Philadelphia Water Department

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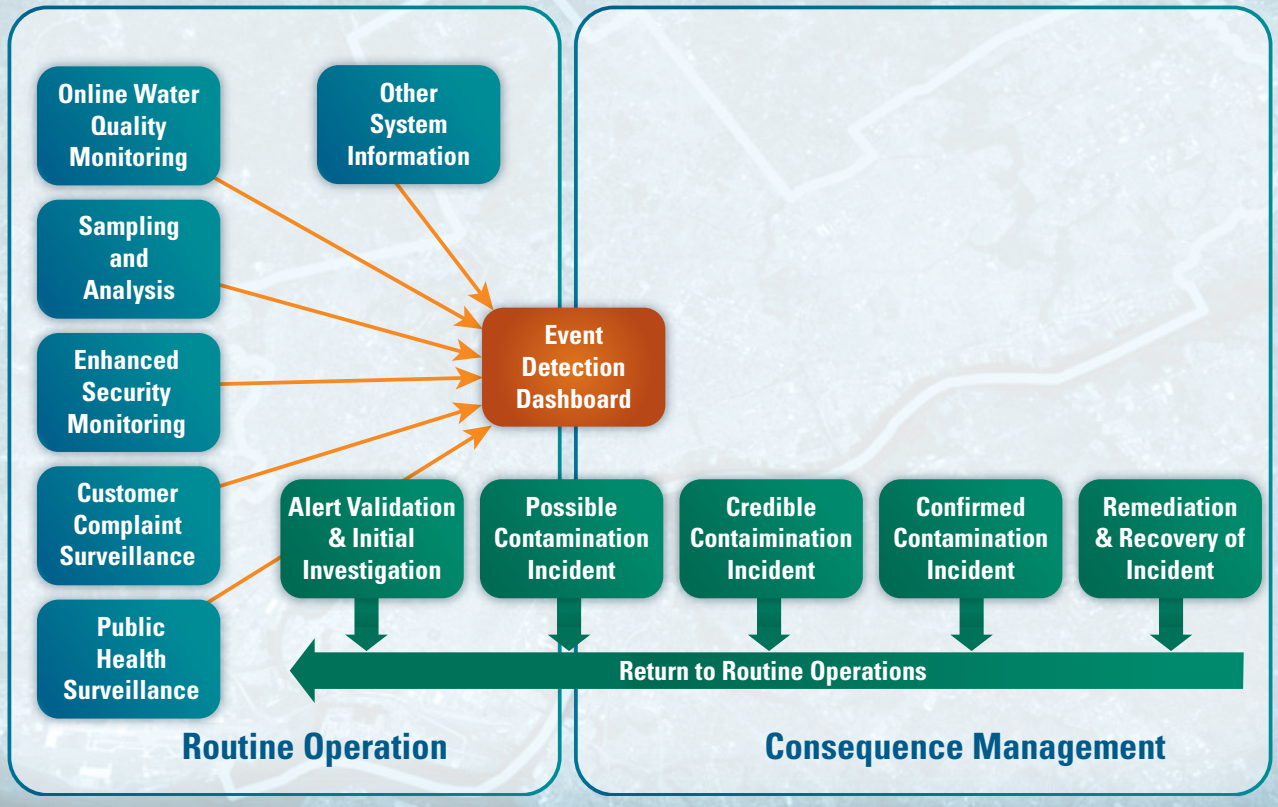
Philadelphia Water Department
Contamination Warning System Demonstration Pilot Project:

Consequence Management





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Abstract

The Philadelphia Water Department (PWD) developed a comprehensive contamination warning system (CWS) for its drinking water system under a Water Security (WS) initiative grant from the U.S. Environmental Protection Agency (EPA). Two major operational phases are associated with an effective CWS: routine operations and consequence management (CM). Routine operational activities include monitoring and surveillance, event detection, and initial alert validation and investigation. CM consists of actions taken to plan for and respond to potential drinking water contamination incidents in the distribution system. The transition from routine operations to CM is significant and changes the focus of response efforts and resource requirements.

This paper provides general information in the design, implementation, and evaluation of CM based on PWD's Pilot Project experience. Information on developing water contamination incident planning documents, equipment purchases, personnel, operations and maintenance, schedule and lessons learned is provided. PWD's implementation of the CM component required a large number of staff from all reaches of PWD and the City throughout the course of the project. The full-scale exercise developed and conducted by the CM component was the capstone event to the CWS program and served as the final test of the newly developed CWS alert detection and response strategies.

Project Background

PWD developed a comprehensive CWS for its drinking water system under a WS initiative grant. The WS initiative is a program developed by the EPA in partnership with drinking water utilities and other key stakeholders in response to Homeland Security Presidential Directive 9. The WS initiative involves designing, deploying, and evaluating a model CWS for drinking water security. A CWS is a systematic approach to collecting information from various sources, including monitoring and surveillance programs, to detect contamination in drinking water early enough to reduce public health or economic consequences. The WS initiative goal is to develop water security CWS guidance that can be applied by drinking water utilities nationwide.

The project has six major components:

1. Online water quality monitoring
2. Sampling and analysis
3. Enhanced security monitoring
4. Consumer complaint surveillance
5. Public health surveillance
6. Consequence management

CM is a key aspect of an effective CWS and consists of actions taken to plan for and respond to potential drinking water contamination incidents in the distribution system. These actions are meant to minimize response and recovery timelines through planned, coordinated effort. Investigative and response actions initiated upon determination of a contamination incident are used to establish credibility, minimize public health and economic impacts, and ultimately return the utility to normal operations.

Two major operational phases are associated with an effective CWS: routine operations and CM. Routine operational activities include monitoring and surveillance, event detection, and initial alert validation and investigation. The transition from routine operations to CM is significant and changes the focus of response efforts and resource requirements.

Routine operation is governed by the water utility's standard operating procedures and operational strategy (OS) for each monitoring and surveillance strategy. Each monitoring and surveillance component also has unique alerts to identify anomalous conditions. If, through the use of the OS investigation procedures, an alert is determined to be an indication of a possible contamination incident, then the water utility's Consequence Management Plan (CMP) will be activated to determine the incident's credibility and mitigate the potential impacts.

CH2M HILL served as the project contractor and supported PWD in development of its CWS. CH2M HILL supported PWD in the implementation of CM, including developing response plans, procuring equipment, and planning and completing training and exercises.

Implementation

PWD's CM component developed incident response plans like the OS, CMP, Risk Communication Plan (RCP), and Emergency Communications Plan (ECP). It also facilitated purchasing 800 MHz radios and field laptops to aid PWD staff during incident response. A significant level of effort was dedicated to listing the roles and responsibilities of staff to develop a training and exercise program designed to leverage the competencies among PWD personnel and external response partners and test the newly developed incident response procedures.

Response Plan Development

The primary water contamination incident response plans developed by PWD's CM component included the OS, CMP, RCP, and ECP. The OS focuses on initial alert investigation at the CWS component level and escalation to the CM phase. The CMP focuses on formation of an incident response team, performing additional investigation activities and operational response actions, and engaging external response partners. The RCP provides guidance and materials that PWD and its partners can use to address the public in an emergency. The ECP provides procedures to support tactical emergency communications and includes provisions to support communication interoperability. Although developed by PWD's Sampling and Analysis component, the Site Characterization and Sampling Plan is another essential response plan to safely guide PWD's sampling teams during site investigations. All of the response plans leveraged existing plans and procedures to the extent possible and were developed through a series of workshops involving interested parties. Response plans were later tested in PWD's robust training and exercise program.

PWD's core CWS response plan is the CMP. The CMP serves as a blueprint to guide PWD through actions that should be taken upon notification of a possible contamination incident, as detected by one of the CWS monitoring and surveillance components. The CMP was developed through extensive planning efforts by PWD staff at every level of the organization through a series of workshops. It provides PWD response personnel with clear roles, responsibilities, and guidelines for response, including when to request support from external response partners. The CMP is supported by ancillary response plans to address implementation of operational responses, development of public communications, and planning for site characterization and sampling. PWD elected to keep the CMP separate from the ancillary response plans because each will be managed by a different unit within PWD.

To develop the CMP and ancillary response plans, PWD used some of its existing emergency response plans and organizational structure. The EPA WS initiative *Interim Guidance on Developing Consequence Management Plans for Drinking Water Utilities,* published in October 2008, was also reviewed early in the project. A gap analysis was completed to identify existing information sources, pertinent information that could be leveraged from existing information sources, and information that was needed to further develop procedures to ensure smooth transitions from routine operations to alert investigation to CM. Workshops with key utility staff and external partners were conducted to identify and document existing procedures. Once existing procedures were documented, the CMP and supplementary response plans were written. The following information sources were reviewed for pertinent information:

- PWD standard operating procedures
- PWD emergency response procedures, specifically for water contamination, public communication, water treatment emergencies, water supply emergencies, and water distribution/conveyance emergencies
- Existing roles and responsibilities of PWD staff
- PWD and City organizational structure
- A list of external response partner agencies that may provide support during a water contamination incident, possibly through mutual aid agreements and Emergency Operations Centers
- After-Action Reports (AAR) from previous emergency incidents or training exercises

- National Incident Management System (NIMS)/Incident Command System (ICS) training records
- Public notification response procedures and message templates
- List of communication equipment used for emergency responses
- Alternative potable water supply plans

Equipment and Costs

PWD acquired additional equipment to enhance its incident response capability (Table 1). Based on PWD's experience, the additional equipment provided dual-use benefit because it can be used for all incident types, as well as routine operations. For the most part, the equipment (e.g., vehicles, radios, laptops) is similar to that typically used to respond to incidents affecting water utilities.

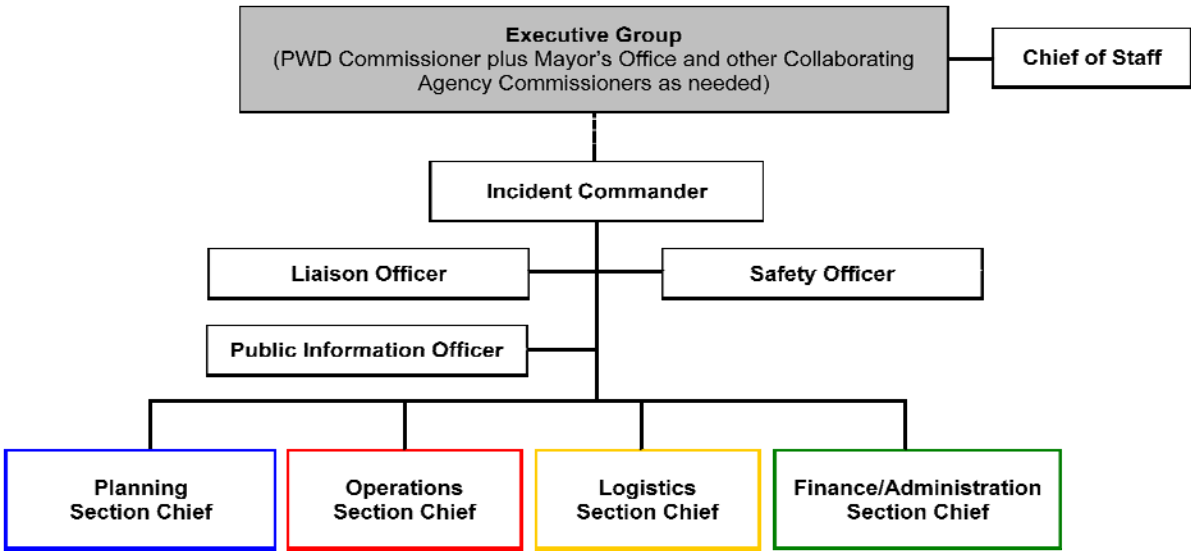
TABLE 1
Equipment Purchased by PWD to Enhance Incident Response Capabilities

Item	Description	Approximate Cost
800 MHz radios	PWD chose to expand its cache of interoperability channel 800 MHz radios to facilitate communications with external response partners such as the Fire Department and local law enforcement agencies. The radio specifications matched those of other City departments and comply with the National Public Safety Planning Advisory Committee standards. PWD personnel with significant ICS roles during a contamination incident response were provided with or have access to the 800 MHz radios to provide regular field status reports to the Incident Commander.	$82,500 for 15 new radios
Field laptops with wireless Internet connection	Laptops were procured for recording key information in the field and accessing critical utility software during incident investigations. Laptops will be supplied to the site characterization and sampling teams and key utility personnel requiring access to the critical incident information during off hours.	$30,000 for 25 new laptops
Department Operations Center	The Department Operations Center typically serves as the incident command center for PWD during an incident and may be the primary point of contact with a City Emergency Operations Center if one is activated. Fortification of the Department Operations Center with robust network communications, conference call capabilities, and visual display equipment was implemented. Multiple telephone lines were installed to allow responders to make multiple calls without relying solely on cellular phones that may become overburdened during an emergency. Ethernet connections were installed to provide the laptops with Internet and CWS alert status. One large liquid crystal display (LCD)/television (TV) screen was installed to display key information and resources. A high-quality speaker phone was installed to effectively conduct conference calls from the conference room, and multi-channel 800 MHz radios dedicated to the Department Operations Center were provided to allow for communication with City departments and utility field response teams. The Department Operations Center also has access to food, water, and restroom facilities in case the incident last many days or weeks.	$12,000 for one conference room upgrade
Other considerations	Utility teams involved with site characterization and sampling will require specialized field screening and sampling equipment, but the details of that equipment are addressed by the Sampling and Analysis component of PWD CWS.	

Resource Requirements

The CM component requires involvement from all sections within a water utility and, to some extent, other City departments. PWD did not have a formal NIMS ICS developed for incident response. Therefore, an ICS structure was developed based on PWD's organizational structure. Figure 1 depicts a generalized ICS structure.

FIGURE 1
PWD General ICS Structure



Using the ICS, roles and responsibilities were developed to facilitate smoother coordination with external response partners. For example, a list of PWD managers was identified as potential Incident Commanders who would be responsible for leading incident response. Also, a table was created to track employees' assigned ICS roles versus their training and resource requirements. Use of a NIMS ICS format required additional NIMS/ICS training for PWD staff with roles in the CMP and CWS.

Based on PWD's experience, seven critical roles need to be filled during a water contamination incident: Executive Group, Incident Commander, Public Information Officer, Operations Section Chief, Planning Section Chief, Site Characterization and Sampling Group Supervisor, Laboratory Group Supervisor, and Water Quality Deputy or Specialist (Table 2). All of these positions are within PWD's ICS structure, which was developed within the CMP. Additional roles that were developed but are not listed in Table 2 are filled by existing PWD or City personnel.

Operations and Maintenance

The primary operations and maintenance aspects of PWD's CM component included periodic training and exercises and updates to response plans such as the CMP. Success in implementing the concepts, guidance, and procedures contained in the CMP, OS, and ancillary response plans comes from practical use of the plans. To effectively execute the plans, PWD trained staff and provided opportunities to practice through exercises.

PWD used the Homeland Security Exercise and Evaluation Program (HSEEP) to standardize policy, doctrine, and terminology for designing, developing, conducting, and evaluating emergency exercises. HSEEP is a capabilities and performance-based exercise program that provides tools and resources to facilitate management of a self-sustaining emergency exercise program. HSEEP uses a building block approach, as depicted in Figure 2, to ensure that exercise participants progress at a logical pace (FEMA 2007a). The HSEEP methodology defines seven exercise types ranging from 2-hour seminars to day-long, full-scale exercises. PWD implemented the full range of HSEEP exercises and developed After-Action Reports and Improvement Plans (AAR/IPs) following each exercise to capture lessons learned.

Training and exercises allowed the PWD staff to face hypothetical tasks and situations normally outside of daily operations. The training and exercises tested roles and responsibilities, CWS alert detection and investigation skills, and response procedures. Lessons learned from training and exercise activities were then used to update and improve the CMP and other emergency response plans. External partners were also invited to participate in the training and exercises to integrate response procedures among the various organizations. Table 3 summarizes the HSEEP exercises completed by PWD to test the CWS components and response plans. The level of effort for participants in the training and exercises is also provided.

TABLE 2
Minimum Required Staff Resources for Consequence Management Implementation

ICS Role	Description	PWD Positions Filling Role	Utility Resource Options
Executive Group	Consists of PWD executive management and, in a Unified Command environment, other external response agencies' executive management. Provides strategic oversight and direction to the Incident Commander/Unified Command.	Commissioner	Deputy Commissioner
Incident Commander	Establishes utility ICS structure for incident and sets incident objectives, strategies, and priorities. Required to provide overall management of the incident.	Deputy Commissioner Deputy Director of Field Operations	Utility Upper Management Utility Operations Division
Public Information Officer	Helps to prepare and coordinate the release of internal and public communications. Required to develop and issue messages to the public and coordinate with Public Information Officers from other agencies.	Public Information Officer Public Affairs General Manager	Utility or City Public Information Officer
Operations Section Chief	Directs field operational response actions such as system isolation, field sampling, or hydraulic modeling. Required to lead oversight of all field operational activities and resources.	Water Conveyance Chief	Utility Upper Management Utility Operations Division
Planning Section Chief	Maintains incident log, planning documents, and data management functions during an investigation. Required to facilitate development of an Incident Action Plan.	Water Treatment Manager	Utility Upper Management Utility Operations Division Utility Engineering Division
Site Characterization and Sampling and Laboratory Group/ Branch Supervisor/ Director	Manages overall site characterization and field sampling activities. Implements the site characterization and sampling plan. Requests external resource support if hazardous conditions are present. Manages overall laboratory response to incident.	Bureau of Laboratory Services Manager	Utility Laboratory Manager Utility Engineering Division
Water Quality Deputy or Specialist	Provides operational and water quality information from CWS components, sampling and analysis field and laboratory data, contaminant literature information, and other relevant water quality information related to the incident.	Water Quality and Research Manager Load Control Chief	Utility Laboratory Manager Utility Engineering Division Utility Operations Manager

FIGURE 2
HSEEP Building-Block Continuum

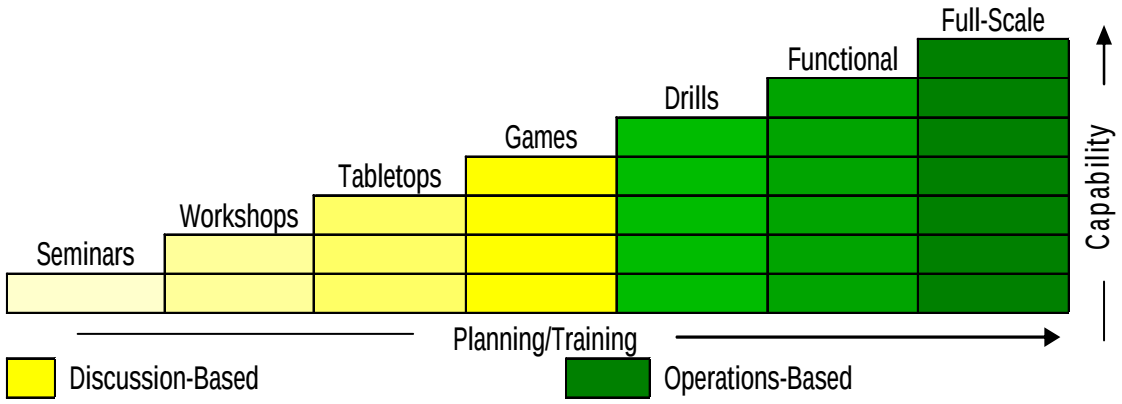


TABLE 3
Summary of PWD HSEEP Exercises

Exercise Types	No. Completed by PWD	Total Level of Effort from Participants[a]	Purpose	Typical Duration
Discussion Based Exercises				
Seminar	7	280 hours	Provide overview of new or current plans, resources, strategies, concepts or ideas.	2-5 hours
Workshop	3	240 hours	Achieve specific goal or build product (e.g., exercise objectives, standard operating procedures, policies, plans)	3-8 hours
Tabletop Exercise (TTX)	5	630 hours	Validate plans and procedures by utilizing a hypothetical scenario to drive participant discussions	4-8 hours
Operational Exercises				
Drill	5	450 hours	Validate a single operation or function of an agency	2-4 hours
Functional Exercise	2	450 hours	Evaluate capabilities, functions, plans, and staffs of Incident Command, Unified Command, intelligence centers, or other multi-agency coordination centers (e.g., Emergency Operations Center)	4-8 hours or several days or weeks
Full-Scale Exercise	1	750 hours	Validate plans, policies, procedures, and cooperative agreements developed in previous exercises through their actual implementation and execution during a simulated scenario; includes actual mobilization of resources, conduct of operations, and integrated elements of functional exercise play (e.g., Emergency Operations Center, command posts)	One full day or several days or weeks

Note: Homeland Security Exercise and Evaluation Program Volume I: HSEEP Overview and Exercise Program Management, p9. Revised February 2007, https://hseep.dhs.gov/support/VolumeI.pdf
[a]Includes level of effort from participation in training/exercises only, not planning or AAR development.

The general process for exercise development includes the following:

- Selecting an exercise design team consisting of subject matter experts, the exercise director/facilitator, controllers, and evaluators
- Developing exercise objectives based on the U.S. Department of Homeland Security Target Capabilities List (37 target capabilities)
  - Examples: Onsite Incident Management, Communications, Planning (FEMA 2007b)
  - Performance Objectives: To support water sector and PWD-specific development and evaluation, specific, measurable, achievable, realistic, and time-sensitive performance objectives were developed.

    Example: Evaluate PWD's ability to activate the Site Characterization and Sampling teams in accordance with the CMP.
- Developing a plausible scenario—Plausibility dictates a broad base of expertise on the design team, including hydraulic modeling.
- Developing Exercise Evaluation Guides—Use existing procedures to identify expected actions.
- Conducting the Exercise
  - Assign an exercise director to lead the exercise.
  - Assign controllers to manage specific operational areas or nodes.
  - Assign evaluators to assess specific operational areas or nodes based on the exercise evaluation guide.

Participants spent close to 3,000 hours participating in PWD's training and exercise program, not including the time spent planning for the training sessions and summarizing the lessons learned in an AAR. The full-scale exercise required the most effort, about 750 hours of participants' time the day of the exercise. A total of 64 PWD employees and 22 external response partners participated in the full-scale exercise. The full-scale exercise was the capstone event to the PWD CWS program and served as the final test of the newly developed alert detection and response strategies. The full-scale exercise was preceded by numerous workshops, tabletop exercises, drills, and a functional exercise.

Planning for the full-scale exercise took almost a year. The exercise included all CWS components and tools. PWD set up its ICS and coordinated with the City's Unified Command structure with external response partner agencies. Public notification was examined under this exercise through a mock press conference. Despite the high level of effort, participants in the full-scale exercise gained a better appreciation for the benefits that advanced preparation has on streamlining responses and coordination with external response partners.

Lessons Learned

Implementation and maintenance of the CM component was a significant undertaking for PWD. Table 4 provides a template of recommended activities to successfully implement a CM component based on PWD's experience. The activities range from initial planning workshops and development of the CMP and ancillary response plans, to conducting a full-scale exercise to test personnel and procedures. The implementation schedule was spread out over a 6-year period, which is 2 years longer than PWD had to implement its CWS. The actual implementation schedule will vary based on the size and complexity of the water system and staff availability.

TABLE 4
CM Implementation Schedule

Years	Activities
0-2	Gather utility existing information and resources
	Document existing processes and resources through workshops with utility staff
	Conduct CWS and CM orientation training for utility staff
	Develop a 3 to 5 year training and exercise plan and schedule
	Participate in NIMS ICS training classes (if necessary)
	Develop draft utility ICS structure and roles summary table
	Develop proposed response procedures and process flow diagrams for CWS component Operational Strategies, CM, Risk Communication, and Site Characterization and Field Sampling
	Review proposed response procedures and ICS structure through workshops with respective utility staff
	Develop first drafts of CWS component Operational Strategies, CMP, Risk Communication Plan, Site Characterization and Sampling Plan and other supplementary response plans
	Conduct internal utility TTX to practice CWS alert investigation, escalation to CMP, activation of utility ICS, and initial response to water contamination incident; Develop AAR for TTX
	Revise draft response plans based on internal TTX AAR
2-4	Conduct coordination workshop with external response partners to update contact information, verify roles and responsibilities, revise response procedures, and schedule future training and exercises
	Plan for and conduct TTX with external response partners; develop AAR/IP for TTX
	Plan for and conduct drills implementing CWS component Operational Strategies, Site Characterization and Sampling, and Public Communication messages; Develop AAR/IP for drills
	Revise draft response plans based on TTX and drill AAR/IPs

TABLE 4
CM Implementation Schedule

Years	Activities
5	Conduct coordination workshop with external response partners to update contact information, verify roles and responsibilities, revise response procedures, and schedule future training and exercises
	Plan for and conduct functional exercise with external response partners
	Develop AAR for functional exercise
	Plan for and conduct additional drills implementing CWS component Operational Strategies, Site Characterization and Sampling, and Public Communication messages; develop AAR/IP for drills
	Revise draft response documents based on functional exercise and drill AAR/IPs
6	Conduct coordination workshop with external response partners to update contact information, verify roles and responsibilities, revise response procedures, and schedule future training and exercises
	Plan for and conduct Full-Scale Exercise with external response partners; develop AAR/IP for Full-Scale Exercise
	Plan for and conduct additional drills implementing CWS component Operational Strategies, Site Characterization and Sampling, and Public Communication messages; develop AAR/IP for drills
	Revise draft response plans based on Full-Scale Exercise and drill AAR/IPs

In addition, the following lessons learned were identified from implementation of the CM component by PWD:

- The Operational Strategy and CMP provided procedural benefits including documentation of response processes, improved streamlined procedures, defined procedures for transfer of knowledge within PWD departments and between staff, better understanding of roles and responsibilities, and clear criteria for when to escalate the response.
- The RCP provided a framework for developing effective messages in a crisis when issues cannot be completely anticipated or known.
- The RCP provided improved processes and documentation (templates, checklists, forms, and other tools) to streamline development and release of accurate messages.
- Training and exercises provided value in testing procedures and clarifying roles and responsibilities. Training helped to improve communication between PWD employees and with external response partners.
- To facilitate extended staffing, roles and responsibility tables were developed to identify key staff to serve as primary and backup ICS positions and to identify position-specific resources and training requirements for each position.
- The planning process and subsequent training program helped to eliminate silos of information between levels within the organization.
- Involvement of PWD executive level staff within the water utility was critical to ultimate acceptance of the CMP, utilization of the ICS with inclusion of the Executive Group, and use of incident response procedures.
- Use of tools displaying real-time CWS alerts, utility ICS structure, and resource status assisted in timely transfer of information during routine operations and during incident response.
- Utilization of the HSEEP guidelines ensured that exercises were developed and conducted systematically, maintained focus on measurable objectives and goals, and recorded lessons learned for continuous improvement.
- The purchase of field laptops and 800 mHz radios and the expansion of phone and Internet capabilities in the utility's Department Operations Center aided overall response capabilities.
- Possible, credible, and confirmed investigative phases, supplemented with incident severity levels, facilitated implementation of the utility ICS, and response procedures at the appropriate time.

Conclusions

PWD developed a comprehensive CWS for its drinking water system under an EPA WS initiative grant. CM is a key aspect of an effective CWS and consists of actions taken to plan for and respond to potential drinking water contamination incidents in the distribution system. PWD's CM component developed water contamination response plans like the OS, CMP and RCP. It also facilitated upgrading of the 800 MHz radios and purchasing field laptops to aid PWD staff during an incident response. The ICS facilitated development of PWD roles and responsibilities during incident response to allow for smoother coordination with external response partners.

Although capital costs for implementation of the CM component were relatively small, a large number of staff members from all reaches of PWD and the City were engaged throughout the course of the project. In addition to developing response plans, PWD staff was busy planning for and conducting training and exercises to test roles and responsibilities, CWS alert detection and investigation, and response procedures. Extensive coordination with each CWS component was required. The most significant labor burden was from the full-scale exercise, which required 750 hours of participants' time. Despite the high level of effort, participants in the full-scale exercise gained a better appreciation of the benefits that advanced preparation has on streamlining responses to water contamination incidents. The full-scale exercise was the capstone event to PWD's CWS program and served as the final test of the newly developed alert detection and response strategies.

Recommendations

Existing response plans, procedures, roles, and responsibilities should be leveraged to the extent possible when developing the CMP, OS, RCP, and other supplemental plans. Additional resources like the EPA WS initiative *Interim Guidance on Developing Consequence Management Plans for Drinking Water Utilities* should also be leveraged. Water utilities like PWD that have well established procedures for responding to "recurring" incidents like water main breaks, floods, or rusty water should be able to develop a CMP to respond to specific water contamination incidents. It is not necessary to have a formal water contamination response plan to develop a CMP. Advanced development of a NIMS/ICS structure is recommended to organize water utility roles and responsibilities and facilitate smoother coordination with external response partners. A series of workshops should be implemented to review existing and proposed response procedures and utility roles and responsibilities. Once the draft response plans are developed, they should be reviewed and updated on a periodic basis and tested through a training and exercise program.

Review and updating of response plans and contacts combined with a training program is the most important element for successful integration of the CWS in the water utility. Training provides water utility staff with the opportunity to test their knowledge in real-world situations. Component-level training and discussion-based exercises lay the groundwork for operational exercises and identify any confusion or overlap of responsibilities. Following the HSEEP approach is recommended to standardize policy, doctrine, and terminology for designing, developing, conducting, and evaluating exercises. Classroom training provides the formalized procedural training for specific roles and responsibilities for emergency response. A water utility should also institute an ongoing program of internal drills to maintain competency in specific procedural activities like Site Characterization and Sampling or the investigation of alert information generated by CWS components. Discussion-based exercises and plan review can be conducted annually to update plans with new contacts, technology, and business processes, to evaluate emergency plans, and to facilitate competency among assigned response personnel. Operational-based exercises, including a functional or full-scale exercise, should be conducted every few years to simulate a real emergency as closely as possible, giving first-hand experience of the knowledge and composure necessary during an emergency.

Abbreviations and Acronyms

AAR	After-Action Report
AAR/IP	After-Action Report/Improvement Plan
CM	Consequence Management
CMP	Consequence Management Plan
CWS	Contamination Warning System
ECP	Emergency Communications Plan
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency
HSEEP	Homeland Security Exercise and Evaluation Program
ICS	Incident Command System
LCD	Liquid crystal display
Mhz	Megahertz
NIMS	National Incident Management System
OS	Operational Strategy
PWD	Philadelphia Water Department
RCP	Risk Communication Plan
TTX	Tabletop Exercise
TV	Television
WS	Water Security

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