ARCADIS Design & Consultancy for natural and built assets

confluence ENGINEERING GROUP LLC | EE&T, Inc. ENVIRONMENTAL ENGINEERING & TECHNOLOGY, INC. | MCCONNELL COMMUNICATIONS, INC.

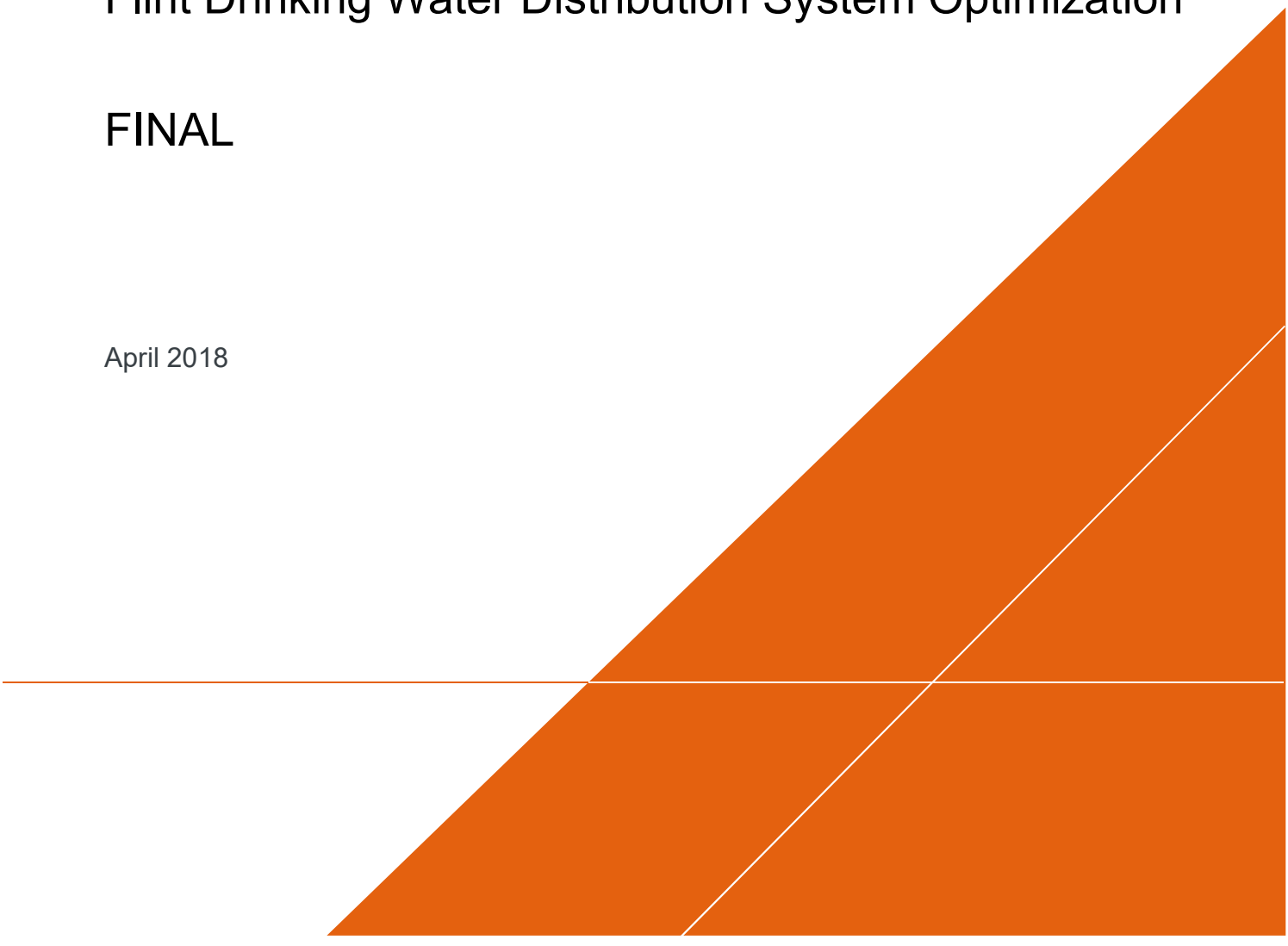
City of Flint, MI

WATER DISTRIBUTION SYSTEM OPTIMIZATION PLAN

Flint Drinking Water Distribution System Optimization

FINAL

April 2018



WATER DISTRIBUTION SYSTEM OPTIMIZATION PLAN

Technical Memorandum

Prepared for:

City of Flint

1101 S. Saginaw Street

Flint, Michigan 48502

Prepared by:

Arcadis of Michigan, LLC

28550 Cabot Drive

Suite 500

Novi

Michigan 48377

Tel 248 994 2240

Fax 248 994 2241

Our Ref.:

20616001.0000

Date:

April 2018

CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

AACE	Association for Advancement of Cost Engineering
AM	Asset Management
AMI	Advanced Metering Infrastructure
AMP	Asset Management Plan
AMR	Automatic Meter Reading
Arcadis	Arcadis of Michigan, LLC
AWWA	American Water Works Association
BSI	British Standards Institution
CCT	Corrosion Control Treatment
CIP	Capital Improvement Plan
City	City of Flint
CLEAR	Confirming Lead Elimination After Replacement
CMMS	Computerized Maintenance Management System
COF	Consequence of failure
CRM	Chlorine Residual Management
CSR	Cedar Street Reservoir
DBP	Disinfection Byproducts
DWRF	Drinking Water Revolving Fund
DWSD	Detroit Water and Sewerage Department
EAM	Enterprise Asset Management
EE&T	Environmental Engineering & Technology, Inc.
ERP	Emergency Response Plan
FEMA	Federal Emergency Management Agency
FTE	Full-Time Equivalent
GCDC	Genesee County Drainage District
GIS	Geographic Information System
GLWA	Great Lakes Water Authority
GO	General Obligation
HUD	Housing and Urban Development

HVAC	Heating, Ventilation, and Air Conditioning
IIMM	International Infrastructure Management Manual
IPWEA	Institute of Public Works Engineering Australia
ISO	International Organization for Standardization
KPI	Key Performance Indicators
KWA	Karegnondi Water Authority
LCR	Lead and Copper Rule
LOF	Likelihood of Failure
LOS	Level of Service
LRAA	Locational Running Annual Average
LSLR	Lead Service Line Replacement
MCL	Maximum Contaminant Level
MDEQ	Michigan Department of Environmental Quality
MDHHS	Michigan Department of Health and Human Services
mg/L	Milligrams per liter
NAMS	New Zealand National Asset Management Steering Group
O&M	Operation and Maintenance
R&R	Rehabilitation and Replacement
RTCR	Revised Total Coliform Rule
SCADA	Supervisory control and data acquisition
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
TM	Technical Memorandum
TTHM	Total Trihalomethanes
UDF	Unidirectional Flushing
USEPA	United States Environmental Protection Agency
WIIN	Water Infrastructure Improvements for the Nation Act
WQ	Water Quality
WQP	Water Quality Parameter
WSO	Water System Operator
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 treated 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 Water 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 compile the results of the analyses conducted as part of an evaluation of the City's water distribution system and its operating practices, including all of the memoranda submitted, and incorporate the results into a prioritized list of recommended improvements to optimize the distribution system. This Water Distribution System Optimization Plan includes a prioritized list of recommended improvements based on industry best practices, complete with required human and financial resources necessary to implement those practices over a period of 20 years based on the prioritization approach and criteria.

Overview of Optimization Program

Several data analysis tools, technical memoranda, standard operating procedures (SOPs), and other recommendations were prepared that collectively make up the overall Optimization Plan. These are summarized below.

Gap Analysis

The City's existing distribution system practices were evaluated using the *Criteria for Optimized Distribution Systems* (Friedman et al., 2010) and *Partnership for Safe Water Distribution System Optimization Program* (American Water Works Association (AWWA, 2011) as a guide for enhancement of system performance based upon improving water quality, physical, and hydraulic characteristics of the system. The recommendations developed therein were used to identify gaps between the City's existing practices and industry best practices to identify areas for improvement. Using the self-assessment approach, the distribution system was evaluated based on three major performance variables:

- Disinfection residual (representative of distribution system water quality integrity),
- Main breaks (representative of distribution system physical integrity), and
- Pressure (representative of distribution system hydraulic integrity).

The Gap Analysis process yielded several high priority recommendations that were marked for immediate action, many of which were completed as part of this Optimization Plan. The detailed results are presented in the *Assessment of Current Practices and Gap Analysis Technical Memorandum, March 2017*. Immediate needs arising from the evaluation included:

- Development of a chlorine residual management program, including expansion of the City's Revised Total Coliform Rule (RTCR) monitoring and development of a tool to track and analyze chlorine residual and disinfection byproduct (DBP) data.
- Enhanced monitoring and data collection, including purchase and installation of online distribution system water quality monitoring panels.
- Development and implementation of a distribution system operator training program.
- Development of standard operating procedures for routine maintenance activities and for those activities that impact water quality (e.g., flushing, customer complaint tracking, water age, etc.)
- Development of a hiring plan to fill vacant positions within the Water Distribution Department
- Updates to and use of the hydraulic model to evaluate water age, pressure and storage.
- Development of an asset management program and implementation of a computerized maintenance management system (CMMS).

Chlorine Residual Management

The City experienced difficulty maintaining adequate chlorine residual concentrations throughout the distribution system during the water crisis. An extensive evaluation of existing chlorine residual data and sampling locations was completed to help the City identify more and more appropriate monitoring locations to stabilize chlorine levels and consistently achieve targeted free chlorine residuals. Trends from the data evaluation were used to identify problem areas of the distribution system and optimize chlorine dosing recommendations at the WTP and storage facilities. The existing RTCR sampling plan was evaluated by visiting the sampling locations and performing a desktop review of the historical data collected at each site. As a result of the review and in accordance with guidance from the USEPA and MDEQ, 14 new RTCR sampling sites were added to the original 10 for a total of 24 routine RTCR monitoring locations. In addition, five "chlorine only" sites were also added to the sampling plan to provide better control of chlorine residual levels in the system and assure effective residual maintenance.

A Chlorine Residual Management (CRM) spreadsheet tool was developed to track site-specific and seasonal performance as well as to calculate and track DBP compliance results for ongoing management of chlorine residual in the distribution system. The CRM Tool was transferred to the City and training was provided.

Given the City's difficulty maintaining chlorine residuals in some areas of the distribution system, unidirectional flushing (UDF) was recommended for water quality control. A UDF pilot test was performed to determine effectiveness and indicated that the City's infrastructure will require some rehabilitation and replacement before routine UDF is recommended.

Internal Corrosion Control

Corrosion control parameter data analysis was performed during the Gap Analysis and updated as part of the final Optimization Plan. All available data collected by the City, Michigan Department of Environmental Quality (MDEQ), and USEPA for lead, orthophosphate, and other water quality parameters were reviewed and statistical analysis was performed to draw out data trends. The update in this Optimization Plan includes analysis of data through December 14, 2017 as well as the Confirming Lead Elimination After Replacement (CLEAR) data.

A whole house flushing procedure for sampling and flushing was developed for Flint's system to address localized high lead concentrations that may have resulted following lead service line replacement. The procedures developed and recommended have been incorporated into *AWWA C810-17 Standard for Replacement and Flushing of Lead Service Lines* (AWWA, 2017a), and will be followed as part of ongoing full lead service line replacement efforts.

Corrosion coupon testing was conducted using water from the City of Flint Water Service Center. A bench-scale coupon immersion test was performed to assess the relative solubility of lead under various corrosion control treatment (CCT) scenarios to inform development of a pipe loop testing plan. Pipe loop testing is ongoing and will continue into late 2018 to determine optimum corrosion control treatment and ensure no future upsets to CCT when Genesee County Drain Commission (GCDC) finished water is blended with GLWA water at a 5 percent GCDC /95 percent GLWA blend for the City's long-term supply.

Resource Analysis and Needs Assessment

Following the Gap Analysis, a Resource Analysis and Needs Assessment was conducted, which outlined the City's current ability to perform essential tasks and future needs (both financial and human resources) to bridge the gaps identified in the Gap Analysis. Needs were identified and included estimates for both initial and recurring costs and number of full-time equivalents (FTEs) for the improvements identified in each category assessed. Additionally, potential options for funding and/or financing the improvements were identified and included both traditional and alternative sources. The approach and results of the analysis are summarized in the *Resource Analysis and Needs Assessment Technical Memorandum, March 2017*.

Standard Operating Procedures

During the Gap Analysis, it was found that no written distribution system operations and maintenance SOPs were available. As a result, a list of recommended SOPs was identified and several key SOPs were developed for the City, aligning each with industry best practices.

Hydraulic Modelling

The Gap Analysis also determined that water distribution hydraulic model utilization and calibration was an area that required strengthening. As part of Optimization Plan development, the model was reviewed and extensive calibration and improvements were performed to ensure the model accurately reflected the system assets and conditions. The model was then used to perform various simulations including a storage analysis, a water age analysis, water quality sensor placement, criticality assessment, and a surge analysis. Major findings of the modeling lead to the recommendation that Westside Reservoir should be permanently retired, and that Cedar Street and the plant elevated tank should be used as the

primary storage for the distribution system to reduce water age impacts and control water quality. During the winter months when the frequency of main breaks increases, Dort reservoir use is recommended for added storage capacity. Results were presented in the *Hydraulic Modeling Technical Memorandum, January 2018*.

Asset Management Program

An *Asset Management Plan Gap Analysis Technical Memorandum, September 2017* was developed as part of the overall Asset Management Program and reviewed a 2016 Asset Management Report completed by Rowe Engineering (Rowe, 2016a). MDEQ feedback on the Rowe report regarding areas of improvement and non-compliance was considered by the team to develop a roadmap to close the gaps in the report to meet MDEQ's asset management plan requirements. A plan was outlined by the Team to align the Asset Management Plan (AMP) with the following publications: *Asset Management Guidance for Water Systems* (MDEQ, 2013a) and *Asset Management Program Checklist* (MDEQ, 2013b). In addition to meeting State requirements, asset management guidance and best practices from *Asset Management: A Best Practices Guide* (USEPA, 2008), *ISO 55000* (ISO, 2014a), *ISO 55001* (ISO, 2014b), *ISO 55002* (ISO, 2014c), and the *International Infrastructure Management Manual* (IIMM) (NAMS and IPWEA, 2011) were leveraged.

A MDEQ-compliant AMP, *2017 Water System Asset Management Plan, January 2018* was developed by the Team. The water system AMP is a living document that serves as a roadmap for the City to develop and implement a full Asset Management Program within the next three to five years. The AMP will be updated annually by the City per MDEQ requirements. The AMP focused on potable water distribution system assets which are owned, maintained, and operated by the City. The horizontal assets include: distribution mains, fire hydrants, control valves, system valves, meters, and service laterals. The vertical assets in the AMP include: mechanical, structural, heating, ventilation, and air conditioning (HVAC), and electrical assets at the treatment facility, pump stations, and water storage facilities.

As part of the asset management program, a *Computerized Maintenance Management System Plan, November 2017* was also developed by the Team. The City plans to implement a CMMS to meet the goal of implementing a full asset management program within the next three to five years. This will be the primary tool used to track large amounts of information, provide automated reports/dashboards, and assist with accurate decision making. That system should be populated with an accurate, up-to-date asset inventory. Use of the CMMS should streamline the work order process as well as the quarterly and annual monitoring and reporting pre-defined level-of-service goals. As of the issuance of this Plan, the Arcadis Team, in conjunction with Johnson & Anderson, Inc., is assisting the City with the early stages of implementing the selected CMMS software, Cityworks.

20-Year Capital Improvement Plan

The recommendations included in the overall Optimization Program are ambitious and are presented to guide the City toward a fully optimized system in accordance with the *Criteria for Optimized Distribution Systems* (Friedman et al., 2010) and the *Partnership for Safe Water Distribution System Optimization Program* (AWWA, 2011). The Partnership for Safe Water's program is comprised of a methodology for utilities to optimize their distribution system through a phased process of commitment to the program, annual data reporting to the Partnership, self-assessment, and optimization, and to provide a path for

continuous improvement for even the most highly functioning system. It is understood that given the City's limited resources, full implementation of the recommended improvements will be challenging even considering the allocated grant funding. As such, the tasks to guide implementation of projects most critical for maintaining regulatory compliance, providing enhanced levels of service, and preventing catastrophic failure were prioritized. Each task was evaluated based on impacts to water quality, water quantity, ease of operation, and sustainability (i.e., social, economic, and environmental triple bottom line) to determine the overall system impact. Additionally, input from USEPA, MDEQ and the City staff provided during update meetings and workshops was incorporated to stratify tasks into high, medium, and low priority. The AMP and Capital Improvement Plan (CIP) are presented as living, breathing documents and are meant to be updated annually to reprioritize those tasks most critical for system operation as the City strives for continuous improvement.

The plan provided is a 20-year CIP. However, many projects extend well into the 20-year planning period. The prioritization effort resulted in three groups of projects – high, medium, and low priority as shown below:

- High priority – 0 to 2 years
- Medium priority – 3 to 5 years
- Low priority – 6+ years

Cost estimates presented in the Resource Analysis and Needs Assessment were further developed and refined (consistent with the methodology described above) during preparation of the CIP presented herein. A prioritized list of 20-year CIP projects is provided in Table ES 1.

Table ES 1: Prioritized Projects Included in the 20-Year CIP

Category	Project Description	20-Year Estimated Project Cost (2017 Dollars)
High Priority Items		
Asset Management	Enterprise Asset Management (EAM) Implementation Coordination	$950,000
Cross Connection	Update Commercial Cross Connection Control Program	$155,000
Cross Connection	Develop a Residential Cross-Connection Control Program	$3,710,000
Customer Complaints	Establish a Call Center	$500,000
Security & Emergency	Update the existing Emergency Response Plan (ERP) to meet Federal Emergency Management Agency (FEMA) standards	$69,000
Valve & Hydrant	Develop a Planned/Preventative Maintenance Plan	$30,000
Valve & Hydrant	Develop Valve & Hydrant Manual Library	$10,000
Water Loss	Develop and Review Water Loss Control Plan	$1,739,000

Category	Project Description	20-Year Estimated Project Cost (2017 Dollars)
CIP, Online Monitoring	Implement Distribution System Online Water Quality (WQ) Monitoring Stations	$955,000
Information Technology	Supervisory control and data acquisition (SCADA) Upgrades	$100,000
Storage Facilities	Contractor: Storage Facility Comprehensive Inspection	$375,000
Security & Emergency	Site Control and Intrusion Detection	$406,200
Security & Emergency	Fencing at Cedar Street Reservoir (CSR)	$15,000
Pipe Rehabilitation & Replacement	Update Pipe Assets in Geographic Information System (GIS) /Valve-Hydrant Model Review	$150,000
CIP	FAST START – Lead Service Line Replacement (LSLR)	$99,000,000
CIP	GCDC Back-Up Supply	$9,164,000
CIP	Northwest Transmission Main	$12,297,000
CIP, Water Loss	Meter Replacement – Automatic Meter Reading (AMR)/Advanced Metering Infrastructure (AMI)	$18,460,000
CIP, Pipe Rehabilitation & Replacement, Valve & Hydrant	Small Main Replacement (Grant funded)	$57,530,000
CIP, Pipe Rehabilitation & Replacement, Valve & Hydrant	Small Main Replacement (City funded)	$280,000,000
CIP, Pump Station	Dort Pumping Station/Cedar St. Pump Replacement	$10,125,000
CIP	Dam Maintenance	$875,000
CIP	72-inch Line Maintenance	$500,000
Pump Station/Storage Facilities/Water Age/CIP	Storage and Pump Station Improvements	$3,015,000
CIP	Atherton Road Main	$7,000,000
CIP	Chemical Building Construction	$3,400,000
CIP, Water Loss	Leak Detection / Annual Meter and Leak Detection	$1,304,000
Asset Management	Miscellaneous Vertical Asset Rehabilitation & Replacement (R&R)	$4,943,000
Valve & Hydrant	Wachs Valve Assessment	$350,000
Valve & Hydrant	Valve & Hydrant Replacement	$24,171,000
Other	Vehicle Replacement	$10,000,000
Medium Priority Projects		
Security & Emergency	Vulnerability Assessment	$180,000

Category	Project Description	20-Year Estimated Project Cost (2017 Dollars)
Security & Emergency	Funding Assessment	$40,000
Valve & Hydrant	Valve & Hydrant Program Hardware and Software Upgrades	$135,000
Water Quality	Laboratory Equipment Upgrades	$100,000
Hydraulic Modeling	Hydraulic Modeling Software	$190,000
Hydraulic Modeling	Hydraulic Model Training	$25,000
Hydraulic Modeling	Develop and implement model maintenance plan	$160,000
Pressure Management	Portable Pressure Data Loggers	$2,000
Low Priority Projects		
Cross Connection	Purchase Cross-Connection Control Software	$24,000
Pipe Rehabilitation & Replacement	Outside Review of Design Standards	$75,000
Security & Emergency	Regular Exercise and Review of ERP / Communications	$270,000
Security & Emergency	Cyber security for SCADA/instruments outside WTP	$72,000
Security & Emergency	Conduct a cyber security gap assessment	$220,000
Flushing	Optimize Flushing Loops	$20,000
Hydraulic Modeling	Conduct WQ Model Calibration	$15,000
Pressure Management	Comprehensive Surge Analysis	$150,000
Pump Station	Contractor: Pump Station Annual Inspections	$765,000
Valve & Hydrant	Hardware and Software Upgrades	$1,120,000
CIP	Water Facility Consolidation	$3,000,000
Flushing	UDF Equipment	$10,000
	Total	**$557,871,000**

Projects were organized into three main categories of capital investment:

- *Administrative* includes items such as customer service, CMMS implementation, GIS maintenance, standards development and maintenance, program development (e.g., emergency response program, water loss control program development, cyber security, etc.), and software and licensing.
- *Water distribution* includes items related to water distribution system capital and operational improvements that are not considered R&R projects, including hydraulic modelling, unidirectional flushing equipment, SCADA upgrades, and facility inspections.

- *Rehabilitation and replacement* includes lead service line and small main replacement, large diameter main replacement, storage facility and pump station improvements, dam improvements, new chemical facilities, valve and hydrant replacement, and replacement of vehicles.

Figure ES 1 shows the proportion of the projected 20-year capital expenditures in each of these three areas. As can be seen, R&R accounts for nearly all of the projected 20-year capital expenditures. One reason for this is the grant funding available for the next several years will allow the City to make significant capital investment in water system R&R. However, when the grant funding (approximately $167 million) is removed, City-funded R&R still accounts for 97 percent of the projected future capital expenditures.

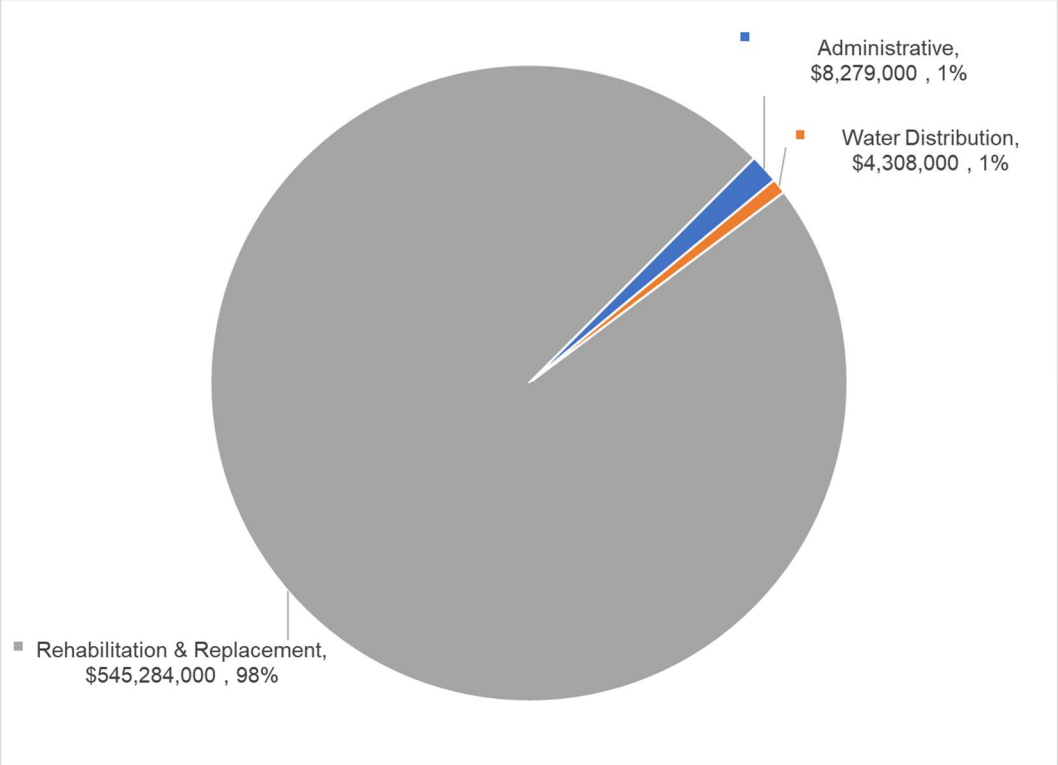


Figure ES 1: Distribution of Projected 20-Year Capital Expenditures

Figure ES 2 provides more detail regarding the projected 20-year R&R capital spending. As noted previously, the City will have significant grant funding available over the next several years to address water system R&R needs. That said, the *2017 Water System Asset Management Plan, January 2018* recommended significant investment beyond the available grant funds for small water main replacement just to maintain the City's current historic annual average break rate. That recommendation alone equates to approximately $280 million over the 20-year capital planning period.

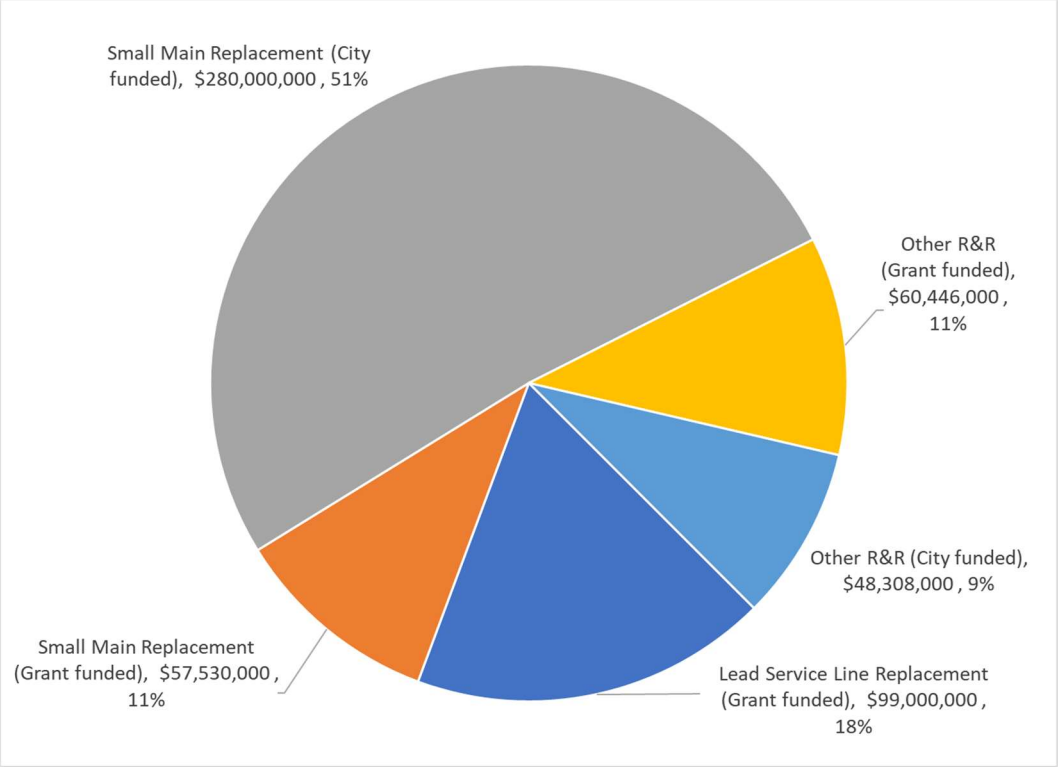


Figure ES 2: 20-Year Projected R&R Budget by Funding Source

A number of recommendations were not included in the CIP for various reasons including:

- The recommendations were completed during preparation of the Optimization Plan.
- Several items were assumed to be completed by the Program Manager overseeing LSLR and other projects associated with grant funding.
- The recommendation was completed by the City or another consultant outside the scope of the Optimization Plan.

In addition, there are three recommendations that were simply not included.

- A whole house flushing demonstration was attempted during preparation of the Optimization Plan and not a single resident was willing to participate. Attempts were coordinated through the Fast Start program and outreach was made at multiple public meetings, yet there were still no volunteers. Household flushing had no associated capital cost, only City labor. LSLR is anticipated to be complete within two to three years (2019 or 2020) and it was determined that hiring of other resources would be a higher priority. A whole house flushing procedure has been provided as a part of this Plan for residents who are interested and should be encourage by the City.
- Participation in the AWWA Water Loss Committee is a worthwhile goal and is encouraged, but given staff limitations it was not considered a priority.
- Similarly, hiring a security guard to monitor video of the City's distribution assets seemed a lower priority and should be considered at a future date, but was not considered necessary at this time.

Resource and Funding Needs

Within the AMP recently submitted to the City and MDEQ, a financial analysis was performed to determine the funding gap for implementing the AMP recommendations. The AMP includes shorter-term capital needs that are planned to be met with a mix of grant funds anticipated by the City and cash from system operations. The AMP also includes longer-term capital needs for main replacement and ongoing renewal and replacement of vertical assets (e.g., pump stations and storage) that could be met with a variety of funding sources. Figure ES 3 provides an assessment of future revenue requirements (projected operation and maintenance (O&M) and capital inflated at annual rates) compared to the City's revenue under existing rates and charges. As can be seen, the projection shows that approximately $95 million annually would be needed by 2037 to implement the recommended improvements, including the inflated $24 million capital budget that reflects replacement of approximately 35 percent of the distribution system.

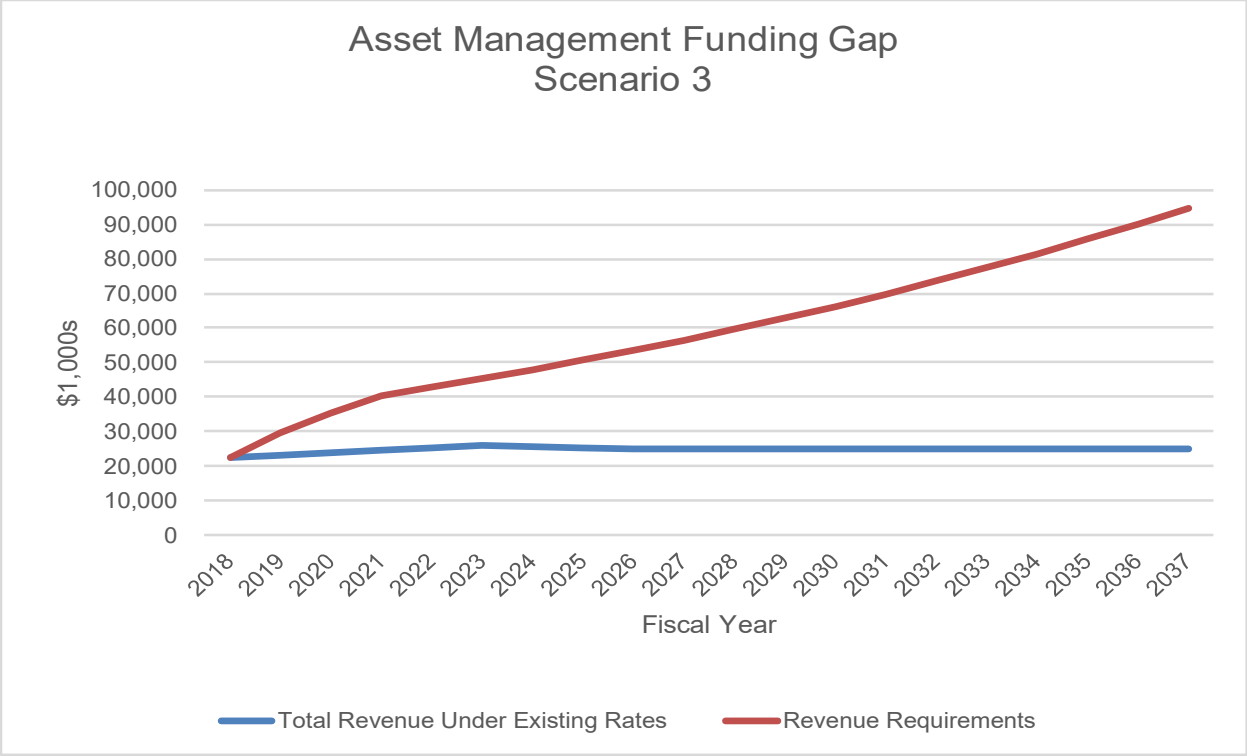


Figure ES 3: Asset Management Funding Gap

Additional improvements beyond those presented in the AMP will require significant funds. The City should consider several funding and financing options for optimizing and improving the distribution system, while mitigating significant increases to the City's water ratepayers. However, there is uncertainty at this point as to what funding sources might be available to the City to offset the projected revenue requirements. A review of potential alternative funding sources was performed, and a prioritized list is shown in Table ES 2.

Table ES 2: Prioritized Potential Funding Sources

Funding Source	Description	Potential Challenges
Rate Increases and Financial Planning	Nominal increases coordinated with planned cash funded renewal and replacement	Rate increases will be affected by affordability goals and the ability of the customer population to cover water bills.
Grant Funding	• Federal • State • Private	Many of the most obvious major grants have already been awarded.
Non-Rate Revenue	• Property sales • Cellular tower leases • Unused asset salvage	Property value is limited based on market conditions.
Cost-sharing	Concurrent City or private utility projects	Requires coordination between City departments and third parties
Special Assessment District/Ad Valorem Tax	Recovering capital improvements above the renewal and replacement levels experienced by a normal utility	The City's property taxes are currently higher than the national average.
Debt Funding	• General Obligation Bonds • Drinking Water Revolving Fund (DWRF) loans • Revenue Bonds	The City's ability to repay debt funding is uncertain.

A staffing needs assessment was also conducted for the existing Water Service Center (i.e., water distribution), including a review of workload and responsibilities during the Resource Analysis and Needs Assessment task. In addition to the additional staff recommended to simply meet current workload and responsibilities, additional staff are recommended to implement and maintain the recommendations presented in the CIP. Staffing needs were prioritized, and a summary of that evaluation including currently budgeted staffing levels, status of those budgeted positions (filled or vacant), and additional recommended staff is provided in Table ES 3.

Table ES 3: Existing and Recommended Staffing Levels

Position / Title	Filled	Vacant	Total
Current Budgeted Staff			
Distribution Superintendent	0	1	1
Water Distribution Foreman	4	0	4
Distribution Operators	24	6	30

Position / Title	Filled	Vacant	Total
Administration	4	1	5
WQ Laboratory Supervisor	0	1	1
Laboratory Technician	1	1	2
Cross Connection Program Manager	1	0	1
Additional Recommended Staff: High Priority			
Laboratory Technician	0	1	1
Cross Connection Program Manager	0	1	1
Water Distribution Valve and Hydrant Crew	0	3	3
Customer Service/Call Center Staff	0	4	4
Enterprise Asset Manager	0	1	1
GIS Specialist/Hydraulic Modeler	0	1	1
Additional Recommended Staff: Medium Priority			
Construction Inspectors	0	2	2
Leak Detection Team	0	2	2
Additional Recommended Staff: Low Priority			
UDF Team	0	2	2

It is acknowledged that the City has had difficulty in attracting and retaining qualified employees. To correct this problem, a two-pronged approach needs to be implemented: retain existing employees and fill vacancies. Retaining employees is significantly easier and less costly than expending resources to find and train new employees and must be the City's first priority. Providing competitive pay, benefits, and comprehensive training will address many current concerns and increase job satisfaction among City staff.

In terms of hiring, there remain many vacancies in the Water Service Center group. Additional steps must be taken to attract and retain good employees. Job vacancies must be posted where potential applicants are looking. The City should use local and national internet job posting websites as well as attending career fairs at local colleges and universities.

For both existing and new employees, training is of vital importance. As part of this Optimization Plan, six training modules have been developed:

1. Introduction to Flint Water System
2. Overview of Distribution System Functions
3. Training leading to Distribution System Operator Certification
4. Safety Training
5. Customer Service Representative Training
6. Heavy Equipment Operation Training

Additionally, materials on AWWA's online Resource Communities are available at no cost for user download and should be used by the City.

Performance Metrics

Key performance indicators (KPIs) were developed based on level of service (LOS) categories during preparation of the AMP. Levels-of-service were developed based on four main sources: *Effective Utility Management: A Primer for Water and Wastewater Utilities* (USEPA, 2017), *2017 AWWA Utility Benchmarking: Performance Management for Water and Wastewater* (AWWA, 2017b), MDEQ Guidance, and the City's goals and objectives for its Asset Management Program. Levels of service also considered the best practices outlined in the *ISO 55000 Asset Management Standards* (ISO, 2014a; ISO, 2014b; ISO 2014c).

Based on the sources above, the City developed a LOS statement to guide the development of the measures:

The City strives to provide safe drinking water to its customers, meeting all regulatory requirements, through the effective maintenance of its assets.

The City will review the LOS statement annually as part of the AMP review and update effort. A total of 25 LOS goals and KPIs were identified by the City. Performance measurement will be implemented using a tiered approach, with the most important LOS and KPI goals implemented first in Tier 1. As the City progresses toward optimization, the KPI priorities may change, and this should be reflected in the annual updates to the AMP. Currently, targets for these measures are not defined. As the City pilots the Tier 1 measures, performance targets can be established, and adjustments may be made to the frequency and data source recommendations.

It is recommended that initially performance be measured based on "continuous improvement" (i.e., year 1 is better than baseline, year 2 is better than year 1, etc.), and that baseline conditions be established on at least one full year (12 months) of data. Tracking of performance against baseline conditions and to industry benchmarks should begin following establishment of baseline conditions, and then performance targets can be established, if appropriate.

Immediate Activities

Implementation of the Optimization Plan and associated AMP will require steady funding over time to improve the condition and overall performance of the distribution system. The following are recommendations for immediate focus:

- Pursuit of grant funds – The City has been successful post-crisis obtaining grant funding for improvements to the water system. While much good work has been done, there is much more required to optimize the distribution system and improve overall water service to customers. It is recommended that the City establish a recurring process to evaluate projects, assess potential grant funding options, and pursue grants to fund a portion of the CIP noted above. Obtaining grant funds will help mitigate rate increases to the City's water customers.
- Gradually increase revenue from rates and other charges – A recommendation in the AMP was to create a process where regular financial planning for the water system occurs. The financial planning will incorporate various funding sources and look at the timing and implementation of the CIP. The funding and financial analysis indicates that increases in rate-based revenue, either from increased collection rates or nominal rate increases or both, will be needed over the next 20 years to implement the CIP and cover necessary operations costs. The City should consider implementing regular rate increases (even if nominal) as part of the planned rate redesign in the near-term as a means for funding the long-term needs of the water system. The rate redesign will also look at affordability and restructuring based on water usage to shift cost to higher water users. Regular rate increases will have the added benefit of returning the water system finances to a stable footing, which is necessary should the City consider issuing debt or obtaining loans in the future for CIP projects.

A number of other tasks identified in the Optimization Plan and immediate regulatory and operations needs to be implemented by the City in 2018 and are outlined below:

- Complete the pipe loop testing and prepare related SOPs. (The Arcadis Team will complete this by the end of 2018.)
- Conduct additional hydraulic modeling scenarios to determine the impacts of compartmentalizing Cedar Street and Dort Reservoirs on system operations.
- Continue with CMMS implementation and implement a comprehensive asset management program in accordance with the AMP.
- Complete the 2018 AMP Update and submit to MDEQ by December 31, 2018.
- Regularly review and update the CIP based on actual work completed and evolving capital needs.
- Continue to aggressively pursue and hire qualified candidates for position vacancies.
- Implement an employee recruitment and retention plan and develop a hiring plan for new positions recommended in this Plan.
- Begin tracking Tier 1 performance measures. The City will need to develop LOS and KPI definition sheets in 2018 for the Tier 1 measures. The definition sheets will assign owners and targets for the measures.

Additionally, to maintain the relationships built throughout the overall Optimization Program, it is strongly recommended that residents continue to be updated as often as possible by:

- Holding regular, monthly community updates that allow residents to ask questions
- Attending neighborhood meetings;
- Surveying residents again to gauge perceptions;

- Placing project information and progress updates in community newsletters;
- Allowing residents to see work underway so that an approach of transparency and two-way conversation continues; and
- Providing information in Spanish as well as English.

1 INTRODUCTION

The City of Flint (City) has retained a team led by Arcadis of Michigan, LLC (Arcadis), including Cornwell Engineering Group (formerly known as 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 third and final task, preparation of the Water Distribution System Optimization Plan. The results of the first two tasks are summarized in the *Assessment of Current Practices and Gap Analysis, March* 2017 (Appendix A) and the *Resource Analysis and Needs Assessment, March 2017* (Appendix B).

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, 2016b). 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.

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 water from 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 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 increased number of 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 and other administrative, technical and managerial responsibilities associated with the Flint water system. 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 has been retained to develop a Water 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 overall optimization plan, which includes the following main tasks:

1. Updates to Recommendations – Each of the recommendations outlined in the *Assessment of Current Practices and Gap Analysis, March 2017* were evaluated and updated and refined them based on operational and financial conditions of the City.
2. Resource and Funding Needs – For each recommended practice outlined, human resources and funding needs were established.
3. Implementation Schedule –An implementation schedule was developed that groups the customized recommendations into immediate (0-2 years), mid-term (3-5 years), and long-term (greater than 6 years) periods. Where possible, items are grouped based on identified synergies to streamline implementation and condense the schedule.
4. SOPs – As few written distribution system operations and maintenance SOPs were available, several key SOPs were developed 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 is presented in the following sections.

5. Performance Metrics – To assess the progress of optimizing the distribution system, the metrics and measures currently in use were reviewed and compared to other similar water and wastewater utilities to identify potential measures that are meaningful to the optimization program. Recommendations were also developed for the preferred approach for performance measure tracking and data comparisons for each Performance Metric selected and frequencies for assessing progress.

1.2 Report Objectives

The purpose of this report is to compile the results of the analyses conducted throughout evaluation of the City's water distribution system and its operating practices, including all the memoranda submitted, and incorporate the results into a prioritized list of recommended improvements to optimize the distribution system. The Water Distribution System Optimization Plan includes a prioritized list of recommended best practices, complete with required human and financial resources necessary to implement those practices over a period of 20 years based on the prioritization approach and criteria.

1.3 Report Organization

The remaining sections of the report are organized as follows:

- ***Section 2.0 Overview of Optimization Program*** is a summary of the work completed during the development of the Optimization Plan including data analysis efforts and technical memoranda. New addenda to previously submitted reports and updates to ongoing tasks are also outlined.
- ***Section 3.0 Recommended Improvements and Implementation Schedule*** presents the refined recommended improvement projects and the 20-year capital improvement plan (CIP), and describes the project prioritization based on the selected evaluation criteria and approach.
- ***Section 4.0 Resources and Funding Needs*** describes the most applicable funding sources available to the City to implement the CIP and provides recommendations for additional staffing and training of City staff.
- ***Section 5.0 Performance Metrics*** outlines a measurable method for identifying, defining, and tracking key performance indicators (KPI) and level of service (LOS) goals.
- ***Section 6.0 Immediate Activities*** presents a list of immediate actions for completion in 2018.

2 OVERVIEW OF OPTIMIZATION PROGRAM

Several data analysis tools, technical memoranda, SOPs, and other recommendations that collectively make up the overall optimization program were prepared. The efforts of the team are summarized below and included in this document as Appendices A through N.

2.1 Assessment and Gap Analysis

The initial Assessment and Gap Analysis included coordination with the appropriate regulatory agencies, review of data from historical sources, and multiple days of on-site interviews and site visits to assess the City's existing distribution system operations against industry best practices for optimization, specifically standards that have been developed as the foundation for the *Criteria for Optimized Distribution Systems* (Friedman et al., 2010) and the *Partnership for Safe Water Distribution System Optimization Program* (AWWA, 2011). The Partnership for Safe Water's program is comprised of a methodology for utilities to optimize their distribution systems through a phased process of commitment to the program, annual data reporting to the Partnership, self-assessment, and optimization, and to provide a path for continuous improvement for even the most highly functioning system.

Analysis of distribution system operation sought to assess the system in terms of water quality integrity, physical integrity, and hydraulic integrity. As such, the following assessment categories were outlined for evaluation:

- Chlorine Residual
- Main Breaks
- Pressure Management
- Cross-Connection Control
- Customer Complaint Tracking and Response
- Disinfection Byproduct Control
- Flushing
- Hydraulic Modeling
- Internal Corrosion Control
- Installation, Operation, and Maintenance of Valves and Hydrants
- Online Monitoring
- Pipeline Installation, Rehabilitation, and Replacement
- Post-Precipitation Control
- Pump Station Design, Operation, and Maintenance
- Security and Emergency Management
- Storage Facility Design, Operation, and Maintenance
- Water Age Management
- Water Loss Control
- Water Quality Sampling and Response

Administrative factors, specifically administrative policies, funding, and staffing, in addition to asset management were also reviewed as part of the Gap Analysis, but were not specifically outlined in the recommendations as they impact all aspects of a water utility, not just the distribution system. These items were analyzed as part of the Resource Analysis and Needs Assessment phase of the optimization plan.

For each of the above categories, industry standards, benchmarks, and best practices for high performing utilities were identified. All available system data, previously prepared reports and documentation were reviewed, on-site interviews with staff of varying levels were conducted, and distribution system facilities were toured to evaluate existing practices. Gaps between existing conditions and defined optimization were identified and each category was defined in terms of areas that meet or exceed industry standards, areas that need minor strengthening, areas that need major strengthening, and areas where no program or practice exists.

An in-depth analysis on available water quality and infrastructure data was performed to address immediate needs of the system and is summarized as follows:

- Chlorine residual and disinfection byproduct (DBP) data collected by the City and USEPA before, during, and after the operation of the Flint WTP were analyzed to obtain an understanding of water quality performance in the distribution system. Results from the analysis were used to develop the Chlorine Residual Management Program and to update the Revised Total Coliform Rule (RTCR) monitoring plan. Detailed results are presented in the *Assessment of Current Practices and Gap Analysis, March* 2017. The chlorine analysis was subsequently updated to include system data collected at water quality monitoring sites through September of 2017. The updated analysis is included as Addendum 1 to the *Assessment of Current Practices and Gap Analysis, March* 2017 in Appendix A.
- During the water quality event leading to the administrative order, the Flint distribution system observed an increase in the number of water main breaks. As part of the gap analysis addressing physical integrity, available main break data against seasonal variations, system pressures, valve operations were analyzed. Based on the analysis, temperature was determined to be the controlling factor in main break frequency, although operational inconsistencies including pump start/stop cycles and valve operation at the reservoirs were believed to contribute as well.
- As a result of increased lead levels throughout the distribution system during the Flint WTP operation, lead sampling data and other water quality data were collected by USEPA and MDEQ under different sampling programs. The data provided an indication of the state of internal corrosion control in the Flint water system over time. In addition to the lead data collected, key corrosion related water quality parameter (WQP) data collected at several monitoring sites were analyzed to evaluate how well WQPs were being controlled. Details of the analysis are presented in the *Assessment of Current Practices and Gap Analysis, March* 2017 including the updated analysis presented as Addendum 2.

The Gap Analysis process yielded several high priority recommendations that were marked for immediate action, many of which were completed as part of this Optimization Plan and are discussed further below. The detailed results are presented in the *Assessment of Current Practices and Gap Analysis Technical Memorandum, March 2017*.

2.2 Chlorine Residual Management Program

Maintenance of an adequate disinfectant residual throughout the distribution system is paramount to protecting public health. In addition to providing microbial control, disinfectant residuals provide oxidizing conditions to help stabilize pipe scales and can serve as an indicator of distribution system integrity. Therefore, a key aspect of distribution system water quality management and optimization is to identify appropriate disinfectant residual level(s) and strategies for monitoring and maintaining them on an on-going basis. The following activities were taken to ensure adequate distribution system disinfectant residuals:

1) A goal of ≥ 1.7 mg/L as free chlorine was set for the Plant Tap
2) A goal of ≥ 0.5 mg/L as free chlorine in 95 percent of monthly RTCR samples was set for the distribution system
3) Control chart spreadsheet tools were developed to assess process control and variability
4) A Chlorine Residual Management (CRM) spreadsheet tool was developed to track site-specific and seasonal performance as well as to calculate and track DBP compliance results. The CRM Tool was transferred to the City and training was provided. The Flint Chlorine Residual Management Tool Description is included as Addendum 1 to the *Assessment of Current Practices and Gap Analysis Technical Memorandum, March 2017*.
5) A Chlorine Residual Maintenance in the Distribution System SOP was prepared. The SOP discusses treatment and O&M response strategies for addressing system-wide, regional, local, or site-specific residual issues.
6) The City's RTCR Plan was updated to include 14 new RTCR sites, in addition to the original 10 RTCR sites. Chlorine residual is monitored from five additional surveillance locations to enhance tracking. Thus, more than 100 chlorine measurements are currently collected from a total of 29 unique locations spread through the distribution system on a monthly basis. The City is in the process of locating one additional RTCR site, so that ultimately 25 unique RTCR sample locations will be monitored. The RTCR Plan as of February 2018 is included as *Final RTCR Monitoring Plan, February 2018* (Appendix C)

Review of available data (through September 2017) indicate that the City has typically maintained a median chlorine residual level of 1.8 mg/L at the Plant Tap, and that 95 percent of monthly distribution system samples have met the goal of ≥ 0.5 mg/L.

A unidirectional flushing (UDF) pilot was conducted in June 2017 to provide startup support for the eventual inclusion of UDF as a maintenance strategy, provide City crews with instruction, and evaluate flushing performance, effectiveness, and risks. The findings of the pilot are summarized in the *Unidirectional Flushing Pilot Evaluation, August 2017* (Appendix D).

2.3 Corrosion Control

An analysis of internal corrosion control parameter data was performed during the development of the *Assessment of Current Practices and Gap Analysis, March* 2017. As part of the Optimization Plan development, this analysis was updated with data through December 14, 2017. Additionally, the Confirming Lead Elimination After Replacement (CLEAR) program data was analyzed to evaluate the impact of lead line replacement on lead concentrations at participating households. The results of the

updated internal corrosion control analysis are included as Addendum 2 to the *Assessment of Current Practices and Gap Analysis, March* 2017

Corrosion coupon testing was conducted using water from the City of Flint Water Service Center. A bench-scale coupon immersion test was performed to assess the relative solubility of lead under various corrosion control treatment (CCT) scenarios. Testing was performed for 12 weeks. Six different orthophosphate dosages were tested at two different target pH levels, with the goal of determining: 1) if orthophosphate would be more effective in controlling lead release at a target pH of 7.2 or 7.5, and 2) what range of orthophosphate doses should be considered for subsequent pipe loop testing.

Based on t-test analysis of the collected data, there was no statistically significant difference between the performance of orthophosphate at pH 7.2 and at pH 7.5. However, a relationship was established between orthophosphate dose and lead release. As Figure 1 shows, the data collected indicated that increasing the orthophosphate dose above 2 mg/L as PO_4 correlated with a decrease in lead concentration, up to a maximum dose of 4 mg/L as PO_4. It was recommended that doses of 2.5, 3.0, 3.5, and 4.0 mg/L as PO_4 be analyzed in subsequent pipe loop testing. The results of the coupon testing are presented in *Lead Corrosion Control Treatment Coupon Study, November 2017* (Appendix E).

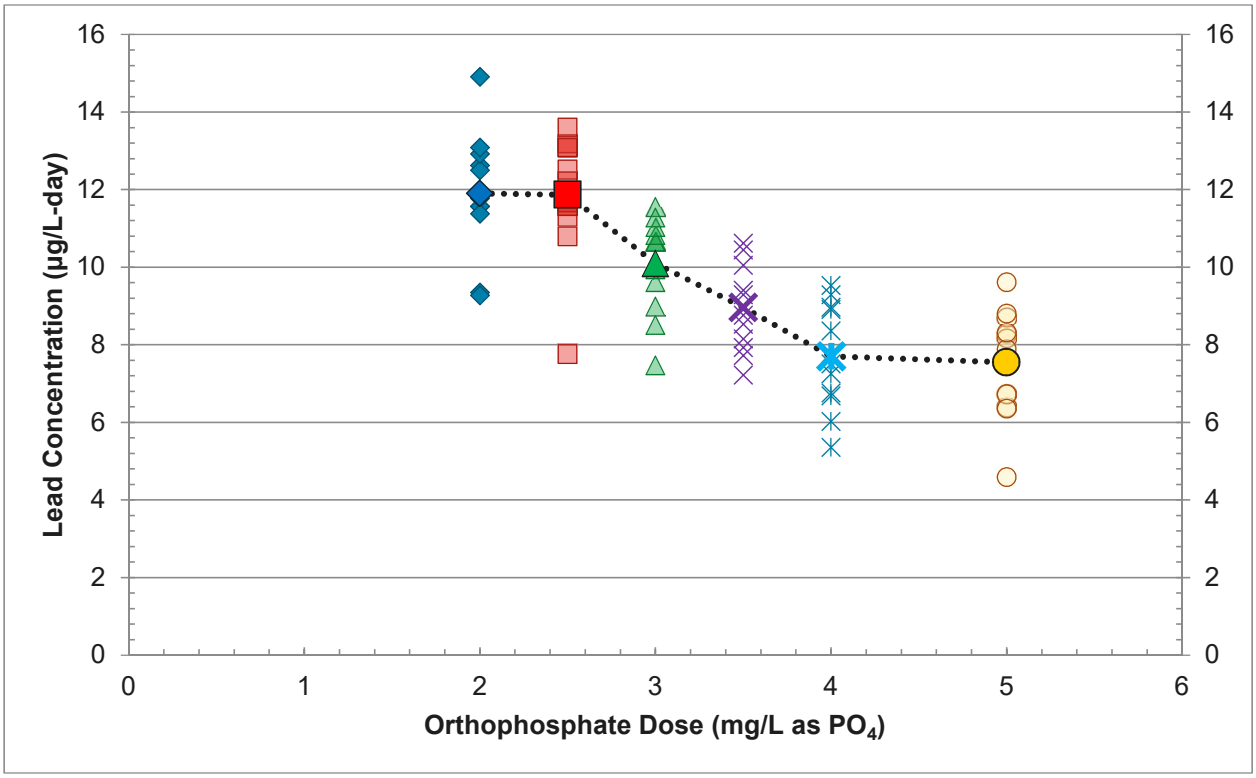


Figure 1: Lead concentrations by orthophosphate dose collected during corrosion coupon testing. Averages are represented with a dotted line.

Pipe loop testing began in March 2018 and the results of the testing will be provided by the end of 2018. Four pipe rigs each with four lead service lines (16 pipes total) will be utilized for testing and will include a range of pH and orthophosphate doses consistent with the results of the coupon study. In addition, testing will first be conducted with GLWA-treated Lake Huron water as well as water provided by the

Genesee County Drainage Commission (GCDC) to ensure there will be no upsets to corrosion control treatment when GCDC finished water is blended with GLWA water at a 5 percent GCDC to 95 percent GLWA blend for the City's long-term supply.

Additionally, in June 2017, a whole house flushing pilot program was established, and procedures for sampling and flushing were developed for Flint's system. However, after attempts to attract willing participants were unproductive, the efforts were abandoned. A summary of the program and procedures for profile sampling and whole house flushing following lead service line replacement are included as *Whole House Flushing Efforts in Flint, MI, February 2018* (Appendix F). It should be noted that the developed procedures were recently adapted in the new *AWWA C810-17 Standard for Replacement and Flushing of Lead Service Lines* (AWWA, 2017a), and USEPA is requiring that the City follow this standard as part of its ongoing full lead service line replacement efforts.

2.4 Resource Analysis and Needs Assessment

Based on the results of the Gap Analysis, the City's existing capital and operations budgets were reviewed to determine the adequacy of those budgets to implement the noted best practices beyond the existing City activities. Total estimated resource needs for one-time initial, and annual recurring activities were generated in terms of capital costs and human resources (full time employees) based on Association for Advancement of Cost Engineering (AACE) Class 5 Estimates, which is considered a concept screening estimate and are typically -50 to +100 percent 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.

A range of traditional and non-traditional funding options to finance the recommended system improvements was also evaluated as part of the financial resource analysis. Available funding options were divided into cash funding and debt financing. The full cost estimation, human resources evaluation, and funding assessment is presented in the *Resource Analysis and Needs Assessment, March 2017*.

The costs, human resource needs, and funding options initially developed as part of the Resource Analysis and Needs Assessment were further refined with input from stakeholders as part of this Optimization Plan and updated results are presented in Sections 3 and 4 of this document.

2.5 SOPs

Standard operating procedures (SOPs) were evaluated as part of the Gap Analysis process. The City's existing SOPs as well as those developed in conjunction with MDEQ during the period following the Flint WTP operation were reviewed and updated based on industry standards and recommendations for optimized system operation. At the time of this report, chlorine residual management, water age management, pressure management, and corrosion control activities are ongoing, and SOPs for these tasks will be developed upon completion of those efforts and submitted as an addendum to this Plan. The SOPs already developed under this effort are as follows and are included in the *Standard Operating Procedures* (Appendix G):

- Water Treatment:
    - Phosphoric Acid Addition at Control Station 2
    - Sodium Hydroxide Addition at Control Station 2

    - Sodium Hypochlorite Addition at Control Station 2
    - Sodium Hypochlorite Addition at distribution Storage Facilities
    - Sodium Hypochlorite Testing
- Storage Facilities and Pumping Stations:
    - Distribution Storage and Pumping Station Operation and Maintenance
- Water Mains and Appurtenances:
    - Emergency Repair of Water Mains
    - Hydrant Inspection, Testing, and Maintenance
    - Valve Inspection, Exercising, and Maintenance
    - Backflow Cross-Contamination Prevention
    - Meter Installation, Inspection, and Testing
- Distribution System Water Quality:
    - Water Quality Instruments Operation and Maintenance
    - Customer Complaint Tracking
    - Control Charting of Water Quality Parameters
    - Conventional Flushing for Water Turnover
    - Unidirectional Flushing

This Optimization Plan was developed for operation and maintenance of the distribution system and does not include SOPs for capital improvement projects. As such, it is recommended that the following additional SOPs be developed by the City:

- Main Cleaning and Rehabilitation
- Water Main Installation
- Tap and Service Installation for Residential, Commercial and Fire Services ¾-Inch to 2-Inch
- Hydrant Installation and Replacement
- Valve Installation and Replacement

2.6 Hydraulic Modeling

The Gap Analysis determined that water distribution hydraulic model utilization and calibration was an area that required strengthening. As part of Optimization Plan development, the model was reviewed and extensive calibration and improvements were performed to ensure the model accurately reflected the system assets and conditions, and presented the results of the analysis in the *Hydraulic Modeling Technical Memorandum, January 2018* (Appendix H). Field work was conducted to obtain working system pressures at 26 hydrant locations throughout the distribution system and flow tests were performed at seven locations to determine Hazen Williams C-factors and available fire flows. The field data collected were used to correct the existing model to and the model asset locations were updated to align with geographical information systems (GIS)-mapped city streets.

The calibrated, improved model was used to evaluate the system as described in Table 1.

Table 1: Hydraulic Model Evaluation Analyses

Analysis	Approach	Results
Storage	Available and minimum required volumes were compared using four storage configurations at maximum day demand of 16 MGD at two storage configurations at "winter" maximum day demand of 24 MGD to capture emergency main break conditions.	Maximum water velocity, minimum junction pressure, and available fire flow are similar between the configurations.
Surge	Rapid start-up and sudden pump shutdown were simulated at Cedar Street Reservoir (CSR) and West Side Reservoir to evaluate impact on pressure fluctuations throughout the system.	Model results show pressure fluctuations are localized around the reservoirs, and there are some correlations to historic main breaks for the WSR scenarios.
Water Quality Sensor Placement	The model was used to evaluate flow paths upstream of existing water quality parameter monitoring locations and identified arears where flow paths overlapped.	Six locations were identified for water quality sensor placement
Water Age	The model was used to simulate the existing operating condition with the WTP and CSR online. Alternative scenarios including bringing Dort Reservoir online and adding automatic flushing devices were also evaluated.	Model results show negative impacts on water age when West Side Reservoir in service, and when Dort Reservoir and Cedar Street Reservoir are operating simultaneously.
Criticality Assessment	Based on maximum day conditions, the model was used to systematically simulate the failure of each pipe within the distribution system to assess the impact on supply delivery.	Due to the heavily looped nature of the distribution system, there are relatively few critical pipe segments. The most critical pipes were identified based on demand shortfall when out of service.

A number of recommendations were determined based on the analysis performed with the hydraulic model. All analyses that were performed indicate the continued utilization of Cedar Street Reservoir (CSR) and the plant elevated tank for system storage. Storage analysis showed excess storage in the system above the required amount, which would allow possible decreases in total storage with the goal of improving water quality. The water age analysis showed an increase in water age when using Dort Reservoir. However, during winter months when main breaks are more prevalent, use of the Dort Reservoir was recommended to ensure system reliability.

The storage analysis also showed increased water age on the west side of the system with West Side Reservoir in operation. The transient analysis also showed some correlation of pipe breaks with West Side Reservoir operation. As a result, it was recommended that the West Side Reservoir and Pump Station remain out of service. The removal of this facility negligibly impacts minimum pressures in the southwest region of the system and the excess storage is not required to meet demand on maximum day conditions. The continued usage of only CSR and the plant elevated tank is recommended for normal system conditions as this presents the best results from these analyses.

Based on the completed storage analysis, the recommended long-term operating strategy should balance attenuating peak supply flow rates from GLWA while minimizing storage for water quality benefit. It is

recommended for the plant elevated tank, Dort Reservoir and CSR to be operated during the winter months (with peak demands of 24 MGD due to main breaks); and, for the plant elevated tank and CSR to be operated in the summer months when there are lower demands and higher reaction rates. Although not expected, if the City experiences significant demand growth in the future, Dort Reservoir should be returned to always-on operations.

The recommended operating strategy during non-peak seasonal demands or typical conditions is to practice deep cycling of the ground storage facilities to maintain water quality. This is necessary to prevent an excessive amount of continuous flushing that would otherwise be necessary to reduce water age in the areas of the system with the highest age. In the event that reservoirs are renovated to split storage and increase operational flexibility, the need to practice deep cycling will be reduced. However, Dort Reservoir and CSR filling should not occur simultaneously to minimize peak water supply rates for filling operations; and, reservoir filling should occur during daily diurnal periods of minimum customer consumption to reduce peaks and the impact of pressure decreases during filling.

Optimized locations were also identified within the distribution system for automated water quality sensors and these are available in the *Hydraulic Modeling Technical Memorandum*, *January 2018.* As part of the capital planning efforts, the City plans to divide CSR into two separate chambers that can be operated independently. To reduce water age impacts, Dort will be used a half capacity during winter months. As such, additional modeling scenarios were added to simulate operation of each as 10 MG storage facilities. The results of these simulations are presented as Addendum 1 to the *Hydraulic Modeling Technical Memorandum, January 2018*.

2.7 Asset Management Program

2.7.1 Asset Management Gap Analysis

The first deliverable the team developed as part of the asset management program was an *Asset Management Plan (AMP) Gap Analysis Technical Memorandum, September 2017* (Appendix I). In 2016, the City published their first Asset Management Report by Rowe Engineering (Rowe, 2016a). MDEQ reviewed the report and provided feedback for areas of improvement and non-compliance. The existing report and the MDEQ's comments to develop a roadmap to close the gaps in the report to meet MDEQ's asset management plan requirements were reviewed by the team. A roadmap to align the AMP was developed with the following publications: *Asset Management Guidance for Water Systems* (MDEQ, 2013a) and *Asset Management Program Checklist* (MDEQ, 2013b). In addition to meeting State requirements, asset management guidance and best practices from *Asset Management: A Best Practices Guide* (USEPA, 2008), *ISO 55000* (ISO, 2014a), *ISO 55001* (ISO, 2014b), *ISO 55002* (ISO, 2014c), and IIMM (NAMS and IPWEA, 2011) were leveraged.

A total of 37 gaps were identified, suggesting the AMP include a mission statement, goals and levels of service, a governance and implementation schedule, stakeholder engagement, a more comprehensive asset inventory, risk methodology and analysis, financial analysis and planning, and other elements. The content was ultimately reorganized according to the MDEQ's "five (5) core components in an Asset Management Plan". This includes chapters for:

- Asset Inventory
- Level of Service
- Criticality
- Capital Improvement Project Plan
- Revenue Structure

The *Asset Management Plan (AMP) Gap Analysis Technical Memorandum, September 2017* provided a detailed outline for the 2017 AMP and proposed a roadmap to close gaps and meet the MDEQ January 1, 2018 submittal deadline.

2.7.2 Asset Management Plan

A MDEQ-compliant AMP, *2017 Water System Asset Management Plan, January 2018* (Appendix J) was developed as part of the asset management program. To close the gaps identified in the gap analysis TM, a request for information was submitted in early 2017. Upon review of the existing electronic data, it was determined by the team that several data sets that were shown as complete in the 2016 Asset Management Report could not be found electronically and that the data gaps would need to be closed prior to producing the AMP. For example, the City was missing asset registries for their booster stations and approximately 50 percent on their pipe segments were missing install dates.

The water system AMP is a living document that serves as a roadmap for the City to develop and implement a full asset management program within the Water Department within the next 3-5 years. The AMP will be updated annually per MDEQ requirements. The financial analysis reflects a conservative estimate of revenue increases to meet requirements, and the AMP updates are recommended once the Optimization Plan is complete.

The AMP focused on potable water distribution system assets which are owned, maintained, and operated by the City. The horizontal assets include: distribution mains, fire hydrants, control valves, system valves, meters, and service laterals. Meters and service laterals are not currently in the GIS inventory; however, it is recommended they are added in the future, and included in future AMP updates. The vertical assets in the AMP include: mechanical, structural, heating, ventilation, and air conditioning (HVAC), and electrical assets at the treatment facility, pump stations, and water storage facilities. Below is a summary of each chapter:

- **Asset Inventory and Condition Assessment:** Through collaboration with the City, an asset inventory was compiled and criteria for scoring assets were developed as part of the condition assessment effort.
- **Level of Service:** The City drafted 25 LOS measures and KPIs using guidance from the MDEQ and the AWWA's Utility Benchmarking publications. The measures will be piloted and implemented in a tiered approach, with Tier 1 containing the most important measures to maintain the required LOS.
- **Criticality:** The condition assessment effort evaluated physical and performance condition at the asset level to determine the likelihood of failure (LOF). With input from the city, consequence of failure (COF) was assigned by asset type, and risk was calculated by multiplying the likelihood and consequence of failure. The highest risk assets were prioritized in the capital improvement plan. Approximately 0.3 percent of horizontal assets fell into the highest risk category, and high

LOF scores were due to the age of pipe and results from the hydraulic model (i.e., low c-factor or high head loss). Roughly 3 percent of vertical assets fell into the high-risk category due to pump leakage, corrosion, and/or steel/concrete support issues at multiple facilities, and a flooded basement at the Cedar Street Pump Station.

- **Capital Improvement Project Plan:**
  - **Horizontal assets:** Four funding scenarios were run to show how the system-wide condition and risk change based on higher or lower funding levels. Scenario 3 was ultimately chosen, with the plan to increased funding by $1M each year starting at $7M in 2020 and finishing at $20M in 2037.
  - **Vertical assets:** Capital projects were developed in Excel based on the risk analysis and remaining useful life. Twenty-four critical assets are included for replacement or repair in the first five years, and a total investment of almost $2M is required.
- **Revenue Structure:** It has been determined that projected water revenue is less than the revenue requirements. To close the gap and maintain the appropriate balance of cash reserves in the Operating Fund, the estimated percent annual revenue increases over the next five years, peaking at 27.5 percent in 2019, and reducing gradually to 3.2 percent in 2022. However, the City has indicated that it will be extremely difficult to undertake revenue increases necessary to implement the Scenario 3 plan and will pursue various funding sources such as state and federal grants to offset the funding gap. The 20-year revenue requirements were also evaluated for O&M and cash funded capital.

2.7.3 Computerized Maintenance Management System Plan

As part of the asset management program, a *Computerized Maintenance Management System Plan*, *November 2017* (Appendix K) was developed. The City plans to implement a computerized maintenance management system (CMMS) to meet the goal of implementing a full asset management program within the Water Department within the next 3-5 years. This is the primary tool used to track large amounts of information, provide automated reports/dashboards, and assist with accurate decision making. That system should be populated with an accurate, up-to-date asset inventory.

Information presented within the CMMS Plan includes:

- Requirements for a future CMMS.
- Data gap analysis.
- List of various data sources currently used to maintain and operate the potable water system.
- List of all City-owned water-related assets and available asset attributes.
- Gaps or information which is currently missing and recommended to be added to the new CMMS.
- Summary of Recommendations and Implementation Considerations

Although the City has not used a CMMS in the past, the Sewer and Stormwater Departments are in the process of implementing the Cityworks Asset Management System. This product includes appropriate CMMS functionality for use by the Water Department. Cityworks is integrated with the Esri GIS software called ArcGIS. As part of the AMP, the best available GIS data for the water system was compiled into a

geodatabase that can be used by Cityworks. As of the issuance of this Plan, the City was in the process of implementing Cityworks for the water system.

The CMMS should streamline the quarterly and annual monitoring and reporting of pre-defined level-of-service goals. Additional details on the recommendations for new level-of-service goals and performance benchmarking guidelines can be found in the *2017 Water System Asset Management Plan, January 2018*.

2.8 Community Outreach

Community outreach activities were performed by McConnell Communications, Inc., a Detroit-based public relations firm, and aimed to communicate details of the project to the residents, garner community feedback, work to rebuild fractured relations, and restore trust.

Four town hall meetings were hosted; resident surveys on communication and other needs were conducted; one-on-one meetings took place with ministers and other key stakeholders: and connections were made with more than 60 neighborhood organizations to update residents. Transparency and regular communication facilitated the discussion with the residents and ensured better results through two-way conversation.

A survey of over 200 residents was conducted in 2016 to identify the concerns and expectations of the residents. The key expectations of the residents include regular updates on the efforts being carried out by the city, better relationships with every branch of government, and access to information in a variety of ways including email, social media, and postal mail (ranked top three in order of preference). A website (ranking fifth out of 7 communication means) was not created as a part of this effort as there were already existing sources of information available online and duplication of efforts was avoided.

3 RECOMMENDED IMPROVEMENTS AND IMPLEMENTATION SCHEDULE

The recommendations included in this Optimization Plan and included memoranda are ambitious and presented in an effort to guide the City toward a fully optimized system in accordance with the Partnership for Safe Water Distribution System Optimization Program (Friedman et al., 2010 and AWWA, 2011). The Partnership for Safe Water's program is comprised of a methodology for utilities to optimize their distribution systems through a phased process of commitment to the program, annual data reporting to the Partnership, self-assessment, and optimization, and to provide a path for continuous improvement for even the most highly functioning system. It is acknowledged that the City will need substantial increases in staffing and funding to implement all of the recommended improvements. The AMP and CIP are presented as living, breathing documents and are meant to be updated annually to reprioritize those tasks most critical for system operation as the City strives for continuous improvement.

3.1 Updates to Recommendations

A comprehensive Resource Analysis and Needs Assessment was conducted detailing the financial and human resource requirements for the recommendations identified in the *Assessment of Current Practices and Gap Analysis, March* 2017. Through subsequent workshops and meetings with stakeholders including the City and MDEQ, including the Optimization Plan Workshop in Flint on February 2, 2018, the recommendations as well as the cost and human resources requirements have been refined and scaled to more accurately reflect predicted costs and time incurred by the City. Below is a summary of the updates to the human resource and capital needs included in the *Resource Analysis and Needs Assessment, March 2017*:

- Cross-connection control
    - Costs for installation of backflow preventers were reduced assuming that these efforts could be completed simultaneously with meter replacement through the planned automated meter reading (AMR)/advanced metering infrastructure (AMI) improvements.
    - An additional recommendation, an update to the commercial cross connection control plan, was identified and includes one-time costs for a contractor update of the commercial cross connection program, external commercial public outreach, and meetings with commercial customers.
- Customer call center
    - Discussion of a customer service call center during the Optimization Plan Workshop in February 2018 focused on establishing a City-wide call center, which the Water Department would support with both initial capital investment and continued staffing. This model assumes costs of the call center would be shared across all other Public Works departments thereby allowing a 24-hour call center to operate with reduced cost to each participating department. While the funding and staffing recommendations did not change, it is recognized that the costs and staffing presented represent the Water Department cost-sharing contribution.

- Valves and hydrants
    - Based on a recent asset inventory completed in 2017 during preparation of the AMP, the number of 1908 Darling hydrants was updated from 60 to 745. However, given the large number needing replacement, it is assumed that the 1908 Darlings will be prioritized for replacement under the annual replacement task. This assumes that 1 percent, or 72, of the 3,604 total surveyed hydrants in the system, will be replaced annually.
    - The costs to replace valves and hydrants were adjusted based on cost estimates from the City.
    - Much of the follow-up work arising from the Wachs Water 2015 Valve Assessment was completed by the City in 2016 and 2017. However, due to lack of work order completion tracking, it is recommended that Wachs Water return to the City within the next two years to complete a new assessment of valving and integrate work orders into the Cityworks software.
- Modeling
    - The City is moving forward with plans to renovate the CSR by creating an internal divider effectively splitting it into two 10 MG reservoirs for greater operational flexibility and water quality control during summer and winter flow conditions.
- Pump stations
    - The cost for annual contractor inspections of pump stations was refined to include individual pricing for Cedar Street, Dort, and Torrey Road pump stations.
- Security & emergency
    - Cost for the following items were refined based on Flint's specific needs:
        - Technical oversight for an initial update of the Emergency Response Plan (ERP) cost was reduced
        - A one-time, initial training and exercise of the ERP with contractor technical oversight task was added
        - The one-time, initial cyber security gap assessment cost was reduced
        - The recurring cyber gap assessment task cost was reduced while the frequency was increased from every 5 years to every 2 years
        - The one-time, initial funding assessment cost was reduced
        - The recurring cost to update the existing ERP to meet Federal Emergency Management Agency (FEMA) standards was reduced and delegated to City staff. A cost for contractor technical oversight was removed.
        - Annual regular exercise and review of the ERP, both with technical oversight by a contractor and by Flint staff cost was reduced
- CMMS
    - A new project was added for assistance in implementing the CMMS software, Cityworks, which includes a one-time, initial cost for set up and a recurring cost for training, complaint tracking, interfacing with customer billing system, and licensing and support.
- Current CIP and Water Infrastructure Improvements for the Nation Act of 2016 (WIIN) Fund Project Updates
    - The City has developed a CIP for 2018 and beyond that includes both cash and grant funded projects. The proposed capital projects were added to the 20-year CIP and are further discussed in Section 3.3.

Updates to the recommendations are included in the updated cost estimates in *20-Year Capital Improvement Plan* (Appendix L).

3.2 Prioritization Approach

It is understood that given the City's limited resources, full implementation of the recommended improvements will be challenging even considering the allocated grant funding. As such, tasks have been prioritized to guide implementation of projects most critical for maintaining regulatory compliance, providing enhanced levels of service, and preventing catastrophic failure. Each task was evaluated based on impacts to water quality, water quantity, ease of operation, and sustainability (i.e., social, economic, and environmental triple bottom line) to determine the overall system impact of the improvement. Additionally, input from USEPA, MDEQ and City staff provided during update meetings and workshops for the Resource Analysis and Needs Assessment and Optimization Plan was incorporated to stratify tasks into high, medium, and low priority.

3.3 Capital Improvement Plan and Schedule

3.3.1 Prioritization Results

The criteria identified in Section 3.2 were used to prioritize the recommendations from the Gap Assessment and Analysis, Resource Analysis and Needs Assessment, Asset Management Plan, the City's current CIP, and recommendations from the AMP. In addition to the criteria discussed in Section 3.2, projects which directly impact the City's technical, managerial and financial capabilities to operate the water system were given a higher priority.

The prioritization effort resulted in three groups of projects – high, medium, and low priority. The guidelines for project initiation by project priority are:

- High priority – 0 to 2 years
- Medium priority – 3 to 5 years
- Low priority – 6+ years

The plan provided is a 20-year CIP, as such the priorities above are provided for project initiation. However, many projects extend well into the 20-year planning period.

The different priorities assigned to each group of projects should not be intended that each recommendation is not worthy of implementation, it is instead intended to be an acknowledgement of the significant capital, human resources, and time investment required to implement the recommendations. Further, it is an acknowledgement that many of the recommendations represent best-in-class practices, and while that may ultimately be the City's goal, those practices exceed what may be needed to ensure sustainable long-term operation of the water system.
Table 2 provides a list of high priority recommendations.

1. Table 3 and Hydraulic modeling projects include costs for model software and training. However, the City may elect to have modeling completed by an outside contractor.
2. Project may be eligible for completion under WIIN program manager

Table 4 provide medium and low priority recommendations, respectively. Three sources of improvements were utilized as described below:

- CIP-# items are from the City-provided CIP used for ongoing rate studies and preparation of the Asset Management Plan.
- AMP-# items are based on recommendations contained in the *2017 Water Distribution System Asset Management Plan*, *January 2018*, resulting from condition assessment of the City's vertical and horizontal distribution system assets (i.e., pump stations and storage facilities)
- All other items resulted from the *Assessment of Current Practices and Gap Analysis Technical Memorandum,* March 2017 and *Resource Analysis and Needs Assessment Technical Memorandum*, March 2017, unless otherwise noted.

The "Project Number / Item" refers to the Item Number in the detailed descriptions and cost estimates provided in the *20-Year Capital Improvement Plan* and can be used for cross-reference to find additional information about the item and assumptions made during cost estimating.

Table 2: High Priority Capital Improvements

Project Number / Item	Source / Category	Brief Description
CIP-1	CIP	FAST START – Lead Service Line Replacement (LSLR)
CIP-2	CIP	GCDC Supply
CIP-3	CIP	Northwest Transmission Main
CIP-4/WL-2-1/2-2	CIP, Water Loss	Meter Replacement – AMR/AMI
CIP - 5	CIP, Pipe Rehabilitation & Replacement, Valve & Hydrant	Small Main Replacement (grant funded)
CIP-6 / RR-2-3/2-4 / VH-6-2B	CIP, Pipe Rehabilitation & Replacement, Valve & Hydrant	Small Main Replacement (City funded)
CIP-7 / PS-1-2	CIP, Pump Station	Dort Pumping Station/Cedar St. Pump Replacement
CIP-9/OM-1-1A/B / OM-1-3 /	CIP, Online Monitoring	Implement Distribution System Online WQ Monitoring Stations
CIP-10	CIP	Dam Maintenance
CIP-11	CIP	72-inch Line Maintenance
CIP-12 / PS-1-1 / PS-1-2 / SF-1-1 / WA-2-1	Pump Station/Storage Facilities/Water Age/CIP	Storage and Pump Station Improvements
CIP-13	CIP	Atherton Road Main
CIP-14[1]	CIP	Chemical Building Construction
CIP-15[1] / WL-4-1B	CIP, Water Loss	Leak Detection / Annual Meter and Leak Detection
AM-1-2[2]	Asset Management	EAM System Implementation Assistance & Maintenance and Support
CC-1-1A	Customer Complaints	Establish a Call Center
XC-1-1B	Cross Connection	Update Commercial Cross-Connection Control Program
XC-1-1A	Cross Connection	Develop Residential Cross-Connection Control Program

Project Number / Item	Source / Category	Brief Description
XC-2-1A / 1B	Cross Connection	Purchase Cross-Connection Control Software
IT-1-0	IT	SCADA Upgrades
SE-1-1A	Security & Emergency	Site Control and Intrusion Detection
SE-1-2A	Security & Emergency	Fencing at Cedar Street Reservoir
SE-2-1A/1B	Security & Emergency	Update the existing ERP to meet FEMA standards
WL-1-1A / 1B	Water Loss	Develop Water Loss Control Plan
SF-2-3B	Storage Facilities	Contractor: Storage Facility Comprehensive Inspection
RR-2-1/VH-4-1	Pipe Rehabilitation & Replacement	Update Pipe Assets in GIS /Valve-Hydrant Model Review
VH-1-1	Valve & Hydrant	Wachs Valve Assessment
VH-6-1A	Valve & Hydrant	Develop a Planned/Preventative Maintenance Plan
VH-6-2A	Valve & Hydrant	Develop Valve & Hydrant Manual Library
VH-6-1B	Valve & Hydrant	Valve & Hydrant Replacement
AMP-1-2	Asset Management	Miscellaneous Vertical Asset Rehabilitation and Replacement (R&R)
OT-1-1A[3]	Other	Vehicle Replacement

1. CIP-14 and CIP-15 were added to the City's proposed CIP following completion of the Asset Management Plan.
2. EAM-1-2 was added following completion of the Resource Analysis and Needs Assessment.
3. Project may be eligible for completion under WIIN program manager

Table 3: Medium Priority Capital Improvements

Project Number / Item	Source / Category	Brief Description
HM-3-1A/1B[1]	Hydraulic Modeling	Hydraulic Modeling Software
HM-3-2[1]	Hydraulic Modeling	Hydraulic Model Training
HM-3-3[1]	Hydraulic Modeling	Develop and implement model maintenance plan
PR-1-3A[2]	Pressure Management	Portable Pressure Data Loggers
SE-3-2A/2B	Security & Emergency	Vulnerability Assessment
SE-3-3A/3B	Security & Emergency	Funding Assessment
VH-7-1A	Valve & Hydrant	V&H Program Hardware and Software Upgrades
WQ-1-1	Water Quality	Laboratory Equipment Upgrades

3. Hydraulic modeling projects include costs for model software and training. However, the City may elect to have modeling completed by an outside contractor.
4. Project may be eligible for completion under WIIN program manager

Table 4: Low Priority Capital Improvements

Project Number / Item	Source / Category	Brief Description
CIP-8 / VH-5-1	CIP, Valve & Hydrant	Water Facility Consolidation
FL-1-1A/1B	Flushing	UDF Equipment
FL-1-3	Flushing	Optimize Flushing Loops
HM-2-1	Hydraulic Modeling	Conduct WQ Model Calibration
RR-1-1C	Pipe Rehabilitation & Replacement	Outside Review of Design Standards
PR-1-2[1]	Pressure Management	Comprehensive Surge Analysis
PS-1-3B	Pump Station	Contractor: Pump Station Annual Inspections
SE-2-1C / 2-2	Security & Emergency	Regular Exercise and Review of ERP / Communications
SE-3-1A	Security & Emergency	Cyber security for SCADA/instruments outside WTP
SE-3-1B/1C	Security & Emergency	Conduct a cyber security gap assessment
VH-7-1B	Valve & Hydrant	Hardware and Software Upgrades

1. Project may be eligible for completion under WIIN program manager

3.3.2 Cost Estimating Methodology

A detailed discussion of the cost estimating methodology is provided in the *Resource Analysis and Needs Assessment Technical Memorandum, March 2017.* 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 and external contractor services were based on an average hourly rate of $150.

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 percent 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.

Cost estimates presented in the Resource Analysis and Needs Assessment were further developed and refined (consistent with the methodology described above) during preparation of the CIP presented herein. The *20-Year Capital Improvement Plan* provides more detailed descriptions of the items included and the assumptions used to develop the costs summarized in the CIP.

3.3.3 Capital Planning Considerations

The CIP presented in this section is based upon prioritization of recommendations from the Gap Assessment and Analysis, Resource Analysis and Needs Assessment, Asset Management Plan and City of Flint proposed capital budget as described previously. Those recommendations were prioritized, and the CIP presented herein attempts to schedule those recommendations in such a manner consistent with

the prioritization category (high, medium, or low). It should be noted that operating costs are not included in this capital plan. None of the recommendations include traditional operational expenses (e.g., chemicals, power, etc.) and the need for additional labor is addressed in Chapter 4.

Early years of the CIP (FY18 through FY20) are extremely aggressive due to the availability of WIIN funding and the hiring of a Program Manager to oversee completion of projects associated with those funds. As a result, projects that are able to be funded through available WIIN funds were given a higher priority and will be completed first. Based on early discussions with the City and the Program Manager, it is believed that those projections are realistic, but it remains to be seen that so much work can actually be completed in such a short period of time. In addition, some projects still need to be approved for WIIN funding by USEPA. With that in mind, the following considerations and recommendations are made with regard to the proposed CIP:

- The CIP includes only capital projects and projects which require outside (i.e., consultant or contractor) assistance. It does not include City labor costs.
- Items for which only City labor (no capital) are required are not included in the CIP. However, additional staff to fill those needs are identified in Section 4.3 as is the recommended timeline for hiring those individuals. Appropriate increases in the operating budget to account for those additional staff would also be required.
- Progress against the CIP, particularly in the early years, should be monitored closely and the CIP adjusted accordingly. It may be that with all of the efforts occurring simultaneously, it is simply not possible to complete everything in such a short period of time.
- Similarly, the level of investment in “small main replacement” is based on the analysis in the Asset Management Plan, which indicated the level of investment to maintain the current break rate. Whether that amount of work in a year is feasible, particularly in the later years, is to be determined.
- The break rate analysis described above should be repeated and regularly updated to determine the future annual investment in small main replacement.
- The CIP should be updated when the Program Manager has completed its Project Plan, which will include more accurate costs and a revised schedule for “CIP” items in the plan.
- The CIP should be updated regularly (at least annually as part of the City’s budgeting process).

3.3.4 Capital Improvements Plan

A 20-year CIP is provided in Appendix L. The table is organized into three main categories of capital investment:

- *Administrative* includes items such as customer service, CMMS implementation, GIS maintenance, standards development and maintenance, program development (e.g., emergency response program, water loss control program development, cyber security, etc.), and software and licensing.
- *Water distribution* includes items related to water distribution system capital and operational improvements that are not considered Rehabilitation and Replacement (R&R) projects, including hydraulic modelling, unidirectional flushing equipment, SCADA upgrades, and facility inspections.

- *Rehabilitation and replacement* includes lead service line and small main replacement, large diameter main replacement, storage facility and pump station improvements, dam improvements, new chemical facilities, valve and hydrant replacement, and replacement of vehicles.

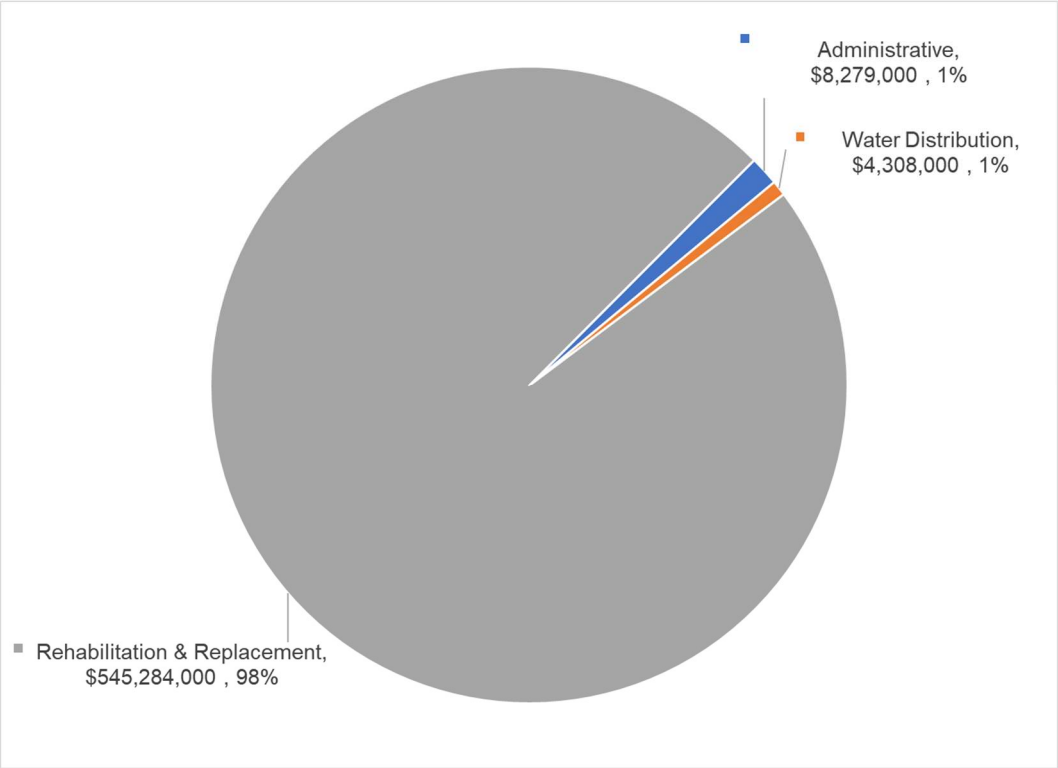


Figure 2: Distribution of Projected 20-Year Capital Expenditures

Figure 2 shows the proportion of the projected 20-year capital expenditures in each of these three areas. As can be seen, R&R accounts for nearly all of the projected 20-year capital expenditures. One reason for this is the grant funding available for the next several years will allow the City to make significant capital investment in water system R&R. However, when the grant funding (approximately $167 million) is removed, City-funded R&R still accounts for 97 percent of the projected future capital expenditures.

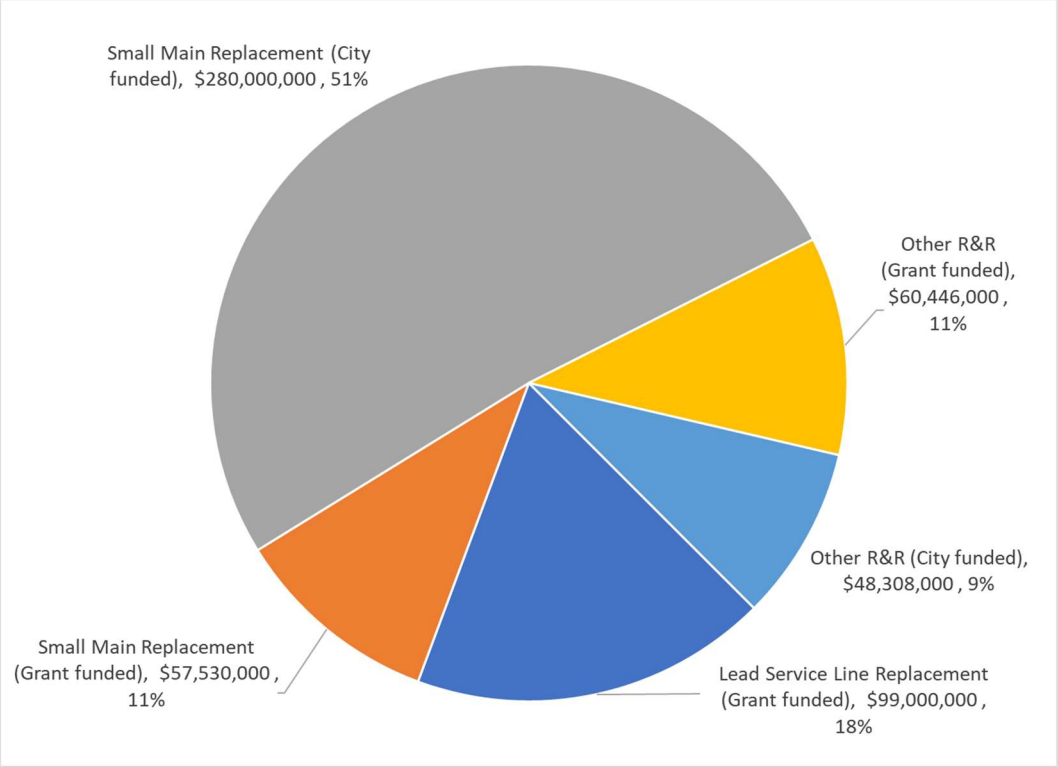


Figure 3: 20-Year Projected R&R Budget by Funding Source

Figure 3 provides more detail regarding the projected 20-year R&R capital spending. As noted previously, the City will have significant grant funding available over the next several years to address water system R&R needs. That said, the *2017 Water Distribution System Asset Management Plan*, January 2018, recommended significant investment beyond the available grant funds for small water main replacement just to maintain the City's current historic annual average break rate. That recommendation alone equates to approximately $280 million over the 20-year capital planning period as shown in Appendix L.

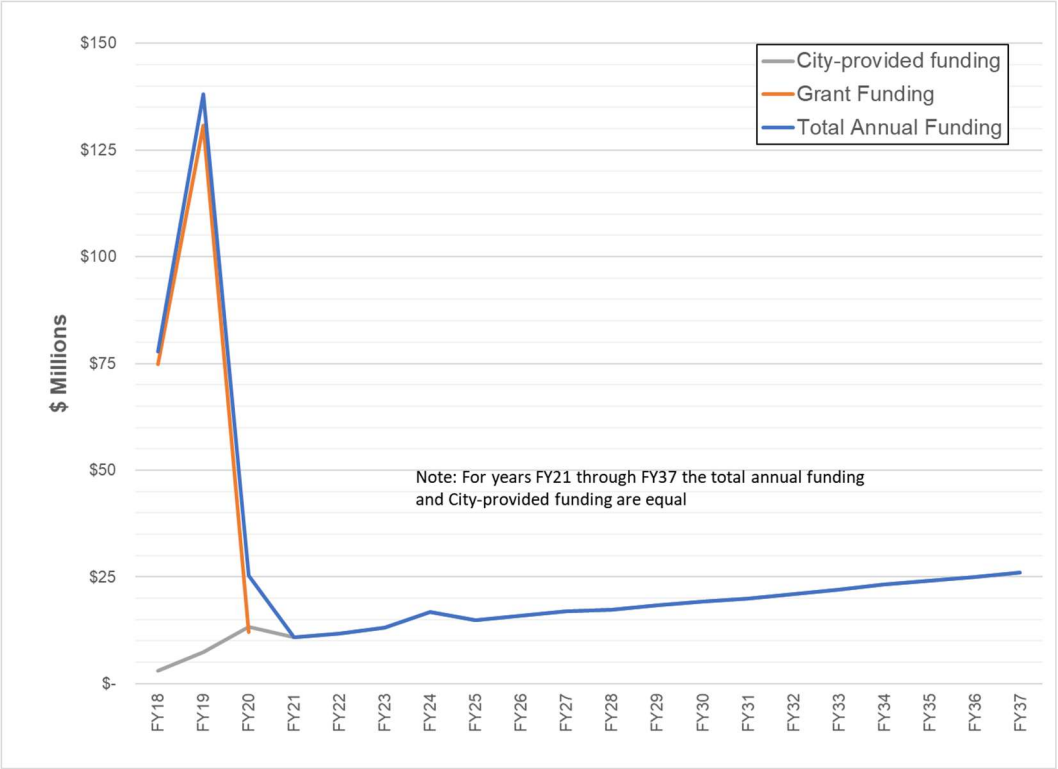


Figure 4: 20-Year Projected Source of Capital Funding

Figure 4 provides a summary of the projected source of capital funding over the 20-year planning period. As can be seen, capital investments in FY18 and FY19 are $69 million and $93 million, respectively, assuming the majority of funding supplied by grant funds. The projected capital budget drops to approximately $12 million in FY20 – again with the majority coming from grant funds. FY21 is the first year of projected fully City-funded capital improvements, which begins at approximately $10 million and ramps up to nearly $26 million by FY37.

3.3.5 Additional Items Excluded from CIP

A number of recommendations were not included in the CIP for various reasons.

- The recommendations were completed during preparation of the Optimization Plan.
- It is assumed that these items will be completed by the Program Manager overseeing LSLR and other projects associated with grant funding.
- The recommendation was completed by the City or another consultant outside the scope of the Optimization Plan.

In addition, there are three recommendations that were simply not included.

- A whole house flushing demonstration was attempted during preparation of the Optimization Plan and not a single resident was willing to participated. Attempts were coordinated through the FastStart program and outreach was made at multiple public meetings, yet there were still no volunteers. Household flushing had no associated capital cost, only City labor. LSLR is

anticipated to be complete within two to three years (2019 or 2020) and it was determined that hiring of other resources would be a higher priority.

- Participation in the AWWA Water Loss Committee is a worthwhile goal and is encouraged, but given staff limitations it was not considered a priority.
- Similarly, hiring a security guard to monitor video of the City's distribution assets seemed a lower priority and should be considered at a future date, but was not considered necessary at this time.

Table 5 provides a summary of those items not included in the CIP.

Table 5: Recommendations Not Included in the CIP

Project Number / Item	Source / Category	Brief Description
Items completed during preparation of the Optimization Plan		
AM-1-1	Asset Management	Develop AMP
FL-1-2	Flushing	UDF Pilot Study
HM-1-1	Hydraulic Modeling	Water Model Calibration
IC-1-1	Internal Corrosion	Whole House Flushing
OM-1-2	Online Monitoring	Identify (online water quality monitoring) Sensor Placement
PR-1-1	Pressure Management	Surge Analysis
RR-2-2	Pipe Rehabilitation & Replacement	Hydraulic Modeling Criticality Assessment
VH-3-1	Valve & Hydrant	Complete inventorying/GPS hydrants (1713 completed/3605 total)
WA-0-1	Water Age	Water Age Analysis
WA-3-1	Water Age	Storage Analysis
VH-4-1	Valve & Hydrant	Comprehensive GIS data model review & update
Items assumed to be completed by the Program Manager		
RR-1-1A	Pipeline Rehabilitation & Replacement	Update Design/Construction Standards
Items to be or already completed by City		
AM-1-1	Asset Management	CMMS Implementation [1]
WA-2-1	Water Age	Storage Facility Mixing Improvements (including Tank Improvements)
SE-3-5	Security & Emergency	Participate in Genesee County Hazard Mitigation Process
WL-3-1	Water Loss	Form an Internal Water Loss Management Team
Items not included		
IC-1-2	Internal Corrosion	Conduct Whole House Flushing Program
WL-4-1A/1B	Water Loss	Participate in AWWA Water Loss Committee

Project Number / Item	Source / Category	Brief Description
SE-3-4	Security & Emergency	Security Guard to Monitor Distribution System Assets

1. CMMS Implementation includes initial acquisition of mobile computers, instrumentation services, software licenses, and support for customer billing interface updates.

4 RESOURCE AND FUNDING NEEDS

The Water Distribution Optimization Plan includes recommendations that will require significant additional funds from both the City and other funding sources. The following sections of this Report provide an overview of funding and financing options that the City should consider for optimizing and improving the distribution system, while mitigating significant increases to the City's water ratepayers.

4.1 Funding and Financing Options

As noted above, the CIP identified significant capital improvements to be implemented over the coming years. Within the Asset Management Plan recently submitted to the City and MDEQ, a financial analysis was performed to determine the funding gap for implementing the AMP recommendations. The AMP includes shorter-term capital needs that are planned to be met with a mix of grant funds anticipated by the City and cash from system operations. The AMP also includes longer-term capital needs for main replacement and ongoing renewal and replacement of vertical assets (e.g., pump stations and storage) that could be met with a variety of funding sources. Figure 5 provides an assessment of future revenue requirements (projected O&M and capital inflated at annual rates) compared to the City's revenue under existing rates and charges. As can be seen, the projection shows that approximately $95 million annually would be needed by 2037 to implement the recommended improvements, including the inflated $24 million capital budget that is shown in Chapter 3 that reflects replacement of approximately 35 percent of the distribution system.

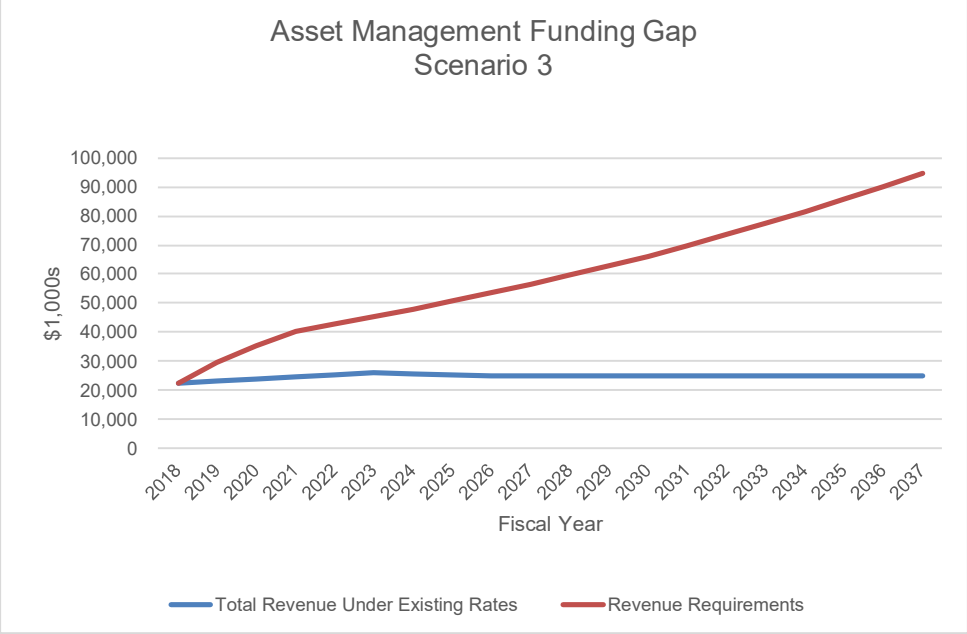


Figure 5: Asset Management Funding Gap

For meeting these future requirements, there is uncertainty at this point as to what funding sources might be available to the City to offset the projected revenue requirements. The sections below discuss

potential alternative funding sources that could be used to offset the future revenue requirements and mitigate rate increases on City customers.

A workshop was hosted at the City of Flint WTP on February 1, 2018 to review work on the Water Distribution Optimization Plan to date. Included in the workshop was a presentation outlining potential funding opportunities that could fund future improvements for the water system and mitigate rate increases for customers. The presentation provided the City with an opportunity to provide feedback on the various funding options, which provided an understanding of their feasibility on a comparative basis.

4.1.1 Cash Funding Sources

Direct cash for the water system can come in several forms. Recently, the City has been relying on water system rates and multiple grant sources to fund operations, planning, and capital improvements for the City. The following provides more information about one or more options that the City could use to obtain needed cash for distribution system improvements.

4.1.1.1 Grants

The City has been successful in obtaining grant funding for several important projects and initiatives related to the water crisis. In March 2017 the City obtained a WIIN grant of $100 million to fund projects including, funding for the replacement of service lines and distribution system improvements. This WIIN grant also included a $20 million match from the State of Michigan. Since 2015, the State of Michigan has also provided over $200 million in appropriated funds in response to the water crisis for items such as water filters, water bill reimbursement credits, public outreach, health services, and other economic development and social initiatives. There have also been multiple private foundations that have provided support to the City in response to the water crisis. One example is the Charles Stewart Mott Foundation's grants to support the purchase of water filters and economic development in response to the water crisis.

The CIP noted above includes grant funding that the City has already identified for several important projects including funds for the replacement of small mains in the distribution system. For the longer term projected needs, it is recommended that the City continue to pursue state and federal grants, particularly to offset significant capital improvements that are needed for replacing the distribution system over 20 years to maintain a main break rate and risk level similar to that of today. The replacement would be a significant effort for a system that dates back to the early 1900s and would be a significant burden to rates if funded only through water customers. The following potential grant funding opportunities exist:

- WIIN – The City has already obtained grant funding for multiple capital projects from the WIIN funding source via MDEQ. This includes funding for lead service line replacement and distribution system improvements. The City CIP anticipates WIIN funding will also be able to be used for replacement of meters; supplementary supply to Genesee County per the City's recent agreement with GLWA; and other projects.
- FEMA – President Obama signed an emergency declaration on January 16, 2016 making federal emergency aid available to the State of Michigan in response to the crisis in Flint. The initial support from FEMA consisted of funds for bottled water; water filters, and water test kits. Communities that have experienced major disasters have been successful in obtaining grants from FEMA for post-disaster recovery, as well as for performing pre-disaster planning. As the current round of WIIN

funding is utilized, the City should explore potential FEMA funding options for funding post-disaster projects such as replacement of distribution system mains that are essential to public health and safety of customers.

- Housing and Urban Development (HUD) Grants - After the 2016 federal disaster declaration, the U.S. HUD was mobilized to see how it could also help the City. HUD assistance generally consisted of direct support in terms of funds for water filters for public housing units; housing choice vouchers for approximately 5,000 units; and blood testing. HUD also appointed a staff member to provide assistance to HUD residents, and collaborate with Federal, State, and Local agencies on assistance activities.

  HUD also provides Section 108 financing in the form of low interest loans to communities, a portion which can be used for publicly-owned real property. A review of documents on the HUD website seem to indicate that the City has the ability to borrow approximately $9.8 million under this program. It is recommended that the City inquire with the HUD representative appointed to assist the City to determine whether it would be feasible to obtain additional HUD grants, or Section 108 loans.

- Recent Legislation (2017 Supplemental Appropriations for Disaster Relief) – The U.S. Congress recently approved additional supplemental disaster relief for disaster recovery efforts. At this time, we are awaiting specific guidance from agencies on the use of these funds. Since the City already has a disaster declaration, it should continue to monitor to see if funds can be used for infrastructure resiliency type projects.

- Future Infrastructure Funding – The Federal government is considering potential legislation to fund infrastructure improvements across the U.S., including water and sewer infrastructure. The City should continue to track progress related to this initiative and leverage any future funds for distribution system improvements.

- State Grants and Appropriations – As noted above, the City has received funds from the State of Michigan for initiatives in response to the water crisis. In the coming years, the City should continue to pursue State funds, including funds for the renewal and replacement of the distribution system.

- Private Foundation Grants – The City should continue to evaluate and seek potential grants from private foundations to support recovery from the water crisis. While these grants may not always directly support infrastructure renewal and replacement, they can cover some water system costs and indirectly allow the City to dedicate more resources to infrastructure renewal and replacement.

4.1.1.2 Steps to Pursue Grant Funding

All infrastructure projects involve complex timing and funding challenges. Any effective implementation plan must maximize use of a variety of strategies to address the citywide scale need. Economic constraints at local, state, and federal levels require the creative application of multiple funding sources to improve, expand, and protect infrastructure. Federal, state, and regional funding sources, such as grants, may provide funding that can be leveraged with other sources to implement infrastructure projects.

Opportunities to meet such funding needs arise on an annual basis, through congressional and state appropriations, as well as after Presidentially Declared Disaster Declarations. Additionally, specific grant

funding and other revenue mechanisms may be discovered or developed that can be utilized to minimize investments made from existing accounts.

Funding programs are rarely static, as agencies will replace or revise existing programs to incorporate innovative design, market changes, and new regulatory requirements into eligibility qualifications. It is important to take a proactive role and develop a funding strategy to track and maintain a list of available funding opportunities, policy developments, and specific criteria that must be met to pursue grant funding for particular types of projects. Developing a funding strategy may include, but are not limited to, the followings steps:

1. Review the list of projects included in the most recent Capital Improvement Program, J100 Vulnerability Assessment, or projects recommended in the Optimization Plan
2. Meet with key stakeholders to review priorities and gain project understanding;
3. Conduct a thorough analysis of potential funding sources and opportunities;
4. Develop an implementation strategy of funding opportunities for specific projects; and
5. Facilitate the grant application development process to maximize receipt of funding.

4.1.1.3 Property Taxes

Over the years the water industry has moved to recovering necessary revenue from customers via water rates and charges that are based in part on metered water usage. As such, the use of property taxes for recovering water revenue is not typical for mid- to large-sized utilities such as the City's. The City does require major expenditures for replacement of distribution system assets, and therefore a property tax assessment to cover a portion of the system replacement could be explored. A property tax assessment would generally consist of a millage per unit of assessed value for City property owners. The advantage of a property tax to cover a portion of the distribution system replacement would be to shield water rates from a significant reinvestment in the water system that is not entirely related to current day water usage. As it is based on the assessed value of property, parcels with greater assessed value would pay a larger share of the total assessment. The main drawback is that customers will still have to pay the property tax assessment in addition to their normal water bill.

4.1.1.4 Special Assessment District

Michigan does allow for special assessment districts to be formed by municipalities that are seeking to fund public improvements, including water infrastructure. The special assessment is generally linked to a benefit received by a property owner. For instance, a public improvement that improves the property value of a parcel may be recoverable via a special assessment that is generally linked or comparable to the increase in value. In some instances, special assessment districts can be limited in scale depending on the project. For the City, where large scale replacement of portions of the distribution system are recommended, it may be worth exploring how a larger scale special assessment district might be feasible. Special assessments differ from property taxes in that the assessment is based on property frontage, land area, or some similar measurement in lieu of a property's assessed value. To implement, the City would need to establish the district and determine the list of properties to be assessed. Public hearings

would be needed to explain the project and benefits to the properties, including the estimated assessed value to pay for the project or debt associated with the project.

4.1.1.5 Water Rates and Charges

The City already has an established water rate schedule for billing its customers. Water rates consist of a two-part structure including a monthly service charge that is graduated by meter size, and a declining block usage charge per unit of metered water use. The City's water rates generate cash from customers that is used to pay for operation and maintenance expenses, as well as any debt service on bonds or loans, and cash funded capital improvements. Currently the City does not have any outstanding debt. Revenue from current water rates, and other minor, miscellaneous revenue are projected to generate approximately $25 million annually. These rates were generally established prior to the water crisis and have not been adjusted to reflect costs of the water crisis or recovery needs. Based on the distribution system needs outlined in this Report and the AMP, water rates will need to increase over the ensuing 20-year period. However, based on the City's ability to obtain grant funding, the water rates could potentially be structured such that they do not recover significant distribution system replacement costs over the next 20 years. The City has initiated a rate redesign that considers affordability and is intended to reduce the impacts to low income customers. The redesign also includes higher rates for those customers with higher water consumption. These actions are anticipated to increase total revenue while providing rate relief for impoverished customers.

4.1.2 Debt Financing

Prior to the water crisis, the City has approximately $20 million in outstanding water debt service related to loans from the state revolving fund. This debt was retired by the State as part of grants provided to the City after the water crisis, and currently the City does not have any water system debt. As there will be significant improvements to the distribution system over the coming years, the City may consider using debt to finance a portion of the longer-term capital improvements. As assuming debt or loans entails repayment of principal and interest, the City will need to stabilize its operations and finances to demonstrate that it can consistently generate revenue to meet O&M expenses and other capital-related expenses.

4.1.2.1 Drinking Water Revolving Fund Loans

MDEQ administers the State Drinking Water Revolving Fund (DWRF) which provides relatively lower interest loans or grants to water utilities. The City has used the DWRF in the past to finance capital improvements. DWRF loan terms are typically set for repayment over a 20-year term with revenues pledged from water rates and charges. The benefit of using a loan for financing capital improvements is that it spreads the upfront cost of a significant investment to future users of the water system. As the City continues to recover from the water crisis, the State DWRF should be considered for financing a portion of longer-term distribution system capital improvements where grants are not available.

4.1.2.2 Revenue Bonds

Revenue bonds are similar to the DWRF loans in that they require repayment from the revenue of the water system. Revenue bonds are typically repaid over a 20-year or 30-year term and have a higher

interest rate compared to DWRF loans. The interest rate obtained for a revenue bond is determined in part on the rating a utility receives from agencies such as Standard & Poors; Fitch; or Moodys. The ratings assigned by agencies such as these reflects their assessment of risk and the utility's ability to effectively repay the bond over its life. A favorable rating generally reflects a lower interest rate associated with the bond. A negative rating generally reflects a higher interest rate associated with the bond. For the City, which is still recovering from the water crisis, it is not recommended that this funding approach be considered for the short-term. Once the City is able to stabilize operations and demonstrate consistent and positive financial performance, revenue bonds may be considered for a portion of future capital requirements.

4.1.2.3 General Obligation Bonds

General obligation (GO) bonds are similar to revenue bonds, with the exception that they would be backed by the City's commitment to repay the bonds from its other funds should water revenues be insufficient to meet annual principal and interest payments. Generally, communities that utilize GO bonds issue them for different project types, including water improvements. The water enterprise fund will then dedicate a portion of its revenue to the City for repayment of its share of the annual principal and interest. GO bonds typically have lower interest rates compared to revenue bonds as they are issued by the City. The use of GO bonds for future water improvements should be considered, although there will likely be some hurdles for approaching the bond market for the City and its water system. The potential for successfully using GO bonds will likely increase as the City finances and water system finances improve over time.

4.1.3 Cost-Sharing and Partnerships

There are other cost-sharing arrangements that are becoming more typical in the water industry as utilities seek more effective ways to fund significant capital improvements and other utility costs. The following sections reflect some potential options for the City to consider that would help mitigate the impact on ratepayers to some degree.

4.1.3.1 City and Water Utility Cost-Sharing

Cost-sharing between the City and its water enterprise fund already occurs to some degree. The City has administrative resources for human resources, finance, and legal that support the water utility. These costs are allocated to the water enterprise fund and included in its budget. Other operating costs that could be considered by the City include the cost of operating a City-wide customer service center that would support both the City and water utility. Currently, water utility service calls are handled by administrative staff that are available, or in some instances the calls are forwarded to water management's cell phones to be addressed. City staff indicated that a call center was needed for both the water utility and the City as a whole. The future implementation of this would be an opportunity to share costs.

Other more significant shared costs may be related to the replacement of the water distribution system. For these projects, it is recommended that the City explore combined projects that renew or replace sewers and streets. Where possible, the cost of engineering and restoration could be shared to and result in some cost savings for the water enterprise fund.

4.1.3.2 Public Private Partnerships

During the workshop, the use of public private partnerships was discussed. Within the water industry, these can be larger in scale, including the operation and management of the entire water system, or smaller in scale where a private operator provides scoped services or small-scale tasks.

Larger scale partnerships could entail a private entity providing the City with an upfront payment in return for the ability to manage the water system for a specified number of years. The arrangement would typically be structured so that the private entity provides management of the system including O&M and capital improvements. In return, the private entity would retain revenue from water rates, including agreed upon rate increases for the period of the agreement. The benefit to the City is the shifting of risk related to management of the water system to the private entity. The benefit to the private entity would be the stream of payments from water revenue over time.

Smaller scale partnerships could consist of an agreement between the City and a private entity for a limited role in operating or managing the water system. In these potential instances, the City would retain responsibility for the overall policy and rate setting responsibilities, while the private entity would be responsible for operating a certain portion of the system, under an agreed upon set of terms and conditions. There would be several benefits to the City including the shifting of responsibility for managing and training some employees to the private entity. The City would typically retain overall responsibility for policy and rate setting.

On an even smaller scale, the City could consider annual contracts to private entities to provide distribution system and maintenance related to the optimization plan on a near-term basis. Important functions could include hydrant testing, regular flushing of mains, valve exercising, and other key areas recommended in this Report. The use of private operators could help establish processes and procedures for implementing the optimization plan, including the development of standard operating procedures. After time, the City could then assume those responsibilities when able.

4.1.4 Other Non-Rate Revenue Options

It is recommended that the City also consider non-rate revenue options to generate additional revenue. While the revenue might not be recurring, it could provide some funds to offset future capital improvements. Examples of non-rate revenue include the sale of unused properties; salvaging or recycling of unused assets; and repurposing of existing assets.

With respect to unused properties, many water utilities do not fully understand the land/property that has been acquired over the years as the system has expanded to meet customer demands. In some instances, there can be valuable property that would fetch a favorable price. It is recommended that the City explore what property, if any, it might own that could be sold for non-utility use.

The City could also look at property and assets that could be converted or sold for other purposes. One example could be the West Side Reservoir, which storage is no longer critical. This parcel and associated asset could potentially be repurposed for private development or as an asset for a sister utility with the sale proceeds coming to the City for offset of water capital improvements. Additionally, the City could ascertain whether cellular companies would have interest in installing cellular towers on the site for a recurring lease payment to the City. Finally, the property could be repurposed as a park or other green space for public use, with sale proceeds reverting from the City to the water enterprise fund.

4.2 Prioritization of Funding

During the workshop conducted February 1, 2018 feedback was provided by the City on the above funding options. The feedback included candid assessment from participants that included:

- The City is still in the assessment and planning stages post-crisis. Much work has been done to stabilize the water system, but organizationally the utility is staffed in a similar, pre-crisis manner which limits its ability to take on additional tasks.
- The City's customer base is still reticent to consistently use the water, which depresses metered usage and associated revenue.
- The City's customer base is economically disadvantaged and has trouble paying water bills.
- City political leaders are reluctant to implement a shut-off program for customers that have not paid their water bills, resulting in reduced revenue collection rates.
- City political leaders are reluctant to implement rate increases.

Considering these circumstances, several recommendations were developed that prioritize actions and funding opportunities that the City should pursue. The following list is rank ordered by importance with the value 1 being the most important. The recommendations are based on the assumption that the existing operating and governance structure will continue for the City's water system.

1. Conduct regular water system financial planning and begin implementing regular rate increases (even if nominal) to establish baseline cash funding of O&M and normal renewal and replacement capital. As a start, the City should strive to cash fund renewal and replacement capital for the distribution system (horizontal) assets and vertical assets. For example, the City could target to begin renewing or replacing 0.1 percent of the distribution system per year with cash funding, with a goal of increasing this over time to a more normal level of 0.5 to 1.0 percent of the system and factoring in other funding sources. This would provide a baseline level of funding similar to "normal" operations that would be supplemented with other funding means discussed below. Establishing regular rate increases will also help to stabilize water system finances, which will help the City should it decide to use future DWRF loans or revenue bonds.
2. Pursue Grant Funding Opportunities – The City has been successful in obtaining grant funds to begin recovering from the water crisis. There are significant capital replacements that are recommended to be done over the next 20 years. The City should pursue grant funding for these and other significant projects as a means for mitigating the impact to customer rates.
3. Non-Rate Revenue – This option already falls within the City's purview and therefore should be explored to determine whether non-rate revenue can be realized for use in offsetting a portion of the future O&M and capital costs. Examples as noted above include sale of surplus property, cell tower leases on water system property, salvaging/recycling unused scrap metal, or other charges. These other revenue types can provide one-time or consistent, annual funding to offset ongoing water system O&M and capital costs.
4. Cost-Sharing – With recommendations to replace a substantial portion of the distribution system over the next 20 years, the City should look to determine concurrent projects where costs for design and construction could be shared. Examples could include projects where streets, sidewalks, or sewers

need replacement along with water mains. In these instances, it may be feasible to replace valves, mains, or other items with at least some portion of design, construction, and restoration shared by other funds in lieu of only using the water fund to pay for the project.

5. Special Assessment District or Ad Valorem Tax – The City's rate structure includes a rater per hundred cubic feet of metered water. As it relies on metered usage and customers are reticent to use water, there is risk in continuing to use the current rate structure as the only means for recovering revenue for the system's existing and future costs. Ad valorem taxes or special assessment districts may be useful for providing the water system with some measure of fixed revenue. From a cost of service standpoint, it would likely be established to recover capital improvements that are above the renewal and replacement levels experienced by a normal utility. Over the years these charges could be phased out as the system normalizes.
6. Debt Funding – As the City's finances stabilize, there should be more certainty around how much of future improvements can be funded from grants and cash. If the utility is generating sufficient cash and has demonstrated greater financial and management capability for operating the system, it could leverage low interest GO Bonds or DWRF Loans for financing a portion of necessary capital improvements. Both of these options typically have lower interest rates than revenue bonds, which provides greater interest savings over the life of the bond compared to revenue bonds. GO Bonds and DWRF Loans may have a shorter payback term which can make their annual payments comparable to a revenue bond payment in the near term. If GO Bonds and DWRF Loans are not available, the City could determine to issue revenue bonds as a means for funding future capital projects. With more stringent requirements for debt service coverage and reserve levels, the City would require much improved, and consistently demonstrated financial performance.

4.3 Human Resource Needs and Training

4.3.1 Additional Staffing Needs

A staffing needs assessment was conducted for current Water Service Center (i.e., water distribution) workload and responsibilities during the Resource Analysis and Needs Assessment. A summary of that evaluation including the current budget staff, status of those budgeted positions (filled or vacant), and additional recommended staff is provided in Table 6.

Table 6: Resource and Needs Assessment Staffing Recommendations

Position / Title	Filled	Vacant	Total
Current Budgeted Staff			
Water Systems Supervisor	1	0	1
Deputy Supervisor	1	0	1
Water Distribution Foreman	4	0	4
Senior Water Distribution Operator	13	1	14

Position / Title	Filled	Vacant	Total
Water Distribution Operator	4	0	4
Water Distribution Operator – Trainee	11	1	12
Cross-Connection Program Manager	1	0	1
Administration	2	1	3
Additional Recommended Staff			
Customer Service	0	2	2
Construction Inspectors	0	2	2

In 2018, the City provided USEPA with a proposed organization chart for the Water Department, inclusive of both Water Service Center (distribution) and Water Treatment Plant Staff. Table 7 compares the 2017 Water Service Center recommendations from the Resource and Needs Assessment to the City's proposed organization.

Table 7: Comparison of 2017 Water Service Center Staffing Recommendations and 2018 City-Proposed Organization

Position / Title	Resource and Needs 2017 Proposed	City 2018 Proposed	Gap
Water Systems Supervisor (Superintendent)	1	1	0
Deputy Supervisor	1	0	1
Operators (Total)	34[1]	30	4
Administration	3	0[2]	3
Customer Service/Call Center Staff	2	0	2
Construction Inspectors	2	0	2

1. Includes foremen, senior operators, operators, and trainees
2. Not shown in City proposed organization

Discussions with the City during preparation of the Optimization Plan address the discrepancies between the 2017 and 2018 recommended staffing levels. It was determined that the Deputy Supervisor was not needed, but that the four missing operator positions were the Foremen and that those positions were needed. In addition, it was not intended in the 2018 proposal that the Administration level staff not be included, but the intent of the proposed organization was to show how the City intended to fulfill its technical and managerial responsibilities for operation of the water system (treatment and distribution). Thus, those three administrative positions are still included in the 2018 staffing plan/budget. Table 8 rectifies the 2017 and 2018 recommendations and summarizes the 2018 Water Service Center staffing

levels. It does not show additional recommended staff as identified during the Resource and Needs Assessment.

Table 8: Summary of 2018 Water Service Center Staffing

Position / Title	Total Staff
Water Systems Supervisor (Superintendent)	1
Water Distribution Foreman	4
Operators (Total)	30[1]
Administration	3

1. Includes senior operators, operators, and trainees

In addition to the additional staff recommended to simply meet current workload and responsibilities, the Resource and Needs Assessment identified additional staffing needs associated with implementation of the Gap Analysis recommendations. Those recommendations were prioritized, and an implementation schedule is presented in Section 3. Based on the schedule for implementation of recommended capital and operational improvements, a schedule for hiring of additional staff to meet the future technical and managerial capabilities of the Water Department is provided in Table 9.

Table 9: Additional Staffing Recommendations and Hiring Schedule

Position / Title	Proposed Staff	Hiring Timeframe
Enterprise Asset Management Manager	1	Immediate
GIS Specialist/Hydraulic Modeler	1	Immediate
Laboratory Technician/WQ Sampling/Data Management	1	Immediate
Water Distribution Valve and Hydrant Crew	2-4	Immediate
Customer Service/Call Center Staff[1,2]	3-5	Immediate
Cross-Connection Program Manager	1	Immediate
Construction Inspectors[1,3]	2	By 2021
Leak Detection Team	2	2-5 yrs
UDF Team	2	< 5 yrs

1. Included in Resource and Needs Assessment Recommendations
2. To assure 24/7 staffing of a call center, staff and the cost of those staff could be shared across multiple Public Works departments (i.e., water, trash, transportation). A minimum of three would be needed (1 per shift), but more are recommended to help cover weekends, holidays, illness, etc.
3. Needed when Program Manager contract ends

It should be noted that the existing cross-connection control program manager has been completing inspection duties in the recent past, which has left the program in need of updating and routine maintenance. Additionally, the staff member holding this position is expected to retire in the near future. To restore the program to functioning fully and implement the optimization recommendations, it is recommended that construction inspectors are hired separately, a second staff member is hired to manage the cross-connection control program, and that a third party is hired for a one-time update of the program as discussed in Section 3.

4.3.2 Proposed Water Department Organization

As mentioned previously, the City provided USEPA with an organization chart for the Water Department in 2018 in response to a requirement from its Administrative Order. That organization chart is reproduced in Figure 6.

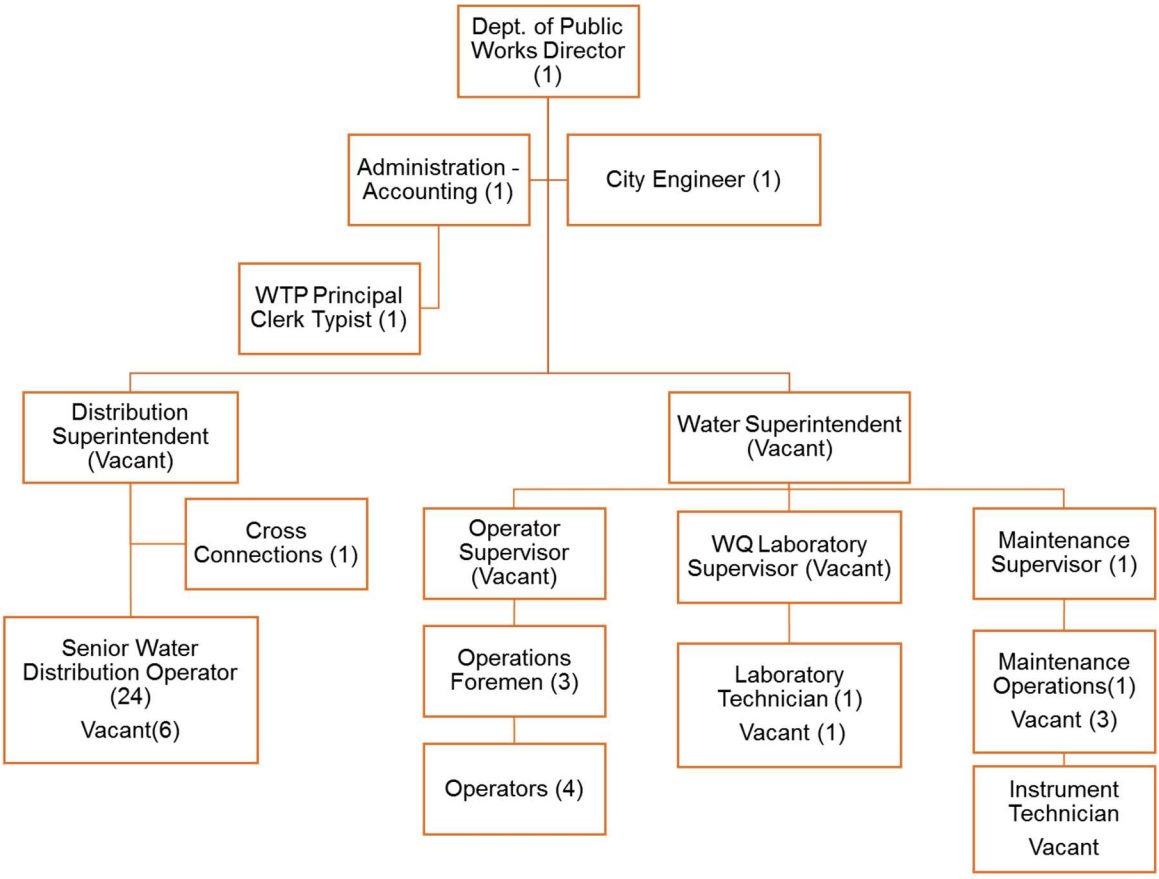


Figure 6: 2018 City-Proposed Water Department Organization

As discussed, Figure 6 inadvertently omitted a few key roles and responsibilities (foremen and administration) from that proposed organization. A corrected Water Department organization chart is provided in Figure 7. Note that this does not include the additional recommended hiring needs identified in Table 9. The primary additions to the organization are four Water Distribution Foremen and three Administrative/Clerical staff. "Water Distribution Operators" in Figure 7 includes all senior operators, operators and trainees, as these titles are fluent as staff progress through their careers.

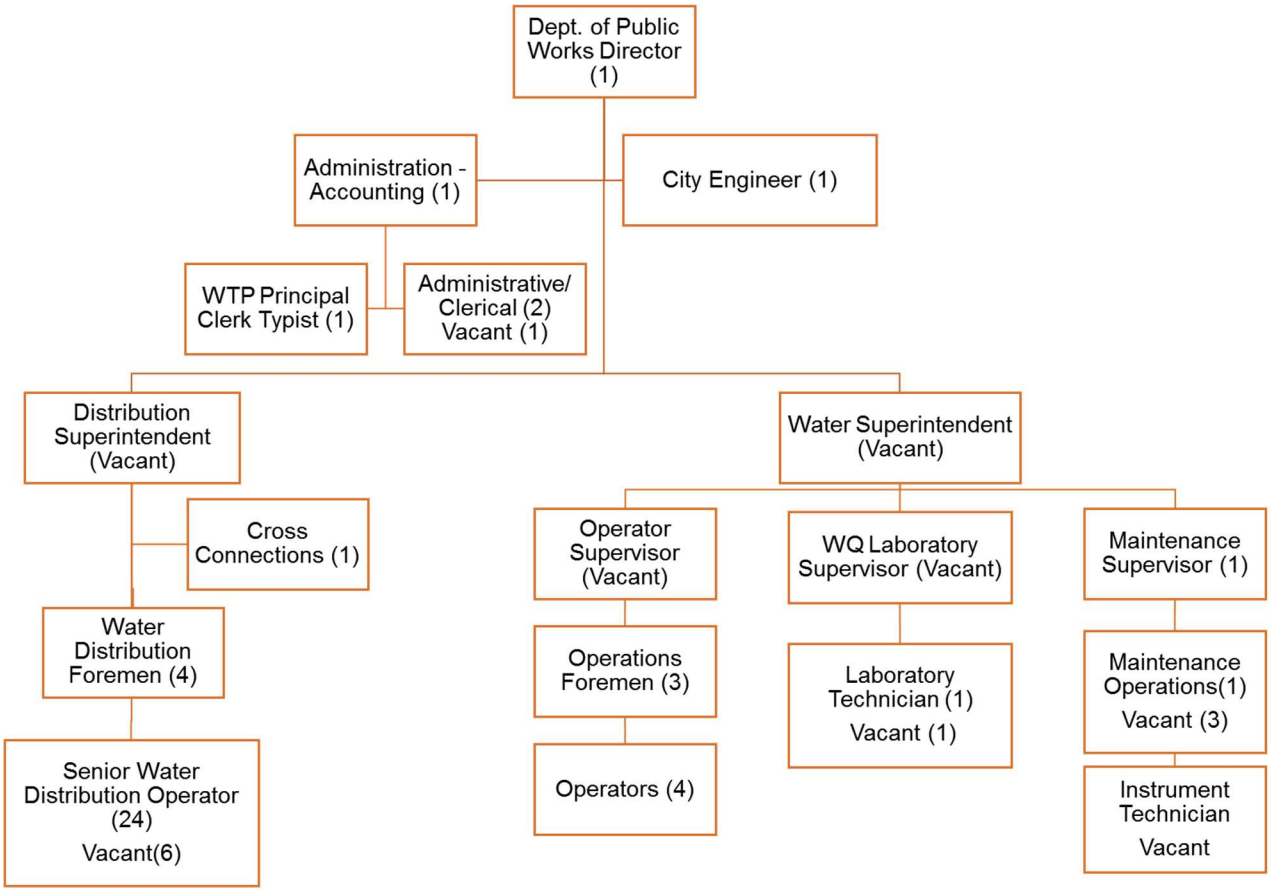


Figure 7: Final 2018 Water Department Organization (as of January 2018)

4.3.3 Updated Job Descriptions

The existing job descriptions for the positions in the Water Service Center were reviewed for content and consistency. Recommended changes are included in *Job Position Description Review, December 2017* (Appendix M).

4.3.4 Priority Hires and the Use of Contract Operations

It is acknowledged that the City has had difficulty in attracting and retaining qualified employees. To help address that issue, workforce development and recruitment is discussed in the following section. *Priority should be placed on filling the Distribution Superintendent and Water Superintendent roles.* In the meantime, the City has utilized contract operations for the treatment and laboratory functions shown in Figure 7. The use of contract operations is a viable solution and helps to address the short-term technical functions of the Water Department, however, it should be viewed as a temporary, albeit not necessarily short-term solution.

The City has also recently stepped up its efforts to hire qualified employees, including the following:

- Hired six new Water Distribution Operator trainees (start date February 19, 2018).
- Posted the WQ Laboratory Supervisor position on March 1, 2018).
- Exploring having the Wastewater Division run the laboratory.
- Shortlist of potential WTP Operator trainees is being reviewed for further consideration. One additional WTP trainee will be hired.
- Distribution Superintendent and Water Superintendent jobs were posted officially on March 2, 2018 and existing employees are encouraged to apply.

4.3.5 Workforce Development and Recruitment Strategy

Currently, there are approximately six vacancies in Distribution Operator positions. This represents nearly 20 percent of the workforce available to do the tasks currently required by the Water Service Center (repair main breaks, read/replace/remove water meters, turn off water, install new lines, perform preventative maintenance, etc.) Therefore, the Water Service Center is seriously limited in the amount of work that can be done. By default, most of the available operator hours are used to address emergencies, such as main breaks, and preventative maintenance is being deferred.

To correct this problem, a two-pronged approach needs to be implemented:

- Retain existing employees
- Fill vacancies.

4.3.5.1 Retain Current Employees

Retaining employees is significantly easier and less costly than expending resources to find and train new employees. The first priority of Flint's workforce program must be to retain existing employees.

During the Workforce Evaluation conducted in 2016/2017 the personnel were asked a series of questions related to job satisfaction. Interestingly, most indicated that they were satisfied with the job itself, but a common concern was the decrease in benefits in recent years. Also, there are similar jobs available locally that have higher pay rates. Clearly, addressing salary and benefit gaps between Flint's position and those locally is needed to retain valuable employees.

Providing training as described earlier is an important part of employee retention. A concern heard during the Workforce Evaluation interviews was that some staff feels disconnected from the entire City operation, and the first module of training seeks to alleviate that concern. Common knowledge about Flint Water must be shared with all employees.

4.3.5.2 Fill Vacancies

As noted, there are many vacancies in the Water Service Center group. Additional steps must be taken to attract and retain good employees.

Job vacancies must be posted where potential applicants are looking. On the internet, Monster, and Indeed have far reaching audiences and posting the openings on that site would be beneficial, assuming that the applicants have internet access. Trade publications and internet sites such as AWWA's

www.careercenter.org, www.workforwater.org, and www.tpo.org based on “Treatment Plant Operator” magazine are national but they are directed at people who want to work in water.

Because applicants interested in these jobs in Flint may not be willing to move to take such a position, local sites should also be utilized.

Based in Michigan, www.Michigan.works is a good internet-based job search portal which could be used to attract a pool of applicants, but again, only if the applicants have internet access. To attract the local pool of applicants that does not have internet access, advertising through churches, community centers and postings at city offices may be fruitful. Outreach via community newsletters and neighborhood meetings could support the spread of information to individuals who do not use the internet for job searches.

Additionally, hosting job-specific career fairs at Flint area colleges and universities could help to bolster the pool of applicants. Among those that should be considered are the University of Michigan-Flint, Mott Community College, Kettering University, Baker College and Jordan College.

4.3.5.3 Growing applicants

Other utilities have addressed the problem of filling vacancies in water operations by offering internships and apprenticeship programs. By creating these programs in high schools and community colleges, young people are given the opportunity for paid work at utilizes and determine if they are interested in pursuing a career. For some utilizes, it has been very successful.

Developing sustainable apprenticeship programs is important when the job category entails using heavy equipment required for excavating, repairing water main breaks and backfilling. The Local 324 Heavy Equipment Operator Training site in Howell, Michigan is just 40 miles from Flint. The opportunity exists to partner with Local 324 to create a one-day training session which aligns specifically with the job categories needed in Flint.

Similarly, the City of Detroit offers the Detroit Registered Apprentice Program, which utilizes a local employment agency to pre-screen apprentice candidates to meet current and emerging industry needs. A program modeled after this one could prove useful to growing job candidates for the utility.

4.3.6 Recommended Training

A comprehensive workforce evaluation was included in the *Resource Analysis and Needs Assessment, March* 2017. Water Service Center personnel were interviewed to determine how closely the positions align with the duties and competencies identified in earlier work based on other, similar utilities. The evaluation assessed the ability of the current staff (in numbers, skill sets and provided training) to implement the recommended best practices and to identify gaps.

In that assessment, it was recommended that:

- Vacancies in the current organization chart be filled
- Additional staff is needed so the department can proactively perform preventative maintenance, valve exercising, etc.
- Additional staff is needed to oversee construction activities related to service line replacement work

- Training offered to personnel should be more formalized than the current on the job training

To meet the requirements of the last recommendation, a training program was created to meet the needs identified in the Workforce Evaluation and is included as *Distribution Operator Training Module* (Appendix N). The six training modules include:

1. Introduction to Flint Water System
2. Overview of Distribution System Functions
3. Training leading to Distribution System Operator Certification
4. Safety Training
5. Customer Service Representative Training
6. Heavy Equipment Operation Training

The training modules are described below. Much of the material is adapted from training produced for water professionals by AWWA. The materials are appropriate for the kind of work Flint personnel perform, and they will also reinforce the AWWA "brand", which focuses on helping utilities provide drinking water to consumers that meet all health requirements.

The training needs were based on the identified core competencies of the Flint Distribution Operators identified through the Workforce Evaluation described above. Those are core competencies:

- Maintains and install water mains and related items
- Provides healthy and palatable water to customers
- Represent Flint Water because of frequent customer interaction potential
- Fields and answers customer service complaints

An outline of the training needs is provided in the *Distribution Operations Training Needs* (Appendix O).

4.3.6.1 Introduction to Flint Water System

This module Introduces basic water treatment processes and goes on to describe the treatment processes used by GLWA at Port Huron WTP and GCDC WTP. It also discusses the additional treatment (phosphate and chlorine) at the Flint WTP and describes the Flint distribution system. The level of detail is appropriate for a water professional, but is an overview not requiring prior knowledge of hydraulics, or chemistry. It contains sixty original slides and represents ninety minutes of training.

4.3.6.2 Overview of Distribution System Functions

This one-hour training is centered on the AWWA DVD "*Water System Operator (WSO) Maintaining Distribution and Storage Systems*." This video is an overview that focuses on water quality, distribution system hydraulics, physical Installation and system security. This video is more technically oriented than the first training module, but it is aimed at distribution system operators that have a basic knowledge of the mentioned elements but who would benefit from a deeper discussion. The video and discussion are meant to be completed in one hour.

4.3.6.3 Training leading to Distribution System Operator Certification

MDEQ, and the City do not require that all distribution Operators possess a certification license. But, at least one member of the department must possess this license. Some other utilities require that

personnel work towards this license, and some require it for increased responsibility and compensation. This training module provides training in all of the aspects of distribution operation that is contained in the certification exam. The training materials include a textbook and student review materials centered on thirty-seven chapters. The training can be presented by an instructor in weekly sessions, or it can be self-taught. In March 2018, this material will also be available on an electronic platform (app for smartphones.)

The training is based on AWWA's "*Water System Operator (WSO) Water Distribution Grades 1, 2, 3 and 4."* The training in line with national (and Michigan) Operator Certification tests and licenses. It is suggested that this training be made available in the electronic version so that a motivated individual could complete the program, successfully pass the test and so earn a Distribution Operator license. This training would require 9 months to one year to complete.

4.3.6.4 Safety Training

This recommended training module is a weekly session based on AWWA's "*Let's Talk Safety 2018*" training materials. The materials include a book with fifty-two suggested safety topics with a discussion of each. Also included in the materials is a DVD that has twelve videos that go along with some of the safety topics. Using this material, each week a discussion could be held on the identified topic, and once each month the session would include the video. Using this prepared information, the personnel could use this material without a formal instructor, but still gain knowledge in a short weekly session. The topics covered Include common issues relevant to water utility operations, such as trenching, handling chlorine, wet weather situations, etc.

4.3.6.5 Customer Service Representative Training

This training module is a three-day training based on AWWA's "Customer Service Certificate Program." Each day covers a separate topic: Customer Relationship Building, The Business of Customer Service and Water Industry Operations. The AWWA materials would be the basis for this training, and they provide instructions on how employees facilitate and complete the course at their location.

This training takes three full days and is meant to train Customer Service Representatives once those positions are created and filled.

4.3.6.6 Heavy Equipment Operation Training

Operators operate heavy equipment on a daily basis. Currently they are trained by senior staff on the job. This training module would include a one-hour session using "*AWWA Safety First: Heavy Equipment Yard Practices*" DVD. It provides an overview of the types of equipment used at water utilities, and also describes in depth safety issues surrounding the proper use of such equipment. Once the current vacancies are filled, it is recommended that a one-day training course be held at a local heavy equipment operator school that will provide hands on training in controlled environment with equipment.

4.3.6.7 Priority Training Package Resources

AWWA is an important resource for any utility, and so we have recommended training based, in part, on their materials. Additionally, materials on AWWA's online Resource Communities are available at no cost

for user download. Resource Communities provide a collection of relevant resources on a variety of water and wastewater topics including Distribution System Water Quality, Lead, How Water Works, and more.

AWWA has offered at no cost to Flint, the following resources:

- WSO Water Distribution, Grades 1, 2, 3, and 4 (books)
- WSO Maintaining Distribution and Storage Systems DVD
- Let's Talk Safety 2018 Book & Dual-Disc Set
- Safety First: Heavy Equipment Yard Practices DVD

The *Distribution Operations Training Needs* includes a listing of more AWWA resources that complement the training modules developed for Flint. Those products are available at the costs listed in Appendix P.

5 PERFORMANCE METRICS

5.1 Description

Key performance indicators were developed while establishing LOS categories during preparation of the AMP. The AMP and a detailed discussion of LOS and KPI determination is provided in the *2017 Water System Asset Management Plan (AMP), January 2018*.

Levels of service were developed based on four main sources: *Effective Utility Management: A Primer for Water and Wastewater Utilities* (USEPA, 2017), *2017 AWWA Utility Benchmarking: Performance Management for Water and Wastewater* (AWWA, 2017b), MDEQ Guidance, and the City's goals and objectives for its Asset Management Program. In addition, levels of service also considered the best practices outlined in the *ISO 55000 Series Asset Management Standards* (ISO, 2014a; ISO, 2014b; ISO, 2014c).

Based on the sources above, the City developed an LOS statement to guide the development of the measures:

The City strives to provide safe drinking water to its customers, meeting all regulatory requirements, through the effective maintenance of its assets.

The City will review the LOS statement annually as part of the AMP review and update effort.

5.2 Summary of Proposed Performance Measures

A total of 25 LOS goals and KPIs were identified by the City. This is more than are typically utilized and represents a good goal for measurement of system improvements; however, it is also more than can be reliably tracked and measured until more staff, capital resources, and systems (such as EAM) are in place. As such, performance measurement will be implemented using a tiered approach, with the most important LOS and KPI goals implemented first in Tier 1. Table 10 provides a summary of Tier 1 KPIs and LOS goals. As the City progresses toward optimization, the KPI priorities may change, and this should be reflected in the annual updates to the AMP.

Table 10: Tier 1 KPIs and LOS Goals

No.	KPI/LOS Measure	Definition	Recommended Data Source	Recommended Frequency
1	Water Quality Monitoring	Number of Incidents Out of Target Range as Measured by Achieving Standard at Specified/Critical Points in The System	Water Quality reports/Compliance Spreadsheet	Monthly
2	Total Water Quality Complaints	Discoloration, Taste / Odor	Customer Information System	Monthly
3	Water Pipeline System Integrity	Total Water Main Breaks and Leaks Per 100 Miles	Break tracking sheet	Annual

No.	KPI/LOS Measure	Definition	Recommended Data Source	Recommended Frequency
4	Aged Accounts Receivable / Delinquent Accounts/Revenue Collection Rate/Rolling Average	1-29 Days, 30-59 Days, 60-89 Days, 90+ Days	Customer Information System	Monthly, Quarterly
5	System Renewal and Replacement Rate	R&R Expenditure / Present Value of Assets	Capital Planning Model	Annual
6	Affordability Index	To be defined in definition sheets.	Customer Information System	Annual
7	OSHA Recordable Incident Rate		OSHA reports/ Employee Safety tracking sheet	Monthly
8	Total Percent of Non-Revenue Water	System Water Loss	Customer Information System	Annual

Tracking of Tier 1 measures should begin immediately. The City will need to develop LOS and KPI definition sheets in 2018 for the Tier 1 measures. The definition sheets will assign owners and targets for the measures. The implementation of Tier 2 and 3 measures will follow, after the Tier 1 measures are piloted and any necessary adjustments are made as part of the familiar continuous improvement cycle of plan-do-check-act. This approach enables staff buy-in and ensures that measures are meaningful for decision making. Preliminary Tier 2 and 3 KPIs and LOS goals are shown in Table 11.

Table 11: Preliminary Tier 2 and Tier 3 KPIs and LOS Goals

No.	KPI/LOS Measure	Definition	Recommended Data Source	Recommended Frequency
		Tier 2 Measures		
9	Total Meter Reading Errors Per Cycle[1]	Meters That Were Misread During Routine Billing Cycle	Customer Information System	Monthly, Quarterly
10	Certification Coverage	Percent of certifications achieved or maintained	HR/Training database	Annual

No.	KPI/LOS Measure	Definition	Recommended Data Source	Recommended Frequency
11	Work Order Completion Ratio	Percent of Total Maintenance Work Orders Issued/Scheduled That Were Completed	CMMS	Monthly
12	Percent of Work Orders Completed on Schedule	Percent of Total Maintenance Work Orders Completed on or Before Their Schedule Date	CMMS	Monthly
13	Valve Inspection and Maintenance Program Productivity	Valves Inspected and Exercised/Repaired Per FTE or Crew	CMMS	Monthly
14	Asset Inspection and Assessment Productivity (per AMP requirements)	Assets Inspected or Assesses Per FTE or Crew	CMMS	Monthly
15	Equipment Uptime / Downtime	Total Amount of Time Equipment is Functional / In Service as a Percentage of Total Hours	CMMS/SCADA	Monthly
16	Equipment Failures/Breakdowns	Number of Equipment Failures/Breakdowns	CMMS/SCADA	Monthly
Tier 3 Measures				
17[2]	Average Response Time for Customer Correspondence	Average Response Time in Working Days from Customer Inquiry	Customer Information System	Quarterly
18[2]	Customer Service Appointments Kept Within Scheduled Time	Percent of Total Appointments Kept Within Scheduled Time or Within a Set Hour Window	Customer Information System	Quarterly
19	Percent Employee Turnover Rate	Voluntary and Involuntary	HR/Training database	Annual
20	Vacancy Rate	Open and vacant positions as a percent of total employees	HR/Training database	Annual
21	Compensation Equality	Average salary	HR/Training database	Annual
22	Average Training Hours Per Employee		HR/Training database	Annual

No.	KPI/LOS Measure	Definition	Recommended Data Source	Recommended Frequency
23	Lost work Days Per FTE	As Reported in OSHA Form 300A	OSHA reports/ Employee Safety tracking sheet	Annual
24	Lost Time Incidents Per 200,000 Hours Worked	Total Incidents / Total Hours Worked by All Staff	Employee Safety tracking sheet	Annual

1. Meter reading errors may be redefined or eliminated after the implementation of the AMR/AMI system.
2. To be implemented with the completion of the customer call center.

Each of the 25 LOS and KPI goals will be further defined by the City as the pilot performance measurement begins with the Tier 1 measures. Many of the measures will be measured manually at the start, but as the City implements its EAM system reports can be developed to make the process more automated.

Currently, targets for these measures are not defined. As the City pilots the Tier 1 measures, performance targets can be established, and adjustments may be made to the frequency and data source recommendations.

5.3 Implementation Schedule

It is recommended that performance measurement be implemented according to the preliminary schedule shown in Table 12. Regular measurement of the indicator (in accordance with the frequency identified in Table 10 and Table 11) should begin in the year during which the baseline is established. It is recommended that baseline conditions be established on at least one full year (12 months) of data. Tracking of performance against baseline conditions should begin following establishment of baseline conditions.

Table 12: Performance Measurement Implementation Schedule

Tier	Establish Baseline
1	2018
2	2020-2022 (years 3 – 5)
3	2023-2027 (years 6-10)

As noted above, targets for these measures are not yet defined. As the City pilots the Tier 1 measures, and baseline conditions are established performance targets can be established, and adjustments may be made to the frequency and data source recommendations. It is recommended that initially performance be measured based on “continuous improvement” (i.e., year one is better than baseline,

year two is better than year one, etc.). After the baseline has been established and the City is able to see how it compares to industry benchmarks, then performance targets can be established, if appropriate.

Tracking of performance against these measures, as well as revisions to the measures, and performance targets will be reported to MDEQ with annual AMP updates. In the future, the City may also wish to develop a customer service dashboard, available at the City's website, which allows customers to see and view its progress against these measures. However, this is not recommended at this time.

6 IMMEDIATE ACTIVITIES

To implement the Distribution System Optimization Plan and associated AMP will require steady funding over time to improve the condition and overall performance of the distribution system. Arcadis recommends that the City immediately focus on two important areas including:

- Pursuit of grant funds – The City has been successful post-crisis with obtaining grant funding for improvements to the water system. While much good work has been done, there is much more to do as outlined in this Report to optimize the distribution system and improve overall water service to clients. It is recommended that the City establish a recurring process to evaluate projects; assess potential grant funding options including both state and federal sources of grant funding; and pursue grants to fund a portion of the CIP noted above. Obtaining grant funds will help mitigate rate increases to the City's water customers.
- Gradually increase revenue from rates and charges – A recommendation in the AMP was to create a process where regular financial planning for the water system occurs. The financial planning will incorporate various funding sources and look at the timing and implementation of the CIP. Funding and financial analysis indicates that increases in rate funding through either increased collection rates, nominal rate increases or some combination of the two will be needed over the next 20 years to implement the CIP and cover necessary operations costs. The City should consider implementing regular rate increases (even if nominal) as part of the planned rate redesign in the near-term as a means for funding the long-term needs of the water system. The rate redesign will also look at affordability and restructuring based on water usage to shift cost to higher water users. Regular rate increases will have the added benefit of returning the water system finances to a stable footing, which is necessary should the City consider issuing debt or obtaining loans in the future for CIP projects.

A number of other tasks related to the Optimization Plan and immediate regulatory and operations needs should be implemented by the City in 2018 and are outlined below:

- Complete the pipe loop testing and prepare related SOPs. The Arcadis team will complete this by the end of 2018.
- Conduct additional hydraulic modeling scenarios to determine the impacts of compartmentalizing Cedar Street and Dort Reservoirs on system operations.
- Continue with CMMS implementation and implement a comprehensive asset management program in accordance with the AMP.
- Complete the 2018 AMP Update and submit to MDEQ by December 31, 2018.
- Regularly review and update the CIP based on actual work completed and evolving capital needs.
- Continue to aggressively pursue and hire qualified candidates for Water Department vacancies.
- Implement employee recruitment and retention plan and develop hiring plan for new positions recommended by this Plan.
- Begin tracking Tier 1 performance measures. The City will need to develop LOS and KPI definition sheets in 2018 for the Tier 1 measures. The definition sheets will assign owners and targets for the measures.

Additionally, to maintain the relationships built during the Optimization Plan development process, it is strongly recommended that residents continue to be updated as often as possible by:

- Holding regular, monthly community updates that allow residents to ask questions
- Attending neighborhood meetings;
- Surveying residents again to gauge perceptions;
- Placing information in community newsletters;
- Allowing residents to see work underway, so that an approach of transparency and two-way conversation continues; and
- Providing information in Spanish as well as English.

7 REFERENCES

American Water Works Association (AWWA). (2011). *Partnership for Safe Water Self-Assessment Guide for Distribution System Optimization.* Denver, CO: AWWA

American Water Works Association (AWWA). (2017a). *C810-17 Standard for Replacement and Flushing of Lead Service Lines*. AWWA.

American Water Works Association (AWWA). (2017b). *2017 AWWA Utility Benchmarking*. AWWA.

Flint Advisory Task Force. (2016). *Flint Water Advisory Task Force Final Report*.

Friedman, M., Kirmeyer, G., Lemieux, J., LeChevallier, M., Seidl, S., & Routt, J. (2010). *Criteria for Optimized Distribution Systems*. Denver, CO: Water Research Foundation.

New Zealand National Asset Management Steering Group (NAMS) and the Institute of Public Works Engineering Australia (IPWEA). (2011). *International Infrastructure Management Manual*. (4th ed.) Wellington, New Zealand: NAMS.

International Organization for Standardization (ISO). (2014a). *ISO 55000: Asset Management — Overview, Principles and Terminology*. Geneva, Switzerland: ISO.

International Organization for Standardization (ISO). (2014b). *ISO 55002: Asset Management — Management Systems — Requirements.* Geneva, Switzerland: ISO.

International Organization for Standardization (ISO). (2014c). *Asset Management — Management Systems — Guidelines for the Application of ISO 55001.* Geneva, Switzerland: ISO.

Michigan Department of Environmental Quality (MDEQ). (2013a). *Asset Management Guidance for Water Systems*. MDEQ.

Michigan Department of Environmental Quality (MDEQ). (2013b). *Asset Management Program Review Checklist*. MDEQ.

Rowe Professional Services Company (Rowe). (2016a). *Asset Management Report*.

Rowe Professional Services Company (Rowe). (2016b). *Drinking Water Revolving Fund – Draft Project Plan*.

United State Environmental Protection Agency (USEPA). (2008). *Asset Management: A Best Practices Guide*. USEPA.

United State Environmental Protection Agency (USEPA). (2017). *Effective Utility Management: A Primer for Water and Wastewater Utilities*. USEPA.

Arcadis of Michigan, LLC

28550 Cabot Drive

Suite 500

Novi, Michigan 48377

Tel 248 994 2240

Fax 248 994 2241

www.arcadis.com