SŌLITUDE
LAKE MANAGEMENT

Lake Thunderbird HOA

Water Quality Analysis
Management Recommendations

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Introduction and Background

Lake Thunderbird is a private reservoir managed by the local homeowners association. The lake is located in Smithville, Texas and is an aesthetic asset to the club used by members for fishing and recreational activities. SOLitude Lake Management was contracted to collect and review the water quality within the 22-acre lake. This report provides an analysis of the water quality and algae composition at the time of the sample. Aquatic vegetation species were visually observed and noted during the collection. The following discussion includes survey findings, analysis and level of significance, and lake management recommendations.

Methods:

On September 01, 2020, a Solitude Lake Management biologist collected water samples from two different locations to test the water quality and identify the level of algae, fecal coliform, and E. coli (*Escherichia* coli) present in the water (Site 1 and Site 2). The two water samples were analyzed in a laboratory for 12 parameters pertinent to lake management. Dissolved oxygen and temperature profiles and Secchi depths were measured at three sampling sites shown on the map below (Represented by DO). This data will be used to develop solutions that will improve water quality, develop fish habitat, and provide long-term beneficial results.

Image 1. Sampling site locations in Thunderbird Lake
Algae and water quality samples were collected from Site #1 and Site #2
(DO stands for dissolved oxygen)

Water Quality Analysis

PHYSICAL PARAMETERS

The physical parameters were tested *in situ* (within the waterbody).

Dissolved Oxygen – Dissolved oxygen (DO) is the amount of oxygen gas dissolved in the water column. Small amounts of oxygen enter the water column by direct diffusion at the air/water interface. However, the primary source of oxygen in a lake or pond is production during photosynthesis by aquatic plants and algae. Lakes and ponds impacted by heavy sediment loads may experience low DO levels since the increased turbidity (cloudiness) caused by suspended clay and soil particles can restrict light penetration and limit photosynthesis. The breakdown of organic matter (i.e., aquatic plants, leaf litter, manure, fish waste) also consumes large amounts of oxygen from the water column. Fish require oxygen for respiration, and become stressed at levels less than 5 mg/L. Colder water is physically able to hold a greater concentration of oxygen then warmer water, and waterbodies may become naturally stressed with low dissolved oxygen levels during the warmer months.

<2 mg/L likely toxicity with sufficient exposure duration; <5 stressful to many aquatic organisms; ≥5 able to support most fish and invertebrates

Temperature – Water temperature affects the dissolved oxygen concentration of the water, the rate of photosynthesis by aquatic plants, the metabolic rates of aquatic organisms, and the sensitivity of organisms to toxic wastes, parasites, and diseases. All aquatic organisms are dependent on certain temperature ranges for optimal health. If temperatures are outside of this optimal range for a prolonged period of time, the organisms become stressed and can die. Water temperature generally increases with high suspended sediment readings because the particles absorb heat, which reduces dissolved oxygen levels. Since warmer water is able to hold less oxygen than colder water, lakes and ponds may become naturally stressed with low dissolved oxygen levels during the warmer months.

Secchi Depth – The Secchi depth of a waterbody is a measure of turbidity (or lack or water clarity). Turbidity does not measure the amount of materials suspended in the water column (such as algae, soil, and plankton), but does measure the amount of light scattered by these particles. Turbid waters appear murky or cloudy, and exhibit reduced photosynthesis due to limited light penetration into the water column. In some cases (i.e., in lakes and ponds where a productive fishery is the primary goal), turbid water from heavy phytoplankton growth may be considered a desirable condition. The shading and reduction in photosynthesis caused by phytoplankton growth may also inhibit the growth of invasive aquatic plants and undesirable algal species in some circumstances.

CHEMICAL PARAMETERS

A water sample was collected and sent to the laboratory for analysis of the chemical parameters.

Nutrients – Nutrients are essential for plant growth, but periodic over enrichment can lead to the excess growth of algae and aquatic plants, and can alter the composition and species diversity of

the aquatic community. Nitrogen and phosphorus are the elements most likely to control plant growth, although phosphorus is generally the limiting nutrient in fresh water bodies.

Phosphorus – Phosphorus can be found in several forms in freshwater, but the biologically available form for nuisance plant growth is soluble, inorganic orthophosphate. Organic phosphates quickly bind to soil particles and plant roots, and consequently, much of the phosphorus in aquatic systems is bound and moves through the system as sediment particles. This organic form of phosphorus is considered to be biologically unavailable. However, under anoxic (zero oxygen) conditions, bound phosphorus can be released from bottom sediments, and the concentration of biologically available orthophosphate can increase dramatically.

The erosion of soil particles from steep slopes, disturbed ground, and streambeds is the primary source of phosphorus in aquatic systems. Surface runoff containing orthophosphates from fertilizers and decaying organic matter will also contribute to biologically available phosphorus enrichment.

> **Total Phosphorus (TP)** is the measure of all phosphorus in a sample as measured by persulfate digestion and includes: inorganic, oxidizable organic and polyphosphates. This includes what is readily available, potential to become available and stable forms. *<12 µg/L oligotrophic; 12-24 µg/L mesotrophic; 25-96 µg/L eutrophic; >96 µg/L hypereutrophic*
>
> **Free Reactive Phosphorus (FRP)** is the measure of inorganic dissolved reactive phosphorus (PO_4^{-3}, HPO_4^{-2}, etc.). This form is readily available in the water column for algae and nuisance aquatic plant growth.

Nitrogen - Nitrogen can exist in organic and inorganic, particulate and soluble forms. The soluble, inorganic forms (ammonium, nitrite, and nitrate) are the most available for plant growth. Particulate and dissolved organic forms of nitrogen are not immediately available for plant growth, but they can be converted to ammonium by bacteria and fungi, and can be oxidized to form nitrites then nitrates. Surface runoff can contain nitrogen in various forms. Inorganic nitrogen from fertilizers and organic nitrogen from animal waste and poorly functioning septic systems are examples.

> **Total Nitrogen –** Total nitrogen is the quantity of all of the nitrogen in the water and is calculated by adding the measured forms of organic nitrogen, oxidized nitrogen and ammonia. Nitrogen is an essential nutrient that can enhance growth of algae.
>
> **Nitrites and Nitrates** are the sum of total oxidized nitrogen, often readily free for algae uptake. *<1 mg/L typical freshwater; 1-10 potentially harmful; >10 possible toxicity, above many regulated guidelines*

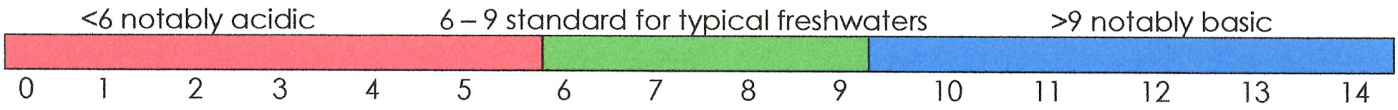
Chlorophyll *a* – Chlorophyll is the green pigment in plants that allows them to photosynthesize. The measurement of chlorophyll provides an indirect indication of the quantity of photosynthesizing plants found in the water column, such as algae and phytoplankton. More specifically, chlorophyll *a* is a measurement of the portion of the pigment that was still actively respiring and photosynthesizing at the time of sampling and does not include dead biomass.

0-2.6 µg/L oligotrophic; 2.7-20 µg/L mesotrophic; 21-56 µg/L eutrophic; >56 µg/L hypereutrophic

Conductivity – Conductivity is the ability of water to conduct an electrical current. Conductivity increases when more dissolved inorganic solids (positive and negative ions) are present. High sediment loads do not generally increase conductivity readings since sediment particles are generally considered to be suspended rather than dissolved because of their larger size (greater than 2 microns). The geology of the area around the waterbody is the primary factor affecting conductivity, and the readings for a waterbody will generally be within a relatively constant range. Once baseline data for a waterbody has been determined, periodic conductivity readings can be useful to identify potential problems that may need future investigation.

<50 uS/cm relatively low concentration may not provide sufficient dissolved ions for ecosystem health; 50-1500 typical freshwaters; >1500 may be stressful to some freshwater organisms, though not uncommon in many areas

pH – The concentration of acids and bases in the water determines its pH. A low pH (less than 7) is considered acidic, while a high pH (greater than 7) is basic. A pH of 7 is considered neutral. Most aquatic organisms survive best in waters with a pH between 6.8 and 8.2.



Alkalinity – The alkalinity of a waterbody is a measure of the acid-neutralizing or "buffering" capacity of the water. Waterbodies with higher alkalinity are resistant to broad swings in pH, which can be stressful for aquatic organisms. Waters with lower levels are more susceptible to pH shifts. Alkalinity is influenced by bicarbonates, and is reported as the concentration of calcium carbonate ($CaCO_3$) in the water.

≤50 mg/L as $CaCO_3$ low buffered; 51-100 moderately buffered; 101-200 buffered; >200 high buffered

Hardness – Hardness is a measurement of calcium and magnesium ions in the waterbody and can be important for aquatic organisms that obtain their calcium directly from the water.

0-60 mg/L as $CaCO_3$ soft; 61-120 moderately hard; 121-180 hard; >181 very hard

Turbidity – Turbidity is a measurement of water clarity. Suspended particulates in the water such as algae and plankton, detritus, and soil particles are the primary constituents influencing turbidity. High turbidity can have both detrimental and positive effects on aquatic ecosystems depending on the suspended particles. Algae and plankton in moderation serve as a great source of food for aquatic life while suspended soil particles and detritus materials can clog fish gills and impair respiration, smother spawning areas, negatively affect egg and larval development, and reduce growth rates in fish. Since high turbidity does attenuate light, photosynthesis and the related production of dissolved oxygen may be dangerously reduced. Suspended particles also play a role in transporting phosphates and other compounds, including toxic substances.

Suspended solids usually settle out of standing water over time. However, clay particles can remain in suspension because of the negative electrical charges associated with them. Therefore, persistent turbidity is generally due to the presence of clay particles in the water column.

<4 NTU is clear to the naked eye; <10 NTU drinking water standard and typical trout waters; 10-50 NTU moderate; >50 NTU potential impact to aquatic life

Table 1: Temperature and dissolved oxygen profile.

Water Depth (Feet)	DO 5 Feet Temperature (deg F)	DO 5 Feet Dissolved Oxygen (mg/l)	DO 7 Feet Temperature (deg F)	DO 7 Feet Dissolved Oxygen (mg/l)	DO Temperature (deg F)	DO Dissolved Oxygen (mg/l)
Surface	85.6	1.18	85.2	2.08	85.4	4.54
1	86.2	1.28	85.4	2.13		
2			85.4	1.60		
3	86.2	1.14	85.0	1.19	85.8	4.27
4	86.1	0.36				
5	85.2	0.22	84.9	0.89		
6					85.9	4.21
9					85.9	4.18
11					85.7	3.81
12					84.3	0.75

Table 2: Water quality, Sites 1-2.

Parameter	Site 1	Site 2	Optimal Range
Secchi Depth (feet)	5	6	n/a
Total Phosphorus (µg/L)	18.6	16.9	<25
Free Reactive Phosphorus (µg/L)	<5	<5	<25
Conductivity (us/cm)	204.0	202.0	>50
pH	7.4	7.5	6.8-8.2
Alkalinity (mg/L)	84	83.2	>20
Hardness (mg/L as $CaCO_3$)	60.5	62.5	>30
Turbidity (NTU)	3.1	2.9	<10
Nitrates (mg/L)	<0.02	<0.02	<5.0
Nitrites (mg/L)	<0.02	<0.02	<0.25

Total Nitrogen (mg/L)	1.2	1.1	<1.0
Chlorophyll *a* (µg/L)	<10	<10	<20
Total Kjeldahl Nitrogen (mg/L)	1.2	1.1	<5
Total Nitrate & Nitrite (mg/L)	<0.02	<0.02	<5
Fecal Coliform (CFU/100mL)	2180	65	
E. Coli (MPN/100 mL)	<1.0	1.0	

Image 1. Algae identification and enumeration from site 1.

Algae ID Results
Thunderbird HOA

Identification	Classification	Description	Density/Biomass (gww/cm^3)
Sample 3			
Scytonema sp.	Cyanophyta-Blue-green algae	Filamentous, mat-forming, potential toxin producer	0.8 ★★★★
Mougeotia sp.	Streptophyta-Desmids	Filamentous, mat-forming	0.1
Spirogyra sp.	Streptophyta-Desmids	Filamentous, mat-forming	0.1

Other algae in the sample associated with mat, include: *Botryococcus, Oedogonium* (Chlorophyta); *Leibleinia, Lyngbya* (Cyanophyta); *Trachelomonas* (Euglenophyta); *Cosmarium* (Streptophyta)

SeSCRIPT* ALERT INDEX	EXPOSURE RISK	CYANOBACTERIA LEVELS (cells/mL)
★	Low	<20,000
★★	Moderate	20,000 to 100,000
★★★	High	>100,000
★★★★	Extreme	>100,000 with scums/mats

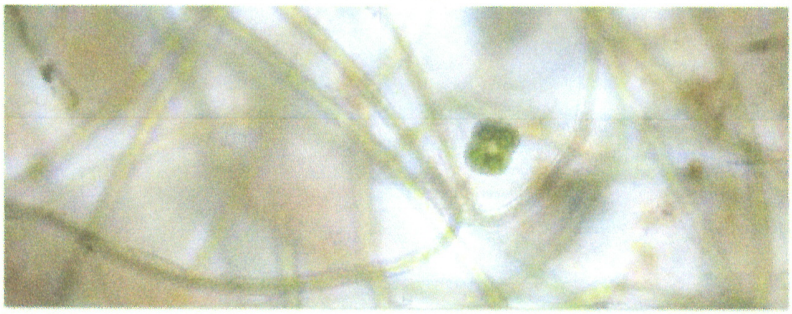
See the following Cyanobacteria Alert Guide for additional information

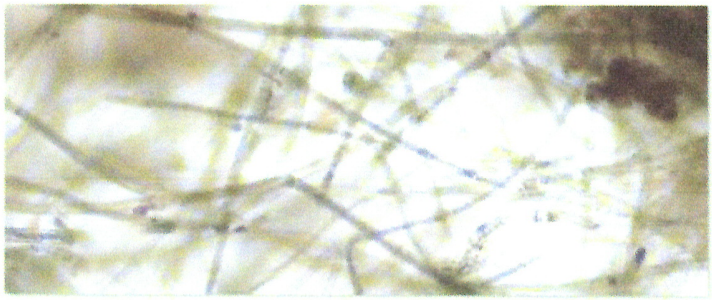
Image 2. Algae identification and enumeration from site 2.

Algae ID Results (cont.)
Thunderbird HOA

Identification	Classification	Description	Density/Biomass (gww/cm^3)
Sample 6			
Scytonema sp.	Cyanophyta-Blue-green algae	Filamentous, mat-forming, potential toxin producer	1.0 ★★★★

Other algae in the sample associated with mat, include: *Botryococcus, Sphaerocystis* (Chlorophyta); *Lyngbya* (Cyanophyta); *Cosmarium, Mougeotia* (Streptophyta)





Summary and Recommendations

During the site visit, an estimated 40% of the lake had rooted aquatic vegetation growth identified as two different species, Eurasian Watermilfoil and Coontail. In terms of fish productions, we recommend that 20% of the lake contains suitable habitat for fish, which can be composed of aquatic vegetation, brush piles, or artificial structure. The 40% coverage of vegetation is not detrimental to the health of the fishery; however, performing spot treatments to reduce the total amount of vegetation would help improve lake access. Additionally, Cattails, Willows, and other broadleaf plants were found growing along the dam. SOLitude Lake Management recommends treating any large rooted plants growing along the damn. The roots of these plants grow into the dam and can potentially compromise the dam's structural integrity. Over time this can cause the dam to leak.

The dissolved oxygen and temperatures for all three locations, recorded in table 1, shows an insufficient level of oxygen for fish growth and production. It is anticipated that the lake has recently turned over, which causes the bottom non-oxygenated water to be brought to the surface and mixed with the warmer oxygen-rich water resulting in depleted dissolved oxygen levels throughout the water column. Turnovers are common in deep water bodies this time of year. Installing a bottom diffused aeration system would help prevent future turnovers. Bottom diffused aeration systems are designed to improve water quality by continuously mixing the water from the bottom up and artificially turning the lake over. This provides uniform water temperatures and increased dissolved oxygen levels throughout the lake. The uniform oxygen aids in water quality by adding oxygen to previously oxygen-deprived environments. This oxygen-enrichment promotes the growth of beneficial microbes in the lake-bottom sediment that are necessary for breaking down the accumulation of organic material and reducing the level of nutrients that contribute to plant and algae growth. Installing a bottom diffused aeration system is the best way to improve any lake and provide enhanced long-term results.

The water quality results are fair considering the goal of improving the fishery. For aesthetics and vegetation growth, the two key parameters are phosphorous and nitrogen. The phosphorous and nitrogen levels in Lake Thunderbird are within the recommended range; however, the algae identification found a mat-forming species of blue-green algae in Site 1 and Site 2 (Image 1 and Image 2). Although the blue-green algae was not dominant, it's important to note that some of the nutrients are being stored in the vegetation present. As the amount of vegetation reduces in the colder months, additional nutrients will be released into the lake. Plants will also release these two nutrients when they are treated. This is one of the reasons we only recommend treating some of the present growth and not treating all of it.

The other values that are important to consider are visibility, recorded as the Secchi disk depth, and the dissolved oxygen. For fish production, we recommend that the visibility be between 18-24 inches this time of year. One way to reduce visibility is by promoting growth of beneficial phytoplankton in the water column. These phytoplankton are the base of the food chain. The lake currently appears to be lacking phytoplankton, as observed in the Chlorophyll-a level and the algae composition analyzed in the lab. This lack of phytoplankton may be caused by the lake turnover event that recently occurred. As part of a proactive management plan, we recommend reducing the phosphorous within the water column and treating the aquatic vegetation as it emerges next spring. Phosphorous can be reduced by applying a product called Phoslock, which is a clay-based product that binds phosphorous into the sediment. It is important to note that the phosphorous may begin to build over time as nutrients enter the system. An excellent example of this is a heavy rain event. In an effort to proactively manage the lake, we recommend annual water quality testing to monitor changes over time and update management recommendations as needed to continue improving the lake.

Fecal Coliform and E. Coli were found within the water body. Both Fecal Coliform and E.Coli are an indicator of the potential presence of pathogens within the water body. The E.coli measurements were recorded at less than 1.0 MPN/100 mL at site 1 and 1.0 MPN/100 mL at site two. This is below the Texas Commission on Environmental Quality Standards (TCEQ) of 126 MPN/100 mL. Fecal coliform was measured at 2180 CFU/100 mL at site 1 and 65 CFU/ 100 mL at site two. TCEQ utilizes E. Coli as the

freshwater indicator for bacteria. Information on the TCEQ standards can be found at https://www.tceq.texas.gov/waterquality/standards/2018-surface-water-quality-standards#fifthAnchor

If fisheries are an essential component of the resource, we recommended completing an annual or one-time fisheries survey. To conduct the fisheries survey a Midwest electrofishing boat will be utilized to sample and study the fish population and composition within the reservoir. The information gained will be utilized to provide management recommendations and future fish stockings.

Recommendations summary

- Define the goals of the reservoir
- Maintain and treat aquatic vegetation and algae through a monthly management plan with SOLitude Lake Management: $1,635/month (Includes costs of herbicides)
- Conduct annual water quality and algae tests to identify algae and monitor reservoir changes through time: $1,685/test
- Treat the vegetation along the dam: Quote
- Install a bottom diffused aeration system: Quote
- Complete an annual or one-time electrofishing survey this fall: $2,720
- Per request- complete sonar side-scan mapping to provide a detailed map of the lake: $3,487
- Proactively manage the nutrients by reducing the phosphorous, apply 1,760 pounds of phoslock this winter: $11,045

Thank you
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