LAKE ROAMING ROCK
Water Quality Monitoring 2022

Prepared for: **Rome Rock Association**
1875 U.S. Route 6
Roaming Shores, OH 44085

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Authorization for Release

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The undersigned attest, to the best of their knowledge, that this document and the information contained herein is accurate and conforms to EnviroScience's internal Quality Assurance standards.

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EXECUTIVE SUMMARY

Lake Roaming Rock (LRR) is a 464-acre lake created to support a private lake community located in Rome Township, Ashtabula County, Ohio. It is a recreational impoundment of Rock Creek, a major tributary to the Grand River watershed. The watershed area is comprised of predominately residential and agricultural land-use types. In early 2020 RomeRock Association (RRA) expressed interest in a diagnostic study of the lake after observing a general decline in water quality throughout the last decade. Common observations included: excessive algae, increased turbidity, and low dissolved oxygen. EnviroScience proposed several tasks to help gain a better understanding of the overall health of LRR, including implementation of a water quality monitoring program. Tasks in the program included:

- Lake Sampling, including biological and chemical analyses
- Tributary Sampling, including chemical analyses

By analyzing the water quality in the lake and feeder streams, LRR can begin to identify the cause(s) and degree of degradation by the following factors:

- Tributary nutrient and sediment loading, e.g., phosphorus inputs and/or sediments from upstream in the watershed (analytical sampling of tributaries)
- Biotic contributions from within the lake itself, e.g., nutrients derived from the digestive processes of fish and plankton suspended in the water column and/or re-suspended from the sediments.

The 2021 and 2022 monitoring events aimed to determine which of these factors are having the greatest effect on the water quality to prioritize future management decisions. These decisions will be prioritized based on how to best improve the overall health of the lake at the lowest possible cost with actions such as dredging, watershed restoration, fishery management, aquatic plant management, etc.

EnviroScience, Inc. tested several parameters at LRR during 2021-2022 in response to the RRA's increasing concerns with degraded water quality, including persistent algae blooms. Targeted areas included both open water and tributaries.

The results showed that LRR continues to be in a eutrophic state, but has improved during 2022 based on both chemical and biological water quality indicators. Ohio EPA inland lake water quality criteria for total phosphorus and total nitrogen (Erie Ontario Lake Plain ecoregion) are 0.034 ppm and 0.740 ppm respectively. Both primary nutrient groups (Phosphorus and Nitrogen series) were consistently higher than inland lake water quality criteria set forth by Ohio EPA standards (OEPA, 2010), but have decreased since 2021. Bottom samples exhibited higher nutrient values than surface samples. Pairing this knowledge with observed stratification, internal loading is an ongoing factor contributing to algal blooms.

Biological indicators monitored during 2022 include chlorophyll-a, phytoplankton, and zooplankton. In most instances chlorophyll-a was lower than Ohio EPA criteria (14 ppb). Phytoplankton analyses validated the chlorophyll-a data. In general, blue-green algae (cyanobacteria) were dominant throughout sampling season, but only exhibited bloom densities (>100,000 cells/ml) pre-algaecide treatment. Due to issues in coordinating sampling efforts, samples were taken post-algaecide application on the southern portion of the lake, but before the whole-lake treatment was completed.

As in 2021, LRR contracted with Aqua Doc LLC to provide another whole-lake treatment of Vodaguard® C, a copper-based herbicide manufactured by AgroShield, LLC for 2022. The decision to apply Vodaguard® to open water and bays of LRR was made with the understanding that it provides only short-term management of harmful algal blooms and does not resolve the underlying issue of excess nutrients entering the reservoir.

Summer dominance of cyanobacteria in the 2021 and 2022 samples suggests that a potential human (and domestic animal) health risk is still present in the lake, but may be abated through continued monitoring, controlled algaecide treatments, and implementation of long-term management strategies (still to be determined). Similar to 2021, the survey showed a eutrophic zooplankton community structure. Characteristic of a cyanobacteria-dominant phytoplankton community, rotifers were the dominant zooplankters throughout the entire sampling season. Rotifer abundance is often positively correlated with high levels of blue-green algae because they can feed on these more successfully than cladocerans or other more desirable zooplankton.

Four tributaries within RRA boundaries with the largest drainage areas influent to LRR other than Rock Creek were sampled monthly from June-August. The mainstem of Rock Creek was sampled independently by AquaDoc Inc. Of the four smaller tributaries, each one contributed nutrients (total nitrogen and total phosphorus) throughout the sampling season but had relatively small contributions compared with the Rock Creek mainstem. External loading of nitrogen and phosphorus will likely continue and should be addressed in the long term, but may be more difficult to mitigate versus internal loading.

Considering the suite of parameters measured in the lake and tributaries, the 2022 sample results indicate that Lake Roaming Rock has improved in water quality since 2021. The system still maintains it’s eutrophic status, but has decreased by 7 points across all TSI values on average. Harmful algal blooms should remain an ongoing concern based on algal assemblage and continued nutrient inputs, however we are optimistic that the situation can be managed.

1.0 INTRODUCTION

In 2020 EnviroScience, Inc. was contracted by RRA for lake advisory services to evaluate current in-lake conditions and guide future management programs at LRR. In recent years, the frequency of algal blooms has increased and these blooms are currently the top concern of the community due to their unsightly characteristics and the potential to limit recreation due to algal toxins. Up until 2021, treatment efforts to mitigate these blooms have been scattered. From the early 2000s to 2020 all treatment efforts mainly focused on invasive submerged aquatic vegetation and the control of Eurasian Water Milfoil to keep waterways open. In 2020-2021 primary focus shifted to treating Harmful Algal Blooms (i.e. Cyanobacteria) due to human health, water quality, and aesthetic concerns. During the summer of 2021 LRR, under the guidance of EnviroScience, partnered with AquaDoc to implement a whole-lake algaecide treatment in order to mitigate potential blooms. EnviroScience monitored pre- and post-application conditions (outlined in the 2021 report - EnviroScience 2021) and found the treatment to be highly effective. By the end of summer 2021, cyanobacteria made a slight reprise, but maintained an innocuous concentration. Considering the nutrient levels consistently observed over the course of the sampling season, the rebound of the cyanobacteria was not unexpected.

The 2021 report described evidence for both internal and external nutrient loading, with consistent high levels of nitrogen and phosphorus leaching from the sediments and elevated inputs from influent streams (specifically Rock Creek). Based on the 2021 results and multiple committee meetings, it was determined that continued monitoring was required in 2022 to further guide both short- and long-term management decisions.

The objectives of the 2022 study were to:

1. Continue monitoring the chemical, physical, and biological characteristics of the lake using the same evaluation techniques employed during the summer of 2021. Utilize the data to assess current conditions, measure lake response to short-term management decisions (implementation of another whole-lake algaecide treatment), and compare current conditions to recent studies.
2. Gather quantitative information on nutrients in the major influent streams to the lake under both high and low flow conditions.
3. Take sediment cores for phosphorus analysis to gain further insight into internal nutrient loading and to evaluate nutrient inactivation technologies as a long-term management strategy. In addition, a sub-sample of sediment was analyzed for copper to provide a baseline should the use of copper-based algaecides continue in the future.

Detailed analysis of both zooplankton and phytoplankton, as well as analysis for algal toxins were completed throughout the study. Analysis of the phytoplankton communities is critical to generating meaningful management recommendations, and algal toxin monitoring is important to protect public health.

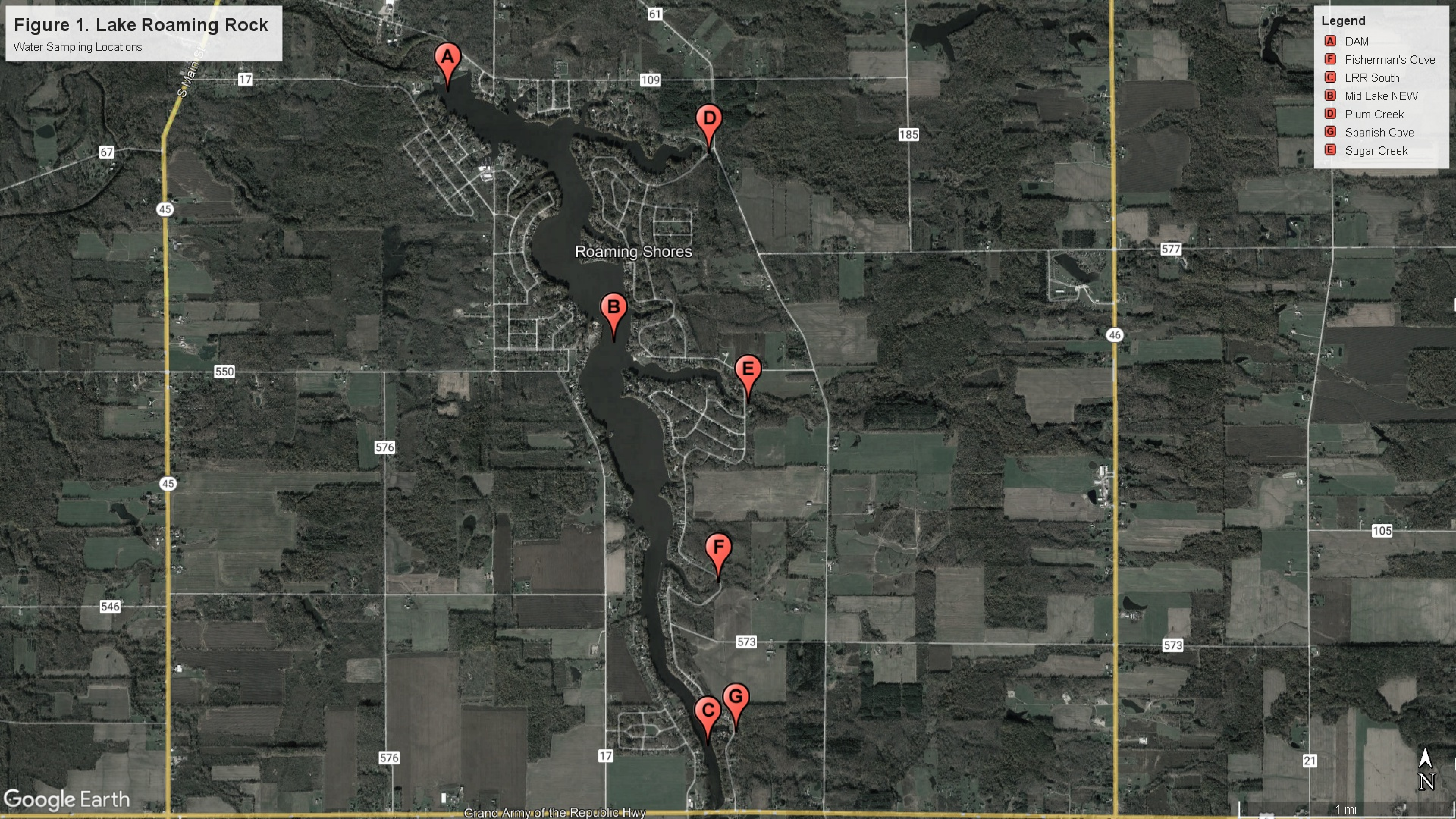
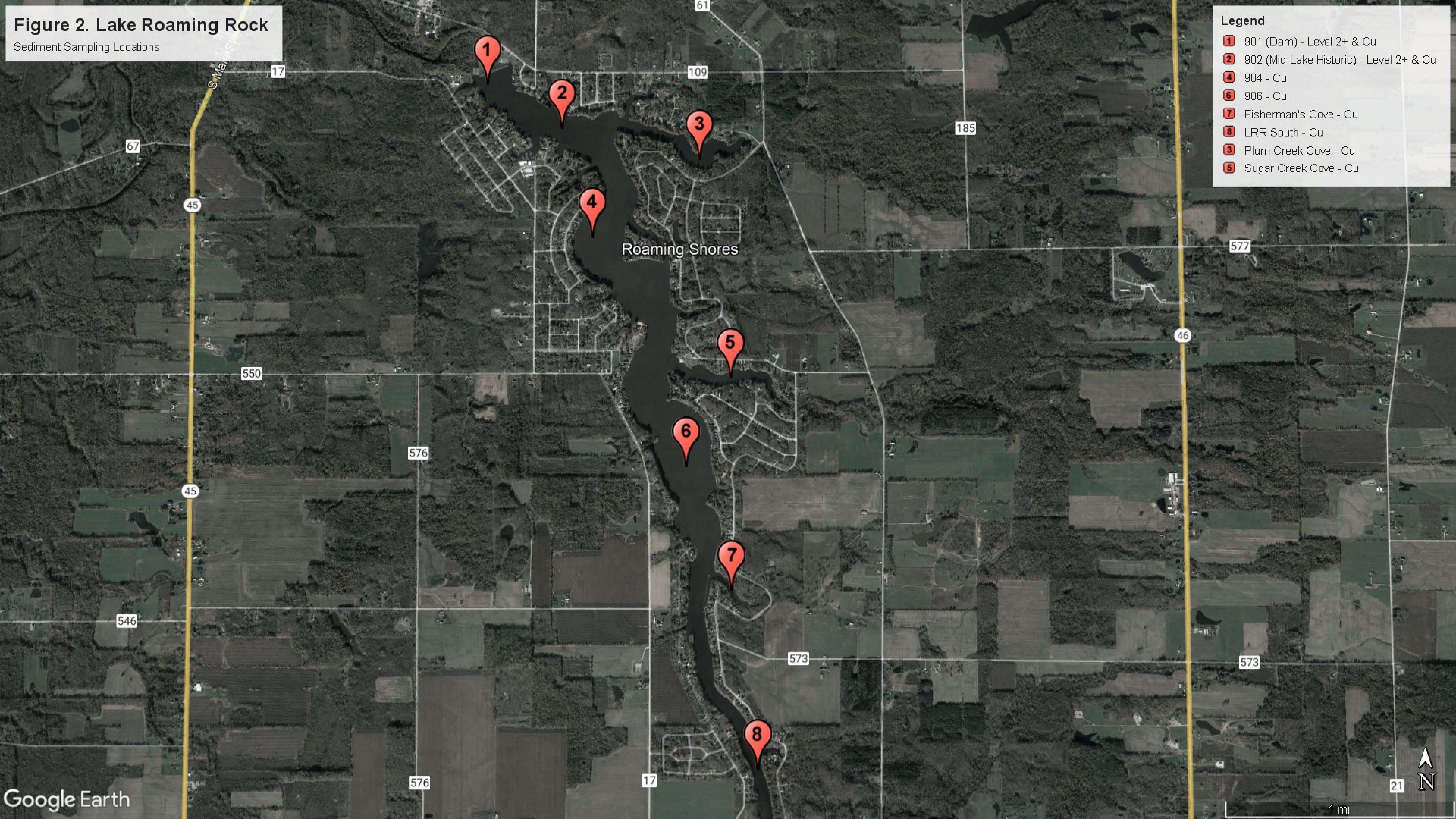


Figure 1. Lake Roaming Rock

Water Sampling Locations

Figure 2. Lake Roaming Rock

Sediment Sampling Locations



2.0 METHODS

EnviroScience visited LRR on four occasions (April 26 – sediment only, June 27, July 25, and August 24) during the summer of 2022 to gather representative data under both wet and dry weather conditions, capturing any influx of nutrients or changes in water chemistry in the watershed. For the purposes of this study, dry weather conditions were defined as being a period where no measurable precipitation had occurred within the past seven days and the influent streams were flowing at relatively low levels. Wet weather conditions were defined as periods where a minimum of 0.5 inches of precipitation had been recorded at a nearby National Weather Service monitoring station within the previous 24-hour period. Sampling locations are shown in Figure 1. Stream sampling locations were selected to provide information on potentially significant sources of nutrients/sediments based on USGS Stream Stats drainage areas.

2.1 LAKE WATER QUALITY MONITORING METHODS

Water Chemistry & Chlorophyll-a

During each summer lake sampling event (June, July, August), samples were collected at three locations: near the dam (Dam), the middle of the lake (Mid-Lake New), and just north of Route 6 at the southern portion of the lake (LRR-South) (Figure 1 – A, B, C). Sample sites were geo-located using a handheld GPS device to facilitate re-sampling. Water samples were collected using a 2.0-liter Van Dorn sampler one meter below the lake surface and one meter above the lake bottom. Each sample was analyzed for total suspended solids (TSS), total phosphorus (TP), low-level dissolved reactive phosphorus (LLDRP), total Kjeldahl nitrogen (TKN), ammonia-N (NH4), and nitrate-nitrite (NO_2NO_3).

In addition, the surface samples were analyzed for chlorophyll-a and transparency (Secchi depth). The water samples collected for chlorophyll-a analysis were collected at a depth of 0.5 meters. Chlorophyll samples were processed utilizing modified EPA 446 methods (USEPA 1997). Each sample was taken to the EnviroScience laboratory, drawn through GFF filters via vacuum filtration, and frozen until analysis. Chlorophyll-a was extracted using acetone, and the absorbance of the pigment was measured using a spectrophotometer. Concentrations of chlorophyll-a and pheophytin-a (the degraded form of chlorophyll-a) in the sample were determined using Lorenzen's Pheopigment-corrected Chlorophyll-a and Pheophytin-a equations. Transparency was measured with a 20-centimeter Secchi disk at each sampling station.

To capture measurements of thermal stratification, temperature, dissolved oxygen, specific conductance, and pH were profiled at both locations in the lake by immersing a portable YSI™ Pro DSS multiprobe water quality meter at half a meter, then subsequent one-meter intervals from the surface to the bottom.

Biological Analyses

During the first and third water quality specific sampling events (June and August), zooplankton and phytoplankton samples were collected for identification and enumeration.

Phytoplankton

Phytoplankton samples were taken using an integrated tube sampler to collect organisms from the water column at each lake sampling site. The sample was homogenized in a triple-rinsed stainless-steel bucket and transferred to a sample jar, then preserved with Lugol's solution and transported to the EnviroScience laboratory for analysis.

Samples were analyzed with an Olympus™ IX73 phase contrast microscope at 400x total magnification. Subsamples were concentrated for ease of identification, and each subsample was counted in an Utermöhl plankton counting chamber. Phytoplankton taxa were reported in natural units per milliliter, cells per milliliter, and relative abundance.

Zooplankton

Zooplankton samples were collected using a 0.3-meter diameter Wisconsin-style tow net with a 0.2-meter throat and 50 µm mesh. A vertical tow was performed, sampling the entire water column from the bottom. The net was rinsed, and the collection jar removed. The sample was preserved in ethanol and transported to the EnviroScience laboratory for analysis.

The collection jar was transferred to a 500 mL container to analyze the zooplankton community using subsamples. The zooplankton were then identified to the lowest practical taxonomic unit and enumerated.

2.2 LAKE SEDIMENT SAMPLING

Lake water and sediment quality are closely interlinked with one another. Collecting information about the lake sediments is crucial in identifying and quantifying any sources of internal nutrient loading or chemical insults. Sediment samples were taken at eight (8) locations (five in the main lake; three in the coves) previously identified by EnviroScience (Figure 2). The top 10 cm of sediment was collected at each location and analyzed for and Copper. Sediment was sent to Eurofins Environment Testing North Central, Barberton, Ohio for copper analysis to monitor any potential build up of elemental copper due to copper-based algaecide application moving forward.

In addition, sediment cores were taken at two (2) historic lake sampling locations (Dam and Mid-Lake Historic) for more comprehensive analyses to identify the source of high metal oxides detected in the 2021 sediment samples. At each location 2 independent samples (replicates) were taken for result verification. Each core was shipped to the SePro Research & Technology Campus, Whitakers, NC, where they were fractionated for metal-oxide analyses.

2.3 STREAM WATER QUALITY MONITORING

EnviroScience monitored four (4) water quality sampling stations previously identified in 2021. Field parameters including temperature, conductivity, pH, and DO were measured using a YSI Pro DSS multi-parameter meter, and stream height was measured via the staff gauge. Analytical parameters analyzed by Northeast Ohio Regional Sewer District’s laboratory (NEORSD – Cleveland, OH) included total suspended solids (TSS), total phosphorus (TP), total Kjeldahl nitrogen (TKN), ammonia-N (NH_4), and nitrate-nitrite (NO_2NO_3). Sampling was completed during a multitude of conditions (representing at least 1 wet- and dry-weather event) coinciding with summer lake monitoring efforts.

3.0 RESULTS AND DISCUSSION

3.1 LAKE WATER QUALITY MONITORING

In Situ Measurements

The results for temperature, conductivity, and pH throughout the three sampled time periods were within expected ranges and are conducive to aquatic life use (Appendix A). Surface dissolved oxygen (DO) at all locations was adequate but drops dramatically below 3-5 meters in depth, with the exception of LRR-South where the max depth only reached 1-2 meters (Figure 3). In eutrophic systems, DO generally declines with depth and approaches zero near the bottom of the lake as the summer progresses (thermal stratification). Lake Roaming Rock exhibits textbook, normal eutrophic lake characteristics. Dissolved oxygen was consistently below 5 mg/L from 4 meters to the bottom at the two main lake sampling locations. Throughout the summer bottom DO measurements were consistently low ranging from 0.10-0.37mg/l. Low DO readings (in the hypolimnion) are not conducive to aquatic life and generally restrict fish activity in these areas except for short periods. The low DO conditions at the sediment/water interface also results in the release of phosphorus and metals such as iron and manganese from the sediments to the water column, which as is seen in the analytical results in the following section.

Figure 3. Lake Roaming Rock Dissolved Oxygen (mg/L) Profiles

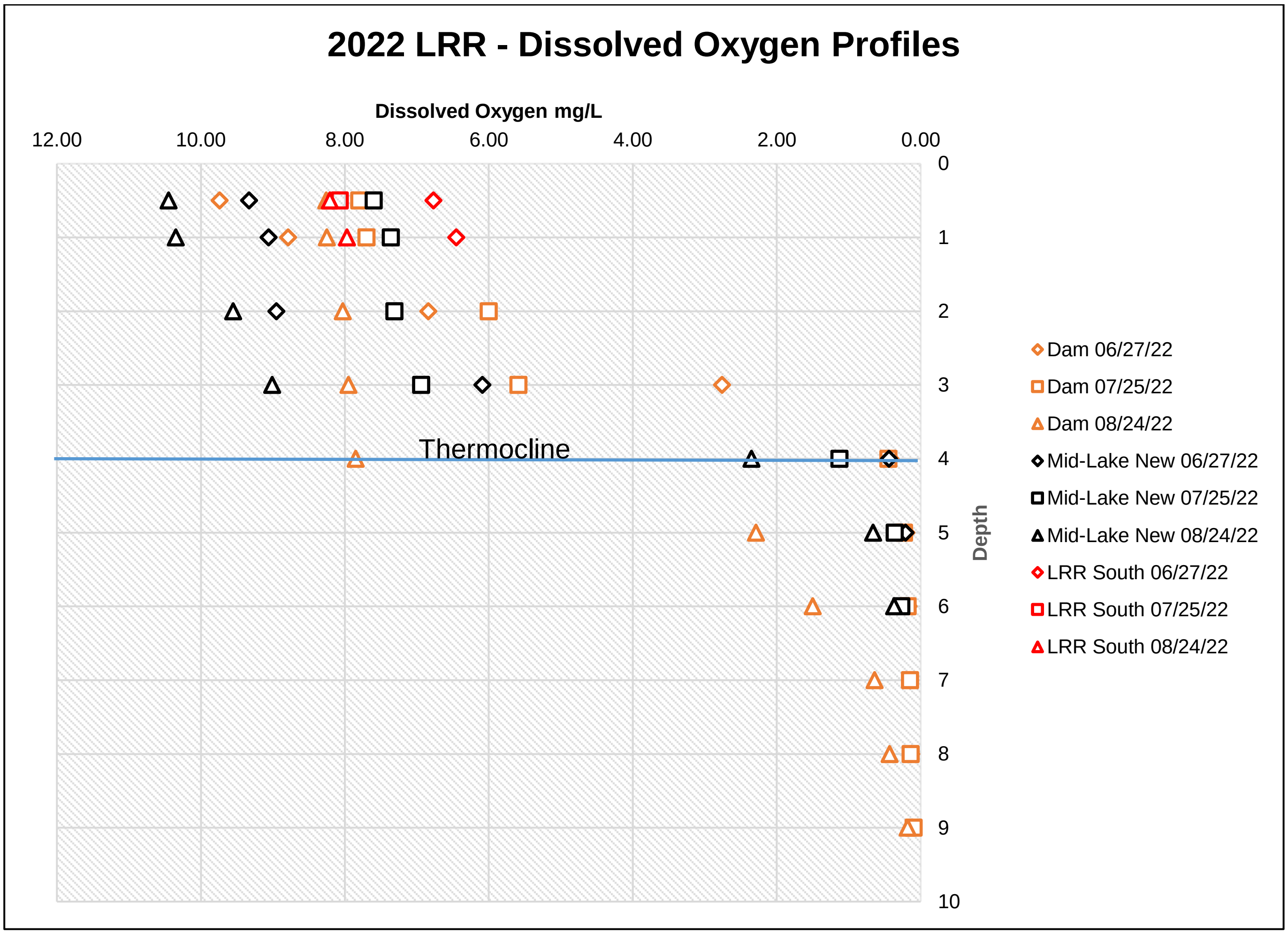
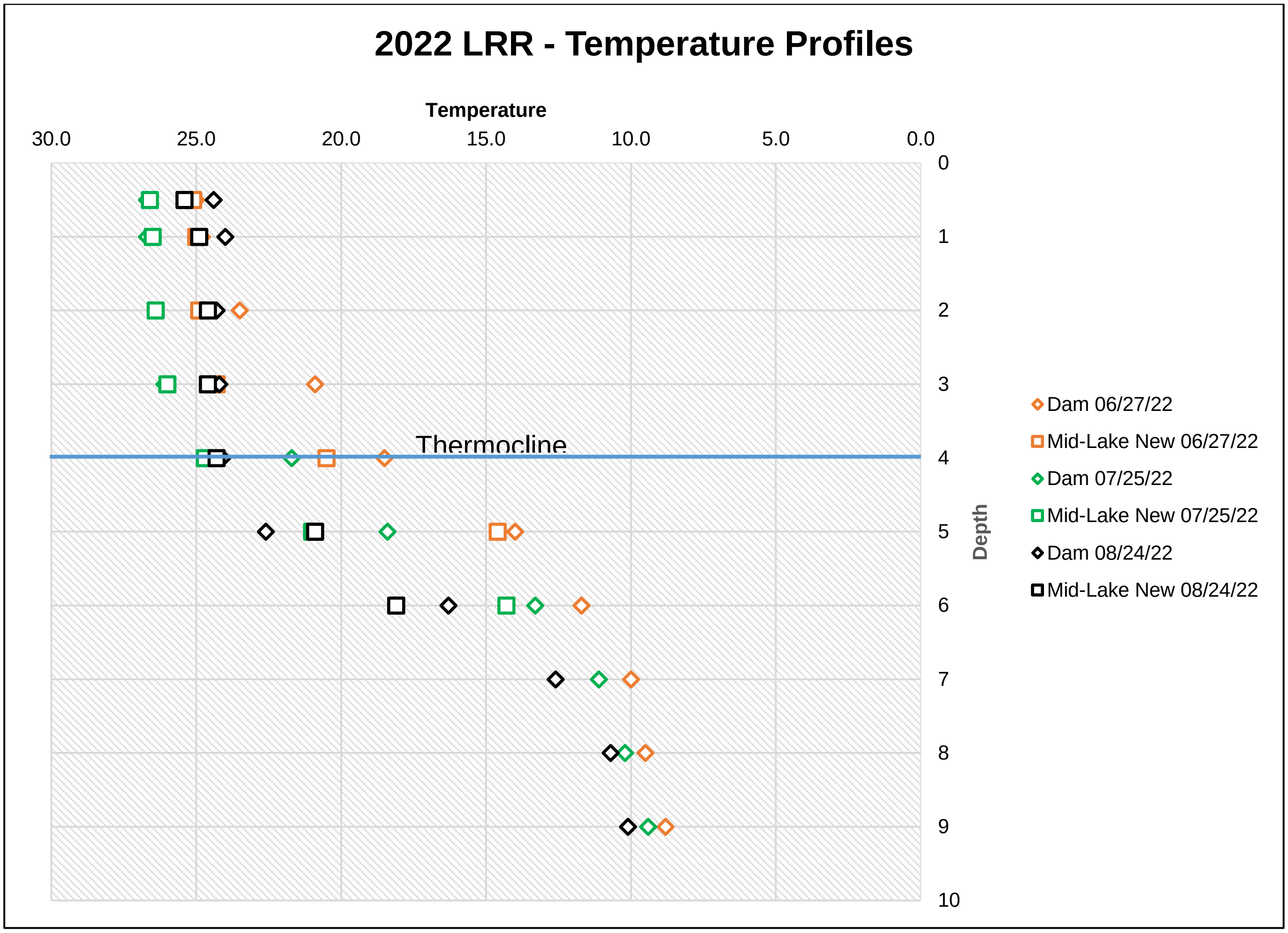


Figure 4. Lake Roaming Rock Temperature Profiles



Analytical Results

In general, nutrient concentrations were found to be above state-wide nutrient criteria (Criteria for Erie Ontario Lake Plain: total phosphorus = 0.034 ppm; total nitrogen = 0.740 ppm) for both surface and bottom samples (OEPA 2010). Total Phosphorus and LLDRP samples, were significantly different when comparing surface and bottom concentrations in LRR. Internal phosphorus mechanisms in LRR most likely include the classic sediment release through iron-redox reactions, cyanobacteria uptake and migration, bacteria mineralization of sediment phosphorus, and bioturbation of aquatic organisms. Given the very low DO concentrations in the hypolimnion, significant internal loading of phosphorus is occurring and may be the dominant source of phosphorus loading to the overall water column. All other phosphorus measurements taken from the surface waters (both lake and feeder streams) were relatively low in comparison to the bottom samples. However, Rock Creek is undoubtedly a major contributor to external phosphorus loading with TP producing levels double the recommended EPA limit of 50 ppb for most sampling locations (AquaDoc 2022) during both high and low flow conditions. Despite elevated phosphorus levels in Rock Creek surface waters upstream, much of it appears to be assimilated as it approaches LRR boundaries and continues throughout the reservoir considering the relatively low TP and LLDRP measurements in the Mid-Lake and Dam surface water samples (outside of rain events).

While phosphorus is certainly the main concern, nitrogen is the other crucial element that contributes to primary production. As with phosphorus, total nitrogen values observed at LRR are consistently greater than state-wide nutrient criteria. Nitrogen was speciated by measuring levels of ammonia-nitrogen (NH3-T), biologically available nitrogen in the form of nitrate-nitrite (NO3NO2), organically bound nitrogen and ammonia (TKN), and total nitrogen by calculation (TKN + NO3NO2). Overall, ammonia levels were relatively low in surface samples, but were slightly elevated near the bottom. In relation to the other nitrogen species, these are relatively negligible. The dominant nitrogen species (which contribute to total nitrogen) are organically bound nitrogen (measured through TKN) and biologically available nitrogen (measured as Nitrate-Nitrite). Higher nitrogen values observed in the bottom waters suggests leaching from sediments.Throughout the entire sampling season among both sites, total nitrogen values from the surface and bottom ranged from 0.716 – 1.462 ppm and 0.908 – 1.592 ppm respectively. On average, observed values were 2 times greater than statewide nutrient criteria, but greatly improved in comparison to LRR 2021 values. Observed nitrogen values were half of what was observed in 2021.

Turbidity is a water quality parameter that refers to how clear the water is. The greater the amount of total suspended solids (TSS) in the water, the murkier it appears and the higher the measured turbidity. Clay, silt, and sand from soils, phytoplankton (suspended algae), bits of decaying vegetation, industrial wastes and sewage are common suspended solids. Total suspended solids (TSS) values were relatively constant throughout the sampling period and on average were lower than observed 2021 values. In general, the values observed were normal-low for this sort of environment.

Table 1. Lake Roaming Rock Water Chemistry – Dam

SURFACE	6/28/2022 (DRY)	7/26/2022 (WET)	8/24/2024 (DRY)
LLDRP (ppb)	4.31	3.77	5.62
NH3-T (ppm)	0.0780	0.0335	0.0262
NO3NO2 (ppm)	<0.012	<0.012	<0.012
TP (ppm)	0.0405	0.0333	0.0236

TKN (ppm)	1.45	1.25	0.704
TSS (ppm)	10.1	4.5	2.3
Total Nitrogen (ppm)	1.4622	1.262	0.716
BOTTOM	**6/28/2022 (DRY)**	**7/26/2022 (WET)**	**8/24/2024 (DRY)**
LLDRP (ppb)	34.9	79.3	127
NH3-T (ppm)	0.478	0.561	0.599
NO3NO2 (ppm)	0.128	0.0163	<0.012
TP (ppm)	0.148	0.195	0.290
TKN (ppm)	1.14	1.36	1.37
TSS (ppm)	3.1	4.7	3.5
Total Nitrogen (ppm)	1.268	1.3763	1.382

Table 2. Lake Roaming Rock Water Chemistry – Mid-Lake NEW

SURFACE	**6/28/2022 (DRY)**	**7/26/2022 (WET)**	**8/24/2024 (DRY)**
LLDRP (ppb)	3.97	4.19	10.4
NH3-T (ppm)	0.0712	0.0247	0.0241
NO3NO2 (ppm)	0.0169	<0.012	0.0261
TP (ppm)	0.0526	0.0474	0.0746
TKN (ppm)	1.44	1.13	1.15
TSS (ppm)	8.0	5.8	8.6
Total Nitrogen (ppm)	1.4569	1.142	1.1761
BOTTOM	**6/28/2022 (DRY)**	**7/26/2022 (WET)**	**8/24/2024 (DRY)**
LLDRP (ppb)	23.9	71.0	150
NH3-T (ppm)	0.270	0.320	0.585
NO3NO2 (ppm)	0.0531	<0.012	<0.012
TP (ppm)	0.105	0.180	0.378
TKN (ppm)	1.30	1.41	1.58
TSS (ppm)	9.1	6.4	6.8
Total Nitrogen (ppm)	1.3531	1.422	1.592

Table 3. Lake Roaming Rock Water Chemistry – LRR South

SURFACE	6/28/2022 (DRY)	7/26/2022 (WET)	8/24/2024 (DRY)
LLDRP (ppb)	6.60	5.69	15.7
NH3-T (ppm)	0.105	0.0388	0.0760
NO3NO2 (ppm)	0.115	<0.012	0.101
TP (ppm)	0.0592	0.0466	0.0528
TKN (ppm)	0.982	0.953	0.764
TSS (ppm)	4.2	3.7	3.7
Total Nitrogen (ppm)	1.097	0.965	0.865
BOTTOM	**6/28/2022 (DRY)**	**7/26/2022 (WET)**	**8/24/2024 (DRY)**
LLDRP (ppb)	7.19	6.02	16.4
NH3-T (ppm)	0.0957	0.0349	0.0864
NO3NO2 (ppm)	0.142	0.0131	0.0860
TP (ppm)	0.0629	0.0452	0.0684
TKN (ppm)	1.00	1.03	0.822
TSS (ppm)	4.1	2.2	4.7
Total Nitrogen (ppm)	1.142	1.0431	0.908

Trophic Status and TSI Calculation

In any given lake system, the trophic state of the lake can be defined as the total amount of living material (biomass) present in the water column at a given time. Trophic state is generally accepted as a biological response to factors such as nutrient addition, with phosphorus being the primary growth-limiting nutrient for algae and macrophytes in lakes (Horne and Goldman, 1994). Eutrophication, although a natural process over time, is often accelerated by human activities, namely those that increase plant nutrients (i.e., phosphorus) in the lake. Nutrients enter the lake through run-off or direct input from fertilizer-rich agricultural soils, sewage, or other wastewater. Enrichment of the nutrients in the water results in increased algal densities (algal "blooms"), which in turn may produce a host of undesirable effects including discoloration, taste and odor problems, low DO conditions, changes in fish species abundance, and toxicity problems. Toxicity is of concern with increasing awareness that some strains of algae produce toxins at doses that are lethal to animals and humans.

Due to its importance in lake dynamics, monitoring of total phosphorus was an important part of the current study. Samples of chlorophyll-a (Table 4) provided an estimate of the amount of primary production in the system. The more chlorophyll-a that is present, the larger the algal biomass, and the more eutrophic the lake is. Additionally, the clarity of the lake, as measured by Secchi disc transparency, is a function of the density of varying algal concentrations and other suspended material.

Table 4. Lake Roaming Rock Chlorophyll-a Data

Site	Sample Date	Chl-a (ppb)
Dam	6/28/2022	17.40
Mid-Lake NEW	6/28/2022	14.70
LRR South	6/28/2022	4.00
Dam	7/26/2022	13.60
Mid-Lake NEW	7/26/2022	15.20
LRR South	7/26/2022	7.20
Dam	8/24/2022	8.00
Mid-Lake NEW	8/24/2022	12.00
LRR South	8/24/2022	4.00

Carlson's Trophic State Index (TSI) (Carlson, 1977) is a relatively simple way of comparing these three measurements. Chlorophyll a (CHL), Secchi depth (SD), and total phosphorus (TP) are used in the TSI calculations to independently estimate algal biomass. Each measurement is converted to an index value ranging from 0 to 100 using the following equations:

$$\mathbf{TSI(SD) = 60 - 14.41 \ln(SD)}$$

$$\mathbf{TSI(CHL) = 9.81 \ln(CHL) + 30.6}$$

$$\mathbf{TSI(TP) = 14.42 \ln(TP) + 4.15}$$

Based on its TSI values, a lake can be placed into one of four categories of trophic status (Table 5): oligotrophic, mesotrophic, eutrophic, and hypereutrophic. Oligotrophic lakes (TSI <40) are typically clear, well-oxygenated throughout, with little phytoplankton and low nutrient levels. Mesotrophic lakes (TSI between 40-50) are intermediate between oligotrophic and eutrophic lakes and are characterized by moderate clarity and nutrient levels and increasing probability of anoxic conditions at depth during the summer. Eutrophic lakes (TSI between 50 and 70) are often characterized by a disappearance of oxygen (anoxia) in the deeper parts of the lake and nuisance levels of macrophytes and blue-green algal scums during the summer. Hypereutrophic lakes (TSI >70) have algal densities so high that light rather than nutrients becomes limiting to plant growth. Macrophytes often disappear because there is insufficient light to support their growth. Fish species shift towards roughfish that can tolerate low oxygen levels. In extreme hypereutrophic situations, winter and summer fish kills may occur.

Table 5. TSI Scoring Rubric (NALMS – Carlson, 1996)

TSI	Chl(µg/L)	SD(m)	TP (µg/L)	Attributes	Water Supply	Fisheries & Recreation
< 30	< 0.95	> 8	< 6	**Oligotrophy:** Clear water, oxygen throughout the year in the hypolimnion.	Water may be suitable for an unfiltered water supply.	Salmonid fisheries dominate.
30 – 40	0.95 – 2.6	8 – 4	6 – 12	Hypolimnia of shallower lakes may become anoxic.		Salmonid fisheries in deep lakes only.
40 – 50	2.6 – 7.3	4 – 2	12 – 24	**Mesotrophy:** Water moderately clear; increasing probability of hypolimnetic anoxia during summer.	Iron, manganese, taste, and odor problems worsen. Raw water turbidity requires filtration.	Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate.
50 – 60	7.3 – 20	2 – 1	24 – 48	**Eutrophy:** Anoxic hypolimnia, macrophyte problems possible.		Warm-water fisheries only. Bass may dominate.
60 – 70	20 – 56	0.5 – 1	48 – 96	Blue-green algae dominate, algal scums and macrophyte problems.	Episodes of severe taste and odor possible.	Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating.
70 – 80	56 – 155	0.25 – 0.5	96 – 192	**Hypereutrophy:** (light limited productivity). Dense algae and macrophytes.		
> 80	> 155	< 0.25	192 – 384	Algal scums, few macrophytes		Rough fish dominate; summer fish kills possible.

TSI values calculated for Lake Roaming Rock are as follows:

Table 6. Calculated TSI Values

Date	TSI(SD)	TSI(CHL-a)	TSI(TP)
Dam			
6/27/2022	60.74	58.62	57.52
7/25/2022	55.68	56.20	54.70
8/24/2022	47.09	51.00	49.74
Average	**54.50**	**55.28**	**53.99**
Mid-Lake New			
6/27/2022	60.74	56.97	61.29
7/25/2022	55.68	57.30	59.79
8/24/2022	57.37	54.98	66.33
Average	**57.93**	**56.41**	**62.47**
LRR South			
6/27/2022	60.00	44.20	63.00
7/25/2022	55.68	49.97	59.55
8/24/2022	51.94	44.20	61.35
Average	55.87	46.12	61.30
Combined Average	56.10	52.60	59.25

Trophic State Index values across all indicators were approximately 7 points lower versus 2021. Similar to 2021, the 2022 calculated values still place Lake Roaming Rock in the eutrophic range, but there has been an improvement across all indicators. The fact that the three indices tend to trend similarly on the same dates is indicative that there is little non-algal turbidity in the water and that the transparency is being largely affected by algae concentrations. Situations where there are similarities between the average phosphorus and chlorophyll index values suggest that phosphorus is the limiting nutrient, as is typical for most lakes in the Midwest.

Biological Analyses

Phytoplankton

The results of the phytoplankton (algae) analysis are provided in Appendix B. Due to scheduling conflicts, the first sampling event in June occured after the first dose of the whole-lake algaecide treatment. Fortunately only the southern half of the lake had been treated, allowing for some pre-treatment conditions to be observed. Even after the first part of the treatment, the lake was already exhibiting bloom conditions (cell counts >100,000 cells/ml) in the main lake. Overall diversity was low among sites (<13 species) and the community was comprised of >97% blue-green algae (for Mid-Lake New and Dam locations). The LRR South location was still mostly comprised of cyanobacteria (>55%), but had a significantly lower cell density (12,265 cells/ml). This result was likely due to the proximity to Rock Creek. The southern portion of the lake is shallow and exhibits some consistent flow, allowing for “clearing” of the phytoplankton community into the main lake.   In August there was a significant decrease in algae cell density post-treatment (<25,000 cells/ml) and an increase in diversity (Appendix B). Originally, during the short-term management planning phase it was posited that two treatments throughout the season may be necessary to mitigate bloom conditions.The phytoplankton results trended similarly with the summer of 2021. Consistent monitoring by

AquaDoc showed that the single algaecide treatment provided enough efficacy to not warrant a second treatment.

The algae community is largely dominated by blue-green algae, with *Aphanizomenon flos-aquae*, *Dolichospermum spp.*, *Woronichinia naegeliana*, and *Aphanocapsa delicatissima* being the most dominant species. These species are common in nutrient-rich surface water and generally do well in warm temperatures and in high light levels. Some species, such as *Aphanizomenon flos-aquae,* can increase their population size every year, due to their physiology. Certain blue-green algae produce specialized resting cells called akinetes. When conditions become unfavorable the cyanobacteria die-off and settle to the bottom, but the akinete can persist in the sediment allowing for easy recolonization the next season. If conditions are right, significant blooms may be observed in fall, winter, and spring.

All the dominant species observed in LRR can potentially produce cyanotoxins under certain conditions. For water quality managers, blue-green algae blooms can prove to be a conundrum. Bloom severity is not always a good indication of toxin concentration. While most minor cyanobacteria blooms will only have very low levels of toxins present, in other cases minor blooms can have higher concentrations of toxins. Multiple possible explanations exist for why some blooms of the same species produce toxins and some do not, and these include environmental conditions and the presence or absence of toxin-producing genes. Therefore, what may look like a minor bloom, may have high toxins and what may look like a major bloom may not be producing toxin at all. In addition, some cyanobacteria are more likely to produce toxins than others, so it is impossible to assess toxin concentrations by visual evidence alone. For these reasons, consistent cyanotoxin monitoring is still warranted.

Cyanotoxin concentrations (microcystin) were measured throughout the season in areas with the greatest recreational exposure (i.e. beaches). No samples had a concentration above the OEPA recreational advisory limit (8 ppb), and in all cases except one (Beach 1 – 6/28/22) levels were below OEPA drinking water standards (<0.3 ppb).

Table 7. Cyanotoxin Analysis (Microcystin ppb)

Date	Roaming Rock Blvd (Beach #1)	Morningstar Drive (Beach #2)
5/24/2022	0.027	0.052
6/15/2022	0.112	0.071
6/28/2022	0.343	0.219
7/19/2022	0.093	0.116
7/26/2022	0.137	0.157
8/2/2022	0.038	0.064
8/9/2022	0.058	0.045
8/16/2022	0.017	0.018
8/23/2022	0.019	0.025
8/30/2022	0.039	0.063

Zooplankton

Zooplankton are microscopic invertebrates that are the second form of biological production in a waterbody after the primary producers (phytoplankton). They play a vital role in a lake's ecosystem by providing forage for larval and juvenile fish. Analysis of the lake's zooplankton can provide insight into the availability and quality of larval fish forage and reveal facets of the LRR food web from the lower trophic perspective. Zooplankton communities are dynamic, changing throughout the year, with populations responding to available phytoplankton communities as well as predation by larval fish. Their role in the food web is crucial to converting energy from the phytoplankton to a form that can be utilized by the larvae and juvenile fish populations of the lake, including top predators like bass and pike.

Overall, the 2022 zooplankton survey reveals a typical assemblage and density of zooplankton commonly established in eutrophic lakes, most notably the cladocerans *Daphnia spp*., *Bosmina sp.*, *Diaphanosoma sp.,* and the rotifers *Keratella*, and *Kellicotia.* No exotic or invasive zooplankton species, such as zebra mussel veligers (larvae), were observed in the sample. The zooplankton community consisted of species at densities typical of other eutrophic lakes and would adequately sustain larvae and juveniles of the fish community, such as largemouth bass, crappie, sunfish, and catfish.

Changes in zooplankton community structure were noticeable as the season progressed, however, the system was rotifer dominant throughout. Rotifers are very small multi-cellular animals that filter planktonic algae for food. The dominance of rotifers in the lake is likely related to the abundance of blue-green algae. Rotifer abundance is often positively correlated with high levels of blue-green algae because rotifers seem to be able to feed on toxin-producing blue-green algae more successfully than cladocerans or other zooplankton. Continuing zooplankton analysis can reveal long-term trends in recruitment, food web dynamics, and reflect potential environmental stressors in the lake. The results of the zooplankton analysis are presented in Appendix B.

3.2 SEDIMENT ANALYSIS

Differing from 2021, sediment phosphorus data was only collected at two (2) locations for SePro "Level 2 Plus" analysis. Sediment cores were fractionated into three depths: surface (0-1.5"), middle (1.5-3"), and deep (3-4.5") in order to gather more information on the metal-oxide components. Sediment samples exhibited high concentrations of bio-available phosphorus, similar to what was observed in 2021. Each location and fractionation had similar characteristics. Overall, results suggested high levels of iron in a stable form and low aluminum in LRR soils accounting for roughly 30% of the metal oxide components. This data provides one more component to accurately assess long-term management of internal/sediment phosphorus and treatment potential using nutrient inactivation technologies. Sediment results for each separate location are located in Appendix C.

In addition to the "Level 2 Plus" analysis, copper analysis was also completed on the fractions to get an idea of changes in copper. Lake Roaming Rock sediments across all sites generally had a normal level of elemental copper present (Range: 11-43 mg/kg – Table 8). The highest levels of copper (values of 43 mg/kg) were observed in the deeper portions of the lake (902-Mid Lake). Ohio EPA sediment quality guidelines for freshwater ecosystems list copper to have a threshold effect concentration (TEC) of 31.6 mg/kg (Ohio EPA, 2008). The TEC is a concentration below which adverse effects on benthic organisms are unlikely to occur. LRR does exhibit values greater than the TEC, but only in the deepest portions of the lake, seldom used by fish or invertebrate populations due to the low DO conditions. Considering the parent material (general soil profiles in the surrounding watershed) the values continue to be well within the range of normal, and not a human health concern if removed or disturbed. Consistent copper monitoring will help establish a baseline upon which comparisons can be made, as lake-wide, copper-based herbicide treatments are likely to continue in the future.

Table 8. Concentration of Copper in LRR Sediments (mg/kg)

Location	4/26/22	10/25/22
901 – Dam (Surface)	30*	29
901 – Dam (Middle)	33*	
901 – Dam (Deep)	33*	
902 – Mid Lake (Surface)	43*	33
902 – Mid Lake (Middle)	35*	
902 – Mid Lake (Deep)	38*	
904		40
906		11
LRR South (908)		19
Plum Creek Cove		28
Sugar Creek Cove		27
Fisherman's Cove		27

*Analysis completed past hold time

3.3 INFLUENT STREAM SAMPLING

The stream sampling results summarized below show moderate levels of nutrients entering LRR from the surrounding watershed. In situ measurements taken via a multiparameter probe were relatively similar among sites and are considered normal for the area (see Appendix A).

In general, both nutrients and suspended solids were generally constant throughout wet and dry weather conditions. Slight increases in both nutrients and total suspended solids were observed during wet weather conditions, but only for certain sites and parameters. Rock Creek is still the major source of phosphorus and nitrogen entering LRR, but the smaller tributaries are undoubtedly adding nutrients as well.

Discharge measurements were taken during two of the three sampling events (Appendix A). Staff gauge data was taken for only two sites this year (Plum Creek and Fisherman's Cove). Both Sugar Creek and Spanish Cove gauge stations had been destroyed by winter flows and were not included in the data set.

The 2022 sampling results and general stream narratives (carried over from 2021) from the major influent sources excluding Rock Creek are presented below. AquaDoc Inc. was tasked with Rock Creek monitoring for 2022 and results are presented in their respective report.

Table 9. Influent Streams - Observed Changes in Staff Gauge Height (feet)

Site ID	6/27/22	7/25/22	8/24/22
Plum Creek	0.16	0.20	-
Fisherman's Cove	1.32	1.46	-

Plum Creek

This tributary drains approximately 3.16 sq miles of the northeastern side of Lake Roaming Rock. The watershed isn't very developed (5.23% urban) and maintains ~44.7% tree/forested cover. The impervious surface percentage is very low at only 0.72%. A majority of the watershed is impacted by agricultural land use, a source of impairment through nutrient runoff. Nitrogen and phosphorus values were slightly elevated throughout the sampling period but are within a normal range for OEPA warmwater criteria (Ohio EPA, 2011). Overall, analytical values were relatively similar to those observed 2021 values (Table 10).

Figure 5. Plum Creek Sub-watershed

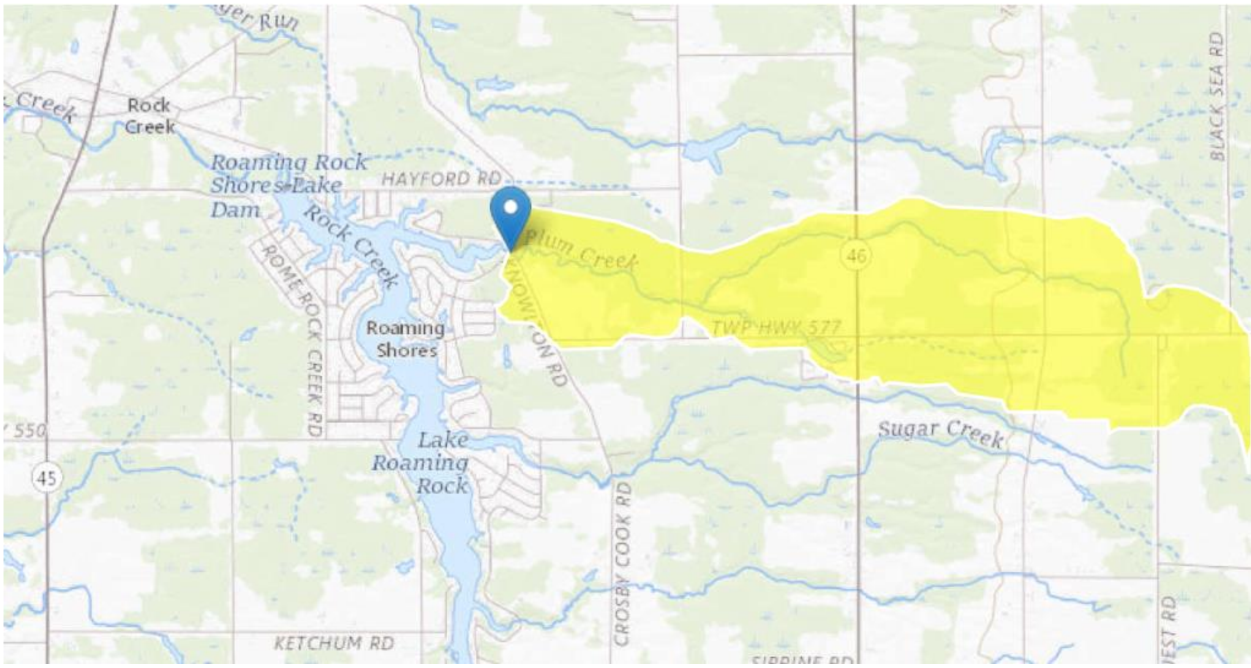


Table 10. Plum Creek Water Chemistry

Date	6/27/2022 (DRY)	7/25/2022 (WET)	8/24/2022 (DRY)
LLDRP (ppb)	*	10.2	13.3
NH3-T (ppm)	0.136	0.120	0.0525
NO3NO2 (ppm)	0.156	0.272	0.594
TP (ppm)	0.0346	0.105	0.0520
TKN (ppm)	0.882	0.896	0.786
TSS (ppm)	81.4	50.4	7.6
Total Nitrogen (ppm)	1.038	1.168	1.38

*Analysis incomplete

Sugar Creek

This tributary drains approximately 3.23 sq miles of the eastern side of Lake Roaming Rock. The watershed isn't developed (3.9% urban) and maintains a similar area covered by forest at ~43.5% when compared to Plum Creek. The impervious surface percentage is very low at only 0.62%. As with Plum Creek, a majority of the watershed is impacted by agricultural land use, a source of impairment through nutrient runoff. Nitrogen and phosphorus values were slightly elevated throughout the sampling period but are within a normal range for OEPA warmwater criteria. Overall, analytical values were relatively similar to those observed in 2021(Table 11).

Figure 6. Sugar Creek Sub-Watershed

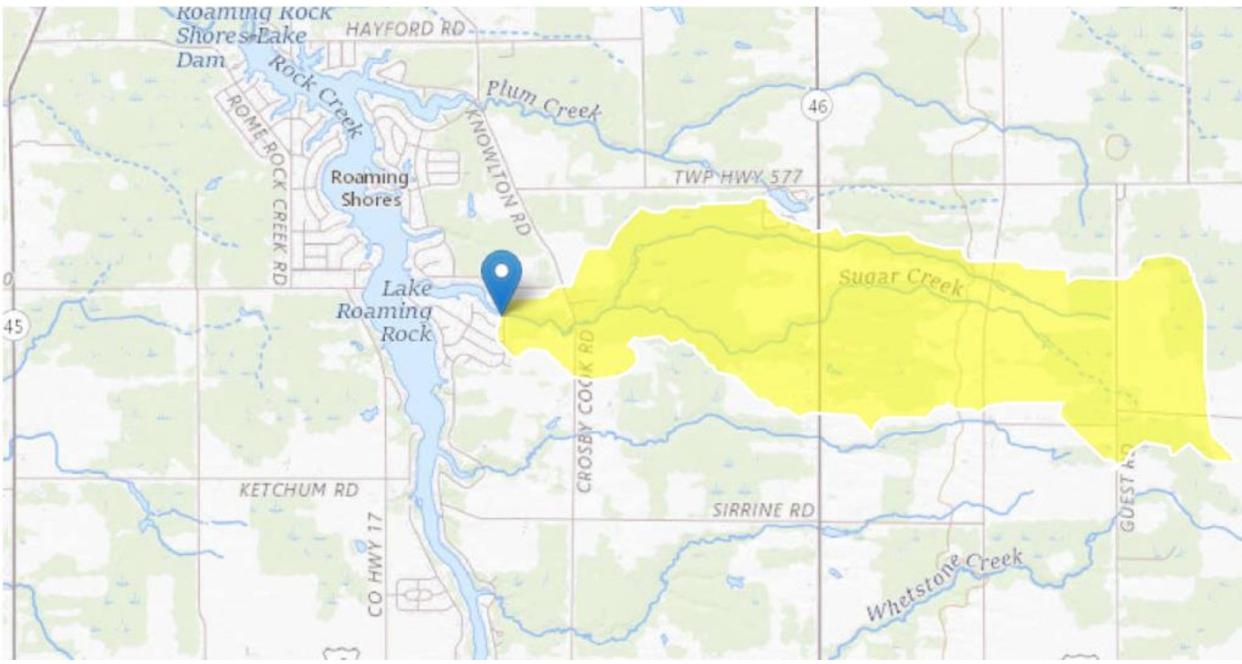


Table 11. Sugar Creek Water Chemistry

Date	6/27/2022 (DRY)	7/25/2022 (WET)	8/24/2022 (DRY)
LLDRP (ppb)	*	13.3	33.0
NH3-T (ppm)	0.0551	0.0403	0.0649
NO3NO2 (ppm)	0.0461	0.600	1.67
TP (ppm)	0.0872	0.0750	0.0817
TKN (ppm)	0.946	1.40	1.08
TSS (ppm)	8.4	10.9	3.1
Total Nitrogen (ppm)	0.9921	2	2.75

*Analysis incomplete

Fisherman's Cove

This tributary drains approximately 1.83 sq miles of the eastern side of Lake Roaming Rock. The watershed is undeveloped (4.1% urban) and only maintains 34.1% forest cover. The impervious surface percentage is very low at only 0.72%. A majority of the watershed is impacted by agricultural land use, a source of impairment through nutrient runoff. Nitrogen and phosphorus values were elevated throughout the sampling period. On average, nutrient values continue to be higher in comparison to other feeder streams (Table 12). Low forest cover, lack of riparian buffers along the stream (observed via satellite imagery), and presence of an elk-farm likely account for this marked difference.

Figure 7. Fisherman's Cove Sub-Watershed

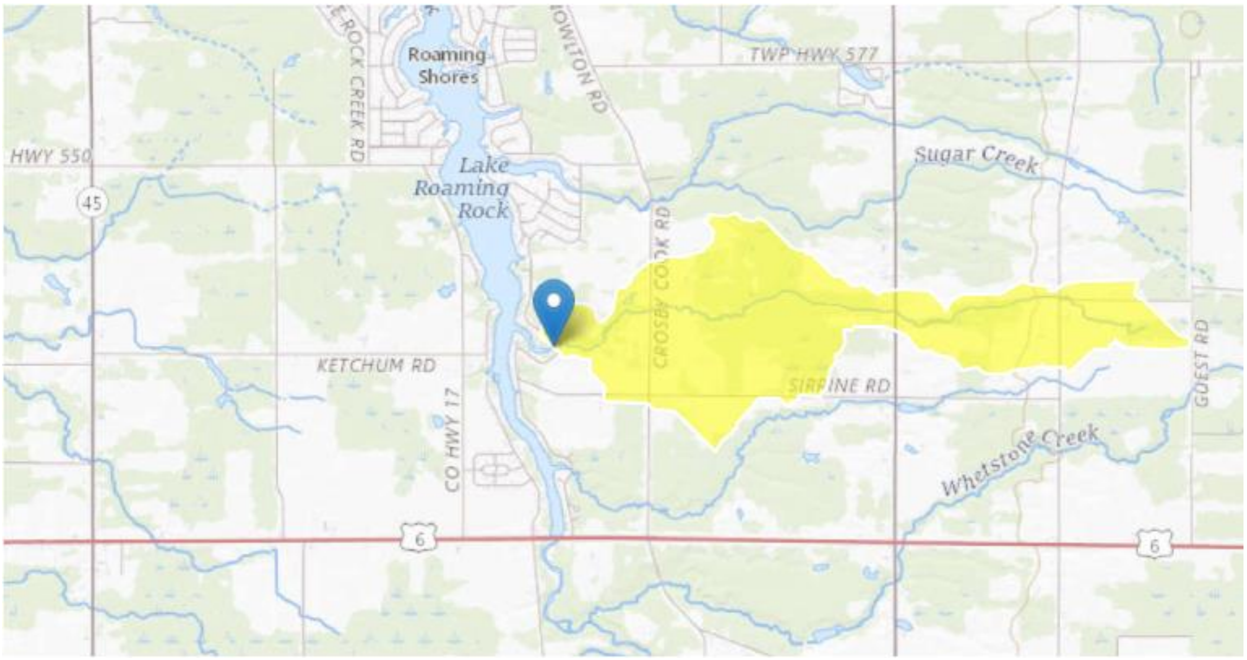


Table 12. Fisherman's Cove Water Chemistry

Date	6/27/2022 (DRY)	7/25/2022 (WET)	8/24/2022 (DRY)
LLDRP (ppb)	*	138	30.6
NH3-T (ppm)	0.0563	0.688	0.148
NO3NO2 (ppm)	0.0310	1.68	0.710
TP (ppm)	0.0386	0.749	0.159
TKN (ppm)	1.04	4.69	1.59
TSS (ppm)	3.9	143	17.6
Total Nitrogen (ppm)	1.071	6.37	2.3

*Analysis incomplete

Spanish Cove

This tributary drains approximately 1.91 sq miles of the southeastern side of Lake Roaming Rock. The watershed is the most developed of the four small feeder streams tested (8.35% urban) and maintains a similar area covered by forest at ~44.6% when compared to Plum Creek and Sugar Creek. Despite the slightly higher urban metric, impervious surfaces are very low at only 1.22%. A majority of the watershed is impacted by agricultural land use, a source of impairment through nutrient runoff. Nitrogen and phosphorus values were slightly elevated throughout the sampling period but are within the normal range for OEPA warmwater criteria.

Figure 8. Spanish Cove Sub-Watershed

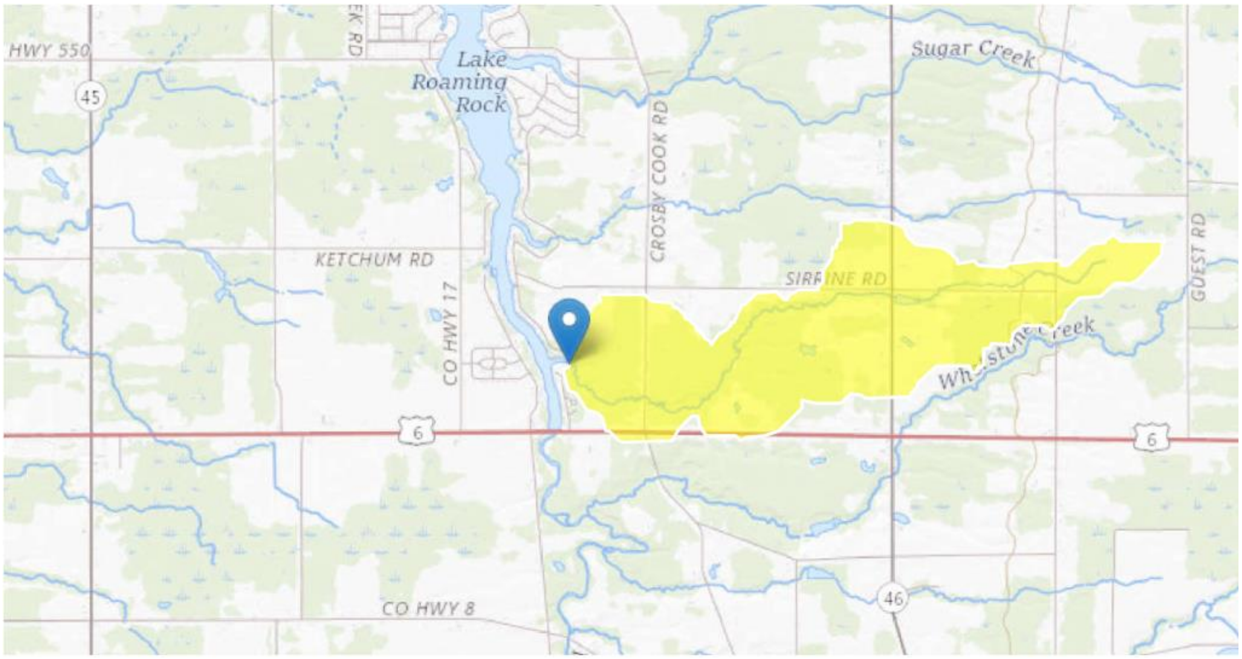


Table 13. Spanish Cove Water Chemistry

Date	6/27/2022 (DRY)	7/25/2022 (WET)	8/24/2022 (DRY)
LLDRP (ppb)	*	22.2	30.3
NH3-T (ppm)	0.0650	0.0400	0.0361
NO3NO2 (ppm)	0.379	0.178	0.361
TP (ppm)	0.0480	0.0544	0.0526
TKN (ppm)	0.584	0.678	0.769
TSS (ppm)	8.8	5.2	2.5
Total Nitrogen (ppm)	0.963	0.856	1.13

*Analysis incomplete

Rock Creek

Rock Creek is the main stream that feeds Lake Roaming Rock. It has a drainage area of approximately 51.9 sq miles. The watershed within the drainage area is 32.9% forested and 5.26% urban. Like all other streams assessed, the majority of the watershed is impacted by agricultural land use, a source of impairment through nutrient runoff. During the 2022 field season, AquaDoc Inc. collected water chemistry data at different locations along the Rock Creek mainstem. Results associated with this study are located in the AquaDoc report provided to RRA in 2022.

4.0 MANAGEMENT RECOMMENDATIONS

The results gathered to date indicate that Lake Roaming Rock is still in a eutrophic state, but showing improvement over previous sampling periods. Consistent algaecide treatments over the past 2 years paired with a favorable decrease in wet weather events for 2022 likely account for some of the observed improvements in water quality. There are still inputs of nitrogen and phosphorus from agricultural sources in the watershed, however mitigation of these non-point source pollutants is currently outside of the scope of LRR Management plans at the moment. Current sediment data has further pushed the focus towards mitigating internal loading of phosphorus, specifically using nutrient inactivation technologies (such as SePro's PhosLock™ or another alum-based chemical).

The entire LRR committee understands that nutrients are the underlying problem, and blue-green algae or cyanobacterial blooms are one of the primary symptoms of that problem. Whole lake algaecide treatments are proving to be a great tool for short-term management goals and will likely remain a useful option in treating the lake's algae issues for the foreseeable future (at least until nutrient releases from the sediment are addressed). Ultimately, a combination of techniques will likely be needed to maintain water quality.

Below are some focused recommendations based on data gathered throughout the past couple of years.

4.1 ALGAE CONTROL

In discussions with the board, the most frequent complaint regarding the lake was the frequent blooms of algae. While 2021 and 2022 had a remarkable decrease in algae across the entirety of each summer, the data still shows consistent bloom levels early each season (i.e June, pre-treatment). Many management options exist for the control of algae in lakes. These can be broadly categorized as 1) nutrient control techniques, 2) physical controls, 3) chemical controls, and 4) biological controls. Several control techniques may overlap with one or more of these categories. Based on multiple factors including: monitoring data, RRA goals, budget, and discussions with the LRR committee, nutrient control and chemical controls are the main algae mitigation techniques showing the greatest potential.

Nutrient Control

LRR Watershed Source Reduction

Because algal growth is fueled by high nutrient levels, consideration should be given to identifying and controlling the sources of nutrients wherever possible. While the ultimate goal is reduce nutrients from all external watershed sources (outside of LRR jurisdiction), it is more feasible to first look at localized nutrient sources (within LRR jurisdiction). Sampling data collected to date reveals that there still is a significant amount of nutrients entering the lake from the surrounding watershed. The nutrients responsible for excess algae growth appear to be both nitrogen and phosphorus. Watershed sources of nitrogen and phosphorus vary and may come from distant points of the watershed as well as agricultural non-point sources.

These types of nutrients are difficult to mitigate and reduction is an LRR long-term objective. In the interim, restoration and nutrient mitigation efforts will focus on the immediate properties within LRR boundaries.

Despite being a worthwhile long-term objective, source reduction of the external nutrients in the watershed is unlikely to affect desirable short-term changes in the lake, and more active control measures are warranted.

Chemical Control Techniques

Two major types of chemical controls are used to control nuisance algae, and they vary greatly in both their mode of action and in their effectiveness over time. They are algaecides and phosphorus inactivation.

Algaecides

As the name implies, chemical algaecides target algae in the lake. The most common and widely used algaecide is copper, a cellular toxicant that comes in a variety of forms. Copper sulfate ($CuSO_4$) is the most common and basic form and can be used in potable water, though restrictions apply in most states. In alkaline water, hard water, or water having high organic content, copper can be quickly lost from solution. In these cases, liquid chelated form is used to allow the copper to remain in solution long enough to kill the algae.

Throughout 2021 and 2022 a single whole-lake treatment (broken up into 2 treatment events) of the copper-based product VodaGuard C, served the lake community for the summer season. In both 2021 and 2022 there was a slight increase in phytoplankton a couple of months after initial treatment, however the lake still maintained a low cell count (below bloom levels; <100,000 cells/ml).

Although the accumulation of copper in the sediments does not appear to be a significant concern after the initial treatments in LRR, sediment monitoring should be completed periodically to guage the increase over time to avoid negatively affecting aquatic life.

Phosphorus inactivation

Phosphorus inactivation controls algae by limiting phosphorus availability. This is accomplished by using chemicals to precipitate phosphorus from the water column and by adding a binder to the lake to prevent the release of phosphorus from the sediments. The most commonly used chemical for this purpose is aluminum sulfate (or alum). Throughout 2021-2022 SePro corporation's "Phoslock" product has come to the forefront of conversations after numerous sediment tests. Phoslock is comprised of bentonite clay with a small amount of the rate earth metal lanthamum, a material that permanently binds to phosphorus to form an inert mineral. In addition, SePro's subsidiary EutroPhix has also introduced LRR to technologies involving direct injection of phosphorus binding chemicals during major inputs (i.e. rain events), capturing phosphorus in the water column before it enters the lake.

Nutrient inactivation has received increasing attention over the last decade as long-lasting results have been demonstrated in many projects (North American Lake Management Society, 2001). The longevity of alum treatments has been generally excellent where external inputs of phosphorus have been controlled. Suitable candidate lakes for phosphorus inactivation are those with low external nutrient loads and high internal phosphorus release from the sediment. Where significant nutrient inputs from the watershed exist, algal blooms may still result. Over the past couple years of monitoring LRR has observed inputs from both external and internal sources, but mitigating internal nutrient sources are the main focus moving forward. The decision to focus on internal loading was made because some of the highest phosphorus values have been observed in the "bottom" water samples, sediment samples have produced high levels of phosphorus (approximately 2-3x normal eutrophic lake sediment values – SePro pers. communication), and practicality (targeting what LRR can control within their boundaries).

5.0 CONCLUSIONS AND RECOMMENDATIONS

Lake Roaming Rock is an outstanding recreational resource and serves as the centerpiece for the community. It currently provides excellent opportunities for swimming, boating, and fishing.

Despite these positive features, several related water quality problems exist. Owing to the agricultural setting of the community, the lake has historically received a steady influx of nutrients, such as nitrogen and phosphorus, from the watershed. Large amounts of these nutrients—in particular, phosphorus—accumulate in the sediments of Lake Roaming Rock where they are seasonally re-entrained into the water column due to anoxic conditions resulting from stratification of the lake and potentially re-suspended by dredging activities.

Data generated as part of the 2022 study indicate that the lake is improving with the use of algaecide treatments, but still retains it's eutrophic status. Lake Roaming Rock's condition and problems are common to most Ohio lakes and reservoirs, and in fact, many of these lakes experience more severe issues including bans on nearly all forms of recreation due to HABs

Regardless of the progress that may be made with long-term nutrient source reduction in the watershed, the internal phosphorus cycling that occurs in Lake Roaming Rock as a result of anoxic conditions is likely to result in ongoing and worsening nuisance algae blooms for the foreseeable future unless in-lake treatment options are implemented.

The short-term approach of using algaecides may be able to keep nuisance algal blooms in check, for the foreseeable future. Although largely successful, this approach does nothing to remedy the problem of elevated nutrient concentrations from internal and external loading.

More comprehensive approaches that address the nutrients,specifically by inactivating phosphorus in the sediment and water column, will likely be more costly but have the potential to provide long-term improvements to LRR's water. We expect to more fully address the potential and costs associated with these approaches as we progress into 2023.

Next Steps Include:

1. Schedule a community meeting to disseminate information gathered from this study and solicit input from RRA leadership and members regarding their priorities for future action.
2. Recommendations for monitoring and algal control activities for 2023 include continuing limited summer in-lake and stream monitoring efforts to further assess the level of nutrients and algae present and how these relate to the amount and concentration of nutrients entering the lake. Early and late-season monitoring will help confirm the internal phosphorus dynamics of the lake and provide information useful in determining the efficacy of phosphorus inactivation products and techniques.
3. Start applying for grants to help subsidize phosphorus inactivation treatments.
4. Conduct aerial and ground surveillance in the LRR watershed to identify locations where it appears that high concentrations of nutrients are found and collect repeated samples. It is important to locate any obvious nutrient sources within the watershed since it may be possible to use existing regulations and cooperative efforts of the local Soil and Water Conservation District Offices and Ohio EPA to lessen the loading to the lake.

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Appendix A

In Situ Water Chemistry Data

2022 Lake Roaming Rock - In Situ Water Chemistry (Lake)

Dam 06/27/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	25.0	9.2	9.74	118.3	197.60
1	24.8	8.7	8.79	106.3	198.70
2	23.5	8.4	6.84	79.1	199.10
3	20.9	7.9	2.76	30.2	197.60
4	18.5	7.7	0.42	4	194.90
5	14.0	7.5	0.20	2	191.30
6	11.70	7.4	0.17	1.5	189.50
7	10.00	7.4	0.15	1.3	190.40
8	9.50	7.3	0.13	1.1	191.90
9	8.80	7.1	0.11	1	200.80
Average Secchi depth (m): 0.95					

Mid-Lake New 06/27/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	25.1	9.2	9.33	113.2	201.10
1	25.0	9.1	9.06	109.7	201.10
2	24.9	9.0	8.95	107.8	201.00
3	24.3	8.4	6.09	72.2	202.20
4	20.5	7.8	0.44	4.2	207.70
5	14.6	7.4	0.21	2	208.10
Average Secchi depth (m): 0.95					

LRR South 06/27/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	24.6	8.1	6.77	81.4	236.70
1	24.3	8.0	6.45	76.5	245.70
Average Secchi depth (m): 1					

Dam 07/25/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	26.7	8.2	7.80	97.4	214.00
1	26.7	8.1	7.70	96	214.00
2	26.4	7.9	6.00	75	213.90
3	26.1	7.8	5.59	69	215.50
4	21.7	7.5	0.45	4.9	217.00
5	18.4	7.2	0.23	2.4	217.50
6	13.30	7.1	0.18	1.7	209.60
7	11.10	7.1	0.15	1.4	207.30
8	10.20	7.0	0.14	1.2	216.70
9	9.40	7.0	0.10	0.9	223.70
Average Secchi depth (m): 1.35					

Mid-Lake New 07/25/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	26.6	8.0	7.60	94.6	214.20
1	26.5	8.1	7.36	91.6	215.00
2	26.4	8.1	7.31	90.8	214.60
3	26.0	7.9	6.94	87.1	214.50
4	24.7	7.7	1.13	12.6	217.80
5	21.0	7.3	0.36	3.8	235.60
6	14.3	7.2	0.27	2.5	251.20
Average Secchi depth (m): 1.35					

LRR South 07/25/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	26.5	8.0	8.07	100.9	268.20
1	-	-	-	-	-
Average Secchi depth (m): 1.35					

Dam 08/24/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	24.4	7.6	8.26	101.2	194.00
1	24.0	7.6	8.25	101.6	194.00
2	24.3	7.6	8.03	98.1	194.00
3	24.2	7.6	7.95	97.2	194.00
4	24.1	7.6	7.85	95.7	194.00
5	22.6	7.3	2.29	27.6	194.00
6	16.30	7.0	1.50	15.2	205.00
7	12.60	7.0	0.64	5.9	202.00
8	10.70	7.1	0.43	4	206.00
9	10.10	7.0	0.18	1.6	219.00
Average Secchi depth (m): 2.45					

Mid-Lake New 08/24/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	25.4	8.5	10.45	130.5	192.00
1	24.9	8.7	10.35	127.6	193.00
2	24.6	8.7	9.55	117.6	194.00
3	24.6	8.6	9.01	111.9	194.00
4	24.3	8.1	2.35	28.6	198.00
5	20.9	7.4	0.66	7.4	215.00
6	18.1	7.2	0.37	4	236.00
Average Secchi depth (m): 1.2					

LRR South 08/24/22

Depth (m)	Temp (°C)	pH	DO (mg/l)	DO (%)	SPC
0.5	24.2	7.7	8.21	100.6	237.00
1	24.0	7.8	7.97	97.5	242.00
Average Secchi depth (m): 1.75					

2022 Lake Roaming Rock - In Situ Water Chemistry (Streams)

06/27/22 (DRY)						
Stream ID	**Temp ˚C**	**DO %**	**DO mg/L**	**SPC µs/cm**	**pH**	**Discharge m^3/s**
Plum Creek	18	63.3	6.05	431.5	7.98	0.0024
Sugar Creek	22.7	67	5.77	252.6	7.87	0.0003
Fishermans Cove	27.4	131.1	10.38	537	8.27	0.0002
Spanish Cove	18.5	88	8.24	278.1	8.46	0.0013

07/25/22 (WET)						
Stream ID	**Temp ˚C**	**DO %**	**DO mg/L**	**SPC µs/cm**	**pH**	**Discharge m^3/s**
Plum Creek	22.4	22.1	1.94	1107	7.26	0.0264
Sugar Creek	23.6	89.1	7.55	343.1	7.76	0.0225
Fishermans Cove	25	96.5	7.93	400.8	7.77	0.0064
Spanish Cove	22.3	88.6	7.69	419.7	8.05	0.0017

08/24/22 (DRY)						
Stream ID	**Temp ˚C**	**DO %**	**DO mg/L**	**SPC µs/cm**	**pH**	**Discharge m^3/s**
Plum Creek	22.4	105.2	8.89	239	7.93	-
Sugar Creek	20.4	93.5	8.25	200	7.56	-
Fishermans Cove	22.4	99.9	8.44	316	7.73	-
Spanish Cove	19.1	85.8	7.78	346	7.73	-

Appendix B

Biological Data

2022 Lake Roaming Rock - Phytoplankton Results

ProjectID	Lab_ID	Lab2_ID	Date_sampled	BioDataTaxonName	ALGALGROUP	%_community_composition	Natural_Units_per_mL	Cells_per_mL
85	ROSH0011	Mid Lake New	6/27/2022	*Aphanizomenon flos-aquae*	Blue-Green Algae	96.68	43,536	291,910
85	ROSH0011	Mid Lake New	6/27/2022	*Pseudanabaena limnetica*	Blue-Green Algae	1.22	148	3,689
85	ROSH0011	Mid Lake New	6/27/2022	*Aphanocapsa sp.*	Blue-Green Algae	1.22	148	3,689
85	ROSH0011	Mid Lake New	6/27/2022	*Aulacoseira spp.*	Diatom	0.29	885	885
85	ROSH0011	Mid Lake New	6/27/2022	*Centric Diatom spp. Live*	Diatom	0.10	295	295
85	ROSH0011	Mid Lake New	6/27/2022	*Chroococcus spp.*	Blue-Green Algae	0.10	148	295
85	ROSH0011	Mid Lake New	6/27/2022	*Ochromonas spp.*	Yellow-Green Algae	0.10	295	295
85	ROSH0011	Mid Lake New	6/27/2022	*Ceratium hirundinella*	Dinoflagellates	0.05	148	148
85	ROSH0011	Mid Lake New	6/27/2022	*Monoraphidium contortum*	Green Algae	0.05	148	148
85	ROSH0011	Mid Lake New	6/27/2022	*Plagioselmis nannoplanctica*	Cryptophytes	0.05	148	148
85	ROSH0011	Mid Lake New	6/27/2022	*Nitzschia spp.*	Diatom	0.05	148	148
85	ROSH0011	Mid Lake New	6/27/2022	*Fragilaria spp.*	Diatom	0.05	148	148
85	ROSH0011	Mid Lake New	6/27/2022	*Chroomonas sp.*	Yellow-Green Algae	0.05	148	148
85	ROSH0012	Dam	6/27/2022	*Aphanizomenon flos-aquae*	Blue-Green Algae	99.88	22,653	179,750
85	ROSH0012	Dam	6/27/2022	*Fragilaria spp.*	Diatom	0.08	148	148
85	ROSH0012	Dam	6/27/2022	*Ankistrodesmus spiralis*	Green Algae	0.04	74	74
85	ROSH0013	LRR South	6/27/2022	*Aphanizomenon flos-aquae*	Blue-Green Algae	54.52	357	6,687
85	ROSH0013	LRR South	6/27/2022	*Centric Diatom spp. Live*	Diatom	35.38	4,339	4,339
85	ROSH0013	LRR South	6/27/2022	*Monoraphidium contortum*	Green Algae	5.21	639	639
85	ROSH0013	LRR South	6/27/2022	*Chlorella spp.*	Green Algae	1.23	150	150
85	ROSH0013	LRR South	6/27/2022	*Monoraphidium minutum*	Green Algae	0.61	75	75
85	ROSH0013	LRR South	6/27/2022	*Chrysochromulina sp.*	Cryptophyte	0.61	75	75
85	ROSH0013	LRR South	6/27/2022	*Scourfieldia spp.*	Green Algae	0.61	75	75
85	ROSH0013	LRR South	6/27/2022	*Ochromonas spp.*	Yellow-Green Algae	0.46	56	56
85	ROSH0013	LRR South	6/27/2022	*Woronichinia naegeliana*	Blue-Green Algae	0.31	19	38
85	ROSH0013	LRR South	6/27/2022	*Pennate Diatom spp. Live*	Diatom	0.31	38	38
85	ROSH0013	LRR South	6/27/2022	*Nitzschia spp.*	Diatom	0.31	38	38
85	ROSH0013	LRR South	6/27/2022	*Schroederia robusta*	Green Algae	0.31	38	38
85	ROSH0013	LRR South	6/27/2022	*Monoraphidium tortile*	Green Algae	0.15	19	19
85	ROSH0017	LRR South	8/24/2022	*Dolichospermum circinale*	Blue-Green Algae	43.32	58	669
85	ROSH0017	LRR South	8/24/2022	*Dolichospermum planctonicum*	Blue-green Algae	17.65	17	273
85	ROSH0017	LRR South	8/24/2022	*Dolichospermum spp.*	Blue-Green Algae	12.30	74	190
85	ROSH0017	LRR South	8/24/2022	*Aphanizomenon sp.*	Blue-green Algae	11.05	11	171
85	ROSH0017	LRR South	8/24/2022	*Planktolyngbya sp.*	Blue-Green Algae	7.49	3	116
85	ROSH0017	LRR South	8/24/2022	*Centric Diatom spp. Live*	Diatom	3.21	50	50
85	ROSH0017	LRR South	8/24/2022	*Pedinomonas minor*	Green Algae	1.07	17	17
85	ROSH0017	LRR South	8/24/2022	*Pennate Diatom spp. Live*	Diatom	0.71	11	11
85	ROSH0017	LRR South	8/24/2022	*Nitzschia spp.*	Diatom	0.71	11	11
85	ROSH0017	LRR South	8/24/2022	*Scourfieldia spp.*	Green Algae	0.71	11	11
85	ROSH0017	LRR South	8/24/2022	*Ochromonas spp.*	Yellow-Green Algae	0.53	8	8
85	ROSH0017	LRR South	8/24/2022	*Ceratium hirundinella*	Dinoflagellates	0.36	6	6
85	ROSH0017	LRR South	8/24/2022	*Trachelomonas sp.*	Euglenoids	0.36	6	6
85	ROSH0017	LRR South	8/24/2022	*Monoraphidium contortum*	Green Algae	0.18	3	3
85	ROSH0017	LRR South	8/24/2022	*Monoraphidium tortile*	Green Algae	0.18	3	3
85	ROSH0017	LRR South	8/24/2022	*Plagioselmis nannoplanctica*	Cryptophytes	0.18	3	3
85	ROSH0018	Mid Lake New	8/24/2022	*Dolichospermum circinale*	Blue-Green Algae	29.33	401	6,474
85	ROSH0018	Mid Lake New	8/24/2022	*Dolichospermum planctonicum*	Blue-green Algae	26.60	488	5,873
85	ROSH0018	Mid Lake New	8/24/2022	*Aphanizomenon sp.*	Blue-green Algae	13.50	188	2,980
85	ROSH0018	Mid Lake New	8/24/2022	*Aphanocapsa sp.*	Blue-Green Algae	8.96	88	1,978
85	ROSH0018	Mid Lake New	8/24/2022	*Woronichinia naegeliana*	Blue-Green Algae	4.25	13	939
85	ROSH0018	Mid Lake New	8/24/2022	*Ceratium hirundinella*	Dinoflagellates	3.97	877	877
85	ROSH0018	Mid Lake New	8/24/2022	*Aulacoseira spp.*	Diatom	3.86	851	851
85	ROSH0018	Mid Lake New	8/24/2022	*Merismopedia tenuissima*	Blue-Green Algae	3.63	13	801
85	ROSH0018	Mid Lake New	8/24/2022	*Plagioselmis nannoplanctica*	Cryptophytes	2.27	501	501
85	ROSH0018	Mid Lake New	8/24/2022	*Planktothrix agardhii*	Blue-Green Algae	0.96	13	213
85	ROSH0018	Mid Lake New	8/24/2022	*Coelastrum astroideum*	Green Algae	0.68	13	150
85	ROSH0018	Mid Lake New	8/24/2022	*Ochromonas spp.*	Yellow-Green Algae	0.68	150	150
85	ROSH0018	Mid Lake New	8/24/2022	*Pedinomonas minor*	Green Algae	0.51	113	113
85	ROSH0018	Mid Lake New	8/24/2022	*Woronichinia sp. - UNKNOWN*	Blue-Green Algae	0.40	88	88
85	ROSH0018	Mid Lake New	8/24/2022	*Carteria spp.*	Green Algae	0.23	50	50
85	ROSH0018	Mid Lake New	8/24/2022	*Monoraphidium arcuatum*	Green Algae	0.06	13	13
85	ROSH0018	Mid Lake New	8/24/2022	*Nitzschia spp.*	Diatom	0.06	13	13
85	ROSH0018	Mid Lake New	8/24/2022	*Scourfieldia spp.*	Green Algae	0.06	13	13
85	ROSH0019	Dam	8/24/2022	*Dolichospermum planctonicum*	Blue-green Algae	45.21	544	8,830
85	ROSH0019	Dam	8/24/2022	*Aphanocapsa sp.*	Blue-Green Algae	11.10	72	2,168
85	ROSH0019	Dam	8/24/2022	*Aphanizomenon sp.*	Blue-green Algae	10.88	138	2,124
85	ROSH0019	Dam	8/24/2022	*Microcystis spp.*	Blue-Green Algae	7.72	14	1,508
85	ROSH0019	Dam	8/24/2022	*Woronichinia naegeliana*	Blue-Green Algae	7.05	29	1,377
85	ROSH0019	Dam	8/24/2022	*Aulacoseira spp.*	Diatom	4.23	826	826
85	ROSH0019	Dam	8/24/2022	*Dolichospermum circinale*	Blue-Green Algae	3.86	36	754
85	ROSH0019	Dam	8/24/2022	*Dolichospermum spp.*	Blue-Green Algae	3.12	29	609
85	ROSH0019	Dam	8/24/2022	*Sphaerocystis schroeteri*	Green Algae	1.82	29	355
85	ROSH0019	Dam	8/24/2022	*Planktolyngbya sp.*	Blue-Green Algae	1.74	14	341
85	ROSH0019	Dam	8/24/2022	*Woronichinia sp. - UNKNOWN*	Blue-Green Algae	1.60	145	312
85	ROSH0019	Dam	8/24/2022	*Carteria spp.*	Green Algae	0.41	80	80
85	ROSH0019	Dam	8/24/2022	*Pedinomonas minor*	Green Algae	0.33	65	65
85	ROSH0019	Dam	8/24/2022	*Ceratium hirundinella*	Dinoflagellates	0.26	51	51

2022 Lake Roaming Rock - Phytoplankton Results

85	ROSH0019	Dam	8/24/2022	*Coelomoron pusillum*	Blue-Green Algae	0.11	7	22
85	ROSH0019	Dam	8/24/2022	*Oocystis spp.*	Green Algae	0.11	7	22
85	ROSH0019	Dam	8/24/2022	*Scourfieldia spp.*	Green Algae	0.11	22	22
85	ROSH0019	Dam	8/24/2022	*Centric Diatom spp. Live*	Diatom	0.07	14	14
85	ROSH0019	Dam	8/24/2022	*Chlamydomonas spp.*	Green Algae	0.07	14	14
85	ROSH0019	Dam	8/24/2022	*Ochromonas spp.*	Yellow-Green Algae	0.07	14	14
85	ROSH0019	Dam	8/24/2022	*Monoraphidium arcuatum*	Green Algae	0.04	7	7
85	ROSH0019	Dam	8/24/2022	*Plagioselmis nannoplanctica*	Cryptophytes	0.04	7	7
85	ROSH0019	Dam	8/24/2022	*Nitzschia spp.*	Diatom	0.04	7	7

2022 Lake Roaming Rock - Zooplankton Results

ZTS INTERNAL ID	SAMPLE	NOTES	COLLECTION DATE	COLLECTION TIME	SAMPLE VOLUME (mL)	SAMPLE ALIQUOT (mL)	GENUS	SPECIES	GROUP	COUNT
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Keratella	cochlearis	Rotifera	60
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Keratella	crassa	Rotifera	48
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Asplanchna	priodonta	Rotifera	16
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Polyarthra	remata	Rotifera	15
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	nauplii		Copepoda	13
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Polyarthra	euryptera	Rotifera	11
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	calanoid copepodid		Copepoda	10
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Trichocerca	similis	Rotifera	9
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	cyclopoid copepodid		Copepoda	8
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Pompholyx	sulcata	Rotifera	8
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Daphnia	retrocurva	Cladocera	2
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Skistodiaptomus	reighardi	Copepoda	2
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Tropocyclops	prasinus mexicanus	Copepoda	2
ZTS-2022-001	Roaming Shores - DAM	numerous ceratium in sample	8/24/2022	1030	547	4	Trichocerca	pusilla	Rotifera	2
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Polyarthra	euryptera	Rotifera	134
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Keratella	cochlearis	Rotifera	66
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	nauplii		Copepoda	49
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Bosmina	longirostris	Cladocera	36
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Pompholyx	sulcata	Rotifera	21
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Asplanchna	priodonta	Rotifera	17
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Keratella	crassa	Rotifera	13
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	calanoid copepodid		Copepoda	12
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Polyarthra	remata	Rotifera	12
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Trichocerca	multicrinis	Rotifera	8
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Ascomorpha	ecaudis	Rotifera	7
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Diaphanosoma	birgei	Cladocera	3
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Conochiloides	dossuarius	Rotifera	2
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Kellicotia	bostoniensis	Rotifera	2
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Skistodiaptomus	reighardi	Copepoda	1
ZTS-2022-002	Roaming Shores - LRR South		8/24/2022	1145	461	2	Filinia	terminalis	Rotifera	1
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Keratella	crassa	Rotifera	100
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Keratella	cochlearis	Rotifera	83
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	nauplii		Copepoda	48
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Trichocerca	multicrinis	Rotifera	12
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Asplanchna	priodonta	Rotifera	11
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Pompholyx	sulcata	Rotifera	11
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Polyarthra	euryptera	Rotifera	8
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Daphnia	retrocurva	Cladocera	7
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Trichocerca	similis	Rotifera	6
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Polyarthra	remata	Rotifera	5
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	calanoid copepodid		Copepoda	4
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Kellicotia	bostoniensis	Rotifera	3
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	cyclopoid copepodid		Copepoda	2
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Skistodiaptomus	reighardi	Copepoda	1
ZTS-2022-003	Roaming Shores - Mid-Lake	numerous ceratium	8/24/2022	1115	527	2	Euchlanis	meneta	Rotifera	1
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Conochiloides	dossuarius	Rotifera	161
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Polyarthra	euryptera	Rotifera	65
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Keratella	cochlearis	Rotifera	42
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Polyarthra	remata	Rotifera	34
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	nauplii		Copepoda	26
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Keratella	crassa	Rotifera	17
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Collotheca	mutabilis	Rotifera	11
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Trichocerca	multicrinis	Rotifera	8
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Kellicotia	longispina	Rotifera	7
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	cyclopoid copepodid		Copepoda	3
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Daphnia	ambigua	Cladocera	2
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Ostracoda		Ostracoda	2
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Kellicotia	bostoniensis	Rotifera	2
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Trichocerca	similis	Rotifera	2
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Daphnia	retrocurva	Cladocera	1
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Mesocyclops	edax	Copepoda	1
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Skistodiaptomus	reighardi	Copepoda	1
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Tropocyclops	prasinus mexicanus	Copepoda	1
ZTS-2022-004	Roaming Shores - Dam	numerous filamentous algae	6/27/2022		532	4	Filinia	terminalis	Rotifera	1
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Conochiloides	dossuarius	Rotifera	139
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Keratella	cochlearis	Rotifera	71
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Polyarthra	euryptera	Rotifera	26
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Polyarthra	remata	Rotifera	12
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Keratella	crassa	Rotifera	8
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Trichocerca	multicrinis	Rotifera	4
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Collotheca	mutabilis	Rotifera	3
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Pompholyx	sulcata	Rotifera	3
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	calanoid copepodid		Copepoda	2
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	cyclopoid copepodid		Copepoda	2
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Mesocyclops	edax	Copepoda	2
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Trichocerca	similis	Rotifera	2
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Daphnia	retrocurva	Cladocera	1
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	nauplii		Copepoda	1
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Filinia	terminalis	Rotifera	1
ZTS-2022-005	Roaming Shores - Mid Lake New		6/27/2022		464	2	Keratella	earlinae	Rotifera	1
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Polyarthra	euryptera	Rotifera	118
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Keratella	cochlearis	Rotifera	111
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Polyarthra	remata	Rotifera	82
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	nauplii		Copepoda	30
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Keratella	crassa	Rotifera	20
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Conochiloides	dossuarius	Rotifera	7
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Ascomorpha	ecaudis	Rotifera	3
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Keratella	earlinae	Rotifera	3
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Trichocerca	similis	Rotifera	2
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	calanoid copepodid		Copepoda	1
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Mesocyclops	edax	Copepoda	1
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Kellicotia	bostoniensis	Rotifera	1
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Pompholyx	sulcata	Rotifera	1
ZTS-2022-006	Roaming Shores - LRR Sout Outlet		6/27/2022	1004	469	3	Trichocerca	multicrinis	Rotifera	1

Appendix C

Sediment Data

Deep 1 Deep.pdf

Deep 1 Mid.pdf

Deep 1 Surface.pdf

Deep 2 Deep.pdf

Deep 2 Mid.pdf

Deep 2 Surface.pdf

Mid 1 Deep.pdf

Mid 1 Mid.pdf

Mid 1 Surface.pdf

Mid 2 Deep.pdf

Mid 2 Mid.pdf

Mid 2 Surface.pdf

SePRO Research
& Technology Campus

Company Name: **Enviroscience Inc.**
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111

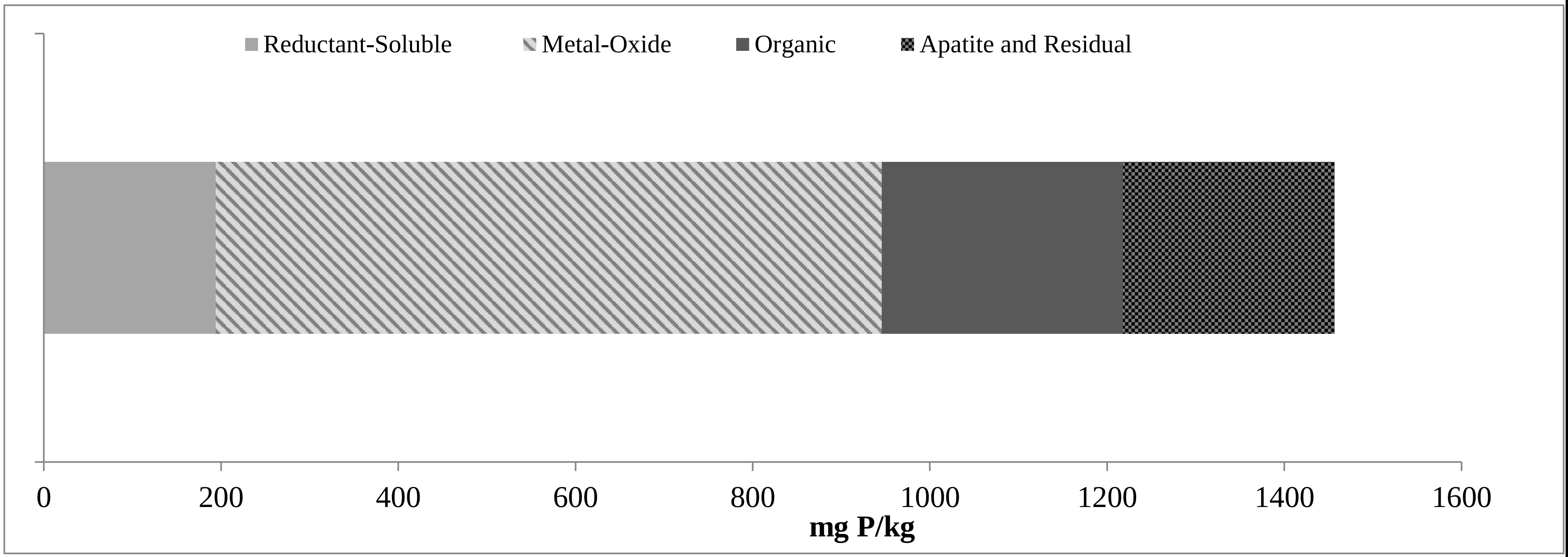
Chain of Custody: COC12244

Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34455-1	*	194	752	272	238

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight



Sample ID: **CTM34455-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance			
Parameter	**Result**	**Units**	**Description**
% Solids	31.0%		Solids content of sediment sample
% Labile Organic Matter	5.57%		Labile organic matter content
% Porosity	60%		Amount of voids within sediment sample
Dry Bulk Density	0.95	g/cm^3	Density of the solids within sediment sample
% Sand	40%		Sand content of sediment sample
% Silt	41%		Silt content of sediment samples
% Clay	18%		Clay content of sediment sample
pH	6.4	SU	pH of sediment sample
Alkaline Cations	3206	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	2705	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	5486	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	28.3		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	18		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.9		Ratio of aluminum to iron in metal-oxide fraction

SePRO Research & Technology Campus

Company Name: **Enviroscience Inc.**
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111

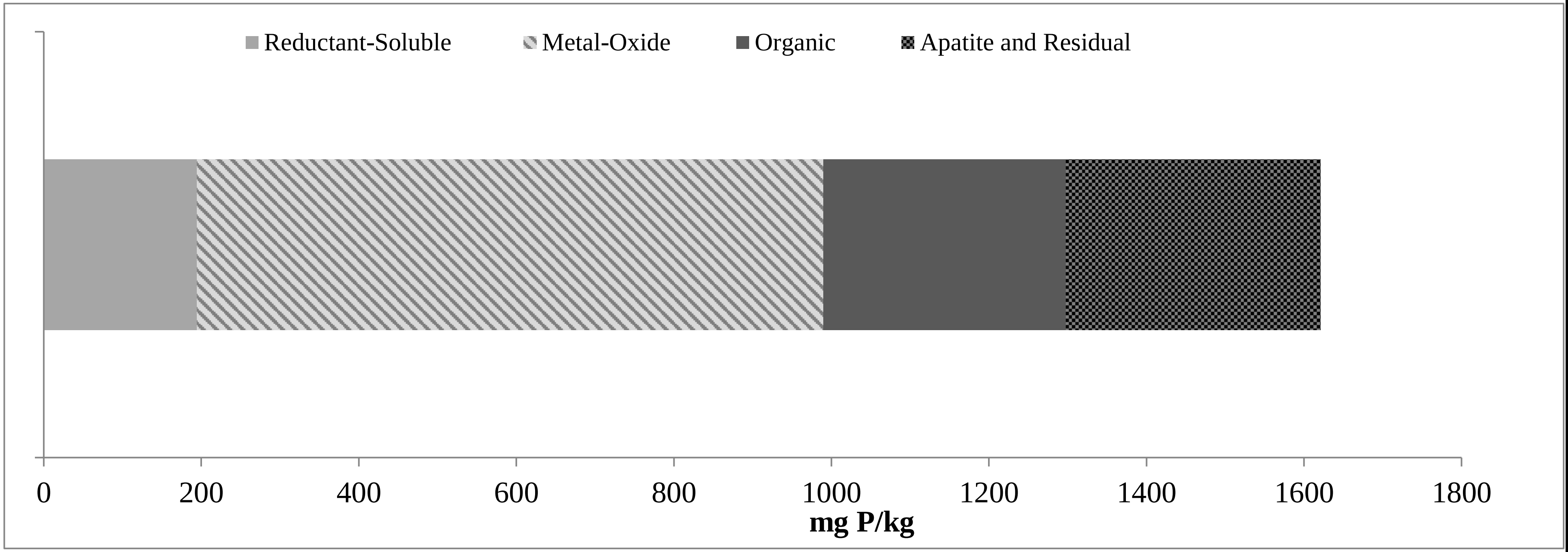
Chain of Custody: COC12244

Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34454-1	*	195	795	308	323

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight



Sample ID: **CTM34454-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance

Parameter	Result	Units	Description
% Solids	30.7%		Solids content of sediment sample
% Labile Organic Matter	5.75%		Labile organic matter content
% Porosity	53%		Amount of voids within sediment sample
Dry Bulk Density	1.01	g/cm^3	Density of the solids within sediment sample
% Sand	45%		Sand content of sediment sample
% Silt	37%		Silt content of sediment samples
% Clay	18%		Clay content of sediment sample
pH	6.3	SU	pH of sediment sample
Alkaline Cations	3487	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	2805	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	7514	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	38.6		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	17		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	2.0		Ratio of aluminum to iron in metal-oxide fraction

SePRO Research & Technology Campus

Company Name: **Enviroscience Inc.**
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Chain of Custody: COC12244

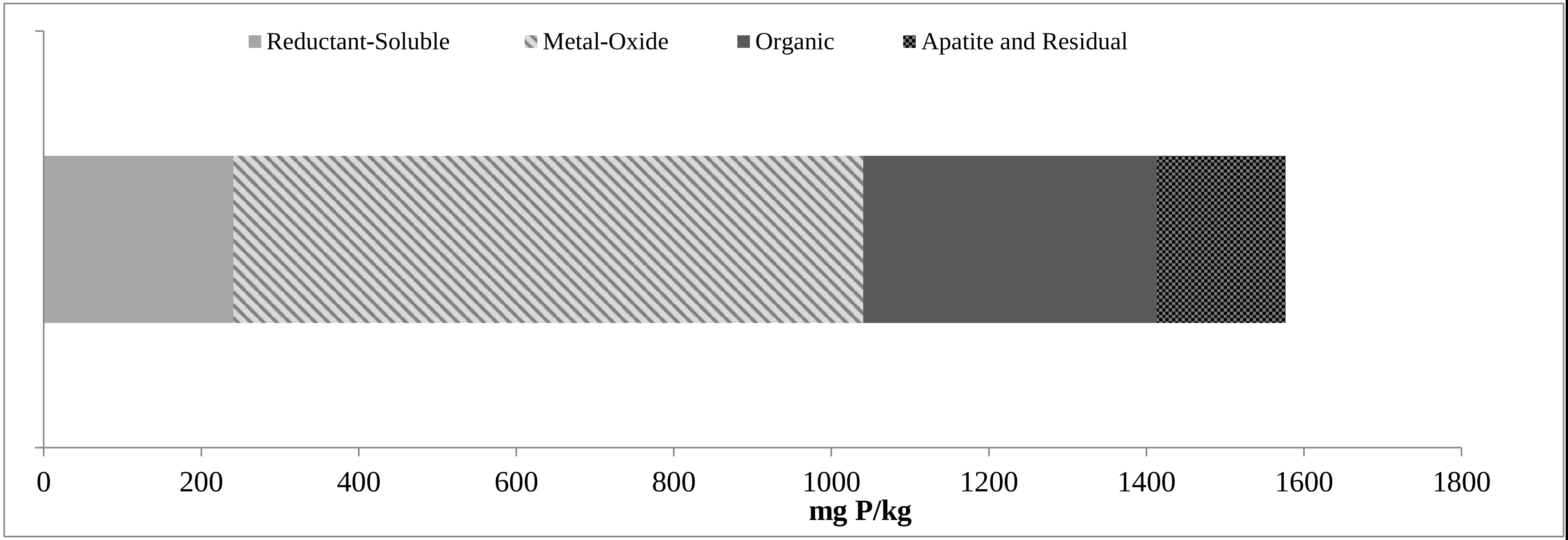
Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34453-1	*	241	800	373	163

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight



Sample ID: **CTM34453-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance

Parameter	Result	Units	Description
% Solids	28.5%		Solids content of sediment sample
% Labile Organic Matter	6.07%		Labile organic matter content
% Porosity	68%		Amount of voids within sediment sample
Dry Bulk Density	1.00	g/cm^3	Density of the solids within sediment sample
% Sand	51%		Sand content of sediment sample
% Silt	36%		Silt content of sediment samples
% Clay	14%		Clay content of sediment sample
pH	6.3	SU	pH of sediment sample
Alkaline Cations	3487	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	2729	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	6470	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	26.8		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	16.7		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.9		Ratio of aluminum to iron in metal-oxide fraction

SePRO Research & Technology Campus

Company Name: Enviroscience Inc.
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Chain of Custody: COC12244

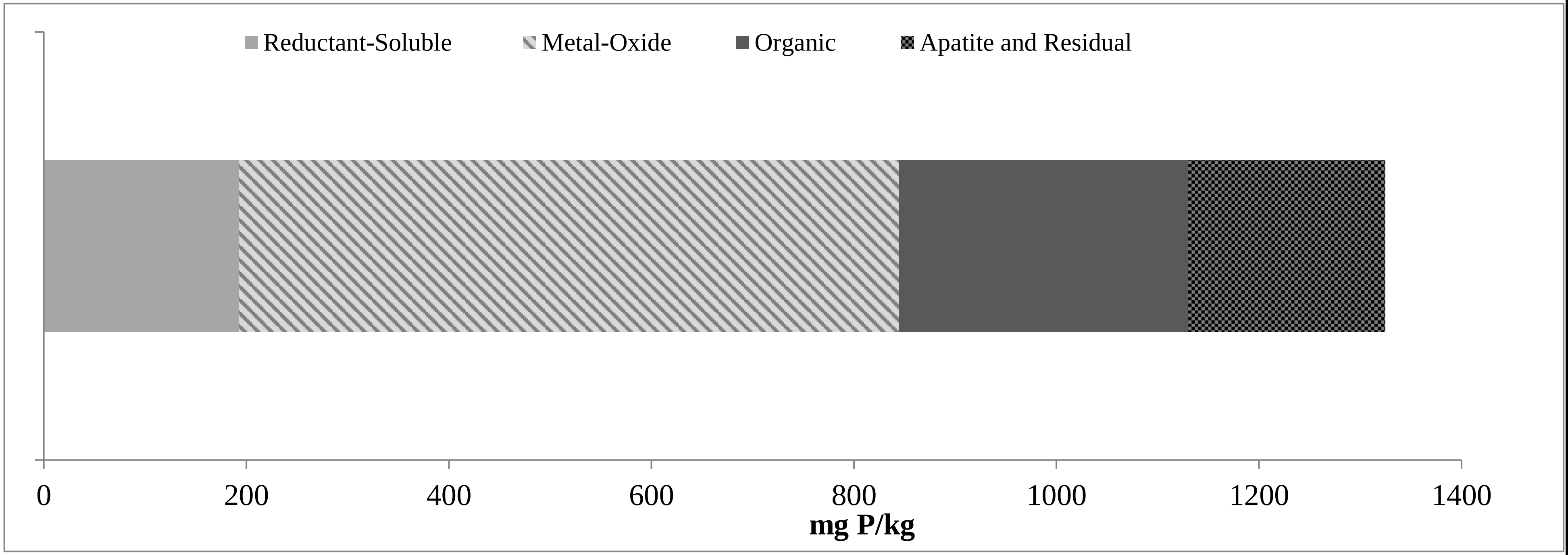
Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34458-1	*	193	651	286	194

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111



Sample ID: **CTM34458-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance

Parameter	Result	Units	Description
% Solids	29.8%		Solids content of sediment sample
% Labile Organic Matter	5.10%		Labile organic matter content
% Porosity	80%		Amount of voids within sediment sample
Dry Bulk Density	0.90	g/cm^3	Density of the solids within sediment sample
% Sand	35%		Sand content of sediment sample
% Silt	44%		Silt content of sediment samples
% Clay	22%		Clay content of sediment sample
pH	6.6	SU	pH of sediment sample
Alkaline Cations	2982	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	2995	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	4019	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	20.8		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	18		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.8		Ratio of aluminum to iron in metal-oxide fraction

SePRO Research & Technology Campus

SRTC

Company Name:	**Enviroscience Inc.**
Billing Address:	5070 Stow Rd.
City, State, Zip:	Stow, OH 44224
Project Name:	N/A
Waterbody Name:	Roaming Rock
Size (ac.):	N/A
Average Water Depth (ft):	N/A
Sample Collection Date:	**4/26/2022**
Contact Person:	Brad Bartelme
Email Address:	bbartelme@enviroscienceinc.com
Telephone:	330-688-0111

Chain of Custody: COC12244

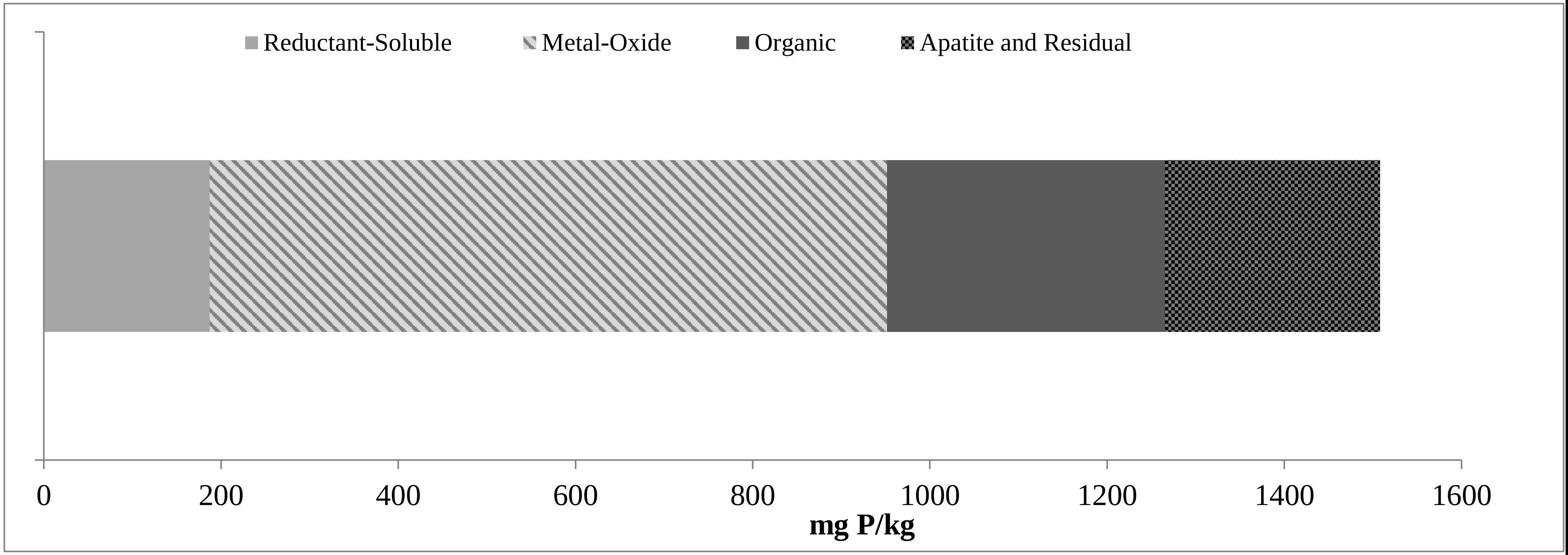
Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34457-1	*	187	765	313	243

*** Concentration was less than reportable limits with 99% confidence**

All concentrations are reported based on dry weight



Sample ID: CTM34457-1

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance			
Parameter	**Result**	**Units**	**Description**
% Solids	28.5%		Solids content of sediment sample
% Labile Organic Matter	5.5%		Labile organic matter content
% Porosity	55%		Amount of voids within sediment sample
Dry Bulk Density	1.01	g/cm^3	Density of the solids within sediment sample
% Sand	57%		Sand content of sediment sample
% Silt	34%		Silt content of sediment samples
% Clay	9%		Clay content of sediment sample
pH	6.4	SU	pH of sediment sample
Alkaline Cations	3215	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	2946	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	5252	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	28.1		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	17		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.9		Ratio of aluminum to iron in metal-oxide fraction

SePRO Research & Technology Campus

Company Name: Enviroscience Inc.
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Chain of Custody: COC12244

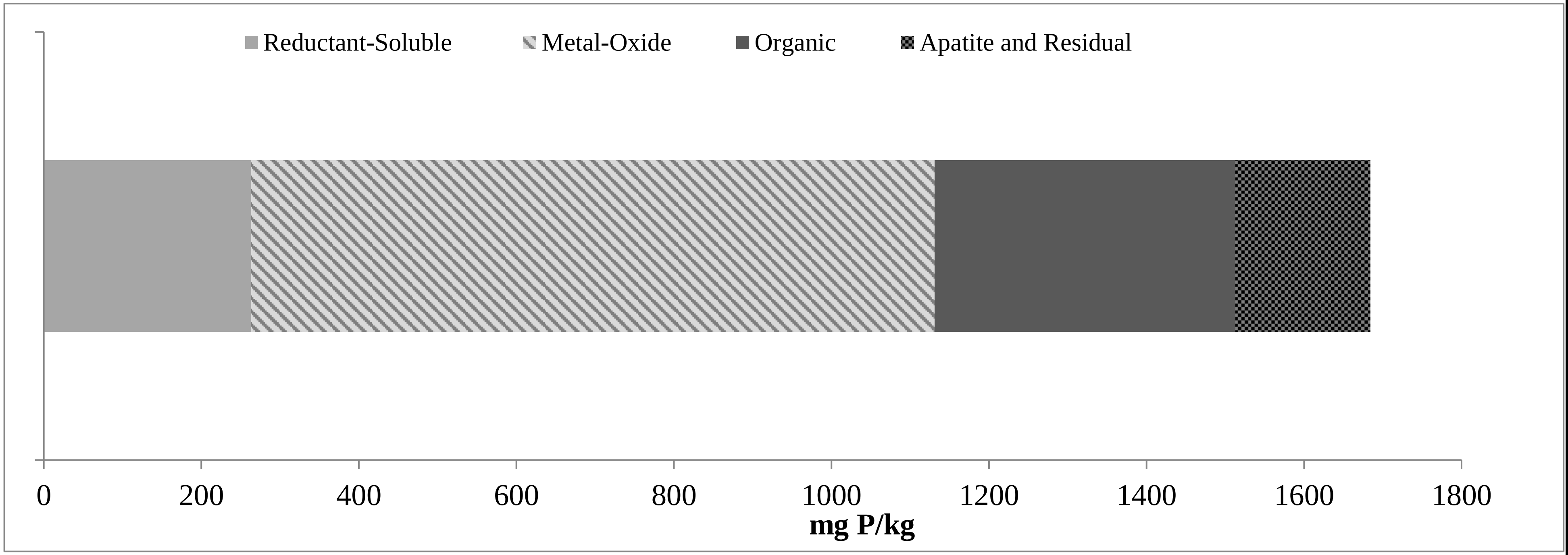
Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34456-1	*	263	868	382	171

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111



Sample ID: **CTM34456-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance			
Parameter	**Result**	**Units**	**Description**
% Solids	26.2%		Solids content of sediment sample
% Labile Organic Matter	6.56%		Labile organic matter content
% Porosity	53%		Amount of voids within sediment sample
Dry Bulk Density	0.97	g/cm^3	Density of the solids within sediment sample
% Sand	51%		Sand content of sediment sample
% Silt	35%		Silt content of sediment samples
% Clay	13%		Clay content of sediment sample
pH	6.4	SU	pH of sediment sample
Alkaline Cations	3604	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	3194	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	5940	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	22.5		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	16		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.9		Ratio of aluminum to iron in metal-oxide fraction

SePRO Research & Technology Campus

Company Name: Enviroscience Inc.
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: 4/26/2022
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111

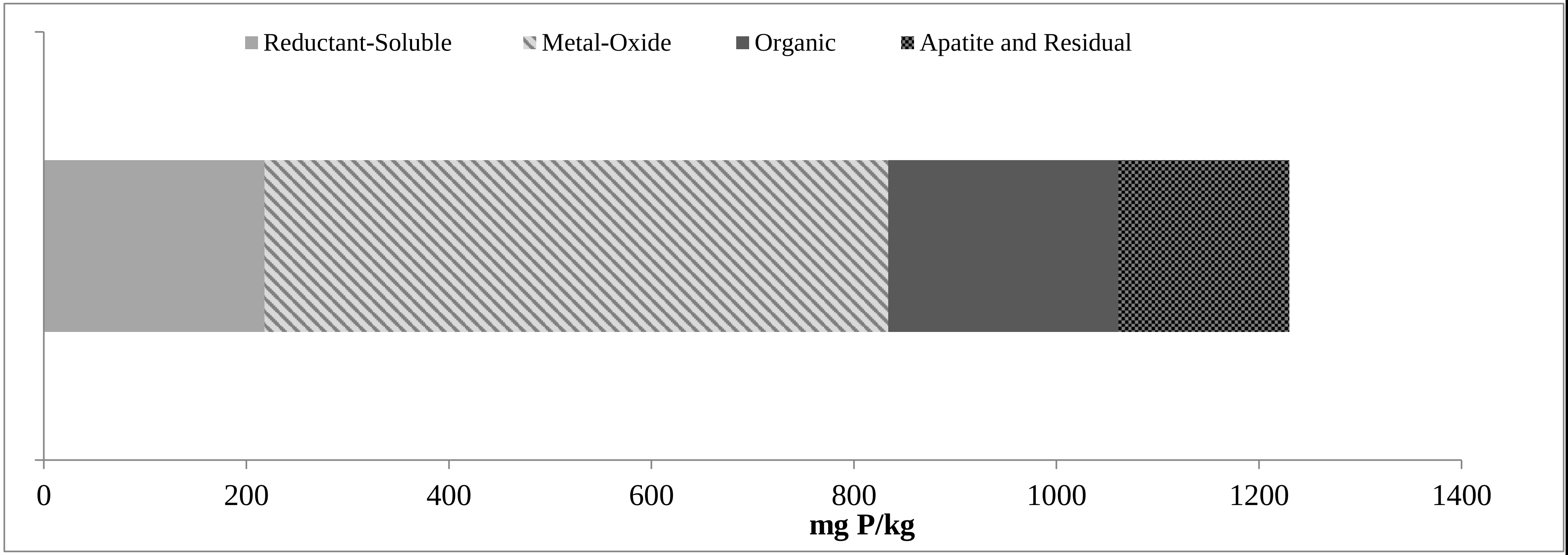
Chain of Custody: COC12244

Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34461-1	*	218	616	227	168

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight



Sample ID: **CTM34461-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance			
Parameter	**Result**	**Units**	**Description**
% Solids	30.9%		Solids content of sediment sample
% Labile Organic Matter	4.6%		Labile organic matter content
% Porosity	60%		Amount of voids within sediment sample
Dry Bulk Density	0.70	g/cm^3	Density of the solids within sediment sample
% Sand	24%		Sand content of sediment sample
% Silt	50%		Silt content of sediment samples
% Clay	26%		Clay content of sediment sample
pH	6.5	SU	pH of sediment sample
Alkaline Cations	2824	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	3564	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	5749	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	26.3		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	18		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.8		Ratio of aluminum to iron in metal-oxide fraction

SePRO Research & Technology Campus

Company Name: **Enviroscience Inc.**
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Chain of Custody: COC12244

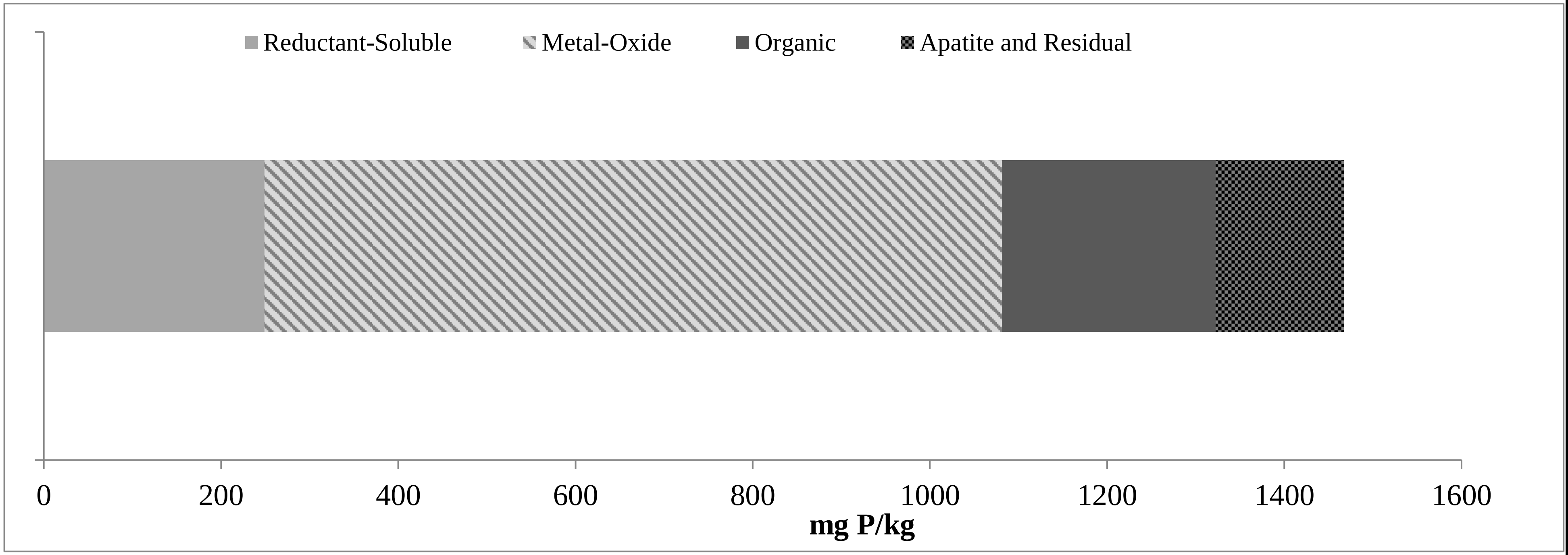
Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34460-1	*	249	832	242	144

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight



Sample ID: CTM34460-1

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance

Parameter	Result	Units	Description
% Solids	29.7%		Solids content of sediment sample
% Labile Organic Matter	5.9%		Labile organic matter content
% Porosity	60%		Amount of voids within sediment sample
Dry Bulk Density	0.69	g/cm^3	Density of the solids within sediment sample
% Sand	26%		Sand content of sediment sample
% Silt	46%		Silt content of sediment samples
% Clay	27%		Clay content of sediment sample
pH	6.3	SU	pH of sediment sample
Alkaline Cations	3111	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	3389	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	6470	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	26.0		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	15		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.9		Ratio of aluminum to iron in metal-oxide fraction

Company Name: **Enviroscience Inc.**
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Chain of Custody: COC12244

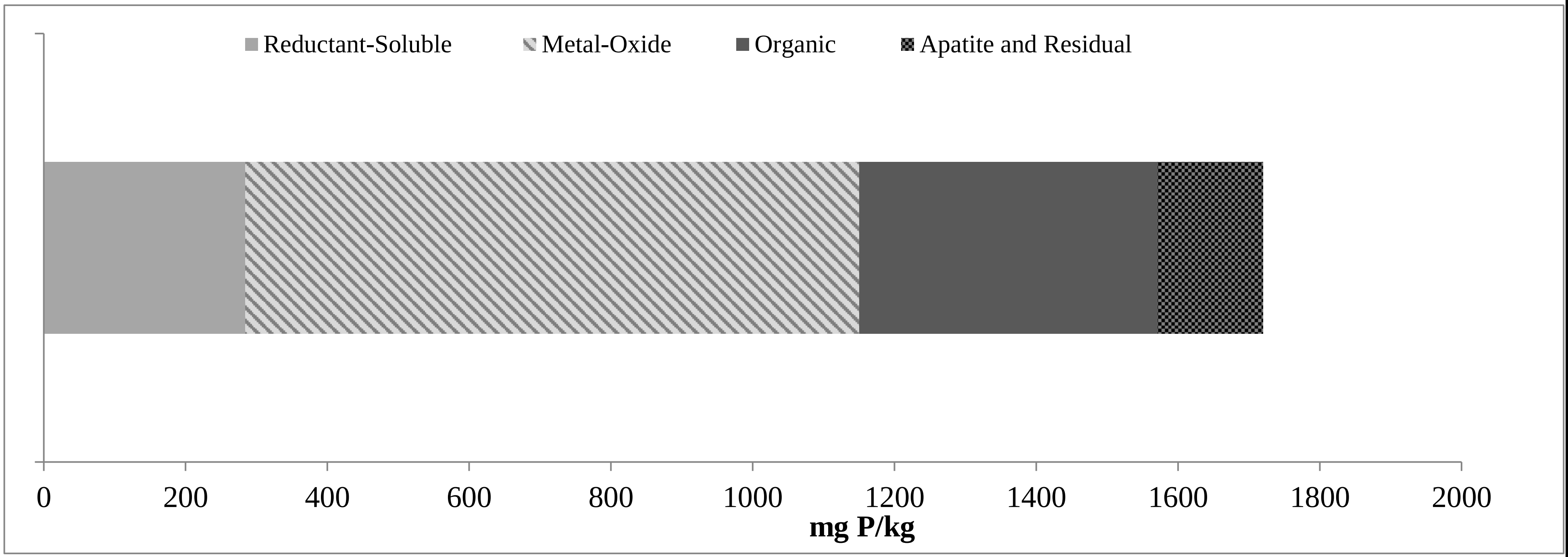
Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34459-1	*	284	866	421	148

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111



Sample ID: **CTM34459-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance

Parameter	Result	Units	Description
% Solids	29.3%		Solids content of sediment sample
% Labile Organic Matter	6.4%		Labile organic matter content
% Porosity	60%		Amount of voids within sediment sample
Dry Bulk Density	0.70	g/cm^3	Density of the solids within sediment sample
% Sand	24%		Sand content of sediment sample
% Silt	46%		Silt content of sediment samples
% Clay	30%		Clay content of sediment sample
pH	6.4	SU	pH of sediment sample
Alkaline Cations	3615	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	3515	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	6972	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	24.5		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	17		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.8		Ratio of aluminum to iron in metal-oxide fraction

Company Name: **Enviroscience Inc.**
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Chain of Custody: COC12244

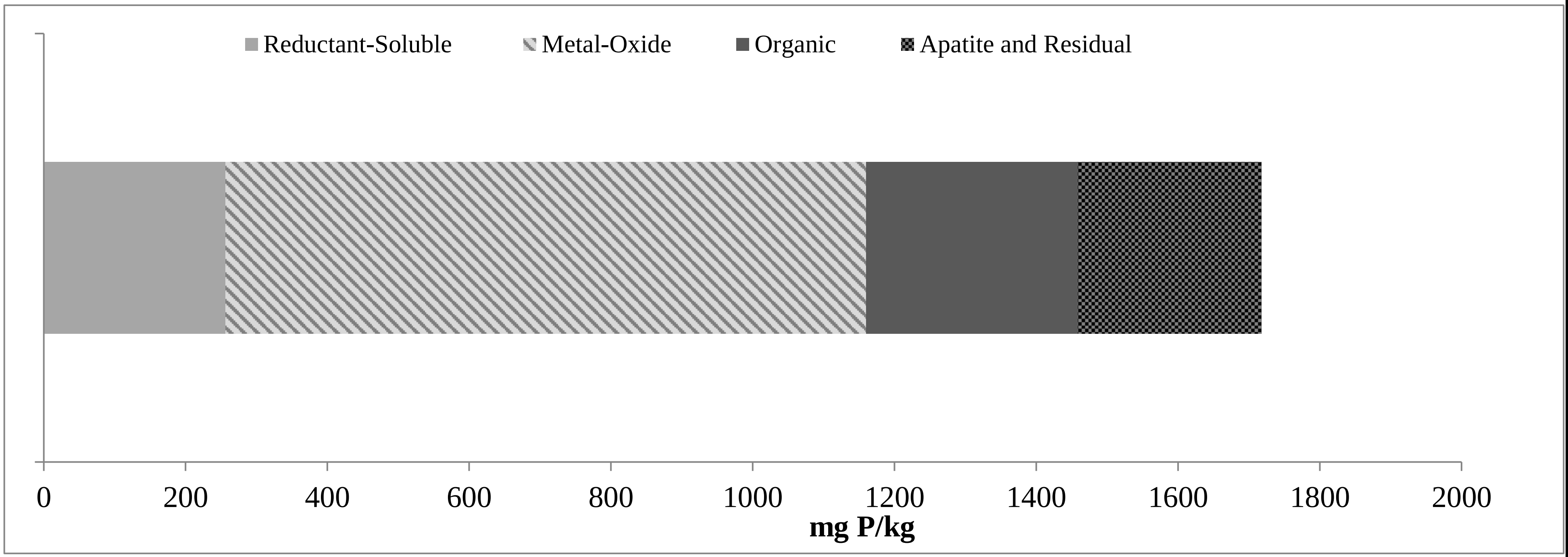
Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34464-1	*	257	904	299	258

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111



Sample ID: **CTM34464-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance			
Parameter	**Result**	**Units**	**Description**
% Solids	28.2%		Solids content of sediment sample
% Labile Organic Matter	6.0%		Labile organic matter content
% Porosity	60%		Amount of voids within sediment sample
Dry Bulk Density	0.71	g/cm^3	Density of the solids within sediment sample
% Sand	34%		Sand content of sediment sample
% Silt	41%		Silt content of sediment samples
% Clay	26%		Clay content of sediment sample
pH	6.5	SU	pH of sediment sample
Alkaline Cations	3299	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	3743	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	5766	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	22.5		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	15		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.8		Ratio of aluminum to iron in metal-oxide fraction

SRTC

SePRO Research & Technology Campus

SePRO

Company Name: Enviroscience Inc.

Billing Address: 5070 Stow Rd.

City, State, Zip: Stow, OH 44224

Project Name: N/A

Chain of Custody: COC12244

Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34463-1	*	266	893	368	237

*** Concentration was less than reportable limits with 99% confidence**

All concentrations are reported based on dry weight

Waterbody Name: Roaming Rock

Size (ac.): N/A

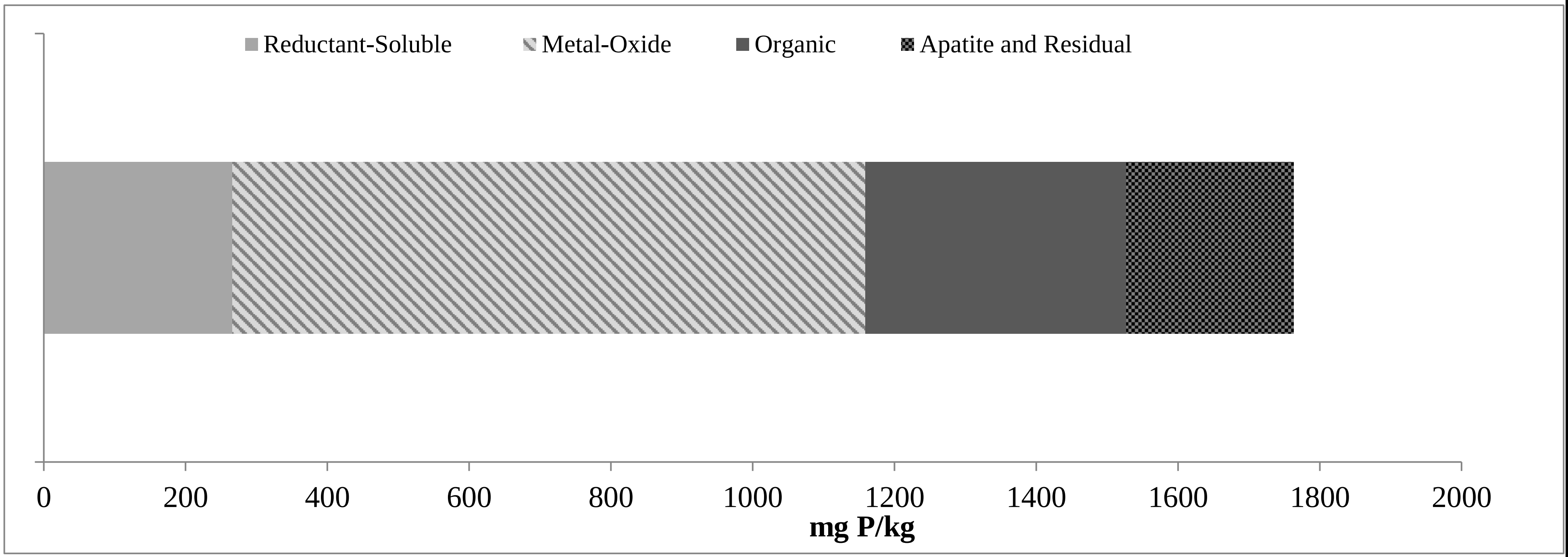
Average Water Depth (ft): N/A

Sample Collection Date: **4/26/2022**

Contact Person: Brad Bartelme

Email Address: bbartelme@enviroscienceinc.com

Telephone: 330-688-0111



Sample ID: **CTM34463-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance

Parameter	Result	Units	Description
% Solids	28.7%		Solids content of sediment sample
% Labile Organic Matter	6.5%		Labile organic matter content
% Porosity	60%		Amount of voids within sediment sample
Dry Bulk Density	0.70	g/cm^3	Density of the solids within sediment sample
% Sand	31%		Sand content of sediment sample
% Silt	41%		Silt content of sediment samples
% Clay	28%		Clay content of sediment sample
pH	6.5	SU	pH of sediment sample
Alkaline Cations	3254	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	3713	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	5314	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	19.9		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	15		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.7		Ratio of aluminum to iron in metal-oxide fraction

SePRO Research & Technology Campus

Company Name: **Enviroscience Inc.**
Billing Address: 5070 Stow Rd.
City, State, Zip: Stow, OH 44224
Project Name: N/A

Chain of Custody: COC12244

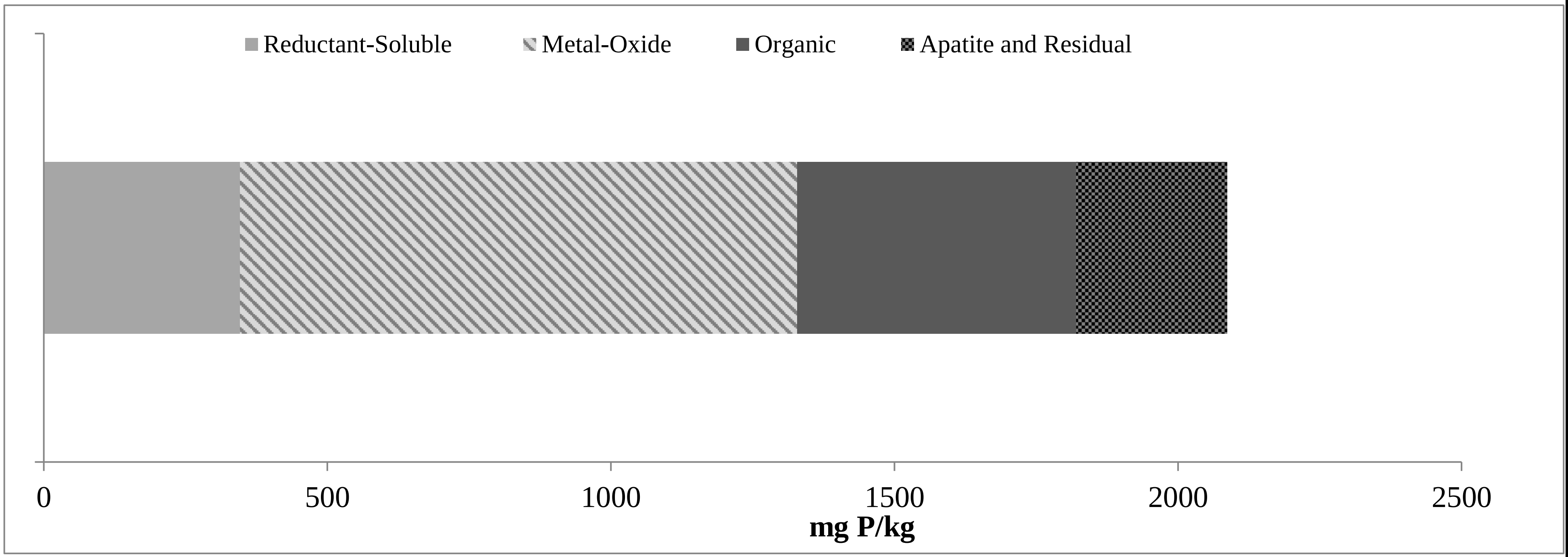
Report Date: 5/13/2022

SeSCRIPT Analysis Performed: SRTC Comprehensive Level 2 **Plus Package**

Waterbody Name: Roaming Rock
Size (ac.): N/A
Average Water Depth (ft): N/A
Sample Collection Date: **4/26/2022**
Contact Person: Brad Bartelme
Email Address: bbartelme@enviroscienceinc.com
Telephone: 330-688-0111

Sample ID	Labile (mg P/kg)	Reductant-Soluble (mg P/kg)	Metal-Oxide (mg P/kg)	Organic (mg P/kg)	Apatite and Residual (mg P/kg)
CTM34462-1	*	346	982	492	266

*** Concentration was less than reportable limits with 99% confidence**
All concentrations are reported based on dry weight



Sample ID: **CTM34462-1**

Plus Package Data - Contact for EutroPHIX Representative for Interpretation and Guidance

Parameter	Result	Units	Description
% Solids	24.6%		Solids content of sediment sample
% Labile Organic Matter	6.5%		Labile organic matter content
% Porosity	60%		Amount of voids within sediment sample
Dry Bulk Density	0.72	g/cm^3	Density of the solids within sediment sample
% Sand	41%		Sand content of sediment sample
% Silt	38%		Silt content of sediment samples
% Clay	21%		Clay content of sediment sample
pH	6.4	SU	pH of sediment sample
Alkaline Cations	3455	mg/kg	Calcium and magneisum cation exchange capcity of sediment
Redox Sensative Cations	3855	mg/kg	Dissolved iron and manganese in sediment porewater
Reducible Iron-oxide/hydroxides	7217	mg/kg	Sediment concentration of redox sensative iron minerals
Reductant Soluble Fe:P Ratio	20.8		Ratio of iron to phosphorus in reductant soluble fraction
Metal-Oxide Al:P Ratio	14		Ratio of aluminum to phosphorus in metal-oxide fraction
Metal-Oxde Al:Fe Ratio	1.8		Ratio of aluminum to iron in metal-oxide fraction