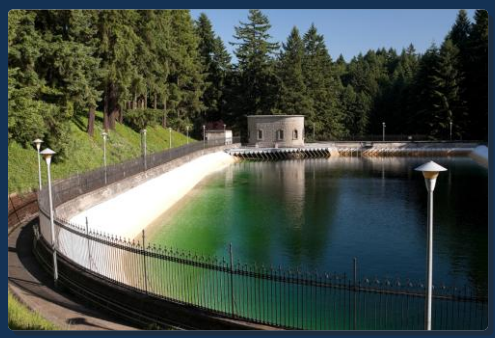

WATER SECTOR COORDINATING COUNCIL AND WATER GOVERNMENT COORDINATING COUNCIL

Contamination Warning System CIPAC Workgroup

FINAL REPORT

March 2012

Acknowledgements

This report was developed by the Critical Infrastructure Partnership Advisory Council (CIPAC) Drinking Water Contamination Warning System (CWS) Workgroup, which was convened by the Water Sector Coordinating Council (WSCC) and Water Government Coordinating Council (WGCC). Contributing individuals include:

WSCC Workgroup Members

Zia Bukhari
American Water

Dean Dickey
Prince William County Service Authority

George Hanson
Chesapeake Ranch Water Company

Sophie James
California Water Service Company

Connie K. Schreppel
Mohawk Valley Water Authority

Jin Yeong Shin
Washington Suburban Sanitary Commission

Stanley States
Pittsburgh Water and Sewer Authority

John Sullivan
Boston Water and Sewer Commission

Dean Trammel
City of Tucson

Paul J. Whittam
Erie County Water Authority

WGCC Workgroup Members

Lance Brooks
Department of Homeland Security

Michael Orbon
North Carolina Department of Environment and Natural Resources – Public Water Supply

Doug Meckes
Department of Homeland Security

David Travers
Environmental Protection Agency

Participating Staff

Michael Arceneaux
WaterISAC

Kevin Morley
American Water Works Association

Bridget O'Grady
Association of State Drinking Water Administrators

Alan Roberson
American Water Works Association

Vance Taylor
Association of Metropolitan Water Agencies

Subject Matter Experts

Tony Fields
Oregon Department of Human Services

Ken Thompson
CH2M Hill

Shannon Spence
Malcolm Pirnie, ARCADIS

Supporting Staff

Steve Allgeier
Environmental Protection Agency

Athena Bertolino
Ross & Associates

Cade Clark
National Association of Water Companies

Chrissy Dangel
Environmental Protection Agency

Jeffery Fencil
Environmental Protection Agency

Rob Greenwood
Ross & Associates

Elizabeth Hedrick
Environmental Protection Agency

Morgan Hoenig
Ross & Associates

John Laws
Department of Homeland Security

Nelson Mix
Environmental Protection Agency

Brian Pickard
Environmental Protection Agency

Dan Schmelling
Environmental Protection Agency

Katie Umberg
Environmental Protection Agency

Matt Umberg
Environmental Protection Agency

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List of Acronyms

CCS: Consumer Complaint Surveillance

CIPAC: Critical Infrastructure Partnership Advisory Council

CM: Consequence Management

CMP: Consequence Management Plan

CWS: Contamination Warning System

EPA: Environmental Protection Agency

ERP: Emergency Response Plan

ESM: Enhanced Security Monitoring

O&M: Operation and Maintenance

PHS: Public Health Surveillance

S&A: Sampling and Analysis

SCADA: Supervisory Control and Data Acquisition

SOP: Standard Operating Procedure

SME: Subject Matter Expert

WQM: Water Quality Monitoring

WGCC: Water Government Coordinating Council

WSCC: Water Sector Coordinating Council

WSi: Water Security Initiative

Executive Summary

The Water Sector Coordinating Council (WSCC) and Water Government Coordinating Council (WGCC) convened the Contamination Warning System (CWS) Critical Infrastructure Partnership Advisory Council (CIPAC) Workgroup to "*evaluate whether or under what conditions monitoring, surveillance, and response practices deployed as components of an early warning system for drinking water contamination are effective, implementable, and sustainable.*" The contamination warning system practices to be evaluated were to include online water quality monitoring, consumer complaint surveillance, public health surveillance, enhanced physical security monitoring, contaminant sampling and analysis, and consequence management.

The Councils further requested the Workgroup develop recommendations for "*the structure of a national program*" to the extent the members identified CWS practices that were effective, implementable, and sustainable, and requested the Workgroup develop recommendations "*to address deficiencies in the design, implementation, or operation of such practices*" to the extent CWS practices were not found to be effective, implementable, and sustainable. Workgroup members have referred to these requests as conditional charge areas "A" and "B."

The CWS CIPAC workgroup consisted of fourteen direct members, representing large, medium, and small, and public and private drinking water providers, along with state and federal government drinking water officials. Several Subject Matter Experts (SMEs), national water sector association staff, and federal agency staff provided support to the direct workgroup members and participated actively in their discussions. **The workgroup's deliberations resulted in consensus on the major topics that are highlighted in this report.**

To structure their evaluation, the CWS Workgroup members established an "analytic framework" comprised of questions related to the "effective, implementable, and sustainable" aspects of CWS components. Environmental Protection Agency (EPA) staff was initially tasked to provide responses to these evaluative questions based primarily on the substantial performance information generated as part of the Greater Cincinnati Water Works' participation in the Water Security Initiative (WSi) pilot project. This information was supplemented through presentations by four additional EPA-funded WSi utilities, four non-WSi utilities from outside of the workgroup, three utility members on the workgroup, and one state health department representative, along with the substantial experience of other members of the workgroup. This approach provided workgroup members exposure to a variety of utility CWS experiences ranging from externally, well funded large utilities seeking to deploy all components of a CWS in a highly integrated and automated manner, to internally (and at times marginally) funded efforts seeking to deploy contamination and detection response capabilities in a more targeted and opportunistic approach.

Based on this evaluation, CWS CIPAC Workgroup members formulated five Critical Considerations, ten General CWS Findings, and a set of Component-Specific Findings for each of the six component

areas. The Critical Considerations establish the context in which CWS CIPAC Workgroup members have made their findings, and the members believe it is essential for the audience of this document (WSCC and WGCC members) to understand that the findings are not deemed valid outside of the Critical Considerations framework. Highlights of the Critical Considerations and General CWS Findings follow below.

Critical Consideration #1: Workgroup members insist that all findings and recommendations in this report are interdependent, and therefore must be viewed and responded to as an integrated package. Workgroup members do not and will not support as valid individual findings treated in isolation or taken out of the context of the broader CWS CIPAC report.

Critical Consideration #2: Workgroup members have interpreted the charge from the Water Sector and Government Coordinating Councils to entail an exploration of whether or not, and under what conditions, a water system **can** take actions to improve water contamination detection and response capability that are effective, implementable, and sustainable. Consistent with this interpretation, workgroup discussions did not explore whether or not, and under what conditions, a water system **should** take such actions. All workgroup findings must, therefore, be understood to in no way suggest or endorse that water systems become subject to requirements for implementing contamination detection and response capabilities.

Critical Consideration #3: Workgroup discussions extensively explored the concept of a "contamination warning system." The workgroup has concluded that there is no single contamination warning system design that could be applied universally to utilities. There is, instead, an array of options available for improving water contamination detection and response capability at water systems.

Critical Consideration #4: Workgroup discussions also explored the "capability objective" that forms the basis for viewing any detection or response action as "effective." These discussions identified the following objectives relative to baseline conditions:

- More timely contamination detection and response resulting in fewer exposures or faster administration of therapeutic actions.
- Improved quality and better-corroborated information producing more confident decisions.
- More deliberate and organized response actions helping maintain public trust/confidence.
- Improved forensic capability supporting more precise and targeted response actions by water system customers and public health partners.

Critical Consideration #5: Approaching contamination detection and response capabilities as an array of options to be tailored individually to local water system conditions will likely produce substantial deployment variability, acknowledged by workgroup members as necessitating creativity on the part of individual water systems, while providing the advantage of impeding any offender from creating a standard operating procedure (SOP) to breach the security of a contaminant warning system.

General Findings

The CWS CIPAC Workgroup established ten general CWS findings. While workgroup members deem all findings of equal importance, the highlights of the three specific findings that speak directly to "effective, implementable, and sustainable" are provided here.

Finding #8: Intelligent, locally-tailored deployment can produce EFFECTIVE contamination detection and response capabilities. Structured assessment, clear design objectives, and tailoring of detection and response practices and investments to local capabilities and needs can reduce consequences. CWS effectiveness will depend on the contaminant type and the location of its introduction into the distribution system relative to deployed design. The detection capability when married with field, laboratory, and consequence management response capabilities can: reduce detection and response time; produce more deliberate and well-planned response actions; increase the confidence of decision making; and enable earlier, more precise, and better-targeted public health intervention.

Finding #9: Utility experience indicates contamination detection and response capabilities can be IMPLEMENTED. The technology, tools, methods, and expertise exist (to a sufficient degree) and needed partnerships can exist to support improved contamination detection and response capabilities. Sufficient monitoring and surveillance data streams and tools, products, and guidance exist to support CWS component deployment and the needed public health and first responder partnerships have been formed by utilities. Workgroup members recognize, however, these partnerships are outside of direct utility control and can come under a variety of pressures (e.g., other priorities) that may leave some utilities unable to establish and maintain these relationships.

Finding #10: Utility experience indicates that SUSTAINABILITY can be achieved, but represents an on-going challenge for water systems. Maintaining detection and response capabilities over time will require strong leadership commitment and sufficient dual-use benefits or a persistent concern about contamination risk. Invalid alerts, even after system optimization, can remain sufficiently high to risk staff desensitization. Invalid alerts will, therefore, necessitate development of a well-managed alert investigation process to minimize impact and maintain attentiveness.

Conditional Charge Areas

CWS CIPAC Workgroup members have concluded that monitoring, surveillance, and response practices implemented as components of an early warning system for drinking water contamination events can be effective, implementable, and sustainable under certain conditions <u>and</u> that some deficiencies in the design, implementation, or operation of contamination warning system practices remain. In response, the workgroup has addressed both the structure of a national program to promote adoption of CWS practices (Conditional Charge Area A), and the gaps identified in the current development and understanding of CWS components (Conditional Charge Area B).

Conditional Charge Area A

In responding to this charge area, the workgroup identified recommended program attributes, objectives, and building blocks in the form of prioritized actions for an organized effort (e.g., a program) to promote adoption of CWS practices by interested water systems. The workgroup believes it is critical that the program be **voluntary**, **flexible** (meaning it can and will be tailored and adaptable to local conditions and needs), and **locally driven** (decisions on the type and degree of investment in contamination detection and response capability will remain fully with local communities). The four national program objectives identified are:

1. Increase knowledge in the water sector regarding:
    a. The options available for increasing contamination detection and response capabilities;
    b. The operational and other requirements for implementing these capabilities; and
    c. The performance, cost-benefit, implementation pros and cons, and other characteristics of these capabilities.
2. Create opportunities for water systems to make well-informed decisions about, and locally tailor, contamination detection and response capability investments.
3. Strengthen the local community context for the emergence and maintenance of public health, first responder, water utility, and state primacy agency partnerships in support of contamination detection and response capabilities.
4. Provide additional, voluntary incentives for the adoption of practices that increase contamination detection and response capabilities.

In support of these objectives, the workgroup produced a rank-ordered list of specific actions. The discussions and ranking exercise led to the identification of a clear top priority category of actions, five high priority categories of actions, four medium priority specific actions, and one category of low priority actions, along with six additional lower priority specific actions. The top and high priority categories are described below.

Top Priority: Increase knowledge and understanding of CWS practices and opportunities. This category of actions focuses on providing both descriptive (e.g., what are the components of a CWS) as well as analytical (e.g., what are the costs and benefits of components of a CWS) information to bolster the understanding of and opportunities for implementation of CWS practices.

High Priority: Encourage and support coordination with key partners. This category of actions focuses on developing and sustaining workable relations between water systems and public health, first responder, and state primacy agency partners, acknowledging that for these relationships to be successful they will have to be forged at multiple levels, as well as encouraged from both sides. These actions also look to strengthen the local context for these needed partnerships to emerge and be maintained.

High Priority: Provide guidance on enhancing emergency response plans (ERPs). This category of actions focuses on emphasizing the importance of establishing contamination response

capability as an important first step in any CWS, as well as supporting utilities in their efforts to establish consequence management planning (CMP) as part of their overall ERPs.

High Priority: Share success stories and best practices. This area speaks to building "communities of practice" with regard to contamination detection and response capabilities.

High Priority: Provide a means for assessment. The actions in this category focus on bolstering a utility's ability to assess and evaluate its current capabilities and needs based on local conditions, and on comparing and choosing implementation options that best fit those capabilities and needs.

High Priority: Identify options and provide procedural guidance for implementation. To complement the assessment actions above, these actions look to help identify and support appropriate implementation efforts.

Conditional Charge Area B

In response to Conditional Charge Area B, the workgroup identified a number of research or other analytical needs to address areas of deficiency in current knowledge of CWS practices. The workgroup believes that addressing these areas can create greater certainty in the future and alleviate some of the concerns raised in the Critical Considerations and Findings. Similar to Conditional Charge Area A, the workgroup conducted a ranking exercise on the identified needs to provide a general sense of what needs are most critical in terms of addressing the existing knowledge gaps. Identified below are the three high priority information need areas:

1. **Information to help identify and manage costs and maximize dual use benefits.**
2. **Evaluation of new technologies.**
3. **Greater development of options for field testing and detection.**

Conclusion

The CWS CIPAC workgroup has concluded that water systems can take actions to improve water contamination detection and response capabilities that are effective, implementable, and sustainable. The workgroup has further concluded that there is no single contamination warning system design that can be universally applied to all water systems. There is, instead, an array of options available for improving water system contamination detection and response capabilities. In this context, an effective, implementable, and sustainable contamination warning system will be voluntary and reflect specific tailoring to local utility and community needs, opportunities, and conditions. Having concluded that CWS practices can be effective, implementable, and sustainable, and recognizing that a variety of water systems around the country are exploring or initiating CWS deployment, the CWS CIPAC Workgroup has provided recommendations for actions that can be taken in support of a national program to promote adoption of practices and in support of addressing deficiencies in the design, implementation, and operation of such practices. Moving forward with these actions will help the water sector draw effectively on current experience, make investments consistent with local needs and conditions, and advance the performance of CWSs in the future.

Introduction and Background

The Water Sector Coordinating Council (WSCC) and Water Government Coordinating Council (WGCC) convened the Contamination Warning System (CWS) Critical Infrastructure Partnership Advisory Council (CIPAC) Workgroup to evaluate the concept of "contamination warning systems" for early detection and response to contamination events in drinking water distribution systems. The workgroup was composed of fourteen direct members, representing large, medium, and small, and public and private drinking water providers, along with state and federal government drinking water officials. Three Subject Matter Experts (SMEs) and five participating staff from national water sector associations and federal agencies provided support to the direct workgroup members and participated actively in their discussions. Additional support for the workgroup was provided by a number of resource personnel from federal agencies with interest and expertise in water utilities and security, primarily the Environmental Protection Agency (EPA) and the Department of Homeland Security. The complete list of workgroup members and supporting staff can be found on the Acknowledgements page at the beginning of this report.

WORKGROUP CHARTER AND APPROACH

In its Workgroup Charter, the CWS CIPAC participants were charged with the following tasks:

1. ***Evaluate Contamination Warning System Practices.*** *The first action undertaken by the workgroup will be to evaluate whether or under what conditions monitoring, surveillance, and response practices deployed as components of an early warning systems for drinking water contamination are effective, implementable, and sustainable. Assessment of these criteria will include, but is not limited to, the following: "effective" will address the potential to reduce public health and/or economic consequences of a drinking water contamination event; "implementable" and "sustainable" will address the practicality of a water system deploying, operating, and maintaining the contamination warning system components, including costs and benefits. The contamination warning system practices to be evaluated will include online water quality monitoring, consumer complaint surveillance, public health surveillance, enhanced physical security monitoring, contaminant sampling and analysis, and consequence management. Information supporting this analysis will come from contamination warning system pilots deployed under EPA's Water Security Initiative (WSi), as well as from other utilities that have deployed contamination warning systems independent of WSi, and from relevant research studies.*

2. ***Conditional***

(a) *If the workgroup identifies contamination warning system practices that are effective, implementable, and sustainable under Objective 1, then the workgroup will develop recommendations for the structure of a national program to be implemented by the EPA in partnership with the water sector to promote the adoption of these practices by*

drinking water utilities. These recommendations should consider the features of other successful voluntary water sector programs and potential opportunities to leverage existing programs. OR

(b) If the workgroup determines that contamination warning system practices evaluated under Objective 1 are not effective, implementable, and sustainable, then the workgroup will develop recommendations to address deficiencies in the design, implementation, or operation of such practices. These recommendations may include additional research and development activities and alternative approaches to early detection of drinking water contamination.

The practices to be evaluated were to include: on-line water quality monitoring, customer complaint surveillance, public health surveillance, enhanced physical security monitoring, contaminant sampling and analysis, and consequence management. These components are considered to comprise the basic areas in which water systems can adopt practices and make investments to increase distribution system water contamination detection and response capabilities.

The articulation of "effective, implementable, and sustainable" criteria resulted from workgroup response to a series of specific questions, with detailed analysis conducted by the EPA, and supplemented through presentations by utilities and a public health representative. The workgroup referred to this series of questions as the CWS Analytic Framework (See Appendix). Questions relating to CWS effectiveness existed in the following categories:

- **Contaminant Coverage:** Priority contaminants covered by components, detection limits relative to health impacts, and sensitivity (e.g., true positive or false negative rates).
- **Spatial Coverage:** Distribution system and populated component scope.
- **Detection and Response Timeliness:** Elapsed time between contamination and alarm, time to investigate alarms, conditions under which contaminant detection enables consequence reducing response action, and/or impact of component data integration on timeliness.
- **Operational Reliability:** Component operational performance, component and system redundancy, completeness and accuracy of data, and/or conditions that affect operational reliability.
- **Alert Occurrence:** Rates of valid and invalid alerts, causes of alerts, and false alert rate management.
- **Consequence Reduction:** Reduction in public health and economic consequences.

Questions related to the implementable and sustainable aspects of contamination warning systems existed in the following categories:

- **Cost:** Deployment costs, and operations and maintenance costs.
- **Specialized Knowledge:** Skills, knowledge, and training requirements for utilities.

- **Tools:** Availability of tools, methods, and guidance to deploy, operate, and maintain.
- **Institutional and Organizational Functions and Constraints:** Community institutional functions needed to deploy and operate, internal organizational change requirements, and authorities needed to deploy and operate.
- **Dual-Use Benefits:** Enhancements to utility operations or community preparedness from deployment and operation.
- **Business Case:** Consequence reduction and dual-use benefits compared to costs, consequences of false alarms, and applicability of components to different utility scales.

WORKGROUP PROCESS

In order to accomplish its chartered goals, the workgroup met four times in person and four times via conference call between May 2011 and April 2012. All meetings followed CIPAC compliance procedures and were led by a neutral facilitator, Ross & Associates. Consistent with the workgroup's designation as a CIPAC, all calls and meetings were closed to the public.

The opinions of and deliberations between workgroup members were informed through individual expertise, relevant information provided by the EPA, and presentations of outside models and evidence throughout the workgroup process. During the workgroup's in-person meetings, a total of nine outside presenters and SMEs spoke on a variety of related topics to provide the workgroup with additional background information and insight. These presentations described experiences of utility providers in activities related to contamination warning systems, including detailed analytical and simulation data derived from the Greater Cincinnati Water Works pilot project. Presenters included:

City of Arlington Water Utilities
Robert Lemus

City of Glendale***
Rick Scott

City of Milwaukee Health Department
Paul Biedrzycki

Dallas Water Utilities*
Jennifer Cottingham
Cassia Sanchez

Erie County Water Authority**
Paul Whittam

Greater Cincinnati Water Works*
Dave Hartman
Yeongho Lee

Metropolitan Water District of Southern California
Eric Crofts

Mohawk Valley Water Authority**
Connie K. Schreppel

New York City Department of Environmental Protection*
Dave Lipsky

Philadelphia Water Department*
Geoff Brock

Pittsburgh Water and Sewer Authority**
Stanley States

San Francisco Public Utilities Commission*
Manouchehr Boozarpour

Seattle Public Utilities***
Rick Scott

*EPA Pilot Utility

**Direct Workgroup member presenting on his/her experience with the implementation of CWS practices

***Rick Scott represented both Seattle Public Utilities (his current position), and the City of Glendale (his previous position)

In addition to the eight full workgroup meetings and conference calls, members of the workgroup formed two task teams to draft specific text relating to the general findings and conditional charge areas. Each task team met for one two-hour conference call in December 2011, and the resulting draft texts were distributed to the full workgroup for review and comment. **The workgroup's deliberations resulted in consensus on the major topics that are highlighted in this report.**

REPORT STRUCTURE

The remainder of the report text covers workgroup considerations and findings. The findings are organized by general and conditional charge areas, as described in the workgroup charter. This report, by design, uses a primarily bullet point format to present the workgroup's findings and recommendations. The workgroup understands that the sole audience for this report is the membership of the Water Sector Coordinating Council and the Water Government Coordinating Council, and the workgroup believed, in this context, a "to the point" report would best serve this readership. Importantly, the workgroup considered producing a more detailed and conventional text with a broader audience in mind and encourages Council members to maintain this report text within the confines of the Councils. An expanded text, with more complete explanations of findings, could be considered at a later date for more widespread distribution depending on the direction Council members select going forward.

Critical Considerations and General Findings

Through deliberations surrounding Charge Area 1, the evaluation of contamination warning system practices, workgroup members reached agreement on five Critical Considerations, ten General Findings and a set of Component-Specific Findings for each of the six component areas related to the potential effectiveness, ability to implement, and the long-term sustainability of contamination warning systems. The Critical Considerations establish the context in which CWS CIPAC Workgroup members have made their findings and the members believe it is essential for the audience of this document (WSCC and WGCC members) to understand that the findings are not deemed valid outside of the Critical Considerations framework.

CRITICAL CONSIDERATIONS

Critical Consideration #1

Workgroup members insist that all findings and recommendations in this report are interdependent, and therefore must be viewed and responded to as an integrated package. Workgroup members do not and will not support as valid Individual findings treated in isolation or taken out of the context of the broader CWS CIPAC report.

Critical Consideration #2

Workgroup members have interpreted the charge from the Water Sector and Government Coordinating Councils to entail an exploration of whether or not, and under what conditions, a water system **can** take actions to improve water contamination detection and response capability that are effective, implementable, and sustainable. Consistent with this interpretation, workgroup discussions did not explore whether or not, and under what conditions, a water system **should** take such actions. All workgroup findings, must, therefore, be understood to in no way suggest or endorse that water systems become subject to requirements for implementing contamination detection and response capabilities.

Critical Consideration #3

Workgroup discussions extensively explored the concept of a "contamination warning system." The workgroup has concluded that there is no single contamination warning system design that could be applied universally to utilities. There is, instead, an array of options available for improving water contamination detection and response capability at water systems. In this context, workgroup members have viewed the Cincinnati pilot contamination warning system as a research model designed to explore possibilities relative to broad, comprehensive, contaminant coverage and meaningful reduction in detection and response times (i.e., detection and response times that can produce consequence reduction). Its detailed and systematic evaluation by EPA does not provide the water sector with a blueprint for action, but rather provides the sector with valuable lessons learned regarding the options available (type, cost factors, performance, etc.). This information, coupled with that from other utility experiences, can assist water systems with tailoring contamination warning and response actions to local threat conditions and service needs.

Critical Consideration #4

Workgroup discussions also explored the "capability objective" that forms the basis for viewing any detection or response action as "effective." These discussions identified the following objectives relative to baseline conditions:

- More timely contamination detection and response resulting in fewer exposures or faster administration of therapeutic actions.
- Improved quality and better-corroborated information producing more confident decision making.
- More deliberate and organized response actions helping to maintain public trust and confidence.
- Improved forensic capability supporting more precise and targeted response actions to be taken by water system customers and public health partners.

Critical Consideration #5

Approaching contamination detection and response capabilities as an array of options to be tailored individually to local water system conditions will likely produce substantial deployment variability. Workgroup members believe this variability is advantageous to the sector and individual utilities, while recognizing the absence of a standard deployment model will necessitate creativity on the part of individual water systems. The absence of a standard deployment model

will also impede any offender from creating a standard operating procedure (SOP) to breach the security of a contaminant warning system.

GENERAL FINDINGS

Finding #1: Water systems have different needs and different opportunities resulting in different implementation.

- Individual water systems will experience different needs, different opportunities, and variable affordability for contamination detection and response capabilities.
- Local conditions, including contamination threat expectations, consequence reduction or other "dual-use" benefits, resources, and capabilities will govern implementation.
- The water sector can anticipate an appropriately varied level of contamination detection and response investment and activity by individual water systems.

Finding #2: Water systems have an array of options and substantial flexibility for improving contamination detection and response capabilities.

- Significant flexibility and many options exist in the design of a contamination warning system approach and supporting components.
  - Water systems can focus on procedural changes and the enhanced use of existing capabilities (e.g., more focused and frequent screening of customer complaints).
  - Water systems can choose to deploy an array of sophisticated equipment and information systems (e.g., on-line, real-time water quality monitors, GIS spatial dashboards).
  - Water systems can seek enhanced detection and response partnerships in their community (e.g., more structured and frequent contact with local public health departments).
- This flexibility makes enhancing contamination detection and response capability accessible in a wide range of water system operational contexts. Analysis and utility experience presented to CWS CIPAC members represented a range of system types, community conditions, starting capabilities, population served, capital and operation and maintenance (O&M) expenses, design objectives, and motivations for action.
  - EPA pilot utilities have or are deploying practices and technologies designed to provide broad contaminant coverage, and provide reductions in detection and response times that can be achieved through sophisticated technologies, automated data integration and analysis, and highly developed procedures and external partnerships. These systems require a substantial capital, O&M, and human resource commitment, even as successive pilots have leveraged previous experience to lower costs over time.

- Some non-pilot utilities (invited to present to the CWS CIPAC) have deployed a range of practices and technologies, with each utility mixing them to reflect specific local needs. Investment levels vary considerably among these systems, and all efforts have been locally funded.
- CWS CIPAC member utilities also have deployed a range of practices and technologies. They are mid-size systems that have self-funded their efforts, have had relatively low capital and O&M expense, and have developed on their own in-house capabilities to support the deployed equipment and practices.

Finding #3: Increases in contamination warning system sophistication and investments can provide for reduced detection and response times, while also placing additional capability demands on water systems and exposing them to additional challenges.

- Analysis indicates that as contamination detection and response capabilities increase and become more systematic (e.g., number, sophistication, and integration of components), the potential for reduced detection time and faster response time occurs.
  - The integration of multiple, independent monitoring and surveillance data streams can provide more rapid detection of a broader range of contaminants than a single data stream.
  - The potential for corroborating information from these multiple sources, in the event of a true contamination incident, can allow utility and public health officials to make decisions designed to protect public health with increased speed and confidence.
- As a water system seeks to increase contamination detection and response performance, particularly through deployment of specialized technology and information systems, the potential for challenges and capability requirements can increase and may include, but are also not limited to:
  - A validated water distribution system model to support sensor placement optimization.
  - Sophisticated information technology needs for integrating and analyzing diverse data streams.
  - Public health and first responder partnerships reflecting a willingness to make and maintain as a priority the possibility of water system contamination.
  - An ongoing and long-lived internal readiness culture despite the low probability of an intentional contamination incident.
  - Increasing capital and O&M cost requirements in the context of unknown total return on investment benefits (as the expected value of contamination risk mitigation depends on speculative event probabilities, leaving any business case dependent on sometimes difficult to quantify dual-use benefits).

- Contamination events, irrespective of contamination detection and response performance, may have consequences sufficient to raise substantial community concern.
- The reality that gaps in detection capability remain.
- The potential for water system staff desensitization from invalid alerts (which are anticipated to persist at rates that could make this a problem for some systems).

Finding #4: Investing in enhanced detection and response capability has produced dual-use benefits for water systems.

- All of the water systems providing information to the CWS CIPAC on their contamination detection and response capability investments have realized dual-use benefits. In certain cases, these benefits have been substantial and are calculated to pay back the investments in the near term (2–5 years).
- The types of dual-use benefits that could be realized based on this water system experience (recognizing that all dual-use benefits will be case specific) include the following:
  - Better understanding of distribution system hydraulics;
  - Improved process control;
  - Improved distribution system longevity;
  - Enhanced customer service;
  - Better detection of and response to accidental contamination or other distribution water quality conditions; and
  - More effective community partnerships for all incidents.

Finding #5: Water systems interested in enhancing contamination detection and response capabilities will be well served by structured assessments that are flexible and responsive to local conditions.

- The critical relationship of effective local tailoring to the effectiveness and implementation and sustainability aspects of contamination detection and response capabilities signals the need for water systems to assess needs and options carefully and in a structured manner.
- Water systems are anticipated to benefit from structured assessment to define needs, set appropriate design objectives, and understand the capability enhancements provided by various deployment options.
- An assessment framework would provide a process to follow and include and support:
  - Understanding vulnerabilities and local risk conditions;
  - Identifying current capabilities;
  - Reviewing enhanced capability options;
  - Providing high transparency regarding requirements, strengths, and limitations of enhanced capability options;
  - Identifying potential dual-use benefits;

- Developing a deployment approach consistent with local opportunities and capabilities; and
- Informing the water system about a progression of investments and practices for deployment that will systematically improve capabilities and optimize investments relative to selected design objectives.

Finding #6: Deploying contamination detection and response capabilities in a systematic manner is anticipated to provide the greatest consequence reduction potential.

- Utility experience indicates that there are at least three aspects of "systematically deployed" contamination detection and response capabilities that can support consequence reduction: establishing a capability for early detection; establishing a capability to corroborate alerts; and developing pre-planned response protocols and actions for sampling and analysis, public communication, and operations.

Finding #7: Consequence management capabilities are necessary under all contamination event scenarios (intentional and unintentional), and are therefore seen as fundamental to a complete emergency response plan (ERP) and need to receive early attention in developing contamination warning system capabilities.

- Early emphasis on pre-planned consequence management was identified as needed for water systems to reduce contamination event consequences.
- Workgroup members recognized that monitoring and surveillance components that are not supported with well-defined response actions related to sampling and analysis and consequence management will likely provide little value in mitigating potential consequences of contamination.

Finding #8: Intelligent, locally-tailored deployment can produce EFFECTIVE contamination detection and response capabilities.

- Structured assessment (see Finding 5), clear design objectives, and tailoring of detection and response practices and investments to local capabilities and needs can reduce consequences.
- Effectiveness, in any given context, will depend on the contaminant type and the location of its introduction into the distribution system relative to deployed design.
    - Consumer Complaint Surveillance (CCS), Public Health Surveillance (PHS), and Water Quality Monitoring (WQM) taken together have demonstrated the capability to detect a wide range of contaminants of concern with data on these selected contaminants indicating detection at concentrations below lethal levels.
    - Surveillance components (CCS and PHS) rely on customer observations and behavior, and, if properly established and used, can provide comprehensive spatial coverage throughout a distribution system.

  - Monitoring components (WQM and enhanced security monitoring (ESM)) have intrinsic limitations to the spatial coverage that each can achieve, while systematic placement of monitors can optimize the spatial coverage achieved.

- This detection capability married with field, laboratory, and consequence management response capabilities can (when capabilities are aligned with design objectives):
  - Reduce detection and response time (know more, sooner);
  - Produce more deliberate and well-planned response actions (know who to talk to, when, about what);
  - Increase the confidence of decision making (better and better understood information); and
  - Enable earlier, more precise and better targeted public health intervention (response and mitigation).

Finding #9: Utility experience indicates contamination detection and response capabilities can be IMPLEMENTED.

- Utility experience indicates that the technology, tools, methods, and expertise exist (to a sufficient degree) and that the needed partnerships can exist, to support improved contamination detection and response capabilities.
  - Needed monitoring and surveillance data streams exist, to some degree, in most drinking water systems.
  - There are tools and products available to support deployment of each of the six components.
  - Guidance is available for the development of plans and procedures that can help a utility of any size utilize existing and enhanced data streams more effectively to monitor distribution system water quality.
- Some utilities have been, and others may be, successful at building the necessary partnerships with public health and first response officials to make response to water contamination a priority.
- The needed partnerships are, however, outside of direct utility control and can come under a variety of pressures that may leave some utilities unable to establish and maintain these relationships.
  - Budget cuts to local public health or first responder agencies can severely limit capacity.
  - Lack of understanding or a preponderance of other priorities can leave water contamination as a lower priority for prospective water utility partners.
  - Limited cooperation can exist due to varied local, jurisdictional interests.

Finding #10: Utility experience indicates that SUSTAINABILITY can be achieved, but represents an on-going challenge for water systems.

- Dual-use benefits are seen as critical to the long-run sustainability of enhanced detection and response capabilities in the absence of a strong contamination risk driver. Operational benefits, such as improved customer responsiveness and operational optimization, provide an ongoing basis for maintaining capabilities.
- Maintaining detection and response capabilities over time will require strong leadership commitment and sufficient dual-use benefits or a persistent expectation of contamination risk.
- Invalid alerts, even after system optimization, can remain sufficiently high to risk staff desensitization. Invalid alerts will, therefore, necessitate development of a well managed alert investigation process to minimize impact and maintain attentiveness.
- The local understanding of contamination risk potential and the overall emphasis on water security at a water system play a critical role in sustainability.

Component-Specific Findings

This section lists a set of bulleted findings related to each of the six components of a CWS. These specific findings support the general findings above.

CONSUMER COMPLAINT SURVEILLANCE

- Based on common utility practice, though baseline capability for utilities can vary substantially, from:
  - Informal telephone response; to
  - Highly automated, trained and dedicated staff, with calls triaged, categorized, and routed based on systematically deployed criteria.
- Procedural or system changes (e.g., water quality matrix) can support more timely detection of contamination incidents that generate customer calls (particularly for contaminants with taste, odor, visual, or aesthetic impacts).
- Automation, along with an event detection system can further increase timeliness of detection, but will require advanced IT skills.
- CCS can produce important dual-use benefits in the form of improved customer service (improved responsiveness).
- Lower requirement CCS investments and actions currently in use by utilities include, but are not limited to:

- Advertise the primary complaint telephone number in the annual consumer confidence report to ensure that more calls are funneled to a central location.
- Implement a "water quality" category for complaint calls that may be indicative of water contamination, and increase the frequency of complaint call reviews from, for example, once per day to two or three times per day.
- Estimate call volume thresholds based on experience rather than statistical analyses.
- Print out a map of the distribution system, display it on a wall, and mark water quality-related work orders on the map to identify clustering of calls that may be indicative of contamination.

PUBLIC HEALTH SURVEILLANCE

- Public health surveillance is broadly practiced, to a varying degree, by local public health agencies.
- Among the detection components, PHS is the component with the potential to detect the broadest range of contaminants. Any contaminant that results in acute symptoms in an exposed individual has the potential to be detected by PHS, and the majority of contaminants of concern to drinking water security can produce acute symptoms within minutes to days of exposure.
  - PHS, deployed effectively, is the only means to detect contamination under certain scenarios.
  - There can be delayed detection times for certain contaminants relative to other detection capabilities (e.g., several days can elapse between exposure to a pathogen and onset of symptoms that would drive health seeking behaviors that are monitored by PHS).
- Establishing a partnership between the water system and local public health agency can support:
  - More timely identification of water contamination-related public health impacts.
  - More deliberate and organized response to water contamination events.
- There are a range of options for water system-public health partnerships:
  - Identification of who to call and basic, joint assessment protocols and joint response procedures.
  - Integration of public health surveillance data with the water system's contamination warning approach.
- Challenges water systems will face include a wide range of local capabilities, capacity, and interest on the part of potential local public health partners setting up difficulties for some systems to establish and maintain effective partnerships:

  - Moving beyond a basic relationship to a partnership that reflects capacity on the part of the public health agency to detect and respond to water contamination.
  - Establishing and maintaining water contamination as a priority.
  - Managing for the varying and potentially declining capacity of local public health agencies.
- Lower requirement PHS practices and investments include, but are not limited to:
  - Establish and maintain communication practices between public health and water utility personnel. These could include:
    - Standard communication procedures;
    - Formation of a User's Group (providing a forum to discuss cross-cutting public health and water quality issues); or
    - Standard procedures for investigation of a possible waterborne disease outbreak.
  - Leverage existing public health surveillance tools and techniques for early detection of possible waterborne contamination.

WATER QUALITY MONITORING

- The WQM component has the potential to provide for rapid detection of a wide range of contaminants, as demonstrated through laboratory tests and distribution system modeling and simulated contamination incidents.
- Simulation studies indicate that monitoring conventional water quality parameters (e.g., chlorine, pH, conductivity) has the potential to detect certain high consequence contamination scenarios (those with no aesthetic effects and with longer times for onset of symptoms) that would not otherwise be detected in time for exposure-reducing response actions.
- The addition of other WQM parameters (e.g., UV, TOC) or sensors (e.g., GC) can further expand the range of contaminants covered or the confidence in detection. In the future, new technologies may augment or replace monitoring for water quality parameters as a surrogate for drinking water contamination with sensors that target specific contaminants or contaminant classes, or which serve as a more precise surrogate for contamination.
- Conventional WQM (e.g., CL(2), conductivity, UV(abs)) has been demonstrated through practical application to be able to detect abnormal water quality (intentional and unintentional).
- Effectiveness depends on:
  - Type, number, and placement of sensors (tools do exist to support sensor placement optimization);
  - Data collection frequency and analysis procedures; and
  - Effective maintenance and calibration of the equipment.

- Dual-use benefits may be achieved in the form of operational optimization, improved compliance, and enhanced distribution system knowledge.
- Useful knowledge and guidance documents exist on technology options and sensor placement for WQM and information exists, and is anticipated to continue to emerge, on pilot and other system performance.
- Challenges can include, but may not be limited to:
  - Achieving an acceptable invalid alert rate and developing an alert investigation process to effectively manage invalid alerts that minimizes operational impact and maintains staff attentiveness.
  - Variability in distribution system water quality (baseline water quality values that fluctuate due to, for example, utilizing different sources of raw water), among other conditions, has been shown to complicate invalid alert rate management.
  - Monitoring for total organic carbon (the instrumentation is expensive and has had reliability problems, while UV absorbance holds potential as a suitable alternative).
  - Relative to other CWS detection components, initial capital costs and on-going O&M costs have been high (actual costs will depend on the number and type of sensors installed) , even as utility experience (learning curves) have provided for more cost optimized deployment approaches.
  - Sensors must be well maintained and calibrated, through ongoing, consistent utility efforts.
  - Detection gaps exist (e.g., radionuclides and direct detection of pathogens).
- Lower requirement CWS practices and investments include:
  - Place sensors using expert knowledge (e.g., a team of staff with detailed distribution system knowledge agree on important areas for sensor placement) rather than using optimization software tools (such as TEVA-SPOT) that depend on a system hydraulic model.
  - Leverage existing water quality monitoring equipment (e.g., online chlorine monitors).
  - Analyze water quality data using set points or visual/manual inspection (in place of more sophisticated event detection software.
  - Establish and maintain communication between water utility departments, including developing standard procedures for the investigation of abnormal water quality.

ENHANCED SECURITY MONITORING

- The water sector has significant experience with enhancing security through real-time notification of intrusion events.

- ESM can be used at the most vulnerable and high-consequence areas at utility facilities to deter intrusion or optimize consequence reduction in the event of actual contamination.
- Guidance is available on vulnerability assessments, risk ranking, and prioritizing enhancements.
- ESM incorporating real-time surveillance can improve timeliness of detection or response to physical intrusions.
  - Provides the potential for consequence prevention:
    - Deterrence effect
    - Witness an intrusion
- Effectiveness depends on:
  - Coverage;
  - Location;
  - The degree to which monitors are embedded and integrated into an overall, comprehensive program including first responder partnerships;
  - Routine monitor maintenance;
  - A staff culture of support (e.g., staff not violating procedures);
  - Nature of event; and
  - Assessment capabilities.
- Provides a variety of dual-use benefits:
  - Vandalism reduction;
  - Intrusion deterrence; and
  - Forensic capability.
- Subject to several challenges including:
  - Rapidly changing technology (providing improved performance but increased maintenance demands and capability sophistication); and
  - Water system alarms may be perceived as a low priority for first responders without adequate outreach and education.
- Lower requirement CWS practices and investments can include:
  - Review an existing vulnerability assessment with emphasis on the contamination risk for each identified site and rank the sites for potential enhanced security monitoring equipment based on historical knowledge or best professional judgment of risk.
  - Install contact switches on hatches, doors, or ladders that have direct access to finished water and wire these devices into equipment that may already be present at the site to leverage existing communications media, such as SCADA combined with alarm assessment capabilities.

- Integrate site investigation procedures with local law enforcement to provide better response and more awareness of the water contamination threat.

SAMPLING AND ANALYSIS

- Sampling and analysis (S&A) is a necessary response action, and pre-planned sampling and analysis is key to timely, safe, and deliberate response action.
- Utilities can implement by utilizing or expanding existing capabilities to collect samples and coordinate sample analyses (in-house or with response partners and external laboratories).
- Basic start-up activities include (note these activities will typically be undertaken as part of contamination-related consequence management planning):
  - Identifying contaminants of concern;
  - Identifying internal and external laboratory capabilities;
  - Determining emergency response partners;
  - Developing emergency response procedures; and
  - Acquiring rapid field test capabilities.
- S & A can be sustainable if:
  - Acquired in-house capabilities have dual-use benefits; and
  - Add minimal costs to normal operations.
- Challenges can include but are not necessarily limited to:
  - Maintaining list of currently active lab contacts and capabilities (laboratory response networks);
  - Establishing distribution system baselines;
  - Obtaining (capturing) contaminated water;
  - Instituting effective contracts with labs (guaranteed turnaround times); or
  - Sampling for unknowns.
- Dual-use benefits include:
  - Compliance support; and
  - Operational optimization support.
- Lower requirement S&A practices and investments include:
  - A utility with minimal in-house capabilities might plan to perform sample collection but rely on response partners (HazMat and contract labs) for field hazard assessment and laboratory analyses, respectively.
  - A utility with minimal in-house capabilities could mine historical data and utilize partner laboratories to establish baseline contaminant occurrence and method performance.
  - Develop procedures for emergency response that encompass all S&A activities to be performed by the utility and establish notification protocols for laboratory and field

response partners. Refine and practice procedures through drills and exercises at the component level, the utility level, and with external partners.

CONSEQUENCE MANAGEMENT PLANNING

- Monitoring and surveillance components that are not supported with well-defined response procedures may have little value in mitigating potential consequences of contamination.
- Response to contamination incidents usually requires specifically tailored procedures and pre-planning.
- Consequence management builds off of conventional utility capabilities in the form of ERPs.
- Execution of pre-planned public notice procedures in parallel with credibility determination activities is critical to consequence reduction potential. Procedures that allow for public notification without completed laboratory results can substantially reduce response timeframes and attendant consequence potential.
- Exercises with staff and community response partners can increase timeliness and efficiency of response.
- Establishing and maintaining water contamination as a local community first responder priority may be challenging without adequate outreach and education.
- Must emphasize that CMP is an integral part of the ERP, not a separate, standalone plan.
- Lower requirement CMP practices and investments include but are not necessarily limited to:
  - Review existing ERPs and pre-plan the credibility determination process associated with a contamination incident. Identify key response partners and gather their input on roles and responsibilities.
  - Ask if local responders use common communication devices, such as 800 MHz radios, during emergency situations and request that the utility receive one or more of the devices for use during a contamination incident or other emergency situations involving water supply.
  - Outline major areas of the distribution system that could be isolated during a contamination incident, and outline a SOP for implementing isolation.
  - Implement an incident command structure at the utility to more effectively respond to a potential contamination incident.
  - Conduct exercises together and become familiar with each other's protocols.

Conditional Charge Areas

The workgroup Charter identified two objectives: 1) evaluate CWS practices; and 2) make recommendations in one of two additional "conditional charge" areas—the structure of a national program to promote adoption of CWS practices; or addressing deficiencies in CWS practices. The workgroup's final Critical Considerations and Findings prepared in response to the first objective have dictated that the workgroup address both conditional charge areas. The workgroup took this approach in response to having concluded both that monitoring, surveillance, and response practices implemented as components of an early warning system for drinking water contamination events can be effective, implementable, and sustainable under certain conditions and that there are some deficiencies in the design, implementation, or operation of contamination warning system practices. What follows are the workgroup's suggestions for the structure of a national program to promote adoption of CWS practices (Conditional Charge Area A), as well as for the gaps identified in the current development and understanding of CWS components (Conditional Charge Area B).

CONDITIONAL CHARGE AREA A

Charge to the CWS CIPAC:

> *If the workgroup identifies contamination warning system practices that are effective, implementable, and sustainable under Objective 1, then the workgroup will develop recommendations for the structure of a national program to be implemented by the EPA in partnership with the water sector to promote the adoption of these practices by drinking water utilities. These recommendations should consider the features of other successful voluntary water sector programs and potential opportunities to leverage existing programs.*

In responding to this charge area, the workgroup identified recommended program attributes, objectives, and building blocks in the form of prioritized actions for an organized effort (e.g., a program) to promote adoption of CWS practices by interested water systems. Regarding program attributes, the workgroup believes it is critical for the program to be **voluntary**, **flexible** (meaning it can and will be tailored and adaptable to local conditions and needs), and **locally driven** (decisions on the type and degree of investment in contamination detection and response capability will remain fully with local communities).

In addition, the workgroup identified four national program objectives that reflect their Findings regarding CWS components and practices. These objectives define the extent to which the workgroup expects a national program to exist, provide an anchor for the specific program actions identified by the workgroup, and establish the ability to track and measure program implementation success.

CWS National Program Objectives

1. Increase knowledge in the water sector regarding:
    a. The options available for increasing contamination detection and response capabilities;
    b. The operational and other requirements for implementing these capabilities; and
    c. The performance, cost-benefit, implementation pros and cons, and other characteristics of these capabilities.
2. Create opportunities for water systems to make well informed decisions about, and locally tailor, contamination detection and response capability investments.
3. Strengthen the local community context for the emergence and maintenance of public health, first responder, water utility, and state primacy agency partnerships in support of contamination detection and response capabilities.
4. Provide additional, voluntary incentives for the adoption of practices that increase contamination detection and response capabilities.

As with any national program, the workgroup has observed that a voluntary water sector program to promote adoption of contamination warning system practices by water systems should be based on a clear understanding of the nature of the need within the sector. Understanding the need can assure that the program is value-added and that there is a compelling reason for the program's existence. The workgroup recognizes that further testing of the specific needs of the sector to refine the sense of valuable actions that can be taken could be beneficial prior to launching a program. In addition, the workgroup recognizes that any national program will require ongoing financial support. Therefore, there is a need as part of program development to identify what sources of funding can or will be available both for the program itself, as well as for direct support for implementation efforts by water systems.

Information Delivery Methods

As part of its discussion of this conditional charge area, the workgroup identified several different modes of delivery for the type of program actions and related methods and tools identified below. Any one of the program actions could be carried out via any one (or combination) of the following modes of delivery.

- **Guidance** covering a range of levels of information from simple one-pagers to more complicated decision support tools, as well as a range of formats (ensuring that no matter the format, it is user friendly) from hard-copy checklists to video presentations (potentially using American Water Works Association's videos as a model) to interactive, IT-based tools.
- **Training** provided through existing water sector agency opportunities or as an independent course (similar to the National Incident Management System type training or the Response Protocol Toolbox training).
- **Reference documents** built off of the extensive, existing body of work.

- **Information sharing networks** allowing for quick and easy access to relevant information and interaction with utilities undertaking similar or desired activities (building on the WaterISAC).
- **Assessment Teams** or other forms of direct technical support.
- **Case examples** providing real-world experience.
- **Lessons learned reports** highlighting pros and cons of various implementation options and activities.

CWS National Program Actions

The workgroup produced a list of specific actions in support of the four program objectives. The initial list was further organized and refined through a ranking exercise designed to provide a general sense of the priority for these actions. This "ranking" of program action items is designed to inform future national program implementers where initial efforts could best take place in support of the voluntary, flexible, and locally-driven program attributes envisioned by workgroup members. Importantly, the results of the exercise indicate the aggregate response of the group, even as individual workgroup member perspectives may diverge (e.g., one workgroup member may have ranked as "high" an item that resides in the "low priority" category). Where specific actions have natural affinities, they are grouped together under a category of actions. The discussions and ranking exercise led to the identification of a clear top priority category of actions, five high priority categories of actions, four medium priority specific actions, and one category of low priority actions, along with six additional lower priority specific actions. Specific actions within each priority level or under each category of actions are listed in no particular order.

Top Priority

Increase knowledge and understanding of CWS practices and opportunities. This category of actions focuses on providing both descriptive (e.g., what are the components of a CWS) as well as analytical (e.g., what are the costs and benefits of components of a CWS) information to bolster the understanding of and opportunities for implementation of CWS practices. The information is meant for use within water systems as well as in outreach efforts by utility managers and others. The specific action items identified in support of this area are:

- Create an overview of the components of a contamination warning system.
- Characterize pros and cons of CWS practices with respect to meeting effective, implementable, and sustainable design objectives, cost factors, and potential primary (reduced impact from contamination events) and dual-use benefits of each of the CWS components.
- Prepare a standard presentation and/or other supporting materials promoting the dual benefits and cost effectiveness of implementing water contamination security actions and clearly demonstrating the value proposition for enhanced capabilities for use in outreach to management and decision makers (e.g., city councils, mayors, state primacy agencies).

- Better articulate and raise the profile of the opportunities for improvement in the area of contamination warning systems and the benefits of doing so, including public health and safety.

High Priority

Encourage and support coordination with key partners. This category of actions focuses on developing and sustaining workable relations between water systems and public health, first responder, and state primacy agency partners, acknowledging that for these relationships to be successful they will have to be forged at multiple levels, as well as encouraged from both sides. These actions also look to strengthen the context for these needed partnerships to emerge and be maintained. The specific action items identified in support of this area are:

- Coordinate at the national and state level with key agencies and associations to create a framework that supports and motivates engagement by local public health and first responder partners with utilities. For example, look for ways to expand Center for Disease Control's regional advance practice centers and to connect with state primacy agencies to aid in providing relevant information to utilities and communities.
- Provide guidance to utility managers on how to recognize the importance of partnerships with public health partners, first responders, and state primacy agencies including benefits of participation in partnerships of this type.
- Equip local utility managers with the information needed to initiate and maintain public health, first responder, and state primacy agency partnerships, including effective partnership models.

Provide guidance on enhancing ERPs. This category of actions focuses on emphasizing the importance of establishing contamination response capability as an important first step in any CWS, as well as supporting utilities in their efforts to establish consequence management planning as part of their overall ERPs. The specific action items identified in support of this area are:

- Provide guidance on how to enhance existing ERPs to include CMP components.
- Include information for utility field personnel regarding potential hazards associated with suspected water contamination incidents and appropriate assessment.

Share success stories and best practices. This area speaks to building "communities of practice" with regard to contamination detection and response capabilities. The specific action item identified in support of this area is:

- Establish a platform for the exchange of information on success stories, best practices, and positive and negative outcomes across the CWS component areas.

Provide a means for assessment. The actions in this category focus on bolstering a utility's ability to assess and evaluate its current capabilities and needs based on local conditions, and on comparing and choosing implementation options that best fit those capabilities and needs. The specific action items identified in support of this area are:

- Develop procedures/methods for utilities to assess existing resources and capability gaps for contamination detection and response, as well as a structured process to identify preferred actions to address those gaps that supports water systems of different sizes and capabilities to customize their participation based on their local security concerns, technical skills, and available resources.
- Develop methods and tools to assist utilities in the evaluation, selection, and configuration of event detection systems.

Identify options and provide procedural guidance for implementation. To complement the assessment actions above, these actions look to help identify and support appropriate implementation efforts. The specific action items identified in support of this area are:

- Provide an overview of options for implementing CWS components.
- Draft easy-to-use practice and procedure guidelines in support of cost-effective contamination detection and response components (e.g., a simple customer service matrix for screening customer complaint calls that could be incorporated into everyday water system operation, and approaches for water quality monitoring placement).

Medium Priority

The items that landed as medium priority were individual in nature and did not relate to a broader category or have a strong affinity with other items. What follows is a list of four specific actions.

- Examine opportunities for leveraging distribution system monitoring performed as part of a CWS for purposes of meeting other utility requirements.
- Explore opportunities for matching fund availability (e.g., State Revolving Fund eligibility).
- Develop guidance on building field and laboratory response capabilities, including coordination with laboratory networks providing specialty analysis, such as select agents.
- Provide information related to threat assessment for both intentional and unintentional contamination.

Low Priority

In the workgroup's ranking exercise, there was a clear cut point for the actions landing as low priority, with few to no high votes and/or less overall votes than other actions or categories of actions. Three individual actions pertaining to providing recognition as a means of motivating water sector behavior all fell into this category, as did a number of individual action items, which follow below.

Provide recognition

- Develop and implement a certification program for utilities or cities verifying their contamination detection and response capabilities.

- Recognize individual operators who have demonstrated obtaining a certain level of knowledge regarding enhanced water contamination security practices.
- Recognize water system efforts through a structured program, perhaps modeled after the Partnership for Safe Water.

Other low priority actions

- Develop guidance on placement of online water quality sensors without a hydraulic model, and improved guidance for use of modeling tools, such as TEVA-SPOT, for placing sensors.
- Provide access to available information on threats (e.g., fusion center relationships).
- Create guidance on how to bolster customer service support in a manner that emphasizes the importance of water utility representatives being able to screen and recognize the serious nature of a water quality complaint.
- Provide information on horizontal and vertical communication and protocols.
- Provide information on the logistical requirements (e.g., the type of equipment needed and the plan and procedures for timely access to that equipment) of detection and response.
- Develop relationships with water sector vendors to incorporate, where applicable, contamination detection and response capabilities into their existing products.

CONDITIONAL CHARGE AREA B

Charge to the CWS CIPAC:

> *If the workgroup determines that contamination warning system practices evaluated under Objective 1 are not effective, implementable, and sustainable, then the workgroup will develop recommendations to address deficiencies in the design, implementation, or operation of such practices. These recommendations may include additional research and development activities and alternative approaches to early detection of drinking water contamination.*

In response to Conditional Charge Area B, the workgroup identified a number of research and other analytical needs to address areas of deficiency in current knowledge of CWS practices. The workgroup believes that addressing these areas can create greater certainty in the future and alleviate some of the concerns raised in the Critical Considerations and Findings. Similar to Conditional Charge Area A, the workgroup conducted a ranking exercise on the identified needs to provide a general sense of what needs are most critical in terms of addressing the existing knowledge gaps. Likewise, the results of this ranking exercise indicate the aggregate workgroup response, even as individual workgroup member perspectives may diverge. High priority needs are grouped into three common areas. Specific actions within each priority level or under each category of actions are listed in no particular order.

High Priority

Information to help identify and manage costs and maximize dual-use benefits

- Further work to identify best practices in the design of a system that can optimize costs and maximize dual benefits.
- More research and analysis on what a range of water systems are doing in practice to implement CWS components, including more documentation of dual benefits (what are they and how are they achieved).
- More data on costs (both capital and O&M) by CWS component and system-wide.
- Lessons learned regarding effective techniques for managing costs.

Evaluation of new technologies

- Continued evaluation of new technologies for cost and performance.
- Assessment of technologies to fill gaps in key water quality parameters detection capability (e.g., pathogens and radiologicals).

Greater development of options for field testing and detection

- Further development of sampling methods and conformity criteria for rapid field detection and response decision making.
- Additional research and development on simple and affordable field testing equipment and sampling methods for rapid detection and response, including information on comparative technology performance and validation.

Medium Priority

- Additional research to examine different combinations of individual CWS components to better characterize the improvement in detection and response capabilities, cost, effectiveness, and level of effort they represent and the potential dual benefits, including performance evaluation of alternative approaches to event detection.
- Information that addresses needs related to consequence management/moving past detection and response to recovery (e.g., decontamination procedures for distribution systems and processes for regulatory waivers/suspensions).
- Methods for system or component sustainability, such as using policies and standards and protocols to address the challenge of utility staff and management changes.
- Information on staffing type and level needed for implementation of CWS components.
- Further development of information sharing and data management protocols for use with public health and first responder partners.

Low Priority

- Additional assessment of syndromic public health data streams.
- Further refinement and availability of the list of contaminants determined to be of potential concern to water systems.
- Real life examples and approaches taken by small systems in implementing CWS components.
- Characterization of vulnerabilities that can arise from greater dependency on data automation and response options to those vulnerabilities.
- Exploration of the influence EPA grant requirements may have had on costs for implementing CWS components at the pilot utilities.

Conclusion

The CWS CIPAC workgroup has concluded that water systems can take actions to improve water contamination detection and response capabilities that are effective, implementable, and sustainable. The workgroup has further concluded that there is no single contamination warning system design that can be universally applied to all water systems. There is, instead, an array of options available for improving water system contamination detection and response capabilities. In this context, an effective, implementable, and sustainable contamination warning system will be voluntary and reflect specific tailoring to local utility and community needs, opportunities, and conditions. Producing such a tailored outcome will be substantially aided by the availability of structured assessments that are flexible and responsive to the needs of individual utilities. The workgroup also recognized that consequence management capabilities are necessary under all contamination event scenarios, and are therefore fundamental to a complete ERP and need to receive early attention in developing CWS capabilities.

Having concluded that CWS practices can be effective, implementable, and sustainable, and recognizing that a variety of water systems around the country are exploring or initiating CWS deployment, the CWS CIPAC workgroup has provided recommendations for actions that can be taken in support of a national program to promote adoption of practices and in support of addressing deficiencies in the design, implementation, and operation of such practices. These actions focus on better informing the water sector of the options, requirements, and performance of CWS practices; on enabling water systems to make well informed decisions about and locally tailor contamination detection and response capability investments; strengthening the local community context for the emergence and maintenance of public health, first responder, and state primacy agency partnerships that are an essential part of effective deployment; and enhancing capabilities either where gaps currently exist or where current performance remains less that optimal. Moving forward with these actions will help the water sector draw effectively on current experience, make investments consistent with local needs and conditions, and advance the performance of CWSs in the future.

Appendix – Analytical Framework

DRINKING WATER CONTAMINATION WARNING SYSTEM ANALYTICAL FRAMEWORK

Criteria from the Workgroup Charge

The first action undertaken by the workgroup will be to evaluate whether or under what conditions monitoring, surveillance, and response practices deployed as components of an early warning systems for drinking water contamination are effective, implementable, and sustainable. Assessment of these criteria will include, but is not limited to, the following: "effective" will address the potential to reduce public health and/or economic consequences of a drinking water contamination event; "implementable" and "sustainable" will address the practicality of a water system deploying, operating, and maintaining the contamination warning system components, including costs and benefits.

Effective: A component's effectiveness is the degree to which it can contribute information of sufficient quality and in a time frame during a contamination event that allows response actions to reduce public health or economic consequences.

Questions to be Addressed	Applicable Contamination Warning System Component						
	WQM	PHS	CCS	ESM	S&A	CM	CWS
1. Contaminant coverage 1.1. What priority contaminants or contaminant classes does the component have the potential to detect? 1.2. What are the detection limits relative to concentrations of health concern? [1] 1.3. For contaminants at concentrations that the component has the potential to detect, what is the sensitivity (e.g., true positive or false negative rate)?[1]	X	X	X		X		X
2. Spatial coverage 2.1. What percentages of the distribution system and population does the component cover? [1]	X	X	X	X			
3. Timeliness of detection and response 3.1. How much time will elapse between contaminant injection and a component alarm? [1]	X	X	X	X	X	X	X

3.2. How much time is required to investigate component alarms? [1] 3.3. Under what conditions can the component detect a contaminant in time to allow response actions that reduce consequences? [1,2] 3.4. What is the impact of data integration among multiple components on timeliness of detection? [1,2]							
4. Operational reliability 4.1. What percentage of time is the component operational? [1] 4.2. What redundancy is associated with the component and system and how important is redundancy for maintaining contaminant coverage? [1] 4.3. How complete and how accurate are the data generated by the component? [1] 4.4. What conditions (e.g., power outage, equipment problems, communication disruption) affect the operational reliability of the component and system, and can these conditions be reduced?[1]	**X**	**X**	**X**	**X**	**X**		**X**
5. Alert occurrence 5.1. What are the rates of invalid and valid alerts generated by the component and system? [1] 5.2. What were common causes of valid and invalid alerts, and can invalid alert rates be reduced?	**X**	**X**	**X**	**X**	**X**		**X**
6. Consequence reduction 6.1. What reduction in public health and economic consequences can be attributed to a contamination warning system (considering different designs and configurations, including all components vs. a subset of components)? [2]							**X**
Implementable and Sustainable: Is it practical for a drinking water utility to deploy, operate, and maintain the component or system in a manner that operates effectively (as addressed above)?							
Questions to be Addressed	**Applicable Contamination Warning System Component**						
	WQM	**PHS**	**CCS**	**ESM**	**S&A**	**CM**	**CWS**
7. Cost 7.1. How much does deploying the component or system cost (e.g., utility LOE, contractors, equipment costs)? [1]	**X**	**X**	**X**	**X**	**X**	**X**	**X**

7.2. How much does operating and maintaining the component or system cost (e.g., utility LOE, contractors, maintenance contracts, supplies, equipment replacement)? [1]							
8. Specialized knowledge 8.1. What specialized skills, knowledge, and training are required to deploy, operate, and maintain the component or system? [1]	**X**	**X**	**X**	**X**	**X**	**X**	**X**
9. Tools 9.1. Are currently available tools, methods, and guidance information adequate to deploy, operate, and maintain the component or system?	**X**	**X**	**X**	**X**	**X**	**X**	**X**
10. Institutional and organizational functions and constraints 10.1. What institutional functions (e.g., public health department monitoring and screening of public health complaints for linkage to drinking water contamination) and communication mechanisms are needed in the community to deploy and operate the component or system? 10.2. What types of internal organizational changes were necessary (e.g., procedures, work flows between departments); how difficult were they to make; have they been sustained; and what is their overall impact on organizational effectiveness? 10.3. What types of authorities are needed to deploy and operate the component or system; and what authorities should control the component or system?	**X**	**X**	**X**	**X**	**X**	**X**	**X**
11. Dual-use benefits 11.1. What dual use benefits does the parameter, component, or system provide to the utility and community (e.g., aside from detecting intentional contamination events, how can the component enhance utility operations or improve general preparedness in the community)? [1,2] 11.2. What dual-use benefits are associated with the monitoring of different suites of contaminants? [1]	**X**	**X**	**X**	**X**	**X**	**X**	**X**

12. **Business case** 12.1. What is the business case for the component or system (e.g., how do the contamination event impact reduction benefits and dual-use benefits compare to costs)? 12.2. What are the consequences of false alarms in a contamination warning system? 12.3. What do current data indicate about the application of the component or system to utilities of different sizes?[3]	**X**	**X**	**X**	**X**	**X**	**X**	**X**

[1] Response will be conditional on the component and/or contamination warning system design and existing utility infrastructure
[2] Response will be conditional on the integrated contamination warning system
[3] Envisioned as question that the workgroup will explore