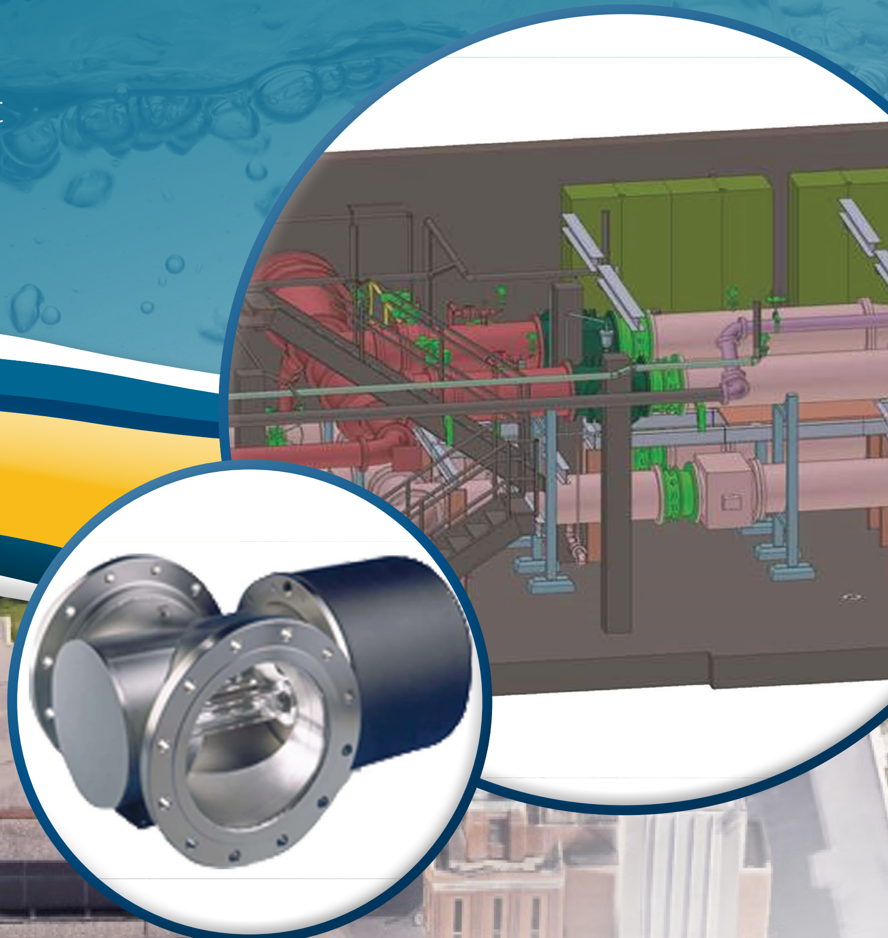
Drinking Water Revolving Fund Project Plan

Ann Arbor Water Treatment Plant UV Disinfection System Project

City of Ann Arbor, Michigan
Water Treatment Services Unit



Prepared for
Michigan Department of Environmental Quality

Prepared by
JACOBS

April 2019

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FINAL

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Acronyms and Abbreviations

ACM	asbestos-containing materials
CFE	combined filter effluent
DWRF	Drinking Water Revolving Fund
EPA	U.S. Environmental Protection Agency
gpcd	gallons per capita per day
HMI	Human Machine Interface
IFE	individual filter effluent
kW	kilowatt
LT2	Long-term 2 Enhanced Surface Water Treatment Rule
MDEQ	Michigan Department of Environmental Quality
mgd	million gallons per day
MIOSHA	Michigan Occupational Safety and Health Administration
OSHA	Occupational Safety and Health Administration
PFAS	per- and polyfluoroalkyl substances
PLC	programmable logic controller
SCADA	supervisory control and data acquisition
SEMCOG	Southeast Michigan Council of Governments
UV	ultraviolet light
UVDGM	*Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule* (EPA 2006)
UVT	ultraviolet light transmittance
WTP	Water Treatment Plant

1. Project Background

1.1 Summary of Project Need

The purpose of this project is to provide an ultraviolet light (UV) disinfection system at the Ann Arbor water treatment plant (WTP) to assist with reliable compliance with the Long-term 2 Enhanced Surface Water Treatment Rule (LT2) drinking-water regulations, and further protect public health.

In 2017, the Michigan Department of Environmental Quality (MDEQ) notified the City of Ann Arbor that its source of drinking water contains levels of *Cryptosporidium* (a parasitic pathogen) that require additional protection to comply with LT2 drinking-water regulations. MDEQ stated that compliance was required by June 2020 (Appendix A). In late 2017, CH2M (now Jacobs[1]) worked with Ann Arbor Utilities on a study to comply with the LT2 regulations for *Cryptosporidium* (Appendix B). The study indicated that Ann Arbor can use existing treatment processes such as optimized filtration, ozone, and two-stage lime softening to provide additional protection from *Cryptosporidium* and meet LT2 regulations. However, meeting the regulations continuously under varying operational, maintenance and water quality conditions would be difficult. Ultimately, the study recommended ultraviolet light (UV) disinfection as a method to comply with the regulations and best protect public health.

Implementing a permanent UV disinfection system in Ann Arbor's large, complex water plant is a long-term project. Rapid implementation of an interim UV disinfection system is being conducted to provide enhanced disinfection at the water plant. This not only protects public health sooner but provides operational and regulatory benefits to the water system and its customers. Installation of an interim UV system will allow the City of Ann Arbor to meet the MDEQ June 2020 deadline for additional *Cryptosporidium* protection. Having the interim UV system in place will make construction of future water plant improvements project easier and less risky. In addition, UV equipment from the interim system may be able to be reused in a potential permanent UV system, if desired.

The City of Ann Arbor met with MDEQ on September 6, 2018, to discuss the concept of installing an interim UV disinfection system until Ann Arbor implements its future water plant capital improvements plan. MDEQ endorsed the concept of an interim UV disinfection system.

The City of Ann Arbor has proceeded with an evaluation of the best method to implement UV disinfection into the water plant (Appendix C) and has completed final design bidding documents of the UV disinfection system. These bidding documents have been submitted to MDEQ for review, along with a 399 Permit Application (Appendix D). The WTP UV Disinfection System project went out for bids on January 31, 2019, with a bid date of February 28, 2019.

This Project Plan provides information on the Ann Arbor water system and summarizes the evaluation of alternatives and design concepts of the WTP UV Disinfection Project.

Ann Arbor has a proud history of providing safe, reliable drinking water to its customers, complying with drinking water regulations, and planning for the future. In the 1990s, Ann Arbor implemented ozone disinfection and granular activated carbon to enhance disinfection, reduce disinfection by-products, and provide better tasting water for its customers. In 2006, Ann Arbor completed a comprehensive Water Treatment Facilities and Water Resources Master Plan. This plan outlined prioritized improvements over the next 50 years. Also in 2006, Ann Arbor added equalization for its recycle streams to comply with the Filter Backwash Recycle Rule. The City of Ann Arbor recently completed an asset management plan that was submitted to the State of Michigan in 2018. This plan presents the City's approach to managing its horizontal and vertical assets.

[1] On December 15, 2017, CH2M HILL Engineers, Inc. became a wholly owned subsidiary of Jacobs Engineering Group Inc.

1.1.1 Water Quality

The City of Ann Arbor is in compliance with the drinking water standards defined in the Administrative Rules for Act 399.

The City of Ann Arbor has no active acute violations of a Maximum Contaminant Level or surface water treatment technique.

The City of Ann Arbor has not had any waterborne disease outbreaks. A high concentration of *Cryptosporidium* (1 cyst per liter) was detected in the Huron River supply in December 2014. This sample result increased the running annual average above the regulatory limit, requiring Ann Arbor to provide additional *Cryptosporidium* control.

The City of Ann Arbor has experienced discoloration, odor, or taste problems in limited areas where the water main is in poor condition and in dead-end areas of the distribution system. These areas are flushed and monitored periodically by field personnel. A copy of the Ann Arbor Public Services 2017 Annual Report on Drinking Water can be found in Appendix E.

A Community Water Supply Sanitary Survey of the existing water treatment plant and distribution system was conducted and approved by Water Bureau staff of MDEQ in 2017. Appendix F contains a copy of the cover letter from the Sanitary Survey.

1.1.2 Orders or Enforcement Actions

There are no active court or enforcement orders against the City of Ann Arbor, nor any written enforcement actions, such as a Notice of Violation, Consent Agreement, or Department Order to correct deficiencies and achieve compliance with Act 399.

1.1.3 Drinking Water Quality Problems

The City of Ann Arbor has experienced occasional discoloration, odor, or taste problems in limited areas where the water main is in poor condition and in dead-end areas of the distribution system. These areas are flushed and monitored periodically by field personnel.

The City of Ann Arbor is concerned with groundwater contamination. 1,4-Dioxane is a potential human carcinogen that has been found in some groundwater aquifers in the City of Ann Arbor. One aquifer where 1,4-dioxane has been detected contains one of the City's drinking water supply wells. 1,4-Dioxane has been measured at low levels in the well. Subsequent to detection in March 2001, the well was taken out of service.

The City of Ann Arbor has detected very low levels of per- and polyfluoroalkyl substances (PFAS) in their Huron River supply. This is not a drinking-water regulatory violation. As a precautionary measure, Ann Arbor is implementing regular replacement of granular activated carbon that already exists in water plant filters to remove PFAS.

1.2 Delineation of Study Area

This project is within the existing Ann Arbor water treatment plant main building. Additional land will not be impacted. A summary the City of Ann Arbor area is provided below for background information.

The City of Ann Arbor (City) was founded in 1824 and the City charter was adopted in 1851. The City is located in Washtenaw County, Michigan. The City consists of approximately 27.7 square miles bounded to the north by Michigan State Route 14, to the west by Wagner Road, to the south by Interstate 94, and US Route 23 to the east. The City is a regional water supplier for the area and supplies water to portions of the communities of Ann Arbor Township and Scio Township, which operate and maintain their own water distribution systems.

The City operates 156 parks, 2,055.5 acres of park land, including: 4 city pools, 2 city golf courses, 1 city ice rink (regulation-size), 1 outdoor seasonal ice rink, 2 city canoe liveries, 1 city cross-country ski center, and 1 city skate park. In addition, the City benefits from 18 miles of bicycle lanes on the city's primary road system and 60 miles of park bicycle paths. Through recycling and composting, Ann Arbor recovers over 50 percent of its residential solid waste, one of the best recovery rates in the country.

The University of Michigan is the city's largest employer, with more than 30,000 employees.

1.3 Land Use

This project is within the existing Ann Arbor water treatment plant main building. Additional land will not be impacted. The following subsections from Ann Arbor's 2009 Project Plan to MDEQ summarize land uses in the City of Ann Arbor, and is provided for background information.

1.3.1 Residential

Residential land uses comprise 49.5 percent of all land in the City of Ann Arbor. This land is primarily single-family homes and multiple-family units. In the West Area, single-family homes are particularly highly concentrated: they compose 47.6 percent of the West Area. Multiple-family units are most heavily concentrated in the South and Northeast Areas, while two-family units, which compose only 2 percent of all land in the city, are almost exclusively located in the Central and West Areas. The Central Area has the most diverse mix of residential uses, including the highest concentration of group housing.

1.3.2 Office and Commercial

Office and commercial land uses each compose 3 to 4 percent of the land in the city. The majority of office and commercial acreage is still located in the South Area, which contained about half of this acreage (569 acres total) as of August 2000. The smallest concentration of office uses can be found in the West Area, with 1.2 percent of the land, and the smallest concentration of commercial uses is in the Northeast Area, with 1.7 percent of the land. The Central Area includes Ann Arbor's central business district, but only 2.3 percent of the acreage falls under pure office use, while only 2.2 percent of the land is currently under commercial use. Mixed use is more prevalent in the Central Area and is discussed in Section 1.3.8, Mixed Use.

1.3.3 Industrial

Industrial land uses compose 2.5 percent of all land in the city and are most heavily concentrated in the South and Northeast Areas. Over half of the industrial land in the city is used for research facilities. Warehousing and heavy manufacturing make up another quarter of the acreage devoted to industrial uses.

1.3.4 Transportation/Communications/Utilities

Legal parcels used for transportation, communications, and utilities comprise 3.8 percent of the City. This land is primarily used for parking and utilities. Road transportation and railroad rights of way comprise a significantly higher amount of the City, but are not classified as legal parcels, and were therefore not counted in this inventory.

1.3.5 Public / Quasi-Public / Institutional / Organizations

This category, which includes public and private schools, colleges and universities, religious institutions, hospitals, cemeteries, libraries, City Hall, fire departments, and fraternal organizations, composes 10.3 percent of all land in the city. Almost half of all this land is located in the Northeast Area due to the size of the University of Michigan's North Campus, as well as Concordia College's campus in the area. The remainder of public/quasi-public land is distributed fairly equally between the three other planning areas.

1.3.6 Recreation

Approximately 18 percent of all land in the city is devoted to recreational uses. This land is distributed fairly equally throughout the city. Two park acquisitions, in the Northeast and West Areas, accounted for a 1.6 percent increase in total recreational land in the city from 1998-2000. The Northeast Area continues to have the highest percentage of park land, currently at 19.4 percent, while the Central Area has 15.8 percent recreational land, the lowest percentage of land devoted to recreation among the plan areas.

1.3.7 Vacant

The majority of vacant land is located in the perimeter areas of the city, and over half of all vacant land is located in the Northeast Area. In addition, about half of all vacant land is located on township islands under the jurisdictions of Ann Arbor, Scio, and Pittsfield Townships. Not all of this land appears completely vacant; however, this category also includes many small vacant parcels in residential neighborhoods, which may be considered to be backyards for adjacent single-family homes.

1.3.8 Mixed Use

Mixed-use land composes 1.7 percent of all land in the City of Ann Arbor. Of that land, less than a fifth includes a residential use. Mixed-use land is most highly concentrated in the Central Area at 3.2 percent of the land. The Northeast Area has the smallest concentration with 0.9 percent mixed-use land.

1.3.9 Ownership in Study Area

The City of Ann Arbor owns the WTP. The proposed UV disinfection system is wholly within the Ann Arbor WTP.

1.3.9.1 Private

Private land composes 70 percent of all land in the City of Ann Arbor. Over two-thirds of this land is residential. Other common private land uses include office, commercial, industrial, vacant, and mixed land uses.

1.3.9.2 Public

Approximately 20 percent of the land in the City of Ann Arbor is in public ownership (either city, state, or federal public entities). Sixty-six percent of this land is used for recreation. Education and utility facilities uses occupy another 23 percent, while 5 percent of publicly owned land is vacant.

1.3.9.3 University of Michigan

The University of Michigan owns 10.3 percent of the land in the City of Ann Arbor. The acreage is primarily occupied by recreational land uses (30 percent), followed by educational land uses (25 percent), and residential land uses (14 percent).

1.4 Population Projections

The *Water Treatment and Water Resources Master Plan* (CH2M 2006) provided population projections for the purpose of estimating future water demand. Population projections were based on the Southeast Michigan Council of Governments (SEMCOG) projections. SEMCOG provided projections for Ann Arbor, Ann Arbor Township, and Scio Township by 5-year intervals up to the year 2050. These projections were based on the census taken in 2000. The population of the City of Ann Arbor was projected to grow from the current population of about 116,000 people to about 119, 260 by the year 2050. Similarly, Ann Arbor Township is projected to grow from a present population of 3,900 to roughly 5,900, and Scio Township from a present population of 15,500 to 27,130 people. Note that these projections include the whole township, and Ann Arbor currently serves only a portion of both Townships. Figure 1 shows the population projections for the City of Ann Arbor, Ann Arbor Township, and Scio Township.

Based on the 2010 census, SEMCOG estimates that the existing population of the city is approximately 113,943 people. SEMCOG projects the population to increase by the year 2035 to 115,218. These estimates are less than those from the 2000 census.

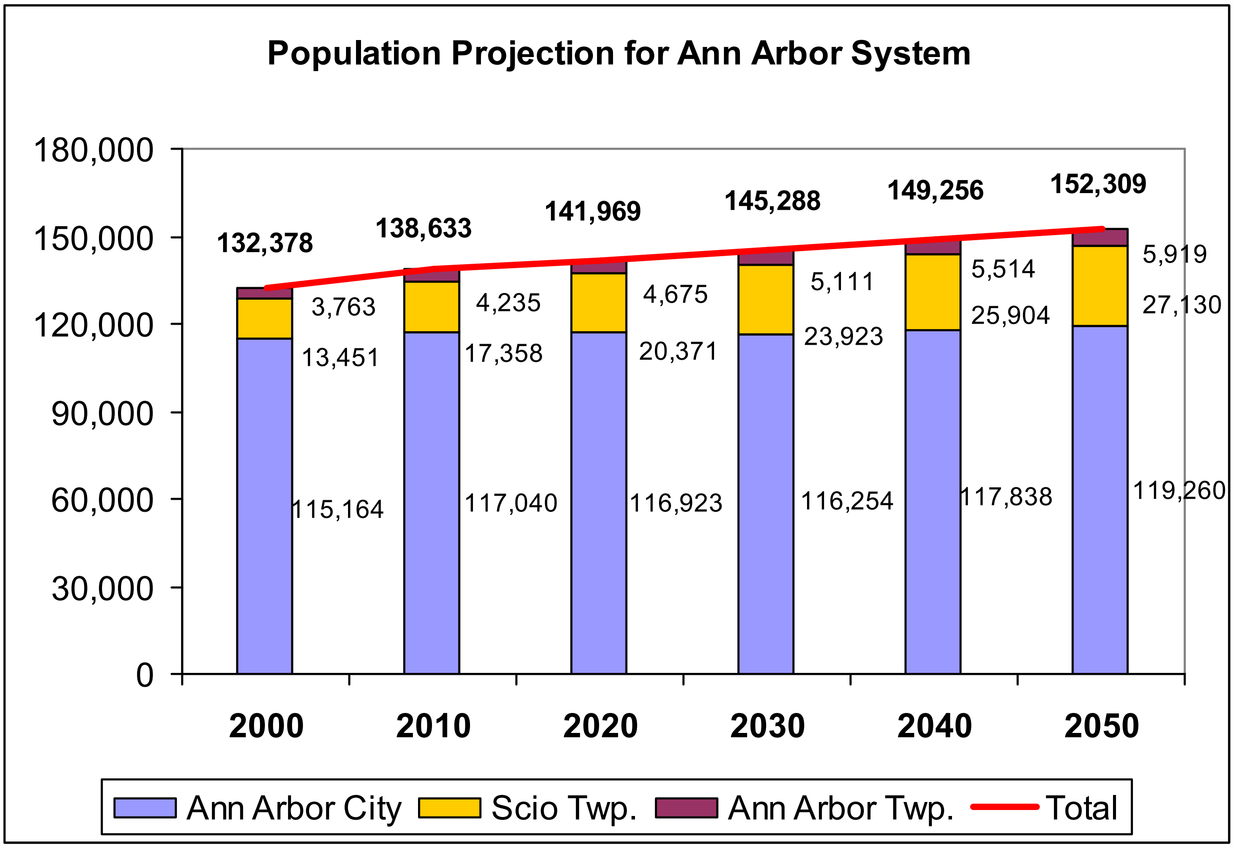


Figure 1. Population Projection for Ann Arbor System

1.5 Water Demand

A water demand forecast for the City of Ann Arbor WTP service area (City of Ann Arbor, a portion of Ann Arbor Township [also serving Superior township], and a portion of Scio Township) was based on population projections and historical water use during the 2006 Water Treatment and Water Resources Master Plan. Figure 2 summarizes the water demand projections. The water demand forecast was developed on a decade-by-decade basis through 2050. Although the planning horizon for basic water treatment infrastructure typically is 20 years, a 50-year horizon is necessary to plan for water supply capacity because of the long lead-time potentially associated with water supply development, property procurement (if needed), and securing water rights.

The average per-capita water demand was calculated at 132 gallons per capita per day (gpcd) for Ann Arbor, 92 gpcd for Ann Arbor Township, and 86 gpcd for Scio Township. Water that is unaccounted for is included in this per-capita demand, as well as industrial and commercial water usage. Combining population projections with per-capita water demands provided the water demand projections.

It is anticipated that the existing plant capacity of 50 million gallons per day (mgd) will meet current service area water demands through 2050.

As stated previously, the 2010 census projected lower populations, and thus water demand would be expected to be lower. MDEQ's 2017 Sanitary Survey also provided water demand data from 2012 to 2016 that are lower than those projected in Figure 2.

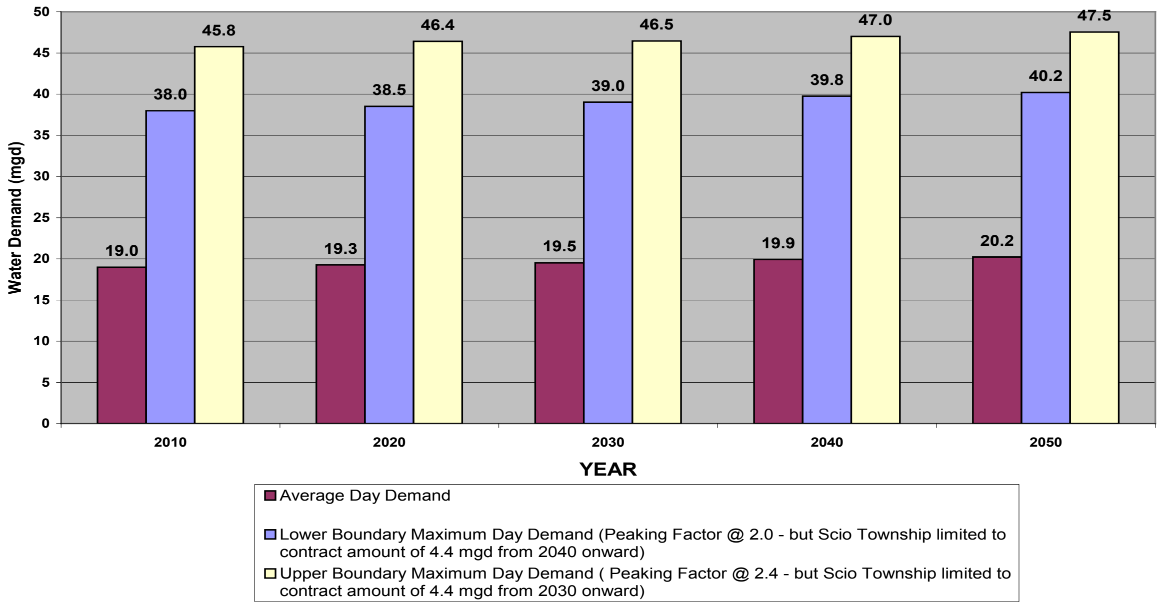


Figure 2. Water Demand Projections

For the purposes of this Drinking Water Revolving Fund (DWRF) Project Plan, these water demand projections are conservative (on the high end). For example, recent average day demand is around 14 mgd, versus the projected 19 mgd in the 2006 Water Treatment and Water Resources Master Plan.

1.6 Existing Facilities

The source of Ann Arbor's water supply is an impoundment on Huron River at Barton Pond, and a groundwater wellfield located near the Ann Arbor airport near Steere Farms. The water is pumped to the Ann Arbor WTP.

The City of Ann Arbor owns and operates a 50-mgd lime-softening WTP. The WTP consists of two softening plants: Plant 1 has a capacity of 22 mgd, and Plant 2 has a capacity of 28 mgd. Treatment processes in Plants 1 and 2 consist of two-stage rapid-mixing, flocculation, and lime softening. Water from Plants 1 and 2 are combined and pass through recarbonation, ozonation, filtration, and final disinfection with chloramines as illustrated in Figure 3.

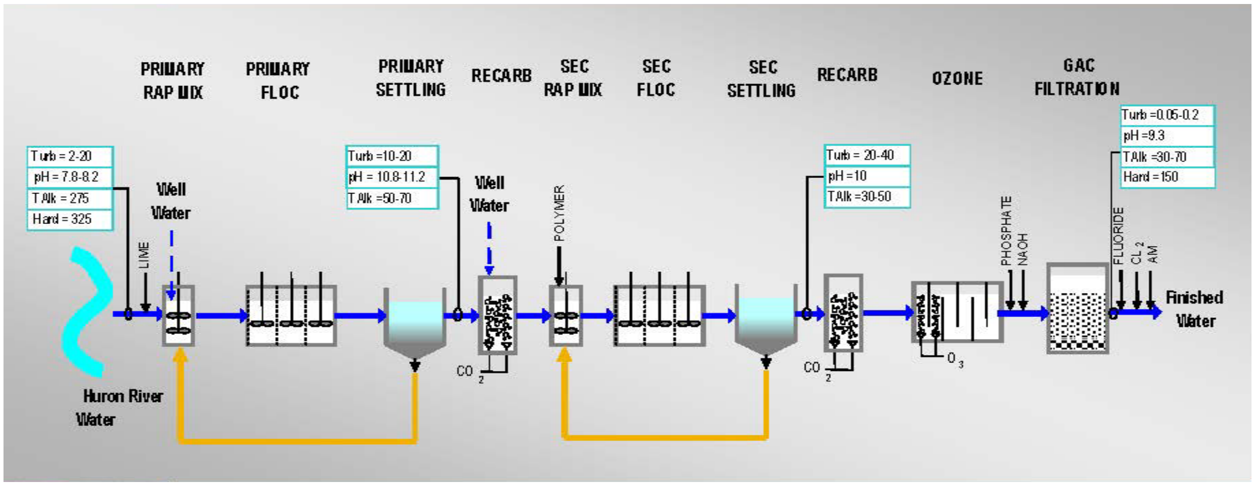


Figure 3. Ann Arbor Water Treatment Plant Schematic

After filtration, the water passes through two clearwells and then is pumped to a storage reservoir. Water is distributed to customers by high-service pumps and can also flow by gravity to a portion of the distribution system.

The water is distributed throughout the city through the main reservoir, three outlying reservoirs, four remote pump stations, and two elevated tanks supply to five pressure districts. The distribution system consists of about 500 miles of water mains, 3,171 fire hydrants, and 7,403 water main valves.

Potable water is produced at the WTP and stored in the main reservoir. The city is divided into five pressure districts that are supplied water from this reservoir by a variety of means.

The five districts of the City of Ann Arbor water distribution system are summarized in the following subsections.

1.6.1 Gravity Pressure District

The Gravity Pressure District is the central part of the city and includes downtown, the old west side, central campus, and Burns Park. Since the elevation of the main reservoir is very high above this area, water is supplied to the district without pumping.

1.6.2 West High-Service District

The West High-Service district is on the west side of the city. It is west of State Street on the south, west of Spring Street on the north, and of course west of the Gravity District. The district is supplied water from the WTP via West High-Service pumps at the plant and supplemented by a storage reservoir and pump station. There is no elevated water tank in this district, so pressure is maintained by continuous pumping with variable speed control. Scio Township is supplied water from this district.

1.6.3 Northeast High-Service District

The Northeast High-Service District is largely north of the Huron River and east of North Main and M-14. The district is supplied water from the WTP via East High-Service pumps at the plant and supplemented by a storage reservoir and pump station. The water pressure in this district is regulated by the height of the water in the 0.5-million-gallon elevated tank. As water is used in this district, the water level in the elevated tank drops. When a trigger level is reached, a pump is turned on at the pump station, and the elevated tank is refilled. Furthermore, water can be released from this district into the neighboring district through a remotely controlled valve. Ann Arbor Township is supplied water from this district.

1.6.4 Geddes High-Service District

The Geddes High-Service District is bounded by Washtenaw Avenue on the west and south, the Huron River on the north, and US 23 on the east. East High-Service pumps at the WTP provide water to the district. Secondly, a booster pump station pumps water from the Gravity Pressure District into the Geddes High-Service District. The supply to the district is supplemented by water flowing through a remotely controlled valve that connects Geddes High-Service District to Northeast High-Service District.

1.6.5 Southeast High-Service District

The Southeast High-Service District is south of Washtenaw/Stadium and east of State Street. The main source of supply to this district is a storage tank within the district. There is a pump station associated with the storage tank that pumps water into the district from the storage tank. The water in the storage tank is replenished by water from the Gravity Pressure District under gravity pressure. The supplementary source of supply is a remote valve that connects this district to the West High-Service district. The water pressure in the Southeast High-Service District is regulated by the height of the water in the 0.5-million-gallon elevated tank within this district. As water is used in the district, the water level in the elevated tank drops. When a trigger level is reached, a pump is turned on at the pump station. and the elevated tank is refilled.

1.6.6 Condition of Facilities

A condition assessment of water supply and treatment facilities was conducted during the 2006 Water Treatment and Water Resources Master Plan to document current facility condition and make recommendations for future improvements. The condition assessment included review of existing maintenance and design information, onsite observation of facilities, diagnostic testing (vibration, oil analyses, electrical testing, thermography) of selected equipment, and documentation in data sheets.

Approximately 800 pieces of equipment or building components were evaluated during the condition assessment.

The City recently completed their Water Asset Management Program which looks to update the condition assessments. In accordance with the program, the water plant plans to perform condition assessments on all critical assets over the next two years, and complete condition assessments of less critical assets over the next 10 years.

Potential future water plant improvement projects include:

- Dredging lime residuals lagoon
- Replacing Huron River intake
- Replacing filter underdrains
- Replacing the Plant 1 softening basins

With completion of the facility and equipment condition assessments and Water Asset Management Program the Ann Arbor Water Utility is well-positioned to upgrade its overall maintenance management program.

The water supply and treatment facilities are aging but generally well maintained. Some assets have served beyond normal expected life but functioning adequately because of maintenance and repair programs. The asset database developed from the condition assessment was used to identify capital improvement projects and can be used to identify future improvements.

1.7 Exploratory Well Investigations/Well Site Selection/Test Well Drilling Procedures

This project does not include any new wells. This section is not applicable to this project.

2. Analysis of Alternatives

2.1 No-Action Alternative

A no-action alternative would require Ann Arbor to comply with the LT2 regulations with existing facilities. As explained in the LT2 study (CH2M 2017), the existing Ann Arbor water treatment plant could meet LT2 regulations during certain times of the year but would have difficulty meeting regulations when a softening basin is out of service for maintenance, if filtered water turbidity increased, or ozone was used for *Cryptosporidium* disinfection credit during colder water temperatures. Meeting LT2 regulations will be much more difficult during a future Plant 1 improvement project when facilities will be out of service for construction.

Not meeting the LT2 regulations would result in a violation of a primary drinking-water standard, along with public notice and likely issuance of an Administrative Consent Order by MDEQ.

2.2 Optimum Performance of Existing Facilities

Optimal performance of existing facilities was analyzed during the LT2 study (CH2M 2017) to determine if existing facilities could be used to meet LT2 regulations. A summary of that analysis follows. Appendix B contains details of the analysis.

The LT2ESWTR "Microbial Toolbox" provides a roadmap of available alternatives for obtaining additional removal/inactivation credit for *Cryptosporidium*.

The Microbial Toolbox alternatives were screened for applicability to the City of Ann Arbor, and the results are listed in Table 1. Alternatives carried forward for further analysis are presented in RED.

Table 1. LT2ESWTR Microbial Toolbox Screening of Alternatives

Toolbox Option	*Cryptosporidium* Treatment Credit with Design and Implementation Criteria	Comments
Source Water Components Toolbox Components		
Watershed Control Program	0.5-log credit for state-approved program comprising required elements, annual program status report to the state, and regular watershed survey. Unfiltered systems are not eligible for credit. See 40 *Code of Federal Regulations* (CFR) 141.716 (a) and Chapter 2 for specific criteria.	Ann Arbor has a surface water intake protection plan and strives to promote good watershed practices. Ann Arbor has a Greenbelt program that can improve source water quality. The Huron River watershed is extensive with multipurpose use that is not under the control of the City of Ann Arbor. Implementing watershed control under multi-jurisdictional conditions can be difficult.
Alternative Source/ Intake Management	No presumptive credit. Systems may conduct simultaneous monitoring for treatment bin classification at alternative intake locations or under alternative intake management strategies. See 40 CFR 141.716(b) and Chapter 3 for specific criteria.	Alternative water sources have been evaluated by Ann Arbor in Master Plans and studies. There are no practical water sources to replace the Huron River. Moving the intake location is possible, but extensive study would be needed, and the *Cryptosporidium* sources could be anywhere in the large watershed. Water depth at the intake is only about 25 to 30 feet, so an alternative intake depth is not likely to significantly reduce *Cryptosporidium*. For these reasons, an alternative water source or intake management is not recommended for further evaluation.

Table 1. LT2ESWTR Microbial Toolbox Screening of Alternatives

Toolbox Option	*Cryptosporidium* Treatment Credit with Design and Implementation Criteria	Comments
Pre-Filtration Components		
Presedimentation Basin with Coagulation	0.5-log credit during any month that presedimentation basins achieve a monthly mean reduction of 0.5-log or greater in turbidity or alternative state-approved performance criteria. To be eligible, basins must be operated continuously with coagulant addition and all plant flow must pass through the basin. See 40 CFR 141.717(a) and Chapter 5 for specific criteria.	Ann Arbor does not have a presedimentation basin with coagulant addition. It would require a large amount of land and facilities to operate and maintain. There is inadequate land, and costs would be high. The water quality benefit of this technology is less than other treatment technologies considered in this Toolbox. Therefore, this alternative is not recommended for further evaluation.
Two-Stage Lime Softening	0.5-log credit for two-stage softening where chemical additional and hardness precipitation occur in both stages. All plant flow must pass through both stages. Single-stage softening is credited as equivalent to conventional treatment. See 40 CFR 141.717(b) and Chapter 6 for specific criteria.	Ann Arbor currently has two lime-softening basins in series. Therefore, this alternative is recommended for further evaluation.
Bank Filtration	0.5-log credit for 25-foot setback; 1.0-log credit for 50-foot setback; aquifer must be unconsolidated sand containing at least 10 percent fines; average turbidity in wells must be less than 1 nephelometric turbidity unit (NTU). Systems using wells followed by filtration when conducting source water monitoring must sample the well to determine bin classification and are not eligible for additional credit. See 40 CFR 141.717(c) and Chapter 4 of the LT2ESWTR Guidance manual for specific criteria.	Bank filtration was evaluated in the Source Water Master Plan for Ann Arbor. Bank filtration was deemed impractical given the local hydrogeology. Therefore, this alternative is not recommended for further evaluation.
Treatment Performance Toolbox Components		
Combined Filter Performance	0.5-log credit for combined filter effluent (CFE) turbidity less than or equal to 0.15 NTU in at least 95 percent of measurements each month. See 40 CFR 141.718 (a) and Chapter 7 for specific criteria.	Ann Arbor combined filters can achieve less than 0.15 NTU. Therefore, this alternative is recommended for further evaluation.
Individual Filter Performance	0.5-log credit (in addition to 0.5-log combined filter performance credit) if individual filter effluent (IFE) turbidity is less than or equal to 0.15 NTU in at least 95 percent of samples each month in each filter and is never greater than 0.3 NTU in two consecutive measurements in any filter. See 141.718 (b) and Chapter 7 of the T2ESWTR Guidance manual for specific criteria.	Ann Arbor individual filters can achieve less than 0.15 NTU. Therefore, this alternative is recommended for further evaluation.
Demonstration of Performance	Credit awarded to unit process or treatment train based on a demonstration to the state with a state-approved protocol. See 40 CFR 141.718 (c) and Chapter 12 for specific criteria.	This would involve full-scale tests to prove that the existing water plant processes can achieve more *Cryptosporidium* credit than granted in the regulations. Aerobic spores or fluorescent microspheres could be used as surrogates to *Cryptosporidium*, if approved by MDEQ. There is no guarantee that the tests would indicate better performance, and *Cryptosporidium* protection would not change from existing processes. Therefore, this alternative is not recommended for further evaluation.

Table 1. LT2ESWTR Microbial Toolbox Screening of Alternatives

Toolbox Option	*Cryptosporidium* Treatment Credit with Design and Implementation Criteria	Comments
Additional Filtration Toolbox Options		
Bag or Cartridge Filters (Individual Filters)	Up to 2-log credit based on the removal efficiency demonstrated during challenge testing with a 1.0-log factor of safety. See 40 CFR 141.719(a) and Chapter 8 for specific criteria.	This technology is not practical or applicable to a large lime-softening plant and will not be considered further.
Bag or Cartridge Filters (In Series)	Up to 2.5-log credit based on the removal efficiency demonstrated during challenge testing with a 0.5-log factor of safety. See 40 CFR 141.719(a) and Chapter 8 for specific criteria.	This technology is not practical or applicable to a large lime-softening plant and will not be considered further.
Membrane Filtration	Log credit equivalent to removal efficiency demonstrated in challenge test for device if supported by direct integrity testing. See 40 CFR 141.719(b) and Chapter 14 for specific criteria.	This technology is much more expensive than other technologies that can achieve equal or better *Cryptosporidium* protection and will not be considered further.
Second Stage Filtration	0.5-log credit for second separate granular media filtration stage if treatment train includes coagulation prior to first filter. See 40 CFR 141.719 (c) and Chapter 9 for specific criteria.	This technology is much more expensive than other technologies that can achieve equal or better *Cryptosporidium* protection and will not be considered further.
Slow Sand Filters	2.5-log credit as a secondary filtration step; 3.0-log credit as a primary filtration process. No prior chlorination for either option. See 40 CFR 141.719(d) and Chapter 9 for specific criteria.	This technology is not practical or applicable to a large lime-softening plant. It also requires large amounts of land. Therefore, this alternative is not recommended for further evaluation.
Inactivation Toolbox Components		
Chlorine Dioxide	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(b) and Chapter 10 for specific criteria.	This technology is not common for *Cryptosporidium* inactivation. The chlorine dioxide dose required for *Cryptosporidium* would likely exceed regulated disinfection by-products of chlorine dioxide. There are other disinfectants that are more effective and do not have the by-product concerns. Therefore, this alternative is not recommended for further evaluation.
Ozone	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(b) and Chapter 11 for specific criteria.	Ann Arbor currently has ozone. Ozone can inactivate *Cryptosporidium*. Therefore, this alternative is recommended for further evaluation.
UV	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(d) and Chapter 13 for specific criteria.	UV is effective for *Cryptosporidium* and is a common technology for pathogen control. UV has no disinfection by-products that are regulated. Therefore, this alternative is recommended for further evaluation.

Source: 40 CFR 141.715

2.2.1 Short-Listed Alternatives

Screening identified the following alternatives for further evaluation:

1. Watershed Control Program
2. Two-stage Lime Softening
3. Combined Filter Performance
4. Individual Filter Performance
5. Ozone
6. UV

Based on Ann Arbor's current tools in the Microbial Toolbox to provide additional *Cryptosporidium* inactivation, combined filter effluent (CFE) turbidity appears to be the most reliable. However, CFE turbidity alone does not provide enough *Cryptosporidium* inactivation to meet the Bin 2 requirements. Two-stage softening is not available at all times due to maintenance and could possibly be eliminated in the future. Individual filter effluent (IFE) turbidity requirements cannot be met most of the time, and ozone does not provide enough *Cryptosporidium* inactivation most of the time. Relying on two-stage softening and CFE to meet the *Cryptosporidium* inactivation requirements provides no safety factor for compliance and limits the WTP's operational flexibility. While two-stage softening and CFE can help Ann Arbor comply in the short term, it is not a recommended long-term solution.

Ann Arbor is involved in voluntary watershed control programs to improve the watershed and control contamination. However, Ann Arbor cannot rely on watershed control practices to achieve regulatory *Cryptosporidium* credit due to lack of control and jurisdiction over watershed practices. For these reasons, watershed control was not recommended as a reliable means to meet the drinking water new regulations.

It was recommended to look further into UV disinfection as the long-term method of providing additional *Cryptosporidium* credit and multiple barriers to public health protection.

2.2.2 UV Disinfection

UV disinfection can easily provide 3-log *Cryptosporidium* inactivation. By achieving 3-log *Cryptosporidium* inactivation, 3-log Giardia inactivation is also achieved. UV can reduce the dependence on ozone for primary disinfection of Giardia and *Cryptosporidium.* UV and ozone work well together because ozone breaks down organic matter to improve ultraviolet light transmittance (UVT), which reduces the UV energy required to disinfect water.

UV would eliminate the need to obtain additional *Cryptosporidium* inactivation credit from CFE turbidity, ozone or two-stage softening. UV disinfection would greatly simplify operations and provide another robust disinfection barrier for public health protection. In addition, future *Cryptosporidium* monitoring could cease. Since UV disinfection is effective for many bacteria, protozoan, and viruses, it positions Ann Arbor for future regulations on pathogens. The U.S. Environmental Protection Agency's (EPA's) Contaminant Candidate List 4 contains 12 microbial pathogens that are being considered for future regulations.

A UV system would be a new process for the Ann Arbor water plant. As plant improvements are planned in the future, UV will be considered and the best way to integrate UV into the treatment processes evaluated.

Alternatives to implement UV disinfection into Ann Arbor's WTP are described under Principal Alternatives.

2.3 Regional Alternatives

A regional alternative for water supply was evaluated in the WTP Alternatives Evaluation report (Black and Veatch 2015). The only water utility with capacity to serve Ann Arbor is the Great Lakes Water Authority. Two alternatives to obtain water supply from the Great Lakes Water Authority were evaluated using monetary and non-monetary criteria. These two regional alternatives were compared to upgrading the current water system and enhancing the groundwater supply.

Capital and life-cycle costs were considered, as well as non-economic factors such as capacity, reliability, operational flexibility, staffing, and existing facility use. This evaluation concluded that upgrading the current water system was the most cost-effective alternative. This alternative also had benefits for system operations, staffing, existing utilities use, and alignment with Ann Arbor's sustainability goals.

3. Principal Alternatives

The following alternative locations and configurations for the UV disinfection system were initially considered:

1. Filter effluent piping
2. Transfer pump discharge piping from Pumps 4-6
3. Containerized UV systems near the finished water reservoir

The following subsections briefly describe the viability of each of these alternatives. Due to technical limitations, Alterative 1 was eliminated from further detailed consideration. For Alternatives 2 and 3, a detailed comparison of the monetary, environmental, and technical considerations is provided in the subsequent sections.

3.1 Summary of Principle Alternatives

3.1.1 Alternative 1: Filter Effluent Piping

In some water plants, it is possible to place UV reactors on the filter effluent discharge piping. At the Ann Arbor WTP, this is not possible for Filters 1–10 due to the piping configuration and lack of space or access.

In Filters 11–26, there are exposed filter effluent pipe headers that could possibly be locations for UV reactors. A minimum of three UV reactors would be needed (2 for Filters 11–20 and one for Filters 21–26). However, even a three UV-reactors configuration does not include a backup UV reactor.

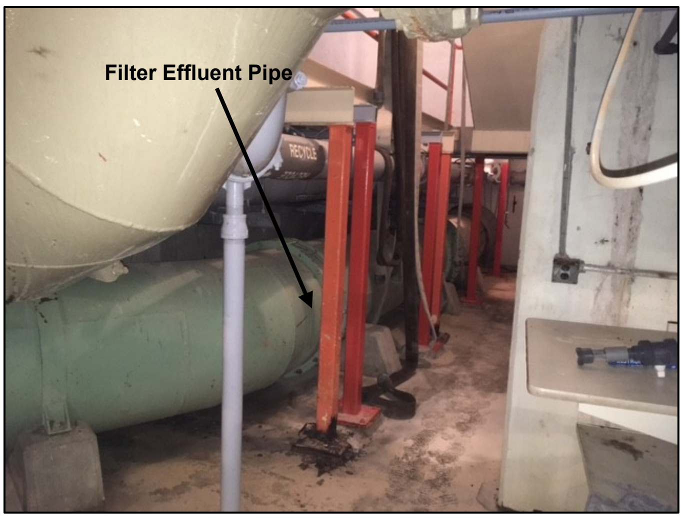


Figure 4. Filter 21–26 Effluent Pipe

Placing UV reactors on the filter effluent pipe headers poses several complications, including the following:

- Filters 1–10 could not be operational when UV was operational. This creates a significant plant capacity reduction and operational difficulties when shutting off and turning on 10 filters.
- Loss of a UV reactor in Filters 11–20 can mean loss of up to 20 out of 26 filters, assuming Filters 1-10 cannot be used for compliance. This creates more plant capacity reduction and operational difficulty.
- Access to the UV reactors is poor, especially in the Filter 21–26 pipe header (see Figure 4). This can cause operational and maintenance difficulty.
- Head loss in the filter effluent piping can shorten filter runs or decrease volume in the clearwells.

Due to these technical limitations, Alternative 1 was eliminated from further consideration.

3.1.2 Alternative 2: Transfer Pump Discharge Piping

The Ann Arbor WTP has six transfer pumps that convey water from the filter effluent clearwells to the finished water reservoir. Transfer Pumps 1–3 pump from Clearwell 1, and Transfer Pumps 4–6 pump from Clearwell 2. There is inadequate space on the discharge of Transfer Pumps 1–3, so this location was not evaluated further. Transfer Pumps 4–6 discharge in a lower room that used to contain high-service pumps. The high-service pumps have been removed, leaving available space. Figure 5 shows the Transfer Pump Room 4-6. The blue pipe in the background is the existing transfer pump discharge header.

Figure 5. Transfer Pump 4–6 Room

Figure 6 contains a conceptual layout for two UV reactors on the discharge of Transfer Pumps 4–6. One UV reactor can treat up to 25 million gallons per day (mgd), and the other reactor is a backup. The UV power supply panels are also shown installed within the same room on an elevated platform.

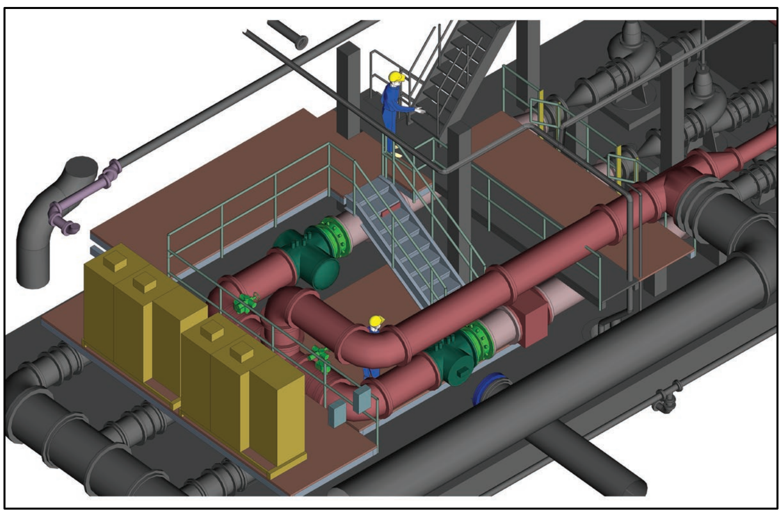
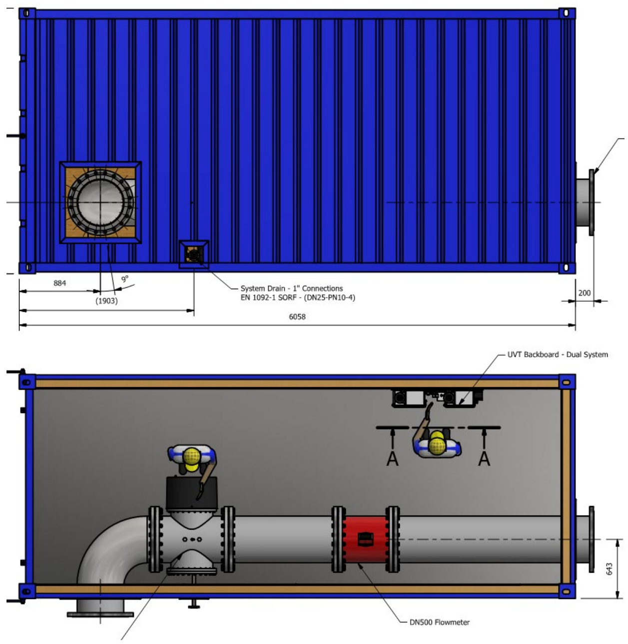


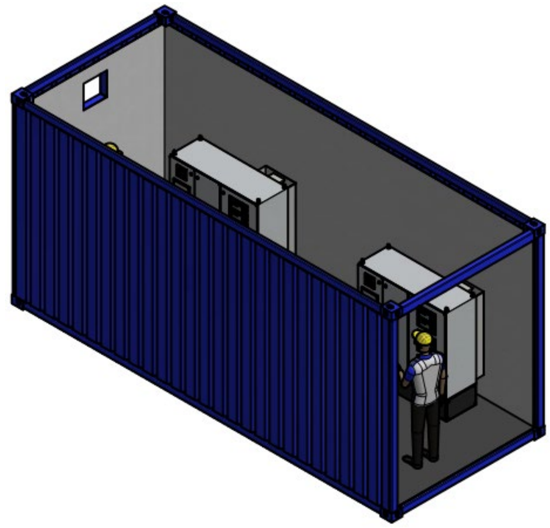
Figure 6. UV Concept in Transfer Pump Room

3.1.3 Alternative 3: Containerized UV Systems

UV reactors and power supply panels can also be packaged inside a weather-protected container, approximately 8 feet wide by 20 feet long each. Based on the size of UV reactors needed for Ann Arbor, three containers would be required, two for the UV reactors and UV transmittance analyzers and one for the power-supply panels. Figure 7 shows a conceptual arrangement for these containers.



UV Reactor Container



UV Power Supply Panel Container

Figure 7. UV System Inside Weatherized Containers

Given the existing yard piping arrangement and lack of available space on the Ann Arbor WTP site, locating the UV containers on the east side of the finished water reservoir was selected (Figure 8). Existing yard piping (transfer pump discharge piping) requires tie-ins and valves to direct water to the UV containers and then back into the reservoir.

Figure 8. UV Containers Near Finished Water Reservoir

3.2 Monetary Evaluation

Budgetary level (+50/-30 percent) capital, annual operating, and life-cycle costs were developed for each alternative for comparative purposes. Capital costs include:

- Estimated construction costs for UV equipment, structural modifications, site work (if applicable), piping and valves, instrumentation and controls, and electrical improvements
- Contractor overhead and profit, mobilization, bonds, insurance costs, and contingency
- Engineering costs for design, services during construction, and commissioning support

- Capital costs based on US dollars, November 2018
- Escalation to mid-point of construction is included
- Salvage value is not included in the estimates since the expected equipment life is 20 years

Annual operating and maintenance (O&M) costs include:

- Energy costs associated with additional pumping energy and UV lamps
- Routine replacement of UV system consumables (i.e., UV lamps, sleeves, sensors)
- Labor for UV equipment O&M
- UV equipment operation based on 18-mgd average flow rate, UVT of 88 percent, 3-log *Cryptosporidium* inactivation target, 24/7 operation, 365 days per year

Net present-value calculations were based on:

- 20-year equipment life
- 3 percent real discount rate per 2018 Office of Management and Budget recommendations

Alternative	1: Filter Effluent Piping	2: Transfer Pump Station	3: Outdoor Containers
Capital Cost	n/a	$2,436,400	$4,011,071
Annual Operating Costs	n/a	$72,739	$72,739
Net Present Value	n/a	$3,518,029	$5,092,700
Notes	This alternative is not technically feasible; therefore, costs were not developed.	This alternative was selected for design. Cost estimates have been revised to reflect actual construction costs.	O&M costs are the same between Alternatives 2 and 3 since the same number of UV reactors are installed, and headloss across the system is similar.

3.3 Environmental Evaluation

All three alternatives reside within the City of Ann Arbor WTP site; two of which would be restricted to within an existing facility. Therefore, the alternatives will not have direct impacts on historical/archaeological/tribal resources, wetlands, rivers/streams, agricultural land, or endangered species. For Alternative 3, the containerized UV system, there would be some yard piping and general site/civil work required; therefore, appropriate stormwater-control measures would be required.

For all alternatives, the UV disinfection system will enhance the potable water treatment process by providing up to an additional 3-log (99.9 percent) removal of *Cryptosporidium* parvum oocysts and *Giardia lambia* cysts.

All UV systems use UV lamps containing elemental mercury. Appropriate training and emergency operating procedures are required to minimize the risk of an accidental lamp break and clean up the release if a lamp break occurs. For Alternative 2, existing piping is coated with lead-based paint and pipe joint gaskets contain asbestos, which require following proper abatement work to remove safely and per regulations.

Alternative	Land/Site Impacts	Water Quality	Environmental
2: Transfer Pump Station	None.	Adds pathogen disinfection barrier.	Lamps contain mercury; risk for accidental breakage and release. Pump room pipe coated with lead paint and uses asbestos gaskets, which require abatement.
3: Outdoor Containers	Disruption of soils to install new piping and containers onsite at WTP.	Adds pathogen disinfection barrier.	Lamps contain mercury; risk for accidental breakage and release.

3.4 Mitigation

The following table summarizes the mitigation strategies required to mitigate anticipated risks.

Alternative	Land/Site Impacts	Water Quality	Environmental
2: Transfer Pump Station	None.	Develop and implement proper lamp-handling training and emergency cleanup procedures.	Implement proper lead-based paint and asbestos abatement program.
3: Outdoor Containers	Implement proper stormwater erosion control plan.	Develop and implement proper lamp-handling training and emergency cleanup procedures.	None.

3.5 Implementability and Public Participation

The three alternatives are similar with respect to implementability and public participation. All three alternatives would provide enhanced pathogen disinfection, and disruptions would be limited to the WTP site.

3.6 Technical Considerations

All alternatives would comply with Act 399 and would be designed to meet the standard recommended guidelines established in the “Recommended Standards for Waterworks” as published by the Great Lakes and Upper Mississippi Board of State Sanitary Engineers, as well as the MDEQ regulations and EPA’s *Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule* (UVDGM; EPA 2006) for UV disinfection systems.

The UV disinfection system would serve as a standby, backup process to the existing WTP with a capacity of 25 mgd, which is sufficient to meet average-day and peak-day demands. It would tie into the existing electrical grid at the WTP and be connected to the standby emergency generator at the WTP. The UV system would be designed to include a standby UV train (N+1), allowing it to operate if the primary UV train fails.

Alternatives 2 and 3 were evaluated based on the following technical criteria:

- Performance for UV disinfection
- Ease of operations and maintenance
- Reliability
- Constructability
- Cost

Table 2 summarizes the evaluation. Each alternative was scored on a scale of 1 to 10 for each criterion, with 10 being the highest score.

Table 2. UV Alternative Evaluation Summary

Criterion	Transfer Pump 4–6 Room (Alternative 2)	Containers Near Reservoir (Alternative 3)	Comments
Performance for UV Disinfection	10	10	Both UV systems can meet the criterion for disinfection. Both systems have one duty and one backup reactor.
Ease of Operations and Maintenance	10	7	The Transfer Pump Room is easier to access by plant staff since it is within the existing plant and near other facilities. The container system is hundreds of feet away from the main plant and more difficult to access, especially in winter. Space and climate for working are more adverse in the container system.
Reliability	7	8	The closer Transfer Pump Room location makes it more reliable if issues arise. There is potential for the container system to treat water from either transfer pump station if yard piping and valves are arranged to do so.
Constructability	10	6	The container system requires excavation, retaining walls, and outdoor yard piping work. Electrical facilities will need to travel long distances underground. Delivery of the container system takes several months longer. The Transfer Pump Room is all inside the existing building making construction easier. No earthwork or yard piping work is required. UV panels need to be installed in sections.
Cost	10	6	The container UV system is about 60 percent more expensive on a capital-cost basis. This is mainly due to the additional cost of containers, earthwork, retaining walls, and yard piping. The container system will cost slightly more to operate since heat is needed in the winter.
TOTALS	**47**	**37**	

Based on this evaluation, placing the UV disinfection system in the Transfer Pump Room (Alternative 2) was selected as most beneficial for the City of Ann Arbor.

3.7 Residuals

There are no water treatment residuals generated by any of the three alternatives. UV lamps require periodic replacement, and proper disposal was discussed previously.

3.8 Contamination

There are no soil contamination issues associated with any of the three alternatives.

3.9 New/Increased Water Withdrawals

There are no new or increased water withdrawals as part of this project.

4. Selected Alternative

As discussed in Section 3, UV disinfection can easily provide 3-log *Cryptosporidium* inactivation. By achieving 3-log *Cryptosporidium* inactivation, 3-log *Giardia* inactivation is also achieved. UV can reduce the dependence on ozone for primary disinfection of *Giardia* and *Cryptosporidium.* UV and ozone work well together because ozone improves UVT, which reduces the UV energy required to disinfect water. UV would eliminate the need to obtain additional *Cryptosporidium* inactivation credit from CFE turbidity, ozone, or two-stage softening. UV disinfection would greatly simplify operations and provide another robust disinfection barrier for public health protection. In addition, future *Cryptosporidium* monitoring could cease. Since UV disinfection is effective for many bacteria, protozoan, and viruses, it positions Ann Arbor for future regulations on pathogens. EPA's Contaminant Candidate List 4 contains 12 microbial pathogens that are being considered for future regulations.

UV disinfection will be a new process for the City of Ann Arbor WTP. Integration of this new treatment process into the existing WTP was critical. Based on the possible locations evaluated, retrofitting UV disinfection inside the existing Transfer Pump Station 4-6 was selected as the most viable and economical location. Figure 9 shows a schematic of the new UV disinfection system within the existing water treatment process.

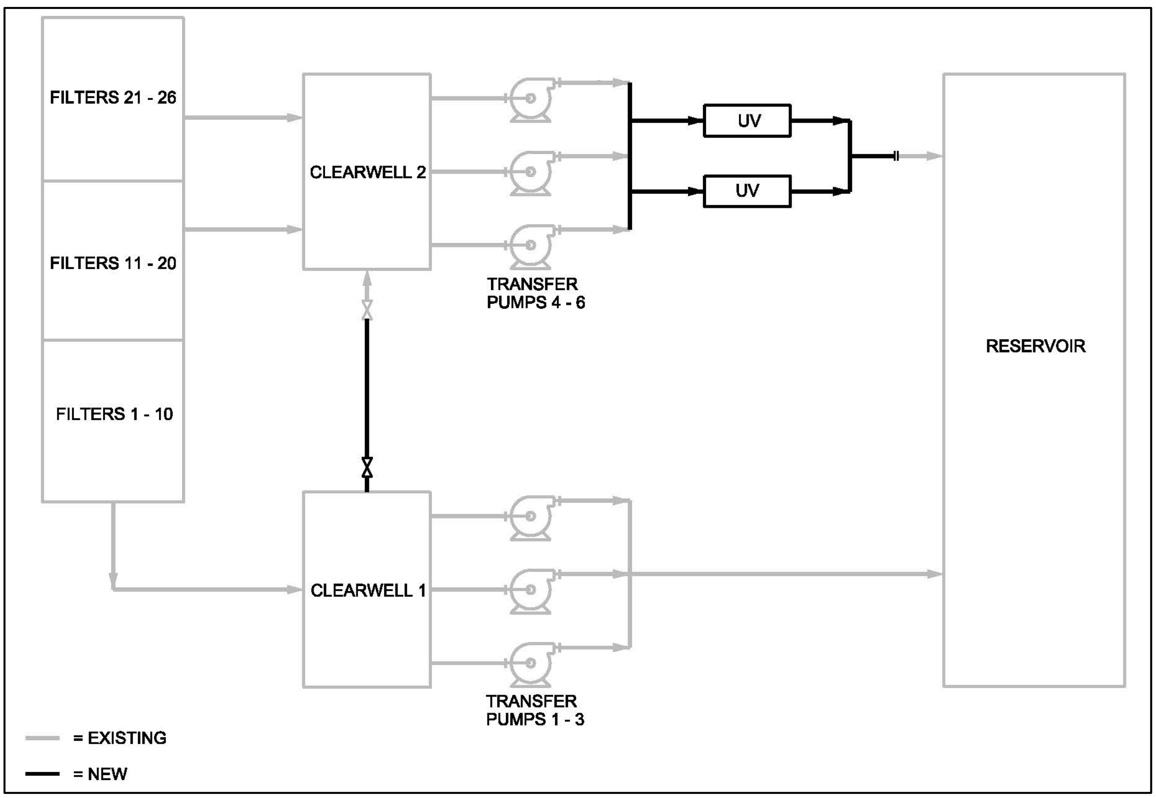


Figure 9. Flow Schematic from Filters to Reservoir

Detailed design for this alternative was completed in January 2019 and is currently advertised for tender. Contract Documents are included as part of the DWRF application. The following subsections further summarize the design details of the selected alternative.

4.1 Design Parameters

Currently, the Ann Arbor WTP can meet the LT2 regulations for *Cryptosporidium* through a combination of low combined filter effluent turbidity and two-stage softening. If either of these barriers is not in place, the LT2 regulations may not be met at all times. Low combined filter effluent turbidity is a very reliable barrier. Softening basins are typically taken out of service during low water-demand periods (November to April) for routine maintenance. It is during these times that UV would be required as an additional *Cryptosporidium* barrier because the two-stage softening process may not be available. For additional details on LT2 compliance, see the report *Long Term 2 Enhanced Surface Water Treatment Rule Study* (CH2M 2017).

4.1.1 Flow Rate

The Ann Arbor WTP has a capacity of 50 mgd, but maximum day flows rarely exceed 25 mgd (Figure 10). Because UV disinfection is likely to be needed during low-demand periods, it is unlikely that the water demand would exceed 25 mgd when UV disinfection is operational. Figure 10 shows that water demand from November to April during the past 3 years typically does not exceed 15 mgd. Therefore, the Transfer Pump 4-6 firm capacity of 17 to 24 mgd is adequate.

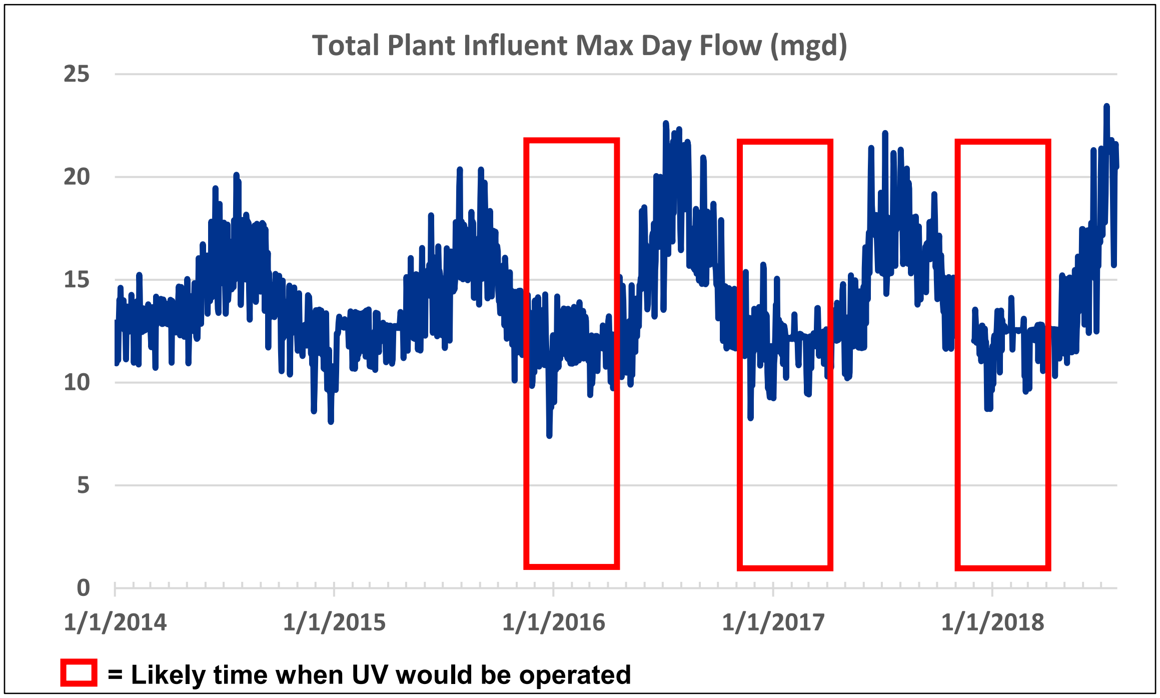


Figure 10. Water Plant Influent Maximum Day Flows (mgd)

4.1.2 UV Transmittance

UVT measures the ability of light at a wavelength of 254 nanometers to pass through water. A common measurement is percent transmittance. If water has a UVT of 90 percent, then 90 percent of the UV light passed through the water (measured in a 1 cm quartz cell) and the other 10 percent was absorbed by the water.

The design UVT of 88 percent was selected for Ann Arbor based on the 99th percentile value obtained from clearwell and reservoir samples. As shown in Figure 11, a minimum UVT of 86 percent was observed but occurred in May when flows are lower. Higher UVT values were observed in the summer during high-demand periods. Figure 11 shows historical UVT data. Ann Arbor will continue to collect UVT data, and the design value may be adjusted accordingly. Each UV reactor has been validated per the EPA UVDGM guidelines (EPA 2006).

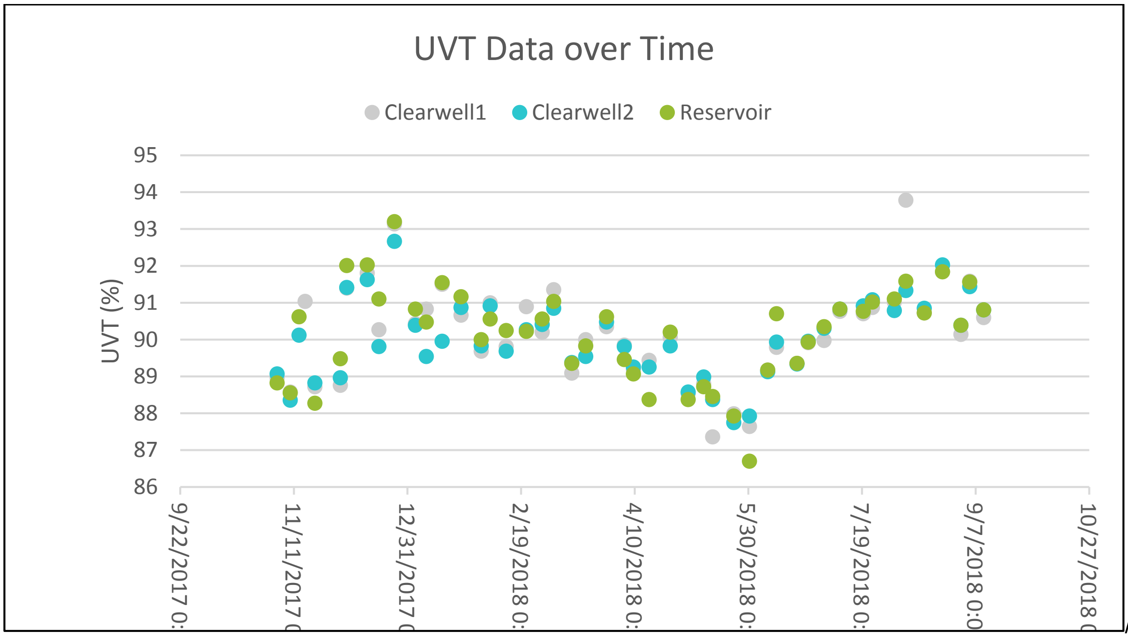


Figure 11. UVT in Clearwells and Reservoirs

4.1.3 UV System Design Criteria

Each UV reactor will be sized to treat 25 mgd of flow for a firm capacity of 25 mgd, so UV reactor capacity is not limiting. Table 3 summarizes the design criteria for the new UV disinfection system.

Table 3. UV Disinfection System Design Criteria

	Parameter	Design Value (for Capital Sizing)	Operational Value (for Operations and Maintenance Estimates)	Future Expansion (Full Plant)
1	Number of UV Reactors	1 duty, 1 standby	1 duty, 1 standby	2 duty, 1 standby
2	UV Disinfection System Flow rate	25 mgd	15 mgd	50 mgd
3	Target Organism	*Cryptosporidium* (*Giardia* optional)		*Cryptosporidium* (*Giardia* optional)
4	Target Log Inactivation	3.0 log	1.0 log	To Be Determined
5	Surrogate Validation Organism	MS2 RED (T1 RED Optional Control Method)		To Be Determined
6	Validation Protocol	2006 EPA UVDGM		2006 EPA UVDGM
7	Ultraviolet light transmittance	88%	90%	88%
8	Lamp Aging Factor	0.9	0.95	0.9
9	Sleeve Fouling Factor	0.9 with mechanical/acid auto wiping 0.8 with mechanical auto wiping only	0.9 with mechanical/acid auto wiping 0.85 with mechanical auto wiping only	To Be Determined
10	Action Spectra Correction Factor	Variable per Water Research Foundation 4376 Guidance		Variable per Water Research Foundation 4376 Guidance
11	UV Lamp Type	Medium-Pressure		Medium-Pressure
12	Flange Size	24-inch ANSI		24-inch ANSI
13	Number of Lamps/Sleeves per UV Reactor	8 (TrojanUV) 9 (CalgonUV)		8 (TrojanUV) 9 (CalgonUV)
14	Lamp Technology	Medium Pressure		Same
15	Lamp Ballast Type	Electronic (TrojanUV) or Electromagnetic (CalgonUV)		Same
	Total Connected Load	156-kilowatt (TrojanUV) 180-kilowatt (CalgonUV)		234-kilowatt (TrojanUV) 270-kilowatt (CalgonUV)

UVDGM = *Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule* (EPA 2006)

Only UV equipment suppliers with significant similar installation experience and who have been pre-validated per the UVDGM guidelines (EPA 2006) were considered. The two UV reactors selected include the TrojanUV SWIFT 8L24 and the Calgon Sentinel 9L24. The TrojanUV Swift reactor contains 8 MP lamps of 9.1 kilowatts (kW) each and would have a total connected power load of 156 kW. The Calgon Sentinel reactor contains 9-MP lamps of 10 kW each and would have a total connected load of 180 kW.

In either case, a minimum of five straight pipe diameters, in addition to the number of straight pipe diameters provided during validation, will be provided upstream of the UV reactor to ensure that good hydraulics entering the UV reactor are achieved. This approach is consistent with Section 3.6.2 of the Final EPA UVDGM (2006).

Each UV reactor will be equipped with an automatic mechanical or chemical cleaning system to reduce the fouling due to iron, manganese, or hardness. Ann Arbor also adds a polyphosphate to the filter influent water (upstream of UV), which can reduce the potential for calcium carbonate scaling. Both UV systems being considered have automated wiping systems to remove scale buildup and can be programmed as frequently as once per hour. The TrojanUV system includes an acid cleaning system that would be beneficial for removal of carbonate scales compared to mechanical wiping only. Occasional manual cleaning of the UV lamp sleeves and UV intensity sensor ports may be necessary. Due to the scaling potential of the water, sleeve-fouling factors will be applied to the design criteria to account for the potential loss of UV intensity due to scale formation.

Each UV reactor will also be equipped with an air-vacuum release valve and drain valve, to allow for easy draining of the UV train for maintenance purposes. Air-release valves will also be installed on the UV effluent header to remove air from the piping high point.

4.1.4 Finished Water Clearwell Interconnect Pipe

Clearwells 1 and 2 are connected by a single pipe with a single valve (Figure 12). As part of this project, most of that pipe will be replaced due to age and corrosion. A second valve will be added to the clearwell interconnect pipe to accommodate construction and provide more reliability. One of the valves will be electrically actuated so that it can be easily opened when UV disinfection is needed. There will be an electrical interlock to open the valve connecting Clearwells 1 and 2 when UV disinfection is operational. This interlock will also shut down Transfer Pumps 1–3, so that all plant flow passes through UV treatment.

From Clearwell 1

To Clearwell 2

Figure 12. Clearwell Interconnect Pipe

4.1.5 Instrumentation and Controls

Each individual UV system/reactor will have a dedicated local control panel with an Allen Bradley CompactLogix programmable logic controller (PLC). The main responsibility of this PLC is to control the UV disinfection process and alert of any fault conditions. A Human Machine Interface with custom screens will be included with each local control panel and will allow for manual operation of the disinfection process, if necessary. Should the power supplies be in a separate location from the reactors, a remote Human Machine Interface mounted on a pedestal located near the reactor would be provided for local operator control and monitoring.

It is proposed to provide a Master UV Control Panel to handle all signals external to the reactor, such as valve actuators. The master control panel would be centrally located between the local control panels. The master control panel would also contain the same type of Allen Bradley CompactLogix PLC and would communicate via Ethernet communications to the individual local control panels, as well as upstream to the supervisory control and data acquisition (SCADA) system. If the length of the communication conduit to SCADA is more than 300 feet, fiber-to-copper converters would be installed, and fiber would be used for the Ethernet communications. Select hardwired signals would be incorporated, such as interlocks for the transfer pumps and clearwell valve, as required.

Additional network hardware, such as Ethernet switches or fiber-to-copper converters, required to interface the complete system to SCADA will be evaluated and included, as necessary.

4.1.6 Flow Measurement

An electromagnetic flowmeter on each UV reactor line will be installed to provide the necessary flow signal back to the UV system PLC for continuous UV dose measurement.

4.1.7 UVT Measurement

Two UVT analyzers will be installed inside the transfer pump station to continuously monitor the UVT of the water and provide the necessary UVT signal back to the UV system PLC for continuous UV dose measurement.

4.1.8 Off-Specification Water

Obtaining inactivation credit for the UV disinfection system to meet LT2 requires that at least 95 percent of the water treated by UV is within validated limits [40 *Code of Federal Regulation* 141.720(d)(3)]. This allows for up to 5 percent of the water volume treated with UV disinfection per month to be off-specification, or about 72 minutes of off-specification operation in a single day. Off-specification water is any volume of water that does not receive the target UV dose, flow exceeds validated limit, UVT is below validated limit, or the UV system is not operated in a manner that was simulated in validation testing. Off-specification water can be produced during routine system startup or in the event of UV system failure, UV equipment critical alarm, or plant electrical power failure. The interim UV disinfection system is designed to minimize off-specification water from entering the finished water reservoirs through several mechanisms, including having the UV system tied to the water treatment plant backup-power generator, an uninterruptable power supply for each UV control panel PLC, a standby UV reactor, and automated valves. The UV control system will automatically track off-specification events, totalize the off-specification volume in 1-minute increments, and calculate the monthly total volume treated by UV disinfection to be included in monthly reports to MDEQ.

4.1.9 Chloramination

Filtered water is disinfected with chlorine and ammonia to form chloramines. The chlorine and ammonia are added before Clearwells 1 and 2 through separate chemical lines to each clearwell influent. Chloramines, free chlorine, and free ammonia are measured at the effluent of Clearwell 1 on the Transfer Pumps 1–3 discharge pipe and at the effluent of Clearwell 2 on the Transfer Pumps 4–6 discharge pipe.

When UV is in operation, Transfer Pumps 1–3 will not be operational. Water will flow from Clearwell 1 into Clearwell 2 through an interconnecting pipe. This interconnecting pipe will be replaced with a new interconnecting pipe during construction of the interim UV facility. All the plant water will be pumped to the reservoir through Transfer Pumps 4–6.

A new sample location and analyzer will be added on the new pipe connecting Clearwells 1 and 2. This location will be used to control chloramination in Clearwell 1 during UV disinfection. The sample location on the discharge of Transfer Pumps 4–6 will also be equipped with a new analyzer. This location will indicate chloramination conditions on the blend of water from Clearwells 1 and 2 and can be used to control chloramination in Clearwell 2.

4.2 Hydrogeological Analysis

A hydrogeological analysis does not apply to this project.

4.3 Finalization of Well Design

Final well design details do not apply to this project.

4.4 Maps

All work activities will occur within the City of Ann Arbor WTP site at 919 Sunset Drive, Ann Arbor, Michigan. A map key plan is provided in the Contract Documents.

4.5 Schedule for Design and Construction

The anticipated schedule for the project is:

Final Design Completion	January 2019
Bidding	February 2019
DWRF Loan Application	March 2019
DWRF Loan & City Contracts Reviews	March 2019 through June 2019
Contractor Notice to Proceed	July 2019
Shop drawing submittal and approval complete	September 2019
Equipment manufacture and delivery	October 2019 through January 2020
Construction Complete	April 2020
Startup and Testing	May through June 2020

4.6 Cost Estimate

An estimated construction cost for the interim UV system in the Transfer Pump Room is $2,436,400 based on the Contract Documents. This cost estimate includes the cost of replacing the clearwell interconnect pipe and adding a valve, abatement of lead-based paint and asbestos pipe gaskets, new water quality instrumentation, and new UV disinfection system and associated controls. Cost details are in Appendix G. Bids for the project will be received at the end of February 2019, which will provide actual construction costs. Total costs incurred for engineering design, DWRF loan application, and services during construction are anticipated to be $345,000, which would be in addition to the construction cost, resulting in a total capital cost of $2,781,400.

The estimated annual O&M cost, including labor, is $72,739 per year. The net present value is $3,863,029.

Update: Bids were received on February 28, 2019. One bid was received in the amount of $2,582,770.

4.7 User Costs

The estimated cost for debt service for this project is estimated at $183,470 annually, for a total project cost of approximately $3,000,000. The annual payments require an annual revenue requirement increase of 0.825 percent per year. At current rates, the average residential customer using 18 hundred cubic feet per quarter, would see a bill increase of 74 cents per quarter or $2.97 per year for debt service retirement of this project. With the debt service expected to be 20 years, this means the average residential customer would pay an additional $59.40 for the duration of this debt repayment period. Current rates are detailed below.

	Residential 1 Rate is based on a single water meter used in a home/duplex	**Residential 2** Rate when a second Water-Only meter is also used in a home	**Water Only**** Rate for the second meter for non-sewer water uses, such as for irrigation	**Non Residential Rate** (Locations may also have a second, Water Only** meter)	**Multi Family Rate** Locations with 3 or more units
1-9 CCFs*	$1.77 per CCF	$1.77 per CCF	$8.73 per CCF	$3.83 per CCF	$2.13 per CCF
10-18 CCFs*	$2.83 per CCF	$2.83 per CCF	$8.73 per CCF	$3.83 per CCF	$2.13 per CCF
19-36 CCFs*	$6.57per CCF	$2.83 per CCF	$8.73 per CCF	$3.83 per CCF	$2.13 per CCF
Over 36 CCFs*	$14.08 per CCF	$2.83 per CCF	$8.73 per CCF	$3.83 per CCF	$2.13 per CCF
Water Customer Charge	$20.89/quarter for 5/8 inch and 3/4 short standard residential meter; charge varies by meter size	$20.89/quarter for 5/8 inch and 3/4 short standard residential meter; charge varies by meter size	$20.89/quarter for 5/8 inch and 3/4 short standard residential meter; charge varies by meter size	Customer charge varies by size of water meter	Customer charge varies by size of water meter

CCF= hundred cubic feet

Because this is a system-wide impact of the water treatment process, not specific to any customer class nor area, the revenue requirement costs would be borne equally among all customer classifications in the volumetric charges. There are 33,897 Equivalent Residential Units in the system, which are multipliers of the volume flow through a 5/8 meter. The townships of Scio and Ann Arbor also are in long-term contracts whereby they pay revenue requirements, which would also increase for them at a rate of 0.825 percent to accommodate the debt service for this project.

4.8 Disadvantaged Community

The City of Ann Arbor is not applying for the DWRF as a disadvantaged community.

4.9 Ability to Implement the Selected Alternative

The City of Ann Arbor has the capability of designing, overseeing the construction, and placing into service the proposed UV disinfection system improvements proposed in this Project Plan to serve the residents of the City of Ann Arbor.

5. Environmental Evaluation

The scope of this project will be confined to within the existing City of Ann Arbor WTP facilities at 919 Sunset Road, Ann Arbor, Michigan 48103. Work will be confined to within the building footprint; therefore, environmental impacts are expected to be minimal. Potential environmental impacts are discussed in more detail in the following subsections.

5.1 Historical/Archaeological/Tribal Resources

This project will not have any historical, archaeological, or tribal resource impacts.

5.2 Water Quality

This project will have no adverse groundwater or surface water quality or quantity impacts but will have a beneficial impact on the potable water supply. An additional disinfection barrier to pathogens will be added, increasing an already robust multi-barrier water treatment system to further protect public health.

The UV disinfection system will enhance the potable water treatment process by providing up to an additional 3-log (99.9 percent) removal of *Cryptosporidium* parvum oocysts and *Giardia lambia* cysts with inactivation credits provided by MDEQ ranging from 1-log (90 percent) to 3-log (99.9 percent) depending on the mode of operation. Additional removal of bacteria and enteric viruses is also anticipated.

The new UV disinfection equipment will be tested to confirm performance prior to placing into operation. Once operational, the UV disinfection system will be monitored continuously for proper operation and summary operational reports generated and sent to MDEQ monthly.

The UV disinfection system will consist of two new UV disinfection chambers (1 duty, 1 standby). Each UV disinfection reactor will contain 8 UV lamps, or 16 total in the system. Each UV lamps contains about 700 to 750 milligrams of elemental mercury, and each lamp is housed within a quartz sleeve. Under normal conditions, the mercury is contained within the lamp and quartz sleeve and is not exposed to the air or water. At the end of its useful life (about 9,000 hours), the lamp will be returned to the UV system supplier for proper disposal and mercury recycling. City treatment operations staff will be trained on the proper use and handling of UV lamps. Lamps and sleeves are brittle and can break if not handled properly, releasing the mercury into the potable water supply (if in operation) or the local environment (if handled outside the UV reactor). Emergency operating procedures and clean up kits will be available to clean up after an accidental lamp breakage and release of mercury. MDEQ would be notified of any lamp break and remedial actions taken which would include collection of the mercury to the extent possible, proper disposal of collected mercury, and sampling in downstream piping and water storage reservoirs to confirm the mercury Maximum Contaminant Level was not exceeded.

All new pipeworks will be disinfected per MDEQ standards prior to placing into service. Chlorinated water will be quenched prior to disposal to the sanitary sewer.

5.3 Land/Water Interface

This project will not have any wetlands, floodplains, rivers/streams, and coastal zones.

5.4 Endangered Species

This project will not have any endangered species impacts.

5.5 Agricultural Land

This project will not have any agricultural land impacts.

5.6 Social/Economic Impact

This project will enhance public health protection for all customers by providing an additional disinfection barrier to waterborne pathogens.

For the average residential customer using 18 hundred cubic feet per quarter, this project represents a 0.725 percent increase in rates, or 96 cents annually, and $19.20 total for the duration of the debt repayment for this project.

5.7 Construction/Operational Impact

This project scope of work resides within the City of Ann Arbor WTP site. Therefore, it is anticipated that there will be little impact to the public.

Construction impacts are anticipated to include:

- Intermittent car/truck traffic on Sunset Road and feeder routes due to materials delivery and construction staff over the duration of the construction phase of the project. Contract Documents limit working hours to daytime only.
- Lead-based paint has been identified in some of the work areas inside the WTP facility on existing water pipes, valves, and equipment. Demolition and lead paint abatement provisions have been included in the Contract Documents with the intent to safely remove all lead-based paint from the work areas and disposed of in a proper manner meeting all EPA, State of Michigan, Michigan Occupational Safety and Health Administration (MIOSHA), and U.S. Occupational Safety and Health Administration (OSHA) requirements. Health and safety procedures will be developed and enforced to ensure no untrained or unqualified personnel are exposed to lead-based paint dust while remedial activities are active.
- Asbestos-containing materials (ACM) have been identified in some of the work areas inside the WTP, specifically in the existing pipe joint gaskets. Demolition and lead paint abatement provisions have been included in the Contract Documents with the intent to safely remove all ACM from the work areas and disposed of in a proper manner meeting all EPA, State of Michigan, MIOSHA, and OSHA requirements. Health and safety procedures will be developed and enforced to ensure no untrained or unqualified personnel are exposed to ACM while remedial activities are active.

5.8 Indirect Impacts

No indirect impacts are anticipated to be incurred because of this project.

6. Mitigation Measures

Table 4 summarizes the mitigation measures set forth for the known environmental risks associated with this project.

Table 4. Mitigation Measures

Environmental Risk	Mitigation Measures
Increased car/truck traffic on Sunset Road and feeder roads	Limit work to daytime hours only. Use multiple entrance gates to divert traffic through multiple route. Provide signage at WTP site. Post project status information on City website.
Lead-based paint	Perform lead-based paint abatement per regulations. Develop and follow health and safety procedures to reduce risk of accidental exposure.
ACM	Perform ACM abatement per regulations. Develop and follow health and safety procedures to reduce risk of accidental exposure.
Release of mercury in UV lamps due to accidental breakage	Develop and implement emergency operating procedures to mitigate the release of mercury, collect mercury to extent possible, properly dispose of collected mercury, and conduct additional sampling to confirm effectiveness of remediation. Training of City staff on proper use and handling of UV lamps.

7. Public Participation

7.1 Formal Public Hearing and/or Recording

Ann Arbor conducted a formal public hearing on April 8, 2019. There were no attendees from the public.

7.2 Public Hearing Advertisement

A notice of the public hearing was posted at least 30 days before the meeting in a local Ann Arbor newspaper and the City website. A draft of the Project Plan was made available during the 30-day public comment period. Appendix H contains a copy of the public hearing notice.

7.3 Public Hearing Transcript of Recording

A transcript of the public meeting is provided with the final project plan and is included in Appendix H.

7.4 Public Hearing Contents

The contents described in the Project Plan Guidance Document were used to develop the slide presentation for the public hearing. The slides are included in Appendix H.

7.5 Comments Received and Answered

The final project plan includes the sign-in sheet. There were no public attendees. There were no questions from the public.

7.6 Adoption of the Project Plan

After the public hearing, the final alternative was selected. The final project plan will include a resolution from the City of Ann Arbor to formally adopt the project and implement the selected alternative. The date of the City Council meeting is April 15, 2019.

Appendix A
MDEQ Letter (June 20, 2017)

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
UPPER PENINSULA DISTRICT OFFICE

C. HEIDI GRETHER
DIRECTOR

June 20, 2017

Mr. Brian Steglitz, Water Treatment Plant Manager
City of Ann Arbor
919 Sunset
Ann Arbor, MI 48103

WSSN: **0220**

Dear Brian:

SUBJECT: Long Term 2 Enhanced Surface Water Treatment Rule
Round 2 Source Sampling Bin Classification

The Long Term 2 Enhanced Surface Water Treatment Rule (LT2 Rule) was promulgated by the U.S. Environmental Protection Agency (EPA) on January 5, 2006. The Michigan Department of Environmental Quality (DEQ) adopted this rule into the Michigan Administrative Rules in December 2009. All public water systems that are supplied by a surface water source and systems supplied by a ground water source under the direct influence of surface water (GWUDI) are subject to this rule.

This letter is to acknowledge the DEQ received the second round of *Cryptosporidium* monitoring required under LT2 and the data has been used to determine the city's Bin Classification. Based on the source water sample results collected from April 2015 to March 2017 the city of Ann Arbor has been placed in **Bin 2**. According to LT2, water systems classified as Bin 2 must provide an *additional* 1.0-log removal/inactivation of *Cryptosporidium*. Because the city's conventional WTP currently meets the LT1 and Interim Enhanced Surface Water Treatment Rules, it receives a 3.0-log removal credit. Therefore, the city will be required to achieve a total *Cryptosporidium* removal/inactivation of 4.0-log.

Please note that the EPA was contacted about the possibility of resampling the source water at a different sampling location. They indicated that the monitoring location could have been contested during development of the sampling plan prior to sampling, but that no provisions exist in the rules for resampling after receiving results from an approved plan.

Next Steps:

The EPA's Long Term 2 Enhanced Surface Water Treatment Rule Toolbox Guidance Manual provides information on the options water systems have to meet the additional treatment requirements. Enclosed is a summary of Toolbox Options that can be used to start evaluating alternatives. The city must provide the additional *Cryptosporidium* removal/inactivation **by June 20, 2020**.

Upon completion of source water monitoring, any system that plans to make a significant change to its disinfection practices must:

1. Create disinfection profiles for *Giardia lamblia* and viruses;
2. Calculate a disinfection benchmark; and
3. Consult with the DEQ prior to making a significant change in disinfection practice.

Significant changes to disinfection practice are defined as follows:

1. Changes to the point of disinfection;
2. Changes to the disinfectant(s) used in the treatment plant;
3. Changes to the disinfection process; or
4. Any other modification identified by the DEQ as a significant change to disinfection practice.

We are happy to meet with the city to provide further explanation and look forward to our continued joint effort to provide quality drinking water to your customers. If you have any questions, please contact Ms. Stephanie Johnson by phone at (586) 506-6137 or by email at johnsons18@michigan.gov.

Sincerely,

Michael Bolf

Michael Bolf, P.E.
Water Treatment Specialist
Drinking Water and Municipal Assistance Division
Community Drinking Water - Engineering Unit
906-630-4107

MB:KB

Enclosures
cc: Mr. Craig Hupy, Public Service Administrator, Ann Arbor
File: City of Ann Arbor Water Supply Correspondence

Additional *Cryptosporidium* Treatment Table					
Cryptosporidium Concentration (oocysts/L)	Bin Classification	Additional *Cryptosporidium* Treatment Required			Alternative Filtration
		Conventional Filtration	Direct Filtration	Slow Sand or Diatomaceous Earth Filtration	
< 0.075	1	No additional *Cryptosporidium* treatment required			
0.075 to < 1.0	2	1 log	1.5 log	1 log	(1)
1.0 to < 3.0	3	2 log	2.5 log	2 log	(2)
≥ 3.0	4	2.5 log	3 log	2.5 log	(3)

(1) As determined by the State, such that the total removal/inactivation is > 4.0-log
(2) As determined by the State, such that the total removal/inactivation is > 5.0-log
(3) As determined by the State, such that the total removal/inactivation is > 5-log

The following table summarizes options available to public water systems for achieving the additional treatment required, and is provided solely for reference. Systems must comply with the specific regulatory criteria associated with the toolbox option(s) selected.

Toolbox Option	*Cryptosporidium* treatment credit with design and implementation criteria
Source Water Protection and Management Toolbox Options	
(1) Watershed control program..................	0.5-log credit for State-approved program comprising required elements, annual program status report to State, and regular watershed survey.
(2) Alternative source/intake management........	No prescribed credit. Systems may conduct simultaneous monitoring for treatment bin classification at alternative intake locations or under alternative intake management strategies.
Pre Filtration Toolbox Options	
(3) Presdimentation basin with coagulation......	0.5-log credit during any month that presedimentation basins achieve a monthly mean reduction of 0.5-log or greater in turbidity or alternative State-approved performance criteria. To be eligible, basins must be operated continuously with coagulant addition and all plant flow must pass through the basins.
(4) Two-stage lime softening.....................	0.5-log credit for two-stage lime softening where chemical addition and hardness precipitation occur in both stages. All plant flow must pass through both stages. Single-stage softening is credited as equivalent to conventional filtration.
(5) Bank filtration..................................	0.5-log credit for 25-foot setback; 1.0-log credit for 50-foot setback; aquifer must be unconsolidated sand containing at least 10 percent fines; average turbidity in wells must be less than 1 NTU. Systems using wells followed by filtration when conducting source water monitoring must sample the well to determine bin classification and are eligible for additional credit.
Treatment Performance Toolbox Options	
(6) Combined Filter performance..............	0.5-log credit for combined filter effluent turbidity less than or equal to 0.15 NTU in at least 95 percent of measurements each month.
(7) Individual Filter performance.................	0.5-log credit (in addition to 0.5-log combined filter performance credit) if individual filter effluent turbidity is less than or equal to 0.15 NTU in at least 95 percent of samples each month in each filter and is never greater than 0.3 NTU in two consecutive measurements in any filter.
(8) Demonstration of performance..............	Credit awarded to unit process or treatment train based on a demonstration to the State with a State-approved protocol.
Additional Filtration Toolbox Options	
(9) Bag or cartridge filters (individual filters).....	Up to 2-log credit based on the removal efficiency demonstrated during challenge testing with a 1.0-log factor of safety.

(10) Bag or cartridge filters (in series)............	Up to 2.5-log credit based on the removal efficiency demonstrated during challenge testing with a 0.5-log factor of safety.
(11) Membrane filtration.........................	Log credit equivalent to removal efficiency demonstrated in challenge test for device if supported by direct integrity testing.
(12) Second stage filtration......................	0.5-log credit for second separate granular media filtration stage if treatment train includes coagulation prior to first filter.
(13) Slow sand filters............................	2.5-log credit as a secondary filtration step; 3.0-log credit as a primary filtration process. No prior chlorination for either option.
Inactivation Toolbox Options	
(14) Chlorine dioxide.............................	Log credit based on measured CT in relation to CT table.
(15) Ozone..	Log credit based on measured CT in relation to CT table.
(16) Ultraviolet Light (UV).......................	Log credit based on validated UV dose in relation to UV dose table; reactor validation testing required to establish UV dose and associated operating conditions.

Appendix B
CH2M 2017 *Final Long-Term 2 Enhanced Surface Water Treatment Rule Study*

Final

Long-Term 2 Enhanced Surface Water Treatment Rule Study

Prepared for

**City of Ann Arbor –
Water Treatment Services Unit**

Prepared by

ch2m

December 2017

FINAL REPORT

Long-Term 2 Enhanced Surface Water Treatment Rule Study

Prepared for

City of Ann Arbor - Water Treatment Services Unit

Prepared by

ch2m

December 2017

Contents

Exhibits

Acronyms and Abbreviations

°C	degree(s) Celsius
cm	centimeter(s)
BMP	best management practice
CFE	combined filter effluent
CFR	*Code of Federal Regulations*
DNA	deoxyribonucleic acid
EPA	U.S. Environmental Protection Agency
IFE	individual filter effluent
kW	kilowatt(s)
kWh	kilowatt-hour(s)
LT2ESWTR	Long-Term 2 Enhanced Surface Water Treatment Rule
MDEQ	Michigan Department of Environmental Quality
mg/L	milligram(s) per liter
mgd	million gallon(s) per day
mJ/cm^2	milijoule(s) per square centimeter
nm	nanometer(s)
NTU	nephelometric turbidity unit
O&M	operation and maintenance
RED	reduction equivalent dose
RNA	ribonucleic acid
SWTR	Surface Water Treatment Rule
UV	ultraviolet
UVT	ultraviolet transmittance

Introduction

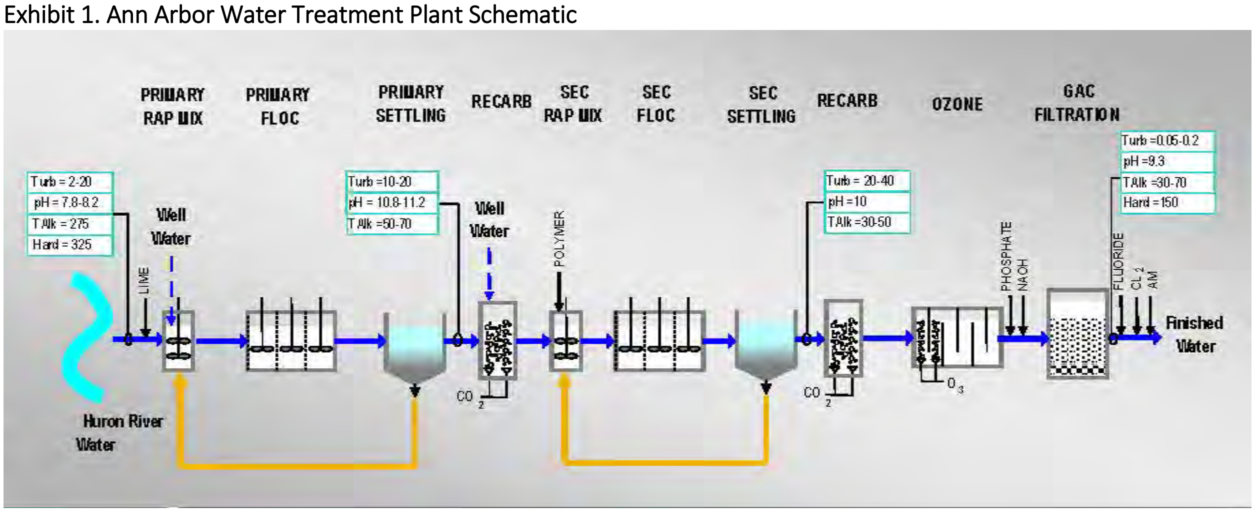
Purpose

The purpose of this study is to identify potential methods for the City of Ann Arbor water plant to comply with the requirements of the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), and recommend a course of action. The LT2ESWTR is a U.S. Environmental Protection Agency (EPA) drinking water regulation designed to further protect potable water supplies from microbial contaminants, including the protozoan pathogen *Cryptosporidium*. The intent of this report is to leverage what the City of Ann Arbor water plant already has in place for *Cryptosporidium* protection, and investigate applicable new technologies or methods.

Ann Arbor Water Plant

The source of Ann Arbor's water supply is an impoundment on Huron River and a well field located near the Ann Arbor airport. The City of Ann Arbor owns and operates a 50-million gallon per day (mgd) lime softening water treatment plant. The water plant consists of two softening plants: plant 1 has a capacity of 22 mgd and plant 2 has a capacity of 28 mgd. Treatment processes in plant 1 and 2 consist of two-stage rapid mixing, flocculation and lime softening. Water from plants 1 and 2 are combined and pass through recarbonation, ozonation, filtration, and final disinfection with chloramines as illustrated in Exhibit 1.

Exhibit 1. Ann Arbor Water Treatment Plant Schematic



After filtration, the water passes through two clearwells and then is pumped to a storage reservoir. Water is distributed to customers by high-service pumps, and can also flow by gravity to a portion of the distribution system.

Ann Arbor has a proud history of providing safe, reliable drinking water to its customers, complying with drinking water regulations and planning for the future. In the 1990s, Ann Arbor implemented ozone disinfection and granular activated carbon to enhance disinfection, reduce disinfection byproducts and provide better tasting water for its customers. In 2006, Ann Arbor added equalization for its recycle streams to comply with the Filter Backwash Recycle Rule. The City of Ann Arbor is currently completing an asset management plan that will be submitted to the State of Michigan in January 2018. This plan will present the City's approach to managing its horizontal and vertical assets.

Recent Regulations

The EPA promulgated the LT2ESWTR in 2006. The purpose of the Rule is to further protect potable water supplies from microbial contaminants, including the protozoan pathogen *Cryptosporidium*. This rule espouses the EPA's a multi-barrier approach for treating drinking water. A multi-barrier treatment process provides a number of protective "layers" against contamination by using more than one method of prevention and treatment to remove or inactivate microorganisms. Depending on the amount of *Cryptosporidium* in a utility's raw water supply, different treatment schemes may be required.

The LT2ESWTR requires water utilities to sample their source water for *Cryptosporidium* in two periods of monthly sampling. Based on a 12-month running average of results (*Cryptosporidium* cysts per liter), water utilities may or may not have to further protect the water supply from *Cryptosporidium.*

Sample results place water utilities into "Bins" for determination of actions required. The Bin categories and supplemental *Cryptosporidium* treatment requirements are listed in Exhibit 2.

Exhibit 2. Bin Classifications[a]

If your *Cryptosporidium* concentration (oocysts/L) is...	Your bin classification is...	Treatment
< 0.075	1	No additional treatment beyond conventional surface water treatment
≥ 0.075 and < 1.0	2	Additional 1-log treatment[b]
≥ 1.0 and < 3.0	3	Additional 2-log treatment[c]
≥ 3.0	4	Additional 2.5-log treatment[c]

[a] 40 *Code of Federal Regulations* (CFR) 141.710 and 40 CFR 141.711.

[b] Systems may use any technology or combination of technologies from the microbial toolbox

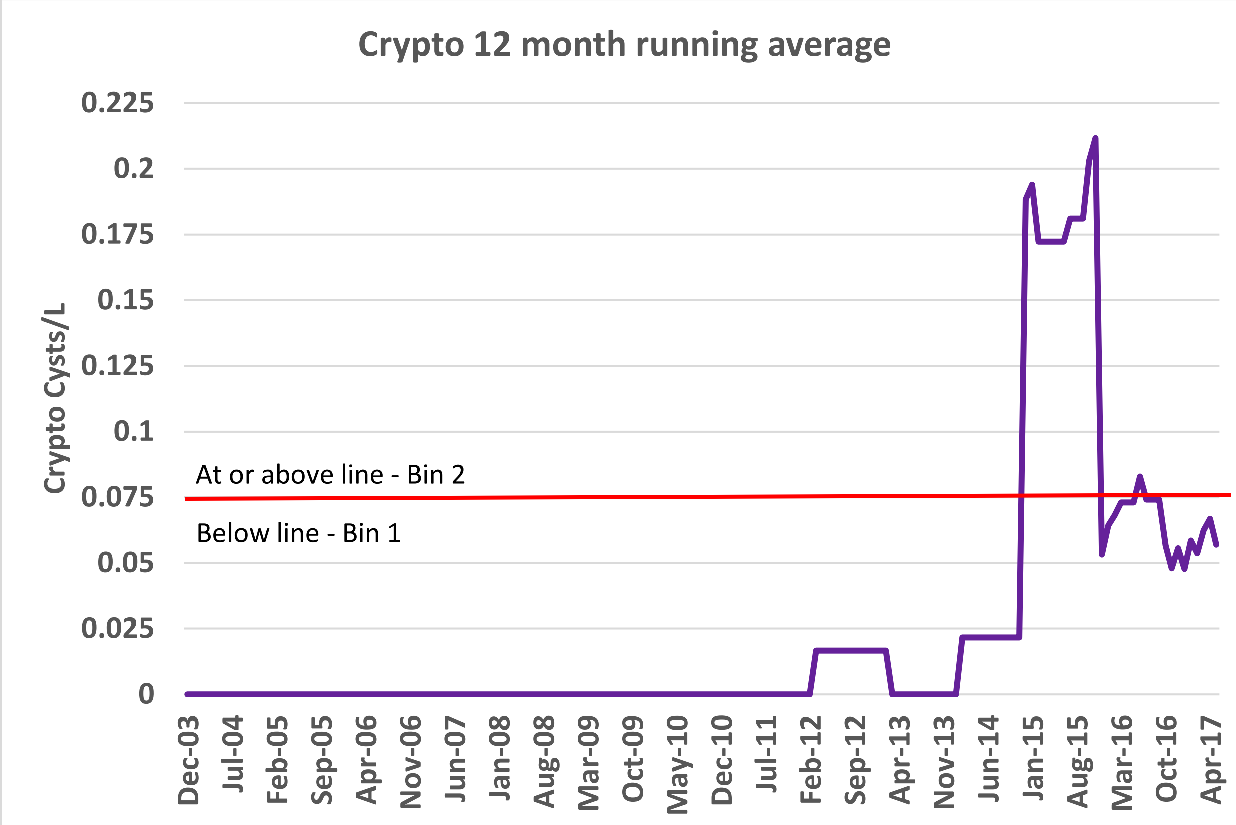
[c] Systems must achieve at least 1-log of the required treatment using ozone, chlorine dioxide, ultraviolet (UV), membranes, bag/cartridge filters, or bank filtration.

As listed in Exhibit 2, *Cryptosporidium* sample results that average less than 0.075 cyst per liter are in Bin 1 and require no additional treatment beyond conventional surface water treatment and complying with the Surface Water Treatment Rule (SWTR). Conventional surface water treatment plants are granted a 3-log (99.9 percent) *Cryptosporidium* removal/inactivation credit.

If *Cryptosporidium* sample results are equal or greater than 0.075 cyst per liter but less than 1 cyst per liter, the water utility is in Bin 2 and an additional 1-log (90 percent) *Cryptosporidium* removal/inactivation credit is required beyond the 3-log credit granted for conventional surface water treatment. Therefore, a 4-log (99.99 percent) *Cryptosporidium* removal/inactivation credit is required for Bin 2.

The results from Ann Arbor's *Cryptosporidium* sample results starting in 2003 when monthly samples were collected are shown on Exhibit 3.

Exhibit 3. Ann Arbor *Cryptosporidium* Sample Results



As shown on Exhibit 3, Ann Arbor falls in Bin 2. A high concentration of *Cryptosporidium* (1 cyst per liter) was detected in December 2014 and the running annual average increased above 0.075 cyst per liter. Additional *Cryptosporidium* detections in 2016 increased the running annual average just above 0.075 cyst per liter for a short period.

The City of Ann Arbor received a letter from the Michigan Department of Environmental Quality (MDEQ) on June 20, 2017 stating that Ann Arbor was placed into Bin 2 based on *Cryptosporidium* sampling results from April 2015 to March 2017. MDEQ stated that Ann Arbor must provide the additional *Cryptosporidium* inactivation/removal by June 20, 2020.

The Bin 2 designation requires an additional 1-log *Cryptosporidium* inactivation/removal credit, beyond the 3-log credit granted for conventional surface water treatment. The LT2ESWTR identifies many methods to obtain additional *Cryptosporidium* inactivation/removal credit (Microbial Toolbox of “accepted” technologies). The Microbial Toolbox is provided in Exhibit 4.

Exhibit 4. LT2ESWTR Microbial Toolbox[a]

Toolbox Option	*Cryptosporidium* Treatment Credit with Design and Implementation Criteria
Source Toolbox Components	
Watershed Control Program	0.5-log credit for state approved program comprising required elements, annual program status report to the state, and regular watershed survey. Unfiltered systems are not eligible for credit. See 40 CFR 141.716(a) and Chapter 2 for specific criteria.
Alternative Source/ Intake Management	No presumptive credit. Systems may conduct simultaneous monitoring for treatment bin classification at alternative intake locations or under alternative intake management strategies. See 40 CFR 141.716(b) and Chapter 3 for specific criteria.

Exhibit 4. LT2ESWTR Microbial Toolbox[a]

Toolbox Option	*Cryptosporidium* Treatment Credit with Design and Implementation Criteria
Pre-Filtration Toolbox Components	
Presedimentation Basin with Coagulation	0.5-log credit during any month that presedimentation basins achieve a monthly mean reduction of 0.5-log or greater in turbidity or alternative state-approved performance criteria. To be eligible, basins must be operated continuously with coagulant addition and all plant flow must pass through the basin. See 40 CFR 141.717(a) and Chapter 5 for specific criteria.
Two-Stage Lime Softening	0.5-log credit for two-stage softening where chemical additional and hardness precipitation occur in both stages. All plant flow must pass through both stages. Single-stage softening is credited as equivalent to conventional treatment. See 40 CFR 141.717(b) and Chapter 6 for specific criteria.
Bank Filtration	0.5-log credit for 25-foot setback; 1.0-log credit for 50-foot setback; aquifer must be unconsolidated sand containing at least 10 percent fines; average turbidity in wells must be less than 1 nephelometric turbidity unit (NTU). Systems using wells followed by filtration when conducting source water monitoring must sample the well to determine bin classification and are not eligible for additional credit. See 40 CFR 141.717(c) and Chapter 4 for specific criteria.
Treatment Performance Toolbox Components	
Combined Filter Performance	0.5-log credit for combined filter effluent (CFE) turbidity less than or equal to 0.15 NTU in at least 95 percent of measurements each month. See 40 CFR 141.718 (a) and Chapter 7 for specific criteria.
Individual Filter Performance	0.5-log credit (in addition to 0.5-log combined filter performance credit) if individual filter effluent (IFE) turbidity is less than or equal to 0.15 NTU in at least 95 percent of samples each month in each filter and is never greater than 0.3 NTU in two consecutive measurements in any filter. See 141.718 (b) and Chapter 7 for specific criteria.
Demonstration of Performance	Credit awarded to unit process or treatment train based on a demonstration to the state with a state-approved protocol. See 40 CFR 141.718 (c) and Chapter 12 for specific criteria.
Additional Filtration Toolbox Options	
Bag or Cartridge Filters (Individual Filters)	Up to 2-log credit based on the removal efficiency demonstrated during challenge testing with a 1.0-log factor of safety. See 40 CFR 141.719(a) and Chapter 8 for specific criteria.
Bag or Cartridge Filters (in Series)	Up to 2.5-log credit based on the removal efficiency demonstrated during challenge testing with a 0.5-log factor of safety. See 40 CFR 141.719(a) and Chapter 8 for specific criteria.
Membrane Filtration	Log credit equivalent to removal efficiency demonstrated in challenge test for device if supported by direct integrity testing. See 40 CFR 141.719(b) and Chapter 14 of this manual for specific criteria.
Second Stage Filtration	0.5-log credit for second separate granular media filtration stage if treatment train includes coagulation prior to first filter. See 40 CFR 141.719 (c) and Chapter 9 for specific criteria.
Slow Sand Filters	2.5-log credit as a secondary filtration step; 3.0-log credit as a primary filtration process. No prior chlorination for either option. See 40 CFR 141.719(d) and Chapter 9 for specific criteria.
Bag or Cartridge Filters (Individual Filters)	Up to 2-log credit based on the removal efficiency demonstrated during challenge testing with a 1.0-log factor of safety. See 40 CFR 141.719(a) and Chapter 8 for specific criteria.
Inactivation Toolbox Components	
Chlorine Dioxide	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(b) and Chapter 10 for specific criteria.
Ozone	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(b) and Chapter 11 for specific criteria.
UV	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(d) and Chapter 13 for specific criteria.

[a]40 CFR 141.715.

Alternatives

The LT2ESWTR "Microbial Toolbox" (Exhibit 5) provides a roadmap of available alternatives for obtaining additional removal/inactivation credit for *Cryptosporidium*. These alternatives will be analyzed in this section.

Screening of Alternatives

The Microbial Toolbox alternatives were screened for applicability to the City of Ann Arbor, and the results are listed in Exhibit 5. Alternatives carried forward for further analysis are in red.

Exhibit 5. LT2ESWTR Microbial Toolbox Screening of Alternatives

Toolbox Option	*Cryptosporidium* Treatment Credit with Design and Implementation Criteria	Comments
Source Water Components Toolbox Components		
Watershed Control Program	0.5-log credit for state approved program comprising required elements, annual program status report to the state, and regular watershed survey. Unfiltered systems are not eligible for credit. See 40 CFR 141.716 (a) and Chapter 2 for specific criteria.	Ann Arbor has a surface water intake protection plan and strives to promote good watershed practices. Ann Arbor has a Greenbelt program that can improve source water quality. The Huron River watershed is extensive with multipurpose use that is not under the control of the City of Ann Arbor. Implementing watershed control under multi-jurisdictional conditions can be difficult.
Alternative Source/ Intake Management	No presumptive credit. Systems may conduct simultaneous monitoring for treatment bin classification at alternative intake locations or under alternative intake management strategies. See 40 CFR 141.716(b) and Chapter 3 for specific criteria.	Alternative water sources have been evaluated by Ann Arbor in Master Plans and studies. There are no practical water sources to replace the Huron River. Moving the intake location is possible, but extensive study would be needed and the *Cryptosporidium* sources could be anywhere in the large watershed. Water depth at the intake is only about 25-30 feet, so an alternative intake depth is not likely to significantly reduce *Cryptosporidium*. For these reasons, an alternative water source or intake management is not recommended for further evaluation.
Pre-Filtration Components		
Presedimentation Basin with Coagulation	0.5-log credit during any month that presedimentation basins achieve a monthly mean reduction of 0.5-log or greater in turbidity or alternative state-approved performance criteria. To be eligible, basins must be operated continuously with coagulant addition and all plant flow must pass through the basin. See 40 CFR 141.717(a) and Chapter 5 for specific criteria.	Ann Arbor does not have a presedimentation basin with coagulant addition. It would require a large amount of land and facilities to operate and maintain. There is inadequate land and costs would be high. The water quality benefit of this technology is less than other treatment technologies considered in this Toolbox. Therefore, this alternative is not recommended for further evaluation.
Two-Stage Lime Softening	0.5-log credit for two-stage softening where chemical additional and hardness precipitation occur in both stages. All plant flow must pass through both stages. Single-stage softening is credited as equivalent to conventional treatment. See 40 CFR 141.717(b) and Chapter 6 for specific criteria.	Ann Arbor currently has two lime softening basins in series. Therefore, this alternative is recommended for further evaluation.

Exhibit 5. LT2ESWTR Microbial Toolbox Screening of Alternatives

Toolbox Option	*Cryptosporidium* Treatment Credit with Design and Implementation Criteria	Comments
Bank Filtration	0.5-log credit for 25-foot setback; 1.0-log credit for 50-foot setback; aquifer must be unconsolidated sand containing at least 10 percent fines; average turbidity in wells must be less than 1 NTU. Systems using wells followed by filtration when conducting source water monitoring must sample the well to determine bin classification and are not eligible for additional credit. See 40 CFR 141.717(c) and Chapter 4 of this manual for specific criteria.	Bank filtration was evaluated in the Source Water Master Plan for Ann Arbor. Bank filtration was deemed impractical given the local hydrogeology. Therefore, this alternative is not recommended for further evaluation.
Treatment Performance Toolbox Components		
Combined Filter Performance	0.5-log credit for CFE turbidity less than or equal to 0.15 NTU in at least 95 percent of measurements each month. See 40 CFR 141.718 (a) and Chapter 7 for specific criteria.	Ann Arbor combined filters can achieve less than 0.15 NTU. Therefore, this alternative is recommended for further evaluation.
Individual Filter Performance	0.5-log credit (in addition to 0.5-log combined filter performance credit) if IFE turbidity is less than or equal to 0.15 NTU in at least 95 percent of samples each month in each filter and is never greater than 0.3 NTU in two consecutive measurements in any filter. See 141.718 (b) and Chapter 7 of this manual for specific criteria.	Ann Arbor individual filters can achieve less than 0.15 NTU. Therefore, this alternative is recommended for further evaluation.
Demonstration of Performance	Credit awarded to unit process or treatment train based on a demonstration to the state with a state-approved protocol. See 40 CFR 141.718 (c) and Chapter 12 for specific criteria.	This would involve full scale tests to prove that the existing water plant processes can achieve more *Cryptosporidium* credit than granted in the regulations. Aerobic spores or fluorescent microspheres could be used as surrogates to *Cryptosporidium*, if approved by Michigan Department of Environmental Quality (MDEQ). There is no guarantee that the tests would indicate better performance, and *Cryptosporidium* protection would not change from existing processes. Therefore, this alternative is not recommended for further evaluation.
Additional Filtration Toolbox Options		
Bag or Cartridge Filters (Individual Filters)	Up to 2-log credit based on the removal efficiency demonstrated during challenge testing with a 1.0-log factor of safety. See 40 CFR 141.719(a) and Chapter 8 for specific criteria.	This technology is not practical or applicable to a large lime softening plant and will not be considered further.
Bag or Cartridge Filters (In Series)	Up to 2.5-log credit based on the removal efficiency demonstrated during challenge testing with a 0.5-log factor of safety. See 40 CFR 141.719(a) and Chapter 8 for specific criteria.	This technology is not practical or applicable to a large lime softening plant and will not be considered further.

Exhibit 5. LT2ESWTR Microbial Toolbox Screening of Alternatives

Toolbox Option	*Cryptosporidium* Treatment Credit with Design and Implementation Criteria	Comments
Membrane Filtration	Log credit equivalent to removal efficiency demonstrated in challenge test for device if supported by direct integrity testing. See 40 CFR 141.719(b) and Chapter 14 for specific criteria.	This technology is much more expensive than other technologies that can achieve equal or better Cryptosporidium protection and will not be considered further.
Second Stage Filtration	0.5-log credit for second separate granular media filtration stage if treatment train includes coagulation prior to first filter. See 40 CFR 141.719 (c) and Chapter 9 for specific criteria.	This technology is much more expensive than other technologies that can achieve equal or better Cryptosporidium protection and will not be considered further.
Slow Sand Filters	2.5-log credit as a secondary filtration step; 3.0-log credit as a primary filtration process. No prior chlorination for either option. See 40 CFR 141.719(d) and Chapter 9 for specific criteria.	This technology is not practical or applicable to a large lime softening plant. It also requires large amounts of land. Therefore, this alternative is not recommended for further evaluation.
Inactivation Toolbox Components		
Chlorine Dioxide	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(b) and Chapter 10 for specific criteria.	This technology is not common for *Cryptosporidium* inactivation. The chlorine dioxide dose required for *Cryptosporidium* would likely exceed regulated disinfection byproducts of chlorine dioxide. There are other disinfectants that are more effective and do not have the byproduct concerns. Therefore, this alternative is not recommended for further evaluation.
Ozone	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(b) and Chapter 11 for specific criteria.	Ann Arbor currently has ozone. Ozone can inactivate *Cryptosporidium*. Therefore, this alternative is recommended for further evaluation.
UV	Log credit based on measured CT in relation to CT table. See 40 CFR 141.720(d) and Chapter 13 for specific criteria.	UV is effective for *Cryptosporidium*, and is a common technology for pathogen control. UV has no disinfection byproducts that are regulated. Therefore, this alternative is recommended for further evaluation.

40 CFR 141.715.

Analysis of Alternatives

Screening identified the following alternatives for further evaluation:

1. Watershed Control Program
2. Two-stage Lime Softening
3. Combined Filter Performance
4. Individual Filter Performance
5. Ozone
6. UV

Each of these alternatives are analyzed below.

Watershed Control Program

Up to 0.5-log *Cryptosporidium* credit can be achieved for a Watershed Control Program, if granted by MDEQ. Elements of a Watershed Control Program include:

- Develop a Watershed Control Plan for approval by MDEQ
- Delineate the area of influence for *Cryptosporidium*
- Identify potential sources of *Cryptosporidium*
- Prioritize potential sources of *Cryptosporidium*
- Develop Cryptosporidium control measures
- Conduct a sanitary survey of the watershed every 3 years
- Implement the Plan, continue efforts, and report annually

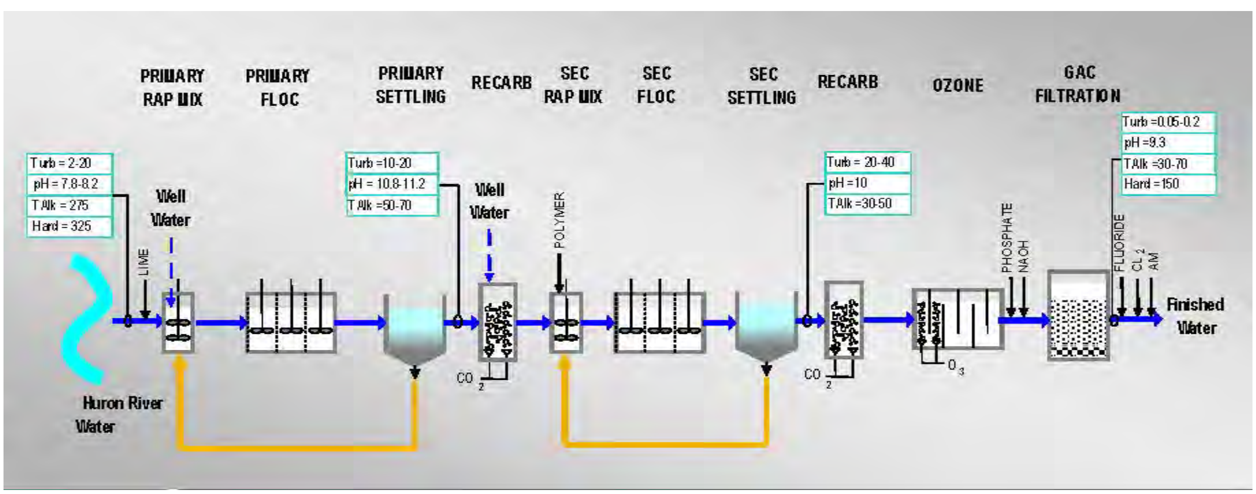
Cryptosporidium control measures included in watershed protection plans may include such diverse activities as structural best management practices (BMPs), land use control regulations, and public education. Control measures that address the sources of *Cryptosporidium* contamination must be analyzed. The analysis of control measures must discuss the effectiveness and feasibility of each measure in reducing *Cryptosporidium* loading in the source water. The LT2ESWTR Toolbox Guidance Manual (Appendix F) summarizes many Watershed Control BMPs for controlling *Cryptosporidium*.

Ann Arbor's source water intake protection plan identified several sources of *Cryptosporidium* contamination, such as septic tanks and concentrated animal feed operations. However, many of these sources are outside the City of Ann Arbor jurisdiction. Although partnerships with other entities can be pursued, implementation of effective *Cryptosporidium* control measures may prove difficult.

Efforts by Ann Arbor to improve the watershed and control contamination should continue. However, Ann Arbor may not be able to rely on watershed control practices to achieve 0.5-log *Cryptosporidium* credit due to lack of control and jurisdiction over watershed practices.

Two-Stage Lime Softening

Ann Arbor currently has the ability to operate two lime softening basins in series. The treatment plant schematic is shown on Exhibit 1 and below.



To obtain 0.5-log *Cryptosporidium* credit, the following conditions must be met:

- The plant must have a second clarification step between the primary clarifier and filter which is operated continuously. For split treatment processes, only the portion of flow going through two clarification stages can receive credit. If a portion of flow bypasses one stage, additional treatment must be provided to the bypassed portion.

- Chemical addition and hardness removal must occur in two separate and sequential stages.

As shown on Exhibit 1, Ann Arbor has a second clarification step. All the surface water goes through both lime softening stages. Groundwater can be mixed with surface water in both the primary and secondary lime softening steps, or could be added to one or the other softening steps. Groundwater can be added after primary clarification as a separate groundwater stream. However, groundwater mixed with surface water is not bypassed around primary clarification. The groundwater is not surface water and does not need to be treated in both stages of softening, nor does it require additional treatment.

Chemical addition occurs in both softening stages, and hardness is removed in both stages. In the first stage, excess lime is added to precipitate hardness. In the second stage, polymer is added for coagulation and the excess lime from the first softening stage is carried over and precipitates additional hardness in the second softening stage.

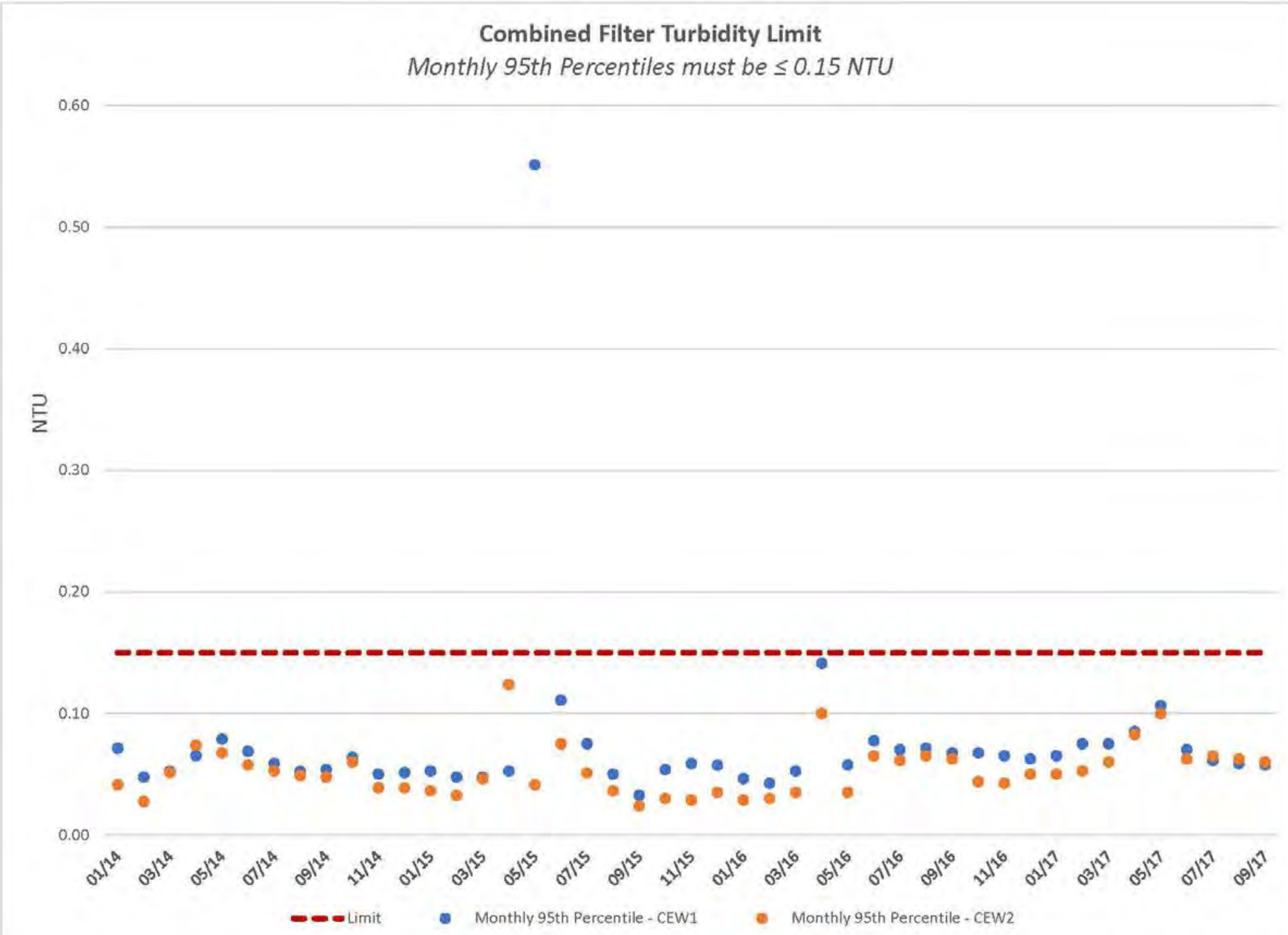
Based on this process, Ann Arbor can meet the 0.5-log *Cryptosporidium* credit for two-stage lime softening. However, there are times when Ann Arbor needs to use single-stage softening for maintenance and operations. In these situations, the two-stage lime softening credit would not be available. In addition, a lime softening alternatives analysis report (Black & Veatch 2015) recommended single-stage lime softening for future improvements. Therefore, the two-stage lime softening credit would not be available in the future. Single-stage lime softening requires less space than two-stage lime softening, so more space is available on the plant site for future improvements.

Combined Filter Performance

Ann Arbor filters the water after lime softening, recarbonation and ozonation. There are 26 conventional gravity granular activated carbon/sand filters. For systems using conventional filtration treatment to obtain an additional 0.5-log *Cryptosporidium* removal credit, the LT2ESWTR requires the CFE turbidity measurements taken for any month are less than or equal to 0.15 NTU in at least 95 percent of the measurements (40 CFR 141.718(a)). The monitoring frequency and compliance calculation requirements are that CFE turbidity must be measured at 4-hour intervals (or more frequently) and 95 percent of the measurements from each month must be less than or equal to 0.15 NTU (40 CFR 141.721).

Ann Arbor's CFE turbidity data are shown on Exhibit 6.

Exhibit 6. Ann Arbor CFE Turbidity Data



***CEW1 – Clearwell 1**

***CEW2 – Clearwell 2**

As shown on Exhibit 6, Ann Arbor can meet the CFE turbidity requirements to achieve an additional 0.5-log *Cryptosporidium* removal credit.

To receive the 0.5-log removal credit for the LT2ESWTR, a water system must submit monthly verification of CFE turbidity levels less than or equal to 0.15 NTU in at least 95 percent of the 4-hour CFE measurements taken each month (40 CFR 141.721).

Individual Filter Performance

The LT2ESWTR also allows systems using conventional filtration treatment to claim an additional 0.5-log *Cryptosporidium* removal credit for any month that meets both of the following IFE turbidity requirements (40 CFR 141.718(b)):

1. IFE turbidity must be less than 0.15 NTU in at least 95 percent of values recorded at each filter in each month, excluding the 15-minute period following return to service from a filter backwash.

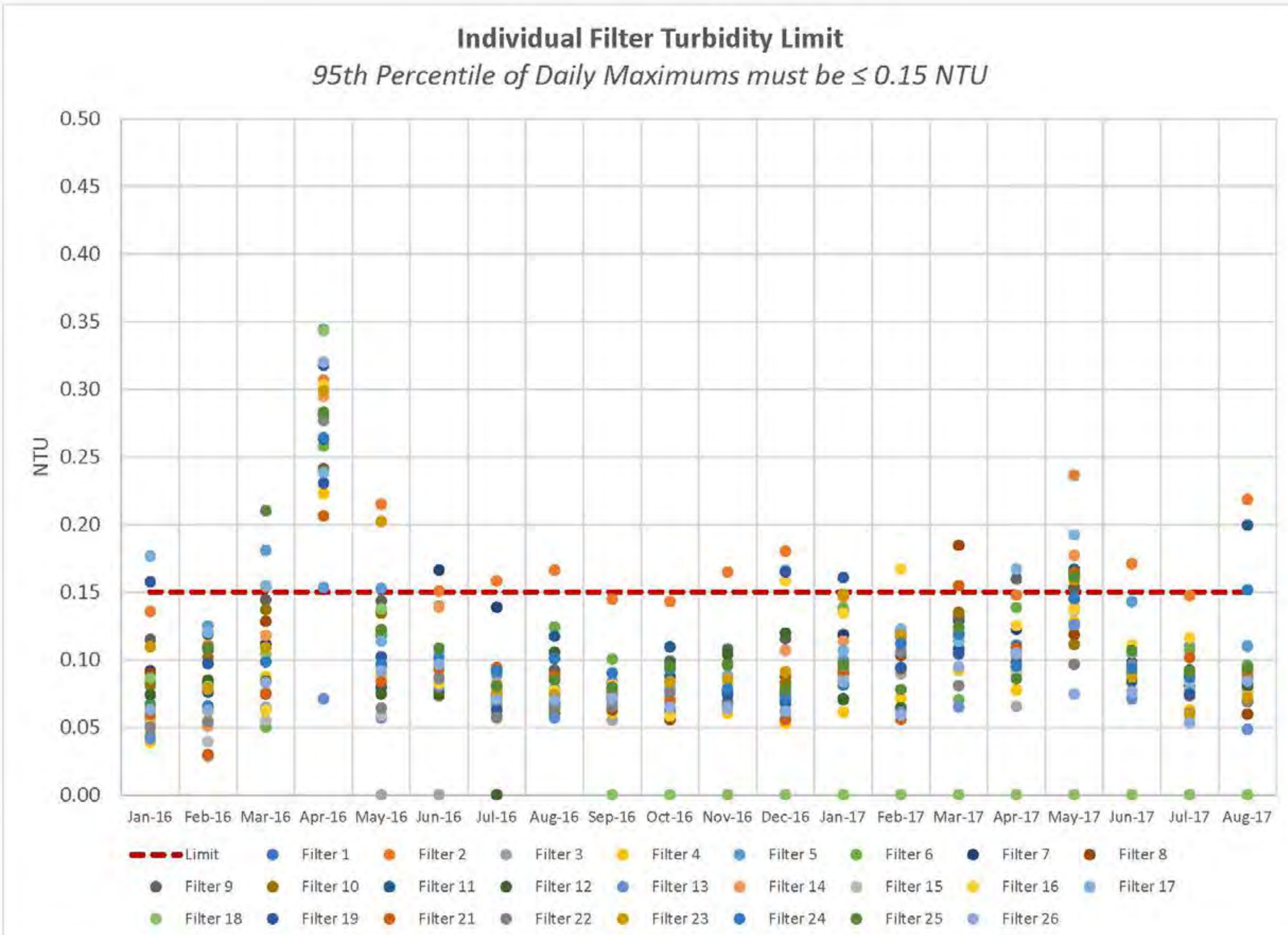
AND

2. No individual filter may have a measured turbidity greater than 0.3 NTU in two consecutive measurements taken 15 minutes apart. Systems may claim credit for combined filter performance AND individual filter performance in the same month (40 CFR 141.718(b)) for 1.0-log total.

The monitoring frequency and compliance calculation requirements for the IFE option are that IFE turbidity must be measured every 15 minutes (excluding the 15-minute period following return to service from a filter backwash) and 95th percentile of the daily maximum measurements from each month must be less than or equal to 0.15 NTU (40 CFR 141.721). If the individual filter is not providing water which contributes to the CFE (i.e., it is not operating, is filtering to waste, or its filtrate is being recycled) the system does not need to report the turbidity for that specific filter.

Ann Arbor's IFE turbidity data are summarized on Exhibit 7.

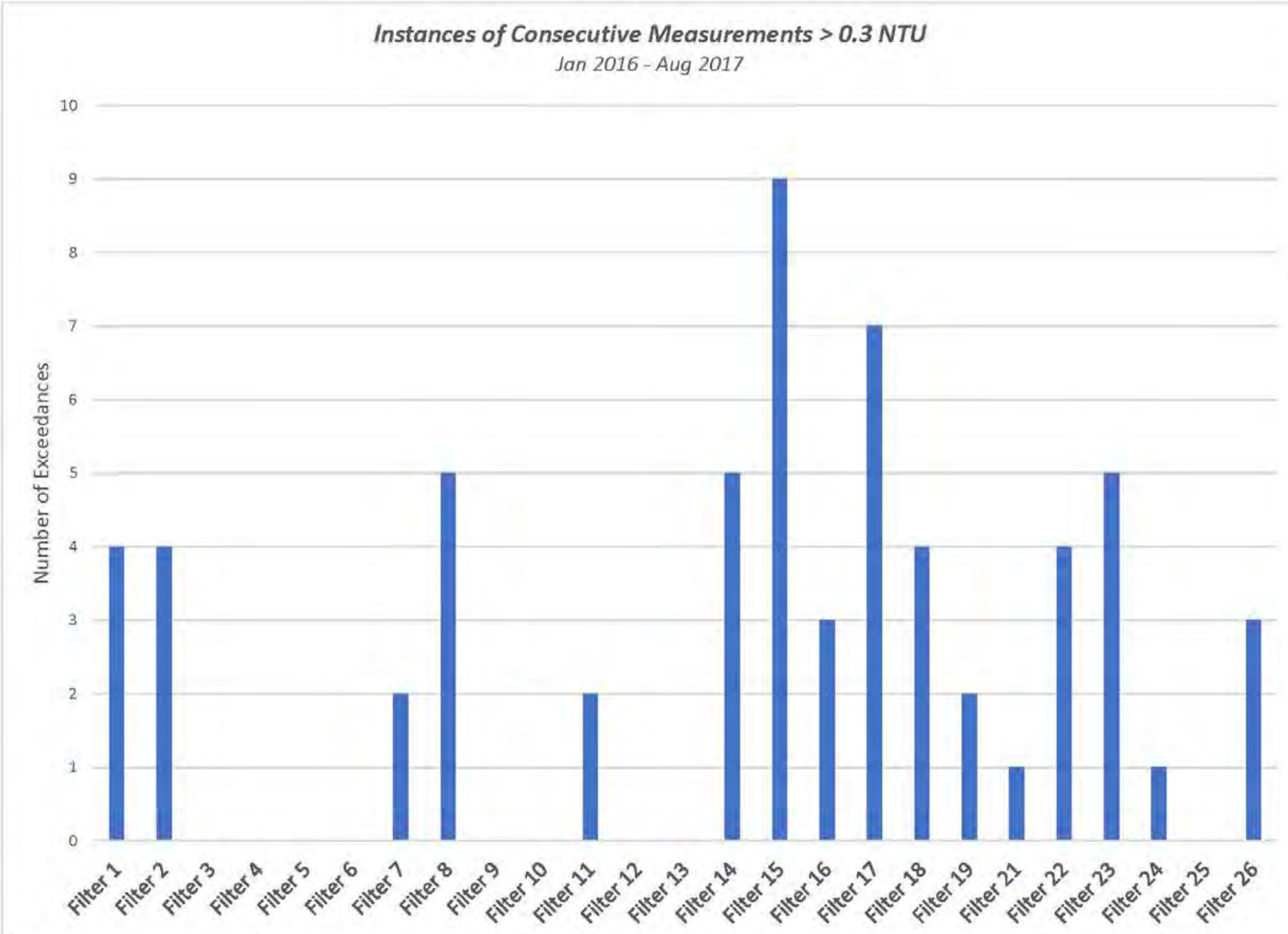
Exhibit 7. Ann Arbor IFE Turbidity Data



As shown on Exhibit 7, there are a few months in 2016/2017 when Ann Arbor meets the IFE turbidity requirements to achieve an additional 0.5-log *Cryptosporidium* removal credit. However, there are many months when Ann Arbor does not meet these requirements. Most of the higher turbidity values occur shortly after a filter backwash, during the filter ripening stage. Ann Arbor does not have filter to waste capability, which could reduce higher turbidity values at the beginning of a filter run. In addition, most of the turbidity is thought to be calcium carbonate particles and not pathogens. Measuring filter effluent turbidity before and after acidification can prove that the particles are calcium carbonate. Acidification can improve the chance of compliance with the IFE turbidity requirements, if MDEQ approves the method and will accept the turbidity value after acidification.

The second part of the IFE turbidity requirement is: “No individual filter may have a measured turbidity greater than 0.3 NTU in two consecutive measurements taken 15 minutes apart.” An analysis of Ann Arbor’s IFE turbidity data over the past year regarding this requirement is shown on Exhibit 8.

Exhibit 8. Ann Arbor IFE Turbidity Data >0.3 NTU



To receive the 0.5-log removal credit for the LT2ESWTR, a water system must submit monthly verification of IFE turbidity levels. Based on this analysis, Ann Arbor cannot rely on IFE turbidity for an additional 0.5-log *Cryptosporidium* removal credit all the time. Additional improvements such as individual filter-to-waste piping and valves and/or filter optimization can help reduce turbidity. However, the ability to consistently meet the IFE turbidity requirement is not guaranteed.

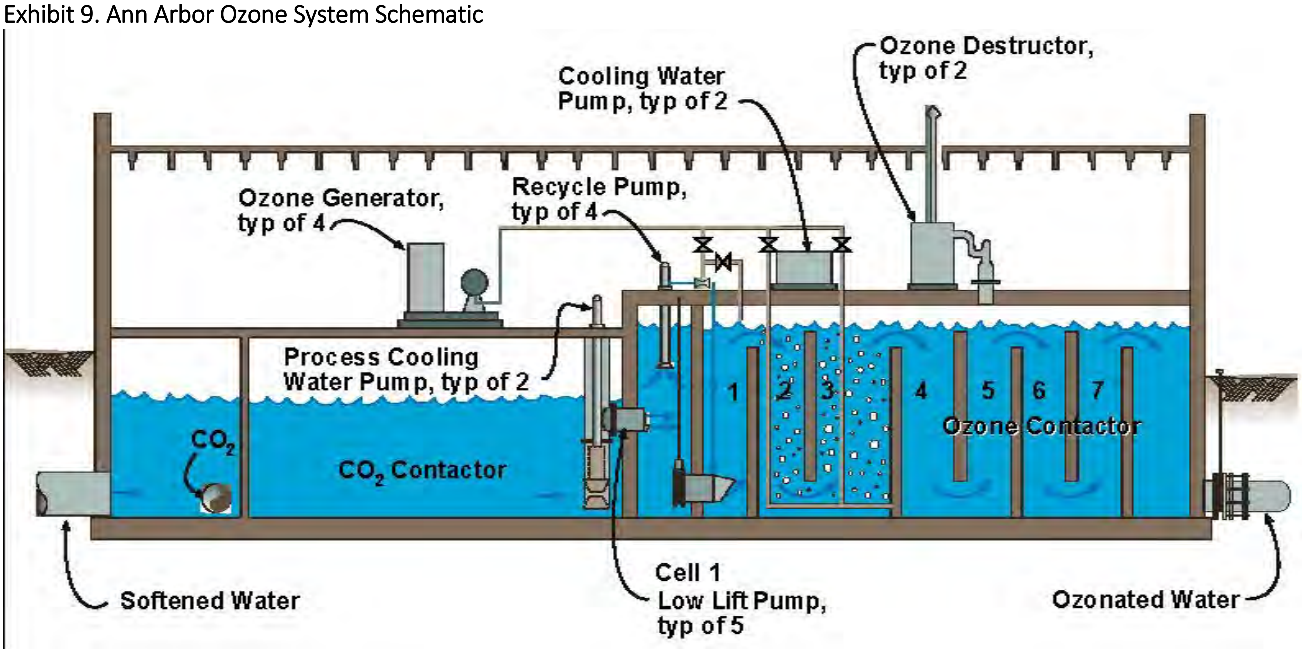
Ozone

The Ann Arbor water plant has an ozonation process that was installed in 1995. Exhibit 9 shows the ozonation system. Ozone is added after recarbonation and before filtration. Ozone gas is produced from liquid oxygen in four ozone generators. The ozone gas (6 to 10 percent ozone) is diffused into the recarbonated water through four parallel ozone contactors. Each ozone contactor has seven contact cells in series with over/under baffles.

Ann Arbor has two methods of diffusing ozone gas into the water:

- Fine bubble diffusion where the ozone gas is bubbled through porous diffusers at the bottom of the ozone contactor in Cells 2 and 3.
- Side stream injection where the ozone gas is educted into a water side stream, then injected into the main water stream in Cell 1.

Exhibit 9. Ann Arbor Ozone System Schematic



With side stream injection ozone is introduced into the first contactor cell and there is longer contact time available, thus potential for more disinfection. However, this method requires the use of recycle pumps and is more complicated than the fine bubble diffusion method.

Ozone residual can be measured at the effluent of Cells 1,2,3, and 4. A single ozone analyzer is provided per contactor, and sample lines from each of the first four cells can be routed to the ozone analyzer by manually operating valves. The sample line from Cell 4 to the ozone analyzer is the longest, so significant ozone decay can occur before analysis. Due to site constraints, walkways between ozone contactors were not possible. Walkways could have exposed ozone contactor side walls for easy ozone residual measurement along the contactor length, and a more accurate picture of ozone residuals.

The ozonation process was designed for 0.5-log Giardia inactivation, and not for *Cryptosporidium.* However, inactivation of both organisms is determined by the CT parameter. CT is defined as the product of the disinfectant concentration and disinfectant contact time:

CT = Disinfectant Residual (milligrams per liter [mg/L]) x Contact Time (minutes)

- "**T**" is the time it takes the water to move from the point where the initial disinfectant residual concentration is measured to the point where the final disinfectant residual concentration is measured in a specified disinfectant segment.
- "**C**" is the concentration of dissolved ozone in mg/L.

CT values for *Cryptosporidium* are shown in Exhibit 10. The CT values are strongly dependent on water temperature, with high CT required at lower water temperature. For example, the 0.5-log *Cryptosporidium* CT is 12 mg-min/L at 1 degree Celsius (°C) and only 2 at 20°C. For comparison, 0.5-log Giardia CT is 0.48 mg-min/L at 1°C and 0.12 at 20°C.

Exhibit 10. CT Values for *Cryptosporidium* Inactivation by Ozone (40 CFR 141.730)

Log credit	Water Temperature, °C[1]										
	<=0.5	**1**	**2**	**3**	**5**	**7**	**10**	**15**	**20**	**25**	**≥30**
0.25	6.0	5.8	5.2	4.8	4.0	3.3	2.5	1.6	1.0	0.6	0.39
0.5	12	12	10	9.5	7.9	6.5	4.9	3.1	2.0	1.2	0.78
1.0	24	23	21	19	16	13	9.9	6.2	3.9	2.5	1.6
1.5	36	35	31	29	24	20	15	9.3	5.9	3.7	2.4
2.0	48	46	42	38	32	26	20	12	7.8	4.9	3.1
2.5	60	58	52	48	40	33	25	16	9.8	6.2	3.9
3.0	72	69	63	57	47	39	30	19	12	7.4	4.7

[1]CT values between the indicated temperatures may be determined by linear interpolation.

Typical CT values at the Ann Arbor water treatment plant are 0.5 to 1.5 mg-min/L. This is adequate for Giardia inactivation and oxidation. Ann Arbor's typical CT values may provide significant *Cryptosporidium* inactivation in very warm water, but not cold water. The ozone CT can be increased in several ways, including:

- **Increase the ozone dose.** Ozone dose can be increased up to a point, depending on flowrate. The ozone system was designed for a nominal dose of 4 mg/L at 50 mgd, although the equipment is capable of higher doses depending on ozonation generation conditions. Bromate formation needs to be considered so that the bromate regulations are not exceeded at higher ozone doses.
- **Lower the pH.** Ozone is more stable at lower pH and the ozone residual will persist in the ozone contact basins longer, thus increasing CT. Lower pH can also reduce bromate formation. However, the pH needs to be increased after ozonation with sodium hydroxide to stabilize the water for distribution system corrosion and reduction of nitrification potential. Chemical costs for carbon dioxide and sodium hydroxide will increase.
- **Increase the contact time.** By operating all four ozone contactors the contact time will increase, thus increasing CT. At low flow rates, this may not be practical.
- **Side Stream Ozone Injection.** Side stream injection will use more of the ozone contact basin because ozone is added to the first cell. This increases contact time and CT. However, the recycle pumps need to be operated, resulting in higher cost. This is not the normal operating method, so other operational or maintenance issues may arise. Side stream injection can also increase bromate formation.
- **Request modification of the CT calculation method.** This will be discussed in the following section.

All the above methods, and combination of methods can increase ozone CT. However, there are other impacts that must be considered.

CT Calculation Method

Conventional Method

If tracer test results are available, the T_{10} method is the conventional method used to determine time (T) for the CT calculation. T_{10} is the time at which 10 percent of the water in the contactor or cell has passed through the contactor or cell. Based on tracer studies, Ann Arbor's T_{10} factor is 0.7. For example, if the theoretical contact time (ozone contactor volume/flowrate) is 10 minutes, the T_{10} is 10 x 0.7 or 7 minutes.

Ozone concentration (C) is measured directly in the ozone contactor, and calculated as follows based on the contactor cell configuration.

Co-current Cell (water and ozone traveling in the same direction): $C = (C_{in} + C_{out}) / 2$ or $C = C_{out}$

Counter current Cell (water and ozone traveling in opposite directions): $C = C_{out}/2$

Reactive Cell (no ozone added, ozone decay only): $C = C_{out}$

<u>An important distinction for *Cryptosporidium* inactivation is that no credit is granted for the first ozone contact cell, per LT2ESWTR regulations.</u> This is different than Giardia inactivation where the first cell can be used for CT determination, per SWTR regulations. Therefore, CT values will be lower *Cryptosporidium* credit.

Ann Arbor uses the conventional method to calculate CT and report to MDEQ for Giardia and Virus inactivation. This is a straightforward and conservative method and ensures good disinfection. As an alternative to the conventional CT calculation, an ozone residual of 0.3 mg/L or greater in the first ozone dissolution cell effluent achieves 0.5-log Giardia inactivation credit per the SWTR. Ann Arbor obtains CT credit in the first ozone dissolution cell by the conventional CT calculation. There may be times in very cold water that the SWTR 0.5-log Giardia inactivation credit for an ozone residual of 0.3 mg/L or greater in the first ozone dissolution cell effluent is greater than the conventional CT calculation. For example, an ozone residual of 0.3 mg/L at an effective contact time of 1 minute would have a CT of 0.3 mg-min/L. At 1°C, the Giardia inactivation credit in the Ann Arbor CT spreadsheet would be about 0.3 log. However, since an ozone residual of 0.3 mg/L was achieved, the Giardia inactivation credit per the SWTR is actually 0.5-log. Ann Arbor may want to add this first cell ozone residual Giardia credit alternative to their CT calculation sheet and apply it for very cold water conditions.

Integration Method

Instead of using the simple formulas above for calculating average ozone residual in a cell, integration over the ozone decay curve can be used to determine average ozone residual. This typically produces higher average ozone residuals, and thus higher CT. However, the ozone decay constant must be determined and the math is more complicated.

The SWTR Guidance Manual (Appendix O) allows use of the integration method to determine CT, but it needs to be verified and approved for specific conditions. In December 2000, CH2M HILL Engineers, Inc. developed the Ozone Operations Report. In that report, data were collected for the integration method. In a letter dated February 7, 2001, MDEQ approved the integration method concept and method to determine the ozone decay constant. However, the integration method would need to be proven for at least 6 months for consistency, then re-evaluated before any approval. A sampling apparatus to determine the ozone decay constant is needed, and different equations to calculate CT are needed. In addition, documentation of the full-scale results of this method need to be submitted to MDEQ for approval.

Ozone Summary

If it were possible to triple the current ozone CT, 0.5-log *Cryptosporidium* inactivation may be possible in warm water, but not cold water. Therefore, increasing CT of the current ozone system is not a year-round method of achieving additional *Cryptosporidium* credit. However, significant *Cryptosporidium* inactivation credit (i.e. 0.5 log) may be possible in warm water seasons. Therefore, ozone may be a temporary method to help comply with the LT2ESWTR under certain conditions if other methods such as combined filter effluent turbidity or two-stage lime softening are not possible.

UV Disinfection

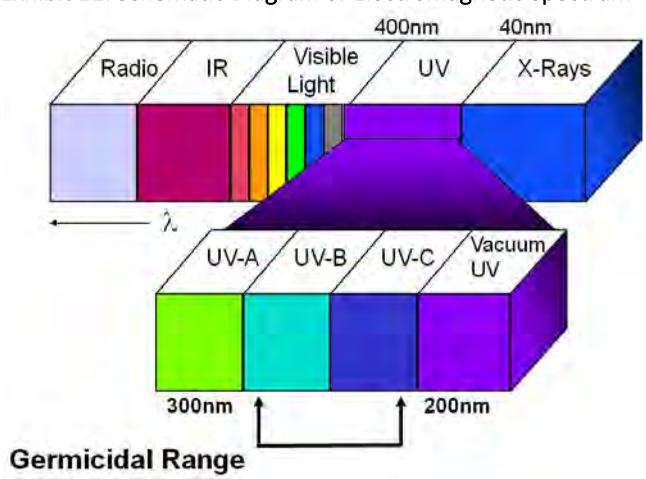
Fundamental Aspects of Ultraviolet Light

UV wavelengths occupy a region of the electromagnetic spectrum between x-rays and visible light. The UV spectrum is divided into four regions, based on wavelength (Meulemans 1986):

- Vacuum UV (100 to 200 nanometers [nm])
- UV-C (200 to 280 nm)
- UV-B (280 to 315 nm)
- UV-A (315 to 400 nm)

UV disinfection occurs due to the germicidal action of UV-C with microorganisms. Virtually all UV disinfection systems generate UV light by applying a voltage across a mercury vapor lamp. Mercury is an advantageous gas for UV disinfection applications in that it emits light in the germicidal wavelength range. Exhibit 11 shows a schematic of the electromagnetic spectrum.

Exhibit 11. Schematic Diagram of Electromagnetic Spectrum



Ultraviolet Transmittance

UV transmittance (UVT) is an important process control parameter in UV disinfection. UVT is the efficiency with which water transmits UV light, expressed as a percentage.

$$\%\boldsymbol{UVT} = \mathbf{100} * \mathbf{10}^{-\boldsymbol{A}_{254}}$$

Where A_{254} is specific absorbance of the medium at 254 nm, using a 1 centimeter (cm) path length quartz cuvette. Measurement of A_{254} is described in Standard Method 5910B.

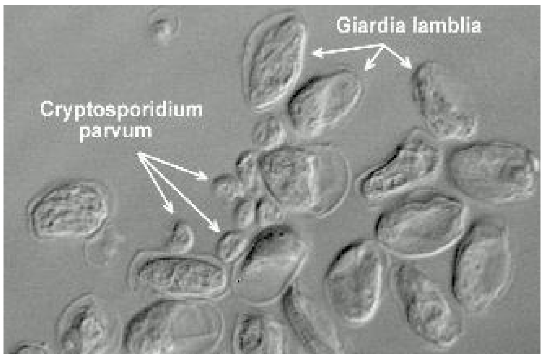
Ann Arbor should develop a database for UVT in the filtered water if future UV disinfection treatment is being considered. UVT is also useful as an indicator of organics removal through the treatment processes.

Mechanics of Ultraviolet Disinfection

UV light inactivates microorganisms by damaging the organism's deoxyribonucleic acid (DNA) or ribonucleic acid (RNA), thereby interfering with the organism's ability to reproduce and cause infection in a host organism. Damage to nucleic acids does not prevent the cell from undergoing metabolism and other cell functions. The organism is alive after exposure to UV light, but it cannot reproduce.

Variations in DNA content cause microorganisms to absorb UV light differently, thereby contributing to the differences in microorganism susceptibility to UV disinfection. Among pathogens of interest to drinking water, viruses are most resistant to UV disinfection, followed by bacteria, *Cryptosporidium* oocysts and *Giardia* cysts.

Photograph of *Cryptosporidium* parvum oocysts and Giardia lamblia cysts.



Ultraviolet Dose

UV dose is a measurement of the energy per unit area that is incident on the surface. UV dose is a product of the average intensity acting on a microorganism from all directions and the exposure time. Units commonly used to express UV dose are: milliwatts per second per square centimeter or millijoules per square centimeter (mJ/cm^2).

Dose delivery in a continuous-flow UV reactor is subject to hydrodynamics, UV intensity distribution, UVT of the water and flow rate. It is therefore difficult to directly calculate UV dose.

Unlike chemical disinfection (a chemical residual can be measured contact time estimated) there are currently no methods to directly measure the dose distribution in a continuous flow UV reactor. Therefore, the UV dose in a UV reactor is estimated as the reduction equivalent dose (RED). The RED is a calculated dose for a flow-through UV reactor that is based on biodosimetry and validation testing. The RED is set equal to the UV dose in a collimated beam test that achieves the same level of inactivation of the challenge microorganism as measured for the flow-through UV reactor during biodosimetry testing.

Due to these sources of uncertainty, the LT2ESWTR requires Public Water Systems to use UV reactors that have undergone validation testing. Validation testing must determine the operating conditions under which the reactor delivers the required UV dose for treatment credit (40 CFR 141.720(d)(2)). These operating conditions must include flow rate, UV intensity as measured by a UV sensor, and UV lamp status.

UV doses to inactivate *Cryptosporidium*, Giardia and viruses are shown in Exhibit 12. These doses are not the RED, nor do they account for specific UV equipment factors that may increase the dose. In general, the actual applied UV reactor dose can be about two to three times the dose shown in Exhibit 12. The UV doses in Exhibit 12 are applicable to filtered water.

Exhibit 12. EPA UV Dose Requirements

	Target Pathogens (mJ/cm^2)		
Log Inactivation	***Cryptosporidium***	***Giardia***	***virus***
0.5	1.6	1.5	39
1	2.5	2.1	58
1.5	3.9	3	79
2	5.8	5.2	100
2.5	8.5	7.7	121
3	**12**	**11**	143
3.5	15	15	163
4	22	22	186

UV is very effective for inactivation of *Cryptosporidium* and Giardia. Three-log *Cryptosporidium* and Giardia inactivation is a common design criteria for UV disinfection. With UV, all the Giardia inactivation requirements can be met as well. With a UV treatment approach, Ann Arbor would be less dependent on ozone for disinfection.

UV disinfection would provide much greater operational flexibility. With Giardia and *Cryptosporidium* inactivation achieved by UV, low CFE turbidity or two-stage softening would not be required. In addition, ozone operation would be simplified since Giardia CT from ozone would not be required when UV is in operation.

UV is not as effective on some viruses, so virus inactivation with ozone and chlorine/chloramines would still be required. There are no known byproducts of UV at the low doses used for inactivation of *Cryptosporidium.*

A 3-log inactivation of *Cryptosporidium* and *Giardia* following UV reactor and UV dose guidelines established in EPA's *UV Disinfection Guidance Manual* (2006) would provide a *Cryptosporidium* barrier for a LT2ESWTR Bin 4 classification and allow Ann Arbor to cease future *Cryptosporidium* monitoring once the UV system is operational.

At UV doses for 3-log inactivation of *Cryptosporidium,* there might be a slight reduction (~0.1 mg/L) in chloramine residual after passing through UV. This can be mitigated by slightly increasing chloramine dose before UV. Chloramination after UV can be considered, depending on the final location of UV.

UV doses for 3-log inactivation of *Cryptosporidium* are not effective for removal of contaminants such as 1,4-Dioxane. Much higher UV doses, combined with hydrogen peroxide can be used for oxidation of certain chemical contaminants. This is called the UV advanced oxidation process.

UV Equipment

A typical UV reactor is shown in Exhibit 13. Water passes through a pipe and around lamps in the UV reactor that emit UV light. A water plant UV installation is shown in Exhibit 14. Each UV reactor train includes a flowmeter and valves. Flowrate and UVT can be measured on-line to control power requirements to the UV lamps to maintain a specified UV dose. There are specific upstream and downstream pipe length requirements for good UV performance within the validation parameters.

Exhibit 13. UV Reactor

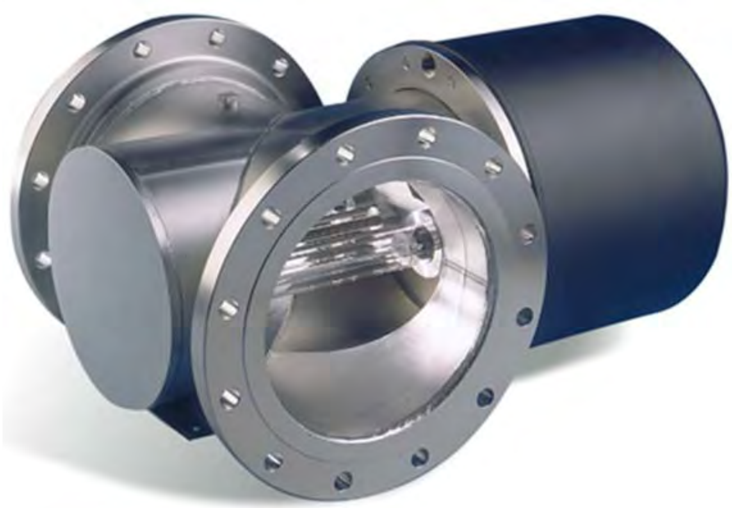


Exhibit 14. Water Plant UV Installation

Each UV reactor has a power supply unit, which contains lamp ballasts, electrical power equipment and controls. Typical UV power supply units are shown in Exhibit 15.

Exhibit 15. UV Power Supply Units

UV Operations and Monitoring

UV systems are typically operated automatically, with flowrate and UVT controlling the UV dose. Sensors in the UV reactor measure UV intensity and this is converted to UV dose through the control system logics. Remotely operated valves can be used to select which UV reactors are in operation and control flowrate. There are specific start up and shut down procedures programmed into the UV controls.

Off-spec water is any water that does not receive the target UV dose. It is produced during routine system startup, UV system failure, UV equipment critical alarm, or plant electrical power failure. EPA allows 5 percent off-spec water on a monthly volume basis. Individual States may have more stringent requirements. If a lamp breakage occurs, a protocol must be in place to minimize release of mercury into the water.

UV reactors need to be periodically shut down for regular maintenance, including UV sensor calibration, checking lamp fouling and cleaning mechanisms, and replacing lamps and sleeves.

The LT2ESWTR requires water systems to submit validation test results demonstrating operating conditions that achieve required UV dose. These are available from UV equipment manufacturers that have validated reactors. A monthly report summarizing the percentage of water entering the distribution system that was off-spec is also required. States may require additional information in the monthly report such as daily minimum UV dose and log inactivation.

UV Integration into the City of Ann Arbor Water Plant

UV is most often installed on filtered drinking water. At the City of Ann Arbor water plant, a logical conceptual location would be downstream of the filtered water transfer pumps and upstream of the finished water reservoir. Space is limited on the plant site. A UV facility building might have an area of approximately 3,000 square feet, including the electrical room. There may be space for such a facility near the finished water reservoir. Yard piping provisions into the UV facility and into the reservoir would need to be evaluated. Additional head on the existing transfer pumps would also need to be considered.

Conceptual UV design criteria for the Ann Arbor plant is presented in Exhibit 16.

Exhibit 16. Conceptual UV Design Criteria

Design Parameter	Value
Average Flow Rate	18 mgd
Design Flow Rate	50 mgd
Inactivation Goal	3-log Crypto/Giardia
Design UV Dose	12 mJ/cm^2
RED Dose	30 mJ/cm^2
Design UVT (needs verification)	88%
Total UV Reactors	3
Standby Reactors	1
Max Flow per Reactor	25 mgd
Lamps/Sensors per Reactor	10/10
Total Connected Load	120.0 kW
Power Draw at Average Flow	38.4 kW

kW = kilowatt(s)

UV Cost Estimate

Conceptual level construction cost estimates (Association for the Advancement of Cost Engineering Class 5; +100/-50 percent) in 2017 dollars were developed for the UV facility. Cost estimates were prepared based on information available at the time of the estimate. Detailed engineering design has not been done. The final cost estimate of any project will depend on market conditions, site conditions, final project scope, schedule and other variable factors. As a result, final project costs will vary from the estimates presented here. Construction costs include contractor mobilization, insurance, bonds, and other overhead costs as well as a 25 percent contingency. The UV cost estimate was prepared with CH2M HILL Engineers, Inc.'s proprietary parametric cost estimating system. Ann Arbor specific design criteria are entered into the cost estimating system to size the UV facility and determine quantities. It is based on actual UV installations around the world and updated annually.

A summary of the UV construction cost estimate is provided in Exhibit 17.

Exhibit 17. UV Conceptual Construction Cost Estimate

Component	Cost
Sitework	$20,000
Concrete	$100,000
Yard Piping	$750,000
Masonry	$700,000
Metals	$100,000
Equipment	$1,500,000
Instrumentation and Control	$500,000
Mechanical, Piping, Valves	$1,000,000
Electrical, UPS	$1,300,000
Finishes	$100,000
Subtotal	**$6,070,000**
Contractor Markups	
Overhead (12%)	$728,000
Subtotal	$6,798,000
Profit (5%)	$340,000
Subtotal	$7,138,000
Mob/Bonds/Insurance (5%)	$357,000
Subtotal	$7,495,000
Contingency (30%)	$2,249,000
Total	**$9,744,000**

Annual operation and maintenance (O&M) costs are estimated in Exhibit 18. UV may also reduce ozone costs, if lower ozone doses meet water treatment goals.

Exhibit 18. UV O&M Cost Estimate

	Cost per Year	Comments
Energy	$21,864.96	$0.065/kWh, 18 mgd average day demand
Lamp Replacement	$3,750.00	9,000 hours, $375 per lamp
Ballast Replacement	$9,000.00	10 years, $3,000 per ballast
Sleeve Replacement	$900.00	10 years, $300 per sleeve
Sensor Replacement, Calibration	$5,975.00	10 years, $1,325 per sensor, sensor checks, UVT calibration
Labor	$31,250.00	625 hours at $50 per hour average
Annual O&M Cost for MPUV	$72,739.96	--
Unit Cost per 1,000 Gallons	$0.011	18 mgd average day demand

kWh = kilowatt-hour(s)

UV Summary

UV is a very effective *Cryptosporidium* inactivation technology. Typical UV systems are designed for 3-log *Cryptosporidium* inactivation. UV can also meet the Giardia inactivation requirements. UV along with ozone and chloramines provides good multiple barrier disinfection for pathogens. Operational flexibility is greatly increased with UV.

UV could be integrated into the water plant between the filters and finished water reservoir. There are many considerations and design investigations required to integrate UV into the complicated Ann Arbor water plant. A conceptual design level construction cost estimate for a 50-mgd UV facility is approximately $9.7 million in 2017 dollars. Annual O&M costs are estimated at $73,000 for an average day flow of 18 mgd, or $0.011/1,000 gallons in 2017 dollars.

UV should be considered along with future improvements at the Ann Arbor water plant for meeting the disinfection requirements of the LT2ESWTR and providing a good multiple barrier approach to disinfection.

Recommendations

Six alternatives for complying with the Bin 2 requirements of the LT2ESWTR were evaluated. The following alternatives were evaluated:

1. Watershed Control Program
2. Two-stage Lime Softening
3. Combined Filter Performance
4. Individual Filter Performance
5. Ozone
6. UV

Based on the evaluation of alternatives, the following recommendations are made.

Short Term (1 to 2 years)

The following alternatives are recommended to begin implementation.

Two-Stage Lime Softening

Use the Two-Stage Lime Softening tool from the LT2ESWTR Microbial Toolbox to obtain an additional 0.5-log *Cryptosporidium* credit. Submit required documentation to MDEQ and include data in monthly operating reports.

Combined Filter Performance

Use the Combined Filter Performance tool from the LT2ESWTR Microbial Toolbox to obtain an additional 0.5-log *Cryptosporidium* credit. Submit required documentation to MDEQ and include data in monthly operating reports.

Together, Two-Stage Lime Softening and Combined Filter Performance can provide the additional 1.0-log *Cryptosporidium* credit required for Bin 2. However, two-stage softening may not be available at all times currently, and is planned to be eliminated in the future. Therefore, a longer-term plan for compliance is needed.

Individual Filter Performance

Continue good filtration practices and collect data for the Individual Filter Performance 0.5-log *Cryptosporidium* credit. With good individual filter performance, an additional 0.5-log *Cryptosporidium* credit may be available at times in case the Two-Stage Lime Softening credit is not available. However, the Individual Filter Performance 0.5-log *Cryptosporidium* credit cannot be met at most times, based on current data.

Ozone

Further investigate ways to obtain greater ozone CT. An additional 0.5-log *Cryptosporidium* credit may be available in warmer water conditions as a temporary measure. This credit could be used under the right conditions if one of the Two-Stage Lime Softening or Combined Filter Performance credits are not available.

Methods to obtain greater ozone CT may include:

- **Increase the ozone dose.** Ozone dose can be increased up to a point, depending on flow rate. Bromate formation needs to be considered so that the bromate regulations are not exceeded at higher ozone doses. The addition of small amounts of ammonia and chlorine before ozone can reduce bromate formation.

- **Lower the pH.** Ozone is more stable at lower pH and the ozone residual will persist in the ozone contact basins longer, thus increasing CT. Lower pH can also reduce bromate formation. However, the pH needs to be increased after ozonation with sodium hydroxide to stabilize the water for distribution system corrosion and reduction of nitrification potential. Chemical costs for carbon dioxide and sodium hydroxide will increase.

- **Side Stream Ozone Injection.** Side stream injection will use more of the ozone contact basin because ozone is added to the first cell. This increases contact time and CT. However, the recycle pumps need to be operated, resulting in higher cost. This is not the normal operating method, so other operational or maintenance issues may arise. As with increasing the ozone dose, bromate reduction also needs to be considered.

- **Request modification of the CT calculation method**. Using the integration method to determine average ozone concentrations can increase CT. A sampling apparatus to determine the ozone decay constant is needed, and different equations to calculate CT are needed. In addition, documentation of the full-scale results of this method need to be submitted to MDEQ for approval.

To obtain ozone CT credit for *Cryptosporidium* using the conventional CT method, a different CT calculation is required because the first ozone dissolution cell does not get CT credit for *Cryptosporidium.* This results in lower CT values for *Cryptosporidium* than currently calculated for Giardia. Even if the integration method were used for CT, obtaining 0.5 or 1-log *Cryptosporidium* inactivation with ozone in cold water would not be practical. Therefore, the current ozone system is not a long-term solution for additional *Cryptosporidium* inactivation.

Unless an alternative method is approved by MDEQ, the conventional method of CT determination should continue to be used. The CT spreadsheet should be modified to obtain additional Giardia inactivation credit in very cold water if a 0.3 mg/L ozone residual is established in the first cell.

Long Term (3 to 6 years)

Based on Ann Arbor’s current tools in the Microbial Toolbox to provide additional *Cryptosporidium* inactivation, CFE turbidity appears to be the most reliable. However, CFE turbidity alone does not provide enough *Cryptosporidium* inactivation to meet the Bin 2 requirements. Two-stage softening is not available at all times, and is planned to be eliminated in the future. IFE turbidity requirements cannot be met most of the time, and ozone does not provide enough *Cryptosporidium* inactivation most of the time. Relying on two-stage softening and CFE to meet the *Cryptosporidium* inactivation requirements provides no safety factor for compliance, and limits the water treatment plant's operational flexibility. While two-stage softening and CFE can help Ann Arbor comply in the short term, it is not a recommended long-term solution.

It is recommended to look further into UV disinfection as the long-term method of providing additional *Cryptosporidium* credit and multiple barriers to public health protection.

UV Disinfection

UV disinfection can easily provide 3-log *Cryptosporidium* inactivation. By achieving 3-log *Cryptosporidium* inactivation, 3-log Giardia inactivation is also achieved. UV can reduce the dependence on ozone for primary disinfection of Giardia and *Cryptosporidium.* UV and ozone work well together because ozone improves UVT, which reduces the UV energy required to disinfect water.

UV would eliminate the need to obtain additional *Cryptosporidium* inactivation credit from CFE turbidity, ozone or two-stage softening. UV disinfection would greatly simplify operations, and provide another robust disinfection barrier for public health protection. In addition, future *Cryptosporidium* monitoring could cease. Since UV disinfection is effective for many bacteria, protozoan and viruses, it positions Ann Arbor for future regulations on pathogens. EPA's Contaminant Candidate List 4 contains 12 microbial pathogens that are being considered for future regulations.

A UV system would be a new process for the Ann Arbor water plant. As plant improvements are planned in the future, UV should be considered and the best way to integrate UV into the treatment processes evaluated.

UVT should be measured in the filtered water once daily for at least a year to develop a database on UVT for sizing the UV system. UVT can also indicate organics removal through treatment processes.

Changing disinfection methods requires a disinfection profile to document current disinfection practices, and disinfection benchmarking to document the new disinfection methods. These plans need to be approved by MDEQ.

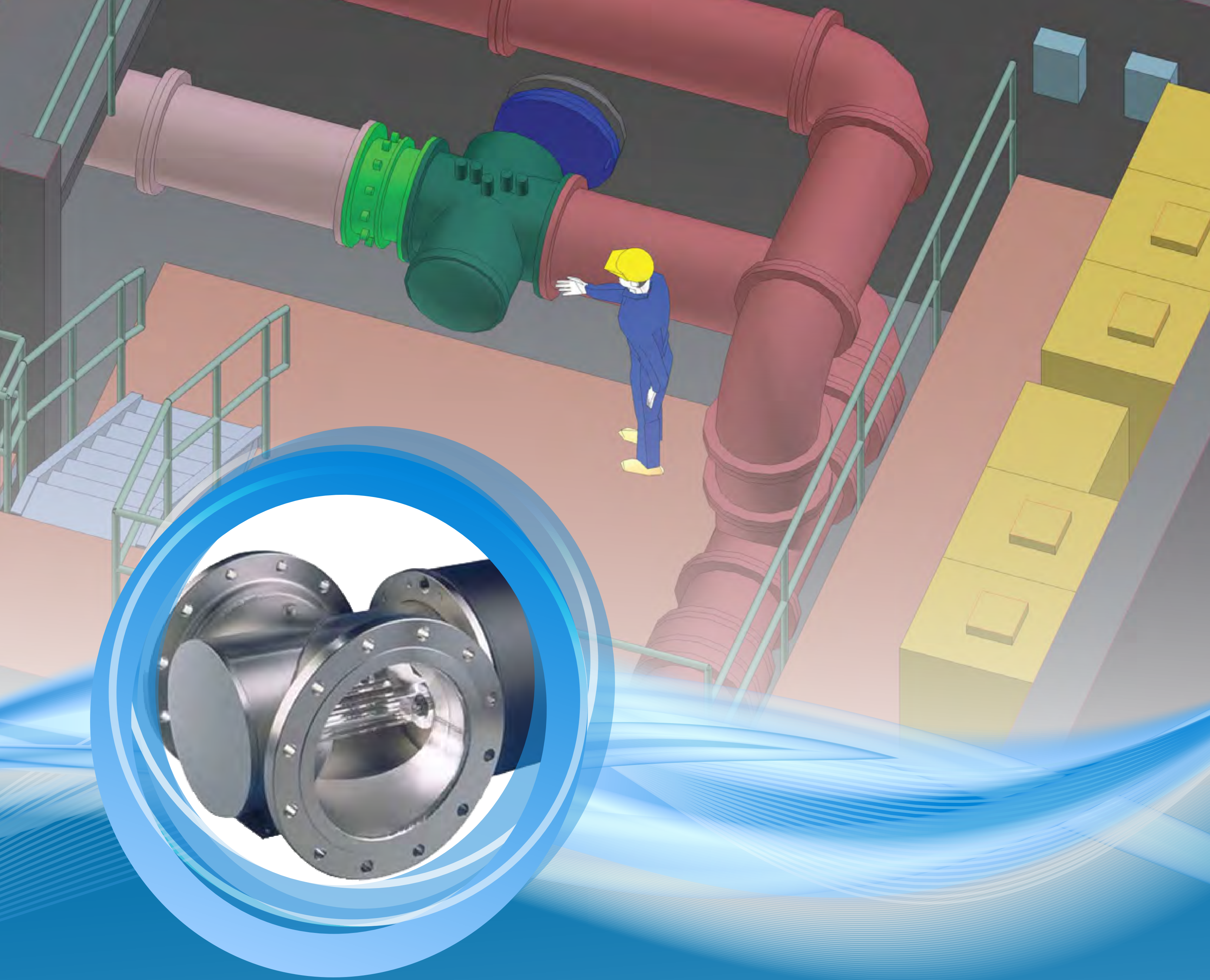
Watershed Protection

Efforts by Ann Arbor to improve the watershed and control contamination are commendable and should continue.

Ann Arbor may not be able to rely on watershed control practices to achieve 0.5-log *Cryptosporidium* credit due to lack of control and jurisdiction over watershed practices or other reasons. However, practical watershed management practices that improve water quality and are implementable are valuable whether *Cryptosporidium* credit is obtained or not. The LT2ESWTR Toolbox Guidance Manual (Appendix F) summarizes many Watershed Control BMPs for controlling *Cryptosporidium*. These methods should be considered based on the following:

- Effectiveness to reduce *Cryptosporidium* in the source water
- Implementability
- Cost

Appendix C
Jacobs 2018 *Interim Ultraviolet Light Disinfection System Conceptual Design Report*



Interim Ultraviolet Light Disinfection System Conceptual Design Report

Prepared for
City of Ann Arbor –
Water Treatment Services Unit

JACOBS

November 2018

Interim Ultraviolet Light Disinfection System Conceptual Design Report

Draft

November 15, 2018

Prepared for

City of Ann Arbor –
Water Treatment Services Unit

Prepared by

JACOBS

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Acronyms and Abbreviations

EPA	U.S. Environmental Protection Agency
HMI	Human Machine Interface
kVA	kilovolt
kW	kilowatt
LT2	Long-term 2 Enhanced Surface Water Treatment Rule
MCC	motor control center
MDEQ	Michigan Department of Environmental Quality
mgd	million gallons per day
ng/L	nanograms per liter
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PLC	programmable logic controller
PTFE	polytetrafluoroethylene
SCADA	supervisory control and data acquisition
UPS	uninterruptable power supply
UV	ultraviolet light
UVDGM	*Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule* (EPA 2006)
UVT	ultraviolet light transmittance
V	volt

1. Background

In 2017, the Michigan Department of Environmental Quality (MDEQ) notified the City of Ann Arbor that its source of drinking water contains levels of *Cryptosporidium* (a parasitic pathogen), that require additional protection to comply with the Long-term 2 Enhanced Surface Water Treatment Rule (LT2) drinking-water regulations. MDEQ stated that compliance was required by June 2020. In late 2017, CH2M HILL (now Jacobs) worked with Ann Arbor Utilities on a study to comply with the LT2 regulations for *Cryptosporidium*. The study indicated that Ann Arbor can use existing treatment processes such as optimized filtration, ozone, and two-stage lime softening to provide additional protection from *Cryptosporidium* and meet LT2 regulations. However, meeting the regulations continuously under varying operational and water quality conditions would be difficult. Ultimately, the study recommended ultraviolet light (UV) disinfection as a method to comply with the regulations and best protect public health.

Implementing a permanent UV disinfection system in Ann Arbor's large, complex water plant is a long-term project. Rapid implementation of an interim UV disinfection system is being conducted to provide enhanced disinfection at the water plant. This not only protects public health sooner but provides operational and regulatory benefits to the water system and its customers. Installation of an interim UV system will allow the City of Ann Arbor to comply with the MDEQ June 2020 deadline for additional *Cryptosporidium* protection. Having the interim UV system in place will make construction of the future water plant improvements project easier and less risky. In addition, UV equipment from the interim system may be able to be reused in a potential permanent UV system, if desired.

The City of Ann Arbor met with MDEQ on September 6, 2018, to discuss the concept of installing an interim UV disinfection system until Ann Arbor implements its future water plant capital improvements plan. MDEQ endorsed the concept of an interim UV disinfection system.

2. Purpose

The purpose of this report is to present the conceptual design of the interim UV disinfection facility at the Ann Arbor water plant. UV equipment suppliers were evaluated, and the top suppliers were selected to base the conceptual design around. Several alternatives for location of the interim UV disinfection facility were evaluated, and the best alternative was selected. Design criteria for the interim UV disinfection system are summarized in this report.

3. UV Equipment Supplier Evaluation

An information request was sent out on September 18, 2018, to six potential UV disinfection system suppliers. The purpose of the information request was to select a short list of UV equipment suppliers to provide UV equipment for the interim UV facility. Proposals were received by all six UV suppliers, and four were selected for onsite presentations on October 18 and 19, 2019. The presentations were conducted to an audience consisting of Ann Arbor water plant staff, Jacobs, and MDEQ. Appendix A provides a copy of the information request and agenda for the UV disinfection system presentations. Table 1 briefly summarizes the four UV systems that were presented.

Table 1. Summary of UV Disinfection System Characteristics

Supplier/System	UV Reactor Configuration	Lamp Type/Number
Calgon Carbon Corporation/Sentinel Series (24-inch)	1 duty; 1 standby	Medium Pressure Lamps 9 x 10 kilowatts per UV Reactor
TrojanUV, Swift Series (24-inch)	1 duty; 1 standby	Medium Pressure Lamps 8 x 9 kilowatts per UV Reactor
Xylem/Wedeco, Spectron 4000e Series	1 duty; 1 standby	Low-Pressure, High Output Lamps 24 x 0.6 kilowatts per UV Reactor
Suez/Ozonia, Aquaray Series (36")	1 duty; 1 standby	Medium Pressure Lamps 10 x 8 kilowatts per UV Reactor

A team from the Ann Arbor water plant and Jacobs evaluated the information and presentations. UV equipment suppliers were ranked with respect to drinking water experience, equipment characteristics, operations and maintenance considerations, and life-cycle costs. Both medium-pressure UV lamps and low-pressure, high-output lamps were considered. Table 2 describes some of the key UV disinfection technical criteria. A summary table of the UV disinfection system equipment characteristics is provided in Appendix A for reference.

Table 2. Summary of Key UV Disinfection System Evaluation Criteria

Criteria	Pertinence	Evaluation Summary
Physical Dimensions	Impacts the ability to retrofit UV inside the existing transfer pump station.	Medium-pressure UV reactors have a smaller footprint than low-pressure high-output reactors, making retrofit more feasible. TrojanUV has smaller, lighter control panels than CalgonUV, but both can fit by installing in pieces.
Ballast Technology: Electronic vs. Electromagnetic	Ballast technology impacts size, weight, power quality tolerance, and distance from panels to reactors	Electronic ballasts (TrojanUV, Wedeco, Ozonia) are smaller, lighter, and less costly, but require panels to be close (30 to 80 feet) from reactors. They are also less tolerant to voltage sag/surge Electromagnetic ballasts (CalgonUV) are heavier and costlier but allow up to 500 feet between panel and reactor. They also are more tolerant to power sags/surge.
Cleaning Systems	Automatic quartz sleeve cleaning system is required to remove scales that may accumulate	All medium-pressure UV reactors include automatic cleaning systems. TrojanUV used viton and Teflon mechanical wipers with integral cleaning solution. CalgonUV uses stainless-steel brushes for mechanical wiping only. Therefore, periodic manual cleaning may be required to maintain optimal energy efficiency.
Lamp Power Turndown	The ability to turn down UV reactor power draw impacts operations and maintenance costs	All UV reactors have the ability to vary lamp power between ~30% to 100% power level. Only CalgonUV also has the ability to turn lamps on/off, increasing the turndown capacity range from ~5% to 100%, potentially saving energy.
Experience	UV systems with greater number of installations and years of experience will have more reliable equipment and be more responsive to issues	TrojanUV and CalgonUV have the greatest number of similar installations. Wedeco and Ozonia have few installations in the US with similar equipment.

Based on this evaluation, two UV suppliers—Calgon Carbon Corporation and TrojanUV—were scored the highest. Both UV suppliers provide medium-pressure UV lamps. The equipment configuration of these two suppliers is similar and was used as the basis of the conceptual design. Appendix A contains responses to the information request from CalgonUV and TrojanUV.

Both systems selected use Teflon® or PTFE (polytetrafluoroethylene) as part of their automatic sleeve cleaning systems. PTFE is a synthetic fluoropolymer of tetrafluoroethylene commonly used in the drinking water industry due to its robust nature under a wide variety of operating conditions. Depending on the production date and method, PTFE can be a source of perflourinated compounds like PFOA (perfluorooctanoic acid) and PFOS (perfluorooctane sulfonate), which are currently being considered for more stringent maximum contaminant limits by MDEQ and the U.S. Environmental Protection Agency (EPA). Therefore, the City is interested in minimizing or avoiding the use of PTFE in the UV system.

Inquiries were made to both suppliers to estimate the quantity of PTFE used in the UV reactors and potential for alternate materials available. In addition, calculations were made to conservatively estimate the net concentration of PFOA that could enter the water supply based on leaching results from past groundwater sampling projects completed by Jacobs using Teflon® tubing (5.4 nanograms per liter [ng/L] of PFOA per gram of PTFE per day). CalgonUV uses about 1 lb of PTFE to hold stainless-steel sleeve wipers and the material is exposed to the water. CalgonUV can supply an alternate material, but with added cost ($15,000) and delays for equipment delivery due to NSF 61 certification required. If alternate materials are not used, the estimated PFOA concentration is about 1 x 10^-4 ng/L (ppt) to the finished water supply at 7 million gallons per day (mgd) of minimum flow, well below current detection limits.

TrojanUV uses about 0.022 lbs of PTFE as a bearing seal for the wiper mechanism, but the material is not exposed to the water matrix. The PTFE gasket is exposed to the cleaning solution inside a sealed chamber; therefore, while it is possible that some PFOA could leach out into the cleaning solution chamber, it is not expected to contribute significant PFOA to the finished water. Assuming the same leaching rate noted above, the estimated PFOA concentration is about 5.0 x 10^-9 ng/L at 7 mgd of minimum flow.

4. UV Alternatives Description

The following alternative locations and configurations for the UV disinfection system were considered:

1. Filter effluent piping
2. Transfer pump discharge piping
3. Containerized UV systems near the finished water reservoir

4.1 Alternative 1: Filter Effluent Piping

In some water plants, it is possible to place UV reactors on the filter effluent discharge piping. At the Ann Arbor plant, this is not possible for filters 1–10 due to the piping configuration and lack of space or access.

In filters 11–26, there are exposed filter effluent pipe headers that could possibly be locations for UV reactors. A minimum of three UV reactors would be needed (2 for filters 11–20 and one for filters 21–26). However, even three UV reactors does not include a backup UV reactor.

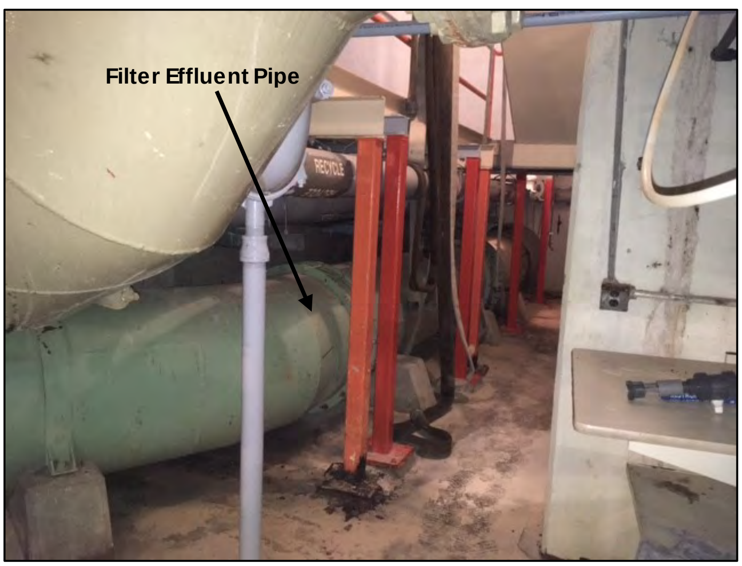


Figure 1. Filter 21–26 Effluent Pipe

Placing UV reactors on the filter effluent pipe headers poses several complications, including the following:

- Filters 1–10 could not be operational when UV was operational. This creates a significant plant capacity reduction and operational difficulties when shutting off and turning on 10 filters.
- Loss of a UV reactor in filters 11–20 can mean loss of up to 20 out of 26 filters, assuming filters 1-10 cannot be used for compliance. This creates more plant capacity reduction and operational difficulty.
- Access to the UV reactors is poor, especially in the filter 21–26 pipe header. This can cause operational and maintenance difficulty.
- Head loss in the filter effluent piping can shorten filter runs or decrease volume in the clearwells.

For these reasons, placing UV reactors on filter effluent piping was not considered further.

4.2 Alternative 2: Transfer Pump Discharge Piping

The Ann Arbor water plant has six transfer pumps that convey water from the filter effluent clearwells to the finished water reservoir. Transfer pumps 1–3 pump from clearwell 1, and transfer pumps 4–6 pump from clearwell 2.

There is inadequate space on the discharge of transfer pumps 1–3, so this location will not be evaluated further.

Transfer pumps 4–6 discharge in a lower room that used to contain high-service pumps. The high-service pumps have been removed, leaving available space. Figure 2 shows the transfer pump room.

Figure 2. Transfer Pump 4–6 Room

Figure 3 contains a conceptual layout for two UV reactors on the discharge of transfer pumps 4–6. One reactor can treat up to 25 million gallons per day (mgd), and the other reactor is a backup. The UV power supply panels are also shown.

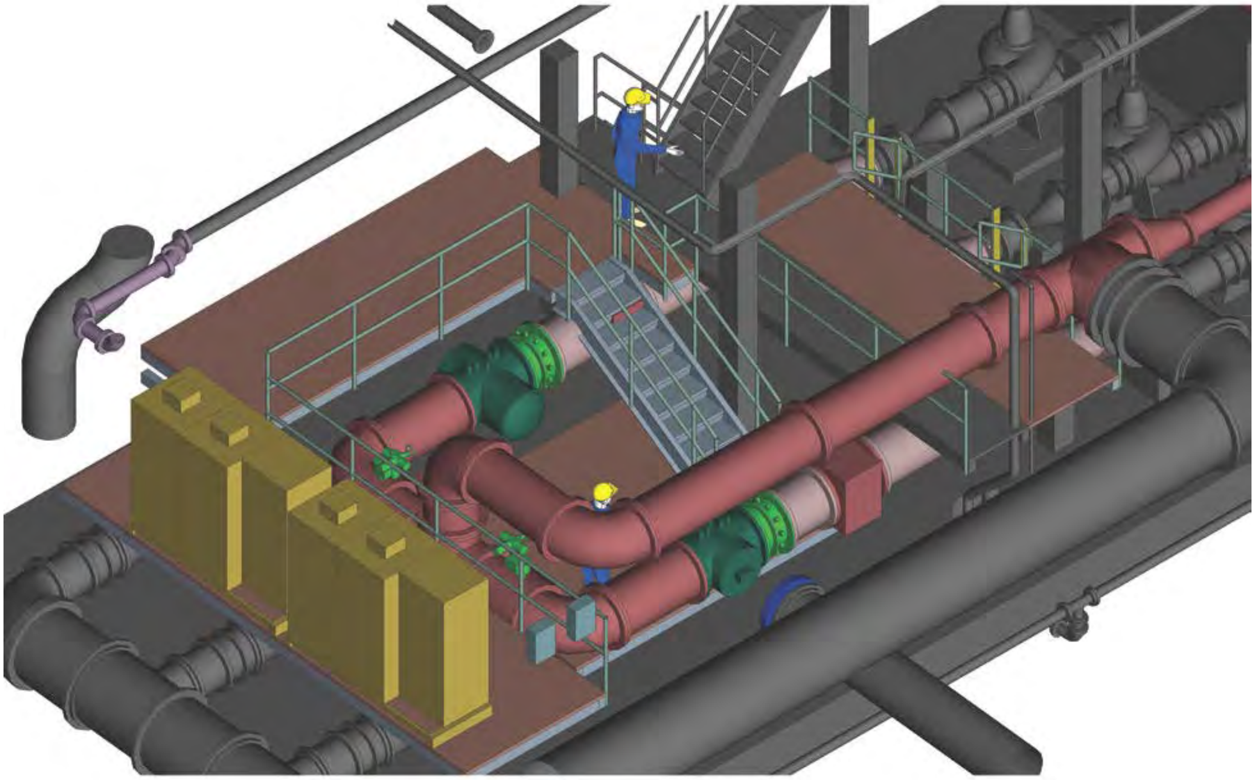
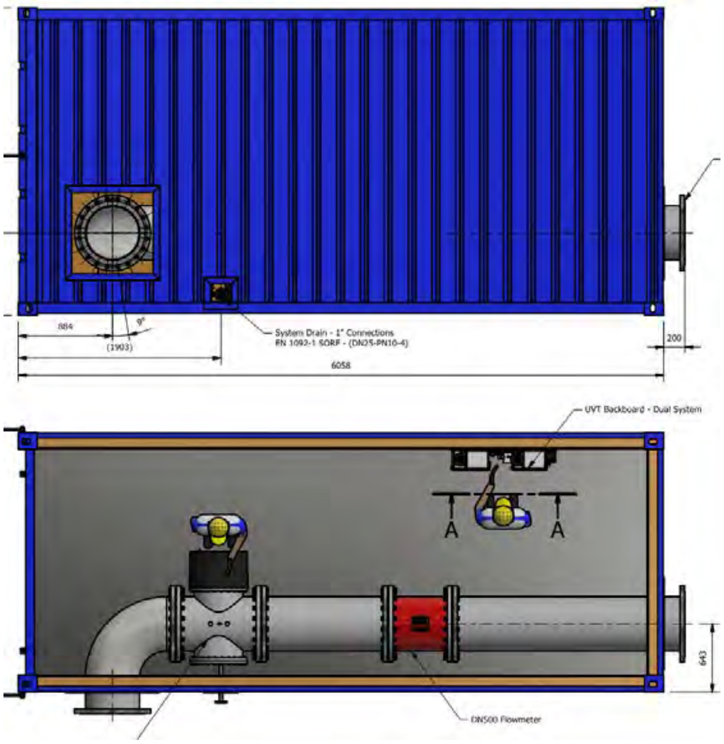


Figure 3. UV Concept in Transfer Pump Room

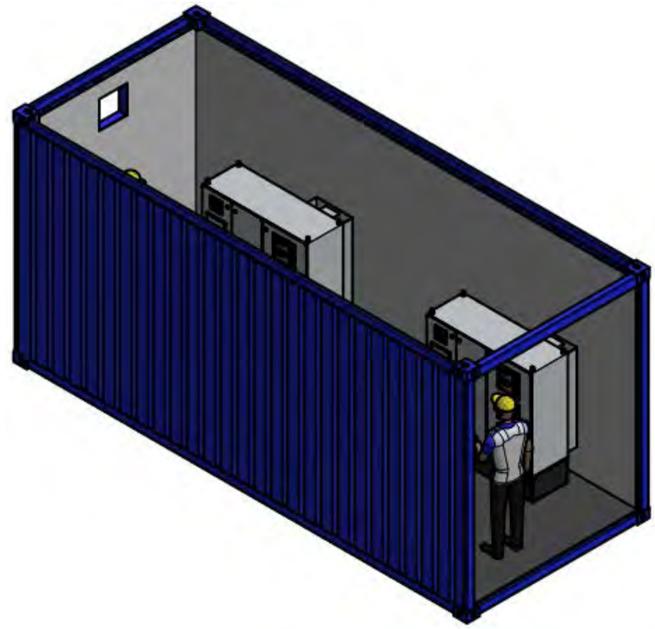
4.3 Alternative 3: Containerized UV Systems

UV reactors and power supply panels can be packaged inside a metal container, approximately 8 feet wide by 20 feet long. Based on the size of UV reactors needed for Ann Arbor, three containers would be required, two for the UV reactors and UV transmittance analyzers and one for the power supply panels.

Figure 4 shows a conceptual arrangement for these containers.



UV Reactor Container



UV Power Supply Panel Container

Figure 4. UV Containers

Given the existing yard piping arrangement and lack of available space on the Ann Arbor water plant site, locating the UV containers on the east side of the finished water reservoir was selected (Figure 5). Existing yard piping (transfer pump discharge piping) requires tie-ins and valves to direct water to the UV containers and then back into the reservoir.

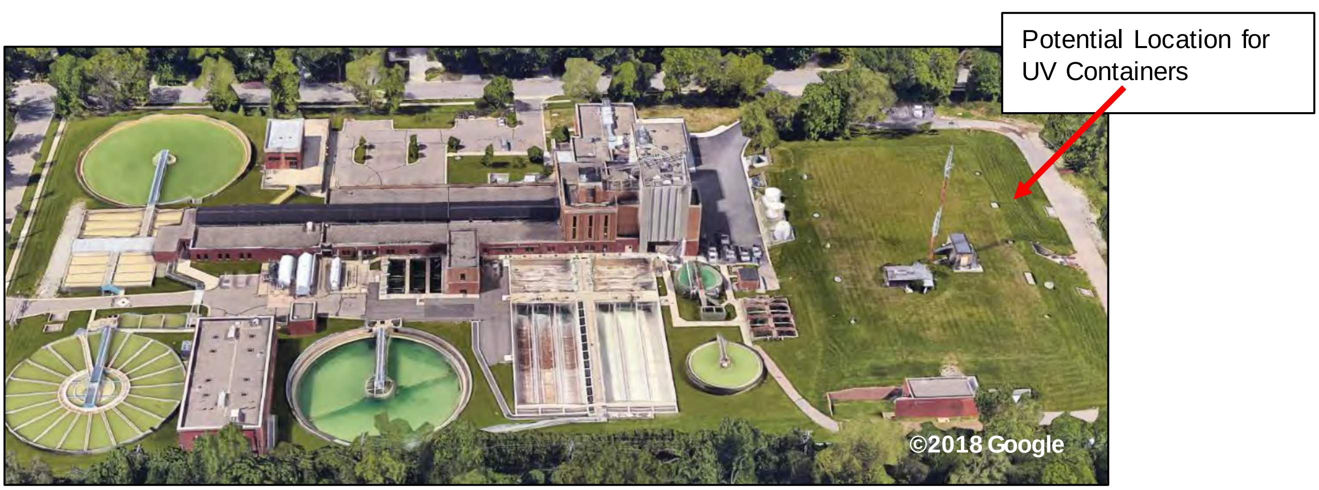


Figure 5. UV Containers Near Finished Water Reservoir

5. Alternatives Evaluation

Alternatives 2 and 3 were evaluated based on the following criteria:

- Performance for UV disinfection
- Ease of operations and maintenance
- Reliability
- Constructability
- Cost

Table 3 summarizes the evaluation. Each alternative was scored on a scale of 1 to 10 for each criterion, with 10 being the highest score.

Table 3. UV Alternative Evaluation Summary

Criterion	Transfer Pump 4–6 Room (Alternative 2)	Containers Near Reservoir (Alternative 3)	Comments
Performance for UV Disinfection	10	10	Both UV systems can meet the criterion for disinfection. Both systems have one duty and one backup reactor.
Ease of Operations and Maintenance	10	7	The transfer pump room is easier to access by plant staff since it is within the existing plant and near other facilities. The container system is hundreds of feet away from the main plant and more difficult to access, especially in winter. Space and climate for working are more adverse in the container system.
Reliability	7	8	The closer transfer pump room location makes it more reliable if issues arise. There is potential for the container system to treat water from either transfer pump station if yard piping and valves are arranged to do so.
Constructability	10	6	The container system requires excavation, retaining walls, and outdoor yard piping work. Electrical facilities will need to travel long distances underground. Delivery of the container system takes several months longer. The transfer pump room is all inside the existing building making construction easier. No earthwork or yard piping work is required. UV panels need to be installed in sections.
Cost	10	6	The container UV system is about 60% more expensive on a capital cost basis. This is mainly due to the additional cost of containers, earthwork, retaining walls, and yard piping. The container system will cost slightly more to operate since heat is needed in the winter.
TOTALS	**47**	**37**	

Based on this evaluation, placing the UV disinfection system in the transfer pump room (Alternative 2) was selected.

6. UV System Basis of Design

The preferred alternative is placement of the UV disinfection system inside the existing transfer pump 4–6 room. Table 4 summarizes the design criteria.

Table 4. Interim UV Disinfection System Design Criteria

	Parameter	Design Value (for Capital Sizing)	Operational Value (for Operations and Maintenance Estimates)	Future Expansion (Full Plant)
1	Number of UV Reactors	1 duty, 1 standby	1 duty, 1 standby	2 duty, 1 standby
2	UV Disinfection System Flow rate	25 mgd	15 mgd	50 mgd
3	Target Organism	*Cryptosporidium* (*Giardia* optional)		*Cryptosporidium* (*Giardia* optional)
4	Target Log Inactivation	3.0 log	1.0 log	To Be Determined
5	Surrogate Validation Organism	MS2 RED (T1 RED Optional Control Method)		To Be Determined
6	Validation Protocol	2006 EPA UVDGM		2006 EPA UVDGM
7	Ultraviolet light transmittance	88%	90%	88%
8	Lamp Aging Factor	0.9	0.95	0.9
9	Sleeve Fouling Factor	0.9 w / mech/acid auto wiping 0.8 w / mech auto wiping only	0.9 w / mech/acid auto wiping 0.85 w / mech auto wiping only	To Be Determined
10	Action Spectra Correction Factor	Variable per Water Research Foundation 4376 Guidance		Variable per Water Research Foundation 4376 Guidance
11	UV Lamp Type	Medium-Pressure		Medium-Pressure
12	Flange Size	24-inch ANSI		24-inch ANSI
13	Number of Lamps/Sleeves per UV Reactor	8 (TrojanUV) 9 (CalgonUV)		8 (TrojanUV) 9 (CalgonUV)
14	Lamp Technology	Medium Pressure		Same
15	Lamp Ballast Type	Electronic (TrojanUV) or Electromagnetic (CalgonUV)		Same
	Total Connected Load	156-kilowatt (TrojanUV) 180-kilowatt (CalgonUV)		234-kilowatt (TrojanUV) 270-kilowatt (CalgonUV)

UVDGM = *Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule*

Only UV equipment suppliers with significant similar installation experience and who have been pre-validated per the Final EPA *Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule* (UVDGM) guidelines (EPA 2006) were considered. The two UV reactors selected include the TrojanUV SWIFT 8L24 and the Calgon Sentinel 9L24. The TrojanUV Swift reactor contains 8 MP lamps of 9.1 kilowatts (kW) each and would have a total connected power load of 156 kW. The Calgon Sentinel reactor contains 9 MP lamps of 10 kW each and would have a total connected load of 180 kW.

In either case, a minimum of five straight pipe diameters, in addition to the number of straight pipe diameters provided during validation, will be provided upstream of the UV reactor to ensure that good hydraulics entering the UV reactor are achieved. This approach is consistent with Section 3.6.2 of the Final EPA UVDGM (2006).

Each UV reactor will be equipped with an automatic mechanical or chemical cleaning system to reduce the fouling due to iron, manganese, or hardness. During the initial 3 months of operations, the rate of fouling should be monitored closely, and the frequency of the automated cleaning system established. The Ann Arbor water treatment plant uses a lime-softening process and produces water with potential to precipitate calcium carbonate. As a result, there is potential for scaling on the quartz sleeves.

An automated wiping system is required. Ann Arbor also adds a polyphosphate to the filter influent water (upstream of UV), which can reduce the potential for calcium carbonate scaling.

Both UV systems being considered have automated wiping systems to remove scale buildup and can be programmed as frequently as once per hour. The TrojanUV system includes an acid cleaning system that would be beneficial for removal of carbonate scales compared to mechanical wiping only. Occasional manual cleaning of the UV lamp sleeves and UV intensity sensor ports may be necessary. Due to the scaling potential of the water, sleeve fouling factors will be applied to the design criteria to account for the potential loss of UV intensity due to scale formation.

Each UV reactor will also be equipped with an air-vacuum release valve and drain valve, to allow for easy draining of the UV train for maintenance purposes. Air-release valves will also be installed on the UV effluent header to remove air from the piping high point.

Figure 6. Example photograph of UV reactor quartz sleeves with calcium carbonate fouling

6.1 UV System Conceptual Layout

Appendix B contains conceptual layout drawings of the proposed UV system in the transfer pump room. All UV system components will be located in the transfer pump room, including control power panels and ultraviolet light transmittance (UVT) analyzers. The system will operate as duty/standby. One flowmeter will be provided for each UV reactor for ease of operations and maintenance, more reliability, and to better account for off-specification water. A master control panel will be installed to coordinate functionality of the UV reactor on/off operation, inlet/outlet valve operation, and transfer pump operation.

In consideration of possible future expansion, the two UV reactors, flowmeters, and control/power panels could be relocated to a new treatment facility. Adding a third UV reactor and panel would provide a firm capacity of 50 mgd.

6.2 UV System Hydraulics

Hydraulics for the existing system were assessed based on a letter dated September 21, 2001 from Barr Engineering to the City of Ann Arbor. Pump curves for transfer pumps 4, 5, and 6 were provided along with system head-loss curves through the existing pipe systems. Figure 7 shows an example pump curve for transfer pump 6. Pump curves for transfer pumps 4 and 5 are similar. The best efficiency point for these pumps occurs around 7 to 8 mgd and 30 to 40 feet total dynamic head, although the pumps can deliver up to 12.5 mgd at reduced efficiency.

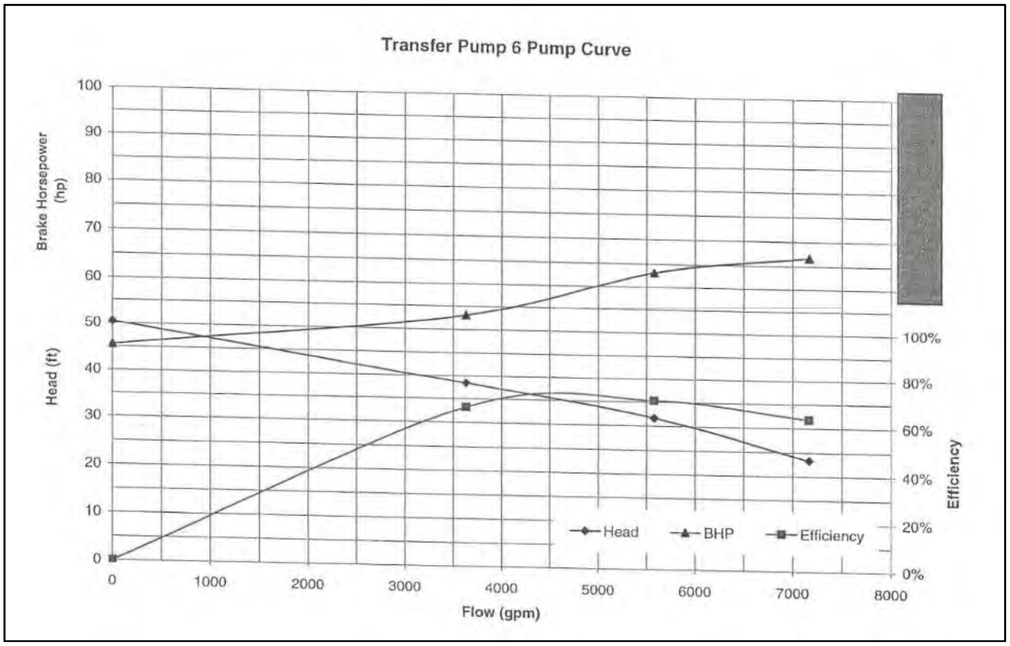


Figure 7. Pump curve for Transfer Pump 6 (Barr Engineering, 2001)

The ability of transfer pumps 4–6 to deliver a maximum flow of 25 mgd depends on the clearwell and reservoir levels. There is an approximately 13-foot range in static head due to clearwell and reservoir levels. The clearwell water surface elevation ranges from 972.5 to 976.5 feet while the reservoir water surface elevation ranges from 990 to 999 feet according to the Barr Engineering letter (2001). The City reports that the clearwell and reservoir water surface elevations vary as transfer pumps are turned on/off and pump speed changes to meet level setpoints programmed in the system. This approach ensures turnover of water through the clearwells and reservoirs. The estimated pump curve and system curve for the existing transfer pumps 5 and 6 were provided in the Barr Engineering letter (2001) and provided in Figure 8.

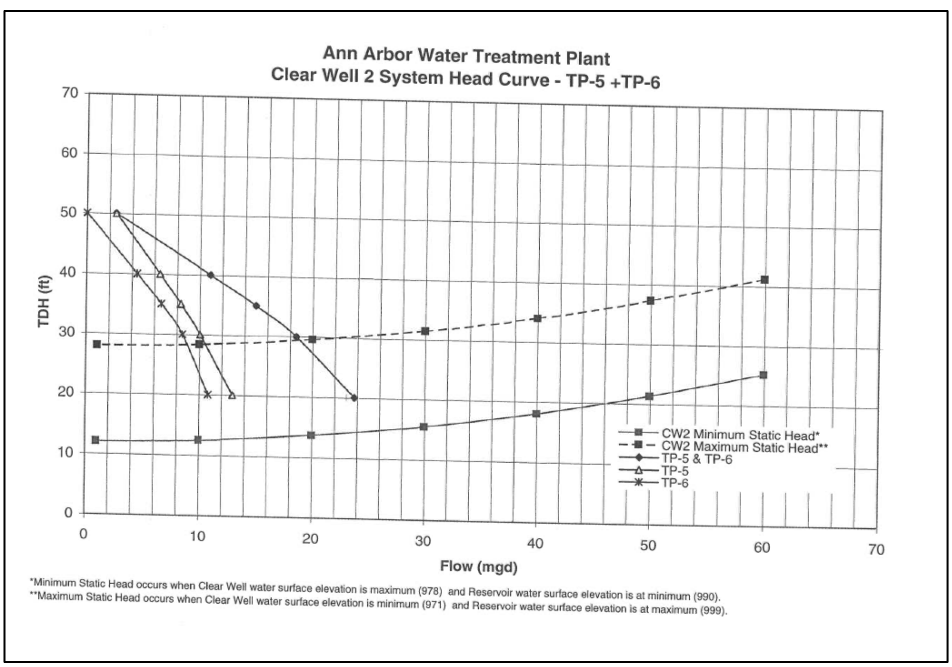


Figure 8. Existing Pump and System Curves for Transfer Pumps 5 and 6 (Barr Engineering, 2001)

The entire UV train, including pipes, valves, and UV reactors, will introduce a net increase in total dynamic head on the existing transfer pumps. A new system curve was developed, including the head loss induced by the UV reactors, piping, and valves, but subtracting out head loss incurred by portions of the discharge piping that will be removed (i.e., 16-inch pump discharge elbow up and connecting tees). The UV reactor head loss associated with the TrojanUV SWIFT 8L24 or Calgon Sentinel 9L24 UV reactor is about 22 inches and 29 inches at 25 mgd, respectively. Both UV reactors use 24-inch-diameter flanges. The head-loss curve for the Calgon Sentinel 9L24 UV reactor is provided in Figure 9.

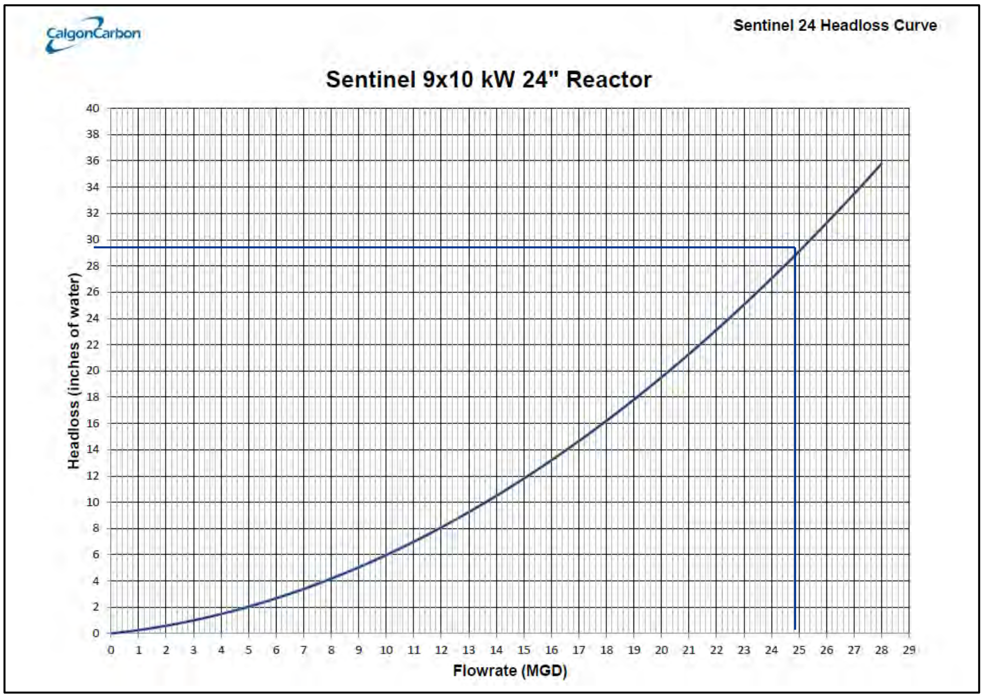


Figure 9. Head-Loss Curve for Calgon 9L24 UV Reactor

Figure 10 shows the revised system curves with additional head loss from the UV reactor and piping. Based on 24-inch UV system piping as shown in the proposed layout drawings***, two existing transfer pumps can deliver between 17 and 24 mgd, depending on clearwell and reservoir levels***. This hydraulic analysis assumes that the existing 16-inch pump inlet and discharge piping is retained.

Due to the varying flow rate delivered by the transfer pump station, the UV system control logic will need to respond rapidly to flow increases but can ramp down slowly during flow decreases. This will reduce the overall energy efficiency of the UV system, but will ensure adequate disinfection is achieve. Turndown of the lamp power will also be a key operational consideration. During periods of low flow, lamp power may be reduced to minimum levels to conserve energy. CalgonUV offers the additional advantage of operating fewer lamps as well.

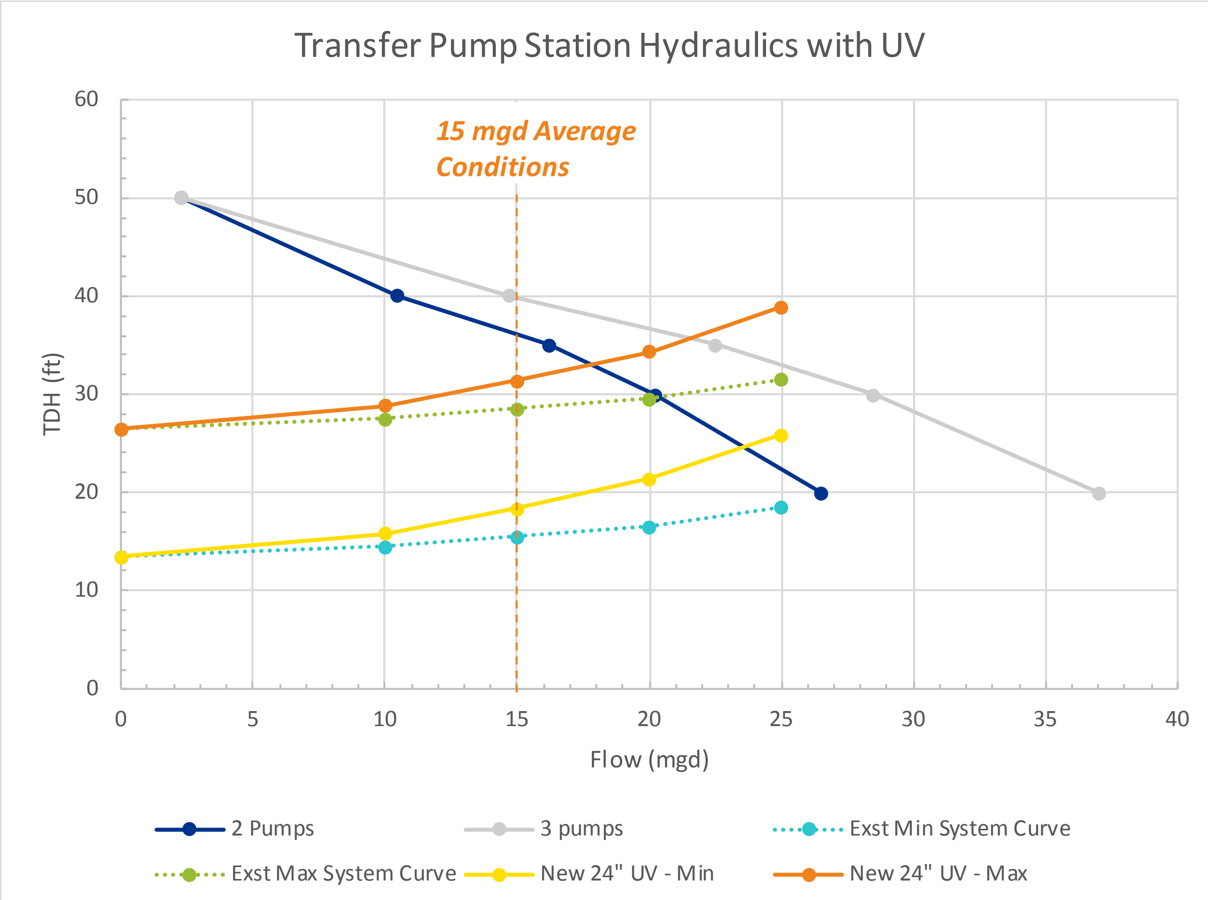


Figure 10. Transfer Pumps 4–6 System Head and Pump Curves

6.3 UV Disinfection System Flow Rate

Currently the Ann Arbor water plant can meet the LT2 regulations for *Cryptosporidium* through a combination of low combined filter effluent turbidity and two-stage softening. If either of these barriers is not in place, the LT2 regulations may not be met at all times. Low combined filter effluent turbidity is a very reliable barrier. Softening basins are typically taken out of service during low water-demand periods (November to April) for routine maintenance. It is during these times that UV would be required as an additional *Cryptosporidium* barrier because the two-stage softening process may not be available. For additional details on LT2 compliance, see the report *Long Term 2 Enhanced Surface Water Treatment Rule Study*, CH2M HILL December 2017.

The Ann Arbor water plant has a capacity of 50 mgd, but maximum day flows rarely exceed 25 mgd (Figure 11). Because UV disinfection is likely to be needed during low-demand periods, it is unlikely that the water demand would exceed 25 mgd when UV disinfection is operational. Figure 11 shows that water demand from November to April during the past 3 years typically does not exceed 15 mgd. Therefore, the transfer pump 4-6 firm capacity of 17 to 24 mgd is adequate. A third transfer pump can also be turned on for more capacity if needed.

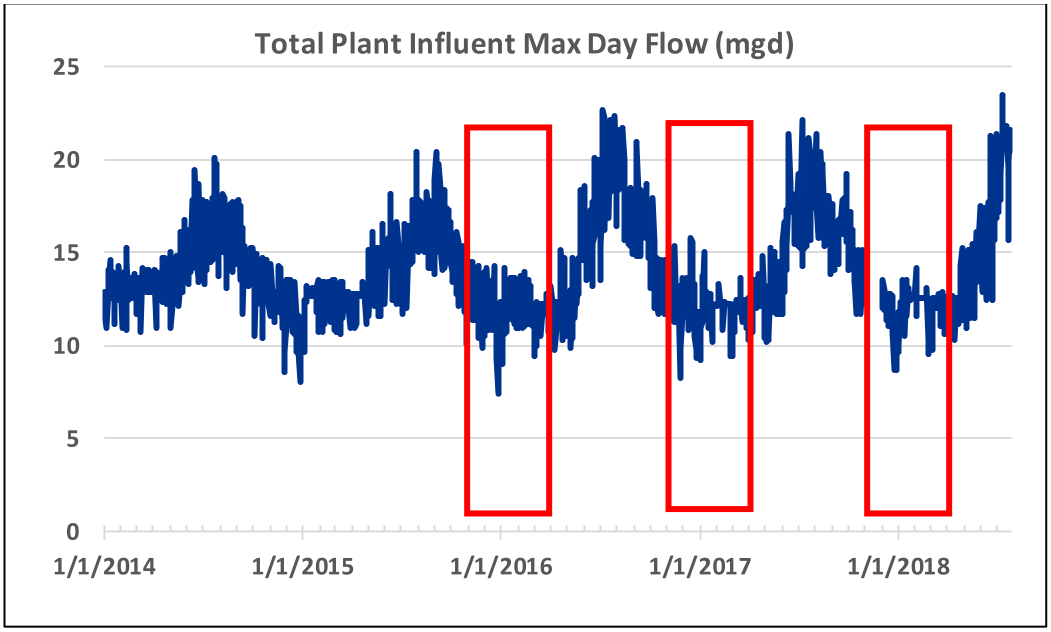


Figure 11. Water Plant Influent Maximum Day Flows (mgd)

Time when UV is required.

Each UV reactor will be sized to treat 25 mgd of flow for a firm capacity of 25 mgd, so UV reactor capacity is not limiting.

Another *Cryptosporidium* barrier that Ann Arbor has available is ozone disinfection. Based on the current ozone system design, an additional 0.5-log *Cryptosporidium* inactivation can be obtained when the water temperature is above about 20 degrees Celsius (see CH2M 2017 for additional details on LT2 compliance). This 0.5-log *Cryptosporidium* inactivation from ozone is equal to the credit given for two-stage softening. Therefore, ozone can be another method to comply with LT2 regulations in the rare event that two-stage softening is not available during summer months.

A general flow schematic from filtration to the reservoir is shown in Figure 12. A portion of the filtered water typically flows into clearwell 1 and is pumped to the reservoir by transfer pumps 1–3. The other portion of the filtered water typically flows into clearwell 2 and is pumped to the reservoir by transfer pumps 4–6. When UV disinfection is required, all filtered water will flow from clearwell 1 to clearwell 2 in series before being pumped to the reservoir through transfer pumps 4–6. Transfer pumps 1–3 will be shut down when the UV disinfection system is operational to ensure that all water passes through UV disinfection.

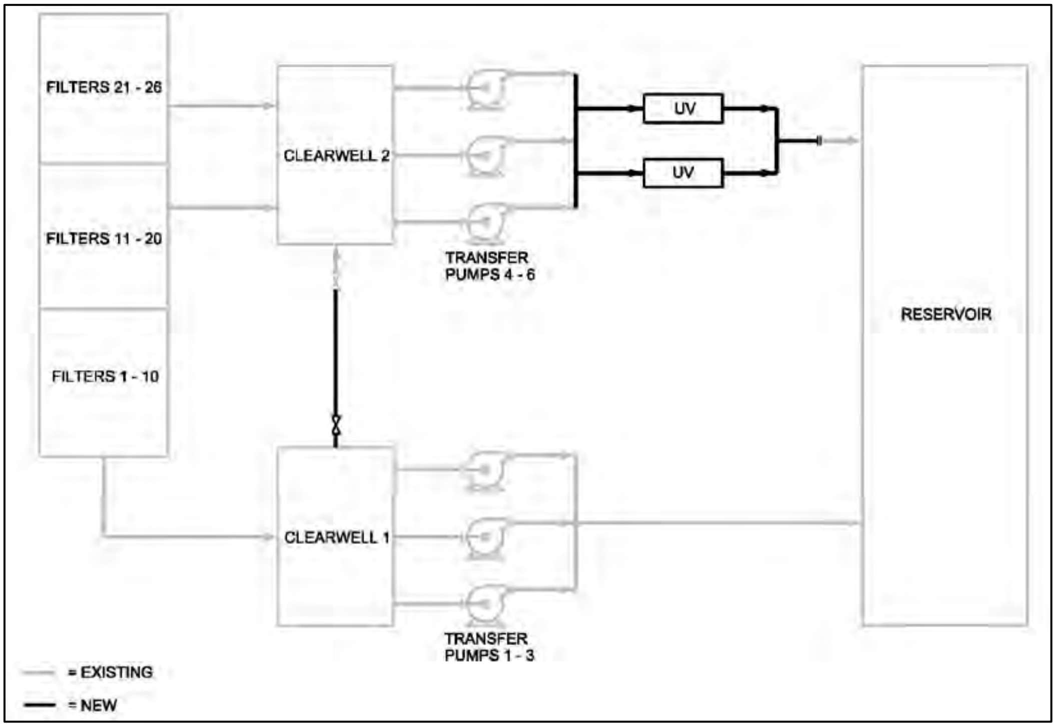
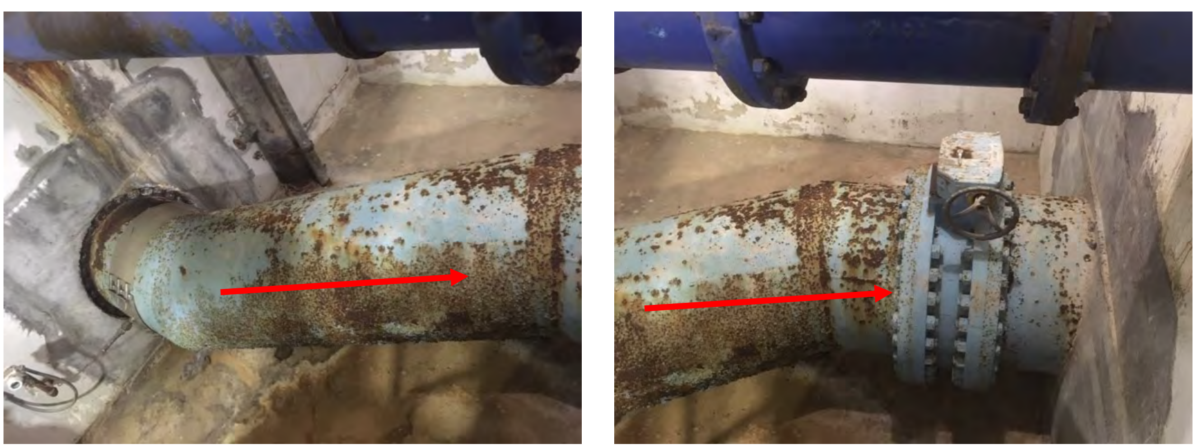


Figure 12. Flow Schematic from Filters to Reservoir

Clearwells 1 and 2 are connected by a single pipe with a single valve (Figure 13). As part of this project, most of that pipe will be replaced due to age and corrosion. A second valve will be added to the clearwell interconnect pipe to accommodate construction and provide more reliability. One of the valves will be electrically actuated so that it can be easily opened when UV disinfection is needed. There will be an electrical interlock to open the valve connecting clearwells 1 and 2 when UV disinfection is operational. This interlock will also shut down transfer pumps 1–3 so that all plant flow passes through UV treatment.



From Clearwell 1 *To Clearwell 2*

Figure 13. Clearwell Interconnect Pipe

6.4 UV Transmittance

UVT measures the ability of light at a wavelength of 254 nanometers to pass through water. A common measurement is percent transmittance. If water has a UVT of 90 percent, then 90 percent of the UV light passed through the water (measured in a 1 cm quartz cell) and the other 10 percent was absorbed by the water.

The design UVT of 88 percent was selected for Ann Arbor based on the 99th percentile value obtained from clearwell and reservoir samples. As shown in Figure 14, a minimum UVT of 86 percent was observed but occurred in May when flows are lower. Higher UVT values were observed in the summer during high-demand periods. Figure 14 shows historical UVT data. Ann Arbor will continue to collect UVT data, and the design value may be adjusted accordingly. Each UV reactor has been validated per the EPA UVDGM guidelines (EPA 2006).

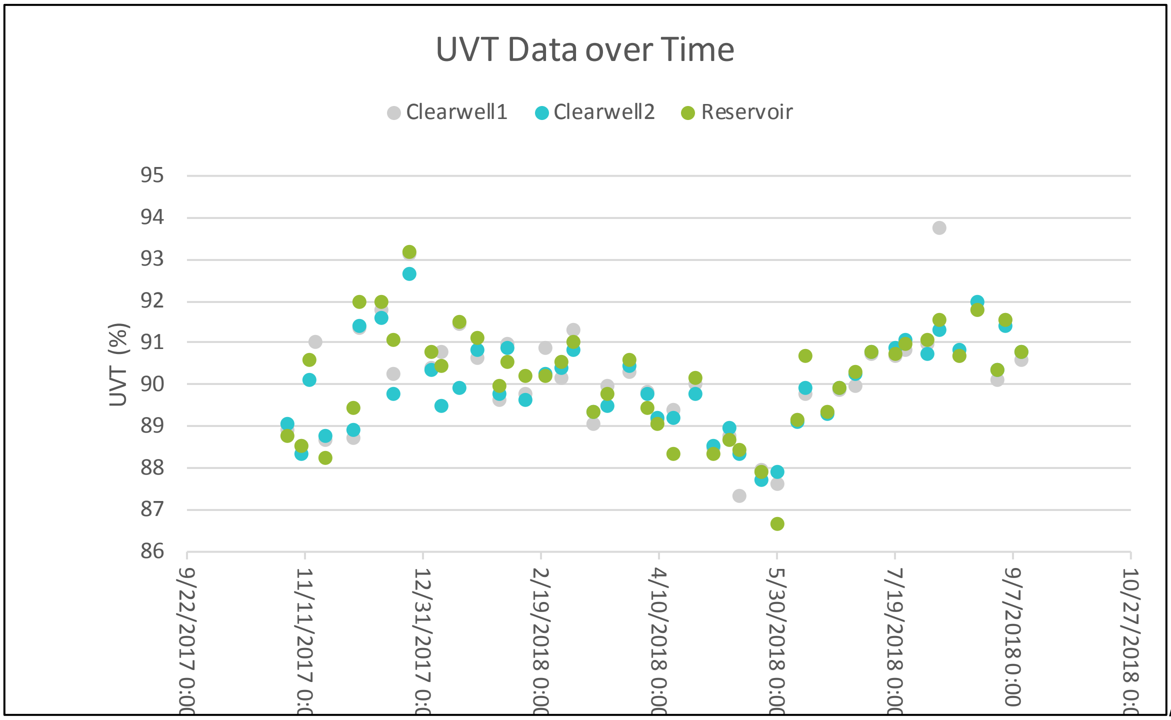


Figure 14. UVT in Clearwells and Reservoirs

6.5 Instrumentation and Controls

Each individual UV system/reactor will have a dedicated local control panel with an Allen Bradley CompactLogix programmable logic controller (PLC). The main responsibility of this PLC is to control the UV disinfection process and alert of any fault conditions. A Human Machine Interface (HMI) with custom screens will be included with each local control panel and will allow for manual operation of the disinfection process, if necessary. Should the power supplies be in a separate location from the reactors, a remote HMI mounted on a pedestal located near the reactor would be provided for local operator control and monitoring.

It is proposed to provide a Master UV Control Panel to handle all signals external to the reactor, such as valve actuators. The master control panel would be centrally located between the local control panels. The master control panel would also contain the same type of Allen Bradley CompactLogix PLC and would communicate via Ethernet communications to the individual local control panels, as well as upstream to the supervisory control and data acquisition (SCADA) system. If the length of the communication conduit to SCADA is more than 300 feet, fiber-to-copper converters would be installed, and fiber would be used for the Ethernet communications. Select hardwired signals would be incorporated, such as interlocks for the transfer pumps and clearwell valve, as required.

Additional network hardware, such as Ethernet switches or fiber-to-copper converters, required to interface the complete system to SCADA will be evaluated and included, as necessary.

6.5.1 Flow Measurement

An electromagnetic flowmeter on each UV reactor line will be installed to provide the necessary flow signal back to the UV system PLC for continuous UV dose measurement.

6.5.2 UVT Measurement

Two UVT analyzers will be installed inside the transfer pump station to continuously monitor the UVT of the water and provide the necessary UVT signal back to the UV system PLC for continuous UV dose measurement.

6.5.3 Off-Specification Water

Obtaining inactivation credit for the UV disinfection system to meet LT2 requires that at least 95 percent of the water treated by UV is within validated limits [40 *Code of Federal Regulation* 141.720(d)(3)]. This allows for up to 5 percent of the water volume treated with UV disinfection per month to be off-specification, or about 72 minutes of off-specification operation in a single day. Off-specification water is any volume of water that does not receive the target UV dose, flow exceeds validated limit, UVT is below validated limit, or the UV system is not operated in a manner that was simulated in validation testing. Off-specification water can be produced during routine system startup or in the event of UV system failure, UV equipment critical alarm, or plant electrical power failure. The interim UV disinfection system is designed to minimize off-specification water from entering the finished water reservoirs through several mechanisms, including having the UV system tied to the water treatment plant backup-power generator, an uninterruptable power supply (UPS) for each UV control panel PLC, a standby UV reactor, and automated valves. The UV control system will automatically track off-specification events, totalize the off-specification volume in 1-minute increments, and calculate the monthly total volume treated by UV disinfection to be included in monthly reports to MDEQ.

6.5.4 Chloramination

Filtered water is disinfected with chlorine and ammonia to form chloramines. The chlorine and ammonia are added before clearwells 1 and 2 through separate chemical lines to each clearwell influent. Chloramines, free chlorine, and free ammonia are measured at the effluent of clearwell 1 on the transfer pumps 1–3 discharge pipe and at the effluent of clearwell 2 on the transfer pumps 4–6 discharge pipe.

When UV is in operation, transfer pumps 1–3 will not be operational. Water will flow from clearwell 1 into clearwell 2 through an interconnecting pipe. This interconnecting pipe will be replaced with a new interconnecting pipe during construction of the interim UV facility. All the plant water will be pumped to the reservoir through transfer pumps 4–6.

A new sample location and analyzer will be added on the new pipe connecting clearwells 1 and 2. This location will be used to control chloramination in clearwell 1 during UV disinfection. The sample location on the discharge of transfer pumps 4–6 will also be equipped with a new analyzer. This location will indicate chloramination conditions on the blend of water from clearwells 1 and 2 and can be used to control chloramination in clearwell 2.

7. Building Code Review

7.1 Egress

The 2015 Michigan Building Code requires a 75-foot-maximum common-path travel distance when only one exit is provided. The common-path travel distances from the northeast corner of the new UV control panel platform to the top of the stairs is 52 feet, and the common-path travel distance from northeast of the new UV reactor area to the top of the stairs is 40 feet. Both paths are under the 75-foot maximum distance with one exit route. At the top of the stairs from the transfer pump room egress, there are two exits in the existing building. One exit is to the north through a corridor and entry to the outside, and the other exit is to the south through another pump room that has several exit routes to stairs up to the ground floor and then outside.

7.2 Stairs and Ladders

The existing stairs going down to the existing transfer pump room will not have to be brought up to current code because it is existing and not being modified. However, the new stairs need to meet current code. The new stairs down to the UV reactor area require a 3-foot-minimum width, risers not more than 7 inches, and treads not less than 11 inches. Guardrails with handrails are required on both sides of the new stairs to the UV reactor area.

Self-closing gates are required on the new ladders going down to the existing transfer pumps.

7.3 Fire Protection

The work on this project would be classified as Level 2 Alteration with no change in occupancy according to the 2015 International Existing Building Code. The current building code required the basement to have a sprinkler system, because it is a windowless story. However, the work area is under 1,500 square feet and is exempted from this requirement.

Fire and smoke alarms are not required due to the limited occupancy loads of the basement.

7.4 Electrical Code

The design will be based on the following codes and standards:

- 2014 National Electrical Code (NEC)
- 2012 National Electrical Safety Code (ANSI C2-2012)
- 2015 NFPA 70E – Standard for Electrical Safety in the Workplace
- Michigan Building Code

7.4.1 Clearance and Access

Per NEC 110.26, working space shall be maintained in front of electrical equipment that may require servicing while energized. The depth of the working space is dependent on voltage level and whether other electrical equipment or grounded objects are in front of the equipment. The UV power supplies operate at 480V (277V to ground) and will have grounded metallic handrails in front. Per NEC Table 110.26(A)(1), the depth of the working space in front of the UV power supplies is required to be 42 inches.

The valve panelboard and potential isolation transformers (required for Trojan equipment) will operate at 480V (277V to ground), and depending on the exact placement, will require either 42 or 48 inches of front clearance.

7.4.2 Dedicated Space

Per NEC 110.26(E), space directly above switchboards, switchgear, panelboards, or motor control centers shall be kept clear and reserved only for the electrical installation. The valve panelboard will fall into this category and will require the space directly above the panel to a height of 6 feet to remain clear and be used for conduits.

The UV power supply units and the potential isolation transformers do not fall into one of the listed electrical equipment categories, so the space above the panels is not required to be free of process equipment or other foreign systems.

8. Electrical Approach

The UV equipment will consist of two 100-kW (approximate) medium-pressure UV reactors and associated 480-volt (V), 3-phase power supplies. One reactor will be the primary unit, and one will be standby. The total projected load (maximum) for each power supply, which includes the reactor ballasts, cleaning/wiping system, control power, and instrumentation power, is 151 amps. This load will require a 200-amp trip feeder circuit breaker for each unit.

The TrojanUV system requires a 480/277V, 4-wire electrical service, which will require the installation of two 150-kilovolt-ampere (kVA), 480:480/277V isolation transformers. Typical dimensions for a 150-kVA transformer are 32 inches wide by 24 inches deep by 52 inches tall. The transformers can either be wall mounted (with appropriate brackets), or floor mounted on a concrete pad. Ideally, the transformers should be installed in a dry, clean atmosphere, but special enclosures and sealed transformer windings are an option if available space does not permit the installation of the transformers in a conditioned space. The CalgonUV system does not require these transformers.

The power supply panels are large, with a maximum total size of approximately 99 inches wide, 36 inches deep, and 85 inches tall and a weight of 5,000 pounds (e.g., Calgon Carbon UV). The Trojan power-supply unit is slightly smaller and much lighter (2,000 pounds). The power-supply panels will need to be shipped and installed in modular sections. The sections will be composed of two ballast cabinets, each approximately 32 inches wide by 36 inches deep by 85 inches tall, and a control cabinet with dimensions of 30 inches wide by 36 inches deep by 78 inches tall. Each section will be placed in the final location with internal wiring terminations being reconnected and tested, preferably by the UV system manufacturer.

A major limiting factor with UV systems is the cable distance from the reactor to the power supply. In general, most UV manufacturers are limited to a cable length between 30 and 80 feet. Calgon Carbon UV uses electromagnetic ballasts and is one of the only manufacturers with a longer distance and has a cable distance limitation of 500 feet. Taking this into consideration, three options are summarized in the following subsections for possible locations of the UV power supplies.

8.1 Option 1 (Transfer Pump Room)

Electrically, the preferred option is to place the UV power supplies in the same room where the UV reactors will be located. The transfer pump room is not conditioned but is not corrosive. Additional protection from humid air, such as panel heaters or upgraded enclosures, will be investigated during final design.

Due to the potential for flooding in the lower level, the power supplies would be elevated on a platform approximately 6 feet above the finished floor. Power would be from the existing Red MCC-1 located on the upper level of the transfer pump room. One power supply would be fed from an existing spare 200-amp circuit breaker, and the other power supply would be fed from a new, matching 200-amp circuit breaker placed in a blank space of Red MCC-1. If required, the 15-kVA isolation transformers could be floor-mounted next to Red MCC-1 where existing storage cabinets are located. Power conduits from the MCC feeder breakers would feed the transformers, then from the transformers, pass through cored openings in the floor to the respective, elevated UV power supplies below. If isolation transformers are not required, the power conduits would pass directly through cored openings in the floor and feed the respective, elevated UV power supplies.

All required conduits between the power supplies and associated reactor would be provided per the UV manufacturer's recommendations. Conduit routes would either begin through the top of the power supply or through the bottom and would continue to the destination device, while maintaining clearance and access around the process equipment. The distance from the power-supply units to the reactors should be within the distance limitations for all UV system manufacturers.

A new 480V panelboard, subfed from an existing 480V panelboard, would be installed on the upper level to feed the new 480V valve actuators. Power conduits would drop through the floor and land on the respective valve actuator. Control wiring from the valve actuators would route to the UV Master Control Panel. Power required for instruments (120V) would come from single-pole circuit breakers located within the UV Master Control. Instrument power and signal conduits would remain separate and would route from either the UV Master Control Panel or Local UV Panel to the respective devices (flowmeter, UVT analyzer).

To alert plant staff of water infiltration in the lower level, multiple high-water alarms would be proposed for installation. The hardwired signals from the floats or high-water switches would route to the UV Master Control Panel, and through relay logic, would activate an alarm horn, strobe light, and generate an alarm to SCADA through spare digital PLC inputs.

8.2 Option 2 (West High-Service Pump Station)

The second option for the UV power supplies is the north wall of the new West High-Service Meter Room. The space is not conditioned and is not corrosive. The proposed NEMA 12 enclosures for the equipment will provide adequate protection from the environment. Several non-process pipes are currently located along the north wall and would need to be relocated in order for the UV power supplies to fit, but the relocation would be relatively minor and would not disrupt plant operations. The source of power would be from two existing, spare 400-amp circuit breakers out of the Main Switchboard in the west Electrical Room. New 200-amp rating plugs would be required to reduce the trip to 200 amps. Since the new Pump Station is more than 80 feet from the reactor location, the CalgonUV system is the only system that can meet the maximum distance requirement. The Calgon system only requires a 3-wire electrical service, so the 15-kVA isolation transformers would not be required with this option. The power conductors would route from the new switchgear and travel overhead through the electrical and pump room walls into the top of the respective UV power supply units.

Figure 15. North Wall of East High-Service Pump Station

All required conduits between the power supplies and associated reactor would be provided per the UV manufacturer's recommendations. A group of approximately 14 to 16 conduits ranging in size from 0.75 to 2 inches will likely be required. Conduit routes would begin through the top of the power supplies and continue to the destination devices at the reactors. The exact conduit route through the existing plant would be provided during detailed design.

A new 480V panelboard, subfed from an existing 480V panelboard near existing Red MCC-1, would be installed on the upper level to feed the new 480V valve actuators. Power conduits would drop through the floor and land on the respective valve actuator. Control wiring from the valve actuators would route to the UV Master Control Panel located near the UV power supplies in the new Pump Room. Power required for instruments (120V) would come from existing spare, single-pole circuit breakers located in existing 208/120V panelboards located near existing Red MCC-1. Signals from the instruments would route either to the UV Master Control Panel or Local UV Panel to the respective devices (flowmeter, UVT analyzer).

Even though the power supplies are not located in the lower level of the transfer pump room, multiple high-water alarms would still be proposed for installation. The hardwired signals from the floats or high-water switches would route to a dedicated relay panel, which would activate an alarm horn, strobe light, and generate an alarm to SCADA through an existing PLC digital input. The existing PLC used for the alarm would be selected during detailed design.

8.3 Option 3 (Outdoors)

An option to place the UV Power Supplies outdoors between the Chemical Unloading area and the new west High-Service Pump Room was evaluated. Due to existing 36-inch pipes being buried below the proposed location for the UV Power Supplies, this option was no longer considered.

Another outdoor option is near the front of the plant on the northeast filter building wall, behind the screen wall (Figure 16). This is closer to the UV reactors, but access and space is limited.

Figure 16. Screen Wall Electrical Equipment

8.4 Recommendation

It is recommended to place the UV power supply panels in the transfer pump room. This is the easiest location for operations and maintenance since it is within the plant building and near the reactors. Costs are also less because cable lengths are minimized. The disadvantage is potential for flooding. Placing the panels above the floor and providing leak detection mitigates this concern.

8.5 Standby Power Requirements

Power quality at the plant has historically been satisfactory and has recently been improved with utility-line enhancements. It is not common for the plant to experience voltage sags or surges, other than those associated with lightning.

A full-size UPS capable of operating the UV power supply at maximum load to ride out power disturbances is not anticipated. Between the two utility sources and onsite standby generator, power is always expected to be available for the UV system. However, properly sized UPS units should be incorporated into the local control panels to maintain power to each PLC.

9. Project Costs

An estimated construction cost for the interim UV system in the transfer pump room is $2.1 million. This cost estimate includes the cost of replacing the clearwell interconnect pipe and adding a valve. Appendix B provides cost details.

10. Schedule

The anticipated schedule for the interim UV project is:

Final Design Completion	January 15, 2019
Bidding	February 2019
Contractor Notice to Proceed	July 2019
Shop drawing submittal and approval complete	September 1, 2019
Equipment manufacture and delivery	September 1, 2019 through January 31, 2020
Construction Complete	April 2020
Startup and Testing	May 2020

11. Summary

Ann Arbor plans to install an interim UV facility to further protect public health from *Cryptosporidium*, improve operations, and ease construction of a future project for Plant 1 improvements. Two qualified UV equipment suppliers were selected to base the UV design around.

The selected location for the interim UV facility is in the existing transfer pump 4–-6 room. This location is close to plant operations, does not require construction of a building or outdoor container, has the least adverse operational impacts, and is the lowest cost option.

The interim UV facility is estimated to cost $2.1 million. Final design is planned to conclude in January 2019, and the UV system is planned to be operational in May 2020.

12. References

Barr Engineering. 2001. Letter from Barr Engineering to the City of Ann Arbor regarding “Clear Well Management Project”, dated September 21, 2001.

CH2M HILL. 2017. *Long Term 2 Enhanced Surface Water Treatment Rule Study*. December.

U.S. Environmental Protection Agency (EPA). 2006. *Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule.* EPA 815-R-06-007. November.

Appendix D
399 Permit Application

PERMIT APPLICATION FOR WATER SUPPLY SYSTEMS

(CONSTRUCTION - ALTERATION - ADDITION OR IMPROVEMENT) AS DESCRIBED HEREIN

Required under the Authority of 1976 PA 399, as amended

This application becomes an Act 399 Permit only when signed and issued by authorized Michigan Department of Environmental Quality (DEQ) Staff. See instructions below for completion of this application.

1. **Municipality or Organization, Address and WSSN** that will own or control the water facilities to be constructed. This permit is to be issued to: City of Ann Arbor, Michigan Public Service Area/Water Treatment Services Unit Water Treatment Plant 919 Sunset Road, Ann Arbor MI 48103 **WSSN**: 0220	Permit Stamp Area (DEQ use only)	
2. **Owner's Contact Person** (provide name for questions): Contact: Glen Wiczorek, P.E. Title: Senior Utilities Engineer Phone: 734.794.6426 x43958		
3. **Project Name** (Provide phase number if project is segmented): WTP UV Disinfection System	4. **Project Location** (City, Village, Township): City of Ann Arbor, Michigan	5. **County** (location of project): Washtenaw

ISSUED UNDER THE AUTHORITY OF THE DIRECTOR OF THE DEPARTMENT OF ENVIRONMENT QUALITY

cc:

Issued by: ______________________________

Reviewed by: ______________________________

☐ **If this box is marked see attached special conditions.**

Instructions: Complete items 1 through 5 above and 6 through 21 on the following pages of this application. Print or type all information except for signatures. Mail completed application, plans and specifications, and any attachments to the DEQ District Office having jurisdiction in the area of the proposed construction.

Please Note:

a. This **PERMIT** only authorizes the construction, alteration, addition or improvement of the water system described herein and is issued solely under the authority of 1976 PA 399, as amended.
b. The issuance of this **PERMIT** does not authorize violation of any federal, state or local laws or regulations, nor does it obviate the necessity of obtaining such permits, including any other DEQ permits, or approvals from other units of government as may be required by law.
c. This **PERMIT** expires two (2) years after the date of issuance in accordance with R 325.11306, 1976 PA 399, administrative rules, unless construction has been initiated prior to expiration.
d. Noncompliance with the conditions of this permit and the requirements of the Act constitutes a violation of the Act.
e. Applicant must give notice to public utilities in accordance with 1974 PA 53, (MISS DIG), being Section 460.701 to 460.718 of the Michigan Compiled Laws, and comply with each of the requirements of that Act.
f. All earth changing activities must be conducted in accordance with the requirements of the Soil Erosion and Sedimentation Control Act, Part 91, 1994 PA 451, as amended.
g. All construction activity impacting wetlands must be conducted in accordance with the Wetland Protection Act, Part 303, 1994 PA 451, as amended.
h. Intentionally providing false information in this application constitutes fraud which is punishable by fine and/or imprisonment.
i. Where applicable for water withdrawals, the issuance of this permit indicates compliance with the requirements of Part 327 of Act 451, Great Lakes Preservation Act.

6. **Facilities Description** – In the space below provide a detailed description of the proposed project. Applications without adequate facilities descriptions **will be returned**. SEE EXAMPLES BELOW. Use additional sheets if needed.

This project provides an ultraviolet light (UV) disinfection system to inactivate Cryptosporidium (3-log) at the Ann Arbor water plant. The UV system will assist in complying with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2) as Ann Arbor's source water is in Bin 2. Ann Arbor can meet the LT2 requirements with filtration and 2-stage softening. However, 2-stage softening may not be available at all times due to maintenance activities, typically in winter when water demand is low.

The UV system will be placed inside the existing water treatment plant main building, on the discharge of transfer pumps 4-6. There will be two UV reactors, one duty and one backup. Piping and valves will be in place so that all plant water is routed through the UV system when it is operational. The firm capacity of the UV system is 25 mgd, but is limited by the capacity of Transfer pumps 4-6, with a firm capacity of 17-24 mgd depending on water levels in clearwells and reservoir. The maximum day flowrate through the water plant has been less than 25 mgd over the past 4 years. Because UV disinfection is likely to be needed only during low-demand periods, it is unlikely that the water demand would exceed 25 mgd when UV disinfection is operational. Therefore, the transfer pump 4-6 firm capacity of 17 to 24 mgd is adequate.

This UV system is anticipated to be an interim system to provide additional public health protection until a permanent solution can be constructed with a future water plant improvement project. If UV is selected for the permanent solution, the UV equipment may be able to be re-used.

Other components of this project are listed below. The Engineering Report and Bid Documents provide details on design criteria and facilities.

* Replacement of the clearwell interconnect pipe and valve with new pipe and valves for improved reliability and operational flexibility.
*New electromagnetic flowmeters for each UV reactor.
*New analyzers for total chlorine, monochloramine, free ammonia, UV transmittance for better operational control.
*New grating to access the UV equipment.
*Demolition of existing grating and piping.
*New lighting for the UV area

EXAMPLES – EXAMPLES – EXAMPLES – EXAMPLES – EXAMPLES – EXAMPLES	
Water Mains	500 feet of 8-inch water main in First Street from Main Street north to State Street. **OR** 250 feet of 12-inch water main in Clark Road from an existing 8-inch main in Third Avenue north to a hydrant.
Booster Stations	A booster station located at the southwest corner of Third Avenue and Main Street, and equipped with two, 15 Hp pumps each rated 150 gpm @ 200 feet TDH. Station includes backup power and all other equipment as required for proper operation.
Elevated Storage Tank	A 300,000 gallon elevated storage tank located in City Park. The proposed tank shall be spherical, all welded construction and supported on a single pedestal. The tank shall be 150 feet in height, 40 feet in diameter with a normal operating range of 130 – 145 feet. The interior coating system shall be ANSI/NSF Standard 61 approved or equivalent. The tank will be equipped with a cathodic protection system, and includes a tank level control system with telemetry.
Chemical Feed	A positive displacement chemical feed pump, rated at 24 gpd @ 110 psi to apply a chlorine solution for Well No. 1. Chlorine is 12.5% NaOCL, ANSI/NSF Standard 60 approved and will be applied at a rate of 1.0 mg/l of actual chlorine.
Water Supply Well	Well No. 3, a 200 foot deep well with 170 feet of 8-inch casing and 30 feet of 8-inch, 10 slot screen. The well will be equipped with a 20 Hp submersible pump and motor rated 200 gpm @ 225 feet TDH, set at 160 feet below land surface.
Treatment Facilities	A 5 million gpd water treatment plant located at the north end of Second Avenue. The facility will include 6 low service pumps, 2 rapid mix basins, 4 flocculation/sedimentation basins, 8 dual media filters, 3 million gallon water storage reservoir and 6 high service pumps. Also included are chemical feed pumps and related appurtenances for the addition of alum, fluoride, phosphate and chlorine.

General Project Information – Complete all boxes below.

7. Design engineer's name, engineering firm, address, phone number, and email address:	8. Indicate who will provide project construction inspection:
Tony Myers, P.E. Jacobs Engineering Corporation 135 south 84th street, suite 400, Milwaukee WI 53214 414-847-0238 tony.myers@jacobs.com	☐ Organization listed in Box 1. ☒ Engineering firm listed in Box 7. ☐ Other - name, address, and phone number listed below.

9. Is a basis of design attached?
☒ YES ☐ NO

If no, briefly explain why a basis of design is not needed.

10. Are sealed and signed engineering plans attached?
☒ YES ☐ NO

If no, briefly explain why engineering plans are not needed.

11. Are sealed and signed construction specifications attached?
☒ YES ☐ NO

If specifications are not attached, they need to be on file at DEQ.

12. Were Recommended Standards for Water Works, Suggested Practice for Water Works, AWWA guidelines, and the requirements of Act 399 and its administrative rules followed?
☒ YES ☐ NO

If no, explain which deviations were made and why.

13. Are all coatings, chemical additives and construction materials ANSI/NSF or other adequate 3rd party approved?
☒ YES ☐ NO

If no, describe what coatings, additives or materials did not meet the applicable standard and why.

14. Are all water system facilities being installed in the public right-of-way or a dedicated utility easement? (For projects not located in the public right-of-way, utility easements must be shown on the plans.)
☒ YES ☐ NO

If no, explain how access will be obtained.

15. Is the project construction activity within a wetland (as defined by Section 324.30301(d)) of Part 303, 1994 PA 451?
☐ YES ☒ NO

If yes, a wetland permit must be obtained.

16. Is the project construction activity within a 100-year floodplain (as defined by R 323.1311(e)) of Part 31, 1994 PA 451, administrative rules?
☐ YES ☒ NO

If yes, a flood plain permit must be obtained.

17. Is the project construction activity within 500 feet of a lake, reservoir, or stream?
☐ YES ☒ NO

If yes, a Soil and Erosion Control Permit must be obtained <u>or</u> indicate if the owner listed in box 2 of this application is an Authorized Public Agency (Section 10 of Part 91, 1994 PA 451) ☐ Owner is APA.

18. Will the proposed construction activity be part of a project involving the disturbance of five (5) or more acres of land?
☐YES ☒NO
If yes, is this activity regulated by the National Pollutant Discharge Elimination System storm water regulations?
☐YES: NPDES Authorization to discharge storm water from construction activities must be obtained.

☐NO: Describe why activity is not regulated:
Please call 517-241-8993 with questions regarding the applicability of the storm water regulations.

19. Is the project in or adjacent to a site of suspected or known soil or groundwater contamination?
☐YES ☒NO

If yes, attach a copy of a plan acceptable to the DEQ for handling contaminated soils and/or groundwater disturbed during construction. Contact the local DEQ district office for listings of Michigan sites of environmental contamination.

20. IF YOU ARE A CUSTOMER/WHOLESALE/BULK PURCHASER, COMPLETE THE FOLLOWING

1) Name and WSSN of source water supply system (seller) ______

2) Does the water service contract require water producer/seller to review and approve customer/wholesale/bulk purchaser water system construction plans?
☐YES ☐NO

If yes to #2, the producer/seller approval letter must be attached when submitted to DEQ.

21. **Owner's Certification** The owner of the proposed facilities or the owner's authorized representative shall complete the owner's certification. It is anticipated that the owner will either be a governmental agency (city, village, township, county, etc.) or a private owner (individual, company, association, etc.) of a Type I public water supply.

OWNER'S CERTIFICATION

I, Glen Wiczorek (print) (name), acting as the Senior Utilities Engineer (print) (title/position) for

City of Ann Arbor - Water Treatment Plant (print) (entity owning proposed facilities) certify that this project has been reviewed and approved as detailed by the Plans and Specifications submitted under this application, and is in compliance with the requirements of 1976 PA 399, as amended, and its administrative rules.

Glen W[signature] 2-12-19 734 845-2857
Signature* Date Cell Phone

*Original signature only, no photocopies will be accepted.

PROJECT BASIS OF DESIGN – FOR WATER MAIN PROJECTS

PROJECT NAME: ____

For this PROJECT the following information must be provided per Act 399 unless waived by the Department. For projects other than water main installation, or if additional space is needed, attach separate sheet(s) with detailed Basis of Design calculations.

A. A general map of the initial and ultimate service areas
☐Included on engineering plans ☐Attached separately

B. Number of service connections served by this permit application ____

C. Total number of service connections ultimately served by entire project ____

D. Residential Equivalent Units (REUs) served by this permit application ____

E. Total Residential Equivalent Units (REUs) ultimately served by entire project ____

F. Water flow rates for proposed project based on REUs listed in "D' and "E" above

1. Initial design average day flow (mgd) ____
2. Initial design maximum day flow (mgd) ____
3. Total design average day flow (mgd) ____
4. Total design maximum day flow (mgd) ____
5. Required fire flows: (1) ____ gpm for ____ hours

G. Actual flows and pressures of existing system at the connection point(s) (2)
____ gpm at ____ psi
____ gpm at ____ psi
____ gpm at ____ psi
____ gpm at ____ psi

H. Estimated minimum flows and pressures within the proposed water main system (3)
____ gpm at ____ psi

(1) Every water system must decide what levels of fire fighting flows they wish to provide. Fire flow should be appropriate for the area (residential, commercial, industrial) being served by the project. Typical fire flow rates can be obtained from the water supply, local fire dept., ISO or AWWA. The water system must then be designed to be able to provide the required fire flows while maintaining at least 20 psi in all portions of the distribution system.

(2) Flows and pressures at the connection points must be given to determine if the existing water main(s) are able to deliver water to the new service area. These numbers can be obtained from a properly modeled and calibrated distribution system hydraulic analysis or hydrant flow tests performed in the field. If more than one connection is proposed, list as needed.

(3) List what the estimated minimum flows can be expected in the proposed water mains based on estimated water demands, head losses, elevation changes and other factors that may affect flows, such as dead end mains.

Appendix E
Ann Arbor Public Services 2017 Annual Report on Drinking Water

City of Ann Arbor

2017 Water Quality Report

Safe • Affordable • Reliable

WHAT'S INSIDE

Published March 2018
a2gov.org/A2H2O

A Message to Our Customers

We, at the City of Ann Arbor Water Treatment Services Unit, are pleased to share with you our annual drinking water quality report. The U.S. Environmental Protection Agency (EPA) and Michigan Department of Environmental Quality (MDEQ) require that all water suppliers produce an annual report that informs its customers about the quality of their drinking water. **This report explains where your drinking water comes from, what is in it and how we keep it safe.**

Last year I wrote about our long term infrastructure needs. This continues to be a focus for the utility. In order to prepare for future capital investment, the City has recently completed a study that reviewed the water and sewer rate structures to ensure that all of our customers are being charged for the services that the utility provides, and that future rate adjustments will be sufficient to finance our capital improvement plans. In the Spring of 2018, this revised rate structure will be presented to City Council for their consideration and adoption. Examples of future capital projects include replacing water mains in areas that experience a large number of main breaks and/or water quality problems, as well as replacing parts of the Water Treatment Plant that date back to 1938.

As you may remember, the City of Ann Arbor won the Best Tasting Water in Michigan in 2016 and was fortunate enough to repeat as the winner in 2017. The City is the only utility in Michigan to have won this award three times since its inception in 1985. In June of 2017, at the American Water Works Association Conference in Philadelphia, the City competed against over 40 utilities from around the country and Canada (winners from many of the states and several Canadian provinces) and finished in 4th place, which is the closest that a Michigan utility has ever come to winning this event.

Eddy the Water Drop holding the 2017 Award for Best Tasting Water in Michigan

While it is an honor to be known for great tasting water, it is more important that the water delivered every day to our customers is of the highest quality. In order to meet this standard the City performs over 145,000 water quality tests every year, and staff continually work to ensure safe, reliable water is delivered to your home or business every day. The City also participates in the Partnership for Safe Water Program which is a voluntary program that sets more stringent water quality goals than required by both the State of Michigan and EPA.

If you have the opportunity, please contact us for a group tour or attend our annual open house on May 5, 2018, which is free to the public. These are great opportunities to learn more about your drinking water.

If you have questions about this report, or water quality in the City of Ann Arbor, please contact us at (734) 794-6426 or email us at water@a2gov.org or visit us on the web at www.a2gov.org/a2h2o.

Sincerely,

Brian Steglitz, PE
Manager of Water Treatment Services

About This Report

In the following pages, you will find an overview of the required and voluntary water testing programs that protect our drinking water system. In order to ensure that tap water is safe to drink, EPA prescribes regulations which limit the amount of certain contaminants in water provided by public water systems. FDA regulations establish limits for contaminants in bottled water which must provide the same protection for public health. Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the EPA's Safe Drinking Water Hotline at (800) 426-4791.

The City of Ann Arbor's source water is comprised of both surface and ground water sources. About 85% of the water supply comes from the Huron River with the remaining 15% provided by multiple wells. The water from both sources is blended at the Water Treatment Plant.

Photo of Barton Pond by Greg Croasdill

How Do Sources of Drinking Water Become Polluted?

The sources of drinking water - both tap water and bottled water - include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally-occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity.

Contaminants that may be present in source water include:

- Microbial contaminants, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife.
- Inorganic contaminants, such as salts and metals, which can be naturally-occurring or result from urban stormwater runoff, industrial, or domestic wastewater discharges, oil and gas production, mining, or farming.
- Pesticides and herbicides, which may come from a variety of sources such as agriculture, urban stormwater runoff, and residential uses.
- Organic chemical contaminants, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production, and can also come from gas stations, urban stormwater runoff, and septic systems.
- Radioactive contaminants, which can be naturally occurring or be the result of oil and gas production and mining activities.

Source Water Assessment Program

Federal regulations require states to develop and implement Source Water Assessment Programs (SWAP) to compile information about any potential sources of contamination to their source water supplies. This information allows us to better protect our drinking water sources. In 2004, the MDEQ performed a Source Water Assessment on the City's system. To obtain a copy of the assessment, request one by calling (734) 794-6426.

In 2017, the City completed a Surface Water Intake Protection Plan (SWIPP), addressing an efficient and economical means of source water protection allowing the City to continue to produce high quality drinking water. Implementation of this plan continues through system-wide data collection and monitoring, community staff training, contingency planning, public outreach, and vegetation management. If you have further questions about the City's SWIPP, please see the City's website at: www.a2gov.org/departments/systems-planning/programs/Pages/SWIPP.aspx

Water Quality Data

The City of Ann Arbor is committed to providing exceptional water quality. We routinely monitor for contaminants in your drinking water according to federal and state standards. Many additional parameters were tested, but not detected, and are not included in this report. This report includes information on all regulated drinking water parameters detected during calendar year 2017. We are required to monitor for certain contaminants less than once per year because the concentration of these contaminants are not expected to vary significantly from year to year.

Regulated Contaminants Detected (abbreviations and definitions on page 7)

Parameter Detected	Your Water Results		Regulatory Requirements		Likely Source
	Highest Level Detected	Results Range	EPA LIMIT MCL, TT, or MRDL	EPA GOAL MCLG or MRDLG	
Disinfection Byproducts, Disinfectant Residuals, and Disinfection Byproduct Precursors					
Bromate	3.8 ppb [1]	ND – 10.6 ppb	10	0	Byproduct of ozone disinfection
Chloramines [3]	2.4 ppm [1]	0.17 – 3.4 ppm	MRDL: 4	MRDLG: 4	Disinfectant added at Water Plant
Haloacetic Acids (HAA5) [3]	5.0 ppb [2]	ND – 8.0 ppb	60	N/A	Byproduct of disinfection
Total Organic Carbon (TOC)	57% removed [1]	49 – 64% removed	TT: 25% minimum removal	N/A	Naturally present in the environment
Total Trihalomethanes (TTHM) [3]	3.9 ppb [2]	1.4 – 4.7 ppb	80	N/A	Byproduct of disinfection
Radiochemical Contaminants (tested in 2017)					
Gross Alpha	0.817 ± 1.35 pCi/L	N/A	15	0	Erosion of natural deposits
Radium 226 and 228	1.39 ±0.91 pCi/L	N/A	5	0	Erosion of natural deposits
Inorganic Contaminants					
Arsenic	1.1 ppb	N/A	10	0	Erosion of natural deposits
Barium	18.3 ppb	N/A	2000	2000	Erosion of natural deposits
Chromium (total)	<1 ppb	N/A	100	100	Discharge from steel and pulp mills; erosion of natural deposits
Fluoride	0.85 ppm	0.52 – 0.85 ppm	4	4	Erosion of natural deposits; water additive which promotes strong teeth
Nitrate	0.8 ppm	0.2 – 0.8 ppm	10	10	Runoff from fertilizer use; leaching from septic tanks and sewage
Nitrite	0.031 ppm	ND – 0.031 ppm	1	1	Runoff from fertilizer use; leaching from septic tanks and sewage
Microbiological Contaminants					
Total Coliform [3]	6 positives out of 131 tested in Oct.	0 – 4.6%	TT: ≤ 5% positive per month	N/A	Naturally present in the environment
Turbidity	0.20 NTU	100% of samples ≤0.3 NTU	1 NTU and 95% of samples ≤0.3 NTU	N/A	Naturally present in the environment
2017 Lead and Copper Results from Customer Faucets					
Copper[4]	100 ppb (90% of samples ≤ this level)	0 out of 62 (number of sites above action level)	1300	1300	Corrosion of household plumbing
Lead[4]	3 ppb (90% of samples ≤ this level)	0 out of 62 (number of sites above action level)	15	0	Corrosion of household plumbing

[1] highest running annual average [2] highest locational running annual average [3] measured in the distribution system
[4] Lead and Copper are regulated by action levels

2017 Special Monitoring

Parameter Detected (units)	Your Water Results		Likely Source
	Average level detected	Range	
1,4-Dioxane (ppb)[1]	<0.07	N/A	Groundwater contamination from manufacturing process and landfills
N-Nitrosodimethylamine (NDMA) (ppb)	<0.48	N/A	Byproduct of disinfection
Perchlorate (ppb)	<0.54	N/A	Nitrate fertilizer runoff; contamination from industrial manufacturing process
Sodium (ppm)	62	47-73	Erosion of natural deposits; road salt and water softeners
Perfluorooctanesulfonic Acid (PFOS) (ppb) [2]	0.0029	ND – 0.0079	Consumer products such as Teflon, Scotch Guard, Stain Master, and firefighting foam.
Perfluorooctanoic Acid (PFOA) (ppb) [2]	0.0012	ND – 0.0036	Consumer products such as Teflon, Scotch Guard, Stain Master, and firefighting foam.

[1]To date, no 1,4-Dioxane has ever been detected in the municipal drinking supply. Additional information can be found at Michigan.gov/deq

[2] EPA health advisory level for PFOS and PFOA combined is 0.07 ppb

PFOS & PFOA

Perfluoroalkyl substances (PFAS) have been widely used in manufacturing cookware, food packaging, clothing, carpeting, personal care products, firefighting foams, and other applications. Once introduced into the environment, PFAS are highly persistent and may be linked to adverse human health effects. In Michigan, the issue has been highlighted in the news because there are several communities where these compounds were detected in drinking water at low levels.

The Environmental Protection Agency (EPA) has required the City of Ann Arbor to test for PFAS as part of an unregulated contaminant monitoring rule. In 2016 the EPA issued a health advisory level of 0.07 parts per billion (ppb) for the combined amount of two PFAS compounds, perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). All the City's results in treated water for these compounds are below the EPA health advisory level. The City is investigating alternate methods of removing PFAS using activated carbon should additional treatment be required.

Other Water Quality Parameters of Interest

Parameter Detected (units)	Your Water Results	
	Average level detected	Range
Alkalinity, total (ppm as $CaCO_3$)	63	40 – 125
Aluminum (ppm)	0.012	N/A
Ammonia as N (ppm)	<0.10	<0.10 – 0.18
Arsenic (ppb)	1.1	N/A
Calcium (ppm	34	19 – 69
Chloride (ppm)	111	75 – 148
Conductivity (µmhos/cm)	611	479 – 749
Hardness ($CaCO_3$) (ppm)	137	96 – 210
Hardness ($CaCO_3$) (gpg)	8.0	5.6-12.3
Iron (ppm)	<0.1	N/A
Lead (ppb) (at Water Treatment Plant tap)	<1.0	N/A

Parameter Detected (units)	Your Water Results	
	Average level detected	Range
Magnesium (ppm)	14	10 – 20
Manganese (ppb)	1.0	N/A
Mercury (ppb)	<0.20	N/A
Non-Carbonate Hardness (ppm)	74	26 – 117
pH (S.U.)	9.3	8.9 – 9.5
Phosphorus, total (ppm)	0.25	0.10 – 0.43
Potassium (ppm)	2.6	N/A
Sulfate (ppm)	54	37 – 73
Temperature (° Celsius)	15.5	7.0 – 26.6
Total solids (ppm)	355	286 – 418
Zinc (ppb)	<5.0	N/A
[1] Nitrite in distribution (ppm)	0.013	ND- 0.28

[1] Nitrite in the distribution system comes from the decomposition of the chloramine disinfectant. Its concentration is a function water age and increased temperature. Levels are highest in August and September in places far from the plant where the flow is low.

The table above contains both regulated and unregulated contaminants. Unregulated contaminants are those for which EPA has not established drinking water standards. Monitoring helps EPA to determine where certain contaminants occur and whether it needs to regulate those contaminants.

Contaminants of Concern

Lead

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. The City of Ann Arbor is responsible for providing high quality drinking water, but cannot control the variety of materials used in plumbing components. In 2017, the City completed a project to remove the last remaining lead components of City-owned service lines.

When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available for the Safe Drinking Water Hotline at (800) 426-4791 or on the EPA Web site:
(http://water.epa.gov/drink/info/lead/index.cfm)

Cryptosporidium

Cryptosporidium is a microbial pathogen found in surface water throughout the U.S. Although filtration removes Cryptosporidium, the most commonly used filtration methods cannot guarantee 100% removal. Our testing indicates the presence of these organisms in our source water, but not in the finished water. Current test methods do not allow us to determine if the detected organisms are capable of causing disease, or if they are dead. Ingestion of Cryptosporidium may cause cryptosporidiosis, an abdominal infection. Most healthy individuals can overcome the disease within a few weeks. Cryptosporidium must be ingested to cause disease, and it may be spread through means other than drinking water.

1,4-Dioxane

Groundwater in parts of Washtenaw County, including some areas under the City of Ann Arbor and Scio and Ann Arbor Townships, is polluted with the industrial solvent 1,4-Dioxane. This is due to Gelman Sciences' (now Danaher Corporation) improper disposal of wastewater containing the chemical between 1966 and 1986. As a result of their actions, the chemical seeped through soil and rock layers into the groundwater and has since spread. It is important to note, however, that Ann Arbor's drinking water is safe. **To date, no 1,4-Dioxane has ever been detected in the municipal drinking water supply.** Additional information can be found at Michigan.gov/deq.

Do I Need to Take Any Special Precautions?

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/CDC guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Drinking Water Hotline at (800) 426-4791.

Definitions and More Information

Abbreviations and Definitions

Action Level (AL): The concentration of a contaminant, which, if exceeded, triggers treatment or other requirements which a water system must follow.

$CaCO_3$: Calcium carbonate

gpg (Grains per Gallon): A unit of water hardness defined as 1 grain (64.8 milligrams) of calcium carbonate dissolved in one US gallon of water (3.785 L). This is a term often used by appliance manufacturers.

MCL (Maximum Contaminant Level): The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.

MCLG (Maximum Contaminant Level Goal): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.

MRDL (Maximum Residual Disinfectant Level): The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

MRDLG (Maximum Residual Disinfectant Level Goal): The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

N/A: Not Applicable

ND: Not detected at or above the minimum reporting level - laboratory analysis indicates that the constituent is not present.

NTU (Nephelometric Turbidity Units): Turbidity is a measure of the cloudiness of the water. We monitor it because it is a good indicator of the effectiveness of our filtration system.

pCi/L: picocuries per liter (a measure of radioactivity).

ppm (1 part per million) or mg/L (milligrams per liter): corresponds to one minute in two years or a single penny in $10,000. 1 ppm = 1000 ppb.

ppb (1 part per billion) or µg/L (micrograms per liter): corresponds to one minute in 2,000 years, or a single penny in $10,000,000

S.U.: Standard Units

TT (Treatment Technique): A required process intended to reduce the level of a contaminant in drinking water.

We invite public participation in decisions that affect drinking water quality!

Attend a City Council meeting if you would like to learn more about issues affecting our community. City Council meets at 7:00 p.m. on the 1st and 3rd Monday of every month in the City Hall Council Chambers, 2nd floor of Larcom City Hall, 301 East Huron Street.

A full calendar of events is available at a2gov.org.

Water By the Numbers

The Water Treatment Plant runs 24/7/365!

At the Water Treatment Plant, about 5 billion gallons of water are processed annually, over 145,000 tests are run each year, and over 125,000 people rely on the water that is processed at the City of Ann Arbor Water Treatment Plant.

City of Ann Arbor Public Works maintains approximately 500 miles of water distribution pipes.

Printed copies are available. Please share this report with all people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools and businesses). You can do this by posting this notice in a public place or distributing copies by hand and mail. To receive a printed copy of this report, please call (734) 994-2700.

H2O WORD SEARCH

T	U	P	N	O	L	L	A	G	E	N	K	R	H	F
P	N	B	B	M	V	D	G	B	W	N	S	N	A	H
S	I	E	Y	R	T	S	I	M	E	H	C	U	I	W
W	K	P	M	A	E	W	M	Q	T	H	C	U	A	S
T	R	G	E	T	K	X	I	M	U	E	H	T	S	N
E	I	W	E	S	A	J	R	I	T	A	E	W	F	O
S	V	L	N	U	V	E	H	L	R	R	L	L	T	R
T	E	L	E	A	T	C	R	N	Q	O	G	I	K	U
I	R	E	S	I	E	M	F	T	M	O	N	K	T	H
N	R	W	L	T	U	L	E	M	I	L	I	F	M	Y
G	S	F	K	I	F	T	C	O	B	M	K	M	Z	J
H	H	H	C	P	I	F	J	B	D	F	N	M	O	B
I	M	L	R	F	I	L	T	E	R	N	I	F	Y	C
W	A	M	O	N	I	T	O	R	J	E	R	T	C	G
C	C	K	Y	I	O	Z	O	N	E	A	D	P	K	F

CALCIUM
CHEMISTRY
CLEAN
DRINKING
FAUCET
FILTER
GALLON
HURON
LIME
LITER
MONITOR
OZONE
PIPES
QUALITY
RIVER
SINK
TESTING
TREATMENT
WATER
WELL

May is Water Month!

May 5: Water Treatment Plant Open House
May 6-12: Water Week
May 14-21: Infrastructure Week
May 20: Huron River Day
May 20-26: Public Works Week

Drinking Water Week | May 6-12, 2018

Protect the SOURCE

Appendix F
Sanitary Survey Cover Letter

RICK SNYDER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY
SOUTHEAST MICHIGAN DISTRICT OFFICE

C. HEIDI GRETHER
DIRECTOR

November 1, 2017

Mr. Brian Steglitz, P.E.
Manager Water Treatment Services
City of Ann Arbor Public Services
919 Sunset Road
Ann Arbor, Michigan 48103-2924

WSSN: 00220

Ms. Molly Maciejewski
Manager Public Works
City of Ann Arbor Public Services
4251 Stone School Road
Ann Arbor, Michigan 48108-9792

Dear Mr. Steglitz and Ms. Maciejewski:

SUBJECT: City of Ann Arbor Water System Sanitary Survey

This letter summarizes recent visits and subsequent review and discussion of the water supply facilities serving the City of Ann Arbor. The purpose of these visits was to evaluate the water system with respect to the requirements of the Michigan Safe Drinking Water Act, 1976 PA 399, as amended (Act 399). The enclosed sanitary survey has been updated based on information collected through October 2017.

We are very pleased that the water plant, as currently operated, is producing water in compliance with all existing regulations. All the water plant facilities are clean and well maintained. We also applaud the effort you made to remove all remaining lead goosenecks and your upcoming residential meter replacement program.

The following table summarizes the findings from our survey of the water system:

Survey Element	Findings
Source	**Recommendations**
Treatment	**Recommendations**
Distribution System	**Recommendations**
Finished Water Storage	**Recommendations**
Pumps	No deficiencies/recommendations
Monitoring & Reporting	**Recommendations**
Management & Operations	**Recommendations**
Operator Compliance	No deficiencies/recommendations
Security	No deficiencies/recommendations
Financial	**Recommendations**

Enclosed with this letter is a comprehensive list of recommendations which are included in the Sanitary Survey. It is hoped they will prove useful in enhancing the operation and maintenance of your water supply.

We would like to thank city staff for their time and assistance offered in completing this survey. If you have any questions, feel free to contact me by phone at 586-506-6137, by e-mail at johnsons18@michigan.gov, or by mail at the address below.

Sincerely,

Stephanie Johnson, P.E.
Surface Water Treatment Specialist
Drinking Water and Municipal Assistance Division
Community Drinking Water – Engineering Unit

Enclosure(s)
cc: Mr. Jon Bloemker, P.E., PhD, Chief, Engineering Unit, DEQ-DWMAD
Washtenaw County Division of Environmental Health
cc/enc: Mr. Craig Hupy, City of Ann Arbor Public Services Administrator
Mr. Larry Sanford, City of Ann Arbor Public Services

WATER TREATMENT PLANT AND DISTRIBUTION SYSTEM RECOMMENDATIONS

The following list of recommendations are intended to be a concise summary of the items contained in the Sanitary Survey. Since some improvements are a higher priority or will take longer to complete than others, we have divided the recommendations into two categories to indicate immediate and long-term implementation schedules.

Water Treatment Plant Recommendations

Immediate or ASAP Implementation (<12 months)

1. The City has prioritized the replacement of Plant No. 1 with more efficient technology that meets Ten States Standards for Water Treatment. The design phase is planned for 2019 with the construction phase in 2021-2025. During this period, continue to operate the entire plant within rated capacity and Plant No. 2 within its rated treatment capacity while only a single side is in operation.

2. The City is replacing the 6" sand portion with GAC in two filters to evaluate whether the increased depth of GAC in these filters will improve the filters' ability to remove contaminants. As indicated in the permit, the effective size of the GAC varies from 10 States Standards. The City must ensure the water from these two filters is meeting treatment goals.

3. A project has been initiated to install a new 42" pipeline to convey raw source water from a new intake crib located in Barton Pond to the existing Barton Raw Water Pump Station. This new pipe will upsize the current 20/24" intake pipe which restricts raw water flow to the water treatment plant. This project will help to address the recommendation to evaluate the overall capacity of the Barton Pond pumping station to assure the 40 MGD limit can be achieved.

4. Investigate the addition of proper rapid mix equipment for the treatment plant in accordance with Ten States Standards and EPA 815-R-99 012.

5. This survey reviewed the laboratory procedures (Methods and Calibration Frequencies) and recommends the following:

    a. Magnetic stirrers for the pH meter and the alkalinity and hardness titrations for consistency in reaching end points.

    b. Ann Arbor will begin monitoring for additional corrosion control parameters at the plant tap and in the distribution system as indicated in the table below. This additional monitoring information will be used to calculate the Langelier Saturation Index (LSI), Chloride:Sulfate Mass Ratio (CSMR) and the Larson-Skold index. These analyses and calculations will be reported in the plant's monthly operation report or other preferred method. This information will aid in reviewing Ann Arbor's corrosion control and for reassessing whether any additional water quality parameter monitoring may be necessary to demonstrate continued optimal corrosion control treatment.

Corrosion-Related Parameters (Measured) - Report in MORs		
Parameter	Location	Frequency
Chlorine (free and total)	Plant Tap	Daily
Turbidity	Plant Tap	Daily
Carbonate Alkalinity	Plant Tap	Daily
Bicarbonate Alkalinity	Plant Tap	Daily
Calcium	Plant Tap	Daily
pH	Plant Tap	Daily
Temperature	Plant Tap	Daily
Chloride	Plant Tap	Monthly
Sulfate	Plant Tap	Monthly
Conductivity	Plant Tap	Monthly
Corrosion Indices (Calculated) - Report in MORs		
Corrosion Index	Location	Frequency
Langelier Saturation Index	Plant Tap	Daily
Chloride:Sulfate Mass Ratio	Plant Tap	Monthly
Larson-Skold Index	Plant Tap	Monthly
Distribution Water Quality Parameters - Report in TBD		
Parameter	Location	Frequency
Chlorine (free and total) & Turbidity	Distribution System	5 days/week
Chloride, Sulfate, Carbonate Alkalinity, Bicarbonate Alkalinity, pH, Conductivity, Temperature	Distribution System	Quarterly
Corrosion Indices (Calculated) - Report in TBD		
Corrosion Index	Location	Frequency
Langelier Saturation Index	Distribution System	Quarterly
Chloride:Sulfate Mass Ratio	Distribution System	Quarterly
Larson-Skold Index	Distribution System	Quarterly

Long Term Implementation (>12 months)

1. Based on the results of the second round of LT2 monitoring, the City of Ann Arbor has been placed in Bin 2 which requires an additional 1.0-log removal/inactivation of Cryptosporidium. The plant will be required to achieve a total Cryptosporidium removal/inactivation of 4.0-log by June 20, 2020. The City has hired an engineering firm to review this requirement.

2. Continue with replacement of well water transmission main and/or provide in-line booster pumps in existing transmission main for increased reliability and capacity.

3. Well 74-2 should be properly abandoned and plugged by a licensed well driller. The City has planned this in its 2018 capital budget.

4. Identify all critical valves at the water treatment facility and exercise all valves on a routine basis.

5. This office recommends a comprehensive filter study be performed every 5 years. The sand has been used for up to 40 years. This study should include measuring the sand depth, core sampling and a sieve analysis to determine the effective size and uniformity coefficients. The sand should also be evaluated for any calcium carbonate buildup. We recommend the filter bed expansion rate be determined during backwash. We also recommend any surface rust on the filter pipes or troughs be removed and repainted along with any chipped paint on the filter walls. The filter underdrains should be inspected whenever work in the filter basins allow. The surface sweeps should be checked and repaired as necessary. Appropriate records of all these activities need to be maintained.

Distribution System Recommendations

Immediate or ASAP Implementation (<12 months)

1. The City must pursue an operation and maintenance agreement with the University of Michigan for water main that is owned and controlled by the university but conveys water back into the City owned main. A substantial agreement must be reached by March 1, 2018 and a full agreement by June 30, 2018. The maintenance agreement should address how routine leak detection will be performed and by whom.

2. We suggest reconsideration of the decision not to provide gravity (elevated) storage for the West Side High Pressure District. Gravity storage increases reliability, increases public health protection, would likely reduce customer pressure fluctuations and allow significant change in pump run profiles (number of pumps running during high water demand - - high electrical demand or energy charge periods).

3. Update the City's Standard Specifications for Water Main Construction. The City is currently preparing updated specifications with a draft expected in 2017.

4. Community water systems serving a population greater than 1,000 are required to have an Asset Management Plan (AMP) by January 1, 2018. We are pleased to have been informed that the City has contracted with an engineering firm to prepare an AMP by the deadline.

Long Term Implementation (>12 months)

1. Replace self-draining hydrants as they need repair or in conjunction with construction projects.

2. Replace old double disk valves with resilient wedge valves at critical locations and/or for 12" and greater water main.

3. Continue with installation of auxiliary shut off valves on all hydrants as time and resource allow.

4. A complete inspection is recommended for all the reservoirs at least once every 5 years. In-house visual inspections of the concrete storage tanks should be performed every 5 years at a minimum.

Appendix G
Construction Cost Estimate

JACOBS

To: Summary Sheet

ANN ARBOR, MI WTP UV DISINFECTION SYSTEM (90% Design)

PROJECT NO: D3156100.A.PN.OE.T102

PREPARED BY: E.R.MEYER

ANN ARBOR, MI WTP UV DISINFECTION SYSTEM (90% Design)

(Costs are as of January 2019, ENR CCI 20 City Average = 11205.44)

DESCRIPTION	QUANTITY	UNIT	$/UNIT *(includes Material & Installation)*	TOTAL COST	REFERENCE
UV SYSTEM - BASE BID					
Demolition:					
Demolish Existing Platform	139.5	SF	$75.00	$10,463	
Demolish Existing Stairs	27	RISERS	$100.00	$2,700	
Demolish Existing Handrail	105	LF	$25.00	$2,625	
Demolish Existing 36" Pipe	2	LF	$300.00	$600	
Demolish Existing 36" x 16" Tee	1	EA	$1,000.00	$1,000	
Demolish Existing 36" x 30" Reducer	1	EA	$1,000.00	$1,000	
Demolish Existing 30" Filler Flange	1	EA	$200.00	$200	
Demolish Existing 30" x 16" Tee	1	EA	$1,000.00	$1,000	
Demolish Existing 30" x 20" Reducer	1	EA	$750.00	$750	
Demolish Existing 20" Pipe	1	LF	$100.00	$100	
Demolish Existing 20" x 16" Tee	1	EA	$500.00	$500	
Demolish Existing 20" x 12" Reducer	1	EA	$500.00	$500	
Demolish Existing 12" BWS Pipe	20	LF	$50.00	$1,000	
Demolish Existing 12" Bend	2	EA	$100.00	$200	
Demolish Existing 16" Pipe	12	LF	$75.00	$900	
Demolish Existing 16" Bends	3	EA	$300.00	$900	
Demolish Existing 16" Spool Pipes	3	EA	$200.00	$600	
Demolish Existing 16" Plug Valve	3	EA	$500.00	$1,500	
Demolish Existing 6" Filtrate Pipe	20	LF	$40.00	$800	
Demolish Existing 3" FD	25	LF	$30.00	$750	
Demolish Existing 30" FW, Supports and Link Seal	15	LF	$200.00	$3,000	Difficult construction
Demolish Existing 30" Valve	1	EA	$750.00	$750	Difficult construction
Lead and Asbestos Abatement for Pipe	1	LS	$10,000.00	$10,000	
Demolish Light Fixtures, Switches and Associated Conduit and Wire	16	EA	$500.00	$8,000	
Demolish Existing Electric Panels	2	EA	$750.00	$1,500	
Metals:					
Aluminum Grating	611.8	SF	$135.80	$83,075	
Handrail	30	LF	$93.65	$2,810	
Gates	4	EA	$387.50	$1,550	
Ladders	4	EA	$1,200.00	$4,800	
Equipment:					
UV Equipment (reactors, power supply panels, PLC, UVT analyzers)	2	EA	$177,000	$354,000	Based on quote from Trojan
Portable Submersible Dewatering Pump (13 hp)	1	EA	$25,000	$25,000	
I&C:					
24" Flow Meter	2	EA	$18,000	$36,000	
Chloramine Analyzer	2	EA	$27,000.00	$54,000	
Water Quality Analyzer	2	EA	$18,000.00	$36,000	
Mechanical:					
24" UVI Pipe (CLDI)	55	LF	$228.35	$12,559	2019 RSM 02510-730-2180
24" Bend	4	EA	$5,523.50	$22,094	2019 RSM 02510-730-8180
24" Dismantling Joint	4	EA	$1,200.00	$4,800	
24" V500 (motor operated)	2	EA	$11,597.50	$23,195	Based on 2019 RSM 02080-500-3500
24" x 20" Reducer	2	EA	$2,418.00	$4,836	Based on 2019 RSM 02510-730-8500
20" Tee	3	EA	$7,169.00	$21,507	2019 RSM 02510-730-8360
20" Bend	2	EA	$3,557.50	$7,115	2019 RSM 02510-730-8160
20" Filler Flange	2	EA	$750.00	$1,500	
20" x 16" Reducer	2	EA	$2,015.00	$4,030	2019 RSM 02510-730-8500
16" UVI Pipe (CLDI)	6	LF	$144.70	$868	2019 RSM 02510-730-2140
16" V500	3	EA	$3,647.50	$10,943	2019 RSM 02080-500-3440
24" UVE Pipe (CLDI)	12	LF	$228.35	$2,740	2019 RSM 02510-730-2180

JACOBS

ANN ARBOR, MI WTP UV DISINFECTION SYSTEM (90% Design)

To: Summary Sheet

PROJECT NO: D3156100.A.PN.OE.T102

PREPARED BY: E.R.MEYER

ANN ARBOR, MI WTP UV DISINFECTION SYSTEM (90% Design)

(Costs are as of January 2019, ENR CCI 20 City Average = 11205.44)

DESCRIPTION	QUANTITY	UNIT	$/UNIT (includes Material & Installation)	TOTAL COST	REFERENCE
24" V500 (motor operated)	2	EA	$11,597.50	$23,195	Based on 2019 RSM 02080-500-3500
Connect New 36" UVE to Existing Wall Pipe Flange	1	LS	$500.00	$500	
36" UVE Pipe (CLDI)	3	LF	$342.53	$1,028	Based on 2019 RSM 02510-730-2180
36" x 24" Reducer	1	EA	$3,627.00	$3,627	Based on 2019 RSM 02510-730-8500
24" Tee	2	EA	$9,902.00	$19,804	2019 RSM 02510-730-8380
24" UVE Pipe (CLDI)	3	LF	$228.35	$685	2019 RSM 02510-730-2180
24" x 12" Eccentric Reducer	1	EA	$2,418.00	$2,418	Based on 2019 RSM 02510-730-8500
12" BWS Pipe	13	LF	$119.25	$1,550	2019 RSM 02510-730-2100
12" Bend	1	EA	$1,177.50	$1,178	2019 RSM 02510-730-8080
12" V500	1	EA	$1,507.00	$1,507	2019 RSM 02080-500-3340
2" Vacuum Release	2	EA	$3,000.00	$6,000	
Air Release Valve	1	EA	$3,000.00	$3,000	
Tie New 12" BWS Into Existing 12" BWS	1	LS	$500.00	$500	
30" V500	1	EA	$12,509.06	$12,509	Based on 2019 RSM 02080-500-3500, difficult construction
30" FW Pipe	5	LF	$313.98	$1,570	Based on 2019 RSM 02510-730-2180, difficult construction
30" Bend	2	EA	$7,594.81	$15,190	Based on 2019 RSM 02510-730-8180, difficult construction
30" V500	1	EA	$12,509.06	$12,509	Based on 2019 RSM 02080-500-3500, difficult construction
30" V500 (motor operated)	1	EA	$15,259.06	$15,259	Based on 2019 RSM 02080-500-3500, difficult construction
Tie Into Existing 30" FW	1	LS	$1,000.00	$1,000	
Link Seal	1	LS	$1,000.00	$1,000	
Relocate Existing 12" CLDI Filtrate	1	LS	$750.00	$750	
6" Filtrate (CLDI)	20	LF	$61.31	$1,226	2019 RSM 02510-730-2040
6" Bend	6	EA	$397.00	$2,382	2019 RSM 02510-730-8020
Connection to Existing 6" Filtrate	2	LS	$500.00	$1,000	
6" UVE Drain (PVC)	7	LF	$50.00	$350	2019 RSM 15108-520-1960
6" Bend	2	EA	$200.00	$400	
6" V500	1	EA	$787.00	$787	2019 RSM 02080-500-3140
3" FD	50	LF	$50.00	$2,500	
Connection to Existing 3" FD	2	LS	$300.00	$600	
3" UVI DR	50	LF	$40.00	$2,000	
3" V500	2	EA	$650.00	$1,300	Based on 2019 RSM 02080-500-3100
Electrical:					
Electrical Equipment	1	LS	$198,365.48	$198,365	
Lights	14	EA	$750.00	$10,500	
Subtotal				$1,110,948	
Allowance for Misc Items	5%		$1,110,948	$55,547	
Subtotal				$1,166,496	
ALLOWANCES:					
Finishes Allowance	2.0%		$1,166,496	$23,330	
I & C Allowance	6.0%		$1,166,496	$69,990	
Mechanical Allowance	5.0%		$1,166,496	$58,325	
Electrical Allowance	1.0%		$1,166,496	$11,665	other electrical equipment and wiring
Subtotal				$1,329,805	
Allowance for Difficult Construction	7.0%		$1,329,805	$93,086	
Subtotal				$1,422,892	
CONTRACTOR MARKUPS:					

JACOBS
ANN ARBOR, MI WTP UV DISINFECTION SYSTEM (90% Design)

To: Summary Sheet

PROJECT NO: D3156100.A.PN.OE.T102

PREPARED BY: E.R.MEYER

ANN ARBOR, MI WTP UV DISINFECTION SYSTEM (90% Design)

(Costs are as of January 2019, ENR CCI 20 City Average = 11205.44)

DESCRIPTION	QUANTITY	UNIT	$/UNIT *(includes Material & Installation)*	TOTAL COST	REFERENCE
Overhead	12%		$1,422,892	$170,747	
Subtotal				$1,593,639	
Profit	5%		$1,593,639	$79,682	
Subtotal				$1,673,321	
Mob/Bonds/Insurance	5%		$1,673,321	$83,666	
Subtotal				$1,756,987	
Contingency	15%		$1,756,987	$263,548	
SUBTOTAL with Markups				$2,020,535	
Escalation	2.0%		$2,020,535	$40,411	
SUBTOTAL Construction Cost with Escalation				**$2,060,945**	
Tax	6%		$1,236,567.12	$74,194	
TOTAL Construction Cost with Escalation & Tax				**$2,135,139**	
TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor	100%			**$2,135,139**	
Market Adjustment Factor	5%		**$2,135,139.23**	**$106,757**	
TOTAL Construction Cost with Escalation & Tax, Location Adjustment Factor and Market Adjustment Factor				**$2,241,896**	
Engineering Design Services	7%		$2,241,896.19	$156,933	
TOTAL Construction Cost with Escalation & Tax, Location Adjustment Factor, Market Adjustment Factor and Non-Construction Costs				**$2,398,829**	
American Iron and Steel Requirements				**$ 37,500**	
Total Cost				***$2,436,329***	

Appendix H
Public Hearing

- Notices of Public Hearing
- Sign-in Sheet
- Slide Presentation
- Minutes from Court Recorder

Notices of Public Hearing

Washtenaw Legal News
- printed advertisement
- City printed newspaper of Record

NOTICE OF PROJECT PLAN PUBLIC HEARING

The City of Ann Arbor, Water Treatment Services Unit will hold a public hearing on the proposed Water Treatment Plant UV Disinfection System project for the purpose of receiving comments from interested persons.

The hearing will be held at
6 - 7 p.m. on Monday April 8, 2019
at the following location:
Water Treatment Plant,
919 Sunset Rd.,
Ann Arbor, MI 48103

The purpose of the proposed project is to install an additional disinfection barrier at the Ann Arbor drinking water treatment plant to assist with meeting new regulations and continue providing excellent public health protection.

Project construction will involve installation of a new ultraviolet light (UV) water disinfection system inside the existing water treatment plant building. Project components include UV equipment, pipes, valves, electrical and instrumentation equipment. The project will utilize existing water treatment plant facilities to minimize cost and maximize operational efficiency.

Impacts from the proposed project may include intermittent deliveries or construction related traffic in the vicinity of the City of Ann Arbor Water Treatment Plant site (919 Sunset Road, Ann Arbor, MI) during daytime hours between July 2019 through August 2020. All work activities related to this project will be conducted within the site limits of the City of Ann Arbor Water Treatment Plant.

The estimated cost to users for the proposed project will be approximately $152,891 annually for the debt repayment period of 20 years, representing a total project cost of approximately $2,500,000. For the average residential customer using 18 CCFs per quarter, this represents a 0.725% increase in rates, or 96 cents annually, and $19.20 total for the duration of the debt repayment for this project.

Copies of the plan detailing the proposed project are available for inspection at the following location: Water Treatment Plant, 919 Sunset Rd., Ann Arbor MI 48103

Applicable written comments received before the hearing record is closed on Monday, April 8, 2019 will receive responses in the final project plan. Written comments should be sent by email to: water@a2gov.org

03/07 ← Date printed

Press Release / City Website

April 8 Public Meeting will Discuss Water Treatment Plant UV Disinfection System Project

March 5, 2019 - The City of Ann Arbor Water Treatment staff will hold a public hearing on the proposed water treatment plant ultraviolet (UV) light disinfection system project for the purpose of receiving comments from interested persons. The hearing will be 6–7 p.m. Monday, April 8, 2019, at the City of Ann Arbor Water Treatment Plant, 919 Sunset Road, Ann Arbor.

The purpose of the proposed project is to install an additional disinfection barrier at the Ann Arbor drinking water treatment plant to assist with meeting new regulations for the treatment of cryptosporidium. Cryptosporidium is a microscopic waterborne parasite that can be found in stormwater runoff, agricultural runoff, failed septic systems or sewage overflows. The city's current treatment processes, including ozone disinfection and filtration, are effective at removing cryptosporidium, but new regulations require additional treatment.

Project construction will involve installation of a new UV water disinfection system inside the existing water treatment plant building. Project components include UV equipment, pipes, valves, electrical and instrumentation equipment. The project will use existing water treatment plant facilities to minimize cost and maximize operational efficiency.

Impacts from the proposed project may include intermittent deliveries or construction-related traffic in the vicinity of the City of Ann Arbor Water Treatment Plant site during daytime hours July 2019 through August 2020. All work activities related to this project will be conducted within the site limits of the City of Ann Arbor Water Treatment Plant.

The estimated cost to users for the proposed project will be approximately $152,891 annually for the debt repayment period of 20 years, representing a total project cost of approximately $2,500,000. For the average residential customer using 18 cubic feet (CCF) per quarter, this represents a 0.725 percent increase in rates, or $0.96 annually, and $19.20 total, for the duration of the debt repayment for this project.

Copies of the plan detailing the proposed project are available for inspection at the following location: City of Ann Arbor Water Treatment Plant, 919 Sunset Road, Ann Arbor 48103.

Applicable written comments received before the hearing record is closed, at 7 p.m. on Monday, April 8, 2019, will receive responses in the final project plan. Written comments can be sent via email to water@a2gov.org (mailto:water@a2gov.org).

# # # # #

From: Satterlee, Joanna <JESatterlee@a2gov.org>
Sent: Tuesday, March 05, 2019 1:24 PM
To: Satterlee, Joanna
Cc: Wondrash, Lisa
Subject: April 8 Public Meeting Will Discuss Water Treatment Plant UV System Project

Dear news media and community:

The City of Ann Arbor Water Treatment Plant is holding a public meeting with a public hearing **Monday, April 8 at 6 p.m.**, regarding its ultraviolet disinfection system project. Please see the news release, below and online, for details.

We hope you will share this opportunity with your audience.

Thank you for your consideration,

Joanna E. Satterlee
City of Ann Arbor | Communications Unit | Larcom City Hall · 301 E. Huron St., Third Floor · Ann Arbor · MI · 48104
734.794.6110, extension 41105 (O) | jesatterlee@a2gov.org | www.a2gov.org | www.facebook.com/thecityofannarbor | http://twitter.com/a2gov

A2 Be Safe. Everywhere. Everyone. Every day.
a2gov.org/A2BeSafe

PRESS RELEASE
For Immediate Release
Contact: Lisa Wondrash, Communications Director, lwondrash@a2gov.org | 734.794.6152

April 8 Public Meeting will Discuss Water Treatment Plant UV Disinfection System Project

ANN ARBOR, Michigan, March 5, 2019 — The City of Ann Arbor Water Treatment staff will hold a public hearing on the proposed water treatment plant ultraviolet (UV) light disinfection system project for the purpose of receiving comments from interested persons. The hearing will be 6–7 p.m. Monday, April 8, 2019, at the City of Ann Arbor Water Treatment Plant, 919 Sunset Road, Ann Arbor.

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Project construction will involve installation of a new UV water disinfection system inside the existing water treatment plant building. Project components include UV equipment, pipes, valves, electrical and instrumentation equipment. The project will use existing water treatment plant facilities to minimize cost and maximize operational efficiency.

Impacts from the proposed project may include intermittent deliveries or construction-related traffic in the vicinity of the City of Ann Arbor Water Treatment Plant site during daytime hours July 2019 through August

2020. All work activities related to this project will be conducted within the site limits of the City of Ann Arbor Water Treatment Plant.

The estimated cost to users for the proposed project will be approximately $152,891 annually for the debt repayment period of 20 years, representing a total project cost of approximately $2,500,000. For the average residential customer using 18 cubic feet (CCF) per quarter, this represents a 0.725 percent increase in rates, or $0.96 annually, and $19.20 total, for the duration of the debt repayment for this project.

Copies of the plan detailing the proposed project are available for inspection at the following location: City of Ann Arbor Water Treatment Plant, 919 Sunset Road, Ann Arbor 48103.

Applicable written comments received before the hearing record is closed, at 7 p.m. on Monday, April 8, 2019, will receive responses in the final project plan. Written comments can be sent via email to water@a2gov.org.

# # # # #

Poster at City Hall

Please join us!

Water Treatment Plant UV Disinfection System Project Public Meeting

Monday, April 8, 2019
6 – 7 p.m.
Ann Arbor Water Treatment Plant
919 Sunset Road
Ann Arbor, MI 48130

The purpose of the proposed project is to install an additional disinfection barrier at the Ann Arbor drinking water treatment plant to assist with meeting new regulations and continue providing excellent public health protection.

Project construction will involve installation of a new ultraviolet light (UV) water disinfection system inside the existing water treatment plant building. Project components include UV equipment, pipes, valves, electrical and instrumentation equipment. The project will utilize existing water treatment plant facilities to minimize cost and maximize operational efficiency.

Impacts from the proposed project may include intermittent deliveries or construction related traffic in the vicinity of the City of Ann Arbor Water Treatment Plant site (919 Sunset Road, Ann Arbor, MI) during daytime hours between July 2019 through August 2020. All work activities related to this project will be conducted within the site limits of the City of Ann Arbor Water Treatment Plant.

Copies of the plan detailing the proposed project are available for inspection at the following location: Water Treatment Plant, 919 Sunset Rd., Ann Arbor MI 48103

Applicable written comments received before the hearing record is closed on Monday, April 8, 2019 will receive responses in the final project plan. Written comments should be sent by email to: water@a2gov.org

Contact information
www.a2gov.org

CITY OF ANN ARBOR MICHIGAN

Sign-in Sheet

CITY OF ANN ARBOR
WATER TREATMENT SERVICES

Sign-in Sheet

Ultraviolet (UV) Disinfection System Project

MDEQ DWRF Public Hearing

Date: Monday, April 8, 2019, 6-7p.m.

List of Attendees:

Name (Please Print)	Company / Address	Email Address	Phone Number
1. Glen Wiczorek	Ann Arbor WTP	gwiczorek@a2gov.org	
2. BRIAN STEGLITZ	"	bsteglitz@a2gov.org	
3. Maddy Way	Jacobs – Consulting Engineer	maddy.way@jacobs.com	
4.			
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12.			

Water Treatment Plant, 919 Sunset Road, Ann Arbor, Michigan 48103-2924
(734) 994-2840 • Fax (734) 994-0151
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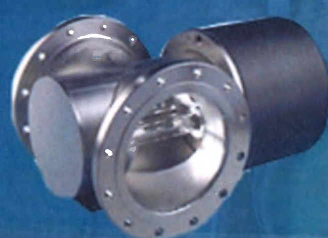
Slide Presentation

City of Ann Arbor Water Treatment Plant UV Disinfection System

Public Meeting

April 8, 2019



Introduction

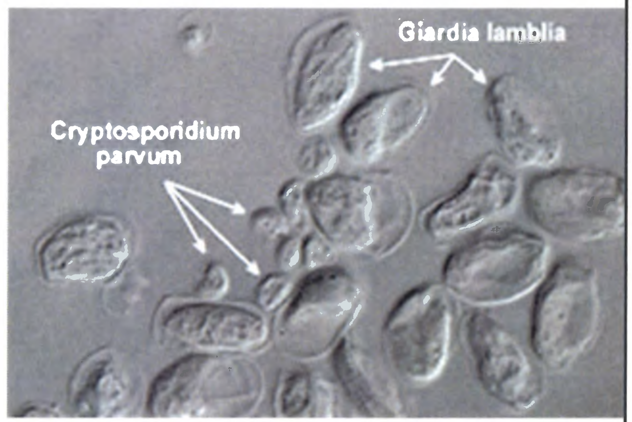
- Glen Wiczorek, PE (Engineer)
- Brian Steglitz, PE (Water Treatment Services Unit Manager)

MDEQ Drinking Water Revolving Fund (DWRF) Program

- Designed to assist water suppliers in satisfying the requirements of the Safe Drinking Water Act by offering low-interest loans

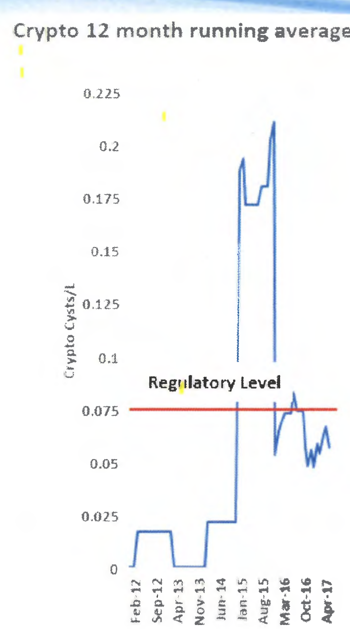
What is Cryptosporidium?

- A protozoan parasite found in water
- Sources include animal waste in stormwater, agricultural runoff, impaired septic tanks, sewage overflows
- Causes intestinal distress (diarrhea) in humans
- More severe consequences in the very young, elderly or immune compromised



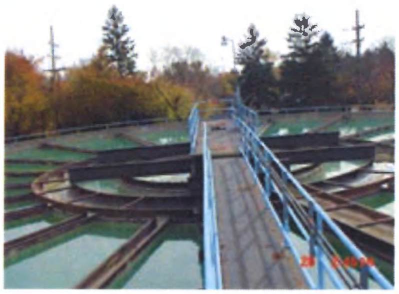
Background

- 2006 EPA regulation requiring additional removal or disinfection of Cryptosporidium (a waterborne parasite).
- The levels of Cryptosporidium in the Huron River are variable and have been above the threshold level.
- MDEQ notified Ann Arbor of the requirement for additional removal or disinfection of Cryptosporidium, and required compliance by June 2020.

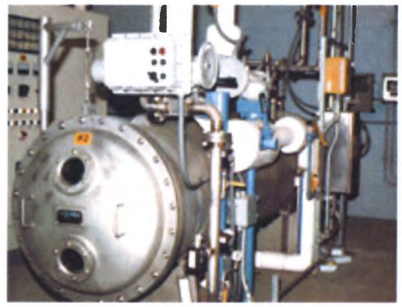


The Ann Arbor Water Treatment Plant has barriers to Cryptosporidium

Lime Softening Clarification



Ozone Disinfection (oxidizer)



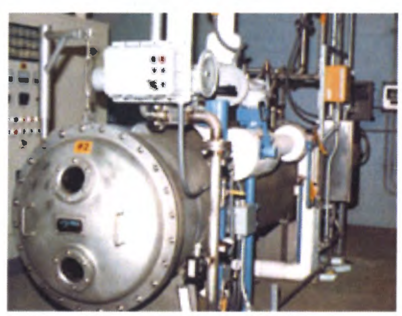
Filtration

Cryptosporidium has not been detected in Ann Arbor's finished drinking water

Issue: If a barrier is out for maintenance or not functioning properly, new Cryptosporidium regulations may not be met at all times

Lime Softening Clarification

Ozone Disinfection

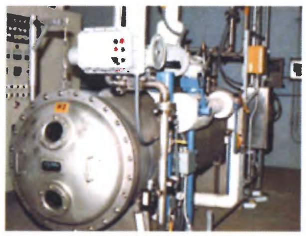


Filtration

Solution: Ultraviolet Light (UV) Disinfection provides an additional barrier that meets all Cryptosporidium regulations

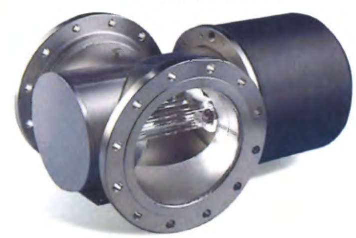
Lime Softening Clarification

Ozone Disinfection



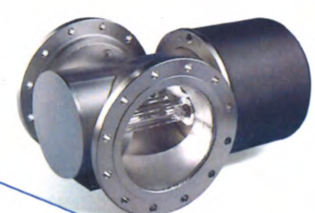
Filtration

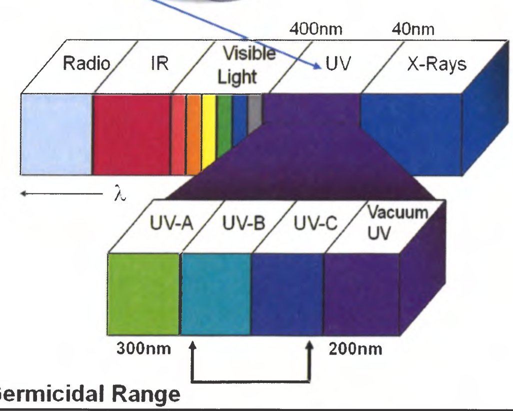
UV Disinfection



What is UV Disinfection?

- Water passes by lamps that emit light in the UV range
- UV light inactivates Cryptosporidium (and many other pathogens) so they can't make people sick
- There are no chemicals added

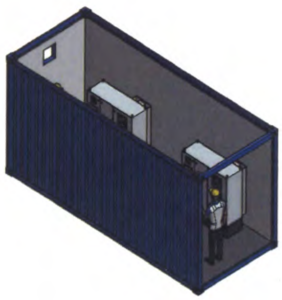




Many Alternatives Were Evaluated

- 17 alternatives were reviewed per EPA Guidance in a 2017 report.
- 3 UV alternatives were evaluated for the Ann Arbor plant in a 2018 report.

UV in containers outside the plant

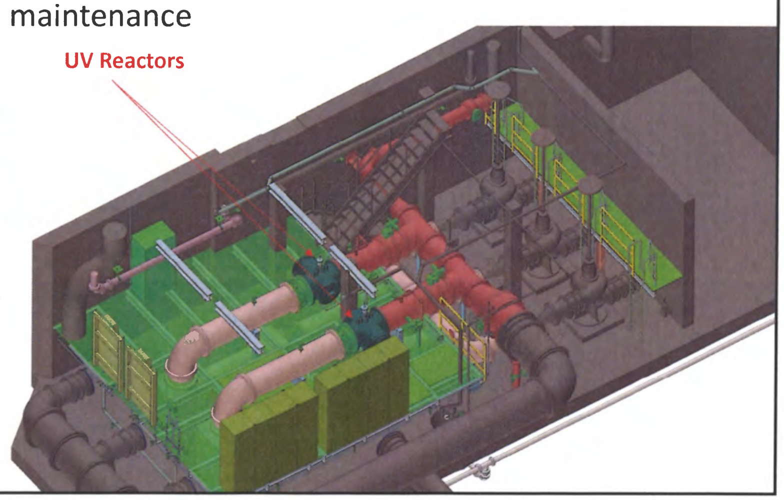


UV in existing pipes inside the plant

UV in an existing pump room inside the plant

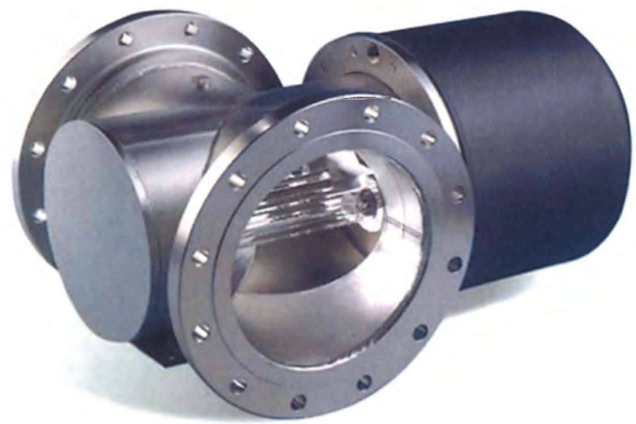
UV in an existing pump room was selected

- Lowest cost (half the cost of other alternatives)
- Convenient for operations and maintenance



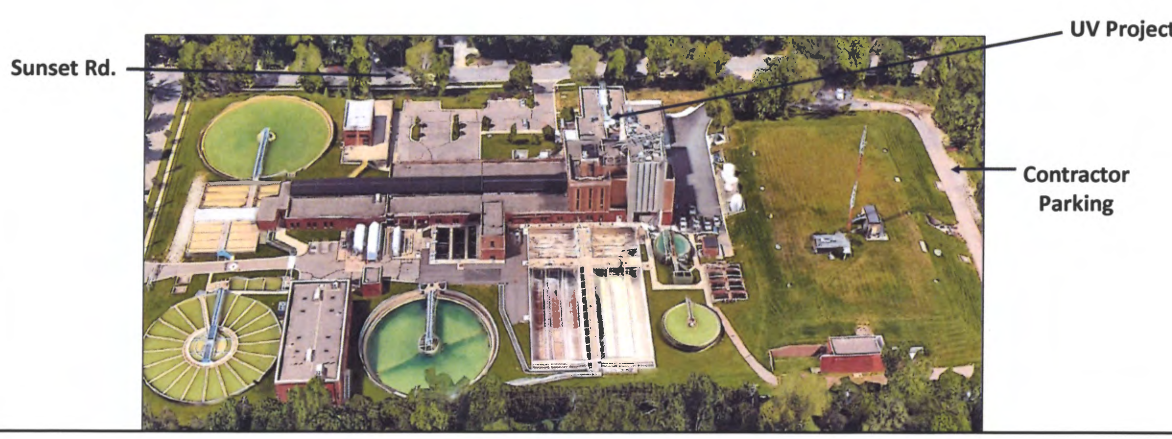
Benefits of UV

- Provides additional public health protection
- Improves water treatment plant flexibility for operations, maintenance and construction
- Additional assurance of regulatory compliance
- Avoids an administrative consent order from MDEQ
- Lower cost than other alternatives



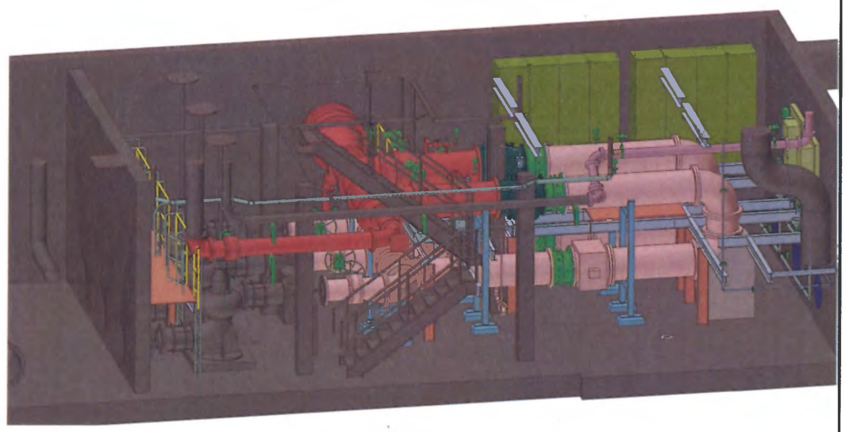
Project Impacts

- Intermittent Traffic during construction
- Removal of lead based paint and some asbestos material during demolition



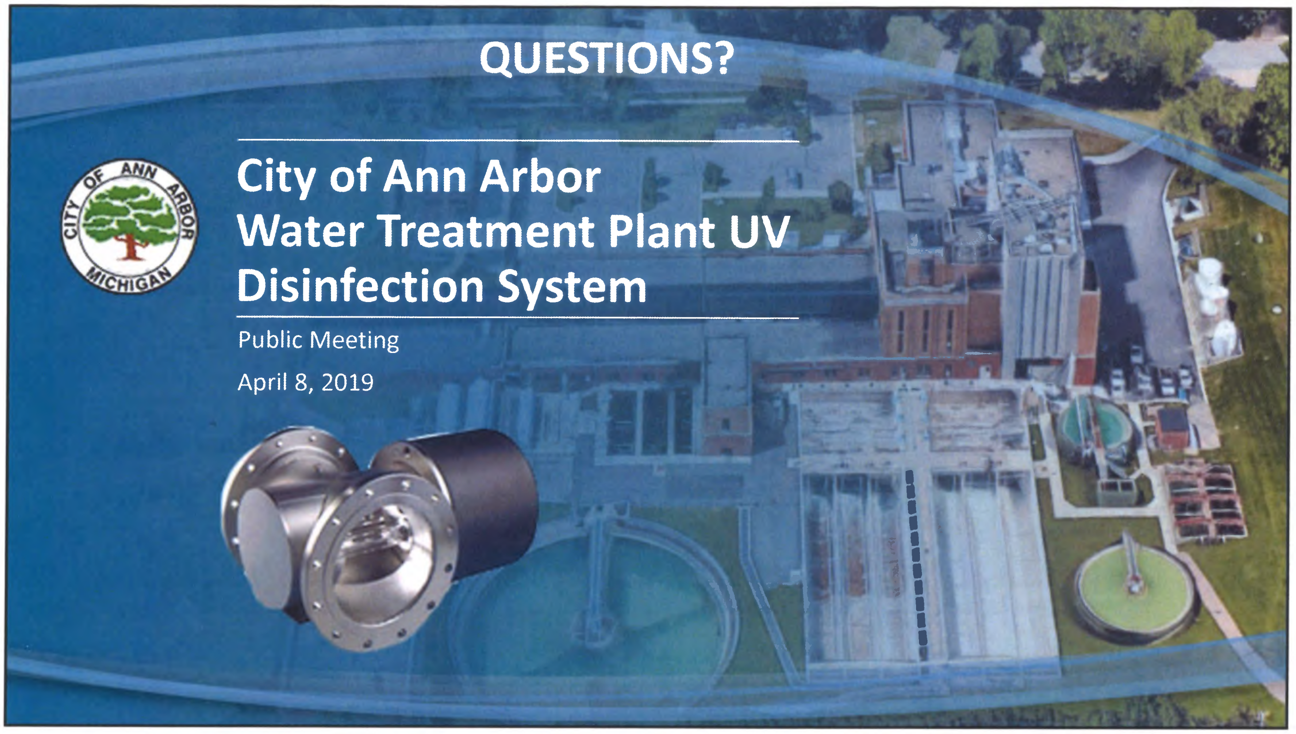
Project Costs

- Approx $3.0 million total project cost
- 0.825% rate increase
- Approx $3.00 per year for 20 years for a typical residential customer



Project Schedule

Date	Event
Nov 2018 – Jan 2019	Detailed Design of UV system
February 7, 2019	Construction Bids Received
March – June 2019	Drinking Water Revolving Loan Application, City Contracts Review
July 2019	Anticipated start of Construction
April 2020	Construction mostly complete
May 2020	Startup, testing, commissioning
June 2020	Project Completion, reporting to MDEQ


QUESTIONS?
City of Ann Arbor
Water Treatment Plant UV
Disinfection System
Public Meeting
April 8, 2019
CITY OF ANN ARBOR
MICHIGAN

Minutes from Court Recorder

CITY OF ANN ARBOR

WTP ULTRAVIOLET (UV) DISINFECTION SYSTEM PROJECT

MDEQ DWRF PUBLIC HEARING

MONDAY, APRIL 8, 2019

6:00 P.M.

Ann Arbor, Michigan

Monday, April 8, 2019

(At about 6:15 P.M.)

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MR. WICZOREK: My name is Glen Wiczorek. I'm the engineer at the water plant. It is now 6:15 P.M., and we have no attendees here from the public, and at this point we will close the public hearing.

(Proceedings concluded)

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CERTIFICATE OF NOTARY PUBLIC - COURT REPORTER

I do certify that the attached proceedings were taken before me in the above-entitled matter; that the proceedings contained herein was by me reduced to writing by means of stenography, and afterwards transcribed upon a computer. The attached pages are a true and complete transcript of the proceedings.

I do further certify that I am not connected by blood or marriage with any of the parties, their attorneys or agents, and that I am not an employee of either of them, nor interested, directly or indirectly, in the matter of controversy.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my notarial seal at West Bloomfield, Michigan, County of Oakland, this 9th day of April 2019.

Theresa L. Roberts

Theresa L. Roberts, CSR
Certified Shorthand Reporter - CSR-4870
Notary Public - Oakland County, MI
My commission expires 10-04-2020