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Action Plan for Beaches and Recreational Waters

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EPA Action Plan for Beaches and Recreational Waters

Reducing Exposures to Waterborne Pathogens

Office of Research and Development
and
Office of Water
U.S. Environmental Protection Agency
Washington, DC 20460

Notice

The U.S. Environmental Protection Agency (EPA), through its Office of Water and Office of Research and Development, generated the information described in this plan for beach and recreational waters. This plan has been subjected to the Agency's peer and administrative review process and has been approved for publication as an EPA document.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Dear Reader:

We are pleased to provide the Environmental Protection Agency's (EPA) "*Action Plan for Beaches and Recreational Waters*" (*Beach Action Plan*). The *Beach Action Plan* identifies the Agency's multi-year strategy for monitoring recreational water quality and communicating public health risks associated with potentially pathogen-contaminated recreational rivers, lakes, and ocean beaches.

This plan is the first of its kind. It differs from research or media-specific program plans or strategies in that it integrates all associated program, policy, and research needs and directions. Greater emphasis is placed on articulating the Agency's rationale and goals addressing a specific problem with less discussion on the details of each activity. However, the *Beach Action Plan* does provide significant detail on the timing, products, and lead organization for each of the activities.

The *Beach Action Plan* is an important tool for measuring accountability and progress because it describes the logic and timing of the products of EPA's recreational water efforts. By specifying how EPA will manage its program and scientific activities, the Agency can communicate results more effectively and can provide a clearer picture of what can be expected in the future.

EPA will continue to work with other agencies, interested parties, and members of the public to implement this plan and refine it, as appropriate, in the future.

Sincerely,

J. Charles Fox
Assistant Administrator
Office of Water

Norine E. Noonan
Assistant Administrator
Office of Research and Development

Executive Summary

EPA recognizes the need for stronger beach monitoring programs, improved water quality standards, and broader public guidance relating to the use of recreational waters in the United States. In response to national directives such as the Beaches Environmental Assessment, Closure and Health (BEACH) Program and the Clean Water Action Plan, EPA has prepared this *Action Plan for Beaches and Recreational Waters* (the "*Beach Action Plan*")—a multi-year strategy for reducing risks of infection to recreational water users through improved recreational water quality programs, risk communication, and scientific advances.

The *Beach Action Plan* describes EPA's actions to improve and assist in state, tribal, and local implementation of recreational water monitoring and public notification programs. It describes related activities of the Office of Water (OW) and the Office of Research and Development (ORD).

As long as contamination of ambient waters remains a threat, more and more Americans face risk of exposure to waterborne microbial pathogens as increasing numbers of people visit or move to coastal areas, lakes, and rivers. Exposure to pathogens can occur during swimming or other recreational activities via ingestion, inhalation, or direct contact with polluted water. Despite the potential risks to the public from gastrointestinal illness and other infections, water quality monitoring programs vary widely at the state and local levels.

The *Beach Action Plan*'s first objective, therefore, is to enable consistent management of recreational water quality programs. EPA will sponsor conferences and meetings with federal, state, tribal, and local representatives to identify the needs and deficiencies of recreational water quality monitoring programs. Based on this information, EPA will strengthen water quality standards and implementation programs by developing policies and assisting local managers in their transition to recommended criteria. EPA will also develop and issue guidance on managing risk at recreational waters and on using monitoring methods and indicators developed during subsequent research.

To expedite the pace at which states and tribes strengthen their water quality standards, EPA will develop policies to ensure that states and tribes adopt the currently recommended *Ambient Water Quality Criteria for Bacteria–1986* and make the transition to monitoring for *E. coli* and enterococci indicators rather than total coliforms or fecal coliforms.

EPA recognizes that the science and policies related to the protection of recreational waters will constantly evolve. Thus, the Agency will develop and support training as needed. These efforts may involve training in new methods, other technology transfer opportunities, and guidance documents.

Because recreational waters are primarily managed by local agencies, risk communication practices vary widely throughout the United States. EPA will provide risk communication tools to regional and local authorities to promote consistent effectiveness. EPA will maintain a website to communicate timely recreational water quality information to beach managers and the public. The "BEACH Watch" website (*http://www.epa.gov/ost/beaches*) will provide real-time details on advisories and closings to authorities as well as to members of the public with access to the Internet. Input from other EPA programs, federal agencies, and regional pilot projects will be used to develop the site.

Regional managers will be able to provide this information to the public in a format deemed locally feasible.

EPA will conduct a National Beach Health Survey annually to collect detailed data on state and local monitoring efforts, applicable standards, water quality communication methods, the nature and extent of contamination problems, and any protection activities.

EPA will develop a national inventory of digitized beach maps. These maps will be linked with locations of pollution sources through a Geographic Information System. They are expected to become an invaluable source of information to local organizations and the general public.

EPA will develop and support strong regional and local partnerships through the Environmental Monitoring for Public Access and Community Tracking Program (EMPACT). Current beach-specific EMPACT projects with EPA offices in New England, the Mid-Atlantic, the Southeast, the Great Lakes region, the South, the West, and the Gulf Coast region are investigating the use of better bacterial indicators, exploring improved monitoring methods, developing site-specific predictive tools, and making timely beach information available to the public.

The second objective of the *Beach Action Plan* is to improve the science that supports recreational water monitoring programs. The *Beach Action Plan*'s scientific research addresses three broad areas:

(1) *Water Quality Indicators Research.* Rapid analytical methods are needed to identify risk *before* exposure takes place. Real-time or near-time analytical methods would trigger warnings or closures or set in motion a more rigorous monitoring protocol.

Although the 1986 criteria are an improvement over prior ones, better indicators of the potential presence of enteric pathogens must be developed and assessed for their public health risk predictive value. Discriminating between human and animal sources of contamination is important not only to locate sources, but because not all animal pathogens cause human disease and their presence may lead to unnecessary precautions. Furthermore, current indicator microbes are based solely on fecal contamination and may not accurately assess the risk of disease due to a myriad of other potential pathogens that cause skin, upper respiratory tract, eye, ear, nose, and throat diseases.

Finally, EPA will assess whether currently used indicator bacteria proliferate naturally in soil and water under tropical conditions. If they do so, their use as indicators in tropical climates would be ineffectual.

(2) *Modeling and Monitoring Research.* Although some local water quality managers estimate impending beach pollution through computer models or other tools, most must wait for laboratory test results before they can make a determination of health risk. In the meantime, this leaves the potential for exposing the public to pathogens. EPA will assess the utility of existing models; those that provide improved assessments of water quality will be recommended to local authorities.

EPA will assemble a workgroup with expertise in monitoring recreational waters, determining the risks associated with currently used indicator levels, and determining the need for public health controls at recreational waters. The workgroup will recommend guidelines for new testing protocol. The protocol will address the timing and locations of samples and other factors influencing the levels and types of fecal indicators in recreational water samples. Guidance will be developed for public health professionals on when, where, and how to set up and conduct an appropriate monitoring program for typical beaches.

(3) *Exposure and Health Effects Research.* Combined Sewer Overflows (CSOs) are mixed discharges of storm water and domestic waste that occur when the flow capacity of a sewer system is exceeded during rainstorms. They are potentially a greater risk to swimmers than dry-weather discharges from other point sources. The effects of CSO discharges on recreational waters need to be quantified. EPA will conduct research to determine pathogen occurrence and indicator relationships associated with wet weather flows.

The zone of the shoreline that is constantly washed by waves or tides offers micro-habitats where organic matter may collect and where warm, moist sand may be conducive to the growth of certain bacterial pathogens protected from dilution with open waters. EPA will conduct research necessary to determine if special consideration of this interstitial zone and its impact on children and other sensitive populations is warranted.

A significant uncertainty in recreational water risk assessment is the actual exposure level associated with ingestion, inhalation, and skin contact with contaminated water and the corresponding level of illness. EPA will conduct epidemiological studies to establish the link between water quality indicators and disease.

EPA intends to coordinate with other agencies in recreational water related activities. The next phase of the *Beach Action Plan* will integrate EPA activities with those carried out by agencies such as the National Oceanic and Atmospheric Administration, the Centers for Disease Control and Prevention, the U.S. Geological Survey, and state environmental and public health departments.

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1.0 Introduction

As growing numbers of persons move to coastal areas and pollution continues to threaten the waters in which we swim and play, many Americans still risk illness from exposure to contaminated recreational waters. While there is no true measure of the magnitude of disease associated with recreational water exposures, epidemiology studies in the United States and abroad have consistently found an associated disease burden. In addition, thousands of beach advisories and closings are issued at recreational rivers, lakes, and oceans every year throughout the United States. According to the Natural Resources Defense Council's eighth annual survey on beach water safety, at least 4,153 days of beach closings and advisories were caused by pollution in 1997 alone, and "adequate monitoring and notification procedures are still lacking at many of the nation's most popular beaches." This number of advisories may be an underestimate of incidents of contamination because many states and localities do not conduct, nor are they required to have, regular recreational water quality monitoring programs.

Beach advisories and closings in the United States are generally due to elevated levels of indicator organisms which may indicate the presence of pathogens, disease-causing microorganisms. The source of these indicator organisms can be discharges of untreated or partially treated sewage into ambient waters. Recreational water users are at risk of infection from waterborne pathogens through ingestion or inhalation of contaminated water or through contact with the water. Some people may face a disproportionate risk from exposure to the pathogens because of heightened susceptibility. For example, children may be more vulnerable to environmental exposure due to their active behavior and their developing immune systems.

Adverse events at treatment plants can lead to recreational water users being exposed if there is inadequate monitoring or untimely notification. Currently, monitoring programs vary widely at the local level. While they may have prevented some exposure and illness in the past, many of these programs are not using the best possible indicators of microbial pathogens presence. Beginning in 1976, EPA recommended fecal coliforms to the regulatory community as indicator organisms for the presence of pathogens in recreational waters. Coliforms are bacteria found in the intestinal tract of humans and animals; therefore their presence in ambient water indicates fecal pollution and the potential presence of pathogens. In 1986, based on new research data, EPA recommended new monitoring guidelines, including the use of *Escherichia coli (E. coli)* and enterococci as indicators to replace fecal coliforms. The presence of these bacteria in recreational waters correlates with swimming-associated gastrointestinal disease better than a total fecal coliform count. About one-third of all states have adopted either *E. coli* or enterococci for monitoring fresh and marine waters. However, other states have continued to use fecal coliforms, and a small number still use total coliforms to indicate water quality.

The inconsistent use of indicator organisms for monitoring recreational waters has resulted in occurrences of one state prohibiting use of recreational waters that were considered safe by a neighboring state. A scientifically based investigative process to determine potential health risks and eliminate their sources in recreational waters is sorely needed in order to foster consistent use of indicators. To be effective, this process must be recognized and accepted by state and local officials. Flexibility in the program would allow for differences in health risk from differing sources, source elimination as an alternative to monitoring, and regional differences in climate, resources, and geography. Research is needed to improve the scientific basis of monitoring programs. This will include identifying appropriate indicators, determining relationships between indicators and risk levels for disease, and developing more accurate models and faster analytical methods to ensure timely notification of problems.

2.0 Beach Action Plan Overview

Recognizing the need for consistent and improved monitoring programs, EPA's Administrator, Carol Browner, announced the Beaches Environmental Assessment, Closure and Health (BEACH) Program on May 23, 1997. The goal of this program is to significantly reduce the risk of disease to users of the nation's recreational waters through improvements in recreational water programs, communication, and scientific advances. The BEACH Program applies to fresh water recreational areas such as lakes, ponds, and rivers, as well as marine waters such as oceans and bays, as does the *Beach Action Plan*. They do not apply to public or private swimming pools or water parks.

The Clean Water Action Plan (CWAP), released on February 14, 1998, describes a series of actions needed to strengthen clean water programs, including the release of a plan for federal, state, tribal, and local implementation of beach monitoring and notification programs. This *Action Plan for Beaches and Recreational Waters*, referred to hereafter as the *Beach Action Plan*, lays out EPA's strategy to implement the BEACH Program as mandated by the CWAP.

The actions of the federal government are directly affected by the requirements of the Government Performance and Results Act (GPRA), which sets performance goals throughout the government. The BEACH Program and this *Beach Action Plan* address, in part, three of EPA's performance goals. These GPRA goals are:

- Clean and Safe Water
- Empowering people with information and expanding their right to know
- Provide sound science to improve understanding of environmental risk and develop and implement innovative approaches for current and future environmental problems

The *Beach Action Plan* furthers the three main themes laid out in the BEACH Program:

- Strengthen beach programs and water quality standards;
- Inform the public about recreational water quality; and
- Conduct research to improve the scientific basis for beach programs.

The *Beach Action Plan* is a dynamic, multi-year strategy governing all EPA activities protecting the public's health from pathogens in recreational waters. This focus enables rapid progress on the issue and provides a working point from which a broader plan, including the contributions of other organizations and other recreational water health issues, can be developed.

Of course, the most desirable solution to protect public health is to eliminate the need for beach closings through the effective control of pollution sources. This need is being addressed by several programs within EPA. The *Beach Action Plan* focuses on identifying and reducing the risk of exposure to pathogens should they contaminate recreational waters. The *Beach Action Plan* does not address the ecological impacts of pathogens or the control of harmful algal blooms, because these activities are planned or have begun in other programs at EPA and other agencies.

Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, and EPA's *Policy on Evaluating Health Risks to Children* mandate that EPA standards, rules, and risk assessments evaluate and characterize risks to children. Therefore, the elements of the *Beach Action Plan* address specific issues that relate to children's health.

Several organizations within EPA have principal roles in implementing the *Beach Action Plan*. The Office of Water (OW) is providing the overall leadership for planning and developing the BEACH Program. OW's primary responsibility lies with developing and promulgating protective standards for recreational water quality, and providing the tools and guidance necessary for implementing those standards. The Office of Research and Development (ORD) is working closely with scientists in OW and in other agencies to plan and conduct the research necessary to support the sci-

entific needs of the *Beach Action Plan*. Both OW and ORD will participate in training programs designed to communicate the standards and underlying science to environmental managers and stakeholders within and outside of the EPA.

EPA's ten Regional Offices are the Agency's primary contacts with state and local water quality managers, public health professionals, and the general public. The Regions will disseminate the tools and information that state and local managers need to implement the recreational water standards and the science developed by OW and ORD. They will also convey information to the states and local governments that they, in turn, can communicate to the beach-going public. The Regions will also relay back the needs and problems identified at the state and local levels, which will drive future research and regulatory activities. Agency-wide contacts are provided in Appendix C.

The following sections discuss specific EPA activities that meet the BEACH Program's goal through improved recreational water quality programs, risk communication, and scientific advances. These efforts will improve local management of recreational water quality programs through program development, training for beach monitoring program managers, and communication of risks to the public.

The schedule for completion of the activities that support this plan can be found in the table on Page 10. EPA is committed to working with federal, state, and local agencies on the implementation of this Plan and has begun a dialogue with other federal agencies. EPA will update the plan as needed to reflect the latest science, changes in policy, and progress. For an overview of the science and regulatory history behind the *Beach Action Plan*, please see Appendix A.

2.1 Enabling Consistent Management of Recreational Water Quality Programs

EPA will implement activities to enable consistent management of recreational water quality programs across the United States. These activities emphasize program development and communication of risks to the public. The proposed program development activities result from EPA's long involvement with water quality criteria and state-adopted standards. The risk communication activities reflect the federal government's support for the public's "right to know" about pollution problems. To identify other priorities, EPA reviewed available information on existing local and state beach programs and consulted other external reviews, such as the "Testing the Waters" reports published by the Natural Resources Defense Council.

After developing a preliminary list of activities, EPA gave it a detailed public review at the first national BEACH conference in October 1997, hosted by EPA and the Association of State and Territorial Health Officials. The conference was attended by representatives from federal, state, and local governments, as well as from environmental, academic, and industry groups. Participants were asked to identify needs for technical assistance, assign priorities for short- and long-term actions, and, where possible, recommend protocols and procedures to encourage greater consistency among jurisdictions.

Conference participants strongly supported EPA's efforts to improve consistency and research, but asked that more flexible implementation be allowed. They stressed a need for guidance on water quality sampling protocols, predictive modeling, and adequacy of monitoring programs. They also supported additional research to improve the science behind beach health issues (Section 2.2). Risk assessment and communication was another key area of consensus, and the conference supported consistent but flexible guidance on risk assessment approaches; criteria for closing and reopening beaches; assessing risks on human *versus* nonhuman sources; and simplified forms of public risk communication.

A complete report of the conference is available in EPA's publication *National Beach Conference–Report on Action Items*, EPA/823/R-98/004. EPA incorporated its main priorities into the following programmatic activities and into the scientific research activities described in Section 2.2.

2.1.1 Program Development Activities

Conferences and Meetings

EPA will arrange a series of technical conferences intended for state and local recreational water quality managers. The first national conference in October 1997 defined current issues and activities related to beach health; provided a forum for learning about beach health initiatives across the country; identified unaddressed beach health needs; assigned priorities to short-term and long-term actions; and recommended protocols and procedures to encourage greater consistency among jurisdictions in beach monitoring and notification.

EPA is arranging four regional conferences and a second national conference with objectives similar to the first. The regional conferences will emphasize regional issues and implementation of national guidance.

Guidance Documents
EPA will coordinate the planning and issuance of BEACH Program guidance documents addressing recreational water quality monitoring, risk assessment, risk management, and risk communication and incorporating results of ORD's research, input from OW, and technical input from state and local participants. The first integrated guidance document will be a national overview of current beach advisory practices.

During Fiscal Years (FY) 1999 and 2000, EPA will prepare and issue guidance that includes:

- Adjustments in the risk-based criteria to reflect recreational water use and acceptable risk;
- An evaluation and recommendation of scientifically valid tools for predicting health risks to recreational water users;
- Strategies for monitoring recreational waters and conducting beach sanitary surveys (see Section 2.2, *Improving the Science that Supports Recreational Water Monitoring Programs*);
- Guidance on assessing and managing risk at recreational waters; and
- Case examples of effective recreational water management programs.

Strengthening Water Quality Standards and Implementation Programs
Strong state and tribal water quality standards provide the scientific and programmatic framework for enhancing protection of beaches and recreational waters. Water quality standards provide the legal basis for regulatory and water quality improvement programs. Attainment of beach and recreational water quality standards provides a benchmark for measuring the success of EPA and state programs in meeting the Government Performance and Results Act goal of reducing exposure to microbial and other types of contaminants in recreational waters and increasing the percentage of waters designated acceptable for recreational use. The water quality standards program framework is flexible, allowing for revisions as new bacteriological indicators, monitoring protocols, and models are developed.

To expedite the pace at which states and tribes strengthen their beach and recreational water quality standards, EPA will develop policy to ensure that states and tribes adopt the *Ambient Water Quality Criteria for Bacteria–1986* and make the transition to monitoring for its recommended *E. coli* and enterococci indicators, rather than total coliforms or fecal coliforms, by FY2003. EPA intends to complete development and publication of this policy as soon as possible but not later than the end of FY1999. The policy will:

- Affirm the scientific validity of the *Ambient Water Quality Criteria for Bacteria–1986*.
- Supplement the criteria with a literature review of studies since 1986.
- Outline an approach for monitoring the safety of recreational waters in tropical climates where *E. coli* and enterococci may occur in the soil environment.
- Identify appropriate approaches for managing risk in non-primary contact recreational waters (*e.g.,* boating waters).

By the end of FY1999 EPA also intends to propose, in the *Federal Register,* microbiological methods for water ambient monitoring using *E. coli* and enterococci. These methods will be proposed for promulgation of 40 CFR Part 136. By the end of FY1999, EPA also intends to announce the availability of a training video and manual for laboratory personnel using these methods.

The transition to *E. coli* and enterococci indicators will be a priority for the triennial reviews of water quality standards that will occur in FY2000-2002. Beginning with FY2000, EPA Headquarters and Regional Offices will develop management agreements with the states and tribes that will include commitments to have states and tribes adopt the *Ambient Water Quality Criteria for Bacteria—1986*. Where a state does not amend its water quality standards to include the 1986 criteria, EPA will act under Section 303(c) of the Clean Water Act to promulgate the criteria with the goal of assuring that the 1986 criteria apply in all states not later than 2003.

As the results of research studies become available, EPA will prepare additional policy, guidance, and training to supplement the framework for managing risk at beaches and in other recreational waters.

Training and Technology Transfer
EPA recognizes that the science and policies related to the protection of recreational waters will constantly evolve. Thus, the Agency will develop and support training as needed. These efforts may involve training on new methods, other technology transfer, and guidance implementation. Training will be provided to Regional Offices and state and local agencies.

As noted earlier, in FY1999, EPA will produce a video that demonstrates two indicator test methods for *E. coli* and enterococci, which must be filtered out of water samples and grown in culture. The video will compare methods and demonstrate the use of new growth media—mEI for enterococci and modified mTEC for *E. coli* species.

The video and accompanying manual will be distributed to local organizations through the partnership program.

2.1.2 Risk Communication Activities

Recreational water samples are generally collected by local agencies, such as county health departments and sanitation districts, which may perform all aspects of sampling and analysis. These agencies are also responsible for notifying the public of water quality problems through advisories or closures. Because of varying resources and diverse local circumstances, risk communication practices vary widely throughout the United States. EPA is committed to improving the effectiveness of risk communication methods at national, regional, and local levels.

Beach Watch Website
EPA will maintain a national Internet-based "information hub" to communicate timely recreational water-quality information to the public and to local authorities. Regional managers will be able to provide this information to the public in a format deemed locally feasible. The website will incorporate innovative national, regional, and local efforts. The current "BEACH Watch" website (*http://www.epa.gov/OST/beaches*) will become a real-time electronic database for all beach health-related information and will provide recreational water users with national and local details on advisories and closings. The website will also provide information identifying those beaches where monitoring and assessment activities are conducted in a manner consistent with EPA's national guidance. Survey information collection, digitized map development, and innovative delivery of information will be expedited at "BEACH Watch" and will link to other websites such as "BASINS" and "Surf Your Watershed" (*http://www.epa.gov/surf*). EPA regularly updates the "BEACH Watch" website to include new beach information and links to regional projects. Other EPA programs, federal agencies, and regional pilot projects will be consulted to develop the information and make it available to selected areas.

National Beach Health Survey
The only practical way to assess practices and track improvements is to conduct a national survey. EPA will conduct an annual National Beach Health Survey to collect detailed national data on state and local beach monitoring efforts, applicable standards, beach water quality communication methods, the nature and extent of beach contamination problems, and any protection activities. Results will be made available to local water quality managers and the public via the Internet and through regional and local information outlets.

Beach Maps
An important part of EPA's efforts to make beach information available to the public is to develop a national inventory of digitized beach maps. EPA will develop protocol for mapping beaches and start mapping in priority areas. These easy-to-read maps will ultimately be linked with locations of pollution sources, such as combined sewer overflow (CSO) outfalls, through a Geographic Information System (GIS) available to local organizations and over the Internet to the general public. EPA recognizes the need to ensure that the information be as up-to-date as possible. Once interlinked, beach maps are expected to become an invaluable source of information to local organizations and the general public. Research activities associated with CSOs are described in Section 2.2.3, on Page 8.

Regional and Local Partnerships
To explore innovative Risk Communication methods, among other things, EPA will develop and support strong regional and local partnerships. The Environmental Monitoring for Public Access and Community Tracking Program (EMPACT) is a relatively new Agency-wide initiative to work with communities to collect, manage, and present real-time environmental information. EMPACT and the BEACH Program share the mutual goal of enhanced public access to environmental monitoring information.

In addition to experimenting with novel public risk communication methods, current beach-specific

EMPACT projects in EPA Regions 1 (New England), 3 (Mid-Atlantic), 4 (Southeast), 5 (Great Lakes), 6 (South Central), 9 (Pacific Coast) and the Gulf Coast Program Office are investigating better indicators, genetic fingerprinting of bacteria, improved monitoring methods, and site-specific predictive tools in order to make time-relevant beach information available to the public.

Risk Communication Guidance
Guidance on how to interpret data consistently and communicate water quality risks effectively is essential. As noted in Section 2.1.1 (*Guidance Documents*), EPA will develop guidance and provide technical training as methodology is developed. For the risk communication portion of the effort, EPA will provide state-of-the-art guidance. EPA will compile information on current risk communication efforts, evaluate current and emerging practices, and present recommendations as part of the overall beach guidance series.

2.2 Improving the Science that Supports Recreational Water Monitoring Programs

The research activities described in this section will be conducted to improve the science supporting recreational water monitoring programs and will serve as a framework from which a logical sequence of research can be implemented. Toward this end, a workgroup of ORD and OW scientists outlined and conducted a peer review of the research identified to progress from outdated water quality monitoring methods to truer measures of health risk. Relative priorities and estimated timing of research activities were based on scientific need and projected availability of resources and are charted in the table on Page 11. Initial sampling and monitoring improvements will be concentrated on existing indicator methods, i.e., enterococci.

Development of improved water quality indicator analytical methods was identified as a critical early step because they are an integral part of subsequent research. Another near-term priority is a scientifically defensible marine and fresh water sampling protocol. An appropriate sampling protocol is essential if recreational waters are to be precisely monitored using currently recommended methods. Work has already begun in this area, as well as in predictive modeling, and will continue as new methods are developed. Defining the nature of exposures and associated health effects requires that these studies be done subsequent to methods development. Research results stemming from all of the above will be field tested to validate their use by environmental risk managers in assessing the safety of recreational waters.

2.2.1 Water Quality Indicators Research

Recreational water quality indicators are biological or chemical agents whose presence in water stems from, or is a surrogate for, contamination by sewage. The historical use of indicators in protecting the quality of bathing beach waters in the United States is described in Appendix A.

Rapid Indicators of Fecal Pollution
Rapid analytical methods are needed to identify risk *before* exposure takes place. Current microbial testing methods for indication of possible pathogen presence require 24 to 48 hours of incubation before problems can be detected, leaving ample time for exposure to occur.

Real-time or near-time analytical methods, such as a simple "dipstick" color-change test for detecting human fecal contamination, must be developed to provide an immediate identification of potential problems. In using a real-time or near-time indicator, the measurement of certain levels of fecal pollution would either trigger warnings or closures or set in motion a more rigorous monitoring protocol.

*Enhanced Analytical Methods for Detecting Presence of Intestinal Pathogen*s
Better indicators of the potential presence of enteric pathogens must be developed and evaluated for confirming the risks associated with recreational waters. They should indicate the presence of pathogens that may have longer incubation times, lower infective doses, and/or cause more serious disease than pathogens currently identified with swimming-associated illness.

This study may require the use of novel techniques for sampling and characterizing pathogens of concern.

Indicators that Distinguish Between Human and Animal Fecal Contamination
Forest, pastureland, and urban storm water runoff, which carry fecal material of domestic and feral animals, often flow into recreational waters. Another more direct source of fecal contamination is from aquatic birds.

Analytical methods currently available for measuring water quality are unable to distinguish between human and animal fecal contamination. Therefore, risk associated with exposure to animal contaminants is treated the same as that from human contaminants. Methods able to discriminate between human and animal fecal contamination would provide a valuable tool to improve risk assessments of health effects associated with

polluted recreational water. Although risk of exposure to recreational waters affected by point sources of pollution is well characterized, the risk associated with animal contaminated waters is unknown. New methods would enable more-informed health studies to be conducted. They also would provide instructive monitoring data as well as a potential means of tracking water pollutants to their sources.

Indicator Microbes for Pathogens Causing Non-Enteric Diseases
Current indicator microbes of non-enteric illnesses are based on fecal contamination and may not accurately assess the potential for disease from a myriad of other potential pathogens that may cause skin, upper respiratory tract, eye, ear, nose, and throat diseases. A number of these other pathogens may be associated with non-fecal bodily wastes, as well as household wastes, certain types of industrial wastes, and animal wastes. Bacteria such as staphylococcus and *Pseudomonas aeruginosa* may indicate the presence of some of these pathogens in areas impacted by wastewater. These and other potential indicators should be evaluated for their effectiveness in indicating other sources of pollution including storm sewers, storm water runoff, industrial wastewater, animal wastes, as well as human recreational contributions. The presence of specific pathogen groups, including those causing skin infections such as leptospirosis, should be well-represented by the selected indicators.

Tropical Indicators
Currently recommended fecal indicators may not be suitable for assessing human health risks in the tropics. Studies have suggested that at tropical locales such as Puerto Rico, Hawaii, and Guam, *E. coli* and enterococci can be detected in waters where there is no apparent warm-blooded animal source of contamination.

Whether or not current indicator bacteria proliferate naturally in soil and water under tropical conditions must be determined. If so, the range of conditions (such as nutrients, temperature, pH, and salinity) under which the bacteria proliferate will be characterized and their geographical boundaries defined. If the phenomenon is widespread under tropical conditions, additional research will be conducted to modify approaches for monitoring, or to develop new tropics-specific indicators. Further evaluation of *Clostridium perfringens* and other microbial indicators (including coliphages) that do not flourish naturally in the tropics will be conducted to determine their usefulness as alternative indicators.

2.2.2 Modeling and Monitoring Research

Improvement of Predictive Models
Although some local water quality managers estimate impending beach pollution through computer models or other tools, most must wait for laboratory test results before they can make a determination of health risk. In the meantime, the public is left with a potential exposure to pathogens. A number of mathematical models have been or are being developed to assess the migration of pollution near recreational waters. EPA will assess the utility of these models; those that provide acceptable assessments of water quality would be recommended to local authorities.

EPA is working with interested parties to catalogue the full range of predictive tools in current use and to evaluate and improve them. These may range from "rules of thumb" for predicting risks, such as the occurrence of intense rainfall, to complex hydrodynamic models.

Experimental Validation of Models
Predictive models are available or being designed to assess the migration of pollution near recreational waters. Many of them are based on stream hydrology or tracing certain chemical and physical parameters downstream of pollution sources.

In conjunction with the implementation of a monitoring strategy, EPA will assess and validate the utility of these models for tracking pathogens or their indicators to downstream recreational waters under various hydraulic, tidal, and atmospheric conditions. Models that provide acceptable assessments of microbial travel would be recommended to state and local authorities to assess when upstream conditions may adversely impact recreational waters. Such models could be used to preemptively post or close a beach.

Monitoring Strategy
The monitoring approach recommended by EPA in 1987 uses the geometric mean of five samples taken over a 30-day period as a water quality limit. The rationale for using this approach was never published in

regulatory guidance manuals nor in open scientific literature, and is widely considered outdated. There is a great interest in monitoring approaches that use the analytical results of single samples, rather than five samples, to make risk management decisions. The uncertainty associated with both approaches, however, must be thoroughly defined before EPA can recommend refined monitoring guidance to the states and regions.

To this end, EPA will assemble an expert international workgroup whose members are involved with representative problems associated with monitoring recreational waters, determining the risks associated with indicator levels (and the statistical basis for such), and determining the needs for public health controls at beaches.

After appropriate peer review, the workgroup's recommendations will be used as guidelines in developing a testing protocol. The protocol will address the timing and locations of samples, and other factors influencing the levels and types of fecal indicators in recreational water samples. Intensive field sampling studies will be conducted at a selected number of fresh and marine water sites, and the significance of indicator density (which varies with water depth and distance to the shore, sunlight, tides, other currents, wind, waves, bather load, and rainfall) on indicator levels during typical beach days will be determined. Guidance will be developed for public health professionals on when, where, and how to establish an appropriate monitoring program for typical beaches.

2.2.3 Exposure and Health Effects Research

Combined Sewer Overflows
CSOs discharge a mixture of storm water and domestic waste when the flow capacity of a sewer system is exceeded during rainstorms. Due to the presence of untreated sewage in CSO discharges, they are potentially a greater risk to swimmers than dry-weather discharges from other point sources.

The effects of CSO discharges to recreational waters need to be quantified. Research is proposed to determine pathogen occurrence and indicator relationships associated with wet-weather flows.

Increased pathogen exposure at recreational areas may also occur due to sanitary sewer overflows (SSOs) or watershed runoff during heavy rainfall. While it is known that CSOs are capable of contributing excessive enteric pathogens to surface waters, the contributions of SSOs and watershed runoff have not been well-characterized with respect to their contribution of enteric or other human pathogens or indicators.

Non-point contamination components, such as septic systems, domestic and wild animals, and livestock, may contribute different pathogen types, numbers of pathogens, and human health risks. EPA will characterize and quantify the pathogen types, concentrations, and relationships with indicator organisms for comparison during dry-weather and wet-weather events under various geographical and watershed conditions.

Shoreline Interstitial Water
The zone of the shoreline that is constantly washed by waves or tides is simultaneously an attractive recreational area and a possible habitat for microbial pathogens. This "swash zone," as it is called by coastal scientists, has not received the research attention it deserves. The interstices, or spaces between the sand grains, offer micro-habitats where organic matter may be filtered out, and where warm, moist sand may be conducive to the growth of certain bacterial pathogens protected from dilution with open waters. When storms or increased wave energy resuspend sand and trapped particles, these pathogens are released into the environment.

These interstitial waters may pose an increased risk for toddlers and young children who play, wade, and swim in the swash zone. Research is needed to determine if special consideration of interstitial water and its impact on sensitive populations is warranted.

Human Exposure Factors
A significant uncertainty in recreational water risk assessments is the actual exposure level associated with ingestion, inhalation, and skin contact with contaminated water and the corresponding level of illness. Although the frequency of illness or infections can be determined through epidemiological studies, the factors that contribute to these adverse health effects—other than entering the water—are largely unknown.

Behavioral patterns, such as time spent in the water and the volume of water swallowed, have not been well-defined. Skin abrasions or cuts also may contribute to swimming-associated infections, but are seldom documented. The personal hygiene of swimmers while in the water also is poorly documented for natural rec-

reational waters. However, there is evidence from swimming pool studies that accidental fecal releases are not uncommon.

Another uncertain situation is the crowding together of swimmers at smaller recreational areas (bather load) during hot weather, weekends, and holidays. The increased proximity of people within an area may promote swimmer-to-swimmer transmission of disease.

All of these factors can be correlated to swimming activities, especially those of children. More definitive assessments of health risks associated with swimming will be possible with a better understanding of the exposure-effect process. The following research projects are proposed:

- *Characterize swimmer behavioral patterns* that may affect risk characterization activities and risk management practices with regard to recreational water safety.
- *Characterize typical exposures* that may be experienced through recreational water use and determine the exposure-response and mode of infection during these events. For instance, do skin infections occur predominantly if sores or abrasions are present? It has been estimated that only 100 mL of water enters the mouth and nasopharynx during a typical swimming episode. Although this amount is considered sufficient to cause gastrointestinal disease, it is not known whether it is adequate to cause other types of infections, given the expected pathogen density, their mode of action, and the disease threshold levels. The mode of action in upper respiratory tract infections needs to be investigated. Studies will be conducted to determine the mechanisms of infection from these types of exposures and determine the effective dose of enteric and non-enteric waterborne pathogens.
- *Evaluate the relationship between water quality and diseases associated with bather load*. Research will be conducted at well-characterized marine and freshwater beaches having low exposure risks from contaminant sources such as CSOs, but having high bather loads. The study approach will allow the differentiation of health risks due to bather load from other pollution risks. The study will also attempt to detect and quantify specific bather contribution of pathogens of concern at the exposure locations.

Epidemiological Studies

There will likely be a critical need for additional epidemiological studies in the future. They would be targeted at ensuring that improved or new indicator methods or procedures are well-grounded in their relationships to health effects for the various types of diseases related to recreational exposure. To fully address this research need, it may be necessary for EPA to partner with other agencies and organizations to ensure an adequate level of financial and scientific support.

EPA will conduct epidemiological studies to establish the link between water quality indicators and disease endpoints so that the level of exposure demonstrates a specific level of risk for disease. Epidemiological studies will be conducted at selected marine, estuarine, and fresh- water recreational locations. Cohort studies will be conducted on populations of recreational water users having full-body exposures to waters known to have specified levels of fecal contamination (or contamination causing non-enteric illnesses). New and innovative potential indicator methods will be used to sample the waters at representative locations in the exposure area during the exposure periods to assess or validate their efficiency for determining health risks. The relative risks of exposure to animal and human fecal contamination also will be evaluated.

Beach Action Plan Implementation Table

Activity	FY 1998				FY 1999				FY 2000				FY 2001	
	1	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*
2.1 Enabling Consistent Management of Recreational Water Programs														
2.1.1 Program Development Activities														
Conferences and Meetings:														
National conferences	◆											◆		
Regional conferences								◆	◆					
Guidance Documents						◆								◆
Strengthening Water Quality Standards and Implementation Programs:														
Develop and issue policy memorandum					◆			◆						
Reiterate policy at next triennial review							◆							
Prepare and issue guidance					◆							◆		
Training & Technology Transfer:														
Prepare new video and manual	◆			◆										
Distribute video							◆	◆						
2.1.2 Risk Communication Activities														
Beach Watch Website	◆			◆										
National Beach Health Survey:														
Initiate survey (Great Lakes and coastal areas)	◆		◆											
Update and expand survey					◆									✎
Beach Maps:														
Develop consistent protocol for mapping beaches. Begin mapping in priority areas								◆				◆		
Continue beach maps and identify sources													◆	✎
Regional & Local Partnerships:														
Boston Harbor/Charles River: Real-Time Monitoring and Reporting of Water Quality (EMPACT)		◆						◆						
Providence, RI: Improved Management of beaches (EMPACT)						◆						◆		
Coastal Virginia: genetic “fingerprinting” & testing of *E. coli*						◆						◆		
Florida: Develop Predictive Wet Weather Model for Beach Closure and Real-Time Monitoring for Public Notification (EMPACT)			◆					◆						
NW Indiana: Develop Publicly Accessible GIS database for the *E. coli* Monitoring Network (EMPACT)						◆		◆						
Lake Ponchartrain, New Orleans, Louisiana: Predictive Modeling of Bacterial Indicators (EMPACT)	◆										◆			
Mississippi Gulf Coast: Beach Water Quality Monitoring (EMPACT)		◆						◆						
So. California/Hawaii: Public Access to Bacteriology Data (EMPACT)		◆						◆						
Risk Communication Guidance					◆			◆						

(Continued)

Beach Action Plan Implementation Table

Activity	FY 1998				FY 1999				FY 2000				FY 2001	
	1	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*	*1*	*2*
2.2. Improving the Science that Supports Beach Programs														
2.2.1 Water Quality Indicators Research														
Rapid indicators of fecal pollution					◆									✎
Enhanced analytical methods for detecting intestinal pathogens											◆			✎
New or modified indicators that distinguish between human and animal fecal contamination					◆							◆		
Indicator microbes for pathogens causing non-enteric diseases					◆							◆		
Tropical indicators					◆							◆		
2.2.2 Modeling and Monitoring Research														
Improvement of predictive models			◆									◆		
Experimental validation of models									◆					✎
Monitoring Strategy:														
Primary workshop: Identify problems and issues			◆	◆										
Pilot beach sampling study	◆			◆										
Workshop: Establish DQOs and design comprehensive sampling plan					◆	◆								
Conduct comprehensive sampling study multi-environments with partner cities							◆	◆						
Workshop: Statistical analysis of data									◆	◆				
Workshop: Translate technical data and design communication plan												◆		✎
2.2.3 Exposure and Health Effects Research														
Combined Sewer Overflows					◆							◆		
Shoreline Interstitial Water					◆							◆		
Human Exposure Factors:														
Characterize typical exposures and swimmer behavioral patterns									◆					✎
Evaluate the types and incidence of diseases associated with bather load					◆							◆		
Epidemiological Studies													◆	✎

NOTE: The timelines projected in this table are subject to change based on scheduling of priorities and availability of resources.

Appendix A
Overview of the Science and Regulatory History

Regulations for protecting the quality of bathing beach waters in the United States were first considered in 1924 by the American Public Health Association's Committee on Bathing Places. They decided not to propose standards because of the lack of solid epidemiological data and their reluctance to alarm the public about dangers of outdoor bathing places without good evidence. The Committee maintained this position until 1936 when it proposed that bathing water quality was unacceptable if the total coliform density was greater than 1,000 per 100 mL. This decision was based on the belief that total coliforms are intimately associated with fecal material from the gut of warm-blooded animals and that their presence in water implies the potential presence of enteric pathogens. Similar legal standards were soon proposed in California, Connecticut, and by the Ohio River Valley Water Sanitation Commission in Ohio.

In the late 1940s and early 1950s, the U.S. Public Health Service conducted a series of epidemiological studies at bathing places in Chicago, Kentucky, and Long Island, New York to determine the health effects associated with swimming. These studies showed that there was a detectable health effect (*e.g.*, diarrhea) when total coliform densities were about 2,000 coliforms per 100 mL of water. Based on this and the finding that the fecal subset of coliforms were better indicators for contact recreation, the National Technical Advisory Committee of the Federal Water Pollution Administration (Department of the Interior) made criteria recommendations in its 1968 *Report to the Committee on Water Quality Criteria* (the "Green Book"). For evaluating the microbiological suitability of primary-contact waters, the committee proposed that fecal coliforms not exceed an average density of 200/100 mL, nor should more than 10% of the samples collected during any 30-day period exceed 400/100 mL.

In 1972, EPA's *Water Quality Criteria* ("Blue Book") summarized the state of the science on microbiological considerations for recreational waters; however, no specific recommendations concerning the microbiological content of recreational waters were presented. In the 1976 *Quality Criteria for Water* ("Red Book"), EPA proposed the criteria for fecal coliforms recommended previously in the Green Book.

New recommendations for maintaining the quality of bathing beach waters were issued by the EPA in 1986; the geometric mean density of enterococci could not exceed 35 per 100 mL in marine recreational waters or 33 per 100 mL in fresh waters. In addition, it was recommended that the density of *E. coli* should not exceed 126 per 100 mL in fresh water. The densities of these two bacteria in recreational waters, which occur in high numbers in the feces of warm-blooded animals and humans, had been shown epidemiologically to cause gastrointestinal symptoms in swimmers in marine or fresh waters. About one-third of all states have adopted either *E. coli* or enterococci for monitoring fresh and marine waters. Other states continue to use fecal coliforms, and a small number still use total coliforms.

The relationship between the quality of bathing water and health effects was established in a series of studies which examined differences in symptomatic illness between swimming and non-swimming beach-goers at marine bathing beaches in 1972-1978 and freshwater bathing beaches in 1978-1982. These studies showed that: (1) swimmers who bathe in water contaminated with sewage are at greater risk of contracting gastroenteritis; (2) as the quality of bathing water degrades, the swimming-associated illness rate increases; and (3) at equivalent indicator densities in marine and fresh waters, the illness rate in swimmers was greater in marine swimmers than in freshwater swimmers. Other studies suggest that activities such as wind surfing, snorkeling, and canoeing are also associated with an increased risk of contracting gastrointestinal disease.

Many other studies of recreational water quality and health effects have been conducted since these EPA studies were completed. Two of these studies were conducted

in freshwater environments in Canada and in France. Both studies used a prospective cohort design. In Canada, significant associations were found between all symptomatic illnesses and the water quality indicators, *Staphylococcus* and fecal coliforms. In France, significant relationships between gastroenteritis and the water quality as measured with fecal coliforms and fecal streptococci were also found; streptococci appeared to show a much stronger relationship to gastrointestinal illness than did fecal coliforms.

Additional studies in marine environments were conducted in Hong Kong, the United Kingdom, Israel, Australia, New Zealand, the United States, and South Africa. Water quality was usually measured using multiple microbial indicators. Fecal *streptococci*, fecal coliforms, *E. coli*, and enterococci were the indicator bacteria most commonly used.

All of the recreational water quality studies showed that there was a risk of gastrointestinal illness associated with swimming water contaminated by feces. Some of the studies also showed a dose-response type relationship—the illness rate increased as the water quality decreased. Several of them indicated that enterococci or fecal *streptococci* have a stronger correlation with the incidence of illness than coliforms or fecal coliforms. In the many studies conducted since, there have been no new principles defined beyond those developed by the EPA studies in the 1970s and early 1980s.

While epidemiology studies in the United States and abroad have consistently found a surfeit of disease burden associated with natural recreational water exposures, there is no adequate estimate of the true magnitude of disease because of limitations in past efforts to quantify the extent of the problem. Past studies generally considered acute gastrointestinal (AGI) illness and did not look for serious disease sequelae or skin, upper respiratory tract, eye, ear, or throat infections. Based on studies conducted so far, it is evident that the resulting human illnesses would be substantial if even a small percentage of the millions of U.S. recreational water users became ill with AGIs caused by exposure to those waters. It is unlikely over the short term that the Agency will have the resources to conduct costly large-scale epidemiology studies similar to those being done for food and drinking water, in order to assess the national magnitude of the problem.

Research projects have been delineated in seven general areas: monitoring strategy, improved indicators, modeling, combined sewer overflows, interstitial beach zones, exposure, and epidemiology studies. Other research needs will be identified as work and coordination progress.

Appendix B
Glossary

***Clostridium perfringens*:** A species of anaerobic (oxygen intolerant), spore-forming bacteria present in the intestinal tract of humans and animals. Since it does not flourish naturally in the tropics, it may be an appropriate indicator to detect possible fecal contamination.

Coliforms: Group of bacteria that inhabits the intestinal tract of humans and animals. Their presence in water indicates fecal contamination and the possible presence of pathogens. Coliform bacteria may be found in water, plants, air, or soil. (See *Fecal coliform*, below)

Coliphage: (or bacteriophage) A virus that infects coliform bacteria. Studies have shown that counts of coliphage may give a useful estimate of numbers of pathogens in sewage-polluted water.

Combined sewer overflow (CSO): Discharge to waterways of a mixture of storm water and domestic waste that occurs when the flow capacity of combined storm drains and sewer systems are exceeded during rainstorms. Normally, the entire flow of a combined sewer goes to a wastewater treatment plant, but during heavy storms the higher volume may cause overflows of untreated mixtures of storm water and sewage into waterways. About 900 cities in the U.S. continue to use these combined sewer systems.

Contamination: General term referring to the introduction of undesirable materials (*e.g.*, microorganisms, chemicals, toxic substances, wastes, or wastewater) into an environment (*e.g.*, water, air, soil, biota, or surface of solid objects).

Criteria: Measurable physical, chemical, or biological characteristic used to assess water quality. Commonly used as a basis for setting legally enforceable standards.

***E. coli*:** *Escherichia coli*, a subset of the coliform group that is part of the normal intestinal flora in humans and animals and is, therefore, a direct indicator of fecal contamination of the water.

Enteric: Of or within the intestine.

Enterococci: Enteric streptococcal (round) bacteria used to indicate fecal contamination and the possible presence of pathogens.

Enteric bacteria: Bacterial species that normally inhabit the intestinal tract of humans and animals. Included in this group of organisms are some of the most important intestinal pathogens of humans. Most enteric bacteria do not cause disease when confined to the intestinal tract of a healthy host, but given a susceptible host or an opportunity to invade other body sites, many have the capability to produce disease in any tissue.

Epidemiology: Study of diseases or other health-related states and events as they affect populations.

Fecal coliform: Subgroup of coliform bacteria that has a high correlation with fecal contamination associated with warm-blooded animals.

Fecal streptococci: Enterococci

Gastrointestinal: Of or relating to the stomach and intestines.

Guidance: Recommendations issued by EPA that do not have the force of law.

Indicator: A biological or chemical agent whose presence indicates specific environmental conditions or contaminants. Indicators of bacterial contamination of recreational water currently in use are the coliforms and enterococcus.

Infection: Introduction of a foreign organism into the body that can multiply and result in a physiological and immunological change from normal.

Interstitial water: The water contained in the spaces between sand grains or other sediment particles.

Pathogen: Organism capable of eliciting disease symptoms. The identification of microorganisms (*e.g.*, bacteria, viruses, or parasites) pathogenic to humans can be difficult. Therefore, the presence of coliforms in water is usually determined as an indicator of the possible presence of fecal-derived pathogens.

Pollution: The presence of a harmful contaminant in the environment.

Pseudomonas aeruginosa: Bacterial species found as normal flora in the gut of humans.

Sequelae: Long-term effects and consequences of a disease.

Standard: Legally binding limit on the amount of pollutant or emissions produced. EPA may establish minimum standards, but states are allowed to be stricter.

Staphylococcus: Type of bacteria commonly found as normal flora in the gut and other areas of humans.

Swash Zone: The area at the water's edge that is not always fully submerged and is influenced by tides and waves.

Tropical: In this document, refers to a hot and humid climate characteristic of the zone between the tropic of Cancer and the tropic of Capricorn.

Water quality criteria: Specific levels of pollutants which, if reached or exceeded, are expected to render a body of water unsuitable for its designated use. Commonly refers to criteria established by EPA.

Water quality guidelines: Specific levels of water quality criteria which, if reached or exceeded, may adversely affect human health or aquatic life. These are unenforceable guidelines issued by a governmental agency or other institution.

Water quality standards: State-adopted and EPA-approved standards for water quality measures.

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