Introduction
Optimization is what water utility operators do every day. Starting in 2011, the Partnership for Safe Water’s Distribution System Optimization Program (DSOP) has provided the opportunity for water utilities to be recognized for this effort. Participation in the Partnership’s DSOP should enable a utility to achieve higher quality water, create a utility culture utilizing best practices, increase staff involvement and engagement, improve customer satisfaction, help ensure routine regulatory compliance, and achieve recognition ofthis effort by the drinking water community.

Water utilities across North America are professionally staffed, operated, and managed. These organizations work diligently to support activities to plan, design, operate and maintain their infrastructure to ensure the distribution of high quality drinking water from the treatment plant, through the distribution system, and to the customer’s taps. The water distribution system represents the last barrier of the multiple-barrier approach used by public water systems to maintain safe and high-quality water. The Partnership for Safe Water created the voluntary DSOP to support the water industry’s efforts to protect public health by enhancing practices which help to provide and ensure the effectiveness of this critical barrier to safeguard drinking water quality.

Both local and federal drinking water regulations continue to place an increased emphasis on monitoring and maintaining water quality. Distribution system water quality depends on the monitoring and control of chemical, microbiological, and physical parameters that can affect the safety, color, taste, or odor quality of water. Water utilities strive to operate efficiently and safely while providing water that protects the health of the public, fosters customer satisfaction, and promotes public trust in the quality of tap water. The Partnership’s DSOP is one more step to assure that water quality delivered to the customer is central to utility practices, programs, and design. The Partnership’s self-assessment process is designed to be a systematic and periodic activity that assesses a utility’s performance and operations in relation to certain pre-established operational objectives and optimization criteria including disinfectant residual, pressure management, and main breaks.

The Partnership for Safe Water’s DSOP builds upon the self-assessment and optimization pillars of the established treatment plant optimization program but focuses more specifically on the distribution system. Recognizing that water quality changes from the time the water leaves the plant until it reaches the customer, this program is designed to encourage and assist utilities in evaluating their distribution system operations and performance and developing strategies for improvement. The program emphasizes improving distribution system integrity, particularly in the areas of water quality, hydraulic reliability, and physical integrity. The core task of the program is a comprehensive self-assessment of distribution system performance and operations, where project participants identify performance limiting factors (PLFs) to achieve optimization. This list of PLFs is used to develop a long-term improvement plan.

The DSOP was created following the completion and issue of the Water Research Foundation (WRF) Project #4109, Criteria for Optimized Distribution Systems. This study developed the optimization criteria to define distribution system optimization, based on a performance assessment of water quality, hydraulic, and physical integrity, represented by the measurement parameters of disinfectant residual, pressure, and main breaks, respectively. These three parameters are considered to be the primary optimization and reporting parameters for the program.

The WRF report also identified a total of 19 Performance Improvement Variables (PIVs) for utilities to assess in order to determine the system’s current optimization status and create and implement an action plan to improve performance and work towards optimization. Each of these 19 PIVs was selected based on its ability to influence, or be influenced by, any of the three primary optimization parameters (disinfectant residual, pressure, and main breaks). The self-assessment process involves the identification of PLFs, prioritizing the PLFs, developing and implementing an action plan to improve performance, and creating a long-term process to assess and report performance improvements (which is achieved through the Partnership’s annual reporting process). Following these steps will optimize activities in the identified areas.

The 19 Performance Improvement Variables include:

- Disinfectant Residual
- Cross-Connection Control
- Customer Complaints
- DBP Control
- Energy Management
- External Corrosion Control
- Flushing
- Hydrant and Valve Maintenance
- Internal Corrosion Control
- Main Breaks
- Nitrification
- Pipe Rehabilitation and Replacement
- Inorganic Accumulation Control
- Pressure Management
- Security and Online Monitoring
- Storage Tank O&M
- Water Age Management
- Water Loss Control
- Water Sampling and Response
Under the DSOP, utilities are asked to submit a one-year Baseline Report for their initial year of program participation. In subsequent years, Annual Reports are submitted, covering the Partnership’s reporting period, which runs from June 1 to May 31. The reports are expected to include a summary of disinfectant residual data from the routine sample sites throughout the distribution system, as well as distribution system entry point disinfectant data, using the Partnership’s data collection software. Utilities report daily minimum values from the distribution system, identification of all sites with a low residual value (that is, below 0.2 mg/L for free chlorine systems or 0.5 mg/L for total chlorine systems), entry point disinfectant concentrations, and the number of samples collected on any given day. The Partnership keeps all data confidential and only reports data in aggregate in the program’s Annual Data Summary Report. Along with the data, utilities also submit a statement of compliance indicating the system’s compliance status with respect to all applicable distribution system regulations.

The following discussion describes three approaches to complete the DSOP self-assessment (SA process). First, assign a single knowledgeable utility supervisor to complete the SA. Second, assign a group of knowledgeable senior managers to complete the work. The third approach was used by a very large utility (population served >100,000) which decided to institute a utility-wide effort. They organized a Steering Committee of experienced technical managers to over-see the self-assessment process which was conducted by an energetic team of recently-hired technical staff members. This team completed the Partnership forms and obtained answers to the self-assessment questions through an intense interview process of knowledgeable and experienced in-house subject matter experts (SME). A summary of these three types of approaches is provided in the following section.

### Self-Assessment Approaches

The Partnership for Safe Water Distribution System Optimization Program includes four phases;

- **Phase I – Commitment**
- **Phase II – Definition of baseline conditions**
- **Phase III – Performance of the distribution-system self-assessment**
- **Phase IV – Demonstrated optimization**

Utility management has the obligation to balance the level of effort to the resources available. Depending on the size of the utility and the complexity of the infrastructure, the project resource commitment can be considerable – but is highly achievable for utilities of all sizes and configurations with proper planning. The SA process has been successfully completed by retail systems, wholesale systems, and consecutive systems alike. The SA process will require the utilization of appropriate technical and administrative resources, and management will need to approve the assignment of staff resources from across the utility to complete the Phase II and Phase III tasks. A diverse team, drawing individuals from across the organization, is critical to obtaining accurate and meaningful results from the self-assessment process, which can provide a highly beneficial system-specific learning opportunity. Management must also participate in reviewing and approving the utility action items to produce a long-term performance improvement plan.

### Approach #1 - Let Mikey Do It!

Assign the most experienced Distribution System Supervisor to read through the Partnership’s self-assessment guidance manual (Self-Assessment for Distribution System Optimization) and to complete the disinfectant residual data input forms for the Baseline Year, using the results from routine water quality samples. Direct the Supervisor to seek assistance and information from colleagues on the technical and administrative staff to provide answers to the questions in the guidance manual (chapters 2, 3, 4, 5 & 6).

This is a quick and efficient method to rapidly wade through the Partnership’s self-assessment process using a minimum of resources available to the utility to complete the forms and to answer all of the questions. It is estimated that a Distribution System Supervisor could complete the baseline data collection and conduct the self-assessment in approximately 12-18 months, depending on the amount of time allocated to the effort. With input from the Water Quality Lab Supervisor, a Distribution System Design Engineer, Field Operations, and staff representatives from Finance and Administration to assist with answering all of the Partnership self-assessment questions, utility management should expect to commit an estimated 330 hours of total staff time. The DS Supervisor, with assistance from others in the organization, should expect to spend less than 5% of their time on the program. While this approach may minimize the utilization of staff time, a broader approach, encouraging involvement of utility staff at all levels of the organization is recommended. Utilizing a team approach, system-specific learning opportunities are maximized, and the Partnership process may be applied to the fullest potential to change utility culture and improve performance.

### Approach #2 – Form an “A” Team!

Establish a Management Team comprised of senior staff from Engineering, Planning, the WQ Laboratory, and an Operations expert from the Distribution System. Although it’s likely that the DS representative will be the Team Leader, encourage the 4-person group to make their own choice for this role. Have them read through the Partnership’s self-assessment guidance manual in preparation for a series of monthly meetings to answer the full list of questions (chapters 2, 3, 4, 5 & 6). Pay careful attention to Table 1.1, which provides a list of the data required to complete the self-assessment process.

This is an efficient method to bring together an experienced and knowledgeable senior staff team to complete the self-assessment process. Using a moderate amount of resources, staff should be able to complete the baseline data collection forms, answer all of the self-assessment questions, and conduct the self-assessment over a 12-24 month period. The WQ Laboratory representative should be assigned the task to complete the residual chlorine data input forms for the Baseline year, using knowledge of the monthly results from routine water quality samples. Monthly progress meetings for the four senior staff members plus their time to collect data, develop answers to the questions in the self-assessment guidance manual, and the creation of a long-term action plan to address the identified PLFs is expected to require no more than an estimated 700 hours of total staff time. The DSOP Team, along with assistance from others in the organization, should expect to spend just over 3% of their time on the program. While this approach is preferable to Approach #1, due to the engagement of a larger project team, the narrow composition of the team may continue to limit, to some extent, the potential for system-specific learning. The larger and more diverse
the composition of the team, the greater the benefit that will be derived from the self-assessment process.

**Approach #3 – Perform a Comprehensive Utility Evaluation**

Under this approach, three DSOP project teams can be created, consisting of a Steering Committee, a Self-Assessment Team, and a team of in-house Subject Matter Experts (SME). The lead project team will be the Steering Committee. The Self-Assessment Team and the Subject Matter Experts should cross all organizational lines.

The project Steering Committee should consist of senior managers from Engineering, Planning, the WQ Laboratory, and Operations experts from both the treatment plant and the distribution system. They will guide the self-assessment effort. The Self-Assessment Team, identified and assigned, to the project should come from the core work-units of Operations, Engineering, and the Water Quality Laboratory. The individuals selected should be relatively new to the utility, as they will be assigned to complete the Partnership’s data collection forms and to conduct interviews of experienced staff. The rigorous and comprehensive interview process follows the format of the Partnership’s self-assessment guidance manual. A cross-section of in-house Subject Matter Experts are to be interviewed. These teams can be of varying size, depending on utility size and staffing numbers.

This approach creates a process and an environment to support participation and collaboration across the agency; from top to bottom (managers to technical staff to operators and field staff) and across division lines (operations, labs, engineering, planning and finance). A broad cross-section of utility staff can be engaged in the distribution system self-assessment process. Employees from across the agency can participate to identify opportunities for improvement and to advance the utility’s optimization status. It requires, however, the commitment of a significant amount of resources to coordinate the activities of a large team of experienced and knowledgeable staff members to complete the forms and to answer all of the guidance manual questions. It is estimated that this comprehensive approach to complete the residual chlorine baseline data collection form and to conduct the self-assessment process will occur over a 12-30 month period. The Steering Committee will need to meet regularly to manage the process, review the efforts of the technical staff to collect data, and review the responses of the SME interviews conducted to answer the self-assessment questions. The WQ Laboratory representative should complete the residual chlorine data input forms for the Baseline Year using knowledge of the monthly results from your routine water quality samples. The overall self-assessment process and the creation of a long-term plan in response to the identified PLFs are expected to require an estimated total of about 1300 hours of collective staff time. The senior staff members on the Steering Committee should expect to commit only about 2% of their time over the project period. The SMEs and the technical staff conducting and documenting the interviews and completing the PSW database forms will take up the bulk of the project time, although it will be spread out over the estimated project period of 12-30 months.

The utility, on which this approach is based, experienced an increase in compliance with the Partnership’s disinfectant residual goal by continuously reviewing water quality data and making data-driven disinfectant feed adjustments. The trigger value used to initiate communication between the water quality monitoring group and the water treatment plant staff was changed in order to meet the Partnership’s disinfectant residual goal, which was higher than the utility’s previous performance goal. These adjustments were in addition to the procedures already in place to fine tune the finished water disinfectant dose to more closely match the seasonal temperature changes of the surface water supplies and to meet target disinfectant residuals in system storage. On the other hand, the data for water district pressures were found to meet the Partnership’s optimization goals. However, the Partnership’s goal for reported leaks and main breaks per 100 miles of utility owned pipeline per year mains was found to be unattainable by the utility at this time. Although the utility’s break trend had declined and now remains stable, it was observed that a standard definition for this metric does not currently exist in the water utility industry.

An estimate of the hours needed to conduct the Partnership’s distribution system self-assessment process, for each approach, is summarized in the graph below. Note that this information is presented using the highest number of hours presented for each approach. The actual amount of time required to complete the self-assessment process will vary depending on the specific properties of the utility:

![PSW Self-assessment - Estimated hours](image)

A portion of the utility staff hours could be reduced by enlisting the assistance of a consultant to assist with documentation and administrative tasks of the project, including the preparation and distribution of the initial and updated master project schedule, agendas for meetings and workshops, record keeping for the monthly project meetings, preparation of technical memorandums, documentation of the self-assessment process, and preparation of draft reports and data submittals to the Partnership. Note that, even if a consultant is employed, the self-assessment process and addressing the self-assessment questions should remain as utility-driven tasks.

Based on a recent EPA fact sheet, there are approximately 53,000 community water systems (CWS) in the United States, serving just over 300 million people. Twenty-three percent of these systems are considered to be very large (>100,000 served), large (10,001-100,000 served), and medium size (3,300-10,000 served). The EPA also reports that two-thirds of the US population receives treated surface water. Although there are innumerable combinations of water treatment plants and distribution systems across North America, for the purposes of this study, it is assumed that the numbers and sizes of the distribution systems parallel the EPA statistics for treatment plants. Therefore, the suggested mechanisms to conduct a DSOP project could be applied to medium, large and very large systems, as follows; the single supervisor for a...
medium system, the Management Team for a large system, and the utility-wide approach for a very large system. Note that the larger and more diverse the composition of the project team, regardless of system size, the greater the benefit that will be derived from the process.

Potential Benefits

Organizationally, there are a number of potential benefits to a utility that decides to conduct a self-assessment following the guidelines of the Distribution System Optimization Program. Generally, a self-assessment effort results in a variety of positive outcomes by giving individual workers the opportunity to contribute their ideas and suggestions to improve the performance of the utility. From this may come several other benefits such as individual workers becoming more productive, staff involvement, the creation of a culture to embrace best practices, improved customer satisfaction, higher quality water, more consistent regulatory compliance, and the opportunity for the recognition of the utility’s effort among its customers and throughout the water community.

Other potential benefits include:

- **Facilitation of communication**: communication in an organization is an essential element to motivate employees. It has been suggested that the opportunity for an employee to make a contribution improves job satisfaction and management-employee communication.

- **Enhancement of employee focus through promoting trust**: behaviors, thoughts, and other issues may distract employees from their work. Trust issues may be among these distracting factors. The self-assessment process can demonstrate management’s skills and abilities to act in the best interest of the organization. This captures the “can-do” component of trustworthiness. This ability to successfully focus the organization on a collective task can reduce or replace distracting factors and encourage trust within the organization.

- **Goal setting and desired performance reinforcement**: the utility benefits when the organization and the staff have the same goals. The self-assessment process provides the opportunity for a collaborative discussion about individual and organizational goals. Employee acceptance and job satisfaction result when there is agreement.

- **Performance improvement**: when utility-wide best practices are identified and communicated to the staff, this creates the opportunity to compare utility and individual performance to world-class metrics. The self-assessment process provides a valuable tool to communicate these metrics to project participants about how their job performance compares to the “best of the best”. The result is an improvement at both the individual and organizational performance levels.

- **Increase knowledge of new staff members**: by assigning relatively inexperienced technical staff to collect data and conduct interviews of experienced staff members (i.e. SMEs), they are exposed to new people and information outside of their respective work groups. Peer relationships are formed, institutional knowledge is gained and a broader understanding of the utility is achieved.

- **Determination of training needs**: staff training and development are crucial components in helping an organization achieve strategic initiatives. The self-assessment process can be instrumental to identify training needs for new and existing employees.

In addition to the PLFs identified using the Partnership criteria, encourage all participating Subject Matter Experts to provide suggestions or recommendations to improve work processes, staffing, training, financing or communication, or any other factor in their area of expertise; their specific water utility area of work for which they were considered an SME. The suggestions or ideas produced can be evaluated by the utility outside of the Partnership process, so that the self-assessment process can be applied outside of the areas specifically covered by the self-assessment questions. It can be beneficial to record this information at the time the SME is engaged during the self-assessment process.

A summary table of the possible approaches and staff engagement in the process follows:

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<th>Single Experienced DS Supervisor</th>
<th>Management Team DS, Engrg &amp; Labs</th>
<th>Full Utility Engagement</th>
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1 - DSOP forms for baseline residual disinfectant prepared
2 - Assessment conducted
3 - PLFs identified & Long Term Plan prepared to address deficiencies
4 - Cross functional team created
5 - Entry-level professionals participate for exposure to utility-wide activities
6 - SME participation; experienced professionals contribute to effort
7 - In-house performance improvement ideas generated which exceed PSW criteria

Although completion of the self-assessment process by a Single Experienced DS Supervisor is referenced in the above table, the Partnership encourages engagement of a diverse team to complete the self-assessment process.

**Long-term Improvement Plan**

Following the self-assessment of the distribution-system and the identification of the list of Potential Limiting Factors, the utility is able to develop a multi-year long-term improvement plan to address the identified factors which could inhibit achieving the Partnership’s optimization goals for disinfectant residual, pressure management, and main breaks. The improvement plan should identify the issues, actions, responsible parties, priority, and a time frame for completion. The plan may include both long and short-term goals. When actions are identified that may improve performance, the utility should not hesitate to act to realize the improvements that may most immediately impact distribution system performance. The plan is expected to be updated annually and submitted to the Partnership along with the required annual data for disinfectant residual, pressure, and main break statistics. As the utility works through the PLF list, the annual report to the PSW should document progress to address the issues.

The factors and categories that can improve performance through operational adjustments can be assembled and prioritized. The Partnership’s self-assessment guidance manual, Self-Assessment for Distribution System Optimization, recommends that the long-term action plan direct resources first to those factors that will lead to optimum performance through operational changes rather than through the expenditure of capital resources.
In addition to the performance limiting factors (PLFs) identified through the self-assessment process, the utility could also encourage all participating Subject Matter Experts to provide suggestions or recommendations to improve the work processes, staffing, training, financing or communication, or any other factor in their area of expertise. The suggestions and ideas produced could be summarized into an internal improvement plan. The organization’s progress to address each suggestion should be updated annually, but kept internal.

According to the Partnership’s procedures, the DSOP self-assessment report is reviewed by a team of trained utility distribution system volunteers called the Program Effectiveness Assessment Committee - Distribution (PEAC - D). The PEAC-D members work closely with the Partnership’s Program Manager and current and future utility Partnership representatives.

Conclusion
The Partnership for Safe Water program is based on the philosophy of continuous improvement. It is organized to guide a utility towards optimization in operational performance through a process of self-assessment and comparison to best industry standards and practices.

Public utilities that elect to participate in the Partnership program are professionally managed. Many already successfully produce drinking water of the highest quality. Utilities pride themselves on being responsible and successful public servants which routinely practice the philosophy of continuous improvement. Utility managers understand the value and the benefits of adopting best practices in conducting the business of drinking water supply. More efficient and effective practices can be embraced when new and better ideas are known.

Using the DSOP self-assessment guidance manual as a tool, the self-assessment process can identify those areas needing improvement in a systematic and deliberate manner over a self-defined period of time. DSOP Project Managers have the opportunity to create a process and an environment which encourages participation and collaboration across the agency; from top to bottom and across division lines. Management’s objective should be to engage a broad cross-section of utility staff in the self-assessment process; managers, designers, operators and in-house experts. Employees from across the agency should participate to identify opportunities for improvement and to advance the utility’s optimization status.

Managers of large and complex utilities can use participation in the DSOP process as an opportunity for staff from around the organization to meet and learn about the responsibilities and issues of the distribution system and how their respective work unit supports those activities. When individuals from different work units realize that capable and talented individuals exist throughout the utility, this fosters trust, lessens conflict and leads to better opportunities for future cooperative relationships. Entry-level self-assessment team members can gain exposure to experienced utility managers and senior engineering staff. They should be selected based on their job responsibilities as they relate to water quality in the distribution system. It is through the involvement in this project, that the individuals selected will develop a valuable base of knowledge, strengthen their understanding of utility operations, thereby making them a valuable resource for future responsibilities in the organization.

A thank you is extended to Charles Zitomer, Assistant General Manager Field Operations with the Philadelphia Water Department who initiated and managed the DSOP project for the utility and to Barb Martin, AWWA Partnership Program Manager who assisted with editing this document.

References; Distribution System Optimization 1.01
www.wikipedia.org
Performance appraisal, from Wikipedia, the free encyclopedia

www.water.epa.gov

www.awwa.org
Self-Assessment for Distribution System Optimization (AWWA, 2011)