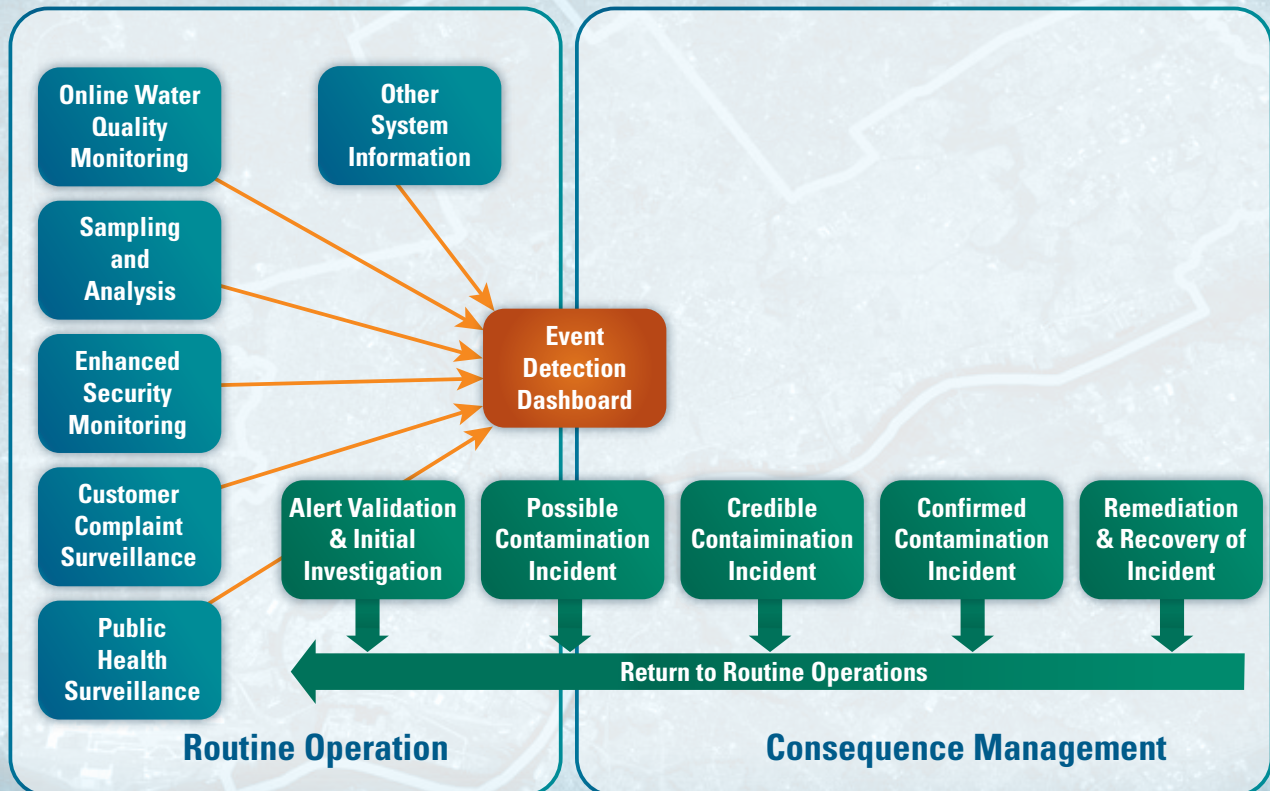


Philadelphia Water Department
 Contamination Warning System Demonstration Pilot Project:

How to Select an Online Water Quality Monitoring Data Management System



EPA Disclaimer

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This paper can also be downloaded from www.ch2mhill.com/iws.

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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). The integration of multiple information streams is a core element of a CWS. The primary objective of the system engineering and data integration component is to combine the five surveillance components into a centralized platform that can be used to determine whether a water contamination event has occurred and to facilitate appropriate response and consequence management actions. The Online Water Quality Monitoring (OWQM) data management system (DMS) must include the functionality for accessing water quality and must have interfaces to allow interaction with other systems in the CWS. After a comprehensive review of the water quality monitoring data requirements and an open solicitation of software solutions from appropriate software vendors, PWD purchased a new OWQM DMS.

This paper provides information and recommendations for selecting an OWQM DMS based on PWD's experience during the CWS Pilot Project. PWD selected an OWQM DMS to analyze the data for both operational and contamination detection purposes. The OWQM DMS was selected using a two-step process: 1) definition of the OWQM DMS requirements and 2) vendor selection.

Project Background

PWD developed a comprehensive CWS for its drinking water system under a Water Security (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 (OWQM)
2. Sampling and analysis
3. Enhanced security monitoring
4. Customer complaint surveillance
5. Public health surveillance
6. Consequence management

The integration of multiple information streams is a core element of a CWS. The primary objective of the system engineering and data integration component is to combine the five surveillance components into a centralized platform that can be used to determine whether a water contamination event has occurred and to facilitate appropriate response and consequence management actions. The OWQM component of a CWS provides continuous water quality data from online monitors installed at critical locations throughout the drinking water distribution system.

The OWQM component includes the water quality sensors, local and central data collection hardware, and software required to detect potential contamination in the distribution system and provide an alarm to remote monitoring facilities. As part of the CWS, the OWQM data management system must include the functionality to access water quality and must have interfaces to allow interaction with other systems in the CWS.

After a comprehensive review of the water quality monitoring data requirements and an open solicitation of software solutions from appropriate software vendors, PWD purchased a new OWQM DMS. PWD selected an OWQM DMS to analyze the data for both operational and contamination detection purposes. The OWQM DMS was selected using a two-step process: 1) definition of the OWQM DMS requirements and 2) vendor selection.

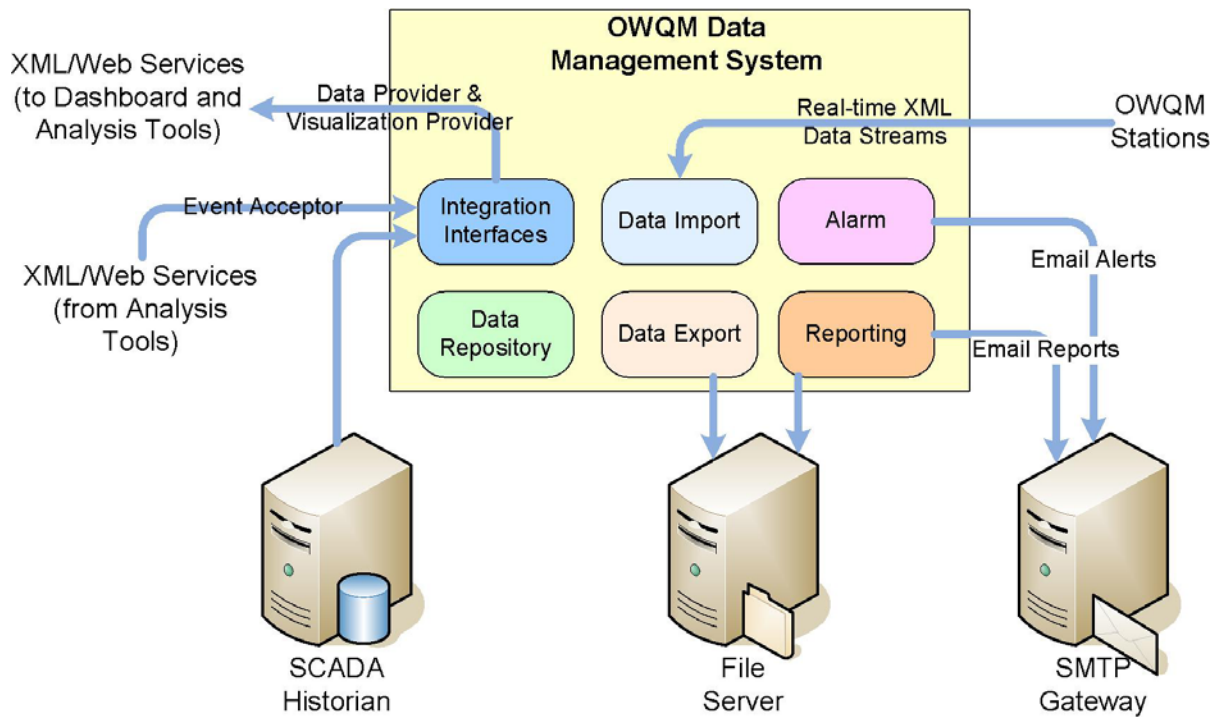
OWQM Data Management System Definition

The main functions of an OWQM DMS are to store, analyze, and visualize the water quality data on a continuous basis. The OWQM DMS also supports water quality studies and detects the impact of operational changes in water quality parameters. The OWQM DMS must include interfaces to import and export data and results, generate reports, and send notifications.

The objectives of an OWQM DMS are to 1) perform advanced data analyses, such as time-series trend analysis, multi-parameter clustering, and single parameter thresholding for identifying unusual water quality events due to either intentional or unintentional causes and 2) facilitate response to address these issues.

Figure 1 illustrates the role of an OWQM DMS within the overall CWS data architecture.

FIGURE 1
OWQM Data Management System Overview for a CWS



From a high-level requirements perspective, an OWQM DMS should perform the following:

- Import and store sensor measurement and state data (operational and communication status) at a specified time frequency from other relevant databases and systems.
- Based on operational and communication status and other characteristics, determine whether data are valid or invalid, and whether the quality of the data is sufficient to assess water quality.
- Analyze valid sensor data to assess water quality and sensor states.
- Generate and manage alarms based on sensor states and water quality determined by the analysis of a) valid sensor data and b) calculated water quality parameters.
- Generate notifications, follow-up notifications, and escalated notifications to appropriate personnel in the event of alarms.
- Generate standard and user-configured reports.
- Control access to all data, results, reports, and system administration tools.
- Run 24/7 and be accessible to authorized users at all times.
- Securely store data and allow easy retrieval. Typically data repositories should house the past 10 years' worth of data.

In summary, OWQM data management system definition should cover detailed functional requirements and technical requirements for the OWQM DMS. Utilities should take the time to meet with key users and stakeholders to document these specific requirements. Requirements should focus on data management, analysis, and reporting capabilities.

Functional Requirements

PWD's extensive OWQM DMS requirements analysis produced a detailed list of system requirements related to the assessment of water quality and the use of a data management system both as an operations and event detection tool. General descriptions of essential functional requirements are provided below:

- **Data Repository / Storage** – Should be capable of storing multi-parameter data for a certain period of time and at pre-determined intervals, and managing water quality control limits. These limits can be used to assess water quality at each sensor and location as well as information to assess sensor status.
- **Data Processing and Calculations** – Should be able to compare measurements with control values to determine whether the sensor values are within range. It should also perform single parameter thresholding and multiparameter clustering for alarm generation.
- **Data Quality Control** – Should be capable of assigning and storing data flags such as valid, invalid data, or out of baseline range.
- **Alarming / Alerting / Notifications** – Should be capable of programmed response to OWQM sites and parameters out of range with the generation of automatic notifications that are sent to appropriate personnel or groups. Notifications can be customized to contain summary information and links to allow the end recipient to view all relevant data for allowing assessment and decision-making.
- **Data Quality Control** – Should be capable of tracking all changes made to data and settings.
- **System Reporting** – Should be capable of reporting functions (scheduled and ad-hoc) such as trend charts, data exports, tabular reports, summary reports, performance reports, and regulatory compliance reports.
- **System Integration** – Should have an Application Programming Interface (API) to allow for the import and export of data, generation of reports and charts, and the creation of event notifications. The system must operate in a distributed computing environment including multiple servers, multiple software systems, and multiple users. It must be able to access data generated and managed in other software systems (e.g., Supervisory Control and Data Acquisition [SCADA] and Laboratory Information Management System [LIMS]). The system must be able to access and deliver data through Web services. It must have flexibility to accommodate other software upgrades (operating systems, Web browser, and network setup).
- **System Administration** – Should be able to provide configuration forms for user administration; access control; modification of control parameters, groups, and reports; and generating new reports.
- **Data Accessibility** – Should allow access to the water quality data, analysis capabilities, and administration by appropriate users 24 hours a day, 7 days a week. The information systems and tools must be available at multiple locations. Change of control parameters cannot require an application reload or restart, or a system reboot to take effect.
- **Disaster Recovery** – Should have comprehensive backup and the ability to resume operations through implementation of data retrieval from storage.

Vendor Selection Process

PWD developed a clear vendor selection process upfront to minimize confusion and maximize efficiency. It selected the DMS vendor using a two-step process: 1) request for qualifications (RFQ) and 2) request for proposal (RFP) with interview. The goal of the first step was to identify vendors who demonstrate that they have the capabilities to meet the requirements for an automated information system that is capable of handling online water quality data, quality control, data analysis, and administration of the system in the PWD environment. The second step was to request proposals from a short list of vendors to address the detailed requirements of the OWQM DMS in writing and to prepare for an onsite interview to demonstrate their software's capabilities.

Request for Qualifications

The first step to initiate the selection process was the development and release of the RFQ. The RFQ was released through readily available venues such as websites, newspapers, and trade magazines to solicit detailed functional and technical requirements of data management software. The RFQ provided an overview of the project, point of contact, submittal and evaluation schedule, evaluation criteria, terms and conditions, and functional requirements.

PWD also requested OWQM DMS technical specifications from vendors to determine the software compatibility with its existing systems. These were often constraints that were placed on the system to determine whether the selected solution would work within the destined IT environment. PWD prepared and provided a technical response questionnaire to vendors as part of the RFQ. PWD recommends that an electronic questionnaire be prepared as this will allow the vendor to respond in the spaces provided and then submit this document electronically to the point of contact. Requested information in the technical response questionnaire, at a minimum, should include the following:

- General Information – general company information, including a point of contact.
- Product Information – name of product, current version and a short description of the product; technical support available for the product.
- Technical Information such as:
 - System Architecture including server architecture (client-server, n-tier web based architecture, etc.), supported programming languages and version for customization, back-end database engine and version.
 - Product licensing and support, type of licensing structure offered, and associated costs (e.g., individual, server, number of simultaneous users, site, development, etc.). Description of support services. (e.g., toll-free numbers, dial-in diagnostics, Internet support, hours of support, and location of support office), maintenance programs and fees, and availability of software documentation.
 - Product roadmap - A description of how often the product is updated and how updates are distributed to clients. A list of expected features in upcoming releases.
 - Identify all software modules and options that are available and not part of the basic product.
- Functional Information – whether the current off-the-shelf system meets each general requirement; if the system could be modified to meet the requirements, an explanation of how the system would be modified and an estimate of the attendant cost.
- References – information on customers currently using the software product.
- Pricing – a preliminary price estimate for the product, including initial cost, customization costs, and maintenance fees.

RFQ Evaluation Criteria

All RFQ submittals should be rated to allow the evaluation committee to rank the submitters. PWD used the following evaluation criteria to evaluate the vendor responses:

- Demonstration of existing software that can be used to manage the collection, processing, storage, and dissemination of complex online water quality monitoring data from multiple instruments at multiple locations all connected through an integrated SCADA system.

- Capabilities within the software to manage those users that have access to the system for reading, writing, modifying, and deleting data, with multiple levels of access control.
- Demonstration that vendor supplying the software and associated support services have been in business successfully over an extended period of time and is likely to stay in business for the foreseeable future. The vendor must have sufficient staff and financial ability to support the installation and maintenance of the system in a large municipal system.
- Demonstration that the vendor is able to work within the structure of a City of Philadelphia contract with the terms required by the City.
- Sufficient references from other clients with installation of the offered system indicating the effectiveness of both the software and the vendor at supplying the required capabilities and services.
- Demonstration of a price structure that is in a competitive range with other offerers.

Request for Proposal and Interviews

The vendors who were selected became eligible to participate in the second phase of the selection process, during which an RFP was released asking vendors to address the detailed requirements for the OWQM system in writing and to prepare for an onsite interview to demonstrate their software's capabilities. The demonstration of capabilities was to be made based on a prescribed demonstration script that the vendors were required to follow. The written response and the demonstration script would ensure that vendors address all primary requirements. Detailed system requirements, instructions for a scripted demonstration, and associated data sets, direction and supporting material were sent only to the second phase vendors.

The scenarios developed to demonstrate the capabilities of the vendors' software during the interview were intended to be relatively simple, and they were to enable vendors with an opportunity to demonstrate the basic features of their software. A narrative that described the terms used in the scenarios was provided by PWD. A data dictionary for water quality data, control table parameters, and spectral data were also provided in a separate document to run the scenarios. Based on PWD's experience, the following features are recommended to develop scenarios for vendor interviews:

- Single Parameter Alarm/Warning to demonstrate single-parameter alarms and to identify ongoing alarms.
- Moving average alarms to demonstrate moving average alarms for a single parameter and to identify ongoing moving average alarms.
- Multiple parameters simultaneously being out of range to demonstrate the ability to handle multiple alarms, to group those alarms appropriately, and display alarm data from multiple sites in an integrated report/notification.
- Ability to recognize sensors in calibration mode and a sensor requiring calibration.
- Ability to generate sensor quality control reports that show power, communication, and calibration of multiple sensors over time.
- Ability to allow users to maintain the system, including control limits, access, and communications.
- The data management system should allow simple integration with other systems such as SCADA or systems that generate spectral data.

Evaluation Criteria for the Interview

In the second phase of selection, vendors were evaluated based on the extent to which their DMSs met the requirements developed by PWD. The number and priority of requirements that were and were not met were evaluated. PWD recommends that the following criteria be considered during the process:

- Vendor' staff and ability to handle training, support, and enhancements
- Feedback received from existing clients
- Quality of the written response and the presentation during the interview
- Timetable for modification, installation, and training

- Project staff offered by the vendor to lead the effort for customization of the system to meet PWD's requirements
- Final cost of the software, enhancements, maintenance, and ongoing support

Recommendations and Conclusions

As part of the CWS Pilot Project, PWD selected an OWQM DMS using a two-step process: 1) definition of the OWQM DMS requirements and 2) vendor selection. First, the OWQM DMS technical and functional requirements were defined by focusing on data management, analysis, and reporting capabilities requirements. PWD recommends that utilities meet with key users and stakeholders to document these specific requirements. Second, the vendor should be selected through 1) the development and release of an RFQ to vendors, and 2) the development and release of an RFP with detailed requirements for the OWQM DMS in writing and vendor interviews. A clear vendor selection process should be developed upfront to minimize confusion and maximize efficiency. PWD recommends that an electronic technical response questionnaire be prepared and provided to vendors as part of the RFQ. An electronic questionnaire allows for concise responses that can be easily received and tracked by the point of contact and evaluated by the utility. The RFP then allows the utility to receive details on the OWQM DMS that informs them whether the vendors can address all primary requirements. Similarly, the interviews give the vendors an opportunity to demonstrate their software capabilities.

Abbreviations and Acronyms

API	Application Programming Interface
CWS	Contamination warning system
DMS	Data management system
EPA	United States Environmental Protection Agency
LIMS	Laboratory Information Management System
OWQM	Online Water Quality Monitoring
PWD	Philadelphia Water Department
RFP	Request for proposal
RFQ	Request for qualifications
SCADA	Supervisory Control and Data Acquisition
WS	Water Security

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