United States
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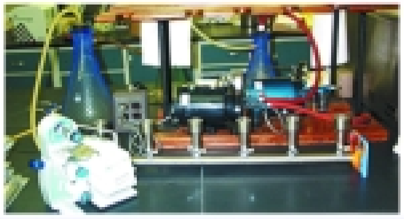
Time-Relevant Beach and Recreational Water Quality Monitoring and Reporting



EMPACT

Environmental Monitoring for Public Access & Community Tracking

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TIME-RELEVANT BEACH AND RECREATIONAL WATER QUALITY MONITORING AND REPORTING

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1 INTRODUCTION

1.1 OVERVIEW

Is it safe to swim at local beaches today? What are the best ways to communicate current water quality conditions to the public? This handbook provides information on how to design and implement a time-relevant water quality monitoring program for beaches and other recreational waters. The handbook is intended for people who are considering developing a recreational water quality monitoring program for their community or wish to enhance their existing program.

The National Risk Management Research Laboratory of EPA's Office of Research and Development initiated the development of this handbook to help interested communities learn more about the beach monitoring projects associated with EPA's Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program, and to give communities the information they need to conduct their own projects. Much of the information in this handbook is provided through case studies of three monitoring projects that address the concerns of recreational swimmers, boaters, and other water users, primarily by:

- Monitoring recreational waters for indicators of waterborne pathogens (disease-causing organisms).
- Collecting and managing water quality data in efficient ways.
- Notifying the public in a timely fashion of water quality conditions.

The handbook follows the three case study projects through the design and implementation of their time-relevant recreational water quality monitoring programs, the development of management and delivery systems for water quality data, and the creation and implementation of public notification and risk communication programs.

The three beach/recreational water case study projects highlighted in this document were conducted before Congress passed the Beaches Environmental Assessment and Coastal Health (BEACH) Act in October 2000, and these projects may not necessarily reflect guidance associated with the BEACH Act. The EPA *National Beach Guidance and Required Performance Criteria for Grants*, or Beach Guidance Document (U.S. EPA, 2002), lists the beach program monitoring and notification criteria, as established in the BEACH Act, that a state must meet to obtain BEACH grants. To learn more about the BEACH Act, BEACH grants, and the Beach Guidance Document, visit *http://www.epa.gov/ost/beaches/ on the Internet.*

1.2 REGULATIONS AND GUIDANCE FOR BEACH AND RECREATIONAL WATER QUALITY

It is important for beach and recreational water quality managers to be familiar with the applicable statutes, regulations, and programs discussed below; they contain specific requirements and useful design and implementation guidance for developing and improving water quality monitoring and public notification programs.

Beach and recreational water quality has been protected for over 30 years by the federal Clean Water Act (CWA). Water quality criteria developed under Section 304 of the CWA include *Ambient Water Quality Criteria for Bacteria*—1986 (U.S. EPA, 1986; see *http://www.epa.gov/ost/standards/bacteria/*), which specifies levels of certain bacteria that should not be exceeded in marine and fresh recreational waters to protect public health/recreation and aquatic life.

In 1997, EPA established the BEACH Program. Its goals were to improve public health and environmental protection programs for beachgoers and provide the public with information about the quality of their beach water. The BEACH Program has focused on strengthening beach standards and testing, providing faster laboratory test methods, predicting pollution, investing in health and methods research, and informing the public about water quality and any associated health risks.

The 1999 EPA *Action Plan for Beaches and Recreational Waters* (U.S. EPA, 1999), developed as a strategy for accomplishing the goals of the BEACH Program, identified EPA activities that would enable consistent management of recreational water quality programs and improve the science that supports recreational water monitoring programs. The signing into law of the BEACH Act, in October 2000, established certain EPA BEACH Program activities as statutory requirements. The Act requires states and tribes that have coastal recreational waters to adopt new or revised water quality standards for pathogens and pathogen indicators for which EPA has published water quality criteria, and requires that EPA promulgate new or revised standards for states and tribes that fail to do so. The BEACH Act also requires EPA to develop and publish new, improved criteria for pathogens and pathogen indicators. In addition, the Act authorizes EPA to award grants to states and tribes to develop and implement programs to:

- Monitor and assess, for pathogens and pathogen indicators, coastal recreational waters adjacent to beaches or similar points of access that are used by the public for swimming, bathing, surfing, or similar water contact activities.
- Notify the public when coastal recreational water quality standards are exceeded.

EPA BEACH Program activities have included conducting conferences with federal, state, and local authorities to identify the needs of recreational water quality programs; helping states and tribes adopt updated water quality criteria for *E. coli* and/or enterococcus bacteria into their water quality standards; developing a new, faster laboratory test method for enterococcus bacteria (Method 1600); publishing a review of potential predictive modeling tools; conducting research on new methods and indicators to assess waterborne pathogens; establishing a grant program to provide support to states, territories, tribes, and local governments for coastal recreational water quality monitoring and public notification programs; conducting an ongoing National Health Protection Survey of Beaches to gather information on state and local monitoring and beach advisory actions; and establishing a "Beach Watch" Web site to improve public access to information about recreational water quality. Additional information on EPA's BEACH Program can be found at *http://www.epa.gov/ost/beaches*.

EPA's Beach Guidance Document

As required under the BEACH Act, EPA has published *National Beach Guidance and Required Performance Criteria for Grants* (U.S. EPA, 2002), also known as the Beach Guidance Document, to help states develop and implement their beach monitoring and public notification programs. The document lists grant performance criteria and gives guidance for states seeking to meet the criteria, including:

- **How to evaluate beaches for risk-based classification.**
- **Beach monitoring and assessment procedures for water sample collection, sample handling, and laboratory analysis.**
- **Using predictive models to estimate bacteria levels.**
- **Developing procedures, such as beach advisories, closings, and openings, for public notification of beach conditions.**

This handbook is independent of the Beach Guidance Document and therefore does not necessarily reflect guidance associated with the BEACH Act. Readers are encouraged to refer to the Beach Guidance Document for more detailed information on the topics addressed in this handbook and for specific information related to the BEACH Act and BEACH grants. The Beach Guidance Document can be found at *http://www.epa.gov/ost/beaches/technical.html*.

1.3 INTRODUCTION TO THE CASE STUDY PROJECTS

The projects on which this handbook's case studies are based are listed in Table 1-1 and summarized below.

Table 1-1. Time-Relevant Beach and Recreational Water Quality Monitoring Case Study Projects

Charles River Basin/Boston Harbor Beaches Project	Boston, Massachusetts	http://www.state.ma.us/mdc http://www.crwa.org http://www.mwra.state.ma.us
Cities of Milwaukee and Racine Health Departments Community Recreational Water Risk Assessment and Public Outreach (Beachhealth)	Milwaukee and Racine, Wisconsin	http://infotrek.er.usgs.gov/pls/beachhealth
Rhode Island Department of Health Narragansett Bay Bathing Beaches Monitoring Project	Narragansett Bay, Rhode Island	http://www.healthri.org/environment/beaches/index.html

1.3.1 REAL-TIME MONITORING AND REPORTING OF WATER QUALITY FOR THE CHARLES RIVER BASIN/BOSTON HARBOR BEACHES PROJECT

Several groups—the Metropolitan District Commission, the Massachusetts Water Resources Authority, the Boston Harbor Association, the Charles River Watershed Association, and others—have worked as partners for a number of years to improve the water quality of the Charles River and Boston Harbor in Massachusetts. In 1998, EPA's EMPACT Program funded a project to enhance real-time monitoring and reporting of water quality for the Charles River and Boston Harbor. Through this project, the partner groups expanded their existing efforts to provide the public with timely information about water quality conditions in the Charles River and at Boston Harbor beaches.

1.3.2 CITIES OF MILWAUKEE AND RACINE HEALTH DEPARTMENTS COMMUNITY RECREATIONAL WATER RISK ASSESSMENT AND PUBLIC OUTREACH (BEACHHEALTH)

In 1998, EPA's EMPACT Program funded the Community Recreational Water Risk Assessment and Public Outreach project to enhance the public beach monitoring and associated health risk advisory efforts that the City of Milwaukee Health Department and the City of Racine Health Department had been conducting for several years. Through the "Beachhealth" project, people in Wisconsin can learn about daily water quality conditions at beaches in the Milwaukee and Racine areas throughout the swimming season.

1.3.3 RHODE ISLAND DEPARTMENT OF HEALTH NARRAGANSETT BAY BATHING BEACHES MONITORING PROJECT

In 1999, EPA's EMPACT Program helped to fund the Rhode Island Department of Health's Bathing Beaches Monitoring Project. This project provides time-relevant water quality and safety information for seven licensed bathing facilities in the Upper Narragansett Bay in Rhode Island. Through effective management of these beaches, the Rhode Island Department of Health sought to develop a pilot project to minimize public health risks associated with swimming at all Rhode Island beaches. The Project sampled a number of other sites to determine whether water quality would support licensing additional beaches in the area in the future.

2 HOW TO USE THIS HANDBOOK

This handbook provides information on how to design and implement a time-relevant water quality monitoring program for beaches and other recreational waters. The information in the handbook is intended for multiple audiences, including managers of public and private beaches, technicians and operators of water-quality monitoring equipment and data management systems, public affairs staff, and other professionals tasked with implementing a timely beach/recreational water quality monitoring program. Section 2.1 provides a "road map" that directs you to chapters that may be of greatest interest for your particular program. Section 2.2 answers frequently asked questions regarding time-relevant beach and recreational water quality monitoring.

2.1 ROAD MAP

1. ***Design a program*** **that addresses water quality monitoring, data management, and public notification, based on specific program goals (Chapter 3).**
2. ***Implement a water quality monitoring program*** **to collect and analyze time-relevant beach and recreational water quality data (Chapter 4).**
3. ***Develop and implement a data management system*** **to manage and deliver time-relevant water quality data (Chapter 5).**
4. ***Create and implement a public notification and risk communication program*** **to inform the public of potential health risks (Chapter 6).**

Each chapter of this handbook provides general information about the particular topics being introduced, followed by case study examples from three EMPACT time-relevant beach/recreational water quality monitoring projects. The examples include successful approaches that you might want to consider in developing your own programs, as well as references to additional sources of information such as Web sites and guidance documents.

Specifically, the handbook provides the following information:

- *Chapter 3* discusses program design, beginning with an overview of health concerns and conventional beach and recreational water quality monitoring. It then describes time-relevant water quality monitoring and some key factors to consider when designing a time-relevant monitoring program. Lastly, it discusses the stated goals and objectives of each of the three case study projects.
- *Chapter 4* discusses water quality sampling and analysis, including information on sample collection, sample analysis, quality assurance and quality control, predictive models, and interpretation and use of monitoring results.
- *Chapter 5* focuses on data management and data delivery, beginning with a discussion of the design considerations involved in developing or modifying a system to manage time-relevant data. For each of the case study programs, the chapter discusses the design, use, and maintenance of data management systems and the mechanisms used to deliver data to the public via the Internet.

- *Chapter 6* describes methods for effectively notifying the public of potential health risks associated with contamination of beach and other recreational waters. The chapter discusses the methods used by the three case study projects for public notification and presents the steps needed to create and implement a comprehensive outreach plan for public notification.
- *Appendix A* contains a survey form used by the Rhode Island beach program, and *Appendix B* includes examples of sample collection procedures.

2.2 FREQUENTLY ASKED QUESTIONS

Whether you are just beginning to consider time-relevant beach and recreational water quality monitoring for your community or want to expand an existing program, the following answers to *frequently asked questions* may be helpful.

Q: How is a time-relevant water quality monitoring program different from a conventional beach monitoring program?

A: A time-relevant water quality monitoring program seeks to reduce the time needed to analyze water quality samples as well as the time it takes to notify recreational water users of any health risks associated with current water quality conditions. Alternative analysis methods, predictive modeling, and innovative and quick methods of distributing sample results to the public are some of the ways in which time-relevant programs achieve their goals. In contrast, conventional water quality monitoring programs are often driven by the (relatively long) time it takes to obtain results using traditional methods of sample analysis and may not emphasize new and quicker ways to get information to the public.

Q: What are the benefits of designing and implementing a time-relevant recreational water quality monitoring program?

A: Exposure to recreational waters contaminated with bacteria, viruses, or other disease-causing organisms can result in a variety of illnesses (e.g., gastrointestinal problems) in people using these waters. Time-relevant water quality monitoring and reporting can help reduce the period of time in which people are potentially exposed to high levels of these waterborne organisms. In addition, since bacteria exceedances are often transient events, time-relevant monitoring allows water quality managers to reopen or unpost these waters sooner.

Q: Can my existing data management system be used for a time-relevant water quality monitoring program?

A: Yes, most existing data management systems can be used for time-relevant monitoring projects. A system can be used if it includes the basic components needed to manage and communicate the data, including a data storage and retrieval system, a data delivery system, and procedures for quality assurance, quality control, and data security. An information systems specialist can help you to determine what your existing system can do and how to modify it, if necessary, to meet real-time project requirements.

Q: What are some good ways to tell the public about recreational water quality and associated health risks?

A: Some quick, effective methods are: placing flags at beaches and other key locations that indicate whether the water quality on a particular day is acceptable for swimming, boating, etc.; training beach lifeguards to inform beachgoers of daily water quality conditions; developing water quality forecasts that are used by local media (e.g., television, newspapers) to report daily or weekend recreational water quality conditions; setting up a water quality information telephone "hotline"; and posting water quality results (e.g., daily or near-daily) on a well-publicized Web site. See Chapter 6 for more discussion of these and other methods. It is often useful to include several of these methods in your program to reach a larger number of people.

3 GETTING STARTED: PROGRAM DESIGN CONSIDERATIONS

The first step in designing a time-relevant water quality monitoring and public notification program for beaches or other recreational waters is to clearly identify the goals of your program. The ultimate goals are to protect public health from potential health risks associated with use of these waters, and to notify members of the public who use these waters of any potential risks. This chapter first presents an overview of health concerns and of beach and recreational water quality monitoring (Section 3.1), then discusses factors to consider when designing a program (Section 3.2). Section 3.3 describes three case study projects, focusing on examples of design factors that these projects considered important.[1]

3.1 OVERVIEW OF HEALTH CONCERNS AND WATER QUALITY MONITORING

3.1.1 WATER-RELATED HEALTH CONCERNS

People can be exposed to disease-causing organisms (such as bacteria, viruses, and protozoa) in beach and recreational waters mainly through accidental ingestion of contaminated water or through skin contact. These organisms, called pathogens, usually come from the feces of humans and other warm-blooded animals. If taken into the body, pathogens can cause various illnesses and, on rare occasions, even death. Waterborne illnesses include diseases resulting from bacterial infection (such as cholera, salmonellosis, and gastroenteritis), viral infection (such as infectious hepatitis, gastroenteritis, and intestinal diseases), and protozoan infections (such as amoebic dysentery and giardiasis).

3.1.2 WATER QUALITY MONITORING

Conventional beach and recreational water quality monitoring often relies on the use of "indicator organisms" to measure the likelihood of the presence or absence of pathogens. The most commonly monitored recreational water indicator organisms are fecal coliform, E. coli, and enterococci:

- *Fecal coliform.* These bacteria are a subgroup of coliform bacteria that usually live in the intestinal tracts of warm-blooded animals, including humans. Fecal coliform was originally recommended in 1968 by the Federal Water Pollution Control Administration (the predecessor to EPA) as an effective water quality indicator organism for beach and recreational waters. It is thought to be a better indicator than total coliform of human (or other warm-blooded species) pathogens. Studies conducted in the 1970s and 1980s indicated that the presence of this organism showed less correlation to illnesses associated with swimming than does the presence of some other indicator organisms, including *E. coli* and enterococci.
- *Escherichia coli (E. coli).* *E. coli* is an accurate indicator of fecal contamination because it constitutes greater than 90 percent of the fecal coliform bacteria found in human and animal waste. These bacteria can become pathogenic when they contact tissues outside the intestinal tract, particularly the urinary and biliary tracts, lungs, peritoneum, and meninges. EPA currently recommends *E. coli* (or enterococci) as an indicator organism for fresh waters (U.S. EPA, 1986).
- *Enterococci.* Enterococci are a type of fecal streptococcus bacteria that live in the intestinal tract of humans and some animals. The risk to swimmers of contracting gastrointestinal illness appears to be predicted better by enterococci than by fecal coliform; EPA currently recommends enterococci as an indicator organism for both fresh and marine waters (U.S. EPA, 1986).

[1] This handbook reflects lessons learned primarily through three EMPACT projects initiated prior to the passage of the BEACH Act in 2000 and the publication of *National Beach Guidance and Required Performance Criteria for Grants* (U.S. EPA, 2002). Some of the practices described in these projects may not be consistent with current regulatory requirements and guidance. For updated regulatory and guidance information, see Chapter 1, Section 1.2.

What Are Bacteria, Viruses, and Protozoa?

Bacteria **are one of the most common single-celled microorganisms. Many types of bacteria are found in recreational waters. Some types of bacteria can be beneficial, while other types, including fecal coliform, salmonella, staphylococcus, and *E. coli,* can cause diseases. Fecal waste from warm-blooded animals (including humans) is a key source of bacteria found in water bodies. Bacteria in recreational waters can often be successfully eliminated or reduced to levels associated with relatively low health risks through chemical disinfection treatments, such as chlorination or ozonation of wastewater before it enters the surface water in the beach area.**

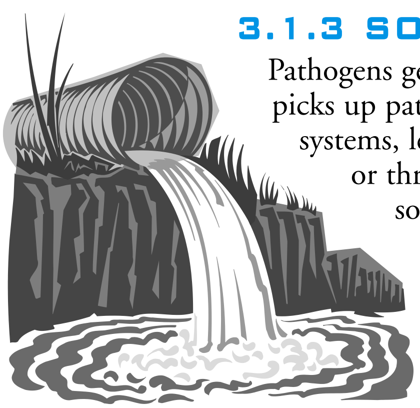
Viruses **are submicroscopic infectious agents that require host cells in which to live. Many of the viruses affecting water quality and human health originate in the gastrointestinal tracts of infected animals (including humans) and are then released to the environment in fecal wastes. Examples of some of the more common waterborne, disease-causing viruses include hepatitis A, rotaviruses, Norwalk-type viruses, adenoviruses, and enteroviruses. Viruses are more resistant than bacteria to conventional water treatment such as chlorination. Treatments such as ultraviolet light and ozonation are more effective than chlorination in treating viruses.**

Protozoa **are single-celled organisms that live primarily in the aquatic environment. Some disease-causing protozoa exist in the environment as cysts that hatch, grow, and multiply after ingestion, causing illness. Two disease-causing, waterborne protozoa of major concern are *Giardia lamblia* and Cryptosporidium. Like viruses, protozoa are more resistant to conventional treatment such as chlorination.**

Ingesting water containing bacteria, viruses, or protozoa is the most common route of human exposure to these microorganisms. A key factor in the successful treatment of these microbes is allowing adequate contact time with the disinfecting agent. Certain physical and chemical conditions (e.g., high suspended solids) can reduce treatment effectiveness if not addressed.

For more information on bacteria, viruses, and protozoa, visit *http://www.epa.gov/microbes/*.

3.1.3 SOURCES OF PATHOGEN CONTAMINATION



Pathogens generally enter beach/recreational waters through rainfall runoff, which picks up pathogens as it moves through the environment (e.g., from failing septic systems, leaking sewers, wastes from wildlife such as birds or domestic animals), or through point source discharges (i.e., sewage from a pipe or other specific source). Heavy rainfall ("wet weather") events can elevate pathogen levels in beach/recreational waters because rainfall can flush pathogens into a water body from other areas of the watershed. Also, combined sewer overflow (CSO) pipes may discharge into a recreational water body during rainfall events, releasing excess discharges of storm water and sanitary wastewater into the environment with little or no treatment. Sanitary sewer overflows (SSOs), which are occasional unintentional discharges of raw sewage, are another potential source of pathogens in recreational water bodies. In areas with separate storm-water and sanitary-sewer systems, both storm-water discharges and SSOs can carry high bacteria levels. Contamination from CSOs and SSOs is potentially a greater risk to swimmers than dry-weather discharges from other point sources because the raw human sewage in CSOs and SSOs often contain elevated bacteria levels. Other point sources of potential water contamination include discharge pipes from businesses that adjoin water bodies. Nonpoint-source discharges from poorly maintained or failing septic systems or other sources of groundwater contamination can also contribute to bacterial contamination of beach water.

More About CSOs and SSOs as Contamination Sources

Not all sewer systems are created equal. While modern systems generally handle rainwater and sanitary wastewaters from homes and businesses in different pipes, some older systems have "combined" sewers that carry both rainwater and sewage flows. During normal conditions, the combined flows are delivered to treatment plants. During heavy rainfall, however, flows sometimes double and even triple. These combined systems are designed so that excess flows (called *combined sewer overflows* or CSOs) are released from outfalls along the system into water bodies with little or no prior treatment. This overflow system prevents sewer backups into homes and onto area streets and also prevents overloading of the treatment plant, but it does so at considerable cost to local water quality. For more information on CSOs, visit *http://www.epa.gov/npdes/cso/.*

A sanitary sewer system is meant to collect and transport all of the sewage that flows into it to a publicly owned treatment works. Occasionally, though, raw sewage is unintentionally discharged from municipal sanitary sewers before it reaches the treatment works. These discharges, called *sanitary sewer overflows* (SSOs), occur in almost every system. SSOs have a variety of causes, including but not limited to infiltration and inflow of ground water and water from other sources, severe weather, improper system operation and maintenance, and vandalism. These discharges contaminate our waters, causing serious water quality problems. For more information on SSOs, visit *http://www.epa.gov/npdes/sso/.*

3.1.4 WHY TIME-RELEVANT WATER QUALITY MONITORING IS NEEDED

When elevated waterborne pathogen levels are found in an area, the public should be notified quickly about the potential health risks in that area. One problem with conventional beach and recreational water quality monitoring is the time lag between collecting water samples and providing the public with results. This lag is due to the time it takes (from 24 to 72 hours) to analyze indicator organism levels. During this time, pathogen levels, weather, and water conditions may change, and related health risks may also change. Thus, authorities responsible for informing and protecting the public often must decide on beach and recreational water postings, closings, and re-openings using indicator organism data that reflect conditions as they were 1 to 3 days earlier. This delay could be particularly problematic after certain events, such as a significant rainstorm or a sewage spill. To address this time lag problem, *time-relevant water quality monitoring strives to shorten analysis times, use quicker predictive methods, and communicate beach/recreational water quality information to the public on a timely (e.g., near-daily) basis so the public can make more informed decisions regarding recreational water use.*

3.2 FACTORS TO CONSIDER IN DESIGNING A TIME-RELEVANT WATER QUALITY MONITORING PROGRAM

Program goals and objectives are key factors to identify when designing a time-relevant beach and recreational water quality monitoring program. Regulatory requirements that protect water quality and public health (e.g., state water quality standards, public health codes) must also be incorporated into the water quality monitoring program. In addition, available resources and community involvement are important considerations for program design. These factors are discussed below.

- *Program objectives.* Your program objectives should support your goals of public health protection and public notification of health risks. Thus objectives should identify how to effectively and quickly (1) monitor beaches and other recreational waters to determine whether water quality is sufficient to protect public health and (2) communicate health risks to those people who use or are otherwise impacted by area beach and recreational waters (e.g., swimmers, boaters, fishermen, water skiers).

Program elements that support these objectives can include monitoring more frequently or at additional locations, using analytical methods that provide results sooner, using a predictive model to supplement monitoring and reduce time lags, and improving the public notification process. These program elements are discussed in Chapters 4 and 6. Your program will be unique; you may decide to incorporate any or all of these or other elements.

- *Water quality standards.* To comply with CWA requirements, states must establish water quality standards, which must be approved by EPA. These standards are at the core of each state's water quality management program. While standards may differ considerably from state to state, they must contain several key elements to be consistent with EPA regulations. The first of these key elements is the identification of *designated uses* for all waters. These use designations should be consistent with CWA goals—that, wherever possible, waters provide for the protection and propagation of fish, shellfish, and wildlife and provide for recreation in and on the water. These use goals are usually referred to by the expression "fishable/swimmable." Examples of designated uses most relevant to beach and recreational waters include primary contact recreation (i.e., swimming and other recreational activities that can result in ingestion of or immersion in the water) and secondary contact recreation (e.g., boating and fishing, in which minimal body contact with or ingestion of the water is expected). Another potentially important designated use relevant to public health is shellfish harvesting, which would result in direct human consumption of the shellfish. Some states designate uses through a class system (Class A, B, or C), while other states specify the use (e.g., primary contact recreation, drinking water).

  A second key element of water quality standards is the adoption of *water quality criteria* that must be met to support the designated uses. EPA publishes water quality criteria that guide the states in setting their own criteria, as required by the CWA (Section 304). *Ambient Water Quality Criteria for Bacteria—1986* (U.S. EPA, 1986) recommended the use of *E. coli* and enterococci as indicator organisms for bacteria for the designated use of swimming. In that document, EPA recommended that water quality criteria be based on geometric mean (i.e., drawn from a statistically sufficient number of samples) densities of bacteria and on maximum single-sample bacteria densities, neither of which are to be exceeded in marine and fresh recreational waters. The criteria that EPA recommended for bacteria are shown in Table 3-1. Check with your state environmental or public health agency to find out what water quality criteria your state has adopted. A state's water quality criteria are used as the basis to close (or post) and reopen a beach. As discussed below, while many states still use fecal or total coliform as the basis for their water quality criteria, the BEACH Act requires that coastal states adopt criteria consistent with the EPA 1986 guidance by 2004. For example, Rhode Island's state standard currently is 50 colony-forming units per 100 milliliters (50 CFU/100 ml) of fecal coliform, as shown in Table 3-2; however, Rhode Island anticipates switching to enterococci. The water quality criteria used by the three projects highlighted in this handbook are discussed in Chapter 4, Table 4-4.

Table 3-1. Water Quality Criteria Recommended by EPA for Bacteria

	Steady-State Geometric Mean Indicator Density[1]	Most Commonly Used Single-Sample Maximum Allowable Density[1] Designated Beach Area (Upper 75% CL[2])
Fresh Water (in CFU/100 ml)[3]		
Enterococci	33	61
E. coli	126	235
Marine Water (in CFU/100 ml)[4]		
Enterococci	35	104

[1] For an explanation of "geometric mean" and "single-sample maximum allowable density," see the box entitled "EPA Water Quality Criteria Reflect Health Risks and Recreational Water Uses." For single samples, the "Designated Beach Area" criteria listed above are usually used. Other single-sample densities (included in EPA's list of recommended criteria but not shown here) may be selected if a reason exists to do so (e.g., a reduced risk due to an area being less frequently used for swimming). See *Ambient Water Quality Criteria for Bacteria—1986* on EPA's Beaches Web site *(http://www.epa.gov/ost/standards/bacteria/)* for other single-sample density values for other levels of water use.

[2] CL = confidence level. A confidence level (or interval) is an estimate of the probability that an interval around the mean value contains the true mean value. A 95% CL is larger than a 75% CL because there is a higher likelihood that this interval will capture the true mean.

[3] Freshwater densities are based on a risk of eight illnesses per thousand swimmers. CFU = colony-forming units; ml = milliliters.

[4] Marine water densities are based on a risk of 19 illnesses per thousand swimmers. CFU = colony-forming units; ml = milliliters.

Source: U.S. EPA, 1986.

Table 3-2. Water Quality Criteria Used by Three Case Study Projects[1]

Boston, Massachusetts	Milwaukee/Racine, Wisconsin	Narragansett Bay, Rhode Island
Charles River (Boston area, fresh water): 1,000 CFU/100 ml FC (secondary contact waters, e.g., boating) - geometric mean; also 2,000 CFU/100 ml FC (≤10% of single samples)[2] 200 CFU/100 ml FC (Class B waters for swimming/fishing) - geometric mean; also 400 CFU/100 ml FC (≤10% of single samples) ***Boston Harbor (marine water):*** 35 CFU/100 ml enterococci - geometric mean 104 CFU/100 ml enterococci - single samples	235 CFU/100 ml *E. coli* - single samples (general recreational water use)	***Salt water:*** 50 MPN/100 ml FC - geometric mean; also 500 MPN/100 ml FC (≤10% of single samples) (swimming/boating)[2] ***Fresh water:*** 200 MPN/100 ml FC (swimming) - geometric mean

[1] All of the programs listed anticipate switching to *E. coli* or enterococci by 2004 or sooner.

[2] CFU = colony-forming units; ml = milliliters; FC = fecal coliform; MPN = most probable number.

In addition to the federal and state requirements and guidance discussed above, additional state and local requirements may apply. For example, in Massachusetts, beaches are managed and monitored based on the state public health code (revised in 2000 to make it consistent with EPA requirements), which includes state water quality criteria. Local protocols may also be established to meet state codes and regulations. Beach management and monitoring in Rhode Island is based on state codes and regulations as well as beach opening and closure procedures established by the Rhode Island Department of Health and the Rhode Island Department of Environmental Management. In Wisconsin, the state issues a model beach ordinance, which municipalities may, but are not required to, use. The City of Milwaukee developed its own beach ordinance based on the state's model ordinance.

EPA Water Quality Criteria Reflect Health Risks and Recreational Water Uses

The EPA water quality criteria listed in Table 3-1 reflect specific health risks and water uses, as described below (U.S. EPA, 1986).

Geometric mean. **The geometric mean values summarized in Table 3-1 are based on specific levels of risk of acute gastrointestinal illness: no more than 8 illnesses per 1,000 swimmers for fresh water and no more than 19 illnesses per 1,000 swimmers for marine water (U.S. EPA, 1986). EPA has determined that, when these water quality criteria are implemented in a conservative manner, they are protective for prevention of gastrointestinal illness resulting from primary contact recreation. EPA recommends that at least five samples over a 30-day period be taken to calculate the geometric mean.**

Single-sample maximum. **Noncompliance can also be indicated by unacceptably high single-sample measurements. Single-sample maximum values can help determine whether to close or post a beach when a single-sample measurement shows a value that exceeds the single-sample maximum. The maximum for single samples is set higher than the geometric mean to prevent unnecessary closures based on a single sample. Use of a single-sample maximum is also important because it is assumed that environmental conditions that can affect bacteria levels in water (such as rainfall, wind, currents, tides, and temperature) will vary temporally and spatially. Like the geometric mean, these single-sample maximums, summarized in Table 3-1, are based on specific levels of risk of acute gastrointestinal illness: again, no more than 8 illnesses per 1,000 swimmers for fresh waters and no more than 19 illnesses per 1,000 swimmers for marine waters.**

- *Availability of resources.* Funding and staffing constraints can limit the design of a water quality monitoring program. These resource limitations can impact when, where, and how often you monitor water quality and can also impact your public notification process. If resources are a limiting factor, consider having program partners administer your monitoring, data management, or notification program. Other agencies or organizations involved in recreational water quality issues (e.g., watershed associations, community groups, other state and local agencies) may be interested in contributing funds and/or staff to support a time-relevant water quality monitoring program. See the latter part of this chapter and Chapters 5 and 6 for more information on program partners.
- *Community input.* The design of a successful time-relevant water quality monitoring program should include public input regarding what people want and need to know about beach and recreational water quality and related health risks, as well as how they prefer to receive this information (e.g., the Internet, beach flags, newspaper notices). Also, community members are often a valuable source of information about an area (e.g., possible sources of contamination).

3.3 EXAMPLES OF PROGRAM OBJECTIVES AND PROGRAM DESIGN CONSIDERATIONS

This section presents an overview of the objectives for each of the three projects discussed in this handbook, along with a discussion of some of the design factors (as discussed in Section 3.2) considered by each of the projects. More detailed information on these projects is provided in later chapters. It should be noted that all three of these projects were developed prior to the passage of the BEACH Act in 2000 and the Beach Guidance Document (U.S. EPA, 2002); program managers should review these sources for current requirements and recommendations.

3.3.1 REAL-TIME MONITORING AND REPORTING OF WATER QUALITY FOR THE CHARLES RIVER BASIN/BOSTON HARBOR BEACHES PROJECT

Boston Harbor is adjacent to Boston, Massachusetts, and influenced by a prominent, densely settled, urban recreational watershed. The Charles River Basin/Boston Harbor Beaches Project is a key initiative supporting the EPA–New England goal of making the Charles River fishable and swimmable by Earth Day 2005. The overall project objectives are:

- To help reduce public health risks associated with pathogen contamination in the Charles River Basin and at Boston Harbor area beaches.
- To enhance existing monitoring efforts by the Charles River Watershed Association (CRWA), Metropolitan District Commission (MDC), and Massachusetts Water Resources Authority (MWRA) in the Charles River Basin and at Boston Harbor area beaches.
- To enable the public to make more informed decisions related to river and beach use and public health.
- To evaluate two different analytical methods for enterococci, one of which provides results more quickly, within 24 hours.

Two key design factors for the Charles River Basin/Boston Harbor Beaches Project were the use of project partners to enhance the resources available to the project and the importance of community input and outreach, as discussed below.

Project partners. The project was designed to expand the efforts of several partner organizations that have been working for a number of years to improve the water quality of Boston-area beaches and the Charles River. The project enhanced these partners' ability to provide the public with time-relevant information about water quality conditions. The project design maximized the use of program partners for both monitoring and public notification efforts. Wherever possible, The Boston Harbor Association (TBHA) collaborated with the CRWA to conduct public outreach aimed at enabling a diverse, multi-cultural public to make more informed decisions related to the use of both the Boston Harbor beaches and the Charles River. Additional partners included the MWRA, the MDC, members of the Wollaston Beach Task Force, and members of the Boston Harbor Water Quality Task Force.

Outreach to the community and public input. The Charles River Basin/Boston Harbor Beaches Project uses several different types of public outreach to collect feedback on the water quality notification system and to build community awareness of recreational water quality issues. One example of this process is a public meeting, hosted by TBHA, that included a discussion by the program partners on water quality conditions during the beach season and efforts to provide the public with "real-time" information. Another example is another TBHA-hosted public workshop, during which comments were solicited from workshop participants.

The public outreach components of this program are many and varied and have included:

- Availability of daily water quality conditions from the MDC Web site.
- A telephone hotline that provides updated water quality conditions for Boston Harbor beaches on a daily basis throughout the beach season.
- Media coverage that includes daily or weekly reports highlighting the water quality conditions at Boston Harbor beaches.
- Special training sessions to educate lifeguards and other staff about implementing the notification program and informing the public about water quality conditions.
- Participation in annual beach water quality monitoring symposia organized with Massachusetts Coastal Zone Management, the Massachusetts Department of Public Health, the Massachusetts Department of Environmental Protection, and local boards of health.
- Posters, water bottles, and brochures that explain and highlight the beach flagging program.
- "Back to the Beaches" events to promote use of the beaches by neighbors and visitors to Boston Harbor. During these events, staff from TBHA and the MDC provide the public with in-depth information on water quality issues, the notification system, and access to online information on water quality conditions.
- Notification and other communications with the Massachusetts Department of Public Health and local boards of health.

See Chapter 6 for a more detailed discussion of the public notification and risk communication efforts undertaken by all three of the case study projects.

3.3.2 CITIES OF MILWAUKEE AND RACINE HEALTH DEPARTMENTS COMMUNITY RECREATIONAL WATER RISK ASSESSMENT AND PUBLIC OUTREACH (BEACHHEALTH) PROJECT

For approximately the past 30 years, the City of Milwaukee Health Department (MHD) has monitored Milwaukee public beaches for contamination that could negatively affect public health. MHD has partnered with the City of Racine Health Department, the U.S. Geological Survey, the University of Wisconsin–Milwaukee Great Lakes Water Institute, and other organizations to study the beaches in Milwaukee and Racine, Wisconsin. The objectives of the Milwaukee/Racine Beachhealth project are:

- To improve documentation and dissemination of environmental data related to health risks associated with the recreational use of public beaches.
- To improve the type, quantity, and quality of environmental data collected at and around public beaches in both Milwaukee and Racine Counties for development of a public health risk model.
- To standardize and improve coordination and collaboration of environmental data collected between local public health agencies (LPHAs), community stakeholders, and other organizations.
- To build community awareness of surface-water pollution prevention.

Three key design factors for the Milwaukee/Racine project included consideration of beach classification issues, the use of project partners to enhance the resources available to the project, and community input and outreach, as discussed below.

Beach classification. The project's design included consideration of which beaches were most at risk for public exposure to pathogens and increased data collection at those sites. For example, two automated environmental monitoring stations were added to provide physical and chemical data (including water temperature, turbidity, fluorescence, conductivity, oxidation/reduction potential, wind speed and direction, and air temperature) to support health risk determinations. One station is located at Milwaukee's South Shore Beach, and the other is at North Beach in Racine. These two beaches have historically been prone to elevated bacteria levels; according to historical monitoring data, both can have elevated pathogen levels after wet weather events. Also, LPHAs collect water samples at five Milwaukee and Racine beaches during the summer swimming season. The beaches are tested daily, Monday through Friday. The LPHAs also conduct daily testing on weekends during the beach season at beaches posted as unsafe due to potentially poor water quality. Other near-shore data are collected by the City of Milwaukee from the watershed twice weekly at three recreational sites. In addition, volunteer environmental monitoring is conducted at designated sites.

Project partners. To improve coordination and collaboration in the collection of environmental data by LPHAs, community stakeholders, and other organizations, MHD partnered with community environmental education organizations to form a near-shore volunteer monitoring program. Nearly 50 volunteers were involved in the onsite water quality testing of 13 sites for nine scheduled monitoring events, as well as rainfall events during the summers of 1999 and 2000. In addition, MHD formalized agreements with other agencies to share near-shore data and enter the data into a Web site *(http://infotrek.er.usgs.gov/pls/beachhealth/).*

Community input and outreach. The Milwaukee/Racine project has used several types of public outreach to collect feedback on new advisory postings at Milwaukee and Racine beaches and to build community awareness of surface-water pollution prevention. For example, beachgoers at Milwaukee's South Shore Beach completed surveys, and the beach was posted with large advisory signs providing daily water quality data during the course of the project. Other public outreach components of this project included:

- Development of a Web site for the project, in both English and Spanish, that includes a technical user's page with all of the Milwaukee and Racine county and volunteer monitoring data. These data can be queried and downloaded.
- A beach water quality telephone hotline, which includes recorded advisories, updated daily, for three Milwaukee beaches.
- Outreach materials such as two brochures on beach pollution. These were handed out at community events, including the 1999 Wisconsin Beach Sweep and at an EMPACT booth at the Environmental Expo, held in Milwaukee as part of the International Joint Commission's biennial meeting.

3.3.3 RHODE ISLAND DEPARTMENT OF HEALTH NARRAGANSETT BAY BATHING BEACHES MONITORING PROJECT

Rhode Island's project is designed to address bacteriological water quality and swimmer safety issues at beaches in the Providence metropolitan area. Its four main objectives are:

- To develop a comprehensive beach management program through frequent water quality monitoring at swimming beaches and other potential recreational sites in the upper Narragansett Bay.
- To communicate monitoring information to the public in a time-relevant, easily accessible, and effective format so the public can make informed decisions regarding environmental health risks and their daily activities.
- To investigate faster methods and alternative indicators for evaluating water quality.
- To collect specific wet weather data for use in developing a predictive beach closure model based on rainfall/sewage discharge volume.

One of the key design factors for the Bathing Beaches Monitoring Project was consideration of known, historical sources of contamination, as discussed below.

Historical sources of contamination. Sewage releases have caused use restrictions in large areas of the upper Narragansett Bay. In the northernmost reaches of the Bay, where many sewage outfalls are located, one area is permanently closed to shellfishing due to consistently high bacteria levels, while two other areas are deemed "conditional"—they are automatically closed to shellfish harvesting after certain amounts of rainfall (0.5 inches in one area, 1 inch in the other). While there are no state-licensed beach facilities within the permanently closed area, there are several beach areas that are used by the public as swimming areas. In addition, there are several licensed beaches that fall within the conditional areas, and primary contact activities, such as swimming, diving, and water skiing, occur in these conditional areas. This occurrence of primary contact activities in areas with use restrictions is a public health concern and demonstrates the need to consider historical sources of contamination and spatial and temporal factors in a beach management program.

To address this public health issue, the Rhode Island Beaches Monitoring Project chose sampling sites that provided spatial coverage of the upper bay, including sites that were not licensed beaches; sampling at these unlicensed areas could help to determine whether water quality in these areas would support efforts to pursue beach licenses. The results of the project sampling were used to confirm that the unlicensed sampling sites in upper Narragansett Bay are not suitable for becoming licensed public beach facilities at this time. Many of these sites display consistently poor water quality, exceeding the state standard more than 50 percent of the time. (Standards and criteria used by the three case study projects are listed in Table 3-2 and Table 4-4).

The water quality sampling conducted at licensed facilities in the northernmost regions of the bay found fluctuating water quality. While these areas frequently displayed acceptable water quality and are suitable for primary use, the fluctuation demonstrates the need for frequent sampling at these sites.

Information on historical water contamination at sites can contribute to the design and proper management of a water quality monitoring program by helping to determine where and how frequently monitoring is needed. More frequent monitoring may be needed at certain areas, even at some licensed beaches, based on prior history.

4 TIME-RELEVANT BEACH/RECREATIONAL WATER QUALITY MONITORING AND MODELING

Once you have identified the important program design factors to consider and have incorporated them into your beach and recreational water quality program (as discussed in Chapter 3), the next step usually involves developing a monitoring protocol that meets the goals of your particular program. The general steps needed to develop and implement a time-relevant beach/recreational water quality monitoring program include:

- Establish a monitoring plan that addresses what, where, when, and how water quality monitoring will occur (Section 4.1).
- Develop plans that specify quality assurance (QA) and quality control (QC) procedures to be followed during sample collection and analysis and data interpretation (Section 4.2).
- Conduct analyses of water quality samples (Section 4.3).
- Determine whether it is feasible to develop predictive modeling to provide quicker estimates of water quality (Section 4.4).
- Interpret the monitoring and modeling results, including information on water quality exceedances and beach closing and reopening procedures (Section 4.5).
- Notify the public of the monitoring and modeling results and any associated public health risks (see Chapter 6).

Also, beach program managers should check with state and local authorities to identify the regulatory requirements that apply to your program. See Chapter 3, Section 3.2, for potentially applicable federal, state, and local requirements.[2]

4.1 OVERVIEW OF MONITORING AND SAMPLE COLLECTION

This section discusses what should be monitored and where, when and how monitoring should be conducted, and who should conduct it. Each of these considerations should be addressed ahead of time in a monitoring plan, which can be revised if needed. This section also provides examples of monitoring considerations addressed by three case study projects.

4.1.1 WHAT WATER QUALITY PARAMETERS SHOULD BE MONITORED?

Decisions about what to monitor should be based on the uses of your beach and recreational waters, the applicable regulatory standards, and the questions and concerns raised by recreational water users. For example, are people primarily interested in whether it is safe to swim at a particular beach? Are they also interested in whether it is safe to boat, fish, or dig clams in the area? The parameters to be monitored and their levels of acceptable health risk should be chosen to answer such questions. As described in Chapter 3, water bodies need to meet criteria set by state water quality standards, which apply to existing and designated uses for specific waters, such as primary contact recreation (e.g, swimming) and secondary contact recreation (e.g., boating). See Chapter 3 for a discussion of designated uses and state water quality criteria.

[2] This handbook reflects lessons learned primarily through three EMPACT projects initiated prior to the passage of the BEACH Act in 2000 and the publication of *National Beach Guidance and Required Performance Criteria for Grants* (U.S. EPA, 2002). Some of the practices described in these projects may not be consistent with current regulatory requirements and guidance. For updated regulatory and guidance information, see Section 1.2.

In addition, the BEACH Act requires all coastal and Great Lakes states to adopt EPA Ambient Water Quality Criteria for the pathogen indicator organisms *E. coli* or enterococci for beach and recreational water quality monitoring. About one-third of all states monitor for *E. coli* or enterococci indicator organisms as a measure of bacteria densities in fresh and marine waters. Other states continue to use other pathogen indicator organisms, such as total coliforms or fecal coliforms.

Beach and recreational water quality monitoring may include a number of measurements in addition to those for bacteria indicator organisms—for example, parameters such as rainfall, water and air temperature, water turbidity, and wind speed and direction. These parameters can be used as supplemental water quality information to help evaluate chemical, aesthetic, and transport effects that can affect water quality. For example, wind speed and direction can help identify the direction of water currents that spread a sewage outfall discharge through a water body. Lake circulation patterns can also be influenced by wind and rainfall. These parameters may also be used as inputs for predictive models that supplement monitoring, as discussed in Section 4.4. Table 4-1 summarizes the indicator organisms and supporting measurements currently evaluated by each of three case study projects. Appendix A includes a survey form used by Rhode Island to record information on some of these parameters, as well as others. (Note that the Rhode Island project also observes whether storm-water pipes or other flows across beach areas are present.)

Water quality samples can also be analyzed for nutrients such as nitrate and phosphate. These parameters may provide information regarding certain contamination sources (e.g., farm runoff or animal feeding operation discharges). Elevated nutrient concentrations may cause increased algae or aquatic weed growth, which can reduce recreational water use, especially if the algae or weed growth is severe.

Table 4-1. Parameters Monitored in Three Case Study Projects

	Charles River Basin/Boston Harbor Beaches Project	Milwaukee/Racine Beachhealth Project	Rhode Island Beach Monitoring Project
Indicator Organisms	Fecal coliform Enterococci	*E. coli*	Fecal coliform Enterococci
Other Environmental Measurements	Rainfall Temperature Conductivity/salinity Weather conditions	Rainfall Water and air temperature Turbidity Fluorescence Conductivity Oxidation/reduction potential Wind speed/direction Chlorophyll Nitrate Phosphate	Rainfall Water temperature Turbidity Weather conditions Prevailing wind

4.1.2 WHERE SHOULD MONITORING SITES BE LOCATED?

Generally, areas with the greatest risk of public exposure to pathogens need more frequent water quality monitoring and public notification. Therefore, consider monitoring the primary contact beaches and recreational areas that have high use or high-density use. Also, consider monitoring along beaches close to storm-water and sewer outfalls, since these locations may be prone to high bacteria levels; although people may not swim in these areas, monitoring them can help identify sources of pathogens.

Coastal states that receive BEACH Act funds are required to evaluate and classify their waters based on public health risk and frequency of use. Monitoring locations and frequency of monitoring in those states should be consistent with these beach classifications.

Some municipalities monitor all beaches in their area (regardless of proximity to pollutant sources, for example), while others select monitoring locations based on some or all of the following factors:

- *Designated and existing use of the water body,* including whether the water body supports primary contact recreation, secondary contract recreation, shellfishing, drinking water, or other designated uses. Under the CWA, each state, territory, or tribe is required to designate a use or uses for each water body within its jurisdiction. (See Chapter 3 for a discussion of designated uses.)
- *Frequency and density of use.* Monitoring sites should also be selected based on the frequency and density of use of a beach/recreational water body. Samples should be collected where many people typically swim or otherwise use the water often, since these areas often pose the highest potential risk of public exposure to pathogens.
- *Potential pollution sources and storm-water discharges.* The condition of the watershed feeding a recreational water body, including the number and location of point and nonpoint pollution sources and storm-water discharges, is an important factor in where pathogen contamination may occur. Common sources of pathogen pollution include wastewater treatment (e.g., publicly owned treatment works) outfall pipes, CSOs, SSOs, storm-water pipes, and malfunctioning septic systems. Recreational waters near such sources should be considered as potential monitoring sites.

To minimize unwarranted variation among sampling results, collect water samples from the same location within a site (e.g., in front of a lifeguard station or another clearly defined area) each time sampling occurs.

Choosing Monitoring Sites

The Charles River Basin/Boston Harbor Beaches Project in Massachusetts monitors water quality at 13 locations along four historically contaminated beaches daily and other beaches weekly. Some of the sampling sites are at lifeguard stations where people typically swim. These beaches were also selected because they are located in or near heavily populated and/or industrial areas that are directly impacted by sewer system overflows and contaminated storm drains. Combined sewer overflows have been a major source of pollution to the beaches and the harbor in general. Research by the Massachusetts Water Resources Authority indicates that beach water quality is highly variable in response to rainfall, even among different locations along the same beach.

4.1.3 WHEN SHOULD WATER QUALITY MONITORING OCCUR?

When designing your water quality monitoring program, consider the time of day samples are collected, the frequency of monitoring, and wet weather events. Take into account the analysis time required for indicator organism monitoring: if it takes 24 hours to get results, note that sampling early in the day allows for public notification earlier the next day. To keep your data consistent, try to collect water samples at the same sites at the same time of day each time the water is monitored—on sunny days, early morning samples can have more bacteria than afternoon samples. The frequency of sampling is often determined by how heavily a beach is used. Beaches used often by a lot of people and beaches located near major sources of potential contamination need to be monitored more frequently. Seasonal beach use can also impact the frequency of monitoring: beaches that are unused in the winter will not pose an exposure threat to the public when not in use.

It is important to monitor after exceedances of water quality criteria (which in some cases may be after rainfall events) to ensure that bacteria concentrations have returned to acceptable levels. Such monitoring can help you determine when beaches that have been closed because of high bacteria levels may be reopened.

Deciding When To Monitor

Rhode Island's Beaches Monitoring Project conducts beach monitoring from mid-May through mid-September to coincide with the summer beach season. Samples are collected weekly at each of 23 sites. If a beach is closed because of an exceedance, it is resampled daily until bacteria densities fall back below the threshold. Rainfall event samples are collected in place of weekly sampling when it rains prior to a scheduled sampling date. Most samples are collected between 8:00 a.m. and 11:30 a.m. and delivered to the laboratory for analysis within 4 hours of collection.

In deciding when to monitor, consider when the monitoring results will be received, since this may have important public notification implications. For example, consider organizing your monitoring program so that enough time is allocated for sample results to be received and any associated health risks communicated to the public before the weekend, when beach and recreational waters are typically used the most.

4.1.4 HOW ARE BEACH/RECREATIONAL WATER QUALITY SAMPLES COLLECTED?

It is important to develop, in advance, specific written procedures for the collection, preservation, and storage of water samples and to adhere to those procedures. The reference text *Standard Methods for the Examination of Water and Wastewater* (Clesceri et al., 1998) provides general guidelines for water sampling. The text covers such matters as obtaining representative samples and avoiding sample contamination, both of which are critical to the accuracy of your results. Many states have developed their own protocols. A typical sample collection protocol for recreational waters might incorporate the following guidelines, among others:

- Collect samples in areas of greatest use by swimmers (or other relevant recreational water users), where the water is about 3 feet deep, at about knee-depth or 1 foot below the water surface.
- The sample analysis method to be used[3] will specify appropriate sample containers, identify whether any preservation is required (such as storing samples on ice until analysis) and indicate acceptable holding times.

[3] See Section 4.3.

- Remove the sample container cap carefully, ensuring that you do not touch the inside of the cap or the lip of the sampling container, and face into the current or waves to avoid sample container contamination.
- Minimize sediment or debris in the sample (which may require waiting for sediment to settle after wading out to the sample collection location). If sediment or debris is present throughout the sample, note this fact on the sample collection form.

Appendix B includes examples of sample collection procedures used by two of the case study projects.

You should also develop standard procedures for the collection of environmental monitoring data, such as rainfall, water temperature, wind speed, and any other supporting environmental parameters you monitor, such as those listed in Table 4-1. (As discussed in Section 4.1.1, these parameters can influence the water quality of a receiving water body.)

Environmental data can be collected manually or automatically. Manual collection of environmental parameters usually occurs at the time of water quality sampling and involves meters, monitors, and test kits. The MWRA in Boston installed three stationary rainfall gauges that automatically monitor rainfall every 15 minutes. The Milwaukee/Racine Beachhealth project uses two automated environmental monitoring stations that provide physical and chemical data to MHD using a call-in system. The system monitors water temperature, turbidity, fluorescence, conductivity, oxidation/reduction potential, wind speed and direction, and air temperature on a continual basis. These data are relayed to on-shore computers via radio at predetermined intervals and on demand. Figure 4-1 shows a schematic of the Milwaukee/Racine automated monitoring system.

Note that other water quality monitoring programs (e.g., volunteer monitoring programs) may already be collecting environmental data.

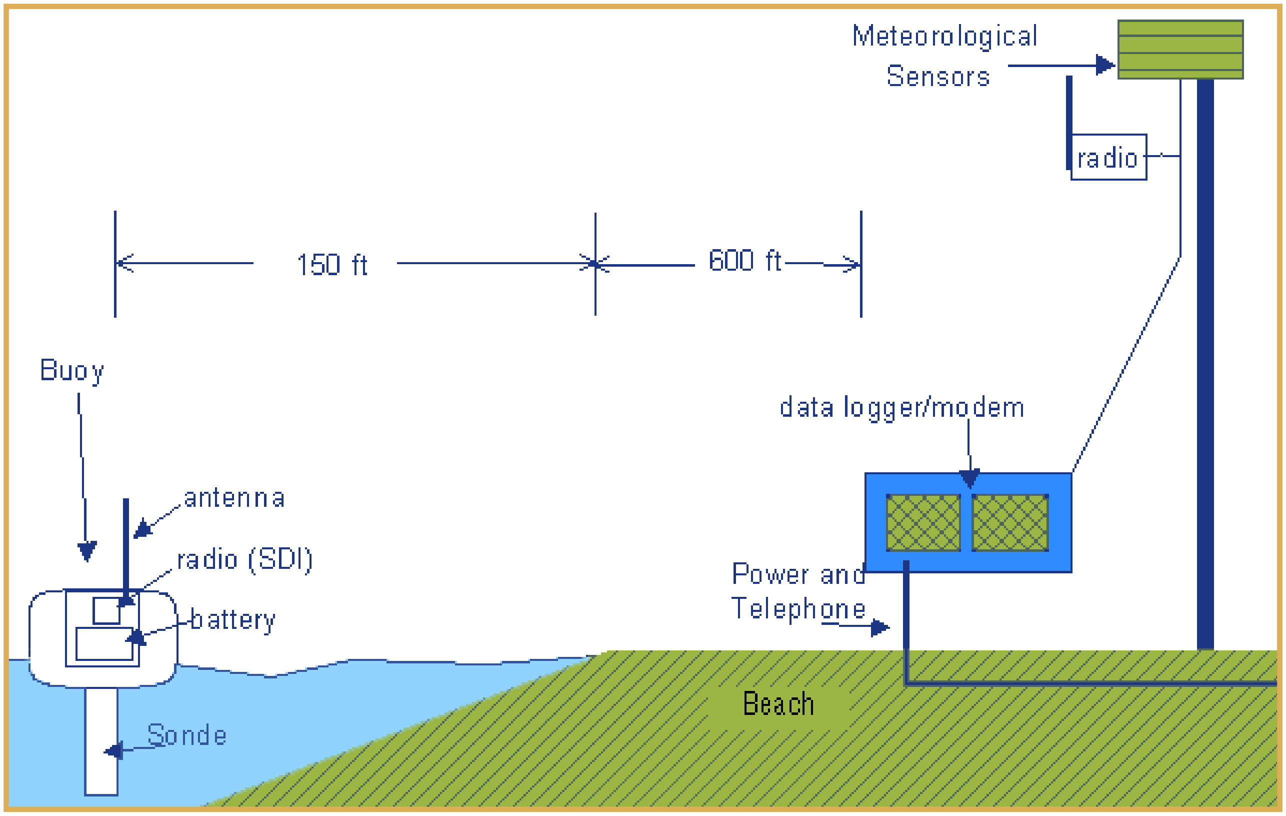


Figure 4-1. Schematic of the Milwaukee/Racine, Wisconsin, automated beach monitoring system.

4.1.5 WHO SHOULD CONDUCT WATER QUALITY MONITORING?

The quality of data produced by a monitoring program depends on the quality of the work undertaken by field and laboratory staff. Professional health agency personnel, volunteers, and/or contractors have been successfully used for the collection of water quality samples and environmental monitoring data. Whether drawn from professional staff or a pool of volunteers, the personnel responsible for sample collection and environmental measurements at beaches and recreational water areas must be adequately trained for those activities.

Consider the following factors as you determine the best type of personnel to use:

- The objectives and requirements of the agency legally responsible for the monitoring.
- The availability of staff and funding for monitoring. The use of volunteer personnel can allow your agency to increase the amount of monitoring performed, although you will need resources for training volunteers if you use them.
- Program partners, such as other public agencies, community-based environmental groups, or research and educational entities (such as colleges and universities). These can sometimes be a source of monitoring or public outreach personnel.

Monitoring Personnel

In the Milwaukee/Racine Beachhealth project, both professional staff from local public health agencies and volunteer personnel conduct water quality monitoring. The agencies' environmental health specialists and environmental hygienists are responsible for collecting samples on which health advisories are based. Additional near-shore data are collected by other agencies and community-based environmental groups made up of volunteer personnel. The City of Milwaukee Health Department coordinates the volunteer environmental monitoring events. Training for the volunteers is provided by the Wisconsin Department of Natural Resources Environmental Center, the University of Wisconsin–Extension, and the Riverside Urban Environmental Center.

4.2 QUALITY CONTROL PLANS AND PROCEDURES

To ensure data quality, create good QC documentation for all beach and recreational water quality monitoring and analysis programs. Develop a quality assurance project plan (QAPP), which should include data quality objectives (DQOs) and standard operating procedures (SOPs).

A QAPP is a formal document that specifies in detail what sampling and analysis procedures are to be used, how and when sampling will be done, what QA and QC activities are necessary to ensure that the data collected meet specified standards, and how the data will be analyzed and reported. DQOs are qualitative and quantitative statements that clarify monitoring program objectives, define the appropriate types of data, and specify tolerable error levels. DQOs are used as bases for establishing the quality and quantity of data needed to support decisions.

SOPs describe in detail the method for a given operation, analysis, or action. They are used for technical activities that need to be performed the same way every time (i.e., standardized). Among such activities are field sampling, laboratory analysis, and database management. It is often helpful to present an SOP in sequential steps that reflect the stages of the actual work to be done; it is also helpful to include specific facilities, equipment, materials and methods, QA and QC procedures, and other factors required to perform the operation, analysis, or action. An SOP's format and content requirements are flexible because its content and level of detail will depend on the nature of the procedure being performed.

QAPPs should also include data *verification* and *validation* procedures (described below). These procedures will help you ensure that QA/QC objectives and requirements have been met, enable you to verify that the results of your sampling are accurate, and aid in data interpretation.

To learn more about QA/QC procedures and how to develop a QAPP, see *EPA Guidance for Quality Assurance Project Plans,* available at *http://www.epa.gov/quality/qs-docs/g5-final.pdf.*

What Is an Accredited (Certified) Laboratory, and Why Use One?

An accredited laboratory is one that meets certain requirements set by an accrediting agency, including having qualified personnel, appropriate instrumentation, and standard operating procedures, and has demonstrated proficiency in the analysis of samples, for example for particular bacterial indicators.

Some states have established accreditation processes for environmental analyses and require the use of accredited laboratories. This is often true for drinking water analysis. The use of an accredited laboratory is recommended for recreational water analyses as well, especially when beach advisory or closure decisions are to be based on the analytical results. Check with your state regarding its requirements and recommendations for the use of accredited laboratories.

4.2.1 DATA VERIFICATION METHODS

Data verification provides the confirmation that specified requirements have been fulfilled. For water quality sampling and analysis, this is done by evaluating whether data have been collected in accordance with the specifications of the QAPP and whether the DQOs specified in your QC plan have been met. Data verification also includes a review of the sampling data obtained and QC sample data (e.g., sample duplicates). Examples of data verification procedures for bacterial indicator samples include:

- Additional tests on samples to identify false positives or false negatives. A false positive rate is calculated as the percent of colonies that were falsely identified as being made up of indicator microorganisms. A false negative rate is calculated as the percent of colonies that were made up of indicator microorganisms but were not identified as such. EPA-approved methods specify acceptable false positive and false negative rates for the relevant media.
- Review of sample records, chain of custody records, and sample tracking records to verify that all samples collected were analyzed and that the data set results will be complete.
- Data entry checks to detect any potential data entry errors.
- Other types of check, such as graphing data to visually inspect for any potential errors and using statistical methods to detect invalid data.
- Review of data reductions, transformations, and calculations by rechecking computations and reviewing the assumptions used.

Verifying that a data collection effort conforms with the QAPP requires confirming that the data pass specified QC tests, calculations were performed correctly, all samples were treated consistently, and the data are complete and comply with all plans, DQOs, and SOPs. Data verification should always be followed by data validation, as described below.

4.2.2 DATA VALIDATION

Data validation provides the confirmation that the requirements for an intended use have been fulfilled. Once data have been verified as meeting QAPP requirements, they are then validated to determine their technical usability with respect to the planned objectives. This process should produce a validation report that assesses the usability of the data (and whether any of the data are suspect or need to be qualified), summarizes data results, and summarizes QC and QA results. The report should discuss any discrepancies between a program's DQOs and the data collected.

4.3 SAMPLE ANALYSIS

Several methods are available to detect the presence of bacterial indicator organisms as part of an assessment of beach and recreational water quality. This section briefly discusses EPA-approved and other standard methods and describes the methods used by the three case study projects, including new analysis methods that are under investigation.

Many government agencies, universities, and other organizations develop analytical methods. EPA evaluates these methods and approves those methods that meet its requirements for monitoring organic, inorganic, or microbiological contaminants. The purpose of developing and using EPA-approved and other acceptable standard methods is to ensure consistency and quality of analytical results. Furthermore, only certain methods may be used for compliance monitoring (e.g., of wastewater or drinking water); requirements for recreational water monitoring may not be as strict, but some states may have requirements or preferences for the use of certain methods for recreational water quality monitoring in some situations. Check with your state to identify any such requirements.

EPA-approved and other standard methods for the analysis of bacterial indicator organisms are listed in Table 4-2. For more information, see *http://www.epa.gov/waterscience/methods/*.

Table 4-2. EPA-Approved and Other Acceptable Standard Methods for the Analysis of Bacterial Indicator Organisms in Ambient Waters

Bacterial Indicator	EPA-Approved and Other Acceptable Standard Methods[1]	Type of Analysis[2]
E. coli	EPA Method 1103.1 (same as Standard Method 9213D (m-TEC)	MF
	Modified EPA Method 1103.1 (modified m-TEC method)	MF
Enterococci	EPA Method 1106.1 (same as Standard Method 9230C)	MF
	EPA Method 1600	MF

[1] Standard Methods are from *Standard Methods for the Examination of Water and Wastewater* (Clesceri et al., 1998). In 2002, EPA intends to publish a revised rule for EPA-approved methods in the Code of Federal Regulations (40 CFR Part 136). The proposed rule, published on August 30, 2001, in 66FR45811, included the Enterolert™ and multiple tube fermentation methods discussed later in this chapter. Also, while some states still use fecal coliform or total coliform as indicator organisms, EPA's *Ambient Water Quality Criteria for Bacteria—1986* (U.S. EPA, 1986) recommends using *E. coli* or enterococci instead and the BEACH Act requires that all coastal and Great Lakes states switch to *E. coli* or enterococci by 2004. Therefore, approved methods for fecal or total coliform are not listed here.

[2] MF = Membrane filtration, described below.

4.3.1 INDICATOR ORGANISM ANALYSIS METHODS

Indicator organism analysis methods generally fall into one of the following two categories:

- *Membrane filtration (MF)* tests, in which samples are passed through membrane filters that are then transferred to petri plates containing selective growth and substrate media (i.e., primary isolation agar or an absorbent pad saturated with selective broth). Bacteria density estimates are based on a direct count of bacteria colonies.
- *Most probable number (MPN)* tests, in which multiple tubes are allowed to ferment for a set period of time. Certain probability formulas are applied to the number of tubes or wells that produce a positive reaction, resulting in an estimate of the average density (i.e., concentration) of target organisms in the sample. (This procedure is used in several standard methods for analyzing fecal and total coliform. It is also used in some methods for measuring *E. coli,* e.g., Colilert™, and enterococci, e.g., Enterolert™.)

The time required for some of the most commonly available and used sample analysis techniques ranges from 24 to 72 hours. This relatively long analysis time is a disadvantage: it can lead to a situation in which the public is exposed to high bacteria levels for the 1 to 3 days it takes to obtain sample results. This problem, which is particularly pronounced for the methods with the longest analysis times, can hinder timely decisions on advisories or closures of recreational water areas and delay public notification. Methods that require 24 hours of analysis time are an improvement over methods requiring even more time, but even a 24-hour turn-around time is not ideal; researchers are working on identifying even quicker, valid methods of sample analysis for recreational water quality.

The Charles River Basin/Boston Harbor, Milwaukee/Racine, and Rhode Island projects all use one or more of the methods listed in Table 4-2. Some of the projects involved evaluations of alternative methods that require 24 hours or less for sample analysis; the projects sought to determine whether use of these methods could reduce sample analysis time and provide more time-relevant information to the public.

Table 4-3 lists the bacterial indicator organism analysis methods used by each of the three case study projects, including required analysis times. The following subsections discuss the alternative methods evaluated.

Table 4-3. Analysis Methods Used by the Three Case Study Projects

Project	Bacterial Indicator	Test Method	Analysis Time
Charles River Basin/ Boston Harbor Beaches Project	Fecal coliform	Standard Method 9222D	24 hours
	Enterococci	EPA Method 1106.1	48 hours
		EPA Method 1600	24 hours
Milwaukee/Racine Community Recreational Water Risk Assessment and Public Outreach (Beachhealth)	*E. coli*	EPA Method 1103.1 (Standard Method 9213D [m-TEC])	24 hours
		Pilot study method (not recommended by Milwaukee/Racine program)	6 hours
Rhode Island Beach Monitoring Project	Fecal coliform	Standard Method 9221B and E (with EC broth)	48–72 hours
		Standard Method 9221E (A-1)	24 hours
	E. coli	EPA Method 1103.1 (Standard Method 9213D [m-TEC])	24 hours
	Enterococci	EPA Method 1600	24 hours
		Enterolert™	24 hours

4.3.1.1 CHARLES RIVER BASIN/BOSTON HARBOR BEACHES PROJECT

As part of the Charles River Basin/Boston Harbor Beaches Project, the MDC compared EPA's enterococci methods (Method 1106.1 and Method 1600). Method 1106.1 requires an incubation time of 48 hours, while the incubation time for Method 1600 (released by EPA in 1997) is 24 hours. Thus using Method 1600 can result in faster, more timely public notification of recreational water quality information.

To compare the accuracy of both methods, MDC collected split samples on a weekly basis at 38 sites (representing 20 beaches) during the June-through-August beach season. The split samples were compared statistically; both methods were found to give similar results, and both demonstrated comparable accuracy and precision. Method 1106.1 resulted in a false positive rate of 4 percent, compared to a 2 percent rate for Method 1600. False negative rates were 8 percent for Method 1106.1 and 7 percent for Method 1600. The precision rate for Method 1106.1 was 38.7 average relative percent difference (RPD), while Method 1600 had a similar precision rate of 45.2 average RPD. MDC concluded that Method 1600 may result in a slight, but probably insignificant, increase in beach postings. Method 1600 has the advantage of enabling the MDC to sample area beaches one day closer to the weekend, which is when the greatest beach use occurs. Because of the advantages and relative accuracy of Method 1600, MDC has switched from Method 1106.1 to Method 1600.

4.3.1.2 MILWAUKEE/RACINE BEACHHEALTH PROJECT

For the Beachhealth project, a 6-hour method was compared to traditional analysis methods. The data collected from the 6-hour alternative method were found to be inconsistent, and the test often took much longer than was predicted, requiring a 7.5-hour incubation instead of the expected 6 hours. This test method also took longer than expected for the filtering of turbid samples. The Milwaukee/Racine Beachhealth Project concluded that this 6-hour method was not a satisfactory solution to reducing the time needed for sample analysis.

4.3.1.3 RHODE ISLAND BEACH MONITORING PROJECT

The Rhode Island Beach Monitoring Project evaluated and compared several analytical methods to determine whether the state could switch to a faster method. The project compared two methods for fecal coliform analysis, including the Standard 48-hour MPN Method (9221B and E, with EC broth) it had been using and a 24-hour method (9221E [A-1]). Seeking to find faster methods that might also meet BEACH Act requirements, the Project also tested two analytical methods for enterococci: the 24-hour EPA Method 1600 and another 24-hour method, called Enterolert™. In addition, Rhode Island tested an *E. coli* method (EPA Method 1103.1, which is the same as Standard Method 9213D [m-TEC]). In some cases the results varied among the different methods tested, but, for the majority of samples, all of the methods used would result in the same action taken. Rhode Island concluded that:

- Standard Method 9221E (A-1), with its 24-hour reporting time, is quicker but requires the most man-hours. This method underestimates bacteria counts at higher densities, but as long as Rhode Island continues to use a (very protective) 50 CFU/100 ml (fecal coliform) water quality standard, this underestimation does not change the acceptability of the method's results for this state. Since concluding this project, Rhode Island has switched to using Standard Method 9221E (A-1) in monitoring recreational waters.
- In anticipation of a switch to using enterococci as an indicator organism, Rhode Island concluded that the Enterolert™ method was its preferred method for beach water quality analyses. EPA is currently considering this alternative method for inclusion as an EPA-approved method. EPA Method 1600 was problematic in Rhode Island's comparative tests because it resulted in filter clogging and poor verification of positive colonies.

4.4 PREDICTIVE MODELS

The primary goal of a beach/recreational water quality monitoring program is to minimize the public health risk associated with infectious diseases caused by exposure to harmful microorganisms. As discussed in Section 4.3, laboratory methods commonly used to analyze potentially harmful microorganisms can take from 24 to 72 hours. To address the public health risks associated with this delay, health agencies need additional tools that can provide a rapid, reliable indication of water quality conditions. The use of validated predictive models to supplement monitoring can meet this need, providing quick, conservative estimates of bacterial indicator organism levels.

Developing a predictive model requires a large amount of data. These data are correlated with other relevant factors—such as rainfall, tides, and number of bathers—that can affect bacteria levels or the probability that a water quality standard will be exceeded. An equation (algorithm or calculation) is developed that defines the relationships between the different variables (e.g., bacteria density, rainfall, etc.). The model is then verified by plugging actual monitoring results into its equation to see if the model reflects actual conditions. If it does not, it is adjusted until a fully calibrated and verified model is developed.

Predictive models for beach/recreational water quality often correlate elevated levels of bacterial indicator organisms with environmental factors that can influence bacteria levels, such as rainfall or the number of bathers using a beach. While elevated bacteria counts often correlate with rainfall events, defining a relationship can be difficult. Rhode Island, for example, was not comfortable enough with the relationship between bacteria levels and 3-day cumulative rainfall to adopt a rainfall-based predictive model. Other factors, such as fecal contamination from large concentrations of waterfowl, decaying beach vegetation, and water conditions, may also impact bacteria levels; these factors can be used in a model. Any validated predictive model needs to address program-specific conditions and elements.

The Milwaukee Health Department uses a rainfall-based model in conjunction with monitoring of *E. coli* levels at South Shore Beach in decisions regarding beach advisories. Water quality at South Shore Beach may be influenced by several environmental factors affecting the Milwaukee River watershed, which contains hundreds of storm-water outfalls and several CSOs. The watershed drains to Lake Michigan just north of South Shore Beach, where a southward current is generally present. South Shore Beach water quality may also be affected by effluent from a sewage treatment plant, sewage treatment bypass, and other sources, including waterfowl, domestic pets, and litter from bathers. The Racine Health Department does not use a rainfall-based model at this time; one of the objectives of the Beachhealth project was to collect data to explore the possibility of using a rainfall model for Racine.

One of the monitoring objectives of the Charles River Basin/Boston Harbor Beaches Project was to develop a predictive model relating rainfall and CSO operations to bacterial indicators at four Boston Harbor beaches. The four beaches were sampled seven times per week and analyzed for fecal coliform and enterococcus. Rainfall gauges were also installed close to these beaches.

A simple rainfall model for each individual Boston Harbor beach was developed. Data analysis showed that that previous day's rainfall predicted water quality better than the previous 24-hour enterococcus measurement. A combined rainfall and bacteria protocol was implemented for beach postings.

For the Charles River, the Charles River Watershed Associaton developed a conservative in-house model/protocol, based on historical data to predict whether bacteria levels would exceed the boating standard for fecal coliform of 1,000 CFU/100 ml. CRWA then modified the protocol for the four sites monitored under the EMPACT project, and modified it again for the 2000 monitoring season. The model determined the appropriate water quality notification level based on antecedent rainfall data and CSO activation.

CRWA analyzed the success and accuracy of the model by determining whether a strong or weak relationship existed between fecal coliform and total rainfall over a certain period of days and by assessing whether the predicted water quality was the same as that indicated by sample analysis. Overall, the model was found to predict water quality conditions fairly accurately, and CRWA determined that the correct water quality notification flag was used 84 percent of the time. The comparison also showed that the predictive model tended to err on the conservative side, declaring that water quality posed a potential health risk when the sampling results showed that it did not.

For more information on predictive models, including different types of models, see EPA's Beach Guidance Document (U.S. EPA, 2002) at *http://www.epa.gov/ost/beaches/technical.html*.

4.5 INTERPRETATION AND USE OF MONITORING AND MODELING RESULTS

Water quality sampling results and predictive modeling results need to be interpreted by designated, qualified public health officials, environmental pollution managers, or beach managers; these people are in a position to determine whether a health risk exists and what appropriate action, if any, should be taken. Possible actions range from a posting, warning, or advisory to closing the beach and prohibiting people from using the recreational water there until further testing or model predictions indicate that bacterial indicator levels no longer exceed water quality criteria.

EPA recommends closing or posting a beach when there is an exceedance of water quality standards or when a predictive model indicates a likelihood of an exceedance. However a state chooses to respond to exceedances, *it is important that authorities responsible for interpretation of water quality monitoring results develop policies and procedures that are clear and specific (i.e. specify what actions are to be taken).* For example, a policy could state that if a single monitoring result exceeds the single-sample criterion value listed in the state's recreational water quality standard, an advisory will be issued and an additional sample will be taken from that location within 24 hours. If the second sample still exceeds water quality criteria, a beach closing will be issued.

Likewise, clear procedures should be established for the lifting of an advisory or closing and the reopening of a beach. For example, one aspect of a reopening policy could state that a closed beach is to be resampled within a specified time period. The decision to either issue or remove an advisory or closing should be based on statistically valid data and an assessment of risks to potential swimmers and other water users. The beach closing and reopening procedures used by the three case study projects are summarized in Table 4-4.

The Rhode Island Beach Monitoring Project's procedures for beach closures, for example, specify that decision-makers must consider (1) whether a direct sewage discharge has been identified in the immediate bathing area and (2) whether any relevant regulations have been violated, as well as other factors, in determining whether to take action that could result in closure. After a single high bacteria count is found, the procedures specify, decision-makers must review the beach profile (e.g., history) of the site. If the site is located near a CSO or if there are recent reports of a discharge from a nearby wastewater treatment plant, the beach is closed immediately and resampled. Other area beaches are also resampled. If a second sample exceeds the criteria, the beach is closed using the following procedures:

- Notify appropriate municipal and state officials.
- Post advisory or closure notices (e.g., change the flag posted at the beach) as needed.
- Issue a press release and update the Web site and hotline with current conditions.

On beaches with more than one sampling location, the beach is closed immediately if measurements from the majority of the sampling stations exceed the criteria.

Beaches are resampled daily until testing shows that bacteria levels have dropped below the criteria. Rhode Island's reopening procedures involve:

- Notifying town and state officials of the reopening, including flag changes needed.
- Updating the Web site and hotline with new test results and an indication of the reopening.
- Resuming normal sampling procedures.

Chapter 6 of this document discusses techniques for the posting and public notification of water quality results.

Table 4-4. Beach Closing and Reopening Procedures of the Three Case Study Projects

	Charles River, Massachusetts	Boston Harbor, Massachusetts	Milwaukee/Racine, Wisconsin	Narragansett Bay, Rhode Island
Water Quality Criteria Used (If criteria are exceeded, action is taken, e.g., an advisory/posting or a closing)	Fresh water, secondary contact waters (e.g., boating), geometric mean: FC < 1,000 CFU/100 ml; also FC < 2,000 CFU/100 ml (≤10% single samples)[1] Class B waters for swimming/fishing, geometric mean: FC < 200 CFU/100 ml; also FC < 400 CFU/100 ml (≤ 10% single samples) (Criteria are based on state water quality standards. Note that Massachusetts is considering changing from fecal coliform to E. *coli* or enterococci.)	Marine water, single samples: enterococci < 104 CFU/100 ml Marine water, geometric mean of most recent five samples within the same bathing season: enterococci < 35 CFU/100 ml (Criteria are based on state water quality criteria and state public health code.)	Fresh water, single samples: *E. coli* < 235 CFU/100 ml (general recreational water use)	Salt water, swimming/boating, geometric mean: FC < 50 MPN/100 ml[1] Saltwater, swimming/boating: FC < 500 MPN/100 ml (≤10% of single samples) Saltwater: To be conservative, if a single sample exceeds the geometric mean, the beach is retested or closed. Fresh water (swimming), geometric mean: FC < 200 MPN/100 ml
Beach Advisory/Closing Procedures	Posting of water quality flags (blue = suitable boating conditions; red = potential health risks associated with elevated bacteria counts) are based on estimates of the previous day's fecal coliform concentrations, 24-hour rainfall levels, and/or combined sewer overflow. To be conservative, boathouses are posted with red flags if a single sample exceeds the geometric mean of 1,000 CFU/100 ml FC.	Whenever water contamination exceeds criteria, or after any significant rainstorm (particularly at beaches with a history of violations of water quality requirements), a swimming advisory sign is posted at the entrance to each parking lot and beach. Flags are changed from "blue" (indicating good swimming conditions) to "red" (indicating potential health risks associated with elevated bacteria counts).	Milwaukee Health Department uses *E. coli* and rainfall data for the past 24 to 90 hours in a model, and Racine Health Department uses *E. coli* data for issuing advisories. The state issues advisories to counties, which decide whether to close a beach. (Counties almost always follow state advisories). A "good" rating = yesterday's *E. coli* < 235 CFU/100 ml; a "poor" rating = yesterday's E. coli > 235 CFU/100 ml if there was a recent rainfall or > 500 CFU/100 ml if not; other environmental conditions are also considered (e.g., high wave action may clear bacteria from an area).	Beaches are closed based on fecal coliform exceedances and known or potential sources of contamination. Each beach or sampling site is unique and possesses its own history, which may play a role (based on prior releases) in deciding whether or not a specific beach should be closed. If a release near a beach occurs from a prior source of contamination (e.g., wastewater treatment plant, combined sewer overflow), the Department of Health closes the site preemptively, without waiting for analysis results. If noncompliance with the state standard still occurs after resampling, the bathing area is closed. It is tested every day and does not reopen until test results fall below criteria. Rhode Island's program uses a flagging system similar to Boston's.
Beach Reopening Procedures	River areas reopen based on either monitoring results indicating that criteria are no longer exceeded, or on 4th or 5th day (depending on the amount of rainfall) after a significant rainfall event.	The beach is resampled on the same day of exceedance; if it still exceeds criteria, or if a significant rainfall has occurred, it remains closed for the next 6 days. It is then reopened if monitoring results indicate that its water meets criteria.	The beach reopens if the previous day's *E. coli* level < 235 CFU/100 ml, or if the level has dropped with no recent rainfall and a further drop is expected to result in a level < 235 CFU/100 ml, based on historical experience.	The beach is reopened if five consecutive samples collected at least 24 hours apart are at or below the fecal coliform standard. Upon reopening, at least three samples are collected each week for 3 months.

[1] CFU = colony-forming units; ml = mililiters; FC=fecal coliform; MPN= most probable number.

5 DATA MANAGEMENT

Managing data efficiently can contribute to quicker dissemination of water quality results and reduce potential public exposure to contaminated waters. The key elements of data management for beach and recreational water quality programs are shown in Figure 5-1. Data management can be broadly defined as the handling of sample data results (e.g., recording and analyzing laboratory results) as well as the delivery of the results to the public (e.g., through Web sites, telephone hotlines, on-site warning flags). This chapter presents some design considerations for data management systems, provides examples of the data management approaches used by three beach and recreational water quality monitoring projects, and focuses on one aspect of data delivery to the public—Web site development. Additional methods for public notification and risk communication, as well as more information on using Web sites for these purposes, are discussed in Chapter 6.

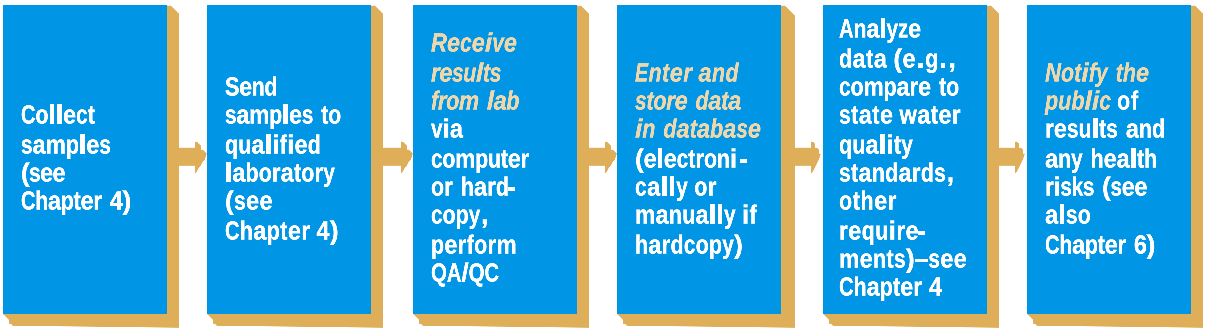


Figure 5-1. Data flow for beach/recreational water quality results. Highlighted steps are covered in this chapter.

As Figure 5-1 shows, water quality samples are collected (as described in Chapter 4), then taken or sent (e.g., via courier), using proper QC procedures, to a qualified laboratory. The laboratory determines the densities of indicator organisms of pathogenic bacteria present. The laboratory then communicates the results to water quality authorities via hardcopy reports, fax, or electronic transfer of results from the laboratory data-base system. Methods for sending these results as soon as they become available should be included as SOPs in your program. Your program staff then enters these laboratory data into your database (via electronic data transfer, or manually for hardcopy data) for analysis, comparing them to state water quality criteria (see Chapter 3) and any other requirements that might trigger certain actions. The results are then delivered to the public, e.g., via the Internet (see Section 5.3) and other communication methods (see Chapter 6).

5.1 DESIGN CONSIDERATIONS FOR A DATA MANAGEMENT SYSTEM

This section describes some of the important considerations for designing a data management system, the use of spatially related data (such as geographic information systems, or GIS), considerations for enhancing an existing system for a time-relevant beach/recreational water quality monitoring program, and QC and data security considerations.

5.1.1 DESIGNING OR MODIFYING A DATA MANAGEMENT SYSTEM TO MEET PROGRAM OBJECTIVES

The best design for a data management system depends on the needs and objectives of your program. An information systems expert can help you identify the best system design based on your answers to the following questions:

- What are the program's data needs?
- How are the data results received (manually or electronically)?
- What hardware and software infrastructure is currently available?
- What personnel are available to maintain the data management system?

When designing a data management system, consider the following factors:

- ***Data storage and retrieval system.*** You will need a central repository, such as an electronic database, within which to organize and store laboratory results. For bacterial indicator organisms, laboratory data results are often entered into a central database from hardcopy result reports, although electronic transfer may be an option. The central database can be as simple as a collection of spreadsheets or as complex as a full-scale relational database.
- ***Data delivery system.*** A data delivery system is a method of distributing data to your audience.Examples of data delivery systems include Web sites, newspaper and television forecasts, and signs. Software and Web sites are increasingly used for data delivery. An effective electronic data delivery system includes a method to convert database files into an easily understood format for the Web and open-access formats that allow the public to make secondary use of data. Database files can be converted for use on the Web using a variety of software, both off-the-shelf and customized.
- ***QA, QC, and data security procedures.*** These include processes used to ensure accurate transfer of data from the laboratory to the central database; provide timely maintenance, backup, and archiving of the central database; and protect the database and Web site from unauthorized access.

  For guidance on QA/QC and security planning, see *EPA Guidance for Quality Assurance Project Plans* at *http://www.epa.gov/quality/qs-docs/g5-final.pdf*.

Important questions to ask your information systems expert are:

- How will the data management system preserve data quality, assurance, and integrity?
- How will data be maintained (back-ups or archives)?
- How will the data be delivered to the public via the Web? What are the system's software and personnel needs?
- How will Web content be updated and maintained?

An existing data management system can be used for a time-relevant water quality monitoring program if it meets the following fundamental objectives:

- To collect and manage microbiological data, as well as handle predictive model data if such a model is used.
- To communicate the data results as quickly as possible to the public.

If your existing data management system cannot accomplish these tasks, you can probably modify it with the assistance of an information systems specialist.

5.1.2 SPATIALLY RELATED DATA (SUCH AS GIS)

A spatially related data system relates data to a physical location that then can be shown visually—for example, in the form of maps. A popular medium for spatially related data is the Geographic Information System (GIS), which can display, analyze, and model spatially related information. GIS technology allows users to quickly overlay several data layers (such as water resources and land uses) and view them at once; a GIS can be designed so that its users can view and compare different future scenarios and their possible impacts. Often a GIS is set up so that users can retrieve information, generate maps (including customized maps), and query data simply by clicking on a map feature. Some GIS maps are useful only for particular geographic locations. GIS has been used by state agencies for watershed protection, Total Maximum Daily Loads development, and implementation of other water quality programs.

To generate and display spatially related data, data management systems must include specific location information such as latitude and longitude or street addresses. Detailed data usually need to be input into the system by skilled staff; this process can be labor-intensive and fairly expensive. Once developed, GIS maps are relatively easy to use and understand by local officials and the public. State environmental agencies and private organizations are increasingly developing GIS maps that include a variety of environmental features relevant to water quality; these maps may be readily available at no cost for display and use, including through the Internet.

Software applications available for spatially related data range from simple and free software applications to customizable data management systems designed specifically for integrating GIS data with the Internet. For communicating beach water quality data to the public, only simple applications are usually needed.

5.1.3 QUALITY ASSURANCE/QUALITY CONTROL

All water quality monitoring projects should have QA/QC plans that include SOPs for data entry, QA/QC protocols to check and validate the data, and protocols for system tests/audits to verify that the system is producing expected results. See Section 4.2 for more information on QA/QC plans.

5.2 DATA MANAGEMENT SYSTEMS USED BY THE CASE STUDY PROJECTS

5.2.1 SELECTING A DATA MANAGEMENT SYSTEM

The three case study projects discussed in this handbook developed their data management systems after considering the following factors:

- ***Data needs:*** factors such as the number of water quality monitoring stations, sampling frequency, and data retrieval and storage needs.
- ***Technical and human resources:*** the software, hardware, and human expertise available to maintain and operate the data management system.
- ***The existing database structure:*** the need to ensure that existing (historical) data as well as new data can be incorporated in the system to provide a complete historical context for the monitoring project.
- ***The ease of use and flexibility of the system:*** factors, for example, that impact the software/hardware, training costs, and longevity of the system.

All three case study projects use off-the-shelf technologies to store monitoring data and update Web content. The software selected was based on ease-of-use considerations and experience with particular software already used for data storage. Using these software platforms, project staff constructed (or modified) databases to accommodate any new data to be collected and to communicate these data to the public in meaningful ways. They based the design of their databases and Web sites on the factors mentioned above. Information technology specialists helped project staff design and implement the systems.

5.2.2 ALTERING EXISTING SYSTEMS TO MEET PROJECT OBJECTIVES

All three case study projects enhanced their existing data management systems to meet project objectives. Table 5-1 describes how the projects altered their systems to meet new project objectives.

Table 5-1. Changes Made to Existing Data Management Systems To Meet Project Objectives

Project	Web Site Management	Changes Made to Existing Data Management Systems
Charles River Basin/Boston Harbor Beaches Project	Some project partners host their own Web sites, while others use an outside Internet service provider/vendor.	• Added a Web site with daily, monthly, and historical data.
Rhode Island Beach Monitoring Project	The Rhode Island Department of Health hosts its own server.	• Created a Web site with beach closure information and access to daily, monthly, and historical data.
Milwaukee/Racine Community Recreational Water Risk Assessment and Public Outreach (Beachhealth)	The U.S. Geological Survey hosts the Web site.	• Automated monitoring equipment and Web-based data entry forms. • Added a Web site with beach closure information and access to daily and historical data.

In some cases (e.g., for the Charles River Basin/Boston Harbor and Rhode Island projects), an increase in the frequency of monitoring contributed to the need to alter or expand data management systems. Table 5-1 shows the changes these projects made. The decision to host your own Web site or use an Internet service provider will depend on your program's priorities and available resources. For example, you may be able to convey data more quickly if you host your own server, but achieving this quicker delivery may incur additional costs, including more labor for Web site maintenance, quality control, etc. In addition, keep in mind that there are ways other than Web sites to communicate your data, such as telephone hotlines, signs, and the media, as discussed in Chapter 6.

5.2.3 SYSTEM USE AND MAINTENANCE

Data entry, validation, and maintenance are critical to providing accurate data to the public. In the context of a data management system, this involves entering data into a central database, performing QA/QC procedures, updating Web content, and performing regular backup and archival operations. All programs must strike a balance between providing timely data and ensuring data quality. Addressing this challenge is an important part of the QA/QC plan.

The project partners involved in the Charles River Basin/Boston Harbor Beaches Project use a variety of different software and data entry and validation procedures:

- ***The MWRA laboratory*** enters sampling data into a Laboratory Information Management System for validation and QA/QC. After QA/QC, the MWRA uploads data to a database on a server on the MWRA's internal network, then formats the data for the Web.
- ***The MDC and CRWA*** receive data from the laboratory via fax, transcribe the data to a spreadsheet file, check the data for accuracy, and then update their Web sites with beach and boating postings.

The Rhode Island Beach Monitoring Project follows procedures similar to those of the CRWA. The Rhode Island staff manually enter data into a spreadsheet, check the data for accuracy, and upload the data to their Web site.

The Milwaukee/Racine Beachhealth project uses a combination of automated and manual data entry procedures. Meteorological and lake condition data are retrieved via automated telephone modem transfer and uploaded directly to a database. Water quality information is entered directly into the database using customized Web-based input forms. Data validation occurs before the forms are submitted to the database. After submittal, these data are immediately available to the public via the Beachhealth Web site. Figure 5-2 shows a data query form that the public can use on the Beachhealth Web site to obtain beach water quality information, based on which parameters they select.

Maintenance procedures are typically based on those already in place for the project's computer network. In all three case study projects, the network and data management database are routinely backed up and archived.

Data Management Partners

Beach/recreational water quality monitoring project staff and associated partners can learn from one another in developing a data management system, and can also share data management system responsibilities. For example, the Charles River Watershed Association's Web site design for the Charles River Basin/Boston Harbor Beaches Project was used as a starting point for the Rhode Island Bathing Beaches Monitoring Project Web site. The Rhode Island project's data management system is managed by the Rhode Island Department of Health, whereas the Charles River Basin/Boston Harbor project's three program partners maintain separate data management systems but share their data. For example, the Massachusetts Water Resources Authority stores data for 17 beaches in a database, assists in analysis, and provides daily bacteria and rainfall data on its Web site for five of the beaches that have a history of being contaminated; the Metropolitan District Commission uses the monitoring results from the 17 beaches for a telephone hotline, to issue flags at the beaches, and to place flag icons on its Web site that advise the public on recreational water use.

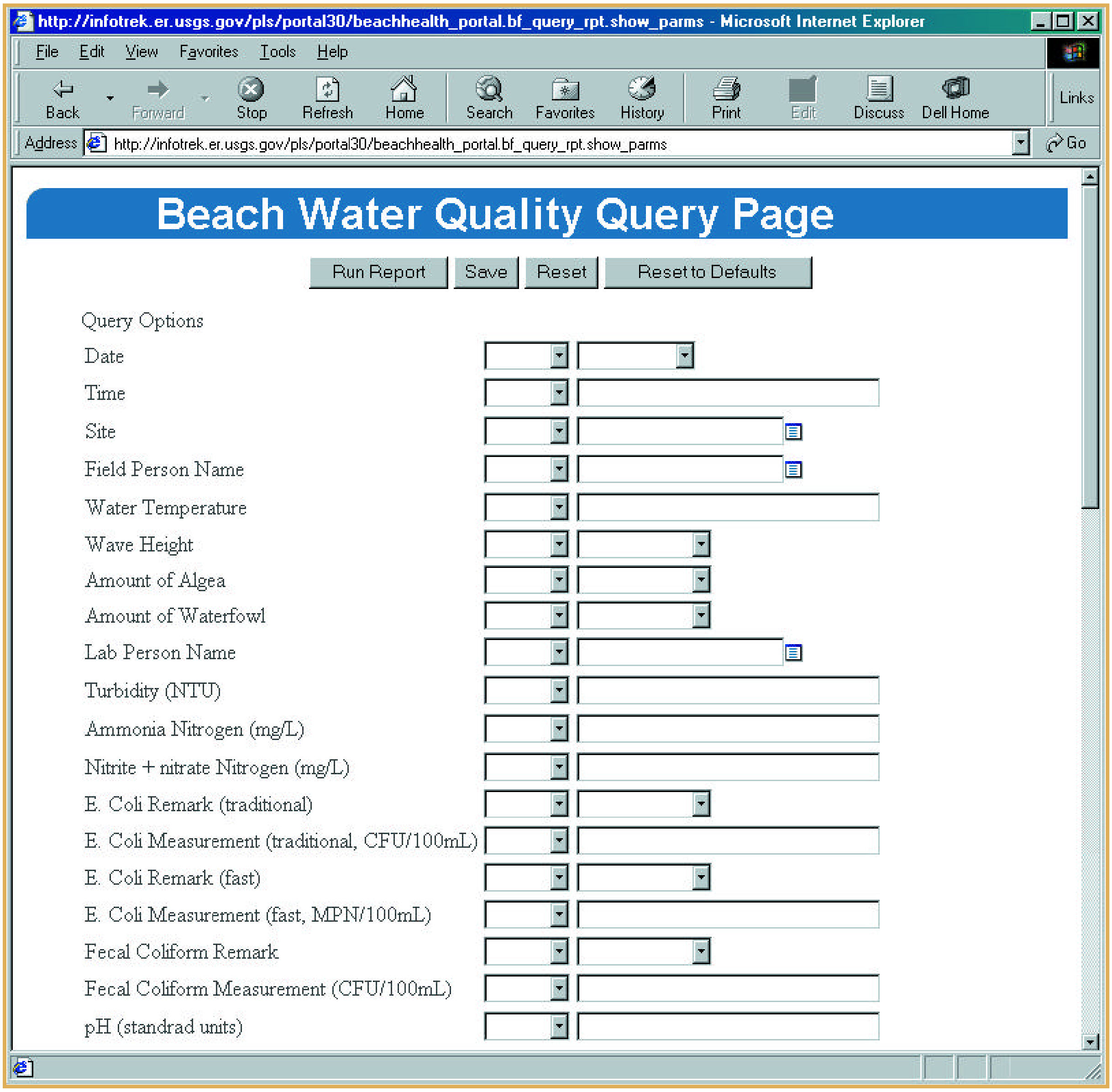


Figure 5-2. Sample data form available to the public on the Milwaukee/Racine Beachhealth Web site.

5.2.4 SYSTEM SECURITY

At its most basic, ensuring the security of a data management system involves restricting access to the database and the software and processes used to update Web content. All three case study projects use password protection to limit access to their Web development software: to update Web content, a user must enter a valid user ID and password to access the appropriate files. The projects also use additional security steps, such as placing their databases behind firewalls with no connection to the Internet.

The Milwaukee/Racine Beachhealth project database is linked to the Web but has additional safeguards—for example, the general public may not modify the database (other than filling out a site feedback form), and the code that describes how the Web interface program is designed is hidden (in a package of procedures inside the software). The latter measure prevents unauthorized users from accessing database tables or passwords or otherwise disturbing database integrity.

5.3 DATA DELIVERY VIA THE WEB

5.3.1 WEB CONTENT

All three case study projects use their Web sites to provide time-relevant water quality information to the public. Table 5-2 describes the main content of each of the Web sites.

Table 5-2. Web Content of the Three Case Study Projects[1]

	Web Content
Charles River Basin/Boston Harbor Beaches Project • CRWA *http://www.crwa.org*	• Color-coded maps of Charles River water quality for each month in the current year. • Tables of historical Charles River water quality data. • Latest available boating flag notice and sampling data for eight Charles River locations. • Results from 1998, 1999, and 2000 daily sampling.
• MDC *http://www.state.ma.us/mdc*	• Latest available water quality notices and water temperature for 17 Boston-area beaches.
• MWRA *http://www.mwra.state.ma.us*	• Latest available water quality and rainfall data for five Boston-area beaches.
Rhode Island Bathing Beaches Monitoring Project *http://www.healthri.org/environment/beaches/index.html*	• Latest available beach closure information. • Tables of beach water quality data for over 100 beaches from 1995 to present. • Additional beach- and bather-related information.
Milwaukee/Racine Community Recreational Water Risk Assessment and Public Outreach (Beachhealth) *http://infotrek.er.usgs.gov/pls/beachhealth*	• Latest available beach water quality conditions for 11 Milwaukee/Racine-area beaches/recreational waters. • Real-time meteorological and lake conditions. • Dynamic query access to beach, river, and harbor water quality data for the 1999–2001 swimming season. • Dynamic query access to meteorological data for the 1999–2001 swimming season.

[1] These Web sites may be inactive when it is not beach season.

The Web sites of the Charles River Basin/Boston Harbor project and the Rhode Island Beach Monitoring Project display icons of the different-colored flags the projects use at beaches, as well as explanations of the flags (see Figure 5-3). These projects' Web sites also provide access (via static tables or online query) to historical data for secondary analysis. Clicking on the beach name links the user to the historical water quality data profile. Summary tables for the 1999 and 2000 data are also available for all sampling sites. In addition, the Rhode Island Web site provides a list of current beach closures. The Milwaukee/Racine Web site provides links to static monthly sampling data and to a dynamic query interface through which a user can generate customized reports.

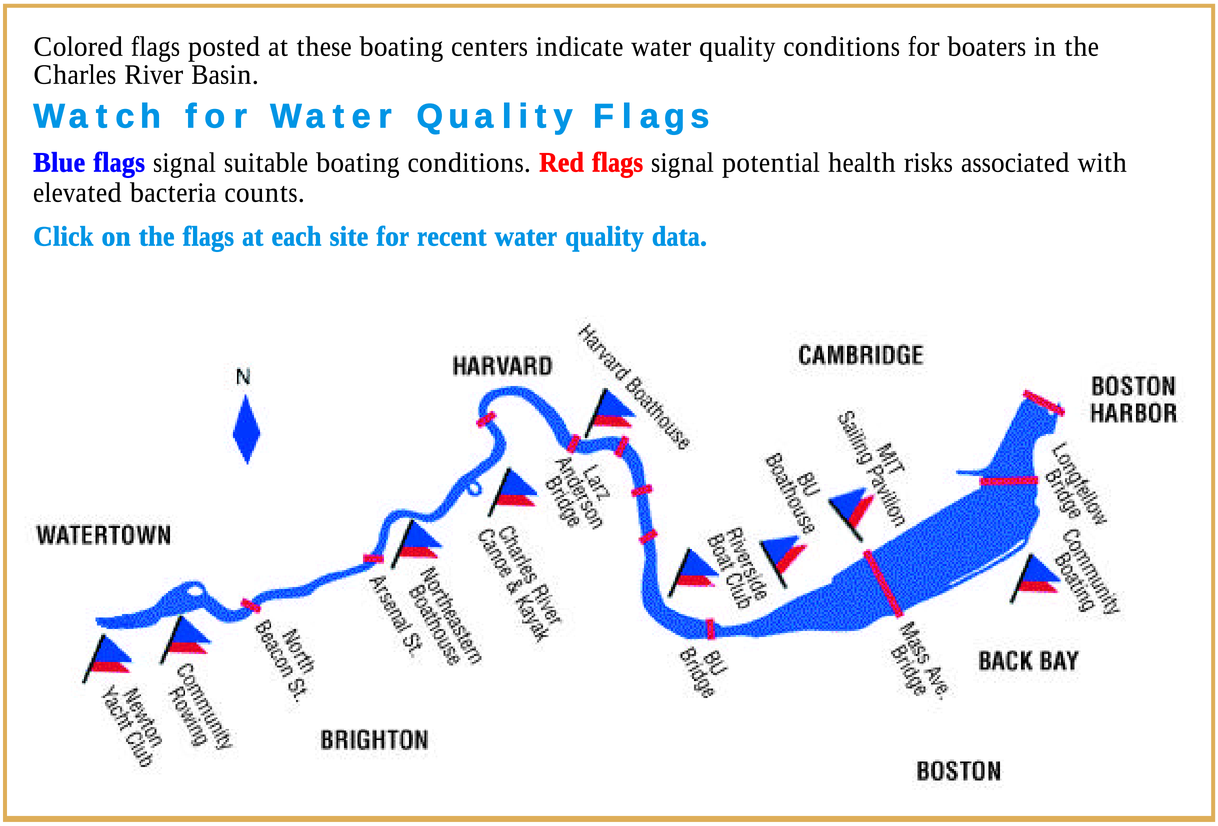


Figure 5-3. Colored flag icons used in the Charles River Basin/Boston Harbor Beaches Project to indicate water quality. *Source:* Charles River Watershed Association *(http://www.crwa.org).*

5.3.2 FUTURE WEB SITE GOALS

Developing a data management system is often an iterative process, in which a program begins with a relatively simple system and then enhances the system as program goals and technologies evolve. Taking this approach allows the program to get started in a reasonable time frame and to further improve service to the public over time. All three case study projects plan future enhancements to their Web sites, including:

- Two of the ***Charles River Basin/Boston Harbor Beaches Project*** partners (the MWRA and MDC) plan to provide a tool for predicting water quality (see Chapter 4) based on rain gauge data. This, they believe, will help them better educate the public about water quality issues and provide data on a more real-time basis.
- The ***Rhode Island Beach Monitoring Project*** intends to survey its Web audience to determine how to enhance its Web site, with the aim of giving the public a better context for understanding water quality information. Project staff expect to add more static maps and, possibly, customized dynamic GIS mapping capabilities.
- The ***Milwaukee/Racine Beachhealth*** project plans to include additional beaches on the Web site as funding becomes available to test the beaches and post the data. Recent enhancements to data input forms will facilitate smooth integration of additional water quality data.

For more information about the future goals of these projects, please visit their Web sites (listed in Table 5-2).

6 PUBLIC NOTIFICATION AND RISK COMMUNICATION FOR BEACH/ RECREATIONAL WATER QUALITY

6.1 INTRODUCTION

One key purpose of a water quality monitoring program is to notify swimmers, boaters, water skiers, fishermen, and other recreational water users of any potential health risks associated with the water at a particular place and time. Once water samples are collected and analyzed and results are compiled (as discussed in Chapters 4 and 5), a system must be in place to quickly communicate the results to the public so that people can make informed decisions about whether to use a particular beach or other recreational water area on a specific day.[4]

A number of municipalities and organizations have developed effective public notification programs for recreational water quality. This chapter presents the general types of information that need to be communicated to the public (Section 6.2), key methods used in selected public notification programs for beaches and other recreational waters (Section 6.3; use of the Internet is discussed in more detail in Chapter 5), additional types of public notification and outreach methods (Section 6.4), and step-by-step information on how to develop an outreach plan for public notification (Section 6.5).

6.2 TYPES OF INFORMATION TO COMMUNICATE TO THE PUBLIC

Agencies and organizations that monitor recreational waters typically need to present one or more kinds of information to the members of the public who use those waters, including:

- *Public health information.* Providing information about the potential public health risks of using beaches and other recreational water areas is a key goal of any recreational water quality monitoring agency or organization. Public health information should include an indication of the level of risks associated with using (e.g., swimming, boating, or fishing in) the waters and a description of associated potential health effects.

- *Monitoring information.* It is important that water quality monitoring programs clearly convey the significance of their monitoring results to the public. This means presenting a clear and simple indication of current water quality and providing additional details for persons interested in more information.

- *Pollution prevention information.* Monitoring agencies and organizations can provide information on pollution prevention while providing public health information and water quality monitoring results. Pollution prevention information often includes information on how pollutants enter the water and what individuals and businesses can do to prevent or reduce this pollution.

- *Self-promotional information.* Members of the public cannot benefit from an information service if they do not know it exists. Therefore, a water quality monitoring organization must advertise its services to the public so that they will think to consult the organization when they have questions about water quality.

[4] This handbook reflects lessons learned primarily through three EMPACT projects initiated prior to the passage of the BEACH Act in 2000 and the publication of *National Beach Guidance and Required Performance Criteria for Grants* (U.S. EPA, 2002). Some of the practices described in these projects may not be consistent with current regulatory requirements and guidance. For updated regulatory and guidance information, see Section 1.2.

6.3 KEY PUBLIC NOTIFICATION METHODS FOR BEACH/RECREATIONAL WATERS

There are many ways to inform the public about recreational water quality. A number of beach and other recreational water monitoring programs, including the three case study projects presented in this handbook (the Charles River Basin/Boston Harbor, the upper Narragansett Bay in Rhode Island, and Milwaukee/Racine projects) have found certain methods to be particularly successful for public notification purposes, including warning flags, signs, hotlines, Web sites, and the media, as described below.

6.3.1 WARNING FLAGS

The use of warning flags involves the posting at strategic locations of different-colored flags reflecting different levels of health risk. For example, both the Charles River Basin/Boston Harbor Beaches Project and the Rhode Island Beach Monitoring Project use flags to give the public a highly visible indication of recreational water quality. Boat houses along the lower Charles River in Boston and surrounding communities are marked with red flags when fecal coliform levels exceed 1,000 CFU/100 ml. Beaches along the Boston Harbor are marked with red flags when enterococci levels exceed 104 CFU/100 ml. At other times, when water quality meets boating or swimming standards set by the Massachusetts Department of Environmental Protection, the river and harbor are marked with blue flags to indicate suitable conditions for these recreational pursuits.

Health Risk Communication: Effective Methods

Health risk communication. **An educational brochure gives river users the following risk communication message about "red flag" days:**

> **"While it is always a good idea to wash after being on the river, it is particularly important on red flag days. Some boaters choose to stay off the river on red flag days because elevated bacterial levels pose a health risk."**

Watch for Water Quality Flags, Charles River Watershed Association

Effective methods. **Boston's Metropolitan District Commission drew the following conclusions about which public notification tools were the most valuable:**

> **"...it seems that the best medium for informing the public has been the flagging and web site. For example, prior to the flagging project many people visiting Wollaston Beach believed that the Beach was permanently closed for swimming [due] to pollution. Now beach goers look for the flags to see if it is safe to swim. Although there are more red flag days than we would like, at least the public is informed about the conditions. As evidence of the public's cognizance of the postings, we haven't had a reported illness as related to the water conditions in several years of which we know."**

2000 Final EMPACT Report, **Metropolitan District Commission**

6.3.2 BEACH SIGNS

All three of the case study projects found beach signs to be useful for notifying the public of potential health concerns at specific beaches. The Milwaukee/Racine project designed special advisory signs with changeable panels that made it possible to update the current date and list water quality as good or poor. ("Good" means that the previous day's *E. coli* levels were lower than 235 CFU/100 ml. "Poor" means that the previous day's *E. coli* levels were higher than 235 CFU/100 ml if a recent rainfall occurred, or were higher than 500 CFU/100 ml if no recent rainfall occurred.) During the summer beach season, the signs are posted at eye level on the backs of lifeguard stands. The Charles River Basin/Boston Harbor and Rhode Island projects use signs to explain their colored flags: the signs explain that red flags indicate poor water quality and blue flags indicate good water quality. If your program is considering using water quality/health risk signs, think about providing them in more than one language—Spanish as well as English, for example. Other languages may be valuable as well, especially if your site is near communities where those languages are spoken.

6.3.3 TELEPHONE HOTLINE

All three case study projects also use telephone hotlines that allow persons without Internet access to obtain timely information about local beaches (e.g., about beach closures). Some beach information hotlines are operational only during the beach season. The Milwaukee/Racine project advertises its bilingual (English/Spanish) hotline on television and postcards (see right). The Charles River Basin/Boston Harbor and Rhode Island projects advertise their hotlines in brochures, Web sites, and newspapers.

6.3.4 PROJECT WEB SITE

Increasingly, beach and recreational water quality monitoring programs are maintaining Web sites as part of their overall public notification and outreach strategies. All three case study projects provide timely information on water quality conditions at monitored locations on their Web sites (as discussed in Chapter 5, Section 5.3). This kind of online information allows people who are interested in swimming, boating, or other water activities to find out if a particular area is closed or poses a potential health risk before actually going there. In addition to water quality results, some beach Web sites include:

- Technical information about how water quality evaluations are conducted.
- Educational information about how the public can prevent future pollution of recreational waters.
- Links to related Internet resources.
- An option for the user to provide feedback to the Web site developers.

6.3.5 NEWS MEDIA

The Charles River Basin/Boston Harbor project and the Milwaukee/Racine Beachhealth project both have extensive experience working with local news media to promote their programs and distribute time-relevant recreational water quality information. For example, the CRWA, one of the partners in the Charles River Basin/Boston Harbor project, was able to get a local television station to broadcast information about the Charles River's water quality on its noon weather forecast and a local newspaper to report this information once a week. The Milwaukee/Racine project educated the public about its services in the news coverage it obtained on local television stations. This project also garnered attention from the news media by sending out frequent press releases and sending daily faxes to media representatives. The Rhode Island Department of Health has developed a standard operating procedure for distributing press releases on beach closings/openings; press releases can be faxed out minutes after the decision is made to close or reopen a beach area.

6.4 ADDITIONAL PUBLIC NOTIFICATION AND OUTREACH METHODS

In addition to using warning flags, signs, telephone hotlines, Web sites, and the media for public notification (as discussed in Section 6.3), the Boston Harbor/Charles River, Milwaukee/Racine, and Rhode Island projects all have used a variety of other mechanisms. Table 6-1 summarizes these additional public notification and outreach methods (those methods used by all three projects are emphasized with shading). The public notification and outreach initiatives listed in Table 6-1 are discussed below, except for those already discussed as key methods in Section 6.3.

Table 6-1. Public Notification and Outreach Initiatives Used by the Three Case Study Projects

	Charles River Basin/ Boston Harbor Project	Milwaukee/Racine Beachhealth Project	Rhode Island Beach Monitoring Project
Advertising and promotional items	✓	✓	✓
Annual water quality "Report Card"	✓		
Beach signs	✓	✓	✓
Printed fact sheets/brochures	✓	✓	
School curriculum materials/teacher training	✓		✓
Kiosks/information booths	✓	✓	
News media	✓	✓	✓
Project Web site	✓	✓	✓
Special public events	✓		✓
Telephone hotline	✓	✓	✓
Visits to local industries/dischargers	✓		✓
Volunteer program	✓	✓	
Warning flags	✓		✓

Advertising and promotional items. The case study projects use a variety of techniques borrowed from commercial advertising, including the distribution of promotional "novelty" items, to increase people's awareness of the program. The Rhode Island Beach Monitoring Project hands out business cards with the address of its Web site to beachgoers on weekends. The Charles River Basin/Boston Harbor project distributes water bottles that display the different-colored flags used to identify whether beaches meet boating and swimming standards. The Milwaukee/Racine Beachhealth project advertised its program on the backs of buses, using bright colors and engaging visuals including cartoon images of children of different ethnic backgrounds playing on the beach with a cityscape in the background; the headline read, "Check out beach water qualities," with a hotline phone number and a Web address prominently displayed. The University of Wisconsin–Extension's Infosource, a resource that assists nonprofit organizations with public outreach, places similar ads at no cost to the Beachhealth program.

Annual "Water Quality Report Card"

Each year on Earth Day, the Charles River Watershed Association (a partner in the Charles River Basin/Boston Harbor Beaches Project) publishes a "report card" that serves as a focal point for media interest. The "grades" (A, B, C, D, and F) are based on the percentage of days on which the lower Charles River was fishable and swimmable during the preceding year and a comparison of bacteria levels to swimming and boating standards. Three letter grades are assigned: one for wet weather, one for dry weather, and one for overall conditions. The grades help provide an indication of the progress being made in river and harbor water quality conditions toward the goal of having these waters be fishable and swimmable by the year 2005.

Fact sheets and brochures. The Charles River Basin/Boston Harbor Project and the Milwaukee/Racine Beachhealth project have developed educational brochures and fact sheets as part of their public education efforts. Milwaukee/Racine Beachhealth, for example, publishes two brochures to educate the public about pollution prevention efforts. One brochure, *It's All Connected,* describes the migration pathways of surface water, drinking water, and wastewater. It also discusses sources of pollution and how target areas are affected. The other brochure, *Simple Solution to Water Pollution: Making Your Home a Pollution Free Zone,* describes how to improve water quality in urban environments. Both of these brochures have been posted on the project's Web site and distributed at festivals and expositions.

School activities and teacher training. The Charles River Basin/Boston Harbor project has worked with the Urban Ecology Institute at Boston College *(http://www.bc.edu/bc_org/research/urbaneco/)* to develop a high-school curriculum based on the work that the CRWA is conducting in the lower Charles River. The curriculum, intended for high schools near this geographic area, teaches basic watershed science and biology and involves tracking the recovery of the Charles River using specially designed field studies that monitor plant and animal activity. The Marine Programs project at the University of Rhode Island plans to sponsor an institute for 20 teachers *(http://omp.gso.uri.edu).* Any teacher from the communities of Rhode Island and Massachusetts that surround Narragansett Bay will be eligible to apply. The teacher institute will focus on a wide range of environmental, historical, cultural, and economic factors affecting local health and the urban coastal environment. Institute products will include materials for incorporation into the project Web site, activity kits for hands-on use in the classroom, and related resource materials. The Milwaukee/Racine project has also conducted teacher training.

Kiosks and information booths. The MDC, one of the Charles River Basin/Boston Harbor Project partners, set up several kiosks on the beaches of Boston Harbor. Each kiosk contains information about water quality monitoring in seven languages: English, Haitian, Spanish, Portugese, Italian, Vietnamese, and Chinese. The Milwaukee/Racine Beachhealth project also used information booths—project staff set them up at several Milwaukee festivals, where they handed out brochures and fact sheets.

Special public events. The Charles River Basin/Boston Harbor Project, in collaboration with a local radio station, sponsored a series of "Back to the Beach" parties in 1998, 1999, and 2000. The events were intended to promote use of local beaches by neighbors and visitors to Boston Harbor. At each event, information on water quality conditions, the flagging system, and online resources was provided to the public.

Volunteer programs. In 1999, the Milwaukee/Racine Beachhealth project collaborated with community environmental educational organizations to create a near-shore volunteer monitoring program. Nearly 50 high-school volunteers tested water quality at 13 different sites throughout the summer. Students gained experience with scientific methods and learned about different kinds of field test kits, different sources of Lake Michigan's pollution, and how rain can alter water quality. This program is being continued on a limited basis.

6.5 DEVELOPING AN OUTREACH PLAN FOR PUBLIC NOTIFICATION

Outreach to the public is a key component of public notification, as discussed in Sections 6.2 and 6.3 above. It is important to define your outreach goals before you develop any outreach activities. It is useful to develop clear, simple, action-oriented statements about what you hope to accomplish through outreach. Once you have established your goals, every other element of the outreach plan should relate to those goals. Answering the following questions can be helpful:

- Who do you want to reach? (Step 1)
- What questions need to be answered? (Step 2)
- What are the most effective ways to reach your audience? (Step 3)

These and additional questions are addressed in more detail below. Developing an outreach plan that addresses these questions helps to ensure that the message of your public notification program is the right one and that it reaches its intended audience.

Lifeguards and Risk Communication

In addition to the more typical outreach activities described in this section, the training of lifeguards in risk communication can be an important part of your outreach program. Lifeguards have a unique and important role in communicating with swimmers and other users of recreational waters and can help provide water quality and health risk information quickly to beachgoers.

An outreach plan provides a blueprint for action and does not have to be lengthy or complicated. An outreach plan is most effective when a variety of stakeholders and people with relevant expertise are involved in its development, such as:

- A communications specialist or someone who has experience in developing and implementing an outreach plan.
- Technical experts in the subject matter (both scientific and policy).

- People who represent the target audience (i.e., the people or groups you want to reach).
- Key individuals who will be involved in implementing the outreach plan, such as beach managers and local health departments.

As you develop your outreach plan, consider inviting other organizations to work cooperatively with you to develop, plan, and implement the outreach effort. Potential partners may include shoreline owner associations, local businesses, environmental organizations, schools, boating or fishing associations, local planning and zoning authorities, and other local or state agencies. Partners can participate in the planning, development, or review of outreach materials, as well as distribution. Partnerships can be valuable mechanisms for leveraging resources as well as enhancing the quality, credibility, and success of outreach efforts.

Developing an outreach plan is a creative and iterative process involving a number of interrelated steps, as described below. As you move through each of these steps, you might want to revisit and refine the decisions you made in earlier steps until you have an integrated, comprehensive, and achievable plan.

6.5.1 STEP 1: WHO DO YOU WANT TO REACH?

6.5.1.1 IDENTIFYING YOUR AUDIENCE(S)

After you identify your goals and put together a development team for your outreach plan, as described above, the next step is to clearly identify the target audience or audiences for your outreach efforts. Outreach goals often define the target audiences. You might want to refine and add to your goals after you have specifically considered which audiences you want to reach.

Your primary audience for public notification and outreach will be users of your beaches and other recreational waters, including swimmers, boaters, water skiers, fishermen, and others. You must reach these people to achieve your goals of public health protection and notification. Your secondary audience might include local decision-makers, landowners, businesses, schools, and other members of the general public who may use the beaches and other recreational waters. Some audiences, such as educators and certain organizations (e.g., fishing and boating clubs), may be willing to help disseminate information to other audiences you have identified, such as the general public.

Consider whether you should divide "the public" into two or more audience categories. For example, will you be providing different information to certain groups, such as citizens and businesses? Does a significant portion of the public you are trying to reach have a different cultural or language background from other members? If so, it may be most effective to consider these groups as separate audiences.

6.5.1.2 PROFILING YOUR AUDIENCE(S)

Outreach will be most effective if you tailor the content, type, and distribution of outreach products to your target audiences. This tailoring can be accomplished by developing profiles of your audiences' situations, interests, and concerns. Such profiles will help you identify the most effective ways of reaching the audience. For each target audience, consider:

- What is their current level of knowledge about recreational water quality?
- What do you want them to know about recreational water quality, and what actions would you like them to take?
- What information is likely to be of greatest interest to them?
- How much time are they likely to give to receiving and assimilating the information?
- How do they generally receive information?
- What professional, recreational, and domestic activities do they typically engage in that might provide avenues for distributing outreach products? Are there any organizations or centers that represent or serve them and might be avenues for disseminating your outreach products?

Profiling an audience essentially involves putting yourself in your audience's shoes. Ways to do this include consulting with individuals and organizations that represent or are members of the audience, consulting with colleagues who have successfully developed other outreach products for the audience, and using your imagination.

6.5.2 STEP 2: WHAT QUESTIONS NEED TO BE ANSWERED?

The second step in outreach planning is to think about what you want to communicate by identifying the questions that your target audience wants answered. One possible way to identify such questions is to distribute a beach/recreational water user survey, if resources are available. For example, a key question that users probably want answered is:

"Is it safe to swim here today?"

Think about the key points, or "messages," you want to communicate. Messages are the "bottom-line" information you want your audience to walk away with, even if they forget the details. Outreach products often have multiple related messages. You may have different messages for different audiences.

6.5.3 STEP 3: WHAT ARE THE MOST EFFECTIVE WAYS TO REACH YOUR AUDIENCE?

The next step in developing an outreach plan is to consider what types of outreach product will best reach each target audience. There are many types of useful outreach products: print, audiovisual, electronic, and novelty items, as well as events, as shown in Table 6-2.

The audience profile information you have already assembled will help you select appropriate outreach products. A communications professional can provide valuable guidance in choosing the most appropriate products to meet your goals within your resource and time constraints. Questions to consider when selecting outreach products include:

- When does your audience need the information to make a timely decision on whether to use a particular beach or other recreational water area?
- What and how much information does your audience really need to know? (The simplest, most straightforward product generally is most effective.)
- Is the product likely to appeal to the target audience? Is the audience likely to take the time to read, view, attend, or purchase the product?
- How easy and cost-effective will the product be to distribute or, in the case of an event, organize?
- What time frame is needed to develop and distribute the product?
- How much will it cost to develop the product? Do you have access to the resources needed for development?
- What related products are already available? Can you build on existing products?
- How newsworthy is the information? Information with inherent news value may be rapidly and widely disseminated by the media.

Table 6-2. Examples of Outreach Products

Print Items	Daily newspaper notices	Press releases
Audiovisual Items	Exhibits and kiosks (with risk information changed daily or near-daily as needed) Cable television programs (if airing is timely)	Radio public service announcements (if made on a daily or near-daily basis)
Electronic Items (Assuming that your audience has access to and uses these products daily or near-daily)	E-mail messages Subscriber list servers	Web pages
Events	(Timely) press conferences	
	For Your Secondary Audience (less "time-relevant" methods)	
Print	Brochures Editorials Educational curricula Fact sheets Newsletters	Newspaper and magazine articles Posters Press releases Question-and-answer sheets Utility bill inserts or stuffers
Audiovisual	Cable television programs	Videos
Events	Briefings Community days Fairs and festivals Media interviews	One-on-one meetings Press conferences Public meetings Speeches
Novelty Items	Banners Bumper stickers Buttons Coloring books	Floating key chains for boaters Frisbee™ discs Magnets Mouse pads

6.5.4 Step 4: How Will Your Outreach Products Reach Your Audience?

Effective distribution is essential to the success of an outreach strategy. There are many avenues for distribution, including those listed in Table 6-3.

Consider how each product will be distributed and determine who will be responsible for distribution. For some products, your organization might manage distribution. For others, you might rely on intermediaries (such as the media or educators) or organizational partners that are willing to participate in the outreach effort. Consult an experienced communications professional to obtain information about the resources and time required for the various distribution options. Some points to consider in selecting distribution channels include:

- How does the audience typically receive information?
- What distribution mechanisms has your organization used in the past for this audience? Were these mechanisms effective?

- Can you identify any partner organizations that might be willing to assist in the distribution?
- Can the media play a role in distribution?
- Will the mechanism you are considering really reach the intended audience? For example, the Internet can be an effective distribution mechanism, but certain groups may have limited access to it.
- Are sufficient resources available to fund and implement distribution via the mechanisms of interest?

Table 6-3. Examples of Distribution Methods

For Your Primary Audience (e.g., beach/recreational water users)	*For Your Secondary Audience*
Phone (including hotline)/fax	Mailing lists (yours and those of partner organizations)
E-mail (assuming that your audience has access)	Journals or newsletters of partner organizations
Web site (if timely updates are possible and your audience has access)	TV and radio (for less time-dependent messages)
TV/radio (if information can be aired timely)	Print media
Print media (for daily beach conditions, and for less timely information, e.g., pollution prevention education)	Hotline that distributes products upon request
	Meetings, events, or locations (e.g., libraries, schools, marinas, public beaches, tackle shops, and sailing clubs) where products are made available

6.5.5 Step 5: What Follow-up Mechanisms Will You Establish?

Successful outreach may generate requests for further information or concern about issues of which you have made the audience aware. Consider whether and how you will handle this interest. The following questions can help you develop this part of your strategy:

- What types of reaction or concern are audience members likely to have in response to the outreach information?
- Who will handle requests for additional information?
- Do you want to indicate on the outreach product where people can obtain further information (e.g., provide a contact name, number, or address)?

6.5.6 Step 6: What Is the Schedule for Implementation?

Once you have decided on your goals, messages, audiences, products, and distribution channels, you will need to develop an implementation schedule. For each product, consider how much time will be needed for development and distribution. Be sure to factor in enough time for product review. Wherever possible, build in time for testing and evaluation by members or representatives of the target audience in focus groups or individual sessions so that you can get feedback on whether you have effectively targeted your material for your audience.

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APPENDIX A: SAMPLE BEACH SURVEY

Bathing Beach Survey

Name of Beach: ______________ Date: __________ Time of Day: _________ Water Temp: _______

Weather Conditions:

Sunny & Clear _______ Cloudy/Overcast _____ Rainy _____ Foggy _____ Windy _______

Tidal Flow:

Slow _______ Moderate ________ High _________ High tide _______ Low tide _______

Activity on Beach:

Approximate # of people _________ Adults _________ Children _______ Swimming _______

Sunbathing _____ Fishing _______ Boating _______ Walking ______ Other activity _______

Conditions of the Beach:

Overall Appearance: _________ Debris on shore: ____________ Debris in water: ______________

Vegetation in water: 1 <25% 2 25% 3 50% 4 75% 5 100% cover

Vegetation in shore: 1 <25% 2 25% 3 50% 4 75% 5 100% cover in 1 meter quadrat

Width of wrack on shore (in meters) _______________________________

Visible Sewage or Sewage Odor __________________________________

Stormwater pipes or other flows across beach _________________________

Conditions of Water:

Clear: ________ Cloudy & Murky: ________ Oily Film: ________

Sources of Pollution:

Water fowl Approximate #—Seagulls _______ Ducks _______ Geese _______ Swans ________

Approximate # of boats: _______

Wind and Weather Conditions:

____

Additional Comments:

____

Source: Rhode Island Department of Health; EPA Region 1

APPENDIX B: EXAMPLES OF SELECTED SAMPLE COLLECTION PROCEDURES

Example 1:

Field Sampling Procedures

The sampler will stand in the water and collect a sample from a minimum of 3 feet of water, adjacent to, but not impacted by, moderate swimmer activity and in an undisturbed area of water. The sample will be taken at least one foot above the bottom. The sampler will stand away from and "downstream from" the bottle.

- Fill pre-labeled, sterile, screw-capped 250 ml Nalgene bottles to 90% capacity.

- Place samples in iced cooler (4°C).

- Maximum holding time: 6 hours (for fecal coliform, enterococci).

- Delivery to the [certified] laboratory within one hour of completion.

Source: U.S. EPA Region 1 and Metropolitan District Commission, 1998

Example 2:

Procedure for Collection of Bathing Beach Water Samples for Bacteriological Analysis

Arrangements with Laboratory: Testing must be performed by laboratories that are licensed by the RIDOH for bacteriological testing of water. Because samples must be collected in sterile bottles and because the laboratory may have special requirements for submissions of samples, be sure to contact the laboratory that will be analyzing the samples prior to collection. The samples must be kept in an iced cooler and must be tested ... following the procedures in the *Standard Methods for the Examination of Water and Wastewater...*

Source: Rhode Island Department of Health, 2001

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