APPENDIX B

RESOURCE ANALYSIS AND NEEDS ASSESSMENT TECHNICAL MEMORANDUM

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City of Flint, MI

RESOURCE ANALYSIS AND NEEDS ASSESSMENT TECHNICAL MEMORANDUM

Flint Drinking Water Distribution System Optimization

FINAL

March 2017

RESOURCE ANALYSIS AND NEEDS ASSESSMENT

Technical Memorandum

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ACRONYMS AND ABBREVIATIONS

AACE	Association for Advancement of Cost Engineering
AWWA	American Water Works Association
CAP	Consumer Assistance Program
CDBG	Community Development Block Grant
CDL	Commercial Driver's License
CIP	Capital Improvement Plan
CPR	Cardiopulmonary Resuscitation
DBP	Disinfection Byproduct
DWSD	Detroit Water and Sewerage Department
DWSRF	Drinking Water State Revolving Fund
EDA	Economic Development Administration
FEMA	Federal Emergency Management Agency
FTE	Full-Time Equivalents
GLWA	Great Lakes Water Authority
GO	General Obligation
HUD	Housing and Urban Development
IT	Information Technology
KWA	Karegnondi Water Authority
LCR	Lead and Copper Rule
LRAA	Locational Running Annual Average
MCL	Maximum Contaminant Level
MDEQ	Michigan Department of Environmental Quality
MDHHS	Michigan Department of Health and Human Services
P3	Public-Private Partnership
PDM	Pre-Disaster Mitigation Grant
R&R	Rehabilitation and Replacement
SDC	System Development Charge
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure

TIF	Tax Increment Financing
TTHM	Total Trihalomethanes
UDF	Unidirectional Flushing
USEPA	United States Environmental Protection Agency
WIIN	Water Infrastructure Improvements for the Nation Act
WRF	Water Research Foundation
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

The City of Flint (City) purchases finished water from the Great Lakes Water Authority (GLWA), formerly known as the Detroit Water and Sewerage Department (DWSD). For several decades GLWA provided the sole source of supply for the City. However, on April 25, 2014 the City stopped purchasing water from GLWA and began treating water at the Flint Water Treatment Plant (WTP), which is maintained by the City and treats water from the Flint River as a backup emergency supply. Several water quality issues soon arose, leading to a boil water advisory in August 2014, a Safe Drinking Water Act (SDWA) violation related to total trihalomethanes (TTHM) in December 2014, an observed increase in Legionnaire's disease in the City, and an increase in lead levels at customers' taps. As a result, the City resumed purchasing water from GLWA on October 17, 2015.

A state of emergency was declared by the City of Flint on December 14, 2015, by the State of Michigan on January 14, 2016, and by the President of the United States on January 16, 2016. The United States Environmental Protection Agency (USEPA) issued an emergency administrative order on January 21, 2016 to address outstanding lead and copper rule (LCR) violations. As a part of this administrative order, the City was to develop and implement a distribution system water quality optimization plan. The City has retained a team led by Arcadis of Michigan, LLC (Arcadis) and including Environmental Engineering & Technology, Inc. (EE&T), Confluence Engineering Group, LLC, and McConnell Communications, Inc. to develop a Distribution System Optimization Plan, which consists of three main tasks: (1) assessment and gap analysis, (2) resource analysis and needs assessment, and (3) development of the Plan.

The purpose of this report is to document the approach and results of the second task, the resource analysis and needs assessment. The results of the assessment outline the City's current ability to perform essential tasks and future needs (both financial and human resources) to bridge the gaps identified in the first task, which are summarized in the *Assessment of Current Practices and Gap Analysis Technical Memorandum, March 2017*.

Needs Assessment

An analysis was performed to identify the preliminary needs (both financial and staffing) associated with the opportunities for improvement identified under the assessment and gap analysis task, which are presented in the *Assessment and Gap Analysis Technical Memorandum, March 2017*. Needs were identified and include estimates for both initial and recurring costs and number of full-time equivalents (FTEs) for the improvements identified in each of the following categories:

- Asset Management
- Cross-Connection Control
- Customer Complaints
- Disinfectant Residual and Disinfection Byproduct Monitoring
- Flushing
- Hydraulic Modeling
- Information Technology
- Internal Corrosion and Post-Precipitation Control

- Main Breaks
- Online Monitoring
- Pipeline Rehabilitation and Replacement
- Pressure Management
- Pump Station Design, Operation and Maintenance
- Security and Emergency Management
- Storage Facility Design, Operation and Maintenance
- Valves & Hydrants Testing, Maintenance and Replacement
- Water Age Management
- Water Loss Control
- Water Quality Sampling
- Other

The estimates do not include activities that are currently performed by the City, but rather focus on those that would be needed to achieve industry best practices, which are largely based on the AWWA Partnership for Safe Water Distribution System Optimization Program. All costs were developed based on 2017 dollars and are consistent with an AACE Class 5 Estimate, which is considered a concept screening estimate and are typically -50% to +100% accurate. Additionally, potential options for funding and/or financing the improvements were identified, and included both traditional and alternative sources.

Financial and Human Resource Needs

Total estimated costs for one-time, initial and annual recurring activities were estimated for each optimization category, and are summarized in Figure ES-1 and Figure ES-2, respectively. The total one-time, initial and annual recurring costs for the recommended improvements are $24.7M and $45.0M (which includes $41M in pipe, valve and hydrant testing, R&R), respectively. The largest cost categories include asset management; cross-connection control; pipe R&R; pump station operation and maintenance; valves and hydrants testing, maintenance and replacement; and water loss control. It should be noted that the annual pipe R&R costs assume $37M for the first thirteen years (i.e., targeting approximately 5% replacement per year to reduce the age of all the pipes is the system to less than 100 years), after which this is reduced to $7.9M annually (i.e., 1% replacement per year to maintain pipe age below 100 years).

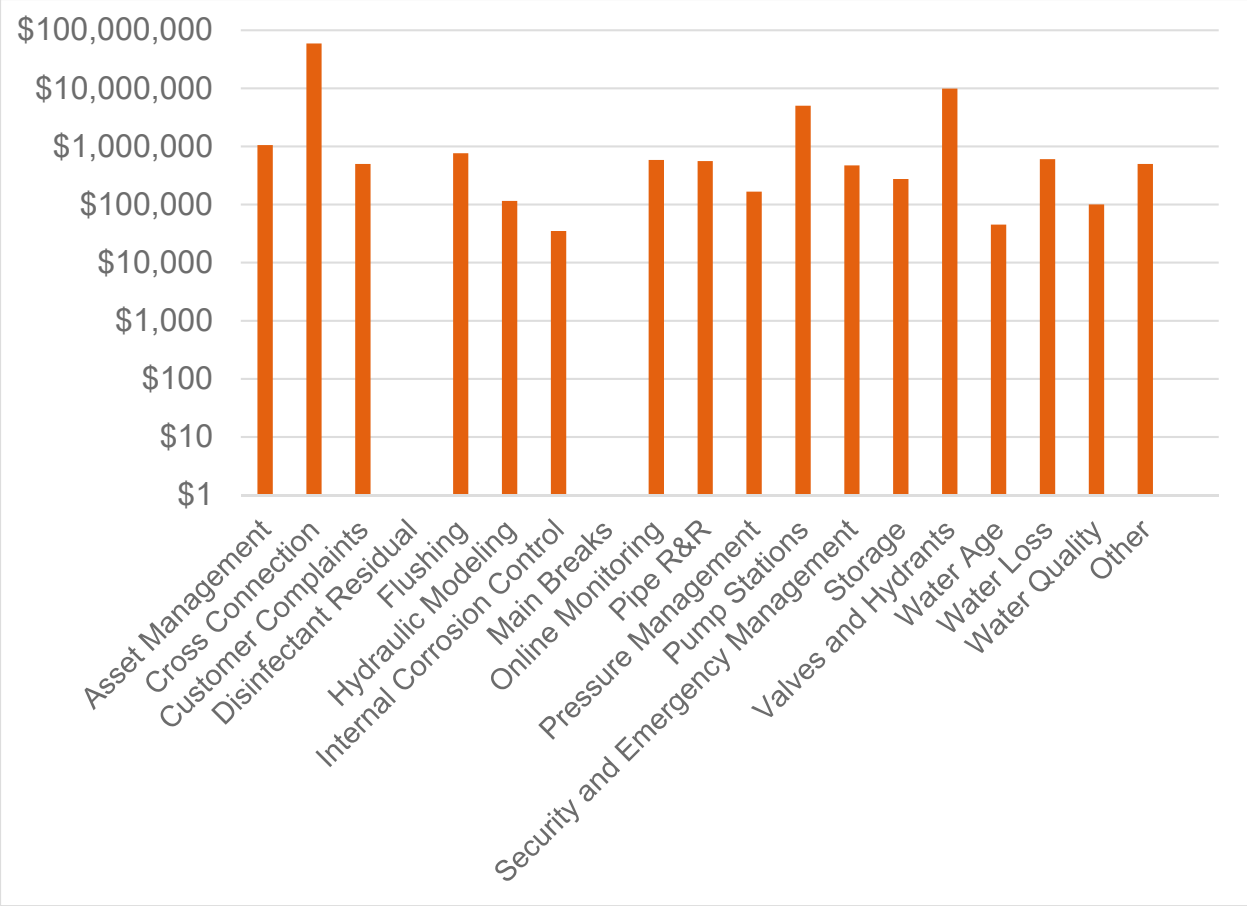

Figure ES-1: Estimated Initial, One-Time Costs Required to Implement Recommended Improvements by Optimization Category

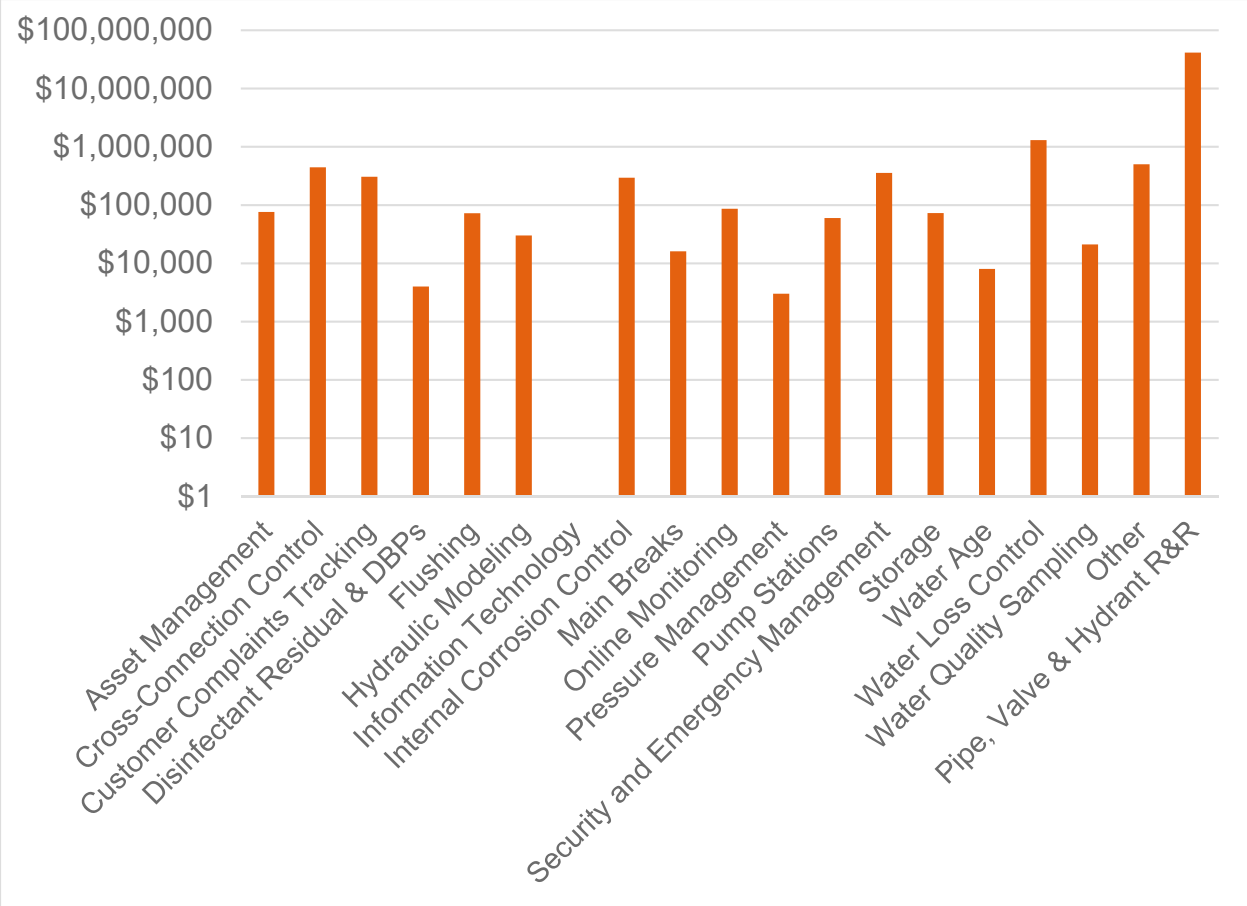

Figure ES-2: Estimated Recurring Costs Required to Implement Recommended Improvements by Optimization Category*

*Note that Pipe R&R decreases by $29M annual after all the pipes in the system are not older than 100 years.

The estimated total initial and annual FTEs for the recommended improvements are 15 and 31, respectively (refer to Figure ES-3 for staffing needs by category). It was assumed that third-party organizations (i.e., consulting firms, vendors, etc.) would be needed to assist with the development and implementation of select programs, practices or tools, after which City staff would be responsible for ongoing maintenance, resulting in greater staffing needs following implementation. Most of the staff needed for recurring activities would be solely dedicated to valve and hydrant inspection, testing and maintenance due solely to the sheer number of valves and hydrants in the system.

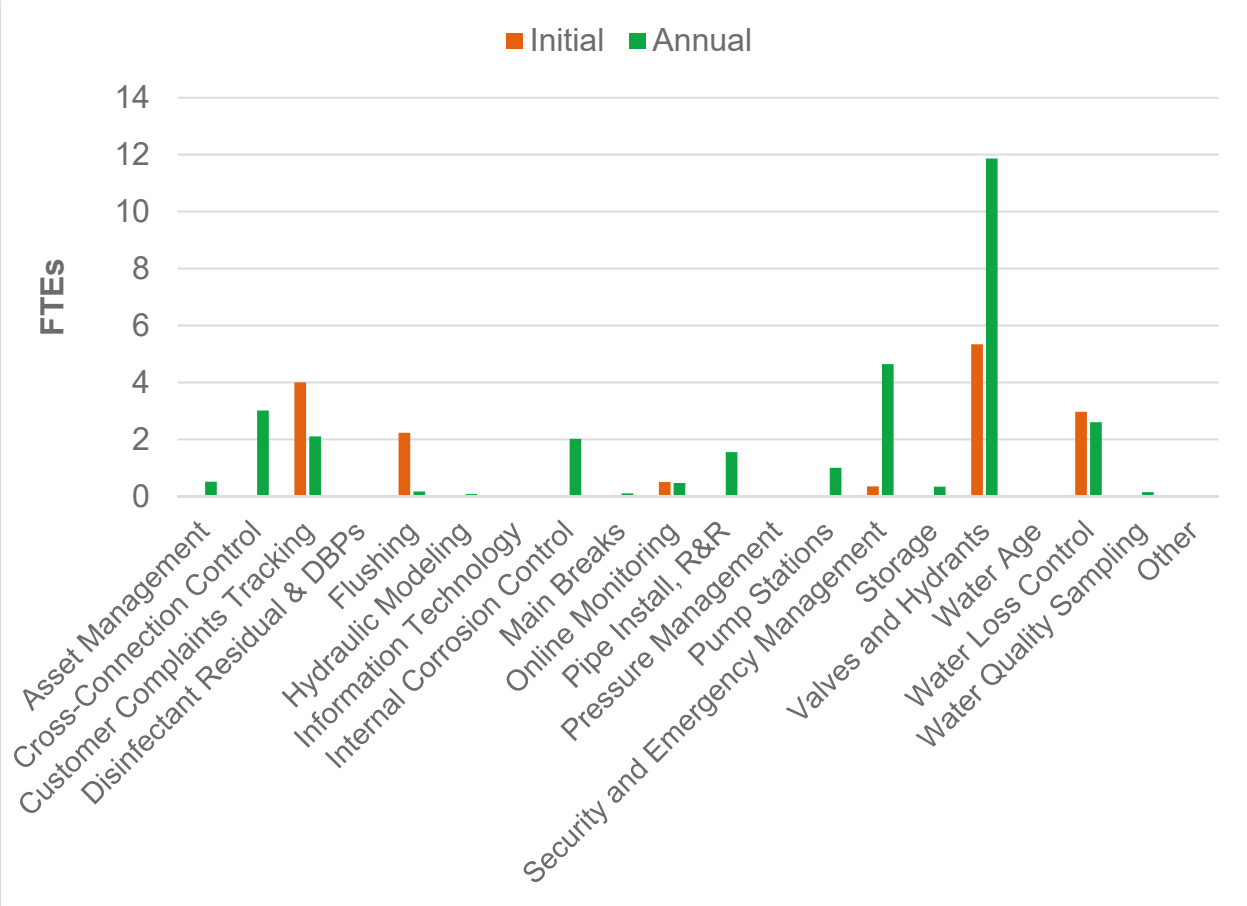

Figure ES-3: One-Time and Annual Full-Time Employees Required to Implement Recommended Improvements by Optimization Category

The improvements, and subsequently costs and staffing estimates, will be modified under the final task to develop a customized set of prioritized improvements for the City's distribution system given the system constraints (e.g., schedule, cost) and overall City goals and objectives. This will include combing select activities to reduce both the financial and human resource needs.

Funding and Financing Options

Several potential cash funding and debt financing options for the City's water distribution system projects have been identified and include:

- Cash Funding
  - Grants
  - Cost sharing
  - Consumer assistance programs
  - Special assessment districts
  - Property taxes
  - Public-private partnerships

- Debt Financing
    - Drinking Water State Revolving Fund (DWSRF)
    - Water Infrastructure Finance and Innovation Act (WIFIA)
    - Tax exempt municipal bonds
    - Other:
        - Local banks
        - Social impact and green bonds
        - Tax increment financing

It is recognized that some of these options may not be realistic for the City, particularly given the relatively high water rates and large number of economically disadvantages customers (Raftelis Financial Consultants, 2016). Additionally, several funding sources have been awarded to the City and could potentially be used to implement select improvements. As part of final task, these options will be further evaluated to identify a shortlist of options to consider as the City moves forward with the prioritized list of recommendations.

Workforce Evaluation

An assessment of the ability of the current staff (in numbers, skill sets, and provided training) to implement the recommended best practices and to identify recommendations for additional staff and/or training to perform current or future duties. Staff levels and organization were reviewed to assess current staffing needs and identify improvements for streamlining roles and responsibilities, where applicable. A competency-based approach was used to identify important skill sets and staff training needs. A total of fifteen interviews were conducted, which represents almost half of the existing personnel in the water distribution group. The intent of the interviews was to determine how closely the positions in the water distribution group (Water Service Center) align with the duties and competencies identified in earlier work based on other water utilities (McTigue & Mansfield, 2011; Department of Labor, 2016). Training offered and needs identified in training and work environment were also identified through these interviews. In addition to the competency model effort, MDEQ operator certification requirements were reviewed to identify staff training requirements.

Staffing Levels and Organization

The water system distribution group is currently short-staffed, resulting in mainly reactive rather than proactive or preventative maintenance. Additionally, certain times of the year have a high number of water main breaks, taxing the existing staff. Although the staff works to repair breaks in a timely manner, that effort requires significant effort by the short-staffed crews. Based on the established the number of positions required for the FY 2016 budget, there are currently eight vacant positions. Based on interviews conducted for this assessment, that number is reasonable to accomplish the current required tasks of the distribution system.

Competency Model for Flint Water Distribution Operator

Based on the results of the interviews, the competency model for the water distribution operator developed in the WRF study (McTigue & Mansfield, 2011) was revised to describe the duties and needed

competencies for the work performed by the water distribution operators in Flint, MI, and is shown in Table ES-1.

Table ES-1: Competency Model for Flint, MI Water Distribution Operator

Competency
1. Knowledge of water distribution systems
a. Understanding of water distribution systems b. Understanding of the function of water mains, hydrants and valves c. General knowledge of electrical and mechanical principles and system infrastructure operations d. Comprehends hydraulic and pneumatic principles e. Knowledge of main flushing procedures f. Operates, calibrates, maintains, troubleshoots, and diagnoses system infrastructure equipment g. Knowledge of start-up and shut-down operations h. Knowledge of meter readings, turn on and offs
2. Mechanical aptitude and ability
a. Ability to use hand tools and mechanical equipment specific to line maintenance b. Ability to operate heavy and large equipment such as backhoes, end loaders and dump trucks; possess Class A CDL license c. Ability to perform maintenance activities such as system flushing, valve exercising and fire hydrant maintenance
3. Ability to work safely in challenging environments
a. Understands traffic laws, ordinances and rules involved with heavy equipment operation b. Utilizes occupational hazard and safety practices c. Follows established safety procedures during main repairs, including confined space, trenching and hazard material handling procedures
4. Understanding of public health principles and drinking water regulations
a. Ability to collect water samples b. Knowledge of disinfection principles
5. Non-technical competencies
a. Professionalism: Taking pride in oneself and one's work, and treating others with respect and courtesy. b. Ability to interact with customers and act as a representative of the Company c. Conscientiousness: follows standard procedures, ensure safety of self and others, completes work in a timely way d. Interpersonal skills, to include working in a team, communicating with the team and management and communicating with the customers e. Critical and analytical thinking: Ability to recognize problems and effectively work independently or with others to reach a viable solution f. Trustworthy; strong personal integrity g. Demonstrates strong level of accountability, ownership and dependability h. Collaborative/Team oriented i. Emotional maturity j. Willingness to perform a variety of manual tasks for an extended period of time in unfavorable weather conditions k. Establish and maintain effective working relationships with those contacted in the course of work

Some of these competencies are needed coming into the job, while others can be learned through work experience and training. Most importantly, the operator must have mechanical aptitude. In this case, the aptitude involves the ability to use or learn to use tools and heavy equipment, such as jackhammers and driving heavy equipment. Some of the important non-technical competencies similarly need to be possessed by the apprentice before starting the job. These include critical thinking and good judgment, accountability, dependability, commitment to teamwork and the willingness to work in adverse conditions for extended periods of time. The remaining competencies, while desired in an applicant, could be taught on the job.

Training

Based on reviewing how the five competencies were utilized and taught at Flint, a training program for each competency was identified. As noted, the current training through the apprenticeship program or mentorship has worked well as reflected by the good safety record and the crews' ability to complete the required work. But, this method may not be sustainable due to the in service (years) gap between the foremen and supervisors (mentors) and the operators. Currently, there are only two operators below the supervisory level that have more than five years' experience working on the Flint system. The current mentors are eligible to retire (possibly in the next five years), and if they choose to retire, there will be a knowledge gap because the new foremen and supervisors will not have been on the job as long as the current foremen. Therefore, the following training programs were identified to support the critical competencies identified above:

1. Water distribution knowledge training on driving and heavy equipment operation
2. Heavy equipment training
3. Safety training (traffic, confined space, first aid), focused on Flint
4. Training on Flint water treatment and measures needed to protect public health
5. Training on customer communication and relations.

Next Steps

Several key next steps to occur as part of this project include:

- **Develop key Standard Operating Procedures (SOPs).** As no written distribution system operations and maintenance SOPs were available, Arcadis will be developing several key SOPs for the City, aligning each with industry best practices, where applicable. A list of the developed SOPs in addition to recommendations for development of additional SOPs will be presented in the final Plan.
- **Prioritize Recommended Improvements for Flint's System.** It should be noted that the Partnership program is a rigorous process and that even well-run systems may have difficulty achieving fully optimized status as defined by the performance goals of the program. Improvements were based on achieving excellence in each category rather than simply complying with regulations or meeting reported average conditions, and will be prioritized based on selected criteria and system constraints (e.g., financial and human resource limitations) to

develop a customized set of improvements for the City's distribution system. These improvements, including modified costs and staffing estimates, will be presented in the final Plan.

- **Shortlist the Funding and Financing Options.** Given the relatively high water rates and large number of economically disadvantages customers (Raftelis Financial Consultants, 2016), some of the presented funding and financing options may not be realistic for the City. As part of the final optimization task, the Arcadis team will work with the City to generate a short-list of alternatives for consideration as the City moves forward with the prioritized list of recommendations
- **Identify Performance Metrics.** To assess the progress of optimizing the distribution system, Arcadis will review the metrics and measures currently in use and compare these with other similar water, wastewater and solid waste utilities to identify potential measures that are meaningful to the optimization program. Arcadis will develop recommendations for the preferred approach for performance measure tracking and data comparisons for each Performance Metric selected and frequencies for assessing progress.
- **Develop an Implementation Schedule.** Arcadis will develop an implementation schedule that groups the customized recommendations into immediate (0-2 years), short-term (3-5 years), mid-term (6-10 years) and long-term (10+ year) periods. Where possible, items will be grouped based on identified synergies to streamline implementation and condense the schedule.

1 INTRODUCTION

The City of Flint (City) has retained a team led by Arcadis of Michigan, LLC (Arcadis), including Environmental Engineering & Technology, Inc. (EE&T), Confluence Engineering Group, LLC, and McConnell Communications, Inc., to develop and implement a distribution system water quality optimization plan as required under the *United States Environmental Protection Agency (USEPA) Emergency Administrative Order, dated January 21, 2016*. The Distribution System Optimization Plan (Plan) consists of three main tasks: (1) assessment and gap analysis, (2) resource analysis and needs assessment, and (3) development of the Plan. This report focuses on the work completed under the second task, the resource analysis and needs assessment, which includes an evaluation of the financial and human resources needed to implement the improvements identified under the first task that are summarized in the *Assessment of Current Practices and Gap Analysis Technical Memorandum, March 2017*.

1.1 Project Background

The City distributes drinking water to an estimated population of 98,310 through approximately 580 miles of distribution system mains (Rowe, 2016). For several decades, the City of Flint purchased finished water from Great Lakes Water Authority (GLWA), formerly known as the Detroit Water and Sewerage Department (DWSD), which treats water from Lake Huron for compliance with all Safe Drinking Water Act (SDWA) standards. The water contained a free chlorine residual to prevent biological regrowth and an orthophosphate residual to control corrosion in the water distribution system. Purchased water from GLWA was the sole source of supply and no additional treatment was performed prior to distribution to the City of Flint.

The City maintained the Flint Water Treatment Plant (WTP), which treats water from the Flint River, as a backup emergency supply. On April 25, 2014, the City stopped purchasing water from GLWA and began treating the Flint River at the Flint WTP. This change occurred as part of a plan to join the Karegnondi Water Authority (KWA) upon the original pipeline anticipated completion date of late 2016. From April 25, 2014 through October 16, 2015, the City continued to treat and distribute water from the Flint River. During this time, orthophosphate addition was not in place at the plant.

Several water quality concerns arose while on the Flint River supply including the following:

- A boil water advisory was issued on August 15, 2014 due to *Escherichia coli* (*E. coli)* detection in distribution system sample.
- A Safe Drinking Water Act (SDWA) tier two quarterly violation on was issued on December 16, 2014 due to concentrations of total trihalomethanes (TTHM) greater than the maximum contaminant level (MCL) at four distribution sampling locations when calculated as a locational running annual average (LRAA).
- An increase of Legionnaire's disease was observed in Genesee County including 42 potential cases reported to the Michigan Department of Health and Human Services (MDHHS) (Flint Advisory Task Force, 2016).
- Rising levels of lead detected in distribution samples collected between July 2014 and July 2015.

The City resumed purchasing finished water from GLWA on October 17, 2015 because of the rising water quality concerns. On December 9, 2015, the City began boosting orthophosphate at the WTP to re-stabilize the distribution system piping network. The City also began boosting the concentration of chlorine, and as needed, adjusting the pH via caustic addition prior to distribution.

A state of emergency was declared by the City of Flint on December 14, 2015, by the State of Michigan on January 14, 2016, and by the President of the United States on January 16, 2016. On January 21, 2016, the USEPA issued an emergency administrative order to address outstanding lead and copper rule (LCR) violations. The order was directed to the Michigan Department of Environmental Quality (MDEQ), the City of Flint, and the State of Michigan and stipulated that the respondents complete the following action items:

- Create a publicly available website publishing information and sampling results relevant to the lead crisis,
- Respond to requests and recommendations by the USEPA Flint Task Force,
- Provide water quality parameter measurements from distribution samples,
- Provide an inventory of lead service lines, water interruptions, and unoccupied homes,
- Cooperate with the USEPA LCR sampling,
- Develop and maintain a chlorine residual throughout the distribution system,
- Establish and maintain a corrosion control plan,
- Ensure appropriate staffing at the WTP,
- Develop and implement a distribution system water quality optimization plan, and
- Assemble an Independent Advisory Panel to make recommendations to ensure safe drinking water.

In accordance with the order, the Arcadis team been retained to develop a Distribution System Optimization Plan. Development of the Plan consists of three main tasks: (1) assessment and gap analysis, (2) resource analysis and needs assessment, and (3) development of the Plan. The purpose of this memo is to summarize the resource analysis and needs assessment, which included the following main tasks:

1. Financial Resource Analysis – This analysis included a determination of the estimated initial and recurring costs associated with implementation of the recommended improvements outlined in the *Assessment and Gap Analysis Technical Memorandum, March 2017*. In addition, potential options for funding and/or financing the improvements were identified.
2. Human Resource Analysis – This analysis included a determination of the number of staff required to implement and maintain the recommended best practices outlined in the *Assessment and Gap Analysis Technical Memorandum, March 2017*. Arcadis also assessed the ability of the current staff (in numbers, skill sets, and provided training) to implement the recommended best practices and to identify recommendations for additional staff and/or training to perform current or future duties.
3. Standard Operating Procedures (SOPs) – The City's existing distribution system operations and maintenance SOPs were evaluated for adequacy and completeness. As no written SOPs were available, Arcadis will be developing several SOPs for the City, aligning each with industry best practices, where applicable. A list of the developed SOPs in addition to recommendations for development of additional SOPs will be presented in the final Plan.

1.2 Report Objectives

The purpose of this report is to document the approach and results of the resource analysis and needs assessment. The results of the assessment outline the City's current ability to perform essential tasks and future needs (both financial and human resources) to bridge the gaps identified in the *Assessment of Current Practices and Gap Analysis Technical Memorandum, March 2017*, which were identified via a comparison to industry standards generally following the American Water Works Association (AWWA) Partnership for Safe Water (Partnership) approach.

1.3 Report Organization

The remaining sections of the report are organized as follows:

- ***Section 2.0 Needs Assessment*** outlines the methodology and results of the analysis performed to identify the preliminary needs (both financial and staffing) associated with implementation of the recommended improvements outlined under the assessment and gap analysis task.
- ***Section 3.0 Workforce Evaluation*** presents the approach and findings of the current staffing assessment (including numbers, skill sets, and provided training) to identify additional staffing recommendations and/or training needs.
- ***Section 4.0 Summary and Next Steps*** presents a summary of the approach and results of the resource analysis and needs assessment and a brief discussion of the next steps to be completed under this project.

2 NEEDS ASSESSMENT

This section describes the methodology and results of the analysis performed to identify the preliminary needs (both financial and staffing) associated with implementation of the recommended improvements outlined under the assessment and gap analysis task.

2.1 Methodology

Preliminary needs associated with the opportunities for improvement identified under the assessment and gap analysis task, which are presented in the *Assessment and Gap Analysis Technical Memorandum, March 2017*, were identified and include estimates for both initial and recurring costs and number of full-time equivalents (FTEs). These estimates do not include activities that are currently performed by the City, but rather focus on those that would be needed to achieve industry best practices, which are largely based on the AWWA Partnership for Safe Water Distribution System Optimization Program. It should be noted that the Partnership program is a rigorous process and that even well-run systems may have difficulty achieving fully optimized status as defined by the performance goals of the program. These improvements were based on achieving excellence in each category rather than simply complying with regulations or meeting reported average conditions, and will be prioritized based on selected criteria and system constraints (e.g., financial and human resource limitations) to develop a customized set of improvements for the City's distribution system, which will be presented in the final Optimization Plan. Figure 2-1 illustrates the overall approach used to develop the cost estimates and identify the number of additional FTEs needed to implement and maintain the recommended improvements in each optimization category. Details of each step are provided below.

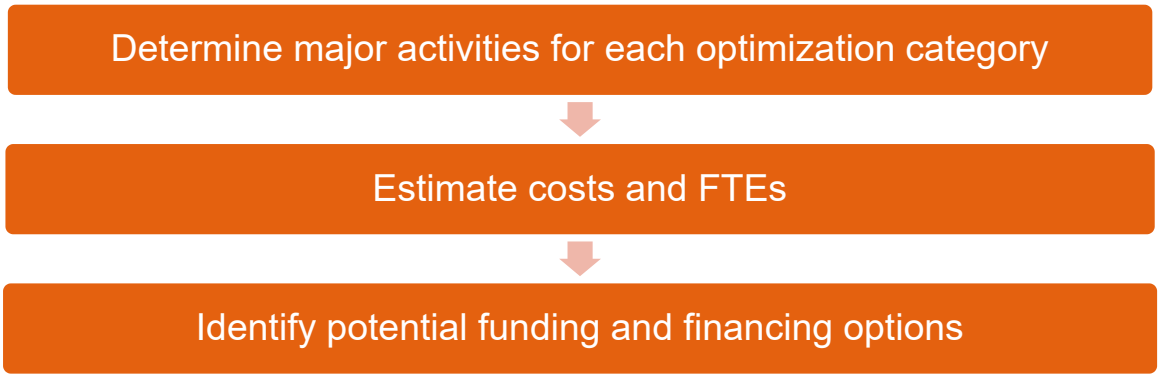

Figure 2-1: Summary of Financial Resource Estimate Approach

Step 1: Determine major activities for each optimization category. Major activities needed to implement the recommendations for each optimization category were identified for both one-time, initial items as well as recurring items. One-time, initial costs largely included activities for developing or implementing new programs or tools (i.e., develop a water loss control plan), and in select cases, included activities for the design and construction of critical system upgrades. While many of these activities could be performed within a single year, development and implementation of some larger programs or projects may be distributed over several years. It should also be noted that the development of SOPs was not included in the one-time, initial activities as several SOPs will be developed under this

project. Recommendations, including costs, for developing any additional SOPs will be presented in the final Plan. Recurring costs included both smaller programmatic activities (i.e., monthly tracking of water quality data or annual updates to SOPs) and larger R&R activities for critical system assets (i.e., valves and hydrants). For recurring items, the recommended frequency at which each item should occur was also determined. Where practical, common activities or initiatives were grouped to streamline costs and staffing requirements. Activities were grouped into the following optimization categories:

- Asset Management
- Cross-Connection Control
- Customer Complaints
- Disinfectant Residual and Disinfection Byproduct (DBP) Monitoring
- Flushing
- Hydraulic Modeling
- Information Technology (IT)
- Internal Corrosion and Post-Precipitation Control
- Main Breaks
- Online Monitoring
- Pipeline Rehabilitation and Replacement (R&R)
- Pressure Management
- Pump Station Design, Operation and Maintenance
- Security and Emergency Management
- Storage Facility Design, Operation and Maintenance
- Valves & Hydrants Testing, Maintenance and Replacement
- Water Age Management
- Water Loss Control
- Water Quality Sampling
- Other

Step 2: Estimate costs and FTEs. Costs were estimated for both one-time, initial and recurring activities, and included major equipment and materials, software fees, utility labor, professional engineering services, installation/construction, and contingency, where appropriate. In-house labor costs include employee benefits and assume an average hourly rate of $70. Professional engineering services were based on an average hourly rate of $150.

All costs were developed based on 2017 dollars and are consistent with an Association for Advancement of Cost Engineering (AACE) Class 5 Estimate, which is considered a concept screening estimate and are typically -50% to +100% accurate. Costs were prepared using a combination of approaches including stochastic methods (i.e., unit pricing, recent vendor pricing, allowances, etc.), costs from similar projects, and engineering judgment.

Step 3: Identify potential funding and financing options. Under this final step, potential options for funding and/or financing the improvements were identified, and included both traditional and alternative sources. It is recognized that some of these options may not be realistic for the City, particularly given the relatively high water rates and large number of economically disadvantages customers (Raftelis Financial Consultants, 2016). The options will be further evaluated under the final task, development of

the Optimization Plan, and a shortlist of options to consider as the City moves forward with the prioritized list of recommendations will be developed based on subsequent discussions and feedback from the City.

2.2 Results

The following section presents the results of the needs assessment associated with recommended improvements outlined under the assessment and gap analysis task.

2.2.1 Financial and Human Resources Needs

Total estimated costs for one-time, initial and annual recurring activities were estimated for each optimization category, and are summarized in Figure 2-2 and Figure 2-3, respectively. The total one-time, initial and annual recurring costs for the recommended improvements are $24.7M and $45.0M (which includes $41M in pipe, valve and hydrant testing, R&R), respectively. Most of the optimization areas require initial and/or annual investments of less than $1M, with the exception of asset management; cross-connection control; pipe R&R; pump station operation and maintenance; valves and hydrants testing, maintenance and replacement; and water loss control. Activities with a recurrence interval less frequent than annually were normalized to an annual period. It should also be noted that the annual pipe R&R costs assume $37M for the first thirteen years (i.e., targeting approximately 5% replacement per year to reduce the age of all the pipes is the system to less than 100 years), after which this is reduced to $7.9M annually (i.e., 1% replacement per year to maintain pipe age below 100 years). Additionally, there may be some opportunities for cost savings where select activities are combined. These will be identified and addressed in the final Plan.

The estimated total initial and annual FTEs for the recommended improvements are 15 and 31, respectively (refer to Figure 2-4). It was assumed that third-party organizations (i.e., consulting firms, vendors, etc.) would be needed to assist with the development and implementation of select programs, practices or tools, after which City staff would be responsible for ongoing maintenance, resulting in greater staffing needs following implementation. Most of the staff needed for recurring activities would be solely dedicated to valve and hydrant inspection, testing and maintenance due solely to the sheer number of valves and hydrants in the system. Additionally, most programs require a fractional FTE, which presents opportunities to combine roles and responsibilities into various staff member positions. This will be discussed in more detail in the final Optimization Plan.

Details on specific activities and assumptions included in each category are provided in the sections below and in Appendix A. The improvements, and subsequently costs and staffing estimates, will be modified under the final task to develop a customized set of prioritized improvements for the City's distribution system given the system constraints (e.g., schedule, cost) and overall City goals and objectives.

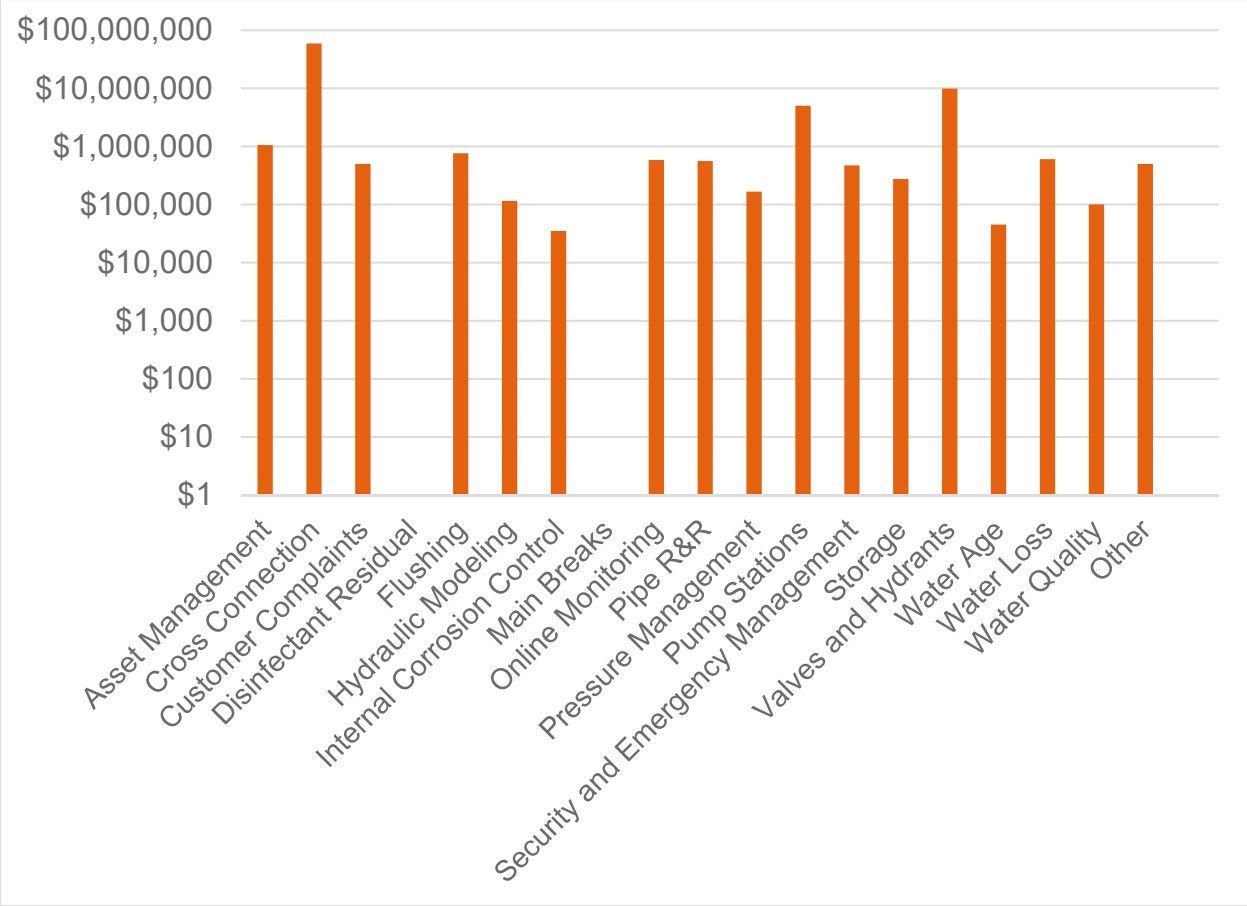

Figure 2-2: Estimated Initial, One-Time Costs Required to Implement Recommended Improvements by Optimization Category

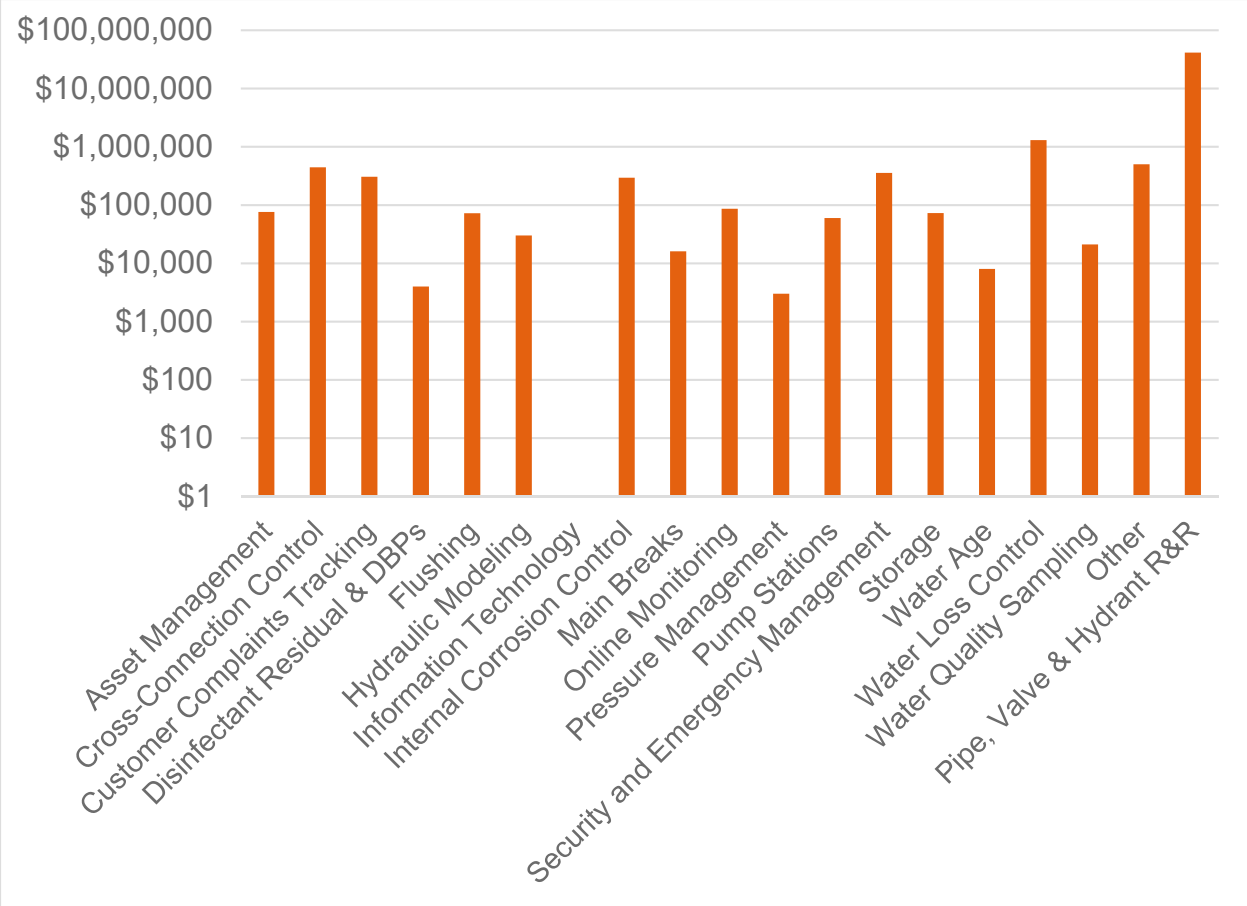

Figure 2-3: Estimated Recurring Costs Required to Implement Recommended Improvements by Optimization Category*

*Note that Pipe R&R decreases by $29M annual after all the pipes in the system are not older than 100 years.

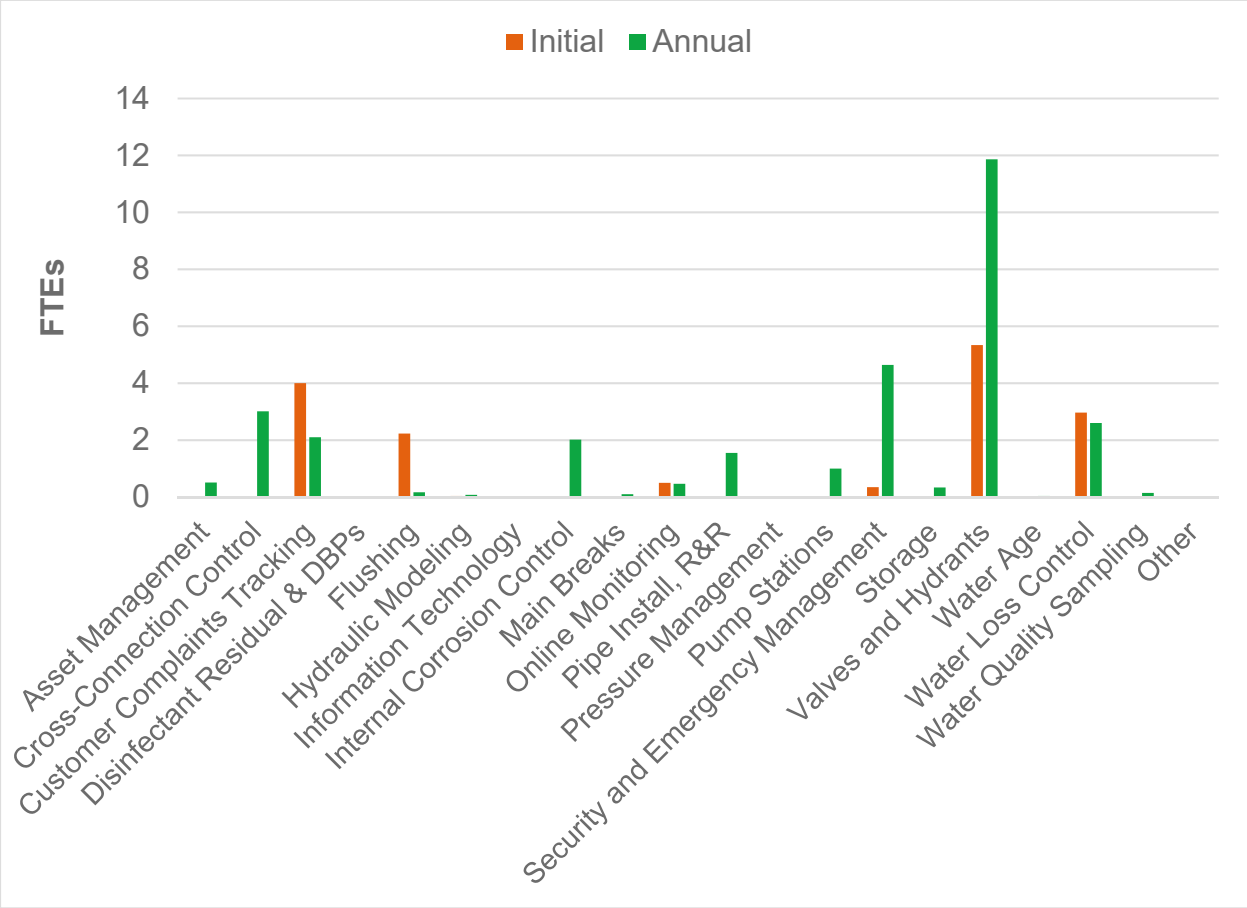

Figure 2-4: Estimated Initial, One-Time and Annual Full-Time Employees Required to Implement Recommended Improvements by Optimization Category

Table 2-1: Summary of Financial and Staffing Needs to Implement Recommended Improvements by Optimization Category [1]

Item	One-Time, Initial	Recurring	Recurrence Interval	Total Estimated Cost[2]	Estimated Staffing Needs
Asset Management					
Develop and implement an asset management program	X	X	Annually	Initial $1,055,000 Annual $75,000	Initial -- Annual 2 FTEs for 1 m/yr
Review and update SOPs		X	Annually	$1,000	2 FTEs for 1 d/yr

Item	One-Time, Initial	Recurring	Recurrence Interval	Total Estimated Cost[2]	Estimated Staffing Needs
Cross-Connection Control					
Develop and implement a residential cross-connection control program	X	X	Annually	Initial $5,970,000 Annual $220,000	Initial 1.5 FTEs Annual 1.5 FTEs/yr
Purchase and implement a cross-connection control software	X	X	Annually	Initial $6,000 Annual $2,000	Initial 1 FTE for 1 wk Annual 2 FTEs for 1 d/yr
Perform ongoing oversight of non-residential cross-connection control efforts		X	Annually	$220,000	1.5 FTEs/yr
Customer Complaint Tracking					
Establish a call center	X	X	Annually	Initial $500,000 Annual $290,000	2 FTEs/yr
Enter and track customer complaints in GIS		X	Annually	$15,000	1 FTE for 2 d/mo
Review and update SOPs		X	Annually	$1,000	2 FTEs for 1 d/yr
Disinfectant Residual and DBP Monitoring					
Enter and track chlorine data in chlorine residual management tool spreadsheet	Included in Water Quality Sampling				
Track dosing at storage facilities		X	Annually	$3,000	1 FTE for 2 hrs/mo
Review and update SOPs		X	Annually	$1,000	2 FTEs for 1 day/yr
Flushing					
Purchase basic unidirectional flushing (UDF) equipment	X	X	Every 10 years	$10,000	--
Perform a UDF pilot study (2 miles)	X			$25,000	1 FTE for 1 wk

Item	One-Time, Initial	Recurring	Recurrence Interval	Total Estimated Cost[2]	Estimated Staffing Needs
Perform UDF throughout the entire system	X			$730,000	2 FTEs for 6 m/yr for 3 yrs
Perform UDF in problematic areas (assumed 10% of system)		X	Annually	$70,000	2 FTEs for 1 m/yr
Review and update SOPs		X	Annually	$1,000	1 FTE for 1 d/yr
Hydraulic Modeling					
Calibrate and test model	X			$40,000	2 FTEs for 1 wk
Conduct water quality calibration	X			$15,000	--
Develop and implement model maintenance plan	X	X	Annually	Initial $60,000 Annual $30,000	Initial 4 FTEs for 2 d Annual 1 FTE for 2 wk/yr
Information Technology					
SCADA upgrades	X			$100,000	
Internal Corrosion Control					
Develop and maintain whole house flushing plan	X	X	Annually	Initial $35,000 Annual $291,000	Initial -- Annual 2 FTEs
Develop and implement phosphate management plan		X	Annually	$3,000	1 FTE for 2 h/m
Main Breaks					
Locate valves and hydrants using GPS and enter into GIS	Included in Valves & Hydrants				
Populate pipes in GIS	Included in Pipe Install, R&R				
Perform hydraulic modeling evaluations	Included in Pipe Install, R&R				
Perform annual leak testing	Included in Water Loss Control				

Item	One-Time, Initial	Recurring	Recurrence Interval	Total Estimated Cost[2]	Estimated Staffing Needs
Enter and track main break data in GIS		X	Annually	$15,000	1 FTE for 2 d/mo
Review and update SOPs		X	Annually	$1,000	2 FTEs for 1 d/yr
Online Monitoring					
Implement 6 online monitoring stations	X			$570,000	2 FTEs for 10 h/wk for 1 yr
Identify optimal sensor placement	X			$15,000	--
Perform water distribution panel maintenance		X	Annually	$80,000	1 FTE for 2 d/wk
Review data and setpoints		X	Annually	$5,000	1 FTE for 1 d/m
Review and update SOPs		X	Annually	$1,000	1 FTE for 2 wk/yr
Pipe Installation, R & R					
Update and review design and construction standards	X	X	Annually and every 5 years	Initial $150,000 Annually $5,000 Recurring $25,000	Initial -- Annually 1 FTE for 2 wk/yr Recurring --
Populate pipe assets in GIS and update as needed	X	X	Annually	Initial $150,000 Annually $76,000	Initial -- Annually 1 FTE for 6 mo/yr
Develop and implement a risk-based pipe R&R program	X	X	Annually	Initial $260,000 Annually *2018 to 2031* $36,960,000 *2031+* $7,920,000	Initial -- Annually *2018 to 2031* 3.5 FTEs *2031+* 3.5 FTEs

Item	One-Time, Initial	Recurring	Recurrence Interval	Total Estimated Cost[2]	Estimated Staffing Needs
Pressure Management					
Perform surge analysis & pressure management – PS and Storage	X			$15,000	--
Perform surge analysis & pressure management – comprehensive	X			$150,000	--
Install and assess data from portable pressure loggers		X	Annually	Initial $2,000 Annual $3,000	Initial -- Annual 1 FTE for 5 d/yr
Pump Station Design, Operation and Maintenance					
Rehab pump station facilities	X			$5,000,000	--
Develop specifications	X			$25,000	--
Perform routine inspections (by utility staff)		X	Annually	$73,000	0.5 FTEs
Perform annual inspection (by contractor)		X	Annually	$50,000	--
Perform long-term maintenance		X	Every 3-5 years	$73,000	1 FTE for 26 wk
Review and update SOPs		X	Annually	$1,000	2 FTEs for 1 d/yr
Security and Emergency Management					
Increase control and intrusion detection	X	X	Annually	Initial $215,000 Annual $5,000	Initial 1 FTE for 5 wk Annual 1 FTE for 1 wk
Update, maintain, and exercise ERP to FEMA standards	X	X	Annually and every 5 years	Initial $85,000 Annually $40,000 Recurring $70,000	Initial 1 FTE for 4 wk Annually 1 FTE for 1 m/yr Recurring 1 FTE for 4 wk

Item	One-Time, Initial	Recurring	Recurrence Interval	Total Estimated Cost[2]	Estimated Staffing Needs
Develop and update asset and cyber vulnerability assessment and monitor assets	X	X	Annually and every 5 years	Initial $170,000 Annually $270,000 Recurring $70,000	Initial 1 FTE for 8 wk Annually 4.5 FTEs Recurring 1 FTE for 8 wk
Storage Facility Design, Operation and Maintenance					
Replace valves	X			$250,000	--
Conduct inspections and develop specifications	X	X	Annually and every 3-5 years	Initial $25,000 Annually $21,000 Recurring $155,000	Initial -- Annually 1 FTE for 8 wk/yr Recurring 1 FTE for 10 wk
Valves and Hydrants - Installation, Operation and Maintenance					
Complete recommendations per the Wachs 2015 study[3]	X			$9,060,000	6 FTEs
Replace 1908 Darling hydrants	X			$305,000	2 FTEs for 3 m
Finish inventory and GPS locates of hydrants	X			$50,000	--
Resource Optimization Study (Water Service Center)	X			$80,000	--
Perform a comprehensive data model review and update	X			$150,000	--
Review and update SOPs		X	Annually	$1,000	2 FTE for 1 d/yr
Perform resource optimization study	X	X		$85,000	6 FTEs
Develop and implement a preventative maintenance and R&R program[4]	X	X	Annually	Initial $40,000 Annual $4,180,000	Initial -- Annual 7 FTEs

Item	One-Time, Initial	Recurring	Recurrence Interval	Total Estimated Cost[2]	Estimated Staffing Needs
Update and maintain hardware and software	X	X	Annually	Initial $135,000 Annual $165,000	Initial -- Annual 1 FTE for 8 m
Water Age Management					
Perform water age analysis and distribution system storage analysis and optimization study	X			$45,000	--
Evaluate flushing locations (auto-flushers)		X	Annually	$2,000	1 FTE for 4 d/yr
Update water system demand projections		X	Annually	$5,000	1 FTE for 1 wk/yr
Review and update SOPs		X	Annually	$1,000	2 FTEs for 1 d/yr
Water Loss Control					
Develop and implement a water loss control plan	X	X	Annually	Initial $605,000 Annual $446,000	Initial 3 FTEs Annual 3 FTEs
Implement a meter replacement program		X	Annually	$850,000	2 FTEs for 1 d/yr
Establish an internal water loss management team		X	Annually	Initial $10,000 Annual $10,000	Initial 12 FTEs for 1 h/m Annual 12 FTEs for 1 h/m
Participate in the AWWA Water Loss Control Committee		X	Annually	$1,000	1 FTE for 20 h
Water Quality Sampling					
Perform lab upgrades	X			$100,000	--
Analyze and trend water quality data		X	Annually	$20,000	1 FTE for 3 d/m

Item	One-Time, Initial	Recurring	Recurrence Interval	Total Estimated Cost[2]	Estimated Staffing Needs
Review and update SOPs		X	Annually	$1,000	2 FTEs for 1 d/y
Other					
Implement vehicle replacement program		X	Annually	$500,000	--

1. Cost and staffing estimates will be refined under the final task, development of the final Optimization Plan, to develop a customized set of prioritized improvements for the City's distribution system given the system constraints (e.g., schedule, cost) and overall City goals and objectives.
2. Capital cost are presented in 2017 dollars and are consistent with an AACE Class 5 Estimate, which is considered a concept screening estimate and are typically -50% to +100% accurate.
3. Recommendations from Wachs Water (2015) included replacement of valves that are inoperable or confirmed poor condition, Op-Nut replacements, addressing paved over valves, further investigation of "unable to locate" valves, reconciliation of map discrepancies and other minor valve repairs.
4. Annual costs for valve and hydrant replacement ($8.8M per year) are included in the annual pipe R&R costs.

2.2.2 Funding and Financing Options

The City of Flint is facing significant challenges to fund needed distribution system improvements, everything from smaller optimization programs (i.e., updating and calibrating the hydraulic model) to larger R&R programs (i.e., main replacement). There is currently no funding for a water distribution system capital improvement plan, and more staff are needed to perform current operations and maintenance duties, which are reactive rather than proactive. Additionally, the City has some of the highest water rates when compared to peer communities, despite being among the most economically-disadvantaged cities in the nation (Raftelis Financial Consultants, 2016).

While the new GLWA contract is expected to offer the best combination of water security, reliability and cost savings relative to alternatives, historical analysis suggests that future rates, even without new investment, might not be expected to fully recover water system costs and will likely come with affordability concerns. A 2016 Flint Water Rate Analysis report identified supply and treatment costs, system size, population trends, fund transfers, non-revenue water, and employee healthcare costs as system challenges (Raftelis Financial Consultants, 2016). Given these challenges, it will be important for the City to look beyond current or increased rate revenues to support recommended distribution system improvements. As such, a range of funding alternatives are presented below, and will be explored in the final task, development of the Optimization Plan, to develop a shortlist of options to consider as the City moves forward with the prioritized list of recommendations. The options presented herein are generally categorized as either "Cash Funding" (i.e., options that use new or existing sources of cash to pay-as-you-go), or "Debt Financing" (i.e. options that require repayment of creditors with principal and interest), and include the following:

- Cash Funding
    - Grants
    - Cost sharing
    - Consumer assistance programs
    - Special assessment districts

    - Property taxes
    - Public-private partnerships
- Debt Financing
    - Drinking Water State Revolving Fund (DWSRF)
    - Water Infrastructure Finance and Innovation Act (WIFIA)
    - Tax exempt municipal bonds
    - Other:
        - Local banks
        - Social impact and green bonds
        - Tax increment financing

2.2.2.1 Cash Funding

Cash funding of capital improvements is limited to the cash reserves on hand accumulated from user rates as well as charges such as impact fees, miscellaneous charges, and other sources. This is referred to as pay-as-you-go financing and is generally used to pay for smaller projects and those projects related to normal system R&R, or in the case of impact fees, projects related to system growth. Cash reserves can also be used to offset the cost of larger, debt-funded projects, thereby reducing interest costs. Funding of larger scale, longer-lived capital projects with cash is generally considered inefficient from a funding standpoint, as it requires current customers to fund projects that will last well into the future and that will benefit future customers. Several cash funding options are described in more detail below, and will be shortlisted based on their applicability to Flint and City preferences in the final task, development of the Optimization Plan.

2.2.2.1.1 Grants

In March 2017, USEPA awarded MDEQ and the City supplemental Drinking Water State Revolving Funds totaling $100M for continued improvements to the City's water system as part of the Water Infrastructure Improvements for the Nation Act (WIIN) (USEPA, 2017). As part of the award, the State of Michigan is providing a required $20M match, for a total amount of $120M. The USEPA notes that the funds are initially approved for three projects identified by MDEQ in the Intended Use Plan submitted by MDEQ on February 17, 2017 including:

1. Service Line Replacement - $40M
2. Distribution System / Transmission Main Improvements - $10M
3. Corrosion Control Studies and Asset Management Program - $1.5M

The remaining funds could eventually be utilized for two pending projects related to meter replacement ($10M) and water treatment plant improvements ($58.5M), but are contingent upon the City submitting a project plan for approval and USEPA confirming eligibility for the meter replacement project.

There have also been other State and Federal grant funds that were allocated to the water system before and after the disaster declaration that have already been claimed (including those offered by the Federal Emergency Management Agency (FEMA) and United States Department of Housing and Urban Development Community Development Block Grant Program (CDBG)). Nevertheless, it will be important to confirm that the use of these funds has been maximized. Specifically, any remaining capacity within

the HUD Section 108 capped loans should be identified. While not specifically a grant option, Section 108 allows CDBG communities to borrow up to five times the amount of annual CDBG grants at low interest rates. HUD data suggests that, as of December 2016, Section 108 borrowing capacities were as follows (www.hudexchange.info, 2017):

- City of Flint - $9,535,270
- Genesee County - $8,580,710
- State of Michigan – $153,832,030

HUD notes that several Section 108 projects include investments in infrastructure activities (which are among the 28 eligible CDBG grant investments as well), including water and sewer facilities, streets and sidewalks, parking structures, and other facilities. As part of the next phase of this project, the City may wish to determine the viability of HUD pursuits for the distribution system optimization plan. HUD has assigned a full-time staff member to the City of Flint. One next step in pursuit of Section 108 funds or any other additional CDBG funds should be to reach out to the designated HUD staff member to discuss the project ambitions and any remaining grant and associated low interest loan funding opportunities (https://portal.hud.gov, 2017). CDBG funding requirements may include a range of procurement and co-benefit requirements such as green infrastructure investment that could increase project costs. Depending on the program, CDBG funding generally requires a local match of 10-20%.

The Governor's attempt to increase FEMA funding in 2016 was met with resistance. The City should consider confirming that the Pre-Disaster Mitigation Grant Program (PDM) was reviewed for viability of funds for projects such as distribution system optimization, which will serve to prevent future water supply challenges. Other water supply projects have applied for the program, though PDM funds must be used for projects designed to prevent natural hazard related impacts (e.g., power supply hardening depending on project specifics). Similarly, the Department of Homeland Security's State Homeland Security Grant Program, typically applied to terrorism and severe weather-related projects, includes infrastructure mitigation and improvements among its covered investments and should also be explored.

The United States Economic Development Administration (EDA) is an additional federal grantor that could be leveraged, considering the impact that water supply has on the area businesses. EDA Public Works and Development Facilities grant applications would likely need to be positioned in support of local business corridors where distribution system optimization projects will support water supply used for commercial purposes.

Private grants may be an option for the City's distribution system projects given the high visibility of the water challenges. The City would need to identify private foundations or corporations that are interested in being part of drinking water solutions for the City. Large foundations that have worked nationally with American cities such as Kresge, Rockefeller, and Ford may be targeted for more costly projects. Coca Cola is an example of a large corporation that has contributed to many clean water projects in the developing world and may be willing to support the City of Flint. Smaller projects impacting specific neighborhoods or areas adjacent to schools may target a different set of foundations that are more locally focused. These grants might also help to avoid potential complications involving the use of public funds on private property should those conflicts emerge. It is important to note that grant opportunities are often extremely competitive and thus can be challenging to secure.

2.2.2.1.2 Cost Sharing

Opportunities for cost sharing between government entities could be explored whenever overlapping priorities exist and one unit of government is facing budget shortfalls or capital needs. Based on discussions with City staff, it is our understanding that historically some water system funds have been transferred to the City's general fund. Prior reports have also suggested that these transfers are in excess of peer communities (Raftelis Financial Consultants, 2016). Transfers from the water fund are typically supported through cost allocation analysis to ensure these amounts are appropriate to recover costs associated with services provided by the general fund. In addition, there may be opportunities for other utilities (such as housing agencies) to support water system investments if they benefit from an optimized distribution system. While opportunities for cost sharing may not seem available upon a cursory review of a given year's budget, parallel efforts to increase local government efficiency could reveal these opportunities going forward in future budget cycles as investment needs are identified. It is recommended that the City consider potential ancillary benefits of the optimized distribution system to other City agencies or external stakeholders as a means for potentially sharing some of the system costs.

2.2.2.1.3 Consumer Assistance Programs

A water rate increase can be more challenging for some customers than others. With a formal consumer assistance program (CAP), a utility can offer protections for the most vulnerable and lowest-income customers by providing credits, discounts, waivers, coupons or vouchers that increase these customers' ability to pay. CAPs can help communities balance customer affordability concerns when rate increases are needed to fund necessary repairs. CAPs have been employed in cities such as San Antonio and Detroit. For the City, existing affordability challenges might require a more extensive CAP program than those seen in other cities due to the socioeconomic and potential political challenges associated with any rate increase. Several affordability programs do already exist in Flint including disparate small, private charities throughout the City, such as churches that help individuals in need pay water bills. Other larger CAP programs have also been employed in recent years. A State CAP program that provided water bill credits of 20% for commercial customers and 65% for residential customers in the City of Flint recently ended in March 2017 after over $40,000,000 was credited in total since it began in April 2014 (www.freep.com, 2017). A new United Way grant of $100,000 was confirmed in April 2017 to provide up to $350 in matching funds to customers with delinquent water bill accounts (www.cityofflint.com, 2017). CAPs require funding and active participation; however, they may help support rate increases, with the associated revenue being used to cash fund projects.

2.2.2.1.4 Special Assessment Districts

Special assessment districts represent another funding approach that could serve to more directly align benefits with paying customers. A special assessment district would be defined for areas requiring particularly concentrated levels of distribution system optimization. While special assessment charges are typically delivered with property taxes for logistical simplicity and do represent charges against real property ownership, they are distinct from property taxes in several ways. These charges are generally exempt from any imposed tax caps and do not require approval through the vote of electors but can also add administrative costs beyond general millage increases. Where special assessment districts can be tied to defined benefits, they often recover costs more equitably (www.michigan.gov, November 2016).

2.2.2.1.5 Property Taxes

Billed water usage is the primary revenue source for the City of Flint water supply; given billed usage and associated rate pressures, property taxes could also be considered for providing a potential mechanism for supporting distribution system optimization projects. Property taxes apply a rate to assessed property values and therefore, to some degree, scale with wealth. Fluctuations in home values associated with market influences can make property tax revenues unstable, depending on how frequently homes have their value assessed. To pursue property tax revenues, the City of Flint would likely need to develop a clear value proposition and implementation plan to improve taxpayer understanding.

2.2.2.1.6 Public-Private Partnerships

Public-Private Partnerships (P3) represent a hybrid approach seeking to leverage limited public resources and private capital, skills, and assets. These funding arrangements can come in a variety of forms, but for water infrastructure purposes they generally consist of fully contracted construction and/or management of critical water system infrastructure. For example, in the City of Bayonne, New Jersey a joint venture comprised of the private operator Suez/United Water and the private equity firm Kohlberg Kravitz & Roberts monetized assets for the city, restructured debt, and transferred asset management responsibility to the private sector with carefully regulated and monitored rate increases. An arrangement limited to distribution system optimization would likely be somewhat unique. The City could consider seeking private capital to fund optimization projects and/or O&M services after the projects are built. But to consider this program a true P3, rather than basic contracting, the arrangement would likely scale across the distribution system optimization projects, include performance incentives and guarantee the private operator a piece of future water system revenues over a specified timeframe.

2.2.2.2 Debt Financing

For many utilities, sufficient cash reserves are not available to fully fund system needs, particularly major or long-lived capital assets. When cash is unavailable major capital projects are typically funded through debt financing. Traditional forms of debt financing, including tax-exempt municipal bonds, allow utilities to pay for capital projects that would otherwise not be constructed until adequate cash was available, while also allowing them to repay the debt overtime. This approach, when used prudently, has the effect of:

- Avoiding the accumulation of a costly and risky capital improvement plan (CIP) backlog (i.e. unfunded projects);
- Promoting generational rate equity by spreading the cost of long-life infrastructure assets over many years rather than burdening existing rate payers;
- Avoiding high, and likely fluctuating water user rates, that would be required to cash fund projects; and
- Allowing projects to be constructed in anticipation of future customers and associated revenue should the City's population stabilize and return to growth.

Several options for debt financing are discussed below, and will be shortlisted based on their applicability to Flint and City preferences in the final task, development of the Optimization Plan.

2.2.2.2.1 Drinking Water State Revolving Fund (DWSRF)

The USEPA Drinking Water State Revolving Fund (DWSRF) is a traditional source of low interest loans used to finance water infrastructure projects. In Michigan, USEPA state grant funds are used to fund loans then offered as 20-year or 30-year loans to local governments with current interest rates at approximately 2.5%. The MDEQ Drinking Water Revolving Fund also has a Green Project Reserve that can be leveraged for projects with sustainability elements or for any projects related to water conservation, efficiency, and reuse that would reduce downstream wastewater flows. Finally, the Michigan Finance Authority also administers a Local Government Loan Program with a more general source of funds for municipal infrastructure investments. These low interest loans do come with some level of management and administration cost to utilities, but can represent an affordable and familiar financing option should larger distribution system projects or bundled projects ultimately justify such a pursuit. The City has used this type of funding in the past. A review of the City's 2016 financial statements show that the water system has approximately $20.8 of outstanding debt related to past use of this program. The outstanding debt is to be repaid from FY 2021 to FY 2036.

2.2.2.2.2 Water Infrastructure Finance and Innovation Act (WIFIA)

The Water Infrastructure Finance and Innovation Act (WIFIA) is a low interest loan program providing funding for projects, or bundles of projects, totaling at least $20,000,000. WIFIA funding is limited to 49% of project costs, and the total amount of federal funding for the project may not exceed 80%. The WIFIA program accepted a first round of loan applications on April 10, 2017. The City could explore whether any future WIFIA-type funding could be considered for system distribution optimization projects.

2.2.2.2.3 Tax-Exempt Municipal Bonds

Utilities can issue tax-exempt bonds for capital project financing. The interest on these bonds is exempt from federal taxation, resulting in relatively lower interest rates that make them more cost-effective options for utilities and their rate payers. Tax-exempt debt generally comes in two varieties, which include:

- **General Obligation (GO) Bonds** - secured by the general tax-raising ability of the local government or, in other words, by the full faith and credit of the issuing entity. To ensure the tax-exempt status, projects funded with this type of debt must be demonstrated to be for the public good. This type of debt has the disadvantage of increasing liabilities on a City's balance sheet which could restrict their ability to borrow for non-utility projects. However, this type of debt generally has a lower interest rate compared to revenue bonds.
- **Revenue Bonds** - collateralized directly by cash flows from utility rates, fees or dedicated taxes (and depending on bond covenants impact fee/system development charge (SDC) revenues can also act as collateral). Repayment of this debt is governed by bond agreements and rate covenants that provide the investor with some confidence that the debt will be repaid from future revenues. Because the repayment of this debt is dependent on the generation of future revenues, it is seen as higher risk compared to GO Bonds and generally has a higher interest rate.

2.2.2.2.4 Local Banks

Local banks or financial institutions might be interested in providing loans in exchange for publicity and public relations opportunities. Support for Flint water projects would establish strong community development credentials and could possibly generate more business locally for a small institution. The distribution system projects are of a range and scale that could be attractive to banks of varying sizes. This financing alternative might also promote community awareness and buy-in, but it is unclear if a local bank could participate at interest rates that are comparable to DWSRF and tax-exempt municipal bond options.

2.2.2.2.5 Social Impact and Green Bonds

Social or environmental impact bonds are marketed as benefitting the community and the environment, with a focus on achieving a social benefit. These bonds target socially responsible investors and there is currently high demand in the market for these investments, which may lead to interest rate savings. This form of issuance would require that the utility manage the financing contract and incur some administrative costs, but does represent an emerging and innovative approach if investors have confidence in Flint's ability to deliver returns. These are not traditional bonds tied directly to the credit rating of the City and are privately offered, performance-based and relatively complex. The appeal of helping Flint could generate investor interest but would require environmental performance verification and confidence in some level of returns. Social impact bonds are benefitting from the involvement of philanthropic investors, but currently suffer from transaction costs that are perceived to be high, and the stark differences between program success and failure. More traditional green bonds also represent a growing sector but would be tied to the City of Flint's bond rating and may be less appropriate given the scale of the distribution system optimization projects.

2.2.2.2.6 Tax Increment Financing

Tax increment financing (TIF) entities borrow money today and repay loans from their claims on future property tax revenues. A TIF uses tomorrow's dollars to pay for today's projects, and therefore assumes that future revenues will be adequate to cover present project costs plus interest payments. Over time it is expected that growing property values and inflationary pressures make these arrangements viable, but soft markets can lead to additional bond issuances to cover TIF payments. Other concerns about TIFs relate to the reduced oversight that these authorities enjoy relative to elected bodies.

3 WORKFORCE EVALUATION

This section describes the approach and findings of the current staffing assessment, including staffing levels and organization, skill sets, and training, to identify additional staffing recommendations and/or training needs.

3.1 Methodology

Staff levels and organization were reviewed to assess current staffing needs and identify improvements for streamlining roles and responsibilities, where applicable. A competency-based approach was used to identify important skill sets and staff training needs. A competency model is a set of skills and behaviors that lead to effective or superior performance in a job. Interviews of current employees and their managers were conducted to determine if the competencies identified in the utility-wide models were present and valued by managers. The interviews were used to identify skills and behaviors that are needed, but may require training. Onsite interviews were conducted with the staff from the Water Service Center (WSC) in December 2016 and January 2017. Those interviewed included:

- Administrative Personnel (2)
- Water Distribution Foremen (3)
- Senior Water Distribution Operators (3)
- Water Distribution Operators (2)
- Water Distribution Operator Trainees (2)
- Water System Supervisor (1)
- Deputy Supervisor (1)
- Sewer System Supervisor (1)

A total of fifteen interviews were conducted, which represents almost half of the existing personnel in the water distribution group. Also, a main break repair by a crew was observed. The intent of the interviews was to determine how closely the positions in the water distribution group (Water Service Center) align with the duties and competencies identified in earlier work based on other water utilities (McTigue & Mansfield, 2011; Department of Labor, 2016). Training offered and needs identified in training and work environment were also identified through these interviews. In addition to the competency model effort, MDEQ operator certification requirements were reviewed to identify staff training requirements.

3.2 Results

Key findings from the human resources assessment are provided in the following sections.

3.2.1 Staffing Levels and Organization

Table 3-1 shows the FY 2016 budgeted, filled and vacant positions in this group at the time this evaluation was conducted. Not included in this table are the three administrative positions (1 vacancy), data technician, the building maintainer or the personnel in the sewer systems group. This table shows that eight positions are vacant, mostly in the Water Distribution Operator Trainee category.

Table 3-1: Summary Water Service Center Department Staffing Summary

Position Description	Budgeted	Filled	Vacant
Water Service Center Supervisor	1	1	0
Deputy Supervisor	1	1	0
Senior Water Distribution Operator	14	13	1
Water Distribution Foreman	4	4	0
Water Distribution Operator	4	4	0
Water Distribution Operator Trainee	12	5	7
TOTAL	**36**	**28**	**8**

3.2.1.1 Functional groups

The Flint Water Distribution Group is functionally divided into the following:

- Mains Crews: two crews with four to six operators and a foreman each;
- Service Crew: two to four crews with two operators, one foreman, staker and heavy equipment operator for all crews in this category;
- Meter Crew: two to four crews with one or two operators each, one foreman for all crews in this category.

There are also a Water System Supervisor and a Deputy Supervisor. This summary totals two supervisors, four foremen and 28 system operators.

Operators are hired as “Water Distribution Operator Trainees,” and work for one year in this position, rotating among the three categories above. During this time, they are required to get their commercial driver’s license (CDL). After a successful completion as a trainee, they are then categorized as “Water Distribution Operators,” again for one year.

The two years described above constitute an apprenticeship, during which the operators learn the skills they need from their foremen and senior operators. They also have yearly safety training as described later.

3.2.1.2 Number of Staff

As noted above, the water system distribution group is divided into three functional groups (mains crews, service crews and meter room crews.) As discussed above, staffing requires 28 operators and four foremen. Currently, there are only 22 filled operator positions, with eight vacancies. If the eight vacancies were filled, the crews of the three functional groups would be filled, and two additional operators would be available for projects and complete coverage due to leave.

Because the water system distribution group is currently so short-staffed, many preventative maintenance and meter crew tasks are not completed. Obviously, repairing main breaks is a priority and so the available crew is assigned to that task. Certain times of the year have a high number of water main breaks, taxing the existing staff. Although the staff works to repair breaks in a timely manner, that effort requires significant effort by the short-staffed crews.

Utilities need to have a preventative maintenance and planned replacement program, or the infrastructure will continue to degrade. Further, the meter replacement program has been hardest hit by the shortage.

The water distribution system management established the number of positions required for the FY budget as cited in Table 3-1. Based on interviews conducted for this assessment, that number is reasonable to accomplish the current required tasks of the distribution system.

3.2.1.3 Additional Staff

Two additional operators should also be added to this budget for oversight of the ongoing lead service line replacement programs. This position requires a Senior Operator, since the operator would be sent to excavation sites alone and under the current training procedures for apprentices this would not be allowed for an operator with less than two years' experience, and it requires knowledge of the distribution system and procedures used in Flint.

3.2.1.4 Type of Staff

The competency model shown in Section 3.2.2 does a good job of describing the type of individual needed to fill the vacancies. It is important to recognize that training, and then losing apprentices is expensive in terms of staff time in training. It is recommended that the job description or the initial screening process eliminate those applicants that have no interest or ability to perform the job.

It is recommended that the meter crew position positions include competencies that include ability to work with instruments that require precision and accuracy. If the meter crew is dedicated to certain tasks having to do with meter reading, replacing and change outs, then those skills should be highlighted.

Recent budget issues have led to reductions in pay, pay increases, health benefits, overtime pay and retirement benefits. Although most of those interviewed expressed job satisfaction, it is apparent that these changes have affected morale and employee retention. A number of mid-level operators, with 5 to 10 years of service have recently left, and it is difficult to fill those positions.

3.2.1.5 Job Posting and Outreach

The notice of positions available in the Flint Water Distribution system was posted on various career sites during 2016. On March 4, 2017, a search of Indeed.com, Monster.com, cityofflint.com and Michiganworks.org did not yield any results for these positions. The jobs need to be posted on as many of these sites as possible to get a competent applicant pool. Consideration might be given to partnering with vocational programs and universities to advertise and fill the positions. The local power company has instituted a summer job program with high school students that has been a successful way to introduce people to their positions. This may be a tactic that could be used to attract more applicants.

3.2.2 Competency Model for Flint Water Distribution Operator

Based on the results of the interviews, the competency model for the water distribution operator developed in the Water Research Foundation (WRF) study (McTigue & Mansfield, 2011) was revised to describe the duties and needed competencies for the work performed by the water distribution operators in Flint, MI. The competency model for the Flint water distribution operators is shown in Table 3-2. It is similar to the one developed in the WRF work, but some tasks done by other utilities which are not done by this group in Flint, such as cross connection control, were eliminated.

Table 3-2: Competency Model for Flint, MI Water Distribution Operator

Competency
6. Knowledge of water distribution systems
a. Understanding of water distribution systems b. Understanding of the function of water mains, hydrants and valves c. General knowledge of electrical and mechanical principles and system infrastructure operations d. Comprehends hydraulic and pneumatic principles e. Knowledge of main flushing procedures f. Operates, calibrates, maintains, troubleshoots, and diagnoses system infrastructure equipment g. Knowledge of start-up and shut-down operations h. Knowledge of meter readings, turn on and offs
7. Mechanical aptitude and ability
a. Ability to use hand tools and mechanical equipment specific to line maintenance b. Ability to operate heavy and large equipment such as backhoes, end loaders and dump trucks; possess Class A CDL license c. Ability to perform maintenance activities such as system flushing, valve exercising and fire hydrant maintenance
8. Ability to work safely in challenging environments
a. Understands traffic laws, ordinances and rules involved with heavy equipment operation b. Utilizes occupational hazard and safety practices c. Follows established safety procedures during main repairs, including confined space, trenching and hazard material handling procedures
9. Understanding of public health principles and drinking water regulations
a. Ability to collect water samples b. Knowledge of disinfection principles
10. Non-technical competencies

Competency
a. Professionalism: Taking pride in oneself and one's work, and treating others with respect and courtesy. b. Ability to interact with customers and act as a representative of the Company c. Conscientiousness: follows standard procedures, ensure safety of self and others, completes work in a timely way d. Interpersonal skills, to include working in a team, communicating with the team and management and communicating with the customers e. Critical and analytical thinking: Ability to recognize problems and effectively work independently or with others to reach a viable solution f. Trustworthy; strong personal integrity g. Demonstrates strong level of accountability, ownership and dependability h. Collaborative/Team oriented i. Emotional maturity j. Willingness to perform a variety of manual tasks for an extended period of time in unfavorable weather conditions k. Establish and maintain effective working relationships with those contacted in the course of work

The competency model illustrates that certain competencies or attributes are necessary to perform well in the operator position. Some of these competencies are needed coming into the job, while others can be learned through work experience and training. As noted, there are five major groups of competencies needed for this work, including knowledge of how the distribution system functions and of how repairs are made, mechanical aptitude and ability, the ability to work safely in challenging environments, understanding of public health principles and drinking water regulations, and non-technical competencies. Each of these general categories has a number of subcategories associated with it.

This model demonstrates that an applicant must have certain competencies or abilities before starting the job. Most importantly, the operator must have mechanical aptitude. In this case, the aptitude involves the ability to use or learn to use tools and heavy equipment, such as jackhammers and driving heavy equipment. Some of the important non-technical competencies similarly need to be possessed by the apprentice before starting the job. These include critical thinking and good judgment, accountability, dependability, commitment to teamwork and the willingness to work in adverse conditions for extended periods of time.

The remaining competencies, while desired in an applicant, could be taught on the job.

Each of the identified group of competencies is described below.

3.2.2.1.1 Competency 1. Knowledge of water distribution systems

This general competency describes the knowledge needed to perform specific tasks that are required in the maintenance of Flint's distribution system, understanding of the function of water mains, hydrants and valves, meters and associated equipment, knowledge of electrical and mechanical principles and system infrastructure operations, an understanding of hydraulic and pneumatic principles, and devices, a knowledge of main flushing procedures, knowledge of start-up and shut-down operations, and a knowledge of meter reading, and meter turn on and offs.

All of the above are needed to know how to fix main breaks, change out and read meters, flush hydrants and various other routine tasks. In addition to that knowledge, an understanding of how the team must proceed to accomplish these tasks is needed, including locating the leak, getting the hole dug, making the repair and restoring the area. Also, one of the team members has to understand how records are developed and kept.

3.2.2.1.2 Competency 2. Mechanical aptitude and ability

A successful water distribution operator in Flint needs to have mechanical aptitude and ability. That is, he/she must have the ability to use hand tools and mechanical equipment specific to this job, such as leak detectors, shovels, jackhammer, hydrant spanners, and pressure gauges. The operator must be able to operate heavy and large equipment such as backhoes, end loaders and dump trucks and possess or be able to earn a Class A CDL license, and to perform maintenance activities such as system flushing, valve exercising, and fire hydrant maintenance.

As noted, mechanical ability is a core competency for this position, and not one that can be learned. Specific tasks, such as driving heavy equipment can be learned, but the core capacity to handle such equipment must be possessed by the operator.

3.2.2.1.3 Competency 3. Ability to work safely in challenging environments

This competency recognizes that the distribution operator often works in dangerous and busy environments, often in the middle of traffic or in neighborhoods with curious on-lookers. So, the operator must have the ability to understand traffic laws, ordinances and rules involved with heavy equipment operation. The operator must be knowledgeable about and utilize occupational hazard and safety practices and follow established safety procedures during main repairs, including confined space, trenching and hazard material handling procedures.

3.2.2.1.4 Competency 4. Understanding of public health principles and drinking water regulations

Knowledge of public health principles is an important attribute for anyone working in the distribution system, because of the risk of contamination of the water supply. The delivery of safe drinking water to consumers is the most important task of any water utility, so an understanding of disinfection principles and practices is important for the operators to understand. It is not necessary to be able to do calculations, but a good working knowledge of the role that disinfection plays in water treatment is an important competency. Tied to this knowledge of public health and disinfection is the importance that operators have a good knowledge of how the Flint water is treated. Again, an in-depth knowledge of calculations and chemistry is not needed, but correct information about water source and treatment is important.

In the WRF Competency Model study cited earlier (McTigue & Mansfield, 2011) this competency was regarded as the most important in all job categories for superior performance. It was cited by many in that work as the reason why job holders were satisfied to work at a water utility. Regarding themselves as protectors and stewards of public health tended to create behavior that led to superior performance.

3.2.2.1.5 Competency 5. Non-technical competencies

The non-technical competencies required to do the job of water distribution operator in Flint include:

- Professionalism: Taking pride in oneself and one's work, and treating others with respect and courtesy
- Ability to interact with customers and act as a representative of the Company
- Conscientiousness: follows standard procedures, ensure safety of self and others, completes work in a timely way
- Interpersonal skills, to include working in a team, communicating with the team and management and communicating with the customers
- Critical and analytical thinking: Ability to recognize problems and effectively work independently or with others to reach a viable solution
- Trustworthy; strong personal integrity
- Demonstrates strong level of accountability, ownership and dependability
- Collaborative/Team oriented
- Emotional maturity
- Willingness to perform a variety of manual tasks for an extended period of time in unfavorable weather conditions
- Establish and maintain effective working relationships with those contacted in the course of work

The descriptions are included to illustrate that an operator's personality and attitude are critical to the effective and safe performance of the job. The non-technical competencies further illustrate that not everyone would be able to do well at this job, or in some cases, do the job at all. Many of these competencies cannot be learned on the job, but must be present before beginning the job.

3.2.3 Training

3.2.3.1 Observations

The apprenticeship program, with the yearly training on confined space, trenching and CPR (safety training) has worked well. This conclusion is based on the interviews conducted where it was determined that:

- The section has an excellent safety record,
- Interviewees were unanimously familiar with safety protocols and standard operating procedures,
- The individuals interviewed considered the in-house managers to be competent and concerned about them,
- No one interviewed identified any training needs, but did identify the desire for more training.

A strong management (in-house) commitment to jobsite safety was evident.

MDEQ only requires one certified operator in the water system distribution group. At the time of the interviews, both the Water System Supervisor and Deputy Supervisor each maintain this license (S-1). Some of the operators interviewed expressed interest in training for this license. Unlike some other utilities, there is not an incentive (pay increase, potential for promotion) associated with earning this

license. Management interviewed stated that if an operator expressed interest in this exam and license, they were furnished with appropriate books (Sacramento Series Manuals).

3.2.3.2 Recommendations

Based on reviewing how the five competencies were utilized and taught at Flint, a training program for each competency was identified. As noted, the current training through the apprenticeship program or mentorship has worked well as reflected by the good safety record and the crews' ability to complete the required work. But, this method may not be sustainable due to the in service (years) gap between the foremen and supervisors (mentors) and the operators. Currently, there are only two operators below the supervisory level that have more than five years' experience working on the Flint system. The current mentors are eligible to retire (possibly in the next five years), and if they choose to retire, there will be a knowledge gap because the new foremen and supervisors will not have been on the job as long as the current foremen.

Therefore, the following training programs were identified to support the critical competencies identified above in Table 3-2.

1. Water distribution knowledge training on driving and heavy equipment operation
2. Heavy equipment training
3. Safety training (traffic, confined space, first aid), focused on Flint
4. Training on Flint water treatment and measures needed to protect public health
5. Training on customer communication and relations.

Training Program 1: Water Distribution System Training

Water system operators must have a good knowledge of how the system they are maintaining works, along with all of the components of that system. Currently, this is taught through an apprenticeship program with seasoned senior staff and foremen and it seems to be effective. But, in the future, there may not be sufficient system knowledge as the more experienced personnel retire. So, it is recommended to maintain the current apprenticeship training as much as possible, but start developing a more structured training course that can substitute for these experienced operators.

It is recommended that the training materials currently available through MDEQ for distribution system operators be used as a basis for this training, but that the course is limited to topics of direct relevance to the Flint system. MDEQ currently approves courses taught on-line by AWWA through two different vendors. Further, they approve the use of the Sacramento Series training that uses texts and workbooks. There could also be the opportunity for operators to use this material to prepare for the Operators' License Exam, but only after they pass an in-house test, which will assure they are committed to passing the exam.

An important aspect of this training is the development of SOPs for the Flint system. Although operators confirmed that they were available, no one actually appeared to reference them. If they are developed along with the course, some video SOPs could be developed. Other utilities with retiring senior workforce find that this approach works well in capturing historical knowledge. SOPs that need to be updated or created include (it should be noted that each of these is being prepared under this effort):

- Disinfection of mains

- Main break repairs (isolated, etc.)
- New service connections
- Specialty valve maintenance, such as pressure reducing valves or altitude valves
- Flushing
- Valve exercise program
- Cross-connection control
- Disinfectant residual monitoring and reporting
- Meter testing and calibration (master, service, others)
- Recordkeeping SOPs for types of records and duration

***Water Distribution System Training Course Description*:** students will obtain a working knowledge of the Flint water distribution system. The topics of this course include water storage facilities, operation and maintenance of water mains, general water quality issues, basic disinfection, and safety.

Training Program 2: Heavy Equipment Training

As described, all operators in this group are expected to have the ability to operate or learn to operate all the heavy equipment used by this section. Currently, apprentice operators are trained by experienced staff at the Water Service Center. As described in the previous section, however, the more experienced operators will possibly retire and so a more formalized training program should be considered in the future. The course would be specific to the equipment used by Flint distribution operators with the goal of all operators gaining their Class A CDL.

***Heavy Equipment Training Course Description*:** students will obtain a working knowledge of the heavy equipment used by the Flint water distribution system. The training should be conducted on-site or at a local commercial driving provider. Human Resources should consider the ability to use appropriate tools in the hiring process as on the job training is not always possible.

Training program 3: Safety Training

The work and environment of the Flint water distribution operators has many potential dangers: traffic, failed trench walls, power tools, hand tools, hazardous materials, as well as “routine” hazards of tripping and falling. Safety training is the best way to protect workers. As described, the staff currently attends safety training in Lansing that appears to be effective. The gap observed is that the training is given only once per year and so if an employee is hired shortly after the training is given, he/she would not have the training for an extended period of time.

Safety is trained through observation on the jobsite, but it is recommended that a safety training program be developed for new employees and as a refresher. The course would be one day or shorter, and include situations typically encountered by the crews in Flint.

***Safety Training Course Description*:** students will acquire a working knowledge of the following topics as it affects their work environment in flint: Confined Space Entry and Lockout and Tag out, Trenching/confined space, and CPR and basic first aid.

Training program 4: Public Health and Flint Water System

The Water Research Foundation Competency Report, (McTigue & Mansfield, 2011) stated: “The most important competency for superior performers in every job category was a commitment to public health.

Develop training materials describing water treatment, distribution and the role of the distribution operator in protecting public health. Develop training materials that help the operators interact with customers in a positive way."

Currently, there is no standard training or information available to the operators at Flint tailored on the Flint water and distribution system. This course should be developed using some of the industry standard materials such as AWWA's series, "Principles and Practices of Water Supply Operation: Water Treatment," and the Flint Consumer Confidence Report (https://www.cityofflint.com/2016/07/07/annual-water-quality-report-for-city-of-flint/).

The information presented should be basic and general and focus on the processes used in Flint. Further, the importance of the water distribution operators' role in providing safe water should be highlighted.

***Public Health and Water Treatment Training Course Description*:** The student will be presented with information on how a water utility works, from source to tap. The material will focus on Flint's water system, particularly on the distribution system. This course will be one day, so it will be a general discussion of water treatment processes and public health implications of drinking water. The students will acquire knowledge of water treatment and their own role as water distribution operators in protecting public health. Further, it will provide the students with information on the water quality concerns during 2014 and 2015.

Training program 5. Customer Service Training

Water distribution operators are often the only contact a customer has with a water utility. But, sometimes that contact can be confrontational, and that type of publicity should be avoided. With proper training on the best techniques to use with difficult customers, these operators can be a public relations benefit to the water utility. One of the most important non-technical competencies described above is the "ability to interact with customers and act as a representative of the Company and the ability to establish and maintain effective working relationships with those contacted in the course of work." This course would provide the operators with the tools to be effective with customers and provide a positive message. Standard training materials from AWWA, such as the AWWA Public Communications Toolkit and material from the AWWA Customer Service Certificate Program would provide the basics of the course.

***Customer Service Training Course Description*:** The student will be introduced to Communication Skills, Diversity and Inclusion, Listening Skills, Customer Service in Action and Working with Challenging Customers.

3.2.4 Additional Resource Needs

Several additional resource needs were identified during the course of the interviews and include:

- **Heavy Equipment.** Most of the trucks are near the end (or past) their useful lives, posing a risk to operators and others in traffic situations. Some utilities have used the panel trucks for public relations signage, which would benefit the utility in a different area than distribution repairs.
- **Electronic Recordkeeping.** Recordkeeping/job information storage needs to be updated. Currently, the process is nearly all paper based, making it difficult to retrieve information quickly. Implementation of an enterprise asset management (EAM) system will improve recordkeeping

capabilities. Training on why and how to utilize the EAM system is critical to buy-in from Flint staff and long-term success of the asset management program.

- **Customer Service Call Center.** As described in other sections, the administrative staff at the Water Service Center acts as a de facto Call Center, since the existing Call Center only handles billing inquiries. How customer complaints and inquiries, especially those related to water quality concerns must be standardized with correct, current information made available to the Call Center, or to the Water Service Center if this practice continues.

4 SUMMARY AND NEXT STEPS

This section presents a summary of the approach and results of the resource analysis and needs assessment and a brief discussion on the next steps to be completed under this project.

4.1 Summary

4.1.1 Needs Assessment

An analysis was performed to identify the preliminary needs (both financial and staffing) associated with the opportunities for improvement identified under the assessment and gap analysis task, which are presented in the *Assessment and Gap Analysis Technical Memorandum, March 2017*. The approach and key findings from this analysis are summarized below.

4.1.1.1 Approach

Preliminary needs were identified and include estimates for both initial and recurring costs and number of FTEs for the improvements identified in each of the following categories:

- Asset Management
- Cross-Connection Control
- Customer Complaints
- Disinfectant Residual and Disinfection Byproduct Monitoring
- Flushing
- Hydraulic Modeling
- Information Technology
- Internal Corrosion and Post-Precipitation Control
- Main Breaks
- Online Monitoring
- Pipeline Rehabilitation and Replacement
- Pressure Management
- Pump Station Design, Operation and Maintenance
- Security and Emergency Management
- Storage Facility Design, Operation and Maintenance
- Valves & Hydrants Testing, Maintenance and Replacement
- Water Age Management
- Water Loss Control
- Water Quality Sampling
- Other

These estimates do not include activities that are currently performed by the City, but rather focus on those that would be needed to achieve industry best practices, which are largely based on the AWWA Partnership for Safe Water Distribution System Optimization Program. All costs were developed based on 2017 dollars and are consistent with an AACE Class 5 Estimate, which is considered a concept

screening estimate and are typically -50% to +100% accurate. Additionally, potential options for funding and/or financing the improvements were identified, and included both traditional and alternative sources.

4.1.1.2 Results

4.1.1.2.1 Financial and Human Resource Needs

The total one-time, initial and annual recurring costs for the recommended improvements are $24.7M and $45.0M (which includes $41M in pipe, valve and hydrant testing, R&R), respectively. The largest cost categories include asset management; cross-connection control; pipe R&R; pump station operation and maintenance; valves and hydrants testing, maintenance and replacement; and water loss control. It should be noted that the annual pipe R&R costs assume $37M for the first thirteen years (i.e., targeting approximately 5% replacement per year to reduce the age of all the pipes is the system to less than 100 years), after which this is reduced to $7.9M annually (i.e., 1% replacement per year to maintain pipe age below 100 years).

The estimated total initial and annual FTEs for the recommended improvements are 15 and 31, respectively. It was assumed that third-party organizations (i.e., consulting firms, vendors, etc.) would be needed to assist with the development and implementation of select programs, practices or tools, after which City staff would be responsible for ongoing maintenance, resulting in greater staffing needs following implementation. Most of the staff needed for recurring activities would be solely dedicated to valve and hydrant inspection, testing and maintenance due solely to the sheer number of valves and hydrants in the system.

The improvements, and subsequently costs and staffing estimates, will be modified under the final task to develop a customized set of prioritized improvements for the City's distribution system given the system constraints (e.g., schedule, cost) and overall City goals and objectives. This will include combing select activities to reduce both the financial and human resource needs.

4.1.1.2.2 Funding and Financing Options

Several potential cash funding and debt financing options for the City's water distribution system projects have been identified and include:

- Cash Funding
    - Grants
    - Cost sharing
    - Consumer assistance programs
    - Special assessment districts
    - Property taxes
    - Public-private partnerships
- Debt Financing
    - Drinking Water State Revolving Fund (DWSRF)
    - Water Infrastructure Finance and Innovation Act (WIFIA)
    - Tax exempt municipal bonds
    - Other:
        - Local banks

- Social impact and green bonds
- Tax increment financing

It is recognized that some of these options may not be realistic for the City, particularly given the relatively high water rates and large number of economically disadvantages customers (Raftelis Financial Consultants, 2016). Additionally, several funding sources have been awarded to the City and could potentially be used to implement select improvements. As part of final task, these options will be further evaluated to identify a shortlist of options to consider as the City moves forward with the prioritized list of recommendations.

4.1.2 Workforce Evaluation

An assessment of the ability of the current staff (in numbers, skill sets, and provided training) to implement the recommended best practices and to identify recommendations for additional staff and/or training to perform current or future duties.

4.1.2.1 Approach

Staff levels and organization were reviewed to assess current staffing needs and identify improvements for streamlining roles and responsibilities, where applicable. A competency-based approach was used to identify important skill sets and staff training needs. A total of fifteen interviews were conducted, which represents almost half of the existing personnel in the water distribution group. The intent of the interviews was to determine how closely the positions in the water distribution group (Water Service Center) align with the duties and competencies identified in earlier work based on other water utilities (McTigue & Mansfield, 2011; Department of Labor, 2016). Training offered and needs identified in training and work environment were also identified through these interviews. In addition to the competency model effort, MDEQ operator certification requirements were reviewed to identify staff training requirements.

4.1.2.2 Results

4.1.2.2.1 Staffing Levels and Organization

The water system distribution group is currently short-staffed, resulting in mainly reactive rather than proactive or preventative maintenance. Additionally, certain times of the year have a high number of water main breaks, taxing the existing staff. Although the staff works to repair breaks in a timely manner, that effort requires significant effort by the short-staffed crews. Based on the established the number of positions required for the FY 2016 budget, there are currently eight vacant positions. Based on interviews conducted for this assessment, that number is reasonable to accomplish the current required tasks of the distribution system.

4.1.2.2.2 Competency Model for Flint Water Distribution Operator

Based on the results of the interviews, the competency model for the water distribution operator developed in the WRF study (McTigue & Mansfield, 2011) was revised to describe the duties and needed competencies for the work performed by the water distribution operators in Flint, MI, which include the following:

- **Knowledge of water distribution systems.** The operator must have the knowledge needed to perform specific tasks that are required in the maintenance of Flint's distribution system, understanding of the function of water mains, hydrants and valves, meters and associated equipment, knowledge of electrical and mechanical principles and system infrastructure operations, an understanding of hydraulic and pneumatic principles, and devices, a knowledge of main flushing procedures, knowledge of start-up and shut-down operations, and a knowledge of meter reading, and meter turn on and offs.
- **Mechanical aptitude and ability.** The operator must have the ability to use hand tools and mechanical equipment specific to this job, such as leak detectors, shovels, jackhammer, hydrant spanners, and pressure gauges, and be able to operate heavy and large equipment such as backhoes, end loaders and dump trucks and possess or be able to earn a Class A CDL license, and to perform maintenance activities such as system flushing, valve exercising, and fire hydrant maintenance.
- **Ability to work safely in challenging environments.** The operator must have the ability to understand traffic laws, ordinances and rules involved with heavy equipment operation. The operator must be knowledgeable about and utilize occupational hazard and safety practices and follow established safety procedures during main repairs, including confined space, trenching and hazard material handling procedures.
- **Understanding of public health principles and drinking water regulations**. The operator must have knowledge of public health including an understanding of the Flint treatment and disinfection practices to help ensure delivery of safe drinking water to all consumers.
- **Non-technical competencies.** These include professionalism, ability to interact with customers and act as a representative of the Company, conscientiousness, interpersonal skills, critical and analytical thinking, trustworthy/integrity, demonstrates strong level of accountability, ownership and dependability, collaborative/team oriented, emotional maturity, willingness to perform a variety of manual tasks for an extended period of time in unfavorable weather conditions, and ability to establish and maintain effective working relationships with those contacted in the course of work.

Some of these competencies are needed coming into the job, while others can be learned through work experience and training. Most importantly, the operator must have mechanical aptitude. In this case, the aptitude involves the ability to use or learn to use tools and heavy equipment, such as jackhammers and driving heavy equipment. Some of the important non-technical competencies similarly need to be possessed by the apprentice before starting the job. These include critical thinking and good judgment, accountability, dependability, commitment to teamwork and the willingness to work in adverse conditions for extended periods of time. The remaining competencies, while desired in an applicant, could be taught on the job.

4.1.2.2.3 Training

Based on reviewing how the five competencies were utilized and taught at Flint, a training program for each competency was identified. As noted, the current training through the apprenticeship program or mentorship has worked well as reflected by the good safety record and the crews' ability to complete the required work. But, this method may not be sustainable due to the in service (years) gap between the foremen and supervisors (mentors) and the operators. Currently, there are only two operators below the

supervisory level that have more than five years' experience working on the Flint system. The current mentors are eligible to retire (possibly in the next five years), and if they choose to retire, there will be a knowledge gap because the new foremen and supervisors will not have been on the job as long as the current foremen. Therefore, the following training programs were identified to support the critical competencies identified above:

6. Water distribution knowledge training on driving and heavy equipment operation
7. Heavy equipment training
8. Safety training (traffic, confined space, first aid), focused on Flint
9. Training on Flint water treatment and measures needed to protect public health
10. Training on customer communication and relations.

4.2 Next Steps

Several key next steps to occur as part of this project include:

- **Develop key SOPs.** As no written distribution system operations and maintenance SOPs were available, Arcadis will be developing several key SOPs for the City, aligning each with industry best practices, where applicable. A list of the developed SOPs in addition to recommendations for development of additional SOPs will be presented in the final Plan.
- **Prioritize Recommended Improvements for Flint's System.** It should be noted that the Partnership program is a rigorous process and that even well-run systems may have difficulty achieving fully optimized status as defined by the performance goals of the program. Improvements were based on achieving excellence in each category rather than simply complying with regulations or meeting reported average conditions, and will be prioritized based on selected criteria and system constraints (e.g., financial and human resource limitations) to develop a customized set of improvements for the City's distribution system. These improvements, including modified costs and staffing estimates, will be presented in the final Plan.
- **Shortlist the Funding and Financing Options.** Given the relatively high water rates and large number of economically disadvantages customers (Raftelis Financial Consultants, 2016), some of the presented funding and financing options may not be realistic for the City. As part of the final optimization task, the Arcadis team will work with the City to generate a short-list of alternatives for consideration as the City moves forward with the prioritized list of recommendations
- **Identify Performance Metrics.** To assess the progress of optimizing the distribution system, Arcadis will review the metrics and measures currently in use and compare these with other similar water, wastewater and solid waste utilities to identify potential measures that are meaningful to the optimization program. Arcadis will develop recommendations for the preferred approach for performance measure tracking and data comparisons for each Performance Metric selected and frequencies for assessing progress.
- **Develop an Implementation Schedule.** Arcadis will develop an implementation schedule that groups the customized recommendations into immediate (0-2 years), short-term (3-5 years), mid-term (6-10 years) and long-term (10+ year) periods. Where possible, items will be grouped based on identified synergies to streamline implementation and condense the schedule.

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APPENDIX A

Detailed Financial and Human Resource Needs

LEGEND

Optimization Category	Code
Asset Management	AM
Cross-Connection Control	XC
Customer Complaint Tracking	CC
Disinfection Residual and DBP Monitoring	CL
Flushing	FL
Hydraulic Modeling	HM
Information Technology	IT
Internal Corrosion Control	IC
Main Breaks	MB
Online Monitoring	OM
Pipeline Rehabilitation and Replacement	RR
Pressure Management	PR
Pump Station Design, Operation and Maintenance	PS
Security and Emergency Management	SE
Storage Facility Design, Operation and Maintenance	SF
Valves & Hydrants Testing, Maintenance, and Replacement	VH
Water Age Management	WA
Water Loss Control	WL
Water Quality Sampling	WQ
Other	OT

NOTES:

1. Costs were estimated for both one-time, initial and recurring activities, and included major equipment and materials, software fees, utility labor, professional engineering services, installation/construction, and contingency, where appropriate.

2. All costs were developed based on 2017 dollars and are consistent with an Association for Advancement of Cost Engineering (AACE) Class 5 Estimate, which is considered a concept screening estimate and are typically -50% to +100% accurate.

Item Number	Item
AM-1	Develop and Implement An Asset Management Program (AMP)

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
AM-1-1	**Develop and Implement an Asset Management Program**					**$1,055,000**			
	Asset Management Program	-	1	ls	$353,300	$353,300	-	Planned task. Costs to be refined as part of scope of work	Municipal Water Distribution System Optimization Engineering, Amendment 1, Additional Requested Optimization Assistance, Scope of Services, dated 02/03/2017
	Asset Management Kick-off Workshop	-	-	-	-	incl. above	-		
	Review of Current AMP and Gap Analysis	-	-	-	-	incl. above	-		
	AMP Development	-	-	-	-	incl. above	-		
	Asset Inventory and Condition Assessment	-	-	-	-	incl. above	-		
	Level of Service	-	-	-	-	incl. above	-		
	Assess Criticality	-	-	-	-	incl. above	-		
	Life-Cycle Cost Financial Planning	-	-	-	-	incl. above	-		
	Revenue Structure/Capital Improvement Plan	-	-	-	-	incl. above	-		
	Plan Presentation, Implementation, Communication and Training	-	-	-	-	incl. above	-		
	Enterprise Asset Management					incl. above	-		
	EAM Plan	-	-	-	-	incl. above	-		
	Equipment and Installation	-	1	ls	$700,000	$700,000	-	Costs will vary depending the the requirements for the system. Includes professional engineering services to support procurement and installation of the selected EAM	Assumed
Recurring Costs									
AM-0-1	**Review and update SOPs**	**1**	**16**	**hr**	**$70**	**$1,000**	**0.01**	**Assumes two staff members for one day per year**	**Assumed**
AM-1-1	**Update AMP**	**1**	**1040**	**hr**	**$70**	**$75,000**	**0.50**	**Assumes one staff members half time per year**	**Assumed**

Item Number	Item
XC-1	Develop a Residential Cross-Connection Control Program
XC-2	Implement Cross-Connection Control Software
XC-3	Increase ongoing non-residential cross-connection control efforts

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
XC-1-1A	**Develop a Residential Cross-Connection Control Program**					**$5,970,000**	**-**		
	Perform Cross-Connection Control Survey	-	1	ls	$250,000	$250,000	-	Costs may vary depending on current conditions	Assumed
	Develop a Backflow Incident Response Plan	-	1	ls	$25,000	$25,000	-		Assumed
	Install Backflow Preventers						-		
	Equipment	-	29,520	ea.	$50	$1,476,000	-	Based on 31,520 total accounts (Rowe, 2016), assuming 2,000 industrial accounts based on discussions with City staff	Rowe, 2016
	Install at same time as meter replacement	-	29,520	ea.	$140	$4,132,800	-	Furnish and install price	Based on pricing from similar projects
	Perform Public Outreach						-		
	External Public Outreach Consultant	-	1	ls	$25,000	$25,000	-		Assumed
	Hold & attend meetings	-	6	ea.	$10,000	$60,000	-		Assumed
XC-2-1A	**Cross-Connection Control Software**					**$6,000**	**-**		
	Evaluate Cross-Connection Software	-	40	hr	$70	$2,800	0.02	Assumed 1 staff member for one week	Assumed
	Procure Cross-Connection Software	-	1	ea.	$3,000	$3,000	-		Based on pricing from similar projects
Recurring Costs									
XC-1-1B	**Ongoing oversight of residential cccp**	**1**	**3120**	**hr**	**$70**	**$220,000**	**1.5**		
XC-3-1	**Ongoing oversight of non-residential cccp**	**1**	**3120**	**hr**	**$70**	**$220,000**	**1.5**		
XC-2-1B	**Annual Licensing Fee**	**1**	**1**	**ea.**	**$1,000**	**$1,000**	**-**		
XC-0-1	**Review and update SOPs**	**1**	**16**	**hr**	**$70**	**$1,000**	**0.01**	**Assumes two staff members for one day per year**	**Assumed**

Item Number	Item
CC-1	Analyze and track customer complaints

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time,									
CC-1-1	Establish a Call Center	-	1	ls	$500,000	$500,000	4	Costs depends on technology needs	Assumed
Recurring Costs									
CC-1-3	Enter and track customer complaints in GIS	1	192	hr	$70	$15,000	0.09	Assumes one staff member for two days per month	Assumed
CC-1-2	Compare complaint baseline against industry benchmark	1	-	-	-	incl. in above	-		
CC-1-4	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed
CC-1-5	Operate the Call Center	1	4,160	hr	$70	$290,000	2	Assumes two staff members full time every year	Assumed

Item Number	Item
CL-1	Develop Chlorine Residual Management Plan

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
None identified									
Recurring Costs									
WQ-1-4	Enter and track chlorine residual and DBP data	-	-	-	-	incl. in WQ sampling			
CL-1-1	Track dosing at storage facilities	1	48	hr	$70	$3,000	0.02	Assumes one staff member for two hours per day per month	Assumed
CL-1-2	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed

Item Number	Item
FL-1	Develop and implement a unidirectional flushing (UDF) program

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
FL-1-1A	**Basic Flushing Equipment**	**-**	**1**	**ls**	**$10,600**	**$10,000**	**-**	**Cost includes two sets of the following: 4.5inch or larger diffuser, a pitot gauge or other flow-measurement device, dechlorination equipment, and field analytical equipment. Cost was in 2015 dollars**	**Friedman et al., 2016**
FL-1-2	**UDF Pilot Study**					**$25,000**		**Study to be performed on 2 miles of water pipe.**	
	Professional Engineering Services	-	1	ls	$25,000	$25,000	-	Planned task. Includes optimal loop layout, water disposal, and monitoring to document water quality impacts.	Municipal Water Distribution System Optimization Engineering, Amendment 1, Additional Requested Optimization Assistance, Scope of Services, dated 02/03/2017
	Utility Staff Planning Support	-	8	hr	$70	$600	-	Assumes utility staff rate of $70/hr and 4 hrs of effort	Assumed
	Utility Crew Field Support	-	18	hr	$50	$900	-	Assumes utility staff rate of $50/hr and 20 hrs of effort	Assumed
FL-1-3A	**Full System UDF**					**$730,000**	**2.23**	**Program assumes flushing can occur only 6-months of the year. Based on a 5-day work week and a two man crew flushing 2 miles of main per day, the full prorgam**	**Assumed**
	Utility Labor	-	580	pipe-mile	$860	$498,800	-	See details below. Cost was in 2015 dollars and escalated to 2017 dollars.	Table 7.4 (Friedman et al., 2016)
	Utility Staff Project Planning/Coordination	-	-	-	-	incl. above	-	Based on utility staff rate of $70/hr and 2 hrs of effort	Friedman et al., 2016
	Utility Staff Follow-up Activities/Reporting	-	-	-	-	incl. above	-	Based on utility staff rate of $70/hr and 1 hrs of effort	Friedman et al., 2016
	Utility Crews Asset Pre-Inspection	-	-	-	-	incl. above	-	Based on utility crew rate of $50/hr and 4 hrs of effort	Friedman et al., 2016
	Utility Crew Main Cleaning Operation	-	-	-	-	incl. above	-	Based on utility crew rate of $50/hr and 8 hrs of effort	Friedman et al., 2016
	Other Utility Resources	-	580	pipe-mile	$360	$208,800	-	See details below. Cost was in 2015 dollars and escalated to 2017 dollars.	Table 7.4 (Friedman et al., 2016)
	Vehicle Use: Asset Pre-Inspection	-	-	-	-	incl. above	-	Assumes truck rate of $50/day and 0.5 truck days per pipe mile with a 2 person crew, one truck per crew.	Friedman et al., 2016
	Vehicle Use: Mains Cleaning Operation	-	-	-	-	incl. above	-	Assumes truck rate of $50/day and 1 truck day per pipe mile, one truck per crew member.	Friedman et al., 2016
	Water Use	-	-	-	-	incl. above	-	Based on 4 pipe volumes of water displaced per unit.	Friedman et al., 2016
	Analytical (Lab)	-	-	-	-	incl. above	-	Based on estimated $120 per sample. 1 Sample per	Friedman et al., 2016
	Optimize Flushing Loops	-	1	ls	$20,000	$20,000	-	Professional engineering services to optimize flushing loops through use of the hydraulic model	Assumed
Recurring Costs									
FL-1-1B	**Basic Flushing Equipment**	**10**	**1**	**ls**	**$10,600**	**$10,000**	**-**	**Cost includes two sets of the following: 4.5inch or larger diffuser, a pitot gauge or other flow-measurement device, dechlorination equipment, and field analytical equipment. Expected 10-year service**	**Friedman et al., 2016**
FL-1-3B	**UDF of Problematic Areas**	**1**				**$70,000**	**0.17**	**Assumes a 10% (58 miles) of pipe per year and a two man crew for one month per year**	**Assumed**
	Utility Labor	-	58	pipe-mile	$860	$49,900	-		
	Utility Staff Project Planning/Coordination	-	-	-	-	incl. above	-	Based on utility staff rate of $70/hr and 2 hrs of effort	Friedman et al., 2016
	Utility Staff Follow-up Activities/Reporting	-	-	-	-	incl. above	-	Based on utility staff rate of $70/hr and 1 hrs of effort	Friedman et al., 2016
	Utility Crews Asset Pre-Inspection	-	-	-	-	incl. above	-	Based on utility crew rate of $50/hr and 4 hrs of effort	Friedman et al., 2016
	Utility Crew Main Cleaning Operation	-	-	-	-	incl. above	-	Based on utility crew rate of $50/hr and 8 hrs of effort	Friedman et al., 2016
	Other Utility Resources	-	58	pipe-mile	$360	$20,900	-		

Item Number	Item
FL-1	Develop and implement a unidirectional flushing (UDF) program

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
	Vehicle Use: Asset Pre-Inspection	-	-	-	-	incl. above	-	Based on truck rate of $50/day and 0.5 truck days per pipe mile with a 2 person crew, one truck per crew	Friedman et al., 2016
	Vehicle Use: Mains Cleaning Operation	-	-	-	-	incl. above	-	Based on truck rate of $50/day and 1 truck day per pipe mile, one truck per crew member	Friedman et al., 2016
	Water Use	-	-	-	-	incl. above	-	Based on 4 pipe volumes of water displaced per unit.	Friedman et al., 2016
	Analytical (Lab)	-	-	-	-	incl. above	-	Based on estimated $120 per sample. 1 Sample per	Friedman et al., 2016
FL-1-4	**Review and update SOPs**	**1**	**16**	**hr**	**$70**	**$1,000**	**0.01**	**Assumes two staff members for one day per year**	**Assumed**

Item Number	Item
HM-1	Further calibrate hydraulic model
HM-2	Conduct water quality calibration
HM-3	Develop and implement model maintenance plan

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
HM-1-1	**Further calibrate hydraulic model**					**$40,000**			
	Professional Engineering Services	-	1	ls	$35,000	$35,000	-	Includes calibration, fire flow testing training, identification of large use demand patterns, and determination of peak annual flow conditions	Based on pricing from similar projects
	Utility Staff: Field Fire Flow Testing	-	80	hr	$70	$5,600	0.04	Assumed two staff members for one week	Assumed
HM-2-1	**Conduct water quality calibration**					**$15,000**			
	Professional Engineering Services	-	1	ls	$15,000	$15,000	-	Perform water quality calibration using chlorine residual data	Based on pricing from similar projects
	Utility Staff: Water quality monitoring	-	-	-	-	not incl.	-	Assumed that existing data is robust (based on collection efforts from the City of Flint and USEPA)	Assumed
HM-3-1A	**Purchase model software**	**-**	**1**	**ls**	**$27,800**	**$30,000**	**-**	**Assume use of WaterGEMS or InfoWater and an unlimited pipes license. It should be noted that use of EPANET would be practical for Flint, but EPANET does not interface with GIS and therefore is not a best practice.**	**Based on pricing provided by vendors from June 2014 escalated to 2017 dollars**
HM-3-2	**Model training**	**-**	**1**	**ls**	**$25,000**	**$25,000**	**-**	**Assumes professional engineering services. Includes preparation of training materials, and two workshops with City of Flint staff that will focus on basic model usage, staff modeling goals, location of input/output data, examples of how to export model results for viewing and use of the newly developed hydraulic model for analyzing standard model simulations**	**Based on pricing from similar projects**
Recurring Costs									
HM-3-1B	**Annual software maintenance fees**	**1**	**1**	**ls**	**$6,700**	**$10,000**	**-**	**Assume use of WaterGEMS or InfoWater and an unlimited pipes license. It should be noted that use of EPANET would be practical for Flint, but EPANET does not interface with GIS and therefore is not a best practice.**	**Based on pricing provided by vendors from June 2014 escalated to 2017 dollars**
HM-3-3	**Develop and implement model maintenance plan**					**$20,000**			
	Utility Staff: Model Maintenance	1	160	hr	$70	$11,200	0.08	Assumed one staff member for one month per year to update infrastructure, operating conditions, and calibration; review and update SOPs; compare water quality results against grab sample, online monitoring and complaint data and adjust as needed	Assumed
	Professional engineering support	1	1	ls	$10,000	$10,000	-	As-needed support for troubleshooting and calibration	Assumed

Item Number	Item
IT-1	SCADA Upgrages

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
IT-1-0	SCADA upgrades	-	1	ls	$100,000	$100,000	-	Assumed allowance for needed SCADA upgrades by a third party, including increased staff access	Assumed
Recurring Costs									
None identified									

Item Number	Item
IC-1	Establish and Conduct a Whole House Flushing Program
IC-2	Develop and Implement a Phosphate Management plan (see also Water Quality Sampling and Response)

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
IC-1-1	Whole House Flushing	-	1	ls	$33,500	$35,000	-	Planned Task. Includes development of protocols and support to help implement whole house flushing to remove particulate lead; assumes DEQ will perform samping and analysis services	Municipal Water Distribution System Optimization Engineering, Amendment 1, Additional Requested Optimization Assistance, Scope of Services, dated 02/03/2017
Recurring Costs									
WQ-1-4	Enter and track water quality parameter (WQP) data	-	-	-	-	Incl. in WQ sampling			
IC-1-2	Conduct Whole House Flushing Program	1	4160	hr	$70	$291,000	2	Assume two dedicated full time staff members	Assumed
IC-2-1	Track dosing at storage facilities	1	24	hr	$70	$2,000	0.01	Assumed one staff member for two hours per month	Assumed
IC-0-1	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed

Item Number	Item
MB-1	Develop and implement a main break management plan

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
VH-3-1	GPS valves and hydrants and enter into GIS	-	-	-	-	Incl. in Valves & Hydrants			
RR-2-1	Populate pipes in GIS	-	-	-	-	Incl. in Pipe Install, Rehab & Replacement			
RR-2-2	Hydraulic Modeling Criticality Assessment	-	-	-	-	Incl. in Pipe Install, Rehab & Replacement			
Recurring Costs									
WL-1-1B	Annual leak testing	-	-	-	-	Incl. in Water Loss Control			
MB-1-4	Enter and track main break data in EAM system	1	192	hr	$70	$15,000	0.09	Assumes one staff member for two days per month	Assumed
MB-1-5	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed

Item Number	Item
OM-1	Expand Existing Online Monitoring Capabilities

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
OM-1-1A	**Implement Six Online Monitoring Stations**					**$570,000**			
	Hach Water Distribution Monitoring Panels	10	6	ea.	$14,150	$84,900	-	Includes Hach-CL17 Free Chlorine, Hach-1720E Turbidity, Hach/GLI-Digital pH Sensor, Hach/GLI-Digital Cond. Sensor, Gems-Pressure Sensor, SC1000 Controller, Mounting Panel- Wall Mounted, Fully Assembled & Tested, plus 10% for sales tax and freight	Based on pricing provided by Hach from May 2016 escalated to 2017 dollars
	Hach Water Information Management System (WIMS) Software	10	1	ls	$12,300	$12,300	-	Includes Hach WIMS with 5 concurrent users, 1 facility database and 1 year of support plus standard SCADA interface; standard LIMS interface not included	Based on pricing provided by Hach from May 2016 escalated to 2017 dollars
	Hach WIMS Services	-	1	ls	$34,590	$34,600	-	Includes conversion services, drinking water implementation services, 3 days of onsite training and services, and 2 days of onsite follow up services	Based on pricing provided by Hach from May 2016 escalated to 2017 dollars
	Ancillary Materials	-	1	ls	$10,000	$10,000	-	Assumed	Assumed
	Professional Engineering Services: Design and Construction Administration	-	6	ea.	$18,000	$108,000	-	Includes station design, permitting, contractor procurement and health and safety planning/oversight. Assumes sites have adequate power, sewer, etc. and minimal modifications are needed to accommodate these panels	Based on installation prices from similar projects
	Installation	-	6	ea.	$25,000	$150,000	-	Includes contractor costs for plumbing, electric and equipment installation. Assumes adequate power, telemetry & sanitary sewer connection already at site.	Based on installation prices from similar projects
	Start-up and training	-	1	ls	$20,000	$20,000	-	Assumed 4-day site visit by Hach	Assumed
	Utility Staff: System Troubleshooting and Evaluation	-	1040	hr	$70	$72,800	0.5	Assumes two staff members for three months	Assumed
	Professional Engineering Services: IT and System Troubleshooting	-	1	ls	$75,000	$75,000	-	Includes System Troubleshooting and Evaluation, Communication Testing, Data Integration and IT Troubleshooting and Support	Assumed
OM-1-2	**Indetify optimal sensor placement**	**-**	**1**	**ls**	**$12,980**	**$15,000**	**-**	**Planned Task. Includes hydraulic modeling to review proposed sensor locations**	**Municipal Water Distribution System Optimization Engineering, Amendment 1, Additional Requested Optimization Assistance, Scope of Services, dated 02/03/2017**
OM-1-3	**Implement Event Detection System**	**-**	**-**	**-**	**-**	**incl. above**	**-**	**Assumed no additional hardware or softwarec costs; will establish set points for individual parameters and integrate with WIMS**	**Assumed**
Recurring Costs									
OM-1-1B	**Water Distribution Panel Maintenance**					**$80,000**			
	Hach Field Services	1	6	ea.	$2,330	$14,000	-	Includes on-site calibrations, factory recommended maintenance (including required parts), unlimited technical support calls and firmware updates	Based on pricing provided by Hach from May 2016 escalated to 2017 dollars
	Replacement Parts	1	-	-	-	incl. above	-		
	Consumables	1	1	ls	$5,000	$5,000	-	Assumed	Assumed

Item Number	Item
OM-1	Expand Existing Online Monitoring Capabilities

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
	Utility Staff: Routine Labor	1	704	hr	$70	$49,300	0.34	Assumed one staff member for one day per week for visual inspections and three days per month for monthly sample validation and periodic cleaning for six units	Assumed
	Utility Staff: Miscellaneous Troubleshooting	1	160	hr	$70	$11,200	0.08	Assumes one staff member for four weeks per year	Assumed
OM-1-4	**Review data and setpoints**	**1**	**96**	**hr**	**$70**	**$5,000**	0.05	**Assumes one staff member for one day per month**	**Assumed**
OM-1-5	**Review and update SOPs**	**1**	**16**	**hr**	**$70**	**$1,000**	0.01	**Assumes two staff members for one day per year**	**Assumed**

Item Number	Item
RR-1	Update Design and Construction Standards
RR-2	Develop a Risk-Based Repair and Replacement Program

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
RR-1-1A	Update design and construction standards	-	1	ls	$150,000	$150,000	-		
RR-2-1	Populate pipe assets in GIS	-	1	ls	$150,000	$150,000	-	Assumes professional engineering services and that current GIS condition requires significant resolution, materials and install date updates.	Based on pricing from similar projects
RR-2-2	Hydraulic Modeling Criticality Assessment	-	1	ls	$13,000	$13,000	-	Planned task.	Municipal Water Distribution System Optimization Engineering, Amendment 1, Additional Requested Optimization Assistance, Scope of Services, dated 02/03/2017
Recurring Costs									
RR-1-1B	Annually Review Design Standards	1	80	hr	$70	$5,000	0.04	Assumes one staff member for two weeks per year	Assumed
RR-1-1C	Professional Review of Design Standards	5	1	ls	$25,000	$25,000	-		Assumed
RR-2-3	Pipe repair/replacements 2017-2030	1	147,840	LF	$250	$36,960,000	0.5	Working towards getting pipe age under 100 years. Includes design, construction, hydrants, valves, services, restoration (backfill and paving), contingency, oversight, etc. for pipe up to 8" diameter (the weighted average system pipe size based on miles of installed pipe). Costs are in 2017 dollars and would need to be escalated. Assumes one staff member for program management at half time per year.	Based on unit pricing from similar projects
RR-2-4	Pipe repair/replacements 2030+	1	31,680	LF	$250	$7,920,000	0.5	Based on 1% replacement; typical benchmarks. Includes design, construction, hydrants, valves, services, restoration (backfill and paving), contingency, oversight, etc. for pipe up to 8" diameter (the weighted average pipe size based on miles of installed pipe). Costs are in 2017 dollars and would need to be escalated. Assumes one staff member for program management at half time per year.	Based on unit pricing from similar projects
RR-2-5	Utility Staff: Update GIS Data after R/R	1	1040	hr	$70	$75,000	0.50	Records to be updated following rehab and replacement of assets as well as any new installation. Assumes one staff member for six months per year	Assumed
RR-0-1	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed

Item Number	Item
PR-1	Develop and Implement a Pressure Management Plan

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
OM-1-1A	Install pressure monitoring stations	-	-	-	-	Incl. in online monitoring			
PR-1-1	Surge Analysis/Pressure Management: Booster Pump Stations and Ground Storage Facilities Evaluation	-	1	ls	$14,800	$15,000	-	Planned task. Includes analaysis focused on each of the booster pumping stations and controsl valve structures at the ground storage facilities	Municipal Water Distribution System Optimization Engineering, Amendment 1, Additional Requested Optimization Assistance, Scope of Services, dated 02/03/2017
PR-1-2	Surge Analysis/Pressure Management: Comprehensive Evaluation	-	1	ls	$150,000	$150,000	-	Cost varies depending upon results from other onoing evaluations (i.e., main breaks, item above) and specific modeling scenarios to be included. Includes istallation of impulse pressure recorders, application of transient model (developed above) for a few locations and used to calibrate to entire system, analysis of filter plant backwashing, pump stations, etc.	Assumed
PR-1-3A	Portable Data Loggers	-	2	ea	$1,000	$2,000	-	Assumed	Assumed
Recurring Costs									
PR-1-4	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed
PR-1-3B	Install and AssessPortable Data Logger Data	1	24	hr	$70	$2,000	0.01	Assumes one staff member for three days per year	Assumed

Item Number	Item
PS-1	Install Pump Control Valves
WA-3	Conduct Needs Assessment (See Water Age Recommendations)

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
PS-1-1	**Install Pump Control Valves**	**-**	**1**	**ls**	**$150,000**	**incl. in below**	**-**	**Includes price for TWO valves: $60K each with $30K for engineering and contingency. Assumes control valves in the 8"-12" range. Price could vary significantly based on sizes.**	**Based on similar projects**
PS-1-2	**Pump Station Facility Rehab**					**$5,000,000**			
	Cedar Street Pump Station Rehabilitation	-	1	ls	$2,000,000	$2,000,000	-	Estimate. A detailed evaluation of the pump station assets is needed to develop a more accurate cost estimate.	Assumed
	West Side Pump Station Rehabilitation	-	1	ls	$2,000,000	$2,000,000	-	Estimate. A detailed evaluation of the pump station assets is needed to develop a more accurate cost estimate.	Assumed
	Torrey Road Booster Station Rehabilitation	-	1	ls	$1,000,000	$1,000,000	-	Estimate. A detailed evaluation of the pump station assets is needed to develop a more accurate cost estimate.	Assumed
PS-1-3A	**Develop specification and project requirements for contracted maintenance**	**-**	**1**	**ls**	**$25,000**	**$25,000**	**-**		
Recurring Costs									
PS-1-4	**Utility Staff: Monthly Inspections**	**1**	**520**	**hr**	**$70**	**$36,400**	**0.25**	**Assumes one staff member quarter time per year**	**Assumed**
PS-1-5	**Utility Staff: Annual Inspections**	**1**	**520**	**hr**	**$70**	**$36,400**	**0.25**	**Assumes two staff members for 20 hours per facility per year, includes mechanical, electrical and structural inspection**	**Assumed**
PS-1-3B	**Contractor: Annual Inspections**	**1**	**1**	**ls**	**50,000**	**$50,000**	**-**		**Assumed**
PS-1-6	**Utility Staff: Long-term Maintenance**	**3-5**	**1040**	**hr**	**$70**	**$72,800**	**0.5**	**Assumes one staff member half time per year**	**Assumed**
PS-0-1	**Review and update SOPs**	**1**	**16**	**hr**	**$70**	**$1,100**	**0.01**	**Assumes two staff members for one day per year**	**Assumed**

Item Number	Item
SE-1	Increase Physical Security of the Assets
SE-2	Increase Emergency Preparedness
SE-3	Mitigate Security Risks

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
SE-1-1A	**Increase control and intrusion detection of assets**					**$215,000**		**Based on Standard G430-14**	
	Access control - System (Software and Licensing)	10	1	ls	$30,000	$30,000	--	includes software and licensing	Based on similar project costs
	Access control - Door Contacts and Card Reader Systems (Equipment)	10	8	ea	$4,200	$33,600	--	Assuming two doors per pump station and Water Service Center bldg; costs for door controller panels and access control (card reader, door locks, door contacts,	Based on similar project costs
	Access control - Technical Oversight (Design, protocol development)	10	1	ls	$8,000	$8,000	--	Assumed professional engineering services	Assumed
	Access control - Flint staff time (Installation, protocol development)	10	100	$/hr	$70	$7,000	0.05	Assume 100 hours for one staff member	Assumed
	Security cameras - System (Software, Licensing, General Equipment)	10	1	ls	$71,600	$71,600	--	includes software and licensing, video storage server, uninterruptible power supply per building and one for	Based on similar project costs
	Security cameras - PTZ Cameras (Equipment)	10	8	ea	$5,000	$40,000	--	Assuming two PTZ cameras per pump station and Water Service Center bldg; costs for cameras	Based on similar project costs
	Security cameras - Fixed Cameras (Equipment)	10	4	ea	$3,000	$12,000	--	Assuming one fixed camera per pump station and Water Service Center bldg; costs for cameras	Based on similar project costs
	Security cameras - Technical Oversight (Design, protocol development)	10	1	ls	$8,000	$8,000	--	Assumed professional engineering services	Assumed
	Security cameras - Flint staff time (Installation, protocol development)	10	100	$/hr	$70	$7,000	0.05	Assume 100 hours for one staff member	Assumed
SE-1-2A	**Fence Cedar Street Pump Station and Reservoir**	--	1	ls	$15,000	$15,000		Assumed to be completed by contractor, includes labor and materials for completely enclosing the property in	**Assumed**
SE-2-1A	**Update the existing ERP to meet FEMA standards**					**$85,000**	**--**		
	ERP update - Technical Oversight	5	1	ls	$75,000	$75,000	--	Assuming professional engineering services; ERP would be updated for whole system, not just distribution system, because a partial ERP would not make sense	Assumed
	ERP update - Flint Staff	5	160	$/hr	$70	$11,200	0.08	Assuming 160 hours for one staff member	Assumed
SE-3-1A	**Obtain cyber security for SCADA/instruments outside the plant**					**$40,000**			
	Firewall - Equipment	10	1	ls	$21,000	$21,000	--	equipment includes firewall, OS, server, switch; depending on the network set-up, there are other options that could be considered at different price	Based on similar project costs
	Firewall - Technical Oversight (Design, Installation and configuration)	10	1	ls	$15,000	$15,000	--	Assumed	Assumed
	Firewall - Flint Staff (Training)	10	40	$/hr	$70	$2,800	0.02	Assuming one staff member for one week for firewall training and project assistance	Assumed
SE-3-1B	**Conduct a cyber security gap assessment**					**$60,000**			
	Cyber gap assessment - Consultant (Technical Oversight)	5	1	ls	$50,000	$50,000	--	Assumed	Assumed
	Cyber gap assessment - Flint Staff	5	120	$/hr	$70	$8,400	0.06	Assuming 120 hours for one staff member to assist in gap assessment data gathering and conversations	Assumed
SE-3-2A	**Complete a vulnerability assessment/funding assessment**					**$70,000**			
	Vulnerability Assessment - Consultant (Technical Oversight)	5	1	ls	$45,000	$45,000	--	Assumes professional engineering services including travel	Assumed
	Funding Assessment - Consultant	5	1	ls	$10,000	$10,000	--	Assumed	Based on similar project costs

Item Number	Item
SE-1	Increase Physical Security of the Assets
SE-2	Increase Emergency Preparedness
SE-3	Mitigate Security Risks

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
	Vulnerability assessment - Flint Staff	5	200	$/hr	$70	$14,000	0.10	Assuming 200 hours for one staff member	Assumed
Recurring Costs									
SE-1-1B	**Increase control and intrusion detection of assets**					**$5,000**		**Based on Standard G430-14**	
	Access Control - Perform annual inspection of critical assets	1	40	$/hr	$70	$2,800	0.02	Assuming one staff member for one week	Assumed
	Access Control - Regular maintenance of employee lists and access	1	16	$/hr	$70	$1,100	0.01	Assuming one staff member for two days	Assumed
SE-1-2B	**Cedar Street Fencing - Remove plant growth from fencing**	**1**	**16**	**$/hr**	**$70**	**$1,000**	**0.01**	**Assuming one staff member for two days**	**Assumed**
SE-2-1B	**Update the existing ERP to meet FEMA standards**					**$70,000**	**--**		Assumed
	ERP update - Technical Oversight	5	1	ls	$57,000	$57,000	--	Assuming profressional engineering services including travel; ERP would be updated for whole system, not just distribution system, because a partial ERP would not make sense	Assumed
	ERP update - Flint Staff	5	160	$/hr	$70	$11,200	0.08	Assuming 160 hours for one staff member	Assumed
SE-2-1C	**Regular exercise and review of the ERP**					**$35,000**			
	Regular exercise and review of the ERP - Technical Oversight	1	1	ls	$20,000	$20,000	--	Assuming exercise oversight for two exercises a year	Assumed
	Regular exercise and review of the ERP - Flint Staff	1	200	hr	$70	$14,000	0.10	Assuming two 8-hour exercises for 10 employees, with 40 hours for ERP reviews by one staff member	Assumed
SE-2-2	**Strengthen communications and relations needed for ER**	**1**	**104**	**hr**	**$70**	**$5,000**	0.05	**Assuming one staff member for two hours per week**	**Assumed**
SE-3-1C	**Conduct a cyber security gap assessment**					**$55,000**			
	Cyber gap assessment - Consultant (Technical Oversight)	5	1	ls	$50,000	$50,000	--	Assumed professional engineering services	Assumed
	Cyber gap assessment - Flint Staff	5	80	hr	$70	$5,600	0.04	Assuming one staff member for two weeks to assist in gap assessment data gathering and conversations	Assumed
SE-3-2B	**Complete a vulnerability assessment/funding assessment**					**$70,000**			
	Vulnerability Assessment - Consultant (Technical Oversight)	5	1	ls	$45,000	$45,000	--	Assuming profressional engineering services including travel	Assumed
	Funding Assessment - Consultant	5	1	ls	$10,000	$10,000	--	Assuming profressional engineering services	Based on similar project costs
	Vulnerability assessment - Flint Staff	5	200	hr	$70	$14,000	0.10	Assuming 200 hours for one staff member	Assumed
SE-3-3	**Monitor distribution system assets**	**1**	**8760**	**hr**	**$30**	**$265,000**	**4.21**	**Assuming one security guard 24/7 to monitor assets and security cameras**	**Assumed**
SE-3-4	**Participate in Genesee County Hazard Mitigation Process**	**1**	**52**	**hr**	**$70**	**$3,600**	**0.03**	**Assuming one staff member for 1 hour per week**	**Assumed**
SE 0-1	**Review and update SOPs**	**1**	**16**	**hr**	**$70**	**$1,000**	**0.01**	**Assumes two staff members for one day per year**	**Assumed**

Item Number	Item
SF-1	Replace Inlet Valves
SF-2	Conduct Storage Facility Inspections
WA-3	Conduct Hydraulic Analysis of Storage Facilities (See Water Age Recommendations)

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
SF-1-1	Replace Inlet Valves	-	1	ls	$250,000	$250,000	-	Price includes TWO valves: $100K each with $50K for engineering and contingency. Assumes valves in the 18"-30" range. Price could vary significantly based on sizes.	Based on similar projects
SF-2-3A	Develop specification and project requirements for contracted maintenance	-	1	ls	$25,000	$25,000	-		Assumed
Recurring Costs									
SF-2-1	Utility Staff: Monthly Inspections	1	200	hr	$70	$15,000	0.10	Assumes one staff member for 200 hours per year	Assumed
SF-2-2	Utility Staff: Annual Inspections	1	100	hr	$70	$5,000	0.05	Assumes one staff member for 100 hours per year	Assumed
SF-2-3B	Contractor: Comprehensive Inspection	3-5 yrs	5	ls	$25,000	$125,000	-	Includes Dort Reservoir, Elevated Tank and clearwell at WTP	Assumed
SF-2-4	Utility Staff: Comprehensive Inspections	3-5 yrs	400	hr	$70	$30,000	0.19	Assumes one staff member for 400 hours per year	Assumed
SF-0-1	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed

Item Number	Item
VH-1	Followup on known issues from Wachs 2015 Valve Assessment
VH-2	Replace 1908 Darling Hydrants
VH-3	Finish inventorying/GPS hydrants (1713 completed/3605 total)
VH-4	Complete comprehensive data model review & update
VH-5	Complete Resource Optimization Study (Water Service Center)
VH-6	Develop/Update a Planned/Preventative Maintenance Plan
VH-7	Implement Updated Hardware/Software and Required Support

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
VH-1-1	**Follow up on known issues from Wachs 2015 Valve Assessment**					**$9,060,000**			**Wachs Water (2015)**
	Replace inoperable valves (frozen, spin free, damaged) or confirmed poor condition		332	ea.	$24,000	$7,968,000	2.55	Assumed $2k per inch, assumed 8-in avg diameter	Excluding 85 valves replaced in 2016
	Op-Nut Replacements		333	ea.	$600	$199,800	0.51		Assumed
	Other minor repairs (large vac needed, misaligned/damaged box)		490	ea.	$100	$49,000	0.75	Assume 5 per day, 2 man crew	Assumed
	Valves paved over		715	ea.	$1,000	$715,000		Assumed consultant services	Assumed
	Followup on valves "unable to locate"		1850	hr	$70	$129,500	1.00	Assume 5 per day, 2 man crew and 578 valves	Assumed
	Reconcile map discrepancies		8	hr	$70	$600	0.06	Assume 10 min each and 1217 discrepancies	Assumed
VH-2-1	**Replace 1908 Darling Hydrants**					**$305,000**			
	New Hydrants		60	ea.	$4,000	$240,000	0.46	Hydrant range $2-5K - assume 1%	Assumed
	Utility Staff Labor		960	hr	$70	$67,200		Assume 1 day per hydrant for a 2 man-crew	Assumed
VH-3-1	**Complete inventorying/GPS hydrants (1713 completed/3605 total)**		**1**	**ls**	**$50,000**	**$50,000**		**Assumes professional engineering services; Update GIS to include missing fields (estimate year installed), review manuals and develop PM training**	**Assumed**
VH-4-1	**Comprehensive data model review & update**		**1**	**ls**	**$150,000**	**$150,000**		**Assumed consultant services; includes development of plan to migrate into a single data repository, asset identification number evaluation, identification of potential impact on other City processes/systems/interfaces, review process for tracking leaks, integratation with hydraulic model,**	**Assumed**
VH-5-1	**Resource Optimization Study (Water Service Center)**		**1**	**ls**	**$80,000**	**$80,000**		**Assumed consultant services; evaluate feasibility of department reorganization, inventory hardware and softwar, upgrade computers**	**Assumed**
VH-6-1A	**Develop a Planned/Preventative Maintenance Plan**		**1**	**ls**	**$30,000**	**$30,000**		**Assumed consultant services; includes identification of critical appurtenances, valve sequencing and tracking, coordination with hydraulic model and UDF, establishment of levels of service goals and utility**	**Assumed**
VH-6-2A	**Develop Valve & Hydrant Manual Library**		**1**	**ls**	**$10,000**	**$10,000**		**Assume outsource**	**Assumed**
VH-7-1A	**Hardware and Software Upgrades**		**1**	**ls**	**$135,000**	**$135,000**		**Includes costs to replace current hardware (variety of laptop/tablets/GPS) with 5 new GPS-enabled tablets (consistent hardware in Dept) including data plan, iWater infraMAP software licensing, configuration of iWater, testing, training and support for iWater and**	**Assumed**
Recurring Costs									
VH-6-1B	**Planned/Preventative Maintenance of Valves & Hydrants**					**$4,180,000**			
	Valve Inspections & Exercising (less than 16-in)	1	4,538	hr	$70	$317,700	2.18	Assume 5 per day, 2 man crew	
	Valve Inspections & Exercising (Gate)	1	4,688	hr	$70	$328,200	2.25	Assume 5 per day, 2 man crew	
	Hydrant Inspections & Maintenance	1	320	hr	$70	$22,400	0.15	Estimated - currently unknown count of gate valves	
		1	2,307	hr	$70	$161,500	1.11	Assuming 25 hydrants per day, 2 man crew	

Item Number	Item
VH-1	Followup on known issues from Wachs 2015 Valve Assessment
VH-2	Replace 1908 Darling Hydrants
VH-3	Finish inventorying/GPS hydrants (1713 completed/3605 total)
VH-4	Complete comprehensive data model review & update
VH-5	Complete Resource Optimization Study (Water Service Center)
VH-6	Develop/Update a Planned/Preventative Maintenance Plan
VH-7	Implement Updated Hardware/Software and Required Support

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
	Assume 2% valves replaced/repaired (due to condition)	1	132	ea.	$24,000	$3,162,200	1.01	Assume 2% require replacement x $2k per inch average	per Wachs statistics (199 valves frozen/spin free out of 8228 valves assessed in 2015)
	Assume 1% hydrants need replacement/repair (due to condition)	1	36	ea.	$4,000	$144,200	0.28	Hydrant range $2-5K - assume 1%	
	Winter Preparation	1	400	hr	$70	$28,000	0.19	Estimated 2 weeks x 5 FTE	
	Reporting - KPI Benchmarking (quarterly/annually)	1	160	hr	$70	$11,200	0.1	1 GIS Tech, 1 week every quarter	
	Annual review/update of plan/logistics/KPIs	1	40	hr	$70	$2,800	0.02	1 GIS Tech, 1 week per year	
VH-6-2B	**Planned Repair & Replacement of Valves & Hydrants (due to age)**					**incl. in Pipe R&R item RR-2-3**			
	Replace appurtenances approaching end of useful life	1	339	ea.	$24,000	$8,129,000	2.61	$2k per inch average, assumed 8-in avg dia, 1 valve per day	Same assumption as pipeline replacement (28 miles per year thru 2030)
	Based on results of Preventative Maintenance Plan	1	168	ea.	$4,000	$672,900	1.29	Hydrant avg life expectancy (properly maintained)= 100 years	~5% per year (National avg is 1-2% system replaced per year)
VH-7-1B	**Hardware and Software Upgrades**					**$70,000**			
	Annual tablet data plan cost (or hot spot)	1	5	$/yr	$600	$3,000		Assume $50 per month x 5 iPads	Assumed
	Allowance to buy 1 new iPad per year	1	1	ls	$1,000	$1,000			Assumed
	iWater infraMAP software licensing maintenance	1	1	ls	$50,000	$50,000			Based on similar projects
	iWater infraMAP software support and annual enhancements	1	1	ls	$5,000	$5,000			Based on similar projects
	ESRI licensing (including ArcGIS Online subscription)	1	1	ls	$10,000	$10,000			Based on similar projects
VH-7-2B	**GIS Support**					**$95,000**			
	Quarterly/Annual Map Updates	1	200	hr	$70	$14,000	0.10	Assume 1 week each quarter + 1 week year end	Assumed
	Map/Book Printing	1	200	hr	$70	$14,000	0.10	Assume 1 week each quarter + 1 week year end	Assumed
	Online Portal Updates	1	200	hr	$70	$14,000	0.10	Assume 1 week each quarter + 1 week year end	Assumed
	Annual data model enhancements	1	173	hr	$70	$12,100	0.08	Assume 1 month per year	Assumed
	Annual reporting	1	40	hr	$70	$2,800	0.02	Assume 1 week per year	Assumed
	iWater infraMap Support	1	480	hr	$70	$33,600	0.23	Assume 1 week per month	Assumed
	Annual training	1	1	ls	$5,000	$5,000	0.02	Assume 1 week at ESRI User Conference and travel expenses	Assumed
VH-0-1	**Review and update SOPs**	**1**	**16**	**hr**	**$70**	**$1,000**	**0.02**	**Assumes two staff members for one day per year**	**Assumed**

Item Number	Item
WA-1	Evaluate flushing locations
WA-2	Optimize storage facilities
WA-3	Assess storage needs
WA-4	Develop water system demand projections
-	Develop and implement a unidirectional flushing program (See Flushing Item No. FL-1)

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
WA-0-1	Water Age Analysis	-	1	ls	$17,000	$15,000	-	Planned Task. Includes evaluation of the overall system water age and identification of areas within the distribution system characterized by the highest water age plus simulations to mitigate areas of greatest concern via select methods such as pipe looping, flow path modifications or scheduled flushing	Municipal Water Distribution System Optimization Engineering, Amendment 1, Additional Requested Optimization Assistance, Scope of Services, dated 02/03/2017
WA-2-1	Optimize storage facilities	-	1	ls	$15,000	$15,000	-	Includes model simulations to optimize operation of existing storage facilities	Assumed
WA-3-1	Distribution Storage Analysis	-	1	ls	$13,000	$15,000	-	Planned Task. Includes a storage gap analysis to determine the appropriate total storage volume for current system demands and simulations of each of the storage facilities being individually removed from service to determine the impact to available fire flow rates, system pressure during annual maximum day demands, and pumping operations	Municipal Water Distribution System Optimization Engineering, Amendment 1, Additional Requested Optimization Assistance, Scope of Services, dated 02/03/2017
Recurring Costs									
WA-1-1	Evaluation of flushing locations (autoflushers)	1	32	hr	$70	$2,000	0.02	Assumes one staff member for one day per quarter	Assumed
WA-4-1	Update Water System Demand Projections	1	40	hr	$70	$5,000	0.02	Assumes one staff member for one week per year	Assumed
WA-0-1	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed

Item Number	Item
WL-1	Develop and Implement a Water Loss Control Program
WL-2	Develop a Meter Replacement Program
WL-3	Establish an internal Water Loss (Non-Revenue Water (NRW)) Management Team
WL-4	Participate in the AWWA Water Loss Control Committee Water Audit Data Initiative

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
WL-3-1	**Form an Internal Water Loss Management Team**	**-**	**144**	**hr**	**70**	**$10,000**	**0.07**	**Appoint ex-officio Chair and a Managing Team Leader. Appoint a representative from each involved Department including Water Service Center, Read-to-Bill System, Supply Metering, Customer Metering, Field Services, Customer Services, System Development, Distribution System Operations and Maintenance, Leak Survey and Repair, Instrument Tech, SCADA Tech, IT. Assume 12 persons at monthly**	**Best Practice Guidance, AWWA M36**
WL-1-1A	**Develop Water Loss Control Plan**					**$605,000**			
	Conduct Water Audit - Yr 1 (Internal)	-	2880	hr	70	$201,600	1.38	Assume start-up in one staff member for 30 days (Prep for Kickoff - 1 days, Kickoff - 1 day, Task Development - 5 days, Plan Kickoff - 1 day, Implementation - 10 days , Tracking 1 day per month. Team Leader responsible for Annual Report. Improve Data Validity Score to Level 3 (Year 1). Achieve Water Loss Control Planning objectives for Functional Focus Areas defined in FWAS	Best Practice Guidance, AWWA M36, Free Water Audit Software
	Water Audit Training and Level 1 Validation (External)	-	1	ls	$20,000	$20,000	-	Assume Consultant assistance to train Flint WLM Team to perform annual water audit, with Level 1 validation by 3rd party (Year 1).	Best Practice Guidance, AWWA M36, Free Water Audit Software
	Quantify and align authorized consumption (Yr 1) (Internal)	-	80	hr	70	$5,600	0.04	Align authorized consumption with SCADA supply volume for reporting year. Assume 80 hrs.	Best Practice Guidance, AWWA M36
	Determine present expenditures for water loss control activities (Internal)	-	120	hr	70	$8,400	0.06	Convene Flint WLM Team and review labor allocations and internal/external expenditures for water loss control activities. Assume 12 WLM Team Members,	Best Practice Guidance, AWWA M36
	Determine present expenditures for water loss control activities (External)	-	1	ls	$2,500	$2,500	-	Assumed professional engineering services	Assumed
	Perform Benefit:Cost Analysis of candidate water loss control activities (External)	-	1	ls	$10,000	$10,000	-	Assumed professional engineering services	Assumed
	Test and calibrate supply meters (External)	-	1	ls	$15,000	$15,000	-	Assume $15,000 per yr for all supply meters	Best Practice Guidance, AWWA M36, M6
	Idenitify and control apparent losses								
	Test Residential and small non-Residential Customer Meters (External)	-	300	ea.	$50	$15,000	-	Assume $15,000 per yr for harvesting representative sample of small meters (300 per year or 1%) through 2-inch	Best Practice Guidance, AWWA M36, M6
	Test larger non-Residential Customer Meters (External)	-	80	ea.	$400	$32,000	-	Assume $32,000 per yr for testing representative sample of larger commercial meters (80 per year or 5%)	Best Practice Guidance, AWWA M36, M6
	Identify and minimize unauthorized consumption	-	40	hr	70	$2,800	0.02	Assume 40 hrs per year for one staff member	Best Practice Guidance, AWWA M36
	Review Read-to-Bill System for Systematic Data Handling Error								

Item Number	Item
WL-1	Develop and Implement a Water Loss Control Program
WL-2	Develop a Meter Replacement Program
WL-3	Establish an internal Water Loss (Non-Revenue Water (NRW)) Management Team
WL-4	Participate in the AWWA Water Loss Control Committee Water Audit Data Initiative

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
	Internal	-	10	hr	70	$0	0.005	Assume 10 hrs per year for one staff member	Best Practice Guidance, AWWA M36
	Professional Engineer Services Identify and control real losses	-	1	ls	$10,000	$10,000		Estimate, pending initial discussion with Department sta	Assumed
	Perform Leak Detection Survey	-	2880	hr	70	$201,600	1.4	Assume one 2-man crew to cover 200 miles (approx 1/3 system) each year, assuming 180 days, accounting for weather	Best Practice Guidance, AWWA M36
	Water Audit Level 1 Validation (External)	Year 2 only	1	ls	$5,000	$5,000	-	Level 1 Validation by 3rd Party (Year 2 only)	Best Practice Guidance, AWWA M36, Free Water Audit Software
	Acquire Noise Logger and Pinpointing Equipment -Yr 2 only (Internal)	Yr 2 only	1	ls	$72,500	$72,500		Assume purchase/placement of 100 portable noise loggers in priority areas @$400 each, plus base data collection unit @ $7,500, plus pinpointing correlator and microphone @ $25,000.	Best Practice Guidance, AWWA M36
	Determine present expenditures for water loss control activities and review Benefit:Cost Analysis (External)	Yr 2 only	1	ls	$2,500	$2,500	-	Assumed professional engineering services	Assumed
WL-4-1A	**Participate in AWWA Water Loss Control Committee**	**-**	**20**	**hr**	**70**	**$1,000**	**0.01**	**Select 1 Team Member for WLCC participation (3-yr ter**	**Assumed**
Recurring Costs									
WL-1-1B	**Review Water Loss Control Program**					**$445,000**			
	Monthly WLM Team Meeting	1	144	hr	70	$10,100	0.1	Monitor WLM Plan Progress assuming 12 staff members at one hour per month	
	Conduct Water Audit - Yr 2 and ongoing (Internal)	1	1440	hr	70	$100,800	0.7	Improve Data Validity Score to Level 4 (Year 3), Level 5 (Year 5). Achieve Water Loss Control Planning objectives for Functional Focus Areas defined in FWAS v5.0. Flint WLM Team to perform annual water audit, with Level 1 validation by 3rd party (Year 2). Qualify Flint WLM Team as Qualified Water Loss Audit Validator (Year 2 and ongoing). Assuming 12 staff members for 15 days per year	Best Practice Guidance, AWWA M36, Free Water Audit Software
	Test and calibrate all supply meters (external) Idenitify and control apparent losses	1	1	ls	$15,000	$15,000	-	Assume $15,000 per yr for all supply meters	Best Practice Guidance, AWWA M36, M6
	Test Residential and small non-Residential Customer Meters (External)	1	300	ea.	$50	$15,000	-	Assume $15,000 per yr for harvesting representative sample of small meters (300 per year or 1%) through 2-inch	Best Practice Guidance, AWWA M36, M6
	Test larger non-Residential Customer Meters (External)	1	80	ea.	$400	$32,000	-	Assume $32,000 per yr for testing representative sample of larger commercial meters (80 per year or 5%)	Best Practice Guidance, AWWA M36, M6
	Identify and minimize unauthorized consumption	1	40	hr	70	$2,800	0.02	Assume 40 hrs per year for one staff member	Best Practice Guidance, AWWA M36
	Review Read-to-Bill System for Systematic Data Handling Error (Internal) Identify and control real losses	1	10	hr	70	$700	0.005	Assume 10 hrs per year for one staff member	Best Practice Guidance, AWWA M36

Item Number	Item
WL-1	Develop and Implement a Water Loss Control Program
WL-2	Develop a Meter Replacement Program
WL-3	Establish an internal Water Loss (Non-Revenue Water (NRW)) Management Team
WL-4	Participate in the AWWA Water Loss Control Committee Water Audit Data Initiative

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
	Perform Noise Logger Leak Detection (Internal)	1	720	hr	70	$50,400	0.346	Assume one 2-man crew to cover high priority area each year assuming 45 days to allow for weather	Best Practice Guidance, AWWA M36
	Perform Leak Detection - Yr 2 and ongoing (Internal)	1	2880	hr	70	$201,600	1.4	Assume one 2-man crew to cover 200 miles (approx 1/3 system) each year, assuming 180 days, accounting for weather	Best Practice Guidance, AWWA M36
	Determine present expenditures for water loss control activities and review Benefit:Cost Anaylsis (Internal)	1	120	hr	70	$8,400	0.1	Convene (annually) Flint WLM Team and review labor allocations and internal/external expenditures for water loss control activities. Assume 12 WLM Team Members, each at 10 hrs	Best Practice Guidance, AWWA M36
	Adjust Water Loss Control Program (Internal)	Annual as Needed	20	hr	70	$1,400	0.01	Apply updated Benefit:Cost Analysis, adjust targets if necessary, and recommend modified program (TBD). Assumes one staff member at 20 hours	Best Practice Guidance, AWWA M36
	Adjust Water Loss Control Program (External)	Annual As Needed	1	ls	$5,000	$5,000	-	Assumed professional engineering services	Assumed
WL-4-1B	**Participate in AWWA Water Loss Control Committee**	**1**	**20**	**hr**	**70**	**$1,000**	**0.01**	**Continue 1 Team Member for WLCC participation (3-yr**	**Assumed**
WL-2-1	**Small Meter Replacement Program (External)**	**1**	**3000**	**ea.**	**$150**	**$450,000**	**-**	**Assume 3,000 meters per year @ average $ 150 per meter**	**Best Practice Guidance, AWWA M36, M6**
WL 2-2	**Large Meter Replacement Program (External)**	**1**	**160**	**ea.**	**$2,500**	**$400,000**	**-**	**Assume 160 meters per year @ average $2,500 per meter**	**Best Practice Guidance, AWWA M36, M6**
WL-0-1	**Review and update SOPs**	**1**	**16**	**hr**	**$70**	**$1,000**	**0.01**	**Assumes two staff members for one day per year**	**Assumed**

Item Number	Item
WQ-1	Improve Water Quality Sampling Practices

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
WQ-1-1	Lab Equipment/HVAC Upgrades	-	1	ls	$100,000	$100,000	-	Includes distilled water system, incubator and HVAC upgrades.	Assumed
Recurring Costs									
WQ-1-2	Analyze and Trend Water Quality Data	1	288	hr	$70	$20,000	0.14	Includes all water quality data (incl phosphate, chlorine, DBP, WQP)	Assumed
WQ-1-3	Review and update SOPs	1	16	hr	$70	$1,000	0.01	Assumes two staff members for one day per year	Assumed

Item Number	Item
OT-1	Implement vehicle replacement program

Detailed Cost Estimate (2017 Dollars)

Item Number	Item	Recurrence Interval (Yrs)	Quantity	Unit	Unit Cost	Total Cost	No. of FTEs	Notes	Source
One-Time, Initial Costs									
None identified		-	-	-	-	-	-		
Recurring Costs									
OT-1	Vehicle Replacements	1	1	ls	$500,000	$500,000	-		Based on annual budget from similar size utility

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