

Water Quality Monitoring Strategy

**Delaware Department of Natural Resources and Environmental
Control**

**Division of Water Resources
Watershed Assessment Branch**

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Overview

This document ties together Delaware's water quality monitoring plans for surface and subsurface waters and wetlands and discusses Delaware's monitoring strategies and objectives. The document addresses each of the areas discussed in U.S. Environmental Protection Agency (EPA) document EPA 841-B-03-003, "Elements of a State Monitoring and Assessment Program". The Delaware Department of Natural Resources and Environmental Control (The Department) has a number of monitoring programs for its waters. Copies of recent monitoring plans and reports are attached. The plans have complete details about the strategies, goals, methodologies, data uses, data reporting and quality controls.

The Department routinely monitors surface waters for conventional pollutants, nutrients, bacteria, dissolved oxygen and metals at many locations with a network of approximately 200 stations. See Figure 1 for the location of the monitoring stations. Also, see the attached State of Delaware's FY 2007 Surface Water Quality Monitoring plan for additional information.

As part of a separate monitoring effort, recreational waters (beaches) are monitored with much greater frequency for bacterial levels to provide information to recreational water managers and swimmers regarding risks associated with full body contact in those waters.

Furthermore, the Department has been working with the Delaware Department of Health and Social Services under a memorandum of agreement to collect fish samples, analyze them for toxic chemicals and, when appropriate, issue fish consumption advisories based on the protocols developed by the two agencies. Issuance of fish consumption advisories leads to TMDL development. The monitoring plan for this effort is attached.

The Department has been working with a number of other states, federal agencies and stakeholders to develop and implement wetlands monitoring protocols and use the information to guide restoration efforts. The Wetlands monitoring strategy document attached provides a comprehensive overview of the program and protocols used for this effort.

Many of Delaware's citizens are dependent on groundwater for their drinking water. The Department has been monitoring groundwater throughout the state and reporting the results in 305(b) reports for some time. A sample 305(b) section is included in the appendices.

The Department is working with a number of Citizen monitoring groups to collect surface water information in waters around the state. A sample monitoring result report is attached.

Finally, as a partner and cooperating agency with Chesapeake Bay Program's Non-tidal Monitoring Workgroup, Delaware has added two monitoring sites to its monitoring network and monitors those sites according to protocols developed by the Chesapeake Bay Program. The information collected at the above two sites will be used to estimate nutrient and pollutant loads entering the Chesapeake Bay from the Nanticoke and Marshyhope watersheds.

Elements of Delaware's Monitoring Program Strategy

EPA's guidance document suggests that State's monitoring strategies should address the following 10 elements:

- A: Monitoring Program Strategy
- B: Monitoring Objectives
- C: Monitoring Design
- D: Core and Supplemental Water Quality Indicators
- E: Quality Assurance
- F: Data Management
- G: Data Analysis/Assessment
- H: Reporting
- I: Programmatic Evaluation
- J: General Support and Infrastructure Planning

In the sections that follow each of the EPA elements is addressed.

Element A: Monitoring Program Strategy

DNREC has several different water quality monitoring activities in place or under development whose primary purpose is supporting Clean Water Act objectives. Monitoring programs that support other state priorities are also in place. Current Clean Water Act activities include a Surface Water Monitoring Program, a Ground Water Monitoring Program, Toxics in Biota Program and a Wetlands Monitoring Program and Strategy. Recent copies of the most recent monitoring plans for the programs above are attached. In addition, the Department does shellfish monitoring to meet ISSC requirements and extensive monitoring in coastal waters to comply with Beach Act requirements.

Other programs are also in place and/or under development to supplement the core surface water quality monitoring programs. The Department has been conducting habitat and benthic organism surveys in Delaware's piedmont and coastal plain wadeable streams. In addition, the Department is implementing continuous monitoring using monitors that collect, analyze and store a variety of parameters several times a day for periods of one week to one month or longer at a time. The Department also does other monitoring that may also support water quality goals (e.g. fisheries studies, horseshoe crab monitoring, air quality, special short term projects, etc.) that are not discussed in this document.

All of the Department programs are designed to meet one or more of the following goals:

- Characterize water quality condition of State's waters
- Determine waters that are attaining and not attaining narrative and numeric water quality standards;
- Determine effectiveness of implementation of pollution control strategies and nonpoint source program and projects;
- Determine environmental and public health effectiveness of voluntary and required pollution control programs;
- Identify and define the scope of emerging issues and/or threats to the health of State waters and the public;
- Support human health risk assessments;
- Establishing, reviewing and revising water quality standards;
- Identify causes and sources of water quality impairments;
- Prioritizing efforts on a watershed basis;
- Developing hydrodynamic and water quality models and establishing Total Maximum Daily Loads (TMDLs)
- Supporting other priority activities (e.g. Superfund-related investigations, Clean Lakes studies, National Estuary Program studies, Interstate cooperative studies, emergencies, etc...)

Like other agencies and organizations, the Department must weigh its need for information against available resources, both human and fiscal. The Department seeks to maximize available information in all its monitoring activities. It does so by considering the needs of the program collecting the data, other program needs and available funding. Appropriate parameters, sampling locations and sampling frequencies are also considered in light of the above factors.

Outside Agencies

The Department works closely with other agencies in implementing its water quality monitoring programs. Some of these activities include:

1. The Department works with the Delaware River Basin Commission (DRBC) on surface water monitoring of Delaware River and Bay . In addition the Department works cooperatively with DRBC providing funds to secure and analyze samples for special projects and TMDL related activities. The Department has active members on DRBC committees. The members provide expertise, comments and analysis as needed to support those committee activities. The Department also works closely with DRBC on preparing 305(b) reports that both agencies develop.

2. The Department is participating as a cooperating agency in Chesapeake Bay Program's Non-Tidal Monitoring Program. Two of Chesapeake Bay Program's Non-tidal Monitoring network are in Delaware and monthly and stormwater samples are collected at those sites using protocols developed by the Chesapeake Bay program.
3. The Department cooperates with the United States Geological Survey (USGS) to collect stream flow and tidal elevation data at several locations within the State. In addition, the Department is funding continuous monitors at several USGS locations. Real time and near real time data from the monitors is expected to be online in the very near future.
4. The Department works with academic institutions to support the Department in planning and implementing special surveys
5. The Department works with non-profit organizations to implement Citizen Monitoring Programs. The Department works with these organizations to assist them with their own sampling, analysis and reporting activities. Data from the programs is summarized, compared to Department data and reported in 305(b) reports. As other groups show interest and capacity, the Department expects to extend them similar support in the future.

Costs

The following table shows a breakdown of costs incurred by the Watershed Assessment Section in its primary role of monitoring, assessing and reporting on Delaware water quality. Note that Groundwater and other monitoring costs not managed by the Watershed Assessment Section are not listed below.

Watershed Assessment Annual Monitoring Costs		
Category	Annual Cost	
Direct Monitoring Costs		
TMDL Monitoring	\$385,800	
GAMN Monitoring	\$327,700	
Bacteria Monitoring	\$155,400	
Biological Monitoring	\$75,000	
Shellfish and Recreational Waters	\$32,000	
Toxics in Biota	\$24,800	
Wetlands	\$95,400	
Stream Flow/Tide gage	\$62,600	
Indirect Costs		
Travel	\$19,400	
Supplies	\$25,300	
Salaries		\$474,000
Seasonal/Contractual Support		\$102,250
Total Non-Salary	\$1,203,400	
Total Salary		\$576,250
Total Cost		\$1,779,650

Element B: Monitoring Objectives

All of the Department water quality monitoring programs are designed to meet one or more of the following goals:

- Characterize water quality condition of the State's waters;

- Determine waters that are attaining and not attaining narrative and numeric water quality standards;
- Determine effectiveness of point and nonpoint source programs, controls and projects;
- Determine environmental and public health effectiveness of voluntary and required pollution control programs;
- Identify and define the scope of emerging issues and/or threats to the health of State waters and the public;
- Support human health risk assessments;
- Establishing, reviewing and revising water quality standards;
- Identify causes and sources of water quality impairments;
- Prioritizing efforts on a watershed basis;
- Developing hydrodynamic and water quality models and establishing TMDLs
- Supporting other priority activities (e.g. Superfund-related investigations, Clean Lakes studies, National Estuary Program studies, Interstate cooperative studies, emergencies, etc...)

Element C: Monitoring Design

As noted above, Delaware's most recent monitoring plans are attached. The plans describe in detail the various network designs for the State's waters. Delaware has committed to monitoring its surface waters in a meaningful way by developing a network of 181 permanent stations (the General Assessment Monitoring (GAMN) Network) in its approximately 2500 river miles of surface waters and 25 square miles of estuarine waters. Many of the stations in the GAMN have been in place for up to thirty years. Stations in the GAMN were selected at strategically located areas to assist with water quality characterization of a waterbody. In the past, an additional network of Total Maximum Daily Load/ Special Project (TMDL/SP) was used to support development of hydrodynamic and water quality models and establishment of TMDLs or special short term projects and needs (See figure 1). With establishment of TMDLs for many watersheds within the State, the Department is adjusting the focus and scope of its surface water quality monitoring by increasing the frequency of monitoring at GAMN stations in key TMDL watersheds to measure progress toward achievement of the TMDLs and better capture seasonal variability. Furthermore, the Department is expanding biological and habitat monitoring, toxics in biota monitoring and other water quality monitoring needs. The Department is expanding biological and habitat monitoring by increasing the number of macroinvertebrate surveys. Fish tissue surveys are continuing on track in accordance with plans published elsewhere in addition to taking advantage of sampling opportunities that arise from environmental investigations.

The Department is aware of an interest in probabilistic monitoring programs to evaluate water quality for waters of the State. Given the intense monitoring network that is in place, it is not clear at this time what the benefits of a probabilistic design would be. The Department is interested in evaluating probabilistic design scenarios to establish costs and benefits under various scenarios.

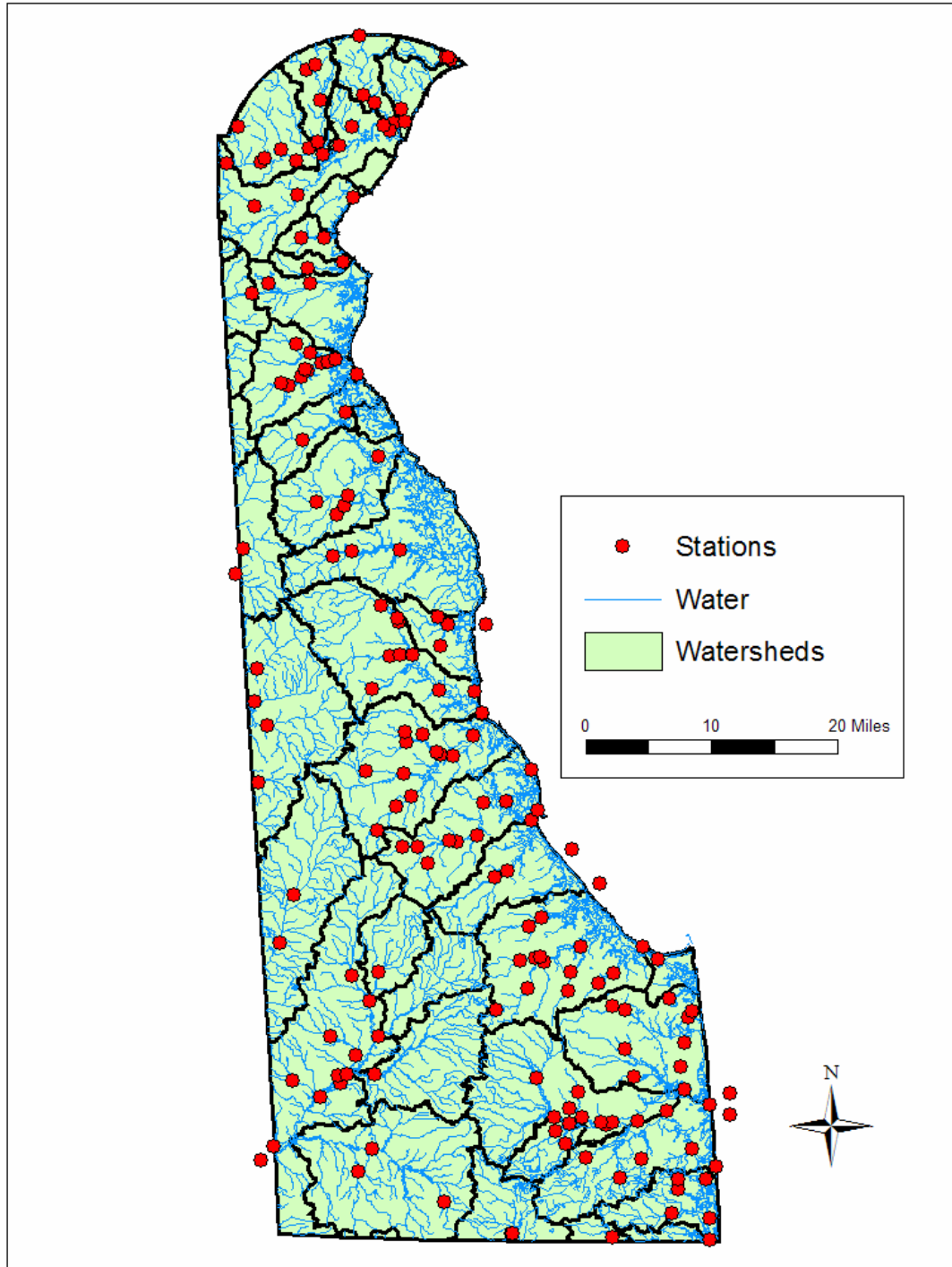


Figure 1: Delaware Surface Water Quality Monitoring Stations

Element D: Core and Supplemental Water Quality Indicators

The tables and figure below compile designated uses and indicators/criteria used to assess them for 305(b) purposes in the State. Criteria assessment guidelines and flow charts are in Delaware's 305(b) assessment methodologies document.

The tables and Figure 2 below show designated uses in watersheds of the State and indicators/criteria used to assess them for 305(b) purposes.

Designated Uses, Indicators and Criteria in Delaware Waters

Designated Use	Indicators/ Criteria
Public Water Supply Source	EPA Drinking Water Criteria, as assessed in Source Water Assessment Reports
Industrial Water Supply	None
Primary Contact Recreation	Enterococcus Bacteria Concentrations
Secondary Contact Recreation	Enterococcus Bacteria Concentrations
Fish, Aquatic Life & Wildlife	dissolved oxygen, pH, temperature, ammonia, contaminants in fish, site specific data, metals
Cold Water Fish (Put-and-Take)	Temperature
Agricultural Water Supply	None
ERES Waters	Trends in nutrients and dissolved oxygen
Harvestable Shellfish Waters	Fecal coliforms / ISSC criteria

Delaware Waterbodies Designated Uses

Basins and waterbodies		Public Water Supply Source	Industrial Water Supply	Primary Contact Recreation	Secondary Contact Recreation	Fish, Aquatic Life & Wildlife**	Cold Water Fish (Put-and-Take)	Agricultural Water Supply	ERES Waters*	Harvestable Shellfish Waters
	Name									
1	Naamans Creek	-	x	x	x	x	-	(a)	-	-
2	Shellpot Creek	-	x	x	x	x	-	(a)	-	-
3	Brandywine Creek	(a)	x	x	x	x	(b)	(a)	(h)	-
4	Red Clay Creek	x	x	x	x	x	(e)	x	q	-
5	White Clay Creek	(a)	x	x	x	x	(f)	(a)	(g)	-
6	Christina River	(a)	x	x	x	x	(c)	(a)	-	-
7	Delaware River	-	-	x	x	x	-	(a)	-	-
8	Army Creek	-	-	x	x	x	-	(a)	-	-
9	Red Lion Creek	(a)(i)	x	x	x	x	-	(a)	-	-
10	Dragon Run Creek	(a)	x	x	x	x	-	(a)	-	-
11	Chesapeake & Delaware Canal East	-	x	x	x	x	-	-	-	-
12	Appoquinimink River	-	x	x	x	x	-	(a)	-	-
13	Blackbird Creek	-	x	x	x	x	-	(a)	-	-
14	Delaware Bay	-	x	x	x	x	-	(a)	-	-
15	Smyrna River	-	x	x	x	x	-	(a)	-	-
16	Leipsic River	-	x	x	x	x	-	(a)	-	-
17	Little Creek	-	x	x	x	x	-	(a)	-	-
18	St. Jones River	-	x	x	x	x	-	(a)	-	-
19	Murderkill River	-	x	x	x	x	-	(a)	-	-
20	Mispillion River	-	x	x	x	x	-	(a)	-	-
21	Cedar Creek	-	x	x	x	x	-	(a)	(d)	-
22	Broadkill River (k)	-	x	x	x	x	-	(a)	-	-
23	Elk Creek	-	x	x	x	x	-	x	-	-
24	Perch Creek	-	x	x	x	x	-	x	-	-
25	Chesapeake & Delaware Canal West	-	x	x	x	x	-	-	-	-
26	Bohemia Creek	-	x	x	x	x	-	x	-	-
27	Sassafras River	-	x	x	x	x	-	x	-	-
28	Chester River	-	x	x	x	x	-	x	-	-
29	Choptank River	-	x	x	x	x	-	x	-	-
30	Marshyhope Creek	-	x	x	x	x	-	x	x	-
31	Nanticoke River	-	x	x	x	x (p)	-	(a)	x	-
32	Gum Branch	-	x	x	x	x	-	(a)	x	-
33	Gravelly Branch	-	x	x	x	x	-	(a)	x	-
34	Deep Creek	-	x	x	x	x	-	(a)	x	-
35	Broad Creek	-	x	x	x	x (p)	-	(a)	x	-
36	Wicomico	-	x	x	x	x	-	(a)	x	-
37	Pocomoke River	-	x	x	x	x	-	x	-	-
38	Lewes & Rehoboth Canal	-	x	x	x	x	-	-	-	-
39	Rehoboth Bay	-	x	x	x	x	-	(a)	x	(j)

Basins and waterbodies		Public Water Supply Source	Industrial Water Supply	Primary Contact Recreation	Secondary Contact Recreation	Fish, Aquatic Life & Wildlife**	Cold Water Fish (Put-and-Take)	Agricultural Water Supply	ERES Waters*	Harvestable Shellfish Waters
	Name									
40	Indian River	-	x	x	x	x	-	(a)	(d)	-
41	Iron Branch	-	x	x	x	x	-	(a)	(d)	-
42	Indian River Bay	-	x	x	x	x	-	(a)	x	(j)
43	Buntings Branch	-	-	x	x	x	-	x	-	-
44	Assawoman	-	-	x	x	x	-	(a)	x	-
45	Little Assawoman Bay	-	x	x	x	x	-	(a)	x	-
	Delaware Bay (waterbody) (l), (n)	-	x	x	x	x	-	-	(m)	(j)
	Delaware River (Waterbody) (l) ,(o)	-	x	x	x	x	-	-	-	-
	Atlantic Ocean (waterbody)	-	x	x	x	x	-	-	(m)	

- (a) Designated use for freshwater segments only.
- (b) Designated use from March 15 to June 30 on:
 1. Beaver Run from PA/DE line to Brandywine.
 2. Wilson Run Route 92 through Brandywine Creek State Park.
- l Designated use from March 15 to June 30 on: Christina River from MD/DE line through Rittenhouse Park.
- (d) Designated use for marine water segments only.
- (e) Designated use year round on:
 - Red Clay Creek from PA/DE line to the concrete bridge above Yorklyn
- (f) Designated use year round on:
 1. White Clay Creek from the PA/DE line to the dam at Curtis

Paper.

- Designated use from March 15 to June 30 on:
 2. Mill Creek from Brackenville Road to Route 7.
 3. Pike Creek from Route 72 to Henderson Road.
- (g) Designated use from PA/DE line to the dam at Curtis Paper.
- (h) Designated use from PA/DE line to Wilmington city line.
- (i) Goal use – not currently attained.
- (j) Parts of these waters are APPROVED shellfish harvesting areas. Information on areas where shellfish may be taken should be obtained from the Shellfish & Recreational Waters Branch, Watershed Assessment Section, Division of Water Resources, Department of Natural Resources and Environmental Control.
- (k) Includes Primehook Creek watershed.
- (l) Includes assorted minor watersheds not explicitly associated with any other designated stream basin.
- (m) The specific portions of the Atlantic Ocean and the Delaware Bay for which the ERES designation shall apply shall be delineated in the Pollution Control Strategy developed for each of those waterbodies. The ERES designation for the Atlantic Ocean and the Delaware Bay does not include water explicitly associated with any other designated stream basis (e.g., Delaware Bay does not include St. Jones River).
- (n) The Delaware Bay extends from River Mile 0.0 to 48.2 as shown on Figure 1.
- (o) The Delaware River extends from River Mile 48.2 to 78.8 as shown in Figure 1.

- (p) The Nanticoke River from the upstream-most limits of the City of Seaford to the Maryland State Line and the Broad Creek from the upstream-most limits of the Town of Laurel to the confluence with the Nanticoke River have special criteria in Section 4.5 that are protective of open water fish and shellfish, shallow-water bay grass and migratory fish spawning and nursery designated uses consistent with the Maryland portion of the tidal Nanticoke River and as described in the U.S. Environmental Protection Agency document Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tidal Tributaries (EPA 903-R-03-002).

Attainment of the water quality criteria that apply to these waters will be determined following the guidelines documented within the same document and any future published addendums or modifications to that original publication.

- Q ERES designation is for Burrows Run from the Pennsylvania Line to the confluence with Red Clay Creek
- x this designated water use to be protected throughout entire stream basin
 - water uses not designated in the stream basin
 - * waters of exceptional recreational or ecological significance
 - ** includes shellfish propagation

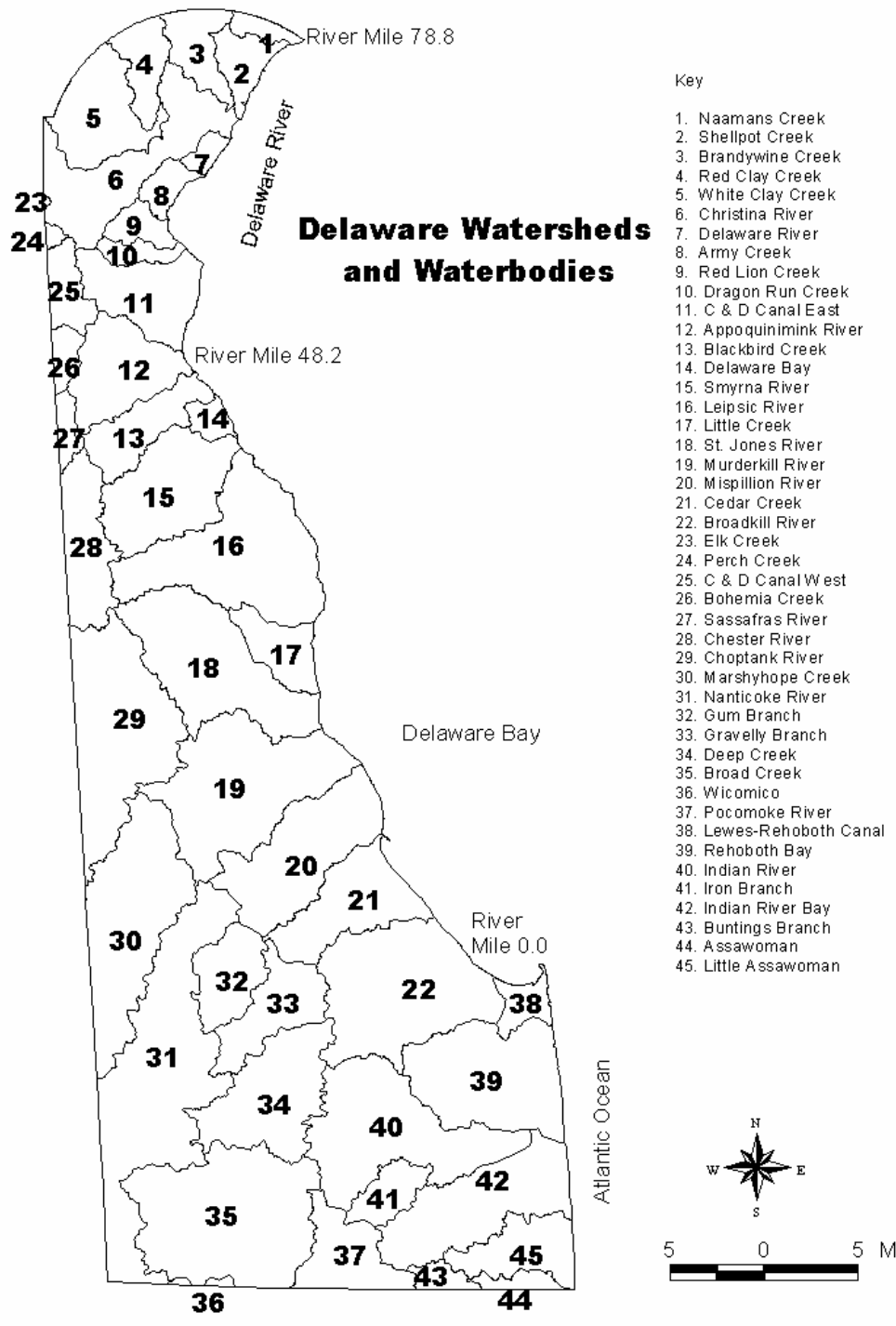


Figure 2: Delaware Watersheds

Element E: Quality Assurance

The Department works closely with EPA on its Quality Assurance Program (QAP) and project plans in accordance with EPA and State Policies. A copy of the State Quality Assurance Management Plan is attached. The Plan describes the overall purpose of the plan, the quality system, staff training, procurement, documentation and records, use of computers and software, work processes and operations, facility and equipment and quality assessment and response. The overall goal of the QAP is to ensure that the laboratory is operating under a standardized rigorous program to demonstrate precision, accuracy and reliability at all levels of service and quality.

The Department laboratory invests significant resources in training and monitoring its staff in quality assurance matters. A Quality Manager reports directly to the Laboratory Administrator. The Quality Manager is responsible for quarterly reports that cover a wide range of issues and ensure that quality remains a top priority. To ensure its continued suitability and effectiveness and to introduce any necessary changes or improvements, laboratory management reviews the quality system and all associated quality documents at least annually.

The Department occasionally uses water quality data collected by other agencies for its 305(b) reporting activities, model development, etc.. The Department considers the quality controls used in collection and analysis of the data to determine their appropriateness for use.

The Department works with citizen monitoring groups in several watersheds in the State to develop and implement monitoring efforts and quality assurance plans that meet the needs and goals of the monitoring groups.

Element F: Data Management

Data generated by monitoring programs is maintained within the laboratory using a Laboratory Information Management System (LIMS). That system is currently being interfaced with other data management systems within the Department to make the data readily available to interested parties. The Department is working to link the results in the management system to the national STORET system and to a web based system that makes a wide variety of data from all areas of the Department available to the general public based on a user friendly and map interface. The Department works closely with the DRBC on monitoring programs and provides data to DRBC on the results of monitoring efforts. As the Department makes progress on its own STORET linkage it is reasonable to expect the DRBC to benefit from that linkage.

Element G: Data Analysis/Assessment

The Department uses water quality data collected as part of elements of the monitoring strategy in this document for its 305(b) assessment and reporting. As an initial step in the process, the Department publishes its assessment methodologies for public comment. The most recent methodology document (ref.) is attached. For most conventional criteria the Department uses non-parametric confidence limits on appropriate parameters to make attainment decisions based on numeric criteria. Departmental data is considered a primary source for 305(b) reports. Other readily available data is sought out from other agencies (e.g. EPA, USGS, Delaware Departments of Agriculture and Public Health, etc, etc.) where available and used. In addition the Department works closely with citizen monitoring programs to use and report their findings in Delaware waters. The Department works closely with DRBC on the DRBC 305(b) report for DRBC waters, then uses those attainment decisions applicable to Delaware waters in the 303(d) listing decisions Delaware makes.

The Department has recently undertaken an effort in partnership with EPA and EPA's contractor to update the Assessment Database (ADB) used by the Department and EPA for 305(b) and 303(d) tracking purposes. It is expected that the updates will make the ADB more useful to the State, EPA and stakeholders.

Element H: Reporting

Delaware reports summary statistics for surface and groundwater in its 305(b) reports every two years as mandated by the Clean Water Act. For the 2006 305(b) cycle the Department is considering ways to report all the raw data available so that end users may use it. Data collected for the Beaches Act §406 is summarized in annual reports and is also considered in the 305(b)/303(d) context. Nonpoint program activities under CWA§319 are reported by the Department's Nonpoint Sources Program in their annual reports and are also considered for 305(b)/303(d) reporting and listing decisions. The Department makes all these reports available on the Internet at the Department website as soon as possible after completion. For reports and decisions that require public input, the Department actively solicits that input through its website and public outreach including press releases, advertisements and direct contact with other government agencies and parties the Department is aware of that have expressed an interest in the process.

As noted in Element G, in addition to the Department's activities in the State, the Department works closely with the DRBC to collect and analyze water quality and quantity data and report on water quality issues in the Delaware River and Bay.

Element I: Programmatic Evaluation

There is no formal process in place for a periodic review of all facets of the monitoring program at this time. However, the Department evaluates its monitoring efforts annually as part of its monitoring plan development process. At that time the Department considers available resources, needs and priorities and balances them for the upcoming fiscal year. The Department provides EPA with the monitoring plans annually.

Element J: General Support and Infrastructure Planning

As noted in Element A of this document, the Department currently spends approximately \$1.8 million annually in its primary surface water quality monitoring efforts. As additional funds become available there are a number of areas that the Department would target for expanded monitoring efforts and projects based on the expected funding amounts, and projected continuity of availability. The list below is a partial list of monitoring projects of interest to the Department. The list is presented in approximately the order of importance to the Department. Some flexibility in priorities is appropriate to account for availability of grants and changes in priority in response to other factors.

As noted in Element C, a one time project to assess the need for a probabilistic monitoring is an area of interest for the Department. If a need for probabilistic sampling is identified, developing a protocol would be the next step. Extra funding could be devoted to both efforts, as needed.

Continuous monitoring of dissolved oxygen and other parameters in the Delaware River and Bay. The Department is exploring opportunities to work with the DRBC and other states and interested parties to implement a network of continuous monitors in the lower Bay. There are significant challenges to a continuous monitoring program in the Bay. Long term monitoring stations have been estimated to cost on the order of \$40,000 each to start up with lower annual costs after the first year. The Department is also considering ways to further develop its continuous monitoring in other waters of the State and would use additional funding to start new sites or upgrade older continuous monitoring sites. The Department has started several monitoring sites in cooperation with USGS in calendar year 2006 and anticipates expanding the program as funding is available.

The Department will also use higher funding levels to expand its fish tissue monitoring program in cooperation with the Delaware Department of Health and Social Services. The two Departments have been working under a Memorandum Of Agreement (MOA) that readily allows for expansion of sampling efforts with additional available funds. Fish tissue sample costs for toxics are roughly the same as for sediment samples.

Expanded biological monitoring is another area of interest to the Department. The Department has devoted extra funding to this effort and anticipates doing so in the future.

The Department will implement a long term effort to measure and assess contaminant levels in sediments at or near STORET stations throughout the waters of the State. High resolution samples for organics and metals are estimated to be in the \$2000 to \$2500 per sample range.

Wetlands Assessment methodologies are under development as noted in the attached documents. Additional funding will be used to expedite and implement that effort.