Water Quality Planning to Transition from Groundwater to Lake Michigan Water

Tony Myers – Jacobs
Kelly Zylstra– Waukesha Water Utility

Waukesha Water Utility
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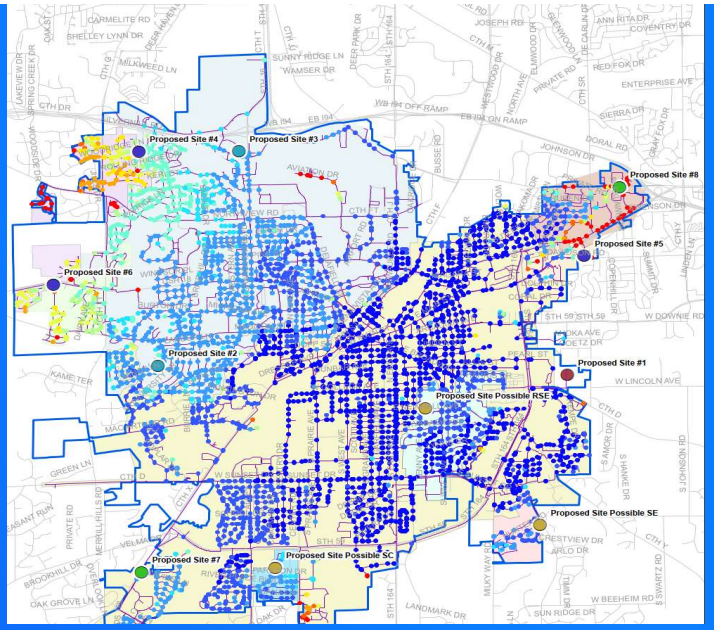
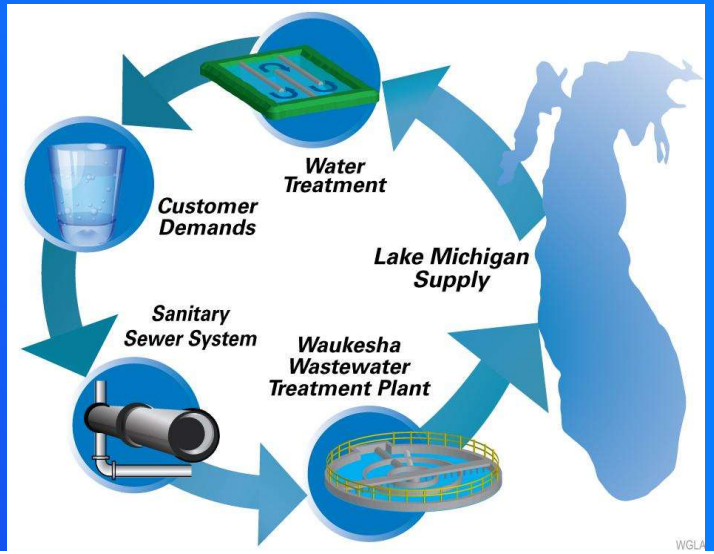
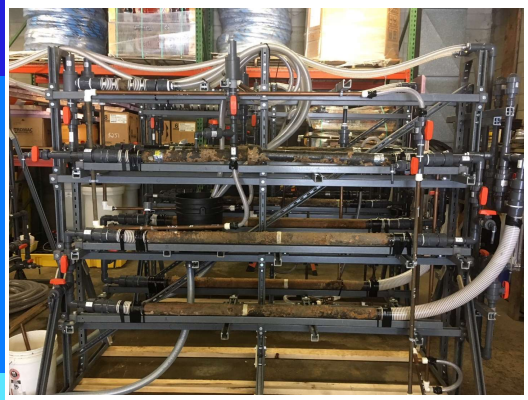
Jacobs

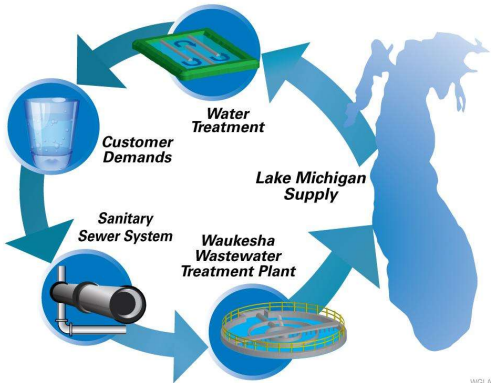




Presentation Outline

- Background – Transition from groundwater to Lake Michigan water
- Pre-Transition Water Quality Planning Studies
- Post-Transition Results





Background

Waukesha Water Utility
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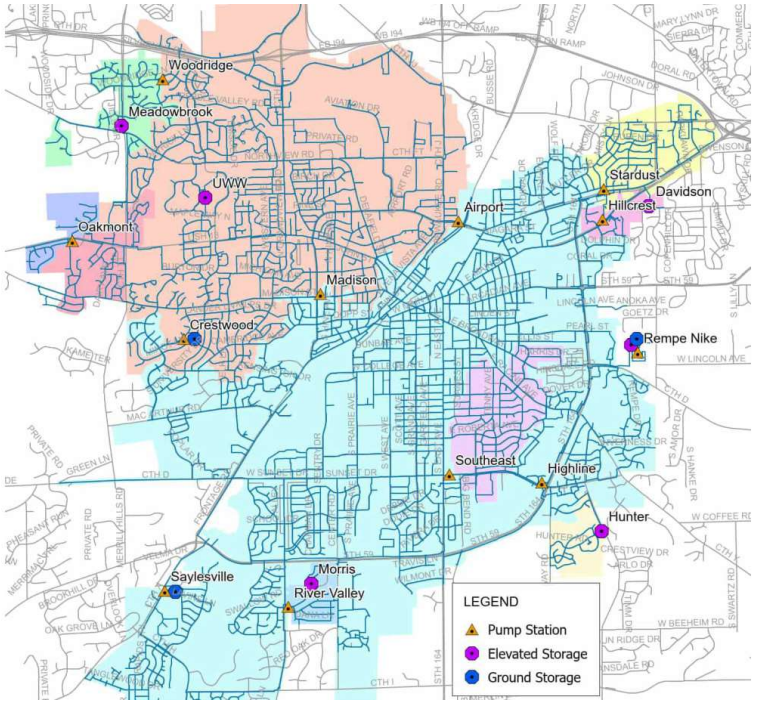
Background – Current Water System

- Waukesha serves about 70,000 people in southeast Wisconsin.
- Waukesha water supply was from deep and shallow wells.
- The deep wells contain radium above the EPA limit
- The aquifer is not sustainable.
- Waukesha has been studying water supply alternatives for over **three decades**.

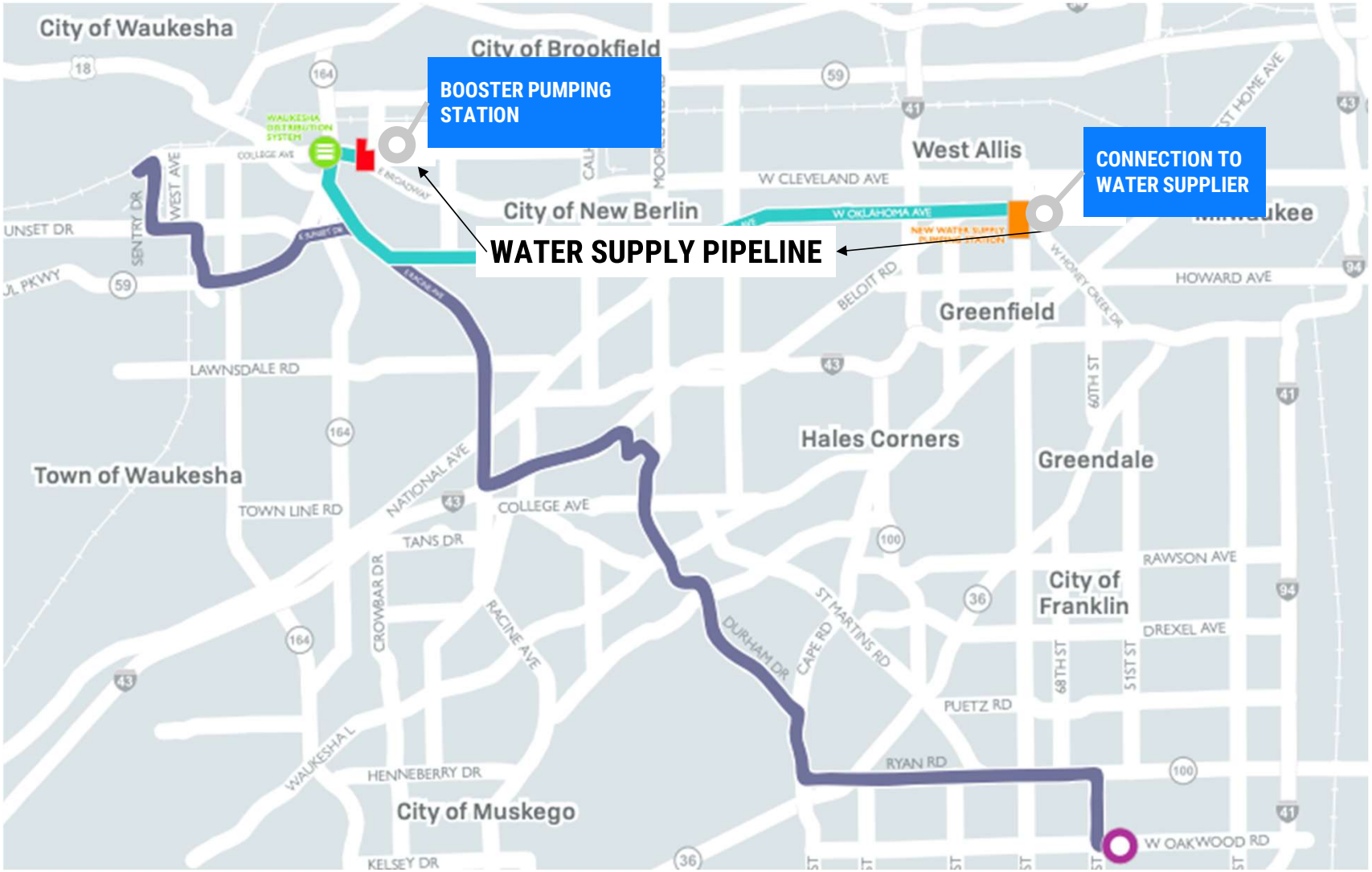
Waukesha Water System - Then and Now

Facility	Groundwater System	Lake Michigan System
Wells	12	4 (Emergency)
Booster Pump Stations	11	12
Ground Storage Reservoirs	6 (12.8 MG)	4 (20.7 MG)
Elevated Towers	5 (2 MG)	6 (3 MG)
Pressure Zones	10	10



Project Route

WATER SUPPLY PIPELINE



Booster Pump Station and Reservoirs

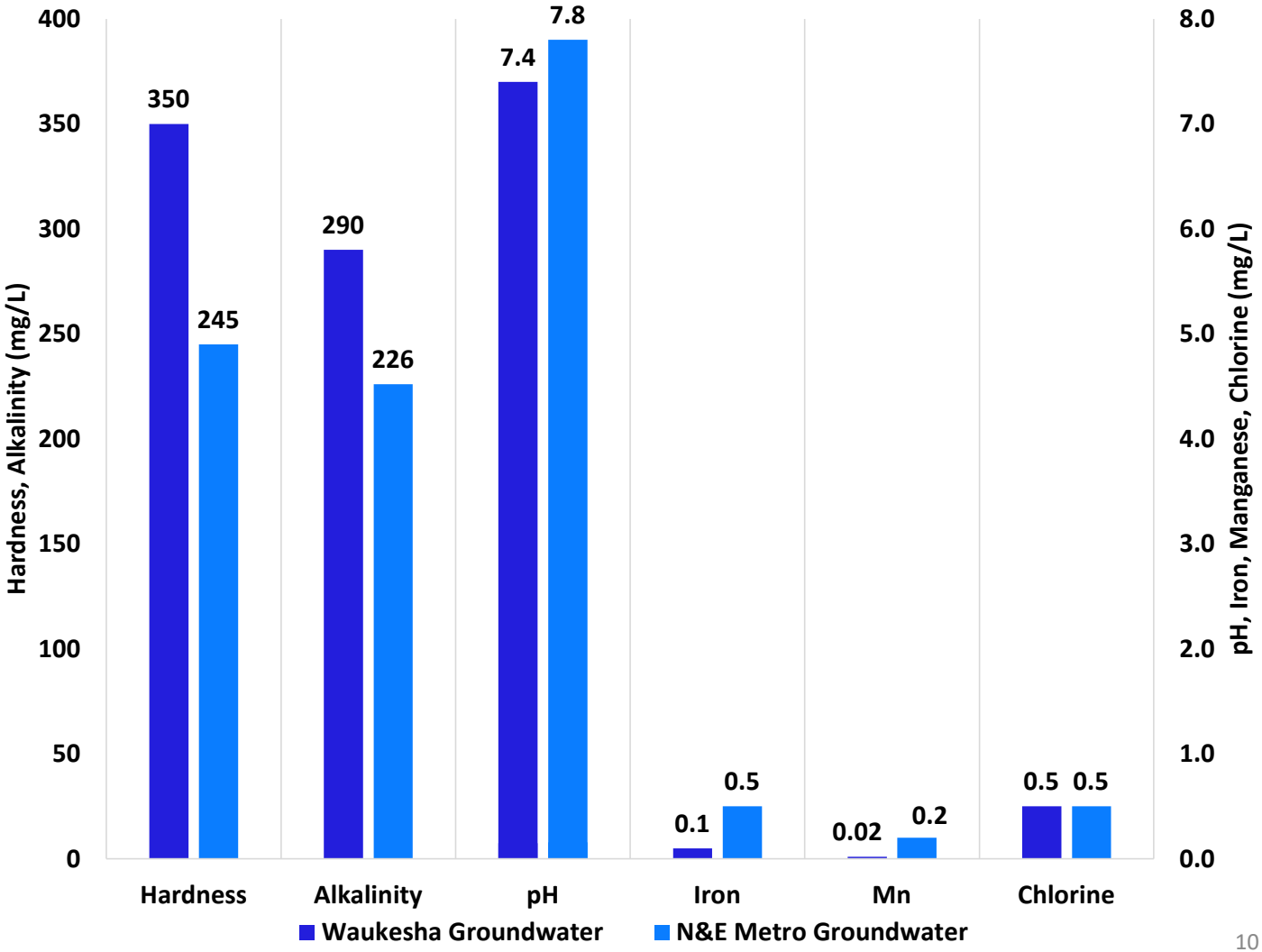
Purpose of Water Quality Planning

- Continue providing high quality drinking water as Waukesha transitions from groundwater to treated Lake Michigan water.

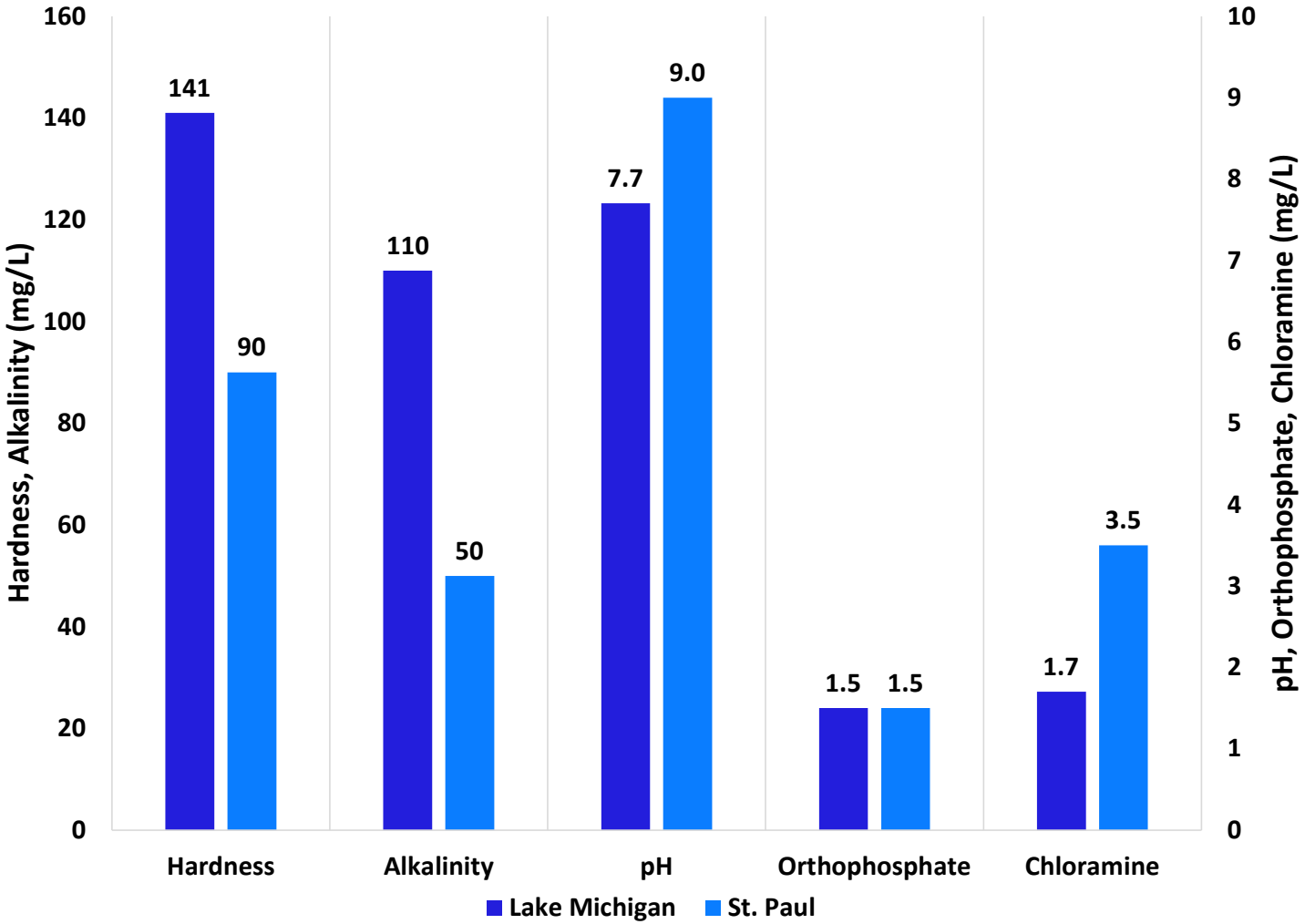
Water Quality Planning Studies

Groundwater Differences Waukesha WI and North and East Metro Area

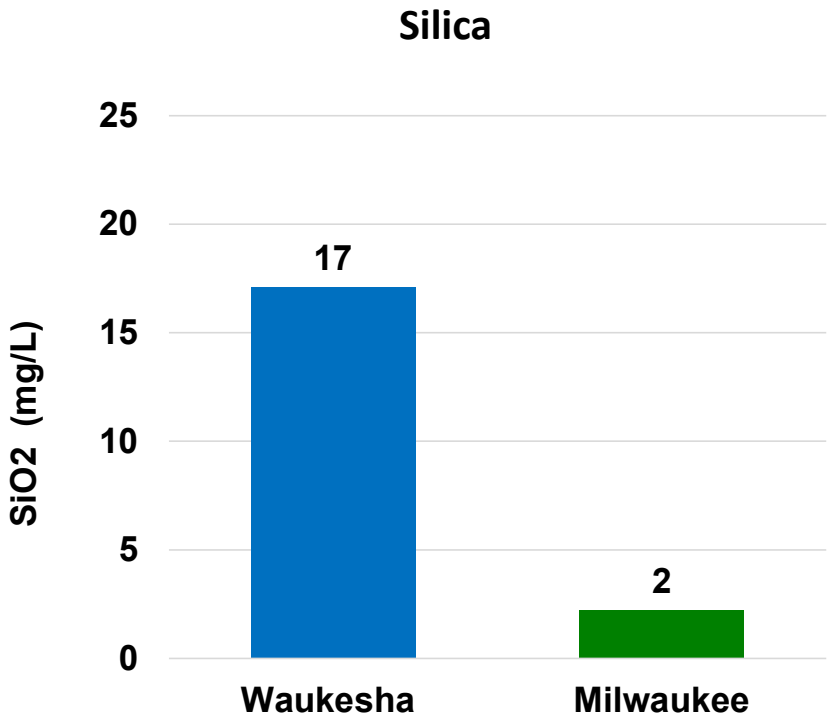
Community
City Of North St Paul
City of Oakdale
Mahtomedi
Vadnais Heights
City of Lake Elmo
City of Hugo
City of New Brighton
White Bear Township
City of Shoreview
White Bear Lake
City of Lino Lakes

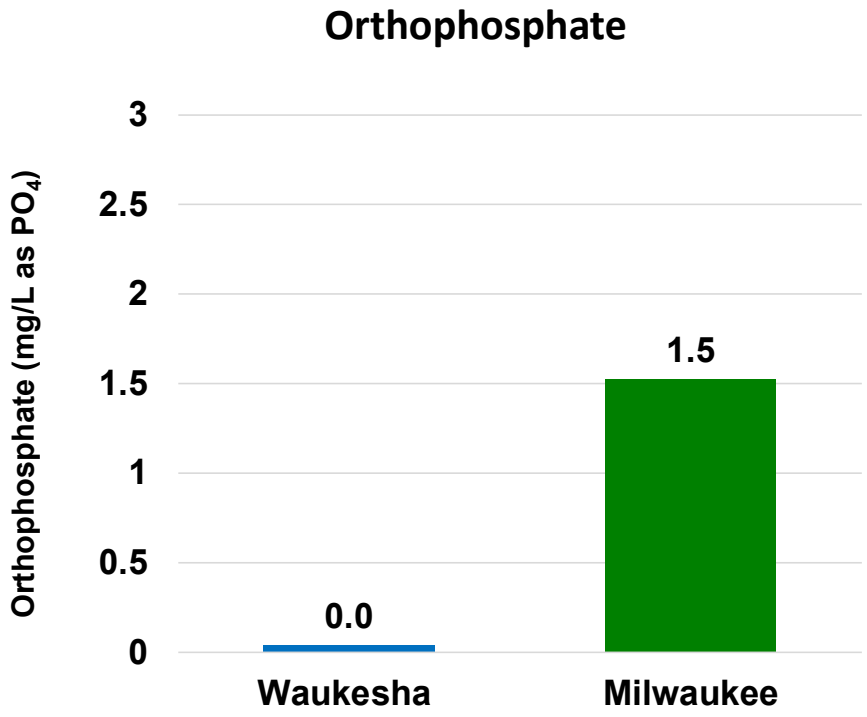


Differences between treated Lake Michigan and SPRWS water

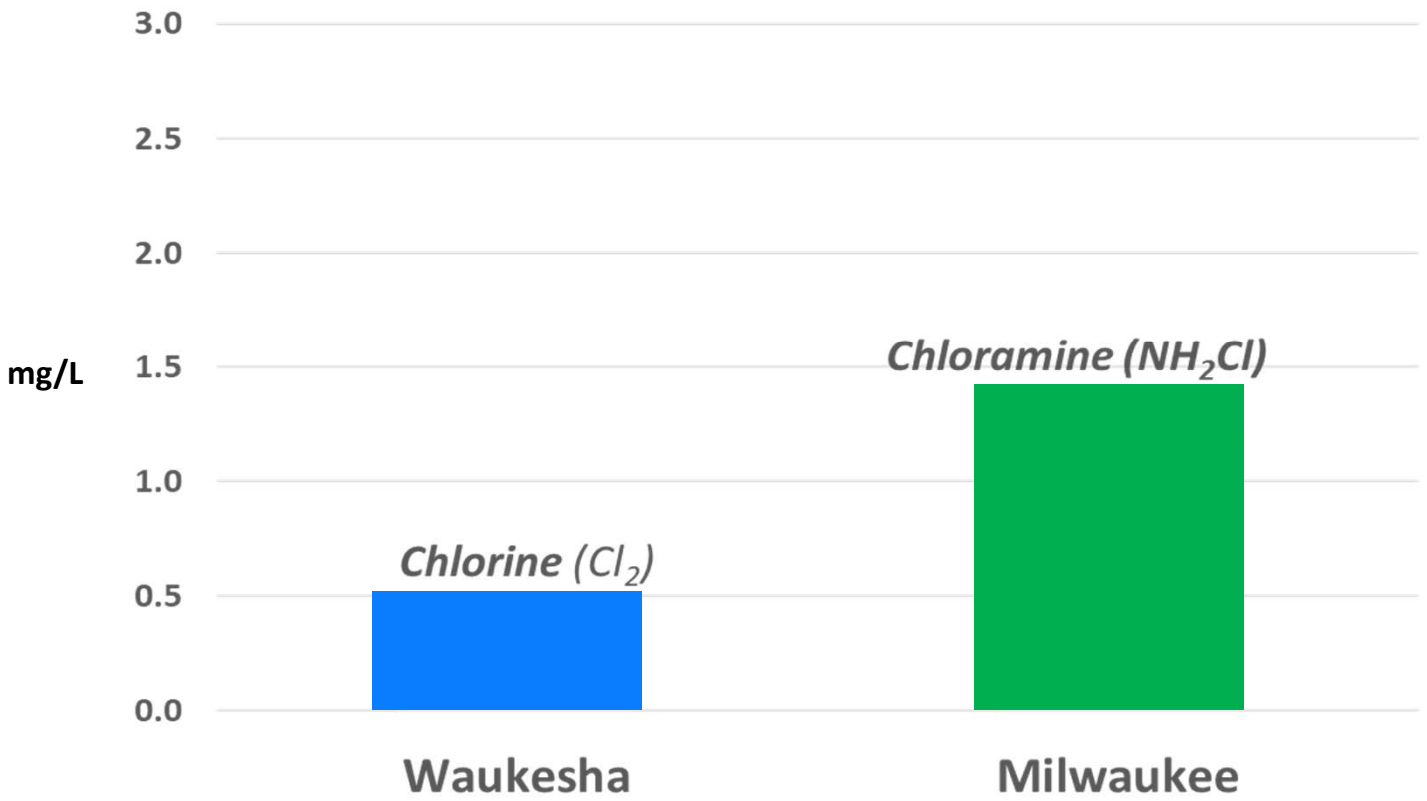


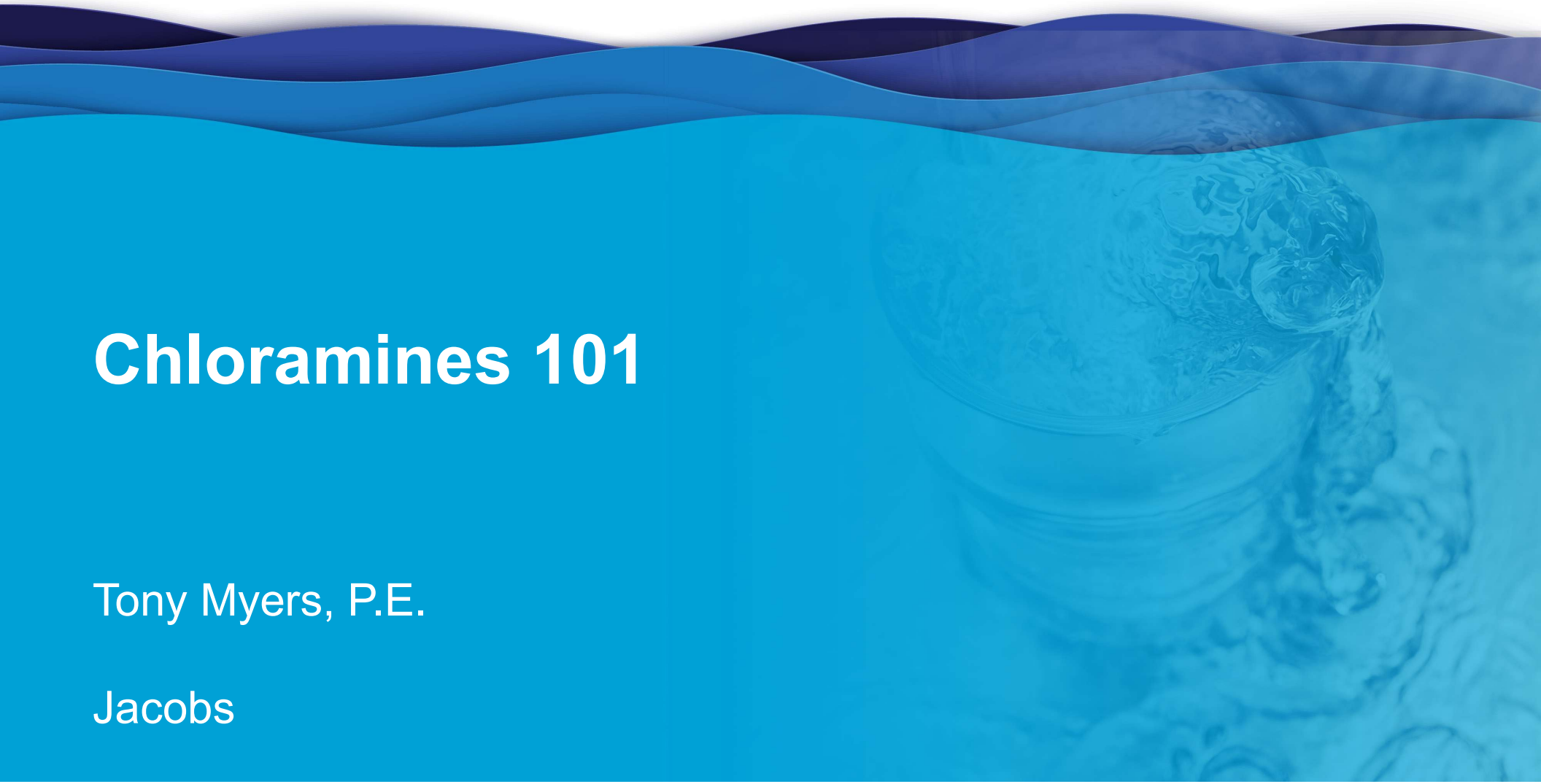
Differences in WI Groundwater vs Lake Michigan – Corrosion Inhibitor





Differences in WI Groundwater vs Lake Michigan – Disinfectant





Chloramines 101

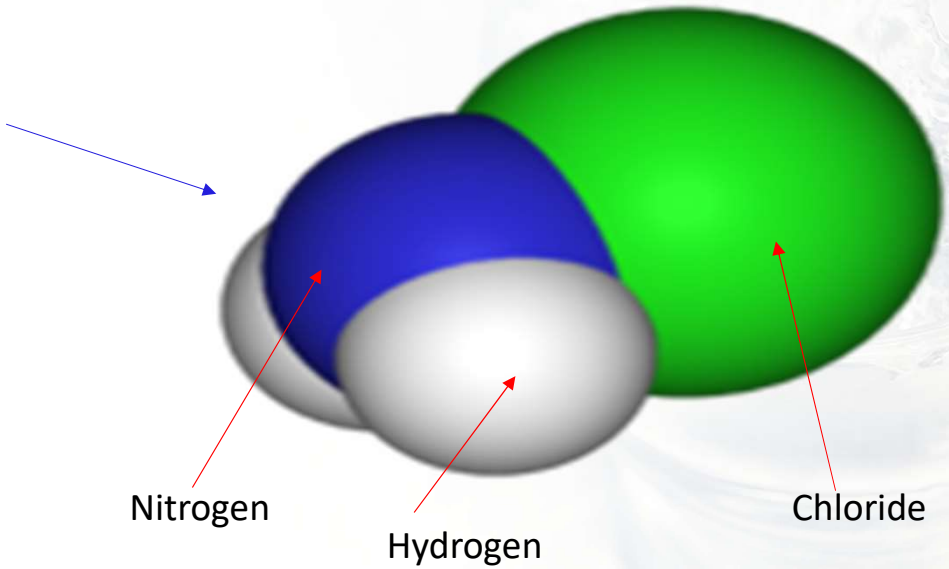
Tony Myers, P.E.

Jacobs

What are Chloramines?

Chlorine + Ammonia = Chloramines

- Monochloramine (NH_2Cl)
- Dichloramine ($NHCl_2$)
- Trichloramine (NCl_3)

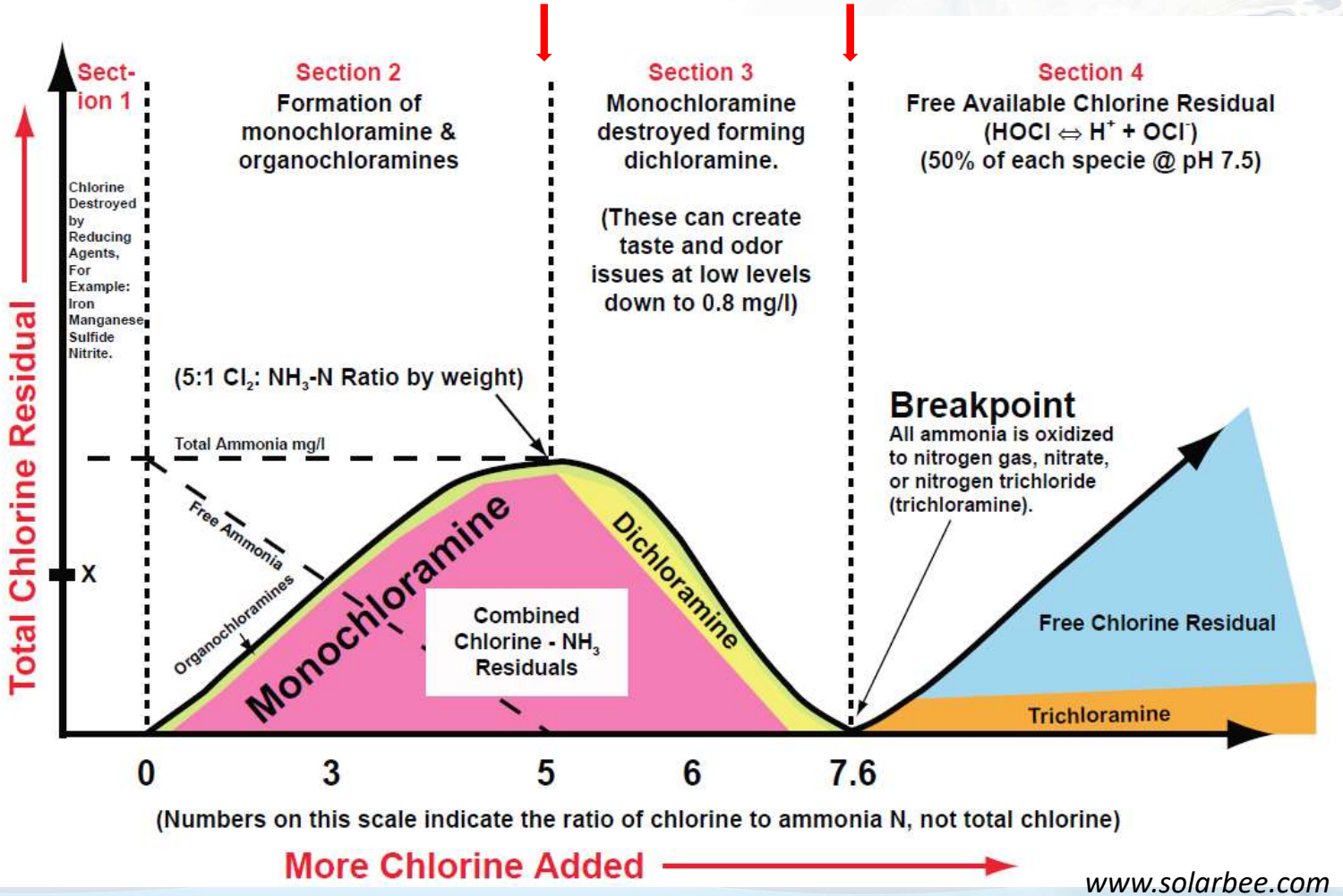


What is the Proper Chlorine to Ammonia Ratio to form Monochloramine?

- About 4.5 parts chlorine (Cl_2) to 1 part ammonia (NH_3-N), by weight

Waukesha uses liquid sodium hypochlorite and liquid ammonium sulfate to "boost" chloramine

Typical breakpoint curve for pH 7.5-8.5



Chlorine vs Monochloramine

Chlorine	Chloramine
Stronger disinfectant, but decays faster in distribution system	Weaker disinfectant but longer lasting residual and good for biofilms in pipes
Easier to use (1 chemical)	More complex (2 chemicals)
Forms regulated chlorinated DBPs	Does not form regulated chlorinated DBPs. Forms some unregulated DBPs.
	Potential for nitrification

What should I measure in my water?

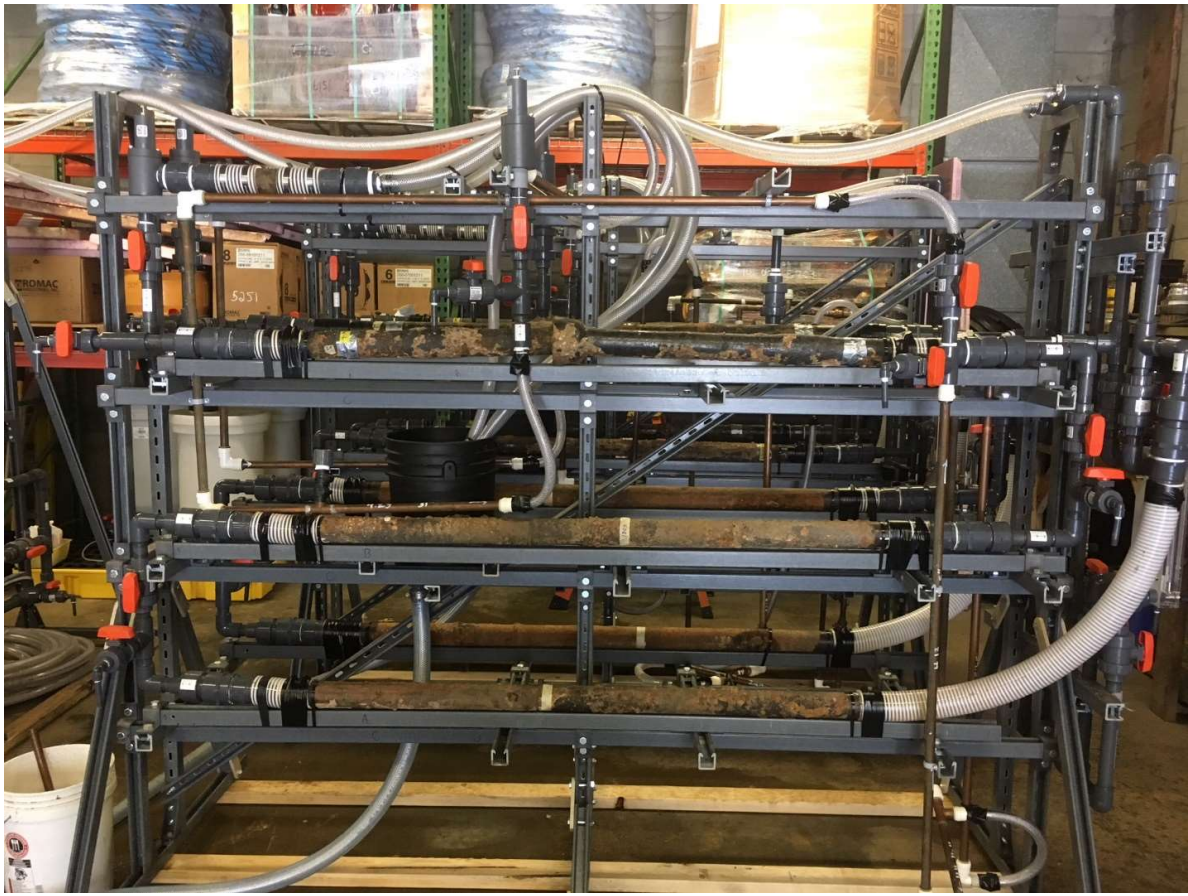
- ✓Total Chlorine
- ✓Monochloramine
- ✓Free Ammonia

- ✓*Nitrite*

6 Elements of Water Quality Transition Planning

Planning for the new water supply (1)

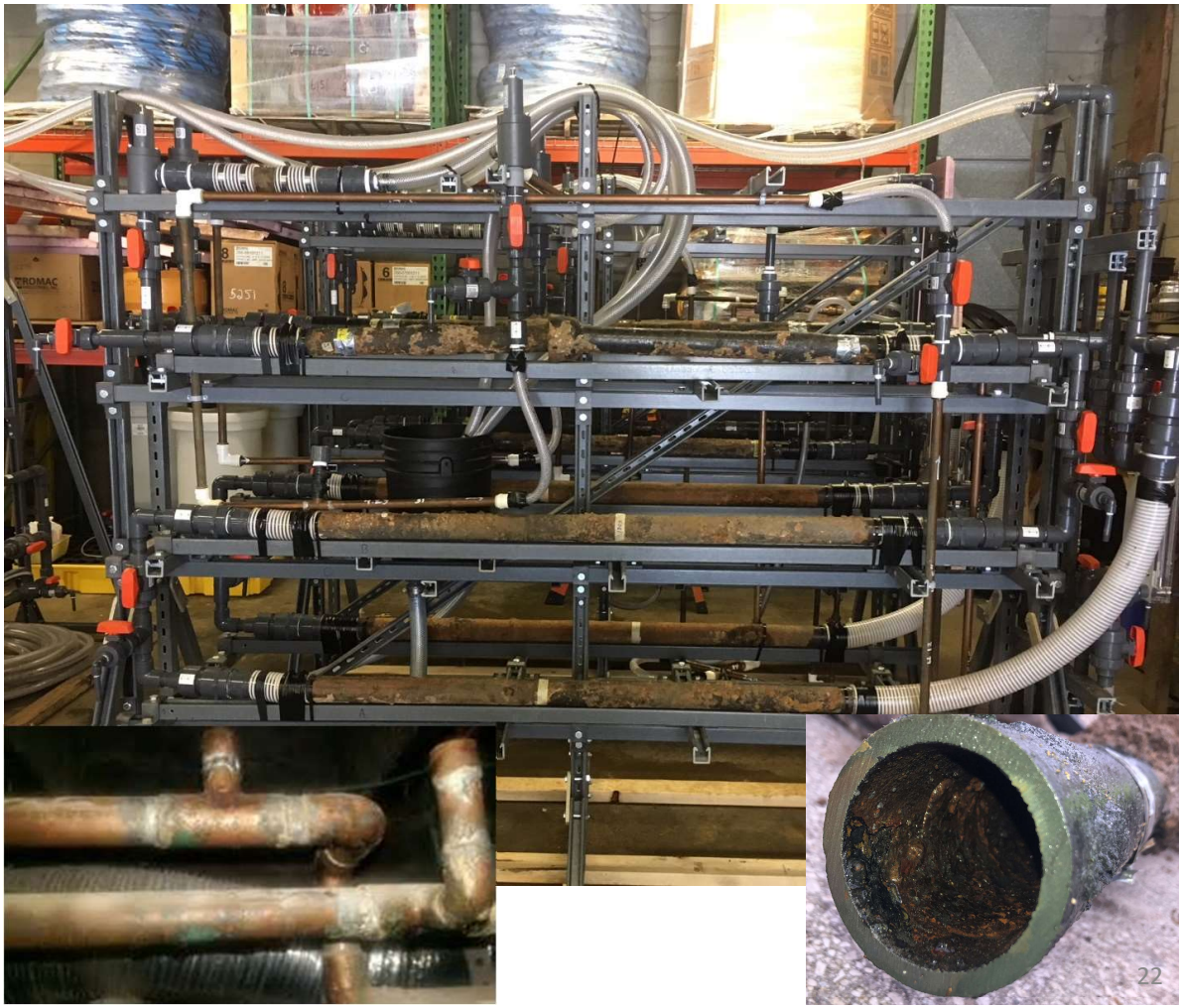
1. **A corrosion control treatment study** using Waukesha pipes and Milwaukee water to determine impacts on water quality. 2018 - 2019



1. Corrosion Control Treatment Study

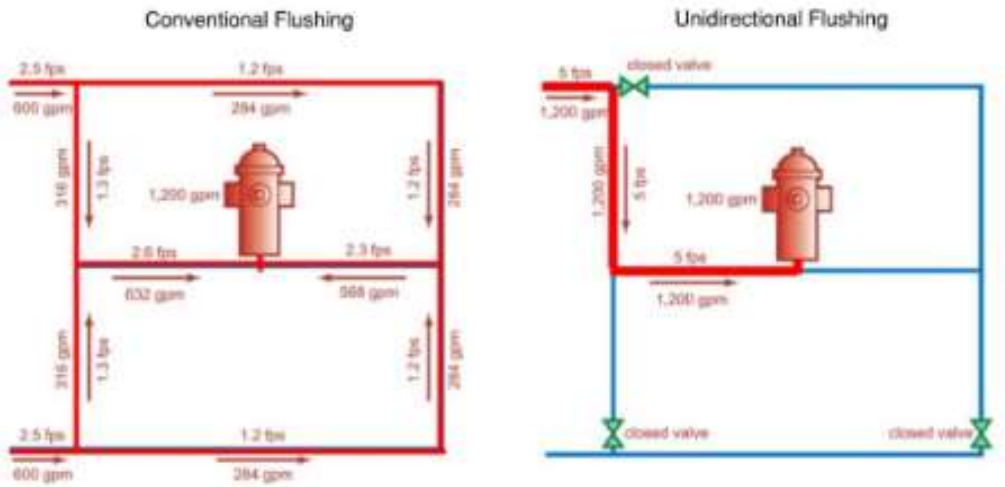
Major Findings

- Lead was lower with Milwaukee water in Waukesha pipes, versus Waukesha groundwater.
- Release of iron and manganese was low
- Radium was not released from the pipe scale.



Planning for the new water supply (2)

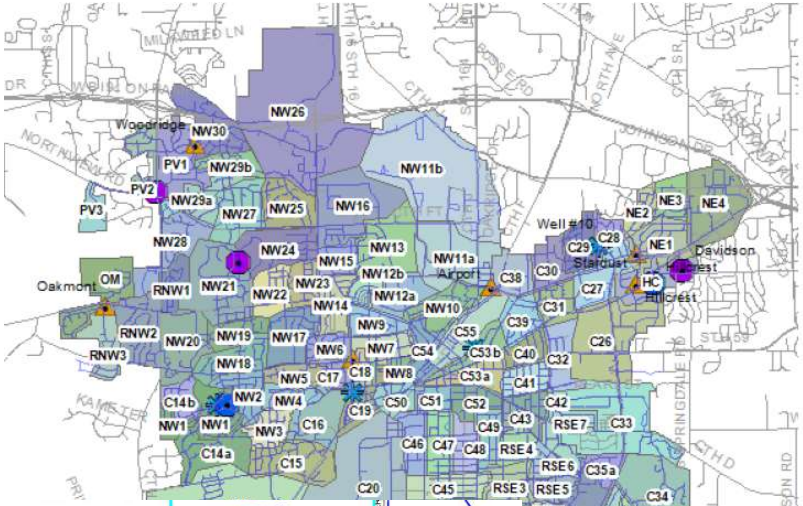
1. A pipe loop corrosion control study using Waukesha pipes and Milwaukee water to determine impacts on water quality.
   2018 - 2019
2. **A unidirectional flushing (UDF) program** to flush sediment from the distribution system pipes before and after the water transition. 2020 – 2021, 2023

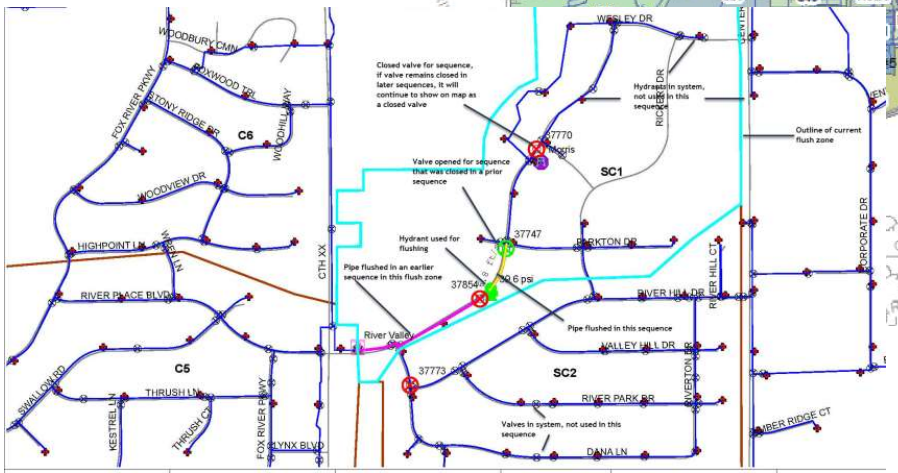


2. Unidirectional Flushing (UDF) Program

Highlights

- Completed in 2021 by Waukesha Water Utility.
- 115 flushing zones and 1,500 flush sequences throughout the distribution system
- Over 1 million feet of water main flushed.
- 4 to 5 person crew, took 4 to 5 months.

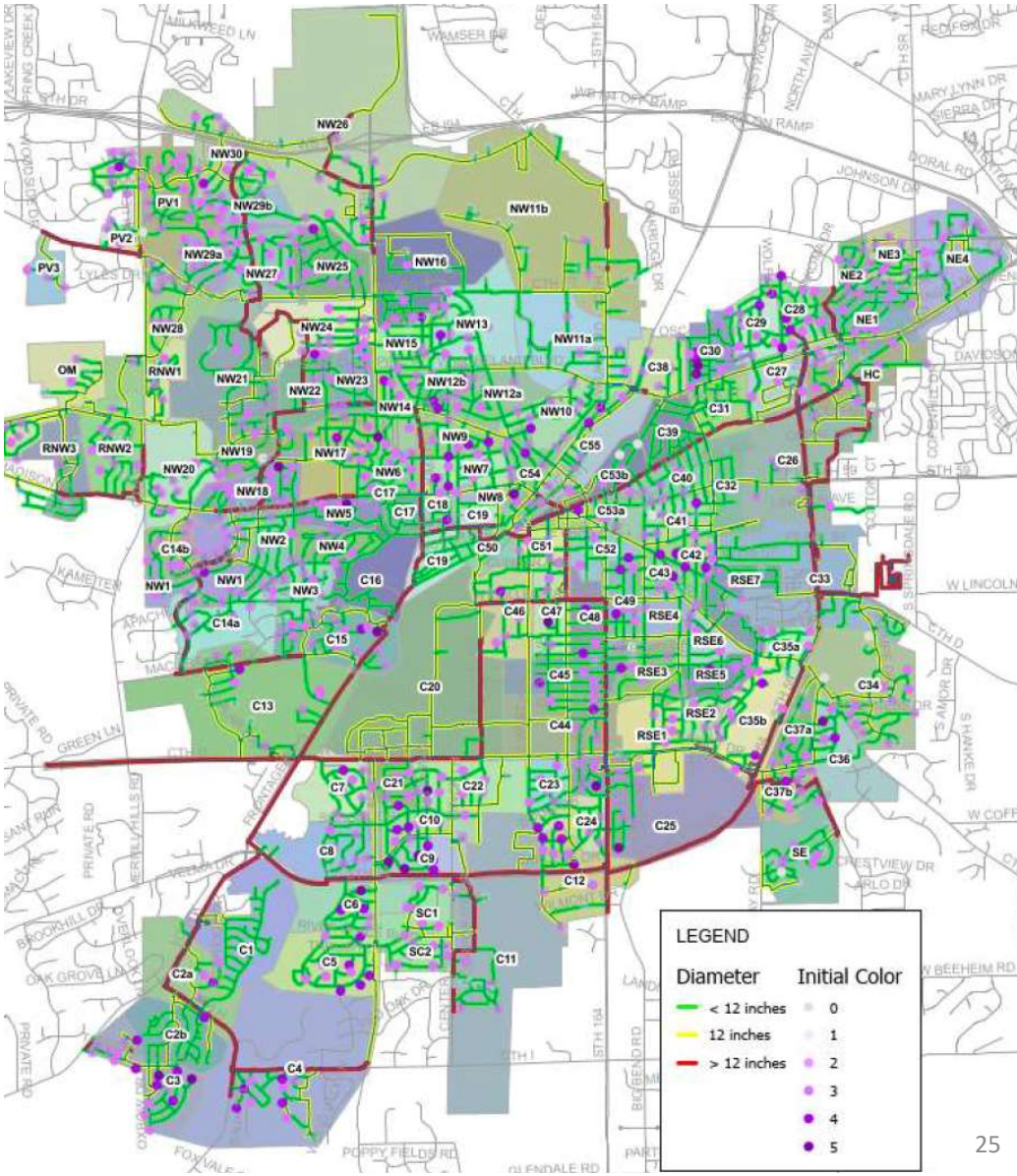




Zone	SOUTH_CENTRAL_1	Sequence	3	Hydraulics	Model
Date of Flush		Start Time		Static Pressure	43.55 psi
Duration	2.3 min.	Open Hydrant	13280	Res. Pressure	39.62 psi
Valves to Open	37747			Discharge Flow	1,060.89 gpm
				Available Flow	2,793.02 gpm
Valves to Close	37854(37770, 37773)			Total Pipe Len.	318.1 ft
				Min Flushing Vol	829.92 gal
Pipes to Flush	25761,26922			Desired Flushing Vol	2,489.76 gal
				Min Flushing Time	0.8 min.
				Desired Flushing Time	2.3 min.

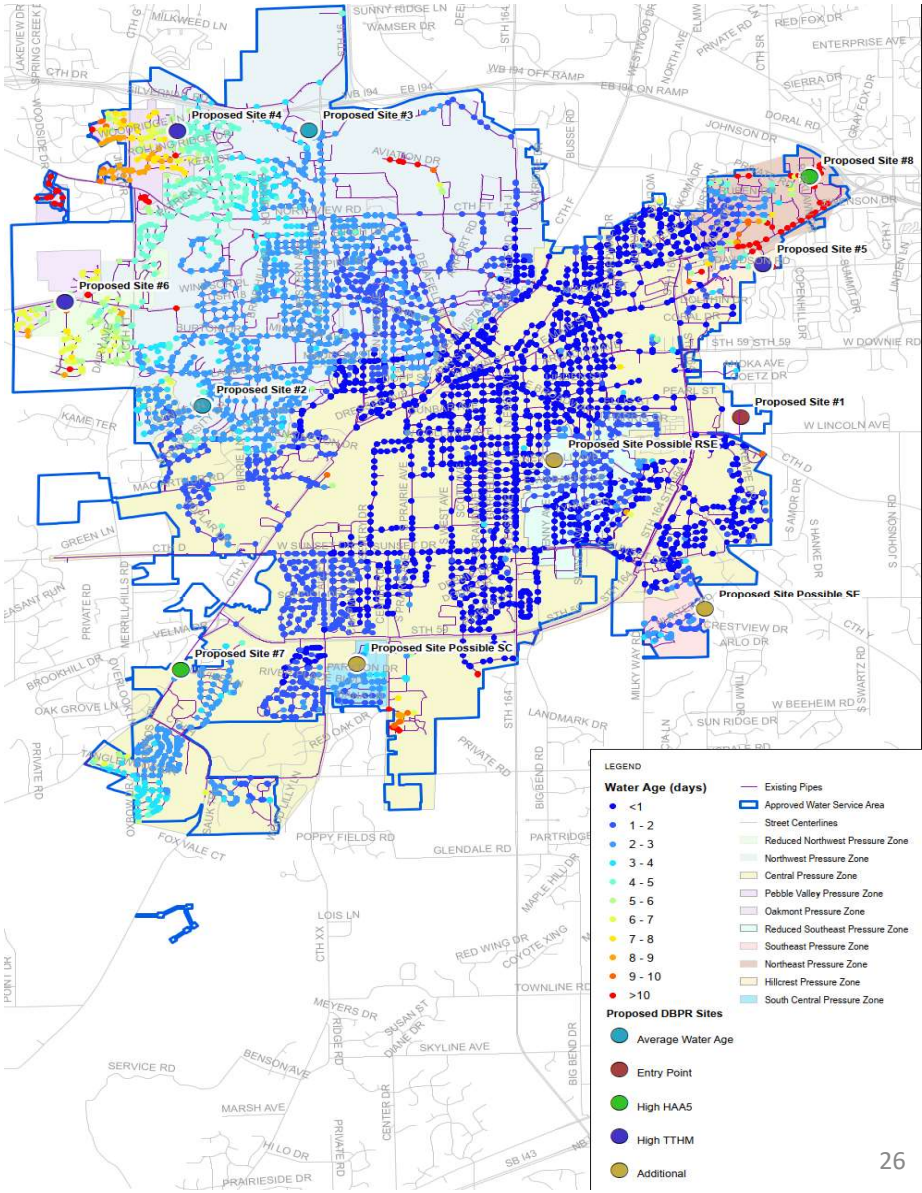
2. Unidirectional Flushing (UDF)

- Gathered good information on areas with high color
- Useful for determining area for follow up flushing



Planning for the new water supply (3)

1. **A pipe loop corrosion control study** using Waukesha pipes and Milwaukee water to determine impacts on water quality. 2018 - 2019
2. **A unidirectional flushing (UDF) program** to flush sediment from the distribution system pipes before and after the water transition. 2020 – 2021, 2023
3. **An Initial Distribution System Evaluation (IDSE)** to determine water sampling locations to meet regulations. 2021.



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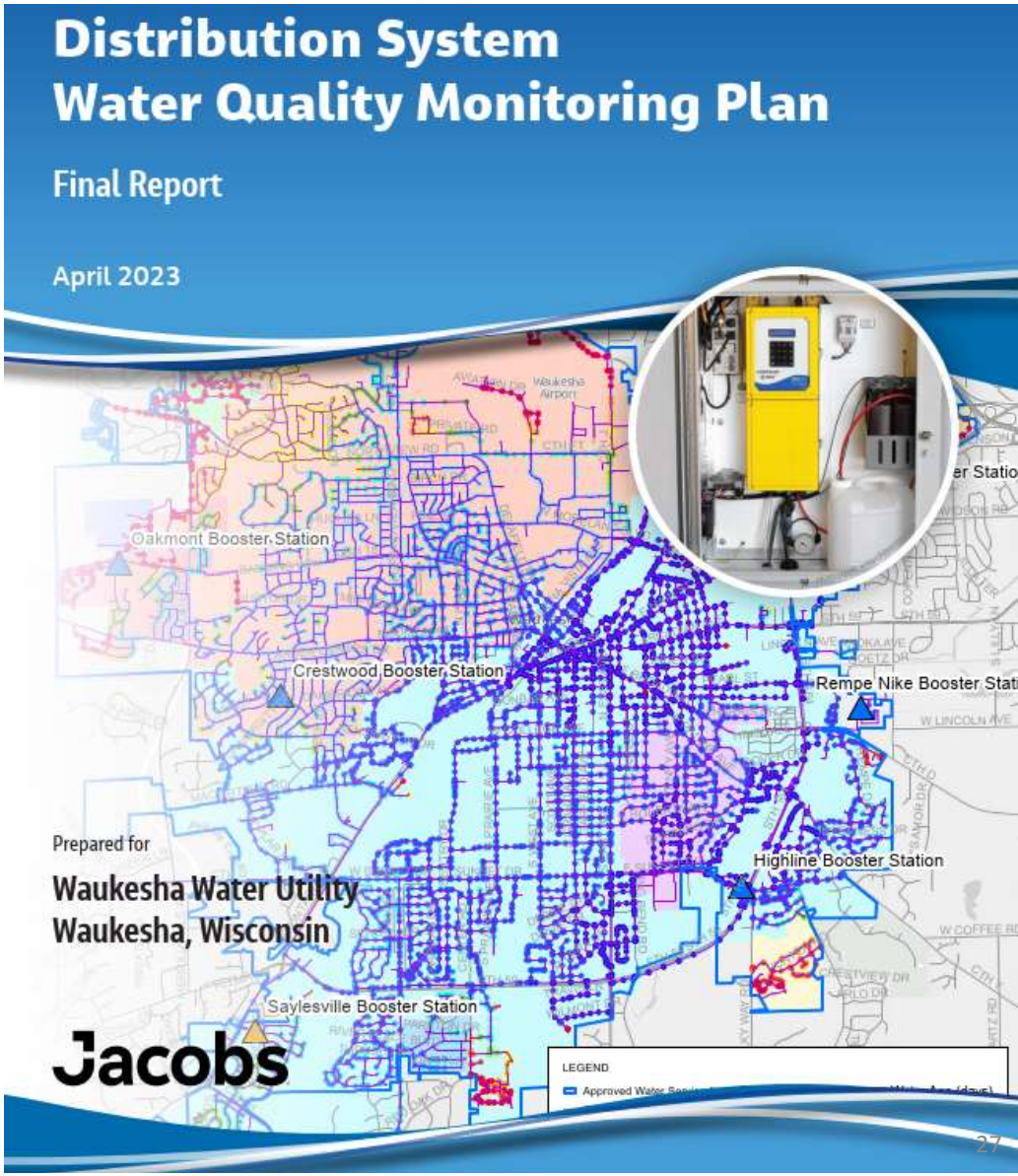
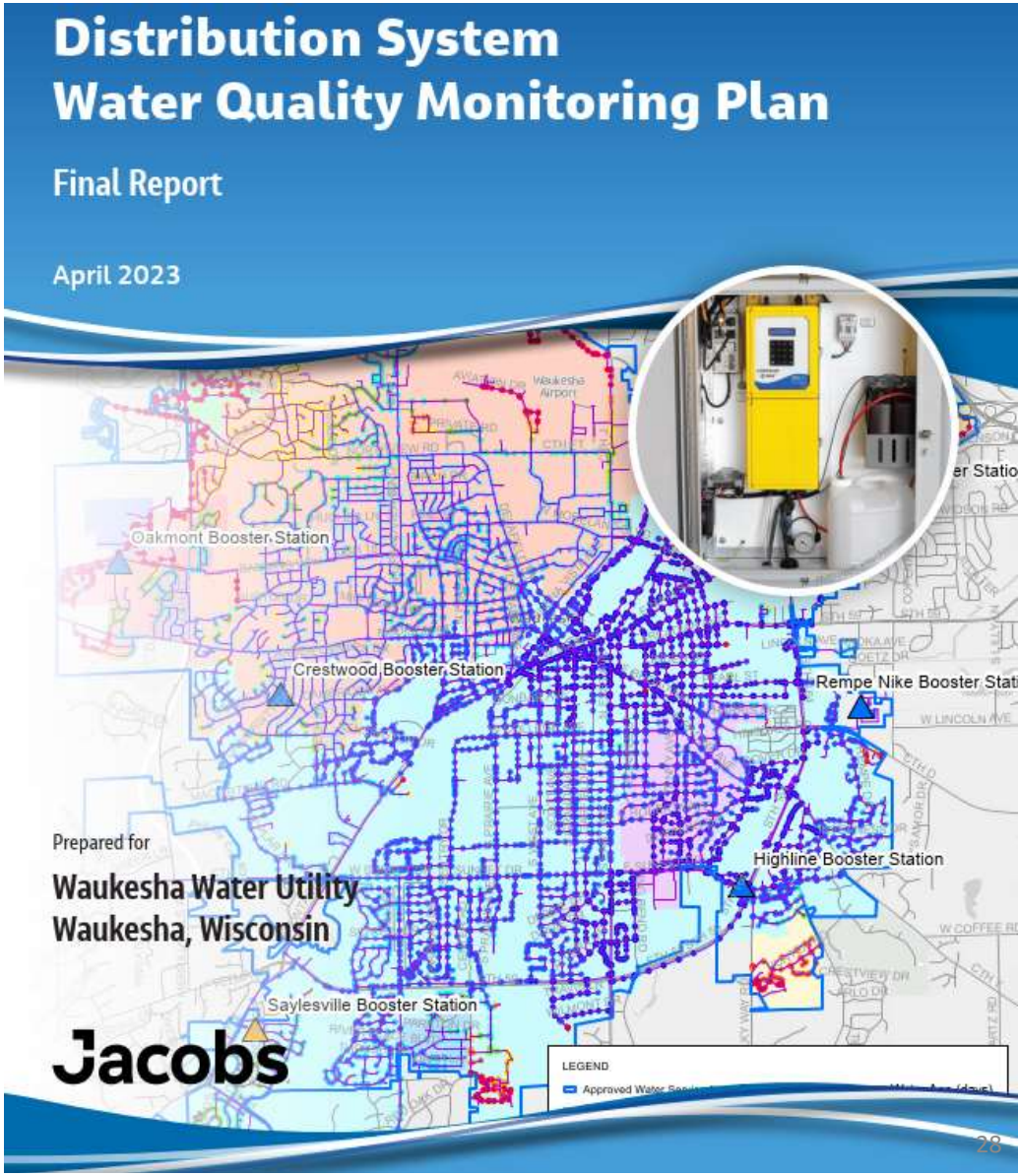


4. Distribution System Water Quality Monitoring Plan (1 of 2)

Highlights

- Not a regulatory requirement
- Better manage water quality at areas with longer water age.
- Measures indicators of nitrification (nitrite, free ammonia) plus monochloramine and others.



4. Distribution System Water Quality Monitoring Plan (2 of 2)

Four locations initially, plus entry point.

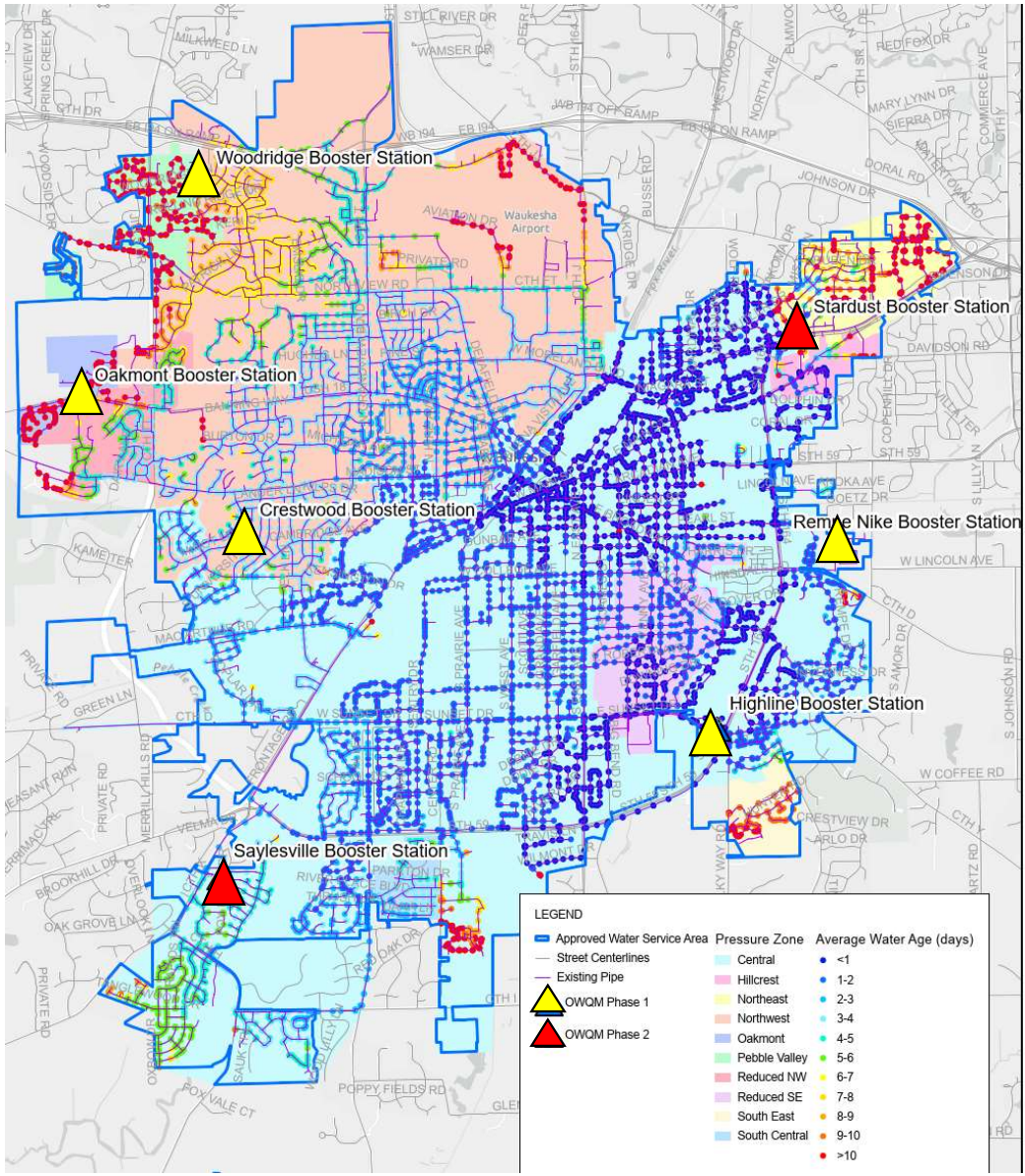
Parameters Measured

On-line

- Monochloramine
- Total ammonia
- Free ammonia
- Nitrite
- Nitrate
- Color
- UV 254
- pH/temp

Grab

- Iron
- Orthophosphate
- Fluoride
- HPC



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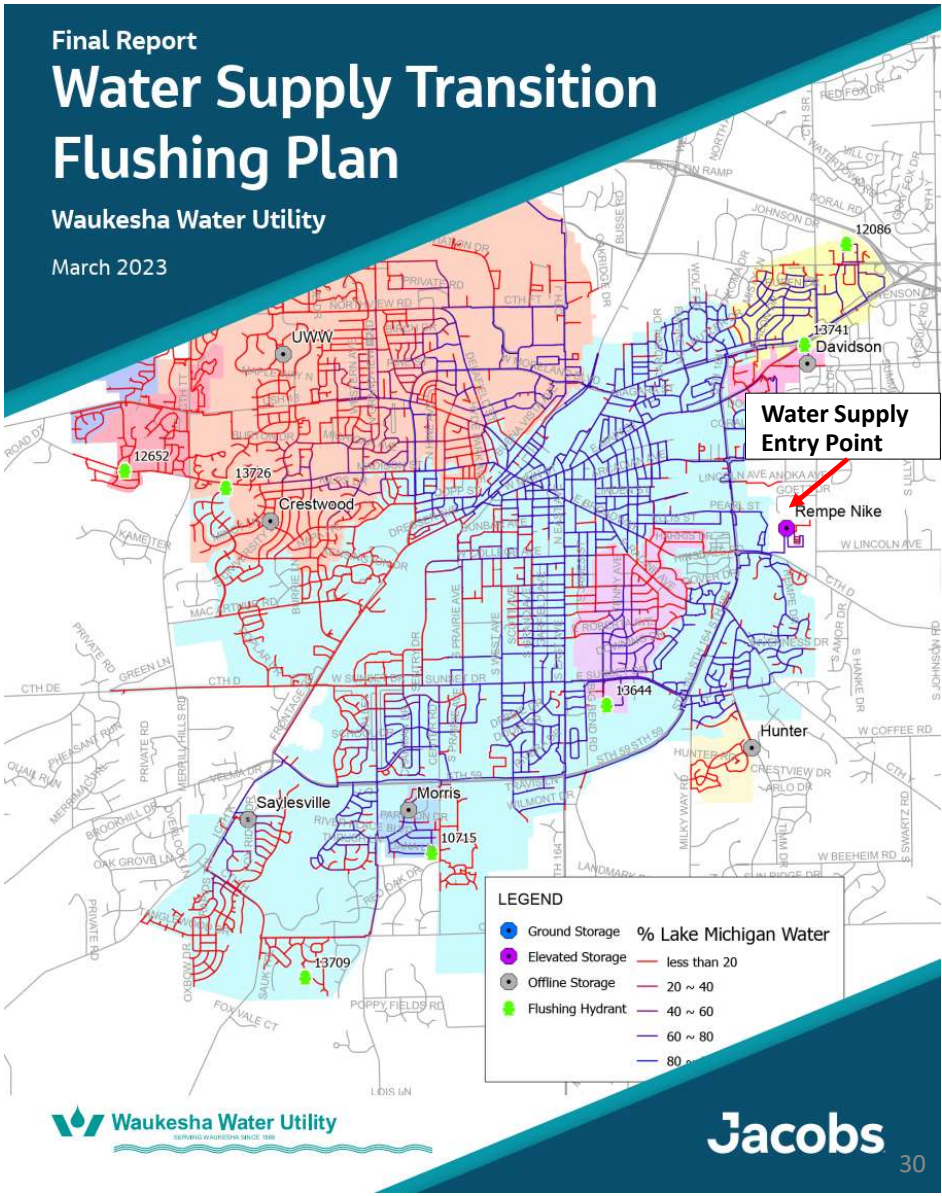
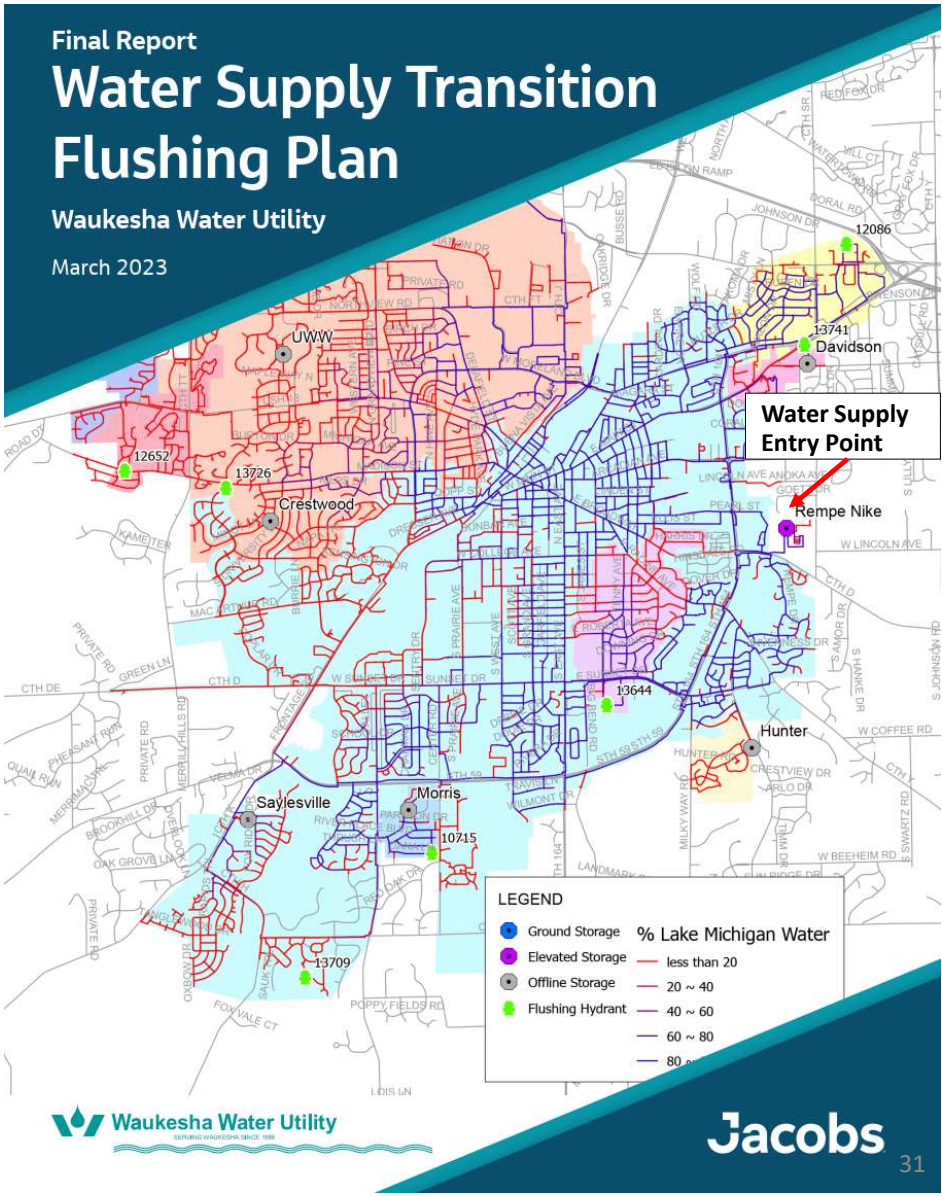
3. **An Initial Distribution System Evaluation (IDSE)** to determine water sampling locations to meet regulations. 2021.
4. **A distribution system water quality monitoring plan** recommending monitoring to maintain water quality. 2021 - 2023
5. **A transition flushing plan** to move the groundwater out and the Lake Michigan water while maintaining water quality 2022 - 2023



5. Transition Flushing Plan (1 of 1)

Highlights

- Minimize mixing chlorinated groundwater and chloraminated Lake Michigan water
- May not be necessary for a chlorine-to-chlorine or chloramine-to-chloramine water transition.
- *Need to incorporate Utility operational expertise with hydraulic modeling.*



5. Transition Flushing Plan (2 of 2)

Three alternatives evaluated.

- **No hydrant Flushing** –Normal tower operations. Water moves based on demand.
- **Active Flushing** – 70 hydrants flushed. All towers offline. 24-hr crew.
- **Staggered Tank** – 12 hydrants flushed. Tower on and off based on water movement.

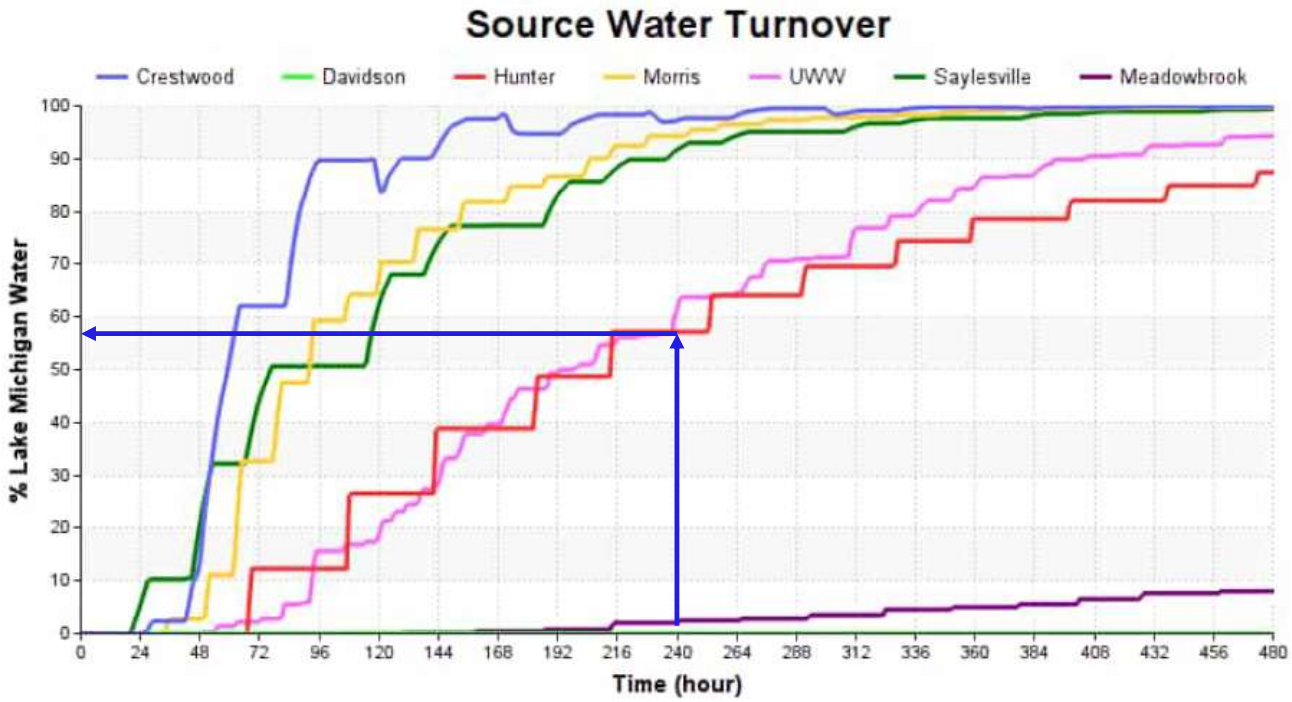
5. Transition Flushing Plan – No Flushing (1 of 2)

Method

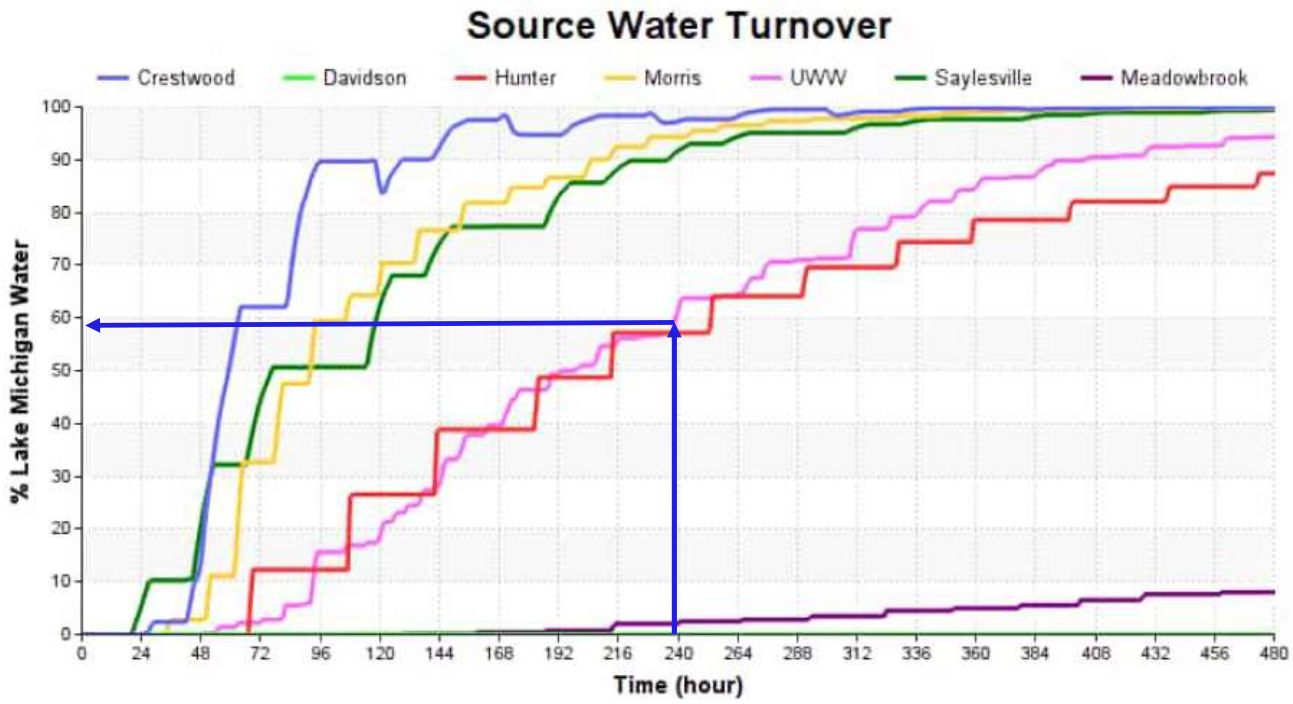
- Normal operations

Results

- Greater than 20 days transition
- Significant mixing of water sources



5. Transition Flushing Plan – No Flushing (2 of 2)



Chloramine Residual

Breakpoint!

Free Chlorine Residual

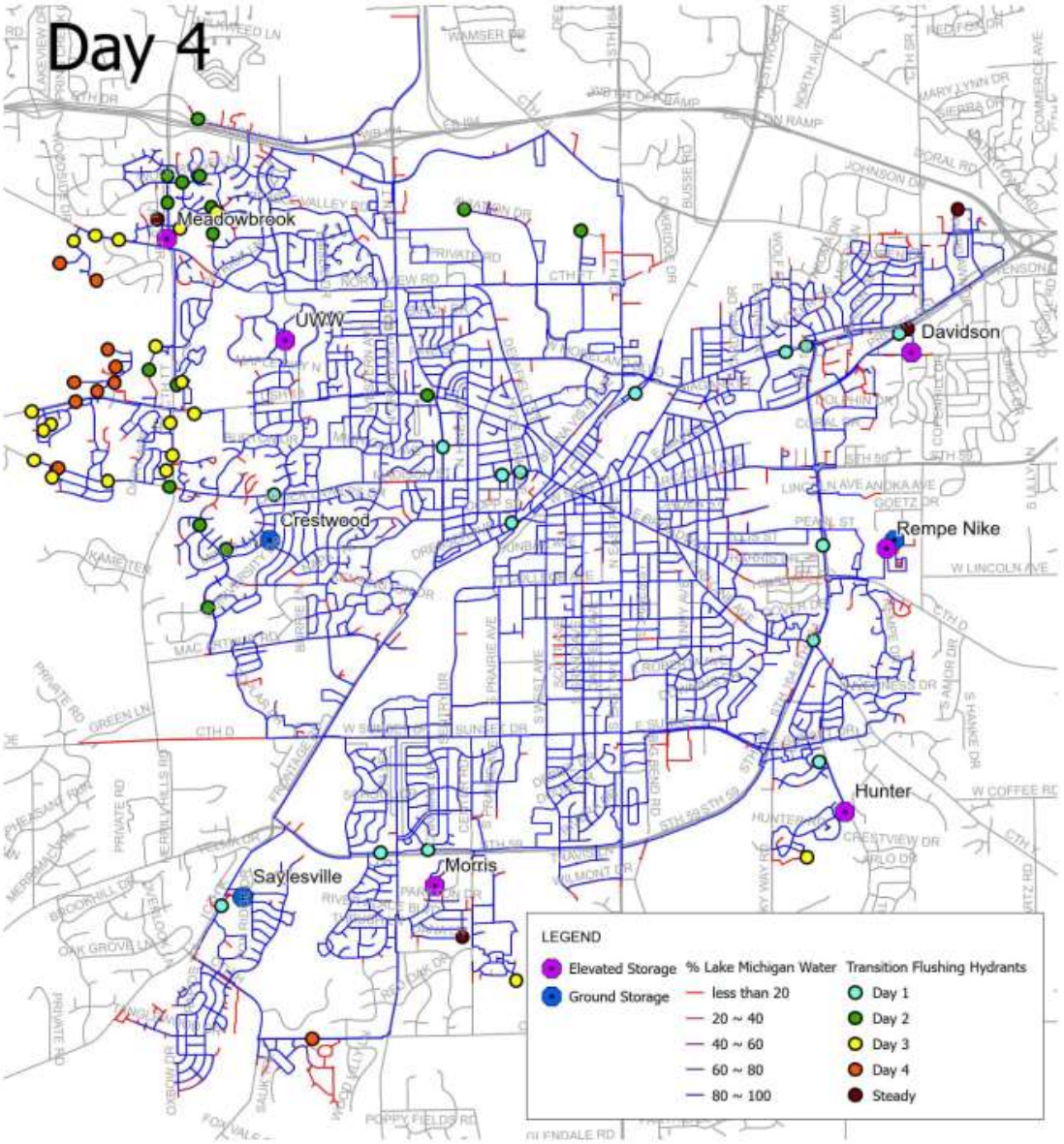
5. Transition Flushing Plan – Active Flushing

Method

- 70 flushing hydrants
- Valved off storage tanks

Results

- About 4 days transition
- Minimal mixing of water sources



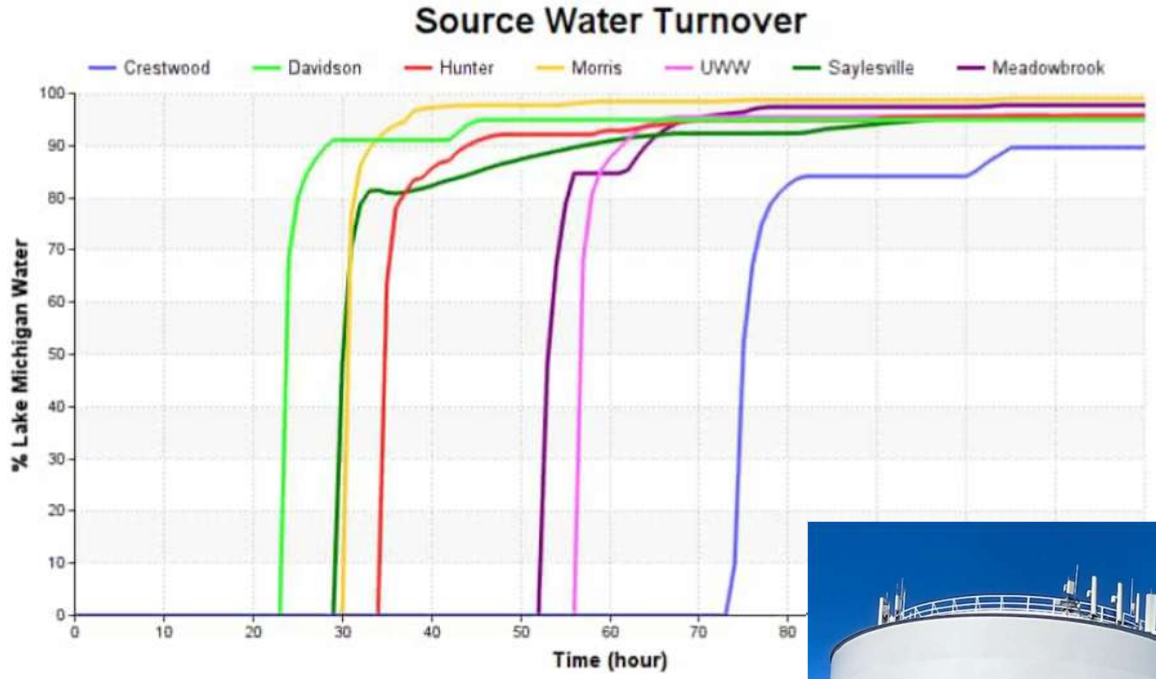
5. Transition Flushing Plan – Staggered Tank

Method

- 12 flushing hydrants
- Tanks offline when Lake Michigan water enters
- Tanks online when Lake Michigan water arrives

Results

- About 5 days transition
- Minimal mixing of water sources
- Better fire protection



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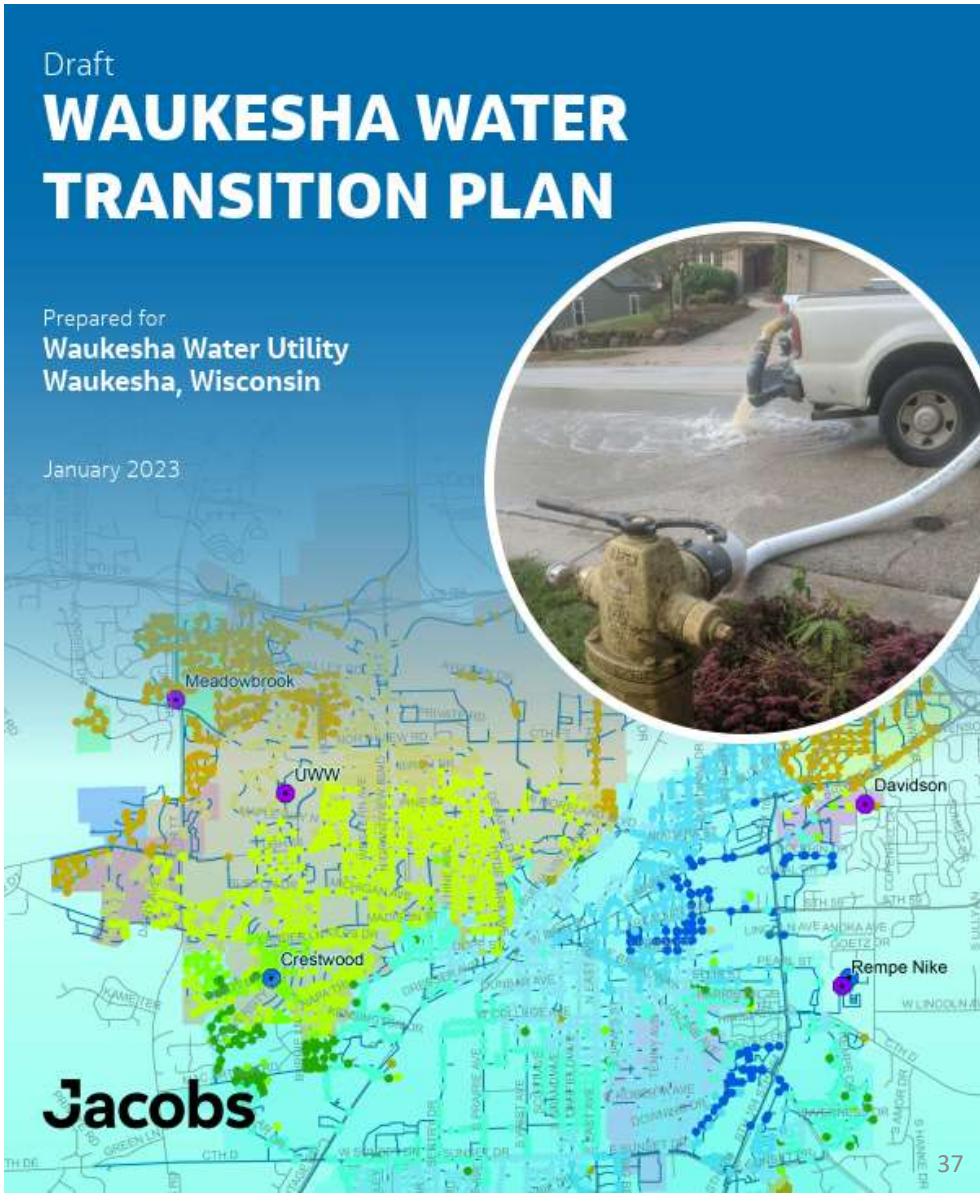
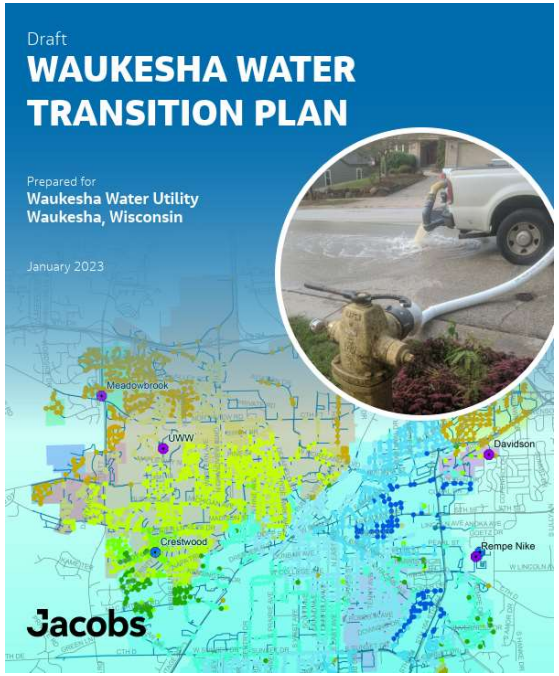
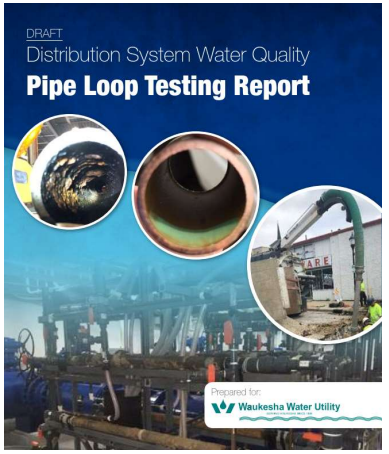
5. **A transition flushing plan** to move the groundwater out and the Lake Michigan water while maintaining water quality 2022 – 2023
6. **An overall Transition Plan** Summarized 5 reports, nitrification control, re-chloramination, distribution system water quality, customer information.

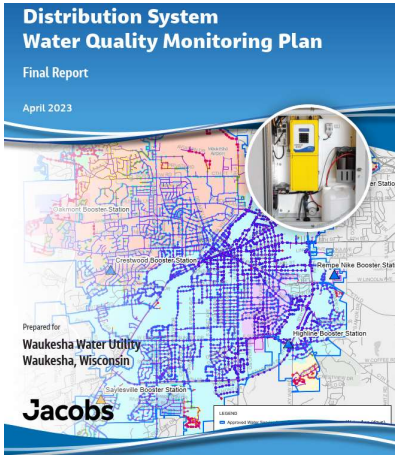


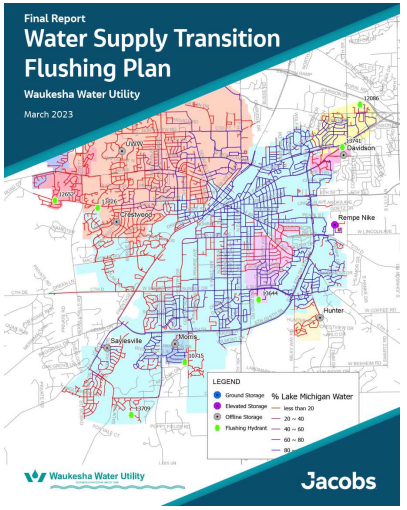
6. Overall Water Transition Plan

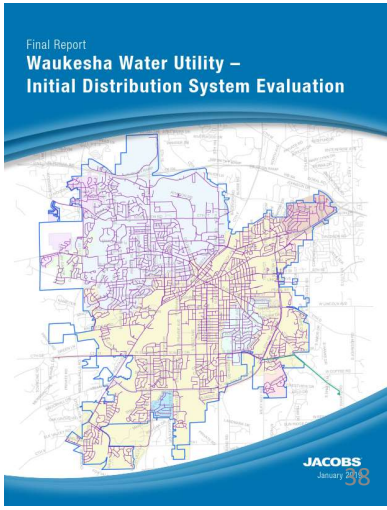
- Summarized 5 previous studies
- Addressed nitrification, re-chloramination
- Best practices for distribution system water quality.
- Information for Water Customers (Dialysis, Fish, Home Softening, etc.)









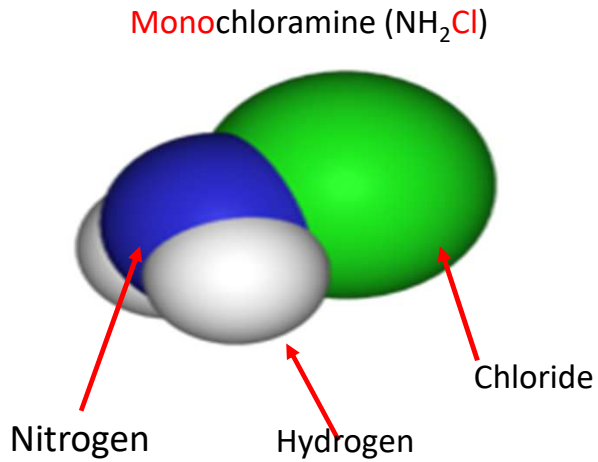


Water Quality at the Start of the Transition

- Boosted monochloramine residual from about 1.5 mg/L to 2.5 mg/L
- Used lower chlorine: ammonia ratio (3.5 to 1)

Water Quality after the Transition

- Reduce monochloramine residual slowly.
- Increase chlorine: ammonia ratio (4.5 or 5 to1)
- Monitored free ammonia.
- Monitor for nitrite and other parameters in the Distribution System Water Quality Monitoring Plan.

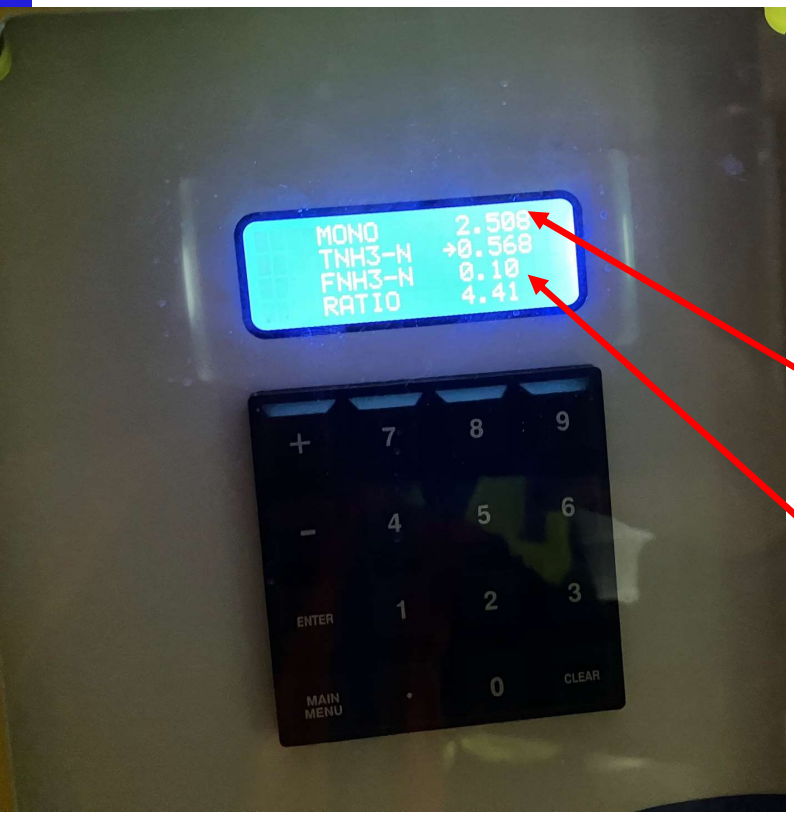


Excel Spreadsheet for determining chlorine and ammonia doses

Parameter	Value	Units
Monochloramine, Upstream of chemical addition	1.36	mg/l
Free Ammonia, Upstream of chemical addition	0.08	mg/l as N
Flowrate in chemical addition pipe	1,950	gpm
Flowrate in chemical addition pipe	2.81	mgd
Desired Monochloramine Residual after chemical addition.	2.50	mg/l
Cl_2:N weight ratio	5.0	
Chlorine dose added	1.14	mg/l as Cl_2
Ammonia dose added	0.148	mg/l as N
Chlorine pump setting		
Gal/hr	0.88	
ml/min	56	
RPM	32	
% speed	15%	
Ammonia pump setting		
Gal/hr	0.19	
ml/min	12	
RPM	7	
% speed	3%	

Getting Ready

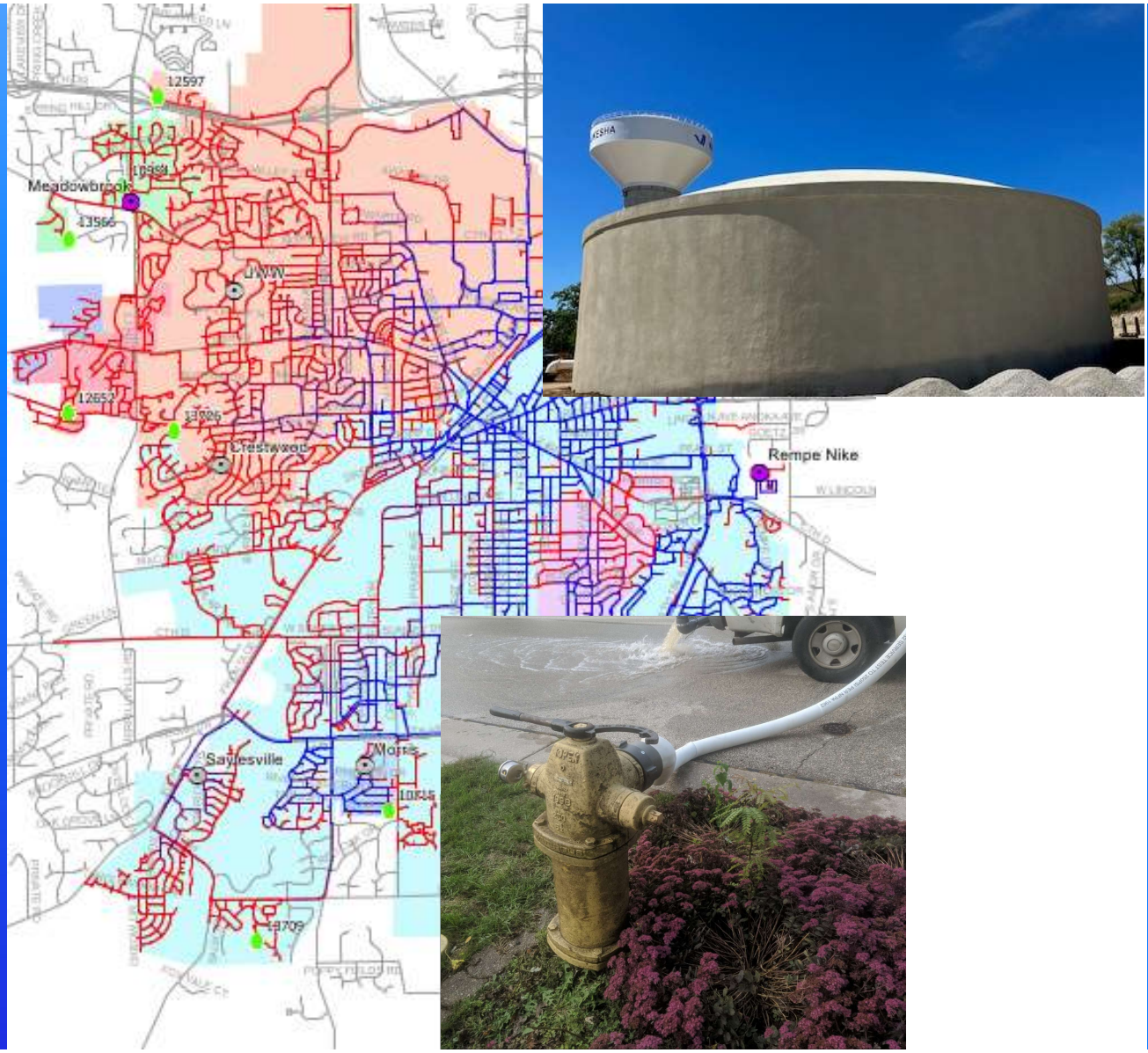
- ✓ **Started filling reservoirs October 6, 2023 (Friday).**
- ✓ **Started delivering water October 9 (Monday).**



Target Monochloramine 2.5 mg/l

Target Free Ammonia 0.10 mg/l

Transition Results

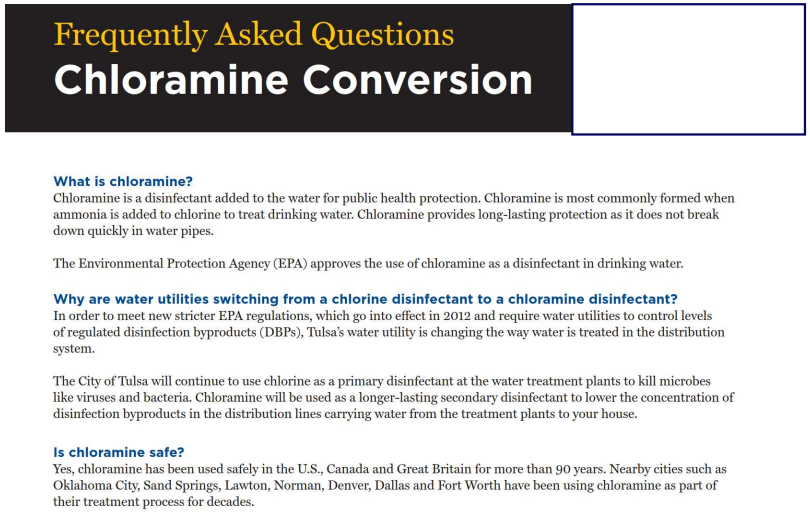


Public Information Early and Often

- Kidney Dialysis centers
- Hospitals and long-term care facilities
- Pet stores
- Major Industry
- Correctional Institutes
- Social media, websites, news outlets

Frequently Answered Questions

- 2023 Water Transition
- Causes
- Construction
- Impact
- Implementation
- Root River
- Waukesha Rates



Frequently Asked Questions

Chloramine Conversion

What is chloramine?

Chloramine is a disinfectant added to the water for public health protection. Chloramine is most commonly formed when ammonia is added to chlorine to treat drinking water. Chloramine provides long-lasting protection as it does not break down quickly in water pipes.

The Environmental Protection Agency (EPA) approves the use of chloramine as a disinfectant in drinking water.

Why are water utilities switching from a chlorine disinfectant to a chloramine disinfectant?

In order to meet new stricter EPA regulations, which go into effect in 2012 and require water utilities to control levels of regulated disinfection byproducts (DBPs), Tulsa's water utility is changing the way water is treated in the distribution system.

The City of Tulsa will continue to use chlorine as a primary disinfectant at the water treatment plants to kill microbes like viruses and bacteria. Chloramine will be used as a longer-lasting secondary disinfectant to lower the concentration of disinfection byproducts in the distribution lines carrying water from the treatment plants to your house.

Is chloramine safe?

Yes, chloramine has been used safely in the U.S., Canada and Great Britain for more than 90 years. Nearby cities such as Oklahoma City, Sand Springs, Lawton, Norman, Denver, Dallas and Fort Worth have been using chloramine as part of their treatment process for decades.

Operational Steps Needed Before Transition, Day - 3

- Begin filling reservoir #1 with MWW water and adjusting chemistry for higher disinfectant for Day 0 (start up)

Operational Steps Needed Before Transition, Day - 2

- Begin filling reservoir #2 with MWW water and adjusting chemistry for higher disinfectant for Day 0

Operational Steps Needed Before Transition, Day -1 (1 of 2)

- Using reservoir mixing pumps, continuously mix water and verify chemistry prior to Day 0
- Mixing lines in reservoirs

Operational Steps Needed Before Transition, Day -1 (2 of 2)

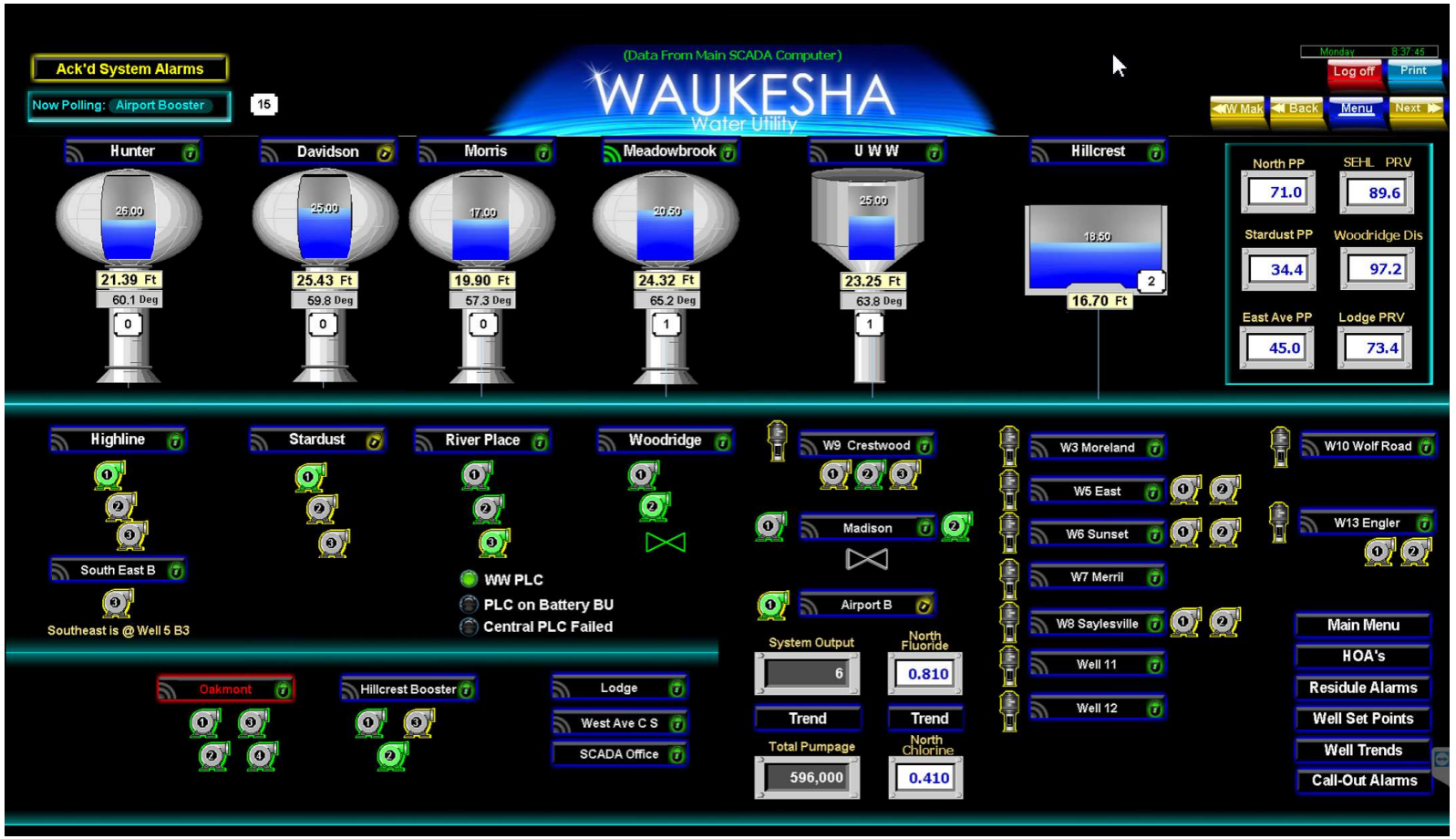
- Move in ‘hotel’ at the BPS for overnight operations.

Operational Steps Transition, Day 0, Monday 10/9/2023 (1 of 2)

Operational Steps Transition, Day 0, Monday 10/9/2023 (2 of 2)

- The Mayor, Commission President and Dan started the pumps.
- Operation staff turned off the wells and started the field work.

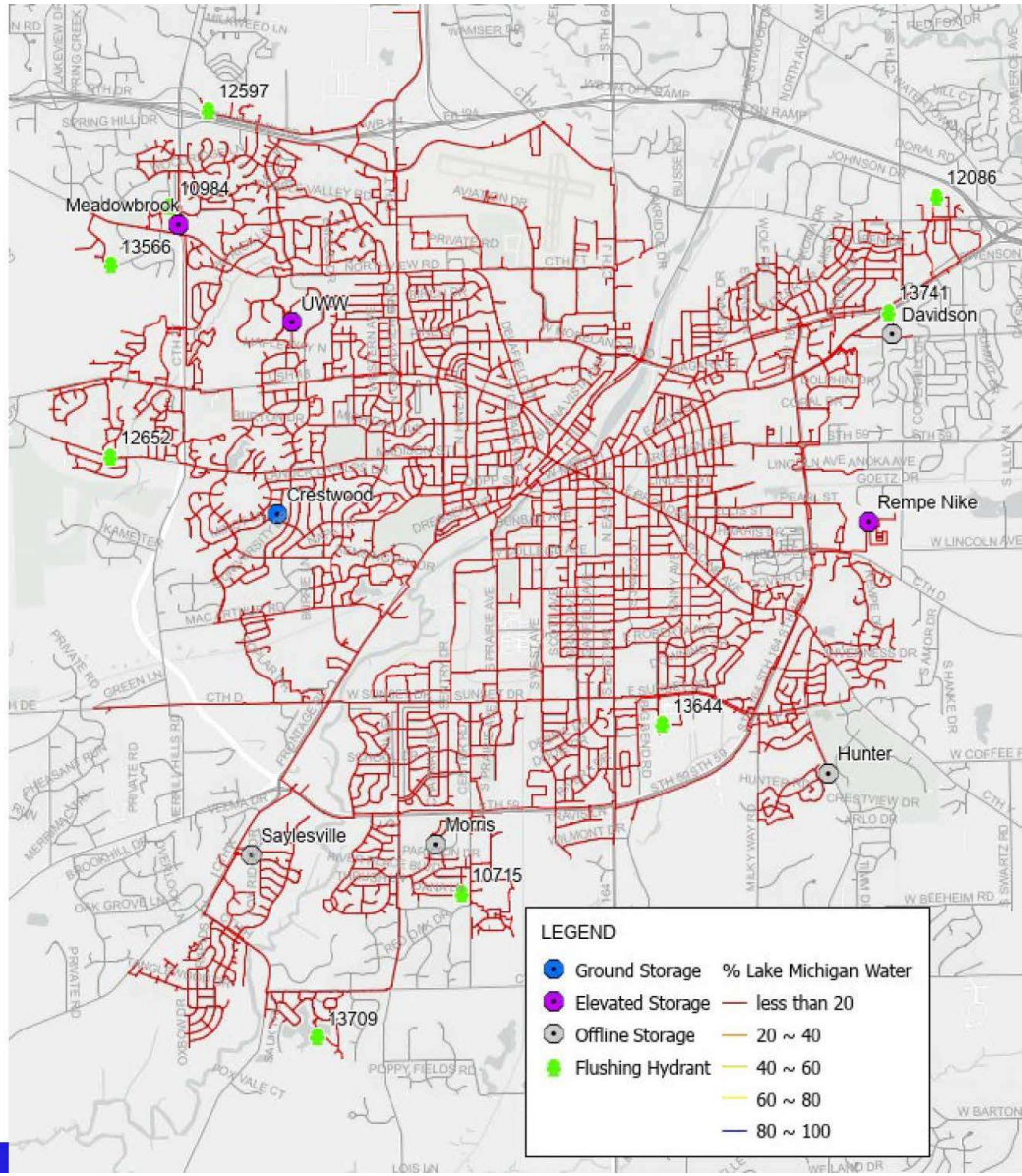
Day 0 + 43 minutes



Water Transition at Hour 0

Tower Fill
Tower Empty
Valve Opened/Closed
Transition Hydrant Flushing
Optional Dead-end Hydrant Flushing

	Day 0											
	7	8	9	10	11	12	1	2	3	4	5	6
Rempe Nike water quality confirmed, start of transition	★											
Close valve at Hillcrest, reservoir is now permanently offline												
Close valve at Davidson												
Close valve at Hunter												
Close valve at Morris												
Close valve at Saylesville												
Open Hydrant ID 10715												
Hydrant ID 10715 flow at 150 gpm												
Open Hydrant ID 12086												
Hydrant ID 12086 flow at 200 gpm												
Open Hydrant ID 13709												
Hydrant ID 13709 flow at 300 gpm												
Open Hydrant ID 12597												
Hydrant ID 12597 flow at 150 gpm												
Open Hydrant ID 10984												
Hydrant ID 10984 flow at 250 gpm												
Open Hydrant ID 12652												
Hydrant ID 12652 flow at 300 gpm												
Open Hydrant ID 13741												
Hydrant ID 13741 flow at 125 gpm												
Open Hydrant ID 13644												
Hydrant ID 13644 flow at 300 gpm												
Open Hydrant ID 13566												
Hydrant ID 13566 flow at 200 gpm												
Empty Davidson												
Empty Morris												
Empty Saylesville												
Empty Hillcrest												
Empty Hunter												
Close valve at Crestwood												
Open Hydrant ID 13726												
Hydrant ID 13726 flow at 300 gpm												
Close valve at UWW, turn on 1 pump at Airport and Madison												

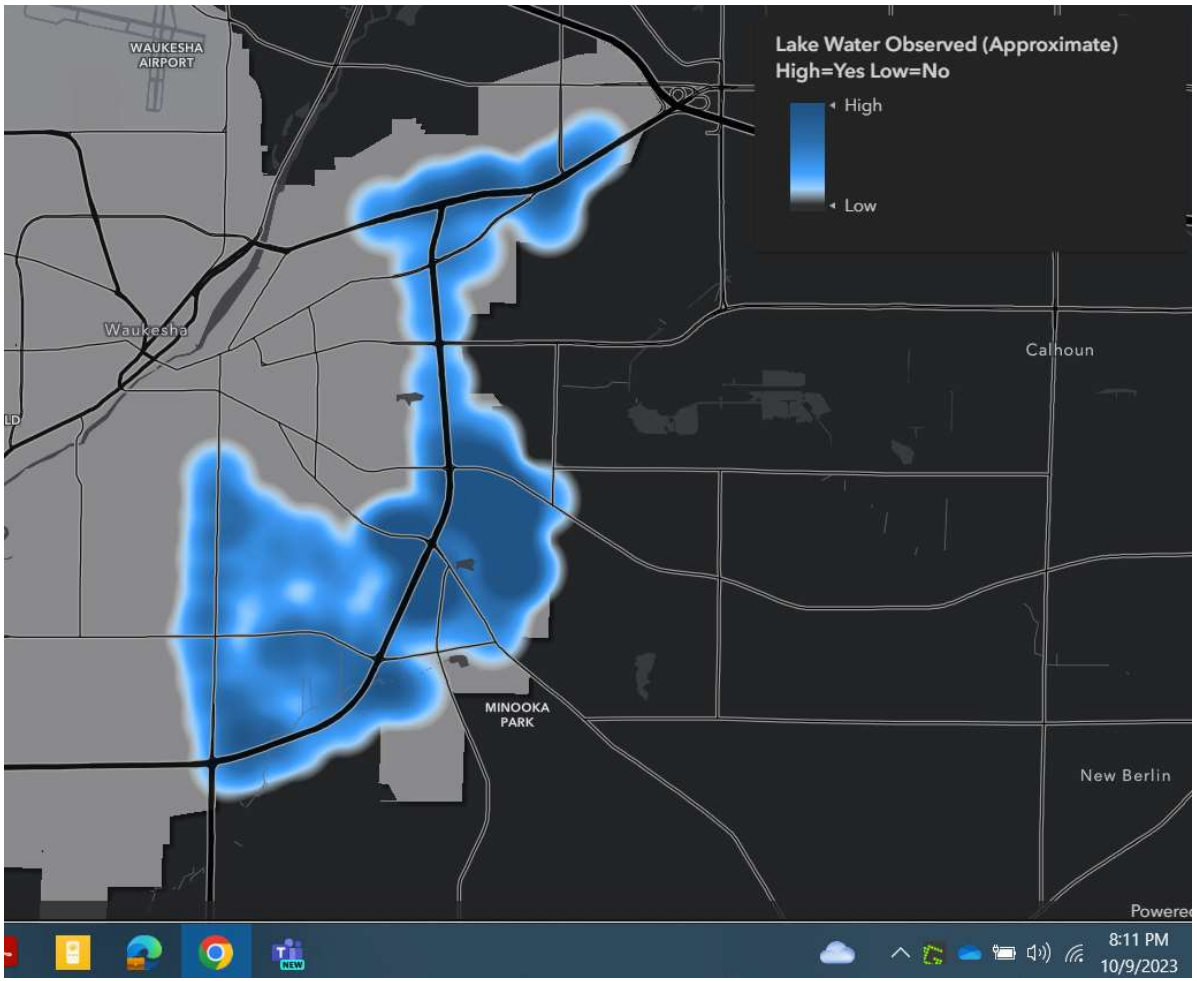


Operational Steps Transition, Day 0, Monday 10/9/2023

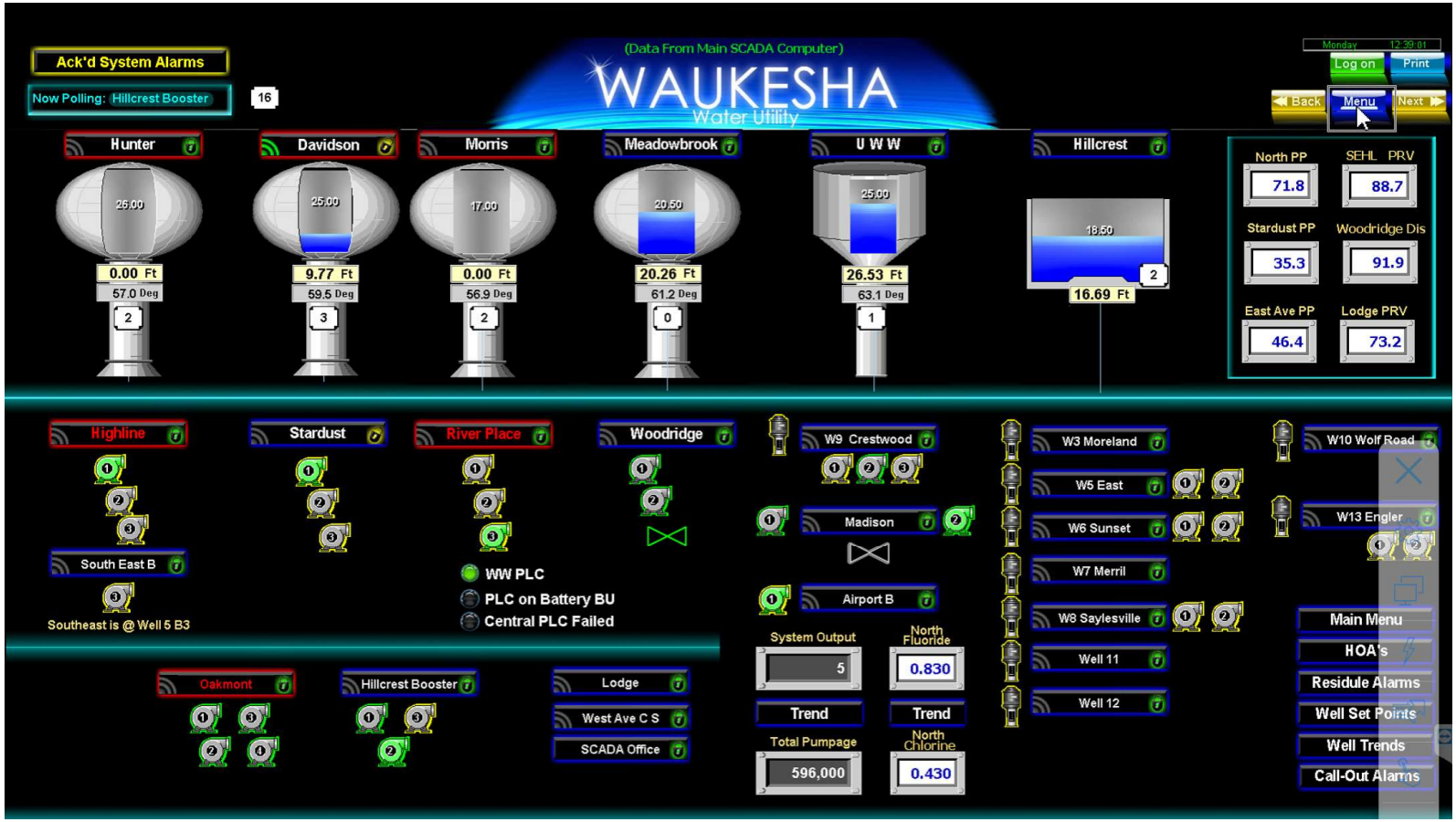
- Consultants field testing water quality entering and leaving BPS.
- BPS required on site monitoring 24/7 by WWU staff.
- Field testing of water quality done by WWU staff in the system; 3 shifts

Transition, Day 0, plus 12 hours

- On-line map was designed so customers would know where the Lake Michigan water was.

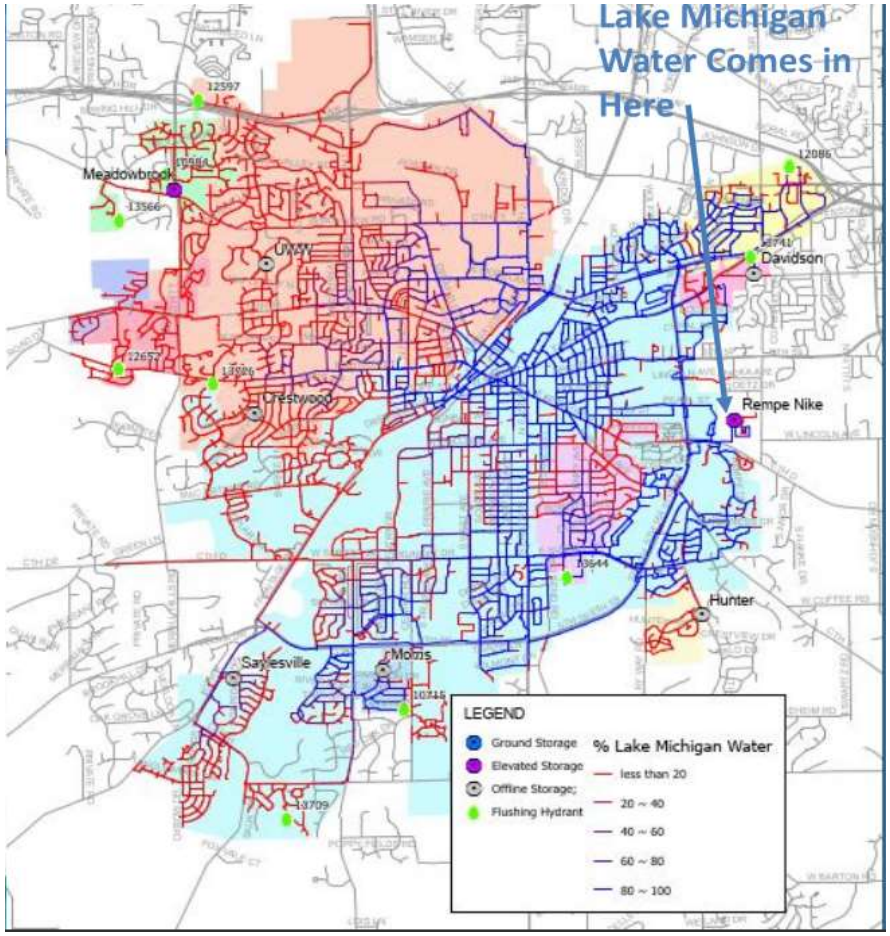


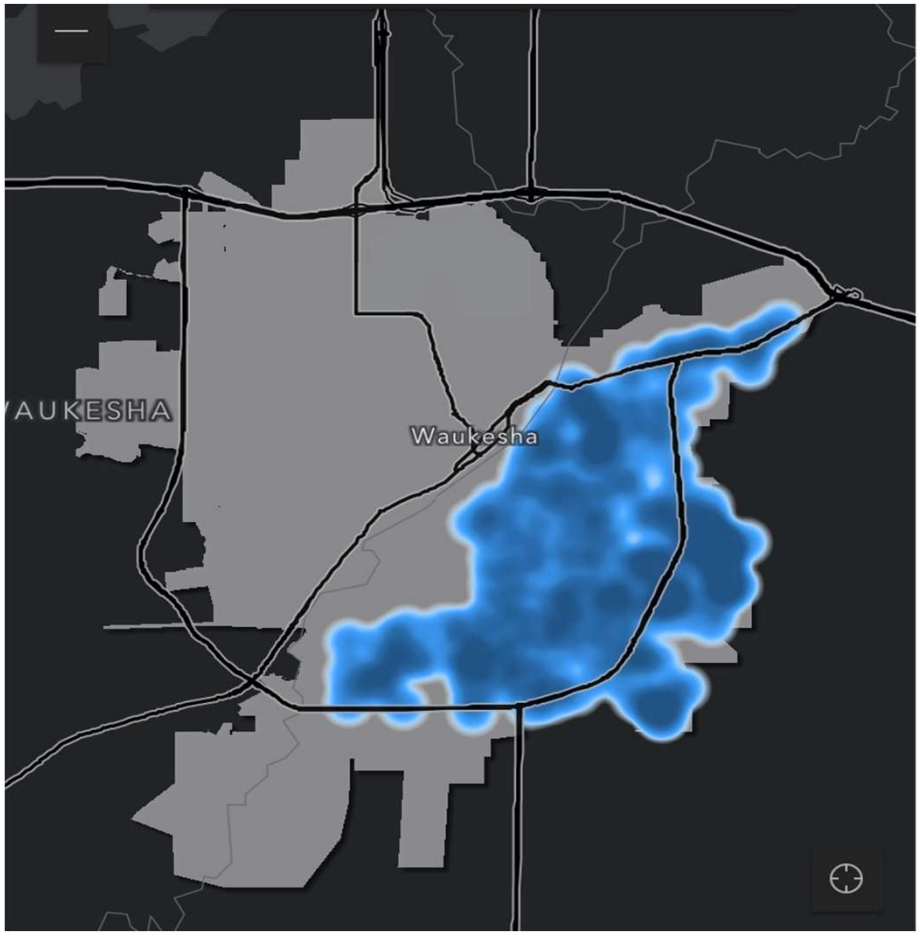
Day 0, plus 12 hours



Day 0, plus 16 hours

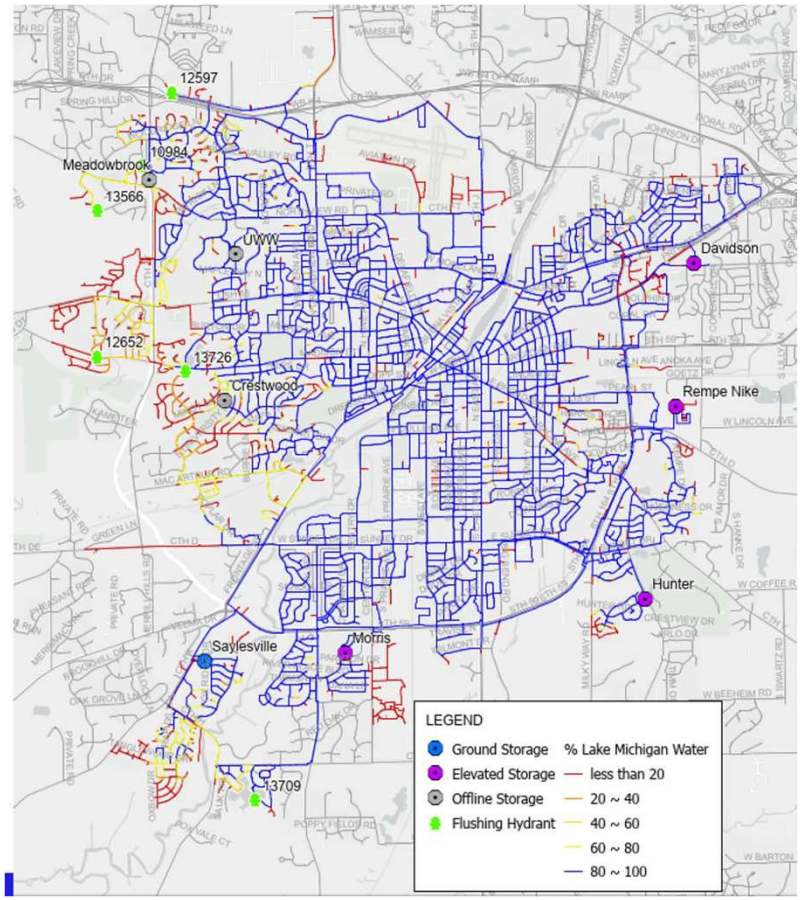
Day 1 – model v map

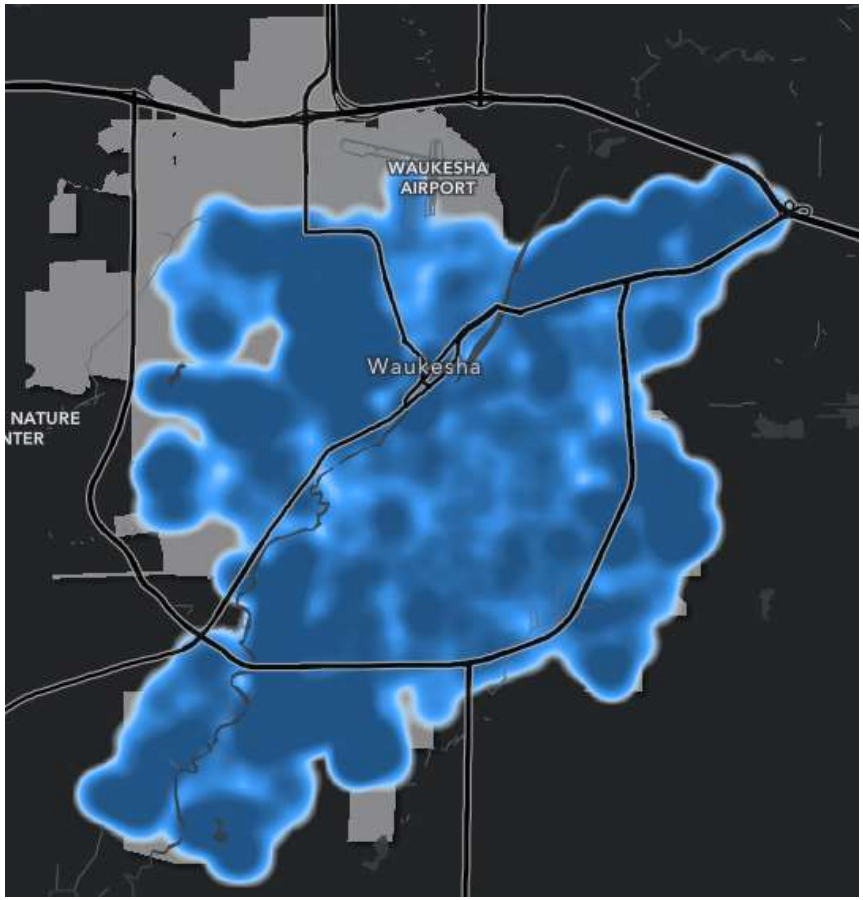




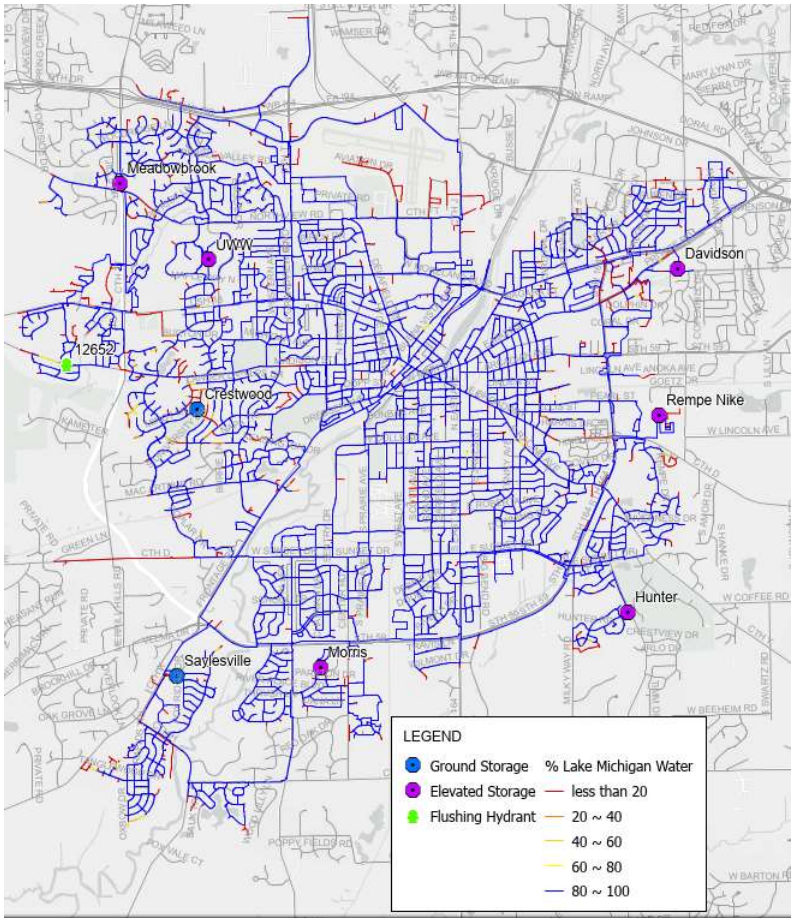
Day One (Tuesday) –
Some time during the day

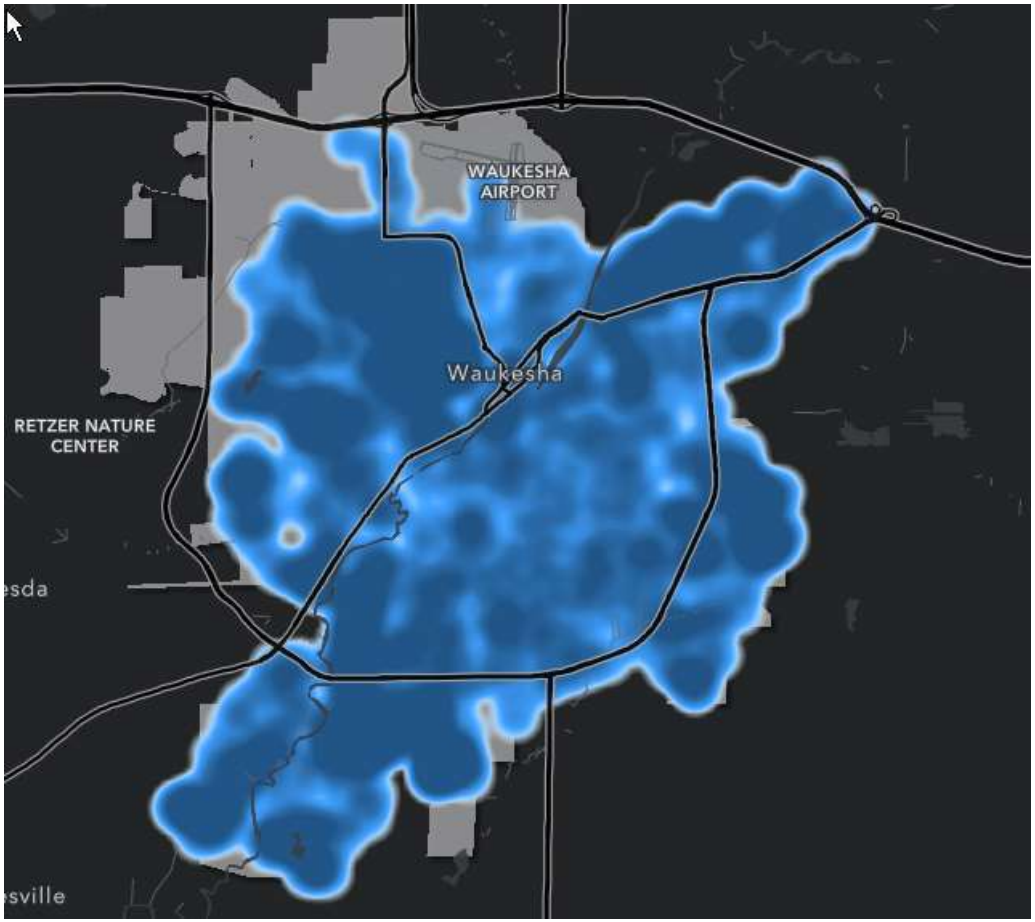
Day 3 – model v map



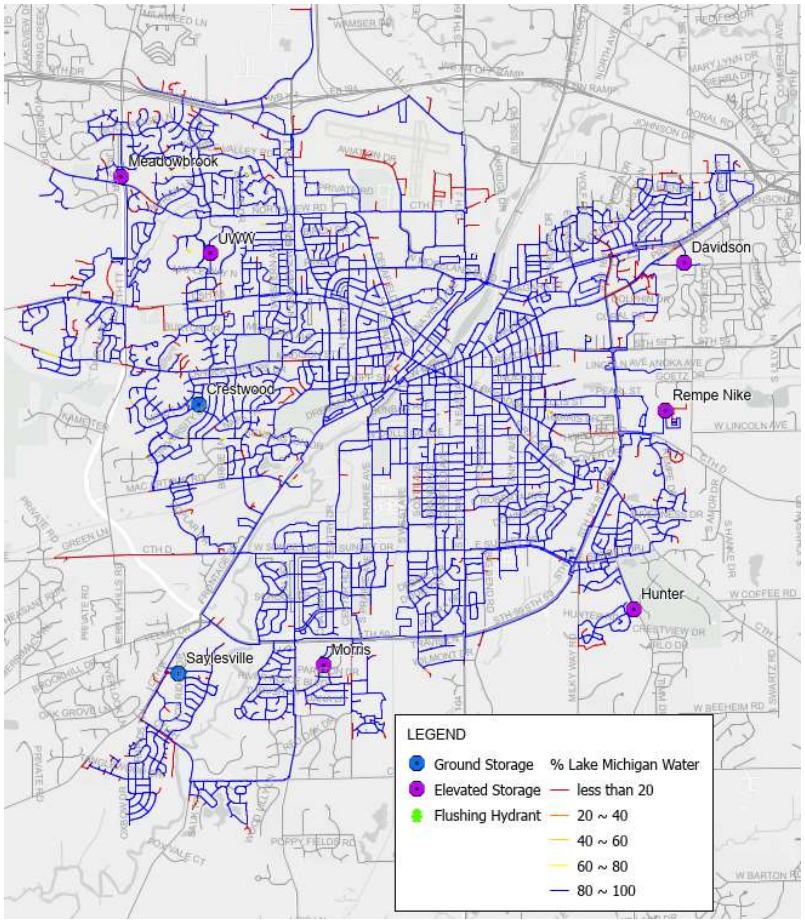


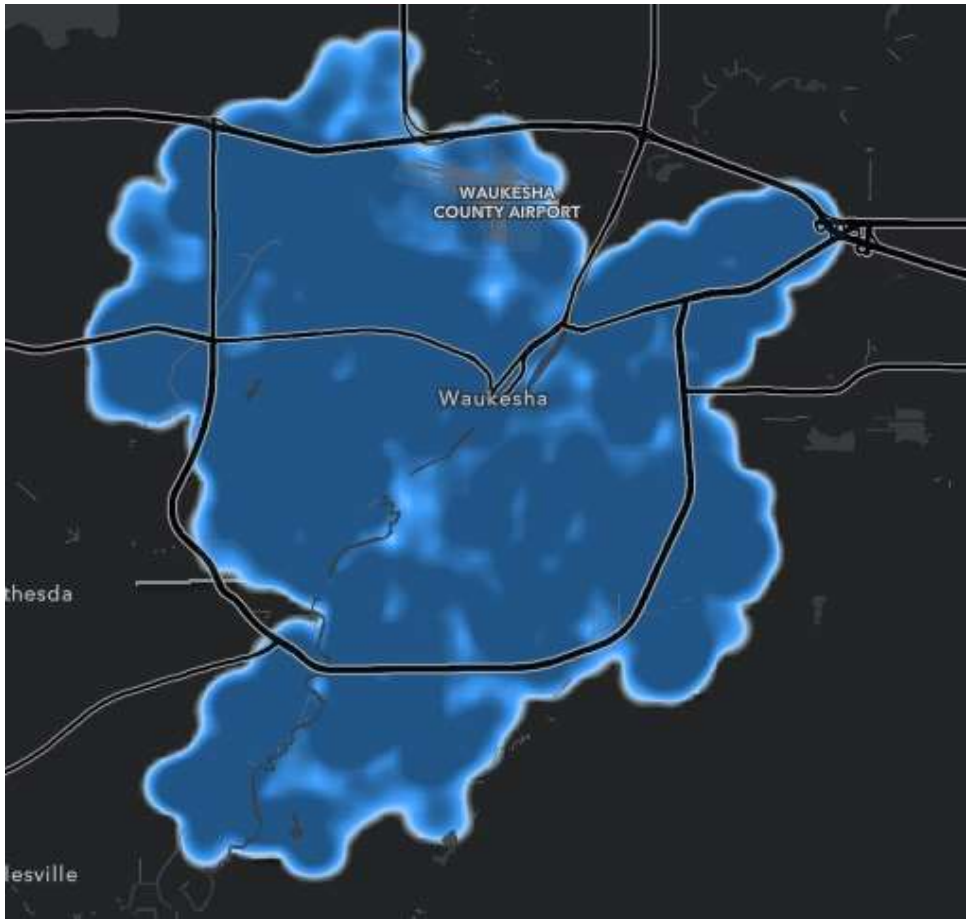
Day 4 – model v map





Day 5 – model v map



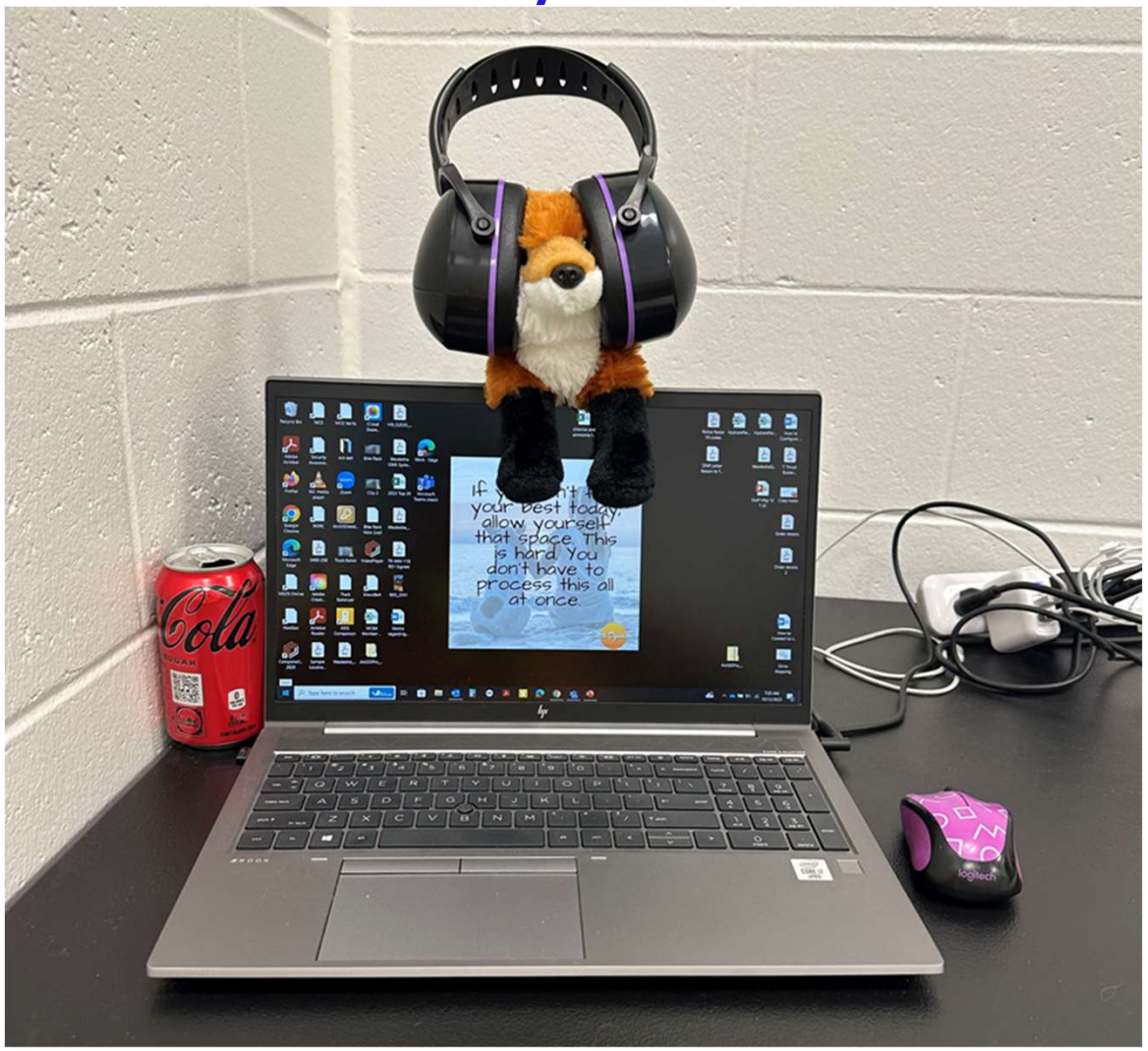


Day – No clue, time not sure, too tired to know.

Water Quality

- ✓ Lead and copper levels very low
- ✓ Radium at detection level
- ✓ Chloramine residual throughout system
- ✓ No signs of nitrification
- ✓ Iron and Manganese levels low
- ✓ Customers are pleased with the new water!

Lucky Mascot



What did Customers Say?

- Mostly positive comments
  - Love the softer water
  - Initial chlorine smell but went away
  - Some localized red water, but nothing out of the ordinary

Water Utility reports transition to Lake Michigan water going smoothly, Waukesha Freeman, October 11, 2023

“It’s better than expected,” “We were very, very pleasantly surprised with the limited number of complaints that we had.”

"Looks pretty good," southeast Waukesha neighbor Andrea Matthis

“Community members didn’t receive any major complaints about the quality of the H2O.”

Acknowledgements

Waukesha Water Utility

Operations
Customer Service
Engineering
Management

Wisconsin DNR

Jacobs

Great Water Alliance

Greeley and Hansen
Black & Veatch
RA Smith
Schreiber GR Group
MKR Agency
Katz and Assoc.

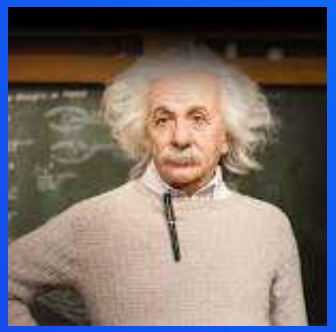
Waukesha Water Utility
SERVING WAUKESHA SINCE 1886

Questions?

Water Quality Planning to Transition from Groundwater to Lake Michigan Water

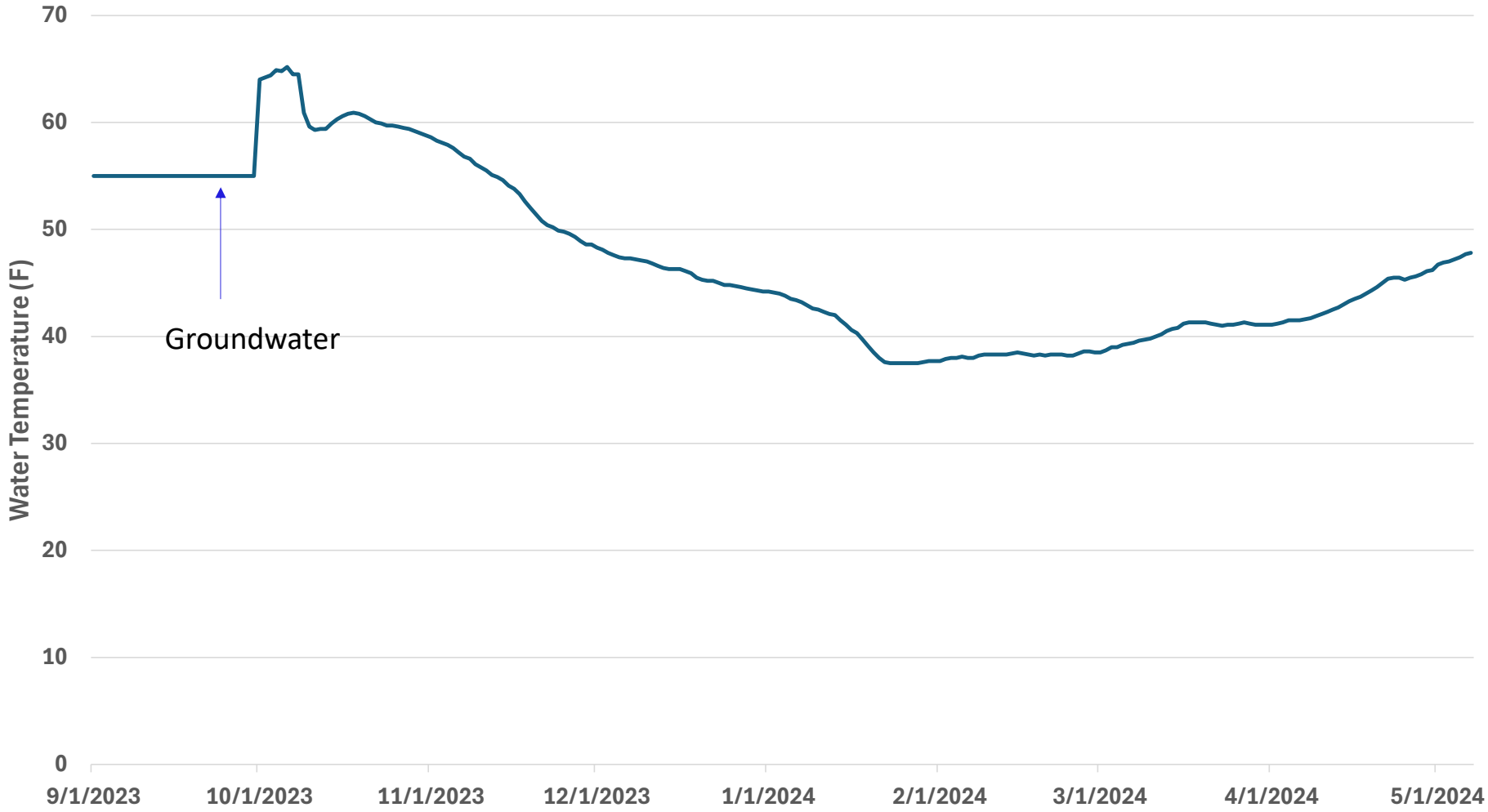
The important thing is to Not stop questioning. Curiosity has its own reasons for existing.

~Albert Einstein



Jacobs

Water Temperature Entering the Distribution System



Water Quality Summary

Community	Total hardness (mg/L as CaCO3)	Alkalinity (mg/L as CaCO3)	pH	Fe (mg/L)	Mn (mg/L)	Free chlorine (mg/L)	Corrosion Inhibitor
City Of North St Paul	255	210	7.5	0.0	0.02		
City of Oakdale	250	200	7.7	0.0	0.01	0.4	
Mahtomedi	200	180	7.8	1.0	0.30	0.2	Polyphosphate
Vadnais Heights	210	210	8.2	0.4	0.05	1.0	Polyphosphate
City of Lake Elmo		210	7.5	0.0		0.7	
City of Hugo	258	207	7.9	0.0	0.08	0.3	Polyphosphate
City of New Brighton	359	360	7.8	0.1	0.32	0.8	Polyphosphate
White Bear Township	230		7.8	0.3	0.15	0.7	Polyphosphate
City of Shoreview	250		7.7	0.2	0.25	0.4	
White Bear Lake	200	210	7.7	0.4	0.06	0.3	
City of Lino Lakes	234	245	7.7	2.7	0.27	0.6	Polyphosphate
Average	***245***	***226***	***7.8***	***0.5***	***0.2***	***0.5***	
Minimum	***200***	***180***	***7.5***	***0***	***0.01***	***0.2***	
Maximum	***359***	***360***	***8.2***	***2.7***	***0.32***	***1***	