Harmful Algal Bloom Abatement in Lake Munson

Intact Cellular Algae Harvesting with Nutrient Removal

Introduction

Harmful Algal Blooms (HABs) are caused by nutrient pollution of water bodies and cost an estimated $1 billion each year in economic damages and losses in the United States alone. The U.S. Environmental Protection Agency (USEPA) has noted that this is "One of America's most widespread, costly and challenging environmental problems."

HABs containing cyanobacteria (HCBs) can produce toxins that threaten our drinking water supplies and pose serious health risks to humans, livestock, and pets. The most sustainable way to control HCBs is by reducing the supply of nutrients, but this approach can take decades to be effective. Immediate action is needed to address the serious human, animal, and ecological health concerns caused by HCBs.

AECOM has led in extensive HAB research and is now complementing that work with mitigation efforts with a focus on full lake and ecological restoration using a hybrid form of dissolved air flotation (DAF) technology to allow algae cells to be removed as intact cells thus preventing the rupture of the cell walls and release of intracellular materials (e.g. nutrients such as phosphorus and nitrogen) and cyanotoxins into the receiving waterbody. For example, in July and October 2019, respectively, AECOM's algae harvesting technology was proven effective in separating and physically removing intact algae cells from the water column of Lake Okeechobee (S-77 lock and spillway, Moore Haven, Florida) and Lake Agawam (Town of Southampton, New York) and offered an effective and environmental-friendly solution to address HABs. The treatment exceeded project expectations (the Lake Munson treatment design incorporates improvements over the Lake Agawam and Lake Okeechobee systems) with average removal efficiencies of:

- Chlorophyll a >99%
- Total Microcystin and Nodularin >90%
- Total Phosphorus >90%
- Total Nitrogen >80%

Advanced oxidation treatment of the treated effluent removed microcystin concentrations to levels below laboratory reporting limits, such that water returned to the C-43 Canal (Caloosahatchee River at S-77 control structure) and Lake Agawam met Federal and State drinking water guidelines for this toxin.

Background

Historically, Lake Munson was a cypress swamp that has since been impounded and now functions as a shallow man-made lake. The lake is an approximately 255-acre, nitrogen-limited lake located south of the City of Tallahassee. It receives most of its water from the heavily altered Munson Slough and its tributaries. Lake Munson has a history of severe water quality and ecological problems, including fish kills, toxic cyanobacterial harmful algal blooms, exotic vegetation and snails, high nutrient and bacteria levels, low game fish productivity, sediment contamination, and depressed oxygen levels. Nutrient pollution can quickly amplify algal productivity resulting in widespread HAB events given the right environmental conditions for temperature, nutrient levels, sunlight, and other factors. Cyanobacteria, a.k.a. blue-green algae, can produce a bloom with associated cyanotoxins such as microcystins that can adversely affect human health as well as domestic animals (commonly dogs) and wildlife.

Figure 1. Lake Munson, experiencing blue-green algae bloom conditions

Project Description

Algae and associated nutrients will be removed from Lake Munson through a through an innovative technology called a Hypernucleation Flotation System (HFS), an advanced form of dissolved air flotation (DAF). The HFS algae harvesting system takes advantage of the inherent characteristic of algae to float. Algae-laden water withdrawn from the source waterbody is conditioned by adding a small amount of commonly used potable water treatment amendment(s), which coagulate (clump) the algae into larger particles to create a "floc" as the water flows through a series of treatment and mixing tanks. Microscopic air bubbles (nano-bubbles) generated by the DAF process attach to algae floc, which imparts buoyancy. The algae floc then floats to the surface of the water in a flotation tank, where it forms a dense "skimmate" layer (the float blanket). The skimmate layer is efficiently separated from the water by a skimmer that moves across the top of the flotation tank to a slurry holding tank.

The project plan provides for a 700 gallon per minute (gpm) HFS algae harvesting system to be operated for approximately 10 months on property owned by Leon County at the Gil Waters Lake Munson Preserve, 5800 Crawfordville Road (Figure 2). The treatment system will be established on the west side of the control structure of Lake Munson. A schematic generalized conceptual site layout is depicted in Figure 3. The extracted algae slurry will be discharged to the City of Tallahassee's wastewater treatment plant. The

Northwest Florida Water Management District and its contractor, AECOM, will work closely with Leon County, the City of Tallahassee, and the State of Florida to obtain all necessary permits and coordinate facility layout and operations.

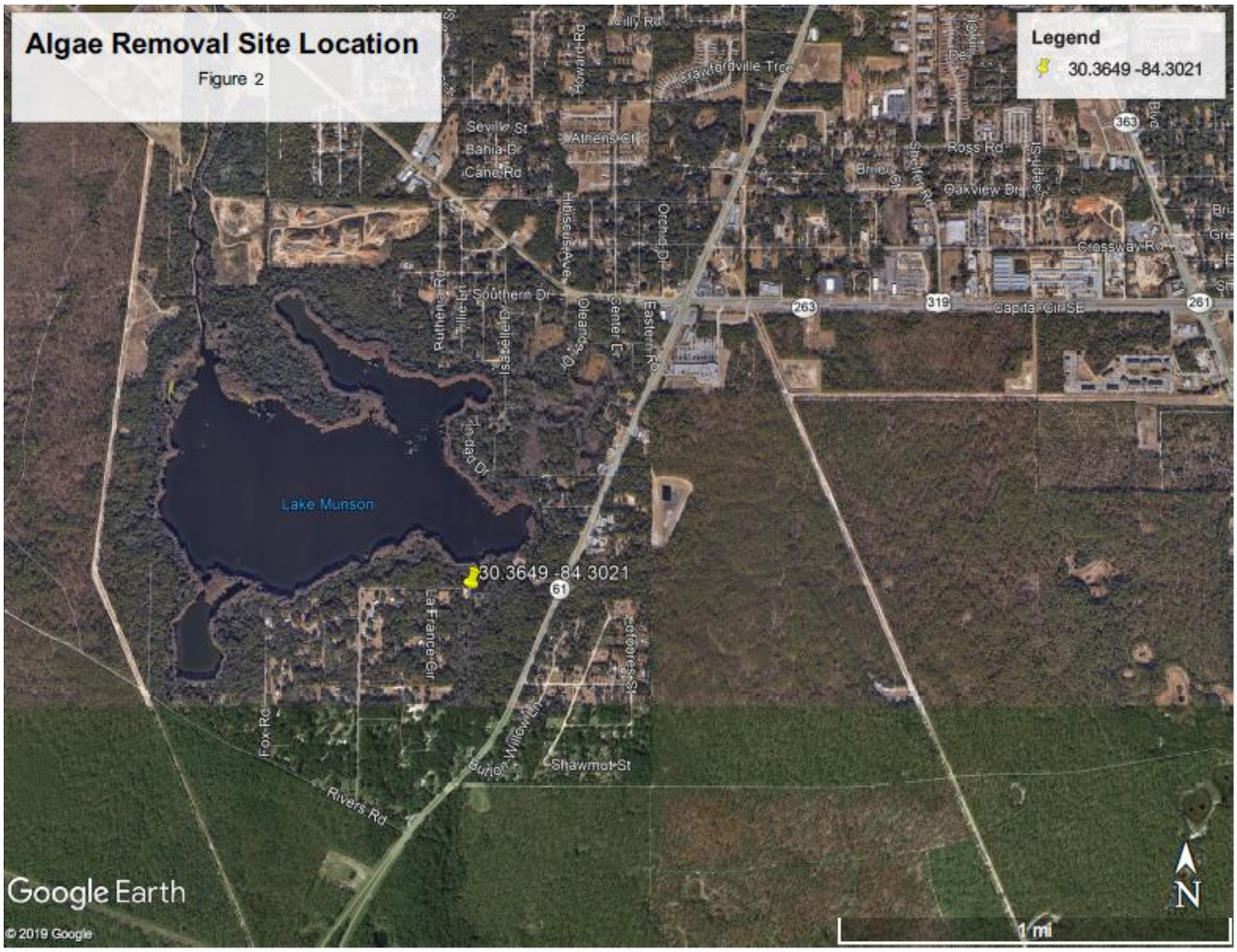

Figure 2. Project Site and Vicinity

Figure 3. Conceptual Site Layout. Final site layout will be in conformance with to-be-issued Leon County Temporary Uses, Construction Staging Areas and Special Events Permit.

Removing intact cellular algae using the algae harvesting and HAB mitigation system will improve water quality by:

- Removing nutrients;
- Reducing chlorophyll-*a* and turbidity associated with planktonic algae, as well as and other suspended solids;
- Returning clarified, highly oxygenated water back to the Lake Munson ecosystem; and
- Removing algal biomass that contributes to oxygen demand and thus the release of legacy nutrients from sediments.

Clarified water will be returned to Lake Munson where it then will continue its natural flow path down Munson Slough to Ames Sink. Water quality improvements achieved through this project will contribute to the wider set of projects and water quality improvements being implemented within the Lake Munson basin and Wakulla Spring contribution area. Additionally, data collected and lessons learned through this project will help demonstrate the applicability of this technology to remove nuisance algae as well as excess nutrients from impaired waterways helping those waterbodies achieve compliance with Total Maximum Daily Load limits established by FDEP.

This project is funded by an innovative technology grant awarded by Florida's Blue-Green Algae Task Force.

Project Components

1. Water Quality Monitoring and Quality Assurance

A water quality monitoring plan and Quality Assurance Project Plan will be developed in cooperation with the Florida Department of Environmental Protection (DEP), Leon County, and the City of Tallahassee. The monitoring will be designed to characterize surface water conditions, meet permit requirements, and obtain data required to calculate percent removal efficiency for select parameters (e.g. TN, TP and chlorophyll-a).

Sampling will be conducted in accordance with the Florida Department of Environmental Protection Standard Operating Procedure FS1000 – General Sampling Procedures and Standard Operating Procedure FS2000 – General Aqueous Sampling. Laboratory-issued, labeled sample containers will be used. Samples that require field-filtering will be collected in clean containers, filtered using a 0.45-micron filter (unless otherwise specified), with the filtrate transferred to the laboratory-issued container. Samples will be placed on wet ice in coolers for shipment to a National Environmental Laboratory Accreditation Program (NELAP) accredited contract analytical laboratory using chain-of-custody protocol. Water samples for laboratory analyses typically include but are not limited to the following:

Table 1: Typical Laboratory Parameters and Analytical Methods

Parameter	Processing	Method	Laboratory
Alkalinity, Total	Unfiltered	SM 2320B	(TBD)
Aluminum	Unfiltered Field Filtered	200.7 Rev 4.4	
Haloacetic Acids 5, Total	Unfiltered	US EPA 552.2	
Iron	Unfiltered Field Filtered	US EPA 200.7 Rev 4.4	
Nitrogen, Ammonia	Unfiltered	US EPA 350.1	
Nitrogen, Nitrate + Nitrite	Unfiltered Field Filtered	US EPA 353.2	
Nitrogen, Total Kjeldahl	Unfiltered Field Filtered	US EPA 351.2	
Nitrogen, Total	Unfiltered Field Filtered	US EPA 350.1+353.2	corrected chl a and pheophytin a
Phosphorus, Ortho-	Unfiltered	SM 4500 P E	
Phosphorus, Total	Unfiltered Field Filtered	SM 4500 P E	and Secchi at WSB
Suspended Solids, Total	Unfiltered	SM 2540D	
Trihalomethanes, Total	Unfiltered	US EPA 524.2	
Chlorophyll *a*		10200H	(TBD)
Total Microcystins and Nodularins		US EPA 546 (ELISA)	GreenWater Laboratories,
Potentially Toxigenic (PTOX) Cyanobacteria Screen		Note - 1	GreenWater Laboratories

Notes: 1. GreenWater Laboratory Standard Operating Procedure. One ml aliquots of sample are prepared using Sedgewick Rafter cells and scanned at 100X for the presence of potentially toxigenic (PTOX) cyanobacteria using a Nikon Eclipse TE200 Inverted Microscope equipped with phase contrast optics. Higher magnification is used as needed.
US EPA = US Environmental Protection Agency; SM = Standard Methods for the Examination of Water and Wastewater; ELISA = Enzyme-Linked ImmunoSorbent Assay.

The final set of parameters, methods, and sampling periodicities will be developed in consultation with Leon County, the City of Tallahassee, DEP, and basin stakeholders.

2. Design and Permitting

AECOM will complete the design and permitting of the DAF algae harvesting system, in coordination with Leon County, the City of Tallahassee, and DEP.

3. Site Preparation, Installation and System Start-up

Site preparation, equipment mobilization and on-site staging, and system startup and "shakedown" of the algae harvesting system will be conducted in accordance with the final design(s) and required permits. This will include the following activities:

- Establishment of temporary, portable generator electric supply
- Site preparation (grading and concrete pad) for DAF harvester
- Staging and connection of all equipment with associated piping and electric power supply
- Installation of security fence around treatment area
- Deployment of "V-boom" and weir-skimmer with associated influent and treated water return piping
- Bench-testing of chemical treatment regimes
- System start-up and process control testing/monitoring

During the shakedown period key harvester operating conditions that will be adjusted or purposely varied to optimize the system include:

- Influent Flow Rate
- Bench testing of lake water to calibrate treatment systems
- Conditioning Tank Mixer Speed
- Recycle Flow Rate
- Process Air Flow Rate Skimming Cycle
- Interceptor weir-skimmer in-lake location and orientation

4. Site Operation, Maintenance and Monitoring:

The DAF algae harvester system will be operated for approximately 10-months. The DAF algae harvester will be operated at various times during each month to evaluate the nutrient removal efficiency under varying conditions, power demands and the characteristics and consistency of the recovered biomass.

5. Decommissioning and Site Restoration

After completion of the operational and monitoring phase, the Contractor will complete the decommissioning and site restoration activities. The DAF algae harvester treatment system will be deconstructed and transported off-site in accordance with required permits, as applicable. The security fence will be removed and the electrical power serving the site will be discontinued. The landscape will be returned to its pre-testing conditions, as much as is practical. A Site Close-out Inspection will be conducted with staff from Leon County and NWFWMD to confirm that all equipment has been removed from the site and the site conditions have been returned, as closely as practical, to pre-study conditions.

6. Final Report

The Contractor will prepare a Final Report summarizing the results of the project, including all tasks in the Project Work Plan. The Final Report must include at a minimum:

Schedule

Project Component	Planned Start Date	Planned End Date
Development of Monitoring and Quality Assurance Project Plan	07/01/2019	08/01/2020
Design and Permitting	07/01/2019	10/01/2020
Site Preparation, Installation and System Start-up	07/01/2019	11/01/2020
Site Operation, Maintenance and Monitoring	07/01/2019	10/01/2021
Decommissioning/Site Restoration	07/01/2019	11/01/2021
Reporting	07/01/2019	12/01/2021