Appendix

B

STATUS OF WATER QUALITY
PAINT CREEK WATERSHED

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There are over 2,500 miles of rivers and streams in the Paint Creek watershed. Of these, 702 miles have been assigned specific aquatic life use designations and 830 miles have had specific recreation use designations. The small headwater streams that have not been explicitly designated carry water chemistry criteria associated with warm water habitats (WWH).

The latest evaluation of beneficial uses was carried out through the 2006 Paint Creek TMDL survey and was put in to rule in October of 2009. The distribution of aquatic life uses are 60 percent WWH, 32 percent exceptional warm water habitat (EWH), four percent modified warm water habitat (MWH), and four percent cold water habitat (CWH). Of the recreation use designations, 85 percent is primary contact recreation class B and 15 percent is primary contact recreation class A.

The technical support document for the Paint Creek study, which has the justification for these use designations as well as most of the data collected throughout the water quality survey, can be found at: http://www.epa.ohio.gov/portals/35/documents/PaintCreekTSD_2006_aug08.pdf.

The appendices to this document can be found at:
http://www.epa.ohio.gov/portals/35/documents/PaintCreek_appendices_2006_jan08.pdf.

B1 Aquatic Life Use Attainment

Paint Creek and its associated tributary streams have demonstrated high quality in the past and in terms of ecological value is considered a high priority watershed by prominent conservation groups. The biological data collected in 2006 show that there clearly are problems in the system limiting the aquatic diversity and health that it could otherwise achieve.

The attainment of the aquatic life use goals throughout the entire Paint Creek watershed were fully met at 69 percent of the sites surveyed. Non attainment, which reflects significant water quality problems, was found at seven percent of the sites and partial attainment, indicating water quality problems of lower magnitude, was found at 24 percent of the sites.

The distribution of sites failing to meet aquatic life use goals are primarily in the ten-digit HUCs that are dominated by agriculture located in the northern portion of the watershed (i.e., upper Paint Creek, Sugar Creek, and Rattlesnake Creek). Figure B-1 is a map of the project area showing the biological survey sites and the aquatic life use attainment status denoted by the respective symbology. An inserted map of land use is included to reference the distribution of impaired sites relative to the surrounding land cover type. Table B-1 lists the top seven 12-digit HUCs that are impaired for aquatic life uses (in terms of the proportion for the overall project as well as the proportion of the sites within the respective 12-digit HUCs), which are all in the upper three ten-digit HUCs that are dominated by cropland. A total of 23 of the 39 impaired sites (58 percent) are found in these three cropland dominated ten-digit HUCs (01, 02, and 03) and this also accounts for four of the nine total sites that are in the more severe non-attainment status. The overall number of sites in these three ten-digit HUCs is 40, or 32 percent of all sites, suggesting that the rate of aquatic life use impairment is nearly double that of the aggregate of the remaining seven ten-digit HUCs.

Figure B-2 is a boxplot showing the distribution of the aquatic life use attainment status relative to the percent of cropland in the associated 12-digit HUC and Figure B-3 is the same analysis but instead using the percent of forest cover. The fairly homogenous distribution of land cover type within the 12-digit HUCs as shown in Figure B-1 validates these comparisons (i.e., the subwatershed associated with each of the sampling sites closely resembles the land cover distribution of the larger 12-digit HUC that they occupy). In both comparisons, there is statistical significance in the differences in the mean values between the three respective groups of full, partial and non attainment (ANOVA; $p = 0.012$ and 0.008, respectively), and as indicated by the values, non attainment is associated with a higher proportion of cropland and full attainment is more associated with a higher proportion of forest land.

The upper portions of the North Fork Paint Creek and its tributaries are likewise in a landscape dominated by row cropland; however, do not have the impaired water quality found the headwaters of Paint Creek, Sugar Creek and Rattlesnake Creek. There is indication that the North Fork Paint Creek system has significant groundwater contributions that mitigate many of the stressors created by a row crop dominated landscape (e.g., dilution of pollutant loading and cooler temperatures to abate the relatively high amount of direct sunlight exposure which raises water temperatures). In addition, many of the tributaries to North Fork Paint Creek have relatively high stream gradients (averaging over 30 feet per mile drop; Ohio DNR, 2001) which improves stream conditions for aquatic life as suggested by the trend in higher biological scores in such streams across Ohio (i.e., based on years of stream survey experience in the State).

The distribution of sites impaired for aquatic life uses relative to wastewater flow volume is shown in Figure B-4. The map indicates, in conjunction with comparison statistics that are not provided, that there is a much weaker, yet significant correlation between locations of wastewater discharges and impaired aquatic life uses. This suggests that improvement in wastewater collection and treatment is warranted; however, cropland based nonpoint sources is also necessary in order to meet water quality goals. Table B-2 shows the percent of wastewater volume compared to various flow statistics based on USGS regression equations (USGS, 2006). Table B-2 is a fairly coarse comparison since flow statistics at the outfalls were not used but instead at the outlet of the ten-digit HUC.

Table B-3 is a list of all of the biological survey sites with the associated aquatic life use attainment status, bio-metric and habitat evaluation scores and basic location information.

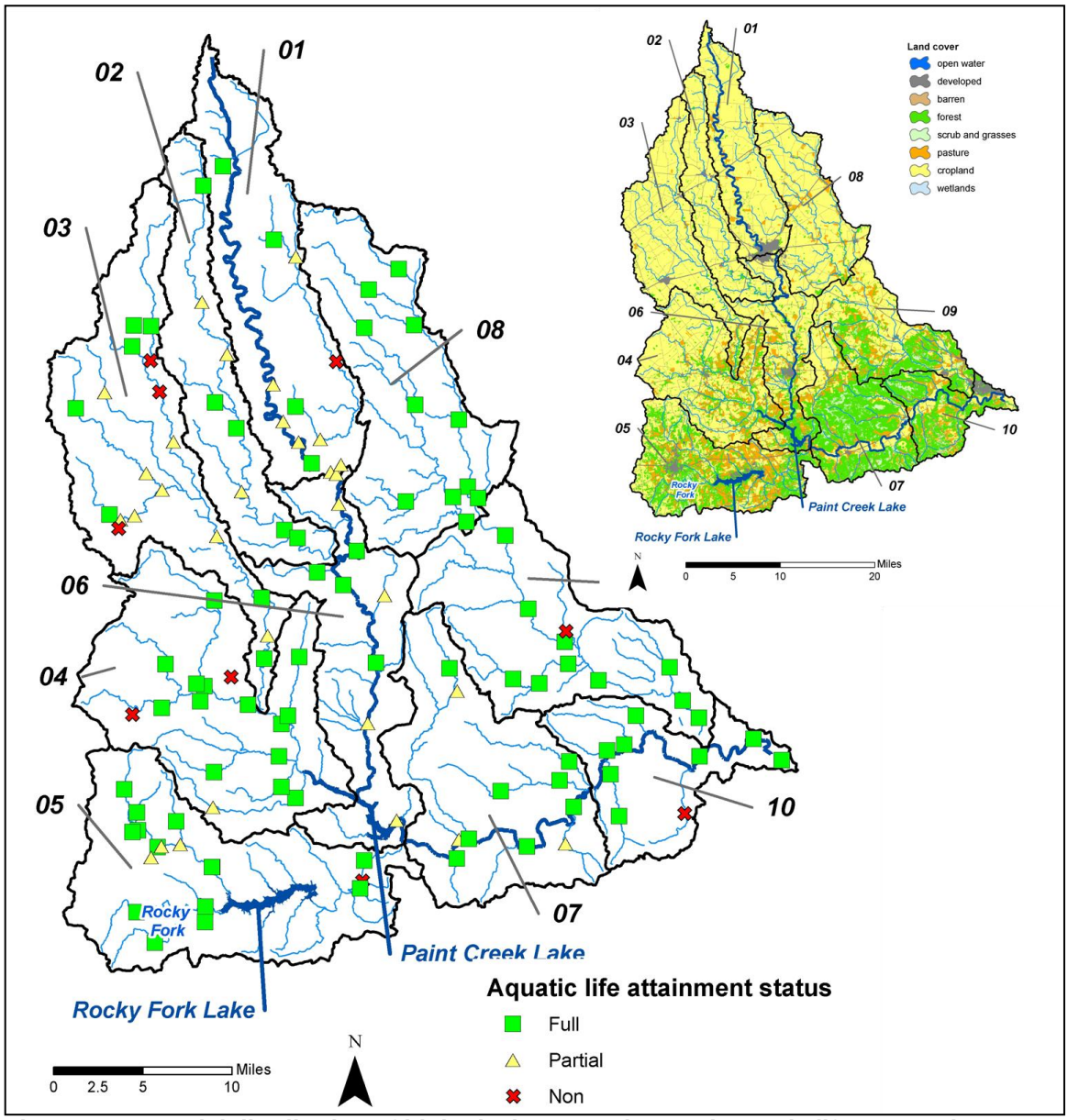

Figure B-1. Spatial distribution of biological survey sites and aquatic life use attainment status.

Table B-1. List of the 12-digit HUCs with the highest proportion of aquatic life use impairment.

12-digit HUC (05060003)	Total sites in HUC	Impaired sites in HUC	Percent of sites impaired in HUC	Percent of all impaired sites	Percent cropland in the 12-digit HUC
01 03	7	5	71%	13%	73%
01 02	6	4	67%	10%	90%
03 04	6	3	50%	8%	91%
03 05	5	3	60%	8%	74%
02 01	4	2	50%	5%	91%
03 01	2	2	100%	5%	87%
03 03	3	2	67%	5%	94%

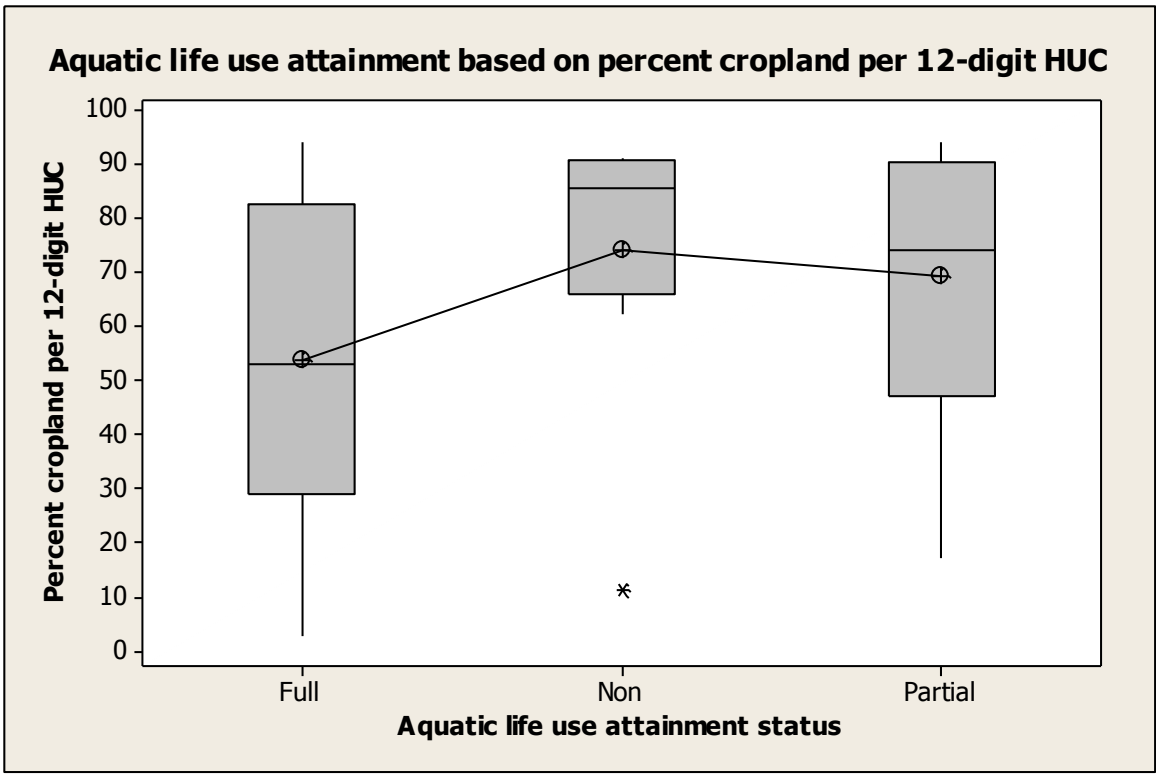

Figure B-2. Distribution of aquatic life use attainment status relative to percent of cropland.

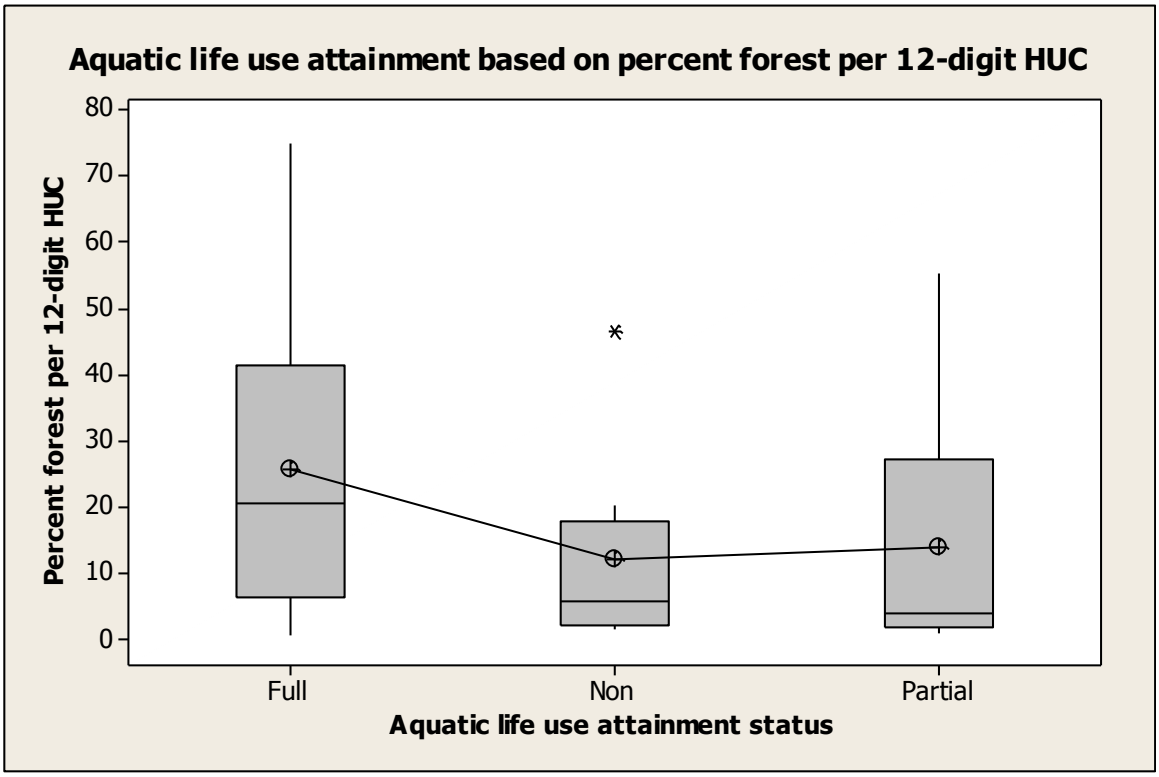

Figure B-3. Distribution of aquatic life use attainment status relative to percent of forest.

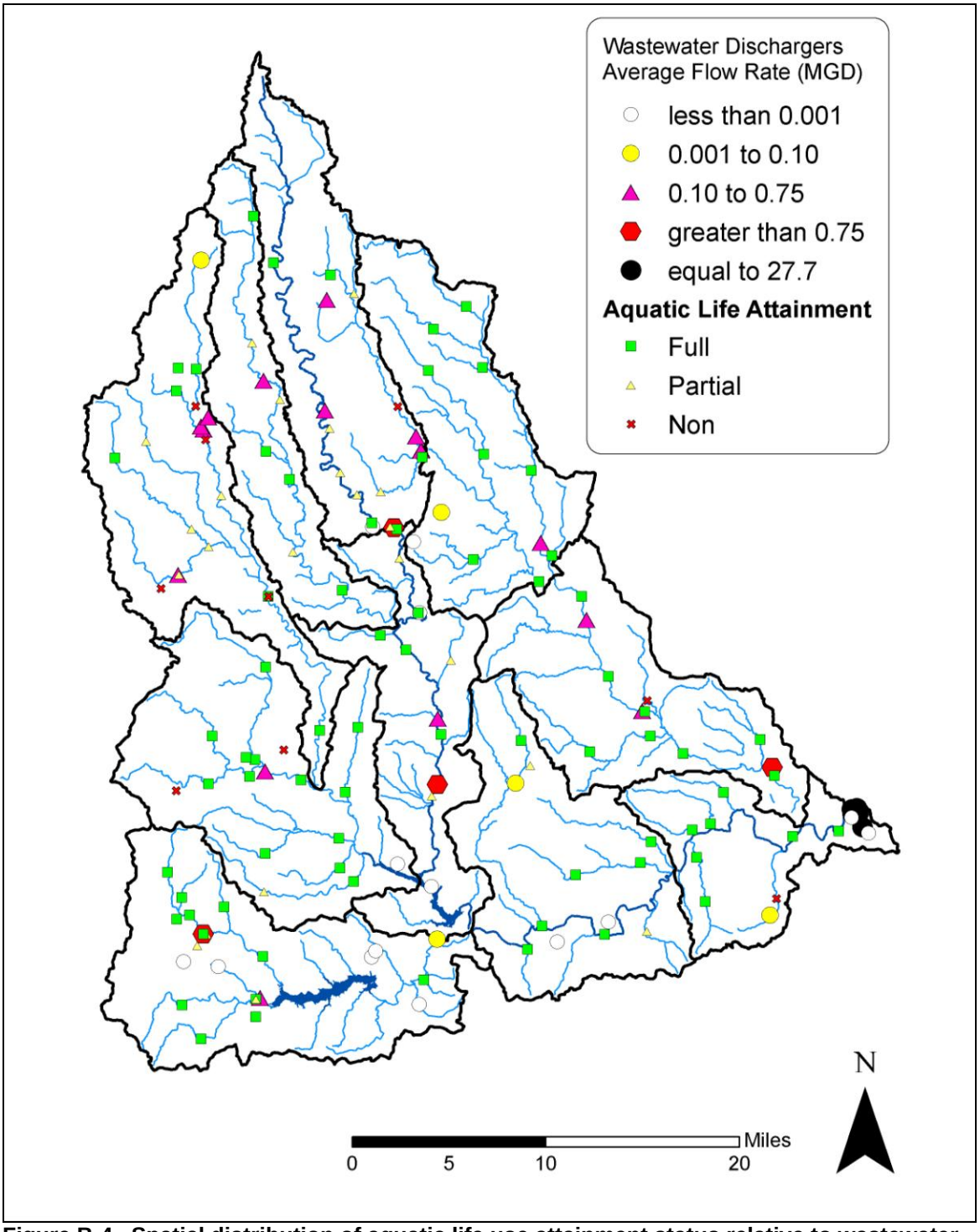

Figure B-4. Spatial distribution of aquatic life use attainment status relative to wastewater discharges.

Table B-2. Proportion of wastewater in the 10-digit HUCs based on flow statistic using drainage areas-flow statistic regressions (USGS, 2006).

Ten-Digit HUC	Percentage of Flow Statistic at HUC Outlet[1]			
	Average	Median	75th Percentile	25th Percentile
01[2]	4.7%	**17.0%**	6.1%	**52.2%**
02	2.3%	4.5%	1.4%	5.5%
03	0.9%	3.3%	1.2%	**10.4%**
04	0.1%	0.4%	0.1%	1.3%
05	1.3%	3.5%	1.3%	**9.4%**
06	0.3%	1.3%	0.4%	4.2%
07	0.0%	0.1%	0.0%	0.2%
08	0.2%	0.6%	0.2%	1.9%
09	0.9%	2.7%	1.0%	**8.5%**
10[2]	3.4%	12.2%	4.0%	40.8%

[1] Bold underline highlights instances where wastewater flow is a notable proportion of the stream flow statistic.
[2] The majority of wastewater in this ten-digit HUC is discharged near the outlet.

Table B-3. Biological and habitat index scores and aquatic life use attainment status for each sampling site.

12-Digit HUC (05060003)	STORET Code	Stream	River Mile	Drainage Area (square miles)	ALU Attainment Status	IBI Score	MiWB Score[1]	ICI Score[1]	ICI Narrative	QHEI Score
0101	V10W18	Paint Creek	96.03	31.0	Full	36	8.5		Very Good	65.5
0102	V10W23	East Fork Paint Creek	8.55	28.0	Non	35	7.1	24		44
0102	V10W24	East Fork Paint Creek	5.06	33.0	Full	36	8.06	34		56
0102	300055	East Fork Paint Creek	0.72	50.0	Partial	41	7.59	40		63
0102	V10K85	William Cathart Ditch	0.2	3.8	Partial	24			Marginally Good	50
0102	V10K86	Vallery Ditch	2.3	5.5	Full	42			Fair	56
0102	V10K83	Big Run	1.8	3.7	Partial	26			Marginally Good	43
0103	V10W20	Paint Creek	79.86	54.0	Partial	39	6.59	54		62
0103	V10S36	Paint Creek	75.33	58.0	Partial	35	7.38	46		77
0103	V10S35	Paint Creek	73.28	60.0	Partial	33	6.64	46		66
0103	V10W21	Paint Creek	71.16	63.0	Full	49	9.36	42		64.5
0103	V10S34	Paint Creek	69.52	67.0	Partial	41	7.8	28		38
0103	V10W02	Paint Creek	69.44	67.0	No status (mixing zone)	39	7.06		Poor	
0103	V10W04	Paint Creek	69.15	67.0	Partial	42	8.27	24		40.5
0201	V10K82	Sugar Creek	36.9	5.3	Full	32			Fair	38
0201	V10W26	Sugar Creek	29.21	23.0	Partial	42	7.65	28		60
0201	V10W27	Sugar Creek	24.21	28.0	Partial	38	6.84	26		48.5
0201	V10K80	Missouri Ditch	1.6	6.4	Full	36			Good	50
0202	V10W28	Sugar Creek	18.48	47.0	Full	48	8.89	56		60.5
0202	V10W29	Sugar Creek	11.99	61.0	Partial	48	7.19	56		69
0202	V10W30	Sugar Creek	5.4	72.0	Full	45	7.85	46		73
0202	300050	Sugar Creek	4.24	75.0	Full	54	9	50		76
0301	300134	Wilson Creek	4.94	16.1	Full	36			Low Fair	38
0301	300133	Wilson Creek	3.81	18.0	Partial	32			Low Fair	43
0301	300135	Wilson Creek	2.9	18.4					Poor	
0301	V10K70	Wilson Creek	2.8	18.4	Partial	26		16		44
0301	V10K71	Trib. to Wilson Creek (RM 4.23)	0.4	5.5	Non	26			Low Fair	33.5

12-Digit HUC (05060003)	STORET Code	Stream	River Mile	Drainage Area (square miles)	ALU Attainment Status	IBI Score	MiWB Score[1]	ICI Score[1]	ICI Narrative	QHEI Score
0302	V10K68	Grassy Branch	8.7	5.2	Partial	28			Good	33
0303	V10K72	West Branch Rattlesnake Creek	11.4	6.3	Full	32			Fair	27
0303	V10S03	West Branch Rattlesnake Creek	4.3	15.8	Partial	32		38		53
0303	V10K69	West Branch Rattlesnake Creek	2.8	41.6	Partial	37	7.51	22		46.5
0304	V10W32	Rattlesnake Creek	40.44	16.5	Full	44			Good	51.5
0304	V10W33	Rattlesnake Creek	38.12	25.0	Non	26	6.23	28	Marginally Good	59.5
0304	V10S37	Rattlesnake Creek	35.36	34.0	Non	27	5.93	38		58
0304	V10W37	Rattlesnake Creek	31.48	40.8	Partial	31	5.94	34		49
0304	V10K73	Maple Grove Creek	1.6	2.3	Full	40			Marginally Good	45
0304	V10K74	Trib. to Rattlesnake Creek (RM 40.21)	1.1	4.6	Full	24			Marginally Good	37
0304	300147	Grassy Branch	6.9	7.4					Marginally Good	
0305	V10W38	Rattlesnake Creek	23.97	110.0	Partial	33	6.36	44		52
0305	V10W39	Rattlesnake Creek	18.01	122.0	Full	42	9.32			59
0305	200429	Rattlesnake Creek	15	125.0	Partial	43	7.57	44		71
0305	V10S05	Rattlesnake Creek	13.23	128.0	Full	45	8.28		Exceptional	77.5
0401	V10K63	South Fork Lees Creek	1.6	15.9	Full	44			Marginally Good	50.5
0401	V10K64	Trib to S Fk Lees Creek (RM 3.83/0.25)	0.23	1.7	Non	40			Poor	49.5
0402	V10K65	Middle Fork Lees Creek	5.1	12.4	Full	56			Marginally Good	70
0402	V10W46	Middle Fork Lees Creek	1.15	36.1	Full	51	9.28	38		53.8
0403	V10K67	Lees Creek	10.4	14.3	Full	40			Good	36.5
0403	V10W44	Lees Creek	4.5	25.6	Full	53	9.25	48		76

12-Digit HUC (05060003)	STORET Code	Stream	River Mile	Drainage Area (square miles)	ALU Attainment Status	IBI Score	MiWB Score[1]	ICI Score[1]	ICI Narrative	QHEI Score
0403	V10W45	Lees Creek	1.16	73.0	Full	51	9.07	42		76.8
0403	V10K61	Trib. to Lees Creek (RM 2.57)	1.3	3.1	Non	28			Very Poor	66
0403	V10K66	Trib. to Lees Creek (RM 4.83)	0.3	2.2	Full	46			Good	56
0404	V10K59	Walnut Creek	4.2	5.7	Full	50			Exceptional	64.3
0404	V10K58	Walnut Creek	0.6	13.4	Full	44			Very Good	75.8
0405	V10K57	Hardin Creek	5.8	2.8	Full	47			Good	61.3
0405	V10K50	Hardin Creek	1.1	20.5	Full	50	8.76	54		74
0406	V10K48	Fall Creek	7.2	3.9	Partial	34			Marginally Good	58.5
0406	V10K47	Fall Creek	1.6	13.3	Full	38			Exceptional	67
0407	300049	Rattlesnake Creek	7.55	209.0	Full	50	9.03	52		71.3
0407	V10K49	Big Branch	1.6	3.7	Full	55			Very Good	65.3
0501	V10K43	South Fork Rocky Fork	3.3	7.2	Full	56			Very Good	73.5
0502	V10K41	Clear Creek	11.3	7.4	Full	58			Very Good	68
0502	V10W47	Clear Creek	8.45	20.1	Full	51	9.32	42		70.8
0502	V10S13	Clear Creek	6.8	24.9	Full	53	9.86	50		74.5
0502	V10S12	Clear Creek	6.6	25.1	Partial	49	9.74	38		71.5
0502	200428	Clear Creek	5.4	28.0	Partial	52	9.69		Good	59
0502	V10P15	Clear Creek	2.7	36.0	Full	49	9.15	54		65.5
0502	V10P14	Coon Creek	0.01	4.1	Full	48			Good	57.5
0502	V10K37	Little Rock Creek	1.4	2.2	Full	52			Exceptional	69.5
0502	V10Q06	Moberly Branch Clear Creek	0.9	2.5	Partial	58			Fair	66
0502	V10K39	Trib. to Clear Creek (RM 8.47)	0.4	2.7	Full	54			Good	66
0502	V10K40	Hussey Run	0.8	3.0	Full	58			Very Good	67.5
0503	V10S16	Rocky Fork Paint Creek	23.27	16.2	Full	56		46		55.5
0503	V10P16	Rocky Fork Paint Creek	18.05	33.0	Full	49	10.09	46		58

12-Digit HUC (05060003)	STORET Code	Stream	River Mile	Drainage Area (square miles)	ALU Attainment Status	IBI Score	MiWB Score[1]	ICI Score[1]	ICI Narrative	QHEI Score
0503	V10K42	Trib. to Rocky Fork (RM 17.55)	1	2.3	Full	52			Very Good	66
0505	V10W42	Rocky Fork Paint Creek	4.47	138.0	Non			40		
0505	610800	Rocky Fork Paint Creek	3.03	140.0	Full	44	9.54		Exceptional	88.5
0505	V10K32	Pickett Run	0.1	1.8	Full	44			Good	50.5
0601	V10S32	Paint Creek	67.1	120.0	Partial	44	9.54	44		61
0601	V10W22	Paint Creek	63.3	131.0	Full	46	10.04	48		68.5
0601	V10S31	Paint Creek	58.75	224.0	Full	52	9.9	50		83
0601	V10K78	Indian Creek	1.6	5.8	Partial	46			Fair	61.5
0601	V10K79	Wabash Creek	0.8	4.6	Full	44			Marginally Good	67
0602	V10S30	Paint Creek	52.54	249.0	Full	49	8.63	50		78.5
0602	V10S29	Paint Creek	48.7	261.0	Partial	44	8.62	54		83
0603	300053	Paint Creek	39.14	570.0	Partial	46	10.1	18		82
0701	V10K04	Buckskin Creek	13.9	4.9	Full	56			Very Good	74
0701	V10K05	Buckskin Creek	0.4	39.7	Full	53	9.66	52		77.5
0701	V10K54	Trib. to Buckskin Creek (RM 12.25)	0.18	2.7	Partial	52			Fair	50.5
0702	V10K20	Upper Twin Creek	5.8	5.5	Full	60			Very Good	75
0702	V10K12	Upper Twin Creek	2	12.2	Full	58			Exceptional	70
0703	V10K07	Lower Twin Creek	2.2	15.0	Full	58			Exceptional	78
0704	V10Q02	Paint Creek	32.5	732.0	Partial	46	11.17	32		81
0704	V10W14	Paint Creek	27.43	788.0	Full	51	10.81	48		84.5
0704	601320	Paint Creek	21.6	807.0	Full	53	11.09	50		80
0704	V10K10	Sulphur Lick	1.5	7.6	Partial	48			Fair	50.5
0704	V10K08	Massie Run	0.1	4.9	Full	56			Good	49
0801	V10K51	Thompson Creek	3.3	8.0	Full	56			Good	68
0802	V10K52	North Fork Paint Creek	42	11.0	Full	50			Very Good	72.5
0803	V10K27	Compton Creek	17.6	6.1	Full	48			Good	55
0803	V10K26	Compton Creek	11.2	19.9	Full	54		36		74

12-Digit HUC (05060003)	STORET Code	Stream	River Mile	Drainage Area (square miles)	ALU Attainment Status	IBI Score	MiWB Score[1]	ICI Score[1]	ICI Narrative	QHEI Score
0804	300048	Compton Creek	3.37	49.7	Full	55	9.88		Exceptional	71.5
0804	V10S02	Compton Creek	1.1	59.0	Full			50		
0804	V10K31	Crooked Creek	3	7.2	Full	44			Very Good	71
0805	V10W16	North Fork Paint Creek	31.02	45.0	Full	52	10.12	48		72.5
0805	300046	North Fork Paint Creek	26.67	51.0	Full			46		
0805	V10K25	Wolf Run	0.3	3.6	Full	46			Good	63
0805	V10K24	Mud Run	0.4	7.3	Full	52			Exceptional	67.5
0902	V10K02	Little Creek	5.62	8.4	Full	52			Very Good	63
0902	300334	Little Creek	3.7	14.7	Full			54		
0902	V10K13	Little Creek	1	22.7	Full	45	8.79			58.8
0903	V10K14	North Fork Paint Creek	22.3	122.0	Full	55	10.38	50		84
0903	V10S01	North Fork Paint Creek	17.5	153.0	Full	56	10.74		Very Good	84
0903	V10K23	North Fork Paint Creek	14.1	164.0	Full	52	10.81	50		86.5
0903	V10K15	Oldtown Run	1.3	8.5	Non	36			Poor	56.5
0904	V10S18	North Fork Paint Creek	10.5	207.0	Full	56	10.51	56		79
0904	V10K01	North Fork Paint Creek	3.9	230.0	Full	58	10.7	56		81.5
0904	300047	North Fork Paint Creek	2.28	232.0	Full	58	10.68	54		75
0904	V10K06	Biers Run	1.5	7.1	Full	52			Good	61.5
1001	V10K21	Black Run	3.96	5.0	Full	54			Very Good	61
1001	V10K16	Black Run	1	8.6	Full	54			Good	40.5
1002	V10K19	Ralston Run	2.8	5.2	Non	36			Fair	44.5
1003	V10K17	Paint Creek	8.9	895.0	Full	56	11.43	56		82
1003	V10P06	Paint Creek	3.8	1138.0	Full	55	10.71	52		83.5
1003	V10W12	Paint Creek	1.2	1143.0	Full	45	9.99	42		79
1003	V10K53	Cattail Run	1.2	2.9	Full	50			Very Good	47
1003	V10K22	Owl Creek	0.35	6.5	Full	48			Very Good	65
1003	V10K03	Plug Run	0.4	5.4	Full	48			Exceptional	68.5

[1] MiWB and ICI scores are only derived for sites considered wadeable or larger (i.e.,. drainage area greater than 20 square miles). Narrative ICI applies in lieu of numeric ICI.

B1.1 Causes and Sources of Impairment

Low concentrations or wide swings in dissolved oxygen concentrations were the top issues causing impaired aquatic life communities (impacting 15 sites). Nutrient enrichment (which often causes issues with dissolved oxygen) and excessive amounts of fine sediment in the bed substrate were other problems identified that were comparable in the extent and magnitude of their impact on water quality (impacting 12 and 11 sites, respectively). Poor habitat quality associated with ditching and ditch maintenance and organic enrichment, and altered flow conditions were other significant causes of impairment (impacting 10, 9, and 8 sites, respectively). Ammonia toxicity was identified as a problem but had a lower distribution across the watershed (2 sites). Additionally, two sites were impaired but there is insufficient information to make a reliable determination of the cause of impairment and one site was impaired due to the natural limitations of the stream system in the vicinity of the survey site. Table B-4 lists the various causes of aquatic life use impairment distributed across the 12-digit HUCs that were impacted and Figures B-5 and B-7 provide graphical representation of the proportional distribution of the respective causes of impairment.

Table B-4. List of the 12-digit HUCs and associated causes of aquatic life use impairment.

HUC 12 (05060003)	DO	Nutrients	Sediment	Poor habitat	Organic	Flow alteration	NH3	Unknown	Natural conditions
01 02	2		2			2			
01 03	4	3	3	2		1			
02 01	2	2		2					
02 02		1							
03 01				1	1		1	2	
03 02						1			
03 03	1		2						
03 04	1			3					
03 05			1	1					
04 01	1				1		1		
04 03	1				1	1			
04 06		1			1				
05 02					2	1			
05 05		1							
06 01		1				1			1
06 02					1				
06 03	1	1							
07 01		1				1			
07 04	2	1	1	1					
09 03			1		1				
10 02			1		1				
GRAND TOTAL[1]	**15**	**12**	**11**	**10**	**9**	**8**	**2**	**2**	**1**
	12%	**10%**	**9%**	**8%**	**7%**	**6%**	**2%**	**2%**	**1%**

[1] The percentage reflects the percent of all sites in the project area (i.e., 124) that are impacted by the respective stressor.

The most significant sources of water quality stressors, proportionally speaking, are those related to crop or livestock production. Runoff from cropland carrying nutrients, sediment, and organic substances is perhaps the most severe problem in the watershed. Habitat degradation and altered flow conditions are likewise impacted by the absence of deep rooted vegetation, lack of longer-term water storage in the soil profile (e.g., due to subsurface drainage) and active maintenance of ditches and adjacent riparian areas. Wastewater is also a notable problem on a local scale for aquatic life use goals; however, its impact on Paint Creek Lake is also a

serious concern. Other sources include urban storm water, discharges from failing septic systems and flow impoundments. Table B-5 lists the various sources of aquatic life use impairment distributed across the 12-digit HUCs that were impacted and Figure B-6 provides graphical representation of the proportional distribution of the respective sources of impairment.

Table B-5. List of the 12-digit HUCs and associated sources of aquatic life use impairment.

HUC 12	Cropland	Channelization	Livestock access	Municipal point source	Urban runoff	Upstream impoundment	Unknown source	Home septic systems	Natural source	Dam or impound-ment
01 02	4	2								
01 03	3	2	3	1	2					
02 01	1		1	1						
02 02	1		1							
03 01	1	1		1	1		1			
03 02	1									
03 03	2	2								
03 04	2	2								
03 05	2	2								
04 01	1						1			
04 03	1		1							
04 06	1		1							
05 02				2	1					
05 05										1
06 01	1								1	
06 02				1						
06 03						1				
07 01	1									
07 04	1	1				1				
09 03								1		
10 02								1		
Grand Total	**23** **19%**	**12** **10%**	**7** **6%**	**6** **5%**	**4** **3%**	**2** **2%**	**2** **2%**	**2** **2%**	**1** **1%**	**1** **1%**

[1] The percentage reflects the percent of all sites in the project area (i.e., 124) that are impacted by the respective source.

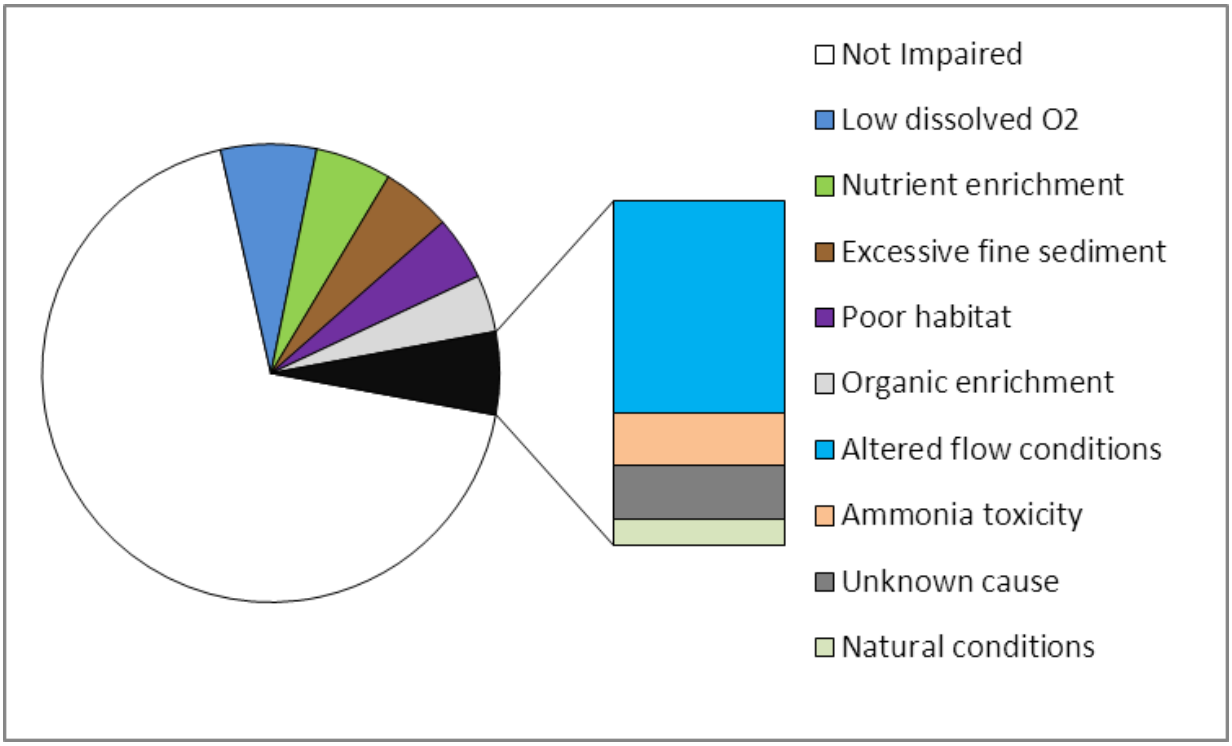

Figure B-5. Distribution of the listed causes of aquatic life use impairments.

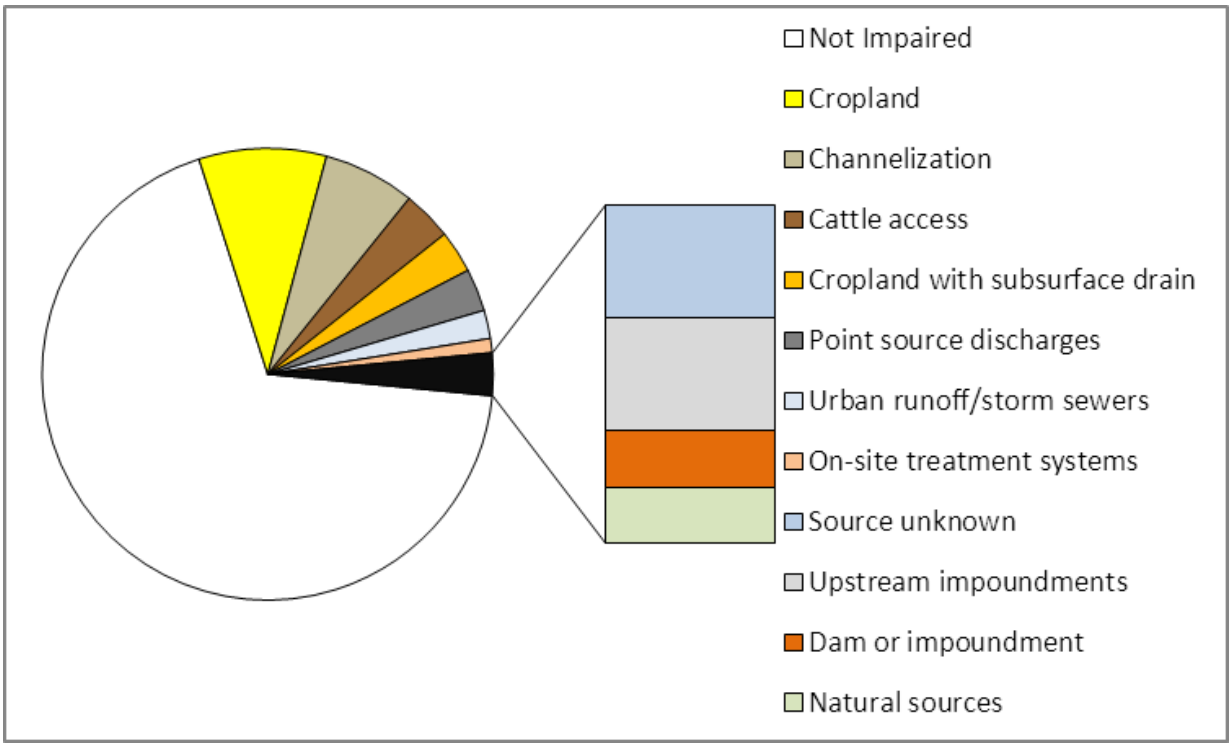

Figure B-6. Distribution of the listed sources of aquatic life use impairments.

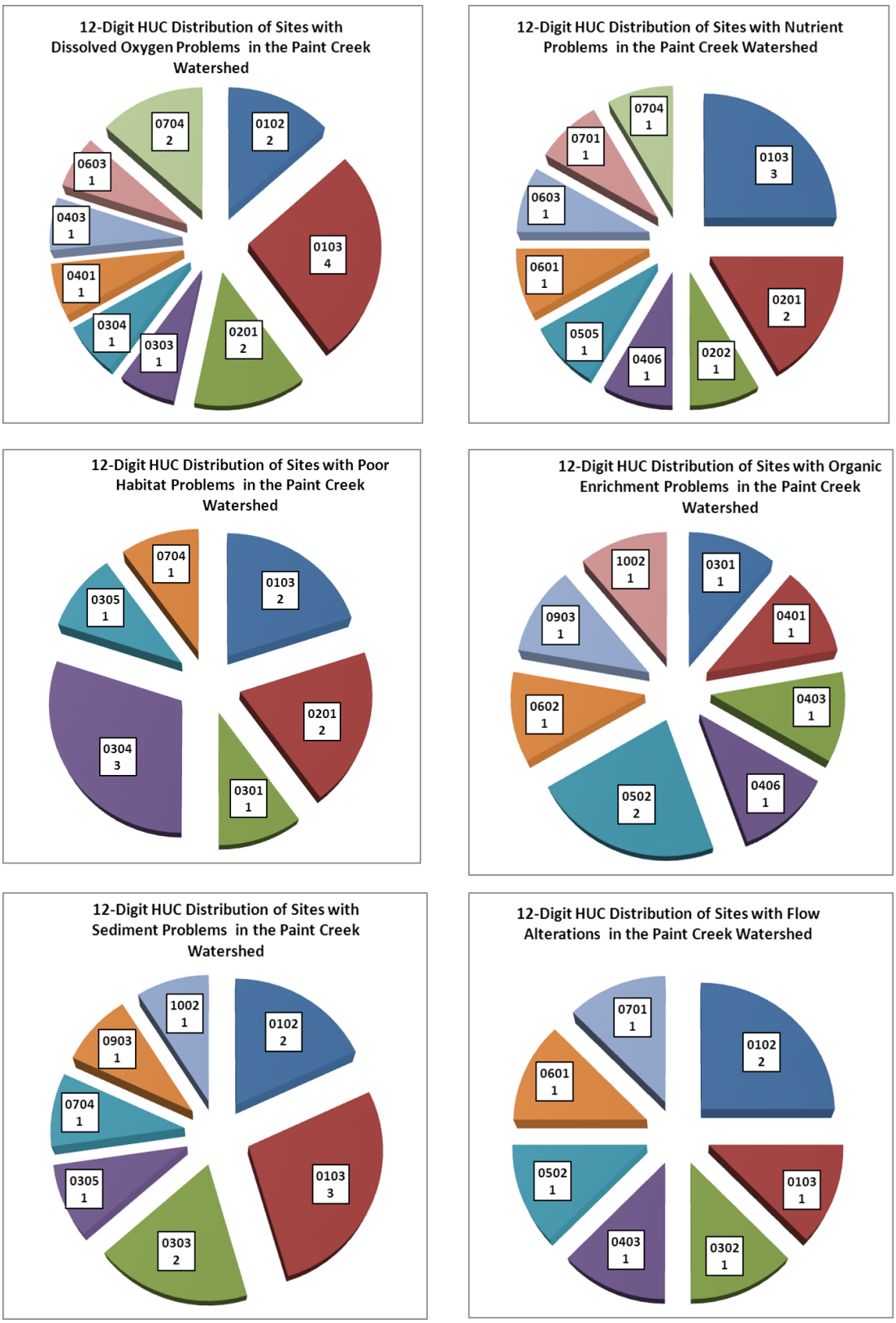

Figure B-7. 12-digit HUC distribution of specified causes of impaired aquatic life uses.

Other comparative statistics were done to look more closely at the impact of various stressors on indicators of biological health and habitat quality. Specifically, the Index of Biotic Integrity (IBI) which is the primary measure of the health of the local fish community was regressed against percent of land covered by crops, forest, and pasture, while the Qualitative Habitat Evaluation Index (QHEI) was regressed against percent cropland. Each of these relationships were statistically significant but with varying strength of the correlations. The IBI versus the percent of cropland and that of forest had the strongest correlations with R-squared values at 0.31 and 0.32, respectively. The IBI versus percent pasture and the QHEI versus percent cropland were weaker correlations with R-squared values of 0.19 and 0.09, respectively. See Figures B-8 through B-11 for a graphical display of these relationships.

In comparing bio-metric scores within a respective HUC12 with the amount of wastewater discharged in that HUC12 there is a very weak (but statistically significant) inverse relationship between the supporting the assertion that waste water is indeed a cause of lower biometric scores in the Paint Creek watershed.

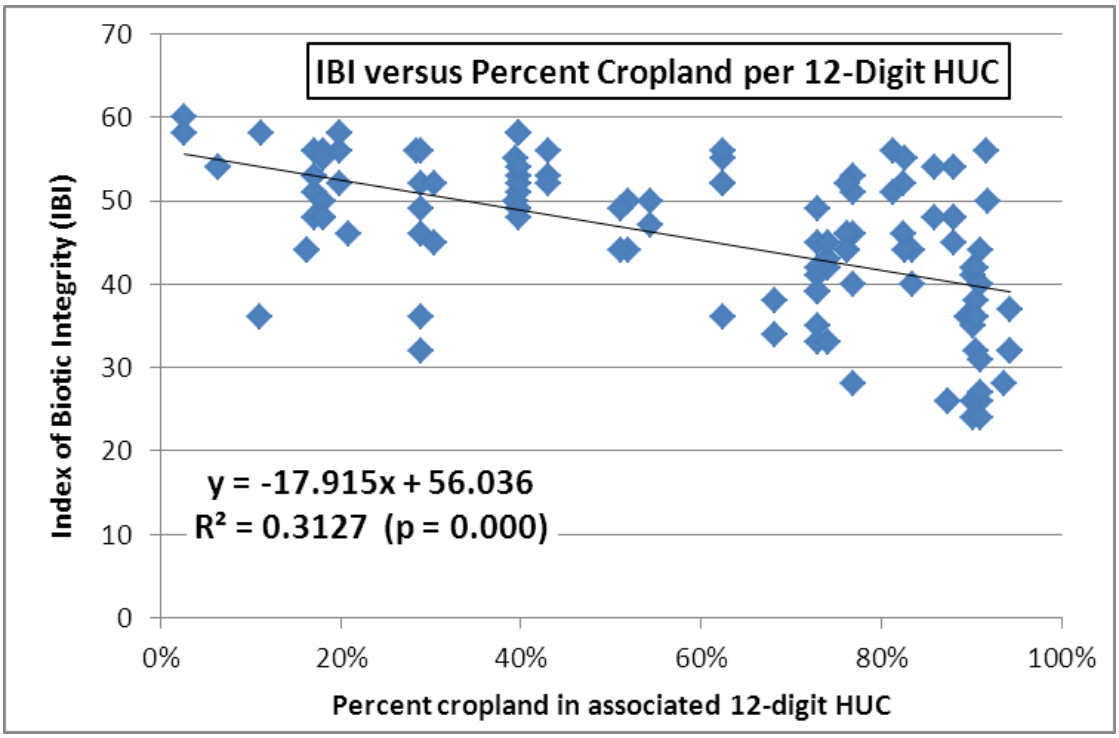

Figure B-8. 12-digit HUC distribution of specified causes of impaired aquatic life uses.

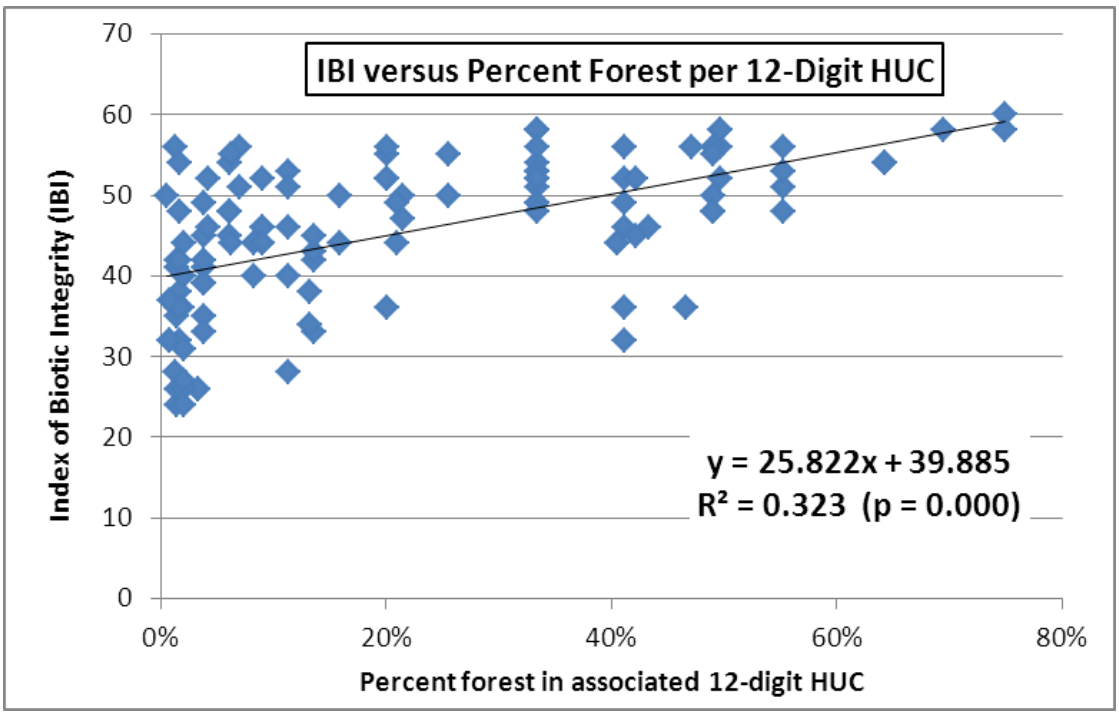

Figure B-9. 12-digit HUC distribution of specified causes of impaired aquatic life uses.

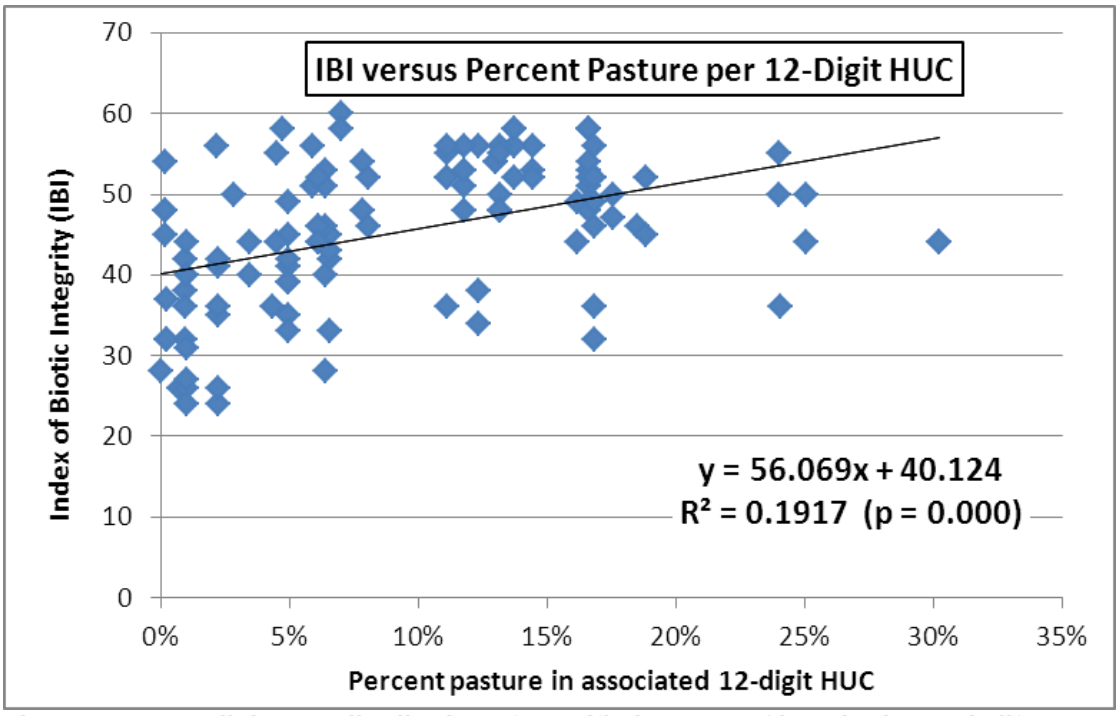

Figure B-10. 12-digit HUC distribution of specified causes of impaired aquatic life uses.

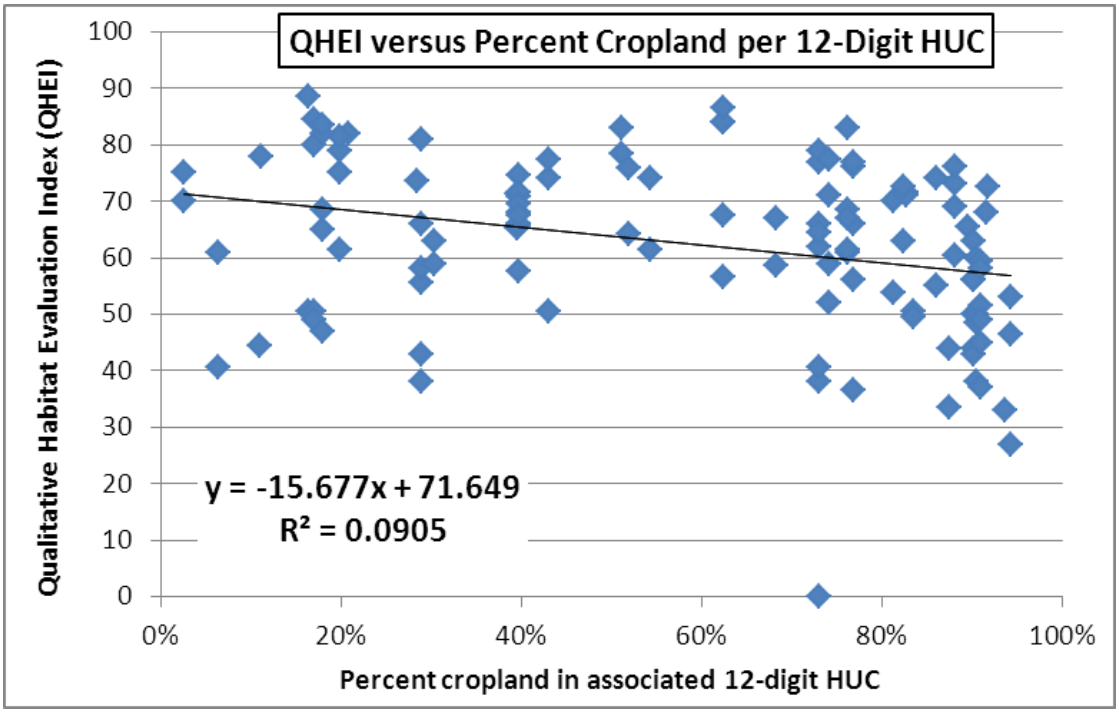

Figure B-11. 12-digit HUC distribution of specified causes of impaired aquatic life uses.

B1.2 Water and Sediment Chemistry

Water Chemistry

Figures B-12 and B-13 show the distribution of concentrations of nitrate+nitrite and total phosphorus, respectively, across the Paint Creek watershed based on the water chemistry results of the survey conducted in 2006.

The maps indicate that nutrients are elevated in the northern portion of the watershed where agriculture predominates in comparison to the lower (southern) watershed, which is much more forested and where there is far less cropland. This is true for both nitrate-nitrite (NO_3-NO_2) and total phosphorus concentrations. Likewise, there are several discrete locations with highly elevated NO_3-NO_2 and total phosphorus concentrations on Sugar Creek, Rattlesnake Creek, Lees Creek, Rocky Fork, East Fork Paint Creek and North Fork Paint Creek. The mainstem of Paint Creek, from just below Washington Court House to above Paint Creek Lake, also show consistently elevated nutrient concentrations. The sampling data suggests that the primary source of the nutrients is wastewater discharges since the mainstem has lower concentrations above the large WWTPs and the tributaries entering Paint Creek below these WWTPs show relatively low nutrient concentration where they enter Paint Creek.

Figure B-14 displays the same sampling locations as Figures B-12 and B-13; however the nitrogen to phosphorus ratio is presented instead of the concentration values. These ratios are based on the overall average nutrient concentrations at each of these sites converted to a molar basis. Nitrogen to phosphorus ratios indicate which nutrient is limiting primary production in the systems and therefore the nutrient that is most meaningful to control in limiting algae production, which is beneficial to local water quality conditions.

The Redfield Ratio (Redfield, 1958) was developed to determine the relative occurrence of nitrogen to phosphorus in the tissues of some algae. This value is estimated to be sixteen to one. Ratios that are well below this suggest that there is not enough nitrogen, making this the limiting nutrient, and a ratio well above 16 suggests phosphorus is in short supply and therefore it is limiting algae production; however, values that are close to sixteen (e.g., 12 through 20) suggest co-limitation. In Figure B-14, circles indicate a Redfield ratio greater than 16, which is the breakpoint at which phosphorus becomes limiting. Three categories have been assigned to the ratios indicating phosphorus limitation; they range from 16 to 20, 20 to 50, and 50 to 338. These somewhat arbitrarily selected categories are indicated by progressively larger circles occurring in progressively darker hues and indicate how strongly phosphorus limited the system is. Three categories of nitrogen limitation have also been somewhat arbitrarily delineated similar to what was done with phosphorus but instead with progressively larger triangles with darker hues of red which is indicating more strongly nitrogen limiting conditions. These ranges are 12 to 16, 5 to 12, and 0 to 5.

The distribution of these ratios shown in Figure B-14 suggests that phosphorus, in many more instances, is the limiting nutrient compared with nitrogen (as indicated by the high number of circles and particularly the larger circles in Figure B-14). This means that algae will grow to the extent that the available phosphorus can support its growth. So reducing in-stream phosphorus concentrations should provide a corresponding reduction in algal biomass. Areas in the Paint Creek watershed where nitrogen concentrations are low compared to phosphorus are generally interspersed within areas where phosphorus is limiting. However, the greatest concentration of nitrogen limited conditions is the lower section of North Fork Paint Creek and its tributaries in that immediate vicinity. The lower portion of the East Fork Paint Creek as well as Paint Creek mainstem just downstream from Washington Courthouse are somewhat nitrogen limited which is mostly due to the much lower nitrogen to phosphorus ratios in the waste water. Other areas notably nitrogen limited are the headwaters of Rattlesnake and Sugar Creeks. To reduce local algal biomass outbreaks in nitrogen limited areas, a shift in NPS abatement strategies could be considered for cropland where greater focus is on providing hydraulic retention such as wetlands and/or controls on sub-surface drainage systems. However in more phosphorus limited areas, reduction of local algae production may be best abated from a focus on controlling soil losses.

However, a seasonal pattern to the nitrogen to phosphorus ratios is observed in the Paint Creek watershed (see Figure B-15 and Figure B-16 for a representation of N:P ratios across time for three regions of the Paint Creek mainstem). There is a peak in the value of the ratio in early to mid-spring (generally April) and a minimum occurring in the dry, low flow period of the year (August to October). The interceding months are generally characterized by a steeper drop in the ratio value from the peak in the spring to the minimum in the late summer and a more gradual increase from the minimum of the late summer to the peak in the spring. One interpretation of this data is that nitrogen loading is more responsive to spring rains than phosphorus loading (possibly due to greater solubility of nitrogen species as well as its higher fertilizer application rates (e.g., approximately 150 lbs. anhydrous ammonia per acre, which is readily converted to NO3 compared to approximately 40 lbs. phosphorus per acre)). The movement towards a more nitrogen limited situation (i.e., low N:P ratios) as the season progresses to summer and stream flows generally decrease can be a function of a higher rate of nitrogen consumption (e.g., more in-stream biological activity from denitrifying bacteria in response to increasing temperatures) as well as the effect on streams with WWTPs of a higher proportion of wastewater in the stream flow which has much lower N:P ratios.

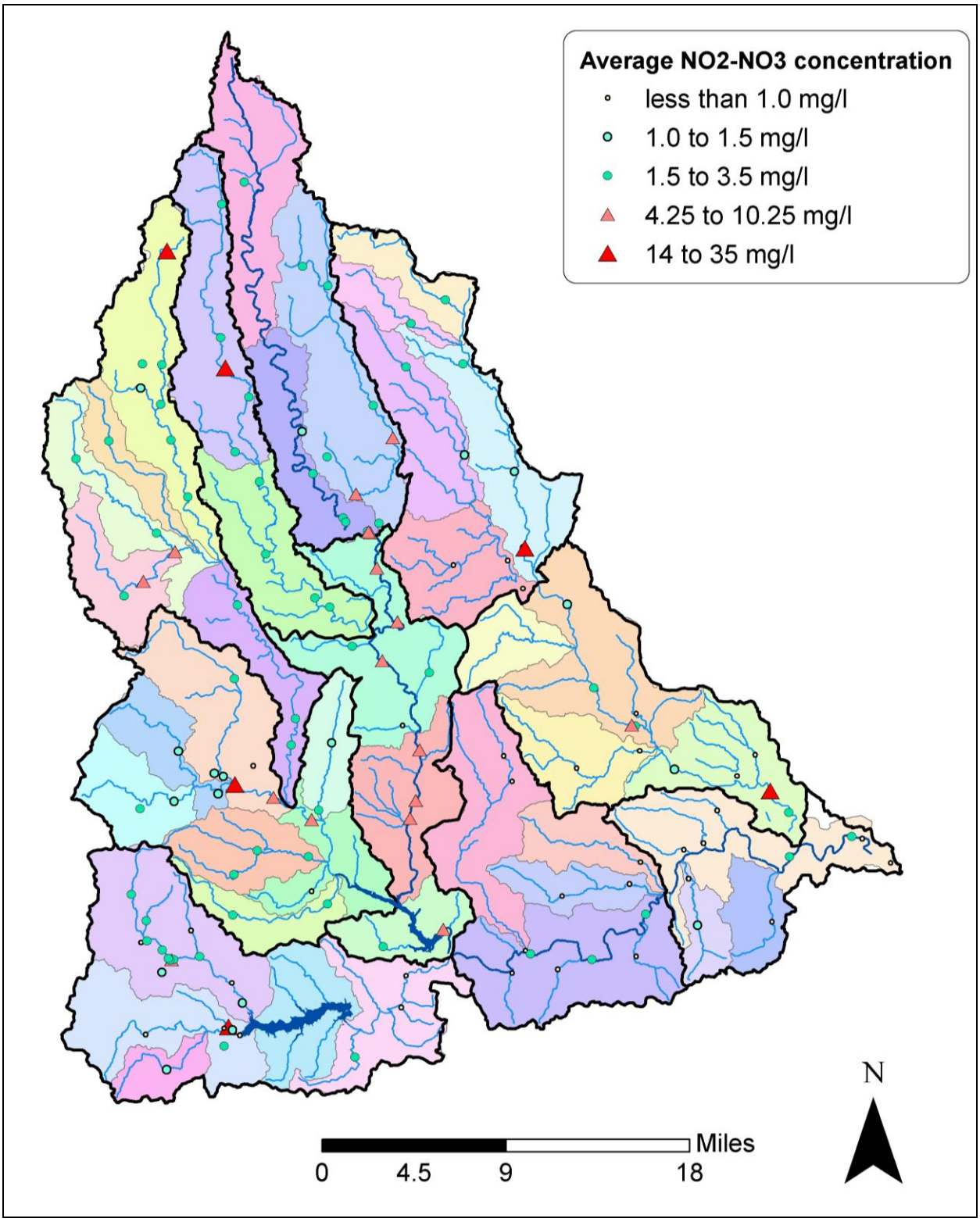

Figure B-12. Mean nitrate+nitrite water chemistry results for the Paint Creek watershed

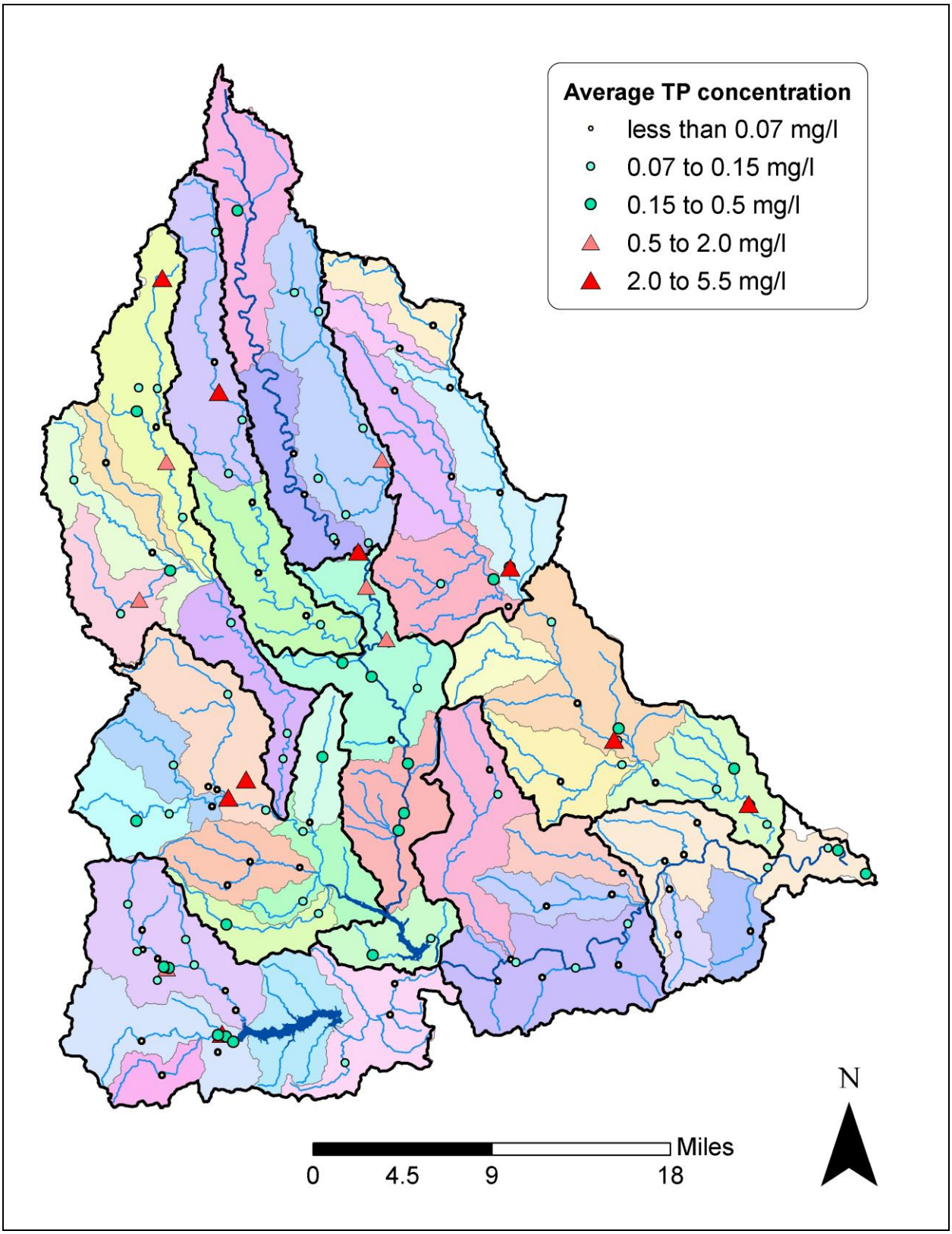

Figure B-13. Mean total phosphorus water chemistry results for the Paint Creek watershed.

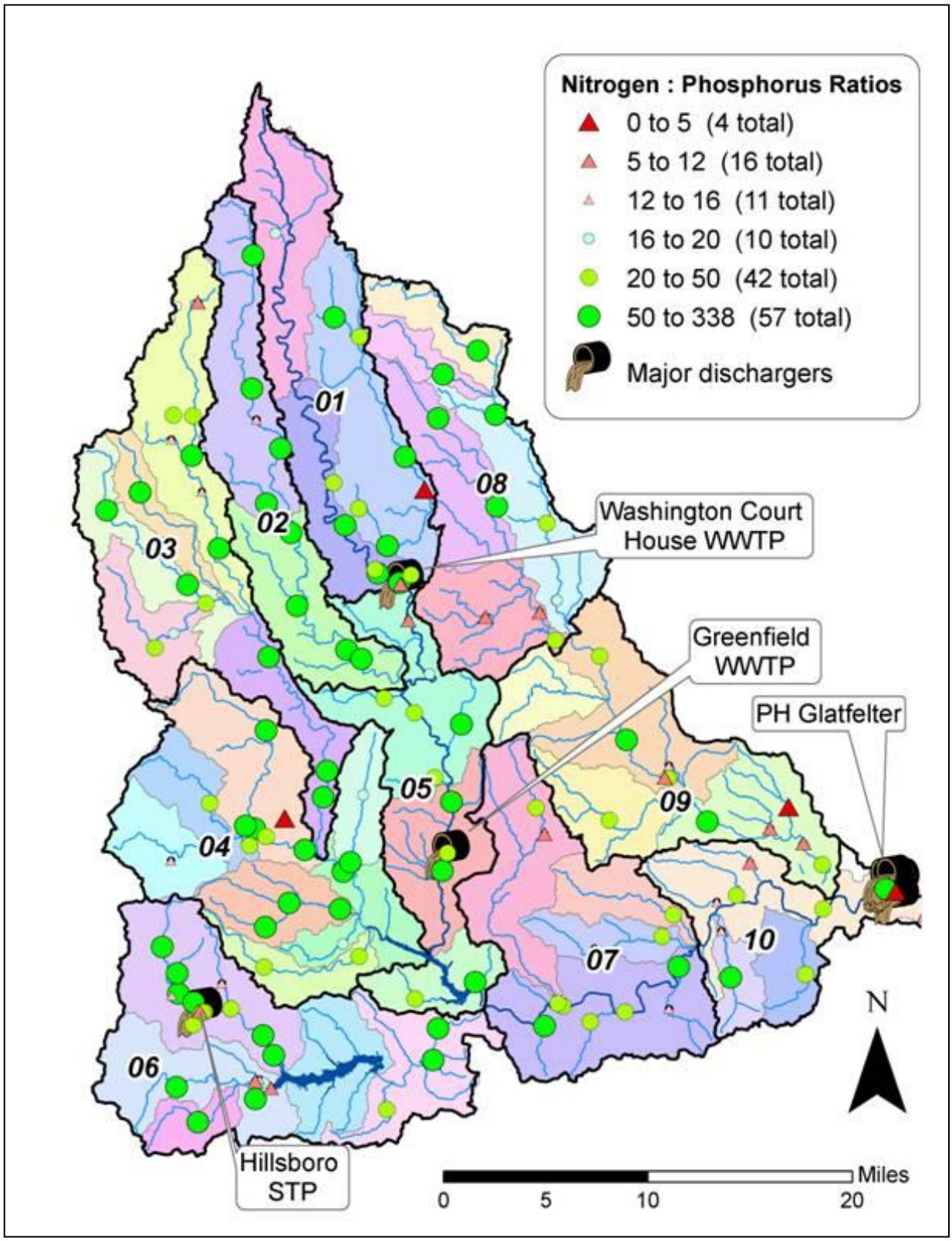

Figure B-14. Spatial distribution of molar ratio of nitrogen to phosphorus based on water chemistry results from TMDL survey only.

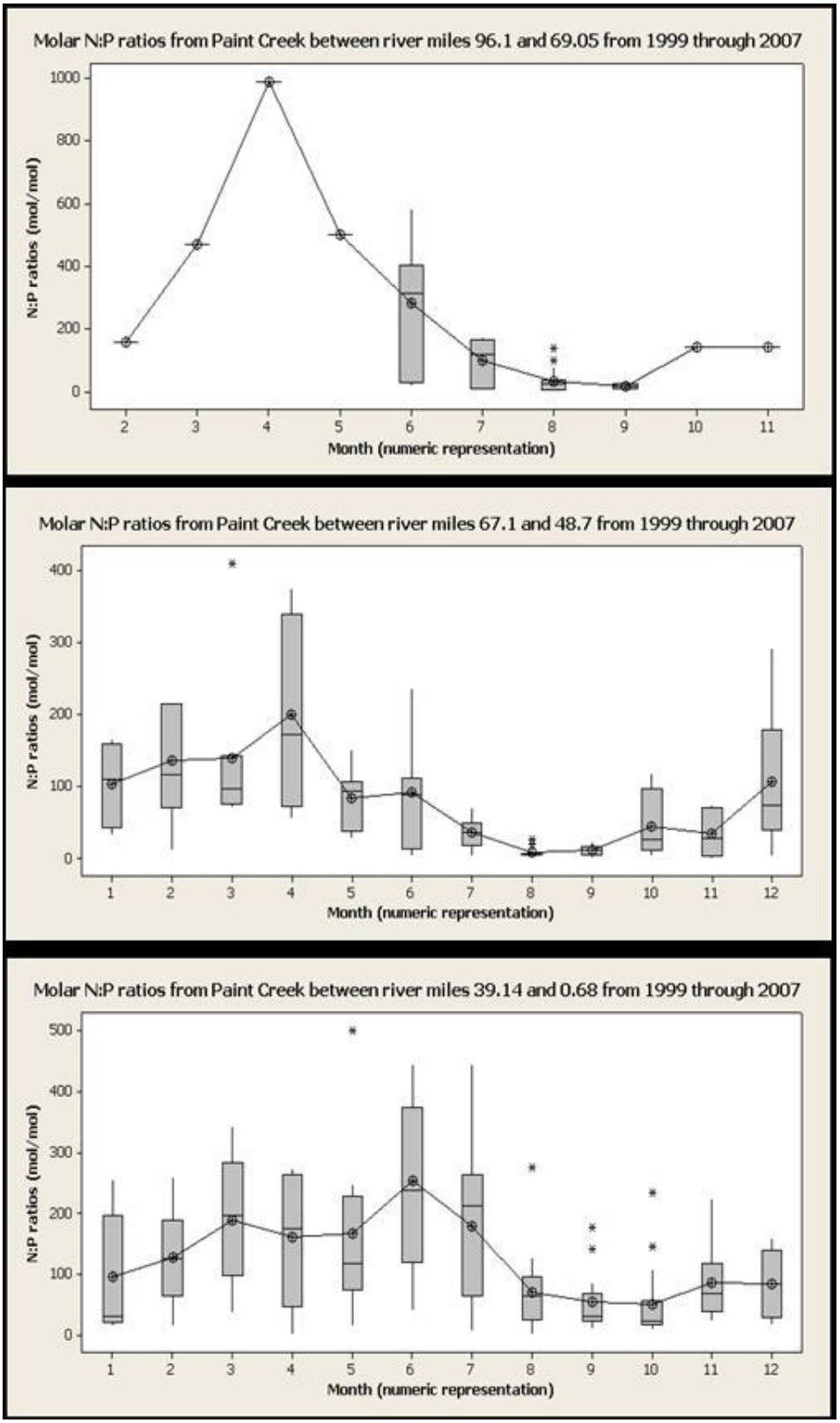

Figure B-15. Monthly distribution of molar ratios of nitrogen to phosphorus on Paint Creek mainstem based on long-term water chemistry results across three distinct zones of the river.

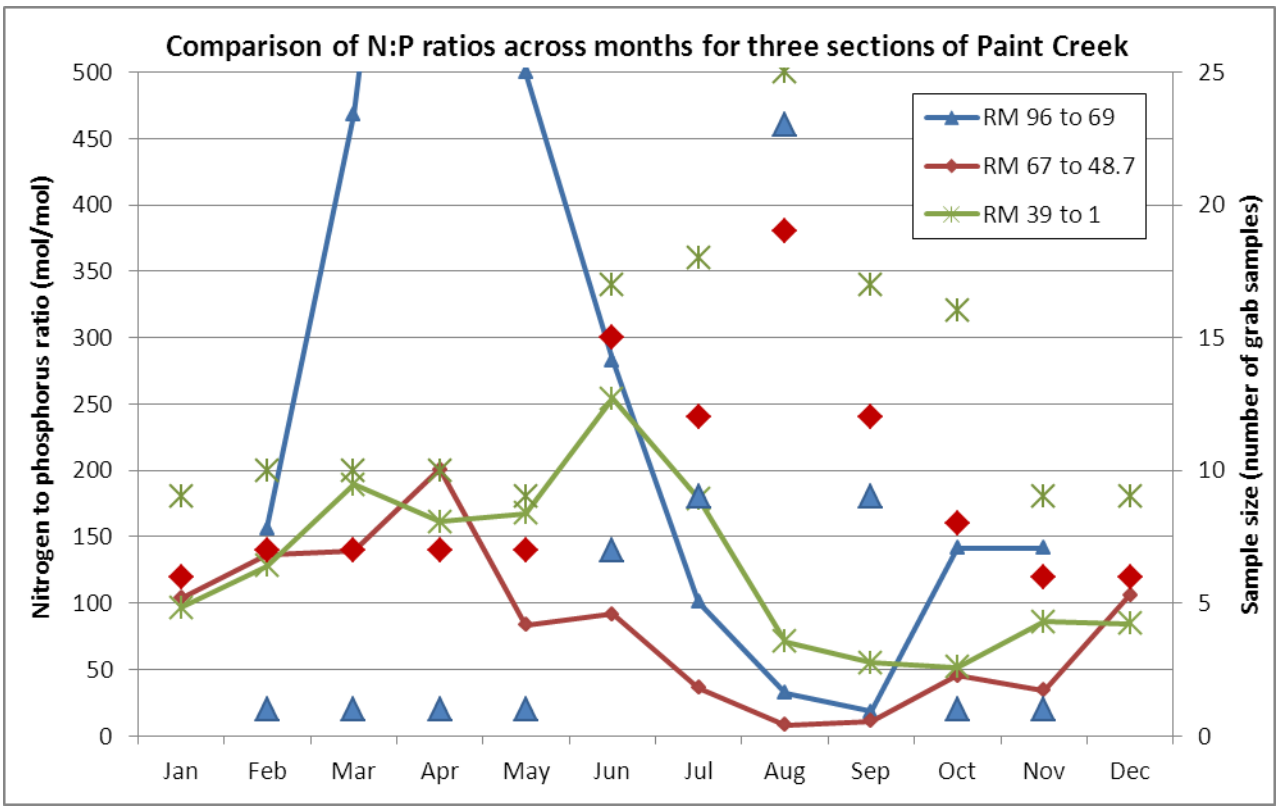

Figure B-16. Comparison of N:P ratios across months of a year for three distinct regions of the mainstem of Paint Creek (small drainage area above WWTPs, larger watershed below significant WWTPs, and large watershed below Paint Creek Lake).

Sediment Chemistry

Sediment samples were obtained from three locations in the Upper Paint Creek watershed. All three locations were on the Paint Creek mainstem. Sediment samples revealed little in the way of contamination from organic chemicals or metals. Pesticides, PCBs, BNAs and VOCs were not detected at any of the three sample locations. Metals (including arsenic) were not detected at concentrations above sediment reference values. Only total organic carbon and sediment phosphorus were detected at concentrations that might be slight cause for concern for the benthic community but impairment of the invertebrate community was not noted at any of these sites.

Figure B-17 shows the concentration of two nutrient based sediment constituents, total phosphorus and ammonia, at the 14 locations in the survey area. The first three bar charts (from top left and proceeding counterclockwise) are individual streams that are each tributary to one of the public reservoirs in the watershed while the top right chart reflects concentrations at the sole sampling locations on each of four relatively small streams. Sediment total phosphorus was at its highest concentration in Paint Creek at the most upstream sediment sampling location (river mile 58.75), which is about eleven miles downstream from the Washington Courthouse wastewater discharges. This value was 914 mg/kg total phosphorus and it fairly rapidly attenuated in the sediment moving downstream, specifically losing over 32 percent and then over 13 percent across a tem mile stretch (for a value of 533 mg/kg). Sites on Lees Creek, Moberly Branch and one site each on Clear Creek and Rocky Fork had comparable values ranging from the mid 500s to a little over 600 mg/kg of total; phosphorus. Sediment ammonia

concentrations were highest in Lees Creek followed by Paint Creek with a range of 160 to 73 mg/kg. By comparison, none of the other sites exceeded 75 mg/kg.

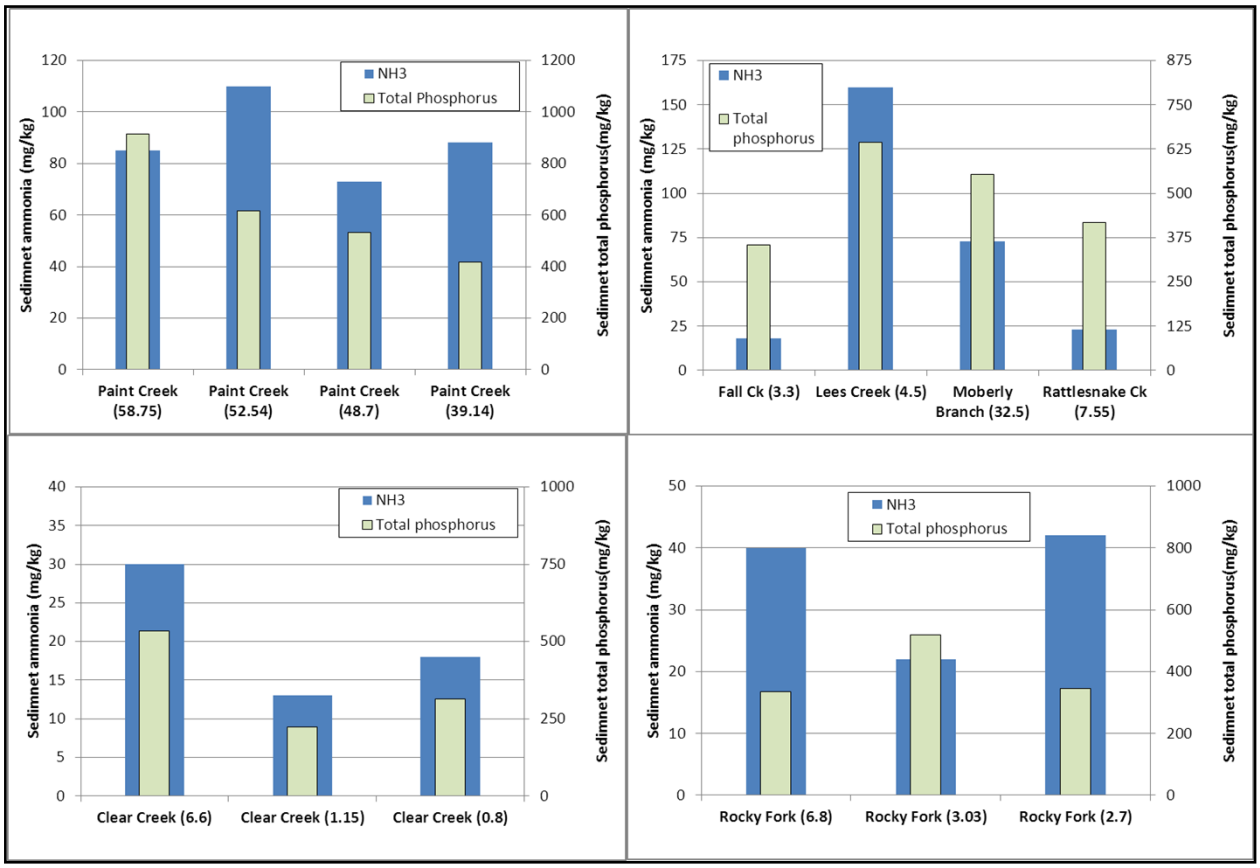

Figure B-17. Nutrient concentrations flow deposited bed sediment at several sites in the Paint Creek watershed.

B2 Recreation Use Attainment

Of the 106 sites assessed for recreation use attainment, 68 percent exceeded the threshold concentration for attainment and the remaining 32 percent are considered in full attainment (see Table B-6 and Figure B-18). Most 12-digit HUCs were assessed and there were ten or more sites within six of the ten larger ten-digit HUCs. Four of the ten-digit HUCs and the large river assessment unit each had five to eight assessment sites. In terms of the number of sites not meeting standards in the various ten-digit HUCs, three of the upper HUCs which are dominated by cropland, namely headwaters of Paint Creek (01), upper Rattlesnake Creek (03) and the upper North Fork Paint Creek (08) accounted for the highest proportion of impaired sites. The Rocky Fork watershed (05) also had a significant amount of impairment. These four ten-digit HUCs not only account for over 60 percent of all recreation use impairment, each HUC had the vast majority of its site in non-attainment. However, in terms of the concentration of E coli bacteria in the samples pooled to the level of the ten-digit HUC, it is the 04, 05, and 06 ten-digit HUCs that had the highest averages and medians concentrations for sites in those watersheds. These issues correspond to Leesburg and Hillsboro, unsewered areas around Rocky Fork Lake, and the area around Greenfield.

Table B-6. List of the 12-digit HUCs and associated recreation use attainment status.

HUC12 (05060003)	STORET Code	Stream Name	River Mile	Drainage Area (sq. miles)	Attainment Status	Geometric Mean
01 01	V10W18	Paint Ck	96.03	31.0	Non	1,111
01 02	V10K83	Big Run	1.80	3.7	Non	2,484
01 02	V10W23	East Fork Paint Ck	8.55	28.0	Non	202
01 02	V10W24	East Fork Paint Ck	5.06	33.0	Non	344
01 02	300055	East Fork Paint Ck	0.72	50.0	Non	328
01 02	V10K86	Vallery Ditch	2.30	5.5	Non	792
01 02	V10K85	William Cathcart Ditch	0.20	3.8	Non	1,538
01 03	V10W20	Paint Ck	79.86	54.0	Non	473
01 03	V10S36	Paint Ck	75.33	58.0	Non	340
01 03	V10S35	Paint Ck	73.28	60.0	Non	271
01 03	V10W21	Paint Ck	71.16	63.0	Full	97
01 03	V10S34	Paint Ck	69.52	67.0	Non	174
01 03	V10W02	Paint Ck	69.44	67.0	Non	346
01 03	V10W04	Paint Ck	69.15	67.0	Non	254
02 01	V10K80	Missouri Ditch	1.60	6.4	Non	166
02 01	V10K82	Sugar Ck	36.90	5.3	Full	91
02 01	V10W26	Sugar Ck	29.21	23.0	Full	88
02 01	V10W27	Sugar Ck	24.21	28.0	Full	62
02 02	V10W28	Sugar Ck	18.48	47.0	Non	564
02 02	V10W29	Sugar Ck	11.99	61.0	Non	223
02 02	V10W30	Sugar Ck	5.40	72.0	Non	244
02 02	300050	Sugar Ck	4.24	75.0	Non	318
03 01	V10K71	Trib To Wilson Ck (4.23)	0.40	5.5	Non	2,068
03 01	V10K70	Wilson Ck	2.80	18.4	Non	478
03 02	V10K68	Grassy Branch	8.70	5.2	Full	74
03 03	V10K72	West Branch Rattlesnake Ck	11.40	6.3	Non	171
03 03	V10S03	West Branch Rattlesnake Ck	4.30	15.8	Full	59
03 03	V10K69	West Branch Rattlesnake Ck	2.80	41.6	Non	168
03 04	V10K73	Maple Grove Ck	1.60	2.3	Non	170
03 04	V10W32	Rattlesnake Ck	40.44	16.5	Non	422
03 04	V10W33	Rattlesnake Ck	38.12	25.0	Non	409
03 04	V10S37	Rattlesnake Ck	35.36	34.0	Non	164
03 04	V10W37	Rattlesnake Ck	31.48	40.8	Full	96
03 04	V10K74	Trib To Rattlesnake Ck (40.21)	1.10	4.6	Non	762
03 05	V10W38	Rattlesnake Ck	23.97	110.0	Non	174
03 05	200429	Rattlesnake Ck	15.00	125.0	Non	256
03 05	V10S05	Rattlesnake Ck	13.23	128.0	Non	368
04 01	V10K63	South Fork Lees Ck	1.60	15.9	Non	3,466
04 02	V10W46	Middle Fork Lees Ck	1.15	36.1	Full	14
04 02	300388	Middle Fork Lees Ck	0.85	36.2	Full	133
04 03	V10W45	Lees Ck	1.16	73.0	Non	1,490
04 03	V10K61	Trib To Lees Ck (2.57)	1.30	3.1	Non	33,715
04 04	V10K59	Walnut Ck	4.20	5.7	Non	21,434
04 04	V10K58	Walnut Ck	0.60	13.4	Full	80
04 05	V10K50	Hardin Ck	1.10	20.5	Full	29
04 06	V10K47	Fall Ck	1.60	13.3	Full	64
04 07	300049	Rattlesnake Ck	7.55	209.0	Non	553
05 02	V10W47	Clear Ck	8.45	20.1	Non	2,639
05 02	V10K38	Clear Ck	7.4	21.0	Non	2,622
05 02	V10S13	Clear Ck	6.80	24.9	Non	2,474
05 02	V10S12	Clear Ck	6.60	25.1	Non	3,642
05 02	V10S09	Clear Ck	1.65	41.0	Full	81
05 02	V10P18	Clear Ck	7.57	20.8	Full	34

HUC12 (05060003)	STORET Code	Stream Name	River Mile	Drainage Area (sq. miles)	Attainment Status	Geometric Mean
05 03	V10S16	Rocky Fork	23.27	16.2	Full	59
05 03	V10P16	Rocky Fork	18.05	33.0	Non	1,963
05 03	V10P02	Rocky Fork	17.53	39.0	Non	10,126
05 05	V10K35	Franklin Branch	1.9	5.6	Non	1,864
05 05	V10K32	Pickett Run	0.10	1.8	Non	1,609
05 05	610800	Rocky Fork	3.03	140.0	Non	178
06 01	V10S32	Paint Ck	67.10	120.0	Non	5,680
06 01	V10S31	Paint Ck	58.75	224.0	Non	3,151
06 02	V10S30	Paint Ck	52.54	249.0	Non	2,235
06 02	V10Q04	Paint Ck	49.4	261.0	Full	29
06 02	V10S29	Paint Ck	48.70	261.0	Non	1,249
07 01	V10K04	Buckskin Ck	13.90	4.9	Full	152
07 01	V10K05	Buckskin Ck	0.40	39.7	Full	108
07 01	V10K54	Trib. To Buckskin Ck (12.25)	0.18	2.7	Non	309
07 02	V10K20	Upper Twin Ck	5.80	5.5	Non	162
07 02	V10K12	Upper Twin Ck	2.00	12.2	Non	806
07 03	V10K07	Lower Twin Ck	2.20	15.0	Non	236
07 04	V10K08	Massie Run	0.10	4.9	Non	689
07 04	V10K10	Sulphur Lick	1.50	7.6	Full	74
08 01	V10K51	Thompson Ck	3.30	8.0	Non	344
08 02	V10K52	North Fork Paint Ck	42.00	11.0	Full	67
08 03	V10K27	Compton Ck	17.60	6.1	Non	590
08 03	V10K26	Compton Ck	11.20	19.9	Non	372
08 04	300048	Compton Ck	3.37	49.7	Non	285
08 04	V10S02	Compton Ck	1.10	59.0	Non	268
08 04	V10K31	Crooked Ck	3.00	7.2	Non	1,025
08 05	V10W16	North Fork Paint Ck	31.02	45.0	Non	325
08 05	300046	North Fork Paint Ck	26.67	51.0	Non	172
08 05	V10K25	Wolf Run	0.30	3.6	Non	472
09 02	V10K02	Little Ck	5.62	8.4	Full	128
09 02	V10K13	Little Ck	1.00	22.7	Non	322
09 03	V10K23	North Fork Paint Ck	14.10	164.0	Non	250
09 03	V10S01	North Fork Paint Ck	17.50	153.0	Full	119
09 03	V10K14	North Fork Paint Ck	22.30	122.0	Full	49
09 03	V10K15	Oldtown Run	1.30	8.5	Non	260
09 04	V10K06	Biers Run	1.50	7.1	Non	242
09 04	V10K01	North Fork Paint Ck	3.90	230.0	Full	77
09 04	300047	North Fork Paint Ck	2.28	232.0	Non	150
09 04	V10S18	North Fork Paint Ck	10.50	207.0	Non	206
09 04	V10K29	Trib To N Fk Paint Ck (6.56)	0.30	6.3	Full	127
10 01	V10K21	Black Run	3.96	5.0	Full	68
10 01	V10K16	Black Run	1.00	8.6	Full	57
10 02	V10K19	Ralston Run	2.80	5.2	Non	192
10 03	V10K53	Cattail Run	1.20	2.9	Non	2,684
10 03	V10K22	Owl Ck	0.35	6.5	Non	183
10 03	V10K03	Plug Run	0.40	5.4	Non	151
LRAU	V10W14	Paint Ck	27.43	788	Full	79
LRAU	300053	Paint Ck	39.14	570	Full	63
LRAU	V10S28	Paint Ck	31.68	773	Full	77
LRAU	601320	Paint Ck	21.6	807	Full	82
LRAU	V10K17	Paint Ck	8.9	895	Full	65
LRAU	V10P06	Paint Ck	3.8	1138	Full	60
LRAU	V10S43	Paint Ck	0.68	1144	Full	51

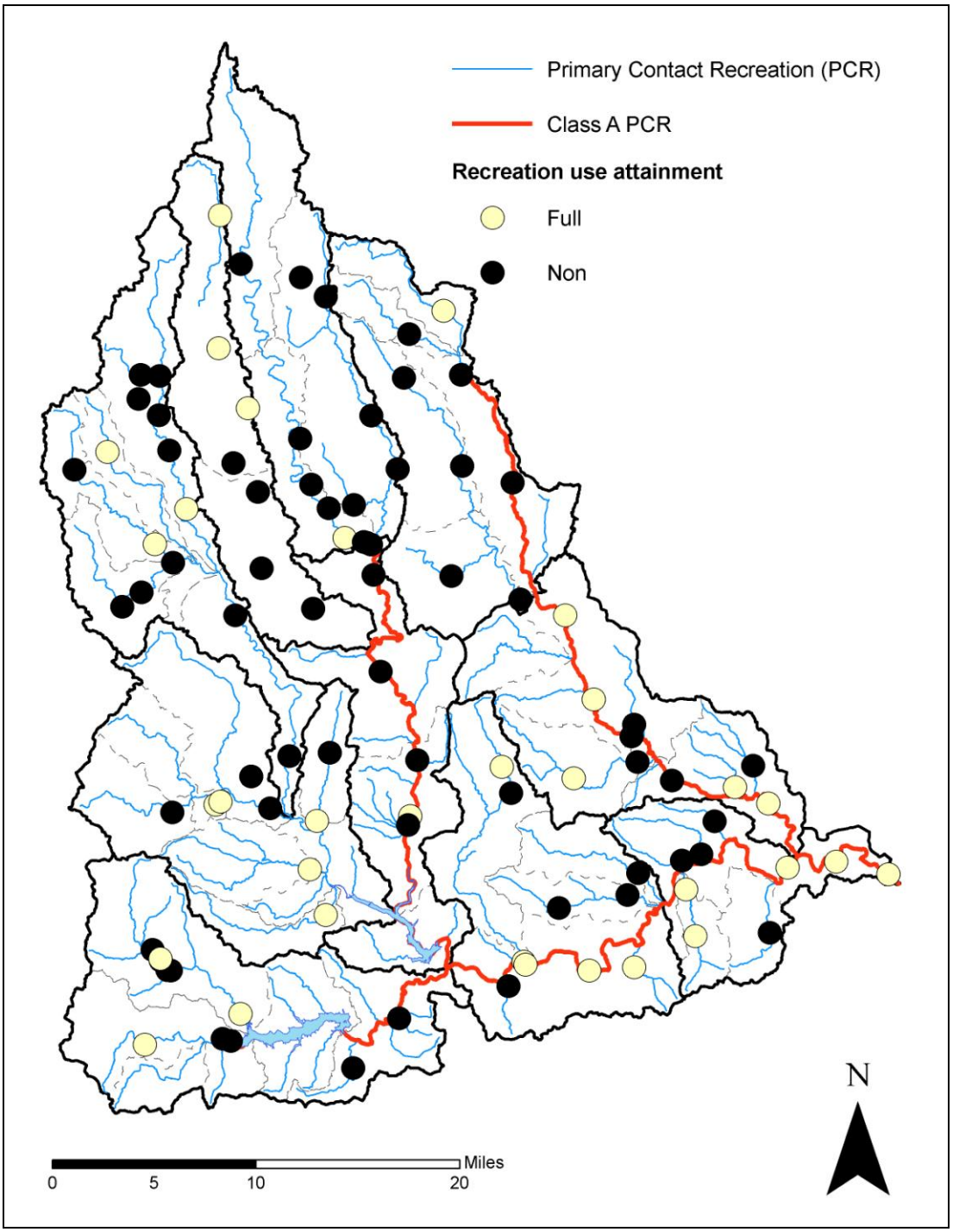

Figure B-18. Spatial distribution of bacteria survey sites and recreation use attainment status.

Table B-7. Distribution of impaired recreation uses according to the 10-digit HUCs.

Ten-Digit HUC	Number of Non Attainment	Number of Full Attainment	Percent Non per Ten-Digit HUC	Percent Non per All Impaired Sites	Number of All Sites
01	13	1	93%	18%	14
03	12	3	80%	17%	15
08	9	1	90%	13%	10
05	9	3	75%	13%	12
09	6	5	55%	8%	11
02	5	3	63%	7%	8
07	5	3	63%	7%	8
04	5	5	50%	7%	10
06	4	1	80%	6%	5
10	4	2	67%	6%	6
LRAU[1]	0	7	0%	0%	7
Grand Total	**72**	**34**	**68%**		**106**

[1] LRAU is the abbreviation for large river assessment unit.

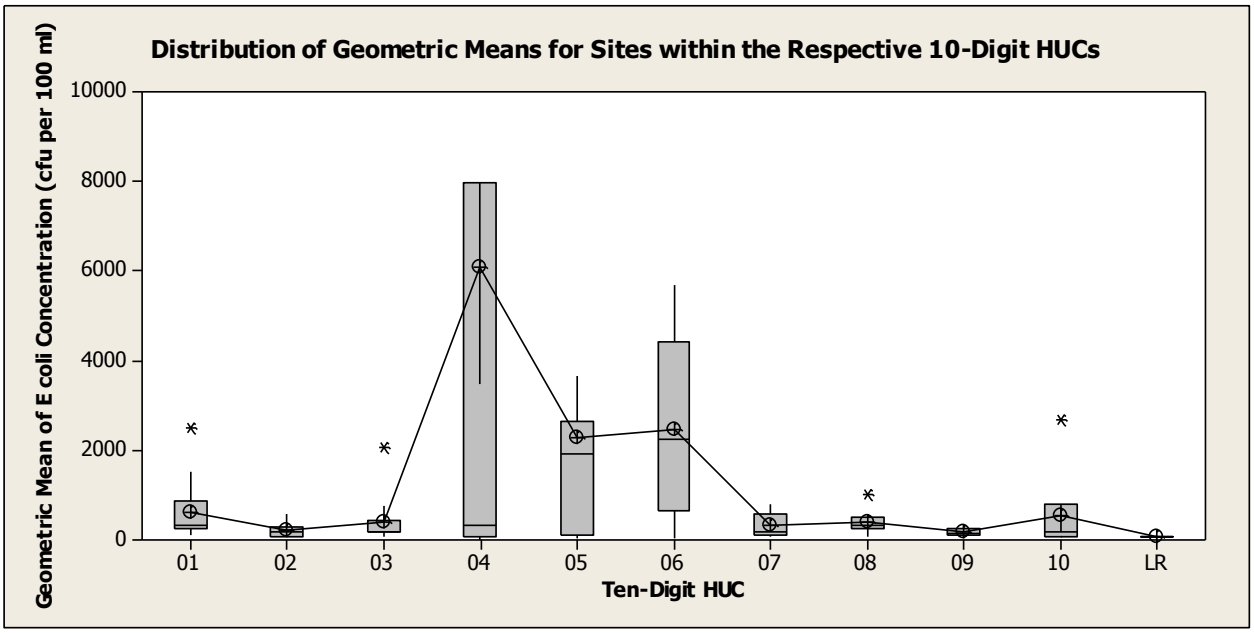

Figure B-19. Distribution of geometric mean concentration for *E coli* by sites within respective 10-digit HUCs.

Table B-8. Distribution of geometric mean concentration for *E coli* by sites within respective 10-digit HUCs.

10-digit HUC	01	02	03	04	05	06	07	08	09	10	Large River
Average[1]	625	219	389	6098	2274	2469	317	392	175	556	68
Standard Deviation[1]	669	165	501	11732	2758	2137	277	265	86	1044	11
Median[1]	342	195	174	343	1914	2235	199	335	150	167	65
Sample Size (N value)	14	8	15	10	12	5	8	10	11	6	7

[1] Displayed values are expressed in colony forming units per 100 ml of sample.

B3 Public Drinking Water Supply Use Attainment

There are two communities within the project area that withdraw surface water for public consumption. However an insufficient amount of data was collected to evaluate the attainment status of the public water supply (PWS) water quality criteria, therefore the Cities of Washington Courthouse and Hillsboro have an undetermined PWS attainment status. Table B-9 lists the purveyors of drinking water with surface water intakes and the most up-to-date attainment status.

Table B-9. Attainment status of the 12-digit HUCs assessed for public drinking water supply uses.

Name/Community	Stream	Nitrate Status	Atrazine Status	Impairment (Y/N)
Town of Washington Court House-Paint Creek 05060003 01 03				
Washington Courthouse	Paint Creek at river mile 71.4	Insufficient data	Insufficient data	Insufficient data
Clear Creek 05060003 05 02				
City of Hillsboro	Rocky Fork at river mile 7.4	Insufficient data	Insufficient data	Insufficient data

B4 Human Health Use Attainment

Of the ten 12-digit HUCs that were to be evaluated against human health criteria (i.e., fish tissue toxicology) four HUCs failed to meet the criteria while five did meet the criteria. One of the 12-digit HUCs which represent a lower portion of North Fork Paint Creek did not have sufficient data evaluated to make an attainment determination. Polychlorinated bi-phenyls (PCBs) are the responsible pollutants for the non-attainment when it occurred. This fish contamination was found in larger fish species in Paint Creek, both upstream and downstream from Paint Creek Lake; however not in the upper reached of Paint Creek near Washington Courthouse. Sites evaluated in Rocky Fork and North Fork Paint Creek did not indicate impairment to human health uses. Table B-10 lists the 12-digit HUCs that were evaluated and results of the assessment.

Table B-10. Attainment status of the 12-digit HUCs assessed for human health uses (fish tissue).

12-Digit HUC Sampled (05060003)	Impairment (Y/N)	Pollutants (Concentration)
01 03	N	
05 03	N	
05 04	N	
05 05	N	
06 01	Y	Historic listing; currently no cause listed
06 02	Y	Historic listing; currently no cause listed
06 03	Y	PCBs (56 ppb)
08 05	N	
09 04	Insufficient data	
10 03	Y	PCBs (168 ppb)