

The Ozarks Environmental and Water Resources Institute (OEWRI)
Missouri State University (MSU)

Historical Water Quality Data Analysis, Pearson Creek, Springfield, Missouri

Prepared by:

Marc R. Owen, M.S., Assistant Director
Robert T. Pavlowsky, Ph.D., Director
Ezekiel Kuehn, Graduate Assistant

Prepared for:

James River Basin Partnership
Joseph Pitts, Executive Director
117 Park Central Square
Springfield, MO 65806

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SCOPE AND OBJECTIVES

The Ozarks Environmental and Water Resources Institute (OEWRI) at Missouri State University (MSU) is performing a water quality monitoring and nutrient load evaluation for the Pearson Creek watershed near Springfield, Missouri. This effort is part of the Show-Me Yards, Neighbors, Farms, and Ranches 319 Grant received by the James River Basin Partnership (JRBP) through the Missouri Department of Natural Resources (MDNR). Pearson Creek is listed as impaired due to unknown toxicity that is thought to result from increased storm water loading from urban development in the watershed (USEPA 2011). Recent studies have also indicated urban land use is adversely impacting Pearson Creek with loadings of toxic compounds that can harm the aquatic environment (Richards and Johnson 2002; Hutchison 2010). Additionally, Pearson Creek is located in the James River Basin, and the James River Total Maximum Daily Load (TMDL) focuses on impairment due to nutrient loadings (MDNR 2001).

The monitoring plan for this project is designed to address and compliment management and regulatory goals including: (i) 319 requirements for evaluating baseline conditions, BMP effectiveness, load reductions, (ii) approved TMDL targets for both James River and Pearson Creek, (iii) approved watershed management plan recommendations for the Upper James River, and (iv) Springfield and Greene County MS-4 management plans. One major objective of the monitoring plan is to compare findings of the current project with available historical water quality data. The purpose of this report is to review and evaluate existing water quality data for the Pearson Creek watershed. Specific objectives for this report are: (i) compile a database of existing published water quality data for total phosphorus (TP) and total nitrogen (TN), (ii) perform a historical trend analysis, and (iii) compare concentrations to current James River TMDL standards. Results of this study will be used to evaluate BMP effectiveness and to help calibrate load reduction modeling.

STUDY AREA

The Pearson Creek watershed is approximately 59.2 km² (22.9 mi²) and drains the eastern edges of the City of Springfield in Greene County flowing south to the confluence of the James River (Figure 1). The underlying geology of the watershed is Mississippian age limestone within which a karst landscape has formed where sinkholes, losing streams, and springs are common (Bullard et al. 2001). There are 23 mapped springs within the basin with the largest being Jones Spring in the southwest portion of the watershed. Land use of the watershed ranges from high-low density urban in the western half of watershed to residential, livestock grazing, and forage crop production outside the city limits to the east (Hutchison 2010).

METHODS

Water quality data has been previously collected from Pearson Creek by several agencies, universities, and groups for a variety of reasons. The James River Basin Water Quality Gap Analysis Report written by OEWRI and MEC Water Resources (MEC 2007) and the Pearson Creek TMDL (USEPA 2011) report that relatively precise data has been collected by the United States Geological Survey (USGS), Missouri Department of Natural Resources (MDNR), Missouri State University (MSU), City of Springfield (CS), and Springfield City Utilities (CU). In addition, a yearlong water quality study of the Middle James River Basin was conducted in 2008-2009, and one of the sites was located at the USGS gage on FR 148 (Hutchison, 2010).

These data were compiled into one data base and evaluated using frequency distribution, time series analysis, and rating curves where appropriate. Concentrations that were < detection limit were entered as half the detection limit in the database. The frequency distribution will evaluate variability in nutrient concentrations from all the samples collected. The time-series analysis will look at temporal changes in nutrient concentrations. Finally, establishing a rating curve from existing data will show how concentrations change with discharge. Additionally, the data collected during the present study will be combined with the data in this report to establish baseline conditions that can be evaluated against future improvements to water quality through best management practices established in the watershed.

RESULTS

Sites and Samples

Historical water quality data is available at three sites in the Pearson Creek Watershed. These sites are; Pearson Creek at Farm Road (FR) 148, Jones Spring, and at the mouth of the Jones Spring Branch Tributary (Table 1). At these three sites, a total of 203 TP and 142 TN samples have been collected going back to 1989, however sampling has not been continuous. This section summarizes the number and type of samples collected and the agencies that collected the samples for each site.

Site # 1 - Pearson Creek at FR 148

The site where the most data was collected is at the USGS gage at Farm Road 148 (Table 2). This site is located approximately 2 km upstream of the confluence of the James River (Figure 1). Sample collection occurred either at the Greene County concrete bridge at FR 148, or approximately 700 m downstream at FR 193. Without any significant drainage area between the two sites data from these two sites were combined. A USGS gaging station (07050690) operating at this location since 1999 is located at FR 148 (Table 3). Total of 148 TP samples were collected at this site beginning in the late 1980s. From 1989-1991 and 1996-1998 CU collected at this location. The MDNR, USGS, and MSU collected samples from 1999-2005 and MSU collected here from 2008-2009. A total of 109 TN samples were collected at this site

beginning in 1999. The MDNR, USGS, and MSU collected samples here from 1999-2005 and MSU collected here from 2008-2009

Site #2 - Jones Spring

The next site with the highest number of samples collected is at Jones Spring (Table 2). Jones Spring is located approximately 1.3 km upstream of the main stem of Pearson Creek just east of the railroad tracks. The spring flow is captured and released in a series of ponds created along the Jones Spring Branch tributary. A total of 46 TP samples were collected at this site in 1993 and from 1996-1998 by CU. The SC collected TP samples at this location from 2002-2008. All 24 TN samples from this site were collected by SC between 2002-2008.

Site #3 - Jones Spring Branch at the Mouth

Finally, a small number of samples have been collected at the mouth of the Jones Spring Branch tributary before it enters the main stem of Pearson Creek. This site is located at the last pond outlet on the tributary along Leaning Tree Lane where Jones Spring Branch enters the main stem of Pearson Creek about 3.2 km upstream of the confluence with the James River. A total of 9 TP and 9 TN samples were collected at this site. The USGS collected samples at this location from 1999-2000 and the CS collected here in 2009.

Total Phosphorus

Concentrations of TP are generally lower than the TMDL target of 0.075 mg/L, but have high variability. Variability in TP concentrations is high at all three sites in this study with coefficient of variation percentage (cv%) >100% at all sites with the highest variability at Site 1 (cv%=194). Site 1, on the main stem of Pearson Creek, has a mean concentration of 0.059 mg/L with a range of <DL-1.30 mg/L (Table 2). Site 2 at Jones Spring has less variability (cv%=150), however has a mean concentration of 0.099 mg/L, ranging from <DL-0.900 mg/L. Finally, Site 3 at the mouth of Jones Spring Branch has the lowest variability (cv%=102), has a mean concentration of 0.092 mg/L and a range from 0.010-0.260 mg/L. However, only 9 samples were collected at this location.

High variability at Site 1 on the main stem of Pearson Creek is due to a few high concentrations collected at this location, but with lower overall concentrations than the less variable Site 2 at Jones Spring. A frequency distribution of values from Site 1 show the median TP concentration is 0.040 mg/L, with 87% of the samples collected here having a concentration < TMDL target of 0.075 mg/L (Figure 2). In contrast, the median TP concentration at Jones Spring (Site 2) was higher at 0.064 mg/L, and around 56% of the samples were less than the TMDL target of 0.075 mg/L (Figure 3).

Annual mean TP concentration at Site 1 and Site 2 were generally lower than the TMDL target of 0.075 mg/L, with the exception of a couple of years from 2000-2005 (Figures 4 and 5).

Annual mean TP concentrations at Site 1 were nearly 0.5 mg/L in 2000 and slightly higher than the TMDL target in 2004. Annual mean TP concentrations at Site two exceeded the TMDL target in 2004 and 2005. These data suggest, in general, TP concentrations are 60-70% higher in Jones Spring than in the main stem of Pearson Creek.

Total Nitrogen

Overall, TN is less variable than TP at these sites with all having a cv% <100%. Also, the majority of samples collected at these sites do not meet the TMDL target concentration of 1.5 mg/L. Similar to TP, Site 1 on the main stem has the highest variability with a cv% of 74%. The average TN concentration is 2.83 mg/L with a range from 1.45-20.24 mg/L (Table 2). Site 2 at Jones Spring has the lowest variability with a cv% of 24% and the highest average TN concentration of 3.62 mg/L, with a range of 2.35-6.4 mg/L. The cv% at Site 3 is 30%, average TN concentration of 2.59, and a range between 1.68-4.02 mg/L. As with TP, only 9 samples were collected at this site.

Neither site meets the TMDL target concentration for TN of 1.5 mg/L, suggesting Pearson Creek is a nitrogen source to the James River Basin. The median TN concentration at Site 1 is 2.54 mg/L, with only 1 sample out of 109 \leq 1.5 mg/L (Figure 6). Site 2 at Jones Spring was significantly higher with a median concentration of 3.38 mg/L and all 24 samples exceeding the TMDL target of 1.5 mg/L (Figure 7).

Mean annual TN concentrations have been fairly consistent over time. Mean annual TN concentrations were generally between 2-3 mg/L at Site 1 and 3-4 mg/L at Site 2 from 1999-2009. Mean annual TN concentrations exceeded 3 mg/L from 2000-2002 at Site 1 (Figure 8). At Site 2, mean annual TN concentrations exceeded 4 mg/L in 2004 (Figure 9). In the Pearson Creek system, TN concentrations in Jones Spring are 25-30% higher than in the main stem.

Nutrient Rating Curves

Nutrient rating curves were developed using existing data at Site 1, but more samples are needed at extreme low and high discharges. Discharge data is available for a portion of the samples collected at Site 1 only. A total of 80 samples collected since 1999 were used to develop nutrient rating curves with the historical water quality data. Total phosphorus concentrations can vary greatly even at the same discharge, which is linked to sediment transport that can change throughout a storm event depending on when the sample was collected on the hydrograph (Figure 10). Conversely, TN concentrations varied far less with discharge since it tends to be in a dissolved phase (Figure 11).

The regression equations developed here were created using discharges between 0.1-4.0 m³/s (3.5-141 ft³/s) since very few samples have been collected at discharges >4 m³/s and <0.1 m³/s (Figures 10 and 11). The current water quality monitoring project is trying to address this by not

only filling in the rating curves at FR 148 and Jones Spring, but also by establishing a monitoring station in the upper watershed. These data along with the monitoring currently underway can help better understand the source of nutrients in the watershed and where to focus management efforts in the future.

CONCLUSIONS

This report compiles the existing water quality data for the Pearson Creek watershed near Springfield, Missouri. There are 5 main conclusions from this report.

1. Water quality data has been collected at three sites with the Pearson Creek watershed. Site 1 is located at FR 148 on the main stem of Pearson Creek at a USGS gaging station in the lower watershed. Site 2 is located at Jones Spring which is also located in the lower watershed west of the main stem near Springfield's city limits. Site 3 is located 1.3 km downstream of Site 2 at the mouth of the Jones Spring Branch.
2. Evaluation of this database shows the need for more sampling to calculate annual loads and identify nonpoint source distribution within the watershed. Site 1 has a fairly good record, particularly since 1999. Water quality data at Site 2 is sporadic. Only a few samples were collected at Site 3, and so trends cannot be determined. Furthermore, these sites are all located in the lower watershed, and little is known about water quality in the upper watershed.
3. Total phosphorus concentrations are highly variable in the dataset with cv% ranging from 102-194% at the three sites. However, average and median concentrations are below the TMDL target of 0.075 mg/L. Of all the samples collected, only 13% of the samples exceeded the TMDL target at Site 1 and 44% exceeded the target at Site 2. The high variability results from elevated concentrations present in samples from a few higher flows. Concentrations were 60-70% higher on average in Jones Spring compared to Pearson Creek at FR 148.
4. Total nitrogen concentrations are less variable in the dataset with cv% less than 75% at all sites. However, the majority of the concentrations exceeded the TMDL target of 1.5 mg/L (>99%). Concentrations were 25-30% higher in Jones Spring compared to Pearson Creek at FR 148.
5. Hutchison (2010) reports nutrient loads for site 1 on Pearson Creek at 40 kg/km²/yr for TP and 1,470 kg/km²/yr for TN. However, nutrient rating curves created with the existing data shows the need for additional samples at higher storm discharges >4 m³/s. The current monitoring program will try to address the gaps in the data by increasing the number of samples at FR 148 and Jones Spring, but also by establishing a new monitoring station in the upper watershed.

LITERATURE CITED

Bullard, L., K.C. Thomson, and J.E. Vandike, 2001. The Springs of Greene County Missouri. Missouri Department of Natural Resources Geological Survey and Resource Assessment Division. Water Resources Report No. 68.

Hutchison, E., C., D., 2010. Mass Transport of Suspended Sediment, Dissolved Solids, Nutrients and Anions in the James River, SW Missouri. Unpublished Masters Thesis, Missouri State University.

MEC, 2007. Southwest Missouri Water Quality Improvement Project (WQIP) James River Basin Water Quality Gap Analysis. MEC Water Resources and Ozarks Environmental and Water Resources Institute at Missouri State University. Prepared for the Environmental Resources Coalition.

MDNR, 2001. Total Maximum Daily Load (TMDL) for James River, Webster, Greene, Christian, and Stone Counties, Missouri. Missouri Department of Natural Resources

Richards and Johnson, 2002. Water Quality, Selected Chemical Characteristics, and Toxicity of Base Flow and Urban Stormwater in the Pearson Creek and Wilsons Creek Basins, Greene County, Missouri, August 1999 to August 2000. Water-Resources Investigations Report 02-4124, United State Geological Survey.

USEPA, 2011. Total Maximum Daily Load Pearson Creek (MO_2373) Greene County, Missouri. United States Environmental Protection Agency Region 7.

USGS, 2012. Water-Resources Data for the United States, Water Year 2011: U.S. Geological Survey Water-Data Report WDR-US-2011, site 07050690, accessed at <http://wdr.water.usgs.gov/wy2011/pdfs/07050690.2011.pdf>.

TABLES

Table 1. Samples Site Information

Site	Location	UTM Northing	UTM Easting	Drainage Area (km ²)	River km
1	Pearson Creek at FR 148	4,114,630	482,386	54.4	2.0
2	Jones Spring	4,115,805	480,980		
3	Jones Spring Branch at Mouth	4,115,610	482,128		

Table 2. Sampling Summary

Site	Location	# TP Samples Collected	Years Collected	Collection Agencies*	# TN Samples Collected	Years Collected	Collection Agencies*
1	Pearson Creek at FR 148	148	1989-1991 1996-1998 1999-2005 2008-2009	CU CU USGS, MSU, MDNR MSU	109	1999-2005 2008-2009	USGS, MSU, MDNR MSU
2	Jones Spring	46	1993 1996-1998 2002-2008	CU CU CS	24	2002-2008	CS
3	Jones Spring Branch at Mouth	9	1999-2000 2009	USGS CS	9	1999-2000 2009	USGS CS

* MDNR= Missouri Department of Natural Resources
 CU = City Utilities
 USGS = United States Geological Survey
 CS = City of Springfield
 MSU = Missouri State University

Table 3. USGS Gaging Station 07050690 Pearson Creek Near Springfield, MO

Period of Record July 21, 1999 to current year <ul style="list-style-type: none"> • Annual Mean Q = 0.75 m³/s • Maximum Peak Q = 84.4 m³/s • Instantaneous Low Q = 0.04 m³/s • 10% exceeds Q = 1.6 m³/s • 50% exceeds Q = 0.31 m³/s • 90% exceeds Q = 0.09 m³/s

Source: (USGS 2012)

Table 4. Summary Statistics for Nutrients by Site

Site	Parameter	n	mean	median	min	max	sd	cv%
1	TP	148	0.059	0.040	0.000	1.30	0.114	194
	TN	109	2.83	2.54	1.45	20.24	2.09	74
2	TP	46	0.099	0.064	0.000	0.900	0.149	150
	TN	24	3.62	3.38	2.35	6.40	0.85	24
3	TP	9	0.092	0.050	0.010	0.260	0.094	102
	TN	9	2.59	2.38	1.68	4.02	0.79	30

FIGURES

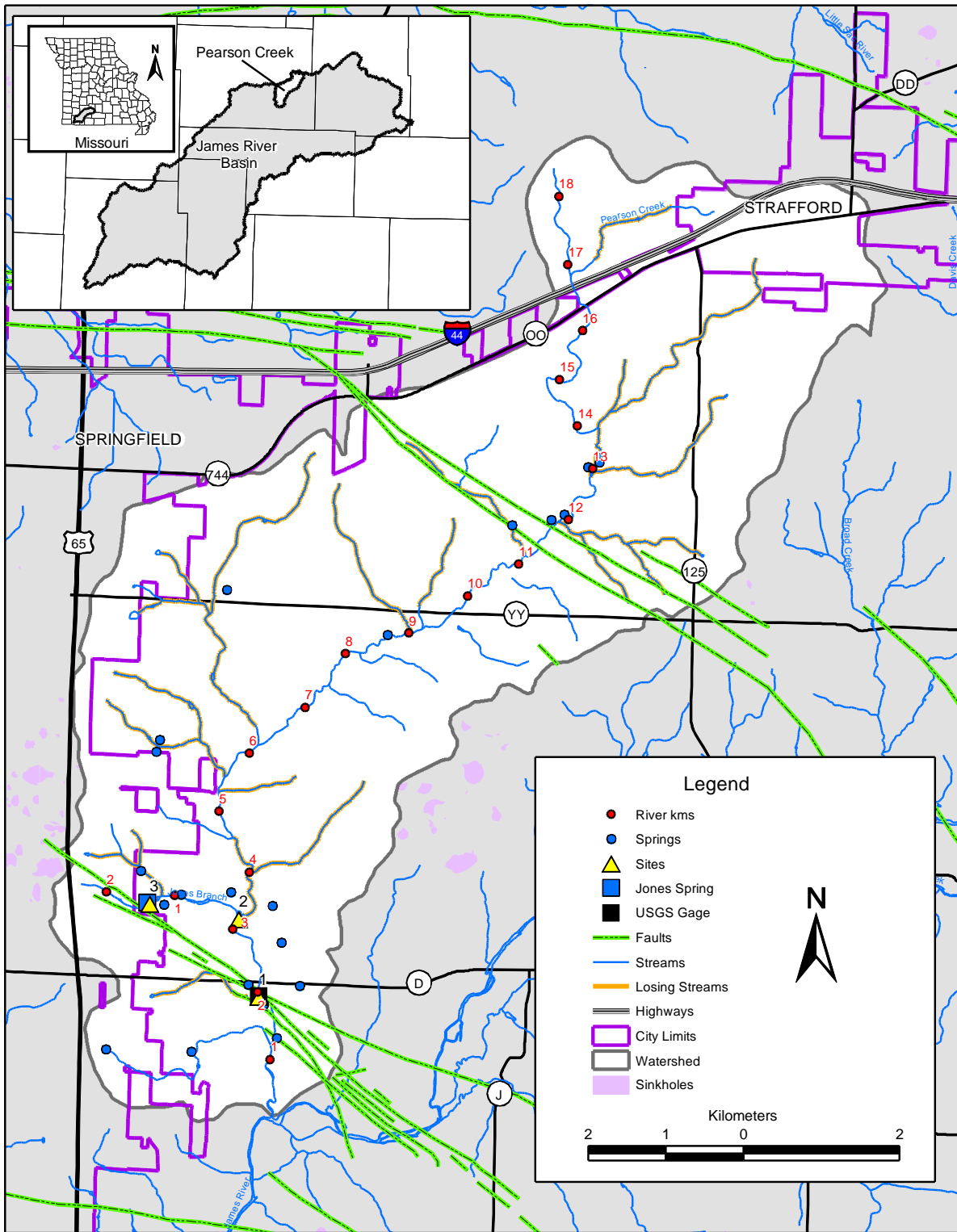


Figure 1. Pearson Creek watershed sampling locations and karst features

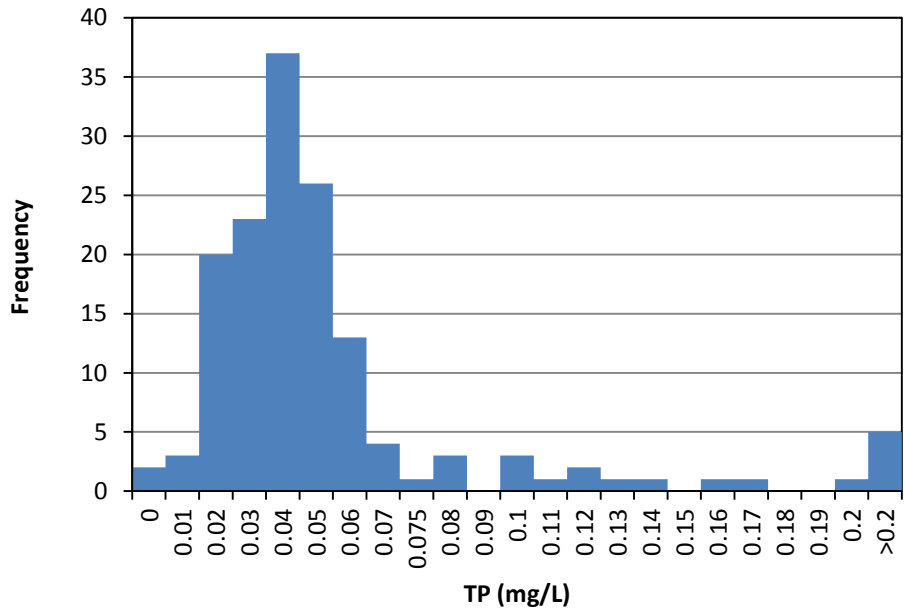


Figure 2. Frequency distribution of TP concentrations at Site 1, lower Pearson Creek.

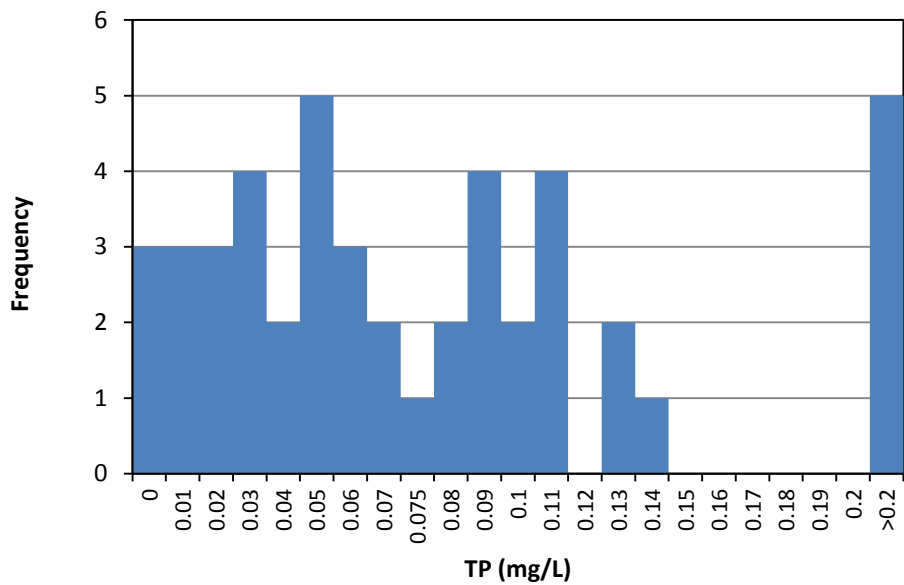


Figure 3. Frequency distribution of TP concentrations at Site 2, Jones Spring.

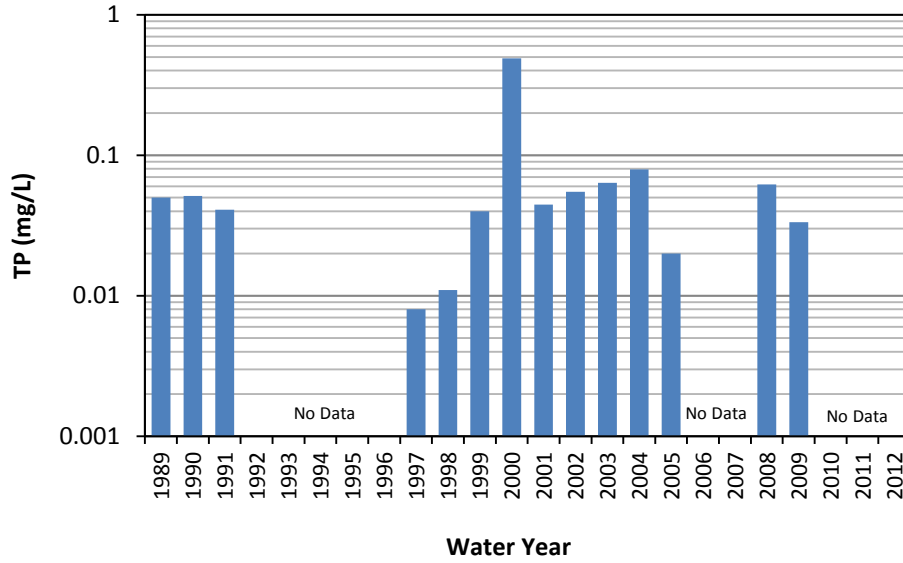


Figure 4. Average annual TP concentrations at Site 1, lower Pearson Creek.

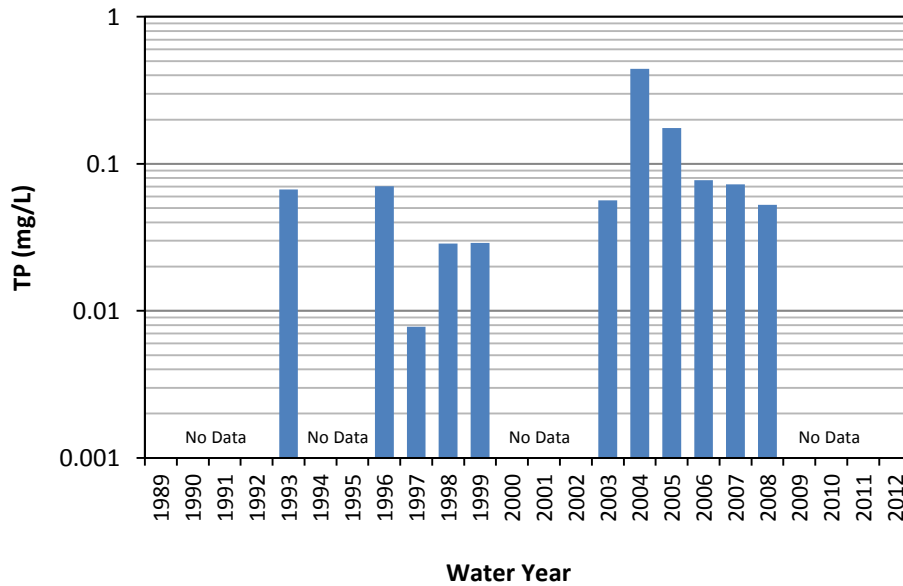


Figure 5. Average annual TP concentrations at Site 2, Jones Spring

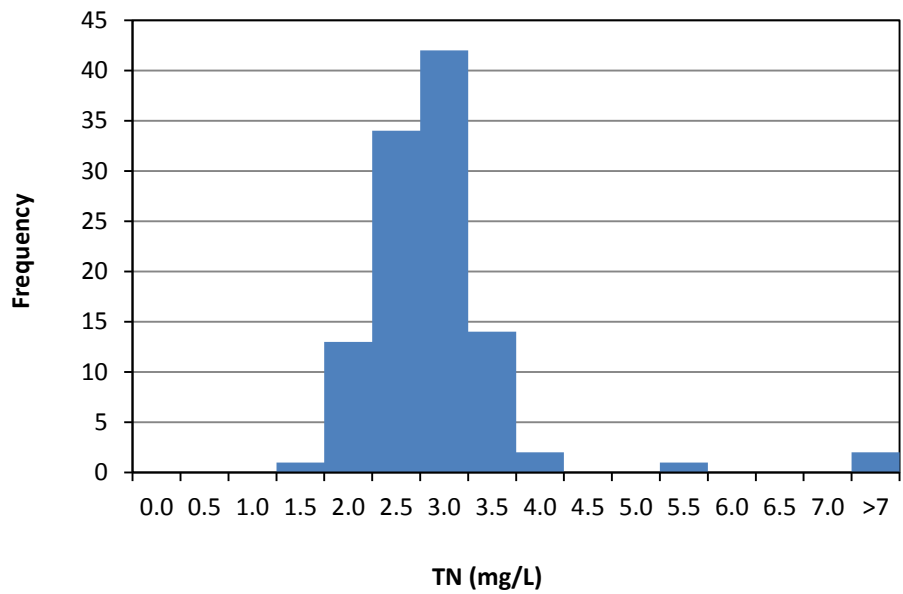


Figure 6. Frequency distribution of TN concentrations at Site 1, lower Pearson Creek.

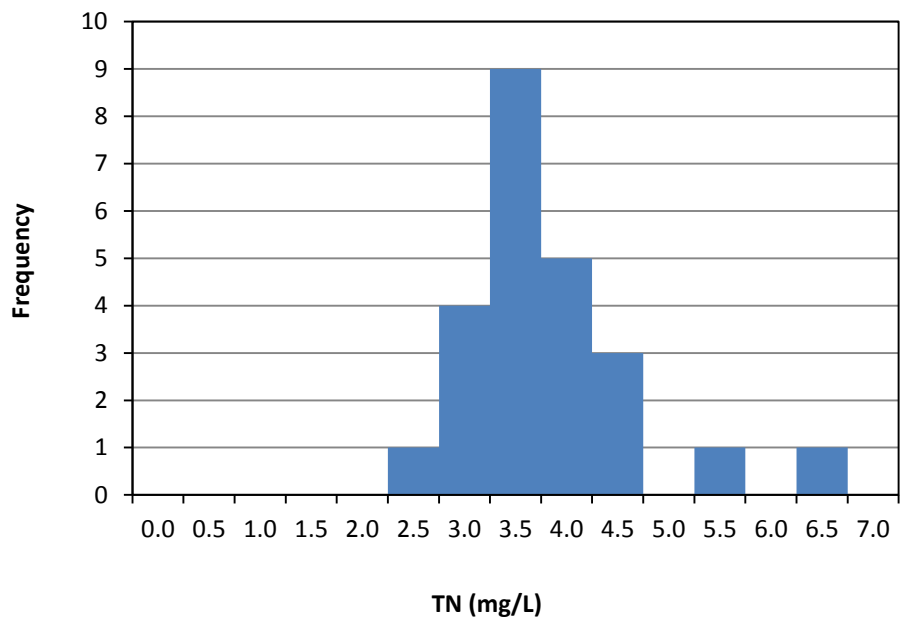


Figure 7. Frequency distribution of TN concentrations at Site 2, Jones Spring.

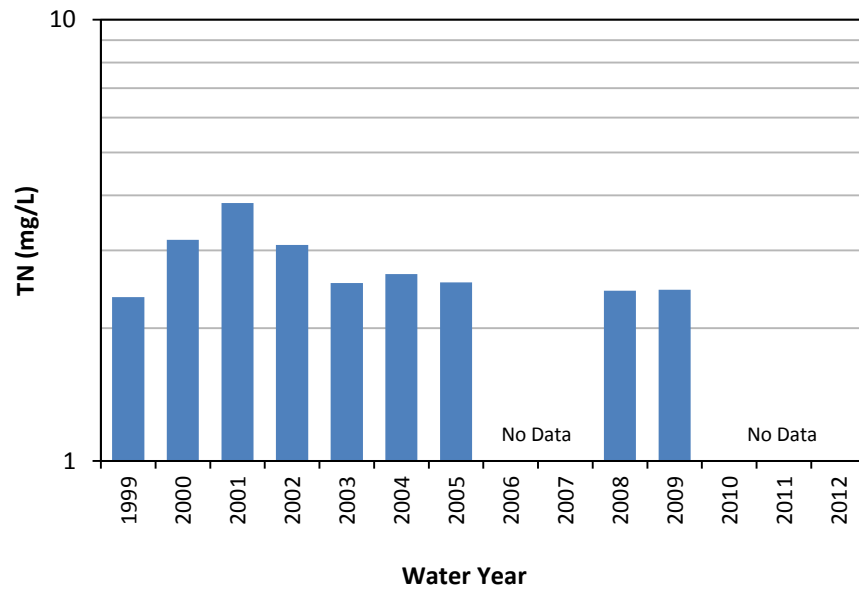


Figure 8. Average annual TN concentrations at Site 1, lower Pearson Creek.

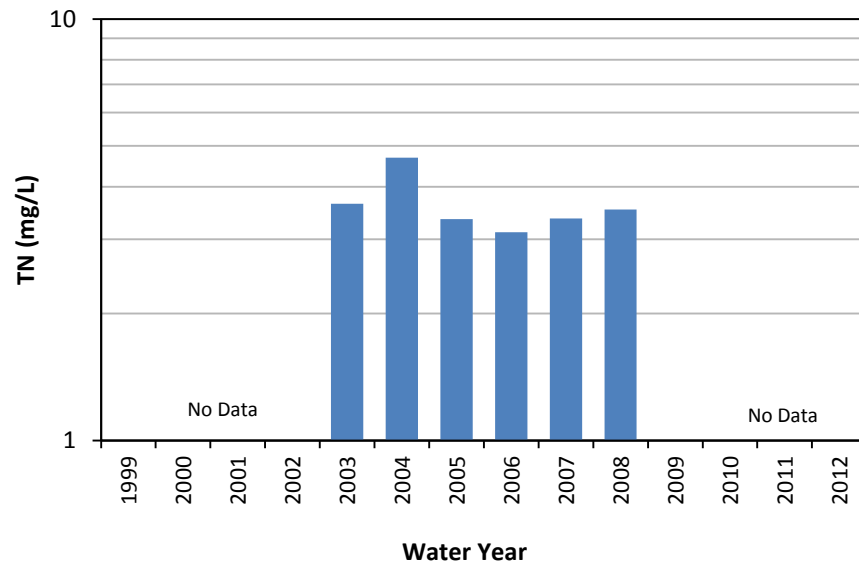


Figure 9. Average annual TN concentrations at Site 2, Jones Spring.

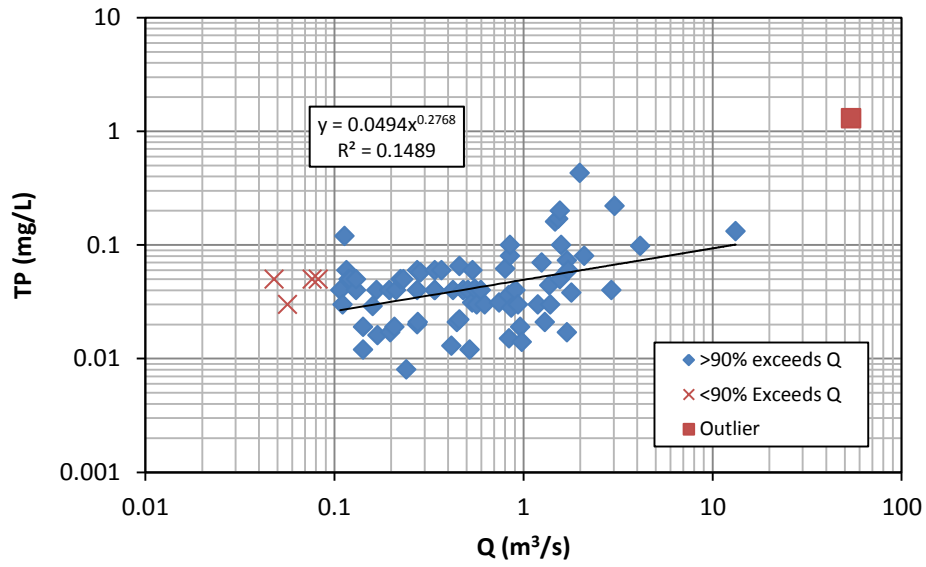


Figure 10. TP rating curve for Site 1, lower Pearson Creek.

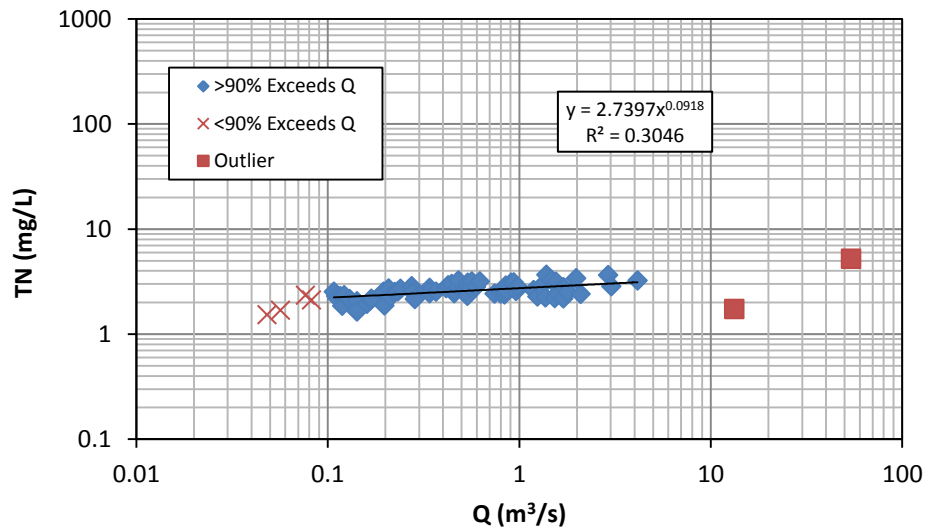


Figure 11. TN rating curve for Site 1, lower Pearson Creek.

APPENDIX

Site	Sample Date	Agency	Sample Time	Analyte	Con. (mg/L)	Q cfs
1	6/5/1989	CU		Phosphorus, Total	0.029	
1	6/16/1989	CU		Phosphorus, Total	0.025	
1	6/28/1989	CU		Phosphorus, Total	0.045	
1	7/26/1989	CU		Phosphorus, Total	0.067	
1	8/1/1989	CU		Phosphorus, Total	0.107	
1	8/23/1989	CU		Phosphorus, Total	0.041	
1	8/30/1989	CU		Phosphorus, Total	0.041	
1	9/20/1989	CU		Phosphorus, Total	0.045	
1	10/25/1989	CU		Phosphorus, Total	0.050	
1	11/1/1989	CU		Phosphorus, Total	0.052	
1	11/8/1989	CU		Phosphorus, Total	0.023	
1	11/15/1989	CU		Phosphorus, Total	0.080	
1	11/29/1989	CU		Phosphorus, Total	0.030	
1	12/13/1989	CU		Phosphorus, Total	0.048	
1	1/3/1990	CU		Phosphorus, Total	0.011	
1	1/17/1990	CU		Phosphorus, Total	0.210	
1	1/25/1990	CU		Phosphorus, Total	0.053	
1	1/31/1990	CU		Phosphorus, Total	0.034	
1	2/14/1990	CU		Phosphorus, Total	0.054	
1	2/22/1990	CU		Phosphorus, Total	0.037	
1	2/28/1990	CU		Phosphorus, Total	0.020	
1	3/14/1990	CU		Phosphorus, Total	0.128	
1	3/26/1990	CU		Phosphorus, Total	0.037	
1	4/9/1990	CU		Phosphorus, Total	0.025	
1	4/23/1990	CU		Phosphorus, Total	0.044	
1	5/21/1990	CU		Phosphorus, Total	0.032	
1	6/4/1990	CU		Phosphorus, Total	0.017	
1	8/13/1990	CU		Phosphorus, Total	0.042	
1	10/12/1990	CU		Phosphorus, Total	0.045	
1	11/5/1990	CU		Phosphorus, Total	0.040	
1	1/7/1991	CU		Phosphorus, Total	0.038	
1	8/12/1996	CU	14:30	Phosphorus, Total	0.000	
1	12/2/1996	CU	14:10	Phosphorus, Total	0.000	
1	7/7/1997	CU	13:50	Phosphorus, Total	0.008	
1	8/4/1997	CU	13:50	Phosphorus, Total	0.006	
1	9/8/1997	CU	14:05	Phosphorus, Total	0.018	
1	3/2/1998	CU	13:40	Phosphorus, Total	0.011	
1	10/5/1998	CU	14:10	Phosphorus, Total	0.030	
1	8/18/1999	USGS	17:15	Phosphorus, Total	0.050	2.7
1	11/23/1999	USGS	05:01	Phosphorus, Total	0.120	4.0
1	6/7/2000	USGS	13:30	Phosphorus, Total	0.050	2.9
1	7/12/2000	USGS	06:12	Phosphorus, Total	1.300	1,910
1	6/27/2001	USGS	08:20	Phosphorus, Total	0.050	8.2
1	7/24/2001	USGS	08:15	Phosphorus, Total	0.040	6.9
1	8/21/2001	USGS	07:55	Phosphorus, Total	0.060	12.0
1	8/22/2001	MSU		Phosphorus, Total	0.049	
1	8/29/2001	MSU		Phosphorus, Total	0.033	
1	9/5/2001	MSU		Phosphorus, Total	0.058	
1	9/10/2001	USGS	12:45	Phosphorus, Total	0.070	44.0
1	9/12/2001	MSU		Phosphorus, Total	0.035	
1	9/19/2001	MSU		Phosphorus, Total	0.028	
1	9/26/2001	MSU		Phosphorus, Total	0.023	
1	10/4/2001	USGS	14:15	Phosphorus, Total	0.040	5.9
1	10/6/2001	MSU		Phosphorus, Total	0.029	
1	10/12/2001	MSU		Phosphorus, Total	0.035	
1	10/21/2001	MSU		Phosphorus, Total	0.018	
1	11/7/2001	USGS	12:55	Phosphorus, Total	0.040	9.7
1	11/8/2001	MSU		Phosphorus, Total	0.018	
1	12/16/2001	USGS	14:30	Phosphorus, Total	0.160	52.0
1	12/19/2001	USGS	09:50	Phosphorus, Total	0.040	103

1	1/24/2002	USGS	11:30	Phosphorus, Total	0.060	9.7
1	2/20/2002	USGS	08:15	Phosphorus, Total	0.060	19.0
1	3/20/2002	USGS	12:00	Phosphorus, Total	0.050	55.0
1	4/20/2002	USGS	17:25	Phosphorus, Total	0.080	74.0
1	4/22/2002	USGS	11:45	Phosphorus, Total	0.060	61.0
1	5/28/2002	USGS	10:45	Phosphorus, Total	0.030	42.0
1	6/13/2002	MSU		Phosphorus, Total	0.120	
1	6/18/2002	MSU		Phosphorus, Total	0.036	
1	6/18/2002	USGS	16:20	Phosphorus, Total	0.060	13.0
1	6/25/2002	MSU		Phosphorus, Total	0.049	
1	7/2/2002	MSU		Phosphorus, Total	0.039	
1	7/10/2002	MSU		Phosphorus, Total	0.226	
1	7/17/2002	MSU		Phosphorus, Total	0.058	
1	7/22/2002	USGS	11:05	Phosphorus, Total	0.050	7.9
1	7/24/2002	MSU		Phosphorus, Total	0.044	
1	7/31/2002	MSU		Phosphorus, Total	0.053	
1	8/7/2002	MSU		Phosphorus, Total	0.046	
1	8/14/2002	MSU		Phosphorus, Total	0.032	
1	8/20/2002	USGS	12:05	Phosphorus, Total	0.060	4.1
1	8/21/2002	MSU		Phosphorus, Total	0.040	
1	8/28/2002	MSU		Phosphorus, Total	0.039	
1	9/4/2002	MSU		Phosphorus, Total	0.034	
1	9/10/2002	USGS	14:25	Phosphorus, Total	0.050	1.7
1	9/11/2002	MSU		Phosphorus, Total	0.042	
1	9/18/2002	MSU		Phosphorus, Total	0.038	
1	9/25/2002	MSU		Phosphorus, Total	0.035	
1	10/2/2002	MSU		Phosphorus, Total	0.038	
1	10/9/2002	MSU		Phosphorus, Total	0.030	
1	10/22/2002	USGS	08:10	Phosphorus, Total	0.030	2.0
1	11/19/2002	USGS	15:30	Phosphorus, Total	0.040	4.6
1	12/10/2002	USGS	14:20	Phosphorus, Total	0.030	3.9
1	1/28/2003	USGS	15:05	Phosphorus, Total	0.040	3.8
1	2/14/2003	USGS	12:27	Phosphorus, Total	0.080	30.0
1	2/20/2003	USGS	13:05	Phosphorus, Total	0.030	49.0
1	3/18/2003	USGS	15:10	Phosphorus, Total	0.040	12.0
1	4/23/2003	USGS	13:40	Phosphorus, Total	0.020	9.7
1	5/6/2003	USGS	21:10	Phosphorus, Total	0.430	70.0
1	5/21/2003	USGS	08:30	Phosphorus, Total	0.030	33.0
1	6/26/2003	USGS	08:30	Phosphorus, Total	0.040	17.0
1	7/28/2003	USGS	10:40	Phosphorus, Total	0.050	4.3
1	8/20/2003	USGS	11:30	Phosphorus, Total	0.050	4.6
1	9/3/2003	USGS	12:45	Phosphorus, Total	0.040	12.0
1	10/15/2003	USGS	14:00	Phosphorus, Total	0.050	4.2
1	11/25/2003	USGS	09:30	Phosphorus, Total	0.040	15.0
1	12/15/2003	USGS	14:35	Phosphorus, Total	0.030	20.0
1	1/13/2004	USGS	10:35	Phosphorus, Total	0.030	22.0
1	2/10/2004	USGS	14:45	Phosphorus, Total	0.040	17.0
1	3/3/2004	USGS	19:15	Phosphorus, Total	0.170	54.0
1	3/16/2004	USGS	13:45	Phosphorus, Total	0.040	32.0
1	4/12/2004	USGS	15:40	Phosphorus, Total	0.040	18.0
1	5/12/2004	USGS	09:15	Phosphorus, Total	0.040	21.0
1	6/13/2004	USGS		Phosphorus, Total	0.100	56.0
1	6/14/2004	USGS	00:24	Phosphorus, Total	0.100	30.0
1	6/17/2004	USGS		Phosphorus, Total	0.220	107
1	6/18/2004	USGS		Phosphorus, Total	0.200	55.0
1	7/21/2004	USGS	16:10	Phosphorus, Total	0.040	7.5
1	9/29/2004	MDNR	15:35	Phosphorus, Total	0.050	
1	3/24/2005	MDNR	11:10	Phosphorus, Total	0.020	
1	9/26/2008	MSU	9:52:00	Phosphorus, Total	0.062	28.2
1	10/14/2008	MSU	9:30	Phosphorus, Total	0.019	7.3
1	10/23/2008	MSU	10:21:16	Phosphorus, Total	0.031	26.2
1	11/5/2008	MSU	10:11:05	Phosphorus, Total	0.017	7.0
1	11/11/2008	MSU	9:18:25	Phosphorus, Total	0.057	10.1

1	11/25/2008	MSU	8:43:34	Phosphorus, Total	0.016	6.0
1	12/4/2008	MSU	8:45	Phosphorus, Total	0.019	5.0
1	12/9/2008	MSU	8:51	Phosphorus, Total	0.029	5.6
1	12/18/2008	MSU	13:53	Phosphorus, Total	0.012	5.0
1	1/23/2009	MSU	8:01	Phosphorus, Total	0.008	8.5
1	2/2/2009	MSU	8:36	Phosphorus, Total	0.013	14.7
1	2/11/2009	MSU	8:15	Phosphorus, Total	0.021	45.8
1	2/20/2009	MSU	8:32	Phosphorus, Total	0.014	34.6
1	3/4/2009	MSU	8:10	Phosphorus, Total	0.012	18.4
1	3/11/2009	MSU	8:27	Phosphorus, Total	0.022	16.2
1	4/8/2009	MSU	9:10	Phosphorus, Total	0.015	29.6
1	4/13/2009	MSU	8:59	Phosphorus, Total	0.044	48.4
1	4/19/2009	MSU	10:48	Phosphorus, Total	0.038	63.2
1	5/1/2009	MSU	9:08	Phosphorus, Total	0.132	468
1	5/15/2009	MSU	10:13	Phosphorus, Total	0.017	59.9
1	5/22/2009	MSU	12:49	Phosphorus, Total	0.019	34.0
1	6/22/2009	MSU	9:54	Phosphorus, Total	0.031	19.0
1	7/8/2009	MSU	9:29	Phosphorus, Total	0.021	9.8
1	7/14/2009	MSU	9:12	Phosphorus, Total	0.036	29.5
1	7/21/2009	MSU	11:45	Phosphorus, Total	0.028	30.4
1	7/30/2009	MSU	14:08	Phosphorus, Total	0.041	19.6
1	8/20/2009	MSU	11:23	Phosphorus, Total	0.073	59.9
1	8/26/2009	MSU	11:27	Phosphorus, Total	0.021	15.7
1	9/9/2009	MSU	11:38	Phosphorus, Total	0.065	16.2
1	9/22/2009	MSU	11:54	Phosphorus, Total	0.098	146.4
2	9/13/1993	CU	21:50	Phosphorus, Total	0.067	
2	4/22/1996	CU	02:46	Phosphorus, Total	0.048	
2	4/22/1996	CU	18:08	Phosphorus, Total	0.049	
2	4/22/1996	CU	14:07	Phosphorus, Total	0.054	
2	4/22/1996	CU	03:17	Phosphorus, Total	0.072	
2	4/22/1996	CU	10:14	Phosphorus, Total	0.076	
2	4/22/1996	CU	08:13	Phosphorus, Total	0.080	
2	4/22/1996	CU	06:19	Phosphorus, Total	0.086	
2	4/22/1996	CU	04:19	Phosphorus, Total	0.088	
2	4/22/1996	CU	09:12	Phosphorus, Total	0.089	
2	4/22/1996	CU	07:10	Phosphorus, Total	0.101	
2	4/22/1996	CU	05:18	Phosphorus, Total	0.102	
2	8/12/1996	CU	14:40	Phosphorus, Total	0.000	
2	12/2/1996	CU	13:55	Phosphorus, Total	0.000	
2	1/6/1997	CU	14:05	Phosphorus, Total	0.000	
2	7/7/1997	CU	13:40	Phosphorus, Total	0.011	
2	8/4/1997	CU	13:35	Phosphorus, Total	0.012	
2	9/8/1997	CU	14:20	Phosphorus, Total	0.016	
2	10/6/1997	CU	14:40	Phosphorus, Total	0.026	
2	8/3/1998	CU	13:55	Phosphorus, Total	0.026	
2	9/14/1998	CU	14:00	Phosphorus, Total	0.034	
2	11/2/1998	CU	14:25	Phosphorus, Total	0.029	
2	11/12/2002	Springfield		Phosphorus, Total	0.030	
2	3/10/2003	Springfield		Phosphorus, Total	0.056	
2	4/7/2003	Springfield		Phosphorus, Total	0.100	
2	5/13/2003	Springfield		Phosphorus, Total	0.040	
2	11/10/2003	Springfield		Phosphorus, Total	0.900	
2	3/9/2004	Springfield		Phosphorus, Total	0.480	
2	3/25/2004	Springfield		Phosphorus, Total	0.320	
2	5/10/2004	Springfield		Phosphorus, Total	0.070	
2	11/8/2004	Springfield		Phosphorus, Total	0.110	
2	3/8/2005	Springfield		Phosphorus, Total	0.210	
2	3/23/2005	Springfield		Phosphorus, Total	0.250	
2	5/9/2005	Springfield		Phosphorus, Total	0.130	
2	11/7/2005	Springfield		Phosphorus, Total	0.010	
2	3/6/2006	Springfield		Phosphorus, Total	0.140	
2	5/15/2006	Springfield		Phosphorus, Total	0.050	
2	5/22/2006	Springfield		Phosphorus, Total	0.110	

2	11/9/2006	Springfield		Phosphorus, Total	0.060	
2	3/5/2007	Springfield		Phosphorus, Total	0.050	
2	5/22/2007	Springfield		Phosphorus, Total	0.050	
2	6/8/2007	Springfield		Phosphorus, Total	0.130	
2	3/11/2008	Springfield		Phosphorus, Total	0.090	
2	4/18/2008	Springfield		Phosphorus, Total	0.100	
2	5/13/2008	Springfield		Phosphorus, Total	0.010	
2	6/25/2008	Springfield		Phosphorus, Total	0.010	
3	8/19/1999	USGS	08:25	Phosphorus, Total	0.050	
3	10/9/1999	USGS	07:51	Phosphorus, Total	0.040	
3	11/23/1999	USGS	03:39	Phosphorus, Total	0.040	
3	6/7/2000	USGS	12:00	Phosphorus, Total	0.050	
3	6/28/2000	USGS	12:45	Phosphorus, Total	0.070	
3	7/12/2000	USGS	12:06	Phosphorus, Total	0.260	
3	1/20/2009	Springfield		Phosphorus, Total	0.010	
3	3/25/2009	Springfield		Phosphorus, Total	0.060	
3	4/19/2009	Springfield		Phosphorus, Total	0.250	

Site	Sample Date	Sample Time	Agency	Analyte	TN (mg/L)	Q (cfs)
1	8/18/1999	17:15	USGS	Total Nitrogen, unfiltered	2.35	2.7
1	11/23/1999	05:01	USGS	Total Nitrogen, unfiltered	2.17	4.0
1	6/7/2000	13:30	USGS	Total Nitrogen, unfiltered	2.11	2.9
1	7/12/2000	06:12	USGS	Total Nitrogen, unfiltered	5.23	1,910
1	6/27/2001	08:20	USGS	Total Nitrogen, unfiltered	2.55	8.2
1	7/24/2001	08:15	USGS	Total Nitrogen, unfiltered	2.53	6.9
1	8/21/2001	07:55	USGS	Total Nitrogen, unfiltered	2.44	12.0
1	8/22/2001		MSU	Total Nitrogen, unfiltered	2.59	
1	8/29/2001		MSU	Total Nitrogen, unfiltered	2.92	
1	9/5/2001		MSU	Total Nitrogen, unfiltered	3.15	
1	9/10/2001	12:45	USGS	Total Nitrogen, unfiltered	2.28	44.0
1	9/12/2001		MSU	Total Nitrogen, unfiltered	3.18	
1	9/19/2001		MSU	Total Nitrogen, unfiltered	2.48	
1	9/26/2001		MSU	Total Nitrogen, unfiltered	14.32	
1	10/4/2001	14:15	USGS	Total Nitrogen, unfiltered	2.09	5.9
1	10/6/2001		MSU	Total Nitrogen, unfiltered	20.24	
1	10/21/2001		MSU	Total Nitrogen, unfiltered	2.85	
1	11/7/2001	12:55	USGS	Total Nitrogen, unfiltered	2.81	9.7
1	11/8/2001		MSU	Total Nitrogen, unfiltered	2.60	
1	12/16/2001	14:30	USGS	Total Nitrogen, unfiltered	3.28	52.0
1	12/19/2001	09:50	USGS	Total Nitrogen, unfiltered	3.66	103
1	1/24/2002	11:30	USGS	Total Nitrogen, unfiltered	2.86	9.7
1	2/20/2002	08:15	USGS	Total Nitrogen, unfiltered	3.08	19.0
1	3/20/2002	12:00	USGS	Total Nitrogen, unfiltered	2.98	55.0
1	4/20/2002	17:25	USGS	Total Nitrogen, unfiltered	2.41	74.0
1	4/22/2002	11:45	USGS	Total Nitrogen, unfiltered	2.74	61.0
1	5/28/2002	10:45	USGS	Total Nitrogen, unfiltered	2.62	42.0
1	6/13/2002		MSU	Total Nitrogen, unfiltered	2.44	
1	6/18/2002	16:20	USGS	Total Nitrogen, unfiltered	2.54	13.0
1	6/18/2002		MSU	Total Nitrogen, unfiltered	3.28	
1	6/25/2002		MSU	Total Nitrogen, unfiltered	2.37	
1	7/2/2002		MSU	Total Nitrogen, unfiltered	2.49	
1	7/10/2002		MSU	Total Nitrogen, unfiltered	3.43	
1	7/17/2002		MSU	Total Nitrogen, unfiltered	2.74	
1	7/22/2002	11:05	USGS	Total Nitrogen, unfiltered	2.52	7.9
1	7/24/2002		MSU	Total Nitrogen, unfiltered	2.67	
1	7/31/2002		MSU	Total Nitrogen, unfiltered	2.47	

1	8/7/2002		MSU	Total Nitrogen, unfiltered	2.86	
1	8/14/2002		MSU	Total Nitrogen, unfiltered	2.39	
1	8/20/2002	12:05	USGS	Total Nitrogen, unfiltered	2.29	4.1
1	8/21/2002		MSU	Total Nitrogen, unfiltered	2.03	
1	8/28/2002		MSU	Total Nitrogen, unfiltered	2.50	
1	9/4/2002		MSU	Total Nitrogen, unfiltered	1.85	
1	9/10/2002	14:25	USGS	Total Nitrogen, unfiltered	1.53	1.7
1	9/11/2002		MSU	Total Nitrogen, unfiltered	1.84	
1	9/18/2002		MSU	Total Nitrogen, unfiltered	1.64	
1	9/25/2002		MSU	Total Nitrogen, unfiltered	1.73	
1	10/2/2002		MSU	Total Nitrogen, unfiltered	1.76	
1	10/9/2002		MSU	Total Nitrogen, unfiltered	1.58	
1	10/22/2002	08:10	USGS	Total Nitrogen, unfiltered	1.69	2.0
1	11/19/2002	15:30	USGS	Total Nitrogen, unfiltered	2.08	4.6
1	12/10/2002	14:20	USGS	Total Nitrogen, unfiltered	2.32	3.9
1	1/28/2003	15:05	USGS	Total Nitrogen, unfiltered	2.53	3.8
1	2/14/2003	12:27	USGS	Total Nitrogen, unfiltered	2.90	30.0
1	2/20/2003	13:05	USGS	Total Nitrogen, unfiltered	3.67	49.0
1	3/18/2003	15:10	USGS	Total Nitrogen, unfiltered	2.76	12.0
1	4/23/2003	13:40	USGS	Total Nitrogen, unfiltered	2.82	9.7
1	5/6/2003	21:10	USGS	Total Nitrogen, unfiltered	3.40	70.0
1	5/21/2003	08:30	USGS	Total Nitrogen, unfiltered	3.11	33.0
1	6/26/2003	08:30	USGS	Total Nitrogen, unfiltered	2.81	17.0
1	7/28/2003	10:40	USGS	Total Nitrogen, unfiltered	2.34	4.3
1	8/20/2003	11:30	USGS	Total Nitrogen, unfiltered	2.15	4.6
1	9/3/2003	12:45	USGS	Total Nitrogen, unfiltered	2.54	12.0
1	10/15/2003	14:00	USGS	Total Nitrogen, unfiltered	1.86	4.2
1	11/25/2003	09:30	USGS	Total Nitrogen, unfiltered	2.91	15.0
1	12/15/2003	14:35	USGS	Total Nitrogen, unfiltered	3.16	20.0
1	1/13/2004	10:35	USGS	Total Nitrogen, unfiltered	3.18	22.0
1	2/10/2004	14:45	USGS	Total Nitrogen, unfiltered	3.23	17.0
1	3/3/2004	19:15	USGS	Total Nitrogen, unfiltered	2.20	54.0
1	3/16/2004	13:45	USGS	Total Nitrogen, unfiltered	3.09	32.0
1	4/12/2004	15:40	USGS	Total Nitrogen, unfiltered	2.63	18.0
1	5/12/2004	09:15	USGS	Total Nitrogen, unfiltered	2.81	21.0
1	6/13/2004		USGS	Total Nitrogen, unfiltered	2.44	56.0
1	6/14/2004	00:24	USGS	Total Nitrogen, unfiltered	2.55	30.0
1	6/17/2004		USGS	Total Nitrogen, unfiltered	2.86	107
1	6/18/2004		USGS	Total Nitrogen, unfiltered	3.15	55.0
1	7/21/2004	16:10	USGS	Total Nitrogen, unfiltered	2.25	7.5
1	9/29/2004	15:35	MDNR	Total Nitrogen, unfiltered	1.45	
1	3/24/2005	11:10	MDNR	Total Nitrogen, unfiltered	2.54	
1	9/26/2008	9:52:00	MSU	Total Nitrogen, unfiltered	2.43	28.2
1	10/14/2008	9:30	MSU	Total Nitrogen, unfiltered	2.72	7.3
1	10/23/2008	10:21:16	MSU	Total Nitrogen, unfiltered	2.43	26.2
1	11/5/2008	10:11:05	MSU	Total Nitrogen, unfiltered	1.87	7.0
1	11/11/2008	9:18:25	MSU	Total Nitrogen, unfiltered	2.16	10.1
1	11/25/2008	8:43:34	MSU	Total Nitrogen, unfiltered	2.17	6.0
1	12/4/2008	8:45	MSU	Total Nitrogen, unfiltered	2.05	5.0
1	12/9/2008	8:51	MSU	Total Nitrogen, unfiltered	1.94	5.6
1	12/18/2008	13:53	MSU	Total Nitrogen, unfiltered	1.64	5.0
1	1/23/2009	8:01	MSU	Total Nitrogen, unfiltered	2.69	8.5
1	2/2/2009	8:36	MSU	Total Nitrogen, unfiltered	2.73	14.7
1	2/11/2009	8:15	MSU	Total Nitrogen, unfiltered	2.83	45.8
1	2/20/2009	8:32	MSU	Total Nitrogen, unfiltered	2.83	34.6

1	3/4/2009	8:10	MSU	Total Nitrogen, unfiltered	2.55	18.4
1	3/11/2009	8:27	MSU	Total Nitrogen, unfiltered	2.58	16.2
1	4/8/2009	9:10	MSU	Total Nitrogen, unfiltered	2.4	29.6
1	4/13/2009	8:59	MSU	Total Nitrogen, unfiltered	2.24	48.4
1	4/19/2009	10:48	MSU	Total Nitrogen, unfiltered	2.51	63.2
1	5/1/2009	9:08	MSU	Total Nitrogen, unfiltered	1.73	468
1	5/15/2009	10:13	MSU	Total Nitrogen, unfiltered	2.80	59.9
1	5/22/2009	12:49	MSU	Total Nitrogen, unfiltered	2.56	34.0
1	6/22/2009	9:54	MSU	Total Nitrogen, unfiltered	2.31	19.0
1	7/8/2009	9:29	MSU	Total Nitrogen, unfiltered	2.52	9.8
1	7/14/2009	9:12	MSU	Total Nitrogen, unfiltered	2.39	29.5
1	7/21/2009	11:45	MSU	Total Nitrogen, unfiltered	2.57	30.4
1	7/30/2009	14:08	MSU	Total Nitrogen, unfiltered	2.77	19.6
1	8/20/2009	11.23	MSU	Total Nitrogen, unfiltered	2.18	59.9
1	8/26/2009	11:27	MSU	Total Nitrogen, unfiltered	2.99	15.7
1	9/9/2009	11:38	MSU	Total Nitrogen, unfiltered	2.44	16.2
1	9/22/2009	11:54	MSU	Total Nitrogen, unfiltered	3.24	146
2	11/12/2002		Springfield	Total Nitrogen, unfiltered	3.83	
2	3/10/2003		Springfield	Total Nitrogen, unfiltered	4.47	
2	4/7/2003		Springfield	Total Nitrogen, unfiltered	2.77	
2	5/13/2003		Springfield	Total Nitrogen, unfiltered	3.52	
2	11/10/2003		Springfield	Total Nitrogen, unfiltered	6.40	
2	3/9/2004		Springfield	Total Nitrogen, unfiltered	4.40	
2	3/25/2004		Springfield	Total Nitrogen, unfiltered	4.16	
2	5/10/2004		Springfield	Total Nitrogen, unfiltered	3.78	
2	11/8/2004		Springfield	Total Nitrogen, unfiltered	3.45	
2	3/8/2005		Springfield	Total Nitrogen, unfiltered	3.60	
2	3/23/2005		Springfield	Total Nitrogen, unfiltered	2.35	
2	5/9/2005		Springfield	Total Nitrogen, unfiltered	4.00	
2	11/7/2005		Springfield	Total Nitrogen, unfiltered	3.26	
2	3/6/2006		Springfield	Total Nitrogen, unfiltered	3.14	
2	5/15/2006		Springfield	Total Nitrogen, unfiltered	3.23	
2	5/22/2006		Springfield	Total Nitrogen, unfiltered	2.86	
2	11/9/2006		Springfield	Total Nitrogen, unfiltered	3.40	
2	3/5/2007		Springfield	Total Nitrogen, unfiltered	3.36	
2	5/22/2007		Springfield	Total Nitrogen, unfiltered	3.36	
2	6/8/2007		Springfield	Total Nitrogen, unfiltered	3.34	
2	3/11/2008		Springfield	Total Nitrogen, unfiltered	3.31	
2	4/18/2008		Springfield	Total Nitrogen, unfiltered	5.08	
2	5/13/2008		Springfield	Total Nitrogen, unfiltered	2.78	
2	6/25/2008		Springfield	Total Nitrogen, unfiltered	2.96	
3	8/19/1999	08:25	USGS	Total Nitrogen, unfiltered	1.68	
3	10/9/1999	07:51	USGS	Total Nitrogen, unfiltered	2.81	
3	11/23/1999	03:39	USGS	Total Nitrogen, unfiltered	2.34	
3	6/7/2000	12:00	USGS	Total Nitrogen, unfiltered	1.71	
3	6/28/2000	12:45	USGS	Total Nitrogen, unfiltered	2.18	
3	7/12/2000	12:06	USGS	Total Nitrogen, unfiltered	3.57	
3	1/20/2009		Springfield	Total Nitrogen, unfiltered	4.02	
3	3/25/2009		Springfield	Total Nitrogen, unfiltered	2.38	
3	4/19/2009		Springfield	Total Nitrogen, unfiltered	2.63	