2007 Inland and Purdy Reservoirs Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
June 2012

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LIST OF ACRONYMS

A&I	Agriculture and Industry water supply use classification
ADEM	Alabama Department of Environmental Management
AGPT	Algal Growth Potential Test
BW	Black Warrior
CHL *a*	Chlorophyll *a*
DO	Dissolved Oxygen
F&W	Fish and Wildlife
MAX	Maximum
MDL	Method Detection Limit
MIN	Minimum
MSC	Maximum Standing Crop
NTU	Nephelometric Turbidity Units
OAW	Outstanding Alabama Waters
ONRW	Outstanding National Resource Water
PWS	Public Water Supply
QAPP	Quality Assurance Project Plan
RRMP	Rivers and Reservoirs Monitoring Program
S	Swimming and Other Whole Body Water-Contact Sports
SD	Standard Deviation
SOP	Standard Operating Procedures
TEMP	Temperature
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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INTRODUCTION

Inland Reservoir

Inland Reservoir's 1,095 acre water body was established in 1939. The reservoir is owned and operated by the Birmingham Water Works and Sewer Board of Birmingham, primarily for water supply. In 2004, the ADEM implemented a specific water quality criterion for nutrient management at one location on Inland Reservoir, which has been monitored by ADEM since 2002. This criterion represents the maximum growing season mean (April-October) chlorophyll *a* (chl *a*) concentration allowable while still fully supporting the reservoir's Public Water Supply and Swimming (PWS/S) use classifications.

Purdy Reservoir

Purdy Reservoir's 1,050 acre water body was established with the completion of the dam in 1929. The reservoir is also owned and operated by the Birmingham Water Works and Sewer Board of Birmingham and is designated with Public Water Supply and Fish & Wildlife (PWS/F&W) use classifications. No criterion existed on this lake in 2007, however this study provided data toward criteria development and eventually criteria establishment at both sampling stations in 2010.

The Alabama Department of Environmental Management (ADEM) monitored Inland and Purdy Reservoirs as part of the 2007 assessment of the Black Warrior and Cahaba River (BWC) Basins under the Rivers and Reservoirs Monitoring Program (RRMP). Implemented in 1990, the objectives of this program are to provide data that can be used to assess current water quality conditions, identify trends in water quality conditions, and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria. Descriptions of all RRMP monitoring activities are available in ADEM's 2012 Monitoring Strategy.

The purpose of this report is to summarize data collected at both Inland and Purdy Reservoirs during the 2007 growing season and to evaluate growing season trends in mean lake trophic status and nutrient concentrations using ADEM's 5 year dataset. Monthly and growing season mean concentrations of nutrients [total nitrogen (TN); total phosphorus (TP)], algal biomass/productivity [chl *a*; algal growth potential testing (AGPT)], sediment [total suspended solids (TSS)], and trophic state [Carlson's trophic state index (TSI)] were compared to ADEM's historical data and established criteria.

METHODS

Sampling stations were selected using historical data and previous assessments (Fig. 1). Specific location information can be found in Table 1. Inland was sampled in the dam forebay. Purdy was sampled at the dam forebay with one additional station in the upper reservoir.

Water quality assessments were conducted at monthly intervals, April-October. Growing season mean TN, TP, chl *a*, and TSS were calculated to evaluate water quality conditions at each site. All samples were collected, preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operating Procedures (ADEM 2007), Surface Water Quality Assurance Project Plan (ADEM 2005), and Quality Management Plan (ADEM 2003).

Figure 1. Purdy Reservoir with 2007 sampling locations. A description of each sampling location is provided in Table 1.

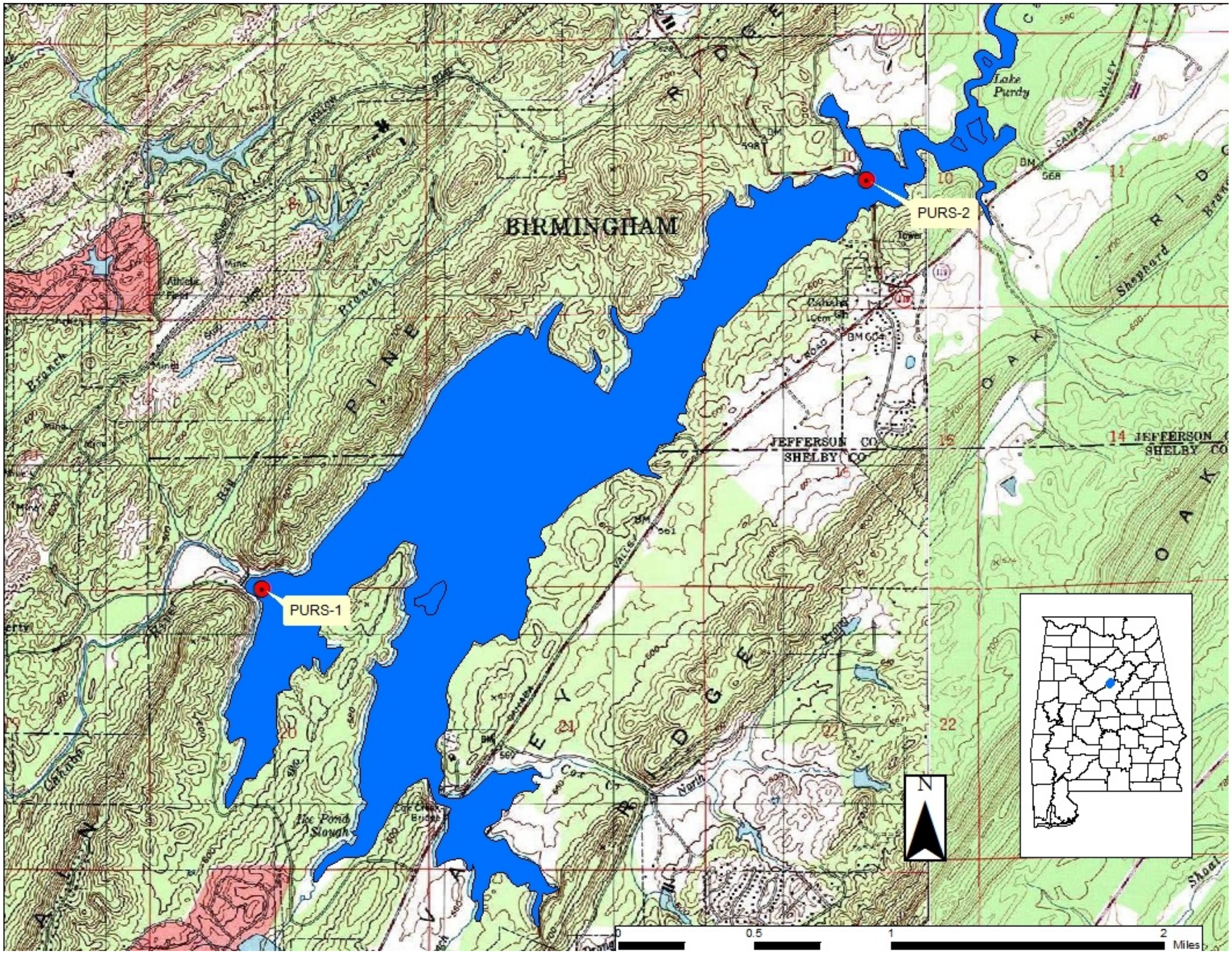


Figure 2. Inland Reservoir with its 2007 sampling location. A description of the sampling location is provided in Table 1.

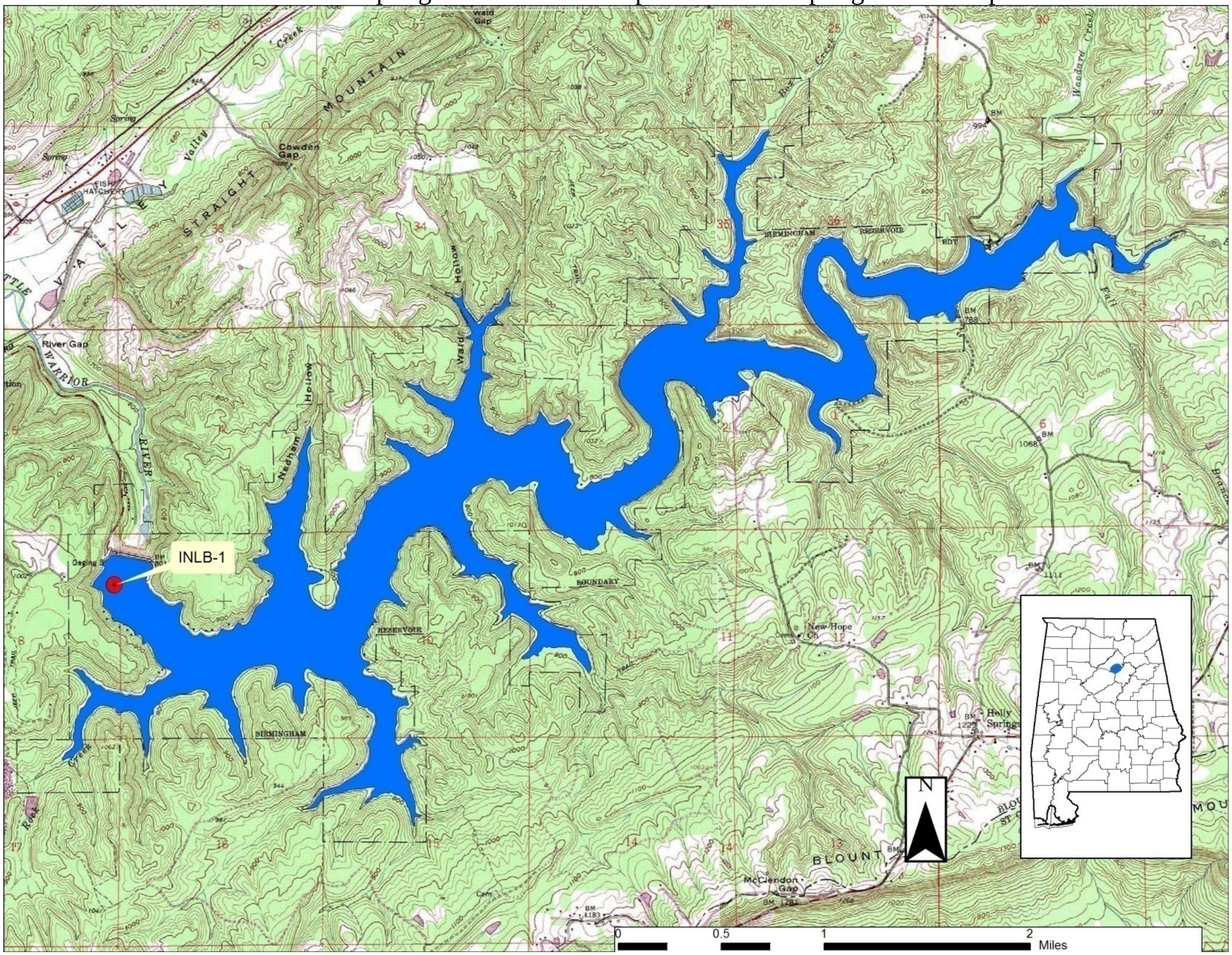


Table 1. Descriptions of the 2007 monitoring stations.

HUC	County	Station Number	Report Designation	Waterbody Name	Station Description	Chl *a* Criteria	Latitude	Longitude
Purdy Reservoir								
031502020103	Shelby	PURS-1	Lower Purdy	Cahaba R	Deepest point, main river channel, dam forebay.	**	33.459449	-86.667274
031502020103	Jefferson	PURS-2	Upper Purdy	Cahaba R	Deepest point, main river channel, immed. downstream of Irondale Bridge.	**	33.481067	-86.628783
Inland Reservoir								
031601110204	Blount	INLB-1*	Inland	Black Warrior R	Deepest point, main river channel, dam forebay.	6 µg/l	33.834688	-86.550942

*Growing season mean chl *a* criteria implemented at this station in 2004.

**Chl *a* criteria implemented at this station in 2010 does not apply to this report.

RESULTS

Growing season mean graphs for TN, TP, chl *a*, TSS, and TSI are provided in this section (Figs. 3, 4, and 12). Monthly graphs for TN, TP, chl *a*, TSS and DO are also provided (Figs. 5-8). Mean monthly discharge is included in monthly graphs for TN, TP, chl *a*, and TSS as an indicator of flow and retention time in the months sampled. Algal growth potential test (AGPT) results appear in Table 2. Depth profile graphs of temperature, DO, and conductivity appear in Figs. 10-11. Summary statistics of all data collected during 2007 are presented in Appendix Table 1. The table contains the minimum, maximum, median, mean, and standard deviation of each parameter analyzed.

According to the National Weather Service, during 2007 Alabama recorded its driest January through August period in the past 100 years. The drought was intensified by a drier than normal preceding winter and spring. Though difficult to quantify, drought of this magnitude will affect water quality in a number of ways and is a likely factor in many of the results to follow.

Stations with the highest concentrations of nutrients, chlorophyll, and TSS are noted in the paragraphs to follow. Though stations with lowest concentrations are not mentioned, review of the graphs that follow will indicate these stations that may be potential candidates for reference waterbodies and watersheds.

In 2007, seasonal mean TN concentrations decreased at both Purdy stations compared to the previous year, which were the highest recorded values at these two stations (Fig. 3). The historical record of seasonal mean TN concentrations at upper Purdy only contains two values but the concentration in 2007 was half of that in 2006 (Fig. 3). Inland had the lowest seasonal mean TN on record during 2007 (Fig. 3). Monthly TN concentrations at lower Purdy were above historic means in all months except July, when the concentration was lowest (Fig. 5). Monthly TN concentrations at Inland were below historic means, April-October (Fig. 5).

Seasonal mean TP concentrations in lower Purdy have decreased each year since 2003 while Inland remained variable each year sampled (Fig. 3). At upper Purdy, mean TP concentrations were lower in 2007 then 2006 (Fig. 3). Monthly TP concentrations for all Purdy and Inland stations were below historic means for most months, April-October (Fig. 6).

Seasonal mean chl *a* concentrations at both Purdy stations decreased from the previous year values but varied little from historic concentrations (Fig. 4). Monthly chl *a* concentrations at both Purdy stations generally increased throughout the season, reaching highest concentrations in October (Fig. 7). A specific water quality criterion for nutrient management was established on Inland in 2005. The 2007 mean chl *a* concentration measured at Inland was the highest on record and above the criteria limit (Fig. 4). The higher seasonal mean concentration can be attributed to unusually high monthly chl *a* concentrations in June and September, all other months were below historic means (Fig. 7).

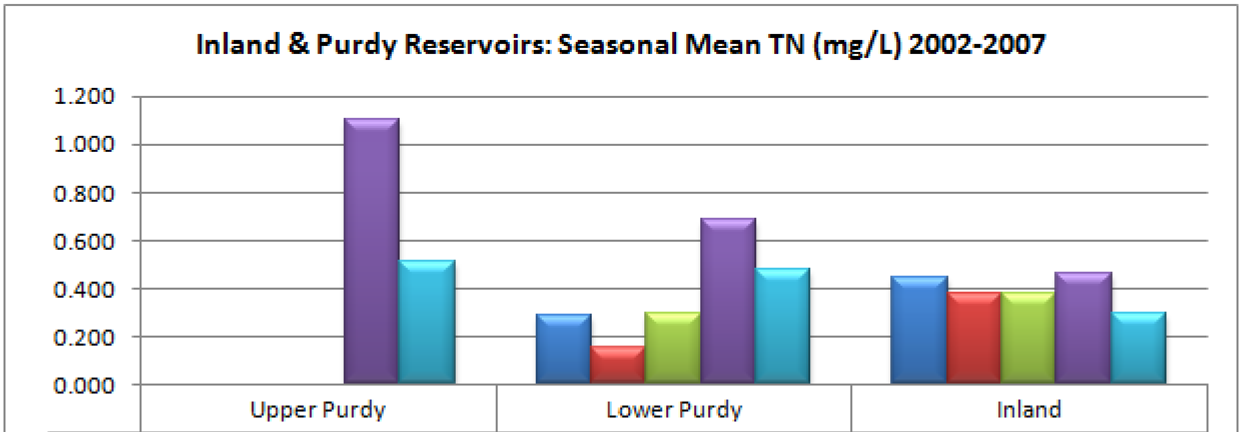
Seasonal mean TSS concentrations in lower Purdy have decreased each year since 2003, returning to a similar concentration to 2002 (Fig. 4). The seasonal mean TSS concentration for Inland, in 2007, was the lowest measured on record (Fig. 4). Monthly TSS concentrations at lower Purdy were below historic means May-September and highest in October, while concentrations in upper Purdy were variable and lowest in October. Inland TSS concentrations were below historic means April-October (Fig. 8).

AGPT results for 2007 indicated that both Purdy and Inland Reservoirs continued to be phosphorus-limited at all stations compared to previous sampling events with the exception of a non-limiting MSC at the lower station in August 2006 (Table 2). All maximum standing crop (MSC) values were well below 5 mg/L, the value that Raschke et al. (1996) defined as protective of reservoir and lake systems.

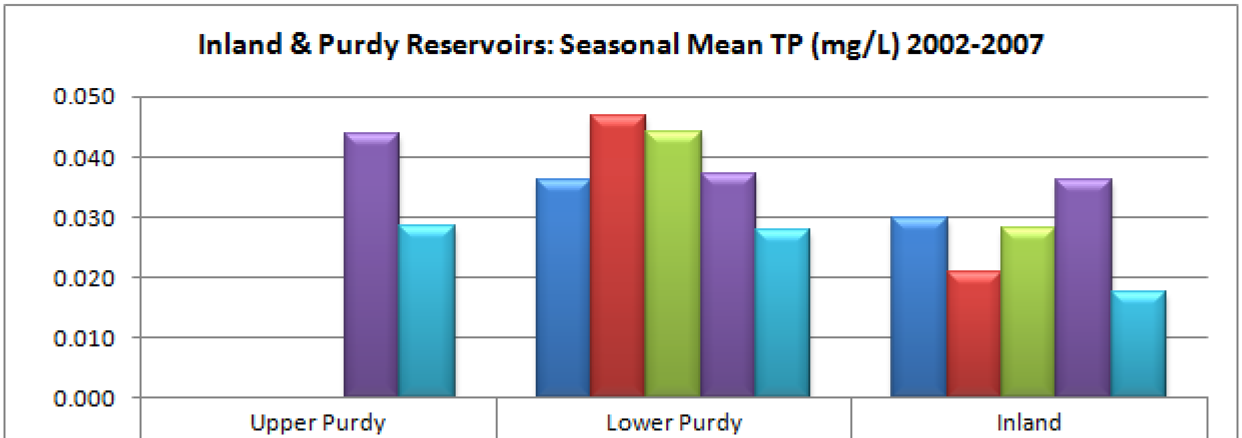
All measurements of dissolved oxygen concentrations at the upper Purdy and Inland reservoir stations met the ADEM Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/l at 5.0 ft (1.5 m)(Fig. 9). The dissolved oxygen concentration at the lower Purdy station was below ADEM criteria limits in October (Fig. 9). Profiles of dissolved oxygen concentrations and temperature indicated that the water column was stratified at both lower Purdy and Inland, in all months, April-October (Fig. 10 & 11). Warmest water temperatures were reached in August, with conductivity increasing below the thermocline in Purdy and remaining similar throughout the water column at Inland (Fig. 10 & 11).

Mean growing season TSI values for lower Purdy indicate eutrophic conditions in all years sampled while Inland fluctuated within the mesotrophic range (Fig. 12). Both stations appear to be stable within their respective categories.

Figure 3. Growing season mean TN and TP measured in Inland and Purdy Reservoirs, April-October.

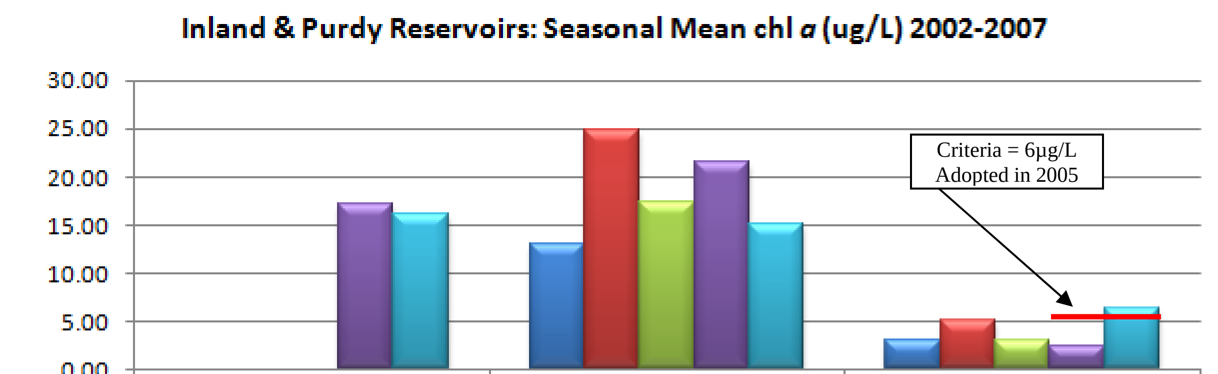


	Upper Purdy	Lower Purdy	Inland
2002		0.285	0.445
2003		0.150	0.379
2004		0.295	0.378
2006	1.100	0.685	0.462
2007	0.511	0.475	0.298

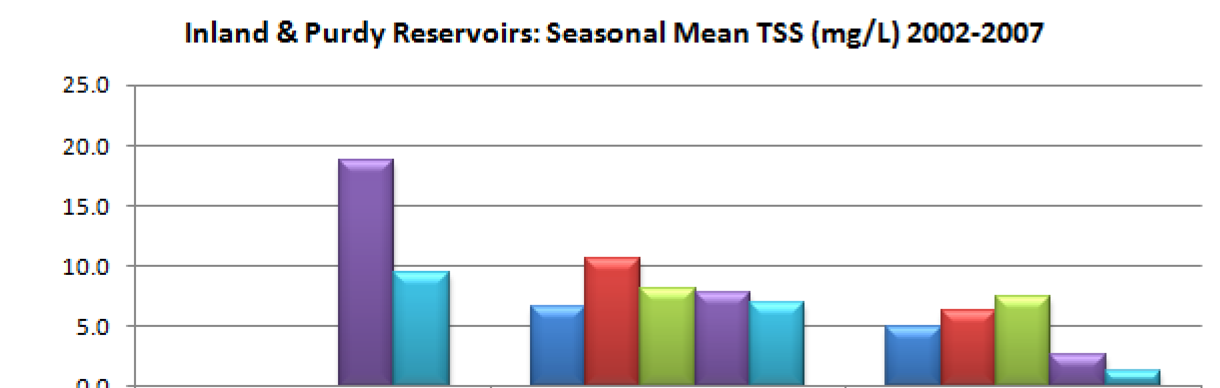


	Upper Purdy	Lower Purdy	Inland
2002		0.036	0.030
2003		0.047	0.021
2004		0.044	0.028
2006	0.044	0.037	0.036
2007	0.028	0.028	0.018

Figure 4. Growing season mean chl *a* and TSS measured in Inland and Purdy Reservoirs, April-October. Chl *a* criteria applies to the growing season mean of the Inland station only.



	Upper Purdy	Lower Purdy	Inland
2002		12.92	3.01
2003		24.76	5.00
2004		17.33	2.98
2006	17.07	21.47	2.40
2007	16.12	15.11	6.23



	Upper Purdy	Lower Purdy	Inland
2002		6.57	4.86
2003		10.57	6.29
2004		8.14	7.43
2006	18.71	7.71	2.64
2007	9.36	6.86	1.21

Figure 5. Monthly TN of the stations in Inland and Purdy Reservoirs, April-October 2007. Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The “n” value equals the number of datapoints included in the monthly historic calculations. Historic comparisons were only graphed when more than three values existed.

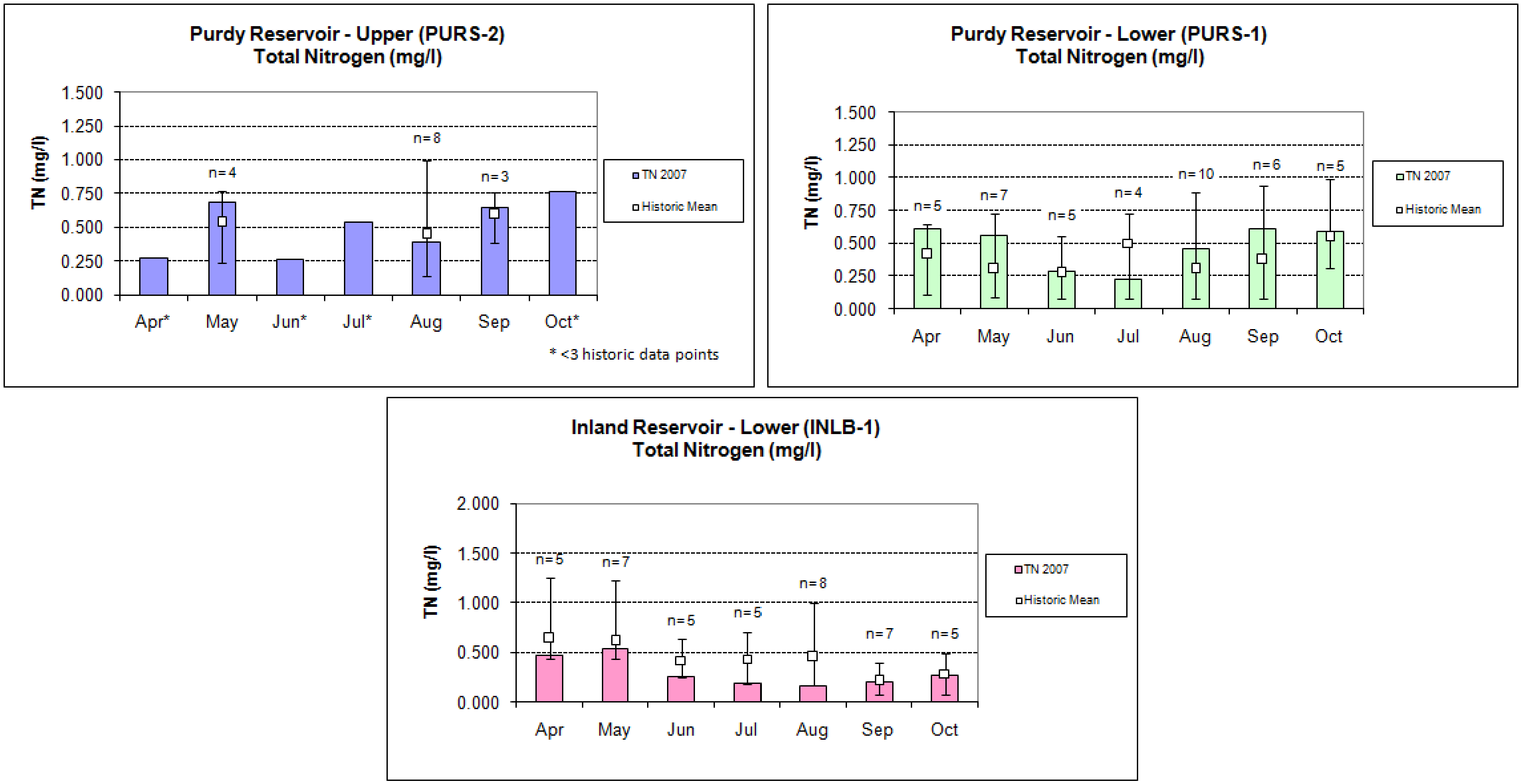


Figure 6. Monthly TP of the stations in Inland and Purdy Reservoirs, April-October 2007. Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The “n” value equals the number of datapoints included in the monthly historic calculations. Historic comparisons were only graphed when more than three values existed.

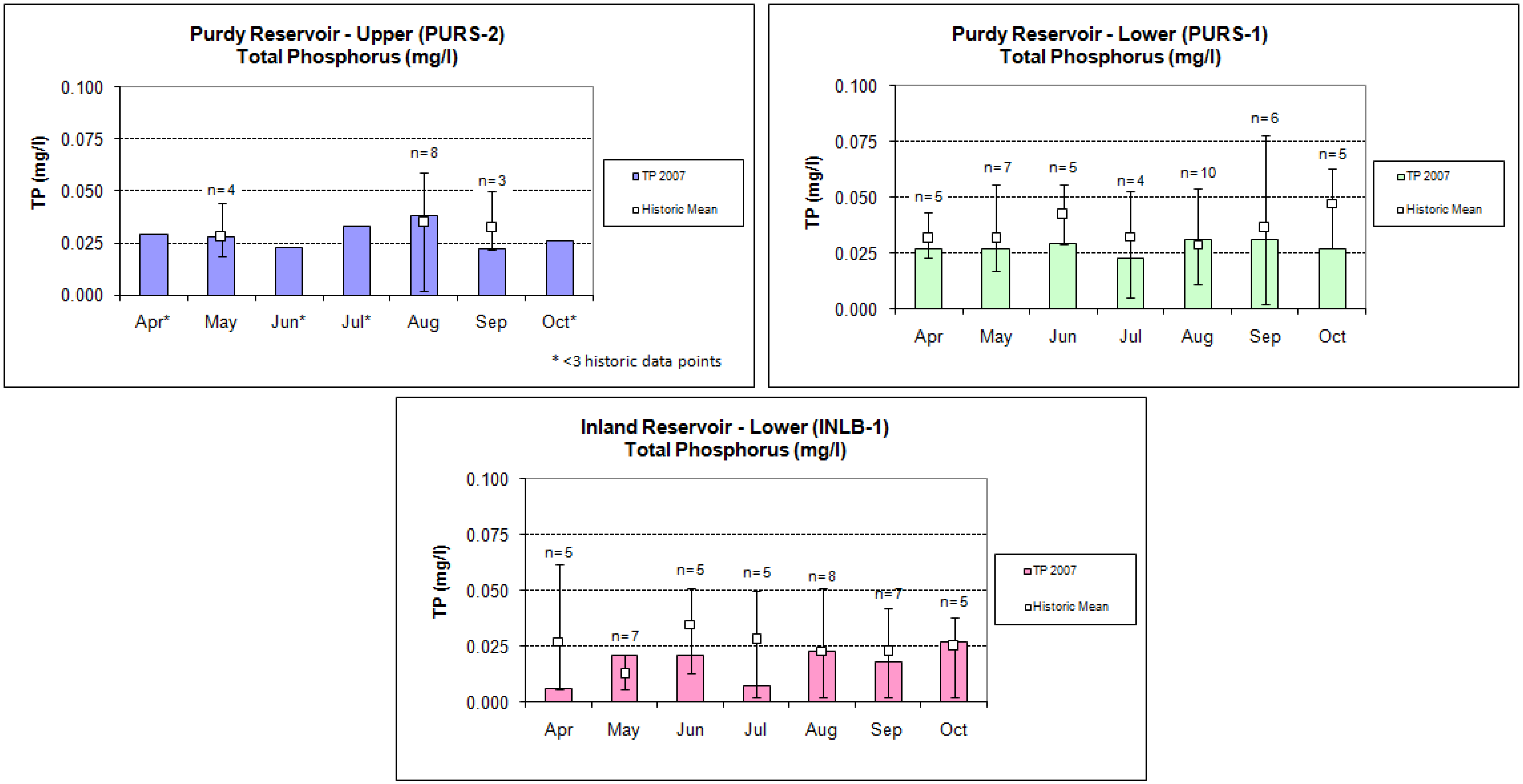


Figure 7. Monthly chl *a* of the stations in Inland and Purdy Reservoirs, April-October 2007. Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The “n” value equals the number of datapoints included in the monthly historic calculations. Historic comparisons were only graphed when more than three values existed.

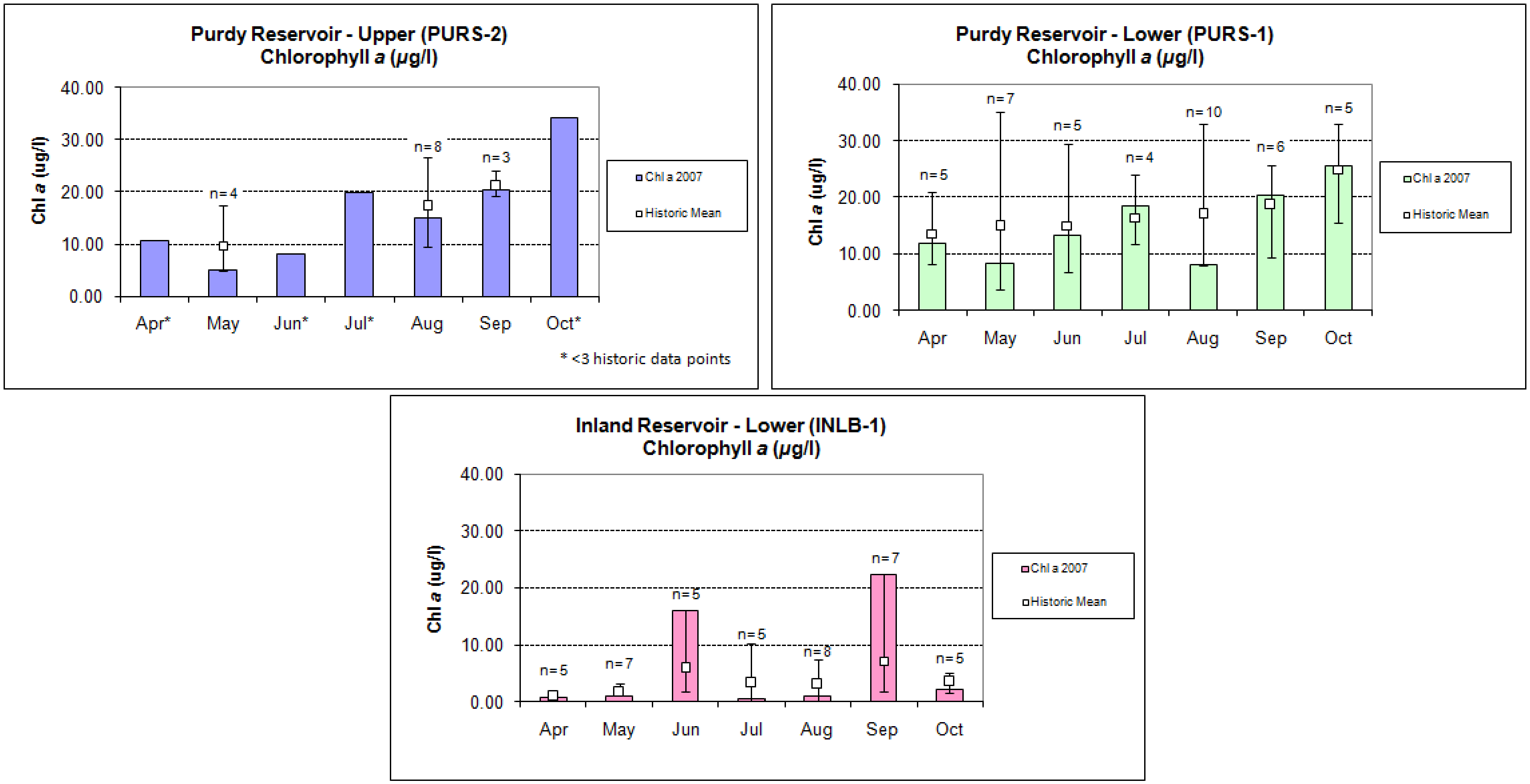


Figure 8. Monthly TSS of the stations in Inland and Purdy Reservoirs, April-October 2007. Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The “n” value equals the number of datapoints included in the monthly historic calculations. Historic comparisons were only graphed when more than three values existed.

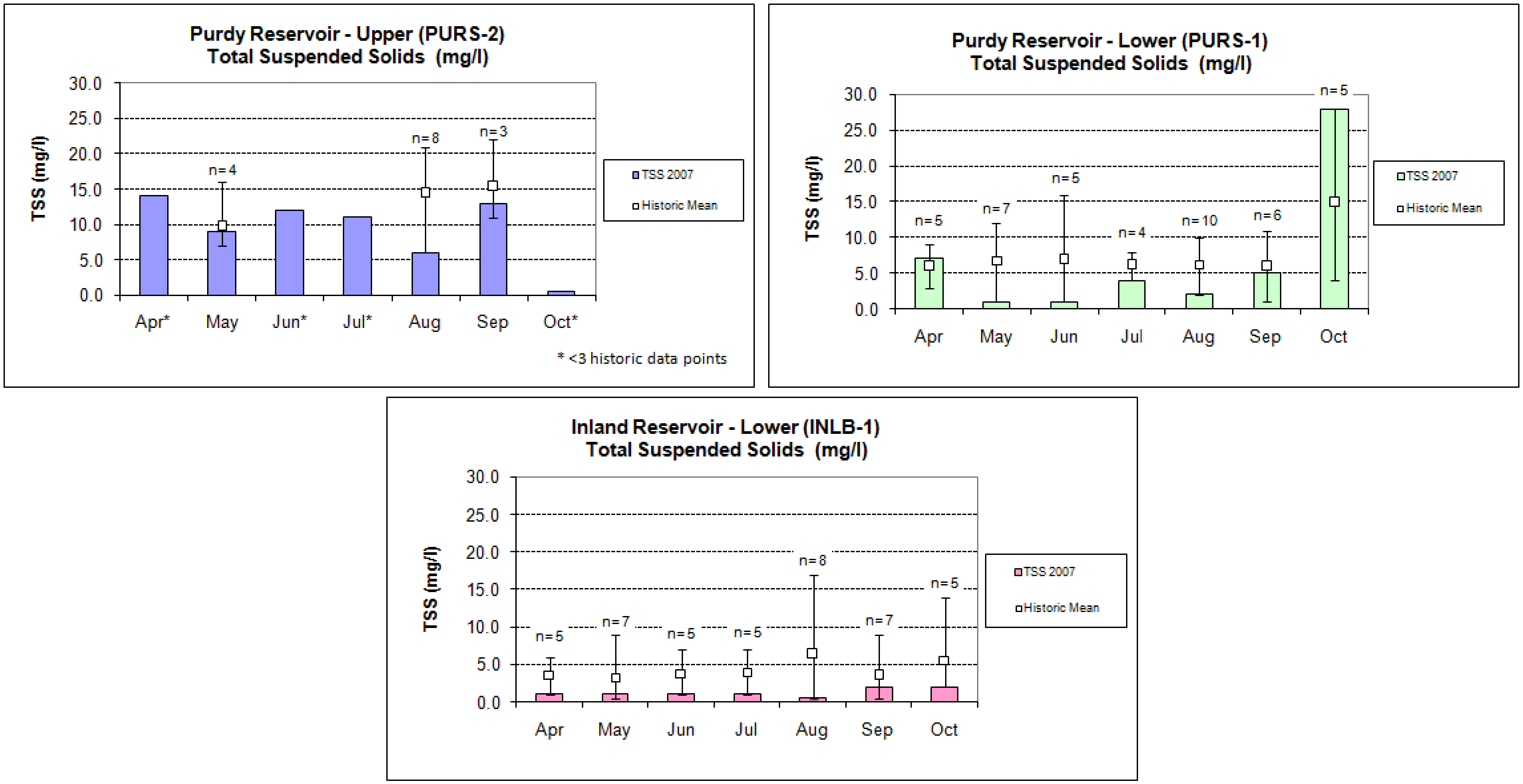


Table 2. Algal growth potential test results (expressed as mean Maximum Standing Crop (MSC) dry weights of *Selenastrum capricornutum* in mg/L) and limiting nutrient status. MSC values below 5 mg/l are considered to be protective in reservoirs and lakes; values below 20 mg/l MSC are considered protective of flowing streams and rivers. (Raschke and Schultz 1987).

Station	Upper Purdy		Lower Purdy		Inland	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
August 2006	1.88	Phosphorus	1.58	Non-limiting	---	---
June 2007	1.41	Phosphorus	1.80	Phosphorus	1.56	Phosphorus
July 2007	1.21	Phosphorus	1.27	Phosphorus	1.25	Phosphorus
August 2007	2.22	Phosphorus	1.55	Phosphorus	1.41	Phosphorus

Figure 9. Monthly DO concentrations at 1.5 m (5 ft) for Inland and Purdy Reservoirs collected April-October 2007. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/l at this depth (ADEM 2005).

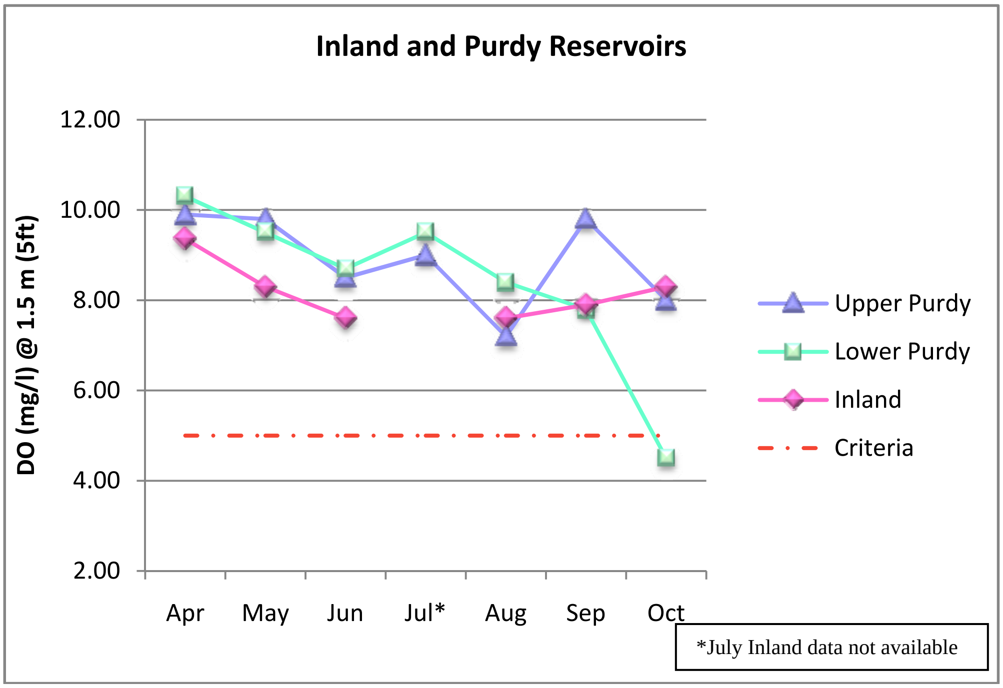


Figure 10. Monthly depth profiles of dissolved oxygen, temperature, and conductivity in lower Purdy Reservoir, April-October 2007.

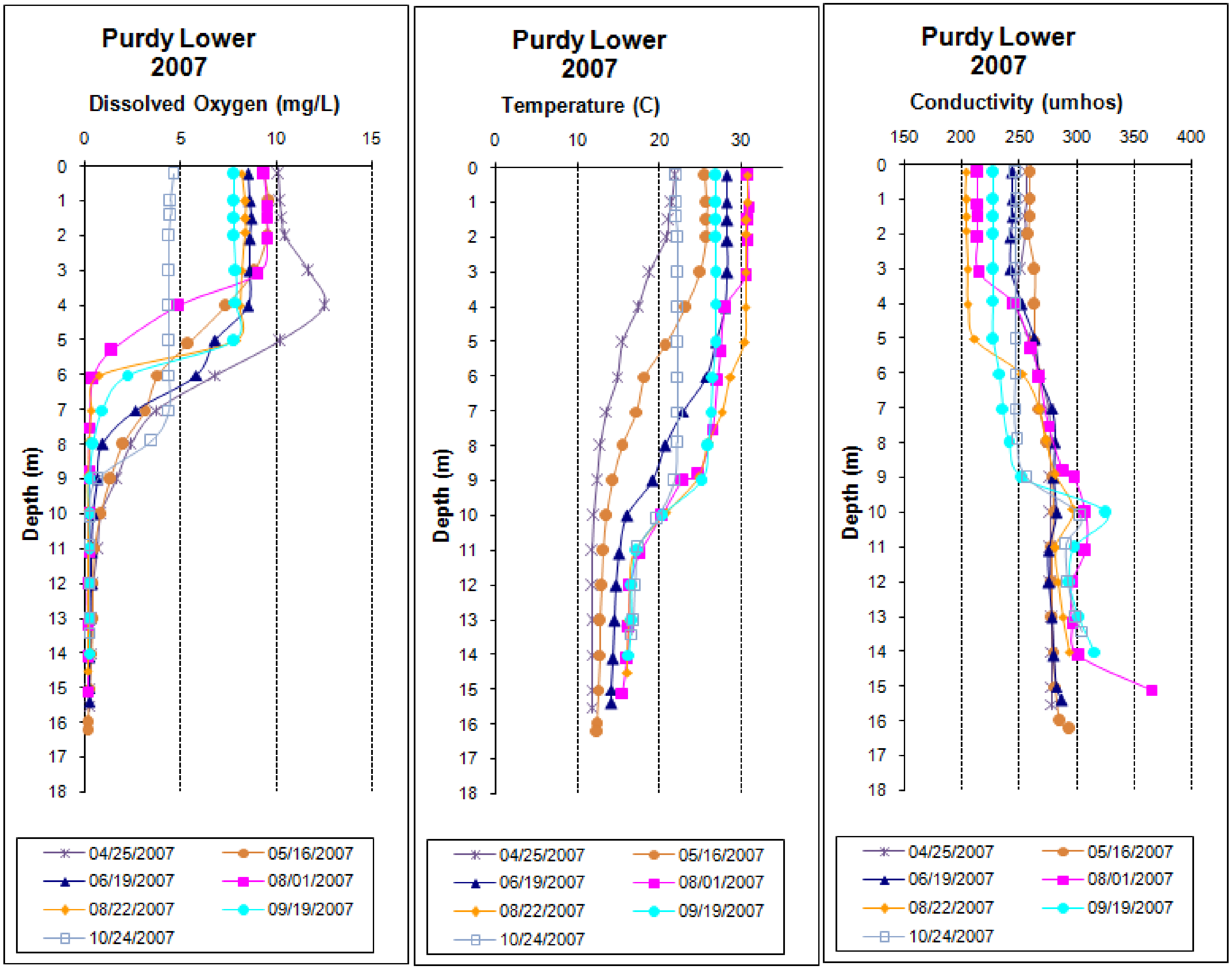


Figure 11. Monthly depth profiles of dissolved oxygen, temperature, and conductivity in Inland Reservoir, April-October 2007.

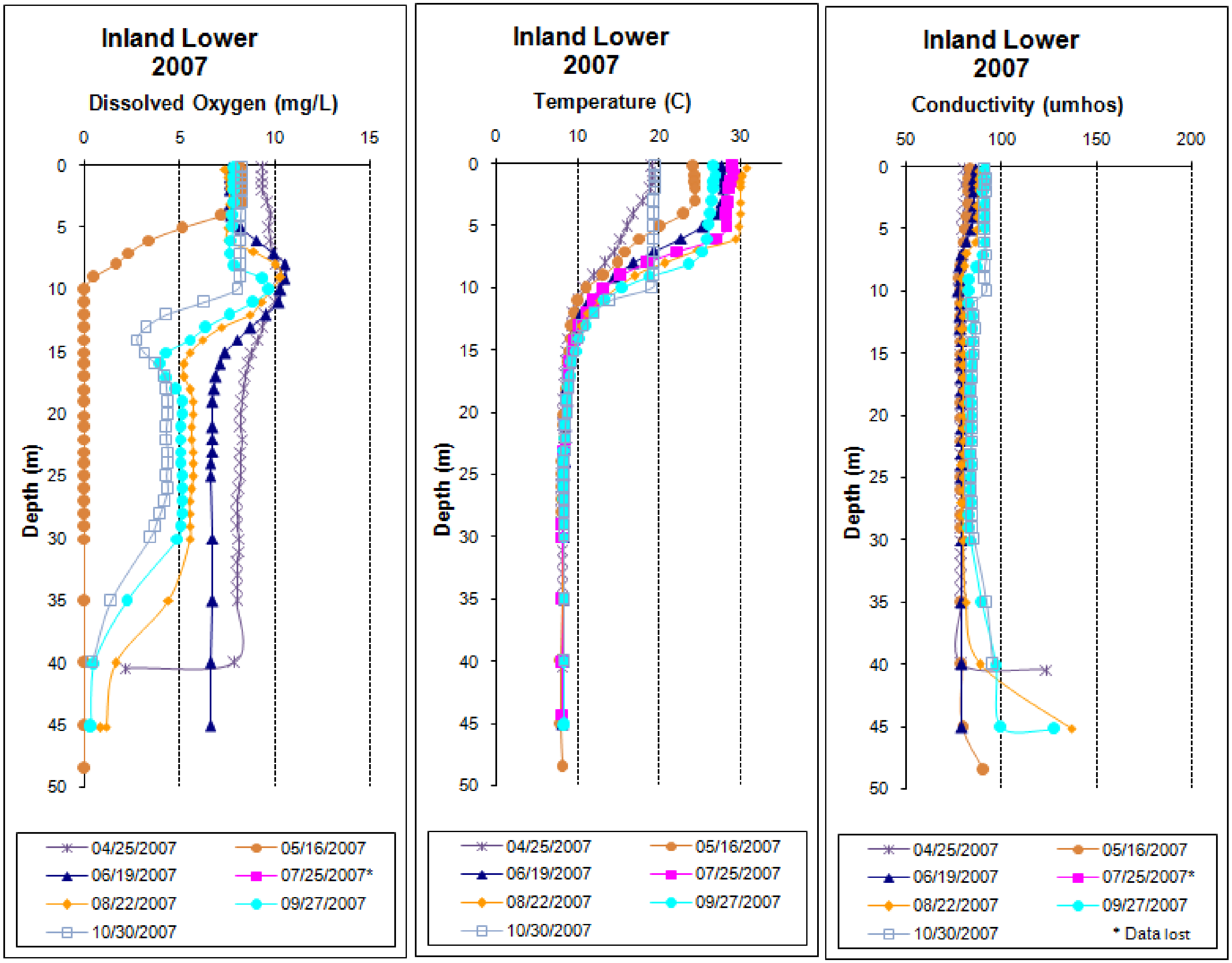
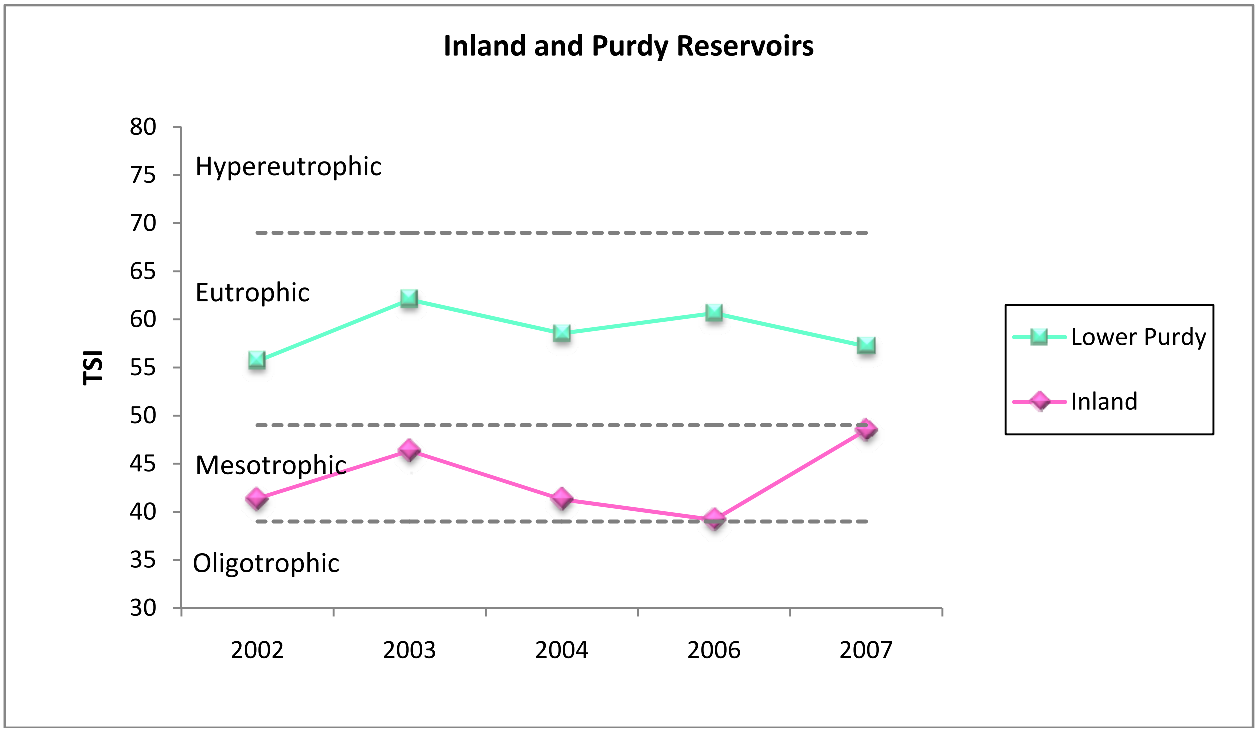


Figure 12. Mean growing season TSI values for Inland and Purdy Reservoirs using chl *a* concentrations and Carlson's Trophic State Index calculation.



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APPENDIX

Appendix Table 1. Summary of water quality data collected April-October, 2007. Minimum (min) and maximum (max) values calculated using minimum detection limits when results were less than this value. Median (med), mean, and standard deviation (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N		Min	Max	Med	Mean	SD
PURS-1	**Physical**							
	Turbidity (NTU)	7		1.6	5.8	3.6	3.6	1.2
	Total Dissolved Solids (mg/L)	7		100.0	208.0	126.0	137.9	36.0
	Total Suspended Solids (mg/L)	7		1.0	28.0	4.0	6.9	9.6
	Hardness (mg/L)	4		69.3	130.0	116.5	108.1	26.8
	Alkalinity (mg/L)	7		85.1	126.7	102.8	107.3	16.2
	Photic Zone (m)	7		3.43	9.32	5.81	6.16	2.10
	Secchi (m)	7		1.07	3.59	1.50	1.81	0.99
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.033	0.008	0.013	0.010
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	<	0.002	0.027	0.003	0.007	0.009
	Total Kjeldahl Nitrogen (mg/L)	7		0.220	0.610	0.530	0.468	0.159
	Total Nitrogen (mg/L) [J]	7	<	0.223	0.611	0.557	0.475	0.160
	Dissolved Reactive Phosphorus (mg/L) [J]	7	<	0.004	0.012	0.007	0.007	0.003
	Total Phosphorus (mg/L)	7		0.023	0.031	0.027	0.028	0.003
	CBOD-5 (mg/L)	7	<	1.0	3.4	1.0	1.3	1.0
	Chlorides (mg/L) [J]	7		3.7	5.6	5.3	5.1	0.7
	Biological							
	Chlorophyll a (ug/L) [J]	7		8.01	25.63	13.35	15.11	6.59
	Fecal Coliform (col/100 mL) [J]	1					< 1	
PURS-2	**Physical**							
	Turbidity (NTU)	7		4.9	14.5	8.5	8.8	3.5
	Total Dissolved Solids (mg/L)	7		88.0	1,190.0	146.0	293.6	396.8
	Total Suspended Solids (mg/L)	7	<	1.0	14.0	11.0	9.4	4.7
	Hardness (mg/L)	4		67.3	140.0	106.1	104.9	32.4
	Alkalinity (mg/L)	7		84.3	131.6	102.7	104.9	16.7
	Photic Zone (m)	7		2.49	3.65	2.82	3.00	0.42
	Secchi (m)	7		0.56	1.51	0.77	0.95	0.36
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	<	0.003	0.202	0.024	0.052	0.070
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.715	0.485	0.459	0.238
	Total Nitrogen (mg/L) [J]	7	<	0.268	0.765	0.543	0.511	0.201
	Dissolved Reactive Phosphorus (mg/L) [J]	7	<	0.004	0.011	0.008	0.008	0.003
	Total Phosphorus (mg/L)	7		0.022	0.038	0.028	0.028	0.006
	CBOD-5 (mg/L)	7	<	1.0	3.2	0.5	1.1	1.0
	Chlorides (mg/L) [J]	7		4.5	5.9	5.7	5.3	0.6
	Biological							
	Chlorophyll a (ug/L) [J]	7		4.98	34.18	14.95	16.12	9.81
	Fecal Coliform (col/100 mL) [J]	1					< 1	

Station	Parameter	N		Min	Max	Med	Mean	SD
INLB-1	**Physical**							
	Turbidity (NTU)	7		0.7	2.4	1.3	1.5	0.7
	Total Dissolved Solids (mg/L)	7		20.0	112.0	44.0	54.3	31.9
	Total Suspended Solids (mg/L)	7	<	1.0	2.0	1.0	1.2	0.6
	Hardness (mg/L)	4		14.0	38.8	22.8	24.6	11.9
	Alkalinity (mg/L)	7		11.5	13.4	13.0	12.9	0.6
	Photic Zone (m)	7		7.34	25.91	14.31	15.99	5.82
	Secchi (m)	7		2.23	7.31	4.04	4.30	1.67
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.066	0.229	0.130	0.146	0.064
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.322	0.075	0.152	0.102
	Total Nitrogen (mg/L)	7	<	0.164	0.544	0.252	0.298	0.149
	Dissolved Reactive Phosphorus (mg/L) [J]	7		0.006	0.014	0.008	0.009	0.003
	Total Phosphorus (mg/L) [J]	7		0.006	0.027	0.021	0.018	0.008
	CBOD-5 (mg/L)	7	<	1.0	3.0	0.5	0.9	0.9
	Chlorides (mg/L) [J]	7		2.0	3.2	3.0	2.9	0.3
	Biological							
	Chlorophyll a (ug/L) [J]	7	<	0.10	22.43	1.07	6.23	9.09
	Fecal Coliform (col/100 mL) [J]	1					3	

J=one or more of the values provided are estimated; < = Actual value is less than the detection limit