United States
Environmental Protection
Agency

Public Health Surveillance Design Guidance

For Water Quality Surveillance and Response Systems

Office of Water (AWBERC, MS 140) EPA 817-B-16-001 July 2016

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Questions concerning this document should be addressed to WQ_SRS@epa.gov or the following contact:

Steve Allgeier
U.S. EPA Water Security Division
26 West Martin Luther King Drive
Mail Code 140
Cincinnati, OH 45268
(513) 569-7131
Allgeier.Steve@epa.gov

Acknowledgements

The document was developed by EPA's Water Security Division, with additional support provided under EPA contract EP-C-15-012.

- Steve Allgeier, EPA, Water Security Division
- Adam Haas, CSRA
- Darcy Shala, CSRA

Peer review of this document was provided by the following individuals:

- Jonathan Colvin, Drug and Poison Information Center, Cincinnati Children's Hospital
- Kirsten Larson, Association of Public Health Laboratories
- Royal Law, Centers for Disease Control and Prevention
- Ami Patel, Philadelphia Department of Public Health
- David Travers, EPA, Water Security Division
- June Weintraub, San Francisco Department of Public Health

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Abbreviations

APHL	Association of Public Health Laboratories
CDC	Centers for Disease Control and Prevention
CSTE	Council of State and Territorial Epidemiologists
ED	Emergency Department
EHR	Electronic Health Record
EMR	Electronic Medical Record
EMS	Emergency Medical Services
EPA	U.S. Environmental Protection Agency
ESSENCE	Electronic Surveillance System for the Early Notification of Community-based Epidemics
NNDSS	National Notifiable Diseases Surveillance System
NPDS	National Poison Data System
NRDM	National Retail Data Monitor
OTC	Over-the-counter (medication sales)
PCC	Poison Control Center
PHS	Public Health Surveillance
RODS	Real-time Outbreak and Disease Surveillance
SRS	Water Quality Surveillance and Response System

Section 1: Introduction

The U.S. Environmental Protection Agency (EPA) designed a ***Water Quality Surveillance and Response System*** (SRS) that employs multiple ***components*** to detect ***water quality incidents*** with potential public health and economic ***consequences***. **Figure 1-1** shows the components of an SRS grouped into two operational phases, surveillance and response. Procedures guide the systematic investigation of anomalies detected by the surveillance components in order to identify its cause. If distribution system contamination is detected, response plans guide actions intended to minimize consequences. An SRS can be implemented by drinking water utilities to improve their ability to detect and respond to undesirable water quality changes. EPA intends the design of an SRS to be flexible and adaptable based on a utility's goals and the resources available to support implementation and operation of the system.

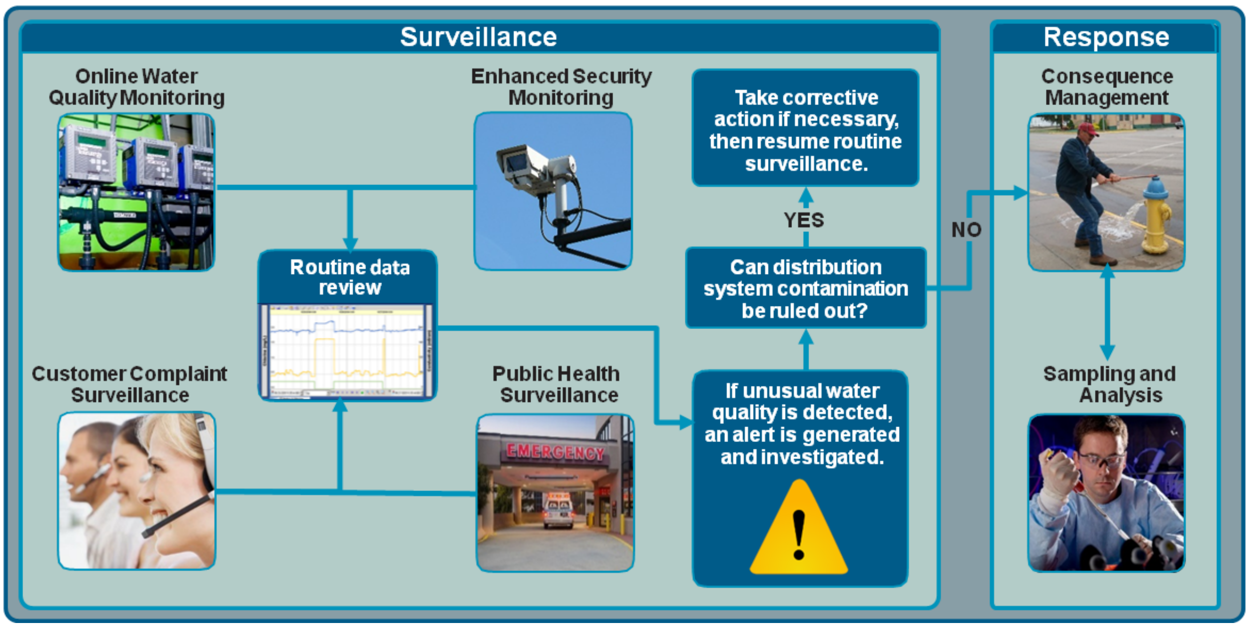

Figure 1-1. Surveillance and Response System Components

Public Health Surveillance (PHS) is one of four surveillance components of an SRS. The purpose of this document is to provide guidance for designing the PHS component of an SRS. It is written for drinking water professionals who would be responsible for coordinating with ***public health partners*** to implement PHS. The guidance provides information about public health partners who may be engaged to support PHS, includes an overview of available ***public health datastreams***, and discusses common surveillance techniques that can be leveraged to improve capability to monitor for illness due to exposure to contaminated drinking water. It does not address the design of new public health surveillance systems, which would fall entirely within the domain of public health professionals.

This document is organized into the following major sections:

- **Section 2** provides information about the generation of public health datastreams and a description of the PHS design elements that define the component. Guidance on developing each design element is presented in the following sections. Section 2 also introduces the concepts of design goals and performance objectives and explains how they inform the design of PHS.
- **Section 3** provides guidance on creating a partnership with public health agencies. The section identifies and describes common public health partners and provides guidance on methods to engage them.

- **Section 4** describes available public health datastreams and common surveillance techniques, and provides recommendations regarding how existing capabilities could be leveraged and potentially enhanced to support the goals of the PHS component of an SRS.
- **Section 5** provides guidance on investigating PHS alerts. It describes attributes of an effective alert investigation procedure, explains a utility's role in the investigation of a PHS alert, describes tools to support the investigation, and provides guidance on investigating alerts in real time.
- **Section 6** describes the process for developing a preliminary design for the PHS component of an SRS.
- **Resources** presents a comprehensive list of documents, tools, and other resources useful for PHS implementation. A summary and link to each resource is provided.
- **References** presents a comprehensive list of published literature cited within the document.
- **Glossary** presents definitions of terms used in this document, which are indicated by bold italic font at first use in the body of the document.

This document is written in a modular format in which the guidance provided on a specific topic is largely self-contained, allowing the reader to skip sections that may not be applicable to their approach to PHS, or that include capabilities that have already been implemented. Furthermore, this document was written to provide a set of core guidance principles that are sufficient to design the PHS component, while pointing the reader to additional technical resources useful for a specific design task.

Section 2: Overview of PHS Design

Public health surveillance is the systematic collection, analysis, and interpretation of public health data for the purpose of detecting ***public health incidents***, or changes in the health status of a community, in sufficient time to mitigate the consequences of the incident. Ongoing collection of public health data can also be used to establish the baseline health status in a community, which is a useful benchmark for any public health initiative, including detection of drinking water contamination. Public health surveillance operates on the principle that individuals experiencing unusual or severe symptoms will seek healthcare. These actions create datastreams that can be monitored to detect signs of a public health incident.

2.1 Generation of Public Health Datastreams

In the context of an SRS, the purpose of PHS is to provide early detection of drinking water ***contamination incidents*** and provide an opportunity to minimize adverse health impacts in exposed individuals. **Table 2-1** presents contaminant classes which can cause significant public health consequences if introduced into a water distribution system, example contaminants within those classes, and ***chief complaints*** (i.e., the primary symptom that a patient states as the reason for seeking medical care). The contaminant classes in Table 2-1 are separated into categories of delayed and rapid symptom onset, based on the delay between exposure to the contaminant and onset of acute symptoms.

Table 2-1. Contaminant Classes that can be Detected through Public Health Surveillance

Contaminant Classes		Example Contaminants	Chief Complaints[1]
Delayed Symptom Onset	Bacteria	*Bacillus anthracis*	Chills, fever, nausea, bloody vomiting
		Campylobacter spp.	Headache, fever, abdominal pain, vomiting, bloody diarrhea
		Legionella pneumophila	Muscle pain, cough, fever, shortness of breath, nausea, vomiting, diarrhea
		Salmonella Typhi	Headache, abdominal pain, fatigue, fever, diarrhea
		Vibrio cholerae	Leg cramps, watery diarrhea, vomiting
	Viruses	Adenovirus	Sore throat, sneezing, headache, cough, fever
		Enterovirus	Muscle pain, cough, sneezing, wheezing, difficulty breathing
		Norovirus	Muscle pain, abdominal pain, nausea, vomiting, watery diarrhea, fever
	Protozoa	*Cryptosporidium parvum*	Abdominal cramps, fever, nausea, vomiting, diarrhea
		Giardia lamblia	Abdominal cramps, fatigue, nausea, vomiting, diarrhea
	Toxins	Botulinum toxin	Muscle weakness, blurred vision, vomiting, difficulty breathing
		Microcystins	Headache, abdominal pain, vomiting, diarrhea, fever
		Ricin	Nausea, vomiting, diarrhea
	Heavy metals	Lead	Abdominal pain, headache, fatigue, memory loss, seizures, vomiting, constipation
	Radiochemicals	Cesium-137	Fatigue, fever, nausea, vomiting, diarrhea
Rapid Symptom Onset	Arsenic (III) compounds	Sodium arsenite	Difficulty swallowing, burning sensation in throat, thirst, dizziness, abdominal pain, vomiting, diarrhea
	Cyanide	Cyanide	Headache, dizziness, confusion, nausea, vomiting
	Mercury compounds	Mercuric chloride	Pain in mouth and throat, abdominal pain, difficulty breathing, vomiting, diarrhea
	Pesticides	Aldicarb, dichlorvos	Sweating, blurred vision, vomiting, diarrhea, difficulty breathing

[1] For a specific contaminant, the chief complaint can vary by the route of exposure to contaminated water, which can include ingestion, dermal contact, and inhalation of aerosols or water vapor.

Individuals exposed to contaminated water may seek healthcare, possibly urgently, depending on the type of symptoms and the rapidity of symptom onset. Healthcare seeking behavior may include calling 911, calling a ***Poison Control Center*** (PCC), calling a health advice hotline, requesting Emergency Medical Services (EMS) response, making an appointment with a primary care physician, visiting a hospital emergency department (ED), or purchasing an over-the-counter (OTC) medication. These actions become public health datastreams through the creation of call logs, patient medical records, or pharmacy medication sales records. Often when individuals seek healthcare by visiting their primary care physician or an ED, nurses or physicians will collect clinical samples and order a laboratory analysis. The results of clinical laboratory analyses are another potential public health datastream.

Public health datastreams are composed of numerous individual records (i.e., call logs, medical records, or medication sales) which contain specific case details (e.g., date, time, location, symptoms). Depending on the specific healthcare seeking behavior that patients pursue when experiencing symptoms, they may or may not be assessed by a medically trained professional before their information is captured and enters a datastream. For example, if a patient purchases OTC medication to alleviate their symptoms, information about the type of medication purchased, and the date, time, and location of the medication sale can be captured. However, the patient would not be assessed by a medical professional when taking this action. Conversely, if a patient schedules an appointment with their primary care physician, information about their health status would be assessed and captured during the visit by a medical professional. **Table 2-2** below presents the level of ***medical assessment*** that occurs for each datastream discussed in this guidance.

Table 2-2. Public Health Datastreams and their Level of Medical Assessment

Public Health Datastream	Assessor	Level of Medical Assessment
911 calls	911 operator	None
OTC medication sales	Salesperson	
PCC calls	Physicians, nurses, and pharmacists	Phone assessment
Health advice hotline calls	Nurses	
EMS runs	Emergency medical technicians	In-person assessment
ED cases	Physicians, physicians assistants, nurses	
Healthcare networks	Physicians, physicians assistants, nurses	
Clinical laboratory results	Laboratory analysts	

Two example drinking water ***contamination scenarios*** are presented below showing timelines associated with symptom onset, healthcare seeking behavior of an exposed individual, and the unique datastreams that are created by these behaviors. **Figure 2-1** shows the timeline, symptoms, and healthcare seeking behaviors of an individual who consumes water contaminated with a carbamate pesticide. In this example, the individual calls 911 following rapid onset of severe symptoms. An EMS unit is dispatched to the individual’s home and transports them to the ED. The attending physician at the ED recognizes symptoms suggesting chemical poisoning and contacts the PCC to discuss treatment of the patient. The physician also collects a blood sample from the patient and orders a clinical laboratory test of the sample. This sequence of healthcare seeking behaviors generates signals in the 911, EMS, ED, PCC, and clinical laboratory results datastreams.

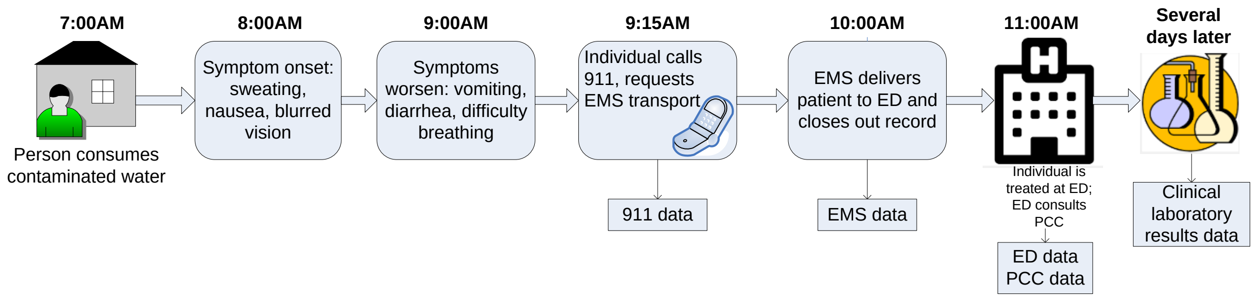

Figure 2-1. Example Chemical Contamination Scenario (Carbamate Pesticide)

Figure 2-2 shows the healthcare seeking behaviors of an individual who consumes water contaminated with *Vibrio cholerae*. In this example, the individual initially purchases OTC medication to treat relatively mild symptoms. Four days later symptoms worsen and the individual drives to the ED to seek urgent healthcare. The patient is assessed by the attending physician at the hospital and clinical laboratory tests are ordered on several clinical samples collected from the patient. This sequence of healthcare seeking behaviors generates signals in the OTC, ED, and clinical laboratory results datastreams. Under a variation of this scenario, the symptomatic individual might visit their primary care provider before going to the ED, thus generating a signal in an additional datastream. The pathogen contamination scenario differed from the carbamate pesticide scenario with respect to the severity and timing of symptom onset, which resulted in a different sequence of health seeking behaviors.

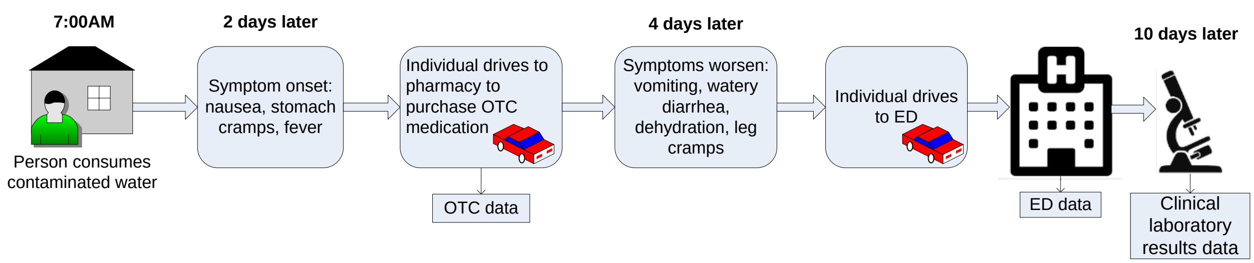

Figure 2-2. Example Pathogen Contamination Scenario (*Vibrio cholerae*)

2.2 PHS Design Elements, Design Goals, and Performance Objectives

Design elements are the functional areas which comprise each component of an SRS. PHS consists of three design elements, which are described in **Table 2-3**.

Table 2-3. Design Elements for Public Health Surveillance

Design Element	Description
Partnership with Public Health	Standing relationships between water utility personnel and public health partners who have developed a mutual understanding of each other's responsibilities and capabilities, and who are committed to supporting the goals of PHS.
Public Health Surveillance Systems	Systems that support routine ***monitoring*** of public health datastreams for indicators of possible public health incidents. This includes medical assessments of patients by ***healthcare professionals*** and monitoring of public health datastreams such as: PCC calls, ED visits, EMS runs, health advice hotline calls, healthcare networks, clinical laboratory results, 911 calls, and OTC medication sales.
Alert Investigation Procedure	A documented procedure for the timely and systematic investigation of PHS ***alerts***, with clearly defined roles and responsibilities for each step of the process.

An effective PHS component should have capability for each of the design elements listed in Table 2-3. Sections 3 through 5 of this document define a ***target capability*** for each of these design elements, which if achieved, will result in a fully functional PHS component. However, the specific manner in which each design element is implemented can vary, and it is possible to substantially improve PHS capabilities without fully achieving the target capability for each design element. Likewise, PHS capabilities can be implemented that exceed the target capability.

The decision regarding how to implement each of these design elements and build the PHS component is informed by ***design goals***, which are the specific ***benefits*** a utility hopes to realize through implementation of an SRS. Design goals for PHS are derived from overarching design goals established for the SRS, as illustrated in **Table 2-4**.

Table 2-4. Common SRS and PHS Design Goals

SRS Design Goal	PHS Design Goal
Detect water contamination incidents	Provide timely detection of ***possible*** water contamination incidents involving contaminants that produce symptoms with either rapid or delayed symptom onset.
Strengthen interagency relationships	Work collaboratively with public health partners to increase mutual awareness of each other's capabilities and to prepare to respond to any emergency.
Coordinate on issues of mutual concern to a utility and its public health partners	Work collaboratively with public health partners to address public health initiatives related to water quality and treatment, such as reducing the risk of *Legionella* outbreaks in hospitals, and monitoring for lead exposure in children.
Demonstrate the safety of the drinking water supply	Demonstrate to the community and regulators that the utility is collaborating with public health partners to investigate drinking water as the possible cause of public health incidents, and that the majority of public health incidents are not waterborne.

Additional factors to consider when designing PHS are ***performance objectives***, which are metrics used to gauge how well the SRS or its components meet the established design goals. While specific performance objectives must be developed in the context of a utility's unique design goals, general performance objectives for an SRS are defined in the *Water Quality Surveillance and Response System Primer* and are further described in **Table 2-5** in the context of PHS. The table also includes a recommended benchmark for each performance objective. The objectives described below are for the performance of the overall PHS component.

Table 2-5. Example PHS Performance Objectives

PHS Performance Objectives	Description	Recommended Benchmark
Contaminant coverage	The number of contaminant classes that can be detected, which is dependent on the types of public health data monitored through PHS.	Detect contaminant classes that produce rapid symptom onset and those that produce delayed symptom onset
Spatial coverage	The percentage of the distribution system service area monitored by PHS, which is dependent on the public health jurisdictions included in the monitored public health datastreams.	100% of the distribution system service area
Timeliness of detection and investigation	The time between when healthcare seeking behaviors enter a monitored datastream and when a PHS alert is generated, which is dependent on the delay between data generation and ***data analysis*** as well as the frequency of data analysis. This performance objective also considers the time to reach a conclusion from the investigation of an alert.	24 hours or less to generate an alert 2 hours or less to reach a conclusion from the alert investigation
Operational reliability	The percentage of time that utility personnel are available to support the investigation of water contamination as the possible cause of a PHS alert, which depends on the availability of trained utility personnel and the ***information management systems*** used during an investigation.	Availability of surveillance capabilities and coverage of PHS ***alert investigation*** responsibilities 24/7/365
Data quality	Availability of sufficient data to support the investigation of water contamination as the possible cause of a PHS alert or public health incident, including utility data and public health case details. Also, the degree to which patients have been assessed by a medically trained professional, as described in Table 2-2 (i.e., none, phone assessment, in-person assessment).	<u>Utility data</u>: water quality parameter measurements, laboratory results, customer feedback <u>Public health case details</u>: demographics, symptoms, date/time of contact, location where exposure occurred
Sustainability	The ability to maintain and operate PHS using available resources, which is dependent on the benefits derived from the component relative to the costs to maintain it.	PHS alert investigation procedures are incorporated into routine utility operations within 1 year of transitioning to ***real-time*** operation

The design goals and performance objectives established by a utility in collaboration with its public health partners provide the basis for designing PHS in a manner that meets the objectives and ***constraints*** of both entities. The following sections present guidance on potential approaches to enhance capabilities for each of the three PHS design elements described in Table 2-3. Additional background on the design elements, design goals, and performance objectives for PHS can be found in the *Public Health Surveillance Primer*.

Section 3: Partnership with Public Health

This design element addresses the relationships between water utility personnel and public health partners with a role in PHS. It is the foundation for establishing notification and investigation procedures that are necessary for effective detection and investigation of possible water contamination incidents.

TARGET CAPABILITY

A standing relationship has been established between a water utility and its public health partners, including the city or county health department and the regional PCC.

This section provides guidance on establishing partnerships with public health and covers the following topics:

- Subsection 3.1 provides guidance on establishing relationships with public health partners
- Subsection 3.2 provides guidance on establishing a joint public health and utility workgroup

3.1 Establishing Relationships with Public Health Partners

Utilities should engage with the following two categories of public health partners to implement PHS:

- **Health department**. Health departments are established for different jurisdictions, such as the city, county, and state. They are generally responsible for implementing various public health initiatives, monitoring the health of the community they serve, and enforcing public health regulations within their jurisdiction. Health departments typically employ epidemiologists, environmental health specialists, and laboratorians with experience in interpreting public health data. Many health departments have established environmental health service programs with complaint hotlines, where citizens can report concerns related to food safety, recreational or drinking water quality, illegal trash dumping, or rodent/insect control. In the context of PHS, health departments may monitor public health datastreams capable of detecting a broad spectrum of potential contaminants, including chemicals, radiochemicals, biotoxins, and pathogens. They conduct an initial investigation of PHS alerts and would contact the water utility, if necessary, to investigate contaminated water as a potential cause of an emerging public health incident.

- **Poison Control Center**. PCCs are regional service centers staffed by physicians, nurses, and pharmacists with toxicological expertise. They provide expert advice to persons who have been exposed to a substance capable of causing illness or injury (e.g., medication, consumer product, household/industrial chemical, bite/envenomation, environmental contaminant), or to persons who are experiencing symptoms suspected to be the result of a poisoning exposure. PCCs are routinely consulted by healthcare professionals who are actively treating poisoned patient(s) within various medical settings. In the context of PHS, PCCs upload call data to the National Poison Data System (NPDS) in near real time, and are capable of monitoring for broad and/or isolated public health incidents involving chemicals, radiochemicals, and biotoxins. During the investigation of a PHS alert, they can assist with contaminant identification, risk analysis, and ongoing situational awareness.

Figure 3-1 provides a four-step process for identifying and engaging public health partners. Guidance on each step of the process is provided below.

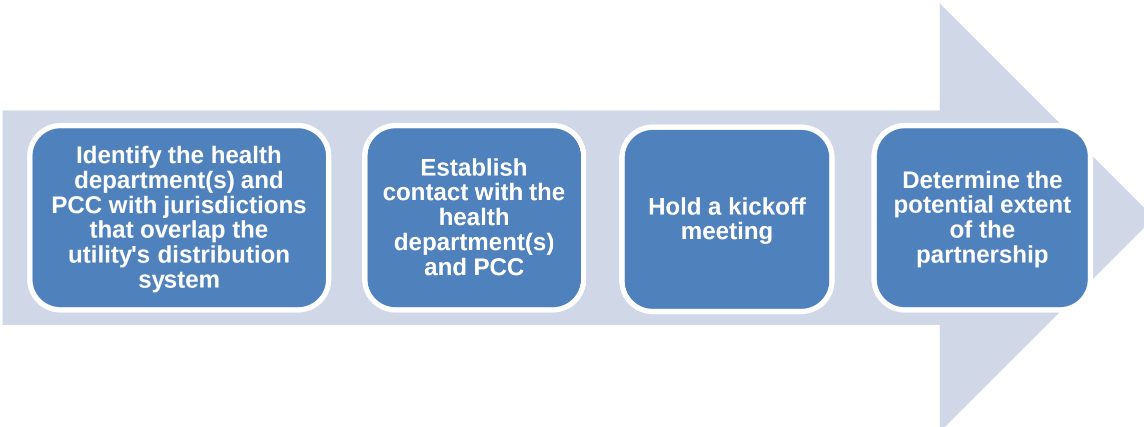

Figure 3-1. Process for Engaging Public Health Partners with a Potential Role in PHS

The first step is to identify public health partners with jurisdictions that overlap all or a portion of a utility's distribution system service area. There may be multiple health departments within a utility's service area, such as a city and county health department. There may also be regional public health entities that serve an area that extends beyond a utility's distribution system boundaries. At a minimum, a utility should identify the health department and PCC with jurisdictional boundaries that provide the broadest spatial coverage of the service area. Local listings or an Internet search should be sufficient to identify the appropriate health department(s). The PCC that serves the community in the utility's service area can be identified through the American Association of Poison Control Centers.

After the appropriate health department(s) and PCC(s) have been identified, the next step is to establish a point of contact within each. It is important to identify an individual within the organization who has sufficient authority to commit a modest amount of the organization's time to preliminary discussions with the utility regarding its role in monitoring and protecting the safety of the community's drinking water. It may be useful to contact existing city or county interagency groups, such as those involved in emergency preparedness planning, to identify specific health department or PCC personnel who could serve a role in the PHS component of the SRS.

After initial contact has been made with the appropriate public health partners, the utility should consider holding a kickoff meeting with this group of potential partners. The objective of this meeting is to make connections, share information, and gauge the interest of public health partners in participating in the PHS component of the SRS. During the kickoff meeting, the utility should describe their system, their organizational structure, their goal and vision for the SRS, and the potential role of PHS in an SRS. The utility should also describe their capabilities for monitoring water quality and supporting the investigation of a possible water contamination incident. Also during this meeting, each public health partner should be provided with an opportunity to present information about their organization, capabilities, and potential to support PHS. The resource *Public Health Surveillance Kickoff Meeting* is a PowerPoint ***template*** which can be opened by clicking the icon in the callout box. The template can be customized to provide an overview of your utility and its surveillance and response capabilities to public health partners during a kickoff meeting.

PPT — This template can be customized to provide an overview of your utility and the SRS.

Ideally, the kickoff meeting would allow the utility to determine which public health partners have the resources and interest to engage in PHS. When discussing the potential role and level of involvement of various public health partners, the utility should keep in mind that the resources of many public health partner organizations are spread thin. This may temper their willingness to commit. However, if PHS is designed and implemented in a manner that aligns with the core mission of participating public health partners, successful implementation and sustained operation of PHS can be achieved.

HELPFUL HINT

Invite public health partners to tour utility facilities and laboratories to increase their understanding of the utility's capabilities.

3.2 Establishing a Joint Public Health and Utility Workgroup

As noted in the previous section, the outcome of initial engagement should result in identification of public health partners who have some level of commitment to PHS as a component of an SRS. These partners will play an important role in the design, implementation, and operation of PHS. To maintain partner engagement throughout this process, it is recommended that a joint public health and utility workgroup be formed. While it will take some time and effort to establish and maintain the workgroup, it should not require financial expenditures by the utility or public health partners.

DID YOU KNOW?

Public health partners in your area may be actively participating in a Community of Practice – established by CDC in collaboration with public health associations – designed to improve communication and enhance data sharing among partners (CDC, 2016a).

When establishing the workgroup, a charter should be created which includes the mission, goals, and responsibilities of members. The workgroup should designate a leader and determine who will assume responsibility for administrative duties. Inclusion of a clear vision statement in the workgroup charter that establishes the purpose of the workgroup can be useful to convey the value of participation to utility and public health personnel.

During the design of PHS, this workgroup will identify design goals and performance objectives for the component that consider applications of PHS beyond the SRS that are important to the public health partners. During the design stage of the project the workgroup will likely need to meet frequently to evaluate alternatives and make decisions about the final design of the component. This may involve a thorough evaluation of existing public health partner capabilities that might support surveillance and alert investigations. The ability of these existing capabilities can be assessed against design goals and performance objectives, and potential enhancements to PHS capabilities can be identified and evaluated.

After PHS has been designed and implemented, the workgroup provides a forum for maintaining the relationships between the utility and public health partners. The workgroup could meet routinely (e.g., once or twice a year) to review operation of PHS and discuss other issues related to drinking water and public health that may not directly relate to the operation of the SRS. Examples of initiatives that may be of mutual interest to the utility and its public health partners include:

- Monitoring for long term exposure to lead or other commonly occurring environmental contaminants
- Public concerns over water quality issues such as fluoridation of drinking water
- Pharmaceuticals in drinking water and public education on proper disposal of medications
- Monitoring and mitigation strategies for waterborne *Legionella* outbreaks in hospitals
- Planning for continuity of operations during severe public health incidents, such as pandemic flu
- Changes in source water availability and quality due to natural disasters or short- and long-term changes in weather or climate
- Effectiveness of various water treatment processes on various chemical and biological contaminants

- Potential impacts of changes in drinking water treatment processes on water quality and public perception

Such initiatives can reinforce the relationship between a utility and its public health partners, which in turn helps to sustain operation of PHS. Furthermore, these relationships can provide lasting benefits to the community that extend beyond the scope and purpose of the SRS.

PUBLIC HEALTH ASSOCIATIONS

Utilities that actively collaborate with their public health partners may consider participating in regional- or national-level events or conferences as a means to remain current on issues that may be of mutual interest to utilities and public health professionals. The following list includes large public health associations which host annual conferences:

- Council of State and Territorial Epidemiologists
- National Association of County and City Health Officials
- Association of Public Health Laboratories
- National Environmental Health Association

Section 4: Public Health Surveillance Systems

Public health surveillance systems are designed to provide early detection of public health incidents. This design element leverages public health surveillance systems currently used by health departments, healthcare professionals, and the PCC that provide service to utility customers. To implement this design element, a utility should collaborate with the health department(s) within its service area and the regional PCC to identify existing public health surveillance systems and determine whether they can be leveraged to support the goals of the SRS. Furthermore, some of these systems can be optimized to improve their ability to detect possible water contamination.

TARGET CAPABILITY

Integrate public health surveillance currently performed by a utility's public health partners into an SRS to provide timely detection of public health incidents that could be related to water contamination.

This section describes public health datastreams and surveillance techniques, providing guidance on assessing existing public health surveillance systems with respect to their ability to detect possible water contamination. This section consists of the following:

- Subsection 4.1 provides an overview of public health datastreams and their attributes
- Subsection 4.2 provides an overview of public health surveillance techniques
- Subsection 4.3 describes a utility's role in integrating public health surveillance into an SRS

4.1 Public Health Datastreams

Public health datastreams are the data produced when symptomatic individuals seek healthcare, which can be monitored for indicators of potential public health incidents, such as unusual patterns of illness or deviations from the normal health status of a community. Public health surveillance techniques, discussed in Section 4.2, are the methods and tools that are used to analyze these datastreams. Datastreams vary with respect to the type of information collected, reporting mechanisms, and other attributes. Because of these differences, monitoring multiple datastreams can improve the detection capabilities of PHS.

This section defines attributes of public health datastreams, including: contaminant coverage, spatial coverage, timeliness, and data quality. This section also includes a brief description of the most common public health datastreams (i.e., PCC calls, ED visits, EMS runs, health advice hotlines, healthcare networks, clinical laboratory results, 911 calls, and OTC medication sales) and explains how well each datastream meets these attributes.

Attributes

Attributes are characteristics of a public health datastream that should be considered when evaluating the effectiveness of a datastream for PHS.

- **Contaminant coverage**. Ability of a datastream to detect a wide range of potential contaminant classes. Public health datastreams vary in their ability to detect contaminants which produce delayed or rapid symptom onset.
- **Spatial coverage**. The percentage of the utility distribution system service area covered by the datastream. Spatial coverage provided by a datastream is often limited to a specific jurisdiction, such as a city, county, state, or multi-state region.
- **Timeliness**. The amount of time between the initial presentation of symptoms and when the call, case record, clinical laboratory result, or OTC medication sale is captured in a datastream.

Timeliness depends on how quickly a symptomatic individual seeks healthcare, which is influenced by the severity of symptoms and speed with which they worsen.

- **Data quality**. The availability of sufficient case details, such as demographics, symptoms or chief complaint, and the date, time, and location where the exposure occurred. Also, the degree to which case details for records entering a datastream have been assessed by a medical professional (i.e., not at all, phone assessment, or in-person assessment [see Table 2-2]).

The overall "value to an SRS" is characterized for each datastream as high, moderate, or low based on the collective set of attributes, experience gained from utilities that have implemented PHS, and feasibility of integrating the datastream into the PHS component of an SRS. Information on the relevance and value of various public health datastreams can be found in a retrospective study published following the Milwaukee cryptosporidiosis outbreak, which evaluated the strengths and weaknesses of eight different datastreams, including some of those discussed in this document (Proctor et al., 1998). A discussion of the efficacy of syndromic surveillance for waterborne disease detection can be found in a review of retrospective, prospective, and simulation studies (Berger et al., 2006).

General Assessment of Public Health Datastreams

This section will briefly explain the types of datastreams that public health partners may already be monitoring. The potential applicability of any of these datastreams to an SRS for detection of possible water contamination will depend on the manner in which monitoring of the datastream is implemented. The datastreams are presented in order of their potential value to an SRS from high to low.

Poison Control Center calls. PCC data is generated when individuals contact a PCC by calling the national Poison Help line at 1-800-222-1222 to seek information or medical advice regarding a potentially harmful substance. Trained toxicologists at PCCs handle calls in real time, provide a preliminary medical assessment, identify specific substances and potential routes of exposures, and enter the caller's case information into an existing database. PCC toxicologists may follow up with the caller to assess whether or not the condition requires further medical attention, and the results of this interaction are added to the record. Healthcare providers treating selected patients may also contact the PCC as a resource for patient diagnosis and treatment advice. Attributes of the PCC datastream are described below:

- *Contaminant coverage*: PCC data is likely to capture contaminants producing rapid symptom onset which may prompt urgent healthcare seeking behavior.
- *Spatial coverage*: PCC coverage spans the country and every region in the U.S. has a PCC assigned to it, thus all utilities have at least one PCC that services the population living within the utility's distribution system area.
- *Timeliness*: PCC calls are very timely, as they typically occur within minutes after an exposure or onset of symptoms. The time elapsed between a call to the PCC and upload to NPDS is often less than 30 minutes (J. Colvin, personal communication, 2016).
- *Data quality*: PCC toxicologists capture data from callers, including: demographics, symptoms, the date and time of the call, the location of the caller. Toxicologists provide a medical assessment of a caller's symptoms and often obtain information about potential sources of exposure from the individuals seeking their assistance. An additional level of medical assessment is involved when PCCs receive toxicology consultations from ED physicians who are in the process of assessing a patient.

Value to an SRS: *High*. Although contaminant coverage for the PCC datastream may be limited to contaminants producing rapid symptom onset, the PCC is a valuable resource for identifying exposures to a wide variety of chemicals and toxins. For this reason, most state and some local health departments already collaborate with the PCC that serves their region (CSTE, 2013). An evaluation of current relationships between health departments and PCCs nationwide demonstrated that many PCCs are already sharing data with health departments electronically through online access to PCC systems, web services, or proprietary applications. The assessment also showed that data is often provided by PCC staff upon informal requests from health department staff (CSTE, 2013). Integrating the PCC datastream into the PHS component of an SRS requires a modest investment of time by the utility or health department but should not require financial expenditures given that it is an existing resource functioning in a capacity that is directly relevant to the design goals for PHS.

Emergency Department visits. ED data is generated when individuals visit an ED as a result of an injury or suspected illness. Trained healthcare professionals (e.g., physicians, nurses) attempt to identify the cause of the symptoms, provide treatment, and document the case details. ED data is typically entered into an existing medical records system. In addition to maintaining case records in-house, cases or suspected cases of ***reportable diseases***, which are established by state regulations, are reported to the health department where they are logged. Attributes of the ED datastream are described below:

- *Contaminant coverage*: ED data provides broad coverage of contaminants producing both rapid and delayed symptom onset.
- *Spatial coverage*: ED data is typically managed and consolidated by health departments. Thus, the spatial coverage provided by the ED datastream depends on the overlap between the catchment area of the ED, the jurisdictions covered by the health departments, and the utility's distribution system area. For large utilities, it may be necessary to coordinate with multiple health departments in order to maximize spatial coverage.
- *Timeliness*: ED data can be timely if procedures are in place for direct reporting from healthcare professionals to health departments if a higher than normal case volume is observed with unusual symptoms not attributable to a known public health incident. However, detection through ED surveillance can be delayed by several days if standard reporting procedures based on state regulations for reportable diseases is relied upon.
- *Data quality*: ED data includes patient demographics, symptoms or chief complaint, date, time, and location. Physicians provide an in-person medical assessment of patients who arrive at the ED which provides a high degree of data quality. In some cases, the datastream may include a discharge diagnosis for patients that have been treated.

Value to an SRS: *High*. The ED datastream provides broad contaminant coverage and high data quality. Furthermore, it is widely monitored by health departments and may require little or no effort to integrate into the PHS component of an SRS. However, modifications to analysis methods or procedures may be necessary to achieve timely detection.

Emergency Medical Service runs. EMS run data is generated when emergency medical technicians respond to an emergency, providing medical assessment, support, and transport. Following an EMS run, trained professionals enter the details of the run into an information management system owned and operated by the jurisdiction served by the EMS unit. EMS runs capture a broad range of situations reported by the public, including injuries, fires, accidents, and illness. For an SRS, EMS runs are filtered to capture only the subset of runs reporting illness that could be linked to an environmental exposure. Attributes of the EMS datastream are described below:

- *Contaminant coverage*: EMS runs are most likely to capture contaminants producing rapid symptom onset which may prompt urgent healthcare seeking behavior.
- *Spatial coverage*: EMS runs are often managed within jurisdictions such as cities, counties, or neighborhoods. Therefore, public health partners and utilities may need to coordinate with multiple EMS departments in order to achieve 100% spatial coverage across a utility's distribution system.

- *Timeliness*: EMS data can be very timely if there is minimal delay between completion of an EMS run and data transmittal.
- *Data quality*: Data from EMS runs usually include patient demographics, a chief complaint, date, time, and location. Patients receive an in-person medical assessment by emergency medical technicians which provides a high degree of data quality.

Value to an SRS: *Moderate*. EMS run data can be timely and is of high quality given that patients are medically assessed in-person. However, if multiple EMS providers operate within the utility's distribution system area, it may be costly to automate monitoring of EMS data from all providers. That limitation aside, EMS data can add value to PHS due to its potential to provide early detection of exposure to contaminants that produce rapid symptom onset.

Health Advice Hotlines. Health advice hotline data is generated when individuals contact a hotline to seek medical advice related to an injury or suspected illness. Trained healthcare professionals, such as registered nurses, handle calls in real time usually following a hierarchy of questions to provide preliminary medical assessment of a patient's symptoms and recommend either self-care or direct the patient to see a healthcare professional. Attributes of the health advice hotline datastream are described below:

- *Contaminant coverage*: Health advice hotline calls provide broad coverage of contaminants producing both rapid and delayed symptom onset.
- *Spatial coverage*: The spatial coverage provided by health advice hotlines can vary depending on the organization that manages the hotline. For example, insurance hotlines or hospital hotlines may not represent the entire population served by a utility, or may cover an area served by more than one utility.
- *Timeliness*: Health advice hotlines can be timely for contaminants producing delayed symptom onset, as sick individuals may call a hotline before seeking other forms of healthcare and thus enter another datastream (e.g., ED, physician, OTC). One study that evaluated a specific healthcare network demonstrated that hotline data captured for that network preceded outpatient visits by 8.3 to 50 hours (CDC, 2004).
- *Data quality*: Health advice hotline calls generally include caller demographics, symptoms, and the date and time of the call. Patients are medical assessed over the phone.

NEW MEXICO'S STATEWIDE HEALTH ADVICE LINE

The state of New Mexico operates a statewide Nurse Health Advice line through a collaboration between the state and the larger private and public provider systems, to provide universal access to residents within the state. This specific hotline has established syndromic surveillance practices and reports increases in specific symptoms to public health officials (Nurse Advice New Mexico, 2016).

Value to an SRS: *Moderate*. The reports that a health department receives from a health advice hotline may precede data that would be captured by OTC sales or from a visit to a primary care physician or ED. Health advice data includes an over-the-phone medical assessment of a patient's symptoms. While this datastream is a pre-established service which can provide an early signal of unusual cases, effective integration of this datastream into PHS may require that health departments educate healthcare professionals responsible for operating health advice hotlines on procedures for timely reporting of unusual cases or clusters of cases to the health department.

Healthcare Networks. Patient data is generated when individuals visit a primary care physician's office as a result of an injury or suspected illness. Trained medical professionals (e.g., doctors, physician assistants, nurses) conduct an in-person assessment during these visits, attempt to identify the cause of the symptoms, and provide treatment. Patient data captured during these visits is entered into an existing medical records system. While paper records are still in use, electronic record management is becoming more common (see callout box), which offers numerous advantages for surveillance. Healthcare networks provide a potential means to effectively monitor this datastream because of the large number of physicians who are members of the network, and the fact that networks may use electronic record management. In addition to maintaining case records in-house, cases or suspected cases of reportable diseases, which are established by state regulations, are reported to the health department where they will be logged. Attributes of the healthcare networks datastream are described below:

- *Contaminant coverage*: The healthcare network datastream provides coverage of contaminants producing delayed symptom onset.
- *Spatial coverage*: Primary care physicians may report unusual cases to the appropriate health jurisdiction, so spatial coverage depends on the overlap between the area served by the healthcare network and the distribution system service area.
- *Timeliness*: Data resulting from primary care physician office visits is not timely, as ill patients will need to schedule an appointment and see the physician, which could delay the physician's assessment of the patient by days. If the patient's condition worsens while waiting for their appointment, they make seek alternate healthcare and enter another datastream, such as the ED datastream.
- *Data quality*: Healthcare network data typically includes patient demographics, symptoms, date, time, and location. Physicians provide an in-person medical assessment of patients resulting in high quality data from primary care physician office visits.

Electronic Medical Records and Electronic Health Records (EMR/EHR)

The Centers for Medicare and Medicaid Services is facilitating the adoption of EHRs through financial incentives to healthcare providers in order to provide improved data sharing between healthcare providers, public health stakeholders, and patients (CDC, 2012). As of 2014, 82.8% of office-based physicians use an EMR/EHR system (HHS, 2016). EHR technology has the potential to aid the development of PHS systems through better access to standardized healthcare data.

<u>Value to an SRS: *Moderate*</u>. While healthcare networks provide high quality data that has been assessed by a medical professional, this datastream will likely not capture patients with rapid symptom onset as they are more likely to seek healthcare urgently through other means (e.g., call a PCC or visit an ED). Also, it may require a significant effort to establish processes to collect and aggregate data from multiple healthcare networks.

Clinical Laboratory Results. Healthcare providers may order ***clinical laboratory testing*** of samples collected from patients. The purpose of this testing is to provide definitive identification of the chemical, toxin, or pathogen that caused illness in a patient. Clinical laboratory analysis is performed by in-house hospital laboratories or by contracted laboratories that receive samples from hospitals and medical offices. Attributes of clinical laboratory results are described below:

- *Contaminant coverage*: Clinical laboratory tests are available for a wide range of contaminant classes including chemicals, toxins, and pathogens; however, clinical test capability will vary by laboratory. Also, there may be some contaminants for which a clinical laboratory test has not yet been developed. Some contaminants may not be detected in clinical samples if they are collected more than several days after exposure, as the contaminant may have been fully metabolized and excreted from the patient's system at that time.
- *Spatial coverage*: Hospitals and primary care physicians request clinical laboratory analyses and report the results to the health department responsible for the jurisdiction in which they operate. Thus, spatial coverage depends on the overlap between the area served by health departments receiving clinical laboratory results and the distribution service area.

- *Timeliness*: The delay between the time of symptom onset and the availability of clinical laboratory results, is often days to weeks, and is affected by the time required to collect and process a clinical sample, and the reporting timeframe required by state regulations for reportable diseases once they are confirmed by a laboratory analysis.
- *Data quality*: Clinical laboratory results provide a definitive confirmation of the presence of a contaminant in a clinical sample as long as the concentration of the contaminant exceeds the detection limit of the test method. Analyses of clinical laboratory samples, ordered by healthcare providers and performed by trained laboratory analysts, confer a high degree of data quality.

Value to an SRS: *Moderate*. Similar to the results from laboratory analysis of water samples, clinical laboratory results can provide definitive identification of a contaminant. However, contaminant coverage is limited by availability of clinical laboratory tests and the capabilities of clinical laboratories. Furthermore, the significant delay in the availability of laboratory results limits the ability of this datastream to provide information in sufficient time to respond to a transient water quality problem in a manner that reduces consequences. Despite these limitations, clinical laboratory results may still prove useful for detection of a sustained source of water contamination that is causing an ongoing public health incident.

911 calls. 911 data is generated when individuals call a 911 dispatch center to report an emergency or to seek medical assistance. Trained 911 dispatchers code each call and enter it into a computer-aided dispatch system that is used by EMS, fire, and police first responders. 911 calls capture a broad range of situations reported by the public, including injuries, fires, accidents, and illness. For an SRS, 911 calls are filtered to capture only the subset of calls reporting illness that could be broadly linked to an environmental exposure. Attributes of the 911 datastream are described below:

- *Contaminant coverage*: 911 calls are most likely to capture contaminants producing rapid symptom onset which may prompt urgent healthcare seeking behavior.
- *Spatial coverage*: 911 dispatch centers often provide coverage within the jurisdiction of a county or fire protection district. Therefore, public health partners and utilities may need to coordinate with multiple dispatch centers to achieve 100% spatial coverage across a utility's distribution system.
- *Timeliness*: A 911 call may be the first record of an individual's healthcare seeking behavior before entering other datastreams, such as EMS and ED, and can be the first indicator of a public health incident.
- *Data quality*: 911 dispatch centers follow a standardized protocol to triage calls according to complaint type and severity. Case details that may be provided in the record include the patient's age, sex, and location, the date and time of the call, and the incident code. 911 calls capture self-reported illness without a medical assessment.

Value to an SRS: *Low*. Although 911 call data is timely, data quality is low. Furthermore, the need to coordinate with multiple jurisdictions can make this an expensive datastream to implement and monitor. These limitations aside, 911 call data can add value to PHS due to its potential to provide early detection of exposure to contaminants that produce rapid symptom onset.

Over-the-Counter medication sales. Sales of medications commonly used to treat symptoms potentially caused by exposure to contaminated water are grouped into categories such as gastrointestinal illness and respiratory illness, and are aggregated across participating pharmacies. Attributes of the OTC medication sales datastream are described below:

- *Contaminant coverage*: OTC medication sales data is most likely to capture contaminants producing minor symptoms or those with delayed symptom onset because individuals purchase OTC medication for self-care to alleviate symptoms which are not severe or life-threatening.
- *Spatial coverage*: It is very difficult to achieve complete spatial coverage due to the number of pharmacies in most communities. Additionally, the only location data available for this datastream is the location of pharmacies, which may not represent the location of exposures.
- *Timeliness*: While this datastream may provide an early indicator of a contaminant producing delayed symptom onset, an increase in OTC medication sales may not be detected until days after the initial exposure due to the delay in symptom onset that is common for many pathogenic diseases.
- *Data quality*: No case details associated with the individual purchasing an OTC medication are captured during the sales transaction. Details associated with OTC medication sales that may be available include the date, time, and location of the transaction and the type of medication that is purchased (e.g., medication for gastrointestinal illness, respiratory illness, or fever). Additionally, OTC medication sales may be biased by market trends or sales. There is no medical assessment associated with this datastream.

Value to an SRS: *Low*. Developing and maintaining relationships and data sharing practices with pharmacy retailers may prove difficult or expensive. Retailers may be reluctant to provide sensitive business information and it may be difficult to coordinate data sharing with all retailers in a region. However, for a public health incident involving a contaminant producing delayed symptom onset, OTC medication sales data could precede a rise in healthcare network visits or ED visits.

UTILIZATION OF PUBLIC HEALTH DATASTREAMS FOR PHS

The information provided in this callout box characterizes the likelihood that public health partners are already using, or would consider using, a particular public health datastream. References are provided that describe the implementation of the datastream to monitor a community's health status.

PCC calls: All health departments coordinate with the PCC serving their region, although the degree to which PCC calls are utilized as a datastream varies (CDC, 2005).

ED visits: All health departments routinely monitor ED data (Hirshon, 2000).

EMS runs: EMS runs are not widely utilized because it is often necessary to coordinate with multiple EMS jurisdictions to achieve complete spatial coverage, which may increase the cost of implementation (Yih et al., 2010).

Health advice hotlines: Use of health advice hotline calls for PHS varies widely and depends on their availability. Most health advice hotlines are affiliated with a healthcare network or insurance carrier. New Mexico is the only state thus far which operates a statewide hotline, funded through a public-private partnership. This hotline is a model that other states could adopt to assist residents during pandemics and emergencies (Preparedness Summit, 2015).

Healthcare networks: All states have laws, statutes, or other regulations that mandate reporting of communicable or infectious diseases and have the authority to collect and monitor a central repository of disease case information where patterns, clusters, and outbreaks may be detected. Although the list of reportable diseases varies from state to state, everyone uses the same criteria to define what constitutes a case of a given disease.

Clinical laboratory results: All states have infectious disease-reporting regulations that require laboratories to report clinical test results to the health department.

911 calls: 911 calls are not widely utilized because they lack medical assessment and can be costly to monitor in an automated manner (Greenko et al., 2003; Haas et al., 2011).

OTC medication sales: OTC medication sales data are not widely utilized because they lack medical assessment, and it is often impractical to achieve complete spatial coverage (Pivette et al., 2014).

Figure 4-1 presents a generalization of the strengths and weaknesses of each datastream described above with respect to the timeliness, data quality, and contaminant coverage attributes. Spatial coverage is not included as it will vary based on the jurisdiction(s) in which the datastream is monitored. The diagram provides a visual comparison of the overall value of each datastream to an SRS. For example, the ED visits datastream provides excellent data quality, captures contaminants which produce both rapid and delayed symptom onset, is moderately timely, and thus has high potential value to an SRS. Because each datastream has strengths and weaknesses, a robust PHS component should involve monitoring of multiple datastreams to detect public health incidents.

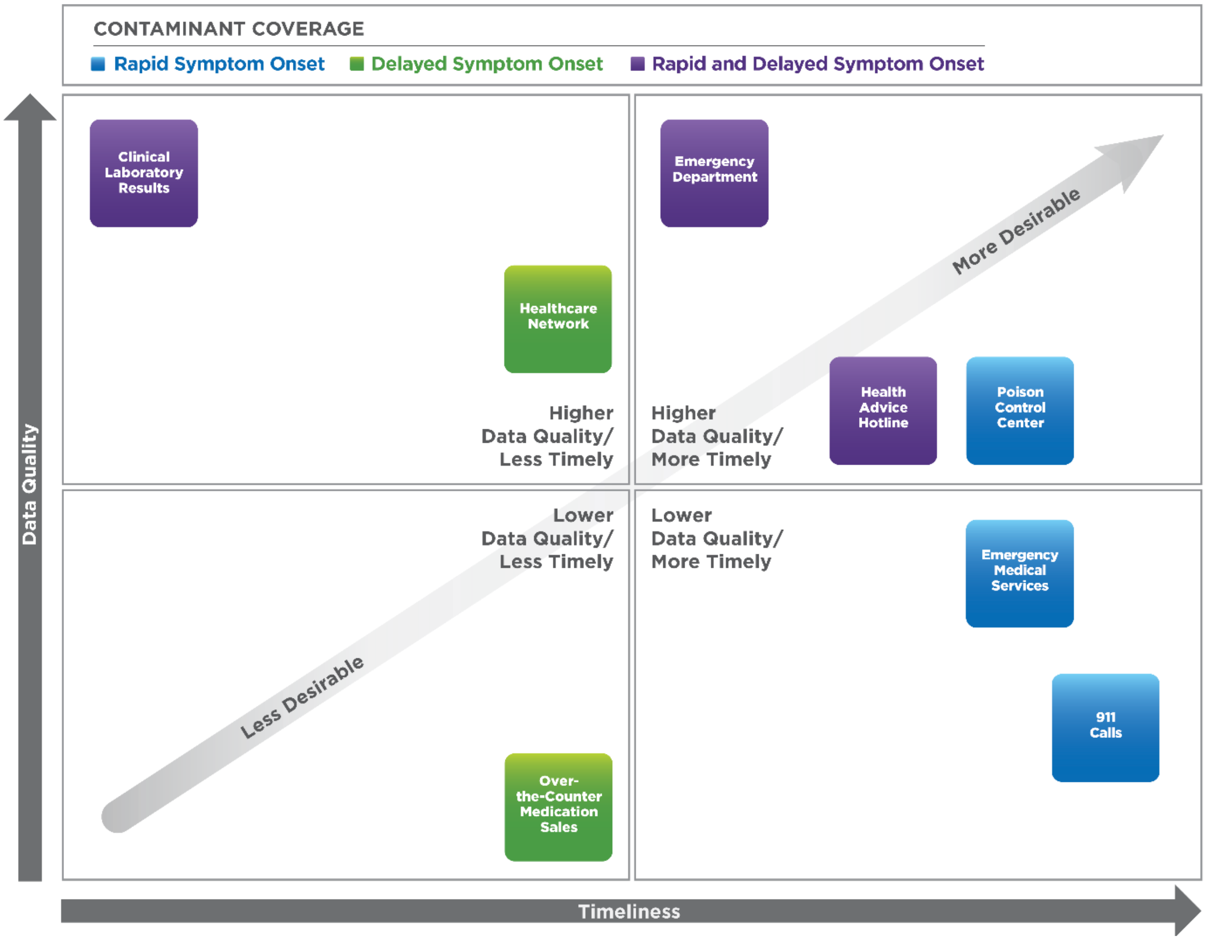

Figure 4-1. Public Health Datastream Attribute Summary

4.2 Public Health Surveillance Techniques

As discussed in the previous section, datastreams are the data produced when symptomatic individuals seek healthcare. Surveillance techniques are methods, tools, and assessments used to analyze these datastreams in order to detect possible public health incidents. A surveillance technique defines the manner in which a datastream is collected, analyzed, and presented to investigators. Utilities should work with their public health partners to determine which public health surveillance techniques are currently in use and characterize these existing surveillance techniques with respect to the design goals and performance objectives of the SRS. Leveraging existing public health surveillance techniques can be an effective, low-cost method of developing PHS as a component of an SRS.

As depicted in **Figure 4-2**, surveillance techniques can be grouped into two broad categories: case-based and syndromic. Both case-based and syndromic surveillance can be applied to any datastream. For example, an ED physician may call the health department to report an unusual case (case-based) while the health department analyzes electronic ED records for a rise in gastrointestinal illness (syndromic). However, some techniques are more useful for some datastreams. For example, 911 call and EMS run datastreams are more amenable to analysis using syndromic surveillance.

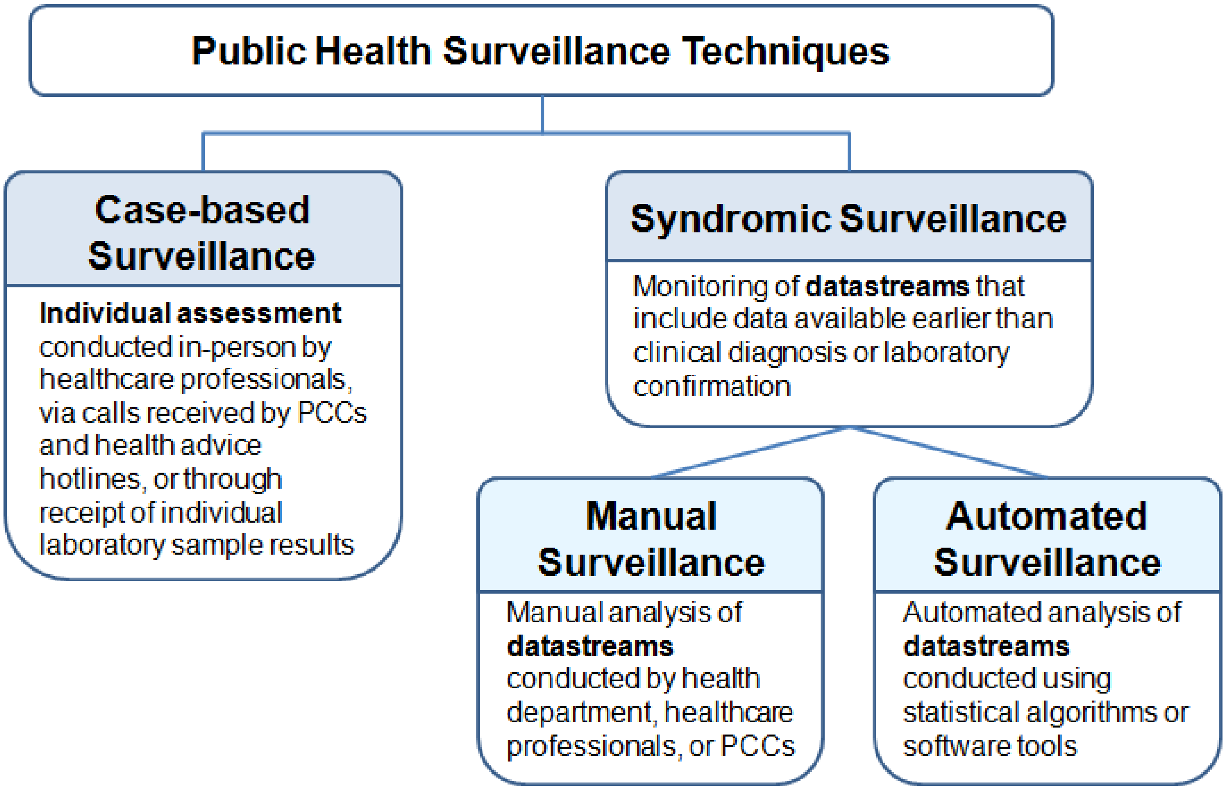

Figure 4-2. Overview of Public Health Surveillance Techniques

Case-based Surveillance

Case-based surveillance involves the identification and reporting of unusual cases or clusters of cases to the health department for investigation. Case-based surveillance relies on the professional judgment of trained healthcare professionals, including physicians, nurses, pharmacists, and EMS technicians who interact directly with patients and conduct medical assessments to consider whether cases of illness in the population represent a threat to public health. For example, an astute clinician may observe the presentation of unusual symptoms during in-person assessments or a rise in the number of patients with common infections. Because the reporting party is often interacting directly with the symptomatic individual, additional case details can be provided to the health department. This type of reporting can be expedited if the reporting party is particularly concerned about the possibility of a public health incident, and may occur before a diagnosis is confirmed via laboratory results. Case-based surveillance also includes mandatory reporting of reportable diseases.

Health departments and their epidemiologists monitor information provided by healthcare professionals who conduct case-based surveillance as described below:

- EMS technicians can report any unusual observations during response, such as similarities in symptoms of multiple individuals receiving treatment by EMS.

- Healthcare professionals in healthcare networks, urgent care facilities, or EDs, can report individual cases or an increased case volume presenting with similar, and possibly unusual number and types of symptoms not attributable to a known ongoing public health incident.
- Clinicians or microbiologists who analyze clinical samples can report a sudden increase in orders for specific laboratory tests for reportable diseases or conditions in advanced of confirmed results.
- Healthcare professionals who answer health advice hotline calls can report a sudden increase in the number of calls with inquiries involving similar and possibly unusual symptoms.
- Pharmacists can report a sudden rise in prescription or OTC medication sales or queries related to unusual symptoms reported by customers.
- PCCs can report an increase in calls or a unique case in which the exposure is closely linked to water.

CASE-BASED SURVEILLANCE: REPORTABLE DISEASES AND NOTIFIABLE DISEASES

Reportable Diseases

Each state has its own laws and regulations defining which diseases are reportable. The list of reportable diseases, including infectious and noninfectious conditions, varies among states and over time. It is mandatory that reportable disease cases be reported to state and territorial jurisdictions when identified by a health provider, hospital, or laboratory. Additionally, the requirements for timeliness of reporting depend on the condition. Diseases which are rare or severe (Ebola virus, botulism) may require immediate notification, while more common diseases, such as influenza, may be reported weekly. While an individual healthcare provider may not recognize the significance of a small increase in cases of a specific disease, a local or state health department epidemiologist may identify a public health incident by surveying all reports across a jurisdiction or region. Some states have disease surveillance systems that can be used to analyze data on a regional basis.

Notifiable Diseases

CDC maintains a list of nationally ***notifiable diseases*** which is reviewed and modified annually by the Council of State and Territorial Epidemiologists and CDC. CDC receives case notifications of notifiable diseases from 57 reporting jurisdictions (including state health departments and territories) which are voluntarily reported into the National Notifiable Infectious Diseases Surveillance (NNDSS) system. This allows for nationwide aggregation and monitoring of disease data. Every nationally notifiable disease is not necessarily reportable in each state (CDC, 2015).

Examples of notifiable diseases and conditions of relevance to water utilities include:

- Biological: Cryptosporidiosis, Shigellosis
- Chemical: Pesticide-related illness and injury
- Toxins: Botulinum
- Waterborne disease outbreak

If optimized for the goals of PHS, case-based surveillance can be a sensitive and timely method of detecting public health incidents, including water contamination. It is importance to note that it is the responsibility of the health department, not the utility, to establish relationships, procedures, and training with healthcare professionals who conduct case-based surveillance. A utility would only interface with the health department if their review of surveillance data suggested that the cases might have resulted from exposure to contaminated water. Case-based surveillance has proven to be effective for detecting drinking water contamination incidents, as illustrated by the examples in **Table 4-1**.

Table 4-1. Water Contamination Incidents Identified Through Case-based Surveillance

Location	Contaminant(s)	Role of Case-based Surveillance in Detection of Outbreak
Alamosa, CO	*Salmonella*	Three cases were reported by healthcare providers from the Alamosa County Nursing Service to the regional epidemiologist, and this information was subsequently reported to Colorado Department of Public Health and Environment. Epidemiologists working on the outbreak later contacted the safe drinking water program team to discuss the outbreak and the possibility that the outbreak was related to Alamosa's public drinking water supply (Berg, 2009).
South Bass Island, OH	Multiple biological contaminants and bacterial indicators	The Ottawa County Health Department in Ohio received several telephone calls from persons reporting gastrointestinal illness after visiting South Bass Island. A food-borne disease outbreak investigation was initiated by the Ottawa County Health Department and the Ohio Department of Health. Subsequently, Ohio EPA was informed about a possible waterborne outbreak and began an investigation of the drinking and wastewater systems (Fong, 2007).
Gideon, MO	*Salmonella* Typhimurium	Seven culture-confirmed cases of *Salmonella* Typhimurium gastroenteritis among Anderson Township residents were reported to the Missouri Department of Health. Food histories revealed no common food exposures, but all patients had consumed water in Gideon. The drinking water was tested and found to contain fecal coliform bacteria (Angulo, 1997).
Netherlands	Multiple biological contaminants and bacterial indicators	Upon receiving several taste and odor complaints, the water company initiated an investigation which discovered a cross-connection with a grey water system incurred during maintenance work on the distribution system. A boil water advisory was issued, which prompted a healthcare provider to notify the public health service of an excessive number of patients with gastrointestinal illness in recent days (Fernandes, 2007).
Bergen, Norway	*Giardia lamblia*	The municipal medical officer was notified by a university hospital of an increase in laboratory confirmed giardiasis cases, which correlated with a rise in gastrointestinal illness visits to healthcare providers. An outbreak investigation team of representatives from public health, food safety, and water and sewage treatment was formed to investigate the cases (Nygard, 2006).

Syndromic Surveillance

Syndromic surveillance is the monitoring of pre-diagnosis public health data, such as chief complaints or other proxy for illness, using categories of similar health issues (for example, gastrointestinal illness or respiratory illness). Syndromic surveillance can be used to group related illness categories or identifiers into one overall category that is monitored on a continual basis for anomalies. For example, a variety of related 911 incident codes might be grouped into a general category (e.g., gastrointestinal) and can be monitored for an incident which might involve exposures to a chemical contaminant producing rapid symptom onset (EPA, 2014).

Syndromes can be defined according to the objective of the surveillance system, and common syndrome definitions have emerged in practice. **Table 4-2** lists syndromes that are applicable to detecting water contamination.

Table 4-2. Syndromes Related to Water Contamination[1]

Syndrome	Description
Gastrointestinal	Includes stomach pain, nausea, vomiting, or diarrhea resulting from exposure to contaminants that cause acute infection or irritation of the upper or lower gastrointestinal tract.
Respiratory	Includes cough, shortness of breath, difficulty breathing, or throat pain resulting from exposure to contaminants that cause acute infection or irritation of the upper or lower respiratory tract.
Cardiac	Includes slow or rapid heart rate, low or high blood pressure, tightness of chest, headache, or sweating resulting from exposure to contaminants that cause cardiac distress or arrest.
Dermal	Includes burning, itching, swelling, or rash resulting from exposure to contaminants that cause an acute skin infection or skin irritation.
Neurological	Includes confusion, dizziness, blurred vision, slurred speech, muscle weakness, or stroke resulting from exposure to contaminants that cause acute neurological symptoms.

[1] This list is not inclusive of all syndromes that may be relevant.

Typically, syndromic surveillance is conducted by epidemiologists at the local, regional, state, and national levels to monitor trends in public health or detect a public health incident. While case-based surveillance can trigger an investigation based on a single, unusual case, syndromic surveillance focuses on detecting anomalous patterns of cases across a defined geographic area. Syndromic surveillance has the advantage of being utilized continuously and across an entire region, identifying broader patterns in the health of a community, and providing ongoing situational awareness for a known incident.

While effective integration of syndromic surveillance into PHS will likely require a greater level of effort and financial investment by the utility's public health partners, this enhancement can significantly improve their ability to identify early signals of public health incidents, including possible water contamination. Health departments may already be conducting some form of syndromic surveillance on at least one datastream. Syndromic surveillance can be conducted manually, but is increasingly performed with automated ***anomaly detection systems***. Data is queried by the epidemiologist or automated system, analyzed by advanced statistical algorithms, and an alert is generated if an ***anomaly*** is detected. **Table 4-3** lists some of the most common automated systems utilized by health partners for syndromic surveillance (Uscher-Pines et al., 2009).

Table 4-3. Common Syndromic Surveillance Systems

Tool/Application	Datastream	Description
BioSense	911 calls ED visits EMS runs	BioSense is a web application used to track health data at regional and national levels and to provide public health partners with the information necessary to monitor, identify, respond, and prevent epidemics and public health incidents. While BioSense was originally developed to identify bioterrorism-related illness, it has been undergoing redesign since 2010 to provide regional and nationwide situational awareness for all-hazard health-related threats and to support national, state, and local responses to those threats (CDC, 2016b).
EpiCenter	ED visits PCC calls Reportable disease data	EpiCenter is a commercial application used by health departments and individual healthcare facilities to conduct syndromic surveillance of ED visits. Surveillance of PCC calls through EpiCenter is available in select areas and reportable disease data is available for regions where this data type is collected (Health Monitoring Systems, 2016).
ESSENCE	ED visits	The Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE) monitors health data as it becomes available to identify epidemics, outbreaks, and other potential public health incidents at the outset. ESSENCE is an open source surveillance tool that is primarily used to monitor ED visits, although it could be applied to other public health datastreams (Johns Hopkins Applied Physics Laboratory, 2016). EPA developed a water security module to aid detection of drinking water contamination (EPA, 2012).
NPDS	PCC calls	The National Poison Data System (NPDS) is the repository for PCC case data that is uniformly collected by all regional PCCs in the U.S. NPDS is used to monitor poison exposure outbreaks in real-time across the country. It enables case definitions to be defined and monitored using manual or statistical search algorithms to analyze calls. Alerts are sent to appropriate PCCs for further investigation (American Association of Poison Control Centers, 2016).
NRDM	OTC medication sales	The National Retail Data Monitor (NRDM) is a public health surveillance tool that collects and analyzes daily sales data for OTC medications. NRDM collects data in near real time from more than 15,000 retail stores and makes them available to public health officials (University of Pittsburgh, 2016a).
PulseNet	Clinical laboratory data	PulseNet is a network of 83 local, state, and federal public health laboratories that can analyze DNA fingerprints of bacteria from patients. Centers for Disease Control and Prevention (CDC)'s PulseNet team compares fingerprint data submitted from laboratories across the country to find clusters of disease that might represent unrecognized outbreaks. Since its inception in 1996, this system has identified numerous foodborne outbreaks, and has also identified outbreaks cause by bacteria from animals and recreational water (CDC, 2016c).
RODS	ED visits OTC medication sales	Real-time Outbreak and Disease Surveillance (RODS) is an open source surveillance resource that enables users to perform surveillance of ED visit records from participating hospitals. It also serves as the ***user interface*** for national OTC medication sales surveillance data collected through NRDM (University of Pittsburgh, 2016b).

4.3 Utility Role in Integrating Public Health Surveillance Capabilities into an SRS

While public health partners own and operate public health surveillance systems, a utility has an important role in the integration of these capabilities into PHS to provide timely detection of possible drinking water contamination. This section provides guidance on the following steps that utilities can take to integrate public health surveillance capabilities into an SRS:

- Identify and characterize existing public health surveillance capabilities
- Assess existing capabilities relative to SRS design goals and performance objectives
- Develop a strategy to address gaps in public health surveillance capabilities relative to SRS design goals and performance objectives

Identify and Characterize Existing Public Health Surveillance Capabilities

Utilities should meet with public health partners to encourage interest in supporting the design goals of PHS and to identify public health datastreams and techniques currently used by public health partners. The datastreams should be assessed with respect to the attributes discussed in Section 4.1 using the resource *Public Health Surveillance Assessment: Interview with Public Health Partners*. This resource, which can be accessed by clicking the icon in the callout box, is a fillable PDF form that can be completed electronically or by hand. The assessment form also includes prompt questions to record information about procedures that may be in place for responding to alerts generated by public health surveillance systems. It is recommended that a separate assessment be conducted with the health department and the PCC.

This fillable form can be used to capture the attributes of existing public health datastreams and techniques.

Syndromic Surveillance Assessment Questions

1. For each datastream currently monitored by the health department, record the name of the PHS system, a brief description, and the system owner/operator. If a datastream other than the four listed is monitored, enter information for that datastream in the "Other" row.

Datastream	Contaminant Class Coverage	Name of PHS System	Description	System Owner/Operator
ED Data	Rapid symptom onset and Delayed symptom onset			
EMS Runs	Rapid symptom onset			
911 Calls	Rapid symptom onset			
OTC Medication Sales	Delayed symptom onset			
Other:				

2. **<u>Spatial coverage</u>:** For each datastream monitored by the health department, does the geographic area monitored by the datastream cover the entire utility service area?

ED Data	EMS Runs	911 Calls	OTC Medication Sales	Other:
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No

3. **<u>Timeliness</u>:** For each datastream monitored by the health department, what is the typical delay between health seeking behavior and alert generation?

ED Data	EMS Runs	911 Calls	OTC Medication Sales	Other:
☐ Real-time ☐ Hours ☐ Days ☐ Weeks	☐ Real-time ☐ Hours ☐ Days ☐ Weeks	☐ Real-time ☐ Hours ☐ Days ☐ Weeks	☐ Real-time ☐ Hours ☐ Days ☐ Weeks	☐ Real-time ☐ Hours ☐ Days ☐ Weeks

Figure 4-3. Excerpt from the *Public Health Surveillance Assessment* (Health Department – Syndromic Surveillance Datastreams)

Assess Existing Capabilities Relative to SRS Design Goals and Performance Objectives

After the existing public health surveillance capabilities have been characterized, the utility should assess how well these public health surveillance capabilities support the primary design goal of PHS in the context of an SRS: to provide timely detection of possible drinking water contamination incidents. The degree to which this design goal is realized depends largely on the performance objectives established for the SRS, specifically: contaminant coverage, spatial coverage, timeliness, and data quality.

Assessment criteria for existing public health surveillance systems can be described in terms of the attributes of public health datastreams, as presented in Section 4.1. For example:

- **Contaminant coverage**: ability of a public health surveillance system to detect a variety of contaminant classes that produce rapid symptom onset or delayed symptom onset in exposed individuals.
- **Spatial coverage**: the percentage of the utility distribution system service area covered by the public health surveillance system.
- **Timeliness**: the time between health seeking behavior and the time that a PHS alert is generated.
- **Data quality**: the completeness of underlying case details (e.g., demographics, symptoms, date, time, and location where exposure occurred) for PHS alerts.

A utility should meet with their public health partners to complete the *Public Health Surveillance Assessment*, which will provide the information necessary to populate this worksheet and conduct the assessment. Once the attributes of existing public health surveillance systems have been assessed, the utility and their public health partners can identify gaps between existing and target capabilities for PHS. In conducting this gap analysis, it is important to consider how the combination of all public health surveillance systems meets the assessment criteria. For example, while an individual surveillance system may have a gap such as 50% spatial coverage, that deficiency may be compensated by another surveillance system which covers 100% of the utility's service area. If the existing public health surveillance systems meet the targets established by the assessment criteria, then integrating public health surveillance capabilities into the SRS may be as simple as establishing an agreement with public health partners to share information about PHS alerts that might be related to drinking water contamination. However, in many cases, gaps will be identified. An example of a completed assessment is provided in **Table 4-4**.

Table 4-4. Example Assessment of Existing Public Health Surveillance Systems

Assessment Criteria	Contaminant Coverage (Rapid/Delayed Symptom Onset)	Spatial Coverage (Percent of Service Area)	Timeliness (Delay from Healthcare Seeking Behavior to Alert Generation)	Data Quality (Sufficient Case Details)
ED Visits	Rapid and delayed symptom onset	70%	Alert notifications are provided daily to health department	No case details provided in alert notifications
PCC Calls	Rapid symptom onset	100%	Alert notifications are not provided daily to health department	Alert details and underlying case details captured in NPDS
Healthcare Networks	Delayed symptom onset	80%	No standard procedure for reporting suspected water contamination	Underlying case details captured
Gap Analysis	No gap	No gap	Data from PCCs and healthcare networks are not reported same day	No ED case details in alert notifications

Strategy for Addressing Gaps in Public Health Surveillance Capabilities Relative to SRS Design Goals and Performance Objectives

Once the utility has characterized and assessed existing public health surveillance capabilities, a strategy should be developed with its public health partners to determine how gaps identified during the assessment can be addressed. The utility and public health partners should collaborate to identify and evaluate alternatives for addressing the gaps from a benefit-cost perspective. The resource *Framework for Comparing Alternatives for Water Quality Surveillance and Response Systems* can be used to compare viable and well-defined SRS design alternatives. For PHS, this resource could be used to compare the relative value and cost of viable enhancements, which might include modifications to existing public health surveillance systems or implementation of new systems. While the utility should be involved in developing this strategy, deference should be given to public health partners who will likely bear the majority of the cost and effort to implement and operate public health surveillance systems.

Potential methods for enhancing existing case-based surveillance techniques are described below:

- *Optimize mechanisms for reporting unusual incidents of disease within the utility's distribution system service area.* The health department may be able to optimize existing procedures for disease reporting from healthcare providers to improve the timeliness of reporting. For example, a procedure may be developed for direct reporting to the health department if a healthcare network or healthcare provider suspects that the cases they are seeing might be related to an emerging public health incident prior to laboratory confirmation. Similarly, a mechanism could be implemented for clinicians and microbiologists to report a significant increase in the volume of orders for analyses of clinical samples for a specific disease in advance of laboratory confirmation. To accomplish this enhancement, the health department could coordinate an outreach campaign to educate healthcare providers about proactively reporting cases that may indicate an emerging possible public health incident.
- *Train healthcare providers on indicators of drinking water contamination.* Public health partners can use the resource *Training for Healthcare Professionals on Indicators of Drinking Water Contamination* to increase knowledge among local healthcare professionals about indicators of water contamination. This training could be presented through established public health workgroups or forums. Most importantly, healthcare professionals should understand who to call and what to report if water contamination is suspected.

Potential methods for enhancing existing syndromic surveillance techniques are described below:

- *Add new syndromes to existing syndromic surveillance systems*. If the syndromes utilized by existing syndromic surveillance systems do not capture the broad range of possible symptoms related to water contamination, then new syndromes (Table 4-2) could be incorporated into existing systems.
- *Extract additional case details from a public health datastream already being monitored through syndromic surveillance*. The utility, health department, and PCC should consider whether the underlying case details available in syndromic surveillance systems would be adequate to support the investigation of water contamination as a potential cause of a PHS alert. If the desired details are not available, the data collection process could be modified, or the public health surveillance system could be updated to extract the missing information.

DEVELOPMENT OF A WATER SYNDROME

One public health partner supporting PHS developed a water syndrome, which was integrated into an existing syndromic surveillance system. The syndrome included a combination of gastrointestinal and respiratory chief complaints to capture a variety of symptoms that may be related to exposure to contaminated water.

- *Build stronger relationships with data providers*. To address issues with data reliability and completeness, the health department can work to increase the participation of data providers. If there is a gap in the timeliness of a syndromic surveillance system, business processes can be changed in order to expedite data uploads.
- *Increase the frequency of analysis by automated surveillance systems.* If data batches are received more frequently than once per day, the health department may consider increasing the analysis frequency of existing syndromic surveillance systems to increase the timeliness of detection.
- *Increase the number of data providers.* To increase spatial coverage, additional data providers that serve customers within the utility's service area could be identified and integrated into an existing syndromic surveillance system (e.g., 911 dispatch, EMS providers, EDs, pharmacy retailers).

When evaluating new systems to support PHS, it may be helpful to consider whether any systems currently in the process of being procured by the public health partners for other initiatives may serve the goals of PHS. Furthermore, public health partners should evaluate whether PHS capabilities could be incorporated during regular upgrades of existing systems to avoid cost associated with procuring a new system. A utility's public health partners will need to consider a variety of factors when evaluating whether to implement a new public health surveillance system. While CDC has developed extensive guidelines for evaluating public health surveillance systems (CDC, 2001), general considerations are presented below:

- Cost and level of effort required to implement and maintain the system
- Specialized skills or knowledge required to implement and maintain the system
- Prospect for reliable technical support over the life of the system
- Ability of frontline users to understand and utilize the system
- ***Information management*** requirements for the system
- Additional ***hardware*** and ***software*** required to implement the system
- Compatibility of the new system with existing systems
- Ability to incorporate new functionality to meet future requirements

Commonly used syndromic surveillance systems are described above in Table 4-3 and should be considered when evaluating new systems. If the health department decides to procure a new system for PHS, they may consider including detection of possible drinking water contamination as a justification for purchasing the new system in grant applications. Likewise, PCCs could incorporate goals related to detection of water contamination through staff training, development of new procedures, or development of water algorithms in NPDS in grant applications or funding request justifications.

INTEGRATING PHS DATA INTO AN SRS INFORMATION MANAGEMENT SYSTEM

Some utilities may elect to integrate one or more public health datastreams into their SRS information management system. Given constraints imposed by the Health Insurance Portability and Accountability Act, PHS alerts may be the only information that can be provided to the utility. While it can be useful for utility personnel to evaluate geospatial relationships between PHS alerts and utility data, utilities should consider potential limitations in the ability of their personnel to use and interpret public health data before deciding to implement this enhancement. However, if a utility decides to integrate some PHS data into their information management systems, they should clearly define requirements for doing so. Two potentially useful resources are:

- *Information Management Requirements Development Tool*
- *Dashboard Design Guidance for Water Quality Surveillance and Response Systems*

The example presented in Table 4-4 demonstrated gaps in an example public health surveillance capabilities assessment. **Table 4-5** below presents an example strategy for addressing those gaps.

Table 4-5. Example Strategy for Addressing Gaps in Public Health Surveillance Capabilities

Assessment Criteria	Gap Analysis	Planned Enhancement
Contaminant Coverage	No gap	Not applicable
Spatial Coverage	No gap	Not applicable
Timeliness	Data from PCCs and healthcare networks is not reported same day	• Health department will work with PCC to implement a procedure for reporting suspected water contamination within a day of symptom presentation • Health department will provide training to healthcare professionals on indicators of possible water contamination
Data Quality	No ED case details in alert notifications	Health department will evaluate which underlying case details could be captured and included in ED alert notifications

Section 5: Alert Investigation Procedure

Once the public health partners who will support PHS have been identified and the specific public health datastreams have been selected for inclusion in the SRS (as described in Sections 3 and 4), a PHS ***alert investigation procedure*** should be developed. The objective of this procedure is to guide the systematic investigation of a PHS alert in order to determine whether or not it may have been caused by contaminated water.

> **TARGET CAPABILITY**
>
> A procedure has been developed, documented, and put into practice to facilitate the timely and efficient investigation of a PHS alert to determine whether or not contaminated water is the likely cause of the alert. The procedure provides a clear and comprehensive sequence of steps for the investigation of alerts and assigns responsibilities for carrying out each of these steps. The procedure is supported by investigation tools, such as checklists. Personnel are trained on proper implementation of the procedure and tools.

This section describes considerations for developing a PHS alert investigation procedure and covers the following topics:

- Subsection 5.1 provides guidance on developing an effective alert investigation procedure
- Subsection 5.2 provides guidance on developing tools to support the investigation
- Subsection 5.3 provides guidance on preparing to implement the procedure as part of real-time monitoring

5.1 Developing an Effective Alert Investigation Procedure

This section describes a methodical process for developing a PHS alert investigation procedure. The steps of the process, listed below, are described in the following subsections.

- Define Potential Alert Causes: develop a discrete list of alert causes used to classify each alert
- Establish an Alert Investigation Process: develop a detailed, sequential listing of steps for investigating alerts
- Assign Roles and Responsibilities: establish a listing of all personnel who have a role in alert investigations and a summary of their responsibilities

The *PHS Alert Investigation Procedure Template* includes an editable table, process flow diagram, and checklist that can be used to document the utility's role during a PHS alert investigation. The template can be opened in Word by clicking the icon in the callout box.

> This template can be used to develop a PHS alert investigation procedure.

Define Potential Alert Causes

The objective of the alert investigation process is to identify the cause of an alert. At the highest level, alerts should be categorized as invalid or valid. While the utility will need to manage and categorize ***invalid alerts*** for the other SRS surveillance components, PHS alerts are initially reviewed by public health partners and invalid alerts should not be passed on to the utility ***SRS Manager***. Thus, from the utility's perspective, only valid PHS alerts need to be investigated.

Valid alerts for PHS are defined as alerts attributable to a public health incident that might be due to contaminated water. Once a utility is notified of a valid PHS alert, they should work with their public health partner to identify the potential cause of the alert. **Table 5-1** lists and describes three potential causes of valid PHS alerts, including the possibility that the PHS alert, while valid, was not caused by contaminated water.

Table 5-1. Example Causes of PHS Valid Alerts

Alert Cause	Description
Unrelated to Drinking Water Quality	Even though a public health partner cannot initially rule out drinking water contamination, the joint investigation by a utility and its public health partners may subsequently rule out drinking water contamination as the cause of the public health incident.
Premise Plumbing Issue	Improper installation or repair of premise plumbing systems, such as an accidental cross-connection with a non-potable source, can result in contamination of the water supply for a building of complex. However, the contaminated water would be contained within the premise plumbing system and would not be a distribution system problem.
Possible Contamination	Accidental or intentional introduction of a contaminant into the distribution system that is causing illness in exposed customers.

Establish an Alert Investigation Process

With potential causes of a valid PHS alert defined, the next step is to develop an alert investigation process to guide investigators through a detailed sequence of steps in order to determine the cause of the alert. In general, the process begins with notification from a public health partner of a valid PHS alert and ends with a determination regarding whether or not water contamination is possible. The steps in between involve a review of available information to investigate potential causes of the alert. The alert investigation process is generally structured to consider the most likely causes first, allowing contamination to be quickly ruled out for the majority of alerts. However, if the cause of the alert cannot be determined through this review, the process concludes with the determination that contamination is possible.

> **HELPFUL HINT**
>
> An alert investigation procedure can be used to identify the information resources accessed during an investigation, which can be useful for developing information management requirements.

The type of information typically documented in an alert investigation process includes:

- Detailed instructions for completing the step
- The name and role of specific individual(s) responsible for completing the step
- Information resources that should be consulted during the step
- Actions that should be taken, including personnel who should be notified, upon completion of the step

When establishing the alert investigation process, the utility should work with its public health partners to understand the PHS alert information that will be provided to the utility SRS Manager (e.g., symptoms, demographics, and location of cases), which may vary with different public health surveillance systems. Some of this information may have been documented during the evaluation of existing public health surveillance systems, as described in Section 4.3. During the development of the process, the utility should also inform its public health partners about the information the utility would review during a PHS alert investigation, such as data from other SRS components and results from ***Sampling and Analysis***.

The alert investigation process can be visually depicted in a diagram that shows the progression of steps through the entire process. This simplified representation of the alert investigation process allows individuals with responsibilities for discrete steps to see how their activities support the overall investigation.

Figure 5-1 provides an example of a PHS alert investigation process flow diagram. The major steps and decision points are shown in the flowchart on the left side of the figure, and additional detail on the actions implemented is shown to the right. Steps taken by the public health partner are shown in green and steps taken by the utility are shown in blue. In general, public health partners are responsible for determining if a PHS alert is valid and indicative of a possible public health incident. As public health partners continue the investigation, they consider whether or not contaminated water might be the cause of the public health incident. If drinking water contamination cannot be ruled out, the public health partner notifies the utility and a joint investigation follows. The utility's role in the investigation is to conduct a targeted review of relevant utility data to determine if there are indicators that contaminated water may be the cause of the alert. The utility investigation should be guided by information provided by the public health partner, such as the location and time of suspected exposures to the contaminant.

HELPFUL HINT

During the investigation, public health professionals may be able to use water utility data or public health case details to tentatively identify a contaminant or contaminant class, which can inform other investigation activities, such as selecting target analytes for analysis of water samples.

If the utility and public health partners jointly conclude that water contamination is not the cause of the PHS alert, the investigation is closed. However, if contamination cannot be ruled out as the cause of the PHS alert, ***Consequence Management*** activities would be initiated and the investigation continued to determine if contamination is ***credible***.

A range of estimated times for properly trained personnel to complete steps in the investigation is shown to the left of the flowchart in Figure 5-1. These times are based on experience at utilities that have implemented PHS (EPA, 2014). The total time for utility personnel to complete a PHS alert investigation could range from 11 to 105 minutes, depending on the number of steps in the investigation process that need to be completed before a conclusion can be reached regarding whether or not contamination is possible.

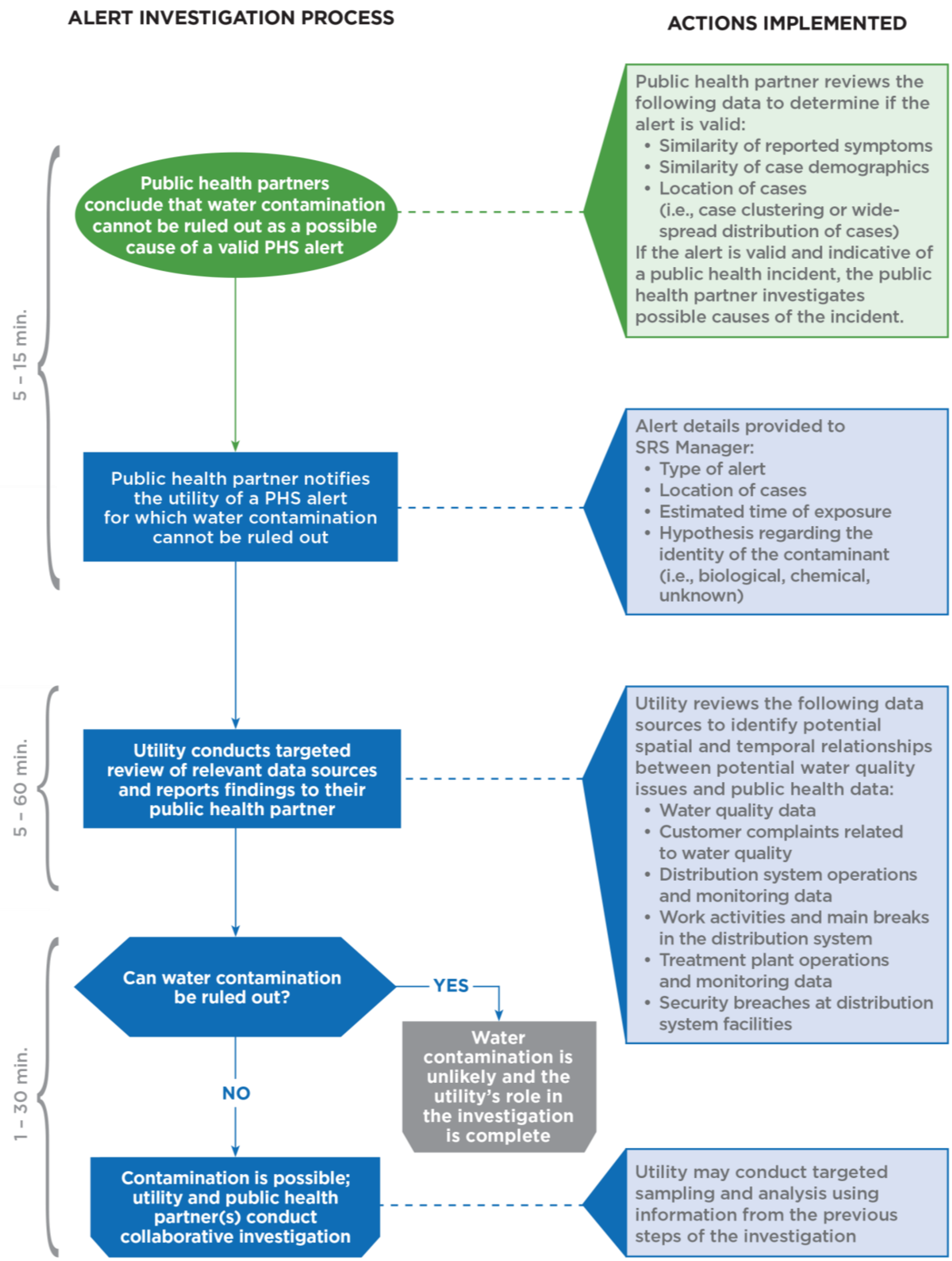

Figure 5-1. Example Alert Investigation Process Flow Diagram for Valid PHS Alerts

Assign Roles and Responsibilities

Table 5-2 lists public health partners and utility personnel who may have a role during the investigation of a PHS alert and describes their potential responsibilities. Utility personnel would only be engaged in the investigation if public health partners could not rule out contaminated water as a potential cause of a valid alert.

Table 5-2. Example of Generic Roles and Responsibilities for PHS Alert Investigations

Role	Alert Investigation Responsibilities
Primary Public Health Partner[1]	• Receives initial notification of PHS alerts • Performs an initial investigation to determine if a PHS alert is valid • Evaluates contaminated drinking water as a potential cause of a PHS alert and contacts the drinking water utility if water contamination cannot be ruled out • Collaborates with the utility during the investigation of possible water contamination incidents
Public Health Data Provider[2]	• Provides detailed case information to primary public health partners during the investigation of a PHS alert • Investigates additional information from the public health datastream managed by the data provider, which may not have been captured in the PHS alert
Utility SRS Manager[3]	• Receives notification from primary public health partners in the event of a valid PHS alert potentially related to contaminated drinking water • Coordinates utility-lead aspects of a PHS alert investigation • Communicates the results of a utility investigation to primary public health partners • Collaborates with primary public health partners to determine whether or not drinking water contamination is possible • Activates Consequence Management • Continues the investigation of the possible water contamination incident in collaboration with primary public health partners
Utility Water Quality Manager	• Reviews data from online water quality sensors and the results from analysis of grab samples collected in the vicinity of cases associated with a PHS alert
Utility Customer Service Manager	• Reviews customer ***water quality complaints*** in the vicinity of cases associated with a PHS alert
Utility Security Manager	• Reviews security records for incidents of unauthorized access to utility facilities that serve the area in which cases associated with a PHS alert are located
Utility Distribution System Manager	• Reviews distribution system work activities and equipment failures that could have impacted water quality in the vicinity of cases associated with a PHS alert
Utility Operator	• Reviews system operating conditions that could have impacted water quality in the vicinity of cases associated with a PHS alert

[1] Includes partners with primary responsibility for monitoring public health, such as health departments (including epidemiologists, environmental health specialists, and laboratorians) and PCCs

[2] Includes entities that manage public health datastreams monitored through PHS, such as 911 call centers, EMS dispatch centers, hospitals, healthcare professionals, and pharmacies

[3] Some utilities may choose to delegate alert investigation responsibilities listed in the table for the SRS Manager to other personnel with sufficient authority and training to perform the tasks

Arrangements should also be made to provide coverage of alert investigation responsibilities at all times, through approaches such as:

- Training personnel from all shifts on the alert investigation procedure
- Assigning backup personnel for each activity in the case that the primary investigator is unavailable
- Cross-training investigators on multiple roles

- Assigning personnel to be on call for critical investigation functions, particularly those requiring a decision about the possibility of water contamination

5.2 Developing Investigation Tools

While the detailed alert investigation procedure described in Section 5.1 is necessary, the detailed documentation of this procedure is generally not used during real-time alert investigations. This section describes tools that can be developed to assist investigators in efficiently carrying out their responsibilities. The investigation tools that will be discussed in this section include:

- Checklists
- Record of Alert Investigations
- Quick Reference Guides

Checklists

Alert investigation checklists are job aids that guide personnel through their investigative responsibilities and document investigation findings. Checklists can help to ensure consistency among investigators, verify that all activities are completed, and reduce the time required to conduct alert investigations. They generally list the activities assigned to specific roles, and thus more than one checklist may be developed to support the PHS alert investigation procedure.

HELPFUL HINT

Public health partners will have their own tools and methods for documenting their investigation of a PHS alert, and would generally not need a new checklist specific to their role in an SRS.

A checklist should be streamlined, concise, and intuitive to use for personnel trained on the procedure. It should guide personnel through the steps of the investigation and provide space for them to record important information for each activity completed. In some cases, it may be sufficient to simply check a box indicating completion of an activity. In others, the investigator may need to record a time or provide more details on a particular conclusion or investigative activity. An editable *PHS Alert Investigation Checklist* can be opened by clicking the icon in the callout box.

This template includes an editable alert investigation checklist.

Record of Alert Investigations

A record of alert investigations provides documentation of key information, including the actions implemented during the investigation as well as the likely cause of the alert. This record can also serve as a resource during investigation of future alerts.

There are a variety of ways to document alert investigations. For example, a simple solution uses a spreadsheet maintained on a shared drive that can be accessed by all investigators as well as the SRS Manager. Use of an electronic tool, such as a spreadsheet, can facilitate standardization of data entry through use of defined lists and data entry masks. **Figure 5-2** provides an example record that shows useful fields to capture.

Component	Alert Date/Time	Alert Location	Investigator	Investigation Start Date/Time	Investigation End Date/Time	Conclusion	Notes
PHS	5/10/2015 11:15	Central Business District	Morgan Wisecarver	5/10/2015 11:20	5/10/2015 11:48	Valid alert: unrelated to drinking water quality	No abnormalities in utility data.
PHS	7/14/2015 13:22	Washington Heights	John Webber	7/14/2015 13:25	7/14/2015 13:57	Valid alert: unrelated to drinking water quality	No abnormalities in utility data.
PHS	8/27/2015 6:27	Morgan	Kim Sullivan	8/27/2015 6:35	8/27/2015 8:43	Cause identified: premise plumbing issue	Cross-connection during AC installation resulted in minor illness.
PHS	10/29/2015 7:13	West Side	Dave Collins	10/29/2015 7:18	10/29/2015 7:46	Valid alert: unrelated to drinking water quality	No abnormalities in utility data.

Figure 5-2. Example Alert Investigation Record

If a ***dashboard*** will be used to support the SRS, electronic alert investigation tracking may be incorporated into the design. For example, electronic checklists can be developed and the information entered can automatically be saved in a database, facilitating further analysis and use of the records. See *Dashboard Design Guidance for Water Quality Surveillance and Response System* for more information on this option.

Quick Reference Guides

While many alert investigation activities become second nature to investigators, additional tools may be useful for guiding investigators through complex or less frequently implemented tasks. Development of quick reference guides, in which key information is concisely summarized in an easily-accessible form such as a factsheet, ensure investigators can quickly and easily get the information they need. Examples of quick reference guides that can be useful for PHS include:

- A list of contact information for all utility personnel and public health partners who may need to be contacted during an alert investigation.
- A list of lag times between exposure and onset of symptoms for a variety of contaminants. The list would guide utility personnel in identifying the time period to target for their data review based on definitive or presumptive identification of the contaminant by a public health partner.
- A list of sampling locations organized by zip code. This is useful if spatial information from public health partners is limited to zip codes.
- Other SRS component alert investigation tools.

5.3 Preparing for Real-time Alert Investigations

This section describes a suggested process for putting the PHS alert investigation procedure into practice. The benefits of PHS can be fully realized only if PHS alerts are investigated in real time and responded to appropriately. The following topics are covered under this section:

- Training
- Preliminary operation
- Real-time operation

Training

Proper training on the alert investigation procedure ensures that all utility personnel with a role in the investigation of PHS alerts are aware of their responsibilities and have the knowledge and expertise needed to implement those responsibilities. It is suggested that training on the alert investigation procedure include the following:

- An overview of the purpose and design of the PHS component, including a description of the datastreams monitored by public health partners
- A description of the public health partners and their role in PHS

- A detailed description of the alert investigation procedure and the role of each participant
- A review of checklists, quick reference guides, information management systems, and other tools available to support PHS alert investigations
- Instructions for using the record of alert investigations, both for entering new records and retrieving previous records to support new alert investigations

Section 6 of *Guidance for Developing Integrated Water Quality Surveillance and Response Systems* provides guidance on implementing a training and exercise program. In general, classroom training is used first to orient personnel to the procedure and their responsibilities during PHS alert investigations. Once they are comfortable with the procedure, drills and exercises give them the opportunity to practice implementing their responsibilities in a controlled environment. The SRS *Exercise Development Toolbox* is an interactive software program designed to help utilities design, conduct, and evaluate exercises specific to PHS and the other SRS components.

Preliminary Operation

A period of ***preliminary operation*** should follow initial training, allowing utility personnel to practice their responsibilities in test mode before the transition to real-time operation. For example, personnel can be asked to investigate alerts in batches as they have time, not necessarily as the alerts are generated. During this period, investigators may or may not receive alert notifications such as emails or text messages.

> **HELPFUL HINT**
>
> Do not rush preliminary operation of the PHS component. This period provides an opportunity for personnel to practice their responsibilities and learn the resources used during investigations, thus improving the efficiency of alert investigations.

One approach to conducting alert investigations during preliminary operation is to hold regular meetings with all utility personnel and public health partners with a role in the process. The group process facilitates sharing of information and ideas about the steps taken to evaluate whether or not a PHS alert is potentially related to contaminated water. Inclusion of both utility personnel and public health partners in this process allows each to gain insight into the other's role in the process. Furthermore, these joint meetings can help to maintain effective communication and coordination between the utility and its public health partners (see Section 3). Meeting monthly during the period of preliminary operation is appropriate and sufficient for most PHS applications.

During real-time operation, it is expected that the number of PHS alerts that require a utility investigation will be small, possibly fewer than one per year. Thus, additional PHS alerts, including those that normally would not be passed on to the utility, should be investigated by both the utility and its public health partners during preliminary operations. This provides personnel with additional opportunities to practice conducting alert investigations and strengthens the utility-public health partnership.

Real-time Operation

During real-time operation, PHS alerts are investigated as they are generated, and Consequence Management is activated if drinking water contamination is considered possible. The transition from preliminary operation to real-time operation should be clearly communicated to all utility personnel and public health partners with a role in PHS alert investigations. This includes establishing a date for the transition as well as providing expectations for how alert investigations will be performed and documented.

To sustain real-time operation, the alert investigation procedure should be integrated into existing job functions and responsibilities to the extent possible. Sufficient time must be allocated for personnel to investigate PHS alerts as they are generated. Public health partners take on the primary responsibility for receiving PHS alerts and performing the initial investigation, and in many cases already receive and review these alerts as part of their core job responsibilities. Utility personnel are involved in the investigation only if contaminated water cannot be ruled out as a possible cause of the PHS alert. In most cases, this will be a small fraction of the total number of PHS alerts generated. Furthermore, the actions taken by a utility to investigate contaminated water as a potential cause of a PHS alert can typically be completed in under an hour. Thus, the overall time commitment of utility personnel to support PHS alert investigations is minimal outside of a contamination incident.

Maintenance of the alert investigation procedure during real-time operation may involve periodic review of the procedure to verify that it is working as intended. Furthermore, the alert investigation record should be reviewed to ensure that the procedure is being correctly implemented. Because PHS alerts requiring utility investigation may be infrequent, refresher training may be needed to maintain proficiency. Finally, it is important to thoroughly train new staff on their responsibilities for supporting the investigation of PHS alerts that may be related to contaminated water.

HELPFUL HINT

Routine updates to the alert investigation procedure and tools are necessary to maintain their usefulness. Recommendations for procedure maintenance include:

- Designate one or more individuals with responsibility for maintaining alert investigation materials
- Establish a review schedule (annual review should suffice in most cases)
- Review the record of alert investigations, conduct tabletop exercises, and solicit feedback from investigators to identify necessary updates
- Establish a protocol for submission and tracking of change requests

Section 6: Preliminary PHS Design

The information presented in the previous sections of this document can guide development of a preliminary PHS design that supports a utility's design goals and performance objectives. If PHS will be a component in a multi-component SRS, the design of the integrated system will likely be guided by a project management team. In this case, guidelines for design of the individual components should be provided to the component implementation teams, and should include:

- Overarching design goals and performance objectives for the SRS
- Existing resources that could be leveraged to implement the SRS components, including personnel, procedures, equipment, and information management systems
- Project constraints, such as budget ceilings, schedule milestones, and policy restrictions
- Instructions or specific guidelines for the development of preliminary component designs

It is also useful to develop a preliminary PHS alert investigation procedure prior to developing a preliminary PHS design. Information is this procedure can inform various aspects of the design, such as information management requirements.

This template can be used to develop the preliminary PHS design.

Regardless of whether PHS will be developed as a stand-alone component or as part of a multi-component SRS, the preliminary PHS design should be documented in sufficient detail to assess whether or not it can achieve the design goals established for the component within project constraints. A *Preliminary PHS Design Template* can be opened and edited in Word by clicking the icon in the callout box. This template covers the following aspects of PHS design:

- Component implementation team: Identify personnel from the utility and public health partner organizations that will have a role in the design and implementation of PHS. Document the role, responsibilities, and estimated time commitment of each team member.
- Design goals and performance objectives: Use the overarching design goals and performance objectives established for the SRS to develop goals and performance objectives for PHS to guide the process of designing the PHS component.
- Public health surveillance systems: Identify all case-based and syndromic surveillance systems that will be used to monitor for customer exposure to waterborne contaminants. If existing systems will be enhanced, describe the enhancements. If new systems will be deployed, provide specifications, including the datastreams that will be monitored. Specifications for enhancements should be worked out with public health partner and agreed to before a preliminary design is developed.
- Preliminary information management requirements: Identify all information management systems that would be used during operation of PHS. This will likely include utility systems that will be accessed during the investigation of PHS alerts as well as systems operated and maintained by public health partners. Develop an information flow diagram depicting user-to-machine and machine-to-machine interactions. Document requirements for any new or modified information management systems. Note any data sharing agreements that will need to be established in order to implement the information management ***solution***.
- Initial training requirements: Develop a training plan to educate personnel about their responsibilities during operation of PHS.
- Budget: Develop a line item budget for the PHS component noting the entity responsible for covering the cost of each line item. Any cost sharing between the utility and public health

partners should be noted. It is recommended that the budget include implementation as well as operation and maintenance costs, which can be used to develop a ***lifecycle cost*** estimate. The budget should indicate the year in which each cost is incurred. Contingencies should be included to avoid cost overruns.

- Schedule: Develop a schedule that shows the planned sequencing of activities as well as any key dependencies. The schedule may reflect a phased implementation over multiple years, which may be advantageous or necessary to overcome resource (financial or personnel) limitations. The schedule should be developed in collaboration with, or at least reviewed by, any public health partners that will have a substantial role in implementing PHS.

In some cases, multiple design alternatives may emerge. A ***benefit-cost analysis*** should be performed to identify the preferred option. The resource *Framework for Comparing Alternative Water Quality Surveillance and Response Systems* provides an objective process for comparing design alternatives with respect to their lifecycle costs and capability.

Resources

Overview of PHS Design

Water Quality Surveillance and Response System Primer

http://www.epa.gov/sites/production/files/2015-06/documents/water_quality_sureveillance_and_response_system_primer.pdf

This document provides an overview of SRSs for drinking water distribution systems. It defines the components of an SRS, describes common design goals and performance objectives for an SRS, and provides an overview of the approach for implementing an SRS. EPA 817-B-15-002, May 2015.

Public Health Surveillance Primer

http://www.epa.gov/sites/production/files/2015-06/documents/public_health_surveillance.pdf

This document provides an overview of the PHS component and presents information about the goals and objectives of PHS in the context of an SRS. EPA 817-B-15-0002D, May 2015.

Partnership with Public Health

American Association of Poison Control Centers

http://www.aapcc.org/

This website provides information about PCCs in the U.S. including the poison help line, the latest poison news, and information about the NPDS. A search field is also provided which can be used to locate local PCCs.

Association of Public Health Laboratories

http://www.aphl.org/Pages/default.aspx

The Association of Public Health Laboratories (APHL) is an organization that works to strengthen laboratories serving the public's health in the U.S. and globally. APHL represents state and local governmental health laboratories in the U.S. Its members, known as public health laboratories, monitor and detect health threats to protect the health and safety of Americans.

Council of State and Territorial Epidemiologists

http://www.cste.org/

The Council of State and Territorial Epidemiologists is an organization of member states and territories representing public health epidemiologists. The Council works to establish more effective relationships among state and other health agencies. It also provides technical advice and assistance to partner organizations and to federal public health agencies such as CDC.

National Association of County and City Health Officials

http://www.naccho.org/

The National Association of County and City Health Officials is an organization which represents the nation's 2,800 local health departments. The Association works in many areas of public health, including public health preparedness, environmental health, community health, and public health infrastructure and systems.

National Environmental Health Association

http://www.neha.org/

The National Environmental Health Association is an organization composed of 5,000 members that has established a standard, known as the Registered Environmental Health Specialist or Registered Sanitarian credential, which signifies that an environmental health professional has mastered a body of knowledge, and has acquired sufficient experience, to satisfactorily perform work responsibilities in the environmental health field.

Public Health Surveillance Kickoff Meeting Template (PowerPoint File)

Click this link to open the presentation template

This customizable presentation template allows utilities to prepare for a kickoff meeting when designing the PHS component with public health partners, such as the health department and PCC. July 2016.

Public Health Surveillance Systems

Public Health Surveillance Assessment: Interview with Public Health Partners

Click this link to open the assessment form

This fillable form allows utilities to conduct an assessment of public health surveillance systems. It includes prompt questions to guide discussions with public health partners responsible for monitoring available public health datastreams, such as epidemiologists at health departments and toxicologists at PCCs. EPA 817-B-15-001, January 2015.

Framework for Comparing Alternatives for Water Quality Surveillance and Response Systems

http://www.epa.gov/sites/production/files/2015-07/documents/framework_for_comparing_alternatives_for_water_quality_surveillance_and_response_systems.pdf

This document provides guidance for selecting the most appropriate SRS design from a set of viable alternatives. It guides the user through an objective, stepwise analysis for ranking multiple alternatives and describes, in general terms, the types of information necessary to compare the alternatives. EPA 817-B-15-003, June 2015.

Training for Healthcare Professionals on Indicators of Drinking Water Contamination

https://www.epa.gov/waterqualitysurveillance/public-health-surveillance-resources

This training module describes how public health professionals can identify signs of drinking water contamination when performing their routine job functions. It also describes the manner in which drinking water and public health professionals can work together to investigate a possible drinking water contamination incident. September 2016.

Information Management Requirements Development Tool

http://www.epa.gov/waterqualitysurveillance/surveillance-and-response-system-resources

This tool is intended to help users develop requirements for an SRS information management system to inform the selection and implementation of an information management solution. Specifically, this tool (1) assists SRS component teams with development of component functional requirements, (2) assists IT personnel with development of technical requirements, and (3) allows the IT design team to efficiently consolidate and review all requirements. EPA 817-B-15-004, October 2015.

Dashboard Design Guidance for Water Quality Surveillance and Response Systems

http://www.epa.gov/sites/production/files/2015-12/documents/srs_dashboard_guidance_112015.pdf

A dashboard is a visually-oriented user interface that integrates data from multiple SRS components to provide a holistic view of distribution system water quality. This document provides information about useful features and functions that can be incorporated into an SRS dashboard. It also provides example interface designs. EPA 817-B-15-007, November 2015.

Alert Investigation Procedure

Alert Investigation Procedure Template (Word File)

Click this link to open the template

The alert investigation procedure template includes an editable table, flow diagram, and checklist that can be used to document the utility's role in a PHS alert investigation process. July 2016.

Alert Investigation Checklist (Word File)

Click this link to open the template

The alert investigation checklist can be used to document the utility's role in a PHS alert investigation. July 2016.

Guidance for Developing Integrated Water Quality Surveillance and Response Systems

http://www.epa.gov/sites/production/files/2015-12/documents/guidance_for_developing_integrated_wq_srss_110415.pdf

This document provides guidance for applying system engineering principles to the design and implementation of an SRS to ensure that the SRS functions as an integrated whole and is designed to effectively perform its intended function. Section 6 provides guidance on developing a training and exercise program to support SRS operations. EPA 817-B-15-006, October 2015.

SRS Exercise Development Toolbox

https://www.epa.gov/waterqualitysurveillance/water-quality-surveillance-and-response-system-exercise-development-toolbox

The Exercise Development Toolbox helps utilities and response partner agencies to design, conduct, and evaluate SRS-related exercises. These exercises can be used to develop and refine SRS procedures, and train personnel in the proper implementation of those procedures. The toolbox guides users through the process of learning about SRS training programs, developing realistic scenarios, designing SRS discussion-based and operations-based exercises, and creating exercise documents. March 2016.

Preliminary PHS Design

Preliminary PHS Design Template (Word File)

Click this link to open the template

This Word template can be used to document aspects of PHS component design, such as: the component implementation team, design goals and performance objectives, public health surveillance systems, preliminary information management requirements, initial training requirements, budget, and schedule. July 2016.

References

American Association of Poison Control Centers. (2016). National Poison Data System. Retrieved from http://www.aapcc.org/data-system/

Angulo, F. J., Tippen, S., Sharp, D. J., Payne, B. J., Collier, C., Hill, J. E., Swerdlow, D. L. (1997). A community waterborne outbreak of salmonellosis and the effectiveness of a boil water order. *American Journal of Public Health*, 87 (4): 580–584.

Berg R. (2009). The Alamosa *Salmonella* Outbreak: A Gumshoe Investigation. *Journal of Environmental Health*, 71 (2): 54-55.

Berger, M., Shiau, R., and Weintraub, J. (2006). Review of syndromic surveillance: implications for waterborne disease detection. *Journal of Epidemiological Community Health*, 60(6): 543–550.

CDC. (2001). Updated Guidelines for Evaluating Public Health Surveillance Systems. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm

CDC. (2004). Comparison of Office Visit and Nurse Advice Hotline Data for Syndromic Surveillance - Baltimore-Washington, D.C., Metropolitan Area, 2002. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/su5301a23.htm

CDC. (2005). Using the National Poison Data System for Public Health Surveillance. Retrieved from http://www.cdc.gov/nceh/hsb/chemicals/pdfs/npds.pdf

CDC. (2012). Meaningful Use. Retrieved from http://www.cdc.gov/ehrmeaningfuluse/introduction.html

CDC. (2015). National Notifiable Diseases Surveillance System (NNDSS). Retrieved from https://wwwn.cdc.gov/nndss/data-collection.html

CDC. (2016a). Poison Center and Public Health Collaborations Community of Practice (CoP). Retrieved from http://www.cdc.gov/nceh/hsb/chemicals/poison_center.htm

CDC. (2016b). National Syndromic Surveillance Program: BioSense Platform. Retrieved from http://www.cdc.gov/nssp/biosense/index.html

CDC. (2016c). PulseNet: Outbreak detection. Retrieved from http://www.cdc.gov/pulsenet/outbreak-detection/index.html

Colvin, J. (2016, May 16). Email communication.

Council of State and Territorial Epidemiologists (CSTE), et al. (2013). Use of Poison Center Data Assessment Report 2012. Retrieved from http://c.ymcdn.com/sites/www.cste.org/resource/resmgr/environmentalhealth/poisonassessmentreport2012.pdf

EPA. (2012). Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE) Water Security Module. 600-R-12-735. Washington, D.C.

EPA. (2014). Water Security Initiative: Evaluation of the Public Health Surveillance Component of the Cincinnati Contamination Warning System Pilot. Retrieved from http://www.epa.gov/sites/production/files/2015-06/documents/wsi_evaluation_of_the_public_health_surveillance_component_of_the_cincinnati_contamination_warning_system_pilot.pdf

Fernandes, T. M. A., Schout, C., De Roda Husman, A. M., Eilander, A., Vennema, H., and van Duynhoven, Y. T. H. P. (2007). Gastroenteritis associated with accidental contamination of drinking water with partially treated water. *Epidemiology and Infection*, 135(5): 818–826.

Fong, T.-T., Mansfield, L. S., Wilson, D. L., Schwab, D. J., Molloy, S. L., and Rose, J. B. (2007). Massive Microbiological Groundwater Contamination Associated with a Waterborne Outbreak in Lake Erie, South Bass Island, Ohio. *Environmental Health Perspectives*, 115(6): 856–864.

Greenko, J., Mostashari, F., Fine, A., and Layton, M. (2003). Clinical Evaluation of the Emergency Medical Services (EMS) Ambulance Dispatch-Based Syndromic Surveillance System, New York City. *Journal of Urban Health,* 80 (2): i50-i56.

Haas, A., Gibbons, D., Dangel, C., Allgeier, C. (2011). Automated surveillance of 911 data for detection of possible water contamination. *Int. Jour. Health Geographics,* 10(22).

Health Monitoring Systems. (2016). EpiCenter. Retrieved from https://www.hmsinc.com/service/epicenter.html

Hirshon, J.M. (2000). The Rationale for Developing Public Health Surveillance Systems Based on Emergency Department Data. *Academic Emergency Medicine*, 7(12):1428-32.

HHS. (2016). Office-based Physician Electronic Health Record Adoption: 2004-2014. Retrieved from http://dashboard.healthit.gov/quickstats/pages/physician-ehr-adoption-trends.php

Johns Hopkins Applied Physics Laboratory. (2016). Electronic Surveillance System for the Early Notification of Community based Epidemics. Retrieved from http://www.jhuapl.edu/sages/tools.html

Nygård, K., Schimmer, B., Søbstad, Ø., Walde, A., Tveit, I., Langeland, N., Hausken, T., and Aavitsland, P. (2006). A large community outbreak of waterborne giardiasis- delayed detection in a non-endemic urban area. *BMC Public Health*, 6, 141.

Nurse Advice New Mexico. (2016). Syndromic Surveillance. Retrieved from http://www.nurseadvice.org/what-we-do/syndromic-surveillance/

Pivette, M., Mueller, J. E., Crépey, P., and Bar-Hen, A. (2014). Drug sales data analysis for outbreak detection of infectious diseases: a systematic literature review. *BMC Infectious Diseases*, 14: 604.

Preparedness Summit. (2015). NurseAdvice New Mexico: A Case Study Analysis. Retrieved from http://www.eventscribe.com/2015/NACCHOSummit/assets/pdf/175305.pdf

University of Pittsburgh. (2016a). How to Obtain Access to the NRDM. Retrieved from https://www.rods.pitt.edu/site/content/view/22/42/

University of Pittsburgh. (2016b). Real-Time Outbreak and Disease Surveillance. Retrieved from https://www.rods.pitt.edu/site/content/category/8/22/36/

Uscher-Pines, L., Farrell, C. L., Cattani, J., Hsieh, Y. H. Moskal, M. D., Babin, S. M., Gaydos, C. A., Rothman, R.E. (2009). A survey of usage protocols of syndromic surveillance systems by state public health departments in the United States. *J Public Health Manag Pract*, 15(5): 432-8.

Yih, W. K., Deshpande, S., Fuller, C., Heisey-Grove, D., Hsu, J., Kruskal, B. A., Kuldorff, M., Leach, M., Nordin, J., Patton-Levine, J., Puga, E., Sherwood, E., Shui, I., and Platt, R. (2010). Evaluating Real-Time Syndromic Surveillance Signals from Ambulatory Care Data in Four States. *Public Health Reports*, 125(1): 111–120.

Glossary

alert. An indication from an SRS surveillance component that an anomaly has been detected in a datastream monitored by that component. Alerts may be visual or audible, and may initiate automatic notifications such as pager, text, or email messages.

alert investigation. The process of investigating the validity and potential causes of an alert generated by an SRS surveillance component.

alert investigation checklist. A form that lists a sequence of steps to follow when investigating an SRS alert. This form ensures consistency with an alert investigation procedure and provides documentation of each investigation.

alert investigation procedure. A documented process that guides the investigation of an SRS alert. A typical procedure defines roles and responsibilities for alert investigations, includes an investigation process diagram, and provides one or more checklists to guide investigators through their role in the process.

anomaly. A deviation from an established baseline in a monitored datastream. Detection of an anomaly by an SRS surveillance component generates an alert.

anomaly detection system. A data analysis tool designed to detect deviations from an established baseline. An anomaly detection system may take a variety of forms, ranging from complex computer algorithms to a simple set of heuristics that are manually implemented.

benefit. An outcome associated with the implementation and operation of an SRS that promotes the welfare of a utility and the community it serves. Benefits can be derived from a reduction in the consequences of a contamination incident and from improvements to routine utility operations.

benefit-cost analysis. An evaluation of the benefits and costs of a project or program, such as an SRS, to assess whether the investment is justifiable considering both financial and qualitative factors.

case-based surveillance. A form of public health surveillance in which frontline healthcare providers detect potential public health incidents through the cumulative assessment of case details or case volume.

clinical laboratory testing. Analysis of clinical specimens performed by laboratories to identify the agent that caused a disease or illness.

component. One of the primary functional areas of an SRS. There are four surveillance components: Online Water Quality Monitoring; Enhanced Security Monitoring; Customer Complaint Surveillance; and Public Health Surveillance. There are two response components: Consequence Management and Sampling and Analysis.

component team. A designated group of individuals responsible for design and implementation of an SRS component.

confirmed. In the context of the threat level determination process, contamination is confirmed when the analysis of all available information provides definitive, or nearly definitive, evidence of the presence of a specific contaminant or contaminant class in a distribution system. While positive results from laboratory analysis of a sample collected from a distribution system can be a basis for confirming contamination, a preponderance of evidence, without the benefit of laboratory results, can lead to this same determination.

consequence. An adverse public health or economic impact resulting from a contamination incident.

Consequence Management. One of the response components of an SRS. This component encompasses actions taken to plan for and respond to possible drinking water contamination incidents in order to minimize the response and recovery timeframe, and ultimately minimize consequences to a utility and its customers.

constraints. Requirements or limitations that may impact the viability of an alternative. The primary constraints for an SRS project are typically schedule, budget, and policy issues (for example, zoning restrictions, IT restrictions, and union prohibitions).

contamination incident. The presence of a contaminant in a drinking water distribution system that has the potential to cause harm to a utility or the community served by the utility. Contamination incidents may have natural (e.g., toxins produced by a source water algal bloom), accidental (e.g., chemicals introduced through an accidental cross-connection), or intentional (e.g., purposeful injection of a contaminant at a fire hydrant) causes.

credible. In the context of the threat level determination process, a contamination incident is characterized as credible if information collected during the investigation of possible contamination corroborates information from a validated SRS alert.

Customer Complaint Surveillance (CCS). One of the surveillance components of an SRS. CCS monitors water quality complaint data in call or work management systems and identifies abnormally high volumes or spatial clustering of complaints that may be indicative of a contamination incident.

dashboard. A visually-oriented user interface that integrates data from multiple SRS components to provide a holistic view of distribution system water quality. The integrated display of information in a dashboard allows for more efficient and effective management of distribution system water quality and the timely investigation of water quality anomalies.

data analysis. The process of analyzing data to support routine system operation, rapid identification of water quality anomalies, and generation of alert notifications.

design elements. The functional areas which comprise each component of an SRS. In some cases design elements are divided into design sub-elements. In general, the information presented in SRS guidance and products is organized by design elements and sub-elements.

design goal. The specific benefits to be realized through deployment of an SRS and each of its components. A fundamental design goal of an SRS is detecting and responding to drinking water contamination incidents. Additional design goals for an SRS are established by a utility and often include benefits to routine utility operations.

Enhanced Security Monitoring (ESM). One of the surveillance components of an SRS. ESM includes the equipment and procedures used to detect and respond to security breaches at distribution system facilities that are vulnerable to contamination.

functional requirement. A type of information management requirement that defines key features and attributes of an information management system that are visible to the end user. Examples of functional requirements include the manner in which data is accessed, types of tables and plots that can be produced through the user interface, the manner in which component alerts are transmitted to investigators, and the ability to generate custom reports.

hardware. A physical IT assets such as servers or user workstations.

healthcare professional. Physicians, physicians' assistants, nurses, nurse practitioners, and EMS technicians who conduct medical assessments of ill or injured patients seeking diagnosis and treatment.

information management. The processes involved in the collection, storage, access, and visualization of information. In the context of an SRS, information includes the raw data generated by SRS surveillance components, alerts generated by the components, ancillary information used to support data analysis or alert investigations, details entered during alert investigations, and documentation of Consequence Management activities.

information management system. The combination of hardware, software, tools, and processes that collectively support an SRS and provides users with information needed to monitor real-time system conditions. The system allows users to efficiently identify, investigate, and respond to water quality incidents.

invalid alert. An alert from an SRS surveillance component that is not due to a water quality incident or public health incident.

IT design team. Personnel responsible for selecting, designing, and implementing the SRS information management system.

lifecycle cost. The total cost of a system, component, or asset over its useful life. Lifecycle cost includes the cost of implementation, operation and maintenance, and renewal.

medical assessment. An evaluation of a disease or condition based on the patient's subjective report of the symptoms and course of the illness or condition and the medical professional's objective findings, including data obtained through physical examination, medical history, clinical laboratory tests, and information reported by family members and other healthcare professionals.

monitoring. The process of collecting and analyzing a datastream over time.

notifiable disease. Cases are voluntarily reported to CDC by state and territorial jurisdictions for nationwide aggregation and monitoring of disease data. The list of nationally notifiable diseases is reviewed and modified annually by the CSTE and CDC.

Online Water Quality Monitoring (OWQM). One of the surveillance components of an SRS. OWQM utilizes data collected from monitoring stations that are deployed at strategic locations in a source water or distribution system. Monitored parameters can include common water quality parameters (e.g., chlorine residual, pH, specific conductance and turbidity) and advanced parameters (e.g., total organic carbon and UV-Vis spectral data). Data from remote monitoring locations is transferred to a central location and analyzed for water quality anomalies.

performance objectives. Measurable indicators of how well an SRS or its components meet established design goals.

Poison Control Center (PCC). An agency employing toxicologists, medical doctors, and other professions with pharmacological expertise for the purpose of providing guidance to persons who may have been exposed to a toxic substance, or to healthcare providers with responsibility for treating exposed persons.

possible. In the context of the threat level determination process, water contamination is considered possible if the cause of an alert from one of the surveillance components cannot be identified or determined to be benign.

Primers. A set of seven concise documents that provides overview information about the SRS or one of its six components. The primers provide an introduction to SRS practices and useful background for the application of technical SRS products and guidance.

public health datastreams. Data generated by individuals seeking healthcare, which may include 911 calls, emergency medical service records, and emergency department data. Public health datastreams are monitored to detect potential public health incidents.

public health incident. An occurrence of disease, illness, or injury within a population that is a deviation from the disease baseline in the population.

public health partner. Public health organizations that may serve a role in PHS include the health department and Poison Control Center.

Public Health Surveillance (PHS). One of the surveillance components of an SRS. PHS involves the analysis of public health datastreams to identify public health incidents, and the investigation of such incidents to determine whether they may be due to drinking water contamination.

real-time. A mode of operation in which data describing the current state of a system is available in sufficient time for analysis and subsequent use to support assessment, control, and decision functions related to the monitored system.

reportable disease. Cases or suspected cases of disease that must be reported to state or territorial jurisdictions by healthcare professionals, hospitals, or laboratories when they are identified. Each state has its own laws and regulations defining what diseases are reportable.

Sampling and Analysis (S&A). One of the response components of an SRS. S&A is activated during Consequence Management to help confirm or rule out possible water contamination through field and laboratory analyses of water samples. In addition to laboratory analyses, S&A includes all the activities associated with site characterization. S&A continues to be active throughout remediation and recovery if contamination is confirmed.

software. A program that runs on a computer and performs certain functions.

solution. The design and configuration of the hardware, software, and other products that will be used to construct an information management system.

syndrome. A group of symptoms that occur together and characterize a particular health condition.

syndromic surveillance. A form of public health surveillance in which electronic public health data, such as 911 calls or emergency department chief complaints, is analyzed in order to detect anomalies that may be indicative of public health incidents. Syndromic surveillance may be automated or performed manually.

target capability. A level of performance or an outcome for a design element that is necessary for an effective PHS component.

technical requirement. A type of information management requirement that defines system attributes and design features that are often not readily apparent to the end user but are essential to meeting functional requirements or other design constraints. Examples include attributes such as system availability, information security and privacy, back-up and recovery, data storage needs, and integration requirements.

template. A pre-defined standard format which is developed for commonly used documents, tables, or graphical displays. Development and use of templates can reduce the time required for data review and reporting.

threat level determination process. A systematic process in which all relevant information available from an SRS is evaluated to determine whether contamination is possible, credible, or confirmed. This is an iterative process in which the threat level is revised as additional information becomes available. The conclusions from this process are considered during Consequence Management when making response decisions.

valid alert. Alerts due to water contamination, verified water quality incidents, intrusions at utility facilities, or public health incidents.

water quality complaints. Complaints received by a utility from a customer indicating that water quality is not as expected. Traits such as an unusual taste, odor, or appearance can all indicate abnormal water quality within the distribution system.

water quality incident. An incident that results in an undesirable change in water quality (e.g., low residual disinfectant, rusty water, taste & odor, etc.). Contamination incidents are a subset of water quality incidents.

Water Quality Surveillance and Response System (SRS). A system that employs one or more surveillance components to monitor and manage drinking water quality in real time. An SRS utilizes a variety of data analysis techniques to detect water quality anomalies and generate alerts. Procedures guide the investigation of alerts and the response to validated water quality incidents that might impact operations, public health, or utility infrastructure.

Water Quality Surveillance and Response System Manager (SRS Manager). A role within an SRS typically filled by a mid- to upper-level manager from a drinking water utility. Responsibilities of this position include: receiving notification of valid alerts, coordinating the threat level determination process, integrating information across the different surveillance components, and activating Consequence Management.

work management system. Software used by a utility to schedule and track maintenance, repair, or other operations in the distribution system.