L) Avg	Chlor-A (ug/L) Max
Appoquinimink River	Silver Lake (Middletown)	DE 010-L02	109031	0.788	0.008	0.031	0.061	20	32
Appoquinimink River	Shallcross Lake	DE 010-L03	109191	0.987	0.012	0.043	0.081	16	29
Army Creek	Lower Army Creek	DE 020-001	114011	1.314	0.033	0.240	0.735	24	67
Army Creek	Upper Army Creek	DE 020-002	114021	0.390	0.021	0.031	0.041	2	3
Army Creek	Tributaries to Army Creek not on the Mainstem	DE 020-003	98 305(b)	--	--	--	--	--	--
Blackbird Creek	Lower Blackbird Creek	DE 030-001	110041	1.192	0.131	0.248	0.533	37	115
Blackbird Creek	Upper Blackbird Creek	DE 030-002	110021	1.209	0.056	0.140	0.264	10	29
Blackbird Creek	Tributaries on the mainstem of Blackbird Creek	DE 030-003	98 305(b)	--	--	--	--	--	--
Broad Kill River	Lower Broadkill River	DE 060-001	303041	1.443	0.142	0.258	0.563	63	144
Broad Kill River	Beaverdam Creek	DE 060-002	303171 303181	0.835	0.147	0.488	1.730	11	19
Broad Kill River	Upper Broadkill River	DE 060-003	303031	0.523	0.015	0.067	0.154	16	32
Broad Kill River	Round Pole Branch	DE 060-004	303311	1.403	0.093	0.171	0.253	10	24
Broad Kill River	Ingram Branch	DE 060-005	303011 303021	1.380	0.078	0.664	2.840	5	13
Broad Kill River	Pemberton Branch	DE 060-006	303341	0.618	0.012	0.044	0.146	3	5
Broad Kill River	Lower Red Mill Branch	DE 060-007-01	303051	3.186	0.066	0.222	0.326	201	425
Broad Kill River	Martin Branch	DE 060-007-02	98 305(b)	--	--	--	--	--	--
Broad Kill River	Heronwood Branch	DE 060-007-03	98 305(b)	--	--	--	--	--	--
Broad Kill River	Primehook Creek Including Its Tributaries	DE 060-008	98 305(b)	--	--	--	--	--	--
Broad Kill River	Red Mill Pond	DE 060-L01	303231	1.236	0.067	0.161	0.261	43	144
Broad Kill River	Waggamons Pond	DE 060-L02	303351	0.548	0.017	0.155	0.727	16	29
Broad Kill River	Waples Pond & Reynolds Pond	DE 060-L03	303331 303381	0.602	0.009	0.036	0.074	7	35
C&D Canal	Chesapeake And Delaware Canal From Maryland Line To Delaware River	DE 090-001	108021 108031	0.655	0.054	0.211	0.452	8	19
C&D Canal	Chesapeake And Delaware Canal Tributaries On Canal From Md line to Delaware River	DE 090-002	98 305(b)	--	--	--	--	--	--
C&D Canal	Chesapeake And Delaware Canal Tributaries Located In The Watershed but not on the Mainstem	DE 090-003	98 305(b)	--	--	--	--	--	--
C&D Canal	Lums Pond	DE 090-L01	108111	0.900	0.016	0.062	0.108	22	36
Cedar Creek	Lower Cedar Creek	DE 080-001	301031 301091	1.292	0.058	0.252	1.060	44	147
Cedar Creek	Upper Cedar Creek, Headwaters To Cedar Creek Mill Pond	DE 080-002	301021	0.496	0.008	0.059	0.213	6	11
Cedar Creek	Slaughter Creek	DE 080-003	98 305(b)	--	--	--	--	--	--
Dragon Run Creek	Lower Dragon Run Creek	DE 130-001	111011	1.111	0.031	0.170	0.566	23	139
Dragon Run Creek	Upper Dragon Run Creek	DE 130-002	111031	0.304	0.014	0.057	0.099	5	8
Leipsic River	Lower Leipsic River	DE 160-001	202031	1.726	0.185	0.389	0.826	20	45
Leipsic River	Upper Leipsic River	DE 160-002	202041	1.354	0.282	0.462	1.120	8	21

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Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Total N (mg/l) Avg	Total P (mg/l) Min	Total P (mg/L) Avg	Total P (mg/l) Max	Chlor-A (ug/L) Avg	Chlor-A (ug/L) Max
Leipsic River	Leipsic, Tributaries From Dam At Garrisons Lake To Mouth	DE 160-003	98 305(b)	--	--	--	--	--	--
Leipsic River	Tributaries of Liepsic River From Headwaters To Garrisons Lake	DE 160-004	98 305(b)	--	--	--	--	--	--
Leipsic River	Garrisons Lake	DE 160-L01	202021	2.773	0.156	0.387	0.855	89	139
Leipsic River	Masseys Mill Pond	DE 160-L02	202011	1.695	0.144	0.310	0.464	24	75
Little River	Lower Little Creek	DE 190-001-01	204031	2.259	0.345	0.611	1.250	65	131
Little River	Upper Little Creek	DE 190-001-02	204041	1.255	0.065	0.206	0.823	14	40
Little River	Pipe Elm Branch	DE 190-001-03	204011	0.495	0.029	0.080	0.191	4	8
Little River	Tributaries of Little River Located In The Watershed But Not On The Mainstem	DE 190-001-04	98 305(b)	--	--	--	--	--	--
Mispillion River	Lower Mispillion River	DE 210-001	208021 208061	1.459	0.078	0.235	0.467	46	187
Mispillion River	Upper Mispillion River, Headwaters To Silver Lake	DE 210-002	98 305(b)	3.128	0.011	0.030	0.030	--	--
Mispillion River	Johnson Branch Including Its Tributaries	DE 210-003	98 305(b)	--	--	--	--	--	--
Mispillion River	Mispillion Tributaries From Headwaters To Silver Lake	DE 210-004	98 305(b)	--	--	--	--	--	--
Mispillion River	Mispillion Tributaries From Dam At Silver Lake To The Mouth	DE 210-005	98 305(b)	--	--	--	--	--	--
Mispillion River	Tub Mill Pond	DE 210-L01	98 305(b)	--	--	--	--	--	--
Mispillion River	Silver Lake (Milford)	DE 210-L02	208211	0.891	0.033	0.054	0.116	15	35
Mispillion River	Haven Lake	DE 210-L03	208011	0.533	0.003	0.032	0.055	4	5
Mispillion River	Griffith Lake	DE 210-L04	98 305(b)	--	--	--	--	--	--
Mispillion River	Blairs Pond	DE 210-L05	208191	3.105	0.003	0.032	0.068	14	67
Mispillion River	Abbotts Pond	DE 210-L06	208181	1.273	0.023	0.076	0.198	25	45
Murderkill River	Lower Murderkill River	DE 220-001	206091 206101 206131 206141 206231	1.325	0.105	0.498	2.680	28	115
Murderkill River	Spring Creek	DE 220-002	206081 206601 206611 206621 206631 206641	1.165	0.014	0.190	0.847	13	83
Murderkill River	Mid Murderkill River	DE 220-003	206211	1.801	0.130	0.177	0.224	116	125
Murderkill River	Browns Branch	DE 220-004	206041 206051 206421 266651	4.546	0.015	0.136	1.360	7	69
Murderkill River	Upper Murderkill River	DE 220-005	206011 206351 206661 206671 206681	3.924	0.011	0.128	0.549	4	11
Murderkill River	Mcginnis Pond	DE 220-L01	206461 206561	0.893	0.020	0.096	0.257	28	131
Murderkill River	Andrews Lake	DE 220-L02	206071	0.715	0.013	0.075	0.158	19	64
Murderkill River	Coursey Pond	DE 220-L03	206451	1.486	0.041	0.144	0.229	65	147
Murderkill River	Killen Pond	DE 220-L04	206021 206691	1.463	0.065	0.107	0.155	131	198

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Murderkill River	Mccauley Pond	DE 220-L05	206361	0.984	0.039	0.084	0.167	35	75
Red Lion Creek	Lower Red Lion Creek	DE 270-001-01	107031	1.155	0.064	0.170	0.282	25	92
Red Lion Creek	Upper Red Lion Creek, Headwaters To Route 13	DE 270-001-02	107011	0.571	0.023	0.054	0.112	3	5
Red Lion Creek	Tributaries Located In The Watershed But Not On Mainstem of Red Lion Creek	DE 270-001-03	98 305(b)	--	--	--	--	--	--
Saint Jones River	Lower St. Jones River	DE 290-001-01	205041	2.326	0.163	0.316	0.546	57	155
Saint Jones River	Upper St. Jones River	DE 290-001-02	205091 205571	1.928	0.083	0.210	0.445	90	216
Saint Jones River	Tributaries of Saint Jones River From Old Lebanon Bridge To The Mouth Of Delaware	DE 290-001-03	98 305(b)	--	--	--	--	--	--
Saint Jones River	Isaac Branch	DE 290-002	205241	0.850	0.019	0.034	0.063	8	16
Saint Jones River	Fork Branch	DE 290-003	205151	1.008	0.114	0.181	0.278	26	91
Saint Jones River	Tidbury Branch	DE 290-004	98 305(b)	--	--	--	--	--	--
Saint Jones River	Moores Lake	DE 290-L01	205181	0.893	0.031	0.081	0.168	31	48
Saint Jones River	Silver Lake (Dover)	DE 290-L02	205191	1.696	0.080	0.134	0.235	87	152
Saint Jones River	Derby Pond	DE 290-L03	205211	0.739	0.020	0.040	0.062	25	53
Smyrna River	Smyrna River	DE 310-001	201041 201051	1.546	0.201	0.316	0.523	52	117
Smyrna River	Mill Creek	DE 310-002	201021	1.517	0.071	0.155	0.236	50	136
Smyrna River	Tributaries of Smyrna River From The Headwaters To The Confluence With The Delaware River	DE 310-003	201161	0.888	0.042	0.086	0.215	18	59
Smyrna River	Lake Como & Duck Creek Pond	DE 310-L01	98 305(b)	--	--	--	--	--	--
Chesapeake Bay									
Broad Creek	Lower Broad Creek, Including Collins & Culvert Ditch, Holly Ditch, Rossakatum and Cooper Branches	DE 050-001	307021 307151	0.796	0.044	0.099	0.151	9	16
Broad Creek	Tussocky Branch	DE 050-002	307061 307291 307331	0.989	0.006	0.026	0.061	4	8
Broad Creek	Little Creek	DE 050-003	98 305(b)	--	--	--	--	--	--
Broad Creek	Chipman Pond Branch	DE 050-004	307111 307121 307341	0.613	0.014	0.059	0.203	6	11
Broad Creek	James Branch Including Pepper Pond Br., Hitch Pond Br., Etc.	DE 050-005-01	307081 307281 307351 307361 307381 307391	0.934	0.018	0.108	0.426	5	13
Broad Creek	Trussum Pond Branch	DE 050-005-02	98 305(b)	--	--	--	--	--	--
Broad Creek	Trap Pond Branch	DE 050-006-01	98 305(b)	--	--	--	--	--	--
Broad Creek	Raccoon Prong	DE 050-006-03	307221 307371	1.031	0.050	0.087	0.160	22	104

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Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Total N (mg/l) Avg	Total P (mg/l) Min	Total P (mg/L) Avg	Total P (mg/l) Max	Chlor-A (ug/L) Avg	Chlor-A (ug/L) Max
Broad Creek	Portsville Pond	DE 050-L01	98 305(b)	--	--	--	--	--	--
Broad Creek	Tussock Pond	DE 050-L02	307101	0.880	0.009	0.041	0.060	6	11
Broad Creek	Horseys Pond	DE 050-L03	307171	1.007	0.028	0.101	0.210	36	80
Broad Creek	Records Pond	DE 050-L04	307011 307401	0.763	0.025	0.050	0.098	15	56
Broad Creek	Chipman Pond & Wileys Pond	DE 050-L05	307131	0.611	0.027	0.063	0.124	20	37
Broad Creek	Trussum Pond	DE 050-L06	307091	1.922	0.019	0.110	0.202	38	144
Broad Creek	Trap Pond	DE 050-L07	307181	2.150	0.057	0.124	0.164	21	72
Broad Creek	Raccoon Pond	DE 050-L08	307201	1.126	0.039	0.101	0.201	30	61
Chesapeake Drainage	Cypress Branch	DE 100-001	98 305(b)	--	0.221	--	--	--	--
Chesapeake Drainage	Sewell Branch	DE 100-002	112021	1.173	--	0.308	0.435	12	40
Chesapeake Drainage	Gravelly Run	DE 100-003	112031	1.291	0.175	0.255	0.300	10	21
Chesapeake Drainage	Tributaries Of Elk River	DE 100-004	98 305(b)	--	--	--	--	--	--
Chesapeake Drainage	Tributaries Of Sassafras River	DE 100-005	98 305(b)	--	--	--	--	--	--
Chotpank River	Tappahanna Ditch	DE 110-001	207081	0.595	0.021	0.061	0.167	7	13
Chotpank River	Culbreth Marsh Ditch	DE 110-002	207091	0.675	0.027	0.102	0.306	6	11
Chotpank River	Cow Marsh Creek	DE 110-003	207021	0.633	0.041	0.078	0.185	5	5
Chotpank River	Mud Mill Pond	DE 110-L01	207111	1.193	0.043	0.180	0.416	33	160
Marshyhope Creek	Marshyhope Creek, Headwaters To State Line	DE 200-001	302021 302031	0.418	0.003	0.048	0.127	9	56
Marshyhope Creek	Tributaries of Marshyhope CreekFrom The Headwaters To State Line	DE 200-002	98 305(b)	--	--	--	--	--	--
Nanticoke River	Lower Nanticoke River	DE 240-001	304021 304031 304071 304091 304101 304141 304151 304171 304461 304471 304621	3.013	0.048	0.115	0.426	65	166
Nanticoke River	Upper Nanticoke River	DE 240-002	304191 304291	0.765	0.018	0.137	0.460	6	24
Nanticoke River	Clear Brook Branch	DE 240-003	304041 304371 304381 304571 304631	4.654	0.015	0.125	0.358	16	136
Nanticoke River	Deep Creek Branch	DE 240-004	304591 304601 304641	0.749	0.015	0.100	0.818	85	1410
Nanticoke River	Gravelly Branch	DE 240-005	316011 316021 316031	0.572	0.012	0.048	0.153	12	125
Nanticoke River	Bridgeville Branch	DE 240-006	304051 304271 304371 304611	4.339	0.015	0.114	0.440	5	29
Nanticoke River	Gum Branch	DE 240-007	304441 304531	0.781	0.027	0.094	0.382	6	21
Nanticoke River	Lewes Creek	DE 240-008	304421 304451 304541 304551 304561	0.642	0.005	0.075	0.318	3	11
Nanticoke River	Dupont Gut	DE 240-009	98 305(b)	--	--	--	--	--	--

"--" = no data in the period of Sept 1, 1997 to Aug 31 1999

Table III-4 Summary Statistics Used For Use Support Determinations for State of Delaware 2000 305(b) Assessment

Watershed	Segment Name	Segment ID	STORET Monitoring Station Numbers	Total N (mg/l) Avg	Total P (mg/l) Min	Total P (mg/L) Avg	Total P (mg/l) Max	Chlor-A (ug/L) Avg	Chlor-A (ug/L) Max
Nanticoke River	Gum Branch, Upper Nanticoke River	DE 240-010	98 305(b)	--	--	--	--	--	--
Nanticoke River	Craigs Pond	DE 240-L01	304301	0.590	0.013	0.077	0.269	5	11
Nanticoke River	Concord Pond	DE 240-L02	304311 304651	0.505	0.013	0.061	0.320	9	40
Nanticoke River	Collins Pond	DE 240-L03	98 305(b)	--	--	--	--	--	--
Nanticoke River	Williams Pond	DE 240-L04	304321 304581	0.809	0.022	0.105	0.349	31	112
Nanticoke River	Hearns Pond	DE 240-L05	304411	1.621	0.032	0.251	0.596	76	288
Pocomoke River	Pocomoke River, Headwaters To Maryland State Line	DE 250-001	313011	0.856	0.092	0.161	0.340	7	13
Pocomoke River	Pocomoke River, Tributaries From The Headwaters To Maryland line	DE 250-002	98 305(b)	--		--	--	--	--

"--" = no data in the period of Sept 1, 1997 to Aug 31 1999

Table III-5 Use Support Determinations for the State of Delaware 2000 305(b) Assessment

Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Piedmont Basin																
Brandywine Creek	DE 040-001	Lower Brandywine River	104011	3.8m	F	N	F	--	--	--	F	--	--	Y	3.8	0.0
Brandywine Creek	DE 040-002	Upper Brandywine Creek, From State Line To Wilmington	104021 104051	9.3m	F	P	F	P	F	F	F	--	--	Y	9.3	0.0
Brandywine Creek	DE 040-003	All Tributaries On Brandywine Creek From The Headwaters to the Confluence with the Christina River	98 305(b)	19.3m	N	N	F	--	F	F	F	--	F		0.0	19.4
Christina River	DE 120-001	Lower Christina River	106011 106291	1.5m	F	N	F	--	--	--	F	--	--	Y	1.5	0.0
Christina River	DE 120-002	Mid Christina River, Between White Clay Creek And Brandywine	106021	8.5m	F	N	F	--	--	--	F	--	--	Y	7.5	1.0
Christina River	DE 120-002-01	Christina River, Tributaries On The Christina River Between White Clay Crrek and Brandywine River	98 305(b)	3.0m	N	N	F	--	F	F	F	--	--		0.0	3.0
Christina River	DE 120-003	Upper Christina River	106031	6.9m	F	N	F	--	F	F	F	--	--	Y	6.3	0.6
Christina River	DE 120-003-01	Nonesuch Creek	98 305(b)	3.0m	N	N	F	--	F	F	F	--	--		0.0	3.0
Christina River	DE 120-003-02	Christina River Tributaries From Smalleys Pond Overflow To White Clay Creek	106321	3.1m	N, DO	N	F	--	F	F	F	--	--		2.8	3.3
Christina River	DE 120-004-01	Lower Christina Creek	106111 106141 106331	8.4m	P, DO	N	F	--	F	F	F	--	--		8.4	0.0
Christina River	DE 120-004-02	Belltown Run	106341	5.6m	N, DO	N	F	--	F	F	F	--	--		3.3	2.4
Christina River	DE 120-004-03	Muddy Run	98 305(b)	13.1m	P	N	F	--	F	F	F	--	--		0.0	13.1
Christina River	DE 120-005-01	West Branch Including Persimmon Run And Stine Haskell Branch	98 305(b)	5.3m	F	N	F	--	F	F	F	--	--		0.0	5.3
Christina River	DE 120-006	Upper Christina Creek	106191	10.8m	F	N	F	--	F	F	F	F	--		8.3	2.5
Christina River	DE 120-007-01	Little Mill Creek	106281	12.8m	F	N	F	--	F	F	F	--	--	Y	5.1	7.8
Christina River	DE 120-007-02	Chestnut Run	98 305(b)	2.8m	P	N	F	--	F	F	F	--	--		0.0	2.8
Christina River	DE 120-L01	Smalleys Pond	98 305(b)	30.0a	F	N	F	--	F	F	F	--	--		0.0	30.0
Christina River	DE 120-L02	Becks Pond	106121 106351	25.6a	F	P	F	--	F	F	F	--	--		25.6	0.0
Christina River	DE 120-L03	Sunset Pond	106131 106361 106371 106381	40.0a	N, DO	P	F	--	F	F	F	--	--		40.0	0.0

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Table III-5 Use Support Determinations for the State of Delaware 2000 305(b) Assessment

Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Naamans Creek	DE 230-001-01	Lower Naamans Creek Including Its Tributaries	101041	0.3m	F	N	F	--	--	--	F	--	--		0.3	0.0
Naamans Creek	DE 230-001-02	Upper Naamans Creek Including North Br. And South Br.	101021 101031	11.0m	F	P	F	--	--	F	F	--	--		7.8	3.2
Red Clay Creek	DE 260-001	Red Clay Creek From Pennsylvania State Line	103011 103031 103041	12.8m	N, Zinc	N	F	--	F	F	F	N	--	Y	12.8	0.0
Red Clay Creek	DE 260-002	Burroughs Run From Pennsylvania State Line Run	103061	4.5m	F	P	F	--	F	F	F	--	--		2.6	1.9
Red Clay Creek	DE 260-003	All Other Red Clay Creek Tributaries Located In The Watershed But Not On the mainstem.	98 305(b)	10.3m	P	N	F	--	F	F	F	--	--		0.0	10.3
Red Clay Creek	DE 260-L01	Hoopes Reservoir	98 305(b)	200.0a	F	N	F	--	F	F	F	--	--		0.0	200.0
Shellpot Creek	DE 300-001-01	Lower Shellpot Creek	102041	1.0m	F	P	F	--	--	--	F	--	--		1.0	0.0
Shellpot Creek	DE 300-001-02	Upper Shellpot Creek	102011	14.2m	F	N	F	--	--	F	F	--	--		7.7	6.5
Shellpot Creek	DE 300-001-03	All Other Tributaries To Shellpot Creek Located In The Watershed But Not On the mainstem.	98 305(b)	7.6m	P	N	F	--	--	F	F	--	--		0.0	7.6
White Clay Creek	DE 320-001	White Clay Creek From Pennsylvania State Line	105011 105031 105151	18.2m	N Zinc	N	F	N	F	F	F	F	--		15.6	2.6
White Clay Creek	DE 320-002	Mill Creek	105071	16.6m	F	N	F	--	F	F	F	F	--		8.3	8.3
White Clay Creek	DE 320-003	Pike Creek	105101	8.2m	F	P	F	--	F	F	F	F	--		5.4	2.8
White Clay Creek	DE 320-004	Middle Run	105131	5.8m	F	N	F	--	F	F	F	--	--		4.5	1.3
White Clay Creek	DE 320-005	All Tributaries to White Clay Creek From The Headwaters To The Confluence With the Christina River	98 305(b)	14.2m	P	N	F	--	F	F	F	--	--		0.0	14.2
Inland Bays/Atlantic Ocean Drainage Basin																
Assawoman Bay	DE 350-E01	Assawoman Bay	98 305(b)	0.6sqm	--	N	--	N	--	--	--	--	F		0.0	.6 sq m
Buntings Branch	DE 070-001	Bunting's Branch	311041	11.1m	N, DO	N	F	--	--	F	--	--	--		4.6	6.5
Indian River/Indian River Bay	DE 140-001	White Creek	310121 312011	11.2m	N, DO	N	F	N	--	--	F	--	--		7.6	3.6
Indian River/Indian River Bay	DE 140-002	Blackwater Creek	308361	13.8m	F	N	F	N	--	--	F	--	--		2.0	11.8
Indian River/Indian River Bay	DE 140-003	Pepper Creek And Tributaries, Including Vines Creek, Mccrays and Deep Hole Branches	308091 308151 308351	53.7m	N, DO	N	F	N	--	--	F	--	--		15.7	38.0

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Table III-5 Use Support Determinations for the State of Delaware 2000 305(b) Assessment

Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Indian River/Indian River Bay	DE 140-004	Indian River	306181 306191	9.4m	P, DO	N	F	N	--	--	F	--	--		5.0	4.4
Indian River/Indian River Bay	DE 140-005	Swan Creek	308301 308341	8.6m	F	P	F	--	--	F	F	--	--		8.6	0.0
Indian River/Indian River Bay	DE 140-006	Stockley Branch	308141 308281 308321	12.1m	P, DO	P	F	--	--	F	F	--	--		9.3	2.8
Indian River/Indian River Bay	DE 140-007	Eli Walls Tax Ditch	98 305(b)	13.6	F	N	F	--	--	F	F	--	--		0.0	13.6
Indian River/Indian River Bay	DE 140-008	Deep Branch, Including Peterkins Br., White Oak Swamp Ditch, Socorockets Ditch, Welsh and Simpler Branches	98 305(b)	16.9	F	N	F	--	--	F	F	--	--		0.0	16.9
Indian River/Indian River Bay	DE 140-009	Mirey Branch, Including Sheep Pen Ditch, And Narrow Drain	98 305(b)	23.5m	N	N	F	--	--	F	F	--	--		0.0	23.5
Indian River/Indian River Bay	DE 140-010	Betts Pond Branch	98 305(b)	23.8m	F	N	F	--	--	F	F	--	--		0.0	23.8
Indian River/Indian River Bay	DE 140-E01	Lower Indian River Bay	306121 306131 306321	13.0sq m	P, DO	P	F	P	--	--	F	--	P		13.0	0.0
Indian River/Indian River Bay	DE 140-E02	Upper Indian River Bay	306161 306331 306341	0.9sqm	N, DO, Temp	N	F	N	--	--	F	--	P		1.0	0.0
Indian River/Indian River Bay	DE 140-L01	Millsboro Pond	308071 308271 308331	126.0a	F	F	P	--	--	F	F	--	--		126.0	0.0
Indian River/Indian River Bay	DE 140-L02	Betts Pond	98 305(b)	80.0a	F	N	P	--	--	F	F	--	--		0.0	80.0
Indian River/Indian River Bay	DE 140-L03	Ingram Pond	98 305(b)	48.0a	F	N	P	--	--	F	F	--	--		0.0	48.0
Indian River/Indian River Bay	DE 140-L04	Morris Mill Pond	98 305(b)	44.0a	F	N	F	--	--	F	F	--	--		0.0	44.0
Iron Branch	DE 150-001	Iron Branch	309021 309041	30.2	N, DO	N	F	N	--	F	F	--	--		13.1	17.1
Lewes and Rehoboth Canal	DE 170-001	Lewes-Rehoboth Canal	305011 305041 305061 305081	14.1m	F	N	F	--	--	--	F	--	--		11.7	2.4
Little Assawoman Bay	DE 180-001	Little Assawoman Canal	312041	9.3m	N, DO	N	F	N	--	--	F	--	--		3.1	6.2
Little Assawoman Bay	DE 180-002	Miller Creek	310101	14.1	N, DO	N	F	N	--	F	F	--	--		6.5	7.6
Little Assawoman Bay	DE 180-003	Dirickson Creek	310031	31.0m	N, DO	N	F	N	--	F	F	--	--		3.6	27.3
Little Assawoman Bay	DE 180-004	Jefferson Creek And Dead End Lagoons	98 305(b)	5.2m	N	N	F	N	--	F	F	--	N		0.0	5.1
Little Assawoman Bay	DE 180-E01	Little Assawoman Bay	310011 310071	3.0sqm	N, DO	P	F	N	--	--	F	--	--		3.0	0.0

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Table III-5 Use Support Determinations for the State of Delaware 2000 305(b) Assessment

Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Rehoboth Bay	DE 280-001-01	From The Headwaters Of Chapel Br. To The Confluence Of Herring Creek	308051	29.8m	N, DO	N	F	N	--	F	F	--	--		27.0	2.8
Rehoboth Bay	DE 280-002	Love Creek	308291 308371	21.5m	F	P	F	P	--	F	F	--	--		8.8	12.7
Rehoboth Bay	DE 280-E01	Rehoboth Bay	306071 306091 306111	12.0sq m	P, DO	F	F	P	--	--	F	--	--		12(sq. mi)	0.0
Rehoboth Bay	DE 280-L01	Burton Pond	308031	33.0a	F	F	F	F	--	F	F	--	--		33.0	0.0
Delaware Bay Drainage																
Appoquinimink River	DE 010-001-01	Lower Appoquinimink River	109091 109121 109141	7.1m	N, DO	N	F	--	--	--	F	--	--	Y	7.1	0.0
Appoquinimink River	DE 010-001-02	Upper Appoquinimink River - Odessa	109041 109051 109151 109171	6.1m	N, DO	N	F	--	--	--	F	--	--		6.1	0.0
Appoquinimink River	DE 010-001-03	Drawyer Creek and Tributaries	109071 109201 109211	19.5m	N, DO	N	F	--	--	F	F	--	--	Y	14.5	5.0
Appoquinimink River	DE 010-001-04	All Tributaries From The Headwaters Of Appoquinimink River to the Bay	98 305(b)	10.3m	N	N	F	--	--	F	F	--	--		0.0	10.3
Appoquinimink River	DE 010-002-01	Upper Appoquinimink - Wiggins Mill Pond Branch	109221 109231	3.4m	N, DO	N	F	--	--	F	F	--	--		3.4	0.0
Appoquinimink River	DE 010-002-02	Upper Appoquinimink, Deep Creek To Confluence With Silver Lake	109241 109251	4.4m	P, DO	N	F	--	--	F	F	--	--		2.4	2.0
Appoquinimink River	DE 010-L01	Noxontown Pond	109131	158.6a	F	F	F	--	--	F	F	--	--		158.6	0.0
Appoquinimink River	DE 010-L02	Silver Lake (Middletown)	109031	38.7a	F	P	F	--	--	F	F	--	--	Y	38.7	0.0
Appoquinimink River	DE 010-L03	Shallcross Lake	109191	43.1a	F	F	F	--	--	F	F	--	--		43.1	0.0
Army Creek	DE 020-001	Lower Army Creek	114011	6.8m	F	F	F	--	--	--	--	--	--		3.8	3.0
Army Creek	DE 020-002	Upper Army Creek	114021	1.9m	F	N	F	--	--	F	--	--	--		1.1	0.8
Army Creek	DE 020-003	Tributaries to Army Creek not on the Mainstem	98 305(b)	6.5m	P	N	F	--	--	--	--	--	--		0.0	6.5
Blackbird Creek	DE 030-001	Lower Blackbird Creek	110041	13.8m	P, DO	N	F	--	--	--	F	--	--		13.8	0.0
Blackbird Creek	DE 030-002	Upper Blackbird Creek	110021	13.6m	N, DO	N	F	--	--	F	F	--	--		13.6	0.0
Blackbird Creek	DE 030-003	Tributaries on the mainstem of Blackbird Creek	98 305(b)	9.7m	N	N	F	--	--	F	F	--	--		0.0	9.7
Broad Kill River	DE 060-001	Lower Broadkill River	303041	10.6m	P, DO	N	F	--	--	--	F	--	--		8.1	2.5

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Table III-5 Use Support Determinations for the State of Delaware 2000 305(b) Assessment

Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Broad Kill River	DE 060-002	Beaverdam Creek	303171 303181	8.3m	N, DO	N	F	--	--	F	F	--	--		8.3	0.0
Broad Kill River	DE 060-003	Upper Broadkill River	303031	7.5m	F	F	F	--	--	F	F	--	--		5.0	2.4
Broad Kill River	DE 060-004	Round Pole Branch	303311	5.2m	N, DO	N	F	--	--	F	F	--	--		5.2	0.0
Broad Kill River	DE 060-005	Ingram Branch	303011 303021	13.0m	P, DO	N	F	--	--	F	F	--	--		7.6	5.4
Broad Kill River	DE 060-006	Pemberton Branch	303341	8.7m	F	N	F	--	--	F	F	--	--		5.0	3.7
Broad Kill River	DE 060-007-01	Lower Red Mill Branch	303051	5.3m	F	P	F	--	--	F	F	--	--		5.3	0.0
Broad Kill River	DE 060-007-02	Martin Branch	98 305(b)	1.5m	N	F	F	--	--	F	F	--	--		0.0	1.5
Broad Kill River	DE 060-007-03	Heronwood Branch	98 305(b)	1.0m	N	N	F	--	--	F	F	--	--		0.0	1.0
Broad Kill River	DE 060-008	Primehook Creek Including Its Tributaries	98 305(b)	23.6m	F	N	F	--	--	F	F	--	--		0.0	23.6
Broad Kill River	DE 060-L01	Red Mill Pond	303231	150.0a	N, DO	N	F	--	--	F	F	--	--		150.0	0.0
Broad Kill River	DE 060-L02	Waggamons Pond	303351	35.0a	F	F	F	--	--	F	F	--	--		35.0	0.0
Broad Kill River	DE 060-L03	Waples Pond & Reynolds Pond	303331 303381	88.8a	P, DO	P	F	--	--	F	F	--	--		88.8	0.0
C&D Canal	DE 090-001	Chesapeake And Delaware Canal From Maryland Line To Delaware River	108021 108031	15.0m	F	P	F	--	--	--	F	--	--	Y	15.0	0.0
C&D Canal	DE 090-002	Chesapeake And Delaware Canal Tributaries On Canal From Md line to Delaware River	98 305(b)	17.8	N	P	F	--	--	--	F	--	--		0.0	17.8
C&D Canal	DE 090-003	Chesapeake And Delaware Canal Tributaries Located In The Watershed but not on the Mainstem	98 305(b)	46.2m	F	P	F	--	--	--	F	--	--		0.0	46.2
C&D Canal	DE 090-L01	Lums Pond	108111	189.3a	F	F	P	--	--	--	F	--	--		189.3	0.0
Cedar Creek	DE 080-001	Lower Cedar Creek	301031 301091	21.8m	N, DO	N	F	N	--	--	F	--	--		8.8	13.0
Cedar Creek	DE 080-002	Upper Cedar Creek, Headwaters To Cedar Creek Mill Pond	301021	22.9m	F	P	F	--	--	F	F	--	--		13.0	9.9
Cedar Creek	DE 080-003	Slaughter Creek	98 305(b)	16.7m	N	N	F	N	--	--	F	--	--		0.0	16.7
Dragon Run Creek	DE 130-001	Lower Dragon Run Creek	111011	3.2m	N, DO	P	F	--	--	--	F	--	--		3.2	0.0
Dragon Run Creek	DE 130-002	Upper Dragon Run Creek	111031	4.5m	N, DO	N	F	--	F	F	F	--	--		4.1	0.4

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Table III-5 Use Support Determinations for the State of Delaware 2000 305(b) Assessment

Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Leipsic River	DE 160-001	Lower Leipsic River	202031	13.6m	N, DO	N	F	--	--	--	F	--	--		13.6	0.0
Leipsic River	DE 160-002	Upper Leipsic River	202041	24.5m	N, DO	N	F	--	--	F	F	--	--		5.8	18.7
Leipsic River	DE 160-003	Leipsic, Tributaries From Dam At Garrisons Lake To Mouth	98 305(b)	37.2m	P	N	F	--	--	F	F	--	--		0.0	37.2
Leipsic River	DE 160-004	Tributaries of Liepsic River From Headwaters To Garrisons Lake	98 305(b)	35.4m	F	N	F	--	--	F	F	--	--		0.0	35.4
Leipsic River	DE 160-L01	Garrisons Lake	202021	85.9a	N, DO	N	F	--	--	F	F	--	--		85.9	0.0
Leipsic River	DE 160-L02	Masseys Mill Pond	202011	30.0a	N, DO	N	F	--	--	F	F	--	--		30.0	0.0
Little River	DE 190-001-01	Lower Little Creek	204031	2.9m	N, DO	N	F	--	--	--	F	--	--		2.9	0.0
Little River	DE 190-001-02	Upper Little Creek	204041	10.2m	N, DO	P	F	--	--	F	F	--	--		5.5	4.7
Little River	DE 190-001-03	Pipe Elm Branch	204011	2.1m	N, DO	N	F	--	--	F	F	--	--		2.1	0.0
Little River	DE 190-001-04	Tributaries of Little River Located In The Watershed But Not On The Mainstem	98 305(b)	6.1m	N	N	F	--	--	--	F	--	--		0.0	6.1
Mispillion River	DE 210-001	Lower Mispillion River	208021 208061	13.2m	N, DO	N	F	--	--	--	F	--	--		13.2	0.0
Mispillion River	DE 210-002	Upper Mispillion River, Headwaters To Silver Lake	98 305(b)	11.2m	P	P	F	--	--	F	F	--	--		0.0	11.2
Mispillion River	DE 210-003	Johnson Branch Including Its Tributaries	98 305(b)	9.8m	P	P	F	--	--	F	F	--	--		0.0	9.8m
Mispillion River	DE 210-004	Mispillion Tributaries From Headwaters To Silver Lake	98 305(b)	5.6m	N	P	F	--	--	F	F	--	--		0.0	5.6
Mispillion River	DE 210-005	Mispillion Tributaries From Dam At Silver Lake To The Mouth	98 305(b)	29.1m	F	P	F	--	--	F	F	--	--		0.0	29.1
Mispillion River	DE 210-L01	Tub Mill Pond	98 305(b)	4.8a	F	F	P	--	--	F	F	--	--		0.0	4.8
Mispillion River	DE 210-L02	Silver Lake (Milford)	208211	28.5a	P, DO	P	F	--	--	F	F	--	--		28.5	0.0
Mispillion River	DE 210-L03	Haven Lake	208011	82.5a	P, DO	F	P	--	--	F	F	--	--		82.5	0.0
Mispillion River	DE 210-L04	Griffith Lake	98 305(b)	32.2a	F	F	P	--	--	F	F	--	--		0.0	32.2
Mispillion River	DE 210-L05	Blairs Pond	208191	28.5a	F	F	F	--	--	F	F	--	--		28.5	0.0

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Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Mispillion River	DE 210-L06	Abbotts Pond	208181	25.6a	N, DO	P	F	--	--	F	F	--	--		25.6	0.0
Murderkill River	DE 220-001	Lower Murderkill River	206091 206101 206131 206141 206231	27.5m	N, DO	N	F	--	--	--	F	--	--		7.6	19.9
Murderkill River	DE 220-002	Spring Creek	206081 206601 206611 206621 206631 206641	36.5m	P, DO	N	F	--	--	--	F	--	--		36.5	0.0
Murderkill River	DE 220-003	Mid Murderkill River	206211	16.2m	F	N	F	--	--	F	F	--	--		9.2	6.9
Murderkill River	DE 220-004	Browns Branch	206041 206051 206421 266651	24.1m	N, DO	N	F	--	--	F	F	--	--		16.4	7.8
Murderkill River	DE 220-005	Upper Murderkill River	206011 206351 206661 206671 206681	21.7m	P, DO	N	F	--	--	F	F	--	--		19.1	2.6
Murderkill River	DE 220-L01	Mcginnis Pond	206461 206561	31.3a	N, DO	N	F	--	--	F	F	--	--		31.3	0.0
Murderkill River	DE 220-L02	Andrews Lake	206071	17.5a	F	P	F	--	--	F	F	--	--		17.5	0.0
Murderkill River	DE 220-L03	Coursey Pond	206451	58.1a	F	P	P	--	--	F	F	--	--		58.1	0.0
Murderkill River	DE 220-L04	Killen Pond	206021 206691	75.1a	F	P	P	--	--	F	F	--	--		75.1	0.0
Murderkill River	DE 220-L05	Mccauley Pond	206361	49.0a	F	P	P	--	--	F	F	--	--		49.0	0.0
Red Lion Creek	DE 270-001-01	Lower Red Lion Creek	107031	3.7m	N, DO	N	F	--	--	--	F	--	--	Y	1.5	2.2
Red Lion Creek	DE 270-001-02	Upper Red Lion Creek, Headwaters To Route 13	107011	6.0m	P, DO	N	F	--	N	F	F	--	--		1.9	4.1
Red Lion Creek	DE 270-001-03	Tributaries Located In The Watershed But Not On Mainstem of Red Lion Creek	98 305(b)	1.8m	P	P	F	--	--	--	F	--	--		0.0	1.8
Saint Jones River	DE 290-001-01	Lower St. Jones River	205041	12.9m	N, DO	N	F	--	--	--	F	--	--	Y	8.3	4.7
Saint Jones River	DE 290-001-02	Upper St. Jones River	205091 205571	11.2m	P, DO	P	F	--	--	F	F	--	--	Y	6.7	4.5
Saint Jones River	DE 290-001-03	Tributaries of Saint Jones River From Old Lebanon Bridge To The Mouth Of Delaware	98 305(b)	13.6m	N	N	F	--	--	F	F	--	--		0.0	13.6
Saint Jones River	DE 290-002	Isaac Branch	205241	17.0m	F	N	F	--	--	F	F	--	--	Y	1.9	15.1
Saint Jones River	DE 290-003	Fork Branch	205151	39.5m	N, DO	P	F	--	--	F	F	--	--		7.7	31.9
Saint Jones River	DE 290-004	Tidbury Branch	98 305(b)	11.5m	N	P	F	--	--	F	F	--	--		0.0	11.5

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Table III-5 Use Support Determinations for the State of Delaware 2000 305(b) Assessment

Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Saint Jones River	DE 290-L01	Moores Lake	205181	27.1a	F	P	F	--	--	F	F	--	--	Y	27.1	0.0
Saint Jones River	DE 290-L02	Silver Lake (Dover)	205191	157.8a	F	P	N	--	--	F	F	--	--	Y	157.8	0.0
Saint Jones River	DE 290-L03	Derby Pond	205211	23.1a	F	P	P	--	--	F	F	--	--		21.3	0.0
Smyrna River	DE 310-001	Smyrna River	201041 201051	10.2m	N, DO	N	F	--	--	--	F	--	--		10.2	0.0
Smyrna River	DE 310-002	Mill Creek	201021	6.3m	N, DO	N	F	--	--	F	F	--	--		5.2	1.1
Smyrna River	DE 310-003	Tributaries of Smyrna River From The Headwaters To The Confluence With The Delaware River	201161	58.0m	F	N	F	--	--	F	F	--	--		4.2	53.8
Smyrna River	DE 310-L01	Lake Como & Duck Creek Pond	98 305(b)	82.0a	F	N	P	--	--	F	F	--	--		0.0	82.0
Chesapeake Bay Drainage Basin																
Broad Creek	DE 050-001	Lower Broad Creek, Including Collins & Culvert Ditch, Holly Ditch, Rossakatum and Cooper Branches	307021 307151	39.2m	N, DO	P	F	N	--	--	F	--	--		16.0	23.2
Broad Creek	DE 050-002	Tussocky Branch	307061 307291 307331	13.0m	F	P	F	P	--	F	F	--	--		5.1	7.9
Broad Creek	DE 050-003	Little Creek	98 305(b)	20.1m	F	N	F	N	--	F	F	--	--		0.0	20.1
Broad Creek	DE 050-004	Chipman Pond Branch	307111 307121 307341	21.7m	F	N	F	N	--	F	F	--	--		9.1	12.6
Broad Creek	DE 050-005-01	James Branch Including Pepper Pond Br., Hitch Pond Br., Etc.	307081 307281 307351 307361 307381 307391	31.7m	N, DO	N	F	N	--	F	F	--	--		8.2	23.5
Broad Creek	DE 050-005-02	Trussum Pond Branch	98 305(b)	18.8m	N	N	F	N	--	F	F	--	--		0.0	18.8
Broad Creek	DE 050-006-01	Trap Pond Branch	98 305(b)	21.5m	F	N	F	N	--	F	F	--	--		0.0	21.5
Broad Creek	DE 050-006-03	Raccoon Prong	307221 307371	21.0m	N, DO	N	F	N	--	--	--	--	--		9.1	11.8
Broad Creek	DE 050-L01	Portsville Pond	98 305(b)	14.5a	F	P	F	P	--	F	F	--	--		0.0	14.5
Broad Creek	DE 050-L02	Tussock Pond	307101	8.6a	F	P	F	P	--	F	F	--	--		8.6	0.0
Broad Creek	DE 050-L03	Horseys Pond	307171	46.3a	F	P	F	P	--	F	F	--	--		46.3	0.0
Broad Creek	DE 050-L04	Records Pond	307011 307401	91.9a	F	P	F	P	--	F	F	--	--		91.9	0.0
Broad Creek	DE 050-L05	Chipman Pond & Wileys Pond	307131	47.0a	F	P	P	P	--	F	F	--	--		47.0	0.0
Broad Creek	DE 050-L06	Trussum Pond	307091	58.7a	N, DO	N	F	N	--	F	F	--	--		58.7	0.0
Broad Creek	DE 050-L07	Trap Pond	307181	88.0a	P, DO	F	P	P	--	F	F	--	--		88.0	0.0

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Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Broad Creek	DE 050-L08	Raccoon Pond	307201	13.5a	N, DO	P	F	N	--	F	F	--	--		13.5	0.0
Chesapeake Drainage	DE 100-001	Cypress Branch	98 305(b)	12.2m	N	N	F	--	--	F	F	--	--		0.0	12.2
Chesapeake Drainage	DE 100-002	Sewell Branch	112021	18.8m	N, DO	N	F	--	--	F	F	--	--		0.0	18.8
Chesapeake Drainage	DE 100-003	Gravelly Run	112031	20.6m	N, DO	N	F	--	--	F	F	--	--		7.7	12.9
Chesapeake Drainage	DE 100-004	Tributaries Of Elk River	98 305(b)	21.7m	N	N	F	--	--	F	F	--	--		0.0	21.7
Chesapeake Drainage	DE 100-005	Tributaries Of Sassafras River	98 305(b)	7.2m	N	N	F	--	--	F	F	--	--		0.0	7.2
Chotpank River	DE 110-001	Tappahanna Ditch	207081	36.3m	N, DO	P	F	--	--	F	F	--	--		7.5	28.8
Chotpank River	DE 110-002	Culbreth Marsh Ditch	207091	34.3m	N, DO	P	F	--	--	F	F	--	--		10.1	24.3
Chotpank River	DE 110-003	Cow Marsh Creek	207021	89.9m	N, DO	F	F	--	--	F	F	--	--		15.1	74.8
Chotpank River	DE 110-L01	Mud Mill Pond	207111	60.0a	N, DO	P	F	--	--	F	F	--	--		60.0	0.0
Marshyhope Creek	DE 200-001	Marshyhope Creek, Headwaters To State Line	302021 302031	20.3m	F	P	F	--	--	F	F	--	--		19.7	0.6
Marshyhope Creek	DE 200-002	Tributaries of Marshyhope CreekFrom The Headwaters To State Line	98 305(b)	145.3m	N	N	F	--	--	F	F	--	--		0.0	145.3
Nanticoke River	DE 240-001	Lower Nanticoke River	304021 304031 304071 304091 304101 304141 304151 304171 304461 304471 304621	69.4m	F	P	F	P	--	--	F	--	--		24.6	44.8
Nanticoke River	DE 240-002	Upper Nanticoke River	304191 304291	62.3m	F	P	F	P	--	F	F	--	--		18.6	43.8
Nanticoke River	DE 240-003	Clear Brook Branch	304041 304371 304381 304571 304631	22.9m	P, DO	N	F	N	--	F	F	--	--		6.3	16.6
Nanticoke River	DE 240-004	Deep Creek Branch	304591 304601 304641	99.2m	P, DO	N	F	N	--	F	F	--	--		9.1	90.1
Nanticoke River	DE 240-005	Gravelly Branch	316011 316021 316031	61.2m	P, DO	P	F	P	--	F	F	--	--		14.1	47.1
Nanticoke River	DE 240-006	Bridgeville Branch	304051 304271 304371 304611	9.6m	N, DO	P	F	N	--	F	F	--	--		9.6	0.0

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Watershed	Segment ID	Segment Name	STORET Monitoring Station Numbers	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Support and Cause	Primary Contact Use Support	Secondary Contact Use Support	ERES	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish	Fish Advisories	Monitored	Evaluated
Nanticoke River	DE 240-007	Gum Branch	304441 304531	12.1m	P, DO	N	F	N	--	F	F	--	--		5.9	6.2
Nanticoke River	DE 240-008	Lewes Creek	304421 304451 304541 304551 304561	25.8m	P, DO	N	F	N	--	F	F	--	--		25.8	0.0
Nanticoke River	DE 240-009	Dupont Gut	98 305(b)	1.0m	P	F	F	P	--	F	F	--	--		0.0	1.0
Nanticoke River	DE 240-010	Gum Branch, Upper Nanticoke River	98 305(b)	46.7m	N	P	F	N	--	F	F	--	--		0.0	46.7
Nanticoke River	DE 240-L01	Craigs Pond	304301	11.9a	P, DO	P	P	P	--	F	F	--	--		11.9	0.0
Nanticoke River	DE 240-L02	Concord Pond	304311 304651	87.4a	F	P	P	P	--	F	F	--	--		87.4	0.0
Nanticoke River	DE 240-L03	Collins Pond	98 305(b)	90.0a	F	F	F	F	--	F	F	--	--		0.0	90.0
Nanticoke River	DE 240-L04	Williams Pond	304321 304581	100.0a	F	P	P	P	--	F	F	--	--		100.0	0.0
Nanticoke River	DE 240-L05	Hearns Pond	304411	67.0a	F	N	P	N	--	F	F	--	--		67.0	0.0
Pocomoke River	DE 250-001	Pocomoke River, Headwaters To Maryland State Line	313011	11.8m	N, DO	N	F	--	--	F	F	--	--		11.8	0.0
Pocomoke River	DE 250-002	Pocomoke River, Tributaries From The Headwaters To Maryland Line	98 305(b)	41.7m	P	P	F	--	--	F	F	--	--		0.0	41.7

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III.4 Chapter Four: Public Health/Aquatic Life Concerns

III.4.1 State of Delaware Fish Consumption Advisory Update

Certain chemicals build up in the food chain to levels that can be harmful to human and ecological health. DNREC and DHSS collect and analyze fish from Delaware waters to monitor the extent that these chemicals accumulate in fish from Delaware waters. When elevated levels are detected, the information is shared with the public and consumption advisories are issued to notify the angling public, their families, and friends regarding contaminants in fish from affected waterways. The advisories include specific advice on the number of meals to be consumed annually and proper trimming and cooking. The goal of this advice is voluntary reduction of exposure until the contamination is sufficiently cleaned up.

Based on the results of over 150 fish samples collected between 1993 and 1998, plus new data assessment methods, DNREC and DHSS recommended several new or revised fish consumption advisories for specific Delaware waterways in June 1999. At that time, six new advisories were made, eight were revised, and six advisories remained unchanged.

New Fish Advisories were issued for the C & D Canal, tidal Appoquinimink River, tidal Drawyers Creek, Silver Lake (Middletown),Wyoming Mill Pond, and Beck's Pond. Of the eight revised advisories, four were extended to include all finfish in the St. Jones River, Moore's Lake, Silver Lake (Dover), and Delaware River. Three advisories were revised to involve more restrictive meal advice in the Delaware Bay, non-tidal Brandywine River , and the non-tidal Christina River. One advisory was revised to be less restrictive in the Red Lion Creek. Six previously issued advisories were reaffirmed in the tidal Christina River, tidal Brandywine River, tidal White Clay Creek, non-tidal White Clay Creek to Paper Mill Road, Red Clay Creek, and Little Mill Creek. (see figure III-6). The following table lists the current fish consumption advisories (recommended limitations on the consumption of particular fish species) issued jointly by the Delaware Department of Natural Resources and Environmental Control and the Department of Health and Social Services, as of June, 1999.

Delaware Fish Consumption Advisories as of June 1999				
Waterbody	**Species**	**Geographical Extent**	**Contaminants of Concern***	**Advice**
Becks Pond	All Finfish	Entire Pond	PCBs, Mercury	No more than six 8-ounce meals per year
Delaware River	All Finfish	Delaware State Line to the C&D Canal	PCBs, Arsenic, Dioxin, Mercury, Chlorinated Pesticides	No Consumption
Red Lion Creek	All Finfish	Rt 13 to the Delaware River	PCBs, Dioxin	No more than three 8-ounce meals per year
Lower Delaware River and Delaware Bay	Striped Bass, Channel Catfish, White Catfish, American Eel, White Perch	C&D Canal to Delaware Bay Mouth	PCBs, Mercury, Dioxin	No more than one 8-ounce meal per year.
Tidal Brandywine River	All Finfish	River Mouth to Baynard Blvd.	PCBs	No Consumption
Non-Tidal Brandywine River	All Finfish	Baynard Blvd. To Pennsylvania Line	PCBs, Dioxin	No more than two 8-ounce meals per year
Tidal Christina River	All Finfish	River Mouth to Smalley's Dam	PCBs, Dieldrin	No Consumption
Non-tidal Christina River	All Finfish	Smalley's Dam to I-95	PCBs	No more than six 8-ounce meals per year
Little Mill Creek	All Finfish	Creek mouth to Kirkwood Highway	PCBs	No Consumption
Tidal White Clay Creek	All Finfish	River Mouth to Rte 4	PCBs	No Consumption
Non Tidal White Clay Creek	All Finfish	Rte. 4 to Paper Mill Road	PCBs	No more than one 8-ounce meal per month
Red Clay Creek	All Finfish	State Line to Stanton	PCBs, Dioxin, Chlorinated Pesticides	No Consumption
Chesapeake & Delaware Canal	All Finfish	Entire Canal in Delaware	PCBs	No Consumption
Appoquinimink River	All Finfish	Tidal Portions	PCBs, Dioxin	No More than one 8-ounce meal per year

Delaware Fish Consumption Advisories as of June 1999

Waterbody	Species	Geographical Extent	Contaminants of Concern*	Advice
Drawyers Creek	All Finfish	Tidal Portions	PCBs, DDT	No More than one 8-ounce meal per year
Silver Lake Middletown	All Finfish	Entire Lake	PCBs, Dieldrin, DDT, Dioxin	No More than one 8-ounce meal per year
St. Jones River	All Finfish	River Mouth to Silver Lake Dam	PCBs, Dioxin, Mercury, Arsenic	No More than two 8-ounce meals per year
Moores Lake	All Finfish	Entire Pond	PCBs, DDT	No More than two 8-ounce meals per year
Silver Lake Dover	All Finfish	Entire Pond	PCBs, Dioxin, Mercury	No More than two 8-ounce meals per year
Wyoming Mill Pond	All Finfish	Entire Pond	PCBs, Dioxin, DDT	No More than two 8-ounce meals per year

* The pollutant listed first is of the greatest concern in this system.

The contaminant of primary concern for these advisories is polychlorinated biphenyl (PCB). To a lesser degree chlorinated pesticides, dioxins and mercury have been identified as contaminants of concern. PCBs have been designated as probable human carcinogens by the EPA, are believed to affect the immune system and have been linked to developmental problems in infants. PCBs were banned in the 1970s but are extremely persistent in the environment. PCBs are found in bottom sediments and continue to enter Delaware waters from upland sources, though not at an increasing rate. Data collected to date show that PCBs in fish are not an imminent public health threat, though they are a significant, avoidable exposure. Exposure may be avoided by eating fish from uncontaminated waters. Delaware will continue to monitor the situation and coordinate work between and within agencies to coordinate remediation activities.

III.4.2 Shellfish and Recreational Waters Program

III.4.2.1 Shellfish Program

Delaware, along with 26 other states, and nine foreign countries, is a member of the Interstate Shellfish Sanitation Conference (ISSC), administrative body of the National Shellfish Sanitation Program (NSSP). The ISSC is a tripartite organization, with the membership including state participants, the U.S. Food and Drug Administration, and the shellfish industry. Member-states / countries establish water quality and pollution source parameters for determining the safety of shellfish for human consumption. Additionally, parameters are established for sanitation in harvesting, processing, and shipping shellfish (molluscan bivalves).

DNREC's role is to maintain Delaware's NSSP conforming status, as per FDA scrutiny (annual Program evaluations), thereby allowing Delaware to ship and receive shellfish. This is necessary for the preservation of Delaware's shellfish industry. Additionally, and most importantly, this ensures a safe product for the shellfish consumer.

III.4.2.2 Recreational Water (beach monitoring) Program

DNREC also ensures that natural bathing beaches are safe for swimming. Of particular concern are viruses shed by humans. Delaware uses total enterococci as an indicator of possible human fecal contamination. As is the case with the Shellfish Program, there is a qualitative component in the assessment of the risk to swimmers. Enterococci in the presence of possible sources of human fecal contamination may represent an unacceptable health risk. However, there is an increasing body of evidence, including studies conducted in Delaware, that so-called indicator bacteria are ubiquitous in the environment. Delaware's standards are based on Delaware-specific bacteria and illness data, and reflect a threshold swimming advisory level of 12.5 illnesses per 1,000 swimmers. The actual prevailing risk may be in the range of two in 100,000. Guarded beaches are tested weekly from mid-May to Labor Day.

Delaware Fish Advisories Map

Part IV Ground Water Assessment

Groundwater Assessment Overview

Ground water provides an abundant, high quality low cost supply of water for residents of the State of Delaware. The latest records indicate that more than 40 billion gallons of water were withdrawn in 1995 from ground water sources, a 25% increase from the 1990 withdrawal of 32 billion gallons. The domestic needs of approximately two-thirds of the State's population are met with ground water provided by both public and private wells. Most of the water used for agriculture, Delaware's largest industry, and self-supplied industrial use, is also derived from ground water sources. These figures will be updated during the next reporting cycle once the next USGS water use values have been compiled.

By maintaining base flow ground water is recognized as the primary supplier of water to streams. By allowing streams to maintain flow even during times of low rainfall ground water is responsible for supporting aquatic ecosystems, wildlife populations, and water supply withdrawals. Recent studies in the Red Clay Creek Basin estimated base flow as comprising 62-71% of stream flow. But during periods of low or no rainfall, essentially all surface water flow is due to ground-water discharge.

Salt water intrusion and high iron content in ground water are the only naturally occurring contaminants that may render ground water undrinkable. Radio nuclides have been found in certain aquifers in both New Jersey and Maryland but additional assessment is needed in Delaware. The occurrences of these contaminants is localized and most of Delaware's ground water is of high quality. Generally, the development of ground water as a water source is less costly than surface water because it does not require as much, if any, treatment. In addition, production wells can be located near demand centers which reduces the need for extensive transmission lines.

Ground water in Delaware is, however, a relatively vulnerable resource due to the State's shallow water table and high soil permeability. The shallow unconfined aquifer is the most vulnerable to contamination and has been made unusable in many localized areas. If ground water resources are improperly managed or inadequately protected, many of the advantages previously mentioned may be lost. Contaminants in ground water originate from sources such as domestic septic systems, landfills, underground storage tanks, agricultural activities, chemical spills and leaks, and many other sources and activities. As population and industrialization of the State continues the standards of purity of ground water are more frequently exceeded over larger areas of the State.

The deeper confined aquifers in the State are also susceptible to contamination. This is because all but one of the confined aquifers in Delaware subcrops beneath the unconfined aquifer and all aquifers receive recharge from leakage from overlying aquifers. Consequently, contamination of the ground water in the surficial unconfined aquifer could eventually affect ground-water quality of the underlying confined aquifers. Studies in southern New Castle County have demonstrated the long-term susceptibility of these deeper aquifers where they subcrop beneath the unconfined surficial aquifer.

The Department is responsible for taking appropriate action to eliminate existing ground water contamination problems and reduce the likelihood of future ground water contamination. This is being accomplished by both regulatory programs (e.g. Underground Injection Control, Underground Storage Tank, RCRA, etc.) and non-regulatory programs (e.g. Pollution Prevention, Non-point Source, etc.).

The 1998-99 ground water portion of this report continues improvements from the previous report. Ground-water quality is addressed both in this general section (Part IV) on overall state ground-water quality and in the Inland Bays/Atlantic Ocean Basin section. The Whole Basin initiative undertaken by DNREC in 1996, has allowed ground water assessments to be completed for this basin. The next two years will see similar assessment in the Delaware Bay Basin. Thus, the next reporting cycle (2000-2001) will complete the first round of ground water assessments for all 4 basins found in Delaware.

Tables IV-1 through IV-12 are at the end of this section (Starting on page 123)

IV.1 Ground Water Quantity

IV.1.1 Delaware's Water Budget

Annual precipitation in Delaware ranges from 30 to 58 inches and averages 44 inches. The annual precipitation usually exceeds the evapotranspiration rate by 12 to 18 inches in every season except summer. In the summer when temperatures are high and plants are most active virtually all of the precipitation is evapotranspired or runs off before being absorbed into the soil. As a result very little water is left to recharge aquifers and the water table falls between the months of April and October. Ground water levels tend to rise again during the late fall and winter.

The amount of water that infiltrates into the ground averages 10 to 12 inches annually or 500,000 to 600,000 gallons per square mile per day. This water eventually discharges into surface water streams or is captured by pumping wells. Water pumped from the unconfined aquifer is at the expense of stream flow. In late summer stream flow often declines to only 100,000 gallons per day per square mile.

Figure IV-1 and IV-2 illustrate changes in ground water levels the unconfined and confined aquifers, respectively, for water year 1998 and 1999 from selected locations. Dry conditions persisted in Delaware from October 1998 until September 1999. Record to near record low ground water levels and stream flow occurred throughout this period. This situation was reversed beginning in September 1999 with a series of storms. Hurricane Floyd added from 10 inches to over 4 inches of precipitation across the entire state. The effects of the drought were most dramatic in stream flows. For instance, record low daily mean stream flow were established for 14 days on Brandywine Creek at Wilmington. Mandatory restrictions were imposed on August 5, 1999 in northern New Castle County, voluntary restrictions were requested statewide. These restrictions were lifted on September 5, 1999 as a result of Hurricane Dennis (DGS, 1999)

Although less dramatic than surface water flows, water table levels declined seasonally and were substantially below normal areas throughout the entire state. For instance, in August 1999 record low water table levels were seen in Qe44-01 (see Figure IV-1) and near record levels in the remaining water table wells. As with surface water flows, ground water levels began to rise in September 1999 (DGS, 1999).

FIGURE IV-1
GROUND-WATER LEVEL CHANGES FROM SELECTED UNCONFINED AQUIFER WELLS 1998-1999 (DGS 1999)

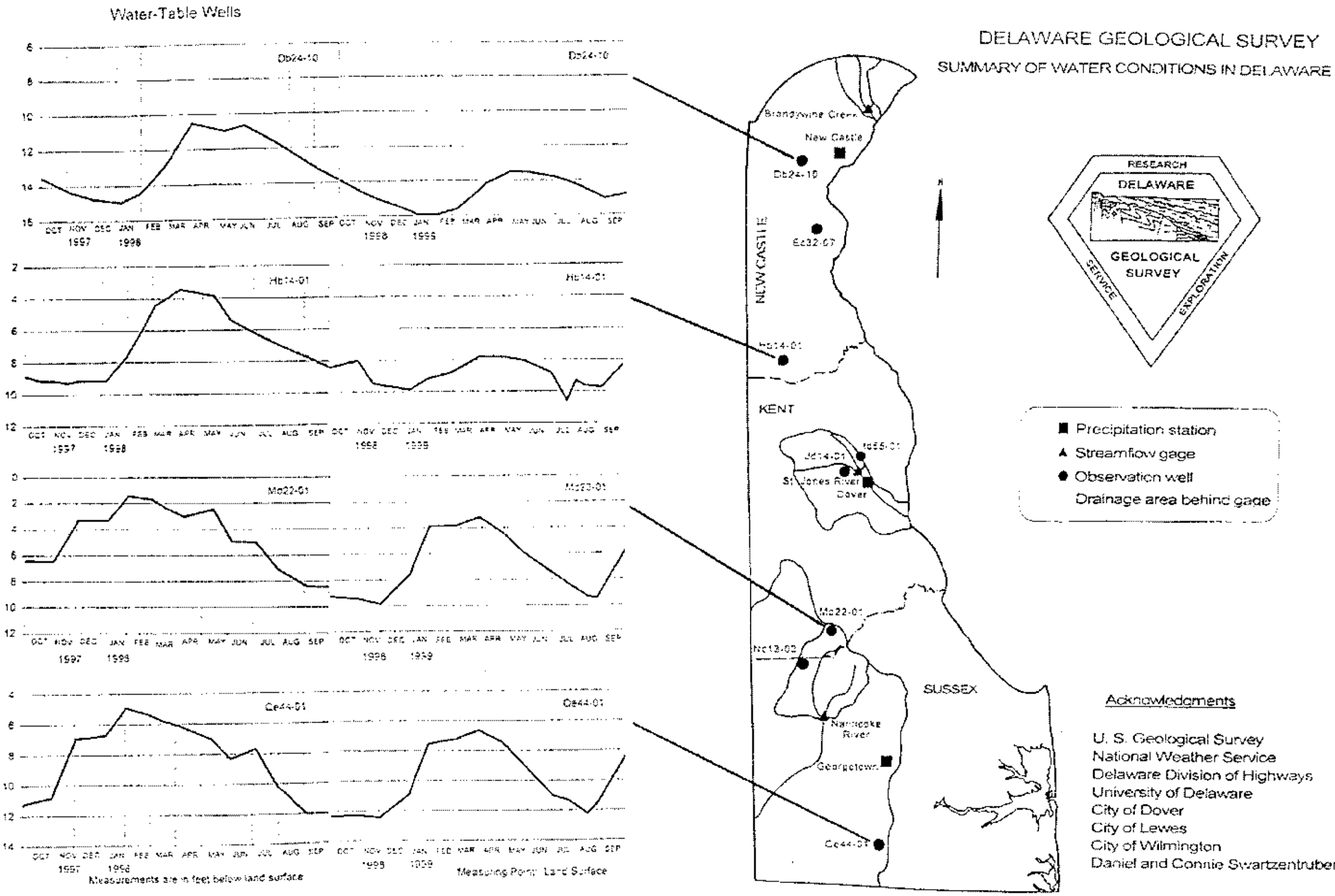
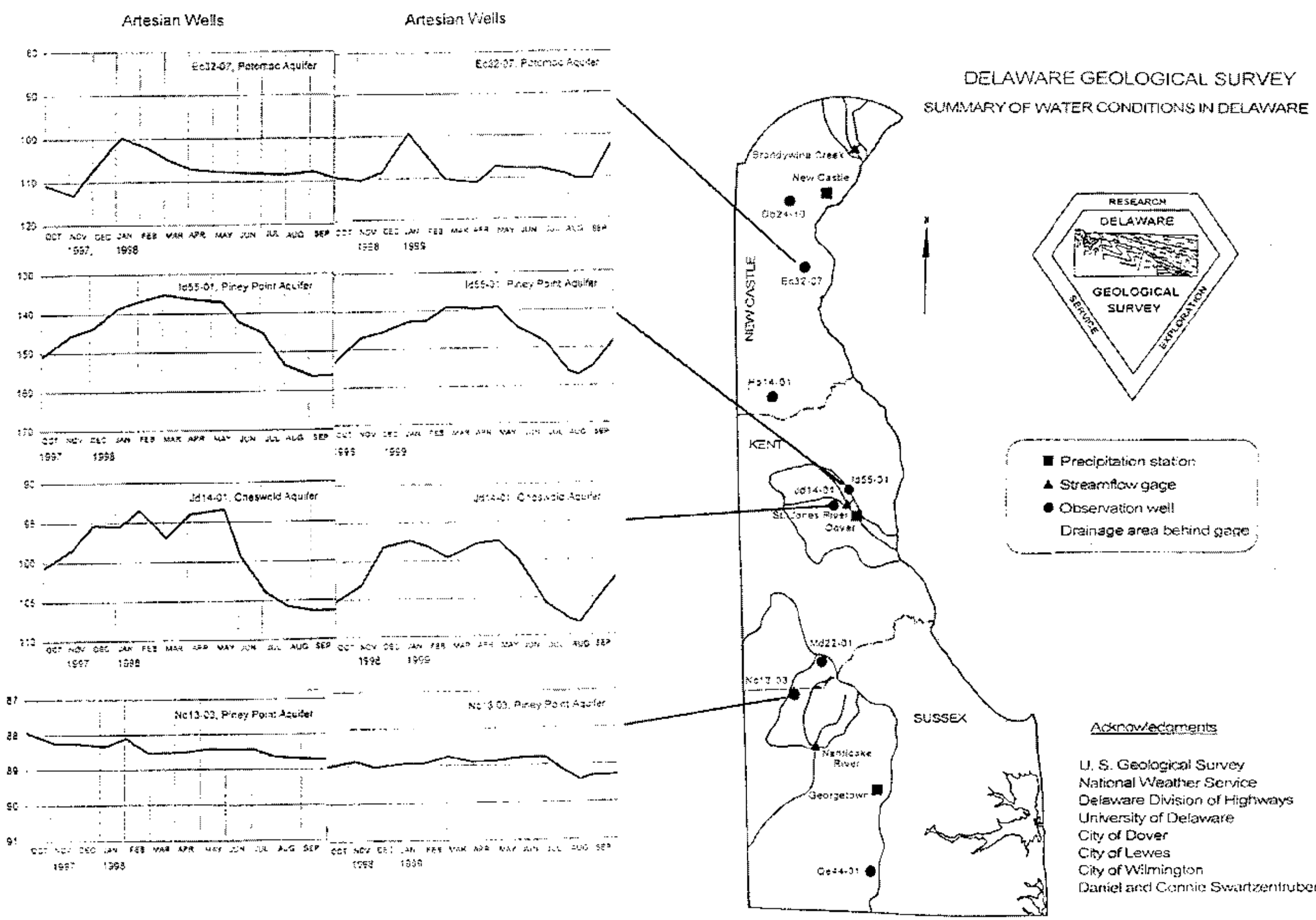


FIGURE IV-2

GROUND-WATER LEVEL CHANGES FROM SELECTED UNCONFINED AQUIFER WELLS 1998-1999 (DGS 1999)



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IV.1.2 Geologic Conditions that Influence the Occurrence and Availability of Ground Water

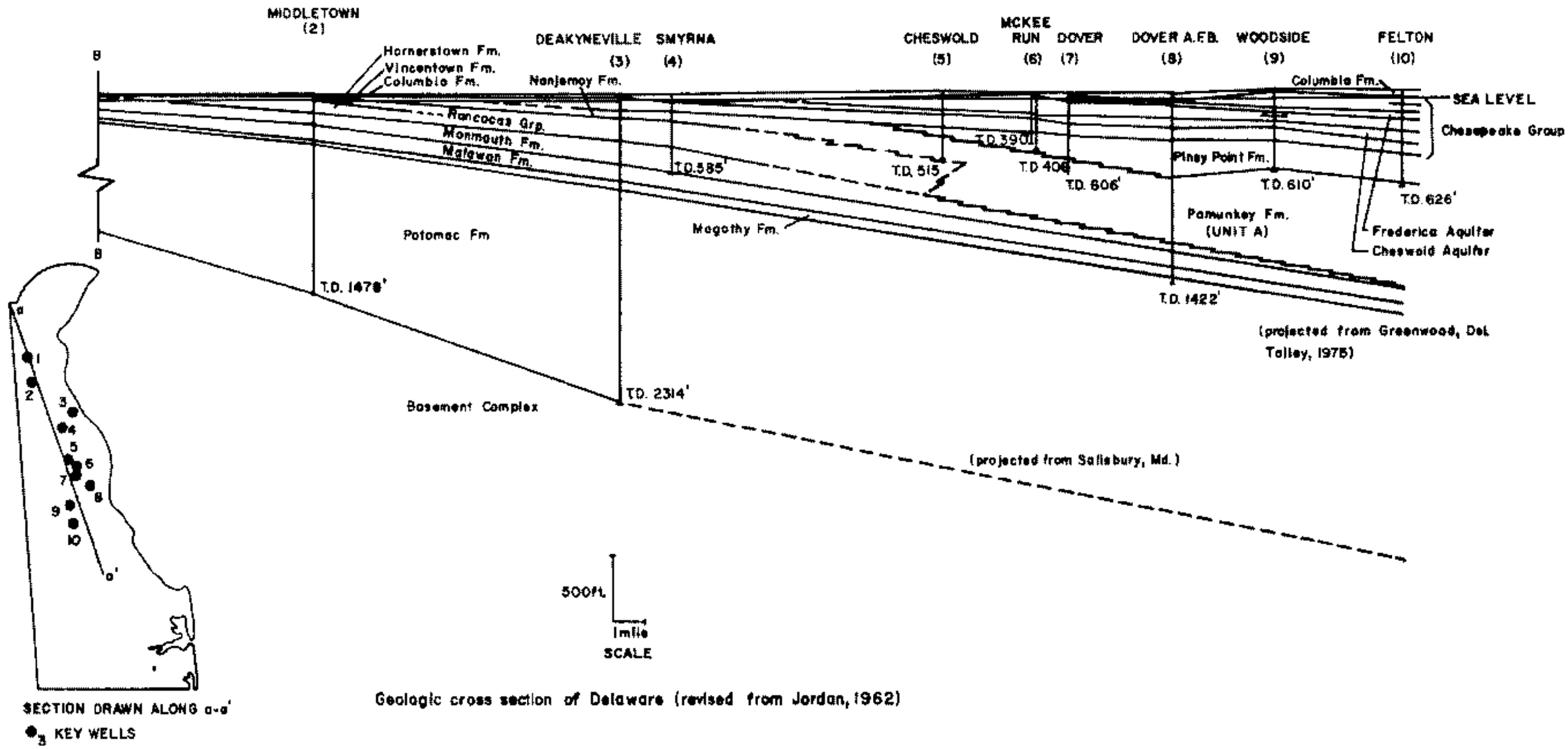
Delaware is situated in two physiographic provinces that are separated by the Fall Line. The Fall Line in Delaware is a boundary that extends from the southwest to the northeast between the cities of Newark and Wilmington. The Fall Line represents the demarcation that separates the Appalachian Piedmont Province to the north and the Atlantic Coastal Plain Province to the south. Figure IV-3 is a general geologic map for Delaware and shows the location of these two provinces.

The Piedmont Province consists of very old igneous and metamorphic rocks, and occupies approximately six percent of the State's land area. The Piedmont Province in Delaware contains the Cockeysville Formation. This formation is a fractured and solution-dissolved marble and dolomite and is able to transmit ground water and serves as an important local aquifer. The formation has been extensively studied by both the Delaware Geological Survey (DGS) and the U.S. Geological Survey (USGS). Their findings indicate that water withdraws from the aquifer are currently at their maximum. However, most water withdrawn in the Piedmont area is from surface water intakes on the Brandywine River and from Red and White Clay creeks.

The Atlantic Coastal Plain Province consists of a seaward dipping wedge-shaped deposit of unconsolidated and semi-consolidated sediments that rest unconformably on crystalline basement rock. The depth of the sediment wedge increases in thickness to the southeast, attaining a thickness of approximately 10,000 feet in southeastern Delaware. The Coastal Plain sediments previously described form the eight principal aquifer systems in the State. All of the aquifers are used to some capacity as a source of potable water. South of the C & D canal the ground water from these aquifers provide almost all of the freshwater needed for all uses. All of the drinking water is derived from ground water. Figure IV-3 illustrates the generalized subcrop areas for some of these confined aquifers. Figure IV-4 is a cross sectional profile of the major aquifers found in Delaware.

Figure IV-3

FIGURE IV-4



Geologic cross section of Delaware (revised from Jordan, 1962)

IV.1.3 Water Supply Problems

The hydro geologic setting of the State, population distribution, and water demands have created a number of water supply problems. The most common water supply problems are limited local ground water availability, salt water intrusion caused by over pumping, reduced aquifer yield due to over pumping, reduced stream flow, and reduced aquifer recharge due to paving and building. These problems are being experienced even in areas where water availability is considered abundant.

Responding to water supply problems, New Castle County adopted a water resource protection ordinance in September 1991 which attempts to address the problem of recharge loss in wellhead areas and recharge areas. Among the requirements of the ordinance are limits on the percentage of impermeable surface allowed within these areas. The ordinance is designed to maintain sufficient recharge to ground water to maintain water use requirements and stream flow.

IV.1.4 Drinking Water Supply

As of 1995 ground water for commercial, domestic, and public use in Delaware, averages about 55 million gallons per day (mgd). [Water supply use will be updated in 2000]. The greatest concentration of population and industry is located north of the C & D canal. This portion of the State accounts for approximately 69% of the States total freshwater use for drinking of which one-third is from ground-water sources. All of the freshwater use for drinking in southern New Castle County, Kent, and Sussex counties is derived from ground water sources.

Water use in coastal Kent and Sussex counties tends to be transient rather than uniform. This is due to the large increase in summer population made up of vacationers and people with summer homes. Irrigation water needs during the growing season also contribute to this seasonal trend in the two southern counties. Consequently, demand on ground water as a source of freshwater is substantially increased during the summer when ground-water levels are already in decline due to evapotranspiration and reduced rainfall.

IV.1.5 Water Use in Delaware

The most recent data available for water use in Delaware is for the period 1990-1995 and is referenced in this discussion. The information for the 1996-2000 period will be available in 2000, not in time for this report. Table IV-1 is a summary of the water use estimate for 1995 for both surface and ground water and from both fresh and saline water bodies. Table IV-2 summarizes the changes in water use over the period 1990 to 1995. Table IV-3 summarizes the number of water well permits that were issued for calendar years 1998 and 1999. All data has been refined to the county level.

Difference in water use between New Castle County and the other two countries are marked with New Castle County highly dependent on surface water withdrawals although with very significant ground water withdrawals. Kent and Sussex counties are almost totally dependent upon ground water withdrawals with the only exception being industrial and thermoelectric surface water use in Sussex County and some surface water used for irrigation in Kent and Sussex counties. Of note is the general increase in ground water for fresh water needs.

The major thermoelectric water users draw water from the Delaware River in New Castle County and Indian River Bay and Nanticoke River in Sussex County; the two former being saline surface water uses and the latter a fresh water use. Consequently, these withdrawals are largely separated from the surface water and ground water systems within much of Delaware. If these water use volumes are not considered, overall water use is essentially fresh water from either streams or aquifers. The relative amount of surface and ground water use, by county is: New Castle 69% and 31%; Kent County, 15% and 85%, Sussex County 47% and 53%, respectively.

For drinking water, Kent and Sussex Counties rely 100% on ground water for public, domestic and commercial uses while in New Castle County public systems obtain 68% from surface water and 32%

from ground water. All private, domestic, and commercial supplies in all three counties are obtained from ground water sources.

Overall use continues to increase for freshwater as illustrated in Table IV-2. From 1990 to 1995 overall ground water use increased 23.96% statewide while overall surface water use decreased 31.65%. Overall water use continues to increase. Of note is that in New Castle County, ground water used increased by 14% while surface water decreased by 33.57%. Table IV-3 provides an indication of increased water use with the number of new water well permits issued increasing between 1996 and 1999 across all three counties except for some decrease in 1997. Domestic well permits statewide increased from 4,339 in 1997/98 to 4,656 in 1998/99. Similarly, public supply wells increased from 141 to 148 over the same periods. These figures discounting wells which replace failing wells, represent continued increase in population and total ground water use across the state. Sussex County experienced the greatest increases with 1150 domestic permits in 1997/98 compared to 1300 in 1998/99.

There is a tremendous amount of water stored as ground water in Delaware, and none of the aquifers has been developed to the point where average withdraws exceed average sustainable safe yield. However, safe limits have been reached in the Cockeysville aquifer in New Castle County, and in the Cheswold and Piney Point aquifers in the Dover area. Consequently, shortages during times of peak demand have been experienced or approached by some of the major ground water users. For example, the City of Dover has developed a new well field in the water table aquifer because allocation limits have been reached in the confined Cheswold and Piney Point aquifers. DNREC also continues to monitor the Potomac Aquifer in New Castle County and various coastal aquifer in Sussex County in order to determine whether salt water intrusion is occurring.

IV.2 Ground-Water Quality

Ground water in Delaware is vulnerable to activities that may contaminate it and render it undrinkable. Delaware’s soils are very permeable in many parts of the State and facilitate the movement of contaminants from the land surface into the water table. The existing or potential sources of ground-water contamination are listed in Table IV-4. The types of sources are basically unchanged since the previous report with the seven highest priority sources being animal feedlots (including poultry), federal/state superfund sites, fertilizer application, hazardous waste sites, salt water intrusion, septic systems, and underground storage tanks (primarily petroleum). Both non-regulatory and regulatory programs are addressing these and other sources.

Tables IV-5, IV-6, and IV-7 provide current information on potential point sources of ground water contamination for each of the three counties. Table IV-8 summarizes this information for the entire state. Programs are continuing to provide information on a watershed by watershed basis as illustrated in the ground water discussion in the Inland Bay/Atlantic Ocean Basin. Advances are underway in data management and geographic information system mapping which will continue to allow reporting in all of Delaware’s Basins. A detailed discussion of the Inland Bays watershed is included in the Inland Bays/Atlantic Ocean portion of the 2000 Delaware 305(b) Report. This presentation is similar to that provided in the 1998 305 (b) for the Chesapeake Basin, and for the Piedmont Basin in 1996. Similarly, the 2002 report will include a ground water quality section for the Delaware Bay Basin. Discussion of selected contaminant sources are listed below.

IV.2.1 Septic Systems

Septic systems are a cause of nitrate and bacteriological contamination. If a septic system is designed properly the soil medium will filter out pathogenic organisms from sewage effluent; however soil is not an effective agent in the removal of oxidizable nitrate compounds. Elevated nitrate concentrations have been found above EPA's maximum contaminant level in many areas of the State.

In areas of poor drainage and high seasonal water table septic system overflow or failure can lead to bacterial contamination of ground and surface waters. Pathogenic organisms may travel with overland water flow and contaminate improperly grouted shallow wells and/or surface water bodies. DNREC's 1985 on-site septic regulations are intended to limit nitrate loading rates in ground water and to eliminate the possibility of septic system failure. To further prevent the possibility of a septic system from contaminating a drinking water well a minimum isolation distance of 100 feet between septic systems and shallow wells has been adopted into the regulations. Domestic septic systems continue to be a common practice for domestic waste disposal, however, areas of the state, particularly in eastern Sussex County, have continued to expand central sewer facilities, thus eliminating existing septic systems in expanded service areas. 3,987 new domestic septic permits were issued during 1998-1999; Of these, 56% were for Sussex County, 26% for Kent County, and 18% for New Castle County. This compares well with the 4,656 domestic well permits issued over the same period with similar percentages in each county. Approximately 1523 domestic well permits were replacement wells, resulting in about 3,133 new domestic wells. The number of actual new septic systems is probably closer to the number of new domestic well permits. The Department estimates that there are approximately 78,600 septic systems statewide. This information is based on a project which counted the number of dwellings outside sewer districts from the 1997 area photo data. Of these, 20% are in New Castle County, 53% in Sussex County, and 27% in Kent County.

Septic systems that discharge in excess of 2500 gallons per day are permitted as large septic systems. These systems are operated by a licensed operator and may have monitoring wells on site to evaluate the septic systems effectiveness. Prior to installation of new large septic systems, an assessment of the impact of these systems on ground water and nearby potable wells is conducted to prevent contamination of wells or surface water bodies. There are approximately 72 large septic systems currently operating statewide. New systems and the discovery of old ones increased the total number from the previous reporting period. Of these, 51 are in Sussex County.

IV.2.2 Landfills

The types of landfills found in Delaware include sanitary, industrial, and dry-waste facilities. Other facilities involved in non-hazardous waste treatment or management include resource recovery facilities, transfer stations, infectious waste facilities, waste treatment facilities, and closed sites. There are 9 active landfill sites in Delaware and others that are closed and managed by other programs.

Sanitary Landfills - The material found in this type of landfill is composed of municipal garbage, commercial waste, some industrial waste, and relatively inert substances. Resulting contamination could be in the form of high dissolved solids, chemical and biochemical oxygen demand, and some volatile organic compounds. Currently, the Delaware Solid Waste Authority owns and operates the three active sanitary landfills in Delaware, one in each of the three counties. These facilities require extensive investigation prior to siting and require stringent source control and monitoring during operation. Impermeable liners are used to prevent leachate from reaching ground water and a ground-water monitoring well network is installed around the site to assess migration from the site.

Industrial Landfills - These types of landfills are site specific as to the nature of the material received. There are presently 4 (four) active industrial landfills in Delaware. They may contain various types of materials including plastics, metals, fly ash, sludges, coke, ore, waste pigment particles, low-level radioactive wastes, polypropylene, wood, brick, cellulose, ceramics, synthetics, and other similar substances. Contamination from these landfills may be in the form of heavy metals, high sulfates, and volatile organic compounds. These landfills are regulated and have liners except for those that existed before 1974. The pre-1974 landfills are being addressed by either the Federal Superfund program, State HSCA program, or the solid waste management program.

Dry Waste Landfills - These types of landfills contain materials such as plastics, rubber, lumber, trees, stumps, vegetation, and other materials that have a minimal potential for degrading the environment or producing leachate. However, some of these sites have caused air and water contamination. Consequently, these sites are regulated by the DNREC and require ground-water monitoring. Dry waste may only go to landfills with leachate collection systems per the Solid Waste regulations. There is one large dry waste landfill which is located in New Castle County.

Inactive Sussex County Landfills - There are six (6) closed landfills in Sussex County - Laurel, Omar, Bridgeville, Stockley, Angola, and Anderson's Crossroads. Of these, Laurel is managed as an NPL site and the other 5 as HSCA sites. All six (6) have established ground water management zones which limit water well installation in close proximity to these sites. These management approaches were done under an agreement between DNREC and Sussex County. Of these, public water supply systems have been established in the vicinity of the Angola, Laurel, and Bridgeville landfills.

IV.2.3 Underground Storage Tanks

Leaking underground storage tanks and pipelines are recognized as a widespread source of ground water contamination. Numerous domestic wells and several public supply wells have been replaced or taken out of service as a direct result of contaminant release from leaking underground storage tanks. Delaware promulgated regulations for underground storage tank installation and monitoring of storage tanks in July 1986 which were later amended in September of 1990. Heating oil tanks over 2,000 gallons are required to meet minimum installations standards, however smaller storage tanks such as domestic heating oil tanks are not proposed to be regulated.

DNREC's UST program administers the state UST regulations and regulates commercial, non-heating oil petroleum and hazardous substance UST's over 110 gallons as well as agricultural, residential, and heating oil UST's over 1,100 gallons, and all leaking UST's. There are approximately 11,365 regulated USTs at 3,462 facilities of which 2,663 tanks at 993 facilities are currently in use. 8,702 USTs have been removed from the ground or properly abandoned in place. Since leaking UST problems were recognized in the early 1980s approximately 2,821 releases have been confirmed. Of these, 2,260 have been closed. Over the period 1998-99, 489 sites had confirmed releases with 54 confirmed ground water releases. Of the confirmed ground water releases, 47% were in New Castle County, 24% in Kent County, and 31% in Sussex County.

The UST Branch has replaced the U.S. EPA's Revelation database with UST Access database. This new database is used to maintain an up-to-date file of facility names, owners, number of tanks, and status. Also, this new database will be more compatible with the Department's data integration efforts. The UST program has prepared maps of public drinking water supplies for New Castle, Kent, and Sussex Counties. The maps are entitled Tank Area Secondary Containment (TASC) maps and are used to determine if a new UST is close enough to a public water supply to warrant secondary containment. The location of leaking UST's and most UST's are mapped and have been included in DNREC's GIS.

IV.2.4 Abandoned Hazardous Waste Sites

There are currently 17 federal National Priority List (NPL) superfund sites in Delaware. 9 of these are in New Castle County, 6 in Kent County, and 2 in Sussex County. Of these, all but one have confirmed groundwater contamination. Cleanups have been completed in 9 of these sites. The state has established groundwater management zones around most of these sites to prevent the inadvertent placement of drinking water supply wells in areas of possible ground-water contamination.

There is one Department of Defense site, the Dover Air Force Base, located in Kent County. This facility contains a number of sites, most handled under the DOD's installation restoration program.

The State Hazardous Substance Control Act (HSCA) provides for the remediation of sites identified as requiring clean-up although not under federal CERCLA/SARA authorities. There are 246 such sites in Delaware with 47 having confirmed ground water contamination. 106 sites have been investigated and remedied. Of the 47 sites with confirmed ground water releases, 33 are in New Castle County, 10 in Kent County, and 11 in Sussex County.

IV.2.5 Hazardous Waste Land Disposal Units

In Delaware, there are 6 hazardous waste land disposal units that have impacted ground water. These units are regulated by the State's Hazardous Waste Program and require permits for operation as well as post closure. Currently only one unit, Motiva's hazardous waste landfill, which receives refinery wastewater treatment plant sludges, is considered an operating unit. The other 5 units have closed and either have a post-closure permit issued or will have one issued within a year. These six units and associated contaminants of concern are:

Facility	Unit	Contaminants of Concern	Permitting Status
Motiva	Land Treatment Unit	VOCs, SVOCs, Metals	Post Closure Permit issued
Motiva	CPI Surge Basin	VOCs, SVOCs, Metals	Post Closure Permit issued
Oxy Chem	Landfill	Mercury	Post Closure Permit Issued
Atlantic Coast Environmental	Waste Pile	Solvents	Post Closure Permit issued
Motiva	Landfill	VOC, Metals	Closure Pending
Dover Air Force Base	Surface Impoundment	Solvents	Post Closure Permit Issued

State of Delaware Hazardous Waste Regulations require the owner/operator of a hazardous waste land disposal unit to establish a ground water monitoring network surrounding the unit to determine if a release of hazardous waste has taken place. The level of monitoring and/or remediation required is determined on a unit by unit basis based on the type and concentration of contaminant and it's potential to do harm to human health and the environment.

IV.2.6 RCRA Corrective Action Sites

The RCRA Corrective Action Program is a state wide environmental investigation and clean-up program, similar to Superfund, designed to clean-up releases of hazardous waste at facilities required to obtain a RCRA permit for the on-site treatment, storage, and disposal of hazardous waste. The State has thirteen sites that are subject to RCRA Corrective Action authorities. EPA Region III maintains authority for this part of the RCRA program, however the State Hazardous Waste Program has built up significant program expertise by providing technical assistance and project oversight on RCRA Corrective Action work performed in Delaware. Of the thirteen sites subject to RCRA Corrective Action, nine sites have impacted ground water. All of these sites also contain hazardous waste land disposal units subject to RCRA permitting requirements.

IV.2.7 Injection Wells

Injection wells are used in the State to return the water used for "water to air heat pump systems" to the aquifer. Contamination from these wells is virtually non-existent. The DNREC is initiating efforts to identify other types of class V wells which may exist in the State in order to evaluate their impact on ground water. Injection of hazardous wastes and brine are specifically banned in Delaware due to the possibility of contaminating water supply aquifers.

The Underground Injection Control Program is continuing to evaluate other classes of injection wells including those used by body shops, service stations, etc. Remediation wells or drain fields (primarily for the corrective actions at petroleum contamination sites) have also been issued. These systems require proper ground water monitoring. The UIC program issued 15 permits during 1998-1999.

IV.2.8 Salt Water Intrusion

Salt water intrusion in Delaware has been a problem along the Atlantic Coast, Delaware Bay and Estuary, and the Inland Bays. Historically, public supply wells have been abandoned as a result of salt water intrusion and replacement wells installed farther inland to avoid the salt water intrusion. As population increases and water use increases, the possibility for salt water intrusion increases. This problem is one of the issues that has or is being addressed by the Governor's Task Force on the Inland Bays, the Delaware Geological Survey, the U.S. Geological Survey, and the States of Maryland and Delaware.

The DNREC manages two programs to monitor for salt water intrusion. The Delaware Geological Survey monitors a group of coastal wells screened in all of the major aquifers from Lewes to Fenwick Island along the Atlantic Coast and Inland Bays. [See Inland Bays/Atlantic Ocean Basin Section for additional information.] The DNREC also samples wells in coastal New Castle County in order to monitor salt water intrusion into the Potomac aquifer. The DNREC's Water Allocation Program monitors and regulates withdraws from coastal wells to reduce the possibility of coastal salt water intrusion. Yearly summaries of the Coastal Sussex network are prepared by the Delaware Geological Survey. DNREC has recently evaluated the Potomac Aquifer network and will recommend changes to the network.

Existing management strategies appear to be working with no major losses of public wells to saltwater during the reporting period. However, localized problems with salt water in a few shallow domestic wells persist primarily in the Inland Bays area and in some coastal communities along the Delaware Bay.

IV.2.9 Land Application and Treatment

Land application and treatment of wastes includes spray irrigation, sludge application, and percolation basins. Sources of these wastes include municipal waste water treatment plants, community wastewater treatment plants, animal wastes, food processing operations, and textile dyeing operations. The wastes generated by these activities can cause contamination by nitrates, brine, metals, and volatile organic compounds. However, land application of waste has been shown to be a viable and environmentally safe disposal method if properly managed.

There are currently 23 proposed or active wastewater spray irrigation sites in the State. The location of all of these facilities are being determined using GPS units and are being entered into the DNREC's GIS system. The DNREC requires ground water monitoring at each of these sites. Some of these sites are being included in ambient ground-water monitoring network in both southern New Castle County and in the Nanticoke Basin. Most wastewater spray sites are found in Sussex County with 18 sites.

There are also 16 active or approved sludge application sites governed by 9 permits in the State. Ground-water monitoring is not required at each site, however, it is encouraged and many of the sites do have ground-water monitoring. Of these, all are located in either Kent or Sussex County.

IV.2.10 Agricultural Activities

Agricultural activities that may contribute to ground-water contamination include fertilizer and pesticide application, animal feedlots, and manure storage and disposal. These activities contribute organically bound nitrogen which is readily converted to nitrate under the aerobic soil conditions that exist in a substantial portion of the State. The nitrate produced primarily effects the shallow unconfined aquifer and has been identified as the most common ground-water contaminant in the State. Best management practices (BMPs) have been developed to reduce and/or prevent pollution from fertilizer application and animal waste. Delaware enacted a nutrient management law during the reporting period. An evaluation of the effect of this law on ground water quality will be made in the 2000-2001 Watershed Assessment Report.

Pesticides in ground water have been detected in Delaware. Studies conducted by the U.S. Geological Survey's NAWQA program detected some pesticide residues at low levels in a few locations in the State. Also, some pesticides have been detected in a small number of public water supply wells. At the present time pesticides are not a significant threat to Delaware's ground-water resources, however, measures have been undertaken by the DNREC and the Delaware Department of Agriculture (DDA) to insure that pesticides do not compromise Delaware's ground-water quality in the future. The DDA has developed an ambient pesticide monitoring network but data is not yet available. Approximately 150 domestic or monitor wells are included this network. Almost all have been identified and sampled. A report is currently being prepared by the DDA and DGS.

The DDA has a training and certification program for pesticide applicators to insure that pesticides are used in an environmentally responsible manor. The DDA and the DNREC, with EPA guidance, have drafted a State Pesticide Management Plan. The emphasizes prevention and will allow the State to responsibly manage pesticides into the future.

IV.3 Drinking Water Quality

The following sections discuss the major contaminants found in Delaware's ground water supplies. Table IV-9 list the major types of contaminants and there relative priority in the State. The statewide summary of raw water for routine chemicals, trace metals, and bacteria is found in Table IV-10 and that for organic compounds in Table IV-11. These tables have been updated for this report and cover the 4 year period from 1996-1999 and are described later in this section. The table for "treated" water from public water supply systems has not been included in this report because of various data retrieval problems.

IV.3.1 Nitrates

Water from a number of public and private water supply wells has been determined to contain a nitrate-nitrogen concentration that nears or exceeds the EPA's drinking water standard of 10 mg/L. Some municipal wells have been removed from service because of a high nitrate concentration in the water. This problem generally occurs in the southern half of the State where the surficial (unconfined) aquifer is used as a water supply source for public and domestic supply wells. Sources of nitrate include agricultural activities (including both confined animal operations and crop fertilization practices), disposal of septic system effluent, and land disposal of residual and solid wastes. The highest concentration of nitrate in ground water occurs in Kent and Sussex counties where the soils are excessively well-drained, there is intensive agriculture and a large number of domestic septic systems, and the unconfined aquifer is used extensively as a source of water.

Studies by the DGS, University of Delaware, USGS, review of public water system data, and other sources have demonstrated that nitrate is the most common contaminant detected in the State's ground water. Programs within DNREC as well as other agencies are working toward reducing the sources that contribute nitrate contamination of ground water. Septic systems (both domestic and large) have been taken off-line in the West Rehoboth Beach area of Sussex County, the Town of Little Creek in Kent County, and the Middletown-Odessa-Townsends area of southern New Castle County, all due to the creation or expansion of central sewer facilities. Additional expansions are is expected.

IV.3.2 Iron

Dissolved iron is commonly found in ground water because of trace amounts of iron present in virtually all soils and sedimentary rocks. The secondary maximum contaminant level for iron in drinking water is 0.3 mg/L, although iron in ground water is rarely a health concern.

Almost all iron contamination in ground water in the State is naturally occurring. However, landfills and related solid waste facilities may cause locally elevated levels of iron in ground waters. A number of studies have demonstrated problems with iron often occur in confined portions of aquifers where anaerobic conditions exist.

IV.3.3 Corrosivity

Water in the Columbia (surficial) aquifer in the Coastal Plain is generally soft, has a low pH, and a high dissolved carbon dioxide concentration. The low pH causes the water to be corrosive. A common value for pH in the unconfined aquifer is about 5.8. Consequently, metals such as iron, lead, copper, calcium, and chromium may be corroded from pipes and solder resulting in fixture and laundry staining. If the corrosion is severe it may pose a health concern if the dissolved metals concentrations exceed their respective MCLs.

IV.4 Overall Ground Water Quality from Public Water Supply Wells – 1996-1999 Data

Tables IV-10 and IV-11 summarize data available from the Delaware Office of Drinking Water for 1996 to 1999 for raw water. Information on organics, (Table IV-11), routine chemical, trace metals, and bacteria (Table IV-10) from the 1996-1999 report are summarized. At present the Delaware Office of Drinking Water is continuing to place data from hard copy files into a large database. The DNREC Water Supply Section is providing well identification numbers to this database. This effort is ongoing as new wells come on-line and others are abandoned.

The above referenced tables provide percentages and numbers of detections for samples from systems relying on one or more wells. Accuracy below these estimates is difficult because samples are not always collected from individual wells. Further, sampling for organic compounds in raw water is only done where a detection has occurred within a distribution system. Consequently, the sampled population is biased and is, therefore, compared with the total number of public systems and wells found statewide. Routine analyses (nitrate, iron, chloride, fluoride and manganese) have a much larger number of samples and are, therefore, more representative.

IV.4.1 Routine Chemical Analyses

The raw water quality data provides an estimate of overall groundwater quality and will be discussed further. Nitrate and iron were the most common ground water quality problems with 4.9% and 44.1% of samples, respectively, exceeding the maximum contaminant level. 37.5% of the samples had nitrate concentrations above the detection level but less than the MCL. Thus nitrates remain a fairly wide spread problem but with a relatively smaller percentage of samples exceeding the MCL.

IV.4.2 Trace Metals Analyses

Very few samples exceeded the MCL for metals with the exception being for 4 samples exceeding the MCL for lead. Further assessment is necessary to ascertain this result as lead is generally not found in raw aquifer water. Barium was the most common metal found above the detection level but below the MCL in 39% of samples. Other metals detected at trace levels were arsenic, cadmium, chromium, lead, mercury, selenium, beryllium and nickel.

IV.4.3 Synthetic Organic Compounds

In developing a strategy for the control of organic chemical contaminants in drinking water, the U.S. EPA has subdivided synthetic chemicals in water into two groups. The first group, the trihalomethanes (THMs), consist of organic chemicals that may be present in water as the result of disinfection practices. The EPA indicated that their studies showed THM to constitute the largest portion of identifiable synthetic organic chemicals in drinking water. The EPA has established a limit of 100 mg/L as the total quantity of THM permissible in public water supplies. THM's are primarily associated with the chlorination of surface water supplies.

The second group of synthetic organic chemicals defined by EPA consist of compounds introduced into water as a result of pollution. Although the concentration of these compounds detected in Delaware's raw water are generally below EPA's prescribed limits there is always concern when these compounds are detected at all. Consequently, the DNREC and Division of Public Health will continue to monitor for and control the presence of synthetic organic compound in Delaware's drinking water. These are pesticide compounds and were found in 7 public water systems which have 38 wells. This represents 1.2% and 3.6% of total systems and wells, respectively. The number and percentage of wells is actually much smaller since any one public water system may have two or more individual wells.

IV.4.4 Volatile Organic Compounds

Due to their mobility in ground water and the relatively large number of potential sources, many more volatile organic compounds were detected. The most common were benzene, toluene, 1,2 –

Dichloropropane, trichlorethene, and tetrachloroethene (perchloroethylene) which accounted for over 70% of the organic compound detected. Volatile organic chemicals were detected in 19 public water supply systems with an estimated 100 individual wells. This represents 3.3% and 9.5% of the systems and wells, respectively. The number and percentages of wells is actually much smaller since any one public water system can have two or more individual wells.

The most common sources of these chemicals are petroleum and cleaning solvent storage facilities such as underground storage tanks.

IV.4.5 Radon

Studies in southern New Castle County have found radon in ground water in certain aquifers above the proposed MCL. See the 1996 Watershed Assessment Report for the Appoquinimink Watershed.

IV.4.6 Radium

Radium in ground water has been identified as a concern in the states of New Jersey and Maryland. The Department is planning to conduct sampling for radium in ground water in Delaware over the next reporting period.

IV.4.7 Ground Water Protection Programs

Delaware's ground water protection goal is to "ensure sufficient ground water quality for the protection of public health." The DNREC recognizes that protecting public water supplies is an integral part of Delaware's ground water protection goal. Priority is also given to public water supplies through the State's Office of Drinking Water. As an indication of the overall ground water quality of the State, the public water supply system data summaries have been prepared (Table IV -10 and IV-11), described previously. Since the majority of public water supplies derive their water from ground water, the Office of Drinking Water records provide a reasonable indication currently available on the overall quality of Delaware's ground water. Delaware has taken the initiative to minimize the occurrence of contaminants in its public water supplies. Some of the initiatives and programs are briefly discussed. Table IV-12 summarizes the status of regulatory and non-regulatory program with significant ground-water protection responsibilities. Detailed description of all significant ground water protection programs are found in the Delaware Comprehensive State Ground Water Protection Program (CSGWPP).

Delaware has a U.S. EPA-approved Wellhead Protection Program (WHPP). Delaware is attempting to implement its WHP Program through coordination and cooperation with local governments. Management of contamination sources in Wellhead Protection Areas will occur through zoning ordinances, site plan reviews, operating standards, sources prohibitions, public education, and/or ground water monitoring. Currently the City of Newark and the New Castle County are undertaking several of these activities as part of their Water Resources Protection Area Ordinances.

Delaware has developed its Source Water Assessment and Protection Program under funding from the SDWA Amendments of 1996. Delaware's SWAPP was approved by EPA on October 27, 1999. The major activities underway in the SWAPP included (1) delineating all source water areas i.e. wellhead areas for all public supply wells and the watersheds and critical areas upstream of all public drinking water supply intakes (This latter includes Brandywine Creek, Red Clay Creek, White Clay Creek, and Christina River); (2) identifying all potential point and non-point sources of contaminants. (This is being compiled in the DNREC "site index database" (See Table IV-13)); (3) conduct a susceptibility assessment of all public water supply systems; (4) develop a source water protection loan fund; and (5) provide for adequate public availability of all source water susceptibility assessments.

Site Type	Count
Animal Operations	1345
Combined Sewer Overflow	49
Dredge Spoil Disposal Areas	9
Hazardous Waste Generators	1178
Landfills & Dump	45
Large On-Site Septic	82
NPDES Outfalls	145
Pesticide Loading, Mixing & Storage	65
Salvage Yards	43
SIRB Sites	437
Sludge Application Sites	11
Spray Irrigation Sites	27
Tire Piles	36
TRI	77
Underground Storage Tanks	3076
Total	6625

Table IV-13 Summary of Potential Point Sources in Site Index Database

Many of the environmental control programs (e.g. Comprehensive Environmental Response Compensation and Liability Act (CERCLA), Delaware's Hazardous Substance Cleanup Act (HSCA), On-Site Wastewater, UST/Leaking Underground Storage Tanks (LUST)) provide additional protection and/or more priority cleanup requirements in the vicinity of both public and domestic water supplies (ground water and surface water derived) and within major recharge areas. As mapping efforts are completed for the entire State, these protection efforts will become increasingly comprehensive.

The Nonpoint Source Program also addresses sources of contamination in Wellhead Protection Areas and priority watersheds. These efforts include inventorying sources of potential and existing nonpoint sources of contamination, public outreach and education measures to prevent contamination, and by developing best management practices to protect ground and surface water. The Ground Water Protection and the NPS Program cooperate extensively on mitigating activities that affect ground water quality through the State's Comprehensive State Ground Water Protection Plan and Nonpoint Source Management Plan, for example. The Ground Water Protection Program has also assisted the Delaware Department of Agriculture with its Pesticide Management Plan.

IV.5 Aquifer Vulnerability Assessment

Delaware has continued progress in mapping ground water recharge-potential areas. This project is done quadrangle by quadrangle under various funding sources. Figure IV-5 summarizes the status of this project for areas that are completed, in-progress, or planned. Recharge protection areas are currently used by New Castle County in their ground water protection efforts. Mapping for all of New Castle County is complete and significant areas of Kent and Sussex Counties have also been completed. The last phase of mapping is expected to be completed in early 2001 for the entire state.

The recharge-potential maps assign relative ratings of excellent, good, fair or poor. The excellent areas are very sandy and would allow relatively rapid infiltration by water and, by extension, contaminants. The relative ranking is based upon the grain-size composition of the first 20 feet of soil materials. Andres (1991) describes the mapping methodology.

Ground Water Recharge Map

IV.5.1.1 Aquifer Mapping

The Delaware Geological Survey (DGS) has completed additional hydro geologic and geologic mapping in the Milford and Mispillion River quadrangles, both located in the Delaware drainage basin. Aquifer mapping is associated with the ongoing refinement of Delaware's geology and hydrology maps and is done by the DGS. The next area to be mapped is the Clayton-Smyrna area.

IV.5.1.2 Comprehensive Data Management System

Delaware has moved to improved both basic data management and geographic information system data across many programs, including ground-water protection programs. Efforts by DNREC, DDA, DHSS-ODW, DGS and other agencies have moved data systems to better integration and database systems that are related.

Programs with point sources are increasingly mapping sites with GPS technology. Other programs such as the drinking water program have begun to enter basic water quality data into a database assessable to agencies outside of that program. Considerable advancement has been demonstrated through the Whole Basin assessments as demonstrated by progress in completing the site index database for the entire state (See Table IV-12).

IV.5.1.3 Non-Point Source Management Program

Both the Delaware NPS Management Plan and NPS Assessment Report were revised during the reporting period. Both the surface water and ground water assessment approaches were revised and basins were prioritized using the new approaches. The ground water assessment was based on hydromorphic units and the relative use of ground water within basins. Priority basins were identified in each of the three counties.

IV.5.1.4 Pesticide Management Program

The Delaware DDA and DNREC completed the recently approved Delaware Pesticide Management Plan. This plan describes Delaware's approach to managing the use of pesticides which have a potential for contaminating ground water. Once regulations are promulgated by the U.S. EPA, Delaware is prepared to begin development of pesticide - specific management plans.

In addition to development of the PMP's, the Delaware DDA has begun development of an ambient network with approximately 150 domestic and monitoring wells which will be sampled for pesticides. This project is currently in progress.

IV.5.1.5 Whole Basin Management

DNREC has developed a schedule for Whole Basin Management for each of Delaware's four defined basins- Piedmont, Chesapeake, Inland Bays/Atlantic, and Delaware River. The initial step in the whole basin management approach is a preliminary assessment at all natural resources and problems, including surface water and ground water resources.

The Preliminary Assessment for the Piedmont Basin has been completed and the Chesapeake Basin and Inland Bay/Atlantic Ocean Basin assessment is very near completion. The information on ground water for these basin have been included in the respective basin assessments of the 1998 Delaware Watershed Assessment Report. The Inland Bays/Atlantic Ocean Basin preliminary assessment began in 1998 and the Delaware River Basin preliminary assessment will begin in 1999.

IV.5.1.6 Ground Water/Surface Water Interactions

The most pressing interactions between ground and surface waters in Delaware occur along all coastal areas, particularly in Sussex County. Salt water intrusion has occurred as a result of ground water withdrawal activities, both for public and other purposes. Both public and domestic drinking water wells have been affected. Monitoring networks are maintained in the Potomac aquifer in New Castle County, and along coastal the Sussex County. Additional monitoring points are being added along the western shore the Inland Bays in the Long Neck area.

Interactions from ground water to surface water also have been documented in Delaware. Andres (1992) demonstrated the potential loading of nitrate-nitrogen from ground water discharge into the Rehoboth and Indian River bays as a result of land-use practices over the past 30-40 years. Some sub-basins contribute almost 50% of the total nitrogen loading through direct ground-water discharge to the Indian River Bay basin. Nitrate-nitrogen loading from ground water from basins with poultry production is greater than from non-poultry farming basins.

Preliminary work in the Cockeysville Aquifer of northern New Castle County illustrates a strong likelihood for surface water interaction with ground water. For instance, Mill Creek which flows across the Hockessin Valley appears to loose water at certain times into the ground water aquifer due to numerous public water supply wells in the basin. In addition, temperature anomalies in ground water wells indicate rapid flow from surface water to ground water, likely due to fractures in the formation. Tables IV-1 through IV-12 follow.

Table IV-1 Water Use (Mgal/day)
1990

Water Source	Kent	New Castle	Sussex	Total
Public Supply (Total)				
GW	8.97	19.59	11.63	40.19
SW	0	49.26	0	49.26
Total	8.97	68.85	11.63	89.45
Commercial Supply				
GW	1.39	0.5	0.9	2.79
SW	0	0	0	0
Total	1.39	0.5	0.9	2.79
Domestic Supply				
GW	4.15	3	5.12	12.27
SW	0	0	0	0
Total	4.15	3	5.12	12.27
Industrial Supply				
GW (FW/Saline)	1.90/0.00	6.82/0.00	8.77/0.00	17.49/0.00
SW (FW/Saline)	0.00/0.00	8.95/3.20	34.19/.01	43.14/3.21
Total (FW/Saline)	1.90/0.00	15.77/3.20	42.96/0.01	60.63/3.21
Thermoelectric Supply				
GW	0.00/0.00	0.00/0.00	0.23/0.00	0.23/0.00
SW (FW/Saline)	0.00/0.00	539.21/452	0.00/288.19	534.21/740.19
Total	0.00/0.00	534.21/452	0.23/288.19	534.44/740.19
Livestock Supply				
GW	0.49	0.08	3.21	3.78
SW	0.16	0.04	0.15	0.35
Total	0.65	0.12	3.36	4.13
Irrigation Supply				
GW	11.8	1.37	20.47	33.64
SW	5.05	0.92	8.77	14.74
Total	16.85	2.29	29.24	48.38
Totals				
GW (FW/Saline)	28.70/0.00	31.36/0.00	50.33/0.00	110.39/0.00
SW (FW/Saline)	5.21/0.00	593.38/455.20	43.11/288.2	641.70/743.40
Total (FW/Saline)	33.91/0.00	624.74/455.2	93.44/288.2	752.09/743.40

GW - Ground Water Supply
SW - Surface Water Supply
FW - Freshwater

Source: USGS 1990 summary

Table IV-2 Water Use Changes (Mgal/day) 1990-1995

Water Type	Kent	New Castle	Sussex	Total
Ground Water (Fresh)				
1990	21.83	27.51	39.71	89.05
1995	28.7	31.36	50.33	110.39
Mgal/d change	6.87	3.85	10.62	21.34
% change	31.40%	14.00%	26.70%	23.96%
Ground Water (Saline)				
1990	0	0	0.01	0.01
1995	0	0	0	0
Mgal/d change	0	0	-0.01	-0.01
% change	0	0	n/a	n/a
Ground Water (Total)				
1990	21.83	27.51	39.72	89.06
1995	28.7	31.36	50.33	110.39
Mg/d change	6.87	3.856	10.62	21.34
% change	31.40%	14.00%	26.70%	23.96%
Surface Water (Fresh)				
1990	2.93	893.25	42.7	938.88
1995	5.21	593.38	43.11	641.7
Mgal/d change	2.28	-299.87	0.41	-297.11
% change	77.80%	-33.57%	0.96%	-32%
Surface Water (Saline)				
1990	0	6.02	333.11	339.73
1995	0	455.2	288.2	743.4
Mgal/d change	0	449.18	-44.91	404.27
% change	0	7461.00%	-13.48%	119.20%
Surface Water (Total)				
1990	2.93	899.27	375.81	1278.01
1995	5.21	1048.58	331.31	1385.1
Mgal/d change	2.28	149.31	-44.5	107.09
% change	77.81%	16.60%	-11.84%	8.38%

Source: USGS 1995 summary

Note: Changes may be due to both improvements in data gathering and actual water use changes.

Table IV-3. Well Permit Issuance
For 1998 and 1999

Well Type	1998				1999				All Years
	Kent	New Castle	Sussex	Total	Kent	New Castle	Sussex	Total	Total
Agricultural	61	15	170	246	91	22	273	386	632
Commercial	16	4	41	61	13	5	34	52	113
Domestic	714	223	1333	2271	789	208	1300	2385	4,656
Dewatering	9	10	30	49	6	7	37	50	99
Heat Pump Supply	3	3	9	15	3	1	7	11	26
Heat Pump Recharge	2	5	10	17	5	2	7	14	31
Industrial/Ind - MW	2	6	0	8	1	1	2	4	12
Irrigation	54	13	173	240	70	15	155	240	480
Monitor	167	288	151	606	203	345	165	713	1319
Observation	26	44	73	143	42	7	7	56	199
Public	20	16	32	68	19	11	50	80	148
Other**	39	46	26	114	48	86	66	197	311
Total	1113	673	2048	3835	1290	708	2193	4191	8026

Source: Delaware Water Use Data System

**Other includes the following classes: Unknown, Fire Protection, Geoprobe, Geothermal, Other, Engineer Test Boring

Table IV - 4. Major Sources of Ground Water Contamination

Contaminant Source	Ten Highest-Priority Sources (X)	Relative Priority	Factors Considered in Selecting a Contaminant Source (1)	Contaminants (2)
Agricultural Activities				
Agricultural chemical facilities		NA	NA	1,2,5
Animal feedlots (including poultry)	X	HIGH	A,C,D,F,G	5,8
Drainage wells		--	NOT ALLOWED IN STATE	--
Fertilizer applications	X	HIGH	C,D,F	5
Irrigation practices (return flow)		LOW	NO INFORMATION	--
Pesticide application		MEDIUM	G	1,2
Storage and Treatment Activities				
Land application		MEDIUM	D,H	9
Material stockpiles		LOW	D,H	9
Storage tanks (above ground)		LOW	G,H	4
Storage tanks (underground)	X	HIGH	A,B,C,D,F,H	4
Surface impoundments		LOW	C,D,H	5
Waste piles		LOW	A,D	9
Waste tailings		NA	NA	--
Disposal Activities				
Deep injection wells (heat pump)		LOW	A	9
Landfills		MEDIUM	D,G,H	3,7
Septic Systems	X	HIGH	A,B,C,D,F,H	5,8
Shallow injection wells		LOW	A	9
Other				
Hazardous waste generators	--	--	SEE HAZARDOUS WASTE SITES	--
Hazardous waste sites (RCRA)	X	HIGH	A,B,E,G,H	3,8
Industrial facilities	--	--	SEE HAZARDOUS WASTE SITES	--
Material transfer operations	--	--	SEE HAZARDOUS WASTE SITES	1,2,3,4,7
Mining and mine drainage		NA	NA	--
Pipelines and sewer lines		MEDIUM	G	5
Salt storage and road salting		LOW	A,B,D	6
Salt Water intrusion	X	HIGH	B,E,F,G	6
Spills		VARIABLE	G	9
Transportation of Materials	--	--	SEE HAZARDOUS WASTE SITES	--
Urban runoff		LOW	C,E	9
Federal or State Superfund	X	HIGH	F,G,H	3,4,7

(1) Factors used in selecting sources
- A - *Human health and/or environmental risk (toxicity)*
- B - *Size of the population at risk*
- C - *Location of the sources relative to drinking water sources*
- D - *Number and/or size of contaminant sources*
- E - *Hydrogeologic sensitivity*
- F - *State findings, other findings*
- G - *High priority in localized areas of the State*
- H - *Regulated activity*
- -- - *Data not available or not applicable*

(2) Contaminant Classes
- 1 - *Inorganic pesticides*
- 2 - *Organic pesticides*
- 3 - *Halogenated solvents*
- 4 - *Petroleum compounds*
- 5 - *Nitrate*
- 6 - *Salinity/brine*
- 7 - *Metals*
- 8 - *Bacteria*
- 9 - *Variable*

Table IV - 5. Ground Water Contamination Summary

County Kent

Source Type	Present in County	Total Number of Sites in County	Number of Sites that are Listed and/or have Confirmed Releases		Number with Confirmed Ground Water Contamination	Contaminants of Primary Concern	Number of Site Investigations (optional)	Number of Sites that have been Stabilized or have had the Source Removed (optional)	Number of Sites with Corrective Action Plans (optional)	Number of Sites with Active Remediation (optional)	Number of sites with cleanup completed (optional)
			Total	Total for 1998 and 1999							
NPL	Yes	6	6		6	TCE, PCE, Benzene	1	--	1	1	3
State Sites (non-NPL)	Yes	37	37	1	3	TCE, Metals	7	--	--	--	17
DOD/DOE	Yes	[N1]		--	--	--	--	--	--	--	--
LUST	Yes	512	512	98 [L1]	13 [L1]	Benzene, Petroleum,MTTBE	115 [L1]	98 [L2]	99 [L3]	99 [L3]	382 [L2]
RCRA[R3]	Yes	2	2	0	2	Solvents	2	1	2	1	1
Solid Waste	Yes	1	1	0	0	Landfill Leachate	--	--	--	--	--
Underground Injection	Yes	[D1]		2 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Large Septic System	Yes	[D1]	17	1 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Domestic Septic	Yes	21,081 [D1]	21,081	1,052 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Spray Irrigation	Yes	2 [D1]	2	1 [D2]	[D3]	Nitrates, Coliform, Chloride, Sodium	--	--	--	--	--
Sludge Application Permits[S1]	Yes	2		2 [S1]	[D3]	Nitrates	--	6 --	--	--	--

NPL - National Priority List
DOE - Department of Energy
DOD - Department of Defense
LUST - Leaking Underground Storage Tanks
RCRA - Resources Conservation and Recovery Act
-- - Data not available or not applicable

D1 - Not Broken-down by County -- See State Summary Sheet
D2 - Reported as new permit issuances
D3 - Permitted ground-water discharges
L1 - Number of sites identified in 1998 and 1999 (subset of total)
L2 - Reported as total number of sites that are closed
L3 - Reported as total corrective action plans approved in 1998/99
L4 - Total # LUST sites through 1999

N1 - One DOD site (Dover AFB) reported as NPL site
R1 - Facilities undergoing corrective action
R2 - Sites in facility investigation stage or earlier
R3 - post closure permit
R4 - See county sheets for specific qualifiers
S1 - Reported as active sludge generator permits

Table IV - 6. Ground Water Contamination Summary

County New Castle

Source Type	Present in County	Total Number of Sites in County	Number of Sites that are Listed and/or have Confirmed Releases		Number with Confirmed Ground Water Contamination	Contaminants of Primary Concern	Number of Site Investigations (optional)	Number of Sites that have been Stabilized or have had the Source Removed (optional)	Number of Sites with Corrective Action Plans (optional)	Number of Sites with Active Remediation (optional)	Number of sites with cleanup completed (optional)
			Total	Total for 1998 and 1999							
NPL	Yes	9	9		9	Solvents, (TCE, PCE Vinyl Chloride)	1	1	1	4	4
State Sites (non-NPL)	Yes	156	156	50	33	TCE, PCE, Metals	75	--	--	- --	73
DOD/DOE	Yes	1	1		1	TCE	1	--	--	--	--
LUST	Yes	1696	1696	294 [L1]	25 [L1]	Benzene, Petroleum	294 [L1]	281 [L2]	274 [L3]	274 [L3]	1434 [L2]
RCRA[R1]	Yes	8	8		8	LNAPLs, Metals, Inorganic Solvents	8	2	8 [R2]	2	2 Partial
Solid Waste	Yes	8	8		7	Landfill Leachate, Coal Ash	--	--	--	--	--
Underground Injection	Yes	[D1]		5 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Large Septic System	Yes	4 [D1]	4	2 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Domestic Septic	Yes	15,454 [D1]	15,454	696 [D4]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Spray Irrigation	Yes	3	3	2 [D2]	[D3]	Nitrates, Coliform, Chloride, Sodium	--	--	--	--	--
Sludge Application Permits[S1]	No	0		0 [S1]	0 [D3]	Nitrates	--	--	--	--	--

NPL - National Priority List
DOE - Department of Energy
DOD - Department of Defense
LUST - Leaking Underground Storage Tanks
RCRA - Resources Conservation and Recovery Act
-- - Data not available or not applicable

D1 - Not Broken-down by County -- See State Summary Sheet
D2 - Reported as new permit issuances
D3 - Permitted ground-water discharges
L1 - Number of sites identified in 1998 and 1999 (subset of total)
L2 - Reported as total number of sites that are closed 1998-99
L3 - Reported as total corrective action plans approved 1998-99
L4 - Total # LUST sites closed, through 1999

N1 - One DOD site (Dover AFB) reported as NPL site
R1 - Facilities undergoing corrective action
R2 - Sites in facility investigation stage or earlier
R3 - post closure permit
R4 - See county sheets for specific qualifiers
S1 - Reported as active sludge generator permits

Table IV - 7. Ground Water Contamination Summary

County Sussex

Source Type	Present in County	Total Number of Sites in County	Number of Sites that are Listed and/or have Confirmed Releases		Number with Confirmed Ground Water Contamination	Contaminants of Primary Concern	Number of Site Investigations (optional)	Number of Sites that have been Stabilized or have had the Source Removed (optional)	Number of Sites with Corrective Action Plans (optional)	Number of Sites with Active Remediation (optional)	Number of sites with cleanup completed (optional)
			Total	Total for 1998 and 1999							
NPL	Yes	2	2		2	TCE, PCE	--	--	--	1	1
State Sites (non-NPL) W1	Yes	53	53	6	11	PAHs, TCE	15	--	--	--	16
DOD/DOE	No	0	0		0	--	--	--	--	--	--
LUST	Yes	611		611 [L1]	17 [L1]	Benzene, Petroleum, MTTBE	85 [L1]	69 [L2]	62 [L3]	62 [L3]	447 [L2]
RCRA[R1]	Yes	1	1		1	Metals	1	--	1 [R2]	--	--
Solid Waste	Yes	3	3		2	Landfill Leachate				--	--
Underground Injection	Yes	[D1]		8 [D2]	[D3]	Oils, TPH, BTEX, Grease, Antifreeze	--	--	--	--	--
Large Septic System	Yes	51	51	14 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Domestic Septic	Yes	41,549	41,549	2,239 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Spray Irrigation	Yes	18	18	4 [D2]	[D3]	Nitrates, Coliform, Chloride, Sodium	--	--	--	--	--
Sludge Application Permits[S1]	Yes	14	14	14 [S1]	[D3]	Nitrates	--	--	--	--	--

NPL - National Priority List
DOE - Department of Energy
DOD - Department of Defense
LUST - Leaking Underground Storage Tanks
RCRA - Resources Conservation and Recovery Act
GMZ - Ground-Water Management Zone
-- - Data not available or not applicable

D1 - Not Broken-down by County -- See State Summary Sheet
D2 - Reported as new permit issuances
D3 - Permitted ground-water discharges
L1 - Number of sites identified in 1998 and 1999 (subset of total)
L2 - Reported as total number of sites that are closed 1998-1999
L3 - Reported as total corrective action plans approved 1998-1999
L4 - Total #LUST sites through 1999

N1 - One DOD site (Dover AFB) reported as NPL site
R1 - Facilities undergoing corrective action
R2 - Sites in facility investigation stage or earlier
R3 - post closure permit
R4 - See county sheets for specific qualifiers
S1 - Reported as active sludge generator permits
W1 - Includes 5 Sussex county landfills with GMZs

Table IV - 8. Ground Water Contamination Summary

State Summary

Source Type	Present in State	Total Number of Sites in State	Number of Sites that are Listed and/or have Confirmed Releases		Number with Confirmed Ground Water Contamination	Contaminants of Primary Concern	Number of Site Investigations (optional)	Number of Sites that have been Stabilized or have had the Source Removed (optional)	Number of Sites with Corrective Action Plans (optional)	Number of Sites with Active Remediation (optional)	Number of sites with cleanup completed (optional)
			Total	Total for 1998 and 1999							
NPL	Yes	17	17		17	TCE, PCE, Benzene Vinyl Chloride	2	1	2	6	8
State Sites (non-NPL) W1	Yes	246	246	57	47	TCE, PCE, PAHs, Metals	99	0	0	0	106
DOD/DOE	Yes	1 N1	1		1	TCE	1	0	0	0	0
LUST	Yes	2821		2821 L1	489 L1	Benzene, Petroleum	494 L1	248 L2	434 L3	434 L3	2260 L2
RCRA R4	Yes	11	11		11	Metals, LNAPLs, Solvents	11	3	11	3	3
Solid Waste	Yes	12	12		9	Landfill Leachate	0	0	0	--	--
Underground Injection	Yes	22		15 D2	D3	Nitrates, Coliform, Chloride	--	--	--	--	--
Large Septic System	Yes	106	72	11 D2	D3	Nitrates, Coliform, Chloride	--	--	--	--	--
Domestic Septic	Yes	78,083	78,083	3987 D2	D3	Nitrates, Coliform, Chloride	--	--	--	--	--
Spray Irrigation	Yes	23	23	7 D2	D3	Nitrates, Coliform, Chloride, Sodium	--	--	--	--	--
Sludge Application Permits S1	Yes	16	16	0 S1	D3	Nitrates	--	--	--	--	--

NPL - National Priority List
DOE - Department of Energy
DOD - Department of Defense
LUST - Leaking Underground Storage Tanks
RCRA - Resources Conservation and Recovery Act
GMZ - Ground-Water Management Zone
-- - Data not available or not applicable

D1 - Reported as new permit issuances (permitted ground-water discharge)
D2 - Reported as new permit issuances
D3 - Permitted ground-water discharges
L1 - Number of sites identified in 1998 and 1999 (subset of total)
L2 - Reported as total number of sites that are closed 1998-1999
L3 - Reported as total corrective action plans approved 1998-1999

N1 - One DOD site (Dover AFB) reported as NPL site
R1 - Facilities undergoing corrective action
R2 - Sites in facility investigation stage or earlier
R4 - See county sheets for specific qualifiers
S1 - Reported as active sludge generator permits
W1 - Includes 5 Sussex county landfills with GMZs

Table IV-9. Ground Water Contaminants

Contaminant Category	Check	Relative Priority	Factors[a]
Organic Contaminants			
Pesticides		MEDIUM	1, 2, 5, 4, 7
Other agricultural chemicals		LOW	4
Petroleum compounds (primarily BTEX)	X	HIGH	1, 2, 4,
Other Organic Chemicals:			
Volatile	X	HIGH	1,2,4
Semi-volatile		MEDIUM	4,5
Miscellaneous		--	No Information
Microbial Contaminants			
Bacteria	X	HIGH	1,2,3,4
Protozoa		--	No Information
Viruses		--	No Information
Inorganic Contaminants			
Pesticides		LOW	
Other agricultural chemicals		LOW	
Nitrates	X	HIGH	1,2,3,7
Fluorides		NA	
Brine/Salinity	X	HIGH	3,5,6,7
Metals		MEDIUM	5
Arsenic		LOW	1
Naturally-occurring Iron		MEDIUM	1,4
Radionuclides		NA	

[a] Factors for Establishing Relative Priority
1 - number of sources
2 - location of sources relative to drinking water
3 - size of population at risk
4 - risk posed to human health and environment from released substances
5 - high priority in localized areas of the State
6 - hydrgeologic sensitivity
7 - report findings
8 - regulated activity

Table IV - 10. Ground-Water Monitoring Data

Raw Water Quality Data from Public Water Supply Wells

Statewide Summary
Data Reporting Period 1996-1999

Parameter Groups	Total No. of PWS Systems Used in the Assessment [S1]	Estimated No. of Wells Used in the Assessment [W1]	Total No. of Samples Used in the Assessment [S2]	No detection (ND) of parameters above MDL	% of Total Samples	Greater than ND and Less Than or Equal to the MCL	% of Total Samples	Parameters are detected at concentrations exceeding MCLs	% of Total Samples
ROUTINE CHEMICAL ANALYSES [M1]									
NO_3	226	503	549	316	57.6	122[N1] 84[N2]	37.5	27	4.9
Fe	221	493	490	126	25.7	148	30.2	216	44.1
Cl	232	522	465	104	22.4	359	77.2	2	0.4
F	232	522	406	322	79.3	84	20.7	0	0.0
TRACE METALS ANALYSES									
As	45	155	100	98	98.0	2	2.0	0	0.0
Ba	45	155	100	61	61.0	39	39.0	0	0.0
Cd	46	159	101	97	96.0	4	4.0	0	0.0
Cr	45	155	100	96	96.0	4	4.0	0	0.0
Pb	47	158	105	90	85.7	11	10.5	4	3.8
Hg	45	155	100	98	98.0	2	2.0	0	0.0
Se	45	155	100	97	97.0	3	3.0	0	0.0
Be	45	155	100	90	90.0	10	10.0	0	0.0
Ni	45	155	99	90	90.9	9	9.1	0	0.0
Sb	45	155	100	100	100.0	0	0.0	0	0.0
BACTERIA ANALYSES				ABSENT		PRESENT		PRESENT WITH E. COLI	
Bacteria	251	524	1110	943	84.9	165	14.9	2	0.2

M1 = Secondary MCLs were used for Fe, Cl, and F
N1 = Samples with NO_3 greater than ND and less than or equal to 5 mg/L
N2 = Samples with NO_3 greater than 5 mg/L and less than or equal to 10 mg/L
S1 = Reported as systems without null or zero results
S2 = Reported as total individual sample ID numbers (Particular wells could be, and were, sampled more than once)
W1 = Reported as all non-repeating sampling locations per system

Table IV - 11. Ground-Water Monitoring Data

Raw Water Organics Data from Public Water Supply Wells

Statewide Summary
Data Reporting Period 1996-1999

Parameter	Total No. of PWS Systems Used in the Assessment S1	Estimated No. of Wells Used in the Assessment W1	Total No. of Samples Used in the Assessment S2	Total No. of Detections Used in the Assessment S3	No detection (ND) of parameters above MDL W2	> ND and < or = to the MCL	Detections at concentrations exceeding MCLs
VOC Group	**19**	**100**	**48**	**85**	**N/A**	**68**	**17**
Benzene	N/A	N/A	N/A	9	N/A	9	0
Monochlorobenzene	N/A	N/A	N/A	2	N/A	2	0
cis-1,2-Dichloroethene	N/A	N/A	N/A	5	N/A	5	0
Carbon Tetrachloride	N/A	N/A	N/A	1	N/A	0	1
1,2-Dichloroethane	N/A	N/A	N/A	4	N/A	4	0
Dichloromethane	N/A	N/A	N/A	2	N/A	2	0
1,2-Dichloropropane	N/A	N/A	N/A	15	N/A	6	9
Ethylbenzne	N/A	N/A	N/A	3	N/A	3	0
Ortho-Dichlorobenzene	N/A	N/A	N/A	1	N/A	1	0
Tetrachloroethene	N/A	N/A	N/A	16	N/A	14	2
1,1,1-Trichloroethane	N/A	N/A	N/A	2	N/A	2	0
Trichloroethene	N/A	N/A	N/A	10	N/A	6	4
Trans-1,2-Dichloroethene	N/A	N/A	N/A	1	N/A	1	0
1,1,2-Trichloroethane	N/A	N/A	N/A	1	N/A	1	0
Toluene	N/A	N/A	N/A	11	N/A	11	0
Total Xylene	N/A	N/A	N/A	1	N/A	1	0
Vinyl Chloride	N/A	N/A	N/A	1	N/A	0	1
SOC Group	**7**	**38**	**13**	**16**	**NA**	**12**	**4**
2,4-D	N/A	N/A	N/A	2	N/A	2	0
Alachlor	N/A	N/A	N/A	3	N/A	3	0
Dalapon	N/A	N/A	N/A	1	N/A	1	0
Heptachlor	N/A	N/A	N/A	1	N/A	0	1
Heptachlor Epoxide	N/A	N/A	N/A	2	N/A	1	1
Lindane	N/A	N/A	N/A	1	N/A	0	1
Methoxychlor	N/A	N/A	N/A	1	N/A	1	0
PCB's	N/A	N/A	N/A	4	N/A	3	1
Picloram	N/A	N/A	N/A	1	N/A	1	0

S1 = Reported as systems without null or zero results
S2 = Reported as total individual sample ID numbers (Particular wells could be, and were, sampled more than once)
S3 = This number may be higher than total number of samples because one sample may be tested for a number of analytes.
W1 = Reported as the total sum of all wells found in the total systems
W2 = Not Applicable because only systems with known VOC/SOC detections in treated water were included in assessment

Table IV - 12. Summary of State Ground Water Protection Programs

Programs or Activities	Check (X)	Implementation Status	Responsible State Agency
Active SARA Title III Program	X	FE	DNREC-DAWM
Ambient ground water monitoring system	X	CE	DGS, DNREC-WSS, DDA
Aquifer vulnerability assessment	X	CE	DNREC-WSS, DGS
Aquifer mapping	X	FE/CE	DGS
Aquifer characterization	X	CE	DNREC-WSS,DGS
Comprehensive data management system	X	UD	DNREC-WSS, DGS
EPA-endorsed Core Comprehensive State Ground Water Protection Program (CSGWPP)	X	UD	DNREC-WSS
Ground water discharge permits			
Ground water Best Management Practices	X		DNREC-WSS
Ground water legislation			
Ground water classification			
Ground water quality standards			
Interagency coordination for ground water protection initiatives	X	UD/CE	DNREC-WSS
Nonpoint source controls	X	CE	DNREC-NPS
Pesticide State Management Plan	X	UD	DDA
Pollution Prevention Program	X	CE	DNREC
Resource Conservation and Recovery Act (RCRA) Primacy	X	FE	DNREC-RCRA
State Superfund	X	FE	DNREC-HSCA
State RCRA Program incorporating more stringent requirements than RCRA primacy	X	FE	DNREC-RCRA
State septic system regulations	X	FE/UR	DNREC-UIC
Underground storage tank installation requirements	X	FE	DNREC-UST
Underground Storage Tank Remediation Fund	X	FE	DNREC-UST
Underground Storage Tank Permit Program	X	FE	DNREC-UST
Underground Injection Control Program	X	FE	DNREC-UIC
Vulnerability assessment for drinking water/wellhead protection	X	UD	DHSS-ODW/DNREC-WSS
Well abandonment regulations	X	FE/UR	DNREC-WSS
Wellhead Protection Program (EPA-approved)	X	UD	DNREC-WSS
Well installation regulations	X	FE/UR	DNREC-WSS
Federal CERCLA*	X	FE	DNREC-CERCLA
Solid Waste Management *	X	FE	DNREC-SWMA
Water Allocation*	X	FE/CE	DNREC-WSS
Emergency response*	X	FE	DNREC-ER

DNREC - *Department Natural Resources and Environmental Control*
DHSS - *Department of Health and Social Services*
DAWM - *Division of Air & Waste Management*
HSCA - *State Hazardous Substance Program*
SWMA - *Solid Waste Management Authority*
DDA - *Delaware Department of Agriculture*
UST - *Underground Storage Tank Program*
ER - *Emergency Response Program*

DGS - *Delaware Geological Survey*
NPS - *Non-Point Source Program*
ODW - *Office of Drinking Water*
CERCLA - *Superfund Program*
WSS - *Water Supply Section*
RCRA - *RCRA Program*
* - *Denotes fields added as "other"*

CE - *Continuing Effort*
FE - *Fully Established*
UD - *Under Development*
UR - *Under Review*

IV.6 Ground-Water Assessment for the Inland Bays

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Aquifer Data provided by Keith Robertson and Blair Venables
Inland Bays Assessment Team

*Note – A larger scale of all maps referenced in this section can be found in the Inland Bays Assessment Report, which will be in printing before September of 2000.

The Inland Bays/Atlantic Ocean Basin lies entirely within the Atlantic Coastal Plain Physiographic Province which consists of a series of southeast-thickening, unconsolidated sediments of Cretaceous through Tertiary age (i.e. older than 135 million years old) deposited atop the Paleozoic and Precambrian (i.e. older that 225 million years old) crystalline rocks of the Appalachian Piedmont. These sedimentary deposits are as much as 8,000 feet thick beneath Fenwick Island in southeastern most Delaware (Cushing and others, 1973). The configuration of the crystalline rock surface beneath these sedimentary deposits is poorly known due to their depth. For more information on the geology of Inland Bays basin, refer to the Geology subsection of the Inland Bays Assessment (work in progress).

Perhaps the most defining characteristic of the Inland Bays/Atlantic Ocean Basin is that it abuts the Atlantic Ocean and contains the entirety of Delaware's oceanic, and most of its estuarine, shoreline. Topographically, the basin is relatively flat. The land surface rises from sea level in the east to an average elevation of about 25-30 feet in the west.

Many of the above sedimentary deposits are water-bearing (aquifers) and theoretically usable for water production. However, extreme depths to some of this strata put practical limitations to the utility of these aquifers. In addition, some of the older (i.e. deeper) aquifers contain salt water in the near shore and inland areas of the basin. As noted above, in the Inland Bays/Atlantic Ocean Basin, the Calvert and Choptank Fms. lie too deep and are often too salty to be of any practical use for drinking water supplies. Thus the St. Marys Fm. represents the base of the freshwater aquifer system in the Basin, which consists of the Manokin, Pocomoke, Ocean City and Columbia Aquifers.

The following sections describe the distribution, aquifer characteristics and both ground water availability and quality of these four aquifer systems within the Inland Bays/Atlantic Ocean Basin. As an overall statement, ground-water quality can vary greatly between the aforementioned aquifers and in the Basin in general, but is well-suited for most purposes. It should be noted that in comparison to the information available for the surficial Columbia Aquifer, detailed information in the literature is sparse for some of the confined and semi-confined aquifers. Interconnection of some of these units further complicate assessments of individual aquifer quality.

IV.6.1 Columbia

The Columbia Aquifer is present at the surface throughout the Inland Bays/Atlantic Ocean Basin except where it may be eroded along the shorelines of present drainages. It ranges up to 120 feet thick west of Millsboro. Nearly all fresh-water use in coastal Sussex County is obtained from ground-water withdrawal from the shallow, water-table Columbia Aquifer.

Recharge occurs predominantly in the form of percolation of both precipitation and surface water from ephemeral (i.e. "losing") streams through the overlying Omar Fm, and localized fluvial sediments (see Recharge Mapping map). Generally, ground-water conditions from the Columbia Aquifer can be described as softer, more acidic, and lower in total dissolved solids ("TDS") and alkalinity when compared to those from confined aquifers due to sediment composition, particularly lower mollusk shell content ($CaCo_3$), and low pH of precipitation (Andres, 1991; USGS, 1989; Woodruff, 1970).

IV.6.1.1 Dissolved Metals

Iron and manganese content in Columbia ground water have been historically high, and in some areas may be a problem. Recorded dissolved iron concentrations in 131 wells in coastal Sussex County range from 3 mg/L up to 80,000 mg/L, with a mean of 1,654 mg/L in a study by Andres (1991). Other authors similarly note elevated iron up to 130,000 mg/L (Hodges, 1984) and 28,000 to 123,000 mg/L (Woodruff, 1970). In a 1989 USGS study of more than 500 wells in the Delmarva Peninsula indicated that at least half of the wells in the unconfined aquifer exceeded the Secondary Maximum Contaminant Level (SMCL) for dissolved iron of 300 mg/L, and manganese (SMCL of 50 mg/L). Denver (1989) attributed the elevated iron in eastern and southern Sussex County ground water to the poorly drained soils and large amounts of organic matter, which result in highly reduced ground-water conditions.

IV.6.1.2 Nitrates

Another characteristic of shallow Columbia ground water, noted in a number of studies (Miller, 1972; Andres, 1991; USGS, 1989) is the presence of elevated nitrate, the most common contaminant in ground water in the Inland Bays/Atlantic Ocean Basin. Andres identified nitrate levels ranging from <0.5 mg/L up to 34 mg/L, with a mean of 6.33 mg/L. Nearly 23 percent of wells sampled in this study exceeded the MCL of 10 mg/L. The highest nitrate concentrations were observed in areas along Rt. 26 East of Dagsboro, and along Rt. 5, west of the Rt. 24 intersection. Nitrate concentrations were observed to generally decrease with depth. Work by the USGS (1989) concurred with the DGS findings. Data from nearly 4,300 wells throughout the Delmarva Peninsula indicated that over 18 percent exceeded the EPA MCL. Unlike problems associated with the high dissolved metals (e.g. iron and manganese) in the unconfined aquifer, which are principally aesthetic in nature, elevated nitrates in the principal water supply for Sussex County are human health concerns, as high nitrate levels (45 mg/L) have been linked to methemoglobinemia in humans (Miller, 1972).

IV.6.1.3 Salinity

In contrast to some of the deeper confined aquifers, much of the Columbia Aquifer, as well as areas of the subcropping Pocomoke, are protected to some extent from high salinity due to salt-water intrusion by an adequate head of fresh water. This may not be the case in areas immediately adjacent the Atlantic Ocean or the Inland Bays water bodies where excessive ground-water withdrawal and/or inundation during coastal storms result in infiltration of seawater into the unconfined aquifer. Sundstrom, et. Al. (1975) found this to be a concern in areas where elevation of the water table was five feet or less above sea level (e.g. along the barrier island beaches of Rehoboth south of Fenwick Island). In general, however, salinity tends to increase with depth, and highly saline waters are a common problem in the deeper, confined aquifers (Groot, 1983; USGS, 1989; Sundstrom et. Al., 1975).

IV.6.1.4 Pocomoke

The Pocomoke Aquifer is generally limited to the area south of Millsboro and Indian River Bay and west of Little Assawoman Bay. In most of eastern Sussex County, the Pocomoke Aquifer is unconfined, and subcrops immediately beneath the Columbia. It is thus, for all practical purposes, considered part of the water-table aquifer. The top of the aquifer ranges in elevation from 35 below sea level east of Millsboro to 110 feet below sea level northwest of Selbyville. Lithologically, the Pocomoke is very similar to the Columbia, although perhaps with a larger and more diverse suite of clay materials, scattered lignite and glauconite, and an increase in shell material (Andres, 1986; Andres, 1991; Sundstrom and Pickett, 1969). While as a general rule water from the deeper, confined and semi-confined aquifers can be characterized as harder and less acidic, with increased TDS, bicarbonate and alkalinity, in much of the study area it is difficult to identify possible water quality differences between the Pocomoke and the Columbia Aquifers given the degree of interconnection between the two strata. Thus, much of the available water-quality data for the unconfined aquifer does not specify “Columbia” or “Pocomoke” as the source. Hodges (1984), however, attempted to differentiate to some extent between the two water-bearing strata based upon well depths and lithology. Ground water analytical results from the Pocomoke for dissolved metals, nitrates, chlorides, etc. were well within the aforementioned ranges for the Columbia. Based upon this limited data set, water from the aquifers can not be distinguished geochemically, although slightly higher hardness and bicarbonate levels were noted in some Pocomoke wells.

Similar to the Pocomoke, but perhaps more so, the Ocean City Aquifer represents not a laterally-contiguous sand body but rather a series of overlapping sand lenses. Unlike the Pocomoke, it is generally discontinuous in all but the most southeastern corner of Delaware. The Ocean City Aquifer emerges as a major source of ground water further to the south near Ocean City, MD. Northeast of a line from Gumboro to Lewes, the confining bed separating the two strata is missing and the Ocean City sands cannot be distinguished from the overlying Pocomoke)Andres, 1986; Hodges, 1984; USGS, 1989). As such, aquifer-specific water quality information is often difficult to discern. Included in Hodges' 1984 hydrologic study of the region are two identified Ocean City wells in the Fenwick Island area. Chemical constituents in these two wells were indistinguishable from those screened in the Pocomoke with the exception of the lack of nitrates in the Ocean City ground water. No other aquifer-specific information was readily available.

IV.6.2 Manokin

The Manokin Aquifer is a gray, silt, medium-to-course-grained sand that frequently contains small gravel (Sundstrom & Pickett, 1969), with some lignite and peat. Along the northern edge of the Inland Bays/Atlantic Ocean Basin area it has been partly eroded and subcrops south of Georgetown and midway between Georgetown and Lewes, where it is difficult to distinguish from the overlying Plio-Pleistocene deposits. This confined aquifer is the deepest of the fresh water aquifer system in the Basin (Talley and Andres, 1987), and is laterally-continuous throughout the basin. It represents a significant source of water for coastal Delaware. The Manokin occurs at a depth of approximately 170' BSL and varies between 50' and 120' thick, with thickness increasing in the down dip direction (Andes, 1986). The Manokin is rated good to excellent in water-bearing characteristics.

Lithogy of the Manokin is relatively complex, consisting of quartzose sands with abundant molluscan shell material, locally lignitic (Andres et. al., 1990; Andres, 1986; Hodges, 1984). The geochemistry of Manokin ground water is reflective of this mineralogy. The most significant characteristics noted by Hodges (1984) were a notable lack of either nitrates of manganese in comparison to the shallow aquifers, and increases in total dissolved solids (TDS) and hardness/alkalinity. Others (USGS, 1989; Woodruff, 1970; and Sundstrom et. al., 1975) also identified higher pH, chloride, sulfate and sodium content in Manokin ground water vs. that from the shallower, unconfined aquifers. A cautionary note is relayed by Hodges (1984) in reporting that highly saline water has caused the abandonment of several wells in the Long Neck area, with increasing chloride over time in the Bethany Beach, Delaware and Ocean City, Maryland supply wells.

IV.6.3 Recharge

The map entitled "Inland Bays/ Atlantic Ocean Basin Recharge Mapping" distinguishes areas according to their potential to accept and transmit water. Fair to good recharge areas dominate the northern half to northern 2/3rds of this map and fall within the Well Drained Upland Region. A fair to good recharge ratings would be expected for the sediment types comprising the USGS Well Drained Upland Region.

The Surficial Confined Region occurs in the southern third portion of the Basin and occupies approximately 35% of the Basin's land area. The Surficial Confined Region lies within the subcrop area of the lower unit of the Omar Fm. Silty, clayey organic and poorly drained sediments typify the Basin's Surficial Confined Region. Seasonal high water tables are considerably higher in this region then in the Well Drained Upland Region. Rainwater does not readily infiltrate through this region.

Much of the recharge mapping has not been completed for the southern third portion of the Basin. A poor recharge rating has, however, been assigned to most of the area that has been mapped. This area of poor recharge potential occurs essentially in the same location as the subcrop area of the Omar Fm's (lower unit) and within the Surficial Confined Region. The poor recharge potential rating for this area is what would be expected for the Surficial Confined Region's sediments. Findings from the recharge-mapping project support the USGS's Surficial Confined Region Designation for this area.

IV.6.4 Ground-Water Quality

The accompanying table entitled, “Known or Potential Contaminant Sources in the Inland Bays Basin**”** shows the number of known or possible contaminant sites in each watershed throughout the basin. The maps entitled “Inland Bays/ Atlantic Ocean Basin Small Septics” and “Inland Bays/ Atlantic Ocean Basin Potential, Possible, and Known Nutrient Sources” show the locations of the above sites, which do or may contribute nutrients as a contaminant to the ground water. The map entitled “Inland Bays/ Atlantic Ocean Basin Potential, Possible, and Known Chemical Sources” shows the locations of the above sites, which do or may contribute chemicals to the ground water.

IV.6.4.1 Nitrates

The map entitled, “Inland Bays/ Atlantic Ocean Basin Nitrate Concentrations in Selected Wells” shows locations of wells for which DNREC has nitrate-nitrogen data. The map ranks nitrate concentrations by dot color and shows the number of samples, the average nitrate concentration of the samples, and the maximum nitrate concentration of the samples for each sampling point. The labels for each sampling point are color coded to distinguish which aquifer was sampled.

The map entitled, “Inland Bays/ Atlantic Ocean Basin Small Septics” shows the distribution of residential on-site septic systems. The highest densities tend to occur around the Inland Bays in the Millville to Ocean view area, west of Millsboro in the Oak Orchard area, and in the Angola area. These systems are a significant source of nutrient loading to the Basin’s shallow unconfined aquifer. Most land areas within the Basin (39%) are utilized for agricultural practices. Poultry operations are scattered through out the basin and form the majority of the 575 animal operations that have been identified in the Basin. The map entitled “Inland Bays/ Atlantic Ocean Basin Potential, Possible, and Known Nutrient Sources” identifies the locations of these operations within the Basin. The highest animal operation density occurs within the Surficial Confined region.

Most forms of nitrogen will stay within the soil profile and do not readily leach to the ground-water table. The exception to this statement is nitrate nitrogen (NO_3^{-1}). Because nitrates are highly soluble and negatively charged, they can rapidly move downward through the soil column and enter the ground-water table. Spray irrigation sites, sludge application sites, septic systems, fertilizers, and landfills are some the possible sources of nitrate contamination to ground water. Manure and fertilizers associated with farming are considered the primary sources of Nitrate in the Basin (Andres, 1991). On-site wastewater disposal associated with residential development is also a significant source of nitrate to the Basin’s unconfined aquifer.

The map entitled, “Inland Bays/ Atlantic Ocean Basin Nitrate Concentrations in Selected Wells” shows a correlation between aquifer and nitrate concentrations. The deeper aquifers, for the most part, have much lower nitrate concentrations than the unconfined Columbia aquifer. There were 10 average nitrate concentrations which exceeded the primary MCL: 5 in the Columbia aquifer, 1 in the Columbia/Pocomoke, 2 USGS wells in the Pocomoke aquifer, and 2 USGS wells in the Manokin aquifer. Three of the samples that exceeded the MCL were reported from wastewater discharge facilities. The majority of the nitrate concentrations that exceeded 5 mg/l were in the Columbia Aquifer. Ground water nitrate concentration data provided on the “Inland Atlantic Ocean Basins Nitrate map” averaged 6 mg/L in shallow monitoring wells located at a total of 17 spray irrigation and large on-site septic facilities lying within the Basin’s Well Drained Upland Region. A maximum nitrate value of 85 mg/L was recorded at one of these sites. A lower average ground-water nitrate concentration of 4.21 mg/L was obtained for ground water samples from 31 public wells lying within this region of the Basin. The highest nitrate concentration recorded in the public well was 12 mg/L. This data shows that the public well’s deeper ground-water samples have less nitrate than ground water samples obtained closer to the ground surface. Ground water nitrate concentrations do generally decrease with depth in an aquifer. However, highly concentrated ground-water nitrate plumes can persist in an aquifer for long periods of time and can travel along a deep ground-water flow path to the bottom of an aquifer.

IV.6.4.2 Chlorides

The map entitled "Inland Bays/ Atlantic Ocean Basin Chloride Concentrations in Selected Wells" shows locations of wells for which DNREC has chloride data. The map ranks chloride concentrations by dot color and shows the number of samples, the average chloride concentration of the samples, and the maximum chloride concentration of the samples for each sampling point. The labels for each sampling point are color coded to distinguish which aquifer was sampled.

Road salt application, septic systems, wastewater spray irrigation systems, dredge spoils, and salt-water intrusion are all sources of chloride contamination to ground water.

The map entitled "Inland Bays/ Atlantic Ocean Basin Chloride Concentrations in Selected Wells" shows that chlorides are not a major concern throughout the basin. The only three sampling points which exceed the secondary MCL (250 mg/l) are two USGS wells north of Fenwick and an USGS well south of Lewes. Also there does not seem to be a correlation of trend between the aquifers and the chloride concentrations found within those aquifers. Only 14 sampling points have average chloride concentrations that are above 50 mg/l. Of those 14 sampling points: 4 are sites that discharge saline wastewater into the ground (2 of which are within close proximity of a saline water-body), 9 are sites that fall within 1 mile of a saline water-body, and 1 is a site which is located 5 miles west of the coast. The above results show that the elevated chlorides in the basin are typically found at sites which directly discharge saline wastewater or sites that are within a close proximity of a large saline water-body.

In an effort to learn more about salt water intrusion, assess the coastal aquifers vulnerability to salt water intrusion, and recognize when and where salt-water intrusion is occurring, the Department and the Delaware Geological Survey (DGS) and the U.S. Geological Survey (USGS) began a two year study in 1985 (Phelan, 1987). Results from this study indicate that salt-water intrusion is not a wide spread problem in the coastal aquifers. Salt-water intrusion has caused significant aquifer degradation in localized areas, and that the coastal aquifers are vulnerable to salt-water intrusion when high capacity wells are located near saline water bodies. Soon after the 1985 study, the DGS and the Department established the coastal salt-water monitoring network. This network consists of 36 wells and is comprised of municipal public and observation wells, subdivision public wells, and USGS and DGS monitor and observation wells. Seven of these wells are screened in the unconfined aquifer, 15 are screened in the Pocomoke Aquifer, and 14 are screened in the Manokin Aquifer. The DGS takes monthly water level readings in many of these wells. Chloride is sampled twice a year in most wells.

A brief summary of the chloride analytical results taken from Talley and Bounds (1999) follows:

IV.6.4.2.1 Columbia Aquifer (unconfined aquifer)

Chloride concentrations for wells not immediately along the coast or near a salt-water surface body ranged from 10- 28 mg/L and averaged 19 mg/L. These values are generally consistent with ambient values for the unconfined aquifer which are found in non-coastal portions of the Inland Bays / Atlantic Ocean Basin.

Salt-water intrusion has degraded the Columbia aquifer at Fenwick Island, South Bethany, along the Barrier Island at Rehoboth Beach and near the Lewes and Rehoboth Canal. Chloride data from Well Ni 43-1 at Cape Henlopen State Park indicates that this area may also be susceptible to salt-water intrusion. From 1944 –1998, chloride values ranged from 13-300 mg/L and averaged 108 mg/L. Chloride concentrations consistently exceeding 100 mg/L occurred in this well from 1984 – 1994. Chloride values have dropped to below 20mg/L since 1996.

To prevent another repeat of the 1943-1944 City of Lewes's and City of Rehoboth Beach's salt water intrusion episode, large capacity supply wells should not be located on the Barrier Island, immediately near the coast or near salt water bodies such as the Lewes and Rehoboth Canal. To virtually eliminate the risk of salt-water intrusion in the Columbia Aquifer, high yielding supply wells should be located in areas where water table elevations are at least 10' (Sundstrom and Pickett, 1969).

IV.6.4.2.2 Pocomoke Aquifer (confined aquifer)

Chloride concentrations for wells not immediately along the coast or near a salt-water surface body ranged from 5-30 mg/L. These values are also generally consistent with ambient non-coastal background levels for the Pocomoke Aquifer. Network wells very near the coast at Bethany Beach also contained low chloride concentrations that fall within background levels.

Although none of the network monitor wells have chloride levels exceeding the 250 mg/L SMCL, 4 do have levels above ambient background values. These four wells include: the Delaware Seashore State Park public well (well Pj 41-4), the Quillans Point public well (well Pj 51-5), the Narrows public well (well Rj 12-4), and the Fenwick Island State Park public well (well Rj 22-13). Data summaries for these wells follow:

Well Pj 41-4: From 1981-1999, chloride levels ranged from 35-58 mg/L and averaged 43 mg/L. The highest level occurred in 1997. The current concentration is 52 mg/L.

Well Pj 51-5: From 1983-1999 chloride levels ranged from 13-48 mg/L and averaged 35 mg/L. The highest level occurred in 1998. The current concentration is 39 mg/L

Well Rj 12-4: From 1990-1997, chloride levels ranged from 33-170 mg/L and averaged 79 mg/L. The highest chloride concentrations occurred from 1991-1994. Concentrations during this period were consistently over 100 mg/L. The most recent chloride value is 33 mg/L.

Well Rj 22-13: From 1989-1999, chloride values ranged from 62-210 mg/L and average 143 mg/L. The highest value occurred in 1992. The current concentration is 123 mg/L.

This data indicates that the Pocomoke aquifer in the Indian River area and the Fenwick Island area is more vulnerable to salt water intrusion than in the Bethany Beach area. A trend of increasing chloride concentrations with time is not, however apparent in these areas. Plans for additional pumpage from these areas should be considered with extreme caution since any additional head loss could cause significant intrusion.

IV.6.4.2.3 Manokin Aquifer (confined aquifer)

The more inland lying wells of the Manokin Aquifer portion of the coastal monitoring network contain water with chloride concentrations generally less than 20 mg/L. These values are consistent with background chloride concentrations for Manokin wells located further to the west.

All of the wells along the Barrier Island, however, have elevated average chloride concentrations, two of which exceed the 250 mg/L drinking water standard. These wells include: the U.S. Coast Guard well (well Pj 41-6) at the Indian River Inlet, the Bethany Beach monitor well (well Qj 32-23), the Bethany Beach public well (well Qj 32-15), the Sea Colony public well (Well Qj 41-2) and the USGS well (well Rj 22-5) near Fenwick Island. Data summaries for these wells follow:

Well Pj 41-6: From 1992-1998 chloride values ranged from 84-530 mg/L and averaged 360 mg/L. The highest reading occurred in 1994. The current value is 377 mg/L.

Well Qj 32-23: From 1991-1998 chloride values ranged from 46-66 mg/L and averaged 50 mg/L. The highest concentration was recorded in 1998.

Well Qj 32-15: From 1979-1995 chloride values ranged from 13-90 mg/L and averaged 59/mg/L. The highest concentration occurred in 1994 and the most recent chloride concentration is 77 mg/L.

Well Qj 41-2: From 1985-1999 chloride concentrations ranged from 28-68 mg/L and averaged 48 mg/L. The highest concentration occurred in 1993 and the most recent chloride concentration is 60 mg/L.

Well Rj 22-5: Only two samples taken. In 1977 and 1986, chloride concentrations of 460 and 450 mg/L were recorded respectively (Phelan, 1987).

This data indicates that along the Barrier Island, the Manokin Aquifer is very vulnerable to salt-water intrusion and that intrusion has occurred to a significant degree at Indian River Inlet and at Fenwick Island where Chloride concentrations exceed the drinking water standard. Elevated concentrations averaging 52 mg/L also occur in the Bethany Beach area. Even though the Manokin Aquifer has been degraded with elevated chloride levels, a trend of increasing chloride concentration with time is not apparent. Increasing the amount of ground-water withdrawal from these areas may exacerbate salt-water intrusion and significantly increase chloride concentrations.

IV.6.4.3 Iron

The map entitled “Inland Bays/ Atlantic Ocean Basin Iron Concentrations in Selected Wells” shows locations of wells for which the Department has iron data. The map ranks iron concentrations by dot color and shows the number of samples, the average iron concentration of the samples, and the maximum iron concentration of the samples for each sampling point. The labels for each sampling point are color coded to distinguish which aquifer was sampled.

Salvage yards and industrial facilities can be sources of iron contamination, but iron is primarily a naturally occurring contaminant. Iron is mainly an aesthetic concern with regard to taste and color.

The average iron concentration for 54 of the sampling points in the basin exceeds the secondary MCL of 0.3 mg/l. Public drinking water supplies may dilute the iron concentrations below the SMCL prior to consumption, however they are not required to do so.

IV.6.5 Conclusion

Ground water is used for 100% of all drinking water in the Inland Bays basin. Other than naturally occurring iron, nitrates are the biggest problem throughout the basin. The nitrates come from a number of sources from septic systems to animal operations. Chloride problems are a particular concern along the Atlantic Coast and the Inland Bay.

IV.6.6 Known or Potential Contaminant Sources in the Inland Bays Basin

Watershed	Site Type	Sites
Assawoman	Animal Operations	14
	SIRB Sites	2
	Underground Storage Tank Sites	2
Buntings Branch	Animal Operations	22
	Hazardous Waste Generators	1
	Large On Site Septic	1
	Salvage Yards	1
	SIRB Sites	1
	TRI's	1
	Underground Storage Tank Sites	1
Indian River	Animal Operations	243
	Hazardous Waste Generators	19
	Large On Site Septic	4
	NPDES Outfalls	1
	SIRB Sites	7
	Sludge Application Sites	2
	Spray Irrigation Sites	3
	TRI's	4
	Underground Storage Tank Sites	82
Indian River Bay	Animal Operations	202
	Hazardous Waste Generators	9
	Large On Site Septic	13
	NPDES Outfalls	3
	SIRB Sites	4
	Salvage Yards	1
	Spray Irrigation Sites	3
	TRI's	1
	Underground Storage Tank Sites	35

Watershed	Site Type	Sites
Iron Branch	Animal Operations	57
	SIRB Sites	1
	Spray Irrigation Sites	1
	TRI's	1
	Underground Storage Tank Sites	4
Lewes – Rehoboth Canal	Animal Operations	1
	Hazardous Waste Generators	2
	Large On Site Septic	4
	SIRB Sites	4
	Spray Irrigation Sites	1
	Underground Storage Tank Sites	40
Rehoboth Bay	Animal Operations	36
	Hazardous Waste Generators	12
	Large On Site Septic	9
	SIRB Sites	4
	Spray Irrigation Sites	5
	Underground Storage Tank Sites	15

IB Figure Chemical Sources

IB Figures Chloride in wells

IB Iron in wells

IB Nitrates in wells

IB Nutrient Sources Map

IB Septics Map

IB Recharge Map

Part V Part Five: Wetlands Assessment

Part V: Wetlands Assessment

V.1 Introduction

Wetlands are areas where water is the primary factor that structures and controls a wetlands' environment and its' associated plant and animal community. These communities are transitional habitats that occur between upland and deepwater habitats and are considered among the most productive ecosystems on earth. They are characterized by fluctuating water tables, wet soils, and plants adapted to living in wet conditions. The Atlantic coast form New Jersey to Florida is characterized by a broad coastal plain ideally suited to the establishment of both coastal (i.e., tidal) and inland (i.e., nontidal).

V.2 Functions and Values of Wetlands

Research over the past couple of decades has found that wetlands provide an abundance of values to society. In fact, some of these values are vital to man's existence. The fact that wetlands intercept pollutants and nutrients from upland runoff protects organisms dependent on clean water (humans included), from the poisonous effects of both non-point and point source pollution.

Ecological processes inherent in wetland ecosystems are usually described by functions. An example of a function would be wildlife habitat support. Further classification of a function, on the basis of its value, connotes usefulness to humans. The location of the wetland, the human pressures on it, or the extent of the wetland may indicate the value of a functional ecological process (Mitch and Gosselink, 1986). For example, clean water associated with wetlands provides drinking water to upland species, and provides an uncontaminated environment necessary for many fish species, and ultimately, recreational value, in the form of hunting and fishing for humans.

It is important to keep in mind the differences between functions and values. Functions are things that a wetland does, and are independent of our attempt to assign an arbitrary monetary value to them. In contrast, values are primarily human constructs, subject to whims of the marketplace. As a result, a wetland with a given function in one locality, may be more highly valued than a wetland of similar function in another locality.

Because wetlands are diverse and occupy a variety of habitats, they do not all provide the same functions and values, therefore, it is generally difficult to determine a wetland's function without a specific site analysis. Variables to consider in assessing a wetlands function include: wetland type, soils, hydrology, size, and adjacent land use.

According to Wohlgemuth (1991), wetlands offer three broad categories of values, these are: fish and wildlife habitat values, environmental quality values and socioeconomic values.

V.2.1 Fish and Wildlife Habitat

Wetlands provide food and habitat for a variety of terrestrial and aquatic species including fish, birds, mammals, amphibians, reptiles, and invertebrates. Some of these animals are either fully or partially dependent on wetlands, to complete their respective lifecycles. Most Commercially important fish species, for example, are wholly dependent on wetlands for spawning and nursery areas. Wetlands also provide breeding ground and habitats for a variety of waterfowl species and furbearers. Some species of frogs, toads, and salamanders- depend on wet habitat for their survival, and provide food for animals in higher trophic levels. Reptiles, such as turtles and snakes, use these areas for the same reasons as the above. Invertebrates such as aquatic bugs or insects, are important in the maintenance of the food web.

V.2.2 Environmental Quality Benefits

Wetlands are considered among the most productive ecosystems in the world. Wetland plants produce more plant material than most very productive cultivated farm fields. The major value of wetland plants occurs when the plants die and are broken down into detritus by bacteria and other microorganisms. Detritus forms the base of the food web that supports higher animals such as commercial fish species.

Wetlands also help maintain and improve water quality. The following are specific environmental quality benefits of wetlands:

- Pollutant removal (heavy metals, pathogens)
- Sediment trapping
- Nutrient uptake and recycling
- Oxygen production
- Wastewater treatment
- Storm water treatment

V.2.3 Socioeconomic Values

Some of the benefits that wetlands provide, are benefits of more tangible economic value, such as protection from flood and storm damage. Because these benefits provide dollar savings, they tend to be more appreciated.

The following are some socioeconomic wetland values:

- Flood and storm water damage protection
- Erosion control
- Water supply and groundwater recharge
- Natural products supply (e.g., timber, fish, wildlife, firewood… etc.)
- Recreation (e.g., waterfowl, fishing, boating, nature study… etc.)

V.3 Wetland Quantity

Estimates of wetland acreages have changed as more technologically refined techniques have been developed over the last couple of years. Until the advent of this higher resolution color aerial infrared photography, it was found that much of the wetland land base was underestimated. In fact, previous estimates by Tiner (1985) assessed 457,000 total acres of tidal and nontidal wetlands in Delaware, while a recent estimate by same author (Tiner et al. 1999), realized a more refined estimate of 640,025. The higher figure reported in the latter estimate can, however, be attributed in part to the inclusion of 24,019 acres of nontidal agricultural wetlands that were intentionally omitted in the previous assessment effort (See table 1).

Table V-1. Current tidal and nontidal Delaware wetland acreage estimates (Tiner et al. 1999).

Tidal wetlands	190,329
Nontidal wetlands*	449,626
Total wetland acreage	640,025

* Includes 24,019 acres of nontidal agricultural wetlands

V.4 Wetland Quality

No comprehensive information currently exists on the ecological condition of Delaware's wetlands at this time. However, a recently completed an EPA grant-funded study by Emslie and Clancy (1999) of plant communities in the St. Jones watershed entitled: *Assessing and Monitoring the Ecological Integrity of Freshwater Wetlands in Delaware*, attempted to do just that. In this study, these researchers attempted to relate nativeness of plant communities as an indicator of wetland ecological integrity. Using a tool known as the Floristic Quality Assessment Index (FQAI), it was presumed that plant nativeness is the primary determinant of floristic quality, and this could be measured to provide one with a useful gauge to measure the degree of human disturbance. Other studies using this same methodology in different locales confirmed that this methodology does have some merit in discerning the "biological signals" of human disturbance; however, the FQAI methodology was unable to discern these same "biological signals" in this study. It was believed that the correlation between FQAI indices and human disturbance, was not supported by this study because of a combination of small sample size, landowner reluctance to grant study participants permission to enter their lands for assessment purposes, and the relative dearth of undisturbed wetlands extant in the watershed to assess.

Wetlands are also important for the removal of sediment, nutrients, and other pollutants, which has direct bearing on the quality of water entering a waterbody. With the recent implementation of federally mandated legislation, amended under the 1972 Clean Water Act and known as Total Maximum Daily Load (TMDL), states are required to list water bodies that are "water quality limited" or in need of pollution reduction efforts or strategies to achieve water quality standards. These water quality standards prescribe goals that all water bodies should meet with respect to swimming, fishing, and drinking water supply. Therefore, active preservation and restoration of high quality wetlands are integral components to the ongoing TMDL process. Presently, TMDL's have been established for only two parameters (nitrates and phosphates), in the Inland Bays and the Nanticoke River watersheds. The following presents the statewide wetland trends in narrative form.

V.5 The Statewide Wetland Mapping Project (SWMP) and Wetland Trends in Delaware (1981/2-1992)

In an attempt to improve existing wetland inventories, the State Wetlands Mapping Project (SWMP) was conceived as a collaborative effort between the Delaware Department of Natural Resources (DNREC), Delaware Department of Transportation (DELDOT), and the United States Fish and Wildlife Service (USFWS; Pomato 1994). Utilizing aerial color digital orthophotography, the SWMP maps (derived from same named project), employ a modified Cowardin et. al. (1979) hierarchical classification scheme for classifying Delaware's wetlands. These aerial color photographs provide higher level resolution "wetland signatures" than the older monochromatic National Wetlands Inventory (NWI) maps, which increases the precision and accuracy of wetland delineation, identification of vegetative types (e.g., broad-leaved deciduous, broad-leaved evergreen…etc), and the identification of hydrologic regimes (e.g., A, B, C…etc.).

Utilizing color infrared aerial photography for the decade-long time period (1981/2-1992), the service assessed statewide wetland losses, gains, and changes in wetland type by photo interpretation of "wetland signatures." Wetland trends were also assessed separately in the following four drainage basins: 1) Northern Piedmont, 2) Delaware Bay, 3) Chesapeake Bay and, 4) Inland Bays.

V.5.1 Statewide Wetland Losses (1981/2-1992)

Approximately 2000 acres of vegetated wetlands were destroyed from 1981/2 to 1992 time period. Most of the wetland losses were palustrine vegetated wetlands (1890 acres), while estuarine wetlands losses were minor. (106 acres; Tiner et al. 1999).

Agricultural activities had the greatest impact on Palustrine wetland losses (954 acres). Residential activities also destroyed significant amounts of wetlands (436 acres). The remaining wetland losses were derived from pond and road construction practices, with each being responsible for 7 percent of the losses. Palustrine vegetated wetlands accounted for 95 percent of all wetland losses in Delaware.

Palustrine forested wetlands experienced the bulk of losses of all palustrine vegetated types (1505 acres; Tiner et al. 1999).

Most of the losses to estuarine wetlands were due to saltwater impoundments (52.2 acres). Filling in wetlands also accounted for some significant acreage losses (32.7acres). Highway road projects and residential development accounted for the balance of estuarine wetland losses (11 acres; Tiner et al. 1999).

V.5.1.1 Northern Piedmont Drainage Wetland Losses

The Northern Piedmont drainage is the smallest and most urbanized drainage basin in the state. About 9 percent of the state's land area fall within this drainage basin, which contains approximately 3.2 percent of the state's wetlands.

During this decade-long study period (1981/2-1992), palustrine vegetated wetlands experienced the greatest losses. These wetland s declined by 137.8 net acres. Of all palustrine vegetated types, palustrine forested wetlands experienced the greatest losses, with about 110 acres or 75 percent of total palustrine vegetated wetland being converted to uplands. Residential and Industrial development were the leading causes attributed to their destruction of 70 percent and 18 percent, respectively. (Tiner et al. 1999).

Estuarine wetlands were not subject to the same degree of destruction as palustrine wetlands during the decade long study period. Approximately 1 acre of wetlands was destroyed by conversion to industrial development, or impounded estuarine deepwater habitat (Tiner et al. 1999).

V.5.1.2 Delaware Bay Drainage Wetland Losses

The Delaware Bay Drainage is the largest drainage in Delaware. About 41 percent of the state's land area fall within this drainage basin, which also contains approximately 34 percent of the state's wetlands. From 1981/2-1992, palustrine vegetated wetlands experienced the greatest losses (679.2 acres), though estuarine wetlands experienced lesser, though not insignificant losses (78.4 acres; Tiner et al. 1999).

The primary agent in palustrine vegetated wetland destruction was residential development, accounting for about 35 percent of the losses. Agriculture and Highway road construction accounted for the remainder of the losses – about 28 percent and 10 percent, respectively (Tiner et al. 1999).

From 1981/2-1992, estuarine wetlands experienced net losses only second to palustrine vegetated wetlands (78.4 acres). The primary cause of their losses was conversion to estuarine open water impoundments and dredged channels (36.8 acres), miscellaneous filling practices (37.4 acres; Tiner et al. 1999).

V.5.1.3 Chesapeake Bay Drainage

The Chesapeake Bay drainage is the second largest drainage in Delaware (approximately 32 percent), and contains the greatest percentage of wetlands (approximately 54 percent) of the four drainages. Palustrine vegetated wetlands are the predominant wetland system type found in this basin. About 712 acres of palustrine vegetated wetlands , or 84 percent of these wetlands, were lost due to agricultural expansion during the 1981/2-1992 study period. Significant acreages of estuarine vegetated wetlands are not found in this basin (Tiner et al. 1999).

Most of the palustrine vegetated wetland losses were palustrine forested wetlands. Approximately 701 acres of these wetlands were destroyed during the 1981/2-1992 study period. Agricultural operations were responsible for 82 percent of the losses of this wetland type (Tiner et al. 1999).

V.5.1.4 Inland Bays Drainage

The Inland Bays Drainage is comprised of three coastal bays: Indian River Bay, Rehoboth Bay, and Little Assawoman Bay. This drainage comprises about 18 percent of Delaware's surface land area and contains both Palustrine and Estuarine wetlands. Consistent with the other three drainages, Palustrine vegetated wetlands experienced the greatest losses (Tiner et al. 1999).

A loss of 271.3 acres of palustrine vegetated wetlands were recorded during the 1981/2-1992 time period, of which forty-eight percent were directly attributed to agricultural operations. The remainder of the losses were agricultural and residential – about 20 percent and 24 percent, respectively (Tiner et al. 1999).

Forested wetlands bore the brunt of these losses. About 254.3 acres of forested wetlands were lost during the 1980s , which represents 90 percent of the drainage's palustrine vegetated wetland base. Palustrine deciduous forests experienced the greatest losses, with 178.4 acres converted to uplands or 70 percent of the palustrine forested wetland base. Agricultural activities were responsible for 38 percent of the total losses. Residential development and pond construction accounted for remaining wetland losses, 33 percent and 26, respectively (Tiner et al. 1999).

V.5.2 Wetland Trends in Delaware (2002)

Wetland trends for the State of Delaware are scheduled for update in the year 2002. By utilizing higher resolution color infrared photography of similar scale as the basis for future wetland trend studies, an even better trends analysis is almost assured.

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Part VI Appendices

Appendix 1: Citizen’s Monitoring Data

Appendix 1: Summary Stream Watch Citizens Monitoring Data

TECHNICAL MONITORING - Brandywine Creek
Site Locations

Brandywine River
Sept. 1997 - Aug. 1999

Site	Water Temperature °C				Dissolved Oxygen mg/L				pH SU				Nitrate Nitrogen mg/L				Alkalinity ppm				Conductivity µs			
	Min	Max	Ave	Std	Min	Max	Ave	Std De	Min	Max	Ave	Std Dev	Min	Max	Ave	Std Dev	Min	Max	Ave	Std Dev	Min	Max	Ave	Std Dev
#1 Brandywine Park	1.1	24.0	10.9	7.9	8.5	12.3	10.0	1.3	7.0	8.5	7.4	0.5	2.3	6.8	3.3	1.6	68.0	95.0	77.9	9.3	232.5	360.5	272.3	46.1
#2 Hagley Museum	3.3	23.0	11.9	8.4	8.3	12.0	10.2	1.6	7.0	8.0	7.5	0.3	2.5	3.0	2.8	0.2	66.0	78.0	73.0	5.1	228.0	336.5	266.4	42.2
#5 Rocky Run	0.4	21.8	10.9	6.6	8.6	16.7	11.9	2.4	7.0	7.5	7.3	0.2	0.0	1.0	0.6	0.3	34.0	59.0	44.9	6.8	139.8	1934.5	291.5	415.3
#6 Beaver Run	0.3	20.6	11.0	6.2	8.9	16.7	12.1	2.4	7.3	8.0	7.5	0.2	0.8	3.0	1.8	0.8	49.0	86.0	67.8	10.9	197.7	486.0	270.1	65.9
#8 Flint Woods	5.0	12.0	8.0	2.5	9.9	13.6	11.3	1.4	7.0	7.3	7.1	0.1	0.3	2.5	1.5	0.8	30.0	53.0	38.9	8.3	172.0	256.0	223.0	30.4

Appendix 1: Summary Stream Watch Citizen's Monitoring Data

TECHNICAL MONITORING - Christina River																		
Site Locations																		
Christina River																		
Sept. 1997 - Aug. 1999																		
	Water Temperature ^{o}C			Dissolved Oxygen mg/L			pH SU			Nitrate Nitrogen mg/L			Alkalinity ppm			Conductivity µs		
Site	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
#1 Rte. 141	2.0	27.5	12.5	7.4	14.2	11.1	7.0	8.0	7.4	0.3	3.0	1.6	44.0	88.0	73.3	233.0	3760.0	968.0
#2 Churchman's boat ramp	2.0	28.0	13.0	7.2	13.8	11.0	6.5	8.0	7.2	0.3	2.0	0.9	38.0	93.0	65.2	178.0	2600.0	689.0
#3 Smalley's Dam Rd.	3.4	28.6	14.8	5.6	11.5	8.7	6.8	7.5	7.0	0.3	1.0	0.5	38.0	63.0	50.8	117.7	464.0	221.7
#4 Walther Rd.	0.1	28.2	13.5	6.0	11.5	8.5	6.8	7.0	6.9	0.3	1.0	0.8	38.0	63.0	51.4	117.2	420.0	224.3
#5 Old Rte. 896 (Muddy Run)	3.3	19.0	11.4	3.3	13.7	8.7	6.0	7.0	6.6	0.3	3.0	1.6	24.0	50.0	40.4	111.9	732.0	238.1
#6 Rte. 40 (Belltown Run)	3.0	19.8	11.6	7.3	12.4	9.8	6.5	7.0	6.6	0.3	4.0	1.8	22.0	42.0	34.6	116.3	289.0	177.3
#7 Cooches Bridge	4.0	4.0	4.0	11.7	12.4	12.1	7.2	7.2	7.2	0.5	2.0	1.3	41.5	58.0	49.8			
#8 Rittenhouse Park	4.0	4.5	4.3	12.2	12.6	12.4	7.2	7.2	7.2	1.0	2.0	1.5	41.0	58.0	49.5			

Appendix 1: Summary Stream Watch Citizen's Monitoring Data

TECHNICAL MONITORING - Red Clay Creek																							
Site Locations																							
Red Clay Creek Sept. 1997 - Aug. 1999																							
	Water Temperature ^{o}C				Dissolved Oxygen mg/L				pH SU				Nitrate Nitrogen mg/L				Alkalinity ppm				Conductivity µs		
Site	Min	Max	Ave	Std Dev	Min	Max	Ave	Std Dev	Min	Max	Ave	Std Dev	Min	Max	Ave	Std Dev	Min	Max	Ave	Std Dev	Min	Max	Ave
#2 Old Kennett Pike (Burrows Run)	5.0	23.5	11.4	6.5	8.3	14.8	11.1	1.9	7.0	8.0	7.5	0.2	0.3	3.5	1.4	1.0	33.0	79.0	61.0	10.3	146.5	232.0	206.5
#3 Yorklyn	2.5	23.7	12.2	7.3	9.2	14.6	11.7	1.9	7.3	9.0	7.6	0.5	3.0	6.0	3.9	0.9	60.0	100.0	85.9	9.6	305.0	469.0	406.1
#4 Ashland	2.5	23.5	12.8	6.8	8.3	13.6	10.8	1.8	7.3	8.0	7.3	0.2	3.0	6.0	4.0	1.1	52.0	104.0	83.9	12.0	299.0	485.0	416.7
#5 Rte. 48 - Woodale	3.0	24.5	13.5	6.5	8.3	13.8	10.6	1.7	7.5	8.5	7.9	0.3	0.5	4.0	3.0	0.9	58.0	96.0	78.4	11.3	238.0	505.0	345.8
# 6 Kiamensi Rd. - Stanton	0.0	24.0	11.8	8.2	8.2	14.9	10.8	2.0	7.0	7.5	7.5	0.2	0.5	4.0	3.1	1.4	64.0	88.0	75.9	7.6	260.0	1340.0	431.3
#7 Faulkland Rd. (Hyde Run)	2.0	22.0	13.5	6.6	8.4	14.5	11.1	2.0	7.0	7.5	7.4	0.2	0.3	4.0	2.1	1.2	38.0	88.0	63.4	13.2	240.0	3900.0	716.3
#8 Outflow from Hoopes Reservoir	6.5	21.0	12.4	4.6	7.1	11.7	9.3	1.1	7.0	7.5	7.2	0.3	0.3	0.5	0.3	0.1	50.0	67.0	59.6	5.6	158.4	233.0	182.0

Appendix 1: Summary Stream Watch Citizen's Monitoring Data

TECHNICAL MONITORING - White Clay Creek

Site Locations

White Clay Creek

Sept. 1997 - Aug. 1999

	Water Temperature °C			Dissolved Oxygen mg/L			pH SU			Nitrate Nitrogen mg/L			Alkalinity ppm			Conductivity µs		
Site	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
#1 Manley	3.0	23.0	12.3	7.6	14.8	11.0	7.0	8.5	7.5	1.0	4.5	3.0	56.0	83.0	67.2	249.0	520.0	327.4
#2 Independence School	6.0	21.0	12.7	9.0	13.2	11.2	7.0	7.5	7.3	2.0	5.0	3.6	46.0	60.0	53.1	224.0	409.0	251.6
#3 Old Possum Park Rd. (Middle Run)	1.0	24.5	11.3	8.5	13.9	10.6	6.5	7.5	7.1	0.5	2.5	1.5	30.0	56.0	42.8	122.5	196.7	150.0
#4 Old Capitol Trail (Mill Creek)	1.5	25.0	12.7	7.8	13.5	11.2	6.5	7.6	7.4	0.3	3.0	1.6	36.0	68.0	54.5	189.6	352.0	241.0
#5 Paper Mill Rd. (Middle Run)	2.5	26.0	13.8	4.0	13.4	8.9	6.5	7.5	7.0	0.3	3.0	0.8	44.0	71.0	54.3	135.0	200.0	166.9
#6 14 White Clay Dr.	3.0	23.5	11.3	8.0	16.4	11.7	7.2	8.0	7.7	0.3	4.0	1.9	51.0	106.0	88.0	223.0	310.0	267.7

Appendix 1: Summary Citizens Monitoring Data For Inland Bays Watershed (1997-1999)

Station	Location	Segment	Min chl a (ug/L)	Max chl a (ug/L)	Ave chl a (ug/L)	Min DIN (mg/L)	Max DIN (mg/L)	Ave DIN (mg/L)	Min DIP (mg/L)	Max DIP (mg/L)	Ave DIP (mg/L)
IR20	BAY COLONY	DE140-E01_00	1.32	49.20	13.57	0.02	2.24	0.50	0.001	0.16	0.04
ML	MASSEY'S LANDING	DE140-E01_00	1.18	24.85	7.64	0.01	0.36	0.09	0.002	0.04	0.02
IR10	STEELE COVE	DE140-E01_00	1.26	26.60	9.69	0.01	0.70	0.16	0.002	0.04	0.01
IR02	GULL POINT	DE140-E02_00	1.70	81.60	28.21	0.02	1.87	0.76	0.002	0.28	0.04
MP	MILLSBORO POND-RT 30 BOAT LAUNCH	DE140-L01_00	1.07	34.80	10.49	0.67	3.68	2.66	0.003	0.02	0.01
RB02	LEWES/REHOB CANAL	DE170-001_00	0.52	76.91	16.98	0.05	1.00	0.37	0.006	0.12	0.05
AG1	AG DITCH NEAR ROXANA	DE180-003_00	0.24	25.80	4.97	0.08	2.07	1.14	0.003	0.13	0.02
LA09	DIRICKSON CREEK, RD 381 BRIDGE	DE180-003_00	9.25	93.80	44.77	0.02	3.04	1.11	0.004	0.22	0.06
LA08	FENWICK-LIGHTHOUSE COVE	DE180-E01_00	4.01	98.40	34.30	0.01	0.58	0.15	0.003	0.04	0.01
LA03	MULBERRY LANDING	DE180-E01_00	7.69	125.20	38.86	0.00	1.74	0.20	0.003	0.06	0.01
RB34	LOVE CREEK AT RT 24 BRDIGE	DE280-002_00	0.94	278.00	44.87	0.00	1.89	0.61	0.002	0.05	0.01
RB01	MOUTH OF ARNELL CREEK	DE280-01_00	0.87	57.40	16.38	0.01	0.51	0.16	0.003	0.06	0.02
RB40	BURTON PRONG	DE280-01_01	0.85	120.40	21.32	0.01	2.06	0.48	0.000	0.07	0.01
RB06	GUINEA CREEK	DE280-01_01	3.18	92.20	24.58	0.01	1.40	0.71	0.003	0.02	0.01
RB06A	GUINEA CREEK AT RD 298 BRIDGE	DE280-01_01	1.50	91.20	19.04	0.03	4.30	2.08	0.003	0.04	0.01
RB04	HERRING CREEK	DE280-01_01	1.09	1436.28	56.58	0.00	1.86	0.45	0.003	1.06	0.03
RB05	MOUTH OF GUINEA CREEK	DE280-01_01	1.83	79.20	19.43	0.00	0.78	0.25	0.001	0.02	0.01
RB07	WEST BAY PARK	DE280-E01_00	1.83	29.60	9.99	0.04	0.51	0.17	0.003	0.09	0.03
BP	BURTONS POND SPILLWAY	DE280-L01_00	0.66	15.02	4.22	0.02	1.71	0.72	0.002	0.01	0.01

Appendix 1: Summary Citizens Monitoring Data in the Inland Bays Watershed (1997-1999)

THESE VALUES ARE BASED ON THE ENTIRE SET OF OBSERVATIONS FOR EACH SITE.

SITE #	SITE DECRIP	DNREC ZONE	D.O. (mg/L) MAX	D.O. (mg/L) MIN	D.O. (mg/L) AVG	D.O. (mg/L) 10%	D.O. (mg/L) 25%	WATER TEMP MAX	WATER TEMP MIN	WATER TEMP AVG	WATER TEMP 90%	PH 10%	PH 90%
IR02	GULL POINT	DE140-E02_00	15.4	3.8	7.18	4.43	5.45	29	5	19.44	28.08	7.1	7.8
IR07	HOLTS LANDING	DE140-E02_00	11.4	2.3	7.80	4.8	6.15	30	3	18.85	26	6.5	7.52
IR10	STEELE COVE	DE140-E02_00	12.1	1.7	7.34	4.76	6	28	1.5	17.56	26	7.3	7.76
IR19	WHITE HOUSE BEACH	DE140-E02_00	12	2.3	7.68	4.8	6.575	28	8.5	19.57	26.25	7.51	8.39
IR20	BAY COLONY	DE140-E02_00	11.4	3.1	6.78	4.4	5.225	30	1	19.14	27	7.2	7.9
IR31	WHITE CREEK	DE140-E02_00	9.5	2.7	6.07	4.46	5.1	29.5	9	21.36	27	6.5	7.65
RB02	LEWES/REHOB CANAL	DE170-001_00	10.3	3.4	6.76	4.52	5.35	29	2	17.69	27	7.1	7.7
LA03	MULBERRY LANDING	DE180-E01_00	12.7	3.5	7.25	4.7	5.3	28.5	1.5	17.71	27	7.2	7.8
LA08	LIGHTHOUSE COVE, FENWICK	DE180-E01_00	10.2	2.6	5.52	3.15	4.025	30	1	17.43	26.3	6.9	7.9
LA09	DIRICKSON CREEK, RD 381 BRIDGE	DE180-E01_00	12.1	1.6	5.69	2.26	3.25	30	4	20.93	29.1	6.84	7.96
LA30	ANCHORAGE CANAL, SO. BETHANY	DE180-E01_00	11.9	2.2	6.96	4.4	5.1	29	3	18.94	27.5	6.86	7.5
RB34	LOVE CREEK AT RT 24 BRDIGE	DE280-002_00	12.4	2.6	6.77	4.34	5.425	31	1	17.67	26.7	6.7	7.4
RB01	MOUTH OF ARNELL CREEK	DE280-01_00	11.7	2.3	6.32	3.18	3.9	28.5	0	16.88	26.15	7.2	7.6
RB04	HERRING CREEK	DE280-01_00	11.5	2.3	7.42	4.42	5.8	30	0.5	16.84	27	7.2	7.9
RB05	MOUTH OF GUINEA CREEK	DE280-01_00	11	2	6.90	4	5	29	-1	17.34	26	7.2	7.8
RB38	JOY BEACH	DE280-01_00	11.5	2	7.53	3.69	5.85	28	4.5	15.14	24.9	7.31	7.9
RB43	MULBERRY KNOLL	DE280-01_00	10.2	3.3	6.02	3.82	4.3	29	3	18.06	25	7	7.8
RB06	GUINEA CREEK	DE280-01_01	10.5	3.6	6.99	5.2	5.9	31	0	22.35	28.5	6.8	7.5
RB16	RUSTY RUDDER	DE280-01_01	9.6	3.5	7.01	4.64	5.325	25	5	13.47	22.3	7.55	7.9
RB35	PELICAN COVE, DEWEY	DE280-01_01	9	4.7	6.81	4.9	5.7	29	11.5	23.78	27.5	7.68	8.24
RB40	BURTON PRONG	DE280-01_01	11.2	2.2	6.90	4.2	6.1	34	3	18.63	28.3	6.9	7.79
RB41	HEAD OF BAY COVE	DE280-01_01	11.9	6.6	9.20	7.44	7.8	24.5	5	14.38	20.65	7.02	7.32
RB42	HEAD OF BAY CANAL	DE280-01_01	14.5	4.5	9.95	6.52	7.8	30.7	1.7	17.42	28	6.9	7.91
RB07	WEST BAY PARK	DE280-E01_00	11.5	2.1	6.40	3.81	4.35	28	0	17.34	26	7.4	8.8
RB44	CAMP ARROWHEAD	DE280-E01_00	10.9	3.1	7.51	5.8	6.2	29.5	4.5	21.37	28.3	7.5	7.91

Appendix Two: Completed TMDL Regulations

Department of Natural Resources and Environmental Control

Division of Water Resources

Statutory Authority: 7 Delaware Code, Chapter 60

Total Maximum Daily Loads (TMDLs) for Indian River, Indian River Bay, and Rehoboth Bay, Delaware

Secretary's Order No. 98-W-0044

Date of Issuance: November 6, 1998

Re: Total Maximum Daily Loads (TMDLs) for Indian River, Indian River Bay, and Rehoboth Bay, Delaware

Effective Date of Regulation: December 10, 1998

I. BACKGROUND

A public hearing was held on September 2, 1998, at the University of Delaware Virden Center in Lewes to receive comment on DNREC's proposal to establish Total Maximum Daily Loads (TMDLs) for nitrogen and phosphorous for Indian River, Indian River Bay and Rehoboth Bay.

As part of the public participation process, DNREC engaged in significant public outreach and then established an interagency TMDL workgroup with representatives from several state and federal agencies. DNREC also organized the TMDL Advisory Committee for the Inland Bays with representatives from many stakeholder groups. The Advisory Committee met on July 28 and August 11, 1998, at which meetings DNREC presented the TMDL proposal and responded to questions and comments. The proposed TMDL Regulations were published in the Delaware Register of Regulations, Vol. 2, Issue, 2, Saturday, August 1, 1998. A workshop was held September 2 and a public hearing was held later that evening. During the workshop, DNREC again presented the proposed regulation and its technical basis and responded to questions and comments from the audience. A number of commentors requested an extension of the deadline to make comments. Therefore, the original deadline to submit comments was changed from September 11 to September 25, 1998.

After the hearing, DNREC prepared a Response Document which summarized each comment and provided the Department's Response. The exhibits introduced at the hearing by the Department (Exhibits A through N), the public comments from the testimony and by letter, and the Department's Response Document are expressly incorporated into this Order. The Hearing Officer prepared his Report and Recommendation dated November 4, 1998, which is also expressly incorporated herein.

II. FINDINGS AND CONCLUSIONS

A. Findings of Fact

1. Proper notice of the proceeding was provided as required by law and efforts to secure public participation went beyond the minimum legal requirements.

2. The water bodies which are the subject of this rulemaking are over-enriched with nitrogen and phosphorous from point and nonpoint sources to an extent that requires elimination or significant reductions in order to achieve and maintain designated uses.

3. The Pollution Control Strategy will incorporate extensive stakeholder input into consideration of economic impacts and practicability for all measures determined to be necessary for compliance along with reasonable and achievable timetables.

4. Differentiation of nutrient sources is not necessary to establish a TMDL which is concerned with total load entering the Inland Bays.

5. Failure to achieve atmospheric deposition reduction targets, should that occur, will be considered along with progress in other areas of nutrient load reductions in assessing pollution control strategies.

6. Establishment of TMDLs is required under the Clean Water Act and implementing regulations. TMDLs include allocations for both point and nonpoint sources.

7. The modeling tool used for establishing the proposed TMDL was developed by the U.S. Army Corps of Engineers and is a state-of-the-art program that has been applied to several estuarine systems, including the Chesapeake Bay. The data used, the technical assumptions made, and the conclusions drawn during the modeling phase were peer reviewed by the Scientific and Technical Advisory Committee of the Inland Bays National Estuary Program. Furthermore, the results of load reduction scenarios and proposed TMDL were peer reviewed by the Interagency TMDL Workgroup and the Scientific and Technical Advisory Committee.

8. Consideration of financial or economic effects is not required under § 303(d) of the Clean Water Act in setting TMDLs. However, such factors will be included in establishing Pollution Control Strategies.

9. Delaware Water Quality Standards for nutrients cannot be achieved without load reductions from point and nonpoint sources.

10. Determining land use practices (e.g., zoning) would be outside the scope of DNREC authority, both in this rulemaking as well as in the Pollution Control Strategy.

11. The margin of safety required by § 303(d) of the Clean Water Act has been adequately addressed through conservative modeling assumptions and projections showing concentrations which are better than existing Water Quality Standards.

12. The Clean Water Act does not require an implementation schedule as part of a TMDL; however, DNREC will proceed expeditiously in establishing the Pollution Control Strategy and to fully involve all stakeholders.

13. Article 1 of the TMDL Regulation applies to all point sources which add nitrogen and phosphorous loads to the Inland Bays but does not apply to nutrients already contained in intake water.

14. Concerns about disproportionate allocation of the burden of compliance with this TMDL will be addressed in the Pollution Control Strategy.

15. Because of mixing mechanisms and sediment nutrient recirculation in the Inland Bays, nutrient input across the entire watershed must be reduced to achieve Water Quality Standards in four water body segments: Indian River (DE140-004), Upper Indian River Bay (DE140-E01), Lower Indian River Bay (DE140-E02) and Rehoboth Bay (DE280-E01).

16. The elimination of all point source nutrient discharges is a long-term, fundamental objective of the Clean Water Act which will be implemented through the Pollution Control Strategy in an equitable manner.

17. Scenario 69 was selected because it results in the attainment of Delaware Water Quality Standards with the overall least restrictive load reduction targets.

18. Nutrient uptake between point of discharge and impacted waterbodies does not significantly affect assumptions about loadings because total contributions remain the same.

19. Failure to adopt the proposed TMDL will result in EPA action to usurp state management of the process and to impose the same requirements by the federal government.

20. Exemptions for certain point sources are not available under the language of the proposed TMDL although the Pollution Control Strategy will be implemented in a manner that should equitably distribute the burdens of compliance by all stakeholders.

B. Conclusions

Based on credible evidence in the record, the Department has a reasonable basis for promulgating the TMDL Regulation (Articles 1 through 8) regarding excess nutrients in the Inland Bays, notwithstanding that some evidence was offered to the contrary.

IV. ORDER

In view of the above findings and conclusions, it is hereby ordered that the proposed TMDLs as set forth in the record be adopted in final form and that the regulatory promulgation process move forward as required by law.

V. REASONS

The record in this matter provides a reasonable basis to support the Department's proposed TMDL regulation, the adoption of which is necessary to remedy the existing severe nutrient overenrichment problem in the affected waterbodies.

Christophe A. G. Tulou, Secretary

Total Maximum Daily Loads (TMDLs) Regulation

for Indian River, Indian River Bay, and Rehoboth Bay, Delaware

A. INTRODUCTION and BACKGROUND

Intensive water quality monitoring performed by the State of Delaware, the federal government, various university and private researchers, and citizen monitoring groups has shown that the Indian River, Indian River Bay, and Rehoboth Bay are highly enriched with the nutrients nitrogen and phosphorous. Although nutrients are essential elements for both plants and animals, their presence in excessive amounts cause undesirable conditions. Symptoms of nutrient enrichment in the Inland Bays have included excessive macroalgae growth (sea lettuce and other species), phytoplankton blooms (some potentially toxic), large daily swings in dissolved oxygen levels, loss of Submerged Aquatic Vegetation (SAV), and fish kills. These symptoms threaten the future of the Inland Bays - very significant natural, ecological, and recreational resources of the State - and may result in adverse impacts to the local and State economies through reduced tourism, a decline in property values, and lost revenues. Hence, excessive nutrients pose a significant threat to the health and well being of people, other animals, and plants living within the watershed.

A reduction in the amount of nitrogen and phosphorous reaching the Inland Bays is necessary to reverse the undesirable effects. These nutrients enter the Bays from several sources including point sources, nonpoint sources, and from the atmosphere. Point sources of nutrients are end-of-pipe discharges coming from municipal and industrial wastewater treatment plants and other industrial uses. Nonpoint sources of nutrients include runoff from agricultural and urban areas, seepage from septic tanks, and ground water discharges. Atmospheric deposition comes from both local and regional sources, such as motor vehicle exhausts and emissions from power plants that burn fossil fuels.

Section 303(d) of the Federal Clean Water Act (CWA) requires States to develop a list (303(d) List) of waterbodies for which existing pollution control activities are not sufficient to attain applicable water quality standards and to develop Total Maximum Daily Loads (TMDLs) for pollutants or stressors causing the impacts. A TMDL sets a limit on the amount of a pollutant that can be discharged into a waterbody and still protect water quality. TMDLs are composed of three components, including Waste Load Allocations (WLAs) for point source discharges, Load Allocations (LAs) for nonpoint sources, and a Margin of Safety (MOS).

The Delaware Department of Natural Resources and Environmental Control (DNREC) listed the Indian River, Indian River Bay, and Rehoboth Bay on the State's 1996 and 1998 303(d) Lists and has established the following Total Maximum Daily Load regulation for nitrogen and phosphorous.

B. Total Maximum Daily Loads (TMDLs) Regulation for Indian River, Indian River Bay, and Rehoboth Bay, Delaware

Article 1. All point sources which are currently discharging into the Indian River, Indian River Bay, and Rehoboth Bay and their tributaries shall be eliminated systematically.

Article 2. The nonpoint source nitrogen loads from tributaries in the upper Indian River shall be reduced by 85 percent (from the base-line period of 1988 through 1990). These tributaries include Swan Creek, Iron Branch, Pepper Creek, Vines Creek, and Millsboro Pond. This shall result in reducing nitrogen loads from these tributaries during a normal rainfall year from 1285 kilograms per day (2833 pounds per day) to 193 kilograms per day (425 pounds per day).

Article 3. The nonpoint source phosphorous loads from tributaries in the upper Indian River shall be reduced by 65 percent (from the base-line period of 1988 through 1990). These tributaries include Swan Creek, Iron Branch, Pepper Creek, Vines Creek, and Millsboro Pond. This shall result in reducing phosphorous loads from these tributaries during a normal rainfall year from 38 kilograms per day (84 pounds per day) to 13 kilograms per day (29 pounds per day).

Article 4. The nonpoint source nitrogen loads from all remaining tributaries to the Indian River, Indian River Bay, and Rehoboth Bay shall be reduced by 40 percent (from the base-line period of 1988 through 1990). This shall result in reducing nitrogen loads from these tributaries during a normal rainfall year from 732 kilograms per day (1614 pounds per day) to 439 kilograms per day (968 pounds per day).

Article 5. The nonpoint source phosphorous loads from all remaining tributaries to the Indian River, Indian River Bay, and Rehoboth Bay shall be reduced by 40 percent (from the base-line period of 1988 through 1990). This shall result in reducing phosphorous loads from these tributaries during a normal rainfall year from 36 kilograms per day (79 pounds per day) to 22 kilograms per day (49 pounds per day).

Article 6. The atmospheric nitrogen deposition rate shall be reduced by 20 percent (from the base-line period of 1988 through 1990). This shall result in reducing the atmospheric nitrogen deposition rate from 765 kilograms per day (1687 pounds per day) to 612 kilograms per day (1349 pounds per day).

Article 7. Based upon hydrodynamic and water quality model runs and assuming implementation of reductions identified by Articles 1 through 6, DNREC has determined that, with an adequate margin of safety, water quality standards will be met.

Article 8. Implementation of this TMDL Regulation shall be achieved through development and implementation of a Pollution Control Strategy. The strategy will be developed by DNREC in concert with the Department's ongoing Whole Basin Management Program and the affected public.

Department of Natural Resources and Environmental Control

Division of Water Resources

Statutory Authority: 7 Delaware Code, Chapter 60

Total Maximum Daily Load (TMDL) for Nanticoke River and Broad Creek, Delaware

Secretary's Order No. 98-W-0045

Date of Issuance: November 6, 1998

Re: Proposed TMDLs for nitrogen and phosphorus for the Nanticoke River and Broad Creek

Effective Date of TMDL: December 10, 1998

I. BACKGROUND

A public hearing was held on September 9, 1998, at the Boy's and Girl's Club of Western Sussex in Seaford, to receive comment on a proposed Total Maximum Daily Load (TMDL) regulation for the Nanticoke River and Broad Creek because Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 requires states to identify those waters within their boundaries which are water quality limited, to prioritize them, and to develop TMDLs for pollutants of concern. A water quality limited water is a waterbody in which water quality does not meet applicable water quality standards, and/or is not expected to meet applicable standards, even after application of technology-based effluent limitations for Publicly Owned Treatment Works and other point sources. The Nanticoke River and Broad Creek in Delaware have been identified as water quality limited waters, included in Delaware's 1996 and 1998 303(d) list, and targeted for development of TMDLs. The major environmental problems in the subbasin are nutrient overenrichment and low dissolved oxygen levels caused by point source discharges and nonpoint sources.

To develop a TMDL for the Nanticoke River and Broad Creek, intensive water quality monitoring was conducted from 1991 through 1994. During this period, water quality and quantity data were collected for the Nanticoke River and its major tributaries. The result of this monitoring activity was used to develop and calibrate a hydrodynamic and water quality model of the Nanticoke River and Broad Creek. The U.S. Environmental Protection Agency's Water Analysis Simulation Program modeling framework was used for this purpose. The Nanticoke River Model was calibrated to water quality and hydrodynamic conditions of the year 1992 (baseline).

Using the calibrated model of the Nanticoke River, several point and nonpoint source loading scenarios were considered for the subbasin. The results of the analysis showed that to improve water quality conditions of the Nanticoke River, pollutant loads to the River should be significantly reduced. Based on the results of these scenario runs, DNREC proposed TMDLs for the Nanticoke River and Broad Creek. The proposed TMDLs call for implementation of the following action plans:

A. Implement Biological Nutrient Removal in the three large municipal wastewater treatment plants in the subbasin. These facilities include: Seaford STP, Bridgeville STP and Laurel STP.

B. Cap pollutant loads from the remaining sewage treatment plants in the subbasin to their present permitted loads.

C. Develop and implement Best Management Practices for all land use activities in the entire subbasin, so that nonpoint source nitrogen loads are reduced by 30 percent and nonpoint source phosphorus loads are reduced by 50 percent (from the 1992 baseline).

As a result of requests during the hearing, the deadline for submitting further comments was extended from September 18 to October 2, 1998. Following the hearing, the Department submitted a Response Document, addressing each public comment which is part of the record and is incorporated into this Order along with Exhibits A through L introduced by the Department at the hearing. The Hearing Officer prepared his Report and Recommendation dated November 5, 1998, which is also expressly incorporated herein.

II. FINDINGS AND CONCLUSIONS

A. Findings

1. Proper notice of the proceeding was provided as required by law and efforts to secure public participation went beyond the minimum requirements to include an extensive public outreach program as set forth in the introduction to the Response Document, attached hereto.
2. The following waterbodies are the subject of this rulemaking: Lower Nanticoke River (DE-240-001), Upper Nanticoke (DE-240-002) and Broad Creek (DE-50-001). These waterbody segments are over enriched with nitrogen and phosphorus and polluted with biochemical oxygen demanding (BOD) materials from point and nonpoint sources to an extent that requires significant reductions to achieve and maintain designated uses.
3. Consideration of financial or economic effects is not required under 303(d) of the Clean Water Act in setting TMDLs. However such factors will be included in establishing Pollution Control Strategies.

4. The Pollution Control Strategy will consider appropriate and cost effective measures designed to improve water quality.
5. Based on literature values and best professional judgment, nutrient concentrations of 3.0 mg/l nitrogen and 0.1 mg/l phosphorus are appropriate targets for these waters. Furthermore the application of a confidence limit of 20 percent for establishing the TMDLs is appropriate.
6. Nutrients in the Delaware portions of the Nanticoke River and Broad Creek originate from Delaware sources.
7. Differentiation between nonpoint sources of nutrients is not necessary to establish a TMDL which is concerned with the total loads entering the Nanticoke River and Broad Creek.
8. Point sources in these waters have made significant reductions in their discharges as a result of improvement of their treatment processes, however further reductions are necessary to meet the goals of the Clean Water Act.
9. The Clean Water Act and its implementing regulations require TMDLs for all water body segments that do not meet water quality standards, regardless of the fact that some local areas or downstream segments may meet standards.
10. Based on comments received, DNREC made a number of adjustments to its assumptions and data used in the model with regard to nutrient inputs from the S.C. Johnson plant. None of those changes affected the proposed TMDL.
11. Some facilities use groundwater sources for noncontact cooling water. These cooling waters are adding loads of nitrogen and phosphorus when they are discharged to the Nanticoke River and Broad Creek. Nutrient loads from these facilities are capped at their current levels in the proposed TMDL.
12. The modeling tool used to develop the proposed TMDL was developed by the U.S. EPA and has been widely used for similar systems. This model is an appropriate model for the Nanticoke River and Broad Creek.
13. The nonpoint source loading assumptions made for the model are appropriate and were validated when field data matched predicted results.
14. Appropriate field data and assumptions were used in the model. Furthermore, the assumptions used, load reduction scenarios and proposed TMDL were peer reviewed by the Interagency TMDL Workgroup.
15. Wastewater treatment plants that are meeting their waste load allocations established by this proposed TMDL are in compliance; further upgrades of these facilities will not be required. For those facilities not meeting their waste load allocations, any equivalent technology that will result in meeting the targets will be acceptable.

16. There is a sufficient margin of safety in the proposed TMDL for dissolved oxygen and nutrients based on the conservative assumptions used in developing the model and establishing the proposed TMDL.
17. The DuPont Gut is a tidally influenced tributary of the Nanticoke River with known beneficial uses. Due to its tidal nature, this tributary would exist regardless of DuPont's discharge. Hence DuPont Gut is considered to be waters of the State.
18. The Pollution Control Strategy will incorporate extensive stakeholder input into consideration of economic impacts and practicability for all measures determined to be necessary for compliance along with reasonable and achievable timetables.
19. The Clean Water Act does not require an implementation schedule as part of a TMDL; however, DNREC will proceed expeditiously in establishing the Pollution Control Strategy and to fully involve all stakeholders.
20. Concerns about disproportionate allocation of the burden of compliance with this TMDL will be addressed in the Pollution Control Strategy.
21. Failure to adopt the proposed TMDL will result in EPA action to usurp state management of the process and to impose the same requirements by the federal government.

B. <u>Conclusions</u>

Based on credible evidence in the record, the Department has a reasonable basis upon which to adopt the TMDL regulation as proposed at the hearing, notwithstanding some evidence in the record to the contrary.

III. ORDER

In view of the above findings and conclusions, it is hereby ordered that the proposed TMDLs as set forth in the record be adopted in final form and that the regulatory promulgation process move forward as required by law.

IV. REASONS

The record in this matter provides a reasonable basis to support the Department's proposed TMDL regulation, the adoption of which is necessary to remedy the existing severe nutrient overenrichment and low dissolved oxygen problems in the affected waterbodies.

Christophe A. G. Tulou, Secretary

Total Maximum Daily Load (TMDL) Regulation for Nanticoke River and Broad Creek, Delaware

A. INTRODUCTION and BACKGROUND

Intensive water quality monitoring performed by the Department of Natural Resources and Environmental Control (DNREC) and studies performed by others have shown that the Nanticoke River and Broad Creek are highly enriched with the nutrients nitrogen and phosphorus. Although nutrients are essential elements for both plants and animals, their presence in excessive amounts cause undesirable conditions. Symptoms of nutrient enrichment in the Nanticoke River and Broad Creek have included frequent phytoplankton blooms and large daily swings in dissolved oxygen levels. These symptoms threaten the future of the Nanticoke River Subbasin - very significant natural, ecological, and recreational resources of the State.

A reduction in the amount of nitrogen and phosphorous reaching the Nanticoke River and Broad Creek is necessary to reverse the undesirable effects. These nutrients enter the rivers from point sources and nonpoint sources. Point sources of nutrients are end-of-pipe discharges coming from municipal and industrial wastewater treatment plants and other industrial uses. Nonpoint sources of nutrients include runoff from agricultural and urban areas, seepage from septic tanks, and ground water discharges.

Section 303(d) of the Federal Clean Water Act (CWA) requires States to develop a list (303(d) List) of waterbodies for which existing pollution control activities are not sufficient to attain applicable water quality criteria and to develop Total Maximum Daily Loads (TMDLs) for pollutants of concern. A TMDL sets a limit on the amount of a pollutant that can be discharged into a waterbody and still protect water quality. TMDLs are composed of three components, including Waste Load Allocations (WLAs) for point source discharges, Load Allocations (Las) for nonpoint sources, and a Margin of Safety (MOS).

DNREC listed the Nanticoke River and Broad Creek on the State's 1996 and 1998 303(d) Lists and proposes the following Total Maximum Daily Load regulation for nitrogen and phosphorous.

B. Total Maximum Daily Loads (TMDLs) Regulation for the Nanticoke River and Broad Creek, Delaware

Article 1. Biological Nutrient Removal (BNR), or equivalent, processes shall be employed in three large municipal wastewater treatment plants in the Nanticoke River and Broad Creek Sub-basin. These three facilities include Seaford Sewage Treatment Plant, Bridgeville Sewage Treatment Plant, and Laurel Sewage Treatment Plant. This shall result in reducing nitrogen load from these three facilities from the current permitted load of 199 kilograms per day (439 pounds per day) to 100 kilograms per day (221 pounds per day). Reduction of phosphorous loads from these three facilities will be from the current permitted load of 33 kilograms per day (73 pounds per day) to 25 kilograms per day (55 pounds per day).

Article 2. For the remaining wastewater treatment plants in the watershed, discharge of nitrogen and phosphorous loads shall be capped at their current permitted loads. These loads are 568 kilograms per day (1252 pounds per day) of nitrogen and 1.0 kilograms per day (2.2 pounds per day) of phosphorous.

Article 3. The nonpoint source nitrogen load to the Nanticoke River and Broad Creek shall be reduced by 30 percent (from the 1992 base-line). This shall result in reduction of nitrogen loads during a normal rainfall year from 2274 kilograms per day (5013 pounds per day) to 1723 kilograms per day (3799 pounds per day).

Article 4. The nonpoint source phosphorus load to the Nanticoke River and Broad Creek shall be reduced by 50 percent (from the 1992 base-line). This shall result in reduction of phosphorous loads during a normal rainfall year from 54 kilograms per day (119 pounds per day) to 36 kilograms per day (79 pounds per day).

Article 5. Based upon hydrodynamic and water quality model runs and assuming implementation of reductions identified by Articles 1 through 4, DNREC has determined that, with an adequate margin of safety, water quality standards will be met in the Nanticoke River and Broad Creek.

Article 6. Implementation of this TMDL Regulation shall be achieved through development and implementation of a Pollution Control Strategy. The Strategy will be developed by DNREC in concert with the Department's ongoing Whole basin management Program and the affected public.

Department of Natural Resources and Environmental Control

Division of Water Resources

Statutory Authority: 7 Delaware Code, Chapter 60

Total Maximum Daily Load (TMDL) for Zinc in the White Clay Creek, Delaware

A. INTRODUCTION and BACKGROUND

Water quality monitoring performed by the Delaware Department of Natural Resources and Environmental Control (DNREC) and others has shown that the concentration of zinc in the White Clay Creek, downstream of Paper Mill Road in Newark, Delaware, occasionally exceeds applicable water quality standards for zinc. Although zinc is an essential element for both aquatic life and humans, excessive concentrations can adversely affect aquatic life and human health. Zinc concentrations in the White Clay Creek are not high enough to adversely affect people who drink water that is withdrawn from the White Clay Creek. Zinc concentrations do, however, occasionally exceed water quality criteria designed to protect fish and other aquatic life from the toxic affects of the metal.

A reduction in the amount of zinc reaching the White Clay Creek is necessary to assure that applicable water quality standards are met and beneficial stream uses are protected. Zinc enters the White Clay Creek primarily from nonpoint sources. Nonpoint sources of zinc in the White Clay Creek include background loading from the area of the White Clay Creek watershed upstream of Paper Mill Road, stormwater runoff of contaminated soils from the old National Vulcanized Fiber (NVF) Company facility in Newark, Delaware, and flux from Creek sediments to the overlying water column.

Section 303(d) of the Federal Clean Water Act (CWA) requires States to develop a list (303(d) List) of waterbodies for which existing pollution controls are not sufficient to attain applicable water quality standards. Section 303(d) also requires each state to develop Total Maximum Daily Loads (TMDLs) for those waterbodies and pollutants placed on the state's 303(d) List. A TMDL sets a limit on the amount of a substance that can enter a water body while still assuring that applicable water quality standards are met and beneficial stream uses are protected. A TMDL is composed of three components, including a Waste Load Allocation (WLA) for point source discharges, a Load Allocation (LA) for nonpoint sources, and a Margin of Safety (MOS) to account for uncertainties.

DNREC listed the White Clay Creek on Delaware's 1996 and 1998 303(d) Lists because applicable water quality standards for zinc were, and continue to be, occassionally exceeded. Therefore, DNREC is proposing the following Total Maximum Daily Load (TMDL) regulation for zinc in the White Clay Creek.

B. Total Maximum Daily Load (TMDL) Regulation for Zinc in the White Clay Creek, Delaware

Article 1. The TMDL for zinc in the White Clay Creek shall be 6.73 pounds per day, measured as total zinc.

Article 2. The mass loading of zinc to the White Clay Creek from the NVF, Newark facility property (i.e., LA_{NVF}) shall not exceed 3.5 pounds of zinc per day, measured as total zinc.

Article 3. The load allocation of zinc from the area upstream of Paper Mill Road (i.e., LA_{up}) shall be capped at 3.07 pounds per day, measured as total zinc.

Article 4. The margin of safety (MOS) for the TMDL listed in Article 1 has been set at 0.16 pounds of zinc per day. This margin of safety (approximately 2% of the TMDL) reflects the modest data set and the highly conservative approach used to establish the TMDL, while at the same time accounting for uncertainties associated with sediment processes in the Creek.

Article 5. DNREC has determined with a reasonable degree of scientific certainty that water quality standards for zinc will be met in the White Clay Creek once the mass loading requirements of Articles 1 through 3 are met.

Article 6. Implementation of this TMDL Regulation shall be achieved through the development of a Pollution Control Strategy. The Strategy will be developed by DNREC in concert with affected parties, the interested public, and the Department's ongoing Whole Basin Management Program. The manner in which the 3.5 pounds per day that is noted in Article 2 above is achieved shall be one particular area of focus as part of the Pollution Control Strategy. The Pollution Control Strategy will also consider how monitoring will be conducted to verify compliance with the TMDL.

Department of Natural Resources and Environmental Control

Division of Water Resources

Statutory Authority: 7 Delaware Code, Chapter 60

Total Maximum Daily Load (TMDL) for Zinc in the Red Clay Creek, Delaware

A. INTRODUCTION and BACKGROUND

Water quality monitoring performed by the Delaware Department of Natural Resources and Environmental Control (DNREC) and others has shown that the Red Clay Creek, adjacent to and downstream of Yorklyn, Delaware, does not meet applicable water quality standards for zinc. Although zinc is an essential element for both aquatic life and humans, excessive concentrations can adversely affect aquatic life and human health. Zinc concentrations in the Red Clay Creek are not high enough to adversely affect people who drink water that is withdrawn from the Red Clay Creek. Zinc concentrations do, however, frequently exceed water quality criteria designed to protect fish and other aquatic life from the toxic affects of the metal.

A reduction in the amount of zinc reaching the Red Clay Creek is necessary to assure that applicable water quality standards are met and beneficial stream uses are protected. Zinc enters the Red Clay Creek from point sources and nonpoint sources. The National Vulcanized Fiber (NVF) Company located in Yorklyn, Delaware, is the only permitted point source discharge of zinc to the Red Clay Creek in Delaware. Nonpoint sources of zinc in the Red Clay Creek include background loading from the area of the Red Clay Creek watershed upstream of Yorklyn, seepage of contaminated groundwater from beneath the NVF facility to the Red Clay Creek, and diffusive flux from Creek sediments to the overlying water column.

Section 303(d) of the Federal Clean Water Act (CWA) requires States to develop a list (303(d) List) of waterbodies for which existing pollution controls are not sufficient to attain applicable water quality standards. Section 303(d) also requires each state to develop Total Maximum Daily Loads (TMDLs) for those waterbodies and pollutants placed on the state's 303(d) List. A TMDL sets a limit on the amount of a substance that can enter a water body while still assuring that applicable water quality standards are met and beneficial stream uses are protected. A TMDL is composed of three components, including a Waste Load Allocation (WLA) for point source discharges, a Load Allocation (LA) for nonpoint sources, and a Margin of Safety (MOS) to account for uncertainties.

DNREC listed the Red Clay Creek on Delaware's 1996 and 1998 303(d) Lists because applicable water quality standards for zinc were, and continue to be, frequently exceeded. Therefore, DNREC is proposing the following Total Maximum Daily Load (TMDL) regulation for zinc in the Red Clay Creek.

B. Total Maximum Daily Load (TMDL) Regulation for Zinc in the Red Clay Creek, Delaware

Article 1. The TMDL for zinc in the Red Clay Creek shall be 1.81 pounds per day, measured as total zinc.

Article 2. The combined mass loading of zinc to the Red Clay Creek from NVF's permitted discharge 002 (i.e., WLA_{002}), plus the mass loading of zinc to the Red Clay Creek from contaminated groundwater beneath the NVF property (i.e., $LA_{g..w.}$) shall not exceed 1.2 pounds of zinc per day, measured as total zinc.

Article 3. The load allocation of zinc from the area upstream of Yorklyn (i.e., LA_{up}) shall be capped at 0.6 pounds per day, measured as total zinc.

Article 4. The margin of safety (MOS) for the TMDL listed in Article 1 has been set at 0.01 pounds of zinc per day. This small margin of safety (less than 1% of the TMDL) reflects the robust data set and the conservative approach used to establish the TMDL, while still accounting for the uncertainty associated with possible diffusion of zinc from Red Clay Creek sediments.

Article 5. DNREC has determined with a reasonable degree of scientific certainty that water quality standards for zinc will be met in the Red Clay Creek once the mass loading requirements of Articles 1 through 3 are met.

Article 6. Implementation of this TMDL Regulation shall be achieved through the development of a Pollution Control Strategy. The Strategy will be developed by DNREC in concert with affected parties, the interested public, and the Department's ongoing Whole Basin Management Program. The manner in which the 1.2 pounds per day that is noted in Article 2 above is allocated between discharge 002 and the contaminated groundwater discharge shall be one particular area of focus as part of the Pollution Control Strategy. The Pollution Control Strategy will also consider how monitoring will be conducted to verify compliance with the TMDL.