CLEVELAND WATER ALLIANCE

and **Lake Erie Volunteer Science Network**

Present

2024 Lake Erie Watershed Health Field Season Report

Data collected and analyzed by:

BGSU Firelands
Buffalo Niagara Waterkeeper
CRWC Clinton River Watershed Council
Erie Conservation District
Huron City Schools
Huron River Watershed Council
Metroparks Toledo
TMACOG
Partners for Clean Streams
Doan Brook Watershed Partnership
Summit Soil & Water Conservation District
Toledo Zoo & Aquarium
Old Woman Creek National Estuarine Research Reserve

Table of Contents

Section 1 – Executive Summary

1.1 Mission, Goals, and Program

The Lake Erie Baseline Assessment Framework (LEBAF) is a process for standardizing data collection, analysis and communication that empowers volunteer water quality monitoring (often called"volunteer," "citizen," or "community" science") groups to elevate the credibility of their data and tell a regional story about the condition of Lake Erie watersheds. LEBAF was first conceived in 2021 by the Lake Erie Volunteer Science Network (LEVSN), a regional collaboration of local monitoring programs convened by Cleveland Water Alliance, to unlock the potential of volunteer science to address gaps in regional water quality data collection. LEBAF was given structure and life by LEVSN's Standards Working Group, a task force composed of volunteer monitoring programs and external experts from Ohio Sea Grant, The Commons, and Ohio EPA. This Working Group led an iterative process of collaborative standards development that engaged the other LEVSN members as well as additional external partners including Academic and Federal Research Institutions, State Agencies, Local Municipalities, and Natural Resource Managers. This process resulted in the official launch of LEBAF at the inaugural Lake Erie Citizen Science Summit, co-hosted by the Cooperative Institute of Great Lakes Research and Cleveland Water Alliance at the International Association of Great Lakes Researchers' State of Lake Erie conference in March of 2022.

Emerging from the Summit, eight local monitoring programs from LEVSN volunteered to participate in the first regionally standardized LEBAF sampling season. In exchange for participation, LEVSN Local Hubs received long-term access to equipment (YSI ProQuatro Multiparameter Water Meters), data management and analysis tools (Water Reporter), technical training (from YSI and Water Reporter), and a set of required and recommended best practices for data collection, management and analysis (LEBAF SOP, Data Manager's Manual, and supporting documents). Participation was further supported by monthly cadence meetings and intensive multi-day workshops on data analysis and program evaluation facilitated by Cleveland Water Alliance.

The first output of LEBAF is a set of Standard Operating Procedures (SOP or "Standards") which describe program, technical, information, and evaluation design elements that guide mutually reinforcing activities for volunteer scientists across the Lake Erie Basin. These activities are defined by shared:

- ***Suite of Monitored Parameters -*** LEBAF participants all must directly sample pH, dissolved oxygen, water temperature, and conductivity at least once per month for each monitored site. Direct conductivity measurements are further interpreted as biocondition, total dissolved solids, chloride, and salinity in data analysis.

- ***Monitoring Purpose:*** Collection of a common set of measures that support screening of conditions that support aquatic life as an indicator for the baseline conditions and trends in the health of Lake Erie watersheds at various scales.
- ***Intended Data Use:*** Data collected is intended to be used primarily as a water quality screening tool that drives 1) benchmarking of watershed health, 2) interoperability of results across watersheds, and 3) educating and engaging local communities. It is secondarily intended for use in resource prioritization and decision making (e.g. use support, advocacy, policy, resource management, and adaptive management).
- ***Target Data Users:*** LEVSN and its partners are the primary target users. Use by Federal, State and local decision makers is a priority, but secondary to the needs of the volunteer science groups implementing LEBAF.
- ***Expected Outcomes and Impacts:*** The implementation of LEBAF will 1) provide a regional condition assessment of Lake Erie streams over time, 2) identify potential problem areas to be investigated for impairment identification, 3) establish a shared lexicon to communicate program elements, shared goals, and watershed status to volunteers and the public, 4) demonstrate the capacity of regional volunteer science collaboration, and 5) create an iterative process for expanding the scope of shared standardizations and collaborations over time.

The second output of LEBAF is a “standardization menu” that documents additional parameters and other program elements that could be standardized to tell a more complete story about watershed health. At the end of each field season, LEBAF participants and collaborating partners convene to evaluate that year’s programming, using this menu to prioritize adjustments and additions to the SOP for the following season. This annual cycle is intended to guide LEBAF’s strategic expansion, using initial wins as a framework on which to build, over iterations, towards greater collective impact.

1.2 Outcomes of 2024 Field Season and Program Year

During the third LEBAF field season, thirteen participating groups collected, analyzed, and interpreted data from over 3,700 samples originating at nearly 150 stations in 54 local watersheds across the Lake Erie Basin (Table 1 and Figure 1). During this third year of standardized data collection, LEVSN added three new participating groups and collected nearly double the samples from a greater number of rivers and streams. Use of the collaboratively developed LEBAF SOP enabled comparable data collection by all participants, allowing groups from as far afield as Ann Arbor and Buffalo to compile an increasingly representative snapshot of Lake Erie watersheds. This shared structure empowered participants to refine a standardized data analysis and interpretation process that provides a robust screening of watershed health across monitored areas and the Lake Erie basin as a whole.

Table 1. Characterization of the 2024 Lake Erie Volunteer Science Network

Monitoring Region	Participating Group	Waterbody (# of stations)
Southeastern Michigan	**Clinton River Watershed Council**	**Large Rivers:** ● Clinton River (1)
	Huron River Watershed Council	**Large Rivers:** ● Detroit River (5) - only sites on direct tributaries of river ● Huron River (21)
Northwest Ohio	**Community Water Action Toledo**	**Large River:** Maumee River (6) ● Swan Creek (10) **Direct Tributary:** ● Ottawa River (4) - some sites on one tributary of the river ○ Tenmile Creek (1) ● Portage River (3)
North central Ohio	**Firelands Coastal Tributaries Watersheds**	**Direct Tributaries**: ● Mills Creek (9) ● Pipe Creek (6) ● Sawmill Creek (3) - one site on a tributary of the creek ● Chappel Creek (6) ● Old Woman Creek (10)
Northeast Ohio	**Summit Soil and Water Conservation District**	**Large River:** Cuyahoga River - only sites on tributaries of the river ● Yellow Creek (11) ● Furnace Run (8) ● Wingfoot Lake (8)
	The Doan Brook Watershed Partnership	**Direct Tributaries:** ● Doan Brook (15)
Buffalo Area (New York)	**Buffalo Niagara Waterkeeper**	**Large River:** Buffalo River (3) **Direct Tributaries:** ● Eighteen Mile Creek (3) ● Rush Creek (2) ● Smoke Creek (1)

Figure 1. Map of Large Rivers and Direct Tributaries (blue shades) and monitoring station (yellow dots) participation in the 2024 LEBAF Program.

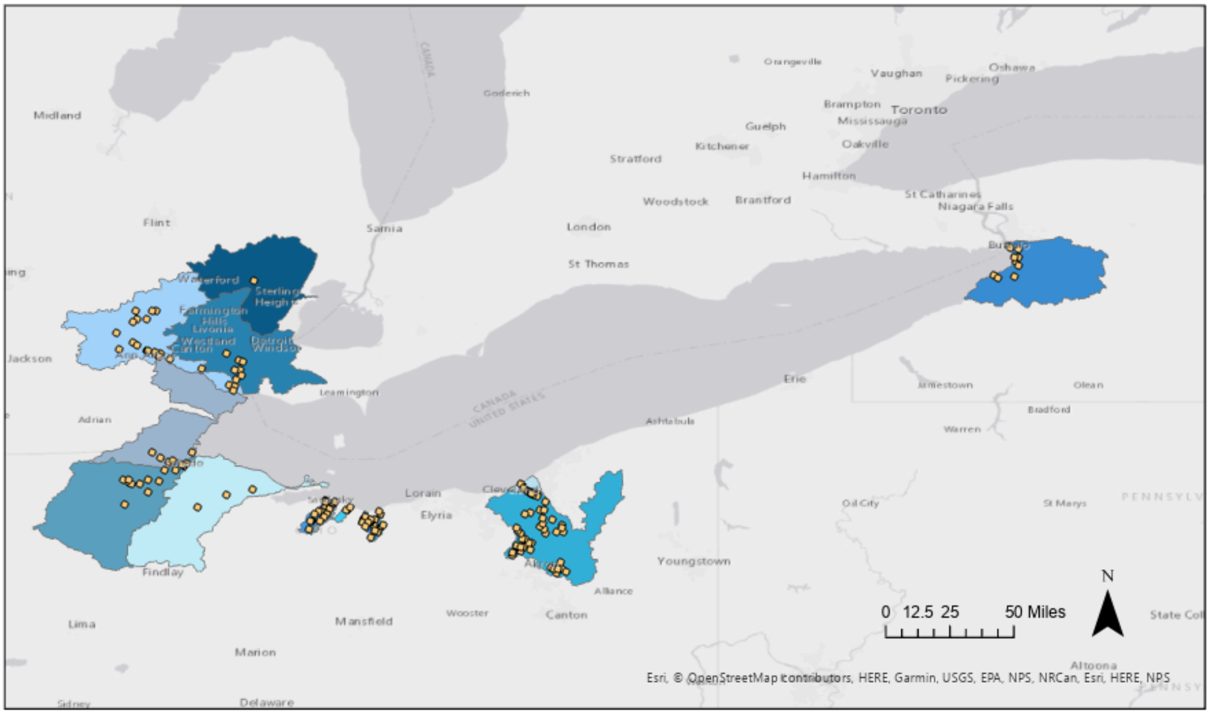


Figure 2. Southeastern Michigan Large Rivers & Monitoring Stations.

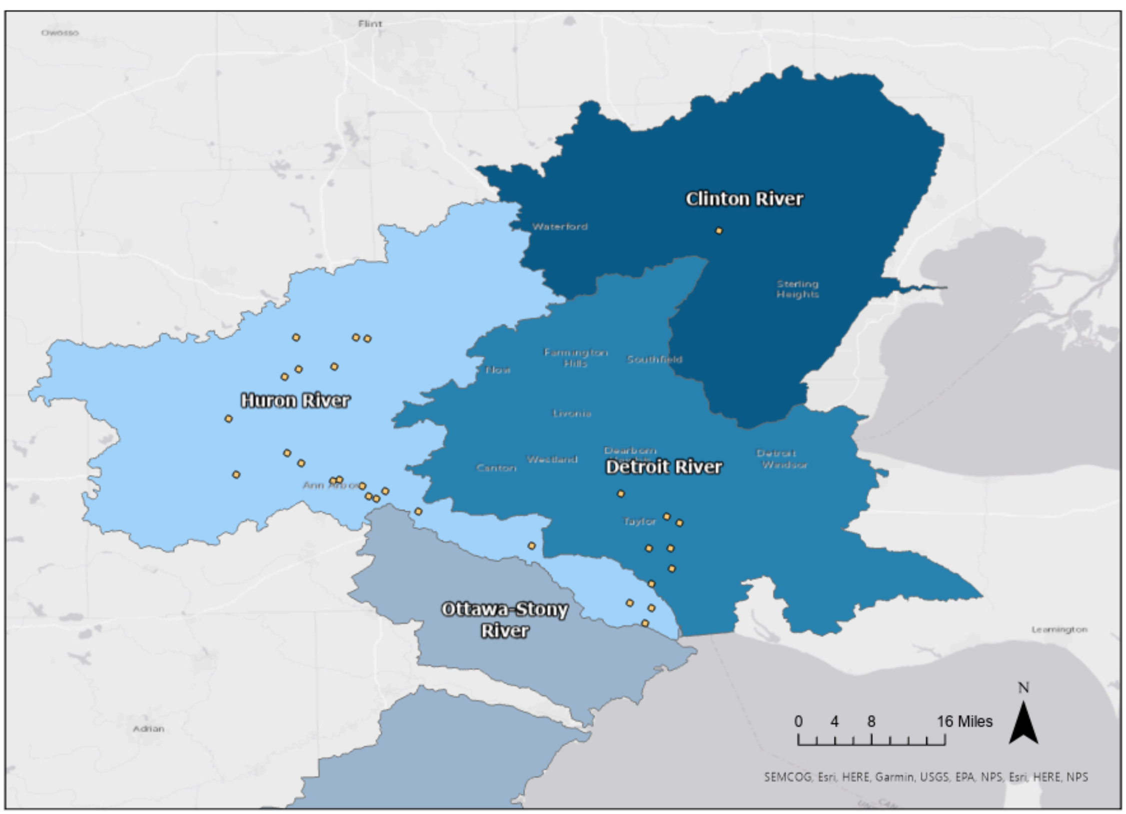


Figure 3. Northwest Ohio Large Rivers & Monitoring Stations

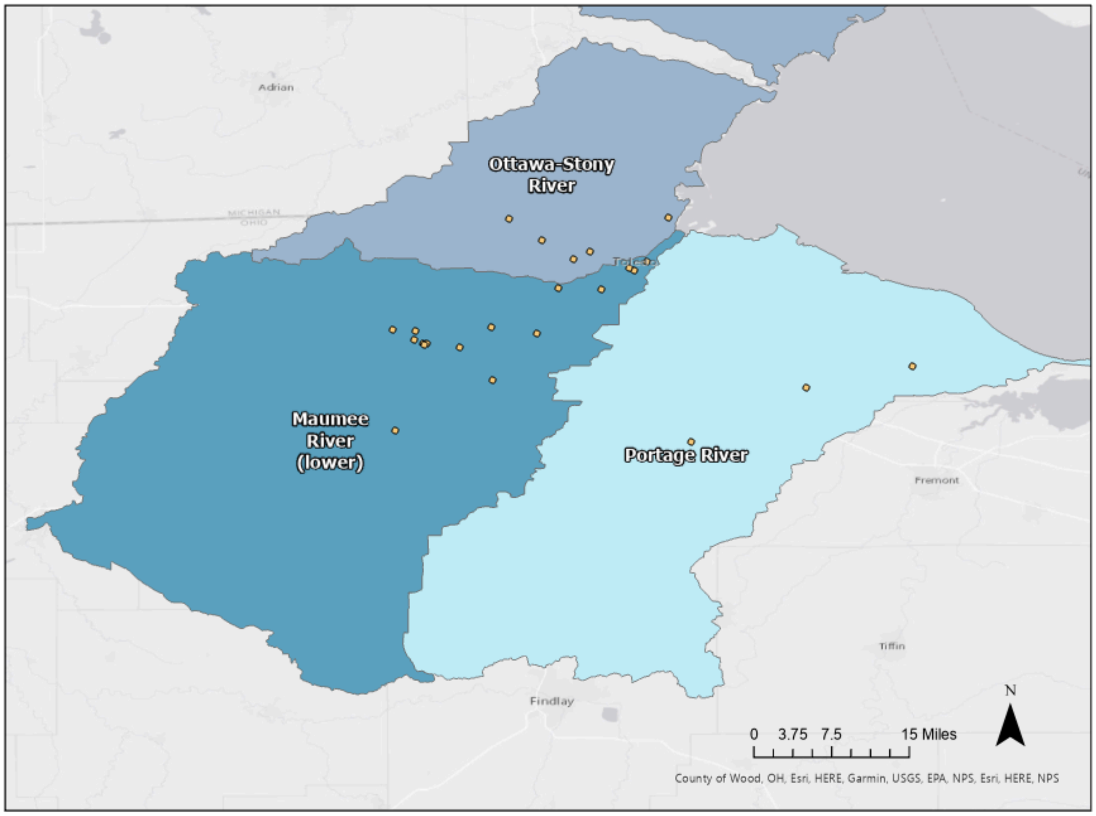


Figure 4. North Central Ohio Direct Tributaries & Monitoring Stations

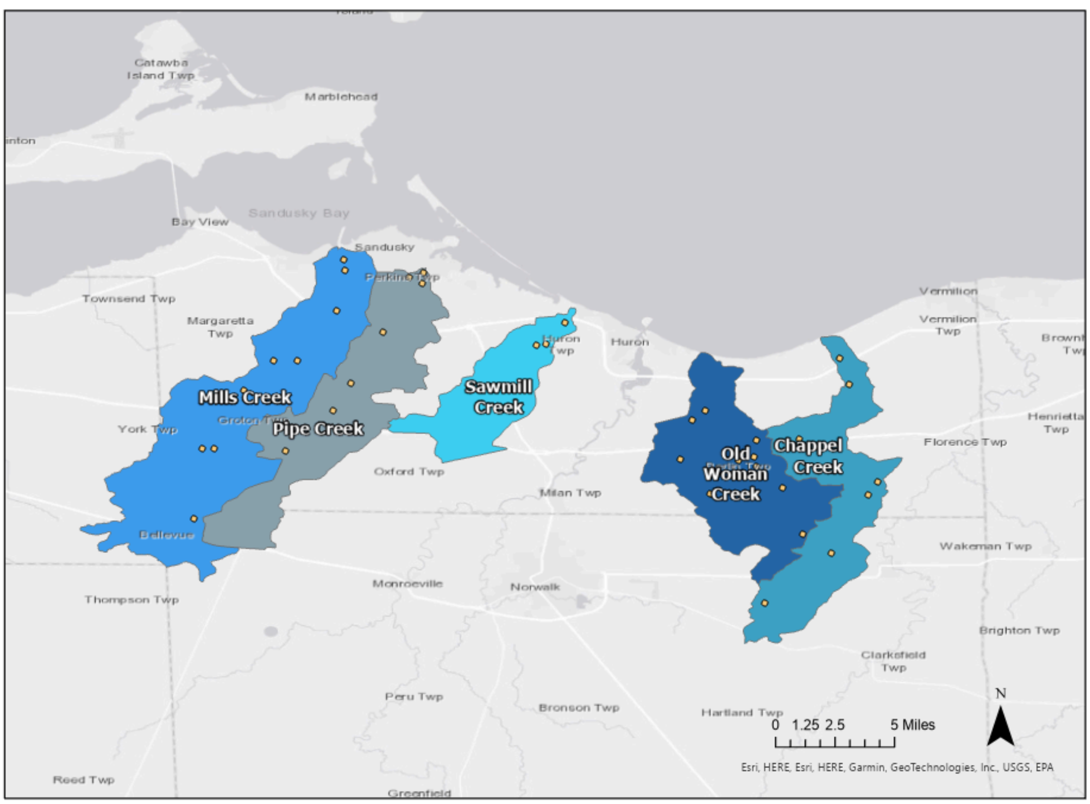


Figure 5. Northeast Ohio Large Rivers, Direct Tributaries, & Monitoring Stations

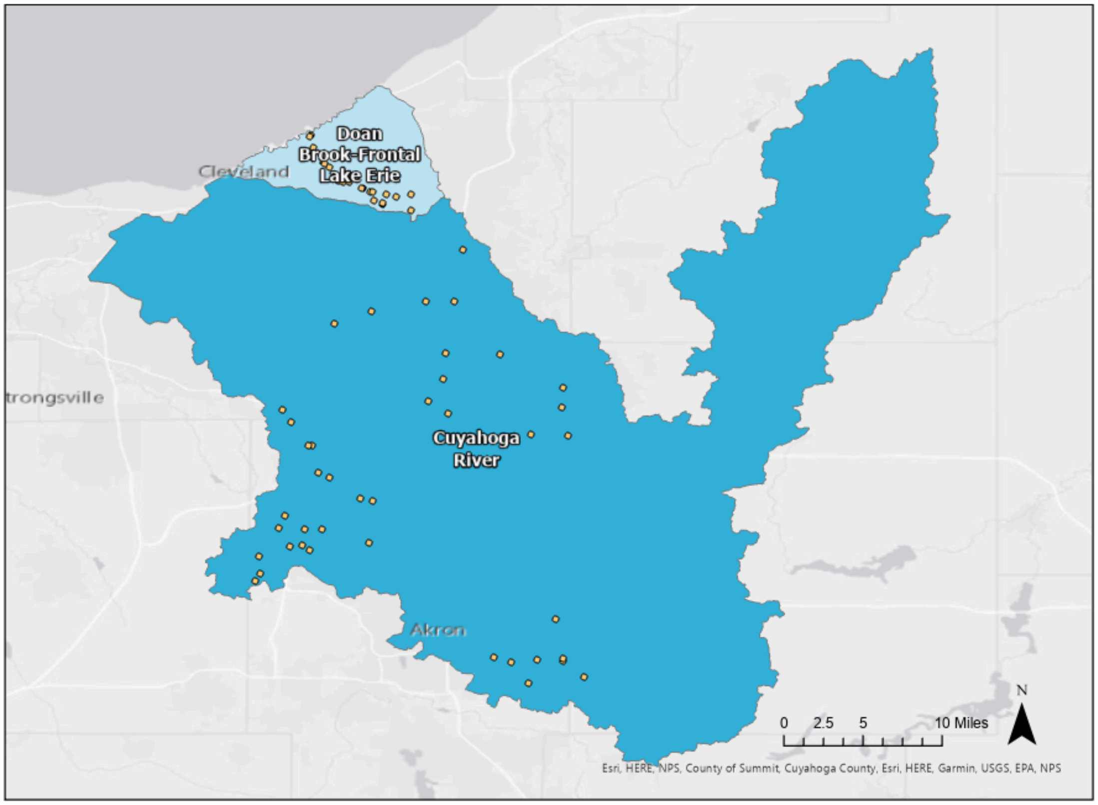
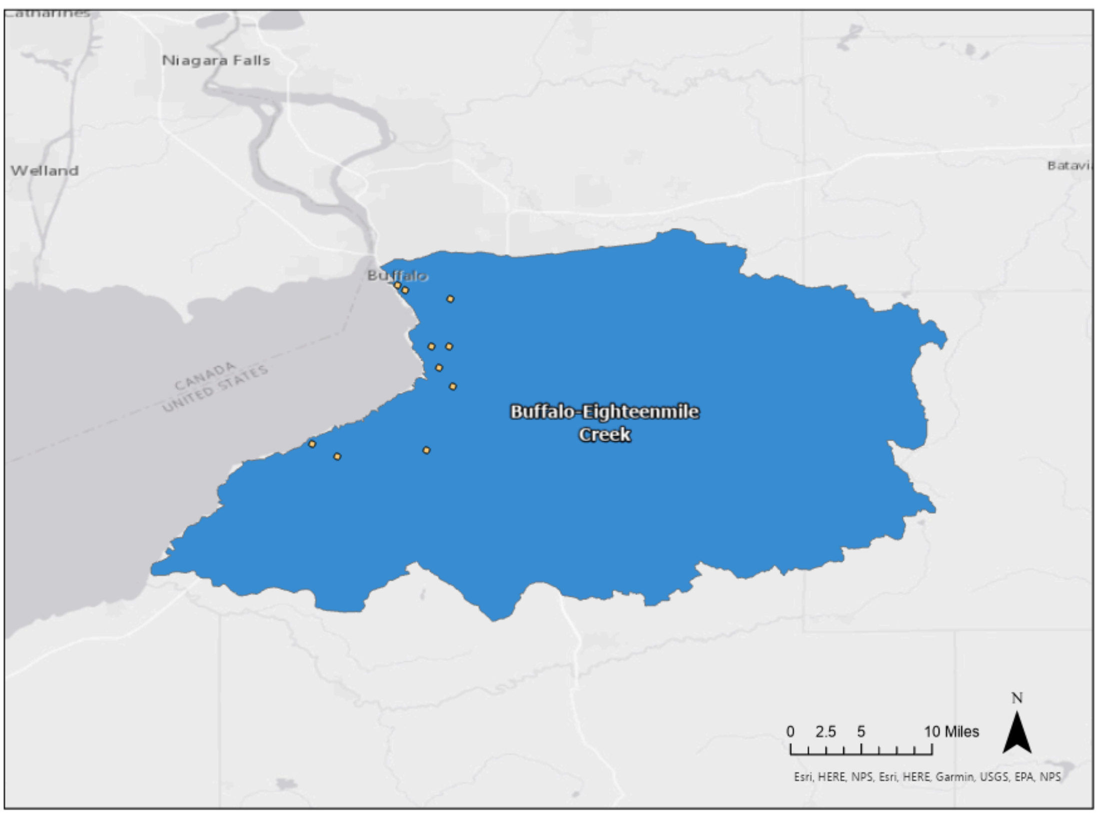


Figure 6. New York Buffalo Area Large Rivers & Monitoring Stations



Through expanded use of this rigorous and standardized assessment, LEVSN can present a regional volunteer-driven perspective on the condition of watersheds that feed Lake Erie and refine benchmarks against which continued monitoring can be compared. Using the definition of health laid out in the LEBAF SOP, 2024 field measurements support 2023 outcomes that suggested Lake Erie's watersheds are generally healthy and able to support aquatic life. These conclusions are again supported by participants' direct measurement of pH and dissolved oxygen as well as expressions of conductivity as TDS, salinity and chloride, although there is some indication that negative impacts may be present regionally.

For the third year in a row, exceedances of the conductivity macroinvertebrate biocondition gradient suggested that all waterways sampled are currently experiencing, or at risk of experiencing, degraded conditions; across all sampling sites, the exceedance rate is above 96%. This parameter is an indicator that looks at stream health through the lens of potential impacts to aquatic life from dissolved substances, chemicals, and minerals present in the water. This could mean that elevated conductivity levels are directly impacting aquatic life in many Lake Erie streams or are associated with other processes and pollutants interacting to limit macroinvertebrate community structure and function. In some cases, it may also reflect localized geology or processes that the assessment macroinvertebrate database does not represent with equal sensitivity. Longer-term monitoring of this parameter will help determine the scope of this potential impact. Aquatic macroinvertebrate community data exists for some sites, and this will help to offer clarity when comparing trends over time.

Analysis of 2024 LEBAF data and sampling design, especially with the added context of local knowledge, highlighted some limitations. In considering the 2024 results, it is essential to note that LEBAF, even with continued growth, has spatial and temporal gaps within currently monitored watersheds as well the fact that fewer cold water streams were sampled, absence of monitoring for some major watersheds to the Lake, and lack of Canadian participants. Three years of standardized data collection does not allow for definitive statements about the overall health of any watershed regardless of how much data was collected. Before drawing any actionable conclusions, it is critical to consider long-term variations that provide better context for each season's observations. As a result, ***all observations and interpretations described in each waterbody's aggregated summary, and in the <u>Recommendations and Conclusions</u> should be taken as heavily qualified by <u>a range of limitations that face this monitoring program</u>, particularly in these early years of operation.***

Further, with few stations located on Lake Erie itself, it is important to recognize that assessment of aquatic life conditions on the open water is not currently possible through LEBAF. With this in mind, LEVSN determined that this report will only include analysis, interpretation, and recommendations for Lake Erie river basins. Exploration of water quality of Lake Erie based on results of basin sampling will be included on a bi-annual basis, beginning in 2025.

The third year of standardized volunteer monitoring continued progress towards LEBAF's intended monitoring purpose, data use, and desired impacts. LEVSN improved its use of industry-standards sensor technology, a cloud data platform, training opportunities, and updated SOPs to maintain standardized, credible volunteer monitoring. Participating groups were able to collaboratively screen for and benchmark the health of their local watersheds, identifying data gaps to guide future monitoring priorities and potential problem areas to be further investigated. Many hours of work from partners across the Lake Erie Basin led to improved analysis and reporting methods. During Spring 2024, a second evaluation of LEBAF's SOP and processes was conducted by its participants to further refine program elements and shared analyses. LEVSN has realized its aim to build on 2023's successes to expand the number of samples collected, geographic coverage, and confidence in its interpretation over future sampling years.

As LEBAF monitoring continues, the standardized, credible, volunteer-collected data will allow LEVSN to provide a regional condition assessment of Lake Erie streams over time to inform local, and potentially regional, restoration and protection activities. While a more comprehensive picture is not yet clear, the network is demonstrating the capacity of a regional volunteer network to generate credible and useful science. Participants have shared knowledge, positively impacted their communities, and expanded access to volunteer monitoring around Lake Erie. The movement will continue to build momentum in pursuit of better water quality and quality of life for all Lake Erie Basin communities.

1.3 How to Use This Document and Supporting Products

This document is the 2024 annual LEBAF report of data collected from rivers and tributaries within the Lake Erie Basin. This is the third annual report that provides a *detailed analysis* of data collected by the Lake Erie Volunteer Science Network (LEVSN). The report includes two different assessments of 2024 LEBAF data.

1. **Local Rivers and Lake Erie Tributary Assessments:** An analysis of individual river or tributary 2024 datasets using a standardized assessment described in Section 2 - Approach and Methods. The assessments for each river and tributary are provided alphabetically in Section 3 - Results: Large Rivers and Other Direct Tributaries to Lake Erie. Each river or tributary subsection provides 1) monitoring organization information, 2) a description of monitoring stations, 3) results, and 4) a summary of recommendations and data limitations. Only elements of importance for data screening of ecosystem health are presented in these assessments. Participating organizations have more information on their monitoring programs and data as well as their own information products available on their websites (linked in Appendix 1).
2. **Lake Erie Basin Assessment:** An assessment of all the collected data by the Lake Erie Volunteer Network (LEVSN) through a Lake Erie Basin-wide lens. This assessment follows the same analysis approach described in Section 2, but aims to identify overall spatial

and temporal trends or differences across the entire Lake Erie Basin. The results for each of the four directly measured, core parameters - 1) pH, 2) dissolved oxygen, 3) temperature, and 3) conductivity - are shared in Section 4 - Results: Lake Erie Watershed and overall findings are summarized in Section 5 - Summary and Recommendations. The parameter results in Section 4 include further information on the 1) data assessment and thresholds, 2) parameter expectations, 3) data characterization, 4) water quality exceedances, 5) factors influencing exceedances, 6) a data summary, 7) data limitations, and 8) recommendations.

This LEBAF report serves as a standardized assessment and report of 2024 data across the Lake Erie Basin. Secondarily the report also provides local (Section 3) and regional (Section 4) recommendations for addressing water quality concerns and ecosystem harm. These recommendations are summarized in Section 5.1 Interpretation of Findings and Corresponding Recommendations and serve as a guide for resource prioritization and decision making (e.g. use support, advocacy, policy, resource management, and adaptive management) for Federal, State, and local decision makers. Additional communication tools with more concise language as well as all the 2024, 2023, and 2022 data are available on the LEVSN Website.

Section 2 – Approach and Methods

2.1 Directly Measured Parameters

The LEBAF SOP presents standards for the direct collection, management, and analysis of basic chemical parameters that indicate watershed conditions using a multiparameter water meter or a set of single parameter water sensors. This section provides basic information about each core parameter measured and the use of each parameter as an indicator of water quality and ecosystem health. Each parameter includes a link to a relevant section of the LEBAF SOP which includes more information on the impact this parameter can have on an aquatic ecosystem, its natural fluctuations, common external factors that influence its dynamics, and LEBAF's standardized method for sampling it.

pH: A measure of hydrogen and hydroxyl ion activity in water or a measure of water acidity/basicity. pH affects many chemical and biological processes in surface water such as the solubility, biological availability, and transport of heavy metals (cadmium, copper, lead), nutrients (carbon, nitrogen, phosphorus), and other aquatic pollutants. pH levels that are either too low or too high are not conducive to aquatic life.

Dissolved Oxygen (DO): The amount of gaseous oxygen (O_2) in the water. DO is governed by temperature, salinity, and atmospheric pressure. DO concentrations are typically near or at saturation for a given temperature. Waters with DO levels at or near the respective temperature saturation are capable of supporting aquatic life adapted to those conditions. The necessary amount of DO, however, varies with species, age and activity, and includes a lower and higher supportive range.

Temperature (Temp): The average kinetic energy of water molecules also known as the degree or intensity of thermal energy in water. Temperature affects the chemical and physical properties of water, and in turn, other elements within an aquatic system. Aquatic temperature regimes drive metabolism, growth, behavior, and reproduction of aquatic biology, determining the type and quantity of aquatic life present in water bodies. Supportive temperatures include cold, warm and transitional temperatures as well as seasonal ranges within each temperature category.

Conductivity: Conductivity is a measure of the collective amount of dissolved ions (salts and other primarily inorganic chemicals) in a waterbody. Since conductivity quantifies a broad range of chemicals, it serves as a general indicator of water quality. Natural rivers and streams tend to be low in ionic content, but the amount of dissolved ions varies with geology, precipitation, and other localized variables. The range of conductivity values, however, tends to be consistent. Thus, if conductivity falls above baseline conditions, it indicates potential pollution from salts, nutrients, or metals that may directly or indirectly affect aquatic life or habitat. Further investigation is needed to identify the specific dissolved ions contributing to the high conductivity.

2.2 Conductivity and Surrogate Measures

As described above, conductivity is a widely used screening parameter rather than a measure of specific constituents. Conductivity is highly correlated with a number of other water quality parameters including total dissolved solids (TDS), salinity, and chloride. As such, surrogate parameters can be mathematically calculated from conductivity measurements. LEBAF calculates the three surrogate measures - TDS, salinity, and chloride - using the equations described in the LEBAF SOP and Table 3. These surrogate parameters can be used to help interpret high conductivity (> 850 µS cm^{-1}) results and suggest further investigation. As the LEBAF SOP is expanded over time, LEVSN hopes to include standardized direct observations of these parameters, as opposed to surrogate values calculated from conductivity measurements. LEBAF also hopes to use direct measurements for comparison to test the local correlations of calculated values whenever possible. Surrogate parameters from conductivity measurements are explained in more detail below.

Conductivity Biocondition: LEBAF participants assessed directly measured conductivity results against a macroinvertebrate community condition gradient based on conductivity levels provided by Ohio EPA. As conductivity increases, it begins to impact aquatic life. The gradient identifies conductivity levels that correlate to *healthy* macroinvertebrate communities, *declining or degrading* communities and *already degraded* communities (see thresholds in Table 3). Comparison of conductivity results to a large temporally, geographically and ecologically relevant macroinvertebrate biocondition dataset allows for interpretation of the degree to which conductivity may be impacting overall aquatic health.

Total Dissolved Solids (TDS): A measure of all solids dissolved in water, including minerals, salts, metal, cations, anions and organic molecules. Very similar to conductivity, TDS doesn't measure specific ions but a combination. The scientific and mathematical relationship between conductivity and TDS is very well established and has a high use confidence for multiple purposes including screening. In fact, the surrogate calculation used by LEBAF is the same equation TDS meters employ automatically converting conductivity to TDS. Most states have well-established Clean Water Act standards for TDS to protect drinking water or water supply, but not for aquatic life. Ohio has a TDS aquatic life standard but uses it with caution as it is underprotective and requires local context to interpret. It can still provide a useful screening threshold. An initial use of Ohio's aquatic life TDS standard of 1500 mg L^{-1} was applied to determine if conductivity levels were high enough to exceed even this underprotective standard. If so, it would suggest that aquatic life is most likely impacted.

Chloride: A measure of the concentration of dissolved salts resulting from the combination of chlorine with a range of positively charged elements such as hydrogen, sodium or magnesium. Elevated concentrations of chloride in streams have been determined to be toxic to some aquatic life. Additionally, the presence of chloride increases the corrosivity of the water, potentially threatening drinking water infrastructure and quality. The relationship between conductivity and chloride is strong and consistent across watersheds, since chloride salts include highly charged ions. State chloride standards to protect drinking water or water supply are well established, but those for aquatic life are relatively new. Where conductivity values were high, they were compared to aquatic life thresholds to determine if chloride itself should be investigated as a potential source.

Salinity: A measure of the concentration of total dissolved salts (not just chlorides) in water. Higher salt concentrations can impact stream biota and reduce biodiversity in streams as well as increase corrosivity of water. Conductivity is also highly correlated to salinity, and well established. Salinity standards for freshwater are lacking in states' Clean Water Act standards, but the USGS provides a continuum of salinity concentrations for fresh to highly saline water. Using those thresholds, a general level of conductivity can be deduced to serve as screening levels for elevated salinity.

2.3 Data Collection and Management

Participating members of LEVSN are expected to adhere to the technical requirements and minimum performance criteria of this regional framework, which is designed to synergize with, rather than replace, their pre-existing sampling plans. The specifications below provide guidance on the minimum technical and programmatic elements required for participation. For more detail, please reference the LEBAF SOP.

- *Monitoring Stations:* Participants are required to monitor at least one station. Ideally, participants should monitor at least one station on each major tributary across their coverage area. More stations are always encouraged. Participants identify stations that are representative of location and flow within the stream and ensure safety and accessibility.
- *Monitoring Frequency:* Participants are expected to monitor all established stations at least one time per month from April to October. More frequent visits are encouraged and date/time flexibility is allowed depending on weather conditions and equipment availability.
- *Data Management:* LEVSN employs Water Reporter (WR), an online data sharing platform, to standardize collection, storage, management, analysis, and reporting of LEBAF data. A regional monitoring dashboard hosted by Cleveland Water Alliance features all data collected across the region and a custom data analysis script generates standardized metrics, graphs, and maps.
- *QA/QC:* Network participants must collect four aquatic chemistry parameter readings using YSI multiparameter water quality meters or equivalent sensor technology, along with required information as detailed in the LEBAF SOP. Sensors must be calibrated and maintained following the procedures prescribed by the device manufacturer and align with the minimum specifications outlined below. All data must undergo QA/QC at point of entry and during the final field season analysis.

Table 2. LEBAF Collection Parameter Information

Parameter	Conductivity	Dissolved Oxygen	pH	Temperature
Resolution	0.001 mS (0 to 0.500 mS) 0.01 mS (0.501 to 50.00 mS) 0.1 mS (>50.0 mS)	≦ 0.01 mg/L	≦ 0.01	≦ 0.1° C
Accuracy	±0% to ±1%	For 0 to 200% Saturation: Between ±0% and ±2% of the reading OR between ±0% and ±2% air saturation. For 200% to 500% Saturation: Between ±0% and ±6% For 0 to 20 mg/L: Between ±0% and ±2% OR between ±0 mg/L and ±0.2 mg/L For 20 mg/L to 50 mg/L: Between ±0% and ±6%	±0% and ±0.2	±0° to ±0.3° C
Range	At Least 0 to 200 mS/cm	At Least 0 to 50 mg/L [OR] 0 to 500% Saturation	0-14	At Least 0° to 50° C

2.4 Analysis and Interpretation

To meet the data objectives, monitoring purpose, and intended data uses for targeted data users in 2024, LEBAF evaluated the data on three scales.

1. Individual Site Analysis
2. Analysis of Large Rivers and Direct Tributaries to Lake Erie
3. Lake Erie Basin

Automated data analysis produced standardized summary statistics (total sample size, maximum, minimum and median result, number and percent exceedance of respective standards) as well as standardized graphs and maps at each scale (see LEVSN webpage). Data analysis focused on evaluating water quality concerns related to the four core parameters measured by the LEVSN network within each Large River and Direct Tributary to Lake Erie and across the Lake Erie Basin as a whole. Parameter exceedances were determined using referenced benchmarks (Table 3) defined by LEBAF for each parameter based on United States Federal and State Clean Water Act (CWA) criteria. Where possible, all assessment criteria are focused on the health of aquatic life communities in lotic or running waters. More detail on each criteria, source, and rationale can be found in LEBAF SOP.

Table 3. LEBAF Screening Assessment Criteria (Benchmarks) Details and Sources

Parameter	Benchmark(s)	Source/Comments
pH	6.5.-9.0 pH Units	Most commonly used Lake Erie CWA pH use assessment standards. Assessed exceedances below 6.5 and above 9.0.
Dissolved Oxygen (DO)	Cold water ≤ 7 mg/L Warm water ≤ 5 mg/L	Adopted Ohio EPA warm and cold water system DO standards.
Temperature (Temp)	Warm and Cold monthly values between states' daily max/mean. LEBAF developed a conservative set of monthly temperature ranges for warm and cold waters as a screening benchmark (Table 47) based on accepted standards.	Lake Erie CWAs all agree that water temperatures should exist within a +/- 5°C range for warm and cold rivers.
Conductivity	**1) Survey Evaluation:** LEBAF conductivity results are compared to a reference and survey conductivity dataset to evaluate data consistency and relevancy. This dataset provides statistical values for two ecoregions and three watershed sizes (Table 50).	Ohio EPA maintains the robust conductivity reference and stream survey dataset used for this comparison. Each station and watershed are compared with the respective ecoregion and watershed size.
	2) Biocondition Evaluation: LEBAF uses the minimum threshold of 412 µS cm^{-1} to define a healthy macroinvertebrate community. LEBAF has built out a set of conductivity criteria based on other biocondition metrics and reference data to better describe macroinvertebrate health that is	LEBAF adopted the minimum biocondition threshold from Ohio EPA and built out the combined conductivity criteria based on additional Great Lakes States' conductivity guidance and the Ohio EPA ecoregion reference and survey dataset. Unlike the other parameters, the LEBAF conductivity criteria is a continuum that helps to diagnose various stages of

	outlined in Table 51. The macroinvertebrate community at sites and watersheds with average or median conductivity values ≥ 850 µS cm^{-1} are likely degrading and warrant further investigation into conductivity surrogate measures.	ecosystem health that guide recommendations. LEBAF conductivity results should be compared to other measures when available and appropriate to better diagnose sources contributing to high conductivity and evaluating the in situ macroinvertebrate community.
Conductivity Surrogate Measures		
Chloride	Aquatic life toxicity levels: Acute = 640,000 µg L^{-1}, 640 mg L^{-1} Maximum = 320,000 µg L^{-1}, 320 mg L^{-1} Chronic = 150,000 µg L^{-1}, 150 mg L^{-1}	LEBAF adopted the Michigan EGLE chloride standards for aquatic life use protection. <u>Calculation of Chloride from Conductivity:</u> $[Cl^{-}]$ = 4.928 EC. This relationship has a 94% R-value. In addition, Ohio EPA provided a large river specific correlation regression for 11 large rivers; LEBAF applied that equation for respective rivers that have better correlation than the above equation. Each river's equation is in the SOP.
Total Dissolved Solids (TDS)	An aquatic life standard of 1500 mg L^{-1}, but is used cautiously with local context because it can be underprotective.	LEBAF adopted this TDS aquatic life threshold from the Ohio EPA. <u>Calculation of TDS from Conductivity:</u> TDS = k EC (in 25 °C). Based on literature for freshwater and low end natural waters, the k-value is 0.55. LEBAF is evolving its measurement of TDS and assessment methods.
Salinity	● Freshwater: < 1,000 parts per million (ppm) or 1 g L^{-1} ● Slightly saline water: 1,000 ppm – 3,000 ppm or 1 - 3 g L^{-1} ● Moderately saline water: 3,000 ppm – 10,000 ppm or 3 - 10 g L^{-1} ● Highly saline water: 10,000	LEBAF adopted these salinity benchmarks from literature and the United States Geological Survey (USGS). Great Lakes States do not yet have salinity water quality standards. LEBAF uses these criteria to identify

	ppm – 35,000 ppm or 10 - 35 g L^{-1}	patterns and potential salt sources contributing to high conductivity and not as a standard assessment. This parameter is most important to assess when conductivity values are > 850 µS cm^{-1} and where road salts and other practices occur. <u>Calculation of Salinity:</u> salinity = 0.4665 x ([Conductivity]$^{1.0878}$) Conductivity concentrations must be in mS m^{-1}. Results are expressed in g L^{-1}. To compare with standards in ppm results need to be multiplied by 1000.

Important to notes about the conductivity assessment:

All directly measured conductivity data was assessed against a conductivity database of reference and survey data filtered by two ecoregions and three watershed sizes (Table 50). The reference and survey data was summarized and provided by the Ohio EPA. This dataset provides the respective conductivity population distribution identifying the minimum, 25th, 50th, 75th percentile and maximum levels. LEBAF compared conductivity result distributions to the respective ecoregion and watershed size to validate that results aligned with the respective conductivity distribution in the database. This assessment was not to determine if conductivity was elevated, but to confirm and validate if results resemble conductivity data from a larger database. Such validation provides confidence to use conductivity for further analyses such as assessment against a conductivity macroinvertebrate biocondition and surrogate expressions of chloride, salinity and total dissolved solids.

LEBAF also conducted a conductivity biocondition assessment. In Section 3, individual conductivity data points and statistical data were compared to the Ohio EPA Biocondition Criteria. The Ohio EPA minimum criterion of 412 µS cm^{-1} was used to determine conductivity exceedances (Table 3). The Ohio EPA biocondition bins of 412 - 655 µS cm^{-1} and > 655 µS cm^{-1} were used to determine if observed values suggested the macroinvertebrate community was declining or degraded, respectively. Then the overall conductivity statistical data for the watershed was compared to LEBAF's combined conductivity criteria (Table 51) to describe the state of the macroinvertebrate community within the Large River or Direct Tributary and provide additional recommendations. This second comparison evaluates the data based on a four bin continuum of health that takes into account the naturally high conductivity of sites in LEVSN due to the geology of the region. Only this combined biocondition criteria was used to evaluate ecosystem health and provide recommendations for the full Lake Erie Basin data assessment in Section 4.

Additionally, expressions of conductivity calculated from mathematical relationships for chloride, salinity and total dissolved solids (TDS) were employed again in the 2024 LEBAF evaluation to provide additional context on the size and implication of exceedance.

Assessment and resulting interpretation of the data at the Local River and Tributary levels included consideration of available ancillary information, alongside the standardized summary statistics, at each level by each corresponding sampling group. At the Lake Erie Basin level, all participating groups participated in a full-day workshop to discuss overall basin trends and develop the basin story. The output from this workshop was synthesized into Section 4. All final results were reviewed and edited by the LEBAF Standards Working Group with feedback from all LEBAF participants. Details on LEBAF's Analysis process can be found in the SOP.

Section 3 – Results: Large Rivers and other Direct Tributaries to Lake Erie

This section represents the summaries of large rivers and direct tributaries to Lake Erie submitted by monitoring groups participating in the LEVSN in 2024. For additional data and visualization tools visit the Lake Erie Volunteer Science Network webpage for an interactive map of basins monitored in 2022, 2023, and 2024.

3.1 Clinton River

3.1.1 Monitoring Organizations: Currently only one organization in the LEBAF Network is monitoring the Clinton River Watershed, the Clinton River Watershed Council (CRWC). CRWC is an organization dedicated to protecting, enhancing, and celebrating the Clinton River, its watershed, and Lake St. Clair, which connects the Clinton River to the Detroit River. The Clinton River Watershed spans 760 square miles, encompassing a wide range of terrains including agriculture, suburban, and urban areas. The Clinton River is one of many tributaries to the Detroit River, the straight between Lake Huron and Lake Erie. Due to the size of the Clinton River, the number of sites monitored, and the many other inputs to the Detroit River, Clinton River results are presented here, separate from the Detroit River Section (3.2).

3.1.2 Station Summary: Data was collected from one station in 2024, Paint Creek 1 (PC1). No direct sampling occurred on the Clinton River itself, as Paint Creek is a coldwater stream in southeast Michigan that is a tributary to the larger Clinton River. The Paint Creek subwatershed is largely suburban, home to about 68,000 people, with many green spaces that allow access to the creek. Paint Creek is considered to be of special concern to many stakeholders because its coldwater supports a popular trout fishery. PC1 is located in Rochester, Michigan, within Rochester Municipal Park. Data was collected on seven separate occasions, once per month from April to October.

3.1.3 Summary of 2024 Findings and Analyses

Table 4. Clinton River Tributary Summary Statistics and Exceedances - 7 Samples, 1 Station

Summary Statistics and Exceedances Basin - Clinton

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	834.71	818.00	796.00	947.00	7.00	7.00	100.00
Dissolved Oxygen	8.91	8.97	7.72	9.98	7.00	0.00	0.00
pH	8.13	8.13	7.78	8.26	7.00	0.00	0.00
Water Temperature	18.31	17.70	14.30	21.90	7.00	6.00	85.71

pH - All pH values reported from the 2024 monitoring season were between the standard thresholds of pH = 6.5 - 9, indicating good quality water. There were no exceedances above the pH threshold, suggesting a healthy river. We can conclude there are minimal impacts from pH to aquatic life along this reach of the river.

DO - Paint Creek is considered a coldwater stream, which means we expect to see higher DO levels within this tributary throughout the year. The dataset examined here only encompassed daytime conditions within the creek. All DO measurements were well above the standard threshold for coldwater defined by LEBAF. Additional data points would help us to fully understand how DO is fluctuating from month to month, although it is only representative of daytime conditions within the creek.

Temperature - Water temperature directly affects aquatic life and can be a limiting factor for many species, including trout and salmon. The temperature of the water is especially crucial during the warmer months, as water levels in Michigan typically drop in July and August. When combined with high summer temperatures, this can harm fish and other aquatic organisms. Coldwater species are particularly vulnerable, as they are restricted to a small range of habitats that maintain the appropriate temperature and DO levels. Additionally, we would expect temperature values to be within the LEBAF cold water thresholds for the duration of the sampling period; however, the only month in which temperatures did not exceed LEBAF seasonal thresholds was August. Temperature exceedances ranged from 0.5°C to 7.9°C above LEBAF standards, with the highest exceedance occurring in May. These exceedances may be reflective of the depth of the water at this monitoring station, as flow was low from April through June, and deeper water has more capacity to remain constant in temperature. The air temperature in May was higher than average, further contributing to the high temperature exceedance that month. Additional data is needed to determine whether coldwater conditions are consistent throughout the entire summer. A maximum temperature of 21.9° C was recorded through this effort in 2024.

Conductivity - Conductivity was expected to be relatively high but stable in Paint Creek. High conductivity in developed areas is a common occurrence and Paint Creek is no different. Conductivity data was compared to Ohio EPA conductivity reference and survey sites for verification. The Clinton River falls within the ECBP ecoregion, but data was only available for two ecoregions, HELP and EOLP, and the EOLP ecoregion and is a river size (500+ square miles) that is the most comparable to reference and survey conductivity percentile values. Interpretation is qualified by this limitation but still useful for condition purpose and screening data use.

Conductivity averaged 835 µS cm^{-1} at PC1 in 2024. The maximum result of 947 µS cm^{-1} is just below the maximum survey sites and higher than the reference maximum. The median result of 818 µS cm^{-1} is closely aligned with the 90th percentile of both reference and survey data sets. The minimum 796 µS cm^{-1} is closer to the 75th percentile of reference and survey data. Although the foregoing comparisons were made using data from different ecoregions, these results suggest that the conductivity of this site is on the higher end of reference and survey sites, providing additional confidence in the conductivity results, but also indicating some level of disturbance within the system.

Conductivity values were compared to Ohio EPA macroinvertebrate bio-condition thresholds. Conductivity at Paint Creek ranged from 796 - 947 µS cm^{-1}, exceeding the low threshold for bio-condition (412 µS cm^{-1}) in 100% of samples in 2024. Conductivity also exceeded the 655 µS cm^{-1} degraded macroinvertebrate community condition threshold 100% of the time. Maximum conductivity occurred in September when water was below base flow, which may have contributed to the conductivity being significantly higher than the median conductivity of 818 µS cm^{-1}. These exceedances suggest that existing macroinvertebrate communities may be in decline or degraded in Paint Creek and that is not healthy for its contribution to Clinton River aquatic life condition. That said, sources of higher conductivity, even in urban areas, can be explored and mitigated to provide the best possible habitat and conditions for macroinvertebrates.

Expressions of conductivity through mathematical relationships for chloride and salinity, along with sensor readings of total dissolved solids were also evaluated due to the exceedances in conductivity. The TDS standard is a drinking water threshold used this year in assessment as LEBAF explores the effectiveness of the Ohio aquatic life threshold of 1500 mg/ L^{-1} and developing its own conductivity thresholds. Results did not exceed 1500 mg L^{-1} and the maximum TDS recorded was 615 mg/ L^{-1}, not approaching this threshold. Calculated chloride concentrations ranged from 39.23-46.67 mg/ L^{-1} throughout the reporting period, and there were no exceedances in the 7 collected samples (0% exceedance) of the final acute, acute maximum, and final chronic aquatic chloride standards. Results were not close to the lowest threshold of 150 mg/ L^{-1}. This suggests aquatic organisms in Paint Creek were at reduced risk to chronic chloride exposure in 2024. Salinity results were compared to the USGS recommended salt content for freshwater. The maximum approaches, but is shy of, the slightly saline category (1000-3000 ppm). The median suggests that 50% of the time salinity levels are close to 700 ppm. Even if salt is in the water based on this range, it doesn’t mean aquatic life is harmed, just exposed.

Chloride concentrations in Paint Creek are expected to be high because much of the watershed is developed. In fact, calculated chloride concentrations in 2024 were lower than previous direct chloride measurements made in Paint Creek over the previous two years. Additional “ground truthing” is recommended to confirm whether calculated chloride accurately reflects concentrations that are measured directly. According to the samples collected in 2024, salinity in Paint Creek is slightly elevated, which corresponds to the TDS, conductivity, and chloride values found within the dataset. Not many conclusions can be drawn from this dataset due to lack of data for the region, but according to several online sources, the salinity levels observed here are indicative of slightly disturbed systems. More salinity data collected from within the region will help to tell this story in more detail.

3.4.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 5. Clinton River Water Quality Summary

pH	***Temperature***	***DO***	***Conductivity***
Acceptable	Concerning	Acceptable	Degraded, Likely Threats

The Clinton River had data for seven parameters from one tributary, Paint Creek, including dissolved oxygen, temperature, conductivity, conductivity macroinvertebrate biocondition, total dissolved solids, chloride, and salinity. Seven samples were collected at 1 station resulting in 7 exceedances with 100% exceedance of the higher conductivity biocondition (655 µS cm^{-1}). One exceedance in temperature occurred but was near the threshold for coldwater streams. Five parameters had no exceedances: pH, dissolved oxygen, TDS, chloride, and salinity. Although salinity thresholds have yet to be determined for this ecoregion, they did not exceed the USGS saline thresholds for freshwater. Based on LEBAF's definitions, this site would be somewhere between healthy and unhealthy with inconclusive reasons why and more monitoring and exploration needed.

Results are mixed in regards to using the expressions of conductivity, chloride, and salinity. Two questions LEBAF wanted to answer, first did calculated respective results mirror ambient conditions and second, do results and assessment methods provide helpful screening guidance? The dataset is limited in space and time and likely does not represent all of Paint Creek much less the Clinton River. One sampling site is not enough to draw any conclusions on water quality within the river basin.

The assessment method using TDS drinking water standards was as expected but may not be informative for aquatic life protection. Effective use of the TDS threshold of 1500 mg L^{-1} as an aquatic life indicator is still unknown, but shows potential if adequate context is included in the assessment. Calculated chloride values were higher than data previously collected by CRWC over the past four years and seven samples from one station is a relatively small sample size. Further investigation and data are needed to determine if calculated chloride is representative of ambient conditions, even if the assessment method is effective. Salinity results appear to represent ambient conditions and assessment methods provided helpful screening, given limitations of the dataset.

If monitoring sites existed in all seven major subwatersheds our dataset would more accurately represent the Clinton River as a whole. We recommend expanding data collection to all major tributaries to the Clinton River, including the main stem, in the future to accurately assess the Clinton's influence on Lake Erie.

3.2 Detroit River Tributaries

3.2.1 Monitoring Organizations: Multiple watershed groups and government agencies conduct water quality monitoring within the Detroit River Watershed. Two of those organizations are members of LEBAF: the Clinton River Watershed Council (CRWC) and the Huron River Watershed Council (HRWC). Due to the complexity of the Detroit River Watershed and the size of the Clinton River, the CRWC reports on water quality data only in the context of the Clinton River which drains into the Detroit River via Lake St. Clair in a separate section (3.1 Clinton River). In the 2024 report and this section, the HRWC presents monitoring data from 4 creeks that drain into the Detroit river south of downtown Detroit, Michigan.

3.2.2 Station Summary: The St. Clair-Detroit River System is complex, draining multiple other river systems in the United States and Canada and acting as a strait between the upper Great Lakes and Lake Erie. HRWC only monitors water quality at 5 locations within 4 creeks located in the most downstream section of the Detroit River watershed: Ecorse Creek (south and north), Frank and Poet Creek, Brownstown Creek, and Blakely Creek. The Frank and Poet, Brownstown, and Blakely Creeks are sometimes referred to as the combined downriver watersheds. **These creeks are all small in comparison to other inputs to the Detroit River and are not representative of the Detroit River main stem.**

All monitoring locations are within the Huron-Erie Lake Plain ecoregion and have bedrock composed of mainly limestone mixed with either shale, sandstone, dolostone, or a combination. The watersheds of these creeks, however, have been highly altered by agriculture and urbanization. The five long-term monitoring locations were chosen based on feedback from municipal stormwater partners and capture the extent of urbanization upstream. The Frank and Poet monitoring site was permanently relocated this year from ADW01 to ADW39 for easier public access. The south branch Ecorse Creek sampling location changed midway through the season from ADW04 to ADW40 due to road construction blocking access to ADW04. This change in location resulted in 6 stations being monitored in 2024, but data collected from ADW04 and ADW40 evaluate the health of the same creek.

The data presented in this report was collected every two weeks throughout the spring, summer, and fall of 2024 as part of the HRWC Chemistry and Flow Monitoring Program that has monitored most of these sites since 2012 as a member of the Alliance of Downriver Watersheds stormwater organization. The HRWC Chemistry and Flow Monitoring and Biological Monitoring Programs both collect additional data not reported here that provides further context for the interpretation of these results. That data is publicly available on HRWC's Maps Webpage.

3.2.3 Summary of 2024 Findings and Analyses

Table 6. Detroit River Tributaries Summary Statistics and Exceedances - 59 total samples, 6 stations

Summary Statistics and Exceedances Basin - Detroit River

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	1,000.47	965.00	442.00	2,714.00	59.00	59.00	100.00
Dissolved Oxygen	6.32	6.25	1.87	10.46	59.00	16.00	27.12
pH	7.83	7.80	7.55	8.23	59.00	0.00	0.00
Water Temperature	17.76	17.70	9.00	25.50	59.00	4.00	6.78

pH – Measurements collected in Ecorse Creek and the other downriver watersheds do not indicate a potential pH impairment based on the prescribed LEBAF standards.

DO – DO concentrations in the Ecorse creek and downriver watersheds followed normal seasonal trends of high DO in the spring and fall with low DO in the summer. At most of the sites, however, DO fell below the 5 mg L^{-1} aquatic life threshold on several occasions between May and September. There were more recurrences of low DO at individual sites than the previous evaluation year. Ecorse Creek had 3 DO measurements that fell below the 5 mg L^{-1} aquatic life threshold. The exceedances occurred only in the north branch of the creek this year; the south branch sampling site generally had higher DO than the north branch. Blakely Creek: ADW02 and Frank and Poet Creek (ADW01 in 2023 and ADW39 in 2024) each had more exceedances this year compared to previous years. Like ADW04, the Frank and Poet sampling location was moved this year for accessibility and this relocation could contribute to the variation in exceedances from year to year. As with previous years, Brownstown Creek: ADW03 had the most exceedances, 7 in total, during the summer months. This site consistently experiences slow flow. The median DO concentration at Brownstown Creek: ADW03 was 4.86 mg L^{-1} and the minimum value was below the hypoxic level at a recorded 1.87 mg L^{-1}.

Temperature – In 2024, April 30th water temperatures at all sites except Brownstown Creek (ADW03) exceeded the prescribed LEBAF seasonal temperature thresholds. Recorded temperatures were between 16.9 and 17.2°C, which is about 1 to 2.2°C above the April warm water LEBAF standard.

Conductivity – All the monitored creeks are in the Huron-Erie Lake Plain ecoregion, which is associated with naturally high conductivity. In 2024, these 4 tributaries of the Detroit River had highly variable conductivity that ranged between 442 and 2714 µS cm^{-1} with a median concentration of 965 µS cm^{-1}. These values were high even by the creeks' ecoregion standards with the 2024 median value above the Ohio EPA Huron-Erie Lake Plain 90th percentile stream reference value of 952 µS cm^{-1}. The range of 2024 conductivity values still overlaps with the expected range for the Huron-Erie Lake Plain ecoregion, but more measurements fall within the upper end of the range. This provides some additional confidence in using our conductivity results, while also clearly showing that ecoregion alone is not responsible for the high conductivity concentrations in these creeks. Rather additional pollutants from anthropogenic influences are likely pushing these values to the high end and above the acceptable ecoregion maximum.

LEBAF also uses a combined conductivity criteria for evaluating macroinvertebrate health: < 412 µS cm^{-1} promotes a healthy community, between 412 and 850 µS cm^{-1} suggests some concern for the community, between 851 and 2000 µS cm^{-1} indicates likely threats to the community, and >2000 µS cm^{-1} suggests the community is impaired. All conductivity measurements within the 4 creeks exceeded the lower limit of 412 µS cm^{-1}. This finding is consistent with 2023 findings that had 98% exceedances of this limit. Only 37% (22 samples) of conductivity measurements fell between 412 and 850 µS cm^{-1} and 61% (36 samples) were between 850 and 2000 µS cm^{-1}. Like in 2023, the highest values were recorded in both the south and north branches of Ecorse Creek with 1 value reaching above 2000 µS cm^{-1}. Together this data suggests that Ecorse, Frank and Poet, Blakely, and Brownstown creeks have degraded macroinvertebrate communities. Supplemental macroinvertebrate sampling in these creeks has confirmed that all four creeks have highly degraded macroinvertebrate populations.

The ecoregion of these creeks contributes to some of these high conductivity concentrations, but extreme highs are likely caused by other factors such as anthropogenic influences. All 4 creeks drain highly urbanized residential areas in the Detroit metropolitan area. All creeks had conductivity values (19 total samples) in 2024 above the 95th percentile Huron-Erie Lake Plain stream reference value of 1107 µS cm^{-1} and 1 value topped the max biocondition criteria of 2000 µS cm^{-1}. Most of these values above 1107 µS cm^{-1} (16 of 19) equated to salinity values above the 1000 ppm freshwater threshold, but not chloride exceedances. Salinity exceedances varied from 1 to 5 (8 – 42%) occurrences between creeks with the north branch of Ecorse Creek experiencing the most exceedances. The occurrences of high salinity at most sites generally occurred during a single month, which may allow aquatic life to seek refuge during these periods of high salinity. The number of exceedances in the north branch of Ecorse Creek (ADW05) and Blakely Creek (ADW02), however, occurred throughout the monitoring season suggesting ecosystem degradation and transitions to slightly saline systems.

3.2.4 Summary of 2024 Conclusions, Recommendations, and Actions

Table 7. Detroit River Tributaries Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Concerning	Degraded, Likely Threats

In 2024, 59 water samples were collected from 4 tributaries of the Detroit River from April through October. Water quality exceedances were only observed for 3 of the 4 parameters measured: dissolved oxygen (27%), temperature (7%), and conductivity (100%). Brownstown Creek: ADW03 was the only creek that did not have occurrences of high temperatures that threatened aquatic life, and the south Branch of Ecorse Creek: ADW04 & ADW40 was the only creek that did not have occurrences of low DO. Results from these tributaries were similar to those reported in the 2023 LEBAF analysis, but there were more dissolved oxygen and temperature exceedances this year. While high conductivity is partially a natural phenomenon, extreme conductivity values and instances of low DO recorded in 2024 often corresponded to changes in stream flow following heavy rains or hot and dry periods further exacerbated by the flashiness of these four urban streams.

2024 conductivity values for all four streams tended to be much higher than the expected Huron-Erie Lake Plain ecoregion reference. The landscape that drains into these creeks does not resemble the natural landscapes of this ecoregion, but rather consists of large residential areas with some interspersed commercial and industrial locations. This shift in land use and the channelization of these streams drastically altered the flow regimes. Flashy flows with little or no baseflow increase physical weathering and land-based inputs of nutrients, pollutants and salts during storms and decreases or ceases flow between wet weather events. While most conductivity values in these streams are above 850 µS cm^{-1}, the highest conductivity value was recorded in mid-September after an extended period of no rainfall. On this same day, 3 exceedances of low dissolved oxygen occurred. About a month prior, when a rain event of ~1 inch occurred the conductivity values plummeted to below 650 µS cm^{-1} only to recover to their usual highs by the subsequent sampling. Again, this oscillation in conductivity values reflects how a pulse of stormwater can dilute the conductivity and the quick return to low base flow post storm allows conductivity to rise again. It also suggests potential groundwater conductivity contamination, such as from winter road salt applications, which is consistent with some of the calculated salinity values in these creeks.

Flashy flows also contributed to the DO exceedances. Low water levels with pools of stagnant water or slow flow can make streams more vulnerable to low DO. In fact, low base flow or stagnant conditions were associated with most DO exceedances in the Detroit River Tributaries. Brownstown Creek: ADW03, in particular, has very flashy flows with minimal baseflow which resulted in 8 exceedances of low DO between storm events. These low DO conditions may have been further exacerbated by high ambient air temperatures reported throughout the season. In fact, the National Oceanic and Atmospheric Administration (NOAA) reported that two thirds of days between May and August fell above historic norms for southeast Michigan. That said, temperature exceedances only occurred on April 30th after a monthly maximum air temperature of 27.8°C (82°F) was reached and it did not directly correspond to DO exceedances, perhaps because biological activity had not yet reached its peak. Seasonally high atmospheric temperatures can, however, influence precipitation, stream flow, and the dissolved gas saturation in water.

The altered flow regime of these urbanized creeksheds wreaks havoc on the ecosystems of these tributaries. While the ecosystems are healthy by LEBAF pH and temperature standards, the intermittent low DO and consistently high conductivity pose threats to aquatic life. Low DO did not pose a threat at the south Branch of Ecorse creek: ADW04 & ADW40 this year, but had in previous years. Low DO is also rare at Blakely Creek: ADW02. Aquatic life, however, is likely affected at Brownstown: ADW03, Frank & Poet: ADW39, and the north branch of Ecorse: ADW05 creeks due to some extended periods of low DO. All four creeks may become more vulnerable to low DO in the future as climate change increases the frequency of dry periods and low water levels. Conductivity values in all creeks also exceeded the LEBAF bio-condition suggesting that the macroinvertebrate communities are highly degraded. Further investigation into the sources of contaminants, such as nutrients and salts, contributing to these conductivity values is needed to help with restoration efforts. Additional data and analysis of these four creeksheds is available on HRWC's maps page and Wayne County results page.

3.3 Huron River

3.3.1 Monitoring Organizations: The Huron River Watershed Council (HRWC) is the only LEBAF organization monitoring the Huron River in Southeast Michigan and its tributaries. HRWC's Chemistry and Flow Monitoring Program was developed in 2002 as a response to community interest in increasing available data on nutrient contributions to the middle section of the Huron River Watershed. Over the years the Program has grown to include stations throughout the Chain of Lakes, middle, and lower sections of the Huron River.

3.3.2 Station Summary: HRWC staff and volunteers in the monitoring program collected data from 21 stations that were selected based on feedback from municipal stormwater partners, HRWC's biological monitoring program sites, likelihood of significant sub-watershed phosphorus loading based on modeling, and capturing the range of sub-watershed and upstream conditions. Of all stations, 5 stations are located within the main stem of the Huron River and 16 are in the tributaries near the confluence with the river. Most of these stations (2 main stem and 9 tributary sites) are situated in the middle section of the Huron River Watershed in Washtenaw County, Michigan. Another 6 sites (2 main stem and 4 tributary sites) are located in the upper-middle section of the watershed in Livingston County, Michigan downstream of the headwaters at Big Lake. The last 4 sites (1 main stem and 3 tributary sites) are in the lower section of the watershed in Wayne County, Michigan, with the main stem sampling location near the mouth of the river and confluence with Lake Erie.

The Upper-middle, Middle, and Lower Huron River Watershed sections fall within three distinctly different ecoregions and geological regions. The Upper-middle Huron falls mostly within the Southern Michigan/Northern Indiana Drift Plains (Ecoregion 56). The Middle Huron falls within the Eastern Corn Belt Plains (Ecoregion 55) and has bedrock composed of sandstone. The Lower Huron section, however, falls within the Huron-Lake Erie Plains (Ecoregion 57) and has bedrock composed of a mix of limestone and sandstone. These differences may contribute to some natural variations between sites. Further, each sub-watershed drains upstream areas with differing land use and cover. The Upper-middle sites drain land dominated by natural woodland and wetlands (4 sites) or agricultural land (2 sites). The Middle Huron sampling stations drain a variety of different dominating land uses with highly urbanized (4 sites), agricultural (3 sites), commercial (1 site), and natural woodland (3 sites) areas all represented within this section of the watershed. The Lower Huron sites drain primarily urban and suburban areas except for 1 tributary station that drains primarily natural woodlands.

The data presented in this report was collected every two weeks throughout the spring, summer, and fall of 2024. The data expands upon the 2023 LEBAF Field Season Report with measurements from the same 15 stations and 6 additional stations (2 main stem sites and 4 tributary sites in the Upper - middle Huron). The HRWC Chemistry and Flow Monitoring Program and Biological Monitoring Program collect additional data not reported here that provides further context for the interpretation of these results. That data is publicly available on HRWC's Maps Webpage.

3.3.3 Summary of 2024 Findings and Analyses

Table 8. Huron River Summary Statistics and Exceedances - 284 total samples, 21 stations

Summary Statistics and Exceedances Basin - Huron

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	964.41	823.00	382.00	2,358.00	284.00	283.00	99.65
Dissolved Oxygen	8.18	8.20	2.07	14.75	284.00	14.00	5.15
pH	8.19	8.21	7.58	8.73	284.00	0.00	0.00
Water Temperature	18.71	18.75	7.00	29.90	284.00	13.00	4.58

pH – Consistent with 2022 and 2023 findings, pH data collected in 2024 does not indicate any potential pH impairment in the Huron River based on the prescribed LEBAF standards.

DO – Of the 284 DO measurements in 2024, 14 measurements fell below the 5 mg L^{-1} DO aquatic life impairment threshold. Nine of these measurements were from sites screened for the first time using LEBAF standards including COL01, COL02B, HS01, and WC01. Many of these new exceedances occurred in the main stem of the Upper-middle Huron River at COL01 from mid-July through September. The consistent low DO at this site may affect aquatic life in this stretch of the river. The remaining five measurements that fell below the aquatic life standard were from tributaries in the lower-Huron watershed (ADW08 and ADW09). ADW08 had recurrences of low DO throughout the season in 2023 and 2024 with the lowest value near hypoxic levels (2 mg L^{-1}) this September. While there were more measurement violations in 2024 compared to the data collected in 2022 and 2023, the majority (95%) of DO values remained above the threshold or high enough to sustain aquatic life. Further most of these exceedances either were single occurrences or non-consecutive occurrences corresponding with hot and dry conditions with slow flow. The short duration of low DO events may allow aquatic life to seek refuge in the short-term and remain unharmed by the events.

Temperature – In 2024, the temperature threshold was exceeded 13 times in the watershed. This is many more exceedances than previous LEBAF reporting years, again due to the incorporation of six new sites this year. Most of the exceedances were single occurrences in the Upper and Middle sections of the watershed in the months of May and June when atmospheric temperatures were above average. The three sites that had two to three exceedances- HR03B, SO06, and BC01 - were all sites located just downstream of dammed reservoirs or outfalls from lakes. Maximum temperatures at these three sites reached 28°C to 29.9°C in June which are 1°C to 2.9°C above the prescribed warm water LEBAF standard for the month of June. Even still, more than 95% of all the water temperature data collected over the last year meets LEBAF seasonal temperature thresholds, which suggests the Huron River is not impaired due to temperature nor is it contributing to a potential Lake Erie temperature impairment.

Conductivity – Natural conductivity values differ between ecoregions and geological areas. While the Upper, Middle, and Lower Huron sections fall within three different ecoregions, all data are compared with the Huron-Erie Lake Plain ecoregion data because no data is available for Eastern Corn Belt Plain nor the Southern Michigan Drift Plains ecoregions. In 2024, conductivity values in the Huron River tributaries ranged from 382 to 2358 µS cm^{-1} with a 50th percentile value of 823 µS cm^{-1}. This median value is closer to the 75th percentile value of 778 µS cm^{-1} for Huron-Erie Lake Plain (HELP) streams reference. In fact, most sites have median values above the appropriate stream or river HELP 75th reference conductivity values across all three years of LEBAF analysis. Only two sites that drain primarily natural lands, Boyden Creek – BC01 and Woods Creek – ADW06, have consistently had median values at or near the HELP median values over the years. Huron River conductivity values had a smaller range between 470 µS cm^{-1} and 870 µS cm^{-1}, but again the median value of 769 µS cm^{-1} was above to the 75th percentile Huron-Erie Lake Plain river reference value of 744 µS cm^{-1}. This comparison with the ecoregion references shows some overlap with our dataset and provides some additional confidence in using our conductivity results. When our dataset strays above these references, it suggests that the variation in conductivity cannot only be explained by variation across ecoregions and suggests need for source identification and remedial strategy development.

LEBAF also uses a combined conductivity criteria for evaluating macroinvertebrate health: < 412 µS cm^{-1} promotes a healthy community, between 412 and 850 µS cm^{-1} suggests some concern for the community, between 851 and 2000 µS cm^{-1} indicates likely threats to the community, and >2000 µS cm^{-1} suggests the community is impaired. 283 of the 284 conductivity measurements in 2024 exceeded the healthy macroinvertebrate threshold of 412 µS cm^{-1}. The lower biocondition threshold of 412 µS cm^{-1} is below the 25th percentile reference values for Huron-Erie Lake Plain streams and river reference. Thus, it is expected that 75% of data collected in this ecoregion would exceed this threshold. A little more than half (159 samples) of Huron River and tributary conductivity measurements fell between 412 and 850 µS cm^{-1} and 38% (108 samples) were between 850 and 2000 µS cm^{-1}. These findings are consistent with 2022 and 2023 data, which found 98% and 100% of conductivity values were > 412 µS cm^{-1}, respectively. The maximum (2358 µS cm^{-1}) conductivity value in 2024 was slightly below the maximums recorded in 2022 and 2023 (2430 and 2610 µS cm^{-1}, respectively). Overall, this data suggests that most of the macroinvertebrate communities in the Huron River and its tributaries are degrading or impaired and macroinvertebrate sampling by HRWC corroborates this finding.

While natural influences may contribute to some of the observed high conductivity values, anthropogenic influences are likely causing the very high observations. A total of 60 measurements (21%) from tributaries of the Huron River (HS01, MH03, MH04, MH05B, MH07, MH08B, MH09, & ADW09) had conductivity values above 1107 µS cm^{-1}, the 95th percentile

Huron-Erie Lake Plain stream reference value. With 16 of those values falling above 2000 µS cm^{-1} impaired threshold. All the measurements above 2000 µS cm^{-1} were taken from sites (MH07, MH08B, MH09) draining highly urbanized creeksheds. Most of the measurements above 1107 µS cm-1 (54 of 60) equated to salinity values above the acceptable freshwater limit of 1000 ppm and measured chloride values in Millers: MH08B, Malletts: MH07, and Swift Run: MH09 creeks exceeded the 150 mg L^{-1} acute stress and 320 mg L^{-1} maximum on multiple occasions, despite calculated chloride values falling below these thresholds. Together this indicates that these urban streams may be approaching a change over to a slightly saline water system.

3.3.4 Summary of 2024 Conclusions, Recommendations, and Actions

Table 9. Huron River Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Acceptable	Degraded, Concern for Biota

Between April and October of 2024, HRWC measured pH, dissolved oxygen, temperature, and conductivity in 284 water samples collected from 21 sites within the Huron River and its tributaries. Water quality exceedances occurred for 14 dissolved oxygen, 13 temperature, and 283 conductivity measurements. Results in 2022 and 2023 were similar with slightly fewer exceedances for dissolved oxygen and temperature. The increase in exceedances for these two parameters is largely attributed to 6 new sites being evaluated this year. There were, however, additional temperature exceedances at sites previously evaluated. Consistent with previous findings, high conductivity values were influenced by the natural ecology and geology of the area and further exacerbated by the anthropogenic influence of urbanization and related pollutant sources. Extreme parameter values occurred most frequently in urbanized watersheds and often corresponded to changes in stream flow following heavy rains or hot and dry periods.

There were 5 dissolved oxygen exceedances at previously evaluated sites, Smith Creek: ADW08 and Silver Creek: ADW09, and 9 dissolved oxygen exceedances at new sites including Horseshoe: HS01, Woordruff: WC01, and Davis: COL02B Creeks and the main stem of the Huron at Hamburg Rd: COL01. The exceedances in the tributaries in the Lower Huron occurred most frequently at ADW08, which also had exceedances in 2023. ADW08 has very flashy flows that result in low dissolved oxygen during base flow after prolonged periods of hot and dry atmospheric conditions. Conversely, dissolved oxygen exceedances in the Upper Huron Watershed were tied to rain events. Most sites had a single exceedance that occurred on June 22nd during a rain event of ~0.5 inches during a particularly hot month. The main stem of the Huron at Hamburg Rd: COL01 had 5 more exceedances following this event as more rain caused the river to rise to the minor to moderate flood range and flow rates reached well above average for the months of July, August, and September. High water and high flow rates are often accompanied with excess sediments and organic pollutants that can influence the drawdown of oxygen. As climate change increases the frequency of weather extremes, dissolved oxygen exceedances may become more frequent and prolonged leading to ecosystem degradation in the Huron River and its tributaries.

2024 was the hottest year on record with atmospheric temperatures around the world averaging 1.5°C above average. Southeast Michigan was no exception with two thirds of days between May and August falling above historic norms according to the National Oceanic and Atmospheric Administration (NOAA). These high atmospheric temperatures can result in elevated water temperatures, especially in surface waters, like those observed in the Huron River Watershed. In 2024, the Huron River had 6 temperature exceedances at previously evaluated sites and 7 temperature exceedances at newly evaluated sites. Most sites had a single exceedance that occurred either at the end of May or end of June following multiple days of above average atmospheric temperatures in the region. These exceedances occurred at both tributary and main stem sites. The only sites with more than one temperature exceedance were situated directly downstream of a lake that likely corresponded with surface water releases from the lake into the streams or river. Lakes often become stratified during summer months with the warmest temperatures at the surface that can be further exacerbated by above average atmospheric temperatures. While temperature exceedances did not directly correspond to other parameter exceedances, seasonally high atmospheric temperatures do influence precipitation and stream flow which affected other parameter values.

The high conductivity values observed over the last three years are partially attributed to the ecoregion and geology of the Huron River watershed. As mentioned in this and previous reports, much of the Huron River watershed falls within an ecoregion for which the Ohio EPA does not have a reference. Our interpretation of this natural variation might be skewed by comparisons of upper-middle and middle-Huron data with the Huron-Erie Lake Plain reference values rather than the *Eastern Corn Belt Plain* and *Southern Michigan Drift Plains* ecoregions for which there is no reference data. Based on the geology of the region, it would be expected that conductivity would increase moving downstream both due to a shift in bedrock from sandstone to limestone and an increasingly larger drainage area. This trend holds true all three years in the river sites located on the main stem of the Middle and Lower Huron, but the main stem in the Upper Huron defies this trend. This may be due to the many lakes that separate the Upper-middle Huron sampling location from the Middle Huron Sampling location and act as natural settling basins that may remove chemicals and other pollutants added upstream. As for the tributaries, the highest tributary conductivity values are recorded in middle Huron creeks.

The extremely high conductivity values tend to correspond with increased urbanization. All the tributaries located in the middle-Huron with median conductivity values above 1000 $\mu S\ cm^{-1}$ over the last three years – MH07: Malletts Creek, MH08B: Millers Creek, and MH09: Swift Run – drain highly urbanized areas with flashy flows. The highest and lowest recorded conductivity values of 2358 and 382 $\mu S\ cm^{-1}$, respectively, were both observed at Swift Run (MH09), a site with extremely flashy flows. Consistent with the site's flashy flows, the highest values at this site were recorded during dry periods when the stream was fed largely by groundwater and the lowest value occurred after a July rain of over 0.5 inches when the stream was fed primarily by stormwater. Similar flashy flows in Malletts and Millers Creeks help to explain variations in their conductivity. Flashy flows may result in more weathering that could increase conductivity and contaminated groundwater can cause higher conductivity during baseflow. Calculated concentrations of chloride and salinity at these sites and other urbanized sites support the latter with road salt build up from winter applications, but further investigation is needed to fully understand all the chemicals and pollutants contributing to the high conductivity values.

Overall, the Huron River and its tributaries can support a healthy ecosystem based on the LEBAF standards for pH, DO, and temperature. Weather extremes, specifically periods of high heat and low precipitation and flood conditions, however, may cause intermittent periods of stress that cause aquatic life to relocate for short periods of time. Since the occurrence of these extreme weather events is expected to increase with climate change, parts of the Huron River may become more vulnerable to DO and temperature impairments in the future. Drier periods, or in extreme cases droughts, may further exacerbate high conductivity in streams causing macroinvertebrate communities to decline or in some cases become less heterogenous for a longer period of time. High conductivity is likely the result of anthropogenic influences from urbanization including increased or flashy flows, increased physical weathering, and the input of more contaminants from land such as nutrients, petrochemicals or salts. Calculated concentrations of salinity suggest some inputs of salts possibly from the application of road salts in urbanized areas during winter. Further investigations are necessary to fully characterize the contaminants and help restoration efforts, especially in the urbanized creeks of Malletts, Millers, and Swift Run. Additional information and data for these HRWC sites is available via HRWC's map webpage and Washtenaw County Results Page.

3.4 Maumee River & Subbasin Swan Creek

3.4.1 Monitoring Organizations: Currently, the only organization in the LEBAF Network monitoring the Maumee River Watershed and Subbasin Swan Creek Watershed is the Community Water Action Toledo (CWAT). CWAT aims to increase the understanding of water quality in Lake Erie tributaries and drive improvement of water quality across Northwest Ohio by aligning sampling protocols with LEBAF, harnessing the existing strengths of collective programs, and engaging a wide range of volunteers in citizen science. Participating members in 2024 included Metroparks Toledo, Partners for Clean Streams, the Toledo Zoo, and TMACOG. Monitoring began in 2023 and continued through 2024.

3.4.2 Station Summary:

Maumee River Main Stem - Monitoring, using the LEBAF protocol, began in 2023 at 6 stations on the Maumee (CWAT-6*+, CWAT-7*+, CWAT-8*+, CWAT-9, CWAT-10, and CWAT-11). Station

CWAT-6 is the most upstream site monitored, moving numerically downstream with CWAT-11 being the most downstream. Stations with an (*) have been monitored by Metroparks Toledo for macroinvertebrate data since 2021. Stations with an (+) have been monitored by ODNR Scenic Rivers for macroinvertebrate data during the 2024 season. Stations CWAT-9, CWAT-10 and CWAT-11 are within the lacustrine zone on the river and urbanized areas, with no buffers and residential or commercial adjacent land use. Stations CWAT-6 and CWAT-7 have primarily agricultural adjacent land use, with wooded buffers. Station CWAT-8 has agricultural and residential adjacent land use.

The Maumee River is 140 miles long and is the largest direct tributary to Lake Erie, draining parts of Michigan, Indiana, and Ohio. Most of the watershed (~ 73 %) is in Ohio, draining 5,024 square miles over 107.8 river miles. Monitored stations are all on the Lower Maumee. Land Use is dominated by row crop agriculture (75.82%).

Swan Creek Subbasin - All 2023 stations monitored on Swan Creek were upstream of the City of Toledo. In 2024, two stations (CWAT-14 and CWAT-20) within the City of Toledo were added to capture a broader picture of the watershed. Stations CWAT-13, CWAT-15, CWAT-18, CWAT-19, and CWAT-21 are all located within Oak Openings Metropark, a 5,000 acre preserve of natural lands and ecosystems managed by Metroparks Toledo and are the most upstream sites monitored. Stations CWAT-16 and CWAT-17 are in the middle of the monitored section of the stream, and have primarily residential and agricultural row crop adjacent land use, with wooded buffers. Station CWAT-12 is located in a preserve within an urban area. Swan Creek joins with the Maumee River in downtown Toledo. Overall, the land use in the Swan watershed is characterized by row crop agriculture (55%), although compared to the Maumee watershed as a whole, there are higher proportions of urban/residential (21%) and forest (18%) land use.

3.4.3 Summary of 2024 Findings and Analysis

Table 10. Maumee River Summary Statistics and Exceedances – 100 total samples, 6 stations

Parameter	Mean	Median	Min	Max	Sample Count	N Exceedance	% Exceedance
Conductivity Biocondition	574.91	560.00	247.50	1002	96	92	95.8
DO (mg/L)	9.65	8.92	5.07	22.15	94	0	0
pH	8.33	8.17	7.44	9.79	98	12	12.24
Water Temperature	21.49	22.25	8.80	34.70	96	19	19.8

Usable sample count varied per parameter. See text below for specifics.

Maumee River Main Stem

pH – There were 12 pH exceedances out of 98 samples (12.24%) observed. Exceedances occurred on June 15, June 20, July 26, August 9, August 14, September 9, October 18, and October 30. All exceedances were slightly above pH 9. 7 exceedances occurred at CWAT-8 Sidecut, 2 exceedances at CWAT-7 Farnsworth, 2 exceedances at CWAT-6 Providence and 1 exceedance at CWAT-9 Walbridge Park. Per Ohio EPA, alkalinity in the basin can be expected due to the geology of the watershed. Sidecut is located in the middle of sampled stations; given the lack of a difference between pH values observed at stations upstream versus downstream of this site, the high pH values observed at Sidecut likely reflect local site conditions. Sidecut sampling occurred in a side channel from the main stem of the Maumee River, where low-flow conditions are more common over the summer. Data collected do not indicate pH as a cause for concern for impairment in the Maumee River based on LEBAF standards.

DO – There were 0 exceedances out of 94 samples (0%) observed. 100% of the DO values recorded on the Maumee River during the 2024 season were within LEBAF standards; therefore DO levels in the river are expected to support aquatic life throughout most of the year.

Temperature – There were 19 exceedances out of 96 samples (19.8%) observed. Exceedances occurred on April 17, April 18, May 26, June 15, June 19, June 20, June 23, July 26, August 9, August 14, and September 19. Exceedances occurred at upstream and downstream locations. All exceedances were close to the threshold limit, only slightly above benchmark.

Conductivity - The Maumee River watershed falls in the Huron-Erie Lake Plain ecoregion, which serves as the reference for our observed values. In 2024, conductivity values in the Maumee River ranged from 247.50 to 1002 µS cm^{-1} with a 50th percentile value of 562 µS cm^{-1}. The median and maximum values are comparable to the 50th percentile value of 659 µS cm^{-1} and 95th percentile value of 1043 µS cm^{-1} for Huron-Erie Lake Plain rivers reference. This comparison with the ecoregion references shows good overlap with our dataset and provides additional confidence in using our conductivity results.

Conductivity results can be used to evaluate how well a stream supports aquatic life. The Ohio EPA sets conductivity thresholds of < 412 µS cm^{-1} to denote a healthy macroinvertebrate community, values between 412 and 655 µS cm^{-1} indicates a degrading macroinvertebrate community, and those > 655 µS cm^{-1} indicates a degraded community. In 2024, 4 out of 96 samples fell under 412 µS cm^{-1}, 76 out of 96 samples fell in the degrading range, and 16 out of96 samples were > 655 µS cm^{-1}. Overall, this data suggests that macroinvertebrate communities in the Maumee River are degrading or degraded. However, supplemental data collected by Metroparks Toledo and ODNR Scenic Rivers at 3 of the 6 sites suggest some resilience within the macros community. Calculated salinity and chloride parameters based on measured conductivity values, did not show any exceedances. The Maumee River watershed drains a heavily used agricultural area, with extensive field tiling and drainage system alterations. Nutrient pollution is a known issue within the watershed, and high conductivity values likely reflect some of that influence.

Table 11. Swan Creek Summary Statistics and Exceedances – 112 total samples, 10 stations

Parameter	Mean	Median	Min	Max	Sample Count	N Exceedance	% Exceedance
Conductivity Biocondition	597	605	219.1	1056	112	95	84.8
DO (mg/L)	7.29	7.28	1.33	12.01	109	10	9.17
pH	7.89	7.91	6.93	8.71	112	0	0
Water Temperature	20.60	21.9	8.3	26.8	112	7	6.25

Swan Creek Subbasin

pH – Data collected in 2024 do not indicate pH as a cause for concern for impairment in Swan Creek based on LEBAF standards.

DO – There were 10 exceedances out of 109 samples (9.17%) observed. Low readings occurred on May 22, July 31, August 12, August 30, September 11, and October 30. 5 exceedances occurred at CWAT-18 Oak Openings: Evergreen Lake. Additionally, 2 exceedances occurred at CWAT-19 Oak Openings: Beach Ridge. While 1 exceedance occurred at CWAT-15, CWAT-16, and CWAT-17. Overall, exceedances occurred throughout the sampling season at different stations. At CWAT-18 Oak Openings: Evergreen Lake had consecutive DO exceedances throughout the sampling season. DO varied as expected seasonally and temporally. Single exceedances at a site are likely more reflective of time of sampling rather than conditions on the stream. Low levels at CWAT-18 Evergreen Lake are likely reflective of low or stagnant water at the time of sampling, a reoccurring site-specific condition. Approximately, 91% of DO values recorded on Swan Creek during the 2024 season were within the LEBAF analytical benchmark of ≥5 mg L^{-1}.

Temperature – There were 7 temperature exceedances out of 112 samples (6.25%) observed. Exceedances occurred from May 21 through May 26, at CWAT-13, CWAT-14, CWAT-15, CWAT-16, CWAT-17, CWAT 18 and CWAT-20. Five of these sites are located within the Oak Openings Metropark, on headwaters or small stream catchments. Two sites are located further downstream on headwaters or small stream catchments. Upper level air temperatures were recorded at 90 degrees with high wind conditions. The measured water temperature exceedances are likely related to the abnormally hot conditions for the season and the susceptibility of smaller catchments to weather extremes. Given the constrained geographic and temporal nature of the measured exceedances, data collected do not indicate temperature as an impairment concern in Swan Creek.

Conductivity – The Swan Creek Subbasin of the Maumee River Watershed falls in the Huron-Erie Lake Plain ecoregion, which serves as the reference for our observed values. In 2024, conductivity values in Swan Creek ranged from 219 to 1331 µS cm^{-1} with a 50th percentile value of 597 µS cm^{-1}. The median and maximum values are comparable to the 50th percentile value of 653 µS cm^{-1} and 95th percentile value of 1107 µS cm^{-1} for Huron-Erie Lake Plain streams reference. While the collected maximum value exceeds the reference, this comparison with the ecoregion references shows good overlap with our dataset and provides additional confidence in using our conductivity results.

Conductivity results can be used to evaluate how well a stream supports aquatic life. The Ohio EPA sets conductivity thresholds of < 412 µS cm^{-1} to denote a healthy macroinvertebrate community, values between 412 and 655 µS cm^{-1} indicates a degrading macroinvertebrate community, and those > 655 µS cm^{-1} indicates a degraded community. In 2024, 17 out of 112 samples fell below 412 µS cm^{-1}, 58 out of 112 samples fell in the degrading range, and 37 out of112 samples were > 655 µS cm^{-1}. Overall, this data suggests that macroinvertebrate communities in Swan Creek are degrading or degraded. Upstream sites appeared to have lower average conductivity readings relative to downstream sites, with headwater sites in Oak Openings Metropark, a large natural preserve, having the lowest readings, and more urbanized sites downstream having the highest readings. Calculated salinity and chloride parameters based on measured conductivity values, did not show any exceedances. The Swan Creek watershed drains a heavily used agricultural area, with extensive field tiling and drainage system alterations upstream, and downstream runs through a heavily urbanized area with stormwater inputs. Nutrient pollution is a known issue within the watershed, and high conductivity values may reflect some of that influence.

3.4.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 12. Maumee River Main Stem Water Quality Summary

pH	***Temperature***	***DO***	***Conductivity***
Acceptable	Acceptable	Acceptable	Concern for biota, degrading

Table 13. Swan Creek Subbasin Water Quality Summary

pH	***Temperature***	***DO***	***Conductivity***
Acceptable	Acceptable	Acceptable	Concern for biota, degrading

Overall, 2024 data suggests that the Maumee River and Swan Creek support aquatic life based on LEBAF benchmarks for water temperature, pH, and DO. Persistently high conductivity values in the watershed are a cause for concern due to potential impacts on aquatic life, and based on

LEBAF standards both waterways are considered degraded with a concern for biota. We recommend continuing LEBAF monitoring to gain a better understanding of stream health and baseline conditions over time. The data collected this year reflects corresponding trend lines relative to the previous monitoring year. At sites that have local conditions with exceedances in a specific parameter (CWAT-18 & CWAT-19), we recommend increased monitoring where feasible, specific to the parameter of concern, and in response to climate events as reasonable. Additional DO monitoring for a 24-hour cycle and/or monitoring on consecutive days when an exceedance is noted is recommended. Monitoring for pH on consecutive days, multiple times a day, and/or capturing multiple locations within the channel is recommended. Lastly, for temperature, monitoring on consecutive days would be recommended.

At all sites where feasible and suitable, we recommend initiating macroinvertebrate monitoring several times during the sample season using ODNRs SQM method. Regular monitoring of the macroinvertebrate community, along with continued monitoring of conductivity per LEBAF standards, will expand understanding of the effect of conductivity in the watershed.

3.5 Ottawa River

3.5.1 Monitoring Organizations: Currently, the only organization in the LEBAF Network monitoring the Ottawa River/Ten Mile Creek Watershed is the Community Water Action Toledo (CWAT). CWAT aims to increase understanding of water quality in Lake Erie tributaries and drive improvement for water quality across Northwest Ohio through aligning sampling protocols with LEBAF, harnessing the existing strengths of collective programs, and engaging a wide range of volunteers in citizen science. Participating members in 2024 included Metroparks Toledo, Partners for Clean Streams, the Toledo Zoo, and TMACOG. Monitoring began in 2023 and continued through 2024.

3.5.2 Station Summary: LEBAF monitoring at 4 stations began in 2023. The most upstream site, CWAT-1, is located on Tenmile Creek, a headwater of the Ottawa River, in Sylvania, with urban/residential adjacent land use and grassy buffers. CWAT-2 and CWAT-4 are in the middle stretch of the monitored stretch of the stream, both located in parks and with wooded buffers, and urban/residential adjacent land use. CWAT-5 is within the zone of lacustrine influence, with no buffers and urban/residential adjacent land use. All but CWAT-1 are located in the city of Toledo. We combined analyses for Tenmile Creek and the Ottawa River. All summary information includes both Ottawa River and Tenmile sample results, referred to collectively as the Ottawa River throughout the remainder of the report.

3.5.3 Summary of 2024 Findings and Analysis

Table 14. Ottawa River Summary Statistics and Exceedances - 34 samples, 3 stations

Summary Statistics and Exceedances Basin - Ottawa River

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	784.06	828.50	9.40	1,485.00	34.00	29.00	85.29
Dissolved Oxygen	8.22	7.80	5.04	17.07	34.00	0.00	0.00
pH	8.17	8.01	7.73	9.55	34.00	2.00	5.88
Water Temperature	19.75	21.40	10.70	29.90	34.00	5.00	14.71

Table 15. Ten Mile Creek Summary Statistics and Exceedances - 11 samples, 1 station

Summary Statistics and Exceedances Basin - Ten Mile Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	802.24	928.00	12.00	1,431.00	11.00	8.00	72.73
Dissolved Oxygen	10.03	10.38	7.92	12.13	11.00	0.00	0.00
pH	8.19	8.25	7.74	8.37	11.00	0.00	0.00
Water Temperature	19.03	22.00	10.00	24.00	11.00	1.00	9.09

pH – Data collected in 2024 do not indicate pH as an impairment concern in the Ottawa River based on LEBAF standards.

DO – There were 0 exceedances out of 45 samples (0%) observed. Overall, DO varies as expected seasonally/temporally. 100% of DO values recorded on the Ottawa River during the 2024 season were within the LEBAF analytical benchmark of >=5 mg L^{-1}.

Temperature – 6 exceedances out of 45 samples (13.33%) were observed. Exceedances occurred on April 18, May 21, May 26, and July 21; 1 exceedance occurred at CWAT-1 Sylvania Northview, Ten Mile Creek, 1 exceedance occurred at CWAT-2 Wildwood Metropark, 2 exceedances occurred at CWAT-4 Ottawa Park, and 2 exceedances occurred at CWAT-5 Howard Pinkley Landing. These stations experienced air temperatures at or above average throughout the sampling season, including leading up to these sampling dates. The majority (~87%) of collected data fell within LEBAF standards, indicating that temperature is not an impairment concern on the Ottawa River in 2024.

Conductivity – The Ottawa River Watershed falls in the Huron-Erie Lake Plain ecoregion, which serves as the reference for our observed values. In 2024, conductivity values in the Ottawa River ranged from 120 to 1485 µS cm^{-1} with a mean value of 793.15 µS cm^{-1}. The mean and maximum values are higher than the 50th and 95th percentile values of 653 µS cm^{-1} and 1107 µS cm^{-1}, respectively, for Huron-Erie Lake Plain streams reference. The mean value observed is comparable to the 75^{th} percentile reference value of 778 µS cm^{-1}. This comparison with the ecoregion references shows some overlap with our dataset and provides additional confidence in using our conductivity results, but also suggests that the Ottawa River is exceeding and/or at the top end in comparison to reference streams for the ecoregion.

The Ohio EPA also sets a conductivity threshold for evaluating macroinvertebrate health: < 412 µS cm^{-1} promotes a healthy community, between 412 and 655 µS cm^{-1} suggests a declining community, and > 655 µS cm^{-1} indicates a degraded community. In 2024, 7/45 samples fell within an acceptable range, 10/45 samples falling in the degrading range, and 28/45 samples > 655 µS cm^{-1}. There was no clear upstream/downstream pattern to the exceedances, and no clear seasonal pattern. Salinity analysis, a calculated parameter based on directly measured conductivity values, indicated a 21% exceedance rate in the Ottawa River, with the highest exceedance rate at the most upstream station, CWAT-1. All sites measured on the Ottawa River fall within urbanized areas. Analysis of local weather data during the 2024 sampling season indicated that high salinity results coincided with prolonged dry periods abnormally high air temperatures leading up to the sampling date, with an onset of moderate to severe drought conditions in late July through the end of 2024. Overall, this data suggests that macroinvertebrate communities in the Ottawa River are primarily degraded, and that conductivity is a concern in the Ottawa River watershed.

3.5.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 16. Ottawa River Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Acceptable	Likely threat, impacts; Degraded

Overall, data collected in 2024 suggest that the Ottawa River supports aquatic life based on LEBAF benchmarks for pH and DO. Persistently high conductivity values in the watershed are a cause for concern due to potential impacts on aquatic life, and based on LEBAF standards the Ottawa River is considered degraded, with likely threats and impacts to ecosystems. We recommend continuing LEBAF monitoring, which will give a more complete picture of stream health and baseline conditions over time. At sites that seem to have local conditions with exceedances in a specific parameter (CWAT-4, CWAT-5), we recommend increased monitoring where feasible, specific to the parameter of concern, and in response to climate events when possible.

At all sites where feasible and suitable, we recommend initiating macroinvertebrate monitoring several times throughout the sample season using ODNR's SQM method. Regular monitoring of the macroinvertebrate community where possible, along with continued monitoring of conductivity per LEBAF standards, will expand understanding of the effect of conductivity in the watershed. For CWAT-1, CWAT-2 and CWAT-4 where multiple salinity exceedances were noted, increased monitoring at these locations should be considered, as well as direct sampling of salinity in addition to the calculated metric. Coordination with groups involved in research on salinity and chlorides in the watershed should also be explored.

3.6 Portage River

3.6.1 Monitoring Groups:

Currently, the only organization in the LEBAF Network monitoring the Portage River Watershed is the Community Water Action Toledo (CWAT). CWAT aims to increase understanding of water quality in Lake Erie tributaries and drive improvement for water quality across Northwest Ohio through aligning sampling protocols with LEBAF, harnessing the existing strengths of collective programs, and engaging a wide range of volunteers in citizen science. Participating members in 2024 included Metroparks Toledo, Partners for Clean Streams, the Toledo Zoo, and TMACOG. Monitoring began in 2023 and continued through 2024.

3.6.2 Station information:

LEBAF monitoring began in 2024 at 3 stations on the Portage River (CWAT-22, CWAT-23, and CWAT-24). Station CWAT-22 is the most upstream site monitored, moving numerically downstream with station CWAT-24 being the most downstream. Station CWAT-24 is within the lacustrine zone on the river and in an urbanized area in Oak Harbor; CWAT-23 is also in a residential/urbanized area. Station CWAT-22 is within a county park, with wooded buffers. The Portage River is 40 miles long and is a direct tributary to Lake Erie, draining 612 square miles. Monitored stations are on the Middle Portage River and Lower Portage River-Frontal Lake Erie sections of the river, with the latter section functioning as an estuary of Lake Erie, with widths up to 3000 ft. Similar to the adjacent, larger Maumee watershed, the Portage River is dominated by row crop agriculture (76%) with developed land accounting for approximately 11% of the watershed.

3.6.3 Summary of 2024 Findings and Analysis

Table 17. Portage River Summary Statistics and Exceedances- 28 samples, 3 stations

Summary of Exceedances by Waterbody and Parameter

Basin	Sample Run..	Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Portage	2024	Conductivity Biocondition	643.64	630.00	397.00	989.00	28.00	27.00	96.43
		Dissolved Oxygen	10.75	9.18	6.42	19.78	28.00	0.00	0.00
		pH	8.31	8.01	7.62	9.85	28.00	4.00	14.29
		Water Temperature	19.78	17.65	11.60	29.30	28.00	4.00	14.29

pH - 14% of samples (4 of 28) collected this season were above the LEBAF benchmark: this is below the 20% concern level. Exceedances occurred on July 20 at station CWAT-24 and July 27 at CWAT-23, and on August 24 at both sites. Overall, data collected in 2024 do not indicate pH as an impairment concern in the Portage River based on LEBAF standards.

DO – There were 0 exceedances out of 28 samples (0%) observed. Overall, DO varies as expected seasonally and temporally. 100% of DO values recorded on the Portage River during the 2024 season were within the LEBAF analytical benchmark of≥5 mg L^{-1}.

Temperature – There were 4 exceedances out of 28 samples (~14%) observed. Exceedances occurred on April 28 at all three sites (CWAT-22, CWAT-23, CWAT-24). On July 20, 1 exceedance occurred at CWAT-23. Both late April and early July experienced air temperatures well above average leading up to these sampling dates. The majority (~86%) of collected data fell within LEBAF standards, indicating that temperature is not an impairment concern on the Portage River in 2024.

Conductivity - The Portage River Watershed falls in the Huron-Erie Lake Plain ecoregion, which serves as the reference for our observed values. In 2024, conductivity values in the Portage River ranged from 630 to 989 µS cm^{-1} with a mean value of 643.64 µS cm^{-1}. The mean and maximum values are comparable to the 50th and 95th percentile values of 653 µS cm^{-1} and 1107 µS cm^{-1}, respectively, for Huron-Erie Lake Plain streams reference. This comparison with the ecoregion references shows some overlap with our dataset and provides additional confidence in using our conductivity results.

The Ohio EPA also sets a conductivity threshold for evaluating macroinvertebrate health: < 412 µS cm^{-1} promotes a healthy community, between 412 and 655 µS cm^{-1} suggests a declining community, and > 655 µS cm^{-1} indicates a degraded community. In 2024, 1 sample fell within an acceptable range, 16 out of 28 samples falling in the degrading range, and 11 of 28 samples > 655 µS cm^{-1}. There was no clear upstream or downstream pattern to the exceedances, and no clear seasonal pattern. Dominant land use in the watershed is agricultural, and all sampling sites are located in small towns. Salinity and chloride analyses showed no exceedances. Analysis of local weather data during the 2024 sampling season indicated prolonged dry periods and in some cases, abnormally high air temperatures during the sampling period, with drought conditions developing and worsening in late July onward in the counties where sampling sites are located. Overall, this data suggests that macroinvertebrate communities in the Portage River are primarily degraded, and that conductivity is a concern in the Portage River watershed.

3.6.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 18. Portage River Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*

Acceptable	Acceptable	Acceptable	Likely threats, impacts; Degraded

Overall, data collected in 2024 suggests that the Portage River supports aquatic life based on LEBAF benchmarks for pH, temperature, and DO. Persistently high conductivity values in the watershed are a cause for concern due to potential impacts on aquatic life. Based on LEBAF standards the Portage River is considered degraded with likely threats and impacts to ecosystems. We recommend continuing LEBAF monitoring, which will give a more complete picture of stream health and baseline conditions over time.

At all sites where feasible and suitable, we recommend initiating macroinvertebrate monitoring several times throughout the sample season using ODNR's SQM method. Regular monitoring of the macroinvertebrate community where possible, along with continued monitoring of conductivity per LEBAF standards, will expand understanding of the effect of conductivity in the watershed.

3.7 Mills Creek

3.7.1 Monitoring Organizations: One entity in the LEBAF network, Firelands Coastal Tributaries (FCT) Watershed Program, has monitored Mills Creek since 2011. Mills Creek is a 42.4 square mile watershed with headwaters that begin in the community of Bellevue and empties into Sandusky Bay on the west end of the City of Sandusky. Most of the watershed is rural/agricultural land use (67%) with more than a quarter being urbanized development and less than 7% natural area. The watershed is located within the karst geological region and has high interaction between the ground and surface water. The watershed has two large industrial discharges, one being a limestone quarry and the other a wastewater treatment plant. Both discharges occur in the upper portion of the watershed.

3.7.2 Station information: The FCT Watershed Program collected data from nine stations in the Mills Creek watershed. Two new sites were added in 2024 and one site was retired. Six stations are spaced from headwaters to mouth along the main channel, with one additional station in a tributary. The watershed is located in the Huron-Erie Lake Plain Ecoregion with unique karst geology. Data collection occurs mid-month from April to November; however, our last month of data was not used in the LEBAF analysis herein. Overall, 50 observations were made in 2024. Six observations could not be made during the sampling year due to dry conditions of certain sites at time of sampling.

3.7.3 Summary of 2024 Findings and Analysis

Table 19. Mills Creek Summary Statistics and Exceedances - 50 total samples, 8 stations.

Summary Statistics and Exceedances Basin - Mills Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	1,219.90	1,152.00	11.67	2,197.00	50.00	49.00	98.00
Dissolved Oxygen	8.87	8.24	4.98	17.45	50.00	1.00	2.00
pH	8.07	7.99	7.68	8.90	50.00	0.00	0.00
Water Temperature	18.11	18.90	6.50	25.20	50.00	3.00	6.00

pH - Consistent with findings from 2022 and 2023, pH data collected in 2024 was within the acceptable range throughout the sampling period, as we found 0% exceedances for this parameter. As such, we conclude that there is no indication of pH impairment in Mills Creek based on the prescribed LEBAF standards.

DO – A slight increase from 2022 and 2023, dissolved oxygen data collected in 2024 exceeded the threshold once during the sampling year but was still within the acceptable range. The exceedance occurred in September when stream base flow was lower than average due to drought-like conditions; however, the exceedance was not a significant departure from the threshold itself. Therefore, the current data suggests no indication of DO impairment in Mills Creek based on the prescribed LEBAF standards.

Temperature - Data collected in 2024 shows an increasing pattern of exceedances compared to 2022 and 2023, although the total exceedances for the year are within an acceptable range. Three exceedances occurred in May at sites lacking woody riparian cover. Daytime ambient air temperatures observed during sampling were ≈85°F, much higher than the historical average highs of ≈72°F. We feel the current data suggests no indication of Temperature impairment in Mills Creek based on the prescribed LEBAF standards.

Conductivity – Similar to 2022 and 2023, conductivity continues to show highly elevated values in Mills Creek compared to the Ohio EPA survey and reference datasets with an average of 1,219.9 µS cm^{-1} and a range from 509.8 to 2,197.0 µS cm^{-1}. The distribution of conductivity results provided some overlap between median and maximum values with the Ohio EPA reference stream and survey data. However, a comparison of medians suggests that Mills Creek tends to have a conductivity much higher than the Ohio data set. The limestone geology and high groundwater input within the watershed influence higher conductivity levels compared to other watersheds of similar size sampled by the Ohio EPA in the Huron-Erie Lake Plain Ecoregion. However, there is a marked difference at several sites in Mills Creek, where industrial discharges of quarry and wastewater treatment effluent enter the system. Stations immediately downstream of these industrial discharges experienced large departures compared to the Ohio data set.

A combined criteria for evaluating potential impacts of conductivity on macroinvertebrate health was developed as follows: < 412 µS cm^{-1} promotes a healthy community, between 412 and 850 µS cm^{-1} suggests a declining community, and > 850 µS cm^{-1} indicates a degraded community. All conductivity measurements in 2024 exceeded the healthy macroinvertebrate threshold of 412 µS cm^{-1}. Most measurements (92%, 46 samples) fell within 412 and 850 µS cm^{-1} and only 8% (4 samples) were > 850 µS cm^{-1}. The average conductivity in the stream indicates a degraded and threatened habitat, meaning impacts to aquatic life are probable.

Macroinvertebrate communities sampled in this watershed ranged from poor to excellent with the lowest score occurring at the site of highest average conductivity. The highest readings consistently occurred at headwater sites where drainage alteration for agricultural land use and small watershed size may play a role in the degraded community and conductivity metrics. No significant exceedances were found in calculated chloride or TDS; but salinity did have 50% exceedance. Since this parameter is calculated and not directly measured, it is not clear if salinity is the driver of high conductivity, because the limestone geology may be a greater factor. In 2024 the stream experienced both lower than average summer flows and excessive nutrients throughout the watershed, which may also be significant contributors to the degradation of stream biota.

3.7.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 20. Mills Creek Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Acceptable	Likely Threats, Impacts

Results from the 2024 sampling year suggest that Mills Creek has acceptable values to support aquatic life for temperature, pH, and dissolved oxygen. However, temperature exceedances increased for several sites lacking riparian cover. Those exceedances also occurred during a period with higher than normal spring ambient air temperatures. Conductivity continues to show elevated values compared to the Ohio EPA survey and reference datasets with an average of 1,219.9 µS cm^{-1} and a range from 509.8 to 2,197.0 µS cm^{-1}. The highest readings consistently occurred at the Strecker Rd West site, which is downstream of two permitted industrial discharge outfalls. Limestone geology and high groundwater likely contribute to elevated values; however, there is a marked difference for several sites on the mainstem and middle portion of the watershed downstream of the two industrial discharges. High conductivity in the stream suggests impacts on the aquatic biota, which is consistent with 2024 macroinvertebrate sampling results ranging from poor to good at most sites. No significant exceedances were found in calculated chloride, or TDS. Calculated salinity exceeded the threshold in 50% of the data. It is unlikely this parameter is a main driver of conductivity due to other factors like geology, low base flow, and sampling season being outside of road salting months. The stream experiences low summer flow at several headwater sites and excessive nutrients throughout the watershed, which may also contribute to the degradation of stream biota.

Conductivity appears to be the greatest concern for Mills Creek. As such, further exploration of these sites is recommended to determine factors that are increasing the conductivity and lowering aquatic biota. While most sites in the watershed exhibit acceptable values for supporting aquatic life for LEBAF parameters, we feel additional exploration into flow, nutrients, and sediment will reveal a more detailed look at stream health.

3.8 Pipe Creek

3.8.1 Monitoring Organizations: The Firelands Coastal Tributaries (FCT) Watershed Program has monitored Pipe Creek since 2008 and participated in the LEBAF analysis since 2022. Pipe Creek is a 48.5 square mile watershed that combines three separate direct tributaries: Pipe Creek, Hemminger Ditch, and Plum Brook. All three subbasins empty into East Sandusky Bay, which is located in the western basin of Lake Erie. The watershed is nearly equal in agriculture and urban land uses with less than 15% in natural areas. This watershed has the highest rate of urbanization with the highest development located at the lower portion of the watershed. The watershed also has two limestone quarry discharges and is part of the karst geological region.

3.8.2 Station Information: The FCT Watershed Program collected data from seven stations in the Pipe Creek watershed. Six stations are spaced from the headwaters to the mouth along the main creek channel, with one station located on a side tributary near the mouth. The watershed is located in the Erie-Huron Lake Plain Ecoregion with unique limestone/karst geology. Data collection occurs mid-month from April to November; however, our last month was not used in the LEBAF analysis. Overall, 49 observations were made in 2024.

3.8.3 Summary of 2024 Findings and Analysis

Table 21. Pipe Creek Summary Statistics and Exceedances - 49 total samples, 7 stations

Summary Statistics and Exceedances Basin - Pipe Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	939.02	829.00	8.67	1,996.00	49.00	48.00	97.96
Dissolved Oxygen	7.98	7.44	3.10	12.44	49.00	4.00	8.16
pH	7.94	7.98	7.49	8.79	49.00	0.00	0.00
Water Temperature	17.07	18.20	8.10	26.40	49.00	0.00	0.00

pH - Consistent with findings from 2022 and 2023, pH data collected in 2024 was within the acceptable range throughout the sampling period, as we found 0% exceedances for this parameter. As such, we feel there is no indication of pH impairment in Pipe Creek based on the prescribed LEBAF standards.

DO – Similar to 2022 and 2023, data collected in 2024 was within the acceptable range of DO with four exceedances occurring mostly in the summer months. Exceedances occurred at both headwater and downstream sites, which differs from past years where exceedances occurred only in headwater sites. As in the previous year, exceedances occurred during the summer months, at a time of elevated ambient air temperatures and low base flows due to lower than average precipitation. We feel the current data suggests no indication of DO impairment in Pipe Creek based on the prescribed LEBAF standards.

Temperature - Data collected in 2024 showed an improvement compared to 2022 and 2023 findings with no exceedances occurring in the sampling year. We feel the current data suggests no indication of temperature impairment in Pipe Creek based on the prescribed LEBAF standards.

Conductivity - Similar to 2022 and 2023, conductivity continues to show highly elevated values in Pipe Creek compared to the Ohio EPA survey and reference datasets with an average of 939.01 $\mu S\ cm^{-1}$ and a range from 604.0 to 1,996.0 $\mu S\ cm^{-1}$. Conductivity result distributions provided some overlap between median and maximum values with the Ohio EPA reference stream and survey data. However, a comparison of medians suggests that Pipe Creek tends to have a conductivity much higher than the Ohio data set. The limestone geology and high groundwater input within the watershed influences higher conductivity levels compared to other watersheds of similar size sampled by the Ohio EPA in the Huron-Erie Lake Plain Ecoregion. However, there is a marked difference at two sites, Oakland Ave and Perkins Ave. The highest readings consistently occurred at the Oakland Ave site, which is located on a small tributary to Pipe Creek within one mile of the quarry discharge. The Perkins Ave site, though located on the main channel and within the coastal zone of Lake Erie, is less than one mile downstream of Oakland Ave suggesting continued influence from the quarry discharge. Water levels were below base flow during this time of year, creating low flow and nearly stagnant water at Perkins Ave, which also could have been a factor in conductivity increase at the site.

A combined criteria for evaluating potential impacts of conductivity on macroinvertebrate health was developed as follows: $< 412\ \mu S\ cm^{-1}$ promotes a healthy community, between 412 and 850 $\mu S\ cm^{-1}$ suggests a declining community, and $> 850\ \mu S\ cm^{-1}$ indicates a degraded community. All conductivity measurements in 2024 exceeded the healthy macroinvertebrate threshold of 412 $\mu S\ cm^{-1}$. More than half (55%, 27 samples) of Pipe Creek's conductivity measurements fell between 412 and 850 $\mu S\ cm^{-1}$ and 47% (23 samples) were $> 850\ \mu S\ cm^{-1}$. The average conductivity in the stream indicates a degraded and threatened habitat, meaning impacts to aquatic life are probable.

The average conductivity at nearly all sites also suggests impacts on the aquatic biota, which is consistent with current macroinvertebrate sampling results of a fair rating at the Oakland Ave site. Other sites in the watershed not influenced by industrial discharges received good and excellent ratings. No significant exceedances were found in calculated chloride, salinity, or TDS. In 2024, the stream experienced extremely low summer flows at several locations throughout the watershed, creating disconnected pools and exposed limestone bedrock, which could have been a significant driver in conductivity increases compared to previous years.

3.8.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 22. Pipe Creek Water Quality Summary

pH	***Temperature***	***DO***	***Conductivity***
Acceptable	Acceptable	Acceptable	Likely threats, impacts

Results from the 2024 sampling year suggest that Pipe Creek has acceptable values to support aquatic life with no exceedances for temperature or pH, and few exceedances for dissolved oxygen. Conductivity continues to show elevated values compared to the Ohio EPA survey and reference datasets with an average of 939.01 $\mu S\ cm^{-1}$ and a range from 604.0 to 1,996.0 $\mu S\ cm^{-1}$. Limestone geology and high groundwater likely contribute to elevated values; however, there is a marked difference for the Oakland Ave site, which consistently has the highest levels compared to other sites in the watershed. The Oakland Ave site is on a small tributary to the Pipe Creek mainstem and is downstream of a permitted industrial discharge outfall from a local limestone quarry. The average conductivity in the stream also suggests impacts on the aquatic biota, which is consistent with the 2024 macroinvertebrate sampling result of a poor rating at the Oakland Ave site. Other sites in the watershed not influenced by industrial discharges received good and excellent ratings in comparison. No significant exceedances were found in calculated chloride, salinity, or TDS. The stream experiences low summer flows at several headwater sites and excessive nutrients throughout the watershed, which may also contribute to the degradation of stream biota.

Conductivity appears to be the greatest concern for Pipe Creek. As such, further exploration of these sites is recommended to determine factors that are increasing the conductivity and lowering aquatic biota. While most sites in the watershed exhibit acceptable values for supporting aquatic life using LEBAF parameters, we feel additional exploration into flow, nutrients, and sediment will reveal a more detailed look at stream health.

3.9 Sawmill Creek

3.9.1 Monitoring Groups: The Firelands Coastal Tributaries (FCT) Watershed Program in partnership with Bowling Green State University and Huron High School began monitoring Sawmill Creek in 2024. Sawmill Creek is a 14.3 square mile watershed that directly discharges at the transition of the western and central basins of Lake Erie. Land use in the watershed is mainly agriculture (60%), followed by nearly equal urban (19%) and natural areas (21%). The headwaters of the watershed begin in NASA plumbrook, a decommissioned TNT manufacturing and storage facility that operated during World War 2. The NASA site is a mixture of forest, wetland, and prairie habitat in an ongoing effort to remediate the site.

3.9.2 Station Information: The FCT Watershed Program partners collected data from three stations in the Sawmill Creek watershed. All three stations were located more downstream in the watershed due to the small drainage site and lack of safe monitoring access further upstream. Two stations are located on the mainstem of the creek, with one station located on a side tributary. The watershed is located in the Huron-Erie Lake Plain Ecoregion near the Erie-Ontario Lake Plain region and possesses both limestone and shale geology. Data collection occurred mid-month from April to October. Overall, 20 observations were made in 2024, one site was unable to be sampled due to low water.

3.9.3 Summary of 2024 Findings and Analysis

Table 23. Sawmill Creek Summary Statistics and Exceedances - 20 total samples, 3 stations

Summary Statistics and Exceedances Basin - Saw Mill Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	717.15	764.61	292.70	1,126.00	20.00	18.00	90.00
Dissolved Oxygen	6.70	6.66	2.44	9.93	20.00	2.00	10.00
pH	7.84	7.84	6.95	8.76	20.00	0.00	0.00
Water Temperature	19.03	20.23	3.07	27.20	20.00	4.00	20.00

pH - Data collected in 2024 was within the acceptable range throughout the sampling period, as we found 0% exceedances for this parameter. As such, we feel there is no indication of pH impairment in Sawmill Creek based on the prescribed LEBAF standards.

DO – Data collected in 2024 was within the acceptable range with two exceedances occurring at a single site (Bogart Rd) in September and October of the sampling year. Exceedance results were 2.4 and 3.78 mg L^{-1} respectively, both significantly below the threshold. The site is immediately downstream of two weir notched dams that create a small impounded pond that is less than ½ acre in size. The site is sampled in the morning when DO levels are typically lower. Lack of precipitation during late summer and early fall resulted in low water in the creek and stagnation of water in the pond. Additionally, organic material such as leaves and other natural debris may also enrich the water, increasing the consumption of oxygen overnight. We feel the current data suggests no indication of DO impairment in Sawmill Creek based on the prescribed LEBAF standards, but should continue to be monitored. If exceedances continue at this site, then increased sampling frequency will be warranted to understand the duration of the exceedance.

Temperature - Data collected in 2024 revealed four instances of temperature exceeding the threshold 20% of the sampling data. Two downstream sites, McBride and Bogart, exceeded the temperature threshold in spring and summer. With the exception of data collected at McBride in April, all other exceedances were only slightly over the threshold. While the Bogart Rd site is immediately downstream of a cemetery with little woody riparian cover, the McBride site represents an extensive woody riparian corridor. Above normal ambient air temperatures could have had a slight influence in exceedances during the summer months, but did not seem to be an issue for the April exceedance. We feel the current data suggests a possible impairment of temperature in Sawmill Creek based on the prescribed LEBAF standards.

Conductivity - Conductivity in Sawmill Creek provided some overlap with the upper range of Ohio EPA survey and reference datasets (see Section 2.2) with an average of 738.38 µS cm^{-1} and a range from 292.7 to 1,1260.0 µS cm^{-1}. Site averages were all above the 50th percentile conductivity value of 629 µS cm^{-1} from the Erie-Ontario Lake Plain headwater survey.

A combined criteria for evaluating potential impacts of conductivity on macroinvertebrate health was developed as follows: < 412 µS cm^{-1} promotes a healthy community, between 412 and 850 µS cm^{-1} suggests a declining community, and > 850 µS cm^{-1} indicates a degraded community. All conductivity measurements in 2024 exceeded the healthy macroinvertebrate threshold of 412 µS cm^{-1}. Nearly all (19 samples) of Sawmill Creek's conductivity measurements fell between 412 and 850 µS cm^{-1} and 5% (1 sample) was > 850 µS cm^{-1}. The average conductivity in the stream indicates a concern for biota, meaning there could be impacts to aquatic life. Bedrock in this watershed is mostly shale, but does have limestone in the headwaters, which can contribute to elevated conductivity. Additionally, it is possible that the elevated conductivity may be due to run-off coming from upstream agriculture land and NASA property. No significant exceedances were found in calculated chloride, salinity, or TDS. Monitoring of macroinvertebrates would help to determine if the aquatic community is degraded in Sawmill Creek.

3.9.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 24. Sawmill Creek Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Concerning	Acceptable	Concern for Bitoa

Results from the 2024 sampling year suggest that Sawmill Creek has acceptable values to support aquatic life with no exceedances for pH and dissolved oxygen. A concerning number of exceedances for temperature were observed in the downstream sites, which did not seem to be directly related to riparian cover (or lack thereof) or ambient air temperature. Most temperature exceedances were only slightly above the threshold, suggesting only a possible impairment to aquatic life. Conductivity shows elevated values compared to the Ohio EPA survey and reference datasets with an average of 738.38 µS cm^{-1} and a range from 292.7 to 1,1260.0 µS cm^{-1}. Geology and low water were identified as likely contributors to elevated values; however, potential run-off from the NASA site could also be a factor. Since 2024 was the first sampling year, we feel that a second year of data may be warranted before suggesting additional monitoring efforts.

3.10 Chappel Creek

3.10.1 Monitoring Organizations: Chappel Creek has been monitored by volunteers of the Firelands Coastal Tributaries (FCT) Watershed Program since 2022. Chappel Creek is a 24 square mile watershed that begins in Huron County and empties into Lake Erie's Central Basin between the City of Huron and the City of Vermilion. The land use of this watershed consists of 58% agriculture, 9% urban, and 33% natural area dominated by forest. The watershed is narrow with a narrow floodplain. Chappel Creek is on the US EPA's impaired waters list for not meeting aquatic life use due to excessive sediment, nutrients, and habitat alteration.

3.10.2 Station Summary: The Firelands Coastal Tributaries Watershed Program collected data from six sites in the Chappel Creek watershed. One site was moved less than one stream mile upstream due to construction blocking access to the site. The watershed crosses two distinct ecoregions: the Eastern Corn Belt Plains and Erie-Huron Lake Plain, with Berea sandstone and shale geology underlying the region. Data collection occurred mid-month from April to November; however, our last month was not used in the LEBAF analysis. Overall, 38 observations were made in 2024. Only two samples were not taken during the sampling year due to dry conditions at the site.

3.10.3 Summary of 2024 Findings and Analysis

Table 25. Chappel Creek Summary Statistics and Exceedances - 32 total samples, 6 stations

Summary Statistics and Exceedances Basin - Chappel Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	590.69	581.50	439.80	947.00	32.00	32.00	100.00
Dissolved Oxygen	7.64	8.36	1.09	13.30	32.00	8.00	25.00
pH	7.94	7.85	7.16	8.79	32.00	0.00	0.00
Water Temperature	16.91	18.10	8.00	25.40	32.00	0.00	0.00

pH - Similar to 2023, data collected in 2024 was within the acceptable range throughout the sampling period (0% exceedances), indicating that there is no pH impairment in Chappel Creek based on the prescribed LEBAF standards.

DO – Dissolved oxygen data collected in 2024 resulted in more exceedances compared to 2023. Three sites representing the upper watershed had DO concentrations that ranged from 3.0 to 4.6 mg L^{-1} when exceedances occurred. All exceedances occurred in summer and fall when base flow conditions were lowest due to below average rainfall in the summer months. The sites that experienced exceedances did differ in riparian cover and buffer width, suggesting immediate site conditions were not great factors affecting dissolved oxygen. With the headwater sites having continuous exceedances in DO, this suggests a possible impairment to the aquatic community based on LEBAF standards.

Temperature - Data collected in 2024 was within the acceptable range of temperatures and did not exceed thresholds, which shows an improvement from 2023.

Conductivity - Conductivity in Chappel Creek fell within the Ohio EPA survey and reference datasets (see Section 2.2) with an average of 590.69 µS cm^{-1} and a range from 372.00 to 670.00 µS cm^{-1} for Erie-Ontario Lake Plain headwater streams.

A combined criteria for evaluating potential impacts of conductivity on macroinvertebrate health was developed as follows: < 412 µS cm^{-1} promotes a healthy community, between 412 and 850 µS cm^{-1} suggests a declining community, and > 850 µS cm^{-1} indicates a degraded community. All conductivity measurements in 2024 exceeded the healthy macroinvertebrate threshold of 412 µS cm^{-1}. Nearly 97% (31 samples) of Chappel Creek's conductivity measurements fell between 412 and 850 µS cm^{-1} and 3% (1 sample) was > 850 µS cm^{-1}. The average conductivity in the stream indicates a concern for biota, meaning there could be impacts to aquatic life. Bedrock, which is dominated by sandstone and shale, should not contribute to elevated conductivity. It is possible that the elevated conductivity may be due to agriculture, which is the dominant land-use in the watershed. No significant exceedances were found in calculated chloride, salinity, or TDS.

3.10.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 26. Chappel Creek Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Acceptable	Concern for biota

Results from the 2024 sampling year suggest that Chappel Creek has acceptable conditions to support aquatic life with no exceedances for pH or temperature and small number of exceedances for dissolved oxygen. With the exception of dissolved oxygen, most results were similar to data collected in 2023.

Conductivity was comparable to the Ohio EPA survey and reference datasets with an average of 590.69 µS cm^{-1} and a range from 372.00 to 670.00 µS cm^{-1} for Erie-Ontario Lake Plain headwater streams. Conductivity appears to be a slight concern for Chappel Creek. Macroinvertebrate sampling in 2024 rated poor to excellent across the watershed with three of four sites monitored receiving a good or excellent score. Thorpe Rd, a site located mid-watershed and immediately downstream of the Ohio Turnpike, had both the highest average conductivity and the lowest macroinvertebrate score. Similar to other watersheds in this region, Chappel Creek experiences low summer flows and excessive nutrients and sediment throughout the watershed related to storm events. While most sites in the watershed exhibit acceptable values for supporting aquatic life for LEBAF parameters, additional exploration into flow, nutrients, and sediment would provide a more detailed look at stream health.

3.11 Old Woman Creek

3.11.1 Monitoring Groups: The Firelands Coastal Tributaries (FCT) Watershed Program is the only LEBAF organization that monitors Old Woman Creek. The FCT has monitored the creek since 2008. Old Woman Creek is a 27 square mile watershed that flows from the headwaters in Huron County through Erie County and empties into the west end of the central Lake Erie basin. The watershed begins as two branches that merge into a central channel upstream of a naturally functioning freshwater estuary. Land use in the watershed is mostly row crop agriculture (66%) followed by natural areas (20%) and rural development, with a small village at the center of the watershed. The watershed geology consists of shale and sandstone with the Berea Escarpment separating the upper and lower watershed at the Village of Berlin Heights.

3.11.2 Station information: The FCT Watershed Program collected data from 10 stations in the Old Woman Creek watershed. Station locations were in the east and west branches of the creek with one site located at the confluence that represents 83% the watershed's drainage basin. The watershed crosses two distinct ecoregions: the Eastern Corn Belt Plains and Erie-Huron Lake Plain, with Berea Sandstone and shale geology. Additional sites represent the estuary portion of the watershed, but are not included in this analysis since they are within the zone of lake influence. Data collection occurred mid-month from April to November; however, our last month was not used in the LEBAF analysis herein. Overall, 68 observations were made in 2024. Two observations could not be made during the sampling year due to dry conditions at the site.

3.11.3 Summary of 2024 Findings and Analysis

Table 27. Old Woman Creek Summary Statistics and Exceedances - 68 total samples, 10 stations

Summary Statistics and Exceedances Basin - Old Woman Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	644.63	614.00	280.00	1,108.00	68.00	67.00	98.53
Dissolved Oxygen	8.28	8.10	3.20	15.50	68.00	9.00	13.24
pH	7.95	7.98	7.35	8.70	68.00	0.00	0.00
Water Temperature	16.83	17.70	6.60	23.60	68.00	2.00	2.94

pH - Consistent with findings from 2022 and 2023, pH data collected in 2024 was within the acceptable range throughout the sampling period, as we found 0% exceedances for this parameter. As such, we feel there is no indication of pH impairment in Old Woman Creek based on the prescribed LEBAF standards.

DO – Although dissolved oxygen collected in 2024 was within the acceptable range for most of the sampling year, exceedances occurred at multiple sites during the summer months. In previous years, exceedances occurred at a headwater site during the summer at a time of higher than normal ambient air temperatures and low base flows in the stream. In 2024, exceedances were observed during July, August, and September at both headwater sites as well as mid-watershed sites on the western channel and were several mg L^{-1} below the threshold. Precipitation data showed below average rainfall in July. Each exceedance also represented observations made before noon. The importance of this suggests dissolved oxygen fluctuations may be extreme at these sites, which could indicate organic enrichment. While the current level of exceedances suggests no indication of DO impairment in Old Woman Creek based on the prescribed LEBAF standards, DO will continue to be closely monitored.

Temperature - A slight decrease from 2023 findings, temperature data collected in 2024 was still within the acceptable range for most of the sampling period, with the exception of two instances that occurred in May. Both exceedances were only one degree above the threshold. When exceedances occur, we typically observe them in headwater sites during the summer months. This is often due to higher ambient air temperatures and low stream flow. Although both sites represented shaded sections of Old Woman Creek, sampling took place in the late afternoon when air temperatures were highest compared to other observations that month. Additionally, air temperature associated with the exceedance events was in the high 70s, whereas the historical average May temperature is ≈65°F.

Conductivity – Similar to findings from 2022 and 2023, conductivity continued to show slightly elevated values in Old Woman Creek compared to the Ohio EPA survey and reference datasets with an average of 644.63 µS cm^{-1} and a range from 280.00 to 1,108.00 µS cm^{-1}. More than half of the samples did, however, fall within the 50th percentile of the value 629 µS cm^{-1} from the Erie-Ontario Lake Plain streams survey.

A combined criteria for evaluating potential impacts of conductivity on macroinvertebrate health was developed as follows: < 412 µS cm^{-1} promotes a healthy community, between 412 and 850 µS cm^{-1} suggests a declining community, and > 850 µS cm^{-1} indicates a degraded community. All but one conductivity measurement in 2024 exceeded the healthy macroinvertebrate threshold of 412 µS cm^{-1}. Nearly 92% (63 samples) of Old Woman Creek conductivity measurements fell between 412 and 655 µS cm^{-1} and 6% (4 samples) were > 850 µS cm^{-1}. The average conductivity in the stream indicates a concern for biota, meaning there could be impacts to aquatic life. Macroinvertebrate communities sampled in this watershed ranged from poor to excellent with the lowest score again occurring at the site of highest average conductivity. The highest readings consistently occurred at the most headwater site in the watershed where drainage alteration for agricultural land use and small watershed size may play a role in the degraded community and conductivity metrics. The second highest reading was observed immediately below an unsewered community.

3.11.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 28. Old Woman Creek Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Acceptable	Concern for biota

Results from the 2024 sampling year suggest that Old Woman Creek has acceptable values to support aquatic life with little to no exceedances for pH and temperature. Increased exceedances were noted in dissolved oxygen at several sites in summer and early fall. In previous years, exceedances occurred at a headwater site during the summer at a time of higher than normal ambient air temperatures and low base flows in the stream. In 2024, exceedances were observed during July, August, and September at both headwater sites as well as mid-watershed sites on the western channel and were several mg L^{-1} below the threshold. Precipitation data showed below average rainfall in July. Each exceedance also represented observations made before noon. The importance of this suggests dissolved oxygen fluctuations may be extreme at these sites, which could indicate organic enrichment.

Conductivity continues to show slightly elevated values compared to the Ohio EPA survey and reference datasets with an average of 644.63 µS cm^{-1} and a range from 280.00 to 1,108.00 µS cm^{-1}. The highest readings consistently occurred at headwater sites. The average conductivity in the stream indicates a concern for biota meaning there could be impacts to aquatic life. Macroinvertebrate communities sampled in this watershed ranged from poor to excellent, with the lowest score occurring at the site of highest average conductivity. No significant exceedances were found in calculated chloride, salinity, or TDS. The stream experiences low summer flows and excessive nutrients and sediment throughout the watershed related to storm events, which may also play a significant factor in degraded stream biota at some sites.

Conductivity appears to be the greatest concern at the headwater sites of Old Woman Creek; however, increasing dissolved oxygen exceedances are troubling. As such, further exploration of these sites is recommended to determine the extent and determine factors that are increasing the conductivity and lowering aquatic biota. While most sites in the watershed exhibit acceptable values for supporting aquatic life for LEBAF parameters, we feel additional exploration into flow, nutrients, and sediment will reveal a more detailed look at stream health.

3.12 Cuyahoga River

3.12.1 Monitoring Organizations:

Summit Soil and Water Conservation District (SSWCD), monitors three sub-basins within the Cuyahoga River basin, the Yellow Creek, Furnace Run, and Wingfoot Lake-Little Cuyahoga sub-basins. SSWCD does not monitor the mainstem directly, but provides a sub-basin analysis and potential implications for the Cuyahoga in this report. SSWCD provides leadership and advocates for the stewardship of our natural resources and responsible land use through the provision of education, technical assistance, and partnerships in Summit County, Ohio. SSWCD's stream volunteer monitoring program utilizes community members as citizen scientists to gather real-time data about their local watershed. During the 2024 monitoring season, data for the LEBAF network was successfully collected for 27 stations in three Cuyahoga River subwatersheds, Furnace Run, Yellow Creek, and Wingfoot, with the help of 30 volunteers. While none of SSWCD's monitoring locations are directly on the Cuyahoga River, inferences regarding the health of this large river can be made through the assessment of its subwatersheds.

Tinker's Creek Watershed Partners (TCWP) has monitored the Tinker's Creek and Brandywine Creek Subbasins in the past but did not contribute data to this year's report.

3.12.2 Station Summaries:

Yellow Creek - Yellow Creek is a basin of the Lower Cuyahoga River Watershed, located in the Erie Drift Plain ecoregion. This watershed is 1 of 26 named tributaries of the Cuyahoga River and is considered one of the most high-quality tributaries entering the Cuyahoga River. Yellow Creek is designated Warmwater Habitat and Primary Contact Recreational use per Ohio Water Quality Standards (OAC Chapter 3745-1). In 2024, 11 stations were monitored along Yellow Creek. Low to high density developed and impervious area is the predominant land use, covering almost 40% of the watershed. About 45% of the watershed is primarily mature deciduous and evergreen forest, and approximately 15% of the watershed is cultivated crop and pastureland.

Furnace Run - Summit Soil and Water Conservation District monitors 8 stations throughout the Furnace Run watershed. Stations are numbered sequentially from the confluence with the Cuyahoga River to the headwaters (i.e. FR1 is located at the confluence, while FR22 is in the tributary headwaters). Much of this watershed (32%) is protected lands that are managed by Summit Metroparks, Cleveland Metroparks, and the Cuyahoga Valley National Park. This watershed contains five valuable, cold water habitat streams and was recently given an EPA health score of 0.67 (scale of 0-1, with 1 being healthiest).

Wingfoot Lake - The Wingfoot Watershed is located along the southern edge of the Lake Erie Basin and has a drainage area of approximately 30.79 square miles (19,706 acres) across both Summit and Portage counties. This watershed contains one of the 26 named tributaries of the Cuyahoga River, the Little Cuyahoga. The eastern segment of the Wingfoot watershed is relatively undeveloped and consists of primarily rural/suburban with some agricultural land use areas and a few Industrial facilities in the Village of Mogadore; while the remaining portion of the Wingfoot watershed is mostly heavily developed and modified, impervious urban/industrial land. This watershed contains Springfield Lake - formerly a vacation destination, currently in non-attainment and prone to Harmful Algal Blooms. Samples from this watershed were included in this report for the first time in 2024.

Tinker's Creek and Brandywine Creek - Data from these sub-watersheds was not included in this year's report.

3.12.3 Summary of 2024 Findings and Analysis

Table 29. Cuyahoga River Summary Statistics and Exceedances - 360 total samples, 27 stations

Summary Statistics and Exceedances Basin - Cuyahoga

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	823.05	779.00	210.00	3,544.00	360.00	353.00	98.06
Dissolved Oxygen	8.09	8.08	1.03	13.16	360.00	27.00	7.50
pH	8.13	8.16	6.63	9.00	360.00	1.00	0.28
Water Temperature	18.50	19.55	7.50	28.80	360.00	48.00	13.33

Yellow Creek - ***166 samples, 11 stations***

pH - Measurements collected in Yellow Creek do not indicate a potential pH impairment based on LEBAF standards.

DO - There were 13 total exceedances in Yellow Creek across six sites. Five of these sites shared one low exceedance each, except YC2 which had two exceedances. YC13 recorded 8 low exceedances. This site has a small drainage area (20 square miles or less) and is downstream of Bath Pond's discharge location**.** While similar results were obtained in the 2023 season at YC13, the minimum reading obtained in 2024 (1.04 mg/L) is approaching hypoxic levels. This station should be given special attention to ascertain the potential causes of these DO exceedances.

Temperature - Yellow Creek measured 10 total high exceedances across eight sites. Each of these exceedances took place from 5/21 to 5/23 when temperatures in the area were 10 degrees higher than the historic average.

Conductivity - Conductivity data was compared to Ohio EPA reference and survey data with respect to ecoregion and stream size. While the Yellow Creek sampling stations are located within the Erie Drift Plain ecoregion, station data were compared to data for the Erie/Ontario Lake Plain ecoregion, as no data is currently available for the Erie Drift plain ecoregion. In 2024, headwater sites of Yellow Creek had conductivity values that ranged from 210 to 1339 µS cm^{-1}, with a 50th percentile value of 779.8 µS cm^{-1}. This median value is closer to the 70th percentile for headwater survey sites within the Erie/Ontario Lake Plain ecoregion. Conductivity values for the stream sites of Yellow Creek had a range between 210 µS cm^{-1} and 1339 µS cm^{-1}; however, the stream site median value (792 µS cm^{-1}) is closer to the 75th percentile for stream survey sites within the Erie/Ontario Lake Plain ecoregion.

The Ohio EPA also sets a conductivity threshold for evaluating macroinvertebrate health: < 412 µS cm^{-1} promotes a healthy community, between 412 and 655 µS cm^{-1} suggests a declining community, and >655 µS cm^{-1} indicates a degraded community. All 23 conductivity measurements from 2023 exceeded the threshold for a healthy macroinvertebrate community. All but 3 conductivity measurements from 2024 exceeded the threshold for a healthy macroinvertebrate community. The median conductivity value of 792 µS cm^{-1} suggests likely habitat degradation and impacts to the macroinvertebrate community. The data would suggest that aquatic life in the Yellow Creek tributary is degraded and likely impaired.

Macroinvertebrate data was collected by volunteers and staff at 7 of the 11 sampling stations during the 2024 field season using the Pollution Tolerant Index (PTI) assessment. Of these sites, 2 were rated "poor", 2 "fair", 4 "good", and 1 "excellent" with an average rating of 16 ("fair").
These results support the biocondition suggestion that macroinvertebrate communities in Yellow Creek are declining or degraded. Further analysis of macroinvertebrate communities is needed to determine if the community is stressed due to conductivity levels, or if other factors (like habitat condition) are affecting macroinvertebrate abundance and biodiversity.

Furnace Run - ***109 total samples, 8 stations***

pH - The pH data collected in 2024 does not indicate any potential pH impairments along the Furnace Run tributary based on LEBAF standards.

DO - A total of eight DO exceedances were observed across 4 sites, however, two sites have only 1 exceedance within 1 mg/L of the standard range, therefore, they are not of concern. The other 6 exceedances are in coldwater headwater streams (FR6 & FR13) and were within 1 mg/L of the standard range. Coldwater habitats should be habitats of focus because they support sensitive coldwater aquatic life. Lower DO can be associated with higher temperatures which these sites showed as indicated in the following section.

Temperature - In the 2024 season, 35 temperature exceedances were recorded across five monitoring stations in Furnace Run (FR1, FR2, FR6, FR7, and FR13). Of these, FR1 and FR2 experienced five exceedances in May, a month marked by record-high temperatures—10 degrees above historical averages. These exceedances coincided with elevated ambient temperatures and low flow velocities.

FR6, FR7, and FR13, classified as coldwater streams, exhibited exceedances on nearly every sampling date except in April and October. Most of these exceedances were within 1–3 degrees of the standard, though FR6 had multiple instances of greater variation. These coldwater streams are situated in suburban areas facing urban development pressures, nearby construction, proximity to roadways, and likely unhealthy backyard practices. Combined with the effects of climate change, these stressors pose significant threats to the thermal stability of these habitats.

With 32% of sampling events exceeding acceptable temperature limits, focused attention is required to evaluate the resilience of these coldwater streams to rising temperatures. Long-term monitoring and mitigation strategies will be critical to preserving these sensitive ecosystems.

Conductivity - Conductivity values for a given waterbody should ideally be compared to the standards of its region, given that conductivity values vary between ecoregions. All Furnace Run stations occur in the Erie Drift Plain ecoregion; however, as no data is available for this region, station data was compared to standards for the Erie/Ontario Lake Plain ecoregion. In 2024, conductivity values ranged from 300 to 3544 µS cm^{-1} with a 50th percentile value of 938.7 µS cm^{-1}. This median value is closer to the 90th percentile value of 942 µS cm^{-1} for the EPA Erie/Ontario Lake Plain stream survey.

The Ohio EPA also sets a conductivity threshold for evaluating macroinvertebrate health: < 412 µS cm^{-1} promotes a healthy community, between 412 and 655 µS cm^{-1} suggests a declining community, and > 655 µS cm^{-1} indicates a degraded community. With a more robust dataset for Furnace Run in 2024, trends and possible impacts will be better supported for protection and restoration activities within the watershed. All 109 conductivity measurements from 2024 exceeded the threshold for a healthy macroinvertebrate community. The median conductivity value of 938.7 µS cm^{-1} is less than the median conductivity of 2023, however, the data still suggests likely habitat degradation and impacts to the macroinvertebrate community. FR21 and FR22 returned values <412 µS cm^{-1}, which suggests that the aquatic life at these sites are healthy, functioning and in need of protection activities. The majority of FR sites (FR1,2,6,12,13) returned values in between 412–655 µS cm^{-1} which suggests that the aquatic life at these sites are degrading with a concern for biota. FR7 returned values above 655 µS cm^{-1} which would suggest that aquatic life in the Furnace Run tributary is degraded and is likely experiencing threats and impacts.

In response to the elevated conductivity values, chloride and salinity were also examined for this tributary. The EPA standard limit for chronic exposure to chloride is 150-320 mg L^{-1}. Except for stations FR7 and FR22, maximum chloride values were between the standard limit for chronic exposure with an average value of 164 mg L^{-1}. The stations with the consistently highest values, FR7 and FR22, are located near heavily modified terrain and returned an average value of 383 mg L^{-1}. FR6, FR13, FR21 all experienced once exceedance for salinity during the sampling season. FR22 experienced 60% exceedances with a high of 3388 mg L^{-1}, which is supported by poor macroinvertebrate data collection and should be considered a site of concern for future sampling. FR7 experienced 92% exceedances with a high of 1597.1 mg L^{-1}. FR7 should also be a site of concern due to exceedances over acceptable salinity values of 1000 ppm in 92% of their samples, indicating that this urban area may be approaching a change from fresh to brackish water systems.

Wingfoot Lake - *85 total samples, 8 stations*

pH - Measurements collected in Wingfoot Lake do not indicate a potential pH impairment based on LEBAF standards as zero exceedances were recorded in the 2024 season.

DO - During the 2024 season, two sites within the Wingfoot Lake watershed recorded exceedances: WF1 had one exceedance, while WF6 had five. Both sites are characterized by small drainage areas (20 square miles or less). The exceedance at WF1 was minor in magnitude and short-lived. At WF6, 75% of the samples (nine out of twelve) were collected during periods of minimal or no flow. The extremely small drainage area and the intermittent nature of this headwater stream make it especially vulnerable to reduced flow, which can intensify low dissolved oxygen conditions.

Temperature - Wingfoot Lake reported three total temperature exceedances in 2024, all of which occurred over a two week period in May. These exceedances occurred at times of elevated ambient temperatures; the temperatures throughout Northeastern Ohio during May of 2024 were frequently 10 degrees above historical averages. While the percentage of temperature exceedances (3.5%) is within an acceptable limit, special attention should be paid to stream resilience to assess their ability to withstand rising temperatures.

Conductivity - Conductivity values for a waterbody should ideally be assessed against regional standards, as conductivity naturally varies across ecoregions. All Wingfoot Lake monitoring stations are located within the Erie Drift Plain ecoregion. However, due to the lack of available data for this specific region, the station data was compared to the standards established for the neighboring Erie/Ontario Lake Plain ecoregion**.** In 2024, conductivity values ranged from 399 to 1430 µS cm^{-1} with a 50th percentile value of 664.8 µS cm^{-1}. This median value is closer to the 50th percentile value of 629 µS cm^{-1} for the EPA Erie/Ontario Lake Plain headwaters survey.

The Ohio EPA also sets a conductivity threshold for evaluating macroinvertebrate health: < 412 µS cm^{-1} promotes a healthy community, between 412 and 655 µS cm^{-1} suggests a declining community, and > 655 µS cm^{-1} indicates a degraded community. All conductivity measurements, except two, from 2024 exceeded the threshold for a healthy macroinvertebrate community. The median conductivity value of 1430 µS cm^{-1} suggests likely habitat degradation and impacts to the macroinvertebrate community. Additionally, as no site returned a value <399 µS cm^{-1}, the data would suggest that aquatic life in the Wingfoot Lake watershed is degrading and likely impaired.

During the 2024 field season, staff collected macroinvertebrate data at seven of the eight sampling stations using the Pollution Tolerant Index (PTI) assessment. Among these seven stations, 50% received a “fair” rating, while 25% were rated as “excellent.” These findings suggest that macroinvertebrate communities in the Wingfoot Lake watershed are experiencing decline or degradation. Further analysis is necessary to determine whether this decline is linked to elevated conductivity levels or if other factors, such as habitat conditions, are impacting macroinvertebrate abundance and biodiversity.

3.12.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 30. Yellow Creek Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Acceptable	Concern for biota

Overall, LEBAF standards for pH, temperature and DO suggest that the Yellow Creek tributary can support a healthy ecosystem, however, conductivity values for the creek are concerning. High conductivity measurements are likely the result of anthropogenic influences from urbanization. Urbanization and development can lead to various environmental challenges such as increases in pollutant availability, surface water runoff, peak flows, stream instability and flashiness. Calculated concentrations of salinity suggest conditions where evaporation may be high, or when road salt or wastewater may be present. Further investigations are necessary to fully characterize the contaminants contributing to these conductivity values. Additionally, this is the second season where DO values for YC13 are in exceedance. This station warrants special attention to investigate the potential causes, and possible mitigations, of these DO exceedances.

Table 31. Furnace Run Water Quality Summary

pH	***Temperature***	***DO***	***Conductivity***
Acceptable	Concerning	Acceptable	Likely threats

LEBAF standards for pH, and DO suggest that the Furnace Run tributary can support a healthy ecosystem, however 2024 results for temperature are concerning. As most of the temperature exceedances occurred in several high value, cold water habitats, it would be beneficial to conduct additional monitoring of these areas to assess if they are experiencing greater temperature variability relative to their warm water counterparts thereby affecting their DO concentration and ability to sustain life. As extreme weather events (e.g. elevated ambient temperatures and periods of extended drought) increase, parts of Furnace Run may become more vulnerable to systemic fluctuations in temperature, DO and pH. The high conductivity values observed are likely the result of anthropogenic influences in this system. Excessive inputs of nutrients, including chloride from nearby highways and nitrogen from highly manicured developments, is likely impacting this waterway. Furthermore, the equation used to calculate the chloride exceedances for Furnace Run uses the Cuyahoga River as a benchmark; as none of the monitored stations are situated on the Cuyahoga River but are in the Cuyahoga basin, it is possible that the calculations are not representative of chloride levels on the Furnace Run tributary.

Ongoing sampling in the coming years will be crucial for identifying trends and patterns within this waterbody. Building on the existing macroinvertebrate data during the 2025 season will provide deeper insights into the communities residing in this ecosystem and their tolerance to the monitored parameters.

Table 32. Wingfoot Lake Water Quality Summary

pH	***Temperature***	***DO***	***Conductivity***
Acceptable	Acceptable	Acceptable	Likely threats

Overall, LEBAF standards for pH, temperature, and dissolved oxygen indicate that the Wingfoot Lake watershed has the potential to support a healthy ecosystem. However, elevated conductivity levels raise concerns. These high measurements are likely linked to anthropogenic influences associated with urbanization, which can introduce environmental challenges such as increased pollutant loads, surface water runoff, higher peak flows, stream instability, and flashiness. Calculated salinity concentrations suggest possible contributions from elevated evaporation rates, road salt application, or wastewater inputs. Further investigation is needed to identify and fully characterize the contaminants driving these elevated conductivity values.

This sampling season offered SSWCD and LEBAF valuable insights into the Wingfoot Lake watershed; however, the limited dataset makes it challenging to draw definitive conclusions about the health of this Cuyahoga River watershed. Continued sampling in the coming years will be essential to identifying trends and patterns within this waterbody. Expanding upon current macroinvertebrate data into the 2025 season will further enhance understanding of the communities inhabiting this environment and their tolerances to the monitored parameters.

Combined Sub-basin Conclusion, Recommendations, and Actions for Cuyahoga River

Table 33. Cuyahoga River Tributaries Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Acceptable	Likely threats

While none of the monitoring locations in the Cuyahoga River watershed are located directly on the Cuyahoga River, inferences regarding the health of this large river can be made through the assessment of its subwatersheds. As such, this report is a summary of the subwatersheds within the Cuyahoga River, not the Cuyahoga River itself.

This sampling season provided valuable insight into the health of the Cuyahoga River watershed. However, as the Wingfoot Lake watershed was sampled for the first time in 2024, it is difficult to draw robust conclusions regarding the overall health of this area with such a limited data set. Overall, the Cuyahoga River basin can support a healthy ecosystem based on LEBAF standards for pH, temperature and DO. Many of the temperature exceedances for the basin occurred in valuable, cold-water habitats, during times of low baseflow and elevated ambient temperatures. These cold-water areas should be given special attention to assess their ability to withstand rising temperatures. DO exceedances for the basin occurred at times of low baseflow and elevated ambient temperatures, like many of the other exceedances. Flow appears to be a valuable indicator of stream quality and as such should be added as a quantifiable value in subsequent monitoring seasons. Currently, flow is estimated via observation of the monitor and therefore is subject to interpretation. By adding a more precise measurement of this variable, a more accurate understanding of factors relating to the exceedances will be obtained.

Even though average conductivity readings were markedly lower in the 2024 season compared to previous seasons (973 $\mu S\ cm^{-1}$ in 2023) they were still high throughout the basin with a 98% exceedance rate and an average value of 823 $\mu S\ cm^{-1}$ which may indicate a degraded aquatic community. These high conductivity measurements are likely the result of anthropogenic factors. Excessive use of chloride containing agents (e.g. road salt or nitrogen from fertilizer) can increase these values exponentially. It is advised that surface deicing protocols, both municipal and residential, be evaluated and education be provided on how to minimize this impact on our waterways. Additionally, the implementation of additional macroinvertebrate surveys in these sub-basins will provide a better understanding of these communities and their tolerance to the measured parameters.

3.13 Doan Brook

3.13.1 Monitoring Groups: The Doan Brook Watershed Partnership began monitoring Doan Brook in 2024. The Doan Brook is a direct tributary which flows from its headwaters in Shaker Heights and Cleveland Heights, down through Cleveland and out into Lake Erie. The watershed begins as three branches which merge into a central channel.

3.13.2 Station information: The Doan Brook Watershed Partnership (DBWP) and its volunteers monitored a total of 15 sites during the 2024 season. Sites were selected to be representative of Doan Brook, as well as to capture changes before and after major disturbances to the Brook's flow. Thus, there are sites at each of the Doan Brook's three initial branches, sites through the Doan Brook Gorge, and sites after the Doan Brook comes out of a culvert in the lower watershed. Of the total 15 stations sampled this year, only 7 were sampled throughout the entire season, with the remaining stations being added in May and June due to limited capacity setting up the program in April.

This year, Doan Brook Watershed Partnership used continuous data logging at 10 second intervals for 1 minute to collect data, which was then uploaded directly to Water Reporter. For this reason, the number of samples noted in Water Reporter reflects an artificially inflated figure. In order to correct for this issue, DBWP staff reviewed data for each station and selected 1 data point per site per sampling day. The single data points selected for each day were each representative of the data collected during the 1 minute interval. Using this data set with only one data point for each discrete sampling date, the summary statistics in Table 34 were recalculated.

3.13.3 Summary of 2024 Findings and Analysis

Table 34. Doan Brook Summary Statistics and Exceedances - 110 total samples, 15 stations

Parameter	Mean	Median	Min	Max	Sample Count	N Exceedance	% Exceedance
pH	8.11	8.12	6.70	9.48	110	4	3.64
DO (mg/L)	8.14	8.35	0.63	12.79	110	12	10.91
Temperature (°C)	19.65	20.65	10.30	32.7	110	11	10.00

Conductivity (uS/cm)	801.12	750.00	358.90	2174	110	107	97.27

pH - pH data collected tended to be within the acceptable range with only 3.64% exceedances. These exceedances occurred at site S3 on 5/16, 8/26, and 9/20, with readings of 9.44, 9.56 and 9.20 respectively, as well as at site R4 on 8/15 with a reading of 9.06. Site S3, which is located just after the dam at Green Lake, often sees many mallards and canada geese using the area adjacent to the dam. This, combined with the heavy urbanization and high impervious surface area may have contributed to pH exceedances. Site R4, on the other hand, is located downstream of multiple known combined sewer overflows which overflow frequently and may have contributed to exceedances.

DO – Dissolved oxygen data collected within the sampling period saw an exceedance rate of 10.91%, which is within the acceptable range. These exceedances occurred at M1 on 5/16, 7/18, 8/15, and 9,20, at site E on 6/21 and 8/26, at LL on 7/18 and 8/15, and at R5 and S6 on 6/20 and 7/18. These exceedances tended to occur during summer months during hot weather as most samples were taken around mid-day. Site M1, which saw the most DO exceedances and at one point measured a DO of 0.63mg/L, is located in a stretch of the stream with very low flow and a large amount of organic material which could have contributed to these low values. Another site, R5, is located just before the culvert that carries the Doan Brook under Route 90 and into Lake Erie. Thus, the low DO at this site could be influenced by low flow as a result of the site's proximity to the culvert. Factors influencing the remaining DO exceedances, particularly the DO exceedance at LL, located just after the Lower Lake Dam, remain unclear, and the partnership will continue to monitor these sites to better understand long term trends.

Temperature - Water temperature data collected was within the acceptable range, and had a 10.00% exceedance rate. These exceedances occurred at M1, G1 and G2 on 4/29, at HS1 on 5/16 and 6/21, at LL on 5/17 and 6/24, at R4 on 4/30, and at S3 on 5/16, 6/21, and 8/26. Of the 7 sites that saw exceedances, 3 of the sites are located directly downstream of dammed lakes which likely contributed to temperature exceedances at these sites. Additionally, measurements were often taken at midday when the air temperature was highest, which could in part contribute to temperature exceedances.

Conductivity - Conductivity saw the highest exceedance rate, with 97.27% of data collected above 412 uS/cm. This high rate of exceedances puts this parameter in the degrading range. While the median reading for all sites was 750.00 uS/cm which is considered a concern for biota according to the average conductivity general recommendation guidance, the maximum reading attained was 2174.00 uS/cm at M1, with sites HS1, HS2 and M1 reporting the highest median conductivity readings of 868.00, 1063.00 and 977.00 uS/cm respectively. These median conductivity readings indicate there are likely threats and impacts to biota due to the high conductivity at these sites.

The high exceedance rate for conductivity, which aligns with Ohio EPA reference survey data, is cause for concern. As this is the first year of data collection, and conductivity exceedances appear to be high across the region, factors influencing these exceedances remain unclear. The partnership will continue to monitor conductivity exceedances across sampling sites, with special attention to HS1, HS2, and M1 as these sites reported the highest median conductivity readings.

3.13.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 35. Doan Brook Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Acceptable	Acceptable	Degraded, Concern for biota

Based on data collected during the 2024 sampling season, pH, temperature and dissolved oxygen were all within the acceptable range, with less than 20% exceedances across sampling sites. Conductivity, on the other hand, is degraded with a 97.27% exceedance rate. Given that the brook is fairly shallow throughout much of its length, has a number of well documented combined sewer outflows that regularly overflow in addition to leaky pipes, a large impervious surface area, and is located in a highly urbanized region, these conductivity exceedances are not unexpected. Further, these findings are supported by their alignment with the EPA reference data for the Erie Ontario Lake Plain ecoregion.

Moving into 2025, Doan Brook Watershed Partnership will closely monitor sites S3 and LL, which had exceedances in multiple parameters, as well as conductivity exceedances at G2, HS1, HS2 and M1 and across the watershed as we continue to establish baseline data for these recently created sampling sites.

3.14 Buffalo River

3.14.1 Monitoring Organizations: Buffalo Niagara Waterkeeper (BNW) is the only organization in the LEBAF network that monitors the Buffalo River. Buffalo Niagara Waterkeeper is an organization based in Buffalo NY, whose mission is to protect and restore the Niagara River/Lake Erie watershed and surrounding ecosystems for the benefit of current and future generations.

3.14.2 Station Information: Buffalo Niagara Waterkeeper stewards three sites sampled once a month from May - October. Data from 2020 through 2023 are available for the Buffalo River at Bailey Peninsula (BR05 - Coordinates: 42.861629, -78.825641) site. Data from 2014 through 2023 are available for the Buffalo River at Riverfest Park (BR02 - Coordinates: 42.870881,

-78.871138) site. Data from 2014 through 2020, as well as a partial data set for 2023 are available for the Buffalo River at Canalside (BR01 - Coordinates: 42.87588, -78.8791) site. All sites were sampled monthly May - October between 9 am and 1 pm.

Buffalo River at Canalside (BR01) is located approximately a half mile upstream of the mouth of the Buffalo River, which feeds directly into Lake Erie. There is one Combined Sewer Overflow (CSO) which outflows into the Buffalo River approximately 467 feet downstream of this site, and one approximately a quarter mile upstream of the site. This location is an extremely popular location for recreational and commercial boats, and business. It is located in a heavily commercial district of downtown Buffalo, nearby many restaurants, offices, attractions, and historic landmarks. Historically, this river was used to transport commercial goods. Many commercial and recreational vessels still utilize the docks at this location, and navigate the nearby city ship canal by passing by this site. It is a half mile downstream from the nearest monitored Buffalo River site (BR02).

Buffalo River at Riverfest Park (BR02) is approximately 1 mile upstream of the mouth of the Buffalo River, which feeds directly into Lake Erie. There are multiple Combined Sewer Overflow (CSO) locations upstream and downstream of this site, and is a popular location for both recreational and commercial boats, fishing, and business. It is near a residential area and a contemporary General Mills factory. Before flowing into the lake, the Buffalo River passes a constructed ship canal.

Buffalo River at Bailey Peninsula (BR05) is located near the confluence of the Buffalo River and Cazenovia Creek, approximately 5 miles upstream of station BR02, and 6 miles upstream from the mouth of the river. There are multiple Combined Sewer Overflow (CSO) locations upstream and downstream of this site, including one located on the Bailey Peninsula. It is a popular location for fishing, kayakers, and is close to a busy road. This peninsula experiences regular ice jams during winter months, and is upstream of active industry including a Tesla factory, and multiple vehicle workshops. It is downstream of a residential area and some commercial businesses.

3.14.3 Summary of 2024 Findings and Analysis

Table 36. Buffalo River Summary Statistics and Exceedances* - 18 total samples, 3 stations.

Summary Statistics and Exceedances Basin - Buffalo

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	412.02	415.25	301.40	603.60	18.00	9.00	50.00
Dissolved Oxygen	8.19	8.14	5.08	10.44	18.00	0.00	0.00
pH	7.89	7.86	7.57	8.39	18.00	0.00	0.00
Water Temperature	21.05	20.89	15.04	26.97	18.00	0.00	0.00

** TDS/DW statistics are included due to high frequency of exceedances*

pH - During the 2024 sampling season, 100% of pH values recorded on the Buffalo River fell within the LEBAF standards of 6.5 – 9, supporting its potential to sustain aquatic life. Throughout the 2024 sampling season, pH values remained within expected ranges and were consistent with 2023 measurements at all three monitored locations along the river.

DO – During the 2024 sampling season, 100% of dissolved oxygen (DO) values recorded on the Buffalo River met the LEBAF benchmark of ≥5 mg L^{-1}, indicating that DO levels supported aquatic life on all sampled dates and times. Comparatively, the 2023 season saw 93.3% of DO values meeting the benchmark, with a single recorded exceedance on July 15th at station BR02, where the DO level was 4.76 mg L^{-1}. This exceedance was not severe and was attributed to BR02's proximity to the river's mouth, making it more susceptible to lacustrine dynamics. The 2024 season showed improvement, with no exceedances observed, highlighting stable and favorable conditions for aquatic life.

Temperature - 100% of temperature values recorded on the Buffalo River during the 2024 season were within LEBAF analytical benchmarks, indicating that water temperatures consistently supported aquatic life on sampled dates and times, with no exceedances this year. In 2023, a single exceedance was recorded on October 5th at station BR02, likely influenced by unseasonably high ambient air temperatures at the start of October. Temperature measurements in 2024 remained within expected ranges, displaying similar maximum, mean, and minimum values to those in 2023 and 2022, despite the previous year’s single exceedance.

Conductivity - The Ohio EPA also sets a conductivity threshold for evaluating macroinvertebrate health: < 412 µS cm^{-1} promotes a healthy community, between 412 and 655 µS cm^{-1} suggests a declining community, and > 655 µS cm^{-1} indicates a degraded community. Conductivity values recorded along the Buffalo River in 2024 fell roughly between the Ohio EPA reference and survey data, with about 50% of collected data falling below the 50^{th} percentile data for both reference and survey data. On average, conductivity values were lower at both reference and survey sites. The average conductivity value for the three stations along the Buffalo River was 412.02 µS cm^{-1}, with 9 out of 18 samples ranging from 436.8 to 603.6 µS cm^{-1}, placing the river in the “concern for biota” category per LEBAF guidelines, indicating potentially stressful conditions for macroinvertebrate communities. The remaining 8 samples ranged from 301.4 to 393.7 µS cm^{-1} . Despite the reduced frequency of conductivity exceedance events in 2024 along the Buffalo River, conductivity exceedances continue to be the primary issue for this river, as was the case in 2022 and 2023. Highly developed land use and prevalent industry along the river likely contributes to consistent conductivity exceedances at these sites.

Four of the twelve samples from BR01 and BR02 exceeded 412 µS cm^{-1}, with low level exceedances at both sites occurring in August and October. This suggests a potential to support a healthy macroinvertebrate community along the lower reaches of the river. Conversely, five out of six samples from BR05 exceeded 412 µS cm^{-1}, with the highest reading recorded in October at 603.6 µS cm^{-1}. Although exceedances are frequent, they generally remain within the "concern for biota" range rather than reaching extreme levels. Monthly variability in conductivity could be influenced by lake dynamics and additional pollution inputs. Conductivity tends to be higher during winter and spring due to runoff from road salts, and high-flow or storm events can lead to spikes due to urban or wastewater runoff. Seasonal factors such as the area's limestone bedrock, commercial and industrial discharges, and recreational or commercial boating activities could further impact conductivity throughout the year.

Limited data is available to determine overall health and heterogeneity of macroinvertebrate communities in the Buffalo River. Sampling of macroinvertebrate communities at all of these sites, and potentially other locations along the river as an additional LEBAF standard, or through cooperation with New York State Department of Environmental Conservation's Watershed Assessment by Volunteer Evaluators program (NYS DEC WAVE) could support future assessments. Other surrogate parameter measurements for salinity, chloride, and TDS/AQ Life do not provide additional context to the exceedances, but analysis of additional metadata might shed light on the source of the exceedances.

All TDS values recorded along the Buffalo River in 2024 met the aquatic life standard for TDS of 1500 mg L^{-1}. Measurements at station BR02 in June and September, as well as at station BR05 in August, and BR01 in September were even below the drinking water standard of 200 mg L^{-1}. TDS remained consistent throughout the sampling period at both BR01, BR02 and BR05. This suggests no abnormal contamination occurred. On average, TDS concentrations observed in 2024 were on average lower than those measured in 2022 and 2023.

3.14.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 37. Buffalo River Water Quality Summary

pH	***Temperature***	***DO***	***Conductivity***
Acceptable	Acceptable	Acceptable	Concern for Biota

Results from the 2024 sampling year suggest that the Buffalo River has generally acceptable conditions for supporting aquatic life. Compared to the infrequent and minor exceedances in temperature and dissolved oxygen along the river in 2023, values for these parameters fell within LEBAF benchmarks for 100% of samples. Based on these parameters, as well as pH, all values for which also fell within LEBAF benchmarks, no systemic threats to aquatic life along the river are suspected. Previous exceedances for temperature are suspected to have been driven by ambient air temperature, and potential lacustrine dynamics. Additional sampling at increased frequency, various times of day, and at additional sites could shed light on broader patterns and potential problem areas. Conductivity values were roughly comparable to the Ohio EPA survey and reference datasets with an average of 412.02 µS cm^{-1}. 9 of 18 samples fell between 412 and 655 µS cm^{-1}, placing the river in the 'concern for biota' category as outlined by LEBAF. This parameter continues to be a point of concern for Buffalo River, and concentrations measured in 2024 are comparable to measurements made in 2023. Of the 9 exceedances, 5 occurred at one site, BR05. The four remaining exceedances were split evenly between BR01 and BR02, occurring at low magnitude during both August and October. Consistent exceedances throughout the year at BR05 are likely due to the location of the site, and its proximity to both legacy and contemporary industry, as well as a densely populated residential area. The other 50% of readings across all three sites fell below the 412 µS cm^{-1} benchmark for an 'excellent/healthy' status for the river. Exceedances regularly fell within the range of 'concern for biota', rather than spiking dramatically. Lake dynamics and other pollution inputs could affect measurements on a monthly basis. Conductivity can be expected to be higher in winter and spring months due to runoff from road salts. High flow/storm events can cause spikes in conductivity due to increased runoff from urban, agricultural, or wastewater input sources. Additional factors including limestone bedrock, commercial and industrial inputs, and recreational/commercial boaters could influence conductivity on a seasonal basis.

Limited data is available to determine overall health and heterogeneity of macroinvertebrate communities in the Buffalo River. Sampling of macroinvertebrate communities at all of these sites, and potentially other locations along the river as an additional LEBAF standard, could support future conclusions. Other surrogate parameter measurements for salinity, chloride, and TDS/AQ Life do not provide additional context to the exceedances, but analysis of additional metadata might shed light on the source of the exceedances.

For all parameters, additional sampling at increased frequency, various times of day, and at additional locations is recommended. Any exceedances that are severe should warrant follow-up sampling and investigation when possible. Collection of additional metadata, including flow, nutrients, and sediment data, and the exploration of surrogate parameter measurements could help shed light on any future exceedances, and guide conclusions for LEVSN.

3.15 Eighteenmile Creek

3.15.1 Monitoring Organizations: Buffalo Niagara Waterkeeper (BNW) is the only organization in the LEBAF network that monitors the Eighteenmile Creek basin. Buffalo Niagara Waterkeeper is an organization based in Buffalo NY, whose mission is to protect and restore the Niagara River/Lake Erie watershed and surrounding ecosystems for the benefit of current and future generations.

3.15.2 Station information: Buffalo Niagara Waterkeeper has three stations that are monitored once per month from May - October between 10am and noon along Eighteenmile Creek. Historical data from 2017 through 2023 are available for both Eighteenmile Creek at Old Lakeshore Road (EMC01 - Coordinates: 42.712208, -78.966392) and Eighteenmile Creek at Gowanda State Road Bridge (EMC03 - Coordinates: 42.706475, -78.849177). A partial data set from 2023 is available for Eighteenmile Creek at Hobuck Flats Fishing Site (EMC07 - Coordinates: 42.699764, -78.940639).

Eighteenmile Creek at Old Lake Shore Road Bridge (EMC01) is approximately a half mile upstream of the mouth of the creek, which feeds directly into Lake Erie. It is located south of the city of Buffalo in Derby, NY. This creek is fast moving, cool, and can be affected by lake seiche events, heavy agricultural use, and upstream runoff. There are no nearby Combined Sewer Overflows (CSOs), although the upstream agriculture and its popularity as a boating, fishing, and recreation site could affect parameter measurements. This site is close to a residential area.

Eighteenmile Creek at Gowanda State Road Bridge (EMC03) is located approximately 9.77 miles upstream of the previous station, and south of the city of Buffalo in the town of Hamburg. This station is near a cemetery, a busy commercial district, and along a busy state road, all of which could affect parameter measurements. Heavy agricultural use and runoff upstream of this site could also affect measurements.

Eighteenmile Creek at Hobuck Flats Fishing Site (EMC07) is located between the previous two sites, approximately 2.25 miles upstream of EMC01 and 7.5 miles downstream of EMC03. It is about 3 miles upstream of the mouth of the creek. It is located south of the city of Buffalo in the town of Derby, and is a popular fishing location. It is located near the residential hamlet of North Evans, NY. There are no nearby Combined Sewer Overflows (CSO), but upstream agriculture, a nearby cemetery, and two heavily trafficked highways in close proximity to this site could affect parameter measurements.

Buffalo Niagara Waterkeeper monitors two additional sites along Eighteenmile Creek, but due to incomplete datasets, they are not included in the 2024 analysis and report.

3.15.3 Summary of 2024 Findings and Analysis

Table 38. Eighteenmile Creek Summary Statistics and Exceedances* - 18 total samples, 3 stations.

Summary Statistics and Exceedances Basin - Eighteenmile Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	559.88	580.20	365.40	648.70	18.00	15.00	83.33
Dissolved Oxygen	9.79	9.51	8.33	12.82	18.00	0.00	0.00
pH	8.09	8.12	7.83	8.29	18.00	0.00	0.00
Salinity	455.77	473.23	286.17	534.31	18.00	0.00	0.00
Water Temperature	19.22	20.27	6.91	27.38	18.00	15.00	83.33

**TDS/DW statistics are included due to high frequency of exceedances.*

pH - 100% of pH values recorded along Eighteenmile Creek in 2024 fell within established LEBAF standards (6.5 – 9), indicating the potential to support aquatic life. This parameter was observed within expected ranges in 2023, based on observations made in 2022 and 2023.

DO – 100% of DO values recorded on Eighteenmile Creek during the 2023 season were above the LEBAF analytical benchmark of >5 mg L^{-1}, suggesting that DO concentrations supported aquatic life during the sampled dates and times. This parameter was observed within expected ranges in 2024, based on observations made in 2022 and 2023, with no exceedances recorded in either year.

Temperature - 83.33% of temperature values recorded on Eighteenmile Creek during the 2023 season exceeded the LEBAF analytical benchmarks, indicating that water temperatures in the stream could potentially present challenges to supporting aquatic life, particularly during the warmer summer months. All stations along the creek experienced regular exceedances in the warmer months of the sampling season, with June and August recording the highest exceedances. Results for this parameter in 2024 followed a similar overall trend when compared to 2023, with a few notable exceptions. Average temperature for all stations was lower in 2023, and all stations recorded significantly higher minimum temperatures, as well as slightly higher maximum temperatures in 2024. Exceedances for this parameter are likely being driven by ambient air temperature.

Conductivity - 2024 conductivity values observed in Eighteenmile Creek fell roughly between the Ohio EPA reference and survey data, with collected data falling between the 50th percentile of reference and survey data, and both max and minimum recorded values falling below the respective reference and survey values. Overall, results suggest lower overall conductivity compared to both reference and survey results. Average conductivity for all three stations along Eighteenmile Creek was 559.88 µS cm^{-1}, with 15 of 18 samples falling between 412 and 655 µS cm^{-1}, placing the creek in the 'concern for biota' category as outlined by LEBAF. The remaining three values fell below 412 µS cm^{-1}, and occurred in May at all three stations. Observations from

2024 suggest the existence of potentially stressful conditions for macroinvertebrate communities along this waterway, with minor spikes occurring at all three sites in August. No clear pattern could be established between the upstream (EMC03) and downstream stations (EMC07) and (EMC01), although all recorded values at the downstream stations were lower than the upstream station. Compared to 2023, measurements across all sites showed less variance and no severe spikes, although measurements at the upstream station remained higher on average than the two downstream stations for this year as well. No fluctuations outside of the 412 – 655 µS cm^{-1} range were recorded, compared to minor exceedances of this threshold at EMC01 and EMC07 in September of 2023. This might indicate that, at these downstream sites, the creek is more susceptible to incidental and quick changes in conductivity values, possibly influenced by lacustrine dynamics. Measurements recorded in 2022 also showed less variance by site than 2023, with no noticeable spikes. While conductivity exceedances remained frequent in 2024, as in previous years, trends between site locations and seasonality are beginning to establish. Erosion, agriculture inputs, and nearby residential/commercial runoff could influence conductivity within the stream on a seasonal basis.

This parameter was observed within expected ranges, based on previous data, with results generally lower in the beginning of the sampling season, before spiking during the summer months, possibly due to the increased presence of recreators, and then tapering off. Exceedances were frequent and regularly fell within the range of concern for biota, rather than spiking dramatically. Lake dynamics and other pollution inputs could affect measurements on a monthly basis. Conductivity can be expected to be higher in winter and spring months due to runoff from road salts. High flow/storm events can cause spikes in conductivity due to increased runoff from urban, agricultural, or wastewater input sources. Additional factors including erosion, agriculture inputs, and nearby commercial/residential runoff could influence conductivity on a seasonal basis. Limited data is available to determine overall health and heterogeneity of macroinvertebrate communities in Eighteenmile Creek. Sampling of macroinvertebrate communities at both of these sites, and potentially other locations along the river as an additional LEBAF standard, or through cooperation with New York State Department of Environmental Conservation's Watershed Assessment by Volunteer Evaluators program (NYS DEC WAVE) could support future conclusions. Other surrogate parameter measurements for salinity, chloride, and TDS/AQ Life do not provide additional context to the exceedances, but analysis of additional metadata may shed light on the source of the exceedances.

All TDS values recorded along Eighteenmile Creek in 2024 met the aquatic life threshold of 1500 mg L^{-1} as established by LEBAF. Compared to previous readings from 2023 and 2024, no values fell below the drinking water standard of 200 mg L^{-1}. Results for this parameter, on average, are higher in 2024 than in 2023, but readings from both 2024 and 2022 show less variance for all stations.

3.15.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 39. Eighteenmile Creek Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Degrading	Acceptable	Concern for Biota

Results from the 2024 sampling year suggest that conditions along Eighteenmile Creek could present challenges for supporting aquatic life based on the above parameters when compared to LEBAF standards. Frequent exceedances in water temperature and conductivity measurements could indicate regularly stressful conditions for aquatic life, and more information will be required to determine driving factors for exceedances, although ambient air temperature is suspected to be the likely driver of exceedances in water temperature. While this driver could continue to present problems for the river in subsequent years, additional sampling at increased frequency, various times of day, and at additional sites could shed light on broader patterns and potential problem areas. Conductivity values recorded along Eighteenmile Creek in 2023 fall roughly between the Ohio EPA reference and survey data, with collected data falling between the 50th percentile of reference and survey data, and both max and minimum recorded values falling below the respective reference and survey values. Overall, results suggest lower overall conductivity compared to both reference and survey results. The average conductivity value for the three stations along the Eighteenmile Creek was 559.88 µS cm^{-1}, with 15 of 18 samples falling between 412 and 655 µS cm^{-1}, and 3 values falling below 412 µS cm^{-1}. The average conductivity value across the three stations places the creek in the 'concern for biota' category as outlined by LEBAF. Observations in 2024 suggest potentially stressful conditions for macroinvertebrate communities along this waterway, with no major seasonal spikes, contrasted with 2023 values. While the available datasets from 2022, 2023, and 2024 are limited, a trend seems to be establishing, where upstream conductivity values are on average higher than those downstream, although measurements at the downstream stations appear to display more variance, possibly due to lacustrine dynamics. The higher values at the upstream location (EMC03) could be due to its proximity to two major highways, and nearby agriculture. More frequent data collection at these stations could help support this trend.

The number of exceedances along this creek in 2024 are similar to the number of exceedances in 2023 and 2022. Conductivity to Biocondition and TDS continue to be issues at these stations, likely due to warmer summer air temperatures, wastewater inputs, runoff, and geology/erosion. Water temperature exceedances were more frequent on average than in 2023, with lower minimum temperatures and higher maximum temperatures at all stations in 2024. This could perhaps be due to increased sample size, although 2024 measurements displayed less variance across sites overall than 2023. These results indicate susceptibility to incidental fluctuations in temperature across all sites, likely resulting from fluctuations in ambient air temperature, with spikes occurring during the same month at each site. Across all parameters and stations, recorded values in 2022 and 2024 showed less variance than in 2023.

Limited data is available to determine the overall health and heterogeneity of macroinvertebrate communities in Eighteenmile Creek. Sampling of macroinvertebrate communities at all stations, and potentially other locations along the river as an additional LEBAF standard, or through cooperation with NYS DEC WAVE program could support future conclusions. Other surrogate parameter measurements for salinity, chloride, and TDS/AQ Life do not provide additional context to the exceedances, but analysis of additional metadata might shed light on the source of the exceedances.

For all parameters, additional sampling at increased frequency, various times of day, and at additional locations is recommended. Any exceedances that are severe should warrant follow-up sampling and investigation when possible to hone in on potential driving factors. Collection of additional metadata, including flow, nutrients, and sediment data, and the exploration of surrogate parameter measurements could help shed light on any future exceedances, and guide conclusions for LEVSN.

3.16 Rush Creek

3.16.1 Monitoring Groups: Buffalo Niagara Waterkeeper (BNW) is the only organization in the LEBAF network that monitors the Rush Creek basin. Buffalo Niagara Waterkeeper is an organization based in Buffalo NY, whose mission is to protect and restore the Niagara River/Lake Erie watershed and surrounding ecosystems for the benefit of current and future generations.

3.16.2 Station information: Buffalo Niagara Waterkeeper monitors two stations along Rush Creek, sampled at least once a month from May - October between 9 am and 2 pm. Data from 2018 through 2023 are available for Rush Creek at Milestrip (RUSH01 - Coordinates: 42.790250, -78.837000). Data from 2018 and 2019, as well as a partial dataset from 2023 are available for Rush Creek at Big Tree Rd (RUSH02 - Coordinates: 42.771464, -78.821798). In August and September of 2024, additional samples were collected from RUSH01. Rush Creek is a 17 mile long, class C stream.

Rush Creek at Milestrip (RUSH01) is located approximately 1 mile upstream of the mouth of the creek, which feeds directly into Lake Erie at Woodlawn Beach, one of Buffalo’s popular swimming beaches. The station is located directly underneath a major expressway, which connects to another nearby highway downstream of the sampling location. It is adjacent to a Ford stamping plant, as well as an active railroad. There are multiple large factories near the sampling location, and both residential and commercial areas in the town of Blasdell, NY upstream of this site. It is monitored once a month May - October, with additional samples taken in August and September of 2024.

Rush Creek at Big Tree Rd (RUSH02) is located approximately 2 miles upstream of site RUSH01, and 3 miles upstream from the mouth of the creek, in the town of Hamburg. This station is located on private property, owned by a construction company, and is surrounded by a residential area. It is downstream of an interstate highway I90 as well as U.S. Route 20, which are both heavily trafficked. The upstream portions of this creek are primarily low density residential areas, although its terminus lies near an agricultural property. Monitoring primarily occurred in the morning at this site.

3.16.3 Summary of 2024 Findings and Analysis

Table 40. Rush Creek Summary Statistics and Exceedances* - 13 total samples, 2 stations.

Summary Statistics and Exceedances Basin - Rush Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	907.44	941.20	532.30	1,267.00	13.00	13.00	100.00
Dissolved Oxygen	9.25	8.92	7.75	11.98	13.00	0.00	0.00
pH	8.02	8.02	7.83	8.15	13.00	0.00	0.00
Salinity	771.41	800.98	430.89	1,106.76	13.00	1.00	7.69
Water Temperature	17.59	18.50	7.57	23.63	13.00	10.00	76.92

**TDS/DW statistics are included due to high frequency of exceedances.*

pH - The lack of exceedances in this parameter indicates that pH values for Rush Creek are within the established LEBAF standards (6.5 – 9). It is assumed that pH will continue to follow the trends established by previous data sets, and that these values indicate potential to support aquatic life. This parameter behaved as expected throughout the 2024 monitoring season, with results climbing between May and July at both sites, and then tapering off for the remaining months. While there were no exceedances for this parameter along Rush Creek in previous years, results in 2024 show higher variance between months than either previous year, with a lower overall minimum value. Between stations, the downstream station showed higher variance in 2024 than its upstream counterpart, potentially due to its location directly under a major thruway and proximity to an adjacent railyard, although the difference is not significant. With relatively minor fluctuations in this parameter between stations and across months, this parameter is not expected to impact the creek's ability to support life throughout the monitoring period.

DO – 100% of dissolved oxygen values recorded along Rush Creek during the 2024 season were within the LEBAF analytical benchmark of >5 mg L^{-1}. Based on this, we can expect that during the sampled dates and times the DO levels in the stream supported aquatic life, and this is an indicator of good stream health. This parameter behaved as expected for the sampling season across both sites, with values decreasing between May and September, likely driven by warmer ambient air temperatures, and then climbing in October as ambient air temperature drops. No clear trend could be established between the upstream (RUSH02) station and the downstream (RUSH01) station, although RUSH01 observed lower minimum and maximum values compared to RUSH02, by a small degree. Results are comparable to previous sampling seasons, with all years observing a late-season spike in DO values, and no exceedances observed in any previous year, and a slightly higher average DO level in 2023 compared to both 2022 and 2024.

Temperature - 76.92% of temperature values recorded on Rush Creek during the 2024 season fell outside of LEBAF analytical benchmarks. Based on this, we expect that water temperature in the stream could potentially present challenges to supporting aquatic life, particularly during the warmer summer months. Exceedances at RUSH01 occurred in all months except October, and in all months except July and October at RUSH02. This parameter behaved as expected throughout the monitoring period, with water temperature measurements being higher in the warmer summer months, and lower in the cooler spring and fall months, reflecting trends in ambient air temperature and weather. Compared to 2022 and 2023, 2024 observed higher average water temperatures along Rush Creek, with lower minimum temperature and higher maximum temperature, reflecting higher variance in the data set. Across all monitored years, this creek experienced frequent and sometimes significant exceedances in temperature benchmarks as established by LEBAF. Additional data from an upstream station in 2024 cannot yet establish a clear trend between upstream and downstream sections of the creek, although temperature values at RUSH01 were higher than values at RUSH02 across all months, potentially due to its proximity to the lake and influence from lacustrine dynamics.

Conductivity - Conductivity values recorded along Rush Creek in 2024 fell significantly outside of the Ohio EPA reference and survey data, with collected data exceeding 50th percentile values for both reference and survey data, but falling below the minimum values for both datasets. Results consistently fell above the maximum value for the survey dataset. Overall, results suggest higher conductivity values along this waterway than both reference and survey locations on average. The average conductivity along Rush Creek was 907.44 µS cm^{-1}, with 10 of 13 of samples falling above 655 µS cm^{-1} (76.92%), placing the creek in the 'likely impaired category' as outlined by LEBAF. Data suggests potentially stressful conditions for macroinvertebrate communities along this waterway throughout the sampling season, with susceptibility to spikes particularly at the RUSH01 station. No clear trend could be established between upstream and downstream measurements based on available data, although values for RUSH01 were higher than their upstream counterparts across all months. Compared to 2023 and 2022 datasets, 2024 observed less variance overall across measurements, although the overall minimum value was lower than both previous years. Data from 2023 and 2022, suggests that this creek experiences frequent and severe exceedances of conductivity standards as outlined by LEBAF. While measurements remained elevated throughout the monitoring period, no clear trend could be established across months, as results showed sudden dips and spikes between sampling events. Rush Creek is on the NYS 2018 303(d) list requiring development of Total Maximum Daily Loads (TMDLs) (pathogens and phosphorus); New York State Department of Environmental Conservation's Priority Waterbodies List (DEC PWL) lists as impaired. The location of station RUSH01 directly under a major thruway and proximity to an adjacent railyard likely make it subject to multiple sources of runoff, while the upstream station RUSH02 is likely more influenced by commercial and residential runoff.

Total Dissolved Solids (TDS) results remained relatively consistent throughout the monitoring period, with 100% of measurements falling below the aquatic life standard of 1500 mg L^{-1}. Results for this parameter show minimal variance compared to previous years, and while no clear trend could be established between the monitored stations in 2024, values from the downstream station (RUSH01) exceeded values recorded at the upstream station (RUSH02) across all sampling events, and displayed a spike in June. Results for this parameter, on average, are lower in 2024 than in previous years, and more consistent.

3.16.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 41. Rush Creek Water Quality Summary

pH	***Temperature***	***DO***	***Conductivity***
Acceptable	Degraded	Acceptable	Likely threats, impacts

Results from the 2024 monitoring year suggest that conditions along Rush Creek could present challenges for supporting aquatic life based on the above parameters when compared to LEBAF standards. Frequent exceedances in water temperature and conductivity could indicate regular stressful conditions for aquatic life, and more information will be required to determine the factors that drive these exceedances, although ambient air temperature is suspected to be the likely driver of exceedances in water temperature. While this driver could continue to present problems for the river in subsequent years, additional monitoring at an increased frequency, at various times of day, and at additional sites could shed light on larger trends and potential problem areas. Consistently elevated conductivity values across monitored locations are a cause for concern in relation to the overall condition of the creek, especially because of its influence on Lake Erie.

Rush Creek is on the NYS 2018 303(d) list requiring development of TMDL (pathogens and phosphorus); DEC PWL lists as impaired. The location of RUSH01 directly under a major thruway, and proximity to an adjacent railyard likely make it subject to multiple sources of runoff. Rush Creek, though small, impacts Lake Erie, especially localized at Woodlawn Beach. Urban stormwater runoff, SSOs and other municipal and sanitary inputs are impacting this Creek. This impacts recreational access and aesthetics of Lake Erie. Elevated levels of phosphorus have been measured through previous studies. Increased frequency of monitoring and the addition of a second sampling location in 2024 reduced the frequency and overall magnitude of exceedances in conductivity standards along the creek, and highlighted significant variance in water temperature across sampling events. More data would be useful to understand the seasonal fluctuations in the above parameters. This creek's position not only in relation to the mouth of the creek (and to Lake Erie), but in relation to multiple potential sources of commercial runoff will likely continue to present challenges to mitigation strategies in the future.

For all parameters, additional monitoring at increased frequency, various times of day, and at additional locations is recommended. Any exceedances that are severe should warrant follow-up sampling and investigation when possible and necessary. Collection of additional metadata, including flow, nutrients, and sediment data, and the exploration of surrogate parameter measurements could help shed light on any future exceedances, and guide conclusions for LEVSN.

3.17 Smoke Creek

3.17.1 Monitoring Groups: Buffalo Niagara Waterkeeper (BNW) is the only organization in the LEBAF network that monitors Smoke Creek basin. Buffalo Niagara Waterkeeper is an organization based in Buffalo NY, whose mission is to protect and restore the Niagara River/Lake Erie watershed and surrounding ecosystems for the benefit of current and future generations.

3.17.2 Station information: Buffalo Niagara Waterkeeper monitors one station along Smoke Creek, sampled once a month from May - October. Data from 2021 through 2023 are available for South Smoke Creek at Johnson Street (SMK04 - Coordinates: 42.812776, -78.826207).

South Smoke Creek at Johnson Street (SMK04) is located approximately 2.3 miles upstream of the mouth of the creek, which flows directly into Lake Erie. It is located on the southern branch of the creek, near the confluence of this branch and the main branch. It is approximately 6 miles south of the City of Buffalo, and is located in a primarily residential area of the town of Lackawanna, NY. Adjacent to this site is a school, and is downstream of the Interstate 90 highway and a small commercial district in Lackawanna. It is monitored once a month May - October, between 9:00 and 10:00 am.

Buffalo Niagara Waterkeeper monitored one additional station along Smoke Creek in 2023 and 2024, but only a limited sample size is available for this station. As such, only those stations that were monitored at least once from May through October of 2024 are included in this report.

3.17.3 Summary of 2024 Findings and Analysis

Table 42. Smoke Creek Summary Statistics and Exceedances* - 6 total samples, 1 station.

Summary Statistics and Exceedances Basin - Smoke Creek

Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Conductivity Biocondition	1,016.70	1,079.00	579.00	1,262.00	6.00	6.00	100.00
Dissolved Oxygen	8.36	7.86	6.30	11.38	6.00	1.00	16.67
pH	7.84	7.85	7.70	8.01	6.00	0.00	0.00
Salinity	873.22	929.34	472.16	1,102.01	6.00	2.00	33.33
Water Temperature	18.80	20.25	7.47	26.03	6.00	5.00	83.33

**TDS/DW statistics are included due to high frequency of exceedances.*

pH - The lack of exceedances indicates that pH values for Smoke Creek are within the established LEBAF standards (6.5 – 9). It is assumed that pH will continue to follow the trends established by previous data sets, and that these values indicate potential to support aquatic life. This parameter behaved as expected throughout the 2024 monitoring season, and results are comparable to both 2022 and 2023 measurements for the monitored location along the creek, although 2023 values displayed less variance overall than 2022 and 2024 measurements. Any fluctuations could be due to its location within a residential/low intensity urban area.

DO – 83% of dissolved oxygen values recorded along Smoke Creek during the 2024 season were within the LEBAF analytical benchmark of >7 mg L^{-1}, based on its ‘cold water’ designation. These results suggest that the DO levels in the stream supported aquatic life during the majority of monitoring dates and times, and this is an indicator of good stream health. The single exceedance for this parameter occurred in June, likely driven by increased ambient air temperatures, and is minor in magnitude. This parameter behaved as expected for the sampling season, with recorded values decreasing in warmer summer months, and higher in the cooler months of spring and fall. Results for this sampling season are generally comparable to the 2023 and 2022 sampling seasons, despite no exceedances occurring in either previous year, although measurements display more variance in 2024 and 2022 than in 2023.

Temperature - 83.33% of temperature values recorded on Smoke Creek during the 2024 season fell outside of the LEBAF analytical benchmarks. Based on this, we expect that water temperatures in the stream could potentially present challenges to supporting aquatic life during the warmer summer months. Exceeds occurred in every month except October, with a spike in June. This suggests a potential susceptibility to sudden changes in temperature values along the creek. Compared to 2023 and 2022, measurements for this parameter at these stations showed much higher variance, with lower minimum and higher maximum temperatures than previous years. It is suspected that ambient air temperature is the likely driver of parameter exceedances.

Conductivity - Conductivity values recorded along Smoke Creek in 2024 generally fell outside of the Ohio EPA reference and survey data, with data exceeding the 50th percentile values for both reference and survey data. Minimum and maximum recorded values fell below their respective counterparts in survey and reference data, possibly indicating that this creek is more susceptible to sudden changes in conductivity than other similar waterbodies. The average conductivity along Smoke Creek was 1016.70 µS cm^{-1}, with 5 of 6 samples falling above 655 µS cm^{-1}, and one sample falling between the 412 - 655 µS cm^{-1} benchmark, placing the creek in the likely threats/impacts category as outlined by LEBAF. Observations suggest potentially stressful conditions for macroinvertebrate communities along this waterway, with high variability between months, and seasonal spikes in the summer months. Compared to 2022 and 2023, 2024 observed higher overall values for this parameter, with lower minimum and higher maximum values in 2024 than both previous years. The magnitude and frequency of exceedances is concerning for all monitored years, and the high variability between individual readings suggests susceptibility to significant fluctuations along this creek for this parameter.

100% of TDS values recorded along Smoke Creek in 2024 met the aquatic life TDS standard of 1500 mg L^{-1} threshold as established by LEBAF. Results remained relatively consistent throughout the monitoring period, with a noticeable dip in May. Results for this parameter, on average, are higher in 2024 than in 2023 and 2022, but more variable and with lower minimum, and higher maximum values than previous years.

3.17.4 Summary of 2024 Conclusions, Recommendations, Actions

Table 43. Smoke Creek Water Quality Summary

pH	*Temperature*	*DO*	*Conductivity*
Acceptable	Degrading	Acceptable	Likely threats/impacts

Results from the 2024 sampling year suggest that conditions along Smoke Creek could present challenges for supporting aquatic life based on the above parameters when compared to LEBAF standards. Frequent exceedances in water temperature and conductivity could indicate regularly stressful conditions for aquatic life, and more information will be required to determine the factors that drive these exceedances, although ambient air temperature is suspected to be the likely driver of exceedances in water temperature. While this driver could continue to present problems for the creek in subsequent years, additional monitoring at increased frequency, various times of day, and at additional sites could shed light on larger trends and potential problem areas. Consistently elevated conductivity values at this site are a cause for concern in relation to the overall condition of the creek, especially with significant variation in values between certain months and between years.

A biological (macroinvertebrate) assessment of South Branch Smoke Creek in Lackawanna (at South Park Avenue) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicate slightly impacted conditions. In such samples some replacement of sensitive species by more tolerant species occurs, although the sample also includes a balanced distribution of all expected species. Aquatic life is considered to be fully supported in the stream, however the community composition and nutrient biotic evaluation suggest conditions and levels of enrichment are sufficient to cause some stress to aquatic life. Impact source determination found the fauna to be most similar to communities influenced by nonpoint nutrients and toxins from urban sources and stormwater runoff.

For all parameters, additional monitoring at increased frequency, various times of day, and at additional locations is recommended. Any exceedances that are severe should warrant follow-up sampling and investigation when possible to determine potential driving factors. Collection of additional metadata, including flow, nutrients, and sediment data, and the exploration of surrogate parameter measurements could help shed light on any future exceedances, and guide conclusions for LEVSN.

Section 4 – Overall Lake Erie River Basins

4.1 Regional Summary

This section provides a Lake Erie Basin-wide analysis of all 2024 LEBAF results by parameter. All 2024 LEBAF data is analyzed together to evaluate spatial and temporal trends or differences across the Lake Erie Basin. Through this analysis, LEBAF examines the health of the entire Lake Erie Watershed through the lens of LEBAF standards outlined in Section 2 of this report and further explained for each parameter in Section 4.3, while also outlining limitations in the dataset and approach. To help summarize some data and trends within the watershed, LEBAF often refers to different regions or waterbodies within the Lake Erie Watershed as defined in Section 1 Table 1 and Figure 1. A more detailed analysis and interpretation of individual direct tributary and large river data is provided in the previous section (Section 3). All the data is also accessible through the LEVSN webpage Water Reporter Widget.

4.2 Regional River Basins Data Summary

Table 44. Lake Erie Basin Cold and Warm Water Summary Statistics.

All LEBAF Stations Summary Table - 136 stations						
Parameter [unit]	**mean**	**median**	**minimum**	**maximum**	**N exceedances**	**% exceedances**
pH	8.70	8.01	6.63	9.85	22	1.6%
Water Temperature [°C]	18.9	19.7	3.07	34.7	157	11.4%
Cold Water	18.3	19.5	6.9	27.4	66	84.6%
Warm Water	19.0	19.7	3.07	34.7	91	7%
Dissolved Oxygen [mg L^{-1}]	8.21	8.13	0.31	22.15	102	7.5%
Cold Water	9.03	8.97	6.30	12.82	7	9.0%
Warm Water	8.17	8.06	0.31	22.15	95	7.3%
Conductivity [µS cm^{-1}]	815	750	120	3544	1317	97%

Table 45. Summary of Exceedances by Waterbody and Parameter. Exceedances are represented by percentages and the max and median values for each parameter are displayed in parentheses. Watersheds with cold water sites are shaded.

Watershed	pH	Temp [°C]	DO [mg L⁻¹]	Conductivity [µS cm⁻¹]
Buffalo River	**0%**	**0%**	**0%**	**50%**
	(8.4, 7.9)	(26.9, 20.9)	(10.4, 8.1)	(603, 415)
Chappel Creek	**0%**	**0%**	**25%**	**100%**
	(8.8, 7.8)	(25.4, 18.1)	(13.3, 8.4)	(947, 582)
Clinton River	**0%**	**86%**	**0%**	**100%**
	(8.3, 8.1)	(21.9, 17.7)	(9.9, 8.9)	(947, 818)
Cuyahoga River	**0%**	**13%**	**7.50%**	**98%**
	(9.0, 8.2)	(28.8, 19.6)	(13.2, 8.1)	(3544, 779)
Detroit River	**0%**	**7%**	**27%**	**100%**
	(8.2, 7.8)	(25.5, 17.7)	(10.5, 6.3)	(2714, 965)
Doan Brook	**4%**	**10%**	**11%**	**97%**
	(9.5, 8.1)	(32.7, 20.7)	(12.8, 8.4)	(2174, 750)
Eighteenmile Creek	**0%**	**83%**	**0%**	**83%**
	(8.3, 8.1)	(27.4, 20.2)	(12.8, 9.5)	(649, 580)
Huron River	**0%**	**5%**	**5%**	**99%**
	(8.7, 8.2)	(29.9, 18.8)	(14.8, 8.2)	(2358, 823)
Maumee River	**11%**	**18%**	**2%**	**96%**
	(9.8, 8.2)	(34.7, 22.3)	(22.2, 8.9)	(1002, 560)
Mills Creek	**0%**	**6%**	**2%**	**98%**
	(8.9, 8.0)	(25.2, 18.9)	(17.5, 8.2)	(2197, 1152)
Old Woman Creek	**0%**	**3%**	**13%**	**99%**
	(8.7, 7.9)	(23.6, 17.7)	(15.5, 8.1)	(1108, 614)
Ottawa River	**6%**	**15%**	**0%**	**85%**
	(9.6, 8.0)	(29.9, 21.4)	(17.1, 7.8)	(1485, 829)
Pipe Creek	**0%**	**0%**	**8%**	**98%**
	(8.8, 7.9)	(26.4, 18.2)	(12.4, 7.4)	(1996, 829)
Portage River	**14%**	**14%**	**0%**	**96%**
	(9.9, 8.0)	(29.3, 17.7)	(19.8, 9.2)	(989, 630)
Rush Creek	**0%**	**77%**	**0%**	**100%**
	(8.2, 8.0)	(23.6, 18.5)	(12.0, 8.9)	(1267, 941)
Sawmill Creek	**0%**	**20%**	**10%**	**90%**
	(8.8, 7.8)	(27.2, 20.2)	(9.9, 6.7)	(1126, 765)
Smoke Creek	**0%**	**83%**	**17%**	**100%**
	(8.0, 7.9)	(26.0, 20.3)	(11.4, 7.9)	(1262, 1079)
Swan Creek	**0%**	**6%**	**12%**	**83%**
	(8.2, 7.9)	(26.8, 21.9)	(12.0, 7.5)	(1056, 597)
Ten Mile Creek	**0%**	**9%**	**0%**	**73%**
	(8.4, 8.3)	(24.0, 22.0)	(12.1, 10.4)	(1431, 928)

4.3 2024 Regional Findings and Conclusions

4.3.1 pH

Thresholds: While pH may fluctuate daily, seasonally or along a river continuum, there is an acceptable range in which aquatic life thrives. The U.S. Environmental Protection Agency suggests a pH range of 6.5-9 for freshwater systems and LEBAF has adopted this range as the standard threshold.

Parameter Expectation: The expectation for pH is that all sites would be within the LEBAF standard range. Even with naturally occurring fluctuations, healthy streams should have relatively stable pH throughout the year that does not fall outside the LEBAF threshold.

Table 46. pH Data Characterization

	# Samples	# Stations	Minimum	Maximum	Median	Exceedance
LEBAF sites	**1,377**	**136**	**6.63**	**9.85**	**8.01**	**1.60%**

Exceedance Locations: Twenty-two total exceedances were recorded across the LEBAF network in 2024. These exceedances were concentrated in two large river basins: Doan Brook (with 4 exceedances) and the Maumee River (with a total of 18 exceedances).

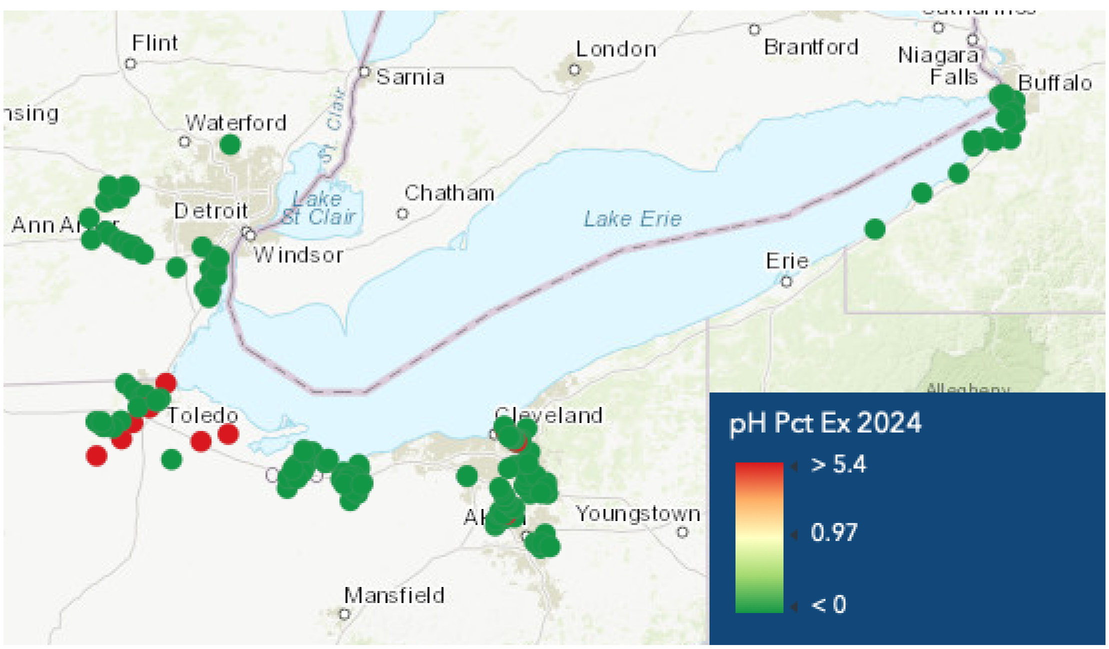


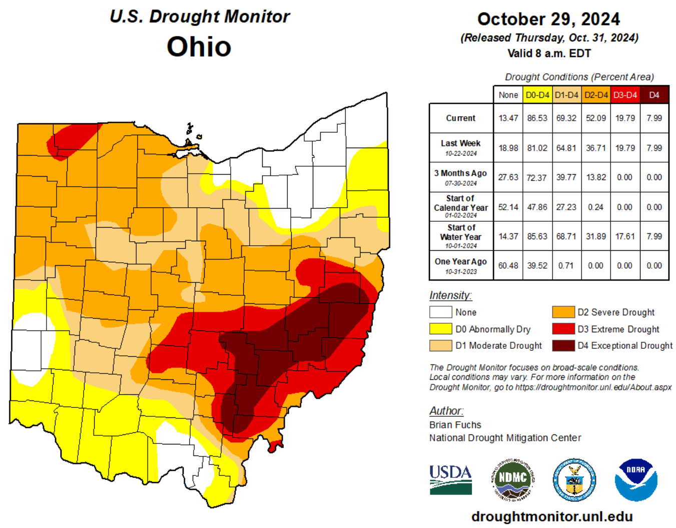
Figure 7. pH exceedances in 2024. Red dots indicate the sampling locations of pH exceedances.

Factors Influencing Exceedances:

- Adjacent high-intensity land use (urban in NE Ohio and agricultural in NW Ohio)
- Low stream flow/severe drought conditions
- Alkaline conditions with exposed bedrock (especially NW Ohio)

Story: While aquatic organisms can tolerate some fluctuations in dissolved oxygen and temperature, pH requirements must remain consistent throughout their life stages. However, if the exceedance is acute in duration, aquatic life may be able to find refuge in a different part of the stream, thus limiting harm. There were slightly more pH exceedances across the LEBAF network in 2024 (1.60%) compared to the data from 2023 (0.9%). Additional stations were also added during the 2024 LEBAF season. In 2024, twenty-two exceedances were recorded within the network representing 1.60% of the overall observations. All exceedances were located above the threshold. These exceedances were limited to two river basins: Doan Brook (0.29% of total samples) and the Maumee (1.31% of total samples). All exceedances in the Doan Brook basin were measured at two sites along the Doan Brook– Sites S3 and R4– and occurred between May 16 and September 20, 2024. Exceedances in the Maumee River basin were obtained from three direct tributaries; Portage River- CWAT-23 and CWAT-24– occurred between July 20 and August 24, 2024; Ottawa River- CWAT-5– occurred on July 21 and October 13, 2024; Maumee River- CWAT-6, CWAT-7, CWAT-8 and CWAT-9– occurred between June 15 and October 30, 2024.

According to the U.S. drought monitor (Figure 8), Northwest Ohio experienced D2-D4 drought conditions. The lack of precipitation directly contributed to the low base flow in the monitored tributaries, which was noted at the time of sampling. D0-D4 drought conditions began in August 2024 and moved up to D2-D4 by the end of October 2024. Furthermore, the sites with exceedances in the Maumee Basin are situated near agricultural land use, whereas Doan Brook's are situated near highly urbanized areas with altered drainage systems and increased impervious surface area, all of which may negatively impact ecological health and contribute to pH exceedances.

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	13.47	86.53	69.32	52.09	19.79	7.99
Last Week 10-22-2024	18.98	81.02	64.81	36.71	19.79	7.99
3 Months Ago 07-30-2024	27.63	72.37	39.77	13.82	0.00	0.00
Start of Calendar Year 01-02-2024	52.14	47.86	27.23	0.24	0.00	0.00
Start of Water Year 10-01-2024	14.37	85.63	68.71	31.89	17.61	7.99
One Year Ago 10-31-2023	60.48	39.52	0.71	0.00	0.00	0.00

Figure 8. Maumee River-Side Cut sampling location (CWAT-8) Figure 5. U.S. Drought Monitor, Ohio 10/18/24

The twelve exceedances in the Maumee occurred at four monitoring sites that typically display more alkaline conditions due to the geology of the watershed. These variations were just above the upper limit for pH, ranging from 9.01-9.79, and corresponded with lower water conditions at the sampling locations. The majority of the exceedances occurred during abnormally dry to extreme drought conditions; these conditions significantly impacted water monitoring efforts towards the latter half of the season. CWAT-6 and CWAT-7 experienced exposed bedrock throughout the sampling season, which was historically unusual for these sites. Volunteers also identified increased vegetation growth in low-flow areas during the recurring low-flow sampling events. See Figure 8 for visual site conditions during mid-October 2024. Additionally, these exceedances appear to be site-specific as pH improves bidirectionally along the Maumee.

Figure 9. 2024 pH in the Maumee River. pH data from four sites monitored in the Maumee river. Site CWAT-6, marked with squares; CWAT-7, marked with plus signs; CWAT-8, marked with a X; and CWAT-9, marked with asterisks, experienced exceedances, which are colored in red.

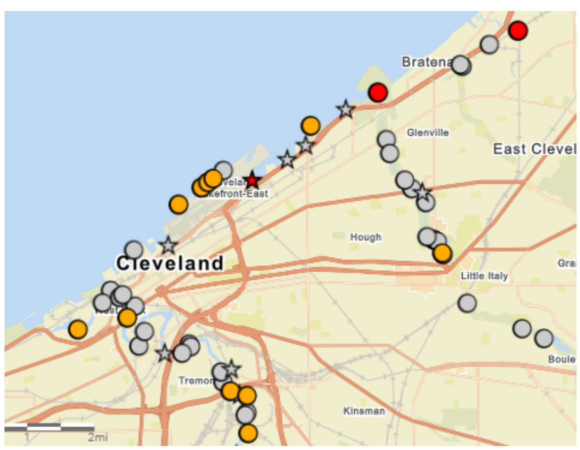


Figure 10. <u>2024 Cleveland, OH CSO Map</u> ***Figure 11. 2024 S3 site photo***

The four exceedances in Doan Brook occurred at two different monitoring locations. These variations were just above the upper limit for pH ranging from 9.06-9.56. One exceedance site (R4) is located in close proximity to multiple upstream combined sewer overflows (CSOs). The additional 3 exceedances (at site S3) are not situated near any known CSOs; however, there have been reports of water leaks in the Shaker Heights area. Site S3 is located downstream of the Green Lake Dam, a popular spot for mallards and Canada geese. Both sites are situated near highly urbanized areas with altered drainage systems and increased impervious surfaces, all of which could potentially contribute to higher pH readings. The true causation can not yet be determined as 2024 was Doan Brook's first sampling season in the LEBAF network.

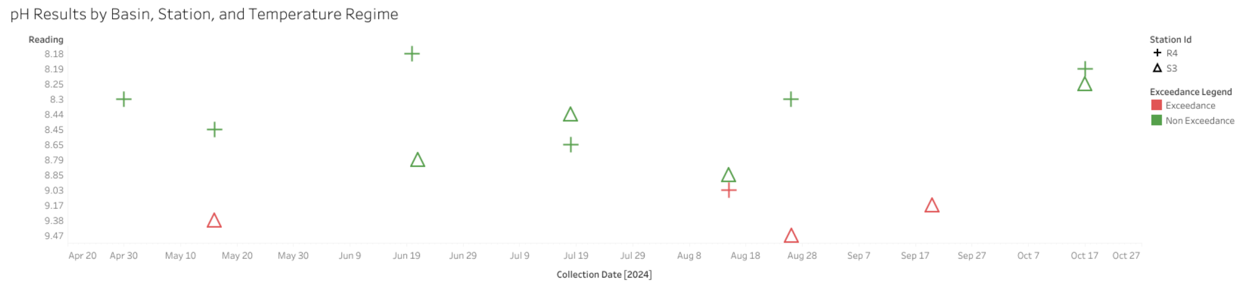


Figure 12. 2024 pH in the Doan Brook. pH data from two sites monitored in Doan Brook. Only sites S3, marked with triangles, and R4, marked with plus signs, experienced exceedances, which are colored in red.

Data Limitations: The data herein appear to show site-specific instances of pH exceeding the acceptable range. However, the low frequency and short duration of data collection makes it difficult to identify trends. A continuous measurement of pH, or multiple measurements taken at different points throughout the day, may help better capture temporal variation. Additionally, flow is measured as a subjective variable, by visual assessment only, and therefore may vary with each individual monitorer. As many of the pH exceedances were correlated to times of low flow at the monitoring location, a precise, objective measurement of flow may depict a more accurate interpretation of site conditions and help to better contextualize these pH exceedances. Further, the Portage River and Doan Brook tributaries were sampled by LEBAF for the first time in 2024. Without historical data to assess, it is difficult to determine the degree to which these variations are typical. Additional sampling over the coming years will allow better identification of pH trends within the LEBAF network.

Recommendations: To achieve a more accurate understanding of pH across the LEBAF network, it is recommended that pH sampling occur at different times of day and across consecutive days at sites with current pH exceedances. This will help to determine whether pH exceedances are a regular occurrence or derived from an infrequent source. Because the sites with exceedances in the Cuyahoga Basin appear to be correlated with high urbanization, it is recommended that stations in this region consider looking more closely into the habitat conditions at sites with exceedances, potentially through sampling macroinvertebrates. An assessment of biota at these sites of pH exceedance will help to clarify the impact of these exceedances on overall ecosystem health. Finally, the addition of flow as a quantifiable variable will allow stations to determine the potential correlation between low flow and pH exceedances across the LEBAF network.

4.3.2 Temperature

Thresholds: Maximum temperature limits change for each month to adjust for natural seasonal variation and seasonality of biological stressors (Table 47).

Table 47. LEBAF Temperature Thresholds. Maximum limits in both Fahrenheit and Celsius for cold water habitat streams (blue) and warm water habitat streams (red).

April	May	June	July	August	September	October
52 F	58 F	64 F	66 F	66 F	63 F	54 F
11 C	14 C	17 C	18 C	18 C	17 C	12 C
61 F	70 F	82 F	85 F	85 F	82 F	70 F
16 C	21 C	27 C	29 C	29 C	27 C	21 C

Parameter Expectation: The expectation for temperature is that all sites would not exceed the monthly maximum LEBAF value established in either cold water or warm water streams. In addition to seasonality, temperature can also vary spatially based on groundwater inputs, as well as factors like impervious surface cover, canopy cover, and stream morphology (slow or stagnant locations should be warmer than areas where water flows faster). Thus, some sites may be expected to get closer to threshold maxima than others. However, to maintain a healthy, heterogenous aquatic biological community, temperatures should stabilize below thresholds.

Table 48. Water Temperature Data Characterization

	# Samples	# Stations	Minimum	Maximum	Median	Exceedance
Cold Water Sites	**78**	**10**	**6.91℃**	**27.38℃**	**19.5℃**	**84.62%**
Warm Water Sites	**1,299**	**126**	**3.07℃**	**34.7℃**	**19.7℃**	**7.01%**

Exceedance Locations: 157 total exceedances (11.38% of samples) were observed across the network of warm and cold water streams, with 16 of the 18 waterbodies included in this report observing at least one exceedance in the 2024 sampling season (see Figure 13). Those exceedances were observed in the following cold water streams: Eighteenmile Creek, Furnace Run, Paint Creek, Rush Creek, and Smoke Creek and in the following warm water streams: Detroit River, Doan Brook, Huron River, Maumee River, Mills Creek, Old Woman Creek, Ottawa River, Portage River, Saw Mill Creek, Swan Creek, Tenmile Creek, Little Cuyahoga River, Wingfoot

Lake Outlet, and Yellow Creek. All samples were lower than the threshold maxima at sites in the following streams: Buffalo River, Chappel Creek, and Pipe Creek. Overall, the majority of streams observed an increase in the frequency of exceedances compared to 2023, with 44.4% of streams observing either less or the same frequency of exceedances compared to the previous year.

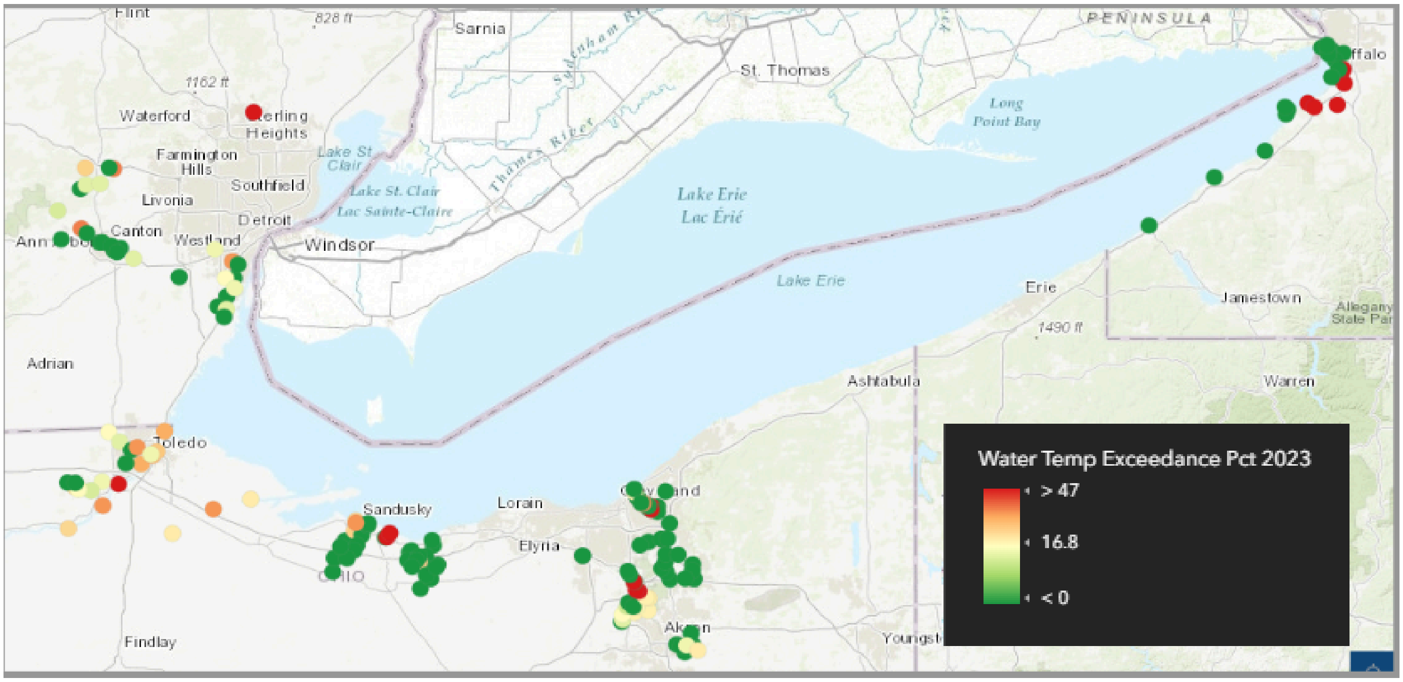


Figure 13. 2024 Temperature exceedances by LEVSN Monitoring Locations. The color of the data points represents the percentage of Temperature exceedances. All non-green points are locations with at least one exceedance.

Factors Influencing Exceedances:

- Ambient air temperature
- Stream flow
- Time of day for sampling efforts
- Lacustrine dynamics
- Drainage area of site (stream/headwater)
- Watershed land use

Story: Stream temperature is important for sustaining aquatic life and can be a critical factor impacting sensitive species living in streams. While water temperature naturally varies due to time of day, seasonal air temperature, and groundwater input, elevated temperatures can create inhospitable conditions that can negatively impact aquatic life. In 2024, one-hundred and fifty-seven exceedances were observed across the network representing about 11.38% of observations made. Exceedances occurred in less than 15% of the samples for most streams except for three Buffalo area streams: Smoke Creek (83.3%), Eighteenmile Creek (83.3%) and Rush Creek (76.9%), and the Maumee River (18.2%) and Clinton River (85.7%). The Buffalo area streams experienced exceedances in 2023 and 2024, while the Maumee River and Clinton River were additional exceedances in 2024. With the exception of the Maumee River, stations monitored along these waterways are all considered ‘cold water’ streams, which have a considerably lower maximum temperature threshold than warm water sites. While these exceedances seem high, the sample size of these streams were low (with the exception of the Maumee River). Overall, most streams experienced 20 or less elevated temperature observations throughout the sampling season that largely correlated with high ambient air temperatures, low stream flow and changes in watershed land use. The Cuyahoga River (number of exceedances=48) experienced higher elevated temperature observations; however, the Cuyahoga basin had the highest sample count (360) for the sampling season. On average, each exceedance in warm water systems ranged from a 1 degree difference to a 3 degree difference when compared to the acceptable warmwater threshold; however, there were a couple of outlier warm water systems that were 4 to 7 degrees above the threshold in May and June. For cold water systems, the majority of exceedances ranged from a 3 degree difference to a couple of basins with a 10 degree difference when compared to the acceptable cold water thresholds.

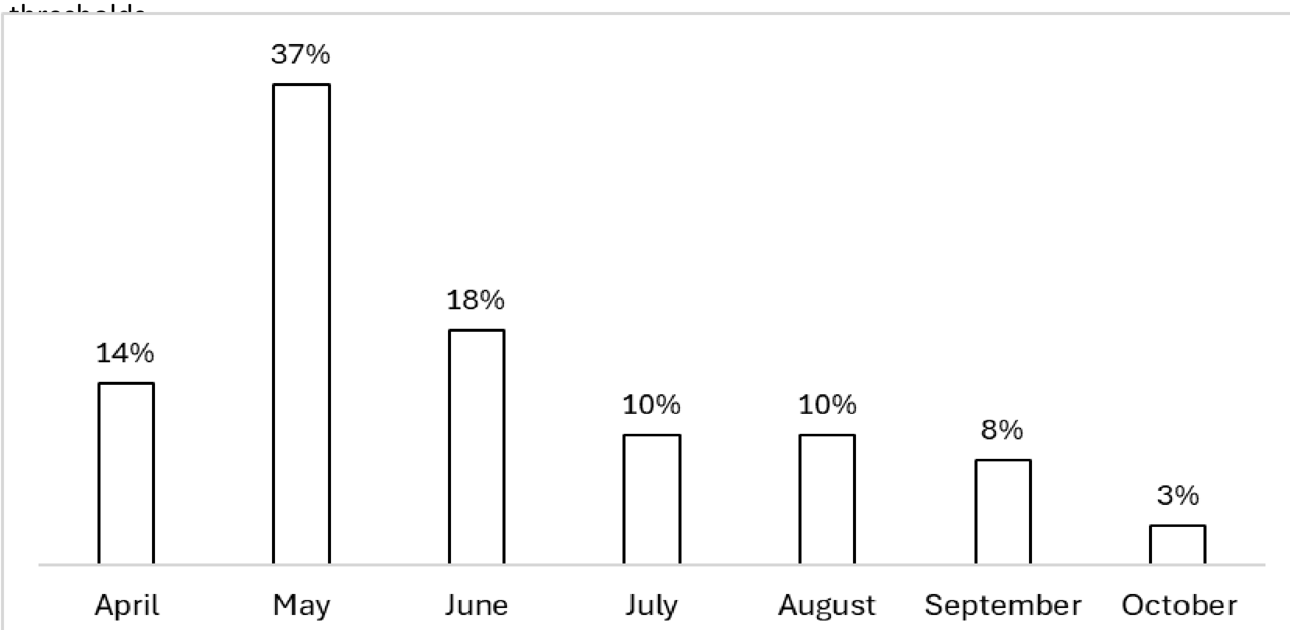


Figure 14. Percent of temperature exceedances by month.

More than 50% of streams with observed exceedances occurred in April, May (highest), and June of the sampling year (consistent with 2023 data, with the addition of April) – mostly occurring in Northwest (Maumee/Ottawa) and Northeast (Cuyahoga/Doan) Ohio. The states surrounding the Lake Erie basin experienced abnormally high ambient air temperatures during the spring months which was also paired with precipitation that was well below average. This lack of precipitation and higher ambient temperatures contributed to low base flow in streams, which was consistent with condition observations made at the time of sampling. As a result, certain areas of Ohio, Michigan, and New York recorded their warmest spring to date (See Figure 15). In addition, several sites were affected by upstream lacustrine influences, where warmer surface water, likely heated by elevated air temperatures, was being drawn from stagnant upstream lakes and ponds, thereby raising stream temperature. Further, multiple samples were recorded in the afternoon when ambient air temperatures were higher and flow was low, potentially resulting in the temperature exceedances for the data collected.

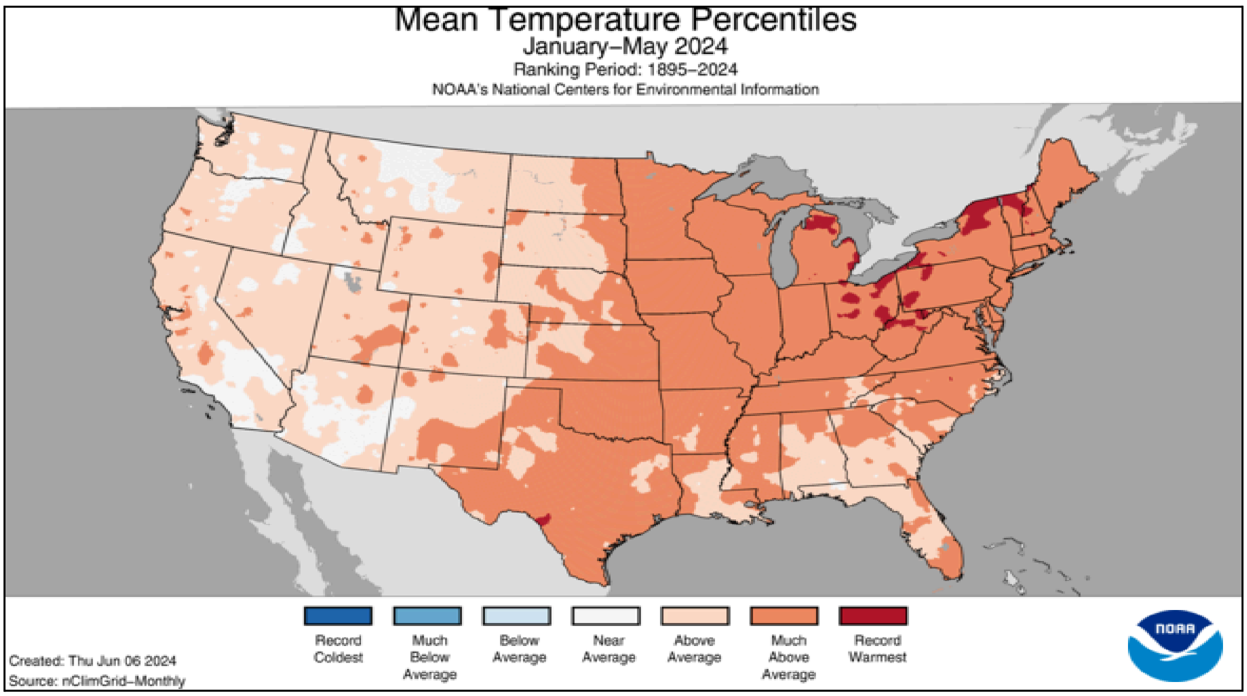


Figure 15. National Climate Report for January-May 2024 - Mean Temperature Percentiles Illustrating Recorded Warmest.

Site drainage and watershed land use were other contributing factors that seemed to align with most exceedances. In 2023, headwater sites experienced more temperature exceedances, especially within sites that lacked suitable riparian cover; however, in 2024 there was no discrepancy in exceedances when it came to river order, drainage area or riparian cover of the system. Exceedances were seen across the board in headwaters and in the main stems of rivers, whether there was suitable riparian cover present or not. Sites in Furnace Run, Maumee River, Ottawa River, and Tinkers Creek noted heavy urban land use where exceedances occured. Heavy land use refers to development and altered drainage systems, which can also contribute to higher storm flow and lower stream baseflow. In watersheds where developed land use is dominant, streams can become very flashy and have increased temperature in stormwater from paved surfaces that absorb heat.

Although a limited number of cold water stations around the Lake Erie basin are monitored using the LEBAF framework, temperature exceedances for cold water stations seemed to be primarily located in the eastern Lake Erie Basin/Western New York area and in the central Lake Erie Basin/Northeast Ohio area (see Figure 16). Eighteenmile Creek and Smoke Creek both experienced an increase in temperature up to a 10 degree difference when compared to the recommended exceedance thresholds for coldwater habitats (See Figure 17). High frequency exceedances along Rush, Smoke, Eighteenmile Creek, and Furnace Run are a cause for concern. The magnitude and timing of exceedances indicate that they are driven primarily by ambient air temperature and low-flow anomalies, but heavy land use in Furnace Run is also impacting temperatures outside of the abnormal ambient air and precipitation rates (See Figure 18). Temperature trends in these waterways followed similar patterns in 2024 as they did in previous years, which suggests that annual high temperatures could be impacting resident biota. Collection of additional data at increased frequency, various times of day, and additional stations could shed light on other drivers of water temperature exceedances. Collection of metadata including flow, ambient air temperature, nutrients, and sediment could support any future conclusions about exceedance drivers and overall impact on Lake Erie.

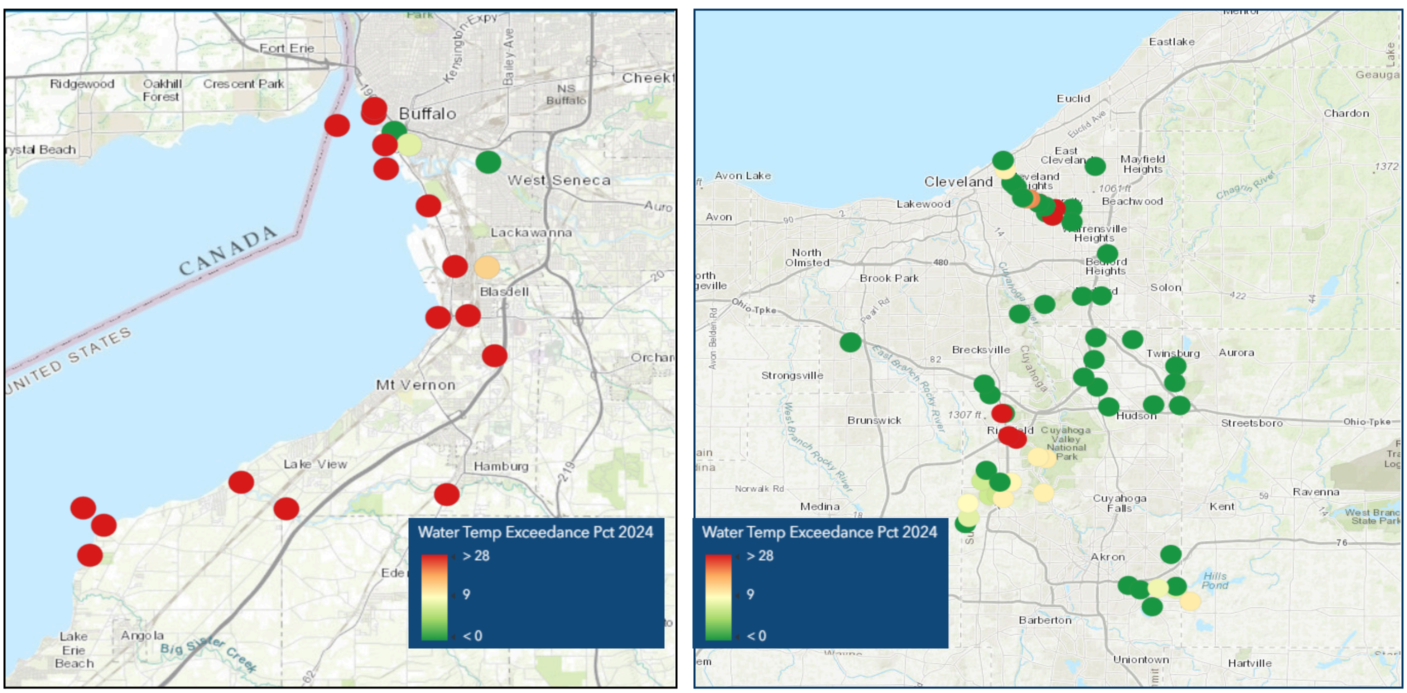


Figure 16. Average water temperature exceedances in the Buffalo and Cleveland/Akron area.

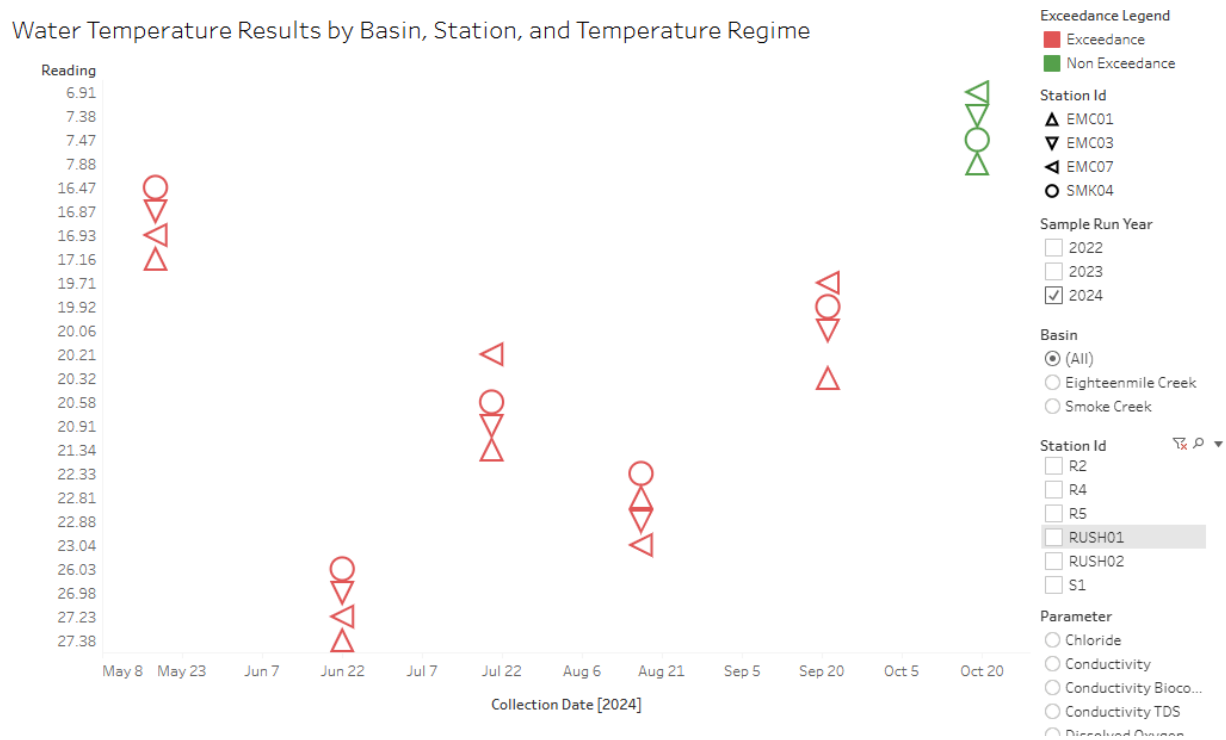
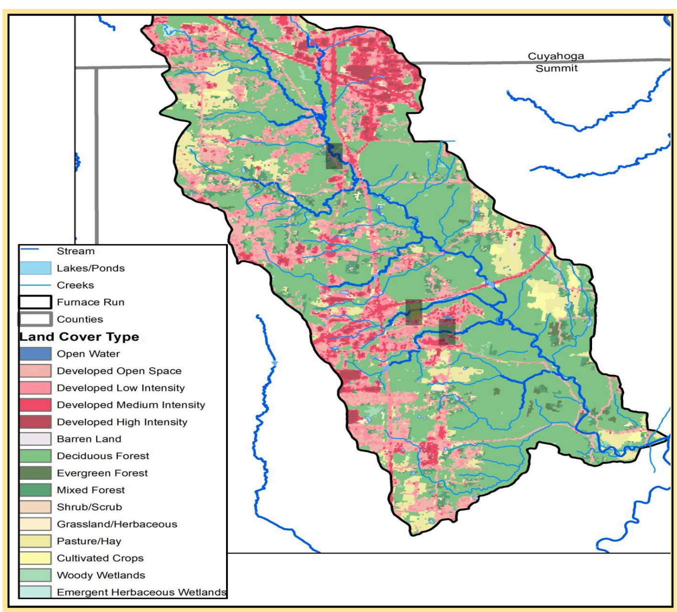


Figure 17. 2024 Temperature Exceedances in Eighteenmile Creek and Smoke Creek illustrate up to a 10 degree difference in temperature data collected compared to threshold requirements.



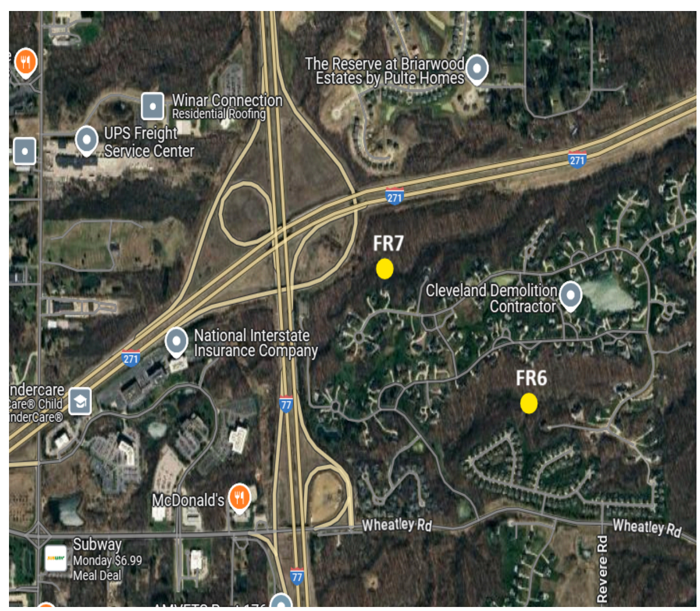


Figure 18. Land Use Maps of Furnace Run. <u>Photo to the left:</u> black boxes are representative of where cold water streams are located within the watershed. <u>Photo to the right:</u> aerial images of two cold water sites. Both pictures illustrate urban sprawl on cold water headwater systems and land use type heavily dominated by some level of development.

Data Limitations: The current frequency of samples taken presents challenges for establishing trends. Each sample was taken at one point in time and often during a similar time of day, so it does not represent the temporal variations in temperature during the daily periods outside of a singular sampling event. Moreover, while the current data can help to determine the magnitude of an exceedance, it fails to determine the duration over which it occurs. A continuous measurement may be able to indicate more consistent trends with data. Flow was also identified as another limitation with this parameter. Many exceedances were associated with observed low flow. The measurement of flow is visual and subjective. More precisely (and numerically) measured flow coupled with increased temperature sampling would provide a greater data set to determine duration of exceedance and related factors contributing to it. In addition to increasing the sampling frequency within a sampling event and over a sampling year, several years of data may also need to be established before this data can be used as a sentinel tool for observing stream response to climate change.

Recommendations: With more exceedances in 2024 than in 2023 and with an extension of exceedances into every subbasin within the Lake Erie basin, it is recommended to improve the understanding of temperature at sites currently experiencing exceedances, while encouraging additional sampling efforts with increased frequencies (e.g. continuous measurements) that focus on months where previous exceedances have occurred. For all sites, it is also recommended that a sampling time, ideally during the afternoon when daytime temperatures are at their highest, be standardized. Finally, the addition of quantified flow measurements should be considered for key sites.

4.3.3 Dissolved Oxygen (DO)

Thresholds: The concentration of dissolved gasses in water, such as dissolved oxygen (DO), is dependent on temperature. The colder the water, the higher the concentration of DO. Thus, cold and warm water streams have different DO thresholds.
Cold water streams: $\geq$ 7 mg L^{-1} DO
Warm water streams: $\geq$ 5 mg L^{-1} DO

Parameter Expectation: All site measurements are expected to be within the LEBAF standard range with some anticipated fluctuations due to daily, seasonal, spatial, and stream condition factors.

> **Diurnal -** Daily fluctuations of DO concentrations are a result of photosynthesis (production of oxygen) during daytime and respiration (consumption of oxygen) at night.
>
> **Seasonal -** The concentration of DO in water fluctuates seasonally as DO levels vary with water temperature. During the winter, higher DO levels should be expected; during summer, lower DO levels should be expected.

Spatially - Smaller streams with higher gradients should have higher DO due to greater mixing. Downstream locations with lower gradients and lower velocity should also have lower DO.

Stream Habitat - Unaltered stream channels have meanders, riffles, and woody debris, which can produce turbulent water. Turbulent water pulls oxygen from the atmosphere and mixes into the water. Higher DO concentrations could be expected in unaltered channels, while lower DO concentrations could be expected in altered stream channels as the water is less turbulent due to the lack of meanders, riffles, and woody debris.

Stream Productivity - Low DO concentrations may be present if oxygen consumers dominate the aquatic system. Oxygen consumers include aquatic animals, decomposition, and various chemical reactions. If oxygen consumption exceeds production, DO levels will decline. High levels of DO may result from an abundance of oxygen producers within the water. This includes plants and algae which produce oxygen as a byproduct of photosynthesis.

Table 49. Dissolved Oxygen Data Characterization

	# Samples	# Stations	Minimum	Maximum	Median	% Exceedance
Cold Water Sites	**78**	**10**	**6.30 mg L^{-1}**	**12.82 mg L^{-1}**	**8.79 mg L^{-1}**	**8.97%**
Warm Water Sites	**1302**	**126**	**0.31 mg L^{-1}**	**22.15 mg L^{-1}**	**8.17 mg L^{-1}**	**7.30%**

Exceedance Locations:

Summary of basins with Dissolved Oxygen Exceedances, (number of exceedances), in warm water streams

Cuyahoga River (21)
Detroit River (16)
Huron River (14)
Old Woman Creek (9)
Mills Creek (1)
Doan Brook (12)
Sawmill Creek (2)
Pipe Creek (4)
Swan Creek (10)
Chappel Creek (8)

Summary of basins with Dissolved Oxygen Exceedances, (number of exceedances), in cold water streams:

Cuyahoga River (6)
Smoke Creek (1)

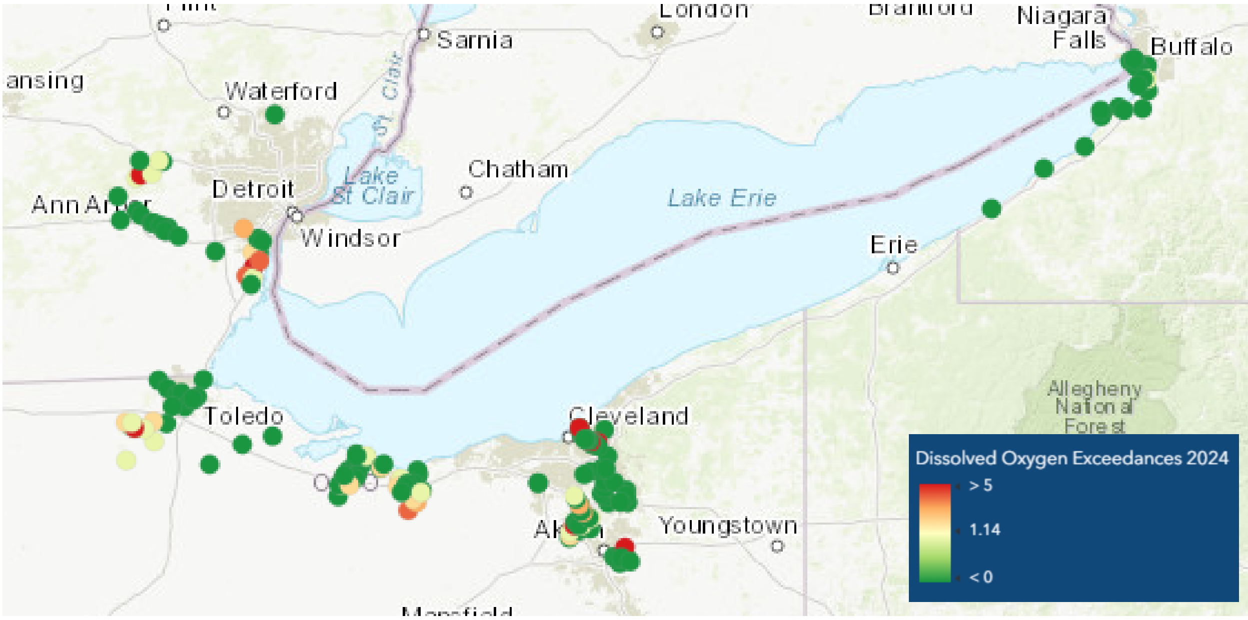


Figure 19. DO Exceedances by LEVSN Monitoring Locations. The color of the data points represents the percentage of DO exceedances. All non-green points are locations with at least one exceedance.

Factors Influencing Exceedances:

- Flow Conditions
- Ambient Air Temperature
- Watershed Land Use
- Drainage Area Size
- Organic Material
- Stream Buffer

Story: In 2024, cold water samples fell below the cold water DO concentration threshold value of 7 mg L^{-1} in two streams, Furnace Run and Smoke Creek. This concerning trend deviates from the 2022-2023 data, which reported no cold water sample data under the 7 mg L^{-1} threshold. In 2024, 7.30% of warm water samples fell below the warm water DO concentration threshold of 5 mg L^{-1}. This trend is slightly elevated from 2023 data, which reported 5.74% of warm water samples below parameter threshold. The 2024 low DO warm water samples were found in 11 of the 17 warm water basins monitored, meaning 64.71% of the basins monitored experienced low DO concentrations in warm water streams at some point during the 2024 monitoring season. Additionally, ten exceedances in 2024 were below the potentially hypoxic level threshold of 2 mg L^{-1}, with 30% of these occurring at one site, YC13 (Figure 20).

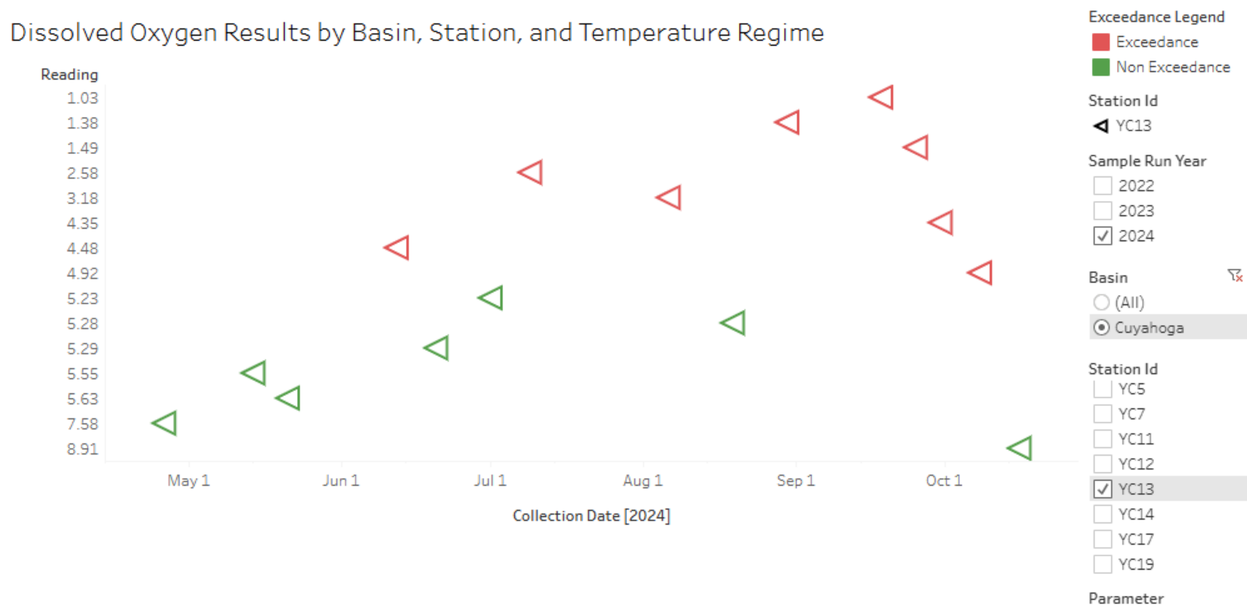


Figure 20: Yellow Creek - YC13 Dissolved Oxygen Results 2024

Flow conditions, in conjunction with elevated organic material present in the stream channel and ambient air temperature, tended to contribute to low DO concentrations. For example, one of the Huron River sites with low DO concentrations exhibited these readings during a moderate flood stage which pushed excess organic material into the waterway, exacerbating low DO concentrations (Figure 21). Sites in Chappel Creek and the Maumee River experienced similar exceedances driven by increased organic matter presence from persistent high flows. In contrast, low-flow conditions had a similarly significant impact on DO levels, with many of the 2024 exceedances linked to stagnant or minimal stream flow. Flow, whether high or low, appeared to be a significant factor in regard to DO concentration. Although temperatures across the basin were elevated during the 2024 season, DO exceedances showed less correlation with high temperatures compared to previous years. Other factors that may be affecting DO concentrations include influence from elevated nutrients in impounded waterway (Figure 22) and possible eutrophication from upstream inputs (Figure 23).

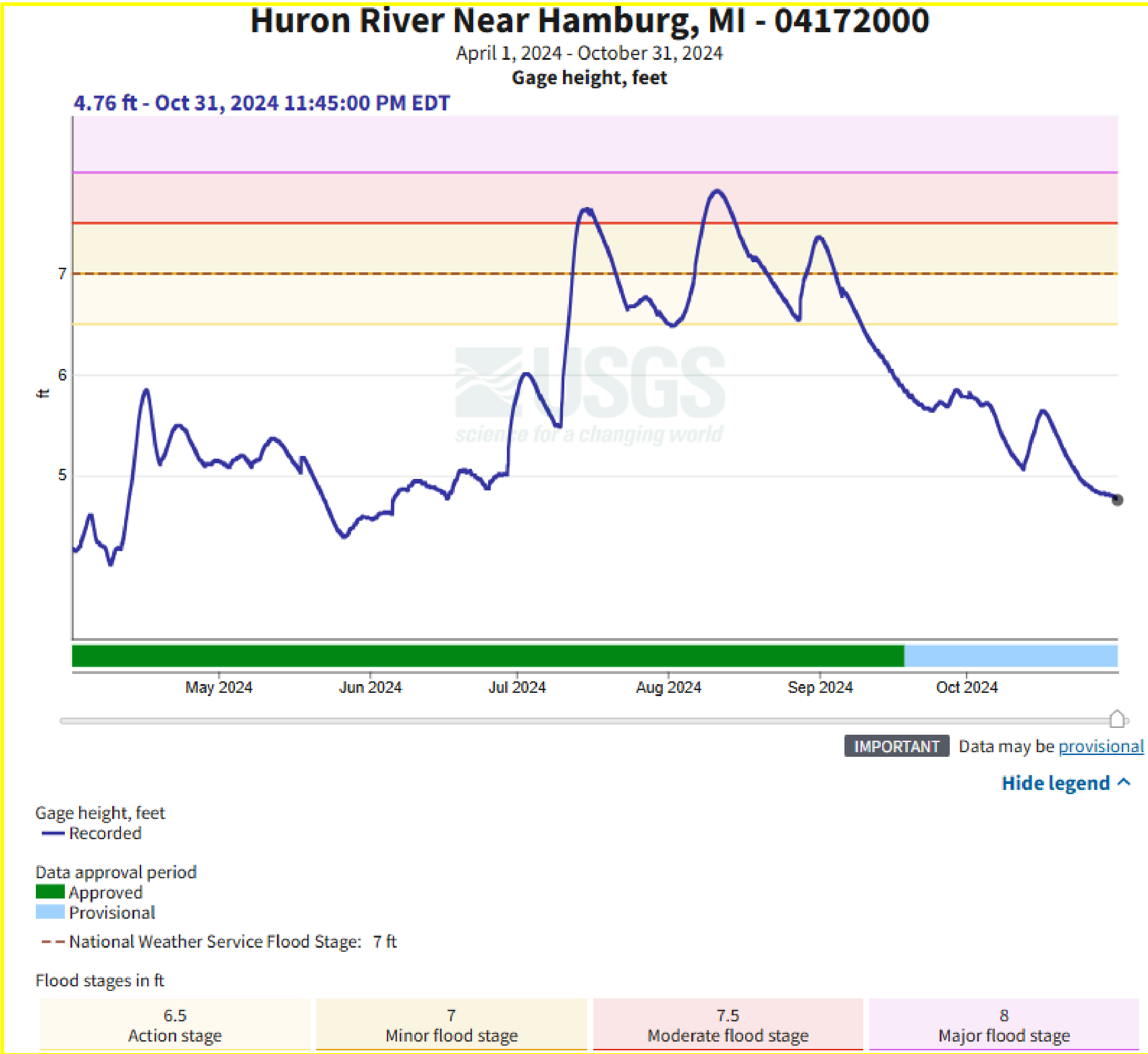


Figure 21: Huron River USGS Gage Height in feet, October 2024 near site COL01

Data Limitations: Sample size remains relatively small, limiting the ability to draw conclusions on daily and seasonal patterns, temperature influences, etc. Additionally, variations in sampling protocols between organizations on pool vs connected flow sampling, sampling time frame requirements, and accessibility of continuous sampling further limit the ability to draw conclusions. This year, no correlation was observed between DO concentrations and temperature fluctuations, potentially due to lack of information about nutrient and organic matter concentrations. Considering the distribution of exceedances, DO impacts to aquatic life at these sites is possible. Evaluation of the exceedance sites and surrounding land could identify potential causes.

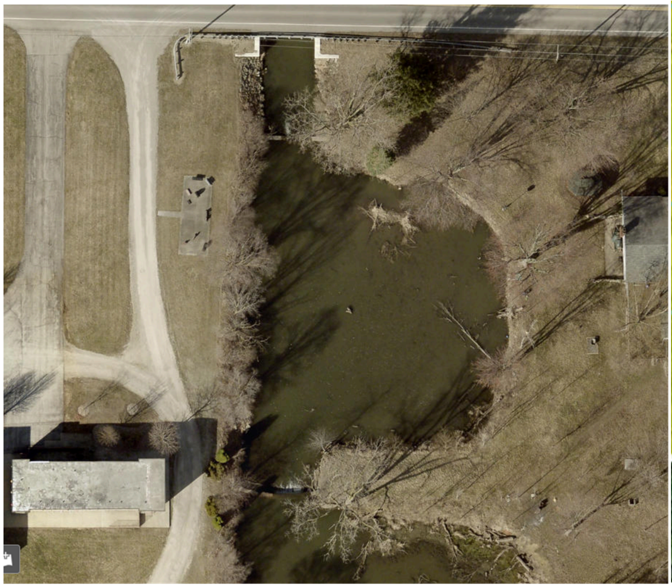


Figure 22: Bogart Rd in Sawmill Creek. Satellite imagery shows two low-head dams, a potential influence on nutrient composition in the waterway.

Figure 23: Yellow Creek Sampling Site, YC13, Drainage Basin. Aerial imagery of discharge from Bath Pond, a possible source of low oxygenated water upstream of the YC13 sampling site.

Recommendations: Low oxygen levels are less than optimal for most aquatic life, including macroinvertebrates and fish. This can result in a loss of species heterogeneity and the overall presence of aquatic life in waterways. It's recommended that macroinvertebrate communities continue to be sampled next season to determine the effects of DO concentrations. If low DO concentrations are constant, biological communities begin to decline.

In addition, it is recommended that nutrient and organic matter concentrations continue to be sampled in the 2025 season as they are critical factors in influencing aquatic ecosystem health. Elevated concentrations can contribute to increases in algal blooms, deplete oxygen, and further contribute to the biological community decline. In 2023, warm water exceedances fell within the acceptable range at 5.75%; however, this value increased in 2024 to 7.30%, still within the acceptable range but bringing growing concerns of DO exceedances. To limit the percentage of exceedances from continuing to grow, it is recommended to focus on capturing spatial and temporal variability through continuous diurnal data collection since seasonal and hydrological fluctuations heavily influence nutrient and organic matter concentrations. Also raising concerns, 2024 is the first year that DO exceedances in cold water streams were observed, which need to be paid special attention to because they support sensitive coldwater aquatic life. Also in 2024, 10 exceedances were below the threshold for hypoxia (2 mg/L) and should be monitored closely to ensure hypoxia levels do not become permanent. Additionally, focus should be paid to areas where exceedances occurred as well as areas with other localized issues including flashy flows and reduced groundwater levels as they can increase nutrient transport and impact water quality.

4.3.4 Conductivity

Thresholds: Conductivity is a measure of all the dissolved ions (salts and other primarily inorganic chemicals) in a waterbody. Conductivity quantifies a broad range of chemicals; thus, conductivity is used as a *general* indicator of water quality. Since waterbodies tend to have a consistent range of conductivity, baseline, or reference, conductivity values such as the Ohio EPA ecoregion and stream size specific reference and survey data (Table 50) are used by LEBAF as a comparator for assessing both the **(1)** validity of conductivity measures and **(2)** water quality. Most watersheds evaluated by LEBAF fall within one of two bioregions: *Erie-Ontario Lake Plains* (EOLP, Ecoregion 83) and *Huron-Lake Erie Plains* (HELP, Ecoregion 57). A few watersheds (e.g. parts of the Clinton River, Huron River, Ten Mile Creek, Old Woman Creek, and Chappel Creek) have sites that fall within other ecoregions, primarily the *Eastern Corn Belt Plains* (Ecoregion 55) and *Erie-Ontario Drift and Lake Plains* (Ecoregion 61), that do not have reference or survey data and were instead compared to either the EOLP or HELP ecoregion that was most like the ecoregion of the watershed.

Table 50. Ohio EPA Ecoregion and Stream Size Specific Conductivity Reference and Survey Data for Erie-Ontario Lake Plains (EOLP) and Huron-Lake Erie Plains (HELP)

Ecoregion	Stream Size	Stream Type	Min	x.25%	x.50%	x.75%	x.90%	x.95%
EOLP	Headwaters	**Reference**	**90**	**351**	**462**	**611**	**702**	**825**
EOLP	Streams	**Reference**	**167**	**405**	**489**	**549**	**643**	**766**
EOLP	Rivers	**Reference**	**183**	**348**	**456**	**602**	**803**	**883**
EOLP	Headwaters	Survey	316	466	629	886	1245	1654
EOLP	Streams	Survey	375	437	568	774	942	1114
EOLP	Rivers	Survey	304	416	585	780	1019	1201
HELP	Headwaters	**Reference**	**510**	**588**	**707**	**875**	**1119**	**1151**
HELP	Streams	**Reference**	**166**	**529**	**653**	**778**	**952**	**1107**
HELP	Rivers	**Reference**	**142**	**543**	**659**	**744**	**877**	**1043**
HELP	Headwaters	Survey	500	570	680	821	1074	1345
HELP	Streams	Survey	248	491	633	740	836	959
HELP	Rivers	Survey	152	573	679	808	1039	1275

LEBAF also evaluates conductivity based on the Ohio EPA minimum biocondition criterion of **412 µS cm**$^{-1}$. Values above this criterion are considered exceedances and were further evaluated using LEBAF's combined conductivity criteria screening, which expands on the Ohio EPA biocondition criteria to further describe the condition of the macroinvertebrate community and suggest appropriate actions for restoration (Table 51).

Table 51. LEBAF Combined Conductivity Criteria Thresholds

Threshold [µS cm^{-1}]	Condition	Action
≤ 412	Excellent, healthy	Protection activities
413-850	Concern for biota	Investigate biota diversity. Identify potential sources.
851-2000	Likely threats, impacts	Investigate chloride and salinity, and possibly other contaminants. Identify and investigate potential sources. Remediate sources
≥ 2001	Likely impaired	Work with state agency to determine further actions.

Several other measures including total dissolved solids, salinity, and chloride concentrations can be calculated from conductivity, as they are highly correlated. When observed conductivity concentrations are **> 850 µS cm^{-1},** LABAF uses these surrogate measures to better deduce potential sources of pollution and further specify aquatic life protective actions. The criteria used to evaluate these surrogate measures are outlined in Section 2.4 Analysis and Interpretation Table 3. LEBAF Screening Assessment Criteria (Benchmarks) Details and Sources.

Parameter Expectations: LEBAF expected watershed ambient conductivity values to overlap with the respective Ohio EPA ecoregion and stream size reference and survey data. LEBAF expected the alignment to vary between watersheds with no watershed data being in perfect alignment, but the overlap would provide additional confidence in the LEBAF conductivity results. Since both the EOLP and HELP reference and survey data have median values above the biocondition criterion of 412 µS cm^{-1}, it was anticipated that at least half of all the conductivity would naturally exceed this criterion. High conductivity values are also expected **(1)** after snow melt in the early spring that flushes anthropogenic sources of salts, **(2)** with warmer water temperatures in the summer months, **(3)** during low-flow events that concentrate minerals and pollutants, and **(4)** in smaller streams that contain smaller volumes of water or less diluent.

Table 52. Conductivity Data Characterization

	# Samples	# Stations	Minimum	Maximum	Median	Exceedances
All LEBAF Sites	1373	136	210* µS cm^{-1}	3544 µS cm^{-1}	750* µS cm^{-1}	1317
Cold Water Sites	78	10	365.4 µS cm^{-1}	1775 µS cm^{-1}	884.8 µS cm^{-1}	75
Warm Water Sites	1295	126	120* µS cm^{-1}	3544 µS cm^{-1}	746* µS cm^{-1}	1242

*4 samples from warm water sites were removed from the data characterization statistics because they were lower than acceptable conductivity values (< 50 µS cm^{-1})

Exceedance Locations: 1317 (96%) of the samples were above the 412 µS cm^{-1} biocondition criterion with almost all LEBAF monitoring sites experiencing at least one exceedance. The only site that did not experience any exceedances was located in Swan Creek. Median conductivity in 5 watersheds - Detroit River, Mills Creek, Rush Creek, Smoke Creek, and Ten Mile Creek - was between 850 µS cm^{-1} and 2000 µS cm^{-1}. All other watersheds - Buffalo River, Chappel Creek, Clinton River, Cuyahoga River, Doan Brook, Eighteenmile Creek, Huron River, Maumee River, Old Woman Creek, Ottawa River, Pipe Creek, Portage River, Sawmill Creek, and Swan Creek - had median conductivity values between 412 µS cm^{-1} and 850 µS cm^{-1}. Most watersheds never had conductivity values that exceeded 2000 µS cm^{-1}. Only 8 creek sites within 5 different watersheds had measured conductivity above 2000 µS cm^{-1}: the Furnace Run tributary headwaters in the Cuyahoga watershed, Ecorse Creek South at Reeck Rd. in the Detroit watershed, Doan Brook Middle Branch in the Doan Brook watershed, Chambers Dr. Huron Parkway and Shetland Dr. stations in the Huron River watershed, and Strecker Rd. W and Mason Rd. stations in the Mill Creek watershed. The Furnace Run tributary headwaters station draining to the Cuyahoga River had the highest conductivity value of 3544 µS cm^{-1} and Ten Mile Creek had the lowest conductivity of 120 µS cm^{-1}.

Factors Influencing Exceedances:

- Differing adjacent and upstream land use
- Flow conditions such as volume, velocity, and mixing
- Geology

Story:

Conductivity measures were generally high compared to all standards evaluated by LEBAF. Conductivity ranged from 210 to 3544 µS cm^{-1} with a median value of 750 µS cm^{-1} (Table 52). About one third of the monitored watersheds (i.e. Buffalo River, Chappel Creek, Eighteenmile Creek, Maumee River, Old Woman Creek, Portage River, and Swan Creek; Table 50) had median values in close alignment with the respective Ohio EPA ecoregion survey and reference median values. The other two-thirds of the watersheds had median values that exceeded the respective ecoregion and stream size median values. Medians recorded in these watersheds were more closely aligned with the 75^{th} percentile values or in some cases even the 90^{th} percentile values (i.e. Clinton River, tributaries of the Detroit River, Ottawa River, Furnace Run, Doan Brook, Rush Creek, and Ten Mile Creek; Table 50). The variations in alignment across the watershed datasets were anticipated. It was also expected that more than half of the datasets would be skewed toward the higher end of the baseline datasets, as most LEBAF monitoring sites are located in anthropogenically altered watersheds, where variability cannot be explained by ecoregion alone. Nevertheless, the comparison with the Ohio EPA baseline datasets further reinforces confidence in the LEBAF conductivity data.

A total of 96% of all LEBAF conductivity data exceeded the 412 µS cm^{-1} Ohio EPA biocondition criterion (Table 51). This was unsurprising as it was consistent with 2022 & 2023 data and because approximately 50% of the data was expected to exceed this criterion based on the natural variability of conductivity within the ecoregions. The known natural variability above this threshold stresses that conductivity alone is not a limiting factor for life since it is a non-specific measure. Even still, the vast majority of LEBAF conductivity data exceeding the biocondition criterion suggests that the conductivity values were indeed high and may be composed of some unnatural or excess inputs that may impact the biological community. Overall, when compared to previous years' data, the basin-wide median value increased in 2024 despite decreases in the median value at six of the monitored watersheds - Buffalo River, Cuyahoga River, Ottawa River, Rush Creek, Swan Creek, and Ten Mile Creek. When comparing medians across the basin, five watersheds (i.e. Detroit River, Mills Creek, Rush Creek, Smoke Creek, and Ten Mile Creek) had median values above the likely threatened or impacted 850 µS cm^{-1} combined conductivity criterion. An additional two watersheds (i.e. Huron River and Pipe Creek) fall above this threshold when means were evaluated. All seven of these watersheds had maximum conductivity values that reached over 1000 µS cm^{-1}.

Table 53. Summary Statistics of Conductivity by Watershed

Summary of Exceedances by Waterbody and Parameter

Basin	Sample Run..	Parameter	Mean Reading	Median Reading	Min Reading	Max Reading	Sample Count	N. Exceeded	Pct. Exceeded
Buffalo	2024	Conductivity Biocondition	412.02	415.25	301.40	603.60	18.00	9.00	50.00
Chappel Creek	2024	Conductivity Biocondition	590.69	581.50	439.80	947.00	32.00	32.00	100.00
Clinton	2024	Conductivity Biocondition	834.71	818.00	796.00	947.00	7.00	7.00	100.00
Cuyahoga	2024	Conductivity Biocondition	823.05	779.00	210.00	3,544.00	360.00	353.00	98.06
Detroit River	2024	Conductivity Biocondition	1,000.47	965.00	442.00	2,714.00	59.00	59.00	100.00
Doan Brook	2024	Conductivity Biocondition	745.99	718.00	275.20	2,033.00	1,105.00	1,045.00	94.57
Eighteenmile Creek	2024	Conductivity Biocondition	559.88	580.20	365.40	648.70	18.00	15.00	83.33
Huron	2024	Conductivity Biocondition	964.41	823.00	382.00	2,358.00	284.00	283.00	99.65
Maumee River	2024	Conductivity Biocondition	574.91	560.00	247.50	1,002.00	112.00	104.00	96.30
Mills Creek	2024	Conductivity Biocondition	1,219.90	1,152.00	11.67	2,197.00	50.00	49.00	98.00
Old Woman Creek	2024	Conductivity Biocondition	644.63	614.00	280.00	1,108.00	68.00	67.00	98.53
Ottawa River	2024	Conductivity Biocondition	828.85	842.00	304.70	1,485.00	34.00	29.00	85.29
Pipe Creek	2024	Conductivity Biocondition	939.02	829.00	8.67	1,996.00	49.00	48.00	97.96
Portage	2024	Conductivity Biocondition	643.64	630.00	397.00	989.00	28.00	27.00	96.43
Rush Creek	2024	Conductivity Biocondition	907.44	941.20	532.30	1,267.00	13.00	13.00	100.00
Saw Mill Creek	2024	Conductivity Biocondition	717.15	764.61	292.70	1,126.00	20.00	18.00	90.00
Smoke Creek	2024	Conductivity Biocondition	1,016.70	1,079.00	579.00	1,262.00	6.00	6.00	100.00
Swan Creek	2024	Conductivity Biocondition	586.83	596.50	219.10	1,056.00	100.00	83.00	83.00
Ten Mile Creek	2024	Conductivity Biocondition	830.46	928.00	120.00	1,431.00	11.00	8.00	72.73

The watersheds characterized by high conductivity did not exhibit consistently high conductivity across all monitoring sites (Table 53 and Figure 24). In most cases, only a few sites within each watershed showed either consistently high values or event-based spikes. Sites with sustained elevated conductivity (> 850 µS cm^{-1}) both in 2023 and 2024 were typically found in smaller creeks and streams draining anthropogenically impacted areas, particularly urbanized regions. In southeast Michigan, the Greater Buffalo Area, and the Cleveland area, sites with conductivity regularly at or above 850 µS cm^{-1} were located in urban and suburban areas with a high proportion of impervious surfaces. Examples include ADW05: Beech Daily Rd in tributaries of the Detroit River (Figure 17A); MH09: Shetland Dr. and MH08: in a tributaries of the Huron River (Figure 25A); and SMK04: South Smoke at Johnson St. and RUSH01: Rush Creek at Milestrip in Buffalo (Figure 25B). Sites with consistently high conductivity in the Greater Toledo area drained rural, agricultural row crop land such as CWAT-1: Sylvania Northview in Ten Mile Creek (Figure 25D). Though, these agricultural sites tended to have lower maximums than sites in the Erie Basin that drain other land uses. A few sites in Sandusky (e.g. MC-7: Strecker Rd. W, PC-5: Oakland Ave., and PC-7: Perkins Ave; Figure 25C) drain a mix of land uses, but sampling organizations attribute the high conductivity to adjacent industrial or wastewater outfalls. Many of these regional site examples were also highlighted in the 2023 report for similarly high conductivity concentrations.

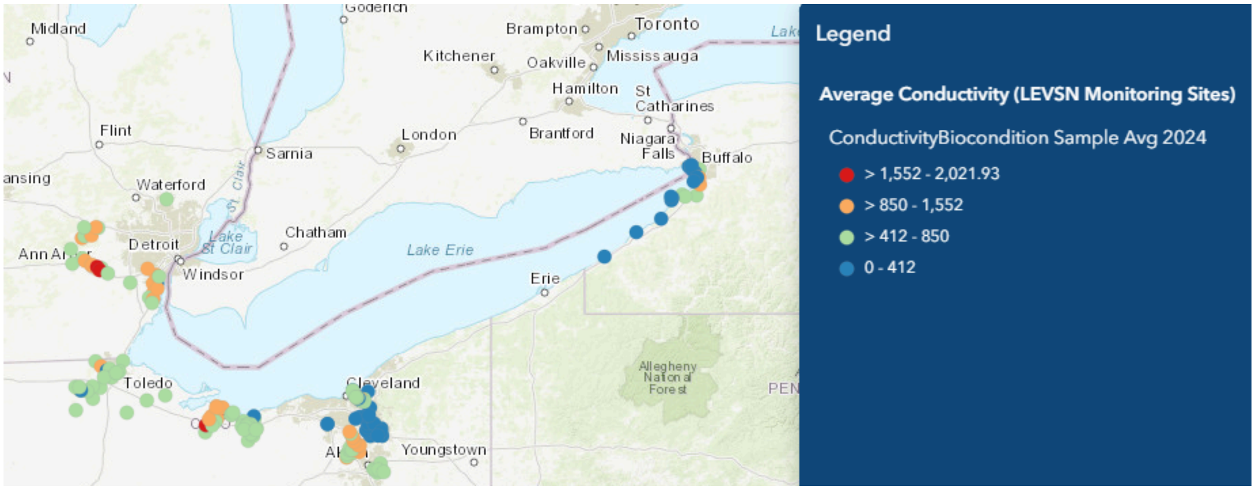


Figure 24. Lake Erie Watershed Average Conductivity Exceedance Map. All circles represent a LEVSN sampling location. All stations marked in non-blue colors had average conductivity values that exceeded the Ohio EPA biocondition (> 412 µS cm^{-1}). Sites with orange and red colors had average conductivity values that likely have impacts on the biological community.

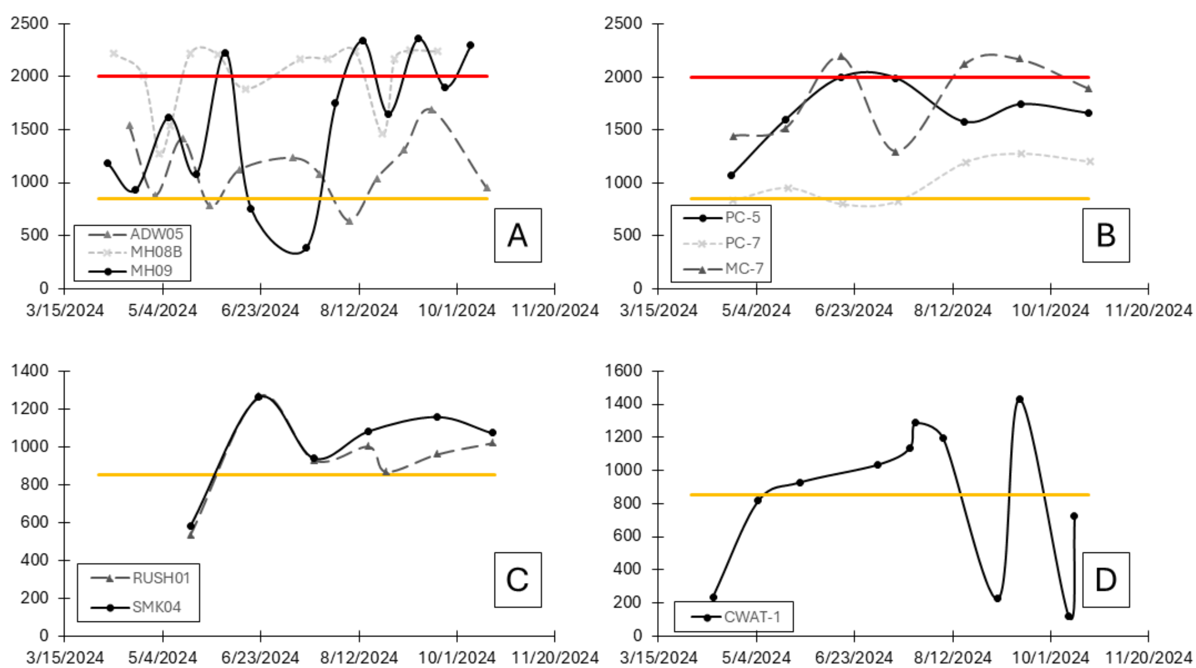


Figure 25. Example Sites in (A) Southeast Michigan, (B) the Buffalo area, (C) Sandusky area, and (D) Toledo area with High Conductivity Over the 2024 LEBAF Monitoring Period. All values

are reported µS cm^{-1}. All yellow lines mark the 850 µS cm^{-1} likely impacts combined criteria threshold and the red lines in A and C mark the 2000 µS cm^{-1} impaired combined criteria threshold. Y-axis scales vary.

Anthropogenic disturbances or changes to upstream land use were most often associated with conductivity exceedances. Such disturbances often alter natural flow regimes to more flashy systems. Drastic changes in flow coincided with spikes and troughs in conductivity data. For example, some sites in flashy, urbanized systems with high conductivity saw drastic declines to levels below the 412 µS cm^{-1} biocondition criterion following storm events (Figure 17A; Troughs in MH09), while others saw spikes (Figure 17B; Peak at RUSH01). This suggests different inputs contributed to conductivity at these sites. When conductivity decreases as flow rate increases, it suggests a constant flow or point source. When conductivity and flow rate increase together, it suggests pollutants in runoff. In 2023, extreme flow conditions and flash drought conditions further exacerbated conductivity extremes, but less extreme conditions were observed in 2024. Even still, extreme weather events are only expected to increase with climate change and may make aquatic systems with already flashy flow regimes more vulnerable to poor water quality or even dry conditions.

No clear seasonal trends nor consistent differences between stream temperature groups (Table 53) emerged when evaluating the full dataset, which further points to potential pollutant sources rather than natural variability. LEBAF calculated three surrogate measures– total dissolved solids (TDS), chloride, and salinity – based on the directly measured conductivity to better understand potential pollutant sources contributing to conductivity. Despite consistently high conductivity above aquatic life thresholds, all but one calculated TDS value fell below the aquatic life threshold of 1500 mg L^{-1}. Additionally, watersheds had relatively few conductivity values that resulted in high calculated chloride (135 exceedances; 10%) and salinity (214 exceedances; 13%; Figure 26). Generally high chloride and salinity values were only observed when conductivity values neared 1000 to 2000 µS cm^{-1}. High calculated chloride concentrations were only calculated in the Cuyahoga River Watershed (all 135 exceedances). These calculated concentrations in the Cuyahoga River were consistently higher than directly measured chloride concentrations in this watershed. Other LEVSN organizations also reported inconsistencies between measured and calculated values. Thus, calculated LEBAF salinity and chloride values and their interpretation may not reflect true concentrations or trends. For most sites, high salinity and some high chloride concentrations were event based or occurred non-consecutively. These fleeting spikes may allow aquatic life to seek temporary refuge during the exceedances. A few sites, however, within watersheds with the highest observed conductivity readings (e.g. Huron River, Detroit River, and Cuyahoga River; Figure 24 and Figure 26), had extended periods (months) with calculated salinity above the 1000 ppm freshwater limit that may suggest these streams are transitioning to slightly saline systems. Such a transition could impair aquatic life.

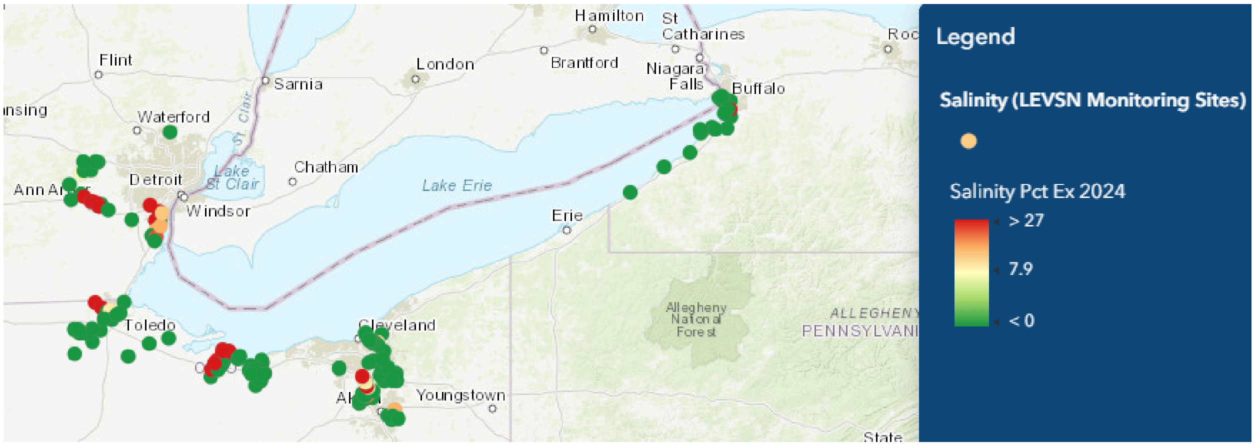


Figure 26. Lake Erie Watershed Salinity Exceedance Map. All non-green point mark sites with at least one salinity exceedance in 2024.

Data Limitations: Existing conductivity data limitations include: the limited number of cold water stations and sites; spatial data gaps including in areas of lower Michigan, tributary rivers and streams along the southeastern edge of Lake Erie, and the entire Canadian side of the Erie basin; and temporal limitations such as a seasonal gap in data between November and April and fine scale frequency gaps (i.e. between biweekly or monthly sampling points) that capture changes in flow especially in flashy systems.

The analysis of the surrogate measures of chloride, salinity, and TDS are also limited by the fact that they are implied and not directly measured parameters. LEBAF calculated these values based on the equations specified in LEBAF Standard Operating Procedure. While these equations are scientifically defensible, comparisons between direct measures of these parameters and the calculated values show some discrepancies. Thus, the salinity, chloride, and TDS calculations may not reflect the actual concentrations found in each stream. Further comparison and analysis is needed to be able to apply potential corrections.

Recommendations: Much of the Lake Erie Watershed has experienced higher than expected conductivity in 2022, 2023, and 2024. The range of values and trends observed are similar year to year. Based on the LEBAF conductivity analysis, 14 of the monitored watersheds (i.e. Buffalo River, Chappel Creek, Clinton River, Cuyahoga River, Doan Brook Creek, Eighteenmile Creek, Huron River, Maumee River, Old Woman Creek, Ottawa River, Pipe Creek, Portage Creek, Saw Mill Creek and Swan Creek) have median conductivity values that are of concern for the macroinvertebrate community and warrant further investigation and direct surveys of macroinvertebrate biodiversity. The other 5 monitored watersheds (i.e. Detroit River, Mills Creek, Rush Creek, Smoke Creek, and Ten Mile Creek) have median conductivity values that suggest the biological community is already impacted and warrants further investigation into pollution sources. LEBAF recommends remediation efforts, especially in the 5 highly impacted watersheds, to prevent further impacts or future degradation of the biological community due to high conductivity. Sites with highly anthropogenically altered sub-watersheds and those that experience flashy flows are high priority sites for remediation. Due to conductivity being a non-specific parameter and the limitations in the spatial and temporal data coverage, further investigations are needed within all monitored watersheds to better understand the specific pollution sources contributing to this high conductivity at each monitoring location.

LEBAF stations with conductivity values that exceeded 1000 µS cm^{-1} drained highly anthropogenically altered land areas. High conductivity in urbanized areas is often compounded by increased point and nonpoint sources of pollution and flashy flows due to impervious surface coverage that may increase both natural weathering and nonpoint source pollution. Other urbanized sites in Southeast Michigan are in highly channelized tributaries that can mobilize large quantities of minerals and pollutants that may contribute to nonpoint sources of conductivity in addition to documented point sources. Increased sample frequency is needed to better understand the influence of flow on conductivity, especially during both high and low flow events such as droughts or storms. LEBAF also aims to incorporate standardized flow measurements into the network's monitoring protocol to help watershed groups better diagnose flow-related water quality issues and provide specific flow related recommendations.

Sites draining industrial areas, for example, Pipe Creek and Mills Creek in the Sandusky area, had high conductivity values downstream of quarry discharge. LEBAF recommends that watershed groups and community members review and comment on the industrial and wastewater permits issued in LEBAF watersheds to ensure state environmental agencies require reductions in pollutants that may contribute to conductivity exceedances detrimental to aquatic life.

Further analysis and surrogate measurement investigations also suggest potential salt inputs from groundwater sources at some urbanized LEBAF sites. Some sites with measured conductivity values > 850 µS cm^{-1} experienced stark declines in conductivity after storm events, which suggest a possible flushing or dilution effect of a constant salt source such as groundwater. Concurrently high calculated salinity and rare occasions of high calculated chloride at these sites further support a possible groundwater salt source likely from winter road applications. An evaluation of flow-corrected concentrations or load calculations as well as direct measures of salinity and chloride, especially at LEBAF sites during the winter months and in the early spring, would strengthen this claim. Even still, LEBAF recommends municipalities consider more efficient and less frequent salt applications during the winter months as a preemptive remediation step to improve water quality across the Lake Erie Watershed.

In some cases, high conductivity was observed at sites draining agricultural or natural areas. Some agricultural products introduce salts as well as inorganic nutrients to streams that increase conductivity. Inorganic nutrient pollution is of particular concern for the health of the Western Lake Erie Basin but warrants a separate investigation of conductivity sources. High conductivity in agricultural and natural areas may also be influenced by environmental and geological factors, some of which may not influence aquatic life as evidenced by the Ohio ecoregion survey and reference dataset (Table 50). To better understand both natural and anthropogenic influences on conductivity, LEBAF hopes to expand its spatial coverage across the Lake Erie Watershed by engaging Canadian volunteer monitoring groups and continuing the expansion of the U.S.-based network.

Section 5 – Recommendations

5.1 Interpretation of Findings and Corresponding Recommendations

In 2024, LEBAF participants monitored over 130 stations across 21 rivers and tributaries located in the Lake Erie Basin. LEBAF participants were required to sample once per month from April to October, although a few participating groups sampled more frequently. The net result was more than 1370 sampling events, for approximately 5400+ parameter samples. Data included the four core parameters – pH, DO, temperature, and conductivity – and four surrogate parameters – conductivity biocondition, TDS, salinity, and chloride. LEBAF evaluated all data, even data collected from sites with a lower number of sampling points to increase the spatial coverage, in the overall analysis. Any sites with sparse data were caveated in the interpretation of results, especially if the data deviated from basin-wide trends. LEBAF also recognizes its short 3-year history and hopes continued sampling at all LEVSN sites in future years will help to better characterize site, watershed specific, and Lake Erie Basin-wide temporal variability.

Based on the 3-year LEVSN dataset and the LEBAF definition of health, as previously described in Section 2, the rivers and tributaries situated in the Lake Erie Basin are generally healthy and support aquatic life, particularly with respect to pH, temperature, and DO, with some degradation in temperature and DO noted when compared with 2023 data. Conductivity measurements are cause for concern in some sections of the rivers and tributaries, but do not suggest that the rivers and tributaries are unhealthy overall. Some rivers and tributaries are healthier than others based on different parameter exceedances. Unhealthy conditions were most often event based (e.g. during periods of drought), short-lived (i.e. observed during a single sampling) and occurred in smaller tributaries of larger systems that drained highly altered land, primarily urban areas or in some cases row crop farmland.

DO and pH showed exceedances in less than 10% of the data collected in 2024 (Table 44), which is similar to 2023 findings, while temperature exceedances were above 11%. Coldwater sites experienced more temperature and DO exceedances than warm water sites (Table 44), and an increase in DO exceedances at coldwater sites in comparison to 2023 data was observed. Many of the temperature and DO exceedances in both warm and cold water systems were observed when atmospheric temperatures were above average (generally ≥ 80°F/26.7°C) and there was below average precipitation, which led to low stream baseflow or even stagnant conditions. In fact, most of these exceedances occurred from late April through June, when NOAA confirmed spring temperatures that were "Much Above Average" or "Record Warmest" throughout the sampling area (Figure 15). Such extreme weather conditions are only expected to become more frequent and intense with climate change. Thus, LEBAF recommends the following, consistent with 2023 recommendations: expand riparian buffer zones to increase river and stream shading and expand the implementation of green stormwater infrastructure (e.g. vegetative swales and rain gardens) to help restore more natural flow regimes. Both recommendations also help to reduce the urban heat island effect that further exacerbates high temperatures in aquatic systems within urban areas. Finally, increased sampling frequency in areas with exceedances could allow for better interpretation of temperature and DO variability.

As in 2022 and 2023, conductivity data showed the greatest concern for ecosystem health, with 96% of all LEVSN data exceeding the Ohio EPA biocondition criterion adopted by LEBAF for evaluating ecosystem health (Tables 50 and 51). LEBAF recognizes that this criterion is difficult to meet when compared to Ohio EPA's natural reference and survey conductivity data for aquatic systems in the geological regions that encompass the LEVSN sites (Table 50). Most conductivity data overlapped with the reference and survey data, but most of the 2024 conductivity data fell on the upper end of the reference and survey datasets (Table 44). Based on median values, about one third of monitored watersheds were in alignment with reference values, and two-thirds exceeded these values. LEBAF ranks macroinvertebrate monitoring standardization highly among the possibilities for additional parameters, and will continue to explore the opportunity to add this to the SOP. Member groups are encouraged to incorporate macroinvertebrate sampling with their data collection to evaluate biocondition of monitored sites.

Watersheds with likely threats and impacts due to conductivity were generally in urban and suburban areas of southeast Michigan, the Greater Buffalo area, and the Cleveland area. Exceedances in the Toledo area had lower maximums than other areas, but agricultural row crop land seems to be having an impact. Event-based spikes were typically associated with extreme weather events, like drought conditions, that also led to many of the other parameter exceedances. Continued exceedances warrant consistent and expanded monitoring, while it is still believed that water bodies are generally healthy. Furthermore, despite high conductivity, all but one of the calculated TDS values fell below the aquatic life threshold and less than 15% of both the calculated salinity and chloride data exceeded LEBAF thresholds.

Even still, considering that all monitored watersheds have median conductivity values that are approaching or above the level of concern for macroinvertebrate communities, LEBAF recommends that all LEVSN participants conduct additional investigative sampling for sources contributing to high conductivity values. Since conductivity is a broad pollutant indicator, sources may differ across sites and watersheds. Initial source evaluations in 2023, based on calculated salinity and chloride, suggested salts as a potential source contributing to high salinity.

Finally, flashy flow regimes continue to be impactful in streams draining urban areas with lots of impervious surfaces or that are highly channelized. As recommended in 2023, it would be beneficial to add quantitative flow measurements to the core measurements of the LEVSN network. Standardized flow measurements would help to characterize pollutant loads and quantitatively describe flow regimes that will allow LEBAF to provide more specific flow-related recommendations in future reports.

Overall, the third year of data collection was a success. The report shows a snapshot of data collected over a three-year time frame that suggests the rivers and direct tributaries to Lake Erie have generally healthy ecosystems that support aquatic life. Noted increases in exceedances should be considered when designing subsequent sampling years. More detailed analyses of the data that supports this conclusion can be found in Sections 3 and 4 of this report. The data collected and presented supports the LEBAF monitoring purpose, data use of screening for primary data users, and the participating organizations.

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5 .2 Limitations of 2024 Monitoring Program and Corresponding Recommendations

As described in the introduction, all observations and interpretations described in each waterbody's aggregated summary, and in the Recommendations and Conclusions should be taken as heavily qualified by a range of limitations that face this monitoring program, particularly in these early years of operation.

In 2023, the second year of the program, we noted key limitations, including sampling gaps and limitations specific to each parameter. These limitations are still present and will be discussed below.

As in previous years, interpretations and recommendations presented in this report have been refined by member groups that bring significant knowledge regarding their local water bodies to the table. LEBAF trusts each group's local wisdom will help inform any use of the data in their outreach, education, restoration and protection efforts. Any groups seeking to leverage LEBAF data or information products outside this local context are heavily encouraged to engage with the relevant participating groups to ensure accurate interpretation. This is particularly true for all stakeholders outside of LEVSN including researchers, agencies, and community members.

Here are the 2024 Monitoring Program's limitations, and corresponding recommendations:

Spatial and temporal gaps in sampling - Even with additional groups joining LEVSN, the amount of data produced by members does not always provide a clear picture of watershed health. The first limitation in three years of sampling is the lack of historical data. Continued sampling using LEBAF protocols will begin to address this. There are spatial gaps across the Lake Erie Basin, notably a lack of data from Canadian watersheds, and limited spatial coverage reported in areas such as the Clinton River watershed. Temporal gaps were noted frequently by members, due to the limited capacity associated with volunteer-supported programs and a lack of continuous monitoring equipment. Increased volunteer engagement and procurement of equipment that can be installed to take more frequent or continuous measurements would minimize these gaps.

Sampling frequency was raised as a parameter-specific limitation for dissolved oxygen, pH, and temperature; specifics on those limitations and associated recommendations are detailed below.

Parameter Specific Limitations

pH data limitations: The low frequency and short duration of data collection makes it difficult to identify trends, although 2024 data appear to show site-specific instances of pH exceeding the acceptable range. A continuous measurement of pH, or multiple measurements taken at different points throughout the day, may help better capture temporal variation. Additionally, flow is measured by visual assessment only, and therefore may vary with each individual monitorer. As many of the pH exceedances were correlated to times of low flow at the monitoring location, a precise measurement of flow may give a more accurate interpretation of site conditions and help to better contextualize pH exceedances. Further, without long-term data, it is difficult to determine the degree to which these variations are typical. Additional sampling over the coming years will allow better identification of pH trends within the LEBAF network.

It is recommended that pH sampling occur at different times of day and across consecutive days, especially at sites with current pH exceedances. Because some sites with exceedances appear to be correlated with high urbanization, it is recommended that stations with this land use consider looking more closely into the habitat conditions at sites with exceedances, potentially through sampling macroinvertebrates.

Temperature data limitations: The current frequency of samples taken presents challenges for establishing trends in temperature. Each sample was taken at one point in time and often during a similar time of day, so it does not represent the temporal variations in ambient water temperature during the daily periods outside of a singular sampling event. Moreover, while the current data can help to determine the magnitude of a temperature exceedance, it fails to determine the duration over which it occurs. A continuous measurement may be able to indicate more consistent trends in temperature.

Flow was also identified as another limitation with this parameter. Many temperature exceedances were associated with observed low flow. The measurement of flow is visual and subjective. More precisely (and numerically) measured flow coupled with increased temperature sampling would provide a more complete data set to use in determining duration of exceedance and related contributing factors. In addition to increasing the monthly and annual sampling frequency, several years of data may also need to be established before temperature can be used as a sentinel tool for observing stream response to climate change.

To improve the understanding of temperature at sites currently experiencing exceedances, it is recommended that additional sampling efforts with increased frequencies (e.g. continuous measurements, if possible) should focus on months where previous exceedances have occurred. For all sites, it is recommended sampling take place in the afternoon when daytime temperatures are at their highest. Finally, the addition of quantified flow measurements should be considered for key sites.

Dissolved oxygen data limitations: Sample size remains relatively small and is not yet sufficient to draw conclusions on daily and seasonal patterns, temperature influences, etc. There are also spatial limitations to the data that have yet to be investigated. Considering the distribution of exceedances, DO impacts to aquatic life at these sites is possible. Evaluation of the exceedance sites and surrounding land uses could help determine likely causes. At sites below the minimum threshold, there may be impacts to aquatic life, especially if DO levels are low for an extended period. Understanding the heterogeneity and tolerances of macroinvertebrate communities would help draw conclusions about DO patterns and fluctuations. Future sampling of macroinvertebrate communities could help determine if low DO concentrations are affecting biota.

Variations in sampling protocols between organizations on pool vs connected flow sampling, sampling time frame requirements, and accessibility of continuous sampling limit the ability to draw conclusions. Aligning sampling practices, sampling at multiple times during the day, and more frequent sampling during each month would help to address these limitations. In addition, it is recommended that nutrient and organic matter concentrations continue to be sampled in the 2025 season as they are critical factors in influencing aquatic ecosystem health.

Conductivity data limitations: Existing conductivity data limitations include: the limited number of cold water stations and sites; spatial data gaps; and temporal limitations such as a seasonal gap in data between November and April and fine scale frequency gaps (i.e. between biweekly or monthly sampling points) that capture changes in flow especially in flashy systems.

The analysis of the surrogate measures of chloride, salinity, and TDS are also limited by the fact that they are implied and not directly measured parameters. Thus, the salinity, chloride, and TDS calculations may not reflect the actual concentrations found in each stream. Further comparison and analysis is needed to be able to apply potential corrections.

Much of the Lake Erie Watershed has experienced higher than expected conductivity in 2022, 2023, and 2024. Consistent exceedances warrant further investigation and direct surveys of macroinvertebrate biodiversity, along with further investigation into pollution sources. LEBAF recommends remediation efforts, especially in the most impacted watersheds. Sites with highly anthropogenically altered sub-watersheds and those that experience flashy flows are high priority sites for remediation. Due to conductivity being a non-specific parameter and the limitations in the spatial and temporal data coverage, further investigations are needed within all monitored watersheds to better understand the specific pollution sources contributing to this high conductivity at each monitoring location.

Increased sample frequency is needed to better understand the influence of flow on conductivity, especially during both high and low flow events such as droughts or storms. LEBAF also aims to incorporate standardized flow measurements into the network's monitoring protocol to help watershed groups better diagnose flow-related water quality issues and provide specific flow related recommendations.

An evaluation of flow-corrected concentrations or load calculations as well as direct measures of salinity and chloride, especially at LEBAF sites during the winter months and in the early spring, would strengthen the claim that road salt leads to conductivity exceedances. Even still, LEBAF recommends municipalities consider more efficient and less frequent salt applications during the winter months as a preemptive remediation step to improve water quality across the Lake Erie Watershed. Additionally, watershed groups and community members are encouraged to review and comment on industrial, wastewater, and stormwater permits to ensure the documents require reductions in pollutants that may be associated with conductivity exceedances.

High conductivity in agricultural and natural areas may also be influenced by environmental and geological factors, although currently available data is not comprehensive enough to explore this possibility. To better understand both natural and anthropogenic influences on conductivity, LEBAF hopes to expand its spatial coverage across the Lake Erie Watershed by engaging Canadian volunteer monitoring groups and continuing the expansion of the U.S.-based network.

5.3 Program and Organizational Outcomes

From a program and organizational perspective, the 2024 LEBAF sampling season was extremely successful. Now in its third year of fully standardized monitoring, LEBAF participation grew substantially as LEVSN's movement to amplify the credibility and power of community water quality action continued to gain momentum. Participants engaged deeply in the highly structured process of collecting, analyzing, and communicating data to support their own local information needs and tell a shared regional story about the health of Lake Erie watersheds.

Participation highlights include -

- Seven 2023 participants returned for the 2024 season (Buffalo Niagara Waterkeeper, Erie Soil & Water Conservation District, Huron River Watershed Council, Metroparks Toledo, Partners for Clean Streams, Summit Soil & Water Conservation District, Toledo Zoo & Aquarium, and Old Woman Creek NERR).

- One additional 2024 participant returned but faced staffing turnover that prevented them from analyzing their collected data for this report (Tinker's Creek Watershed Partners). They intend to resume participation in 2025.
- Two 2022 participants who went on hiatus for 2023 due to technical and logistical issues returned to data collection and analysis (Clinton River Watershed Council and Doan Brook Watershed Partners).
- Two new participants adopted LEBAF standards for the first time (Bowling Green State University Firelands and Huron City Schools).
- Four participants were trained and equipped in preparation for the 2025 field season including three brand new monitoring partners (Defiance College, Defiance Soil & Water Conservation District, and City of Defiance) and our first Canadian participants - Water Rangers' Lake Erie Guardians program.
- Seven participants (Buffalo Niagara Waterkeeper, Doan Brook Watershed Partnership, Erie Soil & Water Conservation District, Huron River Watershed Partners, Summit Soil & Water Conservation District, Tinkers Creek Watershed Partners, Old Woman Creek NERR) and five external partner organizations (NEORSD, Ohio EPA, Organic Connects, Ohio Sea Grant and Water Rangers) took increased ownership over the network as part of its Steering Committee and/or its Standards Working Group.
- The thirteen active 2024 participating organizations leveraged their combined 3,711 data points (collected monthly at nearly 150 sites) and LEBAF's standardized analysis tools to conduct individual assessments of the health of 54 streams and rivers that flow into Lake Erie as well as a collaborative evaluation of the health of the Lake Erie Basin as a whole.
- Network leadership spearheaded the engagement of over 100 representatives of agencies, research institutions, and funders as part of an effort led by the International Joint Commission (IJC) to develop a proposed framework for institutions to support volunteer science across the Great Lakes.
- LEVSN retired our direct partnership with SUNY Fredonia as LEVSN lead Michael Jabot accepted a new role as Deputy Director for Education in NASA's GLOBE Program, a program that engages youth in 127 countries across the world. A loss for LEVSN but a win for Lake Erie volunteer science!

In addition to collecting, analyzing, and reporting 2024 data, the network worked hard to leverage learnings from 2023 to refine its processes and deepen its capacity. A rigorous evaluation process conducted following the second LEBAF field season resulted in the documentation of key gaps, limitations, and opportunities for improvement in a shared action plan. The LEVSN Standards Working Group used this plan to lead the network in updating its processes, tools, and supporting documentation to further refine LEBAF. Additionally, the LEVSN

Steering Committee undertook a strategic planning process and CWA staff led a contract with the IJC to chart the direction of the network and participatory science across the Great Lakes.

Key program improvements integrated into the 2024 field season -

- An improved data analysis tool with more mapping, graphing, and automation options
- A refined data analysis process, including -
    - A more appropriately weighted approach to analyzing Conductivity and its surrogate parameters that improves interpretation and the framing of results
    - A more streamlined individual analysis process that makes it easier for participants to consistently and rigorously evaluate their local watersheds
    - A more collaborative Lake Erie Basin Watershed analysis process that allows the full network to discuss and come to consensus on regional insights
    - A more refined reporting process that improves templates and engages participants to more efficiently compile and share results
    - A critical mass of participant leadership, enabling 2024 to be the first year that the analysis process was entirely led by the Standards Working Group rather than CWA.
- Upgraded Water Reporter, our data platform to deliver enhanced analysis support and create channels for easy upload to two national platforms - Great Lakes DataStream (CA) and US EPA Water Quality Exchange (US) - to increase the accessibility of volunteer collected data.
- Conducted technical trainings fully in-house (rather than relying on vendors), leveraging network leaders' decades of experience to ensure relevance and completeness of the guidance provided
- Empowered local volunteer science champions to lead the 2024 implementation of the Lake Erie Baseline Assessment Framework, the standardized data collection, analysis, and reporting framework that allows LEVSN to tell a story about the health of Lake Erie watersheds.
- The Steering Committee developed strategic growth areas to target for future programming and funding including broadening community partnerships with a focus on Youth Empowerment and Deepening institutional partnerships with a focus on driving data use.

It is worth noting that the identification, prioritization, and execution of these improvements was driven by participant engagement. The issue areas that guided this work was determined by participants feedback from the 2023 field season evaluation process and the development of updated documentation, processes, and tools was delegated by the participant-driven Standards Working Group. This phenomena shows the continued commitment of Local Hubs to not only the standardized implementation of LEBAF, but its continued growth and refinement.

Key program improvements proposed for development during the 2025 field season -

- Expand LEBAF participation across the basin, with particular focus on Michigan, New York, and Ontario, to work towards addressing gaps in geographic coverage
- Continue refinement of data analysis tools and methods with a particular focus on creating even more user friendly documentation to support participants
- Developing non-mandatory guidance to support participants in setting up their sampling plans, site selection, volunteer management, and other best practices that amplify the support provided by required standards
- Develop approach for incorporating in-situ sensors for high-frequency sampling at stations with persistent exceedances to address temporal resolution issues
- Refining approach for engaging K-12 schools in LEBAF to grow participation and expand community impact through youth engagement.
- Evaluate opportunities to standardize and incorporate additional parameters to advance LEBAF's monitoring purpose and intended data uses

Of particular focus is driving continued growth in LEBAF participation, which will help address spatial gaps in data collection as well as build the network's capacity to manage and refine LEBAF. We plan to continue to leverage our reserve of YSI sensors and Water Report licenses, as well as our robust training and onboarding process, to empower both existing groups and new monitoring programs to join the movement. Six new groups are in the process of being onboarded to the network for the 2025 field season as this report is being published.

We are highly encouraged by the continued positive feedback from LEBAF participants as we wrap up the program's third year. When asked about the benefits to their staff, volunteers and programs, participants consistently spoke about how productive and educational it was to participate in a regional effort of this scope for the first time. Thes groups appreciated the support of sensor loading, data platform licenses, and SOP documentation provided by the network and are getting increasingly more proficient in the annual as their experience grows and the process regines.

Participants also enjoyed the opportunity to refine their capacities via standardized data collection, management, and analysis technologies employed as well as to learn from and refine the collaborative process of data analysis, synthesis, and interpretation. Additionally, they appreciated learning about each other's programs and waterbodies, sharing best practices and expanding each other's knowledge about the Lake Erie Basin.

Perhaps most of all, participants see the tremendous potential of standardized, interoperable data being collected at the regional level - the capacity to integrate their work with that of their peers to build a data asset that is bigger than any one community or organization could do by themselves. The potential impacts of this standardized approach is hard to understate. The analytical capability and programmatic credibility it allows for each participating group is complimented by the new capacity they have to build a unified and effective screening tool at the scale of a Great Lake Basin. This process, now shown to be technically and organizationally possible, promises to produce significant value for the Lake Erie region and its communities as it grows and builds a unique historical record that can be used to understand trends over time. As LEBAF evolves and matures, LEVSN aims to tie its recommendations more closely to specific conservation, restoration, and other beneficial actions for various stakeholders, in their relevant localities and at the regional level.

Further, the alignment and activation engendered by the standardization process has transformed the Lake Erie volunteer science ecosystem from a constellation of disparate local groups into a highly organized movement. This shift enables a host of possibilities, ways that the network can build on LEBAF to meet data needs and address water quality issues and ways that external partners can easily plug into the world of participatory science. LEVSN's Steering Committee and Standards Working Group are exploring ways to leverage the network's momentum to expand LEBAF, as well as LEVSN's broader work, for greater collective impact. In order to position the capacity for such action as well as other forms of collaboration such as adding new partners or working with agencies on specific monitoring objectives, LEBAF will communicate the conclusions, recommendations, and organizational accomplishments of the 2024 field season to key stakeholders using a variety of products and channels. The primary information product from 2024 will be this report and its more succinct local and Lake Erie iterations which will be shared by Cleveland Water Alliance and each LEBAF participant respectively as a press and web release. LEVSN also plans to update its shared web page on the Cleveland Water Alliance site. Finally, LEVSN will continue to refine its shared data hub (Water Reporter) and work to publicize and connect this hub to end users via a web app on the shared webpage, local collaborations, and API connection to other data hubs.

In conclusion, LEBAF participants are passionate about their work and desire to keep the collaborative moving forward to create collective impact for Lake Erie waters and the communities they support. LEVSN aims to grow and refine the LEBAF process to build up the effectiveness of its work, the value of its data repository, and the depth of its engagement with decision makers. In 2025, the network will focus on further refining the operation and maintenance of existing protocols, expanding to new parameters, and engaging with the professional (agency and academic) water quality monitoring world. Moving forward, it aims to serve as a model for collaboration of local groups for greater impact across the Great Lakes through its engagement with IJC. If you are interested in supporting or participating in LEVSN or want more information, please refer to section 5.4 below.

5.4 Growing the Movement

Since 2020, LEVSN participation has tripled to include over 20 participating organizations, and the network has partnered with professional scientists and decision makers to create a robust program that can fill data gaps and inform management efforts across the Lake Erie Basin.

The network has already demonstrated the capacity of volunteer science to generate powerful scientific and community impact and we will continue to build momentum as our movement continues to grow. LEVSN invites communities, organizations, and individuals to join us in pursuing better water quality and quality of life for all Lake Erie Basin communities by:

- **Funding the Network** - Direct contributions to the network enable us to retain and grow critical functions such staff capacity, equipment upkeep, and data infrastructure.
- **Funding a Local Hub** - Direct contributions to your local volunteer science program enables their capacity to collect data, address local challenges, and participate in LEVSN.
- **Participation -** Bringing a new or existing volunteer program into LEBAF expands our capacity to collect data for impact and helps fill critical data gaps.
- **Leadership** - Participation in Working Groups or on our Steering Committee grows our organizational capacity to expand and evolve the network to address new challenges.
- **Technical Resources** - In-kind contributions of equipment, data tools, and technical support ensure that the network remains at the forefront of water data technology.
- **Scientific Expertise** - Collaborations with researchers, agency scientists, and water resource managers ensures that our movement remains scientifically rigorous.
- **Data User Relationships** - Leveraging our data helps the network build the partnerships and funding relationships needed to scale impact and ensure long-term sustainability.

If you are interested in supporting or partnering with LEVSN, please reach out to Max Herzog with Cleveland Water Alliance at mherzog@clewa.org. Together, we can ensure a healthier future for all Lake Erie Basin communities. With your help, the story has just begun.

Appendix I – Participating Groups

Buffalo Niagara Waterkeeper has been the guardian of Western New York's fresh water since 1989. Its mission is four-fold: PROTECT the water, RESTORE both the waterways and the surrounding ecosystems, CONNECT people to their waterways, and INSPIRE both economic activity along the waterways and community engagement. Their long-standing water quality monitoring program, Riverwatch, and other staff-led water quality data collection efforts provides a regular stream of data and information allowing us to maintain a strong understanding of our local waterways conditions and threats. This data is used to educate volunteers, community members, and elected officials and advocate for water quality improvements.

Clinton River Watershed Council (CRWC) is a non-profit organization serving the Clinton River watershed, Anchor Bay, and Lake St. Clair direct drainage, located in southeast Michigan. CRWC's mission is to protect, enhance, and celebrate the Clinton River, its watershed, and Lake St. Clair for the benefit of communities, the environment, and our future. Its volunteer science programs serve to fill knowledge gaps and expand understanding of unique and vibrant natural resources throughout the watershed and nearby tributaries

The Doan Brook Watershed Partnership (DBWP) is a multi-stakeholder, non-profit organization with broad participation from the City of Cleveland, Cleveland Heights, and Shaker Heights. Its mission is to protect and restore the Doan Brook and its watershed through collaboration and sharing of resources.

Firelands Coastal Tributaries Watershed Program was created in 2006 and is currently operated through a partnership between the Old Woman Creek National Estuarine Research Reserve and the Erie Soil and Water Conservation District. The program acts as a community lead for watershed planning, stewardship education, grant funded watershed improvement projects, and the development of citizen-based stream monitoring. In 2024 the program expanded to include partnerships with BGSU Firelands and Huron City Schools.

Huron River Watershed Council (HRWC) is southeast Michigan's oldest environmental organization dedicated to river protection. HRWC protects and restores the river for healthy and vibrant communities. HRWC monitors the Huron River, its tributaries, lakes, and groundwater, and leads programs on pollution prevention and abatement, wetland and floodplain protection, public education, and natural resource and land-use planning.

Metroparks Toledo is a public agency serving the citizens of Lucas County by providing a regional system of clean, safe, natural parks. Metroparks engages volunteers in a host of activities including multiple programs centering the monitoring of natural resources. Historically, their water quality monitoring program has centered on biological monitoring to determine the water quality of streams and rivers in and near Metroparks. Now, through LEBAF and the Clean Water Action Toledo (CWAT) partnership, water chemistry monitoring has been added to the program.

Partners for Clean Streams (PCS) is striving for abundant open space and a high-quality natural environment, adequate floodwater storage capacities and flourishing wildlife, stakeholders who take local ownership in their resources, and rivers, streams, and lakes that are clean, clear, and safe. PCS was established in 2007 as a 501c3 non-profit watershed organization. PCS programs focus on engaging the community in caring for and learning about the streams and rivers in northwest Ohio and our everyday connection to Lake Erie. Since 2021 PCS has led the Clean Water Action Toledo (CWAT) partnership, a collaboration with Metroparks Toledo, TMACOG, and Toledo Zoo focused on integrating and growing volunteer water quality monitoring across the greater Toledo area with a focus on implementing LEBAF.

Summit Soil and Water Conservation District (SSWCD) was established to address conservation needs in Summit County, providing local leadership for soil and water resources conservation and water quality enhancement. LEVSN supported SSWCD in developing a Stream Monitoring Volunteer Program to enhance the stewardship of Summit County watersheds by increasing knowledge of local water quality. By participating in LEBAF, SSWCD provides credible water quality data to drive necessary stewardship changes that support watershed health both locally and regionally. In addition, SSWCD documents water quality trends over time and uses the data as an evaluation tool for improvement projects.

Tinker's Creek Watershed Partners' water quality monitoring program teaches volunteers how to monitor a stream, show what conditions to look for that are cause for concern, and who to contact with questions and data. The data will be compiled and logged online and shared with partners to monitor the health of the creek and to find sites for future restoration projects. Volunteers are encouraged to adopt a site where they take on the sampling every month for their favorite spot in the watershed. These data help prioritize work and track pollution.

Toledo Zoo & Aquarium is a recognized conservation leader that conducts research, participates in animal rehabilitation, and implements conservation programs throughout Northwest Ohio and across the globe, seeking to better the lives of animals and ecosystems. Its ZOOTeen program offers volunteer opportunities to students ages 13-17 who have a strong interest in education, animal science and conservation. LEBAF and Clean Water Action Toledo (CWAT) has partnered with the Zoo to provide opportunities for its ZOOTeen program to engage with water quality monitoring.