CITY COUNCIL WORK SESSION AGENDA
CITY OF LINO LAKES

Monday, March 7, 2022
Community Room
<u>5:30 P.M.</u>

(5:30 pm) The Rookery Activity Center (visit facility)

1. Water Treatment Pilot Study, Greg Johnson and Ursinio Puga of WSB and Associates
2. WBL – Water Appropriation Permit Appeal update, Michael Grochala
3. Council Updates on Boards/Commissions, City Council
4. Adjourn

WORK SESSION STAFF REPORT
Work Session Item No. 1

Date: March 7, 2022

To: City Council

From: Rick DeGardner, Public Services Director
Michael Grochala, Community Development Director

Re: Water Treatment Pilot Study

Background

The Minnesota Department of Health tested the City's manganese levels in each of the City's wells as part of the EPA Unregulated Contaminant Monitoring Rule 4 (UCMR4). The water quality testing data from MDH indicated that five of the City's six wells exceed the maximum recommended manganese level for infants, and three of the wells exceeds the maximum recommend level for adults and children.

On June 14, 2021, the City Council authorized WSB to complete the Water Treatment Pilot Study to verify the effectiveness of biological filtration to remove manganese, iron, and ammonia from the City's well water. The purpose of the study is to provide the City with critical information that is required to design and size a water treatment plant to address the high manganese and iron levels in its drinking water.

The attached report recommends construction of a conventional gravity filtration system using biological filtration with an initial treatment capacity of 6,000 gallons per minute (gpm). Biological filtration is promoted by the Minnesota Department of Health and is currently being used by the cities of Minneapolis, St. Paul, St. Cloud, and other communities in Minnesota to effectively treat their drinking water. Biological filtration could potentially save the City almost $1 million in chemical costs and save millions of gallons of water over the first 20 years of plant operation.

The next steps that were previously identified included completion of the utility rate study and a water treatment pilot study. The Utility Rate Study was completed by Baker Tilly and accepted by the City Council on May 10, 2021. Staff is now proposing to move forward with the design phase for the proposed water treatment plant.

Requested Council Direction

Information only.

Attachments

1. Water Treatment Pilot Study Report

WATER TREATMENT PILOT STUDY REPORT

BIOLOGICAL REMOVAL OF AMMONIA, IRON, AND MAGANESE

CITY OF LINO LAKES | ANOKA COUNTY | MINNESOTA

February 28, 2022

Prepared for:
City of Lino Lakes
600 Town Center Parkway,
Lino Lakes, MN 55014

WSB PROJECT NO. 018601-000

WATER TREATMENT PILOT STUDY REPORT

BIOLOGICAL REMOVAL OF AMMONIA, IRON AND MANGANESE AT WELL HOUSE NO. 6

FOR THE

CITY OF LINO LAKES
ANOKA COUNTY, MINNESOTA

February 28, 2022

Prepared By:

February 28, 2022

Mr. Justin Williams
Public Works Superintendent
City of Lino Lakes
600 Town Center Parkway
Lino Lakes, MN 55014

Re: Water Treatment Pilot Study Report
Biological Removal of Ammonia, Iron and Manganese at Well House No. 6
City of Lino Lakes, MN
WSB Project No. 018601-000

Dear Mr. Williams:

WSB is pleased to provide you with this pilot study report for the biological removal of ammonia, iron, and manganese completed at the Lino Lakes' Well House No. 6. The assistance provided by city staff during the pilot study contributed to the success of the study. Staff's knowledge of the raw water quality conditions and commitment to conducting water testing throughout the study was extremely helpful.

We appreciate the opportunity to be of assistance to the City of Lino Lakes and we look forward to assisting you when this project proceeds to the next phase. Please feel free to contact us if you have any questions or if you need additional information.

Sincerely,

WSB

Greg F. Johnson

Greg F. Johnson, PE
Director of Water/Wastewater

178 E 9TH STREET | SUITE 200 | SAINT PAUL, MN | 55101 | 651.286.8450 | WSBENG.COM

CERTIFICATION

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Greg F. Johnson, PE

Date: February 28, 2022 License No. 26430

Ursinio Puga, PE

Date: February 28, 2022 License No. 59303

Ray Theiler, PE

Date: February 28, 2022 License No. 57772

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EXECUTIVE SUMMARY

The City of Lino Lakes completed a Water Treatment Plant Feasibility Study in 2020 that recommended conducting a water treatment pilot study to test the effectiveness of biological filtration to remove manganese from the City's drinking water. The Minnesota Department of Health (MDH) considers biological filtration to be an efficient and effective treatment method remove a wide variety of contaminants including manganese, ammonia, and iron.

WSB's pilot trailer was mobilized to Well House No. 6 towards the end of September 2021 to start a biological filtration pilot study that ended on November 26, 2021. WSB's pilot skid tested two types of filter media to identify the best media type to remove manganese biologically. Although both media types had similar removal performance, gravity filters with silica sand and anthracite filter media are recommended for the proposed water treatment plant since the silica sand filter had a lower rate of headloss than the greensand filter and silica sand media is less expensive. The silica sand filter column also showed faster performance recovery in the backwash and shutdown recovery tests. The silica sand filter produced treated water with an average iron concentration of 0.02 mg/L, an average manganese concentration of 0.040 mg/L, and an average ammonia concentration of 0.02 mg/L, all of which are below the target treatment goals set for this pilot study. In addition to achieving excellent removal performance, the silica sand filter column achieved filter run times longer than one week before filter backwashing was required, which is exceptional for water filtration.

Implementing biological filtration at the proposed water treatment plant will eliminate the need to prechlorinate the water and to feed sodium or potassium permanganate to oxidize iron, ammonia, and manganese. These chemicals are required in conventional filtration facilities and are costly to feed. The reduction in chemical usage is projected to generate approximately $950,000 in operational savings over the next 20 years when compared to a conventional filtration facility in Lino Lakes. In addition to generating operational savings, utilizing fewer chemicals produces less processed and more sustainable water.

Based on the treatment results obtained in this pilot study and the projected operational savings, it is recommended to design and construct a gravity filtration water treatment plant that utilizes biological filtration to remove manganese in Lino Lakes. Data collected in this pilot study will aid in the design of the future facility.

1. INTRODUCTION

1.1 Purpose of Study

WSB was authorized to complete this water treatment pilot study as the first step to verify the effectiveness of a full-scale gravity biological filtration water treatment plant to remove ammonia, iron, and manganese from the City's water. Conducting this pilot study was recommended in the City's Water Treatment Plant Feasibility Study completed in June 2020.

The MDH considers biological filtration to be an efficient and effective treatment method to remove ammonia, iron, manganese, and other contaminants in public drinking water supplies. The purpose of the pilot study is to provide the City with critical information that is required to design and construct a water treatment plant if the City decides to address the high manganese levels in its drinking water. It was decided to conduct the pilot study with groundwater pumped by Well 6 because it contains the highest levels of manganese and iron in comparison to the City's other wells.

1.1 Effects of Iron

Iron in drinking water is regulated by the Secondary Drinking Water Standards (SDWS) set by the U.S. Environmental Protection Agency (EPA). Unlike with the Primary Drinking Water Standards, the SDWS are not enforced since they are not considered to be a health risk. The SDWS are guidelines to assist public water systems in managing their drinking water for aesthetic considerations. The SDWS for iron is 0.30 mg/L. Iron concentrations above the SDWS can stain household fixtures and clothing, cause water discoloration, coat pipes within water distribution systems, and cause unpleasant taste and odors. Dissolved iron can be treated by oxidizing it to its insoluble form and removing it by filtration. Iron is usually oxidized with aeration, chlorine, or a combination of the two.

1.2 Effects of Manganese

Manganese is a common, naturally occurring mineral found in rocks, soil, groundwater, and surface water. The SDWS include a recommended limit for manganese since manganese causes physical and aesthetic effects on drinking water such as staining, taste, and color. Manganese in water can stain laundry, cause scaling on plumbing, and cause water to look, smell, or taste bad. Additionally, manganese can create a brownish-black or black stain on toilets, showers, bathtubs, and sinks. The SDWS recommended limit for manganese in drinking water is 0.05 mg/L.

The EPA is in the process of determining if a Maximum Contaminant Level (MCL) should be established for manganese due to updated research on its health effects. As such, the EPA included manganese in the Fourth Unregulated Contaminant Monitoring Rule (UCMR4), which requires all public drinking water systems serving over 10,000 people and randomly selected small systems to monitor for manganese. The EPA will also consider the health effects of manganese in their regulatory determination and evaluate potential risks to adults, children, and infants.

The MDH, in conjunction with studies conducted by others, has determined that children and adults who drink water with high levels of manganese for an extended period of time may experience problems with memory, attention, and motor skills. These side effects are more acute in infants (babies under the age of one), as they may result in long term learning and behavioral problems. Therefore, the MDH has established a maximum recommended manganese concentration in drinking water of 0.10 mg/L for infants and 0.30 mg/L for adults and children.

Similar to iron, dissolved manganese can be treated in drinking water by oxidizing it to its insoluble form and removing it by filtration. Manganese is usually oxidized with potassium or sodium permanganate. However, manganese can also be removed biologically from water using naturally occurring microorganisms.

1.3 Effects of Ammonia

Many groundwater sources throughout the United States have elevated levels of ammonia due to natural processes, agricultural runoff or animal feeding operations. Although ammonia is not currently regulated by the EPA, elevated levels of ammonia will pose operational and health concerns if nitrification takes place in the distribution system. Nitrification is the conversion of ammonia to nitrite and nitrate, which can lead to potential corrosion issues, taste and odor concerns, and ultimately, elevated nitrite and nitrate levels throughout the distribution system. Nitrite and nitrate are regulated under the PDWS since they are known to have significant effects on human health.

Ammonia is typically treated with the formation of monochloramine and breakpoint chlorination, which results in the removal of ammonia by a chemical reaction with chlorine. Other conventional methods to treat ammonia include advanced oxidation, air stripping, or reverse osmosis. Similar to treating manganese, ammonia can be removed from water biologically. Biological ammonia removal relies on naturally occurring microorganisms to convert ammonia to nitrite and nitrate. Biological ammonia removal at the treatment plant eliminates the likelihood of nitrification taking place in the distribution system and potentially lowers the chlorine dosages needed to maintain adequate free chlorine residuals in the treated water.

1.4 Goals and Objectives

The main objective of this pilot study is to evaluate whether ammonia, iron and manganese can be removed biologically without the use of prechlorination and potassium or sodium permanganate. Another main objective of this study is to obtain data that can be used to design, construct, and operate a gravity filtration water treatment plant utilizing biological filtration in Lino Lakes.

The specific goals of this pilot study are described below:

1. Evaluate if biological filtration can meet the treatment goals set in this study;
2. Compare the biological filtration efficiency of various types of filter media;
3. Evaluate the duration of the biological acclimation process;
4. Evaluate the dissolved oxygen concentration needed to enhance biological filtration;
5. Establish a backwash procedure that effectively cleans the biological filters;
6. Evaluate the filter runtime of each filter media type;
7. Determine if nutrients are needed to enhance the performance of biological filtration;
8. Evaluate whether microorganisms remain effective in colder water temperatures;
9. Evaluate the performance of the biological filters following a backwash; and
10. Evaluate the performance of the biological filters following a period of shutdown.

2. RAW WATER QUALITY AND TREATMENT GOALS

2.1 City-Wide Raw Water Quality

The raw water pumped from each municipal well in the City of Lino Lakes was tested as part of the Water Treatment Plant Feasibility Study completed in 2020. A summary of the raw water manganese, iron, and ammonia concentrations in each well are shown in ***Table 2-1***. Well 6 was used to conduct the pilot study due to its high combined concentrations of iron and manganese.

Table 2-1. Existing Water Supply

Well Name	Total Iron (mg/L)	Dissolved Iron (mg/L)	Total Manganese (mg/L)	Dissolved Manganese (mg/L)	Ammonia (mg/L)
Well 1	N/A	N/A	N/A	N/A	N/A
Well 2	0.181	0.323	0.249	0.256	ND
Well 3	ND	ND	0.383	0.395	0.28
Well 4	0.105	0.084	0.086	0.093	0.21
Well 5	0.310	0.290	0.152	0.151	0.14
Well 6	0.050	ND	0.376	0.357	0.21

N/A – Not Applicable; ND – Non-Detect

2.2 Well 6 Raw Water Quality and Treatment Objectives

The raw water quality measured during the pilot study is presented in ***Table 2-2***. Also shown in ***Table 2-2*** are the target effluent or treatment goal concentrations for the pilot study.

Table 2-2. Raw Water Quality

Parameter	Unit	Raw Water Quality		Target Effluent Concentration
		Average	Range	
Total Iron	mg/L	0.05	0.00 – 0.17	< 0.30
Total Manganese	mg/L	0.410	0.40 – 0.45	< 0.050
Ammonia-N	mg/L	0.35	0.30 – 0.40	< 0.10
Dissolved Oxygen (DO)	mg/L	1.60	0.71 – 3.20	> 4.0
Orthophosphate	mg/L	0.13	0.07 – 0.23	N/A
Total Organic Carbon (TOC)	mg/L	2.6	1.6 – 3.5	N/A
Alkalinity	mg/L $CaCO_3$	254	252 – 255	N/A
pH	SU	7.03	6.4 – 7.9	7.0 – 8.0
Temperature	Degrees F	51.6	50.2 – 53.4	N/A

3. PILOT EQUIPMENT AND SETUP

A small portion of the groundwater pumped by Well 6 was routed to WSB's pilot skid for treatment, which was located inside the pilot trailer parked next to Well House No. 6. The treatment equipment used in the pilot skid is described below.

Detention Basin: The first treatment unit of the pilot skid was a detention basin. Compressed air was introduced upstream of the detention basin at various flow rates to increase the dissolved oxygen (DO) concentration of the raw water to promote biological growth. A 30-minute detention time was targeted in the detention basin.

Transfer Pump: The transfer pump was located downstream of the detention basin and was used to pump water from the detention basin into the filter columns. A pressure reducing valve (PRV) was installed downstream of the pump to maintain an optimal water pressure upstream of the filter columns.

Media Filters: Two 6-inch diameter filter columns were operated in parallel and downstream of the transfer pump. The filter media in Filter 1 consisted of 18 inches of silica sand and 12 inches of anthracite, and the filter media in Filter 2 consisted of 18 inches of greensand and 12 inches of anthracite. Both filters had an underdrain system with reverse graded gravel and torpedo sand. Treated water from each filter was discharged near Well House No. 6.

Other Equipment: The pilot plant was equipped with flowmeters (air and water), a flow totalizer, pressure gauges, sample taps, an air compressor, and a HACH DR900 colorimeter to test water quality.

A flow schematic and photo of WSB's pilot trailer are shown below.

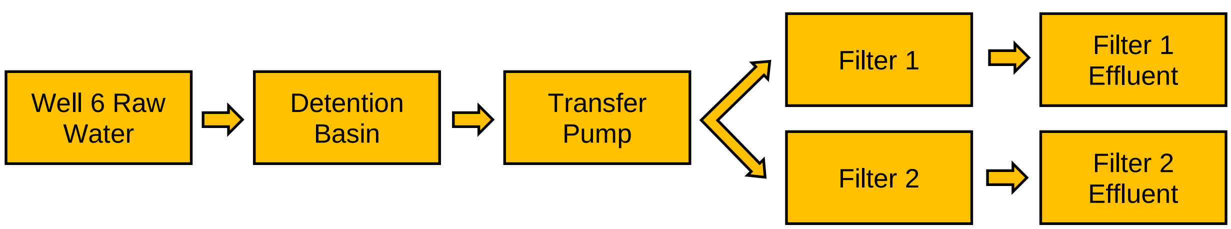

Figure 3-1. WSB's Pilot Trailer at Lino Lakes' Well House No. 6

4. OPERATIONAL OVERVIEW

Influent flow to the pilot skid was maintained at 1.2 gallons per minute (GPM). From there, water was pumped into each filter at a flow rate of 0.6 GPM per filter to achieve a filter loading rate of 3.0 GPM per square foot (SF) of filter media per recommended Ten States Standards. The above water flow rates achieved a 30-minute detention time in the detention basin and an empty bed contact time (EBCT) of 6.2 minutes in each filter column. The filters were backwashed with raw water when a terminal headloss of 120 inches was achieved.

Following set up and staff training, this pilot study was conducted in two operational phases, the microbial acclimation phase and the treatment efficiency phase. The microbial acclimation phase consisted of adjusting the aeration flow rate to promote rapid biological growth. Nutrients were not required in this pilot study as it was determined that the natural orthophosphate concentration in the raw water was sufficient to promote biological filtration. The second phase of the study (treatment efficiency phase) started when the filters were fully acclimated and removing the majority of the manganese. Towards the end of this phase, biological filter performance was measured following a backwash and a 1-week shutdown period.

Regardless of the operational phase, day to day monitoring procedures and water quality sampling remained the same throughout the study. Daily operations included monitoring the flow rates (air and water) and water pressure. Water quality sampling consisted of testing the water at various treatment stages throughout the pilot skid. The majority of the water quality sampling and testing was completed on site by City staff with some samples being shipped to a certified laboratory for testing and QA/QC purposes. City staff were also responsible for daily monitoring of the pilot skid.

Filter backwashing was accomplished using a combination of air and raw water. The duration of the entire backwash was approximately 12 to 15 minutes (for each filter). After draining the filter columns for about a minute, air was introduced through the underdrain system for 5 minutes. The air scouring loading rate was maintained at 2 cubic feet per minute per square foot of filter media (CFM/SF) for the first 3 minutes and then increased to 3 CFM/SF for the following 2 minutes. After the initial 5 minutes of air scouring, a simultaneous air and water backwash took place for 2 minutes. During that time, the air scouring loading rate was reduced to 1 CFM/SF and the water loading rate was maintained at 8 GPM/SF. Following the simultaneous backwash, the filter columns were backwashed with water for a period of 4 minutes. During the water-only backwash, the water loading rate was varied from 8 GPM/SF to 15 GPM/SF. The backwash water flow was stopped when the filter media achieved 50-percent stratification for approximately 1 minute. Following the backwash, the media was allowed to settle for a short period (3 to 5 minutes) to ensure that no media was lost when normal filter operation resumed. This backwashing strategy was effective removing particle clusters without losing a significant quantity of microorganisms. WSB staff conducted all backwashes.

5. RESULTS AND DISCUSSION

The pilot study was conducted for nine weeks beginning on September 22, 2021 and ending on November 26, 2021. The microbial acclimation phase took place over the initial three weeks and the treatment efficiency phase continued until the study was completed. A backwash recovery test was completed during the eighth week and a 1-week shutdown test took place during the last week of the study. Individual treatment results are summarized in the following sections.

5.1 Aeration Requirements

Atmospheric air was fed upstream of the detention basin to promote biological growth in the filter columns and to oxidize the dissolved iron present in the raw water. The air flow rate was optimized during the microbial acclimation phase with the goal of maintaining a pre-filtration DO concentration of 6 to 8 mg/L and a post-filtration DO concentration above 4 mg/L. The final air flowrate used in this study was 0.50 CFM, which generated an air flow and water flow rate relationship of approximately 0.40 CFM/GPM (concurrent air and water flow). It is possible that a full-scale biological filtration facility in Lino Lakes will require a lower air to water flow rate ratio than used in this study to effectively treat ammonia, iron, and manganese. The DO concentration change through the pilot skid is shown in ***Figure 5-1***. As shown in the figure below, the raw water DO concentration increased from an average of 1.6 mg/L to an average of 6.7 mg/L after aeration and then decreased to an average of 5.9 mg/L after filtration. Both biological filters consumed a similar amount of DO regardless of the media type.

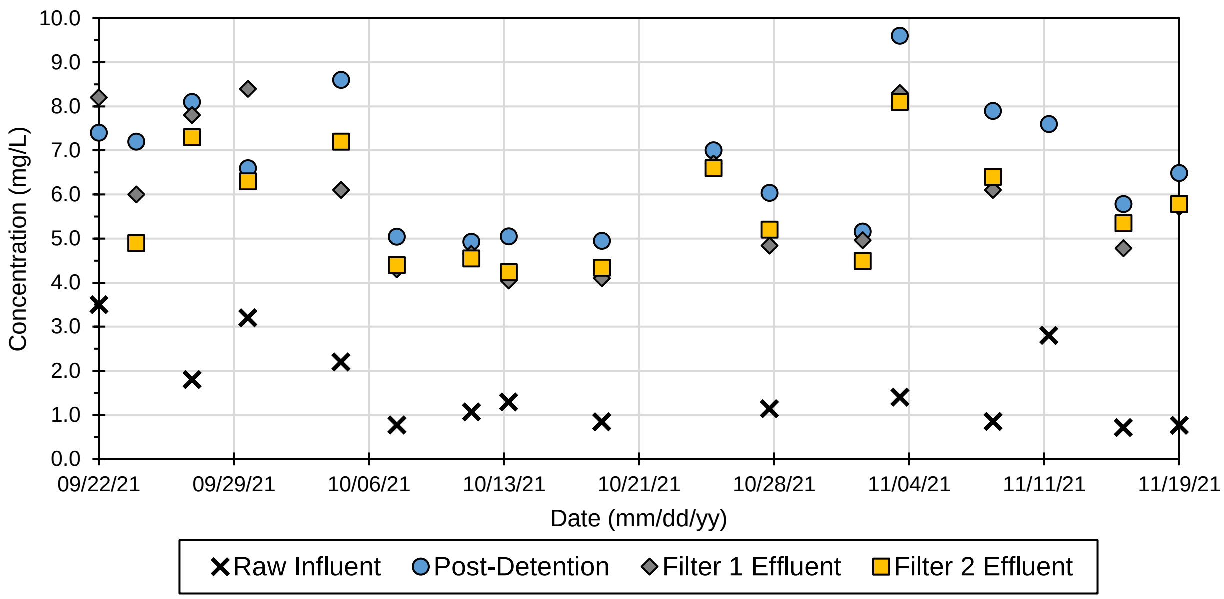

Figure 5-1. DO Concentration Change in the Pilot Skid

The DO consumed by the filters increased significantly during the treatment efficiency phase when compared to the acclimation phase due to the larger microorganism population in the filters at that time. ***Table 5-1*** below summarizes the average DO consumed by the filters during both phases of the study.

Table 5-1. Changes to DO Consumption

Phase	Avg. DO Consumption	
	Filter 1	Filter 2
Acclimation	7%	3%
Treatment Efficiency	14%	13%

5.2 Iron Removal

The iron removal results obtained in this pilot study are shown in ***Figure 5-2***. The figure below shows the raw water iron concentration, the effluent iron concentration (Filter 1 and Filter 2), and the effluent target iron concentration. The iron concentration in the water was reduced from an average of 0.05 mg/L to an average of 0.02 mg/L. Both biological filters produced similar effluent iron concentrations throughout the pilot study. The average filter effluent concentration is approximately 93-percent below the EPA SDWS for iron.

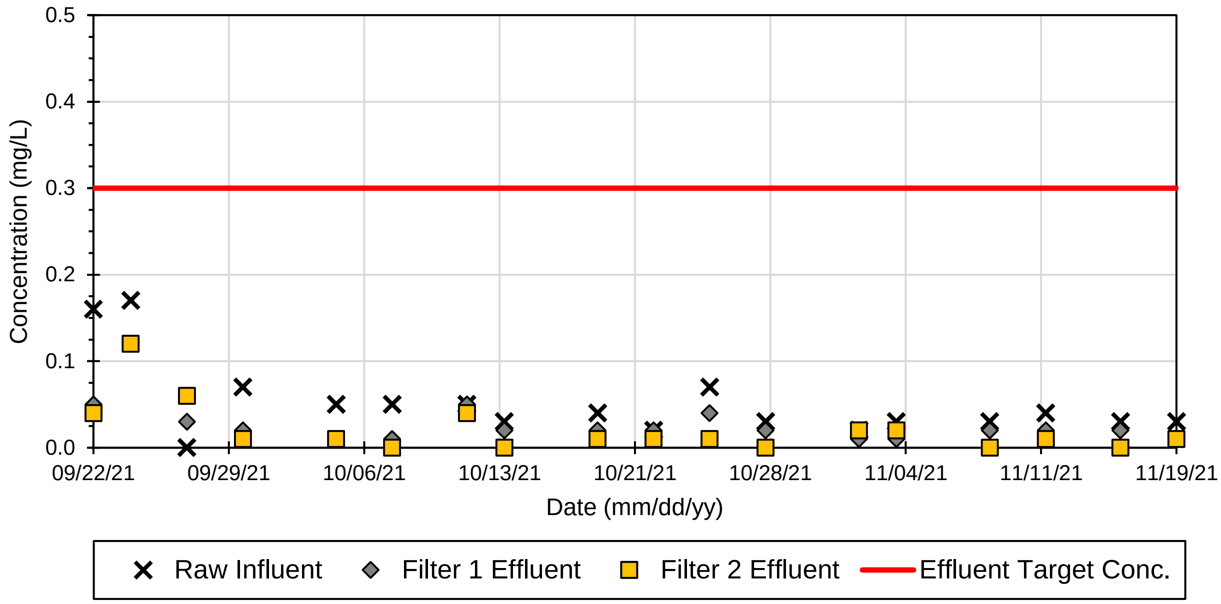

Figure 5-2. Biological Iron Removal

The iron removed by the filters increased during the treatment efficiency phase when compared to the acclimation phase. Although Filter 2 had a better removal performance than Filter 1, the difference in effluent iron concentration between the two filters during the treatment efficiency phase was only 0.01 mg/L. ***Table 5-2*** below summarizes the average iron removed by the filters during both phases of the study.

Table 5-2. Iron Removal Efficiency

Phase	Avg. Iron Removal	
	Filter 1	Filter 2
Acclimation	24%	32%
Treatment Efficiency	63%	82%

5.3 Manganese Removal

The manganese removal results obtained in this pilot study are shown in ***Figure 5-3***. The figure below shows the raw water manganese concentration, the effluent manganese concentration (Filter 1 and Filter 2), and the effluent target manganese concentration. The manganese concentration in the water was reduced from an average of 0.410 mg/L to an average of 0.040 mg/L in Filter 1 and 0.023 mg/L in Filter 2 during the treatment efficiency phase. Although Filter 2 produced water with lower manganese concentrations, the effluent manganese concentrations from both filters were almost identical towards the end of the study. All effluent manganese concentrations during the treatment efficiency phase were below EPA's SDWS for manganese and the MDH's guidance values of 0.10 mg/L for infants and 0.30 mg/L for children and adults.

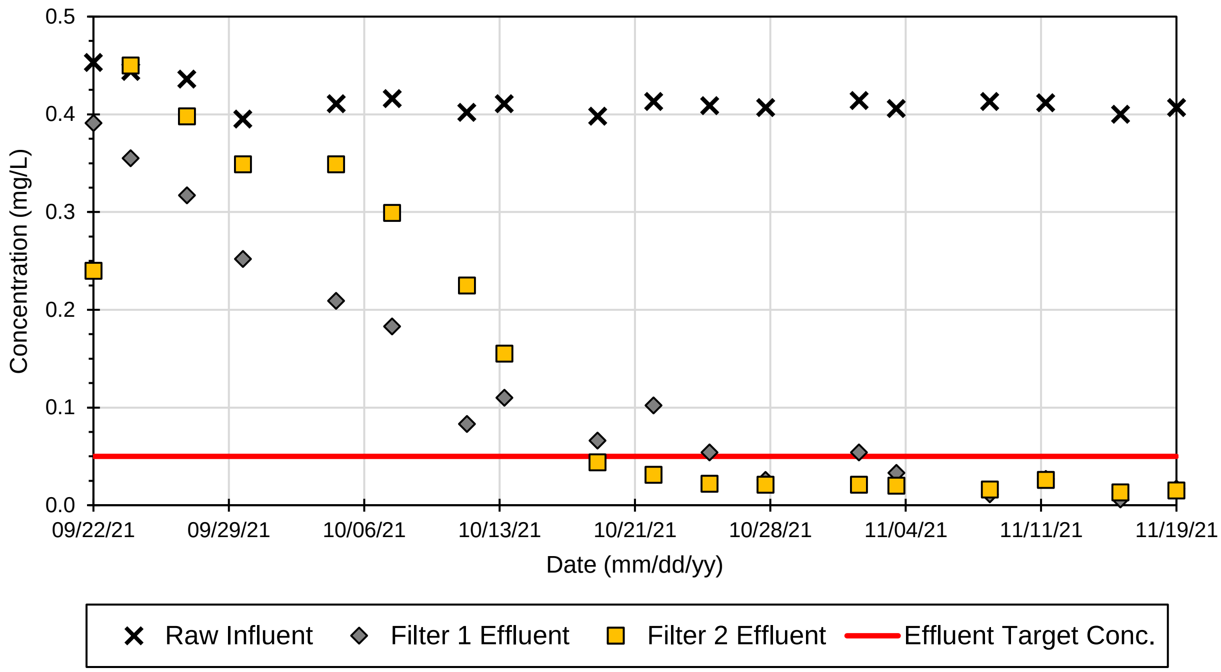

Figure 5-3. Biological Manganese Removal

Similar to the iron removal results, the manganese removed by the filters increased significantly during the treatment efficiency phase when compared to the acclimation phase. Filter 1 performed significantly better during the acclimation phase, but Filter 2 ended up removing slightly more manganese than Filter 1 towards the end of the study. ***Table 5-3*** below summarizes the average manganese removed by the filters during both phases of the study.

Table 5-3. Manganese Removal Efficiency

Phase	Avg. Manganese Removal	
	Filter 1	Filter 2
Acclimation	43%	26%
Treatment Efficiency	91%	95%

5.4 Ammonia Removal

The ammonia removal results obtained in this pilot study are shown in ***Figure 5-4***. The figure below shows the raw water ammonia concentration, the effluent ammonia concentration (Filter 1 and Filter 2), and the effluent target ammonia concentration. The filters' effluent ammonia concentrations were almost identical towards the end of the study and all effluent ammonia concentrations during the treatment efficiency phase were below the target effluent concentration of 0.10 mg/L. It should be noted that the raw water ammonia concentration in Well 6 was higher than expected when compared to the water quality testing completed in 2020 as part of the City's Water Treatment Plant Feasibility Study (see ***Table 2-1*** for the 2020 sampling results).

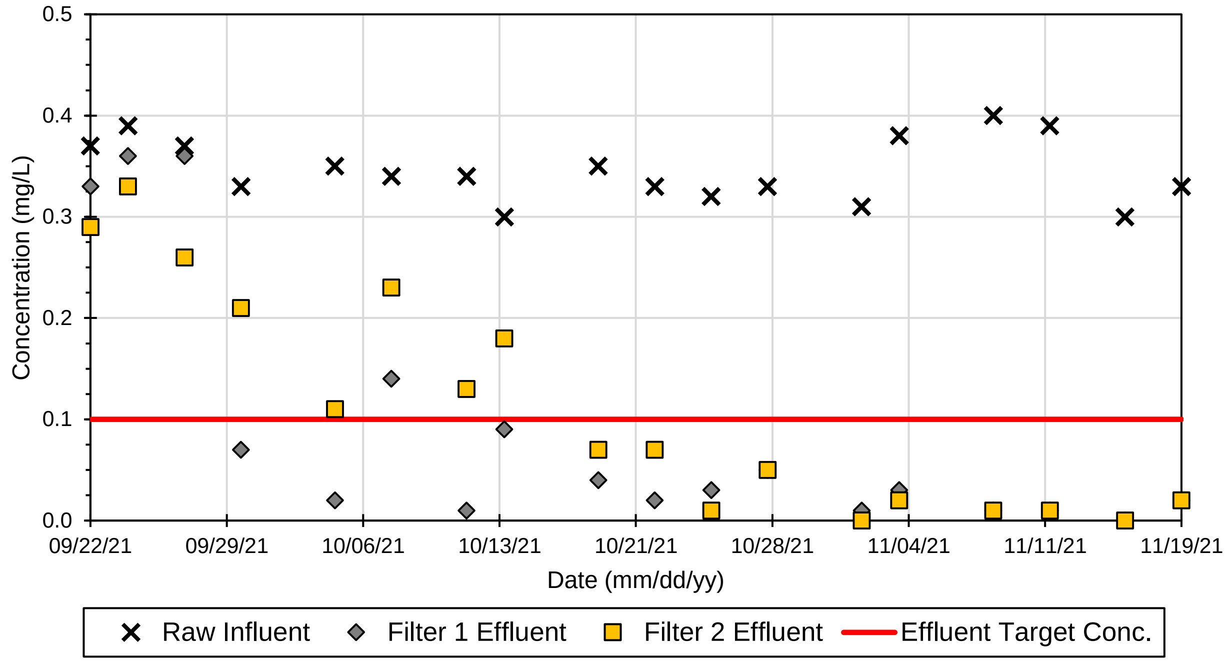

Figure 5-4. Biological Ammonia Removal

Ammonia is removed biologically from the water using a two-step process called nitrification. First, Nitrosomonas microorganisms convert ammonia to nitrite, then Nitrobacter microorganisms convert nitrite into nitrate. The effluent nitrite concentrations increase during the first step of nitrification until the Nitrobacter microorganisms are acclimated, which usually takes 2 to 3 weeks. Due to the expected low concentration of ammonia in the raw water, the MDH did not require monitoring for nitrite or nitrate in Lino Lakes' study. However, since the raw water ammonia was over 0.20 mg/L, randomized testing was completed for nitrite and nitrate by WSB staff to monitor the effluent concentrations. Effluent nitrite and nitrate concentrations were maintained below 0.30 mg/L and around 1 mg/L, respectively, which is significantly below the MLC established by the EPA for each contaminant. Towards the end of the study, the nitrite concentrations were reduced to near zero and almost all the ammonia was converted to nitrate.

Filter 1 performed significantly better than Filter 2 during the acclimation phase. However, both filters achieved similar levels of performance towards the end of the study during the treatment efficiency phase. ***Table 5-4*** below summarizes the average ammonia removed by the filters during both phases of the study.

Table 5-4. Ammonia Removal Efficiency

Phase	Avg. Ammonia Removal	
	Filter 1	Filter 2
Acclimation	50%	37%
Treatment Efficiency	94%	93%

5.5 Nutrient Requirements

Orthophosphate is a form of phosphorus that is dissolved in the water. Because it is dissolved, it is immediately available to be consumed by microorganisms for growth. Since orthophosphate is consumed by the microorganisms, it is important to maintain an adequate concentration upstream of the filters. The natural raw water orthophosphate concentration from Well 6 averaged 0.13 mg/L. This concentration was sufficient to promote rapid biological growth, so additional nutrients were not required during the pilot study.

5.6 Miscellaneous Water Quality Parameters

Other parameters that were monitored during this study included alkalinity, pH, water temperature, total organic carbon (TOC), and coliform bacteria. Water temperature and pH were tested on site while alkalinity, TOC, and coliform bacteria samples were shipped to a certified laboratory for testing.

Alkalinity: Raw water alkalinity averaged 255 mg/L as $CaCO_3$ during the pilot study. Biological filtration had minor impacts on alkalinity as the effluent concentrations were maintained around 250 mg/L as $CaCO_3$ during the treatment performance phase.

pH: Raw water pH averaged 7.0 SU during the pilot study. Effluent average pH concentrations for Filter 1 and Filter 2 were 7.2 SU and 7.3 SU, respectively. The slight increase in pH is due to the water being aerated. When water is aerated, it creates a turbulence which causes the dissolved carbon dioxide (CO_2) and carbonic acid in the water to outgas. Outgasification of CO_2 and carbonic acid from water results in pH increase. Effluent pH concentrations were maintained within the range set by the treatment goals.

Water Temperature: Raw water temperature ranged from 50.2 ºF to 53.4 ºF and effluent water temperatures averaged 53.9 ºF. Microorganisms thrive in warmer and stable environments and the lower water temperatures experienced during the winter months did not affect the performance of the biological filters. Water temperature increased in the pilot skid since the ambient temperature in the pilot trailer ranged between 50 ºF and 60 ºF on most days.

TOC: The raw water TOC concentration averaged 2.6 mg/L during the study. Filter 1 and Filter 2 removed on average 14-percent and 16-percent of the influent TOC, respectively. Both removal performances are on par with results obtained in other biological filtration applications. TOC sampling was conducted both during the microbial acclimation and the treatment efficiency phases.

Coliform Bacteria: Coliform bacteria were tested during both phases of the study. All laboratory results, both influent and effluent, returned absent *E.Coli* results.

Total Trihalomethanes (TTHM): Organic carbon in groundwater is predominantly natural organic matter, which is typically derived from living or decayed vegetation. Natural organic matter can be present in particulate, dissolved, and colloidal forms, and it is usually assessed when TOC exists in the raw water. Disinfection byproducts (DBPs), which are suspected by the EPA to cause cancer, can form in the drinking water when natural organic matter is present along with chlorine. This occurs when chlorine is added to the drinking water for treatment. Higher chlorine doses and TOC concentrations will lead to more DBPs being formed. DBPs can be assessed based on the TTHM concentration in the water. The MDH waived the requirement to test for TTHMs during this study as historically, the TTHM concentrations in Lino Lakes raw water have ranged from 94-percent to 99-percent below EPA's MCL. The future TTHM concentrations in Lino Lakes are expected to be even lower if a water treatment plant is constructed as some of the TOC in the raw water will be removed at the treatment plant. In addition, the TTHMs should become even lower with biological filtration since prechlorination would not be used in the filtration process.

5.7 Filter Backwash Frequency

Obstruction to water flowing through a filter increases as contaminants are removed from the water and accumulate in the media over time. This phenomenon is referred to as headloss through the filter. Headloss will eventually reach a point known as terminal headloss, at which time the filter must be backwashed. If a filter does not reach terminal headloss to initiate a backwash, weekly backwashes are still recommended to avoid channeling and breakthrough of contaminants. The terminal headloss was set to 120 inches.

It is not uncommon for conventional water filtration facilities that treat groundwater to be backwashed every 2 to 3 days. On the contrary, biological filtration facilities tend to experience longer filter run times of 3 to 7 days. Usually, the main groundwater contaminant affecting headloss buildup is iron, and water treatment facilities with high raw water iron concentrations may have to backwash their filters as often as once per day. Backwashing impacts the production capacity of a filter as it cannot treat water when being backwashed. Consequently, it is the goal of any utility to reduce backwashes as much as possible.

The headloss buildup in Filter 1 is shown in ***Figure 5-5*** and the headloss buildup in Filter 2 is shown in ***Figure 5-6***. The pilot filters were not backwash for a period of 3 to 4 weeks at the beginning of the study to minimize media disturbance during the acclimation phase and to analyze if terminal headloss could be reached. However, since the raw water iron concentration was very low, the biological filters never reached terminal headloss. Consequently, the filters were backwashed every 7 to 15 days after the first month of the study following the procedure described in ***Section 4***. The rate of headloss buildup was slightly higher in Filter 2 since greensand media is smaller than silica sand media and can obstruct more water flow. Also, headloss data collected for Filter 2 in November 2021 is inaccurate. It is suspected that media blocked the pressure gauge pipe assembly during this month and then dislodged from the pressure gauge.

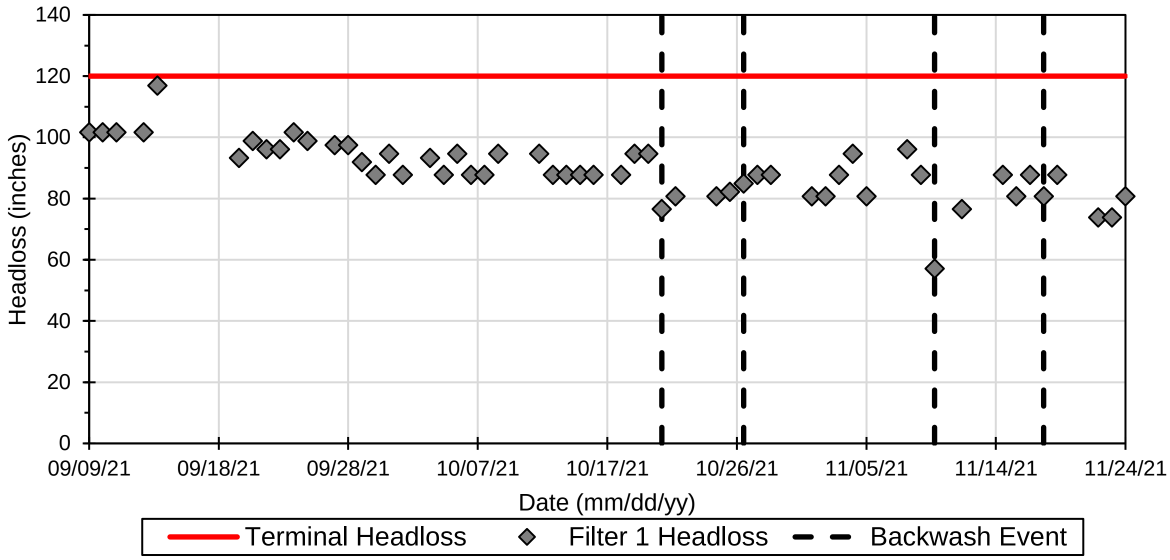

Figure 5-5. Filter 1 Headloss

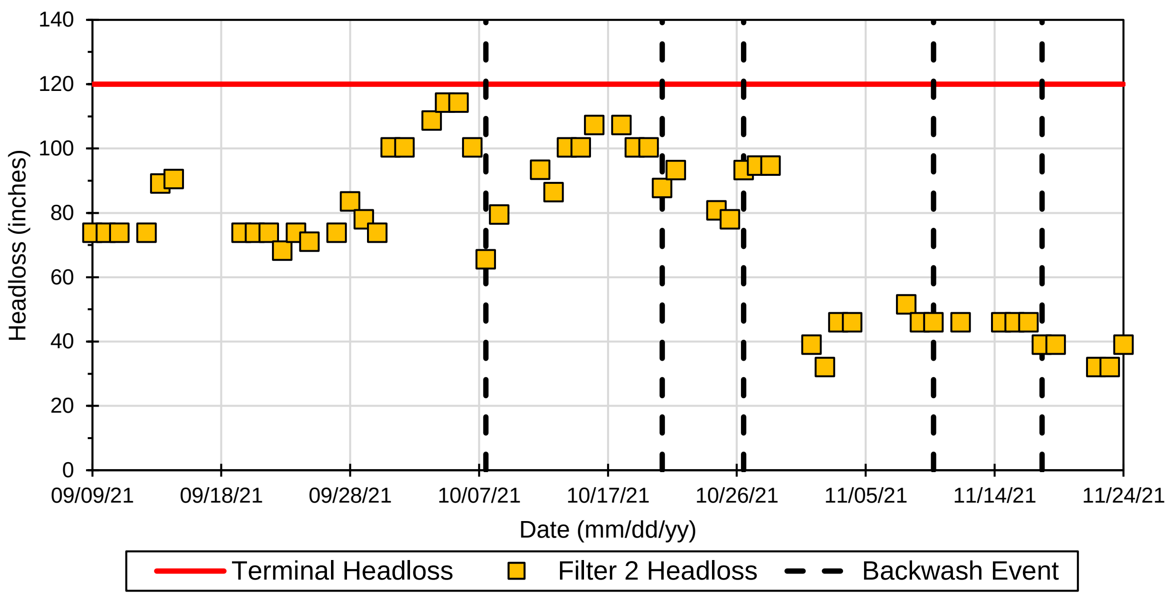

Figure 5-6. Filter 2 Headloss

5.8 Filter Performance Testing

The MDH biological filtration pilot protocol requires two performance tests to be completed when the filters are fully acclimated with microorganisms. The first performance test is a backwash recovery test which is used to evaluate the filtration efficiency of the biological filters immediately after a backwash. The second performance test is a shutdown recovery test which his used to evaluate the filtration efficiency of the biological filters after the filters are out of service for one week.

5.8.1 Backwash Recovery Test

It is almost inevitable that some microorganisms will be washed away when backwashing a biological filter. Therefore, it is important to utilize a backwash strategy that effectively cleans the filters while minimizing the loss of microorganisms. In order to assess the biological filter recovery, water quality samples were obtained in 15-minute intervals following a backwash for 30 to 45 minutes. Prior to sampling the post backwash effluent water, the media was allowed to settle for 5 minutes in each filter. The post backwash results were compared to the pre backwash results to determine how long it required the filter to recover its pre backwash performance. The backwash recovery test results are summarized in ***Table 5-5***. The backwash recovery test was completed during the eighth week of the pilot study.

Table 5-5. Backwash Recovery Test Results

Filter No.	Contaminant	Pre-Backwash Conc. (mg/L)	Post Backwash Conc. (mg/L)			Target Effluent Conc. (mg/L)
			15-min	30-min	45-min	
1	Iron	0.00	0.02	0.02	N/A	0.30
	Manganese	0.029	0.032	0.032	0.023	0.050
	Ammonia	0.03	0.01	0.03	N/A	0.10
2	Iron	0.01	0.03	0.01	N/A	0.30
	Manganese	0.021	0.030	0.036	0.033	0.050
	Ammonia	0.03	0.12	0.03	N/A	0.10

All post backwash concentrations for Filter 1 were below the target effluent concentrations set for this pilot study within 15 minutes of conducting a backwash. The pre backwash iron concentration was not recovered within 45 minutes of the backwash. This is not a concern as the effluent iron concentration was maintained below the target effluent goal following the backwash.

All post backwash concentrations for Filter 2 were below the target effluent concentrations set for this pilot study within 30 minutes of conducting a backwash. The pre backwash manganese concentration was not recovered within 45 minutes of the backwash. This is not a concern as the effluent manganese concentration was maintained below the target effluent goal following the backwash.

5.8.2 Shutdown Recovery Test

Microorganisms need “food” (oxygen, nutrients, and contaminants) in order to survive. Therefore, a portion of the microorganisms may not survive if water flow is stopped and “food” is not available. In order to test the survivability of the microorganisms, both filters were shut down for a period of one week. Similar to the backwash recovery test, the performance of each filter was measured before and after the shutdown to determine the recovery time of each filter for up to 24 hours. The shutdown recovery test results are summarized in ***Table 5-6***. The shutdown recovery test was completed during the last week of the pilot study.

Table 5-6. Shutdown Recovery Test Results

Filter No.	Contaminant	Pre-Shutdown Conc. (mg/L)	Post Shutdown Conc. (mg/L)				Target Effluent Conc. (mg/L)
			30-min	1-hour	2-hour	24-hour	
1	Iron	0.01	0.01	N/A	N/A	N/A	0.30
	Manganese	0.017	0.092	0.023	0.022	0.026	0.050
	Ammonia	0.02	0.10	0.07	0.06	0.01	0.20
2	Iron	0.01	0.02	0.01	N/A	N/A	0.30
	Manganese	0.015	0.087	0.025	0.027	0.022	0.050
	Ammonia	0.02	0.12	0.09	0.11	0.04	0.20

All post shutdown concentrations for Filter 1 were below the target effluent concentrations set for this pilot study within 1 hour of re-starting the filter. The pre shutdown manganese concentration was not recovered within 24 hours of the re-startup. This is not a concern as the effluent manganese concentration was below the MDH guidance value for infants within 30 minutes of filter startup.

All post shutdown concentrations for Filter 2 were below the target effluent concentrations set for this pilot study within 1 hour of re-starting the filter. The pre shutdown ammonia and manganese concentrations were not recovered within 24 hours of the re-startup. This is not a concern as the effluent manganese concentration was below the MDH guidance value for infants within 30 minutes of filter startup and the effluent ammonia concentration was maintained below the target treated goal following the shutdown period.

6. FINANCIAL ANALYSIS

Instead of relying heavily on chemicals like other treatment methods, biological filtration relies on naturally occurring microorganisms to treat water. Therefore, one of the main advantages of biological filtration is the reduction of chemical usage which can result in significant chemical savings over time. In addition, biological filtration produces less processed and more sustainable water due to the reduction of chemical use. Biological filtration eliminates the need to feed chlorine upstream of the filters (prechlorination) to oxidize iron and ammonia and the need to feed permanganate (potassium or sodium permanganate) to oxidize manganese. Similar to conventional filtration, chlorine is still needed downstream of the filters for disinfection purposes. In addition to chlorine, fluoride is also needed in the finished water. Orthophosphate is sometimes also needed in the plant effluent for lead and copper corrosion control in the water distribution system.

Figure 6-1 shows a 20-year projection of the annual water treatment chemical costs in Lino Lakes for a conventional filtration facility and a biological filtration facility. Chemicals included in this analysis consist of permanganate and chlorine. Fluoride and orthophosphate were not included in this analysis as both chemicals may be needed in the same amount regardless of the treatment type used. The chemical cost projection below includes a 3-percent inflation rate.

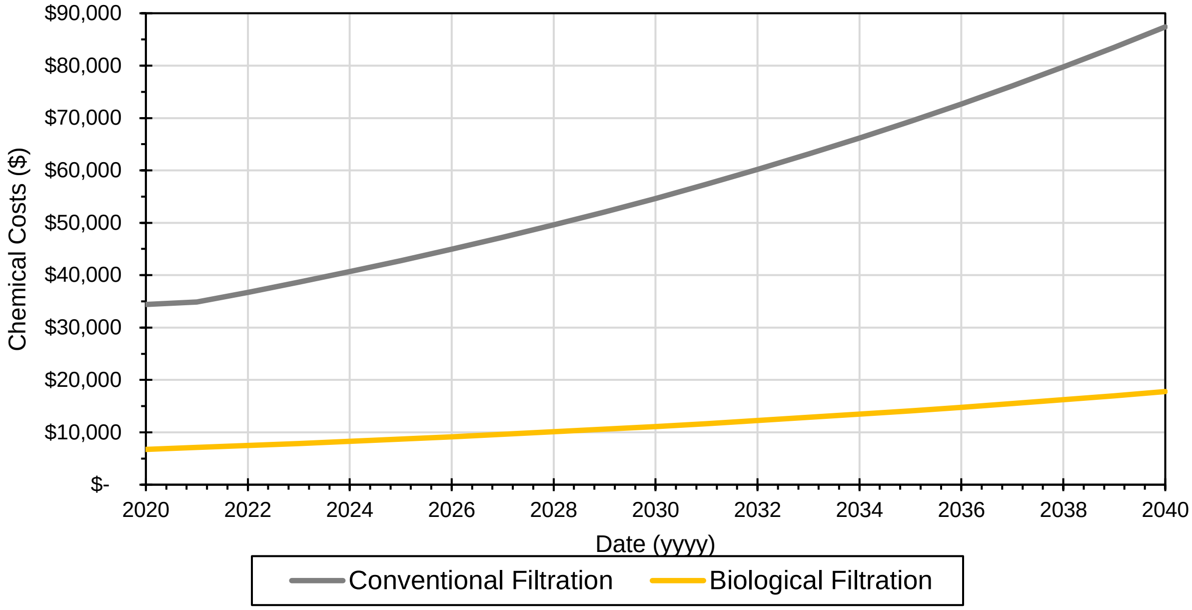

Figure 6-1. Chemical Cost Projection for Water Treatment

The chemical cost projection shown in ***Figure 6-1*** is summarized in ***Table 6-1*** below. As shown in the table below, biological filtration has the potential of generating almost $950,000 in chemical savings over the next 20 years by eliminating the use of permanganate and prechlorination.

Table 6-1. Cumulative Chemical Cost Projection

Year	Conventional Treatment	Biological Treatment	Cumulative Savings
2020	$ 34,405	$ 6,738	$ 27,667
2030	$ 476,597	$ 96,718	$ 379,879
2040	$ 1,192,271	$ 242,339	$ 949,932

7. CONCLUSIONS AND RECOMMENDATION

The final conclusions and recommendations from this pilot study to assess the feasibility of biological filtration as a water treatment method in Lino Lakes are summarized as follows:

7.1 Performance Takeaways

Aeration Requirements: An air flow rate to water flow rate ratio of 0.40 CFM/GPM was sufficient to promote rapid biological growth and to maintain an effluent DO concentration above 4 mg/L.

Iron Removal: The iron concentration in the raw water was reduced from an average of 0.05 mg/L to an average 0.02 mg/L, which is 93-percent below the EPA Secondary Standard for iron. Both biological filters produced similar effluent iron concentrations throughout the pilot study.

Manganese Removal: The manganese concentration in the raw water was reduced from an average of 0.410 mg/L to an average of 0.040 mg/L in Filter 1 and 0.023 mg/L in Filter 2. All effluent manganese concentrations during the treatment efficiency phase were below EPA's Secondary Standard and MDH's guidance values for manganese.

Ammonia Removal: The ammonia concentration in the raw water was reduced from an average of 0.35 mg/L to an average 0.02 mg/L in Filter 1 and 0.03 mg/L in Filter 2. All effluent concentrations during the treatment efficiency phase were below the target concentration of 0.10 mg/L.

Nutrient Requirements: The raw water orthophosphate concentration was sufficient to promote rapid biological growth, and additional nutrients were not required during the pilot study.

Filter Headloss and Backwash Frequency: Terminal headloss was never reached during the study and the biological pilot filters were backwashed every 7 to 15 days. The rate of headloss buildup was slightly higher in Filter 2 when compared to Filter 1.

Filter Performance Testing: Filter performance testing determined that the effluent treatment goals were met within 30 minutes following a filter backwash and within 1 hour following a 1-week plant shutdown. Filter 1 recovered slightly faster than Filter 2.

7.2 Financial Takeaways

Implementing biological filtration in Lino Lakes has the potential of generating approximately $950,000 in chemical savings over the next 20 years when compared to conventional filtration. In addition to generating operational savings, utilizing fewer chemicals produces less processed and more sustainable water.

7.3 Recommendation

As recommended in the City's Water Treatment Plant Feasibility Study, it is recommended to design and construct a gravity filtration water treatment plant with biological filtration in Lino Lakes given its piloted treatment performance and projected operational cost savings. Both media types piloted exhibited similar removal performance, headloss buildup rates, and responded similarly to filter performance testing. However, gravity filters with silica sand and anthracite are recommended for Lino Lakes since the silica sand filter had a lower rate of headloss than the greensand filter and should require less frequent filter backwashing. In addition, silica sand is less expensive than greensand filter media.

WORK SESSION STAFF REPORT
Work Session Item No. 2

Date: March 7, 2022

To: City Council

From: Michael Grochala, Community Development Director

Re: Water Appropriations Permit Amendments
Court Order White Bear Lake Restoration Assoc. v. Mn/DNR

Background

On August 30, 2017, the Ramsey County District Court issued a judgement regarding the groundwater management of White Bear Lake and the Prairie Du Chien-Jordan Aquifer. As a result, the City's Minnesota Department of Natural Resources (DNR) Water Appropriation Permit 1985-6168 was amended to include the following requirements:

- **PREPARE A PLAN TO CONVERT TO SURFACE WATER SOURCE**
- **ENACT AND ENFORE A RESIDENTIAL IRRIGATION BAN WHEN WHITE BEAR LAKE DROPS BELOW 923.5**
- **PREPARE AN ENFORCEABLE PLAN TO LIMIT PER CAPITA WATER USE (75 GPD FOR RESIDENTIAL AND 90 GPD TOTAL)**
- **REPORT ANNUALLY ON COLLABORATIVE EFFORTS WITH NE COMMUNITIES TO MEET THE PER CAPITA REQUIREMENTS**

Lino Lakes along with several other communities and private well permittees are appealing the amendments. The contested case hearings were placed on hold pending the outcome of the DNR's appeals process which has since been completed. The MN Supreme Court issued a ruling in July of 2020 affirming 6 of the 7 issues. The cases have since resumed and we a currently waiting for the court to set dates for the hearing.

In addition, the City is directly affected by other aspects of the order, including:
- A prohibition of the issuance of the new well permits within a 5 mile radius of the lake.
- DNR is required to set a collective annual withdrawal limit for White Bear Lake and adjust permits accordingly.

As the City Council is aware the community continues to grow in accordance with our 2040 Comprehensive Plan and consistent with Metropolitan Council forecasts. Both residential and commercial/industrial development is taking place city-wide. Our comprehensive water plan identifies the need to begin development of Well No. 7 in the near future. DNR has developed a water model that they find sufficient for performing the required analysis under the court order for new well permits. However, in light of other requirements of the order, DNR does not believe it is likely any new permits from the Prairie du Chien aquifer will be issued. Staff has inquired about the possibility to cap existing well no. 2 to allow for construction of well no. 7. Proposed well no. 7 has the potential for better water and higher production than well no. 2 resulting in a net benefit for the city. We are also discussing with DNR the potential to use a different aquifer for production.

Of potentially greater concern is the DNR's proposed collective annual withdrawal limit for White Bear Lake, set at an elevation of 922 that would have significant impact on community use. The proposed limit would result in the need to reduce current use by approximately 40%. That would be extremely difficult to achieve for domestic (household) use alone. This would allow for no population growth and in accordance with the water allocation priorities established in Mn. Statutes § 103G.261, would leave no water for other uses. These would include commercial and industrial uses.

Recognizing the significant impact of such a decision the DNR has requested a hearing with the District Court to secure guidance regarding implementation of this order.

Additionally, Lino Lake, along with several other NE metro communities have worked with our state legislators on a bill (SF 3055) that would:

- Allow cities within 5 miles of WBL to continue to operate under their approved water supply plans.
- Would not allow another lawsuit under the same statutes to be initiated.
- Requires development of a work group to explore options for supply drinking water to these communities, allowing growth, while ensuring the sustainability of White Bear Lake.

A hearing was held before the Senate Environment and Natural Resources Policy and Legacy Finance Committee on Monday, February 28, 2022. The committee approved sending the bill to the Senate floor for consideration. If approved in the Senate it will be forwarded to the House for consideration.

At this time, the City is not subject to this requirement pending completion of the contested case hearings. However, the DNR has requested the City voluntarily implement the ban. Given that we are reaching late fall and irrigation systems are being winterized, we do not believe any action is necessary at this time. We will continue to monitor the issue and determine if any action will be necessary as spring approaches.

Staff is also expecting to schedule a presentation by Mn/DNR representatives at an upcoming work session.

Requested Council Direction

None required at this time. Staff may bring forward a resolution of support for the legislation currently being considered.

Attachments

1. Mn. Statutes § 103G.261

103G.261 WATER ALLOCATION PRIORITIES.

(a) The commissioner shall adopt rules for allocation of waters based on the following priorities for the consumptive appropriation and use of water:

(1) first priority, domestic water supply, excluding industrial and commercial uses of municipal water supply, and use for power production that meets the contingency planning provisions of section 103G.285, subdivision 6;

(2) second priority, a use of water that involves consumption of less than 10,000 gallons of water per day;

(3) third priority, agricultural irrigation, and processing of agricultural products involving consumption in excess of 10,000 gallons per day;

(4) fourth priority, power production in excess of the use provided for in the contingency plan developed under section 103G.285, subdivision 6;

(5) fifth priority, uses, other than agricultural irrigation, processing of agricultural products, and power production, involving consumption in excess of 10,000 gallons per day; and

(6) sixth priority, nonessential uses.

(b) For the purposes of this section, "consumption" means water withdrawn from a supply that is lost for immediate further use in the area.

(c) Appropriation and use of surface water from streams during periods of flood flows and high water levels must be encouraged subject to consideration of the purposes for use, quantities to be used, and the number of persons appropriating water.

(d) Appropriation and use of surface water from lakes of less than 500 acres in surface area must be discouraged.

(e) The treatment and reuse of water for nonconsumptive uses shall be encouraged.

History: *1989 c 326 art 4 s 1; 1990 c 391 art 7 s 25; 1990 c 426 art 1 s 13; 1993 c 186 s 1; 2012 c 272 s 48*