Total Organic Carbon

Presented by *Water and Field Services Team*

February 2025

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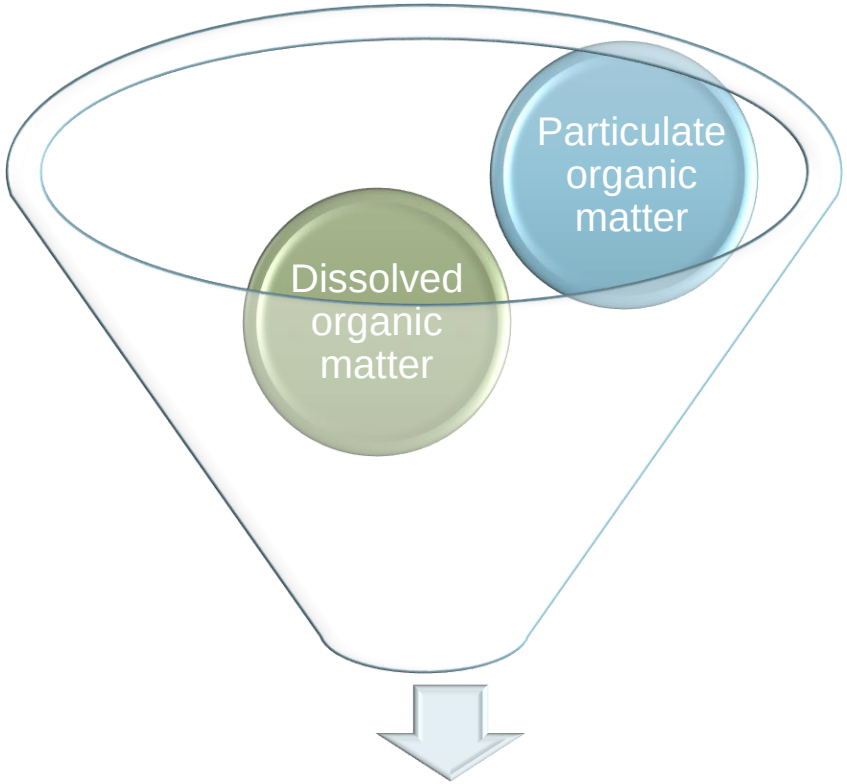
What is TOC?

TOC = Total Organic Carbon

Total organic carbon is a measure of the concentration of dissolved and suspended organic carbon contained in a water and comes from natural decaying vegetation and man-made sources.



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TOC (continued)

- TOC has no known reported health effects.
- TOC is regulated to reduce the potential for **disinfectant byproduct (DBP)** formation and is monitored to ensure that appropriate source water treatment techniques are used.
- Source water contains TOC, and it is decreased by water treatment to meet the regulatory requirements to protect public health from disinfectant byproduct formation.

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Disinfectant Byproducts (DBPs)

What are Disinfectant Byproducts?

- DBPs can be formed by the reaction of disinfectants such as chlorine with the organic precursors (TOC) present in the source water.
  - These include regulated compounds some of which are considered Volatile Organic Compound (VOC).
- These organic precursors are usually natural organic matter (NOM).
- NOM is a complex mixture of organic matter and is found in all groundwater and surface waters and comes from decaying vegetation.

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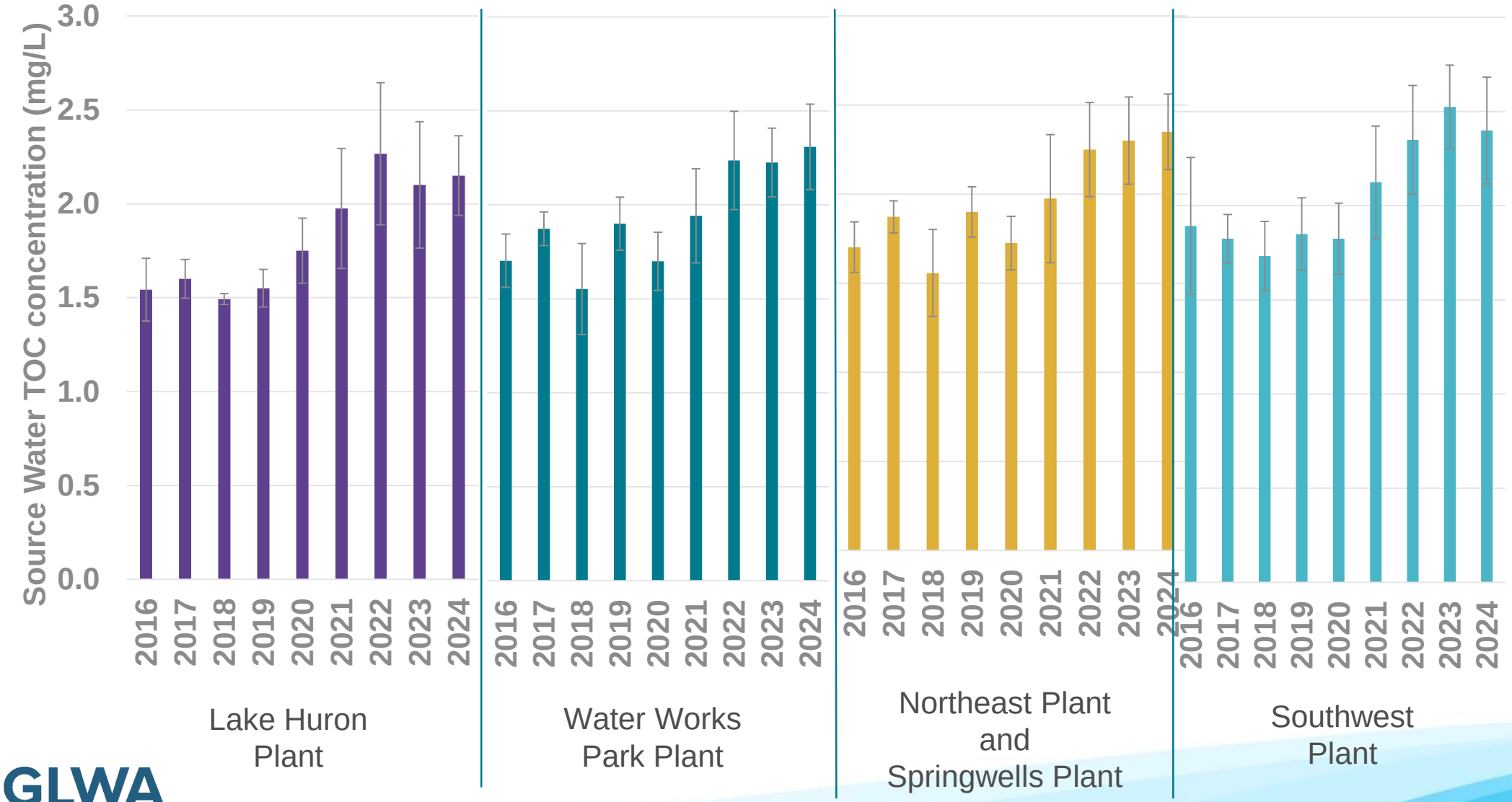
Total Organic Carbon (TOC) levels have been increasing in Lake Huron and the Detroit River since 2021



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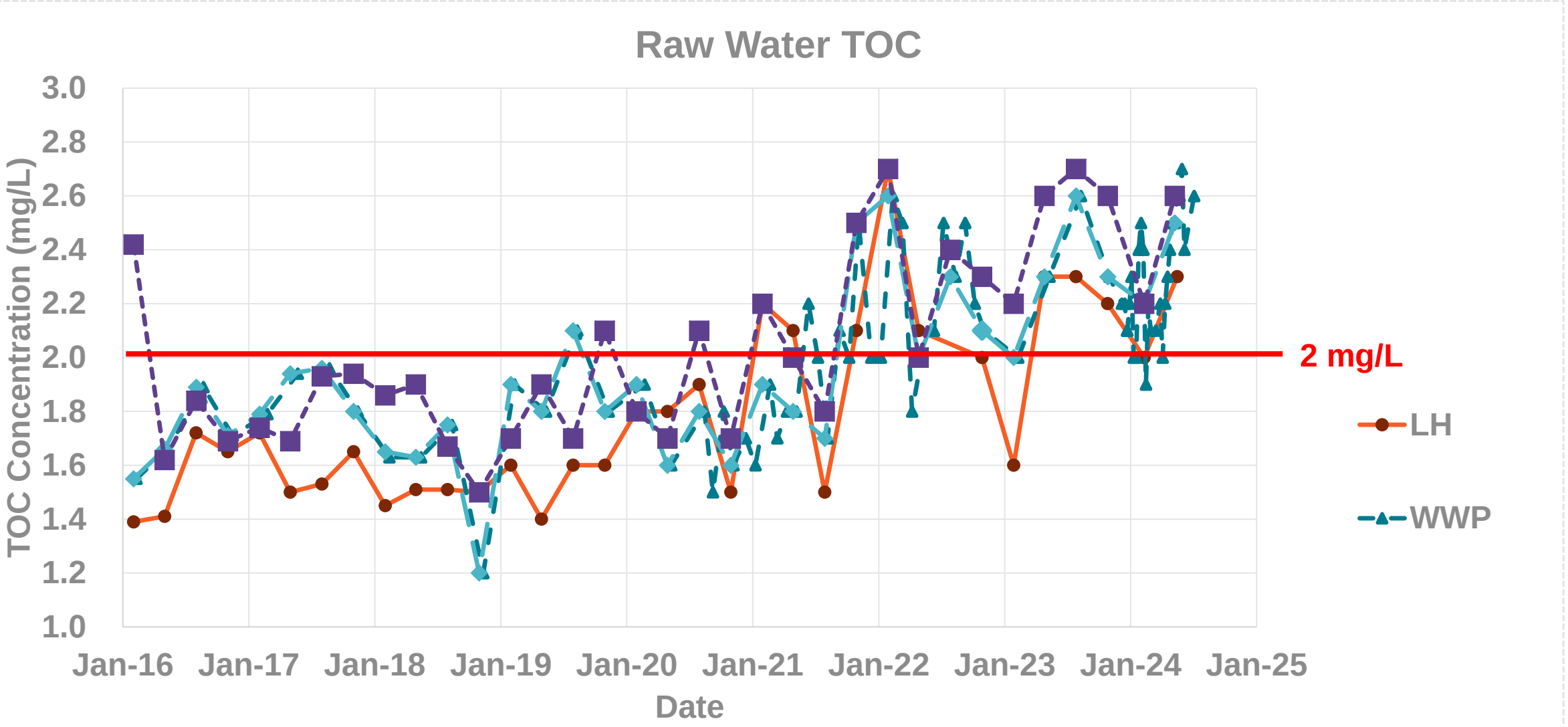

General TOC trend: LH < WWP & NE & SPW < SW

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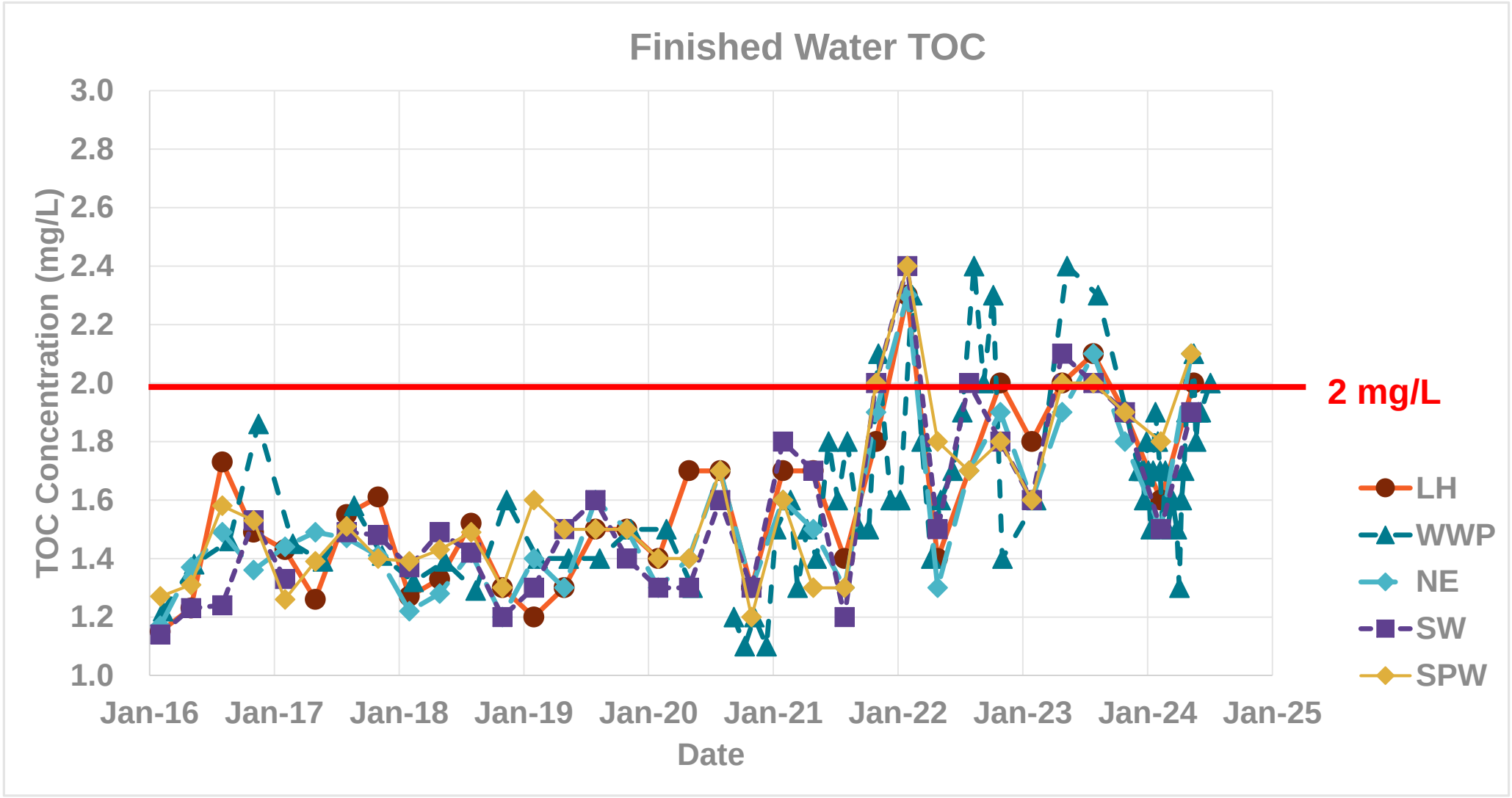

Similar TOC in finished water among 5 plants

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US EPA Stage 1/Stage 2 Disinfectant Byproduct Rule

Source water TOC (mg/L)	Source water alkalinity (mg/L as $CaCO_3$)		
	0 to 60	>60 to 120	>120
>2.0 – 4.0	35.0%	25.0%	15.0%
>4.0 – 8.0	45.0%	35.0%	25.0%
>8.0	50.0%	40.0%	30.0%

Required Removal of TOC by Enhanced Coagulation for Plants Using Conventional Treatment Removal Percentages

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US EPA Stage 1/Stage 2 Disinfectant Byproduct Rule

Enhanced coagulation and enhanced softening plants meeting at least one of the six alternative compliance criteria are not required to meet the removal percentages

- The system's source water TOC is less than 2.0 mg/L
- The system's treated water TOC is less than 2.0 mg/L
- The system's source water TOC is less than 4.0 mg/L, the source water alkalinity is more than 60 mg/L as $CaCO_3$, and the system is achieving TTHM less than 40 µg/L and HAA5 less than 30 µg/L.
- The system's TTHM is less than 40 µg/L, and HAA5 is less than 30 µg/L, and only chlorine is used for primary disinfection and maintaining a distribution system residual.
- The system's source water SUVA prior to any treatment is less than or equal to 2.0 L(mg/m)
- The system's treated water SUVA is less than or equal to 2.0 L(mg/m)

Specific Ultraviolet Absorbance (SUVA)

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US EPA Stage 1/Stage 2 Disinfectant Byproduct Rule

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EGLE Public Notification Rule

The Michigan EGLE Public Notification (PN) rule has several tiers.

- Tier-1 PN: as soon as practical but no later than 24 hours after learning of the violation
  - *E. coli* or fecal coliform present or present failure to test after a positive total coliform sample detected. **MCL exceedance** for nitrate, nitrite; failure to take confirmation samples. Chlorine dioxide, turbidity, waterborne disease outbreak, etc., or other violations determined by EGLE.
- Tier-2 PN: as soon as practical or within 30 days of being notified Repeat notice every 3 months until violation or situation is resolved.
  - All MCL violations and **treatment technique violations** (except if a Tier-1 notice is required). Failure to comply with variance and exemption conditions, etc.
- Tier-3 PN: 12 months and repeat annually until resolved.
  - Monitoring or testing procedure violation, etc., unless elevated to Tier-2 by EGLE.

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Violation

- GLWA was informed by Michigan Department of Environment, Great Lakes, and Energy (EGLE) that its TOC compliance monitoring sample, was higher than the acceptable standards required by the regulations for third quarter of 2023 ending September 2023.
- Water Works Park is the only plant impacted.
  - Detroit, Grosse Pointe Park, Hamtramck, Harper Woods and Highland Park
- Received three Tier-2 public notification for the third, forth quarter ending 2023 and the first quarter of 2024.
- GLWA Water Works Park was cleared on the Tier-2 violation by the end of March 2024.

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GLWA and Member Partner DBPs

- DBPs are health concerns after long exposure and are routinely tested to ensure that they do not exceed their maximum contamination levels (MCL):
  - Four - Trihalomethanes (THMs) – (MCL = 80 µg/L), and
  - Five - Haloacetic acids (HAA5) – (MCL = 60 µg/L)
- GLWA Member Partners test for THMs and HAA5s in their respective distribution systems.
- GLWA tests for volatile organic compounds (VOCs) in the water plants and some THMs are a subset of VOCs.
- **No known DBP MCL exceedances by the GLWA nor their member partner communities.**

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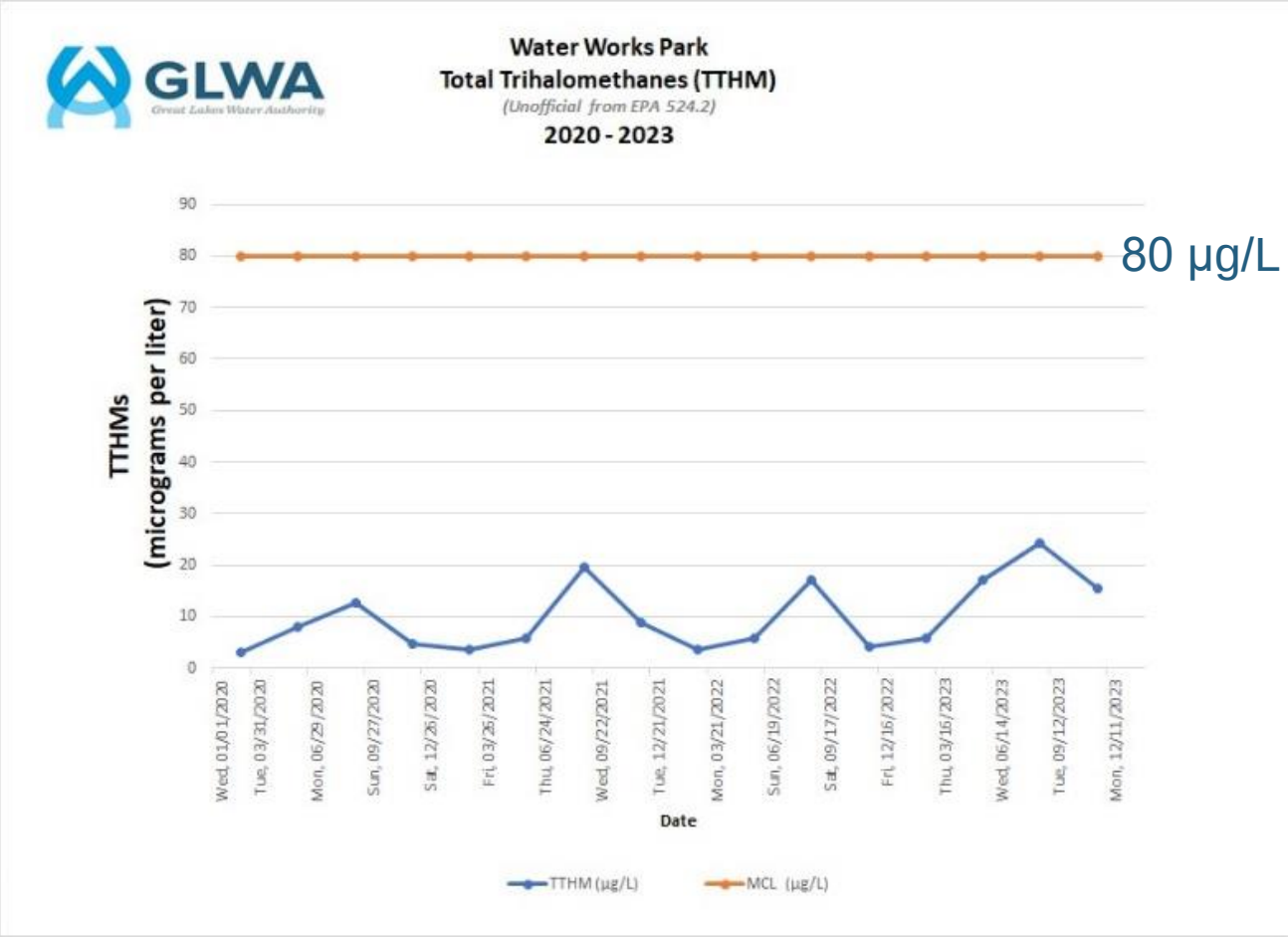
GLWA and Member Partner DBPs (cont.)

Water Works Park Measured Plant TTHMs



TTHMs Are Well Below their Maximum Contamination Limit

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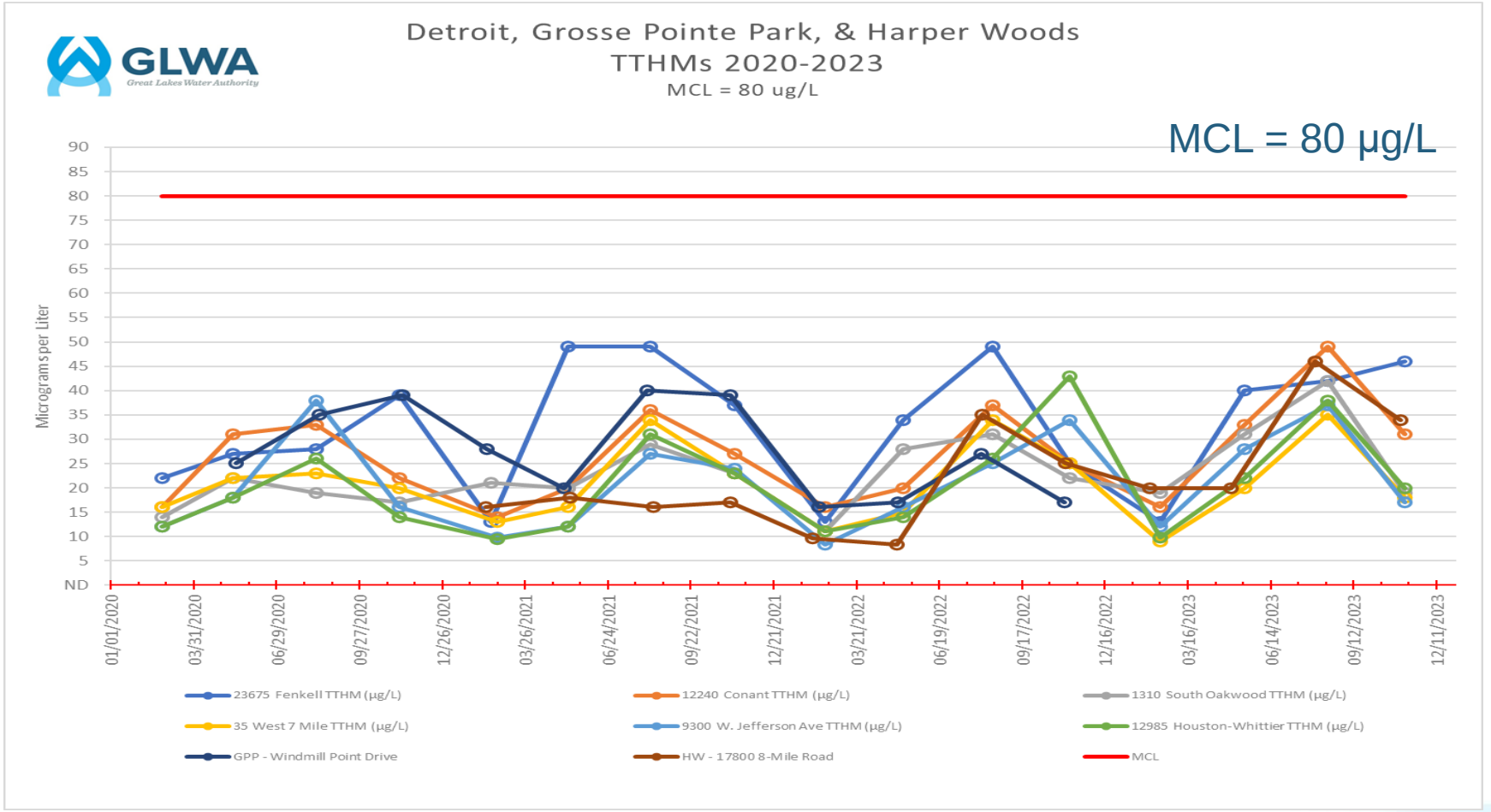
GLWA and Member Partner DBPs (cont.)

Distribution System TTHMs



TTHMs Are Well Below their Maximum Contamination Limit

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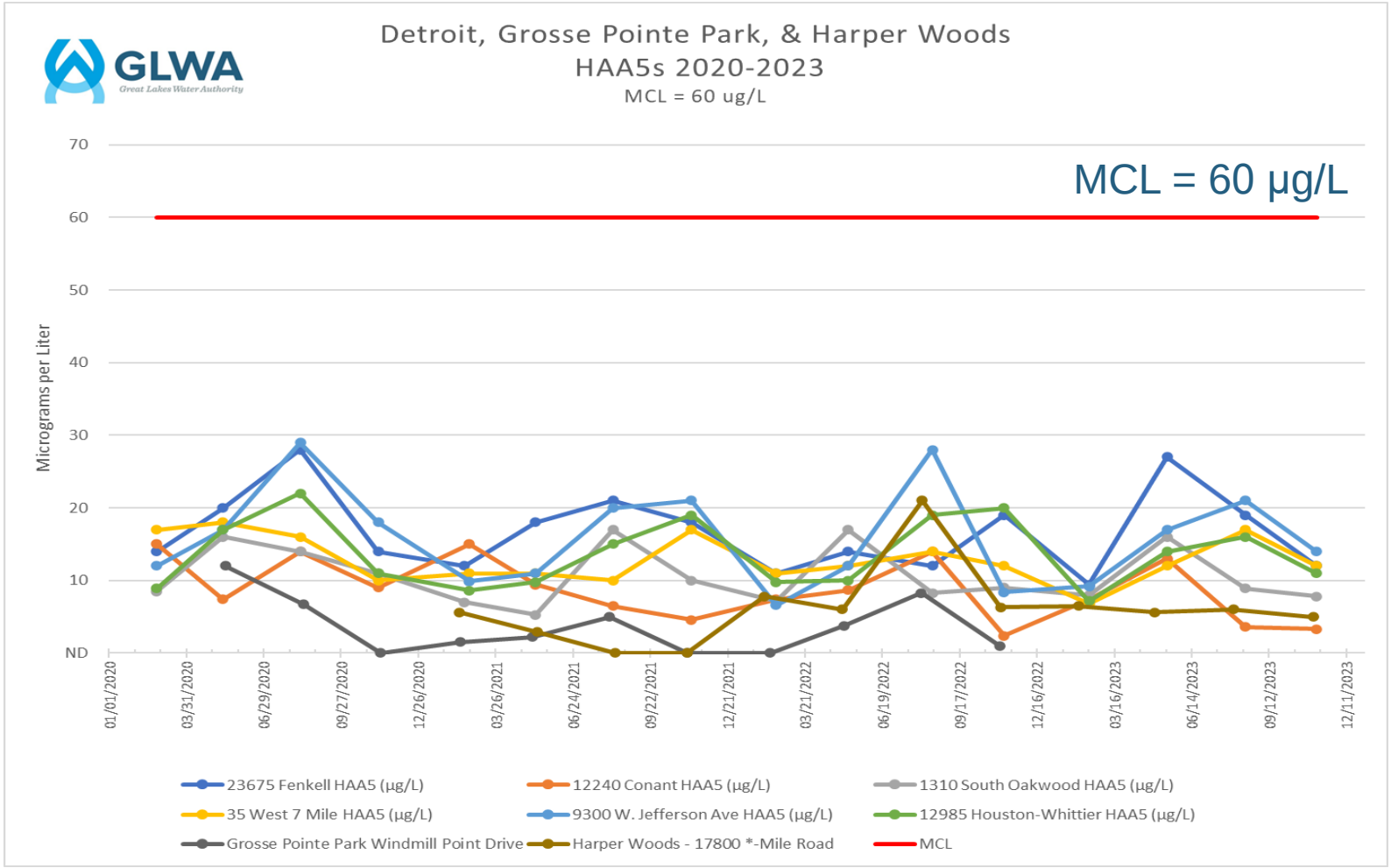
GLWA and Member Partner DBPs (cont.)



HAA5s Are Well Below their Maximum Contamination Limit

GLWA TOC Compliance Status

GLWA is maintaining compliance with the TOC removal requirements in two alternate compliance categories.

a. Treated water TOC is just below the 2 mg/L alternate compliance requirement.

b. SUVA is allowing each water treatment plant to obtain an alternate removal ratio of 1.

Current TOC & SUVA Running Annual Average Results						
Plant →	Lake Huron	Northeast	Southwest	Springwells	Water Works Park	Criteria
Quarter →	Q-4	Q-4	Q-4	Q-4	Q-4	↓
RAA TOC Tap	1.88	1.93	1.88	1.93	1.80	< 2
RAA TOC Raw	2.30	2.50	2.53	2.50	2.40	< 2
RAA SUVA Tap	0.50	0.46	0.50	0.43	0.52	≤ 2
RAA SUVA Raw		0.74		0.74	0.74	≤ 2
RAA Alternate Removal Ratio	1.00	1.00	1.03	1.03	1.09	≥ 1
Meets Criteria	TRUE	TRUE	TRUE	TRUE	TRUE	↑

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GLWA TOC Compliance Status (cont.)

The TOC data from the entire 2024 calendar year indicates in the last row the percent removal and its deviation.

All TOC Results from 01/01/2024 to 12/31/2024						
Plant →	Lake Huron	Northeast	Southwest	Springwells	Water Works Park	Criteria
Average Raw TOC (mg/L)	2.30 ±0.24	2.50 ±0.36	2.53 ±0.36	2.50 ±0.36	2.34 ±0.29	< 2
Average Tap TOC (mg/L)	1.88 ±0.22	1.93 ±0.35	1.88 ±0.33	1.93 ±0.15	1.75 ±0.25	< 2
Average TOC Removal (mg/L)	0.43 ±0.10	0.58 ±0.15	0.65 ±0.10	0.58 ±0.29	0.58 ±0.13	-
Average TOC Removal %	(18.50 ±3.79)%	(23.22 ±6.54)%	(25.95 ±4.47)%	(22.31 ±7.72)%	(24.98 ±5.04)%	≥ 25%

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Treatment Process Changes

- Increased the Alum dosage
- Coagulant Polymer at Water Works Park
- Ozone feed
- Sample lines

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Training

- TOC
- Jar Testing
- Carbon Feed System

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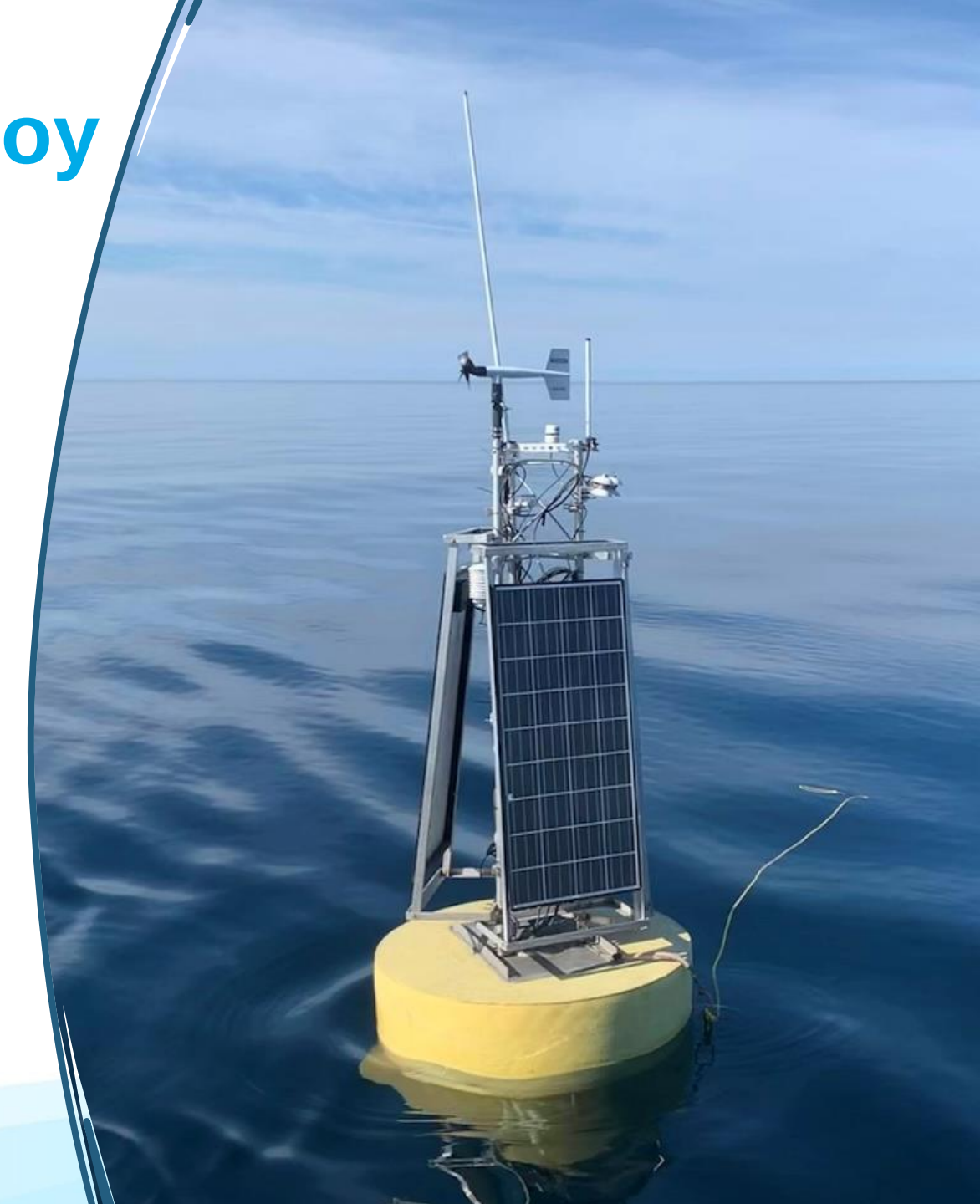
Detroit River Monitoring Buoy

Measuring TOC, Conductivity, Chlorophyll, Blue-Green Algae, Turbidity, pH/Oxygen Reduction Potential (ORP), Dissolved Oxygen and Water Temperature



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What does this mean for TOC and treatability?

A different approach is needed for compliance, process monitoring, and treatment

RESEARCH ARTICLE | DECEMBER 29 2014

The evolution of organic character in a drought- and flood-impacted water source and the relationship with drinking water treatment

Rolando Fabris; Kalan Braun; James Y. Morran; Lionel Ho; Mary Drikas

Check for updates

Journal of Water and Climate Change (2015) 6 (3): 401–413.

https://doi.org/10.2166/wcc.2014.021 **Article history**

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journal homepage: www.elsevier.com/locate/envpol

ELSEVIER

Terrestrial dissolved organic matter source affects disinfection by-product formation during water treatment and subsequent toxicity☆

Hannah M. Franklin [a,*], Katrin Doederer [e], Peta A. Neale [a], Joshua B. Hayton [b,c], Paul Fisher [h], Paul Maxwell [a,f,g,i], Anthony R. Carroll [c,d], Michele A. Burford [a,b], Frederic D.L. Leusch [a,b]

Science of the Total Environment 858 (2023) 159699

Contents lists available at ScienceDirect

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Lindsay E. Anderson [a,*], Isobel DeMont [a], Dewey D. Dunnington [a], Paul Bjorndahl [b], Dave J. Redden [a], Michael J. Brophy [c], Graham A. Gagnon [a]

Environmental Pollution 234 (2018) 726–734

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Shasha Liu [a,b], Yuanrong Zhu [b], Leizhen Liu [c], Zhongqi He [d], John P. Giesy [e], Yingchen Bai [b], Fuhong Sun [b,*], Fengchang Wu [b]

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***Brown and Caldwell*

Efforts by GLWA to Address Issue

- GLWA is taking a proactive approach to address increasing TOC in the raw water and its effect downstream.
- By partnering with Brown and Caldwell effective removal strategies were evaluated through a range of tasks.
- The internal Research and Innovation team continuously test TOC, DOC, and UV-254 (weekly) across the five treatment plants to build a data base to support the water quality team.

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Scope of Work

- Task 1: Kick-off meeting, Site Visits and Interviews
- Task 2: Project Management
- Task 3: Data Collection and Review
- Task 4: Drinking Water Treatment Assessments and Optimization
- Task 5: Pilot and Applied Research Support
  - Blind Interlaboratory Comparison
  - Bench Scale Testing
  - Full Scale Sampling
  - Pilot Scale Testing
- Task 6: Regional water quality trends and drinking water treatment regulations

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Conclusion

1. Due to changes in water quality an increase in total organic carbon led to receiving a technical violation

2. New testing methods (SUVA) and adjusting treatment techniques (chemical dose adjustments) have kept the plants in compliance

3. Continuous evaluation of TOC concentrations and its implication in the distribution system and building plumbing is recommended

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Questions?