Conrad Conero, Braden Brook, Greenfield Park, NY

Introduction

The *National Water Quality Inventory Report to Congress* is the primary vehicle for informing Congress and the public about the quality of water in our nation's rivers, streams, lakes, ponds, reservoirs, wetlands, estuaries, and coastal waters. This document characterizes waters by their capacity to meet water quality standards established by states, territories, and tribes. The Clean Water Act grants states the authority and responsibility for establishing water quality standards and sets a national goal that all waters will, at a minimum, achieve the basic goals of supporting healthy aquatic communities and allowing swimming and other recreational activities.

Section 305(b) of the Clean Water Act requires states and other jurisdictions to assess the health of their waters and the extent to which their waters support water quality standards, including the basic goals of the Clean Water Act. In addition, Section 305(b) requires states to identify the contribution of nonpoint sources to water quality impairment. It also calls for an analysis of the social and economic costs and benefits of achieving the goals of the Clean Water Act. Section 305(b) specifies that states submit reports describing water quality conditions to the U.S. Environmental Protection Agency (EPA) every 2 years. Section 305(b) also requires that EPA summarize the reports submitted by the states and other jurisdictions and convey the information to Congress biennially. This report, the twelfth in a series published since 1975, satisfies the reporting requirements in Section 305(b) of the Clean Water Act.

This report is organized into two major sections. Part I presents the national assessment. The information reported by the 50 states and the District of Columbia, 5 territories, 4 interstate commissions, and 9 tribes is compiled for each type of waterbody and presented in Chapters 3 through 7 of this report. These national summaries identify the portions of waters that were assessed and, of those assessed, the portions found to be supporting the water quality standards and the portions that are impaired. Each chapter also describes the most widespread causes and sources of water quality problems emerging from the information reported. The final chapter in Part I addresses the costs and benefits of achieving the goals of the Clean Water Act.

Part II includes two-page fact sheets that summarize the information reported by each jurisdiction. The first chapter in Part II summarizes recommendations provided by states on improving water resource management and the assessment process. The full report submitted by a jurisdiction is available from the point of contact named on its fact sheet.

This report is a compilation of information submitted in individual

The Clean Water Act of 1972

. . . it is the national goal that, wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water . . .

1998 water quality inventories by states, territories, interstate commissions, tribes, and the District of Columbia. The water quality information contained in this report reflects their efforts to assess their waters against their water quality standards. It is important to note that the states, tribes, and other jurisdictions do not use identical methods to rate their water quality nor are their water quality standards identical.

States exercise flexibility provided in the Clean Water Act and in EPA regulations when they establish water quality standards and assess attainment of those standards. This flexibility is important because there are natural variations among waters across the United States. Variations in location determine the type of fish communities that waters support. Variations in geology influence the natural chemistry of the water, which, in turn, influences the toxicity and bioavailability of pollutants entering the water from human activities.

There is a trade-off between flexibility and consistency. Without consistent monitoring and assessment methods in place, EPA and states cannot compare data over time to identify trends in water quality. For example, states and other jurisdictions may modify their standards or assess different waterbodies from one reporting period to the next. Similarly, it is difficult to compare data from one state to another because they may use different indicators to assess attainment of water quality standards and are quite likely to have different standards.

For more than 10 years, EPA has been working with states to pursue a balance between flexibility and consistency in the Section 305(b) assessment process. The most recent development in this process was the publication in September 1997 of the revised *Guidelines for Preparation of Comprehensive Water Quality Reports*. These guidelines reflect the recommendations of the National 305(b) Consistency Workgroup, which is made up of states, other jurisdictions, and EPA. This 1998 Report to Congress is the first report since the new guidelines were published. The workgroup intends that these guidelines will be in effect for both the 1998 and 2000 reporting cycles. A few key elements of the revised guidelines are

- Comprehensive assessments of all waters and all applicable standards
- Electronic reporting of water quality assessment data
- Georeferencing assessed waters so that both healthy and impaired waters can be located on a map
- Documenting the quality of data used to support assessments.

EPA and the states recognize the need to continue to improve the water quality assessments reported under Section 305(b). Increasingly, these assessments are used to identify and prioritize water quality problems within states. For example, Section 303(d) of the Clean Water Act calls for each state to develop a list of impaired and threatened waters. These are waters that do not or are not expected to meet water quality standards after implementation of water pollution controls. The Section 305(b) assessments are the primary tool for identifying these waters and the pollutants contributing to impairment.

After preparing 303(d) lists, states develop total maximum daily loads (TMDLs). A TMDL is the amount of a pollutant the waterbody can accept and still meet water quality standards. The difference between the TMDL and the current load to the waterbody is the amount of pollutant that must be reduced by pollutant sources (both point source discharges and nonpoint source runoff).

Unified Watershed Assessments also rely heavily on the state 305(b) assessments. In an effort to promote holistic, watershed-based problem solving, the Clean Water Action Plan called for states to work with local and federal partners and identify watersheds most in need of restoration or protection. In addition to 305(b) assessments and 303(d) lists, states use information on wildlife and fisheries, forestry, agriculture, and land use in defining priorities for watershed restoration.

The Index of Watershed Indicators (IWI) is another tool that uses the 305(b) assessment results. In the past, IWI was a discrete tool used to look at national watershed health. It is evolving toward a set of data layers that includes 305(b) assessment results, the 303(d) lists of impaired waters, and other national and local information.

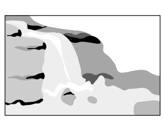
EPA and state water programs are currently working on sequencing water quality monitoring to determine water quality standards (WQS) attainment/nonattainment so that it better supports the full range of water quality management activities. The sequence of activities consists of

- Characterizing waters for the 305(b) assessment
- Using the subset of waters identified as not supporting WQS to develop 303(d) lists
- Identifying source contributions
- Developing TMDLs
- Implementing source controls
- Performing followup monitoring to evaluate the effectiveness of source controls and to track trends in water quality improvements.

Waters of the United States

Integrated water quality management begins with a basic understanding of how water moves through the environment, comes into contact with pollutants, and transports and deposits pollutants. The water cycle depicted on page 6 illustrates the general links between the atmosphere, soil, surface waters, ground waters, and plants.

The United States has diverse water resources. The major types of water resources assessed by states and covered in this report are described below.



Rivers and Streams

Rivers and streams are characterized by flow. **Perennial** rivers and streams flow continuously, all year round. **Intermittent** or ephemeral (nonperennial) rivers and streams stop flowing for some

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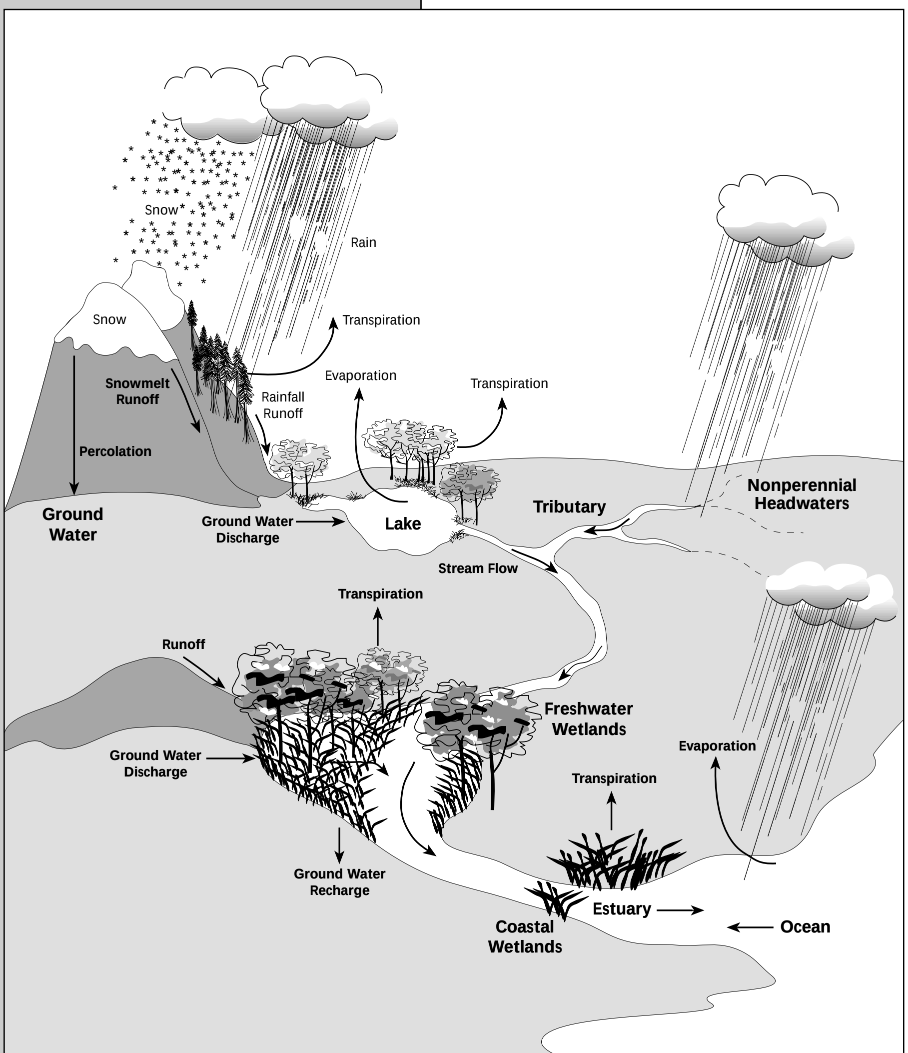
The Water Cycle

The water cycle describes how water moves through the environment and identifies the links between ground water, surface water, and the atmosphere (see figure). For convenience, discussions of the water cycle usually begin and end in the atmosphere. Water in the atmosphere condenses and falls onto the earth in the form of rain or snow. The rain or snow can contain contaminants from air pollution. The rain and snow may fall directly onto surface waters, be intercepted by plants or structures, or fall onto the ground. Intercepted water evaporates directly back into the atmosphere or drips onto the ground.



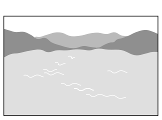
On the ground, rainfall and melting snow percolate deeper into the ground, saturating the soil and recharging ground water aquifers. Trees and other plants take up water in the upper soil zone through their roots and return the water to the atmosphere in a process called transpiration. Ground water below the root zone may migrate many miles and emerge (or discharge) into a distant surface water.

When rainfall or melting snow saturates soils, water runs off the ground into surface waterbodies (such as lakes, streams, wetlands, and coastal waters). Runoff may dislodge soil particles and pollutants and carry them into surface waterbodies. Surface waters may evaporate back into the atmosphere, percolate into the underlying ground water, or flow into other surface waters until reaching the ocean. From the ocean, water evaporates back into the atmosphere, completing the cycle.

period of time, usually due to dry conditions or upstream withdrawals. Many rivers and streams originate in nonperennial headwaters that flow only during snowmelt or heavy rains. Nonperennial streams provide critical habitats for nonfish species, such as amphibians and dragonflies, as well as safe havens for juvenile fish escaping predation by larger fish.

Nonperennial waters pose challenges to monitoring programs because their flow is unpredictable. Some intermittent waters' flow recurs predictably during particular times of the year, for example, following spring snowmelt. Ephemeral waters are almost impossible to monitor because their flow is so unpredictable. Most states focus monitoring activities in perennial waters, although many states monitor intermittent waters during periods of predictable flow.

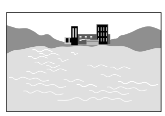
The health of rivers and streams is directly linked to the integrity of habitat along the river corridor and in adjacent wetlands. Stream quality will deteriorate if activities damage vegetation along river banks and in nearby wetlands. Trees, shrubs, and grasses filter pollutants from runoff and reduce soil erosion. Removal of vegetation also eliminates shade that moderates stream temperature. Stream temperature, in turn, affects the availability of dissolved oxygen in the water column for fish and other aquatic organisms.



Lakes, Reservoirs, and Ponds

Lakes, reservoirs, and ponds are depressions that hold water for extended periods of time. These waterbodies may receive water carrying pollutants from rivers and streams, melting snow, runoff, or ground water. Lakes may also receive pollution directly from the air.

Pollutants become trapped in lakes, reservoirs, and ponds because water exits these waterbodies at a slow rate. Therefore, they are especially vulnerable to additional inputs of pollutants from human activities. Even under natural conditions, sediment, nutrients, and organic materials accumulate in lakes and ponds as part of a natural aging process called eutrophication. Increased loads of nutrients from human activities such as wastewater discharges, septic systems, and agricultural runoff can overload lake systems and accelerate eutrophication. Algae blooms, depressed oxygen levels, and aquatic weeds are symptoms of accelerated eutrophication from excessive nutrients.



The Great Lakes

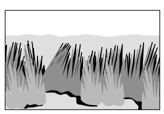
The Great Lakes—Superior, Michigan, Huron, Erie, and Ontario—are the largest system of fresh surface water on earth, by area. They contain approximately 18% of the world's fresh water supply. The Great Lakes basin is currently home to one-tenth of the population in the United States and one-quarter of the population of Canada.

Despite their large size, the Great Lakes are sensitive to the effects of a broad range of contaminants that enter the Lakes from polluted air, ground water, surface water, wastewater discharges,

Both the commercial fishing industry and recreational anglers rely on healthy estuaries to provide habitat for developing fish and shellfish.

and overland runoff. Even dilute quantities of toxic chemicals can have adverse effects on water quality because many toxic chemicals persist in the environment and concentrate in organisms, including fish.

Scientists estimate that atmospheric deposition contributes 35% to 50% of a variety of chemicals entering the Great Lakes each year. Atmospheric deposition occurs in two forms, wet or dry. In wet deposition, precipitation events (such as rain or snow) remove pollutants from the atmosphere. Dry deposition occurs when particles settle out of the air directly on a lake surface or within the extensive land basin draining into a lake. It is difficult to manage atmospheric sources of pollutants entering the Great Lakes because these pollutants may originate in the Great Lakes basin or hundreds of miles away.

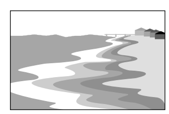


Estuaries

The fresh water of rivers mixes with the salty ocean water in estuaries. Estuarine waters include bays and the tidal portions of rivers. Estuaries serve as nursery areas for many commercial fish and most shellfish populations, including shrimp, oysters, crabs, and scallops. Most of our nation's fish and shellfish industry relies on productive estuarine waters and their adjacent wetlands to provide healthy habitat for some stage of fish and shellfish development. Recreational anglers also enjoy harvesting fish that reproduce or feed in estuaries, such as striped bass and flounder.

Pollutants from both local and distant sources tend to accumulate in estuaries. Most pollutants that enter rivers flow toward the coast. As rivers approach the coast, their mouths broaden and currents slow. The low flow and fluctuating tides, typical of estuarine waters, reduce flushing and trap nutrients and pollutants. This natural trapping process lays the foundation for rich estuarine ecosystems but also makes estuaries vulnerable to overloading of nutrients and pollutants.

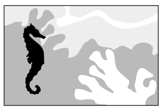
Historic development patterns have amplified this natural process in estuaries and along all our coasts. Historically, industrial development and population centers have clustered around estuarine bays that provided access to shipping and an adjacent waterbody for waste disposal. Now, many coastal cities must address historic contaminated sediments and develop alternative disposal systems for their outdated combined sewer systems.



Ocean Shoreline Waters

Our ocean shoreline waters provide critical habitat for various life stages of commercial fish and shellfish (such as shrimp), provide habitat for endangered species (such as sea turtles), and support popular recreational activities, including sport fishing and swimming.

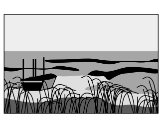
Despite their vast size and volume, oceans are vulnerable to impacts from pollutants, especially in nearshore waters that receive inputs from adjoining surface waters, ground water, wastewater discharges, and nonpoint source runoff. Beach closures due to elevated bacterial concentrations are one of the most visible symptoms of water quality degradation in ocean shoreline waters resulting from activities onshore. Wastes disposed of offshore may also impact nearshore waters. Oil spills from tankers or offshore extraction facilities can generate persistent adverse impacts on ocean shoreline waters.



Coral Reefs

Coral reefs are among the most productive ecosystems in the ocean. These living ecosystems are inhabited by a wide variety of fish, invertebrate, and plant species. They also provide important economic opportunities, primarily in terms of fishing and tourism. Coral reefs are found in three states—Hawaii, Florida, and Texas—and five U.S. territories—American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the U.S. Virgin Islands.

Recent evidence indicates that coral reefs are deteriorating worldwide. To prevent further deterioration of coral ecosystems, President Clinton signed Executive Order 13089 on Coral Reef Protection. This order created the U.S. Coral Reef Task Force made up of representatives from the three states and five territories with coral resources. In response, these areas have initiated or increased efforts to identify the causes of coral reef degradation and approaches to prevent further loss.

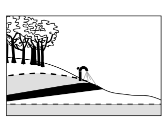


Wetlands

In general, wetlands are a transition zone between land and water where the soil is occasionally or permanently saturated with water. Wetlands are populated by plants that are specially adapted to grow in standing water or saturated soils. There are many different types of wetlands, including marshes, bogs, fens, swamps, mangroves, prairie potholes, and bottomland hardwood forests. Wetlands may not always appear to be wet. Many wetlands dry out for extended periods of time. Other wetlands may appear dry on the surface but may be saturated underneath.

Saltwater wetlands fringe estuaries; freshwater wetlands border rivers, lakes, and the Great Lakes or occur in isolation. In general, wetlands improve water quality, provide critical habitat for a wide variety of fish and wildlife, provide storage for flood waters, and stabilize shorelines. Wetlands filter sediment and nutrients (from both natural and nonnatural sources) out of the water before they enter adjacent waterbodies and underlying ground water aquifers. Wetlands also provide storage for floodwaters and reduce the velocity of overland runoff. Reduced velocity translates into less damage from flood waters.

Wetlands can be physically destroyed by filling, draining, and dewatering, or wetlands can be damaged by the same pollutants that degrade other waterbodies, such as toxic chemicals and oxygen-demanding substances.



Ground Water

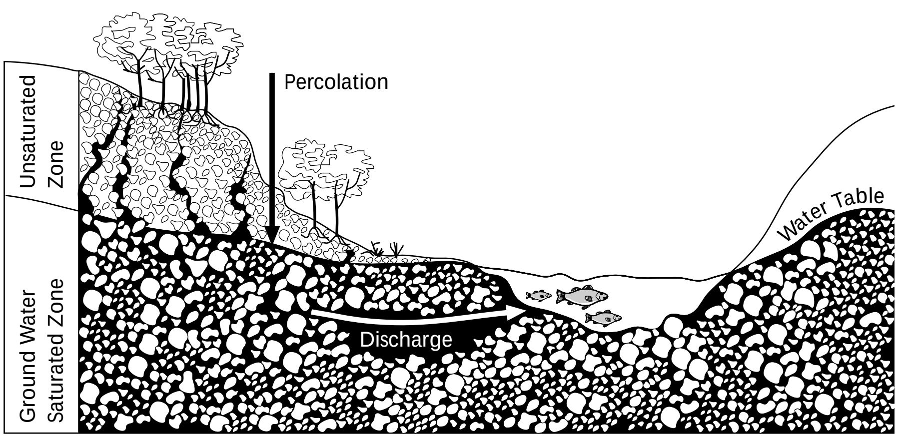
Beneath the land's surface, water resides in two general zones, the saturated zone and the unsaturated zone (Figure 1-1). The unsaturated zone lies directly beneath the land surface, where air and water fill in the pore spaces between soil and rock particles. Water saturates the pore spaces in the saturated zone beneath the unsaturated zone in most cases. The term "ground water" applies to water in the saturated zone. This water is an important natural resource and is used for myriad purposes, including drinking water, irrigation, and livestock uses.

Surface water replenishes (or recharges) ground water by percolating through the unsaturated zone. Therefore, the unsaturated zone plays an important role in ground water hydrology and may act as a pathway for ground water contamination.

Ground water can move laterally and emerge at discharge sites, such as springs on hillsides or seeps in the bottoms of streams, lakes, wetlands, and oceans. Therefore, ground water affects surface water quantity and quality because polluted ground water can contaminate surface waters. Conversely, some surface waters, such as wetlands, contain flood waters and replenish ground waters. Loss of wetlands reduces ground water recharge.

Figure 1-1

Ground Water



Water Quality Standards

In 1972, Congress adopted the Clean Water Act (CWA), which establishes a framework for achieving its national objective ". . . to restore and maintain the chemical, physical, and biological integrity of the nation's waters." Congress decreed that, where attainable, water quality ". . . provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water." These goals are referred to as the "fishable and swimmable" goals of the Act.

The Act required states, tribes, and other jurisdictions to develop water quality standards to guide the restoration and protection of all waters of the United States. EPA regulations require that, wherever attainable, they include, at a minimum, the fishable and swimmable goals of the Act. States must submit their standards to EPA for approval. Once approved, water quality standards are the benchmark against which monitoring data are compared to assess the health of waters under Section 305(b), to list impaired waters under Section 303(d), and to develop Total Maximum Daily Loads in impaired waters. They are also used to calculate water-quality-based discharge limits in permits issued under the National Pollutant Discharge Elimination System (NPDES).

Water quality standards have three elements: designated uses, criteria developed to protect each use, and an antidegradation policy.

■ State **designated uses** are the beneficial uses that water quality should support. Where attainable, all waters should support drinking water supply, recreation (such as swimming and surfing), aquatic life, and fish consumption. Additional important uses include agriculture, industry, and navigation. Waste transport or disposal is not an acceptable designated use. Each designated use has a unique set of water quality criteria that must be met for the use to be realized. States, tribes, and other jurisdictions may designate an individual waterbody for multiple uses.

■ State **water quality criteria** come in two forms, numeric criteria and narrative criteria.

Numeric criteria include aquatic life criteria, human health criteria, biological criteria, and sediment quality guidelines. They establish thresholds for the physical conditions, chemical concentrations, and biological attributes required to support a beneficial use.

Narrative criteria define, rather than quantify, conditions that must be maintained to support a designated use. For example, a narrative criterion might be "Waters must be free of substances that are toxic to humans, aquatic life, and wildlife."

Narrative biological criteria address the expected characteristics of aquatic communities within a waterbody. For example, "Ambient water quality shall be sufficient to support life stages of all indigenous aquatic species."

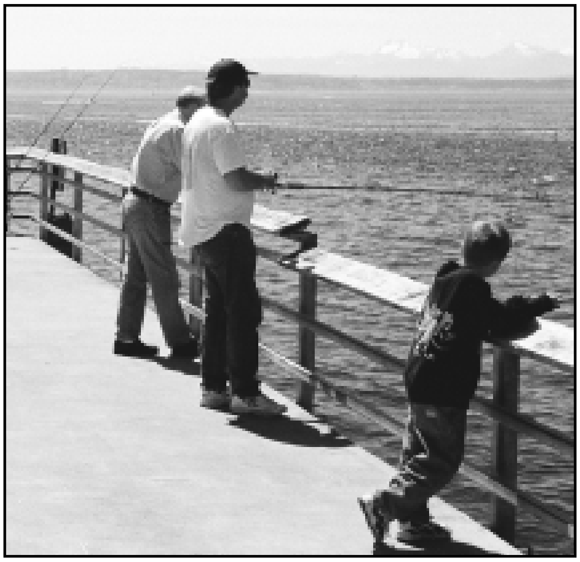
■ **Antidegradation policies** are intended to protect existing uses and prevent waterbodies from deteriorating even if their water quality is better than the fishable and swimmable goals of the Act.

Water Quality Assessment

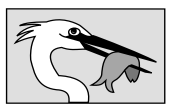
Section 305(b) of the CWA requires that states evaluate the extent to which their state waters meet water quality standards and achieve the fishable and swimmable goals of the Act. This section calls for states to report the results to EPA every 2 years. The states,

Water quality standards consist of

- *Designated beneficial uses*
- *Numeric and narrative criteria for biological, chemical, and physical parameters*
- *Antidegradation policy*

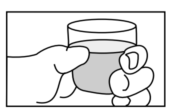

John Theilgard, Puget Sound, WA

participating tribes, and other jurisdictions measure attainment of the CWA goals by determining how well their waters support their designated beneficial uses. They determine designated use support by comparing water quality data to the narrative and numeric criteria developed to ensure use support. States, tribes, and other jurisdictions assess waterbodies for support of the individual uses designated for a particular waterbody, which generally include the following individual uses:



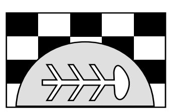
Aquatic Life Support

The waterbody provides suitable habitat for protection and propagation of desirable fish, shellfish, and other aquatic organisms.



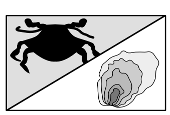
Drinking Water Supply

The waterbody can supply safe drinking water with conventional treatment.



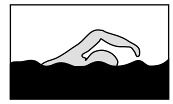
Fish Consumption

The waterbody supports fish free from contamination that could pose a human health risk to consumers.



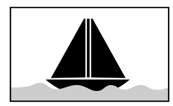
Shellfish Harvesting

The waterbody supports a population of shellfish free from toxicants and pathogens that could pose a human health risk to consumers.



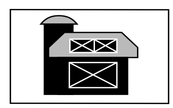
Primary Contact Recreation – Swimming

People can swim in the waterbody without risk of adverse human health effects (such as catching waterborne diseases from raw sewage contamination).



Secondary Contact Recreation

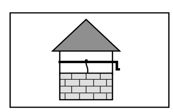
People can perform activities on the water (such as boating) without risk of adverse human health effects from ingestion or contact with the water.



Agriculture

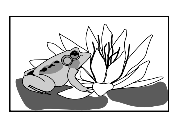
The water quality is suitable for irrigating fields or watering livestock.

States, tribes, and other jurisdictions may also define their own individual uses to address special concerns. For example, many tribes and states designate their waters for the following additional uses:



Ground Water Recharge

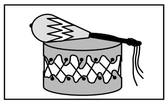
The surface waterbody plays a significant role in replenishing ground water, and surface water supply and quality are adequate to protect existing or potential uses of ground water.



Wildlife Habitat

Water quality supports the waterbody's role in providing habitat and resources for land-based wildlife as well as aquatic life.

Tribes may designate their waters for special cultural and ceremonial uses.



Culture

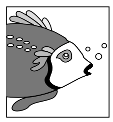
Water quality supports the waterbody's role in tribal culture and preserves the waterbody's religious, ceremonial, or subsistence significance.

States, tribes, and other jurisdictions determine the level of use support by comparing monitoring data with the narrative and numeric water quality criteria adopted to ensure support of each use designated for a particular waterbody. If monitoring data are not available, the state, tribe, or other jurisdiction may determine the level of use support with qualitative information. Valid qualitative information includes land use data, fish and game surveys, and predictive model results.

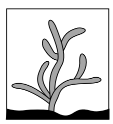
States identify the type of data, monitored or evaluated, that they used to make each use support determination. **Monitored assessments** are based on recent monitoring data collected during the past 5 years. These data include ambient water chemistry, biological assessments, fish tissue contaminant levels, and sediment chemistry. **Evaluated assessments** are based on qualitative information or monitored information more than 5 years old.

Summary of Use Support

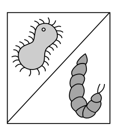
For waterbodies with more than one designated use, the states, tribes, and other jurisdictions consolidate the individual use support information into a summary use support determination:



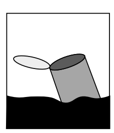
Good/Fully Supporting All Uses – Based on an assessment of available data, water quality supports all designated uses. Water quality meets narrative and/or numeric criteria adopted to protect and support a designated use.



Good/Threatened for One or More Uses – Although all the assessed uses are currently met, data show a declining trend in water quality. Projections based on this trend indicate water quality will be impaired in the future, unless action is taken to prevent further degradation.



Impaired for One or More Uses – Based on an assessment of available data, water quality does not support one or more designated uses.



Use Not Attainable – The state, tribe, or other jurisdiction performed a use-attainability analysis and demonstrated that one or more designated uses are not attainable due to one of six conditions specified in the *Code of Federal*

Regulations (40 CFR 131.10). These conditions include

- Naturally high concentrations of pollutants
- Other natural physical features that create unsuitable aquatic life habitat (such as inadequate substrate, riffles, or pools)
- Low flows or water levels
- Dams and other hydrologic modifications that permanently alter waterbody characteristics
- Poor water quality resulting from human activities that cannot be reversed without causing further environmental degradation
- Poor water quality that cannot be improved without imposing more stringent controls than those required in the CWA that would result in widespread economic and social impacts.

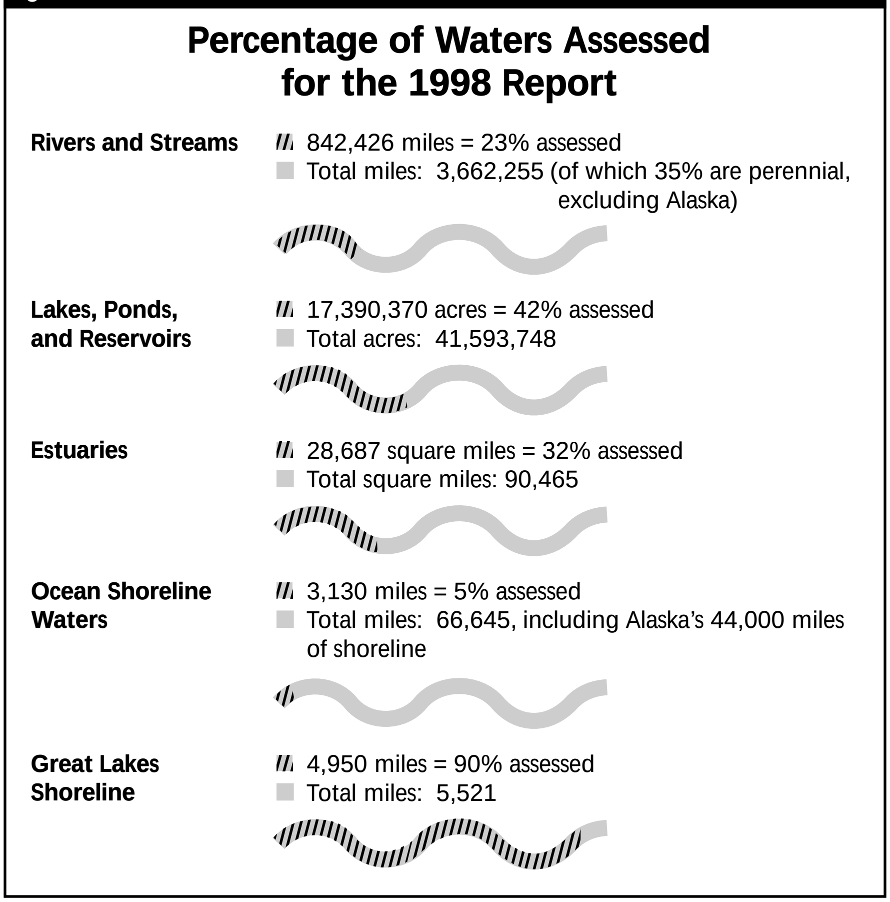
Waters Assessed for the 1998 Report

This report does not describe the health of all waters of the United States. Chapters 3 through 7 summarize the health of only the portion of waters that states reported on in their individual 1998 water quality inventories. Figure 1-2 compares the amount of waters assessed for the 1998 report to the total amount of waters in the United States.

Most states do not assess all of their waterbodies during the 2-year reporting cycle required under CWA Section 305(b). However, following the recommendations of the 305(b) Consistency Workgroup, many states are employing techniques to enable them to characterize all of their waters. The approach used by most states is a rotating basin approach. Some states are using statistically based sample designs.

Under the rotating basin approach, states achieve comprehensive monitoring of all waters over a set period of time (typically 5 years). In each year the state

Figure 1-2



Source: 1998 Section 305(b) reports submitted by the states, tribes, territories, and commissions.

monitors a portion (typically one-fifth) of the watersheds within the state. This approach enables states to integrate their monitoring activities with other regulatory activities such as permit issuance.

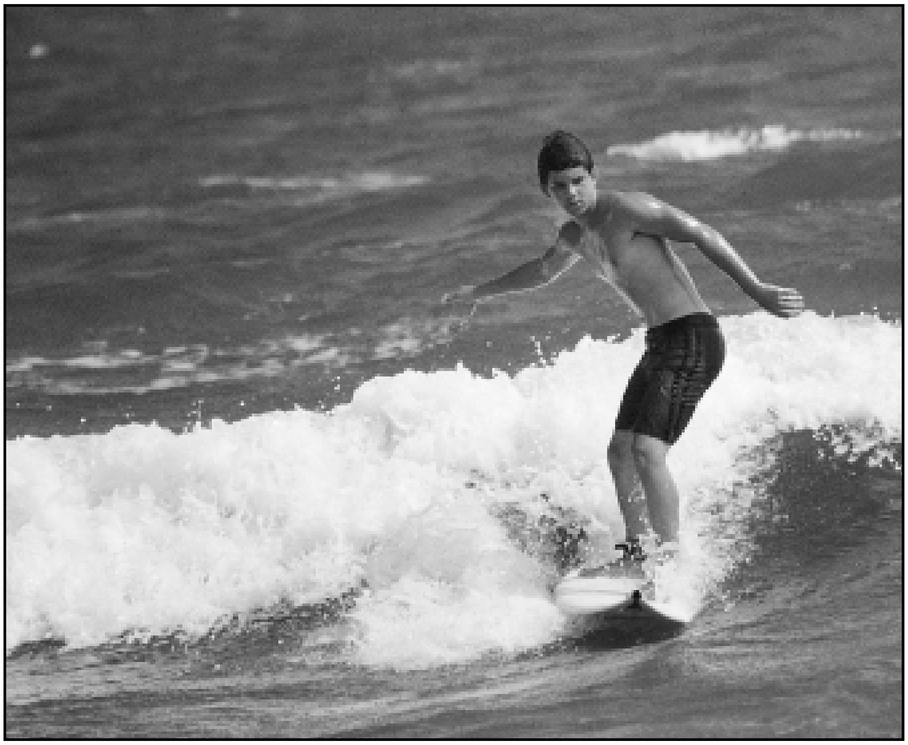
A statistically based approach uses random sampling designed so that data collected at a relatively small number of sample locations can be extrapolated to characterize all waters of the state. An advantage of this approach is that it allows states to characterize statewide water quality each year. A random sample design also reduces the potential for bias in the selection of sample locations.

Some states' monitoring programs combine both of these approaches. They apply a random sampling design within each watershed under a rotating basin monitoring schedule. This allows them to both improve the statistical confidence of sampling results and integrate their monitoring program with other regulatory activities.

Because states employ different monitoring designs and because they have not achieved comprehensive assessment of water quality, the summary information in this report is not intended to predict the health of waters that have not been assessed. Rather this report presents a description of the waters that states have assessed. It identifies which of the assessed waters appear healthy and which are impaired. For those waters characterized as impaired, states provided information on the causes and sources of impairment.

Pollutants That Impair Water Quality and Their Sources

Where possible, states, tribes, and other jurisdictions identify the pollutants causing water quality impairments and the sources of those pollutants. Causes of impairment are pollutants or stressors that prevent water quality from meeting numeric or narrative criteria adopted by states to protect designated uses. Causes of impairment include chemical contaminants (such as PCBs, dioxins, and metals), physical parameters (such as temperature), and biological parameters (such as aquatic weeds). The leading causes of impairment reported by the



Karen Lauterbach, Bald Head Island, NC

states, tribes, and other jurisdictions in 1998 are described in the highlight beginning on page 18.

Sources of impairment generate the pollutants that cause water quality impairment (Table 1-1). Point sources discharge pollutants directly into surface waters from a conveyance. Point sources include industrial facilities, municipal sewage treatment plants, combined sewer overflows, and storm sewers. Nonpoint sources deliver pollutants to surface waters from diffuse origins. Nonpoint sources include urban runoff that is not captured in a storm sewer, agricultural runoff, leaking septic tanks, and deposition of contaminants in the atmosphere due to air pollution. Habitat alterations, such as hydromodification, dredging, and streambank destabilization, can also degrade water quality.

In Chapters 3 through 7, EPA tallies the significance of causes and sources of pollution by the percentage of assessed waters impaired by each individual cause or source (obtained from the Section 305(b) reports submitted by the states, tribes, and other jurisdictions). It is important to remember that this tally reflects the condition of the subset of waters that were assessed and identified as impaired. It does not address the condition of the waters that were not assessed.

Table 1-1. Pollution Source Categories Used in This Report

Category	Examples
Industrial	Pulp and paper mills, chemical manufacturers, steel plants, metal process and product manufacturers, textile manufacturers, food processing plants
Municipal	Publicly owned sewage treatment plants that may receive indirect discharges from industrial facilities or businesses
Combined Sewer Overflows	Single facilities that treat both storm water and sanitary sewage, which may become overloaded during storm events and discharge untreated wastes into surface waters
Storm Sewers/ Urban Runoff	Runoff from impervious surfaces including streets, parking lots, buildings, and other paved areas
Agricultural	Crop production, pastures, rangeland, feedlots, animal operations
Silvicultural	Forest management, tree harvesting, logging road construction
Construction	Land development, road construction
Resource Extraction	Mining, petroleum drilling, runoff from mine tailing sites
Land Disposal	Leachate or discharge from septic tanks, landfills, and hazardous waste sites
Hydrologic Modification	Channelization, dredging, dam construction, flow regulation
Habitat Modification	Removal of riparian vegetation, streambank modification, drainage/ filling of wetlands

In the West

In the West, water flows uphill
Leaping across the Tehachapi Mountains
To fill the mouth of the City of Angels.

In the West, the streams serve us
Captured and prisoned, in tunnels, in siphons and aqueducts
Bleeding into our irrigated lands.

In the West, once the rivers' voices
Coaxed the salmon, surging thick against the current
Lured the antelope and bison herds to their banks.
Now there is silence.

In the West, the rivers are the Disappeared
Their bones buried in a common grave
We forget their names
And call the land "Desolation"

River of Words 1998 Grand Prize Winner (Poetry, Grades 7-9)
Todd Detter, Grade 9, AZ

River of Words 1999 Grand Prize Winner (Art, Grades K-2)
Ella Katherine Darham, *Raging River*, MT

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Pollutants and Stressors That Impair Water Quality

This highlight describes individual pollutants and stressors separately. In reality, water quality usually suffers from the combined effects of several pollutants and processes. EPA encourages water quality managers and the public to use a holistic approach to managing our integrated water quality problems.

Oxygen-Depleting Substances

Dissolved oxygen is a basic requirement for a healthy aquatic ecosystem. Most fish and beneficial aquatic insects “breathe” oxygen dissolved in the water column. Some fish and aquatic organisms (such as carp and sludge worms) are adapted to low-oxygen conditions, but most desirable fish species (such as trout and salmon) suffer if dissolved oxygen concentrations fall below 3 to 4 mg/L (3 to 4 milligrams of oxygen dissolved in 1 liter of water, or 3 to 4 parts of oxygen per million parts of water). Larvae and juvenile fish are more sensitive and require even higher concentrations of dissolved oxygen, ranging from 5 to 8 mg/L.

Many fish and other aquatic organisms can recover from short periods of low dissolved oxygen availability. However, prolonged episodes of depressed dissolved oxygen concentrations of 2 mg/L or less can result in “dead” waterbodies. Prolonged exposure to low dissolved oxygen conditions can suffocate adult fish or reduce their reproductive survival by suffocating sensitive eggs and larvae or can starve fish by killing aquatic insect larvae and other prey. Low dissolved oxygen concentrations also favor anaerobic bacterial activity that produces noxious gases or foul odors often associated with polluted waterbodies.

Oxygen concentrations in the water column fluctuate under natural conditions, but severe oxygen depletion usually results from human activities that introduce large quantities of biodegradable organic materials into surface waters. Biodegradable organic materials contain plant, fish, or animal matter. Leaves, lawn clippings, sewage, manure, shellfish processing waste, milk solids, and other food processing wastes are types of biodegradable organic materials that enter our surface waters.

In both pristine and polluted waters, beneficial bacteria use oxygen to break apart (or decompose) organic materials. Pollution-containing organic wastes provide a continuous food supply for the bacteria, which accelerates bacterial activity and population growth. In polluted waters, bacterial consumption of oxygen can rapidly outpace oxygen replenishment from the atmosphere and photosynthesis performed by algae and aquatic plants. The result is a net decline in oxygen concentrations in the water.

Often, water quality managers measure the biochemical oxygen demand (or BOD) of pollution or natural organic materials in water. BOD is a measure of how much oxygen is consumed during the degradation of organic matter and the oxidation of some inorganic matter. Toxic pollutants can indirectly elevate BOD by killing algae, aquatic weeds, or fish, which provides an abundance of food for oxygen-consuming bacteria. Oxygen depletion can also result from chemical reactions that do not involve bacteria. Some pollutants trigger chemical reactions that place a chemical oxygen demand on receiving waters.

Other factors, such as temperature and salinity, influence the amount of oxygen dissolved in water. Prolonged hot weather will depress oxygen concentrations and may cause fish kills even in clean waters because warm water cannot hold as much oxygen as cold water. Warm conditions further aggravate oxygen depletion by stimulating bacterial activity and respiration in fish, which consumes oxygen. Removal of streamside vegetation eliminates shade, thereby raising water temperatures, and accelerates runoff of organic debris. Under such conditions, minor additions of pollution-containing organic materials can severely deplete oxygen.

Nutrients

Nutrients are essential building blocks for healthy aquatic communities, but excess nutrients (especially nitrogen and phosphorus compounds) overstimulate the growth of aquatic weeds and algae. Excessive growth of these organisms, in turn, can clog navigable waters, interfere with swimming and boating, outcompete native submerged aquatic vegetation (SAV), and, with excessive decomposition, lead to oxygen depletion. Oxygen concentrations can fluctuate daily during algae blooms, rising during the day as algae perform photosynthesis and falling at night as algae continue to respire, which consumes oxygen. Beneficial bacteria also consume oxygen as they decompose the abundant organic food supply in dying algae cells.

Lawn and crop fertilizers, sewage, manure, and detergents contain nitrogen and phosphorus, the nutrients most often responsible for water quality degradation. Rural areas are vulnerable to ground water contamination from nitrates (a compound containing nitrogen) found in fertilizer and manure. Very high concentrations of nitrate

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(>10 mg/L) in drinking water cause methemoglobinemia, or blue baby syndrome, an inability to fix oxygen in the blood.

Nutrients are difficult to control because lake and estuarine ecosystems recycle nutrients. Rather than leaving the ecosystem, the nutrients cycle among the water column, algae and plant tissues, and the bottom sediments. For example, algae may temporarily remove all the nitrogen from the water column, but the nutrients will return to the water column when the algae die and are decomposed by bacteria. Therefore, gradual inputs of nutrients tend to accumulate over time rather than leave the system.

Sedimentation and Siltation

In a water quality context, sediment usually refers to soil particles that enter the water column from eroding land. Sediment consists of particles of all sizes, including fine clay particles, silt, sand, and gravel. Water quality managers use the term "siltation" to describe the suspension and deposition of small sediment particles in waterbodies.

Sedimentation and siltation can severely alter aquatic communities. Sedimentation may clog and abrade fish gills, suffocate eggs and aquatic insect larvae on the bottom, and fill in the pore space between bottom cobbles where fish lay eggs. Suspended silt and sediment interfere with recreational activities and aesthetic enjoyment at waterbodies by reducing water clarity and filling in waterbodies. Sediment may also carry other pollutants into waterbodies. Nutrients and toxic chemicals may attach to sediment particles on land and ride the particles into surface waters where the pollutants may settle with the sediment or detach and become soluble in the water column.

Rain washes silt and other soil particles off of plowed fields, construction sites, logging sites, urban areas, and strip-mined lands into waterbodies. Eroding streambanks also deposit silt and sediment in waterbodies. Removal of vegetation on shore can accelerate streambank erosion.

Bacteria and Pathogens

Some waterborne bacteria, viruses, and protozoa cause human illnesses that range from typhoid and dysentery to minor respiratory and skin diseases. These organisms may enter waters through a number of routes, including inadequately treated sewage, storm water drains, septic systems, runoff from livestock pens, and sewage dumped overboard from recreational boats. Because it is impossible to test waters for every possible disease-causing organism, states and other jurisdictions usually measure indicator bacteria that are found in great numbers in the stomachs and intestines of warm-blooded animals and people. The presence of indicator bacteria suggests that the waterbody may be contaminated with untreated sewage and that other, more dangerous, organisms may be present. The states, tribes, and other jurisdictions use bacterial criteria to determine if waters are safe for recreation and shellfish harvesting.

Toxic Organic Chemicals and Metals

Toxic organic chemicals are synthetic compounds that contain carbon, such as PCBs, dioxins, and DDT. These synthesized compounds often persist and accumulate in the environment because they do not readily break down in natural ecosystems. Many of these compounds cause cancer in people and birth defects in other predators near the top of the food chain, such as birds and fish.

Pesticides are chemicals applied to control or eliminate insect, fungal, or other organisms that may seriously reduce the yields of crops or impact the health of livestock. When pesticides run off the land and enter waterbodies, they may become toxic to aquatic life. Some newer pesticide agents decompose rapidly after application; however, many older types are more persistent. These longer-lived agents can pollute larger areas and many forms (e.g., DDT or chlordane) can build up in sediments or bioaccumulate in food chains, posing potential health risks to wildlife or humans.

"Total toxics" is a term used by a number of states to describe various combinations of toxic pollutants identified in waterbodies. These may include pesticides, toxic organic chemicals, metals, un-ionized ammonia, and chlorine. In some instances, laboratory tests with plankton, minnows, or other target species may show the presence of toxicity, but more work may be required to identify the specific toxicants. These impacts from unknown toxicity may also be summarized under the concept of total toxics.

Metals occur naturally in the environment, but human activities (such as industrial processes and mining) have altered the distribution of metals in the environment. In most reported cases of metals contamination, high concentrations of metals appear in fish tissues rather than the water column because the metals accumulate in greater concentrations in predators near the top of the food chain.

pH

Acidity, the concentration of hydrogen ions, drives many chemical reactions in living organisms. The standard measure of acidity is pH, and a pH value of 7 represents a neutral condition. A low pH value (less than 5) indicates acidic conditions; a high pH (greater than 9) indicates alkaline conditions. Many biological processes, such as reproduction, cannot function in acidic or alkaline waters. Acidic conditions also aggravate toxic contamination problems because sediments release toxicants in acidic waters. Common sources of acidity include mine drainage, runoff from mine tailings, and atmospheric deposition.

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Habitat Modification/ Hydrologic Modification

Habitat modifications include activities in the landscape, on shore, and in waterbodies that alter the physical structure of aquatic ecosystems and have adverse impacts on aquatic life. Examples of habitat modifications to streams include

- Removal of streamside vegetation that stabilizes the shoreline and provides shade, which moderates in-stream temperatures
- Excavation of cobbles from a stream bed that provide nesting habitat for fish
- Burying streams
- Excessive development sprawl that alters the natural drainage patterns by increasing the intensity, magnitude, and energy of runoff waters.

Hydrologic modifications alter the flow of water. Examples of hydrologic modifications include channelization, dewatering, damming, and dredging.

Suspended Solids and Turbidity

Suspended solids are a measure of the weight of relatively insoluble materials in the ambient water. These materials enter the water column as soil particles from land surfaces or sand, silt, and clay from stream bank erosion or channel scour. Suspended solids can include both organic (detritus and biosolids) and inorganic (sand or finer colloids) constituents. Under low-flow conditions, excessively high suspended solids can become siltation problems as the materials settle out and impact the substrate on rivers or fill in reservoirs or the upper ends of estuaries.

Turbidity is an optical property of very small particles that scatter light and reduce clarity in waterbodies. Although algal blooms can make waters turbid, turbidity is usually related to the smaller inorganic components of the suspended solids burden, primarily the clay particles. In addition to creating aesthetically undesirable conditions, turbidity helps trap heat. This can become a problem in cold water trout streams where fish are adapted to a particular range of temperatures.

Noxious Aquatic Plants

Noxious aquatic plants refers to species of rapidly growing macrophytes (vascular plants as opposed to algae) that may lead to unwanted alterations in the ecological balances of lakes, rivers, or other waterbodies and that can also interfere with human recreational activities. In most cases, the nuisance plants are nonnative introductions such as the Eurasian milfoil or hydrilla.

Oil and Grease

Oil and grease can be documented quantitatively from chemical tests or from qualitative observations of surface films with distinctive oily sheens. Oil and grease problems are usually related to spills or other releases of petroleum products. The most dramatic cases are associated with accidents involving oil tankers (e.g., the Exxon *Valdez*) or major pipeline breaks. Minor oil and grease problems can result from wet weather runoff from highways or the improper disposal in storm drains of motor oil. Large amounts of oil can be toxic to fish and wildlife, but even persistent surface films may decrease reaeration rates and cause damage to the gills or other exposed surface membranes of fishes.

Salinity and Mineralization

Salinity and mineralization are measures of the concentrations of various salts or other minerals dissolved in water. In near-coastal areas, these dissolved materials will include appreciable levels of sodium, which is a natural component of seawater. In estuaries where the natural inputs of fresh water have been reduced from upstream dams or diversions, evaporation may increase the salinity levels to very high levels that can stress fish or shellfish. For inland areas, the concerns commonly focus on such chemicals as dissolved chlorides or sulfates that can lead to high levels of mineralization. Areas with underlying gypsum deposits will often show high levels of mineralization as reflected in tests for total dissolved solids. Some reservoirs and river systems in arid regions may experience increases in mineralization levels that may make the water hard to use for drinking water or even irrigation purposes.

River of Words 1999 Finalist, Lauren D. Beebe, *River of Peace*, Age 11, CA

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Comprehensive Assessments

EPA and the states established a goal of comprehensively characterizing all surface and ground waters of each state using a variety of techniques targeted to the condition of, and goals for, the waters. These techniques may include a combination of targeted monitoring and probability-based designs.

Currently, states report on only a fraction of their waters (see Figure 1-2, page 14). In the past, states focused their monitoring on waters with known problems. This puts healthy waters at risk of deteriorating without anyone knowing. The goal of comprehensive assessments is to be able to characterize all waters of the state in an unbiased manner.

Comprehensive assessment is an evaluation of resources that provides complete spatial coverage of the geographic area or resource being studied. It provides information on the assessment value (condition of the resource), spatial and temporal trends in resource condition, causes/stressors and sources of pollution, and locational information.

Different methods are used by the states to achieve comprehensive monitoring. The two primary monitoring designs employed to achieve comprehensive assessment are probability-based design and targeted design. These designs are implemented on a statewide basis or on selected watersheds under a rotating basin approach, or both.

Several states discussed the use of probability-based monitoring. This involves choosing monitoring sites using statistical techniques that allow the state to infer the results for a specific waterbody type across an entire river basin, an entire ecoregion, or the entire state.

■ Maryland used a probability-based design to assess the biological condition of headwater streams statewide.

■ Arizona developed a probability-based network of ground water wells in order to make statistically valid statements about water quality in each of its aquifers; these aquifers will be sampled on a rotating basis until the entire state is assessed.

■ The western states of EPA Regions 8, 9, and 10 are developing a probability-based sampling design to characterize water quality of all perennial rivers and streams of each state under the Environmental Monitoring and Assessment Project Western Pilot.

Many states are expanding their targeted monitoring designs to be more representative of water quality. Monitoring stations are representative of a stream waterbody for a distance upstream and downstream that has no significant influences that might tend to change water or habitat quality. Examples of such influences include point or nonpoint source inputs, change in land use, or a large tributary or diversion. The targeted monitoring design is commonly used in the rotating basin approach.

About half of the states have implemented, or are in the process of implementing, a rotating basin approach. Under this approach, states intensively monitor a different set of basins each year. Typically, each basin in the state is monitored intensively in 1 out of every 5 years. Thus, the total amount of water monitored over the 5-year period approaches 100%. South Carolina has increased the number of sites monitored over a 5-year period by more than 50% due to the state's conversion to a rotating basin approach.

However, since monitoring resources in most states are relatively static, EPA is encouraging states to incorporate probability-based monitoring into their rotating basin frameworks. This may be the most powerful way for a state to achieve the goal of comprehensive assessments without increasing their monitoring budget. Several states are already implementing this concept. Indiana samples water chemistry, fish and aquatic macroinvertebrates, and fish tissue and sediment contaminant levels at probability-based sites in selected basins each year. South Carolina has also implemented a statewide probability-based network. West Virginia is testing a probability-based design within a rotating basin schedule to provide assessment summaries for all streams as well as for a subpopulation of smaller headwater streams. See the highlight on West Virginia's progress in achieving comprehensive assessments in Chapter 3.

Data sharing and coordination is another tool for increasing the amount of waters assessed. Many states have successfully used citizen volunteer monitoring and anticipate increased emphasis on volunteers in the future. Several other states are redesigning their statewide water quality monitoring programs, sometimes in cooperation with the U.S. Geological Survey and other state and federal agencies. A number of states have formed monitoring councils. They provide a forum for local, state, federal, university, and volunteer organizations to coordinate monitoring activities. EPA encourages the states to incorporate the goal of comprehensive assessment of all waters into such monitoring initiatives.