DEPARTMENT OF ECOLOGY
State of Washington

# Quality Assurance Project Plan

## Beach Environmental Assessment, Communication, and Health (BEACH) Program: Monitoring Washington State Marine Beaches

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# Publication Information

Each study conducted by the Washington State Department of Ecology must have an approved Quality Assurance Project Plan (QAPP). The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

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COVER PHOTO: People scuba diving, paddle boarding, surfing, collecting seashells, and collecting water samples, and dog on beach in Puget Sound and the Pacific coast. (BEACH Program photo files)

# Quality Assurance Project Plan

# Beach Environmental Assessment, Communication & Health (BEACH) Program: Monitoring Washington State Marine Beaches

## December 2019

**Approved by:**

| | |
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Signatures are not available on the Internet version.
EAP: Environmental Assessment Program

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# 2.0 Abstract

The Washington State Beach Environmental Assessment, Communication and Health (BEACH) Program supports a public marine recreational beach monitoring and notification program throughout the Puget Sound and coast of Washington. Select Washington marine beaches are tested for Enterococci bacteria, an indicator of fecal contamination, to determine possible health risk to the public from water contact recreation. During the swimming season, water samples are collected at high-use, high-risk marine beaches that are primarily used for swimming, wading, surfing, or SCUBA diving. The public is notified when bacteria levels are high and it is unsafe to swim in the water

Washington's BEACH Program is primarily funded through a U.S. Environmental Protection Agency (EPA) grant. The ongoing monitoring program is co-managed by the Washington State Departments of Ecology and Health. The BEACH Program distributes grant funding for monitoring, beach notification, and public education to local health jurisdictions (LHJs), universities, tribes, and volunteer nonprofit organizations throughout the Puget Sound and Washington coast. Monitoring and program activities are coordinated on a regional basis by BEACH Program staff.

This Quality Assurance Project Plan (QAPP) supersedes the QAPP for BEACH Program monitoring, written in 2014 (Sargeant & Lowe, 2014).

# 3.0 Background

The BEACH Program supports a marine recreational beach monitoring and notification program throughout the Puget Sound and coast of Washington. Washington marine beaches are tested for Enterococci bacteria to determine possible health risk to the public from water contact recreation. During the swimming season, water samples are collected at high-use, high-risk marine beaches primarily used for swimming, wading, surfing, and SCUBA diving. The public is notified when results exceed the BEACH Program Guidance thresholds described in Schneider (2002). The BEACH Program is an ongoing monitoring program that began in 2004.

Washington's BEACH Program is primarily funded through a U.S. Environmental Protection Agency (EPA) grant. In 2000, the federal Clean Water Act was amended, adding the Beaches Environmental Assessment and Coastal Health Act (BEACH Act). Congress authorized EPA to award grants to states for the development and implementation of BEACH programs that reduce the risk of disease to users of the nation's marine recreational waters. States use the grant money to develop and implement programs to support microbiological testing and monitoring of marine recreational waters. The grants also support communication programs to notify the public of potential exposure to disease-causing microorganisms.

In 2012, EPA revised Recreational Water Quality Criteria threshold limits (EPA, 2012). The revised criteria are directly based on health risks to humans swimming in the water. In 2018, Washington State revised their recreational water quality criteria to align with the 2012 EPA Recreational Water Quality Criteria.

The BEACH Program is co-managed by the Washington State Departments of Ecology (Ecology) and Health (Health). The program distributes grant funding for monitoring, beach notification, and public education to local health jurisdictions (LHJs), universities, tribes, and volunteer nonprofit organizations throughout Puget Sound and the coast. Monitoring and program activities are coordinated on a regional basis by BEACH Program staff.

In addition to routine beach monitoring, the program helps to identify sources of bacterial pollution at beaches with high bacteria levels. BEACH Program staff also participate in public education and outreach activities to educate the public about sources of bacterial pollution and what they can do to avoid polluting the water. Staff also educate the public about health risks associated with swimming in contaminated waters and how to minimize those risks.

## 3.1 Introduction and problem statement

The BEACH Program supports a marine recreational beach monitoring and notification program throughout the Puget Sound and coast of Washington. Washington marine beaches are tested for Enterococci bacteria, an indicator of fecal contamination, to determine possible health risks to the public from water contact recreation. During the swimming season, water samples are collected at high-use, high-risk marine beaches primarily used for swimming, wading, surfing, and SCUBA diving.

Logistical problems may include volunteer sampler availability, beach access due to tidal variation, and timing of field work due to the 6-hour holding time for Enterococci bacteria samples.

Beach sampling should be scheduled in advance of the sampling season (May through September). Schedules should include sample timing windows for beaches with high tidal variations. For example, it is unsafe to sample some muddy beaches at low tide and it is difficult to access some beaches at higher tides.

In addition, ample time must be allowed to conduct all sampling and deliver the samples to the laboratory by the appropriate time and within 6 hours of sample collection

For beaches sampled by volunteers (Snohomish and Skagit county beaches, Fort Worden State Park in Jefferson County, Larrabee State Park and Little Squalicum in Whatcom County, and Pries Point Park in Thurston County), it may be difficult to find volunteers to resample beaches with initial high bacteria counts. Beaches sampled by volunteers should include a weekly sample schedule. The sample schedule should also include volunteers on call for resample events.

## 3.2 Study area and surroundings

The study area includes public marine beaches in Puget Sound and the coast. The number of monitored beaches varies from year to year, depending on available funding. The BEACH program sampled 49-73 beaches per year from 2004-2019. Counties currently participating in the program are: Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Mason, Pierce, Skagit, Snohomish, Thurston, and Whatcom.

The Makah Tribe in Clallam County currently obtains funding directly from EPA to administer their BEACH Program. They monitor 5 beaches weekly, year-round. Data from their program is entered into the BEACH database and the EIM database by Ecology staff.

The BEACH program developed a list of 52 core beaches (Table 1 and Figure 1). Core beaches are considered to be the highest-use and highest-risk beaches in Washington. The BEACH Program tries to consistently monitor core beaches, as funding allows, to determine long-term water quality trends. In addition to core beaches, staff reviewed many sources of data in 2002 to evaluate and rank 169 marine beaches in 13 coastal counties to create a list of prioritized beaches for monitoring. Sources included LHJ knowledge of beach usage, potential pollution source problems, and public input. Since then, the list has grown to 211 beaches, based on changing needs and further input from the public and local agencies. Each year BEACH Program staff works with LHJs to determine which high-use, high-risk priority beaches they would like to monitor based on adequate funding to cover monitoring and staff costs.

Table 1. BEACH Program list of core beaches.

| County | Beach | Beach Identification |
|---|---|---|
| CLALLAM | CLINE SPIT COUNTY PARK | WA422935 |
| CLALLAM | SALT CREEK RECREATION AREA | WA496627 |
| GRAYS HARBOR | WESTPORT - THE GROYNES | WA353465 |
| GRAYS HARBOR | WESTHAVEN STATE PARK, SOUTH JETTY | WA620402 |
| GRAYS HARBOR | WESTHAVEN STATE PARK, HALF MOON BAY | WA673259 |
| ISLAND | FREELAND COUNTY PARK / HOLMES HARBOR | WA600271 |
| ISLAND | WINDJAMMER PARK | WA896421 |
| ISLAND | WINDJAMMER LAGOON | WA913096 |
| JEFFERSON | FORT WORDEN STATE PARK | WA515591 |
| KING | CARKEEK PARK | WA121922 |
| KING | LINCOLN PARK | WA160611 |
| KING | GOLDEN GARDENS | WA339253 |
| KING | SEAHURST PARK | WA347545 |
| KING | ALKI BEACH PARK | WA614011 |
| KING | SALTWATER STATE PARK | WA667355 |
| KING | REDONDO COUNTY PARK | WA676420 |
| KING | DASH POINT STATE PARK | WA686013 |
| KING | RICHMOND BEACH SALTWATER PARK | WA705527 |
| KING | RICHEY VIEWPOINT | WA726327 |
| KITSAP | INDIANOLA DOCK | WA175620 |
| KITSAP | SILVERDALE WATERFRONT PARK | WA177646 |
| KITSAP | ARNESS COUNTY PARK | WA192208 |
| KITSAP | EVERGREEN PARK | WA324660 |
| KITSAP | FAY BAINBRIDGE PARK | WA325280 |
| KITSAP | POMEROY PARK - MANCHESTER BEACH | WA369081 |
| KITSAP | EAGLE HARBOR WATERFRONT PARK | WA381199 |
| KITSAP | LIONS FIELD | WA581265 |
| KITSAP | ILLAHEE STATE PARK | WA843240 |

| County | Beach | Beach Identification |
|---|---|---|
| MASON | WALKER COUNTY PARK | WA113345 |
| MASON | TWANOH STATE PARK | WA205748 |
| MASON | POTLATCH STATE PARK | WA521828 |
| PIERCE | DASH POINT METRO PARK | WA261743 |
| PIERCE | WATERFRONT DOCK / RUSTON WAY | WA288467 |
| PIERCE | PURDY SANDSPIT COUNTY PARK | WA370745 |
| PIERCE | TITLOW PARK | WA465917 |
| PIERCE | OWEN BEACH / POINT DEFIANCE PARK | WA473944 |
| PIERCE | JACK HYDE PARK | WA664326 |
| PIERCE | SUNNYSIDE BEACH PARK | WA872803 |
| SKAGIT | BAY VIEW STATE PARK | WA211931 |
| SKAGIT | BAY VIEW BOAT LAUNCH | WA595244 |
| SNOHOMISH | EDMONDS MARINA BEACH DOG PARK | WA207419 |
| SNOHOMISH | PICNIC POINT COUNTY PARK | WA233925 |
| SNOHOMISH | KAYAK POINT COUNTY PARK | WA294978 |
| SNOHOMISH | HOWARTH PARK | WA587438 |
| SNOHOMISH | JETTY ISLAND | WA765635 |
| SNOHOMISH | EDMONDS UNDERWATER PARK | WA928351 |
| SNOHOMISH | EDMONDS MARINA BEACH PARK | WA980702 |
| THURSTON | BURFOOT COUNTY PARK | WA467079 |
| WHATCOM | PORT OF BELLINGHAM MARINE PARK | WA266896 |
| WHATCOM | BIRCH BAY STATE PARK | WA382349 |
| WHATCOM | BIRCH BAY COUNTY PARK | WA486271 |
| WHATCOM | LARRABEE STATE PARK, WILDCAT COVE | WA542379 |

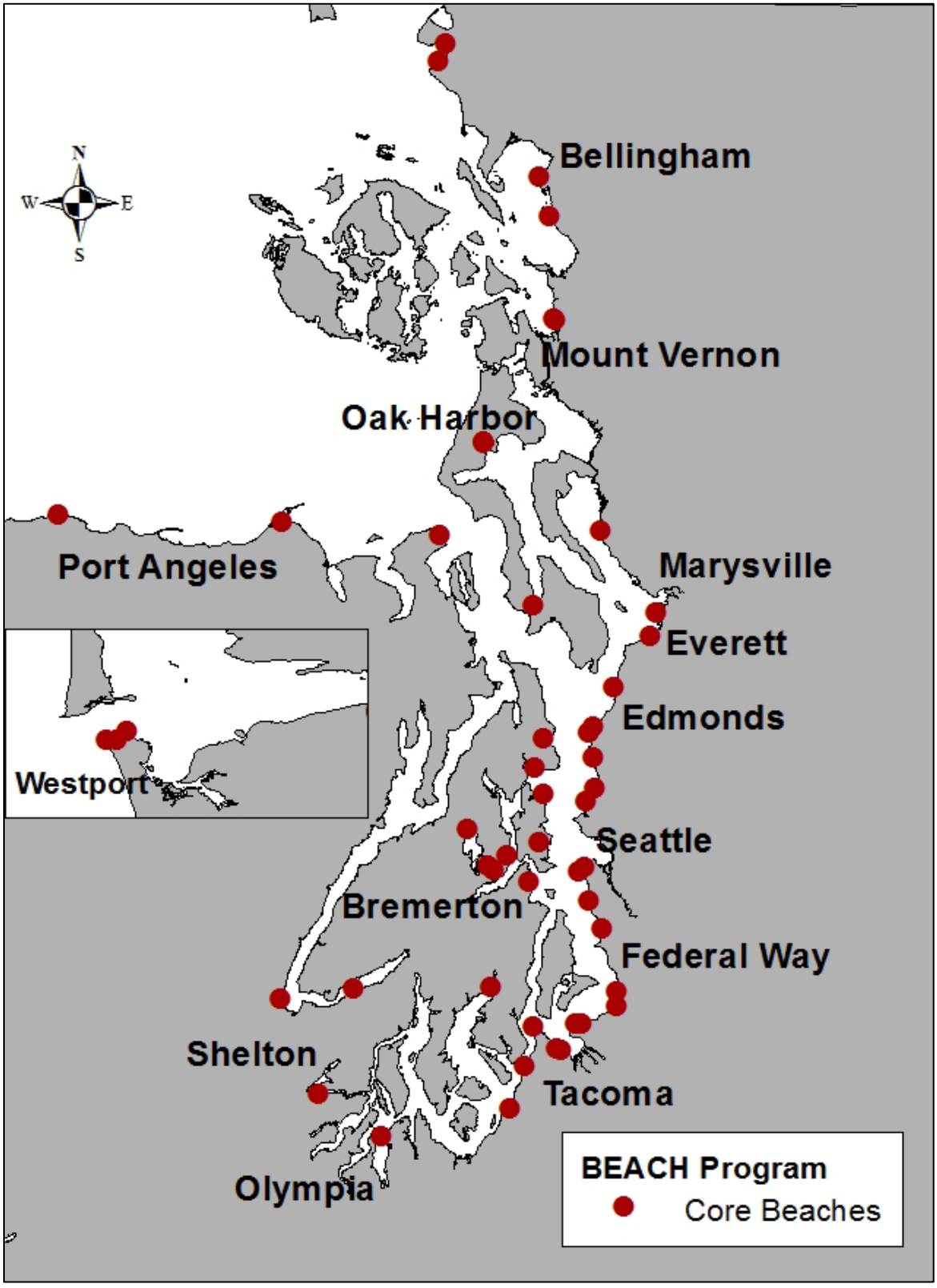


Figure 1. BEACH Program Monitoring study area including the 52 core monitoring stations.

### 3.2.1 History of study area

In 2000, the federal Clean Water Act was amended, adding the Beaches Environmental Assessment and Coastal Health Act (BEACH Act). Congress authorized EPA to award grants to states for the development and implementation of BEACH programs that reduce the risk of disease to users of the nation's marine recreational waters. States use this grant money to develop and implement programs to (1) support microbiological testing and monitoring of marine recreational waters and (2) notify the public of potential exposure to disease-causing microorganisms

Prior to funding and implementation of the BEACH Program, only two counties in Washington (Island and Kitsap) had marine recreational swimming beach monitoring and notification programs. King and Skagit counties also monitored marine beaches, but did not have notification procedures in place. Washington did not have a standardized bacteria monitoring program for marine swimming beaches. In 2001, Ecology applied for and received a BEACH Act Grant from EPA in December 2001.

A group of stakeholders, named the BEACH Committee, convened during the spring of 2002 to plan Washington's BEACH Program. This committee developed both the Draft: Beach Environmental Assessment, Communication, and Health (BEACH) Program Guidance (Schneider, 2002) and the original BEACH Program Quality Assurance Project Plan (QAPP) (Schneider, 2004).

Implementation of the BEACH Program began as a pilot project in 2003. Five counties−Grays Harbor, Island, Kitsap, Pierce, and Skagit−conducted weekly monitoring. The 2003 Beach Program Pilot Project was evaluated, and recommendations were incorporated into the Beach Program Guidance.

Today, the BEACH Program is jointly administered by the Departments of Ecology and Health. The Program distributes grant funding to LHJs, universities, tribes, and volunteer nonprofit organizations throughout the state.

Monitoring takes place at high-use, high-risk beaches and is dependent upon funding. Monitoring and notification of marine water quality provides information to the public about the relationship between water quality and human health and safety.

### 3.2.2 Summary of previous studies and existing data

The BEACH Program has been monitoring beaches throughout Puget Sound and the coast since 2004. Data for this project is available on Ecology's Environmental Information Management (EIM) website.

Current annual assessment includes determining if beaches are passing or failing swimming criteria. Figure 2 presents the percentage of beaches that meet the swimming criteria by year. In 2015, an in-depth data analysis was conducted on the BEACH data set of core beaches. The Regional Kendall test for trend was used to determine if bacterial water quality at core beaches as a whole has changed from 2003-2014. This test looks at trends across a region (Puget Sound and coastal core beaches) that are composed of multiple sample sites. The trend test was computed in the statistical package R (R development Core Team, 2008). Results of the Regional Kendall test for trend showed no trend in either increasing or decreasing bacteria levels at core beaches region-wide (Sargeant 2015).

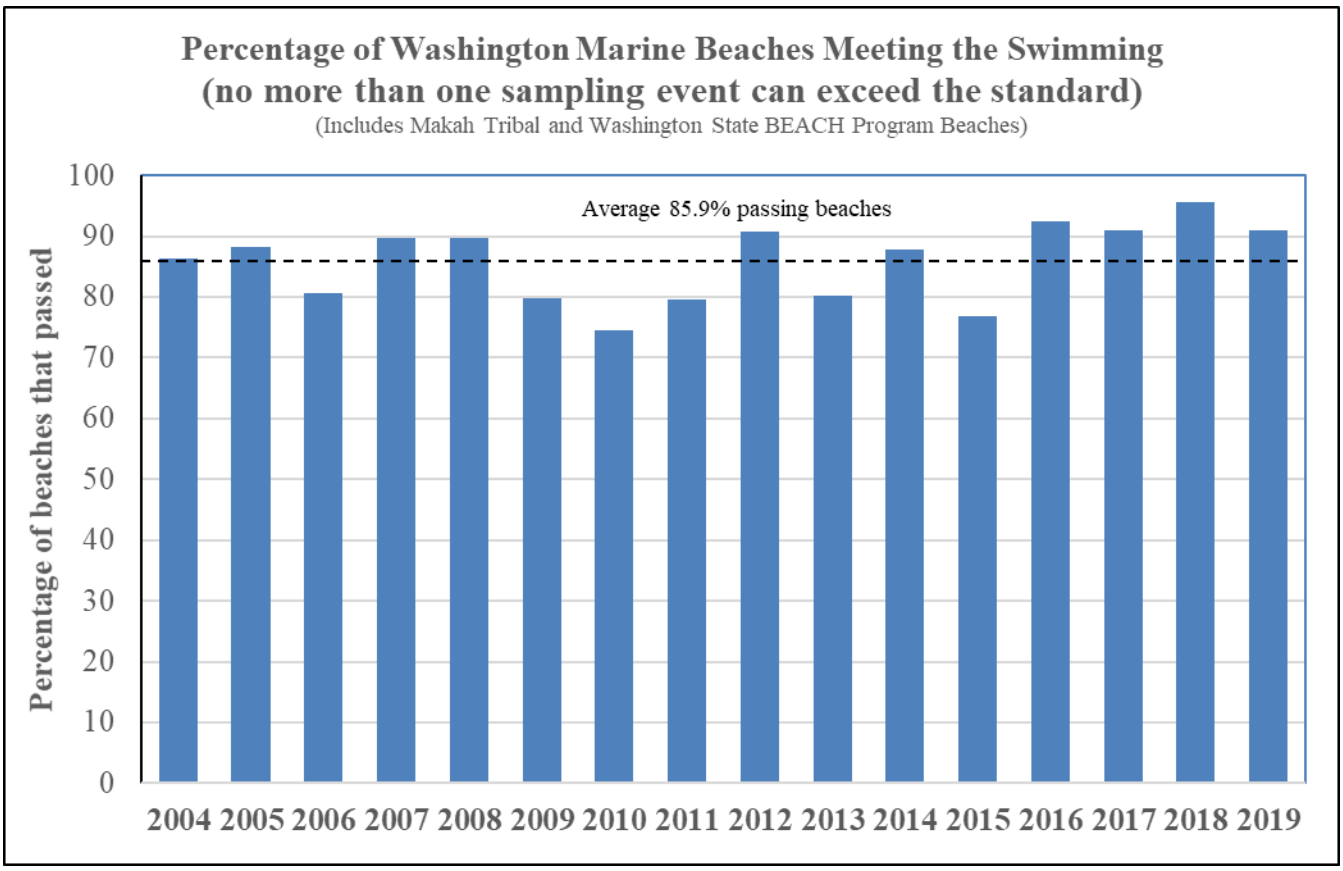


Figure 2. Percent of BEACH Program-sampled beaches that met the swimming criteria each year.

### 3.2.3 Parameters of interest and potential sources

The fecal indicator, Enterococcus, is the primary parameter of interest. EPA recommends monitoring for Enterococci in marine and freshwater, or *E.coli* in freshwater, to determine if water is safe for primary contact recreation. Studies show a link between illness and fecal contamination in recreational waters (EPA, 2012).

### 3.2.4 Regulatory criteria or standards

The BEACH Program's water quality decision criteria are based on EPA's National Beach Guidance and Required Performance Criteria for Grants (EPA, 2014). Enterococcus is used because this fecal indicator has a better correlation between indicator levels and illness rates than either fecal coliform or *E. coli*. The current Washington State Water Quality Standards for primary contact recreation in marine water bacteria is for Enterococcus.

Numeric criteria for the BEACH Program are as follows:

- Geometric Mean (GM) shall not exceed 30 Enterococci/100 mL; based on results from a minimum of 5 weekly samples (including all samples) and a maximum of 12 weekly samples.
- Statistical Threshold Value (STV) shall not exceed 110 Enterococci/100 mL; based on results from a minimum of 5 weekly samples (including all samples) and a maximum of 12 weekly samples.

The beach swimming advisory level or Beach Action Value (BAV) protective bacterial standard for marine recreational beaches used for primary contact recreation is as follows:

- The beach arithmetic average (of the three samples collected at a single beach) for the sample day should not exceed 104 Enterococci/100 mL.

Appendix A presents the BEACH Program decision flow chart to post a "Beach Swimming Advisory" or a "Beach Swimming Closure".

BEACH Program staff do not have authority to take closure actions. Closure action or other emergency action may only be taken by the local health officer under RCW 70.05.070, Local health Officer - Powers and Duties.

In addition, *WAC 246-260-180, Bathing beaches* states that no bathing beach shall be maintained or operated when such water is determined by the local health officer to be so polluted or subject to pollution as to constitute a menace to health if used for bathing. Where bathhouse and toilet facilities are provided for use of bathers, they shall be constructed, maintained, and operated in a sanitary manner approved by the health officer.

# 4.0 Project Description

The BEACH Program supports a marine recreational beach monitoring and notification program throughout the state. Marine beaches are tested for Enterococci bacteria to determine possible health risk to the public from water contact recreation. During the swimming season, water samples are collected at high-use, high-risk marine beaches primarily used for swimming, wading, surfing, and SCUBA diving. Public notification occurs when results exceed the BEACH Program Guidance thresholds. (Schneider, 2002).

In addition to routine beach monitoring, the program helps to identify sources of bacterial pollution at beaches with high bacteria levels. BEACH Program staff also participate in public education and outreach activities to educate the public about sources of bacterial pollution and health risks associated with swimming in contaminated waters.

## 4.1 Project goals

The primary goals of this monitoring project are to:

- Determine possible health risk to the public from marine water contact recreation.
- Identify sources of bacterial contamination to marine swimming beaches.

## 4.2 Project objectives

To accomplish monitoring project goals, Enterococcus bacteria samples will be collected at high-use, high-risk marine beaches primarily used for swimming, wading, surfing, and SCUBA diving. Samples will be collected weekly or every other week (bi-weekly) during the high-use season, generally May through mid-September.

Bacteria results will be reviewed immediately after laboratory analysis to determine if marine water is safe for primary contact recreation. If the average beach results are greater than 104 Enterococcus/100 mL, beach notification procedures will be initiated. The BEACH Program's recommended decision process for notification is presented in Appendix A.

When beaches have consistently high bacteria levels that require beach swimming advisories or closures, BEACH Program staff will work with local jurisdictions to identify sources of bacterial contamination. Bacterial source identification may require additional sampling, such as bacteria sampling of tributaries or discharges to the beach, or adding bacteria sampling sites along the beach shoreline.

## 4.3 Information needed and sources

This project has been ongoing since 2004. At this time, no additional information is needed.

## 4.4 Tasks required

Not applicable.

## 4.5 Systematic planning process used

Not applicable.

# 5.0 Organization and Schedule

## 5.1 Key individuals and their responsibilities

Table 2. Organization of project staff and responsibilities.

| **Staff** (All EAP except client) | **Title** | **Responsibilities** |
|---|---|---|
| Bevin Horn<br>EPA, Region 10<br>Phone: 206-553-1566 | EPA BEACH Program Lead, EPA Grant Manager | Clarifies project scope and provides technical assistance. Administers EPA Beach Monitoring and Notification Program Development Grant. Provides technical assistance. |
| Megan Schell<br>EPA Grant Coordinator<br>DOH Office of Shellfish and Water Protection<br>Phone: 360-236-3307 | NEP Contract Manager | Provides QAPP review and NEP project oversight. |
| Julianne Ruffner<br>MMU, WOS, EAP<br>Phone: 360-407-6154 | Project Manager (PM) | Writes the QAPP. Administers all aspects of the BEACH project including sampling and notification oversight, review of data, data interpretation, and data entry into EIM. Responsible for all reports. |
| Laura Hermanson<br>MMU, WOS, EAP<br>Phone: 360-407-0273 | BEACH Specialist | Provides local partners with technical assistance on sampling, data entry, and beach notification. Conducts QA review of data. Assists Project Manager with duties as needed. |
| Carol Maloy<br>MMU, WOS, EAP<br>Phone: 360-407-6742 | Unit Supervisor for the Project Manager | Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP. |
| Dale Norton<br>WOS, EAP<br>Phone: 360-407-6596 | Section Manager for the Project Manager | Provides internal review of the QAPP, approves the budget, and approves the final QAPP. |
| Arati Kaza<br>Phone: 360-407-6964 | Ecology Quality Assurance Officer | Reviews and approves the draft QAPP, QAPP addendum, and the final QAPP. |

DOH: Washington State Department of Health
EAP: Environmental Assessment Program
EIM: Environmental Information Management database
MMU: Marine Monitoring Unit
QAPP: Quality Assurance Project Plan
WOS: Western Operations Section

Table 3. 2019 BEACH Program local partners.

| Name | Title/Organization |
|---|---|
| Jacob Melly, Sue Waldrip | Clallam County Health and Human Services |
| Riley Smith | Makah BEACH Program Manager |
| Jeff Nelson, Rob King | Grays Harbor County Public Health |
| Jill Wood, Michele Guinn | Island County Health Department |
| Mike Dawson | Jefferson County Public Health |
| Betsy Carlson | Port Townsend Marine Science Center |
| Terry Clements | Public Health Seattle and King County |
| Grant Holdcroft | Kitsap County Health District |
| Alex Paysse | Mason County Environmental Health |
| Lindsay Tuttle | Tacoma-Pierce County Health Department |
| Annie England | Padilla Bay Reserve |
| Lisa Conley, Tim Ellis | WSU Snohomish County Beachwatchers |
| Maggie Taylor | Stillaguamish Tribe |
| Jane Mountjoy-Venning | Thurston County Public Health |
| Liz Schotman | Olympia Chapter, Surfriders |
| Tom Kunesh | Food Safety and Living Environment Program Supervisor, Whatcom County Health Department |
| Eleanor Hines | Northwest Straits Chapter, Surfriders |

## 5.2 Special training and certifications

BEACH Program samplers include BEACH Program staff, local government, tribal staff, and volunteers. All samplers undergo sample training from BEACH Program staff or their respective group coordinator, following the procedures outlined in the BEACH Program Bacteria Sampling SOP, EAP092. The BEACH Program website has a video on how to collect water samples. This video should be used in addition to proper training.

## 5.3 Organization chart

See Tables 2 and 3.

## 5.4 Proposed project schedule

Table 4 describes the annual schedule for BEACH Program activities including site selection, monitoring period, data entry, data reporting, and analysis.

Table 4. Annual schedule for BEACH Program activities.

| Task | Timeline | Responsible Party |
|---|---|---|
| Finalize annual beach sampling list | March each year | BEACH Program Staff, LHJ, volunteer coordinators |
| Volunteer training | April/May each year | BEACH Program Staff |
| Weekly or biweekly collection of bacteria and field data | May through early September | Volunteers, Coordinators or LHJ, or Ecology staff |
| Data entry | Friday each week during beach season | Laboratories, nonprofit organizations, universities, or volunteers |
| Data verification | Upon receipt of final laboratory analytical report | BEACH Program Staff |
| EIM data loaded | November 30 each year | BEACH Program Staff |
| EIM data entry review | December 30 each year | BEACH Program Staff |
| Data analysis | January 30 each year | BEACH Program Staff |
| Data reporting to WQX EPA and EIM Completion | January 31 each year | BEACH Program Staff |
| Report to EPA | March 30 each year | BEACH Program Staff |

LHJ: Local Health Jurisdiction

## 5.5 Budget and funding

Funding for the BEACH Program is provided by an EPA grant as part of the Beaches Environmental Assessment and Coastal Health Act of 2000, regulatory authority 40 CFR PART 31. In addition, the BEACH Program has received National Estuary Program (NEP) grant funds since 2011. The BEACH Program may continue to periodically receive National Estuary Program (NEP) grant funds. The NEP funding is directed toward continued sampling of core and county beaches, as well as continued bacterial source investigations and remediation actions.

The budget for the BEACH Program varies by year, depending on:

- EPA's grant award for the year.
- Additional funds obtained to sample beaches and conduct source control investigations (e.g., NEP funding).

# 6.0 Quality Objectives

Quality objectives are statements of the precision, bias, and lower reporting limits necessary to meet project objectives. Precision and bias together express data accuracy. Other considerations of quality objectives include representativeness and completeness. Quality objectives apply equally to laboratory and field data collected by Ecology, to data used in this study collected by entities external to Ecology, and to other analysis methods used in this study.

## 6.1 Data quality objectives

The Washington BEACH Program's recommended decision process for notification of swimming beaches with high bacteria results is described in Appendix A. The BEACH Program has limited authority to make beach closure decisions. However, we will make recommendations to local health jurisdictions for closures, based on bacteria data results, nearby sewage spills, combined sewer overflow discharge, or other pollution problems that could adversely affect public health.

## 6.2 Measurement quality objectives

Field sampling procedures and laboratory analyses inherently have associated uncertainty, which results in data variability. Measurement quality objectives (MQOs) state the acceptable data variability for a project. *Precision* and *bias* are data quality criteria used to indicate conformance with MQOs. The term *accuracy* refers to the combined effects of precision and bias (Lombard and Kirchmer, 2004).

Precision is a measure of the variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Precision for field replicate samples will be expressed as the relative standard deviation (RSD) for the group of duplicate pairs (Table 5).

Bias is defined as the difference between the sample value and true value of the parameter being measured. Bias affecting measurement procedures can be inferred from the results of quality control (QC) procedures. Bias in field measurements and samples will be minimized by strictly following BEACH Program's measurement, sampling, and handling protocols, including the Standard Operating Procedure, SOP EAP092, for BEACH Program Bacteria Sampling (Sargeant, 2014, recertified in 2017). Field sampling precision and bias will be addressed by submitting field duplicate samples.

Table 5 outlines analytical methods, expected precision of sample duplicates, and method reporting limits. The targets for precision of field duplicates are based on values described in Mathieu (2006). The reporting limits of the methods listed in the table are appropriate for the expected range of results and the required level of sensitivity to meet project objectives.

Table 5. Approved BEACH Program bacteria laboratory methods, holding times, measurement quality objectives, and lowest concentration of interest.

| Parameter | Method | Holding Time/ Maximum Transport Time | Field/Lab Duplicate | Detection Limits |
|---|---|---|---|---|
| ***Enterococci*** | | | | |
| MPN/ multiple well | ASTM 6503-99, SM9230B; and Enterolert Method® SM 9230D | 6 hrs | 50% RSD | 10 MPN/100 mL |
| MF | EPA Method 1600 or SM 9230C | 6 hrs | 50% RSD | 1 cfu/100 mL |
| ***Fecal Coliform*** | | | | |
| MPN | SM 9221E | 6 hrs | 50% RSD | 1.8 MPN/100 mL |
| MF | SM 9222D | 6 hrs | 50% RSD | 1 cfu/100 mL |
| ***Escherichia Coli*** | | | | |
| MPN | EPA Method 1104, SM 9221F, SM 9223B, Colilert Method® | 6 hrs | 50% RSD | 1.8 MPN/100 mL |
| MF | EPA Method 1603 | 6 hrs | 50% RSD | 1 cfu/100 mL |

MPN: Most probable number
MF: Membrane filter
ASTM: American Society for Testing and Materials International
SM: Standard Methods
RSD: Relative standard deviation

### 6.2.1 Targets for precision, bias, and sensitivity

#### 6.2.1.1 Precision

Precision is a measure of the variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Precision for field replicate samples will be expressed as the relative standard deviation (RSD) for the group of duplicate pairs (Table 5).

#### 6.2.1.2 Bias

Bias is defined as the difference between the sample value and true value of the parameter being measured. Bias affecting measurement procedures can be inferred from the results of quality control (QC) procedures. Bias in field measurements and samples will be minimized by strictly following Ecology's measurement, sampling, and handling protocols. Field sampling precision bias will be addressed by submitting replicate samples (Table 5). Laboratories used for this project will assess bias through the use of laboratory replicates and QC procedures described in section 10.1.

#### 6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as a detection limit. Targets for laboratory measurement sensitivity required for the project are listed in Table 5.

### 6.2.2 Targets for comparability, representativeness, and completeness

#### 6.2.2.1 Comparability

BEACH Program monitoring will follow SOP EAP092, BEACH Program Bacteria Sampling (Sargeant, 2014). Bacteria sampling sites for all beaches are documented with a GPS, and maps of sampling sites are provided to our sampling partners. Sampling sites remain consistent once they are established.

#### 6.2.2.2 Representativeness

The study is designed to have enough sampling sites at sufficient sampling frequency to meet study objectives. Bacteria values are known to be highly variable over time and space. Sampling variability can be somewhat controlled by strictly following standard procedures and collecting QC samples, but natural spatial and temporal variability can contribute greatly to the overall variability in the bacteria value.

#### 6.2.2.3 Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (Lombard and Kirchmer, 2004). The goal for this study is to correctly collect and analyze 100% of the samples for each of the sites. However, problems occasionally arise during sample collection that cannot be controlled; thus, a completeness of 95% is acceptable. Potential problems are laboratory issues, site access, or sample container shortages.

## 6.3 Acceptance criteria for quality of existing data

NA

## 6.4 Model quality objectives

NA

# 7.0 Study Design

## 7.1 Study boundaries

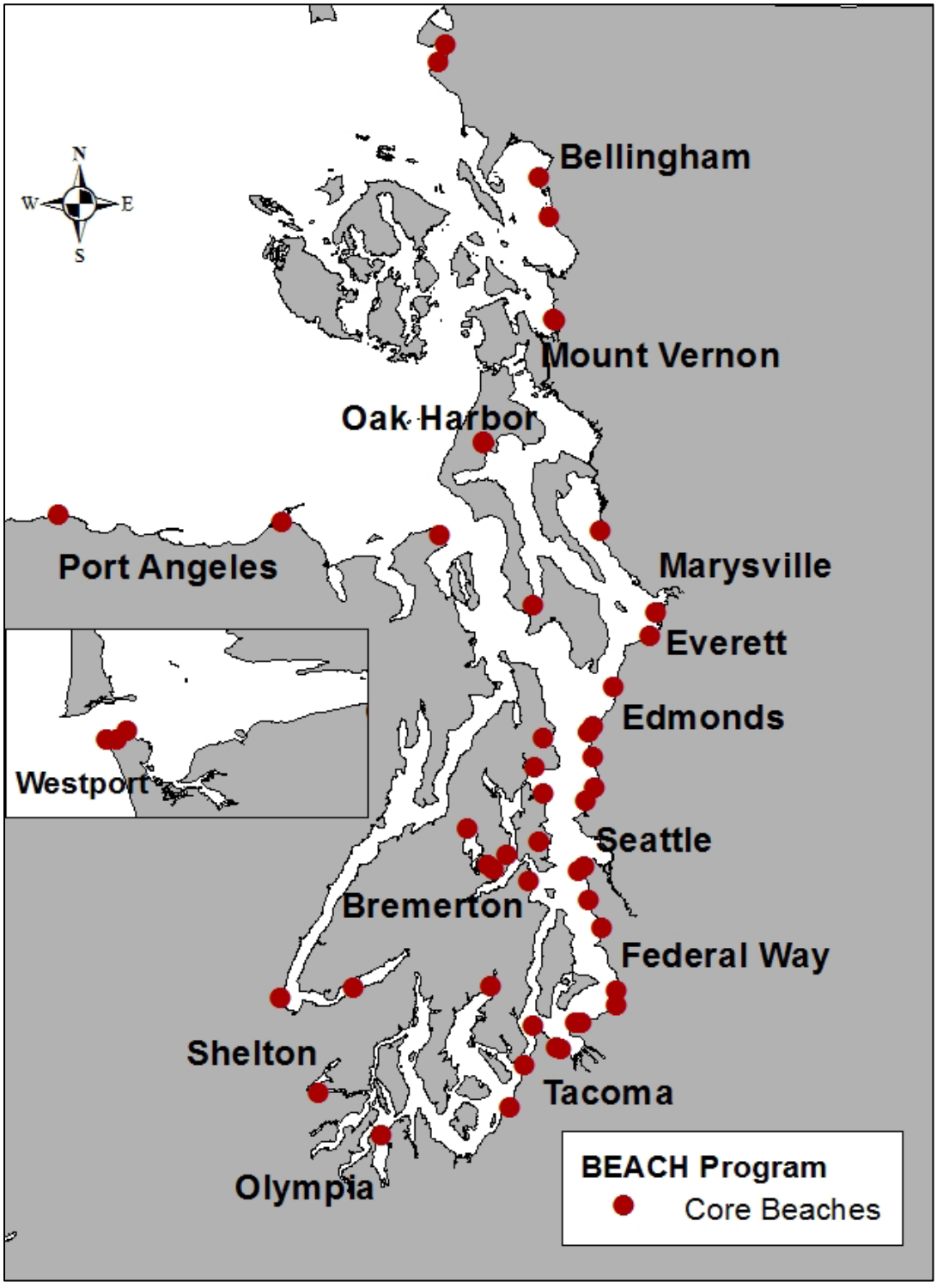


Figure 3. Map showing boundary of project study area.

## 7.2 Field data collection

The study objectives will be met by characterizing bacterial marine water quality during the swimming season (May through September) at select beaches. Three samples will be collected at each beach on a weekly or biweekly basis. The arithmetic average of results of the three samples will be compared to the beach action value (BAV), >104 Enterococci/100 mL to make swimming advisory decisions. When results exceed 104 Enterococci/100 mL the decision criteria in Appendix A will be followed.

Beach water quality stations are sited to capture bacterial source inputs such as freshwater and stormwater discharges. Sampling stations are geo-referenced using a GPS unit and stored in the BEACH Program database. Additional sampling may occur during bacterial source investigations.

### 7.2.1 Sampling locations and frequency

Beach sampling will occur weekly or biweekly during the swimming season, generally Memorial Day through Labor Day. Three bacteria samples will be collected at each beach, according to the SOP EAP092: BEACH Program Bacteria Sampling (Sargeant, 2014). Samplers may collect additional samples of freshwater or stormwater discharges to the beach.

Sampling will occur early in the week. This allows for obtaining results before weekend recreational use of the beach and for re-sampling, if necessary.

### 7.2.2 Field parameters and laboratory analytes to be measured

Marine beaches will be sampled for Enterococci bacteria. Table 6 describes possible sample parameters. Additional types of fecal bacteria samples, such as fecal coliform or *E.coli*, may be obtained for source identification.

## 7.3 Modeling and analysis design

NA

## 7.4 Assumptions in relation to objectives and study area

NA

## 7.5 Possible challenges and contingencies

Beach sampling should be scheduled in advance of the sampling season (May through September). Schedules should include sample timing windows for beaches with high tidal variations. For example, it is unsafe to sample some muddy beaches at low tide, and it is difficult to access some beaches at higher tides.

In addition, ample time must be allowed to conduct all sampling and deliver the samples to the laboratory by the appropriate time and within 6 hours of sample collection.

### 7.5.1 Logistical problems

Logistical problems may include volunteer sampler availability, beach access due to tidal variation, and timing of field work due to the 6-hour holding time for fecal bacteria samples.

For beaches sampled by volunteers (Snohomish and Skagit county beaches, Fort Worden State Park in Jefferson County, Larrabee State Park and Little Squalicum in Whatcom County, and Pries Point Park in Thurston County), it may be difficult to find volunteers to resample beaches with initial high bacteria counts. Beaches sampled by volunteers follow a weekly sample schedule. The sample schedule should also include volunteers on call for resample events.

Beach sampling should be scheduled in advance of the sampling season (May through September). Schedules should include sample timing windows for beaches with tidal issues, whether low or high tide. For example, it is unsafe to sample some muddy beaches at low tide, and it is difficult to access some beaches at higher tides.

In addition, ample time must be allowed to conduct all sampling and deliver the samples to the laboratory by the appropriate time and within 6 hours of sample collection.

### 7.5.2 Practical constraints

NA

### 7.5.3 Schedule limitations

NA

# 8.0 Field Procedures

## 8.1 Invasive species evaluation

Marine beach sites are not in areas of extreme concern. BEACH sampling will follow the SOP to minimize the spread of invasive species, SOP EAP070 (Parsons et al., 2018. For more information regarding invasive species of concern, see Ecology's website on minimizing the spread of invasive species.

## 8.2 Measurement and sampling procedures

Marine and freshwater samples will be collected, using Ecology's BEACH Program Bacteria Sampling SOP EAP092. Field notes will be obtained using the BEACH Program Field Data Form or similar forms approved by the BEACH Program (Appendix B).

## 8.3 Containers, preservation methods, holding times

As described in the BEACH Program Bacteria Sampling SOP (EAP092), sample containers are 150, 250, or 500 mL pre-autoclaved polypropylene bottles. After collection, the sample is labeled with the appropriate tag and immediately placed on ice in a cooler to preserve the sample during shipment to the laboratory. The sample must be delivered to the laboratory within 6 hours of sample collection. We will obtain sample bottles from the laboratory for the next sample event. Sample bottles should not be used after 6 months.

## 8.4 Equipment decontamination

If equipment such as thermometers, refractometers, or sampling poles are used, they should be thoroughly rinsed with fresh water after sampling, to minimize metal corrosion.

## 8.5 Sample ID

Specific sample IDs are provided for each beach site. Sample IDs are stored in the BEACH database and noted on maps provided to samplers. Each sample is tagged with a label that provides the sample ID, sample date and time, type of analysis performed, and whether the sample is from marine water or freshwater.

## 8.6 Chain of custody, if required

Once collected, samples will be stored in coolers in the sampling vehicle. When field staff are not in the sampling vehicle, it will be locked to maintain chain-of-custody. When samples are delivered to the laboratory for analysis, a chain-of-custody sheet may be required.

## 8.7 Field log requirements

Field notes will be obtained using the BEACH Program Field Data Form or similar forms approved by the BEACH Program (Appendix B). Data forms must be filled out for each beach and day sampled.

## 8.8 Other activities

Volunteer samplers will be trained by BEACH Program staff before the beginning of each beach sample season. Training will consist of equipment use, sampling protocols, and data entry into the Secure Access Washington (SAW) system.

# 9.0 Laboratory Procedures

## 9.1 Lab procedures table

Table 6 shows the field and laboratory measurement methods required to meet the goals and objectives of this project.

Table 6. Measurement methods (field and laboratory).

| Analyte | Sample Matrix | Number of Samples | Expected Range of Results | Method | Method Detection Limit |
|---|---|---|---|---|---|
| *Field Measurements (optional)* | | | | | |
| Salinity | Water | Optional | 0-33 ppt | Refractometer | n/a |
| Temperature | Water | Optional | 5-35°C | Thermometer | n/a |
| *Laboratory Procedures* | | | | | |
| Enterococci | Water | 3 per beach per sample event | <10 - > 2000 MPN/100 mL | See Table 5 | |
| *E. Coli* | Water | As needed | 1 – 10,000 cfu/100 mL | See Table 5 | |
| Fecal Coliform | Water | As needed | 1 – 10,000 cfu/100 mL | See Table 5 | |

## 9.2 Sample preparation method(s)

Bacteria samples must be collected in pre-sterilized polypropylene bottles. Bottles should not be used after 6 months.

## 9.3 Special method requirements

No special method is required; however, special notification procedures are required. The laboratory is required to notify the BEACH Program or the LHJ immediately, when the average of the marine Enterococci beach results are higher than 104 MPN/100 mL. This enables BEACH Program staff and the LHJ to initiate the public notification process as soon as possible.

## 9.4 Laboratories accredited for methods

All bacteria analysis will be performed by a laboratory accredited for that method. The following accredited laboratories are used by the BEACH Program and BEACH Program partners:

- Clallam County Environmental Laboratory, Port Angeles
- Edge Analytical Laboratories Microbiology Lab, Bellingham
- Everett Environmental Laboratory, Everett
- Grays Harbor County Water Testing Lab, Montesano
- King County Environmental Laboratory, Seattle
- SPECTRA Laboratories-Kitsap, LLC, Port Orchard & Poulsbo
- Thurston County Health Department Laboratory, Olympia

# 10.0 Quality Control Procedures

## 10.1 Table of field and laboratory quality control

Field and laboratory QC is described in Table 5. Laboratories will conduct annual proficiency testing for bacteria. For the Enterolert method, positive and negative bacteria controls will be run with each new lot media.

Table 7. Quality control samples, types, and frequency.

| Parameter | Field | | Laboratory | | |
|---|---|---|---|---|---|
| | Blanks | Replicates | Check Standards | Analytical Duplicates | Matrix Spikes |
| Enterococci | n/a | 10% | n/a | 1/20 samples | n/a |
| *E. Coli* | n/a | 10% | n/a | 1/20 samples | n/a |
| Fecal Coliform | n/a | 10% | n/a | 1/20 samples | n/a |

## 10.2 Corrective action processes

QC results may indicate problems with data during the course of the project. The lab will follow prescribed procedures to resolve the problems. Options for corrective actions might include:

- Rejecting the results
- Resampling the beach sites
- Qualifying the results

# 11.0 Data Management Procedures

## 11.1 Data recording and reporting requirements

BEACH Program staff manages water quality field and laboratory results via the BEACH Program database.

Samplers will record all field data on the BEACH Program Field Data Form or similar form approved by the BEACH Program (Appendix B). Field Data Forms must be filled out for each beach and day sampled.

The local sampling lead is responsible for entering data from the Field Data Form. Contract laboratories are responsible for entering the laboratory data. Field and laboratory data must be entered into the BEACH Program database by Friday each week.

Final laboratory analytical reports will be mailed, faxed, or electronically transmitted to either the BEACH Program or LHJs. Final reports must be sent to the BEACH Program for data verification as soon as possible. Analytical reports must contain final data, the method(s) used for analysis, and all quality assurance and quality control performed.

BEACH Program staff will verify the data within two weeks of data entry. Once data is verified in the BEACH Program Database, data from this program is available to the public via the BEACH Program website through both Ecology and Ecology's Environmental Information Management (EIM) Database. All records are kept on file for a minimum of 5 years.

## 11.2 Laboratory data package requirements

Final laboratory analytical reports will be mailed, faxed, or electronically transmitted to either the BEACH Program or LHJs. Final reports must be sent to the BEACH Program for data verification as soon as possible. Analytical reports must contain final data, the method(s) used for analysis, and all QA and QC performed.

## 11.3 Electronic transfer requirements

NA

## 11.4 EIM/STORET data upload procedures

All bacteria data will be entered into EIM and STORET, following all existing Ecology business rules and the EIM User's Manual for loading, data quality checks, and editing.

## 11.5 Model information management

NA

# 12.0 Audits and Reports

## 12.1 Field, laboratory, and other audits

To ensure field work consistency, improve adherence to SOPs, and share information, Ecology staff will conduct one audit per year. The field audit will consist of staff accompanying local beach samplers during their routine beach sampling. Each year a field audit will be conducted with a different local partner.

## 12.2 Responsible personnel

See section 12.1.

## 12.3 Frequency and distribution of reports

After data are verified in the BEACH Program Database, data from this program will be available to the public via the BEACH Program website through both Ecology and Ecology's Environmental Information Management (EIM) Database.

An annual report describing BEACH Program activities for the previous year is submitted to EPA every April.

## 12.4 Responsibility for reports

The BEACH Program Manager will be the lead on the EPA annual report.

# 13.0 Data Verification

## 13.1 Field data verification, requirements, and responsibilities

The field lead will verify initial field data before leaving each site. This process involves checking the data sheet for omissions or outliers. If measurement data are missing or a measurement is determined to be an outlier, the measurement will be repeated.

## 13.2 Laboratory data verification

Laboratory staff will perform the laboratory verification following standard laboratory practices. After the laboratory verification, staff will perform a secondary verification of each data package. This secondary verification will entail a review of all parts of the laboratory data package, with special attention to laboratory QC results. Staff will bring any discovered issues to the laboratory manager for resolution.

## 13.3 Validation requirements, if necessary

NA

## 13.4 Model quality assessment

NA

### 13.4.1 Calibration and validation

NA

#### *13.4.1.1 Precision*

NA

#### *13.4.1.2 Bias*

NA

#### *13.4.1.3 Representativeness*

NA

#### *13.4.1.4 Qualitative assessment*

NA

### 13.4.2 Analysis of sensitivity and uncertainty

NA

# 14.0 Data Quality (Usability) Assessment

## 14.1 Process for determining project objectives were met

After all laboratory and field data are checked, staff will examine the entire data package to determine if all the criteria for MQOs, completeness, representativeness, and comparability have been met. If the criteria have not been met, the BEACH Program Manager will decide if affected data should be qualified or rejected based upon the decision criteria from the QAPP. The BEACH Program Manager will decide how any qualified data will be used in the technical analysis.

## 14.2 Treatment of non-detects

For bacteria values below the detection limit, we will use a conservative value of the detection limit minus one. For bacteria values above the detection limit, we will use the upper detection limit plus one.

## 14.3 Data analysis and presentation methods

The arithmetic average of the bacteria samples for the beach and day (generally three samples) will be calculated. This value will be compared to the BEACH Programs swimming criteria (Appendix A) and the Washington State Water Quality Standards, when applicable.

## 14.4 Sampling design evaluation

The BEACH Program Manager will decide whether the data package meets the MQOs, criteria for completeness, representativeness, and comparability, and also whether meaningful conclusions can be drawn from the data. If so, the sampling design will be considered effective.

## 14.5 Documentation of assessment

In the annual report to EPA, the BEACH Program Manager will include a summary of the data quality assessment findings.

# 15.0 References


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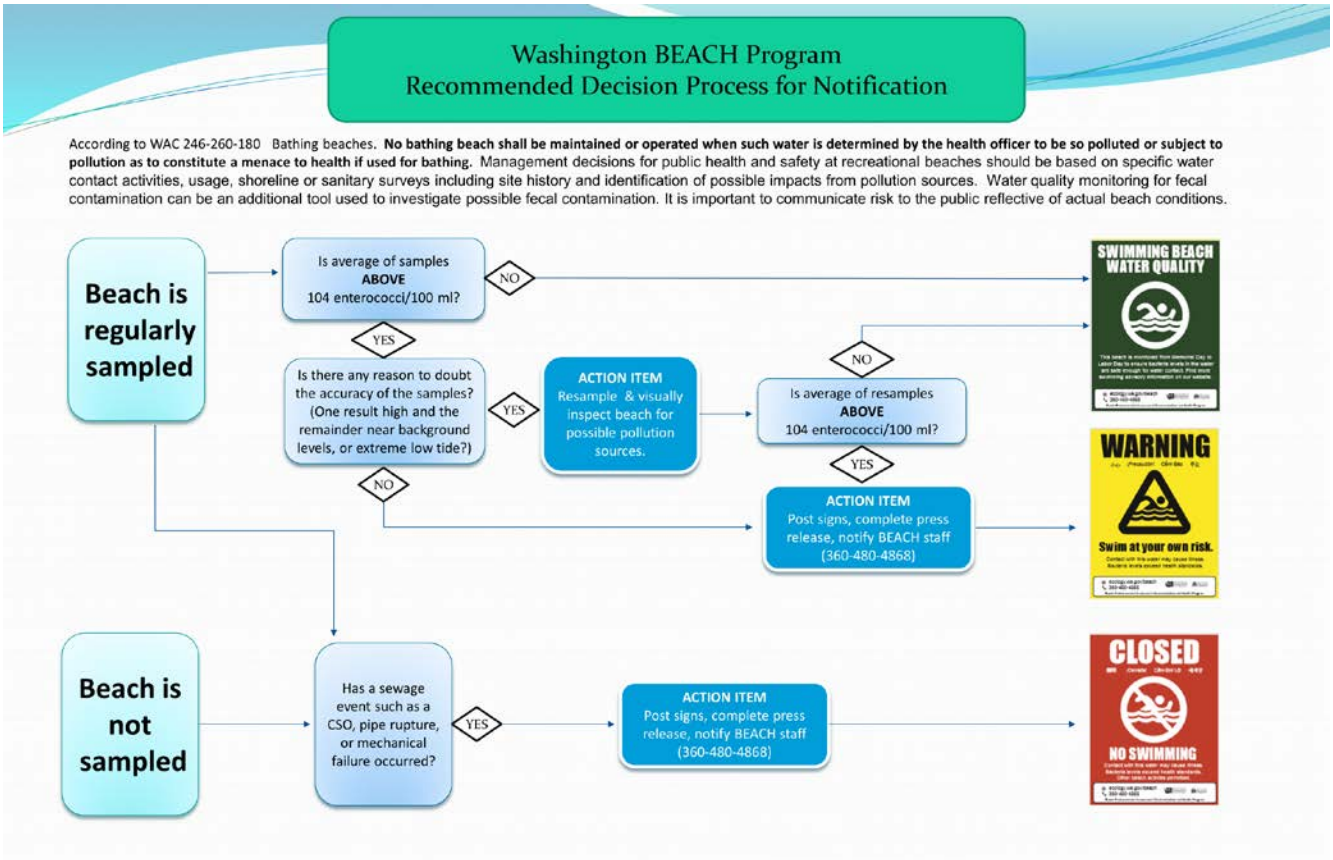
# 16.0 Appendices

## Appendix A. WA BEACH Program Recommended Decision Process for Beach Notification



# Appendix B. BEACH Field Data Form

Beach Name:
Stations:
Duplicate Sample Station:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampled Date | ____/____/_____ Time ___:___ | | | | | | | |
| Sampled By | | | | Tide Height | Feet | | | |
| Tide Phase | LowTide | ¼Flood | MidFlood | ¾Flood | HighTide | ¼Ebb | MidEbb | ¾Ebb |
| Wind Direction | *from the* | N | NW | W | SW | S | SE | E | NE |
| Wind Speed | Calm | 1-3mph | 4-8mph | 9-12mph | 13-18mph | 19-25mph | 25+ | |
| Recent Rain | 24hours | 48hours | 72hours | 4-7days | >1week | | | |
| Weather | Clear/Sun | Hazy | PartCloudy | Cloudy | LightShowers | Rain | | |

| | | |
|---|---|---|
| People in Water | | Comments: |
| People on Beach | | |
| Dogs on Beach | | |
| Birds on Beach | | Algae/seagrass in water? Y/ N |
| Air Temp | °F | Algae/seagrass on beach? None/ Low (1-20%)/ Moderate (21-50%)/ High (>50%) |
| Water Temp | °F | Condition of algae/seagrass: Fresh/ Decaying |
| Salinity (ppt) | | Does the algae/seagrass have a foul odor? Y/ N |
| | | Water Clarity: Clear/ Murky |
| | | Breaking waves on beach? Y/ N |

# Appendix C. Glossaries, Acronyms, and Abbreviations

## *Glossary*

**Ambient:** Background or away from point sources of contamination. Surrounding environmental condition.

**Clean Water Act:** A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

**Enterococci:** A subgroup of the fecal streptococci that includes *S. faecalis*, *S. faecium*, *S. gallinarum*, and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5% sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

***Escherichia coli (E. coli*):** A species of bacteria that inhabit the intestinal tract of warm-blooded animals and remain viable (alive and capable of infecting another organism) in water for a variable period of time. While *E. coli* are normally harmless and live in the intestines of healthy people and animals a few strains may cause illness. The presence of *E. coli* in water indicates fecal contamination by a warm-blooded animal; harmful bacteria, viruses, or protozoa associated with fecal contamination may also be present.

**Fecal coliform (FC):** That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

**Geometric mean:** A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

**Pollution:** Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

**Primary contact recreation:** Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

**Statistical threshold value:** An estimate of the 90th percentile of the data set.

**Stormwater:** The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

**90th percentile:** An estimated portion of a sample population based on a statistical determination of distribution characteristics. The 90th percentile value is a statistically derived estimate of the division between 90% of samples, which should be less than the value, and 10% of samples, which are expected to exceed the value.

## *Acronyms and Abbreviations*

| | |
|---|---|
| BEACH | Beach environmental assessment, communication, and health |
| BEACH Act | Beaches environmental assessment and coastal health act |
| e.g. | For example |
| Ecology | Washington State Department of Ecology |
| EIM | Environmental Information Management database |
| EPA | U.S. Environmental Protection Agency |
| et al. | And others |
| FC | (see Glossary above) |
| Health | Washington State Department of Health |
| LHJ | Local Health Jurisdiction |
| MQO | Measurement quality objective |
| QA | Quality assurance |
| QC | Quality control |
| RPD | Relative percent difference |
| RSD | Relative standard deviation |
| SOP | Standard operating procedures |
| WRIA | Water Resource Inventory Area |

*Units of Measurement*

| | |
|---|---|
| °C | degrees centigrade |
| cfu | colony forming units |
| mg/L | milligrams per liter (parts per million) |
| mL | milliliter |

## *Quality Assurance Glossary*

**Accreditation:** A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

**Accuracy:** The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms *precision* and *bias* be used to convey the information associated with the term *accuracy* (USGS, 1998).

**Analyte:** An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella (Kammin, 2010).

**Bias:** The difference between the sample mean and the true value. Bias usually describes a systematic difference reproducible over time and is characteristic of both the measurement system and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI) (Kammin, 2010; Ecology, 2004).

**Blank:** A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process (USGS, 1998).

**Calibration:** The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured (Ecology, 2004).

**Check standard:** A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards but should be referred to by their actual designator, e.g., CRM, LCS (Kammin, 2010; Ecology, 2004).

**Comparability:** The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator (USEPA, 1997).

**Completeness:** The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator (USEPA, 1997).

**Continuing Calibration Verification Standard (CCV):** A quality control (QC) sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run (Kammin, 2010).

**Control chart:** A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system (Kammin, 2010; Ecology 2004).

**Control limits:** Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean (Kammin, 2010).

**Data integrity:** A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading (Kammin, 2010).

**Data quality indicators (DQI):** Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity (USEPA, 2006).

**Data quality objectives (DQO):** Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (USEPA, 2006).

**Data set:** A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010).

**Data validation:** An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability, and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier – data are usable for intended purposes.
- J (or a J variant) – data are estimated, may be usable, may be biased high or low.
- REJ – data are rejected, cannot be used for intended purposes.
  (Kammin, 2010; Ecology, 2004).

**Data verification:** Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set (Ecology, 2004).

**Detection limit** (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero (Ecology, 2004).

**Duplicate samples:** Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis (USEPA, 1997).

**Field blank:** A blank used to obtain information on contamination introduced during sample collection, storage, and transport (Ecology, 2004).

**Initial Calibration Verification Standard (ICV):** A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples (Kammin, 2010).

**Laboratory Control Sample (LCS):** A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples (USEPA, 1997).

**Matrix spike:** A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects (Ecology, 2004).

**Measurement Quality Objectives** (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness (USEPA, 2006).

**Measurement result:** A value obtained by performing the procedure described in a method (Ecology, 2004).

**Method:** A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed (EPA, 1997).

**Method blank:** A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples (Ecology, 2004; Kammin, 2010).

**Method Detection Limit (MDL):** This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero (Federal Register, October 26, 1984).

**Percent Relative Standard Deviation (%RSD):** A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples (Kammin, 2010).

**Parameter:** A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all parameters (Kammin, 2010; Ecology, 2004).

**Population:** The hypothetical set of all possible observations of the type being investigated (Ecology, 2004).

**Precision:** The extent of random variability among replicate measurements of the same property; a data quality indicator (USGS, 1998).

**Quality assurance (QA):** A set of activities designed to establish and document the reliability and usability of measurement data (Kammin, 2010).

**Quality Assurance Project Plan (QAPP):** A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives (Kammin, 2010; Ecology, 2004).

**Quality control (QC):** The routine application of measurement and statistical procedures to assess the accuracy of measurement data (Ecology, 2004).

**Relative Percent Difference (RPD):** RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

**Replicate samples:** Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled (USGS, 1998).

**Representativeness:** The degree to which a sample reflects the population from which it is taken; a data quality indicator (USGS, 1998).

**Sample (field):** A portion of a population (environmental entity) that is measured and assumed to represent the entire population (USGS, 1998).

**Sample (statistical):** A finite part or subset of a statistical population (USEPA, 1997).

**Sensitivity:** In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit (Ecology, 2004).

**Spiked blank:** A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method (USEPA, 1997).

**Spiked sample:** A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency (USEPA, 1997).

**Split sample:** A discrete sample subdivided into portions, usually duplicates (Kammin, 2010).

**Standard Operating Procedure (SOP):** A document which describes in detail a reproducible and repeatable organized activity (Kammin, 2010).

**Surrogate:** For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis (Kammin, 2010).

**Systematic planning:** A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning (USEPA, 2006).

### *References for QA Glossary*

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