Chapter 3

Water Quality Criteria and Quality of Water at Beaches

EPA has made significant progress in meeting the BEACH Act requirements related to water quality criteria and standards. EPA promptly issued a regulation to promulgate water quality standards in coastal recreation waters in the states that had not adopted criteria as protective of human health as EPA's current recommended bacteria criteria. EPA is conducting research to identify better indicators and develop faster indicator methods. The Agency is assessing this information as part of a process to develop new or revised water quality criteria.

3.1 Existing criteria and standards

Water quality standards consist of designated uses, the criteria necessary to protect those uses, and an antidegradation policy. A waterbody's designated uses determine what criteria apply to the waterbody. CWA section 101(a)(2) sets the national goal of achieving water quality that provides for the "protection and propagation of fish, shellfish, and wildlife" and "recreation in and on the water" wherever attainable. This national goal is commonly referred to as the "fishable/swimmable" goal of the CWA.

CWA section 303(c)(2)(A) requires that water quality standards "be such as to protect the public health and welfare, enhance the quality of water, and serve the purposes of this Act." States have generally provided for the "swimmable" goal by designating "primary contact recreation" as a use for their waters. Primary contact recreation encompasses activities that could be expected to result in ingestion of water or immersion. These activities include swimming, waterskiing, surfing, and any other activity where contact and immersion in the water are likely. Water quality standards form the foundation of the nation's water quality management program and set the baseline by which success is ultimately measured for a given waterbody or watershed.

EPA's existing recommended water quality criteria for bacteria

Section 303(i) of the CWA calls for states to adopt "initial standards and criteria" for the pathogens and pathogen indicators for which EPA has published criteria under CWA section 304(a), namely, EPA's *Ambient Water Quality Criteria for Bacteria–1986* (USEPA 1986). The scientific basis for the criteria was a series of studies conducted by EPA in the late 1970s and early 1980s (Cabelli 1983, Dufour, 1984). The studies considered several organisms, including

fecal coliforms, *E. coli*, and enterococci, as possible indicators.

EPA found that enterococcus is a good predictor of illness in all waters and that *E. coli* is a good predictor in freshwaters. As a result, in 1986 EPA recommended the use of the indicator organisms *E. coli* for fresh recreational waters and enterococci for fresh and marine recreational waters. EPA recommended a geometric mean level of 126/100 mL for *E. coli* in freshwater. EPA recommended geometric mean levels of 33/100 mL for enterococci in freshwater and 35/100 mL for enterococci in marine water.

EPA's *Ambient Water Quality Criteria for Bacteria–1986* can be found online at *www.epa.gov/waterscience/beaches/1986crit.pdf*

Information about EPA's promulgated water quality standards for states can be found online at *www.epa.gov/waterscience/beaches/bacteria-rule.htm#final*

EPA promulgation: State water quality standards for bacteria

The BEACH Act directed coastal and Great Lakes states to adopt for their coastal recreation waters, by April 10, 2004, water quality criteria for pathogens or pathogen indicators as protective of human health as EPA's 1986 water quality criteria for bacteria. The BEACH Act also required EPA to propose and promulgate such standards for states that did not do so.

EPA worked collaboratively with all the states and territories that contain coastal recreation waters to identify their existing water quality standards, review them for consistency with the BEACH Act requirements, and determine what steps were needed to meet the BEACH Act requirements. On November 16, 2004, EPA published in the *Federal Register* a final rule that promulgated water quality standards for 21 states and territories that had not yet adopted water quality criteria for bacteria that were as protective of human health as EPA's 1986 bacteria criteria. The states and territories subject to this rulemaking are listed in Table 3.1.

Table 3.1.
States and Territories Subject to the November 2004 Water Quality Standards Rule

Alaska	Mississippi
California	New York
Florida	North Carolina
Georgia	Ohio
Hawaii	Oregon
Illinois	Pennsylvania
Louisiana	Puerto Rico
Maine	Rhode Island
Maryland	Virgin Islands
Massachusetts	Wisconsin
Minnesota	

3.2 Recommended water quality criteria under development by EPA

Under CWA section 304(a)(9), as amended by the BEACH Act, EPA is required to publish new or revised water quality criteria for pathogens or pathogen indicators for the purpose of protecting human health. The BEACH Act also added section 104(v), which requires EPA to conduct studies for use in developing these new or revised recommended water quality criteria. Section 104(v) directs EPA to initiate new studies by not later than 18 months after enactment (April 10, 2001) and complete the studies by not later than 3 years after enactment (October 10, 2003).

The section 104(v) studies are to provide additional information for use in developing:

(1) an assessment of potential human health risks resulting from exposure to pathogens in coastal recreation waters, including nongastrointestinal effects;

(2) appropriate and effective indicators for improving detection in a timely manner in coastal recreation waters of the presence of pathogens that are harmful to human health;

(3) appropriate, accurate, expeditious, and cost-effective methods (including predictive models) for detecting in a timely manner in coastal recreation waters the presence of pathogens that are harmful to human health; and

(4) guidance for State application of the criteria for pathogens and pathogen indicators to be published under section 304(a)(9) to account for the diversity of geographic and aquatic conditions.

EPA's NEEAR Water Study and methods development

In response to the section 104(v) requirements, EPA's Office of Research and Development, in consultation with the Office of Water, started the ongoing National Epidemiological and Environmental Assessment of Recreational (NEEAR) Water Study in 2001. It is a collaborative research study between EPA and the CDC. EPA also coordinates the study with USGS and other interested agencies.

The indicators and rapid methods that EPA is evaluating through the NEEAR study are bacterial indicators of fecal contamination. The goal of the NEEAR research is to produce information defining the relationship between water quality, as measured with rapid indicators of fecal contamination, and swimming-associated health effects.

Indicator methods development

EPA is developing faster indicator methods that will provide more rapid results than the currently used tests. The goal is to help beach managers to quickly test the water in the morning and make results about the safety of beach waters available in hours, rather than days. Providing faster results to beach managers and the public should help reduce the risk of waterborne illness among beachgoers.

The NEEAR Water Study includes examining detection methods that will produce results in 2 hours or less.

A number of rapid methods were evaluated for use in the NEEAR Water Study, but only a few were included. Methods were included in the study if they met the following criteria:

1. Results could be obtained within a few hours.
2. Enterococci, bacteroides, or other new fecal indicator organisms were detected by the method.
3. The sensitivity and specificity of the method were adequate.
4. The detection limit was lower than the EPA-recommended enterococci limits.
5. Valid data could be obtained because sample carryover or other problems did not occur.

The four methods chosen are as follows:

- *Method 1600* is the EPA-approved membrane filter method using mEI Agar for the detection of enterococci in recreational water.
- The *Quantitative Polymerase Chain Reaction (PCR) Method*, a modified rapid gene probe method, is used to detect enterococci and Bacteroides in water samples.
- The *RAPTOR Fiberoptic Biosensor* is a portable, automated fiberoptic biosensor that can be used to detect microbiological and chemical analytes in water samples.
- The *Luminex 100 System* is a compact flow cytometer that analyzes immunoassays, complex genetic analyses, or enzymatic assays through the use of optics, fluidics, and advanced signal processing.

Epidemiology study

The second part of the NEEAR Water Study is an epidemiology study that combines health data and water quality analyses using the indicator methods described above. The study measures human health outcomes such as diarrhea and gastrointestinal illness as well as non-enteric swimming-related illnesses (such as skin, ear, eye, urinary tract, and respiratory infections). This

health information is collected through interviewer-conducted surveys in beach areas. On the same days that health interviews are conducted at these beaches, multiple water samples are collected and tested using the fast indicator methods described in the previous section.

Planning and implementation of these studies have been under way for several years. The initial studies focused on freshwater sites in the Great Lakes. The beaches were selected on the basis of the potential number of beachgoers, water quality parameters, and sources of microbial pathogens in the water (e.g., domestic sewage vs. animals). These studies place emphasis on beaches that have identified point sources of contamination (e.g., sewage treatment plants).

The NEEAR Water Study team has completed three summers of data collection, including a one-year pilot study and two full-year studies. (EPA also conducted a recreational monitoring characterization study before starting the Great Lakes studies.)

- **Pilot Study**

  West Beach, Indiana Dunes National Lakeshore, Portage, Indiana *(2002)*

- **Full-Scale Study (Freshwater)**

  1. West Beach, Indiana Dunes National Lakeshore, Portage, Indiana *(2003)*
  2. Huntington Beach, Bay Village, Ohio *(2003)*
  3. Washington Park, Michigan City, Indiana *(2004)*
  4. Silver Beach, St. Joseph, Michigan *(2004)*

More than 10,000 volunteer households at freshwater beaches were recruited on weekends during the summers of 2003 and 2004, from Memorial Day through Labor Day. These households provided information about their activities and health status after beach visits. Families and individuals were interviewed about a variety of activities, including swimming, to determine their potential exposure to disease-causing pathogens. During the three-year study, more than 21,000 interviews were completed and more than 1,500 water samples were collected and analyzed.

The data are being analyzed to determine whether swimmers exposed to higher levels of rapid indicators experience more illness than non-swimmers, or swimmers exposed to lower levels of rapid indicators. Analysis of the data from the Great Lakes study shows a promising relationship between one of the rapid indicators methods (Quantitative PCR) and gastrointestinal illness among swimmers. These results have been published in a peer reviewed scientific journal (Wade, 2006).

3.3 Survey of beach advisories and closings

Beach advisories and closings are based on water quality information, and therefore they are, in effect, one measure of water quality. A beach advisory or closing typically occurs when monitoring results show that levels of fecal indicators exceed the applicable water quality criterion. State and local public health agencies use beach advisories and closings to communicate to the public that the level of pathogens in the water is unsafe for swimming. As required under the BEACH Act, EPA collected state data on beach water quality and beach advisories.

EPA was able to build on the existing voluntary National Health Protection Survey of Beaches, which was conducted annually from 1997 to 2002, to collect information about state and local beach programs. The purpose was threefold:

1. Create an accurate national inventory of swimming beaches and the agencies that oversee them.
2. Survey agencies about their beach programs, including applicable water quality standards, monitoring methods, cost, and notification procedures for beach advisories and closings.
3. Document critical aspects of beach advisory and closing issues during the swimming season, including the time and length of the actions, the reason the actions were taken, and the source(s) of pollution that necessitated the actions.

Participation in EPA's beach survey was voluntary. In 2002, the last year the survey was conducted, a total of 227 out of 261 local and state agencies surveyed from

NEEAR Water Study interviewers asked beachgoers about their activities and health status after visits.

A preliminary copy of the NEEAR study report is available online at: *http://ehp.niehs.nih.gov/docs/2005/8273/abstract.html*

31 states and 5 territories submitted information. The number of beaches in the survey had grown from 1,021 in 1997 to 2,823 in 2002.

Beginning with the 2003 swimming season, coastal states were required by the BEACH Act to submit monitoring, notification, and other important information concerning their beaches to EPA. To aid in this effort, EPA developed a database called PRAWN (PRogram tracking, beach Advisories, Water quality standards and Nutrients). This new system of data management replaced the annual volunteer questionnaire EPA had sent out to states, territories, and other agencies since 1997.

The results of the 2004 PRAWN data collection cycle indicate that, of the days that beaches could be open, only 4% were lost due to an advisory or beach closure (26 percent of the beaches—942 of 3,574 beaches—had at least one advisory or area closed). Most of the advisories or closings lasted only one or two days. Monitoring frequency, however, varies among beaches, making state-to-state comparisons of beach water quality difficult.

Table 3.2 presents the trends in agency participation, the number of beaches, and the number and percentage of advisories and closings reported to EPA for 1997–2004.

3.4 Major sources affecting water quality at beaches

Point and nonpoint sources

Both the sources and the mechanisms that transport pathogens and other pollutants that affect beach water quality vary according to location (USEPA, 2001). In general, sources are categorized as either point sources or nonpoint sources.

- *Point sources* include discharges from wastewater treatment plants, combined sewer overflows (CSOs), municipal storm sewer systems, Concentrated Animal Feeding Operations (CAFOs), meat-processing facilities, and fish- and shellfish-processing facilities. Municipal stormwater often contains pathogens from a wide variety of sources,

Table 3.2. National Health Protection Survey of Beaches Trends, 1997–2004 *(USEPA, 2005a)*

	Voluntary Survey						Required Reporting	
	1997	1998	1999	2000	2001	2002	2003	2004
Number of beaches	1,021	1,403	1,891	2,354	2,445	2,823	1,857[a]	3,574
Number of beaches affected by advisories or closings	230	353	459	633	672	709	395	942
Percentage of beaches affected by advisories or closings	23	25	24	27	27	25	21	26

[a] Incomplete data from 11 states; EPA working to complete data set

including domestic animals, wildlife, illicit discharges, and cross-connected sanitary and storm sewers.

- *Nonpoint source* pollution comes from numerous diffuse sources and is the result of water running off the land and picking up pollutants along the way. Identifying potential sources and tracking their movement is often technically challenging. Nonpoint sources of pathogens can include farm animals, wildlife, failing septic systems, and faulty sanitary sewer lines, as well as land application of manure and sludge.

EPA's National Health Protection Survey of Beaches queried participants about the source(s) of pollution that caused beach advisories or closings during the swimming season. Figure 3.1 presents data from the 2002 swimming season. In many cases (42 percent), respondents indicated that the pollution source was unknown. When respondents indicated that the source was known, stormwater runoff was most often identified as the cause for the advisory or closing (21 percent).

SSOs and CSOs

In some areas of the United States, sanitary sewer overflows (SSOs) and CSOs have the potential to impact beach water quality and swimmer's health. As with most pathogen source investigations, CSO and SSO discharges are often hard to identify and characterize. One complication is that the volume and frequency of CSO and SSO discharges vary, usually in response to wet weather. Consequently, they are hard to monitor and track. Nevertheless, their potential impact on beaches might be significant.

In its *California Beach Closure Report 2000*, for example, the California State Water Resources Control Board reported that 42 percent of beach closings in 2000 were attributable to SSOs (CSWRCB 2001). Orange County, California, has noted that the total number of ocean and bay beach closings due to SSOs has increased each year since 1999 (Orange County 2003). In the Midwest, the Alliance for the Great Lakes, an organization that tracks beach closings in Michigan, Indiana, Illinois, and Wisconsin, believes that CSOs are associated with a high percentage of the beach closings. This conclusion is based on data collected from local health departments, parks managers, and other municipal agencies.

3.5 Recommendations for actions to improve beach water quality

EPA, in its *Strategic Plan* (USEPA 2003c) and *National Water Program Guidance* for both FY 2005 and FY 2006 (USEPA 2004a and USEPA 2005b), has identified

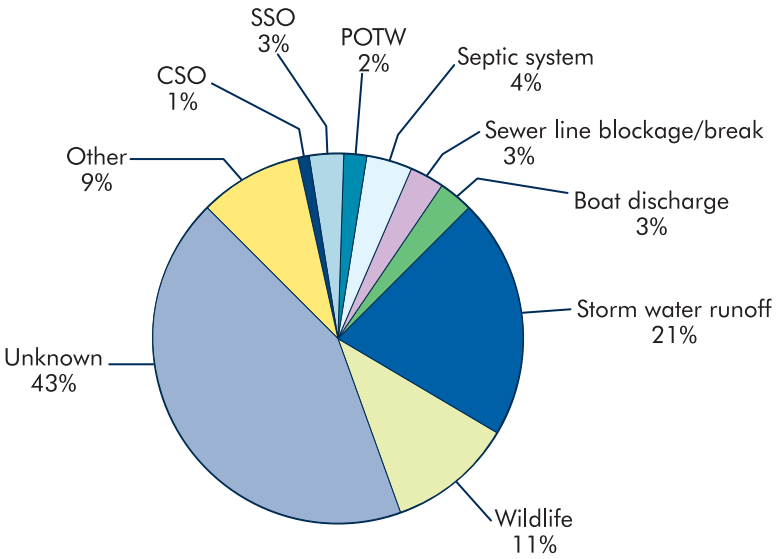


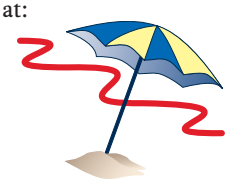
Figure 3.1. Sources of pollution that resulted in beach actions in 2002 *(EPA 2003d)*

"Water Safe for Swimming" as an important objective for the Agency and has summarized its key national strategies and actions to help improve beach water quality. EPA's national strategy for improving the safety of recreational waters includes four key elements:

1. Establish a new generation of pathogen indicators based on sound science.
2. Identify unsafe recreational waters and begin restoration.
3. Reduce pathogens levels in all recreational waters.
4. Improve beach monitoring and public notification.

For beach safety information visit EPA at:
www.epa.gov/waterscience/beaches

For EPA grant information visit:
www.epa.gov/water/waterplan



Establish pathogen indicators based on sound science

EPA worked with states and tribes throughout the country to implement the adoption of the most recent (1986) scientific indicators of unsafe pathogens in all recreational waters.

Identify unsafe recreational waters and begin restoration

A key component of the strategy to restore waters unsafe for swimming is to identify the specific waters that are unsafe and develop plans to accomplish the needed restoration. A key part of this work is to maintain strong progress toward the development of Total Maximum Daily Loads (TMDLs) based on the schedules established by states in conjunction with EPA.

In a related effort, EPA's Office of Water will work in a new partnership with the Agency's Office of Enforcement and Compliance Assurance (OECA) to better focus compliance and enforcement resources on unsafe recreational waters. Moreover, wet weather discharges, which are a major source of pathogens, are one of OECA's national priorities for FY 2005 through FY 2007.

Reduce pathogen levels in recreational waters generally

In addition to focusing on waters that are unsafe for swimming, EPA, states, territories, and tribes will work to reduce the overall level of pathogens discharged to recreational waters using three key approaches:

1. Address point sources discharging pathogens to recreational waters under the permit and enforcement program, including discharges associated with CSOs, SSOs, POTWs, sewer line breaks and urban storm water.
2. In conjunction to implementing NPDES requirements, work with municipalities to support sustainable municipal wastewater infrastructure by insuring adequate funding from all applicable sources, better management, effective water use and watershed approaches.
3. Encourage improved management of septic systems, boat discharges and other nonpoint sources

Discharges from storm sewers, POTWs, CSOs, and SSOs in urban areas can result in high levels of pathogens being released during storm events. Because urban areas are often upstream of waters where people swim, these discharges can be a significant source of unsafe levels of pathogens. EPA is working with states and local

governments to fully implement NPDES requirements for municipal point sources that contribute pathogens to recreational waters. This includes fully implementing the CSO Policy, issuing and implementing permits for municipal storm sewer systems, and clarifying and applying NPDES requirements for wet weather flows at POTWs to improve the capacity, management, operation and maintenance of POTW treatment plants and separate sanitary sewer collection systems.

Other key sources of pathogens to the nation's waters are discharges from CAFOs, municipal storm water systems and industrial facilities. EPA expects to work with states to ensure that CAFOs are covered by permits. EPA expects that most states will have current general permits requiring storm water management programs for Phase II municipalities and construction by the end of 2006.

Finally, there is growing evidence that ineffective septic systems are contributing pathogens to recreational waters. In 2003 EPA issued the *Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems* to enhance the performance and reliability of decentralized wastewater treatment systems through improved management programs. EPA encourages state and local governments to use these voluntary guidelines as a template for their efforts to strengthen existing management programs and implement new ones. In addition, EPA published a draft *Handbook for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems*, which complements the voluntary guidelines, to help state and local governments evaluate and upgrade their management programs for onsite and clustered (decentralized) wastewater treatment systems.

Improve beach monitoring and public notification

Another important element of the strategy for improving the safety of recreational waters is improving monitoring of public beaches and notifying the public of unsafe conditions. EPA is working with states to implement the BEACH Act and has awarded, or is in the process of awarding, $52 million in grants. EPA will continue to receive and display state information on beach water quality through the eBeaches system and will seek to increase the voluntary participation of inland states. EPA will also continue to develop and maintain information on beach safety available through the Internet.

3.6 Improving beach water quality through related programs

EPA's National Estuary Program (NEP)

Improving beach water quality is one focus of EPA's National Estuary Program (NEP). The NEP program was established by Congress in 1987 to improve the quality of estuaries of national importance. The 28 NEPs around our nation's coasts, include many of the country's most popular beaches and recreational waters. A major focus of the Program is protecting and restoring water quality which complements the objectives of the BEACH Act. For example, the Tampa Bay, FL NEP has created an internet portal that provides citizens real-time access to the status of swimming beaches within the Tampa Bay area including recent water quality monitoring information. Also, the Tampa Bay NEP helped establish the Healthy Beaches program. This program was eventually adopted by the State and now Florida's 34 coastal counties perform bi-weekly beach water sampling analyzing for bacteria indicating enterococci and fecal coliform. The New York – New Jersey Harbor Estuary Program (HEP) worked with numerous federal, state, and municipal agencies to initiate a long-term water quality monitoring program that now covers all of the waters of the New York/New Jersey Harbor including the recreational waters of Raritan Bay. This work included assisting 12 municipal wastewater treatment plants in developing a comprehensive monitoring plan with annual reports to the public on the condition the region's waters. Many NEPs have established or support citizen volunteer monitoring networks that provide valuable data. The Buzzards Bay NEP in Massachusetts has recruited over 300 Bay Watchers to monitor 180 stations for various parameters that provide an immediate snapshot of the health of the Bay. The Indian River Lagoon NEP in FL, provides funding for the second largest volunteer estuarine monitoring network in the nation. Additional examples on NEP BEACH Act related activities can be found at www.epa.gov/owow/estuaries.

EPA's National Marine Debris Monitoring Program (NMDMP)

EPA's National Marine Debris Monitoring Program (NMDMP) was developed to determine the amount of marine debris and the sources of marine debris affecting U.S. coastlines. The Program is designed to gather scientifically valid marine debris data using a rigorous statistical protocol. The Monitoring Program covers approximately 88,000 miles of U.S. coastline (including Puerto Rico and the U.S. Virgin Islands). Monitoring is conducted every 28 days by teams of volunteers in nine different regions across the U.S. The program is currently in the fourth year of the five-year study period. A final report and analysis will be developed in late 2007 at the end of the five-year study. The report will provide an introduction to the study, the details of the methodology, and an analysis of the results, including amounts, types, and trends in marine debris.

EPA's Section 319 Nonpoint Source Management Program

Under its section 319 Nonpoint Source Management Program, EPA support includes grants, technical assistance, education, training, technology transfer, demonstration projects, and monitoring for nonpoint source implementation projects. The section 319 program has many projects addressing pathogens throughout the US.

Many watersheds are impaired by pathogens from nonpoint sources. Animal Feeding Operations (AFOs) are one category of nonpoint sources that can affect a given watershed. For example, there are nearly 300,000 Animal Feeding Operations (AFOs) in the United States. When AFOs are concentrated in watersheds, they may create very significant water pollutions problems because they can be prominent sources of pollution such as pathogens and nutrients. Another category, storm water discharges, can affect watersheds. Like AFOs, storm water discharges are often near smaller waterbodies and thus can have significant water quality impacts. Finally, non-human sources of pathogens (such as geese and other wild animals) can raise significant pathogen concerns.

Great Lakes National Program Office

Efforts are underway in the Great Lakes to identify, on a regional basis, the causes of beach closings and advisories. Importantly, state, local, and federal partners have worked together to identify actions that could be taken to improve water quality at Great Lakes beaches. One of these actions is the completion of watershed-based sanitary surveys to identify sources of bacterial contamination. EPA expects that this work will result in the development of a tool for watershed-based sanitary surveys that could be used by others.

3.7 References

Cabelli, V.J. 1983. *Health Effects Criteria for Marine Recreational Waters*. EPA-600/1-80-031. U.S. Environmental Protection Agency, Cincinnati, OH.

CSWRCB (California State Water Resources Control Board). 2001. *California Beach Closure Report 2000*. Division of Water Quality, State Water Resources Control Board, California Environmental Protection Agency, Sacramento, CA.

Center for Watershed Protection. 1999. Microbes and urban watersheds *Watershed Protection Techniques*. 3(1):551–596.

Dufour, A.P. 1984. *Health Effects Criteria for Fresh Recreational Waters*. EPA-600/1-84-004. U.S. Environmental Protection Agency, Cincinnati, OH.

Orange County. 2003. *2002 Annual Ocean and Bay Water Quality Report*. Orange County, California, Health Care Agency, Environmental Health. June.

USEPA (U.S. Environmental Protection Agency). 1986. *Ambient Water Quality Criteria for Bacteria 1986*. EPA 440/5-84-002. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2002. *National Beach Guidance and Required Performance Criteria for Grants*. EPA 823-B-02-004. U.S. Environmental Protection Agency, Office of Water, Washington, DC. June.

USEPA (U.S. Environmental Protection Agency). 2003b. *Draft Management Handbook for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems*. EPA 832-D-03-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC. February.

USEPA (U.S. Environmental Protection Agency). 2003c. *Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. March.

USEPA (U.S. Environmental Protection Agency). 2003d. *2003–2008 EPA Strategic Plan: Direction for the Future.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. September.

USEPA (U.S. Environmental Protection Agency). 2003e. *EPA's BEACH Watch Program: 2002 Swimming Season Update*. EPA 823-F-03-007. U.S. Environmental Protection Agency, Office of Water, Washington, DC. May.

USEPA (U.S. Environmental Protection Agency). 2004a. *National Water Program Guidance: Fiscal Year 2005*. EPA 832-B-03-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC. April.

USEPA (U.S. Environmental Protection Agency). 2004b. *Report to Congress: Impacts and Control of CSOs and SSOs*. EPA 833-R-04-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC. August.

USEPA (U.S. Environmental Protection Agency). 2005a. *EPA's BEACH Program: 2004 Swimming Season Update*. EPA 823-F-05-006. U.S. Environmental Protection Agency, Office of Water, Washington, DC. August.

USEPA (U.S. Environmental Protection Agency). 2005b. *National Water Program Guidance: Fiscal Year 2006.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. April.

Wade T.J., Calderon R.L., Sams E. et al. Rapidly measured indicators of recreational water quality are predictive of swimming-associated gastrointestinal illness. Environ Health Perspect 2006; 114 (1):24-8.