CLEVELAND WATER ALLIANCE

and Lake Erie Volunteer Science Network

Present

2022 Lake Erie Baseline Assessment Framework Field Season Report

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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 will 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 2022 Field Season and Program Year

In 2022, the inaugural LEBAF field season saw eight participating groups collect, analyze, interpret, and disseminate data from 466 samples originating at 67 stations on 14 local waterways across the Lake Erie Basin. Participants' engagement with and ownership of this collaboration were exceptional, ensuring faithful execution of the collectively developed LEBAF SOP. Use of the SOP enabled comparable data collection by all participants, allowing groups from as far afield as Ann Arbor and Buffalo to jointly assemble a reasonably representative snapshot of Lake Erie watersheds. Further, this shared structure empowered participants to co-lead a standardized data analysis and interpretation process that used consideration of streams' capacity to support aquatic life to enable robust screening of watershed health across monitored areas and the Lake Erie basin as a whole.

As a result of this rigorous and standardized assessment, LEVSN is able to present a regional volunteer-driven perspective on the condition of watersheds that feed Lake Erie and provide a benchmark against which future monitoring can be compared. Using the definition of health laid out in the LEBAF SOP, 2022 field measurements appear to indicate that Lake Erie's watersheds are generally healthy and support aquatic life, though our screening did pinpoint localized conditions where some parameters may indicate that stations or waterways are currently experiencing, or are at risk of experiencing, unhealthy conditions. These conclusions are particularly supported by participants' direct measurement of pH and dissolved oxygen as well as expressions of conductivity as TDS, salinity and chloride.

The most significant exception to the general healthy status of monitored Lake Erie watersheds is that every monitored water body experienced at least one exceedance of the conductivity macroinvertebrate biocondition gradient. 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. Results of this parameter were consistently high across space and time and are corroborated by existing macroinvertebrate data where it is available. 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 our assessment macroinvertebrate database does not represent with equal sensitivity. Seasonal plotting of conductivity data collected in future years will help determine the scope of this potential impact with greater confidence as well as establish trends over time and build the reference macroinvertebrate database for more ecoregions.

A significant outcome of the 2022 field season was the identification and acknowledgement of LEBAF's limitations. In considering the 2022 results, it is essential to note that this first iteration of LEBAF has many spatial and temporal gaps within currently monitored watersheds as well as underrepresentation of cold water streams, absence of monitoring for some major watersheds to the Lake, and lack of Canadian participants. Further, a single season snapshot cannot make any definitive statements on 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 water body's aggregated summary, in the Lake Erie Overall 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 its first year 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. It is plausible to suggest that monitored watersheds which appear healthy may have a positive influence on aquatic life conditions in the Lake and waters with at risk or unhealthy conditions may negatively influence aquatic life conditions in the Lake. However, other factors not included in this assessment, such as direct measurements and existing data sets and assessments, should be considered before making any statements about the aquatic health of Lake Erie itself.

Overall, this first year of standardized volunteer monitoring marked great progress towards LEBAF's intended monitoring purpose, data use, and desired impacts. LEVSN was able to equip itself with industry-standards sensor technology, a cloud data platform, training opportunities, and a robust set of SOPs to enable 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. As of Spring 2023, a full evaluation of LEBAF's SOP and processes has been conducted by its participations and improvements are in progress to fill gaps and further refine program elements and shared analyses. Moving forward LEVSN aims to build on 2022's successes to expand the number of sampled parameters, historical data record, geographic coverage, and confidence in its interpretation over future sampling years.

As LEBAF monitoring continues, the standardized, credible data collected will begin to provide a regional condition assessment of Lake Erie streams over time to inform local, and potentially regional, restoration and protection activities. However, even with the program still in its infancy, the network has already demonstrated the capacity of a regional volunteer network to generate credible and useful science. LEBAF has helped each participating program enhance or expand their efforts and now it is enabling new groups to begin volunteer monitoring for the first time. 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 serves as the primary scientific reference for the 2022 LEBAF field season by capturing the breadth and depth of participants' work, process, and findings in a single location. It should be used to examine the high-level takeaways from this field season (executive summary) alongside interpretation of analyses at two primary scales of storytelling (Large Rivers/Direct Tributaries and the Lake Erie Region) and Recommendations and Conclusions across all monitored water bodies. For each water body, this report provides 1) descriptions of participating organizations, 2) statistics describing the measurements of each parameter at each water body over the field season, 3) relevant graphs of parameters' distribution over the season, 4) summary statements for each parameter that integrates all available information about the water body 5) summary statements describing overall interpretations of health for each waterbody and 6) statements regarding conclusions, recommendations, assumptions and limitations. This report does not include analysis or interpretation at the individual station level, except when required to explain phenomena at higher levels or when stations were located directly on Lake Erie rather than a tributary, but full details on station-level analysis are available upon request.

This document is not intended to serve as the primary tool for communicating findings or recommendations to stakeholders. Instead, it holds the core content for two other types of reports which can be found on the LEBAF Website or upon request to CWA or local hubs:

1. ***Local Rivers and Lake Erie Tributaries*** - a report for each participating river produced by the LEBAF group, that provides findings and recommendations regarding the health of that respective river.
2. ***Lake Erie Basin*** - A single report, collaboratively produced by all LEBAF participants, that provides findings and recommendations regarding the health of the entire Lake Erie Basin.

These more succinct reports were produced using a shared template based on the structure and primary content housed in this document and are intended for use in a collective LEBAF communication and outreach plan as well as for use by individual LEBAF participants. Other information products may be developed and shared by LEBAF participants, stakeholders, and the public as part of the shared LEBAF outreach plan or to advance the communications goals of LEBAF participants and their stakeholders. LEBAF's goal in communicating the content contained in this report, through the report itself and the various information products it inspires, is to share our learnings and process while communicating the value of our data and of community science generally.

Section 2 – Approach and Methods

2.1 Directly Measured Parameters

The initial LEBAF SOP presents standards for the direct collection, management, and analysis of basic chemical parameters that indicate watershed condition using a multiparameter water meter or a set of single parameter water sensors. Below is some basic information about each core parameter and how monitoring them contributes to an assessment of conditions that support aquatic life as an indicator for the baseline conditions of and trends in the health of Lake Erie watersheds. Each entry also includes a link to a relevant section of the LEBAF SOP which includes details 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 of sampling it.

pH: A measure of hydrogen and hydroxyl ion activity in water also known as how acidic/basic water is. 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 thus determines whether aquatic life can use nutrients and the degree of toxicity of heavy metals. Supporting pH levels that are either too low or too high are not conducive to aquatic life.

DO: The amount of oxygen (O_2) dissolved in the water. DO is governed by temperature, salinity, and atmospheric pressure and is typically near or at equilibrium with expectations for the given temperature. Waters with dissolved oxygen levels at or near equilibrium with temperatures typical for the waterbody are capable of supporting aquatic life adapted to those sets of conditions. The necessary amount of dissolved oxygen 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 the metabolism, growth, behavior, and reproduction of aquatic biology, determining the type and kinds of aquatic life present in rivers and lakes. Supportive temperature includes cold, warm and transitional temperatures as well as seasonal ranges within each temperature category.

Conductivity: Conductivity is an indirect measure of the collective concentration of dissolved ions in a solution in water. Dissolved ions include particles that aquatic life need or are part of a rivers ecosystem function to move its bedload, nutrients and particles from upstream to downstream, albeit in a natural or background amount. Dissolved ions may also include particles that are directly or indirectly toxic to aquatic life at threshold amounts. Direct toxicity occurs from ingestion or direct exposure while indirect toxicity impacts habitat for example, smothering or embedding habitat with particles reducing habitat or flow of oxygen in those spaces.

Conductivity can be an effective screening parameter as a broad indicator of general water quality. In relatively undisturbed and more natural river systems, ambient conductivity levels are generally low in ionic content. Ionic content, conductivity, increases in a downstream direction with more tributaries, draining more land and bringing more ions to the river. Elevated conductivity may be an indicator of unhealthy, declining or degrading aquatic life communities or habitat. Conductivity levels will vary depending on the geology, precipitation, land use and other localized variables. Which is why ancillary information and what is known about the local watershed is important context to interpret any conductivity measurement.

LEBAF had the opportunity to compare conductivity results to Ohio EPA's reference and stream survey conductivity database. This comparison helps verify conductivity results are valid providing more confidence in other analyzes, recommendations and conclusions for local groups and decision makers. This assessment is not an exercise in identifying exceedances but one of quality assurance. In addition, the Ohio EPA provided the ability to compare conductivity results directly to a macroinvertebrate conductivity biocondition gradient. A biocondition gradient illustrates a biological community's response to a stressor, in this case conductivity. This provides LEBAF with a meaningful use of conductivity that results in direct alignment with our monitoring purpose and data use, screening for aquatic life conditions. In summary, direct measurement of conductivity results are used in two assessments, one against the Ohio EPA conductivity database for reference and stream survey as a quality assurance exercise. Second against Ohio EPA's macroinvertebrate biocondition gradient as a threshold assessment.

The more dissolved ions the higher the conductivity, ions such as salts, metals or dissolved solids. These parameters can be present in amounts that support or harm aquatic life and habitat and when excessive act as pollutants. Because conductivity levels identify dissolved ions in the water but not what comprises those ions, it can be helpful to identify other expressions of conductivity based on scientific relationships to help discern baseline conditions from elevated conditions that could cause harm to aquatic life or habitat.

Conductivity has a scientific and mathematical relationship with chloride, salinity and total dissolved solids. This means that a conductivity measurement can be mathematically expressed in a concentration of chloride, salinity or total dissolved solids. This expression in an assessment acts as a surrogate measurement for these three parameters, which can be indicators of pollution, a widely used approach. That mathematical expression of conductivity to chloride, for example, can be assessed against a chloride aquatic life threshold to help inform further monitoring, direct parameter measurement or other relevant indicators, restoration and protection actions and provide relative conductivity levels that may indicate the presence of chloride, salts or dissolved solids respectively. .

LEBAF used these three surrogate expressions of conductivity, chloride, salinity and total dissolved solids, in its inaugural assessment, giving a transparent and appropriate weight to any recommendations and conclusions. Recommendations to evolve the use of these as screening surrogate indicators of pollution for next year are at the end of this report. The next section characterizes LEBAF's conductivity assessment approach.

2.2 Expressions of Conductivity and Assessment

Conductivity is a widely used screening parameter and accepted surrogate for a range of other water quality parameters. Such surrogate parameters can be interpreted from direct conductivity measurements using mathematical calculations. The LEBAF SOP uses some of these surrogate parameters as part of its screening approach to guide further monitoring or investigation. As the LEBAF SOP is expanded over time, LEVSN hopes to incorporate standardized direct observations of these parameters, as opposed to surrogate values calculated from conductivity measurements, into analysis when possible. We also hope to use direct measurements for comparison to test the strength of calculated values whenever possible. Below characterizes LEBAFs conductivity assessment approach.

Conductivity Representation: LEBAF participants assessed directly measured conductivity results against a large conductivity database for reference and all survey sites filtered by two ecoregions (ELOP and HELP) and three watershed sizes (20 square miles, 20-500 and greater than 500 square miles, called headwater, stream and river respectively), curated and provided by Ohio. This data set provides the respective conductivity population distribution via classic box and whisker plots identifying the minimum, 25th, 50th, 75th percentile and maximum levels. LEBAF compared conductivity result distribution to the respective ecoregion and watershed size to validate results aligned with respective conductivity distribution in the database. This assessment was not to determine if conductivity was elevated and a potential pollutant but to confirm and validate results resemble existing conductivity data. This 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. Each surrogate translation can be compared to a respective threshold and provide an associated level of conductivity to serve as a screening level informing recommendations.

Basic information about each surrogate parameter and how monitoring them contributes to an assessment of conditions that support aquatic life as an indicator for the baseline conditions of and trends in the health of Lake Erie watersheds can be found below. Each entry also includes a link to a relevant section of the LEBAF SOP which includes details on the impact this parameter can have on an aquatic ecosystem, its natural fluctuations, common external factors that influence its dynamics, and LEBAF's corresponding standardized sampling method.

Biocondition: LEBAF participants assessed directly measured conductivity results against a macroinvertebrate community condition gradient based on conductivity levels provided by Ohio. As conductivity increases at some level it impacts aquatic life, animals and plants. The gradient identifies conductivity levels that correlate to *healthy* macroinvertebrate communities, *declining or degrading* communities and *already degraded* communities. Benthic macroinvertebrates, small but visible organisms without backbones that live in stream or lake beds, are commonly used as indicators of the biological condition of water bodies. Because they cannot escape pollution, macroinvertebrates' responses to human disturbance tend to unfold in fairly predictable ways that allow their presence, absence, and community structure and function to characterize "condition" and have that be used as a screening tool to interpret the health of a water body. Comparison of conductivity results to a large temporally, geographically and ecologically relevant corresponding macroinvertebrate bio condition data set allows for interpretation of overall aquatic health, using direct conductivity readings.

Total Dissolved Solids(TDS): A measure of all solids dissolved in water, including minerals, salts, metal, cations, anions and organic molecules. Like 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. In regards to assessment criteria, 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, but it can provide a useful screening threshold. This inaugural year, LEBAF assessed calculated TDS against drinking water standards. It is a common expectation that ambient water in rivers is not drinkable without treatment that removes excess TDS and thus, ambient TDS will likely exceed drinking water thresholds. As a screening tool, assessing TDS results against drinking water standards in absence of common and robust aquatic life standards can indicate where to prioritize resources for further monitoring (in frequency, locations or other parameters as well as using other data sources or analyses) or restoration and protection actions. An initial use of Ohio's aquatic life TDS standard of 1500 mg/l was applied to understand what contextual information is needed to employ this standard effectively for LEBAF screening data use. Evaluation of the initial year will evolve this approach along with all other parameters, assessment criteria and methods.

Chloride: A measure of the concentration of dissolved salts resulting from the combination of the gas chlorine with a metal. Elevated concentrations of chloride in streams can be toxic to some aquatic life. Additionally, the presence of chloride increases the corrosivity of the water, potentially threatening drinking water infrastructure and quality. LEBAF is primarily interested in chloride for its compounds of and use in deicing roads. As such, participants explored using conductivity expression of chloride this year to see if it is informative. The relationship and equation for translating conductivity results into chloride is scientifically established, facilitating effective use of conductivity expressed as chloride in screening assessments, lending to validating credible results. Regarding assessment criteria, like TDS, chloride standards to protect drinking water or water supply are well established but relatively new for aquatic life. Using those thresholds, a general level of conductivity can be deducted to serve as screening levels for elevated chloride. Evaluation will continue to evolve and lend credibility to assessment methods.

Salinity: A measure of the concentration of dissolved salts in water. Higher salt concentrations can impact stream biota and reduce biodiversity in streams as well as increase corrosivity of water in a manner similar to high concentrations of chloride. There are many studies that link higher conductivity levels to high concentrations of salts used in road deicing and is LEBAFs primary interest. As such, participants explored using conductivity expression of salinity this year to see if it is informative. The relationship and equation for translating conductivity results into salinity is scientifically established, facilitating effective use of conductivity expressed as chloride in screening assessments. Regarding assessment criteria, salinity standards for freshwater were lacking in states Clean Water Acts, 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 deducted to serve as screening levels for elevated salinity. Key to this assessment may be relating sampling season to salinity sources, evaluation will evolve the use of this screening indicator.

2.3 Data Collection and Management

Participating members of the Lake Erie Volunteer Science Network are expected to adhere to the technical requirements and minimum performance criteria of this shared 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 from April to October. 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 CWA 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. 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 1. 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 its data objectives, monitoring purpose, and intended data uses for targeted data users in 2022, LEBAF participants conducted analyses that tell stories at three scales:

1. **Local River by each site**
2. **Large Rivers and other 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. Analyses centered calculation of the number and percent of exceedances for each monitored and surrogate water quality parameter at each site as well as the subsequent rolling up of results for all sites across the watershed of each River/Tributary and the Lake Erie Basin. Exceedances were determined using benchmarks (a point of reference against which ambient data may be compared or assessed against in context with intended monitoring purpose and data uses as well as data users' information needs) for each measured parameter. LEBAF's benchmarks were derived from researching respective state Clean Water Act (CWA) criteria, which are in turn based on primary research, literature and laboratory studies. Where possible all assessment criteria are focused on the health of aquatic life communities in lotic or running waters. Such criteria is not available for TDS, and thus a drinking water standard was employed. More detail on each criteria, source, and rationale can be found in LEBAF SOP.

Table 2. LEVSN Screening Assessment Criteria (Benchmarks) Details and Sources

Parameter	**Benchmark(s)**	**Source / Comments**
pH *Direct Measurement*	6.5.-9.0 pH Units	Most commonly used Lake Erie CWA pH use assessment standards. Assessed exceedances of 6.5 and 9.0.
Dissolved Oxygen (DO) *Direct Measurement*	Cold water <=7 mg/L Warm water <=5 mg/L	Most commonly used Lake Erie CWA pH use assessment standards. Assessed for cold and warm water.
Temperature (Temp) *Direct Measurement*	Warm/Cold monthly value between states daily max/mean. Bottom line for acute and chronic exposure by state when applicable.	Lake Erie CWAs all agree that water temperatures should exist within a +/- 5 degree range for warm and cold rivers. Based on these standards, LEBAF uses a conservative set of monthly temperature ranges for warm and cold waters as a screening benchmark. Assessed for cold and warm water, not real time monitoring.
Conductivity Survey *Direct Measurement*	Ohio EPA maintains a robust conductivity data for reference and stream survey sites. LEBAF conductivity results can be compared to these for relevancy (versus a threshold). This data set provides maximum, minimum, percentiles (25,50,75, 90 and 95th) for two ecoregions and three watershed sizes. Please see the table below for respective values.	LEBAF results and metrics, max, min and median can be compared for relevance and consistency. Each station is identified in respective ecoregion and watershed size (headwater, stream or river) to see where maximum, minimum and median data falls. % exceedances are not calculated in this case.
Conductivity Biocondition *Direct Measurement*	Ohio EPA maintains a biocondition macroinvertebrate community health dataset that illustrates healthy, declining, and impaired or unhealthy communities. Conductivity results that bracket the declining community are (412 and 655 mS/cm, used as <>=). Protection would be the focus of conductivities <412 and restoration for sites with >655.	LEBAF conductivity results can be compared to this range and appropriate recommendations for looking at other data (such as actual macroinvertebrate community data, additional investigation, protection or restoration efforts can be explored. This does not behave like a pH or DO lower and higher chemical standard but a continuum of an organism getting 'sicker" as an example if it cannot adapt or move..

Chloride *Surrogate Calculation*	Michigan EGLE adopted chloride standards for aquatic life use protection: Acute = 640,000 ug/L, 640 mg/L Maximum = 320,000 ug/L, 320 mg/L Chronic = 150,000 ug/L, 150 mg/L	LEBAF's data management system uses the scientifically defensible relationship, equation, and associated requirements to calculate a chloride result from conductivity as follows: *$[Cl^-] = 4.928\ EC$.* This relationship has a 94% R value correlation, which is good. In addition, Ohio EPA provided a large river specific correlation regression for 11 large rivers, LEBAF applied that equation for respective rivers that have an even closer correlation relationship than the above equation. Each river's equation is in the SOP.
Total Dissolved Solids (TDS) *Surrogate Calculation*	All Lake Erie states employed a version of the following criteria for drinking water: *200, 500, and 750 mg/L.* This criteria was used in the assessment exceedance calculations. Ohio has a TDS aquatic life standard of 1500 mg/l, but is used cautiously, with local context and can be underprotective. Note: LEBAF Is evolving is measurement of TDS and assessment methods	While evolving the ability to integrate background or natural conditions and explore identifying TDS ranges, and the dearth of aquatic life criteria for TDS, LEBAF is using the drinking water criteria with appropriate weight in translating to aquatic life impacts for screening data use, this year. Exceedances of drinking water standards are expected in ambient water as all ambient water is treated before consumption to meet these standards.. The use of the 1500 mg/L aquatic life standard needs context (geology, hydrology, land use, etc.) to interpret productively. The scientifically defensible relationship, equation and associated requirements to calculate a TDS result from conductivity is: *$TDS = k\ EC$ (in 25 °C).* Based on literature for fresh water and low end natural waters, the k value is 0.55
Salinity *Surrogate Calculation*	States in Lake Erie did not have a salinity standard. The literature and USGS use the following criteria for screening data: ● Freshwater: Less than 1,000 parts per million (ppm) or 1 g/L ● Slightly saline water: 1,000 ppm – 3,000 ppm or 1-3 g/L ● Moderately saline water: 3,000 ppm – 10,000 ppm or 3-10 g/L ● Highly saline water: 10,000 ppm – 35,000 ppm or 10-35 g/L LEBAF uses these criteria to identify patterns, not as a standard assessment.	This parameter is most important to apply where road salts and other practices occur, which may or may not apply to all stations. The scientifically defensible relationship, equation and associated requirements to calculate a Salinity result from conductivity is: *Ensure mS/m units, raise to power 1.0878, multiply the result by 0.4665, product is salinity in g/L. Results need to be X 1000 to compare to ppm or standard divided by 1000. This is done by each group, not database.*

Important to note, expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a two fold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Refer to the conclusion and recommendation section to review the evolution.

The following table provides the Ohio EPA's conductivity metrics for reference and stream survey data for respective ecoregions and stream sizes. Each station's results were compared to their respective ecoregion and stream size to provide validation that conductivity results were similar, providing confidence in further analyzes, recommendations or conclusions. Not all stations are in the two ecoregions with data, but have similarities. If an overlap between results and reference or survey does not exist, that is explored and possible reasons provided, with recommendations qualified and weighted appropriately. For more about this approach please refer to the LEBAF SOP.

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

Assessment and resulting interpretation of the data at the Local and River/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, four teams, each composed of multiple participating groups, completed parallel interpretations that were then synthesized into one by the LEVSN Standards Working Group. All final results were reviewed and edited by this Working Group with feedback from all LEBAF participants. This shared systematic process was intended to steer clear of standardized qualitative scoring or ranking of water body health, given the novelty of the approach being used and the wide range of ambient conditions encompassed across our geographic scope, while providing robust quantitative analysis coupled with relevant qualitative context. Details on LEBAF's Analysis process can be found in the SOP.

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

3.1 Clinton River

Monitoring Organizations: Currently only one organization in the LEBAF Network is monitoring the Clinton River Watershed, the Clinton River Watershed Council (CRWC).

Station Summary: Clinton River Watershed Council (CRWC), specifically data collected by Eric Diesing, Chief Watershed Ecologist, was collected from one station in 2022, Paint Creek 1 (PC1). No stations or direct sampling occurred on the Clinton River itself.
Paint Creek is a tributary to the larger Clinton River. PC1 station is located on Paint Creek in Rochester, Michigan. The site is within a local park called Rochester Municipal Park. Data was collected on three separate occasions, once in July, August and October.

Aggregated Metrics Table - Table 3 Clinton River Summary Statistics

Clinton Summary Statistics - 3 Samples

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	10.96	10.47	10.31	12.09	0	0%
Water Temperature - C	15.7	13.1	12.5	21.5	2	66.7%
Conductivity - uS/cm	745	695	606	934	3	100%
Total Dissolved Solids - mg/L	409.75	382.25	333.3	513.7	3	100%
pH	7.27	7.27	7.27	7.27	0	0%
Chloride - mg/L	36.71	34.25	29.86	46.03	0	0%
Salinity - ppm	622.13	575.92	496.16	794.32	0	0%

2022-08-02 to 2022-10-25

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)
pH: 1 sample, 0 standard exceedances, 0% exceedance rate.
No conclusions for pH can be drawn due to the pH probe being non-functional. Only one data point available in 2022. Knowing Paint Creek as one of the last remaining high-quality coldwater trout streams in Southeast Michigan, we would expect pH levels to remain constant throughout

the year, while supporting aquatic life. CRWC intends to collect pH data throughout the 2023 field season at this site to identify typical pH levels in Paint Creek.

DO: 3 samples, 0 standard exceedances, 0% exceedance rate.
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 includes just three data points, and only encompasses daytime conditions within the creek. The data collected this year shows levels well above the standard threshold defined by LEBAF. We would expect this result, knowing that cold water holds higher DO concentrations than warm water. 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.

Temp: 3 samples, 2 standard exceedances, 66% exceedance rate.
Water temperature has a direct influence on aquatic life and can be a limiting factor for many aquatic species, such as trout and salmon. Water temperatures during the warm months of the year are particularly important, as water levels generally decrease during July and August in Michigan, which when coupled with warm summer temperatures can be detrimental to fish and other aquatic species. This is especially true of coldwater species which inhabit a very limited range of habitats that have suitable 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. More data points are needed to determine whether coldwater conditions are consistent throughout the entire summer, and if the coldwater designation for Paint Creek is being met. The two exceedances reported here indicate that the creek can warm up considerably at certain points in time. A maximum temperature of 21.5 degrees Celsius was recorded through this effort in 2022.

Conductivity Survey: 3 samples, Max=934, Min=606 and Median=695
Conductivity was expected to be relatively high but stable in Paint Creek. Higher conductivity in developed areas is a common occurrence and Paint Creek is no different.

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. 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. The below table illustrates that the maximum conductivity result, 934, is above both reference and survey sites. This may be due to the difference between ECBP and ELOP geology and localization factors.

The maximum result of 934 is below but close to the maximum survey sites while being higher than the reference maximum. The median result of 695 is closer to the 75th percentile of both reference and survey data sets. The minimum 606 is closer to the 75% of reference and median of survey data. The average of the data is 745 µS/cm. This illustrates, with this limited data set, limitations of ecoregion interpolation but does suggest that conductivity of this site is on the higher end of reference and survey sites but there is an population overlap, providing some confidence in results. It is important to recognize that three samples at a single location on the creek is not enough data to make strong conclusions, but conductivity levels here do indicate some level of disturbance within the system.Recommendation to access ECBP conductivity metrics if possible and continued monitoring to establish a baseline.

Table 4. Clinton River Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	183.00	348.00	455.60	602.00	500.00
Survey	304.00	416.00	585.00	780.00	1201.00
Results	606		695		934

Conductivity Biocondition: 3 samples, 3 exceedances, 100% exceedance.
The three conductivity samples were compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm,indicating a healthy macroinvertebrate community, 412 -655 indicating a declining and degrading health and greater than 655 µS/cm, indicating a degrading macroinvertebrate community. The conductivity values at Clinton River ranged from 606 µS/cm - 934 µS/cm. Conductivity in Paint Creek, a tributary to Clinton River, exceeded the low threshold for bio-condition (412) in 100% of samples in 2022. The minimum conductivity was 606 and median was 695, indicating that 50% of the time conductivity exceeds the 655 degraded macroinvertebrate community condition threshold. Three samples is a very small sample size, more data is needed and actual macroinvertebrate data would also be helpful. Paint Cr is one tributary of many in the Clinton River system and while Paint Creek contributes to the overall quality of the Clinton River, it is not appropriate to directly equate the two systems quality. A gap for LEBAF is having no current monitoring locations directly on the Clinton River.

Conductivity is expected to be higher in Paint Creek as an urban river system. The metrics generating this biocondition are not ecoregion specific and other conditions may be influencing these communities in a positive or negative way. These exceedances suggest existing 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
Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a two fold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: 3 samples, 3 exceedances, 100% exceedance.
Paint Creek is located within one of the most densely populated watersheds in the state of Michigan, one that is over 50% developed. This means there is an abundance of impervious surfaces and high amounts of stormwater entering the waterways. 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 and developing its own conductivity thresholds. Results did not exceed 1500 mg/L and the maximum was 513, not approaching this threshold. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Elevated TDS can have direct and indirect impacts on aquatic life. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS. TDS did not exceed the 1500 mg/l Ohio aquatic life threshold. As a screening parameter, and with this limited data set, TDS is not a parameter of concern for aquatic life.

We would expect to see elevated TDS levels in Paint Creek and all our watershed tributaries, due to the amount of stormwater runoff affecting these water bodies. In fact, we see that every data point collected through this effort in 2022, was above the LEBAF threshold for TDS, with one sample above the acute level threshold. High TDS levels are associated with high amounts of chemicals, nutrients and other particles getting into the waterbody. Stormwater runoff contains a variety of different chemicals and particles coming from our impervious surfaces throughout the basin. As we continue to collect TDS levels from Paint Creek, it is important to consider how stormwater runoff can be managed, whether it be by green infrastructure, like rain gardens and bioswales or by simply reducing the amount of fertilizer put on the lawn. Timing of data collection and flow conditions are important to consider when measuring TDS. TDS is calculated from a correlation with conductivity.

Chloride: 3 samples, 0 exceedance, 0% exceedance.
Calculated chloride concentrations ranged from 29.86-46.03 mg/L throughout the reporting period, and there were no exceedances in the 3 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. This suggests aquatic organisms in Paint Creek were at reduced risk to chronic chloride exposure in 2022. Road salt application, fertilizer use, and water treatment discharge, all of which are associated with higher chloride concentrations, occur more frequently in developed areas.

Chloride concentrations in Paint Creek are expected to be high because much of the watershed is developed. In fact, calculated chloride concentrations in 2022 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 or ambient chloride. Another limitation to the assessment of water quality in the Clinton River is based entirely on the single Paint Creek station. Adding monitoring stations to include the main stem of the Clinton and all seven major subwatersheds within the basin would improve future assessments of this river's influence on Lake Erie. Chloride concentrations here are an expression of conductivity based on the mathematical relationship between the two.

Salinity: 3 samples, Max=794, Min=496 and Median=576, 0 exceedances.
Salinity results were compared to the USGS recommended salt content for freshwater. Below 1000 ppm is freshwater and 1000-3000 ppm is slightly saline. The maximum approaches but is shy of the slightly saline category. The median suggests that with this data set 50% of the time salinity levels are close to 600 ppm. Even if salt is in the water based on this range, it doesn't mean aquatic life is harmed just exposed. More data is needed to see if this trend continues throughout the winter and decreases into the summer. In addition, deicing compounds and application protocols can be explored to ensure salt stays out of the creek and these levels stay low.

Salinity refers to the amount of dissolved salts present in the water sample. Salinity can be correlated with TDS and conductivity. High salinity levels can be attributed to both natural and anthropogenic pathways. In our developed watershed, high salinity levels would likely be a result of heavy urbanization. Salinity is calculated from a correlation with conductivity.

According to the samples collected in 2022, salinity in Paint Creek is slightly elevated, which corresponds to the TDS, conductivity and chloride values found within the data set. Not many conclusions can be drawn from this data set due to lack of data for the region, but according to several online sources, the salinity levels seen here are indicative of slightly disturbed systems. More salinity data collected from within the region will help to tell this story in more detail.

Aggregated Overall Summary – (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

The Clinton River had data for seven parameters from one tributary, Paint Creek. The seven parameters were dissolved oxygen, temperature, conductivity, conductivity macroinvertebrate biocondition gradient, total dissolved solids, chloride and salinity. Three samples were collected at 1 station resulting in 3 exceedances with 100% exceedance of the higher conductivity biocondition (655), and 100% exceedances of drinking water total dissolved solids, not by a large magnitude and no exceedances of the 1500 mg/l aquatic life TDS threshold. The median of 382 indicates 50% of the time TDS doesn't approach that threshold even for an urban system with higher conductivities. Four parameters had no exceedances; dissolved oxygen, temperature, 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, TDS 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 data set 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 TDS as a drinking water screening threshold verified ambient water needs to be treated to consume (for TDS) which was expected, and is treated. Thus TDS results may be representative of ambient conditions and for the cost effectiveness of obtaining (calculated from conductivity versus laboratory analyses) may serve as a screening tool for further monitoring perhaps than other direct resource or policy action.

The assessment method using TDS drinking water standards was as expected but may be not informative for aquatic life protection. Effective use of the TDS threshold of 1500 mg/L as an aquatic life indicator is still unknown, but shows potential if adequate context is included in the assessment. Calculated chlorides were higher than data previously collected by CRWC over the past two years and three sample results is a small sample size. Further investigation and data is 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 providing helpful screening, given limitations of the dataset.

If monitoring sites existed in all seven major subwatersheds our data set 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 Cuyahoga River

Monitoring Organizations: Currently one organization from LEBAF is monitoring in this basin, Tinker's Creek Watershed Partnership.

Station Summary: Tinker's Creek Watershed Partners monitor 10 stations throughout the Tinker's Creek watershed. Data was collected at stations arranged throughout Tinker's Creek watershed, from the headwaters to its confluence with the Cuyahoga River. No stations in the LEBAF network currently are directly on or in the Cuyahoga River itself, thus all results in this section are from Tinker's Creek, not the Cuyahoga River itself. While Tinkers Creek contributes to the water quality and aquatic life condition of the Cuyahoga River, it is not appropriate to make direct comparisons. LEBAF's data gaps include monitoring stations on all major Cuyahoga River tributaries and the mainstem. This data can directly inform effective restoration and protection actions for Tinker's Creek but is a hypothetical exercise to extrapolate to the condition or health of the Cuyahoga River. For example, if Tinker's Creek was healthy in every LEBAF indicator it can be said that, that health transfers into the health of the Cuyahoga River and likewise if every indicator in Tinker's Creek was unhealthy, that unhealthy condition contributes to the overall health of the Cuyahoga. In either case we cannot directly understand the health of the Cuyahoga system, but can use the information as a screening potential to the contribution of Cuyahoga River health. As such, Tinker's Creek data set is important but is also an incomplete picture of the Cuyahoga River's impact on Lake Erie.

Aggregated Metrics Table- Table 5 Cuyahoga Summary Statistics

Cuyahoga Summary Statistics - 39 Samples 9 Stations

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	7.62	7.92	2.33	11.15	5	12.8%
Water Temperature - C	19.56	19.7	14	25.8	0	0%
Conductivity - uS/cm	1083.19	1013	639	2677	36	100%
Total Dissolved Solids - mg/L	595.76	557.15	351.45	1472.35	36	100%
pH	7.38	7.5	5.4	8.37	2	6.1%
Chloride - mg/L	211.87	190.35	105.78	657.2	25	69.4%
Salinity - ppm	938.7	867.67	525.62	2497.17	13	36.1%

2022-05-17 to 2022-09-29

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)
pH: Ranged from 5.4 – 8.37, with a median of 7.45 and 2 standard exceedances

From the aggregated data it appears that pH is of minor concern in waters feeding the Cuyahoga and from this perspective, the Cuyahoga is likely not contributing any acid or alkaline loading to the greater Lake Erie basin. The two exceedances reported are minor, not high in magnitude, not frequent based on our study design. The duration of the exceedance is unknown. If aquatic life can find refuge during an exceedance event they do not experience harm. No exceedances were expected and it may be that these are due to error in measurement or isolated local incidents at those particular stations. Further monitoring at more locations could help to confirm this conclusion.

DO: Ranged from 2.33-11.15 with a median of 7.92 and 5 exceedances
The aggregated data also show that the Cuyahoga River is likely healthy with respect to dissolved oxygen. One station at Darrow Rd park in Hudson, OH is responsible for the bulk of the DO exceedances in the Cuyahoga river basin, and should be carefully monitored to explore the situation at that station. All other stations displayed a supportive seasonal DO level and expected up to downstream patterns. Unhealthy DO levels at this station could carry into the Cuyahoga and into the Lake, with this limited data set, the low DO appears to be local to this station.

Temp: Ranged from 14 – 25.8 with a median of 19.7 and 0 exceedance
Temperatures was the only indicator that did not exceed an aquatic life standard. Temperatures were as expected and normal throughout the Cuyahoga River basin, with only one exceedance reported. If aquatic life can find refuge during an exceedance event they do not experience harm. Point data will not capture the magnitude, duration and frequency of other exceedances like a real time monitoring device. No exceedances were expected and it may be that these are due to measurement error as we identified several training issues with volunteers after the season concluded, or an isolated incident. It does not suggest conditions for aquatic life might tend toward an above warm-water standard and exposure for the river basin as a whole.

Conductivity Survey: LEBAF data from 2022 collected a total of 39 samples with a range from 639 - 2677 µS/cm with a median of 1013. These results were compared to the conductivity data set population for the EOLP ecoregion, headwater and stream sizes. The average of the data is 1083.93 µS/cm.

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. The table below illustrates conductivity data distribution in ELOP headwater and stream sizes, reference and survey data sets provided by Ohio EPA, which aligns with the systems that feed into the Cuyahoga River, extrapolating interpretation with transparency to the larger Cuyahoga River. The below table illustrates that the maximum conductivity result, 2677, Is about 1000 units above all reference and stream maximum conductivities, Reference sites maximum is 35,000 units which is indicative of unique features. The median result of 1013 is higher than the median reference and median survey sites and about double in magnitude. The minimum, 639, is closer to the 50th percentile of both size reference and survey sites.

This illustrates, with this limited data set, that there is conductivity population overlap but at the higher end, 50th percentiles and up. This may be because these watersheds are not in the ELOP ecoregion. This does not mean that conductivity is or is not harming aquatic life. This assessment helps inform how the distribution of conductivity collected aligns with a larger and longer conductivity data set. The more they overlap, the more alike they are and this can strengthen associated interpretations. Imperfect overlap does not mean conductivity data is weak, it is just not as representative of the ELOP ecoregion headwater and stream sizes that occur in Ohio.

Table 6. Cuyahoga Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	Minimum	25th	50th	75th	Max
Headwater Reference	90.00	351.00	462.00	611.00	35,000.00
Headwater Survey	316.00	466.00	629.30	886.00	990.00
Stream Reference	167.00	405.10	489.10	549.00	1,008.00
Stream Survey	375.00	437.00	568.00	774.00	1,260.00
Results	639		1013		2677

Conductivity Biocondition: A total of 39 conductivity samples were compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, indicating a healthy macroinvertebrate community, 412-655 indicating a declining and degrading condition, and greater than 655 µS/cm, indicating a degraded macroinvertebrate community. LEBAF data from 2022 ranged from 639 - 2677 µS/cm with a median of 1013 and 36 of standard exceedances or 97.2 % of all Cuyahoga River conductivity data exceeded the 412 threshold and all but a few the 655 threshold. This indicates that Tinker’s Creek resident macroinvertebrate communities are declining and in states of community structure and function degradation. This may not be true for communities in the Cuyahoga River itself, but if Tinker's Creek water comprised the bulk of

Cuyahoga River, which it doesn't, those communities would likely be impacted. Actual macroinvertebrate data, existing or new, would help confirm this result and interpretation.

Tinker's Creek is a highly urban and suburban community. It is frequently subject to urban stormwater runoff from roads, parking lots, rooftops, etc. which likely contributes to these macroinvertebrate degraded community conditions. All the data in this analysis come from a single tributary to the Cuyahoga, with no data collected within the Cuyahoga itself. For screening purposes, we can say that unhealthy conditions in Tinker's Creek contribute to potential unhealthy conditions in the Cuyahoga River, but we didn't directly measure the Cuyahoga. Data from other tributaries and the Cuyahoga itself would provide a better condition assessment.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a two fold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: Ranged from 351-1472, with a median of 557, average of 599, with 36 exceedances, 100%. The aggregated data illuminates that Tinker's Creek TDS load contributes to the TDS load of the Cuyahoga River which then potentially contributes to TDS load in Lake Erie. All stations where TDS was calculated exceeded the LEBAF drinking water standards. All sampling locations and events exceeded drinking water standards suggesting exceedance frequency is often and duration long, without treatment. The magnitude is 100's of units in excess. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS..

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 and developing its own conductivity thresholds. Results did not exceed 1500 mg/L aquatic life threshold, but the maximum approached 1472 mg/L but the median was 557 mg/L. From this perspective, aquatic life may be at risk to elevated TDS. Aquatic life can be more sensitive to some stressors than humans because they are in the water and exposed to these stressors for all life cycles. TDS can be directly toxic or indirectly toxic and associated with other stressors. Direct measurements of response communities such as macroinvertebrates, fish and aquatic vegetation would help confirm or other stressors associated with elevated TDS.

Like Tinker's Creek, the Cuyahoga flows directly through the major metropolitan areas including the City of Akron and City of Cleveland. The river experiences regular urban runoff and stormwater flow which is likely responsible for much of the elevated TDS observed. There is a concerted effort within Northeast Ohio to implement stormwater practices that mitigate these effects, but it is a massive issue that requires considerable effort to overcome.

Chloride: Calculated chloride concentrations ranged from 105.78-657.2 mg/L throughout the sampling period, and there were 25 exceedances in the 39 collected samples (69.4% exceedance) of the final acute, acute maximum and final chronic aquatic chloride standards. Of the 25 exceedances, 23 were chronic while 2 were acute. High calculated chloride concentrations in the Cuyahoga River are likely due to urban runoff, particularly road salt, which is used judiciously during the winter months as a safety precaution.

The data comes from one tributary to the Cuyahoga, Tinker's Creek. As stated above for screening purposes we are extrapolating those results to the Cuyahoga. Tinker's Creek is likely influencing the quality of the Cuyahoga but it is unlikely the conditions are equal given the dilution, other tributaries and land uses in the larger river basin. Elevated stressors in Tinker's Creek warrants more exploration within that watershed to facilitate high quality water flow into the Cuyahoga. For example, calculated chloride concentrations from Tinker's Creek indicate that substantial chloride loading to Lake Erie may be occuring, but this assessment is incomplete without knowing discharge and chloride concentrations in the Cuyahoga. The establishment of additional monitoring stations within the basin would provide a more complete understanding of how the Cuyahoga River is impacting Lake Erie water quality and develop more specific recommendations.

Salinity: The salinity samples within the Tinker's Creek watershed, a tributary of the Cuyahoga River Basin ranged from 525.62 ppm – 2,497.17 ppm with a median of 867.67 ppm and 13 exceedances in 39 samples. These results did exceed the USGS's ranges for slightly saline waters (1000-3000), with the magnitude towards the higher end of this range. All 13 samples exceeded 1000 ppm and at sites where exceedances occurred, exceedances were consistent throughout the sampling period. Notably, salinity exceedances did not occur at sites in Bedford Reservation, a metropark and protected area. Sites where exceedances did occur were in close proximity to roadways, parking lots, and developed areas thought to be sources of road salt application as an example.

The primary concern with salinity is in regards to deicing compounds and application methods such as road salts like sodium chloride. If stations and sampling timing are not proximate to deicing events LEBAF may not be capturing the extent of potential exceedances or harm. More sampling, strategic sampling to deicing applications would help confirm if a real issue is happening. Tinker's Creek Watershed Partners are evaluating extending sampling efforts to include winter months when deicing agents are applied. Perhaps engaging in Izaak Walton League's Salt Watch Program might also provide more information.

Aggregated Overall Summary:

Cuyahoga River, via Tinker's Creek Watershed stations, had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity. Every parameter but temperature had at least one exceedance of respective threshold, ranging from 2 times to 36 or every sampling event.

DO and pH exceedances were few, the magnitudes not extreme. Perhaps aquatic life can find refuge from exceedance events. More data would help characterize the duration and frequency and if specific stations or times of year are more at risk than others to develop specific recommendations. In LEBAFs definition, from DO, pH and temperature, Tinker's Creek stations would be slightly unhealthy and that condition could flow into the Cuyahoga. While Tinker's Creek's condition may not alone strongly influence Cuyahoga River's condition, many smaller watersheds collectively unhealthy conditions may.

Conductivity, which influences TDS, chloride and salinity calculated results, had similar patterns with most or all of the sample events exceeding standards in Tinker's Creek. Conductivity results distribution aligned with EOPL ecoregion headwater and streams size on the higher ends of the distribution, 50% and higher. This is likely due to actual geological and associated differences in the region but could also be associated with anthropogenic sources. Conductivity biocondition was exceeded at all stations almost 100%. This indicates resident macroinvertebrate communities are exposed to enough stressors over time that they are in decline or in a degraded community structure and function. This could be verified with existing or future macroinvertebrate data.

It is known through other monitoring efforts that Tinker's Creek is an urban and impacted Creek. Results confirm, with this limited data set in regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? TDS drinking water standards were exceeded all of the time. The magnitude, duration and frequency with this limited data set suggest further investigation is warranted both in Tinker's Creek and impacts to the mainstem. Some exceedances were expected as no one is consuming ambient water without treatment from these rivers. The upstream/headwater sites in Tinker's Creek exhibited a similar proportion of exceedances (nearly 100% of samples) in TDS and conductivity to the downstream sites nearer to the confluence with the Cuyahoga River. Tinker's Creek is in the greater Cleveland area in its entirety, a highly urban and suburban community. It is frequently subject to urban stormwater runoff from roads, parking lots, rooftops, etc. which is likely the culprit for the TDS drinking water and conductivity exceedances.

TDS results did not exceed 1500 mg/L aquatic life threshold, but the maximum approached 1472 mg/L but the median was 557 mg/L. From this perspective, aquatic life may be at risk to elevated TDS. Thus, calculated TDS results may be representative and an effective screening indicator. Assessment method using drinking water standards was as expected but may be not informative for aquatic life protection.

Chloride aquatic life standards were exceeded about 50% of the time. The proportion of samples with exceedances appears to drop off (100% exceedance upstream to 40% exceedance downstream). Ohio EPA has conducted studies on road salt impacts in Tinker's Creek previously, and found a near perfect correlation between chloride concentrations and conductivity, implying that salt (likely road salt) is responsible for a large portion of the chloride exceedances. It was hypothesized that the lower proportion of exceedances at the downstream sites could be a result of dilution as the creek flows through Bedford Reservation and the outskirts of the Cuyahoga Valley National Park. This region represents protected areas, and less urban zones, and is therefore subject to less urban stormwater. Existing direct chloride measurements were not available, but what is known about Tinker's Creek and limited results from this effort indicate conductivity expressed as chloride may represent ambient conditions and assessment methods may be effective for screening purposes. This is similar for salinity, which also exceeded freshwater thresholds 50% of the time, corresponding to what is known about Tinkers Creek and the Cuyahoga River as it runs through multiple urban centers.

We recommend continuing current monitoring and addition stations to other tributaries and on the Cuyahoga itself. In addition, future years of data collection should include more stations in these protected areas, as well as more stations in general along the creek to determine at what rate (if at all) this dilution is occurring.

3.3 Huron River

Monitoring Organizations: Currently only one LEBAF organization is monitoring the Huron River, the Huron River Watershed Council (HRWC). 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.

Station Summary: HRWC's data are collected from stream and river locations that facilitate the establishment of relationships between land cover and ecological stream health. The locations are selected based on their use by the Michigan Department of Environment, Great Lakes, and Energy, 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. The program monitors every other week from April through September at twelve long-term sites throughout the Middle Huron. Long-term sites help HRWC to determine changing conditions over time.

The data below represent an aggregation of the 2022 data from the twelve long term sites across the Huron River. Of all stations, 11 of 12 sites are from the middle section of the Huron River in Washtenaw County, Michigan, and one site is in Rockwood, Michigan (Wayne County) near the mouth of the River and the Lake Erie confluence. Three of the sites are on the main stem of the Huron with the other 9 on major tributaries to the Huron.

Aggregated Metrics Table - Table 7 Huron River Summary Statistics

Huron Summary Statistics - 161 Samples 12 Stations

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	8.97	8.68	4.61	14.62	1	0.6%
Water Temperature - C	17.15	17.6	6.45	27	1	0.6%
Conductivity - uS/cm	974.4	816	351.9	2035	159	98.8%
Total Dissolved Solids - mg/L	535.92	448.8	193.55	1119.25	160	99.4%
pH	8.14	8.13	7.74	8.6	0	0%
Chloride - mg/L	72.79	61.73	27.73	147.29	0	0%
Salinity - ppm	838.74	685.79	274.69	1853.14	38	23.6%

2022-04-09 to 2022-10-05

Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)
pH - 2022 HRWC data across 12 monitoring sites in the Middle and Lower Huron River indicate little to no influence on potential Lake Erie pH impairment. 0 of the 162 measured values from April through October violated the prescribed LEBAF standards for pH, suggesting little to no negative impact from the Huron River on Lake Erie pH levels and based on LEBAF definitions healthy from a pH perspective.

DO - Of the 162 DO values monitored by HRWC in 2022, only 1 violated the lower DO standard of 5 mg/L. For the most part, monitoring data suggests dissolved oxygen concentrations within the Huron River remain high enough to sustain life and contribute to healthy aquatic conditions in Lake Erie. If aquatic life can find refuge from exceedance events, exposure may not cause harm. Nonetheless, the one exceedance in July indicates potential issues with oxygen saturation during extreme dry and hot summer conditions.

Temp - Water temperature values across the Huron River at the 12 monitored sites remained within the prescribed LEBAF standards, suggesting little to no contribution towards potential Lake Erie temperature impairment. Of the 162 values collected during the 2022 season, 0 exceeded prescribed seasonal thresholds.

Conductivity

Across all 12 stations, conductivity measures ranged from a minimum of 352 uS/cm (Huron River at N. Territorial) to a maximum of 2035 uS/cm (Millers Creek), with a mean of 974 uS/cm and a median of 816 uS/cm. The Huron river increases in size as it moves through these stations.

Huron River over its continuum is located in the ECBP ecoregion for which we don't have conductivity population data. Stations best correlate with the EOLP ecoregion and stream and river sizes data sets. The below table illustrates populations for both streams and river reference and survey conductivity data sets. Typically conductivity increases in a downstream direction as the watershed drains increasing land, exposing the river to more elements that encompass conductivity.

Aggregated station data had a maximum conductivity result, 2035, which is above both reference and survey maximums by 1000 units or so. Perhaps a reflection of ecoregion differences. The aggregate median result of 816 is also higher than all medians, by several hundred. The minimum, 352, is close to both stream and river minimums, 375 and 304 respectively but almost double both reference conductivities. The differences are likely due to differences in ecoregion geology and related factors. It may also be a function of aggregation where some Huron River sites might have a better population overlap. There is an overlap, however it seems the overall conductivity population distribution is overall higher 50% or more of the time. This does not mean conductivity is causing harm. It would be more meaningful to develop these metrics for the ECBP ecoregion.

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. Comparing conductivity results to the respective ecoregion and stream size, reference and survey data set provided by Ohio EPA that align with the Huron basin (see methods section in introduction). Comparing results to the respective Ohio reference streams, many of the measures exceeded 75th percentile levels shown in stations summaries. However, examining the appropriate 75th percentile threshold for *streams* in the *Huron-Erie Lake Plain* of 778 uS/cm, many of the spring values would be below this level. Huron-Erie conductivities are naturally higher than Erie-Ontario levels. Still, most of the stream conductivity values are high in comparison. The 75th percentile value for rivers is similar at 774 uS/cm. The Huron River sites are much closer to this value, with many samples below the threshold.The overlap is still present even though it is not identical. When these conductivity populations overlap it strengthens the confidence in using conductivity results for data screening. When the results population overlaps with reference it helps inform protection recommendations.

Table 8. Huron River Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	Minimum	25th	50th	75th	Max
Stream Reference	167.00	405.10	489.10	549.00	1,008.00
Stream Survey	375.00	437.00	568.00	774.00	1,260.00
River Reference	183.00	348.00	455.60	602.00	500.00
River Survey	304.00	416.00	585.00	780.00	1201.00
Results	352		816		2035

There was no consistent seasonal pattern to conductivity levels at the sampling stations. Most sites did have somewhat lower values in April and May; however, there was no pattern whatsoever for three of the sites. Lower spring values were likely due to higher spring flows which may dilute fixed-rate pollutant sources. If conductivity is due to high chloride levels, road salt ions may be traveling through groundwater into the summer months at fairly constant rates. Dilution in spring and again in fall may be occurring.

Conductivity levels were lowest at the upstream-most river location (MH01), but still exceeded impairment thresholds. Levels were higher at downstream river locations (MH11, ADW23), but highest among tributary stations (MH08B, MH09). Three tributary sites stood out from the other stations with conductivity levels that were much higher. These sites were: MH08B-Millers Creek (Huron Parkway), MH07-Malletts Creek (Chalmers), and MH09-Swift Run (Shetland Dr.). All three tributaries have watersheds in the urbanized area of the city of Ann Arbor, Michigan. It is likely that pollutant sources from urban areas are leading to high conductivity levels; however, these sources are persistent across the watershed, as ALL stations exceeded impairment thresholds.

Overall, it appears that the Huron River is entering the western basin of Lake Erie with conductivity values that exceed most thresholds and may indicate impacts on aquatic biology. Values are higher in urban drainages, but high values persist throughout the watershed, including large river sites. More work is needed to determine which specific chemical components are contributing to high conductivity values as well as their sources.

Conductivity Biocondition: A total of 161 conductivity samples were also compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, indicating a healthy macroinvertebrate community, 412-655 indicating a declining and degrading community and greater than 655 µS/cm, indicating a degrading macroinvertebrate community. Across all 12 stations along the Huron River, conductivity measures ranged from a minimum of 352 uS/cm (Huron River at N. Territorial) to a maximum of 2035 uS/cm (Millers Creek). A full 98% of 2022 field season readings exceeded LEBAF macroinvertebrate biocondition threshold of 412, the minimum result was 351, so close to 412. The median was 816 indicating 50% of the time conductivity is above 655, the degraded community condition threshold. Overall, this indicates most macroinvertebrate communities in rivers represented by this data set are in a degrading or declining condition or perhaps already degraded. Based on LEBAF standards, this is not expected.

Actual macroinvertebrate community data, existing or new would help confirm this screening criteria. In addition, more work is needed to determine which specific chemical components are contributing to high conductivity values as well as their sources.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: The 161 TDS samples ranged from 193.55 mg/L to 1,119.2 mg/L, with a median value of 448.8 mg/L. All but one sample exceeded the LEBAF TDS standard. This standard is a drinking water standard not aquatic life. The Huron River, like most if not all tributaries to Lake Erie, does not meet drinking water TDS standards without treatment. 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 and developing its own conductivity thresholds. Results did not exceed 1500 mg/L and the maximum was 1119, which is approaching this threshold but the median of 449 suggests 50% of the time conditions are supportive. Aquatic life can be more sensitive to stressors than humans as their exposure is full time in the water. From this lens it is possible aquatic life is exposed to elevated TDS levels with unknown impacts.

Chloride: Calculated chloride concentrations ranged from 27.73-147.29 mg/L throughout the reporting period, and there were no exceedances in the 161 collected samples (0% exceedance) of the final acute, acute maximum and final chronic aquatic chloride standards. The maximum result approached the final chronic threshold of 150 mg/L. This suggests aquatic organisms in the Huron River were at reduced risk to chronic chloride exposure in 2022. There were no consistent seasonal patterns observed at the twelve sampling stations, though all but three stations generally had lower calculated chloride concentrations in April and May sampling than during the rest of the year. Lower spring values may have been due to higher flows, which may dilute fixed rate pollutant sources. Furthermore, road salt ions may be traveling through groundwater into the summer months at fairly constant rates, and dilution in spring and again in fall may be occurring. Previous direct chloride measurements at some of the sampled stations have been higher than the calculated concentrations reported here, and have even exceeded the chronic and acute thresholds used in this assessment. Additional "gound truthing" is recommended to confirm whether calculated chloride accurately reflects concentrations that are measured directly. The dataset was too small to detect any longitudinal trends, more data is needed.

Salinity: The 161 salinity samples ranged from 274.69 ppm to 1,853.14 ppm, with a median value of 685.79 ppm and 38 exceedances for 24% of the samples.

Salinity results were compared to the USGS recommended salt content for freshwater. Below 1000 ppm is freshwater and 1000-3000 ppm is slightly saline. The maximum did exceed the freshwater range and was well into slightly saline. The median suggests that with this data set 50% of the time salinity levels are 690 ppm or lower. Perhaps seasonal events or other factors increase salinity several times a year for an extended duration creating the 38 exceedances and 24% of samples. In addition, not all sites had exceedance, only some, so actions can focus on those sites and systems. Even if salt is in the water based on this range, it doesn't mean aquatic life is harmed just exposed. All locations had an increase of salinity as time progressed. More data is needed to see if this trend continues throughout the winter and decreases into the summer. In addition, deicing compounds and application protocols can be explored to ensure salt stays out of the creek and these levels stay low.

Aggregated Overall Summary – (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

Huron River had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity for all stations. Of these, two exceedances occurred one for DO and one for temperature and it is likely aquatic life found refuge from these events. Conductivity biocondition was exceeded 98% indicating existing macroinvertebrate communities may be declining or degraded at those sites. Actual macroinvertebrate data, existing or new, would assist in making further recommendations. Since this data was aggregated, this may not hold for all sites or all year for any given site. This high percentage suggests a frequent and longer duration exceedance condition.

Tentatively, the use of expressions of conductivity chloride, TDS and salinity may be useful but more data is needed. LEBAF wanted to answer two questions, first did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? TDS may reflect ambient conditions in the basin, more data is needed. Second, did assessment methods result in an effective screening data use? In terms of assessment methods, the TDS drinking water standard was exceeded which is expected in that no one expects to consume ambient water without treatment, this may not be a helpful assessment criteria for aquatic life screening. However, the aquatic life threshold of 1500 mg/L was not exceeded but approached by a maximum reading, indicating aquatic life has reduced risk of elevated TDS. This aligns with what is known about the basin from existing data and this assessment method, with appropriate context may prove to be a more effective aquatic life screening tool and better align with LEBAF monitoring purpose and data use..

Calculated chloride results approached the maximum, but did not exceed the aquatic life thresholds. Existing direct measurement chloride data shows higher chloride levels than in this data set, even exceedances. More data is needed, but it appears calculated chloride could represent ambient data and the assessment methods effective for screening purposes. The same conclusion applies to salinity, minus having direct measurements to confirm.

The Huron River and its tributary streams appear to be healthy and support aquatic life via the analyses for pH, dissolved oxygen or temperature, as measured from April through October 2022. However, both large river locations and sites on smaller tributary creeks appear significantly unhealthy and impaired in supporting aquatic life for conductivity. The water entering Lake Erie from the Huron River is likely contaminated by some chemical component that could be impairing aquatic life at many levels. While values are higher at urban sites, they are also persistently high across space (all watershed sites) and time (all months of the sampling season, though a bit lower in spring). Specific chemical components that are driving up conductivity values need to be determined, as do their specific sources. More work is needed to investigate chloride levels and sources in particular. It is important to note that this is a single season snapshot of only a few parameters and is in no way a statement on the overall health of the Huron River watershed. For more information on HRWC's long-term monitoring data, via hrwc.org/maps or hrwc.org/washtenaw-results.

3.4 Rocky River

Monitoring Organizations: Currently there is one organization in the LEBAF network monitoring in this basin: The Watershed Volunteer Program (WVP). WVP is a Cleveland Metroparks Natural Resources department led volunteer program supported by the Northeast Ohio Regional Sewer District. The WVP works with Cuyahoga Soil and Water Conservation District to manage a joint volunteer water chemistry monitoring program. Staff and volunteers monitor 53 stations within three watersheds: Euclid Creek, Rocky River, and Cahoon Porter. 25 WVP volunteers help test water chemistry at sites on a monthly basis from January to December.

Station Summary: In 2022, the Cleveland Metroparks designated three of its stations for regional standards collection using the Lake Erie Baseline Assessment Framework (LEBAF). Two stations were monitored using LEBAF protocols along the Rocky River (Bonnie Park Above and Bonnie Park Below). 14 samples were taken by one volunteer. Both of these stations are located along the same river and reach within several hundred feet of each other, one upstream and one downstream of a removed dam at Bonnie Park. Both are warmwater sites located along the East Branch of the Rocky River within the Rocky River Watershed upstream of the convergence with the West Branch of Rocky River. These sites have a 60.3 square mile drainage area that is approximately 54% forested and 41% developed. The 2011 National Land Cover Dataset (NLCD) data indicates an 8.54 percent impervious area in the drainage area to Bonnie Park.

Aggregated Metrics Table - Table 9 Rocky River Summary Statistics

Rocky Summary Statistics - 14 Samples 2 Stations						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	9.74	9.68	7.89	12.94	0	0%
Water Temperature - C	16.46	20.7	5.7	22.3	0	0%
Conductivity - uS/cm	898.21	769.5	564	1736	14	100%
Total Dissolved Solids - mg/L	494.02	423.22	310.2	954.8	14	100%
pH	8.2	8.16	7.94	8.51	0	0%
Chloride - mg/L	155.91	129.52	91.19	324.67	4	28.6%
Salinity - ppm	766.63	643.4	458.87	1558.96	3	21.4%
2022-03-29 to 2022-10-25						

Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter
pH: 14 samples were collected at 2 stations. Zero out 14 samples exceeded pH standards, resulting in 0% exceedances. Other statistics from the monitoring are: max = 8.51, min = 7.94, median = 8.16.

Aggregated historic pH values from 2020 – 2021 at these sites range from 7.43 - 9.98. The majority (76%) of historic pH values from these sites remain slightly basic, above 8, with values becoming more neutral in the colder winter months. The findings during the 2022 LEBAF field season are consistent with historic trends for pH at these sampling locations. All the pH values reported are between the standard thresholds of pH = 6.5 - 9, indicating good quality water. There are no exceedances above the pH threshold at either station, suggesting a healthy river. We can conclude there are minimal impacts from pH to aquatic life along this reach of the river.

DO: 14 samples were collected at 2 stations. Zero out 14 samples exceeded DO standards, resulting in 0 % exceedances. Other statistics from the monitoring are: max = 12.94 mg/L, min = 7.89 mg/L, median = 9.68 mg/L.

Aggregated historic DO values from 2020 – 2021 at these sites range from 8.52 - 16.2 mg/L. Seasonal trends indicate higher DO values at the sites during the colder months, and lower values during the warmer months. The data from the 2022 LEBAF field season is consistent with historic seasonal variability for DO at these sampling locations. All the DO values reported are above the standards threshold of DO = 5 mg/L, indicating good quality water. There are no exceedances below the DO threshold at either station, suggesting a healthy river. We can conclude there are minimal impacts from DO to aquatic life along this reach of the river.

Water Temperature: 14 samples were collected at 2 stations. Zero out 14 samples exceeded water temperature standards resulting in 0 % exceedances. Other statistics from the monitoring are: max = 22.3 °C, min = 5.7 °C, median = 20.7 °C.

Aggregated historic temperature values from 2020 – 2021 at these sites range from 0.3 °C - 24.9 °C. Historic water temperature at these sites is lower during the colder months and higher during the warmer months. The findings at this site during the 2022 LEBAF field season are consistent with historic trends for temperature at these monitoring locations. All the water temperature values reported are under the standard thresholds, indicating good quality water. There are no exceedances above the water temperature threshold at either station, suggesting a healthy river. We can conclude there are minimal impacts from temperature to aquatic life along this reach of the river.

Conductivity: 14 samples were collected at 2 stations. Fourteen out of fourteen samples exceeded macroinvertebrate biocondition standards resulting in 100 % exceedances. Other statistics from the monitoring are: max = 1736 µS/cm, min = 564 µS/cm, median = 769.5 µS/cm.

Aggregated historic conductivity values from 2020 – 2021 from Rocky River sites range from 657 µS/cm - 1701 µS/cm. Historic values fluctuate seasonally and per sampling event, no historic trends can be used to compare LEBAF conductivity data. The max conductivity from the 2022 LEBAF field season was greater than the maximum historic conductivity values and the min conductivity value from the 2022 LEBAF field season was less than the minimum historic conductivity value. These small differences in magnitude imply a change in site conditions at Bonnie Park.

Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. Conductivity field season data was also compared to Ohio EPA reference and survey site that aligns with this basin ecoregion and stream size (see methods in introduction).

Table 10. Rocky River Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	Minimum	25th	50th	75th	Max

Reference	167.00	405.10	489.10	549.00	1,008.00
Survey	375.00	437.00	568.00	774.00	1,260.00
Results	564		769		1736

Rocky River conductivity results **overlap** the distribution of reference and survey sites for the ELOP ecoregion headwaters stream size. Table 10 illustrates the maximum conductivity result, 1736 µS/cm, is greater than maximums for both reference and survey sites. The median result of 769 µS/cm is higher than the median reference and survey sites, by about 200 units. The minimum, 564 µS/cm, is also above reference and survey sites. These sites are not "least disturbed" sites. This illustrates, with this limited data set that these results overlap with the ecoregion and stream size survey data population but likely have a higher overall range. While not a perfect overlap, this strengthens the confidence in using conductivity results for data screening. The higher 50% and maximum may indicate natural geology or causes or could indicate stressors and unhealthy conditions for aquatic life.

Conductivity data compared to Biocondition Assessment

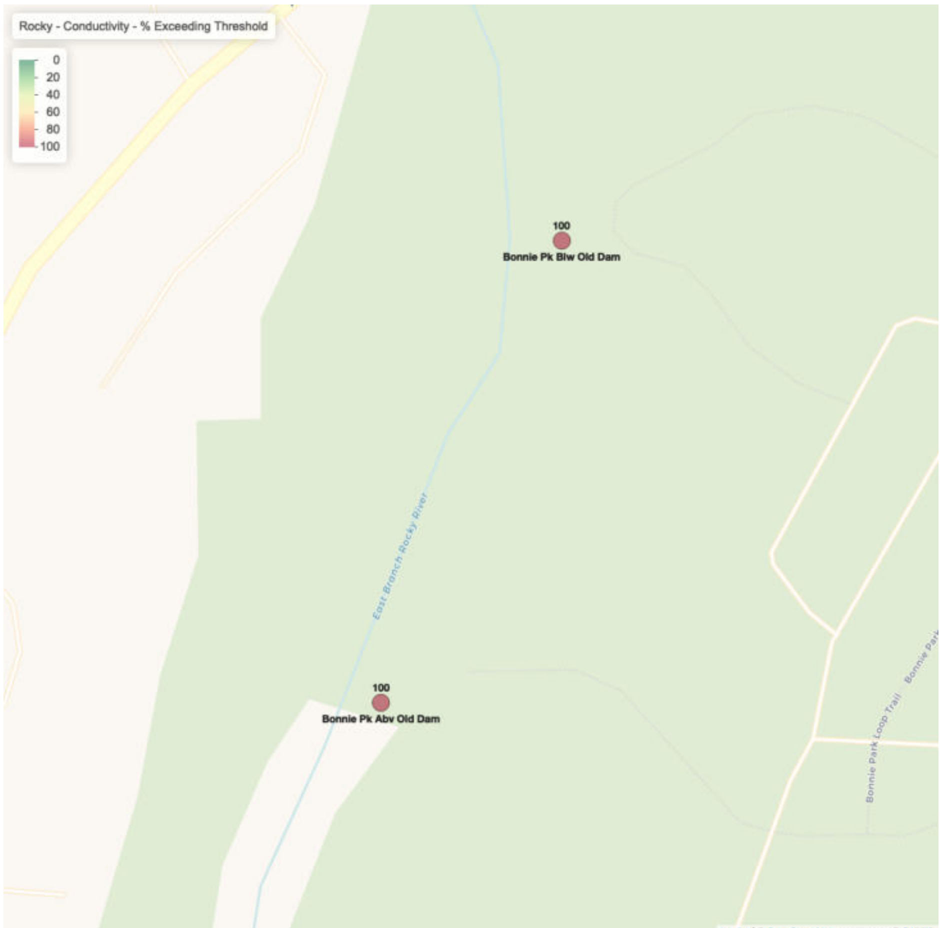
A total of 14 conductivity samples were compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm and 655 µS/cm. Results less than 412 µS/cm indicate a healthy macroinvertebrate community. Results between 412-655 µS/cm indicate declining and degrading health. Any results greater than 655 µS/cm indicate a degraded macroinvertebrate community.

LEBAF 2022 Rocky River conductivity values ranged from 564 µS/cm to 1736 µS/cm. 100 % of 2022 field season conductivity values with every sampling event exceeding the 655 µS/cm threshold, an indicator of a degraded macroinvertebrate community health. The minimum conductivity was 564 µS/cm, which is above the 412 µS/cm threshold for healthy but below the 655 µS/cm threshold for already degraded. Thus, some sites may be in decline while most are already degraded using these thresholds.

However, the use of the macroinvertebrate bio-condition assessment method doesn't address what stressors are present or to what extent high conductivity exposure may be causing harm. It is a screening metric. It is difficult to make conclusions about the direct impact these sites have on macroinvertebrate life along the entire stretch of the Rocky River given the small sampling area (two sites within a few hundred feet of each other).

Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe this site may be unhealthy, or that macroinvertebrate communities may be unhealthy and in a declining if not already degraded community condition. Ohio EPA fish and macroinvertebrate sampling for this site indicate that the river is attaining water quality standards. Ohio EPA fish and macroinvertebrate sampling for Rocky River is more robust than LEBAF data and their monitoring purpose and data use is more rigorous.

Figure 1. Rocky River Conductivity Data Summary Exceedance Map: *Shows the percentage of exceedances of each site along the Rocky River*



Another limitation of the dataset is this data only represents monthly points in time and will not always capture weather or pollution-related events. More macroinvertebrate monitoring data is needed to confirm this screening assessment and the relationship between conductivity and macroinvertebrate populations. Additional data may also help refine this potential discrepancy with Ohio EPA conclusions.

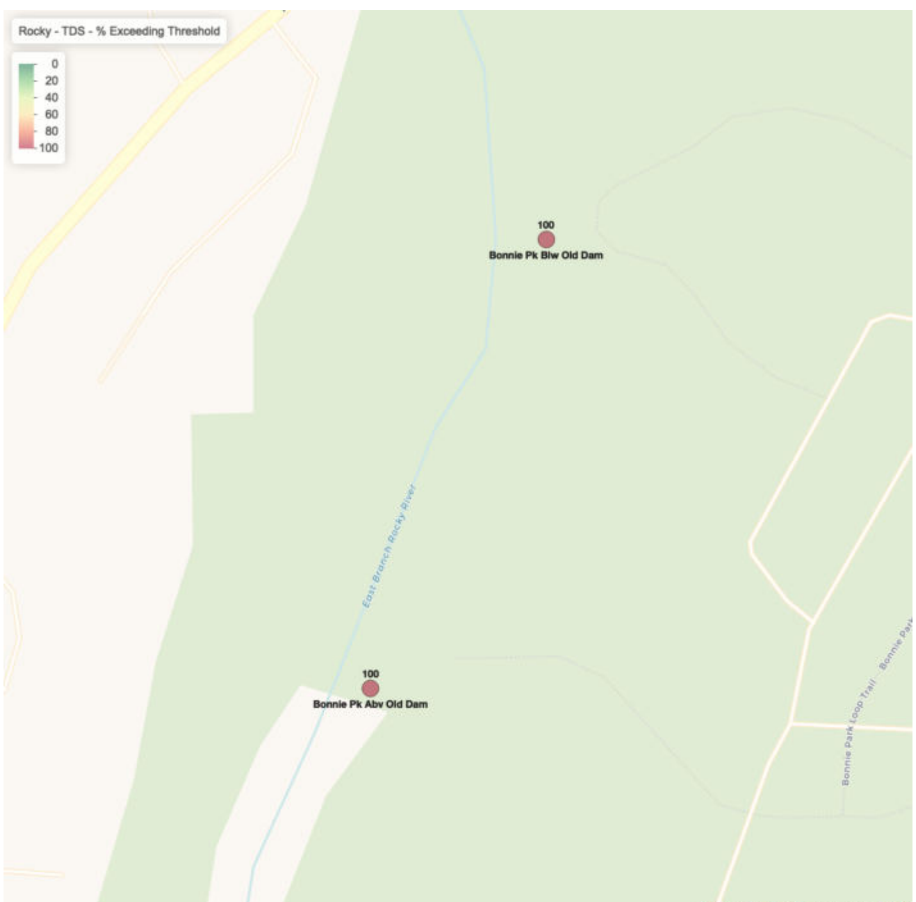
Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be viewed with the lens of these goals.

TDS: 14 samples were collected at 2 stations. A total of 14 out 14 samples exceeded TDS drinking water standards resulting in 100 % exceedances. Other monitoring statistics for TDS were: max = 954.8 mg/L, min = 310.2 mg/L, median = 423.22 mg/L.

Aggregated historic TDS values from 2020 – 2021 at these sites range from 370 mg/L - 4740 mg/L. Historic TDS values at these sites fluctuate. The calculated LEBAF minimum TDS value was below the minimum historic value. The maximum calculated LEBAF maximum TDS value was well below the maximum historic value. This may suggest a reduction of dissolved solids over time. Monthly and seasonal TDS trends can be determined from comparing LEBAF data to historic data.

Figure 2. Rocky River TDS Data Summary Exceedance Map: *Shows the percentage of exceedances of each site along the Rocky River*



This year, the TDS data was calculated from measured conductivity data. For the 2022 LEBAF season, the calculated TDS values were assessed against a drinking water threshold of 200 – 500 mg/L while LEBAF is exploring the effectiveness of the Ohio aquatic life threshold of 1500 mg/L and developing its own conductivity thresholds. The composite calculated TDS values at this location during the 2022 LEBAF field season exceeded drinking water standards 100% of the time with most falling within the chronic TDS range between 200 – 500 mg/L. This corresponds with what is already known about the Rocky River.

Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe this site may be unhealthy at certain sites or times of year looking through the lens of TDS results. Albeit Ohio EPA fish and macroinvertebrate sampling for this site indicate that the river is attaining water quality standards, even with their 1500 mg/L criteria. It is not likely that the TDS levels at this site have a direct correlation to Lake Erie Impacts. This data only represents a point in time monthly; more field data is needed to draw conclusions.

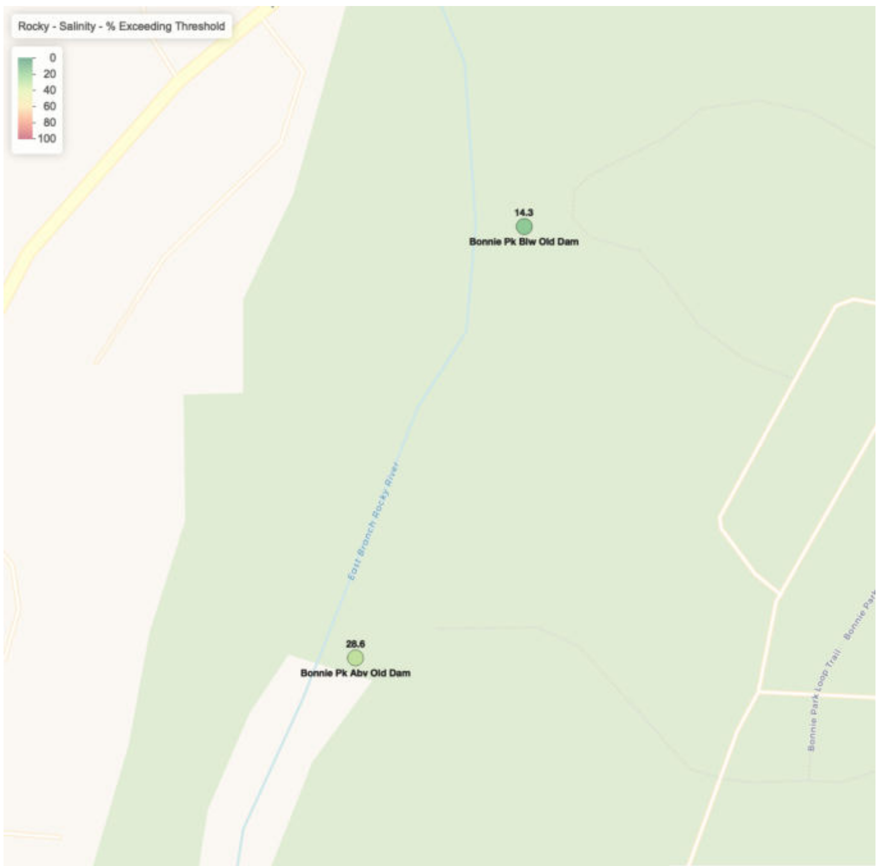
Chloride: 14 samples were collected at 2 stations. Calculated chloride concentrations ranged from 91.19 - 324.67 mg/L throughout the sampling period. Four out 14 samples exceeded chloride standards resulting in 28.6% exceedances of the final acute, acute maximum and final chronic aquatic chloride standards. Of the 4 exceedances, 1 was greater than the 640 mg/L threshold for acute exposure to aquatic life, and 3 were above the 150 mg/L threshold for chronic aquatic life exposure. This suggests aquatic organisms in the Rocky River may have been at risk to both acute and chronic chloride exposure some of the time during 2022. However, Ohio EPA fish and macroinvertebrate sampling at this station indicate the river is attaining water quality standards. Further context about TDS conditions at this site cannot be determined without additional historic data to compare to LEBAF findings. More data is needed to understand if the chloride expression of conductivity is representative of ambient conditions.

One of the limitations to the water quality assessment of Rocky River is that samples were collected only in summer and fall. Higher chloride concentrations are expected to occur in winter and spring because of road salting. One recommendation is to increase the period over which samples are collected to better assess chloride risk to aquatic life. Another limitation to the current assessment is that no historical chloride data exist for this river, which means there is no way to confirm that calculated concentrations reflect direct chloride measurements. Thus, it is too early in monitoring efforts to detect any temporal or longitudinal patterns if they exist. One recommendation to address this limitation is to analyze chloride sampled directly on a subset of samples and compare the results to the calculated concentrations for accuracy.

Salinity: 14 samples were collected at 2 stations. Three out of 14 samples exceeded chloride standards resulting in 21% exceedances. Other statistics observed included: max = 1558.96 ppm, min = 458.87 ppm, median = 643.4 ppm. Historic salinity values from 2020 – 2021 at the site range from 400 ppm - 1500 ppm.

The maximum observed sample calculated from the LEBAF field season exceeded the lowest salinity category and suggests somewhere at sometime waters are slightly saline. The median suggests that with this data set 50% of the time salinity levels are 643.4 ppm and the minimum of 458.87 ppm suggests that salinity conditions could approach the slightly saline category. Storm events are one possible source of this condition. Even if salt is in the water based on this range, it doesn't mean aquatic life is harmed, just exposed.

Figure 3. Rocky River Salinity Data Summary Exceedance Map: *Shows the percentage of exceedances of each site along the Rocky River*



More data and exploration of deicing compounds and application protocols might keep salinity in a freshwater range all year at all stations. These sites are located upstream from Lake Erie and will reflect local conditions in the watershed but will likely not contribute to Lake Erie basin wide trends. However, when this data is compiled with other Lake Erie data it may be possible to speak to a trend in salinity levels gradually increasing over time during warmer months**.** Without Lake Erie data, it would be hard to tell if this effect is diluted at the lake level or also remains elevated and trending upwards. This data only represents a point in time monthly and will not always capture weather or pollution related events.

Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe this site may be unhealthy from the lens of salinity exposure. Ohio EPA has noticed a trend of salinity in streams remaining high throughout the year and not reducing drastically after winter road salting efforts, which makes salinity a valuable screening indicator.

Aggregated Overall Summary:

Rocky River had data for 7 parameters at two stations: pH, DO, conductivity, water temperature, chloride, TDS and salinity. Data from these respective standards or thresholds were exceeded for 3 parameters: drinking water and aquatic life TDS thresholds, chloride and conductivity biocondition gradient. We believe salinity is also a potential concern.

DO, pH and temperature results support aquatic life. Conductivity results, or distribution of results, overlap with the ELOP conductivity results, watershed size of "stream", conductivity data, albeit conductivity from these sites had a higher overall distribution than the ELOP data set. The mean, 75% and maximum were higher than the ELOP stream database but overlap was present. This overlap but higher mean, 75th percentile and maximum conductivity indicates either natural sources or other sources that create higher conductivity. The findings during the 2022 LEBAF field season are consistent with historic trends for DO at these sampling locations. All the DO values reported are above the standards threshold of DO = 5 mg/L, indicating good quality water. There are no exceedances above the DO threshold at either station, suggesting a healthy river. We can conclude there are minimal impacts from DO to aquatic life along this reach of the river. It is not likely that the DO levels at this site have a direct correlation to Lake Erie Impacts. These sites are located upstream from Lake Erie and will reflect local conditions in the watershed but will likely not contribute to Lake Erie basin wide trends.

Exceedances of biocondition gradient, both TDS standards, chloride, conductivity biocondition gradient, and salinity indicate potential concern to the actual or maximum potential health of the Rocky River. The TDS drinking water standard may not be as useful as the aquatic life threshold as a screening tool, but more data and context is needed. This data only represents a point in time on a monthly basis, it does not represent the full spectrum of values you would expect over 24 hours or after different weather events.

Initial results are encouraging in regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? More data is needed however, for TDS the exceedances of drinking water were expected in that no one expects to consume ambient water without treatment. Exceedances of TDS aquatic life criteria with the maximum TDS confers with exceedances in macroinvertebrate biocondition gradient. This data set doesn't represent the entire tributary or Rocky River, calculated TDS may represent ambient conditions and assessment methods appropriate for screening.

Existing data and trends identified by Ohio indicate that the chosen conductivity chloride and salinity expressions show promise in representing ambient conditions and assessment methods appropriate for screening.

Based on LEBAFs definition of healthy and for our monitoring purpose of screening, and with this very limited dataset, we believe this monitoring location is healthy, but may be threatened by sources of conductivity, TDS, chloride and salinity. Both sites are located upstream from Lake Erie. Therefore, it is difficult to make conclusions about the direct impact these sites have before water is discharged into Lake Erie. Adding more sites downstream of this location, on the mainstem of the Rocky River and closer to the discharge point of Lake Erie may help to tell a more comprehensive story about the impacts affecting water quality going into Lake Erie.

1. **Direct Tributaries to Lake Erie**

3.5 Buffalo River

Monitoring Organizations: One organization in the LEBAF network monitors in the Buffalo River, Buffalo Niagara Waterkeeper.

Station Information: Buffalo Niagara Waterkeeper stewards two sites sampled 1x/month from May - October. Data from 2020, 2021, and 2022 available for both sites. Those two sites are the Buffalo River at Bailey Peninsula (Coordinates: **42.861629, -78.825641)** and Riverfest Park (Coordinates: **42.870881, -78.871138)**.

Buffalo River at Bailey Peninsula is located near the confluence of the Buffalo River and Cazenovia Creek. There are multiple 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 site was sampled 1x/month May through October between 10:30 am and 11:30 am.

Buffalo River at Riverfest park is close to the mouth of the Buffalo River, which feeds directly into Lake Erie, and the city ship canal. There are multiple 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. Historically, this river was used to transport commercial goods. This site was sampled 1x/month May - October between 9:45 am and 11:00 am.

Aggregated Metrics Table - Table 11 Buffalo River Summary Statistics

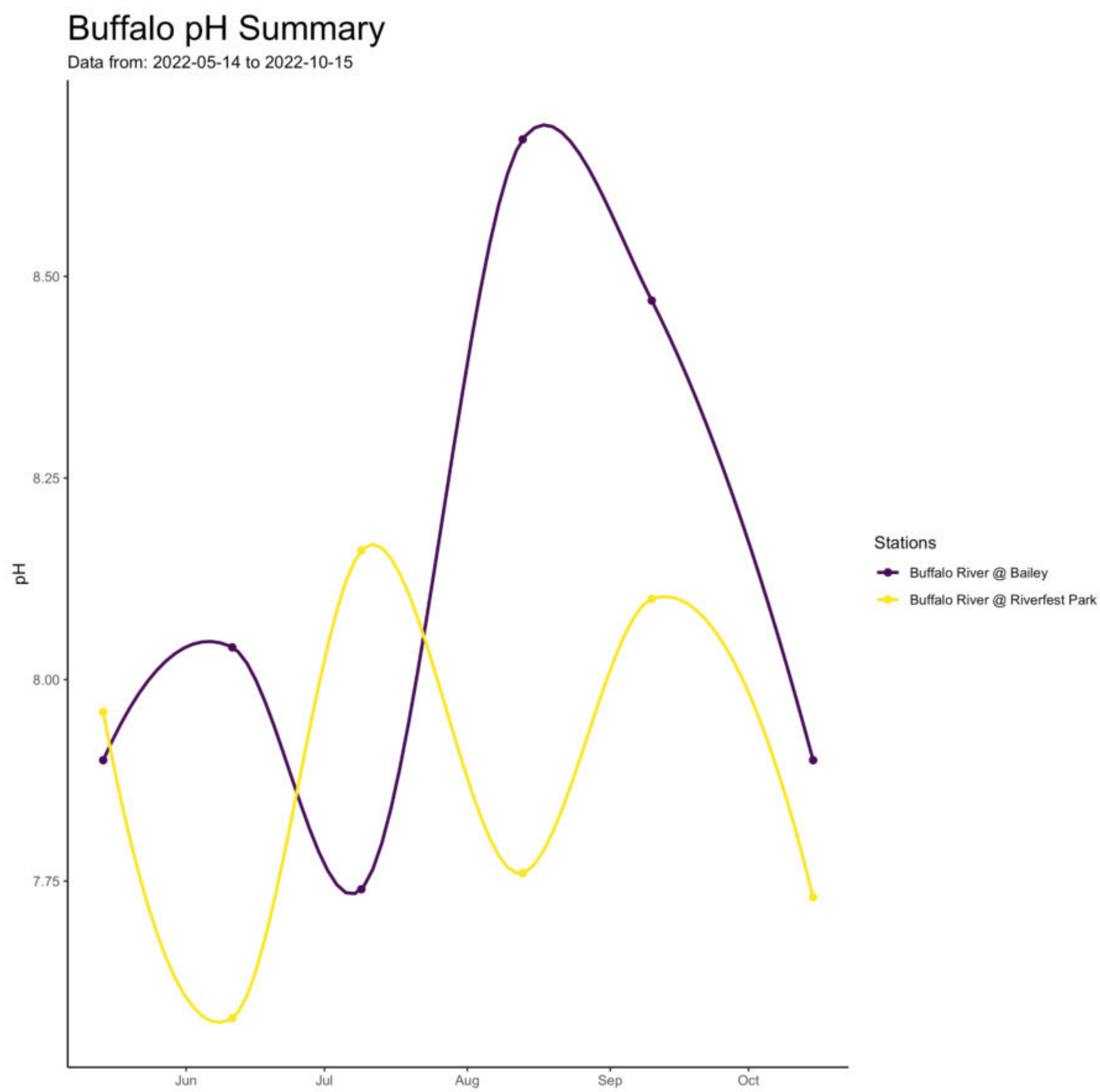
Buffalo Summary Statistics - 12 Samples 2 Stations						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	8.7	8.29	6.06	11.54	0	0%
Water Temperature - C	21.33	22.68	11.53	25.7	1	8.3%
Conductivity - uS/cm	494.95	490.45	339.7	649	10	83.3%
Total Dissolved Solids - mg/L	272.22	269.75	186.84	356.95	11	91.7%
pH	8	7.93	7.58	8.67	0	0%
Chloride - mg/L	24.39	24.17	16.74	31.98	0	0%
Salinity - ppm	398.6	394.18	264.35	534.58	0	0%
2022-05-14 to 2022-10-15						

Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)
pH: 12 samples, Max = 8.67, Min=7.58, Median=7.93, 0 ph Exceedances.

12 samples were collected at 2 stations resulting in 0, or 0%, exceedances of respective standard. Due to impacts on water flow and direction caused by the water level of Lake Erie, as well as CSOs, residential inputs, and runoff, no clear seasonal trend could be established for this parameter on this tributary. Historic data from the 2020 and 2021 sampling seasons all fall within the standards established by LEBAF. Continued monitoring of this tributary at both of these sites is recommended, potentially with additional sites added and more frequent sampling at different times of the year, month, and day. While values for both sites fell within acceptable ranges, they varied noticeably from each other despite being relatively close geographically.

Figure 5. Buffalo River pH Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.

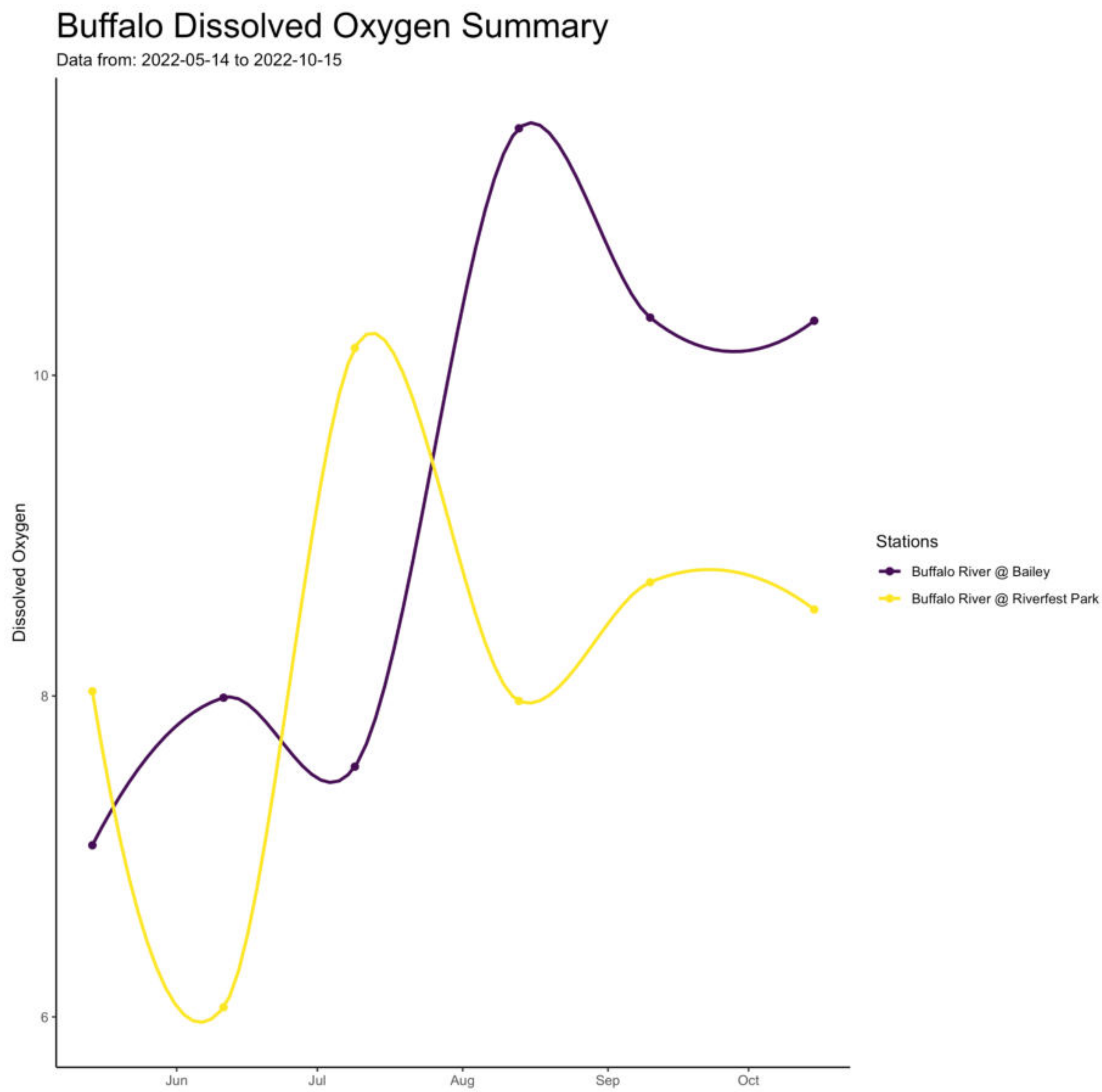


DO: 12 samples, 0 exceedances, Max= 11.54 mg/L, Min 6.06 mg/L, Median= 8.29 mg/L

12 samples were collected at 2 stations resulting in 0, or 0%, exceedances of respective standard. We expect DO to be in range. Our data does not indicate a specific trend (daily, seasonally, etc) there are many factors at play in this large waterway that could be playing a role in variability. Limitations in data include no data collected in winter months and limited data

collected each month. All data was within state standard range, historic data from 2020 and 2021 all fall within standards, with no discernable trend.

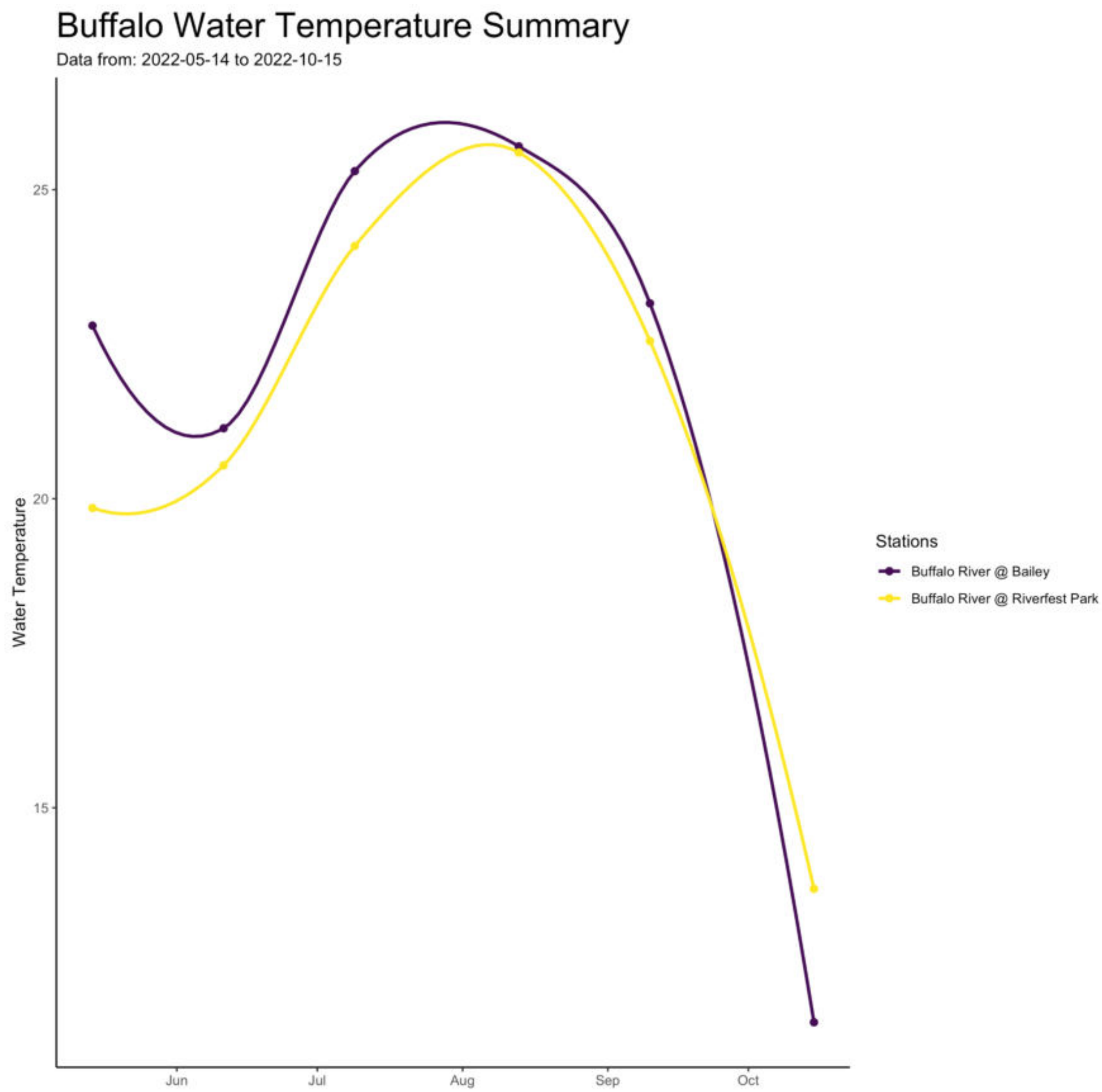
Figure 6. Buffalo River Dissolved Oxygen Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Temp: 12 samples, 1 exceedance = 8.3% (in May), Max=25.7 °C, Min=11.53 °C, Median= 22.68 °C

12 samples were collected at 2 stations resulting in 1, or 8.3%, exceedances of respective standard. We would expect this parameter to trend upwards from May through August, and then begin to taper down. Graphs from both sites affirm this assumption, and show similar trends.

Figure 8. Buffalo River Water Temperature Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



The single exceedance at the Bailey Peninsula site did not fall very far outside of the standards established by LEBAF, and we believe is not a cause for major concern. Historic data from the 2020 and 2021 sampling seasons shows a similar trend at both stations, with values generally falling within range of acceptable standards. Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe that this tributary is healthy, and that there is no cause for concern about this tributary's impact on Lake Erie.

Conductivity Survey: 12 samples were collected at 2 stations resulting in 10, or 83.3%, exceedances of respective standard, N = 12, max = 649 µS/cm , min = 339.7 µS/cm, median = 490.45 µS/cm, 10 exceedances above the macroinvertebrate biocondition for a healthy community (412) but not yet an unhealthy community (655), 83%.

Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. The Buffalo River falls within the EOLP ecoregion and is a stream size (20 -500 square miles). The average of the data is 494.95 µS/cm. The below table illustrates that the maximum conductivity falls between the 75th percentile and maximum reference stream values and between the 50th and 75th stream survey conductivity values. The median result of 450 is lower than the median reference and survey sites. This illustrates, with this limited data set that these sites align with the higher end of both reference and survey sites for this watershed size and ecoregion.

Table 12. Buffalo River Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	167.00	405.10	489.10	549.00	1,008.00
Survey	375.00	437.00	568.00	774.00	1,260.00
Results	339		450		649

It is expected this parameter would follow a similar trend to the TDS and chloride measurements, with a peak in the summer months when activity along the river is highest, and a decrease afterwards. Both stations along the river followed this trend, peaking in July, and trending downwards after, with the exception of the Riverfest station in October, which spiked after a low September reading.

Conductivity Biocondition: A total of 12 conductivity samples were compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, indicating a healthy macroinvertebrate community, and 655 µS/cm, indicating a degrading macroinvertebrate community. Buffalo River conductivity values ranged from *339.7 µS/cm* to *649 µS/cm* and 10/12 or 83% of 2022 field season conductivity values exceeded either the 412 us/cm threshold but not the 655 threshold. The minimum conductivity measured was 339, which is less than 412 indicating healthy conditions. The median was 490 and mean 494 which indicates 50% of the time and on average respectively macroinvertebrate conditions based on conductivity are possibly in a declining or threatened condition. The maximum result was 649 which approaches but doesn't exceed 655, the threshold for already degraded conditions. A screening result or conclusion from this assessment indicates that if the right actions were taken in a timely manner perhaps these communities could return to healthy conditions. More data is needed. Conductivity data from this site during the 2020, 2021, and 2022 sampling years shows that this tributary occasionally falls outside of acceptable ranges for supporting healthy communities of macroinvertebrates. Generally, the measurements fall within acceptable ranges, but are subject to spikes and depressions at different points of the year (713.2 µS/cm in September of 2021, and 312.3 µS/cm in July of 2020). Because of the considerable variability in measurements, continued monitoring of these sites will be essential in determining overall bio-condition, and to ensure that healthy biological communities can be established and maintained.

It is also expected that this parameter would fall within standards consistently throughout the sampling season and into winter, with an early summer peak and potential early fall spike. Stations are affected by storm surges and ice flows pushing up and downstream. Three exceedances of the respective threshold were found and these might be related to stormwater runoff, CSO, industrial inputs, upstream runoff, wildlife activity, restoration work, and boating activities, etc.

Based on the data that was collected, it would not be recommended that this tributary be put on a list for the conductivity parameter. In addition, based on LEBAF's definition of healthy and for our monitoring purpose of screening it is believed that this tributary is somewhat healthy, with minimal impact on Lake Erie.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing, ambient data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

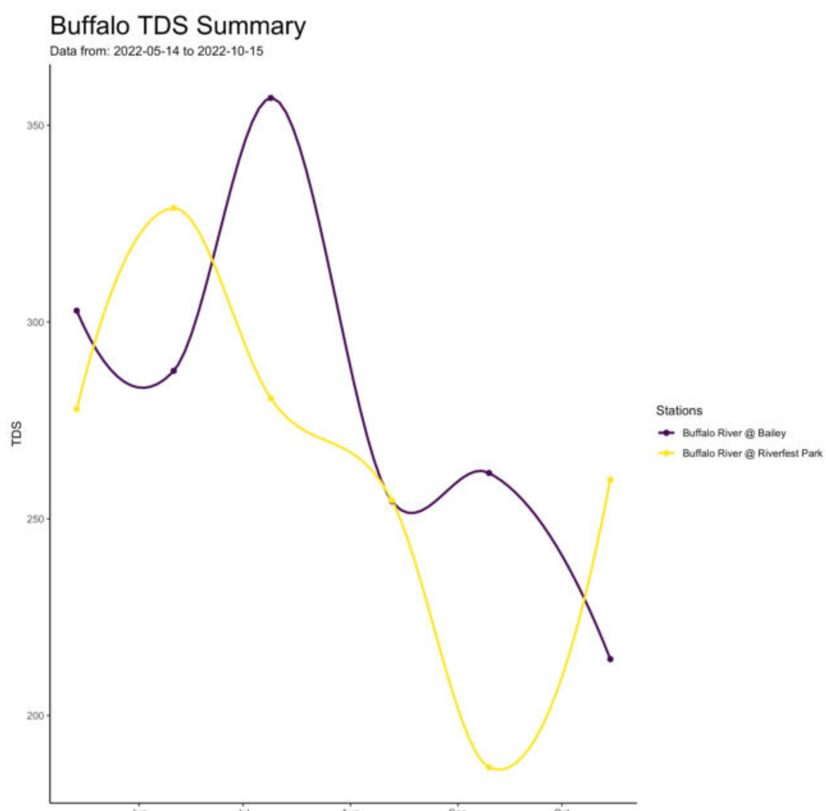
TDS: 12 samples, 11 exceeded at 91.7%, Max=356.95 mg/L, Min=186.84 mg/L, 269.75mg/L

12 samples were collected at 2 stations resulting in 11, or 91.7%, exceedances of respective standard. 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 and developing its own conductivity thresholds. Results did not exceed 1500 mg/L and the maximum was 357, not

approaching this threshold. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Elevated TDS can have direct and indirect impacts on aquatic life. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS. TDS did not exceed the 1500 mg/l Ohio aquatic life.

Overall, LEBAF would expect TDS to vary seasonally with inputs from CSOs, runoff, recreational use, and commercial use. TDS peaked for both sites along the river in August, and generally decreased through the rest of the sampling season, with the exception of the station at Riverfest park in October. All measurements except for the station at Riverfest in September fell outside of the drinking water standards. This is to be expected, as use of the river increases during the warmer summer months and no one expects to consume ambient water without treatment. Historic data shows similar trends, with peaks in the summer, and a general trend downwards afterwards.

Figure 9. Buffalo River TDS Summary Data Graph:Figure 10. Buffalo River Chloride Data Summary Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



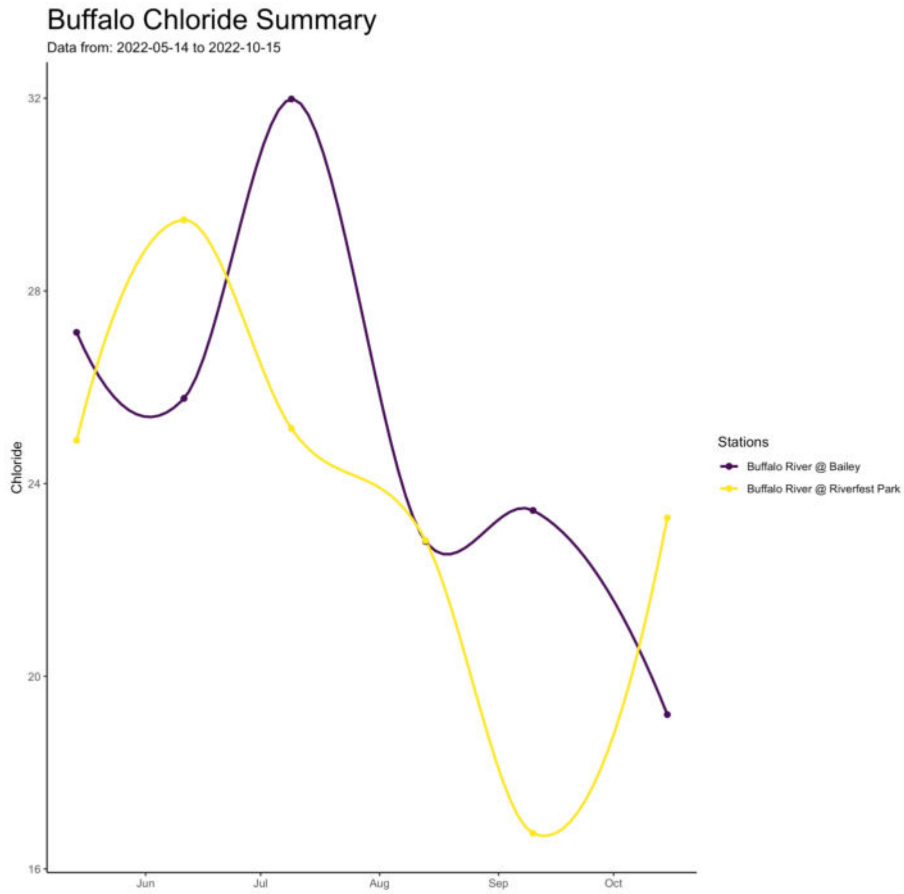
LEBAF expects calculated TDS to exceed drinking water standards consistently throughout the sampling season and into winter with storm surges and ice flows pushing up and downstream.

There were 11 exceedances of LEBAF drinking water thresholds. The exceedances are related to stormwater runoff, CSO, industrial inputs, upstream runoff, wildlife activity, restoration work, boating activities, etc. However, of significant note, calculated TDS did not exceed the aquatic life TDS threshold of 1500 mg/L, which indicates TDS is not at levels with this data set to cause harm. The 11 drinking water exceedances could potentially impact drinking water conditions in Lake Erie, but not likely aquatic life. Since this tributary is so close to the mouth of the Niagara River, impacts to Lake Erie may be limited because of dilution. LEBAF believes that If more data from the early spring could provide more information and possibly show other exceedances; the data is limited to May-October. There is no state (New York) standard for TDS but the Ohio aquatic life threshold of 1500 mg/l indicates TDS is not a threat via this data set Based on LEBAF's definition of healthy, the Buffalo River is believed to be impaired and may potentially impact Lake Erie. LEBAF recommends continued monitoring, adding additional sampling sites, increasing the frequency of sampling at monthly and seasonal levels with collection at varying times of day.

Chloride: Calculated chloride concentrations ranged from 16.74-31.98 mg/L throughout the sampling period, of the 12 collected samples and there were 0 exceedances of the final acute, acute maximum and final chronic aquatic chloride standards.

12 samples were collected at 2 stations resulting in 0, or 0%, exceedances of respective standard. This suggests aquatic organisms in the Buffalo River were at reduced risk to chronic chloride exposure in 2022. Chloride and TDS followed similar temporal trends because both parameters are calculated from direct conductivity measurements. Generally, calculated chloride concentrations at both of the stations along the Buffalo River peaked in July when activity along the river was highest, before decreasing throughout the rest of the sampling period. An exception to this temporal trend occurred at the Riverfest station, where October calculated chloride concentrations were higher than September measurements. No historic data is available for this parameter, so a clear trend could not be established or verify calculated chloride results are or are not representative of ambient conditions. Input from boats, combined sewage overflows, and residential runoff along the river could contribute to higher levels in the summer months. Data collection was limited to May through October at two stations, and early spring may be a time when exceedances are more likely to occur due to road salt application. In addition to continued monitoring, recommendations moving forward include increasing the frequency of sampling, the number of monitoring stations, and to collect samples at different times during the day.

Figure 10. Buffalo River Chloride Data Summary Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Salinity: N= 12, max = 534.58 ppm, min = 264.35 ppm, median = 394.18 ppm, 0 exceedances, 0%

12 samples were collected at 2 stations resulting in 0, or 0%, exceedances of respective standard. Salinity results were compared to the USGS recommended salt content for freshwater. Below 1000 ppm is freshwater and 1000-3000 ppm is slightly saline. The maximum is half the lowest level and the median suggests that with this data set 50% of the time salinity levels are 400 ppm. Even if salt is in the water based on this range, it doesn't mean aquatic life is harmed just exposed. All locations had an increase of salinity as time progressed. More data is needed to see if this trend continues throughout the winter and decreases into the summer. In addition, deicing compounds and application protocols can be explored to ensure salt stays out of the creek and these levels stay low.

We would expect this parameter to follow a similar trend to the TDS, chloride, and conductivity measurements, with a peak in the summer months when activity along the river is highest, and a decrease afterwards. Both stations along the river followed this trend, peaking in July, and trending downwards after, with the exception of the Riverfest station in October, which spiked after a low September reading. Historic data from 2020 and 2021 is not available for this parameter. Measurements generally fall within the standards established by LEBAF. Input from boats, CSOs, and residential runoff along the river could contribute to higher levels in the summer months.

LEBAF expects TDS fall within standards consistently throughout the sampling season and into winter, with an early summer peak and potential early fall spike. The sampling stations are affected by storm surges and ice flows pushing up and downstream. There were 0 exceedances of the TDS threshold. Potential TDS could be related to stormwater runoff, CSO, industrial inputs, upstream runoff, wildlife activity, restoration work, boating activities, etc. No historic data is available for this parameter along this tributary. Even with 0 exceedances, spikes could impact aquatic life in Lake Erie, but since this tributary is so close to the mouth of the Niagara River, impacts to Lake Erie may be limited.

Aggregated Overall Summary:

Buffalo River had data for 7 parameters, pH, DO, temperature,conductivity, conductivity, macroinvertebrate biocondition gradient, TDS, chloride and salinity. Of these parameters, data from temperature, drinking water TDS standards but not aquatic life standards and conductivity macroinvertebrate biocondition gradient exceeded thresholds.

Temperature exceeded one time at the Buffalo River @ Bailey Peninsula site in May. More point data and possibly real time data would be needed to characterize if the frequency, duration and magnitude of this exceedance caused harm or if other exceedances were missed. It is possible aquatic life found refuge from higher temperatures.

Conductivity results aligned with the Ohio ELOP, stream size category, reference and survey data providing confidence in results. Data followed an expected pattern associated with land use, precipitation and other factors. All but two conductivity results did fall between the health community macroinvertebrate biocondition threshold, 412 and 655 the unhealthy threshold at Bailey Peninsula site in July, October and September. Looking at existing macroinvertebrate data aligns and or further review or investigation of other potential stressors in the system during this time would be beneficial.

Results are encouraging in regards to using the expressions of conductivity chloride, TDSand salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? More data is needed and it appears calculated TDS results represent ambient conditions for screening purposes. Regarding assessment methods, exceedances of the drinking water standard for TDS were expected in that no one expects to consume ambient water without treatment. This may not be an effective assessment for aquatic life health. The Ohio TDS aquatic life threshold of

1500 mg/L was not exceeded or even approached. LEBAF is exploring this threshold in the future. TDS results confer possible stress at this same station for all samples in May through October and all samples at Riverfest Park except September. The TDS standard was for drinking water protection versus aquatic life, again suggesting further investigation would help determine what stressors are present and the extent that the macroinvertebrate community may be exposed to harmful conditions. The remaining four parameters, pH, DO, chloride and salinity were all within aquatic life thresholds indicating, with this limited data set, conditions that support aquatic life.

Calculated chlorides and salinity appear to represent ambient conditions. Existing data was not available to confirm, more data is needed. Because temperature and conductivity biocondition was exceeded once each, that indicates the river may be exposed to harmful conditions and more data is needed to confirm. Regarding assessment methods, both chloride and salinity methods appear to be effective for screening, given limitations of the dataset.

LEBAF believes that more sites at locations upstream of Bailey Peninsula and in between the two existing stations could better determine and monitor this creek's condition. More early spring data could provide more information and possibly show exceedances. LEBAF's data is limited to May-October. Based on the collected data, this tributary is not exceeding LEBAF's parameters. Based on LEBAFs definition of healthy and based on sampling, this tributary is "somewhat healthy," with minimal impact on Lake Erie. LEBAF supports continued monitoring, the addition of more sampling sites, and increases frequency of sampling at monthly and seasonal levels that are collected at varying times of day.

3.6 Doan Brook

Monitoring Organizations: One organization in the LEBAF network monitors in this basin, Doan Brook Watershed Partnership. The Doan Brook Watershed Partnership water monitoring program was created in 2021 and 7 volunteers have provided data. For the CWA's LEBAF data, the watershed programs manager has started a monthly schedule to collect data at the end of the month.

Station information:
Doan Brook is 8.4 miles long and flows through Shaker Heights, Cleveland Heights and Cleveland before emptying into Lake Erie. Its watershed is 11.7 square miles with 2/3 or 7.5 square miles used for residential land. The 7 sites are south of Lake Erie along Doan Brook and measure the direct tributary from brook source to lake sink.

Seven sites along the Doan Brook were monitored and include: Green Lake; Southerly Park; the North Branch of Doan Brook that flows through the Nature Center at Shaker Lakes; Lower Lake; the Gorge Trash Rack, Rockefeller Lagoon; and the Albanian Cultural Garden. There is not going to be a monitoring site at Horseshoe Lake until construction is completed. Due to a change in water monitoring equipment, this analysis will only look at 3 data points per site, 21 data points total.

Aggregated Metrics Table - Table 13 Doan Brook Summary Statistics

Doan Brook Summary Statistics - 21 Samples 7 Stations						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	7.06	7.28	2.18	9.9	4	19%
Water Temperature - C	16.12	13.9	11.5	23.8	0	0%
Conductivity - uS/cm	542.9	508	162.6	906	14	66.7%
Total Dissolved Solids - mg/L	298.6	279.4	89.43	498.3	17	81%
pH	7.98	8.02	7.34	8.71	0	0%
Chloride - mg/L	26.75	25.03	8.01	44.65	0	0%
Salinity - ppm	443.02	409.53	118.61	768.45	0	0%
2022-08-31 to 2022-10-31						

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

pH: There were 0 exceedances at 0%. The max was 8.71, the median was 8.02 and the minimum was 7.34.
All locations so far have shown expected pH levels for a freshwater tributary. Green Lake was the only location that saw a more acidic pH as time went on while the other six locations became more basic. This is due to Green Lake being a catch basin for the Shaker Heights Country Club golf course. More data is needed to understand seasonal pH fluctuations.

DO: There were 4 exceedances at 19%. The max was 9.9 mg/L, the median was 7.28 mg/L and the minimum was 2.18 mg/L.
Green Lake had 100% exceedance while Southerly Park had a 33.3% DO exceedance. Green Lake is a catch basin near a golf course and a lot of large lawns. As Doan Brook flows toward Lake Erie, the DO improves. More data is needed to understand seasonal DO fluctuations.

Temp: There were 0 exceedances at 0%. The max was 23.8°C, the median was 13.9°C, and the minimum was 11.5°C.
So far, all locations are following the LEBAF temperature thresholds. More data is needed to see if this trend continues throughout the year.

Conductivity Survey: The max was 906 uS/cm, the minimum was 162.6 uS/cm, and the median was 508 uS/cm. The average of the data is 542.9 µS/cm.

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. Doan Brook conductivity results fall within the EOLP ecoregion and is a stream size (20 -500 square miles).The below table illustrates that the maximum conductivity result, 906, falls between the 75th percentile and maximum reference stream values and between the 50th and 75th stream survey conductivity value, closer to the maximum. The median result of 508 is higher than the median reference yet lower than median survey sites, in the ballpark for both. The minimum, 162, is closer to the minimum reference value than survey sites. This illustrates, with this limited data set that these results align with the data from the survey sites and the 50th to 75th percentile of reference sites for this headwater watershed size and ecoregion. This strengthens the confidence in using conductivity results for data screening.

Table 14. Doan Brook Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	90.00	351.00	462.00	611.00	35,000.00
Survey	316.00	466.00	629.30	886.00	990.00
Results	162		508		906

Conductivity Biocondition: The 21 conductivity samples were also compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, indicating a healthy macroinvertebrate community, 412- 655 indicating a declining or degrading condition, and greater than 655 µS/cm, indicating a degrading macroinvertebrate community. Doan Brook conductivity values ranged from 162.6 *µS/cm* to 906 *µS/cm*. The minimum recorded result of 162.6 indicates some sites some time of the year are in healthy condition. The median was 508, which is above the 412 healthy threshold but below 655 already degraded threshold. This indicates some sites are in decline or degrading 50% of the time. The maximum result of 908 indicates some sites may be exposed at some time during the year to conductivity conditions that degrade macroinvertebrate communities. Overall, 14 of the 21 samples did exceed one of the thresholds or 67% of samples. More data is needed and actual existing or new macroinvertebrate data would help inform action. These results show the effectiveness of this indicator as a screening tool, narrowing in on sites and times of year the macroinvertebrate community is exposed to conductivity conditions that support health, threaten health are validate conditions that degrade community health. More monitoring, protective or restorative actions could be developed and taken once more data (conductivity, other parameters or ancillary information) is integrated. . Further investigation through existing macroinvertebrate and new data, exploring other stressors and or more data in general is needed to understand if the community is indeed unhealthy in structure or function.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: There were 17 exceedances at 81%. The max was 498.3 mg/L, the median was 279.4 mg/L and the minimum was 89.43 mg/L.

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 and developing its own conductivity thresholds. Green Lake had 0% exceedances and Lower Lake had 66.7% exceedances. Southerly Park, Nature Center at Shaker Lakes, Gorge Trash Rack, Rockefeller Lagoon and the Albanian Cultural Garden locations had 100% exceedances. Again, this is of the drinking water standard, which no one expects to consume water without treatment. This may not be an effective surrogate indicator of aquatic life. Results did not exceed 1500 mg/L and the maximum was 498, not approaching this threshold. This suggests TDS is not a threat given this data set. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Conductivity expression of TDS and those results are expected since this Tributary is surrounded by a suburban area.

Chloride: Calculated chloride concentrations ranged from 8.01-44.65 mg/L throughout the sampling period, and there were 0 exceedances in the 21 collected samples (0% exceedance of the final acute, acute maximum and final chronic aquatic chloride standards). This suggests aquatic organisms in Doan Brook were at reduced risk to chronic chloride exposure in 2022. At all 7 stations, calculated chloride concentrations increased throughout the sampling period. This increase is due to runoff from surrounding streets that use road salt. Increased sampling across a greater temporal range is recommended to better determine whether the trend observed in 2022 changes in winter.

Salinity: There were 0 exceedances at 0%. The max was 768.45 ppm, the median was 409.53 ppm and the minimum was 118.61 ppm. Salinity results were compared to the USGS recommended salt content for freshwater. Below 1000 ppm is freshwater and 1000-3000 ppm is slightly saline. The maximum approaches but is shy of the slightly saline category. The median suggests that with this data set 50% of the time salinity levels are 400 ppm. Even if salt is in the water based on this range, it doesn't mean aquatic life is harmed just exposed. All locations had an increase of salinity as time progressed. More data is needed to see if this trend continues throughout the winter and decreases into the summer. In addition, deicing compounds and application protocols can be explored to ensure salt stays out of the creek and these levels stay low.

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

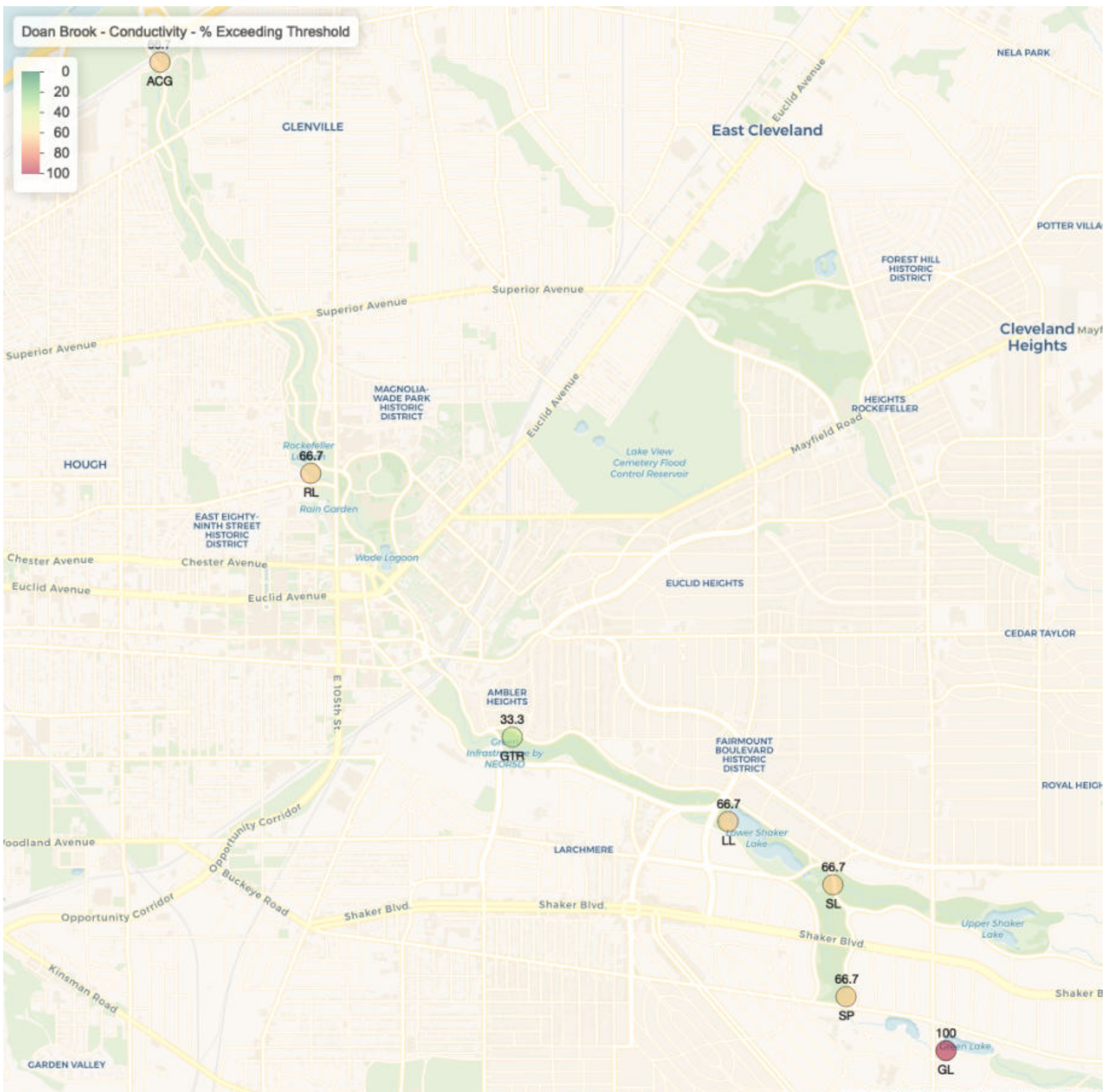
Data for seven parameters was collected or calculated at seven sites, three sampling events. Parameters included dissolved oxygen, water temperature, conductivity, total dissolved solids, pH, chloride and salinity. Aggregating all Doan Brook sites and reviewing exceedances of respective thresholds, Total dissolved solids exceeded 17 drinking water thresholds but not aquatic life TDS. Conductivity exceeded 14 macroinvertebrate biocondition gradient thresholds. Water temperature, pH, chloride and salinity did not exceed thresholds for any event. This indicates a healthy and supportive aquatic life condition.

Dissolved oxygen exceeded thresholds four times and if the magnitude and duration was significant and aquatic life could not find other refuge, it is possible exposure to low dissolved oxygen could be causing harm. Exceedances were focused in two of the seven stations, Green Lake had 100% exceedance while Southerly Park had a 33.3% DO exceedance. Green Lake is a catch basin near a golf course and a lot of large lawns. As Doan Brook flows toward Lake Erie, the DO improves.

Conductivity results were aligned with results from the conductivity reference and survey site databases, particularly in the higher percentiles, this provides confidence that conductivity readings are representative. However, multiple stations exceeded the macroinvertebrate biocondition criteria that indicates a declining and degrading community (412) or an already unhealthy community (655). Green Lake had a 100% exceedance while Southerly Park, Nature Center at Shaker Lakes, Lower Lake, Rockefeller Lagoon and the Albanian Cultural Garden had 66.7% exceedances. The Gorge Trash Rack had 33.3% exceedances.

In general Doan Brooks supports aquatic uses but that support may decline in a downstream direction as the area surrounding Doan Brook becomes more urbanized. The Doan Brook Gorge location has a larger riparian zone than other locations which helps lower the exceedance threshold. Initial results are encouraging in regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? TDS exceedances indicate drink water use may be impaired at certain locations and times of the year but did not exceed the aquatic life threshold of 1500 mg/L LEBAF is exploring, more data is needed to confirm ambient conditions. Thus TDS results may be representative. Assessment method using drinking water standards was as expected but may be not informative for aquatic life protection. Calculated chlorides and salinity results didn't defy expected conditions and may represent ambient conditions, more data is needed. Assessment methods appear effective for these two parameters for screening given limitations of the dataset.

Figure 11. Doan Brook Conductivity Exceedances



Overall the data set is limited due to only having three points each site thus more testing is needed to refine recommendations and inform action. If actual macroinvertebrate data exists or could be collected to provide response community data in addition to chemical stressors. Green Lake, Southerly Park could be prioritized for more monitoring and explored for stressors and best management practices on the land and use of water.

3.7 Eighteenmile Creek

Monitoring Organizations: One entity in the LEBAF network monitors in Eighteen Mile Creek basin, Buffalo Niagara Waterkeeper.

Station information: Buffalo Niagara Waterkeeper has two sites sampled 1x/month from May - October. Data from 2020, 2021, and 2022 available for both sites. Eighteenmile Creek at Old Lakeshore Road (Coordinates: **42.712208, -78.966392)** andat Gowanda State Road Bridge (Coordinates: **42.706475, -78.849177).**
Eighteenmile Creek at Old Lake Shore Road Bridge is close to 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 and heavy agricultural use and runoff upstream of this site. There are no nearby 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. This site was sampled 1x/month May - October between 10:15 am and 10:45 am.

Eighteenmile Creek at Gowanda State Road Bridge is located upstream of the previous station, and south of the city of Buffalo in the town of Hamburg. This site 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. This site was sampled 1x/month May through October between 10:45 am and 11:15 am.

Aggregated Metrics Table - Table 15 Eighteenmile Creek Summary Statistics

Eighteenmile Creek Summary Statistics - 12 Samples 2 Stations						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	9.55	9.14	8.37	11.37	0	0%
Water Temperature - C	18.44	19.78	7.74	22.65	10	83.3%
Conductivity - uS/cm	575.72	615.1	293.5	662.6	11	91.7%
Total Dissolved Solids - mg/L	316.64	338.3	161.43	364.43	11	91.7%
pH	8.29	8.23	7.92	8.84	0	0%
Chloride - mg/L	28.37	30.31	14.46	32.65	0	0%
Salinity - ppm	470.12	504.28	225.48	546.78	0	0%
2022-05-21 to 2022-10-22						

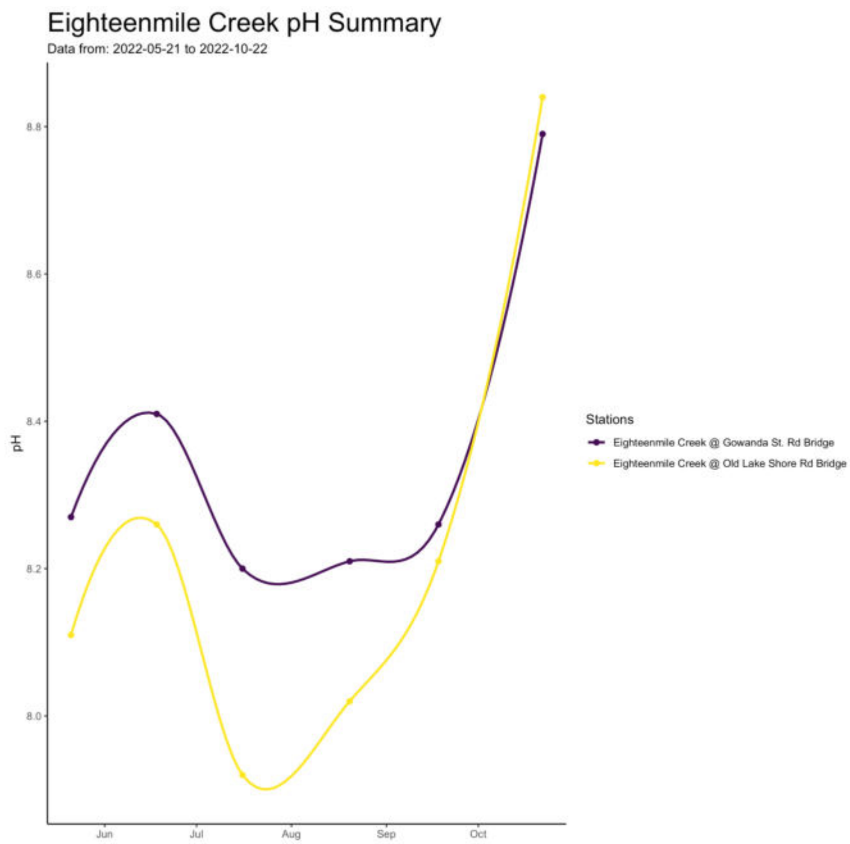
Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation

**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

pH: 12 samples, Max = 8.84, Min= 7.92, Median= 8.23, 0 exceedances, 0%

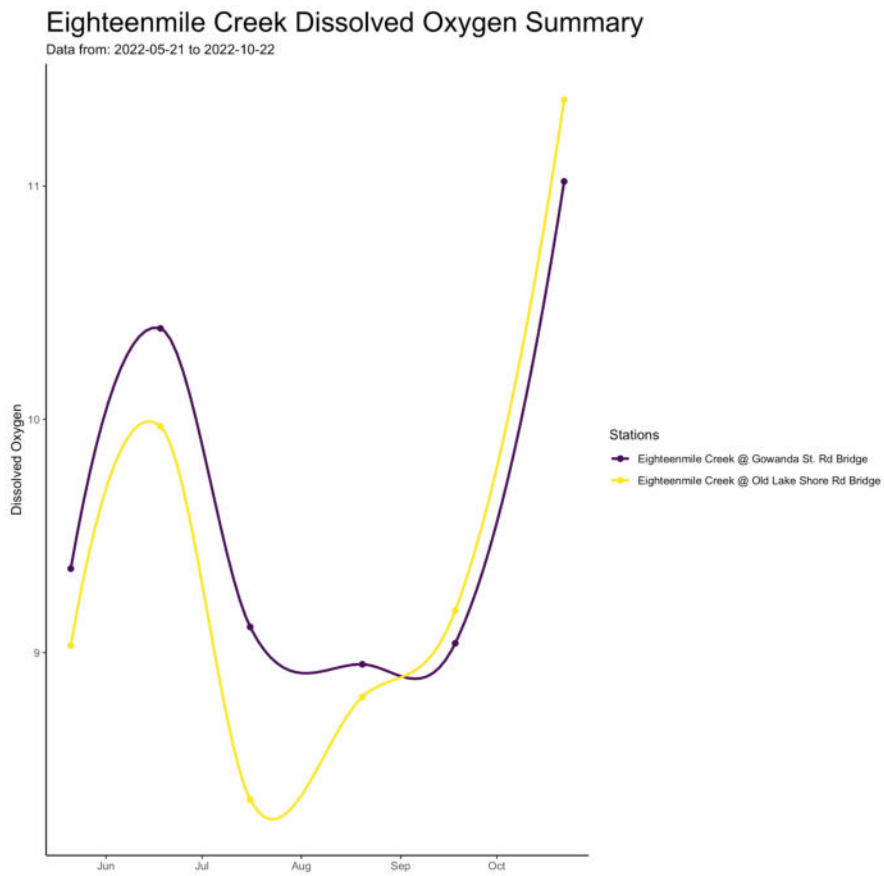
Figure 12. Eighteenmile Creek Water Temperature Summary Graph:Line graphs generated were intended to show seasonal patterns and not long term trends.



12 samples were collected at 2 stations resulting in 0 or 0% exceedances of respective standards. Due to impacts on water flow and direction caused by the water level of Lake Erie, as well as residential inputs, runoff, and nearby agriculture, pH is affected throughout the sampling season. In general, both sites saw an initial spike in June, followed by a decrease in the following month. However, both sites experienced a sharp increase in pH value from September to October, potentially due to the above factors. No clear trend could be established for this parameter, as data from both sites differed. While this data fell within the standards established by LEBAF, the values for October at both sites fell outside of NYS standards (8.5 max threshold). Historic data from the 2020 and 2021 sampling seasons all fall within the standards established by LEBAF, and show no obvious seasonal trend. Continued monitoring of this tributary at both of these sites is recommended, potentially with additional sites added and more frequent sampling at different times of the year, month, and day. While values for both sites fell within acceptable ranges, they varied noticeably from each other despite being relatively close geographically. All samples for all sites are within state standard range, except for October

measurements at both sites (8.79 and 8.84 for Gowanda State Road and Old Lake Shore Road, respectively).

Figure 13. Eighteenmile Creek Water Temperature Summary Graph:Line graphs generated were intended to show seasonal patterns and not long term trends.



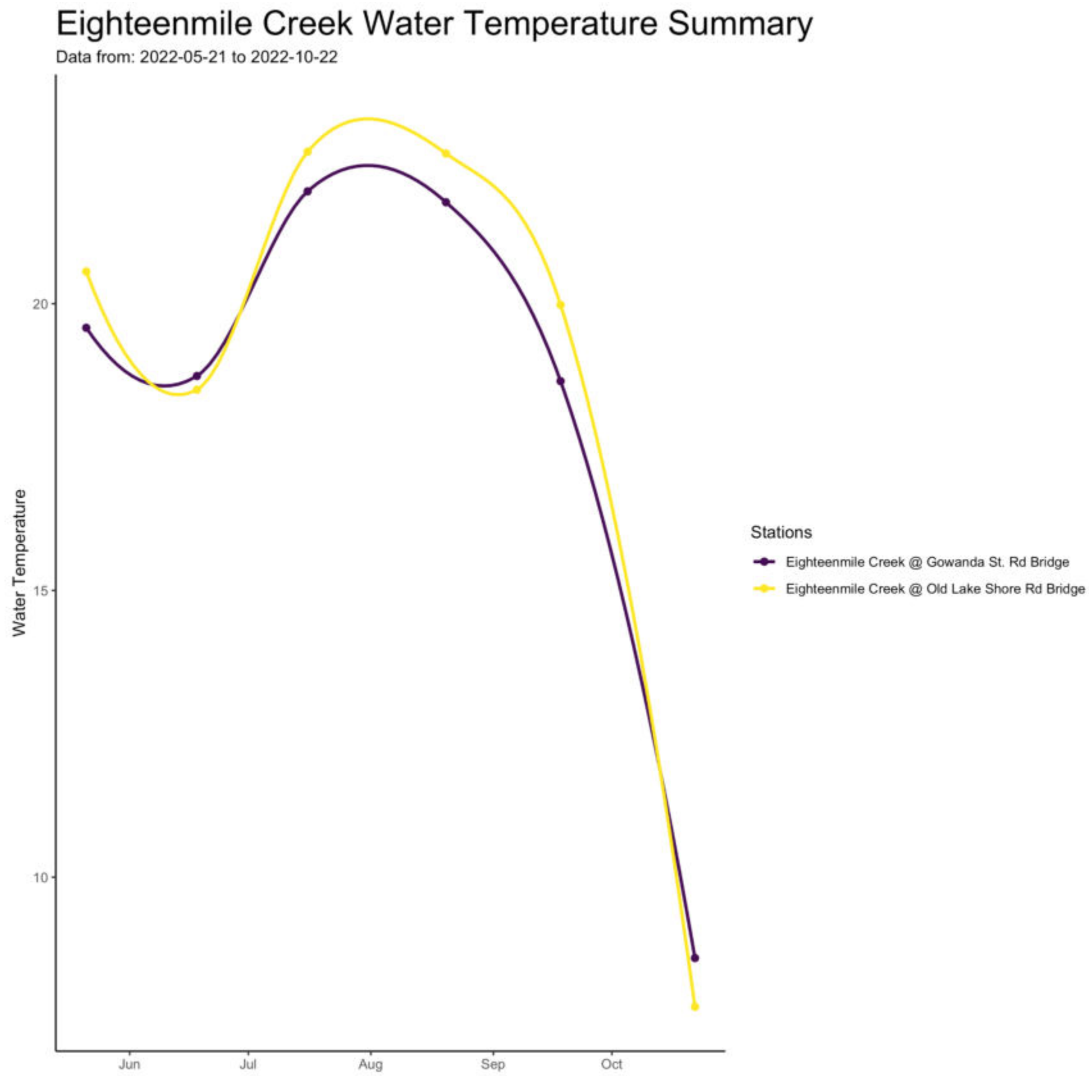
***DO:* N= 12, max = 11.37 mg/L, min = 8.37 mg/L, median = 9.14 mg/L, 0 exceedances, 0%**

12 samples were collected at 2 stations resulting in 0 or 0% exceedances of respective standard. We expect DO to be in range, due to its fast moving state and the presence of many riffles along the creek. Our data shows a similar trend to pH, with an early peak in June at both sites, followed by a decrease, and then a sharp spike from September to October. It can be assumed that residential inputs, runoff, and nearby agriculture could affect this parameter. Water from this creak is used heavily by agriculture, which could decrease water levels and DO. Data from both stations in the 2020 and the 2021 sampling years show consistent DO levels, without the late season spike observed in 2022. Limitations in data include no data collected in winter months and limited data collected each month.

Temp: **N= 12, max=22.65 °C, min=7.74 °C, median= 19.78 °C, 10 exceedances = 83.3%**

12 samples were collected at 2 stations resulting in 10 or 83.3% exceedances of respective standard. We would expect this parameter to trend upwards from May through August, and then begin to taper down. Graphs from both sites affirm this assumption, and show similar trends. The slower moving water and reduced depth at the Old Lake Shore Road site might affect temperature, while the nearby commercial area and agriculture at the Gowanda State Road station might affect measurements there. Exceedances occurred at both sites for every month except for October, but readings that fell outside of the LEBAF standards did not exceed dramatically. Historic data from the 2020 and 2021 sampling seasons shows a similar trend at both stations, with values generally falling outside the range of acceptable standards, except in October.

Figure 12. Eighteenmile Creek Water Temperature Summary Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Conductivity Survey: N = 12, max = 662.6 µS/cm , min = 293.5 µS/cm, median = 615.1 µS/cm

It is expected that this conductivity results would follow a similar trend to the TDS and chloride measurements, with a peak in the summer months when activity along the river is highest, and a decrease afterwards. Both stations along the river followed this trend, peaking in July, and trending downwards after.

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. Eighteen Mile Creek conductivity results fall within the EOLP ecoregion and is a stream size (20 -500 square miles).

The below table illustrates that the maximum conductivity result, 663, falls between the 75th percentile and maximum reference stream values and between the 50th and 75th stream survey conductivity value, closer to the maximum. The median result of 615 is higher than the median reference and median survey sites, in the ballpark for both. The minimum, 294, is closer to the minimum in the middle of reference and survey sites. This illustrates, with this limited data set that these results align with the data from the reference and survey sites and are representative of the ecoregion and the watershed size. This strengthens the confidence in using conductivity results for data screening.

Table 16. Eighteenmile Creek Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	Minimum	25th	50th	75th	Max
Reference	167.00	405.10	489.10	549.00	1,008.00
Survey	375.00	437.00	568.00	774.00	1,260.00
Results	294		615		663

Conductivity Biocondition: 12 samples were collected at 2 stations resulting in 11 or 91.7% exceedances of respective standard
A total of 12 conductivity samples were compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, indicating a healthy macroinvertebrate community, and 655 µS/cm, indicating a degrading macroinvertebrate community. Eighteenmile Creek conductivity values ranged from 293.5 µS/cm to 662.6 µS/cm. The minimum result of 294 was below the 412 healthy condition threshold. The median of 615 and the mean of 575 were above the healthy condition of 412 but below the 655 degraded community threshold. This indicates that 50% of the time and on average, macroinvertebrate communities are exposed to conductivities that may be contributing to a declining or degrading community health. The maximum was 667 which is not much greater that 655 threshold which is not a magic toxicity threshold.

These assessment results may not be true for all stations all times of the year, but as a screening tool, these results indicate that most of the macroinvertebrate communities are in a condition that if action the right timely action was taken could reverse to a healthy condition versus fall into an unhealthy perhaps permanent degraded state. More data is needed (conductivity, other parameters or actual macroinvertebrate data) to verify.   Exposure is not equivalent to impairment, thus any site in that 412-655 range is vulnerable. One station, Gowanda State Road Bridge, exceeded 655 three times in 2022 (June, July, and August), and the other station, Old Lake Shore, had one sample fall below the ideal range.

If conductivity concentrations are subject to spikes and depressions at different points of the year, it is possible communities recover in between. More data would be needed to identify trends. Although the cause of the variability in measurements could not be determined, factors including nearby agricultural runoff, recreational boat use, and urban/stormwater runoff could influence conductivity measurements at this location. Because of the considerable variability in measurements, continued monitoring of this site will be essential in determining overall bio-condition, and to ensure that healthy biological communities can be established and maintained.

Four of the five exceedances came from the Gowanda State Road station, from June through September (above standard), with the fifth exceedance coming from the Old Lake Shore Road station in October (below standard). Historic data from the 2020 and 2021 sampling seasons don't illustrate the same trend, with conductivity values varying significantly throughout the sampling season at both sites. Measurements generally fall within the standards established by LEBAF but conditions at each site are different.

It was expected this parameter would fall within biocondition standards consistently throughout the sampling season and into winter, with the exception of the Gowanda State Road station, which is closer to sources of runoff (agriculture and commercial). This site also had the highest values in the summer months. It is believed that this might be related to stormwater runoff, CSO, industrial inputs, upstream runoff, wildlife activity, restoration work, agriculture use/runoff boating activities, etc.

Eleven of twelve sample exceedances could indicate an impact to aquatic life in Lake Erie, but since the majority of exceedances came from upstream at the site, and not downstream, impacts to Lake Erie may be limited.

More sites at locations upstream of Gowanda State Road and at least one in between the two existing stations could help in better determining and monitoring this creek's condition. More data in the early spring could provide more information and possibly show other exceedances. The data was limited to May-October.

Monitoring at these sites should continue. Consideration should also be given to adding more sites, increasing the frequency of sampling at monthly and seasonal levels, and collecting at varying times of day.

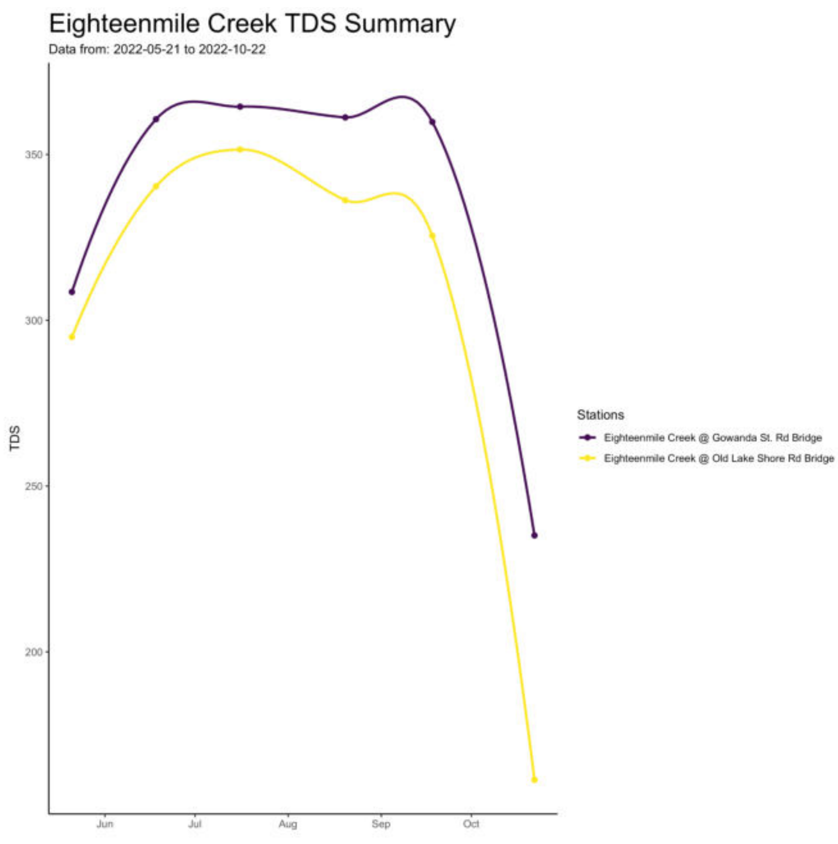
Expressions of Conductivity
Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid

results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: N=12, max = 364.43 mg/L, min = 161.43 mg/L, median, 338.3 mg/L, 11 exceedances, 91.7%

12 samples were collected at 2 stations resulting in 11 or 91.7% exceedances of respective standard. Overall, we would expect TDS to vary seasonally with inputs from CSOs, runoff, recreational use, and commercial use. TDS peaked for both sites along the river in August, and generally decreased through the rest of the sampling season, with a sharp decrease from September to October at both sites. 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 and developing its own conductivity thresholds. Results did not exceed 1500 mg/L and the maximum was 364, not approaching this threshold. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS.

Figure 13. Eighteenmile Creek TDS Summary Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



All measurements except for the station at Old Lake Shore Road in October fell outside of the drinking water standards established by LEBAF, but below the aquatic life threshold LEBAF is exploring. This is to be expected, as use of the river increases during the warmer summer months and ambient water is not consumed without TDS treatment. Historic data shows similar trends, although the data from 2020 shows lower overall values (potentially due to the COVID-19 pandemic).

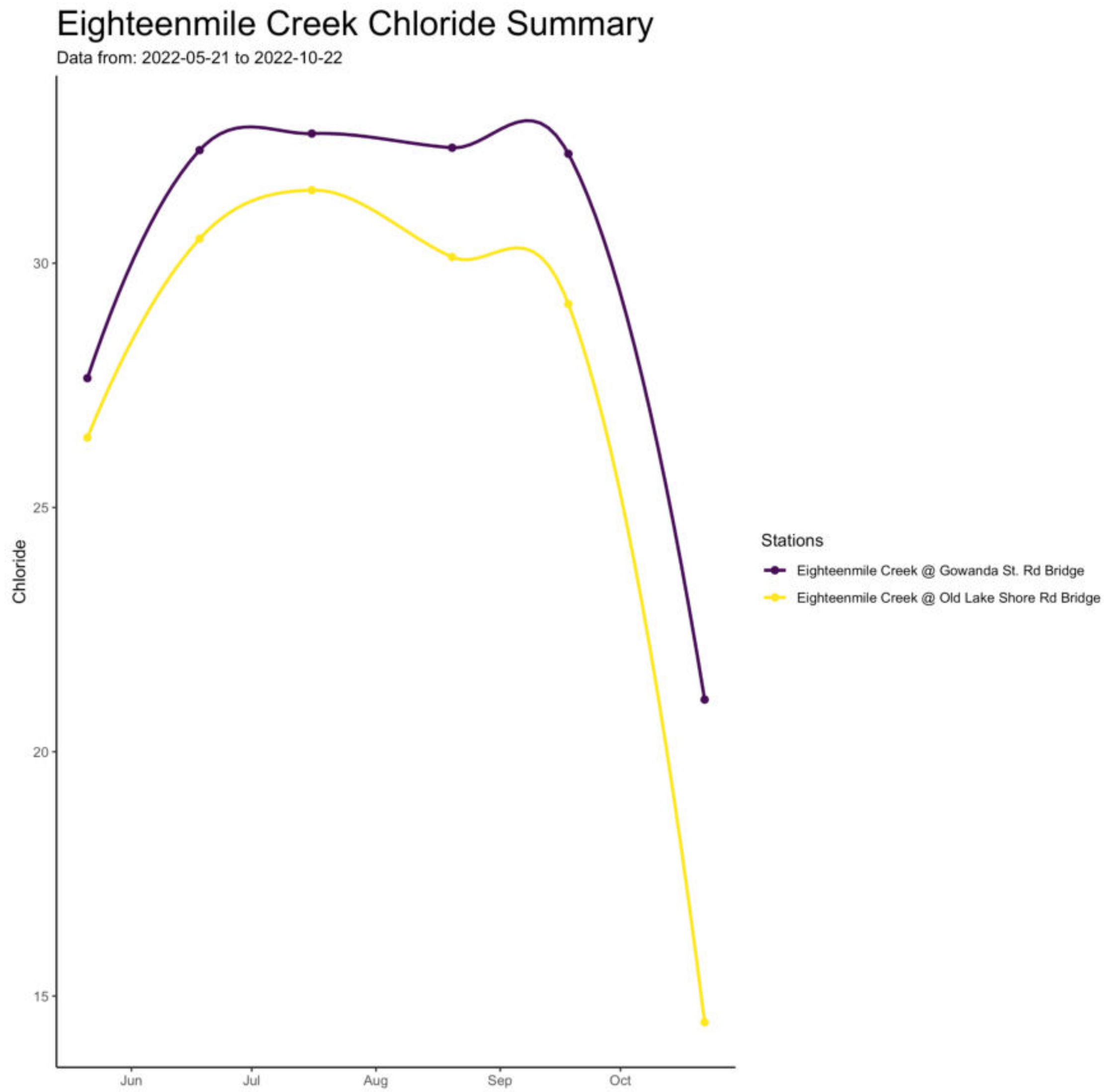
LEBAF expects TDS drinking water standards to exceed the threshold consistently throughout the sampling season and into winter with storm surges and ice flows pushing up and downstream and ambient water is not consumable without treatment. There were 11 exceedances of the respective threshold. The exceedances may be related to stormwater runoff, CSO, industrial inputs, upstream runoff, wildlife activity, restoration work, boating activities, agricultural use/runoff, etc. However, the aquatic life threshold was not exceeded. The 11 drinking water exceedances could impact drinking water conditions in Lake Erie, as it is further away from the Niagara River than the Buffalo stations, but not likely aquatic life and because this tributary is small, its impacts to Lake Erie may be limited.

LEBAF believes that more early spring data could provide more information and possibly show other exceedances. The TDS data is limited to May-October. None of the Lake Erie states, including New York, have an aquatic life use protection standard for TDS but Ohio does, the 1500 mg/L LEBAF is exploring. Based on LEBAFs definition of healthy and for our monitoring purpose of screening Eighteen Mile Creek is believed to be impaired, and may potentially impact Lake Erie. LEBAF supports continued monitoring, the addition of more sampling sites, increased frequency of sampling at monthly and seasonal levels that are collected at varying times of day.

Chloride:

12 samples were collected at 2 stations resulting in 0 or 0% exceedances of respective standard. Calculated chloride concentrations ranged from 14.46-32.65 mg/L throughout the sampling period, and there were 0 exceedances in the 12 collected samples (0% exceedance) of the final acute, acute maximum and final chronic aquatic chloride standards. This suggests aquatic organisms in Eighteenmile Creek were at reduced risk to chronic chloride exposure in 2022. Chloride and TDS followed similar temporal trends because both parameters are calculated from direct conductivity measurements and behave ionically similar in a river system. Calculated chloride concentrations at both of the stations along Eighteenmile Creek peaked in July when activity along the river was highest, before decreasing throughout the rest of the sampling period. Input from boats, combined sewage overflows, and residential runoff along the river could contribute to higher levels in the summer months. Data collection was limited to May through October at two stations, and early spring may be a time when exceedances are more likely to occur due to road salt application. In addition to continued monitoring, recommendations moving forward include increasing the frequency of sampling, the number of monitoring stations in order to assess longitudinal trends in data, and to collect samples at different times during the day.

Figure 14. Eighteenmile Creek Chloride Summary Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.

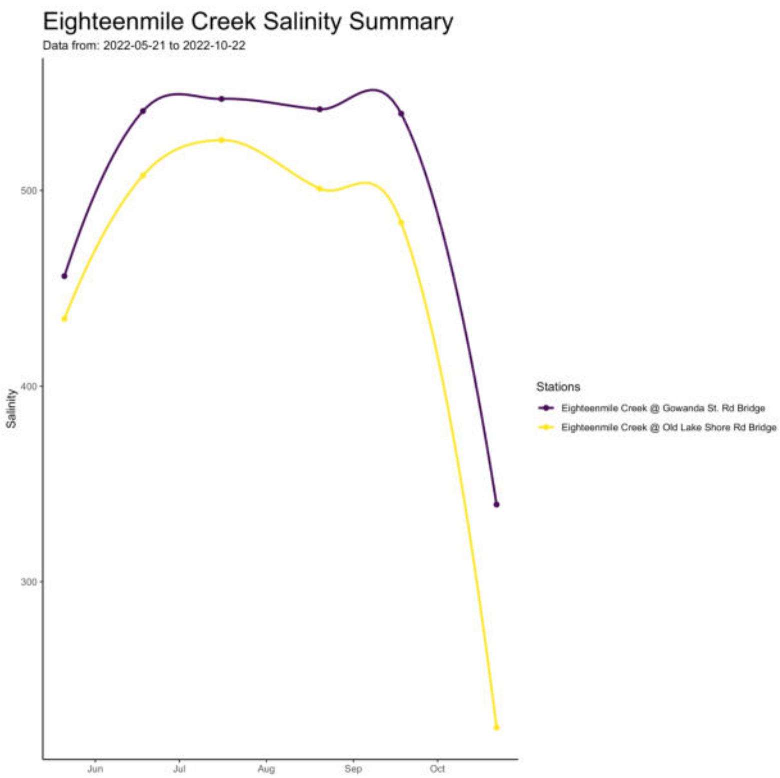


Salinity: N= 12, max = 546.78 ppm, min = 225.48 ppm, median = 504.28 ppm, 0 exceedances

12 samples were collected at 2 stations resulting in 0 or 0% exceedances of respective standard. Salinity results were assessed against the USGS recommended levels for freshwater. Below 1000 ppm is freshwater and 1000-3000 is slightly saline water. Results from this creek suggest that at most 50% of the time, the median salinity values are 500 ppm, well under the freshwater recommended level.

We would expect this parameter to follow a similar trend to the TDS, chloride, and conductivity measurements, with a peak in the summer months when activity along the river is highest, and a decrease afterwards. Both stations along the river followed this trend, peaking in July, and trending downwards after, with a sharp decrease in values from September to October at both stations. Measurements generally fall within the standards established by LEBAF.

Figure 15. Eighteenmile Creek Salinity Summary Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



LEBAF expects salinity to be within the freshwater category consistently throughout the sampling season and into winter, with potential early summer peaks. Stations are affected by storm surges and ice flows pushing up and downstream. Salinity could be related to stormwater runoff, CSO, industrial inputs, upstream runoff, wildlife activity, restoration work, agricultural use/runoff boating activities, etc.

There were 0 exceedances of Salinity, while spikes could impact aquatic life in Lake Erie, but since this tributary is relatively small and fast moving, its impacts to Lake Erie may be limited. No historic data for salinity is available for this tributary.

LEBAF believes that more sampling sites at locations upstream of Gowanda State Road and in between the two existing stations could better determine and monitor this creek's condition. More early spring data could provide more information and possibly show other exceedances. The salinity data is limited to May-October. Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe this Eighteen Mile Creek to be somewhat healthy with minimal impact on Lake Erie. LEBAF supports continued monitoring, the addition of more sampling sites, increased frequency of sampling at monthly and seasonal levels that are collected at varying times of day.

Aggregated Overall Summary – (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

Eighteen Mile Creek had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity. Of these, three exceeded thresholds, temperature, TDS (drinking water) and conductivity exceeded the biocondition thresholds for a healthy macroinvertebrate community.

Four parameters did not exceed respective thresholds, pH, DO, chloride and salinity. Conductivity results aligned with respective ecoregion and stream size for reference and survey datasets. This indicates a supportive aquatic life condition. The cold water temperature threshold was exceeded 10 times at these stations, @ Gowanda State Road Bridge and @ Old Lake Shore Road Bridge May through September. This could indicate conditions that temporarily cause harm if aquatic life cannot find a sufficient refuge. The dataset was limited to characterize duration, frequency and magnitude and these sites might benefit from real time temperature monitoring. Our limited data shows that the magnitude of exceedances, particularly at the Gowanda State Road Bridge station is not severe, with exceedance values ranging from 655.7 µS/cm to 662.6 µS/cm. TDS drinking water thresholds were exceeded 11 times, all readings at the same two stations and duration, with @Gowanda exceeding in October as well. This indicates a higher frequency of elevated TDS. Each episode's duration is unknown and, with exceedance values for both sites ranging from 273.6 mg/L to 420.3 mg/L at both sites. However, no result exceeded the aquatic life threshold of 1500 mg/L LEBAF is exploring. This indicates drinking water, as ambient water needs treatment which is expected, but aquatic life may have reduced exposure to elevated TDS.

In addition, the macroinvertebrate biocondition at these two sites was also exceeded @Gowanda June through September and @ Old Lake Shore in October. It would be helpful to explore existing macroinvertebrate data, collect new data or explore stressors in those reaches to verify this condition, and if verified what actions could be taken to reverse the decline. This metric aligns with temperature and TDS exceedances that unhealthy and unsupportive conditions exist at certain times, magnitudes and duration, while the other four parameters support aquatic life.

Results are encouraging regarding using expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? Calculated TDS, chloride and salinity results appear to represent ambient conditions with this limited data set, based on existing data and what is known about this system. Assessment methods for all three also appear to be effective for screening. The exception is the TDS drinking water standards may not be an effective indicator of aquatic health and the 1500 mg/L Ohio aquatic life threshold may be and may be underprotective. LEBAF is exploring this criteria.

Based on LEBAF's definitions this creek is slightly impaired. We recommend continued monitoring of the stations along this tributary, at least at the same frequency and locations, if not moreso. Incorporating data from the other tributaries in the area would be useful for future analyses. Overall, it would be useful to collect more data on all parameters in this review at a higher frequency, at more locations, and at different times of day to capture seasonal and diurnal changes in parameters more effectively. Additionally, collecting metadata on ambient weather/water conditions, as well as depth of sampling would help us create a more accurate picture of seasonal changes and trends in the data. Incorporating some data from waterways that feed the direct tributaries would be useful, but might not be practical at this stage.

As mentioned previously, because this tributary is relatively small, Eighteen Mile Creek's overall effect on Lake Erie might be minimal. Historical pollution and runoff, and toxic sediments from the 20th century are still present in the water columns, and new and emerging contaminants continue to alter this tributary's water chemistry, including commercial and agricultural runoff. These all would likely affect locations upstream and downstream. Eighteenmile Creek has the highest amount of non-impaired aquatic habitat in the Niagara River Watershed, due to large amounts of natural conditions. Large amounts of AG land exist in the watershed.

3.8 Euclid Creek

Monitoring Groups: The Cleveland Metroparks Watershed Volunteer Program (WVP) contributed to 2022 LEBAF data collection in the Euclid Creek watershed. WVP is a Cleveland Metroparks Natural Resources department led volunteer program supported by the Northeast Ohio Regional Sewer District. The WVP works with the Cuyahoga Soil and Water Conservation District to manage a joint volunteer water chemistry monitoring program in the Euclid Creek watershed.

Station information: Schaefer Park was the only station within the Euclid Creek watershed that was monitored using LEBAF protocols. A total of 17 samples were taken by one volunteer. Euclid Creek has two main branches (east and west) and drains directly to Lake Erie with a drainage area of 24 square miles; it lies on the eastern border of Cuyahoga County and the western border of Lake County. Schaefer Park is a channelized, warmwater site with a confined floodplain. It is located along a small unnamed tributary to the West Branch of Euclid Creek. The site is in Lyndhurst, Ohio and drains 1.91 square miles. Much of the stream network is underground in pipes, but the stream is daylighted at this sampling location. The site is 100% developed and primarily residential land use. The site is directly downstream of a community park with ball fields. A common trend at the site is high phosphate levels.

Aggregated Metrics Table - Table 17 Euclid Creek Summary Statistics

Euclid Summary Statistics - 17 Samples						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	6.99	5.62	3.41	12.3	6	50%
Water Temperature - C	18.69	19.2	5.1	24	2	14.3%
Conductivity - uS/cm	876.21	768.5	310	1438	13	92.9%
Total Dissolved Solids - mg/L	481.92	422.68	170.5	790.9	13	92.9%
pH	8.39	8.53	6.79	10.26	5	29.4%
Chloride - mg/L	43.18	37.87	15.28	70.86	0	0%
Salinity - ppm	745.49	642.59	239.31	1270.17	3	21.4%
2022-03-19 to 2022-10-15						

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of Euclid Creek samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Figure 16. Euclid Creek Box and Whisker Summary Data Plots: *Schaefer Park was the only station monitored within Euclid Creek. The below box and whisker plots display Schaefer Park data.*

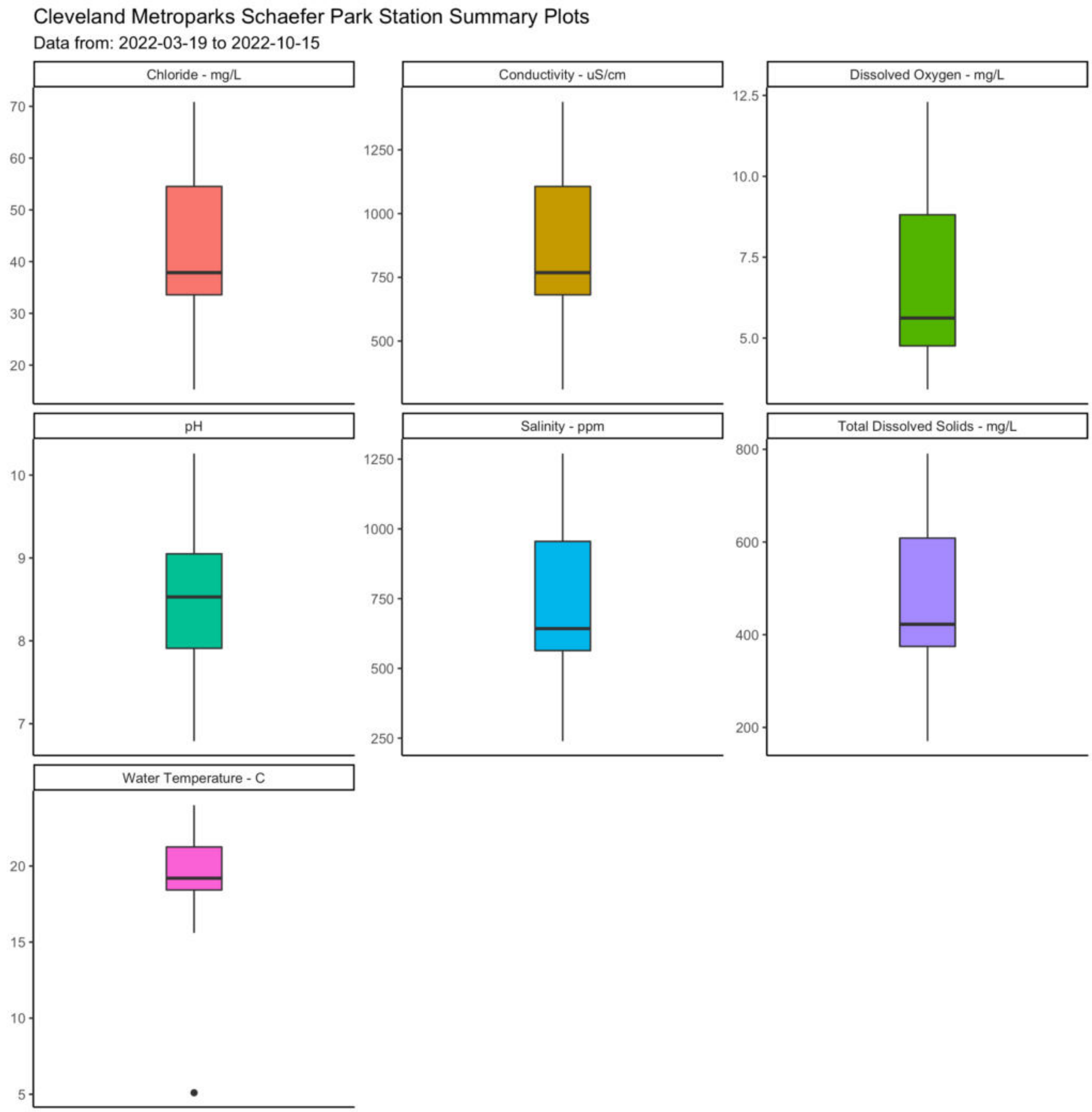


Figure 16 displays a summary of all parameter data collected with median, 25th percentile, 75th percentile, minimum and maximum values observed. This illustrates the distribution of results for this field season.

Summary for each parameter (8)

pH: 17 samples were collected at one station during the 2022 LEBAF field season. Five out 17 samples exceeded pH standards, resulting in 29.4 % exceedances. Other monitoring statistics include: max = 10.26, min = 6.79, median = 8.53. Most of the pH values reported are between the standard thresholds of pH = 6.5 - 9. Five pH values were above 9.

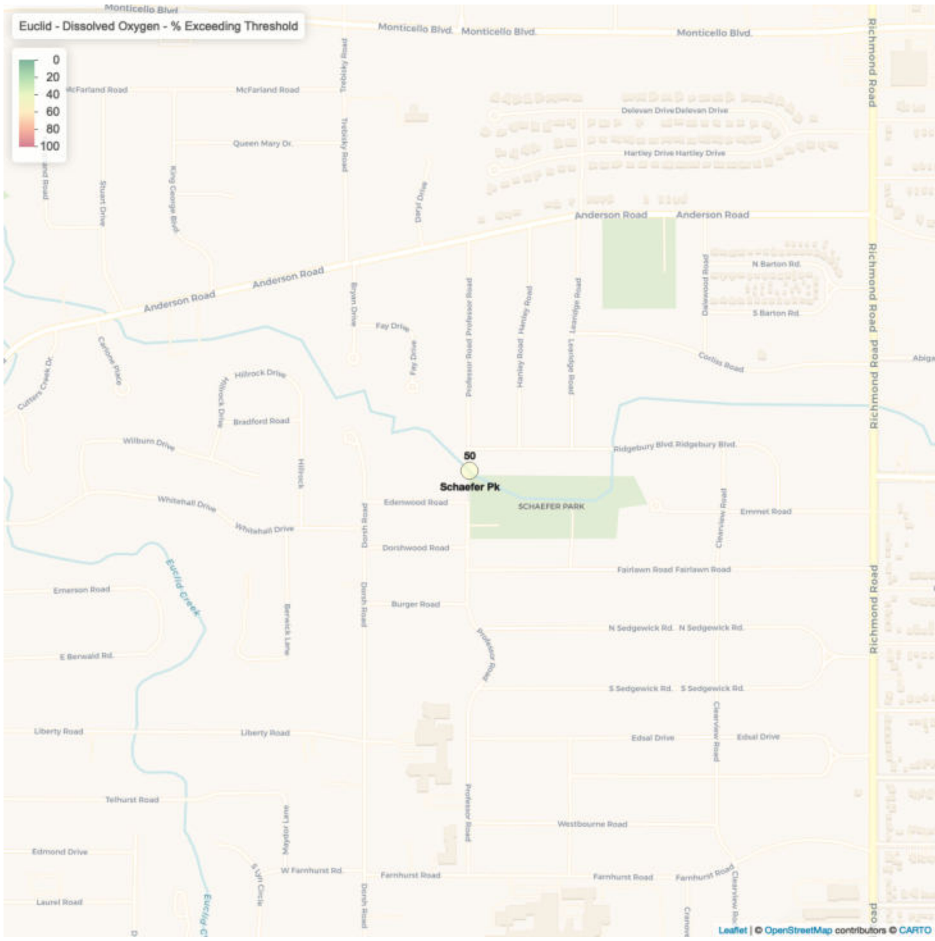
Historic pH values from 2006 – 2021 at the site range from 5.25 - 10.85. Historic pH values at this site remain slightly basic, above 8, with a few high pH values above 10 occurring in July and December. The findings at this site during the 2022 LEBAF field season are consistent with historic trends for pH at this site.

It is not likely that the pH levels at this site have a direct correlation to Lake Erie impacts. This is a headwater stream which will reflect local conditions in the watershed but will likely not contribute to Lake Erie basinwide trends. This data only represents a point in time on a monthly basis, it does not represent the full spectrum of pH values you would expect over 24 hours or after different weather events. None of the values observed at this site would escalate the need for an interpretation versus Ohio state standards.

Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe this site may be affected by pollution/weather events causing spikes in pH. We do not believe the data at this site is indicative of broader Lake Erie health. Initial recommendations for pH are that the study design should remain the same, but that this monitoring kit should be checked for accurate calibration and a deeper analysis of other sites monitored with this kit should be performed. This is screening level monitoring that can help to guide further analysis in relation to watershed conditions like active construction, salt application in winter, childrens activity in the streams during baseball season etc.

DO: 12 samples were collected at one station. Six out 12 samples exceeded DO standards, resulting in 50 % exceedances. Other monitoring statistics include: max = 12.3 mg/L, min = 3.41 mg/L, median = 5.62 mg/L.

Figure 17. Euclid Creek Dissolved Oxygen Data Summary Exceedance Map: *Shows the percentage of exceedances at the Schaefer Park site along the Euclid Creek*

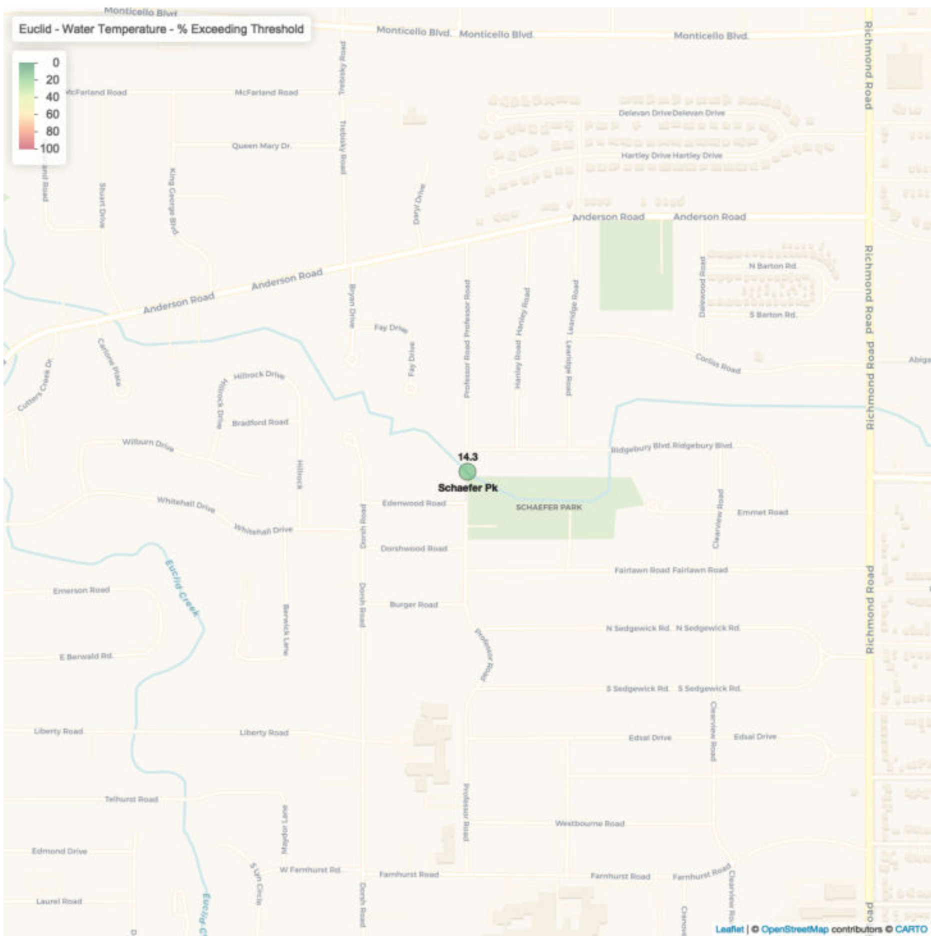


Historic DO values at this site range from 3.86 mg/L to 20.69 mg/L. These values fluctuated both seasonally and daily. The min value from the LEBAF 2022 field season was similar to historic values and the maximum values were also below historic maximum value at the site. No specific DO trends could be determined from looking at the past year's data for this parameter. While exceedances were observed, DO levels remained close to standards during the 2022 field season. Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe that the threat to fish species at the site was observed but minimal during the 2022 field season. It is not likely that the DO levels at this site have a direct correlation to Lake Erie Impacts. This is a headwater stream which will reflect local conditions in the watershed but will likely not contribute to Lake Erie basinwide trends. This data only represents a point in time on a monthly basis, it does not represent the full spectrum of DO values you would expect over 24 hours or after different weather events. We recommend consideration of Ohio EPA analysis for aquatic life standards instead of drinking water at this site and perhaps others.

Water Temperature: 14 samples were collected at one station. Two out 14 samples exceeded temperature standards, resulting in 14.3 % exceedances. Other monitoring statistics include: max = 24 °C, min = 5.1 °C, median = 19.2 °C

Historic temperature values from 2006 – 2021 at the site range from 0 °C - 24.2 °C. The water temperature at this site is lower during the colder months and higher during the warmer months. The findings at this site during the 2022 LEBAF field season are consistent with historic trends for temperature at this site. Temperature data is slightly higher in late July – September compared to the rest of the data. Most of the water temperature values reported are under the standard thresholds, indicating acceptable water quality for aquatic life.

Figure 18. Euclid Creek Water Temperature Data Summary Exceedance Map: *Shows the percentage of exceedances at the Schaefer Park site along the Euclid Creek*



Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe this site is healthy for temperature. It is not likely that the water temperature levels at this site have a direct correlation to Lake Erie Impacts. This is a headwater stream which will reflect local conditions in the watershed but will likely not contribute to Lake Erie basin wide trends. This data only represents a point in time on a monthly basis, it does not represent the full spectrum of values you would expect over 24 hours or after different weather events. None of the values observed at this site would escalate the need for an interpretation versus Ohio state standards.

Conductivity: 14 samples were collected at one station. Thirteen out of fourteen samples exceeded macroinvertebrate biocondition standards resulting in 92.9% exceedances. Other statistics from the monitoring are: max = 1438 µS/cm, min = 310 µS/cm, median = 768.5 µS/cm.

Historic conductivity values from 2006 – 2021 at the site range from 130 µS/cm - 9200 µS/cm. Historic conductivity data at this site fluctuated, with a few high spikes greater than 1000 µS/cm during May and October. LEBAF 2022 Euclid Creek conductivity values ranged from 310 µS/cm to 1438 µS/cm. These conductivity values are typical for this creek, given that historic conductivity values (from 2006 – 2021) fluctuate during a yearly cycle. The majority of the 2022 field season conductivity values exceeded the 655 us/cm macroinvertebrate bio-condition threshold. The minimum was below the 412 healthy condition threshold. This suggests that the macroinvertebrate community health varies over the course of the year and the current dataset cannot speak to the frequency of degradation versus health.

Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. Conductivity data from the 2022 LEBAF field season was compared to Ohio EPA conductivity reference and survey data for the respective ecoregion ELOP and headwater stream size. The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results.

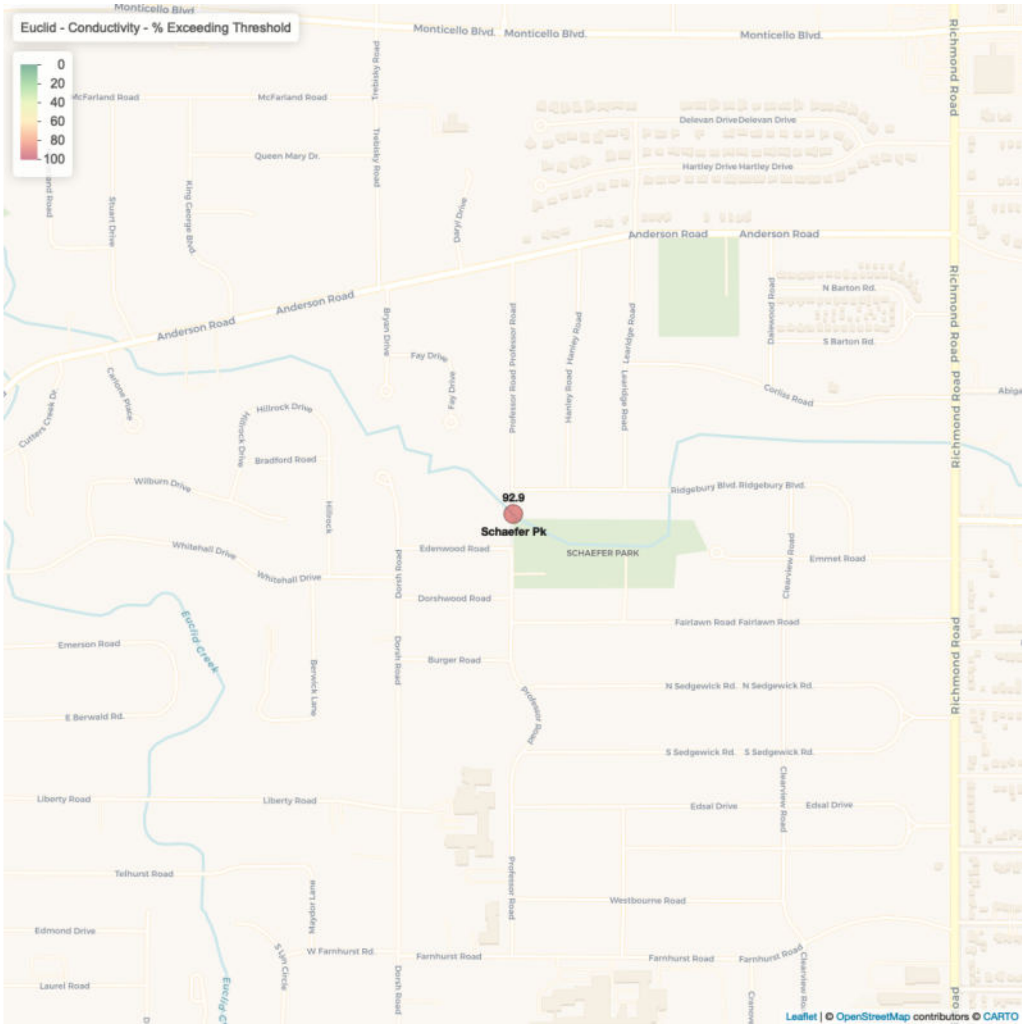
Table 18. Euclid Creek Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	90.00	351.00	462.00	611.00	35,000.00
Survey	316.00	466.00	629.30	886.00	990.00
Results	310		769		1438

The Schaefer Park station conductivity results overlap the distribution of reference and survey sites for the ELOP ecoregion headwaters stream size. Table 18 illustrates that the maximum conductivity result, 1438 µS/cm, falls between the 75th percentile and maximum reference stream values and above the survey maximum. The median result of 769 µS/cm is higher than the median reference and median survey sites. The minimum, 310 µS/cm, is very close to survey sites but higher than reference. This site is not a “least disturbed” site. This illustrates, with this limited data set that these results somewhat overlap with the ecoregion and stream size survey data population. While not a perfect overlap, this strengthens the confidence in using conductivity results for data screening. The higher 50% and maximum may indicate natural geology/causes, but likely indicate stressors and unhealthy conditions for aquatic life since this is a highly urbanized watershed with direct stormwater inputs. Conductivity doesn’t tell us what is in the water, just what in the water will conduct electricity.

This is a headwater stream which will reflect local conditions in the watershed but will likely not contribute to Lake Erie basin-wide trends as the dilution factor alone is large. That said, many small systems' unhealthy conditions can add up to the equivalent of a large tributary in terms of impact on the lake. This data only represents a point in time monthly and will not always capture weather or pollution-related events. Initial recommendations for this site for conductivity are to continue to monitor and compare with available Ohio EPA and NEORSD sampling.

Figure 19. Euclid Creek Conductivity Data Summary Exceedance Map: *Shows the percentage of exceedances at the Schaefer Park site along the Euclid Creek*



<u>*Conductivity data compared to Biocondition Assessment*</u>

A total of 14 conductivity samples were compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm and 655 µS/cm. Results less than 412 indicate a healthy macroinvertebrate community. Results between 412 - 655 µS/cm indicate declining and degrading health. Any results greater than 655 µS/cm indicate a degraded macroinvertebrate community. A total of 13 out of 14 samples exceeded conductivity biocondition standards, resulting in 92.9% exceedances of the respective healthy, declining or degraded biocondition thresholds.

These exceedances could be caused by pollution, erosion, respiration and photosynthesis, or stream evaporation caused by warm weather. The large percentage of exceedances could be indicative of a threat to macroinvertebrate communities. Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe, based on conductivity, if macroinvertebrates are in the river their overall community health is declining or even degraded. The collection of actual macroinvertebrate data by LEBAF or agency partners to compare with this data could help provide more resolution and confirm or deny the health of macroinvertebrates at this station. The addition of more stations, sampling frequency or other parameters including physical habitat features would also be valuable to help define macroinvertebrate health.

We do not believe the data at this site is indicative of broader Lake Erie health. This data only represents a point in time monthly and will not always capture weather or pollution related events. It is important for volunteers to continue monitoring the site for physical, chemical, and biological observations to better determine sources of high conductivity and to help inform this correlation.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

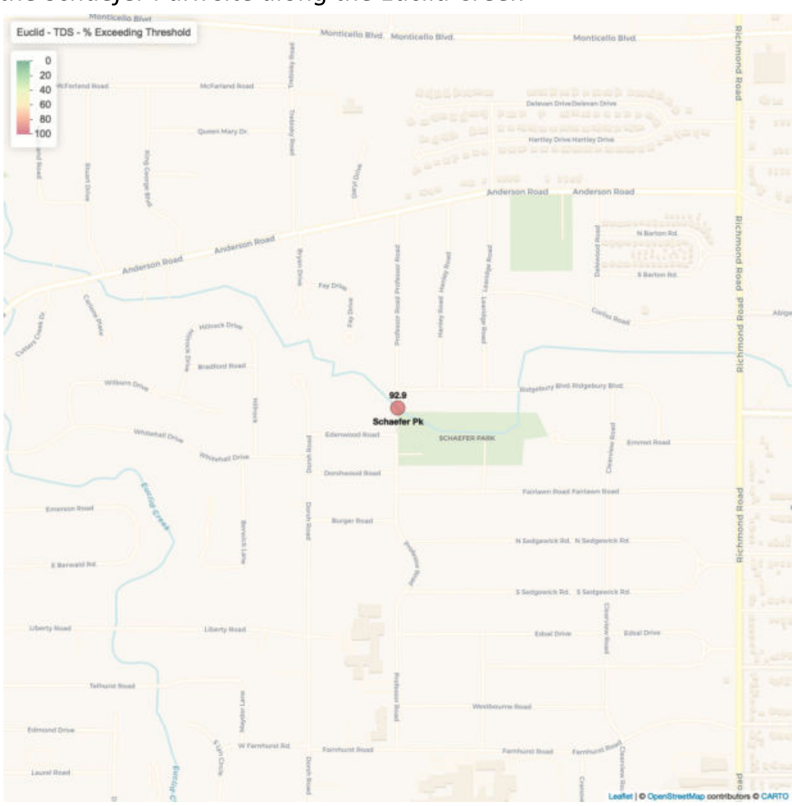
TDS: 14 samples were collected at one station. A total of 13 out of 14 samples exceeded the respective TDS drinking water standard, resulting in 92.9% exceedances. Other monitoring statistics include: max = 790.9 mg/L, min = 170.5 mg/L, median = 422.68 mg/L.

Historic TDS values from 2019 – 2021 at the site range from 266 mg/L - 1080 mg/L. Historic TDS values at this site were higher in the summer and lower for the remainder of the year. The 2022 LEBAF data set aligns with historic TDS data.

The TDS data was calculated from conductivity field data from the LEBAF 2022 field season. For the 2022 LEBAF season, the calculated TDS values were assessed against a drinking water threshold of 200 – 500 mg/L while LEBAF is exploring the effectiveness of the Ohio aquatic life threshold of 1500 mg/L and developing its own conductivity thresholds. The calculated TDS values at this site during the 2022 LEBAF field season mostly fall within the chronic drinking water standard TDS range between 200 – 500 mg/L. Several other data points also fall in the acute range above the TDS threshold of 500 mg/L. Results did not exceed 1500 mg/L and the maximum was 790 mg/L, approaching this threshold for one measurement. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Elevated TDS can have direct and indirect impacts on aquatic life. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS. While TDS drinking water exceedances indicate the system is not healthy to consume without treatment, the aquatic life criteria of 1500 mg/L LEBAF is exploring was not exceeded. This suggests TDS is supporting aquatic life but more data is needed.

Furthermore, It is not likely that the TDS levels at this site have a direct correlation to Lake Erie Impacts. This is a headwater stream which will reflect local conditions in the watershed but will likely not contribute to Lake Erie basin wide trends. This data only represents a point in time monthly; more field data is needed to draw conclusions. Initial recommendations for TDS at this site are to consider additional sampling frequency and an analysis of available Ohio EPA or NEORSD monitoring data for this location.

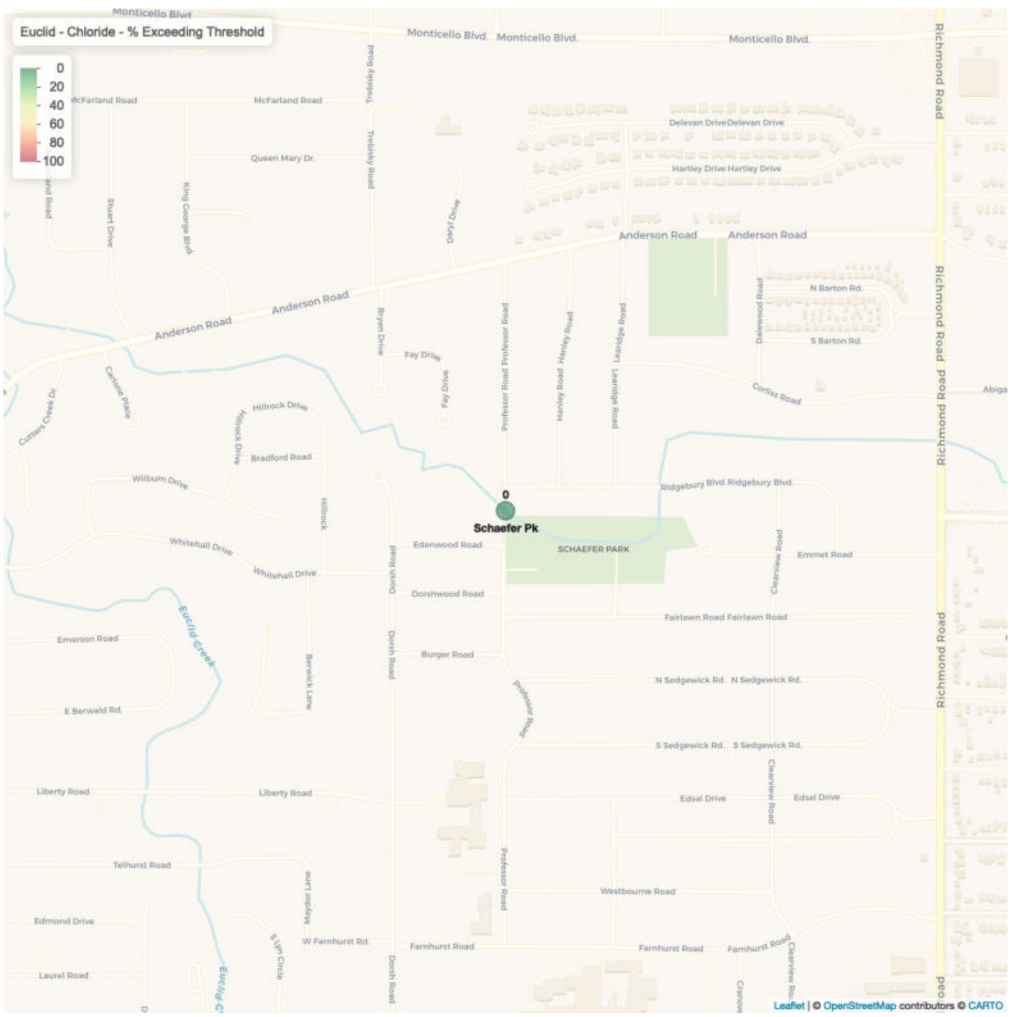
Figure 20. Euclid Creek TDS Data Summary Exceedance Map: *Shows the percentage of exceedances at the Schaefer Park site along the Euclid Creek*



Chloride: 17 samples were collected at one station. Calculated chloride concentrations ranged from 15.28 mg/L - 70.86 mg/L throughout the sampling period. Zero out of 17 samples exceeded the final acute, acute maximum and final chronic aquatic chloride standards, resulting in 0% exceedances. This suggests aquatic organisms in the Euclid Creek were at reduced risk to chronic chloride exposure in 2022.

No historical chloride data exists for Euclid Creek which, along with data collection occurring at monthly intervals, make data availability a limitation to a more robust assessment. Recommendations for future monitoring include extending sampling frequency and duration, especially in winter when road salt application is expected to cause an increase in chloride concentrations. Additionally, analysis of available Ohio EPA and NEORSD data for this station would improve water quality evaluation. The data set is still too small to identify temporal or longitudinal patterns.

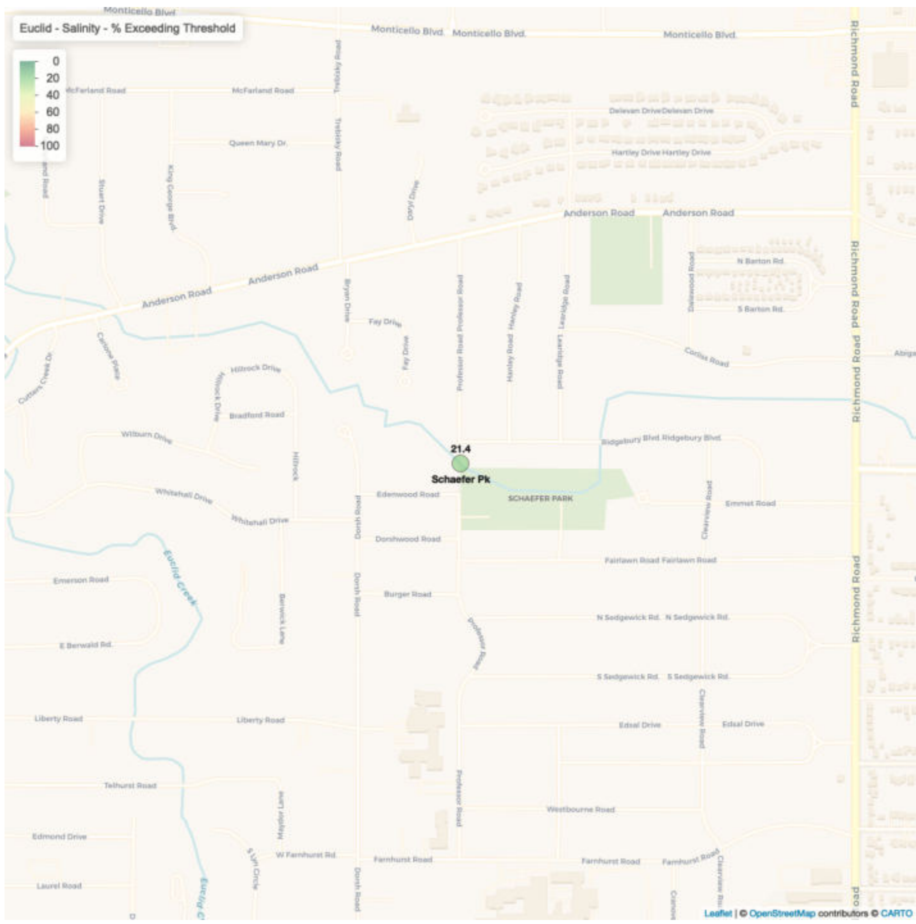
Figure 21. Euclid Creek Chloride Data Summary Exceedance Map: *Shows the percentage of exceedances at the Schaefer Park site along the Euclid Creek*



Salinity: 14 samples were collected at one station. Three out of 14 samples exceeded the salinity standards, resulting in 21 % exceedances. Other monitoring statistics include: max = 1270.17 ppm, min = 239.31 ppm, median = 642.59 ppm.

Historic salinity values from 2019 – 2021 at the site range from 190 ppm - 760 ppm. Field season data was also collected for salinity in 2022. Trends from 2022 data indicate salinity values around 500 in April, salinity values between 300 ppm – 400 ppm from May – October and higher salinity values between 1000 ppm – 5200 ppm in the winter, from February to March. We can conclude that the field data is higher in the winter and lower in the summer and fall. The salinity values were calculated from conductivity field data.

Figure 22. Euclid Creek Salinity Data Summary Exceedance Map: *Shows the percentage of exceedances at the Schaefer Park site along the Euclid Creek*



Salinity results were assessed against the USGS recommended levels of salt in freshwater, less than 1000 ppm and slightly saline 1000 - 3000 ppm. The maximum result exceeded the 1000 ppm freshwater level. The median is under 1000 ppm and infers that 50% of the time salinity is below 1000 ppm. It is likely the exceedances observed represent an event or short duration where the freshwater level is exceeded. These exceedances observed do not mean aquatic life was harmed, just exposed to high salinity. More data could be collected to help confirm these assumptions. Exploration of deicing compounds and application processes to keep salt out of the river are needed to help prevent the rise of salinity in urban freshwater streams.

Based on LEBAFs definition of healthy and for our monitoring purpose of screening we believe this site is not currently impaired for salinity. It is not likely that the salinity levels at this site have a direct correlation to Lake Erie Impacts. This is a headwater stream which will reflect local conditions in the watershed but will likely not contribute to Lake Erie basin wide trends. However, when this data is compiled with other Lake Erie data it may be possible to speak to a trend in salinity levels gradually increasing over time during warmer months like Ohio EPA data has started to indicate. Without Lake Erie data, it would be hard to tell if this effect is diluted at the lake level or also remains elevated and trending upwards. This data only represents a point in time monthly and will not always capture weather or pollution related events.

Aggregated Overall Summary

Euclid Creek had data for 7 parameters at one station: pH, DO, conductivity, water temperature, chloride, TDS and salinity. Five parameters showed exceedances of respective standards or thresholds. Salinity and chloride were the only parameters not exceeded (but came close).

DO tended toward low levels, with the magnitude of exceedances relatively small. With six exceedances over the season (out of 17 sample events) that could indicate frequent but short duration exceedance conditions, but more data, over time, sites and sampling frequency would be needed to make stronger conclusions. If aquatic life can find refuge during exceedance events they may not be impacted by exposure to low DO conditions.

pH range was wide considering pH is a logarithmic scale measurement from 6 to 10 units. Exceedances were 30% of the time and like DO, if organisms can find refuge, this exposure may not be causing harm, especially if not during a sensitive life stage. More sampling is needed.

Temperature was exceeded a few times and not by a large magnitude. These parameters are classic aquatic life health indicators and based on LEBAF's definitions Euclid Creek would be considered unhealthy. More data is needed to determine when and where unhealthy stream conditions occur with this limited data set.

Conductivity results did somewhat overlap with reference and survey population data suggesting results are valid, but that more results are needed. The macroinvertebrate biocondition gradient exceedance is a reflection of a response community to conductivity values. The exceedances of the 412 and 655 declining and degraded community health would align with the exceedances of DO, pH and possibly temperature. This data suggested that when combined with other urban stressors there are likely unhealthy communities in Euclid Creek. Additional data collection and actual macroinvertebrate data, existing and new would help confirm and focus appropriate next steps.

Results are encouraging in regards to using expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? Existing TDS data overlap with calculated TDS results from this limited data set. This indicates calculated TDS is generated by representative ambient conditions. In regards to assessment methods, the TDS drinking water standard threshold was exceeded 92% of the time suggesting a high frequency and long duration condition - for drinking water. This is expected in this watershed in which no one is drinking ambient water without treatment. The aquatic life threshold of 1500 mg/L LEBAF is exploring was not exceeded. Results indicate aquatic life is at reduced risk from elevated TDS. Direct measurements of response communities or other stressors associated with high conductivity and TDS may be more helpful to understand the condition and health of aquatic life.

Existing data does not exist for chloride or salinity but it appears calculated chloride and salinity results represent ambient screening level conditions, but more data is needed. Chloride was not an issue in this watershed based on this data set with no exceedances and a maximum of 70.86. If chloride becomes a concern based on this screening data, direct measurement of chloride would be recommended, as well as source identification and direct measurement of response communities such as macroinvertebrates.

This data is for a less than 2 square mile headwater tributary to the 24 square mile drainage of direct Lake Erie tributary Euclid Creek. More stations downstream of this site would help to understand the health of Euclid Creek. It is likely that the data collected at the Euclid Creek Watershed Scale can help contribute to the wider Lake Erie story, but it would need to be put into the context of the wider watershed analysis. This is a small highly urbanized stream of which the impacts are likely diluted in the overall Lake Erie watershed scale. To tell the larger story it would be useful to have data at this same scale and minimally at this monthly frequency for each large river and Lake Erie tributary along Lake Erie. And yet, many small streams in an unhealthy condition can impact Lake Erie as a larger river might.

Considering the elevated levels, our organization recommends continuously recording the construction, land use changes, pollution, and erosion near the site to determine other impacts. Since this site is in an urban watershed, public education and engagement around the protection of the site is essential. Any restoration opportunities near Schaefer Park or within the riparian buffer can also help to reduce loading to the creek and improve water quality. BEHI surveys may also be useful for determining the extent of erosion at this site. Macroinvertebrate surveys can also indicate the threat to aquatic life at this site. Lastly, we recommend that our volunteer monitors continue to collect data for pH, DO, conductivity, and water temperature to track trends over time. The addition of nutrient monitoring for this direct tributary is recommended as it is a known issue with the state and is on the impaired waters list with a total maximum daily load (TMDL).

3.9 Rush Creek

Monitoring Groups: One entity in the LEBAF network monitors in the Rush River Basin, Buffalo Niagara Waterkeeper.

Station information: Rush Creek is south of the City of Buffalo and flows into Lake Erie at Woodlawn Beach. Rush Creek is a small tributary flowing into Lake Erie at one of Buffalo's Popular Swimming Beaches. There are often beach closures, limiting contact recreation with the Lake. This site is sampled 1x per month May through October. This is a 17 mile stream (class C). Buffalo Niagara Waterkeeper - Riverwatch Citizen Science volunteers monitor one site on Rush Creek at this time which is Rush Creek @ Milestrip (Coordinates 42.790250, -78.837000). This site is on the main branch of Rush Creek, about 1 mile inland from Lake Erie. This site is sampled 1x per month May through October in between the hours of 9:00 am and 11:00 am.

Aggregated Metrics Table - Table 19 Rush Creek Summary Statistics

Rush Creek Summary Statistics - 6 Samples

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	9.22	8.92	8.26	11.19	0	0%
Water Temperature - C	17.1	18.62	9.05	19.9	4	66.7%
Conductivity - uS/cm	1046.67	1105	822.7	1151	6	100%
Total Dissolved Solids - mg/L	575.67	607.75	452.49	633.05	6	100%
pH	8.28	8.18	8.02	9.01	1	16.7%
Chloride - mg/L	51.58	54.45	40.54	56.72	0	0%
Salinity - ppm	899.64	953.73	691.91	996.99	0	0%
2022-05-21 to 2022-10-22						

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

pH: 6 samples, 1 exceedance. Max = 9.01, Min = 8.02, Median = 8.18. October sample exceeded (coldest temp. exceedance was just over the threshold).

6 samples were collected at 1 station resulting in 1, or 16.7%, exceedances of respective standard. Limited data was collected from Rush Creek. However, based on previous years data (which did include an additional site upstream) we would expect for pH to remain in range throughout May-October. We would expect pH to be in range for a majority of samples collected. We found 1 exceedance .01 over the threshold in 2022. If we had more sites along Rush Creek and its tributaries, we could better determine this creek's condition. The New York state pH standard range is 6.5-8.5, so the max of 9.01 is a bit beyond that standard max range, as well. Additional data throughout the sampling season would help to determine if this is a consistent finding in this waterway. The pH of this waterway is likely to have a very minor impact on Lake Erie.

DO: 6 samples, 0 exceedances 0%, Max=11.19, Min=8.26, Median=8.92

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. We expect DO to change seasonally, related to temperature, as well as diurnally, but we do not have multiple samples per day to confirm this expectation. Several inputs could be negatively impacting DO in Rush Creek including urban stormwater runoff, municipal and industrial inputs, and SSOs, to name a few. Low DO could impact the biology of the creek. In general, Rush Creek impacts Woodlawn beach (frequent closures due to elevated bacteria levels). DO levels remain in good range, but further sampling may be needed to draw any firm conclusions. The creek is likely not having a large impact on Lake Erie.

Temp: 6 samples, 4 exceedances, 66.7%. Max=19.9, Min=9.05, Median=18.62

6 samples were collected at 1 station resulting in 4, or 66.7%, exceedances of respective standard. We would expect daily changes and seasonal changes in water temperature. We do not have sample results to show daily changes, however. Inputs like runoff and municipal/industrial discharges could impact stream temperatures. Temperature exceedances are common throughout summer months. We found 4 exceedances of the maximum temperature threshold. This may be related to pollution inputs, like runoff and other discharges, and lack of shade cover. This creek is releasing warm waters into Lake Erie which could have a relatively small impact on lake temperatures, at least locally, which may impact aquatic life. This is a small waterway that flows into Lake Erie. Data from this waterway is limited. With additional sites throughout Rush Creek we could better determine and monitor this creek's condition. Based on our analysis, Rush Creek is impaired due to high temperature. More sampling may be needed to confirm this conclusion.

Conductivity Survey: 6 samples, 100%, Max=1151, Min=822.7, Median=1105

6 samples were collected at 1 station resulting in 6, or 100%, exceedances of respective standard.

Conducti<u>vity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. Rush Creek conductivity results fall within the EOLP ecoregion and is a headwater stream size. The below table illustrates that the maximum conductivity result, 1151, falls between the 75th percentile and maximum reference stream values and between the 50th and 75th stream survey conductivity value, closer to the maximum. The median result of 1105 is higher than the median reference,more than double and almost double the survey sites. The median and maximum conductivities are only about 50 units different. That means for Rush Creek, 50-95% of the time or more, conductivity is in the 1000 units range, which does align with the maximum survey sites conductivity. The minimum, 823, is well above reference and survey sites, again indicating that conductivity is more consistently in duration and frequency closer to 1000 units with this data set. This illustrates, with this limited data set that these results align with the data from the reference and survey sites and are representative of the ecoregion and the watershed size. This strengthens the confidence in using conductivity results for data screening.

Table 20. Rush Creek Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	90.00	351.00	462.00	611.00	35,000.00
Survey	316.00	466.00	629.30	886.00	990.00
Results	823		1105		1151

Conductivity Biocondition: 6 exceedances (high) of conductivity biocondition

6 samples were collected at 1 station resulting in 6, or 100%, exceedances of respective standard. Six conductivity samples were also compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, indicating a healthy macroinvertebrate community, and 655 µS/cm indicating a degraded macroinvertebrate community. Rush River conductivity values ranged from 822.7 uS/cm to 1151 uS/cm. 100 % of 2022 field season conductivity values exceeded the 655 us/cm macroinvertebrate bio-condition threshold. These exceedances suggest a degraded macroinvertebrate community. At this time, there is no macroinvertebrate

data at the site to corroborate these conclusions, and that is our primary recommendation, to access or collect macroinvertebrate community data.

The highest values for conductivity were expected to occur in the spring months, with inputs from snowmelt and road salt runoff, with levels decreasing as the sample season progresses toward fall. In 2022, 100% of the samples exceeded the threshold, at high levels. While there is limited data from sites along the Creek, ancillary data and historic data shows similar findings. Based on LEBAF's definition of healthy and for our monitoring purpose of screening it is believed that this waterway is not healthy in relation to conductivity.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: 6 samples, 6 exceedances 100%, Max=633.05, Min=452.49, Median=607.75 (5 exceed acute, 1 exceed chronic)

6 samples were collected at 1 station resulting in 6, or 100%, exceedances of respective standard. We expect this parameter to be most elevated in spring, slowly trending downward toward the end of the sampling season/fall. Spring rains are likely washing in many sediments and other pollutants impacting TDS. TDS consistently measures high for Rush Creek. This creek is impaired, based on previous analysis by the NYSDEC. This limited data set aligns with as well as additional ancillary information.

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 and developing its own conductivity thresholds. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS. However, results did not exceed 1500 mg/L and the maximum was 633, not approaching this threshold and the median was 607. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Elevated TDS can have direct and indirect impacts on aquatic life.

Chloride: Calculated chloride concentrations ranged from 40.54-54.45 mg/L throughout the sampling period, and there were 0 exceedances in the 6 collected samples (0% exceedance) of the final acute, acute maximum and final chronic aquatic chloride standards.
6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard.
This suggests aquatic organisms in Rush Creek were at reduced risk to chronic chloride exposure in 2022. The highest calculated chloride concentration occurred in July, before declining substantially throughout the rest of the sampling period. Road salt application and combined sewage overflows is expected to increase calculated chloride concentration in winter and spring. Data analysis and interpretation is limited by the sampling period and number of stations on Rush Creek, so recommendations for future monitoring efforts include increasing sampling duration, and adding to the number of monitoring stations on the river.

Salinity: 6 samples, 0 exceedances, Max=996.99, Min=691.91, Median=953.73

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard.
Salinity results were assessed against USGS's recommended saline content for freshwater. Values under 1000 ppm are considered freshwater while values between 1000-3000 pm are considered slightly saline. While no result here exceeded 1000, the maximum came close and the median is close as well, suggesting 50-100% of the time salinity results approach being slightly saline versus freshwater, frequent occurrence with a long duration. This doesn't mean aquatic life is harmed, just exposed. Recommendations for more sampling and exploring application compounds and methods to keep salt out of the rivers may prove productive.
We expect highest exceedances in early spring months, with levels decreasing as the sampling season progresses toward fall.

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

Rush Creek had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity, at one site. No up to downstream patterns can be extracted. The close proximity of the station to the mouth of Rush Creek allows us to understand the collective and accumulative condition of Rush Creek Watershed on aquatic life support and that quality entering Lake Erie. Of these parameters, three exceeded thresholds, pH, temperature, TDS (drinking water) and conductivity exceeded the biocondition thresholds for a healthy macroinvertebrate community.

Three parameters did not exceed respective thresholds, DO, chloride and salinity, the latter two parameters being calculated results from conductivity. Conductivity results aligned with respective ecoregion and stream size for reference and survey datasets but tended toward the higher values suggesting conductivity is frequent and for extended duration around 1000 units, but that is with a limited data set of once a month samples, more data and more stations would help characterize the duration, frequency and magnitude of conductivity and perhaps TDS, chloride and salinity conditions in Rush Creek.

These limited results provide mixed lines of evidence for screening purposes regarding the ability of Rush Creek to support aquatic life. Rush Creek can support aquatic life and other indicators suggest otherwise. Temperature exceeded four of five thresholds, while pH slightly exceeded one and DO did not exceed any thresholds for aquatic life. If aquatic life can find refuge during exceedance events then these events may not be causing harm. These events may be an indication of other stressors occurring on the land or in the water that may be limiting aquatic habitat.

Conductivity results are aligned with results relative to the reference and survey datasets, which have a range of aquatic life use support capacity, some higher conductivity conditions may not limit aquatic life use and some may. However, all six conductivity results exceeded both the declining and unhealthy functioning macroinvertebrate biocondition markers, 412 and 655 respectively, suggesting conditions would not support a healthy macroinvertebrate community or that existing communities may be unhealthy. It would be helpful to explore existing macroinvertebrate data, collect new data or explore stressors in those reaches to verify this condition and if the community can be restored.

Results are encouraging in regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? TDS appears to represent ambient conditions and follow expected seasonal pattern, with the highest acute exceedance occuring in October, a cold month. The assessment methods resulted in the TDS drinking water standards being exceeded, but that too is expected in that ambient water needs to be treated to consume (for TDS). TDS results did not exceed the 1500 mg/L aquatic life threshold LEBAF is exploring. That may mean TDS is not a threat to aquatic life or that threshold is not protective, as the macroinvertebrate biocondition gradient results expressed. More data is needed. Existing data for chloride and salinity was not available, but the calculated chloride and salinity results seem to represent ambient conditions, again more data is needed. Regarding the respective assessment methods, both seem to be effective for screening and as such aquatic life were at reduced exposure to elevated levels of these parameters.

Rush Creek is a headwater system, though small, that has localized impacts at Woodlawn Beach and is impacting Lake Erie. In addition, many smaller tributaries to the Lake such as Rush Creek can equate to an impact of one larger river. Every tributary matters to the overall health of the Lake. The state has recognized this as Rush Creek is on the New York DEC’s 303(d) or impaired waterbody list, also identifying elevated levels of phosphorus. This work and other work has identified urban stormwater runoff, SSO’s and other municipal and sanitary inputs impacting the water quality and habitat of Rush Creek and associated recreational access and aesthetics of Lake Erie.

In addition to more stations, higher sample frequency and extending the sampling season on both ends, for Rush Creek, based on previous work of numerous entities, LEBAF recommends restoration and protection priorities and resources focused on limiting urban runoff source through implementation of living/green infrastructure projects and stream bank restoration. Whether formal or informal, we also recommend employing the effort of identifying the extent and source of pollutants, developing goals and plans to reduce or eliminate sources and then work flow monitoring those plans as they are implemented to determine if aquatic life uses, recreational access, aesthetics and other uses are recovering. In essence, applying the work flow of the Clean Water Act total maximum daily levels approach or equivalent to map a process that would prioritize and leverage resources toward measurable resource and community outcomes.

3.10 Smoke Creek

Monitoring Groups: One entity in the LEBAF network monitors in the Rush River Basin, Buffalo Niagara Waterkeeper.

Station information: Buffalo Niagara Waterkeeper - Riverwatch Citizen Science Program monitors one station on Smoke Creek (Coordinates 42.81278,-78.8262). This site is along South Smokes creek, close to the confluence of south Smoke Creek and the main branch of Smokes Creek, a direct trib to Lake Erie on the Eastern Basin. This is about 6-7 miles south of the City of Buffalo. The site was sampled May-October 1x per month.

Aggregated Metrics Table - Table 21 Smoke Creek Summary Statistics

Smoke Creek Summary Statistics - 6 Samples

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	8.35	7.89	7.5	10.94	0	0%
Water Temperature - C	18.39	19.72	8.76	21.87	5	83.3%
Conductivity - uS/cm	1036.28	1021.5	881.1	1209	6	100%
Total Dissolved Solids - mg/L	569.96	561.82	484.61	664.95	6	100%
pH	8.15	8.07	7.82	8.95	0	0%
Chloride - mg/L	51.07	50.34	43.42	59.58	0	0%
Salinity - ppm	889.81	875.6	745.5	1051.76	1	16.7%

2022-05-21 to 2022-10-22

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***

**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

pH: 6 samples, 0 exceedances. Max = 8.95, Min=7.82, Median = 8.07 The highest sample was in October.

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. We would expect this parameter to remain in range, for a majority of the time. In 2 years of sampling, we found 1 exceedance of the respective threshold. We believe it might be related to possible industrial/municipal discharges or other runoff sources. The exceedance was just above the impairment threshold. The amount of samples along Smoke Creek and its tribs are limited in this data analysis. If we had more sites along Smoke Creek and other sites further upstream on the south branch, we could better determine this creek's overall condition. Based on LEBAF's definition of healthy and for our monitoring purpose of screening, we believe this tributary to be healthy, and is having little negative impact on Lake Erie. Additional sites to sample would help confirm this conclusion.

DO: 6 samples, 0 exceedances. Max=10.94, Min=7.5, Median=7.89.

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. 2 years of data show the creek to be within state standard ranges. The highest value in 2022 was in October. We would expect this parameter to be in standard range and we found 0 exceedances of the respective threshold. Limited sites along Smoke Creek and its tributaries provided a limited representation of this Creek. Based on LEBAF's definition of healthy and for our monitoring purpose of screening, we believe the creek to be healthy and not negatively impacting Lake Erie. An increase in the amount of sample sites would help confirm this conclusion.

Temp: 6 samples, 5 exceedances 83.3% Max=21.87, Min=8.76, Median=19.72

6 samples were collected at 1 station resulting in 5, or 83.3%, exceedances of respective standard. We would expect this parameter to exceed temperature thresholds during spring and summer months. Indeed, we found 5 exceedances of the respective threshold. We believe it might be related to various inputs from runoff, and other municipal/industrial inputs of unnaturally warm waters. Temperatures were a bit above the threshold, but these warmer temperatures could impact Lake Erie and it's aquatic life, at least locally. Limited sites along Smoke Creek and its tributaries provided a limited representation of this Creek.

Based on LEBAF's definition of healthy and for our monitoring purpose of screening, we believe Smoke Creek to be impaired for high temperature and it may be impacting Lake Erie. An increase in the amount of sample sites and sampling frequency would help to confirm the impairment.

Conductivity Survey: 6 samples, Max=1209, Min=881.1, Median=1021.5

6 samples were collected at 1 station resulting in 6, or 100%, exceedances of respective standard.

Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. Smoke Creek conductivity results fall within the EOLP ecoregion and is a headwater stream size. The below table illustrates that the maximum conductivity result, 1209, falls between the 75th percentile and maximum reference stream values and between the 50th and 75th stream survey conductivity value, closer to the maximum. The median is more than double and almost double median reference and survey sites respectively. The minimum result of 881 is higher than the median reference, 10 times reference minimum and more than double the survey sites. The median and maximum conductivities are only about 100 units different. The minimum, 881, is well above reference and survey sites, again indicating that conductivity is more consistently in duration and frequency closer to 1000 units with this data set.

This suggests that for Smoke Creek, 50-95% of the time or more, conductivity is in the 1000 units range, which does align with the maximum survey sites conductivity. This illustrates, with this limited data set that these results align with the data from the reference and survey sites and are representative of the ecoregion and the watershed size. This strengthens the confidence in using conductivity results for data screening.

Table 22. Smoke Creek Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	90.00	351.00	462.00	611.00	35,000.00
Survey	316.00	466.00	629.30	886.00	990.00
Results	881		1021		1209

Conductivity Biocondition: 6 exceedances (100%) of the macroinvertebrate biocondition thresholds.

6 samples were collected at 1 station resulting in 6, or 100%, exceedances of respective standard. Six conductivity samples were also compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, below which indicates a healthy community, between 412 and 655 units, a declining or degrading community health and above 655 units an unhealthy and degraded community. Smoke Creek conductivity values ranged from 881.1 uS/cm to 1209 uS/cm, with the median at 1021. All 2022 field season conductivity values exceeded the 655 us/cm macroinvertebrate bio-condition threshold, indicating a degradation of macroinvertebrate communities.

Limited sites along Smoke Creek and its tributaries provided a limited representation of this Creek. Therefore, the amount of sample sites should be increased. However, historic macroinvertebrate data can help to inform LEBAF conclusions. A biological (macroinvertebrate) assessment of South Branch Smoke Creek in Lackawanna (at South Park Avenue) was conducted by the NYSDEC as part of a biological screening effort in 2005. Sampling results indicated slightly impacted conditions. In such samples some replacement of sensitive ubiquitous 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. Conductivity is a surrogate measurement to direct monitoring of the macroinvertebrate community. The limited conductivity results to date, when compared to the conductivity biocondition gradient, suggests that the macroinvertebrate community is highly degraded or subjected to significant stressors. This metric doesn't measure what those stressors are, or their magnitude, duration and frequency. Furthermore as a surrogate is not directly measuring macroinvertebrate community condition. Thus, more chemical and macroinvertebrate data is needed to validate the relationship between conductivity and macroinvertebrates.

It is expected that conductivity would be elevated along Smoke Creek, especially as one heads closer toward Lake Erie based on historical data and knowledge of the site and creek conditions. This waterway is listed on the NYDEC's 303(d) or impaired waterbody list naming erosion, runoff, and possible industrial and or sanitary discharges as possible sources. Conductivity is one indicator of impact. Limited sites along Smoke Creek and its tributaries provided a limited representation of this Creek. Therefore, the amount of sample sites, sample frequency should be increased which would better inform up to downstream changes as well as duration, magnitude and frequency of conductivity conditions.

Expressions of Conductivity
Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: 6 samples, 6 exceedances 100%. Max = 664.95, Min = 484.61, Median = 561.82

6 samples were collected at 1 station resulting in 6, or 100%, exceedances of respective standard. LEBAF expects TDS along Smoke Creek to be elevated based on historical data and knowledge of site/creek conditions. There were 6 exceedances of the threshold; 5 of the 6 exceedances were acute, 1 was chronic. The exceedances may be related to erosion, runoff, and possible industrial/sanitary discharges.

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 and developing its own conductivity thresholds. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS. However, results did not exceed 1500 mg/L and the maximum was 665, not approaching this threshold and the median was 561. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Elevated TDS can have direct and indirect impacts on aquatic life.

Chloride: Calculated chloride concentrations ranged from 43.42-59.58 mg/L throughout the sampling period, and there were 0 exceedances in the 6 collected samples (0% exceedance) of the final acute, acute maximum and final chronic aquatic chloride standards.

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. This suggests aquatic organisms in Smoke Creek were at reduced risk to chronic chloride exposure in 2022. The highest calculated chloride concentration occurred in May, before generally declining throughout the rest of the sampling period. One exception occurred in September, when calculated chloride concentrations increased, before declining again in October. Based on this limited data, aquatic life is not at risk from excess chloride concentrations. The greatest limitation to data analysis and interpretation on Smoke Creek is the existence of only a single station. Recommendations for a more robust assessment of water

quality conditions in Smoke Creek include adding more stations, both on the main and upstream along the south branch.

Salinity: 6 samples, 1 exceeded 16.7%. Max=1051.76, Min=745.5, Median = 875.6

6 samples were collected at 1 station resulting in 1, or 16%, exceedances of respective standard. The maximum result did exceed the USGS recommended saline content for freshwater of 1000 ppm. The median and median are very close and approach 1000 ppm. This suggests that this river may frequently, for extended duration but a low magnitude approach slightly saline waters, USGS range 1000-3000 ppm. This may not be causing harm to aquatic life but as a screening tool, exploring sources, natural or anthropogenic may inform recommendations to keep salt out of the river.
LEBAF expects Salinity to be within standards consistently throughout the sampling season and into winter, with potential early spring and summer peaks. Based on LEBAF's definition of healthy and for our monitoring purpose of screening, Smoke Creek and its tributaries are believed to be healthy and will not impact Lake Erie. LEBAF recommends increasing the number of sampling sites.

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie

Smoke Creek had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity. Of these, three exceeded thresholds, temperature, TDS (drinking water) and conductivity exceeded the biocondition thresholds for a healthy macroinvertebrate community.

Four parameters did not exceed respective thresholds, pH, DO, chloride and salinity, the latter two being calculated results from conductivity. Conductivity results aligned with respective ecoregion and stream size for reference and survey datasets but tended toward the higher values suggesting conductivity is frequent and for extended duration around 1000 units, but that is with a limited data set of once a month samples, more data and more stations would help characterize the duration, frequency and magnitude of conductivity and perhaps TDS, chloride and salinity conditions in SmokeCreek. In addition, collecting macroinvertebrate samples, as well as sampling over the winter, would also enhance water quality assessments.

These limited results indicate via some parameters, Rush Creek can support aquatic life and other indicators suggest otherwise. Conductivity results are aligned with results relative to the reference and survey datasets, which have a range of aquatic life use support capacity, some higher conductivity conditions may not limit aquatic life use and some may not. All six conductivity results exceeded both the declining and unhealthy functioning macroinvertebrate biocondition markers, 412 and 655 respectively, suggesting conditions would not support a healthy macroinvertebrate community or that existing communities may be unhealthy. It would be helpful to explore existing macroinvertebrate data, collect new data or explore stressors in those reaches to verify this condition and if the community can be restored.

Temperature thresholds were exceeded in all sampling months but October, while pH and DO did not exceed any thresholds for aquatic life. If aquatic life can find refuge during exceedance events then these events may not be causing harm. These events may be an indication of other stressors on the land, in the water limiting aquatic habitat.

TDS calculated from conductivity was compared to drinking water thresholds since aquatic life thresholds do not exist. All TDS results exceeded the drinking water standard with five exceeding acute thresholds and one chronic. Often aquatic life is more sensitive to chemical stressors than humans in part because their entire life cycle in the water exposes them to those stressors, this may or may not be the case for elevated TDS. TDS levels can be an indication of other stressors that cause direct harm or of indirect impacts such as a higher sediment load that is limiting habitat.

Results are encouraging in regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? The data set is limited in space and time more is needed to represent the watershed. TDS results seemed to represent ambient conditions based on other existing data, NY DEQ's assessment and ancillary information. Regarding the assessment method, the drinking water TDS standard exceedances were expected as no one expects to consume ambient water without treatment. However, TDS results did not exceed the 1500 mg/L aquatic life threshold LEBAF is exploring and was 561 mg/L 50% of the time. This indicates TDS is not a threat to aquatic life, more data is needed and other pollutants or conditions may be contributing to degraded macroinvertebrate communities based on the biocondition gradient exceedances. Calculated chloride and salinity results appear to represent ambient conditions, again more data is needed. And assessment methods for these two parameters also appear to provide helpful screening information, given limitations of the dataset.

South Smoke Creek station is in a headwater system that flows into Smoke Creek, which flows into Lake Erie and is below the urban area of Buffalo, New York. Though small, Smoke Creek has localized impacts and impacts Lake Erie. In addition, many smaller tributaries to the Lake such as Smoke Creek can equate to an impact of one larger river. Every tributary matters to the overall health of the Lake. The state has recognized this as Smoke Creek is on the New York DEC's 303(d) or impaired waterbody list. Temperature from Smoke Creek could impact Lake Erie, as could nutrient inputs stemming from runoff, erosion and other industrial/municipal discharges. This work and other work has identified urban stormwater runoff, SSO's and other municipal and sanitary inputs impacting the water quality and habitat of Smoke Creek and associated recreational access and aesthetics of Lake Erie.

In addition to more stations, higher sample frequency and extending the sampling season on both ends, for Smoke Creek, based on previous work of numerous entities, we recommend restoration and protection priorities and resources focused on limiting urban runoff source, identifying areas of elevated erosion and effective restoration projects, increase living/green infrastructure projects and reduce sanitary sewer inputs to all watershed waterways. The next steps after reviewing a screening analyses, whether formal or informal, we recommend is to employ the effort of identifying the extent and source of pollutants, developing goals and plans to reduce or eliminate sources and then monitoring those plans as they are implemented to determine if aquatic life uses, recreational access, aesthetics and other uses are recovering. more screening data would confirm what pollutants to follow up with to focus resources. In essence, applying the work flow of the Clean Water Act total maximum daily levels approach or equivalent to map a process that would prioritize and leverage resources toward measurable resource and community outcomes.

3.11 Mills Creek

Monitoring Organizations: One entity in the LEBAF network is MIlls Creek, which is monitored by Erie SWCD. Mills Creek is a 42.4 square mile watershed that's headwaters begin in Bellevue and empties into the Sandusky Bay on the west end of the City of Sandusky. Most of the watershed is rural/agricultural land use (67%) with more than 25% 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.

Station information: The seven sites sampled in the MIlls Creek watershed are representative of the main channel of Mills Creek. The stations transition from headwaters to mouth and provide collection points both upstream and downstream of land uses that may be the source to stressors in the watershed.

Number of Stations: 7
Station locations: headwaters to mouth
Months Monitored: April, May, June, July, August, September
Total number of observations: 41

Aggregated Metrics Table - Table 23 Mills Creek Summary Statistics

Mills Creek Summary Statistics - 41 Samples 7 Stations						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	9.07	8.6	3.6	16.27	1	2.4%
Water Temperature - C	17.15	19.2	3.9	21.5	0	0%
Conductivity - uS/cm	1015.99	871	411.4	1931	40	97.6%
Total Dissolved Solids - mg/L	558.79	479.05	226.27	1062.05	41	100%
pH	7.9	7.89	7.55	8.51	0	0%
Chloride - mg/L	50.07	42.92	20.27	95.16	0	0%
Salinity - ppm	876.83	736.21	325.57	1750.35	11	26.8%
2022-04-10 to 2022-09-19						

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

pH: 41 samples, Max = 8.51, Min = 7.55, median = 7.89, 0 exceedances (0%)

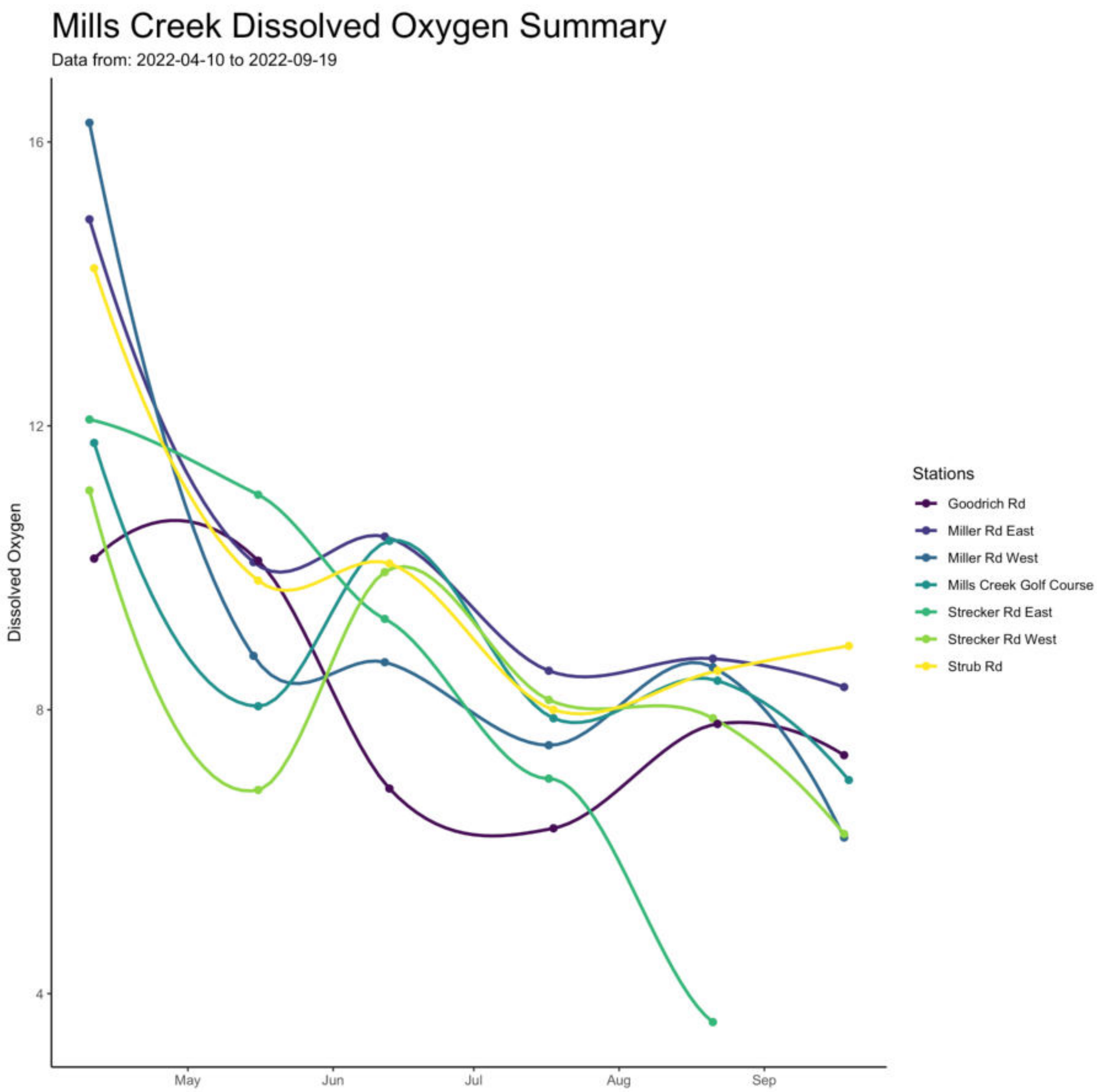
41 samples were collected at 7 stations resulting in 0 and 0% exceedances of pH. pH at all sites throughout 2022 was within the historical range at this site. Variation in pH was small over the course of sampling, which is good since they did not fall outside the desired range. pH was within the acceptable range throughout the sampling period, as we found 0% exceedances for this parameter. As such we feel this stream is generally meeting LEBAF health criteria and should not threaten the aquatic life health in Lake Erie.

DO: 41 samples, Max = 16.27, Min = 3.6, median = 8.6, 1 exceedance (2.4%)

41 samples were collected at 7 stations resulting in 1 and 2.4% exceedances of DO. The highest dissolved oxygen concentration was measured in April while the lowest concentration was measured in September. Many streams in the Great Lakes region follow a similar temporal pattern where dissolved oxygen concentrations are highest in the spring and decrease throughout the summer. Cooler water has the capacity to hold more oxygen, but this pattern

may also be due to biological activity. Higher stream respiration in summer than in spring may explain the decreasing oxygen concentrations throughout the study period.

Figure 23. Mills Creek Dissolved Oxygen Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



DO was within an acceptable range throughout most of the sampling period; however, there was 1 exceedance of the standard for this parameter. We feel this may have been due to the timing of the sample at dawn when DO is at its lowest during the diurnal cycle. The exceedance also occurred at a headwater site that is susceptible to low/no base flow in the summer months. Weather observations in the summer and early fall of 2022 noted higher than average air temperatures with lower than average precipitation. If aquatic life can find refuge during an exceedance exposure event, harm is not experienced. We do not have any recommendations for dissolved oxygen at this point. The low DO measurement was within historical expectations, but more data is needed to determine if there is a stagnation issue at this site.

Temp: 41 samples, Max = 21.5, Min = 3.9, median = 19.2, 0 exceedances (0%)

41 samples were collected at 7 stations resulting in 0 and 0% exceedances of water temperature. Water temperature is often considered a “master variable” in freshwater systems because it affects so many biological and chemical processes. In the temperate Great Lakes region, stream water temperatures are often highest in July and August. This is similar to what we observed in our study period at the Mills Creek site, where water temperatures increased by 17.6 ˚C between April and June. Peak water temperatures were 19.2 ˚C and occurred in June, before declining between June and September. Water temperature in this stream is often slightly cooler in the summer months due to the groundwater inputs. Water temperature was within the acceptable range for all of the sites throughout the sampling period. As such, we feel this stream falls within the LEBAF health criteria and does not likely threaten Lake Erie.

Conductivity Survey: 41 samples, Max = 1931, Min = 411.4, median = 871

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. Mills Creek conductivity results fall within the HELP ecoregion and is a stream size (20 -500 square miles). Mills Creek conductivity results and distribution are compared to conductivity distributions of reference and survey sites in the HELP ecoregion streams sized watershed. The purpose of this comparison is not an assessment against a threshold but to understand the population distribution of results to a robust existing conductivity database, for reference and survey sites. The closer the overlap of distributions, the more similar LEBAF results are to existing data, the greater the confidence in results and more specific recommendations can be developed. Deviations from overlap does not mean conductivity levels are causing harm or are healthy, rather there are different reasons why that could be, a different ecoregion, stream size, localized geology, climate or land use for example.

The below table illustrates that the maximum conductivity result, 1931, is above both reference and survey data by about 500 units. The median result of 871 is higher than the median reference and median survey sites by about 200 units. The minimum, 411 is the same as the median in terms of greater than both minimums by about 200 units. This suggests that the population of conductivity on Mills Creek given this data set overlaps with HELP ecoregion stream size conductivities but is slightly higher. As conductivity values are, 200 - 500 units is not a large magnitude in general. This could be for natural or anthropogenic reasons. It may warrant looking into a representative set of karst watersheds for comparison before looking into anthropogenic causes. This strengthens the confidence in using conductivity results for data screening. Interestingly, the lower conductivity results were taken within 24 hours of a 1+ inch storm event. Since rainwater is very low in conductivity, it is possible the conductivity was diluted by this rain water and decreased post storm event.

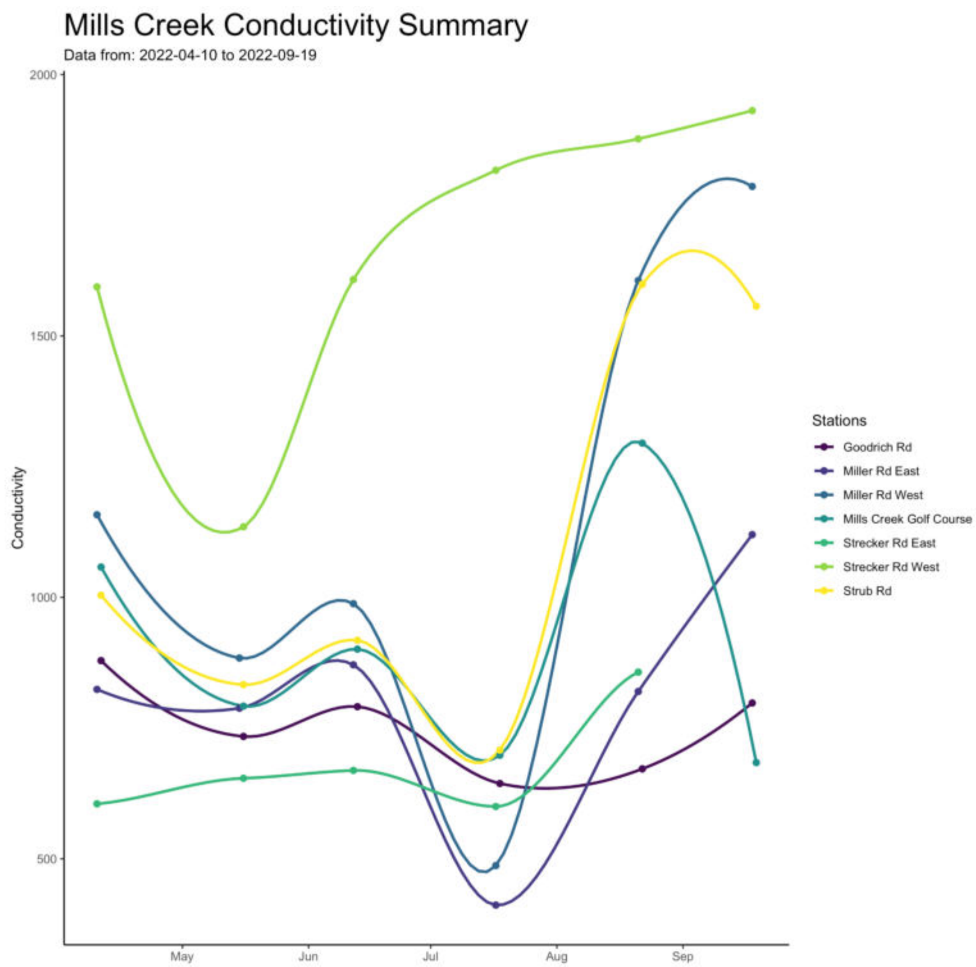
Table 24. Mills Creek Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	166.00	529.48	652.75	778.00	1,400.00
Survey	248.00	490.78	633.10	740.00	1,450.00
Results	411		871		1931

It is also important to look at the conductivity population distribution of each station and across those stations as illustrated below. Conductivity results between the highest and lowest stations is about 1000 units, aggregating the data dilutes these differences. The conductivity results reflect ambient conditions based on existing data and what is known about these rivers. Elements of the assessment methods may need adjustments for rivers in this region.

Conductivity Biocondition: 41 samples, Max = 1931, Min = 411.4, median = 871, 40 exceedances (97.6%)

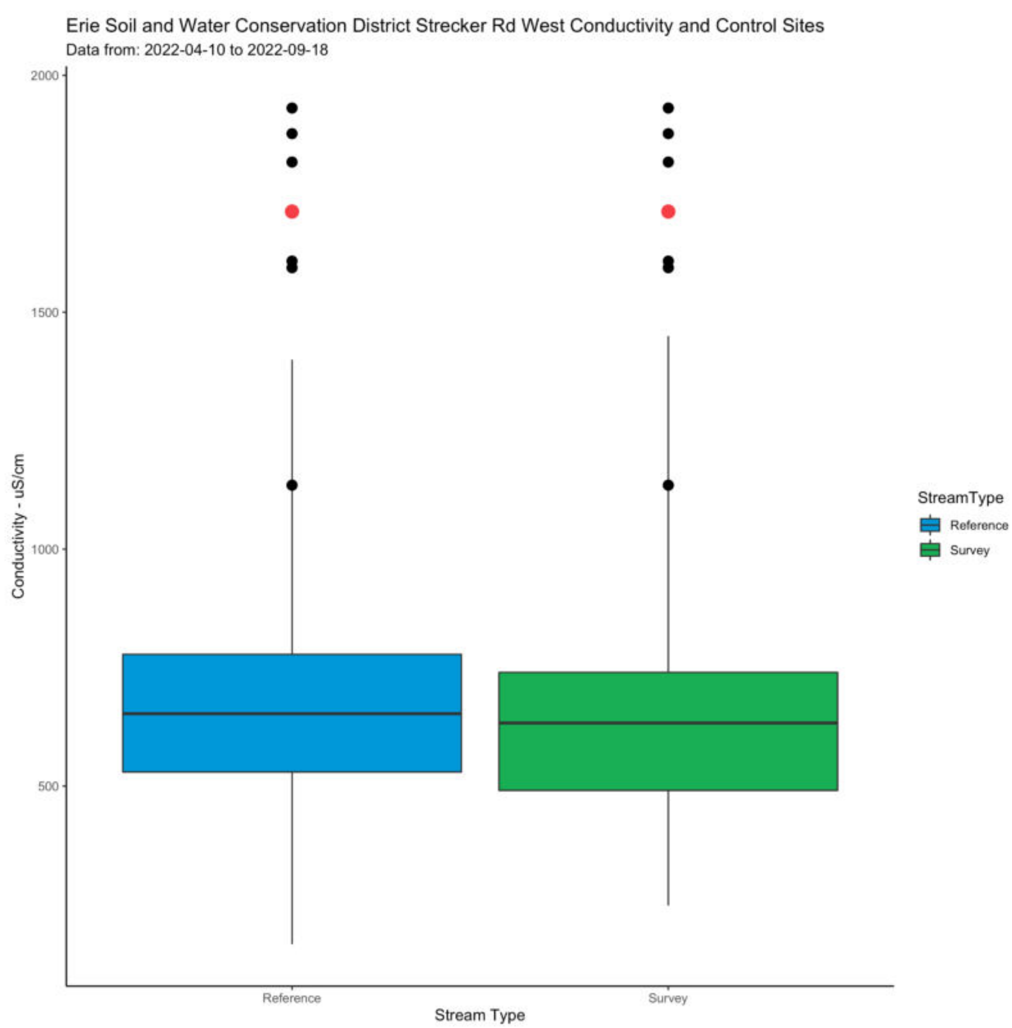
Figure 24. Mills Creek Conductivity Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



41 samples were collected at 7 stations resulting in 40 and 97.6% exceedances of conductivity biocondition. Conductivity can be a surrogate for potential harmful discharges affecting the aquatic life of the stream. Increased conductivity for extended periods of time may also negatively impact macroinvertebrate communities. This is why LEBAF assesses conductivity, a chemical stressor against a biological community response, macroinvertebrate community structure and function biocondition gradient. A total of 41 conductivity samples were also compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, indicating a healthy macroinvertebrate community, 412-655 indicating a declining and degrading community, greater than 655 µS/cm, indicating a degraded macroinvertebrate community.

Mills Creek conductivity values ranged from 411.4 µS/cm to 1931 µS/cm. 92.7% of 2022 field season conductivity values exceeded the 655 µs/cm macroinvertebrate bio-condition threshold, suggesting resident macroinvertebrate communities could be declining and degraded in structure and/or function. With the karst geology of this stream causing higher than average conductivity values for streams in this ecoregion, we would expect macroinvertebrate communities to show signs of stressed environment. Nearly all observations exceeded the criteria for conductivity (>655 microsiemens) suggesting aquatic life may be negatively impacted. Historical macroinvertebrate monitoring at several sites within the watershed show poor to good ratings, which support this finding. Not all macroinvertebrate species will have the same sensitivity to each stressor. Some taxa evolved in karst country for example. This metric doesn't identify by design what stressor may be causing degradation, it is a response community metric. Interestingly, the low data observations were taken within 24 hours of a 1+ inch storm event. Since rainwater is very low in conductivity, it is possible conductivity was diluted by the storm water and decreased during or post the storm event. Further investigation, correlation with these sites to existing macroinvertebrate sites, more chemical and biological data would help refine characterization to develop more specific recommendations. As a screening tool, this assessment is meaningful.

Figure 25. Mills Creek, Strecker Road West Conductivity and Control Sites Box and Whisker Plots



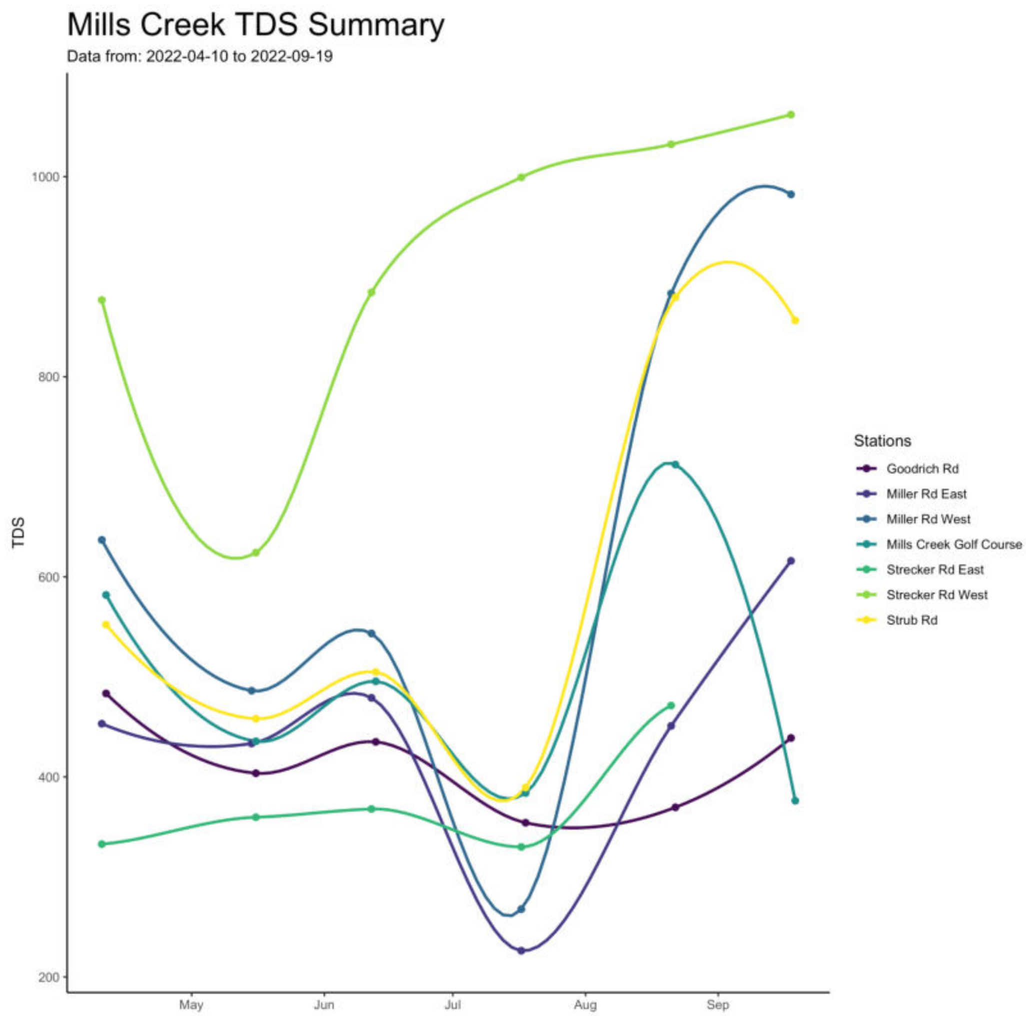
Expressions of Conductivity
Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: 41 samples, Max = 1062.05, Min = 226.27, median = 479.05, 41 exceedances (100%)
41 samples were collected at 7 stations resulting in 41 and 100% exceedances of TDS.

TDS results will follow conductivity patterns because it is calculated from conductivity, either manually or automatically via a meter. TDS has a relationship with conductivity in nature that is reproduced mathematically. It is unknown if TDS results represent ambient conditions and a side experiment currently occuring to provide more insight on this correlation in these watersheds. Calculated TDS was above the “Chronic” and in many cases “Acute” drinking water thresholds for all 7 sampling dates suggests the water is not drinkable without treatment and that aquatic life in Mills Creek may be vulnerable to significant exposure. Interestingly, the lower conductivity results were taken within 24 hours of a 1+ inch storm event. Since rainwater is very low in conductivity, it is possible the conductivity was diluted by this rain water and decreased post storm event to focus resources.

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 and developing its own conductivity thresholds. All TDS results exceeded the drinking water standard, which is expected in that no one expects to consume water in this creek without treatment to reduce TDS. This may not be an effective indicator of aquatic health. However, results did not exceed 1500 mg/L aquatic life threshold LEBAF is exploring The maximum was 1062, approaches 1500 but does not exceed. The median of all sites was 479, well below this aquatic life threshold. If this threshold is protective, aquatic life is not at great risk from TDS, even with the variation between sites. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Elevated TDS can have direct and indirect impacts on aquatic life.

Figure 26. Mills Creek TDS Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



This watershed is highly affected from the karst geology characterized by limestone susceptible to erosion by groundwater and surface water, which can increase conductivity. One site that registered "Acute" is the first downstream site of the Bellevue Wastewater Treatment site. TDS being a common parameter for wastewater analysis may be related to this potential source. This watershed also has limestone quarry discharges which could also increase the conductivity of the stream and can be observed by comparing stations above and below these discharge sites. This certainly warrants attention in future sampling years, though one limitation with this parameter is that it is derived from conductivity measurements. We recommend validating these calculated values by collecting water samples and measuring TDS directly from a subset of stations in future sampling campaigns.

Chloride: 41 samples were collected at 10 stations resulting in 0 and 0% exceedances of chloride of the final acute, acute maximum and final chronic aquatic chloride standards. This suggests aquatic organisms in Mills Creek were at reduced risk to chronic chloride exposure in 2022. Chloride at all 7 stations throughout the sampling period were within the historical range in this river. One potential limitation to data analysis and interpretation for this parameter is that it is not measured directly and without existing data to confirm, it is unknown if it represents ambient conditions. Ground-truthing a subset of samples with direct chloride measurements would increase confidence in using a calculated parameter to assess impacts to aquatic life. Another recommendation for enhancing water quality evaluations in Mills Creek are to measure flow, suspended sediments, nutrient concentrations, e. coli counts, and macroinvertebrate assemblages. Some of these data exist, but are not currently included in the suite of standardized LEVSN parameters to collect but if other data existed could be integrated into these assessments.

Salinity: 41 samples, Max = 1750.35, Min = 325.57, median = 736.21, 11 exceedances (26.8%) 41 samples were collected at 7 stations resulting in 11 samples and 26.8% exceedances of Salinity. USGS general recommendations of freshwater salinity levels below, generates the maximum falls into the slightly saline water category, about the middle. The median is under the freshwater category suggesting that 50% of the time saline is at a supportive level. Exceedances could be related to storm events or other inputs creating perhaps low frequency and short duration exceedance events. More data would need to be collected to verify. Salinity is an indicator for LEBAF, like chloride, primarily related to road salts, deicing compounds and application methods that facilitate those salts entering waterways. The chloride standard was not exceeded and that is an aquatic life threshold, supporting that salinity exceedances are not sufficient magnitude, frequency or duration to cause harm based on this data set.

- Freshwater: Less than 1,000 parts per million (ppm) or 1 g/L
- Slightly saline water: 1,000 ppm – 3,000 ppm or 1– 3 g/L
- Moderately saline water: 3,000 ppm – 10,000 ppm or 3– 10 g/L
- Highly saline water: 10,000 ppm – 35,000 ppm or 10– 35 g/L

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

Mills Creek had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity. Of these, three chemical stressors exceeded thresholds, DO, TDS (drinking water) and salinity and conductivity exceeded the biocondition thresholds for a healthy macroinvertebrate community.

Four dissolved oxygen exceedances occurred, possibly because a particularly dry summer resulted in disconnected surface flows. If aquatic life can find refuge from excess event exposure harm is not experienced. Temperature and pH were supportive of aquatic life. Given these three parameters from this data set, Mills Creek supports a healthy aquatic life condition.

Conductivity is in part higher than HELP ecoregion and stream size reference and survey data because of the karst geology in Mills Creek. Conductivity results likely do represent ambient conditions and align with existing data and what is known about these watersheds, including the geology and groundwater influence on dissolved ion concentrations. Conductivity macroinvertebrate biocondition did indicate that resident macroinvertebrate community structure and function is likely in a degraded condition, which is supported by other data assessing the macroinvertebrate communities in a poor to good range. Other pollutants and habitat conditions may be contributing to this condition.

Results are mixed but encouraging in regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? If conductivity results reflect ambient conditions for the system, it is more likely expressions of conductivity will as well. It is unknown if TDS results do reflect ambient conditions and an additional side experiment to measure TDS directly is ongoing. Regarding TDS assessment methods, exceedances of the TDS drinking water standard are not surprising as no one expects to consume this water without treatment to remove excess TDS. Conductivity and TDS results had a wide variation between stations that is diluted in an aggregate analysis. No TDS result exceeded the 1500 mg/L aquatic life threshold LEBAF is exploring. That may indicate TDS is not a threat to aquatic life. Existing data does not exist for chloride or salinity, but it appears calculated chlorides and salinity results represent ambient conditions but more data is needed. The assessment methods also seem to provide helpful screening, given limitations of the dataset. Salinity levels approached slightly saline, which may be from natural sources or background conditions. It would be helpful to generate conductivity reference and survey metrics for MIlls Creek ecoregion versus using HELP ecoregion, but the overlap in data existed with reference and survey data and expected higher maximum, median and minimum due to karst geology.

Based on LEBAFs definitions, Mills Creek is slightly unhealthy in some locations but healthy in others and warrants continued monitoring and investigation to inform further recommendations. Mills Creek may not support aquatic life in some locations or times of year, these parameters and data are not sufficient to identify the sources or extent. We recommend additional sampling be conducted for flow, sediment, nutrients, bacteria, and macroinvertebrates to build a better description of the health of this watershed. Aside from bacteria, sampling of these parameters have been in process for over a decade but have not been included in the LEBAF analysis.

3.12 Old Woman Creek

Monitoring Groups: One entity in the LEBAF network is Old Woman Creek, which is monitored by Erie SWCD. 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 is broken into 2 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.

Station information: The ten sites sampled in the Old Woman Creek watershed are representative of the stream proper portion of the watershed. The sites are split between the east and west branches of the creek with one site located at the confluence that represents 83% the watershed's drainage basin. Additional sites represent the estuary portion of the watershed but are not included in this analysis.

Number of Stations: 10
Station locations: headwaters to main channel (representing 83% of watershed)
Months Monitored: April, May, June, July, August, September
Total number of observations: 58
Number of dry condition observations: 2

Aggregated Metrics Table - Table 25 Old Woman Creek Summary Statistics

Old Woman Creek Summary Statistics - 58 Samples 10 Stations

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	8.65	7.74	1.9	17.33	4	7%
Water Temperature - C	17.89	19.7	4.9	27.4	3	5.3%
Conductivity - uS/cm	594.63	590	151	934	51	91.1%
Total Dissolved Solids - mg/L	327.04	324.5	83.05	513.7	53	94.6%
pH	7.95	7.94	7.02	9.5	1	1.8%
Chloride - mg/L	29.3	29.08	7.44	46.03	0	0%
Salinity - ppm	487.31	481.93	109.43	794.32	0	0%
2022-04-10 to 2022-09-18						

***Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation**
*** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

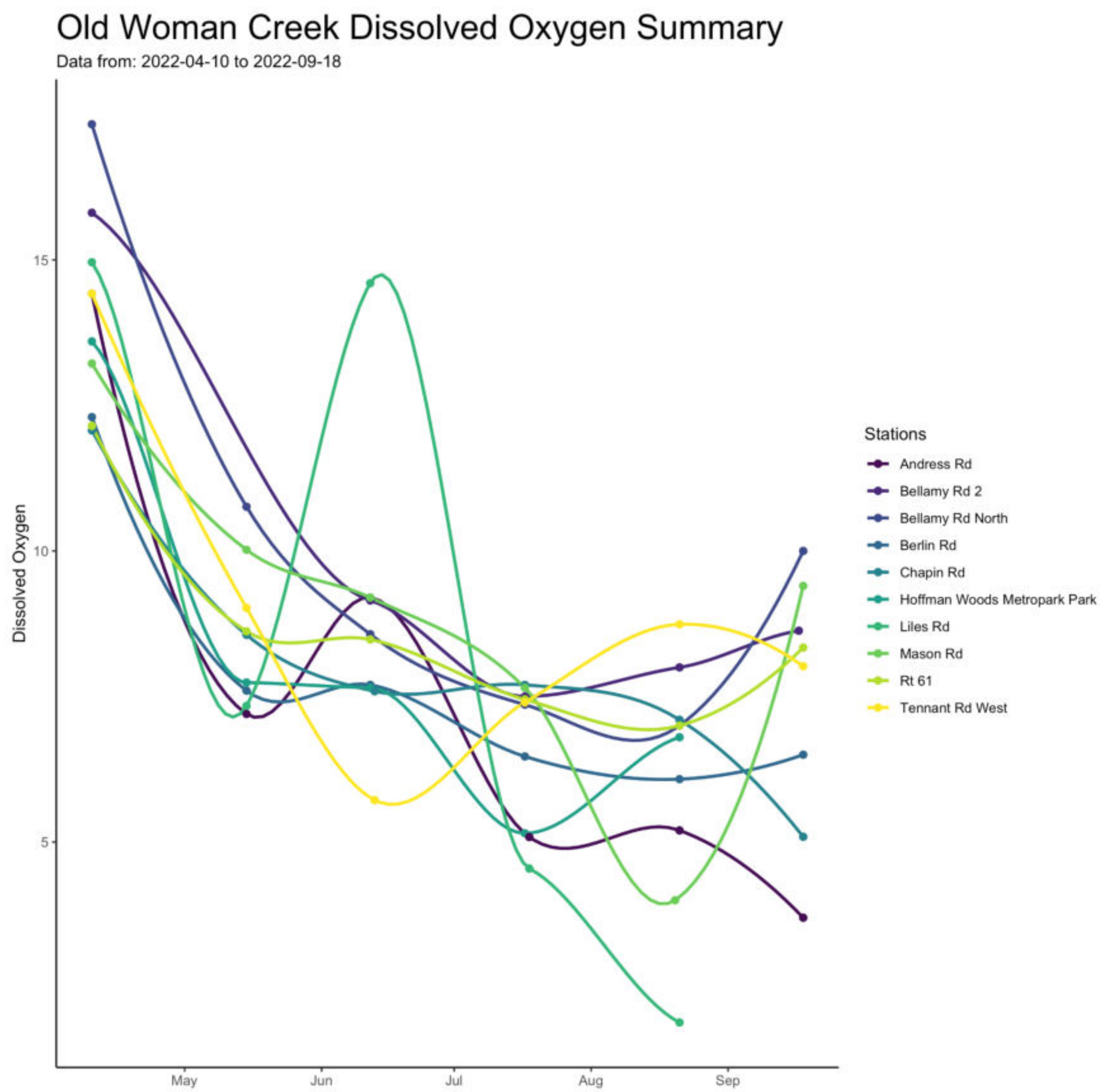
pH: 58 samples, Max = 9.5, Min = 7.94, median = 7.94, 1 exceedances (1.8%)

58 samples were collected at 10 stations resulting in 1 and 1.8% exceedances of pH. pH at all sites throughout 2022 was within the historical range at this site. Variation in pH was small over the course of sampling. pH was within the acceptable range throughout the sampling period except for one observation, which is believed to be an error implementing the sampling protocol. If the exceedance was real, aquatic life that can find refuge during an exposure event escape potential harm. For all other observations, we found 0% exceedances for this parameter. As such, we feel this stream likely falls within the LEBAF health criteria, supports aquatic life in Old Woman Creek and thus should not threaten aquatic life conditions in Lake Erie. However, additional sampling is necessary to rule out potential basic pollutant contamination.

DO: 58 samples, Max = 17.33, Min = 1.9, median = 7.74, 4 exceedances (7%)

58 samples were collected at 10 stations resulting in 4 and 7% exceedances of dissolved oxygen. The highest dissolved oxygen concentration was measured in April while the lowest concentration was measured in September. Many streams in the Great Lakes region follow a similar temporal pattern where dissolved oxygen concentrations are highest in the spring and decrease throughout the summer. Cooler water has the capacity to hold more oxygen, but this pattern may also be due to biological activity. Higher stream respiration in summer than in spring may explain the decreasing oxygen concentrations throughout the study period.

Figure 27. Old Woman Creek Dissolved Oxygen Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.

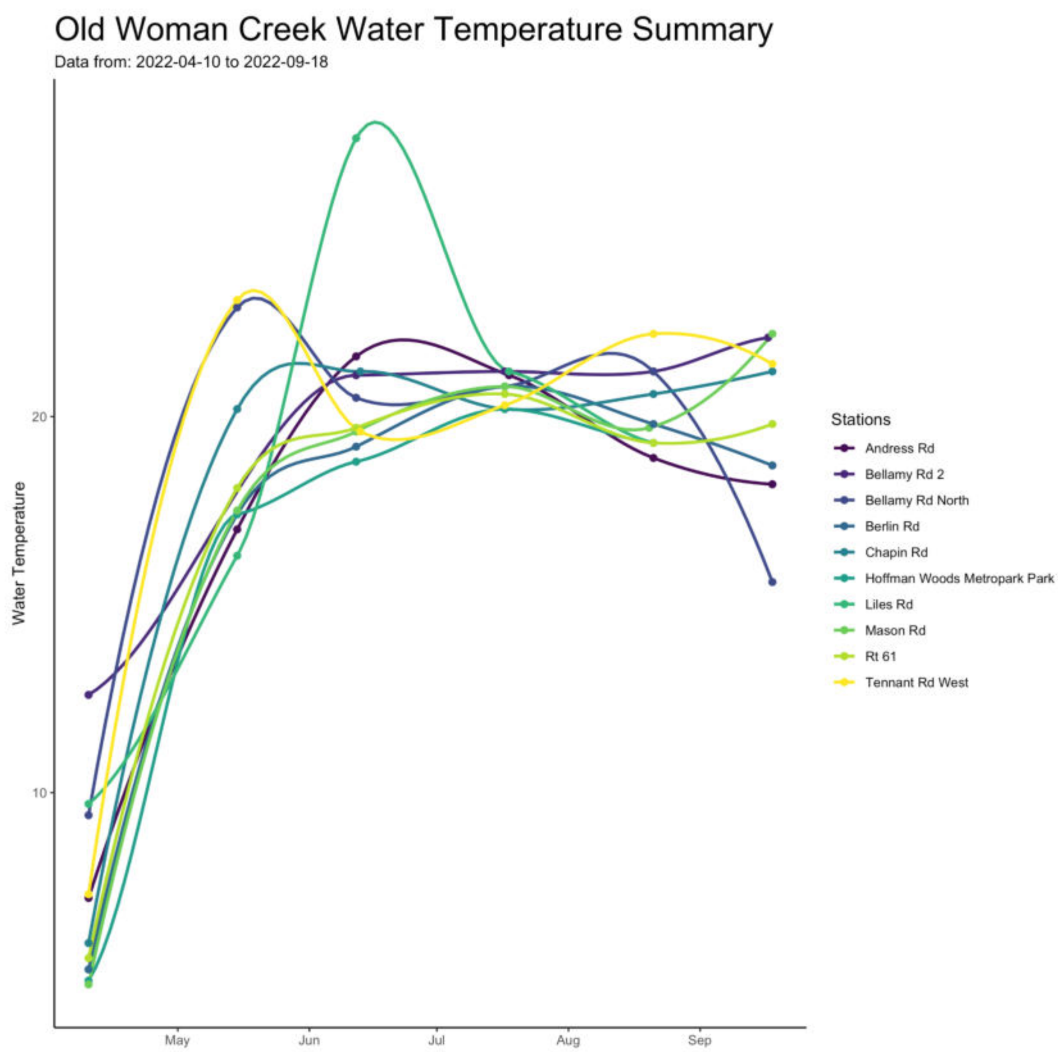


Dissolved oxygen was within the acceptable range throughout most of the sampling period, except for four exceedances of the aquatic life criteria. These four measurements were below the 5.0 mg/L threshold and occurred later in the summer, July, August and September. Weather observations in the summer and early fall of 2022 noted higher than average air temperatures with lower than average precipitation. This created conditions of low to no baseflow especially in the headwater sites where exceedances were noted. Aquatic life that can find refuge during threshold exceedance exposure events can avoid the potential impacts. It is possible aquatic life is harmed by these low dissolved oxygen levels and possibly they find refuge. All 7% of dissolved oxygen exceedances occurred in July, August, and September when baseflow was low, surface water connectivity between sites was broken, and respiration was likely high. Additional monitoring is recommended to see whether dry summers cause reduced flow, and ultimately reduced dissolved oxygen at some of these headwater sites.

Temp: 58 samples, Max = 27.4, Min = 4.9, median = 19.7, 3 exceedances (5.3%)

58 samples were collected at 10 stations resulting in 3 and 5.3% exceedances of water temperature. Water temperature is often considered a "master variable" in freshwater systems because it affects so many biological and chemical processes. In the temperate Great Lakes region, stream water temperatures are often highest in July and August. This is similar to what we observed in our study period, where water temperatures increased by 14.4 ˚C between April and June. Peak water temperatures were 21.6 ˚C and occurred in June, before declining between June and September.

Figure 28. Old Woman Creek Water Temperature Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Water temperature was within the acceptable range for most of the sites throughout the sampling period; however exceedances were noted at 2 headwater sites. One site did not exceed the threshold by very much (magnitude) and is not currently a concern. The smallest headwater site, however, exceeded the temperature for 40% of the sampling period. We feel the lack of shading, higher than average air temperatures, combined with lack of base flow contributed to the higher temperatures. Further sampling is recommended that could inform recommendations to protect or maintain healthy temperature regimes for aquatic life.

Conductivity Survey: 58 samples, Max = 934, Min =151, Median =590,

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results, Old WomanCreek conductivity results fall within the ELOP ecoregion and is a stream size (20 -500 square miles). Old Woman Creek conductivity results and distribution are compared to conductivity distributions of reference and survey sites in the ELOP ecoregion streams sized watershed. The purpose of this comparison is not an assessment against a threshold but to understand the population distribution of results to a robust existing conductivity database, for reference and survey sites. The closer the overlap of distributions, the more similar LEBAF results are to existing data, the greater the confidence in results and more specific recommendations can be developed. Deviations from overlap does not mean conductivity levels are causing harm or are healthy, rather there are different reasons why that could be, a different ecoregion, stream size, localized geology, climate or land use for example.

The below table illustrates that the maximum conductivity result, 934, is less than but very close to both reference and survey data. The median result of 590 is higher than the median reference by 100 units and slightly higher than the median survey. The minimum, 151, is within 20 units of the reference minimum and less than survey sites minimum. This suggests that the population of conductivity on Old Woman Creek given this dataset overlaps well with ELOP reference and survey sites. This strengthens the confidence in using conductivity results for data screening.

Table 26. Old Woman Creek Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	Minimum	25th	50th	75th	Max
Reference	167.00	405.10	489.10	549.00	1,008.00
Survey	375.00	437.00	568.00	774.00	1,260.00
Results	151		590		934

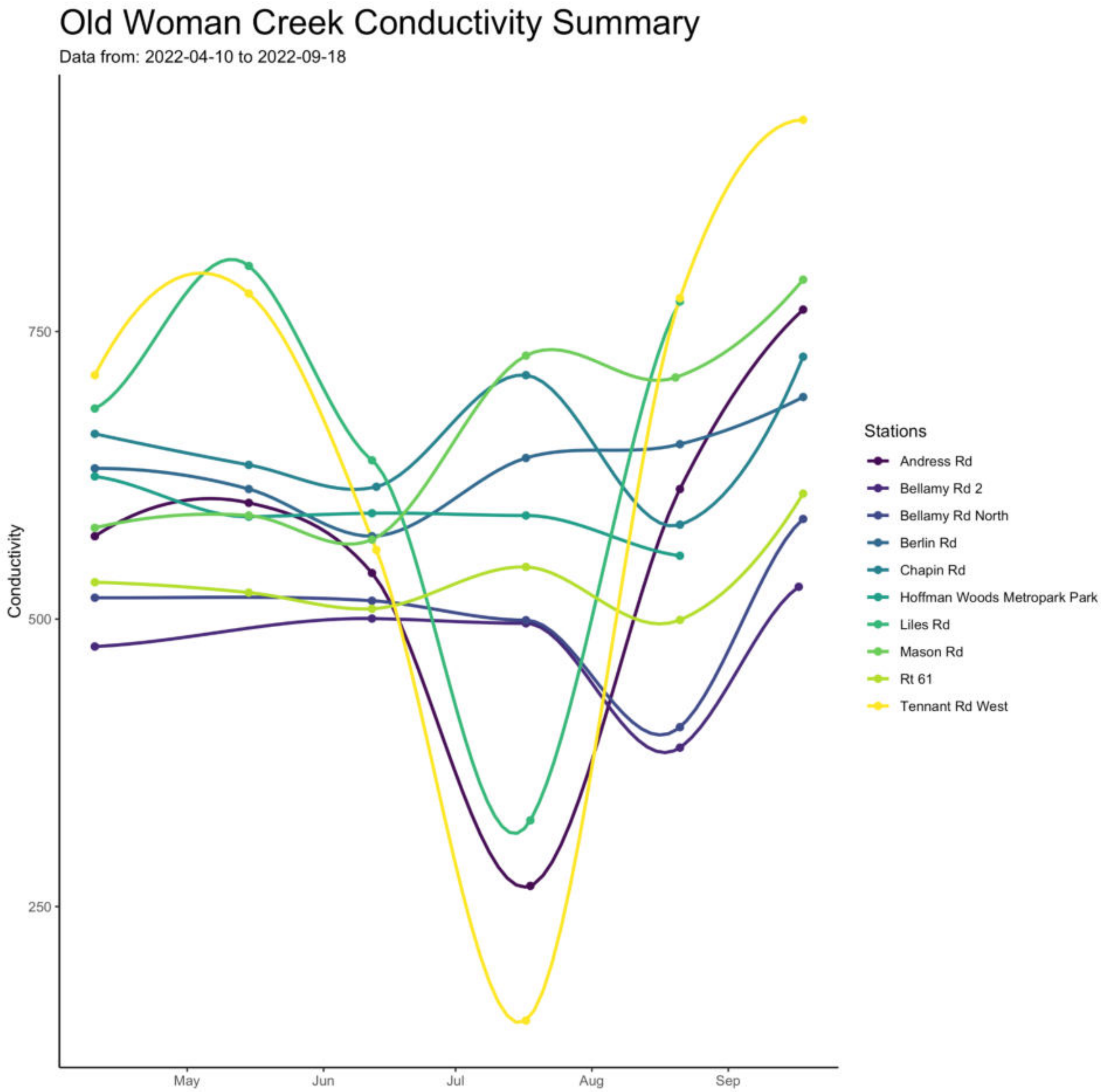
Conductivity results increase in a downstream direction as more land and water drain into the creek. Conductivity in the higher reaches of Old Woman Creek overlap better with reference conductivity data. Sites with conductivity values above the reference data set all occur near the middle of the watershed in and around the Village of Berlin Heights. Higher conductivity values in this area could be driven by aging home sewage treatment system discharges in this area, although it is unclear if aquatic life is being impacted. Macroinvertebrate sampling at sites in and around the Berlin Heights area are good to excellent.

Conductivity Biocondition: 58 samples, Max = 934, Min =151, Median =590, 51 exceedances, 91.1%
58 samples were collected at 10 stations resulting in 51 and 91.1% exceedances of either the 412 or 655 conductivity biocondition thresholds. Conductivity can be a surrogate for potential harmful discharges affecting the aquatic life of the stream. Increased conductivity for extended periods of time may also negatively impact macroinvertebrate communities. A total of 58 conductivity samples were also compared to OEPA macroinvertebrate bio-condition thresholds 412 indicating a healthy macroinvertebrate community, 412-655 indicating a declining and degrading community, and greater than 655 indicating a degrading macroinvertebrate community. Old Woman Creek conductivity values ranged from 151 to 934, with the lowest values associated with a significant precipitation event. Of all samples 91.1% of 2022 field season conductivity values exceeded either the 412 or the 655 macroinvertebrate bio-condition threshold in six of the ten stations. Looking closer we see that:

- The minimum 151 is well below the 412 threshold for healthy communities but it is thought that this result is associated with a storm that diluted non storm event conductivity. However, storm events might provide dilution and relief helping macroinvertebrate conditions.
- About 30, more than half of the conductivity observations were between 412 and 655 microsiemens, which suggest resident communities are in a declining or degrading condition at those sites. Recommendations would focus on verifying this decline and if possible best management practices to reduce or eliminate the decline.

- At 4 stations, conductivity values were above 655 more than 80% of the time. This suggests for resident communities, the frequency and duration of stressors is consistent (80%) and is causing a degraded community condition. The magnitude of exceedance is just over the threshold so perhaps the community condition could be reversed. Verification with actual macroinvertebrate data, existing or new and other stressor identification would help inform restoration actions.
- Of the aforementioned 4 stations where conductivity was higher than 655 on more than 80% of sampling dates, macroinvertebrate sampling showed only one site with a poor community. This site was a headwater location that also exceeded DO and water temperature during the summer months. Increased conductivity for extended periods of time may negatively impact macroinvertebrate communities.
- Four stations were below the 412 threshold and that suggests a healthy community condition and recommendations to identify practices and actions that maintain that condition can be explored.

Figure 29. Old Woman Creek Conductivity Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: 58 samples, Max = 513.7, Min = 83.05, median = 324.5, 53 exceedances (94.6%)
58 samples were collected at 10 stations resulting in 53 and 94.6% exceedances of TDS.

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 and developing its own conductivity thresholds. Throughout the study period, no observations within the study period exceeded the “acute” drinking water threshold. Nearly all observations fell within the “chronic” drinking water thresholds. The magnitude of exceedances was high, but 94% of the samples suggests the frequency is often and duration of events long. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS. This parameter followed the same temporal trend as conductivity in part because it was calculated directly from conductivity measurements and in part because TDS has a relationship with conductivity. However, results did not exceed 1500 mg/L and the maximum was 513, not approaching this threshold and the median 324. This would indicate TDS is not a threat to aquatic life. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Elevated TDS can have direct and indirect impacts on aquatic life.

Fine particulates such as clay might explain these exceedances and could originate from in-stream erosion, as well as runoff. Row crops, which can be susceptible to runoff and erosion, dominate land use throughout the Old Woman Creek watershed and may be another cause for the TDS levels calculated in 2022. More data is needed and LEBAF continue to explore TDS as a screening parameter and its assessment method.

Chloride:
58 samples were collected at 10 stations resulting in 0 and 0% exceedances of the final acute, acute maximum and final chronic aquatic chloride standards. This suggests aquatic organisms in Old Woman Creek were at reduced risk to chronic chloride exposure in 2022. Chloride at all 10 stations throughout 2022 was within the historical range in this river, suggesting that this expression of conductivity is representative of ambient conditions and appropriate for screening purposes. One potential limitation to data analysis and interpretation for this parameter is that it is not measured directly. Ground-truthing a subset of samples with direct chloride measurements would increase confidence in using a calculated parameter to assess impacts to aquatic life. Another recommendation for enhancing water quality evaluations in Old Woman Creek are to measure flow, suspended sediments, nutrient concentrations, e. coli counts, and macroinvertebrate assemblages. Some of these data exist, but are not currently included in LEVSN assessments.

Salinity: 58 samples, Max = 794, Min = 109, median = 482, 0 exceedances (0%)

58 samples were collected at 10 stations resulting in 0 and 0% exceedances of calculated salinity. Calculated salinity did not exceed 794.32 ppm during the study period. The highest observation (794.32 ppm) occurred in September while the lowest (109.43 ppm) occurred in July. This range is consistent with expectations for a Great Lakes stream, and it does not appear that salinity presents any threat to aquatic life in Old Woman Creek. No salinity result at any station exceeded the USGS recommendation for salinity in freshwater (less than 1000 ppm).

The Old Woman Creek NERR measures salinity at several of its downstream monitoring sites at Old Woman Creek and these measurements are consistently within the range of 200-400 ppm. These measurements serve as partial validation for the salinity calculations from conductivity and the relationship between these two.

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

Old Woman Creek had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity. Of these, four chemical stressors exceeded thresholds, DO, pH, temperature and TDS (drinking water) and conductivity exceeded the biocondition thresholds for a healthy macroinvertebrate community.

Exceedances of DO, pH and temperature were few, and if aquatic life can find refuge from excess events, exposure harm may not be experienced. Of all parameters where exceedances occurred, DO is the most threatening to aquatic life. Given these three parameters from this data set, Old Woman Creek supports a healthy aquatic life condition and at some locations and times of year slightly healthy conditions based primarily on DO and low flow conditions.

Chloride and salinity results suggest Old Woman Creek supports aquatic life. These parameters are associated with road salts, deicing compounds and application methods which is not a primary issue in Old Woman Creek.

Conductivity results had similar distribution with ELOP ecoregion and stream size reference and survey data. Conductivity macroinvertebrate biocondition did indicate that stations within Old Woman Creek vary in macroinvertebrate biocondition, which does not identify what stressors may be causing healthy, declining or degraded community conditions, only the status. Some stations were degraded (above 655 µS/cm threshold), some were between 412-655 µS/cm (declining) and four stations were below 412 µS/cm (healthy). When available, existing macroinvertebrate data confirmed this evaluation. Depending on the community status, more macroinvertebrate and stressor data could be explored as well as actions to protect, reverse decline or degradation. All exceedances were not a large magnitude above the thresholds, which are not precise but are a good tool for screening. It is possible other pollutants or habita condition is contributing to macroinvertebrate condition versus parameters LEBAF is monitoring. Each site can follow recommendations as it needs, for example the headwater site Liles Rd observed exceedances in multiple parameters suggesting poor water quality conditions at that station.

Results are mixed but encouraging in regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, first did calculated respective results mirror ambient conditions and second do results and assessment methods provide helpful screening guidance? Conductivity results overlapped with ecoregion and watershed size providing confidence that results do represent ambient conditions. As such it is more likely expressions of conductivity also represent ambient conditions. TDS results varied between stations but didn't seem out of the ordinary for what is known about this system. It is unknown if TDS results do represent ambient conditions and a side experiment measuring TDS directly is ongoing to help confirm. Regarding assessment, TDS results exceeded the TDS chronic drinking water standard but not the acute. This was not a surprise in that no one expects to consume ambient water without treatment. This may not be an effective screening assessment method for aquatic life health. TDS results did not exceed the aquatic life threshold LEBAF is exploring of 1500 mg/L, may or may not be fully protective. Median TDS results were 324, 50% of the time, indicating TDS does support aquatic life.

Existing chloride data supports the expression of conductivity as chloride, suggesting chloride results do represent ambient conditions within the limits of the data set. The chloride assessment method appears to provide valuable information for screening. Existing salinity data does not exist and salinity results seem to represent ambient conditions based on what is known about the river. The salinity assessment method appears to provide valuable information for screening. Direct measurement is always preferred when possible and the role of screening is to provide a feasible method to focus resources for often more expensive direct monitoring.

Based on LEBAFs definitions, Old Woman Creek has some locations that are slightly unhealthy and some that are healthy. Old Woman Creek being a small watershed, is highly susceptible to headwater streams losing base flow in the summer months. This is not only due to small drainage, but also the extensive drainage modifications that have allowed row-crop agriculture to flourish. The modification of the natural flow can be a great factor in several parameters such as water temperature, DO, and conductivity. Those stations with exceedances warrant continued monitoring and investigation to inform further recommendations. The source and extent of stressors causing these exceedances are not necessarily those parameters in this data set but screen for problem areas (the exception is DO in headwaters at specific sites). Old Woman Creek may not support aquatic life in some locations or times of year, these parameters and data set are not sufficient to identify the sources or extent. Old Woman Creekdoes not pose a threat to aquatic life in Lake Erie because it is a small stream. However, many small systems with unhealthy conditions can add up to a large river impact on Lake Erie.

We recommend additional sampling be conducted for flow, sediment, nutrients, bacteria, and macroinvertebrates to build a better description of the health of this watershed. Aside from bacteria, sampling of these parameters have been in process for over a decade but have not been included in the LEBAF analysis.

3.13 Pipe Creek

Monitoring Organizations: One entity in the LEBAF network monitors in Old Woman Creek basin, Erie SWCD. Pipe Creek is a 48.5 square mile watershed that combines 3 separate direct tributaries: Pipe Creek, Hemminger Ditch, and Plum Brook. All three sub basins 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.

Station Information: The seven sites sampled in the Pipe Creek watershed are representative of the stream proper portion of the Pipe Creek. The stations transition from headwaters to mouth and provide collection points both upstream and downstream of land uses that may be the source to stressors in the watershed.

Number of Stations: 7
Station locations: headwaters to mouth (only representing Pipe Creek proper)
Months Monitored: April, May, June, July, August, September
Total number of observations: 41

Aggregated Metrics Table - Table 27 Pipe Creek Summary Statistics

Pipe Creek Summary Statistics - 41 Samples 7 Stations						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	8.42	8.06	1.31	14.27	2	4.9%
Water Temperature - C	17.39	19	3.7	23	0	0%
Conductivity - uS/cm	930.6	914	345.6	1766	39	95.1%
Total Dissolved Solids - mg/L	511.83	502.7	190.08	971.3	40	97.6%
pH	7.99	7.97	7.2	8.8	0	0%
Chloride - mg/L	45.86	45.04	17.03	87.03	0	0%
Salinity - ppm	794.6	775.83	269.35	1588.28	6	14.6%
2022-04-10 to 2022-09-19						

Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

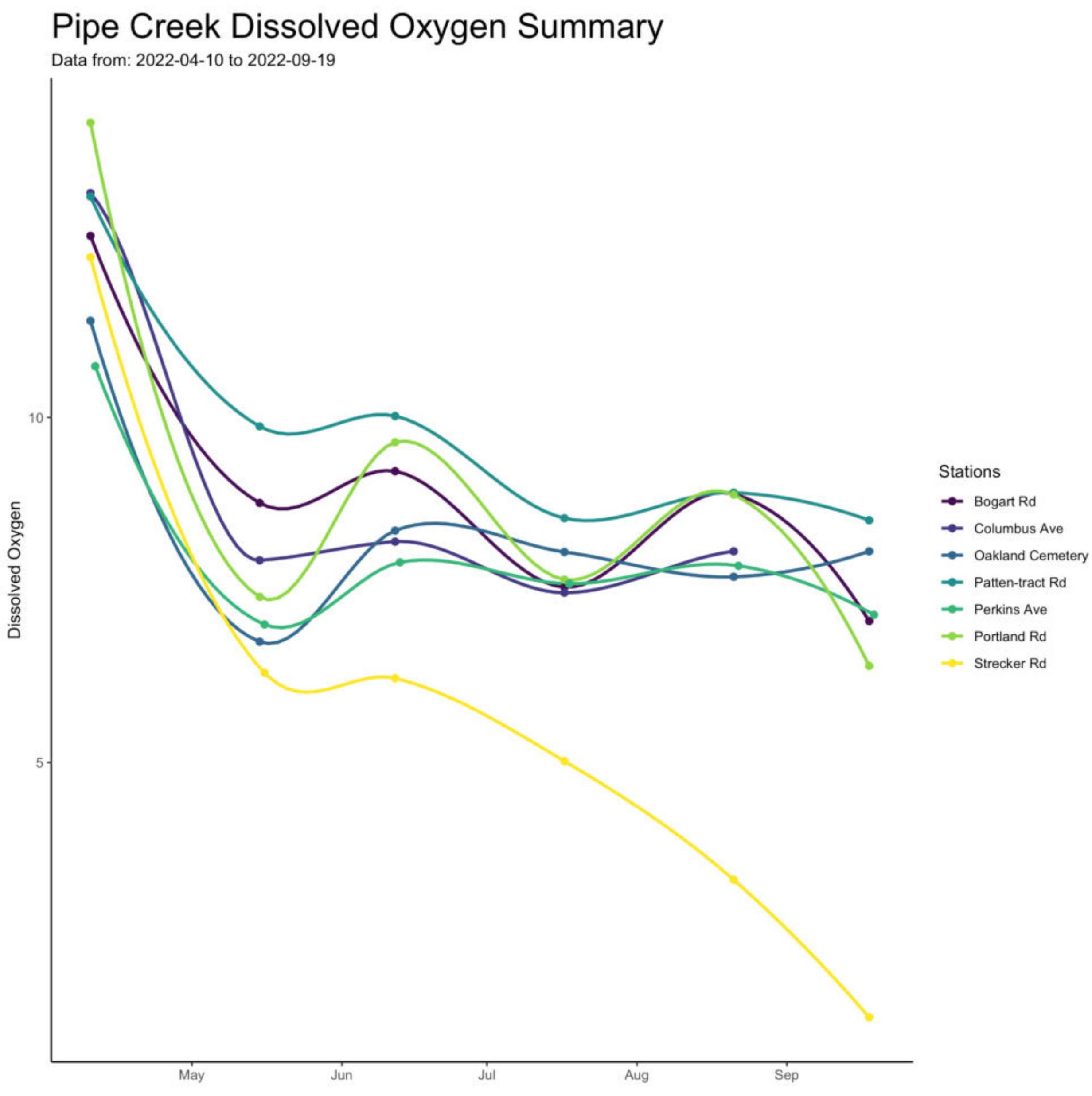
pH: 41 samples, Max = 8.8, Min = 7.2, median = 7.97, 0 exceedances (0%)

41 samples were collected at 7 stations resulting in 0 and 0% exceedances of pH. pH at all sites throughout 2022 was within the historical range at this site. Variation in pH was small over the course of sampling. pH was within the acceptable range throughout the sampling period, as we found 0% exceedances for this parameter. As such, we feel this stream likely falls within the LEBAF health criteria and should not threaten Lake Erie.

DO: 41 samples, Max = 14.27, Min = 1.31, median = 8.06, 2 exceedances (4.9%)

41 samples were collected at 7 stations resulting in 2 and 4.9% exceedances of dissolved oxygen. The highest dissolved oxygen concentration was measured in April while the lowest concentration was measured in September. Many streams in the Great Lakes region follow a similar temporal pattern where dissolved oxygen concentrations are highest in the spring and decrease throughout the summer. Cooler water has the capacity to hold more oxygen, but this pattern may also be due to biological activity. Higher stream respiration in summer than in spring may explain the decreasing oxygen concentrations throughout the study period.

Figure 30. Pipe Creek Dissolved Oxygen Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Dissolved oxygen was within the acceptable range throughout most of the sampling period, except for two exceedances of the aquatic life criteria. These two measurements were below the 5.0 mg/L threshold and occurred in August and September. Weather observations in the summer and early fall of 2022 were higher than average air temperatures with lower than average precipitation. This created conditions of low to no baseflow especially in the headwater sites where exceedances were noted. Aquatic life that can find refuge during threshold exceedance exposure events can avoid the potential impacts. It is possible aquatic life is harmed by these low dissolved oxygen levels and possibly they find refuge. All 4.9% of dissolved oxygen exceedances occurred in August and September when baseflow was low, surface water connectivity between sites was broken, and respiration was likely high. Additional monitoring is recommended to see whether dry summers cause reduced flow, and ultimately reduced dissolved oxygen at some of these headwater sites.

Temp: 41 samples, Max = 23, Min = 3.7, median = 19, 0 exceedances (0%)

41 samples were collected at 7 stations resulting in 0 and 0% exceedances of water temperature. Water temperature is often considered a "master variable" in freshwater systems because it affects so many biological and chemical processes. In the temperate Great Lakes region, stream water temperatures are often highest in July and August. This is similar to what we observed in our study period, where water temperatures increased by 19.3 ˚C between April and June. Peak water temperatures were 23 ˚C and occurred in June, before declining between June and September.

Water temperature was within the acceptable range for all of the sites throughout the sampling period. As such we feel this stream likely falls within the LEBAF health criteria of and does not likely threaten Lake Erie.

Conductivity Survey: 41 samples, Max = 1766, Min = 345.6, median = 914, with the average 931

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. 41 samples were collected at 7 stations resulting in 0 and 0% exceedances of dissolved oxygen. Pipe Creek conductivity results fall within the HELP ecoregion and is a stream size (20 -500 square miles). Pipe Creek conductivity results and distribution are compared to conductivity distributions of reference and survey sites in the HELP ecoregion streams sized watershed. The purpose of this comparison is not an assessment against a threshold but to understand the population distribution of results to a robust existing conductivity database, for reference and survey sites. The closer the overlap of distributions, the more similar LEBAF results are to existing data, the greater the confidence in results and more specific recommendations can be developed. Deviations from overlap does not mean conductivity levels are causing harm or are healthy, rather there are different reasons why that could be, a different ecoregion, stream size, localized geology, climate or land use for example.

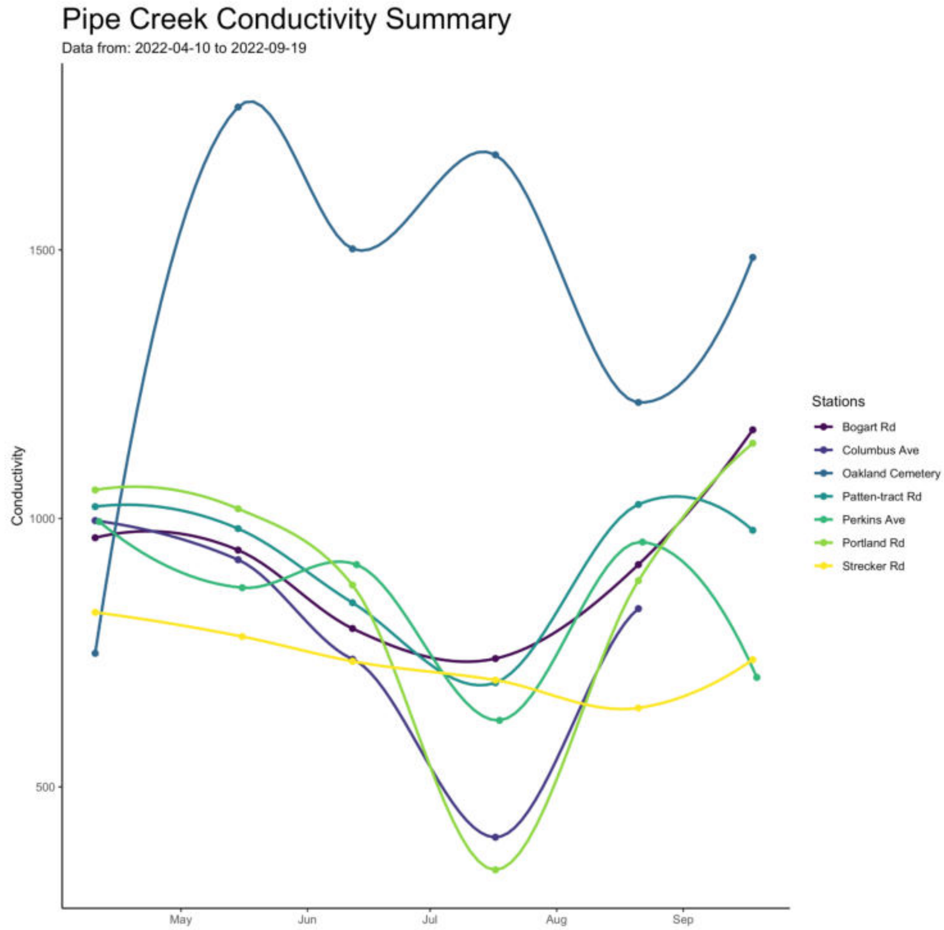
The below table illustrates that the maximum conductivity result, 1766, is greater than both reference and survey sites but only by 300 units which is not a high magnitude for conductivity. The median result of 914 is higher than both data sets again by about 300 units. The minimum, 345 is also higher than both minimums but by much. This suggests that the population of conductivity observations for Pipe Creek overlap with HELP reference and survey sites, however, are higher than reference and survey site data. Alignment and deviation does not mean conductivity is harmful or not harmful in this assessment. This strengthens the confidence in using conductivity results for data screening.

Table 28. Pipe Creek Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	166.00	529.48	652.75	778.00	1,400.00
Survey	248.00	490.78	633.10	740.00	1,450.00
Results	345		914		1766

Conductivity results increase in a downstream direction as more land and water drain into the creek. Differences in the conductivity population can be attributed to natural or anthropogenic sources, such as geology in the former and land use in the latter. With the karst geology of this stream causing higher than average conductivity values for streams in this ecoregion, we would expect macroinvertebrate communities to show signs of stressed environment. One site stood out as having significantly higher conductivity than other sites was Oakland Ave. This site is a small drainage basin with a large NPDES permitted discharge from a local limestone quarry.

Figure 31. Pipe Creek Conductivity Summary Data Graph



Conductivity Biocondition: 41 samples, Max = 1766, Min = 345.6, median = 914, 39 exceedances (95.1%)

41 samples were collected at 7 stations resulting in 39 and 95.1% exceedances of conductivity to biocondition. Conductivity can be a surrogate for potential harmful discharges affecting the aquatic life of the stream. Increased conductivity for extended periods of time may also negatively impact macroinvertebrate communities. A total of 41 conductivity samples were also compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm indicating a healthy macroinvertebrate community, 412-655 indicating a declining and degrading community, and greater than 655 µS/cm, indicating a degrading macroinvertebrate community.

Pipe Creek conductivity values ranged from 345.6 µS/cm to 1766 µS/cm. 97.6% of 2022 field season conductivity. Nearly all observations exceeded the criteria for conductivity (>655 µS/cm) suggesting resident macroinvertebrate communities may be in a degraded community condition. However, some sites or times of year were under the 412 µS/cm threshold suggesting healthy macroinvertebrate community conditions. And some of the exceedances were between

412 and 655 µS/cm, indicating a declining, perhaps reversible community condition. The exceedances were 95% of the time suggesting a high frequency and duration but magnitude is not large. These results align with macroinvertebrate sampling at several sites within the watershed show poor to good ratings. More macroinvertebrate and stressor data would help guide further recommendations to protect healthy sites, reverse declining sites and restore degraded sites.

Expressions of Conductivity

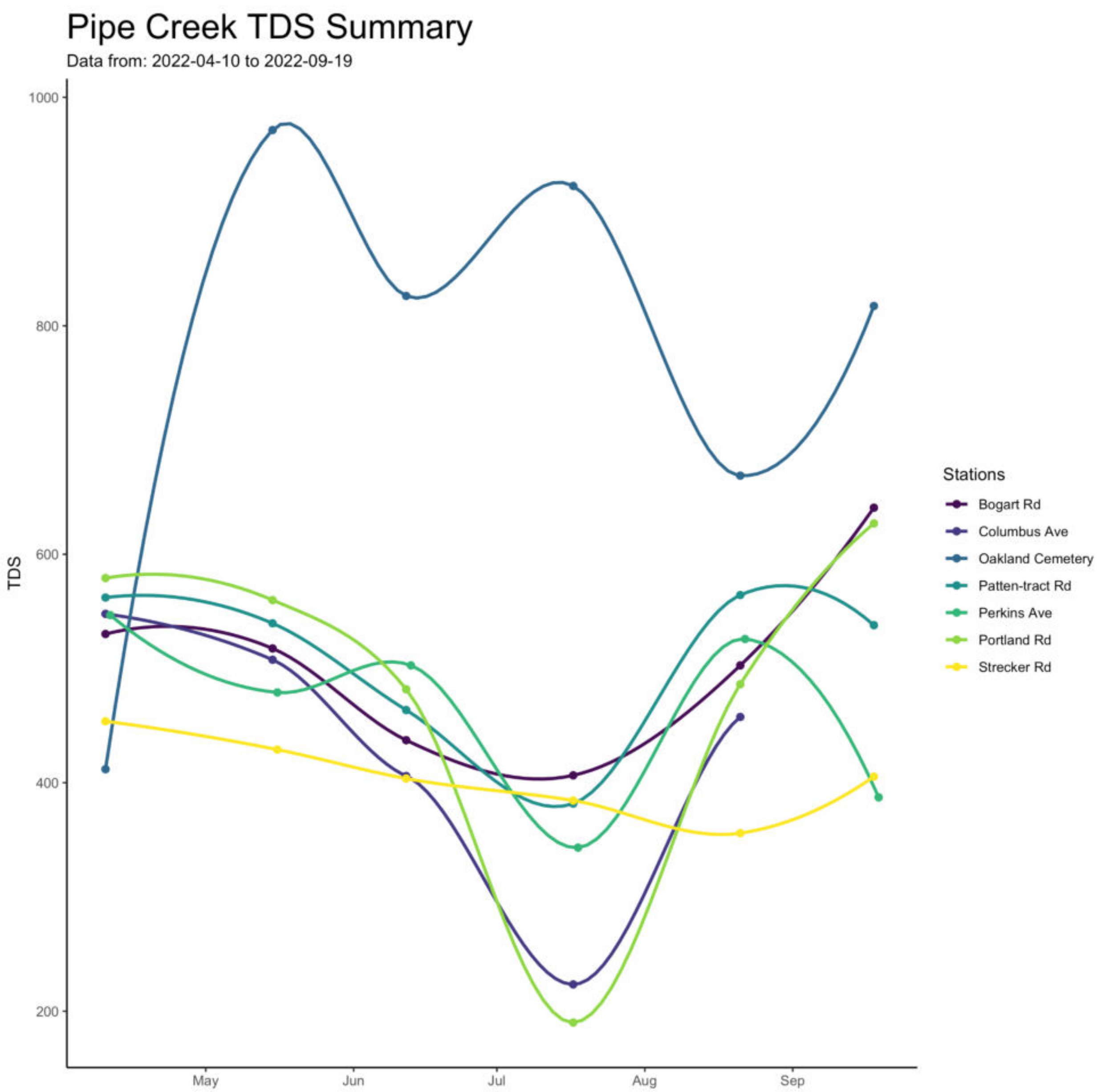
Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: 41 samples, Max = 971.3, Min = 345.6, median = 502.7, 40 exceedances (97.6%)
41 samples were collected at 7 stations resulting in 40 and 97.6% exceedances of TDS.

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 and developing its own conductivity thresholds. Throughout the study period, nearly all observations fell within the "chronic" drinking water standard thresholds. All but one observation within the study period exceeded the acute or chronic drinking water threshold, suggesting that the water is not drinkable without treatment. Exceedances of the drinking water threshold are expected as no one expects to drink water from the river without treatment that removes excess TDS. However, results did not exceed 1500 mg/L and the maximum was971, not approaching this threshold and the median 502, or 50% of the time 1000 units below the threshold. This would indicate TDS is not a threat to aquatic life. Aquatic life can be more sensitive to a stressor than humans as they are in the water and exposed in theory for all life cycles. Elevated TDS can have direct and indirect impacts on aquatic life.

One station had a different pattern than all the others as illustrated below and this may skew aggregate results. This station is responsible for the maximum conductivity and TDS results. TDS is likely not a threat to aquatic life even at this station, if the 1500 mg/L is indeed a protective threshold.

Figure 32. Pipe Creek TDS Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



This watershed is highly affected from the karst geology characterized by limestone susceptible to erosion by groundwater and surface water, which can increase conductivity. This watershed also has two limestone quarry discharges which could also increase the conductivity of the stream and can be observed by comparing stations above and below these discharge sites. This certainly warrants attention in future sampling years. While direct measurement is preferred and recommended, the relationship between conductivity and TDS is scientifically sound. We recommend validating these calculated values by collecting water samples and measuring TDS directly from a subset of stations in future sampling campaigns in addition to identifying other stressors that may be more representative of what is impacting macroinvertebrate communities and the degree they are impacted.

Chloride: 41 samples were collected at 7 stations resulting in 0 and 0% exceedances of the final acute, acute maximum and final chronic aquatic chloride standards. Calculated chloride concentrations ranged from 17.03-87.03 mg/L throughout the sampling period. The absence of exceedances suggests aquatic organisms in Pipe Creek were at reduced risk to chronic chloride exposure in 2022. Chloride at all 7 stations throughout 2022 was within the historical range in this river. One potential limitation to data analysis and interpretation for this parameter is that it is not measured directly. Ground-truthing a subset of samples with direct chloride measurements would increase confidence in using a calculated parameter to assess impacts to aquatic life. Another recommendation for enhancing water quality evaluations in Pipe Creek are to measure flow, suspended sediments, nutrient concentrations, e. coli counts, and macroinvertebrate assemblages. Some of these data exist, but are not currently included in LEVSN assessments.

Salinity: 41 samples, Max = 1588.28, Min = 269.35, median = 775.83, 6 exceedances (14.6%)
41 samples were collected at 7 stations resulting in 6 and 14.6% exceedances of salinity. The maximum salinity exceeded the USGS recommendation for salinity in freshwater (less than 1000 ppm) and was in the slightly saline category (1000-3000 ppm). The analysis application did not include this criteria and assessment thus the metric table above is incorrect. The median is below the freshwater salinity category and suggests that 50% likely even 75% of the time salinity is not an issue.

- Freshwater: Less than 1,000 parts per million (ppm) or 1 g/L
- Slightly saline water: 1,000 ppm – 3,000 ppm or 1-3 g/L
- Moderately saline water: 3,000 ppm – 10,000 ppm or 3-10 g/L
- Highly saline water: 10,000 ppm – 35,000 ppm or 10 - 35 g/L

The exceedance is likely from an isolated event and location, low in frequency, short in duration and a medium magnitude. More sampling would be needed to characterize the distribution and assess real impacts. LEBAFs primary concern with salinity and chloride is associated with road salts, deicing compounds and application methods which is not a primary stressor in Pipe Creek.

<u>Aggregated Overall Summary:</u> (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

Pipe Creek had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity. Of these, three chemical stressors exceeded thresholds, DO, TDS (drinking water) and salinity and conductivity exceeded the biocondition thresholds for a healthy macroinvertebrate community.

Exceedances of DO were few, could be explained and If aquatic life can find refuge from excess event exposure harm is not experienced. Given this and no exceedances of pH and temperature in this, Pipe Creek supports a healthy aquatic life condition and at some locations and times of year slightly healthy conditions based primarily on DO and low flow conditions.

Conductivity results had similar distribution with HELP ecoregion and stream size reference and survey data. Differences which are not large are likely due to geology, such as karst formations and in some cases may be anthropogenic. Conductivity macroinvertebrate biocondition did indicate that stations within Pipe Creek vary in macroinvertebrate biocondition, which does not identify what stressors may be causing healthy, declining or degraded community conditions, only the status. Some stations were degraded (above 655 threshold), some were between 412-655 (declining) and some stations were below 412 (healthy). Existing macroinvertebrate data confirmed this where it was available. Depending on the community status, more macroinvertebrate and stressor data could be explored as well as actions to protect, reverse decline or degradation. All exceedances were not a large magnitude above the thresholds, which are not precise but screening. Each site can follow recommendations as it needs, for example the headwater site Liles Rd observed exceedances in multiple parameters suggesting poor water quality conditions at that station.

Results are mixed but encouraging in regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? Conductivity results overlapped with ecoregion and watershed size providing confidence that results do represent ambient conditions. As such it is more likely expressions of conductivity also represent ambient conditions. TDS results were similar for all stations but one and that difference is explained by land use and geology. It is unknown if TDS results do represent ambient conditions and a side experiment measuring TDS directly is ongoing to help confirm. Regarding assessment, TDS results primarily exceeded the TDS chronic drinking water standard. This was not a surprise in that no one expects to consume ambient water without treatment. This may not be an effective screening assessment method for aquatic life health. TDS results did not exceed the aquatic life threshold LEBAF is exploring of 1500 mg/L, may or may not be fully protective. Median TDS results were 502, 50% of the time, indicating TDS does support aquatic life.

Existing chloride data supports the expression of conductivity as chloride, suggesting chloride results do represent ambient conditions within the limits of the data set. The chloride assessment method appears to provide valuable information for screening. Existing salinity data does not exist and salinity results seem to represent ambient conditions based on what is known about the river. The salinity assessment method appears to provide valuable information for screening. The median suggests that 50-75% of the time or more, salinity falls into a freshwater range, less than 1000 ppm. Results in this data set suggest Pipe Creek supports aquatic life. These parameters are associated with road salts, deicing compounds and application methods which is not a primary issue in Pipe Creek. Direct measurement is always preferred when possible and the role of screening is to provide a feasible method to focus resources for often more expensive direct monitoring.

Based on LEBAFs definitions, Pipe Creek has some locations that are slightly unhealthy or unhealthy part of a year based on a parameter and some that are healthy. Pipe Creek being a small watershed, is highly susceptible to headwater streams losing base flow in the summer months. This is not only due to small drainage, but also the extensive drainage modifications that have allowed row-crop agriculture to flourish. The modification of the natural flow can be a great factor in several parameters such as temp, DO, and conductivity. Those stations with exceedances warrant continued monitoring and investigation to inform further recommendations. The source and extent of stressors causing these exceedances are not necessarily those parameters in this data set but screen for problem areas (the exception is DO in headwaters at specific sites). Pipe Creek may not support aquatic life in some locations or times of year, these parameters and data set are not sufficient to identify the sources or extent. Pipe Creek, likely as a smaller system, does not pose a threat to aquatic life in Lake Erie. However, many small systems with unhealthy conditions can add up to a large river impact on Lake Erie.

We recommend additional sampling be conducted for flow, sediment, nutrients, bacteria, and macroinvertebrates to build a better description of the health of this watershed. Aside from bacteria, sampling of these parameters have been in process for over a decade but have not been included in the LEBAF analysis.

Section 4 – Results: Lake Erie Stations

4.1 Background: Stations Directly on Lake Erie

Aggregated Data - Table 29 Lake Erie Summary Statistics

Lake Erie Summary Statistics - 12 Samples 2 Stations						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	9.53	9.41	7.53	12.83	0	0%
Water Temperature - C	18.84	20.32	9.69	24.94	10	83.3%
Conductivity - uS/cm	295.23	287.75	273.9	361.6	0	0%
Total Dissolved Solids - mg/L	162.38	158.26	150.65	198.88	0	0%
pH	8.32	8.34	8.01	8.54	0	0%
Chloride - mg/L	14.55	14.18	13.5	17.82	0	0%
Salinity - ppm	227.01	220.68	209.15	282.94	0	0%
2022-05-13 to 2022-10-14						

The title should reflect 5 stations, not 2 stations
Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation
*** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Five stations were sampled in 2022 that monitored the shoreline, nearshore, or open water of Lake Erie. Two entities in the network monitored these sites: SUNY Fredonia sampled in three harbors via boat access and Buffalo Niagara Waterkeeper monitored two sites on Lake Erie samples collected on the shoreline. These stations are included in the full Lake Erie Basin Analysis but not in any River/Tributary analysis. As the number of shoreline, harbor, or open water sites grow, LEBAF will work to create a more robust framework for conducting direct analysis on Lake Erie in addition to its watersheds.

Sampling techniques, resources, training and other differences between lentic and lotic systems lend to concentrating volunteer monitoring groups in lotic or running water ecosystems (brooks, streams and rivers) versus lentic or open and standing water systems (ponds, lakes, reservoirs, estuaries, bays and oceans). Likewise, lentic and lotic systems have different habitats and conditions that support different aquatic life and transition zones are also unique. Therefore, criteria to assess aquatic life support is also different between the two systems.

LEBAF employed standards, thresholds and relevant datasets created for lotic or running water systems not lentic or open water systems. However, temperature, pH, dissolved oxygen, for example are common indicators of support in both systems and can be employed in screening for aquatic life support with appropriate transparency and weight given to analyses, interpretation, recommendations and conclusions. Conductivity, macroinvertebrate biocondition thresholds, TDS, chloride and salinity can also be indicators of water quality health but with more caution and attention to lotic systems or rivers, lentic systems and transition zone from rivers to lake differences, including sampling method. Macroinvertebrate communities, a biological indicator versus chemical, shift in composition, structure and function and the database used for these thresholds were lotic communities.

Even though there are differences in chemistry and aquatic life thresholds between lentic and lotic systems, aquatic life thresholds designed for river systems can be used for screening purposes on lake results with proper transparency and assumptions, as we do here. For example, if a conductivity level in a lentic system supports a healthy lotic macroinvertebrate community it is possible to infer, with transparency about limitations of such an inference, that the same conductivity would support lentic macroinvertebrates. The inference is that higher quality biocondition conductivity (<412 units) would likely support macroinvertebrates in shoreline Lake Erie stations with conductivity < 412 units. This is part of an overall set of parameters used as screening information to inform further monitoring or other actions. Likewise, conductivity levels above 655 units may not be as supportive of macroinvertebrate communities.

Thus, the limitations of applying lotic standards to a lentic environment are noted here and applied to the below analyses and interpretation. As are the limitations of making inferences about the health of Lake Erie from results and interpretation of lentic receiving waters and shoreline transition zones. Sampling in harbors and shorelines are collected on the surface and do not account for any changes that may occur in a depth profile, changing tides or micro-climate conditions that may vary from lentic systems such as ice formation. While this study design is not appropriate for all monitoring purposes and data uses, it is for LEBAFs monitoring purpose of condition assessment for the data use of screening.

For reference, in general the following assumptions apply to analyses and interpretation in this section for each parameters standard or threshold:
pH - The lower and higher standard used in lotic systems is representative in harbors, shorelines and lentic systems, often the same standard for aquatic life use.
Dissolved Oxygen - Lotic systems do not have temperature depth profiles or seasonal turnovers with the exception of large rivers that behave more like a slow moving lake than a running river.

Lentic systems are classified as cold and warm, sometimes temperate, as are lotic systems. Often a comparative standard exists between lentic and lotic systems, like pH but not as precise. For LEBAF's monitoring purpose and data screening use, applying lentic standards to the harbor and shoreline sites do help determine support for aquatic life in those transition zones, with appropriate applied limitations for further recommendations.

Temperature - Lotic systems do not have temperature depth profiles or seasonal turnovers with the exception of large rivers that behave more like a slow moving lake than a running river. Lentic systems are classified as cold and warm, sometimes temperate, as are lotic systems. For LEBAF monitoring purpose and data screening use, applying lotic standards to the harbor and shoreline sites does help determine support for aquatic life in those transition zones, with appropriate applied limitations for further recommendations.

Conductivity and Macroinvertebrate biocondition - Referring to freshwater systems only, conductivity values are different between lentic and lotic systems. Dilution, depth, retention time, geology, climate, and proximity to inlets are a few factors that influence conductivity of the lentic system or transition zone. LEBAF compares conductivity to a lotic system database for reference and survey sites, not lentic sites, therefore this comparison is not meaningful for most monitoring purposes or data uses. However, under the assumption that shoreline sites by river mouths and harbor sites are often transition zones (mixing water) and if conductivity of harbor or shoreline sites are comparable to reference and survey datasets, then that site perhaps still represents lentic conductivity conditions and infers a degree of quality.

Regarding macroinvertebrate biocondition threshold comparisons (<412 units healthy, 412-655 units declining and >655 units degraded), if the quality is supportive of a healthy lotic community then perhaps it supports a quality lenticc community. The further assumption is that sampling of the actual response community is a direct, accurate and more precise indicator. Both these indicators will be employed with proper weight and can inform LEBAF's monitoring purpose and screening data use.

Expressions of Conductivity

Calculated TDS - Like conductivity has few aquatic life standards in either lentic or lotic systems. LEBAF is exploring Ohio's 1500 mg/L aquatic life threshold for lotic systems. TDS in lentic systems is often not collected for screening and instead an indicator of clarity by Secchi Dish or other methods is used, sometimes along with TSS. This inaugural year, LEBAF used TDS drinking water standards as a surrogate for aquatic health while exploring the 1500 mg/L aquatic life threshold. LEbAF states that clean enough for drinking water may also be clean enough for aquatic life but may not, it is one indicator and for LEBAF's monitoring purpose and screening data use can be employed at these sites with appropriate transparency.

Calculated Chloride - is a nutrient, pollutant and naturally occurs in both systems, but behaves differently in each system. Chloride tied to salts is toxic for aquatic life at some level. Chloride standards for drinking water can be applied as an indicator but LEBAF employed relatively new aquatic life chloride standards developed in Michigan. Even though aquatic life community composition, structure and function are shifting, LEBAF's chloride standard can be used to

inform condition and data screening. While nitrogen and phosphorus are the primary nutrients of concern in lentic systems, chloride is important as well.
Calculated Salinity - is also a nutrient, pollutant and naturally occurs in both systems. A primary concern or source of salinity is de-icing compounds and applications where salt enters freshwater systems. This indicator is useful at harbor and shoreline sites from this perspective.

4.2 Barcelona Harbor

Monitoring Organizations: SUNY Fredonia monitors in Barcelona Harbor.

Station Information: This station was sampled six times during the season via boat access.

Aggregated Metrics Table - Table 30 Barcelona Harbor Summary Statistics

Barcelona Harbor Summary Statistics - 6 Samples

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	6.94	6.69	6.27	7.78	0	0%
Water Temperature - C	18.4	18.85	12.7	23.7	0	0%
Conductivity - uS/cm	2.16	2.38	1.45	2.6	0	0%
Total Dissolved Solids - mg/L	1.19	1.31	0.8	1.43	0	0%
pH	8.11	8.09	8.01	8.32	0	0%
Chloride - mg/L	10.66	11.75	7.16	12.8	0	0%
Salinity - ppm	1.08	1.2	0.7	1.32	0	0%

SUNY Fredonia 2022-09-04 to 2022-10-09

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

pH: 6 samples, Max = 8.32, Min = 8.01, median = 8.09, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that standards would always be met. This site is in line with expected values.

We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling may be needed to confirm this conclusion.

DO: 6 samples, Max = 7.78, Min = 8.01, Median = 7.04, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that the site would be within the established standards. This site is in line with expected values. We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling could help confirm this conclusion.

Temp: 6 samples, Max = 23.7, Min = 12.7, Median = 18.85, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that the site would be within the established standards. This site is in line with expected values. We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling could help confirm this conclusion.

Conductivity Survey: Max =2.6, Min = 1.45, Median = 2.38

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. This site's conductivity results were compared to EOLP ecoregion and river stream size, as expected to be lower than these data base values. The below table illustrates that conductivity is well below the maximum, median and even the reference minimum at this site. This illustrates that the comparison of conductivity results to lentic conductivities in reference and survey data is not helpful. This site is a lentic site not a lotic site or even in a transition zone like a harbor or shoreline site maybe if proximate to tributaries for example. The data set itself is limited, actual macroinvertebrate data would be helpful. For lake or lentic sites, this comparison does not have much weight.

Table 31 - Barcelona Harber Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	183.00	348.00	455.60	602.00	500.00
Survey	304.00	416.00	585.00	780.00	1201.00

Results	1		2		3

All six measurements exceeded the low standard. This site is not in line with expected values. We would not expect the recorded values that we found. Based on the definition used by LEBAF, this site is not seen as healthy. I am not sure the cause of this discrepancy

Conductivity Biocondition: A total of 6 samples were collected along the Barcelona Harbor with 0 exceedances to the macroinvertebrate biocondition thresholds. Values ranged from 1.45 to 2.6 max, with a data median of 2.38. All six measurements were below the lentic macroinvertebrate biocondition threshold for health at 412. This site is a lentic site, with different macroinvertebrate communities and health thresholds. It is not appropriate to compare conductivity results to this biocondition range. If this site was a river, it would support aquatic life based on conductivity however. The summary metric table shows 100% exceedances but it is in error, there were no exceedances.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: A total of 6 samples were collected with values ranging from 0.8 mg/L to 1.43 mg/L, with a median of 1.31 mg/L. 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 and developing its own conductivity thresholds. Results did not exceed any TDS drinking water standard or the aquatic life threshold of 1500 mg/L. From this perspective, no exceedances of the TDS parameter would suggest there is no threat to aquatic life in the Barcelona Harbor. In the future, LEBAF recommends using another indicator such as clarity and direct measurements for parameters when possible.

Chloride: Calculated chloride concentrations ranged from 0.07-0.13 mg/L throughout the sampling period, and there were 0 exceedances in the 6 samples collected (0% exceedance) of the final acute, acute maximum and final chronic aquatic chloride standards. This suggests aquatic organisms in Barcelona Harbor were at reduced risk to chronic chloride exposure in

2022. Chloride concentrations in all 6 samples throughout 2022 were within expected values for this station. The dataset is too small to detect any temporal trends, more data is needed.

Salinity: A total of 6 samples were collected with values ranging from 0.7 ppm to 1.32 ppm, with a median value of 1.2 ppm. These results were well below the 1000 ppm USGS suggested salinity content for freshwater. Sources of salinity may not reach this station or be diluted and are better captured at the source in tributary watersheds. LEBAF recommends using direct measurements over calculated values whenever possible, but calculated results can inform our monitoring purpose and screening data use.

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

This station had data for all seven parameters collected or calculated. No parameter exceeded any threshold or standard. Comparing conductivity to reference and stream survey data, as well as the lentic macroinvertebrate biocondition gradient is not meaningful for a lentic or lake site. Using LEBAF's definition of healthy this site is healthy, supports aquatic life from a pH, DO, temperature, chloride and salinity perspective and drinking water from a TDS perspective and exploratory 1500 mg/L aquatic life threshold. The data set is limited, and some assessment criteria are for lentic systems and may not provide effective screening for lentic systems. We recommend continued monitoring, more frequency if possible and direct measurements of parameters when possible.

Results are mixed and encouraging regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? The data set is limited and for all three parameters, results likely represent ambient conditions that reflect a lentic system versus lentic. Assessment methods may not be as effective if assessment thresholds were developed for lentic systems, but may apply. For example thresholds for DO and pH apply to both systems, but where measurements should occur on shorelines or in a lakes depth profile matter. Temperature thresholds shift to protect the life cycle of lake species versus river species. TDS drinking water standards apply to both systems and it is likely thresholds for TDS aquatic life, chloride and salinity do as well but variations may apply as lake species thresholds, habitat and movement is different. LEBAF recommends exploring lentic criteria for shoreline and lake sites.

4.3 Cattaraugus Creek Harbor

Monitoring Organizations: SUNY Fredonia monitors in Cattaraugus Creek Harbor.

Station Information: This station was sampled six times during the season via boat access.

Aggregated Metrics Table - Table 32 Cattaraugus Creek Harber Summary Statistics

Cattaraugus Creek Harbor Summary Statistics - 6 Samples

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	7.87	8.1	5.31	11.06	0	0%
Water Temperature - C	17.35	17.1	11	23.9	0	0%
Conductivity - uS/cm	3.42	3.46	1.86	5.34	0	0%
Total Dissolved Solids - mg/L	1.88	1.9	1.02	2.94	0	0%
pH	8.4	8.42	8.22	8.53	0	0%
Chloride - mg/L	16.85	17.07	9.15	26.32	0	0%
Salinity - ppm	1.79	1.8	0.91	2.89	0	0%

SUNY Fredonia 2022-09-04 to 2022-10-09

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

pH: 6 samples, Max = 8.53, Min = 8.22, Median = 8.42, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that standards would always be met. This site is in line with expected values.
We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling may be needed to confirm this conclusion.

DO: 6 samples, Max = 11.06, Min = 5.31, Median = 8.10, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that standards would always be met. This site is in line with expected values.
We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling may be needed to confirm this conclusion.

Temp: 6 samples, Max = 23.9, Min = 11.0, Median = 17.1, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that standards would always be met. This site is in line with expected values.
We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling may be needed to confirm this conclusion.

Conductivity Survey: Max = 5.34, Min = 1.86, Median = 3.46

Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. This site's conductivity results were compared to EOLP ecoregion and river stream size, as expected to be lower than these data base values. The below table illustrates that conductivity is well below the maximum, median and even the reference minimum at this site. This illustrates that the comparison of conductivity results to lentic conductivities in reference and survey data is not helpful. This site is a lentic site not a lotic site or even in a transition zone like a harbor or shoreline site maybe if proximate to tributaries for example. The data set itself is limited, actual macroinvertebrate data would be helpful. For lake or lentic sites, this comparison does not have much weight.

Table 33 - Cattaraugus Creek Harbor Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	183.00	348.00	455.60	602.00	500.00
Survey	304.00	416.00	585.00	780.00	1201.00
Results	2		4		5

Conductivity Biocondition: Max = 5.34, Min = 1.86, Median = 3.46, 0 exceedances.

All six measurements were below the lentic macroinvertebrate biocondition threshold for health at 412. This site is a lentic site, with different macroinvertebrate communities and health thresholds. It is not appropriate to compare conductivity results to this biocondition range. If this site was a river, it would support aquatic life based on conductivity.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: A total of 6 samples were collected with values ranging from 1.02 mg/L to 2.94 mg/L, with a median of 1.9 mg/L. 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 and developing its own conductivity thresholds. Results did not exceed any TDS drinking water standard or the aquatic life threshold of 1500 mg/L. From this perspective, no exceedances of the TDS parameter would suggest there is no threat to aquatic life in the Barcelona Harbor. In the future, LEBAF recommends using another indicator such as clarity and direct measurements for parameters when possible.

Chloride: Calculated chloride concentrations ranged from 0.09-0.26 mg/L throughout the sampling period, and there were 0 exceedances in the 6 samples collected (0% exceedance). This suggests aquatic organisms in Cattaraugus Creek were at reduced risk to chronic chloride exposure in 2022. Chloride concentrations in all 6 samples throughout 2022 were within expected values for this station. The dataset was too small to see any temporal trends, more data is needed.

Salinity: A total of 6 samples were collected with values ranging from 0.91 ppm to 2.89 ppm, with a median of 1.8 ppm. These results were well below the 1000 ppm USGS suggested salinity content for freshwater. Sources of salinity may not reach this station or be diluted and are better captured at the source in tributary watersheds. LEBAF recommends using direct measurements over calculated values whenever possible, but calculated results can inform our monitoring purpose and screening data use.

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

This station had data for all seven parameters collected or calculated. No parameter exceeded any threshold or standard. Comparing conductivity to reference and stream survey data, as well as the lentic macroinvertebrate biocondition gradient is not meaningful for a lentic or lake site. Using LEBAF's definition of healthy this site is healthy, supports aquatic life from a pH, DO, temperature, chloride and salinity perspective and drinking water from a TDS perspective. The data set is limited and we recommend continued monitoring, more frequency if possible and direct measurements of parameters when possible.

Results are mixed and encouraging regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? The data set is limited and for all three parameters, results likely represent ambient conditions that reflect a lentic system versus lentic. Assessment methods may not be as effective if assessment thresholds were developed for lentic systems, but may apply. For example thresholds for DO and pH apply to both systems, but where measurements should occur on shorelines or in a lakes depth profile matter. Temperature thresholds shift to protect the life cycle of lake species versus river species. TDS drinking water standards apply to both systems and it is likely thresholds for TDS aquatic life, chloride and salinity do as well but variations may apply as lake species thresholds, habitat and movement is different. LEBAF recommends exploring lentic criteria for shoreline and lake sites.

4.4 Dunkirk Harbor

Monitoring Organizations: SUNY Fredonia monitors in Dunkirk Harbor.

Station Information: This station was sampled six times during the season via boat access.

Aggregated Metrics Table - Table 34 Dunkirk Harbor Summary Statistics

Dunkirk Harbor Summary Statistics - 6 Samples

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	6.96	6.9	5.87	8.3	0	0%
Water Temperature - C	18.32	19.3	12.3	22.1	0	0%
Conductivity - uS/cm	2.13	2.54	0	2.7	0	0%
Total Dissolved Solids - mg/L	1.17	1.39	0	1.49	0	0%
pH	8.11	8.23	7.39	8.51	0	0%
Chloride - mg/L	10.51	12.49	0	13.32	0	0%
Salinity - ppm	1.08	1.28	0	1.38	0	0%

SUNY Fredonia 2022-09-04 to 2022-10-09

***Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation**
*** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)
pH: 6 samples, Max = 8.51, Min = 7.39, Median = 8.23, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that standards would always be met. This site is in line with expected values.
We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling may be needed to confirm this conclusion.

DO: 6 samples, Max = 8.3, Min = 5.87, Median = 7.22, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that standards would always be met. This site is in line with expected values.
We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling may be needed to confirm this conclusion.

Temp: 6 samples, Max = 22.1, Min = 12.3, Median = 19.3, 0 exceedances.

None of the samples exceeded the LEBAF low or high standards. Expectations for this parameter were that standards would always be met. This site is in line with expected values.
We would expect the recorded values that we found. Based on the definition used by LEBAF, this site is healthy. Further sampling may be needed to confirm this conclusion.

Conductivity Survey: 6 samples, median of 2.54, Max =2.7 and Min = 0.

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. This site's conductivity results were compared to EOLP ecoregion and river stream size, as expected to be lower than these data base values. The below table illustrates that conductivity is well below the maximum, median and even the reference minimum at this site. This illustrates that the comparison of conductivity results to lentic conductivities in reference and survey data is not helpful. This site is a lentic site not a lotic site or even in a transition zone like a harbor or shoreline site maybe if proximate to tributaries for example. The data set itself is limited, actual macroinvertebrate data would be helpful. For lake or lentic sites, this comparison does not have much weight.

Table 35. Dunkirk Harber Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	183.00	348.00	455.60	602.00	500.00
Survey	304.00	416.00	585.00	780.00	1201.00
Results	0		3		3

Conductivity Biocondition: A total of 6 samples were collected along the Dunkirk Harbor. Values ranged from 0 to 2.7 with a data median of 2.54 . Max =2.7 and Min = 0 and 0 exceedances.

All six measurements were below the lentic macroinvertebrate biocondition threshold for health at 412. This site is a lentic site, with different macroinvertebrate communities and health thresholds. It is not appropriate to compare conductivity results to this biocondition range. If this site was a river, it would support aquatic life based on conductivity however. The summary metric table shows 100% exceedances but it is in error, there were no exceedances.

Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: A total of 6 samples were collected with values ranging from 0 mg/L to 1.49 mg/L, with a median of 1.39 mg/L. 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 and developing its own conductivity thresholds. Results did not exceed any TDS drinking water standard or the aquatic life threshold of 1500 mg/L. From this perspective, no exceedances of the TDS parameter would suggest there is no threat to aquatic life in the Barcelona Harbor. In the future, LEBAF recommends using another indicator such as clarity and direct measurements for parameters when possible.

Chloride: Calculated chloride concentrations ranged from 0.00-0.13 mg/L throughout the sampling period, and there were 0 exceedances in the 6 samples collected (0% exceedance). This suggests aquatic organisms in Dunkirk Harbor were at reduced risk to chronic chloride exposure in 2022. Chloride concentrations in all 6 samples throughout 2022 were within expected values for this station. Due to the limited sample size, no temporal or longitudinal trends could be established.

Salinity: A total of 6 samples were collected with values ranging from 0 ppm to 1.38 ppm, with a median of 1.28 ppm. These results were well below the 1000 ppm USGS suggested salinity content for freshwater. Sources of salinity may not reach this station or be diluted and are better captured at the source in tributary watersheds. LEBAF recommends using direct measurements over calculated values whenever possible, but calculated results can inform our monitoring purpose and screening data use.

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

This station had data for all seven parameters collected or calculated. No parameter exceeded any threshold or standard. Comparing conductivity to reference and stream survey data, as well as the lentic macroinvertebrate biocondition gradient is not meaningful for a lentic or lake site. Using LEBAF's definition of healthy this site is healthy, supports aquatic life from a pH, DO, temperature, chloride and salinity perspective and drinking water from a TDS perspective. The data set is limited and we recommend continued monitoring, more frequency if possible and direct measurements of parameters when possible.

Results are mixed and encouraging regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? The data set is limited and for all three parameters, results likely represent ambient conditions that reflect a lentic system versus lentic. Assessment methods may not be as effective if assessment thresholds were developed for lentic systems, but may apply. For example thresholds for DO and pH apply to both systems, but where measurements should occur on shorelines or in a lakes depth profile matter. Temperature thresholds shift to protect the life cycle of lake species versus river species. TDS drinking water standards apply to both systems and it is likely thresholds for TDS aquatic life, chloride and salinity do as well but variations may apply as lake species thresholds, habitat and movement is different. LEBAF recommends exploring lentic criteria for shoreline and lake sites.

4.5 Lake Erie at LaSalle Park

Monitoring Groups: Buffalo Niagara Waterkeeper monitors Lake Erie at LaSalle Park

Station information: Buffalo Niagara Waterkeeper's Riverwatch Citizen Science Program volunteers monitor Lake Erie at LaSalle Park (Coordinates **42.891142, -78.896351).** This site is not far from the mouth of the Niagara River and is protected by a break wall from the rest of the lake. The water at this site flows towards the Niagara River, but is channelized by the break wall and Unity Island to become the Black Rock Canal. It is affected by wind, storm surges and seiche throughout the year, as well as ice during the winter months. There are multiple CSOs nearby, one directly south of the station, and several more that let out into nearby marinas and docks which could affect pH. Additionally, historic PCB and toxic sediment contamination could affect readings (Lake Erie/Niagara River Basin Waterbody Inventory and Priority Waterbodies List). Sampled 1x/month May - October between 9:30 am and 10:30 am. The site was sampled 1x/month from May - October in 2022. Data from 2021 and limited data from 2020 are also available.

Aggregated Metrics Table - Table 36 Lake Erie at LaSalle Park Summary Statistics

Lake Erie @ LaSalle Park Summary Statistics - 6 Samples

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	9.61	9.68	7.53	12.83	0	0%
Water Temperature - C	18.89	20.13	10.99	24.59	5	83.3%
Conductivity - uS/cm	290.57	290.05	277.9	303.2	0	0%
Total Dissolved Solids - mg/L	159.81	159.53	152.84	166.76	0	0%
pH	8.27	8.29	8.16	8.35	0	0%
Chloride - mg/L	14.32	14.29	13.69	14.94	0	0%
Salinity - ppm	223.04	222.6	212.48	233.6	0	0%

Buffalo Niagara Waterkeeper 2022-05-13 to 2022-10-14

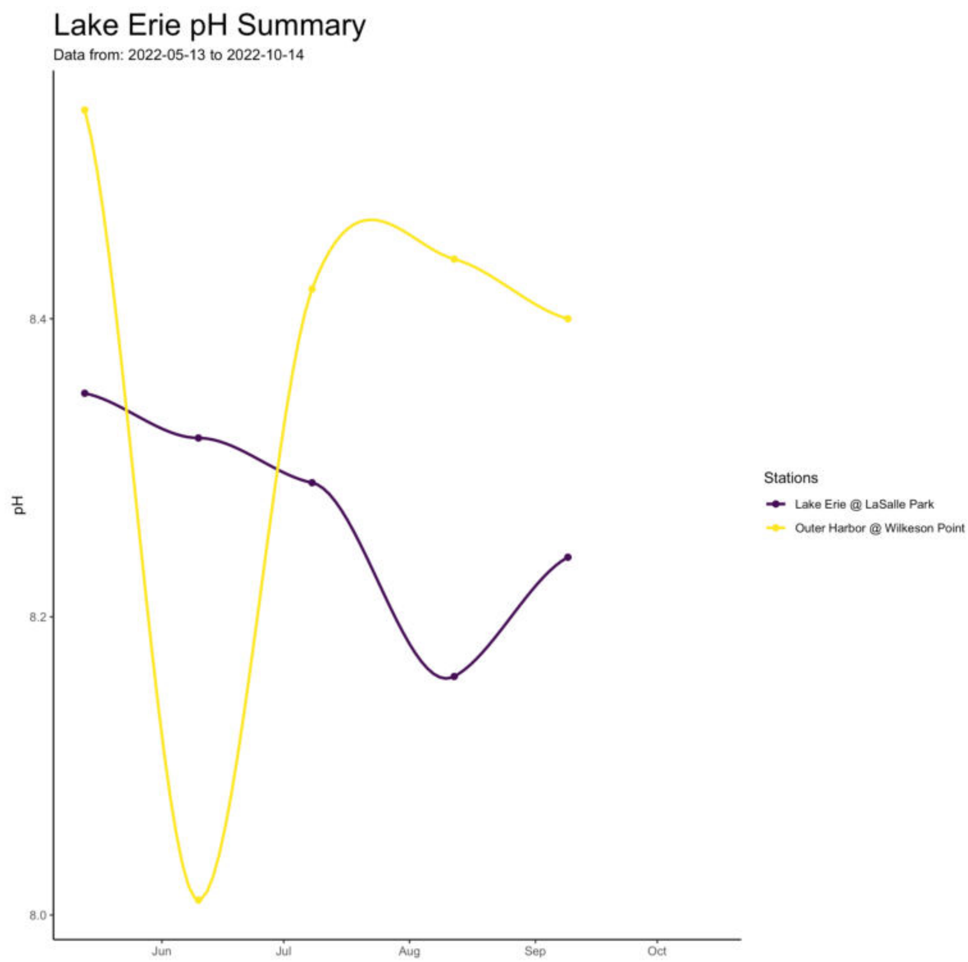
****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)
pH: 5 samples, Max = 8.35, Min = 8.16, Median = 8.29, 0 exceedances.

5 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard.Samples were all taken between the hours of 9:30 am and 10:30 am, which would not

reflect diurnal fluctuations. However, we would expect pH to remain relatively consistent at this site due to the size of the water body. PH at this harbor site had less variation than the other harbor site, dipping in August versus February and overall lower than the other harbor site, but the dataset is limited and thus conclusions cannot be made at this time.

Figure 33. Lake Erie pH Summary Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



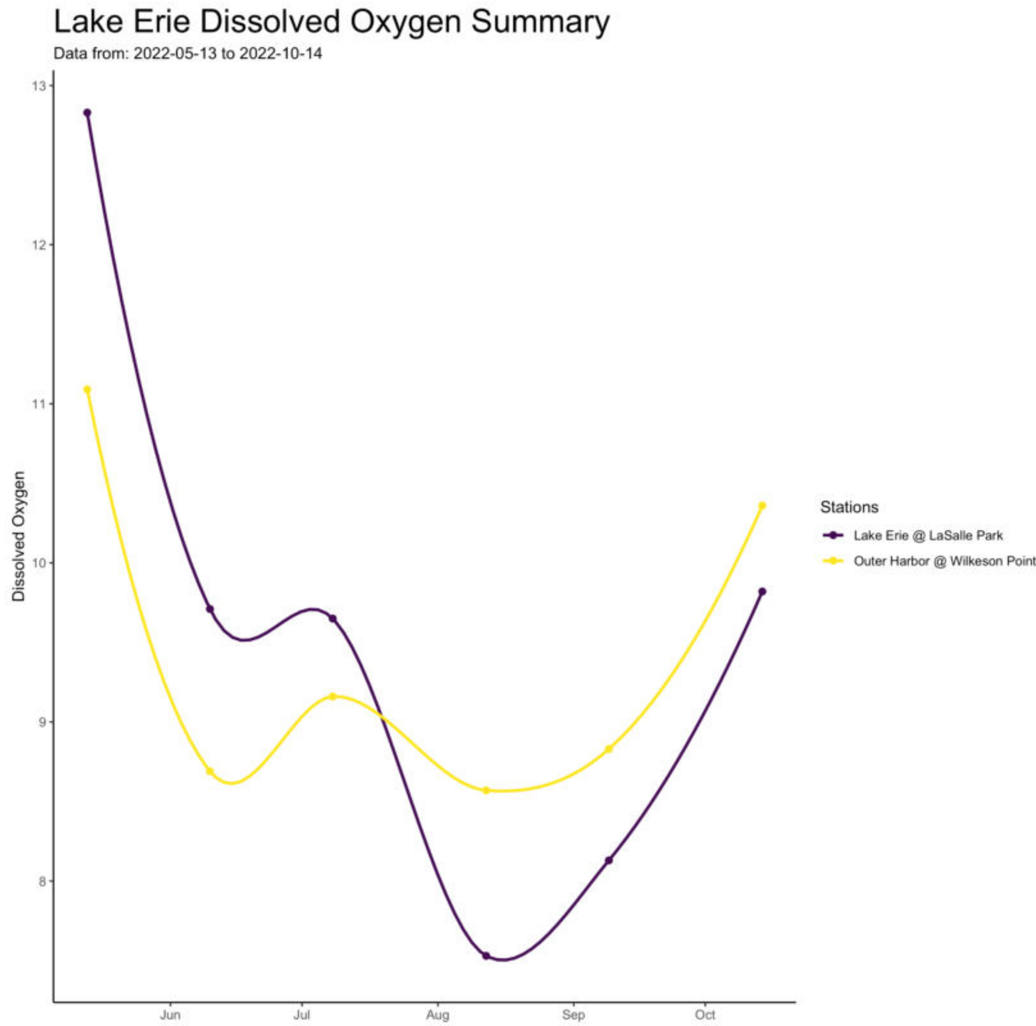
We would expect this parameter to remain relatively consistent and within the standards established by the Lake Erie Baseline Assessment Framework. We found 0 exceedances in the 2022 sampling season, and past data from 2021 and 2020 show consistent readings of between 8.16 and 8.46. No clear seasonal trend could be established, however lake dynamics and other pollution inputs could affect measurements on a monthly basis. Volunteers monitor sites upstream and downstream of this site. If we had data from different times of the day throughout the year for this parameter we might be able to paint a clearer picture of seasonal, daily, and monthly fluctuations, but varying our team's sampling schedule is not realistic. An additional limitation could be consistency in sampling depth, which could be measured in future years. Overall, we believe we have sufficient data to determine this station's condition, based on location and frequency of sampling.

Currently our data suggests pH levels support aquatic life communities. Based on our own historical data, and historical data collected in our ancillary research, the pH value at this site and in the vicinity of this site has remained consistent, and while the overall health of Lake Erie needs improvement, focus and management of this parameter specifically is not necessary. Looking at pH as an indicator of health, this site is 'healthy' using LEBAF's definition. More data is needed and our recommendation is to continue monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month.

DO: 6 samples, Max = 12.83 mg/L, Min = 7.53, Median = 9.68, 0 exceedances.

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. There are multiple CSOs nearby, one directly south of the station, and several more that let out into nearby marinas and docks which could affect DO levels. Samples were all taken between the hours of 9:30 am and 10:30 am, which would not reflect diurnal fluctuations in this parameter. However, we would expect DO to remain relatively consistent at this site due to the size of the water body and the influence of dilution. DO follows a similar pattern at both harbor sites with this station having higher concentrations in winter and lower in summer than the other harbor station, all above the aquatic life standard.

Figure 34. Lake Erie Dissolved Oxygen Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



We would expect this parameter to remain within the LEBAF aquatic life DO standards throughout the year, with the natural inverse relationship to water temperature. At the beginning and end of the sampling period, we would assume DO levels to be higher than in the warmer summer months, with daily fluctuations expected but not measured by our teams. However, the trend of this parameter did not align with the above assumption, as we found a general decrease in DO from the months of May through October. We found 0 exceedances in the 2022 sampling season, and past data from 2021 and 2020 show consistent readings of between 8.28 mg/Land 10.74 mg/L. Volunteers monitor sites upstream and downstream of this site. If we had data from different times of the day throughout the year for this parameter we might be able to paint a clearer picture of seasonal, daily, and monthly fluctuations, but varying our team's sampling schedule is not realistic. An additional limitation could be consistency in sampling depth, which could be measured in future years. Overall, we believe we have sufficient data to determine this station's condition, based on location and frequency of sampling and meet LEBAF's monitoring purpose and screening data use.

Based on DO results alone, this site supports aquatic life. In addition, information from our organization's historical data, and historical data collected in our ancillary research, the DO value at this site and in the vicinity of this site has remained consistent, and while the overall health of Lake Erie needs improvement, focus and management for this parameter specifically is not necessary. Looking at DO as an indicator of health, this site is 'healthy' using LEBAF's definition. More data is needed and our recommendation is to continue monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month.

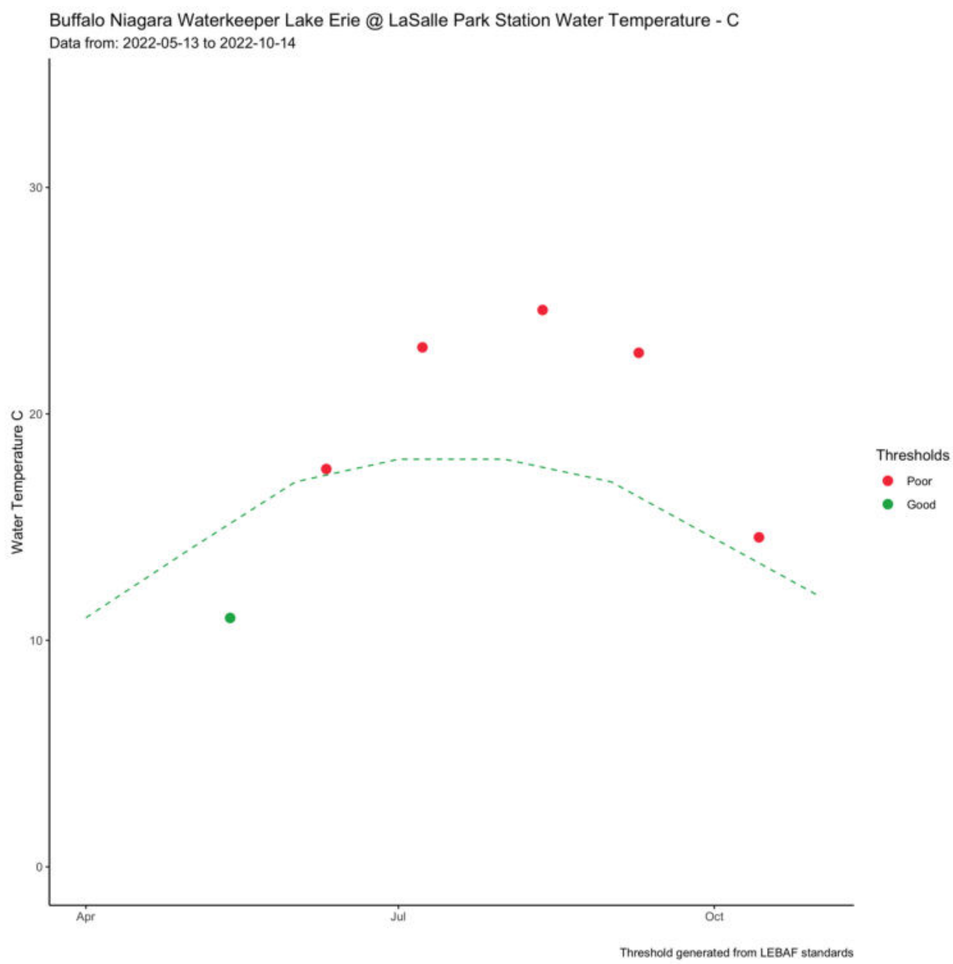
Temp: 6 samples, Max = 24.59°C, Min = 10.99, Median = 20.13, 5 exceedances (83.33%).

6 samples were collected at 1 station resulting in 5, or 83.33%, exceedances of respective standard. There are multiple CSOs nearby, one directly south of the station, and several more that let out into nearby marinas and docks which could affect temperature. Additionally, historic PCB and toxic sediment contamination could affect readings. Samples were all taken between the hours of 9:30 am and 10:30 am, which would not reflect diurnal fluctuations. Temperature fluctuates daily, monthly, and seasonally, with colder temperatures expected in the beginning and end of the day, and in colder months, with warmer temperatures expected towards the middle of the day and during the summer months. However, we would expect temperature to remain relatively consistent at this site due to the size of the water body.

We would expect this parameter to remain relatively consistent, with the lowest values occurring in May and October, and peaking in August. We would also expect this parameter to fall within the standards established by the Lake Erie Baseline Assessment Framework, despite the table illustrating otherwise. We found 5 exceedances in the 2022 sampling season, and past data from 2021 and 2020 show consistent readings of between 12 °C and 25.31 °C. A clear seasonal trend could be established, with temperature values increasing from May through a peak in August, and then declining for September and October sampling periods. This is expected, and is reflected in historic data. Volunteers monitor sites upstream and downstream of this site. If we had data from different times of the day throughout the year for this parameter we might be able to paint a clearer picture of seasonal, daily, and monthly fluctuations, but varying our team's sampling schedule is not realistic. An additional limitation could be consistency in sampling depth, which could be measured in future years. Overall, we believe we have sufficient data to determine this station's condition, based on location and frequency of sampling, and meet LEBAF's monitoring purpose and screening data use.

Based on temperature results alone, this site is unhealthy and may not support aquatic life. In addition, information from our organization’s historical data, and historical data collected in our ancillary research, the temperature values at this site and in the vicinity of this site has remained consistent. Focusing on sources and management that would more accurately characterize temperature regimes and duration, frequency and magnitude of temperature exceedances. The magnitude of exceedances is not large but still may be more than aquatic life can absorb if there is no refuge from exceedance events. Exceedances are an expression of exposure not all exposure causes chronic or acute harm. More data is needed and our recommendation is to continue monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month.

Figure 35. Lake Erie @ LaSalle Park Station Water Temperature Graph



Conductivity Survey: N = 6, max = 303.2 µS/cm , min = 277.9 µS/cm, median = 290.05 µS/cm

We would expect conductivity and calculated indicators of TDS and chloride to follow similar trends, with a peak in the summer months when activity along the river is highest, and a decrease afterwards. As stated in the opening section of Lake Erie Assessment, conductivity comparisons to the lentic conductivity reference and survey sites, is limited. Water in harbors and shore line sites may not be fully mixed and are diluted with lentic or lake water. We would expect conductivities to be less than both the reference and survey sites, and they were.

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. This site's conductivity results were compared to EOLP ecoregion and river stream size, as expected to be lower than these data base values. The below table illustrates that the maximum conductivity result, 303, is well below the maximums for reference and survey sites.. The median result of 291, is close to the median of the other harbor site and closest to both data set minimums, same with the minimum conductivity of 278, which is also similar to the minimum of the other harbor site. The relative difference between minimum, median and maximum suggest there is a consistent conductivity. This illustrates, with this limited data set and limitations of comparing harbor or shoreline data to stream data, but results are on the lower end and if this site was a river, would have low conductivity and is representative of minimum concentrations in reference and survey sites.

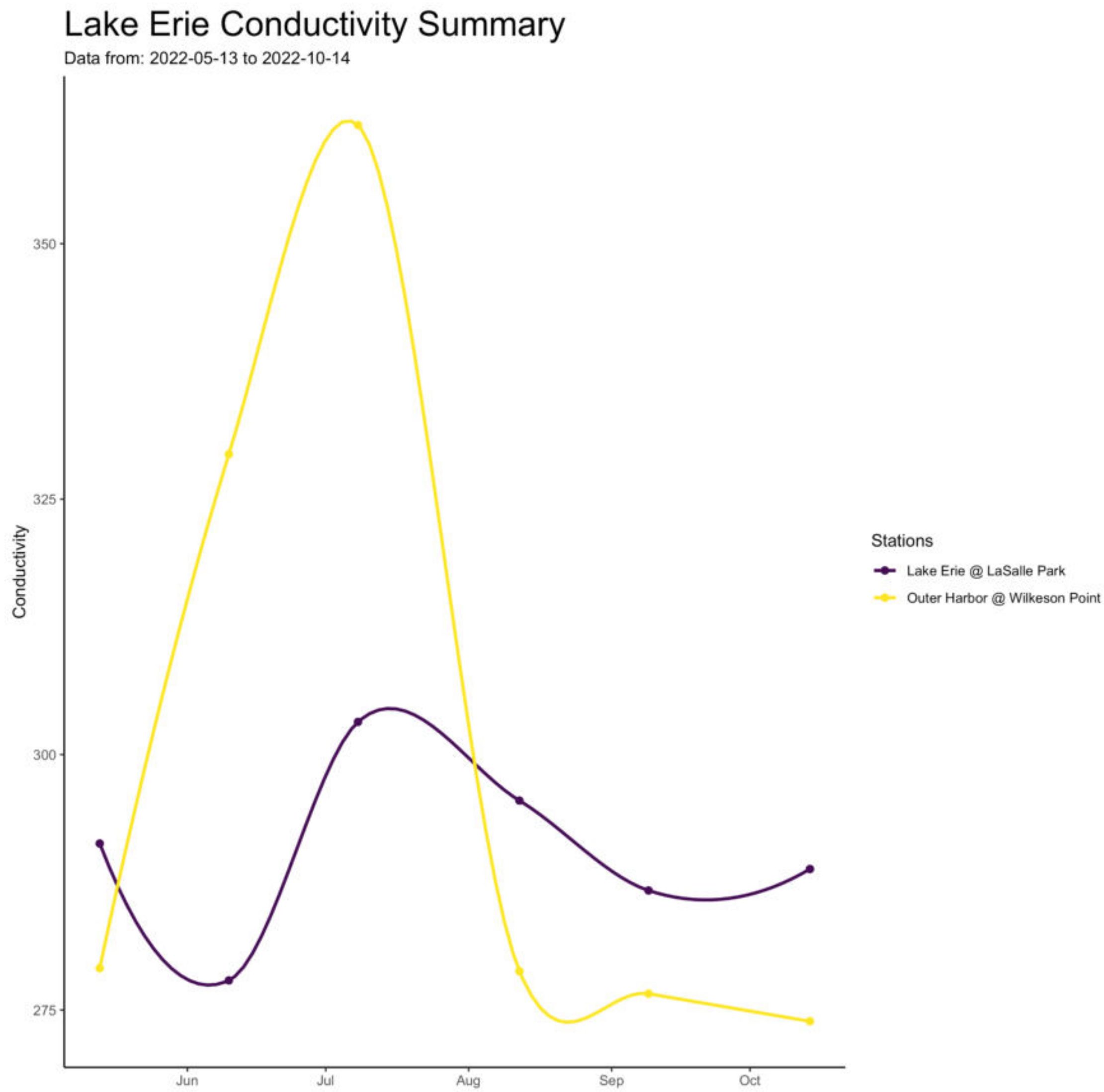
Table 37. Lake Erie at LaSalle Park Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	183.00	348.00	455.60	602.00	500.00
Survey	304.00	416.00	585.00	780.00	1201.00
Results	278		291		303

Both stations we monitored along the lake followed this trend, peaking in July, and trending downwards after. Historic data from the 2020 and 2021 sampling seasons don't illustrate the same trend, with conductivity values remaining more consistent at both sites over the season (where data is available).

Conductivity range and variation was less at this station than the other harbor station. That may be due to one event at the other harbor skewing the distribution. Limited data set so limited conclusions are possible. The variation and range of conductivity is mirrored in the TDS and chloride figures as they are calculated from conductivity.

Figure 36. Lake Erie Conductivity Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



This parameter is expected to fall outside of standards consistently throughout the sampling season and into winter. Stations are affected by storm surges and ice flows pushing up and downstream, as well as recreational and commercial boating. Twelve exceedances of the respective threshold were found. These might be related to the volume of the water at these sites, the depth of the water, and consistent wave action/ motion.

These exceedances could impact aquatic life in Lake Erie, but since all exceedances were below standards, minimal impact is expected. Actual macroinvertebrate data collected or reviewed existing, and more sites at locations upstream of the Wilkeson Point and at least one in between the two existing stations could assist in determining and monitoring this harbor's macroinvertebrate condition. More data in the early spring could provide more information and possibly show other exceedances. The data collected was limited to May-October.

Conductivity Biocondition: Six conductivity samples were collected in 2022 at 1 station resulting in 0 exceedances of respective conductivity biocondition gradient thresholds. The max = 303.2 µS/cm , min = 277.9 µS/cm, median = 290.05 µS/cm

These samples were compared to OEPA macroinvertebrate bio-condition thresholds 412 µS/cm, indicating a healthy macroinvertebrate community, between 412 and 655 a declining community and above 655 µS/cm, a degrading macroinvertebrate community. All samples from both our lake stations fell below the standards established by LEBAF, with measurements from Wilkeson Point varying more significantly than measurements from Lasalle Park, but still falling below LEBAF standards. Dilution from the volume of water could contribute to this trend. It is not appropriate to use this metric and assessment when the environment is primarily lentic versus lotic.

Historic conductivity data from this site during the 2020, 2021, and 2022 sampling years shows that this tributary consistently falls below the standards established by LEBAF, but within an acceptable range of supporting healthy communities of macroinvertebrates. The measurements are subject to spikes throughout the year, but are subject to spikes and depressions at different points of the year, and with no obvious trends from year to year. Because of the considerable variability in measurements, continued monitoring of this site will be essential in determining overall bio-condition, and to ensure that healthy biological communities can be established and maintained.

Expressions of Conductivity

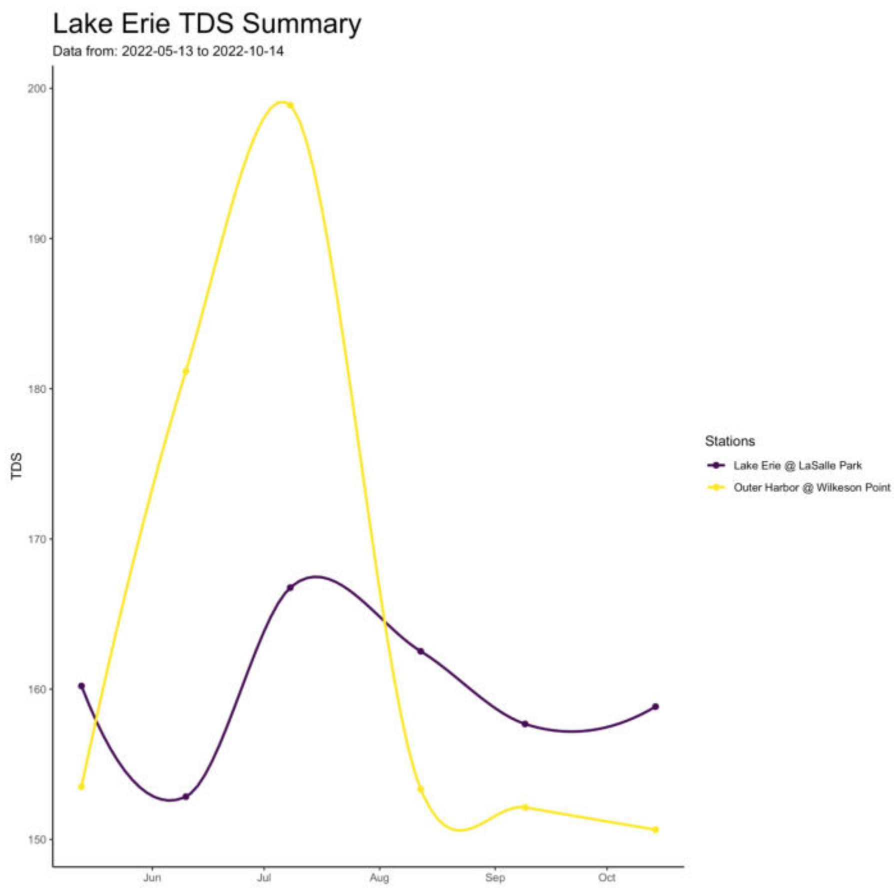
Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS: N=6, Max: 166.76 mg/L, Min: 152.84 mg/L, Mean: 159.81 mg/L, 0 exceedances, 0%

6 samples were collected at 1 station resulting in 0 or 0% exceedances of respective standard. We would expect this parameter to remain relatively consistent and within the standards established by the Lake Erie Baseline Assessment Framework, we found 0 exceedances in the 2022 sampling season, with values generally lower than the previous two sampling years. Historic data from 2021 and 2020 show consistent readings of between 181.6 mg/L and 197.7 mg/L. No clear seasonal trend could be established, as values remained within 10 mg/L for all months of the 2022 sampling season. This station demonstrated a smaller range and variation than the other harbor station. However, one event could have caused the higher TDS at the other station skewing the distribution. Limited data set and thus conclusions are limited.

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 and developing its own conductivity thresholds. Results did not exceed any TDS drinking water standard or the aquatic life threshold of 1500 mg/L. From this perspective, no exceedances of the TDS parameter would suggest there is no threat to aquatic life in the Barcelona Harbor. Lake dynamics and other pollution inputs could affect measurements on a monthly basis. While the overall health of Lake Erie needs improvement, focus and management of TDS specifically would not be as productive as focusing on other indicators. In the future, LEBAF recommends using another indicator such as clarity and direct measurements for parameters when possible.

Figure 37. Lake Erie TDS Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Chloride: Calculated chloride concentrations ranged from 13.69-14.94 mg/L throughout the sampling period, and there were 0 exceedances in the 6 samples collected (0% exceedance).

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. This suggests aquatic organisms at the LaSalle Park station were at reduced risk to chronic chloride exposure in 2022. Notably, this station is separated from Lake Erie by a breakwall, and is located close to the mouth of the Niagara River. Therefore, water quality at this site is expected to be influenced by nearby tributaries and sources of pollution. Furthermore, due to the proximity to the Niagara River and aforementioned breakwall, water quality will likely have a greater impact downstream than it will on Lake Erie. The primary limitation at this station is a paucity of data, and recommendations for monitoring beyond 2023 include sampling at a higher frequency, at more stations, and at variable times throughout the day to improve assessments of temporal variation. The 6 samples collected in 2022 at this station all were taken between 9:30-10:30. Collecting additional metadata, too, like depth of sample, and ambient weather/water conditions would enable a greater understanding of conditions at this station.

The seasonal pattern and variation of chloride at both stations mimic the TDS figure above with the appropriate scale.

Salinity:

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. We would expect this parameter to remain relatively consistent and within the standards established by the Lake Erie Baseline Assessment Framework, we found 0 exceedances in the 2022 sampling season, with no past data available from this site for this parameter. No clear seasonal trend could be established, although levels peaked in July, and remained consistent otherwise. Lake dynamics and other pollution inputs could affect measurements on a monthly basis. Currently our data does not suggest that this site would need to be put on a list for salinity. No historical data from our organization, or others could be found. While the overall health of Lake Erie needs improvement, management for this parameter specifically is not necessary.

Aggregated Overall Summary: (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

This site had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity. The only parameter that exceeded thresholds was temperature, all other parameters indicate aquatic life support, drinking water support (TDS) and representative of lower ends of ELOP and river reference and survey conductivity data. This site can represent more river conditions than lake given the break wall.

Both lake stations are located along the lake shore and are protected by breakwalls from the rest of the lake; their individual effect on the rest of the lake is likely limited. Consistent wave action, and effects of seiche, storm surges, ice, as well as runoff and boating activity could affect readings for these parameters, but the depth/volume, and consistent motion of the water would dilute inputs at these locations. Despite being close to sources of pollution, both of these stations remained relatively consistent in their readings. Historical pollution and runoff, and toxic sediments from the 20th century are still present in the water columns, and new and emerging contaminants continue to alter this tributary's water chemistry, including commercial and agricultural runoff. These all would likely affect locations upstream and downstream.

Results are mixed and encouraging regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? The data set is limited and for all three parameters, results likely represent ambient conditions that reflect a lotic system versus lentic. Assessment methods may not be as effective if assessment thresholds were developed for lentic systems, but may apply. For example thresholds for DO and pH apply to both systems, but where measurements should occur on shorelines or in a lakes depth profile matter. Temperature thresholds shift to protect the life cycle of lake species versus river species. TDS drinking water standards apply to both systems and it is likely thresholds for TDS aquatic life, chloride and salinity do as well but variations may apply as lake species thresholds, habitat and movement is different. LEBAF recommends exploring lotic criteria for shoreline and lake sites.

Based on LEBAF's definitions, this site is mostly healthy, given the limited data set and extrapolation from lotic to lentic standards and interpretation. We recommend continued monitoring of the stations along this lakeshore, at least at the same frequency and locations, if not moreso. Incorporating data from the other tributaries in the area would be useful for future analyses. More stations, higher sample frequency, additional meta-data and varying times of day would all provide more information to understand the condition of this site and changes in that condition.

4.6 Outer Harbor at Wilkeson Point

Monitoring Organizations: Buffalo Niagara Waterkeeper monitors Lake Erie along Buffalo's Outer Harbor at Wilkeson Point.

Station Information: Buffalo Niagara Waterkeeper's Riverwatch Citizen Science Program volunteers monitor Lake Erie along Buffalo's Outer Harbor at Wilkeson Point - Coordinates **42.870570, -78.880380).** This site is just upstream of the outlet of the Buffalo River, as well as our station at Lasalle Park, and close to many marinas. It is protected by a break wall from the rest of the lake. The water at this site flows towards the Niagara River, and eventually to Niagara Falls. It is affected by wind, storm surges and seiche throughout the year, as well as ice during the winter months. There are multiple CSOs in the Buffalo River nearby, although they are separated from this station by the city ship canal. This site is near a historic landfill as well as a Confined Disposal Facility. Sampled 1x/month May - October, from 9:30 am - 10:15 am. The site was sampled 1x/month from May - October in 2022. Data from 2021 is also available.

Aggregated Metrics Table - Table 38 Outer Harbor at Wilkeson Point Summary Statistics

Outer Harbor @ Wilkeson Point Summary Statistics - 6 Samples						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	9.45	9	8.57	11.09	0	0%
Water Temperature - C	18.78	20.34	9.69	24.94	5	83.3%
Conductivity - uS/cm	299.9	278.95	273.9	361.6	0	0%
Total Dissolved Solids - mg/L	164.95	153.42	150.65	198.88	0	0%
pH	8.36	8.42	8.01	8.54	0	0%
Chloride - mg/L	14.78	13.75	13.5	17.82	0	0%
Salinity - ppm	230.97	213.35	209.15	282.94	0	0%
Buffalo Niagara Waterkeeper 2022-05-13 to 2022-10-14						

****Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation***
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Summary for each parameter (8)

pH:

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. We would expect this parameter to remain relatively consistent and within the standards established by the Lake Erie Baseline Assessment Framework, we found 0 exceedances in the 2022 sampling season, and past data from 2021 show consistent readings of between 8.32 and 8.38. No data from 2020 is available for this station. No clear seasonal trend could be established, however lake dynamics and other pollution inputs could affect measurements on a monthly basis. Minimum value occurred in June, with results relatively consistent otherwise.

This site is not far from the mouth of the Niagara River and is protected by a break wall from the rest of the lake. The water at this site flows towards the Niagara River, and eventually to Niagara Falls. It is affected by wind, storm surges and seiche throughout the year, as well as ice during the winter months. This site is near a historic landfill as well as a Confined Disposal Facility, which could affect readings for all parameters. Samples were all taken between the hours of 9:30 am and 10:30 am, which would not reflect diurnal fluctuations. However, we would expect pH to remain relatively consistent at this site due to the size of the water body. Initial recommendations include continuation of monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month. Consider adding a nearby upstream site.

DO:

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. We would expect this parameter to remain relatively consistent and within the standards established by the Lake Erie Baseline Assessment Framework, we found 0 exceedances in the 2022 sampling season, and past data from 2021 show consistent readings of between 11.14 mg/L and 8.51 mg/L. No data from 2020 is available for this station. The data reflects an expected trend of lower DO during warmer summer months, with higher values in the colder months. Lake dynamics and other pollution inputs could affect measurements on a monthly basis. Minimum value occurred in August, with results decreasing generally from May through October.

Based on LEBAF's definition and DO as an indicator, this site is healthy. Historical data collected in our ancillary research, the DO value at this site and in the vicinity of this site has remained consistent, and while the overall health of Lake Erie needs improvement, focus and management for this parameter specifically may not be as productive relative to other parameters. Initial recommendations include continuation of monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month. Consider adding a nearby upstream site.

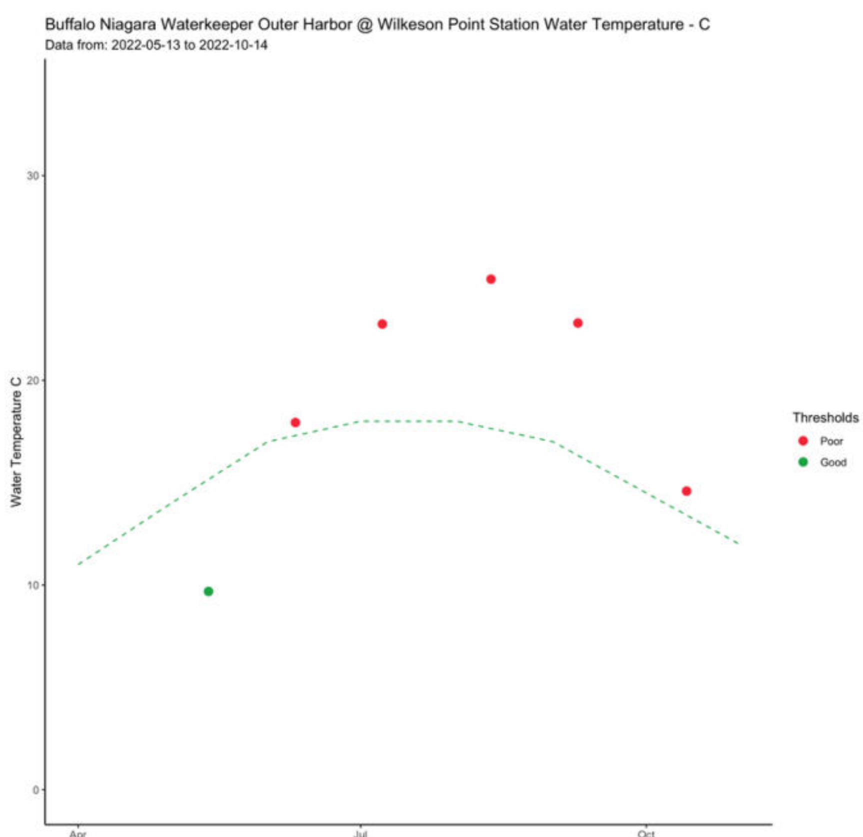
Temperature:

6 samples were collected at 1 station resulting in 5, or 83.3%, exceedances of respective standard. We would expect this parameter to remain fluctuate seasonally within the standards established by the Lake Erie Baseline Assessment Framework, we found 5 exceedances, 83.3%,in the 2022 sampling season with the maximum 24.94°C, minimum 9.69 °C and, median= 20.32 °C . There are multiple CSOs nearby, one directly south of the station, and several more that let out into nearby marinas and docks which could affect temperature. Additionally, historic PCB and toxic sediment contamination could affect readings. Samples were all taken between the hours of 9:30 am and 10:30 am, which would not reflect diurnal fluctuations. Temperature fluctuates daily, monthly, and seasonally, with colder temperatures expected in the beginning and end of the day, and in colder months, with warmer temperatures expected towards the middle of the day and during the summer months. However, we would expect temperature to remain relatively consistent at this site due to the size of the water body.

We would expect this parameter to remain relatively consistent, with the lowest values occurring in May and October, and peaking in August. We would also expect this parameter to fall within the standards established by the Lake Erie Baseline Assessment Framework, despite the table illustrating otherwise. We found 5 exceedances in the 2022 sampling season, and past data from 2021 and 2020 show consistent readings of between 12 °C and 25.31 °C. A clear seasonal trend could be established, with temperature values increasing from May through a peak in August, and then declining for September and October sampling periods. This is expected, and is reflected in historic data. Volunteers monitor sites upstream and downstream of this site. If we had data from different times of the day throughout the year for this parameter we might be able to paint a clearer picture of seasonal, daily, and monthly fluctuations, but varying our team's sampling schedule is not realistic. An additional limitation could be consistency in sampling depth, which could be measured in future years. Overall, we believe we have sufficient data to determine this station's condition, based on location and frequency of sampling, and meet LEBAF's monitoring purpose and screening data use.

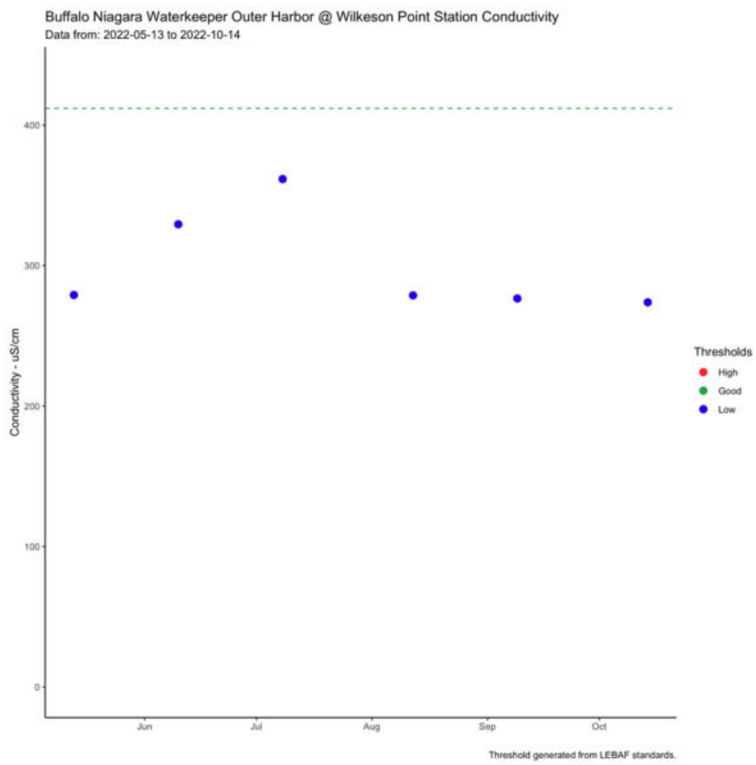
Based on temperature results alone, this site is unhealthy and may not support aquatic life. In addition, information from our organization's historical data, and historical data collected in our ancillary research, the temperature values at this site and in the vicinity of this site has remained consistent. Focusing on sources and management that would more accurately characterize temperature regimes and duration, frequency and magnitude of temperature exceedances. The magnitude of exceedances is not large but still may be more than aquatic life can absorb if there is no refuge from exceedance events. Exceedances are an expression of exposure not all exposure causes chronic or acute harm. More data is needed and our recommendation is to continue monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month.

Figure 38. Outer Harbor at Wilkeson Point Temperature Graph



While the overall health of Lake Erie needs improvement, focus and management for this parameter specifically is not necessary or feasible. However, real time temperature monitoring if implemented well could provide the distribution of temperature data and more information on magnitude, duration and frequency of exceedances. These 5 exceedances were not excessive in magnitude if aquatic life can find refuge from exceedance events, harm may be minimized. Initial recommendations include continuation of monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month. Consider adding an upstream sampling location.

Figure 39. Outer Harbor at Wilkeson Point Conductivity



Conductivity Survey: *N = 6, max = 361.6 µS/cm , min = 273.9 µS/cm, median = 278.95 µS/cm*

We would expect this parameter to remain relatively consistent throughout the year, with a general trend upwards towards the middle of the summer with hotter temperatures. As stated in the opening section of Lake Erie Assessment, conductivity comparisons to the lentic conductivity reference and survey sites, is limited. Water in harbors and shore line sites may not be fully mixed and are diluted with lentic or lake water. We would expect conductivities to be less than both the reference and survey sites, and they were.

<u>Conductivity data compared to Ohio EPA conductivity reference and survey sites for Verification</u>

The next assessment is not an exercise in identifying exceedances, but a quality assurance comparison as one way to verify validity of conductivity results. This site's conductivity results were compared to EOLP ecoregion and river stream size, as expected to be lower than these data base values. The below table illustrates that the maximum conductivity result, 362, is well below both reference and survey site maximums. The median result of 288 is closest to both minimums and the minimum 274 is between the minimum for reference and survey conductivity. This illustrates, with this limited data set and limitations of comparing harbor or shoreline data to stream data, but results are on the lower end and if this site was a river, would have low conductivity and is representative of minimum concentrations in reference and survey sites.

Table 39 - Outer Harbor at Wilkeson Point Conductivity Results Compared to Ohio EPA Reference and Survey Data

Percentiles	**Minimum**	**25th**	**50th**	**75th**	**Max**
Reference	183.00	348.00	455.60	602.00	500.00
Survey	304.00	416.00	585.00	780.00	1201.00
Results	274		288		362

Both stations we monitored along the lake followed this trend, peaking in July, and trending downwards after. Historic data from the 2020 and 2021 sampling seasons don't illustrate the same trend, with conductivity values remaining more consistent at both sites over the season (where data is available). All samples from both our lake stations fell below the standards established by LEBAF, with measurements from Wilkeson Point varying more significantly than measurements from Lasalle Park, but still falling below LEBAF standards. Dilution from the volume of water could contribute to this trend.

We would expect this parameter to remain relatively consistent throughout the year, with a general trend upwards towards the middle of the summer with hotter temperatures. Based on the standards established by the Lake Erie Baseline Assessment Framework, this site would likely continue to exceed conductivity standards throughout future sampling seasons. We found 6 exceedances in the 2022 sampling season, all falling below the standards established by LEBAF. A somewhat clear seasonal trend could be established, with conductivity values trending upwards from May through a peak in July, then slightly tapering off for the following three months. Lake dynamics and other pollution inputs could affect measurements on a monthly basis. Past data from the 2021 sampling season illustrates a different trend, with a max value of

287.1 µS/cm recorded in May, and a minimum value of 268.9 µS/cm recorded in June. Results remained consistent otherwise.

Currently our data does suggest that this site would need to be put on a list for conductivity measurements. Based on our own historical data, and historical data collected in our ancillary research, the conductivity value at this site and in the vicinity of this site has remained consistent, and while the overall health of Lake Erie needs improvement, management for this parameter might prove difficult. Initial recommendations include continuation of monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month. Consider adding more harbor sampling locations.

Conductivity Biocondition: 6 of 6 sample with 0 exceedances. The maximum result measured in 2022 was 303, which is well below the stream biocondition threshold of 412 indicative of a healthy macroinvertebrate community. This suggests, with the limited data set and no actual macroinvertebrate data, that if this site was a river with resident macroinvertebrates, their overall community condition would be healthy given LEBAF's definitions. This is supported by conductivity data from the 2020, 2021, and 2022 sampling years that shows that this site consistently falls below this minimum threshold of 412 conductivity to support a stable and diverse community of macroinvertebrate. The rate of flow, wave action, and rocky substrate support this assumption, and continued monitoring of this site is recommended to determine overall bio-condition.

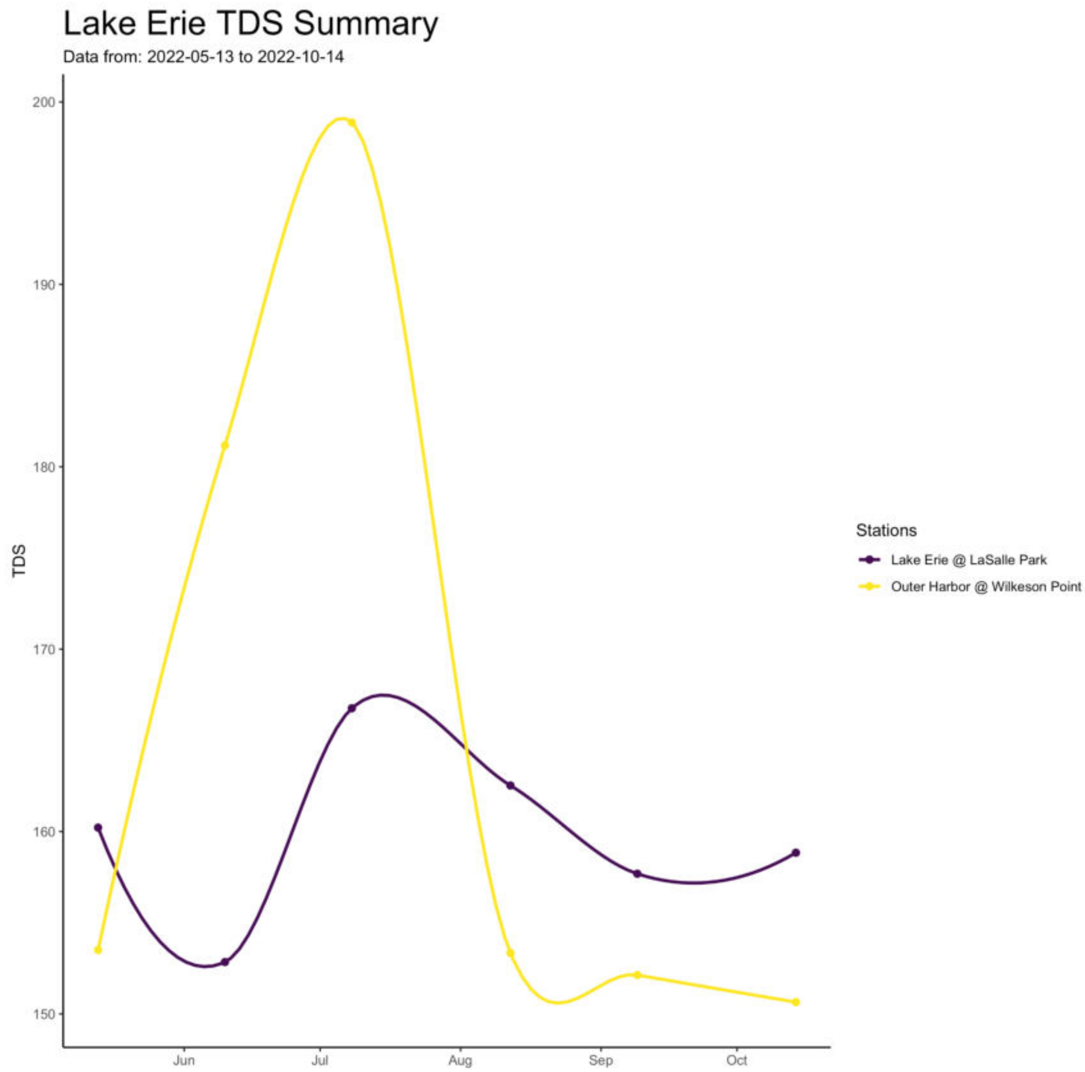
Expressions of Conductivity
Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

TDS:

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. We would expect this parameter to remain relatively consistent and within the standards established by the Lake Erie Baseline Assessment Framework, we found 0 exceedances in the 2022 sampling season, and past data from 2021 show consistent readings of between 172.1 mg/L and 183.7 mg/L. The TDS standard is a drinking water standard indicating the from TDS perspective the water is safe to drink. No data from 2020 is available for this station. The data reflects a trend of decreasing generally from the months of May through October. Lake

dynamics and other pollution inputs could affect measurements on a monthly basis. Minimum value occurred in June. While the overall health of Lake Erie needs improvement, focus and management of TDS specifically would not be as productive as focusing on other indicators.

Figure 40. Lake Erie TDS Summary Data Graph



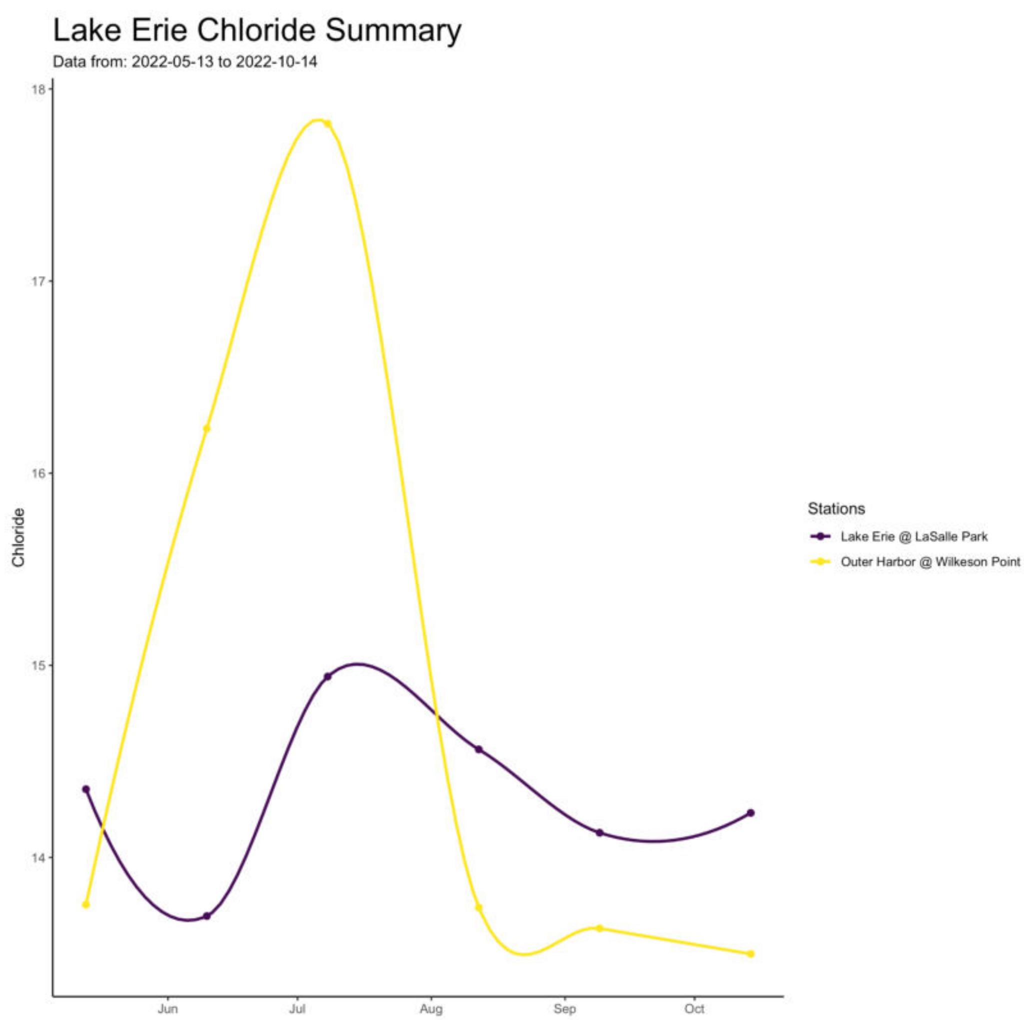
Initial recommendations include continuation of monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month. Consider adding more sampling locations.

Chloride:

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. We would expect this parameter to remain relatively consistent and within the standards established by the Lake Erie Baseline Assessment Framework, we found 0 exceedances in the

2022 sampling season, with no past data available from this site for this parameter. We would expect this parameter to follow a similar trend to the TDS measurements, with a peak in the summer months when activity along the lake is highest, with a decrease afterwards. Both stations along the lake followed this trend, peaking in August, and trending downwards after, without any late season spike. Measurements at the Wilkeson Point station varied more widely than the Lasalle Park station, similar to TDS. No historic data is available for this parameter, so a clear trend could not be established. Input from boats, CSOs, and residential runoff along the river could contribute to higher levels in the summer months. No clear seasonal trend could be established, although results did spike for the months of June and July. Lake dynamics and other pollution inputs could affect measurements on a monthly basis, with inputs potentially higher in the summer months and around holidays.

Figure 41. Lake Erie Chloride Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.

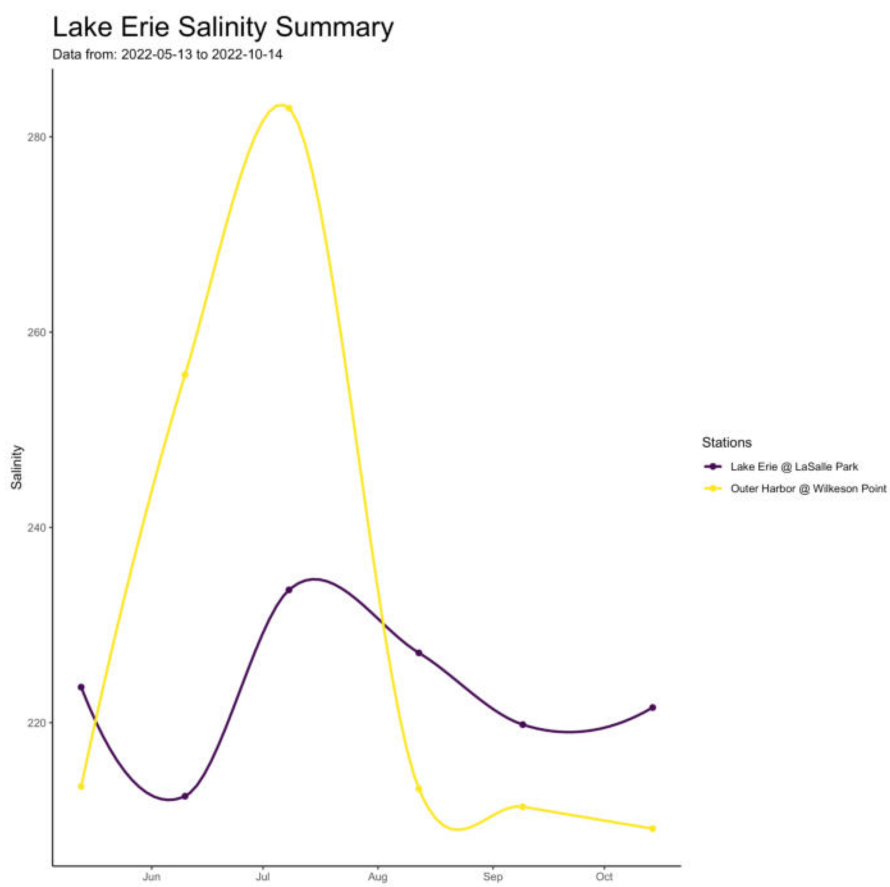


While the overall health of Lake Erie needs improvement, focus and management for this parameter specifically is not as meaningful as other parameters. Initial recommendations include continuation of monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month. Consider adding more sampling sites.

Salinity:

6 samples were collected at 1 station resulting in 0, or 0%, exceedances of respective standard. We would expect this parameter to remain relatively consistent and within the standards established by the Lake Erie Baseline Assessment Framework, we found 0 exceedances in the 2022 sampling season, with no past data available from this site for this parameter. No clear seasonal trend could be established, although results did spike for the months of June and July (likely due to increased activity from boaters and shipping). Lake dynamics and other pollution inputs could affect measurements on a monthly basis, with inputs potentially higher in the summer months and around holidays.

Figure 42. Lake Erie Salinity Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Results for this parameter could be related to stormwater runoff, CSO, industrial inputs, upstream runoff, wildlife activity, restoration work, agricultural use/runoff boating activities, etc. No historic data is available for this parameter along this tributary.. No historical data from our organization, or others could be found. While the overall health of Lake Erie needs improvement, focus and management for this parameter specifically is not as important as other parameters. IInitial recommendations include continuation of monitoring at this site at the same frequency, despite limitations on certain metadata and variation in timing per day/month. Consider adding more sampling locations.

Aggregated Overall Summary – (including up to downstream story), recommendations, conclusions, gaps, assumptions and limitations through the lens of the larger river and potential influence on Lake Erie.

This site had data for seven parameters, pH, DO, temperature, conductivity, TDS, chloride and salinity. The only parameter that exceeded thresholds was temperature, all other parameters indicate aquatic life support, drinking water support (TDS) and representative of lower ends of ELOP and river reference and survey conductivity data. This site can represent more river conditions than lake given the break wall.

Both lake stations are located along the lake shore and are protected by breakwalls from the rest of the lake; their individual effect on the rest of the lake is likely limited. Consistent wave action, and effects of seiche, storm surges, ice, as well as runoff and boating activity could affect readings for these parameters, but the depth/volume, and consistent motion of the water would dilute inputs at these locations. Despite being close to sources of pollution, both of these stations remained relatively consistent in their readings. Historical pollution and runoff, and toxic sediments from the 20th century are still present in the water columns, and new and emerging contaminants continue to alter this tributary's water chemistry, including commercial and agricultural runoff. These all would likely affect locations upstream and downstream.

Results are mixed and encouraging regards to using the expressions of conductivity chloride, TDS and salinity. Two questions we wanted to answer, did calculated respective results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? The data set is limited and for all three parameters, results likely represent ambient conditions that reflect a lentic system versus lotic. Assessment methods may not be as effective if assessment thresholds were developed for lentic systems, but may apply. For example thresholds for DO and pH apply to both systems, but where measurements should occur on shorelines or in a lakes depth profile matter. Temperature thresholds shift to protect the life cycle of lake species versus river species. TDS drinking water standards apply to both systems and it is likely thresholds for TDS aquatic life, chloride and salinity do as well but variations may apply as lake species thresholds, habitat and movement is different. LEBAF recommends exploring lentic criteria for shoreline and lake sites.

Based on LEBAF's definitions, this site is mostly healthy, given the limited data set and extrapolation from lotic to lentic standards and interpretation. We recommend continued monitoring of the stations along this lakeshore, at least at the same frequency and locations, if not moreso. Incorporating data from the other tributaries in the area would be useful for future analyses. More stations, higher sample frequency, additional meta-data and varying times of day would all provide more information to understand the condition of this site and changes in that condition.

Section 5 – Results: Lake Erie Basin

5.1 Aggregated Station Summary

This section aggregates all 2022 LEBAF results from all stations, direct tributaries, large rivers and lake stations together for regional analysis of the health of the Lake Erie Basin. The objective is to look through the lens of the Lake Erie Basin as a whole and, for LEBAF's monitoring purpose of condition and screening data use, ask what story the data tells. What is the same across the Lake's various watersheds and what is different? What might explain the differences? Where are there gaps in location, parameters or sample frequency? This review will examine an aggregation of all 2022 LEBAF data from the lens of Lake Erie to see what story can be told about the health of the Basin. LEBAF aims to tell this story with transparency about the strengths and limitations of its approach and will, when appropriate, "back out" of the Lake Erie Basin lens to help the reader understand the impact of individual tributaries and watersheds on the broader picture.

Table 40. Participating Groups and Individual Waterbodies Aggregated for Lake Erie Basin Analysis

Participating Group	Waterbody (# of stations)
Buffalo Niagara Waterkeeper **Large River = Buffalo River**	Buffalo River (2) Eighteen Mile Creek (2) Lake Erie at LaSalle Park (1) Lake Erie Outer Harbor at Wilkeson Point (1) Rush River (1) Smoke Creek (1)
Cleveland Metroparks **Large River = Rocky River**	Euclid Creek (1) Rocky River (2)
Clinton River Watershed Council **Large River = Clinton River**	Paint Creek (1)
Doan Brook Watershed Partners **Direct Tributary**	Doan Brook (7)
Erie Soil and Water Conservation District	Mills Creek (7) Old Woman Creek (10)

	Pipe Creek (7)
Huron River Watershed Council **Large River = Huron River**	Huron River (12)
SUNY Fredonia	Barcelona Harbor (1) Cattaraugus Creek Harbor (1) Dunkirk Harbor (1)
Tinker's Creek Watershed Council **Large River = Cuyahoga River**	Tinkers Creek (9)
Lake Erie Basin Total	N/A (67 Stations)

5.2 Aggregated Metrics Tables - Table 41 Lake Erie Basin Cold and Warm Water Summary Statistics

Lake Erie Basin Cold Water Summary Statistics - 39 Samples 7 Stations

Parameter	Mean	Median	Minimum	Maximum	N Exceed	% Exceed
Dissolved Oxygen - mg/L	9.42	9.11	7.5	12.83	0	0%
Water Temperature - C	18.14	19.58	7.74	24.94	31	79.5%
Conductivity - uS/cm	645.75	618.9	273.9	1209	26	66.7%
Total Dissolved Solids - mg/L	355.16	340.4	150.65	664.95	26	66.7%
pH	8.24	8.21	7.27	9.01	1	2.9%
Chloride - mg/L	31.82	30.5	13.5	59.58	0	0%
Salinity - ppm	537.66	507.66	209.15	1051.76	1	2.6%
2022-05-13 to 2022-10-25						

Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation

**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

Lake Erie Basin Warm Water Summary Statistics - 422 Samples 60 Stations						
Parameter	**Mean**	**Median**	**Minimum**	**Maximum**	**N Exceed**	**% Exceed**
Dissolved Oxygen - mg/L	8.55	8.38	1.31	17.33	23	5.6%
Water Temperature - C	17.63	18.8	3.7	27.4	7	1.7%
Conductivity - uS/cm	848.34	766	0	2677	376	90.8%
Total Dissolved Solids - mg/L	466.58	421.3	0	1472.35	385	93%
pH	8.02	8.05	5.4	10.26	8	1.9%
Chloride - mg/L	69	49.72	0	657.2	29	7%
Salinity - ppm	724.46	640.2	0	2497.17	74	17.9%
2022-03-19 to 2022-10-31						

Conductivity exceedances are in reference to a conductivity macroinvertebrate biocondition gradient, see below for more explanation
**** Where N exceed refers to the total number of samples that exceed standards and % exceed refers to the percentage of samples that exceed standards***

5.3 Aggregated Parameter Summaries

pH

Data characterization: At cold water streams and sites pH ranged from 7.27 to 9.01, with a median of 8.21. There was one exceedance (9.01 at Rush Creek). At warm water streams and sites, the pH ranged from 5.4 to 10.26, with a median of 8.05. There were 8 exceedances, some of which exceeded the low (acidic) threshold and some the high (basic) threshold.

The expectation for pH is that all sites would be within the LEBAF standard low and high values. Healthy streams should never exceed those values, and pH should be relatively stable throughout the year. This was found to be true for the majority of sites and samples (over 450 measurements) across all sampling in the Lake Erie basin. However, there were some exceptions. Most of the standard exceedances occurred in warm water streams; all from Euclid Creek (in the Cleveland, OH area) with eight very basic readings up to a pH of 10.5. These high readings may have been caused by a miscalibration of equipment during the time of sampling. The sampling team was unable to trace the source of these high pH readings. There are no trends to indicate a long lasting chemical problem near the site. We can’t determine whether pollution, natural chemical processes, error with data collection, or malfunctioning equipment is to blame. As for the exceedance at Rush Creek in the Buffalo, NY area, it was also not possible to determine the source of the basic solution. Overall, at the basin level, Lake Erie is not likely to be severely impacted by the pH readings from each of the direct tributaries, large rivers, and shoreline sites. Special attention should be paid to locations where exceedances occurred, and more information should be collected on the magnitude, frequency, and duration of such exceedances, but overall there doesn't appear to be cause for concern.

Limitations include a lack of pH data several times a day at each site as well as a small number of sites established for data collection. The percentage of exceedances above the pH thresholds at these stations was relatively low, less than 50%. Therefore, we can expect the exposure to aquatic life and possible impacts to Lake Erie to be low. However, these values are still significant enough to warrant further investigation at these sites. Considering most of the data was within expected thresholds, we expect that there is minimal impact to Lake Erie. Much of this data is very local and does not fully encompass enough temporal, weather, and spatial data. Land use for many of our stations was limited. Given data gaps, our organizations are unable to make a conclusion about the water quality going into Lake Erie. More chemistry and ancillary data is needed.

DO

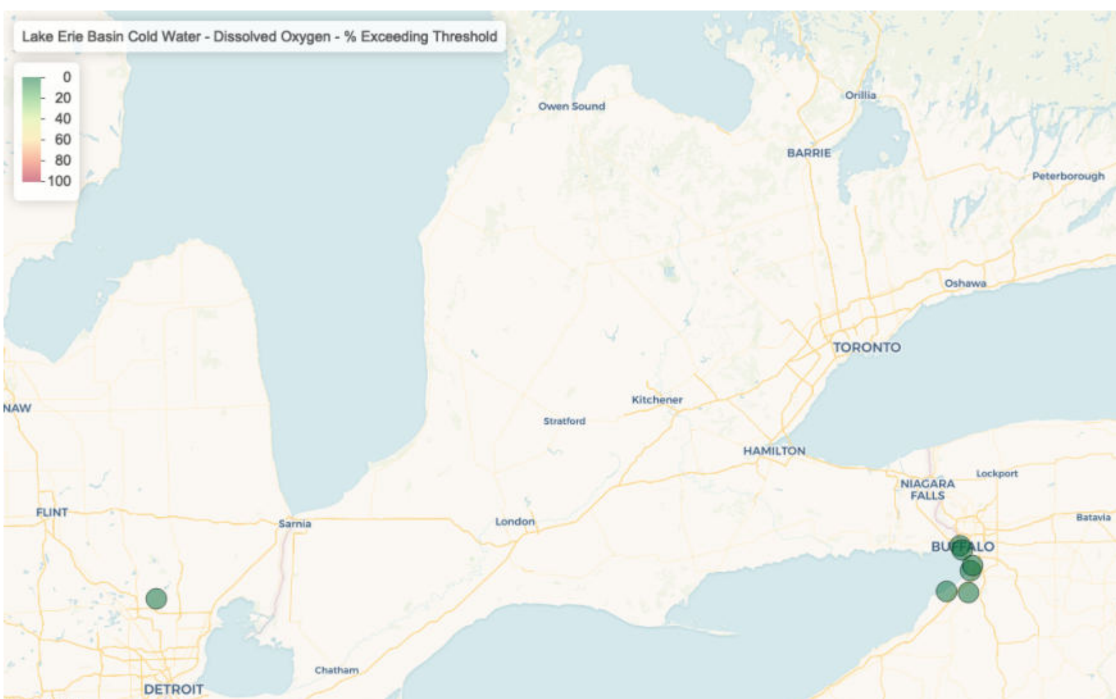
Data characterization: Cold water sites: Minimum = 7.5 mg/l, Median = 9.11, Maximum = 12.83. 0 exceedances.
Warm water sites: Minimum = 1.31 mg/l, Median = 8.37, Maximum = 84.8. 23 exceedances (5.5%)

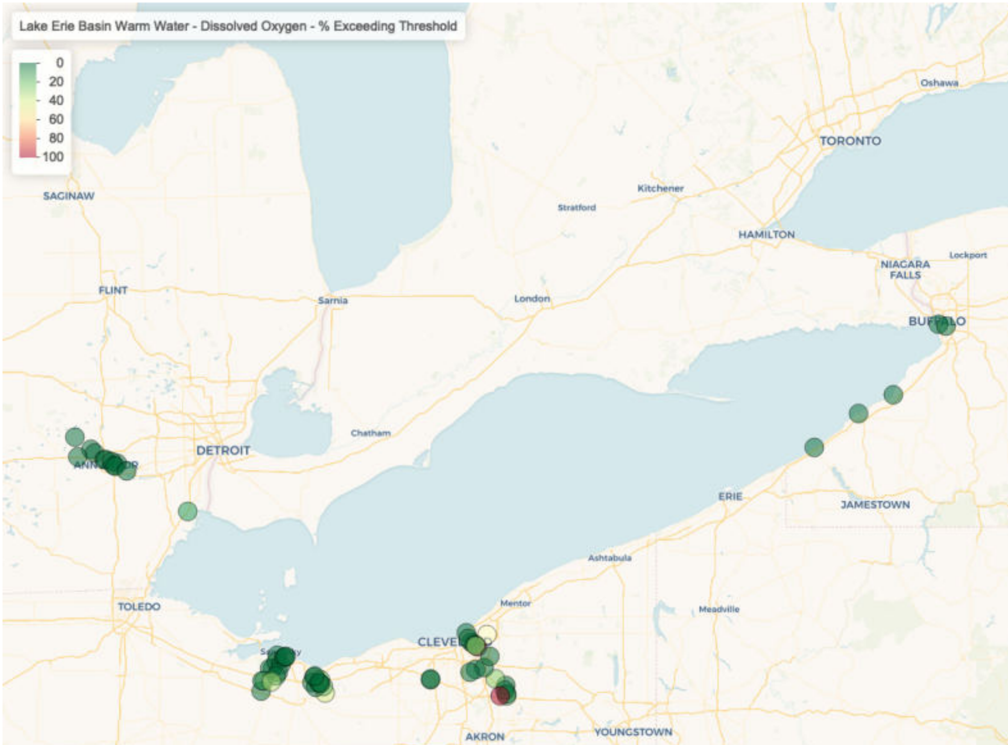
We would not expect any exceedances from LEVSN sampling, as sampling is all in flowing water. Some waterways, however, are man-made channels that may have odd DO levels (surrounding land-use issues). Doan Brook is an example. Daily fluctuations are related to photosynthesis during daytime and respiration at night. Eutrophic waters will tend to have higher levels of both, and an overall higher level of biological activity, so fluctuations in DO would be expected to be greater in such waters. Seasonal fluctuations would be expected due to temperature changes (colder during winter with higher DO levels, and warmer during summer, with lower DO levels). Spatial fluctuations would also be expected, such that 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.

In our 39 cold water stations out of 39 samples, none were lower than the threshold of 7 mg/l, and thus appear to be healthy with regards to oxygen levels. In our 61 warm water stations out of 427 samples, 23 were lower than the threshold of 5 mg/l. As expected, dissolved oxygen varied seasonally with a negative correlation to water temperature. Coldwater stations reported no exceedances with respect to dissolved oxygen, while warmwater stations reported few exceedances. Multiple exceedances occurred at Schaefer Park in Euclid Creek, several sites along Old Woman Creek, two other sites along Pipe Creek, and one site along Mills Creek. The percentage of exceedances at these stations ranged from 16.7 - 50% with the highest percentage occurring at Schaefer Park. Based on the data that was collected, there is likely minimal impact on Lake Erie as a whole. However, there is the potential for localized impacts, especially at the lowest levels of DO that were measured.

Considering the distribution of exceedances, there may be DO impacts to aquatic life at these sites. Evaluation of the 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. Impact to Lake Erie from low DO at these sites is unlikely. Data gaps are limiting assessment of the Lake itself, as we know there are DO issues within the Lake. Continuous monitoring or monitoring at a wider range of times may give more insight to variability and potential issues. Since dissolved oxygen is a function of water temperature, which varies temporally, a greater sampling frequency could be beneficial. The limited number of cold water stations and samples does not give us confidence in summarizing the data for cold waters. There are also spatial limitations to the data, as portions of western Ohio and the Maumee watershed are missing. These regions have historically experienced high nutrient loading, leading to algal blooms which can have drastic effects on dissolved oxygen levels. Particular focus should be paid to areas where exceedances occurred, however they are likely localized issues. Also, particular issues affecting DO, such as the aforementioned algal blooms, also occur seasonally, so a greater spatial and temporal extent of data collection would be helpful.

Figure 43. Lake Erie Dissolved Oxygen Cold and Warm Water % Exceedances Maps





Temperature
Data characterization: Cold: waters: Minimum = 7.74°C, Median = 19.58, Maximum = 24.94. 31 exceedances (79.5%).
Warm waters: Minimum = 3.7°C, Median = 18.9, Maximum = 29.8. 7 exceedances (1.7%).

All sites should meet standards as set (as designated). Temperature can also vary spatially based on groundwater inputs, factors like impervious surface cover and canopy cover, and stream morphology (slow or stagnant locations should warm more than areas where water flows faster). We expect exceedances of the high temperature standard to be higher in areas with more urbanization/impervious surface cover and less canopy cover. We expect cooler temperatures near sources of groundwater contributions to streams. Some sites in Buffalo are small tributaries with a lot of modification from industry, habitat modification and lacking shade and other pollution inputs could be impacting temperature and we might expect exceedances there.

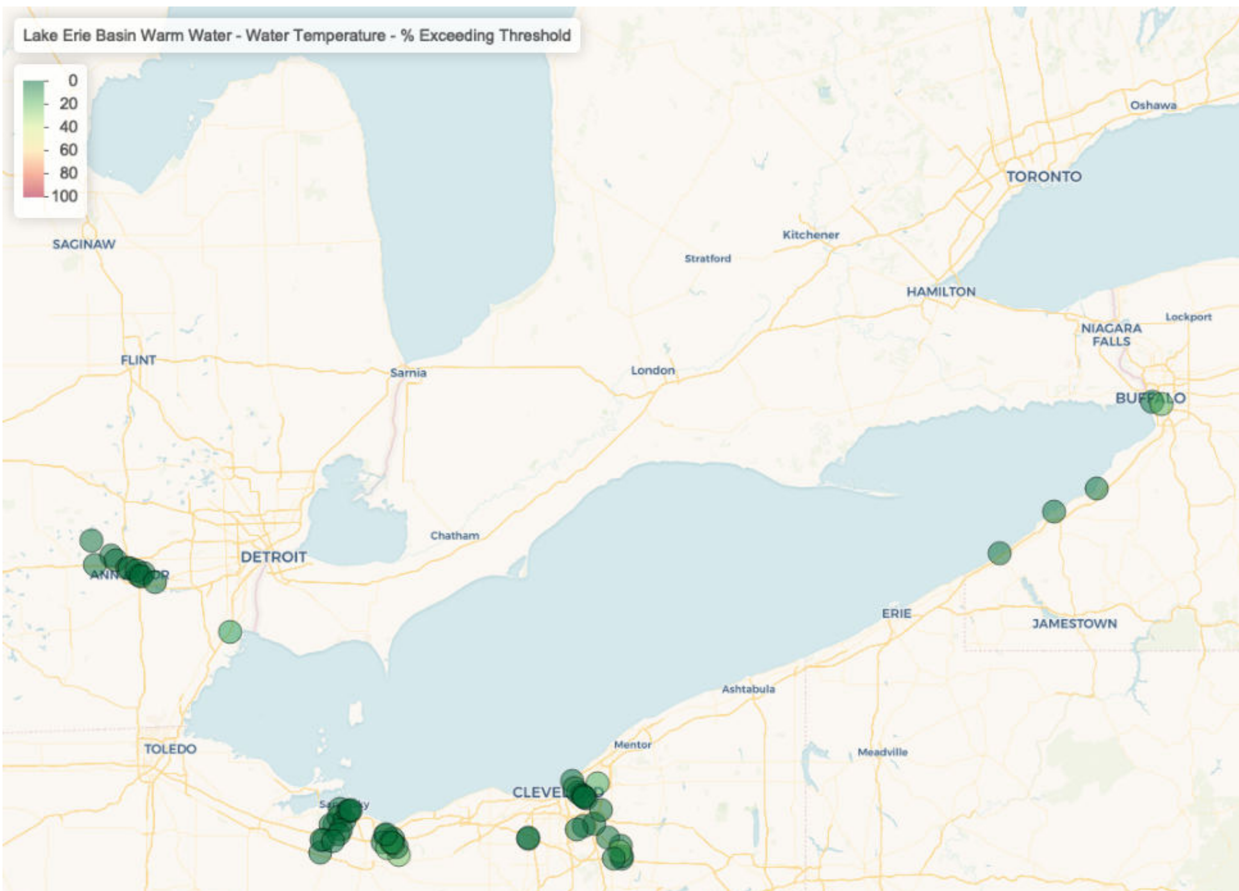
Contrary to what was expected, the coldwater sites had higher mean, median, and minimum temperatures than the warmwater sites. Warm water stations had a low percentage (1.9%) of exceedances, and the data and map show that the measurements are within the expected range. At the cold water stations, we found a high percentage (79.5%) of exceedances. We believe this might be partially due to a low number of samples and a condensed sampling season. It is also possible that there are other influences (e.g., climate/weather, industry) impacting the temperature of cold water stations, but without further information we are not able to determine whether data reflects the conditions of the stations. Also, temperature standards for cold water stations are significantly lower than those for warm water stations, thus they are easier to exceed. Multiple exceedances occurred at Euclid Creek, Paint Creek and at several sites along Old Woman Creek, in the Cleveland area. The percentage of exceedances at these stations ranged from 5.3 - 66.7% with the highest percentage exceedance occurring at Paint Creek.

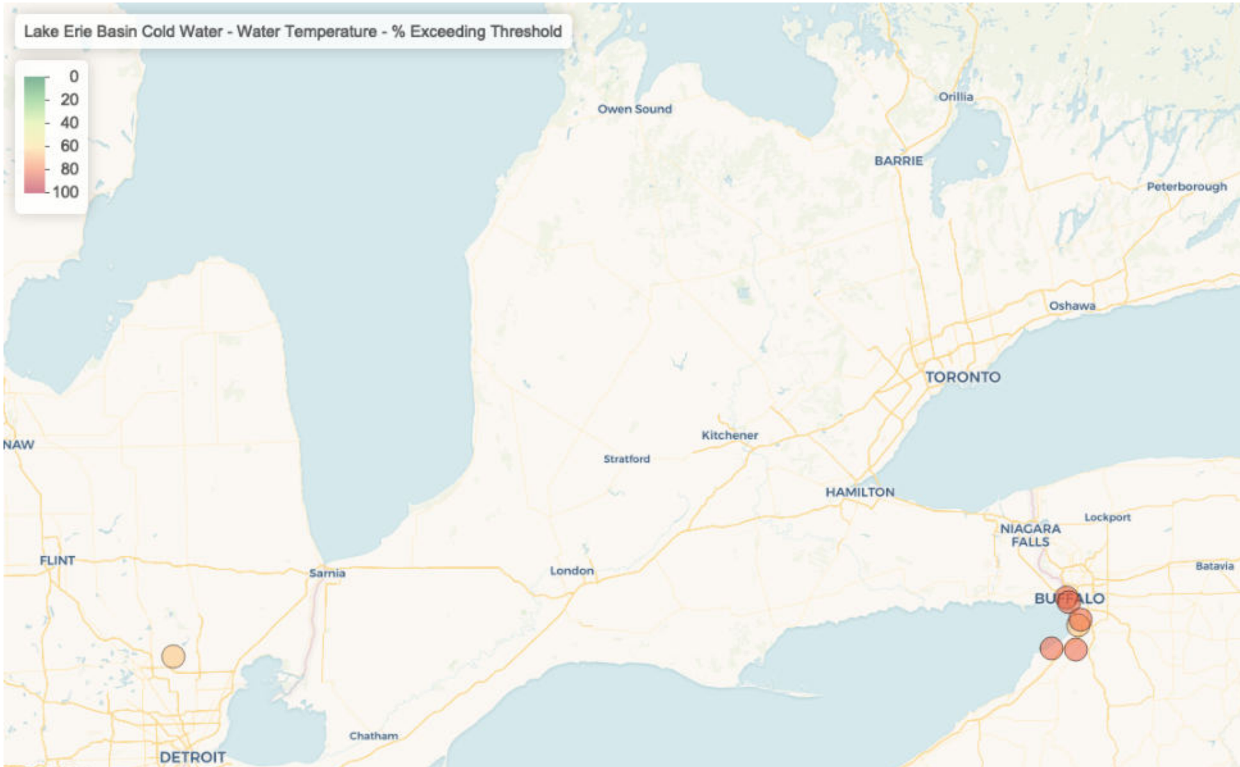
It is difficult to determine Lake Erie impacts from this 2022 LEBAF data. Much of this data is very localized and does not fully encompass enough temporal, weather, and spatial data. Land use information for many of our stations was limited. We believe that, at the basin level, Lake Erie is not impacted severely by the temperature readings from each of the direct tributaries, large rivers, and shoreline sites. For our monitoring purpose of screening, we believe that the cold water data may show a negative impact on Lake Erie as a whole. Most exceedances are in the COLD designated zones. Warmer than expected inputs from cold water Buffalo streams might be compromising the Lake. Warm water pushes east toward Buffalo. However, given data gaps, our organizations are unable to make a definitive conclusion about the temperature impacts on Lake Erie.

More chemistry and ancillary data is needed. We recommend that additional data is collected at cold water stations moving forward, and that the Buffalo local hub is asked to provide insight into the high percentage of exceedances at their sites. Cold water stations regularly exceeded temperature standards as established by LEBAF, potentially due to similar inputs (see above) and potential restrictions on size of the waterways. Because the threshold for these cold water stations is lower than for the warm water stations, effects of runoff and anthropogenic sources of pollution likely have a more noticeable impact on this parameter, and the aquatic organisms that depend on cold water conditions. The number of stations/samples is acceptable in this instance to support initial assumptions about the basin's condition, but having more stations that are sampled more frequently at the monthly and seasonal level, with variations in timing at the daily level would help us paint a more comprehensive picture of this parameter, and its relationship to the overall health/condition of the Lake Erie Basin. Special attention should be paid to locations where exceedances occurred, and more information should be collected on the magnitude, frequency, and duration of such exceedances, but overall there doesn't appear to be cause for concern.

Main limitations for temperature include a lack of data. Each sample was taken over a short timeframe during the day, and cannot capture all the temporal variations outside of a singular sampling event. A continuous measurement may be able to indicate more consistent trends with data. Because the data collected is limited to once a day or potentially once a month, no trends can be determined. Initial recommendations for temperature are to determine why the coldwater sites are, on average, warmer than the warmwater sites. A larger volume of data and metadata such as changes in surrounding land use, date/time of collection, weather, etc., would provide more insight on potential issues at the cold water sites. The volume of data and results at warm water stations leads us to believe that this parameter is within a desired range for the waterways represented. We would recommend an increase in the number of stations, the frequency of sampling at the monthly and seasonal level, and variation in timing on the day of sampling would help create a clearer picture of this parameter. Metadata about water levels, ambient weather conditions, potential pollution sources would also be useful, but might be difficult to collect.

Figure 44. Lake Erie Temperature Cold and Warm Water % Exceedance Maps





Conductivity to Survey
Characterization of the Parameter Data: For cold water sites, 39 samples were collected from 7 stations. The minimum value was 273.9 uS/cm, the maximum was 1209 uS/cm, and the median was 618.9 uS/cm. For warm water sites, 422 samples were collected from 60 stations. The range of measurements for these was much greater than for the cold water sites, with a minimum value of 0 uS/cm, maximum of 2677 uS/cm and median of 766 uS/cm. The figure below shows the percentage of exceedances for the warmwater sites.

This comparison was not a criteria or standard assessment that informs chronic or acute exposure. This was an exercise to see how well ambient conductivity data distribution, population of results, aligned with existing robust data sets provided by OEPA for two ecoregions, ELOP and HELP and three watershed sizes named headwater, stream and river for reference waters and survey sites which include reference sites. When the ambient conductivity population overlaps with either of these data sets it confirms its accuracy and confidence in using it for screening and condition assessments.

There is no 'exceedance' output from this comparison. Some locations were not in either of these ecoregions or had localized factors influencing conductivity and thus the overlap in population data was less. However, conductivity in all rivers aggregated had some overlap. In many cases the overlap was in the 50th percentile and higher. At lake sites conductivity comparisons were not meaningful or appropriate as the databases are from lentic systems.

Some harbor and shore line sites are not well mixed and represent the quality of inlet rivers. We completed the assessment at these sites for educational purposes.

Parameter Expectations: We expected overlap of ambient conductivity with respective ecoregion, watershed size and reference or survey data. We did not expect the alignment to be exact and knew some locations would have better overlap than others, all explainable. Waters with higher salts, ions, particles, and minerals content have a higher conductivity reading. Aquatic systems can experience very small changes in conductivity over a 24-hour period due to respiration and photosynthesis. Conductivity values increase during the winter as snowmelt can flush salts (unnatural ion source). High conductivity values can also be seen during low-flow periods when less fresh water is available to dilute mineral content. Typically, larger rivers are expected to have lower conductivity readings due to the greater volume of water, which can dilute the salts. Additionally, there are many reference streams that could exceed 655 uS/cm naturally and it is expected that there might be a lot of variability. Conductivity measurements at reference sites can also vary regionally, sometimes significantly.

For cold water sites, the median value of 618.9 uS/cm is around the 75th percentile when looking at the Erie-Ontario Lake Plain, but closer to the 25th percentile for the Huron-Erie Lake Plain. Therefore, evaluation of this parameter may be more accurate when examining results at a smaller scale such as at the large river or direct tributary. Measurements at the warm water sites showed a median value of 766 uS/cm, which was greater than that at the cold water ones. Once again, though, these sites should be compared to regional expectations to determine the extent of potential impacts.

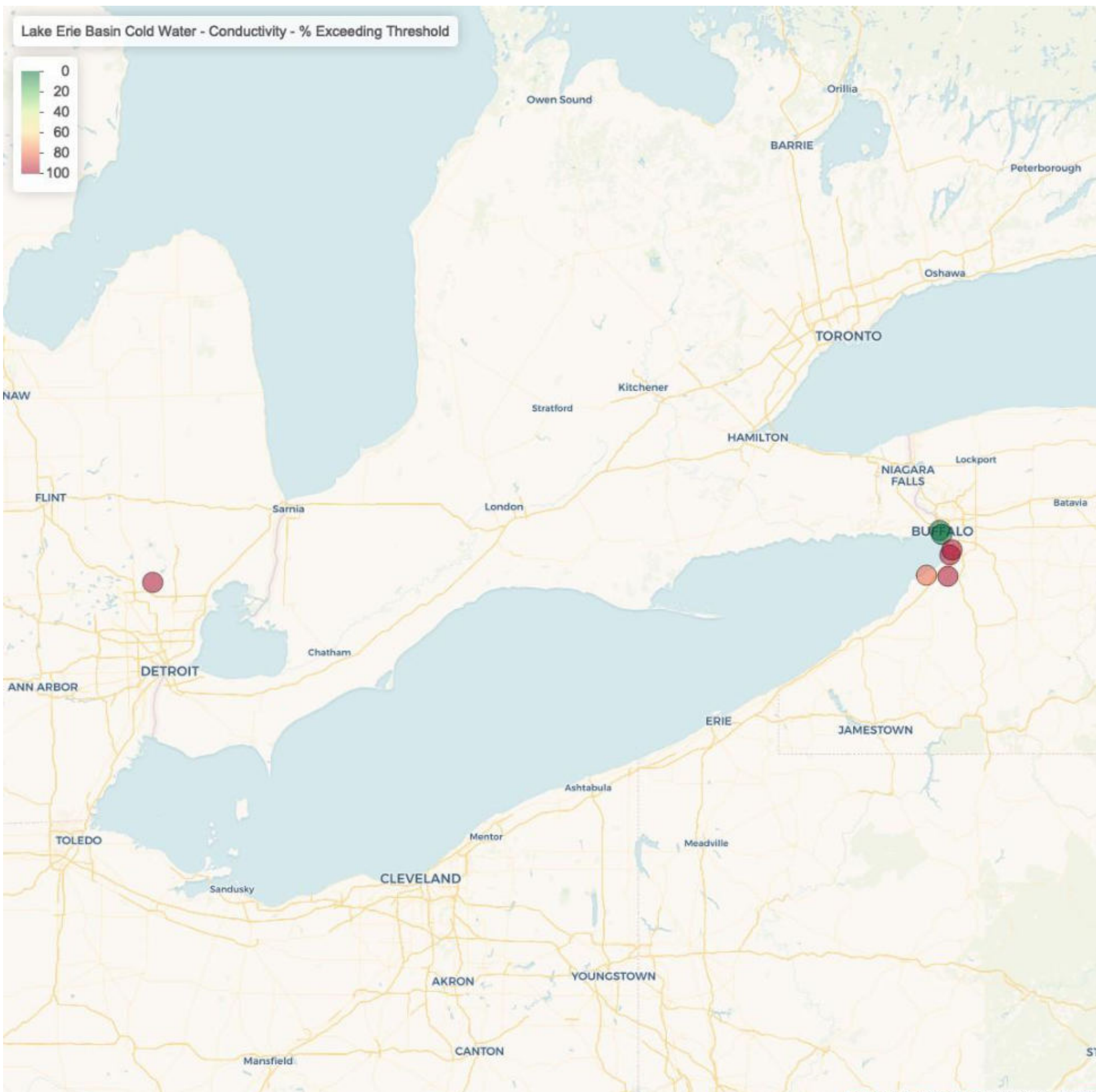
Parameter Story: LEBAF expects conductivity to vary seasonally and spatially (up to downstream) in river systems and to be diluted relatively in lake systems. In addition, localized factors such as geology or land use also influence ambient conductivity. Conductivity does not tell you specifically what is in the water, what elements are able to conduct electricity, but how strong or weak the conductance capacity. A higher conductivity doesn't mean aquatic life is exposed to toxicity or polluted conditions, but it can be an indicator. LEBAF compared conductivity to a larger database of reference and survey sites to corroborate results that were in the same population distribution. Every site in this dataset overlapped with the respective ecoregion and watershed size, and when the dataset was higher than the reference/survey (median, 75th percentile or maximum) it could be explained by localized geology, land use or that it is a different ecoregion. Furthermore, local knowledge of respective watersheds along with other parameters and results help characterize aquatic life conditions and inform recommendations.

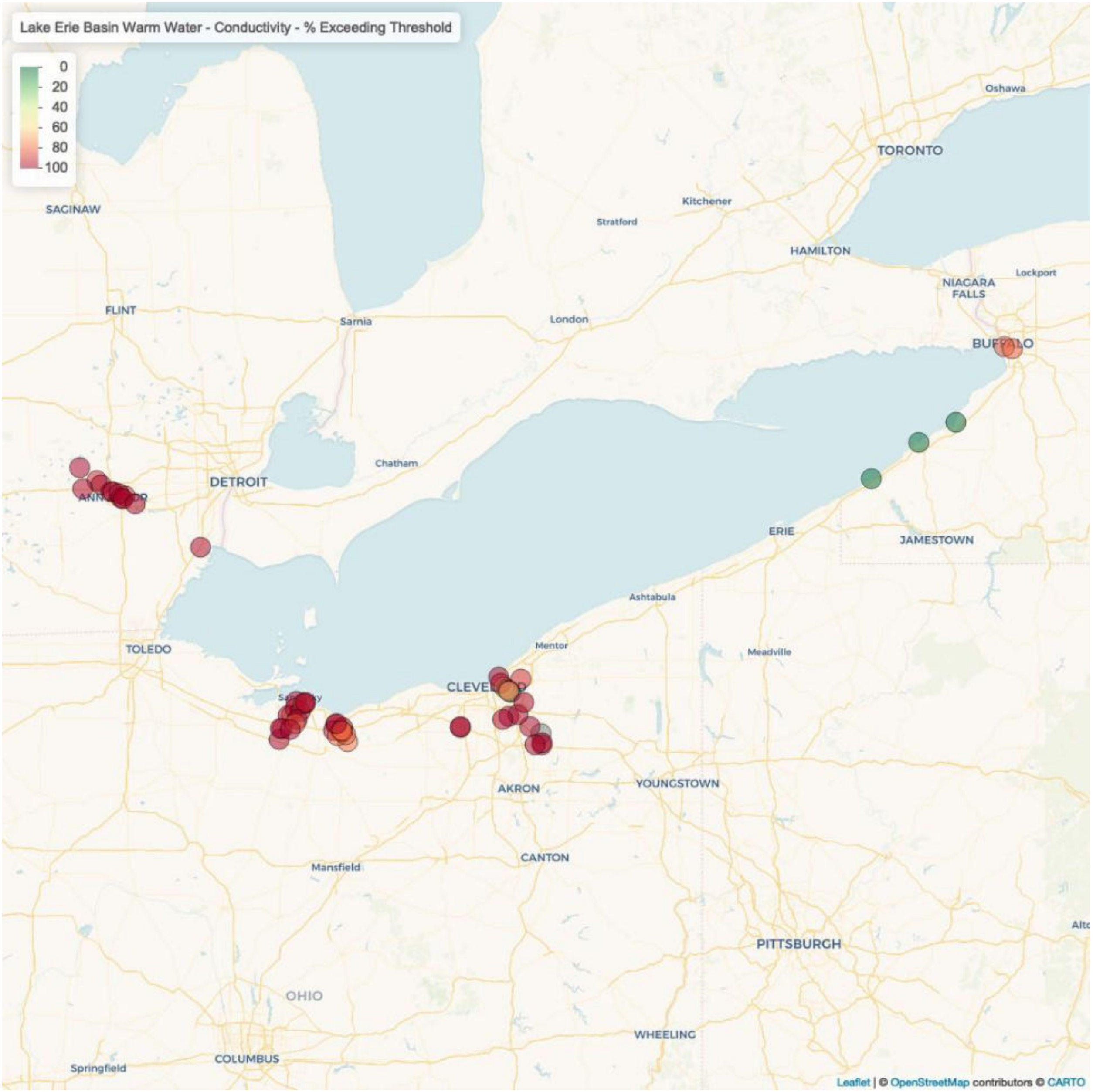
Lake Erie Conductivity to Biocondition Gradient

Characterization of the Parameter Data: This assessment allows LEBAF to use actual conductivity results and include a response community in this analysis, macroinvertebrates.

Ohio EPA built a macroinvertebrate biocondition gradient that was applied across all Lake Erie basin sites. This doesn't integrate localized variables but does serve as a screening tool. The Macroinvertebrate bio-condition threshold is 412 µS/cm, indicating a healthy macroinvertebrate community, 412- 655 indicates a declining or degrading condition, and greater than 655 µS/cm, indicates a degrading macroinvertebrate community. This condition gradient does not identify what may be causing healthy, declining or degraded community conditions, just at status. In addition, exploring actual macroinvertebrate data, existing or new is recommended to confirm or guide further recommendations.

Figure 45. Lake Erie Conductivity Cold and Warm Water % Exceedance Maps





For cold water sites, 39 samples were collected from 7 stations. The minimum value was 273.9 uS/cm, the maximum was 1209 uS/cm, and the median was 618.9 uS/cm. Of the samples collected, 26 were exceedances, which is 66.7% of samples. For warm water sites, 422 samples were collected from 60 stations. The range of measurements for these was much greater than for the cold water sites, with a minimum value of 0 uS/cm, maximum of 2677 uS/cm and median of 766 uS/cm. In total, 376 samples resulted in exceedances, which was 90.8% of samples.

Conductivity is expected to be low in shoreline, harbor or in lake sites that behave more like a lentic system, slower and deeper water allowing suspended material to sink. Shoreline sites or sites impacted by breaking walls or other factors may be in transition from river to lake or stir up suspended material with wave type action. The macroinvertebrate biocondition gradient was developed using riverine communities and is not appropriate to use in shoreline, harbor or in lake sites.

Parameter Expectations: These results suggest that all ranges of macroinvertebrate conditions exist in the basin and we would expect that based on actual macroinvertebrate data collected by various groups. Using conductivity relationship to macroinvertebrate community condition is a feasible screening tool to focus future sampling, protection and restoration efforts. Collectively having the biocondition thresholds exceed 412 or 655 about 78% of the sampling events suggest that stressors, maybe not conductivity alone, are creating conditions which cause declining, degrading, or already degraded communities frequently and perhaps for long durations. The magnitude is not large as conductivity goes with the maximums being 1209 and 2677. Many of the higher conductivity results are explained by natural conditions such as karst geology and anthropogenic sources. If sites below 412 are explored for protection recommendations, sites between 412-655 explored for stressors and actions that might reverse the decline before degradation and sites greater than 655 are explored for restoration, assuming confirmation of actual condition can happen, this metric is an effective screening metric.

Parameter Story: Broad urban/suburban conductivity exceedances were found throughout the Lake Erie Basin, indicating these streams are compromised and likely seeing aquatic life impacts. Of the data that was collected, many of the direct tributaries and large rivers had exceedances greater than 90% and at 100% in some instances. The two direct tributaries with a relatively lower percentage of exceedances included the Buffalo River (25%) and Old Woman Creek (37.5%). The data set was limited, however, lacking sites in Canada and in several locations on the United States side.

In addition to a limited number of sites and data points hindering a more thorough evaluation, in many instances the source of the conductivity exceedances could not be identified. In those instances, it could not be determined whether land use impacts, natural chemical processes, runoff, errors with data collection, or malfunctioning equipment were to blame. Additional monitoring, along with experience gained through continued participation in the network, may help to address some of these issues.

It would be useful to have this data plotted seasonally to look for trends. In general, it appears that many of the waters sampled are experiencing conductivity exceedances and that it could cumulatively impact macroinvertebrate health. However, information on how conductivity from tributaries is changing when meeting the Lake is also needed. For example, dilution impacts may mean that aquatic life impacts that are occurring in the tributaries may not be occurring in the lake itself.

Lake Erie Expressions of Conductivity

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. In essence, develop LEBAF conductivity thresholds as one story to understand aquatic life conditions. Results below should be filtered through these goals.

Conductivity to TDS

Characterization of Parameter Data: In 2022, 39 samples were taken from 7 cold water sites. The minimum value from these sites was 150.65 mg/L, the maximum value was 664.95 mg/L, and the median value was 340.4 mg/L. In total, 26 of the 39 collected samples (66.7%) resulted in exceedances of the drinking water standards. For warm water sites, 427 samples were collected from 61 stations. The minimum value was 0 m/L, maximum value was 1,472.34 mg/L, and the median value was 421.3 mg/L. In total, 385 of the 427 collected samples (93%) resulted in exceedances of the drinking water standard. It is important to note that the TDS standard is a drinking water standard not aquatic life, which doesn't exist. Thus, exceedances do not mean aquatic life are not exposed to harm, but a screening method to explore TDS, actual aquatic life indicators, possible sources or other stressors at exceedance locations and periods.

Parameter Expectations: TDS is expected to be variable and largely driven by runoff events (rainfall and snowmelt). TDS increases are expected in systems with increased erosion, runoff, plant decay, and chemical weathering of rocks. Urban areas are anticipated to have higher TDS values due to increased runoff from impervious surfaces and associated erosion runoff. Variability in TDS values is also expected both seasonally and during runoff events. Seasonally, water bodies commonly experience higher TDS values in the winter from increased salting (snowmelt), in the spring and fall due to seasonal precipitation, and from construction activities in the spring, summer, and fall. TDS can also be variable during runoff events with TDS increasing initially due to runoff, but subsequently decreasing due to dilution. TDS is also expected to be higher and more variable in rivers relative to lakes.

The relationship between conductivity and TDS is well documented. TDS measured by meters is using the same calculation LEBAF employed in the analyses application. Localized events or conditions may deviate or influence this relationship. Whenever possible direct measurements are preferred. As LEBAF explores using conductivity to estimate TDS, it may be that some sites are excluded from this analysis due to local conditions. Groups are comparing calculated TDS to actual results when they can. Direct measurement of TDS requires a laboratory method, which is more precise and facilitates sampling multiple stations at the same time but is not feasible for many volunteer groups.

Parameter Story: The TDS standard used in assessment this year is a drinking water threshold used as LEBAF explores the effectiveness of the Ohio aquatic life threshold of 1500 mg/L and developing its own conductivity thresholds. This aquatic life threshold may or may not be appropriate for lake systems. TDS exceedances of the drinking water standards were high in both cold (>60% exceedance rate) and warmwater sites (>90% exceedance rate). This is not surprising in that no one expects to consume water from regional rivers without treatment to remove excess TDS. The high frequency of exceedances is likely partly attributed to sampling sites being predominantly located in urban areas where higher TDS values are expected from increased runoff and erosion. Using drinking water standards to assess aquatic life health may not be an effective screening approach for aquatic life conditions. However, few if any sites exceeded the 1500 mg/L aquatic life threshold LEBAF is exploring. This indicates in general TDS itself is not a direct threat to aquatic life but may help indicate when other pollutants may be present. Sample sites may not represent all site variations in the Lake Erie Basin. For example, the network and thus analysis would benefit from more non-urbanized sampling sites being included in the TDS data set.

Based on the data available, TDS may have impacts on Lake Erie in regard to drinking ambient lake water but not for aquatic life if the 1500 mg/L threshold is protective. The relatively large number of exceedances, particularly among the warmwater sites, indicates that it is impacted routinely by sources of pollution that can cause high TDS levels. However, interpretation of TDS impacts to Lake Erie is difficult due to sampling data limitations. In addition to the lack of representative samples from non-urban areas, the frequency of the TDS samples makes it difficult to determine the temporal variations in exceedances, as well as the duration, in the Lake Erie Basin.

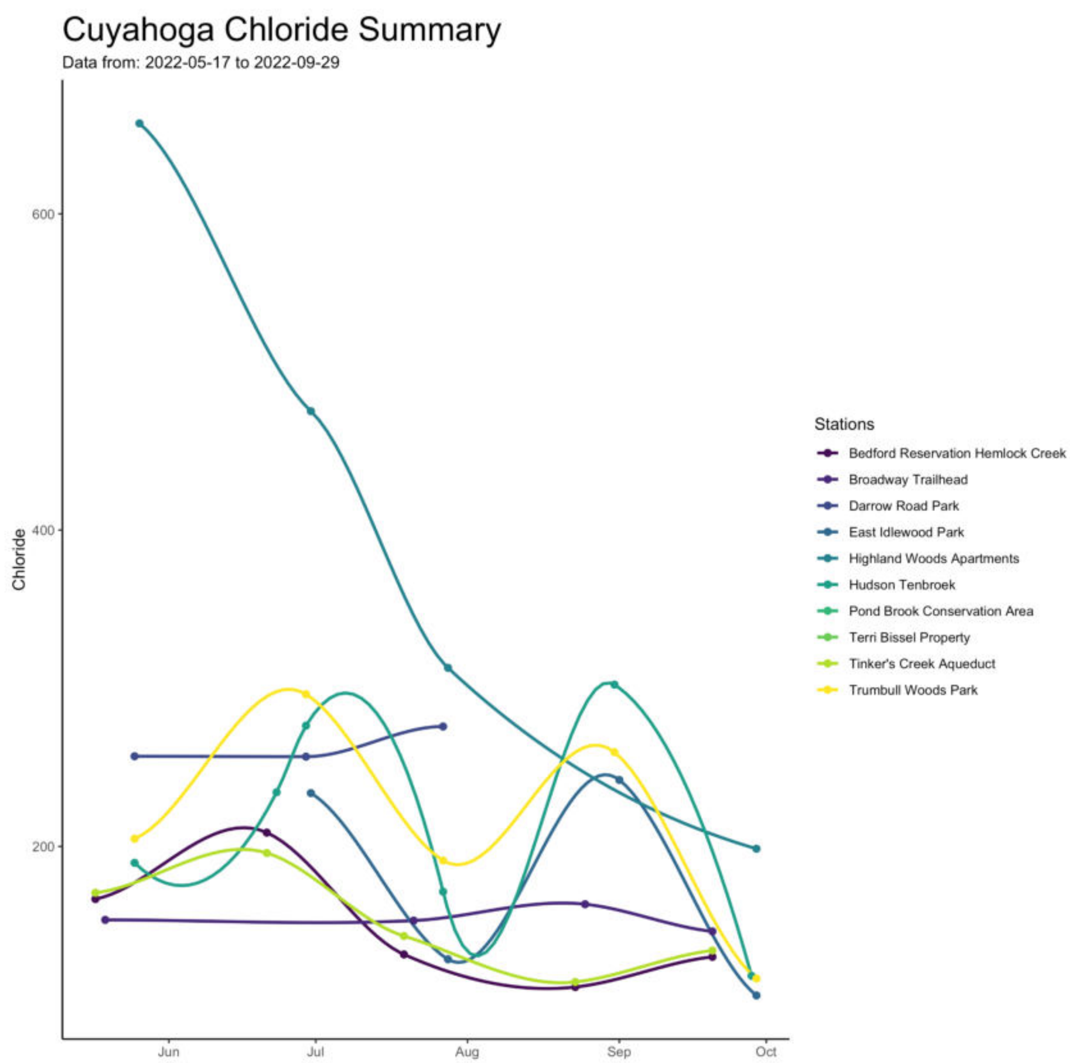
Conductivity to Chloride

Characterization of the Parameter Data: In 2022, 7 stations were located in cold water tributaries. Calculated chloride concentrations ranged from 13.50 to 59.58 mg/L and had a medium of 30.5 mg/L. Of the 39 samples collected in 2022, 0 (0% exceedance) were above the threshold for chronic exposure, suggesting that aquatic life was at a low risk to chloride exposure during sample collection.

In 2022, 61 stations were located in warm water tributaries. Calculated chloride concentrations ranged from 0.00 to 657.20 mg/L, the maximum slightly above the acute threshold of 650 mg/L. The collective medium of 49.72 mg/L, suggest that 50% of the time chloride is well below the lowest chronic aquatic life threshold of 150 mg/L. Of the 427 samples collected in 2022, 29 (7% exceedance) exceeded either the chronic or acute exposure thresholds for aquatic life, perhaps indicating a low frequency, duration along with magnitudes when exceedances occur, but more data is needed.

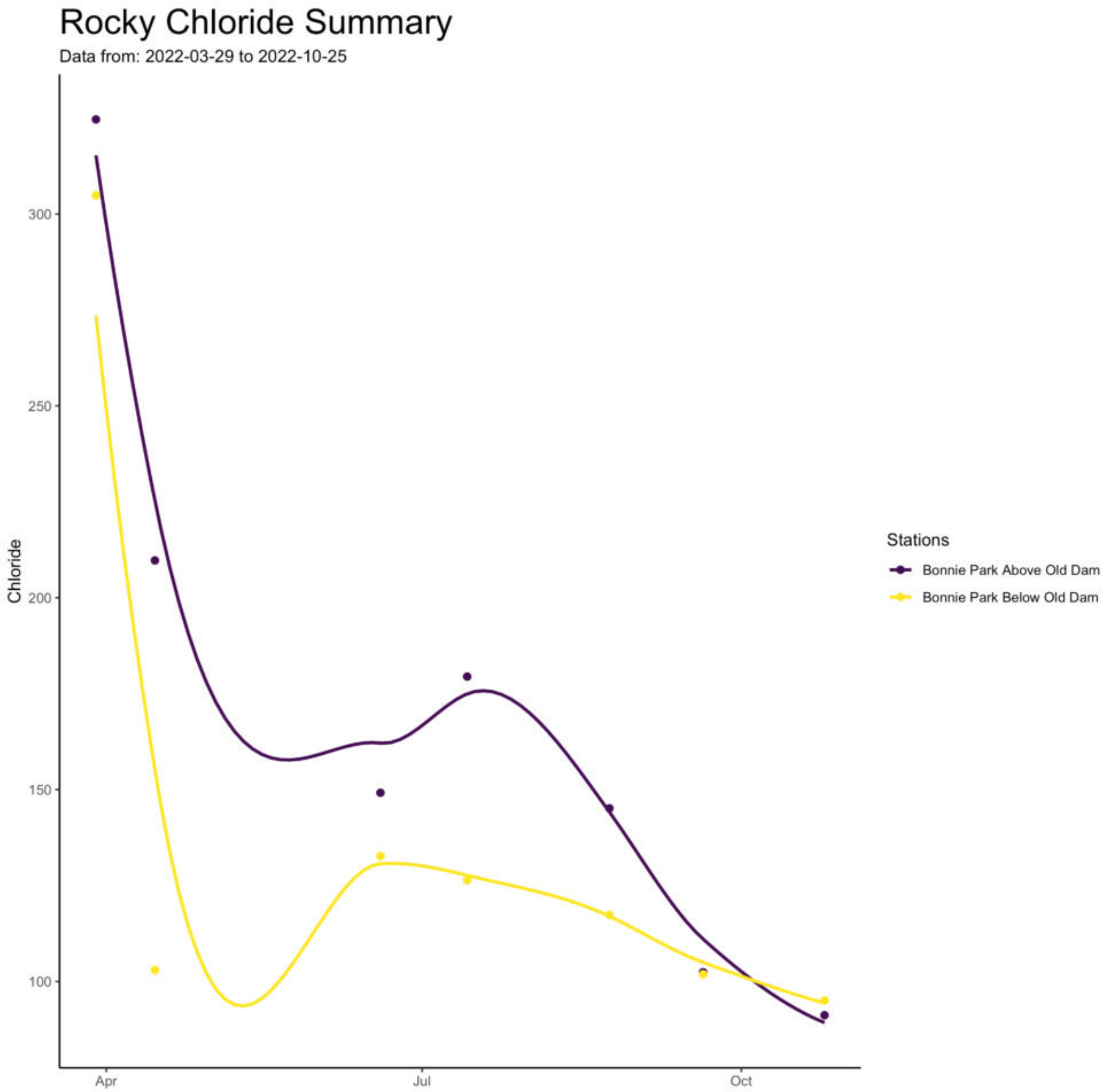
These exceedances are not reflective of the Lake or the entire basin. Of the 29 observed chloride exceedances in 2022, 25 occurred in Tinker's Creek and 4 occurred in the Rocky River Basin, both in the greater Cuyahoga River basin. Generally, aquatic life in warm water systems were at low risk to chloride exposure throughout the sampling period, although this did not appear to be the case for the Tinker's Creek (Cuyahoga River). This would extrapolate to Lake Erie, in this data set, from the tributaries that were included, cold water systems are not a source of chloride and a few tributaries within larger mainstem are responsible for a small load from water water systems. This does not include or account for actual loading or chloride concentrations in larger rivers or direct tributaries not directly measured or absent from this effort.

Figure 46. Cuyahoga River Chloride Summary Graph



Tinker's Creek 2022 Chloride Sampling Data

Figure 47. Rocky River Chloride Summary Data Graph: Line graphs generated were intended to show seasonal patterns and not long term trends.



Rocky River 2022 Chloride Sampling Data

Parameter Expectations: Chloride concentrations in general are expected to be highest in urban areas. Road salt application is one of the primary contributors to chloride concentrations in surface waters. It is expected that areas where more salt is applied, such as urban areas and areas with high snowfall, will have higher chloride concentrations. Temporally, chloride concentrations are anticipated to be most variable in spring and fall when precipitation is highest. This limited data set followed this pattern through conductivity expressed as chloride. In general, cold water systems, higher in the watershed did not exceed the aquatic life thresholds and warm water systems, two in particular that are urban, did exceed some chloride criteria. Exceedances did not appear to be high in magnitude, frequent or long in duration but more data would be needed to characterize the complete ambient condition.

Parameter story: Generally, 2022 sampling indicates that chloride exposure poses a low risk to aquatic life throughout the Lake Erie Basin. All of the observed chloride exceedances in 2022 were isolated to two stations, the Rocky River and Tinker's Creek, in the greater Cuyahoga River basin, see the table below. Interestingly, these two tributaries are located near each other, so it is possible that the cause of elevated chloride concentrations might be the same for both tributaries. This data set does not tell the entire Lake Erie or Cuyahoga River story, no data set does. While chloride appears to be of low concern in most tributaries, at least based on 2022 sampling, there are a couple where it warrants additional attention to determine what potential impacts to aquatic life may be.

A common theme throughout the analyses is that development of a broader, basin wide understanding of chloride concentrations is needed. This includes beginning sampling earlier in the spring, when road salt runoff is likely highest, as well as verifying that calculated chloride values do reflect direct chloride calculations equally well in all basins. Answering some of these questions may lead to a more robust understanding of chloride patterns within the Lake Erie basin. From this perspective, conductivity expressed as chloride would be a feasible and effective screening approach to inform further monitoring and protection or restoration actions.

Conductivity to Salinity

Characterization of the Parameter Data: In 2022, seven stations were located in cold water tributaries. The salinity levels for the 39 samples collected ranged from 209.15 ppm to 1,051.76 ppm with a median level of 507.66 ppm with one exceedance or 2.6% of samples. For warm water sites, 422 samples were collected from 60 stations with 74 exceedances or 17.9% of samples. The salinity levels ranged from 0 ppm to 2,497.14 ppm with a median value of 640.2 ppm. Salinity results were compared to the USGS recommended salt content for freshwater.

- Freshwater: Less than 1,000 parts per million (ppm) or 1 g/L
- Slightly saline water: 1,000 ppm – 3,000 ppm or 1-3 g/L
- Moderately saline water: 3,000 ppm – 10,000 ppm or 3-10 g/L

The maximum for cold and warm water exceeded the freshwater category. The warm water samples were more saline than the cold water samples noting the sample size of warm water samples is about 10 times larger. The median suggests that with this data set 50% of the time salinity levels are 500 for coldwater sites and 640 for warm water sites. Interestingly the minimum was 210 for coldwater and 0 for warmwater. Even if salt is in the water based on this range, it doesn't mean aquatic life is harmed, just exposed. It is likely spikes in salinity levels occur during storm events, winter deicing application or other events. This implies, without evidence, frequency is sporadic, duration short and event associated, but could be long over multiple events. The magnitude is not large, encouraging more data collection and exploring deicing compounds and application protocols to keep salt out of rivers and the Lake.

Parameter Expectations: Salinity levels are expected to fluctuate throughout the year, especially during the winter months when road salt is being applied. However, the current level of data provided will not allow for an analysis of these trends since measurements are not taken throughout the year. As with chloride and similar study design consideration, conductivity expressed as salinity would be a feasible and effective screening approach to inform further monitoring and protection or restoration actions.

Parameter Story: Salinity inputs from the monitored tributaries do not appear to be a risk to Lake Erie aquatic life. Most of the data was within the freshwater category with exceedances only in the slightly saline category. However the 2022 LEBAF data has limitations that make it difficult to determine salinity impacts to Lake Erie. The sampling sites are localized and do not include enough temporal (seasonal), weather, and spatial data. Measurements taken throughout the year, especially during winter months, would assist with determining the salinity impacts to Lake Erie and local waterways.

5.4 Lake Erie Overall Results Summary

Approach

Between the various monitoring efforts conducted on local water bodies in 2022, LEBAF participants came together to monitor a total of 67 stations (60 Warm Water and 7 Cold Water sites with 422 and 39 respective samples) across the Lake Erie Basin. Data for seven parameters (pH, DO, temperature, conductivity, and related measures of expressions of conductivity for TDS, chloride and salinity) were collected at all stations roughly once per month from April to October. A few participating groups didn't begin monitoring until later in the season due to delayed delivery of field equipment caused by global supply chain challenges. ***All observations and interpretation described below, in each individual water body's aggregated summary, and in the Lake's Recommendations and Conclusions section should be taken as heavily qualified by a range of limitations that face this monitoring program in its first year of operation.***

LEBAF aggregated data for all parameters across all sites to see if the approach, even with limited data the first year, would be effective to characterize aquatic life support for screening purposes and provide a Lake Erie level perspective into the future as more data, stations and possible parameters are added. Each parameter is its own indicator of aquatic life health with inherent limitations as well as influence for aquatic life community structure and function. Multiple lines of evidence, created by collecting and analyzing more than one parameter against aquatic life thresholds, builds greater confidence in providing accurate representation of ambient conditions. Each parameter tells its own story regarding aquatic life support and together the story is more compelling and helpful to protection and restoration actions. In addition, chemical parameters and their aquatic life thresholds are a surrogate assessment approach to measuring response communities directly such as macroinvertebrates, micro-organisms, aquatic vegetation, zooplankton or fish. This is the Federal Clean Water Act's primary assessment approach, looking at individual stressors versus accumulative, synergistic effects. The assessment process can but doesn't always take in a multiple lines of evidence approach at various decision points. The multiple lines of evidence assessment approach used by LEBAF did achieve LEBAF's monitoring purpose at the local, large river and direct tributary level where data existed. More data is needed with some cases, more stations are needed to refine that story and assessment methods at these scales.

However, while aggregated data can tell a version of Lake Erie's condition, it can be misleading in that a condition, healthy or unhealthy, in one tributary does not necessarily represent the condition in the region. It is helpful to understand conditions that do apply across the region, that apply in multiple areas but not everywhere or might be related to one area. For this reason, we also provide a summary of respective watersheds to review. Please see Results: Large Rivers and Tributaries or request individual river reports for that scale of assessments and recommendations.

At the Lake Scale, the majority of sites were in rivers and a few were on Lake Erie shorelines or in harbors which can be transition zones from lotic to lentic systems and a few sites were on the Lake itself. Assessment criteria developed for river system aquatic life may or may not always be appropriate for lake systems. This is also addressed in our assessment and recommendations.

In addition, the interpretation is limited but still meaningful at a screening level. If every major tributary of every major river entering Lake Erie was assessed, a view of that collective aquatic life condition would be compelling at the Lake level, a story no one is tracking in this way. This story complements monitoring efforts and results on and in the Lake itself, of which is a challenge for many programs to implement. The connection between rivers and the lake is essential to maintain or restore health to both systems.

DO, pH and Temperature Lake Summary

The tables above illustrate the aggregated exceedances for each parameter. When evaluating DO, pH and temperature, common and effective indicators of aquatic life condition, with this limited data set, Lake Erie aquatic life is relatively supported. Sites in harbors and in the Lake did not exceed DO. Cold water DO was never exceeded at any site and warm water sites had 23 (5%) exceedances, of which the exceedances were primarily of the low DO threshold. The DO high threshold indicates supers saturation which this data set did not find. If aquatic life in both river and lake systems can find refuge during these exposure events, their overall condition, community structure and function is not impacted. In general, DO is not a limiting factor in LEBAF's assessment of aquatic life in Lake Erie by itself. In addition, the relationship DO has with nutrient cycling and algal blooms is complex and beyond a study design for a screening purpose. More data is needed at these sites, perhaps more sites on these rivers, sites on absent rivers and brought into context with data from the lake itself. Most LEBAF groups are focused on rivers but can integrate lake data to explore this regional interconnected story. DO results indicate they are representative of ambient conditions even if collected as part of a robust DO study design. Assessment methods also seem appropriate for screening. Initial results support the use of DO for a screening purpose and the assessment at the local and regional scale.

Table 42, below displays a summary of exceedances in watersheds we collected data. DO exceedances were in order of occurrence, Euclid Cr (6), Tinker' Cr (5), Doan Brook and Old Woman Cr (4), Pipe Cr (2) and Huron River and Mills Cr (1). DO was not found to be severely limiting in any of these watersheds, but perhaps contributing to slightly unhealthy aquatic life conditions especially in Euclid, Tinker's and Old Woman Creek which also had pH and temperature exceedances. Other systems with DO exceedances did not have pH or temperature exceedances.

Exceedances of pH were relatively rare, 9 out of 466 measurements. Cold water pH was exceeded one time and warm water 8 times, primarily the higher threshold but occasionally the lower. All exceedances were not a high magnitude and, like DO, if aquatic life can find refuge, impacts are not detrimental. Shoreline, harbor and on the Lake sites had no pH exceedances. From this limited dataset, pH is not limiting in any one watershed or Lake Erie for aquatic life. Most pH exceedances correspond with systems that also had DO exceedances, Euclid (5), Tinker's (2), Old Woman Cr (1), the exception is one exceedance in Rush Creek. The pH results indicate they are representative of ambient conditions even if not collected as part of a robust pH or diurnal study design. Assessment methods also seem appropriate for screening. Initial results support the use of pH for a screening purpose and the assessment at the local and regional scale.

Exceedances of temperature were more common in cold water than warm water systems. This is common across the region and country as cold water species are more sensitive to temperature, and climate change impacts favor warm water species. Conditions in a harbor or shoreline may still be in transition relative to open water temperatures, where the lake also has a depth temperature profile. In cold water systems temperature was exceeded 31 of 39 measurements or 80% of the time. Compared to warm water systems only 8 or 2% of measurements exceeded thresholds. Like DO and pH, if aquatic life can find refuge from these events, impact may not occur. Exceedances of 80% suggest the frequency is often and duration long, even if magnitude is not high. It does raise the question, as screening should, if these streams are sufficiently meeting cold water designations within respective Clean Water Acts and supporting cold water species. These streams need to be fully characterized to determine whether or not they are able to support cold water species, the directive of gathering more data and/or leveraging existing data. It is possible employing real-time monitoring devices at strategic locations for a critical period of time would be a feasible plan to refine temperature ambient conditions.

Temperature assessment criteria applied to the life cycle and needs of riverine species may differ from lake aquatic life. Of these three parameters, DO, pH and temperature, it appears temperature is the most limiting in rivers, but is not likely limiting in the Lake. More data and appropriate assessment criteria would be needed for Lake assessments. One harbor site did exceed temperature but no other shoreline or harbor site did. All six readings in Outer Harbor at WP exceeded temperature 83% of measurements. Chemistry at this site represents more of a lotic system than lentic and in transition between the two and influenced by a breaking wall.

Temperature exceedances were spread out in the basin with the most occurring in *Eighteen Mile Cr* (10), Smoke Cr (5), Rush Cr (4), Old Woman Cr (3), Euclid Cr (2) and Tinker's Cr, Huron and *Buffalo Rivers* (1). For illustration*, italicized river names* show rivers that had only temperature exceedances, but no DO or pH exceedances; this may indicate different stressors and thus solutions, but may not. Temperature results indicate they are representative of ambient conditions even if not collected as part of a diurnal study design. Assessment methods also seem appropriate for screening. Initial results support the use of pH for a screening purpose and the assessment at the local and regional scale, with adjustments at the Lake scale.

Table 42. Summary of Exceedances by Waterbody and Parameter

River	**DO**	**pH**	**Temp**	**Conductivity Bio Condition (%)**	**TDS (%) (Max, Med)**	**Chloride (%)**	**Salinity (Max, Med)**
Clinton R	0	0	2	3 (67%)	3 (100%) (514,382)	0	0 (794, 570)
Tinker's Cr	5	2	1	36 (100%)	36 (100%) (1422,557)	25 (7%)	13 (2497,867)
Huron R	0	0	1	159 (99%)	160 (90%) (1119,448)	0	38 (1853,685)
Rocky R	0	0	0	14 (100%)	14 (100%) (955,432)	4 (28%)	3 (1559,685)

Buffalo R	0	0	1	10 (84%)	11 (92%) (357,270)	0	0 (535,394)
Doan Br	4	0	0	14 (67%)	17 (81%) (498,279)	0	0 (768,410)
Eighteen Mile Cr	0	0	10	11 (92%)	11 (92%) (364,338)	0	0 (547,504)
Euclid R	6	5	2	13 (93%)	13 (93%) (791,423)	0	3 (1270,693)
Rush R	0	1	4	6 (100%)	6 (100%) (633,608)	0	0 (997,954)
Smoke Cr	0	0	5	6 (100%)	6 (100%) (665,562)	0	1 (1052,876)
Mills Cr	1	0	0	40 (98%)	41 (100%) (1062-479)	0	11 (1750,736)
Old Woman Cr	4	1	3	51 (91%)	53 (95%) (514,325)	0	0 (794,482)
Pipe Cr	2	0	0	39 (95%)	40 (98%) (971,502)	0	6 (1588,776)
Barcelona H	0	0	0	0	0	0	0
Cattaraugus H	0	0	0	0	0	0	0
Dunkirk H	0	0	0	0	0	0	0
La Salle Pk	0	0	0	0	0	0	0
Outer H @ WP	0	0	6	0	0	0	0

Conductivity Lake Summary

Conductivity result data distribution was compared to a reference and survey conductivity data set, based on ecoregion and watershed size. This was not to determine exceedances or impairment but to verify results represented ambient conditions by comparing to existing data. If there is population overlap, that provides confidence that conductivity results are valid and representative of ambient conditions. Further, this provides confidence in employing expressions of conductivity in the next section.

Results from every river had overlap with the respective survey data set and in most cases the reference data set as well. Overlap varied from fairly similar to 50% and higher alignment to one creek, Mills Creek, that had overlap at the 75th percentile and higher. These are not surprising results and somewhat expected. Not all rivers are in the two data set ecoregions and thus localized conditions, geology (Karst in Mill Cr case), groundwater, and other conditions explain the deviations. This does not mean conductivity results in these cases are not representative of ambient conditions. In most cases existing data in respective watersheds aligned with conductivity results from this effort. Results at all locations reflect existing data, expectations and or ancillary information and represent ambient conditions, even if the data set is limited. Conductivity is an effective and common screening parameter. Conductivity results in shoreline, harbor and in Lake sites were significantly lower readings than in rivers sites. It is a physical chemistry property that suspended solids settle out in lentic systems. Conductivity readings at all of these sites were extremely low (less than 5), except the La Salle Pk and Outer Harbor @ WP sites, which were in the 200-300 uS/cm range. These sites resemble water in transition from lotic to lentic systems and influence from a breaking wall.

Conductivity results were assessed against a biocondition gradient for macroinvertebrates. This provided a threshold and exceedance approach similar to assessing against a chemical threshold. The use of the macroinvertebrate biocondition allows direct use of the conductivity reading while also providing a connection between chemistry data and response communities, in this case, macroinvertebrates. The biocondition gradient provides the equivalent of a chronic and acute threshold. Below conductivity of 412 uS/cm, macroinvertebrate community structure and function is intact and the community is in healthy condition. Between 412 and 655 uS/cm, community structure and function is showing signs of decline or degradation. Above 655 , community structure is likely already degraded. Using this as a screening tool, helps inform action, especially if other chemical parameters for aquatic life thresholds are exceeded and existing (or future) macroinvertebrate information aligns.

To note, every single river exceeded this biocondition, some the 412, others the 655 threshold. **Table 42** above shows exceedances ranged from 2 to 132, based on the sampling effort. The exceptions are the shoreline, harbor and on lake sites. These sites show exceedances in the metric tables above, however conductivity results range from 279-303 which is well below 412 and 655. LEBAF is exploring if the data or assessment script are in error, as the conductivity readings are believed to be valid. Furthermore, the biocondition employs species and community metrics in lentic systems with riverine habitat and is not appropriate to apply to transition or lentic systems, which showed 0 exceedances. This suggests that macroinvertebrate communities are in various states of declining, degrading or already degraded across the region in watersheds that feed Lake Erie. In some cases existing macroinvertebrate data from State

Clean Water Agencies confirm this condition and in some cases that data or designation is not available. These thresholds will be revisited in subsequent years to match up with existing macroinvertebrate data from these stations and determine if the thresholds are truly suggestive of aquatic life impacts.

The top five rivers systems with exceedances include (in part due to more samples) Huron (132), Pipe Cr (40), Mills Cr (38), Tinker's (35) and Old Woman Cr (21). The exceedances drop to 15 or less in other rivers with the lowest in Buffalo (3) and Clinton (2). Integrating DO, pH, temperature exceedances apply to Tinker's Cr, Euclid and Old Woman Cr that perhaps confirm unhealthy macroinvertebrate communities.

LEBAF selected aquatic life condition indicators of DO, pH, temperature, conductivity and expressions of conductivity to screen for healthy and unhealthy aquatic life. It is possible and likely in numerous cases that other chemical pollutants, habitat conditions and localized elements are contributing to macroinvertebrate biocondition exceedances. Conductivity results indicate they are representative of ambient conditions even if a limited dataset, and thus using the macroinvertebrate biocondition gradient as an assessment tool for aquatic life condition screening appears effective and meaningful for rivers at the local and regional scale.

More data is needed over time and space. Adding a macroinvertebrate sampling as a standardized parameter or integrating existing macroinvertebrate data into this analysis would confirm and inform more refined recommendations. Exploration of other chemical or physical habitat parameters that might add to this analysis may also be important. Organizations are already active in restoration and protection efforts in respective basins, this serves to help track their progress. In addition, appropriate metrics for lake aquatic life, such as zooplankton, could be explored for lake sites.

Expressions of Conductivity Summary

Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data and local knowledge of conditions. Second, to identify relevant and useful conductivity ranges, via these mathematical relationships, to serve as screening level criteria to inform recommendations. LEBAF collected, analyzed and assessed all parameters including these three calculated parameter results. This became more complicated that intended in part because LEBAF was building the analyses and assessment methods while implementing. This will not be the case to this degree in the future.

If calculated parameters represent ambient conditions, with the ability to qualify locations or circumstances that do not, then these parameters are feasible to employ, collecting only conductivity. If any group measures these directly LEBAF will be using that data over calculated results. If analyses and assessment methods require more resources balanced with adding more events, stations and/or parameters, it may be more productive to keep refining conductivity assessment. Assessment includes criteria but also the workflow to validate and analyze results against thresholds, interpret that analyses, identify limitations, recommendations and conclusions and then report and deliver above information. A potential path to do that is to develop one or a set of LEBAF conductivity thresholds that serve as an initial screening criteria (story) to understand aquatic life conditions and if that criteria is exceeded then analyze and assess further parameters. For example conduct analyses on conductivity against a trigger threshold, compare to reference and survey data to verify in reasonable range or not and assess against macroinvertebrate biocondition thresholds. If the conductivity 'trigger' is exceeded then further conduct analyses on for example TDS, chloride and salinity, resulting in a decision tree tiered analyses. All parameters can still be collected and/or calculated and stored in LEBAF data repository for analyses. Results below should be filtered through these goals. Exploring this embedded in these recommendations, evaluation and revisions.

Results are mixed but encouraging in regards to using the expressions of conductivity chloride, TDS, and salinity. Two questions we wanted to answer, did calculated respective parameter results mirror ambient conditions and do results and assessment methods provide helpful screening guidance? Let us look at each conductivity expression.

Expression of TDS

If conductivity results represent ambient conditions (see above), and we believe they do, even if the dataset is limited, then calculated TDS results likely do as well. The scientific and mathematical relationship between conductivity and TDS is well established and commonly used. TDS meters use the same calculation. Direct measurement of TDS via the laboratory method is more precise but more labor intensive and expensive. It is an effective approach to analyze many samples at once when you may not have multiple meters to deploy. Most TDS results and seasonal patterns reflected expectations and in some cases verified by existing data. In a few rivers, such as Mills Cr, which has a different geology, groundwater and other factors, this may not be the case. As such, a current side experiment where TDS is being analyzed via the laboratory method to confirm representation of the conductivity TDS expression. Results for shoreline, harbor or lake sites were low but believed to be representative.

Regarding assessment methods, like macroinvertebrate biocondition gradient, the TDS drinking water standards of 200 and 500 mg/L were exceeded to some degree in all rivers, but not in the shoreline, harbor or lake sites. For the latter sites suspended solids sink and are diluted by lake water. For river sites, these exceedances are not surprising and expected to a degree. No one expects to consume ambient water without treatment and removal of excess TDS. LEBAF employed an assessment methodology that used a drinking water standard which may not be an effective indicator for aquatic life conditions. Reviewing the summary of all large rivers results in **Table 42** above, most of the exceedances are 90% or more of the measurements, suggesting the drinking water standard is exceeded frequently for long durations. Regarding the magnitude of TDS drinking water standard exceedances, which would be results greater than 200 or 500 mg/L, chronic and acute respective thresholds, results were double the acute or above 1000 mg/L in some rivers and for others slightly over 200 or 500 mg/L. In other words, the magnitude is not large in many cases. This does not mean aquatic life conditions are threatened by TDS and thus this assessment method may not be effective for LEBAF to use in the future for aquatic life conditions.

However, LEBAF is exploring the Ohio aquatic life TDS threshold of 1500 mg/L. This threshold may or may not always be protective and needs to be considered in context with the geology and other factors which is what LEBAF is exploring. If this threshold was adopted as a screening criteria for aquatic life conditions, not a single measurement exceeded this threshold. The maximum measurement in Tinker's Cr (1432 mg/L) approached and the next maximum in the Huron River (1119 mg/L). This suggests, with a limited data set, that TDS is not a limiting factor for aquatic life. The 1500 mg/L TDS aquatic life threshold seems as if it would be an effective screening criteria but cannot be interpreted out of context, or as a strict toxicity threshold like those for pH or a metal. TDS as a standalone indicator of aquatic life has limitations, but used with other chemical parameters and the macroinvertebrate biocondition gradient can provide multiple lines of evidence as screening guidance.

Expression of Chloride

If conductivity results represent ambient conditions (see above), and we believe they do, even if the dataset is limited, then calculated chloride results likely do as well. The mathematical relationship between chloride and conductivity has an R correlation of 94% and for respective rivers a regression equation has higher correlation. As an indicator of aquatic condition, it is valuable and results appear to be representative based on existing data and other available information in each river. Shoreline, harbor and lake sites had no chloride exceedances which is expected since conductivity or dissolved ions tend to sink in those environments. River results were relatively low, but spiked likely with sources such as deicing practices.

The chloride assessment method which used Michigan's aquatic life thresholds resulted in seven rivers experiencing exceedances, most of which were only one time and the maximum measured level. The data set is limited and monitoring does not occur during the winter so shows residual chloride, perhaps from winter de-icing or other sources. All exceedances can be traced to two rivers, Tinker's Cr (25) had the most exceedances with Rocky River (4) next. This aligns with expectations and more data will only refine characterization. Conductivity results indicate they are representative of ambient conditions even with a limited dataset, and thus using conductivity expressed as chloride appears to be representative of ambient conditions as does the assessment method for aquatic life condition screening. LEBAF recommends direct measurements of chloride when possible and to confirm these screening results. Conductivity expressed as chloride appears effective and meaningful for rivers at the local and regional scale and even the lake scale. Michigan’s chloride standard, when translated through conductivity, represents a much higher threshold for suggesting aquatic life impacts than direct correlations with macroinvertebrates.

Expression of Salinity

If conductivity results represent ambient conditions (see above), and we believe they do, even if the dataset is limited, then salinity results likely do as well. The mathematical relationship between salinity and conductivity is well established and follows the same evaluation as chloride above. As an indicator of aquatic condition, it is valuable and results appear to be representative based on existing data and other available information in each river. Shoreline, harbor and lake sites had no salinity exceedances which is expected since conductivity or dissolved ions tend to sink in those environments. River results were relatively low, but spiked likely with sources such as deicing practices.

The salinity assessment method uses the USGS’s designated ranges for fresh, slightly to heavily saline water, as states do not have salinity aquatic life thresholds in their standards. The data set is limited and monitoring does not occur during the winter so likely only shows residual salinity, perhaps from winter de-icing or other sources. Tinker's Cr (13) had the most exceedances with Rocky River (4) next , all others sites had one exceedance, Euclid Cr., Huron R, Smoke Cr and Mills Cr. This aligns with expectations and more data will only refine characterization. Conductivity results indicate they are representative of ambient conditions even with a limited dataset, and thus using conductivity expressed as salinity appears to be representative of ambient conditions as does the assessment method for aquatic life condition screening. It complements and maybe is a more sensitive indicator than chloride conductivity expression. LEBAF recommends direct measurements of salinity when possible and to confirm these screening results. Conductivity expressed as salinity appears effective and meaningful for rivers at the local and regional scale and even the lake scale.

Again for chloride and salinity it is worth noting that the year-round impact of chloride and salinity to local water bodies and Lake Erie is likely underestimated by LEBAF’s April-October monitoring as road deicing, the most intensive known source of these contaminants, is primarily concentrated in winter and early spring.

Summary

Aquatic life conditions and associated recommendations can be made from this dataset and what is already known and in progress for each organization and respective water bodies. Table 42 above illustrates water bodies that have multiple lines of evidence regarding a healthy, possible declining or a degraded aquatic life condition. For specific water body recommendations please refer to the respective organization and river report. LEBAF did present a regional perspective on the condition of aquatic life across the Lake Erie region for watersheds with data that feed the lake. As more data is collected and groups join the network this perspective will become even more valuable, even if data on the lake is not included. Adding more stations on the lake, potentially integrating other data sources of lake data, and evolving current SOP for all study design areas, LEBAF will be able to make better and more direct Lake Erie aquatic life condition recommendations.

Section 6 – Conclusions and Recommendations

Circling back to LEBAF's monitoring purpose, data use for intended data users and desired outcomes, results and impacts - did LEBAF succeed and what progress was made?

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*. Yes, this initial sampling year did succeed in implementing SOP that generated data and information on aquatic life conditions for all participating organizations and the water bodies they monitor. Those results and information are being communicated in this report and a communication effort Spring of 2023. Furthermore, an evaluation of those SOP has been completed and recommendations for updating, clarifying, editing and evolving sample collection, training, data management, meta and ancillary information, assessment criteria, tools and workflow as well as communication of results are in progress for the next season. Exploration of adding additional parameters is also in progress.

Assessment of aquatic conditions at each site and for each river in the network was achieved. More sites are needed on existing and missing water bodies. We did present a regional perspective on the condition of watersheds that feed Lake Erie. However, more stations on or in the Lake, or integrating other data sources is needed along with refinement in the assessment method to make aquatic life condition conclusions for Lake Erie. At local sites and for rivers with multiple stations, some temporal and spatial patterns were visible with some of the parameters. More data over space and time is needed to identify trends.

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).* The study design and associated SOP were effective together in providing a characterization of aquatic life conditions for screening data use. Collection SOP ensured data was comparable across organizations and water bodies. The accountability and communication process in place at the volunteer organization level and at the collaborative level identified and corrected errors and miscommunication effectively. Assessment methods also produced consistent analyses across organizations and waterbodies. Assessment workflow, tools, criteria and interpretation that were not clear, did not serve our monitoring purpose or data use surfaced and were corrected or are in the process of being updated. More detail is provided in the recommendations below. Monitoring, analyses and communication of results is an ongoing iterative process. LEBAF has built a solid foundation that contains the necessary elements in a collaboration to create collective impact.

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.* This is in progress during the spring of 2023 and will be evaluated towards the end of the summer, especially communication with external partners. Participating organizations have been significantly engaged developing robust SOP and implementing their information and evaluation designs. Each program has enhanced, expanded or improved their efforts as a result of participating in LEBAF. Each entity is in the process of integrating the results of this year into their own actions and communications.

Expected Outcomes and Impacts: *The implementation of LEBAF will:*
1) Provide a regional condition assessment of Lake Erie streams over time. LEBAF's inaugural sampling year and previous development of SOP and organizational structure and function to support the network is well on its way to produce this outcome. LEBAF did provide a regional assessment of watersheds that feed the Lake with recommendations to SOP for the Lake in progress.

2) Identify potential problem areas to be investigated for impairment identification. LEBAF did succeed at the local level and for representing rivers identifying for water bodies parameters that indicated healthy aquatic conditions informing protection strategies, parameters indicating concern and where more exploration is needed, and parameters indicating unhealthy conditions to inform and validate restoration strategies. As we collect more data and evolve the assessment, this outcome will be refined and the ability to be more targeted will improve.

3) Establish a shared lexicon to communicate program elements, shared goals, and watershed status to volunteers and the public. This has been achieved, and continues to evolve, via the SOP, assessment methods and communication plan.

4) Demonstrate the capacity of regional volunteer science collaboration. This has been achieved as evidenced by participating organizations' engagement, addition of new groups, this report and the standardization menu at the ready to add new parameters, methods, monitoring purposes and data uses when capacity is sufficient.

5) Create an iterative process for expanding the scope of shared standardizations and collaborations over time. The development of SOP for all study design areas including purpose, technical, information and evaluation, and then implementation of that SOP has been collaborative, inclusive and iterative. The SOP has continued to evolve over two years of development and actions from program evaluation are always in progress. This is also why documentation is key - to capture iterations as success stories and communicate changes to all network participants. The standardization menu was updated and reprioritized this year and will be shared with external partners in Spring 2023. LEBAF will be focusing in 2023 on another sampling season, information design analyses and addressing all recommendations from evaluation while evolving the collaborative organizational structure for sustainability. This solid foundation, which is still evolving to a sustainable structure, has been shared with the greater Great Lakes volunteer monitoring community via the International Joint Commission that oversees science and monitoring for the USA and Canada and the National Water Quality Monitoring Council's network.

6.1 Interpretation of Monitoring Observations and Corresponding Conclusions

Between the various monitoring efforts conducted on local water bodies in 2022, LEBAF participants came together to monitor a total of 67 stations across 14 Lake Erie Basin rivers and tributaries as well as five stations directly on Lake Erie's shoreline. They generated data for 466 sampling events. Data for seven parameters (pH, DO, temperature, conductivity, TDS, chloride and salinity) were collected at all stations approximately once per month from April to October. A few participating groups didn't begin monitoring until later in the season due to delayed delivery of field equipment caused by global supply chain challenges resulting in monthly measurements collected over a shorter time frame.

Throughout the season, participating groups learned that healthy water is not determined by one singular point in time and is influenced by a variety of factors such as weather, chemistry, biology, and physical characteristics of a stream. Spatial and temporal variations also play a large role in determining what happens in a stream. Before making conclusions about the health of a stream, it is important to consider long term variations and compare changes to a baseline or reference point to provide better context for those more recent observations and data. ***All observations and interpretation described below, in each individual water body's aggregated summary, and in the Lake's Recommendations and Conclusions section should be taken as heavily qualified by a range of limitations that face this monitoring program in its first year of operation.***

Based on LEBAF's definition of health, for our monitoring purpose of screening, and with this limited dataset, Lake Erie and its watersheds appear to be generally healthy and support aquatic life. Localized conditions exist where rivers are in healthier condition and some rivers are in unhealthy conditions, depending upon the parameter, magnitude, duration and frequency of exceedances. This conclusion is supported by the direct measurement of pH and dissolved oxygen as well as expressions of conductivity as TDS, salinity and chloride, as characterized by LEBAF sampling.

TDS assessed against drinking water standards did exceed all river sites but that is not surprising and expected to a degree that no one expects to consume untreated water. When TDS is assessed against the 1500 mg/L aquatic life threshold LEBAF has been exploring, no site exceeds that threshold. A few results approach, but none exceed, suggesting TDS is not limiting aquatic life in rivers. Chloride and salinity were exceeded; chloride exceedances came from two rivers -

Tinker's Creek and Rocky River. Salinity exceedances were spread out, few and not high in magnitude. Based on this dataset neither of these two limit aquatic life but seem to be helpful screening parameters. These conclusions hold for lake sites as well, conductivity or dissolved ions tend to sink or be diluted on shoreline, harbor and lake sites.

Temperature in cold water systems indicated many rivers and sites are not supportive of aquatic life. This was not the case for warm water sites. Temperature criteria is based on riverine species and their life cycle needs and is not appropriate to apply to lake sites. These sites themselves may not be supporting aquatic life. More data or real time monitoring at strategic locations and time frames may be a feasible recommendation to refine this result. This was not expected as cold water sites were observed to have higher mean, median, and minimum temperatures than warm water sites, indicating that warmer than expected inputs from cold water streams, clustered in the greater Buffalo area, may be impacting Lake Erie. LEVSN recommends the further investigation of temperature in cold water sites and the addition of more cold water sites for better comparison.

The largest concern generated from this year's limited data set involve exceedances of the conductivity macroinvertebrate biocondition gradient. This assessment integrates a chemical parameter, conductivity, as a stressor to a response community, macroinvertebrates. Developed using riverine species and habitat, it is not appropriate to apply to shoreline, harbor or lake sites. In the summary data table with all rivers and the Lakes results, it shows every river experienced an exceedance of the 412 or 655 criteria, serving equivalent to a chronic and acute threshold for a healthy functioning macroinvertebrate community structure and function(Less than 412 = healthy, between 412-655 = declining or degrading and above 655 = degraded). Results in general are higher at urban sites, they are also persistently high across space and time. No other parameter (DO, pH, temperature, other expressions of conductivity, TDS, salinity or chloride) explains exceedances on every river. This is for several reasons. First, the dataset is limited in space and time and number of stations. Second, these parameters may not be the source of the stress while they may contribute to healthy community conditions. Third, other chemical and or physical or biological conditions may be responsible for the declining or unhealthy conditions. Fourth, these thresholds are too sensitive or not sensitive enough and as a screening tool does not replace actual existing or new macroinvertebrate data.

Of concern however, is where existing macroinvertebrate data exists it corroborates these results. Ancillary information also corroborated these results in some rivers. This parameter as a screening tool to identify locations for protection strategies (<412) and those in decline for further exploration as soon as possible (412-655) and restoration strategies for degraded sites (>655) seems effective and meaningful. Further site-specific ancillary information is needed to uncover the degree of human impact in each tributary, and open lake or tributary mouth measurements are needed to document the degree of impact on the lake itself. As more data is gathered over future years, seasonal plotting of conductivity will help determine trends over time.

Overall, this first year provided encouraging and promising results towards LEBAF's monitoring purpose, data use of screening for primary data users, and the monitoring groups themselves. The standard SOP worked well enough to collect representative data, even if limited. Edits and clarifications are in progress for sampling collection workflows. The information design and assessment methods were being developed and implemented almost simultaneously this year. Improvements to those workflows are in progress as indicated by recommendations in this report. The information design overall did achieve progress toward LEBAF's goals. In addition, participants' engagement, performance and ownership of this collaboration were exceptional.

Finally, It is important to note that this is a single season snapshot of only a few parameters and is in no way a statement on the overall health of the Lake Erie Basin, currently or over time. LEBAF aims to expand the number of parameters sampled, historical data record, geographic coverage, and confidence in its interpretation over future sampling years. Special attention should be paid to locations where exceedances occurred, and more information should be collected on the magnitude, frequency, and duration of such exceedances. Greater detail on each parameter can be found above in the corresponding Aggregated Parameter Summaries.

6.2 Limitations of 2022 Monitoring Program and Corresponding Recommendations

LEBAF's 2022 conclusions are limited by a number of factors with primary limitations stemming from gaps in the temporal and spatial coverage of our data. Consequently, many of the recommendations described below explore options to begin to fill these gaps as much as possible. ***All observations and interpretation described below, in each individual water body's aggregated summary, and in the Lake's Recommendations and Conclusions section should be taken as heavily qualified by a range of limitations that face this monitoring program in its first year of operation.***

This is particularly true for all stakeholders outside of LEVSN including researchers, agencies, and community members. All of the interpretations and recommendations presented here have been refined by participating 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 responsible use.

Key limitations of the 2022 monitoring season include:

Lack of Historical Record: LEBAF's monitoring purpose of screening conditions that support aquatic life as an indicator for baseline conditions and trends in the health of Lake Erie watersheds at various scales is virtually impossible to achieve in a single monitoring season. Many participating groups have been monitoring the same stations that they sampled in the 2022 LEBAF field season for years, in some cases over a decade. This experience, and the resulting data, provide invaluable ancillary information and context for LEBAF analysis. However, variation in collection and management methods make it challenging to directly use historical volunteer science data for LEBAF's robust analysis and interpretation process (hence the need for LEBAF standardization). Instead, all quantitative interpretation, recommendations, and conclusions for 2022 must be built upon a single year of monitoring with additional context provided by historical data and experience. However, existing data did help confirm representation of this data set, validating that the SOP is working. This approach limits the potential for more definitive conclusions about dynamics and trends in watershed health at this stage of the program. The solution to this challenge is simple, if not expedient; LEBAF participants need to collect data for a sustained period of time using standardized methods. Now that these groups are using comparable collection methods, a shared data platform, and a shared analysis process, all future data will be easily integrated with the slowly building LEBAF historical record to enable more robust analysis of Lake Erie Basin conditions and trends over time.

Low Monitoring Frequency: LEBAF's low frequency of monitoring (1x/month) makes it difficult to assess temporal variations and the duration of exceedances for parameters like conductivity and TDS while making it impossible to examine daily fluctuations in parameters such as pH, DO, and temperature. To address issues with longer-term temporal variation, LEBAF will require all participants to sample 1x/month from April to October in future years (some groups were not equipped to do so in 2022 but now are). For those groups who have the capacity, LEBAF will recommend increasing sampling to 2x/month. While it is infeasible for volunteer monitoring programs to reach the sampling frequency required to consistently observe daily fluctuations, LEBAF will recommend pairing time of day metadata with measurements of relevant parameters, collecting relevant parameters twice per sampling trip at least once per season, and conducting a 24 hour focused study at sites where exceedances of daily variable parameters are frequent. In future years, these recommendations may become requirements, but LEBAF must prioritize working with participants at their current level of capacity.

Underrepresentation of Key Components: LEBAF desires a critical mass of key components to achieve its larger vision. Currently the effort is underrepresented in several areas, cold water streams, non-urban streams, Canadian waters, enough sites on some tributaries and larger rivers and either sites on Lake Erie or integrating Lake Erie datasets and analyses to tell a more complete story. LEBAF is actively working on increasing each of these areas. The majority of sample sites are in urban/suburban areas and the monitoring focus of most LEBAF participants. LEVSN recommends expanding monitoring in rural or less developed areas of the Lake Erie Basin. This will provide better representation of the region and help discern between environments that may have lower levels of conductivity and expressions.

The relatively small number of sites and limited geographic scope of LEBAF monitoring means that the data gathered may not be representative of dynamics across the full scope of the Lake Erie Basin. This challenge was particularly poignant with regard to conditions in cold water streams, which were significantly underrepresented compared to warm water stations in 2022 LEBAF sampling (61 warm water stations compared to 7 cold water stations). Considering the potentially concerning observations regarding higher than expected temperatures in the handful of monitored cold water streams, increased coverage of these and other cold water streams across the Lake Erie Basin, as well as collection of more detailed ancillary data regarding surrounding land use, industrial activities, and any other potential sources of heat pollution, is recommended. Ideally, stations in sufficient numbers are active on every major tributary basin to Lake Erie.

Difficult Translation of Tributary Monitoring to Lake Erie Impacts: Station placement and geographic coverage also limited the confidence of LEBAF conclusions regarding impacts of monitored tributaries on the health of Lake Erie itself, which was only monitored directly via a handful of harbor and shoreline stations. Data gaps are likely limiting effective assessment of the impact of DO in particular on open Lake Erie waters. DO was generally shown by LEBAF data to have minimal impact on the Lake despite the fact that that tributaries in the western basin (unmonitored by LEBAF in 2022) are known to contribute significant nutrient loads and that the open waters of the Central Basin are often impacted by hypoxic zones. More generally, it is difficult to assess the degree to which dilution of tributary inputs by the open waters of the lake may mitigate the impact of any upstream exceedances. To address these two challenges, LEVSN recommends expansion of monitoring into as many currently unmonitored tributaries as possible, with an emphasis on large rivers, as well as monitoring at river mouths to assess the degree to which dilution may mitigate aquatic life impacts on the Lake. Target rivers that currently have no LEBAF coverage include Black River (OH), Detroit River (MI), Grand River (OH), Maumee River (OH), River Raisin (MI), and Sandusky River (OH).

Difficulty Pinpointing Exceedance Sources: The final limitation imposed by limited geographic coverage, as well as limited station metadata, was difficulty in identifying the source(s) of measured exceedances. In those instances, it could not be determined whether land use impacts (construction, urbanization, agriculture, etc.), natural chemical processes, runoff, ecology, errors with data collection, malfunctioning equipment, or other elements were to blame for high readings. LEBAF's study was not designed for the data use of source identification but the data use of initial screening in order to further monitor or take other actions. Further monitoring entails modifying or developing a study design whose data use is not screening but source identification. That could include the same SOP and parameters, but would entail different locations, frequencies, meta-data, etc. LEBAF could decide to develop an example study design for each parameter that groups could modify as needed and adopt.

Further evaluation of these sites and integration of surrounding land uses to develop a stronger body of ancillary information that can inform analysis could help mitigate this issue for future monitoring years. Additional monitoring, along with experience gained through continued participation in the network, may also help. Particularly, LEVSN recommends establishment of additional sites upstream and downstream of current sites potentially impacted by conductivity, TDS, temperature, and/or other concerning exceedances to help determine relevant pollution sources. When possible, LEVSN recommends increasing sampling frequency to 2x/month at sites with concerning exceedances to refine our understanding of their magnitude, frequency, and duration.

Limitations of Expressions of Conductivity: In 2022, LEBAF included three expressions of conductivity, sometimes referred to as surrogate or calculated parameters, chloride, salinity and TDS, alongside its four directly measured parameters of DO, pH, temperature and conductivity. Expressions of conductivity through mathematical relationships for chloride, salinity and total dissolved solids were a twofold exploration this year. First, to explore if the translation is an effective screening tool by producing comparable chloride, salinity and total dissolved solid results relative to existing data, ambient conditions and local knowledge of conditions. Is the data representative? Second, is regarding analyses and assessment. Complete analyses and assessment methods for each of these three surrogates adds complexity, time and resources, perhaps for minimal added screening information in some cases. Perhaps those resources could be applied toward data gaps with other indicators. Balancing accuracy, precision and resources to meet monitoring purpose and data uses is a never ending cycle of evaluation and adjustments. If LEBAF can develop a conductivity 'trigger' or set of triggers that embed the chloride, salinity and TDS aquatic life thresholds that might streamline analyses, providing a tier analysis approach, that might be an approach that balances challenges and resources without losing desired impact and outcomes. Results below should be filtered through these goals.

All expressions of conductivity were based on scientific, mathematical and well established relationships with conductivity. All are commonly used as screening indicators. Details on each surrogate parameter and its intended use can be found in the Approaches and Methods section and in the introduction to this report. It is important to separate results representativeness versus assessment method effectiveness toward monitoring purpose and data use. LEBAF asked two questions this year regarding all parameters but in particular these expressions of conductivity. First, did calculated respective parameter results represent ambient conditions and second, do parameter results and assessment methods provide helpful screening guidance? Overall the answers are mixed but encouraging.

Results for all three indicated representation of ambient conditions overall. Conductivity results were verified in a comparison to Ohio reference and survey conductivity data sorted by two ecoregions and three watershed sizes. All conductivity results overlapped with respective surveys and some reference sites. This suggests conductivity results are in a similar population as this robust conductivity dataset. Alignment of results distribution with legacy data varied but every site had overlap. Furthermore, sites that were aligned in the 75% or higher are explained as they are not in either of the two ecoregions. The solution for that is to develop the same metrics and legacy data set for all ecoregions in the lake.

In addition, conductivity representation of ambient conditions was also verified by existing data and what is already known about each river. In cases that were suspect, such as Mills Creek, localized geology (karst), groundwater or other land uses explained the differences. Thus, calculations using conductivity have confidence in their representation of that expression, such as TDS, chloride and salinity. In addition, LEBAF already has a side experiment in operation analyzing laboratory TDS to compare to conductivity expressed TDS to inform the use of this parameter in Mills Cr and in LEBAF as a whole. More data is needed but these expressions of conductivity, given their feasibility appear to provide meaningful screening information. Refinements are in progress.

In regards to assessment methods, chloride and salinity assessment methods seem effective in identifying aquatic life conditions that might be of concern. TDS employed drinking water standards, which resulted in exceedances at all sites. This was not surprising and expected to a degree as no one expects to consume untreated ambient water. However, when TDS results were compared to the aquatic life threshold LEBAF is exploring, no exceedances of TDS occurred. Some sites approached but none exceeded. This suggests the 1500 mg/L could be an effective screening criteria. The recommendation is to drop the drinking water assessment criteria and continue to evolve the aquatic life criteria, which is in progress. Shoreline, harbor and lake sites had low conductivity and thus low TDS, chloride and salinity. This too is expected as dissolved solids settle out of the water column in lentic systems or are diluted.

In regards to implementing the information design and analyses, LEBAF was developing assessment methods while implementing assessment almost simultaneously. This did not allow for piloting and editing before using the criteria. This provided some confusion and inconsistencies on how to adequately qualify and interpret some calculated parameters, especially TDS since it is the only parameter for which LEBAF used a drinking water, rather than aquatic life standard. The workflow and assessment methods changes are already in progress.

Wholistic Conductivity Assessment Approach

One of LEBAF's goals in this effort was to explore conductivity and its various expressions as effective indicators of aquatic life. Conductivity is easy and feasible to measure relative to other chemical parameters and pollutants making it an effective screening parameter. However, not knowing what comprises the dissolved ions makes it a challenge to identify meaningful recommendations for further action beyond additional monitoring. Expressions of conductivity inform that challenge even if imperfect or incomplete.

This inaugural year LEBAF approached each parameter individually and is exploring developing conductivity standards that for screening data use, would reflect different aquatic life conditions from healthy, declining or degraded, with the simplest possible analyses and assessment workflow that does not sacrifice effective responses for protection, restoration or more monitoring and effective desired outcomes. To develop this simple but useful screening criteria, LEBAF used this year's data to convert chloride, TDS and salinity aquatic life thresholds from their 'unit' into equivalent conductivity units and then develop a 'trigger' conductivity standard that represents action ranges. Action ranges refer to analyses, no trigger would potentially mean no further analysis and assessment of chloride, TDS or salinity. A trigger or exceedance would put into motion analyses of one or more of chloride, TDS and salinity, fleshing out the results, interpretation, recommendations and reporting. This trigger conductivity standard (or regionalized set) would be informed by the aquatic life assessment criteria for each surrogate parameter (TDS, chloride and salinity) along with biocondition gradient.

The assessment of conductivity against reference and survey datasets would remain on its own helping to confirm conductivity readings are representative for respective ecoregion and watershed size. If there is no overlap LEBAF will explore ancillary or other data that may explain sampling results, such as the sites are not located in the assessment database ecoregion.

The primary recommendation is to provide the same metrics for all Lake Erie ecoregions. The same parameters will be collected and metrics calculated, including surrogate parameters. The exception is identifying and using direct measurements of TDS, chloride or salinity if they exist in analyses, if conducted.

The exploration is to develop a single conductivity standard that would trigger further analyses of chloride, TDS and salinity, if needed. That trigger conductivity standard would need to include regionalized differences so may be a set of trigger conductivity standards. The table below is an example of the draft conductivity ranges **to be further refined** over the next sample season and to serve as a recommended next step from this year's results. This would consolidate conductivity assessment into one assessment analysis, using just conductivity to screen for aquatic condition levels. Depending upon the conductivity level, inferences to exceeding aquatic life criteria for TDS, chloride or salinity could be made and direct assessment to biocondition conducted.

Table 43. Draft Conductivity Ranges for Screening (all conductivity in uS/cm units)

Conductivity Expressions[1]	Requirements	Conductivity Healthy Protect	Conductivity Concern Explore	Conductivity Unhealthy Restore
Biocondition Gradient	NA	<412	412-655	>655
TDS Expression[2]	Temperature at 25C, mg/L	<363	363-909	>909
Chloride Expression	none	<858	858-3663	>3663
Chloride Criteria[3]	mg/L	<150	150-320	>640
Salinity Expression[4]	Units in uS/M	<2015	2015-5534	>5534

[1]*See conversion equations in the introduction approach section*
[2]*TDS Aquatic Life Criteria is <1500 mg/L TDS*
[3] *Chloride Aquatic Life Criteria Final Chronic Value, Acute maximum and Final Acute Values, 150, 320 and 640 mg/L Chloride*
[4] *Salinity Freshwater USGS Ranges, freshwater <1000 mg/L, slightly saline 1000-3000 and moderately saline >3000 mg/L*

The numbers in this table are in progress towards a regional set of conductivity trigger standards, but are not there yet. What the table illustrates is the associated conductivity standard for each parameter based on their respective aquatic life thresholds. To identify a healthy conductivity standard the numbers in the **Conductivity, Healthy, Protect** column need to be refined into one range and/or set. If that can be accomplished, if your conductivity results were in that range, you would not conduct further analyses on TDS, chloride or salinity.

The numbers in the **Conductivity, Concern, Explore** column and the last column could be worked into a range and regional set of conductivity standards that indicate a 'concern and explore' recommendation or a restoration recommendation. It may be only one standard is needed and that is a trigger from healthy to anything else. This is an example of what LEBAF is exploring for the next iteration. This is a draft, as a recommendation that is a work in progress.

More data is needed over space and time from existing stations and additional stations, especially on rivers not represented. Another year, at least, is needed to continue to refine the assessment methods, which will always be evaluated and evolving. Exploration of additional parameters is also integrated into LEBAF's annual evaluation and consideration against capacity, resources and contribution toward monitoring purpose, data uses and primary users' information needs. Furthermore, next year and in the future these analyses will also include assessments across years at the local, direct tributary and lake levels. In addition, the lack of sampling in Western Ohio and Southeast Michigan watersheds, generally understood to be heavy nutrient contributors, as well as on the open waters of the routinely hypoxic Central Basin likely result in an underestimate of the impact of DO on Lake Erie and its watersheds.

LEBAF's annual evaluation and associated action plan to improve and clarify the SOP, training and related information for sampling, meta and ancillary information, data management, information and evaluation designs are already in motion. LEBAF is focused on refining current efforts and workflows before introducing a new parameter to standardize for this program in addition to addressing leadership and sustainability to continue LEBAF and LEVSN. This means continuing to collect and analyze DO, pH, temperature and conductivity for another season. This includes exploring equivalent aquatic criteria for shoreline, harbor and lake sites and continuing to modify the assessment methods for each of these, including expressions of conductivity, TDS, chloride and salinity. LEVSN also recommends inclusion of direct measurement of these parameters in analysis when possible; some participants already measure TDS and chloride. These direct measurements could also enable direct comparisons to test the strength of surrogate calculations.

Identify Assessment Methods for Lake Erie Stations: LEBAF assessment methods are lotic or river oriented because most organizations are focused on river systems. Some parameter assessment criteria overlap between lentic and lotic systems like DO and pH, if there is not a depth profile in the lake or standing water. But shorelines and harbors have breaking wall and wave action and lake sites can be stratified with depth profiles, requiring a different study design. In general DO and pH results can extrapolate to shoreline, harbor and lake sites for surface samples and screening. Temperature thresholds are associated with riverine species life cycle needs and is what LEBAF used in this assessment. Temperature criteria for lentic or lake species does exist and would need to be identified, added to the SOP and analysis workflow and tools and may involve adding lake sampling methods. Another approach is to use existing lake data and analysis and integrate that with this analysis for a more complete systems story.

Conductivity or dissolved ions tend to sink and are diluted in shoreline, harbor or lake sites. The conductivity assessment against Ohio's survey and reference database as well as the conductivity biocondition gradient was developed for river sites and is not appropriate for shoreline, harbor or lake sites. TDS drinking water standards apply and it is possible Ohio's aquatic life criteria of 1500 mg/L may apply in lakes as well as Michigan's aquatic life chloride acute and chronic criteria. The USGS salinity criteria may also apply but it is likely all three of these will be very low at lentic sites. A better indicator, and a common indicator of suspended material in lentic systems is clarity, turbidity or Secchi disk measurements. Another approach could be explored that identifies other entities monitoring lake sites and integrates those analyses and conclusions into this report. Not all data has to be collected by LEVSN to help develop an approach to serve LEBAF monitoring purpose and data uses.

Only five stations were sampled in 2022 that monitored the shoreline or nearshore of Lake Erie. For the 2022 analysis, these stations were included in the full Lake Erie Basin Analysis but not in any River or Tributary analysis. We completed the assessment at these sites for education purposes though some harbor and shoreline sites are not well mixed and represent the quality of inlet rivers, still mixing with the lake and influenced by breaking walls, distinguishing them as different sites than harbor or lake sites. As the number of shoreline, harbor, or open water sites grow, LEBAF will work to create a more robust framework for conducting direct analysis on Lake Erie in addition to its watersheds. For more details on the limitations of Lake Erie site analysis, please refer to Background: Stations Directly on Lake Erie.

6.3 Program and Organizational Outcomes

From a program and organizational perspective, the 2022 LEBAF sampling season was extremely successful. Throughout 2022, participating members of LEVSN were engaged and proactive about working to evolve and improve the program as it progressively rolled out. Those that were involved in data collection rapidly integrated the new standards into their pre-existing volunteer sampling plans. Though a few groups were unable to participate directly in the first few months of sampling because access to standardized sampling equipment was delayed due to COVID-related supply chain issues, they and other LEVSN members who didn't volunteer for the first field season consistently contributed feedback and development support to the SOP, supporting documentation, and practical implementation of the program. This flexibility and dedication was particularly manifest during the process of executing the collaborative data analysis and interpretation process described as "Information Design'' in the SOP. Program participants followed a standardized format to conduct their own analysis on individual sites and tributaries before partnering with larger groups to conduct and then integrate parallel analyses on the Lake Erie Basin scale.

Like any new program with sufficient self-awareness, a significant outcome of the 2022 field season was the identification of key gaps and limitations. Some challenges, such as the added benefit that high-frequency sampling could bring, are beyond the capacity of volunteer monitoring programs to address and are essential to include as qualifiers in this and future LEBAF information products. However, many concerns can be addressed as the network continues to grow and refine its approach. Recognition of possible improvements to standardized processes, instructions, and technical elements provides invaluable development opportunities for future years. In addition to these program-level improvements, direct involvement in the 2022 data analysis process reinforced the need for consistent data collection and a strong commitment to internal QA/QC procedures for each participating group. Now that participants have crafted and experienced a working process, they can see how to refine it over future iterations. In order to take advantage of these opportunities as comprehensively as possible, LEBAF participants, and the LEVSN Standards Working Group, have documented them in a shared Action Plan and have already begun revising the SOP and its supporting documentation to fine tune their approach for 2023. Further improvements in the form of additional parameters to standardize and incorporate have also been documented but will be pursued on a longer timescale for implementation in 2024 and 2025.

Another set of gaps that provide opportunities for growth are those in geographic coverage. As described above, addition of monitoring in key watersheds and at key sites could add tremendous value to the program in terms of its analytical capability and credibility. As a whole, LEVSN aims to partner with additional existing volunteer groups and support new groups in launching a monitoring program using LEBAF to help fill some of these gaps. In order to enable this growth, LEVSN will develop a more formal onboarding procedure and capitalize on the existing reserve of YSI sensors and Water Reporter Licenses it has pre-purchased to empower new groups to participate. Based on partnership conversations to date, LEVSN currently expects to onboard six new organizations, primarily concentrated in western Ohio, to LEBAF in 2023. Three of these groups have been participating in LEVSN for 1-3 years without yet incorporating water chemistry monitoring and three will be new additions to the network as well as LEBAF. For all but one, their engagement in volunteer water chemistry monitoring was inspired by LEBAF and the 2023 field season will be their introduction to this work. 2023 will also mark the first involvement of middle and high students in LEBAF as at least one new partner program will center youth engagement. Moving forward, refining frameworks for expanding engagement with K-12 schools as well as newly formed adult groups are seen as exciting growth opportunities for the near future.

While participating groups certainly recognize the limitations of the program, especially in its first year, they are also excited by the outcomes of the 2022 field season. When asked about the benefits to their staff, volunteers and programs, they consistently spoke about how productive and educational it was to participate in a regional effort of this scope for the first time. Participants appreciated the opportunity to familiarize themselves with, and critique, the standardized data collection, management, and analysis technologies employed as well as the collaborative process of data analysis, synthesis, and interpretation. They were also eager to learn more about each other's programs and water bodies, sharing best practices and expanding shared knowledge about the Lake Erie Basin and volunteer water quality monitoring. Perhaps most of all, participants saw 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 and more credible than any one community or organization could do by themselves.

It is truly a monumental achievement to establish and implement a standardized process for integrating multiple local monitoring programs into 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. For example:

- Residents near impacted streams could be advised to not mow to the edge of their yard and incorporate other best practices into their daily lives.
- Agricultural Landowners and Developers could be advised to use best management practices to mitigate adverse watershed impacts from their land use.
- Municipalities could be encouraged to make changes to land use, integrate data into planning activities, amend zoning codes, and support pollution source identification.
- Watershed Management Groups could receive support in pinpointing locations for streambank stabilization and other restoration projects.
- Environmental Agencies could investigate problem areas with further monitoring or leverage LEBAF data to target restoration investments or educational signage.

In order to position the capacity for such recommendations, 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 2022 field season to key stakeholders using a variety of products and channels. The primary information product from 2022 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 put on a public webinar covering the same core content and update its shared webpage on the Cleveland Water Alliance site. Finally, LEVSN will continue to update its shared data hub through Water Reporter and work to publicize and connect this hub to end users via 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 2023, the network will focus on refining the operation and maintenance of existing protocols, tools, documentation, and workflows with emphasis on more exchanges between groups and the sustainability of the network. Moving forward, it aims to build on existing standards to improve the credibility of its work and broaden our understanding of the Lake Erie Basin. If you are interested in supporting or participating in LEVSN or want more information, please refer to section 6.4 below.

6.4 Growing the Movement

As a community-based network, no one state or municipality is responsible for supporting the growth of LEBAF or LEVSN's work more generally. As of 2023, LEVSN has wrapped up its initial grant funding and needs your help to transition to sustainable operations. This can look like…

- **Funding the Network** - Direct contributions to build our regional capacity enable the network to retain and grow critical functions such as regional program management, equipment upkeep, and data infrastructure.
- **Funding a Local Hub** - Direct contributions to your local volunteer science program help enable their capacity to collect data, manage local water resources, and participate in regional collaborations like LEVSN.
- **Participation -** Bringing a new or existing volunteer program into LEBAF expands our capacity to collect and analyze data for impact, helps us fill data gaps across the region, and empowers your community to take meaningful action.
- **Leadership** - Participation in Working Groups or on our Steering Committee grows our organizational capacity to develop standards, expand into new program areas, and manage the ongoing evolution of the network.
- **Technical Resources** - In-kind contributions of monitoring equipment, data tools, and technical support ensure that the network remains at the forefront of water resource monitoring and help increase the credibility and reliability of our data.
- **Scientific Expertise** - Advice from and collaborations with researchers, agency scientists, and water resource managers enable us to ensure that the volunteer science movement remains scientifically rigorous and relevant in our priorities and outcomes.
- **Data User Relationships** - Advocating for the credibility of our data or directly leveraging our data for your own purposes helps us build the partnerships and funding relationships needed to scale our impact and ensure our long-term sustainability.

With your help, we aim to spend the next few years working to distribute network management across its participants and leverage our momentum into scaled, sustainable funding. If you are interested in supporting, please reach out to Max Herzog with Cleveland Water Alliance at mherzog@clewa.org to find out more.

Appendix I – Participating Groups

Buffalo Niagara Waterkeeper has been the guardian of Western New York's fresh water for the past 30 years, . 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.

Cleveland Metroparks is home to 18 park reservations, eight lakefront parks, over 300 miles of all-purpose, hiking, biking, and bridle trails, eight golf courses, five nature centers, dining, retail, and the nationally acclaimed Cleveland Metroparks Zoo. The organization serves a mission to protect nature, connect communities, and inspire conservation of our world. The Watershed Volunteer Program (WVP), established in 2012, is offered through Cleveland Metroparks with funding support from Northeast Ohio Regional Sewer District. Its mission is to connect community members concerned with the health of local watersheds.

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.

Erie Soil and Water Conservation District (SWCD) became the 84th District in Ohio in 1953, established for the purpose of protecting, preserving, and restoring the natural resources in the area. Erie SWCD is committed to the protection, preservation, and restoration of natural resources by providing education, funding opportunities, and technical assistance to all land users. The SWCD coordinates a partnership with Old Woman Creek National Estuarine Research Reserve to train volunteers, organize sampling events, manage equipment, analyze samples, and perform data analysis.

Fredonia State University of New York is part of the largest comprehensive system of universities, colleges, and community colleges in the United States. The University Institute for Research in Science Teaching has been organizing volunteer science efforts, in partnership with NASA GLOBE, since 2014. Its monitoring sites are spread across the approximately 30 miles of shoreline in Northern Chautauqua County, NY, and represent three primary locations for access to Lake Erie.

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.

Tinker's Creek Watershed Partners' water quality monitoring program will teach volunteers how to properly monitor a stream in the Tinker's Creek watershed, show what conditions to look for that are cause for concern, and who to contact with questions and data. Each site should take about an hour to sample, and a trained leader will be at every monitoring event. The data will be compiled and logged into the Tinker's Creek Watershed Partners website 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. Monitoring runs from May to September.

Appendix II – A Word on "Volunteer" vs. "Citizen" Science

Since its inception, the movement of scientific research led or supported by nonprofessional volunteers has been referred to by many names. Over the years, this movement has contributed significant findings in fields as diverse as ornithology, epidemiology, and art history. The advent of modern digital tools has dramatically expanded the movement, prompting increased interest from professional researchers, government officials, and private industry. Increased institutional engagement has resulted in exciting opportunities for growth across the movement, as well as a growing consensus around the term "Citizen Science," which became enshrined in US federal law by the "Crowdsourcing and Citizen Science Act" of 2016.

Given the charged nature of citizenship in US public discourse, many participants in the movement have begun to criticize the term "Citizen Science" as a barrier to inclusive participation, resulting in a growing trend of rebranding the work as "Community Science". This debate was further complicated by the 2021 publication of "Inclusion in Citizen Science: The Conundrum of Rebranding" which observes that "Community Science" is already an established term that refers to research that is not only executed by local residents, but is directly led by them and shaped by their priorities/challenges (for example a health study precipitated by grassroots activism in response to a local environmental injustice). This draws a critical distinction between "Community Science" and our movement, which is typically organized by an institution, whether academic, nonprofit, or governmental.

While there is no "correct" approach to naming our movement, the members of LEVSN feel it is important to approach branding with intentionality, both signaling our commitment to equity and ensuring we are not co-opting terms used by more grassroots work. For these reasons, we have opted to refer to our work as "Volunteer Science" and the participants in the work as "Volunteer Scientists." We assert that this work is fully aligned with common definitions of "Citizen Science" used in existing policy, programs, and funding opportunities. We also acknowledge that branding, no matter how well positioned, is far from sufficient to ensure a truly community-centric movement. For this reason, LEVSN commits to creating an "Equity Working Group" that will explore how we can more substantively center the needs and voices of marginalized communities in our programming and decision making. Our goal is to contribute to a more just, equitable, and inclusive future for all Lake Erie residents.