



Engineering
& Design

Consulting Engineer's Report

Operation of the Authority's Water
System by the City of Bethlehem

(2021 Operations)
(2022 Adopted Budget)

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Amended May 31, 2022

Prepared for:

Bethlehem Authority
Bethlehem, Pennsylvania
CED Project #: BHW0009

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Introduction

Purpose and Scope

The Bethlehem Authority (the Authority) owns source water properties and the water treatment and distribution system facilities that serve the City of Bethlehem, Pennsylvania (the City) and portions of eleven (11) surrounding municipalities. The City leases (from the Authority), operates, and maintains these water system facilities.

A full description of the Bethlehem Authority including listing of current Board Members, Staff, and monthly meeting minutes may be found at the Authority website: www.bethlehemauthority.org. The Authority website includes a History of the Water System, which was founded in 1938 as Pennsylvania's first municipal authority; a description of the Wild Creek and Penn Forest Reservoirs located in the Pocono Mountains; and a description of the Authority's award-winning Watershed Forest Management of the nearly 23,000 acres of property. The City of Bethlehem Water & Sewer Resources website also provides a brief history and potable water quality reports which may be found at www.bethlehem-pa.gov/water-sewer-resources.

Colliers Engineering & Design, Inc. is the appointed consulting engineer for the Authority. As consulting engineer, Colliers Engineering & Design's responsibilities include reviewing the City's budget for operation of the water system facilities, reviewing insurance coverage, preparing a written report on the condition and operation of the water system by the City during the preceding year, and setting forth recommendations for the ensuing year.

Through this 2021 Annual Report, Colliers Engineering & Design provides an account of:

- The financial condition of the Authority and City Water Fund during the last fiscal year as reflected by information supplied by the Authority and the City;
- The budget for the current fiscal year for the Authority and the City Water Fund along with pertinent observations and recommendations;
- The physical condition of the water system;
- The general operation and maintenance of the water system during the past year;
- List of recommendations with respect to operations, maintenance, improvements and finances for the ensuing fiscal year;
- List of recommendations as to any renewal and replacement or change in operating policies that may be advisable; and
- Other specific water system matters requested by the Authority or the City. The 2020 Annual Report had a specific focus on system wide security improvements. In late 2021, the Authority authorized a Confidential Water Systems Security Improvements Feasibility Study.

The information used for this report was obtained from Authority and City records, from discussions with personnel, and through visual inspection of many of the system facilities. Investigations for this report do not include an independent check of records, audits, and regulatory compliance or operational testing.

Executive Summary

Colliers Engineering & Design has been working closely with the Authority and the City to assess the physical condition and current operation of the water system facilities. This effort originally began in September 2016 and has followed each year through 2021 with a tour of the water filtration plant, the Wild Creek & Penn Forest reservoirs, and nearly all of the significant water infrastructure facilities.

Colliers Engineering & Design reviewed the then-proposed City of Bethlehem 2022 Operating & Capital Budget with the Authority and City staff, which resulted in the issuance of the Fiscal Certification for 2022 dated January 27, 2022 and the Insurance Certification for 2022 dated February 8, 2022. We corresponded with the City staff in March 2022 and reviewed the draft report on April 28, 2022. We reviewed the 2021 year-end financial data and the capital projects and initiatives completed by the City. During our discussions with the City staff and tour of the facilities, we did not find any major deficiencies which require immediate attention. Based upon the above described efforts, we offer the following statements:

Colliers Engineering & Design has reviewed the financial condition of the Bethlehem Authority and the City of Bethlehem Water Fund during the prior fiscal year 2021 and the current 2022 Budgets of the Authority and City. We have observed the physical condition and current operation of the water system to which we provide observations and recommendations.

In general, Bethlehem Water System is in a "State of Good Repair"; the Authority and City have the financial resources to continue the proper operation and maintenance of the Water System.

Financial Operations

Overview

The finances of the Authority and the City Water Fund are discussed in this section. The Authority has legal title to the water system's assets, including the watershed lands. It leases the assets to the City pursuant to a contract and lease dated January 1, 1992, which has been updated periodically pursuant to various borrowings. The relationship between the City and the Authority is further governed by a trust indenture which, among other things, establishes reserve funds for repairs and maintenance and provides for the orderly payment of the system's debt obligations. The Authority, in cooperation with the Trustee, is responsible for management of all reserve funds/trust indenture funds, payment of all debt service costs, and management of the watershed lands and certain other properties related to the water system.

The Authority's income includes the lease rental payments from the City's water fund pursuant to the Contract and Lease. The lease rental payments are fixed so as to be sufficient for payment of the Authority's debt service requirements related to the water system's various borrowings and the Authority's administrative expenses. The Authority's income also includes timbering revenues, sale of carbon credits, and interest on investments and other property rentals and leases. The Authority has entered into agreements with Atlantic Wind, LLC, which may result in future revenue through the development of a wind turbine energy generation project on two ridgelines within the watershed property located in Penn Forest Township, Carbon County. The Authority will also gain future revenue from the sale of carbon credits.

The City is responsible for managing the water system, operating and maintaining all water system facilities, and complying with regulatory requirements. Financially, the City is responsible for setting water rates and charges (with the approval of the Pennsylvania Public Utilities Commission) to meet all financial requirements including operating and maintenance expenses, and the lease rental payments due under the Contract and Lease.

As additional security for the Authority's borrowings, the City has guaranteed payment of debt service. As guarantor, the City has ultimate responsibility for the repayment of the water system's debt obligations.

Monies for capital additions and long-term maintenance to the system can be provided from Authority reserves, if they are available, or from the City, or from borrowings which are proposed and administered by the Authority and approved by City Council. The 2014 Authority Bond Refinancing and improved financial operations by the City have resulted in additional funds being available for capital projects. The Authority works closely with the City and financial advisors to plan for 10-year capital financing and the retirement of old debt.

The Bethlehem Authority is currently working with the City of Bethlehem and has retained Bond Counsel for long term debt Bond Refinancing anticipated for summer/fall of 2022.

Water Rates

The City serves retail customers inside and outside of the City. The rates charged to the customers outside of the City and the service they receive are regulated by the Pennsylvania Public Utility Commission (PUC). It has been the practice of the City to charge inside-City customers the same rates approved by the PUC for outside-City customers. The current Schedule of Rates is summarized in Appendix 1. Previously, PUC approved City rate increase was 4.7%, which went into effect on July 10, 2014. The City completed work on a year-long water consumption Demand Study in 2019. The City filed with PUC on July 31, 2020, for a new rate increase which was approved by the PUC on April 15, 2021. The average rate class increase approved is 8.4%, which went into effect on June 1, 2021.

Authority Finances

The Authority's administrative operating budget for 2022, and a small Authority Capital Budget, are set forth in Appendix 2. As noted above, the Authority is partly reliant upon the City to fund its operating budget. The Authority's capital budget has been funded from other sources, including past grants, carbon credit revenues, and Authority reserves.

City Water Fund Budget Finances

A summary of the City Water Fund revenues and expenses are shown in Table 1 which has been revised beginning in 2019 for reporting on an all cash basis. Previous years the revenue was reported on an accrual basis and expenditures on a cash basis. This table shows that income (revenues minus expenses) from 2020 operations ended with a net gain of \$1,470,153.92. The estimated 2021 operations ended with a net gain of \$1,884,380 (see footnotes). The revenues and expenditures for FY 2016 through 2022 City financial reports are summarized in Appendix 4.

Table 1
Water Fund Revenues and Expenses
2020 Operating Fund

	BUDGET	YEAR-END RECEIPTS AND DISBURSEMENTS
REVENUES	\$21,075,000	\$21,201,116
EXPENDITURES	\$21,075,000	\$19,730,962
NET (REV – EXP)	\$0	\$1,470,154
2020 YEAR-END CASH BALANCE		\$5,253,637

2021 Operating Fund

	BUDGET	YEAR-END RECEIPTS AND DISBURSEMENTS
REVENUES	\$21,655,000	\$22,399,643
EXPENDITURES	\$21,655,000	\$20,515,263
NET (REV – EXP)	\$0	\$1,884,380
2021 YEAR-END CASH BALANCE		\$7,361,012

2021 Water Capital Fund

	2021 BUDGET	YEAR-END RECEIPTS AND DISBURSEMENTS
2021 BEGINNING OF CASH BALANCE		\$473,191
REVENUES	\$4,799,602	\$3,728,040
EXPENDITURES	\$4,799,602	\$3,779,734
NET (REV – EXP)	\$0	(\$-51,693)
2021 YEAR-END CASH BALANCE		\$421,499

- (a) Numbers rounded to the nearest thousand
- (b) Year-end receipts and disbursements on cash basis

Appendix 3 includes a 2022 Water Capital Budget of \$8,094,497, which lists the capital projects approved to be funded in whole or in part during 2022 (see page titled “2022 Water Capital Fund – Fund Analysis Summary”). Other water capital items noted in Appendix 3 address normal replacements and renewals required to maintain the water distribution system itself and numerous items to improve, protect, and maintain water supply, treatment, transmission, pumping, and storage facilities. The items in the 2022 Water Capital Budget should be implemented in 2022 and beyond to maintain the integrity of the system, improve operating efficiencies and/or meet regulatory requirements.

The 2021 Water Capital Budget was financed in large part by approximately 2020 Year-end \$2.8 million from the Authority’s Bond Redemption and Improvement Fund (BRIF) and approximately \$1.5 million from a capital appropriation from the City’s operating fund.

In 2021, the City's Operating Fund revenues were more than expenditures by 8.4%, while Water Capital Fund expenditures exceeded revenues by 1.4%. However, the cash balance of each fund at year's end combines for \$5,726,829, some of which can be used for 2022 capital projects. The City maintains a minimum unassigned cash balance in each fund.

The Authority has been working with the City to plan for future financing. The goal is to better match debt periods to asset life and provide additional annual capital funds without increasing current annual debt service payment amounts. This would allow the City to better implement the 10-year Capital Plan and more aggressively replace/upgrade critical infrastructure and linear assets.

Working with the Financial Planning Advisors of both the Authority and the City, the City and Authority worked through four refinancing scenarios. The final selected strategy is presented in the 10-Year Water Capital Plan and Capital Financing Plan dated last revised December 2021 (included in Appendix 11). Due to the 1994 debt refinancing to fund the Penn Forest Dam reconstruction project the annual debt service currently dominates expenditures and limits available capital for infrastructure improvements and/or replacement projects.

The goals of the new 10-Year Capital Plan are to: emphasize pay-as-you-go funding versus additional borrowing; minimize debt financing cost; minimize increases in debt service payments; balance investment needs throughout entire system; and level annual capital budgets. Working with the respective Financial Advisors, the City and Authority created a 10-year Capital Plan.

The Bethlehem Authority is currently working with the City of Bethlehem and has retained Bond Counsel for long term debt Bond Refinancing anticipated for summer/fall of 2022.

Physical Plant Conditions

General

The Bethlehem water system comprises many different components, including approximately 23,000 acres of watersheds, 9.9 billion gallons of reservoir impoundments, 20.6 miles of dual raw water transmission mains, a water filtration plant (WFP) with permitted capacity of 28.6 million gallons per day, 530 miles of potable water transmission and distribution mains, 30.5 million gallons of potable water storage facilities, 5 booster pump stations, 4 major pressure control valve stations, 4 independent well systems and consecutive systems (East Allen Township), 14,800 valves, 3,705 hydrants, and 36,671 customer service lines and meters. A full and detailed Description of Water Facilities, dated 3/29/2016, is presented in Appendix 7 of this report.

Description of Facilities

There have been no significant new additions and/or expansions to the water system in 2021. The City commissioned a Distribution System Comprehensive Planning Study which was completed in December 2014 as part of the Long-Term Infrastructure Improvement Program (LTIIP) which was approved by the Pennsylvania Public Utilities Commission (PUC). The Comprehensive Planning Study is referenced as Appendix 10 and includes a list of twenty-two (22) system improvement projects (Appendix 10-Table E-1 is presented at the end of this chapter). Projects 1, 2, 4, 6, 8, 10, 11, 12, 13, 16, 20 and 21 have been completed. Projects 5, 14, 15, 18 and 19 are in design, scheduled for design, or on-going.

The City commissioned the Amended Long-Term Infrastructure Improvement Plan (LTIIP), which was completed in March 2016 and updated in April 2018; this is referenced as Appendix 12. The LTIIP includes additional system description and data. Table 1-1 lists the raw water system components such as reservoirs, intakes, tunnels, and transmission lines, including size, length, and year built. Tables 1-2 through 1-10 list distribution lines, valve, hydrants exact listing by size, age range, and percent of total. Chapter 2 of this report discusses schedules for planned repair and replacement. Table 2-1 provides a main break history outside the city limits. Chapter 5 discusses the annual expenditures for the water system serving areas outside the City. The City has and continues to increase its investment in the Bethlehem Water System as depicted in Figure 5-1 (presented at the end of this chapter).

The 2014 Comprehensive Plan and the 2018 Amended LTIIP are excellent tools developed by the City for long range planning of capital investment. In 2018, the City staff reviewed these prior studies and developed a new 10-Year Capital Plan Spreadsheet; the latest, from December 2021, is provided in Appendix 11. This list of projects, forecasted implementation, and needed capital will act more as a working document to be reviewed and updated annually.

Water System Tour & Observations

The consulting engineer takes a tour of selected water system facilities each year for the purpose of providing general observations of the system and recommendations to the City for its capital and operating budget process. Colliers Engineering & Design toured the water system with the Authority and City Staff. This effort began September 24, 2021 at the 5th & William's Booster Station. The tour proceeded to the William's Street 5 MG Tank, Mountaintop Booster Station & 1 MG Southeast High Tank, and South Mountain Park 0.5 MG Southeast High Tank. We toured the Southwest 2 MG High Service Reservoir, Southwest Booster Station, 12 MG Southwest Low Reservoir, and 5 MG Southwest Tank.

On September 28, 2021, the tour proceeded to the Community College 5 MG Northeast Standpipe Tank, Pennsylvania Avenue PRV Station, and Howertown PRV Station. We next toured the East Allen Gardens Well House & Finished Water Storage Tanks, Country Squire Estates Well System, East Allen Township Shady Lane Well House, EAG Airport Road Booster Pump House, and EAG Wil-Mar Wellhouse.

On October 5, 2021, the tour proceeded to the Wild Creek Watershed Facilities at Pohopoco Drive in Carbon County. We observed the Bethlehem Authority property frontage, the Wild Creek Pretreatment Building, the Watershed Office for the Authority Special Police and the Wild Creek Dam & Intake Building. The tour then proceeded to the Penn Forest Dam, Intake Building, and Dam Inspection Tunnel. The tour proceeded to the Tunkhannock Creek Supplemental Raw Water Intake Building.

On October 8, 2021, the tour proceeded to the Water Filtration Plant and 7 MG Finished Water Clearwell. Appendix 9 includes photos and brief descriptions of the various facilities toured.

Water Filtration Plant

The Water Filtration Plant was put into operation in the fall of 1994. The treatment plant was originally sized for 42 million gallons per day (MGD). The filtration beds were upgraded between 2005 and 2008, which greatly improved the treatment performance. As a result of the filter bed project, PADEP reissued the permit of the filter plant at 28.6 MGD. The water filtration plant currently treats an average maximum day of 20 MGD, and average daily of 15 MGD, and an average night-time rate of just less than 8 MGD.

We met with the water filtration plant Operations Supervisor and Maintenance Supervisor on October 8, 2021. They reiterated that the plant is now 25 years old and is starting to show its age in some areas such as the roof and filter basement concrete beam spalling. Based upon mechanical equipment wear, they have recommended a program of sequential renovation throughout the WFP.

Recent and proposed projects include the following:

1. The carbon bldg. 30-inch raw water transmission main valve has been excavated and repaired in April 2022.
2. The New Emergency Generator Project construction has been completed and the existing underground fuel tank for the old generator has been removed;

3. The first Lagoon baffle curtain was replaced in 2021 and the second Lagoon baffle curtain was replaced in April 2022;
4. All existing exterior plant lighting has been replaced with LED lighting;
5. Several roof patch repairs were completed in 2021 and additional patch repairs are scheduled for 2022.

The water filtration plant supervisors have planned for the following 2022 projects:

1. Order and install second backwash lagoon curtain (completed April 2022);
2. Revuild one (1) plant service water pump;
3. Continue vegetation control plan around plant property.

The City completed a Disinfection Alternatives Study to evaluate renovating the chlorine gas system and/or developing an alternative disinfection system. The City will be appropriating funds for the implementation of a sodium hypochlorite generation facility to provide safe, cost effective water disinfection. There has also been evidence of leaking (mineral deposits) from the sand filter beds into the rooms below which will need to be addressed.

Overall, the filtration plant is well maintained, very clean, and in good repair. The Authority and City received a positive “Commendable” review from PADEP for the Filter Plant Performance Evaluation (FPPE) in 2016.

Water System Control Center

The City operates a Water System Control Center in which the SCADA (supervisory control and data acquisition) data from throughout the water system is reported back to the control center. The water control system operator can monitor the levels in all storage tanks, conditions at PRV stations, et cetera. The operator can remotely turn on booster pumps to fill the water storage tanks as well. The City continues to implement improvements to the SCADA system as facilities are upgraded.

In 2018, the City completed an investigative study to improve SCADA communications. In 2019 as part of the conversion of 911 Service from the City to Northampton County, the City moved the Water System Control Center operations to Water Filtration Plant in Lehigh Township, Northampton County. We believe further improvements to the SCADA communications will be required for the implementation of improved security systems throughout the water system, particularly for the remote watershed facilities.

Watersheds

The nearly 23,000 acres of land owned by the Authority in both Carbon and Monroe Counties are maintained by the City’s staff at Wild Creek. The Authority and the City are actively working with local governments, conservation organizations, and the State to manage the watersheds in a sustainable manner with the primary goal of maintaining and possibly improving the high quality of the pristine drinking water supply. The City has also initiated a Source Water Protection Plan through the auspices of the PADEP, as designed by the PA Rural Water Association, and has been approved by the DEP. An annual meeting is held to review and update this plan.

The Authority continues to actively manage the forest through a timbering plan meant to improve the quality of the timber in the watershed, thus improving the watershed and ultimately the quality of the water, while gaining modest revenues to support the program. In 2012, the Authority and the Nature Conservancy completed a Forest Management Plan which allowed its watershed properties to be certified as sustainable by the Forest Stewardship Council, the preeminent certification standard in the world. This allows the carbon stored in the forests to be sold on the carbon exchange market.

The Wild Creek Dam and the Penn Forest Dam facilities are well-maintained and receive annual inspections by an outside consulting firm. These reports are submitted to PADEP. In 2021 the City of Bethlehem completed and submitted a 10 Year Dam report to the Pennsylvania Division of Dam Safety under the guidance of a consulting engineer. This was a multi-year effort demonstrating the integrity of the Dams and their key features. All submitted objectives were accepted; however, the Wild Creek downstream outlet inspection was not completed due to low visibility at the base of the reservoir.

. The Penn Forest Reservoir Dam was rebuilt in 1998 and is tributary to the Wild Creek Reservoir Dam, originally constructed in 1939 (refer to LTIP Table 1-1 for detail). The Penn Forest Reservoir is released to maintain the Wild Creek Reservoir full. As such, both reservoir levels are monitored and used to predict drought conditions and are included as part of the City's monthly reports to the Authority. The Wild Creek Reservoir raw water intake screens are alternately cleaned annually. The Wild Creek Flow Meter Building includes two (2) 36-inch diameter venturi flow meters, and the building has the ability to be used for chemical pre-treatment if necessary. These facilities are clean and in good repair.

The Tunkhannock Creek diversion facility is utilized to supplement raw water to the Penn Forest Reservoir. The intake building is clean and in good repair. The intake screens are cleaned semiannually. The stream weir structure can become clogged with grasses and must be cleared as needed during the growing season and after storms.

The Tunkhannock Creek raw water transmission main includes 47,000 feet of 30-inch and 42-inch lines and a pressure reducing valve station. This station is located in a remote area. The PRVs appear to be operating properly.

Raw Water Transmission

The raw water transmission lines were initially installed in 1939 as part of the original Wild Creek Dam project and included a 30-inch and 36-inch diameter line to the City. This project also included two (2) rock bored tunnels at Wire Ridge and Blue Mountain (refer to LTIP Table 1-1 for detail). In the 1960s, a redundant parallel 42-inch line was constructed from Blue Mountain to the site of the current filtration plant (see figures at the end of this chapter). In 1997, a parallel redundant 42-inch line was constructed to convey water from Wire Ridge south portal to Blue Mountain north portal.

No parallel raw water transmission facilities exist should these tunnels become compromised by a natural or man-made event. In addition, these tunnels cannot be taken out of service for full inspection and/or maintenance.

We scheduled specific tours of the raw water transmission lines and the tunnel access points in April 2019 and January 2020 to inspect the interior of the tunnel upstream portal chambers, and a few valve chambers along the route to the water filtration plant. New technology may allow for the in-situ evaluation of the tunnels and raw water transmission lines without interruption of service. These technologies have been evaluated in terms of cost benefit verses focused improvements to the emergency interconnection facilities with adjacent water supply systems.

PRV Control Stations

The water system has nineteen pressure reduction valve (PRV) stations throughout the system, of which many are no longer utilized (refer to LTIP Table 1-9 for detail). The Pennsylvania Avenue PRV Station was renovated in 2011, is in continual service, and is in good repair. The Howertown bypass PRV was rebuilt in 2021. The future LTIP projects include replacement of the Howertown flow meters and installation of an additional 16-inch PRV. The Race Street PRV station was relocated as part of road improvements. The Stefko & Pembroke PRV station is currently inactive; however, the below-grade large station was very dirty and in disrepair. We recommend that minor repairs and regular cleaning be implemented by the City for all PRV stations.

Booster Pumping Stations

The Water System includes three large booster pumping stations to lift the gravity-fed finished water in the distribution system up South Mountain, and to balance pressures of the system in South Bethlehem and the Saucon Valley service area (refer to LTIP Table 1-8 for detail).

The 5th & William Street Booster Station renovation was completed in 2016, with two (2) new redundant 900 gpm pumps, flow meter, electrical service, motor control, emergency generator, and building renovations. This booster station is in good repair; however, the meter pit had standing water in it. We recommend that a permanent vault drain be installed to keep the meter pit dry. The fenced area around the emergency generator was full of dry leaves which can be a fire hazard. In addition to clearing the leaves, we recommend that the large adjacent tree be removed to both eliminate the leaves issue and avoid possible damage to the pump station from the tree or limbs falling in a storm event.

The South Side Booster Pump Station was originally built in 1919. Full renovation and pump replacements were completed in 2018 with two (2) new redundant 1,000 gpm pumps, flow meter, electrical service, motor control, emergency generator, and building renovations.

The Mountaintop Booster Pump Station (formerly Fire Pump Station) was built in 1959 and was designed for full renovation and pump replacements renovation with the PADEP Construction Permit issued June of 2020. This full renovation was completed in August 2021 with two (2) new redundant 1,000 gpm pumps, flow meter, electrical service, motor control, emergency generator, and building renovations.

Two minor booster pump stations include the Frank's Corner PS (East Allen Township) and the Weil Street PS (Salisbury Township). Frank's Corner PS was built in 1997 and includes domestic pumps, fire pump, and emergency generator in a metal building. The Weil Street PS is a package steel below grade pump station with 25 gpm pumps built in 2015. Both stations are in good repair.

Finished Water Storage

The Water System includes seven (7) finished water storage tanks throughout the system (refer to LTIP Table 1-10 for detail). All tanks, but one, are located on South Mountain (see figures at end of this chapter). The 5.0 million gallon (MG) Northeast Standpipe (1991 steel) is located on the Northampton Community College campus in Bethlehem Township and has been recently refurbished. The 1.0 MG South Side High Level (1959 steel) tank adjacent to the Fire PS was recently power-washed and cleaned. The 5.0 MG Southeast Low Service Water Tank (1965 steel) is located on William Street and has recently been modified with new control valves and put back online. The 0.5 MG South Mt. High Service (1959 steel) tank located in South Mountain Park has been recently refurbished. The City has been sequentially upgrading/repainting water tanks as part of their program to enter into contracts with a utility maintenance firm for two of the tanks. The 5 MG Southeast Tank was added to this program in 2021 and will be refurbished in 2022.

The 12 MG South Side Low Service Reservoir located behind St. Luke's Hospital was originally constructed in 1890 but has been refurbished over the years with a synthetic liner and cover. The adjacent 5.0 MG steel Southwest Low Service steel tank was built in 1993 and needs roof structure repairs/replacement and recoating of the entire tank as confirmed by inspection in 2018. The 2.0 MG Southwest High Service Reservoir is a two-cell concrete structure which is in disrepair and currently being evaluated by the City for total replacement. The City is evaluating alternatives for the replacement of this tank, possibly as only 1.0 MG tank. We recommend that this concrete tank be replaced as soon as possible. We also recommend that the City accelerate the schedule for tank refurbishment through contracts with utility maintenance firms.

East Allen Township Well Stations

The Bethlehem Authority acquired the assets of the former East Allen Township Municipal Authority in 2013, including four (4) separate well systems serving residential subdivisions: East Allen Gardens (1971), County Squire (1970), Wil-Mar (1969) and Shady Lane (1971). The systems include groundwater wells and well pumps for source water, chemical treatment and disinfection, below grade finished water storage, and booster pumps for distribution pressure. Each system can be supplied with trucked-in potable water should the wells be temporarily affected by drought or mechanical failure. The City completed the Shady Lane replacement Well & Booster Station in 2018. The City received the Country Squire Well No. 3 Operating Permit from PADEP in October 2019.

These independent water systems are in a minimal state of repair. The Comprehensive Planning Study recommends several long-range plans to expand the water distribution system northward in East Allen Township to integrate these water systems and eliminate the well sources. However, the pace of such progress will be driven by future development in East Allen Township.

The City has completed installing emergency generators at the Shady Lane, Country Squire Systems and Wil-Mar System (in 2021). A separate pilot program for manganese treatment has commenced at the Shady Lane System and received a PADEP operating permit in 2017. The pilot study was completed and the full system design is scheduled for 2022. The City will construct the Mud Lane water main extension to the East Allen Gardens system in 2022. The extension will connect the finished water transmission lines north of Howertown, and will include a small booster station and allow the East Allen Gardens wells to be abandoned.

Emergency Interconnections

The Water System has seven (7) emergency interconnections with adjoining water systems. The Comprehensive Planning Study (page 4-23) estimated the total theoretical capacity of all emergency interconnections as 5+ MGD. Many of these interconnections have never been utilized and/or tested. This issue is a significant concern since the average daily demand of all customers is 12 MGD.

Based upon our prior recommendations, the Authority commissioned an Emergency Water Supply Feasibility Study which was completed in October 2018. The hired consultant evaluated the interconnections and other alternatives to supplement emergency water. The executive summary recommended a condition assessment of the raw water transmission tunnels and further evaluation of improvements/replacements of the emergency interconnections with adjacent water systems. The preliminary capital requirements for these projects are significant. The Authority commissioned an Emergency Interconnection Evaluation Study in 2020 which was completed in December 9, 2021 and Accepted by the Authority in March 2022.

Ongoing Initiatives

Forest Management

The Authority conducts an annual timbering program following its Forest Management Plan. This timbering program generally brings between \$10,000 and \$100,000 a year in revenue, depending on the quality and quantity of the harvested timber. In 2021, the Authority appointed Highland Forestry Management as its forestry consultant (forester), replacing Woodland Management Services, who had been the Authority's forester since 2010. The forester selects areas of the watershed that are suitable for sustainable timber harvesting and the Authority contracts with reputable timber contractors to harvest the selected timber stands.

In addition, the forester monitors spongy moth infestations and other invasive plants and insect species. The forester periodically recommends strategic spraying efforts to limit the negative impact of insect and invasive species to the forest health and future forest management activities.

In 2019 an infestation of spotted lantern flies was discovered in a section of the watershed near the Penn Forest Reservoir in Monroe County. The U.S. and PA Departments of Agriculture declared Monroe County a quarantine area for these insects and following investigations, the USDA contracted with a firm to treat the infected trees to eliminate or minimize the spread of these harmful insects. Follow-up monitoring was scheduled for 2020, but USDA staffing and funding issues brought on by the pandemic, halted this program.

Wind Energy

In 2013, the Authority authorized Atlantic Wind, LLC to install six temporary and one permanent wind measuring towers on its property in Penn Forest Township as part of a feasibility study to determine if a wind turbine farm could be developed for the purpose of producing electricity. All temporary MET towers have been removed and the project now appears to be feasible. Should this project be successful, it will produce a significant annual revenue stream for the Authority in the future. Over the past two years, Atlantic Wind and the Authority have been working through the legal system to resolve the local Zoning Hearing Board's denial to develop the project.

GIS/GPS and UAV

The Authority had retained Maser Consulting (now doing business as Colliers Engineering & Design) to assist in the purchase, licensing, and training for an unmanned aerial vehicle (UAV). This equipment is currently being used by the Authority Special Police to aid in recognition and enforcement of watershed property trespass and other watershed related issues. It is anticipated that the geographical information system (GIS) and global positioning system (GPS) technology will provide a means for the Authority to better manage the 23,000 acres of watershed land assets in the office and in the field.

Watershed Land Survey

In response to a property dispute with an adjacent land owner, the Authority retained Maser Consulting and sub-consulting partner, Arthur A. Swallow Associates, LLC, to research and evaluate many of the deeds and survey warrants associated with the original watershed land acquisition of the late 1920s. Some of these deeds and warrants date back to the 1790s. A program for research and physical property survey of the watershed property is being considered to support the accuracy of the GIS database system of the Authority.

Risk and Resilience Assessment

The City completed a Risk and Resilience Assessment (RRA) in accordance with America's Water Infrastructure Act (AWIA) in 2020. This will be followed by an update of the City's Emergency Response Plan incorporating the findings of the RRA. Both were completed in 2021. The purpose of the RRA is to evaluate vulnerabilities, risks, and consequence of failure of water system assets with respect to man-made, malevolent, and natural hazards. The RRA makes recommendations on security enhancements and actions to improve resilience of the system. Prior risk and vulnerability analyses, such as the 2003 US-EPA Vulnerability Assessment and a 2017 and 2020 Department of Homeland Security (DHS) Infrastructure Survey Security and Resilience Reports have been taken into consideration.

Hydroelectricity

The Authority and City may revisit in the future a study of the feasibility of installing equipment in certain pipelines for the purpose of generating electricity.

Solar Power System

The City had evaluated the feasibility of installing solar power generating equipment at the Water Filtration Plant as part of the City's sustainability initiatives. New technology may allow for the potential use of floatable solar on the Wild Creek and Penn Forest reservoirs.

Emergency Interconnection Assessment and Improvements

In July of 2020, the Bethlehem Authority commissioned an Emergency Interconnection Evaluation Study. The goal of the study is to determine if the Authority's maximum day demand of up to 15 MGD could be reliably provided through existing and/or improved interconnections with the neighboring utilities of Lehigh County Authority (LCA), Easton Suburban Water Authority (ESWA), Northampton Borough Municipal Authority (NBMA), Upper Saucon Water & Sewer, Hellertown Borough Authority, Bath Borough Authority, and Salisbury Township. This Study included flow and pressure testing of the Bethlehem Water System and the neighboring utilities systems. This information was used to calibrate Bethlehem's WaterGEMS water distribution system model. The

Emergency Interconnection Evaluation Study was completed in December 2021 and Accepted by the Authority in March 2022.

System Wide Security Improvements

The Bethlehem Authority requested a specific focus and assessment of the existing security measures in place throughout the water system. The Authority requested that we make specific recommendations for security improvements. Colliers Engineering & Design (CED) was aware that the City had previously invited US DHS to conduct security assessments. CED invited DHS to conduct additional assessments as part of the Annual Tour. CED also retained our teaming partner, Instrumentation Controls & Energy Engineering, LLC (IC&EE) to take part in the Annual Tour and provide their security recommendations based on our joint experience with other water system clients. Due to time limitations, the November 9, 2020 tour included specific Bethlehem Authority facilities that would be representative of the entire system.

On November 17, 2020, the DHS Agent met at the Bethlehem Authority's office to review the preliminary findings. The DHS Cybersecurity and Infrastructure Security Agency (CISA) utilizes a standardized model, the Security Assessment at First Entry (SAFE). *SAFE is designated to assess the current security posture and identify options for facility owners and operators to mitigate against relevant threats. It is not intended to be an in-depth security assessment.* The DHS model includes many questions which are used to score the facility's current commendable actions and practices, as well as vulnerabilities and options for consideration of improvement. A significant positive score item listed is the Bethlehem Authority Police and their patrol of the Watershed and the professional relationship to the City Police Department and other first responders throughout the distribution system.

Due to the sensitive nature of the security assessments, a detailed review of the DHS findings and our recommendations for improvement are provided separately in Appendix 14 which should be treated as Confidential and under separate cover. As a follow-up to this security assessment, the Bethlehem Authority approved the Colliers Engineering & Design Confidential Water Systems Security Feasibility Study in September 2021. This Feasibility study was completed, presented to the Bethlehem Authority in Executive session and Accepted in March 2022. The security improvements recommendations will be implemented by the City of Bethlehem moving forward.

System Maintenance and Operations

Maintenance

Maintenance of the water system is an ongoing activity of the City. Each facility has particular maintenance requirements unique to the type of facility. The following paragraphs discuss the maintenance activities conducted on the various types of water system facilities.

Watersheds

Routine monitoring and maintenance activities associated with fire roads and watershed security were conducted by City staff. The Bethlehem Authority continued its Patrol Officer (PO) Program. The special police patrolling is done from an enforcement perspective. The PO continues to develop relationships with many local area residents, municipal officials, and conservation and sporting organizations, as well as other law enforcement agencies, to further the "eyes and ears" philosophy and learn what is occurring on the property. In 2018, the Authority hired three (3) additional part-time watershed police officers for weekends and evening hours. We recommend that the City and Authority watershed staff continue to work together to improve their communication regarding matters of watershed security. The Authority has also installed a number of cameras which have helped increase security in the watershed properties.

Security has been increased by the visible patrols around Authority lands at unpredictable times, not just during normal work hours. The Authority purchased an unmanned aerial vehicle (UAV) with a high-resolution camera at the beginning of 2017, to assist in security patrolling and supplement efforts of implementing graphical information system (GIS) technology for watershed mapping and monitoring forestry issues such as spongy moth infestation.

Dams and Intakes

The Wild Creek and Penn Forest reservoir dams are routinely monitored including the Penn Forest interior dam access tunnel. Each dam receives an annual inspection by a geotechnical engineer as part of the PADEP requirements. The Wild Creek Reservoir raw water intake structure has two (2) complete sets of intake screens which are alternately cleaned, one set each year, with the change-over of each raw water transmission lines to the water treatment plant.

Transmission

Routine maintenance of the transmission system mains, appurtenances, and rights-of-way is ongoing. Pressure monitoring has been completed, and the past studies indicated that there does not appear to be any significant capacity deficiencies in the lines. The Authority and City carefully evaluated the potential impact of the proposed NG pipeline throughout the multi-year negotiations with PennEast Pipeline. The Authority executed a Pipeline Right-of-Way License Agreement in early 2018 which includes many safeguards and monitoring throughout the NG pipeline construction phase, and also during the on-going operations of the NG pipeline when in service. However, in 2021 PennEast announced that they are no longer pursuing the pipeline project.

New technology may allow in situ inspection of the rock bore tunnels and large diameter water transmission lines without taking them out of service. We recommend the City explore this type of investigation for these critical assets of the water system. The large transmission valves on the north

side of Blue Mountain are exercised regularly to alternate the raw water flow in the redundant lines. The valves south of Blue Mountain are exercised yearly between 50% & 75% of fully closed. Only the two valves at the Blue Mountain southern portal are not exercised because the deep portal is flooded.

Treatment

The City maintains the Water Filtration Plant in accordance with documented procedures appropriate for the processes, equipment, and structures involved. The Maintenance Supervisor provided a description of the ongoing maintenance at the plant. The PADEP January 26, 2017, letter and evaluation report praises the performance of the filter plant: "It is our conclusion that your filter plant was operating at a 'Commendable Level'". Follow-up third party filter bed testing is scheduled for 2022.

Storage

Maintenance of storage facilities in 2018 included routine activities. The City has been sequentially upgrading/repainting water tanks as part of their program to enter into contracts with utility maintenance firms. Two of the seven tanks have been completed. During our tour, the maintenance and operations of the storage facilities appear to be satisfactory (except for the 2 MG Concrete Tank and the roof of the 5 MG Southwest Tank). The City added the 5 MG southeast tank (Williams Street) to the program in 2021 for full refurbishing in 2022.

Distribution

Maintenance of the distribution system included hydrant flushing, painting/repair, valve exercising, and the ongoing meter replacement program. The City has initiated an improved hydrant maintenance program and tracking system through the use of state-of-the-art software and field equipment and has assigned an individual to oversee this activity. The target maintenance schedule is as follows: one fifth (1/5) of the distribution system valves are exercised each year; fire hydrants receive maintenance in a three (3) year cycle; fire hydrants are flushed in a two (2) year cycle. The City also maintains the various pressure regulating and water pumping facilities in accordance with established procedures and waterworks practices.

The City purchased equipment to do in-house leak detection and has an active leak detection program that is performed year-round. This program has helped to reduce the City's unaccounted-for water. The City purchased a twin turner valve maintenance trailer, including computer and mapping software that is synchronized with the City's GIS software, to be utilized in a system-wide valve maintenance and exercising program. Distribution pipe breaks are tracked based on location and frequency. This data is one criterion for scheduling water line replacements.

The Accelerated Meter Replacement program has provided more accurate billing for customers and has increased revenues for the City. The strategy targets the largest water consuming customers and largest sized metered customers first. The program has increased the investment in the numbers of meters replaced each year working from the larger to smaller meters:

<u>Year</u>	<u>Meters Replaced</u>
2013	416
2014	577
2015	1,074
2016	1,416
2017	1,192
2018	1,235
2019	1,380
2020	955
2021	1,077
Total	9,322

The 9,322 meters replaced represents 25% of the total 36,671 customer meters. The City has also implemented Advance Metering Infrastructure (AMI) for remote meter reading. Two (2) AMI towers were installed in 2018. Four (4) AMI towers have been completed in 2019. Currently 6,739 water meters can be read remotely through the tower signal reception. The AMI implementation allows for real-time data for more accurate data and faster response to abnormal water use or loss.

The Maintenance Score Card is used to track and report the efforts of the City's distribution system maintenance department. The leak detection data spreadsheet and maintenance graph reports for previous years are provided in Appendix 13 of this report. For the 2021 calendar year we received the following scorecard data from the City:

Water Main Breaks	64
Water Service Lateral Leaks/Replacements	73
Hydrants maintained/valves exercised	1,540
Main Line Valves Exercised	706
Distribution System Flushing (Hydrants Flushed)	840
Leak Detection (Miles Surveyed)	163.3

The total miles of leak detection work executed in 2021 is more than previous years, see Appendix 13. We recommend that the leak detection, and the effort to resolve unaccounted-for-water be increased in 2022. The City of Bethlehem issued a February 2022 Request for Proposals to professional engineering firms to provide a review of the City's past efforts to address unaccounted-for-water and recommend program(s) to further evaluate, implement additional leak detection efforts, and reduce the percentage of unaccounted-for throughout the water in the distribution system.

The 2018 Amended LTIP Tables 1-2, 1-3, and 1-4 document that 40% of the 534 miles of waterlines, 43% of the valves, and 38% of the fire hydrants were installed before 1960. Some water lines and valves were installed before 1920. We also are aware that the largest water transmission lines from the Wild Creek Reservoir and the two single bore rock tunnels were installed between 1939 and 1940. As such, we recommend that the Authority and City work towards increasing capital investment in replacement of the oldest and most critical assets of the water system.

Master Planning

The City has completed a master plan for the distribution system, otherwise known as the Comprehensive Planning Study (CPS). The 2014 Distribution System Comprehensive Planning Study is part of the Long-Term Infrastructure Improvement Program (LTIP). This Study is referenced as Appendix 12 (under separate cover). The 2014 CPS and 2018 Amended LTIP are very thorough and provide priority planning for capital projects. In 2018, the City Staff first created and then last revised in December 2021. The 10-Year Capital Plan Spreadsheet is to be a working document to be reviewed and updated annually.

Customers Served/Service Area

At the end of 2021, the City provided water service to 36,671 domestic, commercial, industrial, institutional, and other customers in the following municipalities:

City of Bethlehem	Hanover Township (Lehigh County)
Bethlehem Township	Hanover Township (Northampton County)
Freemansburg Borough	Salisbury Township
Fountain Hill Borough	Lower Nazareth Township
East Allen Township	Lower Saucon Township
Allen Township	Upper Saucon Township

The number of customers in each customer class and the changes over the last six years are shown in Appendix 5. The total population served is approximately 120,337 (includes all systems, extrapolated from Lehigh Valley Planning Commission 2020 year-end data, an increase of 0.4%).

The City staff is very quick to respond to any interruption of service. We are not aware of above average customer complaints and/or PUC action notices in terms of customer service. Bethlehem water is generally regarded as the best-tasting water regionally.

Water Production/Consumption

In the 2021 calendar year, 5.747 billion gallons of water, or an average of 15.744 MGD, was delivered to the Water Treatment Plant from Wild Creek. Other minor water sources include: East Allen Well Systems, including Bath Borough Authority through the Route 512 interconnections, which delivered

0.045 billion gallons of water, or an average of 0.124 MGD, and Easton Suburban Water Authority (ESWA), which provided water service of 3,094,480 gallons of water, or an average of 0.008478 MGD, through the Hecktown Road interconnection (northern Bethlehem Township). Total metered consumption by customers and other accounted for usage totaled 3.558 billion gallons, or an average of 9.748 MGD. A summary of Water Consumption by Municipality and Customer Category is shown in Tables 2 and 3, respectively.

The Percent Unaccounted Water listed in Table 3 below increased from 26% in 2019 to 30% in 2020 but has remained steady in 2021 at about 30%. The Delaware River Basin Commission (DRBC) and the PA Public Utilities Commission (PUC) have issued a policy statement that: "Levels of unaccounted-for-water should be kept to within reasonable amounts. Levels above 20% have been considered by the Commission to be excessive." Unaccounted Water continues to be an issue.

We recommend that the City implement a water balance audit program following American Water Works Association (AWWA) guidelines. Such a program may include a monthly spreadsheet comparing the water meters at key locations: 1. raw water leaving the Wild Creek Reservoir; 2. to raw water entering the water filtrations plant (WFP); 3. finished water leaving the WFP, less backwash water; 4. water passing through the pressure reduction stations; and 5. the distribution system total customer meters. Water loss such as hydrant flushing, fire department activity, and main breaks should also be estimated for the water budget. The City started using the PUC Method for calculation in addition to the AWWA Method. As part of the 2020 PUC rate case, the City is committed to addressing the unaccounted water issue. A system-wide unaccounted-for water study will be conducted in 2022.

Staffing

The Bureau of Water Supply and Treatment budget for 2022 includes 68 positions, not including one (1) contract Water Engineer. Salaries for 43 positions are split 50/50 with the sewer fund; 25% are paid 100% by the water fund. The water fund also pays partial salaries for three (3) IT positions and 12 service center positions in the General Fund. The Bureau of Water Maintenance will have 33 staff positions. The personnel in the two bureaus perform other duties in addition to operating/maintaining the system. Appendix 6 provides a breakdown of manpower in each division.

The Director, Departmental Business Manager, Manager of Commercial Operations, Water Quality Manager, Microbiologist, Laboratory Technician, and Customer Service Staff in the Water and Sewer Resources Department are budgeted for approximately 50% of their time to the Bethlehem water system.

Insurance

The City maintains an insurance policy to protect the water system against loss or damage by fire or other casualty, and against public liability. A list of the facilities insured by the City is shown in Appendix 8 for informational purposes. The City has reviewed and updated this list to include new

facilities and exclude any abandoned facilities. The revised list of assets was included in the February 8, 2022 Authority Engineer Certification of Insurance.

Asset Management

The City developed and refined over many decades its Hardy-Cross hydraulic pipe network model for analyzing the existing water distribution system, future expansions, and efficiency improvements to the system. The City has also implemented graphic information system (GIS) mapping for much of the water distribution system.

We recommend that the Authority and City work together to fund the full development of the GIS system map to include the finished water transmission lines, water filtration plant, the raw water transmission lines, and the full watershed land and physical assets. The Authority is considering future funding for GIS platform for the watershed properties.

The US EPA has published its Asset Management Guidelines which include the five major planning and analysis components:

- Asset Inventory/Mapping and Condition Assessment
- Level of Service Goals
- Criticality/Prioritization – Risk Assessment
- Life Cycle Costing
- Long Term Funding Strategy

As stated above, the City has already made strides toward asset mapping. We recommend that this component be developed further to include complete mapping and asset inventory in each major facility. This would include asset numbering and identification. The next step would be asset condition assessment including such attributes as type, size, material, age of asset, and more. This exercise also includes determining the remaining life and value of an asset and/or the energy use of an asset.

The Business Risk Exposure (BRE) is a method of calculating (scoring) the nature and level of exposure that a utility is likely to confront through the potential failure of a specific asset. Key questions of this process include:

- Which assets are most critical to the sustained function of the system?
- What is the likelihood of each of these assets failing?
- What are the consequences if each asset fails?

Probability of Failure (PoF) involves assessments of mortality, financial inefficiency, and deficient capacity. Ratings of 5 to 1 are scored for each asset as: imminent to improbable.

Consequence of Failure (CoF) involves assessment of severity of loss a system would incur as a result of failure of a particular asset (public health, safety, environmental impacts, cost of repair, litigation exposure, etc.). Ratings of 5 to 1 are scored for each asset as: catastrophic to insignificant disruption.

Criticality (BRE) Combined Rating= Probability of Failure (PoF) x Consequence of Failure (CoF)

Multiplier		Consequence (Cost) of Failure				
Probability of Failure	X	1	2	3	4	5
	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Vulnerability is a component of risk and should also be considered. The above described analysis provides a vetting process to determine which assets are critical in terms of both probability and consequence of failure. It is these assets which need the most attention for maintenance and capital funding. We believe BRE may be more objective and strategic than the previously completed "Pair-Wise" analysis within the Comprehensive Distribution Planning Study.

The following components of Life Cycle Costing lead to improved O&M programs, repair/replacement schedules, and capital improvement plans. Finally, after the needs are clearly identified, the Long-Term Funding Strategy can be implemented.

We recommend that the Authority and City pursue implementing a full asset management strategy over the next several years to better maintain a sustainable water system. An asset management plan would aid in the critical decision process for funding maintenance and facility replacement capital projects while providing the justification for potentially taking on more long-term debt financing.

TABLE 2
Revised 3/2022
Average Daily Water Consumption (Gallons/Day GPD)

Municipality	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
City of Bethlehem	6,773,000	6,234,600	6,211,300	6,097,500	6,172,900	6,441,201	6,458,623	6,432,657	6,075,211	6,012,081	6,019,856
Bethlehem Twp	973,100	916,000	936,300	935,700	952,900	961,400	939,638	937,726	898,952	888,101	893,852
Hanover Twp (Northampton)	941,300	820,000	919,200	955,600	978,400	1,003,901	996,105	1,006,332	984,353	1,023,709	1,012,394
Hanover Twp (Lehigh)	283,500	241,200	252,600	275,100	302,300	324,400	325,094	350,660	334,158	293,274	341,016
Fountain Hill Borough	426,200	413,900	373,900	393,200	394,200	425,400	412,851	413,219	392,009	374,007	370,236
Freemansburg Borough	190,100	148,900	161,000	130,900	157,300	137,500	187,873	154,571	121,637	153,119	121,292
Salisbury Twp (& Alex Court)	109,000	92,100	88,700	90,400	86,500	86,600	92,924	88,956	89,022	79,092	74,613
Upper Saucon Twp	172,200	123,000	116,900	109,200	115,400	121,600	102,439	107,563	109,745	136,893	107,977
East Allen Twp ¹	125,600	136,300	115,500	123,900	110,900	214,000	202,257	204,820	201,165	211,269	223,552
Lower Saucon Twp	440,400	398,600	400,600	425,400	416,000	421,800	407,722	421,624	371,463	393,931	409,078
Allen Twp	13,400	13,100	12,700	13,800	13,200	13,200	19,327	19,944	18,796	21,319	21,965
Lower Nazareth Twp	-	-	-	-	-	1,200	4,170	5,439	6,463	7,703	8,400
Total Consumption	10,447,900	9,537,800	9,588,800	9,550,800	9,700,000	10,152,400	10,149,023	10,143,511	9,602,974	9,594,498	9,604,231

1) Includes Well Systems and RT512 Consecutive System

TABLE 3
Revised 3/2022
HISTORICAL SUMMARY OF WATER CONSUMPTION
BY CUSTOMER CLASSIFICATION AND DEMAND
Bethlehem Water System
Average Daily Water Consumption/Demand (mgd)

Customer Classification	2010	2011	2012	2013	2014	2015	2016*	2017**	2018	2019***	2020	2021
Domestic	6.02	5.90	5.68	5.69	5.55	5.64	5.61	5.69	5.52	5.37	5.59	5.443
Commercial	1.64	1.69	1.53	1.53	1.64	1.69	1.79	1.78	1.93	1.75	1.71	1.834
Industrial	1.00	1.13	0.85	0.92	0.99	0.99	1.32	1.29	1.30	1.22	1.14	1.2257
Institutional	0.91	0.75	0.65	0.67	0.67	0.69	0.77	0.77	0.78	0.69	0.55	0.553
Public	0.36	0.33	0.28	0.26	0.17	0.14	0.13	0.13	0.09	0.13	0.11	0.215
Bulk Sales	0.70	0.65	0.54	0.51	0.53	0.54	0.53	0.50	0.52	0.45	0.50	0.479
Other	2.52	2.39	2.64	2.66	1.46	1.62	1.49	1.40	1.38	1.33	1.54	0.933
Accounted for Usage	13.15	12.84	12.17	12.24	11.01	11.31	11.64	11.54	11.53	10.93	11.14	10.681
Total Inflow to Plant	14.89	15.10	15.15	14.58	13.57	14.36						
Source of Supply							14.26	13.68	14.67	14.83	15.83	15.124
Unaccounted-for Water	1.74	2.26	2.98	2.34	2.56	3.05	2.62	2.13	3.14	3.90	4.70	3.69
Percent Unaccounted (%)	11.7%	15.0%	19.7%	16.0%	18.9%	21.2%	18.4%	15.6%	21.4%	26.3%	29.7%	29.50%

*Starting in 2016 "Total Inflow to Plant" will be "Sources of Supply" from Main Bethlehem System, well systems and Rt. 512 Consecutive System.

**Starting in 2017 "Total Inflow to Plant" will be "Sources of Supply from Main Bethlehem System, well systems, Rt. 512 Consecutive System and water purchased from ESWA through Hecktown Rd Interconnection.

**Starting in 2017 "Unaccounted for Water" is now termed "Water Loss" and "Percent Unaccounted for Water" is now termed "% Water Loss."

***The City's bulk meters have been calibrated. The City began investigating the increase of unaccounted water in 2019.

Recommendations

As a result of the reviews made during preparation of this Annual Report, we offer the following recommendations for consideration by the Authority and the City:

1. The City of Bethlehem Approved 2022 Operating & Capital Budgets includes the Water Capital Fund Analysis Summary and 2021 Water Capital Project Detail (pages 282-285). We support the execution of these water system improvement projects in 2022. Many of these capital projects include renovation and/or replacement of key water system infrastructure, which is consistent with the responsibilities of the City and Authority to maintain the water system for the rate payers and bond indenture.
2. The Authority and the City are exploring alternative energy sources for and on its facilities including wind energy, hydro power, and solar power. We recommend that these worthwhile efforts continue to be explored to their fullest potential.
3. The Authority commissioned the Emergency Water Supply Feasibility Study which was completed in October 2018. The shortfall of working emergency sources is a significant concern. In July of 2020, the Bethlehem Authority **commissioned an** Emergency Interconnection Evaluation Study which was initially completed in December 2021 and accepted by the Bethlehem Authority Board in March 2022. The next step is for the Authority & City to share and discuss this study with the neighboring water systems who would gain mutual benefits to improve emergency interconnection. We recommend that the Authority and City work together to plan additional long-term funding to further invest in improved emergency water supplies.
4. We recommend the City continue to improve/replace critical equipment at the water filtration plant. We recommend that the City continue towards the planned chlorination system replacement with safer modern disinfection systems. The Water Filtration Plant Staff are aggressively replacing critical equipment for the now 25-year old system. The 10-Year Water Capital Plan includes increased funding for the Water Filtration Plant. The major project planned for 2022 are to complete the second lagoon baffle replacement and repair the roof. The replacement chlorination system is currently planned for design in 2029 and construction in 2030, but could be implemented sooner as capital becomes available.
5. We recommend the City Staff improve their regular maintenance and repair of all facilities in the watershed system, specifically: access roads and fire lanes need to be better maintained for use by the Authority Special Police, and other authorized personnel. Access gates are rusted and difficult to operate, and much of the posted signage needs to be replaced.
6. We recommend that the City continue work to restore and preserve the historic structures of the Watershed Campus which date back to the 1940s. Specifically, several areas of the old masonry stone walls and buildings are in need of repair and/or restoration. Repairs to some of the masonry walls were completed in 2021.

7. We recommend that the City replace the 2 MG concrete Southwest High Service Reservoir as soon as possible and accelerate the refurbishment and maintenance contract for the remaining finished water storage tanks. The City completed a replacement feasibility study in 2020. The 10-Year Water Capital Plan includes funding for design in 2024 and construction in 2025. The major project goals for 2022 are to complete the rehabilitation of the 5 MG Southeast Tank, and repaint the 0.5 MG South Mountain Tank.
8. The City has implemented a program to systematically exercise valves throughout the entire water system every five years and annually exercise fire hydrants through flushing as part of the maintenance program. We recommend that this program continue to ensure proper operation of the distribution system, the detections of problems, and to avoid fire protection limitations. We recommend the City Staff continue to improve their regular maintenance and repair of all facilities in the distribution system.
9. We recommend that the Authority and City continue to explore the new technologies for in-situ inspection of the water transmission lines and rock bore tunnels constructed as early as 1939. We have conducted several meetings and access investigations with specialty contracting firms who believe in-situ analysis of the water transmission piping and robotic cameral analysis of the two tunnels is possible. However, this work is expensive, and the tunnel access will require upfront capital investment. We will continue to investigate.
10. The City has begun an aggressive program of customer water meter replacement starting with the larger commercial and industrial high-water users. We recommend that this program continue each year for the replacement of all water customer meters throughout the system. The 10-Year Water Capital Plan includes significant funding which increases over time toward this goal. It is planned for 1,400 meters to be replaced in 2022. The percent unaccounted-for-water has significantly increased above industry standards, as reported in years 2018, 2019, 2020 and 2021. We recommend that the City increase their efforts to investigate meter accuracy, ramp up leak detection efforts, and track unaccounted for water on a quarterly basis. In February 2022, the City issued a request for proposals for an Unaccounted for Water Study.
11. The City continues its replacement program of water distribution lines throughout the system. In a system with facilities well over 100 years old, it is important that a systematic, annual replacement program be implemented. The City has improved its extensive leak survey and system analysis to determine areas of water mains that are most susceptible to leaks. For the period 2014 through 2019, the city has replaced on average 4,400 linear feet of water main per year. However, this only represents 0.2% of the 500 miles of water main in the system. It is planned for about 1 mile of mains to be replaced in 2022. We recommend the City increase funding of this program over the next decade. The 10-Year Water Capital Plan includes doubling the funding of water main replacement from \$500,000 to \$1,000,000 in year 2023.

12. We recommend that the Authority continue its efforts to maximize the potential of all of its assets through the Watershed Management Program. The Authority continues its annual sale of green energy credits, strategic sale of timber program and the development of alternative energy.
13. We recommend the Authority and City work toward completion of its GIS model for the entire water system and watershed assets. The City plans to hire a GIS consultant in 2022 to upgrade the GIS platform for all underground utilities. This continues to be a long-term goal as funding permits investment.
14. We recommend the City implement full Asset Management based upon the EPA guidelines. This process will vet the most critical assets for a targeted long-range capital improvement plan. This continues to be a long-term goal as funding permits investment and may be mandated by the PA Senate Bill 597 – Water Quality Accountability Act, if it is voted into law.
15. The Authority and City have worked with their respective financial planning consultants to create the 10-Year Water Capital Plan and Capital Improvement Program Funding Plan. We recommend that the Authority and City continue their efforts to monitor the current Funding Plan and its implementation to best balance capital project funding and debt management; and to allow additional new capital funding of City water system improvement projects when needed. In 2022, the Authority has hired Bond Council and began the process to refinance the long-term debt which will free up capital reinvestment and provide additional capital funds over the coming years.
16. In March of 2020, the City completed a Risk and Resilience Assessment (RRA) in accordance with America's Water Infrastructure Act (AWIA) of 2018. We recommend that the City implement the findings of these study reports to reduce vulnerability of the Bethlehem Water System. The Emergency Interconnection and Security Improvements Studies work toward this recommendation.
17. United States Department of Homeland (DHS) assisted Colliers Engineering & Design and our subconsultant in touring specific and strategic water system facilities to assess the current security systems and make recommendations for security system improvements throughout the Bethlehem Water System. The DHS documents and our security recommendations found in Appendix 14 are considered confidential and are provided under separate cover. As a follow-up to this security assessment, the Bethlehem Authority approved the Colliers Engineering & Design Confidential Water Systems Security Feasibility Study in September 2021. This Feasibility study was completed, presented to the Bethlehem Authority in Executive session and Accepted in March 2022. The security improvements recommendations will be implemented by the City of Bethlehem moving forward.

18. The Pohopoco Drive frontage should be secured with a 6-feet high fence across the entire frontage at the ultimate right-of-way, ideally the fence could be decorative. Low shrubbery could be added in front of the fence and "No Parking" signs posted on the fence. A mortorized slide gate should be installed at the main entrance behind the stone walls. These security improvements recommendations will be implemented by the City of Bethlehem moving forward.
19. We recommend that a separate detailed security improvements feasibility study be authorized to develop a full program for implementation program of prioritization and assigned estimated costs for each particular water system facility. The Confidential Water Systems Security Feasibility Study provided a list of security improvements to be implemented over several years which have a total budget of approximately \$2.0M.
20. We recommend that the recently completed Water System Risk and Resilience Assessment Study be implemented and that a specific Cybersecurity Assessment evaluation of the City's current IT systems be commissioned. The recommendations of this third party study should then be addressed.

Annual Recommendations

Recommendations Tracking Spreadsheet

	Recommendation (2020 Report)	2021 Action Taken	2022 - First Quarter
1	Full Water System: Continue Water Capital Projects Renovations and/or replacement of key water system infrastructures as described in the 2020 Water Capital Project Detail .	Projects Completed in 2021 include: 1. Mountaintop Pump Station Rehabilitation 2. Water Filtration Plant Emergency Generator and Chemical Storage Tank Replacement 3. East Allen Emergency Generator Replacement, Hecktown US 22 Bridge Bypass	Major projects planned 2022: 1. Water main extensions/replacements (see 11 below); 2. Lead service lines - \$2.9 million; 3. Convert East Allen Gardens to City water; 4. Install Mn treatment at Shady Lane well system
2	Watershed: Continue to explore alternative energy sources including wind energy, hydropower, and solar power.	Wind Farm at PA Court of Appeals	Partially Positive Outcome; City's climate action plan will provide framework for pursuit of alternative energy sources
3	Distribution System: The shortfall of working emergency sources detailed in the Emergency Water Supply Feasibility Study (October 2018) is a significant concern. In July of 2020, the Bethlehem Authority commissioned an Emergency Interconnection Evaluation Study . Plan additional long-term funding with the City to further invest in improved emergency water supplies.	Emergency Interconnection Study Dated 12/9/21 Completed	Study Accepted by BA Board; next step is to share report with neighboring water suppliers and begin discussions on shared responsibilities/opportunities
4	Treatment: Continue to improve/replace critical equipment at the water filtration plant. Continue towards the planned chlorination system replacement with safer modern disinfection systems. The 2021 Capital Plan includes increased funding for the Water Filtration Plant; the replacement chlorination system is planned for design in 2023 and construction in 2024 .	1. 10 Year Plan Major Project at WFP each year includes \$250,000 for 2022 for Chemical Storage Tanks, Service Pumps, and other miscellaneous equipment. 2. Chlorination system replacement to be implemented in 2030	2022 Projects: 1. Complete lagoon baffle replacement; 2. Roof repairs; 3. Rebuild service water pump
5	Watershed: Improve regular maintenance and repair of all facilities in the watershed system , specifically: better maintain access roads and fire lanes , rusted access gates , and replace posted signage .	The Authority hired a contractor to clear fire lanes in 2021.	TBD
6	Watershed: Repair and/or restoration of historic structures of the Watershed Campus including old masonry stone walls and buildings.	Repairs to old masonry walls completed in 2021.	
7	Distribution System: Replace the 2 MG concrete Southwest High Service Reservoir and accelerate the refurbishment and maintenance contract for the remaining finished water storage tanks. The City completed a replacement feasibility study in 2020. The Capital Plan includes funding for design in 2022 and construction in 2023.	1. 2 MG Tank design planned for 2024 and construction in 2025. 2. South Mountain Park 0.5 MG Southeast High Tank painted.	2022 Tank projects: 1. complete rehab of 5 MG SE tank (paint inside/outside); 2. inspect 5 MG NE tank; 3. Repaint 1/2 MG south exterior
8	Distribution System: Continue implementation of program to systematically exercise valves throughout the entire water system every five years and annually exercise fire hydrants through flushing . Continue to improve regular maintenance and repair of all facilities in the distribution system.	On-Going Annual Maintenance Report completed annually.	1,580 valves exercised in 2021; fire hydrant flushing and maintenance is on a 2 to 3 year cycle
9	Transmission Lines: Explore technologies for in-situ inspection of water transmission lines and rock bore tunnels	Nothing New 2021	
10	Distribution System: Continue program of customer water meter replacement . Investigate meter accuracy, increase leak detection efforts and track unaccounted for water on a monthly basis to reduce percent unaccounted-for-water which has significantly increased above industry standards, as reported in years 2018, 2019 and 2020.	1. The 2022 Budget includes \$600,000 for meter replacement, this will increase each year to be \$1.9 Million in 2028 2. RFP Unaccounted for water study 2/8/22	2022 Meter schedule: 1. 1400 meters 2. 1500 RF units UFW RFP issued March

11	Distribution System: The City continues its replacement program of water distribution lines throughout the system. In a system with facilities well over 100 years old, it is important that a systematic, annual replacement program be implemented. Increase funding of this program over the next decade	In 2022, \$5.4 Million is budgeted for line replacement, and \$2.9 Million of this is lead service. The Capital Plan includes doubling the annual funding of water main replacement from \$500,000 to \$1,000,000 in year 2023.	1. LSL project - \$2.9 million; target 300 +/- lead services 2. Water mains - \$1.3 million; approx 1 mile (8 locations)
12	Watershed: Continue efforts to maximize the potential of all of its assets through the Watershed Management Program . The Authority continues its annual sale of green energy credits , strategic sale of timber program and the development of alternative energy.	Authority continues Watershed Management Program and sales timber and Green Energy Credits	
13	Full System: We recommend the Authority and City work toward completion of its GIS model for the entire water system and watershed assets . This continues to be a long-term goal as funding	CED Renewed GIS Water and Sewer Evaluation 2021, New proposed in 2022	City to hire GIS consultant to upgrade GIS platform for all underground utilities
14	Full System: City continue to implement full Asset Management based upon the EPA guidelines. This continues to be a long-term goal as funding permits investment and may be mandated by the PA Senate Bill 597 – Water Quality Accountability Act, if it is voted into law.	Long Range Goal after GIS update	
15	Funding: Continue to implement 10-Year Capital Plan and Capital Improvement Program Funding Plan and continue efforts to monitor the current Funding Plan and its implementation to balance capital project funding and debt management and to allow additional new capital funding of City water system improvement projects when needed	Authority and City to Refinance Long Term Plan in Fall 2022	Council finance committee meeting March 8
16	Full System: In March of 2020, the City completed a Risk and Resilience Assessment (RRA) in accordance with America's Water Infrastructure Act (AWIA) of 2018. We recommend that the City implement the findings of these study reports to reduce vulnerability of the Bethlehem Water System.	Security Improvements Feasibility Study to be completed in 2022	
17	Security: We recommend that the City and Authority budget for and implement the security initiatives in the DHS documents and our security recommendations found in Appendix 14 of 2020 Annual Engineer's Report (Confidential).	See Security Improvements Feasibility Study 2021-2022	
18	Security Watershed: The Pohopoco Drive frontage should be secured with a 6-foot high fence across the entire frontage at the ultimate right-of-way, ideally the fence could be decorative. Low shrubbery could be added in front of the fence and "No Parking" signs posted on the fence. A mortorized slide gate should be installed at the main entrance behind the stone walls	Security Improvements Feasibility Study to be completed in 2022	
19	Security: We recommend that a separate detailed security improvements feasibility study be authorized to develop a full program for implementation program of prioritization and assigned estimated costs for each particular water system facility. Anticipated budgetary range of \$1.2M to \$2.0M .	Security Improvements Feasibility Study to be completed in 2022	
20	Security: Implement Water System Risk and Resilience Assessment Study. Commission a specific Cybersecurity Assessment evaluation of the City's current IT systems .	City IT Dept maintains cybersecurity program; Assessment effort TBD	



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