Water Quality Monitoring at Little Bitterroot Lake, Montana

Summary Monitoring Report 1999-2013

Submitted to:

Little Bitterroot Homeowners Association
Little Bitterroot Lake, Montana

WATER & ENVIRONMENTAL TECHNOLOGIES

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TABLE OF CONTENTS

ATTACHMENT A – FIGURES AND TABLES

Glossary of Terms

Bloom – a significant increase in algae population triggered by favorable conditions for growth

Chlorophyll *a* – a green pigment found in photosynthetic plants, algae and cyanobacteria

Depth profile – a chart showing a water chemistry parameter at various depths within a lake

Epilimnion – the uppermost portion of a stratified lake

Eutrophic – having high biological productivity (meso-eutrophic is moderately high), high productivity is commonly an indicator of high nutrients and poor water quality

Hypolimnion – the bottom layer of a stratified lake

Mesotrophic – having moderate biological productivity

Metalimnion – the middle (transitional) layer of a stratified lake

Oligotrophic – having low biological productivity (meso-oligotrophic is moderately low), low productivity is an indicator of low nutrient concentrations and good water quality

Trophic – relating to available nutrients (ex. trophic status)

Trophic status – a lake's ability to produce and sustain populations of algae in response to available nutrients, also referred to as lake productivity or biological productivity

1.0 Introduction

The Little Bitterroot Lake Association began in 1988 with the purpose of "preserving the high recreational value of Little Bitterroot Lake, maintaining its aesthetic integrity, and to educate the public and others as to the value of Little Bitterroot Lake as a recreational resource." Little Bitterroot Lake is the headwaters for the Little Bitterroot River and is located southwest of Kalispell near the community of Marion (**Attachment A**, **Figure 1**). The lake has a surface area of 11.8 km^2 (4.6 mi^2) and volume of 4.07 x 10^8 m^3. The lake outlet is controlled by an earthen dam built in 1918, and is managed by the Flathead Irrigation Project for downstream irrigators. Herrig Creek is the only perennial stream flowing into the lake, although there are approximately seven intermittent or ephemeral streams contributing seasonally to the lake. Groundwater also contributes a substantial portion of water to the lake, especially from mountains to the west and northeast. Local uses of the lake include water supply for domestic use, irrigation, fishing and recreational activities.

This report outlines the history of the monitoring program and presents results from 2013 and past monitoring events. Long term trends in nutrient concentrations and trophic status are provided for locations that have been sampled consistently since 1999.

2.0 Monitoring Program History

Water & Environmental Technologies (WET) personnel have completed 14 monitoring events since 1999 at Little Bitterroot Lake to document water quality, track changes in nutrient concentrations over time, and to characterize the lake's productivity and trophic status. Additional data have been collected by staff of the Flathead Lake Biological Station, Montana DEQ, Whitefish Lake Institute, and various volunteer groups, including Flathead High School Advanced Biology class and Little Bitterroot Lake Association with assistance from the Flathead Basin Commission.

The purpose of the monitoring program is to establish a water quality and nutrient baseline for the inflow, outflow, and lake water in conjunction with prior water quality projects. Information from this monitoring program may be used to make management decisions to help maintain the aesthetic and recreational conditions of the lake and surrounding drainages, and to help prioritize future monitoring efforts.

Past monitoring events conducted by Water & Environmental Technologies include:

November 30, 1999	May 24, 2000	September 27, 2004	September 1, 2005
September 25, 2006	October 8, 2007	October 13, 2008	October 5, 2009
June 3, 2010	August 23, 2010	September 20, 2011	September 10, 2012
May 20, 2013	August 29, 2013.		

Little Bitterroot Lake was also sampled on August 1 and October 10, 2013, by the Whitefish Lake Institute, which oversees the Northwest Montana Lakes Volunteer Monitoring Network. For comparison, results from sampling conducted by Whitefish Lake Institute in 2013 are included within this report. Laboratory analysis in 2013 was sponsored by a grant from the Volunteer Monitoring Support Program administered by Montana DEQ.

3.0 Field and Analytical Methods

During each monitoring event, samples are collected from seven to ten locations (**Figure 1**) and analyzed for field and nutrient parameters. Field parameters include water temperature, dissolved oxygen, specific conductance and pH. Nutrient parameters include forms of nitrogen (nitrate plus nitrite, ammonia, total kjeldahl nitrogen, organic nitrogen, total nitrogen) and phosphorous (dissolved ortho-phosphorous and total phosphorous), and analysis for chlorophyll-a concentration. Additional parameters have been analyzed during past sampling events to characterize water quality, including total dissolved solids, alkalinity, carbonate, bicarbonate, hydroxide, chloride, sulfate, calcium, magnesium, potassium, and sodium.

Grab samples for nutrient analysis are collected from 4 - 6 inches below the lake surface. Samples for dissolved ortho-phosphorus are filtered in the field using disposable filters and a hand pump. Samples are preserved (if necessary), labeled, placed in a cooler on ice with chain-of-custody documentation, and shipped for analysis at a certified laboratory. Samples for chlorophyll-a are wrapped in aluminum foil to prevent transmission of light which can degrade samples. All laboratory analyses use standard analytical methods. Field parameters are measured using a portable meter which is calibrated in the field prior to sampling.

The 2013 sampling events also included depth profile sampling for field and nutrient parameters. Depth profile sampling by WET personnel was conducted using a weighted 12 volt pump with a maximum sampling depth of 80 feet. Depth profile sampling by Whitefish Lake Institute was conducted using a portable Hydrolab meter which measures depth, field parameters, and chlorophyll-a with a maximum sampling depth of 140 feet.

The 2013 sampling events were conducted by WET on May 20 and August 29 and by Whitefish Lake Institute on August 1 and October 10. Sampling was conducted at 9 lake locations, the inlet stream (Herrig Creek) and the outlet (Little Bitterroot River. Depth profile sampling was conducted at the lake center location only. The 2013 monitoring events were conducted by John Babcock of WET, Josh Gubits of Whitefish Lake Institute, Anna Marie Bailey and additional members of the Little Bitterroot Homeowners Association.

4.0 Monitoring Results

4.1 2013 Results

Results from the May and August 2013 sampling events are provided in tabular form as **Table 1** in **Attachment A**, and data for total nitrogen and total phosphorus are shown spatially in **Attachment A** in **Figure 2**, organized left to right from the lake inlet (Herrig Creek) to the lake outlet (Little Bitterroot River). In general, nutrient concentrations in 2013 were higher in August than in May. Nitrogen concentrations were highest at the inlet and outlet streams during August, and were consistently low at all sites during May. The highest concentrations of total phosphorus were recorded in August at the lake inlet and in May at the lake center and lake outlet.

Results from depth profile sampling in 2013 are shown in **Figure 3**, including charts for water temperature, dissolved oxygen, pH, and chlorophyll-a concentration. During the May 2013

sampling event, the lake was starting to stratify with higher water temperatures near the surface. During August 2013, the lake was well stratified with an epilimnion (upper layer) from 0 to 25 feet, a metalimnion (transitional layer) from approximately 25 to 100 feet, and a hypolimnion from approximately 100 feet to the lake bottom. By October 2013, the lake was still stratified and the epilimnion had extended to approximately 45 feet below the lake surface. Chlorophyll-a results show the highest concentrations in the metalimnion at approximately 65-80 feet below surface. Chlorophyll-a measurements coincide with the highest concentrations of dissolved oxygen, which is produced by photosynthetic algae in the water column. Dissolved oxygen concentrations are well above the threshold for aquatic life (5 mg/L) throughout the water column, which is typical of an oligotrophic lake with good water quality and low biological productivity.

4.2 Long Term Trends

Results from 2004 to 2013 are shown for all sample locations in **Figure 4,** and **Figure 5** shows minimum, maximum, and average results from 2004-2012. Nutrient concentrations have generally shown a decreasing trend since consistent yearly monitoring began in 2004. In 2013, Little Bitterroot Lake had the lowest average total nitrogen concentration for the entire sampling period, and the second lowest average total phosphorus concentration. Although these trends are encouraging from the standpoint of improving water quality, trends should be interpreted with caution because of the limited data available for Little Bitterroot Lake. Nutrient concentrations can vary significantly between seasons or change rapidly due to episodic events such as runoff or lake turnover, so sample events may not coincide with periods of peak nutrient concentration. Data and trends will become more robust as future measurements are added to the dataset, and continuity and consistency are maintained within the monitoring program.

Data from the entire sampling period (1999 to 2013) were also analyzed spatially by combining all measurements for each sample location, shown in **Figure 6**. These charts show the minimum, maximum, and average nutrient concentrations for each sample site. Sample locations are organized from left to right in the general direction of flow through the lake, from the inlet at Herrig Creek to the outlet at the Little Bitterroot River. Average concentrations of total nitrogen are lowest at the lake center and highest at the lake outlet. Concentrations of total phosphorus are lowest at the inlet and at Slaughter House Bay, and are highest at the center of the lake. However, results for total nitrogen and phosphorus are quite variable at each location and differences between sample locations are not statistically significant.

4.3 Trophic Status

Trophic status refers to a lake's ability to produce and sustain populations of algae in response to available nutrients, also referred to as biological productivity. High biological productivity is an indicator of high nutrients and poor water quality, whereas low biological productivity is an indicator of low nutrient concentrations and good water quality. The trophic status of Little Bitterroot Lake was determined by calculating the Carlson's Trophic State Index (TSI) from measurements of total nitrogen, total phosphorus and chlorophyll-a (Carlson, 1977). The TSI for Little Bitterroot Lake is shown in **Figure 7** for data from 2004 to 2013.

TSI data suggest that Little Bitterroot Lake is classified as eutrophic based on concentrations of total nitrogen; however, measurements of total phosphorus and chlorophyll-a indicate that the lake is oligotrophic with low biological productivity. Total phosphorus concentrations in 2013 were among the lowest measured during the sampling period, suggesting oligotrophic conditions.

Despite having relatively high concentrations of total nitrogen, Little Bitterroot Lake typically does not experience large blooms of nuisance algae and has shown low chlorophyll-a concentrations during sample events conducted in 2010 and 2013. The low biological productivity is likely because the lake's morphology is favorable to oligotrophic conditions and limited by low phosphorus concentrations. Little Bitterroot Lake has steep sides, limited littoral (shallow shoreline) habitat, and a low watershed/lake ratio of 4.8 (Ellis et al. 1998). The lake appears to be phosphorus-limited, meaning that it has an adequate amount of nitrogen compared to the amount of phosphorus needed to support algae growth. Lakes that are phosphorus-limited often show increased algae growth when phosphorus concentrations increase, but not necessarily when nitrogen concentrations increase. Total phosphorus is commonly associated with sediment, so high concentrations often occur in years following land disturbance (such as road building or logging) or increased precipitation and runoff.

5.0 Conclusions

Water quality in Little Bitterroot Lake was very good in 2013, with low concentrations of nutrients and chlorophyll-a. Total nutrient concentrations (nitrogen and phosphorus) have generally been decreasing since the inception of the monitoring program in 1999. The highest concentrations of total nitrogen have typically occurred at Herrig Creek Bay and the lake outlet, while the highest concentrations of total phosphorus have occurred at the lake center. Past sampling events indicate that lake water quality is strongly influenced by ground water inflow.

The trophic state index for Little Bitterroot Lake suggests eutrophic conditions exist due to high concentrations of total nitrogen, but recent measurements of total phosphorus and chlorophyll-a indicate oligotrophic conditions with low biological productivity. Little Bitterroot Lake is likely phosphorus-limited, meaning it has an inadequate amount of phosphorus compared to the amount of nitrogen needed to support algae growth. Based on this observation, Little Bitterroot Lake is more likely to experience algae blooms with the addition of phosphorus since concentrations of nitrogen are already relatively elevated. However, nutrient concentrations can vary significantly, and efforts to reduce inputs of both phosphorus and nitrogen should be encouraged to help maintain the water quality of Little Bitterroot Lake and limit algae growth.

Overall, Little Bitterroot Lake was shown excellent water quality throughout its monitoring history. Nutrient and chlorophyll-a concentrations are low, algae blooms are rare, and field data indicate suitable ranges of temperature, dissolved oxygen and pH to support a viable fishery. Water quality monitoring activities are planned to be continued in 2014 with support from Water & Environmental Technologies and Whitefish Lake Institute, and grant funding for laboratory analysis from the Volunteer Monitoring Support Program administered by Montana DEQ. Water quality sampling is planned for early August 2014 for nutrients, chlorophyll-a, and depth profile sampling. Depth profile sampling is also planned to be conducted in October 2014 by Whitefish Lake Institute.

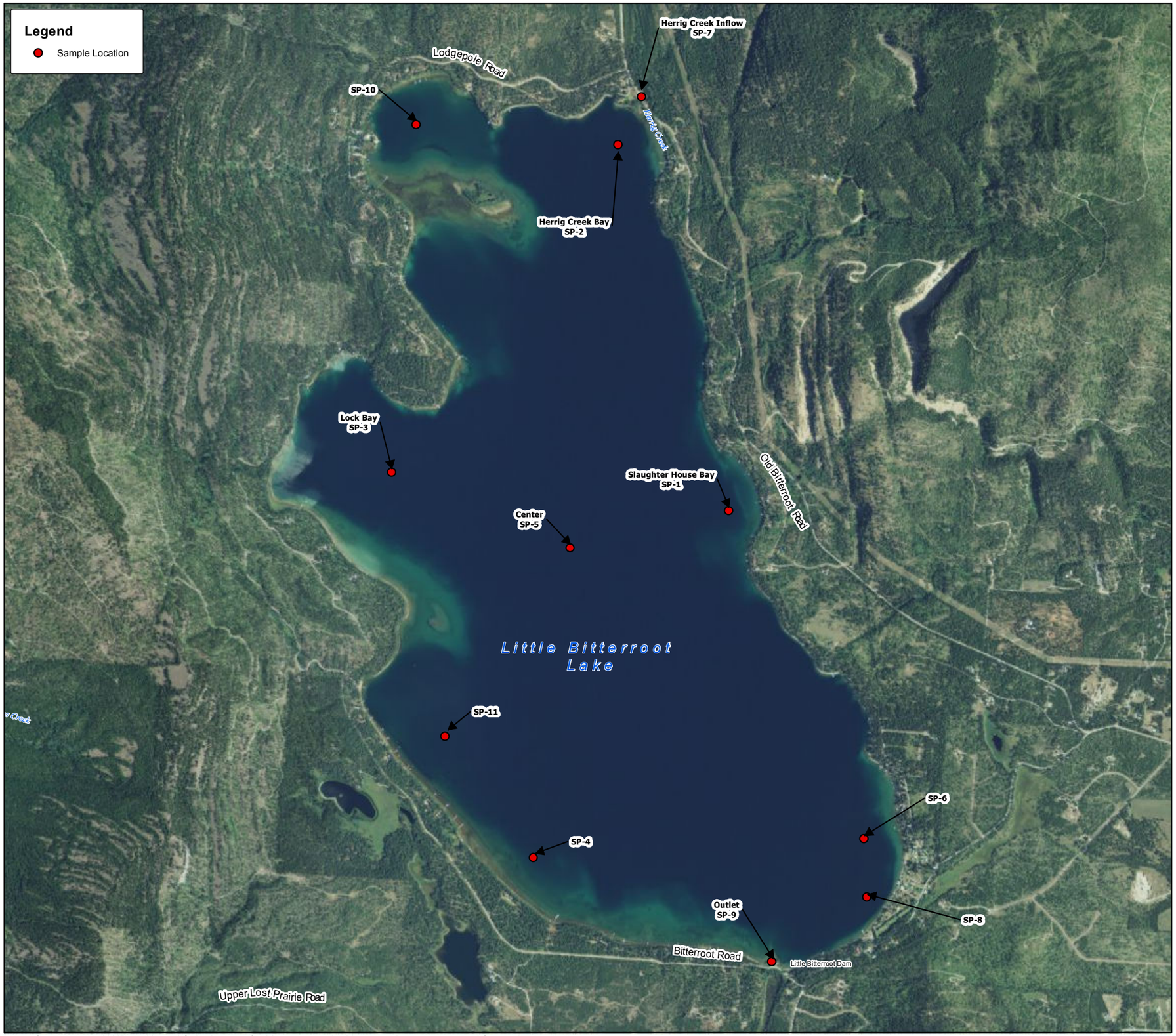
6.0 References

Carlson, R.E. (1977). A trophic state index for lakes. Limnol. Oceanogr. 22, 361-9.

Ellis, B. K., J. A. Craft and J. A. Stanford. (1998). Baseline Water Quality Study of Little Bitterroot, Mary, Ronan, Ashley and Lindbergh Lakes, Montana. Flathead Lake Biological Station, Open File Report 148-98: 1-93.

Whitefish Lake Institute. (2013). Montana Lake Book – Second Edition. Whitefish, MT. Available online at: http://www.nwmtlvmn.org/docs/Montana%20Lake%20Book%202nd.pdf.

Attachment A – Figures and Tables



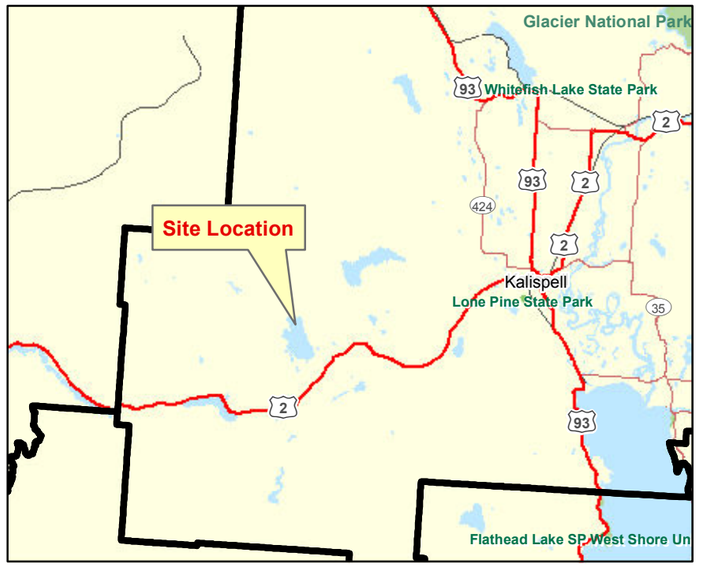


Image Source: 2009 NAIP 1m Natural Color Imagery for Montana acquired between June 23, 2009 and September 2, 2009.

N
W E
S

1 inch = 2,000 feet
Feet
0 1,000 2,000

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Little Bitteroot Lake
Site Location

LBHH M01

10/30/09

FIGURE 1

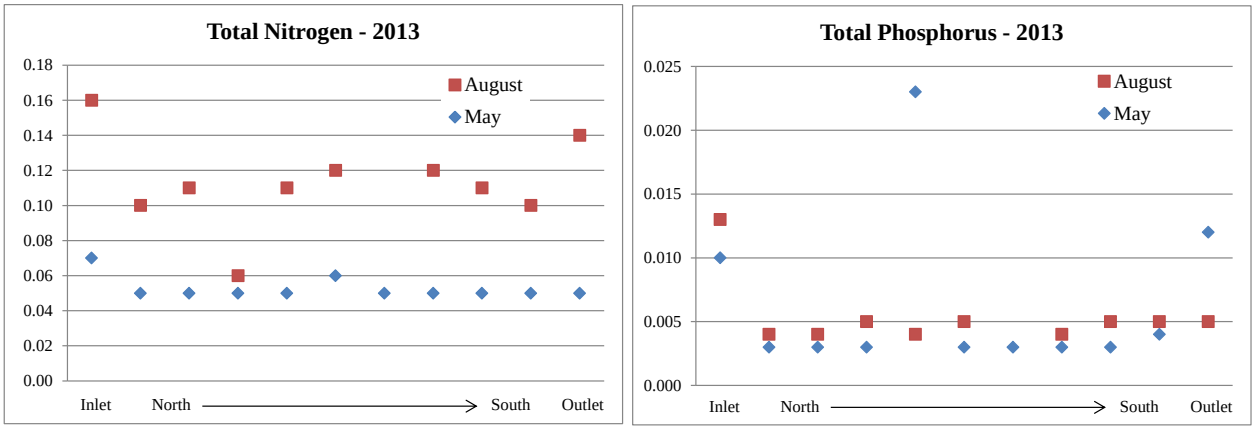


Figure 2. Total Nitrogen and Total Phosphorus Results for 2013.

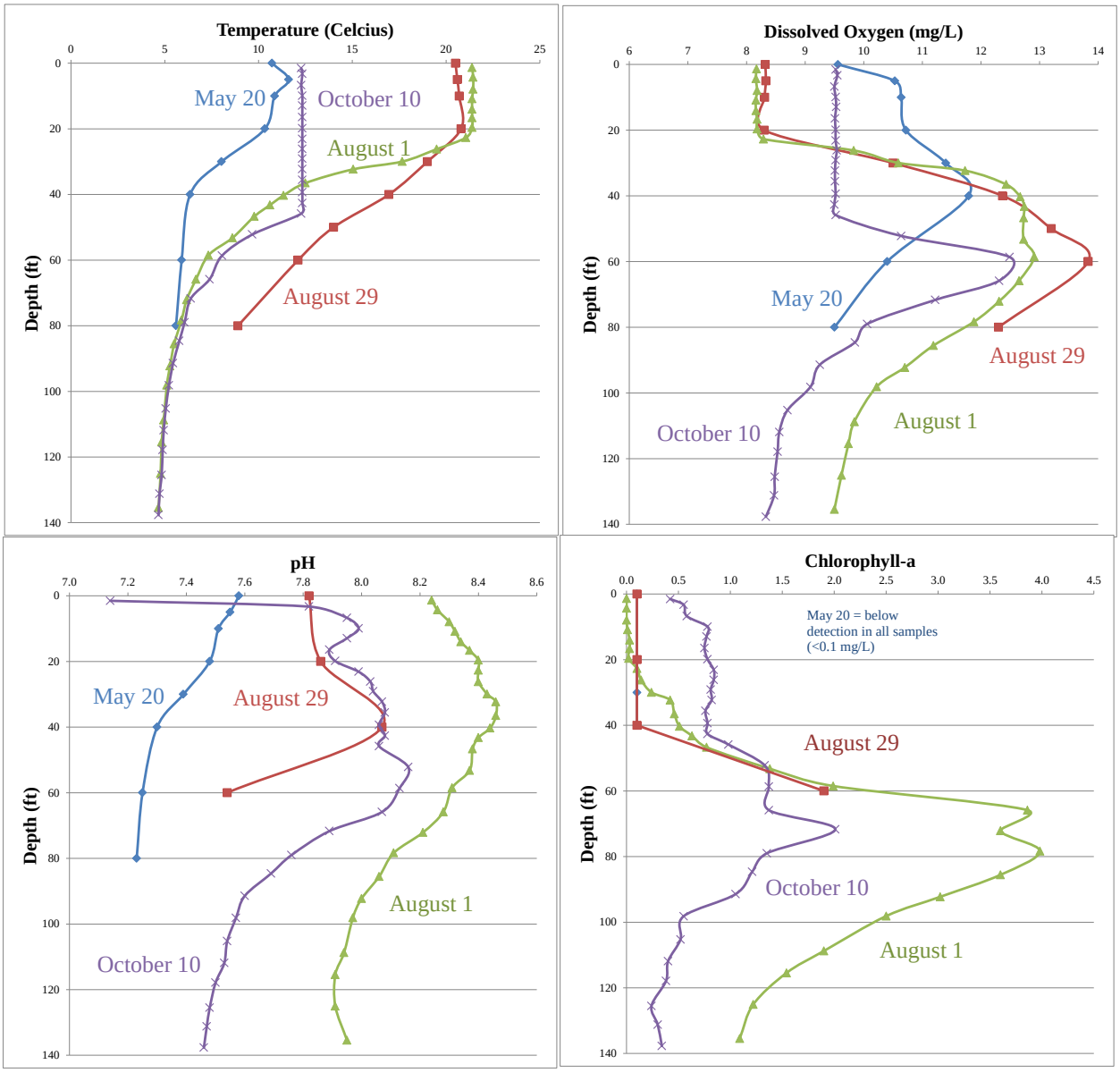
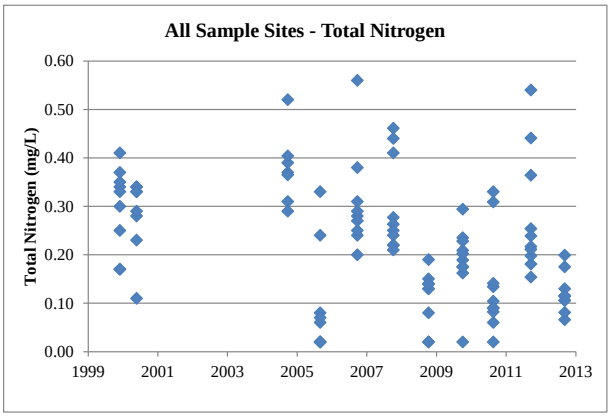


Figure 3. Depth Profile Resutls for 2013.



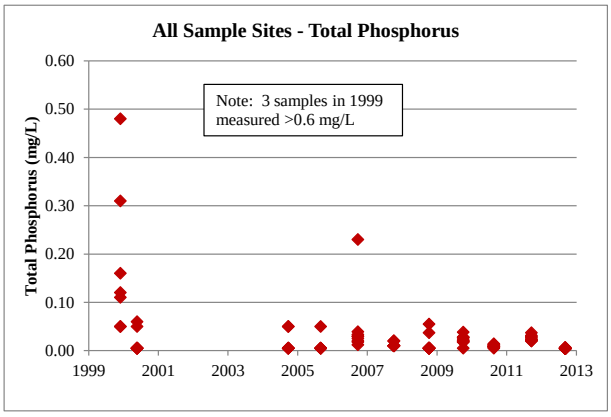
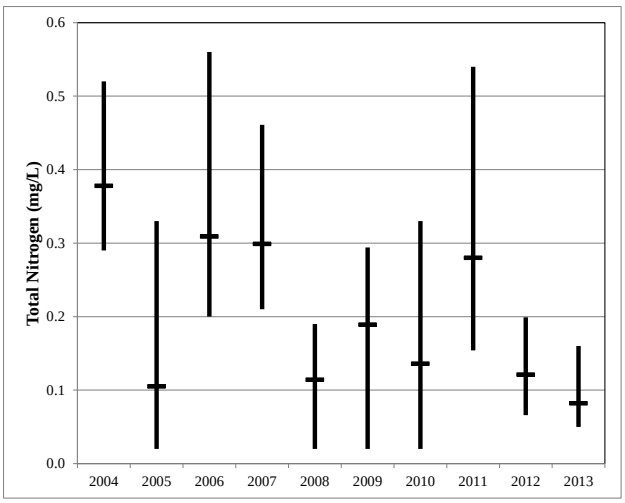


Figure 4. Total Nitrogen and Total Phosphorus Results for 2004-2013.



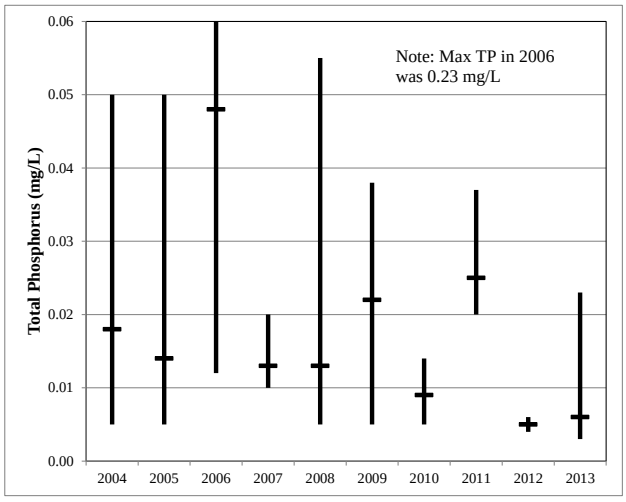
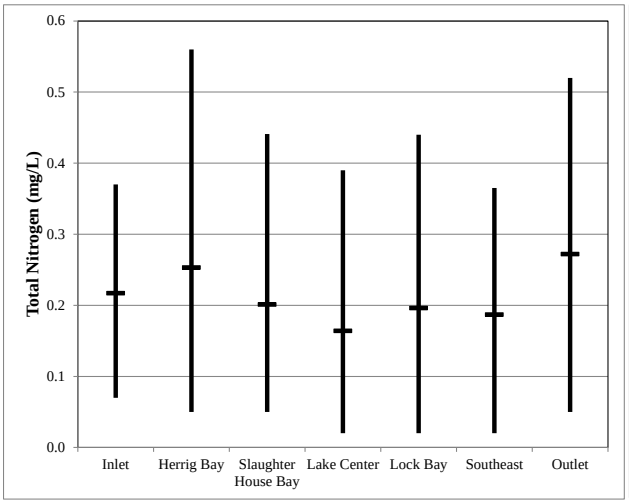


Figure 5. . Yearly Nutrient Statistics (Minimum, Maximum, Average) from 2004-2013.



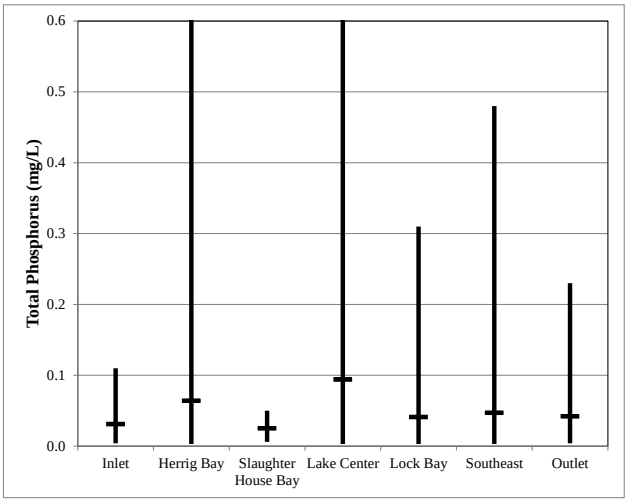


Figure 6. Spatial Nutrient Statistics (Minimum, Maximum, Average) from 1999-2013.

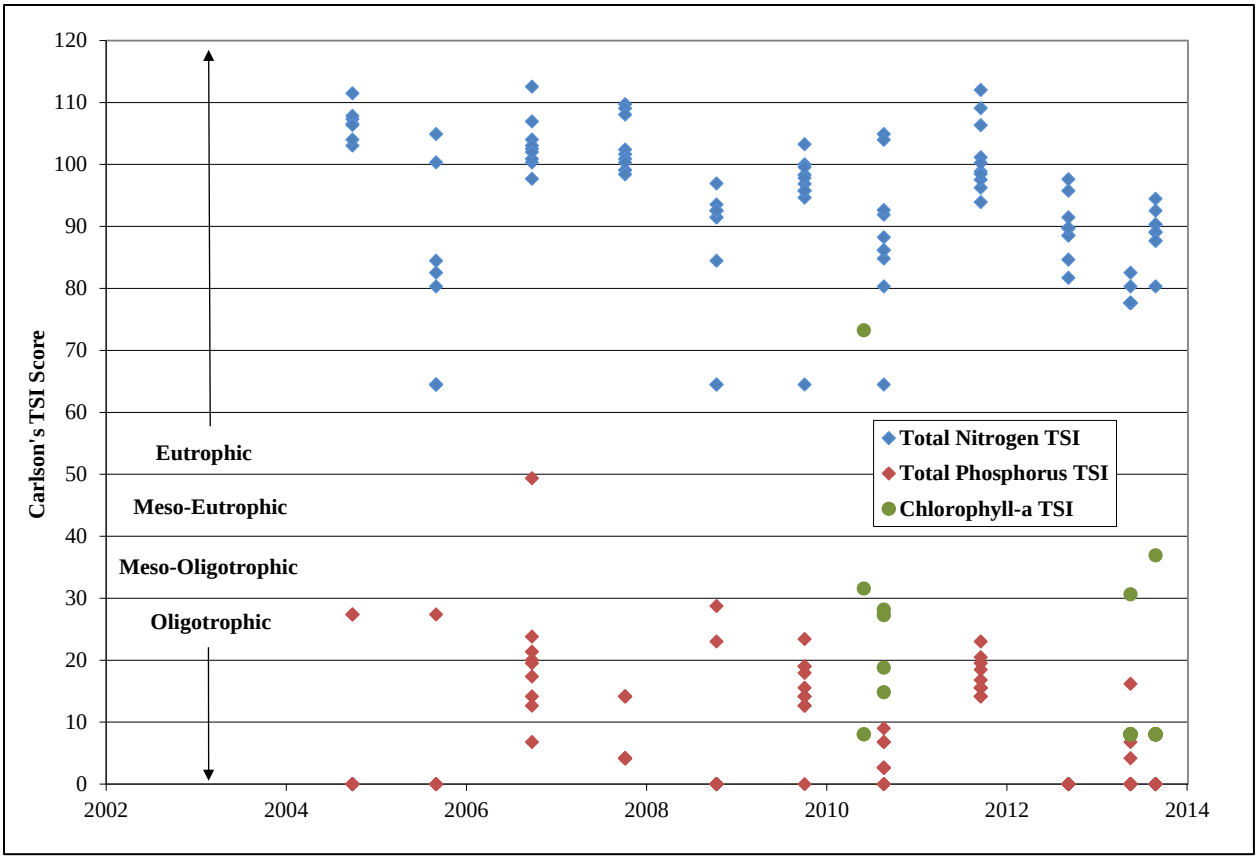


Figure 7. Trophic Status of Little Bitterroot Lake from 2004-2013.

Table 1. 2013 Water Quality Data.

Sample Info			Field Water Quality				Nutrients					
Date	Site ID	Site Description	Temp (°C)	Dissolved Oxygen (mg/L)	Specific Conductance (uS/cm)	pH	Nitrate + Nitrite Nitrogen (mg/L)	Ammonia Nitrogen (mg/L)	Total Nitrogen (mg/L)	Ortho Phosphorus (mg/L)	Total Phosphorus (mg/L)	Chlorophyll-a (mg/L)
							0.01	0.05	0.04	0.001	0.003	0.1
5/20/2013	SP-7	Inlet - Herrig Cr.	9.61	9.7	30	6.62	0.01	0.05	0.07	0.005	0.010	
	SP-2	North - Herrig Cr. Bay	11.22	9.6	102	7.54	0.01	0.05	0.05	0.003	0.003	0.1
	SP-10	Northwest - Northwest Bay	10.20	10.0	104	7.51	0.01	0.05	0.05	0.002	0.003	0.1
	SP-1	East - Slaughter House Bay	10.79	9.9	105	7.61	0.01	0.05	0.05	0.003	0.003	0.1
	SP-5	Center - 0' Depth	10.72	9.6	102	7.58	0.01	0.05	0.05	0.003	0.023	0.1
	SP-5	Center - 5' Depth	11.61	10.5	105	7.55						
	SP-5	Center - 10' Depth	10.86	10.6	103	7.51						
	SP-5	Center - 20' Depth	10.34	10.7	103	7.48						
	SP-5	Center - 30' Depth	8.03	11.4	103	7.39	0.01	0.05	0.05	0.002	0.003	0.1
	SP-5	Center - 40' Depth	6.35	11.8	105	7.30	0.01	0.05	0.05	0.003	0.003	0.1
	SP-5	Center - 60' Depth	5.90	10.4	103	7.25						
	SP-5	Center - 80' Depth	5.60	9.5	103	7.23						
	SP-3	West - Lock Bay	11.23	9.8	104	7.56	0.01	0.05	0.06	0.002	0.003	0.1
	SP-11	Southwest - Near Point	11.97	10.0	105	7.49	0.01	0.05	0.05	0.003	0.003	0.1
	SP-4	Southwest - Moose Lake	11.55	9.9	103	7.55	0.01	0.05	0.05	0.003	0.003	0.1
	SP-6	Southeast - Kenebret	11.97	9.7	103	7.54	0.01	0.05	0.05	0.005	0.003	0.1
	SP-8	Southeast - Carter	11.09	8.9	103	7.70	0.01	0.05	0.05	0.003	0.004	1.0
	SP-9	Outlet - Ltl. Bitterroot R.	12.06	9.5	104	7.62	0.01	0.05	0.05	0.003	0.012	
8/29/2013	SP-7	Inlet - Herrig Cr.	14.97	10.2	51	7.27	0.01	0.05	0.16	0.007	0.013	
	SP-2	North - Herrig Cr. Bay	20.46	7.9	108	7.87	0.01	0.05	0.10	0.005	0.004	0.1
	SP-10	Northwest - Northwest Bay	20.42	8.3	111	7.85	0.01	0.05	0.11	0.005	0.004	0.1
	SP-1	East - Slaughter House Bay	20.59	8.3	107	7.90	0.01	0.05	0.06	0.007	0.005	0.1
	SP-5	Center - 0' Depth	20.50	8.3	109	7.82	0.01	0.05	0.11	0.004	0.004	0.1
	SP-5	Center - 5' Depth	20.60	8.3	110	7.84						
	SP-5	Center - 10' Depth	20.70	8.3	111	7.85						
	SP-5	Center - 20' Depth	20.80	8.3	112	7.86	0.01	0.05	0.09	0.004	0.005	0.1
	SP-5	Center - 30' Depth	19.00	10.5	106	7.94						
	SP-5	Center - 40' Depth	16.95	12.4	105	8.07	0.01	0.05	0.10	0.004	0.004	0.1
	SP-5	Center - 50' Depth	14.00	13.2	105	7.74						
	SP-5	Center - 60' Depth	12.11	13.8	104	7.54	0.01	0.05	0.12	0.005	0.005	1.9
	SP-5	Center - 80' Depth	8.90	12.3	104	7.50						
	SP-3	West - Lock Bay	20.34	8.3	111	7.81	0.01	0.05	0.12	0.004	0.005	0.1
	SP-4	Southwest - Moose Lake	20.31	8.4	110	7.83	0.01	0.05	0.12	0.004	0.004	0.1
	SP-6	Southeast - Kenebret	20.58	8.4	111	7.87	0.01	0.05	0.11	0.007	0.005	0.1
	SP-8	Southeast - Carter	20.67	8.3	109	7.96	0.01	0.05	0.10	0.006	0.005	0.1
	SP-9	Outlet - Ltl. Bitterroot R.	20.76	8.0	109	7.73	0.01	0.05	0.14	0.006	0.005	