City of Bonney Lake

Volunteer Lake Monitoring Program

Introduction

The City of Bonney Lake's volunteer lake monitoring program began in 2004 with the goal of collecting data to establish long-term trends in lake water quality, provide the citizens and the City with a better understanding of lake processes, and provide information on Lake Bonney and Lake Debra Jane that will be helpful in making appropriate management decisions. While conditions may vary from year to year, long-term data collection is the key to tracking trends in water quality over time. This report contains a summary of the data collected during the 2017 lake monitoring season (May – October). Nine volunteers attended the two-hour refresher training in April, and seven volunteers participated in the actual monitoring contributing 56 hours of volunteer time.

Lake Bonney is a 17-acre lake with a maximum depth of 20 feet, and Lake Debra Jane is a 19-acre lake with a maximum depth of less than 10 feet. Both lakes are located in the Puyallup River watershed within the city limits of Bonney Lake.

Monitoring Program

Water chemistry and physical characteristics of lakes vary both seasonally and with depth. Lake volunteers collected physical data (water transparency, water color, weather conditions, lake level), recorded observations of lake conditions, made measurements of temperature and dissolved oxygen, and collected water samples for chemical analysis (total phosphorus, chlorophyll *a*) on a monthly basis beginning in early May and ending in late October.

Measurements of temperature and dissolved oxygen were made throughout the water column at the deepest point in both lakes. The "shallow" samples for total phosphorus and chlorophyll *a* analysis were collected one meter below the surface of the lake in both lakes. Additional "deep" samples for total phosphorus were collected one meter above the bottom in Lake Bonney; deep samples were not collected in Lake Debra Jane, a shallow lake. Field data for both lakes collected in 2017 can be found in Table 1.

Dissolved Oxygen and Water Temperature Profiles

With the onset of warmer weather in spring and early summer, deep lakes will begin to separate into a warmer, low-density layer at the surface, known as the epilimnion, and a cooler, high-density layer at the bottom, known as the hypolimnion. Between the epilimnion and the hypolimnion is a layer of rapidly changing temperature called the thermocline. Thus, begins the process of thermal stratification. Once this condition is fully developed, in summer, there is no vertical mixing of the upper and lower layers because of their density differences.

The vertical profiles of temperature and dissolved oxygen are similar during stratification (see figure 1); warmer water with abundant oxygen near the surface, and cooler water with declining or no oxygen at depth. A well oxygenated epilimnion is usually the result of the diffusion of oxygen from the atmosphere and the presence of algae that generate oxygen as a byproduct of photosynthesis. A hypolimnion with reduced or no oxygen is the result of the decomposition of organic matter that settles into that layer. These conditions occur despite the general rule that, all other factors being equal, cold water can hold more dissolved oxygen than warm water.

With the onset of cooler weather in the fall, the thermal stratification begins to break down and the shallow and deep layers of water begin to mix vertically once again. This phenomenon is usually called turnover.

This year the temperature and dissolved oxygen profiles show that stratification of Lake Bonney was well underway in early May (blue line), as in previous years. Turnover was complete by late October (purple line) with the temperature profile uniform from top to bottom (see Figure 1). The dissolved oxygen profiles are similar to temperature profiles (Figure 2). However, Lake Bonney is a relatively shallow lake and may not remain stratified throughout the summer; it could mix on windy and stormy days.

Lake Debra Jane is a very shallow lake and therefore its temperature and dissolved oxygen profiles do not show stratification (see Figure 3 & 4).

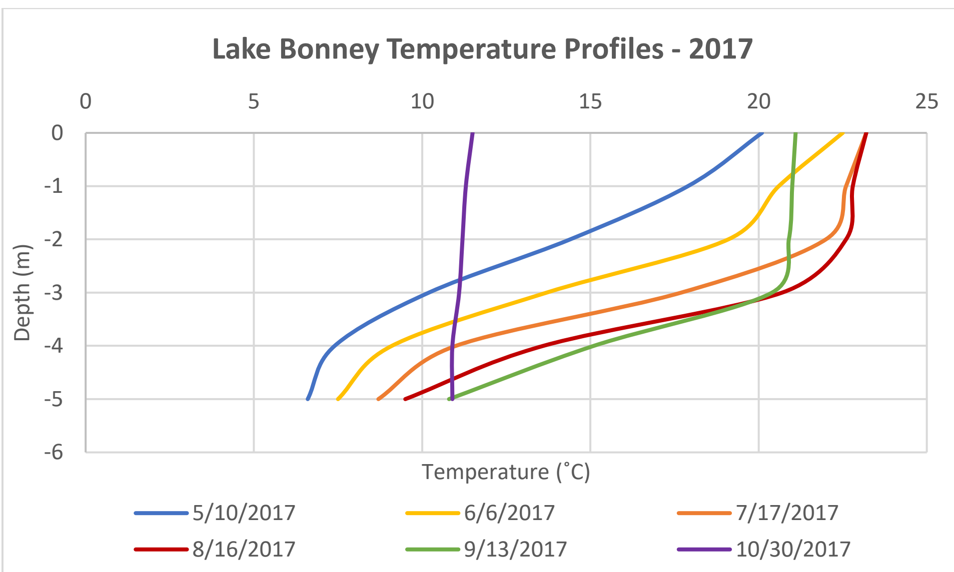

Figure 1.

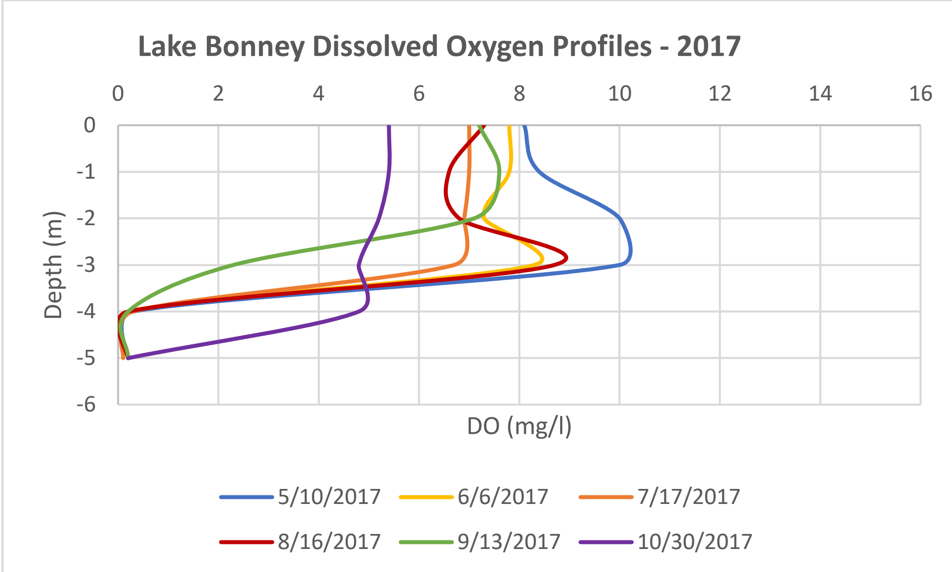

Figure 2.

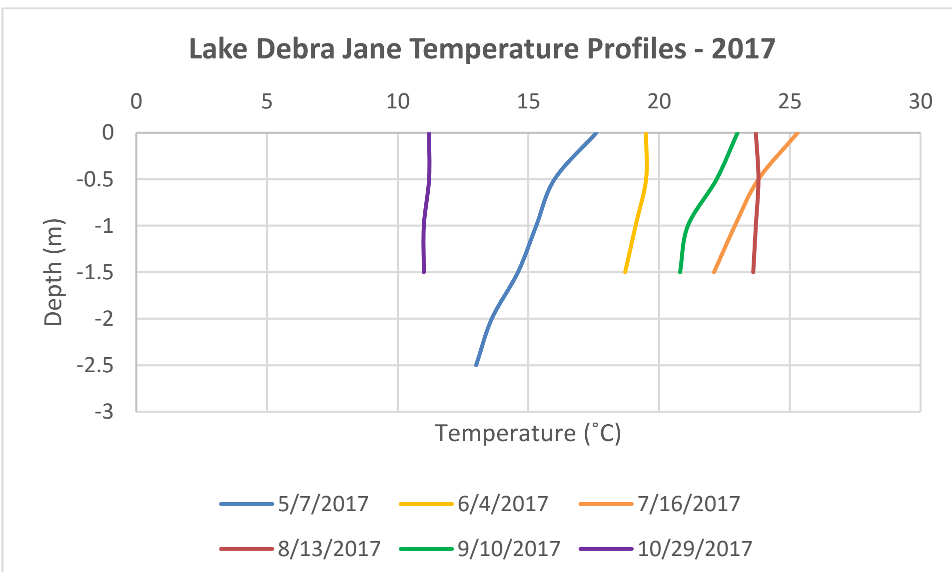

Figure 3.

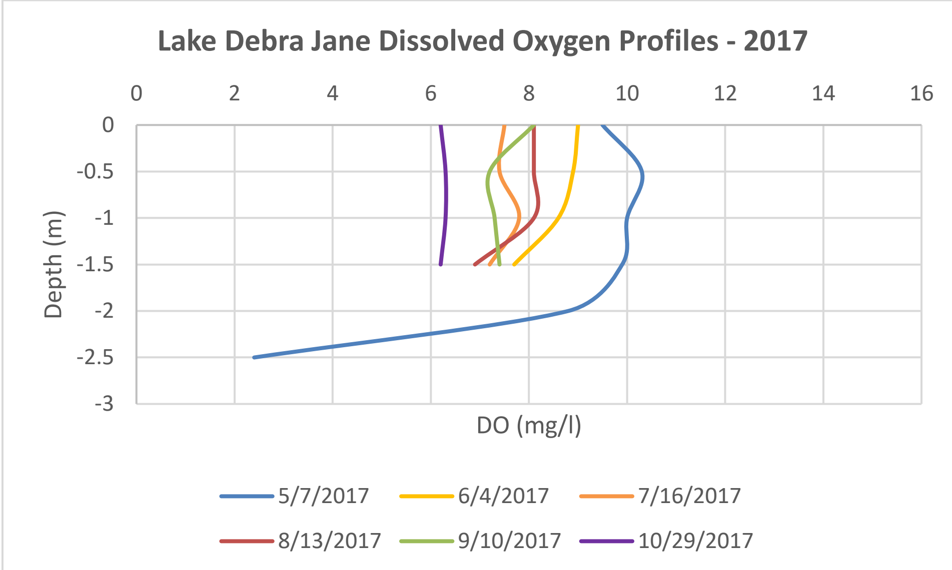

Figure 4.

Lake Levels

Lake levels are dependent on inflows and outflows of water and vary both seasonally and year to year. While precipitation and evaporation are the main cause of fluctuating lake levels, they are also influenced by watershed area, land uses in the watershed, vegetation types and cover, presence of wetlands, geology, surface and subterranean hydrology, and type of outflow structure (if present). The source and composition of the water flowing into lakes impacts the water quality of the lake. Lake monitors record lake levels each sampling session.

Both Lake Bonney and Lake Debra Jane show a typical lake-level fluctuation pattern of highest levels in spring, with a decline throughout the summer, to a seasonal low in fall just before the rains begin. The change observed in lake levels in Lake Bonney during the 2017 monitoring season was 1.97 feet, the same as observed in 2016. The decline in lake levels over the course of the season is much less pronounced in Lake Debra Jane; local residents report that lake levels in that lake are seasonally augmented with well-water. The annual change observed in lake levels in Lake Debra Jane in 2017 was 1.52 feet. 2017 lake levels for both lakes are presented below in Figure 5.

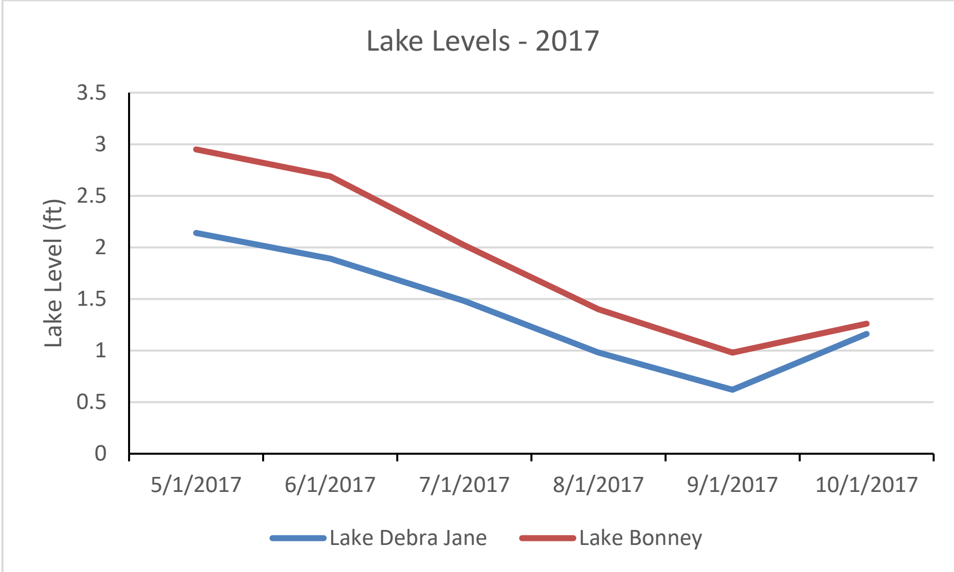

Figure 5.

Transparency

Water transparency is measured using an 8-inch diameter, black-and-white secchi disk and is traditionally reported as secchi depth. It is influenced by several factors such as dissolved substances, algae, and sediment particles. Transparency readings can also be affected by waves, wind, and glare. Higher secchi depth readings indicate clearer water (more transparent) while lower secchi depth readings indicate more turbid water. Clear water allows more light to penetrate deeper in the lake, allowing photosynthesis in aquatic plants and algae to occur; this usually leads to higher levels of dissolved oxygen. Conversely, a decrease in transparency is often seen with an increase in algae, or an influx of sediment and detritus due to a major storm event or because of human activities in the watershed. Nonetheless, secchi depth is commonly used as an approximation of algal abundance.

Secchi depth measurements observed in the 2017 monitoring season for Lake Bonney ranged from 1.25 to 2.8 meters. The secchi depth results for all years of data collection are shown below in Figure 6.

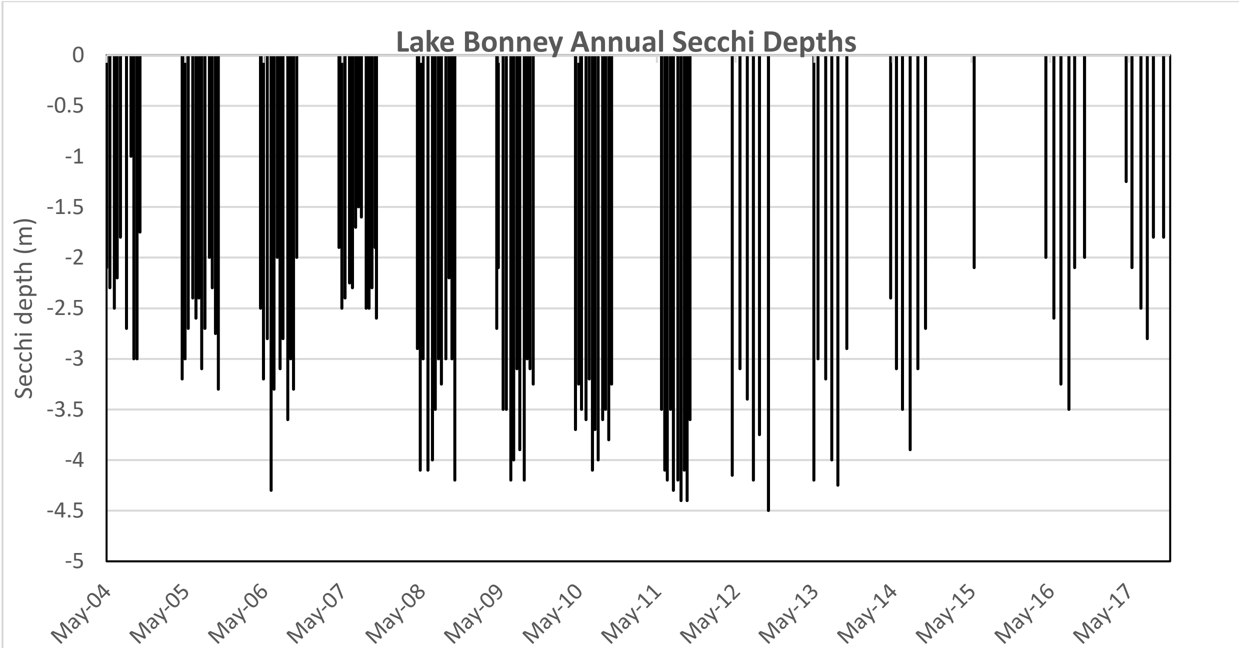

Figure 6.

Secchi depth measurements observed in the 2017 monitoring season for Lake Debra Jane ranged from 0.8 meters to 2.0 meters, with greater transparency occurring in late summer and fall. The results for secchi depth measurements for all years of data collection are shown below in Figure 7.

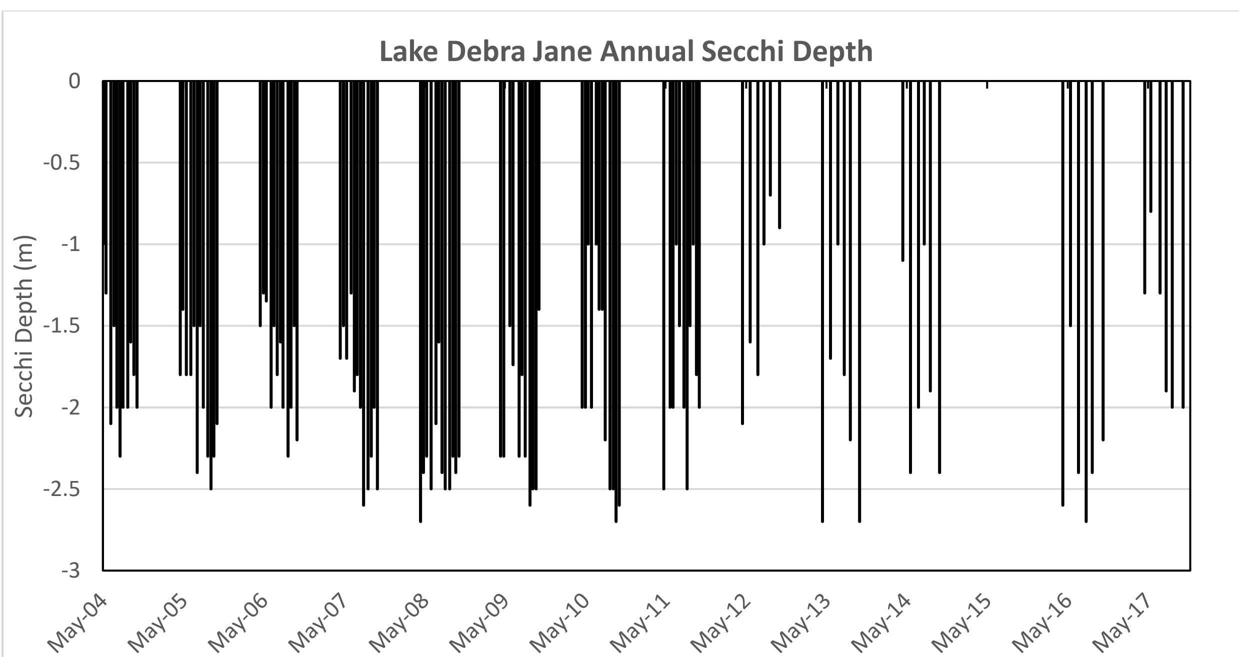

Figure 7.

Nutrients

Nutrients in lakes are essential for the growth of algae and aquatic plants. Phosphorus and nitrogen are the key nutrients in a lake system. In many lakes, phosphorus is the limiting nutrient in the system, which means it is only available to plants and algae in very limited quantities. Once the limited supply of phosphorus is exhausted, the algal population cannot expand further.

In lakes that are deep enough to stratify, typically in summer, total phosphorus concentrations in the hypolimnion increase and remain higher than in the epilimnion until the time of turnover, typically in the fall. This increase in phosphorus in the hypolimnion is caused in large part by the decomposition of phosphorus-rich organic matter at depth, a process that also consumes any oxygen present. Once oxygen is depleted or very low, phosphorus is typically released from the bottom sediments. When vertical mixing eventually occurs in the lake, usually in the fall, the high phosphorus load in the hypolimnion is brought to the epilimnion. With this influx of phosphorus, algal populations in that layer can increase to the point of producing an algal bloom.

The total phosphorus concentrations of the shallow samples for Lake Bonney ranged from 20 µg/l to 60 µg/l. In general, total phosphorus concentrations for the shallow samples are similar to those observed in previous years. Results for all the years of data collection are shown below in Figure 8.

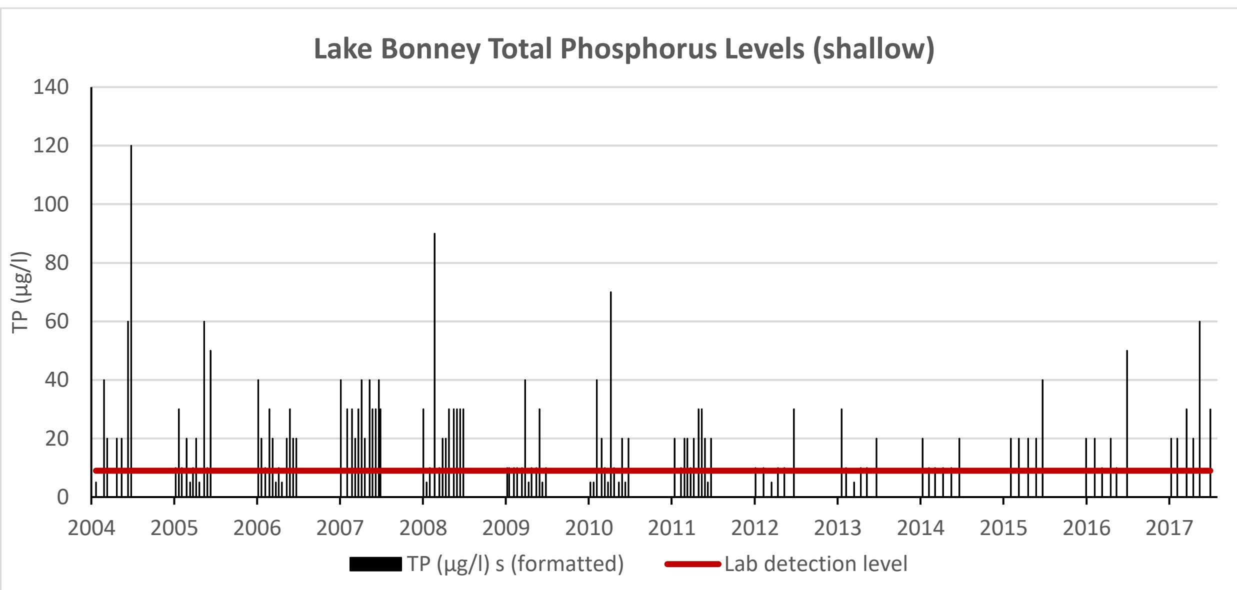

Figure 8.

Deep samples for total phosphorus analysis were collected 3 times (early, mid, late) during the sampling season in Lake Bonney. The highest levels of total phosphorus occurred earlier in the season unlike previous years. Total phosphorus concentrations of the deep samples for all the years of data collection are found in Figure 9 below.

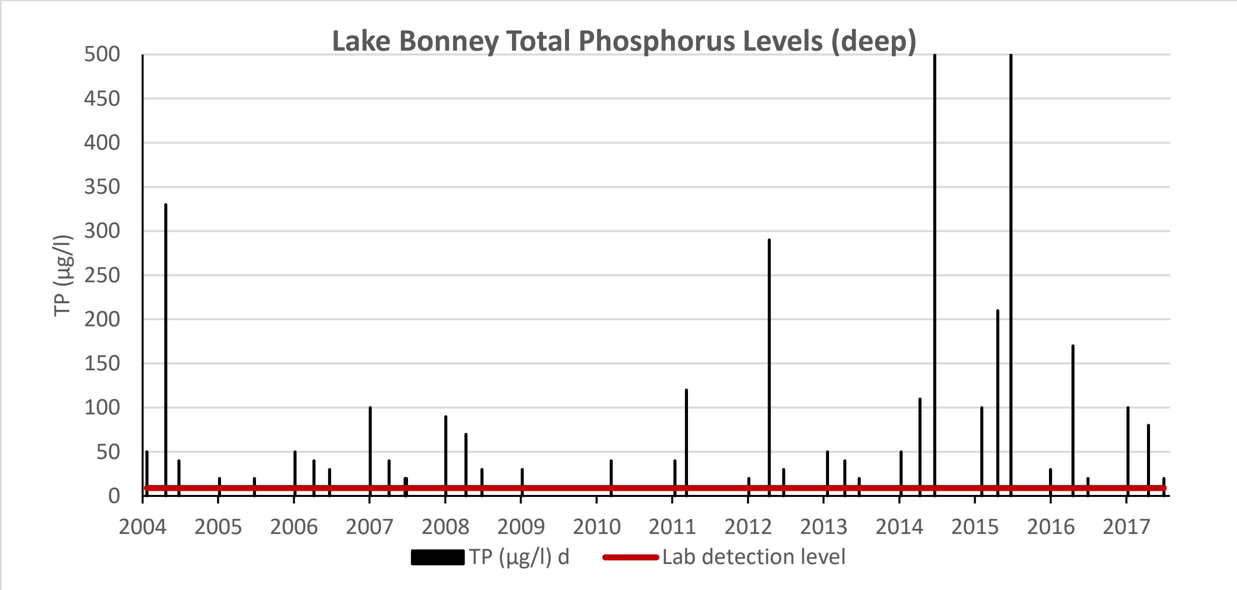

Figure 9.

The total phosphorus concentrations in shallow samples from Lake Debra Jane ranged from 10 µg/l to 60 µg/l. Total phosphorus concentrations in Lake Debra Jane for all years of data collection are shown below in Figure 10. There was no deep sample collected in Lake Debra Jane due to the shallow nature of the lake.

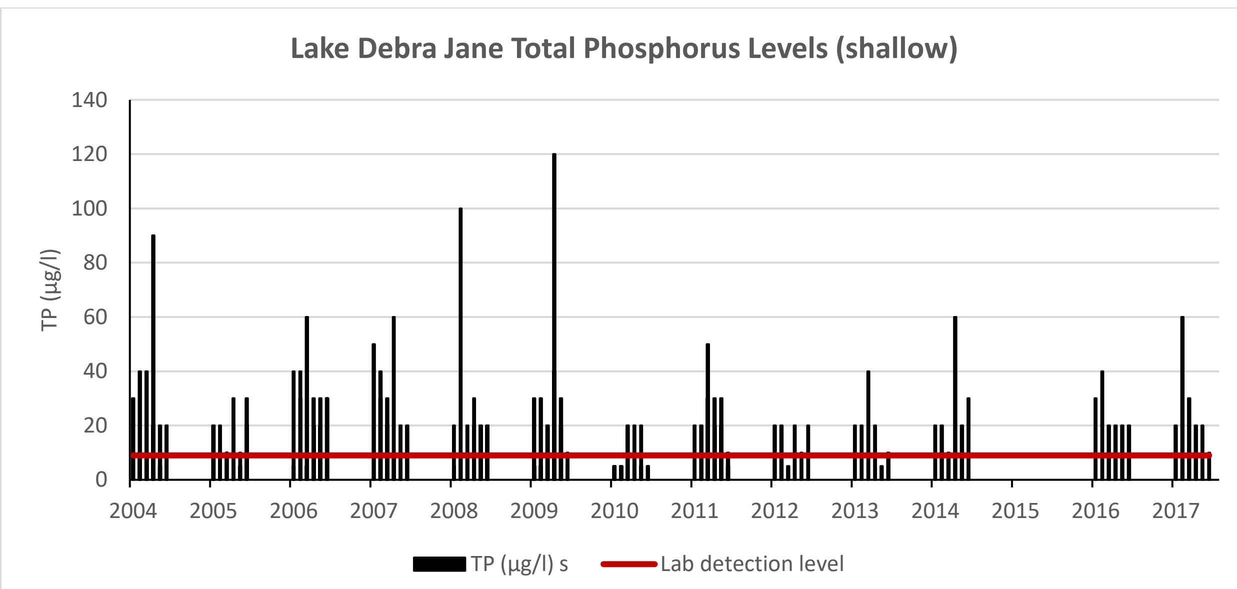

Figure 10.

Chlorophyll *a*

Chlorophyll *a* is one of the green pigments found in nearly all algae. The concentration of chlorophyll *a* is commonly used to estimate algal biomass and to assess the productivity (trophic state – how much life it supports) of the lake. Test results must be interpreted carefully, however, because chlorophyll *a* levels can be fairly variable in time and space. In addition, various species of algae contain differing amounts of chlorophyll per cell. The amount of chlorophyll can also vary with the health and age of the algal population, as well as with weather conditions. Additionally, algae typically concentrate at different levels in the water column in response to preferred light and temperature conditions, thereby escaping collection.

Chlorophyll *a* levels for shallow samples collected in Lake Bonney varied from 2 mg/m^3 to 19 mg/m^3, slightly higher than the last several years. Levels for all years are shown below in Figure 11.

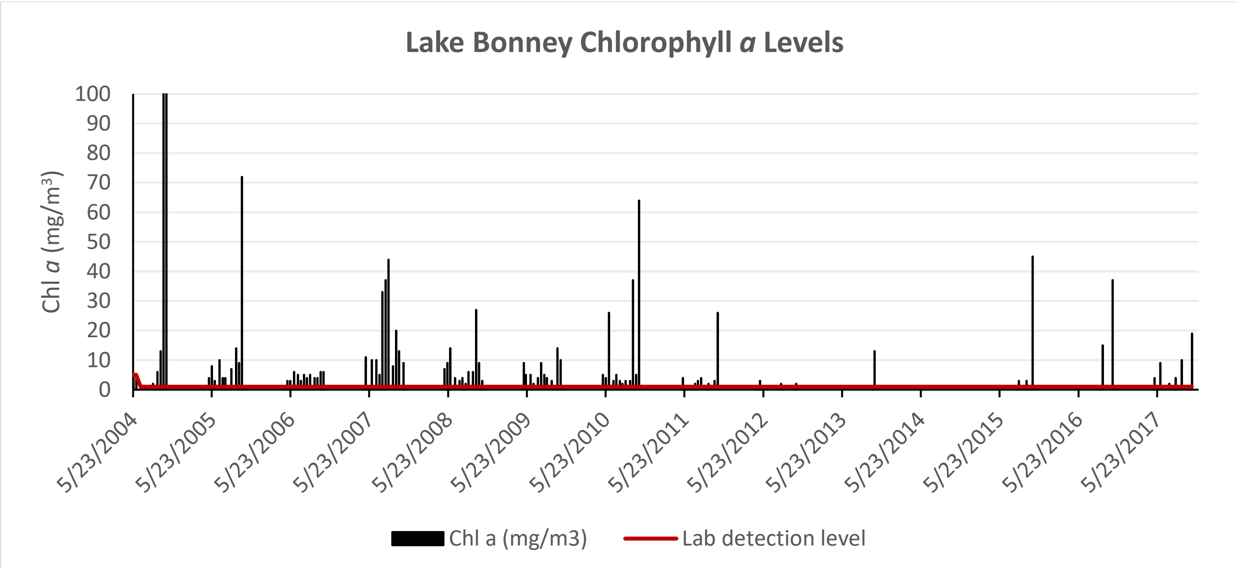

Figure 11.

Chlorophyll *a* levels in shallow samples collected from Lake Debra Jane ranged from 5 mg/m^3 to 74 mg/m^3. The lab reported that the final two chlorophyll *a* samples had exceeded their hold time prior to analysis so those results may not reflect the true amount present at the time of sampling. Levels for all years of data collection are shown below in Figure 12.

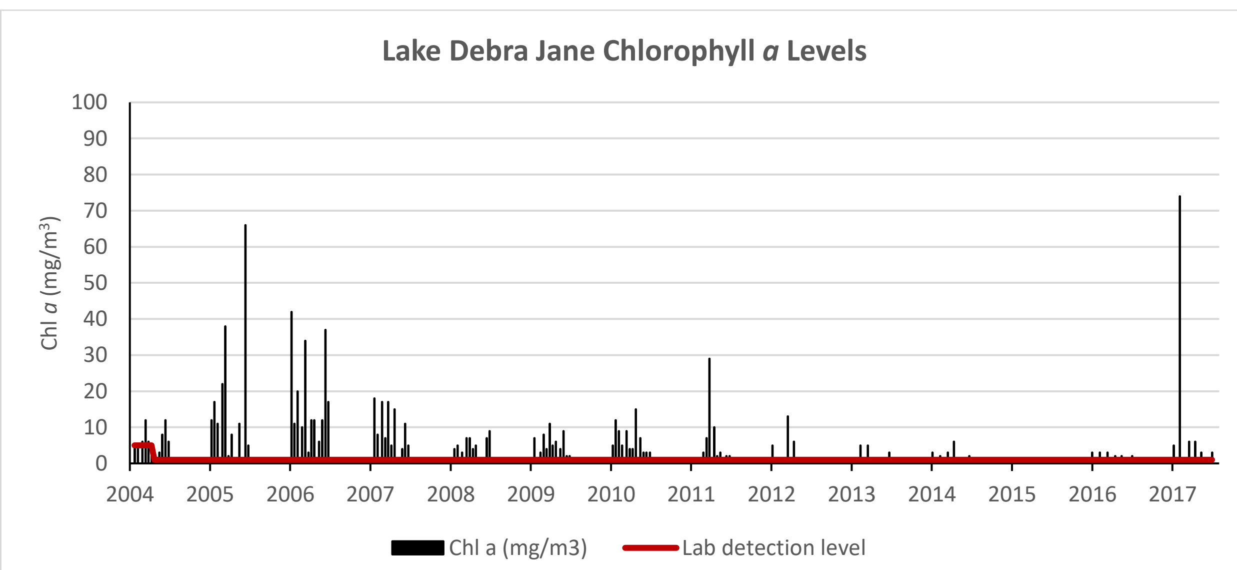

Figure 12.

Trophic State Index

All lakes go through a natural process of aging as a result of enrichment by nutrients and sediment. This process is called eutrophication and as more nutrients and sediment flow into lakes there is increased growth of aquatic plants and algae. Lakes will gradually fill up with organic material over thousands of years.

Lakes can be classified by their degree of eutrophication, also referred to as the trophic state. Lakes are usually classified as being in one of three possible trophic states - oligotrophic, mesotrophic, or eutrophic. Oligotrophic lakes have very clear water, low levels of nutrients, and few aquatic plants and animals. Mesotrophic lakes have more nutrients and tend to support more aquatic plants, and algae, and have lower water clarity. Eutrophic lakes are quite biologically productive and support an abundance of aquatic plants and animals, tend to have frequent algae blooms, lower water clarity, and lower dissolved oxygen in bottom waters.

Cultural eutrophication occurs when the natural aging process is accelerated by human activities in the lake watershed. Stormwater runoff from agricultural areas, fertilized lawns, failing septic systems, logging, urban development, and construction areas all contribute to accelerated enrichment (aging) of our lakes.

The Trophic State Index (TSI), a rating system, is used to determine the trophic state of a lake. The index ranges from 1 to 100 (see Table 2) with low TSI values indicating low biological productivity (oligotrophic) and high TSI (eutrophic) values indicating high biological productivity. TSI values are calculated each year for Lake Bonney and Lake Debra Jane based on averaged summer values for secchi depth, total phosphorus, and chlorophyll *a.*

Table 2: Comparison of Trophic State Index to Water Quality Parameters and Lake Productivity

Trophic State	TSI	Secchi Disk (m)	Total Phosphorus (µg/l)	Chlorophyll *a* (µg/l)
Oligotrophic	0	64	0.75	0.04
	10	32	1.5	0.12
	20	16	3	0.34
	30	8	6	0.94
Mesotrophic	40	4	12	2.60
	50	2	24	6.40
Eutrophic	60	1	48	20
	70	0.5	96	56
	80	0.25	192	154
	90	0.12	38	427
	100	0.062	768	1,183

(NOTE: The original source of this table and the equations is Carlson, R.E., 1977. A Trophic State Index for Lakes. Limnology and Oceanography, 22:361-369.)

The TSI average values for Lake Bonney are shown below in Figure 13. This year's results indicate that Lake Bonney is a mesotrophic lake.

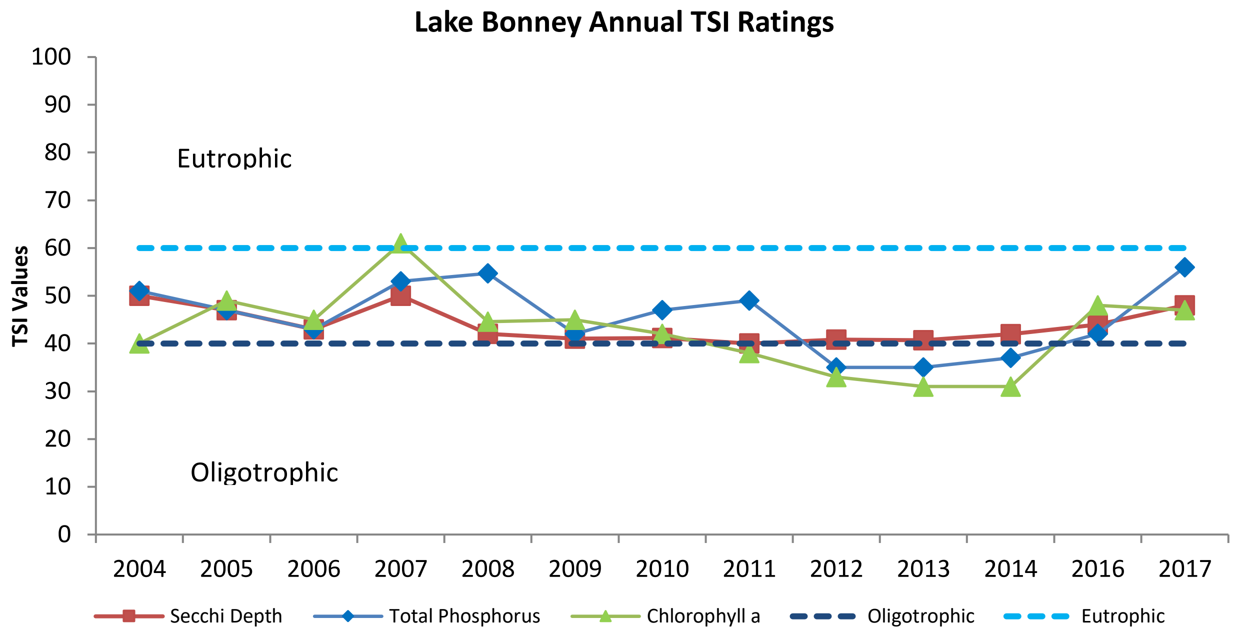

Figure 13.

The TSI values for Lake Debra Jane are shown below in Figure 14. Lake Debra Jane also remains a mesotrophic lake.

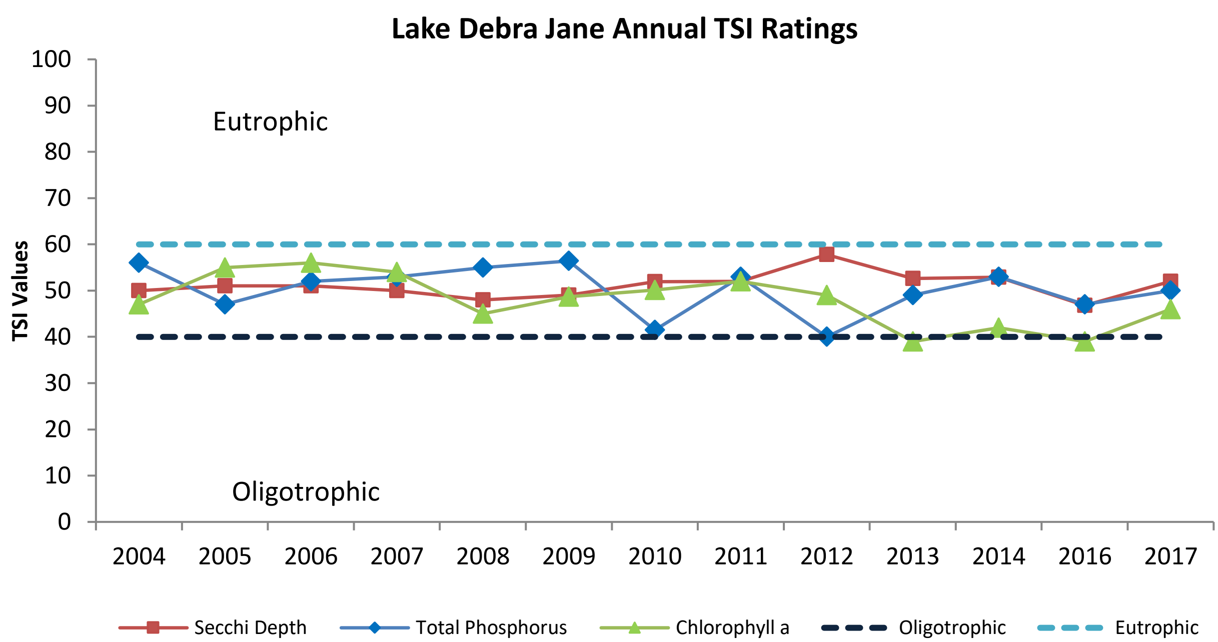

Figure 14.

Summary

Volunteers collected field data in 2017 on Lake Bonney and Lake Debra Jane beginning in early May and ending in late October. The data are summarized as follows:

- Thermal stratification in Lake Bonney was well underway at the first sampling date in early May, and turnover was complete by the last sampling date in late October. Lake Debra Jane is too shallow to stratify thermally.
- Secchi depth (transparency) in Lake Bonney ranged from 1.25 to 2.8 meters, with an average of 2.0 meters. Secchi depth in Lake Debra Jane ranged from 0.8 to 2.0 meters, with an average of 1.6 meters.
- Shallow total phosphorus concentrations ranged from 20 to 60 µg/l in Lake Bonney and 10 to 60 µg/l in Lake Debra Jane. Deep total phosphorus concentrations ranged from 20 to 100 µg/l in Lake Bonney; deep samples were not collected in Lake Debra Jane.
- Chlorophyll *a* concentrations ranged from 2 to 19 mg/m^3 in Lake Bonney, and from 5 to 74 mg/m^3 in Lake Debra Jane.
- TSI calculations for this (2017) summer classify both Lake Bonney and Lake Debra Jane as mesotrophic lakes.

Recommendations

Many lakes suffer from too much phosphorus, which comes from homes in the watershed that drain into the lake. When it rains the phosphorus and bacteria wash into ditches and down storm drains eventually ending up in the lake. This can lead to problems such as excessive algae and plants, lower water clarity, stressed fish and wildlife, and lower property values.

Phosphorus comes from many common household sources like fertilizers, pet and animal wastes, septic systems, and dirt from driveways, roofs, and erosion. Soils in our area are naturally rich in phosphorus.

Here are some voluntary actions lake watershed residents can take to protect the health of the lake:

- Avoid fertilizer. If you do fertilize choose phosphorus-free products.
- Scoop pet waste, bag it and toss it in the trash.
- Divert runoff from roofs and driveways into stable vegetated areas.
- If you have a septic system, schedule routine inspections.
- Cover bare soil area with mulch or plants.
- Fix eroding areas in the yard, driveway, and parking areas.
- Maintain existing natural shorelines – these areas provide additional wildlife benefits for birds, turtles, frogs and other aquatic life.

- Re-establish shoreline vegetation by replacing some lawn with other plants such as shrubs, trees, and perennials. The deeper roots of native trees and shrubs can trap and filter more phosphorus.