Showcase

Title: **Event detection in the distribution network and stakeholder involvement in action programmes**

Sector: drinking water / wastewater; select category (multiple options possible):

☐ drinking water sources
☐ drinking water treatment
☒ drinking water distribution
☐ wastewater collection / influent
☐ wastewater treatment
☐ wastewater effluent / receiving water
☐ other

Utility: **Drinking Water utility A (USA)**

Date: 2014

Introduction & background information

Drinking Water Utility A (DW-A) in the USA serves about 2.2 Million customers and manages about 3,000 miles of pipe for their drinking water distribution system. The distribution system has 11 pressure zones. DW-A operates 2 drinking water treatment plants. These treatment plants are conventional treatment plants which include chlorination and the creation and maintenance of a chloramine residual. The drinking water is also fluoridated.

Water quality challenges

The source waters for DW-A are predominately surface waters that receive inputs from highly urbanised areas and the effluents of wastewater treatment plants and treated industrial wastewaters. The system needs to address many water quality issues including surface water runoff, effects of rain and runoff (some effects may be seasonal), endocrine disruptors, personal care products, sedimentation, turbidity, *Cryptosporidium*, industrial and medical wastes. There are multiple water sources that lead to source mixing and seasonal challenges.

The distribution system is very mature and has had many demographic and business changes that have led to dead ends, low flows and low demand. The very age of the pipes is in and of itself a significant challenge which includes significant tuberculation. The system frequently experiences turbidity spikes, nitrification and requires corrosion control.

Approach and implementation

Need for online monitoring

DW-A is committed to distribution system monitoring which is difficult, given the wide variety of issues identified above. DW-A was selected by the US EPA to develop a contamination warning system under a Water Security Initiative grant, which aimed to develop an early warning system for contamination of drinking water systems. In addition, DW-A monitors for the following other purposes:

- Operational control – online data is now used as a stimulus to treatment strategies. Treatment operators regularly use these data to adjust dosages and treatment. Online monitoring provides continuous data and allows comparisons between time periods.
- Residual monitoring and maintenance – There are many uses for chlorine residual monitoring, including operational maintenance of the residual and as an indicator of other issues. Chlorine residual decay at dead ends is used to determine when enhanced flushing is needed.
- Understanding of hydrodynamics and water quality – Online water quality monitors are very effective at understanding water movements and mixing in a distribution system. Conductivity is useful in identifying water sources and mixing.
- Trouble shooting – When issues arise, online water quality data is useful in diagnosing the problems and in developing options for resolution.
- Customer complaints – Online water quality data are useful in addressing customer complaints.
- Consumer outreach – Online water quality data are useful in explaining water quality and challenges in discussions with clients and regulators. When there are taste- and odour problems, the online water quality data are often useful in helping to identify possible causes and resolutions.
- Research – Online water quality data are used for research, including understanding water quality processes and patterns in source waters, treatment trains and the distribution system. Water quality data are also useful in understanding the effects of changes in treatments and in evaluating alternatives and new technologies.
- Source water monitoring for management and for advising treatment process.

Implementation at the Navy Yard

In a large city, demographics and businesses change. The demands for water change in different areas based on business, economy and technology. For example, the Navy Yard in the supply area of DW-A was a very active area for a long time. When the number and types of ships being built changed, so did the demand for water. Locations which once used extensive amounts of water to support large transient staffs and manufacturing no longer had the same demand, leading to low demand, low flows, chlorine decay, nitrification and many other water quality issues. Online instruments were used to better quantify the issues and help engineers and water quality specialists identify and implement options for improving water quality. Using online instruments, numerous measurements were possible including the collection of time series data. This allowed a better understanding of the processes and mitigation approaches could be evaluated and adjusted.

The combination of grab samples and online monitoring helped identify areas of low usage/flow and oversized mains the from time when Navy base was active. This served as an indicator of the efficacy of the flushing programs. Enhanced monitoring helped customer interactions with industrial users and relationships with the navy, as this data was valuable in discussions with the Navy. Going in to do backflow prevention, survey data were helpful in making a case for on-site investigations. The online sensors were used along with the grab samples which are done taken a week. The grab samples had more data, including microbial data. The online data were more comprehensive temporally.

DW-A used the preliminary data collected by sensors as a key component of their Contamination Warning System Demonstration Pilot Project to participate in the US EPA Water Security Initiative. DW-A was able to demonstrate significant detection of water quality issues with online sensor data. Issues with the sensors were rapidly identified and resolved.

Development of the monitoring programme

DW-A‘s implementation of online monitoring has occurred through a variety of different programmes. Initially, sensors were deployed for basic monitoring and to improve understanding of the distribution system. Initial attempts were considered a proof of concept that sensors could be used effectively. This phase included review of instruments, communications, SCADA network, software and hardware. The desire was for a system that would be plug and play, i.e. the instruments would be easily installed and integrated. A major concern was identifying where the instruments should and could be installed.

The next phase of development evaluated what uses would be appropriate for the on-line data. Example questions were:

- Would the data be useful for compliance reporting?
- Which groups and individuals could use the data and for what applications?

Initial deployments were done at two locations where the initial testing was done, including evaluation of a variety of instruments and parameters, instrument operating procedures, communications and data evaluation methods.

These first two phases led to data being shared by many groups within the utility, including the bureau of lab services, load control and treatment.

Intense enhancement and improvements in the sensor array were facilitated and required when DW-A became a pilot site for the USEPA Water Security Initiative programme. Expansion of the system led to requirements for the development of standard operating procedures for deployment, maintenance, data analysis and integration. Intense data review and study were required in order to integrate the sensor array with two event detection systems: CANARY (US EPA) and Blue Box (Whitewater Security). These were integrated with data from sampling and analysis, customer complaints, advanced security monitoring and public health surveillance. This integration required detailed scrutiny of the online sensor data and led to significant improvements in instrument deployment, maintenance and data processing.

Systems, methods and monitoring instruments

DW-A has tested a number of instruments as part of their sensor programme. Table 1 lists the sensors that are currently being used. These were selected based on a combination of criteria that include accuracy relative to grab samples and limited requirements for maintenance.

Table 1: Online water quality instruments in use at DW-A

Parameter	Instrument
Total Chlorine Residual	ATI Q45H/63-2
Turbidity	ATI A15/76
Conductivity	ATI Q45C4-1 4E
pH	ATI Q45R
ORP	ATI Q45
Temperature	PT1000RTD (taken from Chlorine meter)
Pressure (sample)	AST4000A00200P4A0000
UV254	RealTech UV M4100

Costs and maintenance

Capital and Operational Costs

These costs are general estimates. The information hardware costs include at least one server other than the SCADA server.

Infrastructure

Start-up costs per instrument: total US$ 5,300 + US$ 100/month

Equipment – OnLine WQM: 15K$

Communications – Hardware: 8K$ – wireless modem, redundancy 3K$ Spread spectrum radio (SSR).

Systems integration: 7K$ (may later decrease to 5K$). Recurring cost $100/month (data services)

Plumbing: $ 1,500

Electrical: $ 500

Operations and Maintenance: total US$ 2,370 /month

Reagents buffer replace parts: $120/month

Staff: 2K$/month (engineer, project manager, instrument technicians, interns)

Systems integration: 250K$/year for systems integration contract

Transportation: total US$ 2,950 /month

3 vehicles (SUVs) leases: $700/month

city own: $1,000/month (2 vehicles)

Fuel/maintenance: $250/month per vehicle

Materials and supplies: total US$ 150k$ /year

Plumbing fittings, electrical, valves, etc. 60K$/year

Instrumentation parts and supplies – 90K$/year

Software:

Costs for Clear SCADA, data historian (Kisters WISKI) and for event detection were approximately $500,000. License and maintenance fees for software are approximately 300K$/Year.

Training

Training costs for the entire on-line monitoring system are approximately 3 – 10K$ per year including:

- Communications
- Instrument maintenance
- Conferences
- Seminars
- Data processing

Data handling

During the development of the sensor array, DW-A has had an evolving information capture and analysis approach. Initially, the data were received by a Wonderware SCADA system. The data were immediately sent to an in-house proprietary system that stored all of the available data. Data were then transferred to an SQL data historian. As a result of the Contamination Warning System program this information system has been upgraded to Clear SCADA transferring data to a middleware product called WISKI (from Kisters). Sensor data access and analysis are done from the WISKI system.

Quality Assurance / Quality Control

Many options for on-line processing and quality assurance have been considered. Currently, all data are reviewed electronically, outliers are flagged but not removed. Data are reviewed by engineers and the flags are adjusted manually. Flags may be used to exclude data from some analysis, but the decisions are made based on how the data are used.

Evaluation of successes and limitations

Monitoring of chlorine residuals has helped identify locations and times where enhanced flushing is needed. It has also helped improve communications and interactions among different departments. By instituting online monitoring and sharing the data with other departments, the bureau of lab services has helped other departments understand the effects of their decisions and actions. For example, the load control group now can see how their operating procedures are impacting water quality.

The original goal of OWQM (online water quality monitoring) was the monitoring of key entry points to the distribution system not controlled by treatment. This needed an approach to monitor infrastructure in the distribution system. Once the key locations (stand pipes and basins) were covered, this network was used to enhance the regulatory grab sample programme. It also led to a review of key grab sample points to better understand the temporal distributions and variability of water quality and to establish a baseline at key locations so an understanding of quality divergence could be developed. For this a baseline was required in order to recognise when the system is not in baseline condition. It is impossible to obtain information with sufficient resolution for this analysis from grab samples alone. In other words, the sensor data was used to develop a continuous snapshot of water quality at each key location.

DW-A is hopeful that reliable sensors will be developed for:

- Microbiological entities like *Cryptosporidium*, *Giardia* and coliforms
- Nitrate and Nitrite

DW-A is exploring the use of UV/VIS spectrophotometer instruments for a wide variety of parameters. These efforts are considered experimental at this point.

A major concern is the difficulty in hiring and retaining trained staff for all aspects of the on-line monitoring programme. Once trained and capable, technicians can find work in other industries with better earning potential.

Lessons learnt & recommendations

In order to implement a system of this kind, it is important to have the right personnel and contract support. In the past 5 years, DW-A has implemented online sensors at 30 locations in its distribution system. Operation of this array requires a significant team effort that includes staff and contractor support. Initial implementation required cooperation between utility staff and contractors. The selection of a good system integration contractor was an advantage that helped DW-A achieve its goals. The integrator did the initial installations and the integration of the instruments with communications. DW-A senior engineers believe that for an extensive set of online sensors to be used effectively, a team as specified below is required.

Showcase

Sensor Team – Full-time employees:

- Senior Engineer - Team Supervisor
- 4 instrument technicians to maintain and calibrate the deployed instruments
- 2 Instrument engineers to develop and maintain Standard operating procedures; test and trouble shoot instruments

Water Quality Team – Major commitment to sensor programme but some other collateral duties:

- • Senior Engineer – Water Quality supervisor
- • 4 engineers – review and analysing data
- • 2 interns – data review, analysis and support

Other critical team members:

- • 2 database staff
- • Systems integration and communication support (contract)
- • Consultants to explore data and responses to events