MEMORANDUM

Date: December 13, 2021

To: Jason Sergeant, City Administrator
Chad Renly, Municipal Services Director
City of Evansville

From: Amy Bares, P.E., Senior Project Engineer – Town & Country Engineering
Ben Heidemann, P.E., Vice President – Town & Country Engineering

Subject: Investigation of Discolored Water Occurrences

This memo provides a summary of the work completed to investigate the causes of brown or discolored water occurrences in the City of Evansville.

System Description and Operation

The City's water system includes three water supply wells, a 300,000-gallon elevated storage tank and a 400,000 gallon ground reservoir with booster station, which operate as follows:

- Wells 1 and 2 discharge to the ground reservoir. The reservoir calls for both Well 1 and Well 2 each pumping cycle, with Well 1 starting a few minutes before Well 2. The flow rate from Well 1 is controlled by a VFD to provide the required blending ratio for radium compliance.
- High lift booster pumps at the Well 2 building draw water from reservoir and boost it to system pressure, discharging at Entry Point 200 to the distribution system.
- Well 3 discharges directly to the distribution system.
- When the water level in the tower indicates the need for more water, the SCADA system calls for Well 3 and the booster pumps alternately to fill the tower.

The City currently adds a blended polyphosphate chemical (AquaMag) to sequester iron and manganese in the water and prevent discolored water occurrences, but additional investigation is needed to address aesthetic water quality issues that have been reported by water customers. Chlorine and fluoride are also added for each entry point.

Compliance Sampling

The City is required by the DNR to perform routine sampling to demonstrate compliance with drinking water standards. According to past compliance sampling results, the City's water meets primary regulatory standards for safe drinking water and is safe to consume. However, past samples show elevated concentrations of manganese that are above the secondary aesthetic standard of 50 ug/L but below the Health Advisory Level of 300 ug/L (Table 1). Iron has also been detected, but has not exceeded the aesthetic standard of 0.3 mg/L. Manganese and iron in excess of the secondary aesthetic standards can cause staining of fixtures and unacceptable taste or color, but the water is still safe to drink unless the Health Advisory Level is exceeded.

Table 1 - Recent Compliance Sample Results
Manganese Concentration (ug/L)

Year	Entry Point 200	Well 3
1999	140	Not constructed
2005	Not sampled	86
2008	148	85
2017	67	93
2021	91	151

All of the compliance samples listed in Table 1 exceed the secondary aesthetic standard of 50 ug/L but are below the Health Advisory Level of 300 ug/L. If a public water system reports manganese concentrations greater than the Health Advisory Level of 300 ug/L, the DNR will require the system to post a public notice informing consumers of the water quality. If concentrations exceed the secondary standard of 50 µg/L, the municipality may be required to address the concentrations, especially if customers report aesthetic issues related to the water quality. The DNR recently increased the City's sampling frequency for manganese to quarterly at each entry point, in part due to customer complaints and the results of the compliance and investigative sampling that has been performed. The quarterly compliance sampling requirement starts in 2022.

Iron and Manganese Treatment and History

There are three main options for dealing with iron and manganese in drinking water:

- Changes in source water/well construction to avoid iron and manganese. The presence of these metals in groundwater water is generally due to the dissolution of naturally occurring minerals (iron hydroxides and manganese dioxide) in the aquifer over time.
- Treatment to remove iron and manganese, generally through oxidation followed by filtration.
- Addition of chemicals to sequester dissolved iron and manganese, to keep them in solution and prevent them from being oxidized to particulate forms, which would show up as brown or black discoloration in water.

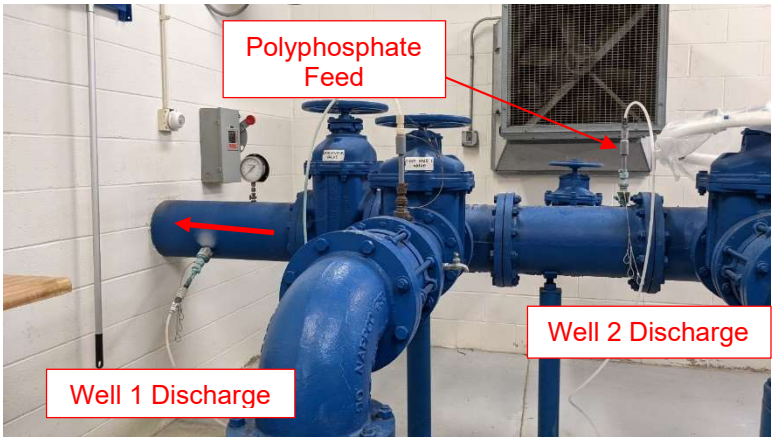
As noted previously, the City uses the third option, sequestration, as the method for treating iron and manganese. This method is usually suitable if the total combined concentration of iron and manganese is less than 1 mg/L, as it is in Evansville. This memo focuses primarily on examining and optimizing the current treatment method and system operation practices, as the other two options would involve considerable capital costs.

AquaMag has been added to the City's water since the mid-1990s to address a long-standing problem with elevated manganese concentrations in the raw water. In a 1989 Comprehensive Water System Study, it was noted that elevated levels of dissolved manganese have been recorded at Wells 1 and 2 and have been linked to discolored water events in the distribution system. The Study reported concentrations of dissolved manganese ranging from approximately 65 ug/L to over 200 ug/L at Wells 1 and 2 from 1966 to 1989. Dissolved iron was also noted as a problem, but concentrations had been below aesthetic standards following reconstruction work on both wells in 1977. Two treatment alternatives, sequestration and filtration, were considered in the 1989 Study to address the problem, with chemical addition for sequestration recommended as the less costly and most practical solution. A subsequent 1991 Comprehensive Water System Study Update noted that discolored water problems could be directly attributed to manganese in the water supply. The report states that "black water complaints usually increase immediately after the water system has been stirred up by flowing hydrants or surges in water usage". Sequestration of manganese with chemical addition of polyphosphates was recommended, to be constructed with the new booster station. According to Martelle, the City's chemical supplier, AquaMag has been added since 1995.

AquaMag is a blend of approximately 70% polyphosphate and 30% orthophosphate. The polyphosphate in the blend is intended to sequester dissolved iron and manganese and keep them from being oxidized. The orthophosphate in the blend provides benefits for corrosion control by forming a protective coating on pipe walls. Polyphosphate can revert to orthophosphate over time in the distribution system.

Oxidized manganese generally forms a black precipitate while oxidized iron is generally reddish-brown/rust colored. The dissolved forms of iron and manganese can be easily oxidized when placed in contact with oxygen or another oxidizing agent such as chlorine. For that reason, polyphosphate should be added as far upstream as possible from chlorine addition in well discharge piping and chemical feed arrangements.

At Wells 1 and 2, the polyphosphate is added to the Well 2 discharge just prior to where the Well 1 discharge joins the piping. Chlorine is added in the chemical room at the downturned elbow, before the piping goes through the floor and to the reservoir. At Well 3, the polyphosphate feed point is just after the well discharge head and the chlorine feed point is as far downstream as possible.



Well 1 and 2 Chemical Feed Points

Well 3 Chemical Feed Points

Discolored Water Occurrences

Current City staff have noted that discolored water events are often linked to disturbances of the distribution system such as construction or flushing events, which is consistent with historical observations. The most discolored water is encountered when they flush near Genesis Drive (northeast area) and Franklin Street (east-central area).

The City has implemented a web-based form for collecting customer complaints, with the location of complaints available on the City's GIS. The map in Attachment 1 shows the locations of the customer comments collected since October 2021, including complaints that were submitted to the PSC in August 2021. The locations of the complaints do not appear to have any specific spatial distribution or pattern but many mention brown/discolored water and sediment. The four complaints that were collected using the web-based form in October-November 2021 are included in Attachment 1. The City will continue to log concerns if received.

Investigative Sampling

In September and October 2021, investigative sampling was performed by City staff at the following locations:

- Raw/untreated water from Wells 1, 2, and 3
- Treated water at Entry Point 200 (ground reservoir discharge, combined Wells 1 and 2)
- Treated water from Well 3 at the nearby park building, considered the Well 3 Entry Point
- Water Tower discharge
- Three distribution system locations - Countryside Park, the City Offices, and the Water & Light building

Four rounds of samples were collected and sent to the Wisconsin State Laboratory of Hygiene for analysis of dissolved and total iron and manganese, hardness, calcium, magnesium, orthophosphate and total phosphorus, total organic carbon (TOC), pH and conductivity. The intent was to provide a comprehensive set of water quality data to help make decisions about optimizing water treatment, operation, and maintenance efforts. The results from the 2021 investigative sampling are provided in the Attachment 2 summary tables for the wells/entry points and the distribution system samples.

Summary of Investigative Results

Table 2 below summarizes the raw and entry point manganese results. Raw water from all three wells exceeded the aesthetic standard for manganese in all of the recent samples, with ranges of 87 – 113 ug/L at Well 1, 140 - 147 ug/L at Well 2, and 49 – 151 ug/L at Well 3. Almost all of the manganese in the raw water is in dissolved form and is likely from dissolution of naturally occurring minerals in the aquifer. Iron was detected in the raw water from Well 2 at approximately 0.15 mg/L, half of the aesthetic standard, and does not appear to be a significant issue. Iron was not detected or near the detection limit for Wells 1 and 3.

Table 2 - Raw and Entry Point Sample Results

Sample Location	Sample Date	Manganese, Total	Manganese, Dissolved	Calculated % Dissolved	Manganese, Particulate*	Calculated % Particulate
Units		ug/L	ug/L	%	ug/L	%
Raw Water Well 1	9/16/2021	87.4				
	10/5/2021	110	114	104%	0	0%
	10/11/2021	113	115	102%	0	0%
	10/18/2021	110	108	98%	2	2%
	10/26/2021	107	112	105%	0	0%
Raw Water Well 2	9/16/2021	140				
	10/5/2021	143	148	103%	0	0%
	10/11/2021	147	146	99%	1	1%
	10/18/2021	141	136	96%	5	4%
	10/26/2021	147	151	103%	0	0%
Entry Point 200 (Well 1 and 2 Combined)	9/20/2021	111				
	10/5/2021	136	73.8	54%	62.2	46%
	10/13/2021	91.3				
	10/11/2021	130	119	92%	11.0	8%
	10/18/2021	129	95.8	74%	33.2	26%
	10/25/2021	136	105	77%	31.0	23%

*Particulate manganese estimated by subtracting dissolved manganese from total manganese.
Shading indicates exceedance of aesthetic standard for total manganese results.

Table 2 - Raw and Entry Point Sample Results (continued)

Sample Location	Sample Date	Manganese, Total	Manganese, Dissolved	Calculated % Dissolved	Manganese, Particulate*	Calculated % Particulate
Units		ug/L	ug/L	%	ug/L	%
Raw Water Well 3	9/16/2021	143				
	10/4/2021	92.5	89.9	97%	2.6	3%
	10/13/2021	151				
	10/13/2021	91.4	89.0	97%	2.4	3%
	10/18/2021	87.6	84.3	96%	3.3	4%
	10/26/2021	48.7	47.9	98%	0.8	2%
Entry Point Well 3 (175 Parkview, D-43)	9/21/2021	25.5				
	10/4/2021	86.2	55.7	65%	30.5	35%
	10/11/2021	26.0	11.6	45%	14.4	55%
	10/19/2021	32.4	19.5	60%	12.9	40%
	10/25/2021	29.8	16.5	55%	13.3	45%

*Particulate manganese estimated by subtracting dissolved manganese from total manganese.
Shading indicates exceedance of aesthetic standard for total manganese results.

A comparison of raw water and entry point sample provides an indication of the effectiveness of sequestration. At Entry Point 200 (Well 1 and 2 combined), total manganese concentrations were similar to the raw concentrations and ranged from 91 to 136, with the majority (54-92%) of it in dissolved form. This indicates that a good portion of the manganese is sequestered by the polyphosphate and is not oxidized in the reservoir, but some oxidation is occurring.

At the entry point sampling location for Well 3, total manganese concentrations ranged from 26 to 86 ug/L, with approximately half (45-65%) of the manganese in dissolved form. This indicates that sequestration may not be as effective at Well 3 as it is at Wells 1 and 2, and that oxidation of manganese is occurring, likely from contact with chlorine before sequestration can occur. However, the total manganese concentrations at the Well 3 entry point are considerably lower than the raw water concentrations, and only one of the three samples exceeded the aesthetic standard. The reason for the difference in total manganese between raw and entry point samples at Well 3 is not entirely known, but it is possible that particulate manganese is settling out before it reaches the entry point at the park building.

Samples were collected at the water tower and three other distribution system sites with four sets of samples each and one additional round of total manganese samples. The manganese results for these samples are summarized in Table 3. Of the 20 total manganese samples, three samples exceeded the aesthetic standard, two at the City Office (53 and 67 ug/L) and one at Countryside Park (78 ug/L). 11 of the 20 samples were 30 ug/L or higher. The lowest manganese concentrations were at the Utility building on S. Madison. The majority of the manganese in the distribution samples is in the particulate form, indicating that it is in the oxidized/colored form. The difference between entry point and distribution system manganese indicates that the manganese is being oxidized and settled out as solids in the distribution system. There is a great deal of variability in the data, which also indicates that water quality may be influenced by movement of water and disturbance of sediment in the distribution system.

Table 3 - Distribution System Sample Results

Sample Location	Sample Date	Manganese, Total	Manganese, Dissolved	Calculated % Dissolved	Manganese, Particulate*	Calculated % Particulate
Units		ug/L	ug/L	%	ug/L	%
200 Cemetery Rd (Water Tower)	9/16/2021	38.4				
	10/5/2021	40.0	3.70	9%	36.3	91%
	10/11/2021	30.1	3.12	10%	27.0	90%
	10/13/2021	23.9	4.80	20%	19.1	80%
	10/26/2021	22.3	5.25	24%	17.1	76%
43 N Water St (Countryside Park, D-37)	9/21/2021	46.3				
	10/4/2021	77.7	25.3	33%	52.4	67%
	10/11/2021	30.0	16.0	53%	14.0	47%
	10/12/2021	16.7	7.20	43%	9.5	57%
	10/25/2021	26.0	9.77	38%	16.2	62%
31 S Madison St (City Office, D-38)	9/22/2021	52.9				
	10/4/2021	67.4	15.7	23%	51.7	77%
	10/11/2021	31.0	19.0	61%	12.0	39%
	10/19/2021	28.1	7.51	27%	20.6	73%
	10/25/2021	17.6	7.41	42%	10.2	58%
535 S Madison (Utility Building, D-40)	9/22/2021	30.4				
	10/4/2021	32.8	2.71	8%	30.1	92%
	10/11/2021	16.4	8.07	49%	8.3	51%
	10/19/2021	19.0	6.78	36%	12.2	64%
	10/25/2021	21.2	4.67	22%	16.5	78%

*Particulate manganese estimated by subtracting dissolved manganese from total manganese.
Shading indicates exceedance of aesthetic standard for total manganese results.

The total and ortho phosphorus data in Tables 4 and 5 shows that the current polyphosphate feed results in fairly consistent residuals at the entry points and in the distribution system, with some reversion of polyphosphate to ortho in the distribution system, as expected.

Table 4 – Total and Ortho Phosphorus Sample Results – Wells/Entry Points

Sample Location	Sample Date	Phosphorus, Total	Phosphorus, Dissolved Reactive (Ortho)
Units		mg/L as P	mg/L as P
Raw Water Well 1	10/5/2021	<0.009	0.00492
	10/11/2021	<0.009	<0.003
	10/18/2021	<0.009	0.00519
	10/26/2021	<0.009	0.00512
Raw Water Well 2	10/5/2021	0.0133	0.006
	10/11/2021	0.0203	0.00853
	10/18/2021	0.00909	0.00686
	10/26/2021	0.0124	0.00727
Entry Point 200 (Well 1 and 2 Combined)	10/5/2021	1.28	0.508
	10/11/2021	1.16	0.451
	10/18/2021	1.12	0.453
	10/25/2021	0.994	0.403
Raw Water Well 3	10/4/2021	<0.009	0.00328
	10/13/2021	<0.009	0.00365
	10/18/2021	<0.009	0.0045
	10/26/2021	<0.009	0.00488
Entry Point Well 3 (175 Parkview, D-43)	10/4/2021	1.27	0.523
	10/11/2021	1.29	0.751
	10/19/2021	1.24	0.709
	10/25/2021	1.16	0.645

Table 5 – Total and Ortho Phosphorus Sample Results – Distribution System

Sample Location	Sample Date	Phosphorus, Total	Phosphorus, Dissolved Reactive (Ortho)
Units		mg/L as P	mg/L as P
200 Cemetery Rd (Water Tower)	10/5/2021	1.26	0.726
	10/11/2021	1.24	0.713
	10/13/2021	1.11	0.719
	10/26/2021	1.12	0.659
43 N Water St (Countryside Park, D-37)	10/4/2021	1.26	0.564
	10/11/2021	1.15	0.580
	10/12/2021	1.15	0.666
	10/25/2021	1.08	0.593
31 S Madison St (City Office, D-38)	10/4/2021	1.26	0.710
	10/11/2021	1.18	0.689
	10/19/2021	1.12	0.801
	10/25/2021	1.06	0.717
535 S Madison (Utility Building, D-40)	10/4/2021	1.24	0.764
	10/11/2021	1.19	0.724
	10/19/2021	1.11	0.685
	10/25/2021	1.04	0.654

Conclusions and Recommendations

The first steps in addressing the City's discolored water issues involve optimizing the current raw water treatment and distribution system maintenance based on the following recommendations:

- Results show that there may be opportunities to improve/optimize chemical addition for sequestration. Some oxidation of manganese is occurring prior to water entering the distribution system and the distribution system samples indicate that manganese is being oxidized and settled out as solids in the distribution system. The recommended next step is to share the data with the City's chemical supplier, Martelle Water Treatment, and ask them about options for better sequestration, including different polyphosphate blends, dosage, and mixing options. Any changes to the type of chemical, phosphate blend, and dosage will require plan review and approval by the DNR.
- Observations from City staff and customer complaints indicate that discolored water events are often associated with disturbances of the distribution system. Since high concentrations of iron and manganese occurred for decades prior to the installation of treatment, and data indicate that particulate manganese is still being created, it is likely that there are substantial deposits of sediment/scale containing iron and manganese in the City's pipes that contribute to discolored water occurrences. Legacy deposits of manganese in a distribution system are sensitive to changes in water quality and chemical addition, as well as physical and hydraulic disturbances. Any of these could cause mobilization of these deposits and lead to discolored water events. Although the City performs routine flushing of its system, this flushing most likely does not develop the scouring velocities needed to remove the legacy deposits. A structured uni-directional flushing (UDF) program should be implemented to develop the required velocities for effective distribution system cleaning. UDF will need to be performed on a regular (annual or semi-annual) basis to clean and maintain the system.
- Property owners that have specific, localized problems with discolored water may have similar legacy deposits in their service lines and premise plumbing. Flushing and/or air scouring of these private lines could be recommended to property owners with specific concerns.

- Additional sampling is recommended after UDF to document system changes and flushing effectiveness. Sampling should be performed at the same locations as the previous investigative sampling and on the same day throughout the system to allow for direct comparison of the results, with analysis for total iron, total and dissolved manganese, total and reactive (ortho) phosphorus, and residual chlorine.
- The City should continue to track water quality complaints and encourage customers to provide feedback using the on-line form. The results should be examined quarterly, particularly following any changes to system operation and maintenance.

If optimization of chemical feed and implementation of UDF are not successful in addressing the discolored water issues, then the City may need to consider other options for dealing with manganese, including rehabilitation of existing wells, constructing a new well, or installing filtration.

Raw water from the City's wells has high concentrations of dissolved manganese, with similar results for all three wells. The current manganese concentrations are similar to data collected in past decades, indicating that this is a long-standing water quality issue in the local aquifer. The wells have similar total depths but differing casing depths, meaning that they may draw water from different geologic formations. All three boreholes are open to the Wonewoc, Eau Claire and Mt Simon formations, with Well 2 also open to the overlying St. Lawrence and Tunnel City formations. Given the similar manganese data for the three wells, there does not appear to be one particular location or geologic formation that is the cause of the manganese issues, and a new well constructed within the City may have the same issues as the existing wells. An investigation of the existing wells could be performed to see if one zone is the source of the high manganese concentrations, and whether casing past or filling this portion of the wells would lead to significant loss of capacity, but these investigations are costly and may not be conclusive.

If filtration is pursued, this will require significant capital costs for installation of a treatment system at each entry point, as centralized treatment is not feasible. Typical treatment for manganese removal includes addition of a chemical oxidant, such as chlorine or permanganate, followed by pressure filtration. This would be required at the both the Well 1 and 2 location and at Well 3. Costs for adding a pressure filter could be as much as $1.5 to $2 Million per location.

AMB
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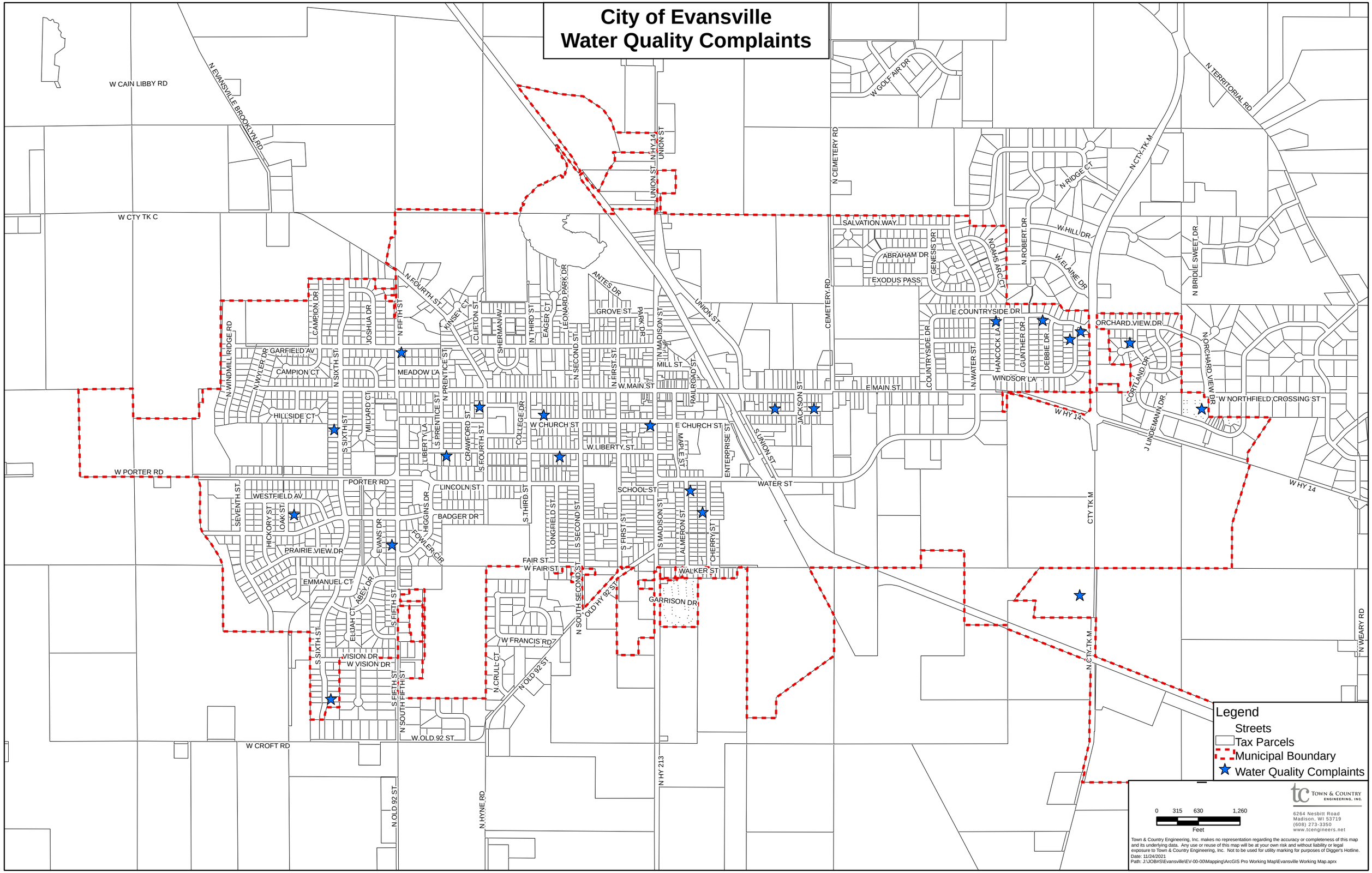
ATTACHMENT 1

Water Quality Complaints Map and Web Forms

City of Evansville
Water Quality Complaints



Legend

- Streets
- Tax Parcels
- Municipal Boundary
- Water Quality Complaints

0 315 630 1,260

Feet

TOWN & COUNTRY ENGINEERING, INC.

6264 Nesbitt Road
Madison, WI 53719
(608) 273-3350
www.tcengineers.net

Date: 11/24/2021

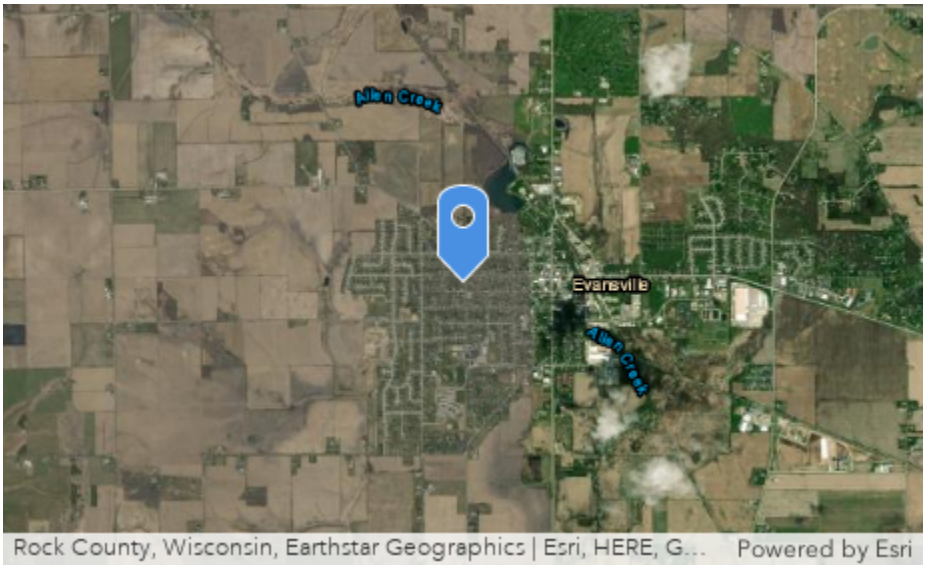
Path: J:\JOB#\Evansville\EV-00-00\Mapping\ArcGIS Pro Working Map\Evansville Working Map.aprx

Water Quality Issue Evansville, WI

Submitted By: Anonymous user

Submitted Time: November 23, 2021 9:32 AM

Location Where Issue Occurred



Name

Sarah Krause

Email Address

Sarah.k.krause@gmail.com

Date Issue Occurred

November 22, 2021

Please describe the issue you observed

Ongoing issue. Water is discolored (brown) and contains black specks of sediment.
23 1/2 S 4th St

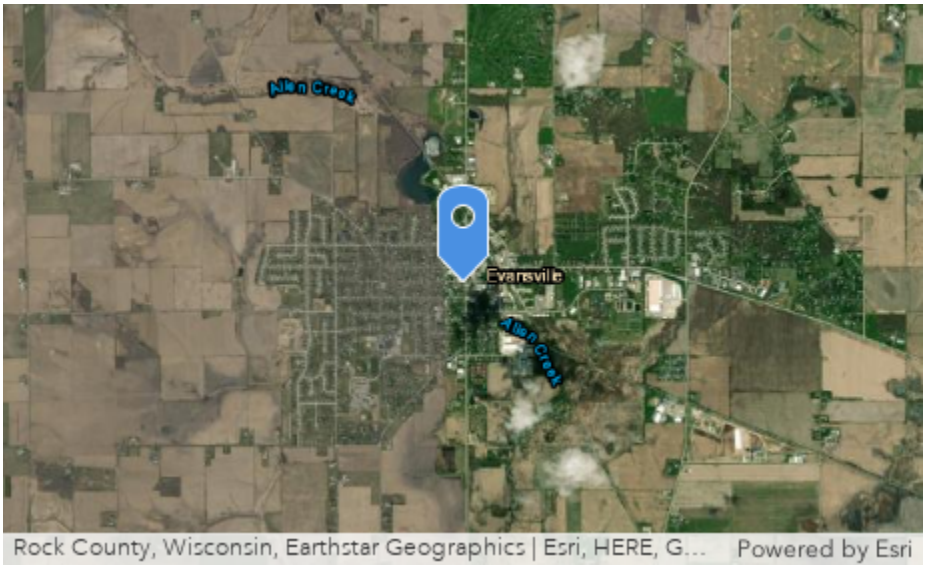
Water Service Type (if known)

Water Quality Issue Evansville, WI

Submitted By: Anonymous user

Submitted Time: October 24, 2021 7:51 PM

Location Where Issue Occurred



Name

Rudolph Lothary

Email Address

lotharyr@yahoo.com

Date Issue Occurred

October 24, 2021

Please describe the issue you observed

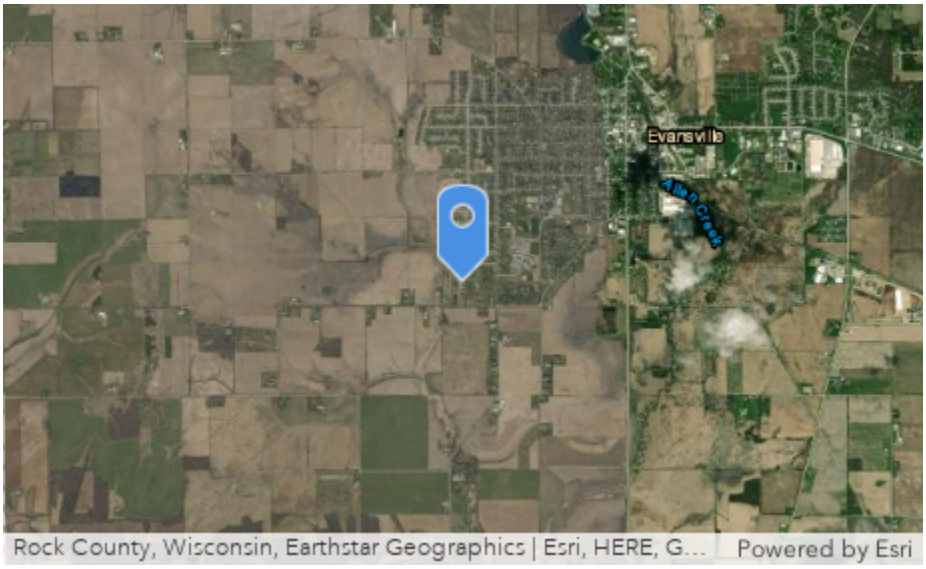
Nasty brown color and taste change. Same problem comes and goes every few weeks. Happened today. We live in the white multi-apartment building across the street from city hall. Not exactly sure what kind of pipe service this building has. 105 S Madison Street

Water Quality Issue Evansville, WI

Submitted By: Anonymous user

Submitted Time: October 8, 2021 8:37 AM

Location Where Issue Occurred



Name

Corey & Brooke Breezer

Email Address

breezer18@gamil.comg

Date Issue Occurred

October 8, 2021

Please describe the issue you observed

Concern about water quality, would like water tested. Animals have been sick and they have had to put one of them down and are now on the way to the vet with the other 2 dogs that had the same thing as the other dog. Also kids have been sick off and on for months with stomach issue. She doesn't know if it is the water but that

seems to be the common denominator. Would like someone to call her today. 608-575-7420

Water Service Type (if known)

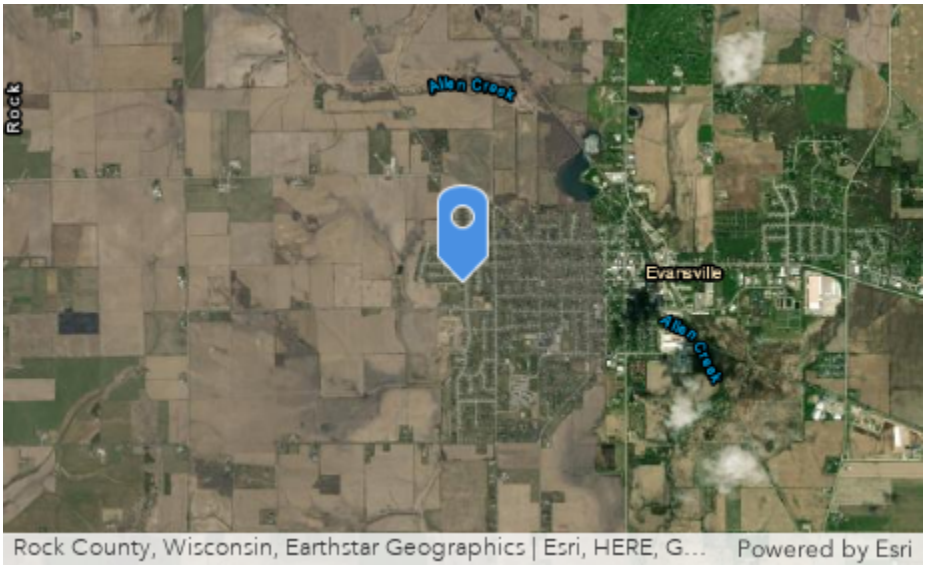
Copper

Water Quality Issue Evansville, WI

Submitted By: Anonymous user

Submitted Time: November 4, 2021 2:02 PM

Location Where Issue Occurred



Name

Barbara Ischi

Email Address

Date Issue Occurred

November 3, 2021

Please describe the issue you observed

Noticed sediment in glass of water from the kitchen sink.

Water Service Type (if known)

Copper

ATTACHMENT 2

Water Quality Data Summaries

City of Evansville

Water Quality Data Summary - Wells and Entry Points

Sample Location		Raw Water Well 1					Raw Water Well 2					Entry Point 200 (Well 1 and 2 Combined)					
Sample Date		9/16/2021	10/5/2021	10/11/2021	10/18/2021	10/26/2021	9/16/2021	10/5/2021	10/11/2021	10/18/2021	10/26/2021	9/20/2021	10/5/2021	10/13/2021	10/11/2021	10/18/2021	10/25/2021
Sample Time		11:30	9:45	10:20	8:00	10:45	11:45	9:50	10:25		11:00	13:00	10:20	12:30	10:30	8:15	9:45
Sample Type		Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Compliance	Investigative	Investigative	Investigative
Parameter	Units																
pH	SU		7.71	7.73	7.69	7.56		7.67	7.58	7.72	7.52		7.58		7.81	7.73	7.71
Alkalinity	mg/L as CaCO3		317	315	315	316		311	309	310	309		311		309	312	308
Hardness	mg/L as CaCO3		311	331	318	316		310	322	307	316		314		320	319	315
Calcium	mg/L		51.1	54.7	52.2	52.7		59.7	63.0	60.3	62.2		59.8		61.0	60.6	60.8
Magnesium	mg/L		44.4	47.2	45.4	44.8		39.2	40.0	38.1	39.0		40.1		40.7	40.7	39.6
Conductivity	uS/cm		565	562	564	566		562	555	563	561		572		562	571	564
Phosphorus, Total	mg/L as P		<0.009	<0.009	<0.009	<0.009		0.0133	0.0203	0.00909	0.0124		1.28		1.16	1.12	0.994
Phosphorus, Dissolved Reactive (Ortho)	mg/L as P		0.00492	<0.003	0.00519	0.00512		0.006	0.00853	0.00686	0.00727		0.508		0.451	0.453	0.403
TOC mg/L	mg/L		<0.40	<0.40	<0.40	<0.40		<0.40	<0.40	<0.40	<0.40		<0.40		<0.40	<0.40	<0.40
Iron, Total	mg/L		<0.05	<0.05	<0.05	<0.05		0.155	0.147	0.106	0.148		0.109		0.11	0.108	0.107
Iron, Dissolved			<0.05	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05		<0.05		<0.05	<0.05	<0.05
Manganese, Total	ug/L	87.4	110	113	110	107	140	143	147	141	147	111	136	91.3	130	129	136
Manganese, Dissolved	ug/L		114	115	108	112		148	146	136	151		73.8		119	95.8	105
Calculated % Dissolved	%		104%	102%	98%	105%		103%	99%	96%	103%		54%		92%	74%	77%
Manganese, Particulate*	ug/L		0	0	2	0		0	1	5	0		62.2		11.0	33.2	31.0
Calculated % Particulate	%		0%	0%	2%	0%		0%	1%	4%	0%		46%		8%	26%	23%

Sample Location		Raw Water Well 3						Entry Point Well 3 (175 Parkview, D-43)				
Sample Date		9/16/2021	10/4/2021	10/13/2021	10/13/2021	10/18/2021	10/26/2021	9/21/2021	10/4/2021	10/11/2021	10/19/2021	10/25/2021
Sample Time		12:45	10:18	10:00	8:00	10:30	10:30		10:20	9:50	9:00	10:15
Sample Type		Investigative	Investigative	Compliance	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative
Parameter	Units											
pH	SU		7.71		7.88	7.82	7.72		7.71	7.62	7.82	7.73
Alkalinity	mg/L as CaCO3		306		305	308	311		306	304	304	306
Hardness	mg/L as CaCO3		301		314	312	310		310	326	301	308
Calcium	mg/L		50.8		53.3	53.1	50.8		52.4	55.6	51.2	53.1
Magnesium	mg/L		42.2		43.9	43.6	44.5		43.6	45.5	42.1	42.5
Conductivity	uS/cm		548		546	555	558		558	551	553	553
Phosphorus, Total	mg/L as P		<0.009		<0.009	<0.009	<0.009		1.27	1.29	1.24	1.16
Phosphorus, Dissolved Reactive (Ortho)	mg/L as P		0.00328		0.00365	0.0045	0.00488		0.523	0.751	0.709	0.645
TOC mg/L	mg/L		<0.40		<0.40	<0.40	<0.40		<0.40	<0.40	<0.40	<0.40
Iron, Total	mg/L		0.055		<0.05	<0.05	0.0917		<0.05	<0.05	<0.05	<0.05
Iron, Dissolved			<0.05		<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05
Manganese, Total	ug/L	143	92.5	151	91.4	87.6	48.7	25.5	86.2	26.0	32.4	29.8
Manganese, Dissolved	ug/L		89.9		89.0	84.3	47.9		55.7	11.6	19.5	16.5
Calculated % Dissolved	%		97%		97%	96%	98%		65%	45%	60%	55%
Manganese, Particulate*	ug/L		2.6		2.4	3.3	0.8		30.5	14.4	12.9	13.3
Calculated % Particulate	%		3%		3%	4%	2%		35%	55%	40%	45%

Notes:

Shading indicates an exceedance of the secondary/aesthetic standard for drinking water.

Investigative Samples were collected by City to investigate water quality and aesthetics.

Compliance Samples were collected by City as part of normal DNR compliance sampling.

*Particulate Manganese estimated by subtracting dissolved maganese from total manganese.

City of Evansville

Water Quality Data Summary - Distribution System

Sample Location		200 Cemetery Rd (Water Tower)					43 N Water St (Countryside Park, D-37)				
Sample Date		9/16/2021	10/5/2021	10/11/2021	10/13/2021	10/26/2021	9/21/2021	10/4/2021	10/11/2021	10/12/2021	10/25/2021
Sample Time		12:30	10:00	11:15	9:15	10:15		10:40	10:10	9:30	10:30
Sample Type		Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative
Parameter	Units										
pH	SU		7.64	7.81	7.98	7.75		7.68	7.65	7.83	7.66
Alkalinity	mg/L as CaCO3		311	307	307	308		311	311	311	310
Hardness	mg/L as CaCO3		301	316	314	306		318	325	299	309
Calcium	mg/L		57.3	60.5	59.9	59.1		60.2	62.2	57.3	59.7
Magnesium	mg/L		38.4	40.0	39.9	38.5		40.6	41.1	37.9	38.9
Conductivity	uS/cm		571	561	563	566		567	564	569	567
Phosphorus, Total	mg/L as P		1.26	1.24	1.11	1.12		1.26	1.15	1.15	1.08
Phosphorus, Dissolved Reactive (Ortho)	mg/L as P		0.726	0.713	0.719	0.659		0.564	0.580	0.666	0.593
TOC mg/L	mg/L		<0.40	<0.40	<0.40	<0.40			<0.40	<0.40	<0.40
Iron, Total	mg/L		0.0521	<0.05	<0.05	<0.05		0.0838	0.0605	<0.05	<0.05
Iron, Dissolved	mg/L		<0.05	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05
Manganese, Total	ug/L	38.4	40.0	30.1	23.9	22.3	46.3	77.7	30.0	16.7	26.0
Manganese, Dissolved	ug/L		3.70	3.12	4.80	5.25		25.3	16.0	7.2	9.8
Calculated % Dissolved	%		9%	10%	20%	24%		33%	53%	43%	38%
Manganese, Particulate*	ug/L		36.3	27.0	19.1	17.1		52.4	14.0	9.5	16.2
Calculated % Particulate	%		91%	90%	80%	76%		67%	47%	57%	62%

Sample Location		31 S Madison St (City Office, D-38)					535 S Madison (Utility Building, D-40)				
Sample Date		9/22/2021	10/4/2021	10/11/2021	10/19/2021	10/25/2021	9/22/2021	10/4/2021	10/11/2021	10/19/2021	10/25/2021
Sample Time		12:00	12:30	11:00	8:30	10:00	12:30	11:55	10:45	8:00	10:45
Sample Type		Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative	Investigative
Parameter	Units										
pH	SU		7.63	7.73	7.79	7.83		7.66	7.78	7.86	7.72
Alkalinity	mg/L as CaCO3		309	308	311	308		309	309	310	310
Hardness	mg/L as CaCO3		315	321	324	310		306	322	319	318
Calcium	mg/L		59.8	61.1	61	59.5		58.4	61.7	61.000	61.6
Magnesium	mg/L		40.2	40.9	41.6	39.2		38.8	40.7	40.6	39.9
Conductivity	uS/cm		563	561	567	562		567	564	564	568
Phosphorus, Total	mg/L as P		1.26	1.18	1.12	1.06		1.24	1.19	1.11	1.04
Phosphorus, Dissolved Reactive (Ortho)	mg/L as P		0.710	0.689	0.801	0.717		0.764	0.724	0.685	0.654
TOC mg/L	mg/L		0.411	<0.40	<0.40	<0.40		<0.40	<0.40	<0.40	<0.40
Iron, Total	mg/L		0.0767	0.0584	0.0659	<0.05		<0.05	<0.05	<0.05	0.0509
Iron, Dissolved	mg/L		<0.05	<0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05
Manganese, Total	ug/L	52.9	67.4	31.0	28.1	17.6	30.4	32.8	16.4	19.0	21.2
Manganese, Dissolved	ug/L		15.7	19.0	7.51	7.4		2.71	8.07	6.78	4.67
Calculated % Dissolved	%		23%	61%	27%	42%		8%	49%	36%	22%
Manganese, Particulate*	ug/L		51.7	12.0	20.59	10.2		30.1	8.3	12.2	16.5
Calculated % Particulate	%		77%	39%	73%	58%		92%	51%	64%	78%

Notes:

Shading indicates an exceedance of the secondary/aesthetic standard for drinking water

Investigative Samples were collected by City to investigate water quality and aesthetics.

*Particulate Manganese estimated by subtracting dissolved maganese from total manganese.