State of Delaware
2002 Watershed Assessment Report
(305(b))

Department of Natural Resources and Environmental Control
August 1, 2002

Preface

The 2002 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. 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 1996 through August 2001.

There are three appendices to the report. Appendix A is the data provided by citizen monitoring programs. Appendix B contains annual Fish Kill reports and Appendix C is the 2001 Nutrient Management Commission Annual Report.

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

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Part I Executive Summary

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:

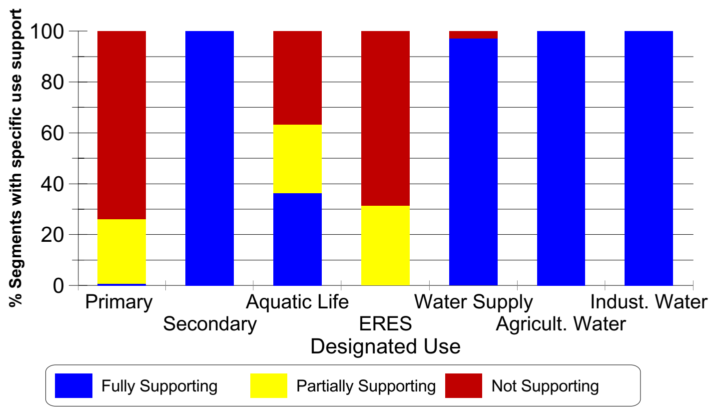
- TMDL-Related Monitoring
- General Assessment Monitoring
- Toxics in Biota Monitoring
- Toxics in Sediment Monitoring
- Biological Assessment Monitoring

I.1.1 Delaware Rivers and Lakes

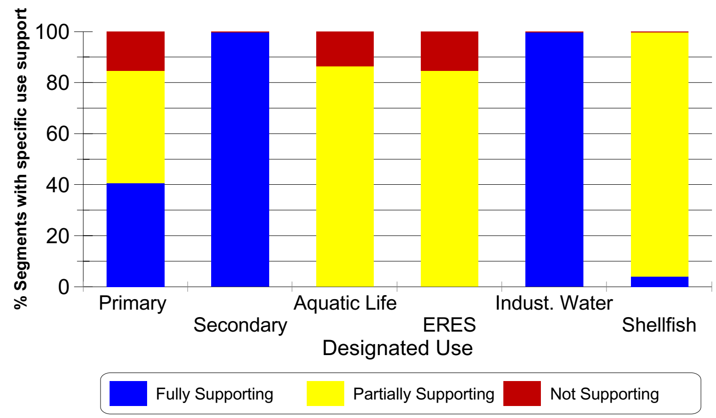
Delaware has more than 2509 miles of rivers and streams, and 2,954 acres of lakes and ponds that have been classified using a rating system called for in the Federal Clean Water Act. The classification system is keyed to a management program designed to protect uses of the waters (referred to as "designated 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 99% of Delaware's rivers and streams do not fully support the swimming use and 64% 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.

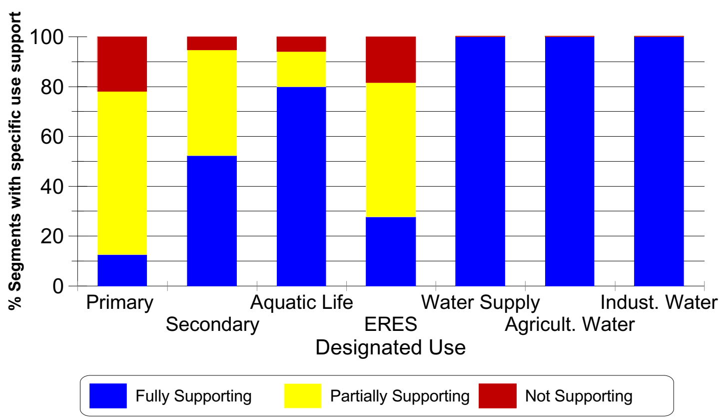
Ponds and lakes in Delaware exhibit many of the same problems as rivers and streams. However, ponds and lakes also serve as "catch basins" for a variety of pollutants that are washed from the land and the air into these water bodies. Two indicators which show the tendency for lakes and ponds to accumulate 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 87% of Delaware's fresh water ponds and lakes do not fully support the swimming use and 21% do not fully support the fish and wildlife use.



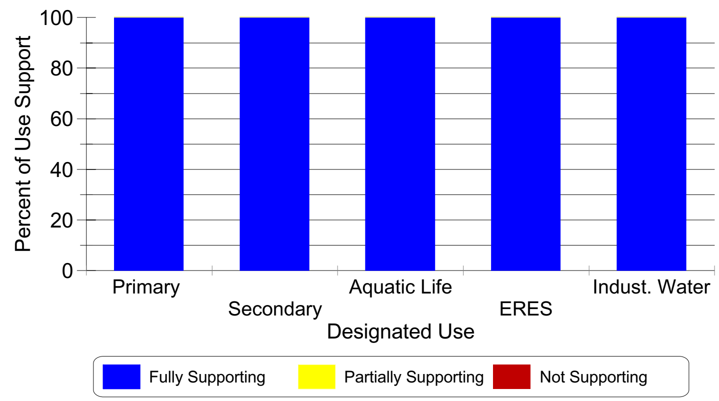
Rivers



Estuaries



Lakes



Shorelines

Figure I-1 Designated Use Support for Waters of the State (2002)

I.1.2 Wetlands in Delaware

Wetlands have many important functions and values to society. They provide fish and wildlife habitat, help maintain water quality, and provide indirect socioeconomic values such as flood and storm water damage protection. With the implementation of federally mandated regulations known as Total Maximum Daily Loads (TMDLs) 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.

Wetlands comprise a significant portion of the water resources of Delaware covering over 300,000 acres (about 470 square miles or 23%) of the state. Throughout the state a wide diversity of wetland types occur including both tidal and nontidal wetlands. While some wetlands are directly connected or adjacent to other surface waters such as salt marshes and floodplains, others occur as isolated areas surrounded by uplands such as forested flats and Delmarva Bays. Preserving the abundance, quality, diversity and proportion of different types of wetlands in the landscape is essential to protecting the natural resources and waters of Delaware. Currently the State of Delaware is actively working in each of these areas to protect our high quality wetland resources and restore degraded systems on the watershed scale.

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 99% of Delaware's rivers and streams, 87% 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

Eutrophication of surface waters is a natural process, spanning hundreds to thousands of years, resulting from natural erosion and the breakdown of organic material. Over these extended periods many lakes and ponds under natural conditions would be expected to fill in with sediments and organic materials, eventually becoming marshes and meadows. Lakes and ponds in various stages of eutrophication 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 eutrophication process. 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 I-2

Use Support Levels in Waters of the State

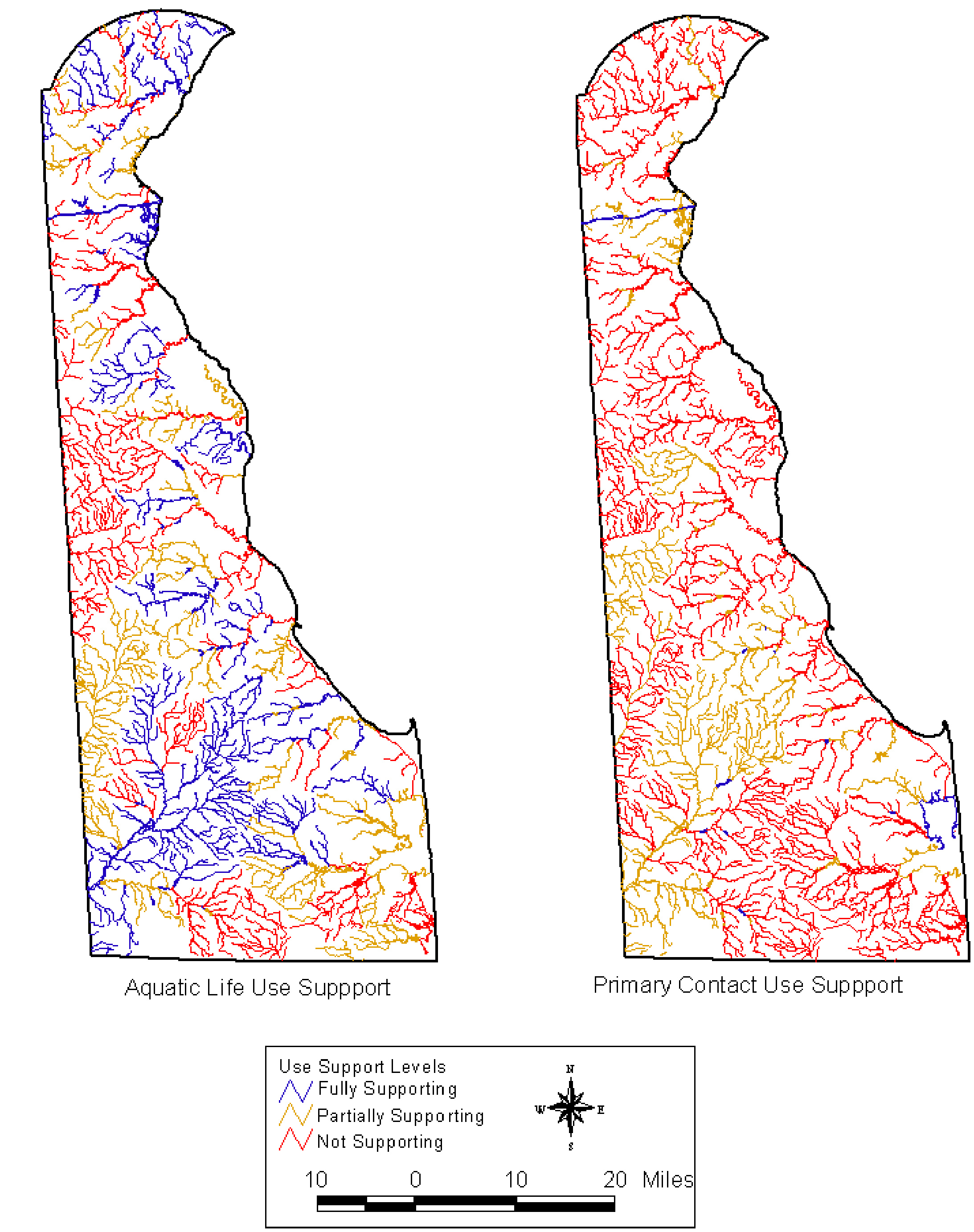
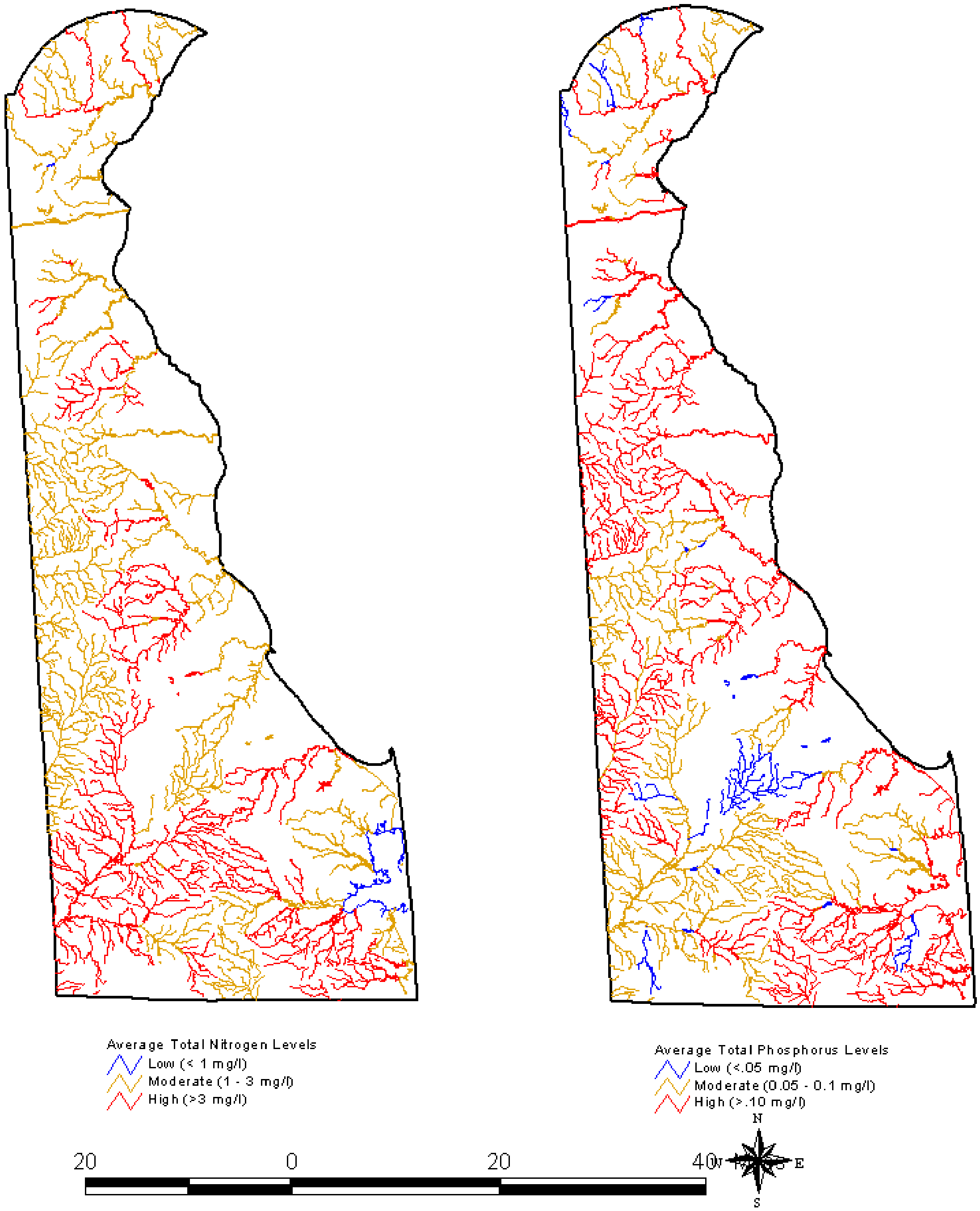


Figure I-3

Nutrient Levels in Waters of the State



Only segments with data in the period of September 1996 through August 2001 are shown in these 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 Department of Natural Resources and Environmental Control and the Department of Health and Social Services issued fish consumption advisories for twenty one waterbodies in the state in February of 2002. There was one new advisory and twenty prior advisories were reaffirmed. See the table in section III Chapter 4 and Figure III-6.

I.1.5.1 National Methylmercury Fish Consumption Advisory

On January 12, 2001, EPA and the Food and Drug Administration (FDA) issued concurrent national fish consumption advisories recommending restricted consumption of freshwater coastal and marine species of fish due to methylmercury contamination. EPA's advisory targeted women of childbearing age and children who may be consuming noncommercial freshwater fish caught by family or friends. The advisory specifically recommends that women who are pregnant or could become pregnant, women who are nursing a baby, and their young children, should limit consumption of freshwater fish caught by family and friends to one meal per week unless the state health department has different advice for the specific waters where the fish are caught. For adults, one meal is six ounces of cooked fish or eight ounces uncooked fish; for a young child, one meal is two ounces of cooked fish or three ounces of uncooked fish.

I.1.6 Fish Kill Investigations in 2000 and 2001

The Division of Fish and Wildlife investigated thirty four fish kills in 2000 and twenty three in 2001. The investigations in 2000 were the highest number of incidents since record keeping began in 1980. Determining the cause of fish kills is problematic since chemical and biological data is not usually available about water quality conditions that precede the event. Many of the incidents were suspected to be the result of low dissolved oxygen content in the water. In the Inland Bays, the situation is complicated by the presence of *Pfiesteria* organisms in the water. Additionally, a previously undescribed (in Delaware) potentially toxic organism, *Chattonella cf. verruculosa* was discovered in water samples throughout the Bays during 2000. Reports for each year are in the appendix to this report. Figure 1-6 shows the locations of investigations and reported numbers of fish killed.

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 and nonpoint 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

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.

Ground water in Delaware is 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 anthropogenic 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.).

In the previous three 305 (b) reports, the summaries of basin assessments for ground water were included. These included those for the Piedmont Basin, Inland Bays/Atlantic Ocean Basin, and the Chesapeake Bay Basin. DNREC is drafting the remaining basin report, namely that for the Delaware River and Bay Basin. That report should be available for inclusion in the next 305 (b) report. In addition, DNREC has begun updating the Piedmont Basin Assessment Report.

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 45 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 have begun 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.

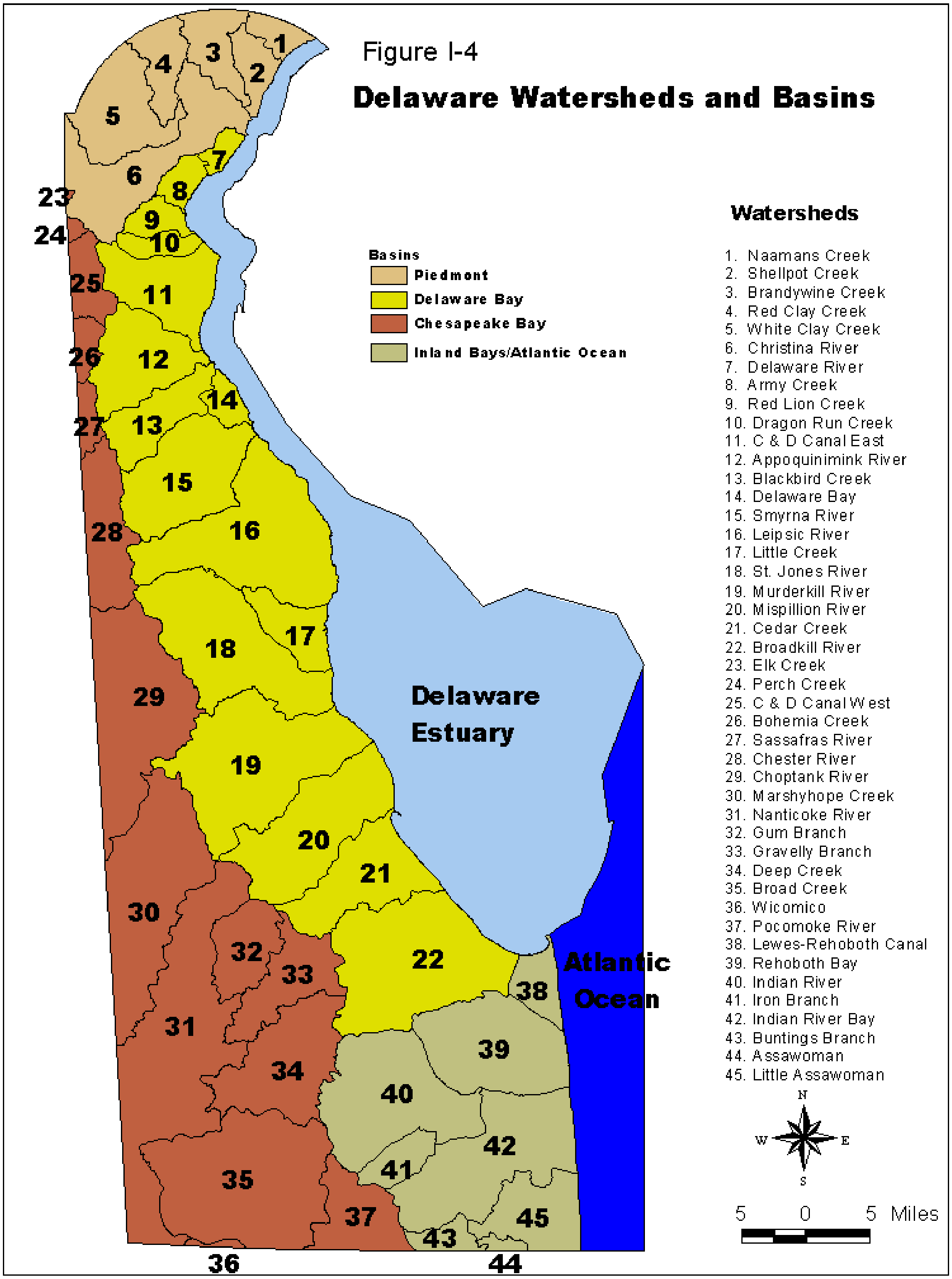
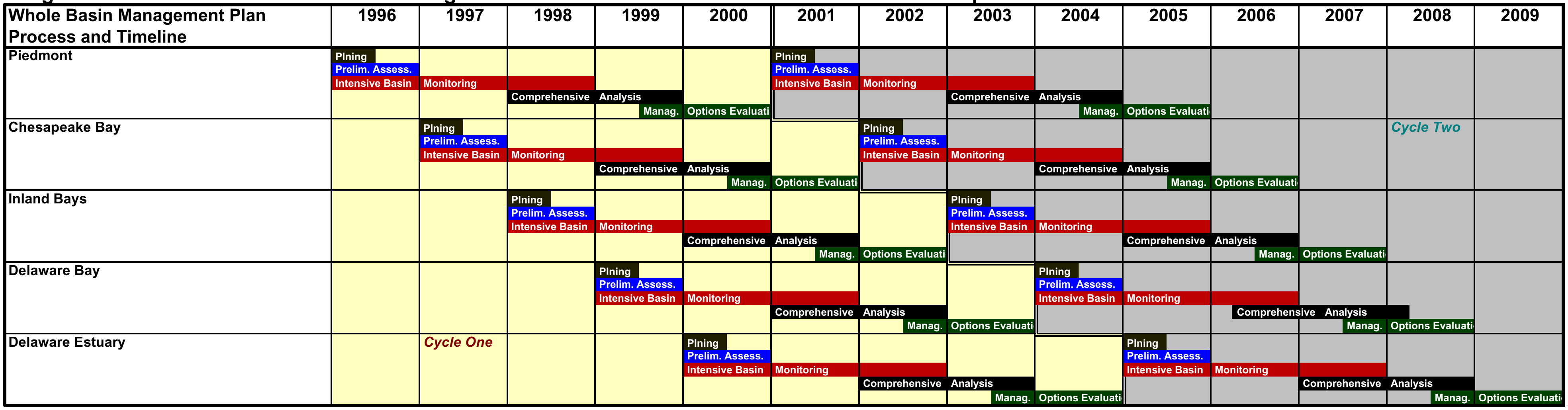


Figure I-4
Delaware Watersheds and Basins
Basins
Piedmont
Delaware Bay
Chesapeake Bay
Inland Bays/Atlantic Ocean
Watersheds
1. Naamans Creek
2. Shellpot Creek
3. Brandywine Creek
4. Red Clay Creek
5. White Clay Creek
6. Christina River
7. Delaware River
8. Army Creek
9. Red Lion Creek
10. Dragon Run Creek
11. C & D Canal East
12. Appoquinimink River
13. Blackbird Creek
14. Delaware Bay
15. Smyrna River
16. Leipsic River
17. Little Creek
18. St. Jones River
19. Murderkill River
20. Mispillion River
21. Cedar Creek
22. Broadkill River
23. Elk Creek
24. Perch Creek
25. C & D Canal West
26. Bohemia Creek
27. Sassafras River
28. Chester River
29. Choptank River
30. Marshyhope Creek
31. Nanticoke River
32. Gum Branch
33. Gravelly Branch
34. Deep Creek
35. Broad Creek
36. Wicomico
37. Pocomoke River
38. Lewes-Rehoboth Canal
39. Rehoboth Bay
40. Indian River
41. Iron Branch
42. Indian River Bay
43. Buntings Branch
44. Assawoman
45. Little Assawoman
Delaware Estuary
Atlantic Ocean
N
W
E
S
5 0 5 Miles

Integration of Delaware's Whole Basin Management Plan Process and Timeline and TMDL Development Process Schedule



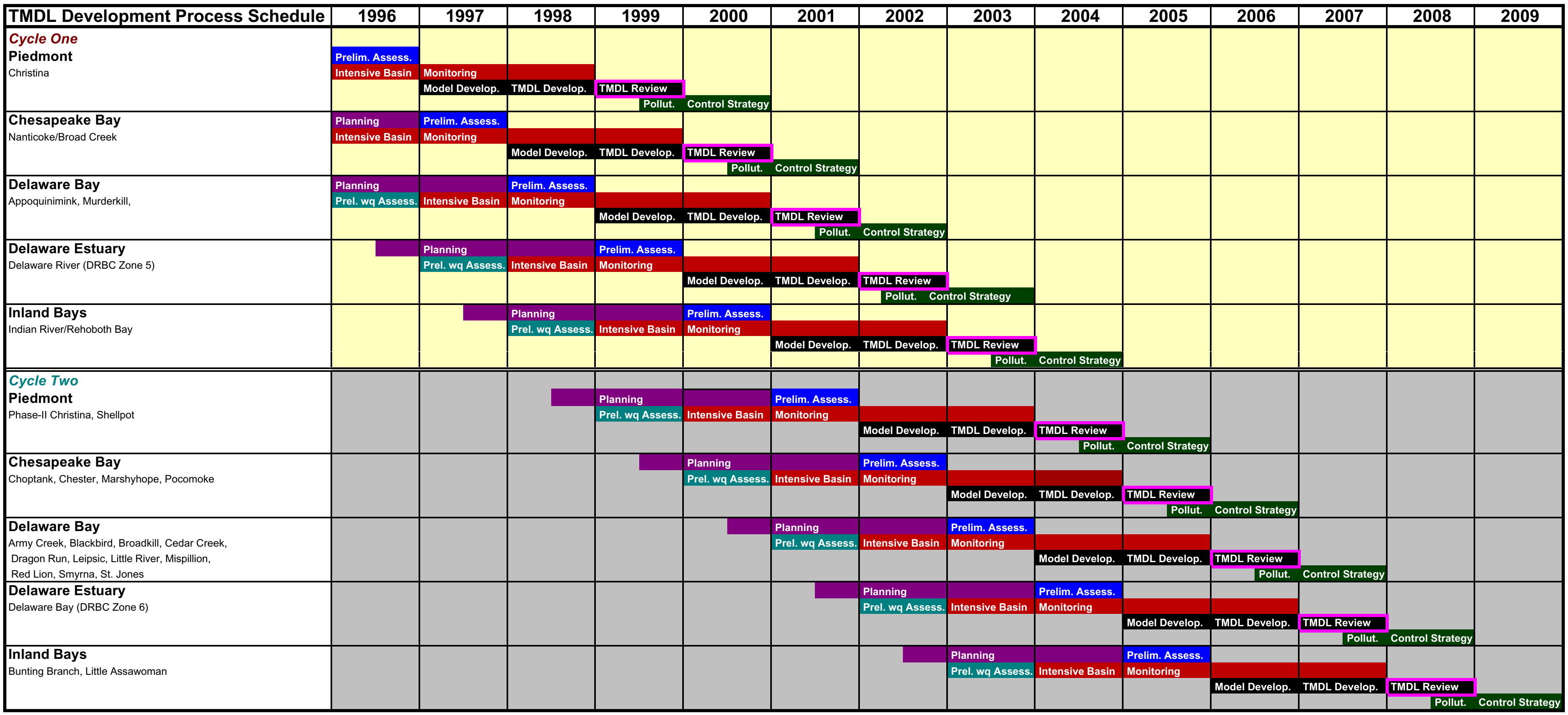
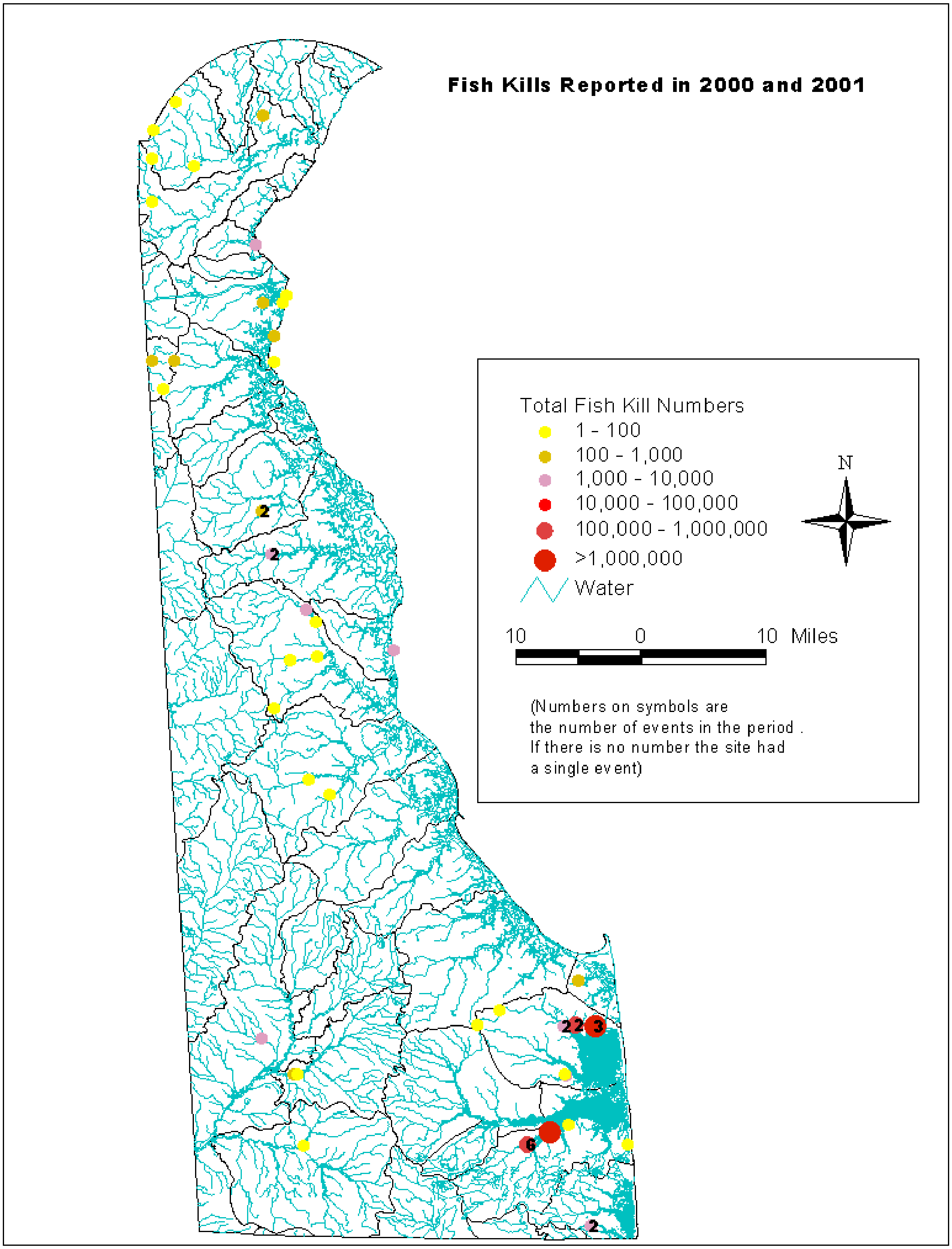


Figure I-6


Fish Kills Reported in 2000 and 2001
Total Fish Kill Numbers
1 - 100
100 - 1,000
1,000 - 10,000
10,000 - 100,000
100,000 - 1,000,000
>1,000,000
Water
N
10
0
10 Miles
(Numbers on symbols are
the number of events in the period .
If there is no number the site had
a single event)
2
2
2
2
3
6
2

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 discharge of nutrients and oxygen consuming matters 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.
6. Christina River Sub-basin. A low-flow nutrient and dissolved oxygen TMDL was established in January 2001 for the entire Christina River sub-basin in Delaware, Pennsylvania, and Delaware. The TMDL requires reduction of discharge of nutrients and oxygen consuming matters from several point source facilities in the sub-basin.
7. Murderkill River Watershed. A nutrient and dissolved oxygen TMDL for the Murderkill River watershed was established in December 2001. The Murderkill River TMDL requires reduction of discharge of nutrients and oxygen consuming matters from point source facilities in the watershed. In addition, it requires that nonpoint sources of nutrients (nitrogen and phosphorous) be reduced by 30 to 50 percent.

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

- Little Assawoman Bay and tributaries and ponds of the Indian River, Indian River Bay, and Rehoboth Bay
- PCB TMDL for Delaware River and Bay (in cooperation with Delaware River Basin Commission and U.S. Environmental Protection Agency Region 3)
- High-flow TMDL for the Christina River sub-basin

- Bacteria TMDL for the Christina River sub-basin.

I.3.1.1 Pollution Control Strategies

Pollution Control Strategies (PCSs) are plans to achieve the pollutant and nutrient load reductions delineated by Total Maximum Daily Loads (TMDLs). They describe the specific actions that are needed to achieve water quality standards and provide a schedule for implementing those actions. PCSs are being developed for four watersheds: Inland Bays (Rehoboth Bay, Indian River and Bay, and Little Assawoman Bay); Nanticoke River and Broad Creek; Murderkill River; and, Appoquinimink River. The PCSs, for these watersheds, are being recommended by diverse groups of citizens (including government officials) called Tributary Action Teams (TATs). These TATs work with the Department's Whole Basin Management Teams and other experts during the process of formulating the PCSs.

The Inland Bays Tributary Action Team, convened by the Center for the Inland Bays, has worked diligently in providing the Department with two sets of recommendations for their PCS. This Team, facilitated by Bill McGowan of the Cooperative Extension, and Joe Farrell, of Delaware Sea Grant, is closest to submitting a final recommended PCS.

The Appoquinimink River Tributary Action Team, convened by members of the Appoquinimink School District, has also worked hard to educate their community while formulating a draft recommended PCS. The Team created a speaker's bureau that made presentations on water quality for community group meetings. They currently have a monthly column in the Middletown Transcript and are close to submitting their first draft PCS.

The Cooperative Extension Service convened the Nanticoke watershed's TAT. This group of concerned residents will be striving to make their recommendations by the end of the 2002.

In the Murderkill River watershed, the Division of Water Resources teamed with the Division of Parks and Recreation to convene the Murderkill TAT at Killens Pond State Park. This Team, formed in 2001, actually began its work before the promulgation of the Murderkill TMDL in December 2001. They have scheduled two public forums for 2002—one in May and another in August.

I.3.2 Delaware Coastal Nonpoint 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.

I.3.3 Delaware Riparian Buffer Initiative

The purpose of the Delaware Riparian Buffer Initiative is to develop priority buffer goals (water quality, wetland and forest habitat protection, erosion control, etc.) and design criteria (widths, vegetation types, etc.). The Delaware Coastal Programs through a series of workshops, meetings, and a literature review of current buffer science is leading this effort through an EPA Wetlands Development Grant. This effort will direct the development of an ArcView GIS application that will offer many advantages in the designing and planning for riparian buffers in the State of Delaware.

The ArcView GIS application will consist of two separate but complementary modules – the Planning Module and the Site Design Module. The Planning Module will enable users to work on a watershed scale to identify riparian and vegetated wetland areas within a watershed that have or do not have vegetated buffers, to review the connectivity between riparian areas and plan for riparian corridors, and to prioritize targeting for riparian buffers. The Site Design Module will allow users to design a riparian buffer based upon the specific needs of the parcel scale site by identifying the priority goal – water quality, erosion control or wildlife habitat enhancement and considering the site's conditions (soil type, slope, etc.) in applying a buffer design.

Local, State, and Federal governments across the country have recognized the benefits of riparian buffers, including protection of water quality, preservation of flood plains, wetlands, and other important wildlife habitats. Because riparian buffers provide so many different benefits, they can be used to serve many purposes. Grassed or tree-lined buffers at the edge of farm fields trap sediment and filter pesticides and fertilizer. Buffers in urban environments slow stormwater runoff from roads and parking lots. And buffers everywhere offer food and habitat for wildlife, as well as recreational opportunities for people.

The Delaware Riparian Buffer Initiative will help to shed light on the proper design, and planning for buffers while protecting water quality, enhancing wildlife habitat and providing recreational opportunities for the citizens of Delaware

I.3.4 Delaware Nutrient Management Commission

The Nutrient Management Act established a 19-member commission that is charged to develop, review, approve, and enforce regulations governing the certification of individuals engaged in the business of land application of nutrients and the development of nutrient management plans. The members of this commission come from many different backgrounds and professions. The Delaware Nutrient Management Commission's official mission is:

"To manage those activities involving the generation and application of nutrients in order to help improve and protect the quality of Delaware's ground and surface waters, sustain and promote a profitable agricultural community, and to help meet or exceed federally mandated water quality standards, in the interest of the overall public welfare.

The mission of The Delaware Nutrient Management Commission is to:

- Consider establishing critical areas for voluntary and regulatory programs.
- Establish Best Management Practices to reduce nutrients in the environment.
- Develop educational and awareness programs.
- Consider incentive programs to redistribute nutrients.
- Establish the elements and general direction of the State Nutrient Management Program.
- Develop nutrient management regulations.

The complete 2001 Nutrient Management Commission annual report is included as an appendix to this documents.

Part II Background

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 1996 through August 2001.

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 that 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]	783,600
State Surface Area	1981 square miles
Number of Basins	5
Number of Watersheds	45
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	226,530
Acres of Tidal Wetlands	127,338

1. U.S. Census Bureau, 2000 Census of Population, Public Law 94-171 Redistricting Data File.

2. Surface area for Delaware River Zone 5 and Delaware Bay provided by the Delaware River Basin Commission (DRBC), 1994 -1995 305(b) Report. For purposes of this report, Delaware reports on the Inland Bays and DRBC reports on the Delaware River and Bay.

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

Surface Water Assessments

III.1 Chapter 1 Monitoring Programs

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.

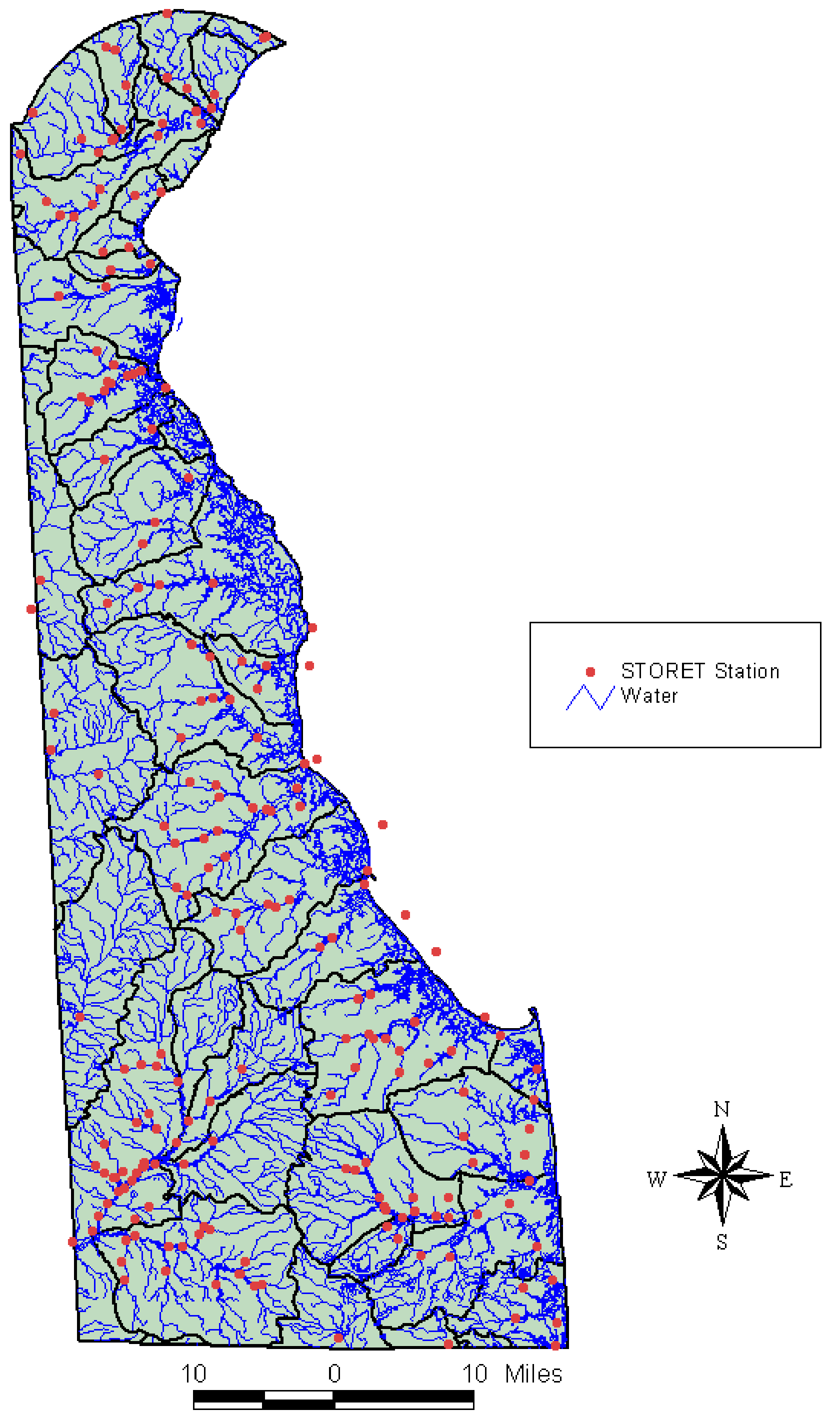
The TMDL related monitoring is designed to provide the necessary information for developing, calibrating, and verifying hydrodynamic and water quality models and/or to support the existing models. The Department uses the hydrodynamic and water quality models as management tools for establishing total 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 Stations in the 2002 305(b) Report



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

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.1.3 Becks Pond Work Group

Becks Pond is one of only two public ponds located in heavily-populated New Castle County. The pond is owned by the Delaware Division of Fish & Wildlife, DNREC, but leased to New Castle County's Community Services Section (NCC). The location of this pond, within an hour's drive of 75% of the State's population, has resulted in heavy use of the pond by anglers (Martin and Whitmore 2000); Becks Pond has been the most heavily-fished pond in Delaware on an area basis (642 angler trips per acre). Heavy development has occurred in the watershed, much of it prior to the Delaware Stormwater Management Act of 1991, resulting in an increase in urbanized land-use from 17% in 1981 (Ritter) to 38.3% by 1994 (Duffield Associates).

Historically, management by the Division of Fish & Wildlife (DFW) has focused on maintaining the pond fish populations to support the heavy demand for recreational angling opportunities. Warmwater fishes such as largemouth bass, black crappie, bluegill, and chain pickerel supported the sport fishery, with the largemouth bass being the primary target. Active management, initiated with the promulgation of restricted bag and size limits in 1984, resulted in substantial recovery of the fish populations. However, poor water quality has limited improvements to the sport fishery and impacted other water-based recreational activities.

A County park was established adjacent to the pond during the early 1970s to provide swimming and picnicking areas, in addition to fishing and boating activities. Total attendance for the swimming area exceeded 10,000 in 1987 (Duffield Associates 1994). However, high levels of *Enterococcus* bacteria and poor water clarity resulted in the periodic closures of the swimming area. The closure became permanent by 1990, so use of the pond by non-anglers has declined (Duffield Associates 1994).

The DFW considered this heavily-fished pond to be a high priority and initiated the formation of a Becks Pond Work Group in March, 2000 to summarize available data, determine data gaps, obtain needed information, and formalize a work plan for the Pond. The Group consists of state, federal, and county agencies in addition to anglers and shoreline residents.

Activities undertaken by the Work Group during 2001 included:

- Collection of data on summer bacteriological levels for a decision about the future possibility of swimming in the pond.
- Measurements of stormwater inputs (total suspended solids, BOD, and CBOD) from Belltown Run and two branches of Salem Run.
- Deployment of remote dataloggers to sample mid-depth water quality parameters (DO, pH, temperature) at two sites in the pond for analysis of the diurnal DO pattern.
- Bathymetric survey of the lower third of the pond to determine the volume of soft sediments.

The major findings of the Work Group to date are:

- The presence of an anoxic area that occurs in the lower portion of Becks Pond during the summer months is not due to algal activity. It is driven by sediment oxygen demand due to historical deposition of organic material.
- Counts of *Enterococcus* bacteria remain above the standard for primary contact recreation at some times.

- Historical and current turbidity levels in the pond are a result of silt deposited in the pond that becomes resuspended following storm events.
- A fish consumption advisory for all finfish harvested from the pond was posted in 1999. The contaminants of concern were PCBs and mercury.

Discussions within the Work Group have suggested some corrective measures to be taken for the improvement the water quality within this pond. The approach should be two-pronged, to include limiting the continued input of sediment with its associated bacteria and nutrients, and devising a strategy to remove or inactivate the accumulated soft sediment within the pond. An Action Plan is currently being developed.

Improvements of facilities in and around the pond as a result of the formation of this Work Group have included:

- Replacement of old dam boards to allow the water to reach historical levels.
- Replacement of the boat ramp.
- Construction of two gazebos for use by park visitors.
- Development of an emergency water adjustment plan between the DFW and NCC for a proactive response to the threat of major storm events.
- Development of a better working relationship among the various governmental agencies and community users of the pond.

Literature Cited:

Duffield Associates. 1994. Phase I diagnostic/ feasibility study for Becks Pond. EPA Region III, Philadelphia. EPA Grant s-003588-01-1.

Martin, C.C. and W. H. Whitmore. 2000. Survey of Delaware fishing activity by licensed anglers during 1998. Annual Report Federal Aid in Fisheries Restoration Project F-41-R-11. Delaware Division of Fish and Wildlife, Dover.

Ritter, W. F. 1981. Survey and classification of Delaware's public lakes. Report Prepared for the Division of Fish and Wildlife, DE Department of Natural Resources and Environmental Control, Dover. Citizen's Monitoring Programs in Delaware

III.1.4 Citizens 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. The Delaware Nature Society in cooperation with DNREC established Delaware Stream Watch in 1985. The Inland Bays Citizen Monitoring program was established in 1990 as part of the Inland Bays Estuary Program. Concerned citizens of the City of Seaford in cooperation with DNREC founded the Nanticoke Citizen Monitoring Program in 1991. 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.1.4.1 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.1.4.1.1 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.1.4.1.2 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.

The following summary of results from the program has been provided by the Stream Watch Program :

"The State of the Christina Basin Watershed

Summary of Conditions in the White Clay Creek, Red Clay Creek, Brandywine, and Christina River sub-basins

The Christina Basin covers 564 miles in Delaware and Pennsylvania. Technical Monitoring Volunteers test water quality at 30 locations in the Delaware portion and have collected monthly chemical data since the end of 1995.

Data for all four sub-basins indicate that water temperature, pH, alkalinity and conductivity are relatively consistent and meet state standards. Of greatest concern for the watershed are low levels of dissolved oxygen during the summer and the amount of nutrients that enter the waterway. Low levels of dissolved oxygen can cause fish kills and can limit the biological diversity of the stream since aquatic organisms need the oxygen in the water just as we need the oxygen in the air. Our results indicate that the state standards for dissolved oxygen were met during the day, however, additional monitoring, especially during the night, may reveal that these standards are not being met. Low levels of dissolved oxygen are caused by several factors, including high water temperatures and excess nutrients.

The presence of excess nutrients such as nitrate-nitrogen is also a threat to the Christina Basin watershed. Excess nutrients impact wildlife indirectly by lowering dissolved oxygen levels and encouraging the proliferation of undesirable species of algae. Results indicate that the suggested levels of total nitrogen are being exceeded in the main stems of White Clay Creek, Red Clay Creek, Brandywine and the Christina River. Nitrates and other nutrients enter local waterways from backyards, farms, golf courses, and sewage treatment plants.

Individual reports have been compiled for all four sub-basins and will soon be available on the Delaware Nature Society's website at www.delawarenaturesociety.org."

III.1.4.1.3 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 survey 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.1.4.1.4 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.1.4.1.5 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.1.4.1.6 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.delawarenaturesociety.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 coliforms 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.1.5 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, 1996 to August 31, 2001.

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, 1996.

III.2.4 Data Analysis

Water quality data for the assessments was retrieved for the period of September 1, 1996 through August 31, 2001. Data collected after August 31, 2001 was reviewed when available. In instances where data for a water body was not available for the 1996 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 (ALUS)

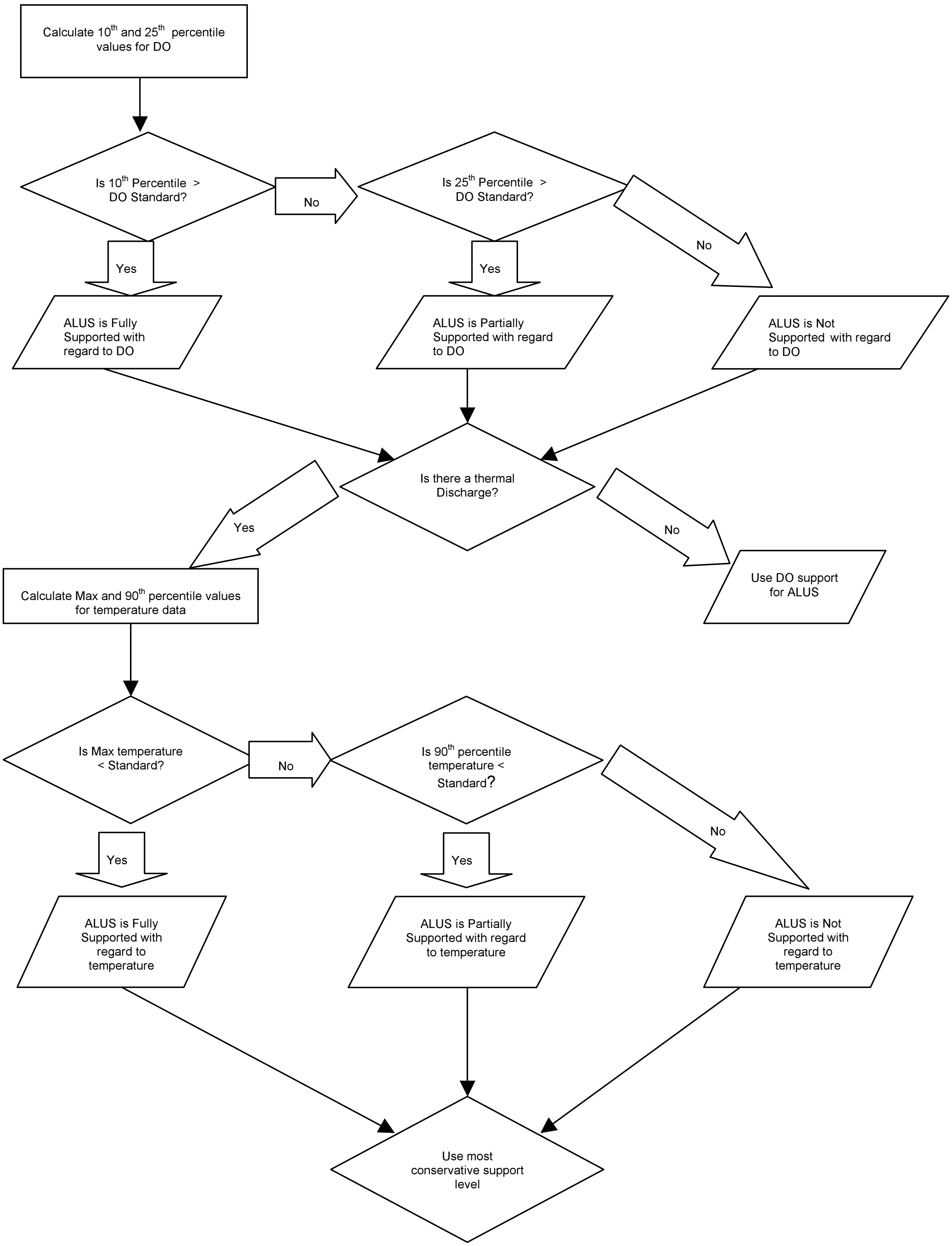
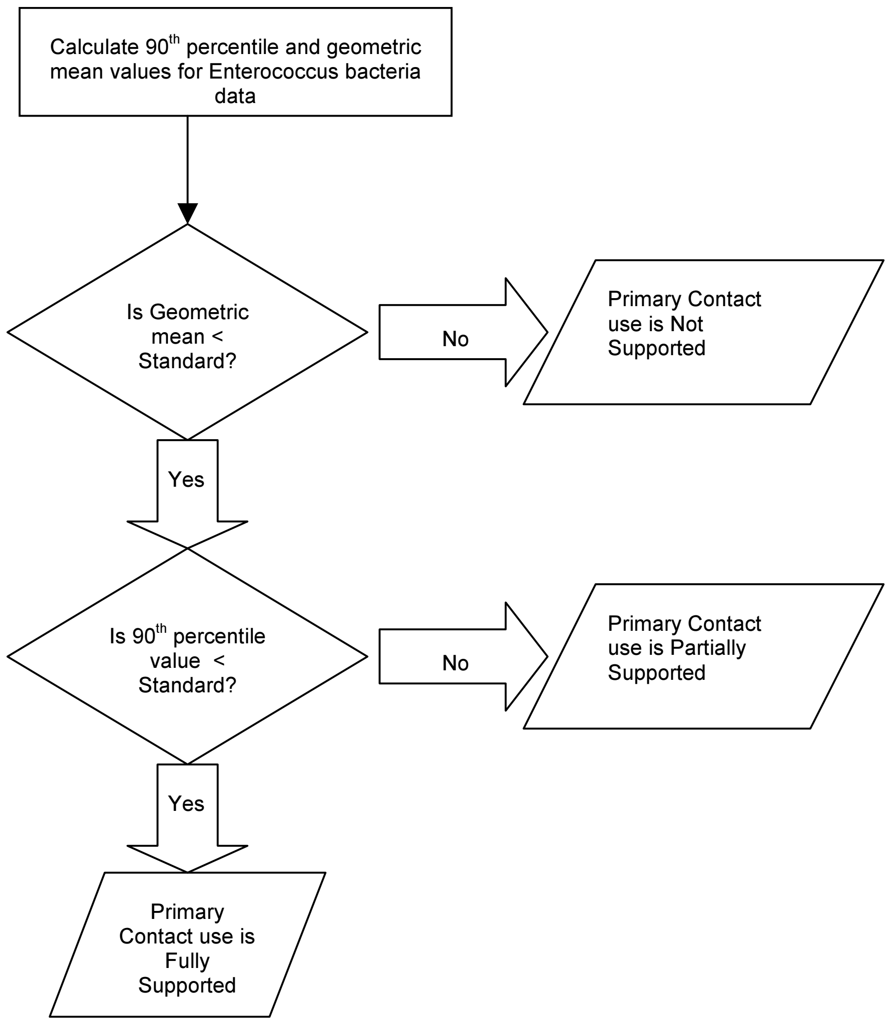


Figure III-3

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, 1996 through August 31, 2001, 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.

Shellfish Growing Area Classification

FIGURE III-4

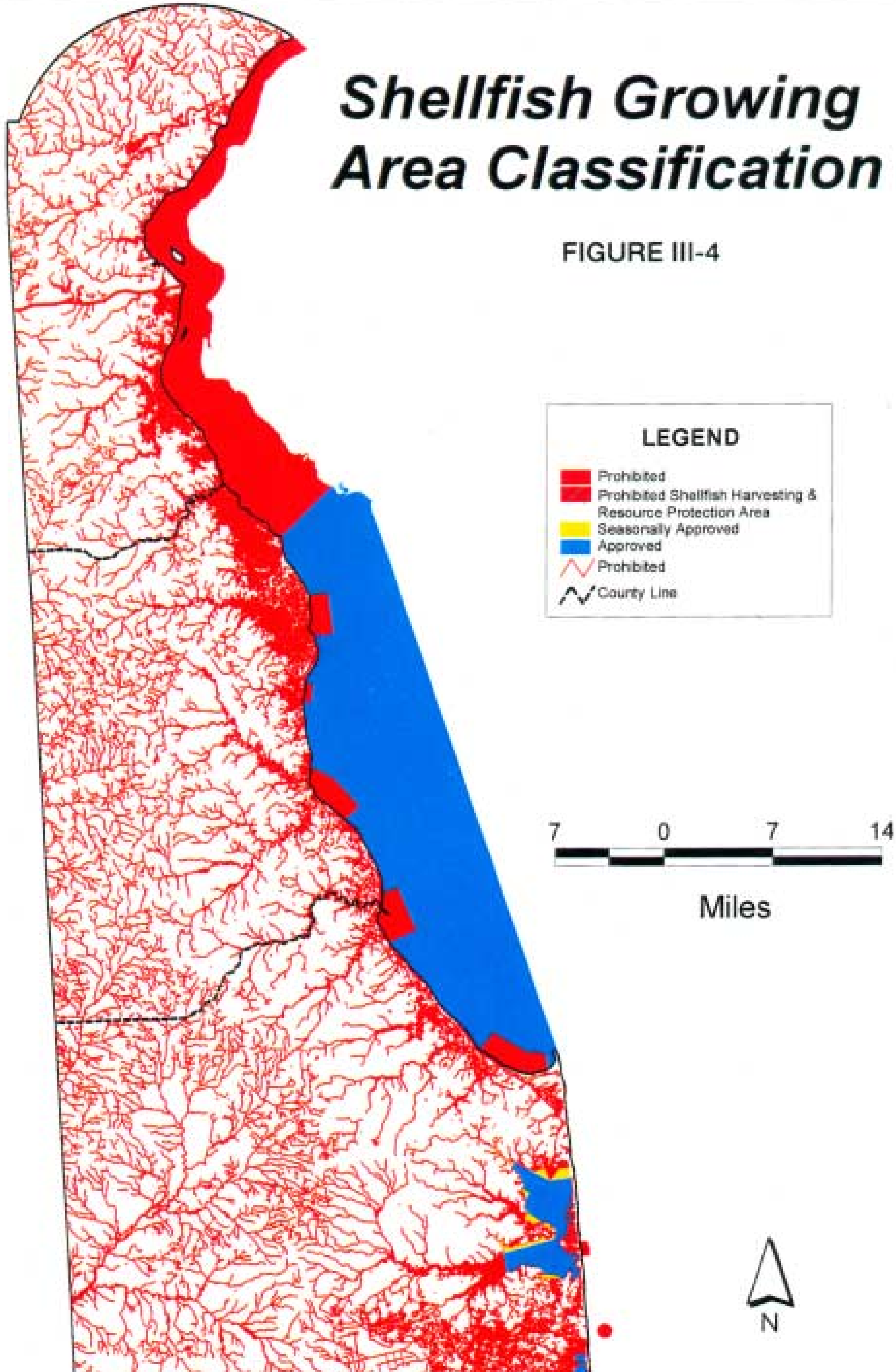


FIGURE III-5

Shellfish Growing Area Classification

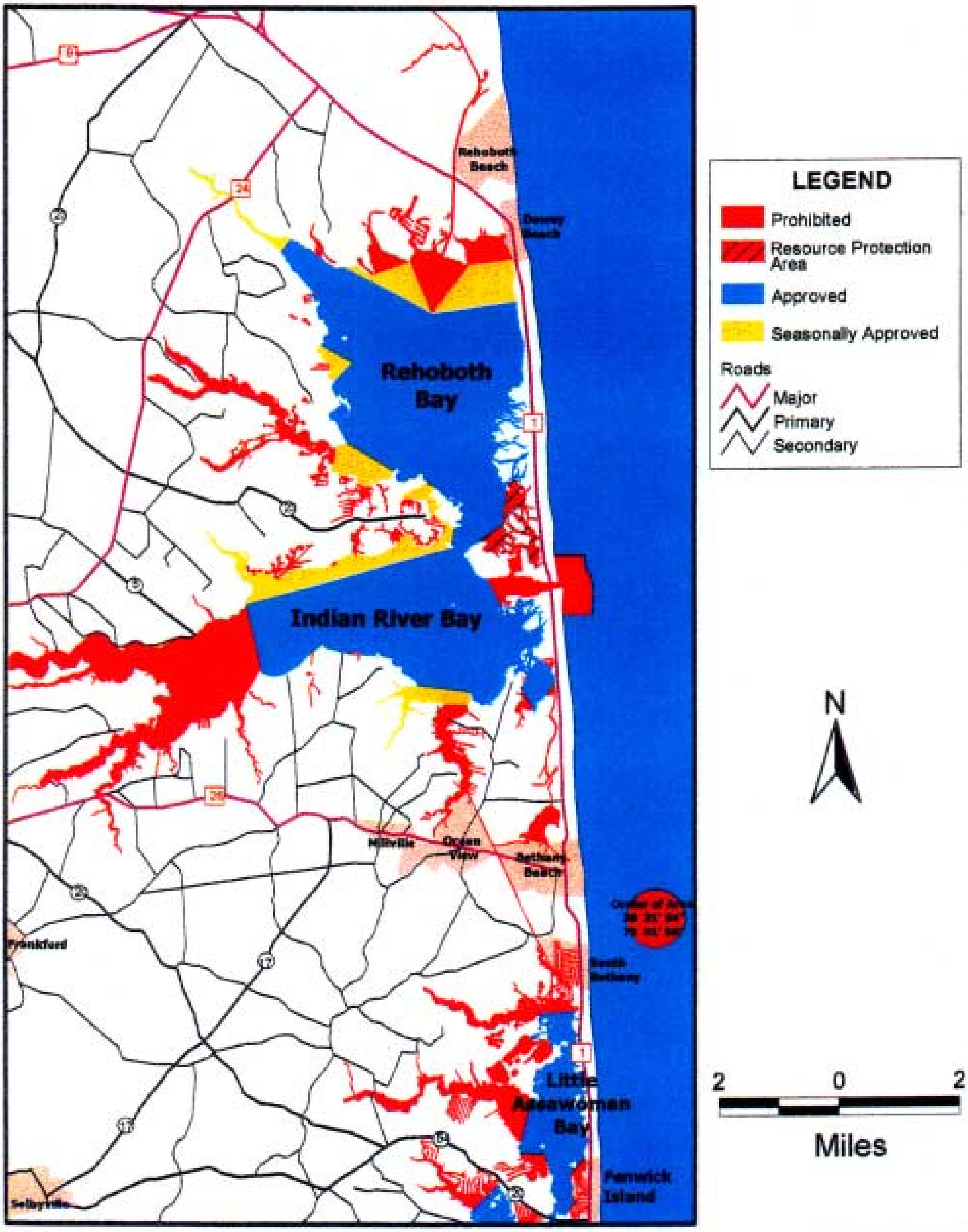


Table III-3 Individual Use Support Summary

(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	910.44	0.00	674.16	921.47	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	276.90	604.15	0.00
Primary Contact (Recr)	2,506.07	17.50	0.00	637.75	1,850.82	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 Acres

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	2,270.20	0.00	481.50	202.20	0.00
ERES (Exc. Rec.& Eco. Sig.)	757.80	210.40	0.00	408.20	139.20	0.00
Primary Contact (Recr)	2,953.90	370.40	0.00	1,936.60	646.90	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)

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	13.00	4.54	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)

Individual Use Support Summary

(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, 1996 through August 31, 2001. 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 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
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	7.0	3.4	6.4	77	703	3.60	0.084	8.0
Broad Creek	DE 050-002	Tussocky Branch	307061 307291 307331	13.0m	8.6	6.3	7.7	28	152	6.80	0.028	4.4
Broad Creek	DE 050-003	Little Creek	2000 305(b)	20.1m	--	--	--	--	--	--	--	--
Broad Creek	DE 050-004	Chipman Pond Branch	307111 307121 307341	21.7m	9.0	6.7	7.7	137	733	6.62	0.054	5.3
Broad Creek	DE 050-005-01	James Branch Including Pepper Pond Br., Hitch Pond Br., Etc.	307081 307281 307351 307361 307381 307391	31.7m	6.3	2.6	4.5	180	907	2.84	0.102	4.7
Broad Creek	DE 050-005-02	Trussum Pond Branch	2000 305(b)	18.8m	--	--	--	--	--	--	--	--
Broad Creek	DE 050-006-01	Trap Pond Branch	2000 305(b)	21.5m	--	--	--	--	--	--	--	--
Broad Creek	DE 050-006-03	Raccoon Prong	307221 307371	21.0m	6.4	3.8	5.0	183.0	1216.8	4.7	0.07	16.8
Broad Creek	DE 050-L01	Portsville Pond	2000 305(b)	14.5a	--	--	--	--	--	--	--	--
Broad Creek	DE 050-L02	Tussock Pond	307101	8.6a	9.2	7.8	8.2	29	330	3.43	0.039	5.1
Broad Creek	DE 050-L03	Horseys Pond	307171	46.3a	9.6	8.3	8.9	27	180	3.33	0.080	26.0
Broad Creek	DE 050-L04	Records Pond	307011 307401	91.9a	9.3	7.8	8.4	77	408	4.16	0.050	12.8

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Broad Creek	DE 050-L05	Chipman Pond & Wileys Pond	307131	47.0a	10.0	9.0	9.3	49	302	5.19	0.056	18.2
Broad Creek	DE 050-L06	Trussum Pond	307091	58.7a	6.2	2.9	4.1	96	567	2.55	0.094	32.0
Broad Creek	DE 050-L07	Trap Pond	307181	88.0a	7.9	5.4	5.9	16	62	2.33	0.106	18.2
Broad Creek	DE 050-L08	Raccoon Pond	307201	13.5a	5.7	1.2	2.6	22	296	1.40	0.084	23.8
C&D Canal	DE 100-004	Tributaries Of Elk River	2000 305(b)	21.7m	--	--	--	--	--	--	--	--
Chester River	DE 100-001	Cypress Branch	112011 112021 112581	12.2m	4.9	1.3	3.8	176	600	2.29	0.226	8.8
Chester River	DE 100-002	Sewell Branch	112591 112601	18.8m	6.2	2.7	4.4	286	1160	1.89	0.242	3.3
Chester River	DE 100-003	Gravelly Run	112031 112611 112621 112631	20.6m	6.1	3.2	4.8	169	855	1.40	0.186	5.6
Choptank River	DE 110-001	Tappahanna Ditch	207081 207121 207131	36.3m	6.3	3.8	4.5	156	1687	1.37	0.199	25.8
Choptank River	DE 110-002	Culbreth Marsh Ditch	207091 207141 207151	34.3m	6.3	3.1	3.8	134	1597	1.92	0.142	8.1
Choptank River	DE 110-003	Cow Marsh Creek	207021 207181 207191	89.9m	6.2	2.4	4.5	72	735	1.54	0.076	5.1
Choptank River	DE 110-L01	Mud Mill Pond	207111 207161 207171	60.0a	5.7	2.3	4.1	141	1507	2.82	0.139	13.0
Marshyhope Creek	DE 200-001	Marshyhope Creek, Headwaters To State Line	302021 302031 302041	20.3m	7.9	4.2	6.4	48	1228	2.55	0.095	6.0

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Marshyhope Creek	DE 200-002	Tributaries of Marshyhope Creek From The Headwaters To State Line	302051	145.3m	6.5	4.1	5.7	123	727	1.99	0.471	32.9
Nanticoke River	DE 240-001	Lower Nanticoke River	304011 304021 304031 304041 304051 304071 304091 304101 304141 304151 304171 304461 304471 304621	69.4m	8.2	5.9	7.1	68	410	3.46	0.094	41.5
Nanticoke River	DE 240-002	Upper Nanticoke River	304191 304291	62.3m	8.7	6.7	7.4	64	576	5.00	0.074	4.6
Nanticoke River	DE 240-003	Clear Brook Branch	304371 304381 304571 304631	22.9m	6.0	2.4	3.7	197	890	4.17	0.135	22.8
Nanticoke River	DE 240-004	Deep Creek Branch	304591 304601 304641	99.2m	7.7	6.1	7.0	160	618	3.22	0.100	90.1
Nanticoke River	DE 240-005	Gravelly Branch	316011 316021 316031	61.2m	7.6	5.7	6.5	62	264	1.93	0.031	10.1
Nanticoke River	DE 240-006	Bridgeville Branch	304271 304611	9.6m	7.7	5.1	5.3	72	270	5.11	0.050	4.6
Nanticoke River	DE 240-007	Gum Branch	304441 304531	12.1m	7.9	5.9	6.7	509	1826	5.97	0.090	7.4
Nanticoke River	DE 240-008	Lewes Creek	304421 304451 304541 304551 304561	25.8m	7.6	4.7	6.8	227	1850	7.34	0.061	3.3
Nanticoke River	DE 240-L01	Craigs Pond	304301	11.9a	8.1	5.3	6.4	40	1044	4.66	0.039	3.8

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Nanticoke River	DE 240-L02	Concord Pond	304311 304651	87.4a	9.4	7.4	8.3	23	97	2.54	0.034	5.4
Nanticoke River	DE 240-L03	Collins Pond	2000 305(b)	90.0a	--	--	--	--	--	--	--	--
Nanticoke River	DE 240-L04	Williams Pond	304321 304581	100.0a	9.2	7.1	7.9	41	440	3.40	0.073	28.7
Nanticoke River	DE 240-L05	Hearns Pond	304411	67.0a	9.1	5.8	7.2	114	345	3.74	0.189	88.5
Pocomoke River	DE 250-001	Pocomoke River, Headwaters To Maryland State Line	313011 313041 313051	11.8m	6.3	5.1	5.4	192	600	2.15	0.122	4.8
Pocomoke River	DE 250-002	Pocomoke River, Tributaries From The Headwaters To Maryland Line	313021 313031	41.7m	6.4	4.5	5.3	154	600	2.62	0.123	4.5
Delaware Bay Drainage Basin												
Appoquinimink River	DE 010-001-01	Lower Appoquinimink River	109091 109121 109141	7.1m	6.6	5.0	5.4	102	417	1.89	0.211	19.7
Appoquinimink River	DE 010-001-02	Upper Appoquinimink River - Odessa	109041 109051 109151 109171	6.1m	6.4	4.3	5.0	196	1033	1.96	0.234	46.6
Appoquinimink River	DE 010-001-03	Drawyer Creek and Tributaries	109071 109201 109211	19.5m	7.0	4.8	5.5	221	1304	2.63	0.256	57.7
Appoquinimink River	DE 010-001-04	All Tributaries From The Headwaters Of Appoquinimink River to the Bay	2000 305(b)	10.3m	--	--	--	--	--	--	--	--
Appoquinimink River	DE 010-002-01	Upper Appoquinimink - Wiggins Mill Pond Branch	109221 109231	3.4m	6.4	4.2	5.6	280	970	3.76	0.065	18.1

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Appoquinimink River	DE 010-002-02	Upper Appoquinimink, Deep Creek To Confluence With Silver Lake	109241 109251	4.4m	8.1	7.3	7.6	111	741	8.39	0.050	6.7
Appoquinimink River	DE 010-L01	Noxontown Pond	109131	158.6a	8.8	6.8	7.3	19	115	2.10	0.073	59.7
Appoquinimink River	DE 010-L02	Silver Lake (Middletown)	109031	38.7a	10.2	8.1	9.0	14	281	4.17	0.030	15.6
Appoquinimink River	DE 010-L03	Shallcross Lake	109191	43.1a	8.8	6.7	7.5	14	266	3.21	0.060	15.5
Army Creek	DE 020-001	Lower Army Creek	114011	6.8m	7.2	5.0	5.6	68	600	1.85	0.180	16.9
Army Creek	DE 020-002	Upper Army Creek	114021	1.9m	8.0	4.9	6.3	272	833	2.00	0.061	2.6
Army Creek	DE 020-003	Tributaries to Army Creek not on the Mainstem	2000 305(b)	6.5m	--	--	--	--	--	--	--	--
Blackbird Creek	DE 030-001	Lower Blackbird Creek	110041	13.8m	6.6	3.9	5.3	128	1120	1.90	0.229	24.3
Blackbird Creek	DE 030-002	Upper Blackbird Creek	110021	13.6m	7.0	3.5	5.9	226	2000	1.64	0.110	6.5
Blackbird Creek	DE 030-003	Tributaries on the mainstem of Blackbird Creek	2000 305(b)	9.7m	--	--	--	--	--	--	--	--
Broad Kill River	DE 060-001	Lower Broadkill River	303041 303061 303081	10.6m	6.6	4.3	5.5	260	1533	3.20	0.229	35.5
Broad Kill River	DE 060-002	Beaverdam Creek	303171 303181 303211	8.3m	6.7	4.2	5.3	280	1037	###	0.350	10.5
Broad Kill River	DE 060-003	Upper Broadkill River	303031 303131	7.5m	8.8	7.5	8.0	30	142	3.29	0.064	16.9
Broad Kill River	DE 060-004	Round Pole Branch	303311	5.2m	6.1	4.3	4.8	189	600	3.21	0.149	8.8

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Broad Kill River	DE 060-005	Ingram Branch	303011 303021 303241 303261 303281 303481	13.0m	6.4	3.9	5.6	162	700	9.92	0.438	4.0
Broad Kill River	DE 060-006	Pemberton Branch	303341	8.7m	8.4	7.3	7.6	193	635	4.03	0.041	4.4
Broad Kill River	DE 060-007-01	Lower Red Mill Branch	303051	5.3m	9.5	7.3	7.9	23	154	2.79	0.182	141.7
Broad Kill River	DE 060-007-02	Martin Branch	303406	1.5m	6.3	6.1	6.2					
Broad Kill River	DE 060-007-03	Heronwood Branch	2000 305(b)	1.0m	--	--	--	--	--	--	--	--
Broad Kill River	DE 060-008	Primehook Creek Including Its Tributaries	2000 305(b)	23.6m	--	--	--	--	--	--	--	--
Broad Kill River	DE 060-L01	Red Mill Pond	303231	150.0a	6.8	4.6	5.7	95	370	3.00	0.114	30.2
Broad Kill River	DE 060-L02	Waggamons Pond	303351	35.0a	9.2	8.1	8.7	22	87	3.29	0.100	11.9
Broad Kill River	DE 060-L03	Waples Pond & Reynolds Pond	303331 303381	88.8a	7.6	4.0	6.1	39	255	2.75	0.031	5.2
C&D Canal	DE 090-001	Chesapeake And Delaware Canal From Maryland Line To Delaware River	108021 108031	15.0m	7.8	6.2	6.6	19	94	2.05	0.171	6.6
C&D Canal East	DE 090-L01	Lums Pond	108111	189.3a	8.7	7.1	7.7	15	107	1.21	0.059	22.6
Cedar Creek	DE 080-001	Lower Cedar Creek	301031 301091	21.8m	6.8	4.5	5.7	87	338	2.56	0.156	27.2
Cedar Creek	DE 080-002	Upper Cedar Creek, Headwaters To Cedar Creek Mill Pond	301021	22.9m	8.8	6.3	7.8	10	125	2.79	0.064	6.5

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Cedar Creek	DE 080-003	Slaughter Creek	2000 305(b)	16.7m	--	--	--	--	--	--	--	--
Dragon Run Creek	DE 130-001	Lower Dragon Run Creek	111011	3.2m	6.2	2.3	3.1	20	190	1.04	0.134	21.4
Dragon Run Creek	DE 130-002	Upper Dragon Run Creek	111031	4.5m	6.6	3.3	5.8	243	1173	1.90	0.095	7.5
Leipsic River	DE 160-001	Lower Leipsic River	202031	13.6m	5.2	2.9	3.3	333	1413	2.00	0.345	16.1
Leipsic River	DE 160-002	Upper Leipsic River	202041 205271	24.5m	4.5	2.6	3.1	417	1817	1.95	0.376	11.0
Leipsic River	DE 160-003	Leipsic, Tributaries From Dam At Garrisons Lake To Mouth	2000 305(b)	37.2m	--	--	--	--	--	--	--	--
Leipsic River	DE 160-004	Tributaries of Leipsic River From Headwaters To Garrisons Lake	2000 305(b)	35.4m	--	--	--	--	--	--	--	--
Leipsic River	DE 160-L01	Garrisons Lake	202021	85.9a	7.4	4.2	6.0	192	980	2.55	0.284	75.3
Leipsic River	DE 160-L02	Masseys Mill Pond	202011	30.0a	6.5	3.1	4.0	289	2000	2.83	0.244	25.9
Little River	DE 190-001-01	Lower Little Creek	204031	2.9m	6.5	4.8	5.2	235	1500	2.59	0.474	43.4
Little River	DE 190-001-02	Upper Little Creek	204041	10.2m	3.8	2.0	2.7	121	1367	1.47	0.169	8.5
Little River	DE 190-001-03	Pipe Elm Branch	204011	2.1m	6.1	4.7	5.4	214	1617	1.25	0.074	3.6
Little River	DE 190-001-04	Tributaries of Little River Located In The Watershed But Not On The Mainstem	2000 305(b)	6.1m	--	--	--	--	--	--	--	--
Mispillion River	DE 210-001	Lower Mispillion River	208021 208061	13.2m	6.9	4.4	4.8	125	700	2.90	0.182	39.1
Mispillion River	DE 210-002	Upper Mispillion River, Headwaters To Silver Lake	2000 305(b)	11.2m	--	--	--	--	--	--	--	--

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Mispillion River	DE 210-003	Johnson Branch Including Its Tributaries	2000 305(b)	9.8m	--	--	--	--	--	--	--	--
Mispillion River	DE 210-004	Mispillion Tributaries From Headwaters To Silver Lake	2000 305(b)	5.6m	--	--	--	--	--	--	--	--
Mispillion River	DE 210-005	Mispillion Tributaries From Dam At Silver Lake To The Mouth	2000 305(b)	29.1m	--	--	--	--	--	--	--	--
Mispillion River	DE 210-L01	Tub Mill Pond	2000 305(b)	4.8a	--	--	--	--	--	--	--	--
Mispillion River	DE 210-L02	Silver Lake (Milford)	208211	28.5a	8.6	6.7	7.3	92	460	3.01	0.038	10.3
Mispillion River	DE 210-L03	Haven Lake	208011	82.5a	6.1	5.3	6.1	35	129	3.48	0.027	3.7
Mispillion River	DE 210-L04	Griffith Lake	2000 305(b)	32.2a	--	--	--	--	--	--	--	--
Mispillion River	DE 210-L05	Blairs Pond	208191 208231	28.5a	8.6	7.4	7.9	91	1499	3.59	0.038	7.2
Mispillion River	DE 210-L06	Abbotts Pond	208181	25.6a	7.6	4.9	5.8	35	116	3.16	0.050	14.6
Murderkill River	DE 220-001	Lower Murderkill River	206091 206101 206131 206141 206231	27.5m	5.4	2.9	3.6	121	833	2.18	0.326	23.8
Murderkill River	DE 220-002	Spring Creek	206081 206601 206611 206621 206631 206641	36.5m	6.6	3.6	5.6	344	2000	3.92	0.170	14.1
Murderkill River	DE 220-003	Mid Murderkill River	206211	16.2m	8.2	7.2	7.6	136	543	4.31	0.177	116.0
Murderkill River	DE 220-004	Browns Branch	206041 206051 206351 206421	24.1m	6.8	4.5	5.6	285	1700	4.39	0.107	5.9

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Murderkill River	DE 220-005	Upper Murderkill River	206011 206651 206661 206671 206681	21.7m	7.0	5.7	6.6	344	2000	3.61	0.098	3.7
Murderkill River	DE 220-L01	Mcginnis Pond	206461 206561	31.3a	8.4	5.2	6.6	75	1830	4.01	0.092	24.5
Murderkill River	DE 220-L02	Andrews Lake	206071	17.5a	9.1	7.2	8.2	61	762	4.30	0.060	17.6
Murderkill River	DE 220-L03	Coursey Pond	206451	58.1a	9.4	7.7	8.1	27	316	2.89	0.117	66.4
Murderkill River	DE 220-L04	Killen Pond	206021 206691	75.1a	10.0	8.5	8.9	12	396	2.15	0.091	126.5
Murderkill River	DE 220-L05	Mccauley Pond	206361	49.0a	9.8	7.4	8.7	37	374	3.73	0.075	31.1
Red Lion Creek	DE 270-001-01	Lower Red Lion Creek	107031	3.7m	7.1	4.0	5.7	123	572	1.89	0.136	20.0
Red Lion Creek	DE 270-001-02	Upper Red Lion Creek, Headwaters To Route 13	107011	6.0m	7.7	5.8	6.4	138	713	1.65	0.052	3.7
Red Lion Creek	DE 270-001-03	Tributaries Located In The Watershed But Not On Mainstem of Red Lion Creek	2000 305(b)	1.8m	--	--	--	--	--	--	--	--
Saint Jones River	DE 290-001-01	Lower St. Jones River	205011 205031 205041 205061	12.9m	4.8	2.5	3.3	113	613	2.02	0.264	29.1
Saint Jones River	DE 290-001-02	Upper St. Jones River	205091 205131 205571	11.2m	8.1	5.2	5.8	107	837	2.50	0.214	77.7
Saint Jones River	DE 290-001-03	Tributaries of Saint Jones River From Old Lebanon Bridge To The Mouth Of Delaware	2000 305(b)	13.6m	--	--	--	--	--	--	--	--

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Saint Jones River	DE 290-002	Isaac Branch	205241 205321 205601	17.0m	7.4	5.8	6.3	275	1267	4.69	0.056	11.6
Saint Jones River	DE 290-003	Fork Branch	205151 205171	39.5m	3.7	1.8	2.4	79	638	1.24	0.260	15.4
Saint Jones River	DE 290-004	Tidbury Branch	205261 205591	11.5m	5.8	3.6	3.7	318	1840	2.42	0.071	3.0
Saint Jones River	DE 290-L01	Moores Lake	205181	27.1a	9.5	7.7	9.1	50	250	3.52	0.085	28.6
Saint Jones River	DE 290-L02	Silver Lake (Dover)	205191 205201	157.8a	9.2	6.9	7.8	89	714	4.15	0.338	399.8
Saint Jones River	DE 290-L03	Derby Pond	205211	23.1a	8.8	5.9	7.6	16	320	2.45	0.050	25.1
Smyrna River	DE 310-001	Smyrna River	201041 201051	10.2m	6.9	3.6	4.9	350	1464	2.42	0.290	40.2
Smyrna River	DE 310-002	Mill Creek	201021	6.3m	7.7	5.2	6.4	147	1567	2.69	0.142	33.7
Smyrna River	DE 310-003	Tributaries of Smyrna River From The Headwaters To The Confluence With The Delaware River	201161	58.0m	7.6	5.9	6.3	250	2000	3.36	0.110	11.0
Smyrna River	DE 310-L01	Lake Como & Duck Creek Pond	2000 305(b)	82.0a	--	--	--	--	--	--	--	--
Inland Bays/Atlantic Ocean Drainage Basin												
Buntings Branch	DE 070-001	Bunting's Branch	311041	11.1m	6.9	5.0	5.9	677	2067	3.04	0.167	6.2
Indian River/Indian River Bay	DE 140-001	White Creek	310121 312011	11.2m	5.8	4.0	4.6	77	600	2.31	0.115	9.7
Indian River/Indian River Bay	DE 140-002	Blackwater Creek	308361	13.8m	6.7	2.9	6.6	215	933	4.19	0.033	3.4

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Indian River/Indian River Bay	DE 140-003	Pepper Creek And Tributaries, Including Vines Creek, Mccrays and Deep Hole Branches	308091 308101 308151 308351 308381 308461	53.7m	6.2	3.2	4.4	161	867	3.38	0.139	38.1
Indian River/Indian River Bay	DE 140-004	Indian River	306181 306191	9.4m	6.4	4.7	5.2	79	544	2.23	0.140	32.3
Indian River/Indian River Bay	DE 140-005	Swan Creek	308061 308301 308341	8.6m	8.4	7.4	7.6	170	1693	3.77	0.051	5.6
Indian River/Indian River Bay	DE 140-006	Stockley Branch	308141 308281	12.1m	7.4	4.4	6.5	117	1273	3.08	0.084	15.0
Indian River/Indian River Bay	DE 140-007	Eli Walls Tax Ditch	2000 305(b)	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	2000 305(b)	16.9	--	--	--	--	--	--	--	--
Indian River/Indian River Bay	DE 140-009	Mirey Branch, Including Sheep Pen Ditch, And Narrow Drain	319011 319101	23.5m	7.8	6.3	6.5	479	2000	5.51	0.058	3.8
Indian River/Indian River Bay	DE 140-010	Betts Pond Branch	308181 308191 308391	23.8m	7.2	1.3	6.0	101	1233	2.57	0.116	11.3
Indian River/Indian River Bay	DE 140-E01	Lower Indian River Bay	306121 306131 306321	13.0sqm	6.6	5.0	5.4	3	21	0.91	0.107	9.6

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Indian River/Indian River Bay	DE 140-E02	Upper Indian River Bay	306161 306331 306341	0.9sqm	6.0	4.3	4.6	19	330	1.98	0.139	24.3
Indian River/Indian River Bay	DE 140-L01	Millsboro Pond	308071 308271	126.0a	8.3	6.8	7.0	36	1520	4.06	0.169	4.9
Indian River/Indian River Bay	DE 140-L02	Betts Pond	308201 308401	80.0a	8.7	6.7	7.5	59	1334	2.24	0.042	7.9
Indian River/Indian River Bay	DE 140-L03	Ingram Pond	308011	48.0a	8.2	7.4	7.7	21	800	2.23	0.064	14.0
Indian River/Indian River Bay	DE 140-L04	Morris Mill Pond	2000 305(b)	44.0a	--	--	--	--	--	--	--	--
Iron Branch	DE 150-001	Iron Branch	309011 309021 309041 309051	30.2	6.9	4.8	5.7	160	1420	3.89	0.113	11.5
Lewes and Rehoboth Canal	DE 170-001	Lewes-Rehoboth Canal	305011 305041 305051 305061 305071 305081 311011 311031	14.1m	5.9	3.3	4.1	53	704	1.86	0.130	12.3
Little Assawoman Bay	DE 180-001	Little Assawoman Canal	312021 312041	9.3m	5.4	3.4	4.4	81	683	1.45	0.118	13.9
Little Assawoman Bay	DE 180-002	Miller Creek	308441 308451 310101	14.1	5.2	2.3	3.6	112	584	3.31	0.152	31.4
Little Assawoman Bay	DE 180-003	Dirickson Creek	210031 310031	31.0m	6.1	5.0	5.3	69	448	3.25	0.474	157.7
Little Assawoman Bay	DE 180-004	Jefferson Creek And Dead End Lagoons	2000 305(b)	5.2m	--	--	--	--	--	--	--	--

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Little Assawoman Bay	DE 180-E01	Little Assawoman Bay	310011 310071	3.0sqm	6.2	4.1	5.0	10	91	1.65	0.130	19.8
Rehoboth Bay	DE 280-001-01	From The Headwaters Of Chapel Br. To The Confluence Of Herring Creek	308051 308431	29.8m	6.7	4.9	5.6	264	1080	2.99	0.078	16.1
Rehoboth Bay	DE 280-002	Love Creek	308021 308291 308371 308411 308421	21.5m	7.4	5.5	6.4	68	1137	2.50	0.072	14.8
Rehoboth Bay	DE 280-E01	Rehoboth Bay	306071 306091 306111	12.0sqm	6.6	4.8	5.5	2	5	0.70	0.123	7.4
Rehoboth Bay	DE 280-L01	Burton Pond	308031	33.0a	8.2	7.0	7.6	11	87	1.34	0.024	8.3
Piedmont Drainage Basin												
Brandywine Creek	DE 040-001	Lower Brandywine River	104011	3.8m	10.3	7.8	8.6	111	607	3.19	0.133	4.5
Brandywine Creek	DE 040-002	Upper Brandywine Creek, From State Line To Wilmington	104021 104051	9.3m	10.3	7.9	8.4	55	419	3.16	0.146	4.2
Brandywine Creek	DE 040-003	All Tributaries On Brandywine Creek From The Headwaters to the Confluence with the Christina River	2000 305(b)	19.3m	--	--	--	--	--	--	--	--
Christina River	DE 120-001	Lower Christina River	106011 106291 106311	1.5m	8.9	6.0	6.7	74	579	2.63	0.137	18.4

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Christina River	DE 120-002	Mid Christina River, Between White Clay Creek And Brandywine	106021	8.5m	9.4	6.9	8.8	116	604	2.68	0.126	47.8
Christina River	DE 120-003	Upper Christina River	106031	6.9m	8.9	6.7	7.0	171	610	1.61	0.075	11.8
Christina River	DE 120-003-02	Christina River Tributaries From Smalleys Pond Overflow To White Clay Creek	106321	3.1m	7.0	3.3	5.1	290	2000	1.21	0.069	7.2
Christina River	DE 120-004-01	Lower Christina Creek	106111 106141 106331	8.4m	8.6	4.9	6.4	156	648	2.66	0.071	5.1
Christina River	DE 120-004-02	Belltown Run	106341	5.6m	7.3	4.4	5.3	340	1014	1.80	0.175	13.4
Christina River	DE 120-004-03	Muddy Run	2000 305(b)	13.1m	--	--	--	--	--	--	--	--
Christina River	DE 120-005-01	West Branch Including Persimmon Run And Stine Haskell Branch	2000 305(b)	5.3m	--	--	--	--	--	--	--	--
Christina River	DE 120-006	Upper Christina Creek	106191	10.8m	10.5	8.1	9.0	179	1220	2.43	0.025	3.1
Christina River	DE 120-007-01	Little Mill Creek	106281	12.8m	9.7	6.9	8.5	225	950	1.77	0.073	7.6
Christina River	DE 120-007-02	Chestnut Run	2000 305(b)	2.8m	--	--	--	--	--	--	--	--
Christina River	DE 120-L01	Smalleys Pond	2000 305(b)	30.0a	--	--	--	--	--	--	--	--
Christina River	DE 120-L02	Becks Pond	106121 106351	25.6a	9.0	6.6	6.9	30	633	0.85	0.047	12.9
Christina River	DE 120-L03	Sunset Pond	106131 106361 106371 106381	40.0a	6.7	3.0	3.6	94	1853	1.56	0.076	16.5

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
Naamans Creek	DE 230-001-01	Lower Naamans Creek Including Its Tributaries	101041	0.3m	8.8	6.1	8.1	199	740	1.67	0.045	3.6
Naamans Creek	DE 230-001-02	Upper Naamans Creek Including North Br. And South Br.	101021 101031	11.0m	9.2	6.5	7.5	209	947	1.51	0.075	5.2
Red Clay Creek	DE 260-001	Red Clay Creek From Pennsylvania State Line	103011 103031 103041	12.8m	10.2	7.6	8.4	180	1680	3.77	0.253	5.3
Red Clay Creek	DE 260-002	Burroughs Run From Pennsylvania State Line Run	103061	4.5m	10.9	8.2	8.9	113	1040	2.15	0.044	4.8
Red Clay Creek	DE 260-003	All Other Red Clay Creek Tributaries Located In The Watershed But Not On the mainstem.	2000 305(b)	10.3m	--	--	--	--	--	--	--	--
Red Clay Creek	DE 260-L01	Hoopes Reservoir	2000 305(b)	200.0a	--	--	--	--	--	--	--	--
Shellpot Creek	DE 300-001-01	Lower Shellpot Creek	102041	1.0m	7.7	5.0	6.0	145	880	3.62	0.286	92.1
Shellpot Creek	DE 300-001-02	Upper Shellpot Creek	102011 102051 102061 102071 102081 102091	14.2m	8.7	6.2	7.5	389	1830	1.94	0.086	3.7
Shellpot Creek	DE 300-001-03	All Other Tributaries To Shellpot Creek Located In The Watershed But Not On the mainstem.	2000 305(b)	7.6m	--	--	--	--	--	--	--	--

Table III-4 Summary Statistics Used for Use Support Determinations for State of Delaware 2002 305(b) Assessments

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Average DO (mg/l)	DO 10th %tile (mg/l)	DO 25th %tile (mg/l)	Enterococcus Geometric means	Enterococcus 90th Percentiles	Average Total N (mg/l)	Average Total P (mg/l)	Average Chlorophyll-A ug/l
White Clay Creek	DE 320-001	White Clay Creek From Pennsylvania State Line	105011 105031 105151	18.2m	10.1	7.2	8.1	142	1284	3.71	0.191	4.7
White Clay Creek	DE 320-002	Mill Creek	105071	16.6m	9.5	6.9	7.4	320	1380	2.06	0.067	3.5
White Clay Creek	DE 320-003	Pike Creek	105101	8.2m	10.7	8.3	8.6	127	1834	2.39	0.050	3.7
White Clay Creek	DE 320-004	Middle Run	105131	5.8m	10.7	8.4	9.2	107	983	2.13	0.051	6.0
White Clay Creek	DE 320-005	All Tributaries to White Clay Creek From The Headwaters To The Confluence With the Christina River	2000 305(b)	14.2m	--	--	--	--	--	--	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
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	P	P	P	F	--	--	F	--	--
Broad Creek	DE 050-002	Tussocky Branch	307061 307291 307331	13.0m	F	P	P	F	--	F	F	--	--
Broad Creek	DE 050-003	Little Creek	2000 305(b)	20.1m	F	N	N	F	--	F	F	--	--
Broad Creek	DE 050-004	Chipman Pond Branch	307111 307121 307341	21.7m	F	N	N	F	--	F	F	--	--
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	N	N	F	--	F	F	--	--
Broad Creek	DE 050-005-02	Trussum Pond Branch	2000 305(b)	18.8m	N	N	N	F	--	F	F	--	--
Broad Creek	DE 050-006-01	Trap Pond Branch	2000 305(b)	21.5m	F	N	N	F	--	F	F	--	--
Broad Creek	DE 050-006-03	Raccoon Prong	307221 307371	21.0m	N	N	N	F	--	--	--	--	--
Broad Creek	DE 050-L01	Portsville Pond	2000 305(b)	14.5a	F	P	P	F	--	F	F	--	--
Broad Creek	DE 050-L02	Tussock Pond	307101	8.6a	F	P	P	F	--	F	F	--	--
Broad Creek	DE 050-L03	Horseys Pond	307171	46.3a	F	P	P	F	--	F	F	--	--
Broad Creek	DE 050-L04	Records Pond	307011 307401	91.9a	F	P	P	F	--	F	F	--	--
Broad Creek	DE 050-L05	Chipman Pond & Wileys Pond	307131	47.0a	F	P	P	P	--	F	F	--	--
Broad Creek	DE 050-L06	Trussum Pond	307091	58.7a	N	P	N	F	--	F	F	--	--
Broad Creek	DE 050-L07	Trap Pond	307181	88.0a	P	F	P	P	--	F	F	--	--
Broad Creek	DE 050-L08	Raccoon Pond	307201	13.5a	N	P	N	F	--	F	F	--	--
C&D Canal	DE 100-004	Tributaries Of Elk River	2000 305(b)	21.7m	N	N	--	F	--	F	F	--	--
Chester River	DE 100-001	Cypress Branch	112011 112021 112581	12.2m	N	N	--	F	--	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
Chester River	DE 100-002	Sewell Branch	112591 112601	18.8m	N	N	--	F	--	F	F	--	--
Chester River	DE 100-003	Gravelly Run	112031 112611 112621 112631	20.6m	N	N	--	F	--	F	F	--	--
Choptank River	DE 110-001	Tappahanna Ditch	207081 207121 207131	36.3m	N	N	--	F	--	F	F	--	--
Choptank River	DE 110-002	Culbreth Marsh Ditch	207091 207141 207151	34.3m	N	N	--	F	--	F	F	--	--
Choptank River	DE 110-003	Cow Marsh Creek	207021 207181 207191	89.9m	N	P	--	F	--	F	F	--	--
Choptank River	DE 110-L01	Mud Mill Pond		60.0a	N	N	--	F	--	F	F	--	--
Marshyhope Creek	DE 200-001	Marshyhope Creek, Headwaters To State Line	302021 302031 302041	20.3m	P	P	--	F	--	F	F	--	--
Marshyhope Creek	DE 200-002	Tributaries of Marshyhope Creek From The Headwaters To State Line	302051	145.3m	P	N	--	F	--	F	F	--	--
Nanticoke River	DE 240-001	Lower Nanticoke River	304011 304021 304031 304041 304051 304071 304091 304101 304141 304151 304171 304461 304471 304621	69.4m	F	P	P	F	--	--	F	--	--
Nanticoke River	DE 240-002	Upper Nanticoke River	304191 304291	62.3m	F	P	P	F	--	F	F	--	--
Nanticoke River	DE 240-003	Clear Brook Branch	304371 304381 304571 304631	22.9m	N	N	N	F	--	F	F	--	--
Nanticoke River	DE 240-004	Deep Creek Branch	304591 304601 304641	99.2m	F	N	N	F	--	F	F	--	--
Nanticoke River	DE 240-005	Gravelly Branch	316011 316021 316031	61.2m	F	P	P	F	--	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
Nanticoke River	DE 240-006	Bridgeville Branch	304271 304611	9.6m	N	P	N	F	--	F	F	--	--
Nanticoke River	DE 240-007	Gum Branch	304441 304531	12.1m	F	N	N	F	--	F	F	--	--
Nanticoke River	DE 240-008	Lewes Creek	304421 304451 304541 304551 304561	25.8m	P	N	N	F	--	F	F	--	--
Nanticoke River	DE 240-L01	Craigs Pond	304301	11.9a	P	P	P	P	--	F	F	--	--
Nanticoke River	DE 240-L02	Concord Pond	304311 304651	87.4a	F	F	F	P	--	F	F	--	--
Nanticoke River	DE 240-L03	Collins Pond	2000 305(b)	90.0a	F	F	F	F	--	F	F	--	--
Nanticoke River	DE 240-L04	Williams Pond	304321 304581	100.0a	F	P	P	P	--	F	F	--	--
Nanticoke River	DE 240-L05	Hearns Pond	304411	67.0a	F	N	N	P	--	F	F	--	--
Pocomoke River	DE 250-001	Pocomoke River, Headwaters To Maryland State Line	313011 313041 313051	11.8m	N	N	--	F	--	F	F	--	--
Pocomoke River	DE 250-002	Pocomoke River, Tributaries From The Headwaters To Maryland Line	313021 313031	41.7m	N	N	--	F	--	F	F	--	--
Delaware Bay Drainage Basin													
Appoquinimink River	DE 010-001-01	Lower Appoquinimink River	109091 109121 109141	7.1m	N	N	--	F	--	--	F	--	--
Appoquinimink River	DE 010-001-02	Upper Appoquinimink River - Odessa	109041 109051 109151 109171	6.1m	N	N	--	F	--	--	F	--	--
Appoquinimink River	DE 010-001-03	Drawyer Creek and Tributaries	109071 109201 109211	19.5m	N	N	--	F	--	F	F	--	--
Appoquinimink River	DE 010-001-04	All Tributaries From The Headwaters Of Appoquinimink River to the Bay	2000 305(b)	10.3m	N	N	--	F	--	F	F	--	--
Appoquinimink River	DE 010-002-01	Upper Appoquinimink - Wiggins Mill Pond Branch	109221 109231	3.4m	P	N	--	F	--	F	F	--	--
Appoquinimink River	DE 010-002-02	Upper Appoquinimink, Deep Creek To Confluence With Silver Lake	109241 109251	4.4m	F	N	--	F	--	F	F	--	--
Appoquinimink River	DE 010-L01	Noxontown Pond	109131	158.6a	F	P	--	F	--	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
Appoquinimink River	DE 010-L02	Silver Lake (Middletown)	109031	38.7a	F	P	--	F	--	F	F	--	--
Appoquinimink River	DE 010-L03	Shallcross Lake	109191	43.1a	F	P	--	F	--	F	F	--	--
Army Creek	DE 020-001	Lower Army Creek	114011	6.8m	P	P	--	F	--	--	--	--	--
Army Creek	DE 020-002	Upper Army Creek	114021	1.9m	P	N	--	F	--	F	--	--	--
Army Creek	DE 020-003	Tributaries to Army Creek not on the Mainstem	2000 305(b)	6.5m	P	N	--	F	--	--	--	--	--
Blackbird Creek	DE 030-001	Lower Blackbird Creek	110041	13.8m	N	N	--	F	--	--	F	--	--
Blackbird Creek	DE 030-002	Upper Blackbird Creek	110021	13.6m	P	N	--	F	--	F	F	--	--
Blackbird Creek	DE 030-003	Tributaries on the mainstem of Blackbird Creek	2000 305(b)	9.7m	N	N	--	F	--	F	F	--	--
Broad Kill River	DE 060-001	Lower Broadkill River	303041 303061 303081	10.6m	P	N	--	F	--	--	F	--	--
Broad Kill River	DE 060-002	Beaverdam Creek	303171 303181 303211	8.3m	N	N	--	F	--	F	F	--	--
Broad Kill River	DE 060-003	Upper Broadkill River	303031 303131	7.5m	F	P	--	F	--	F	F	--	--
Broad Kill River	DE 060-004	Round Pole Branch	303311	5.2m	N	N	--	F	--	F	F	--	--
Broad Kill River	DE 060-005	Ingram Branch	303011 303021 303241 303261 303281 303481	13.0m	P	N	--	F	--	F	F	--	--
Broad Kill River	DE 060-006	Pemberton Branch	303341	8.7m	F	N	--	F	--	F	F	--	--
Broad Kill River	DE 060-007-01	Lower Red Mill Branch	303051	5.3m	F	P	--	F	--	F	F	--	--
Broad Kill River	DE 060-007-02	Martin Branch	303406	1.5m	F		--	F	--	F	F	--	--
Broad Kill River	DE 060-007-03	Heronwood Branch	2000 305(b)	1.0m	N	N	--	F	--	F	F	--	--
Broad Kill River	DE 060-008	Primehook Creek Including Its Tributaries	2000 305(b)	23.6m	F	N	--	F	--	F	F	--	--
Broad Kill River	DE 060-L01	Red Mill Pond	303231	150.0a	P	P	--	F	--	F	F	--	--
Broad Kill River	DE 060-L02	Waggamons Pond	303351	35.0a	F	F	--	F	--	F	F	--	--
Broad Kill River	DE 060-L03	Waples Pond & Reynolds Pond	303331 303381	88.8a	P	P	--	F	--	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
C&D Canal	DE 090-001	Chesapeake And Delaware Canal From Maryland Line To Delaware River	108021 108031	15.0m	F	F	--	F	--	--	F	--	--
C&D Canal East	DE 090-L01	Lums Pond	108111	189.3a	F	P	--	P	--	--	F	--	--
Cedar Creek	DE 080-001	Lower Cedar Creek	301031 301091	21.8m	P	N	N	F	--	--	F	--	--
Cedar Creek	DE 080-002	Upper Cedar Creek, Headwaters To Cedar Creek Mill Pond	301021	22.9m	F	P	--	F	--	F	F	--	--
Cedar Creek	DE 080-003	Slaughter Creek	2000 305(b)	16.7m	N	N	N	F	--	--	F	--	--
Dragon Run Creek	DE 130-001	Lower Dragon Run Creek	111011	3.2m	N	P	--	F	--	--	F	--	--
Dragon Run Creek	DE 130-002	Upper Dragon Run Creek	111031	4.5m	P	N	--	F	F	F	F	--	--
Leipsic River	DE 160-001	Lower Leipsic River	202031	13.6m	N	N	--	F	--	--	F	--	--
Leipsic River	DE 160-002	Upper Leipsic River	202041 205271	24.5m	N	N	--	F	--	F	F	--	--
Leipsic River	DE 160-003	Leipsic, Tributaries From Dam At Garrisons Lake To Mouth	2000 305(b)	37.2m	P	N	--	F	--	F	F	--	--
Leipsic River	DE 160-004	Tributaries of Leipsic River From Headwaters To Garrisons Lake	2000 305(b)	35.4m	F	N	--	F	--	F	F	--	--
Leipsic River	DE 160-L01	Garrisons Lake	202021	85.9a	P	N	--	F	--	F	F	--	--
Leipsic River	DE 160-L02	Masseys Mill Pond	202011	30.0a	N	N	--	F	--	F	F	--	--
Little River	DE 190-001-01	Lower Little Creek	204031	2.9m	P	N	--	F	--	--	F	--	--
Little River	DE 190-001-02	Upper Little Creek	204041	10.2m	N	N	--	F	--	F	F	--	--
Little River	DE 190-001-03	Pipe Elm Branch	204011	2.1m	N	N	--	F	--	F	F	--	--
Little River	DE 190-001-04	Tributaries of Little River Located In The Watershed But Not On The Mainstem	2000 305(b)	6.1m	N	N	--	F	--	--	F	--	--
Mispillion River	DE 210-001	Lower Mispillion River	208021 208061	13.2m	N	N	--	F	--	--	F	--	--
Mispillion River	DE 210-002	Upper Mispillion River, Headwaters To Silver Lake	2000 305(b)	11.2m	P	P	--	F	--	F	F	--	--
Mispillion River	DE 210-003	Johnson Branch Including Its	2000 305(b)	9.8m	P	P	--	F	--	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
		Tributaries											
Mispillion River	DE 210-004	Mispillion Tributaries From Headwaters To Silver Lake	2000 305(b)	5.6m	N	P	--	F	--	F	F	--	--
Mispillion River	DE 210-005	Mispillion Tributaries From Dam At Silver Lake To The Mouth	2000 305(b)	29.1m	F	P	--	F	--	F	F	--	--
Mispillion River	DE 210-L01	Tub Mill Pond	2000 305(b)	4.8a	F	F	--	P	--	F	F	--	--
Mispillion River	DE 210-L02	Silver Lake (Milford)	208211	28.5a	F	P	--	F	--	F	F	--	--
Mispillion River	DE 210-L03	Haven Lake	208011	82.5a	P	P	--	P	--	F	F	--	--
Mispillion River	DE 210-L04	Griffith Lake	2000 305(b)	32.2a	F	F	--	P	--	F	F	--	--
Mispillion River	DE 210-L05	Blairs Pond	208191 208231	28.5a	F	P	--	F	--	F	F	--	--
Mispillion River	DE 210-L06	Abbotts Pond	208181	25.6a	P	P	--	F	--	F	F	--	--
Murderkill River	DE 220-001	Lower Murderkill River	206091 206101 206131 206141 206231	27.5m	N	N	--	F	--	--	F	--	--
Murderkill River	DE 220-002	Spring Creek	206081 206601 206611 206621 206631 206641	36.5m	P	N	--	F	--	--	F	--	--
Murderkill River	DE 220-003	Mid Murderkill River	206211	16.2m	F	N	--	F	--	F	F	--	--
Murderkill River	DE 220-004	Browns Branch	206041 206051 206351 206421	24.1m	P	N	--	F	--	F	F	--	--
Murderkill River	DE 220-005	Upper Murderkill River	206011 206651 206661 206671 206681	21.7m	F	N	--	F	--	F	F	--	--
Murderkill River	DE 220-L01	Mcginnis Pond	206461 206561	31.3a	P	P	--	F	--	F	F	--	--
Murderkill River	DE 220-L02	Andrews Lake	206071	17.5a	F	P	--	F	--	F	F	--	--
Murderkill River	DE 220-L03	Coursey Pond	206451	58.1a	F	P	--	P	--	F	F	--	--
Murderkill River	DE 220-L04	Killen Pond	206021 206691	75.1a	F	P	--	P	--	F	F	--	--
Murderkill River	DE 220-L05	Mccauley Pond	206361	49.0a	F	P	--	P	--	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
Red Lion Creek	DE 270-001-01	Lower Red Lion Creek	107031	3.7m	P	N	--	F	--	--	F	--	--
Red Lion Creek	DE 270-001-02	Upper Red Lion Creek, Headwaters To Route 13	107011	6.0m	F	N	--	F	N	F	F	--	--
Red Lion Creek	DE 270-001-03	Tributaries Located In The Watershed But Not On Mainstem of Red Lion Creek	2000 305(b)	1.8m	P	P	--	F	--	--	F	--	--
Saint Jones River	DE 290-001-01	Lower St. Jones River	205011 205031 205041 205061	12.9m	N	N	--	F	--	--	F	--	--
Saint Jones River	DE 290-001-02	Upper St. Jones River	205091 205131 205571	11.2m	P	N	--	F	--	F	F	--	--
Saint Jones River	DE 290-001-03	Tributaries of Saint Jones River From Old Lebanon Bridge To The Mouth Of Delaware	2000 305(b)	13.6m	N	N	--	F	--	F	F	--	--
Saint Jones River	DE 290-002	Isaac Branch	205241 205321 205601	17.0m	F	N	--	F	--	F	F	--	--
Saint Jones River	DE 290-003	Fork Branch	205151 205171	39.5m	N	P	--	F	--	F	F	--	--
Saint Jones River	DE 290-004	Tidbury Branch	205261 205591	11.5m	N	N	--	F	--	F	F	--	--
Saint Jones River	DE 290-L01	Moores Lake	205181	27.1a	F	P	--	F	--	F	F	--	--
Saint Jones River	DE 290-L02	Silver Lake (Dover)	205191 205201	157.8a	F	P	--	N	--	F	F	--	--
Saint Jones River	DE 290-L03	Derby Pond	205211	23.1a	F	P	--	P	--	F	F	--	--
Smyrna River	DE 310-001	Smyrna River	201041 201051	10.2m	N	N	--	F	--	--	F	--	--
Smyrna River	DE 310-002	Mill Creek	201021	6.3m	P	N	--	F	--	F	F	--	--
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	--	--
Smyrna River	DE 310-L01	Lake Como & Duck Creek Pond	2000 305(b)	82.0a	F	N	--	P	--	F	F	--	--
Inland Bays/Atlantic Ocean Drainage Basin													
Buntings Branch	DE 070-001	Bunting's Branch	311041	11.1m	P	N	--	F	--	F	--	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
Indian River/Indian River Bay	DE 140-001	White Creek	310121 312011	11.2m	N	N	N	F	--	--	F	--	--
Indian River/Indian River Bay	DE 140-002	Blackwater Creek	308361	13.8m	P	N	N	F	--	--	F	--	--
Indian River/Indian River Bay	DE 140-003	Pepper Creek And Tributaries, Including Vines Creek, Mccrays and Deep Hole Branches	308091 308101 308151 308351 308381 308461	53.7m	N	N	N	F	--	--	F	--	--
Indian River/Indian River Bay	DE 140-004	Indian River	306181 306191	9.4m	P	N	N	F	--	--	F	--	--
Indian River/Indian River Bay	DE 140-005	Swan Creek	308061 308301 308341	8.6m	F	N	--	F	--	F	F	--	--
Indian River/Indian River Bay	DE 140-006	Stockley Branch	308141 308281	12.1m	P	N	--	F	--	F	F	--	--
Indian River/Indian River Bay	DE 140-007	Eli Walls Tax Ditch	2000 305(b)	13.6	F	N	--	F	--	F	F	--	--
Indian River/Indian River Bay	DE 140-008	Deep Branch, Including Peterkins Br., White Oak Swamp Ditch, Socorockets Ditch, Welsh and Simpler Branches	2000 305(b)	16.9	F	N	--	F	--	F	F	--	--
Indian River/Indian River Bay	DE 140-009	Mirey Branch, Including Sheep Pen Ditch, And Narrow Drain	319011 319101	23.5m	F	N	--	F	--	F	F	--	--
Indian River/Indian River Bay	DE 140-010	Betts Pond Branch	308181 308191 308391	23.8m	P	N	--	F	--	F	F	--	--
Indian River/Indian River Bay	DE 140-E01	Lower Indian River Bay	306121 306131 306321	13.0sqm	P	P	P	F	--	--	F	--	P
Indian River/Indian River Bay	DE 140-E02	Upper Indian River Bay	306161 306331 306341	0.9sqm	N	N	N	F	--	--	F	--	P
Indian River/Indian River	DE 140-L01	Millsboro Pond	308071 308271	126.0a	F	P	--	P	--	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
Bay													
Indian River/Indian River Bay	DE 140-L02	Betts Pond	308201 308401	80.0a	F	P	--	P	--	F	F	--	--
Indian River/Indian River Bay	DE 140-L03	Ingram Pond	308011	48.0a	F	P	--	P	--	F	F	--	--
Indian River/Indian River Bay	DE 140-L04	Morris Mill Pond	2000 305(b)	44.0a	F	N	--	F	--	F	F	--	--
Iron Branch	DE 150-001	Iron Branch	309011 309021 309041 309051	30.2	P	N	N	F	--	F	F	--	--
Lewes and Rehoboth Canal	DE 170-001	Lewes-Rehoboth Canal	305011 305041 305051 305061 305071 305081 311011 311031	14.1m	F	N	--	F	--	--	F	--	--
Little Assawoman Bay	DE 180-001	Little Assawoman Canal	312021 312041	9.3m	N	N	N	F	--	--	F	--	--
Little Assawoman Bay	DE 180-002	Miller Creek	308441 308451 310101	14.1	N	N	N	F	--	F	F	--	--
Little Assawoman Bay	DE 180-003	Dirickson Creek	210031 310031	31.0m	P	N	N	F	--	F	F	--	--
Little Assawoman Bay	DE 180-004	Jefferson Creek And Dead End Lagoons	2000 305(b)	5.2m	N	N	N	F	--	F	F	--	N
Little Assawoman Bay	DE 180-E01	Little Assawoman Bay	310011 310071	3.0sqm	N	N	N	F	--	--	F	--	--
Rehoboth Bay	DE 280-001-01	From The Headwaters Of Chapel Br. To The Confluence Of Herring Creek	308051 308431	29.8m	P	N	N	F	--	F	F	--	--
Rehoboth Bay	DE 280-002	Love Creek	308021 308291 308371 308411 308421	21.5m	F	P	P	F	--	F	F	--	--
Rehoboth Bay	DE 280-E01	Rehoboth Bay	306071 306091 306111	12.0sqm	P	F	P	F	--	--	F	--	--
Rehoboth Bay	DE 280-L01	Burton Pond	308031	33.0a	F	F	F	F	--	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	Segment ID	Segment Name	Stations	Segment Length (miles) or area(acres or sq. miles)	Aquatic Life Use Support	Primary Contact Recreation Use Support	ERES Use Support	Secondary Contact Use Support	Public Water Supply	Agricultural Water Supply	Industrial Water Supply	Cold Water Fishery	Harvestable Shellfish
Piedmont Drainage Basin													
Brandywine Creek	DE 040-001	Lower Brandywine River	104011	3.8m	F	N	--	F	--	--	F	--	--
Brandywine Creek	DE 040-002	Upper Brandywine Creek, From State Line To Wilmington	104021 104051	9.3m	F	P	P	F	F	F	F	--	--
Brandywine Creek	DE 040-003	All Tributaries On Brandywine Creek From The Headwaters to the Confluence with the Christina River	2000 305(b)	19.3m	N	N	--	F	F	F	F	--	--
Christina River	DE 120-001	Lower Christina River	106011 106291 106311	1.5m	F	P	--	F	--	--	F	--	--
Christina River	DE 120-002	Mid Christina River, Between White Clay Creek And Brandywine	106021	8.5m	F	N	--	F	--	--	F	--	--
Christina River	DE 120-003	Upper Christina River	106321	6.9m	F	N	--	F	F	F	F	--	--
Christina River	DE 120-003-02	Christina River Tributaries From Smalleys Pond Overflow To White Clay Creek	2000 305(b)	3.1m	N	N	--	F	F	F	F	--	--
Christina River	DE 120-004-01	Lower Christina Creek	106111 106141 106331	8.4m	P	N	--	F	F	F	F	--	--
Christina River	DE 120-004-02	Belltown Run	106341	5.6m	N	N	--	F	F	F	F	--	--
Christina River	DE 120-004-03	Muddy Run	2000 305(b)	13.1m	P	N	--	F	F	F	F	--	--
Christina River	DE 120-005-01	West Branch Including Persimmon Run And Stine Haskell Branch	2000 305(b)	5.3m	F	N	--	F	F	F	F	--	--
Christina River	DE 120-006	Upper Christina Creek	106191	10.8m	F	N	--	F	F	F	F	F	--
Christina River	DE 120-007-01	Little Mill Creek	106281	12.8m	F	N	--	F	F	F	F	--	--
Christina River	DE 120-007-02	Chestnut Run	2000 305(b)	2.8m	P	N	--	F	F	F	F	--	--
Christina River	DE 120-L01	Smalleys Pond	2000 305(b)	30.0a	F	N	--	F	F	F	F	--	--
Christina River	DE 120-L02	Becks Pond	106121 106351	25.6a	F	P	--	F	F	F	F	--	--
Christina River	DE 120-L03	Sunset Pond	106131 106361 106371 106381	40.0a	N	P	--	F	F	F	F	--	--

Table III-5 Use Support Determinations for Delaware's 2002 305(b) Assessment

Watershed	**Segment ID**	**Segment Name**	**Stations**	**Segment Length (miles) or area(acres or sq. miles)**	**Aquatic Life Use Support**	**Primary Contact Recreation Use Support**	**ERES Use Support**	**Secondary Contact Use Support**	**Public Water Supply**	**Agricultural Water Supply**	**Industrial Water Supply**	**Cold Water Fishery**	**Harvestable Shellfish**
Naamans Creek	DE 230-001-01	Lower Naamans Creek Including Its Tributaries	101041	0.3m	F	N	--	F	--	--	F	--	--
Naamans Creek	DE 230-001-02	Upper Naamans Creek Including North Br. And South Br.	101021 101031	11.0m	F	N	--	F	--	F	F	--	--
Red Clay Creek	DE 260-001	Red Clay Creek From Pennsylvania State Line	103011 103031 103041	12.8m	F	N	--	F	F	F	F	N	--
Red Clay Creek	DE 260-002	Burroughs Run From Pennsylvania State Line Run	103061	4.5m	F	N	--	F	F	F	F	--	--
Red Clay Creek	DE 260-003	All Other Red Clay Creek Tributaries Located In The Watershed But Not On the mainstem.	2000 305(b)	10.3m	P	N	--	F	F	F	F	--	--
Red Clay Creek	DE 260-L01	Hoopes Reservoir	2000 305(b)	200.0a	F	N	--	F	F	F	F	--	--
Shellpot Creek	DE 300-001-01	Lower Shellpot Creek	102041	1.0m	P	N	--	F	--	--	F	--	--
Shellpot Creek	DE 300-001-02	Upper Shellpot Creek	102011 102051 102061 102071 102081 102091	14.2m	F	N	--	F	--	F	F	--	--
Shellpot Creek	DE 300-001-03	All Other Tributaries To Shellpot Creek Located In The Watershed But Not On the mainstem.	2000 305(b)	7.6m	P	N	--	F	--	F	F	--	--
White Clay Creek	DE 320-001	White Clay Creek From Pennsylvania State Line	105011 105031 105151	18.2m	F	N	N	F	F	F	F	F	--
White Clay Creek	DE 320-002	Mill Creek	105071	16.6m	F	N	--	F	F	F	F	F	--
White Clay Creek	DE 320-003	Pike Creek	105101	8.2m	F	N	--	F	F	F	F	F	--
White Clay Creek	DE 320-004	Middle Run	105131	5.8m	F	N	--	F	F	F	F	--	--
White Clay Creek	DE 320-005	All Tributaries to White Clay Creek From The Headwaters To The Confluence With the Christina River	2000 305(b)	14.2m	P	N	--	F	F	F	F	--	--

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.

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 February 2002 (see also Figure III-6).

Delaware Fish Consumption Advisories as of February, 2002

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

Delaware Fish Consumption Advisories as of February, 2002				
Waterbody	Species	Geographical Extent	Contaminants of Concern*	Advice
Non-Tidal Brandywine River	All Finfish	Baynard Blvd. To Pennsylvania Line	PCBs, Dioxin	No more than two 8-ounce meals per year
Shellpot Creek	All Finfish	Rt. 13 to the Delaware River	PCBs, Chlordane	No Consumption
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 Route 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
Drawyers Creek	All Finfish	Tidal Portions	PCBs, DDT	No More than one 8-ounce meal per year

Delaware Fish Consumption Advisories as of February, 2002				
Waterbody	Species	Geographical Extent	Contaminants of Concern*	Advice
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.4.1.1 National Methylmercury Fish Consumption Advisory

On January 12, 2001, EPA and the Food and Drug Administration (FDA) issued concurrent national fish consumption advisories recommending restricted consumption of freshwater coastal and marine species of fish due to methylmercury contamination. EPA's advisory targeted women of childbearing age and children who may be consuming noncommercial freshwater fish caught by family or friends. The advisory specifically recommends that women who are pregnant or could become pregnant, women who are nursing a baby, and their young children, should limit consumption of freshwater fish caught by family and friends to one meal per week unless the state health department has different advice for the specific waters where the fish are caught. For adults, one meal is six ounces of cooked fish or eight ounces uncooked fish; for a young child, one meal is two ounces of cooked fish or three ounces of uncooked fish.

The FDA issued advice on mercury in fish bought from stores and restaurants, which includes ocean and coastal fish as well as other types of commercial fish. The advice was that women who are pregnant or could become pregnant, nursing mothers, and young children, not eat shark, swordfish, king mackerel, or tilefish. FDA also advises that women who are pregnant or could become pregnant may eat an average of 12 ounces of fish purchased in stores and restaurants each week. EPA recommends that women who are or could become pregnant, nursing mothers, and young children follow the FDA advice for coastal and ocean fish caught by family and friends. EPA and FDA both recommend that the public check with state or local health authorities for specific consumption advice about fish caught or sold in the local area. The EPA and FDA advisories are available through the EPA fish advisory website.

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).

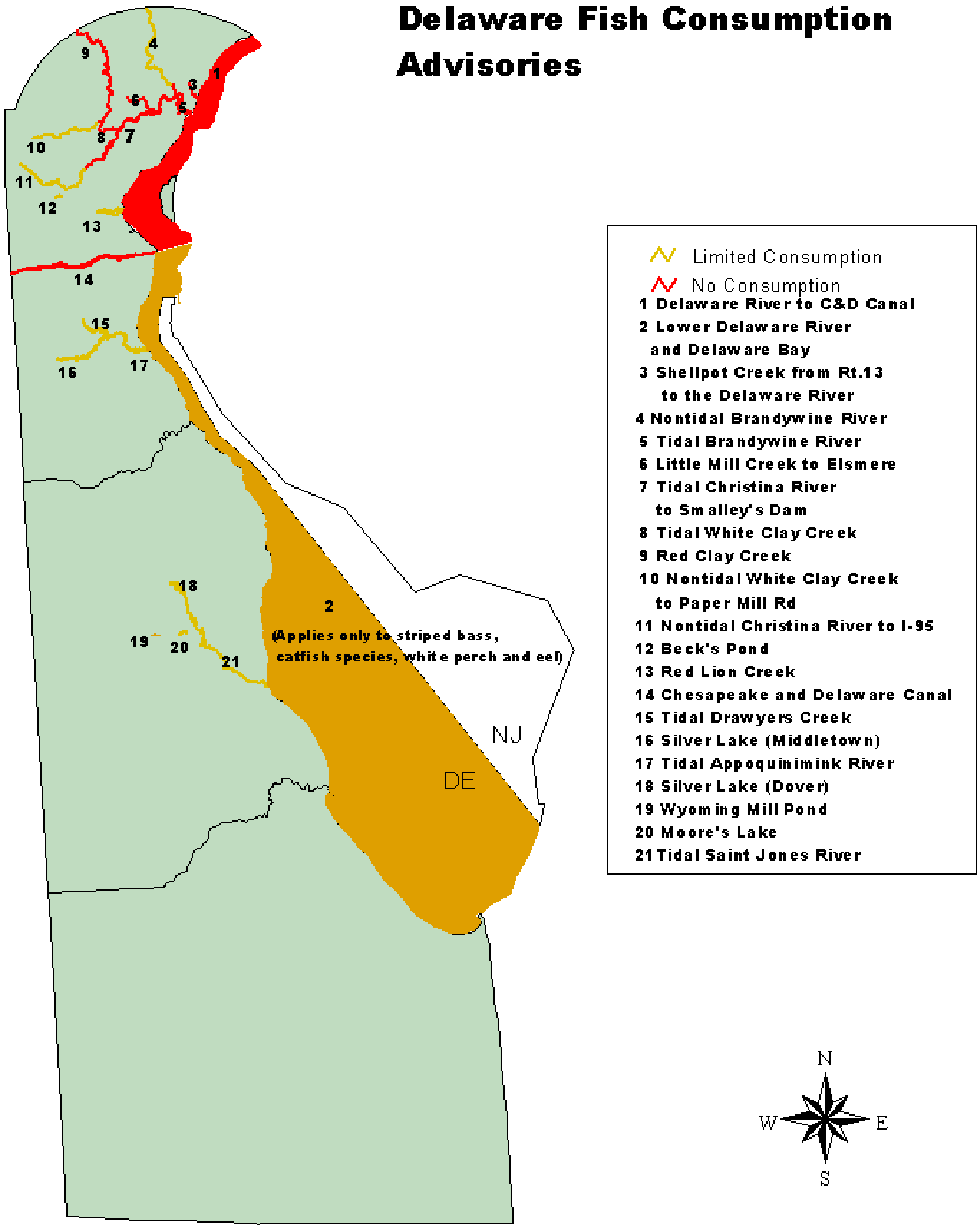
DNREC's role is to maintain Delaware's NSSP conforming status, as per FDA scrutiny (annual Program evaluations), thereby allowing Delaware to ship and receive shellfish. This is necessary for the preservation of Delaware's shellfish industry. Additionally, and most importantly, this ensures a safe product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

Figure III-6

Delaware Fish Consumption Advisories



Advice applies to all finfish species for the listed waterways except as noted for the Delaware portion of the Delaware Bay.
For further informantion, please contact DHSS at (302) 739-5617 or DNREC at (302) 739-4506.

Part IV Ground Water Assessment

IV.1 Ground-Water 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. Work by the USGS in the Red Clay Creek Basin estimated that base flow comprises 62-71% of stream flow (Vogel and Reif, 1993). In Atlantic Coastal Plain streams in Delaware, base flow has been shown to constitute approximately 80 percent of surface-water flow (Johnston, 1976). During periods of low or no rainfall, essentially all surface water flow is due to ground-water discharge.

Saltwater intrusion and high iron content in ground water are two naturally occurring contamination problems that may render ground water undrinkable. Radionuclides have been found in certain aquifers in both New Jersey and Maryland and studies in Delaware (Bachman and Ferrari, 1995; Werkheiser, 1995; Ferrari, 2001) indicate that they, particularly radon, are elevated in some areas. The occurrences of these contaminants appear to be 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 anthropogenic 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.).

In the previous three 305 (b) reports, the summaries of basin assessments for ground water were included. These included those for the Piedmont Basin, Inland Bays/Atlantic Ocean Basin, and the

Chesapeake Bay Basin. DNREC is drafting the remaining basin report, namely that for the Delaware River and Bay Basin. That report should be available for inclusion in the next 305 (b) report. In addition, DNREC has begun updating the Piedmont Basin Assessment Report.

IV.2 Factors affecting Ground-Water Availability

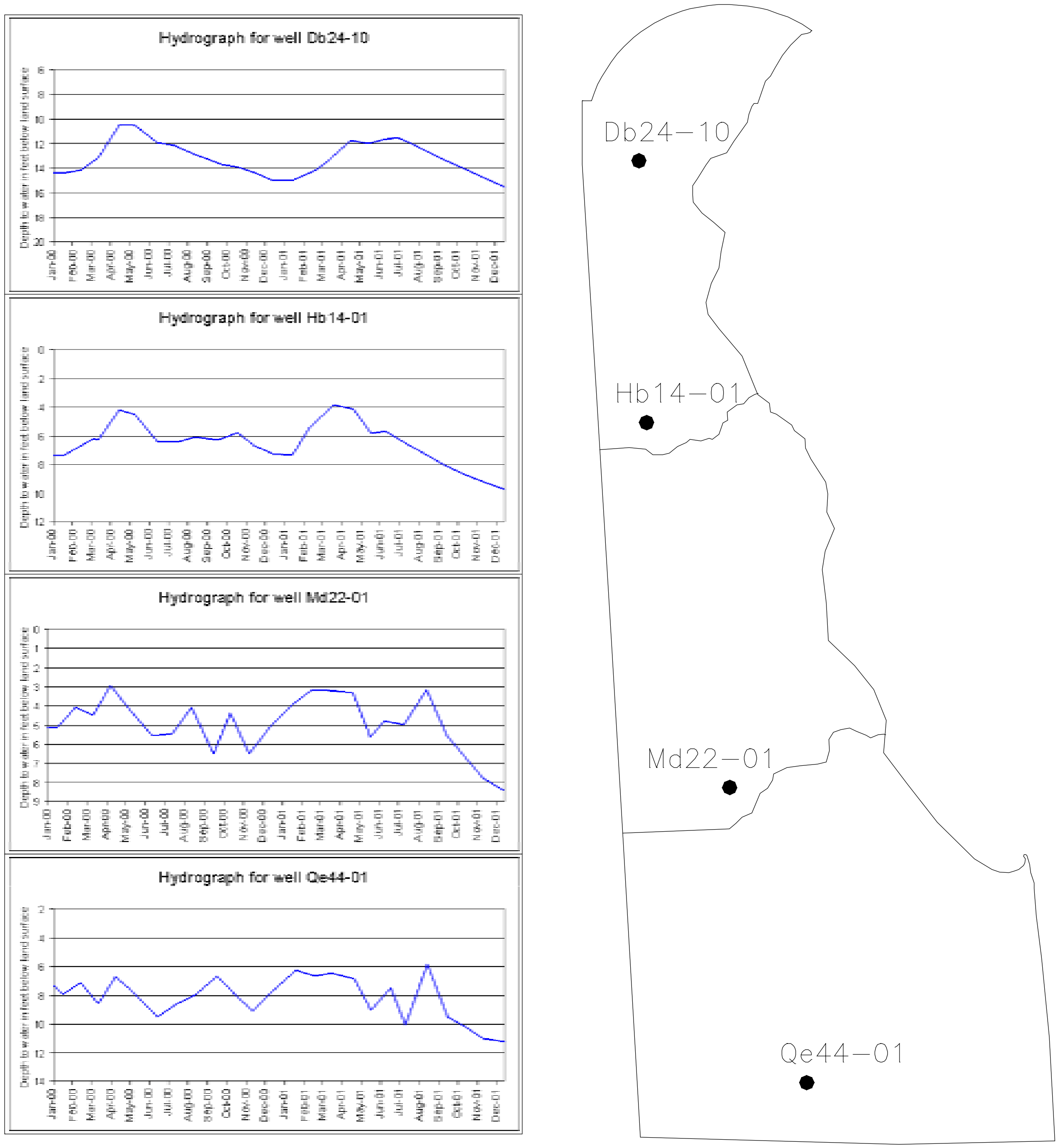
IV.2.1 Delaware's Water Budget

Annual precipitation in Delaware ranges from 30 to 58 inches and averages 44 inches. The annual precipitation rate usually exceeds the evapotranspiration rate by 12 to 18 inches. During summer when temperatures are high and plants are most active, virtually all of the precipitation is lost to evapotranspiration or overland flow. As a result, very little water is left to recharge aquifers and water levels in the water-table aquifer generally decline 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 to streams, rivers, bays, and the Atlantic Ocean, is captured by pumping wells, or recharges deeper, confined aquifers. Shallow ground water is particularly important to the hydrologic regime of Delaware's streams. A study conducted by Johnston (1976), which included four small basins in the Atlantic Coastal Plain of Delaware, concluded that ground-water discharge (i.e., base flow) constitutes approximately 80 percent of surface-water flow. Excessive pumping of water from wells in the water-table aquifer can be at the expense of stream flow. During late summer stream flow often declines to only 100,000 gallons per day per square mile.

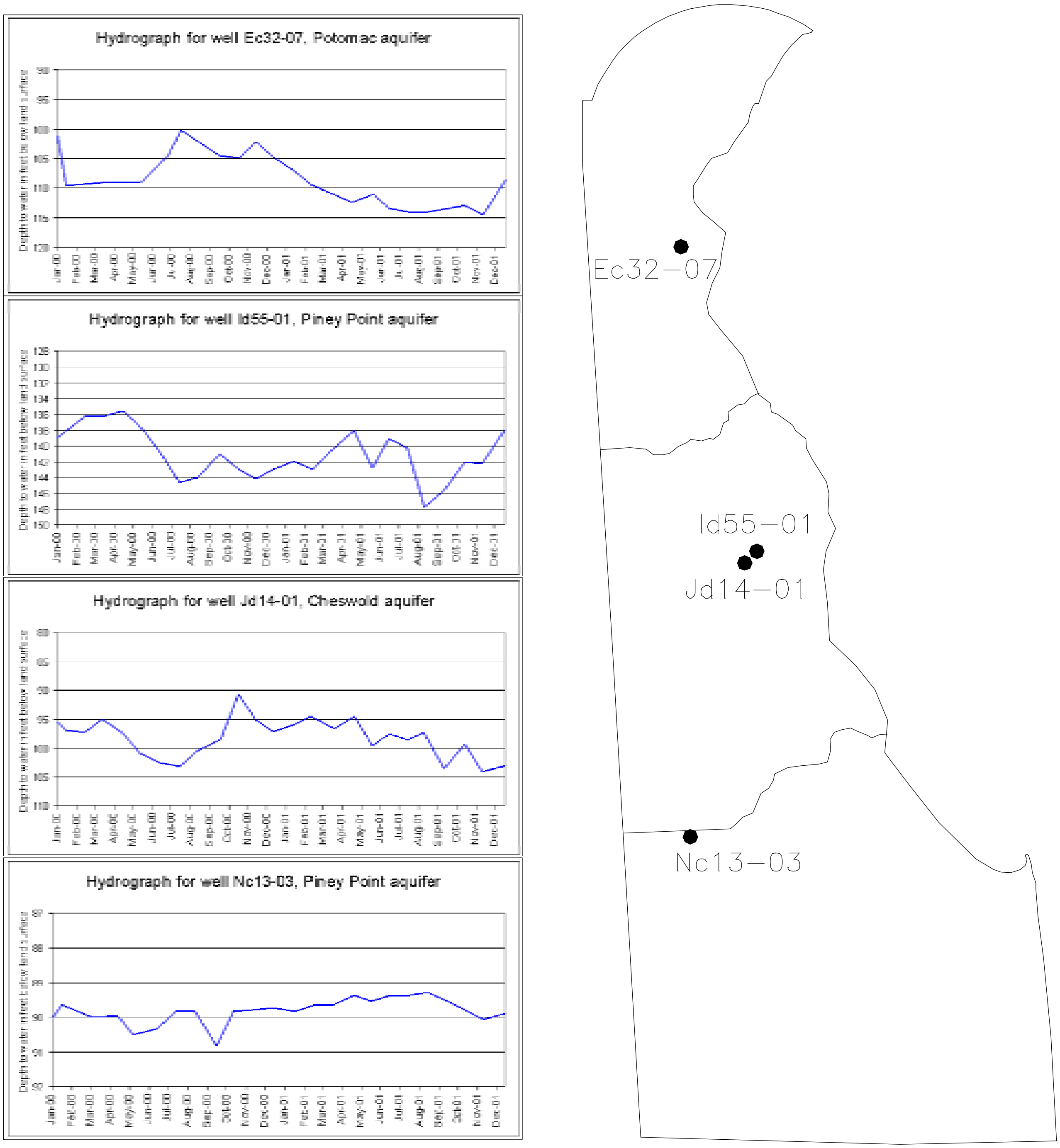
Water conditions for October 1, 2000 through September 30, 2001, as reported by the Delaware Geological Survey (Talley and Baxter, 2001), indicate below normal precipitation in northern Delaware and normal to above normal precipitation in central and southern Delaware. In general, mean monthly stream flows for this period ranged from normal (Brandywine Creek and St. Jones River) to above normal (Nanticoke River) and water-table levels were in the normal range (Talley and Baxter, 2001). However, in September 2001, the water conditions index for New Castle County was in the "potential shortage" range (Talley and Baxter, 2001) and, due to prevailing dry conditions during October, November, and December 2001, the index remained in the "potential shortage" range for the latter part of 2001 (Talley and Baxter, 2002a; 2002b). Throughout Delaware, below-normal stream flows were reported in late 2001, with record low flows on the Brandywine Creek, and water levels in the water-table observation wells have been approaching record low levels (Talley and Baxter, 2002b). At the time of the preparation of this ground-water assessment report (March 2002), Delaware initiated a "drought warning" recommending water conservation.

Figures IV-1 and IV-2 illustrate changes in ground-water levels in the water-table (unconfined) and artesian (confined) aquifers, respectively, for the 2000-2001 reporting period. As indicated on these figures, water-level data are from digital records made available by the Delaware Geological Survey (http://www.udel.edu/dgs/Hydrology/histgw.html). Water levels in water-table observation wells Db24-10 and Hb14-01, which are located in New Castle County (Figure IV-1), have been declining since July 2001. Water levels in water-table observation wells Md22-01 and Qe44-01, which are located in Kent County and Sussex County, respectively (Figure IV-1), have been declining since August/September 2001. Hydrographs for Md22-01 and Qe44-01 (Figure IV-1) indicate that, during the winter of 2001, water levels were approximately 3 feet lower than they were during the winter of 2000. Water levels in the artesian observation wells (Figure IV-2) appear to be fairly stable over the 2000-2001 reporting period.



Source: Delaware Geological Survey (http://www.udel.edu/dgs/Hydrology/histgw.html)

Figure IV-1. Hydrographs and location map for selected water-table (unconfined) observation wells in Delaware. Water-level data are for the 2000-2001 reporting period.



Source: Delaware Geological Survey
(http://www.udel.edu/dgs/Hydrology/histgw.html)

Figure IV-2. Hydrographs and location map for selected artesian (confined) observation wells in Delaware. Water-level data are for the 2000-2001 reporting period.

IV.2.2 Geology, Hydrogeology, and Ground-Water Recharge Potential

IV.2.2.1 Geology

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

The Piedmont Province consists of very old igneous and metamorphic rocks, and occupies approximately six percent of the State's land area. Schenck et al. (2000) recently completed detailed geologic mapping of the Piedmont of Delaware and adjacent Pennsylvania. A report entitled "Bedrock geology of the Piedmont of Delaware and adjacent Pennsylvania" (Plank et al., 2000) accompanies this map. For additional information concerning Delaware's Piedmont geology, the reader is directed to these two publications and their associated reference sections. The Piedmont Province in Delaware contains the Cockeysville Formation. This formation is a fractured and solution-dissolved marble and dolomite that 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 (e.g., Woodruff and Plank, 1995) and the U.S. Geological Survey (e.g., Werkheiser, 1995). Findings presented by Werkheiser (1995) indicate that water withdrawals 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 southeastwardly thickening sequence of unconsolidated and semi-consolidated sediments that rest unconformably on crystalline basement rock. In general, these deposits, which are of fluvial and marine origin, dip gradually toward the southeast and form a sediment wedge. The thickness of this sediment wedge is approximately 10,000 feet in southeastern Delaware.

IV.2.2.2 Hydrogeology

The Atlantic Coastal Plain sediments previously described contain the principal aquifer systems in the State. All of the aquifers are used in some capacity as a source of potable water. South of the C & D Canal, ground water from these aquifers provides almost all of the freshwater needed for all uses, and all of the drinking water is derived from ground water.

The principle hydrologic units in the Atlantic Coastal Plain of Delaware include, from oldest to youngest, the Potomac, Magothy, Englishtown-Mt. Laurel, Rancocas, Piney Point, Cheswold, Federalsburg, Frederica, Milford, Manokin, Pocomoke, and Columbia aquifers. The latter blankets most of the state and is important for water supply, base flow to streams and rivers, and recharge to deeper, confined aquifers. Hydrologic units recognized in Delaware and their associated well yield are summarized in Table IV-1. Figure IV-3 illustrates the generalized subcrop areas for some of the confined aquifers. Figure IV-4 is a cross-sectional diagram of the major aquifers found in Delaware.

More detailed geohydrologic mapping in Delaware has been completed for the Dover area (Woodruff, 1972), Newark area (Woodruff, 1977, 1978), Wilmington area (Woodruff, 1981, 1984a, 1984b, 1985), Milford area (Talley, 1982), northern coastal area (Andres, 1986, 1987a), Chesapeake and Delaware Canal area (Woodruff, 1986, 1988), southern coastal area (Talley, 1987, 1988), Middletown-Odessa area (Woodruff, 1990), Seaford area (Andres, 1994), and Smyrna-Clayton area (Andres, 2001).

Table IV-1. Hydrologic and geologic units recognized in Delaware. Table modified after the Delaware Geological Survey (http://www.udel.edu/dgs/Hydrology/hydrostrat.html).

Age	Geologic Units	Hydrologic Units
Holocene		
Pleistocene	Carolina Bay deposits upland bog deposits Cypress Swamp Fm. Nanticoke deposits Scotts Corners Fm. Lynch Heights Fm.	Columbia/ Unconfined/ Pleistocene aquifer - poor to excellent yield, minor confining beds
	Omar Fm.	Confining unit over Columbia aquifer only in southeastern Sussex County - minor poor aquifer
	Staytonville unit Columbia Fm.	Columbia/ Unconfined/ Pleistocene aquifer - poor to excellent yield, minor confining beds
Pliocene	Beaverdam Fm.	
Miocene	Bethany fm.	Interbedded confining units and Pocomoke aquifer - fair to excellent yield
	Manokin fm.	Manokin aquifer - fair to excellent yield and confining beds
	St. Marys Fm.	Confining beds - minor poor aquifer
	Choptank Fm.	Interbedded unnamed aquifers; fair to good yields, and confining units Milford aquifer - fair to good yield
	Calvert Fm.	Confining beds
		Frederica aquifer - fair to good yield
		Confining beds
		Federalsburg aquifer - fair to good yield
		Confining beds
		Cheswold aquifer - fair to excellent yield
		Confining beds
Oligocene	Glauconitic unit of Oligocene age	
Eocene	Glauconitic unit of late Eocene age	
	Piney Point Fm.	Piney Point Aquifer - poor to excellent yield, interbedded confining units
	Shark River Fm. Deal Fm.	Confining Beds
	Manasquan Fm.	Rancocas aquifer - fair to good yield, interbedded confining units
Paleocene	Vincentown Fm.	
	Hornerstown Fm.	Confining beds
Cretaceous	Navesink Fm.	
	Mount Laurel Fm.	Mount Laurel Aquifer - poor to good yield
	Marshalltown Fm.	Confining bed
	Englishtown Fm.	Englishtown Aquifer - fair to good yield
	Merchantville Fm.	Confining bed
	Magothy Fm.	Magothy Aquifer - fair to good yield

Age	Geologic Units	Hydrologic Units
	Potomac Fm.	Potomac aquifers and confining units - fair to excellent yields
Triassic and Jurassic	Post-rift unconformity rocks (of Jurassic age) Rift basin rocks (inferred)	

Poor yield (<10 gallons per minute (gpm))

Fair yield (10-50 gpm)

Good yield (50-500 gpm)

Excellent yield (>500 gpm)

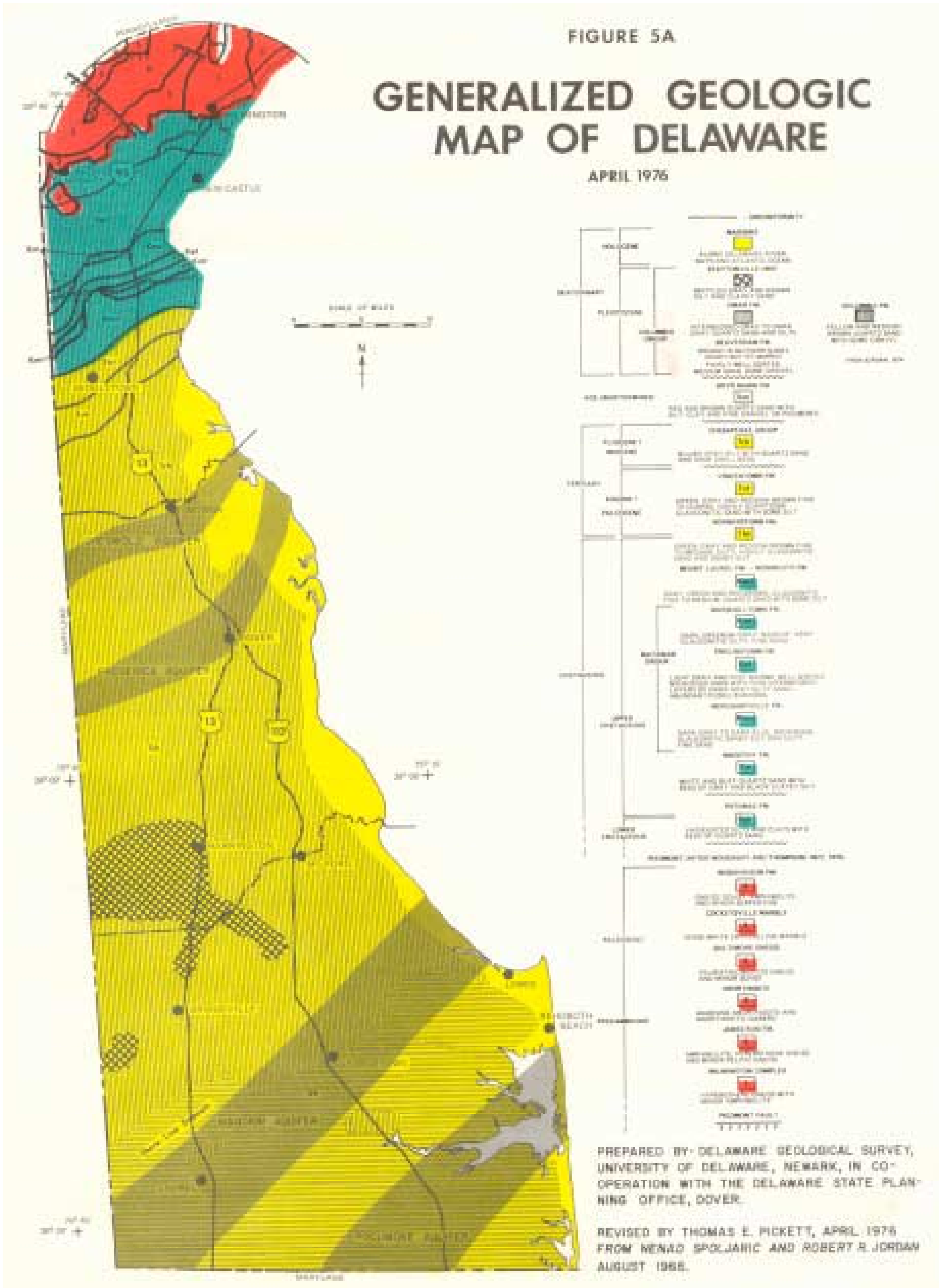


Figure IV-3. Generalized Geologic Map of Delaware (from Pickett, 1976).

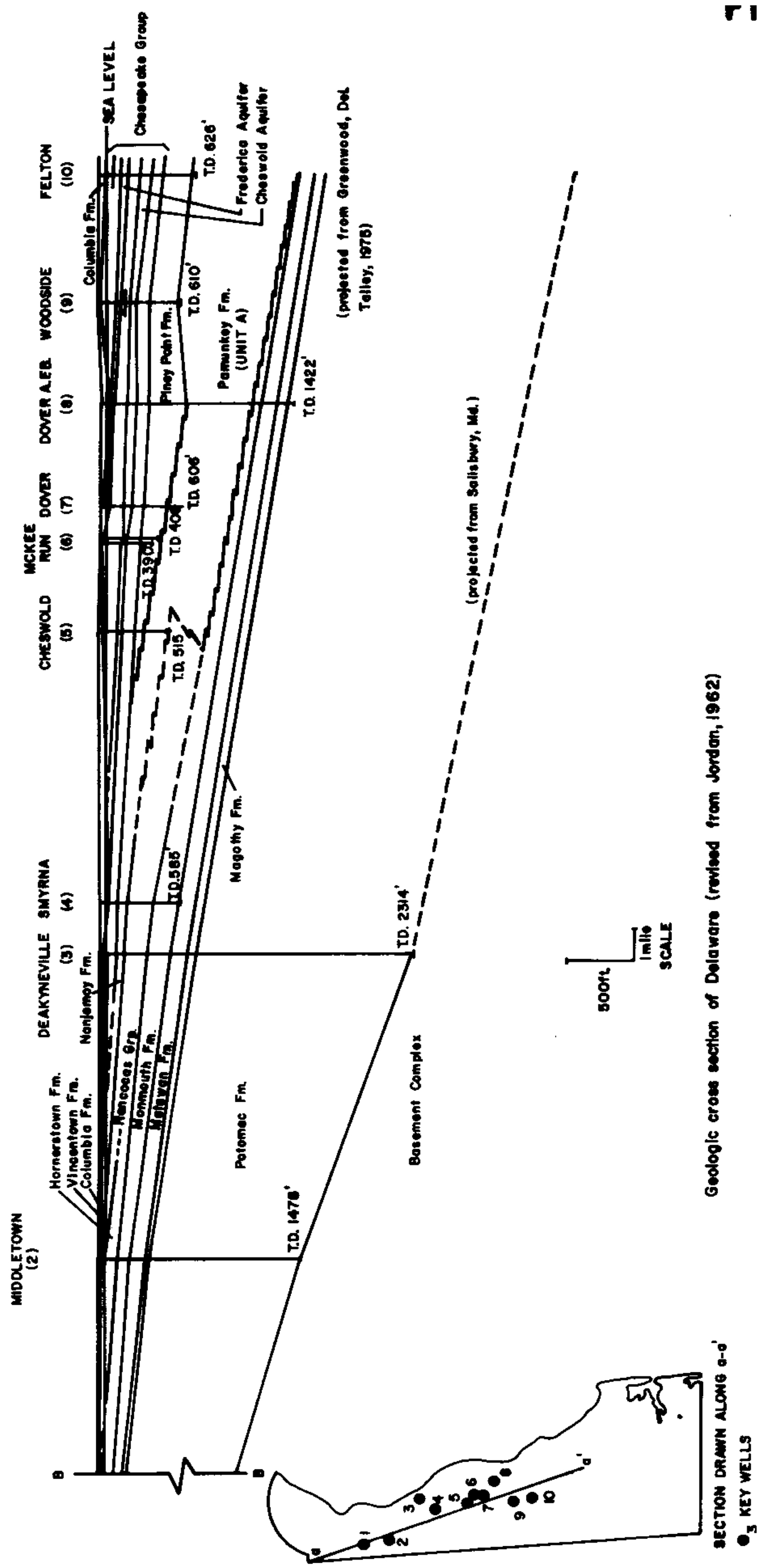


Figure IV- 4. Generalized geologic cross section of the Coastal Plain of Delaware (from Pickett, 1976).

IV.2.2.3 Ground-Water Recharge Potential

In 1990 the DNREC began working with the Delaware Geological Survey to map ground-water recharge potential for the entire state. Ground-water recharge potential is the relative ability of water to pass from the land surface into the underlying aquifer. A rating of excellent, good, fair or poor is assigned based on the relative amount of sand, silt and clay within the first 20 feet of land surface. The excellent areas are those with a very high percentage of sand in that 20-foot interval. The DGS published a report (Andres, 1991), which defines these ratings and also provides a means of challenging a particular rating at a specific location. As with any mapping project, the number of data points dictates the placement of lines between areas, and the addition of more data points helps refine the line.

Recharge mapping for the entire Coastal Plain of Delaware is now complete. Butoryak and Talley (1993) mapped ground-water recharge potential in the Coastal Plain of New Castle County. New Castle County adopted the excellent areas as one of several Water Resource Protection Areas (WRPAs) in their Water Resource Protection Area ordinance. A map showing the distribution of these recharge protection areas in New Castle County is presented in Figure IV-5.

A. Scott Andres et al. of the Delaware Geological Survey recently completed recharge-potential mapping in Kent and Sussex counties. This work was completed on a 7.5-minute quadrangle basis in accordance with methodology described by Andres (1991). The recharge-potential maps assign relative ratings of excellent, good, fair, or poor recharge potential. The excellent recharge areas are very sandy and would allow relatively rapid infiltration of water and, by extension, contaminants. The relative ranking is based upon the grain-size composition of the first 20 feet of soil materials. The maps depict the four recharge potential areas and are available in both hard copy and digital format. Figure IV-6 is a map showing areas of excellent recharge potential in Kent and Sussex counties.

In 2001, the Delaware General Assembly passed a bill that recognized both excellent ground-water recharge areas and wellhead protection areas as critical resource areas that needed to be addressed by the local governments. This included counties, as part of their land use plans, and towns with over 2000 residents.

IV.2.3 Water Use in Delaware

Water-use information, which is published by the U.S. Geological Survey every five years, was not available for 2000 at the time of this ground-water assessment preparation. For discussion on the most recent (1995) water-use information for Delaware, the reader is directed to the 2000 305(b) ground-water assessment or Wheeler (1995). The raw water-use data for 1995 are presented in Solley et al. (1998). Water use for 2000 will be summarized in the 2004 305(b) ground-water assessment section.

Well permit issuances for the 2000-2001 reporting period are summarized in Table IV-2. All data have been refined to the county level. This information demonstrates the continued and increasing reliance on ground water for fresh water needs throughout the state. For each of the reported years, over 2,000 domestic well permits and over 100 public well permits were issued. Well over 50% of these well permits were issued in Sussex County alone, due to increased development in this largely rural county. Kent County had the second highest number of permit issuances; New Castle County had the least number of permit issuances. The number of permits issued in New Castle County likely indicates the trend toward increasing reliance on ground water noted in the previous report and is the result of full utilization of fresh water supplies from surface water. In addition, the southern part of New Castle County is experiencing a considerable amount of residential development with corresponding use of wells for public and domestic water supplies.

Table IV-2. **Summary of well permit issuances for the 2000-2001 reporting period.**

	2000				2001				All Years
	Kent	**New Castle**	**Sussex**	**Total**	**Kent**	**New Castle**	**Sussex**	**Total**	**Total**
Agricultural	72	18	245	**335**	74	15	228	**317**	**652**
Domestic	665	170	1271	**2106**	741	129	1319	**2189**	**4,295**
Dewatering	12	12	53	**77**	16	8	32	**56**	**133**
Heat Pump Supply	6	0	11	**17**	3	0	6	**9**	**26**
Heat Pump Recharge	6	1	13	**20**	2	0	6	**8**	**28**
Industrial/Ind - MW	6	2	5	**13**	12	3	4	**19**	**32**
Irrigation	55	5	94	**154**	56	5	79	**140**	**294**
Monitor	184	276	257	**717**	238	270	148	**656**	**1373**
Observation	38	46	8	**92**	8	38	9	**55**	**147**
Public	23	17	64	**104**	34	28	58	**120**	**224**
Other*	41	62	56	**159**	131	60	47	**238**	**397**
Injection/Temp Injection**	0	0	0	**0**	40	0	0	**40**	**40**
Recovery**	0	2	0	**2**	16	8	1	**25**	**27**
Total	1108	611	2077	**3796**	1371	564	1937	**3872**	**7668**

Source: Delaware Water Use Data System
* Other includes the following classes: Unknown, Fire Protection, Geoprobe, Geothermal, Other, Engineer Test Boring
** New well designations added in 2000

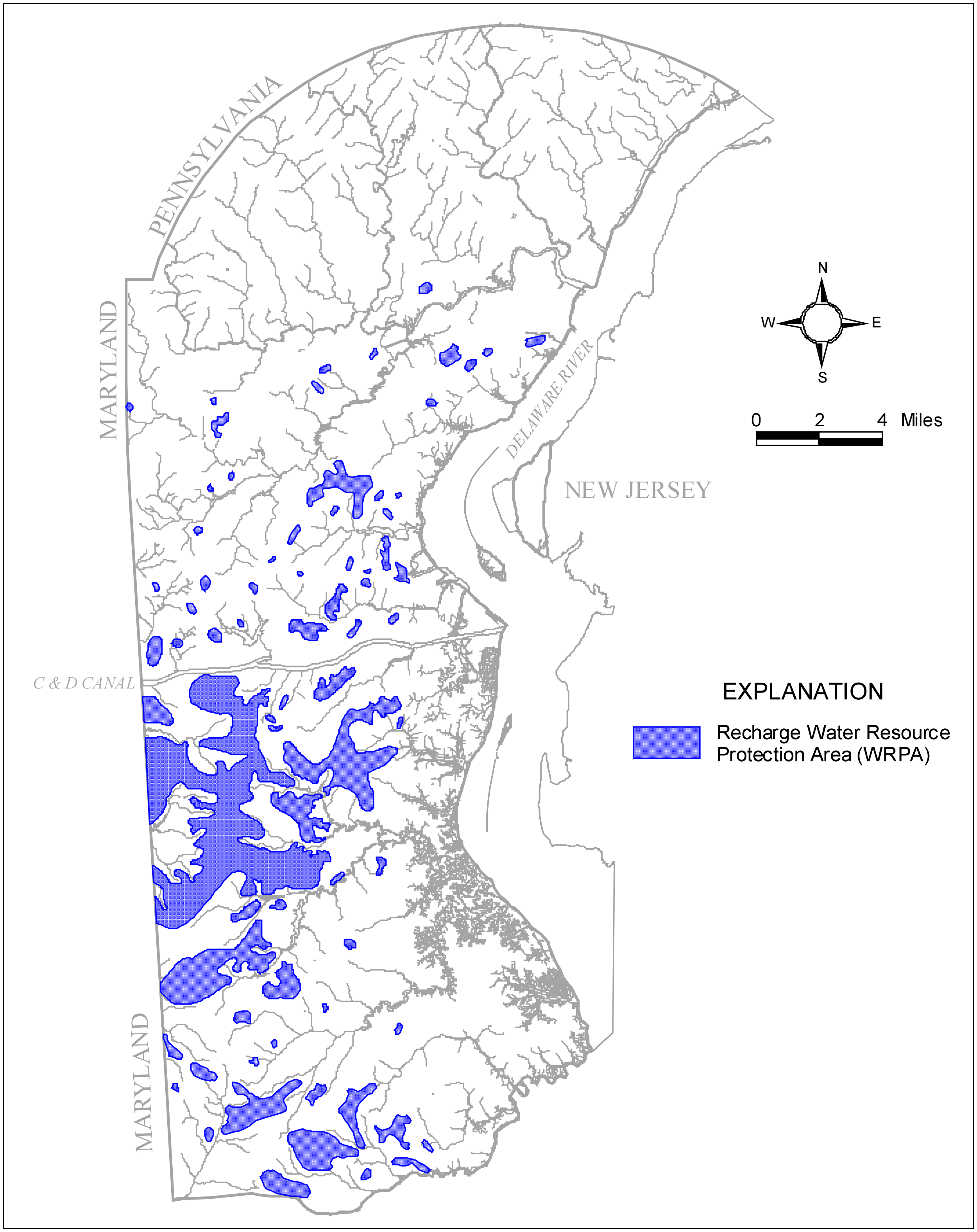


Figure IV-5. Recharge Water Resource Protection Areas (WRPAs) in New Castle County, Delaware (modified after Butoryak and Talley, 1993).

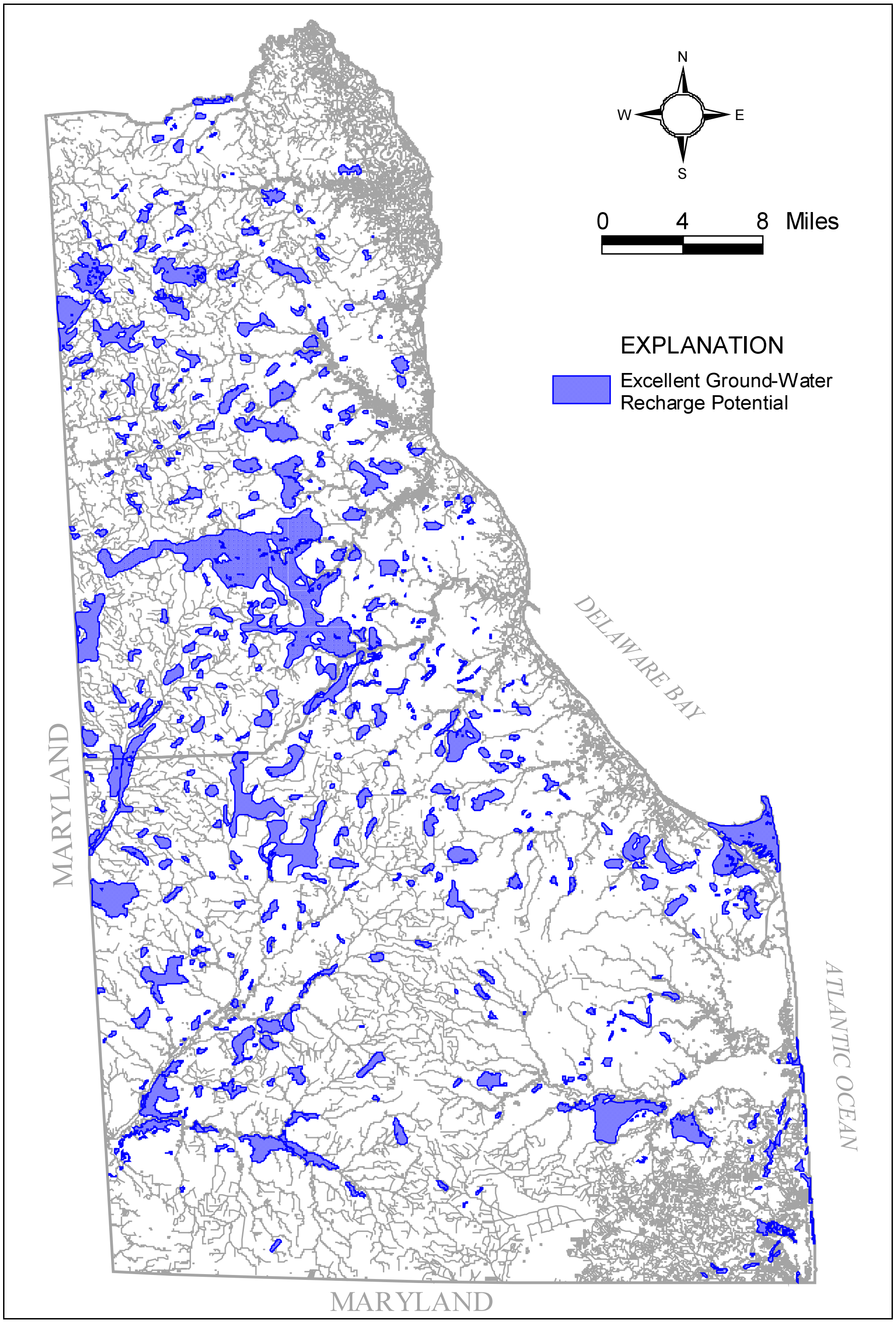


Figure IV-6. Areas of excellent ground-water recharge potential in Kent and Sussex Counties, Delaware. Modified after mapping by A. Scott Andres et al. of the Delaware Geological Survey. Mapping methodology is described by Andres (1991).

IV.3 Ground Water-Surface Water Interactions

The most pressing interactions between ground and surface waters in Delaware occur in coastal areas, particularly in Sussex County. Historically, saltwater intrusion has occurred as a result of ground-water withdrawal activities in coastal areas or along tidal streams, with both public and domestic water-supply wells having been affected. Monitoring networks are maintained along the coasts of New Castle County and Sussex County. The New Castle County network is restricted to wells completed in the Potomac aquifer system. Salt-water intrusion is discussed in more detail in Section IV.4.10.3.

As stated previously, ground-water discharge (i.e., base flow) has been shown to constitute approximately 80 percent of surface-water flow in Coastal Plain streams (Johnston, 1976). Modeling work conducted by Andres (1987b) in the Inland Bays of coastal Sussex County indicates that fresh ground-water discharge to the bays may range from 21 to 43 million gallons per day. Follow up work by Andres (1992) suggests that, on an average annual basis, nitrate "flux" to the Indian River and Rehoboth Bays from direct ground-water discharge may range from 1,303 to 2,500 pounds per day. Because of the importance of base flow to the hydrologic regime of Coastal Plain streams, additional study of ground water-surface water interactions in these areas is needed and is especially important for the determination of non-point source total maximum daily loads (TMDLs).

In recognition of the contribution of nutrient loading from ground-water discharge, the DNREC designed a study to assess the areal and vertical distribution of nutrients in ground water within the Indian River, Indian River Bay, and Iron Branch watersheds in Sussex County. The non-point source components of the TMDL goals for this watershed are considerable and require a detailed understanding of the overall nutrient concentration distributions. Sampling activities, which began in late 2001, will involve approximately 300 wells completed in the surficial (Columbia) aquifer. Work on this project is continuing into 2002. Once all data have been collected, a report of findings will be prepared. This information is to be used to identify areas of the watershed most in need of nutrient reductions in ground water. Future sampling of the network may allow for assessment of long-term trends of nutrients in ground water.

Work conducted by Werkheiser (1995) in the Cockeysville aquifer in northern New Castle County illustrates a somewhat different ground water-surface water interaction. Mill Creek, which originates in a noncarbonate geologic setting and flows over the carbonate, Cockeysville Formation, was found to lose water (about 0.55 million gallons per day) to the outcrop area of this formation. In addition, temperature anomalies were identified in ground-water wells indicating rapid flow from surface water to ground water, likely due to fractures in the formation. Werkheiser (1995) concluded that reduction in base flow in noncarbonate areas upstream of the Cockeysville outcrop could significantly reduce recharge to the Cockeysville aquifer.

IV.4 Potential Sources of Ground-Water Contamination

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-3. 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-4, IV-5, and IV-6 provide current information on potential point sources of ground-water contamination in New Castle County, Kent County, and Sussex County, respectively. Table IV-7 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 is listed below.

IV.4.1 Septic Systems

Septic systems are a source 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 in ground water 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 2001 on-site septic regulations are intended to limit nitrate-loading rates to 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 unconfined wells has been adopted into the regulations.

Domestic septic systems continue to be a common practice for domestic wastewater 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. 3,979 new domestic septic permits were issued during 2000-2001; of these, 54.6% were in Sussex County, 30% were in Kent County, and 15.4% were in New Castle County. This compares well with the 4,295 domestic well permits issued over the same period with similar percentages in each county. The Department estimates that, as of 1997, there were approximately 78,600 septic systems statewide. This information is based on a project that counted the number of dwellings outside sewer districts on 1997 aerial photographs. Of these, 20% are in New Castle County, 53% in Sussex County, and 27% in Kent County.

Septic systems that discharge in excess of 2,500 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 system’s effectiveness. Prior to installation of new large septic systems, an assessment of the impact of these systems on ground water, nearby potable wells, and surface water bodies is conducted to prevent contamination of these potential receptors. There are approximately 67 large septic systems currently operating statewide. Of these, 51 are in Sussex County. The overall decrease represents work on regionalization of wastewater treatment.

IV.4.2 Solid Waste Landfills

The types of landfills found in Delaware include sanitary and industrial. Other facilities involved in non-hazardous waste treatment or management include resource recovery facilities, transfer stations, infectious waste facilities, and closed sites. There are 8 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 5 (five) 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 two that existed before 1974. The two unlined landfills accept only flyash from coal burning electric power generating plants. All of the active landfills include groundwater, and if nearby, surface water monitoring. The pre-1974 landfills are being addressed by the Federal Superfund program, State HSCA program, or the Solid and Hazardous Waste Management program.

Inactive Sussex County Landfills - There are six (6) closed landfills in Sussex County - Laurel, Omar, Bridgeville, Stockley, Angola, and Anderson's Crossroads. EPA is currently in the process of de-listing the Laurel site from the NPL list. The other 5 sites are managed 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.4.3 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 installation standards, however smaller storage tanks such as domestic heating oil tanks are not 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 12,050 regulated USTs at 3,896 facilities of which 2,399 tanks at 1,092 facilities are currently in use. 9,651 USTs have been removed from the ground or properly abandoned in place. Since leaking UST problems were recognized in the early 1980s approximately 3,095 releases have been confirmed. Of these, 2,643 have been closed. Over the period 2000-2001, 274 sites had confirmed releases with 46 confirmed ground water releases. Of the confirmed ground water releases, 63% were in New Castle County, 22% in Kent County, and 15% in Sussex County.

The UST Branch uses the UST Access database to maintain an up-to-date file of facility names, owners, number of tanks, and status. Also, this database will be compatible with the Department's data integration efforts. The UST program has used prepared maps of public drinking water supplies for New Castle, Kent, and Sussex Counties since 1990 to determine if a new UST is close enough to a public water supply to warrant secondary containment. The maps are entitled Tank Area Secondary Containment (TASC) maps. The location of leaking UST's and most UST's are also mapped and are included in DNREC's GIS.

Since the deadline in December 1998 for all in use USTs to have equipment for early detection of leaks and for corrosion protection, the number of reported releases from USTs has declined. DNREC's UST program continues to enforce compliance with operating requirements for in use USTs as well as to require timely investigation and remediation of all suspected and confirmed releases from USTs.

Note: Delaware is looking into the possible regulation of aboveground storage tanks as a result of recent incidents. These may be included in the discussion in the next 305 (b) report as a potential source of ground-water contamination.

IV.4.4 Hazardous Substance Release Sites

DNREC has identified over 532 sites in Delaware as potential hazardous substance release sites. Of which, 439 sites have a higher priority because they are either a site in the State's Voluntary Cleanup Program (VCP) or they pose a risk to public health, welfare, and/or the environment. Of these 439 sites, 412 sites are being addressed either as a HSCA enforcement site, or as a VCP site. There are 17 Sites in Delaware that have been placed on EPA's National Priority List. Also the RCRA Corrective Action Program is addressing 10 Sites listed on the HSCA inventory list. DNREC is currently addressing 103 sites under HSCA, and 89 sites are currently undergoing investigation and cleanup under the Voluntary Cleanup Program (VCP)/ Brownfields Program. Cleanups have been completed at 108 sites, resulting in over 1,500 acres of underutilized property being returned to possible productive use.

In the last two (2) years, DNREC-SIRB has addressed Formerly Used Defense Sites (FUDS) as part of its Pre-Remedial Grant, ten (10) sites have been investigated. Eight (8) sites have undergone a Pre-Screening Assessment in order to provide necessary data to make a determination whether or not to continue pursuing a Site Inspection (SI) of these sites. Two (2) FUDS have undergone SI's, which is a process that evaluates the extent to which a site presents a threat to human health or the environment.

IV.4.5 Hazardous Waste Land Disposal Units

In Delaware, there are 7 hazardous waste land disposal units that have impacted ground water. These units are regulated by the State's Solid and Hazardous Waste Program and require permits for operation as well as post closure. Currently only one unit, Motiva's hazardous waste landfill, which received refinery wastewater treatment plant sludges, is considered an operating unit. The other 6 units have closed and have been issued a post-closure permits. These 7 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
Motiva	Landfill	VOC, Metals	Closure Pending
Atlantic Coast Environmental	Waste Pile	Solvents	Post Closure Permit issued
Oxy Chem	Landfill	Mercury	Post Closure Permit Issued

Dover Air Force Base	Surface Impoundment	Solvents	Post Closure Permit Issued
Hercules Research Center	Landfill	VOCs, SVOCs, metals	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 its potential to do harm to human health and the environment.

IV.4.6 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. As of 2002, EPA Region III maintains project lead status for five of the sites, the State for 6 sites. EPA and the State share primacy for the remaining two facilities. Of the thirteen sites subject to RCRA Corrective Action, ten sites have impacted ground water.

IV.4.7 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.

During the reporting period, UIC permits have been issued for two facilities for Aquifer Storage and Recovery operations where potable water is returned to the aquifer for latter recovery by public water supply wells. Both of these operations are located in New Castle County, Delaware.

The Underground Injection Control (UIC) 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 7 permits during 2000-2001.

IV.4.8 Land Application and Treatment

Land application and treatment of wastes includes spray irrigation, sludge application, and percolation basins. Sources of these wastes include municipal wastewater 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 21 active wastewater spray irrigation facilities in Delaware. Another six facilities are in various stages of design or review. The locations of all of the active 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 southern New Castle County (see Baxter and Talley, 1997) and some may be included in the ground-water-quality survey of the Indian River, Indian River Bay, and Iron Branch Watersheds in Sussex County (see Section IV.3). Most wastewater spray sites are found in Sussex County (16 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.

An additional site for land treatment of restaurant grease trap waste (GTW) has been approved under this program. Roughly 20,000 gallons of GTW are land applied onto this 7-acre site per month. The liquid waste contains primarily food waste (i.e. cooking oil, fat and polysaccharides) which is highly degraded in the soil/microbe matrix. The waste contains no contaminants of concern. There is no groundwater monitoring at the site. Activity is monitored by DWR. This practice may become commonplace as many wastewater treatment facility owners are refusing to accept GTW into their systems.

IV.4.9 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 affects 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.

The Delaware Department of Agriculture, in cooperation with the Delaware Geological Survey, recently completed a study of pesticides in shallow ground water in Delaware (Blaier and Baxter, 2000). Data presented by these workers are from approximately 350 ground-water samples collected from 136 monitoring points, which included domestic, agricultural, and monitoring wells less than 80 feet deep and distributed throughout most of the Atlantic Coastal Plain of Delaware. Analyses of ground-water samples were generally limited to the pesticides atrazine, alachlor, cyanazine, metolachlor, and simazine. Results presented by Blaier and Baxter (2000) indicated that pesticides were not detected in almost 80 percent of analyses, and concentrations were less than 1.0 micrograms per liter (µg/L) in 96 percent of the analyses. Alachlor was detected at concentrations above the PMCL (2 µg/L) in three wells located in Sussex County (PCMN62, PCMN122, and PCMN136). No other PMCL or State health advisory limit (HAL) exceedences were reported.

Analytical data for pesticides and metabolites presented in a recent report by the U.S. Geological Survey (Ferrari, 2001) are in general agreement with results from Blaier and Baxter (2000). The USGS work involved the collection of raw ground-water samples from 30 randomly-selected, unconfined public water-supply wells. Water-quality analyses included 45 pesticides and 13 pesticide metabolites, all of which were generally less than 1.0 µg/L. No PMCL or HAL exceedences for pesticides were reported by Ferrari (2001).

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 (PMP). The PMP emphasizes prevention and will allow the State to responsibly manage pesticides into the future.

IV.4.10 Naturally-Occurring Contaminants of Concern

Major naturally-occurring ground-water contaminants in Delaware include, but are not limited to, arsenic, radionuclides, saltwater, and iron. Each of these contaminants is discussed separately in the following sections.

IV.4.10.1 Arsenic

There are presently limited data for the occurrence and distribution of ambient (naturally-occurring) arsenic in ground water in Delaware. Raw ground-water samples for trace metals analyses collected by the Delaware Office of Drinking water during the 2000-2001 reporting period indicate that arsenic was detected in 11 (18%) of 61 samples (see Section IV.5.2 and Table IV-8). However, none of the reported concentrations exceeded the PMCL for arsenic (0.05 mg/L). It is important to note that sources of arsenic (naturally-occurring or anthropogenic) cannot be ascertained from these data. According to the U.S. EPA (http://www.epa.gov/safewater/arsenic.html), on January 23, 2006 public water systems will have to comply with the new PMCL for arsenic (0.01 mg/L). Seven (11.5%) of 61 samples collected by the Office of Drinking Water during the reporting period showed concentrations of arsenic above 0.01 mg/L. More study of ambient arsenic in Delaware's ground water appears to be warranted.

IV.4.10.2 Radionuclides

Radionuclides include approximately 2,000 species of atoms (both naturally occurring and man-made), which, by way of radioactive decay, emit radiation in the form of alpha particles, beta particles, or gamma rays (Facozio et al., 2000). Alpha and beta radiation are composed of particle emissions that cannot penetrate the skin and, therefore, must be ingested in order to come in contact with internal tissue; gamma radiation, however, is an energy emission that can penetrate through skin and internal tissue (Facozio et al., 2000). The standard unit of measure for radioactivity in water is picocuries per liter (pCi/L). One pCi/L is equivalent to 2.2 radioactive disintegrations per minute per liter of water.

Because they are known carcinogens, the U.S. EPA has established primary maximum contaminant levels (PMCLs) for beta particles and photon emitters (4 millirems per year), gross alpha particle activity (15 pCi/L), and radium-226 and radium-228 combined (5 pCi/L). Effective December 8, 2003, the PMCL for uranium will be 0.03 milligrams per liter (mg/L). The proposed PMCL for radon-222, which is a gas that results from the radioactive decay (alpha decay) of radium-226, is 300 pCi/L. The Delaware Division of Public Health's Office of Drinking water presently enforces PMCLs for gross alpha (15 pCi/L) and gross beta (4 pCi/L) activities.

Studies conducted by the U.S. Geological Survey (Werkheiser, 1995; Bachman and Ferrari, 1995; Ferrari, 2001) have documented the presence of radionuclides in Delaware's ground water. Werkheiser (1995), in his study of the hydrogeology of the Cockeysville aquifer and adjacent noncarbonate aquifer in northern Delaware, collected 29 ground-water samples for radon-222 analysis. Out of the 29 samples, 14 (48%) had radon-222 concentrations greater than 300 pCi/L. The average, minimum, and maximum radon-222 concentrations were 461, <80 (not detected above 80 pCi/L), and 2,500 pCi/L, respectively.

Investigation of ground-water quality and geochemistry in southern New Castle County (Bachman and Ferrari, 1995) involved the collection of 21 samples for radon-222 analysis. The samples were collected from wells completed in the Magothy and Potomac aquifer system (six samples), the Englishtown-Mount Laurel aquifer system (eight samples), and the Rancocas aquifer (seven samples). Although radon-222 was detected in each aquifer system, concentrations greater than 300 pCi/L were limited to the Englishtown-Mount Laurel (seven out of eight samples) and the Rancocas (seven out of seven samples). The maximum radon-222 concentration detected (1,700 pCi/L) was in Englishtown-Mount Laurel well Eb43-09 in Summit, Delaware. Additional data for radon in ground water in southern New Castle County are presented by Baxter and Talley (1997).

The U.S. Geological Survey (Ferrari, 2001) recently completed an assessment of the occurrence and distribution of selected contaminants in public drinking-water supplies in the surficial aquifer in Delaware. This assessment involved the collection of ground-water samples from 30 randomly-selected, unconfined public water-supply wells. A subset of 10 wells was sampled for gross alpha and gross beta activities, radium-224, -226, and -228, and radon-222. Although detectable levels of these radionuclides were identified, none of the activities exceeded a MCL. Only one sample showed a radon-222 activity above the proposed MCL (300 pCi/L).

IV.4.10.3 Saltwater Intrusion

Saltwater 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 saltwater 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 saltwater intrusion. The Delaware Geological Survey monitors a group of coastal wells screened in all of the major aquifers that are used for public water from the Town of Lewes to Fenwick Island State Park, all along the Atlantic Coast and Inland Bays. The DNREC also samples wells in coastal New Castle County in order to monitor for chlorides in the Potomac aquifer. The DNREC's Water Allocation Program monitors and regulates withdrawals from coastal wells to reduce the possibility of salt water intrusion. Yearly summaries of the Coastal Sussex network are prepared by the Delaware Geological Survey (Talley and Bounds 2000, 2001). 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. Both of the networks are subject to changes in wells because of well abandonment, construction problems, and identification of new areas of concern.

IV.4.10.4 Iron

The secondary maximum contaminant level (SMCL) for iron (0.3 mg/L) is a non-enforceable standard because it may cause cosmetic effects such as taste or color. However, iron in ground water is a widespread problem in Delaware and many water supplies have treatment systems to remove iron. Raw ground-water samples for routine chemical analyses collected by the Delaware Office of Drinking water during the 2000-2001 reporting period indicate that iron exceeded the SMCL in 192 (34.22%) of 561 samples (see Section IV.5.1 and Table IV-8).

Table IV-3. Potential sources of ground-water contamination in Delaware

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-4. Summary of known or potential sources of ground-water contamination in New Castle County, Delaware.

Source Type	Present in County	Total Number of Sites in County	Number of Sites that are Listed and/or have Confirmed Releases		Number of sites 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 2000 and 2001							
NPL//EPA Removal	Yes	9//5	1 [K1]	1 [K2]	9//5	Solvents, (TCE, PCE Vinyl Chloride)	--	--	--	--	--
State Sites (non-NPL)	Yes	363	44 [K1]	25 [*, K2]	58 *	TCE, PCE, Metals	--	--	--	--	--
DOD/DOE/FUDS	Yes	5	3 [K1]	0 [K2]	1	TCE	1	--	--	--	--
LUST	Yes	1871	1871	173 [L1]	17 [L1]	Benzene, Petroleum, MTBE	294 [L1]	281 [L2]	274 [L3]	274 [L3]	1434 [L2]
RCRA [R1]	Yes	8	8	--	8	LNAPLs, Metals, Inorganic Solvents	8	2	6 [R2]	--	--
Solid Waste	Yes	4	4	--	4	Landfill Leachate, Coal Ash	--	--	--	--	--
Underground Injection	Yes	21	21	4 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Large Septic System	Yes	10	10	4 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Domestic Septic	Yes	16,066	16,066	612 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Spray Irrigation	Yes	4	4	0 [D2]	[D3]	Nitrates, Coliform, Chloride, Sodium	--	--	--	--	--
Sludge Application Permits [S1]	No	0	0	0 [S1]	[D3]	Nitrates	--	--	--	--	--

NPL - National Priority List
DOE - Department of Energy
DOD - Department of Defense
FUDS - Formerly-Used Defense Sites
LUST - Leaking Underground Storage Tanks
RCRA - Resources Conservation and Recovery Act
-- - Data not available or not applicable
* - Estimated value

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
K1 - Reported as new sites identified in 2000-01
K2 - Reported as new sites with ground-water contamination

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-5. Summary of known or potential sources of ground-water contamination in Kent County, Delaware.

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 2000 and 2001							
NPL	Yes	6	0 [K1]	0 [K2]	6	TCE, PCE, Benzene	--	--	--	--	3
State Sites (non-NPL)	Yes	73	10 [K1]	3 [*,K2]	40 *	TCE, Metals	--	--	--	--	--
DOD/DOE/FUDS	No	--	--	--	--	--	--	--	--	--	--
LUST	Yes	573	573	61 [L1]	11 [L1]	Benzene, Petroleum,MTBE	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	16	16	1 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Large Septic System	Yes	13 [D1]	13	5 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Domestic Septic	Yes	22,276	22,276	1,195 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Spray Irrigation	Yes	1	1	0 [D2]	[D3]	Nitrates, Coliform, Chloride, Sodium	--	--	--	--	--
Sludge Application Permits [S1]	Yes	3	3	3 [S1]	[D3]	Nitrates	--	6 --	--	--	--

NPL - National Priority List
DOE - Department of Energy
DOD - Department of Defense
FUDS - Formerly-Used Defense Sites
LUST - Leaking Underground Storage Tanks
RCRA - Resources Conservation and Recovery Act
-- - Data not available or not applicable
* - Estimated value

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
K1 - Reported as new sites identified in 2000-01
K2 - Reported as new sites with ground-water contamination

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. Summary of known or potential sources of ground-water contamination in Sussex County, Delaware.

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 2000 and 2001							
NPL	Yes	2	0[K1]	0 [K2]	2	TCE, PCE	--	--	--	1	1
State Sites (non-NPL) [W1]	Yes	89	7[K1]	4 [*,K2]	18 *	PAHs, TCE	15	--	--	--	16
DOD/DOE/FUDS	Yes	1	1[K1]	0 [K2]	0	--	--	--	--	--	--
LUST	Yes	651	651	40 [L1]	18 [L1]	Benzene, Petroleum, MTBE	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	27	27	4 [D2]	[D3]	Oils, TPH, BTEX, Grease, Antifreeze	--	--	--	--	--
Large Septic System	Yes	48	48	12 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Domestic Septic	Yes	43,721	43,721	2,172 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Spray Irrigation	Yes	16	16	0 [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
FUDS - Formerly-Used Defense Sites
LUST - Leaking Underground Storage Tanks
RCRA - Resources Conservation and Recovery Act
-- - Data not available or not applicable
* - Estimated value

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
K1 - Reported as new sites identified in 2000-01
K2 - Reported as new sites with ground-water contamination

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 five Sussex County landfills with GMZs

Table IV-7. Statewide summary of known or potential sources of ground-water contamination in Delaware.

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+EPA Removal	Yes	22	1 [K1]	1 [K2]	22	TCE, PCE, Benzene Vinyl Chloride	--	--	--	1	4
State Sites (non-NPL) [W1]	Yes	525	61 [K1]	32 [*,K2]	116 *	TCE, PCE, PAHs, Metals	15	--	--	--	16
DOD/DOE	Yes	6 [N1]	4 [K1]	0 [K2]	1	TCE	1	--	--	--	--
LUST	Yes	3095	3095	274 [L1]	46 [L1]	Benzene, Petroleum	494 [L1]	248 [L2]	434 [L3]	434 [L3]	2260 [L2]
RCRA [R4]	Yes	11	11		11	Metals, LNAPLs, Solvents	11	3	9	1	3
Solid Waste	Yes	8	8		6	Landfill Leachate	0	0	0	--	--
Underground Injection	Yes	64	64	9 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Large Septic System	Yes	71	71	21 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Domestic Septic	Yes	82063	82,063	3979 [D2]	[D3]	Nitrates, Coliform, Chloride	--	--	--	--	--
Spray Irrigation	Yes	23	23	0 [D2]	[D3]	Nitrates, Coliform, Chloride, Sodium	--	--	--	--	--
Sludge Application Permits [S1]	Yes	17	17	17 [S1]	[D3]	Nitrates	--	--	--	--	--

NPL - National Priority List
DOE - Department of Energy
DOD - Department of Defense
FUDS - Formerly-Used Defense Sites
LUST - Leaking Underground Storage Tanks
RCRA - Resources Conservation and Recovery Act
-- - Data not available or not applicable
* - Estimated value

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
K1 - Reported as new sites identified in 2000-01
K2 - Reported as new sites with ground-water contamination

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 five Sussex County landfills with GMZs

IV.5 2000-2001 Ground-Water-Quality Data from Selected Public Water-Supply Wells

Tables IV-8 and IV-9 summarize 2000-2001 ground-water-quality data available from the Delaware Office of Drinking Water. The data are from raw (pretreatment) water samples collected from public water-supply wells. Routine chemical and trace metals data are summarized in Table IV-8. Volatile and synthetic organic compound (VOC and SOC) data are presented in Table IV-9. At present the Delaware Office of Drinking Water is placing analytical data from hard copy files into a database. The DNREC Water Supply Section is providing well identification numbers for 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 chemical analyses (nitrate, iron, sodium, pH, fluoride, chloride, and total dissolved solids) have a much larger number of samples and are, therefore, more representative.

Please note that this summary of ground-water-quality data makes no attempt to associate the data with a specific aquifer or geographic location. Accordingly, the data should be interpreted as a very general overview of ground-water quality in Delaware. As well identification numbers are added to the Delaware Office of Drinking Water database, it will be possible to associate ground-water-quality data with aquifers and geographic location, and more detailed assessments of the areal and vertical distribution of ground-water contaminants may be possible.

IV.5.1 Routine Chemical Analyses

IV.5.2 Trace Metals Analyses

Data for trace metals analyses (Table IV-8) are much more limited than routine chemical analyses, with generally less than 70 results available for the 2000-2001 reporting period. Out of 69 samples for lead (PMCL 0.015 mg/L), 9 samples (13.04%) exceeded the PMCL. Because lead is generally not found in ambient ground water in Delaware, further assessment would be needed to interpret these results. Data for barium (PMCL 2 mg/L), cadmium (PMCL 0.005 mg/L), mercury (PMCL 0.002 mg/L), and nickel (former PMCL 0.1 mg/L) indicate that one sample for each of these trace metals exceeded the respective PMCL. Arsenic and chromium were detected in 11 out of 61 samples and 10 out of 62 samples, respectively, but at concentrations below the PMCLs for these parameters (Table IV-8).

IV.5.3 Synthetic Organic Compounds

In developing a strategy for the control of organic chemical contaminants in drinking water, the U.S. EPA has subdivided synthetic organic compounds (SOCs) in water into two groups. The first group, trihalomethanes (THMs), consists of organic chemicals that may be present in water as the result of disinfection practices. THMs generally constitute the largest portion of identifiable SOCs in drinking water. The EPA maintains that, as of January 1, 2002, the PMCL for total THMs is 0.08 mg/L. THMs are primarily associated with the chlorination of surface-water supplies.

The second group of SOCs defined by EPA consists of compounds introduced into water as a result of pollution (e.g., pesticides). Although the concentrations 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. 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.

No SOCs were detected during the 2000-2001 reporting period (Table IV-9). However, only 26 raw water samples from approximately 15 public water-supply wells were collected for SOC analyses.

IV.5.4 Volatile Organic Compounds

Due to their mobility in ground water and the relatively large number of potential sources, volatile organic compounds (VOCs) are generally detected more frequently than SOCs. Eleven (11) VOC compounds were detected in raw ground-water samples collected during the 2000-2001 reporting (Table IV-9). Seven samples for tetrachloroethylene (PCE) exceeded the PMCL (0.005 mg/L) and one sample for 1,2-dichloroethane (DCA) exceeded the PMCL (0.005 mg/L).

The most common sources of these chemicals are petroleum and cleaning solvent storage facilities that utilize, or have utilized, underground storage tanks.

Table IV-8. **Routine chemical and trace metals data for raw ground-water samples collected from public water-supply wells during the 2000-2001 reporting period.**

Parameter Groups	PMCL*, SMCL**, or HAL*** (mg/L)	Total No. of PWS Systems Used in the Assessment [S1]	Estimated No. of Wells Used in the Assessment	Total No. of Samples Used in the Assessment [S2]	No detection (ND) of parameters above Method Detection Limit	% of Total Samples	Greater than ND and Less Than or equal to the MCL	% of Total Samples	Parameters are detected at concentrations exceeding the MCL	% of Total Samples
ROUTINE CHEMICAL ANALYSES										
Nitrate as N	10*	255	549	566	276	48.76	154[N1] 113[N2]	47.17	23	4.06
Iron	0.3**	255	547	561	248	44.21	121	21.57	192	34.22
Sodium	20***	255	547	560	0	0.00	425	75.89	125	22.32
pH (standard units)	6.5-8.5**	255	546	556	0	0.00	308	55.40	248	44.60
Fluoride	4.0*	247	534	547	417	76.23	129	23.58	1	0.18
Fluoride	2.0**	247	534	547	417	76.23	129	23.58	1	0.18
Chloride	250**	247	533	546	17	3.11	528	96.70	1	0.18
Total Dissolved Solids	500**	246	533	546	0	0.00	544	99.63	2	0.37
TRACE METALS ANALYSES										
Antimony	0.006*	37	61	61	61	100.00	0	0.00	0	0.00
Arsenic	0.05*	36	60	61	50	81.97	11	18.03	0	0.00
Barium	2.0*	38	62	63	59	93.65	3	4.76	1	1.59
Beryllium	0.004*	36	56	56	53	94.64	3	5.36	0	0.00
Cadmium	0.005*	37	61	62	60	96.77	1	1.61	1	1.61
Chromium (total)	0.1*	37	62	62	52	83.87	10	16.13	0	0.00
Lead	0.015*	39	64	69	45	65.22	15	21.74	9	13.04
Mercury	0.002*	36	63	70	66	94.29	3	4.29	1	1.43
Nickel	0.1*	40	64	64	51	79.69	12	18.75	1	1.56
Selenium	0.05*	37	61	61	61	100.00	0	0.00	0	0.00
Thallium	0.002*	36	58	58	58	100.00	0	0.00	0	0.00

mg/L = milligrams per liter

PMCL = Primary Maximum Contaminant Level set forth by the USEPA

SMCL = Secondary Maximum Contaminant Level set forth by the USEPA

HAL = Health Advisory Limit set forth by the Delaware Division of Public Health

N1 = Samples with Nitrate as N greater than ND and less than or equal to 5 mg/L

N2 = Samples with Nitrate as N 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 (individual wells may have been sampled more than once)

Table IV-9. **Volatile and synthetic organic compound (VOC and SOC) data for raw ground-water samples collected from public water-supply wells during the 2000-2001 reporting period.**

Parameter Groups	PMCL (ug/L)	Total No. of PWS Systems Used in the Assessment	Estimated No. of Wells Used in the Assessment	Total No. of Samples Used in the Assessment *S1*	No detection (ND) of parameters above Method Detection Limit	% of Total Samples	Greater than ND and Less Than or equal to the MCL	% of Total Samples	Parameters are detected at concentrations exceeding the MCL	% of Total Samples
VOLATILE ORGANIC COMPOUND ANALYSES										
Total Summary	**---**	**20**	**53**	**102**	**35**	**34.31**	**59**	**47.17**	**8**	**7.84**
Benzene	5	N/A	N/A	N/A	N/A	N/A	1	N/A	0	N/A
1,2-Dichloroethane	5	N/A	N/A	N/A	N/A	N/A	3	N/A	1	N/A
1,1-Dichloroethylene	7	N/A	N/A	N/A	N/A	N/A	5	N/A	0	N/A
cis-1,2-Dichloroethylene	70	N/A	N/A	N/A	N/A	N/A	2	N/A	0	N/A
Dichloromethane	5	N/A	N/A	N/A	N/A	N/A	1	N/A	0	N/A
Dinoseb	7	N/A	N/A	N/A	N/A	N/A	1	N/A	0	N/A
Methyl *tert*-Butyl Ether	10*	N/A	N/A	N/A	N/A	N/A	18	N/A	0	N/A
Tetrachloroethylene	5	N/A	N/A	N/A	N/A	N/A	19	N/A	7	N/A
Toluene	1000	N/A	N/A	N/A	N/A	N/A	2	N/A	0	N/A
1,1,1-Trichloroethane	200	N/A	N/A	N/A	N/A	N/A	5	N/A	0	N/A
Trichloroethylene	5	N/A	N/A	N/A	N/A	N/A	10	N/A	0	N/A
SYNTHETIC ORGANIC COMPOUND ANALYSES										
Total Summary	**---**	**13**	**15**	**26**	**26**	**100.00**	**0**	**0.00**	**0**	**0.00**

ug/l = micorgrams per liter

PMCL = Primary Maximum Contaminant Level set forth by the USEPA

* = PMCL set forth by the Delaware Division of Public Health

S1 = Reported as total individual sample ID numbers (individual wells may have been sampled more than once)

IV.6 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 (Tables IV-8 and IV-9), 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-10 summarizes the status of regulatory and non-regulatory programs 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-11)); (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.

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 recharge mapping effort has been completed and the source water assessment areas for all public water systems are to be completed by April of 2003. Once done, these areas should provide a much better basis for prioritizing ground water protection activities.

The Non-Point 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.

Table IV-10. Summary of 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	FE/CE	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	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
Source Water Assessment and Protection Program	X	FE/CE	DNREC-WSS
Well abandonment regulations	X	FE	DNREC-WSS
Wellhead Protection Program (EPA-approved)	X	FE/CE	DNREC-WSS
Well installation regulations	X	FE	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*

Table IV-11. Summary of Potential Point Sources of Contamination identified in Site Index Database as of March 2002.

Site Type	Count
Animal Operations	1445
Combined Sewer Overflows	49
Dredge Spoil Disposal Areas	27
Hazardous Waste Generators	1177
Landfills & Dumps	46
Large On-Site Septic Systems	82
Wastewater Outfalls	172
Pesticide Loading, Mixing & Storage Facilities	48
Salvage Yards	72
Superfund Sites	477
Sludge Application Sites	11
Spray Irrigation Sites	27
Tire Piles	36
Toxics Release Inventory Sites	121
Underground Storage Tanks	3401
Total	7191

IV.6.1 Comprehensive Data Management System

Delaware has moved to improve 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-11). As a result of the efforts stemming from whole basin assessments, the Department has moved to greatly increase the accessibility and quality of environmental information. Termed the Environmental Information System, programs that regulate, for instance, facilities that could contaminate ground water will be “live” linked to a single database.

IV.6.2 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.

As part of the Pesticide program, the DDA developed a statewide ambient ground-water monitoring network which includes approximately 136 monitoring, domestic, and agricultural wells. These wells are routinely sampled and tested for pesticides that are included in the PMP. The results of the first years of this study are included in a report published by the DGS (Blaier and Baxter, 2000). Key findings of Blaier and Baxter (2000) are discussed briefly in Section IV.4.9 of this 305(b) report.

IV.6.3 Source Water Assessment and Protection Program

The Delaware Source Water Assessment and Protection Program (SWAPP) is responsible for a number of key activities associated with the assessment and protection of the sources of public drinking water. The key activities, as described in the Delaware Source Water Assessment Plan (DNREC, 1999), include the (1) delineation of the source water areas for public water supplies for both surface- and ground-water systems, (2) identification of sources of contamination within the delineated area, (3) preparation of a susceptibility assessment report for each of the over 500 pubic water systems in Delaware, (4) assuring the involvement of the public in both the SWAPP approach in Delaware and in receipt of the source water assessments for their public water purveyor, (5) development of protection measures for sources of public water, and (6) management of a source water protection loan fund.

Begun in 1999, the Delaware SWAPP has worked to address each of the key activities, with some statutory deadlines set by the 1996 amendments to the Safe Drinking Water Act. Both wellhead protection area and watershed basin delineations are being completed. The surface water system assessments are all located in New Castle County within the Christina River Basin with the watersheds for the Brandywine River, Red Clay Creek, White Clay Creek, and Smalley's Pond. All of these watersheds extend into adjacent states of Pennsylvania and Maryland. These assessments were largely completed during the reporting period with the final reports due by March 30, 2002. The wellhead protection area delineations are being conducted in earnest with 25 systems completely finished and approximately 75 in process. The remaining 500 systems are scheduled to be completed by April 2003. The highest priority is being given to the Community Systems, followed by the Non-transient and Transient systems. The Department has developed a sophisticated computer based approach which uses WhAEM, ArcView, and standard databases to gather the information needed to complete the assessments.

The contaminant inventory is based on extensive GIS data now available for both point sources and land use. This information is compiled automatically using the DNREC-GIS to identify the potential contaminant problems within source water areas. The DNREC Site Index Database catalogues the ground water and surface water pollution rankings for the point source sites (e.g. UST, landfills, septic systems, etc) and the 1997 aerial land use maps. In addition, the DHSS Office of Drinking Water analytical database is queried to assemble data for raw water sampling.

The susceptibility assessment reports compile all of the previously mentioned data and rate the source water susceptibility as to it's relative susceptibility based on the intrinsic vulnerability of the system (which is a determination of the relative ease with which contaminants could enter the well or intake) versus the severity of contaminant sources within the source water area.

Source water assessments are made available on the SWAPP web site at www.wr.udel.edu/swap/swp1.html, from the DNREC Division of Water Resources, or from the water system purveyor. There are some limitations placed on the availability of the assessment maps, however.

IV.6.4 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 Assessments for the Piedmont Basin, Chesapeake Basin, and Inland Bay/Atlantic Ocean Basin have been completed. The information on ground water for these basin was included in previous 305 (b) reports. The Delaware River Basin preliminary assessment began in 1999 and is not yet final. It likely will be included in the next 305 (b) report. The Piedmont Assessment report is presently being updated with completion expected in 2002.

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Part V Part Five: Wetlands Assessment

Part V: Wetlands Assessment

V.1 Introduction

Wetlands comprise a significant portion of the water resources of Delaware covering over 300,000 acres of the state. Throughout the state a wide diversity of wetland types occur including both tidal and nontidal wetlands. While some wetlands are directly connected or adjacent to other surface waters such as salt marshes and floodplains, others occur as isolated areas surrounded by uplands such as forested flats and Delmarva Bays. Preserving the abundance, quality, diversity and proportion of different types of wetlands in the landscape is essential to protecting the natural resources and waters of Delaware. Currently the State of Delaware is actively working in each of these areas to protect our high quality wetland resources and restore degraded systems on the watershed scale.

V.1.1 Functions and Values of Wetlands

Wetlands perform a variety of functions including surface and subsurface water exchange, surface and subsurface water storage, sediment retention, nutrient cycling, organic carbon export, providing faunal and flora habitat, maintaining intact food webs, and maintaining interspersion and connectivity in the landscape. Because wetlands are diverse and occur in a variety different ecosystems, they do not all perform the same functions therefore, it is generally difficult to determine a wetland's function without a specific site analysis. Variables to consider in assessing wetland function include: wetland type, landscape position, vegetation, soils, hydrology, size, adjacent land use, and human disturbance.

In contrast to function, wetland value is determined by the usefulness of the wetland and the functions it is performing to humans. According to Wohlgemuth (1991), wetlands offer three broad categories of values: fish and wildlife habitat values, environmental quality values and socioeconomic values. The location of the wetland, human pressures on it, or the size 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. Because wetland values are determined by their benefit to humans, a wetland in one locality may be more highly valued than a wetland performing the same function in another locality.

V.1.2 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 lifecycles. Most Commercially important fish species, for example, are wholly dependent on wetlands for spawning and nursery areas. Wetlands also provide breeding, feeding, and nesting habitats for a variety of waterfowl species and furbearers. Some species of frogs, toads, and salamanders depend on wetland 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 insects are important in the maintenance of the food web.

V.1.3 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. Wetland plant communities sustain a high diversity of plant species including a large number of rare and threatened species in Delaware. Additionally, when the plants die and are broken down into detritus by bacteria and other microorganisms, they form 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

V.1.4 Socioeconomic Values

Some of the functions that wetlands perform are economically valuable, 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.2 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 221,800 total acres of tidal and nontidal wetlands in Delaware, while a recent estimate by the same author realized a more refined estimate of 353,868 (Tiner 2002). The higher figure reported in the latter estimate can, however, be attributed in part to the inclusion of 29,000 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 2002).

Tidal wetlands	127,338
Nontidal wetlands*	226,530
Total wetland acreage	353,868

* Includes 29,000 acres of nontidal agricultural wetlands

I.2.1 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.2.1 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.2.1.1 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.2.1.2 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.2.1.3 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.2.1.4 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.3 Wetland Quality

In addition to evaluating the quantity of wetlands in the state and working towards protection of these areas, the State of Delaware is developing techniques to begin assessing the condition of our wetland resources. Beginning in 1999 we have been working with The Smithsonian Environmental Research Center and The Nature Conservancy in the Nanticoke River watershed to develop hydrogeomorphic models that will evaluate how non-tidal wetlands throughout the watershed are performing various functions compared to reference sites. This study will provide information on the overall condition of wetlands in the watershed and identify the major stressors that are affecting wetland functions. Currently we are completing this work and compiling the information with the goal of producing a strategy for wetland protection and restoration for the watershed that will improve wetland quality on the watershed level.

V.4 Wetlands and Total Maximum Daily Load (TMDL) Regulations

As noted above, wetlands processes can be important in the removal and mitigation of excessive sediment, nutrients, and other pollutants. These pollutants have a direct bearing on the quality of water in the receiving waterbody. Delaware has recently enacted TMDL regulations to improve water quality in waterbodies that are not meeting their designated uses. The Department believes active preservation and restoration of high quality wetlands will be important components of a successful TMDL implementation process.

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Part VI Appendices

VI.1 Appendix A: Citizen Monitoring Data

Summary Statistics for Center for the Inland Bays Volunteer Citizen Monitoring Data 1996-2001											
Site code	**Location**	**Max TSS (mg/l)**	**Ave TSS (mg/l)**	**Max chl(a) (ug/l)**	**Ave chl(a) (ug/l)**	**Max DIP (mg/l)**	**Ave DIP (mg/l)**	**Max DIN (mg/l)**	**Ave DIN (mg/l)**	**Ave DO (mg/l)**	**Min DO (mg/l)**
AG1	AG DITCH NEAR ROXANA	40.3	3.9	25.8	4.1	0.41	0.026	4.69	1.633		
BA01	KEENWIK ON BAY, ROY CREEK	33.1	22.4	27.6	18	0.02	0.011	0.35	0.139	5.6	2.3
BA02	KEENWIK SOUND, UPPER ROY CREEK									4.4	2.6
BP	BURTONS POND SPILLWAY	2.9	0.6	15	4.2	0.01	0.007	1.71	0.72		
IR02	GULL POINT	190	25.3	176	28.1	0.43	0.049	2.29	0.752	7.2	3.2
IR04	WARWICK PARK									7.8	4.0
IR05	CUPOLA PARK									6.5	6.1
IR07	HOLTS LANDING									8.0	2.3
IR10	STEELE COVE	230	31.2	26.6	9.1	0.06	0.013	0.7	0.151	7.6	1.7
IR11	BIG DITCH POINT	18.1	13.6	9	4.1	0.04	0.023	0.22	0.091	6.0	1.4
IR12	QUILLENS POINT									7.1	5.8
IR19	WHITE HOUSE BEACH									7.8	2.3
IR20	BAY COLONY	199	23.6	58.4	13.3	0.16	0.03	2.24	0.56	6.8	2.2
IR31	WHITE CREEK									6.2	2.3
IR32	HOLLY TERRACE ACRES CANAL									5.8	1.5
LA03	MULBERRY LANDING	64.5	21.9	125.2	33.8	0.06	0.007	1.74	0.2	7.1	3.5
LA08	FENWICK-LIGHTHOUSE COVE	193	38.1	98.4	30	0.04	0.009	0.58	0.159	6.3	2.6
LA09	DIRICKSON CREEK, RD 381 BRIDGE	90.3	31.6	634	78.3	0.28	0.057	6.23	1.38	5.9	1.6
LA10	ASSAWOMAN CANAL AT KENT AVE BRDIGE (RD 361)									5.5	2.2
LA30	ANCHORAGE CANAL, SO. BETHANY									6.8	2.2
ML	MASSEY'S LANDING	85	20.5	24.9	8.8	0.04	0.019	0.36	0.076		
MP	MILLSBORO POND-RT 30 BOAT LAUNCH	11.8	2.1	34.8	10.7	0.02	0.008	3.68	2.744		
RB01	MOUTH OF ARNELL CREEK	454.7	38.7	59.4	14.7	0.12	0.02	1.43	0.192	6.2	1.6
RB01A	LAGOON (100m NE of RB01)									2.6	0.7
RB02	LEWES/REHOB CANAL-LEWES	220	59.1	76.9	16.5	0.14	0.047	1.03	0.383	6.6	3.3
RB04	HERRING CREEK	193.5	30.4	1436.3	38	1.06	0.021	1.86	0.432	7.4	2.3
RB05	MOUTH OF GUINEA CREEK	216	33.7	79.2	18.5	0.02	0.007	0.78	0.242	6.7	2.0

Summary Statistics for Center for the Inland Bays Volunteer Citizen Monitoring Data 1996-2001											
Site code	**Location**	**Max TSS (mg/l)**	**Ave TSS (mg/l)**	**Max chl(a) (ug/l)**	**Ave chl(a) (ug/l)**	**Max DIP (mg/l)**	**Ave DIP (mg/l)**	**Max DIN (mg/l)**	**Ave DIN (mg/l)**	**Ave DO (mg/l)**	**Min DO (mg/l)**
RB06	GUINEA CREEK	31.8	11.8	92.2	20.8	0.03	0.007	3.28	0.783	7.1	3.6
RB06A	GUINEA CREEK AT RD 298 BRIDGE	202	16.5	91.2	16.6	0.11	0.012	5.02	1.943		
RB07	WEST BAY PARK	191	29.6	40	10.4	0.09	0.022	0.52	0.177	6.5	2.1
RB16	RUSTY RUDDER									6.1	3.5
RB31	GUINEA CREEK-DEADEND LAGOON	161	49	72.4	19.9	0.08	0.017	1.06	0.456	5.8	1.2
RB34	LOVE CREEK AT RT 24 BRDIGE	180	25.2	743.8	49.3	0.05	0.011	2.24	0.596	7.0	2.6
RB35	PELICAN COVE, DEWEY									7.2	4.0
RB38	JOY BEACH	55	32.2	7.4	4	0.03	0.015	0.31	0.18	7.0	2.0
RB40	BURTON PRONG	171	24.6	120.4	18.6	0.07	0.009	2.06	0.521	6.3	1.8
RB41	HEAD OF BAY COVE									7.8	1.8
RB42	HEAD OF BAY CANAL									10.0	4.5
RB42A	HEAD OF BAY CANAL, 100M FROM RB42									9.5	7.8
RB43	MULBERRY KNOLL									5.8	1.8
RB44	CAMP ARROWHEAD									7.7	3.1
RB45	LEWES/REHOBOTH CANAL-REHOBOTH	142.5	32.3	40.4	15.9	0.12	0.046	0.73	0.402	6.3	2.0

VI.2 Appendix B: Delaware Fish Kill Reports

Delaware Department of Natural Resources and Environmental Control
Fish Kill Investigations in 2000

by

Roy W. Miller
Fish Kill Coordinator
Delaware Division of Fish and Wildlife
Dover, DE

Nov. 6, 2001

Annual Report Federal Aid in Fisheries Restoration Project F-51-T

Job No: III-1 Technical Assistance in Fish Kill Investigations

Objective:

To determine the extent and reasons for fish kills and recommend technical guidance to citizens, businesses and governmental agencies in order to prevent additional fish kills.

Activities:

There were 34 fish kills investigated in Delaware waters in 2000 (Table 1 and Figure 1). This is the most fish kills investigated in any one year in Delaware since the beginning of fish kill record keeping in 1980. There were six kills involving carp in the late spring. These kills were attributed to bacterial gill disease, although this was not confirmed by any laboratory. The general appearance of the gray, necrotic gill filaments in moribund fish were characteristic of the bacterial gill disease that was prevalent at the time in Maryland and Virginia Chesapeake tributaries, based on discussions with fish disease diagnosticians from Maryland (Charles Poukish, MD Department of the Environment, personal communication and Dr. Ana Baya, Maryland Department of Agriculture Animal Health Laboratory, College Park, MD, personal communication). The largest documented fish kill event during this late May through mid-June time period was on Silver Lake, Dover where 1,102 dead and dying fish were counted, and these were primarily black crappie, gizzard shad and carp. Moribund specimens of these three species exhibited the characteristic gray gill filaments, but bacterial cultures taken from a moribund carp and a black crappie from Silver Lake were inconclusive for *Flexibacter columnaris* (State Veterinarian Dr. Wesley Towers, personal communication). Dead carp also were reported from the St. Jones River, the Delaware River at Bayview, and the Murderkill River (unconfirmed). The fact that the carp kills were noted only from those ponds having a fish ladder led to speculation that carp carrying bacterial gill disease entered these ponds from tidal waters downstream via the fish ladders.

The second major wave of fish kills began in the Inland Bays watershed on July 6 in Bald Eagle Creek and Torquay Canal, a tributary system of Rehoboth Bay. There were 10 fish kills in all in the Inland Bays between July 6 and September 6, 2000. Atlantic menhaden was the only species involved in these kills. Estimated numbers killed per event ranged between 1,000 and 2.5 million juveniles. Most of the menhaden killed were a result of spawning in the fall of 1999, but the 2.5 million fish killed July 27 at Indian River Acres at the mouth of Pepper Creek probably were spawned in the spring of 2000 since they were less than one-half the size of those killed in the other fish kills in the Inland Bays. These fish kill events triggered media attention the likes which hadn't been seen in Delaware since the large Indian River fish kill of 1987. The three Torquay Canal and Bald Eagle Creek events seemed to cause the most vocal consternation, probably because the dead menhaden clogged the Canal and connecting waterways, and the rotting carcasses collected adjacent to rather expensive residences. The subsequent public outcry led to attempts by the Division of Soil and Water conservation to remove dead menhaden from the second of these kills with an aquatic weed harvester designed to harvest submerged aquatic weeds. Heretofore, the Department had always relied on natural processes to clean up after fish kills, so this action probably will be precedent setting.

The causes of these Inland Bays menhaden kills generally were ascribed to low dissolved oxygen concentrations. In most cases readings of dissolved oxygen were supersaturated by the time investigators arrived at the scene of the fish kill, leading to speculation that dissolved oxygen concentrations had been much lower earlier in the morning when the fish first started dying. This phenomena is partially a reflection of the intense phytoplankton blooms these systems experience with the lowest oxygen readings expected to occur in the pre-and early post dawn hours after an evening of respiratory activity by the phytoplankton, followed by photosynthesis and supersaturation of dissolved oxygen later in the day. Most of the fish kills were reported by citizens who woke up to find dead or dying fishes in the waterways adjacent to their residences. Other potential causes of the fish kills could include climatic conditions, and the fish themselves. When phytoplankton is very abundant, overcast weather following sunny days can result in oxygen consumption is excess of photosynthesis. A University of Delaware researcher also speculated that elevated sulfides, especially in the deep, stagnate holes (up to 18 feet deep) found in Torquay Canal, may have been a factor in initiating the kills in that system. It also is not hard to imagine that when millions of juvenile menhaden crowd into confined waterways like boat lagoons and small tributaries, the fishes themselves can contribute to the oxygen deficit, especially as they begin to die and decompose. Clearly a strong yearclass of menhaden was produced offshore in late 1999, and these fish invaded Delaware Inland Bays tributaries the following spring and summer in abundances perhaps not witnessed in years.

Another phenomena investigated extensively by the Department of Natural Resources and Environmental Control (DNREC) in 2000 that attracted considerable media attention, was the fact that menhaden in the upper mainstem of Indian River, and to a much lesser extent Pepper Creek, Love Creek and elsewhere had lesions on their bodies thought to be indicative of attacks by *Pfiesteria*. Up to 74% of the 640 juvenile menhaden caught in Upper Indian River in mid-July 2000 had one or more lesions on their bodies. Many of these lesions were quite severe and included extensive tissue erosion and necrosis, particularly in the anal region, to the extent that the live fish appeared to have been attacked with a hole punch. Live specimens with lesions were taken to Dr. Ana Baya for examination, and freshly dead and preserved specimens were sent to several different disease diagnostic laboratories. The lesions examined contained some or all of the following: a ciliated parasitic protozoan, *Kudoa, Aphanomyces* fungus, and several bacterial genera including *Aeromonas hydrophila, Vibrio vulnificus*. Another researcher, Dr. Phil Klesius of the US Department of Agriculture Aquatic Animal Health Laboratory, found the potentially pathogenic bacteria *Acinetobacter calcoacticus* in lesions of Indian River menhaden.

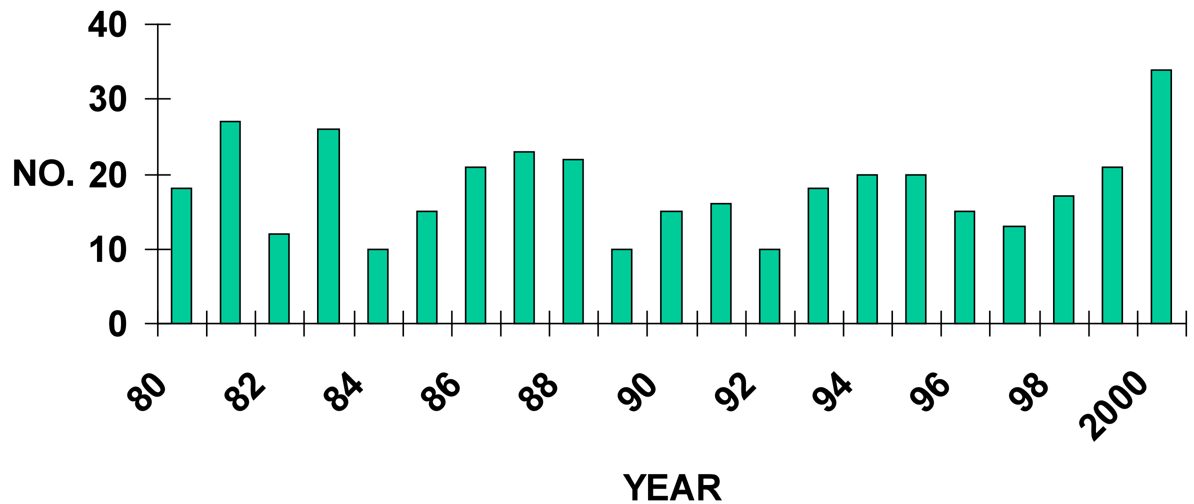
Although the lesions in question did not appear to have been freshly formed since they were not bleeding and the necrotic tissue appeared gray in color rather than hemorrhagic, attacks by free living marine microbes such as *Pfiesteria piscidia* and *P. shumwayae* could not be entirely ruled out either as a cause or contributor to the lesions or to the fish kills that were documented. One or both genera of *Pfiesteria* was confirmed to be present at the Arnell Creek kill on July 19 and in Pepper Creek on August 24 using PCR (polymerase chain reaction) DNA tests that can detect the presence or absence of *Pfiesteria* cells in a water sample. However, none of the water samples taken at the fish kill sites sent to Dr. JoAnn Burkholder's laboratory at North Carolina State University were immediately toxic to test fish, although one culture (using a water sample taken July 10 taken upper Pepper Creek) did develop toxicity a month after culture was initiated according to Dr. Howard Glasgow at Dr. Burkholder's laboratory, even though neither *Pfiesteria* species was detected in initial PCR tests. Twice one lab detected *Pfiesteria*, whereas another lab did not, using water sample splits from the same location (Bald Eagle Creek on August 28 and Pepper Creek also on August 28). In addition, a previously undescribed (in Delaware) potentially toxic organism was discovered in water samples from Bald Eagle Creek taken in August and September. This organism was identified by Drs. Daniel Baden and Carmelo Tomas of the University of North Carolina at Wilmington as *Chattonella* cf. *verruculosa.* These researchers assert that this organism is capable of producing brevitoxin in quantities that can cause fish kills, similar to the brevitoxin produced by the red tide forming organism (*Gymnodinium brevi)* known to cause fish kills in the Gulf states.

2000 DELAWARE FISH KILL INVESTIGATIONS

LOCATION	LAT/ LONG.	CTY.	DATE	NO. KILLED	PROBABLE CAUSE	PREDOMINANT SPECIES	% GAME SPECIES
FORT DE STATE PARK MOAT	39° 36'/75° 35'	NC	1/3	100	ICE COVER	WHITE PERCH	0
LAKE COMO	39° 17'/75° 36'	K	2/29	208	NATURAL CAUSES	GIZZARD SHAD, BLACK CRAPPIE	0.5
AUGUSTINE IMPOUNDMENT	39° 34'/75° 34'	NC	4/19	9	UNKNOWN	CARP, CATFISH SPECIES	0
AUGUSTINE CREEK MARSH	39° 29'/75° 34'	NC	5/8	340	EXTREMELY LOW WATER LEVELS AND PROBABLE LOW DISSOLVED OXYGEN	GIZARD SHAD, CARP, WHITE PERCH, SUN FISH SPECIES, BROWN BULLHEADS	5. 9
AUGUSTINE WILDLIFE AREA	39° 29'/75° 34'	NC	5/8	30	DUMPING OF DEAD FISH CARCASSES	WHITE PERCH	0
CERVELLI FARM POND	39° 44'/75° 46'	NC	5/15	100	PROBABLE LOW DISSOLVED OXYGEN	BLUEGILL	100
LEISURE POINT BOAT LAGOON GUINEA CREEK	38° 38'/75° 9'	S	5/16	2000	LOW DISSOLVED OXYGEN	MUMMICHOG, BLUE CRABS	0
GARRISON LAKE	39° 14'/75° 36'	K	5/30	90	PROBABLE FISH EPIZOOTIC	CARP, BLACK CRAPPIE	2. 2
ST. JONES RIVER	39° 10'/75° 32'	K	5/30	30	PROBABLE FISH EPIZOOTIC	CARP	0
DE RIVER AT BAYVIEW	39° 28'/75° 34'	NC	6/1	7	PROBABLE FISH EPIZOOTIC	CARP, WHITE PERCH STRIPED BASS	0
CHESTNUT RUN POND, DUPONT EXPER. STATION	39° 45'/75° 36'	NC	6/6	200	PROBABLE LOW DISSOLVED OXYGEN	GOLDFISH, MUMMICHOG	0
SILVER LAKE, DOVER	39° 11'/75° 32'	K	6/8	1,102	PROBABLE FISH EPIZOOTIC (BACTERIAL GILL DISEASE)	BLACK CRAPPIE, CARP, GIZZARD SHAD	91
LAKE COMO	39° 17'/75° 36'	K	6/19	5	PROBABLE BACTERIA INFECTION	BLUEGILL, BROWN BULLHEAD	50
MOORES LAKE	39° 7'/75° 32'	K	6/20	2	POSSIBLE FISH EPIZOOTIC	CARP	0
MCCOLLEY POND	38° 58'/75° 30'	K	6/21	25	POSSIBLE FISH EPIZOOTIC	CARP	0
ELLIOTT POND BRANCH NEAR LAUREL	38° 34'/75° 31'	S	6/22	32	UNKNOWN	BLUEGILL, OTTER, SUNFISH, CHAIN PICKEREL, LARGEMOUTH BASS	100
BALD EAGLE CREEK/TORQUAY CANAL	38° 42'/75° 7'	S	7/6	1 ML	LOW DISSOLVED OXYGEN	ATLANTIC MENHADEN	0

LOCATION	LAT/ LONG.	CTY.	DATE	NO. KILLED	PROBABLE CAUSE	PREDOMINANT SPECIES	% GAME SPECIES
PEPPER CREEK	38° 34'/75° 13'	S	7/10	75,000	PROBABLE LOW DISSOLVED OXYGEN	ATLANTIC MENHADEN	0
LANGE FARM IMPOUNDMENT	39° 32'/75° 36'	NC	7/12	120	PROBABLE LOW DISSOLVED OXYGEN	CARP, GIZZARD SHAD	0
ARNELL CREEK	38° 42'/75° 7'	S	7/19	200,000	UNKNOWN	ATLANTIC MENHADEN	0
ARNELL CREEK	38° 42'/75° 7'	S	7/22	250,000	LOW DISSOLVED OXYGEN	ATLANTIC MENHADEN	0
YETTER PRIVATE POND	39° 26'/75° 45'	NC	7/24	7	POSSIBLE LOW DISSOLVED OXYGEN	LARGEMOUTH BASS BLUEGILL,GRASS CARP	86
LOVE CREEK MARINA	38° 42'/75° 9'	S	7/26	1,500	UNKNOWN	ATLANTIC MENHADEN	0
PEPPER CREEK @INDIAN RIVER	38° 34'/75° 10'	S	7/27	2. 5 ML	PROBABLE LOW DISSOLVED OXYGEN	ATLANTIC MENHADEN	0
WOLF RUN POND, LEWES	38° 45'/75° 8'	S	8/3	275	UNKNOWN	LARGEMOUTH BASS, AMERICAN EEL, BLUEGILL	94.6
TRIBUTARY TO WHITE CLAY CREEK @ OGLETOWN	39° 40'/75° 42'	NC	8/9	20	UNKNOWN	ASSORTED MINNOWS,BROWN BULLHEAD, SUNFISH	10
PEPPER CREEK	38° 34'/75° 13'	S	8/24	1,000	PROBABLE LOW DISSOLVED OXYGEN	ATLANTIC MENHADEN	0
BALD EAGLE CREEK @ TORQUAY	38° 42'/75° 7'	S	8/28	1 ML	PROBABLE LOW DISSOLVED OXYGEN	ATLANTIC MENHADEN	0
PEPPER CREEK	38° 34'/75° 13'	S	8/28	50,000	PROBABLE LOW DISSOLVED OXYGEN	ATLANTIC MENHADEN	0
BALD EAGLE CREEK @ TORQUAY	38° 42'/75° 7'	S	9/6	15,000	LOW DISSOLVED OXYGEN	ATLANTIC MENHADEN	0
THISTLEBURY FARMS POND NEAR PIKE CREEK	39° 46'/75° 44'	NC	9/8	24	LOW DISSOLVED OXYGEN	BLUEGILL, CATFISH	96
CONCORD POND RAMP	38° 38'/75° 34'	S	9/12	150	DISCARDS OF DEAD FISH	AMERICAN EEL	0
FONES FARM POND NEAR CAMDEN	39° 04'/75° 35'	K	9/18	37	PROBABLE LOW DISSOLVED OXYGEN	LARGEMOUTH BASS, BLUEGILL	97
BURGESS GOLDFISH POND	39° 39'/75° 46'	NC	12/19	85	UNKNOWN	KOI CARP	0

Figure 1. Numbers of fish kills investigated in Delaware.



Delaware Department of Natural Resources and Environmental Control
Fish Kill Investigations in 2001

by

Roy W. Miller
Fish Kill Coordinator
Delaware Division of Fish and Wildlife
Dover, DE

December 7, 2001

Annual Report Federal Aid in Fisheries Restoration Project F-51-T

Job No: III-1 Technical Assistance in Fish Kill Investigations

Objective:

To determine the extent and reasons for fish kills and recommend technical guidance to citizens, businesses and governmental agencies in order to prevent additional fish kills.

Activities:

There were 23 fish kills investigated in Delaware waters in 2001 (Table 1 and Figure 1). Two of these kills (Motiva Refinery on the Delaware River and Garrisons Lake) involved multiple days of investigation. At the Motiva Refinery there was a fire and the collapse of a 660,000 gallon sulfuric acid tank on July 27. Motiva estimated that nearly 100,000 gallons from this spill drained into an effluent channel and then directly into the Delaware River. For the next two days counts were attempted of fish and blue crabs killed by this acid spill. On the first day of counts (July 18), Motiva representatives judged conditions too hazardous near the spill site because of the acrid plume of air, so all fish counts were made on the Delaware River well upstream (a mile or more) from where the effluent stream entered the Delaware River. A total of 1,615 dead fish were counted that day. The next day (July 19) the air had improved enough for counts to be made on the Delaware River up to and including the entrance of the effluent stream. To avoid double counting from the day before, all counts on July 19 were made downstream of the effluent stream's entrance to the Delaware River, particularly in the Motiva intake channel, also known as Cedar Creek. Another 659 finfish and 26 blue crab juveniles and adults were counted on the 19th. Motiva employees had picked up 133 fish and 219 blue crabs on the 18th and had retained them in ice chests, so these were added to the 2-day Division of Fish and Wildlife counts to yield a total of 2,407 fish and 245 blue crabs. An accurate estimate of the total number of fish killed as a result of this spill was not made because changing tides had deposited fish well up into thick fringing *Phragmites*-dominated marshes along the river front, thus making accurate counts extremely difficult on areas other than bare shoreline. It is safe to assume that the counts made were a minimum estimate of the actual numbers killed. Field measurements of pH concentrations taken in the Delaware River by a DNREC Division of Water Resources crew on July 19 were close to neutral, thus indicating that by the 19th the acid had been diluted by the large tidal volume of water in the River. Apparently the kill occurred largely in the Motiva effluent channel and immediate nearshore area of the Delaware River and did not extend over to Pea Patch Island or to the New Jersey shoreline.

The second kill that required multiple days of investigation took place on Garrisons Lake. On the Friday before the kill (July 27), DNREC employees commuting to Dover noticed fish surfacing on Garrisons Lake, probably as a result of low dissolved oxygen stress. Dissolved oxygen measurements taken late that afternoon indicated that there was a definite problem. The fish started dying on Sunday July 29 and a preliminary count was made that afternoon of the total dead thus far. A site visit the following day revealed a substantial number of fish had already died, but that a much greater number were in distress, gulping for air along the shoreline near the boat launch ramp. The water in the vicinity of the launch ramp was very dark and smelled septic. All species in the pond were affected, including game and non-game species. Dissolved oxygen measurements revealed that there was very little oxygen in the water column throughout much of the lake, but that conditions were particularly critical in the eastern one-third of the pond. The pond was choked with aquatic vegetation, both filamentous algae and Elodea, and there was a coating of duckweed on top of the water surface. Some of the Elodea and algae appeared to be dead or dying, thus contributing to the critical dissolved oxygen conditions. There had been a heavy rain in the watershed Thursday evening before the fish began to show signs of stress. Extensive investigation of the watershed above the pond both from the water and from helicopter during the week of July 29 did not pinpoint any particular run-off problems, so the blame for the low dissolved oxygen conditions could not be tied to any particular land-based source.

In order to attempt to arrest the kill, a gasoline-driven aerator system and pump irrigation equipment were mobilized with the cooperation of the Division of Soil and Water and the Kent County Public Works Department. The aeration equipment was set up Monday afternoon at the launch ramp where most of the fish in distress were observed. By the following morning dissolved oxygen concentrations at the launch ramp had risen from 0.12 ppm the day before to close to 5 ppm. The distressed fish and blackish water coloration were no longer in evidence, so it was presumed that most of the fish had survived. The aeration equipment was run through July 31. No further fish kills were noted in the pond this year.

Although there were seven fish kills in the Inland Bays this year (Fig. 2), the numbers of fish lost did not approach the numbers killed in 2000. The largest menhaden kill observed this year totaled around 60,000 in Pepper Creek on August 27, whereas last year approximately 2.5 million menhaden died in a boat lagoon off of Pepper Creek on July 27. To the best of our knowledge there were no fish kills attributed to Pfiesteria or other toxic dinoflagellates in Delaware in 2001 nor in Maryland or Virginia either.

Once again the ponds of the Mallard Lakes Condominium Association experienced two fish kills. These poorly flushed freshwater to slightly brackish ponds suffer from chronic dissolved oxygen problems, and excessive algae, both filamentous and planktonic, in spite of aeration equipment installed on one of the ponds experiencing a fish kill this summer. The algae continues to be fueled by a large population of resident ducks and geese.

2001 DELAWARE FISH KILL INVESTIGATIONS

LOCATION	LAT/ LONG.	CTY.	DATE	NO. KILLED	PROBABLE CAUSE	PREDOMINANT SPECIES	% GAME SPECIES
Guinea Creek boat lagoon	38° 31' / 75° 7'	S	1/15	50+	Ice and freezing temperatures	Striped mullet	0
Killens Pond	38° 58' / 75°32'	K	1/18	60	Natural kill, freezing temperatures	Gizzard shad	0
Kathy Willey private pond	38° 42' / 75°17'	S	1/31	30	Winter kill	Largemouth bass, bluegill, bullheads, American eel	90
Virgil Brown farm pond	38° 43' / 75°15'	S	2/3	11	Winter kill	Bluegill, black crappie, brown bullhead	91
Ray Benecki fish pond	39° 42' / 75°46'	NC	3/6	13	Unknown	Koi carp	0
Wyoming Pond	39° 7' / 75° 34'	K	4/8	27	Natural kill	Gizzard shad	0
Concord Pond	38° 38' / 75°33'	S	5/1	6	Unknown, probably natural causes	Creek chubsucker, black crappie	16.7
Hearns Pond	38° 41' / 75°36'	S	5/13	1,210	Probable epizootic (Aeromonas bacterial infection plus trematode cercariae)	Bluegill, black crappie, brown bullhead	99.9
Back Creek Golf Course pond	39° 28' / 75°44'	NC	6/14	1000	Low dissolved oxygen	Bluegill, brown bullhead	95
Arnell Creek	38° 42' / 75° 8'	S	6/15	6	Low dissolved oxygen	Atlantic menhaden	0
Yetter private pond	39° 28' / 75°46'	NC	7/2	115	Probably low dissolved oxygen	Black crappie, bluegill, largemouth bass, grass carp, brown bullhead	97
Mallard Lakes Condo Assoc.	38° 28' / 75° 7'	S	7/14	4,853	Low dissolved oxygen	Gizzard shad, white perch	0
Delaware River near Motiva Refinery	39° 36' / 75°37'	NC	7/18	2407 fish 245 blue crabs	Tank rupture and sulfuric acid spill	Atlantic menhaden, gizzard shad, white perch, mummichog, channel catfish, carp, striped bass, spot, weakfish	0.1
Pepper Creek	38° 34' / 75°13'	S	7/20	50,000	Low dissolved oxygen	Atlantic menhaden	0
Garrisons Lake	39° 14' /	K	7/28	1,201	Low dissolved oxygen	White perch, gizzard shad,	5.5

LOCATION	LAT/ LONG.	CTY.	DATE	NO. KILLED	PROBABLE CAUSE	PREDOMINANT SPECIES	% GAME SPECIES
	75°36'					bluegill, golden shiner, largemouth bass,	
Arnell Creek	38° 42' / 75° 8'	S	8/8	400	Probably low dissolved oxygen	Atlantic menhaden	0
Pepper Creek	38° 34' / 75°13'	S	8/9	1,000	Low dissolved oxygen	Blue crab	0
Mallard Lakes Condo Assoc.	38° 28' / 75° 7'	S	8/12	300	Probably low dissolved oxygen - unconfirmed	White perch	0
Love Creek	38° 42' / 75° 9'	S	8/12	2,000	Low dissolved oxygen	Atlantic menhaden	0
Pepper Creek	38° 34'/ 75° 13'	S	8/27	60,000	Probably low dissolved oxygen	Atlantic menhaden	0
Salt Pond, Ocean View	38° 33' / 75° 4'	S	10/5	3	Low dissolved oxygen	Largemouth bass	100
Tidal ditch -The Greens on Indian River	38° 35' / 75° 9'	S	10/5	49	Unknown	Unidentified shiners, largemouth bass, bluegill	4
Pickering Beach	39° 8' / 75° 24'	K	10/9	~2,000	Unknown, perhaps related to dredging	Blue crab	0

Figure 1. Numbers of fish kills investigated in Delaware.

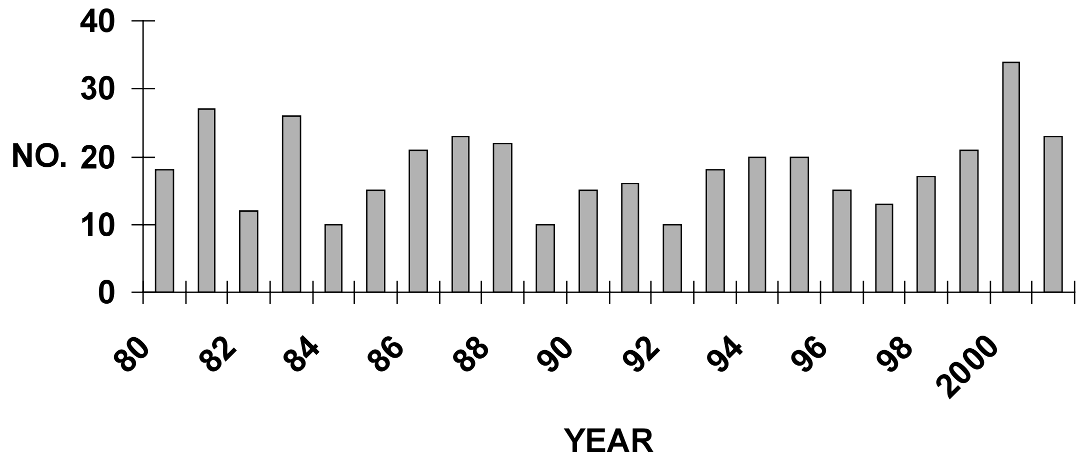
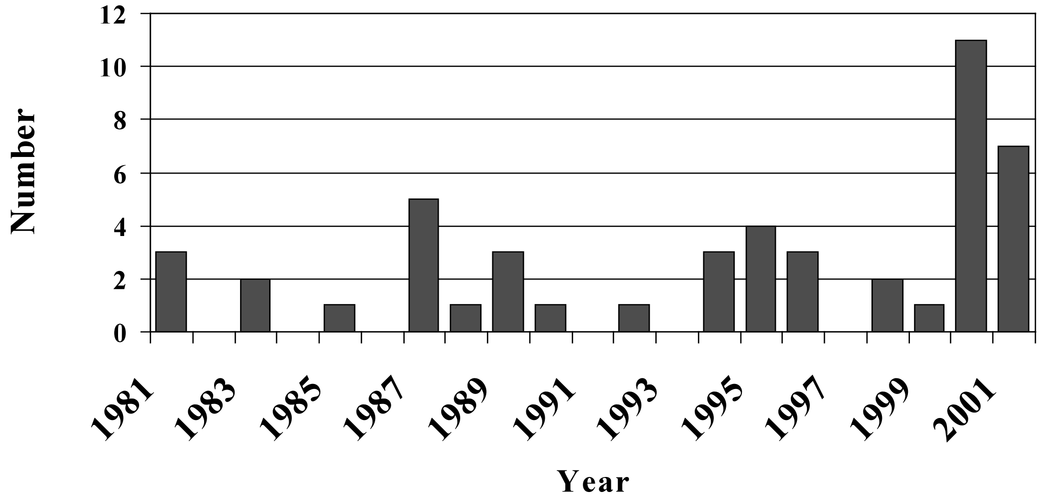


Fig. 2. Delaware Inland Bays fish kills since 1981



VI.3 Appendix C: 2001 Nutrient Management Commission Annual Report

2001
Annual Report

of the
Delaware Nutrient
Management Commission

to Gov. Ruth Ann Minner and the
141st Delaware General Assembly

April 1, 2002

“Water quality is everyone’s responsibility”

Table of contents

2001 Annual Report

Introduction

This report includes information about the Delaware Nutrient Management Commission's activities in 2001, as required by law, and will give an overview of its continuing efforts in 2002.

The commission is continuing its efforts to improve the quality of Delaware's waters, while preserving the State's valuable agricultural industries.

The Delaware Nutrient Management Commission made progress in 2001 towards achieving established goals. Priorities for implementing these goals include:

1. The establishment of a Concentrated Animal Feeding Operation (CAFO) permitting program;
2. Continuation of certification and education of Nutrient Handlers;
3. Provide optimal resources for nutrient planning;
4. Promote and continue support of exporting excess animal nutrients (manure) to farms or alternative use projects in need of nutrients.

The Commission is continuing its efforts to improve the quality of Delaware's waters, while preserving the state's valuable agricultural industries. It is on track in its efforts to meet the nutrient management deadlines established by 1999 legislation. In fact, so many nutrient handlers have met state mandates early that Delaware's efforts have been observed by many other states as they explore the task of mandatory nutrient management.

The following section fulfills reporting requirements to the Governor and the General Assembly as stated in the Nutrient Management Law.

Calendar year 2001

Education classes provide the information relating to the influence of water quality and nutrient non-point sources.

The Delaware Nutrient Management Commission is required by law to annually report on nutrient management training that was offered during the past year, Best Management Practices implemented, the number of acres under nutrient management plans and critical areas that will be targeted for action. It is also required to recommend incentives to promote Best Management Practices.

Those required reports on activities in 2001 start on this page. They are followed by additional information, such as an overview of the commission's budget, a progress report on its continuing efforts in 2002 and other background information.

Nutrient Management Training, Education, and Certification

The Commission continues to offer certification classes, as required by law, for nutrient generators, nutrient handlers, and nutrient consultants. The University of Delaware Cooperative Extension conducts these classes in support of the Nutrient Management Commission. During 2001, the University conducted 70 certification classes in support of the Nutrient Management Commission throughout the State. Class participants pursue one of four certification levels that require multiple classes. To date, over 1,500 people are actively pursing or have been issued a nutrient management certification. Sixty people, representing 27 companies and organizations, are currently certified as nutrient management consultants.

Also during 2001, the University of Delaware Cooperative Extension sponsored 15 seminars on miscellaneous nutrient management topics for groups representing all sectors of the agriculture industry and the commercial nursery, turf, and landscape industries. In addition, newsletters and mailings on nutrient management were issued during the year. These activities reached more than 2,000 people.

Demonstration projects have been implemented throughout the State for the purpose of relating research data to commercial farm production. These projects were conducted by the University Cooperative Extension on 15 Delaware farms, including:

1. Starter fertilization in corn
2. Poultry litter application rates
3. Pre-sidedress Soil Nitrate Test (PSNT)
4. Use of diagnostic tools to improve nutrient management
5. Field evaluations of amended poultry litter that could potentially decrease phosphorus concentration

Best Management Practices

The Nutrient Management Commission promotes Best Management Practices, which are actions that can help reduce pollution. These management practices are the backbone of nutrient management and will have short-term and long-term results on water quality. They include such practices as testing soil before fertilizing, proper timing and methods of fertilizer (commercial and manure) application, the planting of cover crops and vegetative buffer strips, erosion control, the proper disposal of dead animals, and general conservation practices.

The Nutrient Management Commission promotes Best Management Practices that can reduce water pollution.

The Commission works cooperatively with county conservation districts to promote and implement nutrient related Best Management Practices (BMPs). The result of a cooperative relationship with farmers, conservation districts, and the Commission is the construction of 99 structural BMPs. Many other practices are coordinated by the Districts, as the following summary depicts:

New Castle County
Manure storage structures — 3
Acres under conservation plans — 10,625

Kent County
Manure storage structures — 10
Poultry carcass composters — 6
Acres under conservation plans — 14,630

Sussex County
Manure storage structures — 52

Poultry carcass composters — 28
Acres under conservation plans — 16,268

In conjunction with county and federal conservation district offices, the commission is developing a Best Management Practices source book, which will provide nutrient handlers a list of recommended practices. These practices will be part of nutrient management planning that will help reduce nutrient pollution.

The source book provides a detailed explanation of 53 practices. The following practices represent a summary of the Commission approved Best Management Practices:

- Feed Related Amendments
- Poultry Litter Amendments
- Roof Runoff Management in Feedlots
- Stormwater Control in Feedlots
- Pasture Stream Fencing
- Liquid and Non-liquid Manure Handling for Long-term and Short-term Storage
- Animal Mortality Handling
  - Daily Mortality/Catastrophic Mortality
- Analysis and Testing
- Nutrient Application Equipment Calibration and Adjustment
- Residue Management and Tillage Practices
- Buffer Strips
- Windbreaker/Tree Planting for Erosion and Odor Control

Nutrient Management Planning

Any business operation that applies nutrients to greater than 10 acres or manages 8,000 pounds of animals will be affected by mandatory nutrient management. These people will be randomly selected in 20% increments starting in 2003. They are affected by the following methods:

1. The development of a nutrient management plan or animal waste management plan;
2. Must maintain records;
3. Must submit annual report;
4. Must become certified.

Farmers and other nutrient handlers can contact their Conservation District or private nutrient consultants for nutrient management planning

Although plans are not due until 2003, many nutrient handlers have taken advantage of Commission and the Conservation Districts' incentives to help them develop their plans early. These volunteer efforts have resulted in the establishment of nutrient management plans for more than 122,000 acres during 2001. To date, just under 200,000 acres (forty-percent) of agricultural crop land is managed under Commission approved nutrient management planning practices.

Nutrient Management Planning	
Private Sector……………	177,186 acres
Public Sector…………….	19,558 acres
Total……………………	**196,744 acres**

The nutrient management law requires the Commission to report the number of acres and nutrient management plans per watershed. This information will be provided once mandatory planning begins.

Recommended incentives

As the Nutrient Management Program continues to become established, the commission recommends continued financial commitment for nutrient management planning, nutrient relocation, and Best Management Practices. Expenses incurred as a result of voluntary efforts or regulatory requirements to implement these practices would significantly reduce the profitability of agriculture if not assisted by government funding. Continued funding is the key to successfully implementing the Nutrient Management Program.

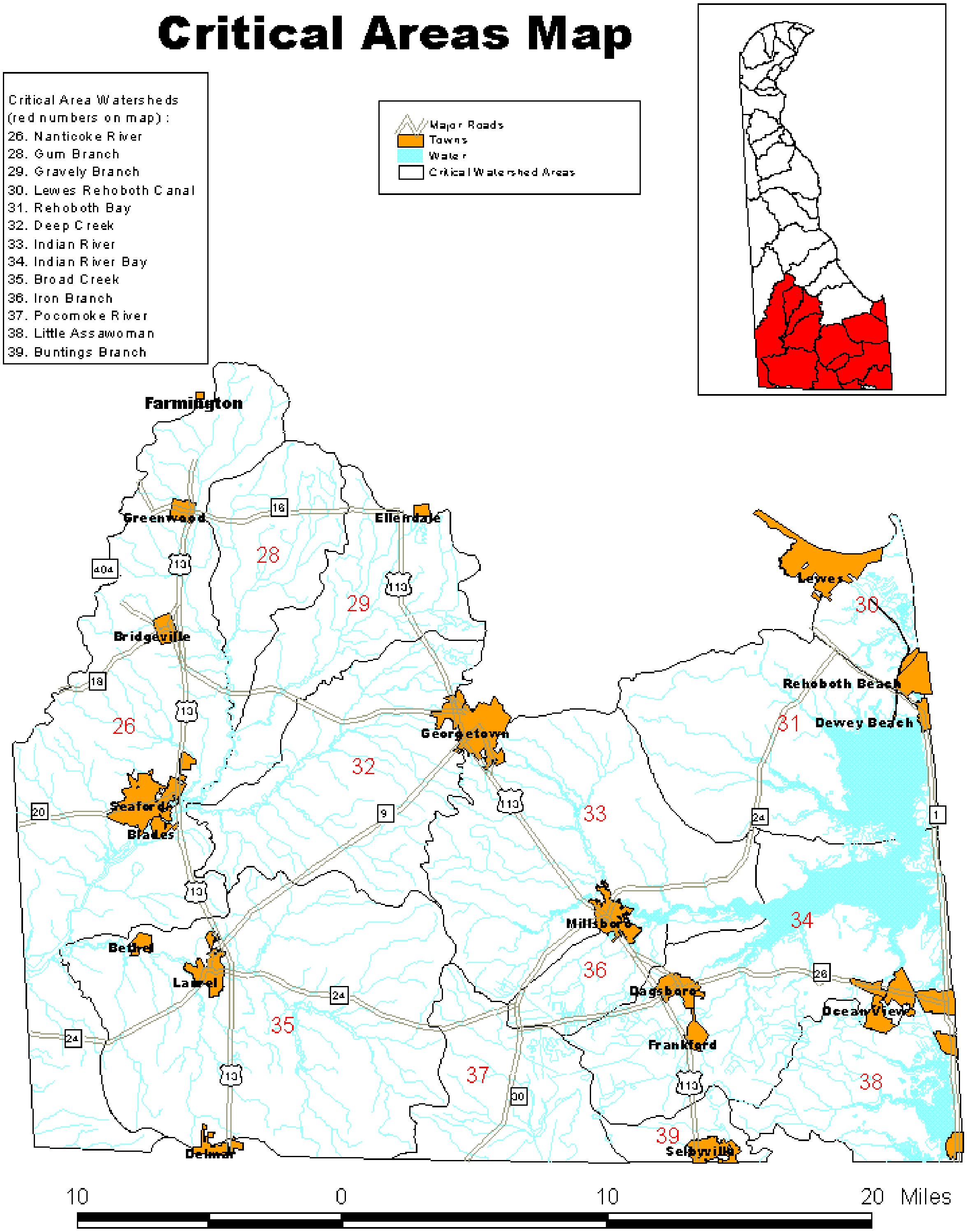
Critical areas

The commission has created a "critical areas" map to help set priorities for the Nutrient Management Program. Such priorities include nutrient relocation involvement for the export of excess poultry litter.

These critical areas encompass about 70 percent of Sussex County, including the Inland Bays, Nanticoke, and Pocomoke watersheds. The commission's choices were based on the impaired-waters list developed by the Department of Natural Resources and Environmental Control and the level of livestock production within those watersheds.

(A copy of the critical areas map is on the facing page.)

Nutrient Management Program
Critical Areas Map



Budget

The Nutrient Management Commission accomplishments were made possible by funding provided by the Legislature and Governor Minner. The Nutrient Management Program is well into developing standards, as required by the Nutrient Management Act, and has begun to implement these standards with voluntary participation. In the coming year, a mandatory twenty-percent increment of people who handle animal manure or commercial fertilizer will be affected.

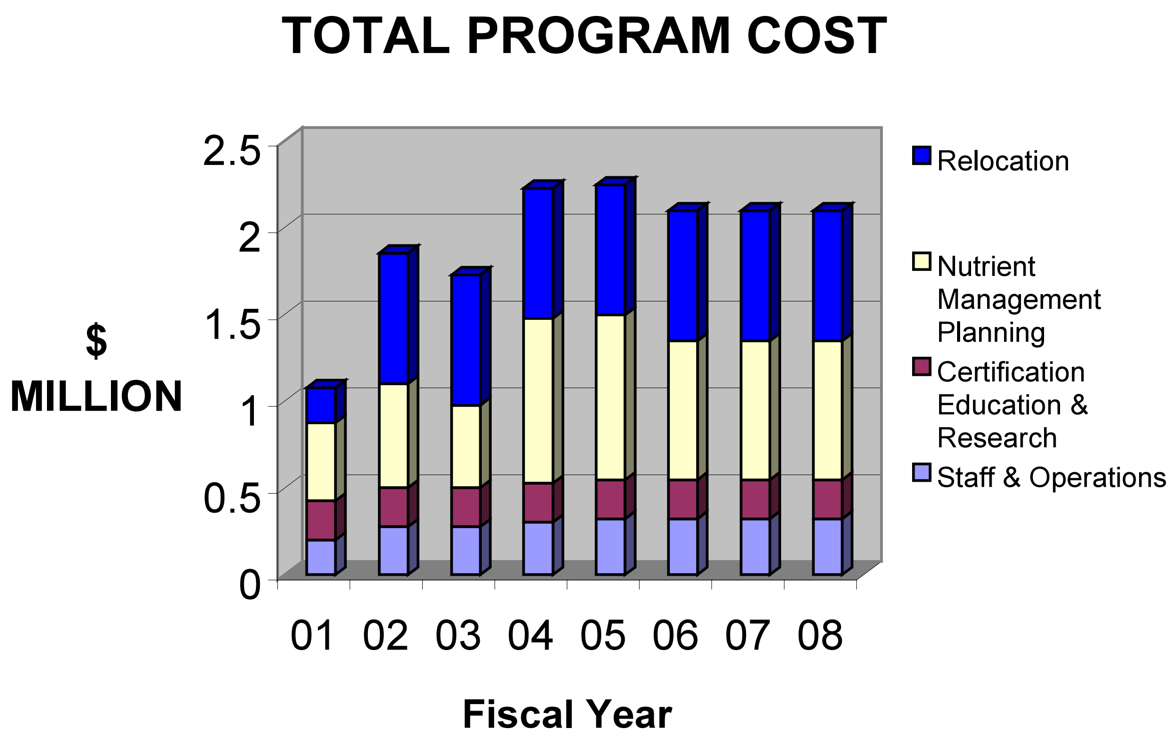
The following is an outline of the Commission's budget needs for fiscal year 2003 that will support mandatory nutrient management practices:

Budget request for Fiscal Year 2003

	FY 2002 Budget	**FY 2003 – Proposal**
Program Operating Costs:		
Personnel	191,900	**191,900**
Travel	5,000	**5,000**
Contractual	15,000	**15,000**
Supplies	8,000	**8,000**
Information/Education/Certification	225,000	**225,000**
Nutrient Relocation Program	250,000	**250,000**
Nutrient Management Planning	600,000	**405,000**
Contingency	124,800	**153,700**
TOTAL	**$ 1,419,700**	**$ 1,253,600**

Long-Range Budget

The following long-range budget chart will provide an overall cost analysis of implementing the State's Nutrient Management Program:



Progress Report

The work of the Nutrient Management Program is ongoing — it strives to improve water quality in Delaware through cost-sharing programs, the approval of alternative-use projects, the education of nutrient handlers and many other measures. The following are overviews of the program's continuing efforts, as well as some of its accomplishments.

Cost-sharing programs

Cost-sharing programs are available to assist in the relocation of excess manure and in nutrient management planning.

Through many efforts of the State's program and Agricultural Industry, 63,000 tons of poultry litter has been exported from farms with inadequate land or high phosphorus levels.

Nutrient Relocation Program — The Delaware Nutrient Management Commission offers a Nutrient Relocation Program that helps with the transportation cost of moving manure to alternative-use projects or to land in need of nutrients. The program has assisted in the relocation of more than 48,000 tons of poultry manure, the majority of which is from the critical areas defined by the commission. Of that total, 30,000 tons have been exported off the Delmarva Peninsula through this program.

Other efforts to relocate excess poultry litter involve the Perdue AgriRecycle Pelletizing Plant. This newly constructed plant has processed and exported approximately 15,000 tons of Delaware poultry litter.

Nutrient Management Planning — The Nutrient Management Program offers cost-sharing support of $5 per acre to help nutrient handlers develop management plans. This cost-sharing program has defrayed the cost of planning for more than 177,000 acres, well ahead of the 2003 deadline for such planning. In addition, the program offers reimbursement for soil sampling and manure testing.

Permits for Large Animal Operations

Federal law requires permits for large animal operations called Concentrated Animal Feed Operations (CAFO). A past agreement between the Environmental Protection Agency (EPA), Department of Natural Resources and Environmental Control, and the Commission has authorized the Nutrient Management program to develop standards for CAFOs.

Presently, a subcommittee of the Commission has reviewed several drafts of standards for CAFOs. These standards will affect large animal feeding operations such as poultry farms that raise more than 100,000 birds at a time. These standards may also apply to smaller operations as designated by the Commission and Secretary of Agriculture. Cooperation and input between the Commission, EPA, other State agencies, and the public will occur before CAFO standards are implemented.

Background & contacts

What is the Delaware Nutrient Management Commission?

The Nutrient Management Act established a 19-member commission that is charged to develop, review, approve, and enforce regulations governing the certification of individuals engaged in the business of land application of nutrients and the development of nutrient management plans. The members of this commission come from many different backgrounds and professions. See pages 11 through 14 for more information about the commission members.

Mission statement

The Delaware Nutrient Management Commission's official mission is:

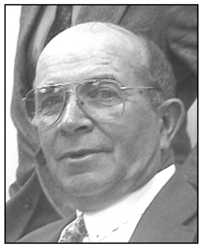
"To manage those activities involving the generation and application of nutrients in order to help improve and protect the quality of Delaware's ground and surface waters, sustain and promote a profitable agricultural community, and to help meet or exceed federally mandated water quality standards, in the interest of the overall public welfare.

What are the DNMC's responsibilities?

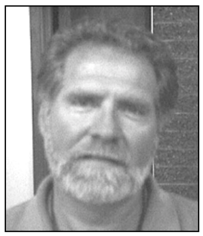
The Delaware Nutrient Management Commission will:

1. Consider establishing critical areas for voluntary and regulatory programs.
2. Establish Best Management Practices to reduce nutrients in the environment.
3. Develop educational and awareness programs.
4. Consider incentive programs to redistribute nutrients.
5. Establish the elements and general direction of the State Nutrient Management Program.
6. Develop nutrient management regulations.

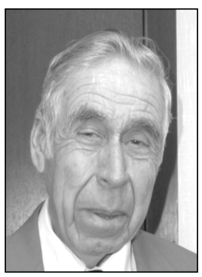
Members of the Nutrient Management Commission



William Vanderwende, Commission Chairman, was appointed to the commission by the Senate, and was named Chairman by the Governor. He is a full-time Sussex County dairy producer who represents the state's dairy industry. He operates a farm with a 700-head dairy, 75,000 broilers, and 3,000 crop acres. He can be reached at (302) 349-4423.

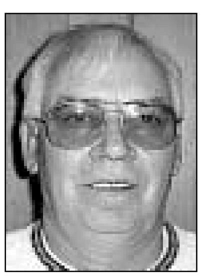


David Baker, Commission Vice Chairman and Chairman of the Personnel Subcommittee, was appointed by the Senate as a representative of the New Castle County grain industry. He is a full-time grain farmer who operates a farm with 1.2 million layers and 3,000 acres of grain. He can be reached at (302) 378-3750.

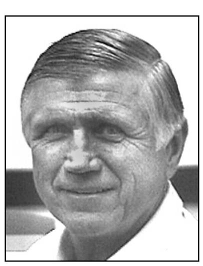


James Baxter, Jr. was appointed by the House of Representatives as a representative of the Sussex County grain and poultry industry. He and his family operate an 1800 acre grain farm with 450,000 commercial broilers. He can be reached at (302) 856-9526.

Stephen Corazza, Chairman of the Government Interaction Subcommittee, was appointed by the House of Representatives to represent New Castle County poultry producers. He operates a 112,000-bird commercial poultry farm. He can be reached at (302) 653-3583.

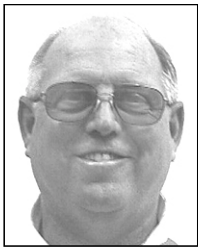


James Elliott was appointed by the Governor as a Sussex County public citizen representative. He is the Chairman of the Center for Inland Bays, an environmental advocacy group. He can be reached at (302) 539-3409.



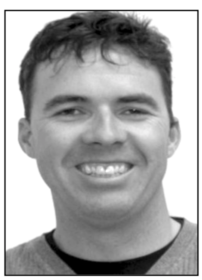
Carlton Fifer was appointed by the Senate. He represents the Kent County vegetable industry, and operates a 2,500-acre fruit and vegetable farm. He can be reached at (302) 697-2141.

John Hughes, director of the Delaware Division of Soil & Water Conservation, was appointed by the Governor. He lives in Rehoboth Beach. He can be reached at (302) 739-4411.

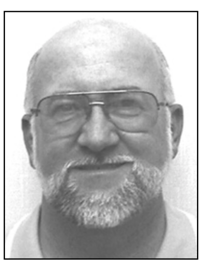


Tony Keen, Chairman of the Technology Sub-committee, was appointed by the Senate as a nutrient consultant. He has owned and operated a private crop consulting firm since 1976. He can be reached at (302) 684-3196.

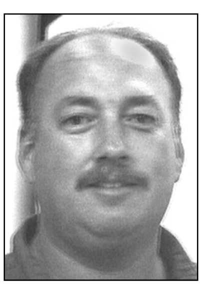
Connie Larimore was appointed by the House of Representatives to represent Kent County poultry producers. She owns a 50,000-capacity poultry operation and 150-acre grain farm. She can be reached at (302) 398-8304.



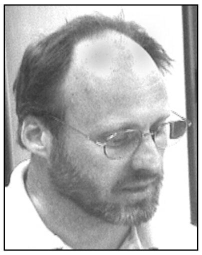
Ed Lewandowski, was appointed by the House of Representatives as an Environmental Advocacy Group representative. He is currently the Education and Outreach Coordinator at the Center for the Inland Bays. He can be reached at (302) 645-7325.



Dale Ockels, Chairman of the Compliance & Enforcement Subcommittee, was appointed by the Governor to represent swine farmers. As a full-time swine farmer, he operates a 5,300-acre grain and hog-finishing farm. He can be reached at (302) 684-0456.

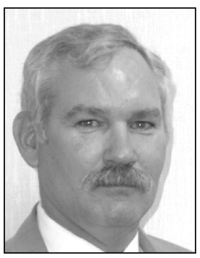


Brian Schilling, Chairman of the Industry Relations Subcommittee, was appointed by the House of Representatives to represent commercial agricultural nutrient applicators. He is a nutrient consultant and manager of a local agricultural cooperative. He can be reached at (302) 934-7684.

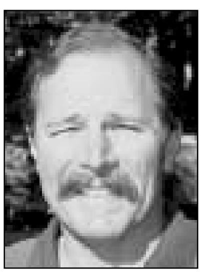


Carl Solberg, Chairman of the Program & Education Subcommittee, was appointed by the Senate. He represents the Environmental Advocacy Group, and is a volunteer for the Delaware Chapter of the Sierra Club. He can be reached at (302) 492-1225.

Richard Sterling, was appointed by the Governor as a representative of the commercial nursery industry. He operates a 75-acre nursery specializing in evergreens. He can be reached at (302) 653-7060.



Michael Scuse, Secretary of the Delaware Department of Agriculture, is an ex-officio member of the commission. He can be reached at (302) 698-4500.

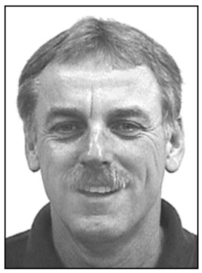


Nicholas A. DiPasquale, Secretary of the Delaware Department of Natural Resources and Environmental Control, is an ex-officio member of the commission. He can be reached at (302) 739-4403.

Vincent Meconi, Secretary of the Delaware Department of Health and Social Services, is an ex-officio member of the commission. He can be reached at (302) 577-4502.

Delaware Nutrient Management Program staff

William Rohrer Jr., is the administrator of the Delaware Nutrient Management Program and an ex-officio member of the Nutrient Management Commission. He can be reached at (302) 698-4500.



Steve Hollenbeck is the environmental coordinator for the Delaware Nutrient Management Program. He can be reached at (302) 698-4500.

Darlene Phillips is the senior secretary for the Delaware Nutrient Management Program. She can be reached at (302) 698-4500.

University of Delaware nutrient specialists

Several experts from the University of Delaware provide certification training for the Nutrient Management Program. They also assist the program by providing technical recommendations and by conducting research and demonstration projects on nutrient management practices. They are:

Dr. Greg Binford, nutrient specialist, at (302) 831-2146.

Dr. David Hansen, nutrient specialist, at (302) 856-7303.

Several people assist Dr. Binford and Dr. Hansen in the training programs and research and demonstration projects. They are:

Carl Davis, of the New Castle County Extension Office, at (302) 831-2506.
Gordon Johnson, of the Kent County Extension Office, at (302) 697-4000.
George (Bud) Malone, extension poultry specialist, at (302) 856-7303.
Shawn Tingle, extension associate, at (302) 856-7303.
Derby Walker, of the Sussex County Extension Office, at (302) 856-7303.
Sydney Young, extension associate, at (302) 856-7303.

How to contact the Nutrient Management Program

To reach program staff members, call (302) 698-4500 or (800) 282-8685, or send an e-mail to nm@dda.state.de.us.

Information about the Nutrient Management Program can be found on the Internet at www.state.de.us/deptagri.