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DRAFT - NATIONAL BEACH GUIDANCE AND PERFORMANCE CRITERIA FOR RECREATION WATERS

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Chapter 1: Introduction

1.1 Program and Document Overview

Coastal and shoreline development, wastewater collection and treatment facilities, septic tanks, animal feeding operations, urban runoff, disposal of human waste from boats, and bathers themselves all contribute to fecal contamination of our nation's recreational waters. People who swim and recreate in water contaminated with fecal pollution are at an increased risk of contracting gastrointestinal disease; respiratory, ear, eye, and skin infections; meningitis; and hepatitis (Rose et al., 1999).

In response to these concerns, the U.S. Environmental Protection Agency (EPA) announced its BEACH Program in 1997. The goal of the program is to assist in reducing the risk of disease to users of U.S. recreation waters by focusing on several key objectives:

1. Strengthening water quality standards for bathing beaches
2. Improving state and local government beach programs
3. Better informing the public
4. Promoting scientific research to better protect the health of public beach users.

Initial efforts focused on current water quality standards, improving our understanding of current state and local programs through national and local conferences, and identifying scientific needs. EPA also started its annual voluntary survey of state and local agencies that monitor water quality at beaches. The *National Health Protection Survey of Beaches* collected information about which local beaches are monitored and what agencies are responsible for beach programs, as well as detailed information about advisories and closures at specific beaches. In March 1999 EPA published the *Action Plan for Beaches and Recreational Waters* (Beach Action Plan), a multiyear strategy that describes the Agency's programmatic and scientific research efforts to improve beach programs and research. It was published jointly by EPA's Office of Water and Office of Research and Development (ORD) and can be accessed at www.epa.gov/ORD/WebPubs/final/ on the Internet. Printed copies of the document (EPA 600-R-98-079) can be ordered through the National Service Center for Environmental Publications (NSCEP), on the Internet at www.epa.gov/ncepi or by telephone at 1-800-490-9198.

1.1.1 BEACH Act

Provisions of the Act

The scope of activities related to managing recreational water quality was changed with the passage of the Beaches Environmental Assessment and Coastal Health Act (BEACH Act). The act was passed on October 10, 2000, and amended the Clean Water Act (CWA) to include section 406. The BEACH Act addresses fecal contamination in coastal recreation waters. It contains three significant provisions, summarized as follows:

1. The BEACH Act amended the CWA to include section 303(i), which requires states that have coastal recreation waters to adopt new or revised water quality standards by April 10, 2004 for pathogens and pathogen indicators for which EPA has published criteria under CWA section 304(a). The BEACH Act amendments further direct EPA to promulgate such standards for states that fail to do so.

2. The BEACH Act amended the CWA to require EPA to study issues associated with pathogens and human health and by 2005, to publish new or revised CWA section 304(a) criteria for pathogens and pathogen indicators based on that study. Within 3 years after EPA's publication of the new or revised section 304(a) criteria, states that have coastal recreation waters must then adopt new or revised water quality standards for all pathogens and pathogen indicators to which EPA's new or revised section 304(a) criteria apply.

3. The BEACH Act amended the CWA to include a new section, section 406, which authorizes EPA to award grants to states for the purpose of developing and implementing a program to monitor, for pathogens and pathogen indicators, coastal recreation waters adjacent to beaches that are used by the public and to notify the public if water quality standards for pathogens and pathogen indicators are exceeded. To be eligible for the implementation grants, the states must develop monitoring and notification programs that are consistent with performance criteria published by EPA under the act. The BEACH Act also requires EPA to perform monitoring and notification activities for waters in states that do not have a program consistent with EPA's performance criteria, using grants funds that would otherwise have been available to those states. A Fact Sheet about the BEACH Act is included as Appendix A. A complete copy of the BEACH Act can be found at http://www.epa.gov/OST/beaches/technical.html

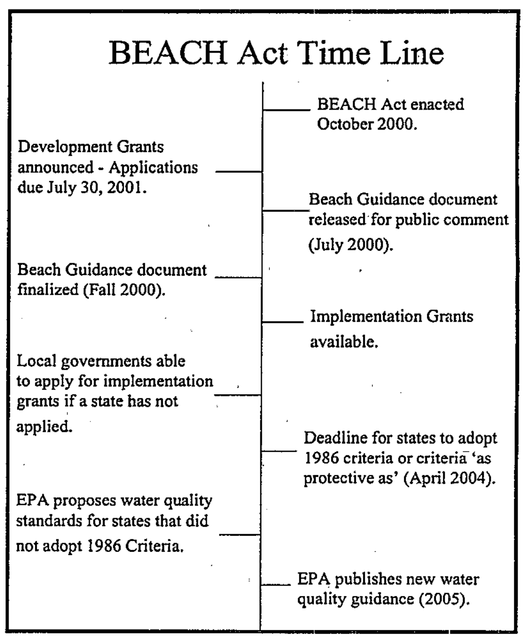

Figure 1-1. BEACH Act time line.

Time Line

Figure 1-1 outlines a BEACH Act time line for EPA, states and local governments.
Section 303(i)(1)(A) of the CWA, as amended by the BEACH Act, requires states that have coastal recreation waters to adopt new or revised water

quality standards for pathogens and pathogen indicators for which EPA has published criteria under CWA section 304(a). Under the statute, states must adopt these new or revised standards by April 10, 2004. If a state fails to adopt water quality criteria and standards in accordance with EPA's 1986 criteria or criteria that are as protective of human health as the criteria for pathogens and pathogen indicators, EPA will propose regulations for the state setting forth revised or new water quality standards for pathogens and pathogen indicators for the coastal recreation waters of the state.

1.1.2 How This Document Should Be Used

For the purposes of this document, recreation water use will be referred to as 'bathing" and "swimming."

This document has three functions. First, it constitutes performance criteria for (a) monitoring and assessment of coastal recreation waters adjacent to beaches (or similar points of access that are used by the public) for attainment of applicable water quality standards for pathogens and pathogen indicators; and (b) the prompt public notification of any exceedance or likelihood of exceedance of applicable water quality standards for pathogens and pathogen indicators for coastal recreation waters. EPA is required to publish such performance criteria under section 406(a). Section 406(b) authorizes EPA to award grants to states and tribes to implement a monitoring and notification program, but only if the program meets certain requirements (See 406(b)(2)(A)(i)-(v)). One of these requirements is that the monitoring and notification program is consistent with EPA's performance criteria. Excerpts from section 406(b)(2)(A) are included in Chapter 2.

Second, this document explains how EPA will evaluate grant applications from states and tribes when deciding whether to award monitoring and notification program implementation grants under section 406(b). This document is intended to be used by potential grant recipients to implement effective programs for monitoring and assessing coastal recreation waters. The next four chapters outline the performance criteria by which EPA will evaluate monitoring and notification programs to determine whether they are consistent with EPAs performance criteria.

Third, this guidance is intended to promote consistency among states, tribes and localities by recommending standard approaches for recreational water quality programs. The document will assist local health departments, water quality managers, beach managers, and other local, state, and tribal agencies to

- Improve microbial water quality monitoring programs for more consistent protection of coastal recreation waters.
- Assess, manage, and communicate health risks from waterborne microbial contamination.
- Notify the public of beach advisories and implement closings to help prevent public exposure to potentially harmful pathogens.

The document can also serve as a reference guide for how and when to conduct preliminary beach assessments, because it includes protocols for water sample collection, sample handling, and laboratory analysis. It provides information about the use of predictive models to estimate indicator levels and includes procedures for public notification about beach advisories, closings, and openings.

1.1.3 Organization of Document

The chapters in this document cover the following topics:

- *Chapter 1* discusses human health concerns and discusses the establishment of water quality standards for bacteria.
- *Chapter 2* addresses the basic requirements that an applicant must meet to receive a program implementation grant. The chapter identifies relevant sections of the BEACH Act, briefly describes the corresponding performance criteria that EPA has developed, and provides additional grant-related information.
- *Chapter 3* describes the risk-based evaluation process that EPA recommends for states and tribes to classify and prioritize their recreational beaches. This step-by-step approach allows states and tribes to assess the relative human health risks and usage of their beaches and assign an appropriate management priority to each of them.
- *Chapter 4* describes the performance criteria related to monitoring and assessment and provides detailed technical guidance.
- *Chapter 5* describes the performance criteria and technical guidance related to the public notification and risk communication portions of a beach program.

The appendices include detailed technical information associated with the topics discussed in the five chapters:

- Appendix A: Beach Act Fact Sheet
- Appendix B: EPA's Water Quality Criteria for Bacteria
- Appendix C: State and Local Programs and Nongovernmental Organizations
- Appendix D: EPA References: Statutes, Programs, and Activities Related to Recreation Waters
- Appendix E: EPA Grant Coordinators
- Appendix F: Beach Evaluation and Classification List
- Appendix G: Conducting a Sanitary Survey
- Appendix H: Monitoring Design Approach
- Appendix I: Data Quality Objectives
- Appendix J: Training
- Appendix K: Sample Collection
- Appendix L: Predictive Tools

1.2 Human Health Concerns

1.2.1 Pathogen Groups

Pathogens are defined as disease-causing microorganisms. Microorganisms are ever present in all terrestrial and aquatic ecosystems. Many types are beneficial, functioning as agents for chemical decomposition, as food sources for larger animals, and as essential components of the nitrogen cycle and other biogeochemical cycles. Some microorganisms reside in the bodies of animals and aid in the digestion of food; others are used for medical purposes such as providing antibiotics. The small subset of microorganisms that cause human diseases are known as human pathogens. If taken into the body, pathogens can cause sickness or even death. The source of these microorganisms is usually the feces of humans and other various warm-blooded animals. The pathogens most commonly identified and associated with waterborne diseases can be grouped into the three general categories: bacteria, protozoans, and viruses.

Bacteria are unicellular organisms that lack an organized nucleus and contain no chlorophyll. They contain a single strand of DNA and typically reproduce by binary fission, during which a single cell divides to form two new cells. Waste from warm-blooded animals is a source for many types of bacteria found in waterbodies, including the coliform group and streptococcus, lactobacillus, staphylococcus, and clostridia. It is important to note, however, that not all bacteria are pathogenic.

Protozoans are unicellular organisms that reproduce by fission and occur primarily in the aquatic environment. Pathogenic protozoans constitute almost 30 percent of the 35,000 known species of protozoans. Pathogenic protozoans exist in the environment as cysts that hatch, grow, and multiply after ingestion, causing associated illness. Encystation of protozoans facilitates their survival, protecting them from harsh conditions such as high temperature and salinity. Two protozoans of major concern as waterborne pathogens are *Giardia lamblia* and *Cryptosporidium parvum*.

Viruses are a group of infectious agents that require a host in which to live. They are composed of highly organized sequences of nucleic acids–either DNA or RNA, depending on the virus. The most significant virus group affecting water quality and human health originates in the gastrointestinal tract of infected animals. These enteric viruses are excreted in feces and include hepatitis A, rotaviruses, Norwalk-type viruses, adenoviruses, enteroviruses, and reoviruses.

1.2.2 Human Health Concerns

The main route of exposure to disease-causing organisms in recreational beach waters is through contact with polluted water while swimming, including accidental ingestion of contaminated water. In waters containing fecal contamination, potentially all of the waterborne diseases that are spread by the fecal-oral route could be contracted by bathers. These illnesses include diseases resulting from the following:

- Bacterial infection (such as cholera, salmonellosis, shigellosis, and gastroenteritis).
- Viral infection (such as infectious hepatitis, gastroenteritis, and intestinal diseases caused by enteroviruses).
- Protozoan infections (such as amoebic dysentery and giardiasis).

Swimming in contaminated water most frequently causes gastroenteritis. Gastroenteritis is a term for a variety of diseases that affect the gastrointestinal tract; symptoms include vomiting, diarrhea, stomachache, nausea, headache, and fever.

Although bathing in contaminated water most often results in contracting diseases that affect the gastrointestinal tract, diseases and conditions affecting the eye, ear, skin, and upper respiratory tract can be contracted as well. With these conditions, infection often results when pathogenic microorganisms come into contact with small breaks and tears in the skin or ruptures in delicate membranes in the ear or nose resulting from the trauma associated with diving into the water. Table 1-1 provides a list of diseases and conditions that can result from contact with water contaminated with bacterial, viral, and protozoan pathogens.

People who contract diseases as a result of bathing in contaminated water do not always associate their illness symptoms with swimming. As a result, disease outbreaks often are inconsistently reported. Because the incidence of diseases among bathers is often difficult to determine, several studies have been conducted in an attempt to establish a link between the concentration of indicators of fecal contamination in bathing waters and the incidence of swimming-associated disease symptoms.

EPA began to study the relationship between the quality of bathing water and the resultant health effects in 1972. Studies in the 1970s and 1980s examined the differences in symptomatic illness between swimming and non-swimming beachgoers at marine and freshwater bathing beaches. The studies found the following (USEPA, 1999a):

- Swimmers that bathe in water contaminated with sewage are at greater risk than non-swimmers of contracting gastroenteritis.
- The swimming-associated illness rate increases as the quality of the bathing water degrades.
- The illness rate in marine swimmers is greater than that in freshwater swimmers when indicator densities are equivalent in marine and fresh waters.

In 1995 researchers launched a large-scale study in the Santa Monica Bay area to assess (1) the effectiveness of bacterial indicators in predicting health risks to bathers and (2) the relative health risk associated with bathing near storm drains. In this study, approximately 15,000 beachgoers that bathed and immersed their heads were interviewed. Approximately 13,000 of the beachgoers were contacted for follow-up interviews designed to assess the occurrence of symptoms such as fever, chills, nausea, and diarrhea. The major findings of the study suggest that there is a significant correlation between swimming in water with high densities of indicator bacteria and the incidence of adverse health effects. In addition, the study confirmed that people who swim in front of flowing storm drains are twice as likely to exhibit adverse health effects than people who swim 400 yards away from storm drains (Haile et al., 1996).

Table 1-1. Waterborne Pathogens

Pathogen		Disease	Effects
Bacteria	*Escherichia coli* (enteropathogenic)	Gastroenteritis	Vomiting, diarrhea, death in susceptible populations
	Helicobacter pylori	Gastritis	Peptic ulcers
	Legionella pneumophila	Legionellosis	Acute respiratory illness
	Leptospira	Leptospirosis	Jaundice, fever (Weil's disease)
	Pseudomonas	Causes infections in immunocompomised individuals	Urinary tract infections, respiratory system infections, dermatitis, soft tissue infections, bacteremia and a variety of systemic infections
	Salmonella typhi	Typhoid fever	High fever, diarrhea, ulceration of the small intestine
	Salmonella	Salmonellosis	Diarrhea, dehydration
	Shigella	Shigellosis	Bacillary dysentery
	Vibrio cholerae	Cholera	Extremely heavy diarrhea, dehydration
	Yersinia enterolitica	Yersinosis	Diarrhea
Protozoans	*Balantidium coli*	Balantidiasis	Diarrhea, dysentery
	Cryptosporidium	Crypotosporidiosis	Diarrhea
	Entamoeba histolytica	Ameobiasis (amoebic dysentery)	Prolonged diarrhea with bleeding, abscesses of the liver and small intestine
	Giardia lambia	Giardiasis	Mild to severe diarrhea, nausea, indigestion
	Naegleria fowleri	Amebic meningoencephalitis	Fatal disease; inflammation of the brain
Viruses	Adenovirus (31 types)	Respiratory disease	Eye infections, diarrhea
	Astroviruses	Gastroenteritis	Vomiting, diarrhea
	Enterovirus (67 types, e.g., polio, echo, and Coxsackie viruses)	Gastroenteritis	Heart anomalies, meningitis

Pathogen		Disease	Effects
	Hepatitis A and E	Infectious hepatitis	Jaundice, fever
	Norwalk- and Sapporo-like viruses	Gastroenteritis	Vomiting, diarrhea
	Reovirus	Gastroenteritis	Vomiting, diarrhea
	Rotavirus	Gastroenteritis	Vomiting, diarrhea

Source: USEPA, 2001.

A review of studies conducted during the past several decades have provided the following overall conclusions (Pruss, 1998):

- A causal dose-response relationship exists between bacterial indicator counts in recreational waters and gastrointestinal symptoms in bathers.
- A strong relationship between bacterial indicator counts and symptoms not related to the gastrointestinal tract could not be established.
- The relative risk of swimming in contaminated versus uncontaminated waters ranged from one to three times above the risk associated with swimming in uncontaminated water.
- Symptom rates were usually higher in individuals with compromised immune systems.
- The indicators showing the best correlation with adverse health effects were enterococci (marine and fresh water) and *Escherichia coli* (fresh water).

1.3 Water Quality Standards for Bacteria

Water quality standards define a use(s) for a waterbody–such as primary contact recreation–and set specific water quality criteria to achieve that use. They are the foundation of the nation's water quality management program and are the goals by which success is ultimately measured for a given waterbody or watershed.

Because it is difficult to directly detect many pathogens or parasites that may be present in surface waters, the presence of fecal bacteria has long been used as an indicator of the possible presence of disease causing organisms. Section 304(a)(1) of the CWA requires the Administrator of EPA to publish criteria for water quality that accurately reflect the latest scientific knowledge on the kind and extent of all identifiable effects on health and welfare that may be expected from the presence of a pollutant in any body of water. Under EPAs regulations at 40 CFR 131.11(b), when a state or tribe is adopting water quality criteria as part of its water quality standards, the state or tribe has three options:

- adopt EPA's section 304(a) criteria,
- adopt 304(a) criteria modified to reflect site-specific conditions, or
- adopt criteria based on other scientifically defensible methods.

In addition, the BEACH Act amended CWA section 303(i) to require states and tribes to adopt water quality criteria that are "as protective as human health as the criteria for pathogens and pathogen indicators for coastal recreation waters published by the EPA."

1.3.1 Organisms That Can Indicate Fecal Contamination

Because many pathogens are not easily detected, indicator organisms are a fundamental monitoring tool used to measure both changes in environmental (water) quality or conditions and the potential presence of hard-to-detect target pathogenic organisms. An indicator organism provides evidence of the presence or absence of a pathogenic organism surviving under similar physical, chemical, and nutrient conditions. For fecal contamination, indicator organisms should

- Be easily detected using simple laboratory tests.
- Generally not be present in unpolluted waters.
- Appear in concentrations that can be correlated with the extent of contamination.
- Have a die-off rate that is not faster than the die-off rate of the pathogens of concern (Sloat and Ziel, 1992; Thomann and Mueller, 1987).

Figure 1-3 provides a summary of the relationships between bacterial indicator organisms for fecal contamination.

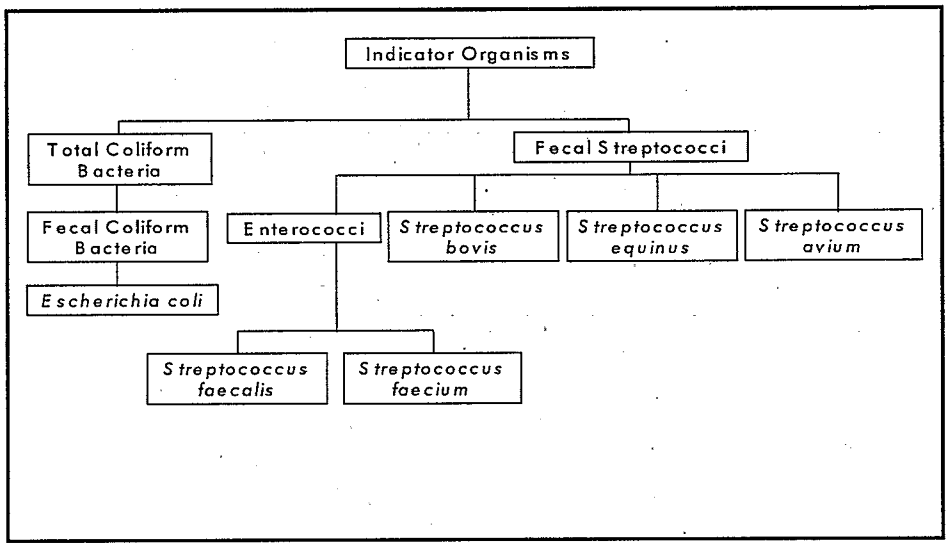

Figure 1-3. Relationship between bacterial indicator organisms for fecal contamination.

1.3.2 EPA's Current Water Quality Criteria for Bacteria: Enterococcus and *E. coli*

In 1986 EPA published *Ambient Water Quality Criteria for Bacteria –1986,* which recommended the use of *E. coli* and enterococci as water quality criteria for bacteria. In this document, EPA recommended that the water quality criteria be based on bacterial geometric mean densities and maximum single-sample bacteria density criteria not to be exceeded in marine and fresh recreational waters. These criteria are summarized in Table 1-2. Additional information on EPA's criteria is provided in Appendix B.

Table 1-2. Criteria for Indicators for Bacteriological Densities

	Steady-State Geometric Mean Indicator Density	Single Sample Maximum Allowable Density			
		Designated Beach Area (upper 75% C.L.)	Moderate Full Body Contact Recreation (upper 82% C.L.)	Lightly Used Full Body Contact Recreation (upper 90% C.L.)	Infrequently Used Full Body Contact Recreation (upper 95% C.L.)
Freshwater[1]					
enterococci	33	61	89	108	151
E. coli	126	235	298	406	576
Marine Water[2]					
enterococci	35	104	158	276	500

[1] Freshwater densities based on a risk of 8 swimmers per thousand.

[2] Marine water densities based on a risk of 19 swimmers per thousand.

Source: USEPA 1986.

Section 303(i)(1)(A) of the CWA, as amended by the BEACH Act, requires states and tribes that have coastal recreation waters to adopt new or revised water quality standards for pathogens and pathogen indicators for which EPA has published criteria under CWA section 304(a). As noted above, EPA has published 304(a) water quality criteria for enterococcus and *E. coli*, but not for fecal coliform. Under the statute, states and tribes must adopt these new or revised standards by April 10, 2004.

Geometric means

The 304(a) geometric mean values recommended in *Ambient Water Quality Criteria for Bacteria –1986* and summarized in Table 1-2, are based on specific levels of risk of acute gastrointestinal illness of 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 (USEPA, 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. Appendix B provides additional information on the equations EPA used to calculate the geometric mean values.

Single sample maximums

In addition to the geometric mean density values, *Water Quality Criteria for Bacteria –1986* also recommended single sample bacteria density criteria for enterococci and *E. coli* not to be exceeded in marine and fresh waters. Use of a single-sample maximum is important because it is assumed that environmental conditions (such as rainfall, wind, currents (including tides), and temperature) will vary temporally and spatially. These single sample maximums, summarized in Table 1-2, are also based on specific levels of risk of acute gastrointestinal illness of 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.

The single-sample density values were based on four levels of water use: designated beach area, moderate full body contact recreation, lightly used full body contact recreation, and infrequently used full body contact recreation. Confidence intervals were assigned to each of these levels of use,. which were then used to calculate the density value for that use and indicator. For example, a smaller confidence level (75 percent) corresponds to a more stringent (lower) single-sample maximum, whereas a greater confidence level (95 percent) corresponds to less stringent (higher) maximum values (USEPA, 1986). EPA assigned a more stringent single-sample maximum to designated bathing beaches because a high degree of caution should be used to evaluate water quality for heavy-use areas (USEPA, 1986) while a less stringent single-sample maximum can be used for less intensively used or more remote swimming areas. Appendix B provides additional information on the equations EPA used to calculate the single sample maximum values.

1.3.3 EPA's Review of Recent Epidemiological Studies

Since the publication of EPA's 1986 criteria, a number of studies related to bacterial indicators have been completed. Therefore, EPA reviewed relevant recent studies to determine whether the studies continued to support EPA's recommendation to use *E. coli* and enterococci as bacterial water quality indicators. EPA's review focused on the epidemiological studies that related swimming-associated health effects to marine and freshwater bacterial water quality using studies performed after 1984. The reviewers searched for evidence that quantitatively proved that better and more predictive indicator bacteria or more protective water quality levels exist.

EPA's Office of Research and Development (ORD) concluded that

> The epidemiological studies conducted since 1984, which examined the relationships between water quality and swimming-associated health effects, have

> not established any new or unique principles that might significantly affect the current guidance EPA recommends for maintaining the microbiological safety of marine and freshwater bathing beaches. Many of the studies have, in fact, confirmed and validated the findings of the U.S. EPA studies. There would appear to be no good reason for modifying the Agency's current guidance for recreational waters at this time (Dufour, 1999).

The new studies added an additional body of evidence that supports EPA's 1986 criteria. As a result of this examination, EPA determined that its 1986 water quality criteria for bacteria continue to represent the best available science and serve as a defensible foundation for protecting public health in recreational waters. EPA found no reason to undertake a revision of the criteria at that time (USEPA, 2000). Additional information on these studies can be found in Appendix B.

1.3 References

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Chapter 2: Grants and Performance Criteria

This chapter addresses the basic requirements that an applicant must meet to receive a program implementation grant. The chapter identifies relevant sections of the BEACH Act, briefly describes the corresponding Performance Criteria that EPA has developed, and provides additional grant-related information.

2.1 BEACH Act Conditions and Requirements Applicable to Section 406 Grants

The BEACH Act establishes a series of conditions and requirements related to grants for developing and implementing a BEACH monitoring and notification program. Some of these conditions and requirements apply to all grants awarded under section 406; others apply only to a subset of grants (e.g., implementation grants or grants to states and tribes). Section 406(c), which addresses Content of Local Programs, applies to all grants awarded to states under the authority of section 406 whether the grant is for development or implementation of a beach monitoring program.. Section 406 (b)(3)(A), which adresses Reporting, applies to all development and implementation grants awarded to states and tribes under the authority of section 406. Section 406(b)(3)(B), which addresses delegation to local governments, applies to development and implementation grants awarded to states only. The requirements set forth at 406(b)(2)(A), which addresses General Requirements, apply only to implementation grants to states, tribes, and local governments. Sections 406(a), (b), and (c) have been reproduced below:

- **Section 406 (a) Monitoring and Notification**

  (1)...the Administrator shall publish performance criteria for –

    (A) monitoring and assessment (including specifying available methods for monitoring) of coastal recreation waters adjacent to beaches or similar points of access that are used by the public for attainment of applicable water quality standards for pathogens and pathogen indicators; and

    (B) the prompt notification of the public, local governments, and the Administrator of any exceeding, or likelihood of exceeding, applicable coastal recreation water quality standards described in subparagraph (A).

- **Section 406(b) Program Development and Implementation Grants**

  (1) IN GENERAL.—The Administrator may make grants to States and local governments to develop and implement programs for monitoring and notification for coastal recreation waters adjacent to beaches or similar points of access that are used by the public.

  (2)(A) In General– The Administrator may make grants to States and local governments to implement a monitoring and notification program if –

    (i) the program is consistent with the performance criteria published by the Administrator under subsection (a);

(ii) the State or local government prioritizes the use of grant funds for particular coastal recreation waters based on the use of the water and the risk to human health presented by pathogens or pathogen indicators;

(iii) the State or local government makes available to the Administrator the factors used to prioritize the use of funds under clause (ii);

(iv) The State or local government provides a list of discrete areas of coastal recreation waters that are subject to the program for monitoring and notification for which the grant is provided that specifies any coastal recreation waters for which fiscal constraints will prevent consistency with the performance criteria under subsection (a); and

(v) the public is provided an opportunity to review the program through a process that provides for public notice and an opportunity for comment.

(2)(B) Grants to Local Governments – The Administrator may make a grant to a local government under this subsection for implementation of a monitoring and notification program only if, after the 1-year beginning on the date of publication of performance criteria under subsection (a)(1), the Administrator determines that the State is not implementing a program that meets the requirements of this subsection, regardless of whether the State has received a grant under this subsection.

(3) Other Requirements

(A) REPORT – A State recipient of a grant under this subsection shall submit to the Administrator, in such format and at such intervals as the Administrator determines to be appropriate, a report that describes –

(i) data collected as part of the program for monitoring and notification as described in subsection (c); and

(ii) actions taken to notify the public when water quality standards are exceeded.

(B) DELEGATION– A State recipient of a grant under this subsection shall identify each local government to which the State has delegated or intends to delegate responsibility for implementing a monitoring and notification program consistent with the performance criteria under subsection (a).

- **Section 406(c) Content of State and Local Government Programs–**

As a condition of receipt of a grant under subsection (b), a State or local government program shall identify:

1. lists of coastal recreation waters in the State, including coastal recreation waters adjacent to beaches or similar points of access that are used by the public;
2. in the case of a State program for monitoring and notification, the process by which the State may delegate to local governments responsibility for implementing the monitoring and notification program;
3. the frequency and location of monitoring and assessment of coastal recreation waters

based on–
(A) the periods of recreational use of the waters;
(B) the nature and extent of use during certain periods;
(C) the proximity of the waters to known point sources and nonpoint sources of pollution; and
(D) any effect of storm events on the waters;

4. (A) the methods to be used for detecting levels of pathogens and pathogen indicators that are harmful to human health; and
(B) the assessment procedures for identifying short-term increases in pathogens and pathogen indicators that are harmful to human health in coastal recreation waters (including increases in relation to storm events);

5. measures for prompt communication of the occurrence, nature, location, pollutants involved, and extent of any exceeding of, or likelihood of exceeding, applicable water quality standards for pathogens and pathogen indicators to–
(A) the Administrator, in such form as the Administrator determines to be appropriate; and
(B) a designated official of the local government having jurisdiction over land adjoining the coastal recreation waters for which the failure to meet applicable standards is identified;

6. measures for the posting of signs at beaches or similar points of access, or functionally equivalent communication measures that are sufficient to give notice to the public that the coastal recreation waters are not meeting or are not expected to meet applicable water quality standards for pathogens and pathogen indicators; and

7. measures that inform the public of the potential risks associated with water contact activities in the coastal recreation waters that do not meet applicable water quality standards.

2.2 Performance Criteria

EPA has developed nine performance criteria for monitoring, assessment, and notification by the agencies of federal agency, state, tribal, or local government. In order to be eligible for a grant to implement a monitoring and notification program, the applicant's program must be consistent with these performance criteria. These performance criteria are based on and incorporate requirements of the sections of the BEACH Act provided above. The criteria are listed in Table 2-1 and summarized in sections 2.2.1 through 2.2.9. More detailed discussions are provided in subsequent chapters.

Table 2-1. Summary of BEACH Act Performance Criteria

Category	Performance Criteria	Requirement	BEACH Act Section	Chapter Discussed
Evaluation and Classification	1	Risk-based Beach Evaluation and Classification	406(b)(2)(A)(ii-iv) 406(c)(1)	3
Monitoring	2	Sampling Design and Monitoring Implementation Plan	406(c)(3)	4
	3	Monitoring Report Submission and Delegation	406(b)(3)(A), (B) 406(c)(2)	4
	4	Methods and Assessment Procedures	406(c)(4)	4
Public Notification and Prompt Risk Communication	5	Public Notification and Risk Communication Plan	406(c)(7)	5
	6	Measures to Notify EPA and Local Governments	406(c)(5)	5
	7	Measures to Notify the Public	406(c)(6)	5
	8	Notification Report Submission and Delegation	406(b)(3)(A), (B) 406(c)(2)	5
Public Evaluation	9	Public Evaluation of Program	406(b)(2)(A)(v)	2

2.2.1 Risk-based Beach Evaluation and Classification (Performance Criterion 1)

The first performance criterion a state or tribe must meet to qualify for an implementation grant is to develop a risk-based beach evaluation and classification plan and apply it to state or tribe coastal recreation waters. A state or tribal program must describe the factors used in its evaluation and classification process and explain how its beaches are ranked as a result of the process. This process must result in the identification of a list of coastal recreation waters in the state or tribe, including coastal recreation waters adjacent to beaches or similar points of access used by the public. This performance criterion is discussed in more detail in Chapter 3.

2.2.2 Sampling Design and Monitoring Plan (Performance Criterion 2)

The second performance criterion a state or tribe must meet to qualify for an implementation grant is to develop a sampling design and monitoring implementation plan. This plan must adequately address the frequency and location of monitoring and assessment of coastal recreation waters based on the periods of recreational use of the waters, the nature and extent of use during certain periods, the proximity of the waters to known point sources and nonpoint sources of pollution, and any effect of storm events on the waters. This criterion is discussed in more detail in Chapter 4.

2.2.3 Monitoring Report Submission and Delegation (Performance Criterion 3)

The third performance criterion a state or tribe must meet to qualify for an implementation grant is to develop a mechanism to collect relevant information and submit timely reports to EPA and document any delegation of monitoring responsibilities to local governments.

Report Submission
A state or tribal recipient of a grant must submit to the EPA Administrator timely information and reports that describes the data collected as part of the monitoring program, and the actions taken to notify the public when water quality standards are exceeded.

Delegation
If monitoring responsibilities are delegated to local governments, the state grant recipient must describe the process by which the state may delegate to local governments responsibility for implementing the monitoring program. This criterion is discussed in more detail in Chapter 4.

2.2.4 Methods and Assessment Procedures (Performance Criterion 4)

The fourth performance criterion a state or tribe must meet to qualify for an implementation grant is to develop detailed methods and assessment procedures. These procedures must adequately address both the methods to be used for detecting levels of pathogens and pathogen indicators that are harmful to human health and the assessment procedures for identifying short-term increases in pathogens and pathogen indicators that are harmful to human health. This criterion is discussed in more detail in Chapter 4.

2.2.5 Public Notification and Risk Communication Plan (Performance Criterion 5)

The fifth performance criterion a state or tribe must meet to qualify for an implementation grant is to develop an overall public notification and risk communication plan. The plan must describe the state's or tribe's public notification efforts and measures to inform the public of the potential risks associated with water contact activities in the coastal recreation waters that do not meet applicable water quality standards. This criterion is discussed in more detail in Chapter 5.

2.2.6 Measures to Notify EPA and Local Governments (Performance Criterion 6)

The sixth performance criterion a state or tribe must meet to qualify for an implementation grant is to identify measures for promptly communicating to EPA and local governments of the occurrence, nature, location, pollutants involved, and extent of any exceeding of, or likelihood of exceeding, applicable water quality standards for pathogens and pathogen indicators. The state or tribe must identify how this information will be promptly communicated to EPA and to a designated official of the local government that has jurisdiction over land adjoining the coastal recreation waters for which the failure to meet applicable standards has been identified. This criterion is discussed in more detail in Chapter 5.

2.2.7 Measures to Notify the Public (Performance Criterion 7)

The seventh performance criterion a state or tribe must meet to qualify for an implementation grant is to develop measures to notify the public through the posting of signs at beaches or similar points of access or through functionally equivalent communication measures that are sufficient to give notice to the public that the coastal recreation waters are not meeting or are not expected to meet applicable water quality standards for pathogens and pathogen indicators. This criterion is discussed in more detail in Chapter 5.

2.2.8 Notification Report Submission and Delegations (Performance Criterion 8)

The eighth performance criterion a state or tribe must meet to qualify for an implementation grant is to develop a mechanism to collect relevant information and submit timely reports to EPA and document any delegation of notification responsibilities to local governments.

Report Submission
A state or tribal recipient of a grant must submit to the Administrator timely information and reports that describes data collected as part of the notification program and the actions taken to notify the public when water quality standards are exceeded.

Delegation
If notification responsibilities are delegated to local governments, the state grant recipient must describe the process by which the state may delegate to local governments responsibility for implementing the notification program. This criterion is discussed in more detail in Chapter 5.

2.2.9 Public Evaluation of Program (Performance Criterion 9)

The ninth performance criterion a state or tribe must meet to qualify for an implementation grant is to identify how to provide the public with an opportunity to review the program through a process that provides for public notice, review, and an opportunity to comment. This can be accomplished through a record of public comments, meetings, forums, or workshops.

The components of a beach monitoring and notification program that a grant recipients must provide opportunity for public comment on are:

- Beach Evaluation and Classification Process, including list of waters to be monitored and beach ranking (Chapter 3.2);
- Sampling Design and Monitoring Plan, including sampling location and sampling frequency (Chapter 4.2);

- Public Notification and Risk Communication Plan, including methods to notify the public of a swimming advisory (Chapter 5.2).

It is beneficial to gather input from the community regarding the recreational waters they would like to see monitored when classifying and ranking beaches. Annual public or community meetings, surveys of the users at the beach, local newspaper articles, or other sources can provide insight into public opinion about the beach, including why the beach is or is not used (e.g., for sunning, running, swimming, or surfing), perceptions of water quality and health problems, and whether beach users desire a monitoring and notification program (if none exists) or how satisfied they are with the program that has been implemented.

2.3 Additional Grant Information

2.3.1 Grant Program Phases

The BEACH Act authorizes a two-phase grant program –an initial program *development* phase followed by a program *implementation* phase. The initial phase of the grant program focuses on the development of state or tribal beach monitoring and notification programs. As a condition of receipt of a Program Development Grant, grant recipients must commit to develop monitoring and notification programs that will ultimately meet the requirements of the BEACH Act. Each year, to awared of implementation grant, EPA will assess whether the recipient has made satisfactory progress in developing a program that is consistent with the BEACH Act and EPA performance criteria. After the program development phase, implementation grant applicants must be carrying out beach monitoring and notification programs that are consistent with the performance criteria outlined in this document.

2.3.2 Eligibility for Grants

State Governments

Coastal and Great Lake states are eligible to apply for grants to develop and implement monitoring and notification programs. For the purposes of the BEACH Act, the term "state" applies to 30 coastal and Great Lake states and includes 6 coastal territories defined in CWA section 502: the Commonwealth of Puerto Rico, the Virgin Islands, Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands. The Trust Territory of the Pacific Islands, however, no longer exists. The Marshall Islands, the Federated States of Micronesia, and Palau, which were previously entities within the Trust Territory of the Pacific Islands, have entered into Compacts of Free Association with the Government of the United States. As a result, each is now a sovereign, self-governing entity and, as such, is no longer eligible to receive grants as a territory or possession of the United States.

Local Governments

The BEACH Act authorizes EPA to make grants to local governments for development and implementation of a monitoring and notification program only if, after the 1-year period beginning on the date of publication of this document, EPA determines that the state is not implementing a program that meets the requirements of the statute.

Tribal Governments

The BEACH Act amended CWA Section 518(e) to authorize EPA to treat Indian tribes in the same manner as states for the purpose of CWA section 406, if the tribe meets the treatment as a state (TAS) requirements in section 518(e). EPA is developing procedures for establishing TAS for section 406 of the BEACH Act.

2.3.3 Funding

CWA section 406(i) authorizes appropriations of up to $30 million per year through fiscal year 2005 to develop and implement beach programs. The actual amount of funding available to individual states and tribes will depend on congressional appropriation levels and an allotment formula for allocating fund among eligible.

2.3.4 Selection Process

The Administrator of EPA has delegated the authority to award BEACH Act program Development and Implementation Grants to the Assistant Administrator of the Office of Water and to the EPA Regional Administrators. The EPA regional offices will award program Development and Implementation Grants through a noncompetitive process.

EPA expects to award grants to all eligible state, territory, and tribal applicants that meet the performance criteria specified in this document.

2.3.5 Application Procedure

BEACH Act grants will be awarded and administered according to the regulations at 40 CFR Part 31 ("Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments"). The EPA regional offices have the lead responsibility for providing grant application packages and advice. Refer to Appendix E for a list of the current EPA Regional Grant Coordinators or visit the Beach Watch Web site at <www.epa.gov/ost/beaches> on the Internet.

2.4 References

USEPA. 2001. *Notice of Availability of Grants for Development of Coastal Recreation Water Monitoring and Public Notification under the Beaches Environmental Assessment and Coastal Health Act*. U.S. Environmental Protection Agency, Office of Water, Washington, DC. *Federal Register* May 2001, 66(104): 29308-29310.

Chapter 3: Risk-based Beach Evaluation and Classification Process

This chapter describes the risk-based beach evaluation and classification process, including the evaluation steps and recommended information that a state or tribe should consider.

3.1 Performance Criterion

The first performance criterion is to develop a risk-based beach evaluation and classification plan and apply it to state or tribal coastal recreation waters. A state or tribal government program must describe the factors used in its evaluation and classification process and explain how its beaches are ranked as a result of the process. This process should result in the identification of a list of coastal recreation waters, including coastal recreation waters adjacent to beaches or similar points of access used by the public.

Risk-based beach evaluation and classification is a means to identify potential risk of disease to swimmers and to protect public health. Although a state or tribe may develop its own approach, it must address these four core elements:

- Identification of factors used to evaluate and rank beaches.
- Identification of coastal recreation waters in the state or tribe.
- Identification of bathing beaches adjacent to coastal recreational waters
- Identification of available information including pertinent reports and water quality monitoring and modeling data, frequency and density of use, public review, and community input.

The goal of the evaluation process is to use these four elements to classify each beach into a priority category—High, Medium, or Low. This classification can then be used to direct resources toward monitoring and notification programs at the beach (Chapters 4 and 5). A classification of High priority, for example, indicates a beach is of such a high risk and/or high usage that significant resources should be devoted to more intensive monitoring and public notification efforts.

3.2 Step 1: Identify Coastal Recreation Waters

According to the BEACH Act, "coastal recreation waters" are defined as the Great Lakes and marine coastal waters (including coastal estuaries) designated under CWA section 303(c) by a state for use for swimming, bathing, surfing, or similar water contact activities. "Coastal recreation waters" do not include either inland waters or waters upstream of the mouth of a river or stream that has an unimpaired natural connection with the open sea. The first step in evaluating and classifying your beaches is to make a list of all coastal recreation waters (Figure 3-1).

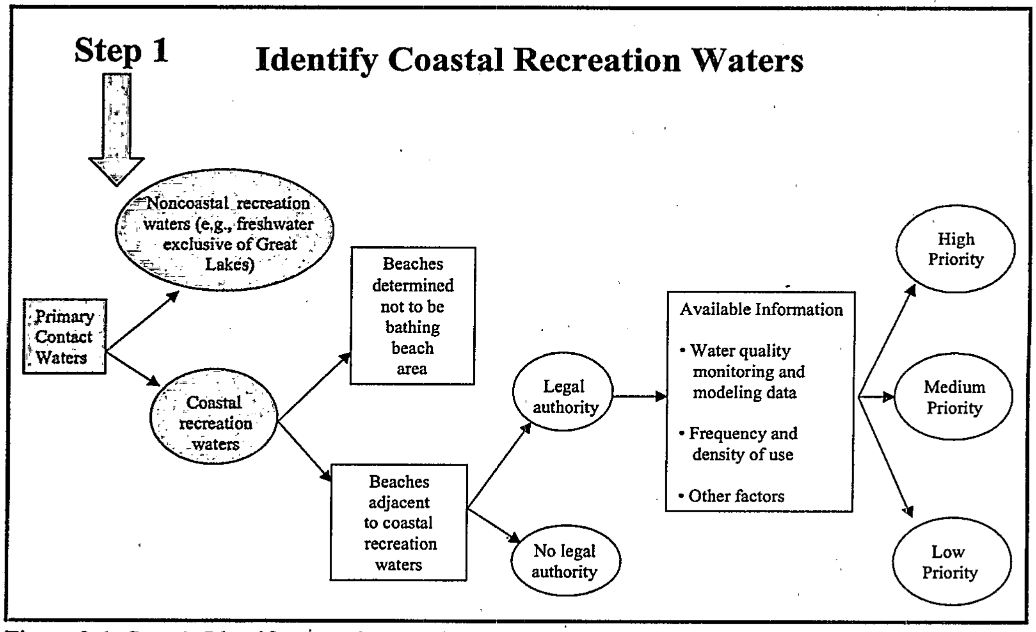

Figure 3-1. Step 1: Identify coastal recreation waters.

3.2.1 Designated Uses of Waterbodies

Proper identification of coastal recreation waters requires an identification of the designated use of a waterbody. Under CWA section 303(c)(2), states adopt water quality standards that consist of the "designated uses" for the water to which the standard applies and criteria to protect the uses. Section 303(c) also authorizes EPA to adopt water quality standards, including designated uses, for states when EPA disapproves a water quality standards submission or in any case when the EPA Administrator determines that new or revised water quality standards are necessary to meet the requirements of the CWA. Therefore, for the purpose of the BEACH Act, recreational uses in coastal waters may be designated by either states, tribes or EPA under 303(c)(4).

Most states and some tribes have established designations for their primary contact waters. Assigning a designated use to a waterbody is a means of identifying and classifying that waterbody's intended use (e.g., aquatic life support, fish consumption, shellfish harvesting, drinking water supply, primary contact recreation, secondary contact recreation). Any change to the designated use of a waterbody must be submitted to EPA for the Agency's review and approval or disapproval. Typically, states and tribes review their water quality standards every 3 years and review and revise the standards as appropriate.

In designating a use for a waterbody and setting the appropriate water quality criteria to protect that use, the state or tribe also takes downstream water quality into consideration and ensures that its water quality standards provide for the attainment and maintenance of the water quality standards for downstream waters.

3.2.2 Recreational Uses of Waterbodies

Recreation occurs in many forms throughout the United States and frequently centers around waterbodies and activities that take place in and on the water. A primary contact recreation use should be adopted for any waterbody where people engage in or are likely to engage in activities that could result in ingestion of the water or immersion. These activities include swimming, water skiing, kayaking, and others. Although factors such as the location of a waterbody, high or low flows, safety concerns, and other physical conditions of the waterbody might make it unlikely that primary contact recreation would occur, EPA strongly encourages states and tribes to adopt primary contact recreation use designations whenever people might swim or make other use of the waterbody such that ingestion could occur.

Often a state or tribe will designate most or all of its surface waters for primary contact recreation. Those waters that are adjacent to bathing beaches typically constitute a subset of the waters designated for primary contact recreation.

Although most recreation waters are designated for year-round primary contact recreation to protect people engaged in primary contact activities, there are some waters where a primary contact recreational use is designated only on a seasonal basis. These uses can include the designation of intermittent, secondary, or seasonal recreation uses. For example, a state or tribe might choose to designate a water primary contact recreation only during certain months of the year if climate precludes such use at other times. Similarly, a state or tribe might designate waters for non-primary contact recreational use, often known as secondary contact use. Subject to the provisions of 40 CFR 131.10, secondary contact recreation uses might be appropriate on a year-round basis, for example, where waters have been irreversibly affected by wet weather events or where protecting a primary contact recreation use at all times would result in substantial and widespread social and economic impact.

3.2.3 Coastal Recreation Waters

Definition of Coastal Recreation Waters

The requirements of section 303(i) apply only to states and tribes that have "coastal recreation waters." As amended by the BEACH Act, the CWA defines "coastal recreation waters" as the Great Lakes and marine coastal waters (including coastal estuaries) that are designated under section 303(c) by a state or tribe for use for swimming, bathing, surfing, or similar water contact activities. Refer to CWA section 502(21). Coastal recreation waters do not include either inland waters or waters upstream of the mouth of a river or stream having an unimpaired natural connection with the open sea. Coastal beaches are intended to exclude areas of tidal influence beyond the mouth of a river. Figure 3-2 illustrates what beaches may or may not be considered coastal recreation waters under the BEACH Act, provided that all of these waters are designated for swimming.. The heavy lines indicate areas that would be designated coastal recreation waters; the smaller lines indicate areas that would not be designated coastal recreation waters. The decision to identify and classify waters as coastal or noncoastal is ultimately up to an individual state or tribe, taking into consideration site-specific conditions.

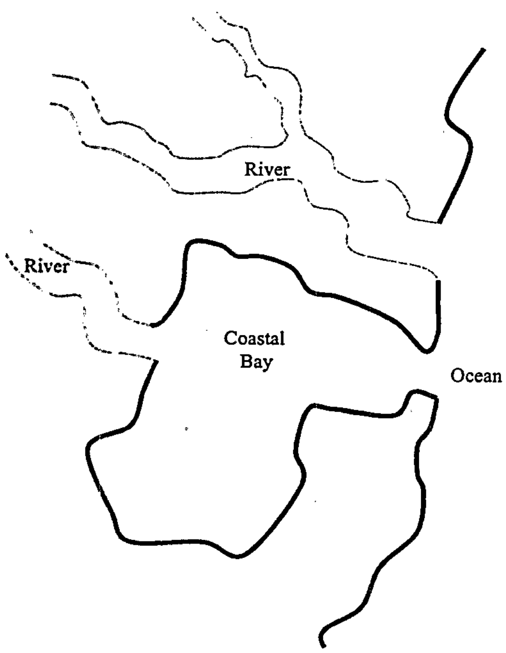

Figure 3-2. Examples of coastal and non coastal recreation waters.

3.3 Step 2: Identify Bathing Beaches

The second step in evaluating and classifying your beach is to identify bathing beaches and similar points of access (Figure 3-3). This can be done by defining the term *beach* and designating the proper legal authority for your beaches. Defining what constitutes a beach will help identify the areas that can be evaluated using the Beach Evaluation and Classification List (Appendix F). The beach definition should encompass both the physical nature of the area and the location of the area adjacent to a waterbody that is designated for recreation. Usually, state, tribal, and local authorities determine the definition of a beach and similar points of access used by the public.

Beach definitions are commonly found in state or tribal water quality laws or regulations. They might take the form of a sanitary code set by a department of health or environmental regulations promulgated by a department of environmental resources. State or tribal beach definitions follow a general pattern and include various descriptions or unique situations. Typically, a bathing beach is defined as a body of water

- Not contained within a man-made structure or building
- Under the control of a state, tribe or local government
- Used for swimming or other contact recreational activity (partial body contact with the water).

This definition includes seashores, oceanfronts, and shorelines associated with estuaries, and bays. It also can incluse shorelines associated with natural lakes, reservoirs, impoundments, ponds, rivers, streams, and creeks, but (except for the Great Lakes), these beaches are not covered by the BEACH Act. A beach can be located in a rural or urban area and can be publicly or privately owned.

Factors to consider when defining a beach include geography, geology, the type of recreational use, and the type of access the beach provides.

- *Geography*. A beach may be defined by a jurisdictional boundary (e.g., nation, state, region, county, township, municipality) or by location on an ocean, a sound, a bay, an estuary, an inlet, or one of the Great Lakes.

- *Geology*. A beach is defined as a gently sloping waterfront area or the shoreline of an ocean, a sea, or a lake, covered by sand, gravel, or larger rock fragments, possibly accompanied by mud.

Examples of Beach Definitions

Annotated Code of Maryland; Environmental Article: Title 26: Department of the Environment; Subtitle 08: Water Pollution; Chapter 9: Public Bathing Beaches: "Bathing Beach" means a beach or bathing place which the owner holds open to the public for bathing, swimming, or other water recreation and which abuts a pond, lake, quarry, stream, bay, or other waterbody. The bathing beach includes the buildings and appurtenances, if any, used in connection with it.

Public Swimming Pools: 64E-9 Florida Administrative Code; portion quoted is from Florida Statute 514 and is not part of the Administrative Code: "Public Bathing Place" means a body of water, natural or modified by humans, for swimming, diving, and recreational bathing, together with adjacent shoreline or land area, buildings, equipment, and appurtenances pertaining thereto, used by consent of the owner or owners and held out to the public by any person or public body, irrespective of whether a fee is charged for the use thereof. The bathing water areas of public bathing places include, but are not limited to, lakes, ponds, rivers, streams, and artificial impoundments (514.011(4) Florida Statute 514).

Massachusetts Department of Public Health; 105 CMR 445.00: Minimum Standards for Bathing Beaches (State Sanitary Code, Chapter VII): "Bathing Beach" shall mean a natural or artificial flowing or impounded pond, lake, stream, river, or other body of fresh or salt water at the location where it is used for bathing and swimming purposes. It shall not mean a swimming pool as defined in 105 CMR 435.000.

New York State Department of Health, Bureau of Community Sanitation and Food Protection: Chapter 1, State Sanitary Code, Subpart 6-2, Bathing Beaches: "Bathing Beach" shall mean a bathing place, together with any buildings and appurtenances, and the water and land areas used in connection therewith, at a pond, lake, stream, or other body of fresh or salt water which is used for bathing or swimming with the express or implied permission or consent of the owner or lessee of the premises or which is operated for a fee or any other consideration or which is openly advertised as a place for bathing or swimming. "Bathing" shall mean to become partially or totally immersed in water.

- *Access*. Access to the waterbody might be from a shoreline structure, or the beach might be adjacent to a recreational waterbody.

- *Designated use*. (See Section 3.1.1)

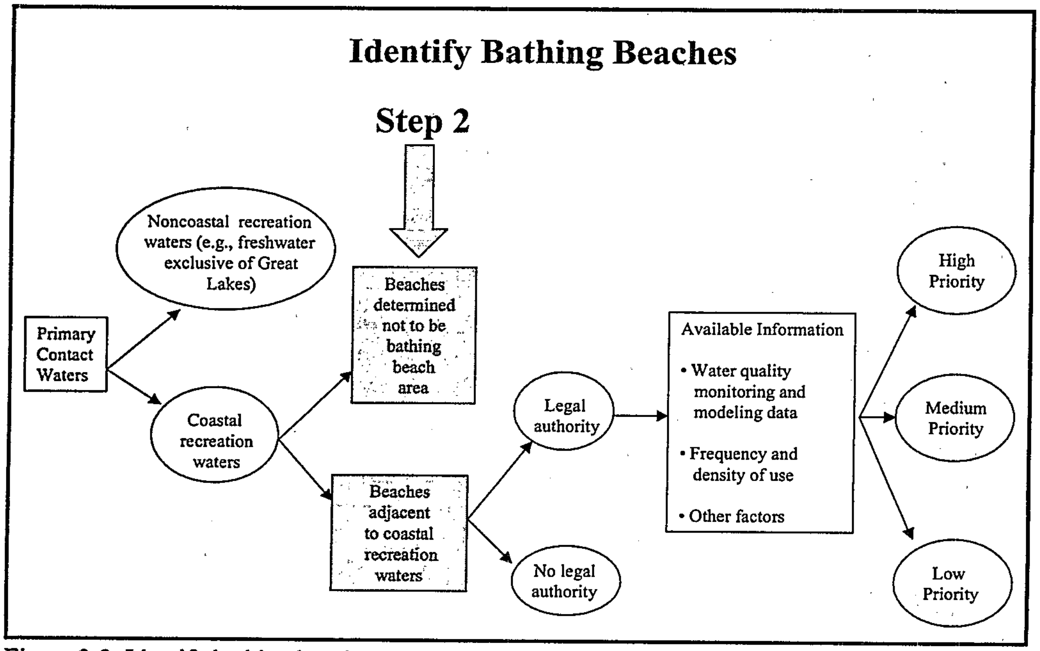

Figure 3-3. Identify bathing beaches.

3.4 Step 3: Determine Legal Authority for Administering Monitoring and Notification Programs

The third step in evaluating and classifying your beach is to identify who has the legal authority for administering monitoring and notification programs (Figure 3-4). You should determine whether the beach is public or private and whether it is subject to monitoring and advisories/closings based on regulation. If the beach is not subject to state, tribal, or local jurisdictional authority (the ability of a local entity to regulate, monitor, and implement advisories or closings), BEACH Act grant funds should not be used to monitor these beaches. Where beaches are subject to jurisdictional authority, you should know the roles and responsibilities of involved agencies and interested parties with respect to beach regulation and management. The laws and regulations relevant to beach management may derive from diverse influences, such as public health, social integration and rights of people with disabilities, navigation for pleasure purposes, aquatic sports, and fishing (Bartram and Rees, 2000).

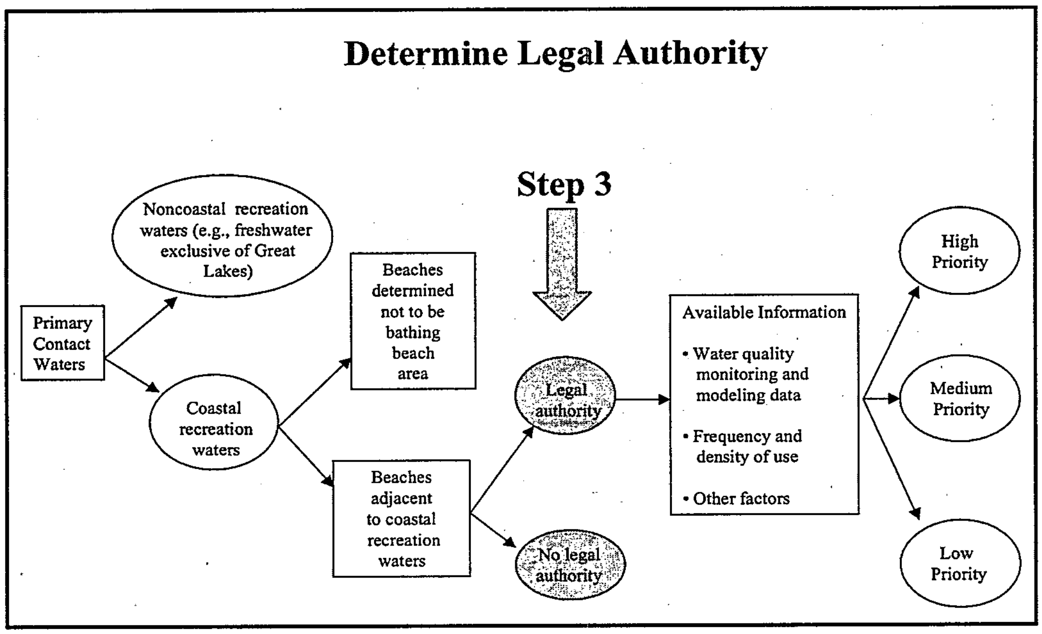

Figure 3-4. Step 3: Determine legal authority.

In most states and some tribes, the health department is responsible for administering a public health code or other administrative codes to determine requirements for recreational water quality management. Sometimes the environmental regulatory agency has this responsibility. These codes should list the agency(ies) responsible for recreational water quality management, which may or may not include some type of monitoring, sampling, and/or notification program. The state level agencies might delegate the legal authority to conduct sanitary surveys, operate sampling and monitoring programs, and issue advisories and closings to the local (e.g., city, county) health departments. Appropriate responsibilities might be further delegated to the individual beach managers or operators for each beach within the city's or county's jurisdiction.

Some states, such as California, have more than 100 federal, state, county, and city agencies with some authority for managing coastal resources. The diversity of regulatory structures throughout the nation requires diverse approaches and solutions, but in general managers concerned with recreational water use areas should consider both common law, the legal precedents set by a judge, and statutory law, the laws passed by the legislature and administrative law (regulations and ordinances adopted by appropriate authorities). The large number of interested organizations requires coordination and cooperation with the state and local governments that have primary responsibility for establishing beach monitoring and notification standards and regulations to limit the health hazards to users of recreational waterbodies.

Local authorities usually contribute to the development and enforcement of beach monitoring, notification, and water quality standards and regulations. In general, public health laws and acts provide that a local authority may make bylaws regarding public bathing and beach management. Municipalities may therefore be responsible for regulating the areas and hours when bathing is permitted. Specific regulations for a beach are frequently determined at the local level on the basis of the physical, environmental, and social characteristics of the area. Chapter 5 provides guidance on public notification if unacceptable risk is associated with bathing.

3.5 Step 4: Review Available Information

The fourth step in evaluating and classifying your beach is to review all available information about the beach, including historical knowledge of the beach, its uses, and possible sources of fecal contamination (Figure 3-5). This information will help you identify the most important issues and data gaps. Source information can be located in state, tribal, or local government agency files, literature and records in local libraries, beach management reports, community association reports, public health records, papers and journals available at colleges and universities, and work performed by local nonprofit organizations. Appendix F provides a list of information that might help in classifying and ranking your beaches.

3.5.1 Pertinent Reports

Part of the process of evaluating potential health risks related to exposure to pathogens during bathing or swimming activities is to compile available information about each beach, including historical knowledge of the beach, designated uses, and possible sources of fecal contamination. This information can be found in reports that include information on waterbodies that are or are not in attainment of their designated uses, lists of impaired waterbodies, medical records, past advisory and closure reports, planning reports, and actual discharge data. The following reports can be used to help classify and rank your beaches.

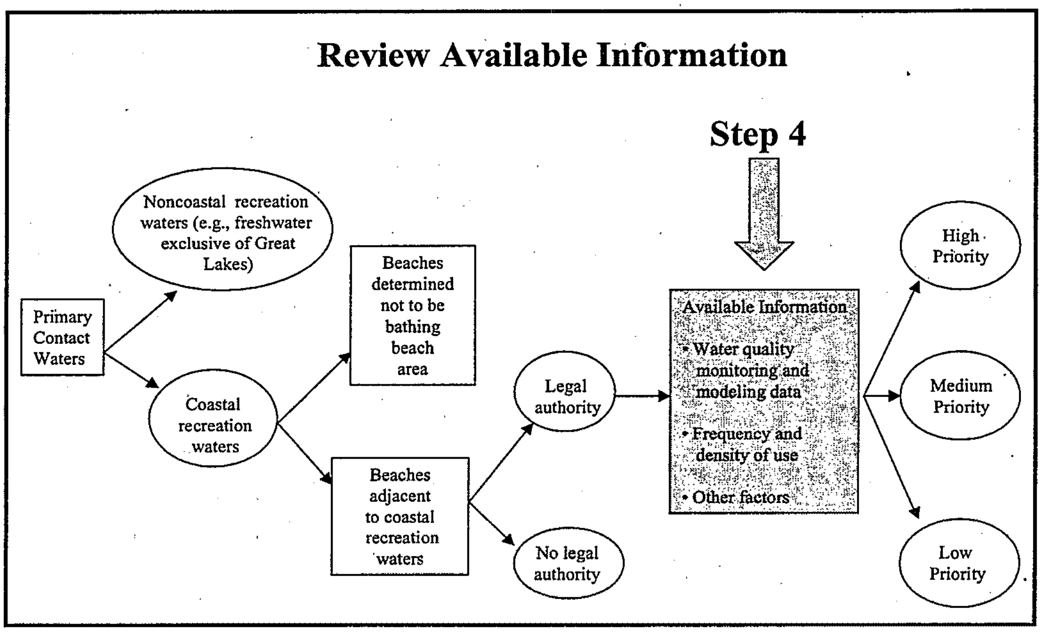

Figure 3-5. Step 4: Review available information.

State Water Quality Report (CWA Section 305(b) Report)

A state's 305(b) report identifies assessed waterbodies that are in full attainment, partial attainment, or nonattainment of their designated uses. Every 2 years, each state submits a report on the quality of its assessed waters to EPA to help determine pollution control and management priorities at the state, tribal, and national levels. The report indicates how the state measures waterbodies against its standards and lists known problems, known or suspected causes, and proposed corrective actions. The 305(b) reports are a good source for locating potential problem areas in recreational waterbodies. EPA also uses the reports to compile the *National Water Quality Inventory* (USEPA, 1998a), a national assessment of progress toward national clean water goals. The National Water Quality Inventory State Reports are available through state water quality management agencies on the Internet at http://www.epa.gov/OWOW/305b/.

List of Impaired Waters (CWA Section 303(d) List)

A state's 303(d) list is a list of impaired waters that have been identified as not meeting water quality standards. Each state must develop waterbody- or watershed-based cleanup and restoration plans, known as Total Maximum Daily Loads (TMDLs) for each waterbody listed. A TMDL presents the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards and includes an allocation of that amount to the pollutant's point and nonpoint sources. The 303(d) lists include a priority ranking of the waters and an identification of the pollutant(s) causing the impairment. Waterbodies on the 303(d) list must be reexamined periodically. The monitoring or sampling performed by the state can sometimes support monitoring or sampling efforts being conducted for beach programs; however, an advisory or closing should not be issued for a particular waterbody simply because it has been placed on the 303(d) list. The BEACH Act addresses concerns about the health risks associated with microbial pathogens. Section 303(d) lists, by contrast, reflect concerns about all types of pollutants that might impair any type of designated use. Therefore, it is quite possible that a water might be listed for a pollutant or stressor that is harmful to aquatic species but does not threaten public health. The 303(d) list for a state can be obtained from the state's water quality management agency. Links to these agencies are provided on the Internet at http://www.epa.gov/owow/tmdl.

Swimmer Reports or Hospital Records

Medical records and epidemiological studies can provide information related to the historical risk of swimming at a particular beach. Swimmer illness reports or complaints to a state or tribal agency are also valuable sources of information and can answer the following questions: Have any swimmers complained to the agency about illnesses that they believed were related to the water quality or debris at a beach? Have any hospitals or other medical facilities documented such reports of illness? Have any epidemiological studies been conducted at a beach (e.g., Calderon et al., 1991; Ferley et al., 1989; Fleischer et al., 1996; Haile, 1996)? Have other government agencies described health problems at this beach or adjacent shoreline areas? Approximately how many reports of illness have occurred? How many have occurred within the past year? The frequency and severity of reports of swimming-associated illnesses can provide important insights into the risks of bathing at a particular beach. In many cases, however, people who contract diseases as a result of bathing in contaminated water do not always associate their illness symptoms with swimming. As a result, disease outbreaks are often inconsistently reported. On the other hand, people might associate illnesses caused by other sources with contaminated water. Caution should therefore be used in determining the significance of such data.

Advisory Reports and Closings

Previously recorded advisories and closings can provide insight into problems associated with maintaining beach water quality, links to closings caused by rain events, the frequency of closings during the swimming season, causes of closings (preemptive, outfalls, increased sampling, rain), and the number of swimming days affected by an advisory or a closing.

Development Planning Reports

Previous management plans or inspection reports can provide information on sewer lines, outfalls, trash areas, septic systems, and other infrastructure and can help to answer questions concerning the identification of potential sources of human pathogens at a beach (e.g., bathrooms). The types of bathroom facilities in the area should be known, as well as any threats of sewage contamination nearby. Potential sources of microbiological contamination of recreational waters might be associated with system failures in municipal wastewater treatment facilities, leaking sewer lines, or rainfall and runoff. Other sources include releases from boat and recreational vehicle holding tanks, pumping stations, portable toilets, and leachate from poorly maintained or flooding septic systems (CADHS, 1998). The sources of contamination listed in the example Beach Evaluation and Classification List (Appendix F) could increase the human health risk of using recreational waters nearby.

Although these plans and reports are useful, it is important to keep in mind other factors affecting contamination. For example, a study conducted by the Texas Natural Resource Conservation Commission found that the density and variability of fecal coliform bacteria appeared to be strongly influenced by storm water runoff. Summer sampling over one 30-day period at six stations (five or six samples were collected) demonstrated that substantial changes in density were observed within as little as 24 to 48 hours. The range of densities around each station's geometric mean varied from 765 to 18,840 colony forming units (CFU) per 100 milliliters (mL) of water. Thus, samples collected on an infrequent basis did not provide an adequate measure of fecal coliform density and variability, particularly in waters affected by storm events (McGinnis, 1996).

Point Source Discharge Data

Facilities authorized to discharge under the National Pollutant Discharge Elimination System (NPDES) program, including combined sewer overflows (CSOs), concentrated animal feeding operations (CAFOs), and publically owned treatment works (POTWs) provide information on the contents of their point source discharges.

CSOs

CSOs consist of mixtures of domestic sewage, industrial and commercial wastewaters, and storm water runoff. Untreated CSOs often contain high levels of suspended solids, pathogenic microorganisms, toxic pollutants, organic compounds, oil and grease, and other pollutants that can cause water quality standards to be exceeded, posing risks to human health (USEPA, 1994b). An increased risk of illness was associated with swimming near flowing storm drain outlets in Santa Monica Bay as compared to swimming more than 400 yards away from the outlets (Haile, 1996; NRDC, 1997).

CAFOs

CAFOs and other animal feeding operations (AFOs) can pose a number of risks to water quality and public health, mainly because of the amount of animal manure and wastewater they generate

(USEPA, 1998a). Manure and wastewater from AFOs and CAFOs have the potential to contribute pollutants such as nutrients (e.g., nitrogen, phosphorus), sediment, pathogens, heavy metals, hormones, antibiotics, and ammonia to the environment.

POTWs

POTWs are waste treatment works owned by a state, unit of local government, or tribe, and they are usually designed to treat predominantly domestic wastewaters.

Nonpoint Source (CWA Section 319) Reports

In 1987 Congress passed CWA section 319, establishing a national program to control nonpoint sources of pollution. EPA 319 guidance defines nonpoint source pollution as pollution "caused by rainfall or snowmelt moving over and through the ground and carrying natural and human-made pollutants into lakes, rivers, streams, wetlands, estuaries, other coastal waters, and ground water." Hydrological modification can also result in nonpoint source pollution. Section 319(h)(11) of the CWA requires states to report annually on their progress in meeting nonpoint source management program milestones. They must also report available information on reductions in nonpoint source pollution and on improvements in water quality resulting from program implementation. States may wish to include a list of further actions necessary to achieve CWA goals, including any recommendations for future EPA programs to control nonpoint source pollution, as well as brief case studies of any particularly successful nonpoint source control efforts.

> **Microbial Analysis of Storm Water**
>
> Coliforms, pathogenic bacteria, and viruses were detected in both combined sewer flows and storm sewer flows in Baltimore, Maryland. The levels of fecal coliforms found in storm flows ranged from 200 to more than 2,000 most probable number (MPN) per 100 mL, and 123 of the 136 samples had fecal coliform bacteria counts of greater than 2,000 MPN/100 mL. Of those 123 samples, 95 percent were positive for *Salmonella*. Six storm water flows were examined for viruses, and all six tested positive (Olivieri et al., 1977).

Environmental Group Reports

Many environmental groups conduct studies and publish reports on local beaches and recreational waters. These reports can be helpful in classifying your beach because they might evaluate levels of pathogen indicators and identify potential sources of pollution that could pose a health risk to swimmers. These environmental reports also might include historical information and report how water quality conditions have changed over time. Additional information on environmental groups that conduct water quality and recreational beach studies is provided in Appendix C.

Chamber of Commerce Reports

Chambers of Commerce and other government agencies often publish reports on the economic value of natural resources or beach recreation. These reports can assist in the evaluation and classification of your beach because they might contain information about how your beaches and recreational waters contribute to your local economy. For example, NRDC (1997) found that tourists spend billions of dollars annually visiting coastal and Great Lakes counties and their beaches. California, Florida, and South Carolina estimated the value of coastal tourism to be more than $37 billion, $23 billion, and $4 billion, respectively (NRDC 1997, 1999). Thus, if your beaches have a designated use of primary contact recreation, you might want to implement a "High" level of monitoring and notification to ensure that your beaches are safe and desirable to the public.

3.5.2 Water Quality Monitoring and Modeling Data

Water Quality Monitoring Reports

State or tribal water quality monitoring reports can provide data to help identify water quality patterns. Monitoring data can include temperature, flow, and turbidity. These data can often be used in evaluating and classifying your beach. For example, Francy and Darner (1998) found a relationship between turbidity and concentrations of *E. coli* at three Lake Erie beaches; as turbidity increased, *E. coli* concentrations also increased. In that study, other environmental and water-quality variables were also shown to be related to *E. coli* concentrations. It is important to note that sampling beaches more frequently will detect fluctuations in levels of indicators more reliably. Therefore, beaches that are sampled only once a month might be a greater health risk to swimmers than those that are sampled more frequently.

Water Quality Modeling Reports

Water quality models can also assist in the evaluation and classification of your beach. Models that predict bacterial contamination during rainfall events can help reduce the risk of swimmer exposure to contaminants between normal sampling periods (USEPA, 1999b). Chapter 4 provides additional information on these types of models.

Sanitary Surveys

A sanitary survey can be used to evaluate and document sources of contaminants that might adversely affect public health. The survey should be performed by a Registered Sanitarian/Registered Environmental Health Specialist or technicians that have experience, knowledge, and competence in the design, operation, and maintenance of water supply systems (USEPA, 1999a). Although sanitary surveys are frequently associated with water supply systems, they can be used to identify sources of pollution and to provide information on source controls and identification, persistent problems such as exceeding of water quality standards, magnitude of pollution from sources, and management actions and links to controls. Thus, a sanitary survey can be an effective tool for protecting human health at bathing beaches and can provide information that helps in designing monitoring programs and selecting sampling locations, times, and frequencies.

Additional information on sanitary surveys is provided in Appendix G. The sanitary survey list can be used to evaluate and identify the potential and existing microbiological hazards that could affect the safe use of a particular stretch of recreational water or bathing beach.

3.5.3 Frequency and Density of Use

Frequency of Use

The frequency of use and thus exposure to pathogens can be determined by measuring the level of use at a beach and identifying peak periods, including consideration of the percentage of people visiting the beach that actually enter the water, beach use during holidays, the length of the swimming season, and a number of other factors.

Density of Use

When people who have a compromised immune system or otherwise are at high risk become infected with pathogens, severe, life-threatening illness can occur (Ahmed, 1991). Thus, children, senior citizens, and people with weakened immune systems (such as persons with AIDS or other immune system diseases, cancer patients receiving chemotherapy, and organ transplant recipients) are more likely to become ill when they come into contact with contaminated water. Fattal et al. (1987) observed a significant association between enteric disease symptoms and recreation waters with high levels of bacterial indicators in children ages birth to 4 years. Alexander et al. (1992) found that children between the ages of 6 and 11 that came into contact with seawater contaminated with sewage were likely to suffer from vomiting, diarrhea, itchy skin, fever, lack of energy, and loss of appetite. These effects can be more significant in areas with restricted circulation.

This increased risk is of particular significance during high-frequency use periods because bacterial densities and the potential presence of pathogens are directly related to the number of swimmers. Studies have demonstrated an association between high swimmer densities and an increase in bacterial densities. Therefore, swimmers should pay special attention when swimming during peak bathing hours, especially if they are immunocompromised or otherwise at high risk.

3.5.4 Other Factors

Additional factors such as the importance to local economy, public comments, and community input are also important considerations in evaluating and classifying your beaches.

Importance to Local Economy

A particularly important factor is whether the beach provides substantial support to the local economy, primarily through residential and tourist income spent at the beach either directly for fees assessed to use the beach or indirectly for hotels and concessions supplying services to beach users. Beaches, rivers, and lakes are the number one vacation destination for Americans. Polluted water puts tourism-dependent economies at risk. Advisories and closings issued for popular tourist beaches, such as Myrtle Beach, South Carolina, Southernmost Point Beach, Key West, Florida, or Huntington Beach, California, cost local economies thousands of dollars (Sanchez, 1999). Some communities might prefer to limit water quality monitoring and public notification because of financial constraints. However, public confidence in the local government might be dramatically affected if an outbreak of diseases was to occur in swimmers at a particular beach. If beaches designated for primary contact recreation that are highly important to the local economy, a high level of monitoring and notification should be implemented.

Public Comments

The BEACH Act requires that a grantee program, and specifically its "List of Waters" be subject to public review and provide the public an opportunity to review the beach program through a process that provides for public notice and an opportunity to comment. It is beneficial to gather input from the community regarding the recreational waters they would like to see monitored when classifying and ranking your beaches. An annual public or community meeting, surveys of the users at the beach, local newspaper articles, or other sources can provide insight into public opinion about the beach, including why the beach is or is not used (e.g., for sunning, running, swimming, or surfing), perceptions of water quality and health problems, and whether beach users desire a monitoring and notification program (if none exists) or how satisfied they are with the program that has been implemented.

3.6 Step 5: Ranking Beaches

The final step in evaluating and classifying your beaches is to rank the beaches (Figure 3-6). It is the discretion of each state or tribe to determine how the beaches in the state or tribe are classified, however the ranking process and the factors used to classify your beach must be documented. This ranking should take into consideration all the factors discussed in this chapter, paying particular attention to 1) the amount of rainfall in the area, 2) the frequency of known and potential pollution sources such as CSOs or SSOs, 3) the density of bathers, 4) the occurrence of failing or malfunctioning septic systems, and 5) public comment. For example, significant rainfall events can frequently cause elevated levels of pathogens and pathogen indicators to reach the beach. Thus, rainfall might be one of the more important factors. Beaches where there are recurring significant rainfall events potentially present a higher risk to public health. Haile et al. (1999) found that there is an increased risk of adverse health effects associated with swimming in ocean water that is contaminated with untreated urban runoff. For this reason, it is important to note the frequency of rainfall events and the occurrence of significant flow from storm water outfalls, as well as CSOs and SSOs. In addition, exposure is another factor that is crucial to consider when evaluating a beach. Beaches that have a high density of bathers have a higher risk of exposure to pathogens.

The public could potentially impact beach evaluation and classification. A beach classified as High priority primarily because of pollution problems might be avoided by the public, and thus a monitoring and notification program might not be warranted. On the other hand, a beach classified as Low priority after the preliminary evaluation might be very popular with the public, and the public might desire improved monitoring and notification to ensure that water quality remains optimal for bathing. If the beach has been classified as High priority because of actual or potential pathogen contamination and it is frequently used by residents and tourists (perhaps because it is the only beach available in the area), a more intense level of surveillance and an increased effort to locate and address the source of contamination are warranted.

Once you have classified your beaches, Chapters 4 and 5 will enable you to design the most appropriate monitoring and notification protocols for each classification of beach. For example, "High" priority means frequent sampling and analysis with weekly posting of advisories or closings if necessary. "Medium" priority means less frequent sampling while still meeting water quality standards or developing a risk-based model to interpret rainfall events that contribute pathogens to the waterbody. "Low" priority indicates that sources of pathogens are rare or that few people bathe in the water. Water quality monitoring could therefore be limited to an annual survey or conducted only on complaint.

An agency with limited resources will need to consider carefully which swimming beaches should be targeted for which level of program implementation in the tiered approach or pursue sources of funding to provide better coverage of all popular low- to high-risk beaches.

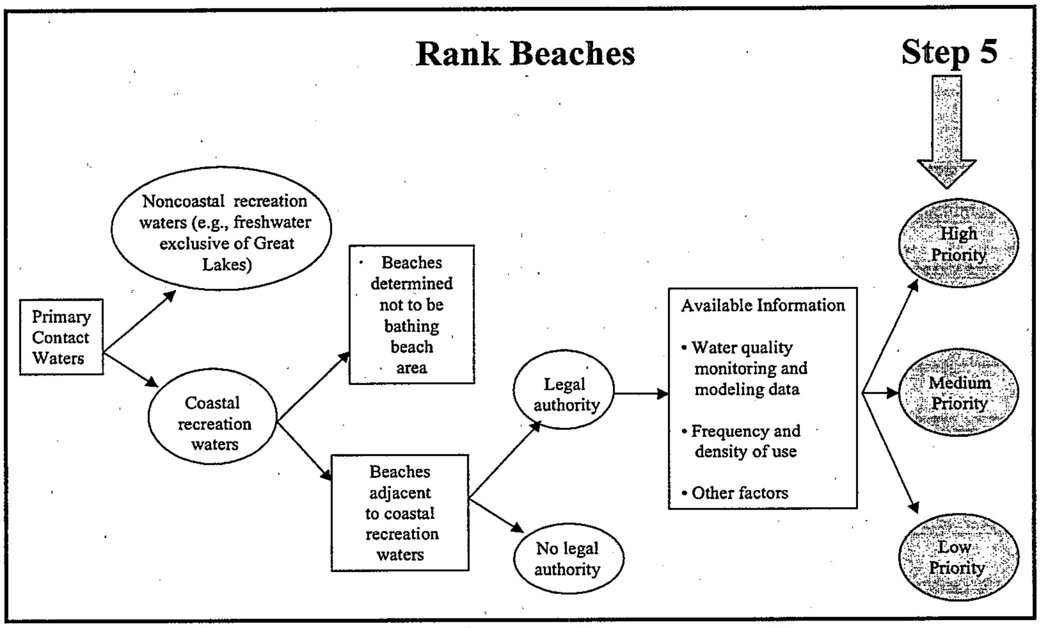

Figure 3-6. Step 5: Rank beaches.

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Chapter 4: Beach Monitoring and Assessment

This chapter describes the performance criteria related to monitoring and assessment and provides detailed technical guidance as required by CWA section 406(a)(2).

4.1 Performance Criteria

Three performance criteria related to monitoring and assessment activities must be met to qualify for BEACH Act Program Implementation Grants: Performance Criteria 2, 3, and 4.

Tiered Sampling Design and Monitoring Plan (Performance Criterion 2). Performance criterion 2 is to develop a sampling design and monitoring implementation plan. This plan must adequately address the frequency and location of monitoring and assessment of coastal recreation waters based on variety of factors, including the periods of recreational use of the waters, the nature and extent of use during certain periods, the proximity of the waters to known point sources and nonpoint sources of pollution, and any effect of storm events on the waters. Refer to Section 4.2 for more details.

Monitoring Report Submission and Delegation (Performance Criterion 3). Performance criterion 2 is for states and tribes to compile and report their monitoring data in timely reports and to describe any delegation of monitoring responsibilities that might have been made to local governments. See section 4.3 for a more detailed explanation.

Methods and Assessment Procedures (Performance Criterion 4). Performance criterion 4 is to develop detailed methods and assessment procedures. The procedure must adequately address both the methods to be used for detecting levels of pathogens and pathogen indicators that are harmful to human health and the assessment procedures for identifying short-term increases in pathogens and pathogen indicators that are harmful to human health in coastal recreation waters. Section 4.4 provides additional information related to this criterion.

4.2 Sampling Design and Monitoring Plan

Once states and tribes have ranked their beaches and assigned a classification of High, Medium, or Low, they can use the guidance in this chapter to develop and implement a monitoring program based on the beach classification. The plan should be composed of two parts: (1) a tiered sampling design and (2) other recommended elements addressing data quality, staffing, training, data management, and program oversight.

Note, the BEACH Act requires states and tribes, as a condition for receiving 406 grants, to provide the public with an opportunity to review the monitoring and notification program. The Performance Criterion for public comments is explained in Chapter 2.

4.2.1 Tiered Sampling Design

Your sampling design must identify when basic sampling will be conducted, when additional sampling will be conducted, where samples will be collected, and the depth at which samples will be collected. The sampling design must be developed to meet the objective of protecting human health and will depend upon the characteristics of the beaches. In accordance with the risk-based approach to evaluating and classifying your beaches, a tiered monitoring approach should be used. Table 4-1 presents examples of monitoring options based on the classification of your beaches (Chapter 3). It includes suggestions for high-, medium-, and low- priority beaches on when to conduct basic sampling, when to conduct additional sampling, where to collect samples, and at what depth to sample. Additional information on a monitoring design can be found in Appendix H.

When to Conduct Basic Sampling
EPA recommends for all beaches that samples be taken at least one month prior to the start of the swim season and at least once per week during the swim season. For high and medium priority beaches, EPA recommends that water quality samples be taken once per week during the swim season. However, at medium and low priority beaches less frequent sampling may be possible due to local conditions or as determined by the state, tribal, and local authorities. Point source dischargers should be encourages to test their discharge for *E. coli* or enterococci.

When to Conduct Additional Sampling
EPA recommends for all beaches that additional sampling be taken after a pollution event where the potential exists that indicator levels may be expected to exceed standards. In addition, EPA recommends that samples be taken as soon as possible after an initial sample shows an exceedence of a water quality standard, but where there is reason to doubt the accuracy of the sample. (Additional sampling may not be necessary if a preemptive closing already exists.) At high and medium priority beaches, EPA recommends that samples be taken after a heavy rainfall, particularly if your jurisdiction has a preemptive standard in place.

Where to Collect Samples
EPA recommends for all beaches that samples be taken in the middle of a typical bathing area. For all high priority short beaches, EPA recommends that samples be taken as a point corresponding to each lifeguard chair, or one for every 500 meters of beach. For all high priority long beaches (> 5 miles), samples be taken at most highly used areas, and spread out along the entire beach. In addition, all high and medium priority beaches should be sampled near known and pollution sources, while low priority beaches should be sampled near potential pollution sources.

What Depth to Sample
EPA recommends that samples be taken at all beaches at knee depth. You are encouraged to sample at one depth for all your beaches to ensure consistency and comparability among your

samples. For example, if the prioritization of your beaches changes over time, the samples would remain comparable due to the consistency in sample depth. At high priority beaches, additional samples can be taken as necessary for your particular beach (e.g., surface of water, waist depth, sediment). However, it is important to identify those at most risk and sample appropriately to protect those bathers at all priority beaches.

Table 4-1. EPA Recommended Tiered Sampling Design for Beach Managers

	When to Conduct Basic Sampling[a]	When to Conduct Additional Sampling	Where to Collect Samples	What Depth to Sample
Low Priority	At least 1 month prior to start of swimming season Sampling frequency at low priority beaches should be determined by state and local authorities, taking into account resource constraints and evaluation of risk factors at individual beaches. Minimum sampling frequency should be consistent with other ambient water quality sampling programs.	After a major pollution event where potential exists that indicator levels may be expected to exceed standard (sewage leak, spill) For situations not based on preemptive closings: Immediate sampling if first sample exceeds water quality standards and there is reason to doubt the accuracy of the sample.	*Depends on characteristics of your beach*: Middle of typical bathing area Near potential pollution sources	Knee depth
Medium Priority	At least 1 month prior to start of swimming season Recommended sampling frequency is once per week. However, less frequent sampling may be possible depending on proximity to suspected sources, beach use, historical water quality data, and other risk factors.	After heavy rainfall (particularly if you have a preemptive standard) After a major pollution event where potential exists that indicator levels may be expected to exceed standard (sewage leak, spill) For situations not based on preemptive closings: Immediate sampling if first sample exceeds water quality standards and there is reason to doubt the accuracy of the sample.	*Depends on characteristics of your beach*: Middle of typical bathing area Near known and potential pollution sources One sample every half-mile or at most highly used area (whichever is less)	Knee depth
High Priority	At least 1 month prior to start of swimming season At least once per week during swimming season	After heavy rainfall (if preemptive standard exists) After a major pollution event where potential exists that indicator levels may be expected to exceed standard (sewage leak, spill) For situations not based on preemptive closings: Immediate sampling if first sample exceeds water quality standards and there is reason to doubt the accuracy of the sample.	*Depends on characteristics of your beach*: Middle of typical bathing area Near known and potential pollution sources For short beaches, one sample at a point corresponding to each lifeguard chair, or one for every 500 m of beach For long beaches (> 8 km [5 miles]), sample at most highly used areas, and spread out samples along the entire beach	Knee depth Other as you feel is necessary for your beach *(e.g., surface of water, waist depth, sediment)*

[a] EPA recommends that you take samples during peak bathing time.
[b] When using 24-hour methods, you might want to collect samples at least 24 hours before high-use days (weekends) in case closures might be required.

Current Research

Monitoring program design is an essential part of any sampling program. EPA's Office of Research and Development (ORD) is currently undertaking a study at marine, estuarine, and freshwater beaches to develop a statistically valid monitoring protocol that takes into account elements that contribute to the uncertainty associated with sampling bathing beach waters, such as tides, wind, solar radiation, bather density, temporal and spatial factors, rainfall, and the proximity of point and nonpoint sources of pollution. New data collected during the summer of 2000 are being evaluated for the purpose of recommending a monitoring protocol that minimizes uncertainty about the quality of bathing waters while requiring the fewest number of samples possible. When published, this protocol will provide additional information to assist in determining when, where, and how many samples should be taken and how the monitoring data should be analyzed. The data quality objectives of this study are provided at www.epa.gov/nerlcwww/bch_dqo.pdf.

4.2.2 Other Elements of a Sampling and Monitoring Plan

4.2.2.1 Ensuring Data Quality

To ensure data quality, EPA recommends that your grant application include documentation on your

- Quality assurance project plan (QAPP),
- Data quality objectives (DQOs), and
- Standard operating procedures (SOPs).

A **QAPP** is a formal document that describes in detail the technical activities and quality assurance (QA) and quality control (QC) procedures that must be implemented to ensure the data meet the specified standards. A QAPP details who is responsible for each task, how it will be done, when it will be done, what QA and QC activities are necessary to ensure that the data collected meet the specified standards, and how the data will be analyzed and reported. EPA offers detailed guidance on the QAPP planning process in *Guidance for the Data Quality Objectives Process* (USEPA, 1994). In addition, general guidance and examples of planning for monitoring programs are provided in several EPA documents, including *Monitoring Guidance for the National Estuary Program* (USEPA, 1991a) and *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls* (USEPA, 1997b).

DQOs are qualitative and quantitative statements that clarify study objectives, define the appropriate types of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 1998c). EPA requires that any organization receiving funding from the Agency to collect environmental data used in decision making or compliance determinations (to select between two opposing conditions) follow the DQO process during the planning stage of the study. EPA's DQO guidance and related documents that can help you plan your monitoring program are available on the Internet at www.epa.gov/quality1/. Another valuable resource is *Quality Planning for the Life Science Researcher: Meeting Quality Assurance Requirements* (Cross-Smiecinski and Stetzenbach, 1994). Additional information on DQOs is provided in Appendix I.

An **SOP** is a written document that describes in detail the method for a given operation, analysis, or action. It should be used for technical (not administrative) activities that need to be performed the same way every time, i.e., are standardized. Such activities may include, but are not limited to, field sampling, laboratory analysis, software development, and database management. The methods can be presented in sequential steps and can include specific facilities, equipment, materials and methods, quality assurance (QA) and quality control (QC) procedures, and other factors required to perform the operation, analysis, or action. The format and content requirements of an SOP are flexible because the content and level of detail in the SOPs will vary according to the nature of the procedure being performed.

4.2.2.2 Staffing Monitoring Programs

A monitoring plan should also include an EPA-approved staffing plan for the beach monitoring program. EPA recommends that professional staff from state, tribal, and local agencies monitor most beaches.

4.2.2.3 Training Monitoring Staff

Once the monitoring program and sampling plan have been developed, the staff that will implement the program should receive specific training. Whether drawn from the ranks of professional staff or volunteers, the personnel responsible for sample collection and environmental measurements at the beach, as well as those performing the bacterial indicator analyses, should be trained for those activities. The quality of information produced by a monitoring program depends on the quality of the work undertaken by field and laboratory staff. Separate training programs should be developed for field staff, laboratory staff, and others involved in the monitoring program. Training should continue for as long as the monitoring program is in action. Additional information on training is provided in Appendix J.

4.2.2.4 Managing Data

One of the most important aspects of a monitoring program is the management of the data, from the collection process through the data analysis. Data management activities include documenting the nature of the data and subsequent analyses in a manner that permits the comparison of the data in one set with those in other data sets. Data management also includes handling and storing both hard copies and electronic files containing field and laboratory data. A data management system that will address the multiple needs of data users should be designed at the beginning of the monitoring program. It is important to understand and comply with all policies and standards in use at your agency regarding data collection and generation.

Computers
The quality of the computer equipment that will be used to store and analyze data should be considered first. Your agency may specify procedures for selecting or developing appropriate hardware and software for projects involving information management, traditional data and geospatial analysis, database management, mathematical modeling, literature search, graphic presentation, and document publishing.

The computer software you use should be recognized by the computer industry and similar users as currently suitable and reliable. The software should also be compatible within the agency or compatible with other agencies' software, if necessary. For example, if data need to be transferred from a county health department to the state health department to meet reporting requirements, the database system selected should be the same as the state's or one that permits seamless data transfers without corrupting parameter fields or values.

Related Databases
Another example of the need to transfer data is providing data to update national ambient water quality databases with the results of local beach monitoring. EPA strongly encourages beach managers (and volunteer monitors) to add their data to EPA's storage and retrieval (STORET) database. EPA maintains two data management systems containing water quality information for the nation's waters: the Legacy Data Center, and STORET. The Legacy Data Center, or LDC, contains historical water quality data dating back to the early part of the 20th century and collected up to the end of 1998. STORET contains data collected beginning in 1999, along with older data that have been properly documented and migrated from the LDC. Both systems contain raw biological, chemical, and physical data on surface and ground water collected by federal, state, and local agencies, Indian tribes, volunteer groups, academics, and others. Each sampling result in the LDC and in STORET is accompanied by information on where the sample was taken (latitude, longitude, state, county, Hydrologic Unit Code, and brief site identification), when the sample was gathered, the medium sampled (e.g., water, sediment, fish tissue), and the name of the organization that sponsored the monitoring. Staff working with the database should have expertise and training in the software, as well as in the procedures for data transport, file transfer, and system maintenance. Additional information on STORET can be found at http://www.epa.gov/storet/.

The operation of the data management system should include QA oversight and QC procedures. If changes in hardware or software become necessary during the course of the project, the data manager should obtain the most appropriate equipment and test it to verify that the equipment can perform the necessary jobs. Appropriate user instructions and system documentation should be available to all staff using the database system. The development of spreadsheet, database, and other software applications involves performing QC reviews of input data to ensure the validity of computed data.

4.2.2.5 Program Implementation and Oversight

The monitoring program should be implemented and its effectiveness assessed at regular intervals. The purpose of assessments such as surveillance, readiness reviews, technical systems audits, performance evaluations, and audits of data quality is to determine whether the established QC procedures are being used and how the program is operating. Checklists or reviews of program documentation and reports can be used to evaluate different aspects of the program. The types and number of assessments to be performed can be documented in the monitoring program oversight plan. In addition, the program should clearly provide for the authority of the assessor (e.g., a QA officer) to stop work and should identify under what conditions this may occur.

The QA program should include procedures for identifying and defining a problem, assigning responsibility for investigating the problem, determining the cause of the problem, assigning responsibility for implementing corrective action, and assigning responsibility for determining the effectiveness of the corrective action and verifying that the corrective action has eliminated the problem. Supervision is important during the program. To provide advice and identify problems when they occur, personnel providing oversight to technical staff should be well versed in the procedures they are performing. This proficiency is needed whether in the field performing the sampling or in the laboratory performing the microbiological analyses.

Public Comment

The BEACH Act requires states and tribes, as a condition for receiving 406 grants, to provide the public with an opportunity to review the monitoring and notification program. This need not be addressed as part of the Public Notification and Risk Communication Plan, if it is elsewhere in a state's program. Note, providing public comment in addressed in Chapter 2 as Performance Criterion number 9.

4.3 Monitoring Report Submission and Delegation

The third performance criterion is for states and tribes to compile and report their data in timely reports and to describe any delegation of monitoring and notification responsibilities that might have been made to local governments.

Delegation
EPA encourages states to coordinate with local governments and to delegate, as appropriate, responsibilities for monitoring programs to local governments. Local governments have traditionally played the lead role in administering beach protection programs. There are many reasons for the local level to take responsibility in protecting recreational waters. For example, local citizens and officials are more familiar with local problems and needs and are in a better position to address local issues and formulate solutions. Also, many of the benefits of protecting natural resources, in this case coastal recreation waters, accrue at the local level.

Report Submission
States and tribes must report their monitoring data to the public, EPA, and other agencies in a timely manner. States and tribes must also report the actions they have taken to notify the public when water quality standards are exceeded. To meet this criterion, states and tribes should coordinate closely with local governments to acquire information and ensure that it is submitted in a consistent fashion. Timely submission of compatible electronic files is a critical component of this reporting requiremnt. Comparability with EPA's *National Health Protection Survey of Beaches* is also a very important factor.

4.4 Assessment Methods and Procedures

States and tribes also must identify assessment methods and procedures for their coastal recreation waters. Strict adherence to specific procedures for sampling is critically important for successful beach monitoring program. Collection, preservation, and storage of water samples are critical to the results of water quality analyses for bacterial indicators at swimming beaches. States and tribes should make every effort to adequately develop these procedures and the various subparts described below.

This section and Appendix K discuss the basic equipment and techniques used to obtain water samples. You should determine the most appropriate sampling procedures for your beach monitoring program based on your sampling design, the availability of facilities and equipment, and how the samples will be processed. In any case, it is important to develop a written plan or SOPs that document the materials used and the steps performed to obtain the samples and submit them to a laboratory for analysis.

Appendix K outlines the EPA-recommended SOPs for sample collection, handling, and subsequent analysis.

4.4.1 Laboratory Analysis

An essential component of the beach monitoring program is the selection of a laboratory experienced in performing microbiological techniques that can provide results in conformance with the standards you have established for precision and bias (accuracy). Your agency might already have such a laboratory, or you might decide to contract with a laboratory. An accredited laboratory should be used to obtain data when beach advisory or closing decisions are to be made.

Policies and procedures for obtaining necessary laboratory and analytical services should be developed as part of this performance criterion. Analytical laboratories should have the capability to analyze the quantity of samples requested within the required time period, the instrumentation/technique expertise to perform the required analyses, and qualified staff to perform the analyses (USEPA, 1998b). Not only do microbiological techniques call for strict adherence to specified methods, but staff also need to avoid introducing microorganism contaminants into media, thereby producing incorrect results. Facilities need to be equipped with proper ventilation and equipment; surfaces need to be kept clean and disinfected on a regular basis. Staff need to have received extensive training in a variety of techniques for the detection of heterotrophic bacteria and other microorganisms and be able to meet the standards set for preparation of sterile media, inoculation procedures, colony counts, and other aspects involved in the analysis of bacterial densities in surface water samples.

SOPs covering general laboratory operations, as well as specific procedures, should be approved and issued by the laboratory's QA Officer. Copies of all approved laboratory operations SOPs should be kept on file. Laboratory operations SOPs usually include discussion of responsibilities for performing and overseeing the work; possible interferences that might affect the analyses; safety considerations; QC activities, equipment, materials, reagents, and standards needed for the analyses; the steps of the procedure in chronological order; an explanation of how data should be analyzed and reported; references; and associated documents and forms. The laboratory should maintain log books for sample receipt, preparation of standards and media, sample analysis, instrument runs, and instrument maintenance. The laboratory should have an established quality management plan that specifies the quality policy, staff responsibilities, record management, types of assessments performed to evaluate the analyses, and how corrective actions are addressed.

Further discussions of good laboratory practices, requirements for equipment and supplies, training programs for staff, QA/QC issues, and health and safety considerations for microbiological laboratories are provided by Cross-Smiecinski and Stetzenbach (1994), Eaton et al. (1995), and Csuros and Csuros (1999). A capable lab should be accredited. Accreditation means that the laboratory has been investigated and found to meet the standards and criteria set by an appropriate accrediting agency, including having qualified personnel, appropriate instrumentation, SOPs, and demonstrated proficiency in the analysis of samples for particular bacterial indicators. Laboratory accreditation is available through EPA's National Environmental Laboratory Accreditation Program (NELAP), which oversees state accrediting authorities. Further information on NELAP is available on the Internet at the National Environmental

Laboratory Accreditation Conference (NELAC) web site, www.epa.gov/ttn/nelac. NELAC is a voluntary association of state and federal agencies that was formed to establish and promote mutually acceptable performance standards for the operation of environmental laboratories.

Your agency's policies and procedures for purchasing analytical services should be reviewed to determine their suitability for implementing the beach monitoring program. Of particular importance are the specification of method requirements that will be used to identify bacterial indicator levels in the water samples, the number of samples that will be submitted for analysis, the frequency of submittals, the schedule and turnaround time for results, deliverables and reporting format, and contractual requirements, including penalty or damage clauses to reduce laboratory default, late data submittals, and improperly performed analyses. Further guidance on soliciting and awarding contracts for analytical services is provided in *EPA's Guide to Laboratory Contracting* (USEPA, 1998b).

4.4.2 Analytical Procedures

Many methods are available to detect the presence of bacterial indicators. Well-developed analytical methods with published standard procedures issued by well recognized standard-setting bodies (e.g., American Society for Testing and Materials [ASTM]) can be used. However, documentation supporting the validity of methods other than those currently recommended by EPA must be provided.

Membrane filtration (MF) and most probable number (MPN) are two types of methods that are currently used for enumerating *E. coli* and enterococci in ambient water. MF is a direct-plating method in which sample dilutions/volumes are filtered through membrane filters that are subsequently transferred to petri plates containing selective primary isolation agar or an absorbent pad saturated with selective broth. A second substrate medium is used in the two-step MF procedures to confirm or differentiate the target organisms. In MPN tests, the number of tubes or wells producing a positive reaction provides an estimate of the original, undiluted density (concentration) of target organisms in the sample. This estimate of target organisms, based on probability formulas, is termed the most probable number. MPN tests can be conducted in multiple-tube fermentation (MTF), multiple-tube enzyme substrate, or multiple-well enzyme substrate formats.

Four membrane filter methods are currently recommended by EPA for making decisions concerning the protection of human health at beaches. (EPA is currently reviewing additional analytical methods that will be published as proposed regulations under 40 CFR Part 136.)

EPA recommends the following membrane filter techniques for detecting enterococci in water:

***EPA Method 1600 (mEI media)*:** Method 1600 is a single-step MF procedure that provides a direct count of bacteria in water, based on the development of colonies on the surface of a filter when placed on selective mEI agar (USEPA, 1997a). This medium, a modification of the mE agar in EPA Method 1106.1, contains a reduced amount of 2-3-5-triphenyltetrazolium chloride, and an added chromogen, indoxyl-β-D-glucoside. The transfer of the filter to EIA is eliminated, thereby providing results within 24 hours. In this method, a water sample is filtered, and the filter is placed on mEI agar and incubated at 41 ± 0.5 °C for 24 hours. Following incubation, all colonies with a blue halo, regardless of colony color, are counted as enterococci. Results are reported as enterococci per 100 mL.

EPA Method 1106.1 (mE media): EPA Method 1106.1 is a two-step MF procedure that provides a direct count of bacteria in water, based on the development of colonies on the surface of a membrane filter when placed on a selective nutrient medium (USEPA, 1985b). A water sample is filtered through a 0.45-µm membrane filter, and the filter is placed on a plate containing selective mE agar. After the plate is incubated at 41 ± 0.5 °C for 48 h, the filter is transferred to an Esculin iron agar (EIA) plate and incubated at 41 ± 0.5 °C for 20 to30 minutes. After incubation, all pink to red colonies on the mE agar that form a black or reddish-brown precipitate on the underside of the filter when placed on EIA are counted as enterococci. The organism density is reported as enterococci per 100 mL.

EPA recommends the following membrane filter techniques for detecting *E. coli* in water:

Modified EPA Method 1103.1 (Modified mTEC Media): Modified EPA Method 1103.1 is a single-step MF procedure that provides a direct count of *E. coli* in water based on the development of colonies on the surface of a filter when placed on a selective modified mTEC medium (USEPA, 1985a). This is a modification of the standard mTEC media that eliminates bromcresol purple and bromphenol red from the medium, adds the chromogen 5-bromo-6-chloro-3-indoyl-D-glucuronide (Magenta Gluc), and eliminates the transfer of the filter to a second substrate medium. In this method, a water sample is filtered through a 0.45-µm membrane filter. The filter is placed on modified mTEC agar, incubated at 35 ± 0.5 °C for 2 hours to resuscitate injured or stressed bacteria, and then incubated for 23 ± 1 hours in a 44.5 ± 0.2 °C water bath. Following incubation, all red or magenta colonies are counted as *E. coli*.

EPA Method 1103.1 (mTEC Agar): EPA Method 1103.1 is a two-step procedure that provides a direct count of *E. coli* in water based on the development of colonies on the surface of a membrane filter when placed on a selective nutrient and substrate medium (USEPA, 1985a). EPA originally developed to monitor the quality of recreational water. This method was also used in health studies to develop the bacteriological ambient water quality criteria for *E. coli*. In this method, a water sample is filtered through a 0.45-µm membrane filter, the filter is placed on mTEC agar (a selective primary isolation medium), and the plate is incubated first at 35 ± 0.5 °C for 2 hours to resuscitate injured or stressed bacteria and then at 44.5 ± 0.2 °C for 23 ± 1 hours in a water bath. Following incubation, the filter is transferred to a filter pad saturated with urea substrate medium. After 15 minutes, all yellow or yellow-brown colonies (occasionally yellow-green) are counted as positive for *E. coli* using a fluorescent lamp and either a magnifying lens or a stereoscopic microscope.

A new EPA video, "Improved Enumeration Media for *E. coli* and Enterococci," demonstrates the four methods currently recommended by EPA, including the mE and the mEI agar methods for enterococci and the modified mTEC and mTEC agar methods for *E. coli*. The purpose of the video is to introduce and demonstrate the improved methods. Accompanying the video is a laboratory manual that explains all four methods in a step-by-step format. The laboratory manual also contains color photographs of the target colonies on all media to aid in identification. The new video and methods manual are now available to state, tribal, and private laboratories. Requests for copies of the manual (*Improved Enumeration Methods for the Recreational Water Quality Indicators: Enterococci and* Escherichia coli, (EPA-821-R-97-004) or videotape (EPA-822-V-99-01) (USEPA, 2000) should be directed to EPA's National Service Center for Environmental Publications (http://www.epa.gov/ncepihom/). The manual is also available on the Internet at www.epa.gov/OST/beaches or www.epa.gov/microbes.

4.4.3 Recommended Sample Collection Techniques

Strict adherence to specific procedures for sampling is criticially important for a successful beach monitoring program. This can be accomplished through an EPA-approved plan or SOP for obtaining samples and submitting them for analysis. Proper collection, preservation, and storage of water samples are critical to accuracy of the results of water quality analyses for bacterial indicators at swimming beaches. This section and Appendix K discuss the basic equipment and techniques used to obtain water samples. You should determine the most appropriate sampling procedures for your beach monitoring program based on your sampling design, the availability of facilities and equipment, and how the samples will be processed. For example, your agency's facility might sterilize sample containers before each visit to the beach, the laboratory performing the analyses might provide its own sterile containers under contract, or your agency might purchase sterile containers from a scientific supply company for the season's sampling effort. In any case, it is important to develop a written plan or SOP that documents the materials used and the steps performed to obtain the samples and submit them to a laboratory for analysis. Appendix I outlines the EPA-recommended SOPs for sample collection, handling, and subsequent analysis.

4.4.4 Data Verification and Validation

Certain procedures should be used to verify whether the microbiological analyses have correctly estimated the densities of indicator bacteria, to ascertain whether particular requirements for a specified use of the results have been fulfilled, and to determine how the data should be interpreted for decision making. This section discusses some of the important aspects of these procedures, which should be included in the monitoring program design to ensure that the data obtained are usable and defensible. Several iterations through these activities might be necessary to ensure that the data and their interpretation are correct.

Verification Methods

Verification refers to confirming, by examining and providing objective evidence, that specified requirements have been fulfilled. Data verification is a systematic process to determine whether the data have been collected in accordance with the specifications of the QAPP (or other plan) with respect to compliance, correctness, consistency, and completeness. Data verification includes consideration of the data that were obtained, as well as data obtained from QC samples, and it assesses whether the measurement DQOs specified in the plan have been met.

Procedures to verify whether the bacterial indicators were correctly determined should be provided for any method used. Verification involves performing additional tests to identify those colonies found on the membrane filter that provided information. A false positive rate is calculated as the percent of colonies that reacted (were identified as the indicator) but were not actually the indicator. A false negative rate is calculated as the percent of colonies that did not react as anticipated (and so were not identified as the indicator) but were in fact that indicator. False positive and false negative rates for the media used in EPA Methods 1600 and 1103.1 are provided in those methods. Verification procedures should be used in establishing QC limits on initial use of the procedure, when using a new technician to perform the procedure to ensure that method requirements can be met, whenever any changes are made in how the procedure is performed or in the materials used in the procedure, and always when the results are to be used in evidence for legal proceedings.

Sample records, chain of custody records, and sample tracking records should be reviewed to verify that all the samples collected were analyzed so that the data set will be complete. Data entries and analyses should also be verified. The input of large quantities of data requires spot-checking to detect potential data entry errors. Additional checks include graphically displaying data to visually inspect for potential errors, using statistical methods to detect invalid data, and checking for duplicate data entries. Input data may be reviewed for accuracy, bias, completeness, precision, representativeness, and/or uncertainty. In addition, data reductions and transformations should be reviewed (audited) to ensure that they have been correctly performed. Review of calculations includes rechecking the computations, reviewing the assumptions used and the selection of input data, and checking the input data against the original sources to be sure transcription errors have not occurred. The types of calculations that might be performed on bacterial indicator filter counts to estimate bacterial densities per sample are provided in the EPA methods. Further examples are shown in *Standard Operating Procedure for Recreational Water Collection and Analysis of* E. coli *in Streams, Rivers, Lakes and Wastewater* (IITF,1999).

Data verification is always followed by data validation (see below) and data analysis. The reviewer should document the results and report them to the beach monitoring program management staff. Verifying conformance of the data collection effort with the plan requires that the data pass the specified numerical QC tests (precision and bias limits), that the plans were followed and calculations performed correctly, that all samples were treated consistently, and that the necessary quantity of data and information relative to the stated DQOs was obtained (completeness). Any components requiring correction should be corrected if possible. If data verification cannot be achieved, the data are not usable.

Data Validation and Quality Assessment

Validation refers to the confirmation that particular requirements for a specified intended use have been fulfilled. Thus, once the data have been confirmed to meet standards and contract requirements, they are systematically examined to determine their technical usability with respect to the planned objectives. This activity can also provide a level of overall confidence in the reporting of the data based on the methods used. For example, if the wrong medium was used or the incubation temperature limit was exceeded, these data would be assigned a qualifier indicating their uncertainty would be rejected from further analyses. A report that provides an assessment of the usability of the data, a summary of environmental sample results, and a summary of QC and QA results should be prepared. The report should discuss any discrepancies between the DQOs and the data collected and any effects such discrepancies might have on the ability to meet the DQOs.

Finally, an assessment of data quality should be performed to evaluate whether the data are of the right type, quality, and quantity to support their intended use. This assessment includes reviewing the DQOs and sampling design, conducting a preliminary data review, selecting the statistical test, verifying the assumptions of the statistical test, and drawing conclusions from the data.

4.5 Use of Predictive Tools in Beach Monitoring Programs

A key objective of any beach monitoring program is to minimize beachgoers' health risk associated with infectious diseases caused by exposure to microbial organisms. Notifications of elevated levels of indicator bacteria are usually based on monitoring of beach waters. Under this system, however, users of recreational waters can be exposed to waterborne pathogens because of inadequate monitoring or delayed notification of monitoring results during periods of poor water quality. The laboratory methods commonly used to detect potentially harmful microorganisms take 24 to 48 hours. During this period, beachgoers can be exposed to harmful pathogens. To reduce exposure to pathogens, government agencies need tools that can provide a quick, reliable indication of the water quality conditions. Thus, these tools supplement monitoring and provide conservative estimates when there is a lag time between the water quality sampling and obtaining results.

This section inventories various predictive models or tools that are currently in use or can be used by local health agencies to evaluate the need for closing beaches or issuing advisories and warnings. Descriptions of the potential predictive tools and their attributes are provided, as well as discussion of the limitations, the input data requirements, and the availability of each of the predictive tools.

4.5.1 Criteria for Evaluating Potential Models

A wide range of models are available and could be adapted to support beach advisory decisions. If beach a manager chooses to use a predictive model, the model chosen for use should be supported by identified selection criteria. Selection of the appropriate model for helping to determine beach advisories and closings depends on the site conditions of the waterbody of concern. Some of the site-specific considerations include the types of sources (point source/nonpoint source), waterbody types, transport and circulation patterns, severity of impairment, and frequency of indicator criteria exceedances. Other issues to consider are the model development and application cost, the accuracy required, the use of the system, training of staff, and public outreach and education requirements. In some cases economies of scale can be identified when related analysis and modeling efforts have been initiated in the waterbody of concern.

If they are properly developed and applied, simple models for dilution and mixing zone evaluations can be used in making beach advisory or closing decisions. More complex models can also be considered in light of their ability to assess dynamic loading and transport processes. Detailed models can be used in the development of a range of decision rules for categories of loading or environmental conditions. These decision rules can be used to address day-to-day operations in a cost-effective and timely manner.

In some cases objectives can best be met by using one model, whereas in others a combination of models is needed. Models are often developed for a particular waterbody type, including rivers and streams, lakes, and offshore ocean waters. When determining the type of model to use, factors such as data needs, application cost, pollutant type, and required accuracy are important to consider. The selection of the appropriate model can be based on the following screening factors:

- ***Combined point and nonpoint sources***. An important screening factor is how the model handles the loadings from point and nonpoint sources. Models based on water quality data implicitly take the point and nonpoint sources into account, whereas models that use continuous simulation of the water quality directly account for the sources. Typically, the sources are part of the input parameters. For example, the rainfall-based alert curves discussed later in this chapter are models based on the water quality conditions. Those models do not explicitly account for the point and nonpoint sources; instead, the sources affect the water quality parameters used in the model. In the case of the CORMIX and PLUME models (described below), point sources are a component of the model input; the flow and concentration must also be included.

- ***Pathogen source characterization***. Pathogens found at a beach site of interest might be from point sources, including sewage treatment plants, sanitary sewer overflows (SSOs), combined sewer overflows (CSOs), and storm water outfalls, or nonpoint sources. Accounting for the different sources of pathogens might require the use and integration of a variety of models.

Watershed loading models are used to characterize nonpoint sources of pathogens by providing concentration and flow rates of pathogens (pollutographs and hydrographs) or unit and total loads of pathogens. Because point sources of loadings are not dominated by wet weather conditions, loading can be easily estimated from the discharge and concentration. Once pathogen loads from point and nonpoint sources are determined, the next step is the routing of the pathogen through the system using a representative model of the dominant mixing and transport processes to estimate the pathogen concentration at the location of interest.

- ***Dominant mixing and transport processes***. The waterbody type dictates the dominant mixing and transport processes of a pollutant. In rivers and streams the dominant processes are advection and dispersion. In estuaries these processes are influenced by tidal cycles and flows. Factors such as waterbody size and net freshwater flow are key in determining the dominant processes. For discharges in the ocean surf zone, dominant dispersion processes include mixture due to breaking waves and transport from nearshore currents.

- ***Pathogen concentration prediction***. This factor describes the ability of the model to predict the pathogen concentration in the receiving water at the location of interest, which in this case is a beach site. Transformation processes such as bacterial kinetics also must be accounted for in the model to allow for a realistic prediction.

- ***Ability to provide time-relevant analysis, decision making, and guideline establishment***. Timely or time-relevant analysis is needed for an effective advisory. Models applied to predict water quality conditions can be used as a basis for decision making and as management tools. For example, a beach authority can use such tools as a basis for beach advisories following a rainfall event or an accidental sewage spill.

- ***Time-relevant use***. Under this category the input data needed, processing time, and postprocessing abilities of the model are evaluated. Potential predictive tools for beach advisories must be able to predict pathogen concentration at the site of interest in a relatively short amount of time. This means that the data input requirements and processing time need to be minimal. Also crucial to the success of the predictive tool is the postprocessing of the output data. Tabular or graphical representation of the output data provides a quick, easy way to interpret results and might serve as a basis for making time-relevant decisions concerning beach advisories.

- ***Evaluation of unplanned and localized spills***. Spills of a pollutant can be caused accidentally by equipment failure or rainfall. In either case, this factor describes how the model handles the additional loading. Models based on water quality data do not account for this increased loading unless samples were collected during rainfall or a spill event and analyzed, and the data were then entered into the model database. On the other hand, models that account for point sources can easily account for the increased loading by including the spill as an input parameter.

- ***Documented application to beach and shellfish closure***. This factor describes the ability of the model to predict the water quality condition surrounding swimming and shellfish areas. Models can be used as water quality predictive tools and as a basis for decision making. For example, several communities use rainfall models, and the New York City metropolitan area uses the Regional Bypass Model (discussed later in this chapter). These models have proven to be effective tools to protect people from exposure to pathogens following rainfall events or sewage spills.

- ***Ease of use***. The level of user experience is an important factor in determining whether a model is easy to use. Some complex models require a great deal of training and experience; simple methods require only a conceptual understanding of the processes, and results can be readily obtained.

- ***Input data requirements***. Input data requirements are a function of a model's complexity. In general, complex models require more specific and complex input data than simple models. Some of these data might not be readily available, and acquiring such data might require expending resources. Therefore, the objective of the model application can be very important in this step.

- ***Calibration requirements***. Decision making and management alternatives based on modeling results require that the model outcome be acceptable and reliable. Not all models can be calibrated. Models that simulate water quality conditions are calibrated against in-stream monitoring stations. Simple models such as the rainfall alert curves are continuously updated to provide accurate results. This is done by continually updating the model's database.

- ***Pollutant routing***. Pollutant routing addresses how a model deals with the fate and transformation of pollutants. Simpler models might not include processes that describe pollutant transformation. More complex models vary in their description of the processes. The range can be from a gross or a net estimate of the process to a detailed mechanism of the process. The focus is on bacterial processes. In general, most environmental models use the first-order decay rate to represent the microbial death rate.

- ***Kinetics of pathogen decay***. The survival of pathogens (and pathogen indicators) in the environment is influenced by many variables, such as age of the fecal deposit, temperature, sunlight, pH, soil type, salinity, and moisture conditions. In general, the death rate of pathogens can be estimated as a first-order rate, which is incorporated into water quality models.

Predictive models are effective tools to supplement actual sampling. It is important, however, to consider that models do not provide perfect predictions of actual conditions but instead provide estimates of current conditions. A public health manager should account for inaccuracies in models when making decisions related to public health.

4.5.2 Predictive Methods Currently Used by Beach Managers

Two approaches were used to identify the predictive tools currently in use by local agencies. First, EPA's National Health Protection Survey of Beaches was used to identify local agencies that currently base their beach advisories on water quality model prediction. Those agencies were contacted regarding the types of models they use and information about extent of use, model developers, and availability.

The second approach was a review of literature and information from previous EPA programs. This approach included reviewing the models and guidelines provided in the CWA section 301(h) program, identifying tools used in the TMDL program, and reviewing other EPA publications that relate to water quality modeling. The beach closure predictive tools identified were characterized based on modeling or prediction application techniques and on modeling components.

The tools currently in use by local and state agencies vary in their complexity and approach to minimizing exposure to pathogens. The cities of Milwaukee and Stamford and the Delaware Department of Natural Resources and Environmental Control (DNREC) used regression analysis to relate rainfall to pathogen concentration. Models developed using this approach are site-specific because they are derived from locally observed water quality and rainfall data.

Simulation of water quality conditions under a variety of scenarios of untreated or partially treated sewage can also be used. Comparison of the resulting water quality conditions to the established criteria can serve as the basis for the beach closure. The metropolitan Boston area in Massachusetts is undertaking such a project. A predictive model that can predict water quality conditions resulting from bypasses of sewage at preselected locations was developed for the New York-New Jersey harbor. Beaches surrounding the discharge locations are closed whenever the predicted pathogen concentrations exceed the water quality criteria.

Closure of beaches based on water quality modeling is also practiced in the states of Virginia and Washington. Computer models that predict pathogen concentration by simulating the dominant mixing and transport processes in the receiving water range from simple to very complex. The Virginia Department of Health uses a simple mixing and transport model to predict water quality conditions surrounding wastewater treatment plant outfalls. Washington uses a more complex model, CORMIX, to predict water quality conditions surrounding wastewater treatment outfalls. Rhode Island is in the early stages of developing predictive models for its beaches. *Review of Potential Modeling Tools and Approaches to Support the Beach Program* (USEPA, 1999c) provides a detailed description of these tools and their attributes, limitations, data requirements, and availability. A summary of the capabilities and applicability of these models is included in Table 4-4.

Table 4-4. Evaluation of model capabilities and applicability

Model	Combined PS/NPS [a]	Real Time and Decision Making	Spills	Application to Beach or Shellfish Closure	Ease of Use	Input Data Required	Calib.	Developing Guidelines	Pollutant Routing
Rainfall-based	xxx	xxx	0	xxx	xxx	x	xx	xx	0
Bypass	x (PS)	xxx	xxx	xxx	xxx	xxx	x	xx	xxx
SMTM	x (PS)	xx	xx	xx	xx	x	x	0	x
PLUMES	x (PS)	x	xx	xx	xx	x	x	x	x
CORMIX	x (PS)	x	x	x	xx	x	x	x	x
JPEFDC	xx (NPS/PS)	x	xxx	xxx	x	xxx	xx	x	xxx

0 Not applicable
x Low applicability
xx Medium applicability
xxx High applicability
[a] Point Source/Nonpoint Source

4.5.2.1 Rainfall-based Alert Curves

A rainfall-based alert curve is a statistical relationship between the amount of rainfall at representative rainfall gauges in the watershed and the observed bacterial indicator concentration at a specific beach area. This relationship is based on simple regression methods and the frequency of exceedance of simultaneous and representative observations of bacterial indicator concentrations and rainfall events. Pathogen data supporting the development of rainfall-based alert curves are generated from the water column concentrations obtained from ambient or targeted monitoring programs. Although these models do not explicitly account for point and nonpoint sources or fate and transport processes, they rely on a direct statistical relationship and provide simple, easy-to-use tools with reasonable accuracy. Rainfall-based alert curves based on regression analysis have been used for preemptive beach closure in Milwaukee, Wisconsin; Stamford, Connecticut; Sussex County, Delaware; and the Boston, Massachusetts, area.

In the case of the city of Milwaukee, city of Stamford, and DNREC, the approach taken was regression analysis to relate rainfall to pathogen concentration. Models developed based on this approach are site-specific because they are derived from locally observed water quality and rainfall data as well as beach location/configuration relative to pathogen sources.

Objectives
The objective of rainfall-based alert curve models is to establish a statistical relationship between rainfall events and bacterial indicator concentrations. This relationship can then serve as a management tool for developing operating (advisory and closing) guidelines based on predicted pathogen concentrations, which suggest the need to restrict or prohibit contact uses of recreation waters. Several agencies have developed beach operating rules based on analysis of site-specific relationships between rainfall and water quality monitoring data. Delaware (DNREC, 1997) and Connecticut (Kuntz, 1998) have successfully used this approach (USEPA, 1999).

Benefits
The rainfall-based alert curves are highly recommended as a predictive tool to determine the need for beach advisories or closings because of their simplicity, ease of development and use, economic feasibility, and virtually instantaneous run time. A great advantage of rainfall-based alert curves is that they can be easily translated to decision logic that a beach manager can use without prior advanced training or a high level of technical skill.

Limitations
It is important to update your model with changes in your watershed or weather pattern. Weather patterns typically have cycles, so predictive models must reflect this variance or acknowledge this limitation. For example, rainfall based alert curves may not be appropriate for use along the arid southern California coast because of an "impact lag" effect where discharges from storm water outfalls can continue for several weeks following substantial rain events.

Overview of Rainfall-Based Alert Curves Technical Approach
Rainfall-based alert curves are developed in three phases: collecting data, analyzing data (linking the rainfall events to bacterial indicators), and developing operating rules for advisories or closings of recreational waters. Although EPA is currently supporting continued efforts in research and development of these techniques, the Agency recommends that state, tribal, and local beach managers consider developing scientifically based and easy-to-use site-specific decision rules based on the technical approaches summarized below:

- Rainfall-based models are site-specific, and their development requires relatively large sets of monitoring data for both rainfall and water quality. The overall relationship can be described by a statistical regression/estimation model. Depending on the number of rainfall stations considered and the number of rainfall characteristics (amount, duration, lag time, etc.), the relationship might require a more complex multiple-regression model. Because of the statistical nature of these types of models, they cannot distinguish between point sources and nonpoint sources of pathogens and do not explicitly incorporate advection, transport, and decay processes. Also because their use is limited to assisting in the development of decision rules for advisories and closings of recreational waters, they do not attempt to provide the spatial and vertical distribution of pathogens.

- Frequency of exceedance analysis is another rainfall-based method that can be used to develop rainfall-based alert curves. An exceedance is defined as any time the observed pathogen concentration exceeds the action level, such as the state water quality standard, specified by a responsible agency. The objective of this method is to determine the minimum amount of rainfall that causes the pathogen concentration to exceed the action level. This amount can be determined by dividing cumulative rainfall amounts over a period of 24 hours or more into segments that range from no rainfall to an upper limit that is representative of the rainfall record, types of storms, and season. For each rainfall amount category, the observed pathogen concentration or the geometric mean of multiple samples is compared to the action level.

- After establishing a relationship between rainfall amounts and pathogen concentrations, developing decision rules for advisories and closings is the next step. An advisory or closing threshold is determined based on the least amount of rainfall that would result in a violation of the action level. This method applies to situations where historical rainfall data and water quality records exist. Decision rules should also be developed to include seasonal variation in rainfall. EPA is currently developing guidance on a number of linear regression techniques that can be used by beach managers to evaluate the need for preemptive advisories or closures. When completed, this guidance will be included in *National Beach Guidance and Grant Performance Criteria for Recreational Waters*.

4.5.2.2 Other Predictive Tools to Supplement Sampling

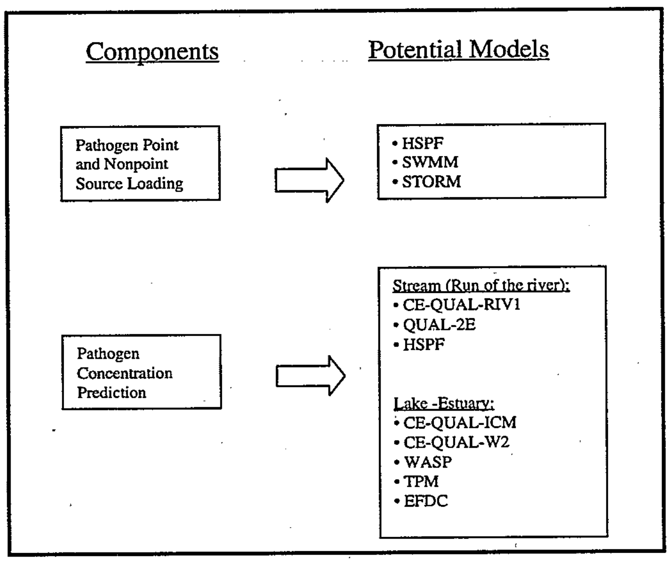

Figure 4-1. Predictive tools applicable to pathogens.

The overall objective of beach closure predictive tools is to minimize the population's exposure to pathogens. The tools currently in use by local agencies vary in their complexity and approach to minimizing exposure but are generally simple, reliable tools. Figure 4-1 shows other predictive tools that can be used to determine the need for a beach closing. The listed models are divided into two categories—watershed pathogen loading models and pathogen concentration prediction models. The latter category is divided into two additional groups to reflect the waterbody types: rivers and streams, and lakes and estuaries. Currently, there is a lack of readily available models that address the coastal nearshore environment; therefore, no models that study the surf zone are included in sections that follow.

Pathogen Loading Estimates

Watershed loading models that can be used to estimate pathogen loadings to receiving waters are presented in Table 4-2. Three considerations are taken into account in the table—real-time prediction, source type, and land use type.

Table 4-2. Watershed-scale loading models

Model Type	Model Name	Real- time Prediction		Source Type			Land Use Type	
		Data Needs	Processing Time	PS	NPS	CSO	Urban	Rural
Watershed-scale loading	HSPF: Hydrological Simulation Program– Fortran	x	x	xx	x		x	xxx
	SWMM: Storm Water Management Model	x	x	x	x	xx	xx	x
	STORM: Storage, Treatment, Overflow, Runoff Model	x	x	x	x	x	xx	

x Low data requirements/applicability
xx Medium data requirements/applicability
xxx High data requirements/applicability

Potential sources of pathogens include point sources (including CSOs) and nonpoint sources. Models differ in their ability to account for these various source types. Models that simulate nonpoint sources are capable of describing the pathogen buildup processes during dry weather and washoff processes related to rainfall-generated runoff. Accounting for the various land uses is very important in estimating the nonpoint source loadings because the processes of buildup and washoff are land-use-specific. CSO loading is a function of the hydraulic routing and the storage capacity within the publicly owned treatment works (POTW). Therefore, a model's ability to deal with the complex land uses in the watershed is an important factor in model selection and applicability. The key loading models suited for real-time prediction summarized in Table 4-2 are briefly described in Appendix L.

Pathogen Concentration Prediction

Loading models, depending on the simulation type, provide estimates of either the total water and pollutant loading or a time series loading of water and pollutants. Pathogen concentration prediction is the process of describing the response of the waterbody to pollutant loadings, flows, and ambient conditions. Because the response is specific to the waterbody, different types of models are required for accurate simulation, as shown in Table 4-3. The models are divided into two categories on the table—rivers and streams, and lakes and estuaries.

Rivers and Streams. Prediction of pathogen concentration in rivers and streams is dominated by the processes of advection and dispersion and the bacteria indicator degradation. One-, two-, and three-dimensional models have been developed to describe these processes, as shown in Table 4-3. Waterbody type and data availability are the two most important factors that determine model applicability. For most small and shallow rivers, one-dimensional models are sufficient to simulate the waterbody's response to pathogen loading. For large and deep rivers and streams, however, the one-dimensional approach falls short of describing the processes of advection and dispersion. Assumptions that the pathogen concentration is uniform both vertically and laterally are no longer valid. In such cases two- or three-dimensional models that include a description of the hydrodynamics are used. The river and stream models summarized in Table 4-3 are briefly described in Appendix L.

Lakes and Estuaries. Predicting the response of lakes and estuaries to pathogen loading requires an understanding of the hydrodynamic processes. Shallow lakes can be simulated as a simplified, completely mixed system with an inflow stream and outflow stream. However, simulating deep lakes with multiple inflows and outflows that are affected by tidal cycles is not a simple task. Pathogen concentration prediction is dominated by the processes of advection and dispersion, and these processes are affected by the tidal flow. The size of the lake or the estuary, the net freshwater flow, and wind conditions are some of the factors that determine the applicability of the models. The lake and estuary models summarized in Table 4-3 are briefly described in Appendix L.

Table 4-3. Potential pathogen fate and transport models

Model Name	Time-Relevant Prediction		Waterbody Type	
	Data Needs	Processing Time	Rivers and Streams	Lakes & Estuaries
HSPF: Hydrological Simulation Program—Fortran	xx	x	x	N/A
CE-QUAL-RIV1: Hydrodynamic and Water Quality Model for Streams	xx	xx	x	N/A
CE-QUAL-ICM: A Three-Dimensional, Time-Variable, Integrated-Compartment Eutrophication Model	xxx	xxx	x	xx

Model Name	Time-Relevant Prediction		Waterbody Type	
	Data Needs	Processing Time	Rivers and Streams	Lakes & Estuaries
CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model	xxx	xx	xx	x
WASP5: Water Quality Analysis Simulation Program	xx	xx	xx	xx
EFDC: Environmental Fluid Dynamics Computer Code	xx	xx	xx	xx
QUAL2E: Enhanced Stream Water Quality Model	x	x	x	N/A
TPM: Tidal Prism Model	x	x	N/A	x

x Low applicability
xx Medium applicability
xxx High applicability

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Chapter 5: Public Notification and Risk Communication

This chapter describes the performance criteria and technical guidance related to the public notification and risk communication portions of a beach program.

5.1 Performance Criteria

Four primary Performance Criteria are related to public notification and risk communication (Performance Criteria 5, 6, 7, and 8).

Public Notification and Risk Communication Plan (Performance Criterion 5). The state or tribe must develop an overall public notification and risk communication plan. The plan must describe the state's or tribe's public notification efforts and measures to inform the public of the potential risks associated with water contact activities in the coastal recreation waters that do not meet applicable water quality standards.

Within this overall plan, the state or tribe should pay special attention to three areas highlighted by the Beach Act.

Measures to Notify EPA and Local Governments (Performance Criterion 6). The state or tribe should adequately identify measures for prompt communication of the occurrence, nature, location, pollutants involved, and extent of any exceeding of, or likelihood of exceeding, applicable water quality standards for pathogens and pathogen indicators. The state or tribe should identify how this information will be promptly communicated to EPA and to a designated official of the local government having jurisdiction over land adjoining the coastal recreation waters for which the failure to meet applicable standards is identified.

Measures to Notify the Public (Performance Criterion 7). A state or tribal program must adequately address the posting of signs at beaches or similar points of access, or functionally equivalent communication measures that are sufficient to give notice to the public that the coastal recreation waters are not meeting or are not expected to meet applicable water quality standards for pathogens and pathogen indicators.

Notification Report Submission and Delegation (Performance Criterion 8). The eighth performance criterion is for states and tribes to compile their notification plans in timely reports and to describe any delegation of notification responsibilities that might have been made to local governments. See section 5.2.4 for more detail.

5.2 Public Notification and Risk Communication Plan

The required Public Notification and Risk Communication Plan should adequately address the following aspects:

- Problem assessment and audience identification
- Content and procedures for public notification
- Evaluation of notification program's effectiveness
- Report submission and delegation

Note, the BEACH Act requires states and tribes, as a condition for receiving 406 grants, to provide the public with an opportunity to review the monitoring and notification program. The Performance Criterion for public comments is explained in Chapter 2.

5.2.1 Problem Assessment and Audience Identification

During the problem analysis phase, the state or tribe should identify specific objectives to be accomplished by a beach notification and risk communication program. Beach program objectives can include general goals, objectives that reflect the agency's mission and mandate, or more specific and measurable program goals.

The audience identification and needs assessment phase includes identifying and characterizing the potential target audiences for beach advisories or closings. During this phase, the beach manager or agency determines what types of information and communication styles are appropriate for each audience. You need to consider the objectives of the notification and risk communication program and the range of behavioral and sociodemographic groups of people that might be affected by that program. Because the different characteristics of beach users might call for different methods of communication, you should use care when identifying all potential target audiences. For example, a sign posted at the beach entrance could be used for local beach users, while a message on an Internet web site or telephone hotline could be used to notify tourists who live farther away.

The public can and should be part of the process of identifying information needs. It is important for communicators to understand the linkages between the public's behavior, knowledge, and beliefs. It is critical in designing a communication strategy to understand which information sources audiences will use to obtain beach information.

If the population in your area is diverse in its ethnic makeup or your area receives international visitors, it might be beneficial to include advisories in both English and other languages. This advice applies particularly to the portion of the advisory that explains health risks to the public.

Example of Notice in Spanish

Coliforms fecales o *E.coli* son bacterias cuya presencia indica que el agua esta contaminada con desechos humanos o de animales. Microbios de esos desechos pueden causar diarrhea, colicos, nausea, dolores de cabeza u otros sintomas. Pueden representar un peligro para la salud de infantes, ninos y ninas de corta edad y personas con sistemas immunologicos en alto riesgo.

5.2.2 Content and Procedures for Public Notification

5.2.2.1 Message: Developing the Content of Advisories and Closings

The most important information to include in a public notification is that swimming is not advisable because of high microbial indicator levels detected in the water. When a sign is posted to notify the public, the content should be simple and state that an advisory or closing is being issued because of high indicator levels. However, when issuing public notices or press releases or notifying the public through a newspaper, it is appropriate to include additional information because the writing space is not as limited.

An advisory or closing should include the following information:

- ***General heading***: Words to the effect of "WARNING," "ADVISORY," or "BEACH CLOSED."

- ***Reason for the advisory or closing***: Exceedance of water quality criteria (if known) and risk of potential health effects (nausea, diarrhea, headaches, cramps, or other symptoms).

AB411 - California Requirement for Signs

Sign information: For public beaches or ocean water contact sports areas closed because of a release or spill of untreated or inadequately treated sewage or for failure to meet microbiological indicator organism standards, warning signs shall be visible from each legal primary beach access point, as identified in the coastal access inventory prepared and updated...and any additional access points identified by the health officer.

Example: WARNING! CLOSED TO SWIMMING AND OTHER WATER CONTACT. BEACH/SWIMMING AREA IS CONTAMINATED AND MAY CAUSE ILLNESS.

For a portion of a public beach or ocean water contact sports area with a storm drain, warning signs should be placed at the affected area and at other locations determined by the local health officer (for example, along walkways to the beach, park entrances) where they are likely to be read. Language should be similar to the following:

Example: WARNING! NO SWIMMING OR OTHER WATER CONTACT. STORM DRAIN WATER MAY CAUSE ILLNESS.

Signs should be large enough to be clearly visible and legible. They should be posted in English and a second language, as deemed appropriate by the local health officer, if a large percentage of users of the public beach or water contact sports area understand only that language. For example, a variation of the

You should explain briefly that you routinely test the water and that the most recent samples indicate an exceedance of the water quality criteria. Appropriate language might be, "We routinely monitor for the presence of bacteria in the water. Our most recent sampling results indicated an exceedance of our action level. Swimming is not advised until [date/time]." You can also explain whether the exceedance is based on an instantaneous criterion or on a rolling average criterion. It might be helpful to explain the lag time associated with sample results, noting that the sample might have been taken 24 hours before the advisory or closing. Finally, listing the source of the contamination reassures the public that you have investigated the problem and are taking steps to address it (USEPA, 1999).

- ***Time and duration of the advisory or closing***: When the sampling was performed and the results reported and when the advisory or closing is expected to be removed. Identify whether the advisory or closing will be in effect until further notice or until the samples obtained meet a certain criterion.
- ***Location involved***: Beach(es), county, park, or miles affected.
- ***Agency name and contact number.***

Table 5-1 at the end of this chapter provides suggestions for the content of advisories and closings.

5.2.2.2 Types of Notification

Measures such as beach closings or advisories should be used to inform the public of the potential risks associated with water contact activities in waters that do not meet applicable water quality standards. Advisories or closings as appropriate should be issued when indicator bacteria levels exceed the state or tribal water quality criteria for recreational waters.

Beach Closings

The term "beach closing" typically means that the beach area is officially closed to the public. The closing of a beach is a local decision; EPA does not set beach closure requirements or conditions. EPA recommends, however, that a closing be issued if there is an imminent public health hazard such as a sewage line break or other high-risk source. During a closing, no one should be in the water. Lifeguards may or may not be present at the beach. The beach might be closed to the public temporarily or for an extended period (for the remainder of the swimming season).

Typical methods of enforcement include placing physical barriers so that the beach is closed to public access and issuing fines or citations to any person who uses the beach while it is posted as closed. For example, in the city of Huntington Beach in California, a person can be fined for going into the water when there is a closing (USEPA, 2000). In addition, having staff regularly patrol the beach can ensure that it has officially been closed and that notification and risk communication procedures have been followed as required.

Beach Advisories

An advisory does not officially close a beach to the public, but for human health reasons it recommends staying away from the water. There are several types of advisories.

- A *water quality exceedance advisory* after indicator bacteria levels have been tested and the results show that water quality criteria have been exceeded.
- A waterbody might have a constant potential human health risk associated with its use. In such a case, you might want to issue a *permanent advisory*, which notifies the public of naturally occurring organisms that might be present in the water at your beach every day.
- A *preemptive advisory* can be issued when there might be higher levels of microorganisms at certain times, such as after significant rainfall, during high temperatures, and in other situations. For example, the Portland (Maine) Department of Health and Human Services places an advisory sign following any rainy period because rainfall can cause an elevation of bacteria levels due to runoff from the land. Another example can be found in Colorado, where a permanent interpretive/referral advisory sign is used (see box).

> **Sample Advisory Sign**
>
> The water in this lake serves many uses. It is here for your recreational use, as well as other uses like irrigation and domestic water supply. Like any natural water body, the water in this lake contains many naturally occurring microorganisms, some of which may cause illness if swallowed. Park staff regularly tests the water quality at the swim beach. However, if you believe you became ill from this water, contact the park office at 690-1166.
> –State of Colorado Swimming Pool and Mineral Bath Regulations, Article 4.6, Natural Swimming Areas,

Practical Applications of Closings Versus Advisories

As a beach manager, you might want to make a distinction between voluntary and involuntary risk. A beach agency or health department does not necessarily have the legal authority to keep people from swimming. Therefore, you might have to issue advisories and let the public use their own discretion. The success of this approach lies in making your advisories as effective as possible.

5.2.2.3 Mechanisms for Disseminating Advisories and Closings

The needs of the target audience(s) determine the most appropriate mechanism(s) to use. The mechanisms by which potential beach users receive information about beach advisories or closings include:

- Beach postings and signs
- Mass media (newspapers, television, radio)
- Internet web sites
- Telephone hotlines
- Technical reports

Beach Postings or Functionally Equivalent Measures

A written posting of an advisory (or closing, if the beach manager chooses) is one of the most useful ways to notify beach users of potential health risks associated with using the water. Signs should state the type of advisory or closing and the reason it was issued—an exceedance of water quality criteria, heavy rainfall and the high levels of bacteria associated with it, or another reason you have determined is appropriate.

It is important to decide where signs are most likely to be noticed by users of your beach. Signs or postings should be placed at beach entrances, on bulletin boards in the office buildings, or in the general vicinity of the common swimming areas. It is important to keep the signs simple and restrict types of signs to a minimum. The signs should be consistent throughout your state or tribe to avoid confusion. The signs should also be large enough to be noticed, legible, and easily understood. They should not contain overly technical language or very small print. The signs should be a bright color such as red or yellow to attract the attention of the public. Graphics (such as a no-swimming symbol) are a good way to get attention and easily convey a risk associated with swimming. The words "WARNING," "ADVISORY," or "BEACH CLOSED" should be written in large letters at the top of the signs to be seen from a distance. Additional information may be written in easily read smaller print. The advantage of posting is that it provides a visual notice or personal interaction at the point of access. The BEACH Act allows states and tribes to develop functional equivalents when

Hart-Miller Island Beach Reopened To Swimming Effective Immediately

Hammerman beach at Gunpowder Falls State Park remains closed through the weekend

Chase, MD (August 24, 2000) - After receiving consistent good results from bacteria testing, the beach at Hart-Miller Island has been reopened to swimming. Results from the fecal coliform bacteria tests which have been conducted show that the water is now safe for swimming.

The beach at the Hammerman area of Gunpowder Falls State Park will remain closed through the weekend as a result of continued high levels of fecal coliform bacteria.

Hart-Miller Island is located in the Chesapeake Bay near the mouth of the Middle River. It encompasses 244 acres and is accessible only by boat. The western shore of the island offers safe mooring and access to a 3,000-foot-long sandy beach. The island is part of the North Point/Gunpowder Falls State Park management area.

Gunpowder Falls State Park encompasses more than 15,000 acres along the Gunpowder River Valley. For more information, please call the park's headquarters at 410-592-2897.
Posted August 25, 2000

notifying recreational water users. A functional equivalent can be a visual notice or personal interaction such as a flag at a beach or interaction with beach or park personnel.

Mass Media

Newspapers, television, and radio are effective means to communicate that swimming is not advisable because they enable you to provide more detailed information to the public than a sign or beach posting. For example, you can inform the public of the reason an advisory or closing has been issued, the area affected, and the anticipated duration of the advisory or closing. Notifying the public through mass media also targets a larger audience than a sign or beach posting. Mass media messages are particularly effective because they inform the public of beach advisories before arrival at the beach. Your Public Notification Plan should include an effective plan for ensuring sufficient and timely media coverage. You should explain how the mass media will be used –through public service announcements, paid media, free media, newspapers, or a radio or television station.

Press Release

Public notification of a beach advisory or closing can be provided in the form of a press release issued by the local health officer or beach manager. A press release is more effective if it comes from the public health authority. The press release should indicate whether an advisory or closing is being issued, the reason for the advisory or closing, the area affected, and the anticipated duration of the advisory or closing. The press release should include the name of the agency and a contact number as well. It may be helpful to issue a press release at the beginning of the swimming season to notify the public that they should not swim 24 hours after a heavy rain. Any notice or press release you issue for beach advisories and closings should be formatted to get the reader's attention and communicate the information effectively. Consider the following tips (USEPA, 1999):

- Place the most important information on the top half of the notice in large print because people often read only the first half of the notice.
- Limit the length of the notice, and use bullets and bold text when appropriate.
- In a press release given to a newspaper reporter, provide a list of the required elements and tell the press that these must be included.
- When the notice is sent to TV and radio stations as well as newspapers, write "PRESS RELEASE FOR PUBLIC SAFETY" at the top of the notice to emphasize its importance.
- Include your name, title, and telephone and fax numbers or e-mail address so the press can be contact you for additional information or clarification.

Internet Web Sites

Internet web sites can be used to report advisories and closings to the public. The message can and should be updated as the status of the advisory or closing changes.

A web site can be a good way to reach many people in a community where the Internet is highly accessible. A local web site might already have been established by another agency or organization. If so, contact the owner of the site so that you and the owner can work together to provide the most useful links. States, tribes, and local governments are also encouraged to establish links between their web sites and EPA's BEACH Watch site. EPA's BEACH Program coordinates the BEACH Watch site to inform the public of trends in water quality at beaches, as well as local information for beaches nationwide. The BEACH Watch site can be found on the Internet at http://www.epa.gov/OST/beaches/.

The contents of a web site can be as simple as a current update of water quality conditions or a list of advisories and closings. If desired, a web site can show previous advisories and closings, water quality sampling results, maps of the area, photographs of the beach, contact names and telephone numbers for the public to contact the health department with comments or questions, and tips for swimming safety to reduce the human health risk of water use.

The style of the web site is more flexible than the style for signs, press releases, and other forms of communication. Creativity should be used to draw the reader's attention. Graphics are helpful, as well as photographs of your beach. You might also choose to include a description of your monitoring program or other efforts under way by your beach agency. People are typically interested in this type of information, and it will show them that you are trying to protect them from any health risks from beach use.

Telephone Hotlines

A telephone hotline can be established to inform the public about all beaches in a given area that are currently closed, posted with an advisory, or otherwise restricted. The hotline message should state whether there is an advisory or closing, what area is involved (beach, city, county, or number of miles), the reason for the closing or advisory, and the time frame involved and date of removal, if known. The name of the responsible agency and a contact telephone number should be included as well. The hotline should be updated as needed to convey changes in the status of beach closings and advisories. Hotlines should follow the same general format as written advisories. The most important information should be stated first, in clear, nontechnical language because many people will listen to only the beginning of the message. The message needs to be updated as the status of the advisory or closing changes.

Technical Reports

To assess the health of the beaches monitored, you might want to compile a monthly or annual report of the beach advisories and closings after the beach season has ended. This report could include the number of times criteria were exceeded, the number of days beaches were under an advisory or closed, the number of beaches affected by an advisory or closing, a compilation of all the sampling results, or other measures of beach advisories or closings such as "beach mile days." This information can assist in completing the annual EPA National Health Protection Survey of beaches. In addition, EPA recommends that this information also be reported to the Agency or entered into EPA's STORET database.

5.2.2.4 Procedures for Notifying the Public

On completion of the data reviews and data quality assessment, values for the specified bacterial indicators should be reported to the beach manager. A value's exceeding a single-sample or geometric mean recreational water criterion should result in a state, tribal, or local action. A state, tribe, or local government can determine whether public notification (posting) or resampling is appropriate based on the state's or tribe's water quality standards. The interpretation of the bacterial indicator densities with respect to posting an advisory or closing the beach should be clear and based on the decision rules established during the planning process.

When indicator levels exceed water quality standards at any state or tribal beach, the public should be notified either immediately or, if appropriate, when resampling indicates an exceedance of standards. EPA recommends that the following two procedures be performed at all high-, medium-, and low- priority beaches.

- Notify the owner, manager, or operator and/or the lifeguards of results. When sample results indicate an exceedance of either the instantaneous or geometric mean water quality standard, the appropriate health agency should notify the beach manager/operator and any staff members (lifeguards) immediately. This approach ensures that the responsible authorities know to take action, ensure the safety of the beach employees, and reduce liability.

- *Prompt public notification.* The means of notification could be a sign or functional equivalent. For High and Medium priority beaches, notification is at the point of access.

At some beaches, however, **alternative steps** should be taken to issue an advisory when a beach has a high level of human health risk or when a sign posted on the beach is not the most effective means of communicating human health risk. For example, a beach that is frequented visited by tourists or users that do not live in the vicinity of the beach may require notification of advisories or closings through news media, telephone hotlines, or an Internet web site. Some alternative methods include:

- *Discuss situation with other agencies.* You should contact other state, tribal, or local agencies, as well as appropriate organizations involved with the beach monitoring and notification program.

- *Provide results on a telephone hotline.*
- *Issue a press release.*
- *Provide information on local beach web site.*

5.2.2.5 Procedures for Removing Advisories and Reopening Beaches

It is important to establish a procedure for removing an issued or expired advisory or reopening a closed beach. The procedure might vary depending on whether the beach was closed or an advisory was issued. This is an important step in risk communication. The public should know when the water meets applicable standards and should be able to recognize the established procedures for reopening the beach or removing an advisory.

EPA recommends that the following procedure be performed at all high, medium, and low priority beaches:

- Resample and compare the bacterial concentrations with the applicable water quality standards to determine whether the levels are below the standards. This procedures should be performed unless the advisory or closing was due to a rain advisory.
- Remove advisories or reopen a beach after a set number of hours or days after a rainfall. This should be done only if significant testing has previously been conducted to support the assumption that bacteria densities are below criteria after a set period of time. Assumptions should be based on statistically significant data and not on best professional judgment alone.

The following **additional procedures** can be used by beach managers for removing advisories and reopening beaches:

- Notify the owner/manager/operator and lifeguards of the test results.
- Provide an announcement to agency staff or local government staff.
- Remove the advisory or closing sign.
- Provide the sampling results on a hotline, water quality information/result phone line, or local radio or TV station or in a local newspaper.
- Remove any physical barriers.
- Assess the number of complaints of sickness. These assessments can be conducted by using bather surveys to determine how many people have become ill because of contact with beach

water. For example, in San Diego, California, surveys conducted by the group Surfers Tired of Pollution provide valuable information on illness rates.

5.2.3 Evaluation of Notification Program's Effectiveness

The public notification and risk communication program should be evaluated continuously throughout the risk communication process. This step is a critical element that helps ensure a notification program has been designed to meet the needs of the public and the objectives of the agency. Throughout the risk communication and notification process, it is important to include activities, benchmarks, and milestones that require formative, process, and summary evaluation data to be collected and used. An evaluation of program effectiveness should include the following considerations.

Ensure that the notification program meets the needs of the audiences and the objectives of the agency.

Evaluations of the notification program are designed to assess the likelihood of attaining program objectives. The appropriateness of potential objectives and the strengths and weaknesses of alternative communication strategies are addressed. An example of this type of assessment is determining how many people pay attention to communication methods such as beach postings and physical barriers or assessing how many people actually contact a telephone hotline or Internet web site to obtain water quality information for a particular beach. Also, the steps involved in your communication process should be evaluated.

To conduct informative evaluations, you will need to use staff members as well as members of the target audience. The time required can range from several hours of staff time spent on brainstorming and reviewing activities to a considerable amount of time spent interviewing your target audience (USDHHS, 1993).

Evaluate the notification program.

Process evaluations occur as the communication strategy is implemented. They are useful in both new and established risk communication programs. These evaluations are designed to determine to what extent communication strategies are being implemented as planned and to assess the adequacy of administrative, personnel, or other resources necessary to keep the communication program on track. How effective is it to resample the water after the first sample indicates an exceedance of water quality standards? Is it beneficial or necessary to continue to contact staff members and other agencies when an advisory is issued or a beach is closed? An example is an assessment of whether the appropriate people are always notified when an advisory is issued, a beach is closed, or a water quality standard is exceeded. Also, you should determine whether the water quality has been resampled as required by your procedures for issuing advisories and closing beaches. Are postings, press releases, and web sites listing appropriate and accurate information? Is the program being conducted on the intended time schedule, with the intended information dissemination mechanisms, within budget, and using the intended staff and other resources?

Process evaluations can be conducted during the course of the communication program and used to modify the communication strategy during implementation. There is no need to wait until the end of the program to evaluate its implementation process. Evaluation activities may include (1) regular contacts with communication partners (media personnel, web site owner, target audience) to evaluate the timing and adequacy of advisory information and (2) interviews with target audience members or focus groups to assess how well the advisory information is reaching the target audience and how receptive they are to that information.

Determine whether the needs of the public and the agency's objectives have been met.

Summary evaluations are designed to document the short- or long-term results of risk communication programs and to evaluate whether objectives were achieved. These evaluations determine whether the beach advisories and closings have been effective in communicating health risks to the public. Did people receive enough information to make an informed decision? Were people protected from bacterial contamination? Did the public respond positively to the advisory and closing program? These questions and others should be considered as part of the evaluation process.

Summary evaluations should occur at the end of the risk communication program. They can include focus groups, mail surveys, and telephone surveys. A large sample size is often needed for the program evaluators to measure statistically significant program outcomes and impacts in large regions (e.g., statewide). You might want to develop a focus group of all staff involved in the beach risk communication program. Examples of questions to ask include the following:

- What agency objectives did the advisory help achieve?
- What objectives were not accomplished?
- What positive reactions have you heard from or observed in target audiences? What is working in the advisory materials?
- What negative reactions have you heard from or observed in target audiences? What methods of communication need improvement?
- What changes do we need to make in our advisory communication program?

Before development of a risk communication plan, surveys can be mailed or conducted over the telephone to gain feedback from a subset of the target audience. These surveys can be used to determine the public's knowledge about the following:

- Human health risks of swimming in contaminated water

- Specific advisory recommendations
- The advisory process

The surveys can also indicate the following:

- The public's reaction to advisories and closings
- The public's willingness to adhere to advisory and closing recommendations
- The public's suggestions for better communication methods

5.2.4 Notification Report Submission and Delegation

As discussed in earlier chapters, Performance Criterion 3 is that states and tribes must compile and report their notification activities in timely reports and describe any delegation of notification responsibilities to local governments that might have been made.

Report Submission
States and tribes must provide notification information to the public, EPA, and other agencies in a timely manner. States and tribes must also report the actions they have taken to notify the public when water quality standards are exceeded. To meet this criterion, states and tribes should coordinate closely with local governments to acquire information and ensure that it is submitted in a consistent fashion. Timely submission of compatible electronic files is a critical component of this reporting requiremnt. Comparability with EPA's *National Health Protection Survey of Beaches* is also a very important factor.

Delegation
EPA encourages states to coordinate with local governments and to delegate, as appropriate, responsibilities for notification programs to local governments. Local governments have traditionally played the lead role in administering beach protection programs. There are many reasons for the local level to take responsibility in protecting recreational waters. For example, local citizens and officials are more familiar with local problems and needs and are in a better position to address local issues and formulate solutions. Also, many of the benefits of protecting natural resources, in this case coastal recreation waters, accrue at the local level.

5.3 References

MDDNR. 2001. *Press Releases: Hart-Miller Island Beach Reopened to Swimming Effective Immediately.* Maryland Department of Natural Resources. <http://www.dnr.state.md.us/dnrnews/2000archive.html>. Accessed April 2001.

USDHHS, 1993. *Recommendations to Improve Health Risk Communication: A Report on Case Studies in Health Risk Communication.* U.S. Department of Health and Human Services, Public Health Service Committee to Coordinate Environmental Health and Related Programs, Washington, DC.

USEPA. 1992. *Protecting Coastal and Wetland Resources: A Guide for Local Governments.* EPA 842-R-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1999. *Public Notification Handbook.* Draft for comment. EPA 816-R-99-004. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2000. *Regional BEACH Program Conferences–1999.* Proceedings. EPA 823-R-00-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Table 5-1. Recommended Content for Advisories and Closings

Exceedance of Water Quality Criteria, Preemptive Advisory or Closing, Permanent Advisory or Closing

Sign/Posting

- Warning," "Advisory," "Beach Closed," or similar language
- Reason for advisory or closing
  - For preemptive advisory or closing: "Heavy rainfall has occurred. Beach is closed/under advisory for the next 24 hours due to predicted elevated bacteria levels"
- Name of beach, city, county, or miles of area affected
- When samples were taken, period of effectiveness, and when advisory will end or beach will reopen
- Agency's name and contact number

Press Release or Public Notice

- Attention-getting title
- Reason for advisory or closing
  - For preemptive advisory or closing: expected high bacteria levels
- What is the health risk and why
- Name of beach, city, county, or miles of area affected
- When samples were taken, period of effectiveness, and when advisory will end or beach will reopen
- Agency's name and contact number, for both the readers and the journalist

Hotline

- "An advisory has been issued for..."
- Reason for advisory or closing
  - Preemptive advisory or closing: expected high bacteria levels
- What is the health risk and why
- Name of beach, city, county, or miles of area affected
- When samples were taken, period of effectiveness, and when advisory will end or beach will reopen
- Agency's name and contact number

Internet

- A list of beaches, cities, and counties, along with their respective status (open, closed, or under advisory)
- Reason for advisory or closing
  - Preemptive advisory or closing: expected high bacteria levels
- What is the health risk and why
- Miles or area affected
- When samples were taken, period of effectiveness, and when advisory will end or beach will reopen
- Agency's name and contact number
- Description of monitoring and notification program
- Links to beach and environmental agencies and the health department
- Maps, photographs, graphics
- Opportunities for volunteer involvement in beach program
- Reference list of materials and guides for beach users

United States Environmental Protection Agency | Office of Water (4305) | EPA 823-F-01-06 January 2001

EPA

Beaches Environmental Assessment and Coastal Health Act of 2000 Public Law 106-284

Overview

On October 10, 2000, the Beaches Environmental Assessment and Coastal Health Act was signed into law. This new law authorizes a national grant program to assist state, tribal, and local governments in developing and implementing monitoring and public notification programs for their coastal recreation waters. It also requires states to adopt improved water quality standards for pathogens and pathogen indicators and requires EPA to conduct studies and develop improved microbiological water quality criteria guidance. In addition, the law requires EPA to develop performance criteria for monitoring, notification, and public information databases and requires other federal agencies to establish certain programs.

BEACH Watch

Purpose and Title

This legislation amends the Federal Water Pollution Control Act (also known as the Clean Water Act, or CWA) to improve the quality of coastal recreation waters and attain other objectives. The following summary is provided for the convenience of the reader. It does not substitute for the statute. Grant applicants should consult the statute and applicable grant regulations prior to filing such applications.

Section 1. Short Title

"Beaches Environmental Assessment and Coastal Health Act of 2000"

Water Quality Standards and Criteria

Section 2. Adoption of Coastal Recreation Water Quality Criteria and Standards by States

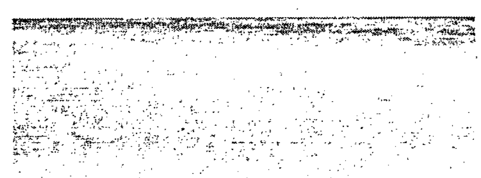
The provisions of this section amend section 303 of the CWA with respect to the following:

- ***Initial Criteria and Standards***: *[By April 10, 2004]*, states having coastal recreation waters are required to adopt water quality criteria and standards for pathogens and pathogen indicators for which the EPA Administrator has published criteria under the act. *[This refers to EPA's 1986 Water Quality Criteria for Bacteria.]*
- ***New or Revised Criteria and Standards***: Requires states to adopt new or revised standards for coastal recreation waters not later than 36 months after the EPA Administrator publishes new or revised criteria guidance for pathogens and pathogen indicators.
- ***Failure to Adopt***: If a state fails to adopt criteria and standards for pathogens and pathogen indicators that are "as protective of human health as EPA criteria *[by April 10, 2004]*," the EPA Administrator shall promptly propose regulations setting forth revised criteria and standards.

Section 3. Revisions to Water Quality Criteria

This section adds the following to section 104 of the CWA as "Studies Concerning Pathogen Indicators In Coastal Recreation Waters":

- ***New Studies***: *[By October 10, 2003]*, the EPA Administrator shall complete studies for use in developing: (1) an assessment of potential health risks from exposure to pathogens in coastal recreation waters; (2) appropriate and effective indicators and appropriate, accurate, and expeditious methods for detecting or predicting the presence of pathogens in coastal recreational waters; and (3) guidance for state application of EPA's criteria guidance for pathogens to account for the diversity of geographic and aquatic conditions.
- ***Revised Criteria***: Requires the EPA Administrator to publish new or revised water quality criteria guidance for pathogens in such waters not later than *October 10, 2005*. Criteria is to be reviewed at least once every five years thereafter.



A copy of the Beaches Environmental Assessment and Coastal Health Act can be found on the BEACH Watch website at <www.epa/ost/beaches>.

Monitoring and Notification

Section 4. Coastal Recreation Water Quality Monitoring and Notification

The provisions of this section amend Title IV of the CWA to add section 406, "Coastal Recreation Water Quality Monitoring and Notification." This section includes the following provisions:

- ***Monitoring and Notification Performance Criteria***: Directs the EPA Administrator, by *April 10, 2002,* to publish "performance criteria" for a monitoring and notification grants program. The criteria will address the following topics: (1) the monitoring and assessment of coastal recreation waters adjacent to beaches for attainment of water quality standards for pathogens, including methods for such monitoring and assessment; and (2) prompt notification of local governments, the public, and the EPA Administrator of exceedances, or the likelihood of exceedances, of standards for such waters so that public health and safety can be maintained.
- ***Program Development and Implementation Grants***: Authorizes the EPA Administrator to make grants to states, tribes, and local governments to develop and implement monitoring and notification programs. To qualify for an implementation grant, a grantee would need to: (1) be consistent with EPA's performance criteria; (2) prioritize use of grant funds based on use of the water and risk to human health, and identify factors considered in setting priorities; (3) develop a list of waters not subject to the monitoring and notification program due to fiscal constraints; and (4) provide an opportunity for public comment. States may delegate responsibilities and provide funding to local governments to implement a program. Local agencies may also apply for a grant under certain circumstances.
- ***Content of State, Tribal, and Local Programs***: As a condition of the grant, a state, tribe, or local government shall: (1) list coastal recreational waters adjacent to beaches used by the public; (2) identify the delegation process; (3) identify monitoring and assessment methods including frequency and location of monitoring; and (4) identify communication procedures and measures.
- ***Federal Agency Programs***: Requires Federal agencies to develop programs for certain coastal recreation waters within three years. These programs should be designed to: (1) protect public health and safety; (2) meet EPA's performance criteria; and (3) address certain other matters required for state and local programs.
- ***EPA Database and Technical Assistance***: Directs the EPA Administrator to: (1) establish a national coastal recreation water pollution occurrence database; and (2) provide technical assistance for development of assessment and monitoring procedures for floatable materials in those waters.
- ***List of Waters***: EPA is required to maintain a publicly available "list of waters" that are subject to a monitoring and notification program, as well as those not subject to a program because of fiscal constraints.
- ***EPA Implementation***: In states that do not have a program consistent with EPA's performance criteria, EPA is required to conduct such a program for listed priority waters using grant funds that otherwise would have been awarded to those states. This "backstop" would commence three years after EPA lists waters in such states.
- ***Authorization of Appropriations***: Authorizes annual appropriations of $30 million for fiscal years 2001 through 2005. *[Actual funding levels depend on specific appropriations enacted annually by Congress.]*

Other Provisions

Section 5. Definitions

- ***Defines "Coastal Recreation Waters"***: This term includes: "(i) the Great Lakes and (ii) marine coastal waters (including coastal estuaries) that are designated under section 303(c) by a State for use for swimming, bathing, surfing, or similar water contact activities." The term does not include "(i) inland waters or (ii) waters upstream of the mouth of a river or stream having an unimpaired natural connection with the open sea."

Section 6. Indian Tribes

- ***Tribes Are Treated Like States***: Adds language which allows EPA to treat Indian tribes in a manner similar to states for purposes of section 406 of the act, which include coastal recreation water quality monitoring and notification programs and grants. EPA already had authority to treat tribes in a manner similar to states for purposes of section 303 of the act.

Section 7. Report

- ***Reporting Schedule***: Requires that EPA report to Congress every four years.

Section 8. Authorization of Appropriations

- ***Appropriation Authority***: Authorizes appropriations to carry out the act.

Appendix B: EPA's Water Quality Criteria for Bacteria

This appendix includes additional information on EPA's methods used in calculating *Ambient Water Quality Criteria for Bacteria - 1986.*

B. 1 Organisms that Can Indicate Fecal Contamination

Because many pathogens are not easily detected, indicator organisms are a fundamental monitoring tool used to measure both changes in environmental (water) quality or conditions and the potential presence of hard-to-detect target pathogenic organisms. An indicator organism provides evidence of the presence or absence of a pathogenic organism surviving under similar physical, chemical, and nutrient conditions. For fecal contamination, indicator organisms should

1. Be easily detected using simple laboratory tests.

2. Generally not be present in unpolluted waters.

3. Appear in concentrations that can be correlated with the extent of contamination.

4. Have a die-off rate that is not faster than the die-off rate of the pathogens of concern (Sloat and Ziel, 1992; Thomann and Mueller, 1987).

Indicator bacteria are usually harmless, more plentiful, and easier to detect than pathogens (Wilhelm and Maluk, 1999). Methods are not currently available to culture or enumerate all of the disease-causing organisms that might be present in natural waters. For example, viruses and protozoans are generally not used as indicators because of difficulties associated with isolating them and detecting their presence in environmental samples. The bacteria species chosen as indicators are indigenous to the intestines of warm-blooded animals and indicate the potential presence of dangerous pathogens that cause human illnesses.

Use and reliability are two aspects that states should consider when selecting an indicator. The lack of correlation between certain indicators and pathogen-caused diseases in humans, as well as the uncertain relationship between indicators and different sources of pathogens, are limitations of bacterial indicators. A positive result for the indicator organism means that the indicator is present in the waterbody, not necessarily that waterborne pathogens are also present. The presence of an indicator might not indicate whether those pathogens (if present) are viable or capable of causing disease and whether the source of the contamination is humans or other animals.

Indicators vary in their ability to reliably predict potential risks to human health. Some indicators have been shown to have a greater statistical relationship to disease than others. Also, current indicators are based on fecal contamination and might not accurately assess the potential for disease from other pathogens that can cause skin, upper respiratory tract, eye, ear, nose, and throat disease (USEPA, 1999a). More research on the use of other bacteria and viruses as indicators is being conducted at the federal, state, and local levels. Despite variability in the ability of indicators to reliably predict potential risks to human health, EPA studies indicate that enterococci and *E. coli* are the most effective available primary indicators of fecal contamination.

One area of current scientific debate is whether indicator bacteria react differently under various climatic and environmental conditions. Preliminary evidence suggests that *E. coli* and enterococci can be detected at tropical locales such as Puerto Rico, Hawaii, and Guam for waters where there is no apparent source of contamination from warm-blooded animals (USEPA, 1999a). EPA and others are evaluating whether the current indicator bacteria are suspected to grow and persist in natural tropical environments. If *E. coli* and enterococci are determined to propagate naturally in tropical conditions, EPA will conduct additional research to identify alternative indicators for tropical areas.

B.2 EPA's Current Water Quality Criteria for Bacteria: Enterococcus and *E. coli*

In 1986, EPA published *Ambient Water Quality Criteria for Bacteria - 1986* which recommended the use of *E. Coli* and enterococci as water quality criteria for bacteria. The data supporting the water quality criteria established in *Ambient Water Quality Criteria for Bacteria - 1986* were obtained from a series of research studies conducted by EPA examining the relationship between swimming-associated illness and the microbiological quality of the waters used by recreational bathers. The results of these studies demonstrated that fecal coliform bacteria, the indicator originally recommended in 1968 by the Federal Water Pollution Control Administration of the Department of the Interior, showed very little correlation to swimming-associated gastroenteritis. Two indicator organisms, *E. coli* and enterococci, showed a strong correlation, the former in fresh waters only and the latter in both fresh and marine waters. The strong correlation could be a result of the similarity in survivability of the indicator organisms and the pathogens of concern. Consequently, EPA's *Ambient Water Quality Criteria for Bacteria - 1986* recommended the use of *E. coli* and enterococci rather than fecal coliforms as indicators. Since the publication of *Ambient Water Quality Criteria for Bacteria - 1986*, many states have adopted these *E. coli* and enterococci criteria.

Geometric Mean

The current section 304(a) criteria recommendations for indicators of fecal contamination are a geometric mean of 126 colony forming units (CFU) per 100 milliliters (mL) for *E. coli*, a freshwater geometric mean of 33 CFU/100 mL for enterococci, and a marine geometric mean of 35 CFU/100 mL for enterococci (Tables B-1 and B-2). These values are based on specific levels of risk of acute gastrointestinal illness. EPA used levels of risk correlating to these values of 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 (USEPA, 1986). The illness rates are EPA's best estimates of the accepted illness rates for areas that had previously applied the fecal coliforms criteria. 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.

As described in EPA's epidemiological studies from the 1970s to 1980s on marine and freshwater bathing beaches, the significance of finding enterococci or *E. coli* in recreational water samples is the direct relationship between the density of enterococci or *E. coli* in the water and swimming-associated gastroenteritis. EPA recommended that criteria be calculated as the geometric mean of a statistically sufficient number of samples, at least five samples equally spaced over a 30-day period (USEPA, 1986). Because of the inherent variability of bacterial indicators, however, states are encouraged to collect as many samples as possible over a 30-day period to assess the standard. If a sixth measurement is made during a 30-day period, it should be included in the calculation of the geometric mean.

EPA calculated the single-sample maximum densities for each confidence level (Table B-1) by using a control chart analogy (ASTM, 1951) and log standard deviations from EPA studies. All single-sample maximum levels should be recalculated for individual areas if differences in log standard deviations occur (Table B-2). A detailed protocol that shows how to determine the confidence level associated with any illness risk once a maximum has been established for single samples is available (USEPA, 1986).

EPA recommends that states adopt the criteria in *Ambient Water Quality Criteria for Bacteria–1986*, which are based on scientifically defensible methods, to protect recreational waters. For those coastal recreational waters where EPA's recommended water quality criteria have been applied, the recreational beach is determined not to be attaining its designated use if the geometric mean of bacterial densities measured within a 30-day period exceeds the recommended criterion.

Single Sample Maximum

Single samples are also used to determine whether beaches meet designated use. A beach does not meet its designated use if the bacterial density in a single bacteria density sample exceeds a single-sample maximum value. Use of a single-sample maximum is important because it is assumed that environmental conditions (such as rainfall, wind, and temperature) will vary temporally and spatially. The confidence intervals in EPA's criteria were based on EPA's judgment, and a qualitative use intensity was then assigned to each confidence level. A smaller confidence level (75 percent) corresponds to a more stringent (lower) single-sample maximum, whereas a greater confidence level (95 percent) corresponds to less stringent (higher) maximum values (Tables B-1 and B-2) (USEPA, 1986). EPA assigned a more stringent single-sample maximum to designated bathing beaches because a high degree of caution should be used to evaluate water quality for heavy-use areas (USEPA, 1986). A less stringent single-sample maximum can be used for less intensively used or more remote swimming areas. Appendix B provides an explanation to assist in this calculation.

EPA calculated the single-sample maximum densities for each confidence level (Table B-1) by using a control chart analogy (ASTM, 1951) and log standard deviations from EPA studies. All single-sample maximum levels should be recalculated for individual areas if differences in log standard deviations occur (Table B-2). A detailed protocol is available that shows how to determine the confidence level associated with any illness risk once a maximum has been established for single samples (USEPA, 1986).

Example 1: The geometric mean indicator density for enterococci in fresh water is 33 CFU. If a segment of fresh water is a designated beach area and is using a 75 percent confidence level to provide a more stringent standard, the enterococci density would have to meet a geometric mean of 33 CFU/100 mL and have no one sample exceeding 61 CFU/100 mL to meet the water quality criteria for bacteria. These criteria are more stringent than those for an infrequently used beach that might use a 95 percent confidence level. The infrequently used beach would have to meet the single-sample maximum of 151 CFU/100 mL for enterococci in addition to the geometric mean. This approach allows for greater fluctuation in sample results at the less frequently used beach than at the more frequently use beach (Table B-2).

Example 2: The geometric mean indicator density for enterococci in marine water is 35 CFU. If a segment of marine water is a designated beach area and is using a 75 percent confidence level to provide a more stringent standard, the enterococci density would have to meet a geometric mean of 35 CFU/100 mL and have no one sample exceeding 104 CFU/100 mL to meet the water quality criteria for bacteria. These criteria are more stringent than those for an infrequently used beach that might use a 95 percent confidence level. The infrequently used beach would have to meet the single-sample maximum of 500 CFU/100 mL for enterococci in addition to the geometric mean. This approach allows for greater fluctuation in sample results at the less frequently used beach than at the more frequently use beach (Table B-2).

Table B-1. Summary of Environmental Protection Agency *Ambient Water Quality Criteria for Bacteria in Recreational Waters, 1986*

**EPA Criteria for Bathing (Full Body Contact)
Recreational Waters**

Freshwater

Based on the samples taken over a 30-day period (generally not less than five samples equally spaced over a 30-day period[1]), the geometric mean of the indicated bacterial densities should not exceed one of the following[2]:

E. coli	126 per 100 mL; or
Enterococci	33 per 100 mL.

No sample should exceed a one-sided confidence limit (C.L.) calculated using the following as a guidance:

Designated bathing beach	75% C.L.
Moderate use for bathing	82% C.L.
Light use for bathing	90% C.L.
Infrequent use for bathing	95% C.L.

based on site-specific log standard deviation, or if site data are insufficient to establish a log standard deviation, then using 0.4 as the log standard deviation for both indicators.

Marine Water

Based on the samples taken over the 30-day period (generally not less than five samples equally spaced over a 30-day period[1]), the geometric mean of the enterococci densities should not exceed 35 per 100 mL.

No sample should exceed a one-sided confidence limit using the following as a guidance:

Designated bathing beach	75% C.L.
Moderate use for bathing	82% C.L.
Light use for bathing	90% C.L.
Infrequent use for bathing	95% C.L.

based on a site-specific log standard deviation, or if site data are insufficient to establish a log standard deviation, then

[1] States are not limited to only five samples per 30-day period. Due to the inherent variability of bacterial indicators, you are encouraged to collect as many samples as possible over a 30 day period to assess the standard. If a sixth measurement is made during a 30-day period, it should be included in the calculation of the geometric mean.
[2] It is only necessary to use one indicator. The regulatory agency should select the appropriate indicator for its conditions.
Source: USEPA 1986.

Table B-2. Criteria for Indicators for Bacteriological Densities

Acceptable Swimming-Associated Gastroenteritis Rate per 1000 Swimmers		Steady-State Geometric Mean Indicator Density	Single Sample Maximum Allowable Density[4,5]			
			Designated Beach Area (upper 75% C.L.)	Moderate Full Body Contact Recreation (upper 82% C.L.)	Lightly Used Full Body Contact Recreation (upper 90% C.L.)	Infrequently Used Full Body Contact Recreation (upper 95% C.L.)
Freshwater						
enterococci	8	33[1]	61	89	108	151
E. coli	8	126[2]	235	298	406	576
Marine Water						
enterococci	19	35[3]	104	158	276	500

[1] Calculated to nearest whole number using equation:

$$\text{(mean enterococci density)} = \text{antilog}_{10}\ \frac{\text{illness rate/1000 people} + 6.28}{9.40}$$

[2] Calculated to nearest whole number using equation:

$$\text{(mean } E.\ coli \text{ density)} = \text{antilog}_{10}\ \frac{\text{illness rate/1000 people} + 11.74}{9.40}$$

[3] Calculated to nearest whole number using equation:

$$\text{(mean enterococci density)} = \text{antilog}_{10}\ \frac{\text{illness rate/1000 people} - 0.20}{12.17}$$

[4] Single sample limit = antilog10 [($\log_{10}$ indicator geometric mean density/100mL) + (Factor determined from areas under the Normal probability curve for the assumed level of probability × $\log_{10}$ standard deviation)]

The appropriate factors for the indicated one-sided confidence levels are:

75% C.L.- 0.675
82% C.L.- 0.935
90% C.L. - 1.28
95% C.L. - 1.65

[5] Based on the observed log standard deviations during the EPA studies: 0.4 for freshwater *E. coli* and enterococci and 0.7 for marine water enterococci. Each jurisdiction should establish its own standard deviation for its conditions, which would then vary the single-sample limit.

Source: USEPA 1986.

B.3 EPA's Review of Recent Epidemiological Studies

The following table includes the relevant findings of the research EPA reviewed that has been conducted on indicator organisms since 1986.

Table B-3. Summary of Research Conducted Since 1986

Researcher/ Year/ Location	Type of Water	Microorganisms Evaluated	Relevant Findings
Fattal et al. (1987) Israel	Marine	Fecal coliforms Enterococci *Escherichia coli*	Of the indicators tested, enterococci were the most predictive indicator for enteric disease symptoms.
Cheung et al. (1990) Hong Kong	Marine	Fecal coliforms *E. coli* *Klebsiella* spp. Enterococci Fecal streptococci Staphylococci *Pseudomonas aeruginosa* *Candida albicans* Total fungi	Of the indicators tested, *E. coli* showed the highest significant correlation with combined swimming-associated gastroenteritis and skin symptom rates.
Balarajan et al. (1991) United Kingdom	Marine	Unknown	Risk of illness increased with degree of exposure.
Von Schirnding et al. (1992) South Africa (Atlantic Coast)	Marine	Enterococci Fecal coliforms Coliphages Staphylococci F-male-specific bacteriophages	Uncertainty about the sources of fecal contamination may explain the lack of statistically significant relationship rates of illness between swimmers and non-swimmers.
Corbett et al. (1993) Sydney, Australia	Marine	Fecal coliforms Fecal steptococci	Gastrointestinal symptoms in swimmers did not increase with increasing counts of fecal bacteria. Counts of fecal coliforms were better predictors of swimming-associated illness than streptococci.
Kay et al. (1994) United Kingdom	Marine	Total coliforms Fecal coliforms Fecal streptococci *Pseudomonas aeruginosa* Total staphylococci	Compared to the other indicators tested, fecal streptococci were the best indicator of gastrointestinal symptoms.

Researcher/ Year/ Location	Type of Water	Microorganisms Evaluated	Relevant Findings
Kueh et al. (1995) Hong Kong	Marine	*E. coli* Fecal coliforms Staphylococci *Aeromonas* spp. *Clostridium perfringens* *Vibrio cholera* *Vibrio parahemotylicus* *Salmonella* spp. *Shigella* spp.	No statistical relationship between *E. coli* and swimming-associated illness was found (possibly because only two beaches were sampled).
Fleisher et al. (1996) United Kingdom	Marine	Total coliform Fecal coliform Fecal streptococci Total staphylococci *Pseudomonas aeruginosa*	Nonenteric illness can be transmitted through recreational contact with marine waters contaminated with sewage.
Haile et al. (1996) California, USA	Marine	Total coliforms Fecal coliforms Enterococci *E. coli*	The association of symptoms with both *E. coli* and fecal coliforms was very weak
McBride et al. (1998) New Zealand	Marine	Fecal coliforms *E. coli* Enterococci	Enterococci were most strongly and consistently associated with illness risk for the exposed groups. If swimmers remained in the water for more than 30 minutes, the risk differences were significantly greater between swimmers and nonswimmers.
Seyfried et al. (1985) Canada	Fresh	Fecal coliforms Fecal streptococci Heterotrophic bacteria *Pseudomonas aeroginosa* Total staphylococci	A small correlation between fecal streptococci and gastrointestinal illness was observed.
Ferley et al. (1989) France	Fresh	Fecal coliforms Fecal streptococci	The best relationship is between fecal streptococci and gastrointestinal illness.
Francy et al. (1993) Ohio, USA	Fresh	*E. coli* Fecal coliforms	In this study, the relationship between *E. coli* and fecal coliform bacteria was found to be statistically significant. This relationship can differ from one data source to another.

B.4 Calculating A Geometric Mean

This appendix provides solution steps for calculating the geometric mean of your water quality samples. The geometric mean of your samples can be calculated using one of two methods; each one will provide an accurate answer. Taking into consideration that calculators differ and have different function keys, choose the method that is easier for you to follow.

QUESTION

Calculate the geometric mean for the following five enterococci samples taken within a 30-day period: 20, 40, 15, 30, and 29.[1]

SOLUTION STEPS

Method 1: Take the n^{th} root of n samples.

Step 1: Multiply all sample values together.

$$20 \times 40 \times 15 \times 30 \times 29 = 10,440,000$$

Step 2: Count the number of samples you are using.

$$= 5$$

Step 3: Make the value of *Step 2* the denominator in a fraction with '1' as the numerator.

$$= 1/5 \Rightarrow 0.2$$

Step 4: Take the answer from *Step 1* and raise it to the power of the answer from *Step 3*.

$$= (\ 10,440,000\ )^{0.2}$$

This calculation can be performed on a scientific calculator in several ways. For example, enter 10,440,000 into the calculator. Press the "x^y" key and then enter "0.2." This calculation can also be performed by entering 10,440,000, pressing the "^" key, and entering 0.2.

Answer: **= 25.336**

[1] If you have more than five samples collected during a 30-day period, the additional samples should be included in the calculation of the geometric mean (for both methods).

Method 2: Take the antilog of the mean of the logarithm of each sample.

Step 1: Take the log of each sample. (This calculation can be performed on a scientific calculator using the "log" key. For example, enter "20" into the calculator and then press the "log" key.)

$\log(20) = 1.30$
$\log(40) = 1.60$
$\log(15) = 1.17$
$\log(30) = 1.47$
$\log(29) = 1.46$

Step 2: Take the average, or mean, of the log samples.

$$1.40 = \frac{1.30 + 1.60 + 1.17 + 1.47 + 1.46}{5}$$

Step 3: Take the antilog of the answer from *Step 2*.

$$25.336 = \text{antilog}\ (1.40374)$$

This calculation can be performed on a scientific calculator in several ways. For example, enter "1.40," press the "Inv" key, and then press the "log" key. This calculation can also be performed by pressing the "2nd" followed by the "log" key and then typing 1.40.

Answer: **25.336**

Note: The values received from Method 1 or 2 should be compared to the values in the "Steady State Geometric Mean Indicator Density" columns of Tables B-2 to determine whether you are meeting the appropriate water quality criteria. Although variation around the steady-state geometric mean indicator density is common, it is important to note that no single sample should exceed your risk-based single-sample maximum allowable density.

Appendix C: State and Local Programs and Nongovernmental Organizations

C.1 State and Local Programs

[Under development]

C.2 Nongovernmental Organizations

Surfrider Foundation

The Surfrider Foundation is a nonprofit environmental organization dedicated to the protection and enjoyment of the world's oceans, waves, and beaches through conservation, activism, research, and education. With 27,000 members and 50 national chapters, the Surfrider Foundation recognizes the biodiversity and ecological integrity of the planet's coasts are necessary and irreplaceable and is committed to preserving the diversity and ecological integrity of the coastal environment. The Surfrider Foundation has established a national beach water quality testing, monitoring, and notification program called Blue Water Task Force. In 2000 this program was implemented by 21 local Surfrider chapters located in 9 coastal states (California, Texas, Florida, North Carolina, Delaware, Rhode Island, New Jersey, New York, and Massachusetts). More information on the Surfrider Foundation can be found at <http://www.surfrider.org/>.

Heal the Bay

Heal the Bay was founded in 1985. This nonprofit environmental advocacy group, which has approximately 10,000 members, works to make Santa Montica Bay and Southern California coastal waters safe and healthy for people and marine life. Heal the Bay uses research, education, community action, and policy programs to achieve this goal. In 1992 Heal the Bay led an effort to create a Beach Closure and Health Warning Protocol that mandates beach closures after every sewage spill and when bacteria exceed certain levels. Heal the Bay also publishes regular reports on the water quality of the Santa Monica Bay.

Heal the Bay produces a weekly Beach Report Card that analyzes data from the City and County of Los Angeles and grades beaches from "A" to "F" based on the bacteria levels in the surf zone. The Beach Report Card is released weekly to the media and to 18 ocean sports stores and marine centers. The group's Santa Monica Bay beach grades are also shown on The Weather Channel in most parts of the county. In addition, from 1990 to 1992 Heal the Bay led a series of studies that found the presence of human gastrointestinal viruses in storm drain runoff at several locations throughout Santa Monica Bay. The studies proved that human fecal material was contaminating certain storm drains, putting the health of beachgoers at risk. The results of this study were used in developing the local Beach Closure Protocol and performing a ground-breaking health risks study. More information on Heal the Bay can be found at <http://www.healthebay.org/>.

Chesapeake Bay Foundation

The Chesapeake Bay Foundation (CBF) is a nonprofit environmental group of more than 80,000 members committed to protecting the bay's natural resources from pollution and other harmful activities by fighting for strong, effective laws and regulations. In addition, CBF works cooperatively with government, business, and citizens in partnerships to restore the bay's essential habitats and filtering mechanisms, such as forests, wetlands, underwater grasses, and oysters, through a variety of hands-on projects. The Chesapeake Bay Foundation publishes an annual *State of the Bay Report* that summarizes trends and accomplishments in the Chesapeake Bay and its watershed, as well as goals for the coming year. Issues for the annual report include habitat, pollution, fisheries, and water quality. More information on the Chesapeake Bay Foundation can be found at <http://savethebay.cbf.org/>.

Natural Resources Defense Council

The Natural Resources Defense Council (NRDC) uses law, science, and the support of more than 400,000 members nationwide to protect the planet's wildlife and wild places and to ensure a safe and healthy environment for all living things. NRDC is an advocacy group working to safeguard drinking water; to protect, preserve, and restore rivers, streams, lakes, wetlands, and coastal waters; and to promote conservation and better water management in the arid western states. For example, in the past 10 years NRDC has undertaken a study of beach closings and beachwater monitoring and public notification programs in coastal and Great Lakes states. This study has triggered expansion of beachwater monitoring programs across the United States and new and emerging laws that will better protect the health of beachgoers. More information on NRDC can be found at <http://www.nrdc.org/>.

Center for Marine Conservation

The Center for Marine Conservation (CMC), established in 1972, is a nonprofit organization dedicated to protecting marine wildlife and habitats and to conserving coastal and ocean resources. In partnership with an international network of business and industry, other conservation groups, government agencies, foundations, associations, and private citizens, CMC works to keep the marine environment healthy and safe for future generations. Every year, the CMC coordinates an International Coastal Cleanup with the mission to

- Remove debris from the shorelines, waterways, and beaches of the world's lakes, rivers, and the ocean.
- Collect valuable information on the amount and types of debris.
- Educate people on the issue of marine debris.
- Use the information collected from the cleanup to effect positive change from the individual to the international to reduce marine debris and enhance marine conservation.

Additional information on the CMC's International Coastal Cleanup is available at <http://www.cmc-ocean.org/cleanupbro/about.php3>.

CMC also identifies existing and new citizen water quality monitoring programs that improve the publics awareness of what is in the water they swim in and the fish they eat. Additional information on CMC's water quality workshops can be found at <http://www.cmc-ocean.org/2_bp/comp.php3>.

American Oceans Campaign

The mission of American Oceans Campaign (AOC) is to safeguard the vitality of the oceans and coastal waters. AOC produces a "Healthy Beaches Brochure," which is an overview of the problems facing coasts and the solutions to ensure safe and healthy beach water. AOC also coordinates Healthy Beaches Workshops to provide citizens with information on how beach water quality monitoring programs help protect local residents, visitors, and businesses; what is being done on the local and national levels to monitor beach water quality: and what people can do to help their communities get the resources they needs to monitor beach water quality effectively, protect public health, and keep beach water clean and healthy. Additional information on AOC is provided at <http://www.americanoceans.com/index.htm>.

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Appendix D: EPA References: Statutes, Programs, and Activities Related to Recreational Waters

1. Clean Water Act

In 1972 Congress enacted the first comprehensive national clean water legislation in response to growing public health concerns related to serious and widespread water pollution. The Federal Water Pollution Control Act, commonly known as the Clean Water Act (CWA), is the primary federal law that protects the health of our nation's waters, including lakes, rivers, and coastal areas.

Section 303 of the CWA directs states, with oversight by EPA, to adopt water quality standards to protect the public health and welfare, enhance the quality of water, and serve the purposes of the CWA. Under section 303, each state is required to develop water quality standards for waters of the United States within the state. Section 303(c) provides that water quality standards must include the designated use or uses to be made of the water and water quality criteria necessary to protect those uses. Water quality criteria must be based on sound scientific rationale and must contain sufficient parameters to protect designated uses. EPA's implementing regulations at 40 CFR 131.11 require states to adopt water quality criteria based on EPA's recommended 304(a) water quality criteria or other scientifically defensible methods.

Several sections of the CWA address the protection of coastal marine and fresh waters. States and tribes can use these sections of the statute (sections 312 and 403(c), in particular) to preserve water quality by limiting or disallowing discharges that might contain high levels of harmful microorganisms or pollutants.

Section 312 of the CWA (33 U.S.C. Sec. 1322) regulates the discharge of sewage from vessels and sets standards for the use of marine sanitation devices (MSDs; boat toilets or heads). States and tribes can use section 312 to protect human health and aquatic habitats by requiring onboard treatment or storage of sewage before it is discharged into coastal waters or a pump-out facility or by designating no-discharge zones. States and tribes may designate all or portions of their waters as no-discharge zones to protect (1) aquatic habitats where pump-out facilities are available, (2) special aquatic habitats or species (whether or not pump-out facilities are available), or (3) drinking water supplies (whether or not pump-out facilities are available). The implementing regulations for section 312 can be found at 40 CFR Part 140.

Section 402 of the CWA requires municipal and industrial dischargers to waters of the United States to obtain a National Pollutant Discharge Elimination System (NPDES) permit, which requires compliance with technology- and water quality-based effluent limits. In addition, because of the complexity and ecological significance of marine ecosystems, dischargers to the marine environment beyond the baseline (the territorial sea, contiguous zone, and oceans) must also comply with section 403 of the CWA, which specifically addresses impacts from such point sources on marine resources. The Ocean Discharge Criteria regulations, which are used to evaluate NPDES permits for dischargers into marine waters, can be fund at 40 CFR Part 140. These criteria emphasize an assessment of the impact of an ocean discharge on biological communities, including human health risks.

2. *Draft Implementation Guidance for Ambient Water Quality Criteria for Bacteria –1986*

EPA released the *Draft Implementation Guidance for Ambient Water Quality Criteria for Bacteria –1986* in January 2000. This draft guidance provides recommendations to help states, territories, and authorized tribes implement EPA's recommended water quality criteria for bacteria. EPA recognizes there has been some uncertainty among states regarding how EPA's recommended 1986 bacteria water quality criteria should be implemented and how the transition should be made from fecal coliforms to *E. coli* and enterococci. This guidance addresses issues states have identified as impeding their progress toward adopting and implementing EPA's current recommended water quality criteria for bacteria. *Draft Implementation Guidance for Ambient Water Quality Criteria for Bacteria –1986* is available at <http://www.epa.gov/ost/standards/bacteria/bacteria.pdf>.

Appendix E: EPA Grant Coordinators

Table E-1 provides the names of the Headquarters and Regional Grant Coordinators and corresponding contact information.

Table E-1. Regional Grant Coordinators

Region	Name	Address	Telephone/Fax	E-mail
Headquarters Washington, DC	Charles Kovatch	USEPA 1200 Pennsylvania Ave., NW Mail code: 4305 Washington, DC 20460	202-260-3754 202-260-9830	kovatch.charles@epa.gov
Region 1 Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island	Matt Liebman	USEPA Region 1 One Congress Street Suite 1100-CWQ Boston, MA 02114-2023	617-918-1626 617-918-1505	liebman.matt@epa.gov
Region 2 New Jersey, New York, Puerto Rico, U.S. Virgin Islands	Helen Grebe	USEPA Region 2 2890 Woodbridge Ave. (MS220) Edison, NJ 08837-3679	732-321-6797 732-321-6616	grebe.helen@epa.gov
Region 3 Delaware, Maryland, Pennsylvania, Virginia	Nancy Grundahl	USEPA Region 3 1650 Arch Street (3ES10) Philadelphia, PA 19103-2029	215-814-2729 215-814-2782	grundahl.nancy@epa.gov
Region 4 Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina	Joel Hansel	USEPA Region 4 61 Forsyth Street, 15th Floor Atlanta, GA 30303-3415	404-562-9274 404-562-9224	hansel.joel@epa.gov
Region 5 Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin	Holly Wirick	USEPA Region 5 77 West Jackson Blvd. (WT-16J) Chicago, IL 60604-3507	312-353-6704 312-886-0168	wirick.holiday@epa.gov
Region 6 Louisiana, Texas	Mike Schaub	USEPA Region 6 1445 Ross Ave. (6WQ-EW) Dallas, TX 75202-2733	214-665-7314 214-665-6689	schaub.mike@epa.gov
Region 9 American Somoa, California, Commonwealth of the Northern Mariana Islands, Guam, Hawaii	Terry Fleming	USEPA Region 9 75 Hawthorne Street (WTR-2) San Francisco, CA 94105	415-744-1939 415-744-1078	fleming.terrence@epa.gov

Region	Name	Address	Telephone/Fax	E-mail
Region 10 Alaska, Oregon, Washington	Pat Cirone	USEPA Region 10 120 Sixth Ave. (OW-134) Seattle, WA 98101	206-553-1597 206-553-0165	cirone.patricia@epa.gov

Appendix F: Beach Evaluation and Classification List

This Appendix provides an example of a list of factors that can be used to rank and classify your beaches. The list includes available information, pollution threats, sanitary surveys, exposure considerations, and monitoring data.

Category	Factors
Available Information	State water quality reports
	Swimmers report health effects from this beach
	Advisories issued at this beach last year during the bathing season because of exceedance of water quality standard or preemptive standard
	Beach was closed to bathing during the season last year because of health concerns or exceedance of water quality standard or preemptive standard
	Suspected sources of human pathogen contamination of the water at this beach
Pollution Threats	Industrial point sources
	Urban point sources: POTWs
	Urban nonpoint sources: Oil, pesticides, other toxics
	Urban nonpoint sources: Sewage, pathogens
	Urban nonpoint sources: Plastics and other floatables
	Agricultural nonpoint sources: Pesticides and other toxics
	Agricultural nonpoint sources: Nutrients/animal wastes
Sanitary Survey	Annual rainfall for this area
	Number of significant rainfall events during the past year (e.g., more than 1 inch in 24 hours) that were known to contribute to pathogen contamination)
	Type of terrain within 5 miles of the beach
	Average high temperature during the swimming season
	Average temperature during the past 30 days
	Average flow if beach is on a river or estuary with a flow
	Flow during past 30 days if beach is on a river or estuary with a flow
	Nearshore water movement if beach is on an ocean, lake, or other nonflowing waterbody with or without a tide
	Number of point source dischargers within 1 mile of this area (include outfalls)

Category	Factors
	Area is subject to combined sewer overflows (CSOs) or storm sewer overflows (SSOs)
	Area is subject to agricultural runoff during storms
	Location of nearest POTW is located
	Number of POTWs within 5 miles of beach
	Approximate number of septic systems within 5 miles of beach
	Water treatment level in the area
	Number of animal feeding operations (AFOs, feedlots) or concentrated animal feeding operations (CAFOs) within 5 miles of beach
	Number of aquaculture facilities within 5 miles of beach
	Nature of discharges from AFOs, CAFOs, aquaculture facilities to waterbody adjacent to this beach
	Availability of sanitary facilities for the bathing public during bathing season
	Number of marina or pleasure craft with toilets
	Wild animals present on or near the beach
	Domesticated animals present on or near the beach
	Approximate number of birds per hour that frequent a typical 50-meter length of this beach or nearshore waters
	Pollution prevention and abatement efforts in this area
Exposure Considerations	Approximate area of beach open to bathers (length x width at high tide)
	Average number of days in the bathing season
	Percentage of beach visitors that go in the water
	Average density of bathers at peak season (include weekends and holidays)
	Average density of bathers during off-peak season
	Average density of bathers from the susceptible population (children, elderly)
	Average time between an observable problem noted during a sanitary survey and public notification
Monitoring Data	Water quality standards used in this jurisdiction
	Number of indicators analyzed
	Enterococci analyzed

Category	Factors
	If freshwater, *E. coli* analyzed
	Monitoring data have been used to model risks due to rainfall levels at this beach
	Turbidity levels at this beach are related to pathogen contamination
	Frequency of sampling at this beach
	Number of exceedances of averaging period standard per sampling station at a beach per month
	Number of exceedances of instantaneous standard per sampling station at a beach per month
Other Factors	Importance of this beach to the local economy
	Results of public comment/concerns about this beach
	If a program is not now in place at this beach, resources available for developing a beach monitoring and notification program
	If a program is in place or planned, resources available for maintaining a beach monitoring and notification program

Appendix G: Conducting a Sanitary Survey

Sanitary surveys are frequently associated with water supply systems. They are used to identify sources of pollution and provide information on source controls and identification, persistent problems, and management actions and links to controls. Thus, a sanitary survey can be an effective tool for protecting human health at bathing beaches and can provide information that helps in designing monitoring programs and selecting sampling locations, times, and frequencies.

Using Sanitary Surveys

In the past several years, Delaware has become increasingly concerned about having to close its beaches to swimming for extended periods because of bacterial contamination. Lake water quality and designated uses, such as public swimming, are threatened primarily by high levels of bacteria.

Trap Pond is one of Delaware's most important freshwater recreational resources. Located in the Nanticoke watershed, a priority watershed that drains into the Chesapeake Bay, Trap Pond is the recreational focus for Trap Pond State Park. Although the watershed has no point source discharges and little developmental pressure, erosion, pollution transport, and increased nutrient influx were contributing to the lake's surface and ground water pollution. Increasing bacteria contamination and symptoms of accelerated eutrophication such as algal blooms were becoming increasingly obvious each season. A comparative study found that Saunders Branch, the major tributary to Trap Pond, had elevated bacteria and phosphorus levels.

Sanitary surveys revealed the two probable causes —a direct discharge from an underground septic system and livestock with direct access to the stream. Property owners were notified of the leaking septic systems and corrected the problem, and the bacteria levels decreased immediately in the affected area of Saunders Branch. Livestock accessibility, the second cause, was addressed with a 1-year section 319 grant of $84,419. This grant funded a conservation planner through the Sussex Conservation District and Soil Conservation Service. The planner provided technical assistance to implement animal waste management systems and nutrient management plans on farms throughout the watershed. Some 98 percent of the producers installed manure storage facilities, buffer strips, and other best management practices, and all producers fenced their livestock out of the streams.

G.1 When to Conduct a Sanitary Survey

A sanitary survey should be conducted in suspected high-risk situations to identify or confirm the presence or absence of contamination sources and to aid in beach classification. In addition, sanitary surveys may be performed periodically during a swimming season, when a bacterial exceedance is measured, or more frequently depending on the length of the bathing season (CTDEP, 1992; Figueras et al., 2000; Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, 1990). A sanitary survey should also be conducted as part of any proposal to expand or develop a recreational beach area or when newly proposed activity would significantly alter the water quality in an existing recreational beach area. The findings of the survey should receive prime consideration in any decision to proceed with development. In some states, such as Maryland, a permit for operation of a bathing beach may not be issued if a detailed sanitary survey reveals sources of pollution that affect or might affect the bathing beach (Maryland Department of Health and Mental Hygiene, 1978). If a significant pollution event occurs during the bathing season, a source identification should be conducted rather than a comprehensive sanitary survey.

G.2 Who Conducts a Sanitary Survey

The *EPA/State Joint Guidance on Sanitary Surveys* recommends that a Registered Sanitarian or a Registered Environmental Health Specialist conduct and/or supervise the sanitary survey. The Connecticut Department of Environmental Protection recommends that the local health department conduct a sanitary survey of any watershed that drains to a public bathing area (CTDEP, 1992). The Great Lakes-Upper Mississippi River Board of State Sanitary Engineers suggests that the official agency regulating the bathing beach or a person or persons acceptable to that agency should conduct the sanitary survey.

G.3 Steps for Performing a Sanitary Survey

The survey should identify new sources of microbiological hazards and evaluate the adequacy of the existing sampling program and the corrective measures in place to deal with existing hazards.

The *Guidance Manual for Conducting Sanitary Surveys of Public Water Systems: Surface Water and Ground Water Under the Direct Influence (GWUDI) of Surface Water* (USEPA, 1999a) established four steps for conducting a comprehensive sanitary survey:

1. Plan the survey
2. Conduct the survey and site visit
3. Compile the sanitary survey report
4. Review and respond to the report

Examples of how to conduct a sanitary survey are also provided in the *Guidance Manual for Conducting Sanitary Surveys of Public Water System* (USEPA, 1999a), the *National Shellfish Sanitation Program Model Ordinance* (NSSP, 1997), and California's *Guidance for Saltwater Beaches* (draft) and *Guidance for Freshwater Beaches* (draft) (CADHS, 2000). A brief description of the process is provided in the following paragraphs.

G.3.1 Planning the Survey

Before initiating other survey activities you should review the previous sanitary survey report as well as collect and review any existing data or reports on the area. These materials will help you design a thorough and efficient on-site evaluation. You can collect historical data on tides, currents, prevailing winds, rainfall, discharges of wastewater treatment plant effluent, storm water outfalls, combined sewer overflows, and urban and agricultural effluents. Compile a checklist to ensure that all potential sources of pathogen contamination or other hazards that need to be identified are assessed during an on-site visit. The purpose of an on-site visit is to identify and evaluate all existing and potential sources of microbiological contamination that could affect the safe use of the area. The checklist in Appendix F can help you target areas to examine as part of the on-site evaluation.

G.3.2 Conducting the Sanitary Survey

For the purposes of this guidance, the significance of rainfall, climate, terrain, flow, and sources of pollution in the watershed and at the beach should be determined to aid in the beach evaluation process.

- **Rainfall and climate.** Pollution can typically be expected to reach a peak after rainfall when storm water runoff washes fecal material into receiving waters (Jagals, 1997). As part of the beach evaluation process, therefore, it can be helpful to identify the annual rainfall for the area, the pattern of rainfall in the 30 days before the survey (i.e., has it been below normal, normal, or above normal?) and the number of significant rainfall events (e.g., more than 1 inch in 24 hours) in the past year. The type of terrain, the permeability of the soils, and the storage characteristics of the watershed can also affect the rate at which runoff reaches the beach (Novotny and Olem, 1994). Very hilly or mountainous terrain increases the amount of runoff and the rate of which it reaches the beach. The average high temperature during the swimming season and the temperature pattern during the last 30 days can affect pathogen survival. Microbial growth rates tend to increase as temperatures rise (Auer and Niehaus, 1993).

- **Water flow.** The average flow and the flow during the last 30 days are important factors to consider for beaches on rivers or estuaries. For nonflowing waterbodies (lakes, oceans) with or without a tide, nearshore water movement is important to consider. Water movement affects the concentration of pathogens. Waterbodies with little or no flow or water movement usually have higher pathogen concentrations.

- **Sources of pollution in the watershed.** Determining the location and impact of pollution sources in the watershed can also aid in the beach evaluation process. Pollution sources that are closer to the beach or that occur more frequently have a greater effect on the beach than pollution sources that are farther away and occur less frequently. These sources all have the potential to contribute to the bacterial and pathogen load affecting the recreational beach, and therefore it is important to identify them during a sanitary survey. Once the sources have been identified public health can be protected by enforcing proper discharge levels (Thomann and Mueller, 1987; USEPA, 1994b).

- **Water treatment level.** The water treatment level and pollution prevention and abatement efforts in the area also play an important role in beach evaluation. Tertiary treatment removes more pathogens than primary, secondary, or no treatment; therefore, areas where tertiary treatment occurs are at lower risk than areas where primary, secondary, or no treatment occurs (Thomann and Mueller, 1983). Pollution prevention and abatement efforts can help to minimize health risks to bathers. Areas that have excellent pollution prevention and abatement efforts can be of lower risk than areas where few such efforts occur.

- **Sources of pollution at the beach.** Human and animal fecal pollution that occurs at the beach is an important source of pollution. The adequacy of the sanitary facilities for the bathing public should be evaluated. Marinas, pleasure craft with toilets, wild or domestic animals and birds, and failing septic drainfileds or tanks can also be direct sources of fecal pollution to recreational waters and the beaches adjacent to them (NRDC, 1999; USDHHS, 1985; Weiskel et al., 1996).

G.3.3 Compiling the Sanitary Survey Report

Final written reports should be prepared for every sanitary survey in a format that is consistent statewide (USEPA, 1999a) or that meets the criteria of the particular program for which the sanitary survey is being conducted. The NSSP (1997) recommends that the following components be included in sanitary survey reports for shellfish growing areas:

- An executive summary that includes a description of the area, a location map, and the history of the water quality of the area (if known).

- A pollution source survey, including a summary of the sources, a map or chart documenting the location of the major sources, and an evaluation of the pollution sources and the magnitude of the pollutants they produce.

- Information about physical factors that can affect the distribution and concentration of microorganisms and microbial water quality.

- A description of the hydrographic and meteorological characteristics, including tides, rainfall, winds, and river dischargers, and a summary discussion concerning the actual or potential effect of transport of pollution to the area.

- Water quality studies, including a map of the sampling stations; the sampling plan and justification; the sample data analysis; and presentation and interpretation of the data, including the effects of meteorological and hydrographic conditions on bacterial loading and the variability of the data.

- A conclusion section that includes recommendations for improvement.

The *Guidance Manual for Conducting Sanitary Surveys of Public Water Systems* (USEPA, 1999a) suggests that the survey report include the date and time of the survey, the names of survey inspectors, a summary of survey findings with the signatures of survey personnel, a listing of deficiencies based on a regulatory reference, recommendations for improvement in order of priority, and a copy of the survey form. For examples of a sanitary survey report, refer to Bartram and Rees (2000) and NSSP (1997).

With a completed sanitary survey report, a more accurate assessment of public health risk at a beach can be made. Also, informed decisions on how to improve public health at the beach and the implementation of new or improved sampling locations and frequencies can be discussed. Evaluation criteria contained in the sanitary survey checklist in Appendix F include the following:

- Annual rainfall for the area
- Amount of rainfall in the last 30 days
- Number of significant rainfall events (e.g., more than 1 inch in 24 hours during the past year) that might have contributed to pathogen contamination
- Area within 5 miles of the beach
- Average high water temperature during the swimming season
- Water temperature during the past 30 days
- Average flow of beach if the beach is on a river or estuary
- Average flow during past 30 days if the beach is on a river or estuary
- Water movement if the beach is on an ocean, lake, or other nonflowing waterbody with or without a tide
- Number of point source dischargers within 1 mile of this area (include outfalls)
- Area subject to combined sewer overflows (CSOs) or storm sewer overflows (SSOs)
- Area subject to agricultural runoff during storms
- Nearest POTW
- Number of POTWs within 5 miles of beach
- Approximate number of septic systems within 5 miles of beach
- Water treatment level in this area
- Number of animal feeding operations (AFOs, feedlots) or concentrated animal feeding operations (CAFOs) within 5 miles of beach
- Number of aquaculture facilities within 5 miles of beach
- Nature of discharges from AFOs, CAFOs, aquaculture facilities to waterbody adjacent to this beach
- Sanitary facilities during peak season
- Presence of a marina or pleasure craft with toilets
- Wild animals present on or near the beach
- Domesticated animals present on or near the beach
- Approximate number of birds per hour that frequent a typical 50-meter length of this beach or nearshore waters
- Pollution prevention and abatement efforts in this area

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Appendix H: Monitoring Design Approach

The National Research Council (NRC, 1990a, 1990b) has evaluated marine monitoring programs and practices and has made a series of recommendations to improve the usefulness of monitoring information. EPA (USEPA, 1991a) suggested the following steps based on the NRC's findings for designing successful monitoring programs. These steps can be used to develop a beach monitoring program.

Step 1. Develop monitoring objectives

Clear objectives should be developed for each component of the monitoring program. Microbiological monitoring of recreational waters, in most cases, is undertaken to establish the degree of allowable microbiological pollution to protect public health and the environment. For beach management programs, recreational waters should attain criteria as protective as those EPA established in *Ambient Water Quality Criteria for Bacteria –1986* (USEPA, 1986). For example, if the geometric mean of the enterococci densities exceeds 35 per 100 mL in marine waters and 35 per 100 mL in freshwater, human health might be affected and an advisory should be considered. Similarly, if the geometric mean of the *E. coli* densities exceeds 126 per 100 mL in freshwater, human health might be affected and an advisory should be considered. Although an advisory should be considered when a sample exceeds water quality standards, it is ultimately a state or local decision to determine when to issue an advisory or closing. Therefore, the corresponding objective of the monitoring program would be to detect exceedances of the appropriate water quality standards.

Step 2. Establish testable hypotheses and select statistical methods

Monitoring program objectives should be translated into statistically testable hypotheses. Establishing testable hypotheses ensures that the results of the monitoring program will be unambiguous and that the objectives of the program can be met. This approach results in the creation of a threshold level for determining when to record an exceedance and notify the public.

Step 3. Select analytical methods and alternative sampling designs

Detailed specifications for the analysis of each environmental variable of the monitoring program should be developed, including field and laboratory protocols and quality assurance/quality control procedures. In addition, alternative spatial and temporal sampling designs should be devised. The sampling designs should specify the number and location of sampling points, sample frequency, and level of sample replication. This information will then be used in the next step to evaluate expected monitoring program performance and to select the most efficient sampling design among the alternatives.

Step 4. Evaluate expected monitoring program performance

The evaluation of monitoring program performance is potentially the most important step in the design and review process (USEPA, 1991a). Before the program begins, an evaluation of alternative sampling designs assists in the selection of the most appropriate design for cost-effective sampling that meets the program objectives. During the course of the monitoring effort, performance evaluations provide a systematic procedure for measuring success in terms of the ability to continue to meet program goals. The periodic evaluation process also identifies the need to modify the sampling design and methods. Without this evaluation, there is a risk of collecting and analyzing too few or too many samples. The results of this evaluation are used to identify the modifications to the initial design necessary to increase monitoring program effectiveness.

Step 5. Implement data analysis

The development of a data management system is an essential task in the design of monitoring programs, and sufficient funds should be provided to cover data analysis. The data management system should be operational before the monitoring program is implemented. In addition to specifying data analysis methods, an expeditious timetable for analyzing the data, and the procedures for reporting and communicating the results, the data management system should be used to assess implementation progress and monitoring program performance. The results of the performance assessment can be used to refine the program objectives and to modify individual study elements to satisfy those objectives.

Appendix I: Data Quality Objectives

This appendix provides information about the basic planning elements of the QAPP, SOP, and DQO process, as well as some additional information. It is important to note that the planning process is an iterative process. The personnel planning the program should incorporate changes as the need for them is identified and should review how those changes affect other elements of the program, making revisions to those elements as necessary.

I.1 Identify the Decision Maker and Program Personnel

A beach water quality monitoring program requires the efforts of program managers, technical staff, and potentially a variety of interested parties or stakeholders. The team involved in planning and implementing the program might include senior government officials from offices established to protect health or environmental quality; technical experts familiar with the issues and methods to be used; data analysts; data users, including risk assessors and the manager or program leader who will make the advisory or closing decision; and quality assurance specialists. Individuals or organizations that might be directly affected by the decision should also be involved in planning the monitoring program to improve communication and build consensus. The members of this group will be able to offer different perspectives and assist in solving problems. They might be involved in development of the plan at different stages and through different types of meetings or other activities.

It is important to note that some personnel manage or perform the work of the monitoring program, while other personnel who do not actually do the work are needed to provide oversight and ensure the quality of the work being performed. Quality control (QC) is a system of technical procedures and activities developed and implemented to produce measurements of requisite quality. Quality assurance (QA) is an integrated system of management procedures and activities used to verify that the QC system is operating within acceptable limits. QA oversight is important to maintain the credibility of a beach monitoring program. QA personnel should be identified at the planning stage and included during the operation of the program to assess all aspects of data collection.

I.2 Clarify Monitoring Program Goals and Objectives

A clear statement of the purpose of the monitoring program and the program's objectives is necessary to avoid confusion and prevent wasting of resources. As noted in EPA's monitoring guidance (1997b), monitoring programs can be undertaken for different reasons and to answer different questions. The types, quantity, and quality of the data can vary considerably to meet different goals. A conceptual model of the potential environmental hazard should be prepared. This model can be in the form of a diagram illustrating known or suspected sites of contamination at one or more beaches, sources of microorganisms, and exposure scenarios (e.g., children playing in sand or shallow water, swimming, or surfing). The problem to be investigated needs to be defined. The following are examples of monitoring program goals:

- Determine whether an impairment exists.
- Determine the spatial and temporal extent of the impairment.
- Determine the causes and sources of the impairment.

An example of the first type of program goal is routine monitoring to protect human health by comparing levels of indicator bacteria to the ambient water quality criteria for bacteria (USEPA, 1986) during the swimming season. The basic decision to be made is whether the criteria are being exceeded so that an advisory can be posted or the beach closed. Based on the initial monitoring results, intensive monitoring involving the collection of water samples at different times (e.g., daily or only after storm events) and from many locations (e.g., waterbodies downstream from the initial location might be indicated). Intensive monitoring might be indicated while establishing your monitoring program to pinpoint the most appropriate locations for the routine sampling effort and the depths, times, and procedures needed to collect the samples. It might be needed during the program to evaluate whether the sampling design in use is continuing to effectively protect human health. Intensive monitoring can be used to determine the most appropriate sampling frequency needed to assess standards. Intensive monitoring might also be desirable or necessary to identify the point and nonpoint sources that could be responsible for waterbody impairment or to evaluate the influence of rainfall on the bacterial load at a particular beach. Extensive sampling is needed for the development of predictive tools using statistical analysis or mathematical models.

This guidance focuses on routine monitoring for beach advisory or closing decisions. An example of a principal study question is

Could levels of bacteria in the water at Bayside Beach affect swimmers' health?

Examples of alternative actions that might be considered if the answer to this question is "yes" include the following:

Post an advisory at the beach to warn swimmers of the potential hazard.
Close the beach and do not permit swimming until further notice.
Conduct a sanitary survey to identify point and nonpoint sources of bacteria.
Take no action.

The following is an example of a decision statement for this type of program:

Determine whether bacterial indicator levels require taking action to protect human health.

Decision rules developed for this program at a freshwater lake might include the following examples:

If the density of enterococci in any one sample exceeds the EPA instantaneous (single-sample) criterion of 61 per 100 mL, the water is sampled again.

If the density of enterococci in the second sample exceeds the EPA instantaneous criterion, the beach is closed.

If the running geometric mean of enterococcal densities from 5 sequential samples taken during the previous 30 days is greater than the EPA averaging period criterion of 33 per 100 mL, the beach is closed.

If the density of indicator bacteria does not exceed the criteria under the above conditions, swimmers are not at risk and the beach remains open.

I.3 Describe the Monitoring Program

The planning team should discuss what information is needed to make the decision. In the above example, it is obvious that bacterial densities are necessary. Other types of information that might be useful are measurements of other environmental factors, such as temperature, nutrients, dissolved oxygen, salinity, turbidity, or water flow, which might provide supporting evidence for the existence of the problem or the seriousness of an exceedance.

The regulatory basis for the decision, in this case EPA's ambient water quality criteria for bacteria, should be documented. In addition, spatial and temporal boundaries for the monitoring program should be examined. For example, a beach might extend for many miles along the coastline of a jurisdiction, but swimmers have access to only a few hundred feet of shoreline at the end of one road. In addition, the presence of a storm sewer outfall on the beach might be the focus of sampling.

One or more members of the planning team should document these elements of the program in the monitoring plan. The team should also review available resources, relevant deadlines, the budget, the availability of personnel, and schedule requirements to determine how they will affect sampling at the beach(es) in question. This information should be evaluated along with the proposed sampling design and the boundaries of the monitoring program (see below) to assess how well the program objectives can be met within the various technical and cost limitations.

I.4 Identify the Type of Data Needed and the Sampling Design

Various sampling designs have been used for monitoring recreational waters adjacent to bathing beaches. The sampling design specifies the number, location, and types of samples to be collected, as well as conditions under which they should be collected, the analyses to be performed, and the QA and QC procedures required to ensure that sampling design and measurement errors are controlled to meet the tolerable decision error rates specified in the DQOs.

Because enterococci and *E. coli* are commonly found in the feces of humans and other warm-blooded animals, the presence of enterococci or *E. coli* in water is an indicator of fecal pollution and the possible presence of enteric bacteria that pose a risk to human health. Epidemiological studies have led to the development of criteria that can be used to promulgate recreational water standards based on the established relationship between health effects and water quality (Chapter 1). The significance of finding enterococci or *E. coli* in recreational water samples is the direct relationship between the density of enterococci or *E. coli* in the water and the incidence of swimming-associated gastroenteritis, as found in studies of marine and freshwater bathing beaches (Cabelli, 1980; Dufour, 1984).

Currently, monitoring the quality of recreational waters should be based on the collection of five samples during a 30-day period and the calculation of a running geometric mean to determine whether the estimated bacterial densities exceed the water quality standards (USEPA, 1986). EPA recognizes, however, that this sampling pattern does not provide timely, accurate information for risk managers or the public.

Although statistical or probabilistic sampling designs are highly desirable, not every sampling problem can be solved with these designs. Local limitations in staff and funding might also strongly affect the number of samples that can reasonably be analyzed during the swimming season. Basic sampling design should address the following seven aspects (Bartram and Rees, 2000):

1. Reasons to sample
2. What to sample
3. How to sample
4. When to sample
5. Where to sample
6. How many samples to take
7. Sampling evaluation

A sampling and analysis plan should include the location of sampling sites, frequency of sampling, duration of the sampling period, and depth of sampling. For each recreational waterbody, the plan should also include other pertinent information, such as the types of containers to be used for sampling, how to package samples for transport, references for analytical methods, how to report data, and requirements for repeat sampling. The plan should be developed in conjunction with the local laboratory that will conduct the bacteriological analyses (CADHS, 1999).

It is difficult to decide the optimum number of samples to take and the most suitable locations to characterize the water quality in the most meaningful way. Sampling marine and estuarine waters requires considering tidal cycles, current patterns, bottom currents, countercurrents, stratification, seasonal fluctuations, dispersion of discharges, multidepth sampling, and many other factors. Sampling lakes and rivers adjacent to beaches requires considering wind and flow and whether the beach is upstream or downstream of pollution sources, as well as time of day (see box at right). Determining the most appropriate, cost-effective use of the resources available for a monitoring program is also difficult. The following aspects of sampling are presented for consideration as you develop your monitoring plan:

Location. Sampling locations are chosen based on historical records, usage, current situations, concentration of bathers, pollution sources, accessibility, and other factors. Areas known to be chronically contaminated, as well as areas that typically have the highest bather density, should be included in the sampling plan. An area close to a storm water outfall might have high counts of bacteria, but it might not be an area commonly used for swimming. Therefore, the priority might be to sample in the area where more swimmers are located to obtain a better estimate of risk to human health. Ultimately, these decisions are appropriate for the beach manager to make. Table 4-1 should be consulted for guidance. In addition, other criteria for sampling might be defined, such as obtaining the sample at a specified distance from swimmers and animals and not in the "swash zone" area of low waves near the shore (IITF, 1999), as well as spacing samples at specified intervals for lengthy stretches of beach.

> A study was conducted at two beaches on Lake Erie to evaluate the water sampling design for the collection of several microbiological indicator organisms in relation to day, time, and location of collection. The concentrations of these organisms were generally found to vary significantly by the specific time of day and day of the weekend that collection took place. However, the concentrations did not vary significantly at various locations in the bathing area. Sampling at different locations in the bathing area might be considered for beaches that have poor dispersion of fecal waste sources (Brenniman et al., 1981).

Frequency. Ideally, when first establishing a recreational water quality monitoring program, the optimum sampling frequency is daily and samples of estuarine or marine bathing waters should be obtained at high tide, ebb tide, and low tide to determine the cyclic water quality and deterioration that should be monitored during the swim season (Bordner et al., 1978; see box below). Lakes and rivers might also be sampled at different times; for example, during calm vs. windy days or during low-flow vs. storm-flow conditions. If a beach monitoring program does not have the resources to sample this often, a minimum frequency of sampling should be established locally, based on historical records, usage, current situations, and the potential for health hazards and in accordance with the number of samples indicated by the water quality standards on which your decision will be based. In highly populated or high-risk areas, more frequent sampling is appropriate, as suggested by the tiered approach (Table 4-1). Sampling might be needed under some circumstances, such as where no sanitary facilities are provided at a beach or when toilets at the beach are not open or operational.

Subsequent sampling might also be needed to determine when to reopen a recreational area after a beach closing. Sampling frequency can be related to the peak bathing period, which is generally in the afternoon, but preferably samples are collected in both the morning and afternoon (Bartram and Rees, 2000), at least for beaches classified as high-priority. Weekends and holidays should be considered in the sampling program. If you wish to characterize the water quality at the beach before the weekend crowd arrives, you might want to sample on Thursday so that the results are ready by Friday. If you wish to characterize the water quality at the beach after the weekend crowd has left, sample late Sunday or on Monday. The frequency of sampling might change according to your beach classification.

> Water quality data for the years 1979 to 1981 were obtained for a marginally polluted beach in New York (New York City Department of Health, 1981). A standard of 2,400 total coliform organisms per 100 mL of sample was used. On a particular day during May through September, one sample per hour was taken for 7 hours. Analysis of the water quality at this location with respect to intra-day variation showed significantly higher mean densities during the first 2 hours of sampling than during the last 2 hours of sampling. During the 3 years studied (1979 –1981), morning coliform densities tended to be significantly greater than the standard, whereas afternoon samples tended to be significantly lower than the standard. These differences were likely due to environmental factors such as wind and local currents. Because such environmental factors vary from location to location, the finding of significant intra-day variation in indicator organism density at this location strongly argued for sampling strategies that ensured numerous determinations could be made on each sampling date.
>
> Analysis of the inter-year variability of coliform density at this location showed this variability to be quite low. Analysis using only one-half of the 3 years of data compiled by the New York City Health Department gave a profile of water quality at this location that showed little difference from the analysis using the full data set. This fact, coupled with the previous findings of the study, indicated that sanitary surveys should maximize the number of replicate determinations made per sampling date instead of maximizing the number of days on which samples are taken (Fleisher, 1990).

Sampling Depth. The primary factor for determining depth of sampling the users at risk. Samples of ankle- and/or knee-depth water might be more appropriate for children and infants, whereas waist- and/or chest-depth samples might be more appropriate for adults (Refer to Table 3-1). Sampling from boats is usually inadequate for beach monitoring because water depths would exceed those common to beach-related recreational activities, especially for young children (CADHS, 1999). Local health agencies, however, might desire to assess water quality away from the shore in additional areas where surfing, windsurfing, or other activities occur.

Sampling Time. The most appropriate time of sampling should be chosen to obtain the best estimates of water quality conditions during the highest periods of risk. Wave and tidal actions affect bacteria levels, as do the number of bathers at the time of sampling and before and after sampling; the water temperature; and the recent, current, and predicted weather conditions (e.g., wind, rain). Bacteria levels change frequently, based on these types of environmental conditions. You should take this factor into account when formulating a sampling design and when interpreting sampling results and analyses. If you want to capture the conditions of your beach when the most people are in the shallow waters, conduct your sampling during high tide when bacteria levels might be higher near the shore (see Table 4-1). To estimate how water quality is affected by the number of swimmers in the water, sample the water during the time of day when there is the highest bather density at your beach.

In addition, you might want to sample after the weekend to capture the conditions of the water after the highest bather density. Or you might want to collect water samples on Thursday so that you can inform weekend visitors about water quality before they swim on the weekend. (This type of sampling is recommended for use only on a temporary basis if resources prevent daily sampling on a routine basis. It should be done only to obtain a better understanding of indicator occurrence patterns on which to base the development of a more minimalistic sampling approach that captures and best represents those patterns.) Ideally, sampling should be done throughout the day and week to look for patterns of bacteria levels. However, it is important to remember that the results of the laboratory test will take approximately 24 hours.

The final sampling design should be carefully documented in a sampling and analysis plan or incorporated into a QAPP. (Refer to USEPA, 1998 and 1999a for further information on QAPP preparation.) The plan should include a rationale and listing of the location of all sampling sites and stations within a site, the frequency of sampling at each station, the depth of water sample collection, and the duration of the sampling period (e.g., one time only, 2 weeks in July, during the open swimming season). The plan should also include the procedures for obtaining the samples and analyzing them for bacterial indicator(s), procedures for collecting other data from the field, when repeat sampling will be performed, and how and to whom data will be reported. Standard Operating Procedures (SOPs) should be prepared for all activities that need to be performed the same way every time. Each SOP should include details on the method for a given operation, analysis, or action in sequential steps, as well as the facilities, equipment, materials and methods, QA and QC procedures, and other factors required to perform the operation, analysis, or action.

I.5 Quality Objectives and Criteria

Data quality is defined by a series of statements that set the standards the data must meet. These standards cover the way the sample is collected and analyzed, as well as certain performance criteria which, if met, ensure that the data are acceptable and usable by the decision maker. As part of the DQO process, the planning team needs to establish program and measurement quality objectives to enable the data user to understand any errors or uncertainties associated with the data. Two categories of errors are commonly recognized, sampling error and measurement error. Sampling error is the difference between sample values and in situ "true" values, and it results from unknown biases due to sampling design, including natural variability due to spatial heterogeneity and temporal variability in microorganism abundance and distribution. Measurement error is the difference between sample values and in situ "true" values associated with the measurement process, including bias and imprecision associated with sampling methodology, specification of the sampling unit, sample handling, storage, preservation, identification, instrumentation, and other factors.

The monitoring program should specify methods and procedures to reduce the magnitude of measurement error sources and frequency of occurrence. For example, using trained staff to perform the data collection and analyses and following standardized, repeatable procedures for data and sample collection can help eliminate sloppy, inconclusive work. Uncertainty in the data because of sampling and measurement errors or errors introduced during data manipulation could result in identifying a risk to human health when one does not exist (i.e., the true density of bacteria is not greater than the criterion) or not identifying a risk when one does exist (i.e., the true density of bacteria exceeds the criterion). Data entry, transfer, calculation, and reporting mistakes can compound these issues. Data entries and the procedures for calculating results must be carefully checked for correctness and completeness.

Measurement performance criteria are qualitative and quantitative statements used to interpret the degree of acceptability or utility of the data to the user. These criteria, also known as data quality indicators (DQIs), include the following:

- Precision
- Bias
- Representativeness
- Completeness
- Comparability

Sometimes DQIs for some parameters cannot be expressed in terms of precision and bias (accuracy) or completeness. In these cases a full description of the method by which the data will be obtained should be included in the plan. The various measurement performance criteria that should be established for beach water quality monitoring parameters are discussed in the following subsections.

Precision

Precision is defined as the degree of mutual agreement or consistency between individual measurements or enumerated values of the same property of a sample. Obtaining an estimate of precision provides information on the uncertainty due to natural variation, sampling error, and analytical error. The precision of sampling methods is estimated by taking two or more samples at the same sampling site at approximately 10 percent of the sites. The precision of laboratory analyses is estimated by analyzing two or more aliquots of the same water sample. This data quality indicator is obtained from two duplicate samples by calculating the relative percent difference (RPD) as follows:

$$RPD=\frac{|C_1-C_2|}{(C_1+C_2)/2}\times 100$$

where C_1 is the first of the two values and C_2 is the second value. Because the absolute value of the numerator is calculated, the RPD is always a positive number. If it is to be calculated from three or more replicate samples, the relative standard deviation (RSD) is used and is calculated as

$$RSD = \frac{s}{\overline{X}} \times 100$$

where s is the standard deviation and $\overline{X}$ is the mean of repeated samples. The standard deviation or the standard error of a sample mean(s) is calculated as

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(X_i-\overline{X})^2}{n-1}}$$

where X_i is the measured value of the replicate, $\overline{X}$ is the mean of repeated sample measurements, and n is the number of replicates. Precision can also be expressed in terms of the range of measurement values.

Because of the heterogeneity of populations of bacteria in surface waters, an RPD of less than or equal to 50 percent between field duplicates for microbiological analyses might be considered acceptable. In laboratory analyses, the precision among laboratories following EPA Method 1600 for detecting enterococci from separate aliquots of the same sample was determined to be 2.2 percent for marine water samples and 18.9 percent for fresh surface water samples (USEPA, 1997a). Analysts should be able to duplicate bacterial colony counts on the same membrane within 5 percent and the counts of other analysts within 10 percent; otherwise, procedures should be reviewed and corrective action implemented (IITF, 1999).

Accuracy

Accuracy is the degree of agreement between an observed value and an accepted reference or true value. Accuracy is a combination of random error (precision) and systematic error (bias), both of which are due to sampling and analytical operations. Bias is the systematic distortion of a measurement process that causes errors in one direction so that the expected sample measurement is always greater or lesser to the same degree than the sample's true value. Because accuracy is the measurement of a parameter and comparison to a "truth" and the true values of environmental physicochemical and biological characteristics cannot be known, use of a surrogate is required.

The accuracy of field measurements is usually evaluated by analyzing samples prepared from known concentrations of the pollutant(s) of interest or by adding known concentrations of the pollutant(s) of interest to field-collected samples (known as "spiked" samples). In studies following Method 1103.1 (USEPA, 1985) to estimate densities of *E. coli*, use of samples prepared from known quantities of freeze-dried and cultured *E. coli* as a surrogate resulted in 97.9 percent recovery of the bacteria from water samples. Based on the mTEC medium, bias was determined to be -2 percent of the true value. This information is helpful in establishing the most appropriate methods to be followed. Accuracy, defined as the similarity of a repeated entity to its original form, such as information, data entry, and calculations, can be controlled by double-checking sources, manual data entries, or electronic data transfers and performing recalculations. Figure G-1 is a graphical representation of the relationship between bias and precision, and accuracy.

Representativeness

Data representativeness is defined as the degree to which data accurately and precisely represent the characteristics of a population, and therefore it addresses the natural variability or the spatial and temporal heterogeneity of a population. It is not quantitative but descriptive in nature, and it can be assessed only by evaluating the sampling design with respect to the particular features of the water at each beach. It is possible to quantitatively estimate sample sizes using estimates of variance and selecting acceptable levels of false positive and false negative error.

In the sampling design, care should be taken to define the area of sample collection and determine whether it is typical and representative of each area of concern. For swimming beaches less than 30 m in length, a single sample taken from water at the midpoint of the beach site might suffice. For lengthy beaches, establishing the number of samples that need to be taken to ensure that the estimated bacterial densities provide a reasonable representation of the potential risk from waterborne pathogens can be problematic. For example, the monitoring program might decide to sample from the middle of the area where most swimmers congregate and then 15 m on either side of that first sampling station to obtain an average value of bacterial densities for comparison against the standard. Alternatively, each individual sample result might be compared to the standard. At beaches where a known point source of pathogens, such as a storm water outfall, enters the water, the sample might be drawn from stations within 15 m of the point source or where swimmers might be considered to be at greatest risk from exposure.

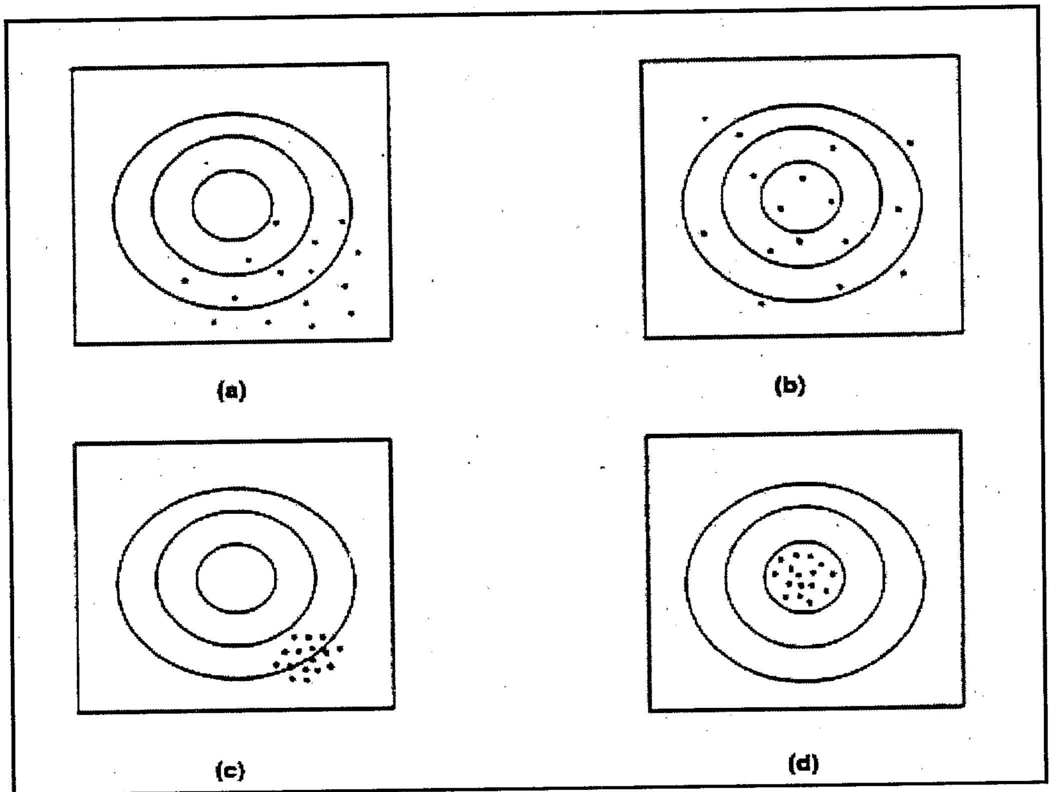

Figure G-1. Graphical representation of the relationship between bias and precision, and accuracy (after Gilbert, 1987). (a): high bias + low precision = low accuracy; (b): low bias + low precision = low accuracy; (c): high bias + high precision = low accuracy; and (d): low bias + high precision = high accuracy.

As noted above, an initial intensive sampling study might be necessary to help decide where and how often samples need to be routinely collected to address bacterial heterogeneity. If sufficient resources are not available to support collecting and analyzing multiple samples along a beach, the monitoring program plan should justify the decision and note the extent of the area that might be affected by an advisory or closing if bacterial densities at a single station exceed the standards.

Completeness

Completeness is defined as the percentage of measurements made that are judged to be valid according to specific criteria and entered into the data management system. Accidental or inadvertent loss of samples during transport or lab activities should be avoided because the loss of the original samples will result in irreparable loss of data. Lack of data entry into the database will reduce the ability to perform analyses, integrate results, and prepare reports. Thus, controlling sample loss by using unbreakable containers, careful sample management (e.g., assigning serial laboratory numbers, completing log books), and tracking samples through analysis and data entry is important. Percent completeness (*%C*) for measurement parameters can be defined as follows:

$$\%C=\frac{v}{T}\times 100$$

where *v* is the number of measurements judged valid and *T* is the total number of measurements. Most monitoring programs should try to achieve a level of completeness in which no less than 95 percent of samples are judged to be valid.

Comparability

Two data sets are considered to be comparable when there is confidence that the two sets can be considered equivalent with respect to the measurement of a specific variable or group of variables. Comparability of data is not defined quantitatively; it is ensured by similarity in sampling based on geographic, seasonal, and method characteristics; the uniform training and experience of field sampling and laboratory personnel; and the use of standardized, repeatable methods for analysis of bacterial indicator densities. The guidance provided in this document is intended to improve comparability among beach water quality monitoring programs through the use of comparable sampling and analysis procedures so that the meaning of the results can be more easily understood by the public nationwide.

Additional Factors Affecting Sampling Design

By establishing the "rules" for data quality at the planning stage, the number of samples that need to be collected and analyzed is adjusted to obtain data that will be used to judge the quality of the data obtained. For example, a duplicate water sample should be collected at least 10 percent of the sites included in the study for calculation of precision. Under some conditions, more frequent collection of duplicate samples might be advised. Monitoring programs need to carefully balance their needs to sample from multiple areas and their resource limitations against considerations of data quality. If only one sample is collected from every site for analysis, your agency might be covering more territory but it will not be possible to detect that an error occurred during sampling that inadvertently reduced the density of bacteria in the sample or that the particular patch of water sampled contained an unusually high number of fecal bacteria and was actually not representative of the entire area. Thus, inappropriate decisions might be made based on these erroneous results.

For the same cost, the number of sites sampled could be reduced while including some QC samples to provide a means to double check your results, both from the field sampling effort and from analyses of duplicate aliquots of single samples in the laboratory. This approach can increase the level of confidence in the data produced and help detect unusual conditions that might lead to errors in decision making.

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Appendix J: Training

Training the volunteers to do their jobs properly is an essential component of a successful monitoring program. Training is a dynamic process and does not simply begin and end with a kickoff classroom session. For example, follow-up training must occur to resolve specific operating problems discovered in an ongoing program. Even experienced staff benefit from occasional continuing education sessions, which help everyone stay in touch with the program and foster the ideal of team effort.

According to USEPA (1991), training should be planned from three basic perspectives:

1. Training new staff
2. Training experienced staff (teaching the use of new equipment or improved methods)
3. Solving specific operating problems

Each of the three training perspectives requires the presentation of unique material. The training processes involved in presenting this material, however, are similar and consist of the following components:

- Creating a job analysis
- Planning the training
- Presenting the training
- Evaluating the training
- Providing follow-up coaching, motivation, and feedback.

J.1 Creating a Job Analysis

The job analysis phase can be the hardest but most important part of the training development. The job analysis is a list of all the tasks volunteers must accomplish when sampling a parameter. Identifying the tasks to be accomplished when sampling or analyzing for a particular parameter should be done to ensure that procedures are performed consistently throughout the program. This list should include a list of sampling tasks, the required quality level for each task, the job elements that compose each task, and a sampling protocol (standard operating procedure) or job description handout that will be referred to and followed by staff members each time they collect water samples or perform laboratory analyses.

J.2 Planning the Training

Once the job analysis has been completed and the job description prepared, the actual training session should be planned. Training might take place in a group setting or individually. Group training saves money and time, especially when many staff must be trained simultaneously. For extensive water sampling efforts throughout a county, however, this approach does have drawbacks. Each beach has unique characteristics, and there might be circumstances or problems that can be addressed only on an individual basis. In practice, it is often best to structure the training program so that there are group sessions as well as individual follow-up sessions.

The training should stress the importance of samples being representative of the waterbody from which they are taken including the theory behind indicator organisms and quality samples, QA/QC (following the protocols specified in SOPs and the monitoring program plan). Ensuring that staff understand how to carry out the protocols to meet those requirements is the primary concern. Training to collect water samples, for example, should also include how to plan sampling activities, how to make field notes describing the sampling site and station, and how to perform on-site inspections. The safety aspects of field sampling and laboratory analysis are an important component as well.

J.3 Presenting the Training

A well-organized, well-paced training session is essential to facilitate understanding and motivate staff. The lesson planning phase provides the trainer with the basic agenda for the session. The trainer, however, is responsible for adapting the lesson to the expectations, knowledge, and experience of the audience. The person presenting the training must know the material and must be organized. Lectures, activities, and discussions should be planned and kept to a timetable. Similarly, demonstration materials, audiovisual equipment, and handouts must be accessible and easily incorporated into the presentation. The trainer must be able to anticipate and respond to problems and questions that might occur during an actual training session. A relaxed presentation that fulfills the education objectives is the basic goal. Although trainers will bring their own styles to the training session, they should incorporate basic public speaking techniques, such as establishing rapport with the audience, enunciating clearly and distinctly, using effective body language and eye contact, and encouraging questions and comments.

Whether in the classroom or in the field, staff must be allowed to demonstrate what they have learned. The trainer should observe closely and offer immediate feedback in the form of positive reinforcement or corrective assistance. This portion of the session is usually when the real learning takes place. During the review portion of the training session, the trainer summarizes what was learned and the staff have an opportunity to ask questions. The session should close with the reassurance that staff will continue to receive training throughout their tenure with the monitoring program.

J.4 Evaluating the Training

Training evaluation encompasses the entire training process. It includes the trainee's perspective, as well as that of the training program designer and trainer, on how effective the session has been. To gain immediate feedback about training, staff should fill out evaluation forms at the end of the session. Perhaps more effective, however, is observing staff in action as they collect or process samples. If there are problems or techniques are not performed according to the desired protocol, trainers might need to apply new methods in subsequent training sessions.

J.5 Providing Follow-up Coaching, Motivation, and Feedback

As stated previously, training is conducted throughout the life of the monitoring program. Follow-up coaching is an integral part of the training process. Coaching usually occurs on a one-on-one basis to maintain communication between team members, resolve problems, instill motivation, and implement new or improved techniques. The key to follow-up coaching is personal contact to increase staff satisfaction. That personal contact should be maintained throughout the life of the program.

J.6 Volunteer Monitoring Programs

EPA acknowledges that citizen volunteers can often be used to perform some beach monitoring program functions. Using volunteers to collect water samples and transport them to a laboratory for analysis is one way to save on program monitoring costs and, at the same time, establish a partnership with local citizens. Some citizen monitoring programs also perform water quality analyses, and a few determine bacterial indicator levels. Program planning officials, however, need to be aware that establishing a volunteer monitoring program requires a commitment of time and resources to ensure that volunteers are properly trained

Volunteer Beach Monitoring Programs Across the Nation

Alabama Coastal Foundation volunteers' data are used for trend research by the Alabama Department of Environmental Management, Dauphin Island Sea Lab, and Mobile Bay National Estuary Program.

Alabama Water Watch is a statewide citizen volunteer water quality monitoring program. More than 50 active groups monitor about 250 sites on 100 waterbodies in 20 to 30 counties in Alabama and Georgia. Six chemical parameters are measured, and several groups are beginning to test for pathogen indicators. The program is coordinated from Auburn University, where the central database is maintained.

The Surfrider Foundation is an environmental organization dedicated to the protection and enhancement of the world's waves and beaches through conservation, research, education, and local activism. The Blue Water Task Force, particularly chapters from Southern California coastal counties, analyzes water samples collected at beaches for bacteria and posts results on the Internet.

The Citizen Stewards Program trains volunteers to assist the Casco BayKeeper in monitoring the water quality of Casco Bay, Maine. Volunteers gather data at more than 100 selected sites along the 500-mile shoreline, collecting surface water and performing tests monthly from April through October. The data are entered into a comprehensive computer database for management and interpretation. Water column profile data are also collected from the BayKeeper's boat at offshore sites, and water is sampled at closed clam flats to test for bacteria.

The Environmental Quality Laboratory at Coastal Carolina University monitors water and sediment quality in the Waccamaw River and 45 sites from the North Carolina state line to Bucksports, South Carolina, using EPA-approved methods. Monthly physical, chemical, and biological analyses are performed, and occasional measurements of nutrients and heavy metals are taken. Results are interpreted using in situ instantaneous U.S. Geological Survey data on water stage and flow. The sampling plan is designed to identify nonpoint pollution sources. Results are shared with South Carolina's Department of Health and Environmental Control.

The Salt Pond Watchers currently monitor fecal coliform bacteria levels in approximately 30 stations in seven coastal salt ponds on Rhode Island's Atlantic coast. Data are provided to the Rhode Island Department of Environmental Management and local communities to help determine areas unsuitable for fishing and swimming.

and managed and that data quality objectives are met. Officials should never view citizen volunteers as unpaid adjunct staff. Typically, their motivation to participate in a monitoring program is not based on a desire to help reduce agency costs. Rather, they donate their time and energy for the purpose of serving as guardians and stewards of their local waters. This recognition needs to be considered in every aspect of the volunteer monitoring program development process.

The EPA document *Volunteer Water Monitoring: A Guide for State Managers* (USEPA, 1990) lists seven "basic ingredients" for developing a successful volunteer program:

1. Develop and articulate a clear purpose for the use of the data
2. Produce "data of known quality" that meet the stated data quality objectives
3. Be aware that volunteer monitoring is cost-effective, but not free
4. Thoroughly train and retrain volunteers
5. Give the volunteers praise and feedback (the psychological equivalent of a salary)
6. Use the data volunteers collect
7. Be flexible, open, and realistic with volunteers

> Most of the volunteer monitoring programs that responded to EPA's survey for the 1994 *National Directory of Volunteer Environmental Programs* focus on river monitoring (585 programs, 76 percent). Monitoring of lakes and reservoirs came in second (34 percent), followed by wetlands (22 percent) and estuaries and marine environments (21 percent). Beach monitoring was listed as an activity by 8 percent of the responding volunteer monitoring programs.

Including these seven basic ingredients in the development of a volunteer monitoring program has produced many success stories across the United States. The latest edition of the *National Directory of Volunteer Environmental Programs* (RISG and USEPA, 1994) documents a total of 772 programs currently in operation (see box on left).

A frequent criticism of volunteer monitoring programs is that using the services of volunteers yields data of less certainty than the data obtained when professionals do the job. In general, however, if the seven "basic ingredients" of a successful program are included, data quality should be the same for both groups. Putting this theory to the test for any particular program requires running parallel water sampling tests that compare data collected by professionals versus those collected by volunteers (Parallel testing, 1997). Periodic parallel testing serves two purposes. First, it assures the sponsoring agency that volunteers' data are reliable and can be used for the program's purposes. Second, it helps identify areas where the volunteer program can be improved, especially if the results indicate there is a difference in quality between the volunteers' data and the professionals' data.

Volunteer Water Monitoring: A Guide for State Managers (USEPA, 1990) discusses several other ways to maintain volunteers' interest:

- Sending volunteers regular data reports.
- Keeping volunteers informed about all uses of their data.
- Preparing a regular newsletter.
- Making program officials easily accessible for questions and requests.
- Providing volunteers with educational opportunities.
- Keeping the local media informed of the goals and findings of the monitoring effort.
- Recognizing the efforts of the volunteers through certificates, awards, or other means.
- Providing volunteers with opportunities to grow with the program through additional training, learning opportunities, and changing responsibilities.

J.7 References

USEPA, 1991. *Volunteer Lake Monitoring: A Methods Manual.* EPA 440/4-91-002. U.S. Environmental Protection Agency, Office of Water, Washington DC.

Appendix K: Sample Collection

K.1 Sample Containers

The sample bottles used to collect water for bacterial density analyses should be able to withstand sterilizing conditions and the solvent action of water. Bordner et al. (1978) suggested wide-mouth borosilicate glass bottles with screw caps or ground-glass stoppers; however, glass bottles can break, causing loss of the sample. Heat-resistant polypropylene bottles may be used if they can be sterilized without producing toxic materials when autoclaved.

Sample bottles should be at least 125-milliliter (mL) volume for adequate sampling and for good mixing. Bottles of 250-mL, 500-mL, and 1,000-mL volume are often used for multiple analyses, such as when determining the density of two or more bacterial indicators. Discard bottles that have chips, cracks, or etched surfaces. Bottle closures must be watertight. Before use, thoroughly cleanse bottles and closures with detergent and hot water, followed by a hot water rinse to remove all traces of detergent. Then rinse three times with laboratory-pure water.

Autoclave glass or heat-resistant polypropylene bottles at 121 °C for 15 minutes. Alternatively, dry glassware may be sterilized in a hot air oven at 170 °C for not less than 2 hours. Ethylene oxide gas sterilization is acceptable for plastic containers that are not heat-resistant. Sample bottles should be stored overnight before they are used to allow the last traces of gas to dissipate.

Commercially available sterile plastic sampling bags (Whirl-pak) are a practical substitute for polypropylene or glass sample bottles when sampling soil or sediment. The bags are sealed by the manufacturer and opened only at the time of sampling.

If you are collecting water samples for the determination of other environmental parameters (e.g., temperature, salinity, turbidity, dissolved oxygen), you may use nonsterile containers. Be sure that the sterile and nonsterile containers are clearly labeled and used for the particular sample for which they were intended.

K.2 Sampling Method

A grab sample of water is obtained using a sample bottle that has been prepared as described above. The basic steps for this procedure, derived from Bordner et al. (1978) and IITF (1999), are as follows.

1. Identify the sampling site on a chain-of-custody tag, if required, or on the bottle label and on a field log sheet.

2. Remove the bottle covering and closure just before obtaining each sample and protect them from contamination. Be careful not to touch the inside of the bottle itself or the inside of the cover.

3. The first sample to be prepared is the trip or field blank (at least one per sampling day for routine sampling is recommended). Open one of the sampling bottles and fill it with 100 mL of sterile buffered dilution solution (see EPA Method 1103.1) when collecting freshwater, estuarine, or marine water samples. Cap the bottle and place it in a cooler.

4. To collect the surface water samples, carefully move to the first sampling location. If wading in the water, try to avoid kicking up bottom material at the sampling station. You should be positioned downstream of any water current to take the sample from incoming flow.

5. Open a sampling bottle and grasp it at the base with one hand and plunge the bottle mouth downward into the water to avoid introducing surface scum. Position the mouth of the bottle into the current away from your hand and away from the side of the sampling platform or boat. The sampling depth should be 15 to 30 centimeters (cm) (6 to 12 inches) below the water surface, depending on the depth from which the sample must be taken. If the waterbody is static, an artificial current can be created by moving the bottle horizontally with the direction of the bottle pointed away from you. Tip the bottle slightly upward to allow air to exit and the bottle to fill.

6. Remove the bottle from the waterbody.

7. Pour out a small portion of the sample to allow an air space of 2.5 cm (1 to 2 inches) above each sample for proper mixing of the sample before analysis.

8. Tightly close the stopper and label the bottle.

9. Enter specific details to identify the sample on a permanent label. Take care in transcribing sampling information to the label. The label should be clean, waterproof, nonsmearing, and large enough for the necessary information. The label must be securely attached to the sample bottle but removable when necessary. Preprinting standard information on the label can save time in the field. The marking pen or other device must be nonsmearing and maintain a permanent legible mark.

10. Complete a field record for each sample to record the full details on sampling and other pertinent remarks, such as flooding, rain, or extreme temperature, that are relevant to interpretation of the results. This record also provides a back-up record of sample identification.

11. Place the samples in a suitable container, and transport them to the laboratory as soon as possible. Adhering to sample preservation and holding time limits is critical to the production of valid data. Bacteriological samples should be iced or refrigerated at 1 to 4 °C during transit to the laboratory. Insulated containers, such as plastic or styrofoam coolers, are preferable to ensure proper maintenance of storage temperature. Care should be taken to ensure that sample bottles are not totally immersed in water during transit or storage.

Samples should be examined as soon as possible after collection. Do not hold samples longer than 6 hours between collection and initiation of analysis (USEPA, 2000). Do not analyze samples that exceed holding time limits.

12. Water samples for analyses of other parameters should be collected in separate appropriate containers at the same time and analyses performed as specified in the particular methods.

13. After samples have been collected from a station, wash hands and arms with alcohol wipes, a disinfectant lotion, or soap and water, and dry to reduce exposure to potentially harmful bacteria or other microorganisms.

K.3 Sample Handling

In cases where an agency must demonstrate the reliability of its evidence in legal cases involving pollution, it is necessary to document the chain of possession and custody of samples that are offered for evidence or that form the basis of analytical results introduced into evidence (Bordner et al., 1978). Although the analytical results of the water samples collected at a swimming beach are being used to make a decision for the protection of human health, a decision to close the beach might be unpopular with local businesses and could be contested. It is thus important that the agency collecting the samples and the laboratory performing the analysis prepare written procedures to be followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed. These are known as "chain-of-custody" (COC) procedures.

The sampling agency should have procedures to ensure the custody and integrity of the samples beginning at the time of sampling and continuing through transport and sample receipt. The laboratory should have procedures for sample receipt, preparation, analysis and storage, data generation and reporting, and sample disposal. A sample is defined as being under a person's custody if any of the following conditions exist: (1) it is in his or her possession; (2) it is in his or her view, after being in his or her possession; (3) it was in his or her possession and he or she locked it up; or (4) it is in a designated secure area (AFCEE, 1998). Records concerning the custody and condition of all field samples are maintained in the field and laboratory files.

A COC form filled out by the person conducting the sampling should provide information such as the following: sampling location (site ID), time of collection, date of collection, time of near or high tide, air temperature, water temperature, rainfall history, collector's name and signature, agency, and other notes or comments. A Chain of Custody Review List and a Sample Handling, Preparation, and Analysis List are provided at the end of this appendix.

Samples are usually transported to the laboratory by the person collecting the sample or picked up by laboratory personnel. Because of the 8-hour holding time limitation, the laboratory should be conveniently located near the sampling site and should be notified a few days in advance of the sampling effort so that it will be ready to process the samples promptly. COC procedures should be followed at the laboratory for all samples. Laboratory personnel receiving samples should do the following:

1. Check the shipping container for damage and a custody seal. Note whether the custody seal is intact and record any anomalies on the sample log-in form.

2. Open the container and inspect the sample containers, noting any damage or breakage. Immediately take the temperature of the samples. Place a calibrated thermometer or temperature probe in the cooler in a representative location (not directly touching any ice or cold packs and not inside a sample bottle). Record the temperature on the sample log-in form and the COC form enclosed with the sample.

3. Remove the individual containers from the shipping container and inspect each one for damage, leakage, or any other problem. Note the condition of each container, the date received, the project number, the batch number, and the airbill or shipping identification number on the sample log-in form and the COC form.

4. Compare each sample container to those listed on the COC form to ascertain whether all the samples are present and whether all the labels on the sample containers match those on the COC form.

5. If no COC form accompanies the samples, complete a COC form and confirm all sample information with the agency that collected the samples. Document any contact with the agency regarding problems or confirmation on the sample log-in and COC forms.

6. Notify the laboratory manager if you note any problems with the samples. Sign and date the COC form upon completion of the sample inspection.

7. Assign each sample a sample ID code. For example, the sample ID code should include a sequential log-in number, a sample type code (e.g., U for upstream, S for site, L for laboratory), a code to identify the collecting agency, the sampling date, and the analysis required. Replicate samples from the same site receive the same code with a suffix such as -A,- B, -C to indicate their replicate status.

8. Record each sample's code on the sample log-in form, the COC form, and the corresponding sample container. Indicate on the form where the samples will be held (e.g., which room in the laboratory). When samples are removed for final disposition, the removal should be documented on the sample log-in form.

9. Record additional information on the sample log-in form, including the collecting agency contact, sample analyses required, and due dates of analyses.

10. Store samples not used immediately at 4 °C.

Chain of Custody Review List

Task
Sample custodian designated
Name of sample custodian
Sample custodian's procedures and responsibilities documented
Standard Operating Procedures (SOPs) developed for receipt of samples
Where are the SOPs documented (laboratory manual, written instructions...)?
Receipt of chain-of-custody record(s) with samples documented
Nonreceipt of chain-of-custody record(s) with samples documented
Integrity of the shipping container(s) documented
Where is security documented?
Lack of integrity of the shipping container(s) documented
Where is nonsecurity documented?
Agreement between chain-of-custody records and sample tags verified and documented
Source of verification and location of documentation
Sample tag numbers recorded by the sample custodian
Where are they located?
Samples stored in a secure area
Where are they stored?
Sample identification maintained
Sample extract (or inorganics concentrate) identification
Samples maintained. How?

Sample Handling, Preparation, and Analysis List

Category	Task
Field Logs	Project name/ID and location
	Sampling personnel identified
	Map
	Geological observations
	Atmospheric conditions
	Field measurements
	Sample dates, times, and locations
	Sample identifications noted
	Sample matrix identified
	Sample descriptions (e.g., odors, colors)
	Number of samples taken per location
	Sampling method/equipment
	Description of any QC samples
	Deviations from the sampling plan
	Difficulties or unusual circumstances
Chain of Custody Records	Project name/ID and location
	Sample custodian's procedures and responsibilities documented
	Sample custodians' signatures verified and on file
	Date and time of each transfer
	Carrier ID number
	Integrity of shipping container and seals verified
	Standard Operating Procedures (SOPs) for receipt on file
	Samples stored in same area
	Holding time protocol verified

Category	Task
	SOPs for sample preservation on file
	Identification of proposed analytical method verified
	Proposed analytical method documentation verified
	QA Plan for proposed analytical method on file
Sample Labels	Sample ID
	Date and time of collection
	Sampler's signature
	Characteristic or parameter investigated
	Preservative used
Sample Receipt Log	Date and time of receipt
	Sample collection date
	Client sample ID
	Number of samples
	Sample matrices
	Requested analysis, including method number(s)
	Signature of the sample custodian or designee
	Sampling kit code (if applicable)
	Sampling condition
	Chain-of-custody violations and identities
Sample Preparation Logs	Parameter/analyte of investigation
	Method number
	Date and time of preparation
	Analyst's initials or signature
	Initial sample volume or weight
	Final sample volume

Category	Task
	Concentration and amount of spiking solutions used
	QC samples included with the sample batch
	ID for reagents, standards, and spiking solutions used
Sample Analysis Logs	Parameter/analyte of investigation
	Method number/reference
	Date and time of analysis
	Analyst's initials or signature
	Laboratory sample ID
	Sample aliquot
	Dilution factors and final sample volumes (if applicable)
	Absorbance values, peak heights, or initial concentrations reading
	Final analyte concentration
	Calibration data (if applicable)
	Correlation coefficient (including parameters)
	Calculations of key quantities available
	Comments on interferences or unusual observations
	QC information, including percent recovery
Instrument Run Logs	Name/type of instrument
	Instrument manufacturer and model number
	Serial number
	Date received and date placed in service
	Instrument ID assigned by the laboratory (if used)
	Service contract information, including service representative details
	Description of each maintenance or repair activity performed
	Date and time of each maintenance or repair activity

Category	Task
	Initials of maintenance or repair technicians
Chemical/Standard Receipt Logs	Laboratory control number
	Date of receipt
	Initials or signature of person receiving chemical
	Chemical name and catalog number
	Vendor name and log number
	Concentration or purity of standard
	Expiration date
Standards/Reagent Preparation Log	Date of preparation
	Initials of analyst preparing the standard solution or reagent
	Concentration or purity of standard or reagent
	Volume or weight of the stock solution
	Final volume of the solution being prepared
	Laboratory ID/control number assigned to the new solution
	Name of standard reagent
	Standardization of reagents, titrants, etc. (if applicable)
	Expiration date

K.4 References

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Appendix L: Predictive Tools

Appendix L includes brief summaries of the models discussed in Chapter 5.

L.1 Pathogen Loading Estimates

HSPF: Hydrological Simulation Program—Fortran. HSPF is a comprehensive watershed-scale model developed by EPA. The model uses continuous simulation of water balance and pollutant buildup and washoff processes to generate time series of runoff flow rate, as well as pollutant concentration at any given point in the watershed. Runoff from both urban and rural areas can be simulated using HSPF; however, simulation of combined sewer overflows (CSOs) is not possible. Because of the comprehensive nature of the model, data requirements for HSPF are extensive and using this model requires highly trained personnel.

SWMM: Storm Water Management Model. SWMM is a comprehensive watershed-scale model developed by EPA. It can be used to model several types of pollutants on either a continuous or storm event basis. Simulation of mixed land uses is possible using SWMM, but the model's capabilities are limited for rural areas. SWMM can simulate loadings from CSOs. The model requires intensive data input and requires a special effort for validation and calibration. The output of the model is time series of flow, storage, and contaminant concentration at any point in the watershed.

STORM: Storage, Treatment, Overflow, Runoff Model. STORM is a watershed loading model developed by the US Army Corps of Engineers for continuous simulation of runoff quantity and quality. The model was primarily designed for modeling storm water runoff from urban areas, but it can also simulate combined sewer systems. It requires relatively moderate to high calibration and input data. The simulation output is hourly hydrographs and pollutographs.

L. 2 Rivers and Streams

HSPF: Hydrological Simulation Program–Fortran. HSPF is a comprehensive watershed-scale model developed by EPA. The receiving water component allows dynamic simulation of one-dimensional stream channels, and several hydrodynamic routing options are available. The model output is time series of runoff flow rate, as well as pollutant concentration at any given point in the watershed. Because of the model's comprehensive nature, the data requirements for HSPF are extensive and running the model requires highly trained personnel.

CE-QUAL-RIV1: Hydrodynamic and Water Quality Model for Streams. CE-QUAL-RIV1 is a dynamic, one-dimensional model for rivers and estuaries consisting of two codes—one for hydraulic routing and another for dynamic water quality simulation. CE-QUAL-RIV1 allows simulation of unsteady flow of branched river systems. The input data requirements include the river geometry, boundary conditions, initial in-stream and inflow boundary water quality concentrations, and meteorological data. The model predicts time-varying concentrations of water quality constituents.

L.3 Lake and Estuary Models

WASP5: Water Quality Analysis Simulation Program. WASP5 is a general-purpose modeling system for assessing the fate and transport of pollutants in surface water. The model can be applied in one, two, or three dimensions and can be linked to other hydrodynamic models. WASP5 simulates the time-varying processes of advection and dispersion while considering point and nonpoint source loadings and boundary exchange. The waterbody to be simulated is divided into a series of completely mixed segments, and the loads, boundary concentrations, and initial concentrations must be specified for each state variable.

CE-QUAL-ICM: A Three-Dimensional Time-Variable Integrated-Compartment Eutrophication Model. CE-QUAL-ICM is a dynamic water quality model that can be applied to most waterbodies in one, two, or three dimensions. The model can be coupled with three-dimensional hydrodynamic and benthic-sediment model components. CE-QUAL-ICM predicts time-varying concentrations of water quality constituents. The input requirements for the model include 140 parameters to specify the kinetic interactions, initial and boundary conditions, and geometric data to define the waterbody to be simulated. Model use may require significant expertise in aquatic biology and chemistry.

EFDC: Environmental Fluid Dynamics Computer Code. EFDC is a general three-dimensional hydrodynamic model developed by Hamrick (1992). EFDC is applicable to rivers, lakes, reservoirs, estuaries, wetlands, and coastal regions where complex water circulation, mixing, and transport conditions are present. EFDC must be linked to a water quality model to predict the receiving water quality conditions. HEM-3D is a three-dimensional hydrodynamic eutrophication model that was developed by integrating EFDC with a water quality model. Considerable technical expertise in hydrodynamics and eutrophication processes is required to use the EFDC model.

CE-QUAL-W2: A Two-Dimensional, Laterally Averaged Hydrodynamic and Water Quality Model. CE-QUAL-W2 is a hydrodynamic water quality model that can be applied to most waterbodies in one dimension or laterally averaged in two dimensions. The model is suited for simulating long, narrow waterbodies like reservoirs and long estuaries, where stratification might occur. The model application is flexible because the constituents are arranged in four levels of complexity. Also, the water quality and hydrodynamic routines are directly coupled, which allows for more frequent updating of the water quality routines. This feature can reduce the computational burden for complex systems. The input requirements for CE-QUAL-W2 include geometric data to define the waterbody, specific initial boundary conditions, and specification of approximately 60 coefficients for the simulation of water quality.

QUAL2E: The Enhanced Stream Water Quality Model. QUAL2E is a steady-state receiving water model. The basic equation used in QUAL2E is the one-dimensional advective-dispersive mass transport equation. Although the model assumes a steady-state flow, it allows simulation of diurnal variations in meteorological inputs. The input requirements of QUAL2E include the stream reach physical representation and the chemical and biological properties for each reach.

TPM: Tidal Prism Model. TPM is a steady-state receiving water quality model applicable only to small coastal basins. In such locations the mixing and transport of pollutants are dominated by the tidal cycles. The model assumes that the tide rises and falls simultaneously throughout the waterbody and that the system is in hydrodynamic equilibrium. Two types of input data are required to run TPM. The geometric data that define the system being simulated are the returning ratio, initial concentration, and boundary conditions. The physical data required are the water temperature, reaction rate, point and nonpoint sources, and initial boundary conditions for water quality parameters modeled.

L.4 References

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