It is very important to note that Phase III is a process that focuses on active participation of as many utility staff as possible to conduct a thorough and candid self-assessment. The ultimate goal is identification of factors limiting optimal performance; and, development of associated action plans to feasibly address these performance limiting factors in a timely fashion.

This report is provided because it is an excellent example of the outputs and outcomes of the previously described self-assessment process; however, it is not intended to provide an example of optimal distribution system operational procedures or modes of operation.

Example Report Development Date – July 2013
February 1, 2013

Mr. Tom Schippert  
Partnership for Safe Water Program Coordinator  
American Water Works Association  
6666 W. Quincy Ave.  
Denver, CO 80235

Dear Mr. Schippert:

The Water Department, a member of the Partnership for Safe Water Distribution System Program, is pleased to submit our Distribution System Phase III Self-Assessment Completion Report. We appreciate the many hours of volunteer hours that went into the program development and the guidance manual, and we completed this report under the spirit of the Partnership process by engaging various groups within the Department with a philosophy of continuous improvement.

Please contact our utility Partnership coordinator, if you have any questions regarding our application.

Ms. Distribution System Manager  
Distribution Services Manager  
The Water Department

We look forward to receiving the reviewers’ comments.

Sincerely,

Mr. Operations Manager  
Deputy General Manager – Operations  
The Water Department
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Section I Introduction

Formed in 1911, the Water Department is a Department of a city. The Water Department provides water, recycled water, and sewer collections services to a total population of approximately 460,000 within a 52 square mile area in the City. The Department is governed by an independent five-member Board of Water Commissioners, who are City residents appointed to serve two five-year terms.

Regulatory Compliance

The Water Department has not received any Notices of Violation during the reporting period.

Organization

There are currently 225 budgeted positions within the Water Department. The Department is governed by a five-member Board, which appoints the General Manager. The General Manager oversees the Department’s various business units, including Business, Engineering and Resources, Water Conservation, Government and Public Affairs, and Operations.

The Operations Bureau is the largest group within the Water Department, and is responsible for the operations and maintenance of water, recycled water, and wastewater facilities. The organizational chart for the Operations Bureau, which is staffed by 175 employees, is shown in Figure 1.1. The Water Operations group is responsible for the installation and maintenance of the water distribution system, including mains, service lines, fire hydrants, meters, and valves. The Water Treatment and Laboratory group is responsible for operation of the water wells, well collection lines, water treatment, distribution system water storage tanks, and all water sampling and analysis.
**Figure 1.1 The Water Department’s Operations Bureau Organization Chart**

**Water System**

The City’s potable water demand ranges from ~45 million gallons per day (mgd) in the winter to ~60 mgd in the summer, and is supplied by two primary sources: local groundwater and treated surface water purchased from the local wholesaler. The percentage of groundwater to surface water used in the system may change from year to year, but the operating principle is to pump and distribute the safe yield for the groundwater, and use the purchased treated surface water to meet the rest of the demand.

Local colored groundwater, containing elevated levels of hydrogen sulfide and organic carbon, is pumped from 28 wells located throughout the city and treated through conventional filtration at the groundwater treatment plant (GWTP). Chemicals used at this facility include an aluminum sulfate mixture and ferric chloride for coagulation, chlorine for disinfection (followed by ammonia addition to form chloramines after primary log inactivation requirements are met), base addition to adjust pH for corrosion
prevention, and hydrofluorosilicic acid for fluoridation. Chloramine is used as the secondary disinfectant to maintain a residual in the distribution system.

The City can receive purchased surface water through a combination of eight service connections that provide the water at elevated pressures into the system (>150 psi). The pressure is reduced through sleeve valves to match the desired system operating pressure (<80 psi). There are also additional interconnections with neighboring utilities that allow for water transfers during emergencies and other non-routine events.

The Department’s water distribution system includes approximately 900 miles of water mains, 20,500 valves, 6,600 hydrants, two primary water quality zones, three pressure zones (Figure 1.2), and two storage facilities (total storage of approximately 110 million gallons (MG)) (Appendix A). The two storage facilities are located at an elevation of 170 ft and the maximum storage tank water level is 33.75 ft. There is sufficient pressure to feed the distribution system by gravity, with a maximum pressure of approximately 80 psi. The pressures at different locations within the system are primarily dependent on the storage facility elevations, except for a small area where booster pumps are used to maintain the system pressure.

The purchased water pressure zone is served by purchased treated surface water through the Purchased Water Reservoir (total storage capacity of ~40 MG). The Blended zone is served by a blend of treated surface water and groundwater through the Blended Water Reservoir (total storage capacity of ~70 MG). A third pressure zone, known as the Boosted zone, receives blended water, and the pressure is boosted to ensure adequate flow and pressure in this area.

The Department maintains an active main replacement program, valve maintenance program and dead end main flushing program to ensure that good water quality is maintained in the distribution system. The goal of the main replacement program is to replace 20,000 to 100,000 linear feet of unlined cast-iron pipe annually with cement mortar-lined ductile iron pipe. The areas selected for replacement varies depending on age of the pipes and history of main breaks in the area. The valve maintenance program consists of scheduled replacement of broken valves and a valve exercise plan. The dead end main flushing program is designed to monitor and flush all identified dead end sites on a routine basis.

Reclaimed water is also used as a supplementary source of water to reduce the demand for potable water, and is utilized for irrigation, subsidence mitigation and seawater barrier injection.

Figure 1.2 The Water Department’s Service Area Zones
(Note: The introduction is a good place to include a general overview map of the distribution system – more detailed maps of sampling sites are a Phase III checklist requirement)
Self-Assessment Approach

A team approach was used to complete the self-assessment review, with subject matter experts representing different areas in the organization. Members from Administration, Engineering, Water Operation, Water Treatment and Laboratory, and Security and Emergency Preparedness formed a Partnership for Safe Water team (PSW team). Operator-level involvement and input was a key part of this process. The team held a series of meetings with interim investigations and work assignments from April 2011 to January 2013 to complete the self-assessment and report according to Partnership guidelines (Please refer to Appendix B for more details).
Section II Performance Assessment

The PSW team collected distribution system data associated with the three primary optimization criteria: disinfectant residual, pressure management and main break frequency and compared these data to Partnership’s performance goals.

Disinfectant Residual

2.1. Disinfectant Residual: do chlorine residual measurements meet the performance goal of total chlorine $\geq 0.50\, \text{mg/L}$ and $\leq 4.00\, \text{mg/L}$ in 95% of time-stepped measurements? Fully optimized.

Chloramine is used as the secondary disinfectant in both the groundwater and purchased water. The total chlorine residual measurements consistently meet the total chlorine performance goal of the Partnership. For 2012, the 95th percentile total chlorine residual from the 56 weekly locations ranged from 2.36 to 2.70 mg/L with a minimum total chlorine residual of 0.48 to 1.16 mg/L (Disinfectant Residual Data Collection Software Version 1.3). This result was detected at a location where lower chlorine residual ($<1\, \text{mg/L}$) has been observed due to the low water usage. An automatic flushing device has been installed at this location and other similar locations during the self-assessment period, with a flushing trigger of 0.65 mg/L total chlorine; this device has yielded improved chlorine residuals within recent months.

2.2. Individual Site Testing: does the utility have a system sampling map? Are sample collection sites representative of the overall distribution system? Does the utility track sites that repeatedly have low disinfectant residuals? Are performance improvement variables used to reduce low residual reoccurrence? Are non-routine low residual sites added to the next year’s routine sample location schedule? Are there any consecutive residual measurements at optimized routine sample locations below the residual goals? Fully optimized.

The Department has 56 sampling taps located throughout the distribution system which were carefully selected to adequately assess all portions of the distribution system. These include more sites than the minimum necessary for approval by the State’s drinking water regulator (Appendix C). Weekly samples are collected and analyzed for various parameters, including chlorine, from the 56 sampling points. Performance variables for improving water quality include flushing, nitrification control, pipeline replacement, storage facility operation, and water quality sampling. These variables will be discussed in detail in Section III. In addition to the 56 distribution system sampling locations, low usage areas are routinely sampled as part of the routine flushing program. The Department has identified 977 dead end locations, which are flushed as part of a routine flushing program. The locations are sampled for chlorine, coliform, turbidity,
Heterotrophic Plate Count (HPC) and color after flushing, and results are used to determine the need for further actions such as additional manual flushing and/or installation of automatic flushing devices; this project is on-going. Non-routine sampling is normally conducted for water-quality related customer complaints, and low chlorine residual has not been a problem identified during these investigations.

2.3. Residual Test Methods and Procedures: is disinfectant residual testing performed using approved methods and digital testing equipment? Are values recorded to two decimal places? Are there on-line continuous chlorine monitors in use throughout the distribution system? Is data collected and continuously displayed for operators by the SCADA system? Partially Optimized.

Disinfectant residual testing is performed according to Standard Methods 4500-Cl G, with results recorded to two decimal places. The Department’s Water Quality (WQ) Lab has been certified by the state regulator (Certification XXXX) to perform total and free chlorine residual analysis with this method. Online chlorine monitors are only used at the storage tank facility, not throughout the distribution system, to continuously monitor the chlorine residual at the point of entry; the monitors are calibrated and maintained according to manufacturers’ recommendations. Readings from these monitors are continuously updated at the control room SCADA for operators to use for system adjustments. Procurement and installation of additional online chlorine residual analyzers would provide operators with valuable information. Identification of the most valuable locations for installation of analyzers is a critical first step, which the team has already begun to discuss.

1) Additional Chlorine Analyzer Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Budget and purchase 3 analyzers</td>
<td>Distribution System Operations Superintendent</td>
<td>1/2014</td>
<td>Review analyzer data trends for optimization opportunities</td>
<td>Treatment Plant and Distribution System Lead Operators</td>
<td>Ongoing/Incorporate into SOPs</td>
</tr>
</tbody>
</table>
2.4. Chlorine and Chloramine Interaction: does the system monitor and operate to minimize odors and other interaction by-products? Is free ammonia monitored where interaction may cause breakpoint issues? Fully Optimized.

Treatment processes have been optimized at the GWTP to minimize odors, disinfection byproducts, and prevent nitrification. For example,

- Raw water is dosed with a small amount of chlorine to remove odors caused by hydrogen sulfide and ammonia present in the raw water
- Free chlorine is dosed to meet Ground Water Rule (GWR) disinfection requirements (CT requirement to achieve 4-log virus inactivation), and optimized to minimize DBP formation.
- Chloramine dosage for the plant effluent is monitored to achieve the target dosage and maintain the optimal chlorine to ammonia ratio for this water source, which was experimentally determined to be in the range of 5-5.5:1. Ammonia is continuously monitored by online instrumentation, and frequent sampling at the chloramine dosing point is performed to assure optimized chlorination is maintained. To prevent nitification, the distribution system is monitored at strategic locations to assure optimal monochloramine levels are maintained, with minimal free ammonia residuals.

The Stage 1 and Stage 2 Disinfectants and Disinfection byproducts (D/DBP) rules established Maximum Contaminant Level (MCL) for total trihalomethanes (TTHM) (80 ppb) and the sum of the five regulated haloacetic acids (HAA₅) (60 ppb). To comply with these rules, the Department monitors TTHM and HAA₅ quarterly at 12 sampling locations. The locations include points of entry, and high TTHM and high HAA₅ locations identified in the initial distribution system evaluation (IDSE). To help assure compliance, the Department voluntarily started Stage 2 monitoring, including evaluation of individual sample site locational running annual averages, in the third quarter of 2009 (EPA required deadline for our system was April 1, 2012). This monitoring documents that our water system has reliably and consistently met the DBP MCL requirements at each location. During 2012, the maximum TTHM detected in the system was 69 ppb and the maximum HAA₅ detected was 19 ppb. Additionally, we have thoroughly evaluated our “normal” baseline DBPs to establish an internal DBP goal of 60/30 for TTHM/HAA₅ respectively; staff will take actions to prevent consecutive sample results exceeding our DBP optimization goals.

The Department’s WQ Lab has trained personnel to perform monthly taste and odor flavor profiling test. When taste and odor complaints increase, the test frequency is increased to help guide treatment strategies to mitigate these issues.
Pressure Management

2.5. Pressure Management Goals: does the system meet all of the pressure management goals? 1) 20 psi minimum (under normal operating conditions including maximum hourly demand and fire flow) in 99.5% of daily minimum measurements. 2) Maximum pressure does not exceed utility specified maximum in 95% of measurements 3) Pressure fluctuations do not exceed utility specified maximum in 95% of measurement. Fully Optimized.

The Department’s distribution system is served by two storage facilities through gravity. Before joining the Partnership, hydraulic models had been developed to map the pressure zones for the entire system (Appendix D). The calculated system pressure through this modeling was predicted to be above 20 psi. Historically, pressures were monitored and continuously updated on SCADA at two critical locations: the Bridge (Blended zone, three sensors) and booster pump station (Boosted zone, two sensors). In 2012, the daily minimum pressures ranged from 25.2 to 45.1 psi. The system maximum system pressure goal is 80 psi, 4.3% exceeded this goal in 2012. The maximum single site pressure range goal is 15 psi, 0.8% exceeded this goal in 2012 (Pressure Performance Assessment Data Spreadsheet V. 1.3).

Upon joining the Partnership, it was determined that the existing pressure monitoring at the two critical locations should be supplemented with additional pressure sensors in order to obtain adequate data and more thoroughly monitor all pressure zones. In January of 2012, pressure sensors with data collection functions have been placed at six locations to further confirm that the system pressure is under control (Appendix D). The pressure data was downloaded monthly and compared against predictions from hydraulic model, and pressure calculations based on elevation differences. It was found that for the Blended and Purchased Water zones, the difference between pressures predicted from elevation calculation/hydraulic model and pressures monitored were <10 psi (Figure 2.1 and Figure 2.2). For the Boosted zone, the elevation calculation pressures were approximately 20 psi lower than actual monitored pressures, but the hydraulic model and pressure monitoring at the booster pump station provided good agreement with field monitoring (Figure 2.3). In addition, the selected Blended zone monitoring location was at the foot of the Blended Water Reservoir, where the lowest pressures are expected because this elevation is higher than the rest of the system; monitoring at this location confirmed that the pressures are >20 psi (Figure 2.1).
Figure 2.1: Measured and Calculated Pressure Monitoring Results in the Blended Zone
Figure 2.2 Measured and Calculated Pressure Monitoring Results in the Purchased Water Zone
2.6. Pressure Monitoring: is pressure monitored in each pressure zone at a minimum of two "critical sites" (areas of high and low pressure)? Are the instruments routinely calibrated? Does the pressure monitoring include maximum day demand flow, fire flow events, and emergency situations (such as main break or power outage)? Partially Optimized.

As mentioned earlier, pressures were historically monitored and continuously updated on SCADA at two critical locations. Upon joining the Partnership, it was determined that the existing pressure monitoring at the two critical locations should be supplemented with additional pressure sensors in order to obtain adequate data and more thoroughly monitor all pressure zones. In January of 2012, pressure sensors with data collection functions have been placed at six locations to further confirm that the system pressure is under control (Appendix D). The pressure data from these additional monitors is downloaded and reviewed monthly. In order to further optimize process control and data management, the additional six sensors will be tied to SCADA to allow real time review of pressure trends so all conditions including maximum day demand flow, fire flow events, and emergency situations will be captured. Annual calibration
has not yet occurred, but is scheduled to be performed on an annual basis through a contract with the pressure sensor manufacturer. In addition, field operators are supplied with portable pressure gauges to monitor pressure during main breaks and when responding to customer complaints. This pressure data will be recorded on the "Report on Service Rendered" and customer complaint investigation logs (Appendix E).

2.7. Permanent Pressure Monitoring: is the pressure sensor data analysis configured to alarm the operator when low pressure (below 35, 20 psi) or high pressure spikes occur? Partially Optimized.

The Bridge pressure sensors display alarms on SCADA when differential pressures among the three sensors (north, south and middle of the bridge) exceed the set points. The alarms notify the operators to dispatch the emergency service team for further investigations. Concurrently, valves will close automatically to isolate the affected section to prevent further damage. The tank levels at the storage facilities, which are good indicators of the system pressure, are continuously monitored and operators are required to record the levels hourly. When the pressure falls below 65 psi in the Boosted zone, a low pressure alarm will notify the operators to investigate. Other pressure sensors installed in the system are not currently connected to the SCADA; until they are tied to SCADA, data generated from these sensors will be periodically checked to verify the pressure conditions.
2) Online Pressure Sensor Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Six pressure sensors provide intermittent data logging only – lack real time SCADA</td>
<td>Identify most feasible plan for SCADA integration of six sensors and report to Team</td>
<td>Distribution Systems Operations Superintendent</td>
<td>3/2013 Team Meeting</td>
<td>Complete Pressure Sensor SCADA Integration, including low pressure alarm</td>
<td>Dist System Maintenance Supervisor w/ contract SCADA programmer</td>
<td>6/2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Review Pressure trends for optimization opportunities</td>
<td>Treatment Plant and Distribution System Lead Operators</td>
<td>Ongoing/Incorporate into SOPs</td>
</tr>
<tr>
<td>Pressure Sensors are not calibrated annually</td>
<td>Organize annual pressure sensor calibration with manufacturer technician</td>
<td>Distribution System Maintenance Supervisor</td>
<td>1/2014 and Annually thereafter</td>
<td>Review pressure sensor calibration results and work with manufacturer to assure timely replacement of faulty pressure sensors</td>
<td>Distribution System Lead Operator III</td>
<td>2/2014 and annually thereafter</td>
</tr>
</tbody>
</table>

2.8. Standard Operating Procedures: is the operator aware of conditions that can cause low or high system pressures? Are Standard Operating Procedures available that account for routine and non-routine operations that might affect pressure? Are maximum system pressures established and supported with documentation? **Fully Optimized.**

Because the distribution system is gravity-fed (except for the Boosted zone), high pressure conditions are unlikely to occur with the exception of a few special instances (e.g. improperly functioning booster pump, water hammer). The purchased water has pressures ranging from 120 to 220 psi when it reaches the Department’s connections; the pressures are reduced to match the Department’s system pressure through pressure reducing valves (PRV). Although unlikely, a malfunction in the PRV might also lead to high system pressures. Low pressures can occur when valves are not seated in the appropriate position, when breaks occur, or booster pumps fail. However, the systems are designed and operated
to prevent those situations: booster pump operations are pressure and flow regulated; PRV at purchased water connections will fail at the normal working position, which prevents high pressures which could potentially occur if the PRV failed in the fully-open position.

Operations impacting system pressures include storage tank operations, valve operations, shutdown of large transmission mains, main break and flushing activities. Established standard operating procedures (Appendix F) are available to minimize the impact of these operations on pressure.

2.9. Emergency Procedures: does the utility have written policies and procedures used to avoid and respond to a low or negative pressure event emergency? **Fully Optimized.**

One scenario outlined in the Emergency Response Plan (ERP) deals with “loss of water/pressure within a large section of the distribution system”. The ERP outlines the duties and responsibilities of various Department staff to respond to an unintentional loss of water within a large section of the distribution system. The Department has three certified Grade 4 Treatment Operators, who are available for 24-hour response, on a rotating basis. The on-duty Grade 4 operator serves as the incident commander (IC) and directs the response actions. Staff conduct an annual table-top training which centers around a loss of distribution system water pressure; this results in updates to the ERP if necessary.

2.10. Pressure Fluctuation Management: are pressure fluctuations monitored, investigated, and procedures used to reduce variations? **Partially Optimized.**

Because the system is gravity-fed, and the impact of normal tank turnover on the system pressure variation is minimal (in 2012, the average turnover is 9 ft, which translates to ~4 psi). The Department has an emergency response program that operates on a 24-hour basis, so when a main break occurs, staff responds within 30 minutes and the likely impact on pressure at the break area is minimized due to the timely isolation and repair of the break. As mentioned earlier, other pressure fluctuations are monitored via eight pressure sensors, but six of those sensors are not yet tied to SCADA. Once tied to SCADA, staff will have greater capability to respond to pressure fluctuations, should they occur, in a timely manner.

Action plan, previously noted, Refer to item 2.7.
Main Break Frequency

2.11. Main Break Goals: does the system meet the main break goals of no more than 15 reported breaks and leaks per 100 miles of utility-controlled distribution and transmission piping per year and a declining rolling 5-year Main Break frequency trend (most recent 5 years)? Fully Optimized.

The Department has been continuously meeting the goal of ≤ 15 main breaks per 100 miles per year since 2000 (Main Breaks and Leaks Self-Assessment Tool v1.00). The rolling 5-year frequency showed a clear declining trend (Figure 2.4). Breaks usually occur in unlined cast iron pipes, and the declining trend is primarily due to the Department’s aggressive main replacement program (Figure 2.5). In the past 20 years, the Department has replaced approximately 200 miles of unlined cast iron pipes with cement mortar-lined ductile iron pipes, and the quantity of cast iron mains have dropped from 340 miles in 1992 to 143 miles in 2012 (Figure 2.5).

![Figure 2.4 Main Break Frequencies](image_url)
2.12. Pressure Effects: are main breaks correlated to variations in pressure? **Fully Optimized.**

Main breaks do not correlate with pressures in the distribution system, breaks occurred in all pressure zones in the system (Appendix G). Main breaks were found to correlate with temperature as more breaks occurred in winter months (December and January) when temperature was lower (Figure 2.6). It was also found that ~65% breaks occurred in cast iron pipes (Figure 2.7). The impact of the storage tank turnover on system pressure is minimal (in 2012, average daily variation is ~4 psi). Operations leading to pressure surges and inducing breaks include water hammer, malfunctioning booster pumps in the booster zone, and malfunctioning PRVs at the purchased water connections. However, the system is designed and operated to prevent the exposure to these conditions.
Figure 2.6 Total Number of Breaks vs. Break Month From 1990 to 2012.

Figure 2.7 Total Number of Breaks vs. Pipe Material From 1990 to 2012.
2.13. **Pressure Stabilization:** are pressure stabilization procedures applied to a wide area surrounding a main break location? *Partially Optimized.*

As part of the Standard Operating Procedure (SOP), when a main break occurs, the first step is to isolate the break, which stabilizes the system pressure in the surrounding area (Appendix F). Pressure is not expected to be impacted in a large area, so pressure monitoring has not been a part of the SOP historically. During the self-assessment process, this was recognized as an area needing improvement, so field staff have been supplied with pressure gauges and instructed to take pressure readings at a minimum of two hydrants surrounding the break. The "Report on Service Rendered form" was also revised to include pressure monitoring and recording surrounding the break.

### 3) Pressure Stabilization During Main Break Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure monitoring is not part of existing main break SOP, which limits ability to verify pressure stabilization</td>
<td>Supply staff with portable pressure gauges</td>
<td>Distribution Systems Lead Operator III</td>
<td>Completed 11/2012</td>
<td>Revise SOPs to reflect pressure is monitored at a minimum of two hydrants surrounding the break</td>
<td>Distribution System Operator II</td>
<td>6/2014</td>
</tr>
</tbody>
</table>
Section III Operational Performance Improvement Variables

In this section, additional operational parameters that have a significant impact on distribution system water quality and distribution system integrity are assessed. Assessment of the following parameters is included in this section of the report:

- Cross Connection Control and Backflow Assessment
- Customer Complaints
- Disinfection By-Product Control
- Energy Management
- External Corrosion Control
- Flushing
- Maintaining Hydrants, Valves, and Blowoffs
- Internal Corrosion
- Nitrification
- Pipeline Installations; Rehabilitation and Replacement
- Post-Precipitation Control
- Security and Online Monitoring
- Storage Facility Operation and Maintenance
- Water Age, Modeling
- Water Loss Control
- Water Quality Sampling and Response

Cross Connection Control and Backflow Assessment

3.1. Enforcement Authority: does the utility have authority to enforce backflow regulations (local, state, federal, or other)? Fully Optimized.

The Department implements, administers, and maintains an ongoing backflow prevention and cross-connection control program (Appendix H) to protect the water system from hazards originating from water service connection that may impair or alter water quality in the distribution system. The Department provides free testing for all external backflow prevention assemblies according to the backflow prevention SOP (Appendix F). The testing of all backflow devices is tracked using the backflow software (XC2 software). The Department works with the City Building Department on plan reviews for new facilities that have been identified as a potential cross-connection or backflow threat. A test must be performed by one of the Department’s certified backflow testers before water service is turned on to any new facilities.

3.2. Backflow Protection Device Location: does the utility have a comprehensive list of locations where backflow prevention devices are required (a testing verification schedule and results)? Fully Optimized.
The Department tracks and tests all backflow devices annually on the XC2 software. For the 2012 evaluation period, the Department has a total of 3,642 active assemblies and is actively testing all assemblies. For assemblies failing the initial test, repairs or replacements are performed, and a second test is conducted to confirm that the devices are properly functioning.

3.3. Backflow Protection Device Installation and Testing: does the utility provide training and verify certification for cross-connection installers and testers? **Fully Optimized.**

The Department provides training to assist internal staff in obtaining backflow tester certification. The Department has four certified backflow testers responsible for all new installations and who perform tests on the assemblies.

3.4. Backflow Program: does the utility have a comprehensive backflow prevention program that includes all the elements in AWWA Manual M14 and meets all local, state, or other applicable requirements? **Fully Optimized.**

The Department’s cross-connection control program is detailed in its Rules and Regulations (Appendix H), and complies with state regulation requirements. The Department evaluates cross-connection hazards through plan check on new/modified construction before service is connected, as well as requesting site inspection when there are suspected hazards. To ensure that no cross-connections and backflow occur in the water system, the Department requires different levels of protection for different facilities based on state regulation requirements and M14 recommendations. The Department also certifies new installation, performs annual assemblies test, and repair or replace the assemblies as necessary.

**Customer Complaints**

3.5. Technical Quality Complaint: what are the annual technical quality complaints per 1000 customer accounts? Is there a plan to reduce the number if it is more than 2.5/1000 accounts? **Fully Optimized.**

The Department continuously compiles water quality complaints and reports to the state regulating agency monthly and annually. The categories include taste and odor (T&O), color, turbidity and particles, pressure, illness, and other complaints. The Department has approximately 89,700 active accounts and a total of 127 complaints were received in 2012, which resulted in a rate of <2.5 complaints/1,000 customer accounts. All complaints were reported to the state regulating agency after corrective actions have been taken. The most frequent complaints were related to color and T&O: of the 127 complaints received, 46 were color-related and 41 were T&O-related. The majority of the T&O problems were resolved after customers add bleach to the drain and after cleaning in-home filtration systems. Color complaints were mostly resolved through main flushing or additional flushing in the customer’s home or at nearby construction work.
T&O complaints also occur when there is a change in source waters (i.e. a switch from groundwater/surface water blend to 100 percent purchased surface water). These situations may occur when the GWTP is taken off-line to perform critical maintenance work. Depending on the duration and extent of the source water change, customers may be notified through public media (i.e. newspapers). Many complaints related to turbidity or particulates have been resolved when customers are advised on routine in-home filtration systems maintenance or flushing the taps which are not frequently used. If the above actions do not resolve the problems, samplers are dispatched to collect samples at customers’ homes and investigate further. For 2012, all samples collected have been confirmed as meeting all State and Federal safe drinking water regulations.

3.6. Customer Complaint Monitoring and Response: are customer quality complaints recorded and is response time tracked? Are technical complaints tracked separately from billing and general information inquiries? Fully Optimized.

Customer water quality complaints are recorded and reported to the state regulating agency. All customer water quality complaints are received by WQ Lab staff during normal working hours, and complaints received outside of these hours are directed to the standby WQ Lab staff, who then responds within an hour and determines if further investigation is needed. The details of the complaints and the Department’s response and corrective actions taken are included in the monthly compliance report. The Department’s website is a good source of information for contact information regarding billing and water quality, with different contact numbers listed.

Disinfection By-product Control

3.7. DBP Goals: do TTHM and HAA5 distribution system test results satisfy the regulatory requirements? (EPA are <80 ug/L TTHM and <60 ug/L HAA5 locational running annual average) Fully Optimized.

The Department has consistently met the Stage 1 and 2 requirements for TTHM and HAA5 in the distribution system. For 2012, all DBP results were lower than the MCLs, and the Locational Running Annual Averages (LRAA) were also below 80 ppb and 60 ppb, respectively (Figure 3.1 and 3.2). As previously discussed, we were proactive in preparing for Stage 2 D/DBP in advance of the regulatory deadline; and, our staff strive to meet more stringent internal DBP goals of 60/30 ppb TTHM/HAA5.
Figure 3.1 TTHM Quarterly Monitoring and LRAAs in 2012
3.8. DBP Monitoring and Trending: are system DBP concentration trends monitored and is there a plan to maintain or reduce the current levels while maintaining adequate disinfectant residual? Partially Optimized.

System DBP concentration trends are monitored (Figures 3.1, 3.2), and treatment processes at the GWTP were optimized to minimize the formation of DBPs. This is accomplished by removing organic precursors through coagulation, and controlling chlorine dosage to meet disinfection requirements while minimizing chlorine residuals. In the distribution system, storage tanks are operated to reduce water age by daily cycling. In addition, specific locations in the system are routinely flushed in order to improve water quality in low usage areas. We consistently meet our in-house goal of <30 ppb HAA5, we are close to consistently meeting our internal goal of <60 ppb TTHM. Staff are constantly aware of the difficult balance between maintaining a robust chlorine residual throughout the entire system and maintaining low DBPs. As a means of reducing TTHMs at points of high water age, without increasing chlorine dosages, the installation and use of automatic flushing devices continues to be fine-tuned.
4) Further Optimize TTHMs at High Water Age Locations Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>High water age locations do not consistently meet in-house TTHM optimization goal of &lt;60ppb</td>
<td>Evaluate existing set points for automatic flushing devices at points with highest TTHM levels</td>
<td>Distribution Systems Lead Operator III</td>
<td>Quarterly Trends last evaluated 1/2013. Next evaluation scheduled for 4/2013</td>
<td>Revise automatic flushing frequency and duration set points and evaluate resulting TTHM and total chlorine residual data. Communicate findings and SOP changes to other operators</td>
<td>Distribution System Superintendent</td>
<td>Ongoing, quarterly basis, within 2 weeks after receiving report from Operator III</td>
</tr>
</tbody>
</table>

**Energy Management**

3.9. Pressure Management: if pressure is managed to reduce energy usage, does the utility monitor the effect on stability insuring that appropriate pressure ranges are maintained? **Fully Optimized**.

The Department’s SOPs for finished water pumping and storage tank operations are designed to minimize energy costs and maintain water quality and pressure stability (Appendix F). The Department’s primary pumping costs are associated with transferring water from the clearwell located within the plant to off-site storage tanks. To minimize energy costs, finished water pumping to the storage tanks takes place outside of the electricity On-Peak hours (noon to 6 p.m.). The storage tanks are filled up prior to the peak hours, and then the tank levels are drawn down by system demand. This creates a daily cycling of the tank (average of ~9 ft turnover in 2012) which ensures that water quality is maintained while pressure fluctuations are minimized (~4 psi variation) (Figure 3.3). In the Boosted zone, pumps are operated to increase the pressure from ~40 psi to >65 psi; this pressure is maintained continuously without regard for the cost of electricity.
3.10. Pump Efficiency: are all major distribution system pumps routinely tested for efficiency? Are there targets for maintenance or replacement based on efficiency? Partially Optimized.

The Department has two pumping facilities: GWTP pump station (11 pumps) and the booster pump station (5 pumps). The Department’s electricians test the system pumps periodically. When one pump’s energy usage/water volume is significantly different from other pumps, further investigation is conducted to determine if the pump needs to be replaced. For example, a recent test showed that one pump’s energy usage/water volume was 53% higher than the other pumps, so this pump is budgeted for replacement during in the next fiscal year. In addition, the local electricity provider offers free pump efficiency tests and incentives for pump repair/replacement, and the Department has been taking advantage of this program by requesting free efficiency tests every two years, and performing follow up pump work. The most recent efficiency test was performed in January 2012. One pump’s test result showed that it was not pumping efficiently (efficiency can be improved from 60% to 72%) and is in the process of being rebuilt.
3.11. Pump Operation: has a hydraulic surge analysis been performed on major system pumps? Is there a plan to reduce hydraulic transients? **Fully Optimized.**

All distribution system pumps have soft starting mechanisms, which minimize electrical and hydraulic surges during start up. At least one pump is in continuous operation at both pumping stations, so hydraulic surge is not expected in the system. Therefore, there is no immediate plan on reducing hydraulic transients, unless field pressure monitoring indicates that hydraulic surge occurs.

**External Corrosion**

3.12. Pipe Inspection: are pipes inspected and sampled whenever they are exposed? **Partially Optimized.**

Pipes are only exposed during main breaks or main replacement work. Staff is required to perform field inspection and record the type of break, location of break, condition of pipe, cause of deterioration, soil classification and apparent cause of break on the main break report (Appendix E). This information is entered into a Global Information System (GIS) database and used to guide future main replacement work. Samples of the pipes are not routinely collected.

### 5) Pipe Sample Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipes are thoroughly inspected; but, not sampled when exposed</td>
<td>Modify SOP to include representative pipe sampling when pipes exposed, along with digital photos</td>
<td>Completed 9/2012</td>
<td>Evaluate Pipe Samples and Provide Report</td>
<td>Ongoing with report provided to Distribution System Superintendent within 2 months of sample collection</td>
</tr>
<tr>
<td>Train Distribution System operators on new SOP</td>
<td>Distribution Systems Lead Operator III</td>
<td>Distribution System Operator II</td>
<td>Establish database to manage pipe sample reports &amp; photos</td>
<td>During next database revision – 1st quarter of 2014</td>
</tr>
</tbody>
</table>
3.13. Main Break and Leak Records: are corrosion observations recorded during all main break and leak repairs? Fully Optimized.

Observations are recorded and entered into the GIS database.


Soil analysis is performed before installing new ductile iron pipes. The Department has also initiated a program for soil corrosivity testing when routine maintenance work is performed. The corrosivity information will be entered into a GIS database, which will establish a corrosivity profile for the overall system. Currently, the program is still in a trial stage and a more detailed work plan is being developed. A revision of the maintenance group’s SOPs will include this analysis, and other actions include training of field operators and the establishment of a good chain of custody system for soil samples.

3.15. Corrosion Protection: is corrosion protection installed when materials and environment requires? Fully Optimized.

Corrosion protection has been an important part of the Department’s Capital Improvement Program (CIP). The Department performs periodic corrosion studies to inspect the conditions of pipeline and tanks. In 2009, the Department installed sacrificial anodes for cathodic protection in all storage tanks. There is also a 10-phase program to install sacrificial anode systems for steel transmission (≥12 inch) mains, with the goal of protecting steel main pipes located in severely corrosive areas. In addition, all new pipes and fittings are bagged prior to installation (main break or main replacement work).

Flushing

3.16. Routine Flushing Program: has the utility instituted a routine flushing program and documented rationale for flushing practices (or lack of) currently in use? Fully Optimized.

The Department has a dead end main flushing program to prevent distribution system water quality degradation. The Department identified 977 dead ends in the distribution system from 2005 to 2006, and flushed each until the total chlorine residual was above 1.0 mg/L. Approximately 200 dead end sites are placed on the flushing list annually based on the diameter of pipes, time, and volume required to meet the goal of >1.0 mg/L total chlorine residual. Total chlorine residual is monitored before and after flushing, and coliform, turbidity, HPC and color are monitored to ensure the water quality at these locations is consistent with the overall system.
3.17. Flushing Methods: is chlorine residual monitored as part of the flushing program? Is chlorine residual used as an indicator of when it is acceptable to terminate a flush? Are routine flows or flush velocities at least 2.5 ft/sec for removal of loose particles? Are routine flushing velocities at least 5 ft/sec for removal of cohesive and loosely adhered particles and biofilm? Is dechlorination of flushing water provided where appropriate? Fully Optimized.

Chlorine is monitored before and after flushing, with the goal of flushing to meet a minimum total chlorine residual of 1.0 mg/L. The flushing plan does not establish a velocity goal, but instructs the operators to open hydrants or blowoff valves fully for a period long enough to stir up the deposits inside the water main (usually 5 to 10 minutes) and flush the lines for 15 to 30 minutes. The pipe size, flushing volume and time flushed are recorded in the flushing records. Assuming a uniform flushing rate, velocity calculations based on these records indicate that most flushing velocities were less than 2.5 ft/sec. The total chlorine target was achieved during all flushing events without increasing water quality complaints; therefore, there are no plans to increase flush velocity during routine flushing. However, flushing activities after main construction work will be performed at higher rates (>5 ft/sec) to remove all construction debris.

To comply with the City Storm Water Management Program’s best management practices, the Department dechlorinates all water generated during the flushing activities (Appendix I).

3.18. Pressure Monitoring: is pressure monitored during flushing (manual and automatic) to verify that pressure goals are continuously achieved? Fully Optimized.

The current flushing plan instructs the operators to maintain a system pressure in nearby areas above 20 psi during flushing. Pressure is also recorded as part of the flushing records, and in 2012, pressure ranged from 43 to 88 psi during the flushing activities.

Maintaining Valves, Hydrants, and Blowoffs

3.19. Location Records: does the system have accurate and current records that document the location and attributes for all valves, hydrants, and blowoffs? Fully Optimized.

There are approximately 20,500 valves within the distribution system, ranging in size from 4 to 42 in. The locations and attributes of all valves are included in the GIS database, which is updated regularly. The Department also employs field tablets with a database program (iWater, Irvine, CA), which allow field personnel to update information out in the field and view maintenance history. There are ~6,600 hydrants in the system, and location and attributes for all these assets are included in the GIS database.
The Department currently does not have a complete inventory of all blowoffs. Updated records for blowoffs included in the dead end main flushing program are maintained. Other blowoffs within the system were installed solely as chlorine injection points when the lines were installed, and remain buried underground. Access to these blowoffs was deemed to be unnecessary because the system has sufficient hydrants to use for flushing.

3.20. Inspection and Assessment: are all valves, hydrants, and blowoffs inspected and evaluated on a schedule? **Partially Optimized**

All valves and blow-offs are exercised within an eight-year cycle, in accordance to the Department’s valve maintenance plan (Appendix F) and the iWater (Irvine, CA) valve exercise program is used for tracking purposes. The valve exercise program is also reported annually to the state regulating agency. Currently, the Department does not routinely inspect the hydrants because, once installed, the Fire Department is responsible for the hydrants. The Department has one person dedicated to the maintenance of hydrants, whose job responsibility includes repairing/replacing broken hydrants, inspecting, painting and performing preventive maintenance by replacing hydrants’ caps, packing, etc. Due to the large number of hydrants in the system (~6,600), the staff is primarily focused on repairing/replacing broken hydrants while trying to maximize inspection and preventive maintenance. The Department also replaces hydrants when the associated main lines are replaced. Additionally, hydrants located at the identified 977 dead ends are subject to routine flushing (~ 200 annually) according to the dead end main flushing program (Appendix I).

### 6) Hydrant Inspections Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Department was responsible for hydrant inspection, but not able to keep up due to staffing issues</td>
<td>Meet with Fire Department to discuss time demands and costs for hydrant inspections</td>
<td>Distribution Systems Maintenance Supervisor with Dist Ops Superintendent</td>
<td>Completed 8/2012</td>
<td>Cost Feasibility Study to determine most feasible plan to re-establish routine inspection</td>
<td>Civil Engineering Associate</td>
<td>Report to Deputy General Manager by 1/2014</td>
</tr>
</tbody>
</table>
3.21. Exercise Program: are all distribution system main valves and hydrants exercised and tested at least every three years (or more frequently if required by regulation)? Partially Optimized.

All valves are exercised and tested within an eight-year cycle. Specifically, all large (14” to 42") valves are exercised within a two-year cycle and small (4” to 12”) valves are exercised within an eight-year cycle. The Fire Department is responsible for routine inspection and testing of hydrants. Historically, all hydrants are inspected and tested annually; however, fire hydrant testing has recently stopped due to budgetary constraints. The Department will further dialogue with the Fire Department to identify costs and develop feasible plans to resume annual hydrant tests by FY2014.

7) Exercising Small (4” to 12”) Valves Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
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<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small valves are exercised and tested within an 8-year cycle. Partnership suggests a 3 year valve exercise frequency optimization goal</td>
<td>Review map and identify highest priority small valves for 3 year exercising frequency</td>
<td>Distribution Systems Maintenance Supervisor</td>
<td>4/2013</td>
<td>Cost Feasibility Study to determine most feasible plan to meet 3 year exercising frequency goal on highest priority small valves, including additional staff needed to meet goal on all valves</td>
<td>Civil Engineering Associate and Distribution Systems Maintenance Supervisor</td>
<td>Report to Deputy General Manager by 12/2014</td>
</tr>
</tbody>
</table>

3.22. Hydrant Repairs: are all hydrant repairs scheduled within 24 hours of discovery? Are inoperable hydrants identified immediately and is this communicated to the fire protection authority? Fully Optimized.

One staff member is dedicated to the repair and replacement of fire hydrants, and all repairs are scheduled within 24 hours of discovery. When a hydrant has been identified as inoperable, the Water Department and the Fire Department will notify each other within 24 hours.
3.23. Hydrant Access: does the system control access to hydrants and provide training for proper third-party use? **Partially Optimized.**

No access control has been installed on the hydrants due to Fire Department concerns over potential delays in response time. Currently, the Department is in discussions with the Fire Department regarding this issue. The Fire Department provides training for its staff and the Water Department does not provide training for other third-party use of hydrants; instead, the Department deploys internal staff to operate the hydrants based on third-party requests.

8) **Hydrant Access Control Action Plan:**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>No access control exists on hydrants due to Fire Department concerns over delayed response time</td>
<td>Investigate potential access control devices that provide adequate tampering protection with minimal delay for fire department emergency use</td>
<td>Security/Emergency Preparedness Manager and Civil Engineering Associate</td>
<td>12/2013</td>
<td>Meet with Fire Department management to review options, costs, and attempt to reach consensus plan of action</td>
<td>Deputy General Manager, Security/EP Manager, Civil Engineering Associate, Distributions Systems Maintenance Supervisor</td>
<td>First Quarter 2014</td>
</tr>
</tbody>
</table>

**Internal Corrosion Control**

3.24. Lead and Copper Action Levels: does the system meet regulatory lead and copper action levels? **Fully Optimized.**

The Lead and Copper Rule (LCR) established a maximum contaminant level goal (MCLG) of zero for lead and action levels (AL) of 0.015 mg/L for lead, and 1.3 mg/L for copper; compliance is based on the 90th percentile values obtained for tap water samples. Although AL exceedance is not a violation, it can trigger
other requirements that include water quality parameter monitoring, corrosion control treatment, source water monitoring and treatment, public education, and lead service line replacement. The standard LCR monitoring frequency is every 6 months, although in the Water Department’s situation, the utility has been allowed to conduct reduced monitoring (every three years) based on the three consecutive years of monitoring results being ≤ AL. For the past three monitoring periods (2004, 2007 and 2010), the 90th percentile levels for lead have been below 0.005 mg/L (detection limit) and the 90th percentile levels for copper have been below 0.15 mg/L.

3.25. Corrosion Monitoring: does the utility have a corrosion testing policy (such as coupons, electronic detection, water quality monitoring) conducted routinely (at locations throughout the system)? Fully Optimized.

For both the Blended and Purchased Water zones, the delivered potable water has been characterized by high alkalinity (70-120 mg/L), high calcium (22-56 mg/L) and controlled pH (7.8 to 8.3). The corrosion index, Langelier Saturation Index (LSI), calculated from the above water quality data, is approximately 0. This indicates that the water delivered is not aggressive in the distribution system, so routine corrosion coupon testing is not performed. However, important water quality parameters, including pH, alkalinity, calcium, hardness, temperature, and total dissolved solids (TDS), are monitored at least monthly. In addition, as part of the Department’s desalination research program, bench-scale coupon tests and pilot-scale pipe loop tests evaluating corrosion and other water quality issues in the distribution system were completed. The test results confirmed the prediction from corrosion indices that the Department’s distribution system water is noncorrosive.

3.26. Main Break and Leak Records: Is the break site examined for tuberculation, pitting, holes or scaling? Fully Optimized.

Field crews are required to record observation of the break and pipe condition during main break work (Appendix E) as part of their routine work. Information reported includes type of break (holes in pipe, broken coupling, etc), cause of break (settlement, deterioration, earthquake, etc), cause of deterioration (pitting, graphitized, etc) and other information. The information is entered into the GIS database, and can be sorted to identify potential breaks in certain areas.

Nitrification Control

3.27. Nitrification Detection: are free ammonia, nitrite, and HPC tested routinely? Are action levels established? Fully Optimized.

The Department has a comprehensive nitrification prevention and control plan to provide guidelines for an early warning, and for operational guidance to prevent and control nitrification episodes within the distribution system (Appendix J). The State-approved plan requires that all storage tanks and distribution sites be
monitored monthly for ammonia and weekly for nitrite, total chlorine residual and HPC (Appendix J). Four action levels have been established based on monitoring results (Table 3.1), and include increasing monitoring, investigating and correcting valve positions, increasing storage tank cycling, flushing, corrective dosing, tank isolation and using an alternative source. Additionally, monochloramine is monitored frequently throughout the distribution system (sampled and analyzed together with total chlorine and free ammonia), with a goal of keeping the highest percentage of total chlorine in the monochloramine species.

Table 3.1. List of Monitoring Results with Corresponding Action Category

<table>
<thead>
<tr>
<th>Parameter (mg/L)</th>
<th>Action 1</th>
<th>Action 2</th>
<th>Action 3</th>
<th>Action 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cl₂ Residual</td>
<td>1.6-2.5</td>
<td>1.0-1.5</td>
<td>&lt;1.0</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>NH₃-N-Free</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Nitrite-N</td>
<td>&lt;0.030</td>
<td>&gt;0.030-.050</td>
<td>&gt;0.050-0.10</td>
<td>&gt;0.10</td>
</tr>
<tr>
<td>HPC (cfu/mL)</td>
<td>&lt;500</td>
<td>&gt;500</td>
<td>&gt;500</td>
<td>&gt;500</td>
</tr>
</tbody>
</table>

3.28. Nitrification Control: are disinfectant residuals maintained >0.50 mg/L total chlorine? Are storage tanks monitored in areas lacking circulation? Are zone boundaries and dead ends monitored for nitrification? Fully Optimized.

Total chlorine disinfectant residuals are maintained at a minimum level of >0.50 mg/L, with an internal goal of >0.65 mg/L. If the total chlorine residual system-wide is <0.50 mg/L, City management and the state regulating agency are notified if any primary MCLs were violated.

All in-service storage tanks are operated with a daily cycling, in 2012, the average daily cycling was ~9 ft, which ensures good tank circulation. Each storage tank is monitored monthly during the winter months and bi-weekly during the summer months for disinfectant residual, HPC, coliform, temperature and nitrification (total and free ammonia, monochloramine, and nitrite). All distribution sampling locations, including the zone boundaries, are monitored weekly for nitrite, total chlorine, monochloramine, and free ammonia. Dead end flushing sites are not directly monitored for nitrification, but monitored for indicators of nitrification, including chlorine residual and HPC.
Pipeline Installation, Replacement, and Rehabilitation

3.29. Pipeline Installation: are all pipelines installed and disinfected as required by applicable regulations? Do procedures follow AWWA/ANSI Standards C600-620 and C651 or other as appropriate? Fully Optimized.

The Department has an active cast iron pipe replacement program; in the past 20 years, approximately 200 miles of unlined cast-iron pipes have been replaced with cement mortar-lined ductile iron pipes, reducing the total length of cast iron mains from 340 miles (1992) to 143 miles (2012). AWWA’s C600 standard is used for pipe replacement, which addresses issues related to alignment and grade, trench construction, pipe installation, joint assembly, backfilling, valve, fitting and hydrant installation and restraint, flushing, tapping and hydrostatic testing. The Water Main Disinfection Plan (Appendix F), developed based on AWWA’s C651 standard, is followed to disinfect pipes prior to placing them into service. This plan covers both newly-installed pipes and main breaks, and it includes main preparation/trench treatment procedures, disinfection procedures and dosages, sampling, and reporting.

3.30. Main Replacement and Rehabilitation: is there a formal process to prioritize main replacements? Fully Optimized.

The Water Department’s distribution system materials are grouped into three categories. The oldest pipes (installed before 1950) are made of cast iron (including both unlined and cement-lined). Asbestos cement pipes were installed between ~1950 and the mid-1980s, and cement-mortar lined ductile iron pipes have been installed since the 1980s. The replacement areas vary, depending on the age of the pipes and history of main breaks in the area. The main break locations are updated continuously on the GIS system and the area with highest rate of breaks/mile of pipe are given priority for replacement. Other factors considered include flow and water quality in the main replacement planning.

3.31. Pipeline Renewal Rate: is the renewal rate adequate to reduce the pipe over 75 years old in the system? Fully Optimized.

Pipes >75 years old were made of cast iron, and in the past 20 years, the Department has replaced ~20,000 to 100,000 linear feet of cast iron pipes annually. Each year, the amount of pipe over 75 years is reduced due to ongoing and targeted replacement efforts. There are approximately 140 miles of cast iron pipes (unlined and lined) remaining, which accounts for <16% of total distribution system piping. At the current replacement rate, it will require as much as 37 years to totally eliminate this pipe. The renewal rates are currently considered adequate because the Department has met the <15 main breaks/100 mile pipes-year since 2000. However, increased replacement frequency is evaluated each fiscal year depending on available budget and other distribution system priorities. Although this is an area considered to be optimized based on Partnership goals, the Department continues to evaluate increases in replacement frequency of pipe >75 years old on an annual basis.
Post Precipitation Control

3.32. Precipitation Recognition: are areas of low disinfectant residual investigated for precipitation? Partially Optimized.

Low total chlorine residual locations are normally checked for turbidity, color, and HPC, and flushing is required if turbidity is >1 NTU. Although no investigative sampling has been conducted, it was recognized that cast iron pipes have a higher potential to have precipitation problems. Iron corrosion and microbial growth are more prevalent in cast iron pipes than other pipe materials in the system, which can contribute to low chlorine residual. Precipitation investigation of low chlorine residual sites will start by June 2013 to monitor for other parameters, including iron, manganese and TDS, and used to compare with sites with normal residual total chlorine levels. Based on findings from this investigation, plans for main replacement, looping to eliminate dead ends and flushing will be modified accordingly.

9) Precipitation Investigation at Low Residual Areas Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation investigation does not routinely occur at low total chlorine residual sites</td>
<td>Modify existing SOP</td>
<td>Distribution System Lead Operator III</td>
<td>Completed 12/2012</td>
<td>Train staff on new SOP</td>
<td>Distribution System Lead Operator III</td>
<td>6/2013</td>
</tr>
<tr>
<td>Create precipitation investigation report form</td>
<td>Water Quality Lab Manager</td>
<td>4/2013</td>
<td>Evaluate data trends and use to influence main replacement, and flushing frequency</td>
<td>Water Quality Lab Manager and Distribution System Maintenance Supervisor</td>
<td>Quarterly beginning 1/2014</td>
<td></td>
</tr>
</tbody>
</table>

3.33. Precipitation Control: are treatment plant practices optimized to reduce precipitation potential? Fully Optimized.

The effluent water pH is adjusted to ~8.0 before exiting the plant to reduce corrosion and precipitation potential in the distribution system. Enhanced
coagulation is used to reduce total organic carbon (TOC), and the potential for microbial growth and precipitation.

3.34. Precipitation Remediation: are areas of precipitation accumulation cleaned at least annually (storage tanks, low water use areas)? Partially Optimized.

Storage tanks are inspected and cleaned at least once every 3 years. The Department also inspects and cleans a tank when it is being taken out of service. Low water usage areas (dead end locations) are flushed routinely in accordance to the Department’s dead end flushing program.

Security, Emergency Management

3.35. Vulnerability Assessment: have the items identified in the distribution system vulnerability assessment been implemented? Fully Optimized.

The hazard and vulnerability assessment required under the Bio-terrorism Act of 2002 was completed in January 2003. The issues identified were divided into five main groups: administrative, emergency response plan (ERP), information technology (IT), engineering and security. The recommendations included building more robust physical protection for the Department’s critical assets. The assessment also addressed the need to include protocols that address physical intrusions and system contaminations in the Department’s ERP. IT enhancements were primarily focused on restricting access to SCADA and continuing to segregate this system from the business network. Engineering enhancements include reinforcing physical facility structural integrity for critical assets and appurtenances. All recommended high risk improvement areas have been addressed, and a new vulnerability assessment is underway to reassess the system and address new areas of improvement.


The Department has a regularly-updated ERP that provides guidance to the employees whenever a National Terrorism Alert System (NTAS, formerly Homeland Security Advisory System) threat condition level is initiated, changed, or operating under emergency conditions. Additionally, it establishes procedures and an organizational structure consistent with the National Incident Command System (NIMS) and the Standardized Emergency Management System (SEMS) for Departmental emergency response.” Table-top exercises for ERP training are held twice annually, at a minimum, or within 30 days after changes to the ERP are made. Functional exercises are also conducted to enhance the ability of personnel to effectively respond to emergencies.

One recent (October 2012) functional exercise was the Department’s participation in a simulated response to a major tropical storm and flooding event.
The exercise involved the evacuation of certain facilities, coordination of communications with other City critical emergency response departments, and testing of remote unmanned operations for other Department’s facilities. The exercise allowed the Department to identify the strengths and areas needing improvement in the flood protection of critical sites and remote operational procedures. Recommendations were developed during the hot wash discussion immediately following the exercise. The recommendations were included to modify the ERP, procedures, and employee training.

3.37. Disinfectant Residual Monitoring: are disinfectant residual records readily available for reference during an emergency? **Fully Optimized.**

Disinfectant residual is continuously tracked and recorded in the SCADA system, which is readily available to the Treatment Plant (TP) staff.

**Storage Facility Operation and Maintenance**

3.38. Disinfectant Residuals: are storage facilities routinely (at least weekly) sampled for disinfectant residual testing? Are special sampling surveys conducted periodically to assess residual uniformity? **Fully Optimized.**

Online chlorine monitors are installed at the storage facilities for continuous total chlorine monitoring, and data from these monitors are displayed on SCADA. Additionally, grab sample monitoring is performed weekly at the storage influent and effluent sites by WQ Lab staff. The individual storage tanks are checked weekly to prevent nitrification in the summer, and bi-weekly during the winter months. In 2012, the total chlorine for the 22 storage tanks in service ranged from 1.54 to 2.64 mg/L, which is well above the 0.5 mg/L minimum residual level.

3.39. Storage Facility Water Use: is water use from the storage facility monitored? Is water age in the storage facility tracked and controlled? **Partially Optimized.**

Water use in the distribution system is monitored by the storage tank elevation levels. The SOPs require a daily cycling of the storage tank (~9 ft average daily cycling in 2012) to reduce water age (Appendix F). Although routine water age monitoring is not performed, total chlorine residual is monitored and maintained to ensure that high quality water is delivered into the distribution system. During 2012, the monthly average chlorine residual at the two storage facilities ranged from 1.61 to 2.18 mg/L, which is well above the 0.5 mg/L minimum residual level. As a result of the self-assessment discussion, a team was established to begin water age evaluation and trending in storage tanks representative of the worst case scenario based on design and drawdown patterns.
10) Storage Tank Water Age Modeling Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine water age monitoring is not performed in storage tanks. This data should provide valuable insight for optimal control of storage tank operations.</td>
<td>Identify software for routine water age monitoring</td>
<td>Civil Engineering Associate</td>
<td>Completed 9/2012</td>
<td>Input SCADA tank data monthly</td>
<td>Treatment Plant Lead Operator</td>
<td>Begin 1/ 2013</td>
</tr>
<tr>
<td></td>
<td>Choose representative tanks throughout the system based on fill/draw cycles and inlet/outlet configurations</td>
<td>Civil Engineering Associate</td>
<td>Completed 10/2012</td>
<td>Evaluate data trends and provide reports on tank water age</td>
<td>Water Quality Lab Manager and Distribution System Maintenance Supervisor</td>
<td>Quarterly beginning 1/2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>If needed, evaluate feasible modifications to tank operating levels</td>
<td>Treatment Plant Superintendent w/ support from Civil Engineer as needed</td>
<td>6/2014</td>
</tr>
</tbody>
</table>

3.40. Inspection: is a routine inspection of all storage facilities conducted annually? Are formal procedures for routine inspections in place and required maintenance identified and addressed? **Partially Optimized.**

Storage tanks are inspected and cleaned within a three-year cycle by a contractor. The contractors are required to videotape, photograph, and clean sediments from each tank. Based on findings during past inspections and water quality results, we consider this frequency adequate. However, we will evaluate a representative number of the oldest tanks annually to determine if findings warrant, and budget allows, more frequent inspections.
11) Increased Inspection of Storage Tanks Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage tanks are inspected once every 3 years, the suggested optimization goal is an annual inspection frequency.</td>
<td>Identify representative subset of the oldest storage tanks</td>
<td>Civil Engineering Associate</td>
<td>12/2012</td>
<td>Modify contract to inspect this storage tank subset annually</td>
<td>Deputy General Manager</td>
<td>First Quarter 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Evaluate storage tank inspection findings and possible future options based on budget.</td>
<td>Dist System Maintenance Supervisor, Civil Engineer, Deputy General Manager</td>
<td>Ongoing</td>
</tr>
</tbody>
</table>

3.41. Cleaning: are all storage facilities cleaned at least every 5 years? Is service interrupted when facilities are isolated for cleaning? **Fully Optimized**.

All storage tanks are inspected and cleaned every five years by a contractor. The Department has a total of 33 potable water storage tanks (each has 3.3 million gallon capacity) at two storage facilities; taking one tank out of service for cleaning would not interrupt service to the overall system.

**Water Age, Modeling**

3.42. Water Age Tracking: does the system have known areas where water age is high? Are these areas closely monitored for disinfectant residual, bacteria and DBPs? **Fully Optimized**.

The Department has identified all dead end locations in its distribution system and these sites are flushed routinely in accordance to the dead end flushing program. Total chlorine residual is monitored before and after flushing, and coliform, turbidity, HPC, and color are monitored to ensure the water quality. For DBP compliance, the Department conducts quarterly Stage 2 monitoring at 12 locations approved by the state regulating agency, which include high TTHM and HAA₅ locations identified in Stage 1 and the IDSE.
3.43. **Water Age Control**: is water age monitored using a calibrated hydraulic model and current operating conditions? Is the system operated to minimize water age? **Partially Optimized**.

Although water age is not monitored by a hydraulic model, the Department performs weekly sampling at 56 sites throughout the distribution system to ensure that water quality is maintained. In lieu of a hydraulic model to estimate water age throughout the distribution system piping, we have chosen to rely on actual chlorine residual data and have established an internal flushing goal of 1 mg/L total chlorine. More specifically, when the total chlorine residual is below 1 mg/L (indicating high water age), flushing is performed to improve water quality. The Department operates the storage tanks to reduce the water age delivered to the system by cycling (average ~9 ft in 2012, which translates to ~20 mgd of water flow). Based on an average system storage capacity of 73 MG in 2012, it is expected that the storage turnover time is less than 4 days. As discussed in Action Plan #10, we are working to more accurately estimate and trend storage tank turnover times.

3.44. **Hydraulic**: does the system have a calibrated hydraulic model that includes water quality parameters? Is the model used regularly and re-calibrated as changes are made? **Partially Optimized**.

Although water quality modeling is not included in the hydraulic model, the Department performs weekly distribution sampling for water quality monitoring. The model is primarily used for hydraulic analysis in master planning and system design. The model is recalibrated as needed (i.e. after installation of new mains) and the latest calibration was performed in November 2010. The model is not currently used by Operations staff, and is an area needing improvement.
12) Water Quality Modeling Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality parameters are not included in the hydraulic model.</td>
<td>Identify most critical water quality parameters to include in the hydraulic model</td>
<td>Full Team consensus</td>
<td>Completed 7/2012</td>
<td>Update existing hydraulic model to include water quality parameters requested by Team</td>
<td>Civil Engineering Associate</td>
<td>First Quarter 2014</td>
</tr>
<tr>
<td></td>
<td>Evaluate most feasible method to integrate these water quality parameters in existing hydraulic model</td>
<td>Civil Engineering Associate</td>
<td>Report to Team by 5/2013</td>
<td>Beta Test</td>
<td>Civil Engineering Associate in conjunction with two Operators</td>
<td>By Third Quarter 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Train staff on how to use the model, when to use the model, and how to apply results (requires pre-approval from supervisor)</td>
<td>Civil Engineer, Treatment Plant Superintendent, Distribution Sys Operations Superintendent</td>
<td>By 1/2015</td>
</tr>
</tbody>
</table>

**Water Loss Control**

3.45. Water Audit: does the system use the AWWA/IWA water audit method described in AWWA Manual M36? Does the system calculate and track: the Infrastructure Condition Factor, the Infrastructure Leakage Index (ILI), and the annual real losses? What is the ILI goal? Is a system water audit performed annually? **Fully Optimized.**

The Department uses the AWWA water audit and loss control program to perform its biannual water audit. The program tracks the volume of water supplied, authorized consumption, and water losses (apparent and real losses).
The software also scores different functional areas of water loss control planning, including audit data collection, short and long term loss control, target setting and benchmarking. Bench marking is the comparison of actual Infrastructure Leakage Index (ILI) to the target ILI. The ILI is the ratio of the current annual real losses to the unavoidable annual real losses. Financial, operational, and water resources considerations suggest that the Department should set the target ILI at a range of 1.0 to 3.0. However, the Department does not have an ILI goal because the system has very low water loss. In 2012, the Department’s system water loss is 5.6% of the total water supply. This water loss is composed of apparent loss (caused by unauthorized consumption and inaccuracy in metering and data handling) and real loss (physical water loss). The real loss is 3.2% of the total water supply in 2012, and 24% of the real loss was categorized as unavoidable loss caused by firefighting, flushing of mains and sewers, and street cleaning.

3.46. Leak Identification: is the system divided into district metered areas (DMA) or pressure zones to optimize leak detection? Does the system have an active leak detection program (acoustic or other)? **Fully Optimized.**

The system is divided into three pressure zones: Blended zone, Purchased Water zone, and Boosted zone. Because the system water loss (apparent loss and real loss) is very low (5.6% of total water supplied in 2012), the Department does not have an active leak detection program; however, the Department has instituted various programs to minimize water loss, including a cast iron main replacement program, main line inspection program, meter replacement program, 24-hour emergency response program and the conservation program.

**Water Quality Sampling and Response**

3.47. Water Quality Sampling and Testing: is there a routine sampling and testing plan that includes monitoring beyond regulatory requirements as appropriate that address system-specific issues? **Fully Optimized.**

The Department’s “water quality laboratory monitoring program and sampling schedule” lists all scheduled water quality monitoring (Appendix K). To ensure that good water quality is delivered to the customers, the Department performs monitoring beyond regulatory requirements. For example, the Department performs extra monitoring in the distribution system to address water quality issues, including nitrification, corrosion, arsenic and other compounds of concern. Table 3.2 shows the regulatory requirements and the Department’s monitoring in the distribution system. The Department also performs additional well monitoring beyond the regulatory requirements: in addition to the required annual and triennial monitoring, the Department also performs monthly monitoring of all wells in operation (Appendix K).
Table 3.2 Distribution System Monitoring Schedule

<table>
<thead>
<tr>
<th>Sampling Points</th>
<th>State required freqency</th>
<th>Department sampling frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine residual, turbidity, color, fluoride</td>
<td>GWTP treated</td>
<td>Daily</td>
</tr>
<tr>
<td>Chlorine residual, HPC, total coliform</td>
<td>Distribution system (DS)</td>
<td>Weekly</td>
</tr>
<tr>
<td>Iron and odor</td>
<td>GWTP raw and treated</td>
<td>Monthly</td>
</tr>
<tr>
<td>Arsenic</td>
<td>GWTP raw and treated</td>
<td>Quarterly</td>
</tr>
<tr>
<td>pH, Conductivity, nitrite, total and free ammonia, temperature</td>
<td>DS</td>
<td>None</td>
</tr>
<tr>
<td>Dissolved Oxygen, phosphate, aluminum, total alkalinity, silica, sulfides, Total dissolved solids (TDS), anions (sulfate, chloride, bromide, nitrate), cations (calcium, magensium, sodium, potassium, lithium), TOC, UV₂₅₄</td>
<td>Raw, treated and entry Points</td>
<td>None</td>
</tr>
<tr>
<td>HAA₅ and TTHM</td>
<td>DS</td>
<td>Quarterly</td>
</tr>
</tbody>
</table>

3.48. Storage Tank Testing: are routine samples (at least weekly) taken from all storage tanks (and facilities) and tested for bacteria, disinfectant residual and other appropriate parameters? **Fully Optimized**.

Samples are collected and analyzed from all storage tanks monthly in the winter and twice every month in the summer for disinfectant residual, temperature, HPC, coliform and nitrification (total and free ammonia and nitrite). Samples for influent and effluent taps from the two storage facilities are collected on a weekly basis for disinfectant residual, temperature, HPC, coliform, turbidity, color, pH, fluoride, conductivity and nitrification (total and free ammonia and nitrite). The monitoring ensures that the Department complies with regulations, and also serves as early detection of nitrification and other potential water quality issues.

3.49. Main Break or Leak Repair Testing: is a Standard Operating Procedure available and followed for main break or leak repair testing including required sampling? **Fully Optimized**.

The Department’s Water Main Disinfection Plan includes the requirements and procedures for bacteriological sampling (Appendix F). Specifically, two consecutive sets of samples are collected from every 1,000 ft of the new main and at every connection. Samples are tested for bacteriological quality and must be absent of coliform organisms, but have a minimum chlorine residual before any new mains are placed into service.
Section IV Design Evaluation

Hydraulic Model Assessment

4.1. Hydraulic Model: is there a calibrated hydraulic model that has water quality modeling features? Not Optimized.

The Department uses WaterGEMS within ArcGIS for distribution system hydraulic modeling. Hydraulic, fire flow, water quality, energy, and capital cost analysis can be performed with this application. The model is calibrated for hydraulic analysis in master planning and system design. It has not been applied for water quality analysis or operational strategies development. These are areas identified during the self-assessment process, as needing improvement and will be addressed in Phase IV of the Partnership program.

Please refer to Action Plan #12 – Water Quality Monitoring Action Plan

4.2. Hydraulic Model: is the hydraulic model available to operations personnel and do they use it regularly? Not Optimized.

No, the model is currently not available to Operations staff due to limited licenses. The Department has engineers dedicated to perform hydraulic modeling when hydraulic analysis is needed for non-routine operational work (i.e. predicting the impact of opening/closing large valves on critical facility and infrastructures).

Please refer to Action Plan #12 – Water Quality Monitoring Action Plan

4.3. Hydraulic Model Upgrades: are upgrades to the water distribution system reflected in the hydraulic model in timely fashion (at least every 6 months)? Partially Optimized.

No, distribution system improvements completed by the Department in recent years include the replacement of cast iron pipes and large valves, pipeline cathodic protection, and rehabilitation of storage tanks. The upgrades have not been reflected in the hydraulic model due to their relatively small impacts on the hydraulic analysis. Routine model upgrades have been recognized as an important component of the continuous improvement process, so this area will be included in the improvement action plan.

Please refer to Action Plan #12 – Water Quality Monitoring Action Plan
Asset Inventory Assessment

4.4. Asset Inventory: is there a complete inventory of all distribution system assets? - an up-to-date schematic map? Fully Optimized.

The Department has the inventory of all distribution system assets in the GIS database. Updated schematics for these assets are loaded on the Department’s server and accessible to all Department staff. The schematics include a water system map (Appendix A), water facility map, large transmission main map, water sampling station map (Appendix C), valve map, and water atlas. Other assets shown on the maps include wells, the treatment plant, purchased water connections, pump stations, reservoirs, piping, and valves. Details related to these assets can be found using the query function of the GIS database.

4.5. Asset Management Program: is there a comprehensive asset management program that includes these elements? Inventory of the distribution system, Condition assessment, Maintenance program, System planning and needs assessment, System financial accounting, Asset management framework, Capital improvement plan and program, Capital budget, Capital management system; Fully Optimized.

The Department’s asset management program includes all the elements mentioned above. The inventory and conditions of distribution system assets such as tanks, mains, valves, hydrants, meters and backflow devices are included in the GIS database and the Fixed Asset Accounting System (FAACS).

The Department’s Engineering Bureau plans and manages the CIP projects to maintain and improve the distribution system. A major component of the CIP is the cast iron main replacement program, and the replacement priorities are based on historical data; including main break frequency, pipe age, and soil conditions. A comprehensive corrosion and structural evaluation was completed in 2007 for the storage tanks, including a master schedule for storage tank rehabilitation. Other distribution system improvement programs including cathodic protection, large valve replacement, water main bridge crossing maintenance and pump replacement are executed according to their respective master plans.

The Department’s financial group and warehouse are responsible for system financial accounting. For all CIP projects, financial tracking starts with assigning a project code number, and all costs (materials, supplies, equipment and labor costs) associated with the project are tracked under project codes. Each project’s revenue and expenses are listed in a monthly and quarterly financial report. Upon project completion, costs incurred for the project are accumulated in the FAACS capital asset system. For asset purchases, the Department uses Advanced Purchasing/Inventory Control System (ADPICS) to initiate, approve, purchase and process payments. When the item is received, the Warehouse section completes an Asset Data Sheet and assigns the item an asset number, asset description, vendor, voucher number, date, program, object code, cost, asset life, and assigned location. The Asset Data Sheet is then forwarded to the
finance group for entry into the FAACS system. The FAACS system automatically calculates depreciation for the capital assets. The Warehouse section is also responsible for completing the annual fixed asset inventory to account for all system assets.

**Pipeline Materials Assessment**

4.6. Distribution Pipeline Asset Management: is there a complete distribution system pipeline inventory that includes: size, length, age, location, and material? Does the asset management plan include specific criteria that are used to determine pipeline replacement? Fully Optimized.

The Department has a complete distribution system pipeline inventory, which includes unlined cast and ductile iron pipes, cement mortar lined ductile iron pipes, asbestos cement pipes and other miscellaneous pipes. The different pipe materials in the system represent the best available pipe materials at the time of installation; the unlined cast iron pipes were installed before 1950, the asbestos cement pipes were installed between 1950 and the mid-1980s, and the cement-mortar lined ductile iron pipes are currently being installed. Other types of pipes in the system include concrete, PVC, and PE, contributing approximately 7.3% of the total pipes (Appendix M-Table 4.3). The Department is actively replacing unlined cast iron pipes installed before the 1950s, and the replacement priority is primarily based on pipe age and history of main breaks in the area.

**Storage Facility Assessment**

4.7. Storage Tank Age: has the system identified the storage tanks that are more than 30 years old? Is there a defined rehabilitation and replacement plan that includes a condition assessment? Fully Optimized.

With the exception of one tank (Blended Water Tank 24, 6 years old), all other potable storage tanks are more than 30 years old. The Department has been continuously rehabilitating up to three tanks each year. In addition, the Department performed a corrosion and structural/seismic/safety engineering evaluation of all storage tanks in 2007, which identified the condition of each tank, and provided recommended actions for the rehabilitation work and schedule. The rehabilitation for all storage tanks has been planned for a 12-year period. The Department also installed cathodic protection in all storage tanks in 2009.
**Pumping Facility Assessment**

4.8. Pump Asset Management: does the asset management plan include specific criteria for replacement and rehabilitation of pumps? Do records include the installation date and inspection results? **Partially Optimized.**

Pumps are replaced based on the results of an efficiency test performed by the Department electricians and our electrical provider. If one pump’s energy usage/water volume is significantly different than other pumps, additional investigation is conducted to determine if the pump needs to be replaced. For example, a recent test showed that one pump’s energy usage/water volume was 53% higher than the other pumps, so this pump was budgeted for replacement. In addition, the Department may rehabilitate pumps ahead of schedule to improve efficiency and take advantage of the electrical utility rebate program. The Department maintains records of all pumps, including dates, manufacturer, size, type, pump curve, efficiency test results and other records in the TP maintenance shop.

4.9. Pump Redundancy: does the system have adequate backup pumping capacity to have the firm capacity to meet the maximum day demand and a continuous pressure >20 psi? **Fully Optimized.**

The GWTP pump station is used to pump treated groundwater to the Blended Water Reservoir, which then blends with purchased water and meets the water demand from the Blended zone. The GWTP pump station has a firm capacity of 60 mgd and purchased water connection has a capacity of 40 mgd. The two combined capacities are greater than the Blended Water Reservoir capacity (21 tanks X 3.3 MG/tank = 69.3 MG) and are able to maintain the reservoir at its maximum level. The Booster Station maintains the pressure for the Boosted zone, and has a firm capacity of 15 mgd at a discharge pressure of >65 psi. During 2012, the maximum daily demand was 74.7 mgd for the overall system; 58.5 mgd for the Blended zone, 16.2 mgd for the Purchased Water zone, and 13.8 mgd for the Boosted zone. All stations can meet the maximum day demand at a continuous pressure of >20 psi.

4.10. Pump Maintenance: does the system report and track the Planned Maintenance Ratio for distribution pumps? **Partially Optimized.**

The Department keeps records of all work on distribution pumps, including emergency repairs or planned maintenance; however, these records cannot be easily sorted and analyzed to calculate the Planned Maintenance Ratio. The Department will set up separate accounting codes for preventive maintenance and emergency maintenance so the planned maintenance ratio can be calculated and tracked. The Department will implement a tablet-based work order system, and include information related to Planned Maintenance Ratio as a category.
13) Pump Maintenance Action Plan:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Short Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work on pumps is recorded but data generated is not analyzed or trended to calculate Planned Maintenance Ratio</td>
<td>Trend historical and current pump efficiency data to identify patterns and plan for preventative maintenance</td>
<td>Engineering Bureau, Distribution System Maintenance Staff (support)</td>
<td>12/31/2013</td>
<td>Implement tablet based work order system for pump maintenance to track records and calculate Planned Maintenance Ratio</td>
<td>Civil Engineer, Distribution System Operations Superintendent</td>
<td>Ongoing, with target project implementation date of 8/31/2014</td>
</tr>
</tbody>
</table>

Valves and Hydrants Assessment

4.11. Valve and Hydrant Age: is there a current (updated) valve and hydrant inventory? Do records include installation date and inspection results? **Fully Optimized.**

The Department has a current valve and hydrant inventory (Appendix M-Table 4.9), and the physical attributes are included in a regularly-updated GIS database. The Department also employs field tablets with the iWater (Irvine, CA) program, which allows field personnel to update valve information and upload the data to the GIS server.

4.12. Valve and Hydrant Asset Management: does the asset management plan include specific criteria for replacement and rehabilitation of valves and hydrants? **Fully Optimized.**

Large valves are replaced annually according to the CIP master plan, which was developed based on valve inspection and exercise records. Small valves are also replaced when the need is identified by field staff during valve exercise. The Department has one staff member dedicated to the maintenance of hydrants, which includes repairing or replacing broken hydrants, and performs preventive maintenance by replacing hydrants’ caps and packing. The Department also replaces hydrants when the associated main lines are replaced.
Section V Application of Operational Concepts

Application of Operational Concepts

5.1. System Testing: does the utility have a routine water quality testing program and established water quality goals? Are the test results communicated to distribution system operators? Do operators make adjustments to pressure and flow based on the water quality test results? Fully Optimized.

Yes. The Department’s “water quality laboratory monitoring program and sampling schedule” establishes the routine water quality monitoring schedule (Appendix K). Test results, including total chlorine residual, monochloramine, turbidity, color, free and total ammonia, nitrite, fluoride, odor, HPC and total coliform are constantly communicated to distribution system operators, who make adjustments accordingly. For example, the nitrification plan provides different action plans based on the analytical test results for total chlorine, ammonia, nitrite and HPC. Because the system is gravity-based, adjustments to pressure and flow based on water quality is minimal except for the targeted adjustments of storage tank cycling levels.

5.2. Demand Management: do system operators anticipate daily and hourly consumption demand changes to reduce the need for large rate changes in treatment plant production (entry point demand)? Is forecasting utilized to minimize rate changes. Fully Optimized.

The Department has a fixed annual pumping right from its groundwater basin. The Engineering Bureau calculates the monthly pumping (treatment plant production) target based on consumption demand; the TP operators follow these targets in setting the daily TP production. Other factors impacting TP production include purchase water flow restrictions, planned plant maintenance affecting capacity, special in-lieu programs, and selection of wells based on capacity and water quality. The Department does not change TP production rate frequently to minimize the impact on treatment and water quality. To achieve energy management and storage tank cycling goals, storage tanks are filled nightly and drawn down during the day, so hourly consumption demand has a minimal impact on treatment plant production.

5.3. Hydraulic Model Access: do system operators have access 24/7 to the hydraulic model? Does the model calculate water age? Are operators trained to use the model in emergency situations? Not Optimized.

The hydraulic model is not currently available to system operators due to a limited number of licenses. This is an area identified as needing improvement during the self assessment process, and will be addressed in Phase IV of the Partnership program.
Please refer to Action Plan #12 – Water Quality Monitoring Action Plan – for more details. Additionally, we will run an emergency situation drill which includes the use of the newly calibrated hydraulic model. The target date for completion of this item is Summer 2015.

5.4. Test Result Evaluation and Communication: is it clearly defined who is responsible for examining test results and operational data and communicating to departments to take action? **Fully Optimized.**

The WQ Lab Manager oversees the WQ Lab monitoring program, examines all analytical results and the laboratory’s Quality Assurance/Quality Control (QA/QC) Program, provides weekly water quality reports to the Operation Bureau, and monthly and annual reports to the state regulating agency. The Water Treatment Supervisor reviews operational data with the Shift Operator and communicates daily with the Water Treatment Superintendent on operational issues. The Water Treatment Superintendent, Deputy General Manager-Operation, and General Manager, are certified Grade 4 Operators, and are available for 24 hour rotational standby duty. The on-duty Grade 4 operator is responsible for communicating with state regulating agency and taking appropriate actions during emergencies.

5.5. Data Review Training: is there periodic data review training for everyone involved in operational decisions? Does the utility perform system performance debriefings at least monthly to understand performance challenges? **Fully Optimized.**

Periodic data review training is provided to all treatment/distribution operators involved in the operation of the GWTP and the distribution system storage tanks and pumps. For example, chemical dosage calculations, GWR CT compliance calculations, nitrification chemistry and data review (e.g., total chlorine residual, monochloramine, turbidity, nitrite, ammonia) and responsive actions training are provided to the operators at the monthly tailgate meetings. Operations meetings are held weekly among supervisors, superintendents, WQ Lab Manager, and Deputy General Manager-Operations to ensure open communications among different divisions.
Section VI Administration

Administrative Factors

6.1. Administrative Policies: does any established administrative policy limit performance (e.g. non-support of training), or is system funding too low because of a desire to avoid rate increases? Do operating staff members have authority to make required operation, maintenance, and or administrative decisions? Do administrators have firsthand knowledge of distribution system needs through on-site visits or discussion with utility staff? Does the lack of long-range plans for facility replacement, emergency response, etc. adversely impact performance? Fully Optimized.

Distribution system operation is not impacted by administrative policies. The supervisors and superintendents for each of the Department’s functional areas are responsible for budgeting employee education and training. The Department’s safety office is responsible for ensuring that safety training requirements are met. Safety training is provided in many formats including internal lectures, on-line, video, and through weekly tailgate meetings. The Department has a generous policy regarding various professional certifications, including Treatment, Distribution, and Wastewater Collection. The Department pays for the certification tests and certificate fees, and also either reimburses employees who attend certification classes, or makes the class available on-site. The Department management recognizes the critical need for trained and knowledgeable staff to operate and maintain the distribution system. The Department financially supports and encourages individual membership, as well as, group membership in professional organizations and participation in subject matter research.

The General Manager and Deputy General Manager – Operations will make field visits for random inspections and during emergency events, such as main breaks. The General Manager holds quarterly All-Employees meetings for the Department in order to update staff of current events and receive feedback. The Deputy General Manager – Operations holds weekly update meetings with the supervisors and managers of the Operations Bureau. The General Manager holds update meetings with the executive management team twice monthly and monthly meetings with the Department’s managers.

Long-range plans for facility improvements include the capital improvement plan, which provides a 10 year schedule. The Department has a master emergency response plan, which includes action plans for different emergencies. The Department also has formed the emergency response team (ERT), which has trained members from various functional groups to act as lead emergency responders. Department staff has also been trained in the national incident management system (NIMS) process, which addresses emergency response during catastrophic events.
6.2. *Supervision*: do management styles, organizational capabilities, budgeting skills, or communication practices at any management level adversely impact plant performance? *Fully Optimized.*

Management does not adversely affect distribution system performance. Management actively participates in distribution system operations through system water quality data analysis and review of tank cycling records. Additional sampling is conducted at key points in the distribution system (i.e. tank farms) during periods that can create water quality challenges (i.e. warm weather), so that potential water quality issues, such as nitrification, can be mitigated. Management is always consulted prior to any significant changes in operations (i.e. tanks taken out of service).

6.3. *Staffing*: does having a limited number of people employed have a detrimental effect on system operations or maintenance? Is staffing adequate to accomplish necessary system operation, repair and maintenance activities? Can appropriate adjustments be made during the evenings, weekends, or holidays? Is staff available to respond to changing conditions during periods of operation? Does the improper distribution of adequate staff prevent process adjustments from being made? *Fully Optimized.*

The Department has sufficient staffing to operate and maintain the distribution system, with a primary goal of sufficient main replacement to maintain an annual break rate of less than 15 breaks/100 miles. Historically, the annual main replacement rate was as high as 100,000 linear ft, but has been scaled back to 24,000 linear ft because the decline in main breaks has been maintained. The Department’s facilities are operated by certified operators through SCADA on a 24/7 basis. The Department also has an on-call Grade 4 staff member to respond to emergencies as well as standby personnel and crew at each of its functional areas to respond to operational needs within an hour on a 24/7 basis.

6.4. *Funding*: does the lack of available funds (e.g. because of an inadequate rate structure) cause non-competitive salary schedules, an insufficient stock of spare parts that results in delays in equipment repair, insufficient capital outlays for improvements or replacement, lack of required supplies, etc? Are funds spent on lower priority items while needed higher priority items are unfunded? Does the annual debt payment limit the amount of funds available for other needed items? *Fully Optimized.*

The Department has always maintained sound fiscal practices in meeting the budget required for operations, maintenance, capital programs, and Board-adopted reserve goals. In order to ensure adequate funding for maintenance, operations, and capital improvements, the managers work closely with their supervisors on the budget required to support these needs. Once identified and approved, a determination is made during budget adoption process whether rate increases are required, or if the existing rate structure is sufficient to fund the
activities. The Department has never been placed in a situation of where required activities have been delayed in order to make debt payments.

6.5. Interest Payments: are interest payments less than 25% of total utility budget? Reporting the value is optional. Fully Optimized.

Historically, interest payments have been well below 10% of the total utility budget. The Department has historically never approached the available debt service limit, which is a sign of a well-run, fiscally-conservative organization.

Table 6.1: Water Fund Debt Service Coverage (in $1,000s)

(Note: The table headings displayed below represent one way that Debt Service Coverage may be communicated. The reporting of financial information helps PEAC reviewers to better understand system performance, although it is not required.)

<table>
<thead>
<tr>
<th>FY Ending</th>
<th>Total Operating Revenue</th>
<th>Operating Expenses</th>
<th>Net Operating Income</th>
<th>Expenses</th>
<th>Amt Avail for Debt Svc</th>
<th>Principal</th>
<th>Interest</th>
<th>Total Debt Svc</th>
<th>Times Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Include data for multiple years to provide a historical perspective and to document improvements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.6. Administrative Benchmarking Measures: does the utility calculate and track the values for the benchmarks below? Are these used to assess improvement efforts? Reporting the values is optional. Debt Ratio, O&M Cost per Account, System Renewal Rate, Training Hours per Employee, Customer Accounts per Employee, MGD Delivered per Employee. Fully Optimized.

These parameters are tracked, and where possible, compared against accepted industry standards (i.e. debt ratio), and historical performance. The general fiscal performance indicator, debt ratio, shows a general decline in the Department’s debt payments. Other performance indicators, including training hours, accounts per employee and money spent per customer account, exhibit an increasing trend. This shows that the Department is making a continuous effort at spending more money on maintaining the water infrastructure and ensuring that the Department personnel have adequate training to perform their jobs. One performance indicator requiring explanation is the increase in the pipe renewal rate category. For the years since 2002, the pipe renewal rate has increased from 56 years to 226 years; however, the main break frequency has decreased from 73 in 2002 to 38 in 2011. This was caused through the targeted replacement of cast iron mains, which had shown to be the most vulnerable to main breaks. As more cast iron mains are replaced, the main break frequency decreases, allowing for reduced replacement of required pipes to maintain an
already low main-break frequency. It is anticipated that all cast iron mains (143 miles) will be replaced within the next 30 years.

**Table 6.2: Key Department Performance Indicators**

*(Note: The Key Performance Indicators provided in this report are just one example of some parameters that may be tracked by a specific utility to document performance. An example of one way that Key Performance Indicators may be displayed in a report is provided below. Similar information can be displayed in many different ways, so every submission may not be identical to this.)*

<table>
<thead>
<tr>
<th>FY Ending</th>
<th>Debt Ratio</th>
<th>O&amp;M/Acct ($</th>
<th>Renewal Rate (yrs)</th>
<th>Main Breaks (#/100mi/yr)</th>
<th>Training Hrs/ Employee</th>
<th>Accts/ Employee</th>
<th>MGD/ Employee</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Include data for multiple years to provide a historical perspective and to document improvements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section VII Continuous Improvement Plan

Evaluation Summary

The Department joined the Partnership distribution program in 2010 with a commitment to optimize the distribution system. A PSW team was formed from organizational staff involved in planning, operation, maintenance and monitoring of distribution system (Appendix B). During the Phase II data collection period, information on chlorine residual, pressure, and main breaks were gathered to evaluate the system against the Partnership’s performance goal. It was determined that the system meets the optimization performance goal for all three categories: total chlorine ≥0.50 mg/L and ≤4.00 mg/L in 95% of time-stepped measurements; the system pressure monthly minimum average >35 psi and <80 psi for all demand situations; the maximum pressure range for a single location <15 psi in 95% of all measurements; and <15 breaks per 100 miles of piping per year.

Performance Limiting Factors and Improvement Plan

During the Phase III self-assessment period, the team evaluated individual performance limiting factors and identified factors that are partially or not optimized (Appendix L). These factors were grouped into categories, ranked by impact and urgency, and then assigned to individual groups (Table 7.1) to develop action plans. To address the identified performance limiting factors, the individual group assigned with each category was asked to develop short term and long term plans. The plans and their associated cost and implementation date are included in Table 7.2.

- Energy Management: Pump Efficiency Test and Replacement Criteria

  This factor was rated as partially optimized because the Department does not trend efficiency test results, and the efficiency test performed by the electrical utility every two years is not sufficient. This factor has minor, but potentially long-term impacts on operational efficiency and cost. Treatment Plant (TP) staff was identified as the responsible group for this area, and short-term and long-term action plans were developed. For the short term, it was proposed that an SOP be developed by March 2013 to test pump efficiency internally (every 6 months), and the internal efficiency test data will be recorded along with the electrical utility test results on an Excel spreadsheet. For the long term, TP staff will report the efficiency trend annually to the Engineering Bureau, who will compare the efficiency with industry standards to determine the maintenance and replacement schedule.

- Pumping Facility: Pump Planned Maintenance Ratio Track

  This factor was rated as partially optimized because the records on distribution pump maintenance work cannot be easily sorted and analyzed to calculate the
Planned Maintenance Ratio. To address this issue in the short term, the Department will set up separate accounting codes for preventive and emergency maintenance so that Planned Maintenance Ratio can be calculated and tracked. For the long term, the Department is starting to implement a tablet-based work order system. When this system is fully implemented, the Planned Maintenance Ratio can be added as a category in the system and better tracked. The Department expects to initially invest ~$50,000 on software and equipment, and it is estimated that ~2,000 work hours annually is required to operate the system.

- **Disinfectant Residual: On-line Chlorine Monitor and SCADA Display**

  This factor was rated as partially optimized because online continuous chlorine monitors are not used throughout the distribution system. On-line monitors are only used at the storage tank facilities to monitor the point of entry chlorine residual. For the short term, the WQ Lab will be the group responsible for investigating the feasibility of installing monitoring devices throughout the distribution system and communicating results to the SCADA system. This investigation is expected to be completed by June 2013. If feasible, online monitors will be installed in dead end areas and areas of low total chlorine residual, and chlorine residuals will be communicated to SCADA to trigger flushing when <1 mg/L chlorine is observed.

- **Post Precipitation Control: Precipitation Investigation at Low Residual**

  This factor was rated as partially optimized because low chlorine residual locations are not investigated for precipitation, although water quality parameters, including turbidity, color and HPC are routinely monitored. Precipitation investigation at low chlorine residual sites will begin by June 2013, and will include monitoring for additional water quality parameters, including iron, manganese, and TDS. The data from these sites will be compared with normal residual sites to determine the impact of precipitation at low residual sites. Based on the findings, plans for main replacement, looping to eliminate dead ends, and flushing will be modified accordingly.

- **Storage Tanks: Inspection and Water Age Modeling**

  These factors were rated as partially optimized because routine water age modeling is not performed for all storage tank sites. Additionally, inspections are routinely performed on a 3-year basis. The Partnership’s optimization goal is that tanks are inspected on an annual basis. Due to the impact that storage tank condition and water age can have on distribution system performance and water quality, plans are being implement to inspection frequency.

- **Pressure Management: Pressure Monitor and Alarm**

  This factor was rated as partially optimized because pressure monitoring throughout the distribution system was not performed until recently. Six pressure sensors were installed in December 2012, to include two critical sites in each of
three pressure zones. The pressure sensors continuously record pressures at one hour frequencies, but are not connected with the SCADA system and cannot alarm the operators. The responsible group, Water Operations, will investigate the feasibility of integrating pressure sensors into SCADA system and setting alarms to notify operators when low pressure or high pressure spikes occur.

- **Main Break Management: Pressure Stabilization Surrounding A Main Break**

  The practice for main break management has always been to close valves around a main break. However, this factor was rated as partially optimized because pressure monitoring surrounding the break was not performed. In January 2013, field staff were supplied with pressure gauges and instructed to take pressure readings at a minimum of two hydrants surrounding the break. The “Report on Service Rendered” form will also be revised to include pressure monitoring recording surrounding the break. Data will be assessed after one year of data collection, and the SOP will be modified accordingly to ensure pressure is stabilized surrounding main breaks.

- **External Corrosion: Pipe Inspection and Sampling when Exposed**

  This factor was rated as partially optimized because pipe sampling is not performed routinely when pipes are exposed. However, pipe inspections are performed and information regarding the type of break, location of break, condition of pipe, cause of deterioration, soil classification and apparent cause of break is recorded. Field staff will be instructed to take pictures when pipes are exposed and submit the picture files with associated inspection report. Main break and main construction work SOPs will be modified to include these procedures by March 2013. In the long term, the Water Operations group will include these pictures in the GIS main break database.

- **Maintaining Valves, Hydrants and Blowoffs: Hydrant Inspection and Access**

  This factor was rated as partially optimized because the Department does not inspect the performance of hydrants on a routine schedule. The Fire Department is responsible for hydrants inspection, and all hydrants were inspected and tested annually; however, in recent years, the Fire Department has stopped fire hydrant testing due to budgetary constraints. The Department will meet with the Fire Department to identify the cost for inspection before June 2013. Additionally, no access control exists on hydrants due to concerns over delayed response times.

- **Maintaining Valves, Hydrants and Blowoffs: Valves/Hydrants Tested Every 3 Years**

  This factor was rated as partially optimized because the Department does not exercise all valves and hydrants on a three year basis. The Department exercises all large (14” to 42”) valves every two years, but exercises all small (4” to 12”) valves every eight years. By June 2014, the Department will investigate
the feasibility of exercising small valves every three years, and possibly implement this new schedule based on further analysis.

- **Hydraulic Model: Modeling for Water Age and Water Quality**
  
  This factor was rated as not optimized because water age and water quality are not currently included in the hydraulic model. The Engineering Bureau will investigate the cost and feasibility of including water age and water quality by March 2013. Engineering is currently evaluating the feasibility of implementing the modeling for these features.

- **Hydraulic Model: Model Access to Operators and Regular Updates**
  
  This factor was rated as partially optimized because the model is currently not available to Operations personnel and the model is not routinely upgraded. To resolve this issue, the Engineering group will post the model onto the Department’s computer network so that it is available to the operators, and the Operations group will train its personnel on the use of hydraulic model. Starting in September 2013, the Engineering group will update the model every six months.

**Conclusion**

The Water Department is fully committed to the Partnership for Safe Water Distribution System Optimization program. Throughout the self-assessment process, the Department has identified areas that are optimized, and more importantly, areas that are partially or not optimized. Optimized areas include disinfectant residual and DBP monitoring, cross connection control, customer complaints, nitrification control, pipe replacement, main breaks management, water loss control, security and emergency management, storage facility operation, asset inventory and administration. The Department, although already committed to delivering excellent quality drinking water, realizes that persistent documentation and shared knowledge of the system operation (Team approach) will enhance and ensure drinking water quality. The Department is committed to maintaining these optimized performances and modifying programs to continue improvements whenever possible. For partially or not optimized areas, the responsible parties will lead the implementations of the proposed action plans to fully optimize these areas. The Partnership Team will continue to have regular meetings to assess performance improvements, and encourage implementation efforts with involvement of as many staff as possible. The greatest benefit realized has been improved communication at all levels of the organization, which has improved sharing of ideas and efforts to continue to optimize. In summary, the Department has recognized the benefits of the Partnership’s distribution program, and continues to optimize the distribution system in order to deliver the highest quality water to its customers.
Table 7.1 Performance Limiting Factor Ranking and Responsible Group

<table>
<thead>
<tr>
<th>Self-Assessment Category</th>
<th>Prioritization</th>
<th>Assigned Group</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Impact</td>
<td>Urgency</td>
<td>Priority Total</td>
</tr>
<tr>
<td>Energy Management: Pump Efficiency Test and Replacement Criteria</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Pumping Facility: Pump Planned Maintenance Ration Track</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Disinfectant Residual: On-line chlorine Monitor and SCADA Display</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Post Precipitation Control: Precipitation Investigation at Low Residual</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Storage Tanks: Inspection and Water Age Modeling</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Pressure Management: Pressure Monitor and Alarm</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Main Break Management: Pressure Stabilization Surrounding a Main Break</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>External Corrosion: Pipe Inspection and Sampling when Exposed</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Maintaining Valves, Hydrants, and Blowoffs: Valves/Hydrants Tested Every 3 Years</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Maintaining Valves, Hydrants, and Blowoffs: Hydrant Inspection and Access</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Hydraulic Model: Modeling for Water Age and Water Quality</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Hydraulic Model: Model Access to Operators and Regular Updates</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 7.2 Prioritized Action Plans for Performance Limiting Factors

<table>
<thead>
<tr>
<th>Self-Assessment Category</th>
<th>Issue</th>
<th>Short Term Solution</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
<th>Long Term Solution</th>
<th>Person(s) Responsible</th>
<th>Target Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Finalize identification of key areas of distribution system for analyzer placement</td>
<td>Full Team, Consensus Decision Needed</td>
<td>Apr 2013</td>
<td>Install analyzers and connect with SCADA</td>
<td>Dist System Maintenance Supervisor</td>
<td>April 2014</td>
</tr>
<tr>
<td>On-line Chlorine Monitor and SCADA Display</td>
<td>Additional online chlorine residual analyzers would provide valuable data</td>
<td>Budget for and purchase 3 analyzers</td>
<td>Distribution System Ops. Super-Intendent</td>
<td>Jan 2014</td>
<td>Review analyzer data trends for optimization opportunities</td>
<td>Treatment Plant and Distribution System Lead Operators</td>
<td>Ongoing, incorp. Int into SOPs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Review analyzer data trends for optimization opportunities</td>
<td>Treatment Plant and Distribution System Lead Operators</td>
<td>Ongoing, incorp. Int into SOPs</td>
</tr>
<tr>
<td></td>
<td>Fire Department was responsible for hydrant inspection but not able to keep up due to staffing issues</td>
<td>Meet with Fire Department to discuss time demands and costs for hydrant inspections</td>
<td>Distribution System Maintenance Supervisor with Dist Ops Super-Intendent</td>
<td>Comp. Aug 2012</td>
<td>Cost feasibility study to determine most feasible plan to re-establish routine inspection</td>
<td>Civil Engineering Associate</td>
<td>Report to Deputy General Manager by Jan 2014</td>
</tr>
<tr>
<td></td>
<td>No access control exists on hydrants due to Fire Department concerns over delayed response times</td>
<td>Investigate potential access control devices that provide adequate tampering protection with minimal delay for fire department emergency use</td>
<td>Security &amp; Emergency Preparedness Manager and Civil Engineering Associate</td>
<td>Dec 2013</td>
<td>Meet with Fire Department management to review options, costs, and attempt to reach consensus plan of action</td>
<td>Deputy General Manager, Security &amp; Emergency Preparedness Manager, Civil Engineering Associate, Dist. Sys. Maintenance Supervisor</td>
<td>Q1 2014</td>
</tr>
<tr>
<td></td>
<td>Storage Tanks – Modeling and Inspection</td>
<td>Identify software for routine water age monitoring, choose representative tanks throughout the system</td>
<td>Civil Engineering Associate</td>
<td>Both items comp. by Oct 2012</td>
<td>Input SCADA tank data monthly, evaluate data trends and provide reports on tank water age, if needed evaluate feasible</td>
<td>Treatment Plant Lead Operator, Water Quality Lab Manager and Dist. System Maintenance Supervisor, Treatment</td>
<td>Begin Jan 2013, ongoing on a quarterly basis, with mods identified by June 2014</td>
</tr>
<tr>
<td><strong>Storage Tanks – Modeling and Inspection (continued)</strong></td>
<td><strong>Insight for optimal control of storage tank operations</strong></td>
<td><strong>Based on fill/draw cycles and inlet/outlet configurations</strong></td>
<td><strong>Modifications to tank operating levels</strong></td>
<td><strong>Plant Super. Support from Civil Engineer as needed</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
<td>--------------------------------------------------------------</td>
<td>---------------------------------------------</td>
<td>--------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Storage tanks are inspected once every 3 years – the suggested optimization goal is inspection on an annual basis</strong></td>
<td>Identify representative subset of the oldest storage tanks for inspection</td>
<td>Civil Engineering Associate</td>
<td>Dec 2012</td>
<td>Modify contract to inspect this storage tank subset annually</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Evaluate storage tank inspection findings and possible future options based on budget</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dist. System Maintenance Supervisor, Civil Engineer, Deputy General Manager</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q1 2014</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ongoing</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Pressure Stabilization Surrounding a Main Break</strong></th>
<th><strong>Pressure monitoring is not part of existing main break SOP, which limits ability to verify pressure stabilization</strong></th>
<th><strong>Supply staff with portable pressure gauges</strong></th>
<th><strong>Revise SOPs to reflect pressure is monitored at a minimum of two hydrants surrounding the break</strong></th>
<th><strong>Dist. System Operator II</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Revise “Report on Service Rendered Form” to include pressure monitoring</td>
<td>Distribution System Lead Operator III</td>
<td>Comp. Nov 2012</td>
<td>Distribution System Operator II</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distribution System Operator II</td>
<td>Comp. Nov 2012</td>
<td>Train Distribution System Operators on new procedures and how to identify most representative hydrant locations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Distribution System Lead Operator III</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>June 2014</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Pressure Monitoring and Alarm</strong></th>
<th><strong>Six pressure sensors provide intermittent data logging only – lack real time SCADA</strong></th>
<th><strong>Identify most feasible plan for SCADA integration of six sensors and report to Team</strong></th>
<th><strong>Complete pressure sensor SCADA integration, including low pressure alarm, review pressure trends for optimization opportunities</strong></th>
<th><strong>June 2014 for SCADA, trends to be reviewed on an ongoing basis and included in SOPs</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Six pressure sensors are not calibrated annually</td>
<td>Distribution System Ops Super-Intendent</td>
<td>Mar 2013 Team Meeting</td>
<td>Distribution System Maintenance Supervisor w/ contract SCADA programmer</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Treatment Plant and Distribution System Lead Operators</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>June 2014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ongoing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th><strong>Pressure sensors are not calibrated annually</strong></th>
<th><strong>Organize annual pressure sensor calibration</strong></th>
<th><strong>Review pressure sensor calibration results and work with mfr</strong></th>
<th><strong>Dist. System Lead Operator III</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Distribution System Maintenance Supervisor</td>
<td>Jan 2014 start, calibrate on an ongoing</td>
<td>Distribution System Lead Operator III</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feb 2014 start, ongoing on an annual</td>
</tr>
<tr>
<td>Category</td>
<td>Task Description</td>
<td>Responsibility</td>
<td>Target Date</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>-------------------------</td>
<td>-------------</td>
<td>-------</td>
</tr>
<tr>
<td>Valves &amp; Hydrants Tested Every Three Years</td>
<td>Small valves are exercised and tested within an 8 year cycle. Partnership suggests a 3 year valve exercise frequency optimization goal.</td>
<td>Distribution System Maintenance Supervisor</td>
<td>Apr 2013</td>
<td>Cost feasibility study to determine most feasible plan to meet 3 year exercising frequency goal on highest priority small valves, including additional staff needed to meet goal on all valves. Report to Deputy General Manager by Dec 2014.</td>
</tr>
<tr>
<td>Water Quality Parameters</td>
<td>Water quality parameters are not included in the hydraulic model. Identify most critical water quality parameters to include in the hydraulic model.</td>
<td>Full Team Consensus</td>
<td>Comp. July 2012</td>
<td>Update existing hydraulic model to include water quality parameters requested by Team.</td>
</tr>
<tr>
<td>Hydraulic Model – Water Age, Water Quality</td>
<td>Evaluate most feasible method to integrate these water quality parameters in existing hydraulic model.</td>
<td>Civil Engineering Associate</td>
<td>Report to Team by May 2013</td>
<td>Beta Test. Train staff on model use, when to use, and application (with supervisor approval).</td>
</tr>
<tr>
<td>Precipitation Investigation at Low Residual</td>
<td>Precipitation investigation does not routinely occur at low total chlorine residual sites. Create precipitation investigation report form.</td>
<td>Distribution System Lead Operator III</td>
<td>Comp. Dec 2012</td>
<td>Train staff on new SOP.</td>
</tr>
<tr>
<td>Hydraulic Model – Operator Access and Regular</td>
<td>Hydraulic model is currently not accessible by all staff. Model will be made available through department network.</td>
<td>Civil Engineering Associate</td>
<td>Sept 2013</td>
<td>An updated model will be posted every 6 months, training will be available. Continuously updated.</td>
</tr>
<tr>
<td>Updates</td>
<td>including operators</td>
<td>drives, and operators will be trained as indicated above</td>
<td>provided on an ongoing basis</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>Pipe Inspection and Sampling When Exposed</strong></td>
<td>Pipes and thoroughly inspected but not sampled when exposed</td>
<td>Modify SOP to include representative pipe sampling when pipes exposed, along with digital photos</td>
<td>Distribution System Lead Operator III</td>
<td>Comp. Sept 2012</td>
</tr>
<tr>
<td><strong>Pump Efficiency Test and Replacement Criteria</strong></td>
<td>Pumps are efficiency tested every two years. Department does not currently trend efficiency testing results for maintenance purposes.</td>
<td>Develop an SOP to internally test efficiency on a semi-annual basis.</td>
<td>Treatment Plant</td>
<td>March 31, 2013</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Engineering Bureau, Distribution System Maintenance Staff (support)</td>
<td>Engineering Bureau, Distribution System Maintenance Staff (support)</td>
</tr>
<tr>
<td><strong>Pump Planned Maintenance Ratio Tracking</strong></td>
<td>Work on pumps is recorded but data generated is not analyzed or trended to calculate a Planned Maintenance Ratio</td>
<td>Trend historical and current pump efficiency data to identify patterns and plan for preventative maintenance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Abbreviation

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADPICS</td>
<td>Advanced Purchasing/Inventory Control System</td>
</tr>
<tr>
<td>AF</td>
<td>Acre-ft</td>
</tr>
<tr>
<td>AL</td>
<td>Action level</td>
</tr>
<tr>
<td>CIP</td>
<td>Capital Improvement Program</td>
</tr>
<tr>
<td>D/DBPs</td>
<td>Disinfectants and Disinfection byproducts</td>
</tr>
<tr>
<td>DS</td>
<td>Distribution System</td>
</tr>
<tr>
<td>ERP</td>
<td>Emergency Response Plan</td>
</tr>
<tr>
<td>FAACS</td>
<td>Fixed Asset Accounting System</td>
</tr>
<tr>
<td>GWR</td>
<td>Ground Water Rule</td>
</tr>
<tr>
<td>GWTP</td>
<td>groundwater treatment plant</td>
</tr>
<tr>
<td>GIS</td>
<td>Global Information System</td>
</tr>
<tr>
<td>HAA$_5$</td>
<td>Five regulated haloacetic acids</td>
</tr>
<tr>
<td>HPC</td>
<td>Heterotrophic Plate Count</td>
</tr>
<tr>
<td>IC</td>
<td>Incident commander</td>
</tr>
<tr>
<td>ILI</td>
<td>Infrastructure Leakage Index</td>
</tr>
<tr>
<td>IT</td>
<td>Information technology</td>
</tr>
<tr>
<td>IDSE</td>
<td>Initial distribution system evaluation</td>
</tr>
<tr>
<td>LCR</td>
<td>Lead and Copper Rule</td>
</tr>
<tr>
<td>LSI</td>
<td>Langelier Saturation Index</td>
</tr>
<tr>
<td>LRAA</td>
<td>Locational Running Annual Average</td>
</tr>
<tr>
<td>MCL</td>
<td>Maximum Contaminant Level</td>
</tr>
<tr>
<td>MCLG</td>
<td>Maximum Contaminant Level Goal</td>
</tr>
<tr>
<td>MG</td>
<td>Million gallon</td>
</tr>
<tr>
<td>NIMS</td>
<td>National Incident Command System</td>
</tr>
<tr>
<td>Acronym</td>
<td>Full Form</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
</tr>
<tr>
<td>NTAS</td>
<td>National Terrorism Alert System</td>
</tr>
<tr>
<td>QA/QC</td>
<td>Quality Assurance/Quality Control</td>
</tr>
<tr>
<td>Partnership</td>
<td>Partnership for Safe Water</td>
</tr>
<tr>
<td>PSW</td>
<td>Partnership for Safe Water team</td>
</tr>
<tr>
<td>PRV</td>
<td>Pressure reducing valves</td>
</tr>
<tr>
<td>SEMS</td>
<td>Standardized Emergency Management System</td>
</tr>
<tr>
<td>SOP</td>
<td>Standard Operating Procedure</td>
</tr>
<tr>
<td>TDS</td>
<td>Total dissolved solids</td>
</tr>
<tr>
<td>TOC</td>
<td>Total organic carbon</td>
</tr>
<tr>
<td>T&amp;O</td>
<td>Taste and odor</td>
</tr>
<tr>
<td>TP</td>
<td>Treatment Plant</td>
</tr>
<tr>
<td>TTHM</td>
<td>Total trihalomethane</td>
</tr>
<tr>
<td>WQ</td>
<td>Water Quality</td>
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Addendum

Main Break Reporting Detailed Information

This addendum is provided to report additional information regarding main breaks. Historically, the Water Department considers and records system distribution main breakage as System Main Breaks whenever they occur via “natural” causes. More specifically, breaks caused by man-made damage during contractor work or traffic accidents are tracked and categorized separately into their different categories as listed below for year 2012. The break numbers reported in Phase III report include only the System Main Breaks. Breaks on tapping saddles are included in the service break category. Fire hydrant breaks are caused by vehicles running into and shearing the hydrants. The Water Department operation procedure is to actively replace fire hydrants when their connecting mains are replaced. Overall, the water Department will focus efforts to assure accurate categorization of breaks. The team discussed the importance of this task in order to consistently evaluate main break data trends in comparison to established Partnership optimization goals.

<table>
<thead>
<tr>
<th>Categories</th>
<th>2012</th>
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<tbody>
<tr>
<td>System Main Breaks</td>
<td>22</td>
</tr>
<tr>
<td>Contractor Hit Breaks Repaired by The Water Department</td>
<td>3</td>
</tr>
<tr>
<td>Contractor Hit Main Breaks Repaired by contractor</td>
<td>3</td>
</tr>
<tr>
<td>System Service Breaks</td>
<td>272</td>
</tr>
<tr>
<td>Contractor Hit Service Breaks Repaired by The Water Department</td>
<td>28</td>
</tr>
<tr>
<td>Contractor Hit Service Breaks Repaired by contractor</td>
<td>3</td>
</tr>
<tr>
<td>Fire Hydrant Breaks</td>
<td>35</td>
</tr>
<tr>
<td>Blow Off Breaks</td>
<td>2</td>
</tr>
</tbody>
</table>
Appendix A

Overall Distribution System Map

Be sure to include a distribution system schematic in the report or in the appendix. This should be the most recent line drawing of the distribution system with major facilities (storage tanks, pump stations, booster stations, entry points, and other important features) clearly labeled with a corresponding map key. Please clearly indicate all routine disinfectant residual monitoring locations on this map (or a separate map, depending on resolution. Refer to Appendix C for further guidance).
Appendix B

PSW Team Approach and Meeting Schedule/Minutes
Partnership for Safe Water Team and Approach

A team approach was used to complete the self-assessment review. The following is a summary of our team dynamics and approach:

The team included individuals from multiple levels and departments throughout the organization, including Management, Distribution System Operations, Distribution System Maintenance, Water Treatment, Water Quality Laboratory, Engineering, and Security and Emergency Preparedness. Distribution system field staff (both operations and maintenance) was actively involved, participating in activities throughout the self-assessment process.

The self-assessment process was led by a core group of individuals, referred to below as the Coordination Team. Each member took the lead for assessing their areas of expertise within the distribution system self-assessment, with other committee members providing supporting resources. Subject matter experts within the utility were utilized to provide knowledge in specific areas of the assessment, and very valuable insights were gained from the distribution system operations and maintenance staff who are most knowledgeable in the day to day distribution system operations and challenges.

A specific Self-Assessment guide chapter, or portion of a chapter, was assigned to all team members. The team was given approximately 1-2 months (depending on other work projects) to review this material, with a special focus on answering questions within that specific section of the manual. The team members also solicited input from as many other staff as possible, within their work area. At routine meetings team members discussed individual responses to questions and feedback from other co-workers, ultimately reaching a consensus response that was included in our Phase III report. This interaction resulted in excellent information sharing between all levels of management and operations.

When potential performance limiting factors were identified during meeting discussions, special study investigations were assigned to specific team members and support staff. Between meetings, additional information was gathered by various individuals via special studies, and this information was shared with the group at the next meeting. Ultimately, action plans were developed at the conclusion of each meeting, with specific individuals assigned as the lead, and others to provide support. We found it beneficial to develop and begin working on action plans as soon as possible; because it helped generate and maintain momentum and progress.
The team held a series of meetings from January 2011 to February 2013 to complete the self-assessment questions and develop the self-assessment report according to Partnership guidelines.

The following members comprised the core Self-Assessment Coordination Team:
- Deputy General Manager
- Distribution System Operations Superintendent
- Distribution System Maintenance Supervisor
- Distribution System Lead Operator III
- Distribution System Operator II
- Distribution System Operator I
- Treatment Plant Superintendent
- Treatment Plant Lead Operator
- Water Quality Lab Manager
- Security/Emergency Preparedness Manager
- Civil Engineering Associate

Subject matter experts provided knowledge in specific technical areas including customer complaints, corrosion control, modeling, and pipeline rehabilitation. Team members shared meeting minutes and solicited input from co-workers in their respective work areas. In this way, the team discussions and report findings reflect input from a very broad group of employees from all levels of our organization.

Minutes for all significant meetings of the Self-Assessment Coordination Team are provided as attachments on the following pages.
Meeting Date: May 6, 2012

Meeting Location: Conference Room 1

Committee Members Present:
Deputy General Manager
Distribution System Operations Superintendent
Distribution System Maintenance Supervisor
Distribution System Lead Operator III
Distribution System Operator II
Distribution System Operator I
Treatment Plant Superintendent
Treatment Plant Lead Operator
Water Quality Lab Manager
Security/Emergency Preparedness Manager
Civil Engineering Associate

Meeting Notes:

- Discussed Partnership for Safe Water mission and history, as well as the importance of a distribution system self-assessment to shaping the direction of future planning and operations.
- Reviewed utility staff commitment to the program and the role of all participants on the self-assessment coordination team. Described use of resources both within the team and outside of the team (utility subject matter experts).
- Discussed approach and timeline for the self-assessment effort. The assessment will be conducted by following along in the chapters of the draft Self-Assessment Guide for Distribution System Optimization. The following steps will be followed for each segment of the book assigned.
  - Data evaluation – is there sufficient documentation and/or data to address the self-assessment questions (if not, may need to plan for a separate special study to collect required data)
  - Self-assessment questions answered/documented
- Action plan created for areas not found to be optimized
  - Initial chapter assignments made

Meeting adjourned – next meeting scheduled. Coordination team members assigned to read introductory chapters to the self-assessment guide and request input from co-workers in their respective areas.
Meeting Date: July 14, 2011

Meeting Location: Conference Room 1

Committee Members Present:
Deputy General Manager
Distribution System Operations Superintendent
Distribution System Maintenance Supervisor
Distribution System Lead Operator III
Distribution System Operator II
Distribution System Operator I
Treatment Plant Superintendent
Treatment Plant Lead Operator
Water Quality Lab Manager
Security/Emergency Preparedness Manager
Civil Engineering Associate

Meeting Notes:
• Team reviewed total chlorine residual sampling locations for optimization versus PSW optimization criteria
  o Current sample locations determined to be sufficient, and represent high HRT and dead end locations; however, routine review of additional locations for special studies and data gathering will be an important ongoing initiative.
• Team carefully reviewed chlorine analysis techniques, both written SOPs and how staff is actually using the SOPs to conduct sampling. This discussion revealed the importance of ongoing consistency in sampling techniques to assure representative data from all locations for trending and comparison to optimization goals.
• PSW optimization criteria require digital measurements accurate to 2 decimal places as well as online monitoring.
  o Field staff use colorimeters reporting to x.xx.
Use of online monitors has provided valuable data; however, monitoring more locations is needed. Water Utility Supervisor to evaluate potential action items to increase the application of online chlorine monitors in key locations across the distribution system.

- Discussion regarding the pros and cons of online chlorine monitors in distribution and what can be done to improve their reliability.
- Discussion on how to identify and agree upon the most valuable sampling locations for these monitors occurred.

- Team reviewed total chlorine residual data to be submitted for optimization versus PSW optimization criteria
  - Data was found to meet PSW criteria; but, team gained significant appreciation for the ongoing need to assure consistency of sampling, data accuracy and integrity.

Meeting adjourned and next meeting scheduled. Assignment to evaluate pressure data.
Appendix C

Disinfectant Residual Sampling Site Map

Be sure to include a map of all routine disinfectant residual monitoring locations, as well as any special sampling locations that may be used intermittently or for special investigations/additional water quality parameters. This information may be included on the overall distribution system schematic or on a separate map. The main goal is to provide the best possible resolution and detail to provide reviewers with a clear picture of your overall sampling scope. If your utility is considering additional disinfectant residual sampling locations in the future or as part of the action plan, you may consider adding these locations (if identified) to this map. Please include a map key which differentiates sampling location types (e.g. current routine, intermittent special, future proposed, etc).

Please note that a map which provides a more detailed view of the portion of the distribution system typically exhibiting the lowest Chlorine residuals is also needed to meet the minimum elements of the report submittal. This map should provide a greater level of detail regarding pipe material, size, and age. It should clearly indicate the routine disinfectant residual sample locations along with the range of residuals noted at each location within the last year. This map should be developed and reviewed by your Phase III team as a graphic to generate discussion of potential causes of the lower chlorine residuals in this area, along with potential action items to improve. Use your discretion regarding the number of sample sites to include on this map, in general, the perimeter should end where routine sample sites again exhibit chlorine residuals that meet your minimum chlorine residual goal.
Appendix D

Pressure Zones and Pressure Monitoring Location Map

Be sure to include a separate map which clearly indicates all pressure zones within your system. For example, color coding various established pressure zones, with a corresponding map key, is suggested as potential method to differentiate between pressure zones within your distribution system. Also, clearly indicate on this map all pressure monitoring locations; please differentiate between pressure monitors with real time data trending via SCADA vs. those that simply data log with intermittent download. If your utility is considering adding additional pressure monitoring locations in the future, you may consider adding these locations to the map.
Appendix E

Report on Service Rendered Form

Include a copy of a typical distribution system service report form in the appendix. While this is not a checklist requirement, this information helps indicate to reviewers the type of information that is collected when field crews are repairing main breaks and the follow up actions that are taken. If service reports are collected electronically, consider including screen shots in this section to demonstrate this type of information.
Appendix F
Example Standard Operating Procedures
List of SOPs

• Storage Tank Standard Operating Procedures
• Disinfectant Residual Sampling Procedures
• Water Main Disinfection Plan
• Corrective Flushing Procedures
• Main Break Repair Procedures
• Main Shutdown Standard Operating Procedures
• Valve Operation Standard Operating Procedures
• Backflow Prevention Devices Testing Standard Operating Procedures

(Note: Minimum required SOPs for report submission include: Corrective Flushing, Disinfectant Residual Sampling, and Emergency Repair of Mains. Include any additional SOPs that support specific self-assessment areas and demonstrate actions taken by the utility in response to specific distribution system events. Be sure to indicate the date the SOP was created and most recent date of revision.)
1. Monitor storage tank levels continuously; at any time, the tank level should be between 18 and 32 ft. Record the level every hour on the daily log.

2. Monitor the Treatment Plant onsite storage level; the level should be between 4 and 22 ft at any time. Record the level every 2 hours on the daily log.

3. The electricity utility has different rates depend on the time of day. Without compromising the storage tank and treatment plant storage level, try to schedule Station 1 & 2 pumping during off-peak and mid-peak hours.

<table>
<thead>
<tr>
<th>Summer (Jun, 1 to Sep, 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 am to noon</td>
</tr>
<tr>
<td>noon to 6 pm</td>
</tr>
<tr>
<td>6 pm to 11 pm</td>
</tr>
<tr>
<td>11 pm to 8 am</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Winter (Oct, 1 to May, 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 am to 9 pm</td>
</tr>
<tr>
<td>9 pm to 8 am</td>
</tr>
</tbody>
</table>

4. If water quantity and quality is within appropriate ranges, minimize pumping during on-peak hours, however, keep one pump in operation continuously to prevent hydraulic surge on the pipe when multiple pumps are started at night.

5. Purchased water should also be brought into the tanks at the same time when station 1 & 2 is pumping; usually after 6 pm. Project the required purchased water flow based on previous day tank level change and call the purchased water center 6 hours ahead to notify the upcoming flow needed.

6. From May 1 to Sep 30, limit purchased water pumping rate to comply with established capacity reservation charge for all purchased water connections.

**NOTE:** If you have any doubts about this procedure, consult with your Supervisor before proceeding.
1. Policy

State regulation requires that prior to use, newly installed water mains, or water mains that have been taken out of service for maintenance or repair, shall be disinfected and sampled for bacteriological quality in accordance with American Water Works Association Standard C651-05. Samples from new mains shall be negative for coliform bacteria prior to the new main(s) being placed into service.

2. Procedures

A. NEW WATER MAINS THROUGH 12"

1) Main preparation
   a) A water main and its appurtenances must be thoroughly cleaned before disinfection step.
   b) To prevent cross contamination, the new main must be isolated from existing main until bacteriological tests are satisfactorily completed.

2) Disinfection
   a) New water mains through 12” shall be disinfected using the tablet method. NSF-approved calcium hypochlorite tablets shall be placed (using food grade adhesive) inside and on top of the pipe in the quantities noted below:
      - 4” main, 2 tablets per 18 ft
      - 6” main, 3 tablets per 18 ft
      - 8” main, 6 tablets per 18 ft
      - 12” main, 9 tablets per 18 ft
   b) When installation has completed, the main shall be filled with water. This water shall remain in the pipe for at least 24 hr and detectable free chlorine residual should be found at each sampling point.
   c) If the tablet method is not effective (as determined by bacteriological sampling results-coliform positive), a slug method
should be used. The slug method feeds the isolated main with a continuous dose of approximately 100 mg/L chlorine for at least 3 hours.

d) After the applicable retention period, the heavily chlorinated water shall be flushed until chlorine measurements show that the concentration is within 10% of normal distribution system levels, as determined by a residual sample collected within one thousand feet of the site.

3) Bacteriological sampling

a) After final flushing and before the new water main is connected to the existing distribution system, two consecutive sets of acceptable samples, taken at least 24 hr apart, shall be collected from the new main.

b) At least one set of sample shall be collected from every 1,000 ft of the new main and at every connection.

c) Samples shall be tested for bacteriological quality and shall show the absence of coliform organisms and the presence of chlorine residual.

d) The new main will not be placed in service until satisfactory laboratory test results on the samples have been obtained.

A. WATER MAIN BREAKS

1) Trench treatment

   e) When trench water is present, the water shall be pumped below the bottom of the pipe before loss of positive pressure if possible.

   f) Chlorine tablets should be applied as many as needed to the open trench area to reduce potential contamination from nearby sewers.

   g) The soil should be excavated below the bottom of the existing pipe and be of sufficient depth, length, and width to provide adequate working room and space for a sump pump.

2) Disinfection

   a) Disinfection will be accomplished by swabbing the ends of the main being repaired and all valves, fittings and pipe sections used for the repair with a 5% hypochlorite solution.

   b) As soon as the repair is completed, the main will be thoroughly flushed until discolored water is eliminated.
c) Where practical, the main affected by the break shall be isolated by limiting the flow to one direction until the laboratory has examined and cleared the water sample.

3) Bacteriological sampling

h) After final flushing, bacteriological samples shall be taken to provide a record of the disinfection effectiveness. Daily samples shall be continued until two consecutive negative samples are recorded.

i) At least one set of sample shall be collected from every 1,000 ft of the main and at every connection.

j) Samples collected shall be sent to the lab and tested for bacteriological quality within 6 hrs of collection and shall show the absence of coliform organisms and the chlorine residual is above 1mg/L.

4) Report

a) Status of main break repairing shall be reported by the crew chief or the employee responsible on the Report on Service Rendered form (W-152), shown in “Attachment A”.

b) Whenever the “Report on Service Rendered” indicates that water sampling is required, the duty operator, on receipt of this report, will notify the Laboratory Services Manager.

c) The Laboratory Services Manager will indicate identification numbers that are to be assigned to these samples. The Water Quality Laboratory Microbiological Test Report will be kept on file with the Report of Service Rendered.

B. NEGATIVE BACTERIOLOGICAL RESULTS

Negative bacteriological results will be transmitted to the duty operator by telephone. After which, valves closed to isolate a main break shall be opened or, in the case of new mains, shall be placed in service.

C. POSITIVE BACTERIOLOGICAL RESULTS

Positive results will be reported immediately to the Deputy General Manager – Operations and the General Manager. The main will remain isolated and out of service pending further investigation.

3. References
Main Break Repair Procedures
Created 10/21/2002

A. Emergency Service Personnel
   1. Arrives on scene.
   2. Assesses the source of water that is visible.
   3. Determines if a crew is needed.
   4. Notifies Communications that a Crew is needed.
   5. Secures the area.
   7. Marks for Underground Service Alert (USA).
   8. Notifies Communications/Control Room of Street Closures.
   10. Takes water temperature.

B. Communications Dispatcher / Control Room Operator
   1. Contacts Water Utility Supervisor II that Crew is Needed.
   2. Crew is assembled or called in if during after hours.

C. Crew Assembles
   1. Crew gathers proper materials needed before leaving yard.
   2. Crew arrives at location.
   3. Crew secures area to make sure it is safe for public and employee travels.
   4. Sandbag around storm drain catch basins.
   5. Confirms applicable Utility Services have been notified to mark.
   6. After all utilities are marked, crew drills test holes over the water main.
   7. Crew uses sound a phone and probe rod to determine the approximate location of the break.
   8. Crew utilizes available resources to make excavation, such as pavement breaker, backhoe, concrete/asphalt saw. Hand digging around utility service markings is done when necessary.
   9. Shoring is to be used as necessary determined by soil conditions.
   10. Once pipe is exposed, the Supervisor determines if a full shutdown is needed. If so, he contacts Emergency Service Personnel to make necessary shutdown.
   11. Evaluation of risk of contamination begins to ultimately determine if an advisory is necessary to any portion of the affected distribution system.
   12. Type of break is assessed by the supervisor at the time of exposure. A square break is a circumference break that is perpendicular to the pipe, a split or couple up break is when the break is parallel with the pipe, etc.
   13. The Supervisor photographs the condition of the pipe and attaches the photo to final Report on Service Rendered.

D. Repairs are made as needed. With a full circle clamp, or bolted couplings.
1. Square breaks
   a. Make sure there is always positive pressure on main at all times, and within area affected by the break
   b. If positive pressure can not be maintained, consider the need for public notification advisory.
   c. Keep debris from getting into pipe
   d. Support the main
   e. Properly disinfect pipe and clamp before it is installed
   f. Install clamp
   g. Inspect for leaks
   h. Grease and wrap the fittings
   i. Flush thoroughly through the hydrant and use dechlorination tabs

2. Couple-Up Break
   a. Excavate enough area around the pipe to keep debris from entering into pipe.
   b. Inspect pipe (visually) to see if debris has entered, if so clean it out.
   c. Swab both ends of pipe fittings and pipe with bleach.
   d. Install fittings and pipe
   e. Leave main on a partial and flush thoroughly using the fire hydrant with dechlorination tablets.
   f. Back fill excavation with sand, class A-base.
   g. Clean area to make it safe for pedestrian and vehicle traffic.
   h. Notify that road closure is now open.
   i. Submit paperwork for permanent paving and all reports as needed.
These procedures apply to mains shutdown for:

- Breaks
- Replacement
- Regular maintenance
- Gate operation

1. The Supervisor will identify the area that has to be shutdown notifies Control 2 that a transmission main is being temporarily taken out of service. Valve operations crew will then operate the gates for the shutdown.

2. No interruptions in water service typically occur. If an interruption in a customer’s service is unavoidable, the customer is notified of the approximate duration. When work completed then Control 2 and any effected customers are notified.

3. When a main is dewatered it is not put back into service until 2 consecutive health samples have been taken.

4. Report on service rendered is used to record shutdown times and returned to Control 1.

5. When a gate ticket is turned in to supervisor, they decide if health samples are required. These are then recorded on report on service rendered and an official sample letter is issued.

6. Flushing and disinfection are used to achieve sanitary quality standards. See Disinfection procedures in "Rules and Regulations."

7. Dechlorination tablets are used in diffusers when flushing.
Gate Valve Installation

When a gate valve is installed, a new gate valve ticket is filled out by crew chief and returned to Engineering. This ticket includes: location, number of turns to operate, make, model, etc.

Engineering then keeps a copy and provides a copy to GIS that inputs the info into the GIS server, which in turn, updates the iWater program

“Normal” Gate Valve Operation

Every gate valve is to be operated annually. The Water Utility Supervisor I assigned to Valve Operations is responsible for dividing up the city geographically and deploying valve op crews in a systematic fashion to make sure that every valve has been operated, its condition documented and its location verified. The gates are to be operated based on data available in iWater, including: valve condition, valve age, torque required to operate the valve and the number of turns required. When the valve is being operated, the crew is to record the condition, number of turns required etc. directly into their “tough books.” Upon return to the Operations Service Center at the end of their shift, they then upload the data from their tough books directly to the iWater server.

“Problem” Gate Valves

When there is a problem with a gate valve, a GIS map is printed of the location and a “Gate Work and Location” form is filled out. GIS is attached to gate work and location form and submitted to the Water Utility Supervisor II (WUS II) in charge of Valve Operations. WUS II prioritizes gate repair/replacement based on the broken gates impact on water quality within the distribution system. A work order is then generated to repair/replace the valve and it is assigned to either a valve operations crew or main construction crew based on the size/location of the valve. In the event that a replacement is made, a “New Gate” form is filled out and turned in to GIS.
Standard Testing Procedures

- At the beginning of each month, the analyst assigned to valve operations prints test sheets for assemblies due in that month and gives them to the Meter Shop/Backflow Supervisor.
- The Meter Shop/Backflow Supervisor will then assign assemblies to testers according to size and location.
- Certified Backflow tester then performs test and any necessary repairs/replacements.
- Tester records test results, including all repairs and replacements and returns the test sheet to the analyst. The analyst then enters the results into the XC2 Backflow database.

Testing Procedures for Special Circumstances

- If backflow is not easily accessible and customer does not provide access when requested by the tester, Meter Shop/Backflow Supervisor will notify the analyst and request that a “Final Request for Access” letter be sent. The letter will be sent certified mail. Customer has 5 days to contact the analyst in response or they may face service interruption.
- If the assembly is inaccessible, customer is notified and given the option to relocate the assembly to an accessible location or to take over the responsibility of testing the assembly annually. If they choose to take over the testing the analyst records this in XC2.
- If the backflow is for a fire line, the backflow tester notifies the customer of the test. The customer must notify the alarm service that the water will be off for the duration of the test. If the tester cannot establish contact with the customer, they notify analyst. The analyst will send a “Request for Access to Backflow Assembly Located on a Fire Line” letter via certified mail. The customer has 5 days from the date of receipt to contact the analyst, or may face service interruption.

New Assembly Installations

- During the plan check for a new service or service transfer, a trained Backflow specialist will notify the customer if backflow protection is required and if so, what type. The customer is then responsible for the purchase and installation. Before service can be turned on to the customer, the customer must notify the Meter Shop/Backflow Supervisor who will dispatch tester to test and certify backflow. Test report is given to analyst for entry into XC2.
- If new install is for a fire line then contractor must come to Engineering Development for a plan check, already having received approval from the fire
department. Engineering Development will notify the Meter Shop/Backflow Supervisor when the assembly has been installed. Meter Shop/Backflow Supervisor dispatches a tester to test and certify the assembly. Completed test sheet is returned to the analyst for entry into the XC2 database.

**Stolen Assemblies**

- If a backflow assembly is stolen from a fire line then the Meter/Backflow Shop will replace it free of charge to the customer. After it has been installed, tested and certified, the test sheet is returned to the analyst for entry into the XC2 database.
- When customer calls dispatch to report stolen backflow assembly from a non-fire service, Emergency Services will respond, turn off water at the meter, lock the meter, and notify the customer and dispatch.
Appendix G

Historical Main Breaks on Pressure Distribution Map

In this section, the goal is to develop and include data that illustrates the influence (or lack of influence) of pressure on main breaks. This may be expressed as a map, graph, table, or in any other format illustrative of this relationship. Please include a brief narrative which references this illustration and provides the conclusions of your team’s interpretation of this data.
Appendix H
The Water Department Rules and Regulations
Cross Connection and Backflow Prevention
RULES, REGULATIONS AND CHARGES GOVERNING POTABLE WATER, RECLAIMED WATER, SEWER SERVICE, AND THE WATER CONSERVATION AND WATER SUPPLY SHORTAGE PLAN
PART 8
CROSS CONNECTION AND BACKFLOW PREVENTION

SECTION 801. GENERAL PROVISIONS AND REQUIREMENTS

The Department has the responsibility to protect the public water system from contamination caused by the backflow of contamination through the water service connection. The City’s Department of Health and Human Services is responsible for the protection program downstream from the meter assembly on private property.

No water service connection shall be installed or maintained to any premises where actual or potential cross-connections are known to exist unless such cross-connections are abated or controlled to the satisfaction of the Department.

Customers with conditions that constitute a potential contamination hazard to the City's water supply system shall install one or more Approved backflow prevention assemblies at the service connection(s). The state regulations are incorporated into and made a part of these Rules by this reference.

SECTION 802. TYPE OF PROTECTION REQUIRED

All water services connected to the public water system may be required to include an Approved backflow prevention assembly of the type designated by the Department. The approval of the type of device shall be based on the existing or potential degree of hazard which exists in the opinion of the Department. All devices shall be approved by the Foundation for Cross-Connection Control and Hydraulic Research, State University.

The installation of the backflow prevention assembly shall be above ground, as close as practical to the service connection meter or to the street right-of-way line, screened from view as Approved by the Department and shall conform to the Department’s standards and requirements.

When water service is initiated, the Applicant must provide sufficient information, including Plumbing and building plans, to enable the Department to determine the level of backflow protection required. Plans and specifications must be submitted to the Department for review of possible cross-connection hazards as a condition of service for new service or modification to existing service.

Each time there is a change of Customer (either owner or tenant) on any commercial or industrial property, the new or previous owner or Customer shall notify the Department immediately. Also, any modification to existing Onsite Facilities that may affect the level of protection must be reported immediately.
The Department may require an inspection of the premises to evaluate cross-connection hazards. If Customer does not allow an inspection Customer must install a backflow prevention assembly providing the highest level of backflow protection.

The type of protective device that may be required to prevent backflow into the public water supply includes: Reduced Pressure Principle (RP) or Double Check (DC) Backflow Prevention Assembly and an air gap separation (AG). It is recognized that conditions vary and that protection will be determined by the degree of hazard. Therefore, the Department may require greater or lower level of protection than listed below, or may require backflow prevention for facilities not specifically listed. The minimum type of backflow protection at the service connection that shall be installed on Customer’s premises whenever the following degrees of hazard exist are as follows:

802.1 Facilities Requiring a Reduced Pressure Principle Device (RP)

A. Aircraft and Automobile Manufacturing Plants
B. Auxiliary Water Systems (Interconnected)
C. Buildings with Sewage ejectors (inadequate in-plant protection)
D. Breweries
E. Canneries, Packing Houses and Reduction Plants
F. Car Wash with water reclamation system
G. Centralized Heating and Air Conditioning Plants
H. Chemical Plants
I. Dye Works
J. Film Processing Laboratories
K. Hospitals and Convalescent Facilities
L. Irrigation Systems (premises having separate systems - such as parks, playgrounds, cemeteries, golf courses, and schools)
M. Laboratories using toxic materials
N. Manufacturing, Processing and Fabricating Plants using toxic materials
O. Medical and Dental Buildings
P. Mortuaries
Q. Oil and Gas Production Facilities
R. Multi-storied Buildings (3 stories or more)
S. Multiple Services-Interconnected
T. Paper and Paper Production Plants
U. Plating Plants
V. Radioactive Materials Processing Facilities
W. Restricted, Classified or other Closed Facilities
X. Rubber Plants
Y. Sewage and Storm Drainage Pump Facilities
Z. Center front Facilities (generally excluding private residences)
AA. Where the use of a substance, process water, or water supplied by this Department is such that the water may be subject to deterioration in sanitary quality and permit its entry into the water system

802.2 Facilities Requiring a Double Check Backflow Assembly (DC)
A. Auxiliary Water Systems (not interconnected)
B. Beverage Bottling Plants
C. Buildings with house pumps and/or water storage tank
D. Buildings with Sewage ejectors (adequate in-plant protection)
E. Chemically Treated Potable Water Systems
F. Commercial Laundries
G. Cold Storage Plants
H. Food Processing Plants
I. High Schools and Colleges
J. Manufacturing, Processing and Fabricating Plants using non-toxic materials
K. Mobile Home Parks

SECTION 803. FIRE PROTECTION SYSTEMS

Backflow prevention assemblies may be required on an automatic closed fire sprinkler system. However, where there is the intent, or provisions are made for the addition of chemical solutions into the fire system or "Special Conditions" exist on the site, an Approved back-flow prevention assembly shall be installed.

The following "Special Conditions" may warrant an Approved backflow prevention assembly at the user connection(s):

A. Underground fire sprinkler pipelines parallel to and within ten feet horizontally of sewer pipelines carrying significantly toxic materials.
B. When water is supplied to a site or an area from two or more services of the water utility, or from two different water utilities, flow problems should be evaluated.
C. Occupancies (or changes in occupancies) which involve the use, storage, or handling of types and quantities of materials in a manner which could present a significant health hazard to the domestic water supply.
D. Sites with unusually complex piping systems.
An Approved backflow prevention assembly shall be installed on a closed automatic sprinkler system that is interconnected with an auxiliary water supply.
A fire line with hose racks, hydrants or roof tanks shall have the same type of backflow prevention as is required on any other domestic or industrial water service entering the property.
An Approved backflow prevention assembly shall be installed at each fire service connection where there is an available auxiliary water supply suitable for fire fighting purposes. This includes any fire system subject to contamination resulting from the introduction of "Foamite," antifreeze solutions, or other biological or chemical additives.

SECTION 804. TESTING AND MAINTENANCE

A developer or its agent shall install all new backflow prevention assemblies. The initial test and certification of these assemblies will be performed by the Department. Thereafter, any assemblies connected directly to the public water system will be
maintained, serviced, and tested annually by the Department. The Department will notify affected Customers when testing of an assembly will be performed.

More frequent testing may be required if, in the opinion of the Department, the severity of the hazard or repeated failures of the backflow prevention assembly to function properly warrants additional testing.

An Applicant or Customer must obtain approval from the Department before an assembly is removed, relocated, or replaced. Whenever an assembly is relocated, modified, repaired, or found to be malfunctioning, the Applicant or customer shall notify the Department immediately and the Department will test the assembly and re-certify it. The assembly shall not be placed in service unless it is functioning as required. Water service to any site may be terminated by the Department if unprotected cross-connections exist on the site, any defect is found in an installed backflow prevention assembly, or if a backflow prevention assembly has been removed or bypassed without written permission from the Department. Water service will not be restored until those conditions or defects are corrected. Charges for terminating service are contained in Appendix A.

Termination of service may be summary, immediate, and without notice whenever, in the judgment of the Department, such action is necessary to protect the quality and/or safety of water and the water supply system.

The City’s Department of Health and Human Services is responsible for the protection program downstream from the meter on private property. Customers shall fully comply with all requirements established, and shall provide, install, test and maintain all required backflow prevention assemblies on private property at the Customers’ expense. All assemblies shall be readily accessible for testing and maintenance.
Appendix I
Dead End Main Flushing Program
DEAD-END MAIN FLUSHING PLAN

A. POLICY

Routine flushing of dead-end lines is often necessary to prevent stagnation of water and degradation of water quality within a distribution system. During 2005 – 2006, the Water Department identified all dead-ends in its distribution system and flushed each until the chlorine residual was above 1.0 mg/L. About 200 dead-end sites are placed on a flushing list annually based on the diameter of pipe, time and volume required to meet this minimum chlorine residual and bacteriological results.

B. PROCEDURES

Flushing should be conducted during periods of low water demand. Prior to flushing, the Water Department will notify the customers who may be affected of the dates and times of the flushing, through billing, leaflets or by door to door information. Following outlines the flushing procedures.

1. The Water Department will isolate the sections to be flushed from the rest of the system by closing the valves slowly to prevent water hammer. **Mark paperwork (valve map) when a valve is closed and erase the marking when the valves are re-opened.**

2. A neutralizing agent, such as sodium thiosulfate, should be applied to the water before being flushed down the storm drains or other water ways.

3. Flushing will begin at or near the water source and work outwards into the distribution system (unidirectional).

4. The Water Department staff will open fire hydrants or blowoff valves slowly and close slowly after flushing is completed.

5. Open hydrants or blowoff valves fully for a period long enough to move the loose deposits inside the water main (usually 5 to 10 minutes) and flush the lines for 15 to 30 minutes.

6. Ensure that the system pressure in nearby areas is maintained above 20 psi (138kPa or 1.5 kg/sq cm). Record pressure.

7. Keep a record of all pertinent data regarding the flushing operation as well as a description of the appearance and odor of the water flushed out.
8. Analyze and record total chlorine residual on site at the beginning and ending of the flushing cycle.

9. Collect two samples from each flushing site (one at the start of the flushing cycle and one at the end). Bring these samples back to the lab for analyses.

10. Flushing system records are maintained in the Water Quality Lab Division AND by the Valve Operations Division.

C. UNSCHEDULED FLUSHING

Unscheduled system flushing will be performed at any distribution site when deemed necessary to reduce stagnant water, sediment build-up or as a preventative or control action to restore water quality. Procedures outlined in Section 1 of this Plan shall be followed.
Appendix J

Nitrification Prevention and Control Plan
NITRIFICATION PREVENTION AND CONTROL PLAN

A. POLICY

This Nitrification Prevention and Control Plan is intended to provide guidelines for both an early warning mechanism and operational means to prevent and control nitrification episodes within the domestic water system.

1. BACKGROUND

Nitrification is the biochemical conversion of reduced forms of nitrogen (primarily ammonia nitrogen), to nitrite and ultimately to nitrate. The use of chloramines is the main source of ammonia nitrogen in drinking water systems; free ammonia nitrogen will be released as water ages and chloramine residual decays. If the environmental conditions are favorable for growth of microorganisms, ammonia oxidizing bacteria (AOB) will convert the free ammonia-nitrogen to nitrite-nitrogen. Nitrite can be oxidized by chloramine residual, releasing more ammonia nitrogen and promoting the nitrification cycle.

Therefore, an increase in nitrite concentration with a decrease in ammonia-nitrogen concentration is expected in the early stages of nitrification. In advanced stages of nitrification, most of the ammonia-nitrogen will be converted to nitrite. Furthermore, the nitrifying bacteria may completely oxidize all the reduced nitrogen to nitrate. Therefore, monitoring results may show low ammonia-nitrogen levels with high or low nitrite levels.

The Water Department serves a population of approximately half a million residents through 900 plus miles of pipelines. The Water Department utilizes chloramines as its residual disinfectant, and has implemented an aggressive nitrification prevention and control action plan that is detailed in this document.

2. NITRIFICATION PLAN

The goal of this nitrification plan is to prevent nitrification from occurring through early detection and elimination of conditions that would promote nitrification. In addition, the plan outlines specific procedures when responding to detection of nitrification with appropriate responses to keep all biological and chemical parameters within acceptable limits.

There are three components to this nitrification plan:
Each of the four components is discussed in the following sections.

A. Prevention

The goal of the nitrification plan is to prevent nitrification. In practice, prevention requires both the education and training of staff and the optimization of the distribution system. Education and training include reviewing chloramine chemistry, nitrification, sampling procedure training, and analysis procedure training. Optimizing operations includes reducing detention times, maintaining minimum disinfectant levels, and maintenance of pipelines and storage tanks. These prevention practices are discussed in detail below.

Education/Training

Chloramine chemistry review: Chloramines are formed by aqueous chlorine reacting with aqueous ammonia. Monochloramine will continue to form up to a chlorine to ammonia-nitrogen ratio (Cl$_2$:NH$_3$-N) of 5:1 (Figure 1). At a Cl$_2$:NH$_3$-N ratio of 5:1, all the free ammonia has been converted to chloramines. As the applied Cl$_2$:NH$_3$-N ratio increases from 5:1 to about 10:1, chloramine residual is destroyed until it reaches the “breakpoint”. Free chlorine is present at a Cl$_2$:NH$_3$-N ratio greater than 10:1. This process is termed “breakpoint chlorination”.

Chloramines will naturally decay over time. Free ammonia will be released as chloramines decay, and chloramines concentration will be left of the maximum point on Figure 1. Because the free ammonia-nitrogen is the primary nitrogen source for nitrifying bacteria, the free ammonia-nitrogen should be minimized. Recombining the free ammonia-nitrogen, at a Cl$_2$:NH$_3$-N ratio of 5:1, to produce chloramines will minimize nitrogen and increase chloramine residual.

A review of the breakpoint chemistry will be performed annually to refresh understanding.

Sampling procedure training: General sampling procedures for tanks and distribution sites are described in Appendix A of this plan. All new field sampling personnel will need to demonstrate to the water quality supervisor proficiency in field sampling. All field sampling personnel will review sampling procedures every year.

Analysis procedure training: Proper analytical procedures for total chlorine, nitrite, and total and free ammonia are outlined in the Department’s Standard Laboratory Procedures. All new personnel responsible for performing analyses
(field samplers and lab analysts) will need to demonstrate proficiency in performing the analyses to the water quality supervisor. All personnel performing analyses will review analytical procedures every year.

OPTIMIZING OPERATIONS FOR PREVENTION OF NITRIFICATION

Minimizing detention times: the Department operates two tank farms (blended water reservoir and purchased water reservoir). The purchased reservoir receives only water purchased from local wholesaler. The blended water reservoir receives a blend of purchased water and groundwater. Both the blended and purchased water reservoirs utilize multiple tanks to provide operational flexibility and allow future expansion. During periods of excessively low water usage, one strategy to reduce the hydraulic detention time while providing sufficient fire storage is to isolate select tanks. The tank(s) isolated will alternate every other week to prevent excessive water quality degradation. The isolated tank will be carefully monitored for disinfectant residual. If the disinfectant residual falls below the target value, disinfectant in the isolated tanks will be boosted to the target residual (see tank residual maintenance below for examples).

Maintaining Disinfectant Levels: The disinfectant residual will be maintained by cycling the tank elevation 4 to 5 feet of daily and perform one deep cycle weekly (8 to 10 feet). This is achieved by minimizing deliveries into the farms during the day time (period of high demand) and fill the farm back up at night (period of low demand). During nitrification sampling, if the nitrite level is below 0.020 mg/L and the disinfectant residual is below the target of 1.6 mg/L for chloramines, the disinfectant residual should be boosted back to 2.5 mg/L total chlorine by recombining the all free ammonia-nitrogen at Cl₂:NH₃-N ratio of 5:1. There are two methods to boost the disinfectant residual; direct addition thru tank hatch and tank to tank transfer. Example of recombining total chlorine is shown in Appendix B for direct addition and Appendix C for tank to tank transfer.

Maintenance: Sediment and biofilm in pipes and storage tanks are also factors which can contribute to nitrification. Flush pipelines in accordance to the Department’s flushing plan to remove sediment and scour biofilm. In addition, the Department’s standard tank cleaning procedure is to clean storage tanks annually, rotate through all 33 tanks every three years.
Figure 1. Typical chloramine dose residual curve.
B. Monitoring

Monitoring is fundamental to the prevention and control of nitrification. The primary goal of the monitoring program is to obtain near “real-time” knowledge of system water quality with respect to nitrification. There are three sections to the monitoring program, which are discussed in detail below.

Monitoring Locations:

The Department will monitor all reservoir storage tanks (12 tanks at the purchased water reservoir and 21 tanks at the blended water reservoir), which are prime locations for nitrification to occur due to their potential for long detention times and higher temperatures. In addition, all of the routine coliform monitoring locations will also be monitored for nitrification to assist in early detection of nitrification.

Sample Analyses:

The following analyses will be performed as part of the monitoring program.

- Temperature: Although nitrification can occur between 0°C to 30°C, the optimal temperature for nitrification is between 25°C and 30°C. Furthermore, chloramine degrades at a higher rate at higher temperatures. Generally, nitrification occurs more frequently in the warm summer and fall months, but given long reservoir detention times, nitrification can occur year-round. Temperature will be measured in the field at the time of sample collection.

- Total Chlorine Residual: Disinfectant residual is necessary to control biological activity. The minimum residual for normal operations is 1.0 mg/L for chloramines. Ideally, chloramine residual should be maintained at about 2.0 mg/L. Total chlorine will be measured in the field at the time of sample collection.

- Nitrite: Elevation of nitrite level in the distribution system is an early warning sign of nitrification. Response levels for nitrite measured are discussed in Section 3 (Nitrification Response Plan). Nitrite samples will be measured in the lab.

- Total and Free Ammonia: A significant decrease in the total ammonia concentrations can be an indication of advanced nitrification. Free ammonia needs to be minimized to prevent nitrification because it is the form of reduced nitrogen used by nitrifying bacteria. Total and free ammonia will be measured in the lab.

- Heterotrophic plate counts (HPCs): As nitrification process begins and chloramines residual drops below threshold levels, HPCs can rise. Although HPC are not directly regulated, they are an indicator of overall
heterotrophic bacteria control in the distribution system. Monitoring levels can be especially helpful indicator in tanks during periods of long detention times. HPCs will be measured in the lab.

- Total Coliform: Loss of chlorine residual due to nitrification may promote bacteria regrowth. Total coliform will be monitored as a precautionary measure to ensure consumer safety. Total coliform will be measured in the lab.
- pH: pH can be an indicator for biological activity. As biological activity increases, a decrease in pH may be observed in poorly buffered waters. pH will also be monitored in the field.

**Monitoring Frequency:**

Monitoring sites are organized into two groups: tanks and distribution sites. Parameters to be sampled and frequency of analyses for each sampling group and proposed method is shown in Table 1. A list of reservoir tanks and distribution system monitoring locations are shown in Table 2 and 3, respectively.
Table 1. Summary of Monitoring Constituent, Frequency and Proposed Method.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Analysis Frequency</th>
<th>Method: Method No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Tanks: <em>Monthly</em>¹</td>
<td>Thermometer</td>
</tr>
<tr>
<td></td>
<td>Distribution Sites: <em>Monthly</em></td>
<td></td>
</tr>
<tr>
<td>Total Chlorine</td>
<td>Tanks: <em>Monthly</em>¹,²</td>
<td>DPD:</td>
</tr>
<tr>
<td></td>
<td>Distribution Sites: <em>Weekly</em></td>
<td>Hach Method 8167</td>
</tr>
<tr>
<td>Nitrite</td>
<td>Tanks: <em>Monthly</em>¹</td>
<td>Hach: FIA</td>
</tr>
<tr>
<td></td>
<td>Distribution Sites: <em>Weekly</em></td>
<td></td>
</tr>
<tr>
<td>Total &amp; Free Ammonia</td>
<td>Tanks: <em>Monthly</em>¹</td>
<td>Indophenol:</td>
</tr>
<tr>
<td></td>
<td>Distribution Sites: <em>Monthly</em></td>
<td>Hach Method 10200</td>
</tr>
<tr>
<td>HPC</td>
<td>Tanks: <em>Monthly</em>¹</td>
<td>Pour Plate Method</td>
</tr>
<tr>
<td></td>
<td>Distribution Sites: <em>Weekly</em></td>
<td></td>
</tr>
<tr>
<td>Total Coliform</td>
<td>Tanks: <em>Monthly</em>¹</td>
<td>Colilert Method</td>
</tr>
<tr>
<td></td>
<td>Distribution Sites: <em>Weekly</em></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>Tanks: <em>Monthly</em>¹</td>
<td>Probe</td>
</tr>
<tr>
<td></td>
<td>Distribution Sites: <em>Monthly</em></td>
<td></td>
</tr>
</tbody>
</table>

¹ Monthly during cold periods (October thru April) and bi-monthly during warm periods (May thru September) except for Total & free ammonia, which were not monitored during cold periods.

² During nitrification monitoring, if the measured total chlorine residual is less than 0.2 mg/L in any of the tanks, collect and measure Total Coliform and HPC for that monitoring site.
Table 2. List of Storage Reservoir Sampling Locations

<table>
<thead>
<tr>
<th>Purchased Water Reservoir</th>
<th>Blended Water Reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent</td>
<td>Influent</td>
</tr>
<tr>
<td>Tank 1</td>
<td>Tank 1</td>
</tr>
<tr>
<td>Tank 2</td>
<td>Tank 2</td>
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<tr>
<td>Tank 3</td>
<td>Tank 3</td>
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<tr>
<td>Tank 4</td>
<td>Tank 4</td>
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<tr>
<td>Tank 5</td>
<td>Tank 5</td>
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<tr>
<td>Tank 6</td>
<td>Tank 6</td>
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<tr>
<td>Tank 7</td>
<td>Tank 7</td>
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<tr>
<td>Tank 8</td>
<td>Tank 8</td>
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<tr>
<td>Tank 9</td>
<td>Tank 9</td>
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<tr>
<td>Tank 10</td>
<td>Tank 10</td>
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<tr>
<td>Tank 11</td>
<td>Tank 11</td>
</tr>
<tr>
<td>Tank 12</td>
<td>Tank 12</td>
</tr>
<tr>
<td>Effluent</td>
<td>Effluent</td>
</tr>
<tr>
<td></td>
<td>Tank 13</td>
</tr>
</tbody>
</table>
Table 3. List of Distribution System Sampling Locations
C. Response

Nitrite buildup occurs during nitrification of chloraminated water. Nitrite is particularly problematic because it exerts a strong oxidant demand and accelerates the breakdown of the chloramine residual. Therefore, nitrite can be the most definitive indicator for nitrification. However, other water quality parameters should be included to aid in the assessment of the extent of nitrification and general quality of the water. Thus, the action plan is broken into four (4) levels using a combination of water quality parameters, where each increasing level corresponds to an increase in response needed. The actions range from no additional action to full nitrification has occurred and notification is required. It is important to note that if any of the parameters for a specific action level occurs, the appropriate response is to proceed into that action level.

Table 4. List of Monitoring Results with Corresponding Action Category.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Action 1</th>
<th>Action 2</th>
<th>Action 3</th>
<th>Action 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine Residual (mg/L)</td>
<td>1.6-2.5</td>
<td>1.0-1.5</td>
<td>&lt;1.0</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>NH₃-N-F (mg/L)</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>Nitrite-N (mg/L)</td>
<td>&lt;0.030</td>
<td>&gt;0.030-0.50</td>
<td>&gt;0.050-0.10</td>
<td>&gt;0.10</td>
</tr>
<tr>
<td>HPC (cfu/mL)</td>
<td>&lt;500</td>
<td>&gt;500</td>
<td>&gt;500</td>
<td>&gt;500</td>
</tr>
</tbody>
</table>
Table 5. General Responses for each Action Level.

<table>
<thead>
<tr>
<th>Action Level</th>
<th>Tanks</th>
<th>Distribution System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tanks</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Monitor at 56 locations weekly |
| **2**        | All Level 1 actions, and, 1. Investigate and correct any valving positions at tank farm 2. Increase reservoir cycling to decrease detention time Individual tanks 3. Add hypochlorite, NH₃ to restore chlorine to 2.5 mg/L at correct Cl₂:NH₃ ratio 4. Transfer and blend waters with waters from non-impacted tanks. | • All Level 1 actions, and,  
• Investigate and correct any valving positions in affected area  
• Perform local hydrant flushing until Cl₂ level is increased to 1.5 mg/L  
• Monitor for water quality after flushing at affected location |
| **3**        | All Level 2 actions, and, 1. Isolate tank in question 2. Breakpoint chlorine, or 3. Drain tank, refill, test, and place back into service Individual tanks | • All Level 2 actions, and,  
• Level 3 incidents may affect a wider area  
• Perform wider-scale unidirectional flushing until Cl₂ level is increased to 1.5 mg/L  
• Monitor for water quality after flushing at affected location |
| **4**        | All Level 3 actions, and, 1. If possible, switch water supply (blended water reservoir only) Reservoir effluent | • All Level 3 actions, and,  
• Notification to City management  
• Notification to DPH if primary MCL was violated |
APPENDIX A (Nitrification Plan)

General Procedures for Sample Collection

1. Obtain clean bottles for the purpose of collecting water samples for analysis (sterile bottles are needed for micro samples).
2. Add appropriate preservatives as needed for analytical procedures.
3. Prior to flushing tap, disinfect the tap with alcohol (septicol) and flame (as appropriate)
4. Representative samples are obtained by flushing the tap fully open for approximately 3-5 minutes.
5. Reduce flow to a level where splashing will not occur during sampling.
6. Using aseptic technique, fill containers; for micro samples -leave a space for mixing (check methods for organic compounds).
7. If bottles have preservatives, be careful not to rinse or flush out during sampling.
8. Analyze and Record: site ID, date, time, chlorine residual, temperature, pH, and analysts name on chain of custody.
9. Place samples in clean cooler with ice and transport to lab within the appropriate time for analysis.
APPENDIX B (Nitrification Plan)

Example of Direct Addition Method to Restore Chlorine Residual at the Correct Cl₂:NH₃-N Ratio in Tanks

During routine nitrification monitoring, blended water reservoir Tank 15 showed:

- Total Chlorine = 1.0 mg/L
- Total Ammonia Nitrogen = 0.5 mg/L
- Free Ammonia Nitrogen = 0.3 mg/L
- Nitrite Nitrogen = 0.010 mg/L
- HPC = < 500 cfu/mL

Based on Action Level 2, chlorine residual should be restored back to 2.5 mg/L at a Cl₂:NH₃-N ratio of 5:1. Because the total ammonia nitrogen is still at 0.5 mg/L, addition of ammonia is not necessary in this example. However, the chlorine residual needs to be boosted back to 2.5 mg/L total chlorine. Thus, 1.5 mg/L of chlorine needs to be added. For the purpose of this example, assume volume is 2.5 million gallons and you will be using 65% calcium hypochlorite (HTH).

\[
\text{lbs Cl}_2 = \frac{1.5 \text{ mg}}{\text{L}} \times \frac{3.785 \text{ L}}{\text{Gallon}} \times \frac{2,500,000 \text{ Gallons}}{1 \text{ lb}} \times \frac{1 \text{ lb}}{453,600 \text{ mg}} \times 65\%
\]

\[
\text{lbs Cl}_2 = 48.13 \text{ lbs}
\]

Once the proper amount of HTH is weighed out, sprinkle in the HTH over through the hatches and avoid pouring the HTH all at once.
APPENDIX C (Nitrification Plan)

Example of Tank to Tank Transfer Method to Restore Chlorine Residual at the Correct Cl\(_2\):NH\(_3\)-N Ratio in Tanks

During routine nitrification monitoring, the blended water reservoir Tank 15 showed:

- Total Chlorine = 1.0 mg/L
- Total Ammonia Nitrogen = 0.5 mg/L
- Free Ammonia Nitrogen = 0.3 mg/L
- Nitrite Nitrogen = 0.010 mg/L
- HPC = < 500 cfu/mL

Based on Action Level 2, chlorine residual should be restored back to 2.5 mg/L at a Cl\(_2\):NH\(_3\)-N ratio of 5:1. Because the total ammonia nitrogen is still at 0.5 mg/L, addition of ammonia is not necessary in this example. However, the chlorine residual needs to be boosted back to 2.5 mg/L total chlorine. Thus, 1.5 mg/L of chlorine needs to be added. For the purpose of this example, the transfer pump transfers at a rate of 1000 gallons per minute (gpm) and a 12.5% bleach solution will be used (SG = 1.20). The rate to pace in this 12.5% bleach in mL per minute is calculated as follows:

\[
\text{Cl}_2 \text{ Rate} = \frac{1.5 \text{ mg}}{\text{L}} \times \frac{3.785 \text{ L}}{\text{Gallon}} \times \frac{1,000 \text{ Gallons}}{\text{Minute}} \times \frac{1 \text{ mL}}{1,200 \text{ mg}} \times \frac{1}{12.5\%}
\]

\[
\text{Cl}_2 \text{ Rate} = \frac{37.85 \text{ mL}}{\text{Minute}}
\]

Once the chlorine feed rate is determined, isolate the Tank. Then, using the transfer pump (1000 gpm), move water from the isolated tank into a nearby tank. While the water is transferring, pace in chlorine following the example above.
Appendix K

Water Quality Monitoring Program and Sampling Schedule
**WATER QUALITY LABORATORY MONITORING PROGRAM AND SAMPLING SCHEDULE**

<table>
<thead>
<tr>
<th>WQ Sampling Schedule:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coliform Bacteria, HPC, Residual Cl₂, temperature, etc.</td>
</tr>
</tbody>
</table>

**Weekly Distribution Samples (Operations)**

**(56 Distribution points & Sources)**

(56 locations were selected to develop an overall representative sample set to adequately cover all areas of the distribution system. All 56 locations are monitored each week, with sample data trended and reviewed at the end of each month.)

1. Turbidity
2. Color
3. pH
4. Sp. Conductivity
5. Residual Chlorine, Total
6. NO₂–N, (plus 25 extra sample points)
7. NH₃–N, Free and Total
8. Monochloramine
9. Temperature
10. Fluoride

**Customer Complaint Samples**

*(Intermediate number of samples)*

pH, Color, Turbidity, Sp. Conductivity, Odor, Coliform, HPC, Pb, Cu, Total Chlorine (*other parameters if needed based on nature of complaint)*

**Quarterly Reclaimed Water from Lakes:**

Temperature, Sp. Conductivity, TDS, Ca²⁺, Mg²⁺, Na⁺, K⁺, NH₄⁺–N, Cu²⁺, Cl⁻, SO₄²⁻, NO₃⁻–N, ortho-PO₄³⁻, F⁻, Br⁻, HCO₃⁻, CO₃²⁻, OH⁻, Residual Cl₂, pH, Turbidity, Total Alkalinity, Corrosivity

**Monthly Treatment Plant Wastewater:** *(Indeterminate number of samples)*

COD, pH, TDS, Suspended Solids, Ca²⁺, Zn²⁺, sulfides

**Monthly Distribution Samples**

**(6 DS) TP Raw and Finished water**

Six Distribution Entry Points Plus Raw and Finished Water

1. Turbidity
2. Color
3. Odor
4. Arsenic (As)
5. pH
7. Residual Chlorine, Total and Free
8. Dissolved Oxygen
9. NH₃–N, Free and Total
10. Monochloramine
11. Iron
12. ortho-PO₄³⁻
13. Fluoride
14. NO₂⁻–N
15. Aluminum
16. Temperature
17. Total Alkalinity
18. Silica
19. Sulfides
20. Total Dissolved Solids (TDS)
21. Anions (SO₄²⁻, Cl⁻, Br⁻, NO₃⁻)
22. Cations (Ca²⁺, Mg²⁺, Na⁺, K⁺, Li⁺)
23. UV₂₅⁴
24. TOC

**Monthly Purchased Water and Blended Water Reservoir Tanks**

1. Coliform Bacteria, HPC
2. NO₂⁻–N
WQ Sampling Schedule:

### Monthly Wells:
- All active wells in operation for the month (variable number, but ≤ 30)
  1. Turbidity
  2. Color
  3. pH
  4. Sp. Cond
  5. Temperature
  6. Fluoride
  7. Total Alkalinity
  8. Iron
  9. Silica
  10. Sulfide
  11. TDS
  12. UV254
  13. TOC
  14. Anions
  15. Cations
  16. Coliform Bacteria and HPC

### Annual Wells:
- All active wells in operation monitored for
  - Nitrate (NO\textsubscript{3} - N)
  - Volatile Organic Chemicals (VOCs) - EPA 524.2 Regulated and un-regulated parameters

### Quarterly Distribution Samples
- (12 THMs, HAA5)

### Annual Performance Proficiency Evaluation Samples (WS and WP package)
- THMs, VOCs, metals, general mineral, general physical, bacteriology, TOC and other parameters for which Lab is certified.

### Annual Samples from Bottling and Entry Points to Distribution System (the purchased water reservoir Effluent, blended water reservoir Effluent and TP Finished Water before Blending with Purchased Water):
- For the Annual Report
  1. Coliform Bacteria
  2. Inorganic Chemicals
     - Trace metals – Al, As, B, Ba, Cd, Cr, Cu, Fe, Pb, Hg, Se, Ag, Sb, Be, Mn, Ni, Ti, Zn, Chromium VI
     - N\textsubscript{3} -N, N\textsubscript{2} -N, Cyanide
  3. General Mineral: Ca\textsuperscript{2+}, Mg\textsuperscript{2+}, Na\textsuperscript{+}, K\textsuperscript{+}, Cl, SO\textsubscript{4} \textsuperscript{2-}, Total Hardness, ClO\textsubscript{4} \textsuperscript{-} 
  5. Radioactivity: Gross Alpha and Gross Beta Particle Activity, Uranium
  6. Volatile Organic Chemicals (VOCs) – EPA 524.2
  7. EDB & DBCP – EPA 504.1
     - Molinate, Simazine, Thiodencarb, Alachlor. Bromacil, etc.
  9. Chlorinated Pesticides – PCBs: - EPA 508
     - Heptachlor, Dieldrin, Endrin, Methoxychlor, Heptachlor, Epoxide, Chlordane, etc.
  10. Phenoxyacid Herbicides – EPA 515.1
      - Bentazon; 2, 4 D; 2, 4, 5-TP Silvex, etc.
  11. Base Neutral Acid (BNA) Extractables – EPA 525
      - Di(2-ethylhexyl) adipate, Benzo(a)pyrene, Pentachlorophenol, etc.
  12. Carbamates – EPA 531.1
      - Aldicarb, Carbofuran, Carbaryl, etc.
  13. Disinfection –by-products (bromate, aldehydes, etc.)-Bottled Water
  14. Glyphosate – EPA 547
  15. Endothall – EPA 548
  16. Diquat and Paraquat – EPA 549
  17. Dioxin – EPA 1613
  18. NDMA – EPA 521/SM6400
  19. Vanadium

Every 3 years, all active wells:

1. Inorganic Chemicals
   - Trace metals – Al, Sb, As, Ba, Be, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, Zn, Chromium VI
   - Cyanide, Fluoride, N\textsubscript{3} -N, N\textsubscript{2} -N
2. General Mineral:
   - HCO\textsubscript{3} \textsuperscript{-} alkalinity, CaCO\textsubscript{3} \textsuperscript{2-} alkalinity, Cl\textsuperscript{-}, OH\textsuperscript{-}alkalinity, Mg\textsuperscript{2+}, Na\textsuperscript{+}, SO\textsubscript{4} \textsuperscript{2-}, Total Hardness
### WQ Sampling Schedule:

3. **General Physical:**
   - Color, MBAS, Odor, pH, Sp. Conductivity, TDS, Turbidity
4. **Synthetic Organic Chemicals (SOCs)** – EPA 507, 508
   - EPA 515.1, 547, 549
5. **Asbestos**
6. **SOCs**: DBCP, EDB, Atrazine, Simazine

| Every nine-fourteen years (per revised 2008 schedule), all active wells: Radioactivity: | Gross Alpha particle activity, combined Radium-226 and Radium-228, Uranium |
| Unregulated Chemicals (Table 64450) | (Boron, Chromium VI, Perchlorate, Vanadium, Dichlorodifluoro Methane (Freon 12), Ethyl Tert-Butyl Ether (ETBE), Tert-Amyl Methyl Ether (TAME), Tert-Butyl Alcohol (TBA), 1,2,3-Trichloropropane (1, 2, 3-TCP)) |
| Unregulated Chemicals | Semivolatiles, Explosives, Herbicides, Herbicide Degradates, Nitrosamines |
| **Nonroutine Sample Frequency: Bulk Chemicals for Water Treatment** | Caustic Soda, Cationic Polymer, Poly aluminum Chloride (PAC), Aluminum Chloride (AC), Ferric Chloride, Zinc ortho-Phosphate, Hydrogen Peroxide, etc. |
Appendix L

Optimization Status Summary
<table>
<thead>
<tr>
<th>Self-assessment Category</th>
<th>Questions for Gauging Optimization</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Disinfectant Residual Assessment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 Residual Test Methods and Procedures</td>
<td>Are there on-line continuous chlorine monitors in use throughout the distribution system? Is data collected and continuously displayed for operators by the SCADA system?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Pressure Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6 Pressure Monitoring</td>
<td>Is pressure monitored in each pressure zone at a minimum of two &quot;critical sites&quot; (areas of high and low pressure)? Are the instruments routinely calibrated? Does the pressure monitoring include maximum day demand flow, fire flow events, and emergency situations (such as main break or power outage)?</td>
<td>X</td>
</tr>
<tr>
<td>2.7 Permanent pressure monitoring</td>
<td>Is the pressure sensor data analysis configured to alarm the operator when low pressure (below 35, 20 psi) or high pressure spikes occur?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Main Breaks Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.13 Pressure Stabilization</td>
<td>Are pressure stabilization procedures applied to a wide area surrounding a main break location?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Energy Management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.10 Pump Efficiency</td>
<td>Are all major distribution system pumps routinely tested for efficiency? Are there targets for maintenance or replacement based on efficiency?</td>
<td>X</td>
</tr>
<tr>
<td><strong>External Corrosion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.12 Pipe Inspection</td>
<td>Are pipes inspected and sampled whenever they are exposed?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Maintaining Valves, Hydrants, and Blowoffs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.20 Inspection and Assessment</td>
<td>Are all valves, hydrants, and blowoffs inspected and evaluated on a schedule?</td>
<td>X</td>
</tr>
<tr>
<td>3.21 Exercise Program</td>
<td>Are all distribution system main valves and hydrants exercised and tested at least every three years (or more frequently if required by regulation)?</td>
<td>X</td>
</tr>
<tr>
<td>3.23 Hydrant Access</td>
<td>Does the system control access to hydrants and provide training for proper third-party use?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Post Precipitation Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.32 Precipitation Recognition</td>
<td>Are areas of low disinfectant residual investigated for precipitation?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Water Age, Modelling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.43 Water Age Control</td>
<td>Is water age monitored using a calibrated hydraulic model and current operating conditions? Is the system operated to minimize water age?</td>
<td>X</td>
</tr>
<tr>
<td>3.44 Hydraulic Model</td>
<td>Does the system have a calibrated hydraulic model that includes water quality parameters? Is the model used regularly and re-calibrated as changes are made?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Hydraulic Model Assessment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1 Hydraulic Model</td>
<td>Is there a calibrated hydraulic model that has water quality modelling features?</td>
<td>X</td>
</tr>
<tr>
<td>4.2 Hydraulic Model Availability</td>
<td>Is the hydraulic model available to operations personnel and do they use it regularly?</td>
<td>X</td>
</tr>
<tr>
<td>4.3 Hydraulic Model Updates</td>
<td>Are upgrades to the water distribution system reflected in the hydraulic model in timely fashion (at least every 6 months)?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Pumping Facility Assessment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.8 Pump asset management</td>
<td>Does the asset management plan include specific criteria for replacement and rehabilitation of pumps? Do records include the installation date and inspection results?</td>
<td>X</td>
</tr>
<tr>
<td>4.10 Pump maintenance</td>
<td>Does the system report and track the Planned Maintenance Ratio for distribution pumps?</td>
<td>X</td>
</tr>
<tr>
<td><strong>Application of Operational Concepts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3 Hydraulic Model Access</td>
<td>Do system operators have access 24/7 to the hydraulic model? Does the model calculate water age? Are operators trained to use the model in emergency situations?</td>
<td>X</td>
</tr>
</tbody>
</table>
Appendix M

Self-Assessment Worksheets
<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Length (miles)</th>
<th>Estimated</th>
<th>Documented</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlined Cast or Ductile Iron</td>
<td>141</td>
<td></td>
<td>141</td>
</tr>
<tr>
<td>Lined Cast or Ductile Iron</td>
<td>291</td>
<td></td>
<td>291</td>
</tr>
<tr>
<td>Concrete (all types)</td>
<td>64.8</td>
<td></td>
<td>64.8</td>
</tr>
<tr>
<td>PVC</td>
<td>0.6</td>
<td></td>
<td>0.6</td>
</tr>
<tr>
<td>PE</td>
<td>1.4</td>
<td></td>
<td>1.4</td>
</tr>
<tr>
<td>Other</td>
<td>411.2</td>
<td></td>
<td>411.2</td>
</tr>
</tbody>
</table>
Table 4.5
Storage Inventory

<table>
<thead>
<tr>
<th>Storage Tank Identification</th>
<th>Type (Elevated or Underground)</th>
<th>Storage Capacity (MG)</th>
<th>Material of Construction</th>
<th>Age (highlight tanks &gt;30 years)</th>
<th>Corrosion Protection (active, passive, or none)</th>
<th>Internal and external inspection results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blended 1</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with wood roof</td>
<td>80</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 2</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with wood roof</td>
<td>80</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 3</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with wood roof</td>
<td>80</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 4</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with wood roof</td>
<td>80</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Blended 5</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with wood roof</td>
<td>80</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Blended 6</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with wood roof</td>
<td>80</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Blended 7</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>76</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 8</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>76</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 9</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>76</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Blended 10</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>76</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Blended 11</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>76</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Blended 12</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>61</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Blended 13</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>61</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 14</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>61</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 15</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>61</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 16</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>61</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Blended 17</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>61</td>
<td>Cathodic Protection</td>
<td>Fair</td>
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<tr>
<td>Blended 18</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>61</td>
<td>Cathodic Protection</td>
<td>Fair</td>
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<tr>
<td>Blended 19</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
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<td>Cathodic Protection</td>
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<td>Blended 20</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
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<td>Cathodic Protection</td>
<td>Fair</td>
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<tr>
<td>Blended 24</td>
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<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>6</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Purchased 1</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Purchased 2</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Purchased 3</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Purchased 4</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Purchased 5</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Purchased 6</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Fair</td>
</tr>
<tr>
<td>Purchased 7</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Purchased 8</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Purchased 9</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Purchased 10</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Purchased 11</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
<tr>
<td>Purchased 12</td>
<td>Elevated</td>
<td>3.3</td>
<td>Steel tank with steel roof</td>
<td>51</td>
<td>Cathodic Protection</td>
<td>Good</td>
</tr>
</tbody>
</table>
### Table 4.7
Pumping Facility Inventory Summary

<table>
<thead>
<tr>
<th>Name of Pumping Facility</th>
<th>Number of Pumps and Sizes</th>
<th>Designed Capacity, MGD</th>
<th>Firm Capacity (largest unit out of service), MGD</th>
<th>Age of the oldest unit in facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>GWTP Station 1 &amp; 2</td>
<td>11</td>
<td>70</td>
<td>60</td>
<td>29</td>
</tr>
<tr>
<td>32nd Street</td>
<td>5</td>
<td>18</td>
<td>15</td>
<td>20</td>
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</table>
Table 4.9
Inventory Summary

<table>
<thead>
<tr>
<th>Valves and Hydrants</th>
<th>Total Number</th>
<th>% &gt;35 years</th>
<th>% &gt; 70 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves &lt;10in</td>
<td>17,591</td>
<td>43.2</td>
<td>14.8</td>
</tr>
<tr>
<td>Valves ≥10in</td>
<td>2,917</td>
<td>54.5</td>
<td>18.8</td>
</tr>
<tr>
<td>Hydrants wet barrel</td>
<td>6,594</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrants dry barrel</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Valves</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5.1  
Operations guidelines outlining System performance goals

<table>
<thead>
<tr>
<th>Subject:</th>
<th>System Performance Goals</th>
<th>Guideline Number:</th>
</tr>
</thead>
</table>
| Objective: | To establish process control targets for each sampling location or location type to ensure optimum system performance. | Date Adopted: 12/10/2001  
Date Revised: 1/2012 |

<table>
<thead>
<tr>
<th>Sampling location or type</th>
<th>Tests</th>
<th>Target value</th>
</tr>
</thead>
</table>
| Entry Point(s) Water Quality | 1. Turbidity  
2. Color  
3. Odor  
4. Arsenic (As)  
5. pH  
7. Residual Chlorine, Total  
8. Dissolved Oxygen  
9. Ammonia, Free and Total  
10. Iron  
11. $\alpha$-PO$_4$  
12. Fluoride  
13. NO$_2$-N  
14. Aluminum  
15. Total Alkalinity  
16. Silica  
17. Sulfides  
18. Total Dissolved Solids (TDS)  
19. Hardness  
20. TOC  
21. Coliform-Total  
22. HPC  
23. TTHM  
24. HAA5  
25. Bromate | 1. <0.10 NTU  
2. <5 CU  
3. None  
4. <2 ug/L  
5. 8.0 – 8.5  
6. <700 umhos/cm  
7. 1.6 – 2.5 mg/L  
8. 10 mg/L  
9. 0.5 mg/L-T; <0.1 –F  
10. <0.1mg/L  
11. <0.1 mg/L  
12. 0.7 – 1.0 mg/L  
13. <50 ug/L  
14. <50 mg/L  
15. ~100 mg/L  
16. <20 mg/L  
17. <0.01 mg/L  
18. <400 mg/L  
19. 70 – 250 mg/L  
20. <2.0 mg/L  
21. 0/100 mL  
22. <500 cfu/mL  
23. <80 ug/L  
24. <60 ug/L  
25. <8 ug/L |
| Distribution System Total Coliform Sites, DBP sites, And other routine (at least monthly scheduled) sample locations | 1. Turbidity  
2. Color  
3. pH  
4. Sp. Conductivity  
5. Residual Chlorine, Total  
6. NO$_2$-N  
7. $\text{NH}_3$ –N, Free and Total  
8. Fluoride  
9. Coliform -T  
10. HPC  
11. TTHM  
2. HAA5 | 1. <0.1 NTU  
2. <5 CU  
3. 8.0 – 8.5  
4. <700 umhos/cm  
5. 1.6 – 2.5 mg/L  
6. <50 ug/L  
7. 0.5 mg/L-T; <0.1 –F  
8. 0.7 – 1.0 mg/L  
9. 0/100 mL  
10. <500 cfu/mL  
21. 0/100 mL  
22. <80 ug/L  
23. <60 ug/L  
24. <80 ug/L  
25. <8 ug/L |
<table>
<thead>
<tr>
<th>Storage Tanks, Reservoirs, Facilities</th>
<th>1. Coliform-T</th>
<th>2. HPC</th>
<th>3. NO₂-N</th>
<th>4. Residual Chlorine, Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0/100 mL</td>
<td>&lt;500 cfu/mL</td>
<td>&lt;50 ug/L</td>
<td>1.6 – 2.5 mg/L</td>
</tr>
</tbody>
</table>

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</tr>
</thead>
<tbody>
<tr>
<td>Water Quality Parameter sites</td>
<td>1. &lt;0.1 NTU</td>
<td>2. &lt;5 C.U.</td>
<td>3. 8.0 – 8.5</td>
<td>4. &lt;700 umhos/cm</td>
<td>5. 1.6 – 2.5 mg/L</td>
<td>6. &lt;50 ug/L</td>
<td>7. 0.7 – 1.0 mg/L</td>
<td>8. ≤0.015 mg/L</td>
<td>9. ≤1.3 mg/L</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>-Storage Facilities</td>
<td>1. 1.6-2.5 mg/L</td>
<td>2. 0.7-1.2 mg/L</td>
<td>3. 8.0-8.5</td>
<td>4. 0.5 mg/L-T; &lt;0.1 –F</td>
<td>5. &lt;0.1 NTU</td>
</tr>
<tr>
<td>-Utility Facilities</td>
<td>1. 8.0 – 8.5</td>
<td>2. &lt;5 C.U.</td>
<td>3. &lt;0.1 NTU</td>
<td>4. &lt;700 umhos/cm</td>
<td>5. None</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. 8.0 – 8.5</td>
<td>2. &lt;5 C.U.</td>
<td>3. &lt;0.1 NTU</td>
<td>4. &lt;700 umhos/cm</td>
<td>5. None</td>
<td>6. 0/100 mL</td>
<td>7. &lt;500 cfu/mL</td>
<td>8. &lt;5 ug/L</td>
<td>9. &lt;200 ug/L</td>
</tr>
</tbody>
</table>
## Table 5.2

**Process control sampling and testing schedule for a distribution system**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sample Location</th>
<th>Tests</th>
<th>Frequency</th>
<th>Sample By</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System Entry Points</strong></td>
<td>Plant Operations Area</td>
<td>pH, Turbidity, Flow, Chlorine residual, TTHM, TOC, Alkalinity, Arsenic</td>
<td>Continuous, Continuous, Continuous, Continuous, Monthly, Monthly, Monthly, Monthly</td>
<td>Operators, Water Quality Samplers</td>
</tr>
<tr>
<td><strong>Distribution System Storage Tanks</strong></td>
<td>Tanks Influent and Effluent</td>
<td>Coliform, HPC, NO₂-N, Residual Chlorine, Temperature</td>
<td>Weekly, Weekly, Weekly, Weekly</td>
<td>Water Quality Samplers</td>
</tr>
<tr>
<td><strong>Lead and Copper Rule Water Quality Parameter Sites</strong></td>
<td>Customer Taps</td>
<td>Lead, Copper</td>
<td>Every 3 years</td>
<td>Customers</td>
</tr>
<tr>
<td><strong>Distribution System</strong></td>
<td></td>
<td>Turbidity, Color, pH, Sp. Conductivity, Residual Chlorine, Total NO₂⁻, Fluoride, Lead, Copper</td>
<td>Monthly, Monthly, Monthly, Monthly, Monthly, Every 3 years</td>
<td>Water Quality Samplers</td>
</tr>
</tbody>
</table>