

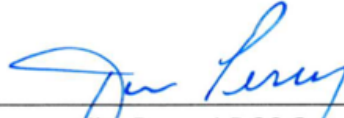
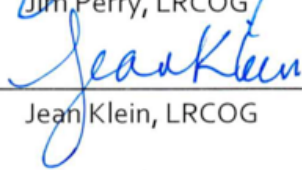
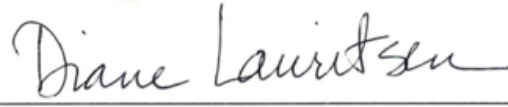
A1 Title and Approval Page

White Lake, NC Monitoring Program QAPP and
Town of White Lake Stormwater Assessments Program QAPP

Lead Agency for Stormwater Assessments 205(j) Grant:
Lumber River Council of Governments (LRCOG)

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June 1, 2019

Project Managers: 205(j) Grant		<u>6/20/19</u>
	Jim Perry, LRCOG	Date
		<u>6/20/19</u>
	Jean Klein, LRCOG	Date
Project Director:		<u>6/28/19</u>
	Diane Lauritsen, LIMNOSCIENCES	Date
Project QA Manager:		<u>6/10/19</u>
	Shannon Brattebo, Tetra Tech	Date

205 (j) Project Officer: _____
Date

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A3 Distribution List

QAPP Recipients:

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Rishi Bastakoti	205 (j) Program Manager, NCDENR Rishi.bastakoti@ncdenr.gov

A4 Project/Task Organization

Project Director: Dr. Diane Lauritsen, LIMNOSCIENCES

Development and coordination of monitoring and special studies for White Lake; maintaining updated QAPP for projects, including 205 (j) funded stormwater assessments; provides communications to decision makers and quarterly reports as required for projects

Project QA Officer: Shannon Brattlebo, P.E., Tetra Tech

Provides QA services for both long-term lake monitoring and 205 (j) funded stormwater project

Project Managers 205 (j) Grant: Jim Perry and Jean Klein, Lumber River COG

Provide management and planning expertise for stormwater project and other projects for the Town of White Lake

LIMNOSCIENCES/Envirochem Analytical Laboratory:

Diane Lauritsen, Field Sampling

IEH Analytical Laboratories:

Dr. Damien Gadowski, Lab Manager

A5 Problem Definition/Background

White Lake is a State-owned, shallow natural lake located in North Carolina's Coastal Plain. It is one of a number of distinctive Bay Lakes found in the region, with an elliptical shape and elevated sand rim. While most of the Bay Lakes are acidic, blackwater systems, White Lake has been very acidic (pH levels 4.2-4.9 SU) but clear, and the water clarity and sandy shoreline have made it a very popular recreational lake for generations of North Carolinians. Within the past decade there has been a decline in the clarity of the water and a dramatic change in pH levels; there are now periods in which the water is not acidic, but basic, as a result of elevated productivity, the very low alkalinity of the water, and a gradual increase in the pH of rainfall (from 4.5-4.6 SU to 5.7-5.8 SU). With the changing of the lake chemistry from acidic to basic, conditions favoring harmful cyanobacteria and the invasive aquatic weed Hydrilla were established.

Special studies conducted by NC DEQ in 2015 and 2017 indicated relatively high benthic productivity (filamentous algae and submerged aquatic vegetation), which could account for much of the pH elevation during the growing season. Vegetation surveys in 2014 and 2017 found most of the lake bottom was covered in each year, with native vegetation only found in 2014 and high coverage of Hydrilla (as well as native species) in 2017.

A cyanobacterial bloom, dominated by the filamentous Planktolyngbya sp., developed in late summer 2017 which greatly affected water clarity, and chlorophyll a levels exceeded the state standard of 40 µg/L for the first time. The bloom persisted into the spring of 2018, and by early May the mean algal biovolume was 151,577 mm³/m³, mean chlorophyll a was 52 µg/L, and the Secchi depth was 0.5 m. As a result, pH levels increased substantially (9.1-9.6 SU) and rapidly throughout the lake.

The Town of White Lake received approval to arrange for and fund an in-lake treatment with alum to flocculate and remove algae and nutrients from the water column, and the treatment was completed by mid-May. The alum treatment gradually and significantly improved water clarity, eliminated the two filamentous cyanobacteria (Aphanizomenon sp. was the second-dominant taxon in early May), reduced pH levels as the algal bloom was mitigated, and reduced levels of the nutrients (nitrogen and phosphorus) that fueled the bloom.

The special study conducted by NC DEQ in 2017 indicated sources of external nutrient loading, via groundwater and surface water (NC DOT drainage ditches), and also suggested that internal loading/recycling was important and that all of these sources needed to be further investigated. As a result, additional special studies were initiated in 2018 and 2019.

External Loading Assessments:

Groundwater: In February, 2018, the Town of White Lake contracted with Bald Head Island Conservancy and UNC-Wilmington researchers to characterize groundwater flows around the lake and determine the significance of nutrient loading based on flow data and a water budget. The project completion date is April 2019.

Surface water/stormwater: In January, 2019, the Lumber River Council of Governments received a 205 (j) grant to conduct stormwater assessments and mapping for the Town of White Lake. That project will be completed by June 2020.

Internal Loading Assessment:

Sediments: In February, 2019, a sediment coring project was initiated to characterize the phosphorus fractions found in sectioned core samples (samples were analyzed by IEH Analytical Laboratories), with a second set of intact sediment cores taken for in-lab phosphorus flux studies (under anoxic conditions). The Town of White Lake funded this project, and the project completion date is June 2019.

Lake Monitoring:

A long-term lake monitoring program has been initiated to supplement the program developed by NC DEQ, in which monitoring is conducted monthly from May-September every five years. The sample stations, which correspond to those used by NC DEQ are indicated in Figure 1. This QAPP is a critical component of the lake monitoring program; the objective is to produce quality data over a longer time frame.

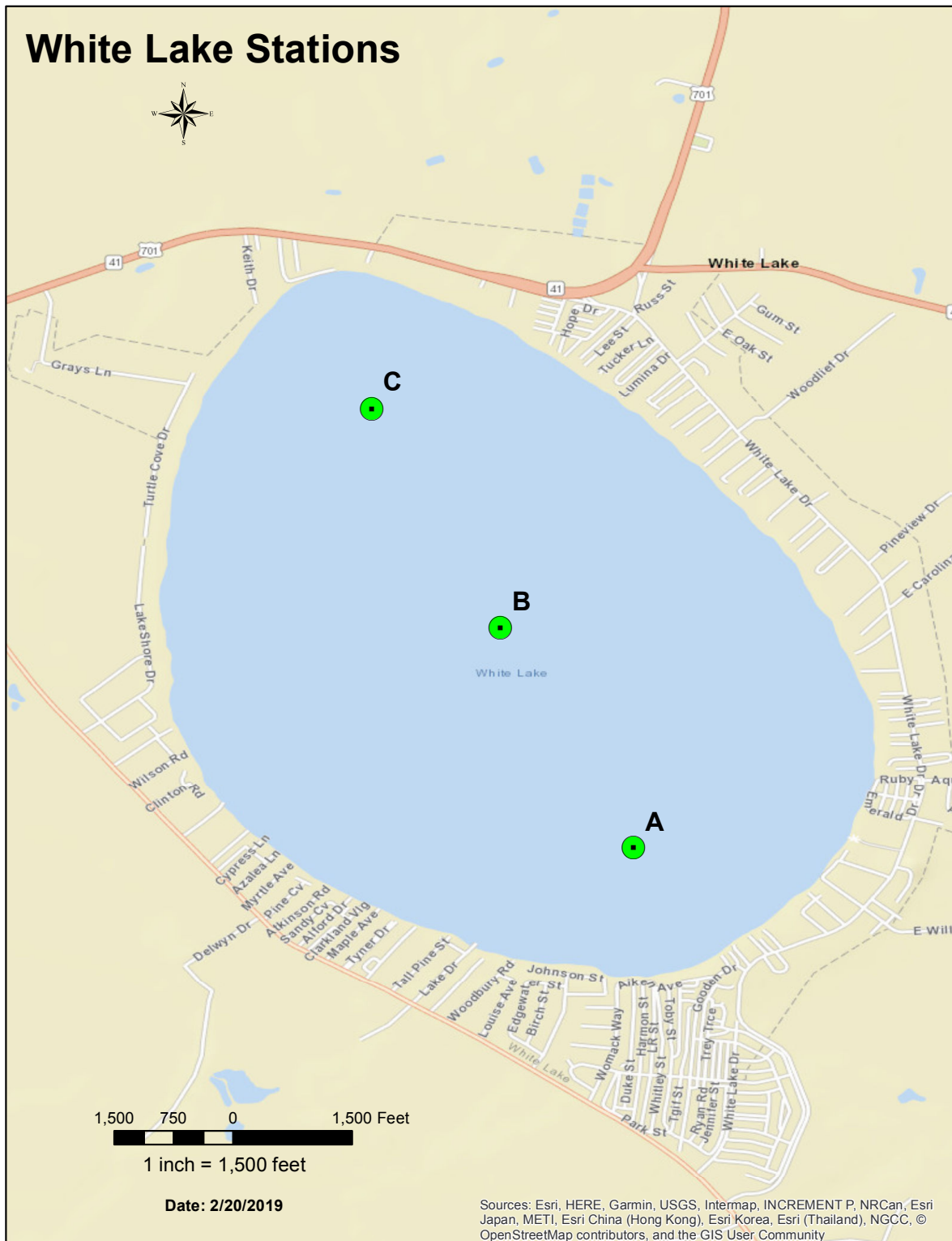


Figure 1. White Lake, Bladen County, NC, with lake monitoring sample stations indicated.

A6 Project/Task Description and Schedule

1. Approval of QAPP: June, 2019
2. **Lake monitoring:** Monthly sampling, April through December
 - a. Physio-chemical parameters: field measurements of Temperature, Dissolved Oxygen (and % saturation), pH and Conductivity. Secchi depth.
 - b. Lab analysis by IEH: Soluble Reactive Phosphorus, Total Phosphorus, Total Nitrogen, Nitrate-Nitrite, Chlorophyll a, phaeophytin. Monthly analytical report and QA packet provided to project director and QA officer.
 - c. Algal abundance and biovolume analysis by Spirogyra Diversified Environmental Services. Monthly report and data spreadsheets provided to project director and QA officer.
 - d. Lake level and precipitation monitoring by Town of White Lake staff, reported monthly in spreadsheet to project director.
 - e. Fecal coliform/other bacterial monitoring May-August by Bladen County Health Department. Monthly report provided to Town of White Lake, project director and State Park Superintendent.
 - f. Quarterly reports on lake monitoring provided to Town of White Lake, NC State Parks, NC DWR by project director.
3. **Stormwater Assessments 205 (j) Grant Project:** Project initiation: April, 2019
 - a. Geolocation and size/drainage area assessments for outfalls and drainage ditches.
 - b. Review and mapping of geolocation data. Identification of sites for water quality sampling. Parameters of primary interest: nutrients.
 - c. Initiate stormwater water quality sampling. Sampling events will be rainfall-dependent.
 - i. Physio-chemical parameters: field measurements of Temperature, Dissolved Oxygen (and % saturation), pH, Conductivity.
 - ii. Lab analysis by IEH: NO₃-NO₂, Total Nitrogen, TKN, Soluble Reactive Phosphorus.
 - iii. Additional parameters for specific conditions will be considered.
4. Completion of stormwater assessments (weather dependent): December 2019
5. Quarterly reports on stormwater assessments and education project: March 2019 until project final report submitted.
6. Stormwater Assessments and Education 205 (j) Final Report submission: June 2020

A7 Quality Objectives and Criteria for Measurement Data

Lake monitoring: parameters selected are comparable to those monitored routinely by NC DEQ and were also used in 2018 monitoring for the alum treatment project. The 2018 samples analyzed by Envirochem (NC state-certified lab) did not meet the performance and measurement criteria for phosphorus (both total and dissolved) that are needed for a long-term monitoring program, and upon recommendation by the QA officer, IEH Analytical Laboratories (WA state-certified lab) will be used for nutrient and chlorophyll testing beginning in 2019. IEH is the laboratory that has conducted the sediment phosphorus analysis for the White Lake special study.

LIMNOSCIENCES Field Parameters:

Temperature, pH, Conductivity, Dissolved Oxygen (and % saturation) measured with YSI Pro DSS field meter/probes, all parameters calibrated prior to each sampling event.

IEH Lab:

<u>Test</u>	<u>Method</u>	<u>Detection Limit</u>
SRP	SM18 4500PF	0.001 mg/L
Total P	SM18 4500PF	0.002 mg/L
NO ₃ +NO ₂	SM18 4500N03F	0.010 mg/L
Ammonia	SM20 4500NH ₃ H	0.010 mg/L
Total N	SM20 4500NC	0.050 mg/L
DOC	EPA 415.1	0.250 mg/L
Turbidity	SM20 2130B	0.10 mg/L
Chlorophyll <u>a</u>	SM18 10200H	0.1 µg/L
Phaeophytin	SM18 10200H	0.1 µg/L

Stormwater Assessments 205 (j) Grant Project: as nutrients, particularly phosphorus is a primary parameter of interest, IEH will also be used for analyzing stormwater samples. Other parameters may be analyzed based on the outcome of the field assessments.

<u>Test</u>	<u>Method</u>	<u>Detection Limit</u>
Total N	SM20 4500NC	0.050 mg/L
NO ₃ -NO ₂	SM18 4500N03F	0.010 mg/L
TKN	SM20 4500NC	0.050 mg/L
SRP	SM18 4500PF	0.001 mg/L
Fecal Coliform	SM189222D	1/100 mls

A9 Documentation and Records

Lake monitoring: Hard copy and electronic records, including field logs, chain of custody forms, QC reports and analytical results will be maintained by the project director for use in future by any parties that would have an interest in them, but the specifics for storage and accessibility have not yet been determined.

Stormwater Assessments 205 (j) Grant Project: Hard copy and electronic records, including field logs, chain of custody forms, QC reports and analytical results will be maintained by the project director. Results of assessments will be used by a Stormwater Working Group during the project as well as in the development of BMPs where situations warrant (providing initial pre-implementation data).

B1 Sample Process/ Experimental Design

Lake monitoring: lake sampling locations (Figure 1) correspond to the locations used by NC DEQ for ambient lake monitoring:

<u>DEQ Station</u>	<u>White Lake Station</u>	<u>Latitude</u>	<u>Longitude</u>
CPF 155A	A	34.635840	-78.493380
CPF 155B	B	34.643460	-78.497990
CPF 155C	C	34.651020	-78.502440

Stormwater Assessments 205 (j) Grant Project: NC DOT drainage ditches will be sampled during rainfall events, as previous sampling (2017 and 2018) indicated elevated nutrient levels. Other ditches and outfalls will be geolocated in the initial phase of this project, and sampling needs will be based on field assessments.

B2-B3 Sampling Methods, Handling and Custody

Lake Monitoring: grab samples for nutrients and chlorophyll a/phaeophytin will be taken at two depths (0.5 m and 2.0 m) at each station using a horizontal Van Dorn Bottle. Sample bottles will be provided by the analytical laboratory for the specific analysis/parameter, and all samples will be kept on ice during transport/shipment to the lab. Chain of custody forms provided by the lab will be completed by the field sampler and cross-checked with sample bottle labels. Hold times: 48 hours from time of collection for nutrients and 24 hrs for chlorophyll a. All samples will be shipped to the analytical lab in coolers that contain ice or ice packs and the chain of custody forms. Samples shipped to IEH will be express-shipped overnight to arrive by 10 am

Lake Monitoring (continued):

the next morning. Grab samples for algal enumeration/biovolume will be taken at 0.5 m depths and preserved with Lugol's solution. Preserved samples and a chain of custody form will be shipped to Spirogyra Diversified Environmental Services.

Field Measurements: Depth profiles will be taken at each station using a YSI Pro DSS field meter for temperature, pH, conductivity, DO (and % saturation); Secchi depth will also be determined at each station. A Turner handheld fluorometer will also be used to measure chlorophyll a. Data is entered into field logs and chain of custody forms. Meter calibrations will be done prior to each sampling event and a field calibration log will be kept. Standard calibration solutions will be used and hold times for opened bottles of calibration solution will be recorded on the bottle labels and in the calibration log.

Stormwater Assessments 205 (j) Grant Project: grab samples for nutrients will be taken with a replicate sample bottle from which the site sample can be poured into labeled sample bottles. Sample labels will include date and location/site information corresponding to field data sheets and chain of custody forms. Hold times: maximum 48 hrs. including shipping time. All samples will be express shipped (overnight) to the analytical lab in coolers that contain ice packs and the chain of custody forms.

A YSI Pro DSS field meter will be used for temperature, pH, conductivity, DO (and % saturation) readings for each site sampled, and data will be entered into a field log and chain of custody form for each sample date. Calibrations will be done prior to each sampling event and a field calibration log will be kept. Standard calibration solutions will be used and hold times for opened bottles of calibration solution will be recorded on the bottle labels and in the calibration log.

B4 Analytical Methods Requirements

<u>Test</u>	<u>Method</u>	<u>Detection Limits</u>
SRP	SM18 4500PF	0.001 mg/L
Total P	SM18 4500PF	0.002 mg/L
NO3+NO2	SM18 4500N03F	0.010 mg/L
TKN	SM20 4500NC	0.050 mg/L
Total N	SM20 4500NC	0.050 mg/L
Chlorophyll <u>a</u>	SM18 10200H	0.1 µg/L
Phaeophytin	SM18 10200H	0.1 µg/L
Fecal Coliform	SM189222D	#/100mls

Algal Identification, Enumeration and Biovolume Determination: Samples are examined (without concentration, unless algal densities are low) with an Accuscope inverted microscope equipped with a calibrated Whipple reticule. Prior to quantitative examination, non-concentrated samples are gently mixed by inversion 100 times; concentrated samples are taken from the bottom layer in undisturbed sample bottles in which the contents have been allowed to settle out to the bottom of the bottle. An aliquot of sample is withdrawn via pipet (from the center of the bottle for samples that have been mixed and from the bottom of the bottle if samples are un-mixed) and placed into a Sedgewick-Rafter counting cell for microscopic examination. Enumerations are performed according to the Sedgewick-Rafter strip counting method (APHA et al., 2012). Specific strips along the prepared slide are chosen randomly for counting at a total magnification of 400 (10X ocular, 40X objective). Counts are made of individual cells and of natural units in the case of colonies or filaments. An organism is counted only if it is determined to be viable at the time of preservation. Lugol's preservative maintains the integrity of cellular structures and pigmentation as they were at the moment of sample collection. Counting is continued until at least 100 units of the dominant taxon are counted (Lund et al., 1958). Data is entered directly into a Microsoft Excel spreadsheet. Numerical densities are determined by converting raw counts to numbers of units or cells per milliliter using the following formula:

$$\text{No. cells/ml} = C \times 1000 \text{ mm}^3/\text{L} \times D \times W \times S \times N$$

Where: C = number of cells or natural units counted

L = length of each strip = 50 mm

D = depth of a strip = 1 mm

W = width of a strip (image field width) = 0.5 mm (20X) or 0.2 mm (40X)

S = number of strips counted

N = concentration factor

Confidence intervals are calculated for all unit counts. Species identifications are made using standard taxonomic references, including Komarek and Anagnostidis (2005) and Komarek et al., (2014).

Size measurements are made of cells from up to 10 individuals of each taxon for each sampling period for calculation of biovolume (APHA et al., 2012). Biovolume calculations are made for each algal taxon by using solid geometric formulas appropriate for each taxon (Hillebrand et al., 1999). Appendix 2 contains references for taxonomy and methods.

B5-B7 Quality Control Requirements

Records for Instrument/Equipment Testing, Inspection, Maintenance Requirements and Instrument Calibration and Frequency are maintained by IEH Analytical Laboratory, Seattle, WA.

A calibration log for field equipment (field meters) is reviewed by the project QA Officer and maintained by the project director. Calibrations for Dissolved Oxygen % Saturation, Conductivity and pH are made before every sampling event, using standard calibration solutions purchased from YSI (the instrument manufacturer).

Conductivity

1,000 μ Siemens/cm calibration solution

pH

pH 4, 7, 10 buffer solutions for 3-point calibration

Appendix 1. Example QA/QC Data Report from IEH Analytical Laboratories



IEH ANALYTICAL LABORATORIES
LABORATORY & CONSULTING SERVICES
3927 AURORA AVENUE NORTH, SEATTLE, WA 98103
PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	TWL001-02	PAGE 2
REPORT DATE:	05/31/19	
DATE SAMPLED:	05/23/19	DATE RECEIVED: 05/24/19
FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER		
SAMPLES FROM TOWN OF WHITE LAKE		

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	N03+N02 (mg/L)	TOTAL-N (mg/L)	CHLOR_a (ug/L)	PHAE0_a (ug/L)	FECAL COLIFORM (#/100mls)
METHOD	SM18 4500PF	SM18 4500PF	SM184500N03F	SM204500NC	SM1810200H	SM1810200H	SM189222D
DATE ANALYZED	05/28/19	05/24/19	05/24/19	05/29/19	05/29/19	05/29/19	05/24/19
DETECTION LIMIT	0.002	0.001	0.010	0.050	0.1	0.1	1
DUPLICATE							
SAMPLE ID	WL-C-2	WL-C-2	WL-C-2	WL-C-2	BATCH	BATCH	
ORIGINAL	0.014	<0.001	<0.010	0.352	3.2	1.1	
DUPLICATE	0.014	<0.001	<0.010	0.347	3.2	0.9	
RPD	6.06%	NC	NC	1.68%	0.00%	18.67%	NA
SPIKE SAMPLE							
SAMPLE ID	WL-C-2	WL-C-2	WL-C-2	WL-C-2			
ORIGINAL	0.014	<0.001	<0.010	0.352			
SPIKED SAMPLE	0.064	0.021	0.182	1.45			
SPIKE ADDED	0.050	0.020	0.200	1.00			
% RECOVERY	99.55%	105.00%	91.00%	109.59%	NA	NA	NA
QC CHECK							
FOUND	0.091	0.039	0.418	0.487			121
TRUE	0.094	0.039	0.408	0.490			110 - 132
% RECOVERY	96.81%	100.00%	102.45%	99.39%	NA	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.050	NA	NA	<1

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski, PhD
Laboratory Manager

Appendix 2.

References for Algal Enumeration, Biovolume Determinations and Taxonomy

- American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF). 2012. Standard Methods for the Examination of Water and Wastewater. E.W. Rice, R.B. Baird, A.D. Eaton, and L.S. Clesceri, (eds.). 22nd Edition, Washington, D.C.: APHA.
- Dvorak, P, A. Poulickova, P. Hasler, M. Belli, D. Casamatta, and A. Papini. 2014. Species concepts and speciation factors in cyanobacteria, with connection to the problems of diversity and classification. *Biodivers Conserv.* (2015) 24:739-757, DOI 10.1007/s10531-015-0888-6
<https://link.springer.com/content/pdf/10.1007%2Fs10531-015-0888-6.pdf> 7/15/18.
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- Jancusova, M., L. Kovacik, A. B. Pereira, R. Dusinsky, and A. Wilmotte. 2016. Polyphasic characterization of 10 selected ecologically relevant filamentous cyanobacterial strains from the South Shetland Islands, Maritime Antarctica, FEMS Microbiology Ecology, Vol. 92, Issue 7,1 July 2016, fiw100. <https://doi.org/10.1-93/femssec/fiw100> 7/15/18
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- Komarek, J., J. Kastovsky, J. Marek, & J. Johansen. 2014. Taxonomic classification of cyanoprokaryotes (cyanobacterial genera) 2014, using a polyphasic approach. *Preslia* 86:295-335, 2014.
- Lund, J.W.G., Kipling, C. and LeCren, E.D. 1958. The inverted microscope method of estimating algal numbers and the statistical basis of estimates by counting. *Hydrobiologia* 11:143-170.
- Wehr, J.D., and R.G. Sheath (eds). 2003. Freshwater Algae of North America. Academic Press, New York. 918 p.

Addendum 1.

B2-B3 Sampling Methods, Handling and Custody

Rainfall Sampling: a shallow glass pan will be triple rinsed with deionized water prior to deployment. Upon collection, a portion of rainwater will be poured into a labeled sample bottle and sent to IEH labs for analysis of NO₃-NO₂, ammonia, total nitrogen, and soluble reactive phosphorus. Rainfall pH will be measured with a YSI Pro DSS meter that has been calibrated prior to measurement.

Using Test Kits and Field Meters: Rainfall amounts are collected Monday-Friday at the White Lake WWTP. A HOBO data logging rain gauge has been installed at Town Hall for continuous recording of rainfall, along with a temperature pendant for continuous measurement of air temperature. A HOBO water level logger has been installed for continuous measurement of lake levels, and the lake gauge at the Turtle Cove outlet will be maintained for confirmation of lake elevations. HOBO temperature pendants have been deployed at several locations in White Lake for continuous measurement of water temperatures.

A more rapid measurement of rainfall nutrients and pH will be done periodically by trained volunteers. The training includes verification of the accuracy of the meters and keeping accurate records and calibration logs. The following meters will be used:

HORIBA LAQUAtwin-22 compact pH meter, with an accuracy of ± 0.01 pH units. The meter will be calibrated with pH 4 and pH 7 buffer solutions prior to use, and the sample chamber will be rinsed with deionized water prior to placing the sample in it.

HANNA Instruments HI736 Checker HC Handheld Colorimeter Marine Phosphorus ULR (accuracy ppb). The meter will be calibrated with HI764-11 ultra-low range phosphorus standard kit, and the cuvette will be rinsed with deionized water prior to putting the sample in it. The outside of the cuvette will be cleaned with a cleaning cloth/tissue prior to insertion in the meter.

HANNA Instruments HI764 Checker HC Handheld Colorimeter Marine Nitrite ULR (accuracy ppb). The meter will be calibrated with HI764-11 ultra-low range nitrite standard kit, and the cuvette will be rinsed with deionized water prior to putting the sample in it. The outside of the cuvette will be cleaned with a cleaning cloth/tissue prior to insertion in the meter.

In addition to sampling rainfall, nearshore lake water samples may be collected after rainfall events and analyzed using the meters described above.

All data will be reviewed by the project manager and then compiled and uploaded to the White Lake Watch web site on a regular basis.