Diversion Approval Report for 2023

Prepared By:

Waukesha Water Utility and the Clean Water Plant on behalf of the City of Waukesha

Supported By:

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Acronyms and Abbreviations

BPS	booster pumping station in Waukesha
CEM	conservation and efficiency measure
CWP	Clean Water Plant
DNR	Wisconsin Department of Natural Resources
gpd	gallons per day
MGD	million gallon(s) per day
MWW	Milwaukee Waterworks
REU	residential equivalency unit
USGS	U.S. Geological Survey
WBR	winter-based rate
WPSC	Wisconsin Public Service Commission
WWU	Waukesha Water Utility

The June 21, 2016, Final Decision approving of the Application by the City of Waukesha, Wisconsin (City), for a Diversion of Great Lakes Water from Lake Michigan and an Exception to Allow the Diversion sets forth various conditions of the approval.

Condition J of the Final Decision requires an annual report be filed that "documents the daily, monthly, and annual amounts of water diverted and returned to the Lake Michigan watershed over the previous calendar year." The City of Waukesha began its transition to Lake Michigan water in October 2023, thereby requiring reporting as specified in the Final Decision and the Wisconsin Department of Natural Resources (DNR) June 29, 2021, Diversion Approval. This report satisfies the requirements and mirrors the lettering format of the Diversion Approval, Section 12, *Reporting* (Diversion Approval, page 10).

A. Compact Principles

Requirement: The City shall summarize that the diversion was implemented consistent with the requirements of the Council Decision.

On August 15, 2023, the Waukesha Water Utility (WWU) first obtained water from Milwaukee Waterworks (MWW) as part of new equipment commissioning and preparing the new system for the transition to Lake Michigan water. This marked the beginning of the start-up phase, which was defined as the time when water was first obtained from MWW, and a water balance would be achieved after an initial transition to Lake Michigan water. On October 9, 2023, the WWU completed its commissioning and testing of new equipment and began the initial transition to MWW water. This initial transition phase continued until more than 90% of customers were supplied by MWW water, a process that took 6 days, ending on October 14, 2023. During this time, the Clean Water Plant (CWP) provided a daily return volume of 5.15 million gallons (the 2022 annual average water demand), consistent with the Final Decision requirements.

At the end of the initial transition phase, there was an 11.12 million gallon deficit in water returned to Lake Michigan. The DNR requested that this volume be "made up" so that a water balance was obtained during the start-up phase. Between October 14 and October 28, the 11.12 million gallons were returned in addition to the daily 5.15 million gallons, and a water balance was obtained. The start-up phase was therefore complete.

By November 2, 2023, the remaining approximately 10% of customers were transitioned to Lake Michigan water after all flushing associated with the commissioning and transition was completed. The final transition was therefore complete.

On November 8, 2023, radionuclide sampling required by DNR was completed. The results of those samples were received on December 20 and are less than the limit of detection for reporting the results.

The WWU has an approved extended well abandonment agreement signed by all parties on November 28, 2023, for all previously active wells, thus changing their status from active to emergency use.

B. City of Milwaukee Water Supply Volumes

Requirement: The total amount of water purchased daily, monthly, and annually from the City of Milwaukee, including the location(s) of the water meter used to determine the amount of water purchased.

The water purchased from MWW is measured by a meter in the pit near the Oklahoma Pump Station in Milwaukee. The annual total of purchased water after testing from MWW for 2023 is 423,229,900 gallons.

The daily water volume of purchased MWW water is included in Appendix A. The monthly water volume of purchased MWW water is summarized in Table B-1.

Table B-1. Monthly Water Purchased from Milwaukee Waterworks

Month	Pumpage from Groundwater (gallons)	Water Purchased from MWW for Testing (gallons)	Water Purchased from MWW for Drinking (gallons)
January 2023	148,167,000	0	0
February 2023	138,224,000	0	0
March 2023	153,631,000	0	0
April 2023	145,197,000	0	0
May 2023	166,400,000	0	0
June 2023	174,854,000	0	0
July 2023	186,680,000	0	0
August 2023	181,580,000	8,530,020	0
September 2023	161,117,000	20,092,248	0
October 2023	39,797,000	15,682,000	130,303,900
November 2023	0	0	143,323,700
December 2023	0	0	149,602,300
2023 Total	1,495,647,000	44,304,268	423,229,900
Grand Total	1,963,181,168		

C. Water Sales Volumes

Requirement: The total amount of water sold monthly to each category of customer within the approved diversion area.

The City sold a total of 1,726,513,000 gallons of water in 2023. Of that total, 423,229,900 gallons were purchased from MWW, with the difference coming from the City's groundwater wells prior to October 9, 2023. The total sold volume is less than the total pumpage volume (1,963,181,168), where the difference includes water-using activities such as hydrant and main flushing, testing and commissioning new equipment, maintenance, and water used for various analyzers.

Table C-1 summarizes the water sales volumes, by month and customer class, for 2023.

Table C-1. 2023 Monthly Water Sales Volumes in Gallons by Customer Class

Customer Class	# of Customers	Jan	Feb	Mar	Apr	May	Jun
RESIDENTIAL	16,886	58,286,000	60,289,800	53,844,300	55,890,200	57,226,100	60,453,800
RES-2 FAMILY	1,253	7,674,000	8,064,600	7,485,400	7,629,800	7,669,500	7,472,500
RES-3 FAMILY	76	501,800	551,500	496,500	487,300	524,900	468,500
MULTI-FAMILY	953	27,374,000	29,784,000	27,066,500	27,535,600	28,834,300	26,923,800
COMMERCIAL-REG	1,271	24,320,100	24,807,500	23,338,700	24,911,200	24,577,600	25,333,600
INDUSTRIAL	142	10,566,000	11,744,800	10,915,000	12,675,600	11,515,800	13,170,000
PUBLIC	118	3,969,000	4,282,400	3,771,700	3,893,000	4,268,200	6,538,400
IRRIGATION	163	10,700	1,800	1,300	1,700	10,400	1,059,400
TOTAL	**20,862**	**132,701,600**	**139,526,400**	**126,919,400**	**133,024,400**	**134,626,800**	**141,420,000**

Customer Class	Jul	Aug	Sep	Oct	Nov	Dec	Total
RESIDENTIAL	74,154,300	74,220,700	69,258,800	63,799,400	54,208,500	54,428,800	**736,060,700**
RES-2 FAMILY	8,254,300	8,639,600	8,304,200	8,098,900	7,181,400	7,407,100	**93,881,300**
RES-3 FAMILY	528,100	571,600	599,200	641,300	550,400	573,200	**6,494,300**
MULTI-FAMILY	29,333,200	31,182,800	32,407,800	32,117,600	27,675,900	28,495,000	**348,730,500**
COMMERCIAL-REG	33,317,300	32,521,800	32,096,300	29,199,300	25,904,700	23,620,100	**323,948,200**
INDUSTRIAL	12,703,200	16,321,700	15,138,000	12,555,700	11,619,900	10,801,400	**149,727,100**
PUBLIC	6,203,600	6,384,200	6,363,000	4,950,200	4,137,600	3,690,700	**58,452,000**
IRRIGATION	2,458,200	2,160,200	2,063,500	1,048,300	335,600	67,800	**9,218,900**
TOTAL	**166,952,200**	**172,002,600**	**166,230,800**	**152,410,700**	**131,614,000**	**129,084,100**	**1,726,513,000**

D. Return Flow Volumes

Requirement: The daily, monthly, and annual volume of treated wastewater discharge returned to the Root River and the daily, monthly, and annual volume of treated wastewater discharge returned to the Fox River.

The City completed constructing most of the return flow infrastructure in August 2023. At this time, return flow was intermittently pumped to the Root River as part of typical construction testing procedures for the pump station, pipeline, and associated control programming, and to support a dye tracer study by the U.S. Geological Survey (USGS) as part of its area-velocity flow meter installation in the return flow outfall building. The transition to Lake Michigan water began on October 9, 2023, where, from that day onward, daily return flow was pumped to the Root River. The transition was completed on November 2, 2023, where, from that day onward, return flow had a daily target volume of 5.15 million gallons (the 2022 previous year average daily water demand). With the exception of November 28, 2023, when the return flow was paused for USGS to perform maintenance on its area-velocity meter, and December 31, 2023, when a gate malfunction caused the return flow pumps to shut down, the daily target return volume was achieved.

The total volume discharged to the Root and Fox Rivers is summarized in Table D-1.

Table D-1. Annual Volumes Discharged to the Root and Fox Rivers

Receiving Water	Volume (gallons)	Date Range
Fox River	2,555,556,000	January 1 to December 31, 2023
Root River		
Pre-diversion	0	January 1 to July 31, 2023
Start-up Phase	186,630,555	August 1 to November 2, 2023
Post-transition	303,151,000	November 3 to December 31, 2023
Total	489,781,555	August 1 to December 31, 2023

To ensure the target of 5.15 million gallons per day (MGD) was returned, and while the CWP staff are becoming more familiar with the return flow pump station operation, a 5.25 million gallon maximum return volume was programmed as a set point. After 5.25 million gallons were measured by the CWP magmeter, the pumps shut down until midnight. When midnight arrived, the pumps restarted to return 5.25 million gallons. This cycle repeated itself each day. The additional 0.10 MGD greater than the target may be changed in 2024 as the CWP becomes more familiar with the pump station operation and confident in meeting the daily return flow volume target.

The monthly volumes discharged to the Root and Fox Rivers are summarized in Table D-2. Daily volumes are included in Appendix B.

Table D-2. Monthly Volumes Discharged to the Root and Fox Rivers

Month	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)
January 2023	256,794,000	-	256,794,000
February 2023	262,425,000	-	262,425,000

Month	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)
March 2023	394,693,000	-	394,693,000
April 2023	358,701,000	-	358,701,000
May 2023	276,756,000	-	276,756,000
June 2023	221,087,000	-	221,087,000
July 2023	215,083,000	-	215,083,000
August 2023	210,798,000	5,555,555	216,353,555
September 2023	177,394,000	30,482,000	207,876,000
October 2023	75,954,000	139,733,000	215,687,000
November 2023	50,409,000	156,440,000	206,849,000
December 2023	55,462,000	157,571,000	213,033,000

The USGS area-velocity meter was installed in the return flow outfall building as a temporary meter to compare against the daily return flow volumes measured by the CWP return flow magmeter. Since the diversion began, the area-velocity meter and magmeter have recorded similar volumes that are within normal levels of instrumentation and measurement error. After the final transition and when the area-velocity meter was repositioned and recalibrated, the meters had mean and median differences of less than 1%. The USGS summarized the return flow volume metering between the area-velocity meter and magmeter in Appendix C.

E. Consumptive Use

Requirement: The total consumptive use as defined in Wis. Stat. §281.346(1)(e).

In 2023, the WWU had 13 ratepayers that measured consumptive use or water volume used during production. The total water usage associated with production was 37,571,800 gallons.

When the City began the Lake Michigan diversion, the DNR requested that consumptive use be calculated using both the winter-based rate (WBR) method and a separate calculation that includes the water loss reported to the Wisconsin Public Service Commission (WPSC) and water used by industry that is incorporated into food and beverage products.

The WBR method primarily focuses on outdoor water use (lawn and landscape watering, car washing, pools) and assumes most of the consumptive use in municipal water supply systems is from evapotranspiration. Given that the City's water use peaks in summer months, the DNR accepts this method to calculate domestic consumptive use. Annual and summer consumptive use are calculated as follows:

- The WBR method calculates annual consumptive use according to the following equation:

  Annual consumptive use coefficient (%) = [(Sum of all monthly withdrawals ÷ 12) – (Sum of winter-month withdrawals ÷ 3)] ÷ (Sum of all monthly withdrawals ÷ 12) × 100

  Note: "All months" are January through December and "winter months" are December through February.

- The WBR method calculates summer consumptive use according to the following equation:

  Summer consumptive-use coefficient (%) = [(Sum of summer monthly withdrawals – Sum of winter monthly withdrawals) ÷ Sum of summer monthly withdrawals] × 100

  Note: "Summer months" are June through August. This basic equation is also used to estimate coefficients for spring (March through May) and fall (September through November).

The annual and summer consumptive use coefficient calculations following the WBR method are summarized in Table E-1. The City's annual coefficient is slightly greater than that calculated by the USGS for other midwestern states (9.1% compared to 6% to 8%), whereas the summer coefficient is within the range (19.7% compared to 16% to 20%)[1].

[1] Shaffer, K.H., 2009, Variations in withdrawal, return flow, and consumptive use of water in Ohio and Indiana, with selected data from Wisconsin, 1999–2004: U.S. Geological Survey Scientific Investigations Report 2009–5096, 93 p. "The public-supply annual average consumptive-use coefficient calculated by use of the WBR method ranged from 6 to 8 percent, and the summer consumptive-use coefficient ranged from 16 to 20 percent for Ohio, Indiana, and Wisconsin." Pg. 65.

Table E-1. 2023 Consumptive Use Coefficients Following the WBR Method

Total Annual Withdrawal (post-transition)	423,229,900	gallons from Lake Michigan
Sum of Winter Withdrawals	149,602,300	gallons from Lake Michigan (Dec 2023)
Sum of Spring Withdrawals	0	gallons from Lake Michigan (Mar–May 2023)
Sum of Summer Withdrawals	0	gallons from Lake Michigan (June–Aug 2023)
Sum of Fall Withdrawals	273,627,600	gallons from Lake Michigan (Oct 9–Nov 2023)
Total of Annual Pumpage from Groundwater	1,495,647,000	gallons from groundwater
Sum of Winter Pumpage	286,391,000	gallons from groundwater (Jan–Feb 2023)
Sum of Spring Pumpage	465,228,000	gallons from groundwater (Mar–May 2023)
Sum of Summer Pumpage	543,114,000	gallons from groundwater (June–Aug 2023)
Sum of Fall Pumpage	200,914,000	gallons from groundwater (Sept–Oct 1-8, 2023)
Sum of Winter Pumpage + Withdrawal	435,993,300	gallons (split of groundwater and Lake Michigan Jan, Feb, and Dec 2023)
% Annual Consumptive-use Coefficient	9.1	using a split of groundwater and Lake Michigan
Sum of Summer Pumpage	543,114,000	gallons from groundwater June 2023 to August 2023
% Summer Consumptive-use Coefficient	19.7	using groundwater data

However, calculating consumptive use, including any industry that uses water (food processing, beverage processing), and distribution system losses reported to the WPSC, including water main breaks, service leaks, or faulty pressure valves, results in greater consumptive use. Calculating the consumptive use, including the WBR method, water loss (WPSC), and water used by industry in food and beverage products, yields a 2023 consumptive use of 409,607,600 gallons or 21.3% (Table E-2).

Table E-2. 2023 Total Calculated Consumptive Use

% Annual Consumptive-use Coefficient	9.1	
Total Pumpage & Withdrawal (less testing and commissioning)	1,918,876,900	gallons split of groundwater and Lake Michigan water
Water Loss (WPSC)	197,132,100	gallons
Water Used by Industry	37,571,800	gallon
Total Consumptive Use	409,607,600	gallons
	21.3%	

The 2023 consumptive use coefficient for Lake Michigan water, from the start of the transition on October 9, 2023, through December 31, 2023, is calculated with the following equation:

> Lake Michigan Annual Consumptive Coefficient (%) = [(Total Water Purchased from City of Milwaukee) – (Total Wastewater Return to Root River)] ÷ (Total Water Purchased from City of Milwaukee) x 100

The City returned slightly more water to the Root River than was purchased from MWW after the transition, resulting in a negative consumptive use coefficient for Lake Michigan water supply of -5.5%.

F. Water Conservation and Efficiency Plan

Requirement: A summary of the impact of the implemented Conservation and Efficiency Measures required under Wis. Admin. Code §§ NR 852.04 and NR 852.05, including quantifiable impacts to water use intensity, as defined in Wis. Admin. Code § NR 852.03(29). Water use intensity metric calculation methods as specified by the DNR.

The City's 2023 conservation and efficiency measures (CEMs) are summarized in Table F-1.

Table F-1. 2023 Conservation and Efficiency Measures

Required CEM	2023 Activity
PWS – 1, Water Use Audit	Water loss is 8%.
PWS – 2, Leak Detection and Repair Program	Replaced 12,509 linear feet of mains. Inspected 1,675 hydrants and repaired leaks.
PWS – 3, Information and Education Outreach	Continued education programs and partnerships.
PWS – 4, Source Measurement	All source water is metered and measured.
PWS – R1, Distribution System Pressure Management	The WWU manages system pressures in 10 pressure zones.
PWS – R2, Residential Demand Management Program	In 2023, 42 toilet rebates were issued, 5 showerhead rebates were issued, and 28 rain barrel rebates were issued. A sprinkling ordinance (for all customer classes) was enacted in 2006. Customers are allowed to irrigate twice a week. Street signs and annual mailers provide information on the sprinkling ordinance. Fines are also in place; 0 violators were reported in 2023. An irrigation ordinance (for all customer classes) was adopted in 2015 requiring permits for landscape irrigation systems to ensure irrigation systems are efficient; 5 permits were issued in 2023. Audit program (for residential and non-residential customers) determines high water consumption and sends a postcard to customers who may have a leak. In 2023, 22 residential water audits were conducted and 77 data logging reports were administered to evaluate for water leaks.
PWS – R3, Commercial and Industrial Demand Management Program	In 2023, 2 multi-family showerhead rebates were issued, 32 commercial toilet rebates were issued, and 4 multi-family toilet rebates were issued. (In addition, there was a large multi-family account that applied for a toilet changeout in 2023. The utility began the pre-inspection process, but the manager who applied for the toilet rebate quit working at the multi-family facility. A second manager was hired and quit, and now a third manager has been hired. With this transition in management, the multi-family facility had put the toilet changeouts on hold. The WWU will follow up with this third manager in 2024.) There were 2 industrial users who participated in the site-specific grant program and completed their projects; however, $0 dollars were given out in 2023 because the utility is waiting to verify the water savings. When the water savings have been calculated, the utility will process the incentives in 2024. Three spray rinse valves were issued. The WWU also has an audit program (for residential and non-residential customers). In 2023, 42 data logging reports were conducted for public, commercial, and industrial customers to evaluate water leaks.

Required CEM	2023 Activity
PWS – R4, Water Reuse	The WWU is required to return 100% of the previous year daily water demand; therefore, water reuse at a utility scale is not feasible.
Tier 3, Additional CEMs	In 2023, 25 sewer credit meters remain compared to 46 in 2022.

PWS = public water system

F.1 Meter Testing

The water production meters at the groundwater wells were tested every 2 years, with the last test having occurred in the spring of 2023. The water meters at the City's booster pump station (BPS) were installed new in the spring/summer of 2023. Testing of the meters used for billing occurs in-house, based on the timing requirements of the WPSC. In 2023, 441 meters were tested.

F.2 Water Use Intensity Metrics

The 2023 per capita per day water use for residential, 2-family residential, 3-family residential, and multi-family residential customer categories is summarized in Table F-2.

Table F-2. 2023 Calculated Average Day Water Use per Capita

Customer Class	# of Customers	Annual Sales (gallons)
Residential	16,886	736,060,700
Res – 2 Family	1,253	93,881,300
Res – 3 Family	76	6,494,300
Multi-Family	953	348,730,500
Total	19,168	1,185,166,800
	Days in 2023	365
	Population as of 7/1/2022	70,454
	Usage per customer per day (gpd)	169
	Usage per capita per day (gpd)	46

gpd = gallon(s) per day

The per capita per day water use calculated using a residential equivalent unit (REU) method is summarized in Table F-3.

Table F-3. 2023 Calculated Average Day Water Use per Residential Equivalent Unit

Meter Size (inch)	Number of Meters	REU Ratio[a]	REU
5/8	17,617	1	17,617
3/4	1,715	1	1,715
1	922	2.5	2,305
1 1/4	-	3.7	-
1 1/2	376	5	1,880
2	369	8	2,952
2 1/2	-	12.5	-
3	56	15	840
4	18	25	450
6	10	50	500

Meter Size (inch)	Number of Meters	REU Ratio[a]	REU
8	-	80	-
10	-	122	-
12	-	160	-
Total	21,083	-	28,259

[a] From Wisconsin Public Service Commission

Average Day Water Use per REU Calculation

Total Water Sales	1,726,513,000	gallons
Average Day Water Use	4,730,173	gallons/day
Water Use/REU	167	gpd/REU

F.3 Water Volume Differences

There is a difference between the daily volume of water purchased from MWW and that which enters the WWU distribution system based on the presence of the onsite storage at the BPS. This is evident by comparing pumpage (purchased from MWW) and demand volumes:

- The maximum daily pumpage from MWW occurred on October 10, 2023, the day after the transition from groundwater to Lake Michigan water. This high pumpage day was associated with system flushing related to the transition and totaled 9,361,000 gallons. The average daily pumpage from MWW, excluding the testing waters used prior to transition, was 5,257,197 gallons. This resulted in a ratio of maximum daily pumpage to average daily pumpage of 1.78.
- The maximum daily demand in the WWU distribution system was 8,684,300 gallons, which also occurred on October 10, 2023. The average daily demand in the WWU distribution system was 5,274,659 gallons. This resulted in a ratio of maximum daily demand to average daily demand of 1.65.

The difference between the pumpage and demand volumes is relatively minor; however, different sections within DNR may use the different volumes. For example, the water use and water supply section will likely use water demand volumes, whereas sections regulating with the Diversion Approval and return flow will likely use pumpage volumes.

G. Additional Conservation and Efficiency Measures

Requirement: A description of any additional Conservation and Efficiency Measures implemented.

Starting in 2006, the WWU implemented a variety of conservation programs. The WWU approved a conservation plan in 2012 that was updated in 2022. An analysis of water savings achieved since the 2012 plan was implemented demonstrates that, by 2021, the WWU has exceeded savings goals established for 2030 and 2050. The near-term program goals (years 1 to 5) were included as Table 5.3 of the 2022 report; and future reporting will include status updates of any new or additional measures implemented from the updated report.

As part of the transition to Lake Michigan water, the WWU performed extra outreach opportunities to increase messaging about water conservation. All transition-related publications and outreach events

included information about the water conservation programs, including newsletters, water/sewer bill inserts, social media posts, press releases, radio and television interviews, open houses, a weekly staffed booth at the farmers market, and a monthly staffed booth at the summer Tribute Tuesday events. Information about rebates, incentives, finding and fixing leaks, the City's sprinkling ordinance, and ideas on how to conserve water were included.

Additional conservation measures are anticipated in 2024, including investigating additional incentives such as water softener disconnection and removal rebates.

H. Customers within Diversion Area

Requirement: A statement verifying that no customers outside of the diversion area were sold Lake Michigan water.

The WWU certifies no customers outside of the approved diversion area were sold Lake Michigan water in 2023.

I. Properties Served by Water Utility

Requirement: A spatially explicit description of the properties served by the City's water utility, in the manner prescribed by the DNR.

A map showing the area served by the WWU is included in Appendix D.

J. Existing Deep Aquifer Groundwater Wells

Requirement: A report of any City wells filled and sealed or changed to emergency use status in the past year. A description of deep aquifer groundwater wells maintained for emergency use, as allowed under Wis. Admin. Code § NR 810.22, and use of these wells in the previous year.

A copy of the DNR approval of extended well abandonment agreement for the utility wells is included in Appendix E.

K. Pharmaceutical and Personal Care Products Recycling and Reduction Program

Requirement: A summary of the implementation of the pharmaceutical and personal care products recycling and reduction program in the past year.

Refer to Appendix F.

L. Root River Monitoring

Requirement: For at least 10 years after the date the diversion begins, the City shall annually report the results of Root River monitoring to DNR. The report shall include a summary of the monitoring results and a summary of any impacts to the Root River from the City's wastewater discharge.

Refer to Appendix G.

M. Federal and State Permits and Approvals

Requirement: A statement of compliance with all applicable federal and state permits and approvals.

The City of Waukesha has complied with all applicable federal and state approvals.

N. Summary

Table N-1 is an executive summary of information provided previously.

Table N-1. Summary Table for Reporting Year 2023

Total Water Supply Pumpage from Groundwater and Lake Michigan (less testing and commissioning)	1,918,876,900	gallons
Lake Michigan Diversion: Water Supply	423,229,900	gallons
Lake Michigan Diversion: Water Supply + Testing and Commissioning	467,534,168	gallons
Water Sold	1,726,513,000	gallons
Population Served	70,454	people
Total per Capita Water Use per Day	75	gpd
Residential per Capita Water Use per Day	46	gpd
Maximum Day Water Pumpage	9,361,000	gallons
Average Day Water Pumpage	5,257,197	gallons
Ratio of Maximum Day Water Pumpage to Average Day Pumpage	1.78	
Average Day Water Pumpage per Residential Equivalency Unit	167	gpd/REU
Average Daily Demand to be Returned to the Root River in 2023 (excludes construction testing waters)	5.26	MGD
Total Clean Water Plant Discharge	3,045,337,555	gallons
Total Clean Water Plant Discharge to the Fox River	2,555,556,000	gallons
Total Clean Water Plant Discharge to the Root River	489,781,555	gallons
Total Consumptive Use (WBR + loss + industry)	21%	

Appendix A. 2023 Daily Water Supply Volumes from Milwaukee Waterworks

APPENDIX A. 2023 DAILY WATER PURCHASED FROM MILWAUKEE WATERWORKS

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
1/1/23	4,696,000	0
1/2/23	4,110,000	0
1/3/23	4,857,000	0
1/4/23	5,062,000	0
1/5/23	5,117,000	0
1/6/23	4,302,000	0
1/7/23	5,425,000	0
1/8/23	5,814,000	0
1/9/23	3,459,000	0
1/10/23	5,086,000	0
1/11/23	5,080,000	0
1/12/23	5,126,000	0
1/13/23	4,308,000	0
1/14/23	5,578,000	0
1/15/23	4,946,000	0
1/16/23	3,903,000	0
1/17/23	5,124,000	0
1/18/23	4,299,000	0
1/19/23	4,973,000	0
1/20/23	3,855,000	0
1/21/23	5,528,000	0
1/22/23	4,907,000	0
1/23/23	4,349,000	0
1/24/23	3,940,000	0
1/25/23	5,397,000	0
1/26/23	4,068,000	0
1/27/23	5,120,000	0
1/28/23	5,584,000	0
1/29/23	5,078,000	0
1/30/23	3,979,000	0
1/31/23	5,097,000	0
2/1/23	5,085,000	0
2/2/23	5,547,000	0
2/3/23	4,224,000	0
2/4/23	6,041,000	0
2/5/23	3,927,000	0
2/6/23	5,109,000	0
2/7/23	4,951,000	0
2/8/23	4,964,000	0
2/9/23	5,113,000	0
2/10/23	4,168,000	0
2/11/23	5,132,000	0
2/12/23	5,472,000	0
2/13/23	4,163,000	0
2/14/23	5,416,000	0
2/15/23	4,965,000	0
2/16/23	3,931,000	0
2/17/23	5,358,000	0
2/18/23	4,359,000	0
2/19/23	5,286,000	0
2/20/23	5,147,000	0
2/21/23	4,569,000	0
2/22/23	4,804,000	0
2/23/23	5,675,000	0
2/24/23	5,110,000	0
2/25/23	4,985,000	0
2/26/23	4,731,000	0
2/27/23	4,844,000	0
2/28/23	5,148,000	0
3/1/23	5,285,000	0

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
3/2/23	4,697,000	0
3/3/23	5,059,000	0
3/4/23	4,802,000	0
3/5/23	4,780,000	0
3/6/23	5,156,000	0
3/7/23	4,916,000	0
3/8/23	5,048,000	0
3/9/23	4,787,000	0
3/10/23	4,920,000	0
3/11/23	4,845,000	0
3/12/23	4,576,000	0
3/13/23	5,480,000	0
3/14/23	3,940,000	0
3/15/23	5,618,000	0
3/16/23	5,493,000	0
3/17/23	4,481,000	0
3/18/23	5,030,000	0
3/19/23	4,730,000	0
3/20/23	5,134,000	0
3/21/23	5,491,000	0
3/22/23	4,867,000	0
3/23/23	4,630,000	0
3/24/23	4,795,000	0
3/25/23	4,944,000	0
3/26/23	5,097,000	0
3/27/23	4,431,000	0
3/28/23	4,864,000	0
3/29/23	5,887,000	0
3/30/23	5,222,000	0
3/31/23	4,626,000	0
4/1/23	4,544,000	0
4/2/23	4,280,000	0
4/3/23	5,188,000	0

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
4/4/23	3,869,000	0
4/5/23	5,609,000	0
4/6/23	4,721,000	0
4/7/23	4,712,000	0
4/8/23	5,416,000	0
4/9/23	4,506,000	0
4/10/23	4,588,000	0
4/11/23	4,884,000	0
4/12/23	5,333,000	0
4/13/23	5,267,000	0
4/14/23	4,836,000	0
4/15/23	5,271,000	0
4/16/23	4,901,000	0
4/17/23	4,067,000	0
4/18/23	5,254,000	0
4/19/23	4,454,000	0
4/20/23	4,720,000	0
4/21/23	4,611,000	0
4/22/23	4,608,000	0
4/23/23	5,212,000	0
4/24/23	5,470,000	0
4/25/23	4,551,000	0
4/26/23	4,725,000	0
4/27/23	4,946,000	0
4/28/23	4,344,000	0
4/29/23	5,250,000	0
4/30/23	5,060,000	0
5/1/23	5,161,000	0
5/2/23	5,166,000	0
5/3/23	4,835,000	0
5/4/23	5,133,000	0
5/5/23	5,126,000	0
5/6/23	5,192,000	0

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
5/7/23	5,781,000	0
5/8/23	4,343,000	0
5/9/23	5,617,000	0
5/10/23	4,757,000	0
5/11/23	4,997,000	0
5/12/23	5,803,000	0
5/13/23	5,619,000	0
5/14/23	3,993,000	0
5/15/23	5,071,000	0
5/16/23	5,079,000	0
5/17/23	4,484,000	0
5/18/23	5,660,000	0
5/19/23	5,118,000	0
5/20/23	6,069,000	0
5/21/23	5,495,000	0
5/22/23	4,678,000	0
5/23/23	5,506,000	0
5/24/23	5,692,000	0
5/25/23	6,253,000	0
5/26/23	4,615,000	0
5/27/23	7,366,000	0
5/28/23	5,676,000	0
5/29/23	5,850,000	0
5/30/23	6,326,000	0
5/31/23	5,939,000	0
6/1/23	5,761,000	0
6/2/23	5,809,000	0
6/3/23	7,080,000	0
6/4/23	6,889,000	0
6/5/23	5,498,000	0
6/6/23	6,523,000	0
6/7/23	5,340,000	0
6/8/23	5,242,000	0

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
6/9/23	5,252,000	0
6/10/23	7,357,000	0
6/11/23	5,418,000	0
6/12/23	4,598,000	0
6/13/23	5,532,000	0
6/14/23	5,438,000	0
6/15/23	5,926,000	0
6/16/23	4,883,000	0
6/17/23	6,111,000	0
6/18/23	5,988,000	0
6/19/23	5,155,000	0
6/20/23	6,865,000	0
6/21/23	6,631,000	0
6/22/23	6,334,000	0
6/23/23	6,602,000	0
6/24/23	5,894,000	0
6/25/23	5,392,000	0
6/26/23	4,109,000	0
6/27/23	5,845,000	0
6/28/23	5,393,000	0
6/29/23	6,010,000	0
6/30/23	5,979,000	0
7/1/23	6,155,000	0
7/2/23	5,736,000	0
7/3/23	4,727,000	0
7/4/23	5,770,000	0
7/5/23	5,818,000	0
7/6/23	5,672,000	0
7/7/23	6,069,000	0
7/8/23	6,344,000	0
7/9/23	5,709,000	0
7/10/23	5,804,000	0
7/11/23	6,452,000	0

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
7/12/23	5,298,000	0
7/13/23	5,033,000	0
7/14/23	6,079,000	0
7/15/23	5,300,000	0
7/16/23	6,003,000	0
7/17/23	5,537,000	0
7/18/23	6,327,000	0
7/19/23	5,987,000	0
7/20/23	6,674,000	0
7/21/23	5,957,000	0
7/22/23	6,777,000	0
7/23/23	5,585,000	0
7/24/23	5,205,000	0
7/25/23	5,902,000	0
7/26/23	5,565,000	0
7/27/23	6,537,000	0
7/28/23	7,041,000	0
7/29/23	7,306,000	0
7/30/23	7,549,000	0
7/31/23	6,762,000	0
8/1/23	7,504,000	0
8/2/23	6,491,000	0
8/3/23	5,709,000	0
8/4/23	6,583,000	0
8/5/23	5,493,000	0
8/6/23	5,759,000	0
8/7/23	5,665,000	0
8/8/23	6,597,000	0
8/9/23	7,862,000	0
8/10/23	7,261,000	0
8/11/23	5,131,000	0
8/12/23	5,536,000	0
8/13/23	5,469,000	0

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
8/14/23	4,541,000	0
8/15/23	6,404,000	296,400
8/16/23	4,942,000	242,000
8/17/23	4,592,000	2,514,000
8/18/23	5,378,000	0
8/19/23	5,801,000	0
8/20/23	6,366,000	0
8/21/23	5,408,000	0
8/22/23	5,934,000	943,000
8/23/23	6,478,000	1,426,800
8/24/23	5,294,000	228,200
8/25/23	5,305,000	183,480
8/26/23	6,027,000	175,140
8/27/23	5,924,000	0
8/28/23	5,186,000	0
8/29/23	5,838,000	2,251,400
8/30/23	5,531,000	0
8/31/23	5,571,000	269,600
9/1/23	6,343,000	193,770
9/2/23	6,129,000	0
9/3/23	5,293,000	0
9/4/23	5,905,000	0
9/5/23	5,642,000	0
9/6/23	6,169,000	0
9/7/23	5,532,000	133,680
9/8/23	5,212,000	0
9/9/23	5,656,000	0
9/10/23	5,473,000	0
9/11/23	4,632,000	0
9/12/23	5,327,000	3,463,164
9/13/23	4,647,000	7,294,647
9/14/23	6,524,000	0
9/15/23	5,046,000	0

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
9/16/23	5,264,000	0
9/17/23	5,411,000	0
9/18/23	4,672,000	0
9/19/23	5,603,000	0
9/20/23	5,386,000	0
9/21/23	4,862,000	0
9/22/23	5,237,000	0
9/23/23	5,340,000	0
9/24/23	5,221,000	0
9/25/23	5,087,000	2,780,920
9/26/23	5,327,000	6,226,067
9/27/23	4,429,000	0
9/28/23	4,951,000	0
9/29/23	5,824,000	0
9/30/23	4,973,000	0
10/1/23	4,761,000	0
10/2/23	5,836,000	0
10/3/23	4,872,000	0
10/4/23	5,118,000	0
10/5/23	5,488,000	0
10/6/23	4,421,000	5,065,000
10/7/23	5,363,000	8,145,000
10/8/23	3,686,000	2,472,000
10/9/23	252,000	4,584,400
10/10/23	0	9,361,000
10/11/23	0	7,678,400
10/12/23	0	7,524,600
10/13/23	0	6,708,600
10/14/23	0	5,867,200
10/15/23	0	4,609,000
10/16/23	0	6,342,400
10/17/23	0	5,874,000
10/18/23	0	5,462,800

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
10/19/23	0	5,266,400
10/20/23	0	5,180,500
10/21/23	0	5,257,100
10/22/23	0	4,674,800
10/23/23	0	5,774,700
10/24/23	0	5,794,000
10/25/23	0	4,812,700
10/26/23	0	4,595,500
10/27/23	0	4,527,600
10/28/23	0	4,808,500
10/29/23	0	4,121,200
10/30/23	0	6,327,700
10/31/23	0	5,150,800
11/1/23	0	5,658,600
11/2/23	0	4,110,500
11/3/23	0	5,022,800
11/4/23	0	4,155,100
11/5/23	0	4,611,800
11/6/23	0	5,870,600
11/7/23	0	5,089,500
11/8/23	0	5,072,500
11/9/23	0	4,905,500
11/10/23	0	3,471,600
11/11/23	0	5,149,500
11/12/23	0	4,051,200
11/13/23	0	5,651,800
11/14/23	0	5,460,700
11/15/23	0	4,929,900
11/16/23	0	4,615,500
11/17/23	0	3,015,200
11/18/23	0	5,857,200
11/19/23	0	3,523,100
11/20/23	0	5,758,600

Date	Pumpage from Groundwater (gallons)	Water Purchased from MWW (gallons)
11/21/23	0	4,638,400
11/22/23	0	5,467,700
11/23/23	0	4,444,100
11/24/23	0	3,027,200
11/25/23	0	5,345,300
11/26/23	0	5,348,900
11/27/23	0	2,921,700
11/28/23	0	6,730,100
11/29/23	0	2,263,600
11/30/23	0	7,155,500
12/1/23	0	3,470,600
12/2/23	0	3,898,400
12/3/23	0	5,229,300
12/4/23	0	4,744,800
12/5/23	0	5,528,400
12/6/23	0	3,629,300
12/7/23	0	7,423,400
12/8/23	0	3,568,500
12/9/23	0	5,547,800
12/10/23	0	4,379,000
12/11/23	0	3,876,100
12/12/23	0	4,640,100
12/13/23	0	6,203,000
12/14/23	0	2,262,800
12/15/23	0	5,630,600
12/16/23	0	5,799,600
12/17/23	0	3,359,800
12/18/23	0	5,028,200
12/19/23	0	7,541,700
12/20/23	0	4,143,400
12/21/23	0	4,841,600
12/22/23	0	4,108,900
12/23/23	0	8,578,500
12/24/23	0	4,485,100
12/25/23	0	4,429,200
12/26/23	0	4,272,000
12/27/23	0	5,332,400
12/28/23	0	3,539,700
12/29/23	0	4,711,100
12/30/23	0	5,936,200
12/31/23	0	3,462,800

MWW = Milwaukee Waterworks

Appendix B. 2023 Daily Clean Water Plant Discharge Volumes to the Root and Fox Rivers

APPENDIX B. 2023 DAILY CLEAN WATER PLANT DISCHARGE VOLUMES TO THE ROOT AND FOX RIVERS

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
1/1/2023	8,698,000	-	8,698,000	
1/2/2023	8,742,000	-	8,742,000	
1/3/2023	8,845,000	-	8,845,000	
1/4/2023	8,951,000	-	8,951,000	
1/5/2023	8,772,000	-	8,772,000	
1/6/2023	8,553,000	-	8,553,000	
1/7/2023	8,334,000	-	8,334,000	
1/8/2023	8,587,000	-	8,587,000	
1/9/2023	8,614,000	-	8,614,000	
1/10/2023	8,531,000	-	8,531,000	
1/11/2023	8,572,000	-	8,572,000	
1/12/2023	8,346,000	-	8,346,000	
1/13/2023	8,105,000	-	8,105,000	
1/14/2023	7,973,000	-	7,973,000	
1/15/2023	8,207,000	-	8,207,000	
1/16/2023	8,579,000	-	8,579,000	
1/17/2023	8,438,000	-	8,438,000	
1/18/2023	8,121,000	-	8,121,000	
1/19/2023	8,472,000	-	8,472,000	
1/20/2023	8,225,000	-	8,225,000	
1/21/2023	8,074,000	-	8,074,000	
1/22/2023	8,142,000	-	8,142,000	
1/23/2023	8,511,000	-	8,511,000	
1/24/2023	8,861,000	-	8,861,000	
1/25/2023	7,393,000	-	7,393,000	
1/26/2023	8,081,000	-	8,081,000	
1/27/2023	7,321,000	-	7,321,000	
1/28/2023	7,652,000	-	7,652,000	
1/29/2023	7,799,000	-	7,799,000	
1/30/2023	7,661,000	-	7,661,000	
1/31/2023	7,634,000	-	7,634,000	
2/1/2023	7,862,000	-	7,862,000	
2/2/2023	7,775,000	-	7,775,000	
2/3/2023	7,278,000	-	7,278,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
2/4/2023	7,907,000	-	7,907,000	
2/5/2023	8,168,000	-	8,168,000	
2/6/2023	8,113,000	-	8,113,000	
2/7/2023	8,286,000	-	8,286,000	
2/8/2023	8,056,000	-	8,056,000	
2/9/2023	9,488,000	-	9,488,000	
2/10/2023	9,517,000	-	9,517,000	
2/11/2023	9,515,000	-	9,515,000	
2/12/2023	9,507,000	-	9,507,000	
2/13/2023	9,364,000	-	9,364,000	
2/14/2023	9,415,000	-	9,415,000	
2/15/2023	9,352,000	-	9,352,000	
2/16/2023	9,125,000	-	9,125,000	
2/17/2023	8,731,000	-	8,731,000	
2/18/2023	9,053,000	-	9,053,000	
2/19/2023	9,341,000	-	9,341,000	
2/20/2023	9,295,000	-	9,295,000	
2/21/2023	9,053,000	-	9,053,000	
2/22/2023	9,076,000	-	9,076,000	
2/23/2023	9,137,000	-	9,137,000	
2/24/2023	8,759,000	-	8,759,000	
2/25/2023	8,843,000	-	8,843,000	
2/26/2023	9,263,000	-	9,263,000	
2/27/2023	16,123,000	-	16,123,000	
2/28/2023	17,023,000	-	17,023,000	
3/1/2023	16,465,000	-	16,465,000	
3/2/2023	15,630,000	-	15,630,000	
3/3/2023	14,847,000	-	14,847,000	
3/4/2023	13,466,000	-	13,466,000	
3/5/2023	13,009,000	-	13,009,000	
3/6/2023	14,525,000	-	14,525,000	
3/7/2023	13,888,000	-	13,888,000	
3/8/2023	13,223,000	-	13,223,000	
3/9/2023	12,749,000	-	12,749,000	
3/10/2023	13,060,000	-	13,060,000	
3/11/2023	12,611,000	-	12,611,000	
3/12/2023	12,240,000	-	12,240,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
3/13/2023	12,302,000	-	12,302,000	
3/14/2023	11,809,000	-	11,809,000	
3/15/2023	12,037,000	-	12,037,000	
3/16/2023	12,798,000	-	12,798,000	
3/17/2023	13,734,000	-	13,734,000	
3/18/2023	12,933,000	-	12,933,000	
3/19/2023	12,651,000	-	12,651,000	
3/20/2023	12,322,000	-	12,322,000	
3/21/2023	11,934,000	-	11,934,000	
3/22/2023	11,734,000	-	11,734,000	
3/23/2023	11,317,000	-	11,317,000	
3/24/2023	10,928,000	-	10,928,000	
3/25/2023	11,399,000	-	11,399,000	
3/26/2023	11,205,000	-	11,205,000	
3/27/2023	11,267,000	-	11,267,000	
3/28/2023	12,039,000	-	12,039,000	
3/29/2023	12,058,000	-	12,058,000	
3/30/2023	11,807,000	-	11,807,000	
3/31/2023	12,706,000	-	12,706,000	
4/1/2023	14,118,000	-	14,118,000	
4/2/2023	13,650,000	-	13,650,000	
4/3/2023	11,983,000	-	11,983,000	
4/4/2023	14,684,000	-	14,684,000	
4/5/2023	17,207,000	-	17,207,000	
4/6/2023	15,976,000	-	15,976,000	
4/7/2023	14,743,000	-	14,743,000	
4/8/2023	13,993,000	-	13,993,000	
4/9/2023	13,242,000	-	13,242,000	
4/10/2023	12,332,000	-	12,332,000	
4/11/2023	12,744,000	-	12,744,000	
4/12/2023	12,435,000	-	12,435,000	
4/13/2023	11,812,000	-	11,812,000	
4/14/2023	11,312,000	-	11,312,000	
4/15/2023	11,248,000	-	11,248,000	
4/16/2023	11,635,000	-	11,635,000	
4/17/2023	12,090,000	-	12,090,000	
4/18/2023	10,518,000	-	10,518,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
4/19/2023	11,373,000	-	11,373,000	
4/20/2023	10,729,000	-	10,729,000	
4/21/2023	10,472,000	-	10,472,000	
4/22/2023	10,258,000	-	10,258,000	
4/23/2023	10,212,000	-	10,212,000	
4/24/2023	10,519,000	-	10,519,000	
4/25/2023	10,259,000	-	10,259,000	
4/26/2023	9,667,000	-	9,667,000	
4/27/2023	9,708,000	-	9,708,000	
4/28/2023	9,599,000	-	9,599,000	
4/29/2023	9,909,000	-	9,909,000	
4/30/2023	10,274,000	-	10,274,000	
5/1/2023	10,926,000	-	10,926,000	
5/2/2023	10,495,000	-	10,495,000	
5/3/2023	9,937,000	-	9,937,000	
5/4/2023	9,748,000	-	9,748,000	
5/5/2023	9,513,000	-	9,513,000	
5/6/2023	9,630,000	-	9,630,000	
5/7/2023	9,488,000	-	9,488,000	
5/8/2023	10,215,000	-	10,215,000	
5/9/2023	9,795,000	-	9,795,000	
5/10/2023	9,359,000	-	9,359,000	
5/11/2023	9,195,000	-	9,195,000	
5/12/2023	8,554,000	-	8,554,000	
5/13/2023	9,092,000	-	9,092,000	
5/14/2023	9,029,000	-	9,029,000	
5/15/2023	9,509,000	-	9,509,000	
5/16/2023	9,064,000	-	9,064,000	
5/17/2023	8,723,000	-	8,723,000	
5/18/2023	8,201,000	-	8,201,000	
5/19/2023	8,802,000	-	8,802,000	
5/20/2023	8,265,000	-	8,265,000	
5/21/2023	8,413,000	-	8,413,000	
5/22/2023	9,121,000	-	9,121,000	
5/23/2023	8,453,000	-	8,453,000	
5/24/2023	8,083,000	-	8,083,000	
5/25/2023	7,640,000	-	7,640,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
5/26/2023	7,907,000	-	7,907,000	
5/27/2023	7,680,000	-	7,680,000	
5/28/2023	7,415,000	-	7,415,000	
5/29/2023	7,807,000	-	7,807,000	
5/30/2023	8,377,000	-	8,377,000	
5/31/2023	8,320,000	-	8,320,000	
6/1/2023	7,985,000	-	7,985,000	
6/2/2023	7,713,000	-	7,713,000	
6/3/2023	7,490,000	-	7,490,000	
6/4/2023	7,624,000	-	7,624,000	
6/5/2023	8,391,000	-	8,391,000	
6/6/2023	7,613,000	-	7,613,000	
6/7/2023	7,516,000	-	7,516,000	
6/8/2023	7,265,000	-	7,265,000	
6/9/2023	7,105,000	-	7,105,000	
6/10/2023	7,077,000	-	7,077,000	
6/11/2023	7,455,000	-	7,455,000	
6/12/2023	6,397,000	-	6,397,000	
6/13/2023	7,933,000	-	7,933,000	
6/14/2023	7,886,000	-	7,886,000	
6/15/2023	7,563,000	-	7,563,000	
6/16/2023	7,272,000	-	7,272,000	
6/17/2023	6,984,000	-	6,984,000	
6/18/2023	7,156,000	-	7,156,000	
6/19/2023	6,822,000	-	6,822,000	
6/20/2023	7,673,000	-	7,673,000	
6/21/2023	7,322,000	-	7,322,000	
6/22/2023	7,222,000	-	7,222,000	
6/23/2023	6,948,000	-	6,948,000	
6/24/2023	6,874,000	-	6,874,000	
6/25/2023	7,683,000	-	7,683,000	
6/26/2023	7,492,000	-	7,492,000	
6/27/2023	6,715,000	-	6,715,000	
6/28/2023	7,603,000	-	7,603,000	
6/29/2023	7,209,000	-	7,209,000	
6/30/2023	7,099,000	-	7,099,000	
7/1/2023	6,707,000	-	6,707,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
7/2/2023	6,597,000	-	6,597,000	
7/3/2023	6,509,000	-	6,509,000	
7/4/2023	6,692,000	-	6,692,000	
7/5/2023	6,991,000	-	6,991,000	
7/6/2023	7,453,000	-	7,453,000	
7/7/2023	6,859,000	-	6,859,000	
7/8/2023	6,657,000	-	6,657,000	
7/9/2023	6,937,000	-	6,937,000	
7/10/2023	7,734,000	-	7,734,000	
7/11/2023	6,268,000	-	6,268,000	
7/12/2023	7,907,000	-	7,907,000	
7/13/2023	7,474,000	-	7,474,000	
7/14/2023	7,122,000	-	7,122,000	
7/15/2023	6,910,000	-	6,910,000	
7/16/2023	6,899,00	-	6,899,000	
7/17/2023	7,024,000	-	7,024,000	
7/18/2023	6,810,000	-	6,810,000	
7/19/2023	6,973,000	-	6,973,000	
7/20/2023	6,055,000	-	6,055,000	
7/21/2023	6,656,000	-	6,656,000	
7/22/2023	6,806,000	-	6,806,000	
7/23/2023	6,801,00	-	6,801,000	
7/24/2023	6,684,000	-	6,684,000	
7/25/2023	6,720,000	-	6,720,000	
7/26/2023	7,379,000	-	7,379,000	
7/27/2023	7,038,000	-	7,038,000	
7/28/2023	7,248,000	-	7,248,000	
7/29/2023	7,406,000	-	7,406,000	
7/30/2023	6,972,000	-	6,972,000	
7/31/2023	6,795,000	-	6,795,000	
8/1/2023	6,821,000	4,000	6,825,000	Begin transition start-up phase with equipment testing.
8/2/2023	6,855,000	4,000	6,859,000	
8/3/2023	6,799,000	-	6,799,000	
8/4/2023	6,868,000	-	6,868,000	
8/5/2023	6,768,000	-	6,768,000	
8/6/2023	6,699,000	-	6,699,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
8/7/2023	6,630,000	-	6,630,000	
8/8/2023	6,506,000	-	6,506,000	
8/9/2023	6,784,000	-	6,784,000	
8/10/2023	6,656,000	-	6,656,000	
8/11/2023	6,578,000	-	6,578,000	
8/12/2023	6,354,000	-	6,354,000	
8/13/2023	6,536,000	-	6,536,000	
8/14/2023	9,147,000	-	9,147,000	
8/15/2023	8,123,000	-	8,123,000	
8/16/2023	7,541,000	-	7,541,000	
8/17/2023	7,483,000	-	7,483,000	
8/18/2023	6,920,000	-	6,920,000	
8/19/2023	6,925,000	-	6,925,000	
8/20/2023	7,071,000	-	7,071,000	
8/21/2023	7,076,000	-	7,076,000	
8/22/2023	7,189,000	-	7,189,000	
8/23/2023	6,851,000	371,730	7,222,730	
8/24/2023	6,898,000	223,000	7,121,000	
8/25/2023	5,566,000	1,222,925	6,788,925	
8/26/2023	6,706,000	-	6,706,000	
8/27/2023	6,547,000	-	6,547,000	
8/28/2023	7,259,000	314,900	7,573,900	
8/29/2023	6,182,000	265,000	6,447,000	
8/30/2023	5,490,000	1,600,000	7,090,000	
8/31/2023	4,970,000	1,550,000	6,520,000	
9/1/2023	5,605,000	810,000	6,415,000	
9/2/2023	6,329,000	-	6,329,000	
9/3/2023	6,258,000	-	6,258,000	
9/4/2023	6,879,000	-	6,879,000	
9/5/2023	3,349,000	3,500,000	6,849,000	
9/6/2023	4,153,000	2,690,000	6,843,000	
9/7/2023	6,612,000	-	6,612,000	
9/8/2023	6,375,000	-	6,375,000	
9/9/2023	6,115,000	-	6,115,000	
9/10/2023	6,581,000	-	6,581,000	
9/11/2023	6,719,000	250,000	6,969,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
9/12/2023	4,943,000	3,560,000	8,503,000	USGS dye-tracer study for area-velocity flow meter
9/13/2023	2,994,000	4,050,000	7,044,000	
9/14/2023	3,130,000	4,730,000	7,860,000	
9/15/2023	6,346,000	-	6,346,000	
9/16/2023	6,316,000	-	6,316,000	
9/17/2023	6,834,000	-	6,834,000	
9/18/2023	6,958,000	-	6,958,000	
9/19/2023	6,853,000	8,000	6,861,000	
9/20/2023	6,489,000	-	6,489,000	
9/21/2023	6,476,000	-	6,476,000	
9/22/2023	6,421,000	-	6,421,000	
9/23/2023	6,140,000	-	6,140,000	
9/24/2023	6,421,000	-	6,421,000	
9/25/2023	6,467,000	5,000	6,472,000	
9/26/2023	2,219,000	6,141,000	8,360,000	
9/27/2023	5,678,000	3,992,000	9,670,000	
9/28/2023	8,013,000	-	8,013,000	
9/29/2023	6,687,000	746,000	7,433,000	
9/30/2023	7,034,000	-	7,034,000	
10/1/2023	7,051,00	-	7,051,000	
10/2/2023	6,534,000	-	6,534,000	
10/3/2023	4,733,000	2,992,000	7,725,000	
10/4/2023	3,059,000	4,241,000	7,300,000	
10/5/2023	6,791,000	-	6,791,000	
10/6/2023	6,653,000	-	6,653,000	
10/7/2023	6,366,000	-	6,366,000	
10/8/2023	6,666,000	-	6,666,000	
10/9/2023	2,338,000	4,277,000	6,615,000	Start of transition to Lake Michigan water supply
10/10/2023	969,000	5,459,000	6,428,000	
10/11/2023	1,219,000	5,382,000	6,601,000	
10/12/2023	1,002,000	5,392,000	6,394,000	
10/13/2023	1,696,000	5,258,000	6,954,000	
10/14/2023	2,152,000	6,050,000	8,202,000	
10/15/2023	1,677,000	5,868,000	7,545,000	
10/16/2023	1,393,000	5,854,000	7,247,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
10/17/2023	1,256,000	5,910,000	7,166,000	
10/18/2023	1,371,000	5,960,000	7,331,000	
10/19/2023	1,275,000	5,950,000	7,225,000	
10/20/2023	1,451,000	5,550,000	7,001,000	
10/21/2023	1,533,000	5,310,000	6,843,000	
10/22/2023	1,125,000	5,750,000	6,875,000	
10/23/2023	1,741,000	5,180,000	6,921,000	
10/24/2023	645,000	6,360,000	7,005,000	
10/25/2023	662,000	6,260,000	6,922,000	
10/26/2023	669,000	6,360,000	7,029,000	
10/27/2023	959,000	6,070,000	7,029,000	
10/28/2023	670,000	6,040,000	6,710,000	Start-up phase complete
10/29/2023	697,000	6,120,000	6,817,000	
10/30/2023	866,000	6,050,000	6,916,000	
10/31/2023	735,000	6,090,000	6,825,000	
11/1/2023	1,189,000	5,610,000	6,799,000	
11/2/2023	1,470,000	5,250,000	6,720,000	Final transition complete. Begin normal return flow operation to meet 5.15 MG target.
11/3/2023	1,314,000	5,250,000	6,564,000	
11/4/2023	1,298,000	5,250,000	6,548,000	
11/5/2023	1,718,000	5,250,000	6,968,000	
11/6/2023	1,409,000	5,250,000	6,659,000	
11/7/2023	1,397,000	5,250,000	6,647,000	
11/8/2023	2,502,000	5,250,000	7,752,000	
11/9/2023	2,639,000	5,260,000	7,899,000	
11/10/2023	2,113,000	5,250,000	7,363,000	
11/11/2023	1,973,000	5,250,000	7,223,000	
11/12/2023	2,135,000	5,250,000	7,385,000	
11/13/2023	1,828,000	5,250,000	7,078,000	
11/14/2023	1,868,000	5,250,000	7,118,000	
11/15/2023	836,000	5,250,000	6,086,000	
11/16/2023	1,576,000	5,250,000	6,826,000	
11/17/2023	1,492,000	5,250,000	6,742,000	
11/18/2023	1,421,000	5,250,000	6,671,000	
11/19/2023	1,582,000	5,250,000	6,832,000	
11/20/2023	1,554,000	5,250,000	6,804,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
11/21/2023	2,238,000	5,250,000	7,488,000	
11/22/2023	2,066,000	5,250,000	7,316,000	
11/23/2023	1,419,000	5,250,000	6,669,000	
11/24/2023	1,141,000	5,250,000	6,391,000	
11/25/2023	1,309,000	5,250,000	6,559,000	
11/26/2023	1,703,000	5,250,000	6,953,000	
11/27/2023	1,537,000	5,250,000	6,787,000	
11/28/2023	2,419,000	3,820,000	6,239,000	Return pumps stopped ~6am to ~3pm for USGS to perform area-velocity meter maintenance.
11/29/2023	1,668,000	5,250,000	6,918,000	
11/30/2023	1,595,000	5,250,000	6,845,000	
12/1/2023	1,479,000	5,250,000	6,729,000	
12/2/2023	1,498,000	5,250,000	6,748,000	
12/3/2023	2,060,000	5,250,000	7,310,000	
12/4/2023	1,642,000	5,250,000	6,892,000	
12/5/2023	1,676,000	5,250,000	6,926,000	
12/6/2023	1,744,000	5,250,000	6,994,000	
12/7/2023	1,644,000	5,250,000	6,894,000	
12/8/2023	1,487,000	5,250,000	6,737,000	
12/9/2023	1,894,000	5,250,000	7,144,000	
12/10/2023	1,917,000	5,250,000	7,167,000	
12/11/2023	2,861,000	5,250,000	8,111,000	
12/12/2023	1,703,000	5,250,000	6,953,000	
12/13/2023	1,602,000	5,250,000	6,852,000	
12/14/2023	474,000	5,260,000	5,734,000	
12/15/2023	1,528,000	5,250,000	6,778,000	
12/16/2023	1,581,000	5,250,000	6,831,000	
12/17/2023	1,731,000	5,250,000	6,981,000	
12/18/2023	1,600,000	5,250,000	6,850,000	
12/19/2023	1,644,000	5,250,000	6,894,000	
12/20/2023	1,648,000	5,250,000	6,898,000	
12/21/2023	1,519,000	5,250,000	6,769,000	
12/22/2023	1,366,000	5,250,000	6,616,000	
12/23/2023	1,417,000	5,250,000	6,667,000	
12/24/2023	1,260,000	5,250,000	6,510,000	
12/25/2023	1,151,000	5,250,000	6,401,000	

Date	Fox River Discharge Volume (gallons)	Root River Discharge Volume (gallons)	Total Clean Water Plant Discharge Volume (gallons)	Comment
12/26/2023	1,845,000	5,250,000	7,095,000	
12/27/2023	1,749,000	5,250,000	6,999,000	
12/28/2023	1,757,000	5,251,000	7,008,000	
12/29/2023	1,702,000	5,250,000	6,952,000	
12/30/2023	1,535,000	5,250,000	6,785,000	
12/31/2023	6,748,000	60,000	6,808,000	Return flow gate malfunction resulted in pumps shutting down. Alarm did not activate in the CWP SCADA system.

Appendix C. Area Velocity and Magmeter Volume Comparison

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Upper Midwest Water Science Center

Minnesota Office
2280 Woodale Drive
Mounds View, MN 55112
763.783.3100

Wisconsin Office
One Gifford Pinchot Drive
Madison, WI 53726
608.828.9901

Michigan Office
5840 Enterprise Drive
Lansing, MI 48911
517.887.8903

January 9, 2024

Brent Brown
Jacobs Engineering
1610 N. 2nd Street
Suite 201
Milwaukee, WI 53212

RE: Summary comparison between City of Waukesha Clean Water Plant and USGS return flow monitoring

Dear Brent,

I am pleased to provide a summary of return flow monitoring at the facility located on W. Oakwood Rd in Franklin, WI. Daily volumes measured by the USGS are compared to those measured by the Clean Water Plant maintained by the city of Waukesha for the period October through December 2023. Summary statistics of daily volumes between both monitoring locations are generally within 2% indicating good agreement that is within normal levels of instrumentation and measurement error.

Please do not hesitate to contact me should you have any questions.

Sincerely,

William Selbig
Research Hydrologist
USGS – Upper Midwest Water Science Center

In July 2023, the USGS Upper Midwest Water Science Center, in collaboration with the city of Waukesha and Jacobs Engineering, installed equipment used to measure return flow discharge from the facility located at the southeast corner of S. 60th St and West Oakwood Rd in Franklin, WI. The USGS equipment consists of redundant area-velocity meter (AV meter) for measurement of water level and velocity in the effluent pipe as well as a bubbler sensor to measure water level of pooled water prior to entering the effluent pipe. All sensors were calibrated to the nearest 0.01 foot. Additionally, dye tracer experiments were done on September 12, 2023 to validate discharge values as well as create stage-discharge regression equations. These equations are used to estimate discharge during periods when velocity may be unreliable. The objective of this study is to provide an impartial comparison of return flow volume measured by the USGS AV meter (herein referred to as USGS) to that of a magmeter maintained by the Clean Water Plant in the city of Waukesha (herein referred to as CWP). The magmeter is located immediately downstream of the return flow pump station with no additions or subtractions of flow in the pipeline between the pump station and the discharge facility.

Continuous measurements at 5-minute increments began on October 9th, 2023. A power failure occurred on October 22nd and was restored on October 31st, causing a 9-day gap in measured data. Figure 1 shows a typical hydrograph for both USGS and CWP discharge observed over the course of one day. The USGS discharge shows an approximately 1-hour lag in response to changes in CWP discharges. This represents the time required for propagation of changes in the pumps maintained by the CWP to make their way through the length of pipe between the two measurement points. For this reason, comparison of volume equivalency was made on a minimum daily time step.

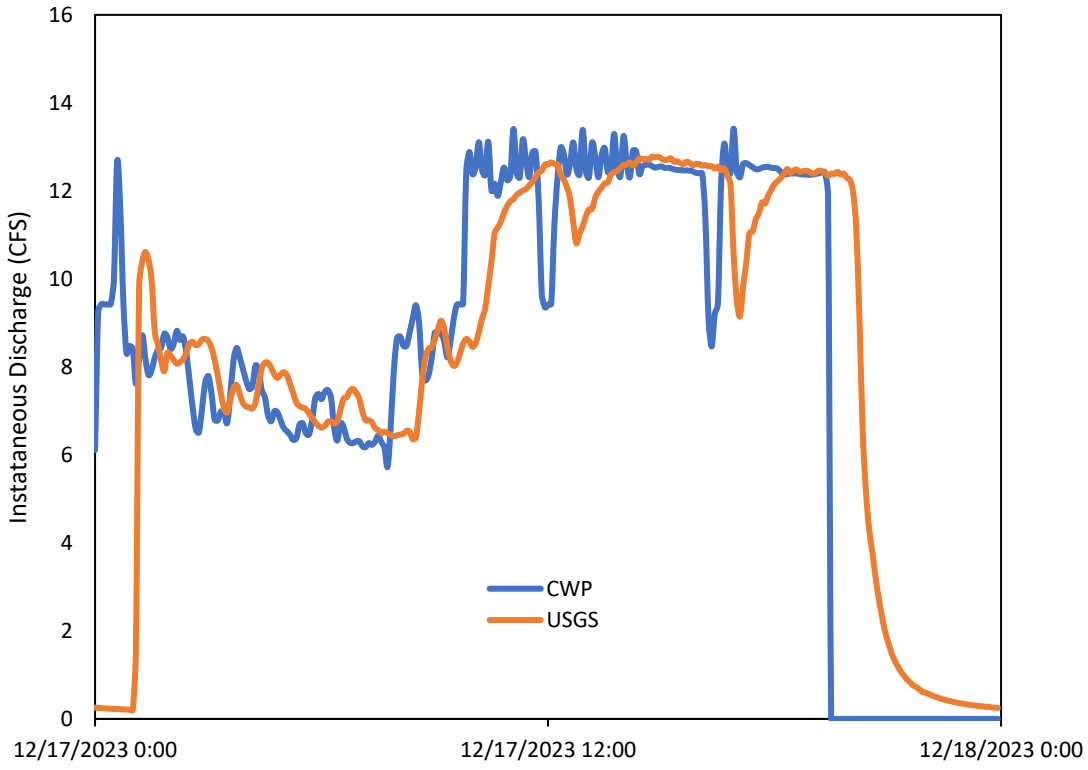


Figure 1. Typical daily hydrograph of instantaneous discharge measured by the USGS and Clean Water Plant.

Daily volumes measured by the USGS were slightly greater than those measured by the CWP (figure 2) for all but one day. October had a greater range in daily volume than both November and December but overall showed very low variability with variation coefficients less than or equal to 0.05 (Table 1).

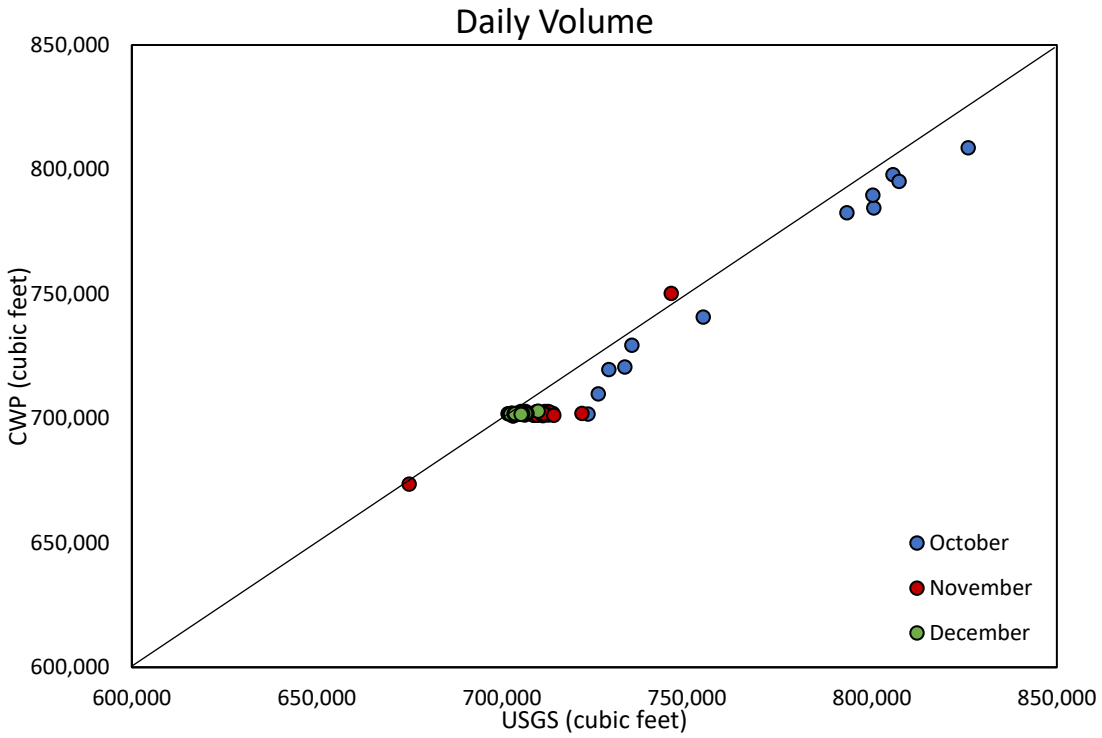


Figure 2. Comparison of daily volumes withdrawn and returned in October through December 2023.

Table 1. Summary statistics for daily return flow volumes measured by USGS and CWP, October – December 2023. All values rounded to the nearest 1,000 cubic feet unless otherwise noted.

Statistic	OCTOBER		NOVEMBER		DECEMBER	
	USGS	CWP	USGS	CWP	USGS	CWP
Days	12[a]	12[a]	29[b]	29[b]	30[c]	30[c]
Minimum	723,000	702,000	675,000	674,000	702,000	701,000
Maximum	826,000	809,000	746,000	750,000	710,000	703,000
Median	774,000	762,000	711,000	702,000	704,000	702,000
Mean	770,000	757,000	711,000	703,000	704,000	702,000
Standard deviation	37,000	38,000	10,000	10,000	2,000	<1,000
Variation coefficient	0.05	0.05	0.01	0.02	<0.01	<0.01
Sum	9,234,000	9,080,000	20,624,000	20,375,000	21,132,000	21,055,000
Sum, % difference	2%		1%		0.4%	

a – power failure created 9-day gap in data

b – pumps at CWP were shut down on 11/28/23 to allow for calibration of USGS meter

c – mechanical gate failure at CWP on 12/31/23 caused pumps to shut down

Daily volumes measured by USGS, although slightly higher, were generally within 2% of those measured by CWP (figure 3). Percent differences decreased each month with October showing the largest deviation from equality and December the smallest. The convergence of equality between the two locations was likely a result of repositioning of the USGS meter in late November (see footnote b in table 1). After the meter was repositioned and recalibrated, the USGS and CWP meters were very similar in December with mean and median differences at less than 1%. The range of percent differences presented in figure 3 is considered acceptable and generally within the accuracy of the meter used to measure discharge at +/- 2%. This trend was similarly observed when daily volumes were summed over the duration of each month (table 1).

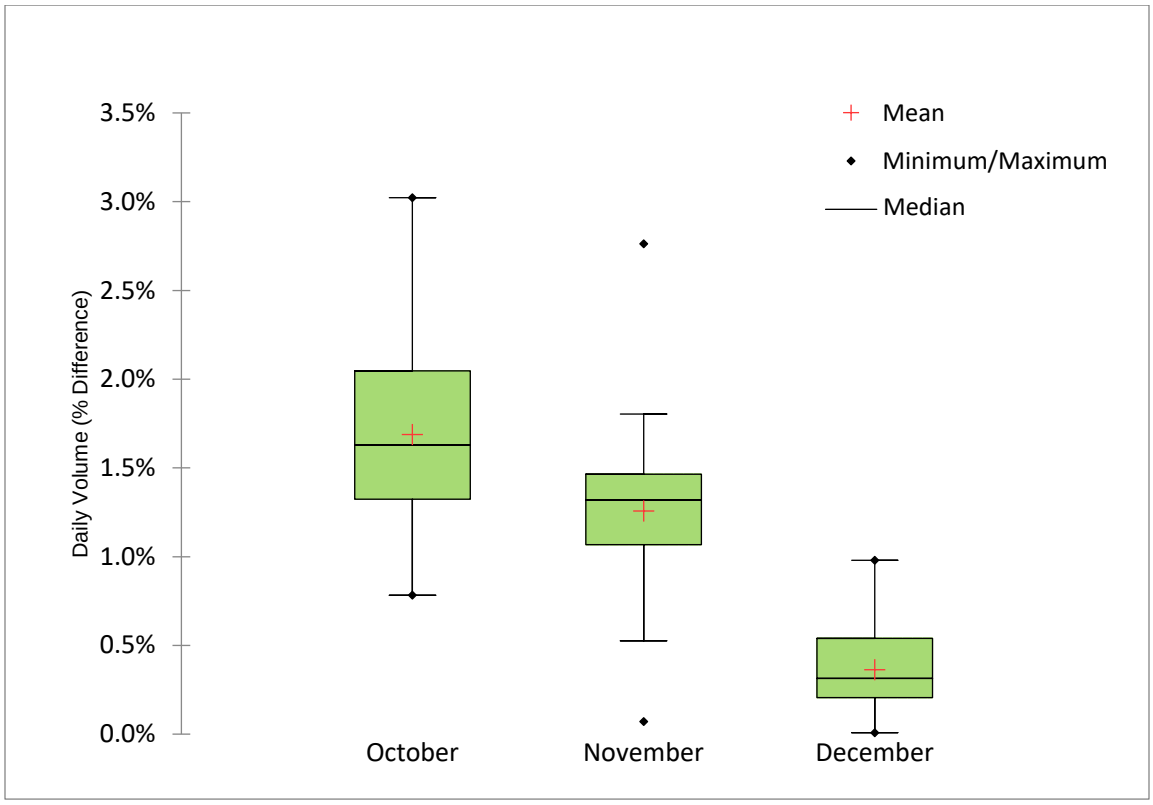
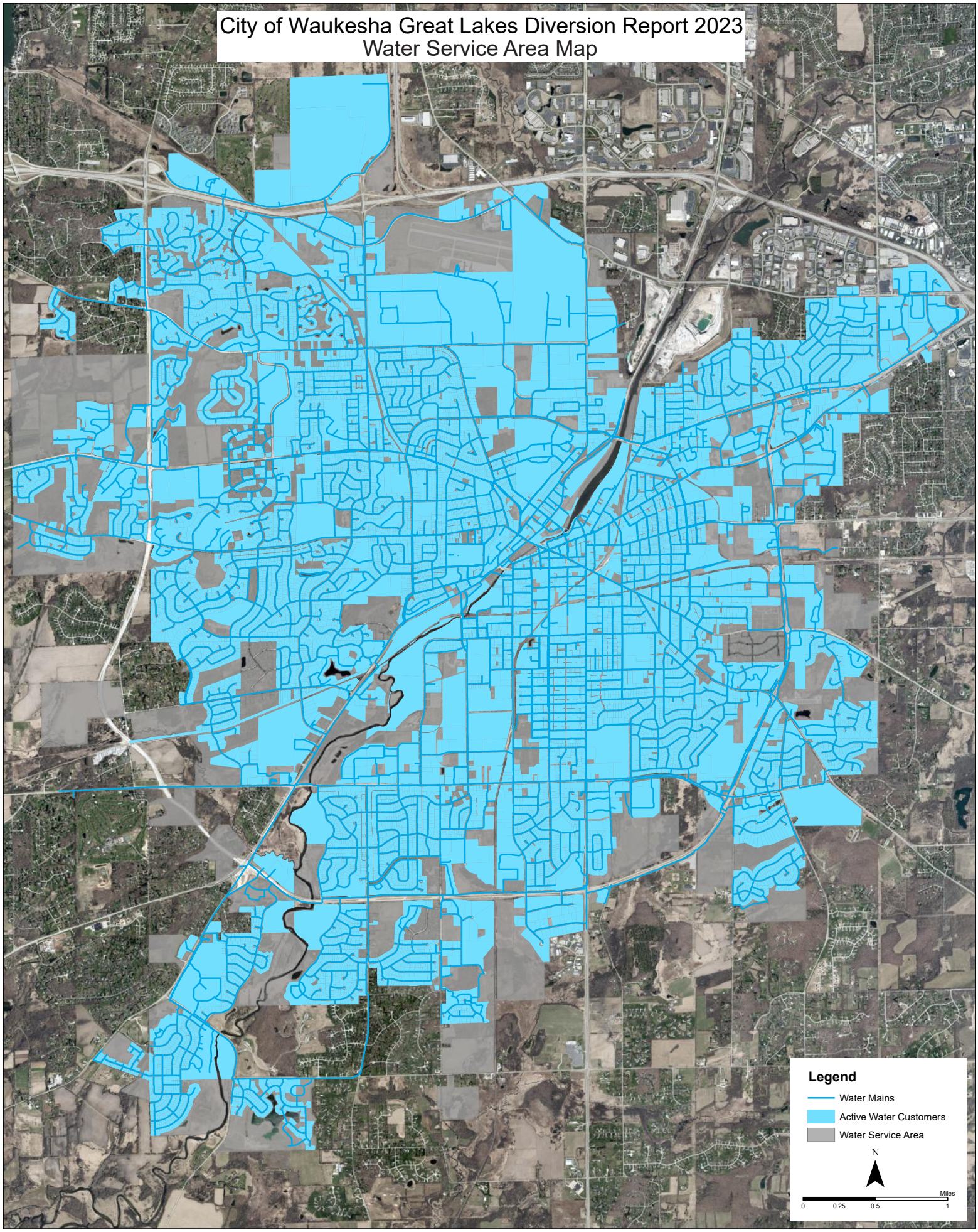


Figure 3. Absolute percent difference in daily volumes measured by USGS and CWP, October – December 2023.

Appendix D. 2023 Service Area Map

City of Waukesha Great Lakes Diversion Report 2023
Water Service Area Map



Appendix E. DNR Approval of Extended Well Abandonment Agreement

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
141 NW Barstow St., Room 180
Waukesha, WI 53188

Tony Evers, Governor
Adam N. Payne, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

November 24, 2023

Waukesha Water Utility
Daniel Duchniak – Water Utility General Manager
115 Delafield St.
Waukesha, WI 53188

PWSID#: 26802380
Region: Southeast Region
County: Waukesha
File Code: 3300

Subject: Approval of Extended Well Abandonment Agreement for Utility Wells

Dear Mr. Duchniak:

The Wisconsin Department of Natural Resources, Division of Water, Bureau of Drinking Water and Groundwater, is conditionally approving the request for the following in accordance with NR 810.22.

Water system name: Waukesha Water Utility (Utility)
Date received: 11/24/2023
Length of time extension: None
Utility Representative: Daniel Duchniak. PE
Regional DNR Contact: Thanintr Ratarasarn – SE Waukesha
Project description: Extended Well Operation Agreement for Utility wells

Per NR 810.22, an emergency well is a well that is not routinely used. The well owner may obtain a written Extended Well Abandonment Agreement with the Department to allow a normally unused or standby well to remain operational and to delay well abandonment for the following Utility wells.

Well # 3 (WUWN BH429)
Well # 5 (WUWN BH431)
Well # 6 (WUWN BH432)
Well # 7 (WUWN BH433)
Well # 8 (WUWN BH434)
Well # 9 (WUWN BH435)
Well # 10 (WUWN BH436)
Well # 11 (WUWN RL255)
Well # 12 (WUWN RL256)
Well # 13 (WUWN WK947)

Approval conditions related to Chapter NR 809, NR 810, and NR 811, Wis. Adm. Code:

1. All wells shall be placed into emergency status no later than **December 31. 2023.**
2. Per the Great Lakes Compact Council approval and the DNR diversion approval, the wells shall not be used as part of the Utility's regular water supply and only used for emergency purposes.
3. The water system will restrict the use of the well if the water quality exceeds the primary drinking water standards to emergency use of no more than 2 days per quarter. The Department may authorize an extended period of use for an individual event if contacted by the Utility.

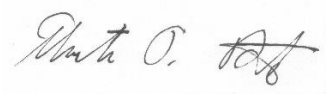
4. The water supplier shall notify all customers of the use of the well. A **Tier II** public notice, in accordance with **NR 809.52** shall be issued if this well is used.
5. The well water entering the distribution system may not exceed any bacteriological or nitrate drinking water standards.
6. The well water may not contain any volatile organic or synthetic organic contaminant levels exceeding the maximum contaminant level or MCL that could lead to further water quality degradation of the groundwater.
7. The well owner agrees to a 5 year cycle of reevaluation. Where the agreement is continued, it shall be renewed in writing every 5 years.
8. A 6-year cycle for water quality monitoring is established.
9. Bacteriological testing is conducted quarterly from the well.
10. Nitrate is monitored annually from the well.
11. The well meets current well construction and pump installation standards.
12. The well owner agrees to televise any well in excess of 70 years old at least once every 15 years.

Approval conditions related to other Department requirements: None

Approval constraints: This approval is based upon the representation that the information obtained by the department from the Waukesha Water Utility is complete and accurately represents 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.

If you have any questions, please do not hesitate to contact me by telephone at 262-765-0912, or by e-mail at Thanintr.Ratarasarn@Wisconsin.gov.

Sincerely,



Thanintr (Tony) Ratarasarn, MS, PE
Drinking Water Engineer

Cc: DG Files – Southeast Region
DG/5 - Madison

Attachments: Extended Well Abandonment Agreement Permit

EXTENDED WELL ABANDONMENT AGREEMENT BETWEEN THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES (DEPARTMENT) AND THE CITY OF WAUKESHA WATER UTILITY

PURPOSE

Per NR 810.22, an emergency well is a well that is not routinely used. The well owner may obtain a written extended well abandonment agreement with the department to allow a normally unused or standby well to remain operational and to delay well abandonment. This Agreement between the Department and the City of Waukesha Water Utility (PWSID # 26802380) has been written to satisfy the requirements of NR 810.22, Wis. Adm. Code. The City of Waukesha Water Utility owns and operates a well that is no longer used and shall place the following well into emergency status:

- Well # 3 (WUWN BH429)
- Well # 5 (WUWN BH431)
- Well # 6 (WUWN BH432)
- Well # 7 (WUWN BH433)
- Well # 8 (WUWN BH434)
- Well # 9 (WUWN BH435)
- Well # 10 (WUWN BH436)
- Well # 11 (WUWN RL255)
- Well # 12 (WUWN RL256)
- Well # 13 (WUWN WK947)

This agreement allows the City of Waukesha Water Utility the use of the above well for emergency purposes where the loss of the primary water source would necessitate the use of this well to protect health and human safety.

REQUIREMENTS

The City of Waukesha Water Utility agrees to comply and shall continuously comply with the following requirements for the well for which this agreement applies:

1. Per the Great Lakes Compact Council approval and the DNR diversion approval, the wells shall not be used as part of the Utility's regular water supply and only used for emergency purposes.The water system will restrict the use of the well if the water quality exceeds the primary drinking water standards to emergency use of no more than 2 days per quarter. The department may authorize an extended period of use for an individual event if contacted by the Utility.
2. The water supplier shall notify all customers of the use of the well. A Tier II public notice, in accordance with NR 809.52 shall be issued if this well is used.
3. The well water entering the distribution system may not exceed any bacteriological or nitrate drinking water standards.
4. The well water may not contain any volatile organic or synthetic organic contaminant levels exceeding the maximum contaminant level or MCL that could lead to further water quality degradation of the groundwater.
5. The well owner agrees to a 5 year cycle of reevaluation. Where the agreement is continued, it shall be renewed in writing every 5 years.
6. A 6-year cycle for water quality monitoring is established.
7. Bacteriological testing is conducted quarterly from the well. Nitrate is monitored annually from the well.
8. The well meets current well construction and pump installation standards.
9. The well owner agrees to televise any well in excess of 70 years old at least once every 15 years.

SIGNATURES

This agreement shall expire five years the date the well is placed into emergency status. The evaluation may be completed by the Department prior to the five-year anniversary, if the Department determines it is necessary.

Mark O. Roff	11/28/2023	11/29/2023	
Thanintr Ratarasarn, PE Regional Water Supply Engineer WI Department of Natural Resources	Date	Daniel Duchniak, PE Water Utility General Manager City of Waukesha Water Utility	Date

Appendix F. Pharmaceutical and Personal Care Products Reduction Program – 2023 Annual Report

Memorandum

Subject	**City of Waukesha Pharmaceutical and Personal Care Products Reduction Program – 2023 Annual Report**
Project Name	City of Waukesha 2023 Diversion Reporting
From	Clean Water Plant: Plant Manager, Pretreatment Coordinator, Administrative Assistant Solid Waste: Solid Waste Coordinator Water Utility: Operations Manager
Date	February 26, 2024

The City of Waukesha, Wisconsin (City) received approval of its application for diverting Lake Michigan water with return flow on June 24, 2016 (Application Approval) and June 29, 2021 (Diversion Approval). As a condition of the approvals, the City is required to implement a Pharmaceutical and Personal Care Products (PPCP) Reduction Program. The purpose of this memorandum is to summarize the progress of the PPCP Reduction Program in 2023.

1. Background

The City operates the Clean Water Plant (CWP) to provide wastewater treatment to City residents and a small number of surrounding residential and commercial areas. There are various existing programs required as part of the CWP discharge permit that reduce the volume of wastewater and constituents in the wastewater conveyed to the CWP. One of these programs includes providing education about the importance of proper disposal of PPCPs, as well as promoting pharmaceutical collection boxes and collection events. The CWP also has partnered with the City's Recycling and Solid Waste Division, the City's Communications and Engagement Group, the City Police Department, and Waukesha County to coordinate efforts related to the PPCP Reduction Program. Examples of past PPCP reduction efforts by the City include:

- Promoting continuous pharmaceutical disposal collection boxes or kiosks at multiple locations within the City.
- Sponsoring National Prescription Drug Take Back Day collection events twice per year – typically, one event in April and a second event in October.
- Providing public education through multiple platforms, including the City, Department of Public Works (DPW), and CWP websites; City weekly email news; DPW mailed newsletters; direct water and sewer bill inserts; and social media postings on Facebook, City televisions within City Hall, and on community message boards.

The PPCP Reduction Program has focused primarily on educating the public, promoting pharmaceutical take back events, and directly supporting the proper disposal of residential prescription and over-the-counter medications. The following sections provide a summary of the program accomplishments.

2. Source Reduction Through Education

The following resources were reviewed for consideration in providing public education:

- Waukesha County Sheriff's Department – Prescription and Over-the-Counter Medicine Collection Program
- Wisconsin Department of Natural Resources (WDNR) – How to Safely Dispose of Household Pharmaceutical Waste
- WDNR – Pharmaceutical and Personal Care Products in the Environment
- WDNR – Wisconsin Household Pharmaceutical Waste Collection: Challenges and Opportunities (UW Extension, October 2012)
- Earth 911
- Product Stewardship Institute
- Wisconsin Department of Health Services – Dose of Reality Partner Materials
- Water Environment Federation – Household Waste Disposal Chart
- Wisconsin Department of Justice – Drug Take-Back Day Information
- Wisconsin Department of Justice – Permanent Drug Drop Box Locations
- U.S. Department of Justice – Year-Round Drop-Off Locations – Search Utility
- U.S. Drug Enforcement Administration (DEA) – Take Back Day

The following educational materials and promotional materials were made available to residents in 2023:

- Three quarterly DPW newsletters included information regarding PPCPs. The newsletters are sent to approximately 21,000 households.
  - Spring – summarized personal care product disposal best practices.
  - Fall – promoted the October National Drug Take Back Day and the City's drop box location.
  - Winter – promoted responsible disposal of pharmaceuticals and the City's drop box location.

  Figure 2-1 includes an example of a PPCP article in the DPW newsletter, promoting personal care product disposal best practices.

Disposal of Personal Care Products

Personal care products – also known as health and beauty products— are part of our daily lives. Many of these products are essential to sustain healthy hygiene, skin care and protection from UV rays, amongst other things. Of course, many of these products are also used for the sake of beautification and fragrance—both of which are socially relevant in our culture.

As essential as these products have become, there can be negative environmental effects when these products are disposed. Many of the products contain micro plastics and other ingredients which will not easily biodegrade in the environment.

Unfortunately, even at our Clean Water treatment plant, we do not have the capability to filter and remove all of these particles and many end up discharging straight into the Fox River.

Due to this potential harmful effect in the water system, there is a three-tiered recommendation for use and disposal of these products:

1) Start with buying only as much as needed, minimizing unused product needing to be disposed beyond normal use.
2) Consider purchasing more natural products containing fewer non-biodegradable ingredients.
3) In the event of an unwanted product, the recommended proper disposal is into your household trash container, which will be landfilled. The excess unwanted products should NOT be poured down a sink drain or flushed for disposal.

While excessive liquids are also not ideal for landfill environmental impact, this option is preferred due to the immediate negative impacts on the water system if sent down the drain. Modern landfills are designed to capture some liquids and manage them before they reach water resources.

Thank you for taking this topic into consideration and doing your part to help protect Waukesha's waterways.

Figure 2-1. Example Personal Care Products Disposal Article in the Spring 2023 DPW Newsletter

- An informational flier created by the DEA was provided by the Waukesha Police Department for the October National Drug Take Back Day. Flyers were available to post in public windows such as stores, cafes, and restaurants and at the public library.
- A "Don't Flush That" article promoting proper disposal of PPCP in the City's March 2023 e-newsletter was sent. The e-newsletter is typically sent to more than 6,000 email addresses.
- The CWP website includes information about PPCPs as well as website links for:
  - Additional educational material
  - Resources regarding proper disposal of PPCPs and best practice recommendations
  - The City's continuous drop box web page

  Figure 2-2 shows information regarding PPCPs on the CWP website.

Prescriptions & Personal Care Products

Doing some spring cleaning and clearing out your medicine cabinet? Stop before you flush old or unwanted prescription, over-the-counter medications, or other personal care products down the toilet or drain. Studies have shown that pharmaceuticals and personal care products are present in the environment. People in Wisconsin use and discard large quantities of over-the-counter medications, prescriptions and personal care products every year. Flushing these products down the drain may contaminate our lakes and rivers and affect fish and wildlife. There is growing evidence that these products may be affecting the environment in unintended ways, and unused medications in homes may be misused or abused.

For more information:

- Pharmaceutical Waste and the Environment - Wisconsin Department of Natural Resources (DNR)
- Household Waste Disposal Chart - Water Environment Federation
- Drug Disposal Program - City of Waukesha Police Department

Figure 2-2. Example PPCP Information on the CWP Website

- Social media articles were posted to the City's Facebook, Instagram, and X (formerly Twitter) accounts. The social media posts included articles such as the following:
  - "Don't Flush That" – an article regarding proper disposal of PPCPs
  - "Police Department Drop Box" – information about the permanent pharmaceutical drop box at the City Police Department
  - "National Drug Take Back Day" – promoting the National Drug Take Back Day on October 28, 2023

Figure 2-3 includes an example social media post, promoting the October National Drug Takeback Day.

Figure 2-3. Example Social Media Post Promoting the October National Drug Takeback Day

- The City included a "Disposal Guide" on its waste collection website that includes disposal options for personal care products and pharmaceuticals.
- "Drug Disposal Program" and "Think Before You Flush" articles regarding best practices for PPCP disposal were posted to the City's online Residents Guide and departmental websites for continuous availability to residents.

  Figure 2-4 shows the continuous drop box information provided by the City in its online Residents Guide.

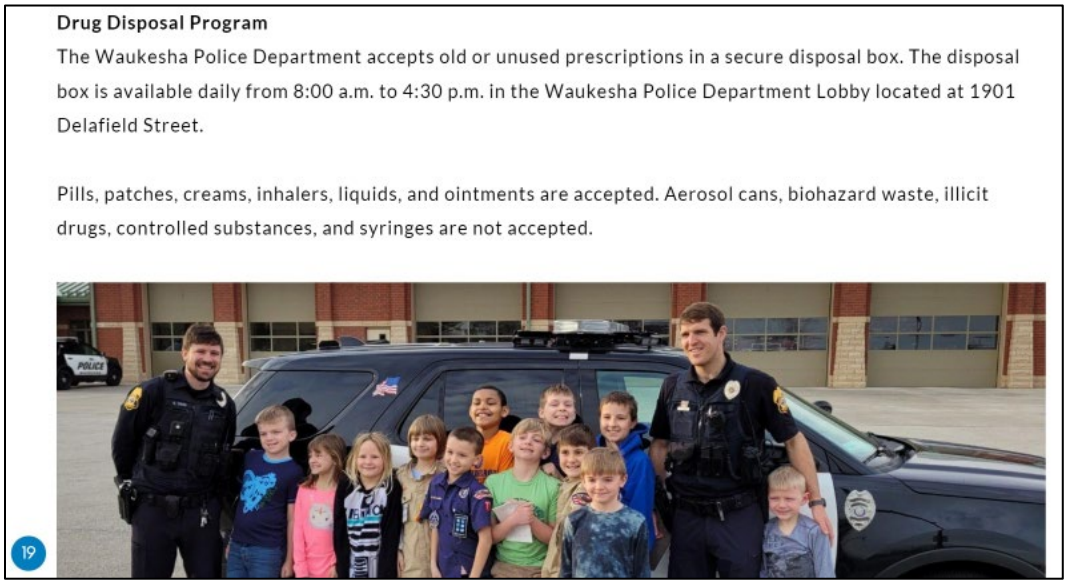


Figure 2-4. Example Information about the Police Department Pharmaceutical Continuous Drop Box published in the City's Residents Guide

3. Source Reduction Through Collection and Reuse

Collection events and continuous collection locations are a central part of the PPCP program. The events, continuous drop box locations, and quantity of collected PPCP is summarized in Table 3-1.

Table 3-1. Quantity of PPCP Collected in 2023

Date	Event Name or Location	Quantity and Units
October 2022 to April 2023	City Police Continuous Drop Box	715.6 lbs
April 2023 to October 2023	City Police Continuous Drop Box	542.2 lbs
April 22, 2023	National Drug Take Back Event	220.0 lbs
October 28, 2023	National Drug Take Back Event	181.8 lbs
	Total	1,659.6 lbs

lbs = pounds

The PPCP reduction program coordinators have discussed expanding the number of events and continuous drop box locations, including completing the following activities:

- Contacted Waukesha Police Department regarding adding a booth promoting PPCP disposal awareness during the Waukesha Night Out event that focuses on health and safety.

- Confirmed new drop box locations available within the City in 2023.
- Verified existing locations and contact information for continuous drop boxes for City police, County sheriff, and local pharmacies (included in Table 3-2).

Table 3-2. Locations of Continuous Drop Boxes

Location Name	Address
Waukesha Police Department (in front lobby)	1901 Delafield Street, Waukesha
Waukesha County Sheriff's Department (in lobby)	515 W. Moreland Boulevard, Waukesha
Waukesha Memorial Hospital (in pharmacy)	725 American Avenue, Waukesha
Walgreens	221 E. Sunset Drive, Waukesha
CVS	1130 W. Sunset Drive, Waukesha
Meijer (in pharmacy)	801 E. Sunset Drive, Waukesha

For significant sources of PPCP, such as hospitals and clinics, the following activities were completed:

- Researched, discussed, and developed potential educational material geared toward entities that are significant sources of PPCP.
- Developed a preliminary list of significant sources of PPCP for future coordination regarding education materials and source reduction (Table 3-3).

Table 3-3. Preliminary List of Significant Sources of PPCPs

Type	Source
Hospitals and Clinics	Rehabilitation Hospital of Wisconsin
	Ascension Wisconsin Hospital – Waukesha
	Waukesha Memorial Hospital
	Froedtert Westbrook Health Center
	Fitzsimmons Hospital Services
	Aurora Health Center
Pharmacies	CVS Pharmacy (two locations)
	Moreland Plaza Pharmacy
	Genoa Healthcare
	Walgreens (two locations)
	ProHealth Pharmacy Waukesha
	Walmart Pharmacy
	Meijer Pharmacy
Veterinary Clinics	Wisconsin Veterinary Referral Center
	Waukesha Animal Hospital
	Cream City Kitty Clinic
	Harmony Pet Clinic

Type	Source
	Waukesha Walk-in Vet Clinic
	Westown Veterinary Clinic
Assisted Living Facilities	Heritage Court Waukesha
	Oak Hill Terrace Senior Living
	Avalon Square
	New Perspective Senior Living
	St. Coletta Greenway Terrace

Non-prescription personal care products (PCPs) such as hair care, lotions, and ointments are not accepted at collection events or continuous drop box locations. This is in part because they are not controlled substances, they may be part of residents' normal daily hygiene, and consequently disposal options simply include placing PCP in garbage or solid waste receptacles. However, reducing waste from disposing of unused PCP through reuse opportunities has been considered. Through initial contacts with entities that may benefit from PCP reuse (e.g., shelters), they can receive more donated products than needed and there is concern that opened PCP could be tampered with and present a safety hazard. These two issues limit reuse opportunities. Consequently, future PCP opportunities will likely focus on proper disposal if materials are discarded before the end of their useful life.

Additional PCP activities included:

- Reviewed general PCP educational information for use in updating Frequently Asked Questions, social media posts, and on associated City websites.
- Reviewed local ordinances and state laws related to PCP disposal best practices.
- Reviewed general PCP disposal and reuse best practices for consideration in future implementation.
- Reviewed additional opportunities for PCP reduction and reuse through the WDNR and U.S. Environmental Protection Agency (EPA).

A preliminary list of potential significant sources of PCP that will be considered for future coordination is summarized in Table 3-4.

Table 3-4. Preliminary List of Potential Significant Sources of PCPs

Type	Source
Hospitals and Clinics	Rehabilitation Hospital of Wisconsin
	Ascension Wisconsin Hospital – Waukesha
	Waukesha Memorial Hospital
	Froedtert Westbrook Health Center
	Fitzsimmons Hospital Services
	Aurora Health Center
Pharmacies	CVS Pharmacy (two locations)
	Moreland Plaza Pharmacy

Type	Source
	Genoa Healthcare
	Walgreens (two locations)
	ProHealth Pharmacy Waukesha
	Walmart Pharmacy
	Meijer Pharmacy
Departments Stores	Walmart Supercenter
	Kohl's
	Meijer
	Target
Hotels/Motels	Baymont by Wyndham Waukesha
	Comfort Inn
	Price Pointe Inn
	The Clarke Hotel
	Extended Stay America
	The Ingleside Hotel
	Avid Hotel
	Best Western Waukesha Grand

4. Future Opportunities

The City has expanded its PPCP Reduction Program from their efforts prior to the diversion. However, additional activities that will be considered in 2024 and beyond could include:

- General PPCP and PCP Information
  - Monitor best practices regarding pharmaceuticals and personal care products provided by the EPA and WDNR.
  - Update list of acceptable PPCPs and PCPs for collection and disposal on City, CWP, Police, and Sheriff websites to be consistent and provide as much specificity as possible.
- Source Reduction through Education
  - Connect with local schools for publishing educational material in their district newsletters and other communication outlets, or to provide educational materials as part of Earth Day instructional events.
  - Improve and expand the educational and awareness materials for significant PPCP sources.
  - Develop PCP flyer for the public and promote posting the flyer at locations such as the City library.
  - Develop PPCP flyer for the public and promote posting the flyer at locations at City events such as Waukesha Night Out and Waukesha Unlocked.

  - Continue to develop and publish PPCP and PCP events and educational material on City Facebook, Twitter, and Instagram accounts.
  - Continue to develop and publish content for PPCP and PCP by electronic methods such as the City's website and email newsletters.
  - Continue to develop and publish content for PPCP and PCP in DPW newsletters.
  - Develop and publish content for PPCP and PCP in water/sewer bill inserts.
- Source Reduction through Collection and Reuse
  - Further inventory potentially significant PCP sources in the City besides hospitals, pharmacies, and department stores to provide educational materials on proper disposal options.
  - Despite initial limitations, continue exploring opportunities to connect PCP sources with users to provide PCP reuse opportunities (connecting hotels with shelters for reuse of unopened PCP).
  - Continue discussions with pharmacies and veterinary clinics to expand continuous collection (drop box) locations.
  - Continue discussions with the Waukesha Police Department to expand collection opportunities at household hazardous waste events at the County's contracted collection site.
  - Further inventory potentially significant PPCP sources in the City besides hospitals, pharmacies, nursing homes, and veterinary clinics.
  - Further provide PPCP and PCP collection opportunities and information to educate the public by staffing events/booths to specifically promote the PPCP program. Future events that may be considered include:
    - Waukesha Night Out – This event is designed to heighten crime and drug awareness, promote safety knowledge, generate support for and participation in local anti-crime programs, and strengthen community spirit and police-community partnerships.
    - Waukesha Unlocked – This event allows the general public to take tours, participate in special activities, learn, and explore at different businesses, organizations, churches, and City buildings.

Appendix G. Pre-Diversion Root River Data Collection Summary

Pre-Diversion Root River Data Collection Summary

Prepared For:

City of Waukesha

Prepared By:

Jacobs

February 2024

Contents

Tables

Figures

Acronyms and Abbreviations

µg/L	microgram(s) per liter
cfs	cubic foot/feet per second
CH2M	CH2M HILL, Inc.
City	City of Waukesha
CPUE	catch per unit effort
DELT	deformities, erosion, lesions, tumors
fps	foot/feet per second
HBI	Hilsenhoff Biotic Index
IBI	Index of Biotic Integrity for Warmwater Fish Communities
Jacobs	Jacobs Engineering Group Inc.
mg/L	milligram(s) per liter
MPTV	mean pollution tolerance value
mS/cm	microsiemens per centimeter
NTU	nephelometric turbidity units
QAPP	Quality Assurance Project Plan
S.U.	standard unit(s)
USGS	U.S. Geological Survey
WDNR	Wisconsin Department of Natural Resources

1 Background

The City of Waukesha, Wisconsin (City) transitioned to a Lake Michigan water supply in October 2023 consistent with the 2021 Diversion Approval granted by the Wisconsin Department of Natural Resources (WDNR). The Diversion Approval requires the City to monitor the Root River to assess the impact of the return flow wastewater discharge. The City also is required to report the Root River monitoring results and impact assessment annually.

In preparation for the diversion and assessing the impact that the diversion and return flow have on the Root River, the City implemented a voluntary pre-diversion data collection program. The data collection began in 2017 to provide pre-diversion baseline water quality, flow, habitat, macroinvertebrate, and fish data (CH2M 2017). The City completed its transition to Lake Michigan water and assessing impact from the return flow can be completed in the future. However, in preparation for the impact assessment, a summary of the pre-diversion monitoring (pre-October 2023) is provided here. Future annual reports will be completed in October through September timeframes and will include post-diversion conditions.

2 Return Flow Volume

The City constructed most of the return flow infrastructure in August 2023. At this time, return flow was intermittently pumped to the Root River for typical construction startup and testing procedures of the pump station, pipeline, and associated control programming, and to support a dye tracer study by the U.S. Geological Survey (USGS) for its area-velocity meter installation in the return flow outfall building. A summary of return flow volumes to the Root River during the startup and testing phases through September 30, 2023, is included in Table 2-1[1].

Table 2-1. Daily Return Flow Volumes During Startup and Testing

Date	Return Flow Volume (million gallons)
8/1/2023	0.004
8/2/2023	0.004
8/23/2023	0.37
8/24/2023	0.22
8/25/2023	1.22
8/28/2023	0.31
8/29/2023	0.27
8/30/2023	1.60
8/31/2023	1.55
9/1/2023	0.81
9/5/2023	3.50
9/6/2023	2.69

[1] A summary of water supply and return flow volumes in 2023 (including October through December) will be summarized in Sections C and D, respectively, of the Diversion Approval Report for 2023.

Date	Return Flow Volume (million gallons)
9/11/2023	0.25
9/12/2023	3.56
9/13/2023	4.05
9/14/2023	4.73
9/19/2023	0.008
9/25/2023	0.005
9/26/2023	6.14
9/27/2023	3.99
9/29/2023	0.75
Total	36.04

2.1 Root River Flow

Through a cooperative partnership with the City, the USGS also maintains a flow gauge along the Root River approximately 760 feet upstream from the return flow outfall (USGS site 04087234). During the intermittent return flow through September 30, 2023, return flow was between 0 and 55% of the combined river and return flow (Table 2-2). At the time of this report, the river flow data were provisional and most days were noted as estimated flow rates because a beaver dam was observed approximately 650 feet downstream of the gauge (about 110 feet upstream of the return flow outfall) creating backwater that may be affecting the gauge accuracy.

Table 2-2. Daily Root River Flows on Days with Return Flow

Average Flow (cubic feet per second)				
Day with Return Flow	Root River	Return	Total Flow (Root + Return)	Return % of Total Flow
8/1/2023	15	0.006	15.006	0.0%
8/2/2023	12.2	0.006	12.206	0.1%
8/23/2023	13.2	0.575	13.775	4.2%
8/24/2023	21.2	0.345	21.545	1.6%
8/25/2023	43.3	1.892	45.192	4.2%
8/28/2023	14.6	0.487	15.087	3.2%
8/29/2023	9.88	0.410	10.290	4.0%
8/30/2023	7.87	2.475	10.345	23.9%
8/31/2023	9.58	2.398	11.978	20.0%
9/1/2023	6.63	1.253	7.883	15.9%
9/5/2023	4.38	5.415	9.795	55.3%
9/6/2023	6.36	4.161	10.521	39.6%
9/11/2023	18	0.387	18.387	2.1%
9/12/2023	39.3	5.507	44.807	12.3%
9/13/2023	37.6	6.265	43.865	14.3%

Average Flow (cubic feet per second)				
Day with Return Flow	Root River	Return	Total Flow (Root + Return)	Return % of Total Flow
9/14/2023	35.9	7.317	43.217	16.9%
9/19/2023	15.8	0.012	15.812	0.1%
9/25/2023	6.98	0.008	6.988	0.1%
9/26/2023	39.1	9.500	48.600	19.5%
9/27/2023	212	6.176	218.176	2.8%
9/29/2023	252	1.154	253.154	0.5%

All data noted by USGS to be provisional.

2.2 Root River Water Level and Velocity

On the day with the greatest percentage of return flow (9/5/2023), the Root River had very low flow (4.38 cubic feet per second; cfs) compared to an average September monthly flow of about 100 cfs (Table 2-2). Based on the USGS stream gauge rating curve, the return flow (5.415 cfs) raised the water surface by 2.28 inches. The velocity change is anticipated to be less than 0.3 feet per second (fps) based on hydraulic modeling completed during the application where an 18 cfs return flow rate resulted in an estimated 0.3 fps increase during 3 cfs low river flow conditions[2]. In future years when return flow consistently outfalls to the Root River, a hydraulic model can be used to assess velocity changes from the range of return flow and river flow rates observed over the year.

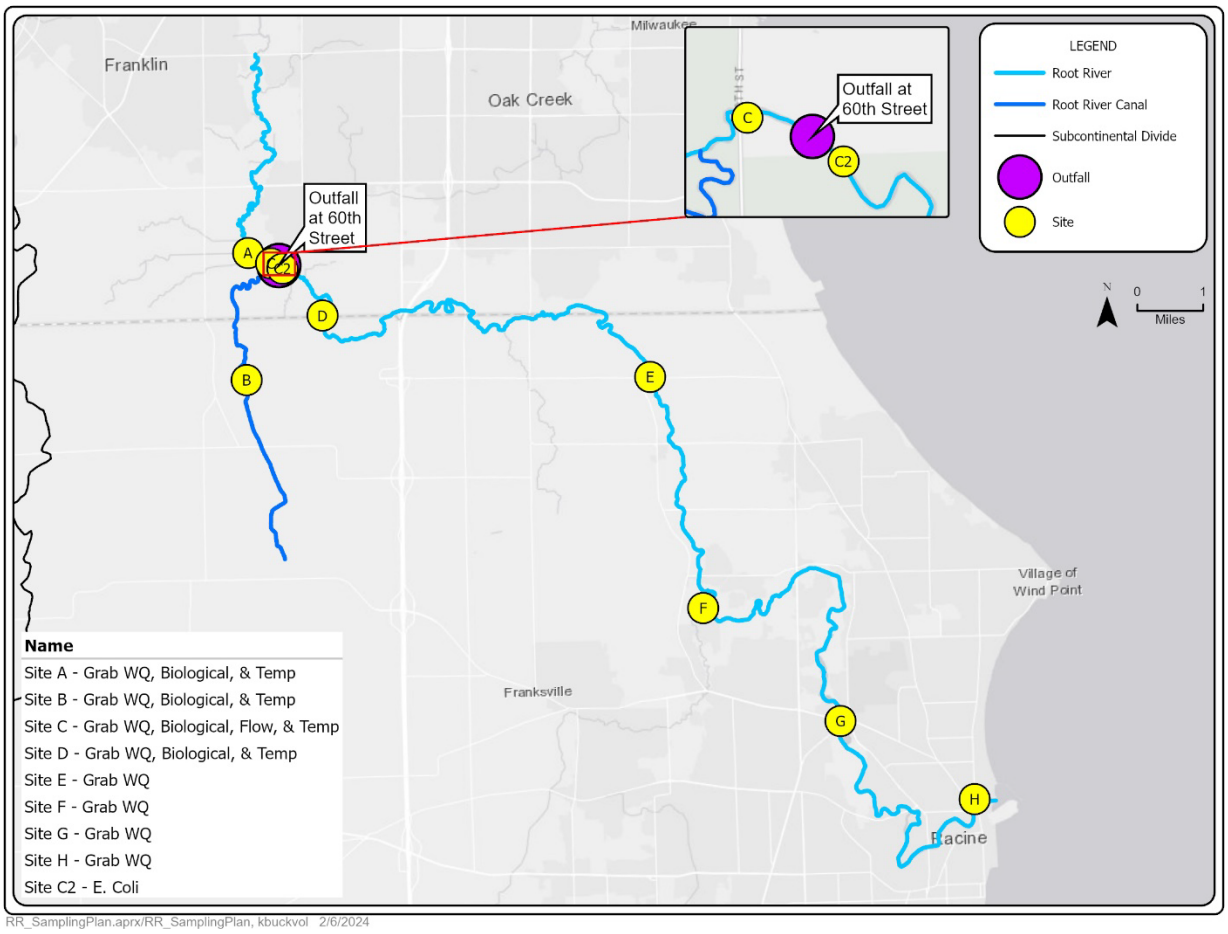
3 Monitoring Locations

Monitoring locations were upstream and downstream of the return flow outfall location (Figure 3-1). These include the following:

- Sampling at Sites A, B, C, D, E, F, G, and H was initiated in 2017 as part of the Pre-Return Flow Root River Data Collection Plan.
- Sampling at Site E and Site H was discontinued in 2020.
- Sites A, B, C, and D include water quality and biological monitoring.
- Sites A through H, minus Site C2, include water quality monitoring.
- Site C2 is only for temperature monitoring and was initiated in October 2023 as part of the Post-Return Flow Root River Monitoring Plan.

[2] Refer to Appendix K, Table 3, in Volume 4 City of Waukesha Return Flow Plan, of the City of Waukesha Application for Lake Michigan Diversion with Return Flow.

Figure 3-1. Monitoring Locations



4 Water Temperature

Continuous temperature monitoring at Sites A, B, C, and D has been conducted by USGS since September 2016. Two HOBOTemp temperature data sondes are used at Sites A, B, and D. Temperature at Site C is captured by an automated USGS gauge.

Data from sondes are regularly offloaded and the sondes are maintained and redeployed according to USGS continuous monitoring protocols. Temperature data were collected at 1-minute intervals at Sites A, B, and D and at hourly intervals at Site C.

4.1 Pre-Diversion Temperature

Pre-diversion temperatures at Sites A, B, C, and D are shown on Figures 4-1 and 4-2. A daily average temperature was calculated that averaged the temperature data from multiple sondes at each 1-minute interval, then averaged by calendar day. Ambient river temperatures are seasonal at all sites, where water temperature is coldest in December and January, and warmest in July and August. Average daily temperature across all sites during the pre-diversion period typically varied by less than 1 degree Fahrenheit.

Sites A and B were plotted together to compare temperature variations from the canal (Site B) and the mainstem (Site A). During most times of year (January to March and June to December), Site B is between 0 and 2 degrees warmer than Site A, on average. Two existing wastewater discharges on the Canal may influence the ambient temperature at Site B, causing the difference in temperature compared to Site A. Both Sites A and B are upstream of the return flow location.

Sites C and D were compared to establish a baseline condition of locations upstream (Site C) and downstream (Site D) of the future return flow discharge location. There were fewer variations in temperature between Sites C and D during the pre-diversion period when return flow was not present. There was not a consistent time of year where either site was warmer when comparing daily and monthly averages.

2022 was notably different than other pre-diversion years where temperature was warmer than previous years at Site C, and where it was warmer on average than Site D. Site A also experienced warmer temperatures in 2022, which may have influenced the temperature at Site C. There are no known causes or events in 2022 that directly influenced the in-stream ambient temperatures.

Figure 4-1. Daily Average Temperature at Sites A and B

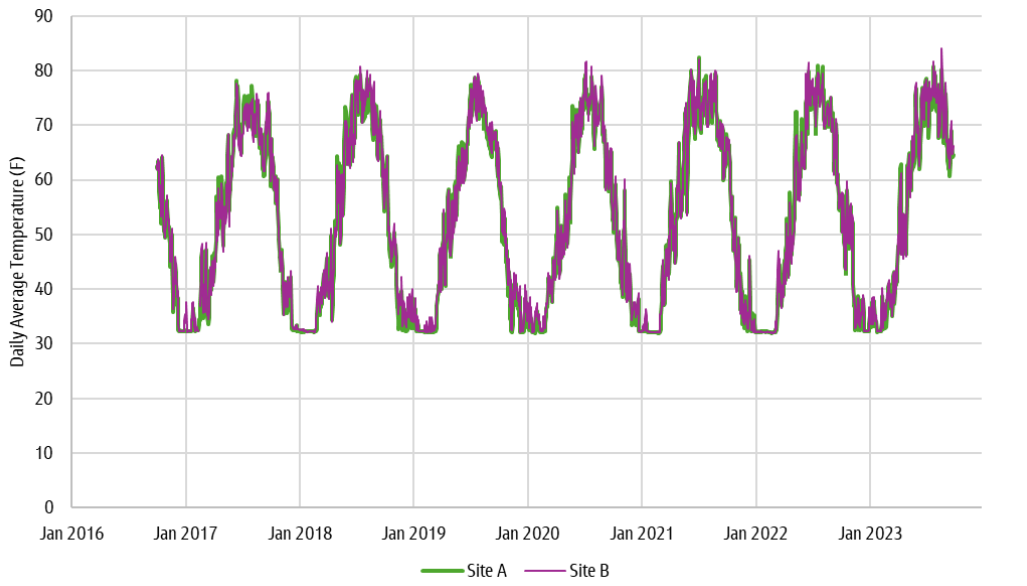
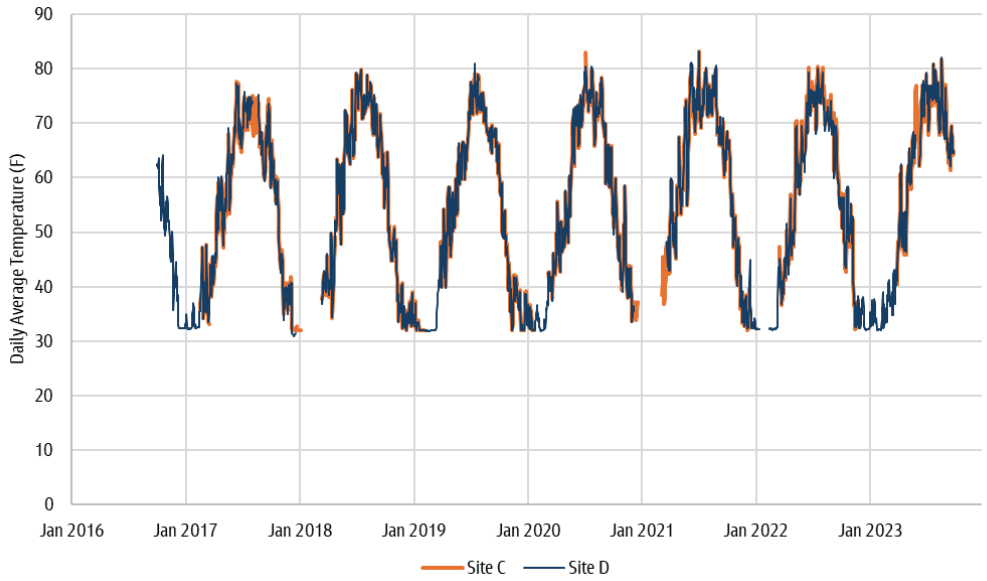


Figure 4-2. Daily Average Temperature at Sites C and D



4.2 Post-Diversion Temperature

This report includes pre-diversion conditions through September 30, 2023. Post-diversion Root River temperature will be summarized in future annual reports to address the following topics:

- Changes in river temperature upstream and downstream of return flow
- Seasonal differences
- Spatial extent of temperature changes caused by return flow

5 Water Quality

During the pre-diversion period, water quality was measured using onsite field water quality meters and state-accredited laboratories as described in the Pre-Return Flow Root River Data Collection Plan (CH2M 2017). Water quality was assessed at eight sampling locations, Sites A through H, although monitoring was discontinued at two sites (Sites E and H) during the pre-diversion period.

5.1 Data Quality

Water quality data collected as part of the pre-diversion monitoring activities were quality controlled at the end of the pre-diversion monitoring period. Field data were reviewed to identify and assess outliers resulting from potential field equipment malfunctions, inaccurate meter calibration, sampling method errors, or other conditions noted by the field teams. Outlier data points that were judged to be the result of field equipment malfunctions, inaccurate meter calibration, and sampling method errors were removed from the dataset. Laboratory data were similarly reviewed, but no data points were removed. Remaining data points that were outside of the parameter expected ranges, as defined in the Post-Return Flow Root River Monitoring and Quality Assurance Project Plan (QAPP; Jacobs 2023), are discussed in the following sections.

5.2 Pre-Diversion Water Quality

A summary of water quality during the pre-diversion period for Sites A through H is shown in Table 5-1.

As part of the QAPP, expected data ranges were established to support assessing data quality. The last two columns in Table 5-1 show the number and percent of data points that fell outside of the parameter expected range during the pre-diversion period.

Parameters that include data points outside of the QAPP expected range include dissolved oxygen, turbidity, orthophosphate, TSS, and chlorophyll. For all parameters except orthophosphate, the percent of data points that fell outside of the QAPP expected range was less than 2%.

Data points outside of the dissolved oxygen and turbidity expected ranges are greater than the 15 milligrams per liter (mg/L) and 120 nephelometric turbidity units (NTU) expected maximums, respectively. For both dissolved oxygen and turbidity, these occurrences may be the result of field water quality meter malfunctions or inaccurate calibrations. In most cases, where field teams did not note issues with the equipment or field procedures, the dissolved oxygen and turbidity data have remained in the dataset. In a few instances, data were removed if levels were clearly inaccurate based on professional judgment.

Some occurrences of high turbidity levels coincided with precipitation events where temporary increases in turbidity may be reasonable. Similarly, these data have remained in the dataset. Dissolved oxygen results are further discussed in the following sections.

Data points outside of the orthophosphate expected range are less than the 0.01 mg/L orthophosphate minimum. The orthophosphate expected range was set based on the anticipated laboratory limit of detection, and therefore orthophosphate results less than 0.01 mg/L do not impact pre-diversion water quality conclusions.

Data points outside of the TSS expected range are greater than the 175 mg/L expected maximum. Data points outside of the chlorophyll expected range are greater than the 360 mg/L expected maximum. For TSS and chlorophyll, these occurrences were infrequent, passed quality assurance and control procedures by the Wisconsin State Laboratory of Hygiene, and were therefore kept in the dataset.

A summary of water quality during the pre-diversion period for Site C and Site D, upstream and downstream of the outfall, respectively, is shown in Table 5-2. Water quality and corresponding statistics for Sites C and D are similar.

Table 5-1. Pre-Diversion Water Quality Summary, Sites A through H

Parameter	Unit	All Sites (A-H)[a]					
		5th Percentile	Average ± Standard Deviation	95th Percentile	QAPP Expected Range[b]	Data Points Outside of Expected Range	Percent of Data Points Outside of Expected Range (%)
pH	S.U.	7.26	7.85 ± 0.36	8.38	6 to 10	0	0
Dissolved Oxygen	mg/L	5.41	9.54 ± 2.95	14.41	0.01 to 15	90	2
Temperature	deg Celsius	-0.10	13.87 ± 8.55	24.30	-5 to 35	0	0
Turbidity	NTU	2.28	19.4 ± 25.77	60.37	0.1 to 120	36	1
Specific Conductance	mS/cm	0.63	1.1 ± 0.36	1.68	0.1 to 10	0	0
Phosphorus	mg/L	0.04	0.13 ± 0.09	0.30	0.01 to 5	0	0
Orthophosphate	mg/L	0.01	0.04 ± 0.04	0.12	0.01 to 3	124	14
Total Nitrogen	mg/L	0.81	2.54 ± 1.69	5.70	0.01 to 15	0	0
Nitrate-Nitrite	mg/L	0.13	1.64 ± 1.6	4.65	0.01 to 15	0	0
Ammonia	mg/L	0.02	0.07 ± 0.08	0.19	0.01 to 3	0	0
Total Suspended Solids	mg/L	5.40	31.04 ± 42.65	90.05	1 to 175	11	1
Chlorophyll	µg/L	1.65	14.5 ± 34.51	53.15	0.01 to 360	3	0

[a] Data collection at Site E and Site H was discontinued starting in 2020.

[b] Post-Return Flow Root River Monitoring Plan and Quality Assurance Project Plan. Jacobs, 2023.

µg/L = microgram(s) per liter

deg Celsius = degrees Celsius

mg/L = milligram(s) per liter

mS/cm = microsiemens per centimeter

NTU = nephelometric turbidity unit(s)

S.U. = standard unit(s)

Table 5-2. Pre-Diversion Water Quality Summary, Site C and Site D

Parameter	Unit	Site C					Site D				
		5th Perc	Average +/- Standard Deviation	95th Perc	Data Points Outside of Expected Range	Percent of Data Points Outside of Expected Range (%)	5th Perc	Average +/- Standard Deviation	95th Perc	Data Points Outside of Expected Range	Percent of Data Points Outside of Expected Range (%)
pH	S.U.	7.27	7.81 ± 0.28	8.24	0	0	7.33	7.85 ± 0.32	8.34	0	0
Dissolved Oxygen	mg/L	4.78	8.92 ± 3.03	14.10	8	1	5.38	9.1 ± 2.98	14.55	13	2
Temperature	deg Celsius	-0.10	13.68 ± 8.4	23.70	0	0	-0.20	13.78 ± 8.34	23.60	0	0
Turbidity	NTU	3.68	22.34 ± 27.5	70.35	5	1	4.40	21.72 ± 25.19	69.89	9	2
Specific Conductance	mS/cm	0.65	1.11 ± 0.33	1.70	0	0	0.68	1.08 ± 0.29	1.43	0	0
Phosphorus	mg/L	0.05	0.13 ± 0.08	0.31	0	0	0.05	0.13 ± 0.08	0.32	0	0
Orthophosphate	mg/L	0.01	0.04 ± 0.04	0.12	16	12	0.01	0.04 ± 0.04	0.12	16	12
Total Nitrogen	mg/L	0.90	2.41 ± 1.3	4.75	0	0	0.88	2.39 ± 1.35	4.71	0	0
Nitrate-Nitrite	mg/L	0.17	1.55 ± 1.22	3.76	0	0	0.15	1.51 ± 1.25	3.68	0	0
Ammonia	mg/L	0.02	0.07 ± 0.08	0.18	0	0	0.02	0.07 ± 0.08	0.15	0	0
Total Suspended Solids	mg/L	6.32	29.95 ± 35.1	78.80	1	1	6.56	30.59 ± 32.54	88.32	1	1
Chlorophyll	µg/l	1.64	8.92 ± 11.87	22.44	0	0	1.62	12.51 ± 21.37	45.06	0	0

Perc = percentile

5.2.1 Phosphorus

Average phosphorus levels for growing and non-growing seasons at each site during the pre-diversion period are shown in Table 5-3. Average phosphorus level values less than the water quality criterion of 0.075 mg/L are shaded in green and values greater than the water quality criterion are shaded in yellow.

For most sampling sites and years, phosphorus levels were higher during the growing season compared to the non-growing season. Phosphorus levels at Site B were higher compared to other sites, and phosphorus levels at Site A were lower compared to other sites. These results are consistent with a well-mixed flow downstream of the Root River mainstem and Root River Canal confluence. The higher phosphorus concentrations at Site B may be because the municipal wastewater discharges upstream.

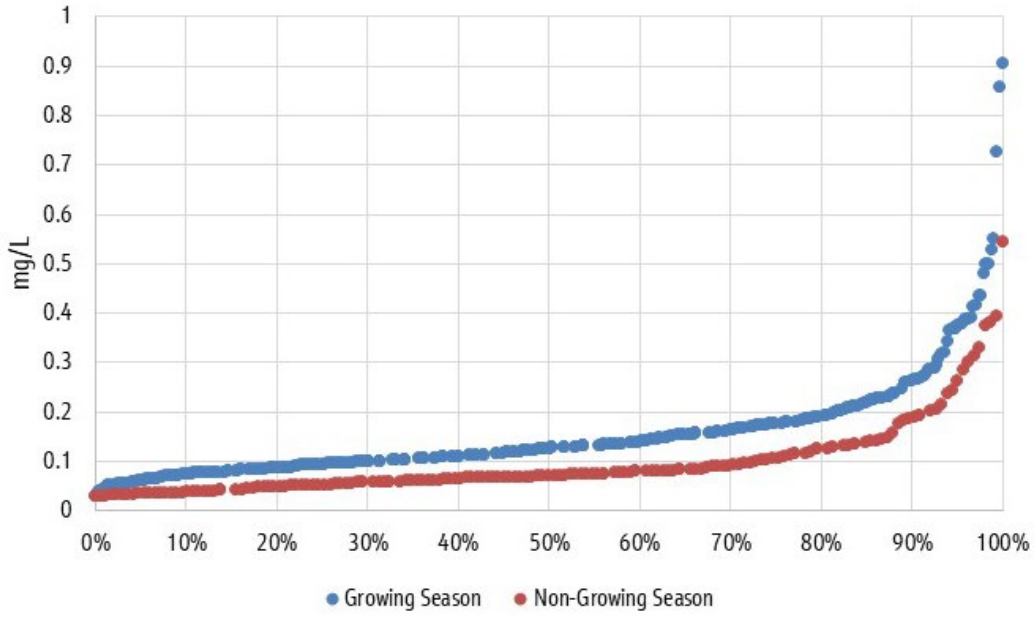
Table 5-3. Average Phosphorus Levels During the Pre-Diversion Period

	All Sites	A	B	C	D	E[a]	F	G	H[a]
Growing Season									
2017	0.143	0.088	0.183	0.132	0.167	0.129	0.128	0.166	0.146
2018	0.161	0.102	0.241	0.149	0.162	0.153	0.153	0.176	0.159
2019	0.175	0.108	0.288	0.170	0.151	0.172	0.162	0.167	0.173
2020	0.173	0.115	0.277	0.179	0.183	-	0.145	0.140	-
2021	0.170	0.134	0.213	0.140	0.143	-	0.166	0.220	-
2022	0.114	0.082	0.150	0.098	0.101	-	0.125	0.131	-
2023	0.134	0.092	0.213	0.117	0.106	-	0.154	0.126	-
Non-Growing Season									
2017	0.097	0.063	0.165	0.095	0.101	0.088	0.079	0.113	0.082
2018	0.082	0.072	0.104	0.067	0.085	0.082	0.061	0.064	0.068
2019	0.108	0.065	0.141	0.115	0.112	0.115	0.133	0.098	0.073
2020	0.068	0.050	0.095	0.063	0.063	-	0.062	0.076	-
2021	0.090	0.069	0.086	0.121	0.082	-	0.062	0.076	-
2022	0.149	0.091	0.238	0.145	0.131	-	0.129	0.079	-
2023	0.064	0.038	0.095	0.058	0.065	-	0.070	0.073	-

[a] Data collection at Site E and Site H was discontinued starting in 2020.

Phosphorus levels during the growing season and non-growing season at Sites A through D for all years during the pre-diversion period are shown in subsequent figures. Key takeaways are summarized below each figure.

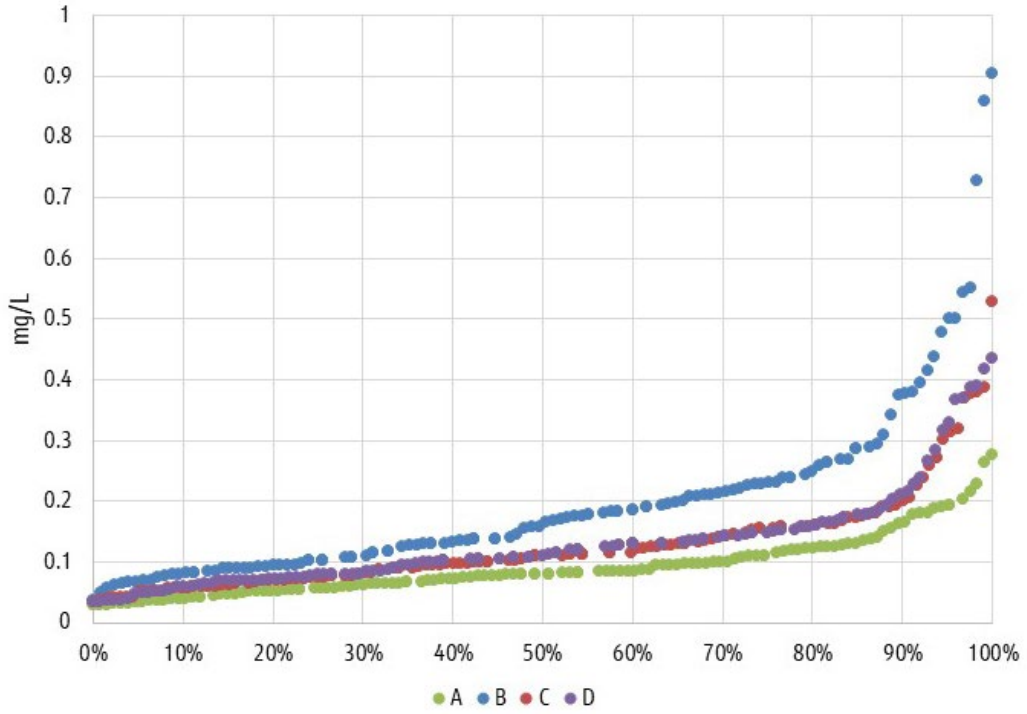
Figure 5-1. Phosphorus Levels Cumulative Percentile, Sites A through D during Growing and Non-Growing Seasons



Key Takeaway:

- Phosphorus levels are higher during the growing season, which is consistent with seasonal fertilizer application and subsequent runoff and impacts to phosphorus levels in wastewater discharges.

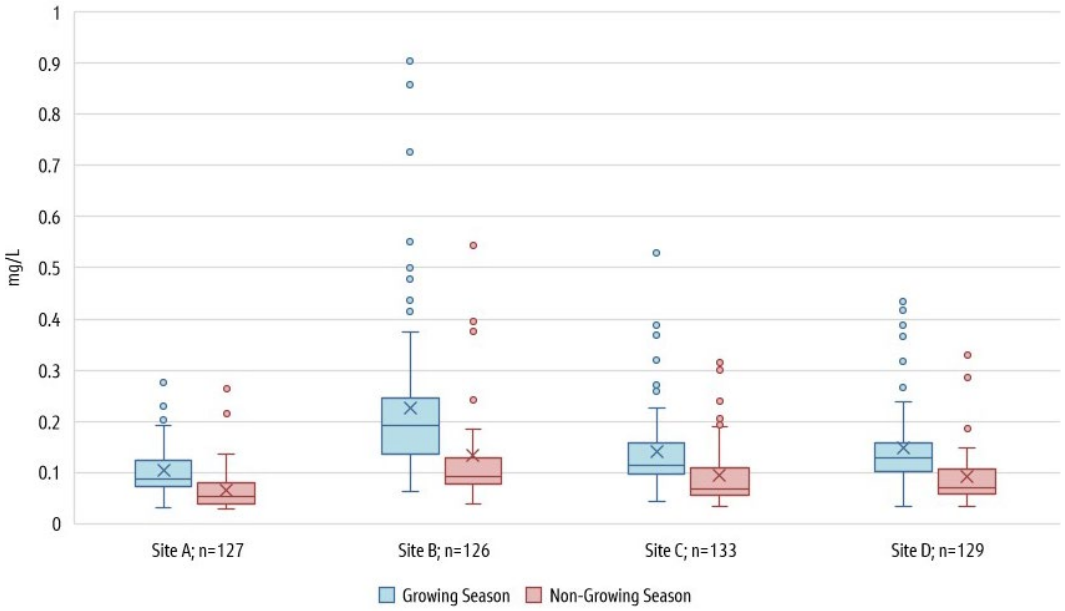
Figure 5-2. Phosphorus Levels Cumulative Percentile, Sites A through D



Key Takeaway:

- Phosphorus levels are higher at Site B, which may be explained by the presence of two active wastewater discharges at the Root River Canal upstream of Site B.

Figure 5-3. Phosphorus Levels Box and Whisker Plot, Sites A through D

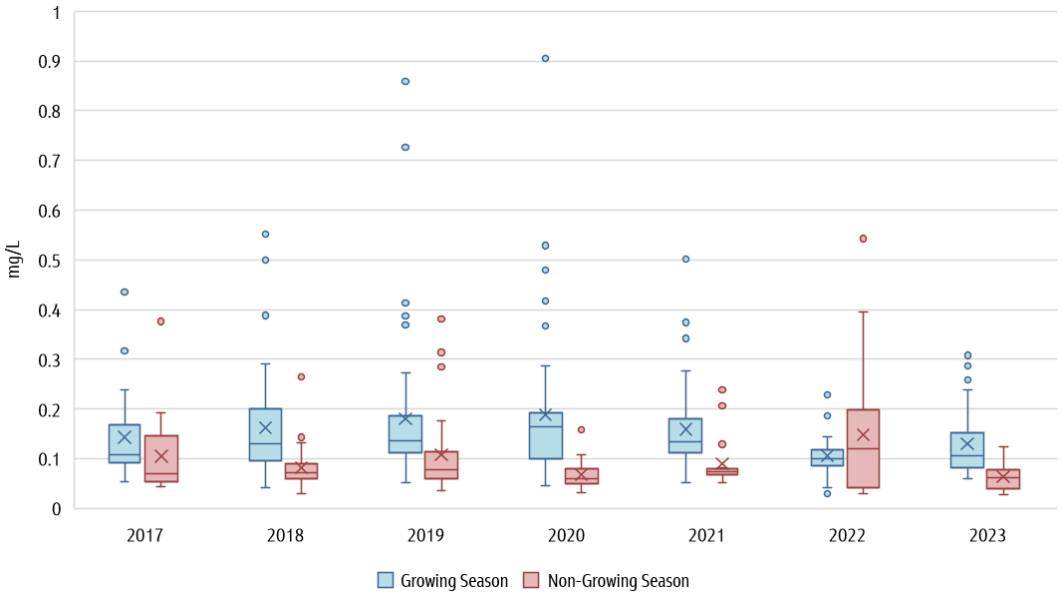


Note: The box represents the 25th through the 75th percentile of data, where 50% of the datapoints are within the box. The center line in the box represents the median and the X represents the mean. The lower and upper whisker represent the 5th and 95th percentile of data, where 90% of the datapoints are between the whiskers. Outliers from the dataset are shown as points.

Key Takeaways:

- Phosphorus levels are higher and more variable at Site B, which may be because of wastewater discharges upstream of the sampling site.
- Downstream of the confluence of the Root River mainstem and Canal at Site C and Site D, phosphorus levels demonstrate a mixed flow from phosphorus levels at Site A and Site B.
- Site A data show the lowest variability in phosphorus levels among the four sites.

Figure 5-4. Phosphorus Levels Box and Whisker Plot – Sites A through D by Season and Year



Key Takeaways:

- Annual trends during growing and non-growing seasons are consistent with elevated and more variable phosphorus levels during the growing season.
- Sampling in 2022 showed a different trend with greater average phosphorus and greater variability in phosphorus levels during the non-growing season.

5.2.2 Field pH

Average pH levels for growing and non-growing seasons at each site during the pre-diversion period are shown in Table 5-4. A relative color scale from yellow to blue for increasing average pH levels is used to visually compare the season, year, and sampling site.

The results demonstrate that average pH levels at the sampling sites are typically between 7.4 and 8.2, and slightly higher pH levels are observed at downstream sites compared to upstream.

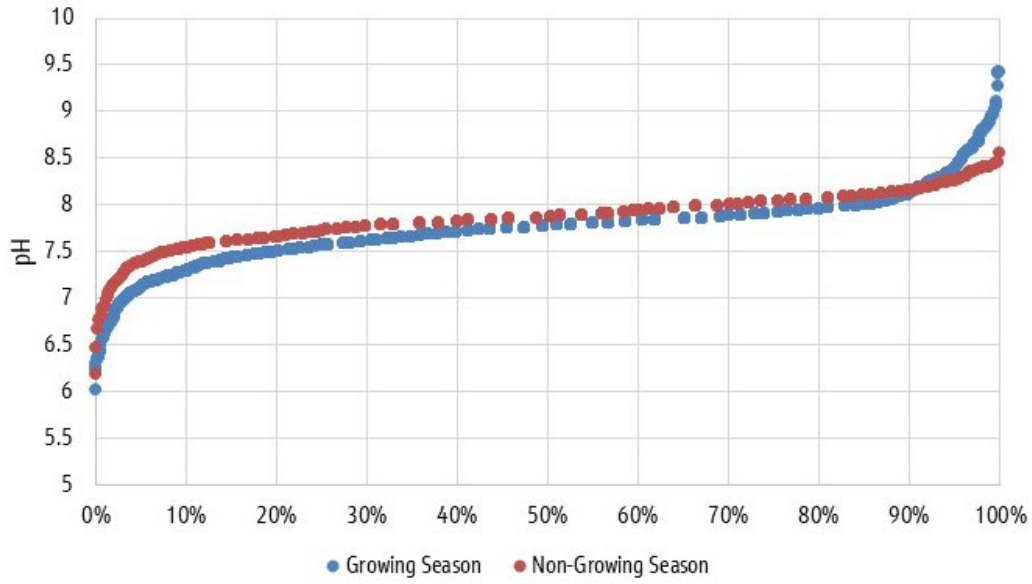
Table 5-4. Average pH Levels for Growing and Non-growing Seasons

	All Sites	A	B	C	D	E	F	G	H
Growing Season									
2017	7.85	7.72	7.71	7.81	7.81	7.80	8.02	8.05	7.88
2018	7.72	7.57	7.55	7.66	7.69	7.69	7.90	7.87	7.82
2019	7.75	7.54	7.62	7.70	7.71	7.72	7.90	7.94	7.86
2020	7.82	7.58	7.65	7.81	7.83	-	7.96	8.12	-
2021	7.75	7.36	7.80	7.72	7.76	-	7.87	8.01	-
2022	7.91	7.77	7.89	7.81	7.87	-	8.08	8.05	-
2023	8.02	8.03	8.08	7.85	7.96	-	8.15	8.03	-
Non-Growing Season									
2017	7.86	7.73	7.67	7.76	7.86	7.82	8.03	7.97	8.03
2018	7.89	7.68	7.80	7.84	7.88	7.87	8.00	7.97	8.07
2019	7.93	7.77	7.79	7.96	7.98	7.98	7.96	7.96	8.20
2020[a]	7.86	7.44	7.75	7.89	7.96	-	8.04	8.06	-
2021	8.07	7.70	8.02	8.14	8.22	-	8.17	8.22	-
2022	7.95	7.83	7.85	7.92	7.97	-	8.09	8.03	-
2023	7.94	7.95	7.73	7.93	7.93	-	8.03	8.08	-

[a] Data collection at Site E and Site H was discontinued starting in 2020.

Field pH measurements during the growing season and non-growing season at Sites A through D for all years during the pre-diversion period are shown on the following figures. Key takeaways are summarized below each figure.

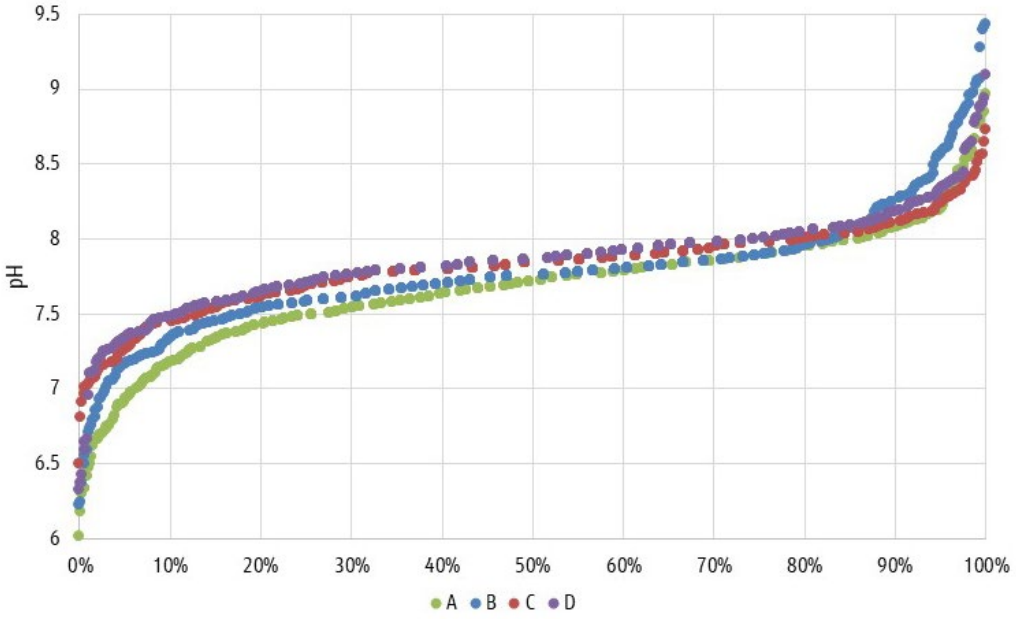
Figure 5-5. Field pH – Cumulative Percentile by Season



Key Takeaway:

- For most data points, pH is slightly higher during the non-growing season compared to the growing season. This may be caused by fertilizer applications increasing soil acidity and subsequent soil runoff during the growing season.

Figure 5-6. Field pH – Cumulative Percentile for Sites A through D



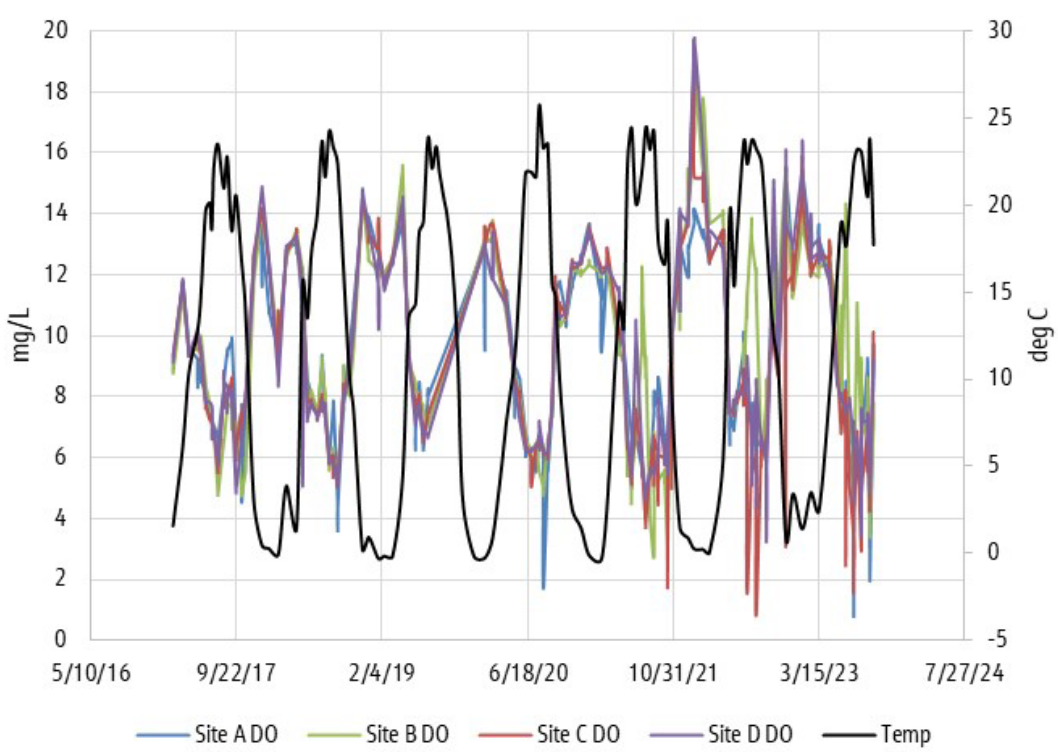
Key Takeaway:

- Unlike other water quality parameters, pH levels do not appear to be the result of a mixed river flow at Sites A and B. For most of the dataset, pH Levels at Sites A and B are slightly lower compared to Sites C and D.

5.2.3 Field Dissolved Oxygen

Field dissolved oxygen measurements during the growing season and non-growing season at Sites A through D for all years during the pre-diversion period are shown on the following figures. Key takeaways are summarized below each figure.

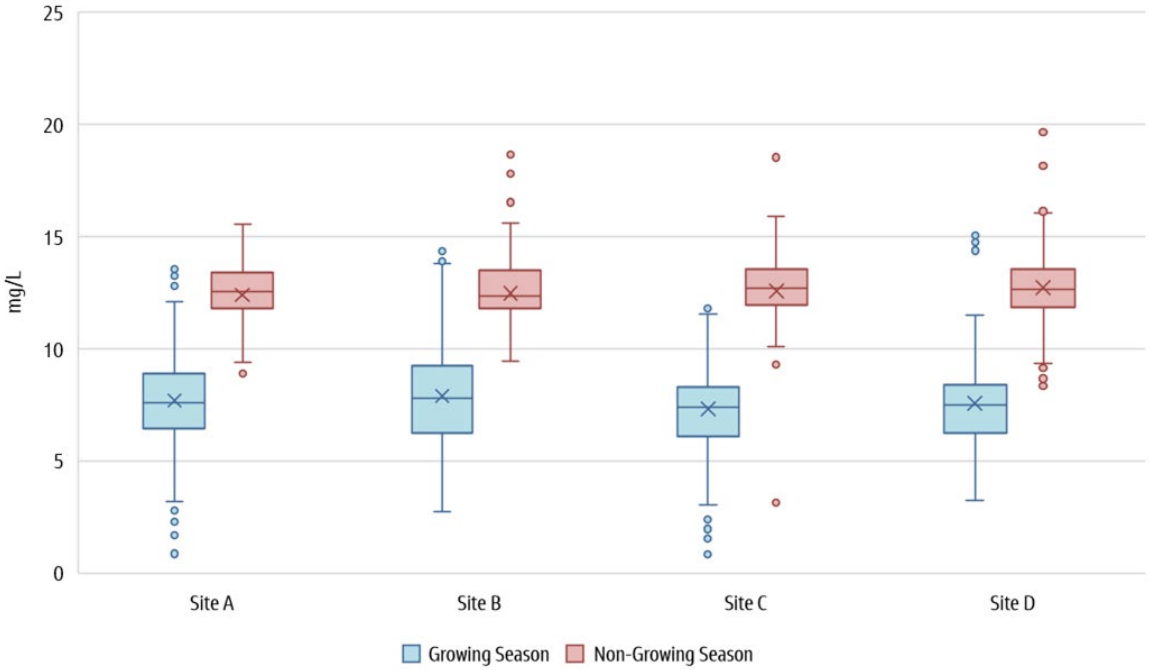
Figure 5-7. Field Dissolved Oxygen for Sites A through D



Key Takeaways:

- Dissolved oxygen and temperature are inversely related, with high dissolved oxygen levels observed at low water temperatures.
- Some dissolved oxygen measurements are greater than the theoretical maximum dissolved oxygen. According to theoretical oxygen solubility in distilled water, dissolved oxygen can reach a maximum level of 14.6 mg/L at 0 degrees Celsius. Approximately 4% (n = 146) of all dissolved oxygen measurements during the pre-diversion period were greater than 14.6 mg/L. This suggests that dissolved oxygen measurements greater than 14.6 mg/L may be exaggerated or inaccurate. However, because these results cannot be directly linked to an equipment malfunction or sampling method error, they remain in the dataset.

Figure 5-8. Field Dissolved Oxygen – Box and Whisker Plot by Site and Season



Key Takeaway:

- Dissolved oxygen levels and variability are similar across the sampling sites between growing and non-growing season periods.

5.2.4 Watershed Impacts

Watershed impacts from environmental events as well as human activity during the pre-diversion period were reviewed to assess potential observational impacts in recorded water quality data. The following activities were completed to summarize watershed impacts during the pre-return flow data collection period:

- Contacted Milwaukee RiverKeeper and Root-Pike Watershed Initiative Network for records of environmental releases and similar impacts.
- Performed internet searches for local news stories.
- Queried the Milwaukee Journal Sentinel online articles.
- Obtained records from the WDNR Spills Coordinator.
- Had verbal conversations with local farmers.

Upstream of the return flow outfall on the Root River Canal, upstream of Site B, there are two active wastewater discharges governed by Wisconsin Pollutant Discharge Elimination System permits. Both facilities operate under a multi-discharger variance for phosphorus and are therefore permitted to have phosphorus discharges above the water quality criterion. Water quality data collected during the pre-diversion period demonstrate higher phosphorus levels at Site B consistent with the presence of these discharges.

To assess acute impacts to the Root River during the pre-diversion monitoring period, spill activities were reviewed using the WDNR Environmental Cleanup and Brownfields Redevelopment database. During the pre-diversion period, a total of seven spills were recorded along the Root River, with three spills located downstream of the sampling sites. Spill activity in the Root River area from 2016 to 2023 with potential impacts to sampling sites are shown in Table 5-5.

Table 5-5. Spill Incidents along Root River Sampling Sites in the Pre-Diversion Period

Start and End Date	Spill Substance	Amount Released	Location	Potential Sampling Site(s) Impacted	Description
8/16/2018 to 8/27/2018	Gasoline	1 Qt	761 Marquette St	Site H	Gasoline release from boat located in the marina
10/26/2018 to 11/5/2018	Unknown Oil, Fuel, or Grease Product	Unknown	761 Marquette St	Site H	Hydraulic line break caused release and subsequent sheen on river surface
5/5/2023 to 8/11/2023	Diesel Fuel	Unknown	State Highway 38 and 5 Mile Rd	Site F and Site G	Oil observed on river surface coming from creeks feeding the river
9/1/2023 to 1/17/2024	Unknown Petroleum	Unknown	State Highway 38 and Johnson Ave	Site G	Abandoned vehicle leaking large amounts of oil or hydraulic fluid

Turbidity and pH data were reviewed to assess the impacts of gasoline, fuel, and petroleum spills. For all spill date ranges, no substantial deviations in data results were observed. Elevated turbidity levels of approximately 150 NTU were observed in two of five samples taken at the river crossing at Site H on October 29, 2018. Minor variations in pH (values between 6.7 and 9.1) were observed at Site F and

Site G from May through June in 2023. However, they remained within QAPP expected data ranges. In both cases, these data variations are not conclusively linked to the spill activities during the pre-diversion period.

5.3 Post-Diversion Water Quality

This report includes pre-diversion conditions. Post-diversion Root River water quality will be summarized in future annual reports to address the following topics:

- Changes in river water quality upstream and downstream of return flow
- Seasonal differences
- Impact of upstream watershed impacts that may be influencing observed changes in river water quality

6 Water-Dependent Resources

Fishery, benthic macroinvertebrate, and quantitative habitat evaluation surveys were completed at Sites A through D starting in 2017. Two events were completed for fish and macroinvertebrates, one during the traditional season near September, and again in November. Table 6-1 summarizes the pre-return flow sampling dates between 2017 and 2023.

Table 6-1. Pre-Return Flow Macroinvertebrate and Habitat Survey Events

Year	Benthic Macroinvertebrate Sampling		Quantitative Habitat Evaluation			
	September	November	Site A	Site B	Site C	Site D
2017	Sept. 11	Nov. 2	Sept. 21	Sept. 19	Sept. 24	Sept. 19
2018	Sept. 13	Nov. 17	Sept. 27	Sept. 20	Sept. 14	Sept. 14
2019	Sept. 5	Nov. 13	Sept. 6	Sept. 20	Sept. 26	Nov. 14
2020	Sept. 3	Nov. 4	Sept. 18	Sept. 11	Sept. 24	Sept. 17
2021	Sept. 3	Nov. 3	Aug. 5	July 27	July 29	Aug. 6
2022	Sept. 2	Nov. 2	July 13	July 8	July 14	July 18
2023		n/a				

n/a = not applicable because survey event was not within pre-return flow conditions.

Table 6-2 summarizes the sampling dates for the pre-return flow fish surveys conducted between 2017 and 2023. All sites were sampled as part of the same survey, except in 2017, when a second event for Sites C and D was required to ensure the sampling was conducted over the defined study reach.

Table 6-2. Pre-Return Flow Fish Survey Events

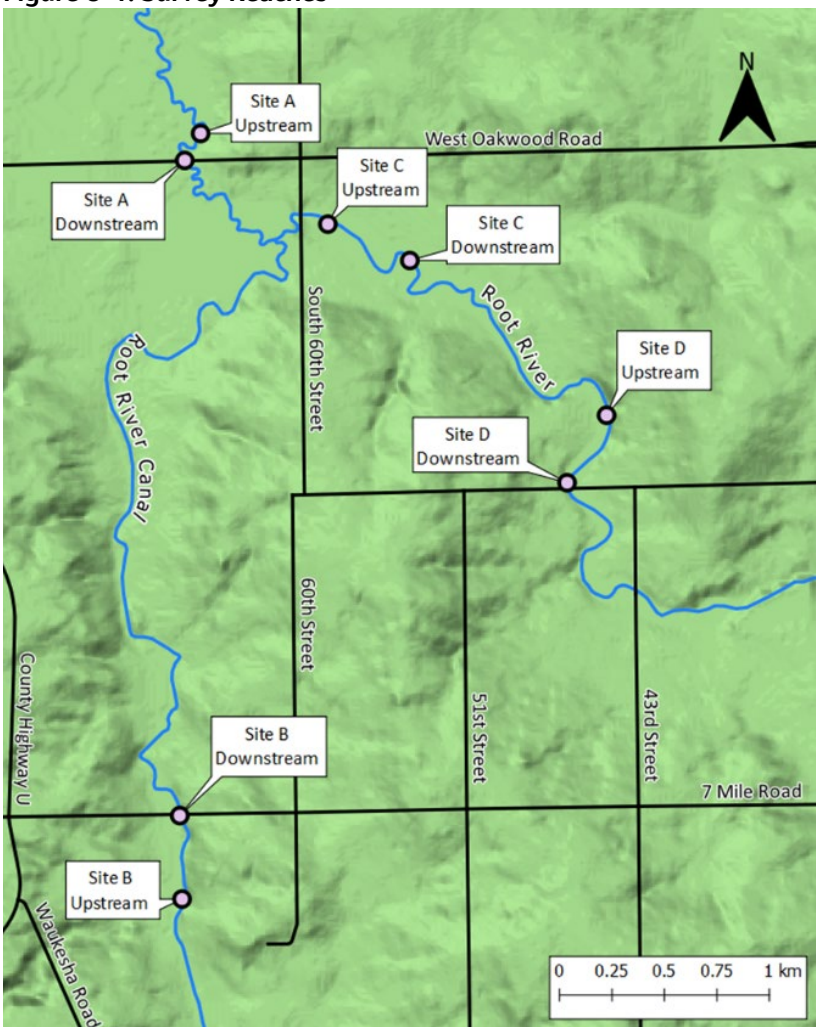
Year	Fish Surveys	
	Summer	Fall
2017	July 27 & 28, Sept. 1	Nov. 7 & 8
2018	July 9 & 10	Nov. 13 & 14

Year	Fish Surveys	
	Summer	Fall
2019	July 26 & 27	Nov. 8 & 9
2020	Aug. 7 & 8	Nov. 5 & 7
2021	July 20 & 22	Nov. 4 & 6
2022	July 22 & 23	Nov. 10 & 11
2023	July 20 & 21	n/a

n/a = not applicable because survey event was not within pre-return flow conditions.

The sampling reaches were established in 2017 and repeated through 2023 (Figure 6-1). Reach lengths differed for each location in proportion to the stream width. Although water levels, and therefore stream widths, differed in 2022 compared to 2017, 2018, 2019, 2020, and 2021, the transects established in 2017 were resampled in 2022 for consistent comparisons.

Figure 6-1. Survey Reaches



6.1 Pre-Diversion Habitat and Biological Data

A summary of habitat and biological data during the pre-diversion period for Sites A through D is described in this section.

6.1.1 Fish Community

Fish sampling was conducted in accordance with the Standard Operating Procedure for the Collection, Identification, and Enumeration of Fishes for the Pre-Return Flow Root River Data Collection Plan (CH2M 2017). Captured fishes were identified in the field, counted, and released, and three statistics were calculated at each sampling location from 2017 through 2023: Catch Per Unit Effort (CPUE), Shannon Diversity, and Index of Biotic Integrity for Warmwater Fish Communities (IBI). Data from these three statistical analyses are displayed as summer (July, August, and September sampling dates) and fall (November sampling dates) for comparison of seasonal differences. No threatened, endangered, or special-concern species were encountered at any of these locations.

CPUE is the number of fishes caught per hour of sampling. CPUE provides information on the overall density of fishes in the river. Fish exhibit spatial and temporal variations in their distribution and activity; therefore, CPUE may vary widely. The CPUE during the summer and fall surveys are shown on Figures 6-2 and 6-3.

Figure 6-2. Summer Fish Survey Catch Per Unit Effort

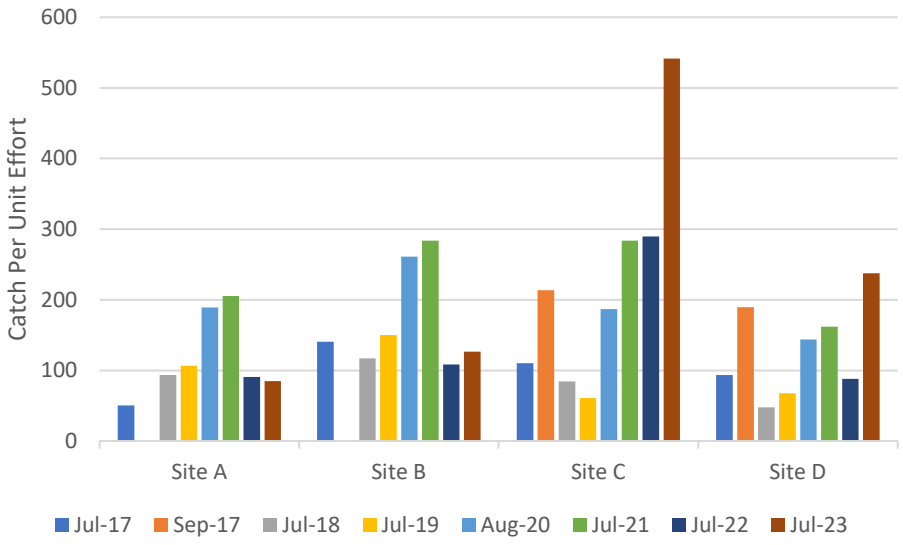
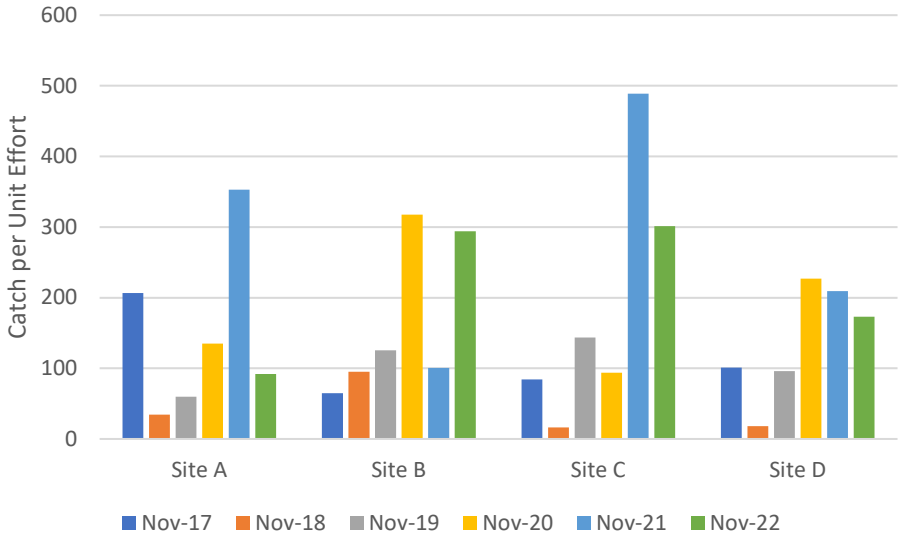


Figure 6-3. Fall Fish Survey Catch Per Unit Effort

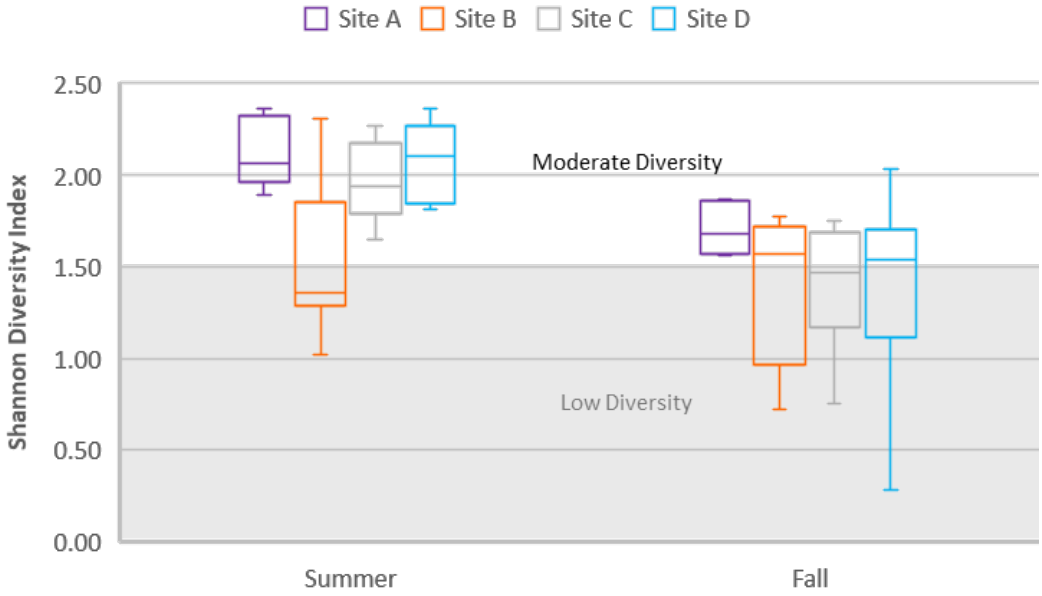


Key Takeaways:

- The CPUE for the summer surveys showed similar trends across all sites, except Sites C and D had their highest CPUE in 2023.
- There is large, but not unexpected, variability in CPUE over time and between seasons possibly from natural variation in recruitment, growth, and mortality.

Shannon Diversity provides a way to combine and compare both the richness (number of species present) and evenness (number of individuals per species) of species in a community. This provides a measure of diversity that can be used to compare communities, habitats, or locations with regard to how many individuals of how many species are present. The Shannon Diversity typically ranges from 0 to 3.5, where values from 0 to 1.5 would indicate low diversity, values from 1.51 to 2.5 indicate moderate diversity, and values above 2.51 indicate high diversity. Figure 6-4 shows Shannon Diversity values across summer (July, August, and September) and fall (November) sampling events.

Figure 6-4. Shannon Diversity Index – Box and Whisker Plot by Site and Season

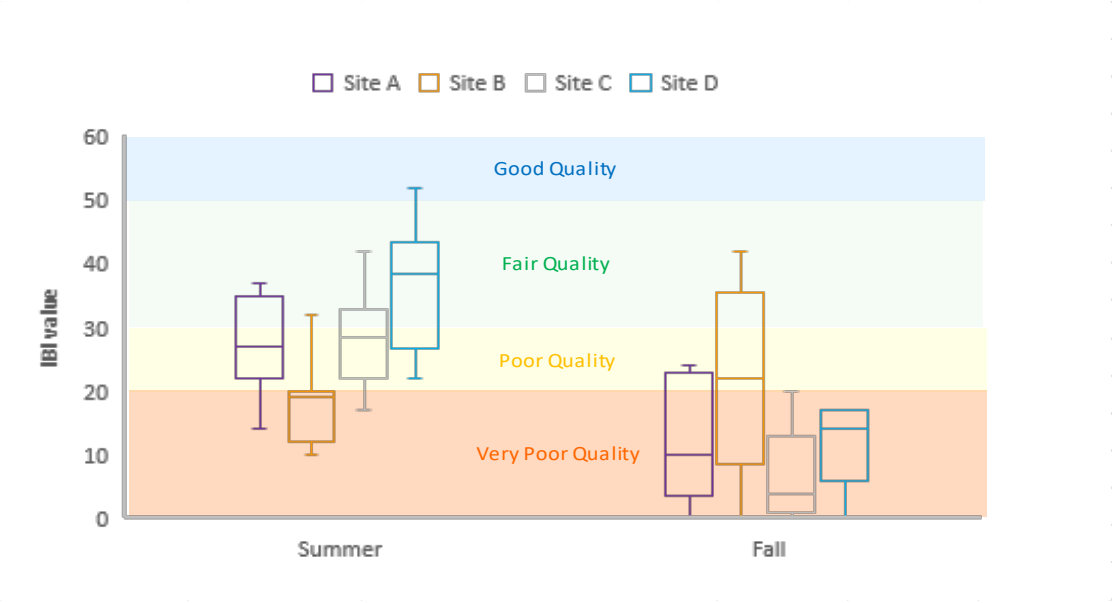


Key Takeaways:

- The Shannon Diversity Index values for the four locations across 7 years of summer sampling consistently indicated moderate levels of species diversity, except for low diversity index values recorded at Site B in August 2020, July 2021, July 2022, and July 2023. Sites A, C, and D had the most consistent Shannon Diversity Index values throughout the sampling events, with little change among the summer samples. Shannon Diversity Index values were most variable at Site B across summer sampling events.
- The Shannon Diversity Index values for the four locations across 6 years of fall sampling have ranged between low and moderate levels of species diversity. Site A has the most consistent scores across all six sampling events, with moderate Shannon Diversity Index values. Sites B, C, and D varied between low and moderate Shannon Diversity values during the fall sampling events.

The IBI is a set of calculations based on the ecological characteristics of the fish present in a given community. This calculation accounts for the numbers of each species caught; the number of tolerant, hardy species versus the number of intolerant, sensitive species; the number of native versus the number of introduced species; the ecological niches (carnivore, omnivore, herbivore) of the species in the sample; the presence of species that require clean, sediment-free gravel and pebbles to spawn; and the presence of certain species (darters, sunfishes, suckers, and salmonids) in the sample. The resulting calculation is a single value indicating the overall quality of the stream habitat, indicating the likelihood of environmental degradation or pollution. The IBI score ranges from 0 to 100, with scores of 0 to 19 rated as very poor quality, 20 to 29 rated as poor quality, 30 to 49 rated as fair quality, 50 to 64 rated as good quality, and 65 to 100 rated as excellent quality. Figure 6-5 shows IBI values across summer (July, August, and September) and fall (November) sampling events. Note that November 2018 was below the minimum required individuals to calculate an IBI score.

Figure 6-5. Index of Biotic Integrity for Warmwater Fish Communities – Box and Whisker Plot by Site and Season



Key Takeaways:

- The IBI values in summer surveys typically ranged from very poor to fair quality. Only one location during one sampling event resulted in a good rating.
- The IBI values in all November surveys typically range from very poor to poor quality, reflecting that in-stream habitats become inhospitable to most fishes during the fall, largely because of the cold temperatures these shallow regions of the Root River experience beginning in October and lasting into mid spring.
- Attributed to very warm weather in early November of 2020, Site B had an IBI ranking of fair because of the unexpected number and diversity of fishes captured.

6.1.2 Macroinvertebrates

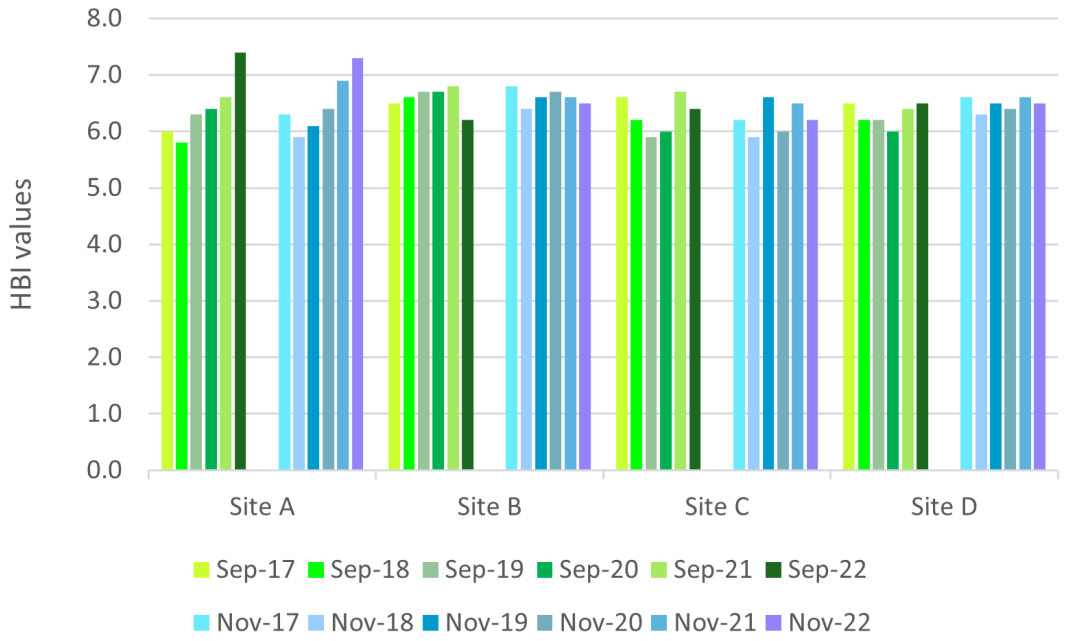
The Hilsenhoff Biotic Index (HBI) value (index ranges from 0 to 10, with lower values indicating higher quality and higher values indicating lower quality) is used to indicate overall water quality – specifically, the presence of organic pollution that would deprive organisms, such as aquatic macroinvertebrates, of dissolved oxygen necessary for cellular respiration. Samples containing more individuals with greater tolerance scores result in greater HBI values, indicating lower water quality and a greater probability of organic pollution. Conversely, samples containing more individuals with lower tolerance scores result in lower HBI values, indicating higher water quality and a smaller probability of organic pollution (Hilsenhoff 1988). Table 6-3 summarizes the range of HBI values correlating to a water quality rating and degree of organic pollution.

Table 6-3. Hilsenhoff Biotic Index Ranges

HBI Value	Water Quality Rating	Degree of Organic Pollution
<3.50	Excellent	None apparent
3.51-4.50	Very Good	Possible slight
4.51-5.50	Good	Some
5.51-6.50	Fair	Fairly significant
6.51-7.50	Fairly Poor	Significant
7.51-8.50	Poor	Very Significant
8.51-10.00	Very Poor	Severe

Macroinvertebrate surveys were conducted during two time periods (early fall and late fall) for six sequential years. Persistent low flows in 2020, 2021, and 2022 may have exacerbated stressful conditions for sensitive taxa at the four locations and may have contributed to lower abundance values in each of these sampling years. Figure 6-6 summarizes the range of HBI values for each sampling site over the past 6 years.

Figure 6-6. Hilsenhoff Biotic Index – Bar Graph by Site and Sampling Date

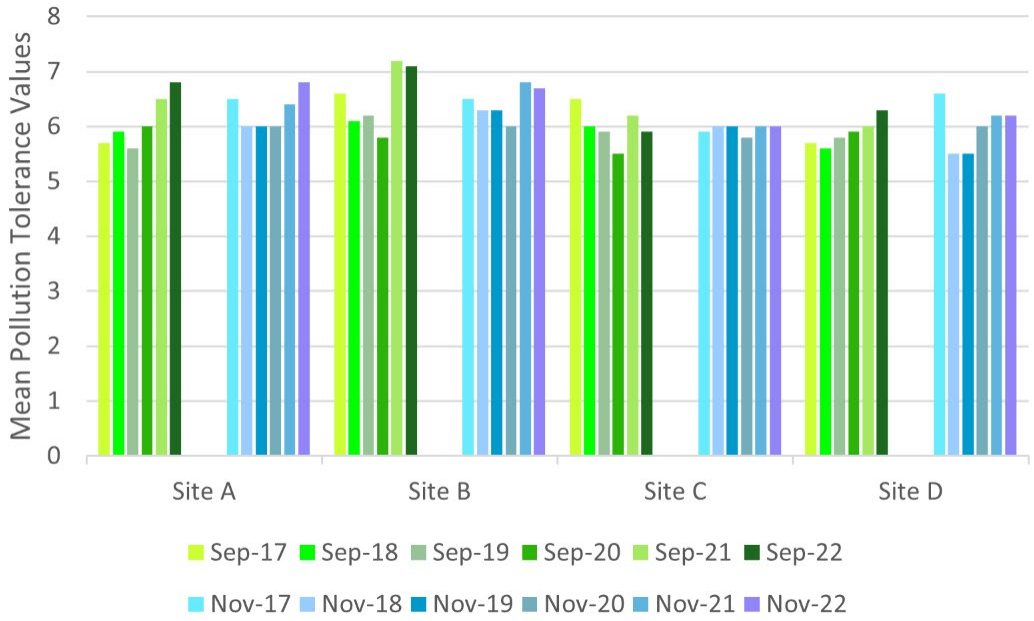


Key Takeaways:

- There is little variability in HBI scores across sites, seasons, and years.
- Since surveys began in 2017, the HBI value at all sites have been classified as either fair or fairly poor in each year or season of sampling.
- Over the past 6 years, HBI designations have consistently indicated that these sites experience impacts from organic pollution.

The mean pollution tolerance value (MPTV) represents the average pollution tolerance value for the macroinvertebrates collected in a sample. Low tolerance values are assigned to taxa that are considered sensitive to organic pollution while higher tolerance values are assigned to taxa that are considered tolerant to organic pollution. This metric calculates the average tolerance score for the taxa present in the sample and is complementary to the HBI because both measures use the same tolerance values. However, the MPTV is not influenced by macroinvertebrate abundance. The MPTV has a range from 0 to 10, with lower values indicating lower average pollution tolerance values (fewer high tolerance value taxa or more low tolerance value taxa) and higher values indicating higher average pollution tolerance values (fewer low tolerance value taxa or more high tolerance value taxa). Figure 6-7 summarizes the range of MPTV for each sampling site over the past six years.

Figure 6-7. Mean Pollution Tolerance Value – Bar Graph by Site and Sampling Date



Key Takeaways:

- There is little variability in MPTV scores across sites, seasons, and years.
- Overall, pollution-tolerant taxa have been more common than pollution-sensitive taxa at all four locations for each sampling period.

6.1.3 Habitat

A wadeable stream quantitative habitat evaluation was conducted at each site and over the entire sampling. Prior to 2021, habitat assessment surveys were conducted in September alongside the aquatic macroinvertebrate sampling. However, the timing of the habitat evaluation changed in 2021 to assess conditions present during summer fish surveys. This change was made to better align with staffing availability and the habitat assessment protocols. No significant changes were observed by the field teams by switching the assessment period to a month earlier in the year.

The same physical and chemical parameters – specifically, pH (S.U.), dissolved oxygen (mg/L), conductivity (mS/cm), water temperature (°C), and turbidity (NTU) – measured during the macroinvertebrate surveys also were assessed during the habitat surveys. Water temperatures were generally warm (22.1 ± 1.1°C) during the habitat surveys, consistent with their classification as warmwater streams. Variation in precipitation events and the associated effects on flow among survey dates may contribute to the minor variations observed in these parameters among sites and sampling dates.

Riparian buffer, substrate, adult gamefish cover, and bank erosion data from the habitat surveys are summarized in the following subsections.

6.1.3.1 Riparian Buffer

Riparian buffer is defined as the length of undisturbed land uses along the transect within 10 meters of the stream (WDNR 2002). Observations during the quantitative habitat evaluation and aerial photographs of the locations confirm that most of the four locations have undisturbed land uses (natural vegetation) within 10 meters of the stream for the length of the reaches surveyed. Exceptions to this may include:

- The right bank of a single transect toward the upstream portion of Site A adjacent to an agricultural field
- The left bank of three transects adjacent to the residential lot in the downstream portion of Site B
- The left and right bank of the two upstream transects of Site C adjacent to agricultural fields

Additionally, the construction of the return flow outfall has altered the riparian area along transect 14 at Site C by replacing 7 feet of the bank with a concrete headwall from the bottom of the river to the top of the bank (about 6 feet tall). The footprint of the outfall structure is small relative to the size of the transect, and the approximately 50 feet of shoreline disturbed during construction was reseeded and stabilized; therefore, in-stream measurements predominantly reflect the natural banks and riparian buffer along this transect. For reference, the return flow outfall structure is shown on Figure 6-8.

Figure 6-8. Return Flow Outfall Structure at the Root River

6.1.3.2 Substrate Data

A significant component of the quantitative habitat evaluation procedure focuses on assessing the percent composition of the substrate. A sediment measurement is taken at four evenly spaced positions along each of the transect lines, with a fifth point added at the deepest point of the channel unless the deepest point has been captured by one of the four evenly spaced positions. Sediment characteristics were estimated for each wadeable transect and summed to calculate the overall proportion of each substrate type present within the reach for each location. **Values reported for silt likely include some proportion of clay because distinguishing between clay and silt is very difficult in the field**. Although flow measurements vary with survey timing and local channel conditions, sediment composition has remained consistent throughout the pre-return flow period. The Root River and Root River Canal sites share similar land use and geology, where these properties contribute to similar substrate characteristics. Overall, the four sites were dominated by fine sediment, including a relatively high percentage of silt, clay, and sand with smaller contributions of larger bed material and moderate amounts of organic material, including the submerged and emergent macrophytes. Organic material continues to be a dynamic component of the substrate at most locations. Over the years, the sites had the following primary composition:

- Site A consisted primarily of silt (ranging from 65.53% to 94.66%) and clay (0 to 20.91%).
- Site B consisted primarily of gravel (6.17% to 29.53%), sand (4.20% to 31.91%), and silt (38.27% to 77.25%).
- Site C consisted primarily of sand (0.90% to 26.66%), silt (51.41% to 93.56%), and organic/detritus (2.14% to 21.00%).
- Site D consisted primarily of gravel (12.10% to 31.92%), sand (0 to 21.01%), silt (26.96% to 83.89%), and organic/detritus (0.14% to 20.73%).

The river bottom was disturbed during construction of the return flow outfall structure where approximately 24 inches of riverbed was replaced with riprap rock. The rock was placed over an

approximately 10-foot by 11-foot area to protect the riverbed from scouring with the addition of the return flow. The same as the riparian buffer, this impacted area is small compared to the transect size and, therefore, instream measurements predominantly reflect the natural riverbed along this transect.

6.1.3.3 Cover for Adult Gamefish

Evidence of fish habitat was documented as part of the surveys. Fish habitat was documented at all sites; however, the type of habitat and the extent of the habitat (number of transects) differed at each location. The proportion and distribution of gamefish habitat differs slightly among years, but several types of fish habitat are generally available in each study reach each year. Despite variation among flow conditions and survey timing, woody debris continues to be the dominant fish cover among all sites, while submerged macrophyte beds persist, particularly at Site A, and overhanging banks appear in a few places.

6.1.3.4 Bank Erosion

During the quantitative habitat evaluation, the degree of bank erosion was assessed by measuring the height of exposed soil within 1 meter of the wetted edge on the left and right banks (facing upstream) at each transect. The evaluation of the extent of exposed bank is influenced by water depth and discharge in the channel at the time of the survey. Thus, these instantaneous, empirical values should still be considered estimates of site characteristics. The average exposed bank height measurement for 2022, collected during a low to moderate flow period, was 2.1 meters (± 0.7 meter). This value is most similar to the value of bank erosion measured in 2020, during another low flow period; however, the 2020 surveys were completed in fall rather than summer. The 2022 bank erosion values are slightly higher (indicate more exposed bank) than was recorded in 2021 during the summer season. Overall, the lowest values of average bank erosion still tended to occur with higher flows (2018: 1.0 meter ± 0.7 meter; 2019: 1.4 meters ± 1.1 meters) rather than low flows (2017: 2.1 meters ± 1.1 meters; 2020: 2.1 meters ± 0.4 meter). Table 6-4 summarizes the exposed bank height measured as part of the bank erosion assessment. Spring flooding, the movement of large woody debris, beaver activity, and the reestablishment of vegetation could have contributed to the variation observed in bank erosion measurements throughout the duration of the Pre-Return Flow Root River Collection Plan effort.

Table 6-4. Exposed Bank Heights

Year	Site A			Site B			Site C			Site D		
	Left	Right	Avg.	Left	Right	Avg.	Left	Right	Avg.	Left	Right	Avg.
2017	1.0 ± 0.5 m	1.0 ± 0.6 m	**1.0 m**	1.0 ± 1.1 m	1.5 ± 0.7 m	**1.3 m**	2.9 ± 1.9 m	3.2 ± 2.0 m	**3.1 m**	3.3 ± 2.5 m	2.3 ± 1.4 m	**2.8 m**
2018	0.3 ± 0.4 m	0.5 ± 0.3 m	**0.4 m**	0.6 ± 0.6 m	0.5 ± 0.6 m	**0.5 m**	1.3 ± 0.7 m	0.9 ± 0.6 m	**1.1 m**	1.6 ± 0.6 m	2.4 ± 1.4 m	**2.0 m**
2019	1.2 ± 0.7 m	0.9 ± 0.3 m	**1.1 m**	1.2 ± 0.6 m	0.8 ± 0.7 m	**1.0 m**	1.1 ± 0.8 m	1.6 ± 1.1 m	**1.3 m**	2.1 ± 0.8 m	2.0 ± 0.7 m	**2.0 m**
2020	2.4 ± 1.0 m	3.1 ± 1.3 m	**2.7 m**	2.4 ± 1.0 m	3.1 ± 1.8 m	**2.7 m**	1.8 ± 1.2 m	1.7 ± 0.9 m	**1.8 m**	1.2 ± 0.7 m	1.2 ± 0.5 m	**1.2 m**
2021	0.7 ± 0.4 m	1.4 ± 1.8 m	**1.0 m**	0.7 ± 0.9 m	0.9 ± 0.4 m	**0.8 m**	0.9 ± 0.7 m	0.8 ± 0.8 m	**0.8 m**	2.7 ± 1.5 m	1.7 ± 0.5 m	**2.2 m**
2022	1.0 ± 0.6 m	1.0 ± 0.7 m	**1.0 m**	0.8 ± 0.8 m	2.1 ± 2.7 m	**1.4 m**	2.7 ± 1.5 m	2.4 ± 1.2 m	**2.5 m**	3.5 ± 1.6 m	3.2 ± 1.7 m	**3.4 m**

6.1.4 Additional Data Collection

The previous fish and macroinvertebrate data summary included indices and common metrics for establishing pre-diversion conditions between 2017 and 2023. Additional data were collected as part of the fish and macroinvertebrate data collection activities where these data may be compared to post-diversion data as part of the assessment of impacts from the return flow. The additional data included:

Fish Community

- Total numbers and percentages of species and individuals captured
- Identification of fish with external deformities, erosions, lesions, and tumors (DELT anomalies)
- Adult individuals of game species (pikes, centrarchid basses, and sunfishes) were measured for total length before release

Macroinvertebrate

- Taxa abundance
- Taxon richness and ephemera, plecoptera, and trichoptera generic richness
- Diversity (Shannon Diversity Index)
- Evenness
- Percent depositional taxa
- Percent Chironomidae
- Functional feeding groups (percent shredder, scraper, gatherer)
- Percent Macrocrustacea (percent isopod and percent amphipod)
- Channel and basin data
- Flow data

6.1.5 Diatom Survey

The WDNR collected pre-diversion diatom data within the Root River. It was not available for inclusion in this report but is anticipated to be included in future-year summaries.

6.2 Post-Diversion Habitat and Biological Data

This report includes pre-diversion conditions. Post-diversion Root River habitat and biological data will be summarized in future annual reports to address the following topics:

- Changes in the river macroinvertebrate, fish, or diatom community (as provided by the WDNR) upstream or downstream of return flow as compared to pre-return flow conditions
- Spatial extent of the changes caused by return flow
- Assessment of the changes as natural variability, an indication of potential upstream watershed impacts, or an indication of changes resulting from return flow

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