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User Manual: Sanitary Surveys for Fresh Water with Recreational Uses

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Executive Summary

The U.S. Environmental Protection Agency (EPA) developed sanitary surveys and a corresponding app, the *EPA Sanitary Survey App for Marine and Fresh Waters,* to help managers of recreational waters in states, territories, tribes, and local jurisdictions identify and synthesize recreational water and watershed information–– including water quality data, pollutant source data, and land use data—so they can improve water quality for swimming. The intent is to provide states, territories, tribes, local governments, non-governmental organizations (NGOs), citizen science and environmental groups, and the public a technically sound and consistent approach to identify pollution sources, collect information on potential harmful algal bloom (HAB) events, and to share information.

The freshwater surveys consist of two surveys, a routine and an annual sanitary survey, to assist with short-term and long-term beach assessments. The *Freshwater Routine Sanitary Survey* is typically done when water quality samples are taken and collects current day data and captures the methods used to collect data during the routine survey. The *Freshwater Annual Sanitary Survey* is better for long-term assessments and collects information about factors in the surrounding watershed that might affect water quality. The annual survey includes, for example, information on septic tanks in the contributing watershed and land use information. This user manual provides guidance for completing the freshwater routine and annual sanitary surveys in the EPA's app and in paper format.

The sanitary survey provides valuable information that can be used to identify and address water quality issues. State public health and environmental programs can use the sanitary survey data to understand what's happening in their watersheds and to characterize potential human health risks from exposure to poor water quality. Managers can then use the risk information to rank their recreational waters and help determine appropriate priorities for monitoring water quality, notifying the public, and other activities. Managers can also use the sanitary survey to help identify sources of contamination that should be considered for remediation to reduce human health risks at swimming areas. The sanitary survey provides a documented historical record of the water quality for the recreational waterbody and the watershed. It serves as a baseline to which future assessments of the overall health of the recreational water and watershed can be compared, and it enables states, territories, tribes and local governments to perform long-range water quality and resource planning. This tool will help managers of recreational waters collect and share pollutant data for watershed assessments, use the data in models to predict water quality, and better enable them to remediate bacterial pollution sources and to identify potential HAB events in recreational waters.

Surveys can also be used for other purposes such as documenting conditions when new recreational areas open, at the beginning of the swimming season, or when waterbodies have been identified as problem areas. Sanitary surveys can also be a valuable tool for identifying and testing research hypotheses. While the surveys were initially developed for use in EPA's Beach Program, they can be used to assess water quality for any waterbody (lakes, rivers, streams, marine beaches), including gathering data on HABs.

For more information on sanitary surveys for recreational waters and the EPA's Beach Program, please visit our sanitary survey web page at https://www.epa.gov/beach-tech/sanitary-surveys-recreational-waters. You can send questions via the Contact Us link there.

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1. Overview

The U.S. Environmental Protection Agency (EPA) developed sanitary surveys for recreational waters and a corresponding app, the *EPA Sanitary Survey App for Marine and Fresh Waters*, to help states, territories, tribes, local jurisdictions and others monitoring and assessing water quality to identify and synthesize recreational waterbody and watershed information—including water quality data, pollutant source data, and land use data. The intent is to provide a technically sound and consistent approach to identify pollutant sources, collect information on potential HAB events and improve water quality for swimming. The freshwater surveys are based on the Great Lakes Beach Sanitary Survey and have been updated to include waterbody-specific questions for lakes and rivers/streams. As part of the Great Lakes Regional Collaboration, EPA's state and local partners helped develop and extensively field test the survey.

Sanitary survey information can be useful to a variety of audiences. Program managers of beaches and other recreational waters and public health officials use the information and it can be a valuable benefit for stormwater program managers, wastewater facility managers, other local officials, nongovernmental organizations, academic researchers, and others.

The *EPA Sanitary Survey App for Marine and Fresh Waters* was developed to make it easier to collect and share sanitary survey data and use the data to develop predictive models for making timely decisions. Users can complete surveys without the need for Wi-Fi or internet access and all their data are uploaded and stored in a central location on the EPA GeoPlatform at no cost. Data can only be accessed and viewed by the individual who submitted it but can downloaded in multiple formats and shared. The GeoPlatform includes tools such as data analysis for analyzing trends in water quality over time.

The freshwater surveys are tailored to the freshwater environment. A different set of surveys, the *Marine Sanitary Surveys for Recreational Waters*, is more appropriate to use with marine recreational waters. While paper versions of the freshwater sanitary surveys are also available, we encourage broad adoption and use of the app. Instructions for accessing the app can be found at https://www.epa.gov/beach-tech/sanitary-surveys-recreational-waters.

2. Introduction

2.1 Why did EPA create the Freshwater Sanitary Surveys?

EPA developed the freshwater sanitary surveys and the corresponding app, *EPA Sanitary Survey App for Marine and Fresh Waters*, to help states, territories, tribes and local governments synthesize all contributing information for the recreational waterbody and the watershed—including water quality data, pollutant source data, and land use data—so that they can improve water quality for swimming. Sanitary survey data (e.g., bacteria levels, source flow, turbidity, rainfall) can be used to develop models to predict daily water quality, if appropriate. The freshwater sanitary surveys can be used to assess both lakes and rivers/streams.

The EPA BEACH Act Grant program provides grants to states, territories, and tribes for beach monitoring and notification programs. As part of the program, grantees are required to prioritize beaches for monitoring. State beach program managers can use sanitary survey data to prioritize which beaches to monitor. While the Freshwater Sanitary Surveys were initially developed for use in EPA's Beach Program for the Great Lakes, these surveys can be used to assess water quality for any waterbody (e.g., lakes, rivers, streams), including gathering data on harmful algal blooms.

2.2 What are the Freshwater Sanitary Surveys?

The freshwater sanitary survey set consists of two surveys, a routine and an annual survey, to assist with short- and long-term assessments of recreational waters. The *Freshwater Routine Sanitary Survey* is designed to be completed each time water quality samples are taken. The current-day information for this survey is collected by observation and measurement at or near the beach or shoreline. The *Freshwater Routine Sanitary Survey* also allows users to document the methods used to collect the information. The *Freshwater Annual Sanitary Survey* is better for long-term assessments and records information about factors in the surrounding watershed that might affect water quality in the recreational water. This survey can include, for example, information on septic tanks in the contributing watershed or land use information, depending on the beach or waterbody being surveyed. Both surveys are available in paper and electronic (via the app) form.

2.3 What are the benefits of the Freshwater Sanitary Surveys?

The freshwater sanitary survey makes it easier to documented historical record of water quality for the recreational waterbody and the watershed. It serves as a baseline to which future assessments can be compared, and it enables managers of recreational waters and city/county planners to perform long-range water quality and resource planning. The sanitary survey also provides support for enforcement actions by establishing a record of conditions and operations at a point in time. The information in the survey also benefits stormwater program managers, wastewater facility managers, local elected officials, local planning authorities, academic researchers, and other beach and water quality professionals.

The freshwater sanitary surveys provide valuable information that can be used to support a variety of purposes, including the following:

- ***Characterize risk and prioritize beaches and other recreational waters.*** State public health and environmental programs can use the data collected with the sanitary surveys or the *Sanitary Surveys for Marine and Fresh Water* app to understand what's happening in their watersheds and to characterize potential human health risks from exposure to poor water quality. Managers of recreational waters can then use the risk information to rank their beaches and other recreational waters and help determine appropriate priorities for monitoring of water quality, notifying the public, and other activities.

- ***Identify appropriate remediation.*** Managers of recreational waters can also use the sanitary survey to help identify sources of contamination that should be considered for remediation to reduce human health risks at swimming areas.

- ***Facilitate waterbody and watershed planning.*** The sanitary surveys make it easier to document the historical record of water quality for the recreational waterbody and its surrounding watershed. The data can serve as a baseline for future assessments of recreational waters and associated watersheds and enables recreational managers and city/county planners to do long-range water quality and resource planning. The tool will help managers collect and share pollutant data for watershed assessments.

- ***Develop predictive models.*** Managers of recreational waters can use sanitary survey data (e.g., bacteria levels, source flow, turbidity, rainfall) to help develop models to predict daily recreational water quality, if desired and appropriate.

- ***Support other uses.*** Surveys can also be used for other purposes such as documenting conditions when new recreational areas open, at the beginning of the swimming season, or when waters have been identified as problem areas. Finally, sanitary surveys are a valuable tool for identifying and testing research hypotheses.

2.4 Who are the intended users of the survey?

Local managers of recreational waters and public health officials can use the survey to identify bacterial sources of pollutants affecting beaches, assess beach health, share information, and conduct watershed planning. The surveys can be used by anyone trained in gathering sanitary survey data and interested in understanding pollution sources impacting any waterbody.

2.5 How can the Freshwater Sanitary Survey be used in a BEACH Act Grant Program?

The freshwater sanitary survey will help beach managers meet the requirements of the BEACH Act Grant Program, as described in the National Beach Guidance and Required Performance Criteria for Grants-2014 Edition (USEPA 2014b).

The Beach Guidance lists 11 grant performance criteria a state must meet when developing and implementing a beach monitoring and notification program. Two grant performance criteria encourage use of sanitary surveys to develop a risk-based approach and to develop a tiered plan for developing and implementing a beach monitoring and notification program.

Chapter 4 of the Beach Guidance describes the use of predictive tools and models to minimize swimmer risk in the recreational water (USEPA 2014b). Models are used at coastal and Great Lakes beaches across the nation. Data collected using a sanitary survey will help a beach manager identify the beaches where a model would benefit the beach monitoring and notification program.

2.6 How is this user manual organized?

This user manual is intended to be used as a reference for completing the freshwater routine and annual sanitary surveys in EPA's app and in paper format.

- Section 3 describes the freshwater sanitary surveys and provides background information on the sanitary survey process.
- Section 4 describes steps to consider in preparing to conduct a sanitary survey.
- Sections 5 and 6 provide detailed information on how to complete each type of survey.
  - The data elements for the *Freshwater Routine Sanitary Survey* are in Section 5.

- The data elements for the *Freshwater Annual Sanitary Survey* are in Section 6.
- The subsection numbers correspond with the numbered sections of the survey.

Screen shots of the app's *Freshwater Routine Sanitary Survey* are provided in this manual. Due to the length and the level of detail in the *Freshwater Annual Sanitary Survey*, the screen shots for that survey are not included here. For information on how to access and use the *EPA Sanitary Survey App for Marine and Fresh Waters* app go to https://www.epa.gov/beach-tech/sanitary-surveys-recreational-waters.

2.7 Disclaimers

The user manual is a companion document for the *Freshwater Routine Sanitary Survey* and *Freshwater Annual Sanitary Survey*. It is intended to provide supplemental discussions, examples and additional references that may be helpful to program managers of recreational waters and others as they conduct sanitary surveys. The user manual does not impose any legally binding requirements on EPA, states, territories, tribes or the regulated community. It is informational only and thus does not establish additional requirements for EPA's BEACH program or other programs. The document may be revised from time to time.

Reference herein to any specific commercial products, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government and shall not be used for advertising or product endorsement purposes.

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3. Types of Sanitary Surveys

3.1 Background

Because freshwater beaches are dynamic systems, they need to be monitored routinely for short- and long-term health risks. EPA has developed two types of sanitary surveys—the *Freshwater Routine Sanitary Survey* and the *Freshwater Annual Sanitary Survey*—to assist with short- and long-term assessments. The *Freshwater Routine Sanitary Survey* is typically conducted during routine monitoring when collecting water quality samples, and it supports the annual survey. This survey includes questions on survey methods used to gather data. The *Freshwater Annual Sanitary Survey* should be completed at least once a year and can be based on field observations and/or results from routine sanitary surveys. Both surveys are included in the *EPA Sanitary Survey for Marine and Fresh Waters* app.

3.2 Surveys

The sanitary survey offers two different approaches to collect and assess information. The surveys are briefly described here and fully described in Sections 5 and 6.

Routine Sanitary Survey

The *Freshwater Routine Sanitary Survey* is designed to be used each time a water sample is collected during regular bacterial monitoring to supplement information collected during water quality sampling. The survey will help to provide useful information on water quality to support the annual surveys. The *Freshwater Routine Sanitary Survey* will help identify underlying conditions in the recreational water that can be observed frequently (e.g., wind speed and direction, wave height, rainfall) and that can contribute to microbiological contamination of the recreational waters and beach areas. The app also collects information on potential harmful algal blooms. This survey is more local and site-specific than the *Freshwater Annual Sanitary Survey*. The *Freshwater Routine Sanitary Survey* includes questions to document the methods used for collecting survey data.

Over time, collecting sanitary survey data with every sample will aid those looking for correlation between conditions in the recreational water and water quality (i.e., fecal indicator bacteria [FIB] levels), leading to the development of predictive models. The data could help show whether bacteria levels correlate to other parameters or observable conditions at a beach or waterbody. Before you conduct your first *Freshwater Routine Sanitary Survey*, perform an initial assessment of the beach or waterbody. Review all available information including historical data and knowledge, uses, and possible sources of bacterial contamination. EPA recommends that you perform at least one routine sanitary survey before the start of the swimming season.

Annual Sanitary Survey

The *Freshwater Annual Sanitary Survey* requires the same type of information collected for the *Freshwater Routine Sanitary Survey* plus area maps, annual and seasonal trends, and additional information on potential sources of contamination. This survey expands geographically to include the contributing watershed and surrounding shoreline.

Ideally, an annual survey should be conducted on each swim area once a year to determine the condition of the water, locate potential pollutant sources, and determine whether there are other issues that can affect water quality. This survey can be performed at the end of a swim season, before the next season begins. That way, you can determine whether you should make any changes to your monitoring program before the next season starts.

In addition, a sanitary survey should be conducted as part of any proposal to expand or develop a recreational swim area or when a newly proposed activity would significantly alter the water quality in an existing recreational swim area. Managers should use the findings of the survey as a prime consideration in any decision to proceed with development. In some states, such as Maryland, a permit for operating a bathing beach may not be issued unless the sanitary survey demonstrates that the beach does not represent a public health risk (Code of Maryland Regulations [COMAR] 26.08.09.03).

EPA has provided a comprehensive, detailed sanitary survey that gives states, territories, tribes and localities a consistent way to share and compare the results of their investigations. In some cases you might want to use only portions of the survey or tailor it to better fit your program's needs. For detailed discussion of the sanitary survey's purpose, consult Section 4.4.

3.3 When should sanitary surveys be conducted?

Sanitary surveys should be conducted to develop or continue a historic record of water conditions and sources of pollutants. They should be used when new swim areas open, at the beginning of the swimming season, and when waters have been identified as problem areas. In addition, you could perform sanitary surveys periodically during a swimming season, when an emergency situation occurs, when a bacterial exceedance is detected, or more frequently (depending on the length of the swim season) to assess sudden changes in water quality (CTDEP 1992; Figueras et al. 2000; Great Lakes-Upper Mississippi River Board of State Sanitary Engineers 1990).

4. Steps for Conducting a Sanitary Survey

4.1 Seek the Assistance of Professional Staff

Before you begin preparing to conduct a sanitary survey, if possible, consult a public health official or a registered sanitarian. EPA recommends that a public health official or registered sanitarian from a state, tribal, or local agency maintain primary responsibility for overseeing the performance of annual sanitary surveys of the recreational water. Lifeguards or citizen volunteers may be used to help complete or gather information for the *Freshwater Routine Sanitary Survey* at the same sampling stations at which they perform bacterial monitoring for a state, tribal, or local agency. Volunteers should be properly trained in completing the survey forms and in using the methods chosen to collect information for the survey (Section 4.5).

4.2 Make an Initial Assessment of Swim Areas

The next step in preparing to conduct a sanitary survey is to make an initial assessment of all swim areas to identify at which ones a sanitary survey should be conducted. During this assessment, compile known data on swim areas with past problems and those that have and have not been sampled for microbial analysis.

4.3 Make an Initial Assessment of the Contributing Watershed

The watershed, basin, or land area contributing runoff to a swim area can vary widely depending on the nearby area. For some beaches, for example, the contributing area could be simply the area from the dunes down to the shoreline. There might not be a stream or river nearby that is contributing drainage from a large land area. The water in a large lake might be coming from other watersheds through long-shore currents; in such a case, you might want to investigate the direction from which water entering the system is coming. During the initial assessment, you might not be sure about whether an area is a contributing area. The sanitary survey process can be used to investigate further and rule something out or confirm that it is contributing drainage to the swim area.

As part of the initial assessment, you should consider information from other Clean Water Act programs that might provide relevant water quality data and information on potential sources of pollutants affecting the swim area.

- *National Pollutant Discharge Elimination System (NPDES).* The NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. For more information on the NPDES permit program, visit https://www.epa.gov/npdes.
- *Nonpoint Source Management Program (Clean Water Act 319).* The Clean Water Act section 319 Nonpoint Source Management Program helps focus state, tribal, and local government nonpoint source efforts. Under section 319, states, territories, and tribes receive grant money that supports a wide variety of activities, including monitoring to assess the success of specific nonpoint source implement tation projects. For more information on the section 319 Nonpoint Source Management Program, visit https://www.epa.gov/nps/319-grant-program-states-and-territories.
- *Total Maximum Daily Load (TMDL) program.* States develop TMDLs for waterbodies that are listed as water quality-limited or impaired because of pollution, including fecal contamination. A TMDL identifies the pollutant sources and the necessary reductions in those sources to achieve water quality standards. For more information on the TMDL program, visit https://www.epa.gov/tmdl.
- *305(b) water quality reports.* Under section 305(b) of the Clean Water Act, states are required to submit a biannual report to EPA that provides water quality information (including information on 303[d]-listed waters) to the public. The information the states provide serves as the basis for EPA's National

Water Quality Inventory Report to Congress. This document characterizes the water quality, identifies widespread water quality problems of national significance, and describes various programs implemented to restore and protect waters throughout the United States. For more information on 305(b) reports, visit https://www.epa.gov/waterdata/national-water-quality-inventory-report-congress.

4.4 Determine the Purpose and Identify the Appropriate Form

After the swim areas have been assessed and identified for a sanitary survey, determine the purpose of the survey (e.g., to characterize risk and prioritize waters, support planning for the recreational waterbody and the watershed, develop predictive models), and develop a plan. The plan should have goals and timelines to identify sources, gather data, conduct monitoring, analyze results, develop a sanitary survey report, and discuss next steps. EPA developed two surveys (*Freshwater Routine Sanitary Survey* and *Freshwater Annual Sanitary Survey*) on the basis of how frequently the surveys would be performed and what resources would be available to the manager of recreational waters. For a detailed description of the surveys and their uses, consult Sections 3.2.

The sanitary surveys will help you to determine the following:

1. An approach to address all the data elements necessary to complete the forms and best describe the conditions at a beach.
2. Which data elements are currently collected through an existing monitoring plan and which additional data elements need to be collected.
3. The equipment and supplies needed to collect the data.
4. The agencies or groups responsible for collecting and analyzing the data.

Sections 5 and 6 provide descriptions of the survey data fields. Not all of the questions on the surveys are applicable to all recreational waters. In addition, you might want to collect specific data for your swim area that are not included on the surveys. You can amend the surveys to best fit your needs.

4.5 Use Trained Staff

The staff who perform the sanitary surveys should be adequately trained in sampling procedures, equipment use, completing the surveys, and health and safety precautions before they begin to perform sanitary surveys. EPA recommends that relevant quality assurance (QA) documentation (e.g., quality assurance project plan, sampling and analysis plan, standard operating procedures [SOPs]) be distributed to all participants during training. The training should stress the importance and relevance of the sanitary surveys in helping to identify potential sources of contamination, how to conduct quality control (QC) activities, and how to follow the protocols specified in the SOPs. The quality of information produced by the sanitary surveys depends on the quality of the work that the field staff and others involved in the beach program perform. Follow-up or continuing training should be held as needed for as long as the sanitary surveys are performed.

4.6 Collect Data

Now that you have identified the beaches to survey and the data to be collected, it's time to collect data. Gather maps and use tools like global positioning system (GPS) units to identify the locations of beach sampling stations, pollutant sources, and watershed uses. The *EPA Sanitary Survey App for Marine and Fresh Waters* will automatically geolocate your beach or pollution sampling location in the field.

Sources of maps include the U.S. Geological Survey (USGS), county/state offices, online companies (e.g., GoogleEarth), and others. You can download USGS topographic maps for your watershed at https://www.usgs.gov/core-science-systems/national-geospatial-program/topographic-maps. Think about other sources of data for your recreational waterbody and the watershed, such as local or state universities or other government offices. Sources of data might vary depending on your waterbody's location and the level of interest in your region. For more ideas on where to find data, consult Section 6.3.

Collect data on water quality and other parameters to complete the *Freshwater Routine Sanitary Survey* and meet the data needs you identified for the *Freshwater Annual Sanitary Survey* in Section 6.

Follow the QA/QC procedures listed in Appendix A.

4.7 Document All Observations and Data Sources

No field data collection is complete without basic information on who collected the data and when. Sometimes basic field observations that might seem insignificant turn out to be very important, but they won't be useful unless they are documented. Also, other personnel will likely use the data you collect in the future, and your documentation will be essential to their ability to understand the data.

4.8 Consider Health and Safety

Health and safety should be a key consideration for all volunteers and others engaged in surveying and monitoring. The fact that surveying and sampling might focus on areas in close proximity to combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) and might be conducted during periods of beach closure suggests that the risk of potential exposure to pathogenic agents will be higher than that of recreational beach users. Heightened awareness of personal protection is the responsibility of every member of the survey team. The effective use of basic personal protective equipment and supplies can significantly limit exposure to potentially contaminated waters. For instance,

- Limit exposure of any open wounds to survey site waters.
- Carry a hand sanitizer and use it immediately after working at each survey location. (Use care when collecting samples not to make any contact with the inside of the sample containers.)
- Wear latex gloves, rubber boots, and safety glasses when contact is required or during sampling to minimize the potential for direct exposure to surface waters that are potentially contaminated.
- Carry a spray bottle with dilute bleach solution as part of your survey supplies for immediate disinfection if accidental exposure occurs.
- Practice good personal hygiene.
  - Avoid direct hand-to-mouth, -nose, or -face contact in the field.
  - Avoid eating, drinking, or chewing gum during site surveys. Delay drinking or consuming snacks and meals until you have removed all personal protective equipment and washed your hands and face thoroughly.
  - Promptly shower and wash your clothing with hot water after a day of surveying.

Although your survey activity might not entail longer or closer contact with surface water than the exposure of swimmers, fishermen, or others, surveys might be required in less desirable areas or during beach closures mandated by measured exceedances of recreational standards.

4.9 Record Data for the Annual Sanitary Survey

After you have collected your data, you can use the *Freshwater Routine Sanitary Survey* data to complete the *Freshwater Annual Sanitary Survey*. All field data should be entered onto the paper survey or the app and stored electronically. It is important to provide all data to and consult with a sanitarian or public health official when analyzing the data and assessing the effects of a pollutant source on a beach.

4.10 Record Management

As mentioned earlier, everything should be well documented, including the person who enters the data, the person who completes the survey, sources of information, and so forth. The *EPA Sanitary Survey App for Marine and Fresh Waters* makes data collection and download in several file formats easy, and data storage free. However, if using the paper surveys, copies of completed paper surveys should be collected, scanned into an electronic format, and stored together, if possible. EPA suggests storing the survey data in a locally accessible database.

4.11 How to Use the Sanitary Survey Data

Analysis of survey results. Although you will perform some analyses while conducting the sanitary survey (the annual survey in particular), after you are finished with the surveys, you should go through the survey results thoroughly and develop a Sanitary Survey Report (described next). For the *Freshwater Routine Sanitary Survey*, you should evaluate the results at the end of the swim season (which might be done as part of the *Freshwater Annual Sanitary Survey*), as well as periodically throughout the season. Evaluating the survey results during the swim season can help you identify trends that you should be aware of, such as "rainfall over 0.5 inches correlates with high bacteria counts," or "algae growth has become worse and needs to be dealt with." You should also evaluate whether you are collecting appropriate data, whether your methods of data collection need to be adjusted, or both.

Sanitary Survey Report. A written Sanitary Survey Report is needed to integrate the data into a comprehensive information analysis. This report should include a compilation of all data collected, an analysis of those data using recognized statistical techniques to determine adverse pollution conditions, conclusions as to the appropriate monitoring strategy and frequency, and recommendations for necessary follow-up actions such as remediation efforts or further investigations.

Resource allocation and beach assessment. Analyzing the sanitary survey data will help you determine data trends and correlations with bacteria sample results. It will provide you with more information to identify pollutant sources and their contribution to water quality impairment. That information, in turn, will help you decide on future allocation of resources and possible remediation needs. The information will also help you to more effectively prioritize swim areas for monitoring frequency and resource allocation.

The sanitary survey can help you determine the best frequency of monitoring (e.g., daily, biweekly, weekly, monthly); the number of samples that should be collected (e.g., one sample collected every 500 meters); and the types of remediation activities that should be performed at your recreational area (e.g., educate pet owners, improve plumbing at public restrooms).

Remediation steps. The results of the sanitary survey will help a manager of recreational waters identify persistent problems, sources of pollutants, and the magnitude of pollution from those sources. The manager will have a documented record of the pollutant sources to use to propose management actions, enforcement, and options to control sources. After the source and extent of pollutants are determined, appropriate remediation activities can be planned with the assistance and collaboration of federal, state, and local programs.

Modeling. Data from sanitary surveys might help a manager of recreational waters identify factors that correlate with bacteria counts in the water. It might be possible to develop a predictive model using these data. A predictive model can benefit a beach monitoring and notification program by allowing managers of recreational waters to make advisory decisions based on predicted high levels of pathogens before people become exposed. An example of a predictive model that is relatively easy to develop is the rainfall advisory model, which statistically correlates the bacteria results with rainfall data collected during the routine sanitary survey.

EPA has conducted research and developed guidance on predictive tools. Predictive Tools for Beach Notification Volume I: Review and Technical Protocol summarizes modeling approaches and associated considerations. The guidance document *Six Key Steps to Developing and Using Predictive Tools at Your Beach* provides a simple, straightforward approach to developing a predictive model for a beach. These documents can be found at https://www.epa.gov/beach-tech/models-predicting-beach-water-quality.

Sharing information. As part of the sanitary survey process, you may choose to electronically store the survey data electronically locally and/or on the EPA GeoPlatform when you use the *EPA Sanitary Survey App for Marine and Fresh Waters*. This approach will make it easier for you to share your data with other counties, agencies, and states.

5. Data Elements for the Freshwater Routine Sanitary Survey

This section describes the data fields for the *Freshwater Routine Sanitary Survey*. While it contains screen shots to show how to collect data using the app, it also contains information that could be useful in collecting information using the paper surveys. For each data field, it gives an example of the data followed by a detailed description and an explanation of methods that you can use to collect the data. Section 6 describes the data fields for the *Freshwater Annual Sanitary Survey*.

The *Freshwater Routine Sanitary Survey* should be filled out each time a water sample is taken for bacterial analysis. The information in this survey is primarily information that can be gathered locally, at the recreational water.

5.1 General Information

This section collects information on swim area identification and location. If you are using the *EPA Sanitary Survey App for Marine and Fresh Waters*, there are only a few required fields (designated with a red asterisk [*]) that must be completed to submit data collected (e.g., beach name, surveyor name and affiliation, time and date of the survey). The remaining fields are voluntary; fill the ones most useful for your program.

Start the survey by selecting the waterbody type being surveyed and then provide basic information about the beach or waterbody, such as the name, ID, surveyor name, surveyor affiliation and location. The Beach IDs you use should include the one you submit to EPA for the PRAWN database, https://watersgeo.epa.gov/beacon2/Beacon.html. If you have a separate ID for other purposes, you may list that as well. Include the Sampling Station ID and Water Quality Exchange (WQX) Organization ID (https://www.waterqualitydata.us/portal/) when possible (Figure 1). In the EPA *Sanitary Survey App for Marine and Fresh Waters* links are available to specific databases to search for these IDs. The app does not autopopulate this information, so you will need to manually enter this information.

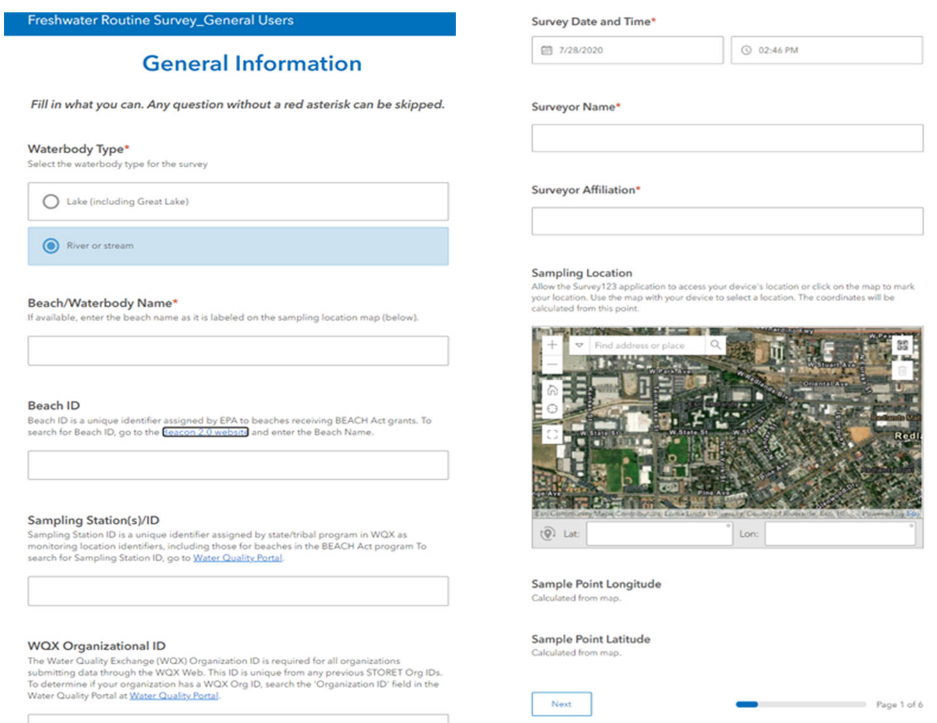


Figure 1. Freshwater Routine Sanitary Survey Beach Location Information Section

Identifying your site or sample location is easy in the *EPA Sanitary Survey App for Marine and Fresh Waters* because the app automatically pinpoints your location in the field even without a Wi-Fi connection (Figure 2). Your current location is shown by an arrow on the map and by latitude and longitude calculated.

To change your location, click on the map shown in the Sampling Location section of the survey. To change the location, enter the new location in the search field or scroll through the map to the designated point. To confirm the location, select the checkmark (✓) at the bottom right corner of the page.

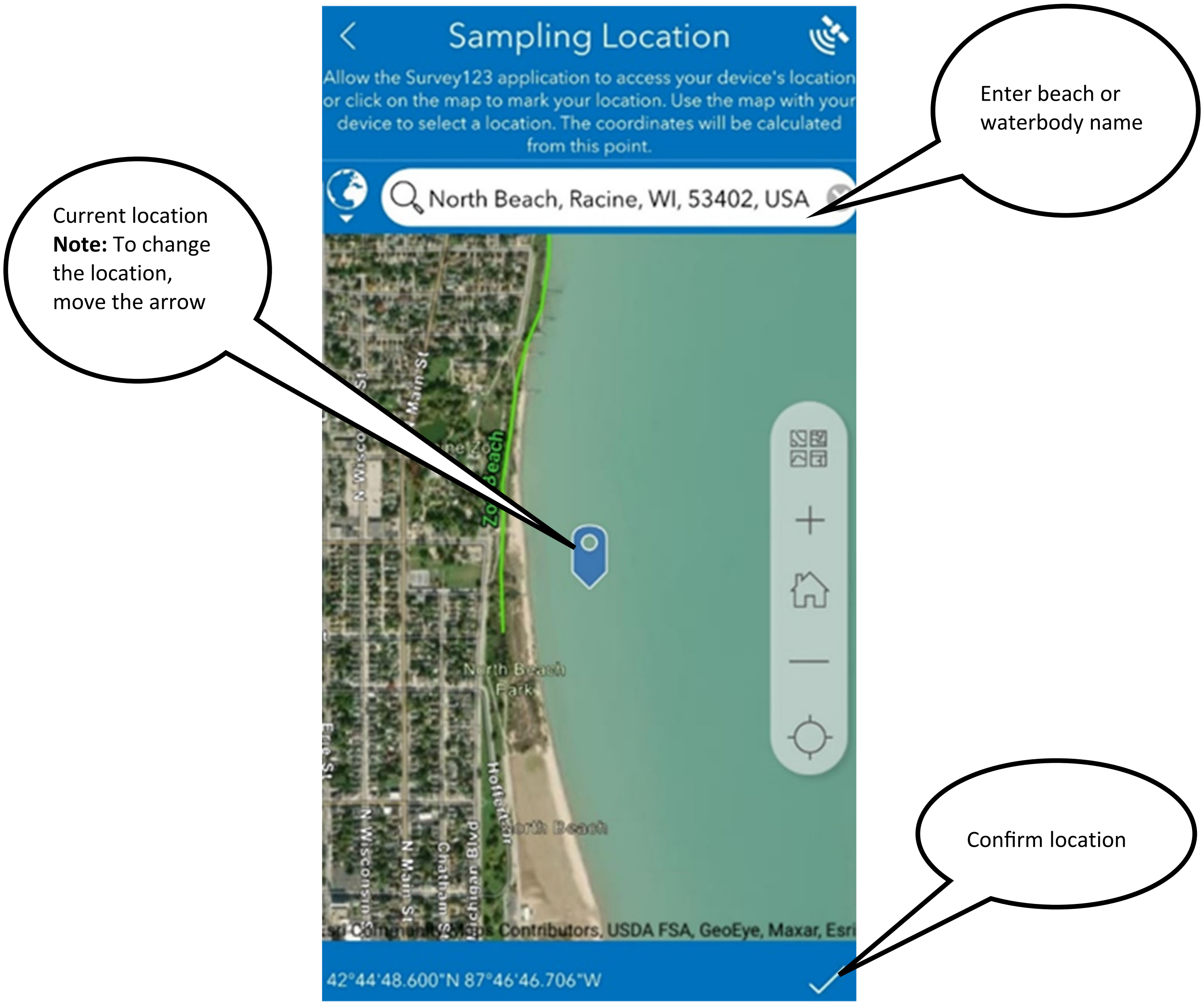


Figure 2. Adding Geolocational Information

5.2 *Quality Assurance Project Plan (QAPP) Requirement*

Most agencies should already have Quality Assurance/Quality Control (QA/QC) procedures for performing monitoring. These procedures should be updated, as needed, to include QA/QC procedures for performing sanitary surveys. States, territories, tribes, and local agencies should use the information in this document and follow their agency-specific QA/QC procedures for data collection, entry, and analysis when performing sanitary surveys. App users are required to certify that sanitary survey data are collected using an approved QAPP and provide a link or submit a copy of the approved QAPP in order to submit their sanitary survey data to the GeoPlatform (Figure 3). More information on QA/QC can be found in Appendix A.

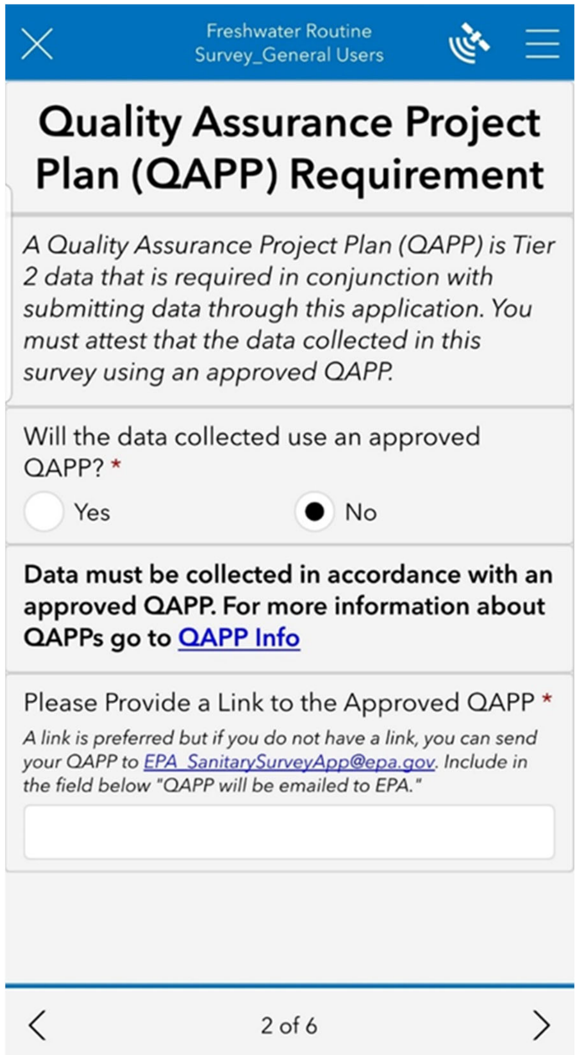


Figure 3. Quality Assurance Requirement to Submit Data

5.3 Part 1: Weather & General Waterbody Conditions

Air temperature

Example
75 °F, 24 °C

Description
Air temperature, in combination with other conditions and situations, such as timing (e.g., after significant rainfall) or a particular wind direction, can increase of the likelihood of higher levels of microorganisms at certain times.

Methods
Liquid-in-glass thermometers are the most common types of thermometers because they are easy to read and inexpensive to manufacture. Highly accurate electrical thermometers measure temperature by measuring the electrical resistance of some material. Because the resistance of these materials changes with temperature, the resistance can be measured and calibrated to the temperature.

Temperature measurements are typically taken at 1.5 meters above grassy surfaces. Ideally, the thermometer should be housed in an instrument shelter that is away from materials that might absorb heat and prevent an accurate air temperature reading. All air temperature readings are conducted in the shade to prevent sunlight from warming the liquid in the thermometer. Instrument shelters should allow air to flow through freely to ensure that the air in the shelter is not warmed by the shelter itself.

Report air temperature in the Fahrenheit or Celsius temperature scale, specifying which one was used (Figure 4a).

Wind speed and direction

Example
East at 5 knots or light breeze

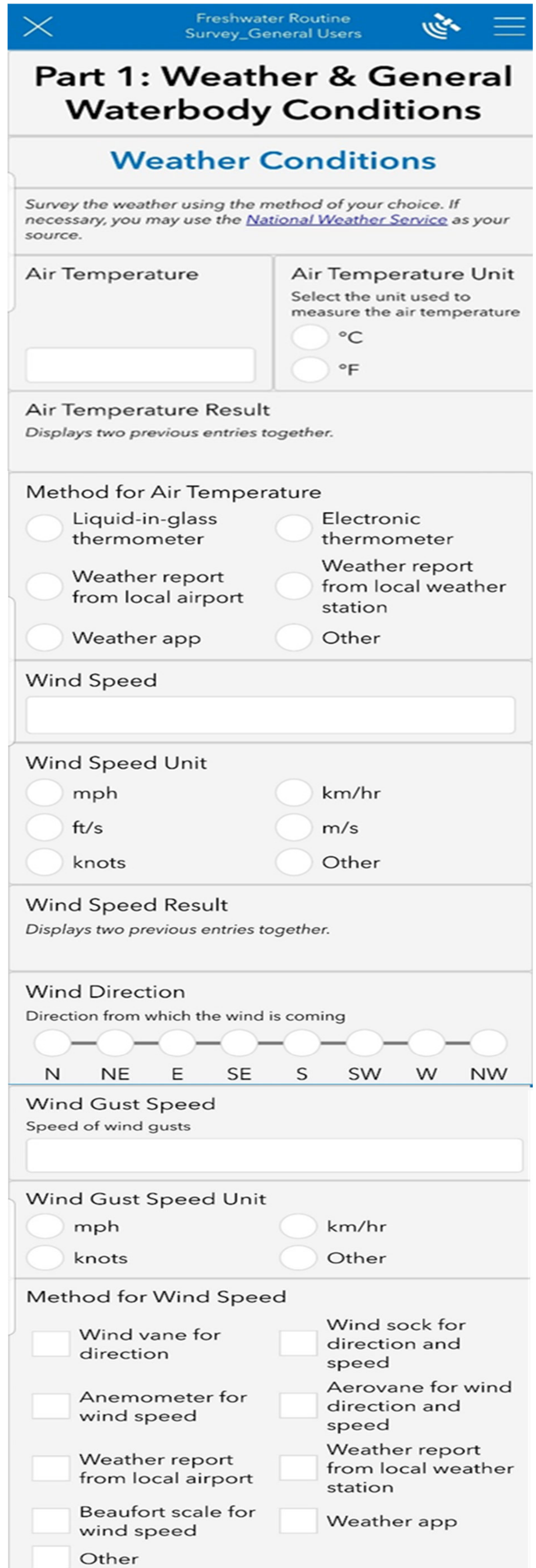
Description
A description of the wind speed and direction using the Beaufort Wind Scale, which can be found at https://www.spc.noaa.gov/faq/tornado/beaufort.html, might provide valuable information concerning the actual or potential effect of pollutant transport to the area.

Methods
Wind is difficult for forecasters to measure because wind speed and direction can vary quickly and abruptly over short distances, especially in cities and other areas with many obstructions.

An anemometer is the main instrument used to measure the speed of the wind. It consists of three or four hemi-spheric cups, mounted on each end of a pair of horizontal arms, which lie at equal angles to each other. A vertical shaft that the cups turn passes through the center of the arms, and a train of wheel-work counts the number of turns the shaft makes. From the number of turns made in any given period, the velocity of the wind during that period is calculated.

Aerovanes are commonly used at many weather stations and airports to measure wind direction and speed. The tail orients the instrument into the wind for direction, while the propellers measure the wind speed.

If you do not have the necessary equipment to measure wind speed and direction, you can provide data from a weather app or nearby weather station, ideally one within a 5-mile radius of the beach. If you use a nearby weather station, note in the survey the distance to the station.


Freshwater Routine
Survey_General Users

Part 1: Weather & General Waterbody Conditions

Weather Conditions

Survey the weather using the method of your choice. If necessary, you may use the National Weather Service as your source.

Air Temperature

Air Temperature Unit
Select the unit used to measure the air temperature
°C
°F

Air Temperature Result
Displays two previous entries together.

Method for Air Temperature
Liquid-in-glass thermometer
Electronic thermometer
Weather report from local airport
Weather report from local weather station
Weather app
Other

Wind Speed

Wind Speed Unit
mph
km/hr
ft/s
m/s
knots
Other

Wind Speed Result
Displays two previous entries together.

Wind Direction
Direction from which the wind is coming
N NE E SE S SW W NW

Wind Gust Speed
Speed of wind gusts

Wind Gust Speed Unit
mph
km/hr
knots
Other

Method for Wind Speed
Wind vane for direction
Wind sock for direction and speed
Anemometer for wind speed
Aerovane for wind direction and speed
Weather report from local airport
Weather report from local weather station
Beaufort scale for wind speed
Weather app
Other

Figure 4a. Weather & General Waterbody Conditions

Wind direction is always reported as the direction from which the wind is coming. In other words, a north wind pushes air from the north to the south. When reporting wind speeds, always provide the units (e.g., miles per hour [mph], kilometers per hour [km/h], knots). (1 knot = 1.15 mph.) (Figure 4a).

Rainfall

Example
72+ hours. Rainfall amount was 1.2 inches.

Description
Bacterial contamination at swimming areas can result from rain events. CSO discharges can occur during heavy rainfall events and can reach swimming areas, causing contamination problems. In addition, nonpoint source pollution can be caused by rainfall or snowmelt moving over and through the ground and carrying natural and human-made pollutants into the receiving water.

Rainfall measurements can be used in models to predict bacterial contamination in recreational waters during rainfall events (USEPA 1999). It is also important to document whether the rain event occurred within 72 hours of a previous rain event to help differentiate between dry-weather and wet-weather contamination sources.

Rain intensity should also be noted. Rain events that are of short duration but high intensity can cause higher runoff than longer rain events of low intensity, possibly correlating more with increased bacteria levels in the water. Rain intensity can be noted by using hourly intervals, or 12-hour totals for rainfall events, and this information can be found through the use of radar-based data such as that available on https://www.wunderground.com/ and other database websites. Weather apps are also another source of rainfall data.

Methods
Record the amount of rainfall in inches or centimeters, as well as the time (24, 48, 72, or more hours) since the rainfall event occurred. If rainfall is measured using a rain gauge near the sampling stations (weather station or airport), record the distance from the rain gauge in miles. Also note the intensity of the rainfall. If two storms occurred back to back, indicate the relative amounts of rainfall if known, along with the duration of the storm for each (include this information in Comments/Observations (Figure 4b). You can use websites such as https://www.ncdc.noaa.gov to gather very specific rainfall estimates for any location in the United States. You can also obtain rainfall data from your local weather station or

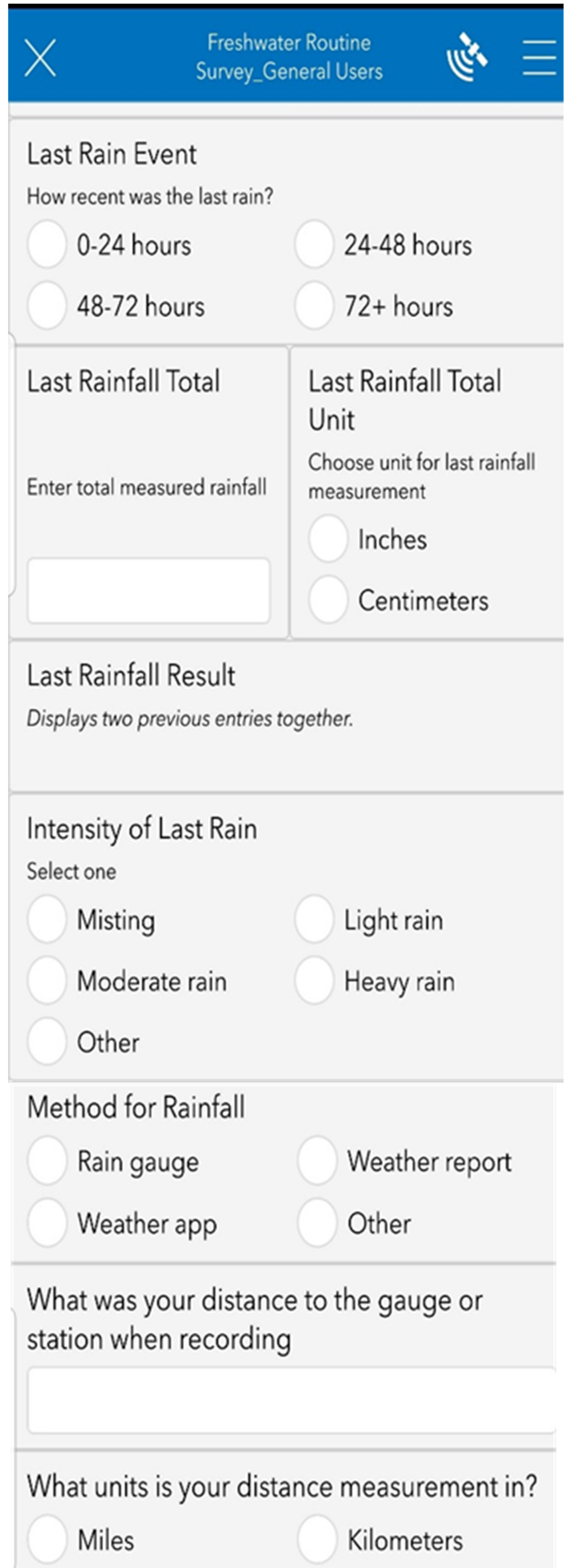


Figure 4b. Weather & General Waterbody Conditions—Continued

from wunderground at https://www.wunderground.com/wundermap/.

Sky conditions

Example
Partly cloudy (3/8 to 4/8 coverage)

Description
The predominant/average sky condition is described by using octants (eighths) of the sky covered by opaque (not transparent) clouds. The National Oceanic and Atmospheric Administration (NOAA) uses the following scale:

Sky condition	Cloud coverage
Sunny	0/8
Mostly sunny	1/8–2/8
Partly cloudy	3/8–4/8
Mostly cloudy	5/8–7/8
Cloudy	8/8

Method
Estimate the weather or provide information from a nearby weather station, https://www.wunderground.com/, or a weather app (Figure 4c).

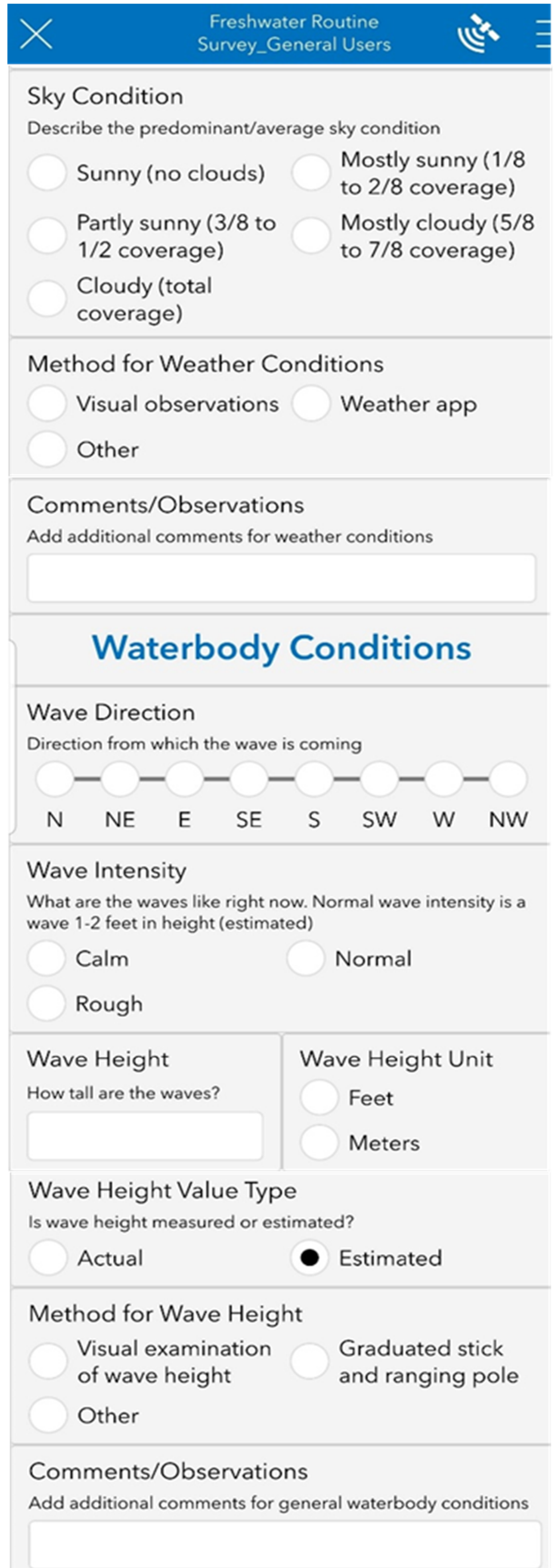
Wave intensity and height

Example
Normal intensity, 1–2 feet in height (estimated)

Description
Waves are the main source of energy that causes beaches to change in size, shape, and sediment type. They also move marine debris between the beach and the offshore zone. Waves are generated by the wind blowing over water. Waves formed where the wind is blowing, which are often irregular, are called wind waves. As these waves move away from the area where the wind is blowing, they sort themselves out into groups with similar speeds and form regular patterns known as swells.

The three main characteristics of waves are the height, the wavelength, and the direction from which they approach. Wave height is the vertical distance from the crest of the wave to the trough. Wavelength is the time, measured in seconds, between two successive wave crests. Wave direction is the direction from which the waves approach.

Bacteria permeating wet sands can be carried away by waves, increasing bacteria levels in the adjacent waters.


Freshwater Routine Survey_General Users

Sky Condition
Describe the predominant/average sky condition
Sunny (no clouds)
Mostly sunny (1/8 to 2/8 coverage)
Partly sunny (3/8 to 1/2 coverage)
Mostly cloudy (5/8 to 7/8 coverage)
Cloudy (total coverage)

Method for Weather Conditions
Visual observations
Weather app
Other

Comments/Observations
Add additional comments for weather conditions

Waterbody Conditions

Wave Direction
Direction from which the wave is coming
N NE E SE S SW W NW

Wave Intensity
What are the waves like right now. Normal wave intensity is a wave 1-2 feet in height (estimated)
Calm
Normal
Rough

Wave Height
How tall are the waves?

Wave Height Unit
Feet
Meters

Wave Height Value Type
Is wave height measured or estimated?
Actual
Estimated

Method for Wave Height
Visual examination of wave height
Graduated stick and ranging pole
Other

Comments/Observations
Add additional comments for general waterbody conditions

Figure 4c. Weather & General Waterbody Conditions—Continued

Studies at beaches along the southern shore of Lake Michigan have also shown that *Escherichia coli* concentrations in the sands of the swash zone are high, or higher, than those of the water (Whitman 1999). When storm winds initiate waves and direct them onto the beaches, the foreshore sand is eroded and "stored" bacteria are released into the water, raising the *E. coli* concentrations to levels above the allowable threshold for full body contact (Whitman 1999; Whitman et al. 2003a).

Method
Wave height is measured by carrying a graduated stick or a ranging pole (a pole with measured sections in red and white) out into the water to just seaward of where the waves are breaking and then recording where the wave crest and the following wave trough cut the stick. The difference between the two is the wave height. Alternatively, you can estimate the wave height. Such estimates should be made in the units with which you are most comfortable. Often it is best to have two observers independently estimate wave height and then compare their results. Measure or estimate the height of at least five separate waves, and then take the average. Also note the wave intensity on the survey (Figure 4c).

Water Flow Speed (Rivers/Streams)

Example
50 ft/s

Description
The speed at which water flows is called as the velocity of water. Surface water velocity is the direction and speed with which the water is moving, measured in feet per second (ft/s) or meters per second (m/s) (Figure 4d).

Methods
Measure velocity in a straight section of the stream or reach that has a stable bottom. Velocity can be measured using a velocity meter (sometimes called a flow meter). It is important to stand downstream and to the side of the velocity meter when taking measurements and to operate the meter properly.

Current velocity meters are available as mechanical or electronic units. A current velocity meter consists of a sensor or current meter, the support system for the sensor, and a counter. The signal from the sensors or current meter is processed or read by the counter. Many factors must be considered when selecting the proper current measuring equipment. In general, you should know if you will be measuring current from an overhead structure or while wading. It also helps to know the approximate

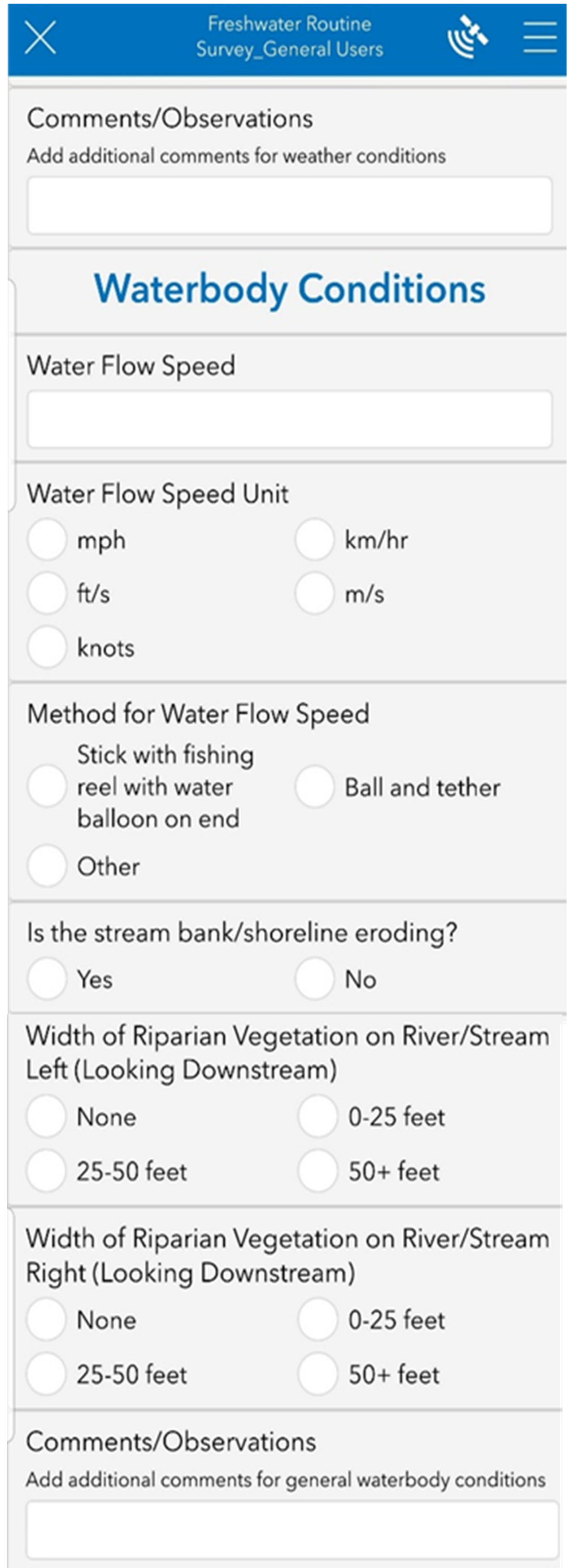


Figure 4d. Weather & General Waterbody Conditions—Continued

speed of the water to be measured because there are specialty meters available for very slow currents, and those are most likely what is present in recreational waters. Training and experience are necessary to operate current velocity meters consistently and to select appropriate stream reaches for taking measurements.

Velocity estimates can be obtained using an orange or a floating ball and a stopwatch. The measurement is the time it takes the floating object to travel downstream a pre-measured (and pre-marked) distance (e.g., 10 meters). Consult the procedure given earlier for longshore current speed measurement.

Riparian Vegetation on River/Stream Left/ Right (Looking Downstream)

Example
0-25 feet

Description
Riparian zones are the lands along streams and rivers that maintain water quality and the ecological health of communities along the water. Riparian zone width is often defined by the vegetation, since plants requiring the wet soils characteristic of riparian zones are usually different from those in the surrounding areas. Riparian vegetation helps stabilize the streambanks, provides cover and food for fish, and intercepts solar radiation (Platts et al., 1983).

Methods
The width of riparian vegetation on the river/stream is estimated visually (Figure 4d).

Aquatic Organism Passage Barrier

Example
Outlet drop of 3.5 ft; severity of any barrier debris is minor - <10% open area of structure blocked (Figure 4e).

Description
Road-stream crossings can sometimes prevent aquatic organism passage into upstream habitat due to accumulation of debris. The following information will help identify additional in-stream barriers that could potentially be removed or remediated.

Methods
For each barrier to aquatic organic passage, measure the outlet drop from the lip of the culvert to the water surface for the most passable structure, to the nearest tenth of a foot. Refer to the Stream Crossing Survey Data Form

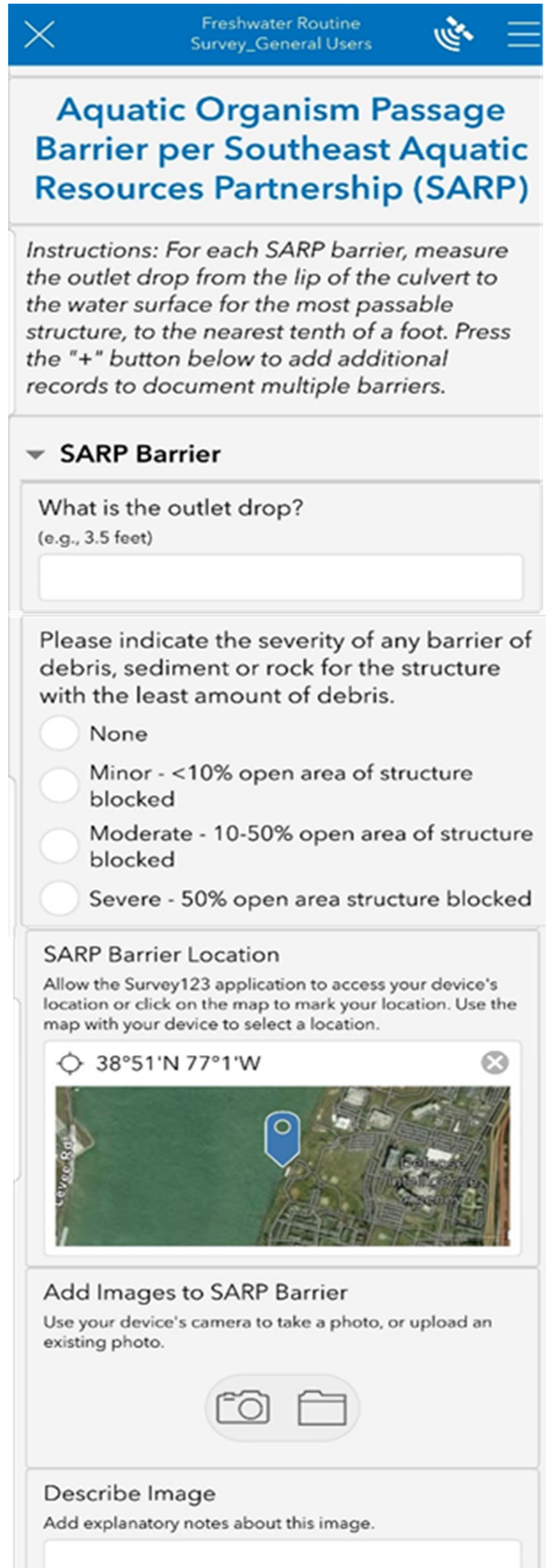


Figure 4e. Weather & General Waterbody Conditions—Continued

Instruction Guide by the Southeast Aquatic Resources Partnership at https://southeastaquatics.net/sarps-programs/southeast-aquatic-connectivity-assessment-program-seacap/culvert-assessments/sarp-culvert-assessment-manual for additional instructions.

5.4 Part 2: Water Quality

Bacteria samples collected

Example
Sample Point: 1-A
Sample ID: 100002
Parameter: *E. coli*
Comments: Grab sample collected at knee depth

Description
Fecal bacteria have been used as an indicator of the possible presence of pathogens in surface waters and the risk of disease, on the basis of epidemiological evidence of gastrointestinal disorders from ingesting contaminated surface water or raw shellfish. Contact with contaminated water can lead to ear or skin infections, and inhaling contaminated water can cause respiratory diseases. The pathogens responsible for these diseases can be bacteria, viruses, protozoans, fungi, or parasites that live in the gastrointestinal tract and are shed in the feces of warm-blooded animals.

Enterococci and *E. coli* are used as the primary indicators of fecal contamination and are recommended as the basis for bacterial water quality standards in EPA's 2012 Recreational Water Quality Criteria document (both for fresh waters, enterococci for marine waters). The standards are defined as a concentration of the indicator above which the health risk from waterborne disease is unacceptably high.

Methods
Qualified local laboratory services are a tremendous information resource. In addition to providing analytical support for monitoring recreational waters for pathogens, laboratories typically provide their own sterilized sample containers and custody documents to record dates, times, and sampling locations. Local laboratories often provide training for sampling personnel or offer laminated sampling guides to assist sampling staff in appropriately collecting samples and completing sample documentation. Sampling procedures should be developed into SOPs on the basis of the variety of sampling requirements for the target sites. For example, variable accessibility and sampling depths in the monitoring design might require that different techniques be employed at different

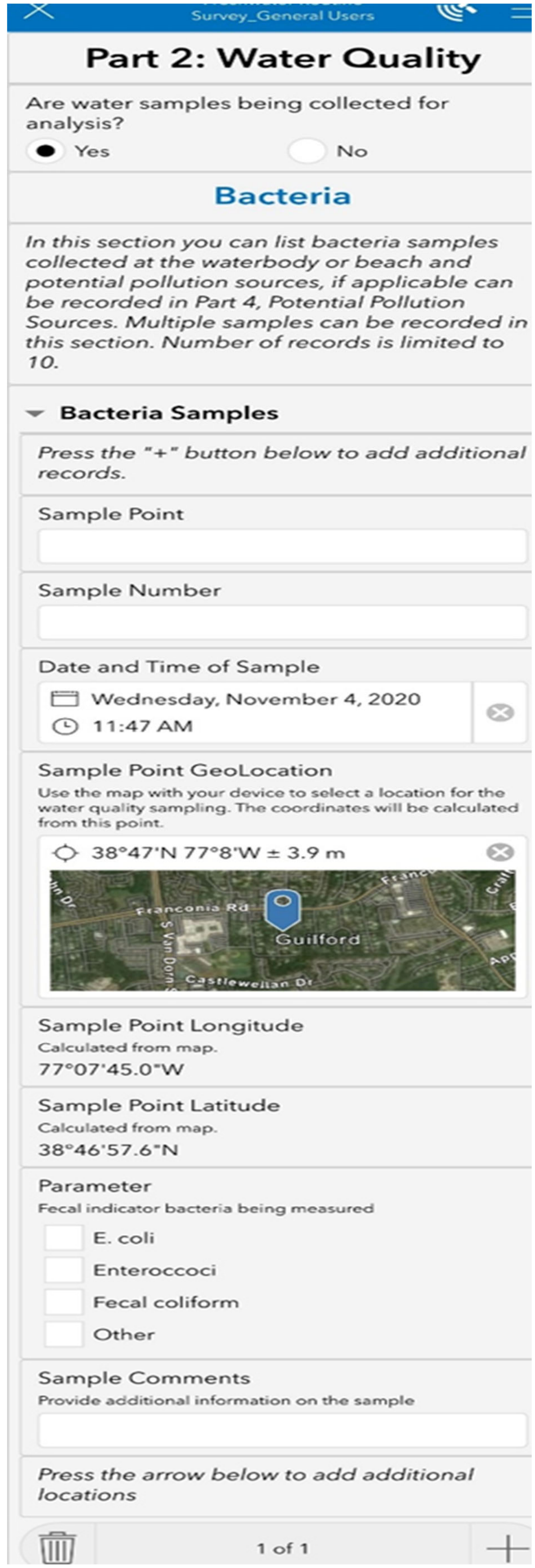


Figure 5a. Part 2—Water Quality Bacteria Section

locations. In general, samples should be collected at the desired depths directly into sterilized containers, sealed, labeled, and chilled for transport to the local laboratory.

Guidance on sampling is in section 4.3 of the National Beach Guidance and Required Performance Criteria for Grants-2014 Edition (USEPA 2014b) include sample considerations such as where and when to sample and sample collection techniques. EPA's general recommendation for all beaches is that samples be taken at knee depth. However, local conditions will dictate the sampling depth selected for a beach.

Appropriate sampling procedures should be determined for a monitoring program on the basis of the sampling design, the availability of facilities and equipment, and how the samples will be processed. In addition, it is important to use consistent procedures and take careful notes in the field when collecting samples. Additional information about EPA-recommended SOPs for sample collection, handling, and subsequent analysis can be found in *Standard Methods for the Examination of Water and Wastewater* (APHA 2018).

EPA recommends the following approved culture methods and validated qPCR methods for recreational waters.

- EPA Method 1603 or any equivalent method that measures culturable *E. coli*
- EPA *Enterococcus spp*. qPCR Method 1609.1

Chapter 4 of the National Beach Guidance and Required Performance Criteria for Grants - 2014 Edition (USEPA 2014b) provides more information on the recommended EPA's methods for testing recreational waters. Approved microbiological analytical methods, Other microbiological CWA methods and information on the alternate test procedure (ATP) program can be found at: https://www.epa.gov/cwa-methods. Figure 5a shows the Bacteria section of the app's *Freshwater Routine Sanitary Survey*.

Water temperature

Example
68 ºF

Description
This parameter is measured for use in taking temperature-dependent measurements such as pH and conductivity. Water temperature can also be important in assessing the quality of potential habitat for aquatic species and for some less-desirable pathogenic organisms.

Methods
With relative ease, you can measure water temperature by using multiprobes or other handheld electronic measurement devices or by using simple graduated thermometers. The accuracy of common, wide-scale thermometers and electronic instruments can be verified with simple ice-point (0 ºC or 32 ºF) and boiling point (100 ºC or 212 ºF) measurements. If the ice point and boiling point do not register correct temperatures, the results for the two measurements can be plotted on simple graph paper to translate field measurements to corrected values. Electronic meters can be professionally calibrated if the manufacturer's specifications do not include calibration procedures. Local and regional water temperatures for recreational beaches are also generally broadcasted on NOAA Weatherband radios and local radio stations. Temperature ranges can be expected to be in the 60s, 70s, and 80s (in Fahrenheit) during the recreational swimming seasons.

Multiprobes are electronic instruments used to measure an array of parameters (e.g., dissolved oxygen, pH, temperature, conductivity, turbidity) in situ (in place) by special sensors. Multiprobes are usually portable, handheld devices that are used to collect instantaneous water quality measurements during focused environmental investigations; however, they can also be deployed for extended periods for specialized studies to capture the diurnal (24-hour) quality cycle. Multiprobes are favored for routine environmental investigations because they can collect data for parameters like dissolved oxygen (DO) and pH, which have extremely limited holding times, and they don't call for the transport and use of field chemistry test kits or necessitate the disposal of waste reagents or spent samples after measurement. (Field test kits often use acids or other toxics that require specialized disposal or pretreatment before disposal.) (Figure 5b).

For larger counties or regional coordinators, using multiprobes can be a cost-effective way to garner a large amount of information relatively quickly. Depending on the background and qualifications of the monitoring teams, the cost of training might be prohibitive because multiple persons would likely require training. Because multiprobes are reasonably portable and are subject to calibration, the uncertainty and subjectivity associated with measurement are highly controlled. Some jurisdictions or regional survey programs might already include the use of multiprobes.

Color

Example
Red

Description
Red water color can indicate an algal bloom is present.

Method
As you walk around the beach, note water color and/or change in color on subsequent sampling visits on the survey (Figure 5b).

Odor

Example
Sulfur

Description
An odor given off by a waterbody can indicate pollution, such as sewage, is present.

Method
As you walk around, note on the survey whether any detectable odor is present (Figure 5b).

Turbidity

Example
Clear, or 0 NTU [nephelometric turbidity units]

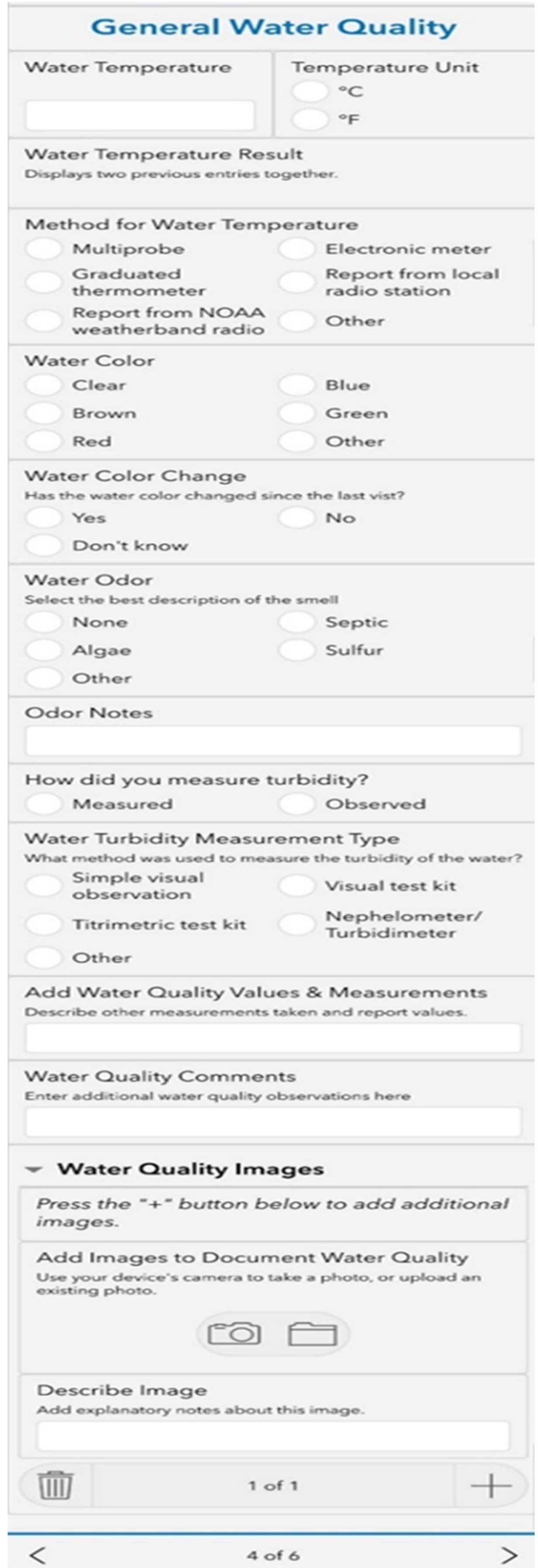


Figure 5b. Part 2—Water Quality General Water Quality Section

Description

Turbidity is a measure of the cloudiness of water and is also measured in situ. It is an aggregate property of the solution. Turbidity is not specific to the types of particles in the water. They can be suspended or colloidal matter, and they can be inorganic, organic, or biological. At high concentrations, turbidity is perceived as cloudiness or haze or an absence of clarity in the water.

Methods

The most common instrument for measuring scattered light in a water sample is a nephelometer. A nephelometer measures light scattered at a right angle (90°) to the light beam. Light scattered at other angles can also be measured, but the 90° angle defines a nephelometric measurement. The light source for nephelometric measurements can be one of two types to meet EPA or International Organization for Standardization (ISO) specifications. EPA specifies a tungsten lamp with a color temperature of 2,200–3,000 K (Kelvin). The unit of measurement for the EPA method is the nephelometric turbidity unit (NTU). The ISO specifies a light-emitting diode (LED) with a wavelength of 860 nanometers and a spectral bandwidth less than or equal to 60 nanometers. The unit of measurement for the ISO method is the formazin nephelometric unit (FNU). Also consult the description of multiprobes in this section under Water Temperature and section 6.6 on measuring turbidity.

Other water quality measurements and values

Report other water quality measurements taken (e.g., pH) and methods used. Consult Section 6.6 for more information on measuring other water quality parameters.

Water quality images

Add images to document water quality in the Water Quality Images section of the app (Figure 5b). Images may show water color, turbidity, or sources of an odor.

5.5 Part 3: People/Bather Load

Example

200 people total, 50 people in the water

Description

The sanitary survey should include a discussion of the effects of people load on recreational areas, particularly for recreational areas with poor water circulation. If there is poor water circulation, a high number of people in the water can cause significant elevation in bacterial counts for *E. coli* and enterococcus bacteria. High-use areas with poor water circulation might also indicate a need for increased monitoring of FIB and might require that attention be paid to the potential for blue-green algae blooms.

Methods

When performing a *Freshwater Routine Sanitary Survey*, count the number of people . If you perform the count in the morning when the number of people is low or zero, note that on the survey and try to obtain people/bather density data from the lifeguards or park gate. Lifeguards often maintain records of people/bather density throughout the day. You can also use gate or visitor numbers for the swim area if available.

The following are some examples of methods for estimating people/bather load:

- Count by hand the number of people. Count the total number of people and estimate the number of people in the water as a percentage of the total number of people. If the beach or swim area is large, choose a representative area to use to count the number of people and extrapolate the number to the entire area using the size of the representative area as it compares to the total size.

- Take photos and count the number of people in them. Make sure to note how much of the area each photo covers. If possible, try to cover the entire area using photos, but make sure the photos do not overlap and that people are not counted twice.
- Count people or take photos from a helicopter or plane flying overhead.
- Count the number of cars at nearby parking lots and use that number to estimate people/bather load.
- Count the number of visitors by using a laser counting device. Laser counting devices have been used at beaches in Encinitas, California, to count the number of people visiting a beach. The devices can be installed alongside stairwells leading to the beach. To tally visitors, the counters use a laser beam that is directed across the stairwells or narrow paths leading to a beach. Each person walking through the beam registers 0.5 on the counter to count a person arriving and departing as one visitor. The laser counter does have its limitations. All beach entrances need to have a counter, and entrances need to be clearly defined. Laser counters would not work at a beach where the main beach entrance is several blocks long or where visitors can access the beach from several other areas or side streets. Also, people who walk past several times are counted as more than one person. Cell phone data can also be used for counting beach visitations (Merrill et al., 2020).

The following data should be recorded when counting attendance (Figure 6):

- Number of people on the beach or shoreline.
- Number of people in the water (e.g., swimming, diving, clamming).
- Number of people not recreating in or on the water alongside stairwells leading to the beach. To tally visitors, the counters use a laser beam that is directed across the stairwells or narrow paths leading to a beach. Each person walking through the beam registers 0.5 on the counter to count a person arriving and departing as one visitor. The laser counter does have its limitations. All beach entrances need to have a counter, and entrances need to be clearly defined. Laser counters would not work at a beach where the main beach entrance is several blocks long or where visitors can access the beach from several other areas or side streets. Also, people who walk past several times are counted as more than one person. Cell phone data can also be used for counting beach visitations (Merrill et al., 2020).

The following data should be recorded when counting attendance (Figure 6):

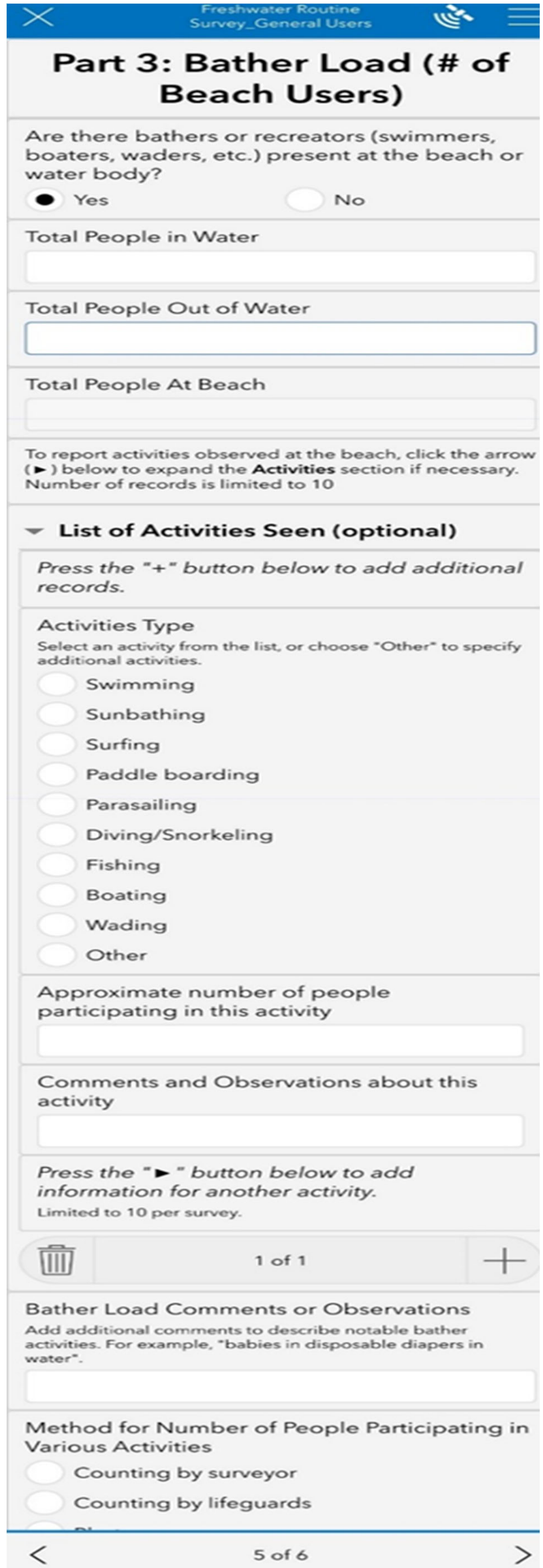


Figure 6. Part 3– Bather Load Section

- Number of people on the beach or shoreline
- Number of people in the water (e.g., swimming, diving, clamming)
- Number of people not recreating in or on the water.

5.6 Part 4: Potential Pollution Sources

The person performing the sanitary survey should identify visible sources of pollutants up to 500 feet from the water boundary and, if possible, quantify the sources. Photos may be taken with or uploaded into the *EPA Sanitary Survey App for Marine and Fresh Waters* to document discharge sources, algae, HABSs, and animal images.

Sources of Pollutants

Example
River is brown and has a bad odor. River is about 500 feet to the east of the designated swim area.

Description
Visible sources, including rivers, ponds, and outfalls, might carry contaminants that affect recreational water quality. Ground water, usually not visible, might also be a pollutant source. Investigating ground water as a pollutant source is not addressed in this sanitary survey. The level of investigation of potential pollutant sources will vary depending on the resources available for the investigation and on priorities.

Documenting the river or stream discharge (or the volume of water passing a certain point per unit time) of the waterbody and the concentration of contaminant or indicator bacteria allows managers to calculate and approximate “load” for that period. Measuring the discharge and the concentration of these sources can provide information about the magnitude of the potential pollutant loads carried by these sources to the swim area. It is important to have information on both the concentration in a stream and the stream discharge because with that information a total load per day can be calculated.

Methods
Identify visible sources that are affecting the water up to 500 feet from the sampling station. If visible sources are suspected of affecting water quality, you might collect bacterial samples from these sources and take discharge measurements, estimate discharge, or find discharge measurements from the USGS or another agency.

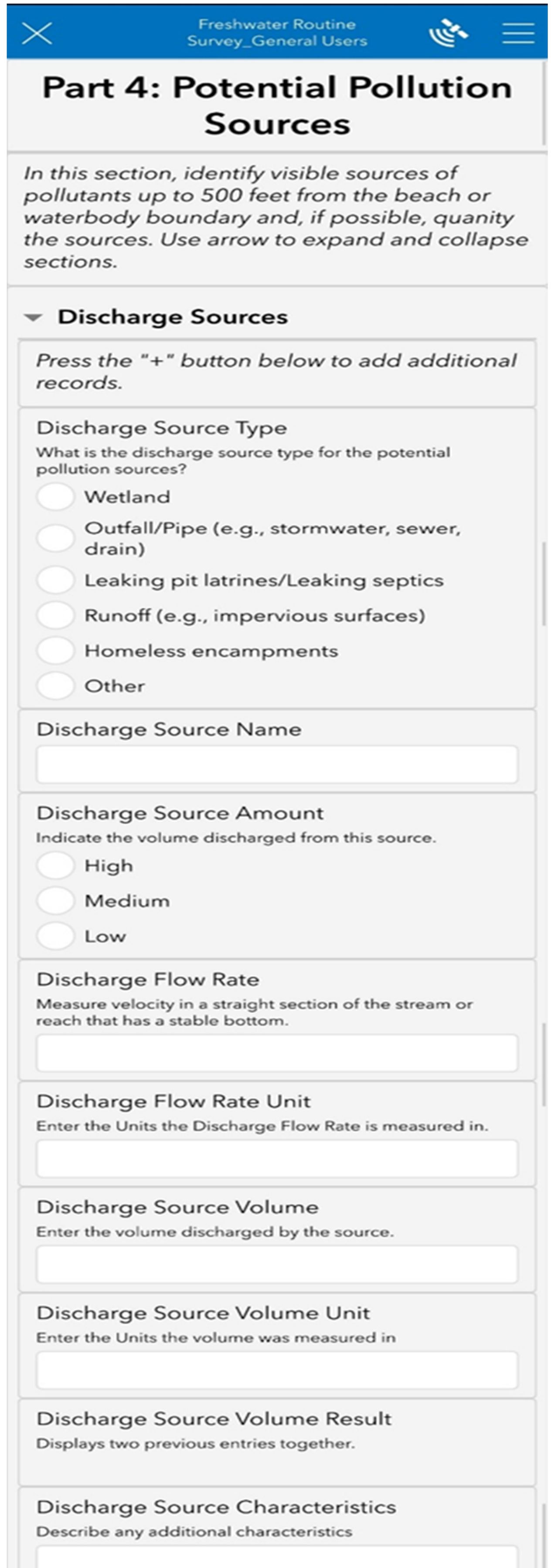


Figure 7a. Part 4—Potential Pollution Sources Discharge Sources Section

Document the name of each visible source and the corresponding velocity or flow rate in Section 4 of the *Freshwater Routine Sanitary Survey* (Figure 7a). In the Comments/Observations section, add additional notes such as whether the visible sources occur only in conjunction with specific weather conditions.

Discharge or Flow Measurement

Discharge from a stream, river or manmade structure (e.g., outfall) is sometimes called “flow.” A discharge measurement is a combination of a velocity measurement and a cross-sectional area measurement. The units in these two measurements are as follows: velocity = length per unit time, and cross-sectional area = width x depth of the stream (units are length squared). When these two values are multiplied together, the resulting units are length cubed, or volume per unit time. Examples of this are cubic feet per second and gallons per day.

Velocity

Measure velocity in a straight section of the stream or reach that has a stable bottom or a discharge source. Velocity can be measured using a velocity meter (sometimes called a flow meter). It is important to stand downstream and to the side of the velocity meter when taking measurements and to operate the meter properly.

- *Current velocity meter*s are available as mechanical or electronic units. A current velocity meter consists of a sensor or current meter, the support system for the sensor, and a counter. The signal from the sensors or current meter is processed or read by the counter. Many factors must be considered when selecting the proper current measuring equipment. In general, you should know if you will be measuring current from an overhead structure or while wading. It also helps to know the approximate speed of the water to be measured because there are specialty meters available for very slow currents, and those are most likely what is present in recreational waters. Training and experience are necessary to operate current velocity meters consistently and to select appropriate stream reaches for taking measurements.
- *Velocity estimates* can be obtained using an orange or a floating ball and a stopwatch. The measurement is the time it takes the floating object to travel downstream a pre-measured (and pre-marked) distance (e.g., 10 meters). Consult the procedure given earlier for longshore current speed measurement.
- *USGS stream flow data* for the stream of interest might be available from the USGS’s National Water Information System (NWIS). The NWIS is a comprehensive and distributed application that supports the acquisition, processing, and long-term storage of water data. Data for a large network of rivers and streams are available for stream levels, stream flow (discharge), reservoir and lake network of rivers and stream levels, stream flow (discharge), reservoir and lake levels, surface water quality, and rainfall. The data are collected by automatic recorders and manual field measurements at installations across the nation. For more information, visit http://waterdata.usgs.gov/nwis/sw.
- *National Hydrography Dataset (NHD)* is another resource that might be useful. The NHD is a comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of water, paths through which water flows, and related entities. The data support many applications, such as making maps, modeling the flow of water, and maintaining data. The NHD is the culmination of cooperative efforts of EPA and the USGS. For more information, visit http://nhd.usgs.gov/index.html.
- *Volume* is another way to document the amount of discharge from a pollutant source. This is often how information from a wastewater treatment plant is reported and recorded on a Discharge Monitoring Report.
- *Estimated amount* is used if you aren’t able to measure the flow or volume of a discharge to the beach. In this case, you can enter a general amount of high (H), medium (M), or low (L) to indicate the significance of the discharge. This information could be useful for making relative comparisons over a swim season, as long as the people making the measurements have the same idea of what constitutes high, medium, and low.

Methods for estimating stream flow can be found at https://www.epa.gov/sites/production/files/2016-05/documents/tech_notes_3_dec2013_surface_flow.pdf and in the Volunteering Stream Monitoring: A Methods Manual at https://www.epa.gov/sites/production/files/2015-04/documents/volunteer_stream_monitoring_a_methods _manual.pdf.

Floatables present

Example
Yes, floatables are present in the water. Types found include trash such as household waste and medical items (Figure 7b).

Description
Floatable debris causes problems because it can easily come into contact with aquatic animals, people, boats, fishing nets, and other objects. Communities also lose money when recreational areas must be closed or cleaned up, and the fishing industry and recreational and commercial boaters spend thousands of dollars every year to repair vessels damaged by floatable debris (USEPA 2002). Floatable debris also can be a source of bacterial contamination to swim areas.

Types of floatables present in water include street litter (e.g., cigarette butts, filters, and filter elements); medical items (e.g., syringes); resin pellets; food packaging; beverage containers; sewage-related items (condoms, tampons, applicators); pieces of wood and siding from construction projects; fishing equipment (e.g., nets, lures, lines, bait boxes, ropes, and rods); household trash; plastic bags and sheeting; and beverage yokes (six-pack rings for beverage containers) (USEPA 2002).

Methods
Record the types and amount of floatable debris. For further guidance on measuring floatable debris, consult EPA's *Assessing and Monitoring Floating Debris* (USEPA 2002), available at https://www.epa.gov/sites/production/files/2018-12/documents/assess-monitor-floatable-debris.pdf.

Amount and type of beach debris/litter

Example
Low (1–20%) amount of beach has litter present. Types of litter found are street litter, household waste, and tar (Figure 7b).

Description
Beach debris or litter can cause problems similar to those caused by floatable debris (described above) because they can easily be washed into the water and affect wildlife. In addition, the presence of certain materials, such as medical waste and sewage-related items, on the beach can pose an immediate health hazard to beachgoers and can be a source of bacterial contamination to the beach.

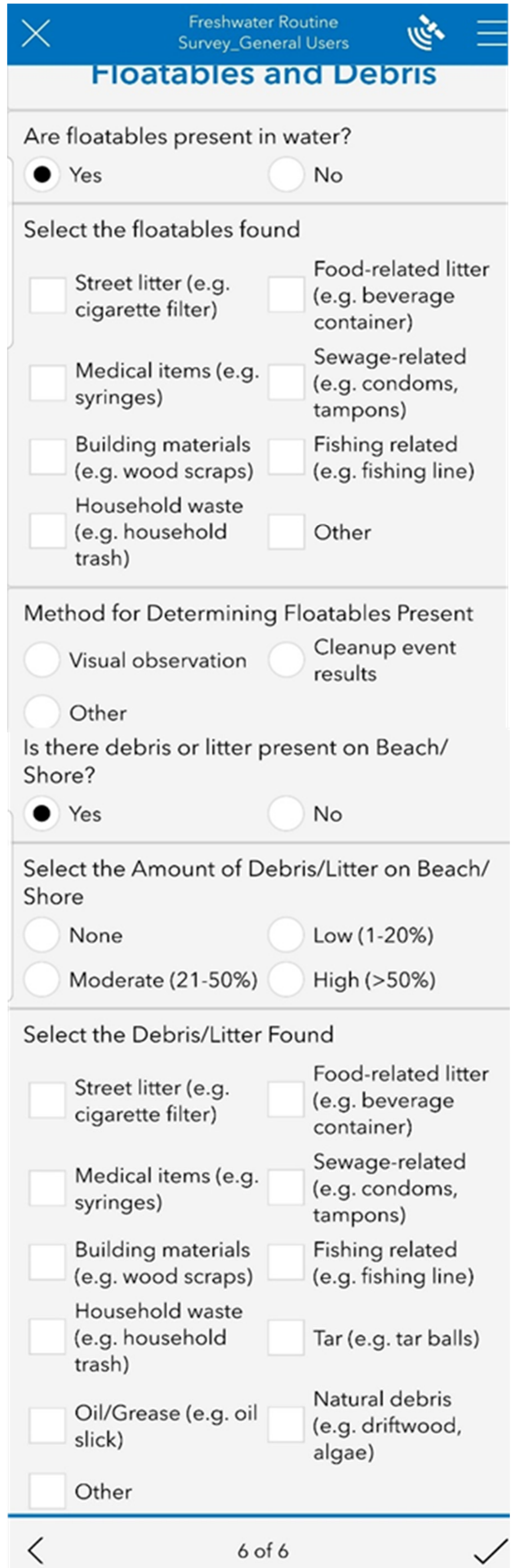


Figure 7b. Part 4—Potential Pollution Sources Floatables and Debris Section

Methods
Record the types of beach debris or litter observed, along with the percentage of the beach length that has each type of debris or litter. Specify additional types of debris or litter not already provided in the survey under Other.

Amount of algae in nearshore water/beach

Example
Low (1–20%) amount of water along shoreline has algae present. Type of algae found is free floating. Color is bright green.

Description
Algae can be a nuisance. Decaying algae can produce a foul odor that can deter people from visiting. Algae also have been suspected of harboring fecal indicator bacteria , which can lead to beach closures (Whitman et al., 2003b).

Methods
Record the amount of algae found in the nearshore water and covering the beach. There are separate fields for algae in the nearshore water and for algae on the beach itself. The types of algae present, if known, should be recorded, as well as the color of the algae. Additional information can be given, if needed, in the Comments and Observations section of the *Freshwater Routine Sanitary Survey* (Figure 7c).

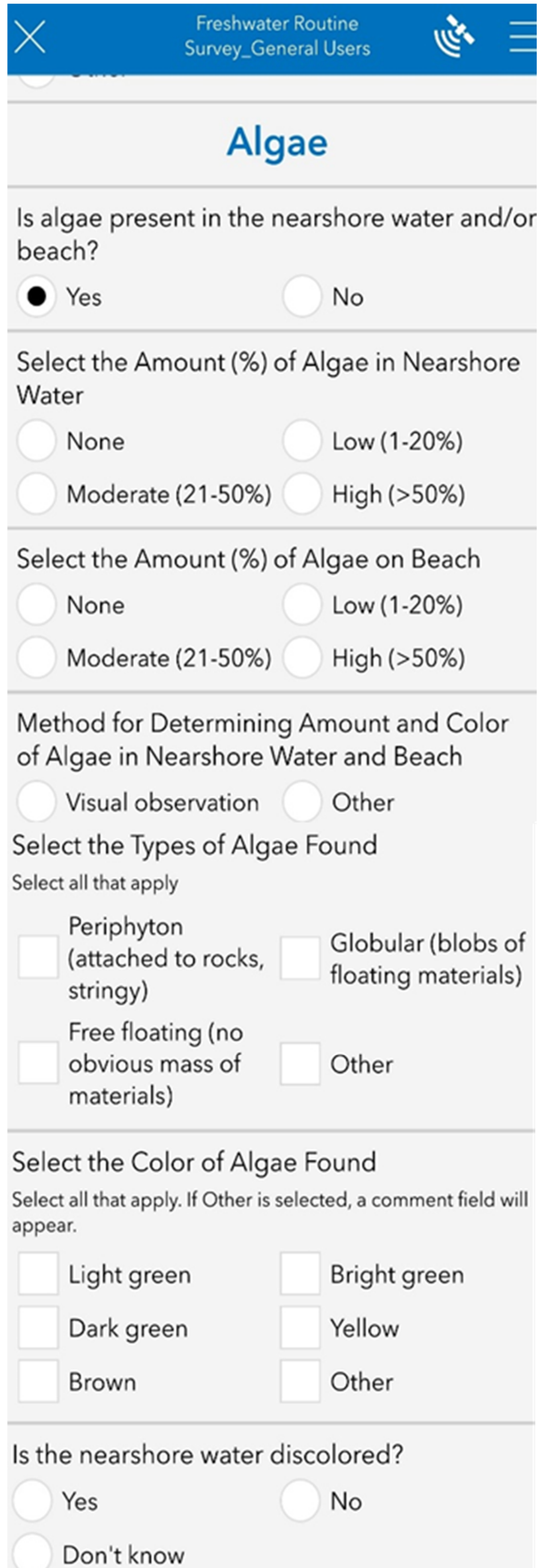


Figure 7c. Part 4—Potential Pollution Sources Algae Section

Presence of a harmful algal bloom

Example
Yes. A harmful algal bloom (HAB) is present (Figure 7d).

Description
An algal bloom is a large accumulation of algae—either microscopic species or the larger, multicellular species. A HAB is visible to the human eye and can affect aquatic species, pets, wildlife, and humans. HABs can have a variety of effects on the environment and humans. In some cases, algae might not be toxic but can discolor water, form piles on beaches, or cause drinking water and fish to taste bad. HABs can cause depletion of oxygen in the water column or clog the gills of aquatic organisms, leading to death of aquatic species. HABs can also be a nuisance for people trying to recreate in or on the water. Some HAB species are toxic and can kill aquatic organisms or cause illness to humans, pets, or wildlife when they come into contact with or ingest water containing the HAB. HABs can appear as scum, mat, or filamentous mass in the waterbody.

Method
Although it is not possible to determine whether an algal bloom is toxic through observation, or whether enough

biomass has accumulated to cause oxygen depletion, visual monitoring for algal blooms is the first step in identifying an HAB. USGS scientists have developed a field and laboratory guide for identification of cyanobacteria that are capable of producing toxins (Rosen et al., 2015). More information about HABs and the field guide can be found at https://www.usgs.gov/mission-areas/environmental-health/science/new-guide-help-identify-harmful-algal-blooms?qt-science_center_objects=0#qt-science_center_objects.

In addition, research programs such as NOAA's Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program collect data used to predict HAB development for coastal states. Report presence of HABs in Section 4 of the *Freshwater Routine Sanitary Survey*.

Presence of wildlife and domestic animals

Example
Gulls (20)

Description
The presence of wildlife and domestic animals at swimming areas affects water quality. Waste from these animals, whether entering the water directly from waterfowl droppings or indirectly from runoff carrying waste from dogs and other animals, can cause bacterial concentrations to rise to the point where recreational standards are exceeded, resulting in closure. Data like the types and numbers of animals present at the swimming area could be used to help identify major sources of bacterial contamination and potential best management practices (e.g., pet owner education, better trash management to reduce available food sources on the beach or shoreline) that could be used to reduce the amount of animal waste reaching the water.

Methods
Record both the types and number of animals present. Determine the presence of animals through visual observation. Use binoculars and a handheld counter to keep track of the number of animals present. Note the presence of any types of animals not already listed on the survey in Other. Also note in the Comments and Observations section the number of each type of animal present in the water, on the beach or shoreline, and in the air (Figure 7d).

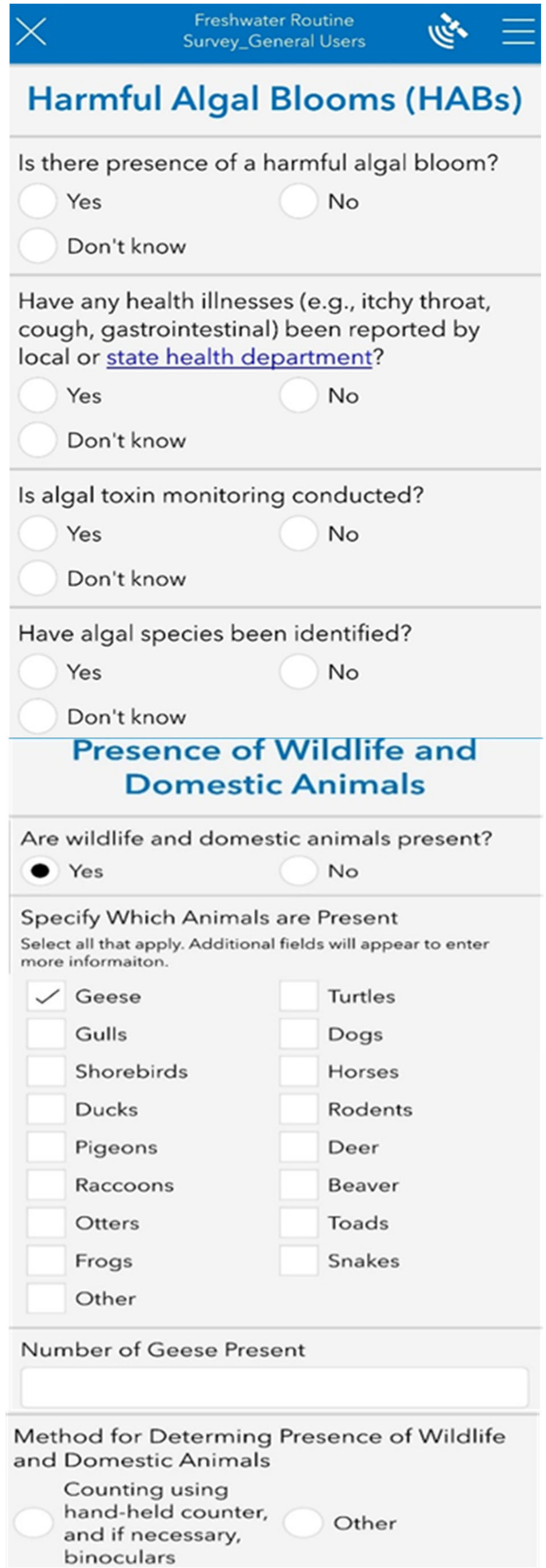


Figure 7d. Part 4—Potential Pollution Sources Harmful Algal Blooms and Animals Section

List the number of each species of bird found dead

Example
Common loons (2), long-tailed ducks (1)

Description
Bird die-offs indicate problems in water quality.

Methods
As you conduct the sanitary survey, look for any dead birds or scat on the shore or in the water. If you can't identify the species of bird, write a description of the bird and take a photo if possible (Figure 7e).

List the number of dead fish

Example
4 dead fish floating at the shoreline

Description
Fish die-offs indicate problems in water quality.

Methods
As you conduct the sanitary survey, look for any dead fish on the shore or in the water. If you can't identify the species of fish, write a description of the fish in the Additional Comments or Observations section of the survey. Take photos if possible (Figure 7e).

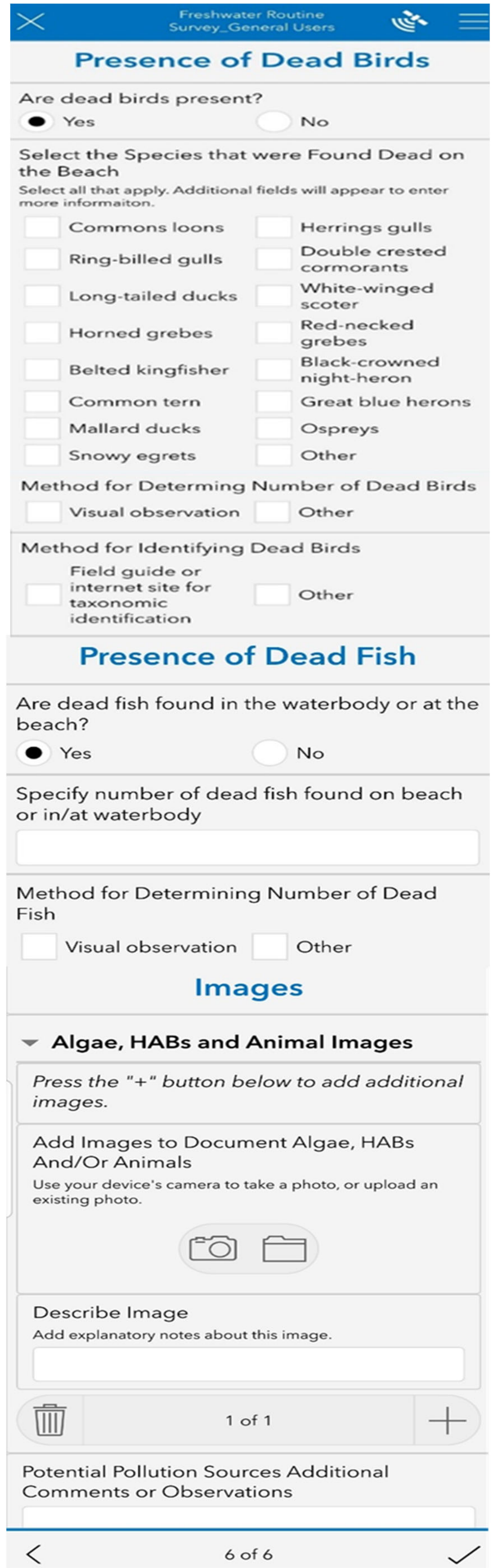


Figure 7e. Part 4—Potential Pollution Sources Presence of Dead Fish

6. Data Elements for the Annual Sanitary Survey

This section includes descriptions of the types of data you should consider collecting if you are conducting a *Freshwater Annual Sanitary Survey*. Information that could be useful in completing the annual survey either using the paper surveys or the app are provided below. Due to the length and the level of detail in this survey, screen shots of the annual survey are not included in this section. Make sure that you document all sources of information, including dates that data were collected or recorded. In addition, if you used the internet to obtain information (such as maps), note the most recent date for the web page.

6.1 Part 1: Basic Information

In the first section of the *Freshwater Annual Sanitary Survey*, list basic information about the beach, such as the name, ID, surveyor name, surveyor affiliation and location. The Beach IDs you use should include the one you submit to EPA for the PRAWN database, https://watersgeo.epa.gov/beacon2/Beacon.html. If you have a separate ID for other purposes, you may list that as well. Include the Sampling Station ID and Water Quality Exchange (WQX) Organization ID (https://www.waterqualitydata.us/portal/) when possible. In the *EPA Sanitary Survey App for Marine and Fresh Waters*, the links are available to specific databases to search for these IDs. You will need to manually enter the IDs in the appropriate fields because the app does not autopopulate this information. Required fields (designated with a red asterisk [*]) must be completed in order to submit data collected using the app.

6.2 Part 2: Quality Assurance Project Plan (QAPP) Requirement

Most agencies should already have QA/QC procedures for performing monitoring. These procedures should be updated, as needed, to include QA/QC procedures for performing the sanitary surveys. States, territories, tribes, and local agencies should use the information in this document and follow their agency-specific QA/QC procedures for data collection, entry, and analysis when performing sanitary surveys. App users are required to certify that sanitary survey data are collected using an approved QAPP and provide a link or submit a copy of the approved QAPP in order to submit their sanitary survey data to the EPA GeoPlatform.

More information on QA/QC can be found in Appendix A.

6.3 Part 3: Description of Land Use in the Watershed

Current land use in watershed and overall development

As described in EPA's National Beach Guidance and Required Performance Criteria for Grants-2014 Edition (USEPA 2014b), you can use beach characterization data, including surrounding land uses, to evaluate potential risk and rank beaches. Pollutant loadings into nearby swimming beaches and other surface waters generally increase as a watershed becomes more developed and more impervious surfaces are created. Using environmentally sound land use planning techniques and implementing controls can help reduce the impacts of development on beaches.

Land use maps or aerial photos of the watershed can usually be obtained through a city, county, or state planning department. In addition, some land use and land cover (LULC) data are available from the USGS for the conterminous United States and Hawaii, although coverage is not complete for all areas. The website for LULC information is https://www.usgs.gov/core-science-systems/eros/lulc. Also, websites like Google Earth at https://www.google.com/earth/ can be helpful in providing maps. When using these types of sources, make sure to note the most recent date on which updates were made to the webpage and when updates are expected.

You can use the information provided by these sources to estimate the percentage of various land uses, including residential, industrial, commercial, and agricultural, in the watershed. You can also use it to visually confirm locations of potential pollutant sources like wastewater treatment plants and concentrated animal feeding operations (CAFOs). In addition, you can use this information to determine the overall percentages of developed and undeveloped area in the watershed.

In addition, you should consider conducting site visits throughout the watershed to verify or update land use data and maps and to collect visual data in unknown areas or areas suspected of being sources of contamination.

Waterbody/Beach Uses

You can use beach use information to identify potential sources of pollutants. For example, if small oil or gasoline spills are often noted, you can investigate nearby motorized boats as a potential source of bacterial contamination. You can determine uses through direct observations of activities that occur and services offered (e.g., boat rentals). The uses included on the *Freshwater Annual Sanitary Survey* are boating, fishing, surfing, windsurfing, diving, and other. Select the uses that occur at your waterbody, and describe them further, if necessary, in the Comments section. Describe any uses not listed in Other. In addition, if the *Freshwater Routine Sanitary Survey* was conducted, you can summarize the results from Part 3, People/ Bather Load, collected over the course of the season (Figure 6).

Mapping

You can use maps to help identify potential impacts on the swim area within the watershed or along adjacent shoreline. They can help you determine the proximity of pollutant sources to the swim area. Even simple maps like those obtained from places such as GoogleEarth can be useful. Attach copies of any maps you have to the *Freshwater Annual Sanitary Survey* or list the locations of the files if hard copies are not available. Document land use in the watershed by uploading photos.

You can obtain topographic maps from USGS directly or through a retailer. Information on ordering these maps is provided on USGS's website at https://www.usgs.gov/core-science-systems/national-geospatial-program/topographic-maps. Topographic maps provide an indication of geographic boundaries and contours that influence stormwater flow and, ultimately, pollutant loads to recreational waters. You can use topographic maps to delineate surface watershed boundaries, if this has not been done already.

Detailed maps of survey areas are valuable to understanding the annual surveys and to ensuring the consistency and continuity of the annual survey program. Maps help you to document specific conditions about waterfront and adjacent properties being developed, which can include pollutant sources or pollutant management controls. Graphic representations of key features help future surveyors verify and document the effects of nearshore development activities and pollutant control or sanitation enhancements from one year to the next.

Local governments maintain maps of their jurisdictions in their planning and zoning offices. You should note on such maps the key features identified in the survey, including primary (central) GPS locations for survey reaches or sub-reaches (permanent structural markers such as buildings [addresses], light poles, or utility poles might serve as references to the location of GPS measurements because some GPS measurement devices have greater resolution than others); locations of water sampling and physical measurement stations; the location and direction of any digital photos (to serve as an index); the locations of significant potential sources (e.g., CSO/SSO or other discharge conveyances or apparent stormwater runoff, marinas, docks with recreational watercraft); surrounding development and land uses, including any active construction; and permanent or temporary sanitary facilities for swimmers and beach patrons. A map of sufficiently small scale should provide an opportunity to make notations regarding most features or perspectives for most of the detailed observations on the *Freshwater Annual Sanitary Survey*.

The survey includes a list of possible items to include on the map, such as pollutant sources, marinas, sanitary facilities, and bounding structures. Check if the things on the list that are applicable to your swim area are on the map, and in the Other category add any additional things that are not on the list.

Erosion/accretion measurements

High water levels, storms, wind, ground water seepage, surface water runoff, ice, and frost are important factors that cause beach erosion. The extent and severity of the problem is worsening with global sea level rise. Shoreline hardening structures such as jetties and seawalls intended to protect against storm waves can actually accelerate beach erosion and reduce the capacity of beaches to absorb storm energy (NOAA 2019). Erosion can result in public losses to recreational facilities, roads, public works, and homes located along the shore.

To determine whether a beach is eroding or accreting over time, and whether you need to implement an erosion control plan, you can take measurements from a fixed object behind the beach, such as a building or parking lot, to the high watermark, and compare changes over time. The high watermark is the highest point that waves reach on the day the measurement is taken. It can usually be identified as the line on the beach between where it is wet and where it is dry or by a line of debris (e.g., seaweed, shells). If there is more than one line of debris on the beach, use the line closest to the waterbody because other debris lines farther from the beach might be the result of previous storms (UNESCO 2005).

Two people are needed to perform this measurement. For beaches at least one mile long, choose at least three points along the beach for the erosion/accretion measurements. You can add additional points as needed. For instance, you can take measurements directly in front of and adjacent to man-made bounding structures to study their effects (UNESCO 2005).

At the first point (point A), select the fixed object and record a description of it on the sanitary survey. In addition, take pictures of both the high watermark location and a corresponding fixed object, and record a description of these photos on the sanitary survey. One person should stand at the high watermark and lay the tape measure on the ground. The other should stretch the tape measure to the fixed object and pull the tape measure taut. One of the persons should record on the sanitary survey the distance in feet or meters. Then proceed to the next point, repeating the measurement and recording corresponding information on the sanitary survey. Finally, the two people should measure the distances between sampling points (UNESCO 2005) and record them on the sanitary survey.

The University of Minnesota Extension Service's website provides examples of some best management practices that can be used to reduce erosion at beaches: https://extension.umn.edu/lakes-and-wetlands/shoreland-properties.

Bounding structures

Alterations of the coastal environment can occur from the installation of man-made bounding structures like jetties, groins, and seawalls. Alterations affect coastal dynamics and have far-reaching effects on coastal ecosystems, hydrodynamic and tidal regimes, and sediment transport rates. Usually, bounding structures are placed in environments to counteract erosion in sediment-deficient areas or to deter accretion in dynamic areas such as inlets. Adjacent downdrift areas typically experience increased erosion after these structures have been installed (NPS 2016).

Groins are perpendicular structures used to maintain updrift beaches or to restrict longshore sediment transport. Jetties, another type of perpendicular hard structure, are normally placed adjacent to tidal inlets to control inlet migration and to minimize sediment deposition within the inlet. Seawalls, bulkheads, and revetments are shore- parallel structures designed to protect the beach in front of a property or properties. Structures like breakwaters, headlands, sills, and reefs are designed to alter the effects of waves and stop or alter natural coastal changes (NPS 2016). Piers are designed more for recreational use but can alter the beach area as well.

Shoreline hardening and circulation control structures can affect water circulation, and this can affect fecal indicator bacteria (FIB) concentrations . Features such as breakwaters or groins can promote non-uniform distribution of FIB (Bertke 2007). For example, Bordalo (2003) reports significant differences in bacterial water quality and in temperature and salinity for two beaches separated by a 250-meter-long jetty. A schematic drawing showing the beach and relevant features is presented in Figure 8. Observed trends at both beaches (response to rainfall events, diurnal variation in FIB density, variations with tidal cycle) were similar, but one beach had consistently higher FIB density. The beach with the consistently higher density was confined on both sides by jetties, whereas the other beach was described as more open to the ocean. Higher densities in the confined waters can be explained by reduced dilution from the inhibition of mixing by the jetties.

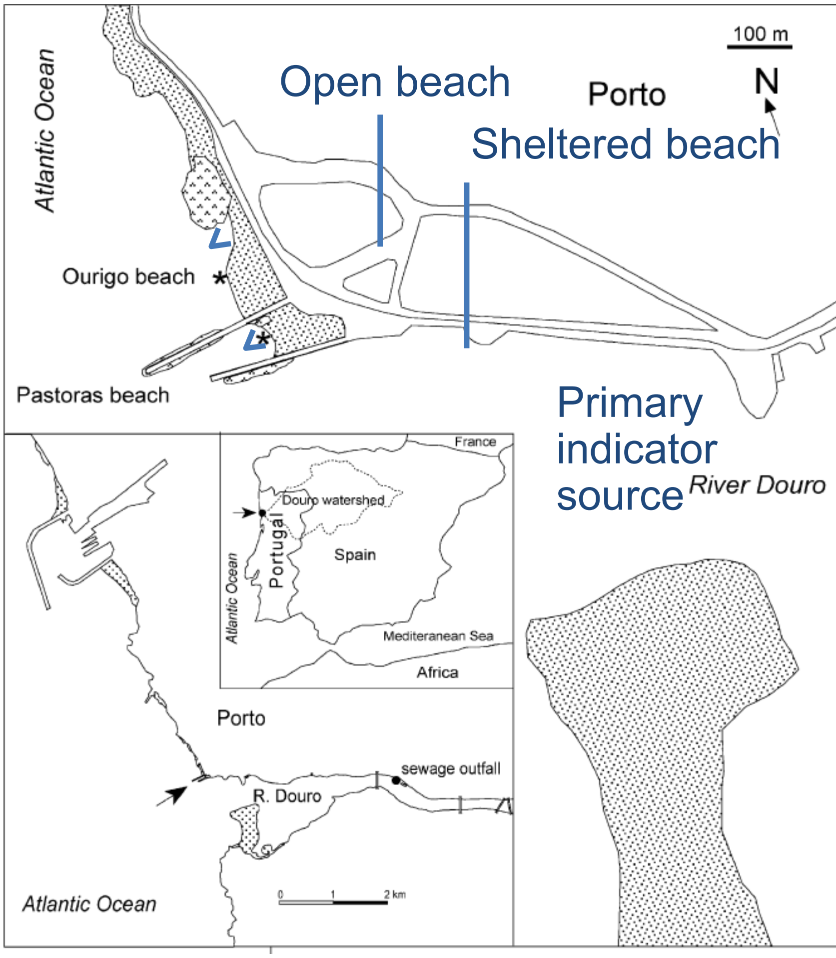
On a Lake Michigan beach, breakwaters are also believed to influence mixing, retaining FIB (and other pollution) originating from terrestrial sources (beach sands, runoff) and carried in a long-shore currents at Chicago beaches (Whitman and Nevers 2008). Among the 23 Lake Michigan beaches studied by these researchers, *E. coli* densities exhibited similar time variation at all beaches but three during a 5-year study; it was surmised that the physical features of the three beaches, particularly the presence of breakwaters, caused the different temporal fluctuations observed at those beaches.

The mobilization of FIB from sands and sediments is related to waves which, in turn, are related to the beach physical configuration. Yamahara et al. (2007) used an N-way ANOVA to determine which factors influenced presence/absence and density of enterococci and *E. coli* in beach sands at multiple beaches along the California coast. Among other factors, presence and density were most influenced by wave action and presence of a source. Sheltered beaches (low wave action) with a FIB source had the highest sand enterococci densities among beaches studied.

Groin extensions and jetties can cause or exacerbate adverse water quality by enclosing beaches. In some cases, a beach area already suffers from poor circulation, and a groin extension exacerbates the problem (e.g., Cabrillo Beach in southern California). In some cases the jetty or groin extension can actually cause the enclosure (e.g., Baby Beach in Dana Point, California). Enclosed beaches have been noted as a significant problem for water quality (Largier and Taggart 2006), and are the locations of the greatest beach water quality issues in the State of California. Some states such as Rhode Island have existing controls on the building of further future shoreline hardening structures. State policy makers have noted the adverse impacts of these structures on water quality and wave action that is primarily responsible for natural sand movement along the coast.

Shoreline hardening structures retain shore-based pollution through trapping and attempts to promote circulation may assist the manager. Contaminated groundwater contributed to areas with reduced circulation due to shoreline hardening structures degrades coastal water quality and may require promotion of advective mixing and diffusion in the beach boundary layer.

Due to the strong impacts of shoreline hardening structures on beach water quality, take photos of shoreline hardening structures. Record corresponding descriptions of the pictures in the Photos section of the survey. In areas where groins and jetties have created *enclosed beaches* note the collection or *trapping* of materials along the beach where the public is recreating. Take photos of bounding structures.



Source: Bordalo 2003

Figure 8. Illustration of beach features promoting non-uniform indicator density in parts of a beach.

Beach materials/sediments

Beaches can be characterized by the types of materials or sediments present. Sediment type can correlate to bacteria densities at some beaches. In addition, changes in the types of materials or sediments present over time (e.g., from fine-grain to coarse sand) can indicate erosion problems. If beach nourishment projects are undertaken, the grain size of the replacement sand should match as closely as possible the existing sand grain sizes to avoid problems like beach narrowing.

In addition, some researchers have found that bacteria can thrive in beach sand, possibly contributing to the bacteria in the beach water. For example, Lake Huron beach sand provides the nutrients, temperatures, and other conditions needed to support growth of *E. coli* (Alm et al. 2006). Data show that wet freshwater beach sand is a reservoir of fecal indicator bacteria and that activity in this zone can bring the bacteria to the sand surface or into the water (Alm et al. 2003). Simple, subjective observations (e.g., “sandy, very”) can be used to describe the materials or sediments present at a beach. This is adequate for most beaches.

If you have the time and resources, however, collecting sediment samples and sending them to a lab for analysis will provide better data. If you choose to do this, the following is a simple procedure for collecting samples (recommended by Richard Whitman of the USGS, 2006).

1. Choose up to three plots that are 1 square meter in dimension. Plots should be approximately 1 meter beachward (i.e., away from the water) from the waterline. If the sediments at your beach are fairly uniform, one plot is likely enough.
2. Describe the locations of the plots and note them on a diagram or photo so that they can be revisited in the future.
3. Within each plot, collect five equally sized sediment samples—one from each corner of the square plot and one from the center of the square. Composite the samples into one pre-labeled bottle or bag.
4. Send the samples to a lab to analyze the sediment size. The lab should determine the mean grain size diameter, as well as the uniformity coefficient.

Grain size is classified on the Udden-Wentworth scale with the following sizes for each type of sand: very coarse sand = 1–2 millimeter (mm), coarse sand = 0.5–1 mm, medium sand = 0.25–0.5 mm, fine sand = 0.125–0.25 mm, and very fine sand = 0.0625–0.125 mm. One commonly used term is sugar sand. Sugar sand is approximately 0.15–0.2 mm, similar to fine sand.

Photos

Photos are a good way to document conditions for the recreational waterbody and the watershed. Take some general photos showing the overall water and shoreline condition and the locations of fixed objects. These photos can be used as a reference points to determine whether changes have been made from year to year. In addition, take photos of beach use, bounding structures, sediments, habitat, sampling locations, pollutant sources, evidence of pollutants (such as pluming from creeks and streams, runoff, and mysterious pipes, evident in aerial photos), sanitary facilities, and other facilities. Upload or attach relevant photos to the survey.

Habitat

Changes in the types of habitats present over time can indicate erosion problems. For example, if dunes are starting to disappear, beach restoration efforts might be needed to slow the erosion process. Special measures might be needed to maintain critical habitat for a threatened species, such as the piping plover (*Charadrius melodus*).

Record on the sanitary survey the types of habitat present (e.g., dunes, wetlands, river/stream, forest, park, urban area, or protected habitat or reserve).

6.4 Part 4: Weather Conditions and Physical Characteristics

One or more weather parameters might correlate with bacteria densities in the water. For this part of the survey, you should closely examine the data you have collected over the previous season(s), if applicable, and look for trends and possible correlations with the bacteria sample results. For example, once you display the data graphically, you might notice that bacteria counts are usually high when the water temperature is at its highest. Or perhaps bacteria sample results at certain sample points at one beach are higher than at other sample points, possibly because a current typically moves from west to east along the shore.

In addition, if sky conditions (such as sunny or cloudy) were observed using the *Freshwater Routine Sanitary Survey*, the survey results should be examined to determine the typical sky condition for the beach. Sky conditions from the routine survey can also be examined along with the bacteria sampling results to determine whether there is any correlation between the sky conditions and the sampling results.

The results of the *Freshwater Routine Sanitary Survey* can be used to calculate the average, typical, or maximum measurements of air temperature, water temperature, and wind speed and direction during swim season. If those data are not available, the National Weather Service website or other websites might be a source of data. The following is a list of Internet sources that you can use to access historical weather data.

> *NOAA-National Weather Service*
> https://www.weather.gov/. The National Weather Service site provides locations of weather stations and weather radio information. Archived data for the previous year is available.
>
> *NOAA–NCDC*
> https://www.weather.gov/timeline. This website contains records for weather stations in the United States ranging from the year 1800 to two or three months ago. The database is searchable by state and city. It gives results as .pdf files showing scanned monthly logs with a daily account of temperature extremes (participating locations) and precipitation, snow, and snow depth. Data are available for the thousands of sites that are a part of the cooperative observing network in the United States.
>
> *NOAA–Great Lakes Environmental Research Laboratory*
> https://www.glerl.noaa.gov/. This website compiles historical rainfall precipitation data from all the weather stations in the states surrounding the Great Lakes in the form of one zipped file for each state. The stations are subfiles that can be opened in Microsoft Excel.
>
> *NOAA*
> https://tidesandcurrents.noaa.gov/historic_tide_tables.html. This website provides tide and tidal current data from 2008 to the present.

6.5 Part 5: Beach/Shoreline Dimension

Beach length or dimensions

Comparing beach dimensions over several years can provide information on how local development might be affecting the beach. For instance, uncontrolled development near the beach can prevent natural dune restoration, which in turn can decrease the width of the beach. Beach length measurements can be used to help identify sampling locations and other features. Beach dimensions can also be useful in calculating how much sand will be needed for a beach nourishment project. In addition, beaches that are receiving funds from the EPA's BEACH Act grant program must provide beach length data to EPA.

Two people are needed to measure the length of the section of beach to which the sanitary survey applies. Note the fixed objects or beach formations that will be used as boundaries for the length of beach (e.g., lifeguard chair to lifeguard chair, edge of building to inlet) on the sanitary survey. Before using objects like lifeguard chairs, make sure they are actually fixed objects and are not moved from year to year. In addition, take pictures of the boundaries and record descriptions of these photos on the sanitary survey. To measure the beach, one person should stand at one end of the beach and lay a tape measure on the ground. The second person should stretch the tape measure to the other end of the beach or as far as it will allow. If the beach is longer than the length of the tape measure, take incremental beach length measurements in a field notebook. Add the incremental measurements and record them on the sanitary survey.

Enter on the sanitary survey the three previously made beach width measurements (distance from fixed object to high watermark) for the erosion/accretion measurements for width Z1, width Z2, and width Z3. Average the three measurements and enter the value on the survey for width (average) (UNESCO 2005).

Alternatively, you can take GPS readings to determine beach length or dimensions, or you can estimate the distances by pacing the beach. Make sure you document on the survey the method you use to calculate beach length or dimensions.

Local water level variation

Variations in water levels affect beach widths; if low water levels are experienced, beach widths expand. During 1998 and 1999, low precipitation and warm water temperatures led to increased evaporation and lower than normal lake levels in the Great Lakes. Several marinas needed to extend their docks during this period to reduce boater maintenance problems experienced in shallow waters. Algal blooms were also more common during this time because of the high-water temperatures (MDEQ 2006).

Comparisons of daily Great Lake water levels with prior levels measured at reference gauges on each lake are on the NOAA Great Lakes Environmental Research Laboratory's website at https://www.glerl.noaa.gov/. Real-time water level data for additional gauges are on the Great Lakes Information Network at https://www.glc.org/glin.

Hydrographic Influences

Report hydrographic influences such as a seiche or storm surges. Seiche is a standing wave in an enclosed or partially enclosed body of water (e.g., lake).

Longshore or nearshore currents

Review data from the prior swim season(s) and determine the significance of longshore or nearshore currents. Examine the current data alongside the bacteria sample results at each sample point to determine whether there might be a correlation between the currents and bacteria concentrations at certain sample points. For more information on measuring currents or data sources, consult the description of currents in Section 5.3.

Slope at the swim area

Beaches exposed to high-energy waves tend to have a steeper slope than those exposed to low-energy waves. Beach nourishment projects that include higher and wider berms can reduce wave energy. New or improved sand dunes can reduce inundation due to storms (NOAA 2019).

Measure the slope at one or more of the locations selected for erosion/accretion measurements. The equipment needed for slope measurements includes two poles of equal length, tied together with several meters of string, and a tape measure. Alternatively, you can use surveying equipment, such as a laser level, if available, to measure slope.

Choose a fixed object behind the beach, such as a building or tree. Use the same fixed starting point when taking future slope measurements so that any changes in slope over time can be measured (UNESCO 2005). Take photos of the fixed starting point and record corresponding information on the sanitary survey.

Place a pole at the fixed starting point and place a second pole down-gradient of the first pole. Pull the string taut. Move the string up or down on the poles until it is level (use a line level to determine this). Measure the distance between the two poles (Z), and the distance between the string and the top of each pole (X and Y), and record the data in a field notebook. For wide beach areas, move the first pole up to the second pole and repeat the process at each break of slope. The end of the profile should be the water's edge. For each set of measurements, calculate the difference between X and Y. That is the elevation or height. Divide this number by the distance between the two polls, and that is the slope. This process is illustrated in Figure 9. You can calculate percent slope for sections of the beach for a beach profile, or you can calculate an overall percent slope using the start and end point measurements.

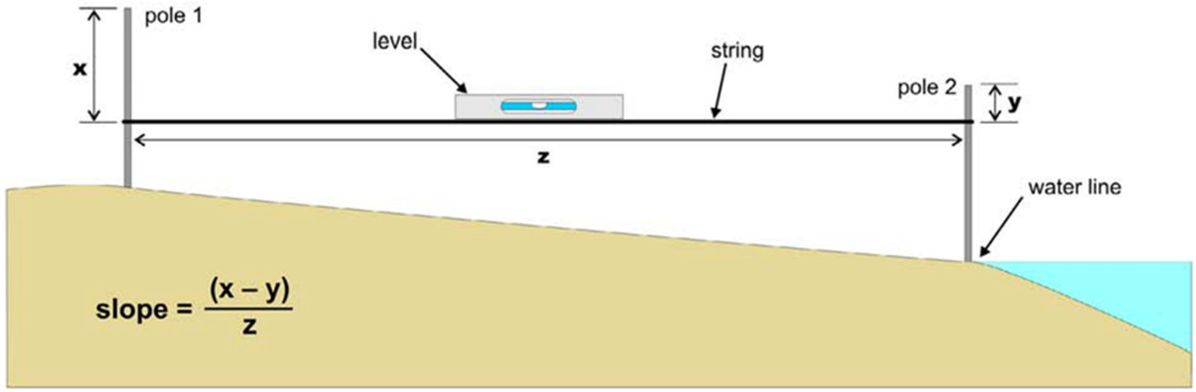


Figure 9. Calculating a beach's slope.

Date and description of the last beach rehabilitation

Beach rehabilitation can help restore major habitats and reduce pollutant sources. Major rehabilitation could include projects such as planting beach grass and erecting fences to protect dune ecosystems, removing litter, dredging, adding sand, and conducting beach nourishment. You should list in Parts 13 and 14 of the *Freshwater Annual Sanitary Survey* the other types of rehabilitation, such as constructing bathroom facilities.

Splash Zone

Describe the splash zone (include sediment makeup, rate of erosion, presence of seaweed wrack). The splash zone is defined as the area immediately above and below the mean water level.

6.6 Part 6: People/Bather Load

It is important for the manager of recreational waters to know the number or approximate number of people using the swim area. You can collect the people/bather load numbers using several different approaches to determine annual, seasonal, and daily cycles. Numbers of people should best be measured during times of the day when people are most likely to be at the recreational water. Lifeguards in many counties routinely collect daily counts during swimming season, and therefore they might have data that are of use in the survey. County health departments or beach program managers might also have historical beach attendance data that could be of use in the annual or routine surveys. For details on how to measure the number of people, consult Section 5.5.

Numbers of people should be reviewed alongside bacteria sample results to determine whether there is any type of correlation between beach use and bacteria concentrations. Evaluate each sample point separately because one sample point might be more affected by the number of people than the others. Describe any trends detected or any particular days when there might have been a correlation between these data sets.

6.7 Part 7: Beach/Shoreline Cleaning

Cleanup activities

Beaches are typically cleaned using mechanical cleaners, volunteers (e.g., Adopt-a-Beach programs, county- or city-sponsored beach cleanup days), or both. Mechanical beach cleaners groom the sand by mechanically raking and sifting it, and they can remove both large and small pieces of debris. This process might or might not be followed by leveling of the sand. Beach grooming without leveling has been shown to significantly reduce the amount of bacterial contamination during dry-weather events (Northeast–Midwest Institute 2003). Mechanical beach cleaning can be performed daily during the early morning or late evening.

In the Great Lakes region, volunteers with Alliance for the Great Lakes can perform manual beach cleaning in year-round Adopt-a-Beach programs, which require participants to clean a designated area of beach at least five times a year and include litter monitoring, cleanup, and simple monitoring activities. Municipalities, counties or other organizations might also sponsor beach cleanup events one or more times a year.

In this part of the survey, note the frequency and give a short description of any cleaning activities. Also list any particular type of equipment that was used, if known.

Amount and types of floatables

Review the results of the routine survey, or other documentation of this type of activity, and estimate how frequently floatables are found and whether it is causing a problem. Note which types of floatables found, including building materials, household waste or medical waste.

Amount and types of beach debris/litter

Review the results of the routine survey, or other documentation of this type of activity, and estimate how frequently debris or litter is found and whether it is causing a problem. Note which types of debris or litter are found, including tar, oil or grease, trash, plastic, or medical waste.

6.8 Part 8: Information on Sampling Location

Sampling point descriptions

Describe the sampling locations, including details about each sample point. List the time of day that samples are usually taken. EPA recommends that water quality samples be taken in the middle of a typical swimming area. Samples can be taken at a point corresponding to each lifeguard chair, or every 500 meters. If a swimming area is more than 5 miles long, samples should be taken at the most populated/used areas and spread out along the length of the swim area (USEPA 2014b).

You can use measurements and landmarks to identify specific locations and to ensure future consistency in sample collection. A more precise way to identify your sampling location is to take a GPS reading and record the coordinates.

Collect samples in the morning if possible to ensure that the holding times are met and that the laboratory has the maximum time to process the samples. Note on the sanitary survey the name of the laboratory, distance from the sampling sites to the lab, and tidal stage to determine the best time for collecting samples.

Hydrometric network

A hydrometric network is the network of monitoring stations that collect data such as flow and rainfall. Check if flowmeters or rain gauges are in place in the watershed, and note their locations and owners. NOAA might be able to provide rainfall data (for website information, consult Section 6.4). However, you might want to operate your own rain gauge or weather station so that it is in the immediate vicinity of your swim area. You could also coordinate with a local university that might be interested in these data or might have a rain gauge or weather station of its own.

Flow data might also be available from the USGS NWIS (http://waterdata.usgs.gov/nwis/sw) (USGS 2007a). The NWIS is a comprehensive and distributed application that supports the acquisition, processing, and long- term storage of water data. Data are available for stream levels, stream flow (discharge), reservoir and lake levels, surface-water quality, and rainfall. The data are collected by automatic recorders and manual field measurements at installations across the nation.

Another resource that might be useful is the NHD, at http://nhd.usgs.gov/index.html (USGS 2007b). The NHD is a comprehensive set of digital spatial data that encodes information about naturally occurring and constructed bodies of water, paths through which water flows, and related entities. The data support many applications, such as making maps, modeling the flow of water, and maintaining data. The NHD is the culmination of the cooperative efforts of EPA and USGS.

6.9 Part 9: Water Quality Sampling

Laboratory information

Use this section to provide the name of the laboratory that analyzes the water samples. List the approximate distance from the waterbody to the laboratory.

Sampling and analysis plan, equipment maintenance and calibration procedures

Note on the survey whether a sampling plan or a sampling and analysis plan exists. Review the plan to determine whether it adequately describes sampling and analysis procedures for this waterbody. If any new equipment will be used, update the sampling plan with information on the new equipment, and train staff appropriately.

Before the swim season, managers of recreational waters and their staff should review the sampling plan and equipment maintenance and calibration procedures (if applicable). Keep these documents on-hand so that before each sampling event, field staff can review them as needed. Review these documents during the annual sanitary survey, and if there are any changes in factors such as amount or duration of use, number of swimmers, new sources, or equipment used, make any adjustments in the sample plan or equipment maintenance and calibration procedures.

Biological survey results

Biological surveys are often performed by county or state natural resource departments as part of a comprehensive approach to water resource protection and management. They are sometimes performed for purposes related to the 305(b) assessments and the Nonpoint Source, TMDL, and NPDES programs, as well as other water quality programs. Our increased understanding of how water systems function and respond to human activity has led to the recognition that environmental protection requires a holistic approach to management and protection. It has been necessary to expand our thinking with respect to monitoring approaches, incorporating biological assessments into traditional chemical and physical evaluations (USEPA 1998). For guidance on how to conduct a biological survey and to help you determine whether such a survey is appropriate, consult the EPA's Biological Assessment - Technical Assistance Documents website at https://www.epa.gov/wqc/biological-assessment-technical-assistance-documents-states-tribes-and-territories.

Since the 1800s, more than 160 nonindigenous aquatic species have invaded the Great Lakes ecosystem, causing severe economic and ecological impacts. These species include zebra mussel, round goby, sea lamprey, Eurasian ruffe, purple loosestrife, Eurasian watermilfoil, and spiny and fishhook waterfleas. The Great Lakes Commission has made preventing the introduction and spread of aquatic nuisance species a priority (GLC 2007).

Pictures and descriptions of aquatic invasive species commonly found in the Great Lakes region are provided on the Minnesota Department of Natural Resources website at https://www.dnr.state.mn.us/invasives/ais/id.html.

Duration and identification of species of algae blooms

Algae can be a nuisance. Cladophora species have been found in the nearshore water and on beaches themselves at the Great Lakes. Cladophora species have been reported to have a foul odor that can deter people from visiting. Algae also have been suspected of harboring *E. coli*, which can lead to closures. Taxonomic guides such as Freshwater Algae of North America: Ecology and Classification (Aquatic Ecology) (Wehr and Sheath 2003) can be used to identify algae observed in the nearshore water and on the beach.

Current and/or historical amounts of algae

- Indicate if algae is present during the swim season.
- Record on the *Freshwater Annual Sanitary Survey* the amount (%) of algae found in the nearshore water.
- Record the amount (%) of algae found covering the beach. This should be measured as the percentage of the length of the beach that has algae present. In the Comments or Observations field of the sanitary survey, record the type of algae present, if known.
- Select the type of algae present, if known, and/or note the color(s) of the algae seen.
- Review the results of the *Freshwater Routine Sanitary Survey* for previous years and summarize them on the *Freshwater Annual Sanitary Survey* to determine whether there are any long-term issues and whether there is a correlation between the presence of algae and bacterial sample results.

In addition, list any other aquatic organisms that were found at your beach, including infectious snails.

Harmful Algal Blooms (HABs)

Algae can cause HABs in fresh waters and can affect nearby beaches. Summarize on the annual survey whether any HABs occurred over the past year and how they affected the beach water quality and recreational activities.

USGS scientists have developed a field and laboratory guide for identification of cyanobacteria that are capable of producing toxins. More information about HABs and the field guide can be found at https://www.usgs.gov/mission-areas/environmental-health/science/new-guide-help-identify-harmful-algal-blooms?qt-science_center_objects=0#qt-science_center_objects.

On the annual survey state whether any HABs were observed during the swim season and include the type of bloom, dates, species, and effects, if known. State whether the bloom was determined to be toxic or harmful and add images to document HABs. Consult Section 5.6 for more details.

Historical presence of wildlife and domestic animals

You can determine the presence of animals at the recreational area by visual observation. This should be performed routinely (during the *Freshwater Routine Sanitary Survey*). Use binoculars and a handheld counter to keep track of the number of animals present. Record on the *Freshwater Annual Sanitary Survey* both the types and number of animals present . Note in Other the presence of any types of animals not already listed. Also note in the Comments and Observations section the number of each type of animal present in the water, on the beach or shoreline, and in the air. Summarize the results from the *Freshwater Routine Sanitary Survey* conducted during prior seasons on the *Freshwater Annual Sanitary Survey*. Determine how often animals were found and whether their presence can be correlated with bacteria sampling results. Also include a discussion of whether any fecal droppings were actually seen or are a common occurrence. If routine surveys were not performed and there are no historical data, note the current presence of any wildlife and domestic animals. Consult Section 5.6 for details.

Bacterial samples collected

Managers of recreational waters should compile bacteria indicator concentrations (*E. coli* or enterococcus or both (USEPA 2012a)) and calculate trends, geometric mean, annual/seasonal averages, minimum concentration, and maximum concentrations to assist in measuring the beach water quality. Bacteria concentrations should be compared to previous years' data to determine whether any significant changes have occurred or whether any trends can be detected. Bacteria data should be examined alongside all other data collected, including weather, rainfall, algae, debris, wildlife, flow, and water quality. Consider doing a statistical analysis on data correlation. Examples of bacteria monitoring methods and calculations are included in Appendix C. Consult section 5.4 for details.

Describe where samples are collected, relative to any potential pollution sources. If samples are collected from pollution sources (such as an outfall or river), describe this on the survey.

Water quality

Water quality data (including water temperature, pH, rainfall, turbidity, and conductivity) should be compared to previous years' data. You should also examine data alongside bacteria results to determine whether there are any correlations between bacteria concentrations and water quality results. The following paragraphs give more details on specific water quality parameters.

Water temperature

- You can measure water temperature with relative ease using one of the following:
  - A multiprobe
  - Other handheld electronic measurement device
  - Graduated thermometer

  The accuracy of common, wide-scale thermometers and electronic instruments can be verified with simple ice point (0 degrees Celsius [°C] or 32 degrees Fahrenheit [°F]) and boiling point (100 °C or 212 °F) measurements. If the ice point and boiling point do not register correct temperatures, you can plot results for the two measurements on simple graph paper to translate field measurements to corrected values. Electronic meters can be professionally calibrated if the manufacturer's specifications do not include calibration procedures (USGS 2006). A description for multiprobe is the Section 5.2.

- Local and regional water temperatures for recreational beaches are also generally broadcast on NOAA Weatherband radios and local radio stations. Temperature ranges can be expected to be in the 60s, 70s, and 80s (in degrees Fahrenheit) during the recreational swimming seasons.

pH

- You can conduct measurement of pH using one of the following:
  - Simple pH strips
  - Field test kits
  - Handheld electronic meters (a description for multiprobe in the previous section under the methods listed for water temperature)
- Common pH strips of a range expected for recreational waters are generally accurate enough for routine surveys.

Rainfall

- You can measure rainfall using a rain gauge near the sampling station(s). You can purchase relatively inexpensive rain gauges that can also provide historical rainfall records.
- Alternatively, you can obtain rainfall measurements from a local airport or weather app. The distance from the airport to the sampling station should be noted, as well as whether they are in the same watershed. Record on the *Freshwater Annual Sanitary Survey* the amount of rainfall in inches or centimeters, as well as the time from the previous rainfall event. The websites listed under Section 6.4: Weather Conditions could also be a source of rainfall data.

Turbidity

- You can use simple, subjective observations (e.g., "slightly turbid, clear") to describe the turbidity of nearshore waters.
- Alternatively, you can use test kits (using a visual or titrimetric test method), such as the LaMotte test kit for turbidity, for interpreting turbidity results. The results from using this method are reported in Jackson turbidity units (JTU). Visual methods use reagents to react with a substance in the sample, causing a change in color. The concentration of the substance can be determined using the included color comparators or color sheets. Titrimetric methods use a titrant solution that is added to the sample in precise quantities until a color change indicates a completed reaction. The amount of titrant added is used to determine concentration.
- There are two common methods for instruments to measure turbidity.
  - Instruments can measure the attenuation of a light beam passing through a sample. In the attenuation method, the intensity of a light beam passing through turbid sample is compared with the intensity passing through a turbidity-free sample at 180° from the light source. This method is good for highly turbid samples.
  - Instruments can measure the scattered light from a light beam passing through a sample. The most common instrument for measuring scattered light in a water sample is a nephelometer, which measures light scattered at a right angle (90°) to the light beam. Light scattered at other angles can also be measured, but the 90° angle defines a nephelometric measurement. The light source for nephelometric measurements can be one of two types to meet EPA or ISO specifications. EPA specifies a tungsten lamp with a color temperature of 2,200–3,000 K. The unit of measurement for the EPA method is the nephelometric turbidity unit (NTU). The ISO specifies a light-emitting diode (LED) with a wavelength of 860 nanometers and a spectral bandwidth less than or equal to 60 nanometers. The unit of measurement for the ISO method is the formazin nephelometric unit, or FNU (APHA 2018).
- Portable turbidimeters are available for use in the field. Water is first collected in the vial provided in the turbidimeter kit and then placed in the turbidimeter to obtain measurements. The results, provided in NTUs, are based on comparisons to known turbidity standards (also provided in the kit) through instrument calibration. Also refer to the information on multiprobes given in the previous section under the methods for water temperature.

Conductivity

- A conductivity meter is commonly included in several types of multiprobes. Conductivity is measured electronically primarily, using a device called the Wheatstone bridge, which measures the conductance across two electrodes. Also refer to the information on multiprobes given in the previous section under the methods for water temperature.
- Conductivity is highly correlated with the concentration of dissolved solids within the water column. It is one way to measure the overall health of a lake because aquatic organisms require a relatively constant concentration of the major dissolved ions in the water. Levels too high or too low may limit survival, growth, or reproduction.
- By measuring conductivity (how easily electric current passes through the seawater), scientists can obtain a measurement of that water sample's salinity because electric current passes much more easily through water with a higher salt content. If you know the conductivity of the water, you can calculate how much salt is present in the water.
- The conductivity of lake water is influenced by a number of factors, explained in more detail in *A Citizen's Guide to Understanding and Monitoring Lakes and Streams* (Michaud 1991).

6.10 Part 10: Modeling and Other Studies

In this section on the *Freshwater Annual Sanitary Survey* you provide details on predictive models used at your swim area. You can also provide information on other studies that have been done that provide information related to water quality, including quantitative microbial risk assessment (QMRA), microbial source tracking (MST), tests for optical brighteners, smoke testing for sanitary sewer cross connections, and results of visual screening for pollutants. If other studies were done, summarize those as well.

Predictive models

Predictive models are used to estimate FIB concentrations (USEPA 2010; Gonzalez et al. 2012). They are based on single or multiple correlations between hydrologic meteorology or other data with bacterial indicator counts. In most cases, several years of data have been used to develop a good model. These correlations are useful information in a sanitary survey because they might provide information on sources of contamination on or near the beach that could be remediated. The usefulness of models to predict indicator bacteria counts is mostly in the models' timeliness: Bacteria samples currently take at least 18 hours to analyze, and models can predict bacteria counts—or the likelihood of an exceedance of the water quality standard—more quickly so that timely decisions can be made. Predictive models do not replace the need for sampling. Successfully managed beach programs that use models continually verify their models, and models might change as remediation efforts take place or as conditions change.

If your swim area already has had a model developed for it, you should collect information on the type of model, how it was developed, how it is applied, the frequency of use, and results from its application. If the model used is a rainfall advisory, investigate and document how this advisory was developed and how the rainfall threshold level was determined. In addition, if you are not using models but have plans to use them in the future, describe your plans in the Comments/Observations section.

Nowcast models provide quick, reliable indicators of recreational water quality. Real-time forecasting using mathematical models can help resolve the delayed notification problems inherent with the present approach. Mathematical models use easily measured environmental and water-quality variables (explanatory variables), such as wave height and rainfall, to estimate the *E. coli* concentrations or the probability of exceeding 235 col/100 mL of *E. coli*. This method provides a nowcast of recreational water quality, which is similar to a weather forecast except that it estimates current conditions instead of future ones. Additional information on Nowcast models can be found at https://pubs.usgs.gov/fs/2019/3061/fs20193061.pdf.

Quantitative microbial risk assessment (QMRA)

QMRA can be used to predict the illness risk to beachgoers from pathogens attributed to nonpoint sources at recreational waters. If a QMRA has been done, you should summarize the conclusions from the study in the *Marine Annual Sanitary Survey* and consider the results as you review other pollution source data.

Microbial source tracking (MST)

MST methods are sometimes used to help identify nonpoint sources responsible for the fecal pollution of water systems. MST tools are now being applied in developing TMDLs as part of Clean Water Act requirements and in the evaluation of the effectiveness of best management practices.

MST might be a useful tool for managers of recreational waters too. MST can be used to detect and quantify specific types of fecal contamination to a beach, estuary, or other waterbody. The studies need to be done over a range of conditions, and it is important to make measurements of markers that are relevant for use in your geographic area.

Selection of MST tools and approaches are dependent on the goals of the study and the availability of technical and financial support. If MST has been done at your beach you should summarize the conclusions from the study in the *Annual Sanitary Survey* and consider the results as you review other pollution source data.

Optical brighteners

Optical brighteners are often used in commercial or retail products such as detergents and personal care products. Excess product is typically flushed down the drain, so the presence of optical brighteners in water can indicate human sources of contamination (i.e., from an illicit discharge/straight pipe or gray-water, or malfunctioning septic system) (Maine Healthy Beaches Program 2010). A beach or program manager can determine whether a test for optical brighteners would be useful. If a test for optical brighteners has been done, you should summarize the results in the Annual Survey and consider them as you review other pollution source data. Optical brightener data should be treated with care because specific compounds can cause false positive readings. Therefore, newer approaches such as that presented by Cao et al. (2013) should be used to ensure that false positives have been appropriately assessed.

Smoke testing for sanitary sewer cross connections

Smoke testing can be used to find leaks in sewer systems responsible for inflow and infiltration that could lead to high flows during storm events. It can be used to find cross connections between sanitary and storm sewers. During the test, smoke-filled air is forced through a sewer system, and leaks are detected by points where the smoke escapes. Leaks can be from things such as broken pipes, cracks in pavement, and improper connections. You can check with your public utilities whether smoke testing has been done for the sewer system near your beach.

Visual screening

A visual inspection of the recreational area can provide useful information for managing the area. You can walk or drive around the area to inspect for pollution sources and issues. Take notes and photos of what you find and make sure they are documented, as appropriate. This type of inspection could also provide details about what types of issues might need future investigation.

6.11 Part 11: Advisories/Closings

Advisory and closing data from the previous season provide useful information about water quality and potential sources of contamination. Managers of recreational waters should maintain records of this information in a central file to facilitate compiling advisory and closing data from previous swim seasons and comparing those data with data from the current swim season.

By finding out the number of days the swim area was under advisory or closed during a season, a manager of recreational waters can determine whether overall water quality is improving or declining. Bacteria levels can be compared to the 2012 Recreational Water Quality Criteria statistical threshold values or beach action values recommendations to determine if there were exceedances. In addition, a manager of recreational waters can determine whether the dates the swim area was under advisory or closed during a season correlate with conditions such as rain events, elevated water temperatures, pollutant discharges, high winds, or high wildlife counts. The manager of recreational waters should be able to obtain notes on the conditions during sample collection from previous routine sanitary surveys conducted. Multiple advisories and closings can be reported in the table on the *Freshwater Annual Sanitary Survey*.

6.12 Part 12: Potential Pollutant Sources

The most important objectives of the sanitary survey are to identify sources that affect the swim area, determine their exact location, and measure/calculate the source contribution. The manager of recreational waters should compile potential pollutant information from previously conducted routine sanitary surveys. The manager of recreational waters should also use mapping tools; review the topographic map and the detailed map developed for the annual sanitary survey to determine what nearby sources (e.g., landfills, marinas, bathhouses) might be affecting recreational water quality; and add this information, along with corresponding latitude and longitude data, to this part of the survey. The manager of recreational waters, with the assistance of a sanitarian or public health official, should then estimate the percent annual contribution and peak contribution amounts for each potential pollutant source. This information will be very useful for prioritizing the potential sources for further investigation.

Potential pollutant sources are listed in Part 12 of the *Freshwater Annual Sanitary Survey*. There are some resources that might be useful in helping you locate pollutant sources. For example, you can access the Permit Compliance System and Integrated Compliance Information System databases (PCS-ICIS) to find dischargers in the watershed. You can check for other state and county documents that might contain information on things like dischargers, industries, and utilities in the area. You can walk or drive around the entire watershed, looking for signs of pollutants and potential sources of discharge. You can use the aerial photos on map sites like GoogleEarth.

Identify whether the source is a high, medium, or low contributor to beach pollution. If possible, determine when the source contributes to bacteria pollution; the frequency of occurrence; the amount of contamination; and how it is influenced during dry, wet, and storm conditions. Depending on the source, this information might be available from city, county, or state reports, or you might be able to estimate contributions until further investigations can be done to quantify the pollutants. Consult section 4.3 for links to Clean Water Act programs with potential sources of pollutants affecting the water.

6.13 Part 13: Description of Sanitary Facilities

You should examine the sanitary facilities to determine whether they could be a source of pollutants to the water. Note the number of toilets, showers, sinks, litter bins, and the like to determine whether the facilities are adequate to accommodate the average and peak people/bather loads. Note their condition, their general location, their distance from the beach and the water line, and frequency of cleaning.

6.14 Part 14: Description of Other Facilities

If other facilities, such as restaurants, play areas, or parking lots, that could be a source of pollutants are present , document and photograph them as well. You can consult with a sanitarian, city official, or public health official to access the plans and layouts of any sewer lines in the area to determine their original intended capacity.

7. References

Adopt-A-Stream Foundation. Field Guide: Watershed Inventory and Stream Monitoring Methods, by Tom Murdoch and Martha Cheo. 1996. Everett, WA.

Alliance for the Great Lakes. *Adopt-a-Beach Program*.<https://greatlakes.org/get-involved/adopt-a-beach/ >. Accessed June 2020.

Alm, E.W., J. Burke, and A. Spain. 2003. Fecal indicator bacteria are abundant in wet sand at freshwater beaches. *Water Research*. 37(16): 3978-3982.

Alm, E.W., J. Burke, and E. Hagan. 2006. Persistence and potential growth of the fecal indicator bacteria, *Escherichia coli*, in shoreline sand at Lake Huron. *Journal of Great Lakes Research* 32 (2): 401-405.

APHA (American Public Health Association). 2018. *Standard Methods for the Examination of Water and Wastewater*, 23rd ed. American Public Health Association, Washington, DC.

Bertke, E.E. 2007. Composite analysis for *Escherichia coli* at coastal beaches. *Journal of Great Lakes Research* 33:335–341.

Bordalo, A.A. 2003. Microbiological water quality in urban coastal beaches: The influence of water dynamics and optimization of the sampling strategy. Water Research 37:3233–3241.

Cao, Y., M. Sivaganesan, J. Kinzelman, A.D. Blackwood, R.T. Noble, R.A. Haugland, J.F. Griffith, and S.B. Weisberg. 2013. Effect of platform, reference material, and quantification model on enumeration of Enterococcus by quantitative PCR methods. Water Research 47(1):233–241.

CTDEP. 1992. *Guidelines for Monitoring Bathing Waters and Closure Protocol*. Connecticut Department of Environmental Protection, Hartford, CT.

Figueras, M.J., J.J. Borego, E.B. Pike, W. Robertson, and N. Ashbolt. 2000. Sanitary inspection and micro biological water quality. In *Monitoring Bathing Waters: A Practical Guide to the Design and Implementation of Assessments and Monitoring Programmes*, ed. J.B. a.G. Rees. E & FN SPON, London.

Francy, D.S., and R.A. Darner. 2006. *Procedures for Developing Models to Predict Exceedances of Recrea tional Water-Quality Standards at Coastal Beaches*. Techniques and Methods 6–B5. U.S. Geological Survey, Reston, VA.

GLC (Great Lakes Commission). 2007. *Great Lakes Aquatic Invasions*. Great Lakes Commission. <https://www.glc.org/wp-content/uploads/2016/10/2007-aquatic-invasions-whole.pdf>. Accessed November 12, 2020.

GLRC (Great Lakes Regional Collaboration of National Significance). 2005. *Great Lakes Regional Collaboration Strategy*. Great Lakes Regional Collaboration of National Significance.

Gonzalez, R.A., K.E. Conn, J. Crosswell, and R.T. Noble. 2012. Application of empirical predictive modeling using conventional and alternative fecal indicator bacteria in eastern North Carolina waters. Water Research 46(18):5871–5882

Great Lakes Information Network. 2020. *Great Lakes Water Levels*. Great Lakes Information Nework. <https://www.glerl.noaa.gov/data/wlevels/>. Accessed November 12, 2020.

Great Lakes–Upper Mississippi River Board of State Sanitary Engineers. 1990. *Recommended Standards for Bathing Beaches*. Health Education Service, Albany, NY. <https://www.health.state.mn.us/communities/environment/water/docs/tenstates/bathingbeaches.pdf>. Accessed November 13, 2020.

Largier, J., and M. Taggart. 2006. Improving Water Quality at Enclosed Beaches: A Report on the Enclosed Beach Symposium and Workshop (Clean Beaches Initiative). <http://www.waterboards.ca.gov/water_issues/programs/beaches/cbi_projects/docs/enclosed_beaches_report.pdf>. Accessed November 13, 2020.

MDEQ (Michigan Department of Environmental Quality). 2006. *Background Information on Lake Levels in the Great Lakes*. Michigan Department of Environmental Quality. <http://michigan.gov/deq/0,1607,7-135-3313_3677_3704-12566--,00.html>. Accessed June 7, 2006.

Meals, D.W. and S. A. Dressing. 2008. Surface water flow measurement for water quality monitoring projects, Tech Notes 3, March 2008. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 16 p. <https://www.epa.gov/sites/production/files/2016-05/documents/tech_notes_3_dec2013_surface_flow.pdf>. Accessed on November 13, 2020.

Merrill, N.H., S.F. Atkinson, K.K. Mulvaney, M.J. Mazzotta, and J. Bousquin. 2020. Using data derived from cellular phone locations to estimate visitation to natural areas: An application to water Recrea tion in New England, USA. PLoS ONE 15(4): e0231863. <https://doi.org/10.1371/journal.pone.0231863>.

Michaud, J.P. 1991. A citizen's guide to understanding and monitoring lakes and streams. Publ. #94-149. Washington State Department of Ecology, Publications Office, Olympia, WA, USA 360-407-7472.

Mitchell, M.K., and W. Stapp. Field Manual for Water Quality Monitoring. 5th Edition. Thompson Shore Printers.

Missouri Stream Teams. Volunteer Water Quality Monitoring. Missouri Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102. <https://dnr.mo.gov/env/wpp/vmqmp/vwqmp-work shops.htm.> Accessed on November 13, 2020.

New Jersey Marine Sciences Consortium. *Longshore Current.* 2010. <http://njseagrant.org/wp-content/uploads/2014/03/longshore_current.pdf>. Accessed November 11, 2020.

NOAA (National Oceanic and Atmospheric Administration). 2019. *U.S. Coastal Resilience Toolkit – Coastal Erosion*. National Oceanic and Atmospheric Administration. <https://toolkit.climate.gov/topics/coastal-flood-risk/coastal-erosion>. Accessed November 12, 2020.

NOAA (National Oceanic and Atmospheric Administration). 2020. Great Lakes Water Level Data. National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory. <https://www.glerl.noaa.gov/data/wlevels/>. Accessed November 12, 2020.

NOAA (National Oceanic and Atmospheric Administration). 2006c. National Oceanic and Atmospheric Administration, National Weather Service. <https://www.nws.noaa.gov/>. Accessed March 21, 2007.

NOAA (National Oceanic and Atmospheric Administration). NOAA Satellite and Information Service. <https://www.noaa.gov/satellites>. Accessed November 13, 2020.

Northeast-Midwest Institute. 2003. *Racine Beach Grooming Tactics to Reduce Swimming Bans*. <https://glslcities.org/wp-content/uploads/2015/08/Racine-Beaches.pdf>. Accessed November 13, 2020.

NPS (National Parks Service). 2016. *Coastal Adaptation Strategies Handbook*. National Park Service Report 2016. Edited by Rebecca Beavers, Amanda Babson, and Courtney Schupp. U.S. Department of Interior, National Parks Service.

NPS (National Parks Service). 2019. *Coastal Geology in Our National Parks: Engineering Impacts on the Coastal Environment*. National Parks Service. <https://www.nps.gov/subjects/geology/engineering-the-coastal-environment.htm>. Accessed November 13, 2020.

Platts, W.S., W.F. Megahan, G. W. Minshall. 1983. Methods for Evaluating Stream, Riparian, and Biotic Conditions. Gen Tech Rep. INT. 138. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Rose, J.B., R.M. Atlas, C.P. Gerba, M.R. Gilchrist, M.W. LeChevallier, M.D. Sobsey, M.V. Yates, G.H. Cassell, and J.M. Tiedje. 1999. *Microbial Pollutants in Our Nation's Water: Environmental and Public Health Issues*. American Society for Microbiology, Washington, DC.

Rosen, B.H., A. St. Amand. 2015. Field and laboratory guide to freshwater cyanobacteria harmful algal blooms for Native American and Alaska Native communities. Open-File Report 2015-1164. U.S. Geological Survey. <https://doi.org/10.3133/ofr20151164> Accessed on November 20, 2020.

Southeast Aquatic Resources Partnership. 2017. SARP Stream Crossing Survey Data Form Instruction Guide, Version SE2.1. <https://southeastaquatics.net/sarps-programs/southeast-aquatic-connectivity-assessment-program-seacap/culvert-assessments/sarp-culvert-assessment-manual>. Accessed November 13, 2020.

UNESCO (United Nations Educational, Scientific, and Cultural Organization). 2005. *Introduction to Sand watch: An educational tool for sustainable development*. Coastal region and small island papers 19. United Nations Educational, Scientific, and Cultural Organization, Paris. <https://unesdoc.unesco.org/ark:/48223/pf0000142786 >. Accessed November 13, 2020.

University of Minnesota Extension Service. 2018. *Stabilizing Your Shoreline to Prevent Erosion—Shoreland Best Management Practices*. Number 7 of 18 in the Series. Communication and Educational Technology Services, University of Minnesota Extension. <https://extension.umn.edu/shoreland-properties/stabilizing-shoreline-prevent-erosion>. Accessed November 13, 2020.

Minnesota Department of Natural Resources. 2021. *Aquatic Invasive Species (AIS)*. <https://www.dnr.state.mn.us/invasives/ais/id.html>. Accessed April 13, 2021.

US Army Corps of Engineers. Great Lakes Hydraulics and Hydrology. <https://www.lre.usace.army.mil/Missions/Great-Lakes-Information/Great-Lakes-Information-2/Basin-Conditions/Basin-Conditions/#ICG_ETH_21547>. Accessed November 13, 2020.

USEPA (U.S. Environmental Protection Agency). 1985. *Test Methods for Escherichia coli and Enterococci in Water by the Membrane Filter Procedure*. EPA 600/4-85-076. U.S. Environmental Protection Agency, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 1997. *Volunteer Stream Monitoring: A Methods Manual*. <https://www.epa.gov/sites/production/files/2015-06/documents/stream.pdf>. Accessed November 13, 2020.

USEPA (U.S. Environmental Protection Agency). 1998. *Lake and Reservoir Bioassessment and Biocriteria Technical Guidance Document*. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds and Office of Science and Technology, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 1999. *Review of Potential Modeling Tools and Approaches to Support the BEACH Program*. Final Draft. March 1999. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2000. *Improved Enumeration Methods for the Recreational Water Quality Indicators: Enterococci and Escherichia coli*. <https://www.epa.gov/beach-tech/improved-enumeration-methods-recreational-water-quality-indicators-enterococci-and>. Accessed on November 13, 2020.

USEPA (U.S. Environmental Protection Agency). 2002. *Assessing and Monitoring Floating Debris*. U.S. Environmental Protection Agency, Office of Water, Office of Wetlands, Oceans, and Watersheds, Oceans and Coastal Protection Division, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2006. *Volunteer Estuary Monitoring: A Methods Manual, Second Edition*. EPA-842-B-06-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2009. Method 1600: *Enterococci in Water by Membrane Filtration Using Membrane- Enterococcus Indoxyl- Indoxyl-β-D-Glucoside Agar (mEI).* EPA821-R-09-016. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2010. Predictive *Tools for Beach Notification Volume I: Review and Technical Protocol*. EPA-823-R-10-003. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2012a. *Recreational Water Quality Criteria*. EPA 820-F-12-058. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2014a. *Method 1603: Escherichia coli (E. coli) in Water by Membrane Filtration Using Modified membrane-Thermotolerant Escherichia coli Agar (Modified mTEC).* EPA-821-R-14-010. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2014b. *National Beach Guidance and Required Performance Criteria for Grants, 2014 Edition*. EPA-823-B-14-001. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2015. *Method 1609.1: Enterococci in Water by Taq Man® Quantitative Polymerase Chain Reaction (qPCR) with Internal Amplification Control (IAC) Assay.* EPA-820-R-15-099. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USGS (U.S. Geological Survey). 1982. *Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge, Volume 2 Computation of Discharge.* Water Supply Paper 2175. <http://pubs.usgs.gov/wsp/wsp2175/>. Accessed April 23, 2008.

USGS (U.S. Geological Survey). 2005. *Topographic* Mapping. <https://www.usgs.gov/science-explorer-results?es=topographic+mapping>. Accessed April 13, 2021.

USGS (U.S. Geological Survey). 2006. *National Field Manual for the Collection of Water-Quality Data*: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chapters A1–A9. <http://pubs.water.usgs.gov/twri9A>. Accessed March 22, 2007.

USGS (U.S. Geological Survey). 2007a. USGS Surface-Water Data for the Nation. U.S. Geological Survey, National Water Information System. <http://waterdata.usgs.gov/nwis/sw>. Accessed March 21, 2007.

USGS (U.S. Geological Survey). 2007b. National Hydrography Dataset. U.S. Geological Survey. <http://nhd.usgs.gov/index.html>. Accessed March 21, 2007.

Wehr, John D. and Robert G. Sheath. 2003. *Freshwater Algae of North America: Ecology and Classificaion (Aquatic Ecology)*. Elsevier Science (USA), Academic Press, San Diego, CA.

Whitman, Richard. 1999. Interaction of ambient conditions and fecal coliform bacteria in southern Lake Michigan beach waters: Monitoring program implications. *Natural Areas Journal* 19(2): 166-171.

Whitman, R., M. B. Nevers 2003a. Foreshore Sand as a Source of *Escherichia coli* in Nearshore Water of a Lake Michigan Beach. *Applied and Environmental Microbiology*, 69(8):5555–5562.

Whitman, R., D.A.Shively, H. Pawlik, M.B. Nevers 2003b. Occurrence of *Escherichia coli* and Enterococci in Cladophora (Chlorophyta) in Nearshore Water and Beach Sand of Lake Michigan. *Applied and Environmental Microbiology*, 69(9):4714–4719.

Whitman, Richard. USGS. March 2006. Personal Communications.

Whitman, R.L., and M.B. Nevers. 2008. Summer E. coli patterns and responses along 23 Chicago beaches. *Environmental Science and Technology* 42:9217–9224.

WHO (World Health Organization). 1999. *Health-Based Monitoring of Recreational Waters: The Feasibility of a New Approach* (The “Annapolis Protocol”). WHO/SDE/WSH/99.1. World Health Organization, Geneva, Switzerland.

Yamahara, K.M., B.A. Layton, A.E. Santoro, and A.B. Boehm. 2007. Beach sands along the California coast are diffuse sources of fecal bacteria to coastal waters. Environmental Science and Technology 41:4515–4521.

Appendix A. Quality Assurance and Quality Control

States, tribes, and local agencies should use the information in this document and follow their agency-specific QA/QC procedures for data collection, entry, and analysis when performing sanitary surveys.

Most agencies should already have QA/QC procedures for performing beach monitoring because such procedures are required to obtain BEACH Grants in accordance with the EPA regulations at 40 CFR 31.45 governing grants to states, tribes, and local governments. Specifically, the regulations require the following:

> If the grantee's project involves environmentally related measurements or data generation, the grantee shall develop and implement quality assurance practices consisting of policies, procedures, specifications, standards, and documentation sufficient to produce data of quality adequate to meet project objectives and to minimize loss of data due to out-of-control conditions or malfunctions.

An agency's QA/QC procedures should be updated, as needed, to include QA/QC procedures for performing the sanitary surveys described in this document. An agency's QA/QC procedures are generally documented in quality management plans (QMPs), quality assurance project plans (QAPPs), and standard operating procedures (SOPs). If an agency needs to develop additional quality documentation for performing sanitary surveys, it should refer to the following documents for non-EPA available on EPA's quality website at https://www.epa.gov/quality/agency-wide-quality-system-documents:

- EPA Requirements for Quality Management Plans (QA/R-2)
- EPA Requirements for QA Project Plans (QA/R-5)
- Guidance for Quality Assurance Project Plans (QA/G-5)
- Guidance for Preparing Standard Operating Procedures (QA/G-6)

EPA has also developed QA guidance and templates specifically for the citizen science which can be found at https://www.epa.gov/citizen-science/quality-assurance-handbook-and-guidance-documents-citizen-science-projects.

Typically, the written quality documentation takes the form of a QAPP. A QAPP details the technical activities and QA/QC procedures that should be implemented to ensure that data meet the specified standards. The QAPP should identify who will be involved in the project and their responsibilities; the nature of the study or monitoring program; the questions to be addressed or decisions to be made on the basis of the data collected; where, how, and when samples will be taken and analyzed; the requirements for data quality; the specific activities and procedures to be performed to obtain the requisite level of quality, including QC checks and oversight; and how the data will be managed, analyzed, checked to ensure that it meets the project goals, and reported. The QAPP should be implemented to ensure that data collected and analytical data generated are complete, accurate, and suitable for the intended purpose.

States, tribes, and local agencies should also document their methods and assessment procedures in their quality system documentation. For routine implementation of these methods, SOPs, which can be referenced in and provided with the quality system documentation, provide a tool to assist the person(s) performing the activities. An SOP typically presents in detail the method for a given technical (not administrative) operation, analysis, or action in sequential steps. It includes specific facilities, equipment, materials, and methods; QA and QC procedures; and other factors necessary to perform the operation, analysis, or action. If the SOP is followed, the operation should be performed the same way every time; that is, the operation is standardized. The activities being performed might include field sampling and database management.

The format and content requirements for an SOP are flexible because the content and level of detail vary according to the nature of the procedure. SOPs should be revised when new equipment is used, when comments by personnel indicate that the directions are not clear, or when a problem occurs. States, tribes, and local agencies should ensure that obsolete documents are removed and that the revised SOPs are used in subsequent tasks.

EPA recommends that a registered sanitarian supervise the first few routine sanitary surveys performed by volunteers or lifeguards. In addition, as routine sanitary surveys are completed, the registered sanitarian or designee should review them for any problems (e.g., incomplete answers, questionable responses). The registered sanitarian should provide some guidance to volunteers or lifeguards to ensure that problems are remedied. The following are some additional quality guidelines that should be followed:

- Make sure a second person checks the sanitary surveys to be sure it has been filled out correctly.
- Follow the calibration procedures for each instrument carefully. Flow meters have been factory-calibrated, but they must be checked regularly to ensure that they are working properly before use. The calibration of pH, conductivity/salinity, dissolved oxygen, temperature, and turbidity probes should be checked (at a minimum) once daily, before initial deployment, or as deemed necessary by the equipment manufacturer, using the standard solutions.
- Contact the laboratory at least 8 to 10 hours (24 hours is ideal) before the start of the sampling event to determine whether additional volumes of samples must be collected for QC analyses in the laboratory. If field blanks, trip blanks, and field duplicates are required (requirements should be specified in the QAPP), they must be collected as specified by the lab. If a sampling trip is cancelled, notify the lab immediately.
- Prevent contamination of samples at all times. Take care with respect to equipment handling, container handling and storage, decontamination, and record keeping. Rinse and clean sample collection equipment as necessary before and after each sampling episode, with the exception of pre-preserved containers. Wear clean, powder-free gloves or make sure your hands are clean.

In addition to the general quality considerations, EPA recommend that you develop SOPs for each activity or piece of equipment. Because completing the survey and performing sampling generally require the application of best professional judgment in addition to following predetermined steps, EPA recommends that only persons who have received training in the operation of each type of equipment and have experience in monitoring water quality be responsible for completing the sanitary survey.

Appendix B. Equipment and Supplies

A list of potential vendors to help you locate water quality supplies is in Appendix E of the Minnesota Pollution Control Agency Volunteer Surface Water Monitoring Guide, at https://www.pca.state.mn.us/sites/default/files/wq-s1-15.pdf.

The overall potential cost of a sanitary survey ranges from tens to thousands of dollars. For the purposes of this evaluation, the expense assessment is associated with monitoring equipment and health and safety equipment for the survey teams. Health and safety are not considered optional; however, there are some cost-control opportunities in the selection and use of safety equipment. For the purpose of this analysis, the minimum safety requirements are safety glasses, gloves, and rubber boots.

The cost or investment in conducting sanitary surveys is due primarily to the sampling and water quality testing equipment and supplies. Some or most of this expense might already be covered by a monitoring program. Critical to these are (1) what capital equipment might be available in the survey sponsorship organizations; (2) what data are most important to the sponsors; (3) the overall qualifications of the sampling team staff; (4) how many survey stations or locations are identified within a sponsor's jurisdiction; and (5) the time frame for completing the surveys. A significant number of stations or transects to be surveyed might dictate the need for a more expensive monitoring option, but the number of stations will ultimately drive down the cost per survey.

Much of the equipment a volunteer will need is easily obtained from either hardware stores or scientific supply houses. Other equipment can be found around the house. In either case, the volunteer program should clearly specify the equipment its volunteers will need and where it should be obtained (USEPA 1997).

Listed below is some basic equipment appropriate for any volunteer field activity. Much of this equipment is optional but will enhance the volunteers' safety and effectiveness.

- Boots or waders; life jackets if you are sampling by boat
- Personal identification (e.g., driver's license)
- Walking stick of known length for balance, probing, and measuring
- Bright-colored snag- and thorn- resistant clothes; long sleeves and pants are best
- Hat
- Rubber gloves to guard against contamination
- Insect repellent/sunscreen
- Eye protection (e.g., sunglasses)
- Small first aid kit, flashlight, and extra batteries
- Whistle to summon help in emergencies
- Refreshments and drinking water
- Clipboard, preferably with plastic cover
- Several pencils
- Tape measure
- Thermometer
- Compass or Global Positioning System receiver
- Information sheet with safety instructions, site location information, and numbers to call in emergencies
- Camera and film, to document particular conditions
- Cellular phone, tablet or computer with downloaded sanitary survey app
- Paper copies of sanitary surveys as backup

More information on field equipment for monitoring can be found in the Volunteer Stream Monitoring: A Methods Manual at https://www.epa.gov/sites/production/files/2015-04/documents/volunteer_stream_monitoring_a_methods_manual.pdf and the Volunteer Estuary Monitoring A Methods Manual at https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual.

Appendix C: Sampling and Analytical Methods for Bacteria

C.1 Methods of sample collection

Qualified local laboratory services are a tremendous source for information. In addition to providing analytical support for monitoring recreational waters for pathogens, laboratories usually provide their own sterilized sample containers and custody documents to record dates, times, and sample locations. Local laboratories often provide training for sampling personnel, or laminated sampling guides to assist in appropriately collecting samples and completing sample documentation. Sampling procedures should be developed into standard operating procedures (SOPs) based on the variety of sampling requirements for the target sites. (For example, variable accessibility and sampling depths in the monitoring design could require that different techniques be employed at different locations.) In general, samples should be collected at the desired depth(s) directly into sterilized containers. The containers should then be sealed, labeled, and chilled for transport to the local laboratory.

Chapter 4 of the National Beach Guidance and Required Performance Criteria for Grants-2014 Edition (USEPA 2014b) provide information on sample collection, sample handling, and suggested procedures. EPA's general recommendation for all beaches is that samples be taken at knee depth. However, local conditions will dictate the sampling depth selected for a beach.

Appropriate sampling procedures should be determined for a monitoring program on the basis of the sampling design, the availability of facilities and equipment, and how the samples will be processed. In addition, it is important to use consistent procedures and take careful notes in the field when collecting samples. Additional information about EPA-recommended SOPs for sample collection, handling, and subsequent analysis can be found in Standard Methods for the Examination of Water and Wastewater (APHA 1998).

C.2 Methods of analysis

EPA recommends a number of analytical methods for use in testing recreational waters. These are methods that EPA has approved and codified at 40 CFR part 136 or validated in single or multi-lab validation studies. These methods, with their associated indicators are used to determine whether water quality at a beach exceeds or is likely to exceed the applicable water quality standard. EPA recommends the following approved culture and validated qPCR methods:

- EPA Method 1603 or any other equivalent method that measures culturable *E. coli*.
- EPA Enterococcus spp. qPCR Method 1609.1

Chapter 4 of the Beach Guidance provides more information on the recommended EPA's methods for testing recreational waters.

C.3 Data interpretation

In 2012, EPA released revised water quality criteria for recreational waters. EPA recommended that the water quality standards based on the 2012 recreational water quality criteria (RWQC) include the following:

- Magnitude – the numeric expression of the maximum amount of pollutant that might be present in a waterbody that supports the designated use.

- Duration – the period of time over which the magnitude is calculated.

- Frequency of excursion – the maximum number of times the pollutant might be present above the magnitude over a specified time period (duration).

EPA determined that the primary contact recreation designated use would be protected if one of the following criteria sets consisting of a GM and an STV were adopted into a state's WQS and approved by EPA (USEPA 2012a).

In addition to the RWQC values described above, EPA provided Beach Action Values (BAV) as a conservative precautionary tool for making beach notification decisions. The BAV is not a component of EPA's recommended criteria, but a tool that states may choose to use, without adopting it into their WQS as a "do not exceed" value for beach notification purposes (such as advisories) (USEPA 2012a). It represents the 75th percentile value of the water quality distributions for the Clean Water Act section 304 (a) recommended criteria (USEPA 2014b).

States have the flexibility to choose the criterion illness rate to determine the corresponding BAV. For states that choose to use a BAV (Table C-1), any single sample above the BAV could trigger a beach notification until another sample below the BAV is collected. For states that do not use a BAV, EPA suggests using the criteria STV values (provided in Table C-1) as "do not exceed" values for beach notification or retaining their current beach notification values in their WQS (USEPA 2012a).

Table C-1. EPA's Recommended 2012 RWQC

Criteria Elements	**Estimated Illness Rate (NEEAR GI): 36 NGI per 1,000 recreators**		**Estimated Illness Rate (NEEAR GI): 32 NGI per 1,000 recreators**	
	Magnitude		**Magnitude**	
Indicator	GM (CFU/100mL)[a]	STV (CFU/100mL)[a]	GM (CFU/100mL)[a]	STV (CFU/100mL)[a]
Enterococci – marine and fresh water	35	130	30	110
OR				
E. coli – fresh water	126	410	100	320
Duration: The waterbody GM and STV should be evaluated over a 30-day interval.				
Frequency: The selected GM magnitude should not be exceeded in any 30-day interval, nor should there be greater than a 10 percent excursion frequency of the selected STV magnitude in the same 30-day interval.				

[*]EPA recommends using EPA Method 1600 (USEPA 2009) to measure culturable enterococci, or another equivalent method that measures culturable enterococci and using EPA Method 1603 (USEPA 2014a) to measure culturable *E. coli*, or any other equivalent method that measures culturable *E. coli*.

Table C-2. Beach Action Values

Indicator	Estimated Illness Rate (NEEAR GI): 36 NGI per 1,000 recreators		Estimated Illness Rate (NEEAR GI): 32 NGI per 1,000 recreators
	BAV (units per 100 mL)		BAV (units per 100 mL)
Enterococci – culturable (fresh and marine) [a]	70 cfu	OR	60 cfu
E. coli – culturable (fresh)[b]	235 cfu		190 cfu
Enterococcus spp. – qPCR (fresh and marine)[c]	1,000 cce		640 cce

[a] Enterococci measured using EPA Method 1600 (US EPA 2009), or another equivalent method that measures culturable enterococci.
[b] *E. coli* measured using EPA Method 1603 (USEPA 2014a), or any other equivalent method that measures culturable *E. coli*.
[c] EPA *Enterococcus spp*. Method 1609.1 for qPCR (USEPA 2015).

Additional information and guidance on using BAVs for beach monitoring and notification can be found in Chapter 4 of the National Beach Guidance and Required Performance Criteria for Grants 2014 Edition (USEPA 2014b). The 2012 RWQC recommendations can be found at https://www.epa.gov/sites/production/files/2015-10/documents/rwqc2012.pdf.

Appendix D – EPA Recommended Criteria, Methods and Other Resources for Cyanotoxins

D.1 EPA's National CWA Section 304(a) Recommended Recreational Water Quality Criteria for Microcystins and Cylindrospermopsin

In 2019, EPA issued its national Clean Water Act (CWA) Section 304(a) recreational water quality criteria recommendations for two cyanotoxins, microcystins and cylindrospermopsin, reflecting the latest peer-reviewed scientific knowledge. The criteria are designed to protect the public from incidental exposure to harmful levels of these cyanotoxins while participating in water-contact activities in freshwater where immersion and incidental ingestion of water are likely. Such activities include, but are not limited to, swimming, water skiing, tubing, skin diving, water play by children, or similar water-contact activities in waterbodies designated for such recreational uses. EPA issued its 2019 recommended criteria under the statutory authority of CWA Section 304(a).

EPA's 2019 recommended criteria for microcystins and cylindrospermopsin are summarized in Table D-1, below. For more information on the magnitude, duration and frequency components of the criteria, see *Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin 2019* (https://www.epa.gov/cyanohabs/recommendations-cyanobacteria-and-cyanotoxin-monitoring-recreational-waters.)

Table D-1. National CWA Section 304(a) Recommendations for Recreational Water Quality Criteria for Microcystins and Cylindrospermopsin[a]

Microcystins Magnitude (µg/L)	Cylindrospermopsin Magnitude (µg/L)	Duration	Frequency
8	15	1 in 10-day assessment period across a recreational season	Not more than 3 excursions in a recreational season in more than one year[b]

[a] States and authorized tribes can choose to adopt one or both criteria recommendations.
[b] An excursion is defined as a 10-day assessment period with any toxin concentration higher than the recommended criteria magnitude. When more than three excursions occur within a recreational season and that pattern reoccurs in more than one year, it is an indication the water quality has been or is becoming degraded and is not supporting its recreational use. As a risk management decision, states and authorized tribes should include in their WQS an upper-bound recurrence frequency stating the number of years that pattern can reoccur and still support its recreational use

D2. Using the Recommended Recreational Water Quality Criteria Values for Microcystins and Cylindrospermopsin for Swimming Advisories

EPA envisions that if states or authorized tribes decide to use the recommended criteria magnitude values for swimming advisory purposes, they can manage a cyanotoxin monitoring and advisory program in the same way as they manage any existing recreational water advisory program (e.g., those for pathogen indicators, like E. coli or enterococci). States and authorized tribes may choose to apply either or both recommended criteria magnitude values as the basis for public notifications (i.e., swimming advisories or closures) at recreational waterbodies. EPA's swimming advisory recommendations for microcystins and cylindrospermopsin are summarized in Table D-2, below.

Table D-2. Swimming Advisory Recommendations for Microcystins and Cylindrospermopsin[a]

Microcystins Magnitude (µg/L)	Cylindrospermopsin Magnitude (µg/L)	Duration	Frequency
8	15	One day	Not to be exceeded

[a] States and authorized tribes can choose to apply one or both recommended magnitude values as the basis for swimming advisories.

D.3 Analytical Methods to Monitor for Cyanotoxins

EPA does not require any single method to monitor for cyanotoxins. In addition to the list below, EPA refers readers to the National Environmental Methods Index (https://www.nemi.gov/home/) for information on analytical methods. Also, the Interstate Technology and Regulatory Council Harmful Cyanobacterial Blooms project team has included a comprehensive summary of analytical methods and a method selection tool on its website (https://www.itrcweb.org/Team/Public?teamID=82).

Methods for quantifying cyanotoxins (total or individual congener concentrations) include, but are not limited to:

- Standardized methods developed by EPA for analyzing cyanotoxins in ambient and drinking Water.
- EPA Method 544, a standardized, single laboratory validated liquid chromatography/tandem mass spectrometry (LC/MS/MS) method for the detection of microcystins and nodularin in drinking water.
- EPA Method 545, a standardized, single laboratory validated LC/MS/MS method for the detection of cylindrospermopsin and anatoxin-a in drinking water.
- EPA Method 546, a standardized, single laboratory validated method using an Adda enzyme-linked immunosorbent assay for the detection of microcystins and nodularin in ambient and drinking water.
- Lab-based Enzyme-Linked Immunosorbent Assay (ELISA) method. The ELISA method is typically run with only a microcystin-LR standard for comparison but can quantify a broad range of microcystin congeners (especially if using an ADDA-based antibody).
- Field test kits (e.g., Eurofins Technologies (formerly Abraxis) test strip, Envirologix QualiTube). These field-based methods do not require laboratory instrumentation and can produce semi-quantitative results within about an hour; however, these methods may be better suited for screening purposes, given their limited range of quantification.
- High performance liquid chromatography (HPLC) combined with ultraviolet/photodiode array detectors (UV/PDA). This method requires known toxin standards to be run alongside the water sample(s) to quantify the toxin concentration(s), and its results are limited to only those congeners for which standards are available and analyzed. HPLC-UV/PDA methods are based on a non-selective detector and co-eluting interferents can prevent accurate identification of components and quantitation. It is less sensitive than mass spectrometry methods (see below).
- Liquid chromatography/tandem mass spectrometry (LC/MS/MS). Like HPLC-UV/PDA, this method requires known toxin standards to be run alongside the water sample(s) to quantify the toxin concentration(s) and its results are limited to only those congeners for which standards are available and analyzed. It is, however, the most precise method for quantitation of analytes (such as specific microcystin congeners) if standards are available. This method may also require the use of solid phase extraction for analytes with weak product ion abundance (microcystins). The LC-MS/MS MMPB (2-methyl-3(methoxy)-4-phenylbutyic acid) method analyzes the chemically cleaved ADDA group common to all microcystin congeners and therefore provides an alternative LC-based approach for analyzing a broad range of microcystin congeners. The MMPB method may also detect microcystins break-down products and could potentially overestimate microcystin concentrations in some settings.

- Protein phosphatase inhibition assay (PPIA). This method has varying degrees of specificity depending on its substrate composition and may react to compounds in the sample other than microcystins.

EPA recognizes that several states or authorized tribes may monitor for cyanobacterial cell densities in addition to, or in lieu of, monitoring for cyanotoxins. Laboratory-based methods for quantifying cyanobacterial cells include microscopy and quantitative polymerase chain reaction (qPCR) and microarrays/DNA chips. Field-based methods include, but are not limited to, remote sensing based on satellite imagery, FlowCam (imaging particle analysis), flow cytometry, and derivative spectrophotometry.

D.4 Additional Information and Resources

Additional materials to assist recreational waterbody managers and others interested in monitoring for and responding to cyanobacteria and cyanotoxins in recreational waters are listed below.

- Customizable Infographics to Help Educate the Public on HABs Basics: https://www.epa.gov/cyanohabs/infographics-help-educate-public-habs-basics.
- Communicating about Cyanobacterial Blooms and Toxins in Recreational Waters: https://www.epa.gov/cyanohabs/communicating-about-cyanobacterial-blooms-and-toxins-recreational-waters.
- Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters: https://www.epa.gov/cyanohabs/monitoring-and-responding-cyanobacteria-and-cyanotoxins-recreational-waters.
- Recommendations for Cyanobacteria and Cyanotoxin Monitoring in Recreational Waters.
- Field and Laboratory Guide to Freshwater Cyanobacteria Harmful Algal Blooms for Native American and Alaska Native Communities: This 2015 guide, produced by the USGS, provides field images to help differentiate between cyanobacterial blooms (some of which produce toxins), non-toxic algal blooms, and floating plants that might be confused with algae.
- Cyanobacterial Harmful Algal Blooms in Water (website): https://www.epa.gov/cyanohabs.
- Communication Toolbox for Cyanobacterial Blooms and Toxins in Recreational Waters: https://www.epa.gov/cyanohabs/communicating-about-cyanobacterial-blooms-and-toxins-recreational-waters.