Pilot Study Report

Removal of Iron and Manganese - Well No. 1 and Well No. 2

Rib Mountain Sanitary District

RMTSD 145756 | January 28, 2019

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January 28, 2019

RE: Removal of Iron and Manganese - Well No. 1 and Well No. 2
Pilot Study Report
Rib Mountain Sanitary District
SEH No. RMTSD 145756 4.00

Mr. Michael Heyroth, Utilities Director
Rib Mountain Sanitary District No. 1
5703 Lilac Avenue
Wausau, WI 54401

Dear Mr. Heyroth:

Short Elliott Hendrickson Inc.® (SEH) is pleased to provide you this pilot study report for the study of the potential reduction of iron and manganese in Well No. 1 and Well No. 2. The purpose of the study was to identify the best available treatment processes, treatment chemicals, and dosing required for treatment of the public water supply to remove iron and manganese. This study analyzes different treatment alternatives with respect to performance and operations of the pilot study, and makes recommendations for the Sanitary District to move forward with different alternatives based on that performance.

We are appreciative of the help provided by you and your staff at the Rib Mountain Sanitary District in completing your pilot study. Your history and knowledge of the water system was extremely helpful in conducting the study and in writing this pilot report. We are confident that the results and recommendations contained in this report will be a building block for the future water treatment improvements in your water system and in moving your utility forward in continuing to provide the best water available to your community.

If you have any questions, please do not hesitate to call John Thom, Water Operations Specialist at 612-618-9804 or me at 715-720-6255. Upon your approval of this report we can submit it to the Wisconsin DNR for review and concurrence.

Sincerely,

Jeff Nussbaum, PE (WI)
Senior Professional Engineer

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Pilot Study Report

Pilot Study Report
Rib Mountain Sanitary District

Prepared for:
Rib Mountain Sanitary District
Town of Rib Mountain, Wisconsin

Prepared by:
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JEFFREY S. NUSSBAUM
E-37104
EAU CLAIRE
WI
PROFESSIONAL ENGINEER

January 28, 2019

I, Jeff Nussbaum, PE (WI), hereby certify that I am a registered Professional Engineer in the State of Wisconsin in accordance with Ch. A-E 4, Wis. Adm. Code and that this report has been prepared in accordance with the Rules of Professional Conduct in Ch. A-E 8, Wis. Adm. Code.

	E-37104	January 28, 2019
Jeff Nussbaum, PE (WI) Senior Professional Engineer	PE Number	Date

SEH

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Prepared for Rib Mountain Sanitary District

1 Introduction

1.1 Background

Rib Mountain Sanitary District has 4 wells all located within the vicinity of W. Lakeshore Drive and Lilac Avenue in the Town of Rib Mountain. The District supplies water and sewer services for the Rib Mountain area. These services were started in 1985 and currently serve about 6,000 people. Rib Mountain has a large and growing commercial customer base along with residential customers. The water utility provides water from four wells all constructed in 1984, except for Well No. 4 which was constructed in 2000. All the wells are in the sand and gravel aquifers located west of the Wisconsin River. They are all relatively close together. These aquifers are known for their iron and manganese. A Vyredox® iron and manganese removal treatment process was installed in 1985 for Well No. 1 and Well No. 2. The Vyredox® treatment system oxidizes the iron and manganese in the soil, leaving the iron and manganese in the water source, except their non-soluble form. This system has diminished over time in its efficiency for removing iron and manganese from the water source(s). The water utility on an average day produces and provides 500,000 gallons of water. During the skiing season, the water utility provides over double that average day demand to Rib Mountain to make snow for skiing. This increase in demand has historically riled up the distribution system by causing changes in the way water flows and has caused some system issues with complaints on dirty water. In 2014, the District hired a consultant to complete a study of the biological issues in the wells. Recommendations in this study consisted of maintenance treatment of the wells and flushing of the distribution system in general. The study recommended that if these measures were not adequate to control microbial growth in the wells and the distribution system, that a central water treatment system may be needed to remove organic carbon, iron and manganese.

The Sanitary District would like to replace the existing Vyredox® treatment system at Well No. 1 and Well No. 2 with new a central water treatment system, with the ability to remove iron and manganese from both Well Nos. 1 and 2. The objective of this pilot study is to find a treatment solution in which the iron and manganese are removed from the water sources, rather than being left to accumulate in the aquifers.

Short Elliot Hendrickson has now completed a pilot test for iron and manganese removal. This study was performed in July of 2018 on Well No. 1 and No. 2.

1.2 Drinking Standards

National Primary Drinking Water Regulations (Standards) (NPDWRs) are legally enforceable standards that apply to public water systems. NPDWRs, or Primary Standards, set mandatory water quality standards for drinking water contaminants. These are enforceable standards called "maximum contaminant level". The maximum contaminant level (MCL) is the highest level of a contaminant that is allowed in drinking water which is delivered to the consumer, as delineated by the NPDWRs. These levels are based on consideration of health risks, technical feasibility of treatment, and cost-benefit analysis. MCLs are established to protect the public against consumption of drinking water contaminants that present a risk to human health.

In addition, EPA has established National Secondary Drinking Water Regulations (NSDWRs) that set non-mandatory water quality standards for 15 contaminants. EPA does not enforce these "secondary" MCLs (SMCLs). They are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL.

1.3 Objectives

The objectives of the study were to evaluate treatment processes that will reduce levels of dissolved iron and manganese in the community's raw water to less than the SMCLs, and to select a best available treatment method for the design of a Water Treatment Plant (WTP) for the Rib Mountain Sanitary District. The SMCL concentrations of dissolved iron and manganese in drinking water supplies are 0.3 mg/L and 0.05 mg/L, respectively. Based on this criteria and the goals of the Rib Mountain Sanitary District, the following objectives were included with this pilot study:

- Determine the optimum method (permanganate, chlorine, aeration) to oxidize both dissolved iron and manganese, for effective removal of the precipitated minerals by filtration.
- Evaluate the effectiveness of different filtration media types for the removal of dissolved iron and manganese from the well(s) water supply.
- Establish the effective filter loading rate (Gpm/ ft2) for each media evaluated and thereby determine the optimum filter run times and filtration rates.
- Determine the treatment operating parameters for maintaining filter run duration of 20 to 30 hours.
- Determine required backwash requirements (flow rate and time) for each media evaluated.
- Use the data to evaluate treatment processes that consistently produce finished water concentrations of iron and manganese less than the SMCLs and recommend the optimum treatment process options for Well No. 1 and Well No. 2.

2 Existing Facilities

2.1 Wells

Two out of Rib Mountain's four wells are proposed for adding water treatment. They are Well Nos. 1 and 2. The District may also consider the possibility of connecting Well Nos. 3 and 4 to a new WTP in order to combine them with the effluent from the WTP for a single combined point of entry. The four wells are located near each other in the Town of Rib Mountain and each currently has its own entry point into the distribution system. Table 1 below shows the well characteristics as documented by the utility. The locations of each well and pump house are shown on the Existing Facilities Location Map, in Appendix C.

Well No. 1 (DNR Unique Well ID No. VX778) and Well No. 2 (DNR Unique Well ID No. DG454) are very similar when it comes to capacity of production, and they currently operate year-round with both wells having a design capacity of 550 gallons per minute each. The theoretical average daily yield at each well is 750,000 gallons, with a total yield per day of 1.5 million gallons.

Well 1 produced a total of 71.8 million gallons of water in 2016 and 60.7 million gallons of water in 2017.

Well 2 produced a total of 48.2 million gallons in 2016 and a total of 49.2 million gallons during 2017. (Source: Rib Mountain Water Utility & PSCW Annual Reports)

Table 1 – Well Characteristics

	Well No. 1	Well No. 2	Well No. 3	Well No. 4
Construction Date	1984	1984	1984	2000
Casing Diameter (inch)	16	16	16	20
Well Depth (ft.)	75	90	90	78
Static Water Level (ft.)	34.6	32	27.2	30.5
Design Capacity (GPM)	550	550	400	300

Source: Rib Mountain Sanitary District 11/15/2017

2.2 Water Quality

The water quality for the Rib Mountain Sanitary District is in compliance with the NPDWRs. However it exceeds both SMCLs for iron and manganese of the National Secondary Drinking Water Regulations (NSDWRs) in both Well 1 and 2. Neither contaminate is a health issue at the levels present in the raw water, but they will cause (taste, color, odor) staining on laundry and plumbing fixtures; can clog wells, pumps, sprinklers and other devices such as dishwashers, and also give a "metallic" taste to the water that can affect foods and beverages. The Rib Mountain Water Utility has provided historical annual raw water data for iron (Fe) and manganese (Mn) in the wells, which are shown in Table 2 and 3 below. According to this data, since 2016 there is a distinct upward trend in Fe at Well 1 and a slight increase at Well 2. A slight increase in Mn concentrations at Well 2, with a varying level at Well 1 is noticeable in the same time period.

Table 2 – Well(s) Historical Annual Raw Water Data - Iron

Fe (mg/L)	Well No. 1	Well No. 2	Well No. 3	Well No. 4
YEAR				
2000	0.288	0.324	0	0.077
2008	0.195	0.363	0.018	0.049
2016	0.57	0.83	0	0
2017	0.87	0.9	0.079	0.32
2018	0.84	1.0		
Data not available between 2001 and 2007 nor 2009 and 2015. Fe SMCL = 0.30 mg/L				

Source: Rib Mountain Sanitary District 11/15/2017

Table 3 – Well Historical Annual Raw Water Data - Manganese

Mn (mg/L)	Well No. 1	Well No. 2	Well No. 3	Well No. 4
YEAR				
2008	0.039	0.06	0.003	0.005
2016	0.15	0.12	0.007	0.0057
2017	0.18	0.13	0.011	0.017
2018	0.14	0.17		
Data not available between 2009 and 2015. Mn SMCL = 0.05 mg/L				

Source: Rib Mountain Sanitary District 11/15/2017

3 Pilot Testing Processes and Equipment

This section summarizes the treatment equipment and processes used to complete the pilot treatment testing for Well No. 1 and 2.

3.1 Water Chemistry for Iron and Manganese Removal

The most common practice used for the treatment of dissolved iron and manganese from drinking water supplies is chemical oxidation followed by physical removal by filtration. In this water treatment approach dissolved iron (Fe) is oxidized from soluble Fe+2 to its less soluble Fe+3 state, and dissolved manganese (Mn) is oxidized from soluble Mn+2 to less soluble Mn+4. The insoluble Fe+3 and Mn+4 oxides are precipitates that can be removed from the water through filtration.

The oxidation process and rates for iron and manganese are significantly different. Iron oxidizes rapidly and relatively easily. Simple aeration or chlorine is effectively used in many filtration systems for the removal of iron. Manganese requires a stronger oxidant and typically more time for the reaction to go to completion. The use of powerful oxidants such as potassium permanganate or ozone has been successful for removing manganese. Catalytic media is also used successfully to aide in the oxidation process for manganese. Effectively and efficiently removing iron and manganese from a water source requires the right combination of oxidant, time, and media.

3.2 Pilot Testing Processes

The pilot study was conducted to establish the loading rates, chemical feed requirements, efficiency and reliability of each media for the treatment of Wells 1 and 2 raw well water. Based on the historical data as collected by the Rib Mountain Water Utility for dissolved iron and manganese, Tables 2 and 3 of section 2.2 above, and on SEH's extensive prior water treatment experience, the most cost-effective treatment processes selected for pilot testing of these two well water sources include chemical and mechanical oxidation and filtration using catalytic media, performed with and without detention. For simplicity of operation, mechanical and chemical oxidation was used on Column 1 and 2 and only chemical oxidation was used on Columns 3 and 4. Potassium permanganate was used on Columns 1 and 2 in this pilot. Potassium permanganate was not used on the pyrolucite media.

3.3 Pilot Testing Equipment Description

Granular media pressure filtration equipment was utilized during the field testing phase of the pilot study. SEH's pilot trailer was parked immediately adjacent to the each well during the testing phase. Photo 1 shows the SEH pilot trailer set up next to Well No. 1 during the pilot testing performed July 24 through July 25, 2018.

The SEH pilot trailer is equipped with the following equipment for testing oxidation-detention-filtration treatment processes on new and existing groundwater supplies for iron and manganese removal:

- Aerator
- Chemical feed pumps
- Chemical storage containers with mixers and motors
- Detention tank
- Booster pumps and process piping
- Four vertical pressure filters
- Pressure gauges and piping isolation valves
- Sampling taps
- Lab area with water quality testing equipment

Photo 1 - SEH Pilot Trailer at Well No. 1

Pilot testing at Well 2 was completed on July 19 - July 20, 2018. The pilot trailer was moved to Well No. 1 and pilot testing was completed on July 24 - July 25, 2018. During the set up at each well, temporary flexible discharge piping was tapped into the well head piping to provide the raw water supply to be tested within the pilot trailer. Figure 1 illustrates the treatment flow schematic used during each unit well pilot testing, as submitted with the Well No. 1 and No. 2 Pre-Pilot Study Report on July 12, 2018 and approved by Wisconsin DNR on July 16, 2018 under W-2018-0543. See Appendix D for a copy of this report and approval letter.

3.3.1 Aeration Oxidation

Aeration was selected as an additional oxidizing process to remove dissolved gases and to begin oxidizing iron and manganese in the raw water. Potassium permanganate is typically fed as an oxidant with a manganese coated media filtration system. However, using other oxidizing agents or other oxidation methods, such as aeration, can reduce the amount of potassium permanganate needed to treat water. Unlike chlorine or other chemical oxidation methods, aeration does not create a residual. It was the desire of the Rib Mountain Sanitary District to minimize chemical residuals in their drinking water, thus aeration was selected.

A draft aerator was used to aerate the system, at an approximate rate of 15 cubic feet per minute to 1 cubic foot of water.

3.3.2 Detention

Detention provides time for oxidation reactions to occur. Incorporating detention increases iron and manganese removal and decreases the amount of potassium permanganate required. Ten State Standards recommends a minimum detention time of 30 minutes.

Detention was achieved with 150 gallon tank with a feed and overflow rate of 5 gpm. This combination of volume and flow rate results in a detention time of 30 minutes.

3.3.3 Filters

Photo 2 Pilot Trailer Filters

A total of four (4) filters, each with a column diameter of 8-inches and a height of 72-inches tall, were used during the pilot testing. Each filter column included a 3/4 inch diameter inlet, 1 1/2 inch diameter backwash waste outlet, under drain system, air release system, and rate of flow meters, sample taps, and filter media. Each filter column provided 0.35 square feet (ft.^{2}) of surface area per column. When the filter columns are operated at 2 gpm/ft.^{2}, then each column has an equivalent water flow rate of 0.7 gallons per minute applied. The filters were operated in a parallel flow pattern but with independent flow rates. Pressure gauges were located on the inlet and outlet piping of each filter column so the filter pressure head loss across each column could be observed and recorded during the test.

Flow was held constant at 3 gpm/ft.^{2} on Columns 1 and 2, which is an equivalent applied flow rate of 1.05 gallons per minute (gpm). Columns 3 and 4 were operated at 5 to 6 gpm/ft.^{2}, which is an equivalent applied flow rate of 1.75 - 2.1 gpm.

3.3.4 Filter Media

Filtration separates the oxidized iron and manganese from the treated water. Ten State Standards recommends the following design parameters for a filtration system:

- Media depth between 24 and 30 inches.
- Minimum of 12 inches of media with an effective size of 0.45 mm to 0.55 mm.
- Filtration rate between 3 and 8 gpm/ft2.
- For manganese coated media filters, a minimum anthracite media cap of 6-inches.
- For manganese coated media filters, a normal filtration rate of 3 gpm/ft2.

Multiple filter media were considered for this pilot test. The filter media evaluated in the pilot study included:

- Pyrolucite media (mined manganese dioxide ore)
- GreensandPlus™ (silica sand coated with manganese dioxide)
- Silica Sand

Table 4 summarizes the filter media characteristics used during the pilot testing.

Table 4 – Filter Column Media Type, Depth, & Characteristics

Filter Media Characteristics	Column 1	Column 2	Column 3	Column 4
	Silica Sand & Anthracite	GreensandPlus™ ™/Anthracite	Pyrolucite	Pyrolucite
Media Depth (inches/inches)	12 Anthracite 18 Silica Sand	12 Anthracite 18 G.S.P.	30	36
Effective Size (mm / mm) or (mesh)	0.45 – 0.55 0.9 – 1.0	0.30 – 0.35 0.9 – 1.0	20x40	20x40
Note: Column arrangements and filter media depths for Well #1 and #2 were the same.				

Pyrolucite is a granular catalytic water filtration media used for the removal of hydrogen sulfide, iron and manganese. Both Well No. 1 and Well No.2 were used to test pyrolucite. Typical bed depths range from 24-inches to 36-inches. A bed depth of 30-inches and 36-inches was used for this study. Generally the various configurations of pyrolucite media provides extensive surface sites available for oxidation of soluble iron and manganese. Pyrolucite media operates at a comparatively higher filtration rate than other filter media. Generally, filtration rates for pyrolucite of 6 to 15 gpm/ft.^{2} have been achieved. Higher filter loading rates have a distinct advantage in significantly reducing the size of the filters required. Smaller filters result in smaller facilities and lower overall construction costs.

Backwash is critical for proper filter operation. To adequately clean and restore any media requires sufficient flow to expand and fluidize the bed. Attrition or friction from rubbing the media during backwash can be a benefit, as it exposes more surface sites for oxidation of soluble iron and manganese. The flow rate is determined by media weight and size. The required backwash rate for pyrolucite is 25 gpm/ft.^{2}. Frequent filter backwashing is typically recommended for pyrolucite media to maintain the effectiveness of the media for oxidizing and removing iron and manganese. Backwash frequency is determined by finished water quality and filter head loss during operation. To determine required backwash rates and frequency, multiple backwashes were performed during the pilot testing filter runs.

GreensandPlus™ is a silica based black colored catalytic filter media used for removing soluble iron, manganese, hydrogen sulfide, arsenic and radium from groundwater supplies. It is another manganese dioxide filtering media and is an exact replacement for manganese greensand. Both Well No. 1 and Well No. 2 were used to test GreensandPlus™. The manganese dioxide coated surface of GreensandPlus™ acts as a catalyst in the oxidation reduction reaction of iron and manganese. This coating of manganese dioxide results in a black color filter media. To improve filter hydraulics, an anthracite cap is typically provided. The anthracite was pre-treated with potassium permanganate to add a manganese oxide coating prior to the start of the pilot testing. GreensandPlus™ filters are generally most effective when the combined iron and manganese concentrations are below 5mg/L. Hydraulic loading rates for greensand filters are typically between 2 and 8 gpm/ft.^{2}. The required water backwash rate is typically 10 to 15 gpm/ft.^{2} which will fluidize the bed, scrub the media, and redistribute the media throughout the bed. Bed expansion of 40 percent is recommended. The higher loading rates have been demonstrated to be successful, although the filter run times are typically shorter for the higher filtration rates due to early breakthrough of the precipitated minerals.

Anthracite was used in conjunction with GreensandPlus™ and also with silica sand.

3.3.4.1 Media Testing and Filter Column Operation

The four filters in the trailer, which were operated the same for Well 1 and Well 2, were plumbed to operate each pair of two columns in a parallel flow pattern with independent flow rates. The first filter column (Column 1) was bedded with 18 inches of silica sand media and capped with 12 inches of anthracite media. The second filter column (Column 2) was bedded with 18-inches of GreensandPlus™ media and capped with 12 inches of anthracite media. Two columns (Columns 3 and 4) were bedded with 30-inches of pyrolucite and 36-inches of pyrolucite, respectively. The two different depths of pyrolucite were tested to determine the effect that a deeper media bed has on the effective filter loading rate (gpm/ft.^{2}). Higher filter rate capabilities can lead to smaller footprint for equipment.

Prior to beginning the pilot test filter runs, each column was backwashed to remove fines and to clean the media. Column 1 and Column 2 were saturated with a solution of potassium permanganate to fully charge the filter media material. Before operation, the filter Columns 1 and 2 were backwashed again to remove excess permanganate.

3.3.5 Chemical Feed Systems and Oxidation

The chemical feed systems used in the Rib Mountain Sanitary District pilot testing were Blue and White peristaltic metering pumps capable of feeding 0.2 gallons per day (GPD) up to 3.5 GPD. The pumps were setup to feed less than 2.5 GPD for this study.

- Sodium hypochlorite (bleach) for oxidation
- Potassium Permanganate for oxidation and media charge

The only chemical that was continuously fed during the pilot was a 6 percent sodium hypochlorite (household bleach) solution. The post-treatment target free chlorine level was a minimum 0.3 mg/L. The solution was neat. For this pilot study, a 6 percent sodium hypochlorite (household bleach) solution was used and pumped into the raw water flow stream to produce a target residual of 0.3 mg/L in the filter effluent. Chlorine is the preferred oxidant for its availability, safety, and ease of use. Rib Mountain Utility currently uses sodium hypochlorite for disinfection purposes at each well. Testing with sodium hypochlorite during the pilot study was consistent with current operations and the target residual.

In many groundwater treatment plants that remove iron and manganese, the oxidation process of the dissolved minerals is improved by using chlorine or chlorine combined with potassium permanganate (KMnO4). The oxidation of dissolved iron with chlorine is very rapid, but oxidation of manganese with chlorine can be much slower. Typically potassium permanganate is very effective for the oxidation of both dissolved iron and manganese.

KMnO4 is a chemical that has a much higher cost than chlorine and due to its strong oxidizing characteristics is more difficult to handle and hard on equipment. Operational preference in most cases is to not use KMnO4 if at all possible. If KMnO4 is overfed, it can discolor the water giving it a pink color. KMnO4 should only be used for the oxidation of iron and manganese when chlorine is not effective alone. During the pilot process permanganate was used during the initial charge of the sand in Columns 1 and 2 and as an oxidant after detention in these columns.

As mentioned above, potassium permanganate is typically fed as an oxidant when a manganese coated media filtration system is used. Potassium permanganate was selected because it rapidly oxidizes the manganese and does not create a residual. For this pilot study the potassium permanganate was mixed at 2 grams per liter of distilled water. Thus 1 milliliter in a liter of water represents 2 mg/L as permanganate. Potassium permanganate was feed between aeration and detention, at an average concentration of 0.67 mg/L.

3.3.6 Water Quality Testing Lab

The SEH pilot trailer included a fully-equipped water quality testing lab, and was staffed for the duration of the pilot testing by SEH's experienced pilot treatment specialist. The pilot trailer lab equipment and specialist were capable of performing all the required water quality field tests needed for this study.

3.4 Pilot Testing Operations and Processes

Ten State Standards outlines seven (7) treatment standards for iron and manganese removal: removal by oxidation, detention and filtration; removal by lime-soda ash softening, removal by manganese coated media filtration, removal by ion exchange, biological removal, sequestration by polyphosphates, and sequestration by sodium silicates.

The water quality analyses performed on the raw water during this pilot study indicated that Well No. 1 and Well No. 2 contained elevated levels of both dissolved iron and manganese as exemplified in Table 7. Based on the contaminant concentrations, SEH's prior experience, and the preferences of the Rib Mountain Sanitary District, the processes selected and approved in the pre-pilot report for this pilot study was a combination of oxidation (mechanical and chemical), detention, and filtration by manganese coated media.

For each column tested, one complete cycle was operated. Field samples were collected for each column including time, chlorine feed rate for pyrolucite, permanganate feed rate for detention, chlorine feed rate for detention, water flow, and filter head loss. Finished water quality for iron, manganese, chlorine and pH were recorded as well. This data for each well can be found in Appendix C.

Backwashing was completed after the cycle for each well was completed. Backwash water was discharged to the ground surface to infiltrate. Chlorine residuals in the discharged water were not greater than the water in the distribution system and therefore safe for discharge onto the ground surface.

3.5 Pilot Testing Treatment Flow Trains

Flow trains for each filter being tested during this study are listed below as a sequential progression of activities that make up the pilot treatment process for each column. Figure 1 shows the information graphically and how the pilot trailer was plumbed. The configuration was the same for Well No. 1 and Well No. 2.

Table 5 – Pilot Treatment Train No. 1- Well No. 1 and No. 2

Filter Column 1	Filter Column 2
Aeration- 15 cfm / cubic foot of water	Aeration- 15 cfm / cubic foot of water
Chlorine feed	Chlorine feed
Detention – 30 min.	Detention – 30 min.
Permanganate feed	Permanganate feed
Anthracite / Silica Sand	Anthracite / GreensandPlus™
Flow rate: 3 gpm/ $ft.^2$	Flow rate: 3 gpm/ $ft.^2$
Water quality sampling and testing	Water quality sampling and testing
Discharge to waste	Discharge to waste
Backwash	Backwash

Table 6 – Pilot Treatment Train No. 2 - Well No. 1 and No. 2

Filter Column 3	Filter Column 4
Chlorine feed	Chlorine feed
30-inch Pyrolucite	36-inch Pyrolucite
Flow rate: 5 gpm/ $ft.^2$ at W1 6 gpm/ $ft.^2$ at W2	Flow rate: 5 gpm/ $ft.^2$ at W1 6 gpm/ $ft.^2$ at W2
Water quality sampling and testing	Water quality sampling and testing
Discharge to waste	Discharge to waste
Backwash	Backwash

3.6 Sampling and Analysis

Water quality was tested hourly throughout the pilot testing. Field water quality sampling and testing of the raw water and filtered water was conducted during each filter run.

The influent water to the pilot trailer was tested for iron and manganese with a Hach DR900 Colorimeter. Temperature and pH were measured using Hach HQ 40 pH meter. The chemical feed rates were monitored using calibration cylinders on each of the chemical feed systems to measure the amount of chemicals fed per hour for each treatment train. The volume of each chemical in milliliters was measured per unit of time and the dosage was calculated based on the flow to the individual treatment trains.

4 Pilot Test Results Well No. 1 and Well No. 2

This chapter summarizes the results from the pilot testing completed for Well No. 1 and Well No. 2. Pilot testing was conducted at the wells on July 19 through July 20, 2018 and July 24 through July 25, 2018.

4.1 Raw Water Quality and Sample Results

Table 7 summarizes the raw water quality testing completed for iron, manganese, and pH during the pilot study. Samples were taken for both Well No. 1 and Well No. 2.

The Vyredox® treatment system was turned off and not utilized for two months prior to completing this raw water testing and the pilot testing.

Table 7 – Well No. 1 and Well No. 2 - Raw Water Quality- Pilot Study Data

			Well No. 1					
Iron			**Manganese**			**pH**		
Min	*Max*	*Avg*	*Min*	*Max*	*Avg*	*Min*	*Max*	*Avg*
0.952	1.10	1.025	0.177	0.420	0.241	5.98	6.78	6.093
			Well No. 2					
Min	*Max*	*Avg*	*Min*	*Max*	*Avg*	*Min*	*Max*	*Avg*
0.889	1.30	1.132	0.126	0.393	0.223	6.01	6.64	6.227

At the request of the Rib Mountain Sanitary District, during the pilot testing of Well 1 and Well 2, Short Elliot Hendrickson also tested Well No. 1, 2, 3, and 4 for the following parameters which are summarized below in Table 8.

Table 8 – Well No. 1, 2, 3 and 4 - Raw Water Quality Parameters

Parameter	Wells Raw Water Quality				
	Units	1	2	3	4
pH	---	5.92	5.88	5.84	5.90
TDS	mg/L	217.5	188	293	646
P Alkalinity	mg/L				
M Alkalinity	mg/L	24.8	19.2	30	33
OH Alkalinity	mg/L				
Carbonate Alkalinity	mg/L				
Bicarbonate Alkalinity	mg/L	24.8	19.2	30	33
Manganese	mg/L	**0.393**	**0.307**	**0.039**	**0.027**
Iron	mg/L	**1.004**	**1.119**	**0.139**	**0.097**
Total Hardness	mg/L	82.8	75.2	106	190
Calcium Hardness	mg/L	54.4	46.4	80	109
Magnesium Hardness	mg/L	28.4	28.8	25.6	81.2
Carbonate Hardness	mg/L	24.8	19.2	29.6	33.2
Non Carbonate Hardness	mg/L	58	56	76	157.2
Langilier Index	--	-2.28	-3.38	-2.77	-2.53
Flow Rate	MGD	0.72	0.72	0.72	0.40
Chloride	mg/L	23.4	20.3	27	555
Sulfate	mg/L	5	4	3	6

These results from the wells indicate that Well No. 1 and Well No. 2 exceed the SMCLs for iron and manganese and should be treated for removal. However, Well No. 3 and 4 are currently below the SMCLs level for recommending treatment for iron and manganese and should be monitored closely. Figure 2 and Figure 2A illustrate the combined raw water iron and manganese concentrations in each well.

The total dissolved solids (TDS) in Well No. 4 should be continue to be monitored regularly as well as the chloride levels.

4.1.1 Iron

The dissolved iron concentration for Well No. 1 during the pilot testing ranged from a low of 0.952 mg/L to a maximum of 1.10 mg/L with an average of 1.025 mg/L. These results are 3.4 times higher than the SMCLs established by the EPA. Figure 3illustrates the raw water iron results throughout the pilot testing period for Well No. 1.

The dissolved iron concentration for Well No. 2 during the pilot testing ranged from a low of 0.889 mg/L to a maximum of 1.30 mg/L with an average of 1.132 mg/L. These results are

3.7 times higher than the SMCLs established by the EPA. Figure 3A illustrates the raw water iron results throughout the pilot testing period for Well No. 2.

4.1.2 Manganese

The dissolved manganese concentration for Well No. 1 ranged from a low of 0.177 mg/L to a maximum of 0.420 mg/L with an average of 0.241 mg/L during the pilot testing. These results are 4.8 times higher than the SMCLs established by the EPA. Figure 4 illustrates the raw water manganese results throughout the pilot testing period for Well No. 1.

The dissolved manganese concentration for Well No. 2 ranged from a low of 0.126 mg/L to a maximum of 0.393 mg/L with an average of 0.223 mg/L during the pilot testing. These results are 4.5 times higher than the SMCLs established by the EPA. Figure 4A illustrates the raw water manganese results throughout the pilot testing period for Well No. 2.

4.1.3 pH

The pH of both Wells were also monitored at several times during the pilot testing. pH is a measure of how acidic or basic a substance is. In the case of Well No. 1, the raw water pH ranged from a low of 5.98 and a maximum of 6.78, averaging 6.093. This raw water measurement is considered slightly acidic to neutral.

Well No. 2, the raw water pH ranged from a low of 6.01 and a maximum of 6.64, averaging 6.227. This raw water measurement is considered slightly acidic to neutral.

4.1.4 Backwash Water

Backwash flow rates were not the prime objective of this pilot study. However Ten State Standards and WDNR NR regulations have commonalties of design standards and code for media backwash rates. This study assumes the designers of the future water treatment plant will be using those standards The Wisconsin Department of Natural Resources NR 811.853 allows backwash water from iron and manganese filters to discharge to a sanitary sewer and requires that radionuclide content of the backwash water shall comply with NR 811.856. Furthermore NR 811.853 states that backwash wastewater may be discharged to a sanitary sewer if the discharge will not overload the facilities or adversely affect the wastewater treatment process. An equalization tank would need to be provided when it is necessary to prevent overloading the sewers or wastewater treatment plant. Discharge of backwash water is also allowed to detention tanks or lagoons if the criteria are met for such discharges.

Sanitary sewer main is available near all of the well sites for connection of a future backwash discharge line from a new water treatment plant, if the plant were to be located near one of the existing wells or utility building. Recycling of a percentage of the backwash water could be considered for the new treatment plant. Radionuclide content is not an issue with Rib Mountain's current Wells 1 through 4.

4.2 Finished Water Quality and Sample Results

The pilot testing was conducted to evaluate the effectiveness of different filter treatment processes for iron and manganese removal. The testing treatment trains were the same at each well. Chemical feed optimization testing was performed for each of the four columns. Filter loading rates were prepared at 3gpm/ft^2 for Silica Sand and GreensandPlus™ (Columns 1 and 2) and at 6 gpm/ft^2 for pyrolucite (Columns 3 and 4). The treatment train of aeration, sodium hypochlorite feed, detention, and permanganate feed were used in advance of filtration for Silica Sand and GreensandPlus™ (Columns1 and 2). Sodium hypochlorite was fed in advance of filtration for pyrolucite (Columns 3 and 4).

Evaluation criteria for the performance of treatment in this pilot study and the termination of the tests on each column were as follows:

- Industry standard filter run times of around 20 hours:
  - OR (1) until breakthrough of iron or manganese
  - OR (2) a pressure drop of more than 100 inches across the filter media was observed.
- If filter breakthrough for iron and manganese is greater than 0.30 mg/L and 0.05 mg/L respectively.

Head loss is the difference in pressure across the media in each column. The head loss in a filter will increase as the filter media gathers contaminants from the water, causing more pressure (head) being required to drive water through the filter. Typically, head loss is allowed to build until it reaches a 100-inch difference from the filter influent to the filter effluent. Head loss is also dependent on the size of filter media and the pore sizes between the media grains. Which means that different filter medias have different head loss characteristics. In this pilot study, the silica sand and GreensandPlus™ have a larger grain size than the pyrolucite media. In addition to particles and filter media size, flow rate has an impact on head loss accumulation. Higher flow rates through the filter will cause a higher head loss. Figure 5 illustrates the head loss for all the columns for Well No. 1 and Figure 5A illustrates the head loss for all the columns tested for Well No. 2.

4.2.1 Well No. 1

Table 9 summarizes the finished water quality results for Well No. 1.

4.2.1.1 Column 1 - Anthracite/Silica Sand - 30-inch Bed Depth

Eighteen inches of Silica Sand with 12-inches of anthracite cap was loaded into Column 1. After aeration, chlorine feed, detention, and permanganate feed, the column was operated at 3 gpm/ft² until manganese breakthrough which occurred at run hour three. The concentration of Mn in the finished water jumped from 0.092 to 0.185 mg/L at that time. The cycle was considered complete and the test terminated. Figure 6 illustrates the filtered water iron levels over the duration of the pilot test for Column 1 -Well 1. Figure 6A illustrates the treated water manganese levels during the pilot test for Column 1 - Well 1.

Dissolved iron was removed consistently below the evaluation criteria, but manganese was not removed below the levels of the evaluation criteria.

4.2.1.2 Column 2 - Anthracite/GreensandPlus™ - 30-inch Bed Depth

Eighteen inches of GreensandPlus™ with 12-inches of anthracite cap was loaded into Column 2, backwashed and charged with potassium permanganate. After aeration, chlorine feed, detention, and permanganate feed, the column was operated at 3 gpm/ft² until Mn breakthrough which occurred at run hour twenty-one. At that time the concentration of manganese went from 0.004 to 1.004 mg/L.

Figure 7 illustrates the filtered water iron levels over the duration of the pilot test for Column 2 - Well 1. Figure 7A illustrates the treated water manganese levels during the pilot test for Column 2 - Well 1.

Dissolved iron and manganese was consistently removed to below the levels of the evaluation criteria. Breakthrough of manganese occurred at run hour twenty-one, but the pressure drop across the filter was only 55 inches. The cycle was considered complete.

4.2.1.3 Column 3 - Pyrolucite - 30-inch Bed Depth

Thirty inches of pyrolucite was loaded into Column 3. Chlorine feed was added and the column was operated at 5.14 gpm/ft² until run hour 15 when it reached 108 inches of pressure drop across the filter. Figure 8 illustrates the filtered water iron levels over the duration of the pilot test for Column 3 - Well 1. Figure 8A illustrates the treated water manganese levels during the pilot test for Column 3 - Well 1.

Dissolved iron and manganese were consistently removed to below the evaluation criteria objective for 15 hours. Breakthrough did not occur. Pressure drop (head loss) across the filter reached 108 inches at 15 hours, therefore the filter run time in the evaluation criteria was not met for this column.

4.2.1.4 Column 4 - Pyrolucite - 36-inch Bed Depth

Thirty-six inches of pyrolucite was loaded into Column 4. Chlorine feed was added and the column was operated at 5.14 gpm/ft² until run hour 21 when it reached 101 inches of pressure drop across the filter. Figure 9 illustrates the filtered water iron levels over the duration of the pilot test for Column 4 - Well 1. Figure 9A illustrates the treated water manganese levels during the pilot test for Column 4 - Well 1.

Dissolved iron and manganese were consistently removed to below the evaluation criteria objective for 21 hours. Breakthrough did not occur. Pressure drop (head loss) across the filter reached 101 inches at 21 hours, therefore the filter run time in the evaluation criteria was met for this column.

Table 9 – Well No. 1 - Finished Water Quality Results

Well No. 1 Finished Water Quality										
Column Number	Iron (mg/L)			Manganese (mg/L)			pH			Filter Rate (gpm/ft2)
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	
1	0.001	0.001	0.001	0.092	0.185	0.139	6.010	6.750	6.260	3
2	0.001	0.011	0.002	0.001	1.004	0.056	6.010	6.800	6.127	3
3	0.001	0.048	0.006	0.001	0.026	0.006	6.010	6.640	6.103	5.14
4	0.001	0.048	0.006	0.001	0.021	0.003	6.000	6.800	6.140	5.14

4.2.2 Well No. 2

Table 10 summarizes the finished water quality results for Well No. 2.

4.2.2.1 Column 1 - Anthracite/Silica Sand - 30-inch Bed Depth

Eighteen inches of Silica Sand with 12-inches of anthracite cap was loaded into Column 1. After aeration, chlorine feed, detention, and permanganate feed, the column was operated at 3 gpm/ft² until manganese breakthrough which occurred at approximately run hour six. The concentration of Mn in the finished water jumped from 0.190 to 0.214 mg/L at that time. The cycle was considered complete and the test terminated. Figure 10 illustrates the filtered water iron levels over the duration of the pilot test for Column 1 - Well 2. Figure 10A illustrates the treated water manganese levels during the pilot test for Column 1 - Well 2.

Dissolved iron was removed consistently below the evaluation criteria, but manganese was not removed below the levels of the evaluation criteria.

4.2.2.2 Column 2 - Anthracite/GreensandPlus™ - 30-inch Bed Depth

Eighteen inches of GreensandPlus™ with 12-inches of anthracite cap was loaded into Column 2, backwashed and charged with potassium permanganate. After aeration, chlorine feed, detention, and permanganate feed, the column was operated at 3 gpm/ft² for twenty-one hours. Figure 11 illustrates the filtered water iron levels over the duration of the pilot test for Column 2 - Well 2. Figure 11A illustrates the treated water manganese levels during the pilot test for Column 2 - Well 2.

Dissolved iron and manganese was consistently removed to below the levels of the evaluation criteria for 21 hours. Breakthrough did not occur. The pressure drop across the filter was only 75 inches. The cycle was considered complete.

4.2.2.3 Column 3 - Pyrolucite - 30-inch Bed Depth

Thirty inches of pyrolucite was loaded into Column 3. Chlorine feed was added and the column was operated at 6.0 gpm/ft² until run hour 15 when it reached 124 inches of pressure drop across the filter. Figure 12 illustrates the filtered water iron levels over the duration of the pilot test for Column 3 - Well 2. Figure 12A illustrates the treated water manganese levels during the pilot test for Column 3 - Well 2.

Dissolved iron and manganese were consistently removed to below the evaluation criteria objective for 15 hours. Breakthrough did not occur. Pressure drop (head loss) across the filter reached 124 inches at 15 hours, therefore the filter run time in the evaluation criteria was not met for this column.

4.2.2.4 Column 4 - Pyrolucite - 36-inch Bed Depth

Thirty-six inches of pyrolucite was loaded into Column 4. Chlorine feed was added and the column was operated at 6.0 gpm/ft² until run hour 20 when it reached 105 inches of pressure drop across the filter. Figure 13 illustrates the filtered water iron levels over the duration of the pilot test for Column 4 - Well 2. Figure 13A illustrates the treated water manganese levels during the pilot test for Column 4 - Well 2.

Dissolved iron and manganese was consistently removed to below the evaluation criteria objective for 20 hours. Breakthrough did not occur. Pressure drop (head loss) across the filter reached 105 inches at 20 hours, therefore the filter run time in the evaluation criteria was met.

Table 10 – Well No. 2 - Finished Water Quality Results

Well No. 2 Finished Water Quality										
Column Number	Iron (mg/L)			Manganese (mg/L)			pH			Filter Rate (gpm/ft2)
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	
1	0.001	0.010	0.004	0.162	0.214	0.183	6.130	6.380	6.268	3
2	0.001	0.020	0.002	0.001	0.035	0.007	6.120	6.640	6.283	3
3	0.001	0.090	0.012	0.001	0.021	0.004	6.130	6.650	6.289	6
4	0.001	0.200	0.013	0.001	0.030	0.004	6.150	6.640	6.289	6

5 Pilot Study Conclusions

5.1 Finished Water Quality - Well No. 1

All of the columns average finished water results were significantly below the EPA SMCL of 0.3 mg/l for finished iron concentrations. With approximate full removal of iron from the finished water.

Columns 2 met the manganese SMCL of 0.05 mg/L. The maximum manganese values in the filter effluent in this column are higher than normally expected because at the startup of the run, after backwash, the column contained raw backwash water with a high manganese content. Column 3 and 4 average finished water results were significantly below the EPA SMCL for finished manganese concentrations. With approximate full removal of the manganese from the finished water.

The 3.0 gpm/ft² Greensand Plus/Anthracite filter (Column 2) could have been run longer in order to obtain the recommended 100 inches of head loss. Based on the trend developed during the study, the filter run time could have been in the 25 hour range. This filter operated with the following flow train: aeration, chlorine addition, 30 minutes of detention, and filtration at 3 gpm/ft². This filter run would have been terminated due to head loss rather than breakthrough had it been run longer.

Columns 3 and 4 (pyrolucite media at 5.14 gpm/ft²) operated with higher head loss than the Greensand Plus/Anthracite filter. Column 3 (30” pyrolucite) was terminated after 15 hours and Column 4 (36” pyrolucite) after 21 hours, when head loss reached over 100 inches.

5.2 Finished Water Quality - Well No. 2

All of the columns average finished water results were significantly below the EPA SMCL of 0.3 mg/l for finished iron concentrations. With approximate full removal of iron from the finished water.

Columns 1 exceeded the manganese SMCL of 0.05 mg/L. Columns 2, 3, and 4 average finished water results were significantly below the EPA SMCL for finished manganese concentrations. With approximate full removal of the manganese from the finished water.

Similar to Well No. 1, the 3.0 gpm/ft² Greensand Plus / Anthracite filter (Column 2) could have been run longer than the 21 hours in order to obtain the recommended 100 inches of head loss. Based on the trend developed during the study, the filter run time could have been in the 25 hour range. This filter operated with the following flow train: aeration, chlorine addition, 30 minutes of detention, and filtration at 3 gpm/ft^2. This filter run would have been terminated due to head loss rather than breakthrough had it been run longer.

Also similar to Well No. 1, Columns 3 and 4 (pyrolucite media at 6.0 gpm/ft^2) operated with higher head loss than the Greensand Plus/Anthracite filter. Column 3 (30-inch pyrolucite) was terminated after 15 hours and Column 4 (36-inch pyrolucite) after 20 hours, when head loss reached over 100 inches.

6 Recommendations for Water Treatment

6.1 Option 1 - Iron & Manganese Removal Filtration Plant - 3 gpm/ft^2

This recommended iron and manganese removal process includes the combination of aeration, chemical oxidation, 30 minutes detention followed by permanganate addition and then by gravity flow filtration at 3 gpm/ft^2 through 18 inches of Greensand Plus capped with12 inches of anthracite (Column 2 for Well No. 1 and 2)

The stated immediate needs of the community are for up to 800 gpm of water treatment, with stated future needs of the utility being closer to approximately 1,200 gpm of treated water. This figure should be refined during preliminary design of the water treatment plant and should be based on an evaluation of the past and potential future demands of the community.

This treatment sequence was shown in the pilot study to meet or exceed the EPA secondary standards for iron and manganese removal. Backwash rates are recommended to range from 10-15 gpm/sf and should include a combination air/water wash in order to conserve water. An approximately sized 50,000 gallons for a buried clear well tank, after the filters, should be considered for equalization. An approximately sized 40,000 gallon buried backwash tank could be considered and would provide backwash water storage during maintenance and also during backwashing of the gravity filters. The plant is recommended to be designed at a filtration rate of 3 gpm/ft^2, based on this pilot study, in order to provide added treatment capacity in the future. That is n case future wells need to be treated in the future in order to meet demands. This allows operational flexibility and flexibility in treatment for accommodating water quality changes (increases in iron or manganese) within the aquifer, all while meeting EPA standards for iron and manganese removal. If new wells are added in the future, the filters could be operated a rate of 3 gpm/ft^2 to produce an increased volume of up to 1,200 gpm of treated water.

Sanitary sewer is reportedly available near the site, of sufficient size to consider for backwash water from the plant to be discharged to. Capacity of the sanitary sewer system should be reviewed during preliminary design to ensure that the correct size and capacity exists for discharge of the backwash water and solids to downstream pipe, lift stations, and treatment plants. Solids handling should also be reviewed along with the option of recycling backwash water. The estimated construction costs for Option 1 are around $4.7 million. A detailed cost estimate for Option 1 is located in Appendix B.

6.2 Option 2 - Iron & Manganese Removal Filtration Plant - 6 gpm/ft^2

This recommended treatment process includes chemical oxidation, followed by pressure filtration through 36-inches of pyrolucite. As discussed with Option 1, the immediate needs of the community show the need for up to 800 gpm of water treatment, with future needs of the utility closer to 1,200 gpm of treated water. This figure should be refined during preliminary design of the water treatment plant and based on an evaluation of the past and future needs of the community.

This pressure filtration media treatment sequence in the pilot study meets or exceeds the EPA secondary standards for iron and manganese removal. Backwash rates for pyrolucite are recommended to be 25 gpm/ft^2 and should include combination air/water wash in order to conserve water. An approximately sized 40,000 gallon buried backwash tank would provide backwash water during maintenance and backwashing of the filters. The plant should be designed at a filtration rate of 6 gpm/ft^2, based on this pilot study, in case future wells are needed for production. This allows for a smaller foot print for equipment, and for keeping the existing well pumps pumping to the system with only minor reduction of their existing head conditions. If new wells are added in the future, then additional filters could be added and operated a rate of 6 gpm/ft^2 in order to produce an increased volume of water up to 1,200 gpm.

Sanitary sewer is reportedly available near the site, of sufficient size to consider for backwash water from the plant to be discharged to. Capacity of the sanitary sewer system should be reviewed during preliminary design to ensure that the correct size and capacity exists for discharge of the backwash water and solids to downstream pipe, lift stations, and treatment plants. Solids handling should also be reviewed along with the option of recycling backwash water. A clear well could be considered as an option with this alternative as well, but it is not included in the cost estimate at this time. The estimated construction costs for Option 1 are around $3.0 million. A detailed cost estimate for Option 2 is also located in Appendix B.

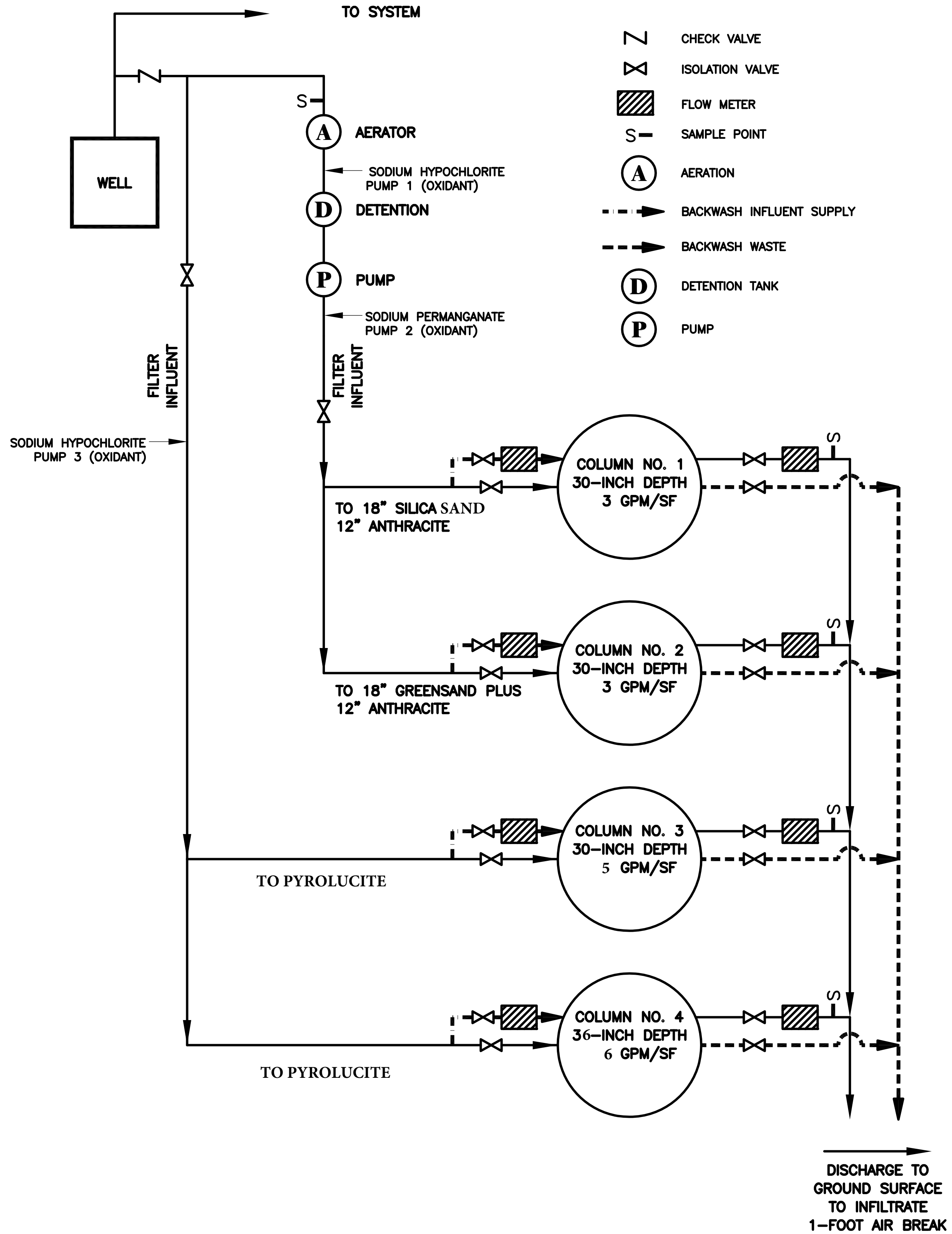
It should be noted that cost estimates are based on best available knowledge and our recent experience and are subject to fluctuating material and construction labor markets. These cost estimates should be for general planning purposes only and should be updated regularly as the Rib Mountain Sanitary District moves through the next steps of concept planning and preliminary design, preparation of an engineering design report, and design for a new water treatment facility to remove iron and manganese.

llb

Figures

FIGURE 1

PILOT TRAILER FLOW TRAIN



SEH

PILOT TRAILER FLOW TRAIN (Columns 1-4)
PILOT STUDY UNIT WELL NO. 1 and No. 2
RIB MOUNTAIN SANITARY DISTRICT

FILE NO. RMTSD 145756

FIGURE NO. 1

PLOTTED: 4–30–2018 4:20 PM
PLOT SCALE: 1:1
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SAVED: 4–30–2018 4:18 PM
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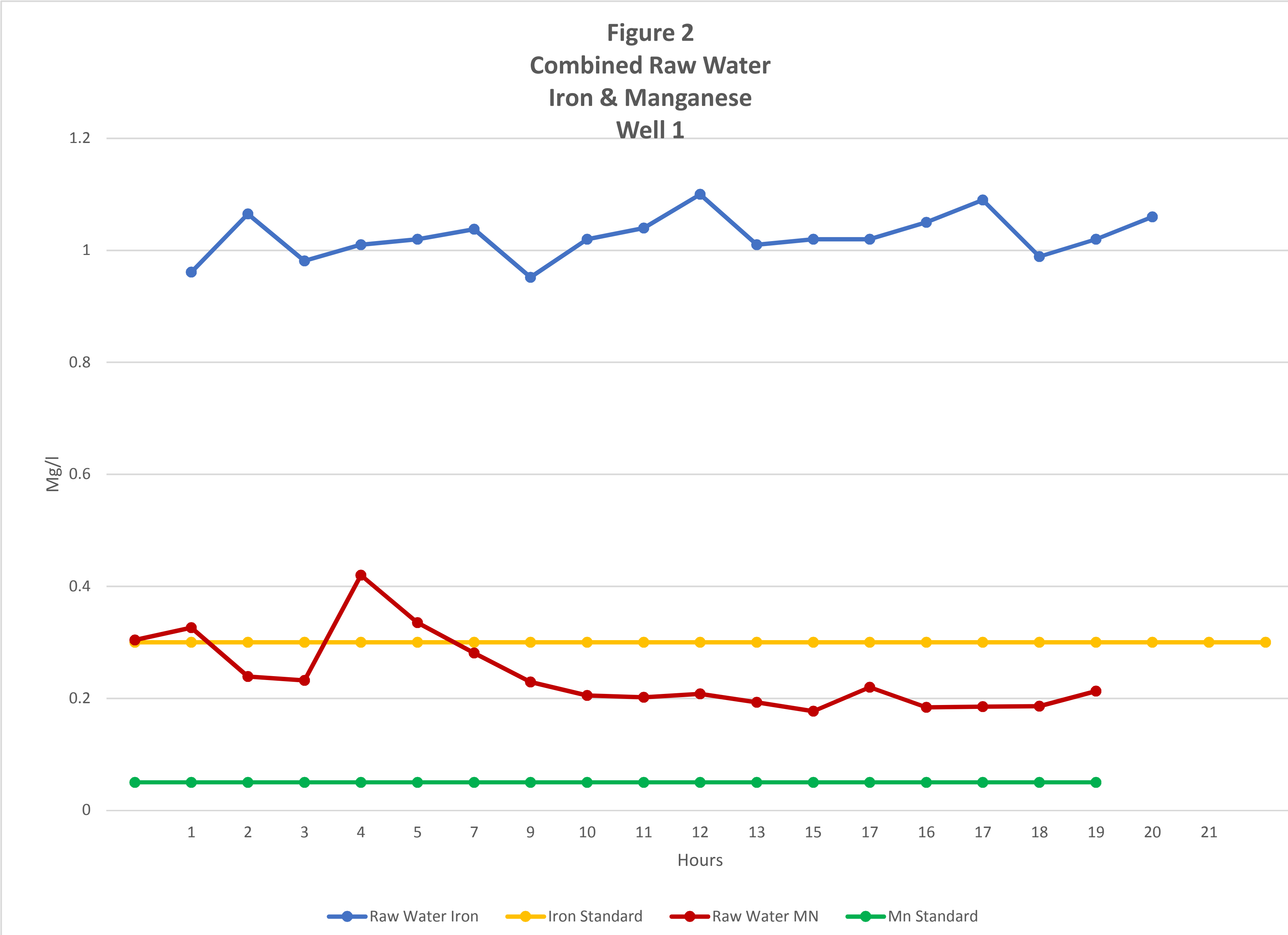


Figure 2
Combined Raw Water
Iron & Manganese
Well 1
1.2
1
0.8
0.6
0.4
0.2
0
Mg/l
1
2
3
4
5
7
9
10
11
12
13
15
17
16
17
18
19
20
21
Hours
Raw Water Iron
Iron Standard
Raw Water MN
Mn Standard

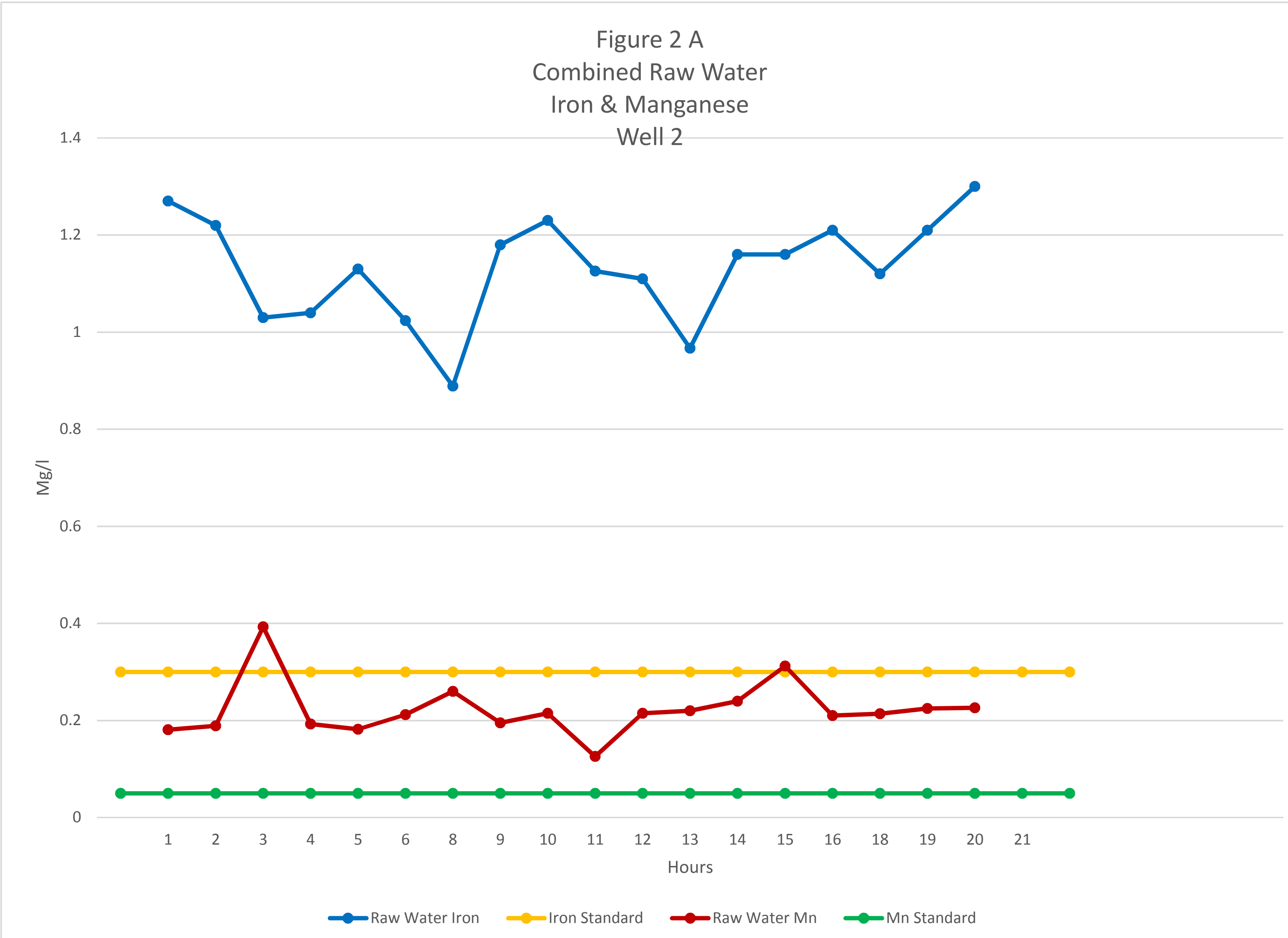


Figure 2 A
Combined Raw Water
Iron & Manganese
Well 2
Mg/l
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Raw Water Iron
Iron Standard
Raw Water Mn
Mn Standard

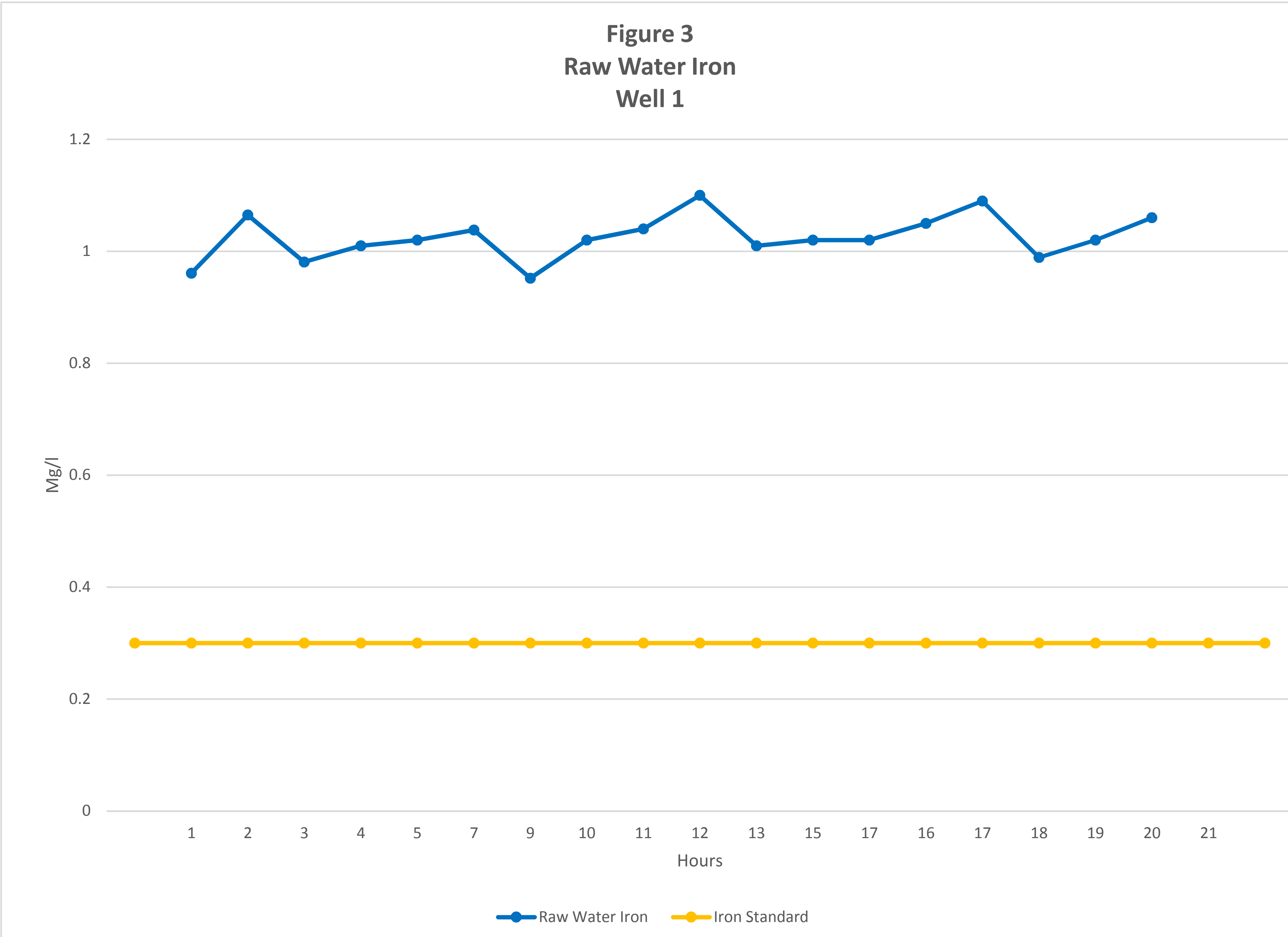


Figure 3
Raw Water Iron
Well 1
1.2
1
0.8
0.6
0.4
0.2
0
Mg/l
1
2
3
4
5
7
9
10
11
12
13
15
17
16
17
18
19
20
21
Hours
Raw Water Iron
Iron Standard

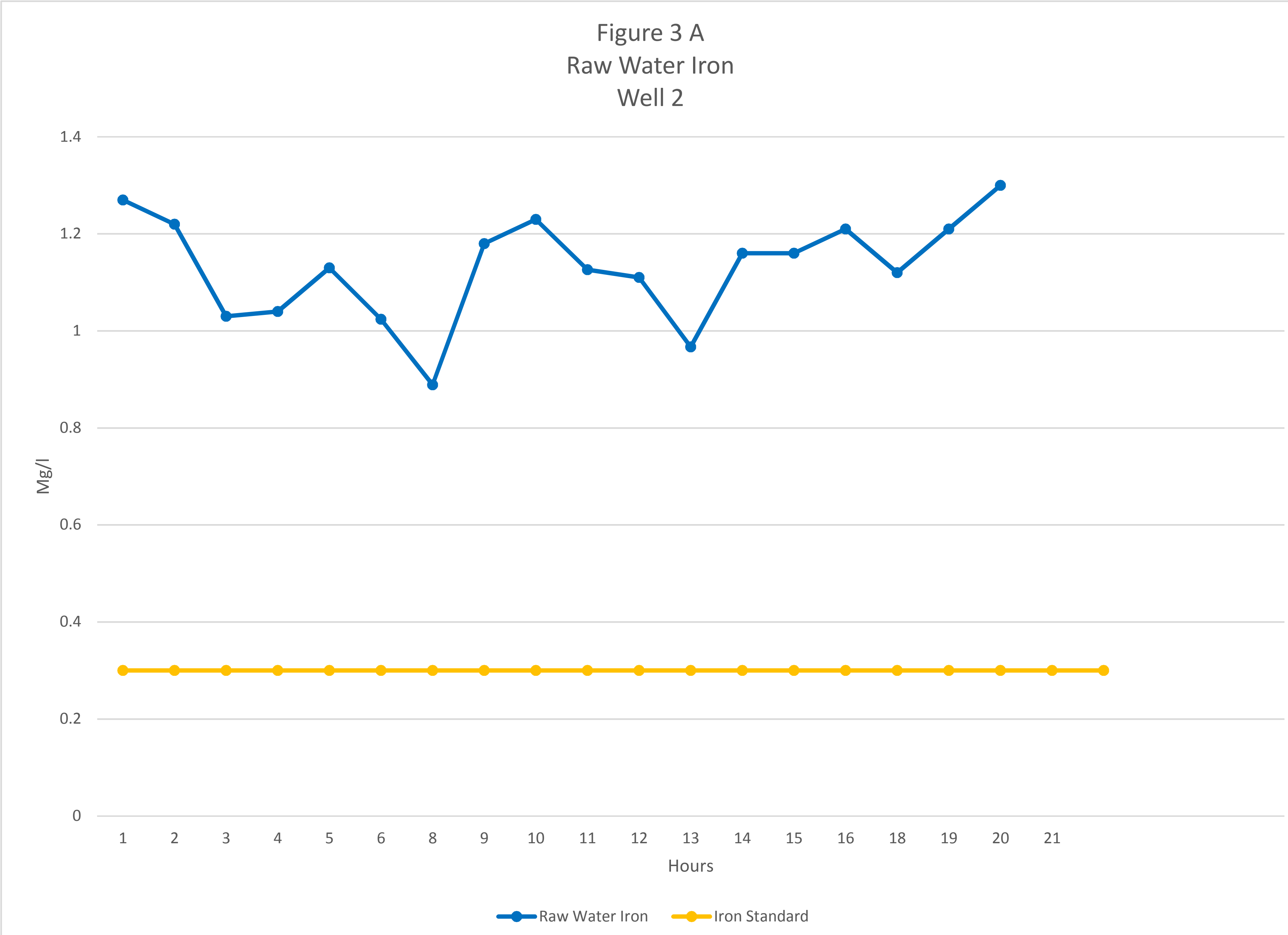


Figure 3 A
Raw Water Iron
Well 2
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Raw Water Iron
Iron Standard

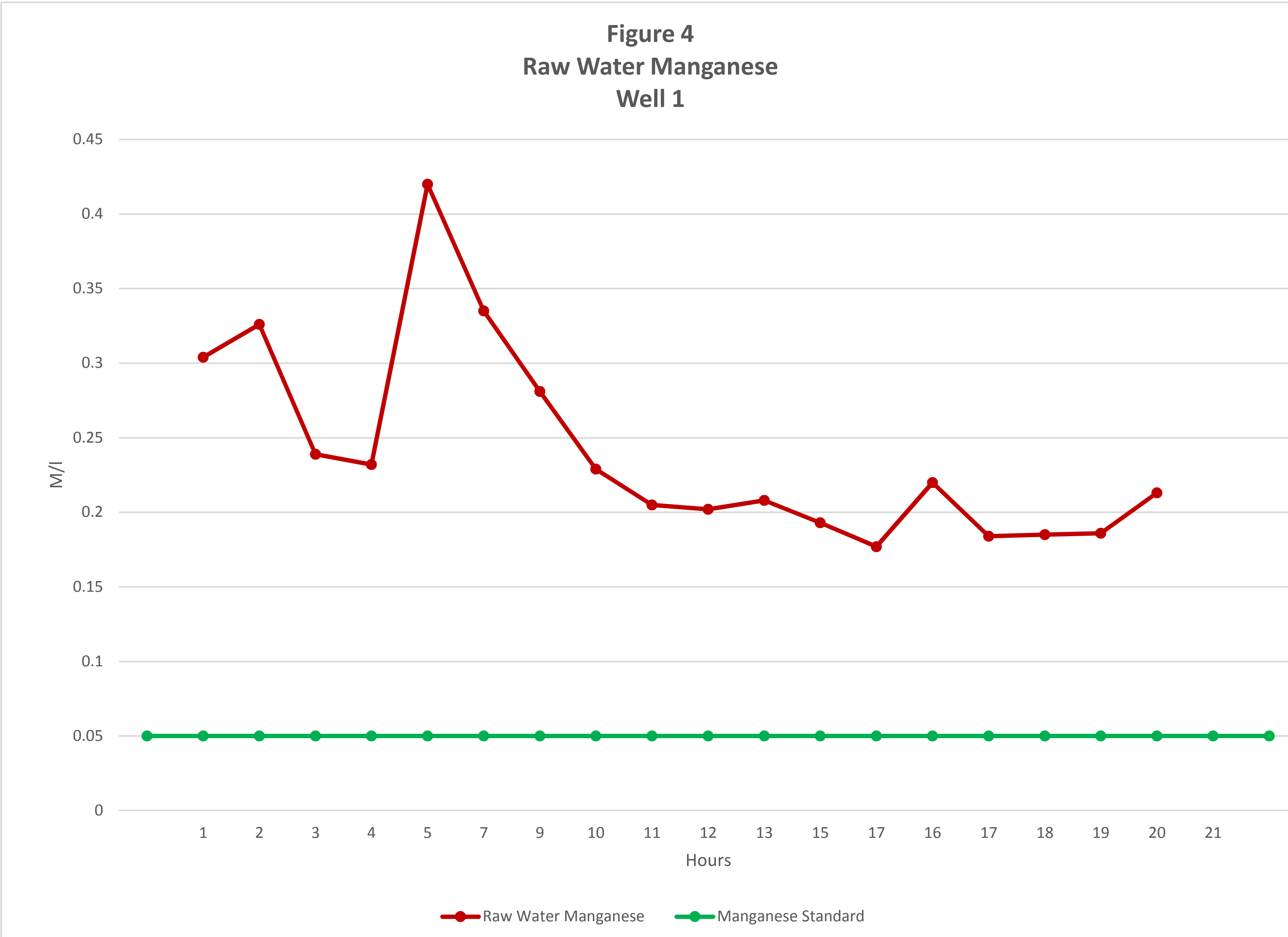


Figure 4
Raw Water Manganese
Well 1
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
M/l
1 2 3 4 5 7 9 10 11 12 13 15 17 16 17 18 19 20 21
Hours
Raw Water Manganese
Manganese Standard

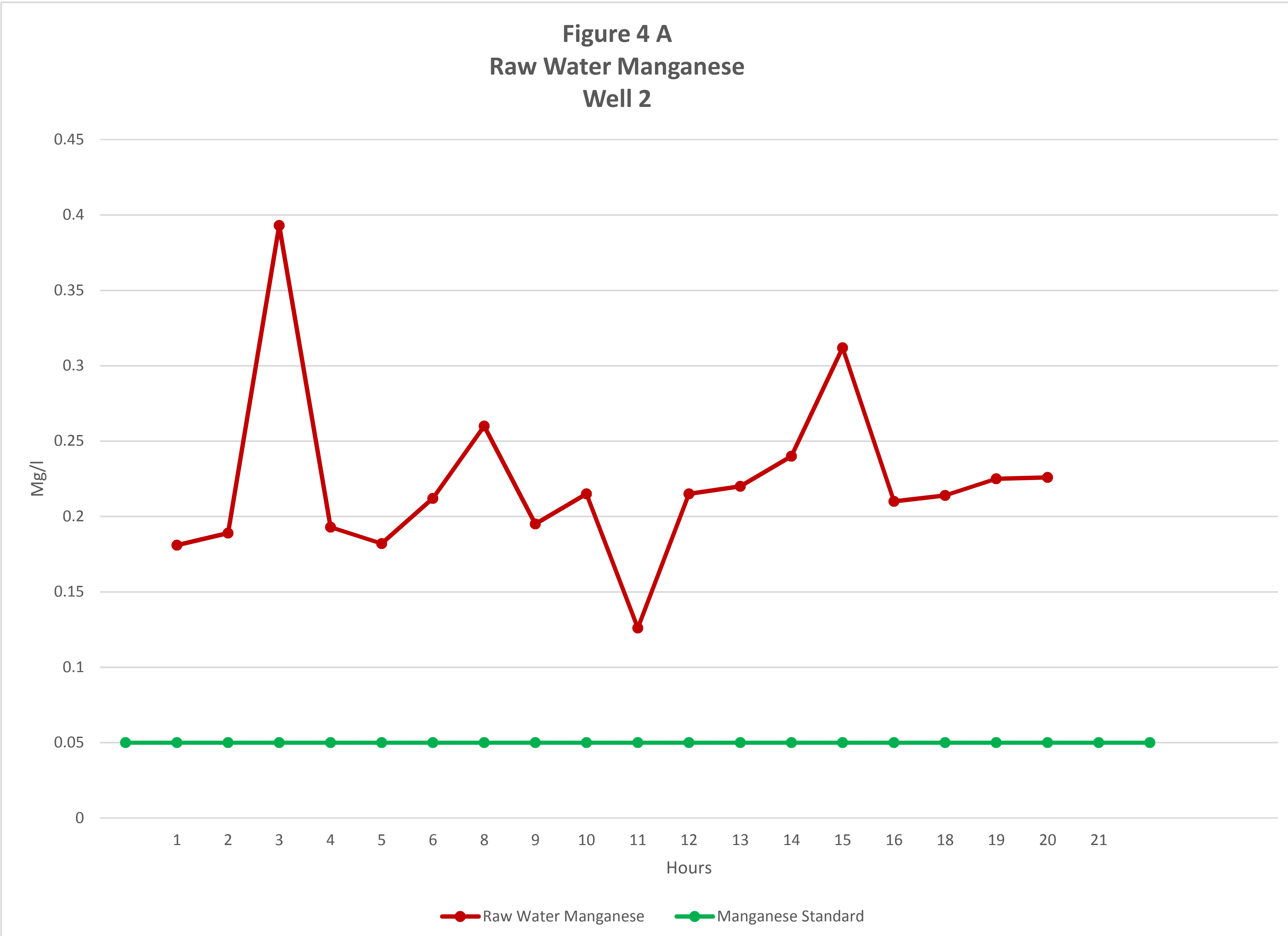


Figure 4 A
Raw Water Manganese
Well 2
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Raw Water Manganese
Manganese Standard

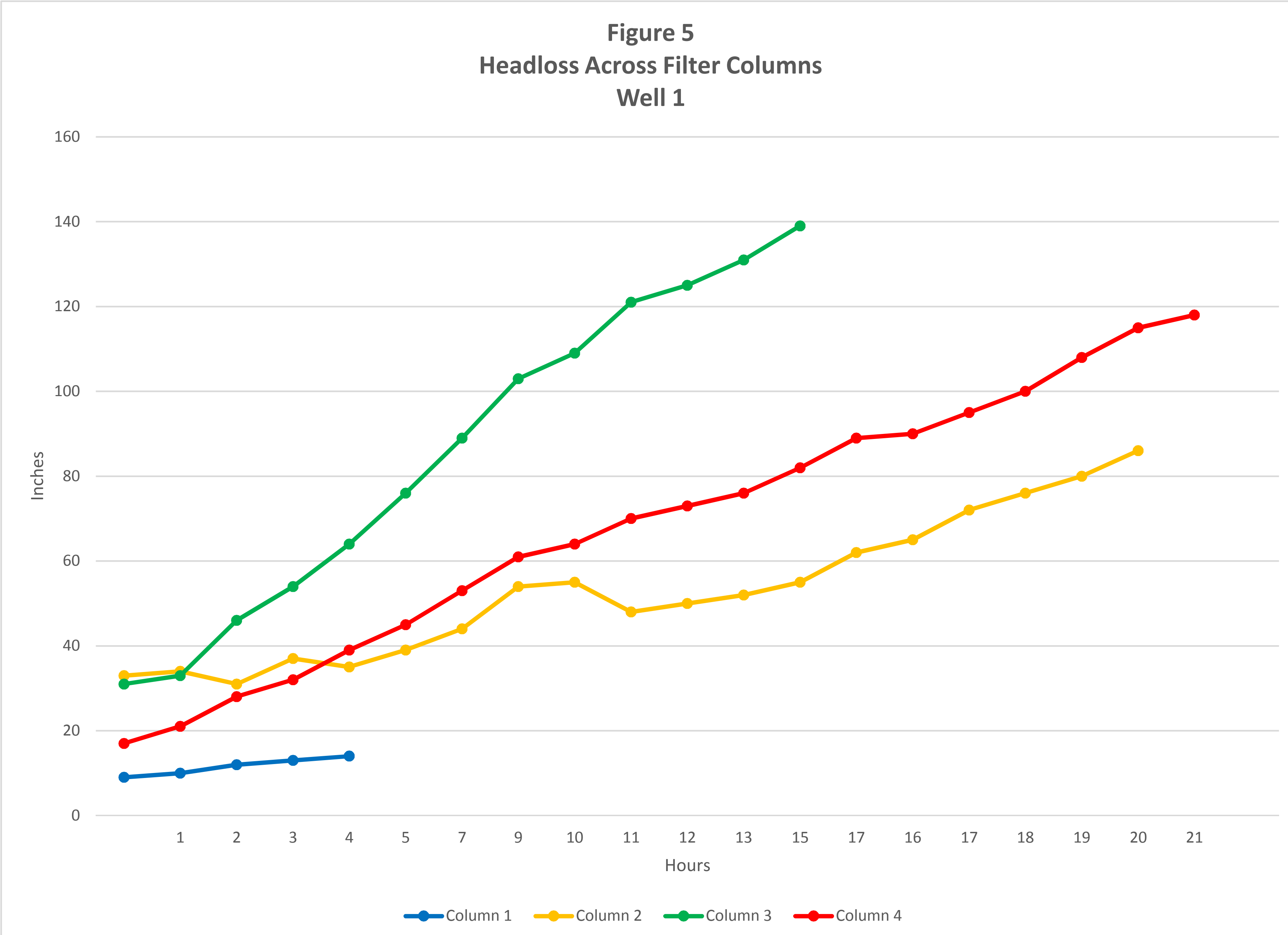


Figure 5
Headloss Across Filter Columns
Well 1
160
140
120
100
80
60
40
20
0
Inches
1
2
3
4
5
7
9
10
11
12
13
15
17
16
17
18
19
20
21
Hours
Column 1
Column 2
Column 3
Column 4

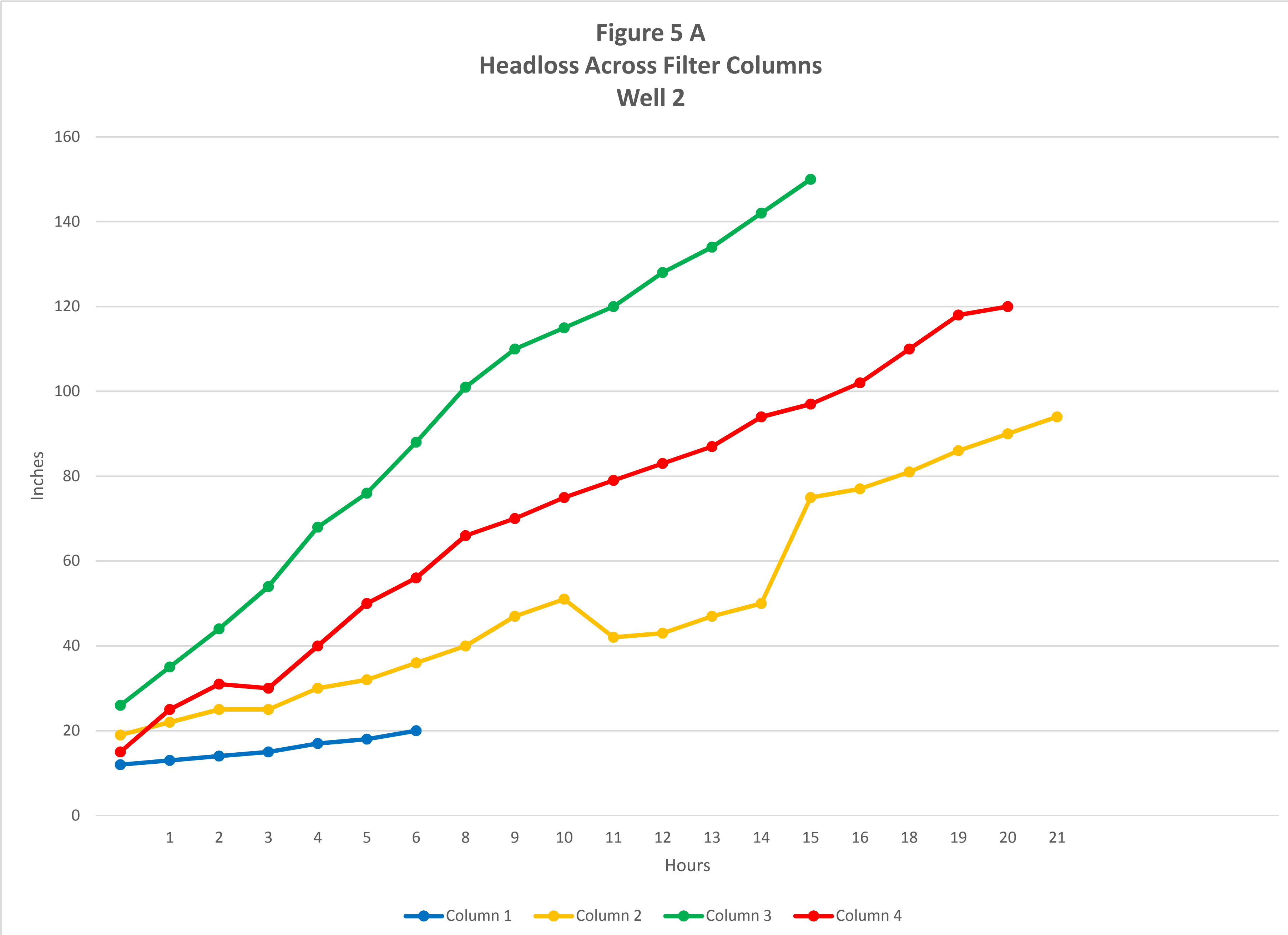


Figure 5 A
Headloss Across Filter Columns
Well 2
Inches
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Column 1
Column 2
Column 3
Column 4

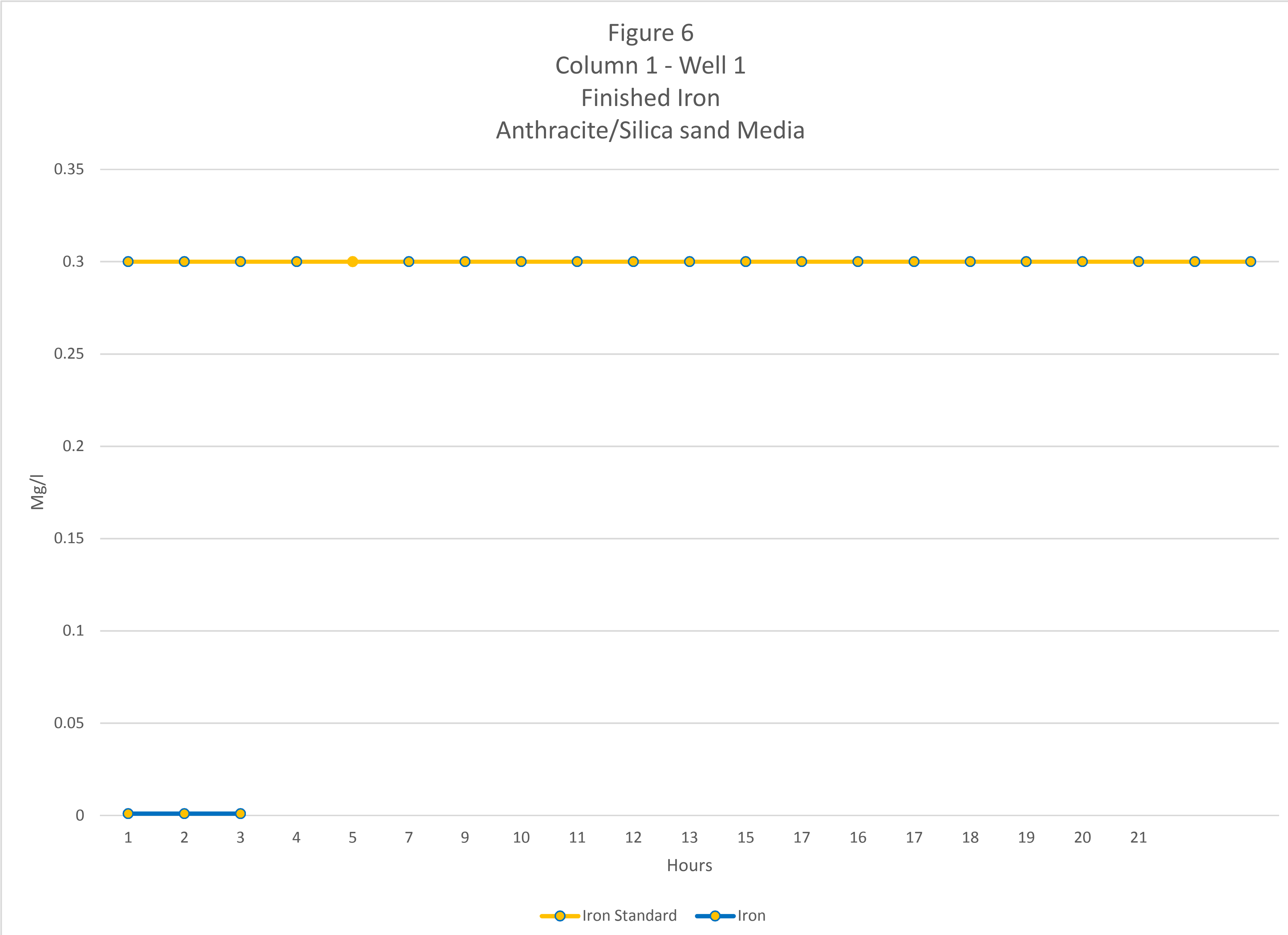


Figure 6
Column 1 - Well 1
Finished Iron
Anthracite/Silica sand Media
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Mg/l
1
2
3
4
5
7
9
10
11
12
13
15
17
16
17
18
19
20
21
Hours
Iron Standard
Iron

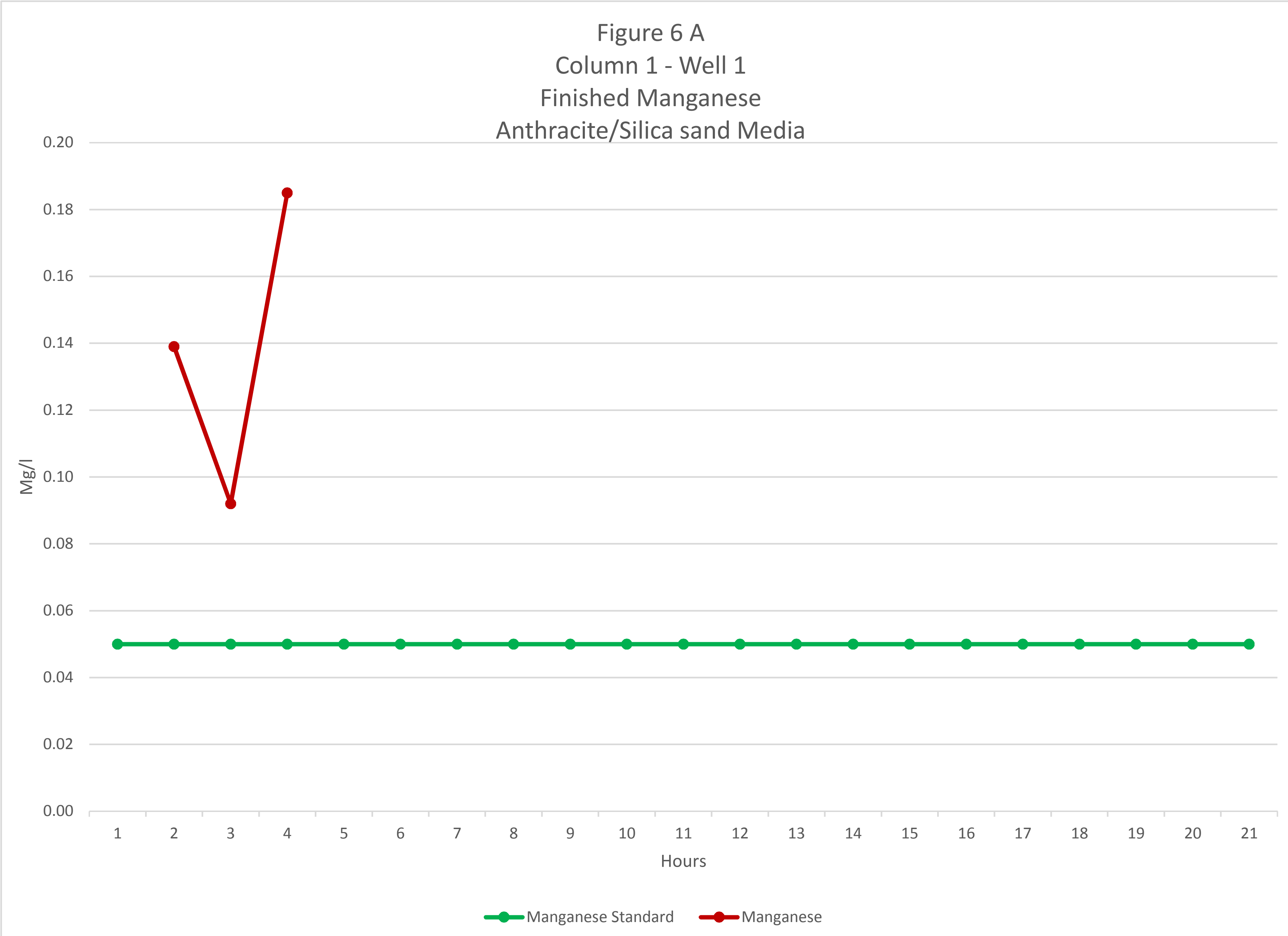


Figure 6 A
Column 1 - Well 1
Finished Manganese
Anthracite/Silica sand Media
Mg/l
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Hours
Manganese Standard
Manganese

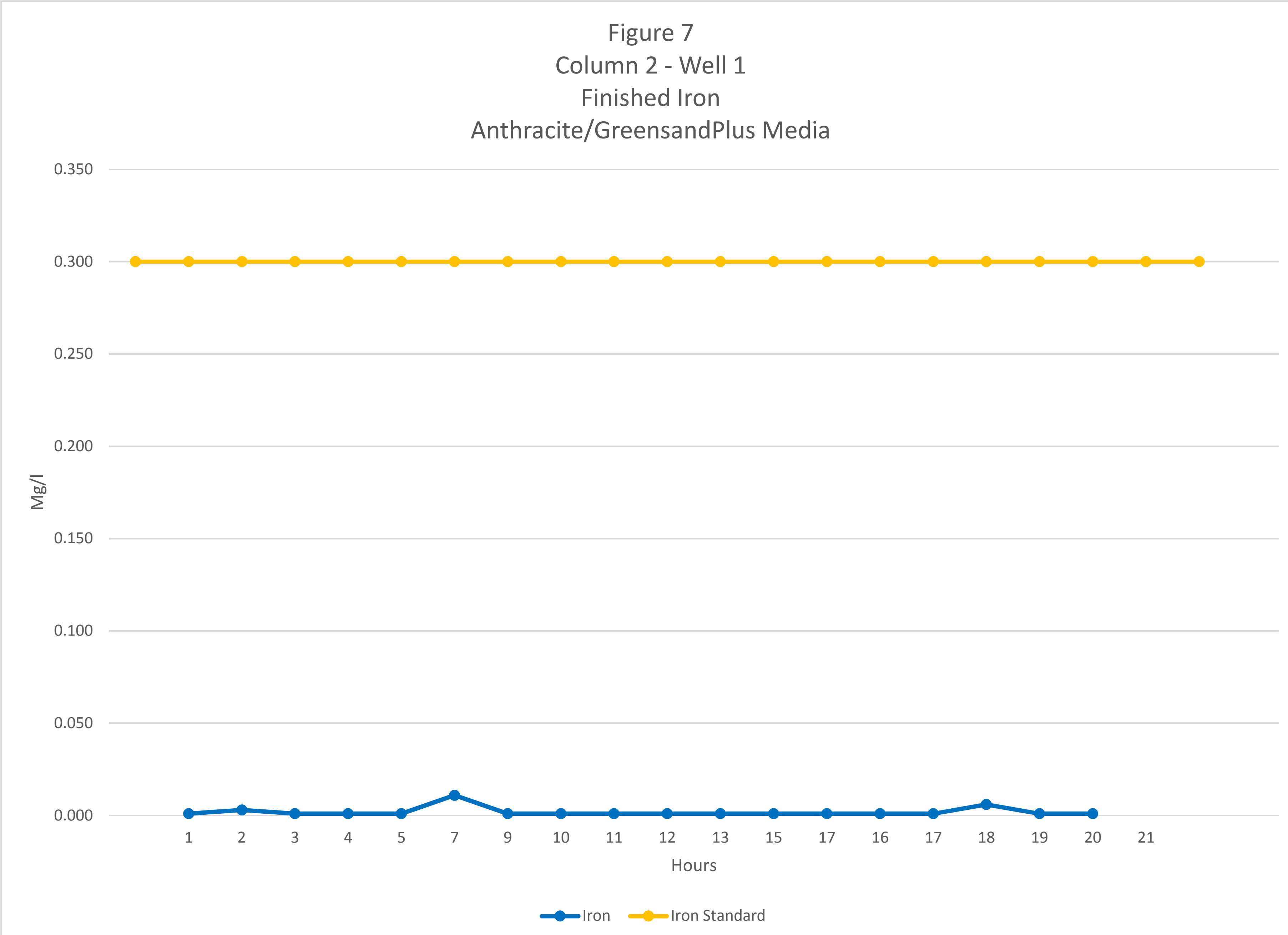


Figure 7
Column 2 - Well 1
Finished Iron
Anthracite/GreensandPlus Media
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Mg/l
1
2
3
4
5
7
9
10
11
12
13
15
17
16
17
18
19
20
21
Hours
Iron
Iron Standard

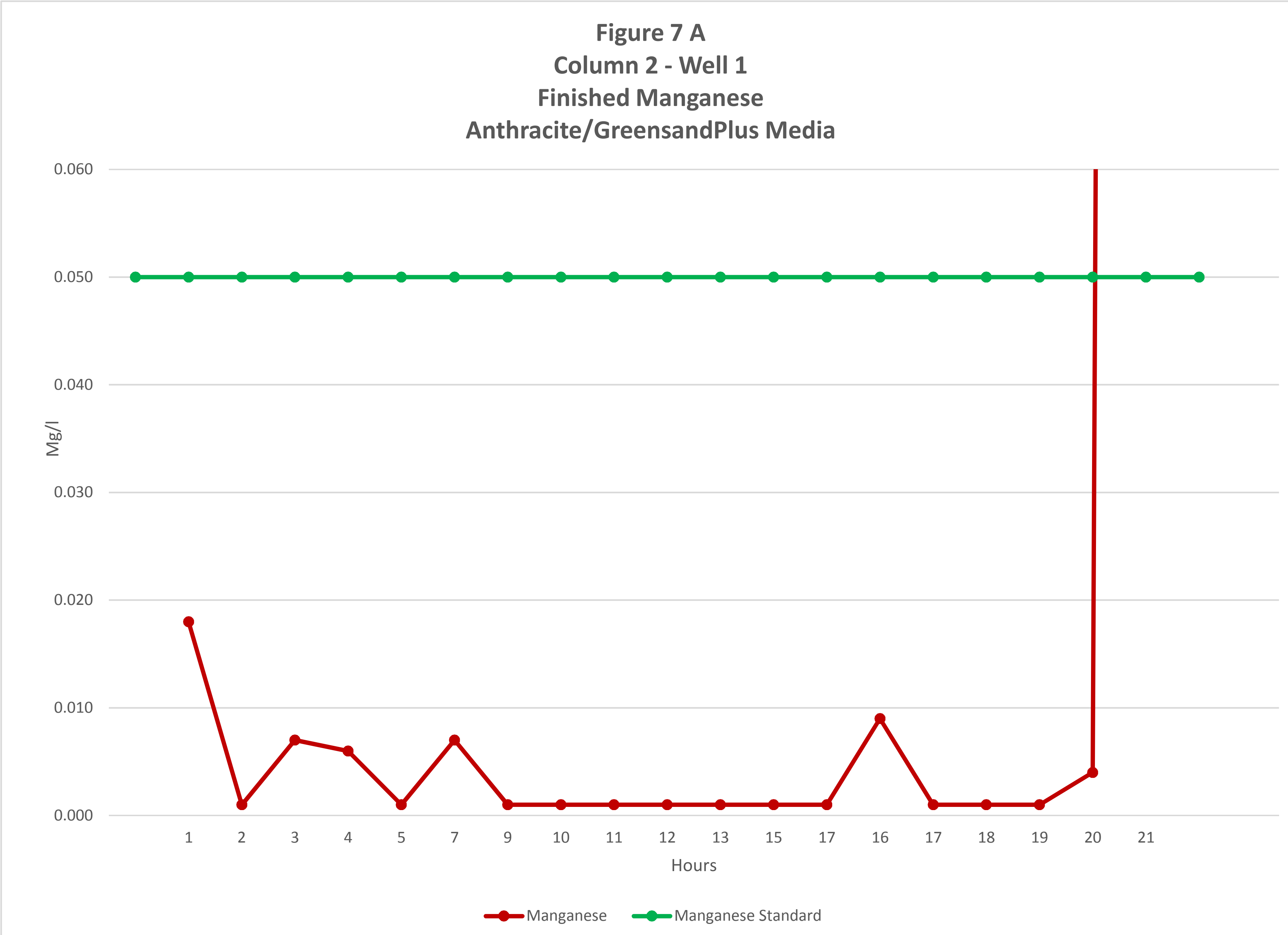


Figure 7 A
Column 2 - Well 1
Finished Manganese
Anthracite/GreensandPlus Media
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Mg/l
1 2 3 4 5 7 9 10 11 12 13 15 17 16 17 18 19 20 21
Hours
Manganese
Manganese Standard

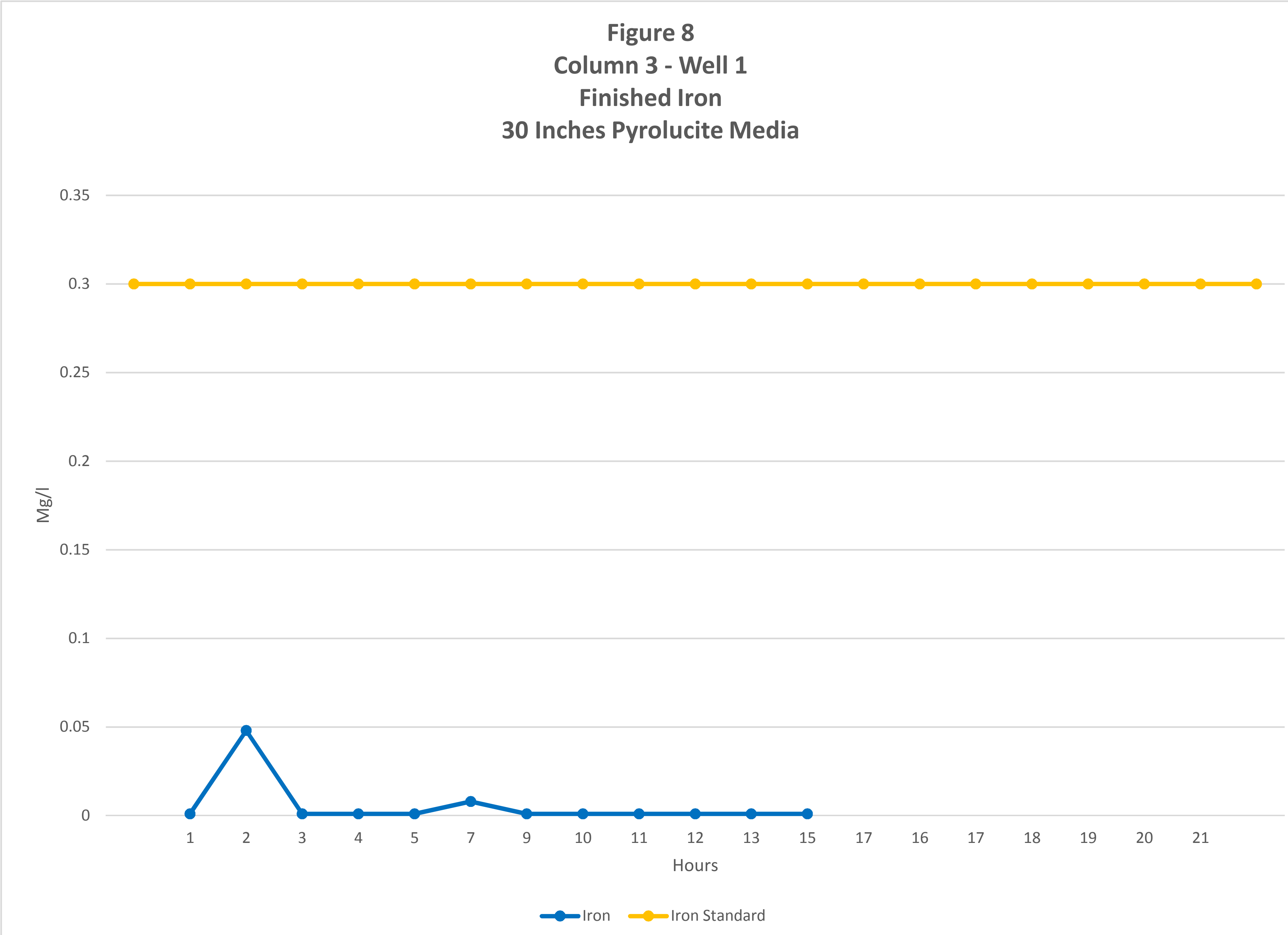


Figure 8
Column 3 - Well 1
Finished Iron
30 Inches Pyrolucite Media
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Mg/l
1
2
3
4
5
7
9
10
11
12
13
15
17
16
17
18
19
20
21
Hours
Iron
Iron Standard

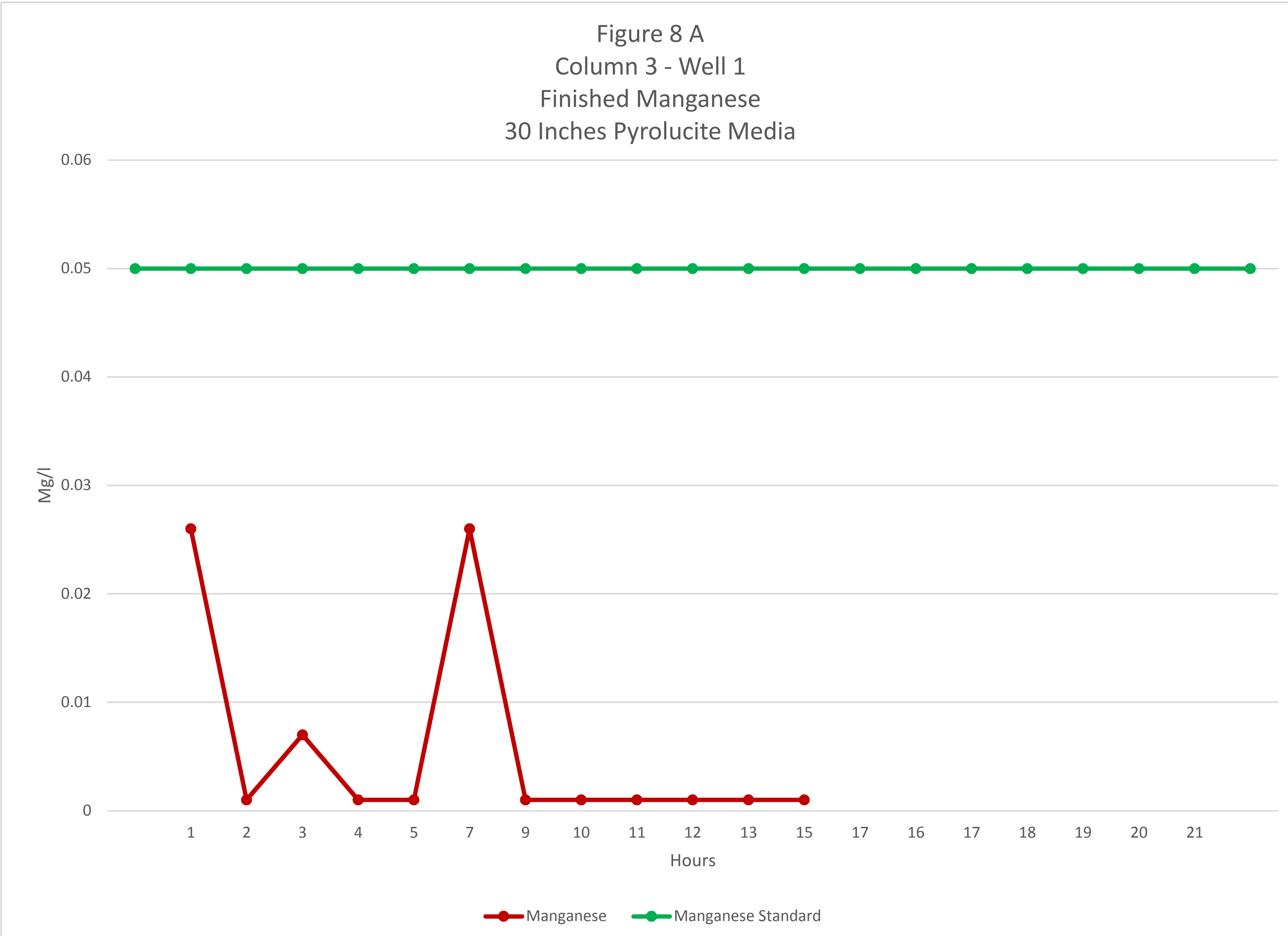


Figure 8 A
Column 3 - Well 1
Finished Manganese
30 Inches Pyrolucite Media
0.06
0.05
0.04
0.03
0.02
0.01
0
Mg/l
1
2
3
4
5
7
9
10
11
12
13
15
17
16
17
18
19
20
21
Hours
Manganese
Manganese Standard

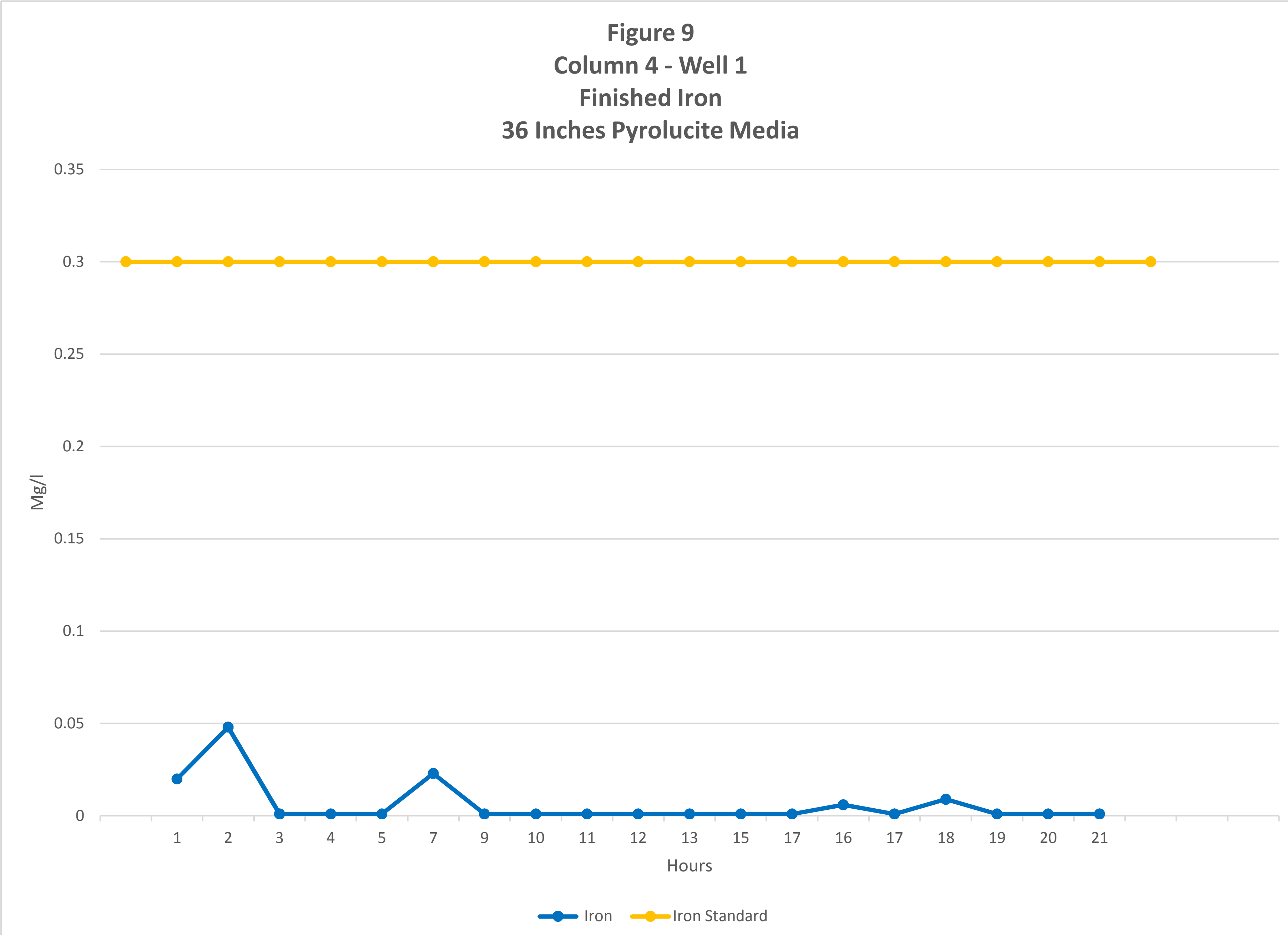


Figure 9
Column 4 - Well 1
Finished Iron
36 Inches Pyrolucite Media
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Mg/l
1 2 3 4 5 7 9 10 11 12 13 15 17 16 17 18 19 20 21
Hours
Iron
Iron Standard

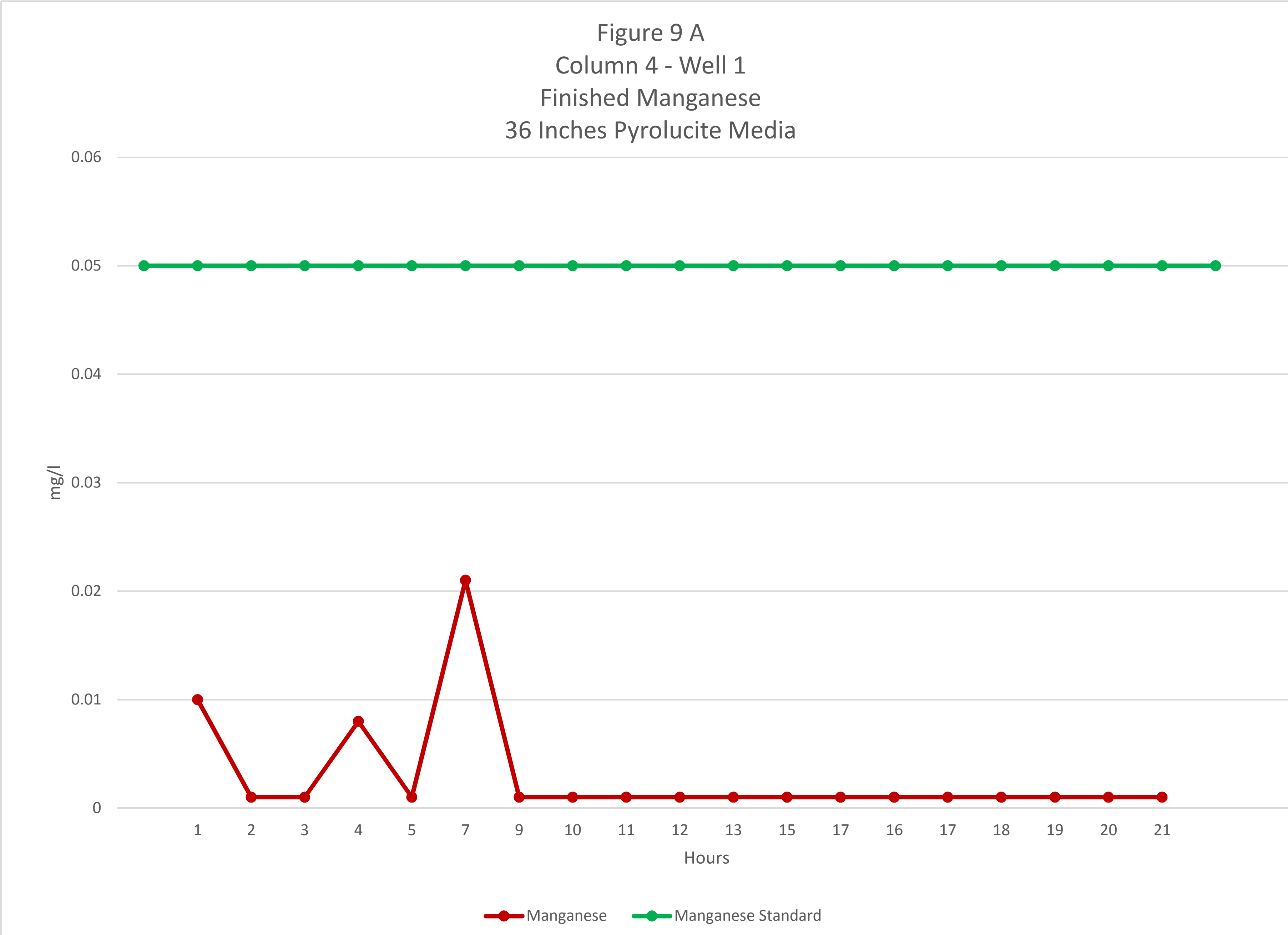


Figure 9 A
Column 4 - Well 1
Finished Manganese
36 Inches Pyrolucite Media
0.06
0.05
0.04
0.03
0.02
0.01
0
mg/l
1
2
3
4
5
7
9
10
11
12
13
15
17
16
17
18
19
20
21
Hours
Manganese
Manganese Standard

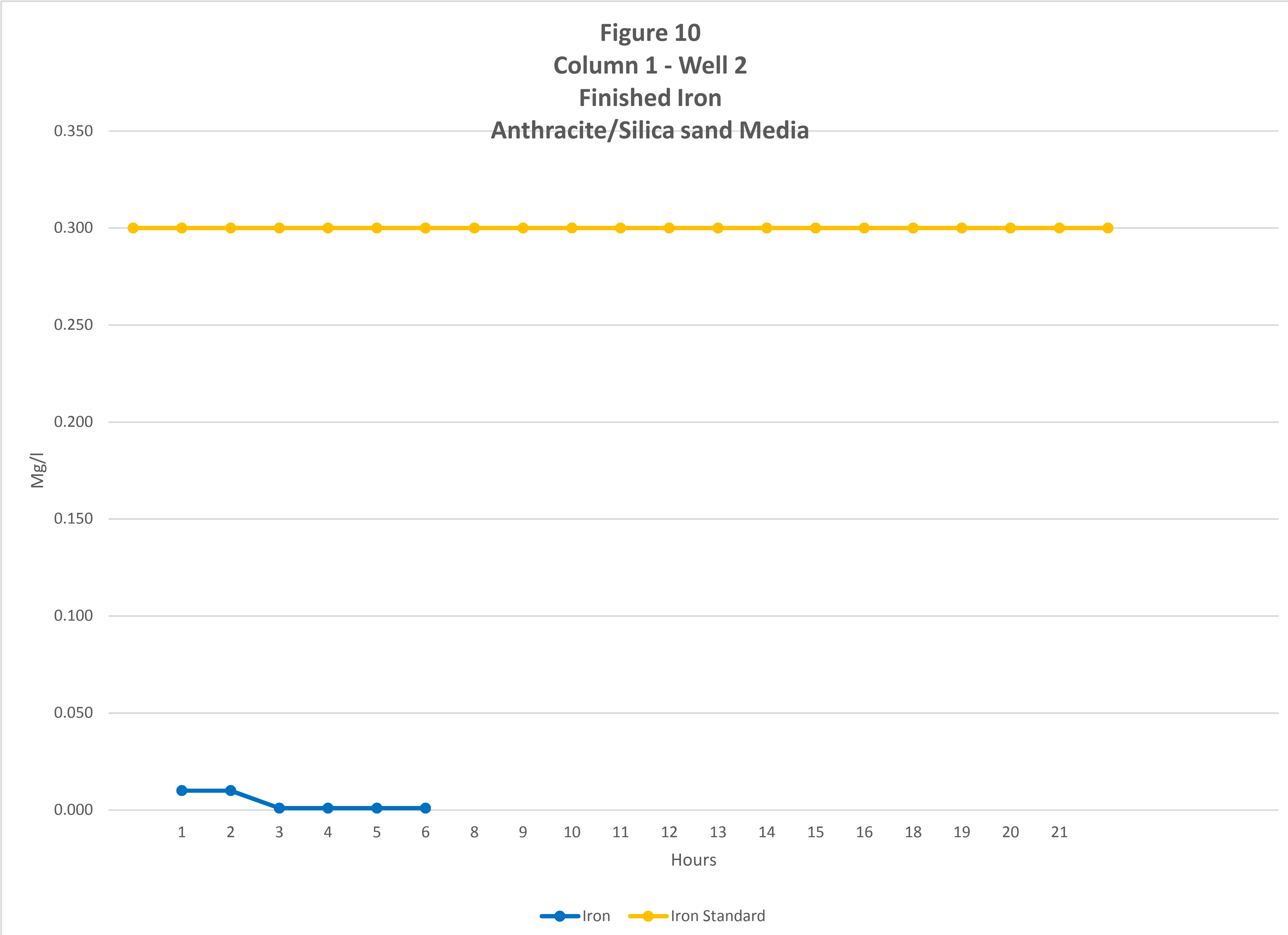


Figure 10
Column 1 - Well 2
Finished Iron
Anthracite/Silica sand Media
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Mg/l
1 2 3 4 5 6 8 9 10 11 12 13 14 15 16 18 19 20 21
Hours
Iron
Iron Standard

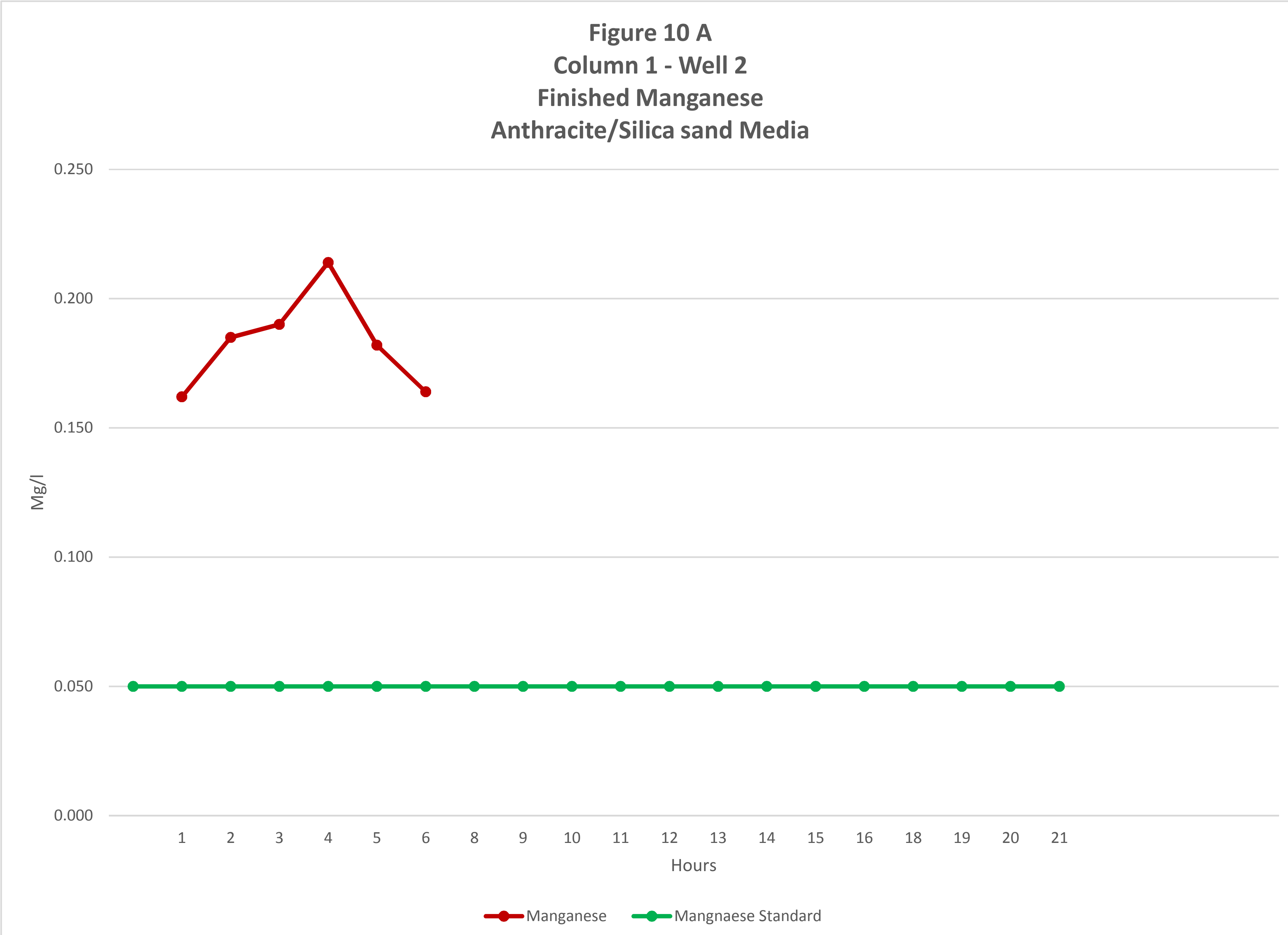


Figure 10 A
Column 1 - Well 2
Finished Manganese
Anthracite/Silica sand Media
0.250
0.200
0.150
0.100
0.050
0.000
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Manganese
Mangnaese Standard

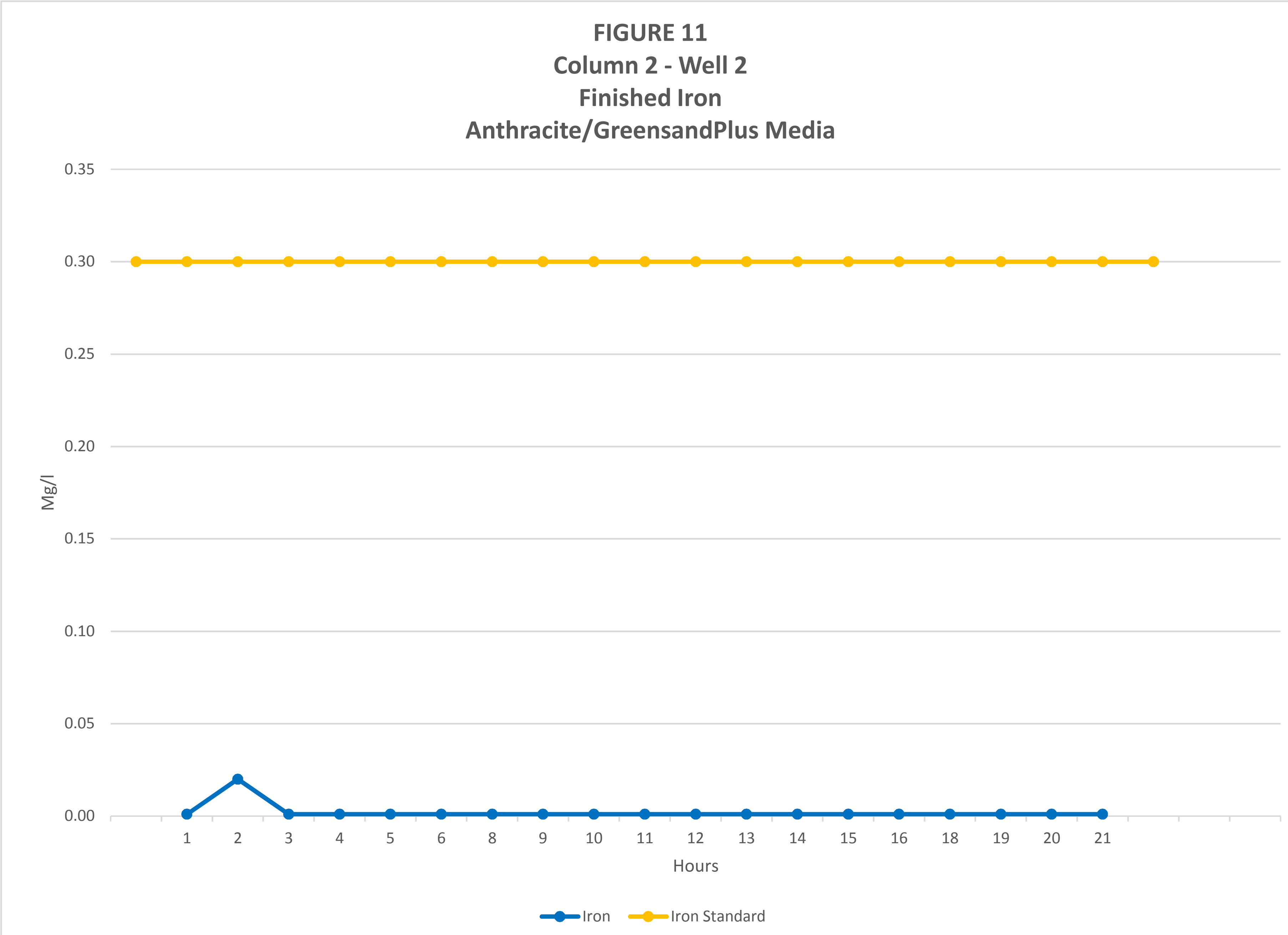


FIGURE 11
Column 2 - Well 2
Finished Iron
Anthracite/GreensandPlus Media
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Iron
Iron Standard

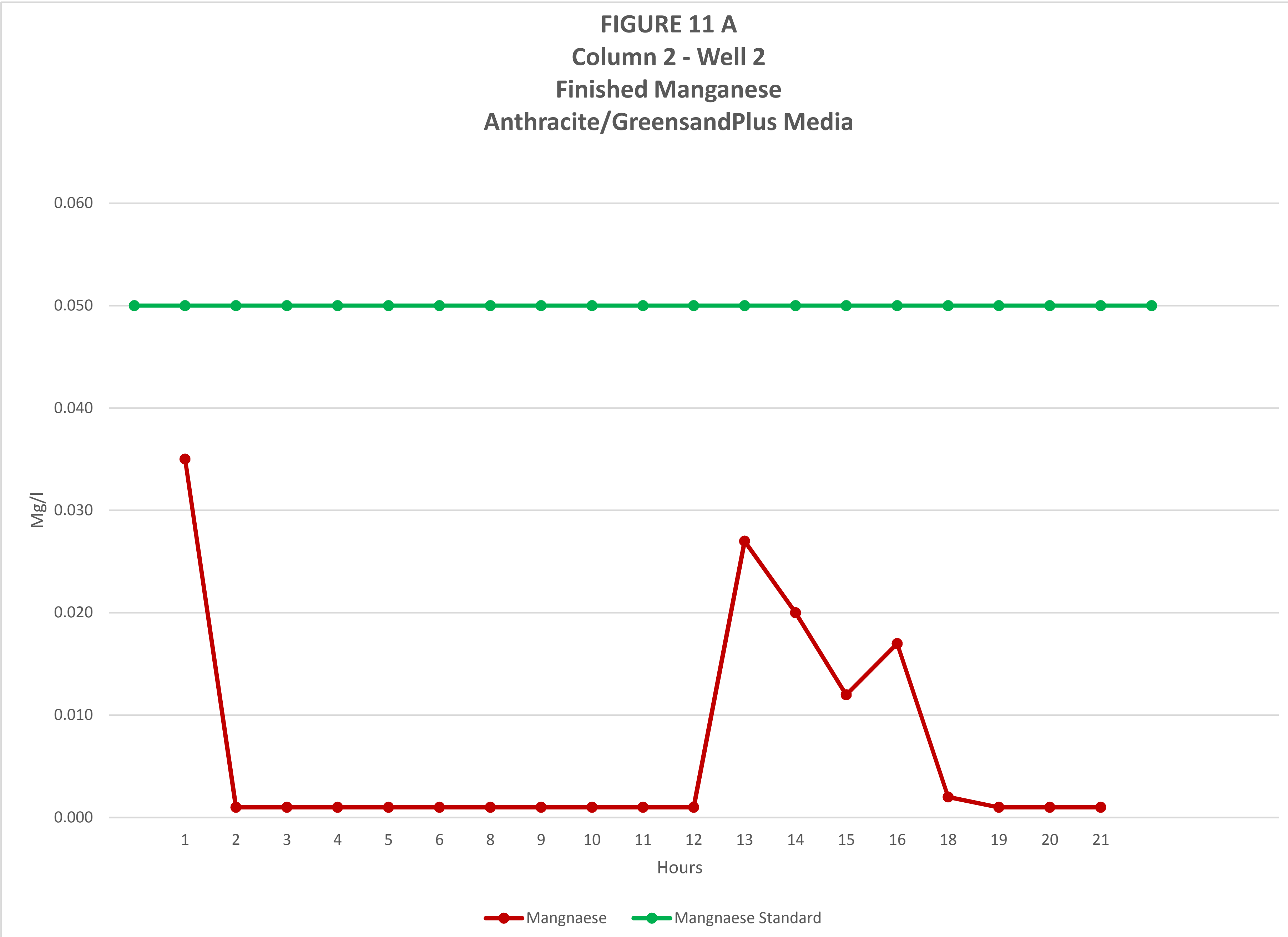


FIGURE 11 A
Column 2 - Well 2
Finished Manganese
Anthracite/GreensandPlus Media
0.060
0.050
0.040
0.030
0.020
0.010
0.000
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Mangnaese
Mangnaese Standard

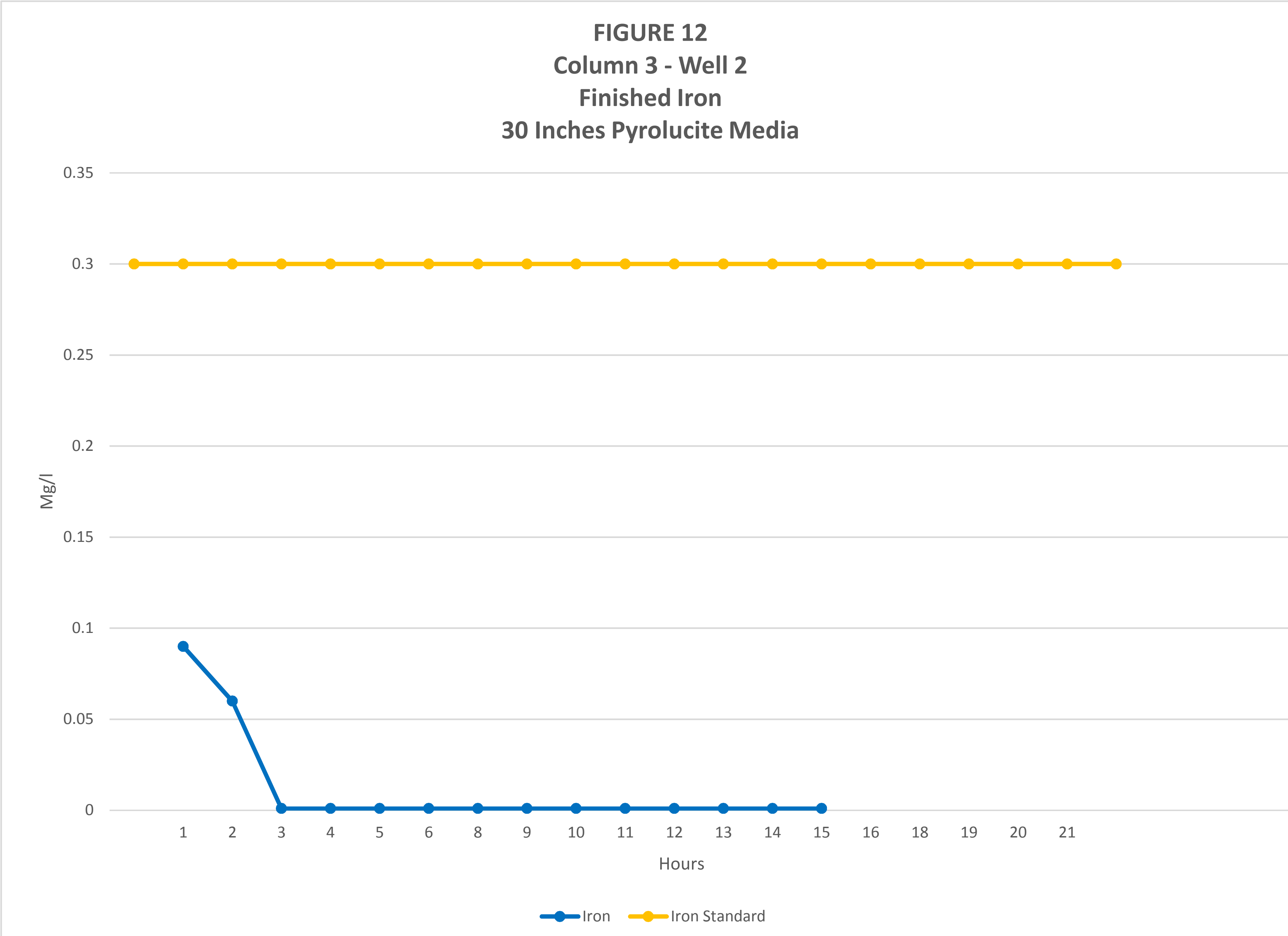


FIGURE 12
Column 3 - Well 2
Finished Iron
30 Inches Pyrolucite Media
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Iron
Iron Standard

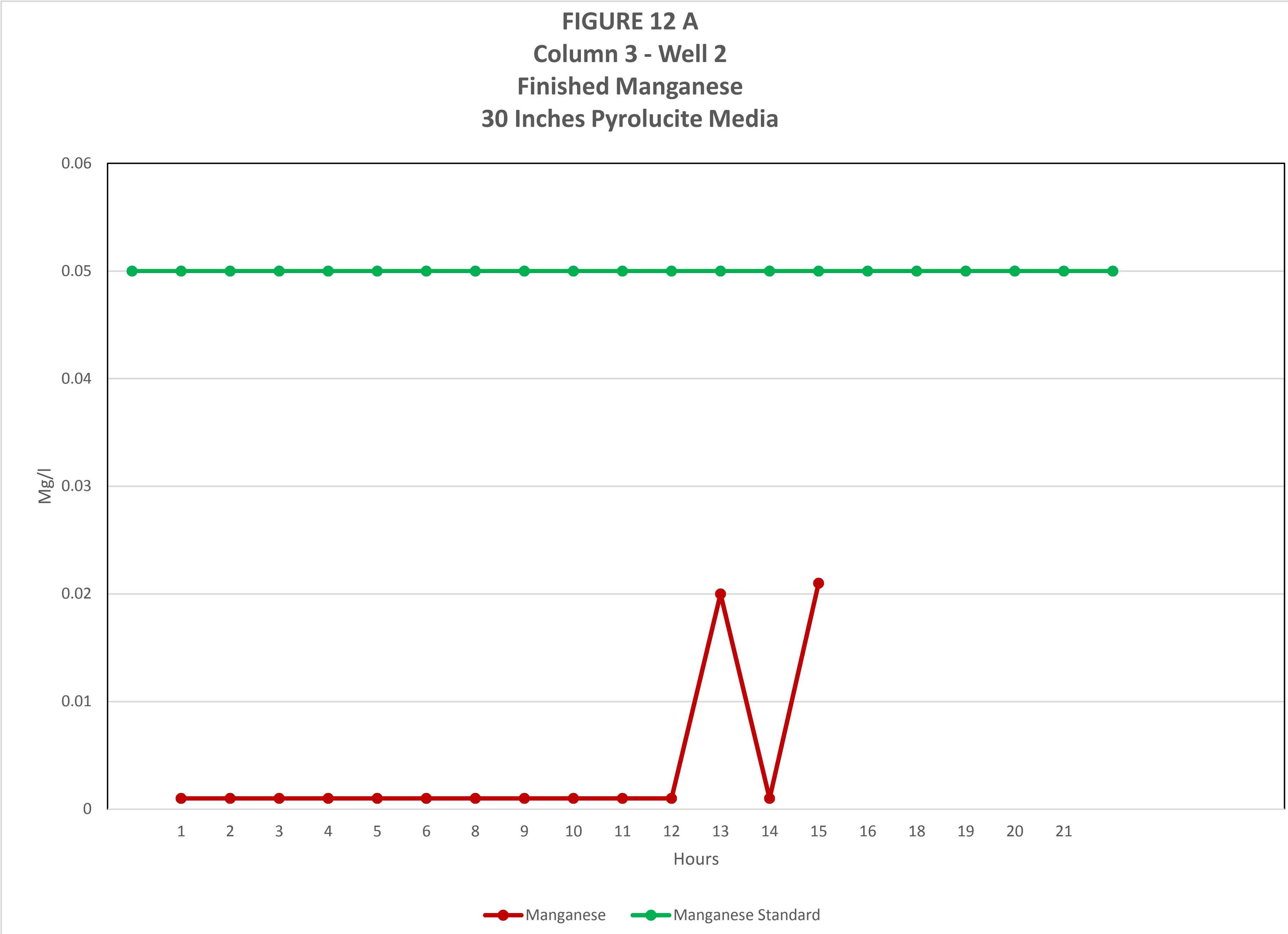


FIGURE 12 A
Column 3 - Well 2
Finished Manganese
30 Inches Pyrolucite Media
0.06
0.05
0.04
0.03
0.02
0.01
0
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Manganese
Manganese Standard

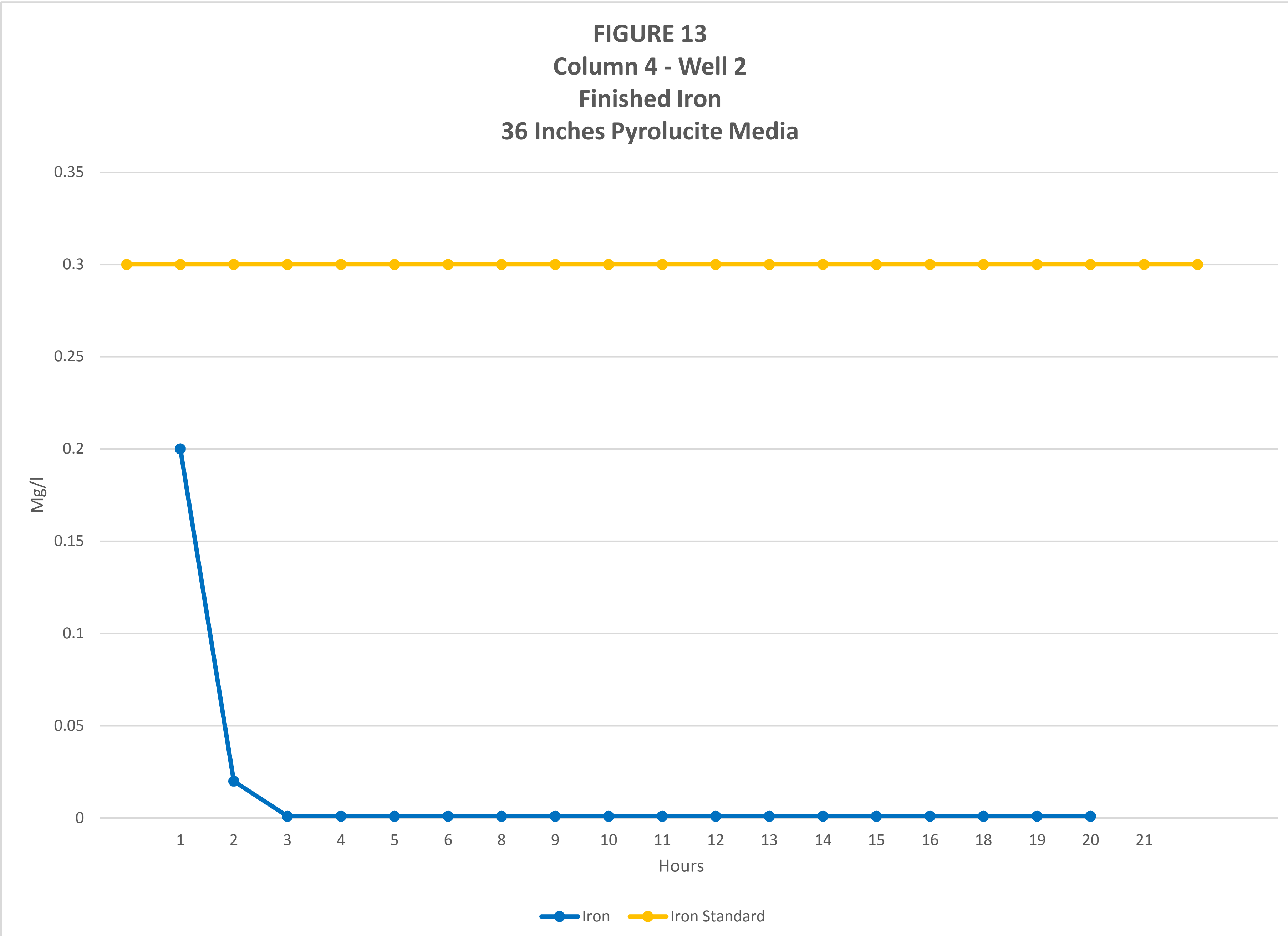


FIGURE 13
Column 4 - Well 2
Finished Iron
36 Inches Pyrolucite Media
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Iron
Iron Standard

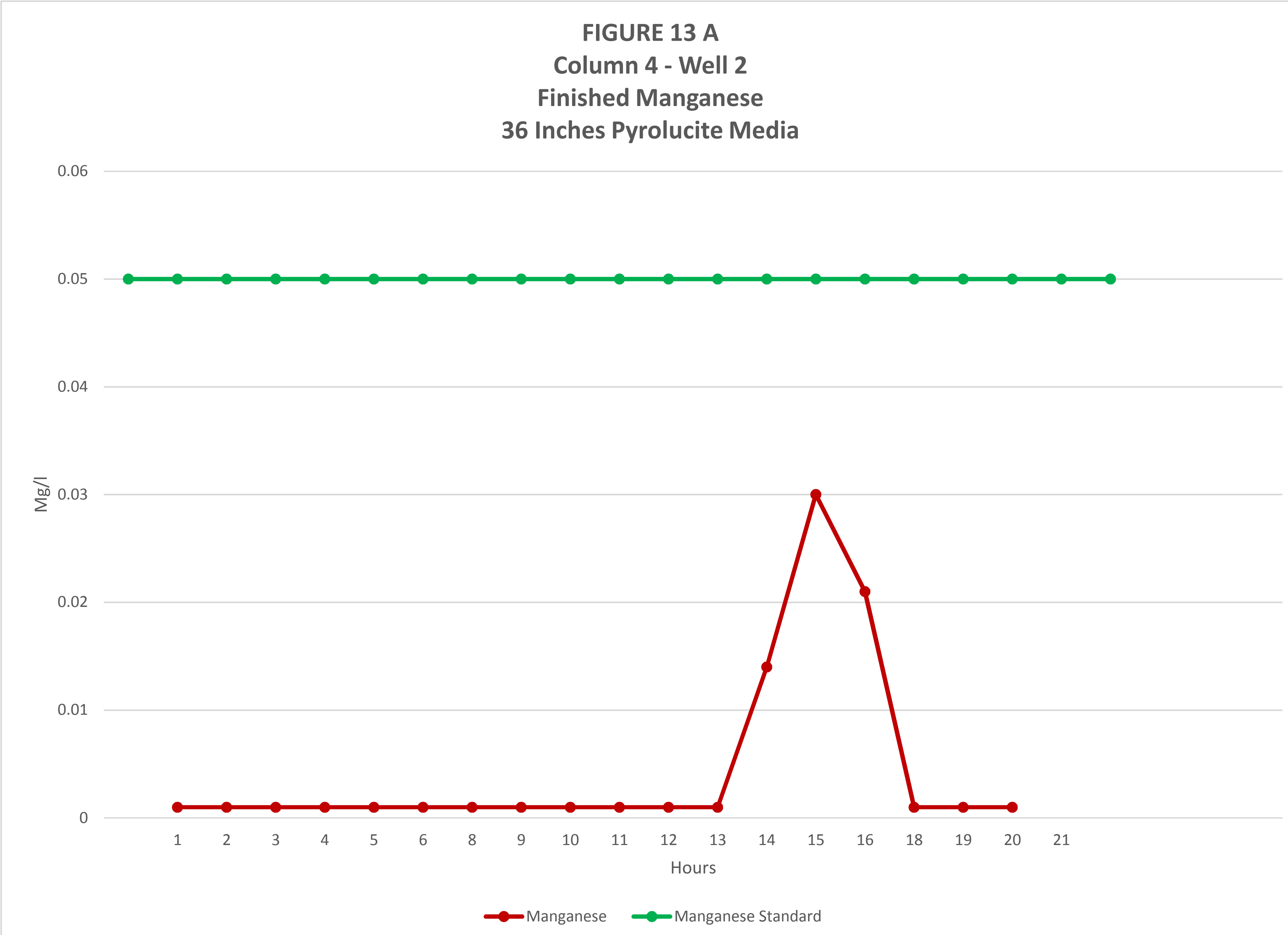


FIGURE 13 A
Column 4 - Well 2
Finished Manganese
36 Inches Pyrolucite Media
0.06
0.05
0.04
0.03
0.02
0.01
0
Mg/l
1
2
3
4
5
6
8
9
10
11
12
13
14
15
16
18
19
20
21
Hours
Manganese
Manganese Standard

Appendix A

Water Treatment Plant Layout Example

DRAWN BY:	X	X	X	X
DESIGNER:	X	X	X	X
CHECKED BY:	X	X	X	X
	X	X	X	X
DESIGN TEAM	NO.	BY	DATE	REVISIONS

SEH
PHONE: 320.229.4300
1200 25TH AVENUE SOUTH
P.O. BOX 1717
ST. CLOUD, MN 56302-1717
www.sehinc.com

Date: XX/XX/XX Lic. No.

TOWN OF RIB MOUNTAIN, WISCONSIN

PROJECT OVERVIEW

FILE NO.
RMTSD 145756

Appendix B

Water Treatment Plant Options 1 and 2 Estimates

PRELIMINARY CONSTRUCTION COST ESTIMATE
RIB MOUNTAIN SANITARY DISTRICT (RMTSD)
Well 1 & 2 WATER TREATMENT FACILITY
Option 1- (1,200 gpm-Gravity Filtration-Greensand Plus Media)

Water Treatment Facility

ITEM	UNIT	QUANTITY	UNIT PRICE	COST
SITE WORK (GRADING, PAVING, LANDSCAPING)	LS	1	$125,000.00	$125,000.00
WATERMAIN	LS	1	$75,000.00	$75,000.00
SANITARY SEWER	LS	1	$15,000.00	$15,000.00
STORM SEWER	LS	1	$8,000.00	$8,000.00
GENERAL BUILDING CONSTRUCTION (WALLS, ROOF, FLOOR, ARCHITECTURAL FINISHES, ETC)	SF	7000	$200.00	$1,400,000.00
MECHANICAL & PLUMBING	LS	1	$200,000.00	$200,000.00
ELECTRICAL (including generator)	LS	1	$610,000.00	$610,000.00
BELOW GROUND BACKWASH TANK CONCRETE (40,000 GAL)	LS	1	$160,000.00	$160,000.00
BELOW GROUND CLEAR WELL TANK CONCRETE (50,000 GAL)	LS	1	$200,000.00	$200,000.00
AERATOR (EXTERIOR)	LS	1	$75,000.00	$75,000.00
FILTRATION EQUIPMENT (4-15'X15' CAST IN PLACE CONCRETE)	LS	1	$450,000.00	$450,000.00
NEW WELL PUMP #1 & #2 (LOWER HEAD CONDITIONS)	LS	1	$50,000.00	$50,000.00
HIGH SERVICE PUMPS (2-1200 GPM)	LS	1	$80,000.00	$80,000.00
PROCESS PIPING, VALVES ETC.	LS	1	$150,000.00	$150,000.00
CHEMICAL FEED EQUIPMENT	LS	1	$50,000.00	$50,000.00
SCADA/SURVELIENCE Automated Control	LS	1	$100,000.00	$100,000.00
SUBTOTAL				$3,748,000.00
CONSTRUCTION CONTINGENCY - 10%				$374,800.00
ENGINEERING, ARCHITECTURAL, FINANCE, LEGAL, ETC. - 15%				$618,420.00
TOTAL ESTIMATED CONSTRUCTION COST				**$4,741,220.00**

NOTE: DOES NOT INCLUDE REMOVAL OR SALVAGE OR DEMO OF EXISTING TREATMENT SYSTEM FOR WELL 1 AND 2 OR REMODEL OF BUILDINGS.

PRELIMINARY CONSTRUCTION COST ESTIMATE
RIB MOUNTAIN SANITARY DISTRICT (RMTSD)
Well 1 & 2 WATER TREATMENT FACILITY
Option 2- (1,200 gpm-Pressure Filtration-Pyrolucite Media)

Water Treatment Facility

ITEM	UNIT	QUANTITY	UNIT PRICE	COST
SITE WORK (GRADING, PAVING, LANDSCAPING)	LS	1	$125,000.00	$125,000.00
WATERMAIN	LS	1	$75,000.00	$75,000.00
SANITARY SEWER	LS	1	$15,000.00	$15,000.00
STORM SEWER	LS	1	$8,000.00	$8,000.00
GENERAL BUILDING CONSTRUCTION (WALLS, ROOF, FLOOR, ARCHITECTURAL FINISHES, ETC)	SF	3500	$200.00	$700,000.00
MECHANICAL & PLUMBING	LS	1	$150,000.00	$150,000.00
ELECTRICAL (including generator)	LS	1	$560,000.00	$560,000.00
BELOW GROUND BACKWASH TANK CONCRETE (40,000 GAL)	LS	1	$160,000.00	$160,000.00
FILTRATION EQUIPMENT (10-54" diameter pressure cylinders)	LS	1	$250,000.00	$250,000.00
WELL PUMP #1 & #2 REHABILITATION	LS	1	$50,000.00	$50,000.00
PROCESS PIPING, VALVES ETC.	LS	1	$120,000.00	$120,000.00
CHEMICAL FEED EQUIPMENT	LS	1	$50,000.00	$50,000.00
SCADA/SURVELIENCE Automated Control	LS	1	$100,000.00	$100,000.00
SUBTOTAL				$2,363,000.00
CONTINGENCY - 10%				$236,300.00
ENGINEERING, ARCHITECTURAL, FINANCE, LEGAL, ETC. - 15%				$389,900.00
TOTAL ESTIMATED CONSTRUCTION COST				**$2,989,200.00**

NOTE: DOES NOT INCLUDE REMOVAL OR SALVAGE OR DEMO OF EXISTING TREATMENT SYSTEM FOR WELL 1 AND 2 OR REMODEL OF BUILDINGS.

Appendix C

Pilot Study Data - Well No. 1 and Well No. 2

WELL No. 1 - CHEMICAL FEED DATA

Date	Time			Chlorine PYROLUCITE						Permangnate detention						Chlorine Detention							Flow		Raw Water			
	Time	Run Hour	Time	Pump	mg/ml	Milliters	ml/min	mg/l	Mg/l Cl	Pump	mg/ml	Milliters	ml/min		mg/l	Pump	mg/ml	Milliters	ml/min	mg/l	Mg/l Cl	Flow 1&2	Aer flow	Flow 3 & 4	Fe	Mn	pH	Minutes
					29																	2.10	5	4.2				
7/24/2018	10:00	1			29						2						29					2.10	5	4.2	0.961	0.304	6.78	60
	11:00	2			29						2						29					2.10	5	4.2	1.065	0.326	6.01	60
	12:00	3	18		29	80	4.44	7.92	3.17		2	55	3.06	0.75	0.38		29	80	4.44	6.65	2.66	2.10	5	4.2	0.981	0.239	6.02	60
	13:00	4	70		29	360	5.14	9.16	3.67		2	250	3.57	0.88	0.44		29	310	4.43	6.63	2.65	2.10	5	4.2	1.01	0.232	6.02	60
	14:00	5	37		29	240	6.49	11.56	4.62		2	165	4.46	1.10	0.44		29	200	5.41	8.09	1.68	2.10	5	4.2	1.02	0.42	6.01	60
	16:00	7	129		29	470	3.64	6.49	2.60		2	370	2.87	0.70	0.35		29	390	3.02	4.53	1.81	2.10	5	4.2	1.038	0.335	6.01	120
	18:00	9	136		29	600	4.41	7.86	3.14		2	550	4.04	0.99	0.50		29	490	3.60	5.39	2.16	2.10	5	4.2	0.952	0.281	6.01	120
	19:00	10	66		29	265	4.02	7.15	2.86		2	230	3.48	0.86	0.43		29	230	3.48	5.22	2.09	2.10	5	4.2	1.02	0.229		60
7/25/2018	7:00	11	43		29	165	3.84	6.84	2.73		2	140	3.26	0.80	0.40		29	130	3.02	4.53	1.81	2.10	5	4.2	1.04	0.205	5.98	60
	8:00	12	86		29	340	3.95	7.04	2.82		2	295	3.43	0.84	0.42		29	270	3.14	4.70	1.88	2.10	5	4.2	1.1	0.202	6	60
	9:00	13	126		29	500	3.97	7.07	2.83		2	435	3.45	0.85	0.42		29	390	3.10	4.63	1.85	2.10	5	4.2	1.01	0.208		60
	11:00	15	133		29	650	4.89	8.71	3.48		2	475	3.57	0.88	0.44		29	420	3.16	4.73	1.89	2.10	5	4.2	1.02	0.193		120
	13:00	17	120		29	500	4.17	7.42	2.97		2	450	3.75	0.92	0.46		29	400	3.33	4.99	2.00	2.10	5	4.2	1.02	0.177		120
	14:00	16	58		29	260	4.48	7.99	3.20		2	220	3.79	0.93	0.47		29	230	3.97	5.94	2.37	2.10	5	4.2	1.05	0.22		60
	15:00	17	127		29	600	4.72	8.42	3.37		2	475	3.74	0.92	0.46		29	445	3.50	5.24	2.10	2.10	5	4.2	1.09	0.184		60
	16:00	18	46		29	210	4.57	8.13	3.25		2	180	3.91	0.96	0.48		29	170	3.70	5.53	2.21	2.10	5	4.2	0.989	0.185		60
	17:00	19	98		29	435	4.44	7.91	3.16		2	300	3.06	0.75	0.38		29	350	3.57	5.35	2.14	2.10	5	4.2	1.02	0.186		60
	18:00	20	48		29	230	4.79	8.54	3.42		2	190	3.96	0.97	0.49		29	180	3.75	5.61	2.25	2.10	5	4.2	1.06	0.213		60
	19:00	21	b																									60
Maximum					29	650	6.4865	11.558	4.6232				**Maximum**		0.50			490	5.4054	8.09	2.6609		**Maximum**		1.1	0.42	6.78	120
Minimum					29	80	3.6434	6.4921	2.5968				**Minimum**		0.35			80	3.0233	4.53	1.68		**Minimum**		0.952	0.177	5.98	60
Average					29	369.06	4.4975	8.014	3.2056				**Average**		0.43			292.81	3.6641	5.48	2.0965		**Average**		1.0248	0.2411	6.0933	72.632

		Well 1 - Column One (18 inches Silica Sand/ 12 inches Antracite)										Well 1 - Column Two (18 inches Greensand/ 12 inches Antracite)									
		Head Loss		FE	MN	CL	pH	Flow		Gallons		Head Loss		Fe	Mn	Cl	pH	Flow		Gallons	
Date	Time	Headloss	Feet	ppm	ppm	ppm	pH	gpm	gph	Gal Treat	gpm/ft²	Inches	Feet	ppm	ppm	ppm	pH	gpm	gph	Gal Treat	gpm/ft²
		9	0.75					1.05	63		3.00	33	2.75					1.05	63		3.00
7/24/2018	10:00	10	0.83	0.001	0.139	0.02	6.75	1.05	63	63	3.00	34	2.83	0.001	0.018	0.02	6.8	1.05	63	63	3.00
	11:00	12	1.00	0.001	0.092	0.36	6.01	1.05	63	126	3.00	31	2.58	0.003	0.001	0.42	6.02	1.05	63	126	3.00
	12:00	13	1.08	0.001	0.185	0.73	6.02	1.05	63	189	3.00	37	3.08	0.001	0.007	0.69	6.02	1.05	63	189	3.00
	13:00	14	1.17									35	2.92	0.001	0.006	0.63	6.02	1.05	63	252	3.00
	14:00											39	3.25	0.001	0.001	1.33	6.01	1.05	63	315	3.00
	16:00											44	3.67	0.011	0.007	0.85	6.01	1.05	126	441	3.00
	18:00											54	4.50	0.001	0.001	0.78	6.01	1.05	126	567	3.00
	19:00											55	4.58	0.001	0.001	0.81		1.05	63	630	3.00
7/25/2018	7:00											48	4.00	0.001	0.001	0.27		1.05	63	693	3.00
	8:00											50	4.17	0.001	0.001	0.81		1.05	63	756	3.00
	9:00											52	4.33	0.001	0.001	1.1		1.05	63	819	3.00
	11:00											55	4.58	0.001	0.001	1.79		1.05	126	945	3.00
	13:00											62	5.17	0.001	0.001	0.22		1.05	126	1071	3.00
	14:00											65	5.42	0.001	0.009	0.99		1.05	63	1134	3.00
	15:00											72	6.00	0.001	0.001	1		1.05	63	1197	3.00
	16:00											76	6.33	0.006	0.001	1.26		1.05	63	1260	3.00
	17:00											80	6.67	0.001	0.001	0.92		1.05	63	1323	3.00
	18:00											86	7.17	0.001	0.004	1.29		1.05	63	1386	3.00
	19:00														1.004						
Maximum		14		0.001	0.185	0.73	6.75	1.05	63		3	86	7.17	0.011	1.004	1.79	6.8	1.05	126		3
Minimum		9		0.001	0.092	0.02	6.01	1.05	63		3	31		0.001	0.001	0.02	6.01	1.05	63		3
Average		11.6		0.001	0.1387	**0.37**	6.26	1.05	63		3	53.0526	4.20	0.002	0.0562	0.8433	6.1271	1.05	76.263		3

		Well 1 - ColumnThree (30 inches Pyrolucite)										Well 1 - Column Four (36 Inches of Pyrolucite)									
		Head Loss		Fe	Mn	Cl	pH	Flow		Gallons		Head Loss		Fe	Mn	Cl	pH	Flow		Gallons	
Date	Time	Inches	Feet	ppm	ppm	ppm	pH	gpm	gph	Gall Treat	gpm/ft²	Inches	Feet	ppm	ppm	ppm	pH	gpm	gph	Gall Treat	gpm/ft²
		31	2.58					1.8	108		5.1429	17	1.42					1.8	126		5.1429
7/24/2018	10:00	33	2.75	0.001	0.026	0.53	6.64	1.8	108	108	5.1429	21	1.75	0.02	0.01	0.56	6.8	1.8	108	108	5.1429
	11:00	46	3.83	0.048	0.001	0.68	6.02	1.8	108	216	5.1429	28	2.33	0.048	0.001	0.71	6.1	1.8	2.1	216	5.1429
	12:00	54	4.50	0.001	0.007	0.59	6.02	1.8	108	324	5.1429	32	2.67	0.001	0.001	0.89	6.02	1.8	108	324	5.1429
	13:00	64	5.33	0.001	0.001	0.61	6.01	1.8	108	432	5.1429	39	3.25	0.001	0.008	0.56	6.04	1.8	108	432	5.1429
	14:00	76	6.33	0.001	0.001	1.41	6.01	1.8	108	540	5.1429	45	3.75	0.001	0.001	0.62	6.01	1.8	108	540	5.1429
	16:00	89	7.42	0.008	0.026	0.85	6.01	1.8	216	756	5.1429	53	4.42	0.023	0.021	0.72	6.01	1.8	216	756	5.1429
	18:00	103	8.58	0.001	0.001	0.89	6.01	1.8	216	972	5.1429	61	5.08	0.001	0.001	0.85	6	1.8	216	972	5.1429
	19:00	109	9.08	0.001	0.001	0.89		1.8	108	1080	5.1429	64	5.33	0.001	0.001	0.74		1.8	108	1080	5.1429
7/25/2018	7:00	121	10.08	0.001	0.001	0.7		1.8	108	1188	5.1429	70	5.83	0.001	0.001	0.7		1.8	108	1188	5.1429
	8:00	125	10.42	0.001	0.001	0.79		1.8	108	1296	5.1429	73	6.08	0.001	0.001	0.8		1.8	108	1296	5.1429
	9:00	131	10.92	0.001	0.001	1.1		1.8	108	1404	5.1429	76	6.33	0.001	0.001	1.1		1.8	108	1404	5.1429
	11:00	139	11.58	0.001	0.001	1.1		1.8	216	1620	5.1429	82	6.83	0.001	0.001	1.1		1.8	216	1620	5.1429
	13:00											89	7.42	0.001	0.001	0.73		1.8	216	1836	5.1429
	14:00											90	7.50	0.006	0.001	1.18		1.8	108	1944	5.1429
	15:00											95	7.92	0.001	0.001	0.78		1.8	108	2052	5.1429
	16:00											100	8.33	0.009	0.001	0.96		1.8	108	2160	5.1429
	17:00											108	9.00	0.001	0.001	0.86		1.8	108	2268	5.1429
	18:00											115	9.58	0.001	0.001	0.89		1.8	108	2376	5.1429
	19:00											118	9.83	0.001	0.001	0.83		1.8	108	2484	5.1429
Maximum		139	11.58	0.048	0.026	1.41	6.64	1.8	216		5.1429	118	9.83	0.048	0.021	1.18	6.8	1.8	216		5.1429
Minimum		31		0.001	0.001	0.53	6.01	1.8	108		5.1429	17	1.42	0.001	0.001	0.56	6	1.8	2.1		5.1429
Average		86.2308	5.19	0.0055	0.0057	0.845	6.1029	1.8	132.92		5.1429	68.8	5.73	0.0063	0.0029	0.82	6.14	1.8	125.21		5.1429

Head Loss Across Filter (Column One)

inches	feet	psi
5	0.42	0.18

Head Loss Across Filter (Column Two)

Inches	feet	psi
55	4.58	1.97

Head Loss Across Filter (Column Three)

inches	feet	psi
108	9	3.87

Head Loss Across Filter (Column Four)

inches	feet	psi
101	8.42	3.62

Well No. 2 - CHEMICAL FEED DATA

Date	Time	Run Hour	Time	Chlorine PYROLUCITE Pump	mg/ml	Milliters	ml/min	mg/l	Mg/l Cl	Permangnate detention Pump	mg/ml	Milliters	ml/min		mg/l	Chlorine Detention Pump	mg/ml	Milliters	ml/min	mg/l	Mg/l Cl	Flow 1&2	Flow: Aer flow	Flow 3 & 4	Raw Water Fe	Mn	pH	Minutes
7/19/2018	13:00				29																	2.10	5	4.2				60
	14:00	1	120		29	325	2.71	4.83	1.93		2	280	2.33	0.57	0.29		29	265	2.21	3.31	1.32	2.10	5	4.2	1.27	0.181	6.29	60
	15:00	2	43		29	270	6.28	11.19	4.48		2	155	3.60	0.89	0.44		29	235	5.47	8.18	3.27	2.10	5	4.2	1.22	0.189	6.19	60
	16:00	3	120		29	500	4.17	7.42	2.97		2	320	2.67	0.66	0.33		29	500	4.17	6.24	2.49	2.10	5	4.2	1.03	0.393	6.18	60
	17:00	4	55		29	145	2.64	4.70	1.88		2	170	3.09	0.76	0.38		29	165	3.00	4.49	1.80	2.10	5	4.2	1.04	0.193	3.32	60
	18:00	5	106		29	280	2.64	4.71	1.88		2	310	2.92	0.72	0.29		29	330	3.11	4.66	1.68	2.10	5	4.2	1.13	0.182	6.34	60
	19:00	6	56		29	150	2.68	4.77	1.91		2	180	3.21	0.79	0.39		29	155	2.77	4.14	1.66	2.10	5	4.2	1.024	0.212	6.32	60
	21:00	8	51		29	120	2.35	4.19	1.68		2	125	2.45	0.60	0.30		29	155	3.04	4.55	1.82	2.10	5	4.2	0.889	0.26	6.64	60
	22:00	9	128		29	320	2.50	4.45	1.78		2	310	2.42	0.60	0.30		29	380	2.97	4.44	1.78	2.10	5	4.2	1.18	0.195	6.21	60
	23:00	10	36		29	120	3.33	5.94	2.38		2	140	3.89	0.96	0.48		29	120	3.33	4.99	2.00	2.10	5	4.2	1.23	0.215	6.23	60
7/20/2018	7:00	11	40		29	120	3.00	5.35	2.14		2	110	2.75	0.68	0.34		29	120	3.00	4.49	1.80	2.10	5	4.2	1.126	0.126	6.29	60
	8:00	12	100		29	245	2.45	4.37	1.75		2	245	2.45	0.60	0.30		29	310	3.10	4.64	1.86	2.10	5	4.2	1.11	0.215	6.21	60
	9:00	13	164		29	380	2.32	4.13	1.65		2	390	2.38	0.58	0.29		29	480	2.93	4.38	1.75	2.10	5	4.2	0.967	0.22	6.31	60
	10:00	14	51		29	115	2.25	4.02	1.61		2	125	2.45	0.60	0.30		29	145	2.84	4.26	1.70	2.10	5	4.2	1.16	0.24	6.22	60
	11:00	15	117		29	260	2.22	3.96	1.58		2	260	2.22	0.55	0.27		29	295	2.52	3.77	1.51	2.10	5	4.2	1.16	0.312	6.01	60
	12:00	16	152		29	335	2.20	3.93	1.57		2	390	2.57	0.63	0.32		29	430	2.83	4.23	1.69	2.10	5	4.2	1.21	0.21	6.01	60
	14:00	18	120		29	260	2.17	3.86	1.54		2	360	3.00	0.74	0.37		29	220	1.83	2.74	1.10	2.10	5	4.2	1.12	0.214	6.12	60
	15:00	19	58		29	150	2.59	4.61	1.84		2	145	2.50	0.61	0.31		29	170	2.93	4.39	1.75	2.10	5	4.2	1.21	0.225	6.16	60
	16:00	20	64		29	155	2.42	4.32	1.73		2	160	2.50	0.61	0.31		29	180	2.81	4.21	1.68	2.10	5	4.2	1.3	0.226	6.12	60
	17:00	21																										
Maximum					29	500	6.28	11.19	4.4754			**Maximum**			0.48			500	5.47	8.18	3.27		**Maximum**		1.3	0.393	6.64	60
Minimum					29	115	2.17	3.86	1.5443			**Minimum**			0.27			120	1.83	2.74	1.10		**Minimum**		0.889	0.126	3.32	60
Average					29	236.11	2.83	5.04	2.0163			**Average**			0.33			258.61	3.05	4.56	1.81		**Average**		1.132	0.2227	6.065	60

Well 2 - Column One (18 inches Silica Sand/ 12 inches Antracite) and Well 2 - Column Two (18 inches Greensand/ 12 inches Antracite)

Time	Col. One Head Loss: Headloss	Feet	FE ppm	MN ppm	CL ppm	pH	Flow gpm	gph	Gallons: Gal Treat	gpm/ft^2	Col. Two Head Loss: Inches	Feet	Fe ppm	Mn ppm	Cl ppm	pH	Flow gpm	gph	Gallons: Gal Treat	gpm/ft^2
13:00	12	1.00					1.05	63		3.00	19	1.58					1.05	63		3.00
14:00	13	1.08	0.010	0.162	0.69	6.31	1.05	63	63	3.00	22	1.83	0.001	0.035	0.53	6.24	1.05	63	63	3.00
15:00	14	1.17	0.010	0.185	1.4	6.15	1.05	63	126	3.00	25	2.08	0.020	0.001	1.7	6.12	1.05	63	126	3.00
16:00	15	1.25	0.001	0.190	1.4	6.13	1.05	63	189	3.00	25	2.08	0.001	0.001	1.5	6.13	1.05	63	189	3.00
17:00	17	1.42	0.001	0.214	1.74	6.32	1.05	63	252	3.00	30	2.50	0.001	0.001	1.02	6.32	1.05	63	252	3.00
18:00	18	1.50	0.001	0.182	1.1	6.38	1.05	63	315	3.00	32	2.67	0.001	0.001	0.91	6.29	1.05	63	315	3.00
19:00	20	1.67	0.001	0.164	1.29	6.32	1.05	63	378	3.00	36	3.00	0.001	0.001	0.76	6.32	1.05	63	378	3.00
21:00											40	3.33	0.001	0.001	0.42	6.64	1.05	63	441	3.00
22:00											47	3.92	0.001	0.001	0.85	6.21	1.05	63	504	3.00
23:00											51	4.25	0.001	0.001	0.56	6.24	1.05	63	567	3.00
7:00											42	3.50	0.001	0.001	0.59	6.29	1.05	63	630	3.00
8:00											43	3.58	0.001	0.001	0.56	6.29	1.05	63	693	3.00
9:00											47	3.92	0.001	0.027	0.56	6.31	1.05	63	756	3.00
10:00											50	4.17	0.001	0.020	0.69		1.05	63	819	3.00
11:00											75	6.25	0.001	0.012	0.63		1.05	63	882	3.00
12:00											77	6.42	0.001	0.017	0.58		1.05	63	945	3.00
14:00											81	6.75	0.001	0.002	0.63		1.05	63	1008	3.00
15:00											86	7.17	0.001	0.001	0.59		1.05	63	1071	3.00
16:00											90	7.50	0.001	0.001	0.53		1.05	63	1134	3.00
17:00											94	7.83	0.001	0.001	0.49		1.05	63	1134	3.00
Maximum	20		0.010	0.214	1.74	6.38	1.05	63		3	94	7.83	0.020	0.035	1.7	6.64	1.05	63		3
Minimum	12		0.001	0.162	0.69	6.13	1.05	63		3	19	1.58	0.001	0.001	0.42	6.12	1.05	63		3
Average	15.571429		0.004	0.183	1.27	6.2683	1.05	63		3	50.6	4.22	0.002	0.0066	0.7421	6.2833	1.05	63		3

Well 2 - ColumnThree (30 inches Pyrolucite) and Well 2 - Column Four (36 Inches of Pyrolucite)

Time	Col. Three Head Loss: Headloss	Feet	Fe ppm	Mn ppm	Cl ppm	pH	Flow gpm	gph	Gallons: Gall Treat	gpm/ft^2	Col. Four Head Loss: Headloss	Feet	Fe ppm	Mn ppm	Cl ppm	pH	Flow gpm	gph	Gallons: Gall Treat	gpm/ft^2
13:00	26	2.17					2.1	126		6	15	1.25					2.1	126		6
14:00	35	2.92	0.09	0.001	1.01	6.28	2.1	126	126	6	25	2.08	0.2	0.001	0.96	6.25	2.1	126	126	6
15:00	44	3.67	0.06	0.001	1.8	6.19	2.1	126	252	6	31	2.58	0.02	0.001	0.99	6.16	2.1	2.1	252	6
16:00	54	4.50	0.001	0.001	1.4	6.13	2.1	126	378	6	30	2.50	0.001	0.001	0.96	6.15	2.1	126	378	6
17:00	68	5.67	0.001	0.001	1.23	6.32	2.1	126	504	6	40	3.33	0.001	0.001	1.38	6.32	2.1	126	504	6
18:00	76	6.33	0.001	0.001	0.93	6.26	2.1	126	630	6	50	4.17	0.001	0.001	1.62	6.34	2.1	126	630	6
19:00	88	7.33	0.001	0.001	0.96	6.34	2.1	126	756	6	56	4.67	0.001	0.001	1.72	6.31	2.1	126	756	6
21:00	101	8.42	0.001	0.001	0.62	6.65	2.1	126	882	6	66	5.50	0.001	0.001	0.61	6.64	2.1	126	882	6
22:00	110	9.17	0.001	0.001	0.68	6.21	2.1	126	1008	6	70	5.83	0.001	0.001	0.68	6.21	2.1	126	1008	6
23:00	115	9.58	0.001	0.001	0.53	6.24	2.1	126	1134	6	75	6.25	0.001	0.001	0.52	6.23	2.1	126	1134	6
7:00	120	10.00	0.001	0.001	0.56	6.28	2.1	126	1260	6	79	6.58	0.001	0.001	0.53	6.27	2.1	126	1260	6
8:00	128	10.67	0.001	0.001	0.63	6.26	2.1	126	1386	6	83	6.92	0.001	0.001	0.61	6.27	2.1	126	1386	6
9:00	134	11.17	0.001	0.02	0.53	6.31	2.1	126	1512	6	87	7.25	0.001	0.001	0.58	6.32	2.1	126	1512	6
10:00	142	11.83	0.001	0.001	0.71		2.1	126	1638	6	94	7.83	0.001	0.014	0.56		2.1	126	1638	6
11:00	150	12.50	0.001	0.021	0.59		2.1	126	1764	6	97	8.08	0.001	0.03	0.94		2.1	126	1764	6
12:00											102	8.50	0.001	0.021	0.56		2.1	126	1890	6
14:00											110	9.17	0.001	0.001	0.93		2.1	126	2016	6
15:00											118	9.83	0.001	0.001	0.68		2.1	126	2142	6
16:00											120	10.00	0.001	0.001	0.59		2.1	126	2268	6
17:00																				
Maximum	150	12.50	0.09	0.021	1.8	6.65	2.1	126		6	120	10.00	0.2	0.03	1.72	6.64	2.1	126		6
Minimum	26		0.001	0.001	0.53	6.13	2.1	126		6	15	1.25	0.001	0.001	0.52	6.15	2.1	2.1		6
Average	92.7333	6.44	0.0116	0.0038	0.87	6.2892	2.1	126		6	70.9474	5.91	0.0131	0.0044	0.8567	6.2892	2.1	119.12		6

Headloss Across Filter (Column One)

inches	feet	psi
8	0.67	0.29

Headloss Across Filter (Column Two)

Inches	feet	psi
75	6.25	2.69

Headloss Across Filter (ColumnThree)

inches	feet	psi
124	10	4.44

Headloss Across Filter (Column Four)

inches	feet	psi
105	8.75	3.76

Appendix D

Pre-Pilot Study Report and WDNR Approval Letter

Building a Better World
for All of Us®

May 8, 2018

RE: Rib Mountain Sanitary District
Well No. 1 & 2 Pre-Pilot Study Report
SEH No. RMTSD 145756 14.00

Cathrine Wunderlich, Public Water Engineering Section Chief
Wisconsin Department of Natural Resources
Bureau of Drinking Water and Groundwater, DG/5
101 South Webster Street - P.O. Box 7921
Madison, WI 53707

Dear Ms. Wunderlich:

The Rib Mountain Sanitary District, just southwest of Wausau, currently treats water from Well No. 1 and Well No. 2 for iron and manganese using a proprietary Vyredox® air injection well field system which was constructed in the 1980's. The performance of the air injection system has diminished over time and the wells are in need of new treatment. Enclosed herein you will find a Pre-Pilot Study Approach Submittal corresponding with Well No. 1 and Well No. 2.

EXISTING TREATMENT AND NEED FOR STUDY

The existing Vyredox® water treatment system which treats both Well No. 1 and Well No. 2 has diminished over time in its efficiency for removing iron and manganese from the water source(s). The Sanitary District would like to replace the existing treatment system with new a system. The current Vyredox® treatment system oxidizes the iron and manganese in the soil, leaving the iron and manganese in the water source, except their non-soluble form. The objective of the pilot study would be to find a treatment solution in which the iron and manganese are removed from the water source, rather than being left to accumulate in the aquifer. The Vyredox system will be shut down approximately one month prior to the pilot work to obtain iron and manganese water for the pilot work. This shut down has been discussed with the regional WDNR representative and will be coordinated ahead of time with the same.

The objective of the proposed pilot study is to evaluate alternative iron removal options utilizing various filter media, oxidants, and various loading rates. The raw and finished water will be evaluated for pH, iron and manganese, alkalinity, hardness organics, and THM. The study is anticipated to reveal which media combination, oxidant, at which filter rate will achieve the most efficient iron removal rate versus backwash.

PILOT STUDY WATER SOURCES AND WATER ANALYSIS

The water for the pilot study will be taken from the raw water well piping. Proper backflow prevention will be provided.

PILOT STUDY OBJECTIVES

USEPA National Secondary Drinking Water Standard (MCL) recommendation for the concentration of dissolved iron and manganese in drinking water supplies is 0.3 mg/L and 0.05 mg/, respectively. Based on this criteria, the objectives of this pilot study are as follows:

- Evaluate treatment processes that will reduce levels of dissolved iron and manganese to less than the secondary MCLs of each contaminant.
- Evaluate various methods for oxidation of manganese: permanganate, chlorine, and aeration.
- Evaluate the effectiveness of different filtration media and filtration rates for the removal of dissolved manganese.
- Establish the effective filter loading rate (GPM/ft^2) for each media evaluated.

RAW WATER QUALITY

Water quality measurements were made on 4/6/2018. Well No. 1 contained **0.14 mg/L manganese** and **0.84 mg/L iron**. Well No. 2 contained **0.17 mg/L manganese** and **1.0 mg/L iron**. The secondary MCL per the EPA is listed as 0.05 mg/L for manganese and 0.3 mg/L for iron. The measured iron and manganese are both greater than their respective secondary standards. The iron and manganese will be tested and to verify if it is oxidized or un-oxidized.

PILOT TESTING EQUIPMENT

Chemical Feed System

The chemical feed systems to be used during the pilot treatment testing are peristaltic metering pumps capable of feeding 0.2 gallons per day (GPD) up to 3.5 GPD. The pumps will be set up to feed less than 3.5 GPD for this study. The treatment chemicals to be used will be:

- Sodium hypochlorite (bleach)
- Permanganate mixed at a concentration of 2 grams per liter

Aeration

Aeration will be provided before detention by using a draft aerator for the oxidation of the iron and manganese and the removal of any dissolved gases.

Detention

The detention equipment within the pilot trailer consists of a rectangular PVC basin with adjustable heights to manage alternate detention requirements when necessary. When the tank is operated with a flow of 5 GPM, the approximate raw water detention time is 30 minutes. The tank is constructed with baffles that provide an over and under flow pattern to prevent short circuiting of the tank. The tank also contains a draft tube mixer which will not be used for this pilot.

Filters

A total of up to four (4) filters, each with a diameter of 8 inches by 72 inches tall, will be used during the pilot testing. Each filter vessel has a ¾ inch diameter inlet, 1 ½ inch diameter backwash waste outlet, underdrain system, air release system, rate of flow meters, sample taps, and filter media. Each filter column provides 0.35 square feet (ft^2) of surface area. When the filters are operated at 2 GPM/ft^2, each column has an equivalent water flow rate of 0.7 GPM applied. The filters will be operated in a parallel flow pattern.

PILOT TESTING PLAN

A copy of the pilot plant process flow diagram and the media data sheets can be found in Appendix A. Below is a description of the testing that will take place within the pilot trailer.

Filter Media

The filter media recommended to be tested for this pilot study is based on previous experiences with iron and manganese removal and previous pilot study results. Below is a brief overview of each filtration media.

Pyrolusite is a granular catalytic water filtration media used for the removal of hydrogen sulfide, iron and manganese. The brand name product to be used which is very similar to Pyrolusite is Oxiplus75 TM Media. Both Well No. 2 and Well No.1 will be used to test Oxiplus75 TM. Typical bed depths range from 24-inches to 36-inches. A bed depth of 36-inches will be used for this study. The grain size is 0.4 - 0.5 mm (20 x 40 mesh).

GreensandPlus™ is a silica based black colored catalytic filter media used for removing soluble iron, manganese, hydrogen sulfide, arsenic and radium from groundwater supplies. Because Well No.2 contains more iron than Well No. 1, Well No.2 will be used to test GreensandPlus. The manganese dioxide coated surface of GreensandPlus™ acts as a catalyst in the oxidation reduction reaction of iron and manganese.

Anthracite (effective size 0.9 - 1.0 mm) will be used in conjunction with GreensandPlus™ on Well No. 2. A dual media bed depth of 12-inches of anthracite and 18-inches of GreensandPlus™ is expected. The effective grain size for GreensandPlus™ is 0.30 to 0.35 mm.

Silica sand and anthracite media will be used in columns with detention and without detention on Well No. 2. The size of the media will be 0.45 mm to 0.55 mm with a 1.5 coefficient.

Anthracite will be sized at 0.9 mm to 1.0 mm and will be used on both the silica sand and greensand -plus columns on Well No. 2.

Column #	**1**	**2**	**3**	**4**
Aeration	no	no	yes	yes
Detention	no	no	30 min	30 min
Oxidant	Chlorine	Chlorine	Chlorine	Chlorine
	Permanganate	Permanganate	Permanganate	Permanganate
Media	18 inches silica	18 inches Green Sand	18 inches silica	18 inches Green Sand
	12 inches anthracite	12 inches anthracite	12 inches anthracite	12 inches anthracite
Loading Rate	2-3 GPM/sf	2-3 GPM/sf	2-3 GPM/sf	2-3 GPM/sf

Pyrolusite will also be evaluated for the removal of iron and manganese. Two columns will be operated to assess the effectiveness of this media on Well No. 1.

Column #	**1**	**2**
Aeration	no	no
Detention	no	no
Oxidant	Chlorine	Chlorine
Media	30 inches	36 inches
	Pyrolusite	Pyrolusite
Loading Rate	6 GPM/sf	6 GPM/sf

Oxidants

Sodium hypochlorite will be used as the oxidant for the columns containing Pyrolusite media.

Data Collection

The pilot test will include two full filter cycles to a terminal head loss of 8 psi or Fe or Mn breakthrough. On-site water chemistry will be analyzed by the SEH pilot plant operator and will include free chlorine residual, pH, iron, and manganese. Analysis will be completed using a Hach colorimeter and wet chemistry.

In addition to water chemistry, the pilot plant operator will record flow rate, chemical feed rate, head loss, and time.

Waste Disposal

Treated water and backwash water will be discharged to the ground surface to infiltrate. Chlorine residuals in the discharged water will not be greater than the water in the distribution system and therefore safe for discharge onto the ground surface.

Operator Safety

The SEH pilot trailer is equipped with safety equipment that includes an eyewash unit, fire extinguisher, first aid kit, and traffic cones.

Backflow Protection for Water System Facilities

A backflow prevention assembly will be provided between the pilot testing equipment and the connection to the well piping.

Pilot Plant Security

All equipment is housed in a secure trailer. The SEH operator is generally on site at all times during pilot operation. The door on trailer will be locked when operator is absent.

Water Quality Testing

The plan for water quality testing is described below:

1) On site water chemistry will be analyzed by a pilot plant operator during each run:

a) Testing will include free chlorine residual, pH, iron, manganese, and carbon dioxide
b) Analysis will be completed using a Hach colorimeter and wet chemistry

Report

Upon completion of the described pilot treatment testing, a final pilot study report will be prepared and submitted to the Department for review and approval.

SUMMARY

Your timely review of this submittal would be greatly appreciated. We trust that the enclosed information is sufficient for you to complete your review of the recommended pilot study approach. Please do not hesitate to contact us if you have any questions or if you need additional information. You may me at 715.720.6255 or jnussbaum@sehinc.com.

Sincerely,

SHORT ELLIOTT HENDRICKSON INC.

Jeff Nussbaum, PE (WI)
Senior Professional Engineer

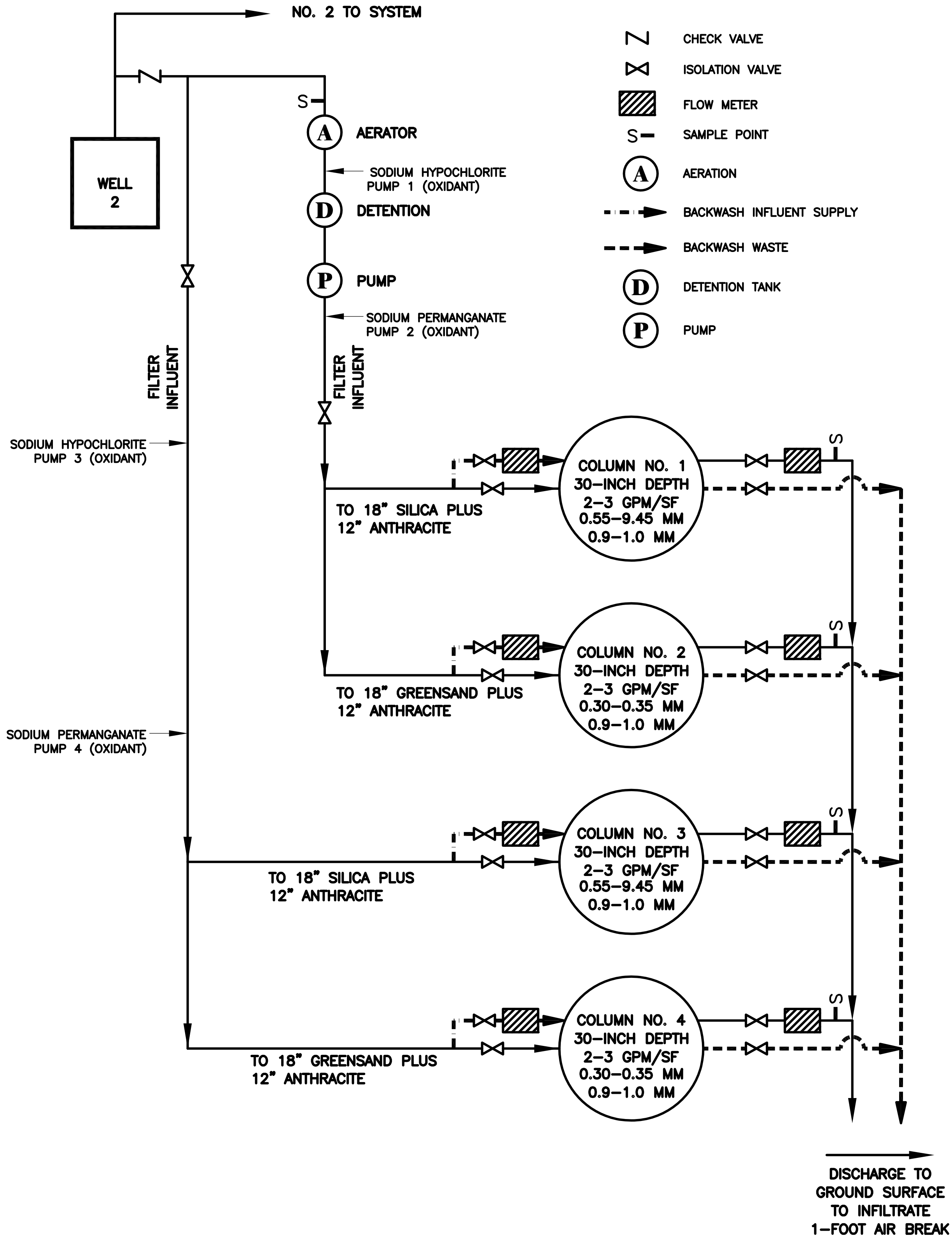
Attachments

Enclosure: DNR Form 3300-260

c: Michael Heyroth, Utility Director, Rib Mountain Sanitary District (by email)
John Thom, SEH (by email)
Joshua Bohnert, SEH (by email)

p:\pt\r\rmtsd\145756\4-prelim-dsgn-rpts\pre pilot report\final prep report 5.8.18\submittal_05082018_rib mountain pre-pilot letter report.docx

PILOT TRAILER FLOW TRAIN



SEH

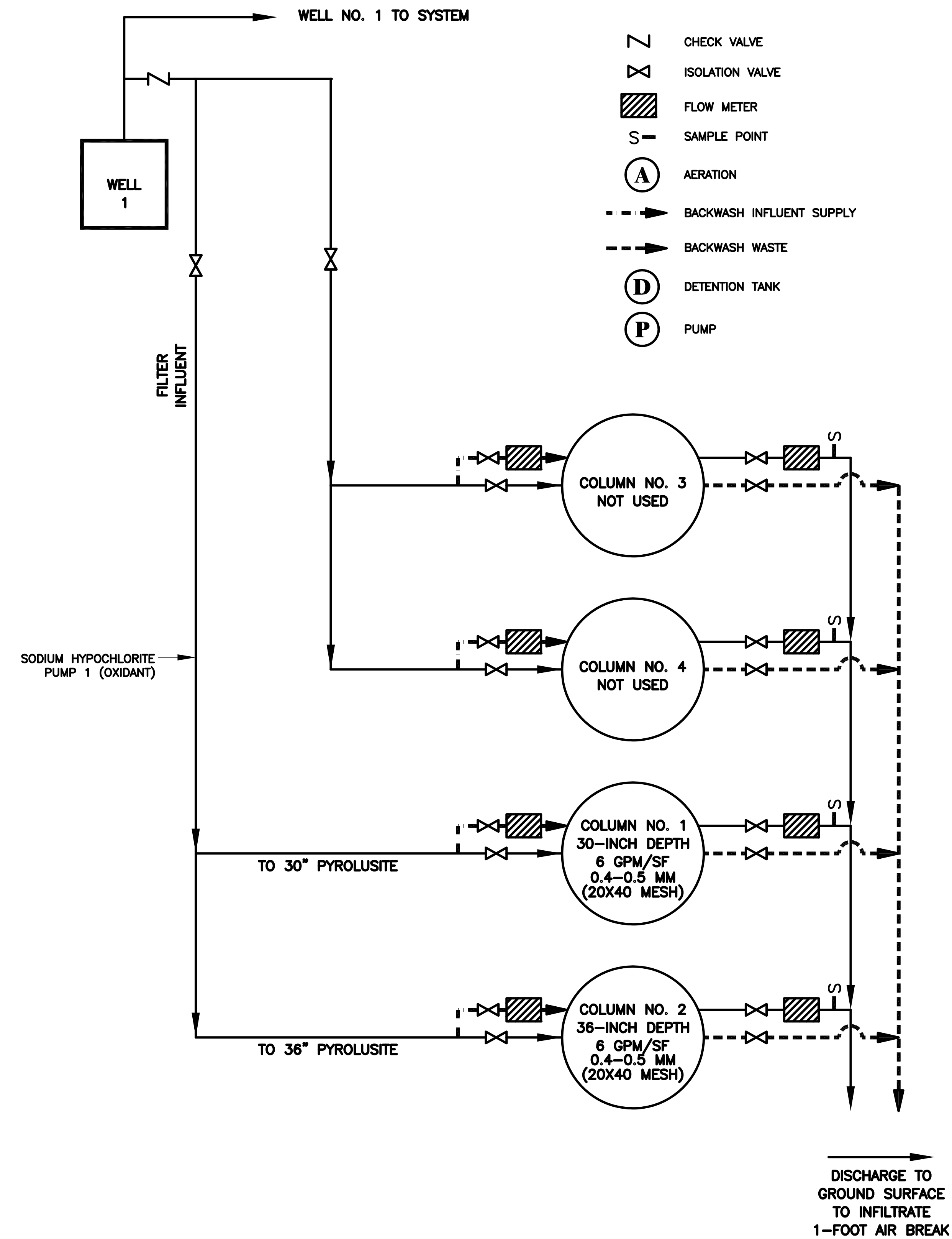
PILOT TRAILER FLOW TRAIN (RUNS 1–4)
PILOT STUDY UNIT WELL NO. 2
RIB MOUNTAIN SANITARY DISTRICT

FILE NO. RMTSD 145756

FIGURE NO. 1

PLOTTED: 4-30-2018 4:20 PM
PLOT SCALE: 1:1
USER: JOSH J. BOHNERT
E:\PREPILOT REPORT\RIB MOUNTAIN\PILOT FLOW TRAIN.DWG
SAVED: 4-30-2018 4:18 PM
XREFs: C:\Users\nyhagen\Documents\01PCM\Thorp\figs\811xref.THORW; E:\PrePilot Report\Rib Mountain\Pilot Flow Train Border; E:\PrePilot Report\Rib Mountain\Pilot Flow Train Border 2

PILOT TRAILER FLOW TRAIN



SEH

PILOT TRAILER FLOW TRAIN (RUNS 5-6)
PILOT STUDY UNIT WELL NO. 2
RIB MOUNTAIN SANITARY DISTRICT

FILE NO.
RMTSD 145756

FIGURE NO.
2

PLOTTED: 4-30-2018 4:20 PM
PLOT SCALE: 1:1
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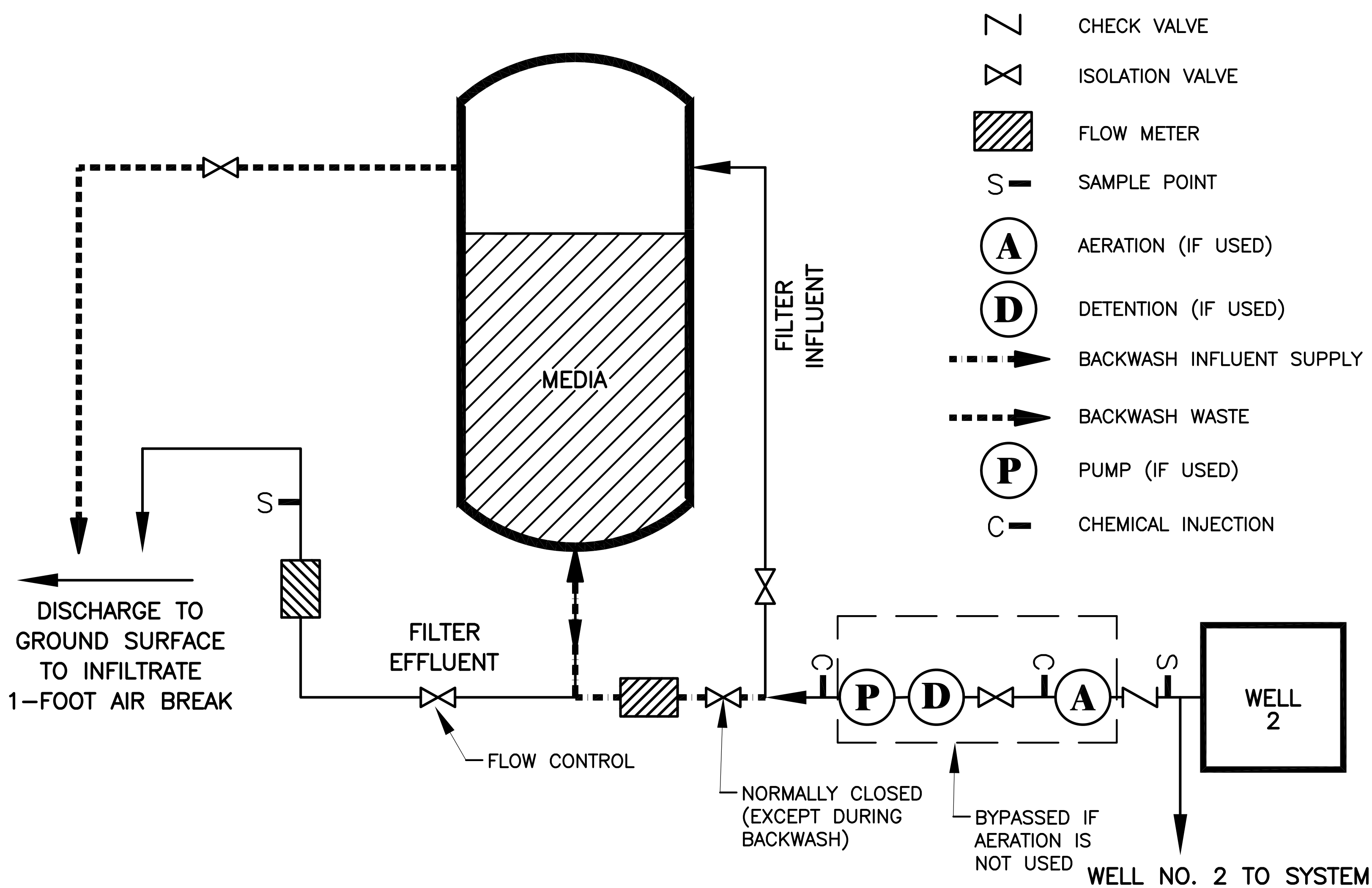
E:\PREPILOT REPORT\RIB MOUNTAIN\PILOT FLOW TRAIN.DWG
SAVED: 4-30-2018 4:18 PM
XREFs: C:\Users\nyhagen\Documents\01PCM\Thorp\figs\811xref.THORW; E:\PrePilot Report\Rib Mountain\Pilot Flow Train Border; E:\PrePilot Report\Rib Mountain\Pilot Flow Train Border 2

PILOT FILTER VESSEL FLOW TRAIN



SEH

PILOT FILTER VESSEL FLOW TRAIN
PILOT STUDY UNIT WELL NO. 2
RIB MOUNTAIN SANITARY DISTRICT

FILE NO.
RMTSD 145756

FIGURE NO.
3

Well Construction Report
WISCONSIN UNIQUE WELL NUMBER VX778

State of WI - Private Water System-DG/2
Department of Natural Resource, Box 7921
Madison WI 53707

Form 3300-077A (R 8/15)

Property Owner	RIB MOUNTAIN SAN DISTRICT
Phone #	(715)359-6177
Mailing Address	5703 LILAC AVENUE
City	RIB MOUNTAIN
State	WI
Ziip Code	54401
County of Well Location	Marathon
Co. Well Permit No.	
Well Completion Date (mm-dd-yyyy)	12-23-2014
Well Constructor (Business Name)	LAYNE CHRISTENSEN COMPANY
Lic. #	582
Facility ID # (Public Wells)	737066000
Well Plan Approval #	2014-0707
Address	W229 N5005 DUPLAINVILLE PEWAUKEE WI 53072
Approval Date (mm-dd-yyyy)	12-12-2014
Hicap Permanent Well #	81958
Common Well #	1
Specific Capacity	23.40

1. Well Location

Town of	RIB MOUNTAIN
Fire # (if avail.)	
Street Address or Road Name and Number	LILAC AVENUE #1
Subdivision Name	
Lot #	
Block #	
Method Code	SCR002

SW	SW or Govt Lot #	Section	Township	Range
SW	SW	14	28 N	7 E

2. Well Type Reconstruction

of previous unique well # BG332 constructed in 1984

Reason for replaced or reconstructed well ? COMPROMISED CASING

3. Well serves # of MUNICIPALITY

Examples: home, barn, restaurant, school, industry

High Capacity Well ? Yes

High Capacity Property ? Yes

Heat Exchange__________# of drillholes

Construction Type Other

4. WATER WELL & HEAT EXCHANGE DRILLHOLE - ON REVERSE SIDE

5. Drillhole Dimensions and Construction Method

Dia. (in.)	From (ft.)	To (ft.)
38	Surface	75

Upper Enlarged Drillhole	Method	Lower Open Bedrock
No	1. Rotary - Mud Circulation	No
No	2. Rotary - Air	No
No	3. Rotary - Air & Foam	No
No	4. Drill-Through Casing Hammer	
Yes	5. Reverse Rotary	
No	6. Cable-tool Bit ____in. dia...	No
No	7. Temp. Outer Casing ____in. dia	
No	Removed? ____depth ft. (If NO explain on back side)	
No	8. Dual Rotary	No

8. Geology

Geology Codes				Type, Caving/Noncaving, Color, Hardness, etc...	From (ft.)	To (ft.)
T	-	G	-	GRAVEL	Surface	55
T	-	S	-	SAND	55	70
R	-	G	-	GRAVEL	70	75

6. Casing, Liner, Screen

Dia. (in.)	Material, Weight, Specification Manufacturer & Method of Assembly	From (ft.)	To (ft.)
16	NEW ASTM A53 GR B EXISTING	Surface	60
26	NEW ASTM A53 GR B EXISTING	0	57
14	NEW ASTM A53 BR B, 0.375" WALL	0	60

Dia. (in.)	Screen type, material & slot size	From (ft.)	To (ft.)
14	SS .045 IN. WIRE WRAP	60	75

7. Grout or Other Sealing Material

Method

Kind of Sealing Material	From (ft.)	To (ft.)	# Stack Cements
CLASS A MIX/6BAG/CONCRETE	Surface	57	6
GRAVEL PACK		75	

9. Static Water Level

35 ft. below ground surface

10. Pump Test

Pumping level 60 ft. below surface

Pumping at 584 M for 1 Hrs.

11. Well Is

24 in. above grade

Developed ? Yes

Disinfected ? Yes

Capped ? Yes

12. Did you notify the owner that the well you removed from service/replaced must be filled and sealed within 90 days?

Did you fill and seal all unused, noncomplying or unsafe wells on this property? If no, explain on reverse.

13. Signature of Well Constructor / Supervisory Driller	Lic #	Date Signed
DOUG		12-23-2014
Name of Drill Rig Operator (unless same as above)	Lic #	Date Signed
		12-23-2014

Make additional comments on reverse side about geology, additional screens, water quality etc...

Notification #

Comments on reverse side ? No

Variance No

4a. WATER WELL Is the well located in floodplain ? No

WISCONSIN UNIQUE WELL NUMBER **DG454**

SOURCE: WELL CONSTRUCTION

State of Wi-Private Water Systems-DG/2
Department Of Natural Resources, Box 7921
Madison, WI 53707

Form 3300-77A (Rev 12/00)

Depth 90 FT

Property Owner	RIB MOUNTAIN SANITARY DISTRICT
Telephone Number	715 - 359 - 6177
Mailing Address	5703 LILAC AVE
City	RIB MOUNTAIN
State	WI
Zip Code	54401
County of Well Location	37 MARATHON
WC	
Co Well Permit No	W
Well Completion Date	September 6, 1984
Well Constructor	MILLER WELL & PUMP
License #	208
Facility ID (Public)	737066000
Address	
Public Well Plan Approval#	84-0692
City / State / Zip Code	
Date Of Approval	08/08/1984
Hicap Well #	81959
Common Well #	002
	29.1 gpm/ft

1. Well Location

T T=Town C=City V=Village Fire#

of RIB MOUNTAIN

Street Address or Road Name and Number: LILAC AVE #2

Subdivision Name | Lot# | Block #

Gov't Lot or SE 1/4 of SW 1/4 of

Section 14 T 28 N R 7 E

2. Well Type 1 1=New 2=Replacement 3=Reconstruction (See item 12 below)

GRN Status

of previous unique well # __________ constructed in ______

Reason for replaced or reconstructed Well?

1 1=Drilled 2=Driven Point 3=Jetted 4=Other

3. Well Serves # of homes and or (eg: barn, restaurant, church, school, industry, etc.)

M M=Munic O=OTM N=NonCom P=Private Z=Other X=NonPot A=Anode L=Loop H=Drillhole

High Capacity: Well? Property?

4. Is the well located upslope or sideslope and not downslope from any contamination sources, including those on neighboring properties?

Well located in floodplain?

Distance in feet from well to nearest: (including proposed)

1. Landfill
2. Building Overhang
3. 1=Septic 2= Holding Tank
4. Sewage Absorption Unit
5. Nonconforming Pit
6. Buried Home Heating Oil Tank
7. Buried Petroleum Tank
8. 1=Shoreline 2= Swimming Pool
9. Downspout/ Yard Hydrant
10. Privy
11. Foundation Drain to Clearwater
12. Foundation Drain to Sewer
13. Building Drain 1=Cast Iron or Plastic 2=Other
14. Building Sewer 1=Gravity 2=Pressure 1=Cast Iron or Plastic 2=Other
15. Collector Sewer: ___ units ___ in . diam.
16. Clearwater Sump
17. Wastewater Sump
18. Paved Animal Barn Pen
19. Animal Yard or Shelter
20. Silo
21. Barn Gutter
22. Manure Pipe 1=Gravity 2=Pressure 1=Cast iron or Plastic 2=Other
23. Other manure Storage
24. Ditch
25. Other NR 812 Waste Source

5. Drillhole Dimensions and Construction Method

Dia.(in.)	From (ft)	To (ft)
38.0	surface	90

Upper Enlarged Drillhole / Lower Open Bedrock

-- 1. Rotary - Mud Circulation
-- 2. Rotary - Air
-- 3. Rotary - Air and Foam
-- 4. Drill-Through Casing Hammer
X -- 5. Reverse Rotary
-- 6. Cable-tool Bit _____ in. dia
-- 7. Temp. Outer Casing _____ in. dia. _____ depth ft. Removed ?

Other

6. Casing Liner Screen

Dia. (in.)	Material, Weight, Specification Manufacturer & Method of Assembly	From (ft.)	To (ft.)
16.0	NEW STEEL WELDED ASTM A 53 GR B	surface	70
26.0	NEW STEEL WELDED ASTM A 53 GR B	0	65

Dia.(in.)	Screen type, material & slot size	From	To
16.0	SS SLOT 0 04 SCREEN	70	90

8.

Geology Codes	Geology Type, Caving/Noncaving, Color, Hardness, etc	From (ft.)	To (ft.)
T_I_	SOIL	0	5
T_G_	GRAVEL	5	35
T_S_	SAND	35	90

9. Static Water Level

32.0 feet B ground surface A=Above B=Below

10. Pump Test

Pumping level 49.2 ft. below surface

Pumping at 500.0 GPM 72.0 Hrs

11. Well Is: in. Grade A=Above B=Below

Developed?

Disinfected?

Capped?

7. Grout or Other Sealing Material

Method	Kind of Sealing Material	From (ft.)	To (ft.)	# Sacks Cement

12. Did you notify the owner of the need to permanently abandon and fill all unused wells on this property?

If no, explain

CLASS A MIX	surface	65.0	6 S	13. Initials of Well Constructor or Supervisory Driller — Date Signed
GRAVEL PACK	0.0	60.0		Initials of Drill Rig Operator (Mandatory unless same as above) — Date Signed

Additonal Comments?
Owner Sent Label? Y
Variance Issued?
More Geology?

SWAP PROJECT KEYED

Batch 560

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services
400 North Lake Avenue - Crandon, WI 54520
Ph: (715)-478-2777 Fax: (715)-478-3060

ANALYTICAL REPORT

WDNR Laboratory ID No. 721026460
WDATCP Laboratory Certification No. 105-330
EPA Laboratory ID No. WI00034

NLS Project: 296899
NLS Customer: 93382
Fax: 715 359 3364 Phone: 715 359 6177

Client: Rib Mountain Sanitary District
Attn: Mike Heyroth
5703 Lilac Lane
Wausau, WI 54401

Project: Investigative Drinking Water

Well 1 NLS ID: 1047424
COC: 215607:1 Matrix: DW
Collected: 03/28/18 13:05 Received: 03/29/18

Parameter	Result	Units	Dilution	LOD	LOQ/MCL	Analyzed	Method	Lab
Calcium, tot. recoverable as Ca by ICP-MS	20	mg/L	1	0.15*	0.30*	03/31/18	EPA 200.8, Rev 5.4	721026460
Chloride, as Cl (unfiltered)	100	mg/L	20	5.0	10	04/03/18	EPA 300.0, Rev 2.1	721026460
Iron, tot. recoverable as Fe by ICP-MS	0.84	mg/L	1	0.018*	0.064*	03/31/18	EPA 200.8, Rev 5.4	721026460
Manganese, tot. recoverable as Mn by ICP-MS	140 .14	ug/L	1	1.0*	2.0*	03/31/18	EPA 200.8, Rev 5.4	721026460
Sodium, tot. recoverable as Na by ICP	57	mg/L	1	0.045	0.15	03/29/18	EPA 200.7, Rev 4.4	721026460
Solids, tot. dis. (TDS)	240	mg/L	1	2.0*	2.0*	03/30/18	2540 C-1997	721026460
Lab filtration for TDS	yes					03/30/18	EPA 160.1	721026460

Well 2 NLS ID: 1047425
COC: 215607:3 Matrix: DW
Collected: 03/28/18 13:10 Received: 03/29/18

Parameter	Result	Units	Dilution	LOD	LOQ/MCL	Analyzed	Method	Lab
Calcium, tot. recoverable as Ca by ICP-MS	16	mg/L	1	0.15*	0.30*	03/31/18	EPA 200.8, Rev 5.4	721026460
Chloride, as Cl (unfiltered)	82	mg/L	10	2.5	5.0	04/03/18	EPA 300.0, Rev 2.1	721026460
Iron, tot. recoverable as Fe by ICP-MS	1.0	mg/L	1	0.018*	0.064*	03/31/18	EPA 200.8, Rev 5.4	721026460
Manganese, tot. recoverable as Mn by ICP-MS	170 .17	ug/L	1	1.0*	2.0*	03/31/18	EPA 200.8, Rev 5.4	721026460
Sodium, tot. recoverable as Na by ICP	49	mg/L	1	0.045	0.15	03/29/18	EPA 200.7, Rev 4.4	721026460
Solids, tot. dis. (TDS)	190	mg/L	1	2.0*	2.0*	03/30/18	2540 C-1997	721026460
Lab filtration for TDS	yes					03/30/18	EPA 160.1	721026460

Well 3 NLS ID: 1047426
COC: 215607:5 Matrix: DW
Collected: 03/28/18 13:16 Received: 03/29/18

Parameter	Result	Units	Dilution	LOD	LOQ/MCL	Analyzed	Method	Lab
Calcium, tot. recoverable as Ca by ICP-MS	20	mg/L	1	0.15*	0.30*	03/31/18	EPA 200.8, Rev 5.4	721026460
Chloride, as Cl (unfiltered)	99	mg/L	10	2.5	5.0	04/03/18	EPA 300.0, Rev 2.1	721026460
Iron, tot. recoverable as Fe by ICP-MS	0.12	mg/L	1	0.018*	0.064*	03/31/18	EPA 200.8, Rev 5.4	721026460
Manganese, tot. recoverable as Mn by ICP-MS	12	ug/L	1	1.0*	2.0*	03/31/18	EPA 200.8, Rev 5.4	721026460
Sodium, tot. recoverable as Na by ICP	48	mg/L	1	0.045	0.15	03/29/18	EPA 200.7, Rev 4.4	721026460
Solids, tot. dis. (TDS)	210	mg/L	1	2.0*	2.0*	03/30/18	2540 C-1997	721026460
Lab filtration for TDS	yes					03/30/18	EPA 160.1	721026460

Well 4 NLS ID: 1047427
COC: 215607:7 Matrix: DW
Collected: 03/28/18 13:21 Received: 03/29/18

Parameter	Result	Units	Dilution	LOD	LOQ/MCL	Analyzed	Method	Lab
Calcium, tot. recoverable as Ca by ICP-MS	41	mg/L	1	0.15*	0.30*	03/31/18	EPA 200.8, Rev 5.4	721026460
Chloride, as Cl (unfiltered)	350	mg/L	50	13	25	04/03/18	EPA 300.0, Rev 2.1	721026460
Iron, tot. recoverable as Fe by ICP-MS	ND	mg/L	1	0.018*	0.064*	03/31/18	EPA 200.8, Rev 5.4	721026460
Manganese, tot. recoverable as Mn by ICP-MS	7.6	ug/L	1	1.0*	2.0*	03/31/18	EPA 200.8, Rev 5.4	721026460
Sodium, tot. recoverable as Na by ICP	180	mg/L	1	0.045	0.15	03/29/18	EPA 200.7, Rev 4.4	721026460
Solids, tot. dis. (TDS)	630	mg/L	1	2.0*	2.0*	03/30/18	2540 C-1997	721026460
Lab filtration for TDS	yes					03/30/18	EPA 160.1	721026460

WATERPLUS®

PRE-ENGINEERED SOLUTIONS

OXIPLUS^{75}™ Media

OXIPLUS^{75}™ is a highly effective media for the removal of iron, manganese, arsenic, radium and hydrogen sulfide. This robust filter media has proven highly successful in municipal and industrial pretreatment applications where manganese is in the water. Though each treatment application is unique, there are certain general guidelines that need to be followed in order to realize the full benefits of OXIPLUS^{75}™.

When used in combination with the WATERPLUS® filter units, efficient and durable filtration systems are the end result. With our industry leading filtration knowledge, we can ensure the proper media is being used in your system so you can achieve the results you need at a price you can afford.

Product Features

- Reduced system footprint sizes due to the catalytic properties of OXIPLUS^{75}™ allow for high filter loading rates while maintaining high treatment efficiency.
- High volume backwash rates result in reduction in total backwash volumes as compared to standard sand-anthracite or greensand applications.
- NSF/ANSI-61 Certified
- Long media life allows for economical water treatment operation
- When used with an oxidant such as sodium hypochlorite, long-term performance and capability of the media is maintained.

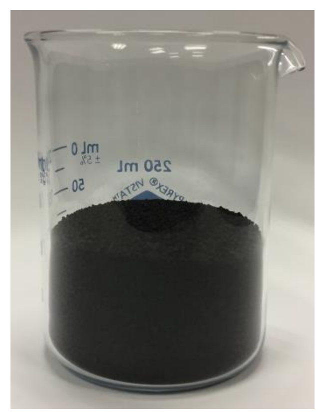


Figure 1: OXIPLUS^{75} Media Sample

Physical Properties

Bulk Density: 115 lb/ft^3 (1.84 kg/L)

Specific Gravity: 3.8 g/cm^3

Mesh Sizes: 20x40 mesh

Packaging: 60 lb. bags or super sacks available

Conditions for Operation

pH: 6.5-9.0

Bed Depth: Actual bed depth dependent on application and water quality, typically 36".

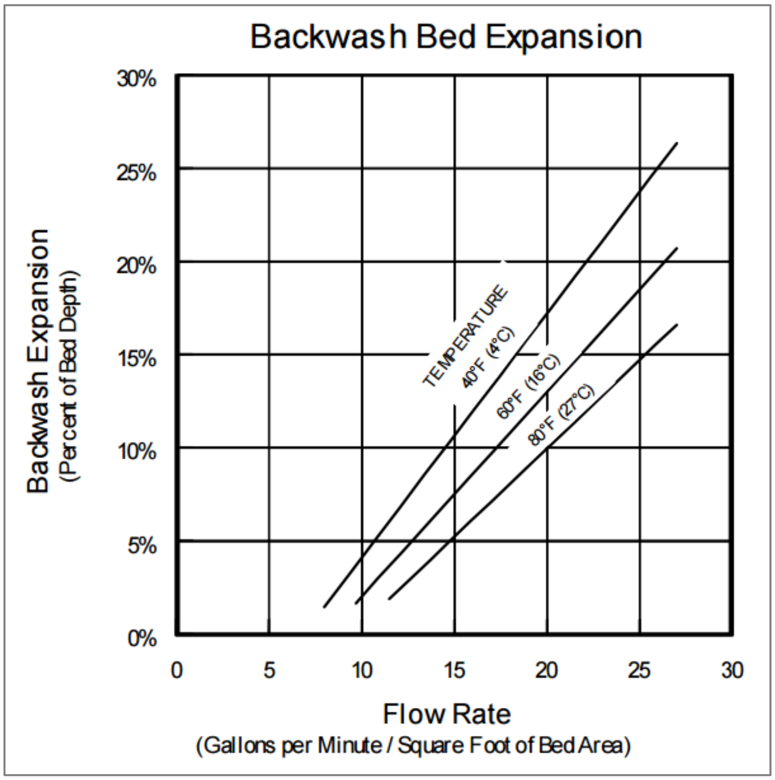
Underbed: 1/2" to 1/4" Gravel, 1/4" to 1/8" Gravel, and 1/8" to 1/16" washed, well sorted transition sand.

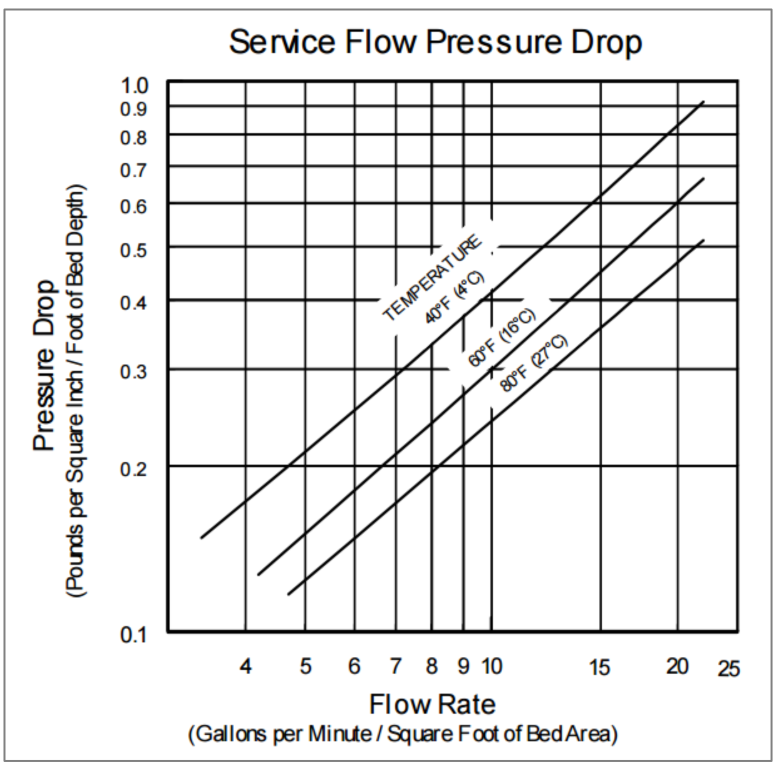
Freeboard: at least 25% of bed depth

Typical Treatment Loading Rate: 6 – 12 gpm/ft^2

Typical Backwash Rate: 25 – 38 gpm/ft^2

OXIPLUS[75]™ Media





226 Atlantic Avenue, P.O. 650 • Clayton, NJ 08312
Phone 856-881-2345 Fax 856-881-6859
Email: info@inversand.com • www.inversand.com

GREENSAND*plus*™

Performance Media for Water Filtration

Removes iron, manganese, hydrogen sulfide, arsenic and radium.

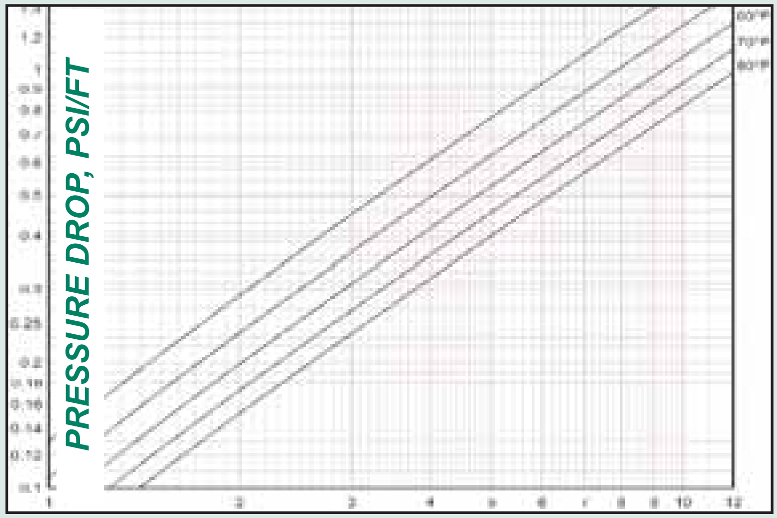
GreensandPlus™ is a black filter media used for removing soluble iron, manganese, hydrogen sulfide, arsenic and radium from groundwater supplies.

The manganese dioxide coated surface of GreensandPlus acts as a catalyst in the oxidation reduction reaction of iron and manganese.

The silica sand core of GreensandPlus allows it to withstand waters that are low in silica, TDS and hardness without breakdown.

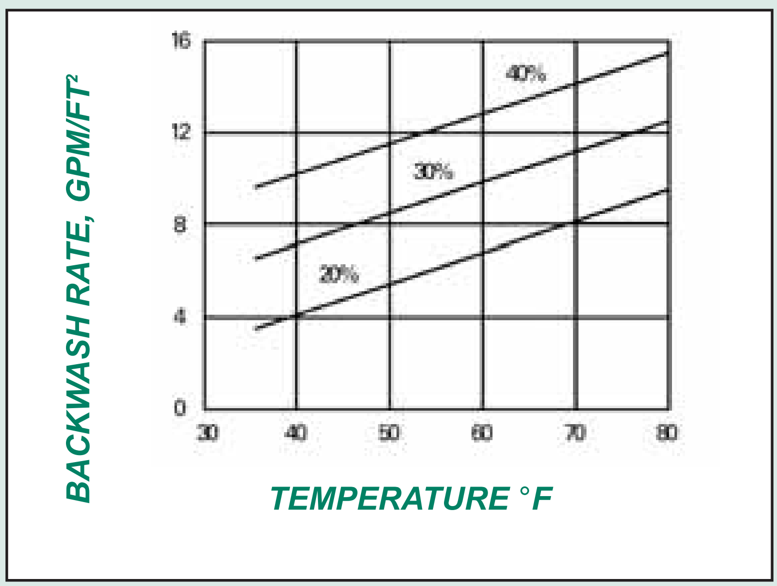
GreensandPlus is effective at higher operating temperatures and higher differential pressures than standard manganese greensand. Tolerance to higher differential pressure can provide for longer run times between backwashes and a greater margin of safety.

GREENSANDPLUS PRESSURE DROP (CLEAN BED)



FLOW RATE (GPM/FT²)

BED EXPANSION DURING BACKWASHING



Systems may be designed using either vertical or horizontal pressure filters, as well as gravity filters.

GreensandPlus is a proven technology for iron, manganese, hydrogen sulfide, arsenic and radium removal. Unlike other media, there is no need for extensive preconditioning of filter media or lengthy startup periods during which required water quality may not be met.

GreensandPlus is an exact replacement for manganese greensand. It can be used in CR or IR applications and requires no changes in backwash rate or times or chemical feeds.

GreensandPlus has the WQA Gold Seal Certification for compliance with NSF/ANSI 61. Packaging is available in 1/2 cubic foot bags or 1 metric ton (2,205 lbs) bulk sacks.

PHYSICAL CHARACTERISTICS

Physical Form
Black, nodular granules shipped in a dry form

Apparent Density
88 pounds per cubic foot net

Shipping Weight
90 pounds per cubic foot gross

Specific Gravity
Approximately 2.4

Porosity
Approximately 0.45

Screen Grading (dry)
18 X 60 mesh

Effective Size
0.30 to 0.35 mm

Uniformity Coefficient
Less than 1.60

pH Range
6.2-8.5 (see General Notes)

Maximum Temperature
No limit

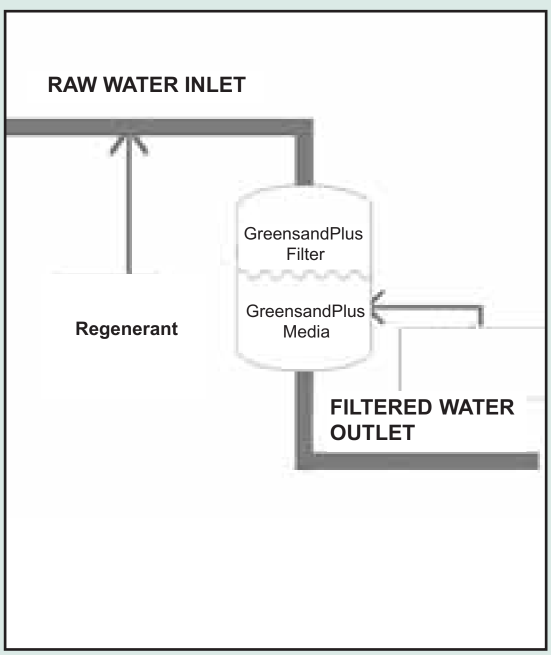
Backwash Rate
Minimum 12 gpm/sq. ft. at 55ºF

Service Flow Rate
2 – 12 gpm/sq. ft.

Minimum Bed Depth
15 inches of each media for dual media beds or 30 inches of GreensandPlus alone.

METHOD OF OPERATION CO

GreensandPlus: Catalytic Oxidation (CO)



Catalytic Oxidation (CO) operation is recommended in applications where iron removal is the main objective in well waters with or without the presence of manganese. This method involves the feeding of a predetermined amount of chlorine (Cl_2) or other strong oxidant directly to the raw water before the GreensandPlus Filter.

Chlorine should be fed at least 10-20 seconds upstream of the filter, or as far upstream of the filter as possible to insure adequate contact time. A chlorine residual carried through the filter will maintain GreensandPlus in a continuously regenerated condition.

For operation using chlorine, the demand can be estimated as follows:

mg/L Cl_2 = (1 x mg/L Fe) + (3 x mg/L Mn) + (6x mg/L H_2S) + (8 x mg/L NH_3)

Initial Conditioning of GreensandPlus

0.2 gal (0.75 L) of 12% sodium hypochlorite for every 1 cu. ft. (28.3 L cu. m) of GreensandPlus into 6.5 gallons (25 L) of water.

Drain the filter enough to add the diluted chlorine mix. Apply the diluted chlorine to the filter being sure to allow the solution to contact the GreensandPlus media. Let soak for a minimum of 4 hours, then rinse to waste until the “free” chlorine residual is less than 0.2 mg/L. The GreensandPlus is now ready for service.

Radium and Arsenic Removal Using GreensandPlus

The GreensandPlus CO process has been found to be successful in removing radium and arsenic from well water. This occurs via adsorption onto the manganese and/or iron precipitates that are formed. For radium removal, soluble manganese must be present in or added to the raw water for removal to occur. Arsenic removal requires iron to be present in or added to the raw water to accomplish removal. Pilot plant testing is recommended in either case.

REFERENCES

USA

American Water Company, CA
San Jacinto, CA
City of Tallahassee, FL
City of Mason City, IL
City of Goshen, IN
City of Hutchinson, KS
City of Burlington, MA
Dedham Water Co., MA
Raynham Center, MA
Northbrook Farms, MD
Sykesville, MD
City of New Bern, NC
Onslow County, NC
Fort Dix, NJ
Jackson Twsp. MUA, NJ
Churchill County, NV
Suffolk County Water Authority, NY
City of Urbana, OH

International

Ozogram, Laval, Quebec, Canada
Sydney, Nova Scotia, Canada

The manufacturing of GreensandPlus is an ongoing, 24/7 process to ensure the highest quality water treatment media.

Inversand Company SINCE 1925
226 Atlantic Avenue • P.O. Box 650 • Clayton, NJ 08312 USA
Tel: **856-881-2345** • Fax: **856-881-6859** • Email: info@inversand.com • **www.inversand.com**

SEH
Building a Better World for All of Us®

July 12, 2018; Revised on July 12, 2018

RE: Rib Mountain Sanitary District
Well No. 1 & 2 Pre-Pilot Study Report
SEH No. RMTSD 145756 14.00

Cathrine Wunderlich, Public Water Engineering Section Chief
Wisconsin Department of Natural Resources
Bureau of Drinking Water and Groundwater, DG/5
101 South Webster Street - P.O. Box 7921
Madison, WI 53707

Dear Ms. Wunderlich:

The Rib Mountain Sanitary District, just southwest of Wausau, currently treats water from Well No. 1 and Well No. 2 for iron and manganese using a proprietary Vyredox® air injection well field system which was constructed in the 1980's. The performance of the air injection system has diminished over time and the wells are in need of new treatment. Enclosed herein you will find a Pre-Pilot Study Approach Submittal corresponding with Well No. 1 and Well No. 2.

EXISTING TREATMENT AND NEED FOR STUDY

The existing Vyredox® water treatment system which treats both Well No. 1 and Well No. 2 has diminished over time in its efficiency for removing iron and manganese from the water source(s). The Sanitary District would like to replace the existing treatment system with new a system. The current Vyredox® treatment system oxidizes the iron and manganese in the soil, leaving the iron and manganese in the water source, except their non-soluble form. The objective of the pilot study would be to find a treatment solution in which the iron and manganese are removed from the water source, rather than being left to accumulate in the aquifer. The Vyredox system will be shut down approximately one month prior to the pilot work to obtain iron and manganese water for the pilot work. This shut down has been discussed with the regional WDNR representative and will be coordinated ahead of time with the same.

The objective of the proposed pilot study is to evaluate alternative iron removal options utilizing various filter media, oxidants, and various loading rates. The raw and finished water will be evaluated for pH, iron and manganese, alkalinity, hardness organics, and THM. The study is anticipated to reveal which media combination, oxidant, at which filter rate will achieve the most efficient iron removal rate versus backwash.

PILOT STUDY WATER SOURCES AND WATER ANALYSIS

The water for the pilot study will be taken from the raw water well piping. Proper backflow prevention will be provided.

PILOT STUDY OBJECTIVES

USEPA National Secondary Drinking Water Standard (MCL) recommendation for the concentration of dissolved iron and manganese in drinking water supplies is 0.3 mg/L and 0.05 mg/, respectively. Based on this criteria, the objectives of this pilot study are as follows:

- Evaluate treatment processes that will reduce levels of dissolved iron and manganese to less than the secondary MCLs of each contaminant.
- Evaluate various methods for oxidation of manganese: permanganate, chlorine, and aeration.
- Evaluate the effectiveness of different filtration media and filtration rates for the removal of dissolved manganese.
- Establish the effective filter loading rate (GPM/ft^2) for each media evaluated.

RAW WATER QUALITY

Water quality measurements were made on 4/6/2018. Well No. 1 contained **0.14 mg/L manganese** and **0.84 mg/L iron**. Well No. 2 contained **0.17 mg/L manganese** and **1.0 mg/L iron**. The secondary MCL per the EPA is listed as 0.05 mg/L for manganese and 0.3 mg/L for iron. The measured iron and manganese are both greater than their respective secondary standards. The iron and manganese will be tested and to verify if it is oxidized or un-oxidized.

PILOT TESTING EQUIPMENT

Chemical Feed System

The chemical feed systems to be used during the pilot treatment testing are peristaltic metering pumps capable of feeding 0.2 gallons per day (GPD) up to 3.5 GPD. The pumps will be set up to feed less than 3.5 GPD for this study. The treatment chemicals to be used will be:

- Sodium hypochlorite (bleach)
- Permanganate mixed at a concentration of 2 grams per liter

Aeration

Aeration will be provided before detention by using a draft aerator for the oxidation of the iron and manganese and the removal of any dissolved gases.

Detention

The detention equipment within the pilot trailer consists of a rectangular PVC basin with adjustable heights to manage alternate detention requirements when necessary. When the tank is operated with a flow of 5 GPM, the approximate raw water detention time is 30 minutes. The tank is constructed with baffles that provide an over and under flow pattern to prevent short circuiting of the tank. The tank also contains a draft tube mixer which will not be used for this pilot.

Filters

A total of up to four (4) filters, each with a diameter of 8 inches by 72 inches tall, will be used during the pilot testing. Each filter vessel has a ¾ inch diameter inlet, 1 ½ inch diameter backwash waste outlet, underdrain system, air release system, rate of flow meters, sample taps, and filter media. Each filter column provides 0.35 square feet (ft^2) of surface area. When the filters are operated at 2 GPM/ft^2, each column has an equivalent water flow rate of 0.7 GPM applied. The filters will be operated in a parallel flow pattern.

PILOT TESTING PLAN – REVISIONS ON 7/12/18

A copy of the pilot plant process flow diagram and the media data sheets can be found in Appendix A. Below is a description of the testing that will take place within the pilot trailer.

Filter Media

The filter media recommended to be tested for this pilot study is based on previous experiences with iron and manganese removal and previous pilot study results. Below is a brief overview of each filtration media:

Pyrolusite is a granular catalytic water filtration media used for the removal of hydrogen sulfide, iron and manganese. The brand name product to be used which is very similar to Pyrolusite is Oxiplus75 TM Media. Both Well No. 2 and Well No.1 will be used to test Oxiplus75 TM. Typical bed depths range from 24-inches to 36-inches. A bed depth of 30-inches and 36-inches will be used for this study. The grain size is 0.4 - 0.5 mm (20 x 40 mesh). Pyrolusite will be evaluated for the removal of iron and manganese. Columns #1 and #2 will be operated to assess the effectiveness of this media on Well No. 1 and on Well No. 2.

GreensandPlus™ is a silica based black colored catalytic filter media used for removing soluble iron, manganese, hydrogen sulfide, arsenic and radium from groundwater supplies. Both Well No. 1 and Well No.2 will be used to test GreensandPlus. The manganese dioxide coated surface of GreensandPlus™ acts as a catalyst in the oxidation reduction reaction of iron and manganese. The effective grain size for GreensandPlus™ is 0.30 to 0.35 mm.

Anthracite (effective size 0.9 - 1.0 mm) will be used in conjunction with GreensandPlus™ and also with silica sand on Well No. 2 and Well No. 1. A dual media bed depth of 12-inches of anthracite and 18-inches of GreensandPlus™ and 12-inches of anthracite and 18-inches of silica sand is expected for columns number 3 and 4. (See chart below)

Silica sand will be used in conjunction with anthracite in column 3 with detention on Well No. 2 and Well No. 1. The size of the media will be 0.45 mm to 0.55 mm with a 1.5 coefficient.

The four filters in the trailer at Well 1 and Well 2 will be operated as follows:

Column #	**1**	**2**	**3**	**4**
Aeration	no	no	yes	yes
Detention	no	no	30 min	30 min
Oxidant	Sodium Hypochlorite	Sodium Hypochlorite	Sodium Hypochlorite	Sodium Hypochlorite
			Permanganate	Permanganate
Media	30 inches	36 inches	18 inches silica	18 inches Green Sand Plus
	Pyrolusite	Pyrolusite	12 inches anthracite	12 inches anthracite
Loading Rate	6 GPM/sf	6 GPM/sf	2-3 GPM/sf	2-3 GPM/sf

Oxidants

Sodium hypochlorite will be used as the oxidant for all of the columns. In addition, permanganate will be used as and oxidant for columns 3 and 4.

Data Collection

The pilot test will include two full filter cycles to a terminal head loss of 8 psi or Fe or Mn breakthrough. On-site water chemistry will be analyzed by the SEH pilot plant operator and will include free chlorine residual, pH, iron, and manganese. Analysis will be completed using a Hach colorimeter and wet chemistry.

In addition to water chemistry, the pilot plant operator will record flow rate, chemical feed rate, head loss, and time.

Waste Disposal

Treated water and backwash water will be discharged to the ground surface to infiltrate. Chlorine residuals in the discharged water will not be greater than the water in the distribution system and therefore safe for discharge onto the ground surface.

Operator Safety

The SEH pilot trailer is equipped with safety equipment that includes an eyewash unit, fire extinguisher, first aid kit, and traffic cones.

Backflow Protection for Water System Facilities

A backflow prevention assembly will be provided between the pilot testing equipment and the connection to the well piping.

Pilot Plant Security

All equipment is housed in a secure trailer. The SEH operator is generally on site at all times during pilot operation. The door on trailer will be locked when operator is absent.

Water Quality Testing

The plan for water quality testing is described below:

1) On site water chemistry will be analyzed by a pilot plant operator during each run:
    a) Testing will include free chlorine residual, pH, iron, manganese, and carbon dioxide
    b) Analysis will be completed using a Hach colorimeter and wet chemistry

Report

Upon completion of the described pilot treatment testing, a final pilot study report will be prepared and submitted to the Department for review and approval.

SUMMARY

Your timely review of this submittal would be greatly appreciated. We trust that the enclosed information is sufficient for you to complete your review of the recommended pilot study approach. Please do not hesitate to contact us if you have any questions or if you need additional information. You may me at 715.720.6255 or jnussbaum@sehinc.com.

Sincerely,

SHORT ELLIOTT HENDRICKSON INC.

Jeff Nussbaum, PE (WI) (Revised on July 12, 2018)
Senior Professional Engineer

Attachments

Enclosure: DNR Form 3300-260

c: Michael Heyroth, Utility Director, Rib Mountain Sanitary District (by email)
John Thom, SEH (by email)
Joshua Bohnert, SEH (by email)

p:\pt\r\rmtsd\145756\4-prelim-dsgn-rpts\pre pilot report\final prep report 5.8.18\rev submittal_07.12.18_rib mountain pre-pilot letter report.docx

State of Wisconsin
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Madison WI 53707-7921

Scott Walker, Governor
Daniel L. Meyer, Secretary
Telephone 608-266-2621
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WISCONSIN
DEPT. OF NATURAL RESOURCES

July 16, 2018

WENDY BELANGER CLERK
RIB MOUNTAIN SANITARY DIST
5703 LILAC AVE
WAUSAU WI 54401

Project Number:	W-2018-0543
PWSID#:	73706600
DNR Region:	WCR
County:	MARATHON

SUBJECT: WATER SYSTEM FACILITIES PLAN AND SPECIFICATION APPROVAL

Dear Ms. Belanger:

The Wisconsin Department of Natural Resources, Division of Environmental Management, Bureau of Drinking Water and Groundwater, is conditionally approving plans and specifications for the following project. An engineering report or information of sufficient detail to meet the requirements of s. NR 811.09(3), Wis. Adm. Code, was submitted along with the plans and specifications.

Water system name: Rib Mountain Sanitary District
Date received: 05/10/2018
Length of Time Extension: None
Engineering firm: SEH Inc
Professional Engineer: Jeff Nussbaum
Regional DNR Contact: Glenn Falkowski, DNR, 5301 Rib Mt Drive, Wausau, WI 54401, (715) 359-5284, glenn.falkowski@wisconsin.gov

Project description: It is proposed to install and operate a water treatment pilot plant at existing well Nos. 1 and 2. The most recent well water collected during the pumping of the two wells was analyzed as containing concentrations of iron at 0.84 mg/l and 1.0 mg/l, and manganese at 140 ug/l and 170 ug/l. The iron and manganese concentrations exceed the secondary aesthetic drinking water standards of 0.3 mg/l and 50 ug/l respectively. The goal of the pilot plant work is to evaluate oxidation of the iron and manganese by sodium hypochlorite, permanganate, and aeration followed by detention and with subsequent removal by gravity and pressure filtration. Presently, a Vyredox treatment system is utilized at these wells. The Vyredox system relies upon a series of recharge wells positioned around the main production wells. Oxygenated water is injected into the recharge wells in order to oxidize iron and manganese within the water bearing geologic formation. In theory, the water pumped from the production well contains lower concentrations of dissolved iron and manganese due to the oxidized iron and manganese being tied up in the geologic formation. The system appears to be losing its effectiveness which has prompted the need for a pilot study to identify a replacement treatment system. The Sanitary District currently adds sodium hypochlorite for disinfection purposes, fluorosilicic acid for the dental health of the community, and sodium hydroxide for pH adjustment and corrosion control within the distribution system.

This is to inform you that the installation and operation of the pilot plant at both well sites may proceed as proposed subject to the conditions below.

Pilot plant operation: The SEH pilot plant trailer will be set up at both wells and individual pilot plant work performed for each well.

The four filters in the trailer at well No. 1 and well No. 2 will be operated as follows:

Filter	Oxidant	Aeration	Detention	Media	Filtration rate
1.	sod. hypo.	No	No	pyrolucite – 30 inches	6 gpm/sq ft
2.	sod. hypo.	No	No	pyrolucite – 36 inches	6 gpm/sq ft
3.	sod. hypo. & permanganate	Yes	30 min	silica & anthracite	2-3 gpm/sq ft
4.	sod. hypo. & permanganate	Yes	30 min	greensand & anthracite	2-3 gpm/sq ft

Two filter runs and one filter backwash will be conducted for each option. Each run will be conducted to a terminal head loss of 8 psi or until iron or manganese breakthrough occurs. The anticipated chemical feed rates are approximately 2.0 mg/l sodium hypochlorite and 0.5 - 1.0 mg/l potassium permanganate.

The backwash rate for the greensand and silica sand medias is expected to be approximately 8 gpm/sq. ft. and 15 gpm/sq. ft. when using pyrolucite. It is anticipated that each filter run will be 15 hours or more in length. The treated water and the filter backwash water will be discharged to the ground surface. Backflow prevention equipment will be installed to protect the well No. 1 and well No. 2 installations.

Water quality sampling: For both pilot plant trials pre-treatment and post-treatment water samples will be analyzed in the trailer for iron, manganese and pH. In addition, flowrate, chemical feed rate, headloss, and elapsed time will be recorded. Post-treatment chlorine residuals will be monitored.

Final report: Upon completion of the pilot plant work, a summary report will be submitted to the Department for review and comment. The report will make recommendations for full scale water treatment improvements to treat the water from both wells.

Approval conditions related to Chapters NR 810 and NR 811, Wis. Adm. Code:

1. Glen Falkowski shall be contacted prior to starting the pilot plant operations so that he can be present on site during the pilot plant operations as he deems it necessary.
2. A final report summarizing the results of the pilot plant work and making recommendations for the design and operation of a full scale WTP shall be submitted to the Department for review and comment.
3. Construction of a final water treatment plant and any associated water system improvements shall not commence until such time as plans and specifications have been submitted to the Department for review and the subsequent written approval of the Department obtained.

Approval conditions related to other Department requirements: None.

Approval constraints: The project was reviewed in accordance with ss. 281.34 and 281.41, Wis. Stats. for compliance with Chapters NR 108, NR 810, NR 811 and NR 820, Wis. Adm. Code and is hereby approved in accordance with ss. 281.34 and 281.41, Wis. Stats. subject to the conditions listed above. This approval is valid for two years from the date of approval. If construction or installation of the improvements has not commenced within two years the approval shall become void and a new application must be made and approval obtained prior to commencing construction or installation.

This approval is based upon the representation that the plans submitted to the Department are complete and accurately represent the project being approved. Any approval of plans that do not fairly represent the project because they are incomplete, inaccurate, or of insufficient scope and detail is voidable at the option of the Department.

Be advised that this project may require permits or approvals from other federal, state or local authorities. For example, a certificate of authority from the Public Service Commission of Wisconsin may be required per s. 196.49, Wis. Stats. and ch. PSC 184, Wis. Adm. Code.

Appeal rights: If you believe that you have a right to challenge this decision, you should know that the Wisconsin Statutes and administrative rules establish time periods within which requests to review Department decisions must be filed. To request a contested case hearing pursuant to s. 227.42, Wis. Stats., you have 30 days after the decision is mailed, or otherwise served by the Department, to serve a petition for hearing on the Secretary of the Department of Natural Resources. Requests for contested case hearings must be made in accordance with ch. NR 2, Wis. Adm. Code. Filing a request for a contested case hearing does not extend the 30 day period for filing a petition for judicial review. For judicial review of a decision pursuant to ss. 227.52 and 227.53, Wis. Stats., you must file your petition with the appropriate circuit court and serve the petition on the Department within 30 days after the decision is mailed. A petition for judicial review must name the Department of Natural Resources as the respondent.

Recommendations: The following recommendations are based on staff review of the project. The owner is not required to implement the recommendations in order to comply with the approval.

1. None

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES

For the Secretary

Ken W Scherer

Ken W. Scherer, PE
Public Water Engineering Section
Bureau of Drinking Water and Groundwater
(715) 520-3981

cc: Michael Heyroth – Rib Mountain Sanitary District (email)
Jeff Nussbaum – SHE Inc. (email)
John Thom – SHE Inc. (email)
Glen Falkowski – DNR, Wausau (email)
Troy Stapelmann – DNR, Eau Claire (email)
Steve Kemna & Mark Williams – PSC, Madison (email)
Ken Scherer – DNR, Spooner (email and copy to file)

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