PROJECT SUMMARY
LAKE PALESTINE DIURNAL SURVEY, OCTOBER 2005-2006

Texas Commission on Environmental Quality
Field Operations Division—Region 5 Tyler

Introduction

Lake Palestine was constructed in 1962 and covers 25,560 surface acres. The Texas Commission on Environmental Quality (TCEQ) and its predecessor agencies have been sampling selected areas of the lake since 1973. The upper half of the lake, north of SH155 has been an area of potential water quality concern for high chlorophyll-*a* and high pH for several years. There are six TCEQ permitted wastewater treatment plant (WWTP) point source dischargers in the watershed: The Tyler Westside WWTP 13.0 mgd, Van 0.60mgd, Chandler, 0.5mgd, Brownsboro 0.067mgd, and Murchison 0.08 mgd, and Lindale 0.072mgd (Figure 1). There are also numerous possible nonpoint areas, including, a dairy, several developments, and two small towns. In addition, there are several subdivisions along the lakeshore with septic systems.

The transition zone area of the lake between deeper water and the two main tributaries, Neches River and Kickapoo Creek, is shallow and heavily vegetated with submerged and floating vegetation. The middle part of the lake has less aquatic vegetation, but tends to have higher phytoplankton concentrations. The City of Tyler operates a raw-water intake structure in this area. Since the plant came online in November 2003, there have been several taste and odor issues associated with elevated *geosmin* concentrations. The TCEQ placed several areas above SH155 on the 2006 Texas Water Quality Inventory 303(d) list for not meeting pH maximum criteria.

Objectives

The main objectives of this study were to collect additional information to confirm the 303(d) listing for pH, the concern for elevated chlorophyll-*a* concentrations, and to see if there was a seasonal nature to the problem. The TCEQ typically collects quarterly samples at all routine water quality station locations. The sample frequency at the three sites on upper Lake Palestine was increased to monthly because of the concern.

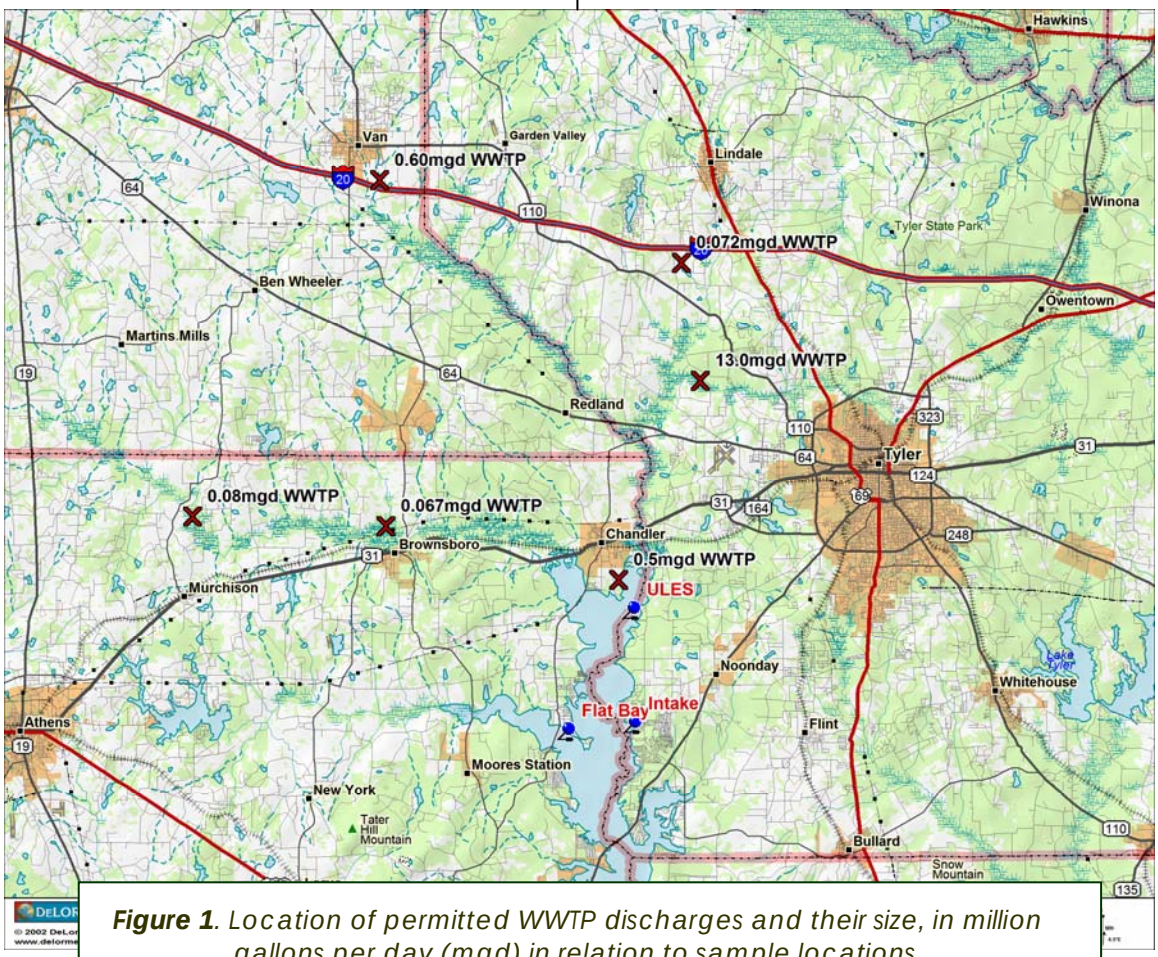

***Figure 1**. Location of permitted WWTP discharges and their size, in million gallons per day (mgd) in relation to sample locations.*

What is Geosmin? *Geosmin* literally translates to "*earth smell*". It is an organic compound with a distinct earthy flavor and aroma produced by several classes of microbes, including cyanobacteria (blue-green algae). *Geosmin* is released when these microbes die. Communities whose water supply depends on surface water can periodically experience episodes of unpleasant-tasting water when a sharp drop in the population of these bacteria releases *geosmin* into the local water supply.

Methods

From October 2005 through October 2006, Hydrolab DataSondes were deployed from fixed structures at three geographically separate areas: Station 18557 in Flat Bay, Station 16346 near the Tyler Intake, and Station18643 in the upper lake east shore (ULES) (Figure 1). Dissolved oxygen (DO) and pH were collected hourly during a 24-hour period. Routine wet chemistry samples were also collected monthly in support of the DO and pH data.

Sample results from the Hydrolab multiprobe instruments were compared to 24-hour DO (means) and pH (medians), minima, and maxima as described in the *Texas Surface Water Quality Standards* (Title 30 Chapter 307 TAC). Nutrient and chlorophyll-*a* concentrations were compared to screening levels for reservoirs found in the *Guidance for Assessing and Reporting Surface Water Quality in Texas* (Table 1).

Table 1. Nutrient Screening Levels

Water Body Type	Nutrients	Screening Level
Reservoir	NH_3-N NO_3-N OP TP Chl *a*	0.11 mg/L 0.37 mg/L 0.05 mg/L 0.20 mg/L 26.7 µg/L

Results

Results data are presented in Tables 2 through 10 on pages 4-6. Elevated chlorophyll-*a* concentrations occur year around, but they are more pronounced during the summer and fall months (Figure 4).

Chlorophyll-*a* concentrations were consistently high at all three stations: 7 of 12 sample events at Flat Bay, 10 of 13 sample events at the Tyler intake, and 10 of 10 sample events at ULES exceeded screening levels. When chlorophyll-*a* concentrations were elevated, it was visually apparent by green or olive-colored water.

The pH exceedances of water quality maximum criteria followed closely that of the chlorophyll-*a* concentrations: 7 of 12 sample events at Flat Bay, 6 of 12 sample events at the Tyler intake, and 5 of 10 sample events at upper lake east shore exceeded the maximum criteria (Table 2). Four additional data points from ULES were at the very upper limit of the criteria.

The 24-HR DO criteria were exceeded only twice during the whole study—once each at the Tyler intake and ULES. For the most part, mean DO concentrations were in the 7-10 mg/L range (Tables 4 and 5). There were some tendencies for higher DO concentrations in the afternoon hours, but no real classical swings in the opposite direction during the early morning hours.

Analysis of wet chemistry data indicated that higher levels of total phosphorus (Total-P) concentrations were observed at the ULES station than at the other two stations (Table 7). For example, Total-P concentrations at ULES during July to October 2006 were twice that of the other two stations. This is not unexpected since it is the station closest to the point source dischargers located on the Neches River and Kickapoo Creek. At all three stations, nitrogen was mainly present as organic nitrogen (Total Kjeldahl-N or TKN) bound to organic matter such as detritus, bacteria, or algae. TKN concentrations ranged from 0.64-1.94 mg/L (Table 9). Inorganic nitrogen (NO_2+ NO_3) was typically below detection limits and therefore unavailable for uptake and growth (Table 10).

Discussion

The results of this special study confirm the 305(d) listing for pH violations on upper Lake Palestine. They appear to be associated with phytoplankton concentrations (as measured by chlorophyll-*a*) that are present year around, but are heaviest during summer and fall months.

A continuous water quality monitoring (CWQM) station, installed by TCEQ in February 2008, is providing detailed pH data on a daily basis (Figure 2). An additional routine monitoring station has been proposed on the lake south of SH 155 to determine if data indicate concerns in the lower lake as well. This proposal would effectively divide the lake into six assessment units (AU), each with its own representative station (Figure 3).

References

Texas Commission on Environmental Quality. 2000. *Texas Surface Water Quality Standards*. Title 30 of the Texas Administrative Code, Chapter 307.

Texas Commission on Environmental Quality. 2008. *Guidance for Assessing and Reporting Surface Water Quality in Texas.* Austin, TX.

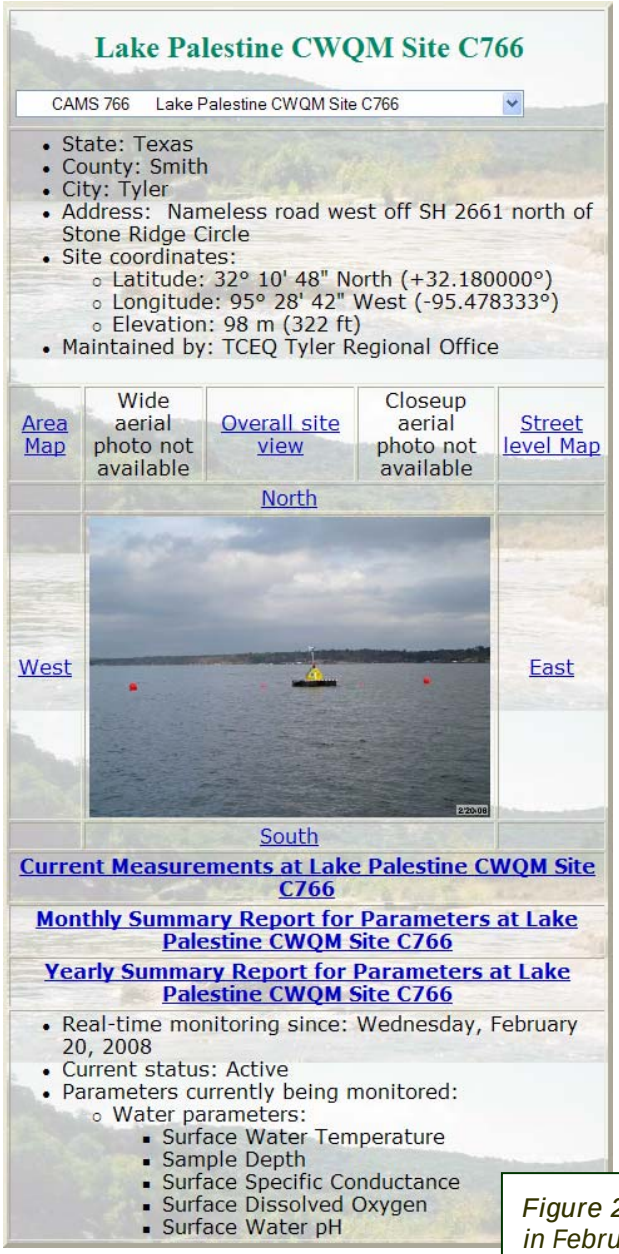

Figure 2. CWQM site installed on Lake Palestine in February 2008. For additional information go to <http://texaswaterdata.org>.

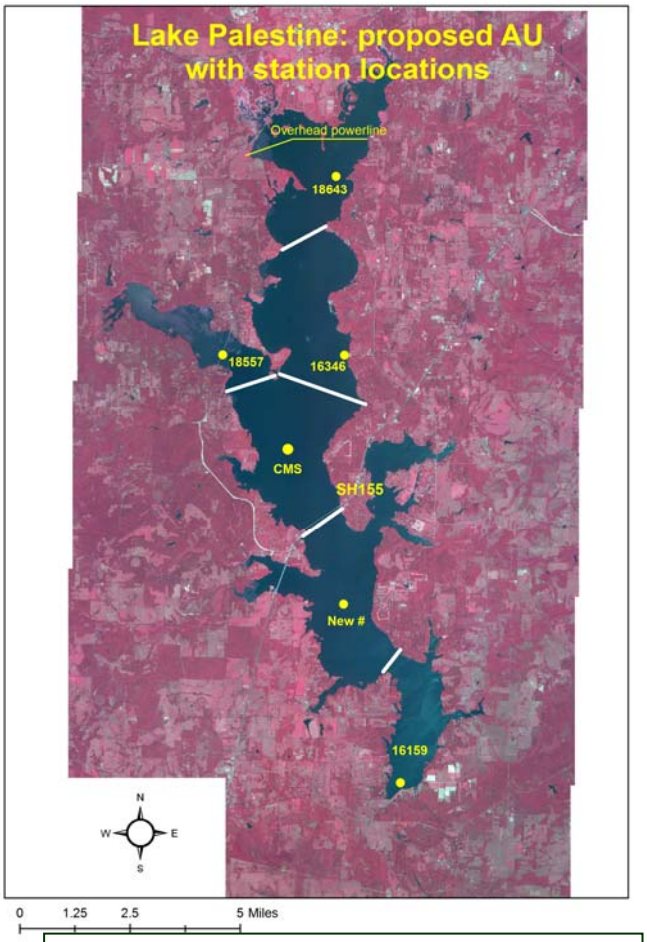

Figure 3. Currently sampled and proposed sample stations on Lake Palestine. New stations would be located at the CWQM station and south of SH155.

Lake Palestine Diurnal Study Data—Chlorophyll a, pH, and Temperature

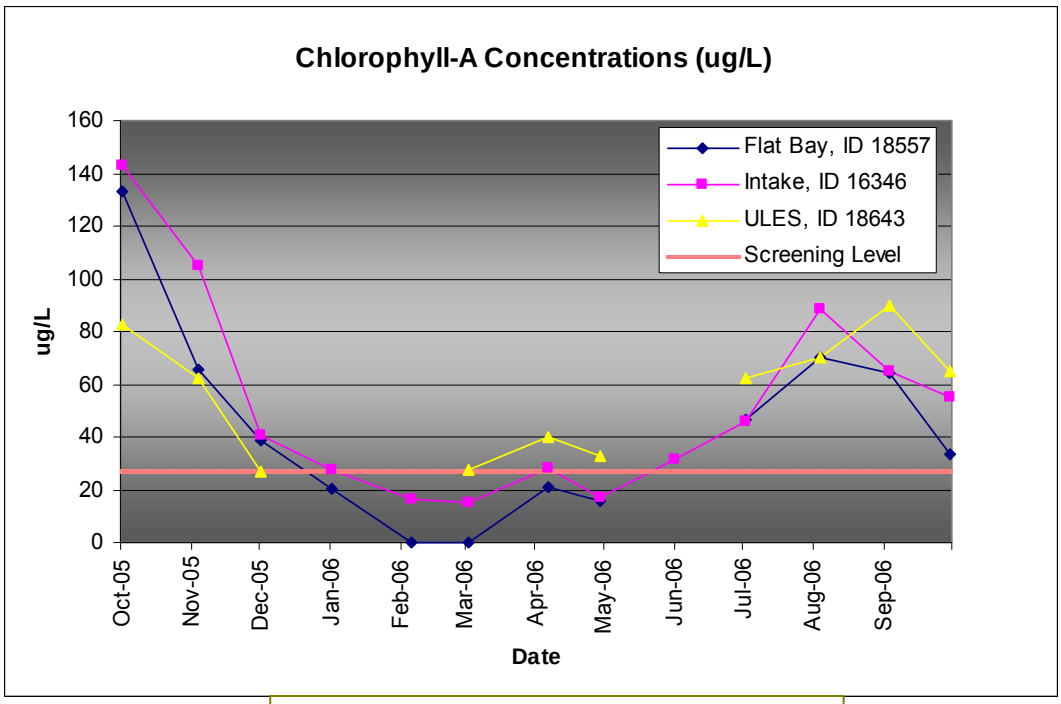

Figure 4. Chlorophyll a (µg/L)

Table 2. Maximum pH (su)

Date	Maximum pH (su)		
	Flat Bay	Intake	ULES
10/5/2005	9.4	9.2	8.9
11/8/2005	8.9	8.6	8.5
12/5/2006	8.1	7.9	8.1
1/5/2006	7.6	7.7	***
2/9/2006	7.5	7.7	***
3/6/2006	7.8	7.9	8.5
4/10/2006	**	**	**
5/3/2006	8.5	8.4	8.6
6/5/2006	9	9.1	8.9
7/6/2006	9.1	7.8	8.5
8/8/2006	9.1	9.4	9.4
9/7/2006	9.1	9	8.5
10/4/2006	9.2	9.2	9.2

Table 3. Mean Temperature (◦C)

Date	Mean Temp. (°C)		
	Flat Bay	Intake	ULES
10/5/2005	28.1	27.8	27
11/8/2005	21.3	20.8	21.5
12/5/2006	12.8	12.9	11.8
1/5/2006	12.9	12.3	***
2/9/2006	12.2	12.2	***
3/6/2006	16.8	17	18.1
4/10/2006	**	**	**
5/3/2006	25.1	24.8	25.1
6/5/2006	28.4	28.3	28.1
7/6/2006	29	28.3	28.4
8/8/2006	30.8	31.8	31.1
9/7/2006	26.8	26.6	25.7
10/4/2006	26.4	26.9	27

Notes:
- The TCEQ lab switched Chl-*a* techniques to fluorometry during April 2006
- Screening level Chl-A = 26.7 µg/L
- pH criteria = 6.0-8.5 (su)
- pH criteria are established as absolute minima and maxima 307.7(b)(4)(B)
- Values in red exceed criteria or screening levels

Lake Palestine Diurnal Study Data—Dissolved Oxygen

Table 4. # Hours Exceeding DO Minima

Date	# Hours Exceeding DO Minima		
	Flat Bay	Intake	ULES
10/5/2005	0	0	0
11/8/2005	0	0	0
12/5/2006	0	0	0
1/5/2006	0	0	***
2/9/2006	0	0	***
3/6/2006	0	0	0
4/10/2006	**	**	**
5/3/2006	0	0	0
6/5/2006	0	0	0
7/6/2006	0	0	0
8/8/2006	0	0	0
9/7/2006	0	0	0
10/4/2006	0	0	0

Table 5. Mean DO (mg/L)

Date	Mean DO (mg/L)		
	Flat Bay	Intake	ULES
10/5/2005	9.9	9.6	7
11/8/2005	10.8	10.3	8.1
12/5/2006	9.8	9.3	9.4
1/5/2006	9.4	10.7	***
2/9/2006	10.3	10	***
3/6/2006	9.8	10.2	9.8
4/10/2006	**	**	**
5/3/2006	8.5	8.3	8.3
6/5/2006	7.1	8.1	6.3
7/6/2006	7	4.2	5.7
8/8/2006	6.7	9.6	7.8
9/7/2006	8	5.8	4.7
10/4/2006	9.6	10.4	7.7

Table 6. Water Color

Date	Water Color (descriptive)		
	Flat Bay	Intake	ULES
10/5/2005	olive	olive	olive
11/8/2005	green	green	green
12/5/2006	light-brown	light-brown	
1/5/2006	clear	clear	***
2/9/2006	clear	light-brown	***
3/6/2006	clear	clear	brown
4/10/2006	light-green	light-green	olive
5/3/2006	light-green	light-green	olive
6/5/2006	olive	olive	olive
7/6/2006	olive	olive	dark-olive
8/6/2006	green	olive-green	dark-olive
9/7/2006	green	green	olive
10/4/2006	green	green	dark-olive

Values in red exceed criteria or screening levels
D.O. criteria = 5mg/L mean and 3mg/L minima
D.O. criteria are applied as 24-hr. means and 8-hr. minima
307.7(b)(3)(A)

Lake Palestine Diurnal Study Data—Nutrients

Table 7. Total P (mg/L)

Date	Total P (mg/L)		
	Flat Bay	Intake	ULES
10/5/2005	0.08	0.08	0.1
11/8/2005	<0.06	0.07	0.88
12/5/2006	0.1	<0.06	<0.06
1/5/2006	<0.06	<0.06	***
2/9/2006	<0.06	<0.06	***
3/6/2006	<0.06	<0.06	<0.06
4/10/2006	<0.06	<0.06	0.07
5/3/2006	<0.06	<0.06	0.07
6/5/2006	*	0.06	*
7/6/2006	<0.06	0.06	0.14
8/8/2006	0.09	0.1	0.22
9/7/2006	0.09	0.08	0.19
10/4/2006	0.09	0.09	0.21

Table 8. Ortho P (mg/L)

Date	Ortho P (mg/L)		
	Flat Bay	Intake	ULES
10/5/2005	0.05	0.05	0.05
11/8/2005	<0.04	<0.04	0.05
12/5/2006	0.04	<0.04	<0.04
1/5/2006	<0.04	<0.04	***
2/9/2006	<0.04	<0.04	***
3/6/2006	<0.04	<0.04	<0.04
4/10/2006	<0.04	<0.04	<0.04
5/3/2006	<0.04	<0.04	<0.04
6/5/2006	*	<0.04	*
7/6/2006	<0.04	<0.04	<0.04
8/8/2006	<0.04	<0.04	0.05
9/7/2006	<0.04	<0.04	<0.04
10/4/2006	<0.04	<0.04	<0.04

Table 9. TKN (mg/L) (mg/L)

Date	TKN (mg/L)		
	Flat Bay	Intake	ULES
10/5/2005	1.26	1.1	1.23
11/8/2005	1.03	1.21	1.28
12/5/2006	1.23	0.77	0.81
1/5/2006	0.64	0.65	***
2/9/2006	0.66	0.78	***
3/6/2006	**	**	**
4/10/2006	0.83	0.92	1.04
5/3/2006	0.95	1	1.02
6/5/2006	*	0.75	*
7/6/2006	1.09	1.1	1.64
8/8/2006	1.35	1.48	1.94
9/7/2006	1.18	1.1	1.55
10/4/2006	1.15	1.26	1.83

Table 10. $NO_3 + NO_2$ (mg/L)

Date	$NO_3 + NO_2$ (mg/L)		
	Flat Bay	Intake	ULES
10/5/2005	<0.04	<0.04	<0.04
11/8/2005	<0.04	0.12	<0.04
12/5/2006	0.3	0.13	0.09
1/5/2006	<0.04	<0.04	***
2/9/2006	<0.04	<0.04	***
3/6/2006	<0.04	<0.04	0.18
4/10/2006	<0.04	<0.04	<0.04
5/3/2006	<0.04	<0.04	<0.04
6/5/2006	*	<0.04	*
7/6/2006	0.07	<0.04	0.05
8/8/2006	<0.04	<0.04	<0.04
9/7/2006	0.04	0.07	<0.04
10/4/2006	<0.04	<0.04	<0.04

Notes:
* sample not delivered in time
** instrument malfunction
*** site too shallow to sample