BYU ENGINEERING
Civil & Construction Engineering

CAPSTONE

E. COLI IN LEHI PRESSURIZED IRRIGATION
PROJECT ID: CEEN_CPST_008

by

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A Capstone Project Final Report

Submitted to

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Executive Summary

PROJECT TITLE: **E. COLI IN LEHI PRESSURIZED IRRIGATION**
PROJECT ID: CEEn_CPST_008
PROJECT SPONSOR: Lehi Public Works Department
TEAM NAME: HEZ Engineers

This project aims to address the critical issue of E. coli contamination in the PI water system of Lehi city in central Utah. The primary objectives are to identify the root cause of the contamination and to develop effective treatment options to deactivate and lower the bacterial levels. These treatment options will include Chlorine. Ultraviolet, and Ozone.

The project tasks involve a comprehensive investigation of the PI water system to pinpoint the source of contamination. This will be followed by research into potential treatment options that can effectively reduce bacterial levels. Regular testing of the PI water system will be conducted to ensure it meets culinary drinking water standards. Additionally, an ongoing education program will be implemented to inform the residents of Lehi about the dangers of E. coli contamination and the importance of maintaining good hygiene practices.

The project timeline is as follows:

- A two-week period is allocated for the investigation of the PI water system.
- The development of the treatment toolbox is expected to take eight weeks.
- Regular testing of the PI water system and the education of Lehi residents are ongoing tasks.

The deliverables for this project include a detailed report on the investigation of the PI water system, a toolbox of treatment options based on current research, regular testing reports of the PI water system, and educational materials for the residents of Lehi.

After thorough research into various treatment options for Lehi's PI basin, including chlorine, ultraviolet, and ozone methods, our findings indicate that none of these options are suitable for implementation. Ozone treatment, while effective, is financially unfeasible due to the substantial costs associated with facility construction and maintenance. Similarly, ultraviolet treatment presents significant financial challenges, requiring costly basin modifications and ongoing maintenance expenses. Though chlorine treatment appears more economically viable, concerns persist regarding residual Disinfection-By-Products (DBPs) that could remain in the water post-treatment, potentially posing health risks to residents.

Given these realities, we recommend a shift towards a community-focused approach centered on public education. By providing residents with comprehensive information about PI water and its practical uses, we propose a cost-effective and sustainable solution for Lehi. This strategy not only alleviates financial strain on the city but also fosters community engagement and awareness, promoting responsible water management practices. Through targeted education initiatives, residents can gain valuable insights into the benefits and safe utilization of PI water, ensuring its seamless integration into daily life while safeguarding public health and environmental integrity. By embracing this approach, Lehi not only sidesteps the financial burdens associated with treatment infrastructure but also cultivates a knowledgeable and empowered community ready to embrace sustainable water practices for the long term.

By addressing the E. coli contamination issue in the PI water system, this project aims to ensure the safety and health of the residents of Lehi.

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Introduction

In the fall of 2023, the city of Lehi was contacted by the health department for E. coli in their PI system. These reports started a chain of events of testing and a collaborated effort from the city of Lehi and the CDC to resolve this issue. The team took samples for E. coli and free copper residuals. Although these testing's gathered inconclusive results shock treatment was determined to be used as a safety measure. The city of Lehi continued consulting with health departments and contacted BYU to work with students to reach a solution.

The consensus from the start was that Lehi would make the final decision. We were only there to give our insight and a report with ideas that could combat the problem of E. coli in the PI system. The team found four possible remedies that were shown to help. These include UV, Chlorine, and ozone treatment as well as a public education campaign. Extensive research was done on all different methods to determine what would be the best fit for the city of Lehi's PI system. Each treatment was determined by the pricing, effectiveness, and applicability.

The expectation for this project was to give a "toolbox" for the city to evaluate and determine the best fit for them. We went into details in each option and kept in mind the limitations of the PI system. Each week we would meet to discuss what we had found on each option and any challenges we had faced to determine the next action of course to resolve this.

Schedule

In the fall of 2023, we received our capstone project and were given a brief rundown of the challenges Lehi was experiencing with E. coli in their PI system. We then went and met with the city of Lehi. They gave us a rundown of what the situation was and what they wanted from us.

After this we met every week to discuss potential options that Lehi could use to treat the E. Coli. We did research on our own and took elements from various classes to make these decisions. In February we met with Dr. Sowby to clarify some of our ideas, and he directed us on what we could present to Lehi. This led to the "toolbox", a report that would discuss various solutions and the pros and cons of each. This would allow Lehi to see all the ways that they could prevent E. Coli from entering the PI system and allow them to decide on what works best for their system.

From this we started creating the toolbox and met every week to discuss any challenges or ideas we had for the group working on this report. On February 26th we met with Dr. Hotchkiss to discuss our progress on the report.

On March 13th we scheduled another meeting with the city of Lehi to present our report. This included all possible solutions for the PI system. From this we and the city of Lehi decided the best move of action would be the public outreach program. We were also invited to represent BYU and the city of Lehi at the utility fair that the city puts on. We would be there to discuss with anyone that has questions about the problem of E. Coli in the PI water and show what we have found along with what the city is doing.

Assumptions & Limitations

In light of the various constraints and circumstances encountered during our research, we had to make several assumptions. To obtain accurate prices and costs for the different water treatments, we reached out to numerous suppliers and manufacturers for quotes. However, we were denied this information as we were only students and not inquiring about a legitimate project. Consequently, we had to find alternative ways to determine prices. Many of the prices we found in the report are based on older projects and are several years old. While these prices come from reliable sources like the EPA, they may not accurately reflect the systems we have discussed or the price changes for the year 2024.

Given that the system is a pressurized irrigation system and not used for drinking water or used consistently throughout the year, our designs were intended for use only during the peak season when residents consistently use the PI water in the summer months. We assumed that it would be feasible to shut down the treatment systems in the winter to conserve resources, whether that be chemicals or energy.

In conclusion, while we have strived to provide the most accurate and comprehensive analysis possible, it is important to note that our research is based on a series of assumptions and faced several limitations. These factors may impact the applicability and accuracy of our findings. We recommend that future research in this area consider these limitations and seek to obtain more current and specific data where possible. Despite these challenges, we believe our work provides a valuable starting point and contributes to the broader understanding of water treatment systems and their costs.

Design, Analysis & Results

Contaminant	MCLG (Maximum Contaminant Level Goal)[1] (mg/L (Milligrams per Liter))[2]	MCL (Maximum Contaminant Level) or TT (Treatment Technique)[1] (mg/L (Milligrams per Liter))[2]	Potential Health Effects from Long-Term Exposure Above the MCL (Maximum Contaminant Level) (unless specified as short-term)	Sources of Contaminant in Drinking Water
Total Coliforms (including fecal coliform and *E. Coli*) • Quick reference guide • Rule Summary <https://epa.gov/dwreginfo/revised-total-coliform-rule-and-total-coliform-rule>	zero	5.0%[4]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[5]	Coliforms are naturally present in the environment; as well as feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.

Figure 1: EPA Maximum Contaminant Level Goal for Total Coliforms (U.S. Environmental Protection Agency. (n.d.). National Primary Drinking Water Regulations.)

EPA/Safe Drinking Water Act

Figure 1 shows the EPA's standards on Maximum Contaminant Level Goal for total coliforms or E. Coli. The goal is zero which is what we have created our designs to do. Even though this is a

Rule Summary

The Environmental Protection Agency (EPA) published the Revised Total Coliform Rule (RTCR) in the Federal Register (FR) on February 13, 2013 (78 FR 10269) and minor corrections on February 26, 2014 (79 FR 10665). The RTCR is the revision to the 1989 Total Coliform Rule (TCR) and is intended to improve public health protection.

All public water systems (PWSs), except aircraft PWSs subject to the Aircraft Drinking Water Rule (ADWR) (40 CFR 141 Subpart X), must comply with the RTCR starting April 1, 2016, or an earlier state effective date. Until then, PWSs must continue complying with the 1989 TCR.

Total coliforms are a group of related bacteria that are (with few exceptions) not harmful to humans. A variety of bacteria, parasites, and viruses, known as pathogens, can potentially cause health problems if humans ingest them. EPA considers total coliforms a useful indicator of other pathogens for drinking water. Total coliforms are used to determine the adequacy of water treatment and the integrity of the distribution system.

Key provisions of the RTCR include:

- Setting a maximum contaminant level goal (MCLG) and maximum contaminant level (MCL) for E. coli for protection against potential fecal contamination.
- Setting a total coliform treatment technique (TT) requirement.
- Requirements for monitoring total coliforms and E. coli according to a sample siting plan and schedule specific to the PWS.
- Provisions allowing PWSs to transition to the RTCR using their existing Total Coliform Rule (TCR) monitoring frequency, including PWSs on reduced monitoring under the existing TCR.
- Requirements for seasonal systems (such as, Non-Community Water Systems not operated on a year-round basis) to monitor and certify the completion of a state-approved start-up procedures.

Figure 2: EPA Rule Summary on Total Coliform (U.S. Environmental Protection Agency. (2014). Revised Total Coliform Rule and Total Coliform Rule)

pressurized irrigation system that is not meant to be consumed, the designs have been done similar to a drinking water facility and will be treated as such.

Figure 2 is a summary of the EPA's rules on E. Coli and Coliform. We followed these rules as we attempted to come up with designs to disinfect the sandpit basin.

Chlorine

Overview

Chlorine has been used to disinfect water in the U.S. since the early 1900s, and it remains the most frequently used water and wastewater disinfectant worldwide due to its low cost and effectiveness at deactivating a wide range of pathogens.

The two most common chlorine products for these applications are chlorine gas (Cl2) and sodium hypochlorite (NaOCl), a.k.a. bleach. For the most part, both chlorine compositions function the same way, in that they dissolve in water to form free chlorine in the form of hypochlorous acid (HOCl) and hypochlorite ion (OCl^-). Treatment plants target the same parts per million of free chlorine regardless of which chlorine source is used.

Despite this, they are two very different products. Choosing which chlorine chemical to use is an important decision among water and wastewater managers, and requires balancing the overall costs, safety procedures, and more.

For optimum performance, a chlorine disinfection system normally should provide rapid initial mixing and a plug flow contact regime. The goal of proper mixing is to enhance disinfection by initiating a reaction between free chlorine and ammonia nitrogen. This helps to prevent free chlorine from reacting with organic carbon compounds and forming hazardous byproducts. In order to allow appropriate time for the disinfection reaction, the contact chamber should be designed with rounded corners to eliminate dead flow areas. It should also be baffled to minimize short-circuiting. This design allows for adequate contact time between the microorganisms and a minimal chlorine concentration for a specific period of time. Since this is a small system, we believe that injecting the chlorine where the water enters the basins should be enough to allow the chlorine to come into contact with most water molecules and disinfect the basin. Similar to what was previously done with the copper sulfate.

Chemical feed systems are used for adding sodium and/or calcium hypochlorite solutions. For sodium hypochlorite, the basic components of a chemical feed system include a plastic or fiber glass storage reservoir, metering pumps, and an injection device to inject the hypochlorite solution into a contact tank or pipeline. Calcium hypochlorite can typically be added to the water either by mixing calcium hypochlorite powder in a mixing device and then injecting it into the water stream, or by immersing chlorine tablets in the water using a tablet chlorinator.

The required degree of disinfection can be achieved by varying the dose and the contact time for any chlorine disinfection system. Chlorine dosage will vary based on chlorine demand, water characteristics, and discharge requirements. The dose usually ranges from 5 to 20 mg/L

Property	Effects on Chlorination	Effects on UV Disinfection
Ammonia	Forms chloramines when combined with chlorine.	Minor effect, if any.
Nitrite	Reduces effectiveness of chlorine and results in THMs.	At high concentrations may absorb UV light and reduce transmittance.
Nitrate	Minor effect, if any.	At high concentrations may absorb UV light and reduce transmittance.
Bio-chemical oxygen demand (BOD)	Organic compounds associated with BOD can consume added chlorine.	Minor effect, if any. If a large portion of the BOD is humic and/or unsaturated (or conjugated) compounds, then UV transmittance may be diminished.
Hardness	Minor effect, if any.	Affects solubility of metals that can absorb UV light. Can lead to the precipitation of carbonates on quartz tubes.
Humic materials, Iron	Minor effect, if any.	High absorbency of UV radiation.
pH	Affects distribution between hypochlorous acid and hypochlorite ions and among the various chloramine species.	Affects solubility of metals and carbonates, and thus scaling potential.
TSS	Shielding of embedded bacteria and chlorine demand.	Absorbs UV radiation and shields embedded bacteria.

Figure 3: Effects on Disinfection (U.S Environmental Protection Agency. (2003), Wastewater Technology Fact Sheet: Disinfection for Small Systems)

When operating chemicals such as chlorine in any form, there comes a need for Risk Management Plans (RMPs). The chlorine should never be stored near other chemicals, if there were ever to be a leak, proper PPE should be worn and used until the danger is mitigated. Proper tools to transferring the chemicals from the tank to the water would be needed as well. If it's a physical form of chlorine, metering pumps can be used to dose the proper amount of chlorine into the system. A gas form of chlorine would need specialized equipment and often specific training on how to operate the equipment.

Installation/Costs

To install a chemical disinfectant system into the basin within Lehi, several things would need to be considered before making a decision. We would like to avoid having to create an entirely new treatment facility similar to the Central Utah Water Conservancy District, to treat this relatively small basin. Doing so would be incredibly expensive and time-consuming. We have researched ideas for the city to be able to treat the basin on site, with minimal costs. Both chlorine gas and sodium hypochlorite (physical tablets) are affordable disinfectants, although the former is slightly cheaper from a raw chemical cost standpoint. The metering equipment used to dispense chlorine gas is more costly. The two most used types of chemical metering pumps for dispensing liquid chlorine are peristaltic and diaphragm types of chemical feed pumps. We recommend the peristaltic pump because are extremely effective when pumping fluids that contain trapped gases since they are not affected by air bubbles. The bubbles simply move through the pump tubing as the pump maintains a constant rate of flow with no potential for vapor lock, and peristaltic pumps do not lose prime. Due to this characteristic, Peristaltic pumps have been widely accepted as the preferred technology in many water and wastewater treatment applications.

To install a peristaltic metering system, the city of Lehi would need to build something like a chemical shed near the sandpit basin. This shed would hold the tanks for the chemicals, all monitoring devices needed to maintain and keep water chemicals at a safe level and would also need the injection point to be close by or attached to the shed. A backflow prevention check valve at the discharge side of the pump to prevent the system fluid from flowing back through the pump during tube replacement. A pressure relief valve is also recommended to prevent wear and damage to pump tubes. After everything is installed, built, and designed to correct specifications, the metering system can be installed. We would also recommend a monitoring device downstream in the system that is connected to the pump that relays current information of the water quality to the pump so that dosing can happen only when needed. Refer to Appendix B for Peristaltic Metering Pump Brochure.

Figure 4: Flexflo Peristaltic Metering Pump (Blue-White Industries. (n.d). M3 Peristaltic Metering Pump.)

After many attempts to acquire information on costs from manufacturers for the peristaltic metering system, we were denied access due to being students without official ties to the city of Lehi and not inquiring about a real construction project. The prices below are based off research from different manufacturers, and guidance from Jon Franklin, an employee of Central Utah Water Conservancy District. If the city decided they wanted to know more about this plan, we can dive deeper into costs and design but would have to be through an employee of the city with an official email. Being students, we were not given the right to know more about costs and product information.

Flow (mgd)			Estimated Capital Costs ($)		
ADWF	PWWF	Cl2 Dose (mg/L)	Chlorination	Estimated O&M Costs	Total Cost
1	2.25	5	$ 410,000.00	$ 49,300.00	$ 459,300.00
10	20	5	$ 1,804,000.00	$ 158,200.00	$ 1,962,200.00
100	175	5	$ 10,131,000.00	$ 660,000.00	$ 10,791,000.00
1	2.25	510	$ 441,000.00	$ 59,200.00	$ 500,200.00
10	20	10	$ 2,051,000.00	$ 226,700.00	$ 2,277,700.00
100	1756	10	$ 10,258,000.00	$ 721,800.00	$ 10,979,800.00
1	2.25	20	$ 445,000.00	$ 76,600.00	$ 521,600.00
10	20	20	$ 2,113,500.00	$ 379,100.00	$ 2,492,600.00
100	175	20	$ 10,273,000.00	$ 1,311,000.00	$ 11,584,000.00

*ADWF = Average Dry Weather Flow
*PWWF = Peak Wet Weather Flow

Figure 5: General Costs of Chlorine Treatment (U.S. Environmental Protection Agency. (n.d.). Wastewater Technology Fact Sheet: Chlorine Disinfection)

Operation and Maintenance

O&M for a chlorine disinfection system should include the following activities:

- Follow all manufacturer recommendations and test and calibrate equipment as recommended by the manufacturer.
- Disassemble and clean system components, including meters and floats, every six months.
- Inspect and clean valves and springs annually.
- If the system includes metering pumps, maintain pumps on a regular basis.
- Remove iron and manganese deposits with muriatic acid or other removal agents.
- If gaseous chlorine is stored on-site, develop an emergency response plan in case of accidents or spills.

Safety Considerations

Because the Sandpit basin is an open basin, there are other safety considerations to consider besides the ones that come with injecting a chemical into water that could be potentially consumed. Chlorine happens to be the only water treatment that produces a Disinfection By-Product (DBPs), which can be harmful to warm blooded creatures if consumed in excess amounts. The Safe Water Drinking Act and EPA do not allow for any trihalomethanes to be found when using chlorine treatment. Even though this is a pressurized irrigation basin/system the rules would still apply since it is still going out to the public and since animals can still get to the basin and consume it themselves. Proper monitoring of the water and contaminant levels would need to be introduced to assure the safety of the water. Below are the standards of DBPs in drinking water.

Contaminant	MCLG (Maximum Contaminant Level Goal)[1] (mg/L (Milligrams per Liter))[2]	MCL (Maximum Contaminant Level) or TT (Treatment Technique)[1] (mg/L (Milligrams per Liter))[2]	Potential Health Effects from Long-Term Exposure Above the MCL (Maximum Contaminant Level) (unless specified as short-term)	Sources of Contaminant in Drinking Water
Bromate	zero	0.010	Increased risk of cancer	Byproduct of drinking water disinfection
Chlorite	0.8	1.0	Anemia; infants and young children: nervous system effects	Byproduct of drinking water disinfection
Haloacetic acids (HAA5) (Haloacetic acids)	n/a[6]	0.060	Increased risk of cancer	Byproduct of drinking water disinfection
Total Trihalomethanes (TTHMs (Total Trihalomethanes))	--> n/a[6]	========-->--> 0.080	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection

Figure 6: MCGL for DBPs (U.S. Environmental Protection Agency. (n.d.). National Primary Drinking Water Regulations.)

As stated before, dealing with chemicals always requires RMPs, PPE, and proper training to handle and operate.

Seasonal Usage

Since the PI system in Lehi is mostly used in the summer months, we recommend only using the treatment in those months. Since the chlorine can be used on site, as soon as treatment is started, the water will be clean for use.

Ultraviolet

Overview

Ultraviolet (UV) light emerges as a highly effective method for treating drinking water by incapacitating harmful microorganisms, such as bacteria, viruses, and protozoa. In this process, UV-C radiation, characterized by wavelengths between 200 and 280 nanometers, plays a pivotal role. Specially designed lamps emit UV-C radiation in water treatment systems, targeting the DNA or RNA structures of microorganisms. As the UV-C light penetrates the cells, it inflicts structural damage on the genetic material, hindering the microorganisms' ability to replicate and function properly. The inactivation of cellular functions prevents reproduction, neutralizing the microorganisms and mitigating the risk of waterborne diseases. UV water treatment systems, which expose water to UV-C light in chambers containing specialized lamps, provide a swift and efficient means of disinfection.

The most common UV system used for small systems is a low-pressure, low-intensity system. Low-pressure signifies the pressure of the mercury in the lamp, which is typically 13.8 Pa (0.002 lbs/in²). The term intensity refers to the lamp power. Standard low-pressure, low-intensity lamps typically have a power of 65 watts. These lamps are generally efficient in producing germicidal wavelengths necessary for damaging DNA in bacteria. The low-pressure, low-intensity lamp typically has 40 percent of its output at 253.7 nm, which is within the ideal range for inactivating bacteria. This type of system can be configured vertically or horizontally. This allows systems to be configured to fit the available space. Safety considerations associated with UV disinfection include UV light itself, and potential release of mercury from lamp bulbs if damaged.

The advantages of UV water treatment include its chemical-free nature, rapid inactivation, and broad-spectrum disinfection capabilities, making it an environmentally friendly and versatile solution for ensuring the microbiological safety of drinking water. However, Ultraviolet light does not hold a residual as well as chlorine does, which means you can't just put lights at the bottom of the basin and hope it disinfect the bacteria. Unlike chlorine that floats around the water and comes in contact with most of the water in the basin, ultraviolet light would need the water to be directed to its lamps with low turbidity to have any effect on the bacteria in the water.

Installations/Costs

To install an ultraviolet light system the city would need to build another facility at the outflow of the basin. Because ultraviolet light works best with low turbidity of water, we believe that since

Figure 7: Glasco NANCO 5000 Series (Glasco UV. (n.d.). NONCON.)

the water is sitting in the basin, most of the turbidity of the water that comes from the inflow will slow down and fall to the bottom of the basin before entering the next facility with ultraviolet lights to treat the water. From our research a possible system that could be used is the “Glasco NONCON Series”. The “NONCON 5000” series is a “flow through” style of UV water disinfection. Unlike other systems where the UV lamps are immersed into the water, this product uses nonconductive transparent fluoropolymer tubes to transport the water close to the UV lamps. Because of this, regular maintenance is not needed as much as traditional UV systems. This product also comes in different sizes so we believe that installing one of these UV systems to act as a discharge pipe before the water enters the city system would be enough to treat the water and kill all bacteria. Refer to Appendix C for Glasco NONCON Series Brochure.

Similar to the chlorine design, costs below are best guesses from research of other manufacturers and water treatment facilities. If the city decided they wanted to know more about this plan, we can dive deeper into costs and design but would have to be through an employee of the city with an official email. Being students, we were not given the right to know more about costs and product information.

General Capital Costs

Items	Cost ($)
Equipment/Facilities	600,000
Structural Modifications	200,000
Electrical	70,000
Miscellaneous	65,000
Total	**935,000**

Figure 8: General Capital Costs for UV System

General Annual Cost

Items	Cost ($)
Energy	5,000
Lamps	10,000
Cleaning	3,000
Maintenance	2,500
Process Control	10,000
Testing	5,000
Total	**35,500**

Figure 9: General Annual Costs for UV System

Operation and Maintenance

Proper O&M of UV disinfection systems should include:

- Sufficient UV radiation is transmitted to organisms to render them sterile.
- All surfaces are clean correctly and frequently. This is one of the biggest causes for failure in a UV disinfection system.
- Average lamp life ranges from 8,760 to 14,000 working hours until they need to be replaced.

Safety Considerations
Ultraviolet light is significantly safer than any other disinfection system. There are no concerns of DBP's or any other harm that could come to the water that is being treated. The only issues that arise with UV is exposure to light. Too much exposure can cause skin burns, or eye damage. Fortunately, this system is enclosed making this exposure to the light not possible. Power to the system is the main concern mostly, if power is too low or not working, then the water will not be disinfected or treated. When in operation the power would need to be overseen and operated correctly.

Seasonal Usage
Since the PI system in Lehi is mostly used in the summer months, we recommend only using the treatment in those months. The UV system can be turned on and off for use when needed. As soon as the system is turned back on, disinfection of the water will run like normal.

Ozone
Overview
Ozone is a powerful oxidizer that can rapidly neutralize biological contaminants such as bacteria, viruses, and parasites. Unlike traditional chemical treatments, ozone introduces no additional chemicals into the water, ensuring purity without compromising quality. Its proven efficacy across various applications, coupled with its rapid action in eliminating metals and organic matter, makes ozone an ideal choice for efficient water purification. Incorporating ozone into water treatment strategies offers a sustainable and environmentally friendly solution, safeguarding both public health and our precious water resources. However, Ozone is a very expensive and specific treatment option that we do not believe would be worth considering in our design efforts for treatment of the Sandpit Basin. In order to install an ozone treatment facility, redirection of the water coming into the basin would be required. Water would need to be directed to a brand-new facility bigger than the site has space for, where tanks would collect the water and infuse the ozone into the water. Ozone also does not do as well as other treatment options at holding a residual within the water for a long period of time. Most likely you would still need to have a chlorine treatment to work with the ozone in order for the water to be safe to drink or remove all contaminants. Because of these reasons we do not recommend using ozone or spending time in consideration of this treatment. In the end it would be too costly and time effective for the city to consider as a liable option of treatment.

Do Not Contact PI Water
The Lehi PI system is not treated so contaminants in the water are almost guaranteed. Drinking water can lead to health effects at different levels. Below are listed contaminants that can be present in the PI water system.

- E. Coli
- Giardia
- Noroviruses
- Lead

- Arsenic
- Atrazine
- Glyphosate
- And many more

These contaminants listed are dangerous to human health. If possible, stay out of contact with PI water. Consuming pi water can lead to various health issues such as gastrointestinal problems, poisoning, or even long-term health complications. Therefore, it is imperative for individuals to refrain from drinking pi water and instead opt for clean, potable sources of drinking water to safeguard their health.

Public Education Plan

We believe that a reach out program/public education plan will be the most effective in this situation. We understand that the city of Lehi is already working with other organizations and cities to implement this into effect here soon. We would like to propose a plan to do so and a way we can track the success of this public education plan. In this report we have included a poster that can be used in the efforts to educate the public. Refer to Appendix D for several examples of this poster.

Communication Channels

We want to inform residents of the harms and correct uses of pressurized irrigation. First, we need to find ways to get in contact with all residents and ensure that they see the information that we will provide them with. These communication channels could include:

1. **City Website:** We can post detailed articles and FAQs about pressurized irrigation.
2. **Social media:** Share infographic that we have designed already and short videos demonstrating the proper use and potential dangers of pressurized irrigation.
3. **Email Newsletter:** Send regular updates and tips to subscribed residents. This could also include similar items as the social media plan.
4. **Public Workshops:** Conduct free workshops demonstrating the use and maintenance of these systems.
5. **Direct Mail:** Send information pamphlets to all residents. Included in these pamphlets or letters we believe that it would be beneficial to include a sticker or tag that residents could put onto PI connections that include a short synopsis of the uses of PI as a quick reminder for them before they decide to use their PI water for whatever reason. Refer to Appendix E for an example of this tag.

Content

Things that we would include in these letters, posts, emails, workshops, and flyers would include:

1. **Benefits of Pressurized Irrigation:** Explain how these systems can help save water and maintain healthy landscapes.
2. **Safe Usage:** Provide guidelines on how to safely use and maintain these systems.

3. **Potential Dangers:** Discuss the risks associated with improper use or maintenance.
4. **Local Regulations:** Inform about any city or state regulations regarding the uses of pressurized irrigation.

Success Metrics

We would like to know the success of our efforts in this plan, and we have come up with several ways that the city could track this success which include:

1. **Engagement Rates:** Monitor the number of views, shares, likes, and comments on online content.
2. **Workshop Attendance:** Track the number of attendees at public workshops.
3. **Feedback:** Collect feedback from residents through online surveys or feedback forms at workshops
4. **Water Usage:** Monitor city-wide water usage statistics to see if there's a decrease in water waste.

Related Issues

Pressurized irrigation systems play a crucial role in maintaining green spaces, gardens, yards, and agricultural lands. However, when E. coli contaminates these water sources, it can have repercussions for public health. E. coli is commonly present in irrigated water. Unlike culinary water, which undergoes treatment to ensure safety, PI water remains untreated. Consequently, it becomes susceptible to contamination by harmful bacteria, including E. coli. The lack of treatment leaves a potential gap in safeguarding public health. E. coli infections can manifest in various ways, affecting both adults and children. Health issues associated with E. coli exposure include gastrointestinal illness symptoms including diarrhea, abdominal pain, and vomiting. E. Coli infection can also lead to sepsis and meningitis, both serious medical issues. Exposure to secondary water is common as it can be used for recreational purposes, which won't likely cause issues unless it is ingested in meaningful amounts, like drinking a glass of water.

Because of the purpose of secondary water, and the outsized costs that would result from treatment, the best solution to prevent E. Coli outbreaks in Lehi and similar communities would be public education. Public education is flexible, low-cost, and adaptable to individual community needs. Outreach and education can take form in many ways. Special emails can be sent to emails. Flyers, warnings, and fact sheets can be sent out with mail that people would normally receive from the city. Social media can be used as well. Another potential solution for outreach is to give reminders that people can use at their individual residences. Giving some sort of visual marker, tag, or sign on or near secondary water sources can help individuals be reminded not to drink secondary water. Although it may seem challenging to manage outbreaks in water systems, effective public outreach measures can help reduce the odds of future outbreaks.

Cultural factors also played a role with infections in Lehi, and likely do around the world. To approach other situations around the world, it is necessary to consider the cultural reasons people interact with water. These cultural perceptions include risk perception, community norms, education and awareness, hygiene practices, and beliefs about water. In terms of risk perception, many people, especially children, might not know about the importance of water quality. If they see clear water, they may assume it is drinkable. Then on a hot summer day, after playing outside, will look to the most convenient source of water, the garden hose, and drink enough water from it to cause an E. Coli infection. This is likely behavior that they have seen before from other individuals – who happened to not get sick. Cultural factors in Lehi, Utah may not relate to cultural factors in cultures in other places around the world. So, it is vital that as an outbreak is evaluated or prevented, that the culture be understood and respected so appropriate action can be taken relative to the culture. For example, a poor rural community without access to separate sources of drinking water and secondary water might ignore the risks of drinking untreated water because of the lack of access to resources. In some places in the world, such as India, people perform religious rituals and bath in highly polluted rivers, which pose a risk of infection. In that case, respect for the cultural practices would need to be employed to help reduce infection risks.

This leads to the next issue of technology and the economy. There are several related issues to the E. Coli outbreak regarding technology and economy. The first issue is the economic and technological feasibility of treating secondary water systems. The second issue relates to the combination of technology and economics as applied to places around the world.

Preventing E. coli outbreaks in secondary water systems by elevating treatment to the standards of potable water is a complex challenge, marred by technological and economic constraints. Secondary water systems, which include non-potable water used for irrigation, industrial processes, and other non-drinking purposes, are diverse in their quality and sources, making uniform treatment a daunting task. The primary hurdle lies in the technological sophistication required to purify secondary water to drinking water standards. This involves advanced treatment processes such as chlorination, ozonation, reverse osmosis and UV exposure, which are not only capital intensive but also demand specialized operational expertise. Such systems must be meticulously monitored and maintained to ensure the removal of pathogens like E. coli, which necessitates a continuous investment in human resources and technology.

Moreover, the economic feasibility of upgrading secondary water treatment facilities is a significant impediment. The cost associated with retrofitting existing infrastructure or constructing new advanced treatment plants is prohibitively high for most municipalities and private entities. This is compounded by the operational costs, which include energy consumption, chemical usage, and routine maintenance. For many regions, especially those with limited financial resources, these expenses can outweigh the perceived benefits, leading to a preference for conventional treatment methods that focus on basic sanitation rather than potable standards. There is the thought that is valuable to prevent E. Coli contamination from getting into secondary water sources. However, that might only be possible for groundwater sources. In the case of Lehi, and many other places, surface water is used for irrigation which is an unfeasible option. Protecting surface waters from E. Coli contamination would mean preventing any animal life from water access, which would not be an environmentally just or economically feasible option.

Additionally, the variability in water quality and the fluctuating nature of secondary water sources present further complications. Secondary systems must contend with a wide range of contaminants originating from agricultural runoff, industrial discharge, and urban stormwater. This inconsistency necessitates a flexible treatment approach, adaptable to changing conditions, which can be both technologically demanding and cost prohibitive. In conclusion, while technological abilities exist to treat secondary water to drinking water standards, the economic and practical realities render it an unfeasible endeavor for most communities. The high costs and technological complexity create a barrier to the adoption of such treatment practices. As a result, efforts to prevent E. coli outbreaks in secondary water systems are often constrained to warning and educating the public not to drink from secondary water sources.

Lessons Learned

Our team encountered a few issues in our research for this project. The issues we faced were scale and complexity of the issue, consistent communication with the client and access to information. Our group was able to approach each issue calmly and confident that we could solve the challenges with this project.

Among the most pressing challenges was the scale and complexity of the project. The scale of the project was represented by the size of Lehi city itself. As shown on the figure in Appendix F., Lehi has a large network of secondary water. Cases were distributed throughout the system suggesting that contamination of the system was widespread. The complexity of the system meant finding the E. Coli contamination sources would need to be done through extensive and regular water testing. Although even this wouldn't necessarily solve all issues, as the cause of the E. Coli was not sure. Lastly, we also understood that providing and trying to design a water treatment system for Lehi would not be feasible. We were able to approach this large scale and complex issue by communicating with the client and in discussion with our faculty mentor, Dr. Sowby. As a result of our preliminary discussions, we were able to settle on our project focus on developing an engineering toolbox. The toolbox was flexible enough to approach the scale of the project and provide different ideas that Lehi city could implement. From this problem, our team learned the value of mentorship. Dr. Sowby helped us develop the idea of an engineering toolbox, which we probably wouldn't have come on had we not confided in him about the challenge we were facing with the scale and complexity of the project.

The next challenge we faced was consistent communication with our client. From our initial meeting in the fall, we had a large gap in time where we didn't have regular communication with our client. However, this didn't last too long. We found that after some initial time, we were able to reignite communication and it ceased to be an issue. So, the primary lesson learned from this time was to be consistent in maintaining communication channels.

Our last challenge was access to information. While we were researching different treatment options, we tried to reach out to manufacturers about the costs of their products. However, they would not provide those details because we were students and not potential clients. We were able to find some data online that we used to perform our cost analysis. The lesson learned was that a better way to support our client would have been to work through them to get cost data. As a city (potential client) they would have been able to get data from specific manufacturers.

While our problems seemed daunting at first, they didn't keep us from meeting our project goals and our client deliverables.

Conclusions

This project provided a meaningful opportunity to confront a real civil engineering problem. Although the task of helping a city manage a public health concern seemed daunting, we were able to face it and help them in their goals. We gained a deeper understanding of how a city manages utilities, interacts with government agencies, and provides good service to the customer. We also grew in our ability to problem solve and deliver meaningful information to our client. Despite having a complex and large-scale project issue, we found that mentorship and research could help us get the start we needed. We are grateful to have had the opportunity to contribute a solution to this issue. After researching the issue, our team arrived at the solution that the best option for the E. Coli outbreak was a public outreach campaign. The campaign is the most feasible option in terms of cost and effectiveness. Pursuing treatment of the secondary water system would prove to be too costly and unattainable and might also not have guaranteed success. It is our opinion that public outreach will provide the education residents need to prevent infection and for Lehi to save considerable amounts of resources.

Recommendations

After extensive research we can only provide the city with our best opinion of what Lehi should do moving forward. With our limited knowledge in the field of water treatment we did our best to provide accurate and reliable information that the city could use to make their decision. Water treatment using disinfectants like chlorine, UV, or ozone are the most expensive options. But if one of those were to be used, we recommend the chlorine treatment option since it would be the cheapest route and the least time consuming to install. Chlorine could be provided by a supplier to the need of the basin and then the water could be treated as often or as little as the city desires. Main costs would come from installation and acquiring the chemicals to keep the water at drinking levels.

In our evaluation we ranked each option on a scale of 1-10 based on the criteria of cost, feasibility, stopping infection, community acceptance, and city preference. The scale is from least favorable to most favorable. 1 being the worst option and 10 the best. The team came to the conclusion of these criteria from the research shown in the report above.

Criteria	Chlorine	Ultraviolet	Ozone	Public Education
Cost	5	3	2	9
Feasibility	5	2	1	10
Stopping Infection	8	8	9	5
Community Acceptance	7	6	6	8
City Preference	6	2	2	8
Total	31	21	20	40

Our overall recommendation, which we know the city is already planning on doing, is the public education plan. The conclusion comes from extensive research that we implemented to reflect in the table above. This is the only option that would truly be beneficial to everyone. Since PI water is not normally treated or disinfected, going through the effort of installing a treatment program for one relatively small basin to be treated to drinking water levels would be too much of a cost to the city, especially when the water is not meant to be consumed in the first place. The public outreach plan would help citizens to understand what the water is truly meant for and help to remind them that it should not be used for anything other than its intended purposes. Working with other cities and organizations, Lehi would be able to get the word out to many residents and be assured that they did all that they could in keeping residents safe from harmful water.

Appendix A: Resume's

Hunter Joy

248-345-2019 · hjoy0013@gmail.com · www.linkedin.com/in/hunter-joy

EDUCATION

Brigham Young University, Fulton College of Engineering — August 2024
Bachelor of Science: Civil Engineering — Provo, UT

- ASCE Club Member

SKILLS

- Portuguese Fluency: Including Translation
- ARCgis Pro, AutoCAD Civil 3D, Storm and Sanitary Analysis, and REVIT
- Computer Programing: VBA, Python, and C++
- Water CAD
- Microsoft Office

EXPERIENCE

LEI Engineers & Surveyors — Sept 2021-Present
Engineer in Training Intern — Spanish Fork, UT

- Conducted storm and sewer evaluation including, sizing of local developments
- Design of lot layouts including grading and design
- Wrote reports for head engineers and other contractors to use in construction
- Reviewed plans of new developments to ensure success of projects

Skyview Glass — Mar 2021-Sept 2021
Draftsman/Estimator — Orem, Utah

- Estimated and evaluate projects typically valued at more than $500,000
- Evaluated and handle over 6 different architectural plans and projects at a time to draw in Revit for project managers and site workers
- Collaborated closely with architects and project engineers to ensure success of projects

Brigham Young University — Nov 2020-Mar 2021
Facilities Crew — Provo, Utah

- Maintained the grounds (557 acres) around BYU campus
- Operated heavy equipment and vehicles

PROJECTS/RESEARCH

Parkway Fields Neighborhood — Sept 2021-Present
Engineer in Training — Eagle Mountain, Utah

- Designed sewer and storm drain systems for 800+ acres, including lot layout for 1000+ lots
- Review and QC of phase plans within project

Firefly Neighborhood — Dec 2022-Present
Engineer in Training — Eagle Mountain, Utah

- Led the design of sewer and storm drain systems for 1000+ acres and grading design for 300 lots
- Review and QC of phase plans within project

BYU Capstone Project — Sept 2023-Apr 2024
Team Lead — Lehi, Utah

- Assisted in treatment of E. Coli found in pressurized irrigation system
- Created report including design cost and function, prevention plan, and public outreach plan

VOLUNTEER EXPERIENCE

The Church of Jesus Christ of Latter-Day Saints — July 2018-Mar 2020
Full-time Volunteer Representative — Santa Maria, Brazil

- Supervised and trained 25+ representatives on goal setting, problem solving, and leadership
- Built strong interpersonal skills working and teaching over 80 weekly English classes
- Mentored and led groups of 20 others to reach individual and group goals

Boy Scouts of America — February 2017
Eagle Scout Project — Detroit, Michigan

- Organized the collection of over 500 pairs of shoes which were distributed in the Detroit Metro area in partnership with Soles for Souls

Zach Moncur

zachary.moncur@gmail.com | 385-226-7709
www.linkedin.com/in/zach-moncur

Education

Brigham Young University, Provo, UT *April 2024*
B.S. Civil Engineering

Experience

Jacobs Engineering *May 2023 - Present*
Water Conveyance Intern

- Provided support to engineers in designing pipeline profiles
- Prepared estimates for multimillion dollar projects
- Collected samples and prepared reports for PFAS contamination studies
- Conducted field inspections for construction of a NDSD pump station and effluent pipeline

Jacobsen Construction *May 2022 – May 2023*
Project Engineer Intern

- Managed submittals and communications with 4 subcontractors
- Created and resolved 20+ reports documenting fixes
- Obtained 15+ special permits for road closures and early morning construction in downtown SLC
- Developed a strong working relationship with the SLCO Department of Health to enable night work and early morning work

Pinnacle Engineering and Land Surveying *September 2021 – May 2022*
Civil Engineer Intern

- 375+ hours of field work including construction staking, topographical, and boundary surveys
- Coordinated onsite with clients and contractors to ensure needs and designs were met
- Prepared and processed surveying data to generate engineering and construction documents

Utah Department of Transportation *April 2021 – August 2021*
Maintenance Group Intern

- Collected and processed data as part of the National Transportation Product Evaluation Program from 8 vendors and 96 products
- Processed data for UDOT's maintenance budget

Silverpeak Engineering *September 2020 – February 2021*
Structural Intern

- Calculated structural loads and sized members accordingly for full sets of custom home plans
- Drafted plans and details in AutoCAD

Skills

- Software: Autodesk Suite, Microsoft Office Suite, Bluebeam
- Understanding of construction processes, documents, schedule, building methods, and technologies
- Operation of surveying equipment, heavy construction equipment and tools
- Technical writing

Ethan Wall

Email: ethangwall@gmail.com **Phone:** 817-707-1570
LinkedIn: www.linkedin.com/in/ethan-wall-b8b066292

Education

Brigham Young University - Provo UT

Civil Engineering Major – Academic journey includes – Technical Design and Drafting, Structural Analysis, Materials and Construction Knowledge, Geotechnical Engineering, Transportation Engineering, Environmental Engineering, Hydraulics and Water Resources, Project Management, Critical Thinking and Professional Ethics.

August 2020 – Projected Graduation Date April 2024

Experience

Engineer in Training - LEI, Spanish Fork Utah

Jan 2024 – Present

• Reviewing plans for development. Underneath learning from professional engineers.

Structural Calculation Designer - Solcius, Provo Utah

Nov 2021 – December 2023

• Conduct structural analyses of homes under the guidance of the Structural Engineer. • Assess the capacity of the roof to support the load of solar panels.

Permit Design Draft - Solcius, Provo Utah

Sept 2021– Nov 2021

• Designed site plans for homes and created layouts for solar panels using AutoCAD. • Utilized AutoCAD to replicate and draft roofs as part of the design process. .

Skills

Technical Skills:

• Proficient in VBA, C++, and Python programming languages.

Attention to Detail:

• Meticulous attention to detail in both design and analysis tasks.

Quick Learner:

• Demonstrated ability to rapidly acquire and apply new skills and knowledge.

Appendix B: Peristaltic Metering Pump Brochure

Blue-White®

Simplified Chemical Feed

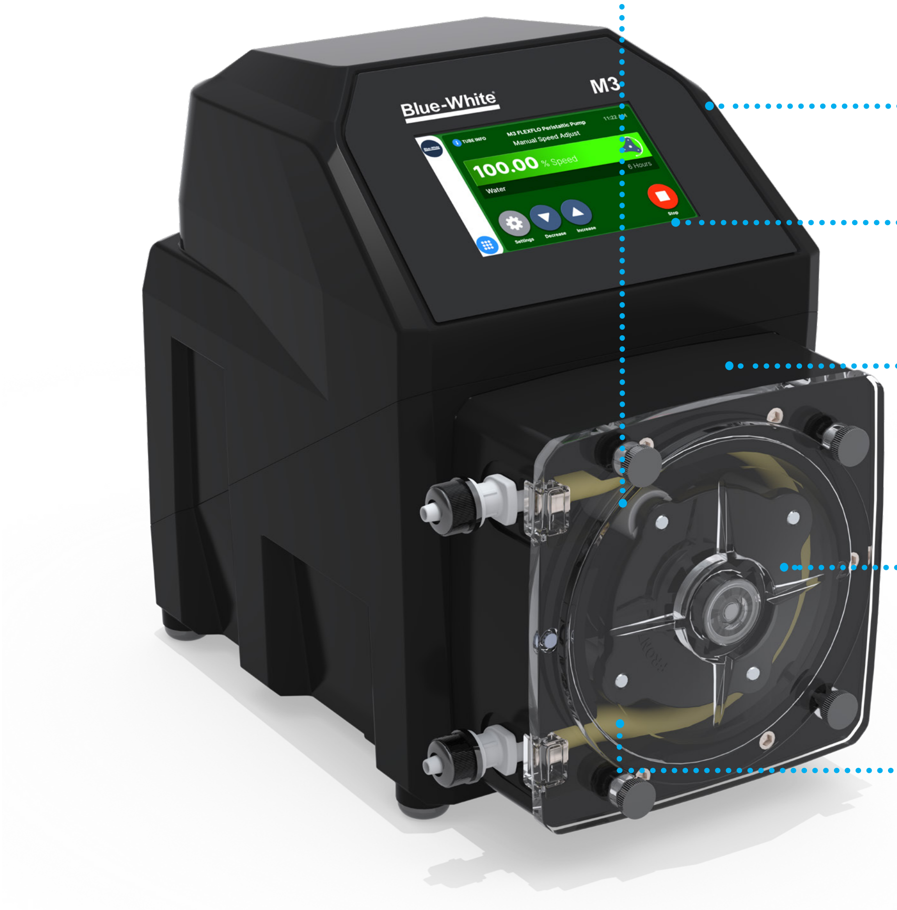
For municipal water treatment applications

FLEXFLO®

Peristaltic Metering Pumps

M3 M4

How do FLEXFLO® pumps simplify chemical feed?



Accurately engineered rollers
CNC precision machined squeeze rollers for optimum squeeze, unparalleled accuracy, and longer tube life.

Brushless DC motor
BLDC motor reduces energy costs and is more durable compared to AC motors.

Touchscreen display
Large UV and chemical resistant 5” display with intuitive icon-based touchscreen controls, works with or without gloves.

Built-in leak detection
Patented Tube Failure Detection (TFD) senses tube rupture by detecting chemical in the pump head. No false triggering. Comes standard with every FLEXFLO® pump.

Minimal maintenance
No tools are required to open the pump head. The only wear part, the tube, can easily be replaced. The integrated ‘life cycle counter’ can accurately determine maintenance intervals.

Tubing options
Three available tube materials for chemical compatiblity: Flex-A-Prene®, Flex-A-Thane®, and Flex-A-Chem®.

Simplified I/O connections

IP rated M12 connection ports
Protect against dust, moisture, and changes in temperature.

Ethernet and PROFIBUS ports
Industrial protocols allow for enhanced supervision and automation.

USBC connection port
Download the latest firmware in the field.

Blue-White®

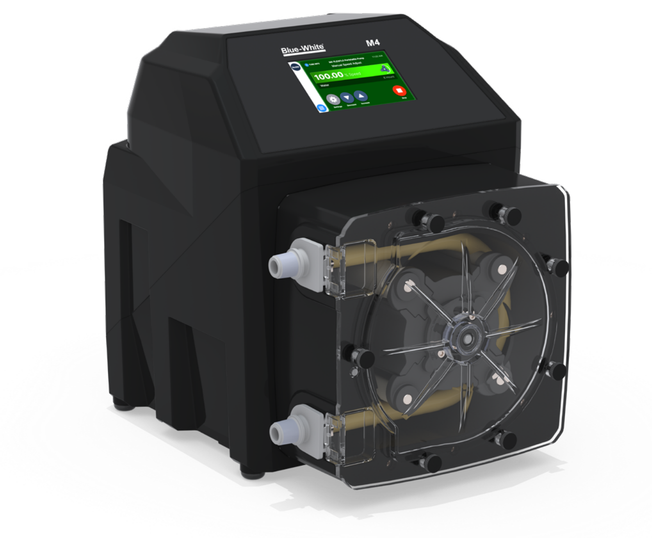
A broad range of outputs and features

FLEXFLO® M3

Specially designed to meet application requirements of medium to large output volumes in water and wastewater where precise chemical metering is necessary. M3 remote control signal options include Pulse, 4-20mA, Modbus TCP, EtherNet IP, and PROFIBUS for enhanced supervision and automation for critical metering and transfer applications.

Technical Overview

GPH	.0002 - 33.3	**Enclosure Rating**	NEMA 4X (IP66)
LPH	.0007 - 126	**Standards**	cETLus, CE, NSF61
PSI	125	**Power Supply**	100 to 240VAC-50.60 Hz
Bar	8.6	**Warranty**	5 years

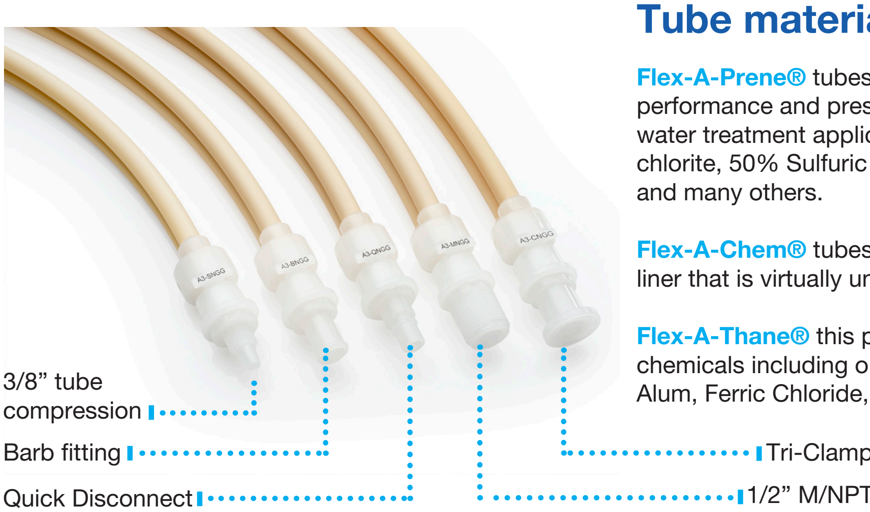


FLEXFLO® M4

When your water treatment application calls for higher volume chemical feed output combined with the latest engineering functions, choose the FLEXFLO® M4. Remote control signal options include Pulse, 4-20mA, Modbus TCP, EtherNet IP, and PROFIBUS for enhanced supervision and automation for critical metering and transfer applications.

Technical Overview

GPH	.0028 - 158.5	**Enclosure Rating**	NEMA 4X (IP66)
LPH	.0108 - 600	**Standards**	cETLus, CE, NSF61
PSI	125	**Power Supply**	100 to 240VAC-50.60 Hz
Bar	8.6	**Warranty**	5 years



Tube materials and fittings

Flex-A-Prene® tubes are uniquely engineered and designed for optimum performance and pressure capability. It is an excellent material for most water treatment applications. Chemically resistant to 25% Sodium Hypochlorite, 50% Sulfuric Acid, 30% Fluosilicic Acid, Ferric Chloride, Alum, and many others.

Flex-A-Chem® tubes consists of an outer Norprene jacket with an inner liner that is virtually unaffected by acids, bases, salts, ketons and alcohol.

Flex-A-Thane® this polyerethane material can be used with a variety of chemicals including oil and water based polymers. Sodium Hypochlorite, Alum, Ferric Chloride, fuels, libricants, and many others.

Premium accessories to complete your system

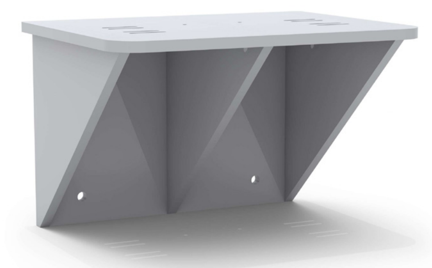
Quick Disconnect Fittings

Safely and quickly disconnect your pump with Blue-White's Quick Disconnect Fittings. The red discharge fitting has an automatic check valve, preventing chemical backflow. The white suction fitting functions as a check valve when tubing is detached, preventing loss of prime and spills during routine maintenance.

- KIT-QSV 1/4" ID Tube Compression Fitting FKM o-rings
- KIT-QSE 1/4" ID Tube Compression Fitting EP o-rings
- KIT-QMV 1/2" M/NPT Fitting FKM o-rings
- KIT-QME 1/2" M/NPT Fitting EP o-rings
- KIT-QBV 1/2" Barb Fitting FKM o-rings
- KIT-QBE 1/2" Barb Fitting EP o-rings

Wall Mount Kit

Mount your pump at a convenient height to improve ergonomics. The wall mount kit comes with a tough, chemical resistant high-density polyethylene bracket and four concrete wall anchors.



- KIT-PSM

M12 Connection Cables

Compatible with Blue-White's FLEXFLO® M3 and M4, our M12 connection cables offer fast and easy connections even in challenging conditions.

- KIT-M12 M12 Cable Assembly, 10 ft, Qty 2
- KIT-M12-2-15 M12 Cable Assembly, 15 ft, Qty 2
- KIT-M12-2-30 M12 Cable Assembly, 30 ft, Qty 2
- KIT-M12-3 M12 Cable Assembly, 10 ft, Qty 3
- KIT-M12-3-15 M12Cable Assembly, 15 ft, Qty 3
- KIT-M12-3-30 M12 Cable Assembly, 30 ft, Qty 3

M12 Network Bus Connection Cable

Compatible with Blue-White's FLEXFLO® M3 and M4, our M12 network bus connection cables offer fast and easy connections for process automation.

- KIT-DP3

5300 Business Drive, Huntington Beach, CA 92649
www.blue-white.com |info@blue-white.com

Appendix C: Glasco NONCON Series Brochure

GLASCO UV
Ultraviolet Light Technologies

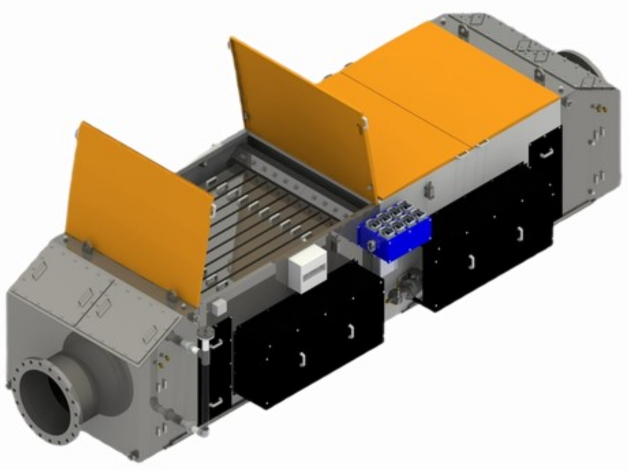
NONCON Series

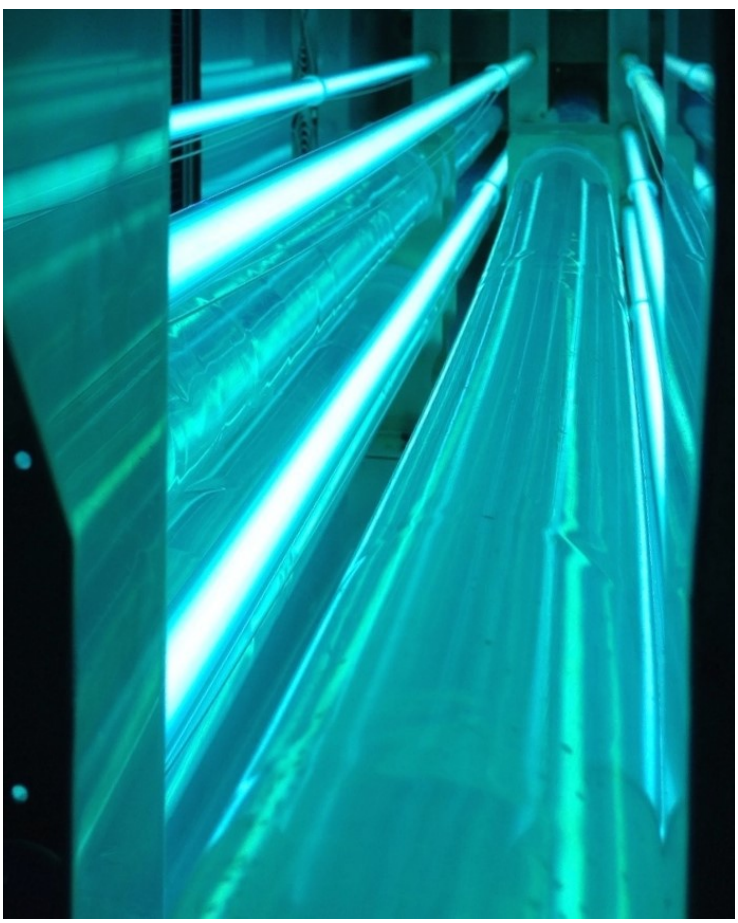
Product Overview

The "NONCON 5000" Series is a "flow through" fluoropolymer style of ultraviolet (UV) water and wastewater disinfection systems.

Unlike our other systems where the UV lamps are immersed into the water (using protective quartz sleeves), the "NONCON 5000" uses non conductive transparent fluoropolymer tubes to transport the water close to the UV lamps.

The UV lamps are positioned in the air and shine their rays (@254 nm) through the fluoropolymer tubes and to their intended targets, microorganisms. The lamps are not in the water.





Standard Features

- Stainless steel disinfection reactor
- Low-pressure high-output UV lamps
- Fluoropolymer flow through tubes
- Multi-voltage power (120-277)
- UV monitoring
- Lamp status and run time indicators
- 45 psi pressure-rated
- Remote electronics
- Environmental temperature management
- Air release valves
- Drain ports

MADE IN THE USA

Operation

Systems use special fluoropolymer tubes to transport water, wastewater and other liquids in close proximity to the UV lamps. The fluoropolymer tubes are transparent and manufactured to allow UV light in the 254 nm range to penetrate the tube's walls and disable microorganisms. Lamps are positioned around the tubes in the reflective reactor.

The tubes are manufactured from a high quality polymer resin. The tubes, which are highly transparent, are neutrally charged (the non-conductive in NONCON) and thus, not susecptible to fouling and scaling from positively charged minerals. In traditional UV systems, the quartz sleeves need to be cleaned.

Over 100 years ago, scientists found that when pathogens were exposed to UV light, their reproduction was limited. The light resided in the UVC range of the spectrum. Specifically, they discovered that light in the 254 nanometer (nm) range was the most effective.

When pathogens are exposed to UV light, their cells become damaged and this inhibits reproduction. UV light damages the cell's DNA and RNA and once damaged, they are unable to replicate and therefore, rendered harmless.

The amount of damage is a result of the intensity of the UV light multiplied by the time the water is exposed to the light (time x intensity). The dosage, referred to as microwatts, is often expressed as mJ/cm2. Doses > 30,000 microwatt dose (30 mJ) are accepted for water disinfection.

GLASCO UV
Ultraviolet Light Technologies

Configurations

Piping connects to the "NONCON" reactor via flange or in the case of larger projects, directly into a poured concrete channel. Water or wastewater enters a pressurized transition box and then feeds into a bank of transparent tubes. Water and wastewater travels through the tubes and exits into the discharge pressure box. Tubes are rated at 45 psi.

Systems can be provided with redundancy. This can be in the form of "in series", "U-turn" or parallel.

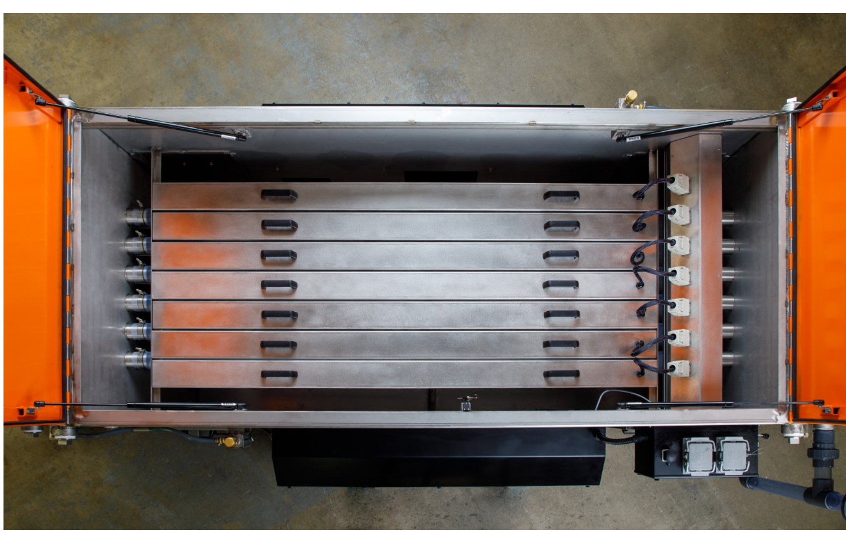
Systems are designed based on a peak flow rate, a UV transmission percentage (UVT%) and information related to the plant's discharge permit. The number of tubes and associated UV lamps are based on the biological testing (bioassay) testing and computational fluid dynamic (CFD) modeling can be supplied in various voltages.

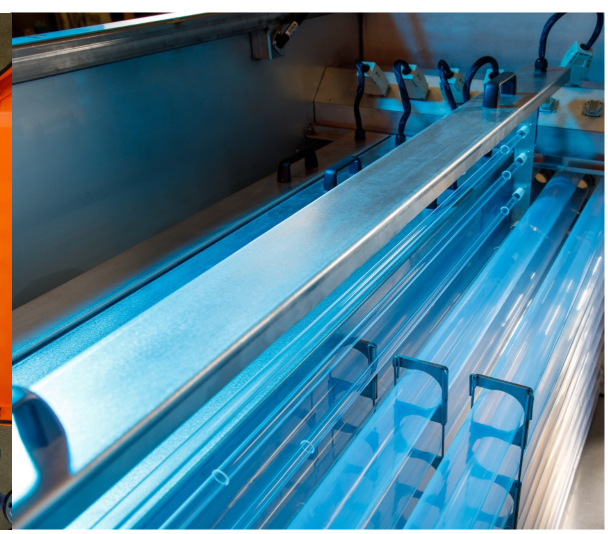
Applications

- Wastewater
- Process waters
- Opaque liquids
- Juices, milks, beverages

Options

- 80 psi
- PLC controls
- Open Channel
- Skid mounting





Installation Design

The NONCON uses a remote Ballast Control Center (BCC). This stainless steel enclosure provides a single point of control for operators and removes sensitive components from reactor, which may be damaged in the event of moisture or flooding. The BCC houses ballasts, power controls, operating displays and UV monitor in a controlled environment. NONCON lamps (low-pressure high-output) are sensitive to temperature.

To maintain optimal lamp temperature, reactor will be provided with a heat exchanger.

System has flexibility when designing for redundancy. Standalone, banks “in-series”, “U-turn” box (shown above) or in parallel. Unlike traditional open channel UV systems, the FEP tube systems have very low maintenance costs due to the lack of quartz sleeve fouling.

Appendix D: Public Outreach Poster

LEHI CITY

THIS SUMMER . . . THINK BEFORE YOU DRINK

DON'T DRINK SECONDARY WATER

SECONDARY WATER (IRRIGATION WATER, WATER FROM THE HOSE) MAY HAVE E. COLI. IF YOU DRINK IT, YOU RISK GETTING SERIOUSLY SICK.

IF YOU NEED A DRINK

USE A WATER BOTTLE

GO INSIDE

DON'T DRINK FROM THE HOSE OR SPIGOT!

https://www.lehi-ut.gov/e-coli-information/

IMPORTANT REMINDER THIS SUMMER.

DON'T DRINK THE SECONDARY WATER.

QUESTIONS? EMAIL US AT COMMUNITYHEALTH@LEHI-UT.GOV

HTTPS://WWW.LEHI-UT.GOV/E-COLI-INFORMATION/

LEHI CITY

SECONDARY WATER MAY CONTAIN E. COLI. IF YOU DRINK THIS WATER, YOU RISK SERIOUS ILLNESS.

IF YOU'RE THIRSTY:

- USE A WATER BOTTLE
- GET WATER INSIDE
- DON'T DRINK FROM THE HOSE OR SPRINKLERS!

Appendix E: PI Tag examples

Option 2 – Uline Weather-Resistant Laser Labels

ULINE WEATHER-RESISTANT LASER LABELS

Ink won't bleed. Weather won't damage.

- Recommended for drums, outside inventory or nursery flower pots.
- Tear-resistant vinyl repels moisture.
- Permanent acrylic adhesive with good initial tack.
- Use only with laser printers and copiers.
- Easy to format Microsoft Word / PDF Templates.

RECTANGLE WEATHER-RESISTANT LASER LABELS ▲ Legal Size Sheet

MODEL NO.	SIZE W x H	LABELS/ SHEET	LABELS/ BOX	PRICE PER BOX 1	PRICE PER BOX 3	PRICE PER BOX 5+	ADD TO CART
S-21906	1 x 1"	80	8,000	$97	$92	$87	1 ADD
S-19297	1 3/4 x 1/2"	80	8,000				1 ADD
S-20177	2 x 2"	20	2,000				1 ADD
S-16643	2 5/8 x 1"	30	3,000				1 ADD
S-21907	3 x 1"	18	1,800	97	92	87	1 ADD
S-21908	3 x 2"	10	1,000				1 ADD
S-21909	3 x 3"	6	600				1 ADD
S-20178	3 x 5"	4	400				1 ADD
S-21910	4 x 1"	20	2,000	97	92	87	1 ADD
S-20179	4 x 1 1/3"	14	1,400				1 ADD
S-16644	4 x 2"	10	1,000				1 ADD
S-19298	4 x 3 1/3"	6	600				1 ADD
S-20180	4 x 4"	4	400				1 ADD
S-19299 ▲	4 x 6"	4	400				1 ADD
S-16645	8 1/2 x 5 1/2"	2	200	97	92	87	1 ADD
S-19300	8 1/2 x 11"	1	100				1 ADD
S-23660 ▲	8 1/2 x 14"	1	100				1 ADD

*Highlighted section shows recommended size range to consider.

Pros:

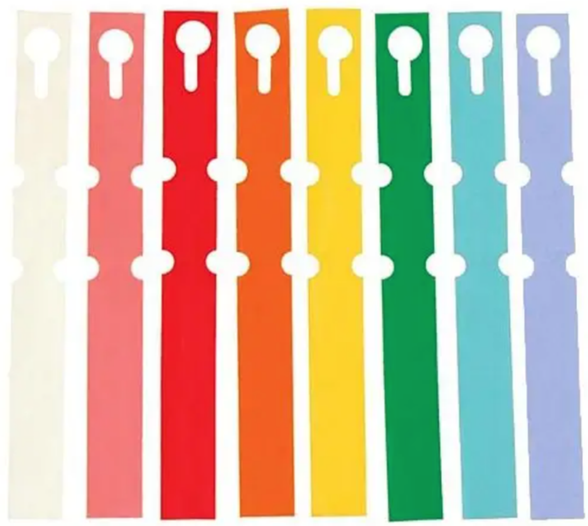
- Weather resistant
- Lehi city controls messaging
- Easy mailing

Cons:

- May not hold up very well over the entire summer.

Link: Weather Resistant Laser Labels in Stock - ULINE

Option 1 – Vinyl slip ‘n lock labels



SL558-LA - Vinyl Slip'N Lock Loop Lock Labels, Lavender, 5/8in x 5-1/2in, Roll of 1,000 Labels | 0
$34.89

SL734-1R - Vinyl Slip'N Lock Loop Lock Labels, Red, 3/4in x 7in, Roll of 1,000 Labels | 0
$56.49

*Colors available as shown in picture. Prices shown reflect difference in price based on size of label.

Pros:
- Waterproof material
- Resident can write their own warning messages
- Available in multiple colors
- Cheapest option

Cons:
- May not wrap around hoses or nozzles tightly enough – label might tend to slip from intended position

Link: [Vinyl Slip 'N Lock Labels, Roll of 1000 (amleo.com)]

Option 3 – Uline Plastic Tags

PLASTIC TAGS

TEAR-PROOF

Tough, durable and ideal for harsh indoor/outdoor conditions.

- Waterproof, good for damp or wet areas.
- Color code inventory and equipment.
- Metal eyelet.

PLASTIC TAGS — White, Black, Yellow, Orange, Green, Blue or Red

MODEL NO.	SIZE	STOCK	QTY./ BUNDLE	PRICE PER BUNDLE			ADD TO CART
				1	2	5+	
S-5544	4 3/4 x 2 3/8" #5	10 Mil	100	$36	$34	$30	Specify Color/Type
S-10749	6 1/4 x 3 1/8" #8			47	45	42	Specify Color/Type

Restrictions apply. See items for details.

CIRCLE PLASTIC TAGS — White, Black, Yellow, Orange, Green, Blue or Red

MODEL NO.	SIZE	STOCK	QTY./ BUNDLE	PRICE PER BUNDLE			ADD TO CART
				1	2	5+	
S-12329	2" Circles	10 Mil	100	$34	$32	$28	Specify Color/Type
S-7219	3" Circles			36	34	30	Specify Color/Type

NYLON NATURAL CABLE TIES

Tamperproof ties secure bags, cords and cables permanently.

- Locks tightly - Won't stretch or slide.
- Made of 6.6 nylon resin.
- Larger quantity quotes available.

Free Offer

NYLON NATURAL CABLE TIES — * UL Listed

MODEL NO.	LENGTH	WIDTH	TENSILE STRENGTH	QTY./ PACK	PRICE PER PACK				ADD TO CART
					1	5	10	20+	
S-3569*	3"	.09"	18 lbs.	1,000	$19	$18	$17	$15	1 ADD

Pros:

- Durable, likely to last for several years
- Residents can write own messaging
- Zip-ties can ensure tight fit on hoses, outlets, etc, not likely to shift position.

Cons:

- Most expensive option

Link: [Plastic Tags, Plastic Tag in Stock - ULINE]

Table of Costs					
	Quantity of Bundles	Price per Bundle	Units per Bundle	Total Units	Total Cost
Vinyl slip 'n lock label					
5/8 x 5-1/2"	20	$34.89	1000	20000	$697.80
3/4 x 7"	20	$56.49	1000	20000	$1,129.80
Uline Weather Resistant Laser Label					
3 x 1"	12	$87.00	1800	21600	$1,044.00
3 x 2"	20	$87.00	1000	20000	$1,740.00
3 x 3"	34	$87.00	600	20400	$2,958.00
3 x 5"	50	$87.00	400	20000	$4,350.00
4 x 1"	10	$87.00	2000	20000	$870.00
4 x 1-1/3"	15	$87.00	1400	21000	$1,305.00
4 x 2"	20	$87.00	1000	20000	$1,740.00
4 x 3 - 1/3"	34	$87.00	600	20400	$2,958.00
4 x 4"	50	$87.00	400	20000	$4,350.00
4 x 6"	50	$87.00	400	20000	$4,350.00
Uline Plastic Tags					
4-3/4 x 2-3/8"	200	$32.00	100	20000	$6,400.00
6-1/4 x 3-1/8"	200	$42.00	100	20000	$8,400.00
2" Circles	200	$28.00	100	20000	$5,600.00
3" Circles	200	$30.00	100	20000	$6,000.00
Uline 3" Zip Ties	20	$15.00	1000	20000	$300.00

*According to [Demographic Information - Lehi City (lehi-ut.gov)] Lehi City has 18,371 total housing units. Accounting for an increase in units, the data above has been calculated so 20,000 units could each have a label on a secondary water outlet or hose.

Appendix F: Lehi City Distribution System

PRESSURE IRRIGATION SYSTEM
Pressure Irrigation Mains
Unknown
2
3
4
6
8
10
12
14
16
17
18
20
21
24
30
Pressure Irrigation Reservoirs
UPDATED: 1/31/2024
N
W
E
S
0
0.25
0.5
1
1.5
2
Miles
I-15
Timpanogos Hwy
Thanksgiving Way
Redwood Rd
Pony Express Rd
Minuteman Dr
Digital Dr
Chapel Ridge Rd
Morning Vista Rd
Traverse Mountain Blvd
Ashton Blvd
Triumph Blvd
Club House Dr
Executive Pkwy
Innovation Way
3200 N
2700 N
2600 N
2100 N
2100 N EB
2100 N WB
Holbrook Way
Drexler Dr
Waterbury Dr
Hardman Way
1500 N
900 N
800 N
600 N
300 N
Main St
State St
East Frontage Rd
Cedar Hollow Rd
Cold Spring Dr
Old Ranch Rd
200 S
700 S
Pioneer Crossing
Market St
Riverside Dr
Pony Express Pkwy
Saratoga Rd
400 S
1900 S
7350 N
Center St