Report on Nutrient and Biological Synoptic Surveys in the Upper Choptank Watershed, March/April 2002

MD Department of Natural Resources
Chesapeake and Coastal Watershed Service
Watershed Restoration Program
Watershed Evaluation Section
September, 2002

Acknowledgements

This work was supported by the 2002 319(h) grant from U.S. Environmental Protection Agency # C9-00-3497-02-0.

This work supports Department of Natural Resources Outcomes –
#2 Healthy Maryland watershed lands, streams, and non-tidal rivers.
#3 A natural resources stewardship ethic for Marylanders.
#4 Vibrant local communities in balance with natural systems.

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Executive Summary

A total of 111 nutrient synoptic sampling sites were identified in the upper Choptank WRAS watershed, and 88 were successfully sampled. No flowing water , no access, or map discrepancies were reasons for not sampling the 23 remaining sites. The upper Choptank watershed had 7 subwatershed areas targeted for sampling. Seventy sampling sites were divided among the targeted subwatersheds as follows: Broadway Branch – 7; Chicken Branch – 8; Forge Branch – 16; Long Branch –2;Little Creek – 6; Watts Branch –14; Talbot County – 17. The remaining 18 sites are noted as 'Untargeted' and were located throughout the upper Choptank watershed to help establish baseline conditions in the watershed as a whole. Broadway Branch had baseline to moderate nutrient concentrations and yields. The macroinvertebrate sample and habitat assessment at the watershed outlet indicated habitat as the primary problem. Chicken Branch had excessive nutrient concentrations and yields throughout the watershed. The macroinvertebrate sample and habitat assessment at the watershed outlet indicated both habitat and water quality problems. Forge Branch had a full range of nutrient concentrations and yields, with moderate yields at the watershed outlet. Macroinvertebrate sampling and habitat assessment indicated only minor habitat problems. Watts Creek had some areas of elevated nutrients, but all yields were baseline at the watershed outlet. Macroinvertebrate sampling and habitat assessment indicated this stream was in excellent condition. Nutrient concentrations and yields in Long Branch were moderate at worst. Macroinvertebrate sampling and habitat assessment indicated a possible water quality problem from something other than nutrients. Little Creek had the full range of nutrient concentrations and yields. Low flow limited the impact of excessive concentrations. The macroinvertebrate sampling and habitat assessment indicated a water quality problem that could be associated with low pH. The Talbot County watersheds also had the full range of nutrient concentrations and yields. The upper portion of the Beaverdam watershed was the focus of the elevated concentrations and yields. Macroinvertebrate sampling and habitat assessment indicated habitat degradation was the primary impact on the benthic community rather than water quality. Sampling in untargeted subwatersheds found the full range of nutrient concentrations and yields. Contributions from Delaware into the upper portion of the watershed were minimal. Seven other subwatersheds, two originating in Delaware, had excessive nutrient yields.

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Introduction

Nutrient synoptic sampling was scheduled for early spring to coincide with the period of maximum nitrogen concentrations in the free flowing fresh water streams. The major proportion of the nitrogen compounds are carried dissolved in the ground water rather than in surface runoff. The higher nitrogen concentrations in the late winter and early spring reflect the higher proportion of nitrogen rich shallow ground water present in the base flow at this time of year. Nitrogen concentrations are reduced in summer as the proportion of shallow ground water is reduced through plant uptake, and replaced by deeper ground water that may have lower nitrate concentrations, or has been denitrified through interaction with anoxic conditions in the soils below the streambed. Point sources can also contribute to in stream nitrate concentrations.

Orthophosphate is generally transported bound to suspended sediments in the water column. In stream orthophosphate concentrations can also be produced through mobilization of sediment bound phosphorus in anoxic water column and/or sediment conditions, sediment in surface runoff from areas having had surface applied phosphorus, ground water from phosphorus saturated soils, and point source discharges.

Ranges used for nutrient concentrations and yields were derived from work done by Frink (1991). The low end values are based on estimated nutrient exports from forested watersheds, and the high end values are based on estimated nutrient exports from intensively agricultural watersheds. As an additional bench mark, the Chesapeake Bay Program uses 1 mg/L total nitrogen as a threshold for indicating anthropogenic impact. The dissolved nitrogen fraction looked at in these synoptic surveys constitutes approximately 50% to 70% of the total nitrogen. For ease of discussion, the four divisions within the concentration and yield ranges will be considered *background, moderate, high,* and *excessive* (Table 1.).

Table 1. Nutrient Ranges and Rating

Rating	NO2+NO3 Concentration mg/L	NO2+NO3 Yield Kg/ha/day	PO4 Concentration mg/L	PO4 Yield Kg/ha/day
Baseline	<1	<.01	<.005	<.0005
Moderate	1 to 3	.01 to .02	.005 to .01	.0005 to .001
High	3 to 5	.02 to .03	.01 to .015	.001 to .002
Excessive	>5	>.03	>.015	>.002

A Note of Caution

Estimates of annual dissolved nitrogen loads/yields from spring samples will result in inflated load estimates, but the relative contributions of subwatersheds should remain reasonably stable. More accurate nitrate/nitrite load/yield estimates need to include sampling during the growing season to account for potential lower concentrations and discharges. Storm flows can also significantly impact loads delivered to a watershed outlet.

The tendency of orthophosphate to be transported bound to sediments makes any estimates of annual orthophosphate loads/yields derived from base flow conditions very conservative. More accurate estimates of orthophosphate loads/yields in a watershed must include samples from storm flows that carry the vast majority of the sediment load of a watershed. Residual suspended sediments from recent rains, or instream activities of *livestock or construction can produce apparently elevated orthophosphate concentrations and yields at base flow.*

Biological (macroinvertebrates and fish) sampling and habitat condition information are collected on a limited basis within the WRAS watersheds. Analysis of the biological data in conjunction with the nutrient and Stream Corridor Assessment information can provide good insight into the location, severity, and causes of water quality problems within a watershed.

Additional analysis that draws in existing and planned land use, and tax map information, can be a useful watershed planning tool to determine what areas might be targeted for protection or remediation.

METHODS

Water Chemistry Sampling

Synoptic water chemistry samples were collected in early spring at all accessible road crossings, or other designated sites within the watershed. Grab samples of whole water (500 ml) were collected just below the water surface at mid-stream and filtered using a 0.45 micron pore size (Gelman GF/C) filter. The samples were stored on ice and frozen on the day of collection. Filtered samples were analyzed by the Nutrient Analytical Services Laboratory at the University of Maryland's Chesapeake Biological Laboratory (CBL) for dissolved inorganic nitrogen (NO_3, NO_2), and dissolved inorganic phosphorus (PO_4). All analyses were conducted in accordance with U.S. Environmental Protection Agency (EPA) protocols. Stream discharge measurements were taken at the time of all water chemistry samples. Water temperature, dissolved oxygen, pH, and conductivity were measured in the field with a Hydrolab Surveyor II at the time of all water quality collections. Watershed areas used to calculate nutrient yields per unit area were determined from a digitized watershed map using Arcview software.

Where sites are nested in a watershed the mapped concentration data for the downstream site is shown only for the area between the sites. Yield calculations for a downstream site are based on the entire area upstream of the site, but are mapped showing just the area between sites. The downstream sites therefore illustrate the cumulative impact from all upstream activities.

Benthic Macroinvertebrate Sampling

Aquatic macroinvertebrates were collected at the time of water chemistry samples during the spring to be within the MBSS spring index period. Macroinvertebrate collections were made over a $2m^2$ area of the best available habitat using a 0.3m wide dip net with a mesh size of 500 microns. The best available habitats include: gravel riffles, snags, submerged vegetation and root mats. Habitats were sampled in the proportion to their occurrence at the station. Samples were composited in a sieve bucket, fine sediments washed out, and large debris rinsed and discarded. The remaining sample was preserved in 70% ethanol and returned to the laboratory for subsampling. Subsampling was done using a gridded tray. Grids were chosen at random until the grid with the 100th organism had been completed. Organisms were identified to genus, recorded on a bench sheet, and archived future reference. Insitu water quality data (dissolved oxygen, pH, conductivity, temperature) were collected during each sampling episode with a Hydrolab Surveyor II. A macroinvertebrate index of biotic integrity (IBI)(MD DNR, 1998) was calculated to facilitate ranking of site quality.

Macroinvertebrate Habitat Assessment

A habitat assessment was completed at the time of the macroinvertebrate collections to provide a qualitative measure of the in stream and riparian habitat quality. The assessment, modified from Plafkin et al. (1989) to focus on macroinvertebrate habitat, rates the in stream structure, channel and lower bank morphology, and the upper bank and riparian zone using a series of metrics. The metrics are weighted to provide more scoring potential to the parameters more directly influencing the in stream macroinvertebrate community. The macroinvertebrate habitat score is weighted by the number of equally scored metrics in each category.

The primary metrics rate in stream habitat quality and quantity available for use by the macroinvertebrate community. This includes the amount and type of woody debris, prevalence of undercut banks, degree of embeddedness (siltation) in riffles, pool depth, and water velocity and flow. These metrics are given the most weight because of their direct importance to the health and diversity of the in stream macroinvertebrate communities. Secondary metrics assess channel morphology, rating the quality of the lower stream bank and the structure of the channel. These metrics include relative measures of riffle extent, channel sinuosity, and extent of channel alterations caused by high flow events. These metrics are weighted less than the primary because of their less direct impact on the in stream macroinvertebrate communities. The tertiary metrics rate the quality of the upper banks and adjacent riparian areas. These metrics include scoring of the type and amount of bank vegetation, amount and frequency of bank erosion, and land use in the riparian area. These characteristics of the watershed are given the least weight because they are less important to the in stream macroinvertebrate community.

Results

A total of 111 nutrient synoptic sampling sites were identified in the upper Choptank WRAS watershed, and 88 were successfully sampled. No flowing water , no access, or map discrepancies were reasons for not sampling the 23 remaining sites. The upper Choptank watershed had 7 subwatershed areas targeted for sampling. Seventy sampling sites were divided among the targeted subwatersheds as follows: Broadway Branch – 7; Chicken Branch – 8; Forge Branch – 16; Long Branch –2;Little Creek – 6; Watts Branch –14; Talbot County – 17. The remaining 18 sites are noted as 'Untargeted' and were located throughout the upper Choptank watershed to help establish baseline conditions in the watershed as a whole. The following discussion is based on these subwatershed units.

Broadway Branch

Twelve road crossing sites were identified as potential nutrient sampling sites within the Broadway Branch watershed. Five sites were not sampled. Two were dry, two had standing water only, and one was a map error. The sites and their road crossing locations are listed in Table 2., and subwatersheds mapped in Figure 1.

Nutrients in this subwatershed are relatively low. The highest nitrate/nitrite concentrations are in the low portion of the 'moderate' range (Table 3). Figure 2 illustrates how these concentrations are distributed throughout the watershed. The concentrations found here would also be considered relatively low when compared to the upper Choptank as a whole and other synoptic results from around the state (Table 4.).

Table 2. Synoptic Sampling Sites in Broadway Branch Watershed, April 2002

Station	Road Crossing	Latitude	Longitude	Sample Type**	Notes
Broadway 01	UT* at MD 287 .	.	.	.	Dry
Broadway 02	Broadway at MD 287	39.03469	-75.77497	N.B	
Broadway 03	UT at MD 311	39.04386	-75.78469	N	
Broadway 04	UT at MD 311	.	.	.	No flow
Broadway 05	UT at MD 311	39.04283	-75.78469	N	No flow
Broadway 06	Broadway at MD 311	39.05808	-75.77947	N	
Broadway 07	UT at Steele rd.	.	.	.	Dry
Broadway 08	UT at Manspeaker La.	.	.	.	No Access
Broadway 09	Broadway at Steele Rd.	39.06750	-75.79636	N	
Broadway 11	UT at Lentz Rd.	39.05617	-75.80256	N	
Broadway 12	UT at Steele Rd.	39.06614	-75.79817	N	

*Unnamed Tributary
**(Benthic, Nutrient)

Table 3. Broadway Branch Nutrient Synoptic Results, April 2002

		Concentration			Daily Loads		Area	Nutrient Yields/Hectare	
DATE	STATION	PO4 (mg P/L)	NO23 (mg N/L)	Discharge (L/s)	PO4 (kg/day)	NO23 (kg/day)	Hectares	PO4 (kg/day/ha)	NO23 (kg/day/ha)
04/05/02	Broadway 01	.	.	0.00	.	.	77	.	.
04/05/02	Broadway 02	0.003	1.28	132.91	0.03	14.70	1444	0.000024	0.010182
04/05/02	Broadway 03	0.001	1.97	3.39	0.00	0.58	78	0.000004	0.007393
04/05/02	Broadway 04	.	.	0.00	.	.	58	.	.
04/05/02	Broadway 05	0.001	0.70	0.00	0.00	0.00	47	0.000000	0.000000
04/05/02	Broadway 06	0.002	1.04	74.95	0.01	6.73	882	0.000015	0.007637
04/05/02	Broadway 07	.	.	0.00	.	.	10	.	.
04/05/02	Broadway 08	.	.	.	.	.	34	.	.
04/05/02	Broadway 09	0.003	0.84	18.64	0.00	1.35	332	0.000015	0.004071
04/05/02	Broadway 10	.	.	.	.	.	.	.	.
04/05/02	Broadway 11	0.001	1.47	9.15	0.00	1.16	115	0.000007	0.010112
04/05/02	Broadway 12	0.002	1.50	3.95	0.00	0.51	103	0.000007	0.004961

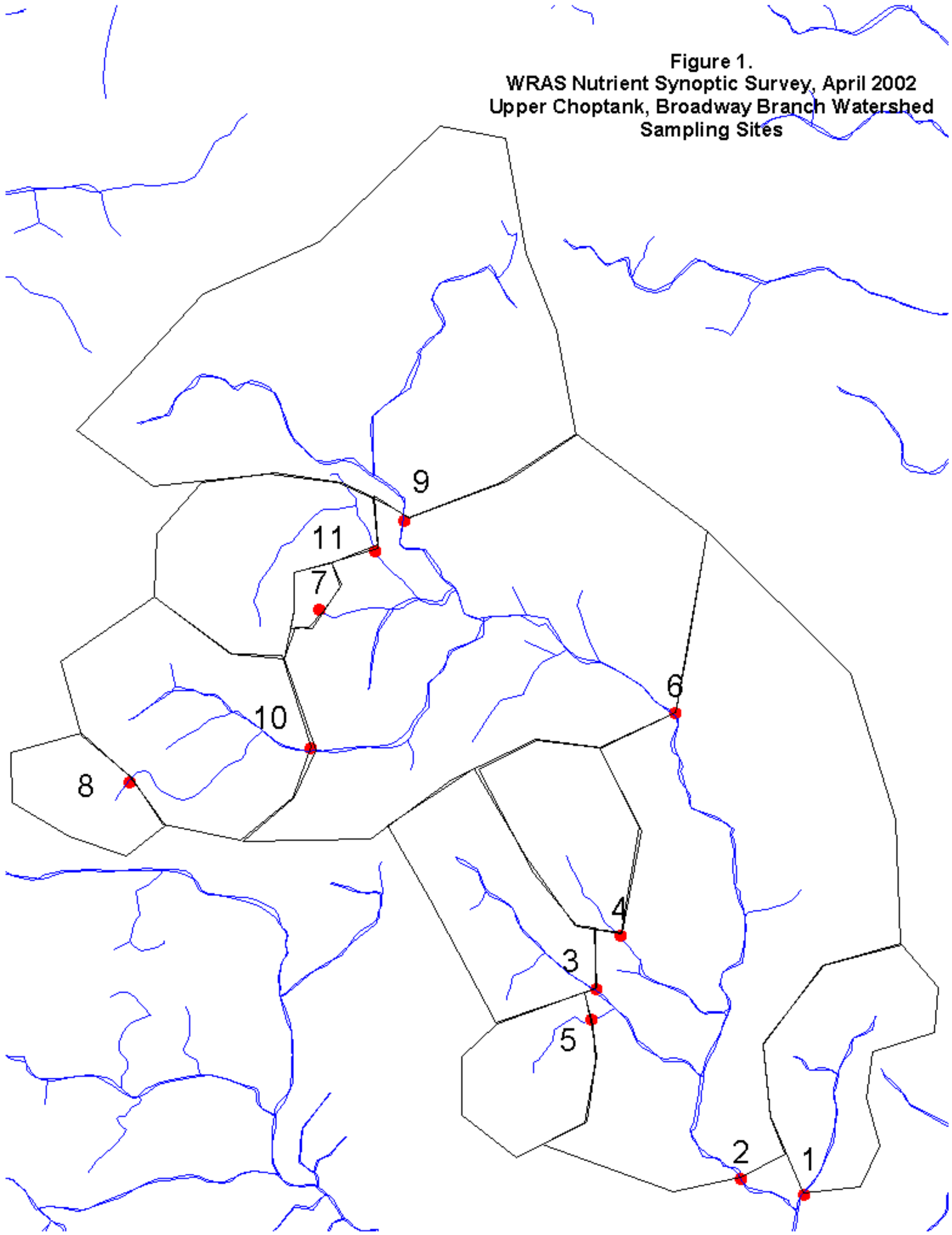


Figure 1.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Broadway Branch Watershed
Sampling Sites
9
11
7
10
6
8
4
3
5
2
1

Figure 2.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Broadway Branch Watershed
Nitrate/Nitrite (NO2+NO3) Concentrations (Mg/L)

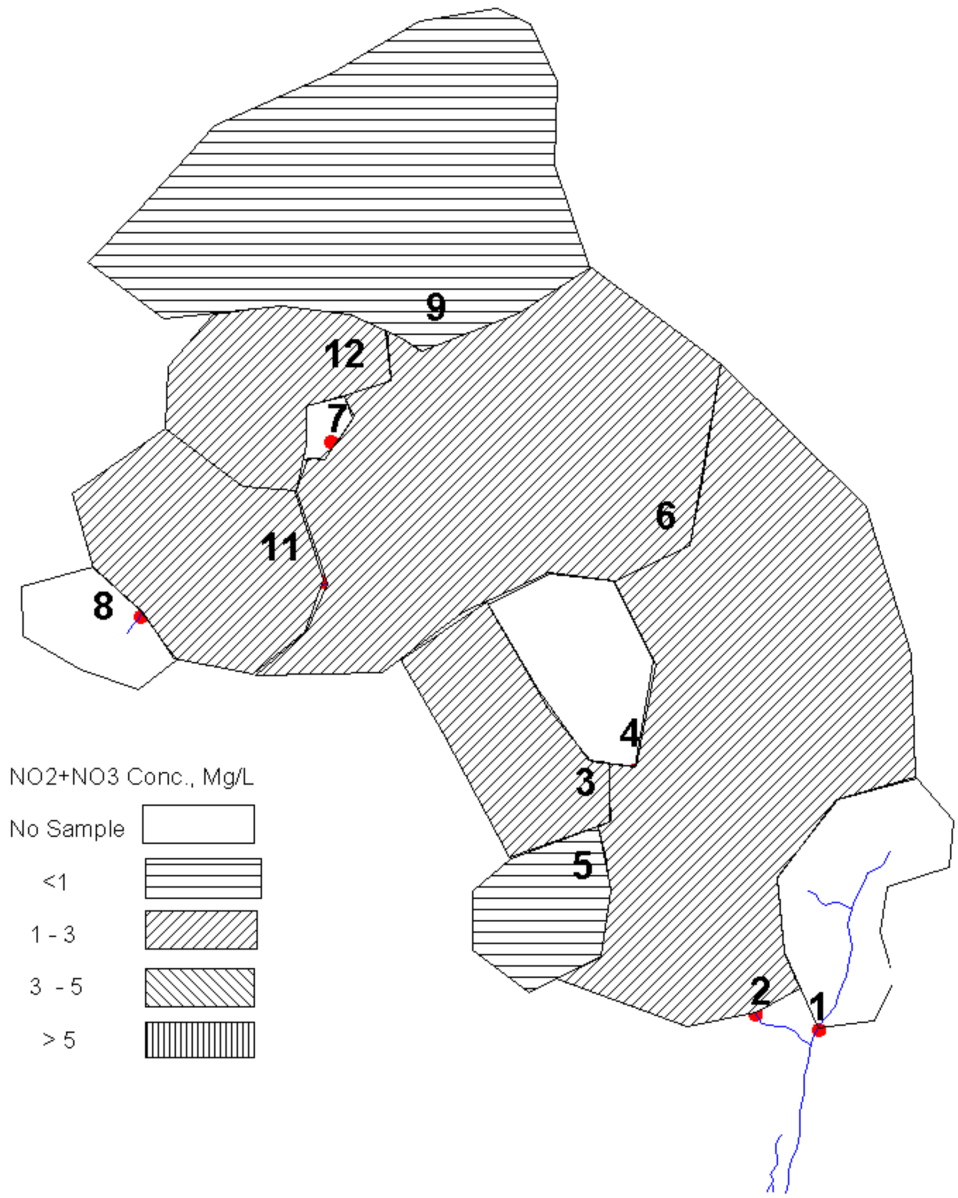


Table 4. Annual & Spring Nutrient Concentration (mg/L) Averages from Other Nutrient Synoptic Surveys

	Piney	German Br.	Pocomoke	Bush	Breton Bay	Patuxent	Choptank	Liberty
NO2+NO3 Spring	3.742	3.832	3.734	1.944	0.223	0.439	2.892	3.410
NO2+NO3 Annual	4.823	4.704	2.384					
PO4 Spring	0.800	0.043	0.028	0.006	0.004	0.012	0.023	0.004
PO4 Annual	1.177	0.067	0.022					

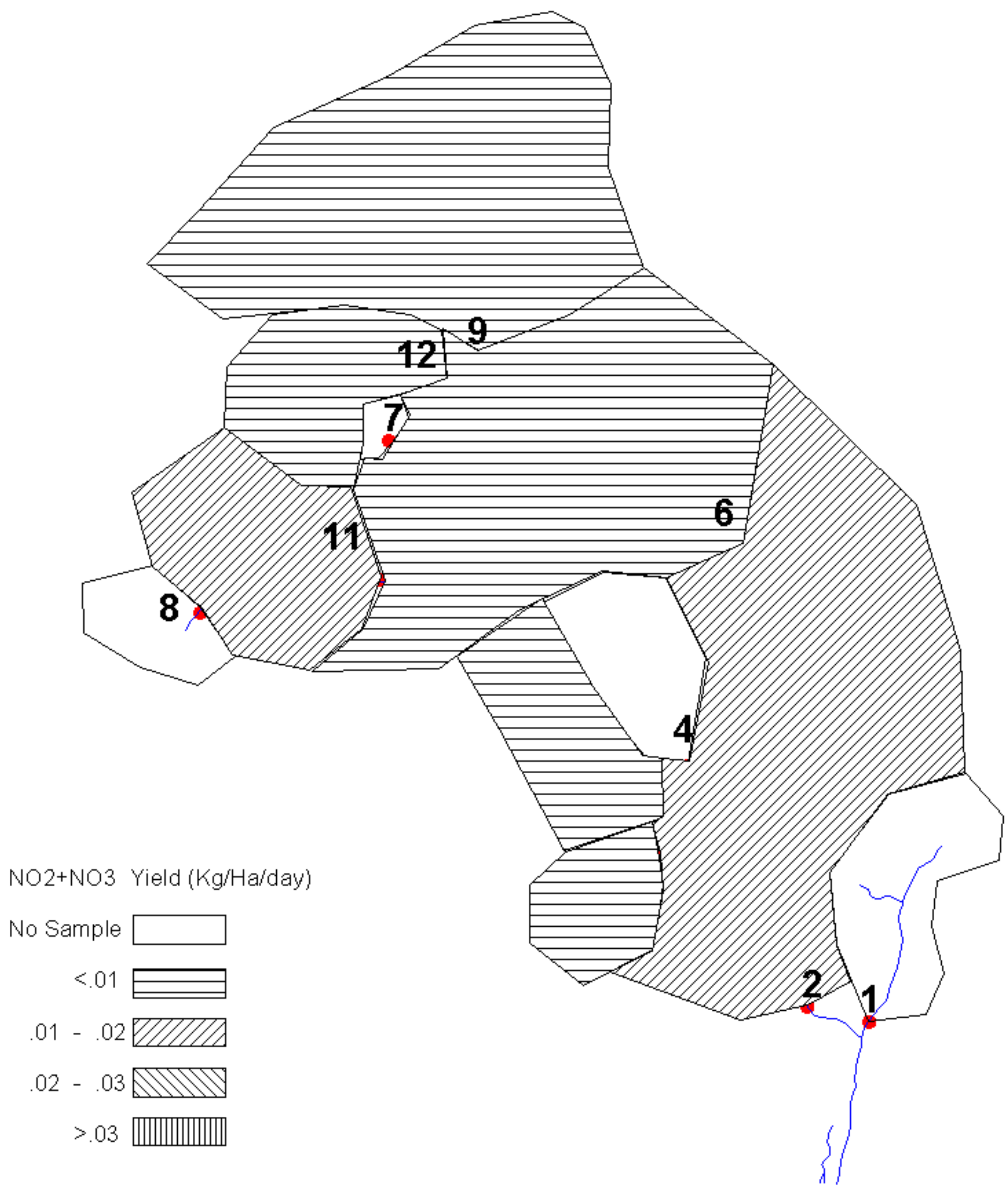
The moderate nitrate/nitrite concentrations translated into moderate yields from only two portions of the Broadway Branch watershed (Figure 3.). These yields are marginally in the moderate range. A small underestimation of the watershed area would have them in the baseline category. Station 5 was sampled even though there was no flow (thus no yields calculated) because of a considerable amount of water ponded upstream of the culvert that could have the potential for a significant nutrient contribution to the watershed during a rain event if concentrations were high. The nutrient concentrations at this site were found to be the lowest in the watershed. Orthophosphate concentrations and yields in the basin were well below baseline values, and well below the averages shown in Table 4 (Figure 4, Figure 5.).

Insitu water quality readings in the watershed are noted in Table 5. The only out of the ordinary readings are the relatively low pH values found at sites 5, 11 and 12. Extensive gravel deposits are a feature that could cause these low pH values, or drainage of acidic water from wooded wetlands. These low ph values also make these streams susceptible to even lower pH pulses during acidic precipitation events. These lower pH values could be detrimental to the biological communities in the system.

Table 5. Broadway Branch Watershed In Situ Water Quality

			InSitu Hydrolab Readings			
DATE	STATION	TIME	Temp. C	pH	Cond. mmohs.cm	DO mg/L
04/05/02	Broadway 01	.	.	.	.	.
04/05/02	Broadway 02	900	9.02	6.66	0.147	13.07
04/05/02	Broadway 03	925	10.05	6.32	0.202	14.26
04/05/02	Broadway 04	.	.	.	.	.
04/05/02	Broadway 05	1100	9.21	5.86	0.186	11.61
04/05/02	Broadway 06	940	10.92	6.27	0.135	11.22
04/05/02	Broadway 07	.	.	.	.	.
04/05/02	Broadway 08	.	.	.	.	.
04/05/02	Broadway 09	1010	9.91	6.41	0.131	12.20
04/05/02	Broadway 10	.	.	.	.	.
04/05/02	Broadway 11	1045	10.80	5.49	0.141	12.98
04/05/02	Broadway 12	1025	9.94	4.77	0.156	12.51

Figure 3.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Broadway Branch Watershed
Nitrate/Nitrite (NO2+NO3) Yield (Kg/Ha/day)



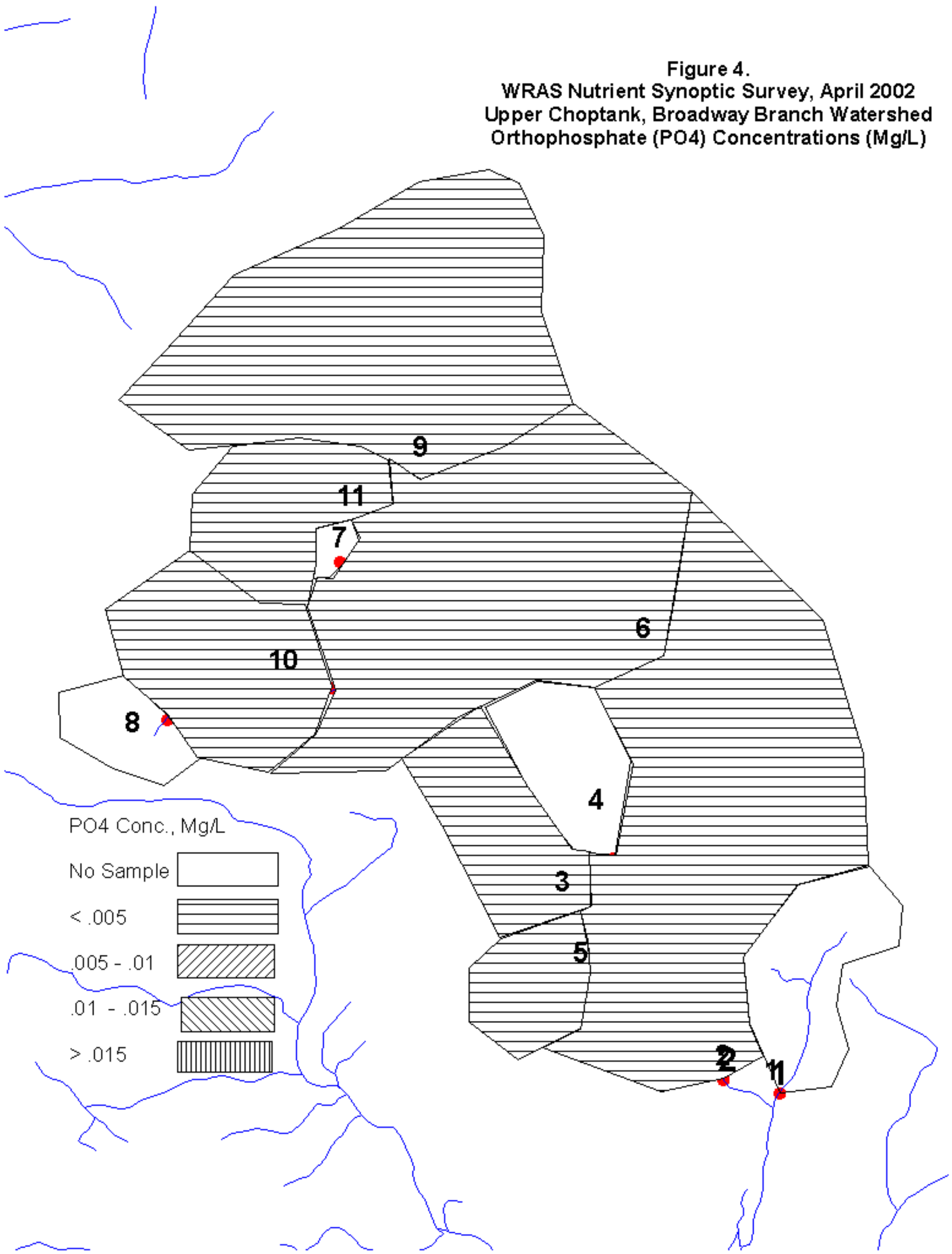
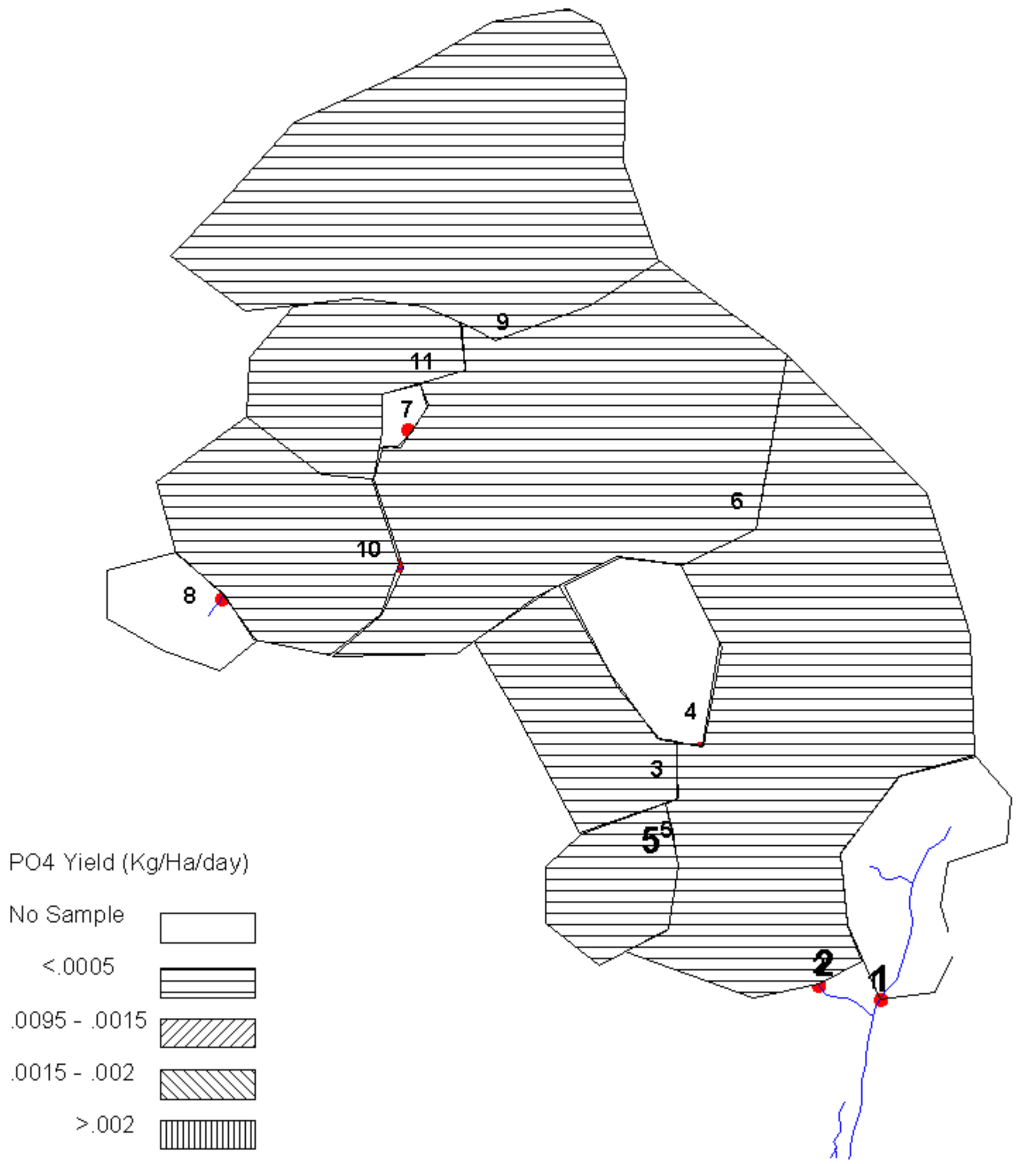


Figure 4.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Broadway Branch Watershed
Orthophosphate (PO4) Concentrations (Mg/L)
9
11
7
6
10
8
4
3
5
2
1
PO4 Conc., Mg/L
No Sample
< .005
.005 - .01
.01 - .015
> .015

Figure 5.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Broadway Branch Watershed
Orthophosphate (PO4) Yield (Kg/Ha/day)



Chicken Branch

Thirteen sample sites were identified on maps of the Chicken Branch watershed. Eight sites were sampled, 4 were dry, and 1 was a map error. The road crossing locations of the sites are noted in Table 6, and the subwatersheds delineated in Figure 6.

Table 6. Synoptic Sampling Sites in Chicken Branch Watershed, April 2002

Station	Road Crossing	Latitude	Longitude	Sample Type**	Notes
Chicken 0	UT* at River Rd	.			Dry.
Chicken 01	UT to Chicken at Holly Rd.	38.93506	-75.85011	N	
Chicken 02	Chicken at Holly Rd.	38.93506	-75.85106	N.B	
Chicken 03	Chicken at Central Ave	38.93619	-75.87753	N	
Chicken 04	UT to Chicken at Central Ave	38.92892	-75.87278	N	
Chicken 05	UT to Chicken at Holsinger La.	38.93122	-75.86052	N	
Chicken 06	UT at MD 480 Ridgely Rd.	.	.	.	Dry.
Chicken 07	UT at MD 480 Ridgely Rd.	.	.	.	Dry.
Chicken 08	UT at Henry Rd.	38.93636	-75.88064	N	
Chicken 09	Chicken at MD 480 Ridgely Rd.	38.93864	-75.88853	N	
Chicken 10	UT at Downes Station Rd.	.	.	.	Dry.
Chicken 11	UT at Henry Rd.	.	.	.	Map error
Chicken 12	Chicken at Holsinger La.	38.93189	-75.86136	N	

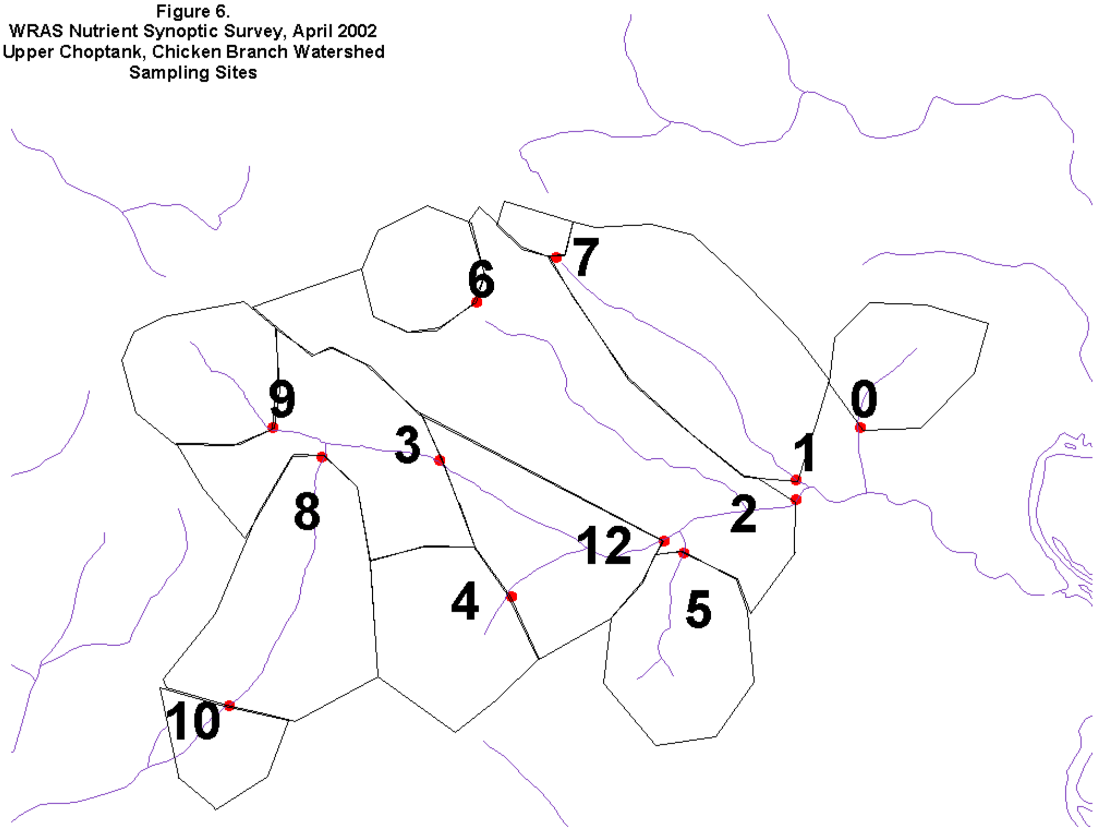
*Unnamed Tributary
**(Benthic, Nutrient)

Nitrate/nitrite concentrations in the Chicken Branch watershed were excessive or high at all sites, with the exception of site 9 (Table 7, Figure 7). Site 4 was exceptionally high at 11 mg/L, more than three times the watershed average. This site may be impacted by the Ridgely STP discharge. The excessive concentrations translated into excessive yields as well, including at site 2, the watershed outlet (Figure 8). As noted in the introduction, the surface flow in streams at the time of sampling is predominantly derived from shallow ground water of relatively young age. This infers that the source(s) of nitrate/nitrite in the watershed is of relatively recent origin and in substantial quantities, such as disposal of sewage liquids or process water through spray irrigation. The spray disposal in the headwaters of Piney Branch and Chicken Branch above site 9, to the south and west of Ridgely, may impact the ground water of Chicken Branch depending on groundwater flow paths. Odors at site 9 indicated anoxic conditions were present in the sediments. These anoxic conditions reduce nitrate/nitrite to nitrogen gas, and could be the reason for the rather low nitrate/nitrite concentration at site 9 when all others were excessive. The anoxia appeared to be due to excess organic material within the stream channel. The source of the organics was not identified.

Table 7. Chicken Branch Nutrient Synoptic Results, April 2002

DATE	STATION	Concentration PO4 (mg P/L)	Concentration NO23 (mg N/L)	Discharge (L/s)	Daily Loads PO4 (kg/day)	Daily Loads NO23 (kg/day)	Area Hectares	Nutrient Yields/Hectare PO4 (kg/day/ha)	Nutrient Yields/Hectare NO23 (kg/day/ha)
04/03/02	Chicken 0	.	.	0.00	.	.	59	.	.
04/03/02	Chicken 01	0.002	7.69	10.24	0.00	6.80	167	0.000011	0.040692
04/03/02	Chicken 02	0.003	6.45	83.37	0.02	46.46	932	0.000023	0.049848
04/03/02	Chicken 03	0.058	6.72	26.39	0.13	15.32	360	0.000368	0.042597
04/03/02	Chicken 04	0.008	11.00	7.06	0.00	6.71	85	0.000058	0.079299
04/04/02	Chicken 05	0.005	2.37	1.54	0.00	0.31	85	0.000008	0.003700
04/03/02	Chicken 06	.	.	0.00	.	.	45	.	.
04/03/02	Chicken 07	.	.	0.00	.	.	11	.	.
04/03/02	Chicken 08	0.019	5.02	0.35	0.00	0.15	174	0.000003	0.000877
04/03/02	Chicken 09	0.416	0.05	1.05	0.04	0.00	70	0.000536	0.000064
04/04/02	Chicken 10	.	.	0.00	.	.	36	.	.
04/03/02	Chicken 11	.	.	0.00	.	.	360	.	.
04/03/02	Chicken 12	0.015	6.04	51.28	0.07	26.76	542	0.000123	0.049344

Figure 6.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Chicken Branch Watershed
Sampling Sites



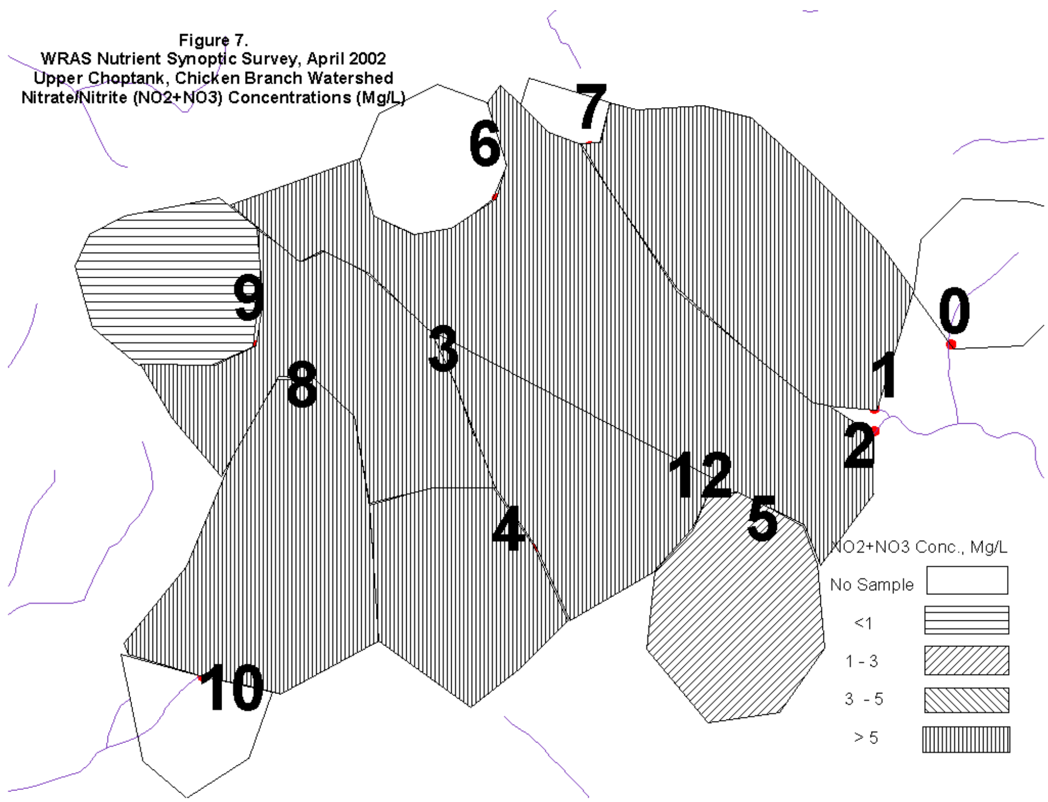


Figure 7.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Chicken Branch Watershed
Nitrate/Nitrite (NO2+NO3) Concentrations (Mg/L)
6
7
9
0
3
1
8
2
12
5
4
10
NO2+NO3 Conc., Mg/L
No Sample
<1
1 - 3
3 - 5
> 5

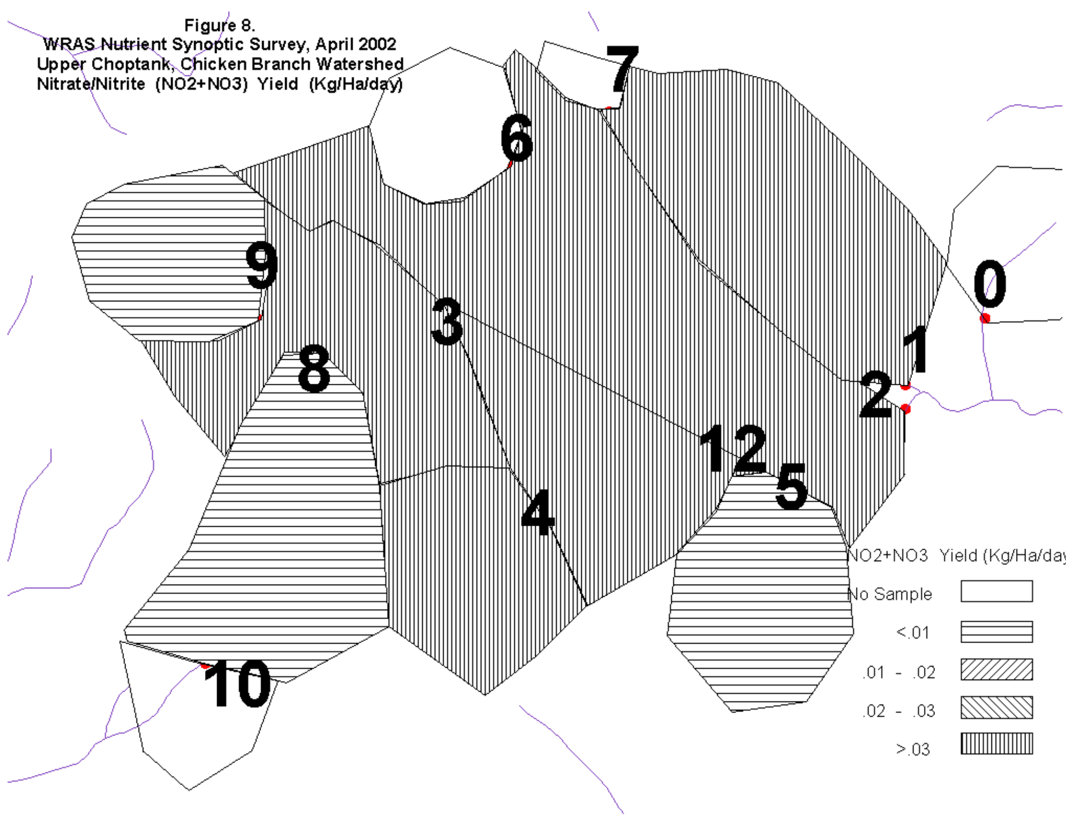
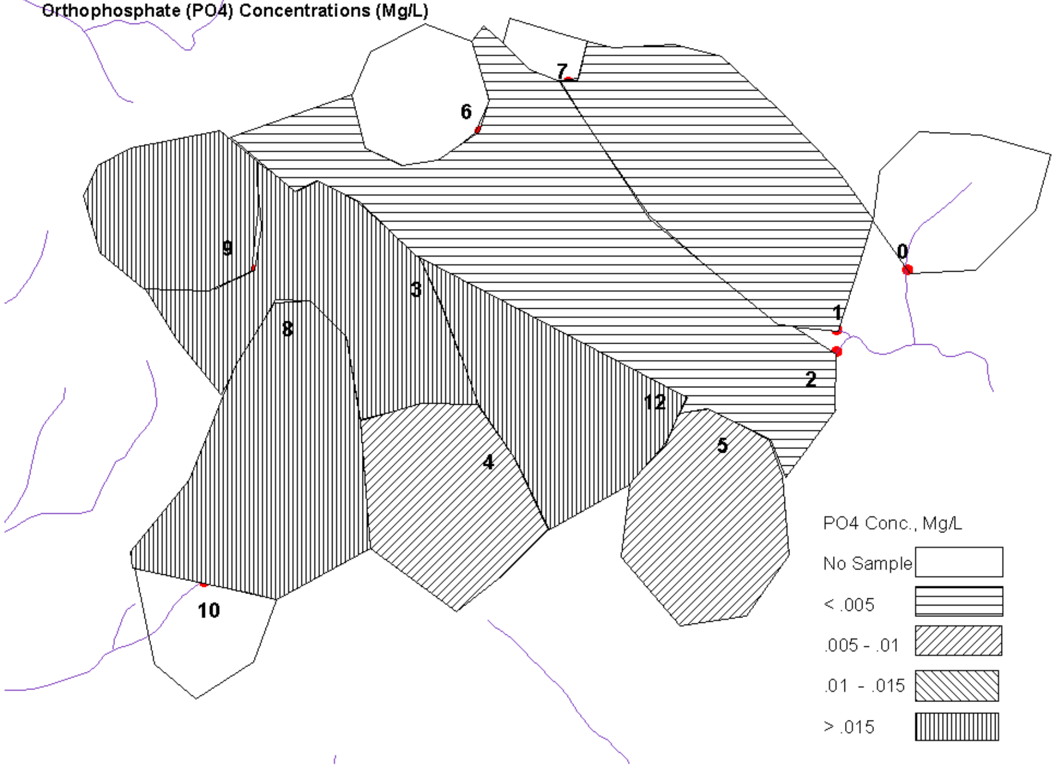
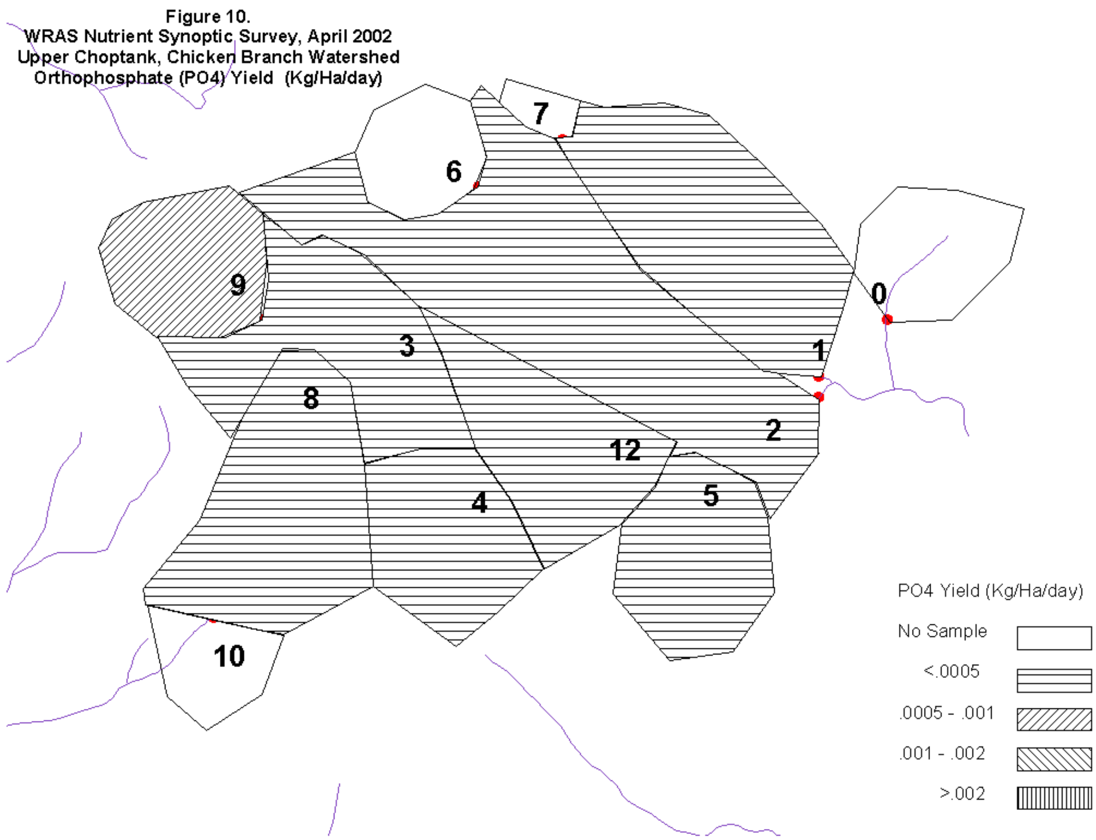


Figure 8.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Chicken Branch Watershed
Nitrate/Nitrite (NO2+NO3) Yield (Kg/Ha/day)
7
6
9
0
3
1
8
2
12
5
4
10
NO2+NO3 Yield (Kg/Ha/day
No Sample
<.01
.01 - .02
.02 - .03
>.03

Orthophosphate concentrations were also excessive in four and moderate in two subwatersheds on the south side of Chicken Branch (Figure 9.). The concentration at site 9 (.416 mg/L) was one and two orders of magnitude higher than the other excessive concentrations in the watershed. As noted previously, odors at this site indicated anoxic conditions were present in the sediments. These anoxic conditions could have caused a release of orthophosphate that had been bound to the sediment thus contributing to the elevated concentrations. The fertilizer distribution facility adjacent to site 9 could be contributing to the high orthophosphate concentrations through spillage and dust from trucks leaving the facility. The elevated concentrations in the other watersheds could be due to increased suspended sediment in the water column due to animal activity in the stream channel. Crayfish are very good at increasing suspended sediments, as are feeding ducks, both of which were observed in these subwatersheds. Although these excessive and moderate concentrations did not make it to the watershed outlet at site 2, any elevated flows through the area have the potential to flush the orthophosphate rich sediments downstream. Orthophosphate yields where all below baseline (Figure 10.). The drought conditions and extremely low flows produce low yields even when concentrations are high.

Figure 9.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Chicken Branch Watershed
Orthophosphate (PO4) Concentrations (Mg/L)





In situ water quality readings for Chicken Branch are shown in Table 8. One large anomaly, the conductivity reading at site 9, stands out by being an order of magnitude higher than anything else in the watershed, including site 4 with its possible impact from the sewage treatment facility discharge. The fertilizer distribution facility adjacent to site 9 could be a contributing factor through spillage/dust from trucks transporting agricultural lime or other soil amenities that could contain organic salts.

Table 8. Chicken Branch Watershed In Situ Water Quality

DATE	STATION	TIME	InSitu Hydrolab Readings Temp. C	pH	Cond. mmohs/cm	DO mg/L
04/03/02	Chicken 0	.	.	.	.	.
04/03/02	Chicken 01	930	14.32	.	0.148	10.68
04/03/02	Chicken 02	920	14.36	.	0.187	11.61
04/03/02	Chicken 03	1015	18.45	7.08	0.194	13.75
04/03/02	Chicken 04	1100	17.83	7.00	0.256	11.16
04/04/02	Chicken 05	915	6.22	7.18	0.137	15.08
04/03/02	Chicken 06	.	.	.	.	.
04/03/02	Chicken 07	.	.	.	.	.
04/03/02	Chicken 08	1030	20.34	7.90	0.170	9.49
04/03/02	Chicken 09	1045	14.49	7.75	1.428	7.72
04/04/02	Chicken 10	.	.	.	.	.
04/03/02	Chicken 11	.	.	.	.	.
04/03/02	Chicken 12	950	15.19	7.45	0.184	11.04

Forge Branch

The Forge Branch watershed had 23 potential sampling sites identified from maps. A total of 16 sites were actually sampled due to no access to 6 sites and one being dry. The road crossing locations of sites are listed in Table 9, and the subwatershed delineations are illustrated in Figure 11.

Nitrate/nitrite concentrations in the Forge Branch watershed ranged from below baseline to high and excessive (Table 10). As shown in Figure 12, all excessive areas have moderate or high concentrations downstream of them. The lower concentrations downstream indicate that the nitrate/nitrite from the high concentration areas upstream is being diluted and/or reduced by natural processes. This process continued to the outlet of the watershed as evidenced by a sample taken further downstream on Forge Branch at Rt. 480 having only moderate concentrations of nitrate/nitrite (see Untargeted site 5 below). The excessive and high concentrations generally translated into high and moderate yields respectively (Figure 13). The two major tributaries and the mainstem all had high yields, but again this was tempered through dilution or reduction to baseline yields prior to the water reaching the watershed outlet (see Untargeted site 5 below). Other than normal agricultural practices, no obvious sources of nitrate/ nitrite where apparent within the watershed.

Orthophosphate concentrations in the Forge Branch watershed where generally at baseline. One small subwatershed at site 0 had excessive concentrations and the lower portions of the two major tributaries had moderately elevated orthophosphate concentrations. (Figure 14.). All orthophosphate yields were at baseline levels (Figure 15.). Orthophosphate concentrations and yields were also baseline at the watershed outlet (see Untargeted site 5 below).

Table 9. Synoptic Sampling Sites in Forge Branch Watershed, April 2002

Station	Road Crossing	Latitude	Longitude	Sample Type**	Notes
Forge 0	UT* to Forge at E. Cherry La.	39.00828	-75.82673	N	
Forge 1	Forge at Holly	38.98497	-75.81669	N.B	
Forge 2	UT to Forge at River Rd.	.	.	N	
Forge 3	UT to Forge at River Rd.	.	.	N	
Forge 4	UT to Forge at River Rd.	39.01032	-75.84887	N	
Forge 5	UT to Forge at East Cherry La.	.	.	N	
Forge 6	Forge at East Cherry La.	.	.	N	
Forge 7	UT to Forge at Farm Rd. north of Cherry La.				No Access
Forge 8	UT to Forge at Farm Rd. north of Cherry La.				No Access
Forge 9	UT to Forge at Farm Rd. north of Cherry La.				No Access
Forge 10	Forge at Farm Rd. off Cedar La.				No Access
Forge 11	UT to Forge at Cedar La.	39.02342	-75.82764	N	Very muddy.
Forge 12	Forge at Cedar La.	.	.	N	
Forge 13	UT to Forge at Farm Rd. north of Cherry La.				No Access
Forge 14	UT to Forge at Bridgetown Rd.	.	.	N	
Forge 15	UT to Forge at farm rd off Bridgetown Rd.				No Access
Forge 16	Forge at Schuyler Rd.	39.03953	-75.83398	N	
Forge 17	UT to Forge at Cedar La.	38.99494	-75.81769	N	
Forge 18	UT to Forge at Sparks Rd.				Dry.
Forge 19	UT to Forge at River Rd.	38.97842	-75.84845	N	
Forge 20	UT to Forge at Holly Rd.	38.96847	-75.83372	N	
Forge21	UT to Forge at Union Rd.	39.00463	-75.80417	N	
Forge 22	UT to Forge at Davis Rd.	39.01622	-75.80773	N	

*Unnamed Tributary
**(Benthic, Nutrient)

There were a number of insitu water quality anomalies in the Forge Branch watershed (Table 11). Low dissolved oxygen levels at sites 11 and 16 could be attributed to the decomposition of organic debris and minimal flows in these headwater streams. The very muddy conditions noted at site 11 would also have contributed to low dissolved oxygen. Marginally low pH values at sites 16, 21, and 22 may be attributable to the geology of the area or organic acidity coming from wooded wetlands, as was described for several sites in Broadway Branch. These lower pH values make the streams susceptible to episodic acidification events due to low pH precipitation. These lower pH values could be detrimental to the biological communities in the system.

Figure 11
Upper Choptank WRAS, Forge Branch Watershed
Nutrient Synoptic Sampling Sites, April 2002

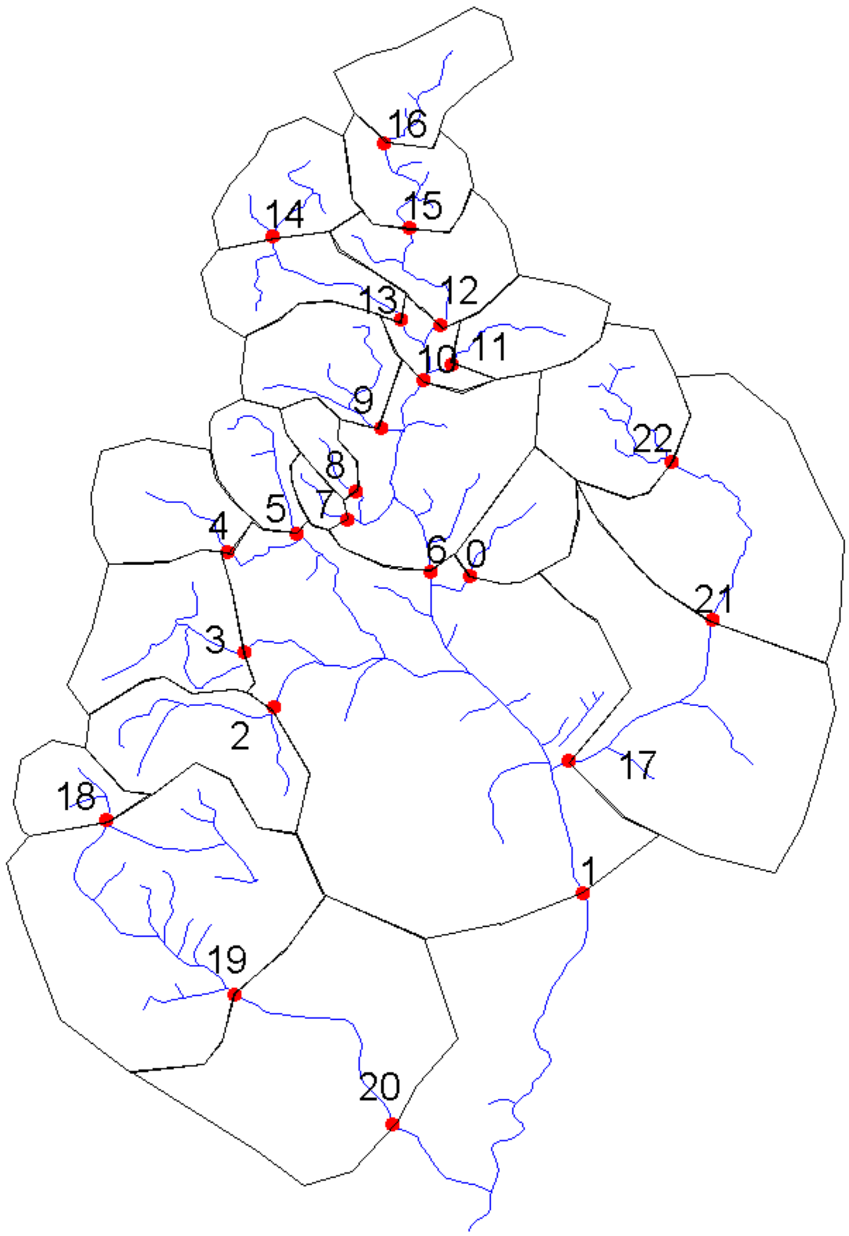


Table 10. Forge Branch Nutrient Synoptic Results, April 2002

		Concentration			Daily Loads		Area	Nutrient Yields/Hectare	
DATE	STATION	PO4 (mg P/L)	NO23 (mg N/L)	Discharge (L/s)	PO4 (kg/day)	NO23 (kg/day)	Hectares	PO4 (kg/day/ha)	NO23 (kg/day/ha)
04/04/02	F 0	0.016	3.01	2.95	0.00	0.77	66	0.000062	0.011641
04/03/02	F 01	0.004	3.08	191.24	0.07	50.89	2785	0.000024	0.018273
04/03/02	F 02	0.002	4.70	2.17	0.00	0.88	130	0.000003	0.006773
04/03/02	F 03	0.001	1.58	1.59	0.00	0.22	128	0.000001	0.001694
04/04/02	F 04	0.003	0.13	0.49	0.00	0.01	97	0.000001	0.000057
04/03/02	F 05	0.003	6.34	2.09	0.00	1.15	57	0.000010	0.020222
04/03/02	F 06	0.003	1.19	60.95	0.02	6.27	814	0.000019	0.007700
04/03/02	F 07	.	.	.	.	.	15	.	.
04/03/02	F 08	.	.	.	.	.	26	.	.
04/03/02	F 09	.	.	.	.	.	92	.	.
04/03/02	F 10	.	.	.	.	.	501	.	.
04/03/02	F 11	0.001	3.81	2.76	0.00	0.91	72	0.000003	0.012665
04/03/02	F 12	0.003	0.39	9.91	0.00	0.33	237	0.000011	0.001408
04/03/02	F 13	.	.	.	.	.	162	.	.
04/03/02	F 14	0.003	0.94	6.61	0.00	0.54	81	0.000021	0.006667
04/03/02	F 15	.	.	.	.	.	153	.	.
04/04/02	F 16	0.004	0.02	0.25	0.00	0.00	87	0.000001	0.000005
04/03/02	F 17	0.008	5.03	40.90	0.03	17.77	744	0.000038	0.023881
04/03/02	F 18	.	.	0.00	.	.	52	.	.
04/04/02	F 19	0.002	5.88	7.45	0.00	3.79	444	0.000003	0.008538
04/03/02	F 20	0.005	4.10	49.13	0.02	17.40	756	0.000028	0.023023
04/04/02	F 21	0.003	5.44	14.22	0.00	6.68	392	0.000009	0.017063
04/04/02	F 22	0.003	4.90	1.00	0.00	0.42	124	0.000002	0.003421

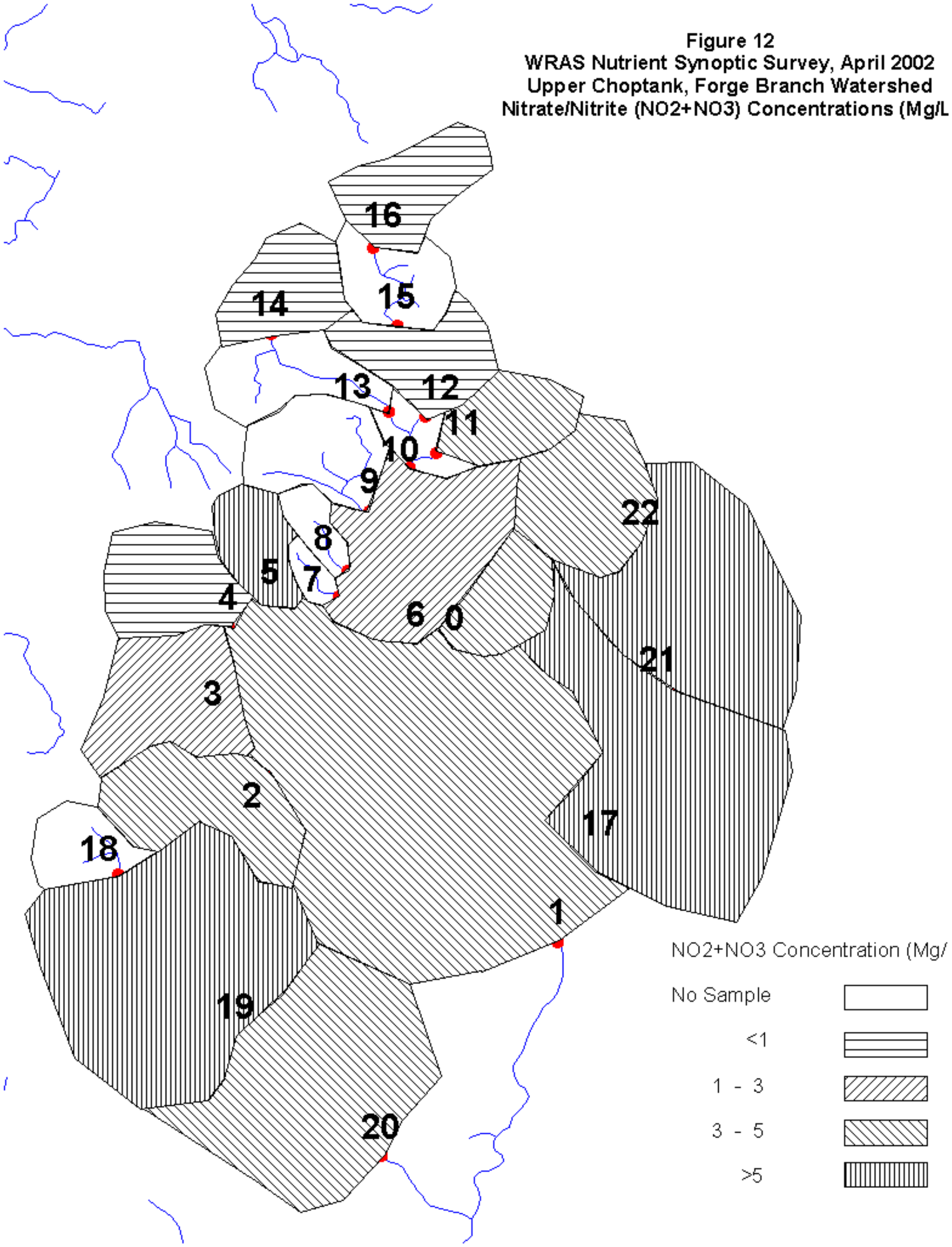


Figure 12
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Forge Branch Watershed
Nitrate/Nitrite (NO2+NO3) Concentrations (Mg/L
16
15
14
13
12
11
10
9
22
8
5
7
4
6
0
21
3
2
17
18
1
19
20
NO2+NO3 Concentration (Mg/
No Sample
<1
1 - 3
3 - 5
>5

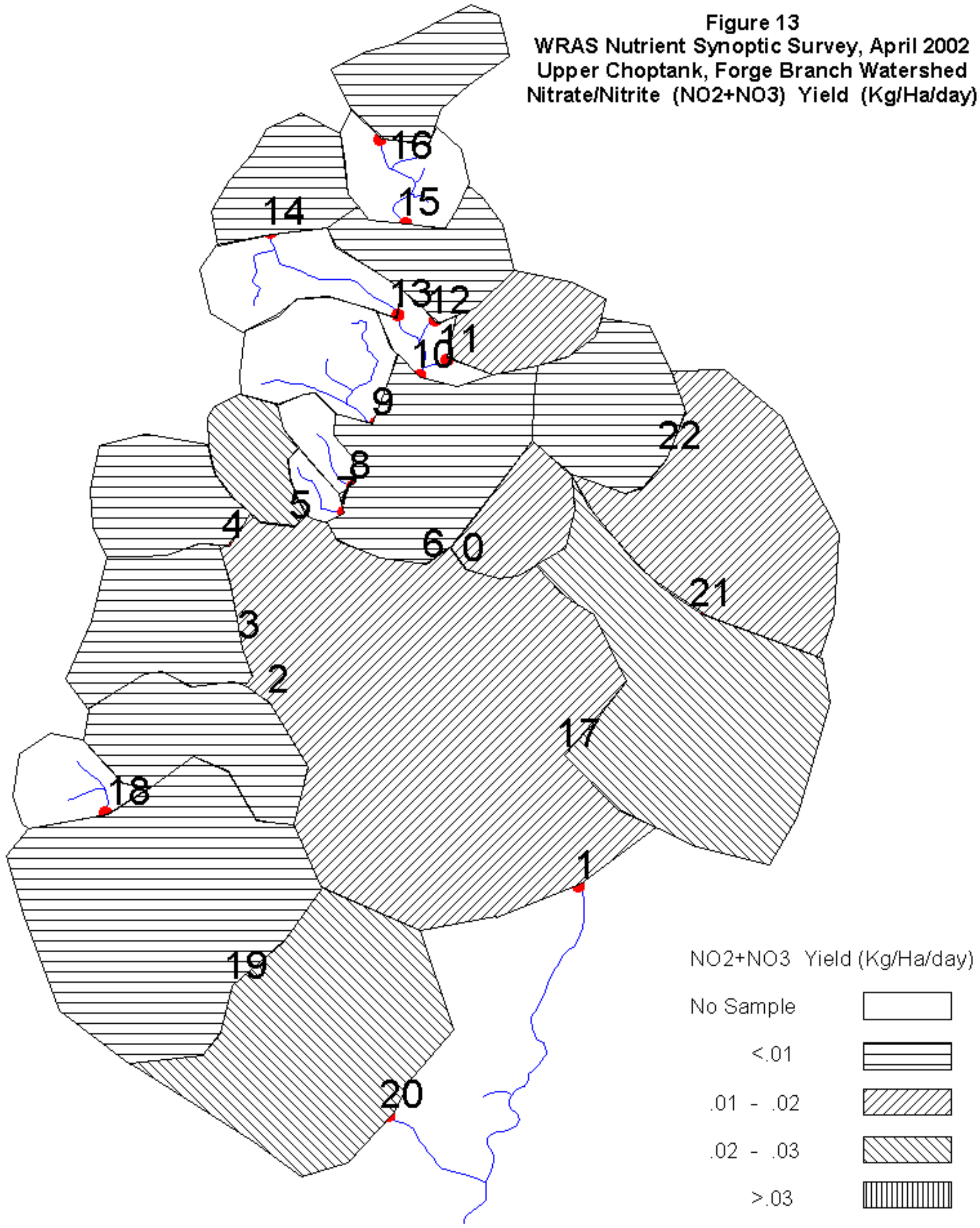


Figure 13
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Forge Branch Watershed
Nitrate/Nitrite (NO2+NO3) Yield (Kg/Ha/day)
16
15
14
13
12
11
10
9
8
7
5
4
6
0
22
21
3
2
17
18
1
19
20
NO2+NO3 Yield (Kg/Ha/day)
No Sample
<.01
.01 - .02
.02 - .03
>.03

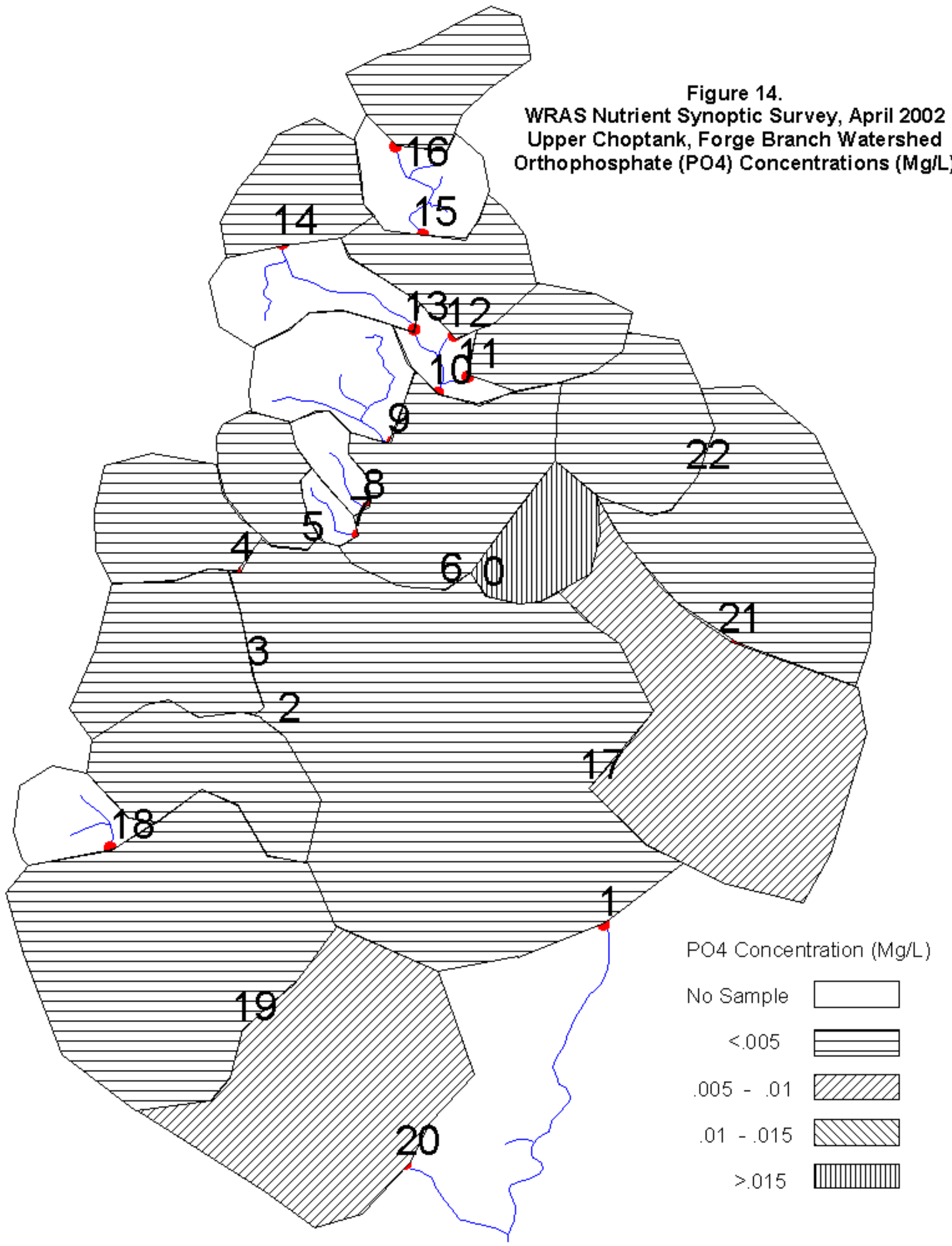


Figure 14.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Forge Branch Watershed
Orthophosphate (PO4) Concentrations (Mg/L)
16
15
14
13
12
11
10
9
8
7
5
4
6
0
22
21
3
2
17
18
1
19
20
PO4 Concentration (Mg/L)
No Sample
<.005
.005 - .01
.01 - .015
>.015

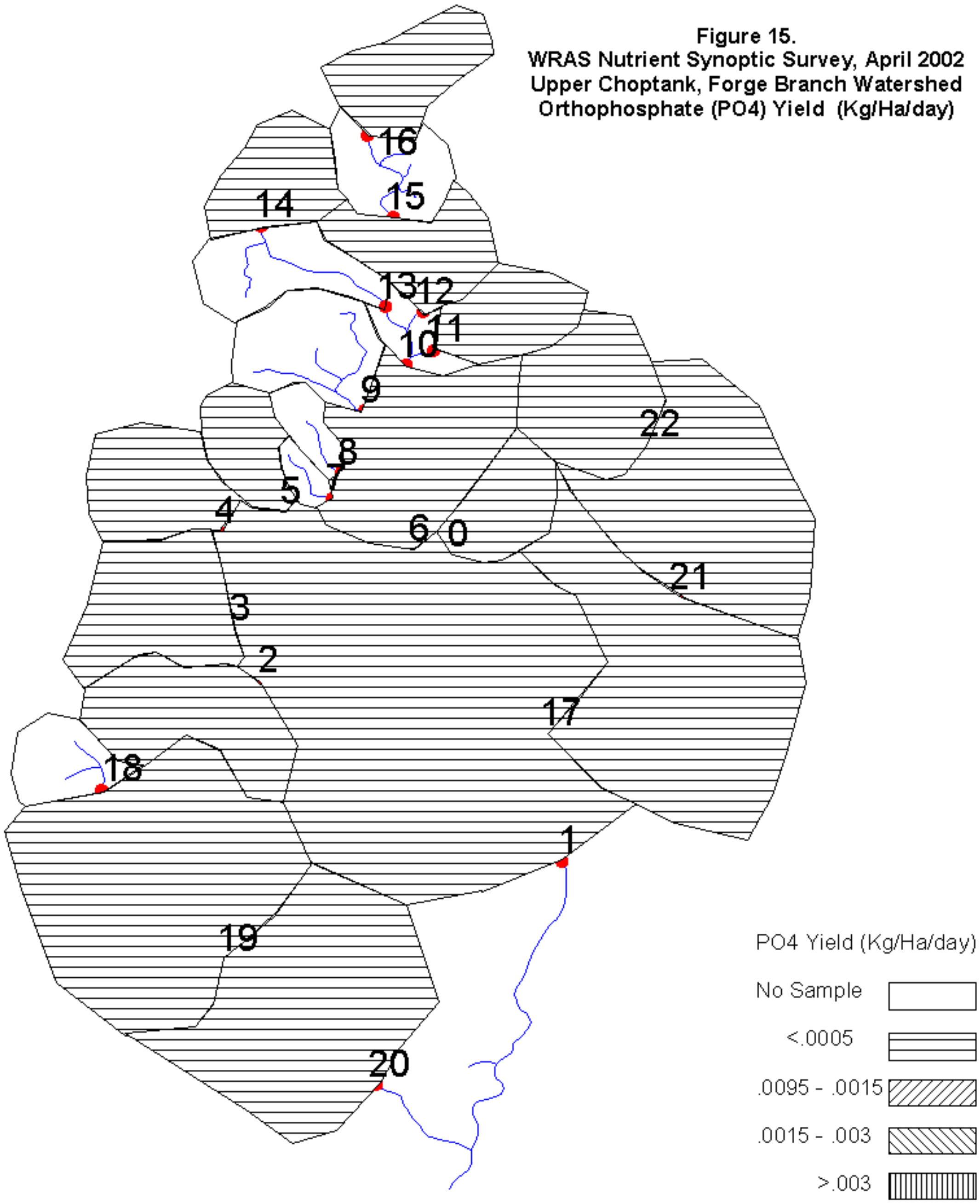


Figure 15.
WRAS Nutrient Synoptic Survey, April 2002
Upper Choptank, Forge Branch Watershed
Orthophosphate (PO4) Yield (Kg/Ha/day)

Table 11. Forge Branch Watershed In Situ Water Quality

			InSitu Hydrolab Readings			
DATE	STATION	TIME	Temp. C	pH	Cond. mmohs/cm	DO mg/L
04/04/02	F 0	1015	8.76	6.52	0.156	9.60
04/03/02	F 01	1305	18.35	6.97	0.156	9.95
04/03/02	F 02	1500	18.60	7.64	0.171	9.07
04/03/02	F 03	1450	22.80	7.32	0.119	8.83
04/04/02	F 04	1025	11.20	6.50	0.179	8.84
04/03/02	F 05	1425	23.79	7.61	0.178	6.10
04/03/02	F 06	1440	22.47	7.85	0.151	8.53
04/03/02	F 07	.	.	.	.	.
04/03/02	F 08	.	.	.	.	.
04/03/02	F 09	.	.	.	.	.
04/03/02	F 10	.	.	.	.	.
04/03/02	F 11	1345	25.64	7.25	0.176	2.80
04/03/02	F 12	1355	21.96	6.79	0.092	10.49
04/03/02	F 13	.	.	.	.	.
04/03/02	F 14	1410	24.38	7.32	0.128	7.49
04/03/02	F 15	.	.	.	.	.
04/04/02	F 16	1110	12.11	5.28	0.076	3.80
04/03/02	F 17	1325	19.38	6.87	0.178	9.72
04/03/02	F 18	.	.	.	.	.
04/04/02	F 19	1045	10.88	6.74	0.138	15.91
04/03/02	F 20	1240	17.35	6.21	0.129	10.16
04/04/02	F 21	1145	10.94	5.71	0.178	13.20
04/04/02	F 22	1130	13.94	5.49	0.190	12.07

Watts Creek

A total of 17 sampling sites were identified in the Watts Creek watershed, and 14 sites were sampled. Two sites were dry and there was no access to a third site (Table 12, Figure 16). No subwatersheds had excessive nitrate/nitrite concentrations, and only one had high concentrations (Table 13, Figure 17). Four other subwatersheds, plus the watershed outlet, had moderate concentrations. Nitrate/nitrite yields from the watershed were generally baseline, including at the outlet (Figure 18). The one subwatershed that had high concentrations and one of the moderate concentration watersheds translated to moderate yields. No contributory activities, other than normal farming operations, were evident during sampling within these two subwatersheds.

Orthophosphate concentrations were found to be excessive in the upper portion of the watershed and moderate or high in much of the remainder (Figure 19). The excessive orthophosphate concentrations in these very slow flow headwater streams are most likely the consequence of residual suspended sediments from a rainfall event a day or two prior to sampling. The excessive concentrations upstream appeared to be the source of the high concentrations in the downstream mainstem portions of the creek. The predominance of elevated orthophosphate concentrations in this watershed indicates the soils contain considerable phosphorus reserves. Only two subwatersheds had concentrations that translated into elevated yields (Figure 20). The mainstem site 5 had a moderate yield and the tributary site 12 was measured as high. The very excessive concentration at site 12, coupled with the relatively high flow for the watershed area, creates a watershed that mimics a point source for orthophosphate.

Table 12. Synoptic Sampling Sites in Watts Creek Watersheds, April 2002

Station	Road Crossing	Latitude	Longitude	Sample Type**	Notes
Watts Creek 0	Watts Cr at Legion Rd.	38.86253	-75.80775	N.B	
Watts Creek 01	Watts Cr at Hobbs Rd.	38.87589	-75.79153	N	
Watts Creek 02	UT* to Watts at Foy Rd.	.	.	.	No sample stream dry.
Watts Creek 03	UT to Watts at Foy Rd.	38.88069	-75.79728	N	2' Drop at culvert.
Watts Creek 04	Watts at Penny Rd.	38.87772	-75.78869	N	
Watts Creek 05	Watts at Anthony Mill Rd.	38.88031	-75.78353	N.B	
Watts Creek 06	UT to Watts Country Farm Rd.	38.88586	-75.77064	N	
Watts Creek 07	Watts Cr at Country Farm Rd.	38.88569	-75.77067	N	
Watts Creek 08	Webber Br at MD 317	38.89881	-75.74272	N	
Watts Creek 09	Watts Cr at Dead End Rd.	38.88728	-75.75286	N	
Watts Creek 10	Webber Br at Knife Box Rd.	.	.	.	No sample stream dry.
Watts Creek 11	UT to Watts at Wilhelm Rd.	38.87186	-75.69728	N	
Watts Creek 12	UT to Watts at Anthony Mill Rd.	38.87192	-75.74936	N	
Watts Creek 13	UT to Watts at Hobbs Rd.	38.86894	-75.78708	N	
Watts Creek 14	Farm road off Anthony Mill rd.	.	.	.	No sample. No access.
Watts Creek 15	UT to Watts at Wilhelm Rd.	38.87475	-75.74236	N	
Watts Creek 16	Burrisville Br at MD 317	38.89547	-75.72756	N	

*Unnamed Tributary
**(Benthic, Nutrient)

In situ water quality measurements within the Watts Creek watershed found few anomalies (Table 14). The heavily wooded riparian areas promote organic acidity that contributes to the marginally low pH readings found throughout the watershed. The headwater site 15 had relatively low dissolved oxygen that could be attributed to almost stagnant water, and decomposition (oxidation) of organic matter on the stream bottom.

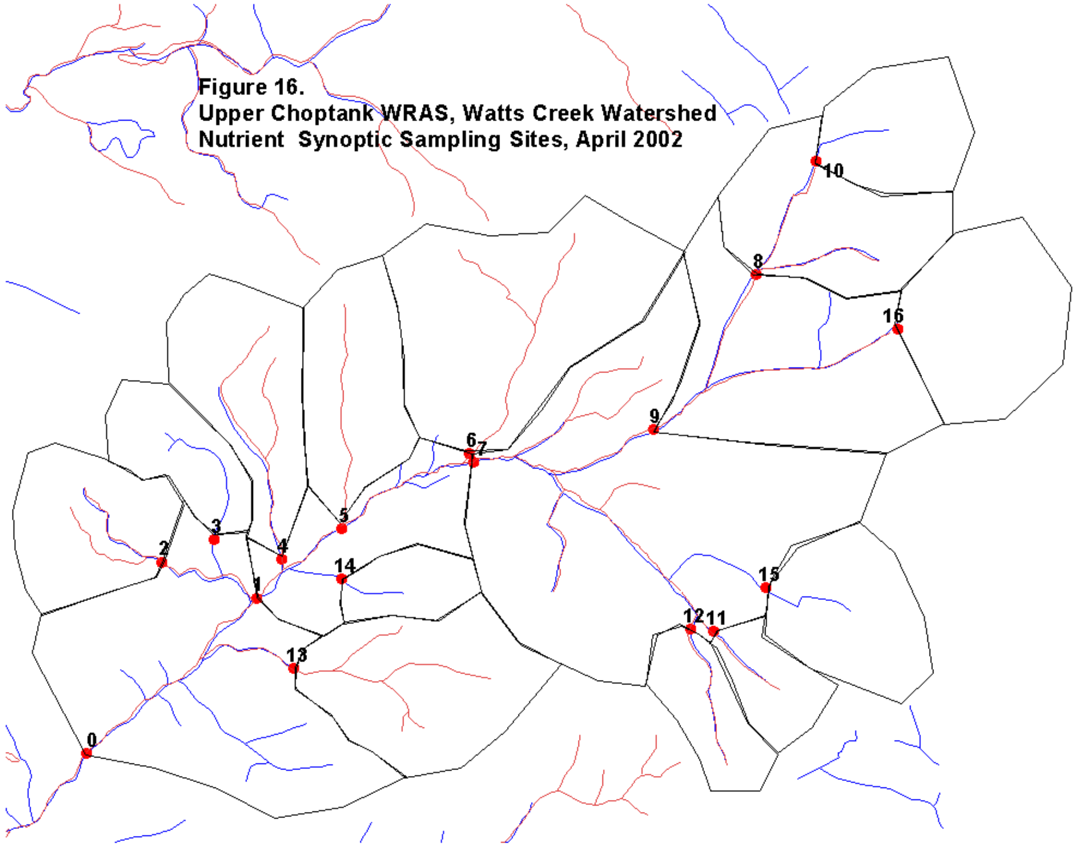


Table 13. Watts Creek Nutrient Synoptic Results, April 2002

DATE	STATION	Concentration PO4 (mg P/L)	Concentration NO23 (mg N/L)	Discharge (L/s)	Daily Loads PO4 (kg/day)	Daily Loads NO23 (kg/day)	Area Hectares	Nutrient Yields/Hectare PO4 (kg/day/ha)	Nutrient Yields/Hectare NO23 (kg/day/ha)
04/02/02	Watts Creek 0	0.014	1.03	285.70	0.35	25.42	3377	0.000102	0.007529
04/02/02	Watts Creek 01	0.014	0.82	203.50	0.25	14.42	2511	0.000098	0.005741
04/02/02	Watts Creek 02	.	.	.	.	.	147	.	.
04/02/02	Watts Creek 03	0.008	2.20	8.61	0.01	1.64	93	0.000064	0.017588
04/02/02	Watts Creek 04	0.003	1.45	11.71	0.00	1.47	172	0.000018	0.008548
04/02/02	Watts Creek 05	0.014	0.66	180.58	0.22	10.30	2209	0.000099	0.004661
04/02/02	Watts Creek 06	0.002	2.72	6.57	0.00	1.55	326	0.000003	0.004737
04/02/02	Watts Creek 07	0.016	0.37	169.54	0.23	5.42	1656	0.000141	0.003272
04/02/02	Watts Creek 08	0.124	1.36	7.22	0.08	0.85	297	0.000261	0.002859
04/02/02	Watts Creek 09	0.028	0.50	89.16	0.22	3.85	764	0.000282	0.005044
04/02/02	Watts Creek 10	.	.	0.00	.	.	118	.	.
04/02/02	Watts Creek 11	0.004	0.03	2.00	0.00	0.01	61	0.000011	0.000085
04/02/02	Watts Creek 12	0.330	0.69	3.15	0.09	0.19	80	0.001126	0.002355
04/02/02	Watts Creek 13	0.005	3.09	10.28	0.00	2.75	210	0.000021	0.013045
04/02/02	Watts Creek 14	.	.	.	.	.	57	.	.
04/02/02	Watts Creek 15	0.008	0.01	0.30	0.00	0.00	146	0.000001	0.000002
04/02/02	Watts Creek 16	0.027	0.57	14.39	0.03	0.71	185	0.000182	0.003839

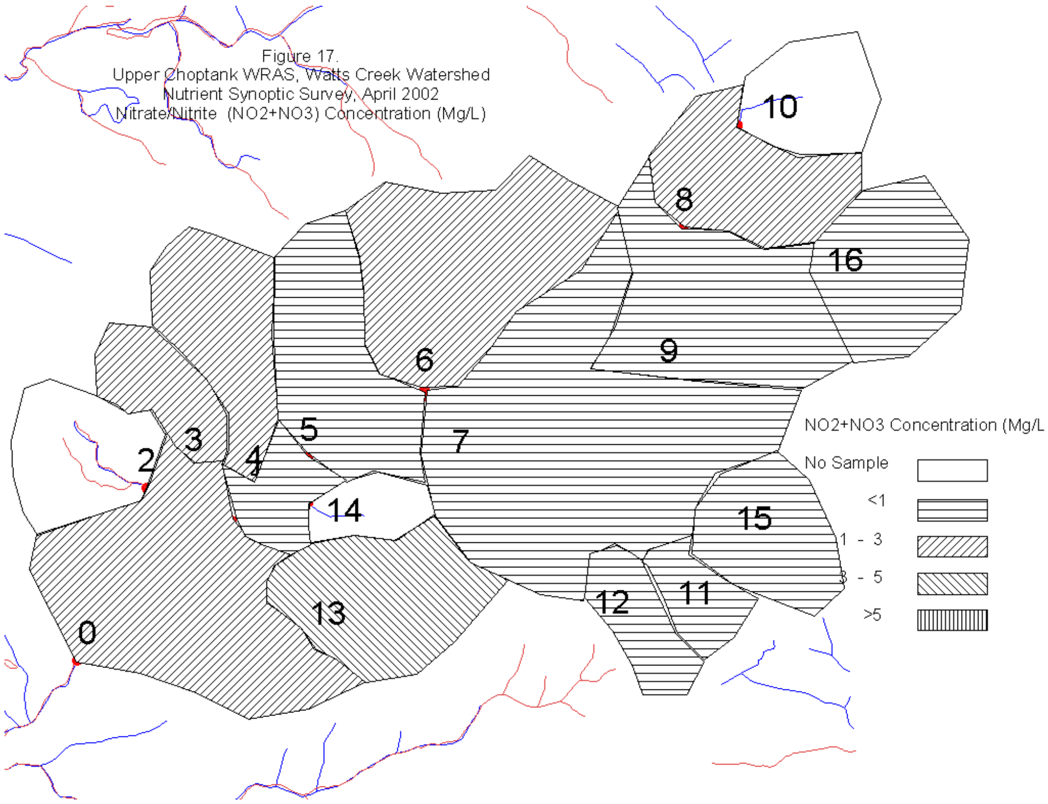


Figure 17.
Upper Choptank WRAS, Watts Creek Watershed
Nutrient Synoptic Survey, April 2002
Nitrate/Nitrite (NO2+NO3) Concentration (Mg/L)
10
8
16
9
6
5
7
3
2
4
14
15
12
11
13
0
NO2+NO3 Concentration (Mg/L
No Sample
<1
1 - 3
3 - 5
>5

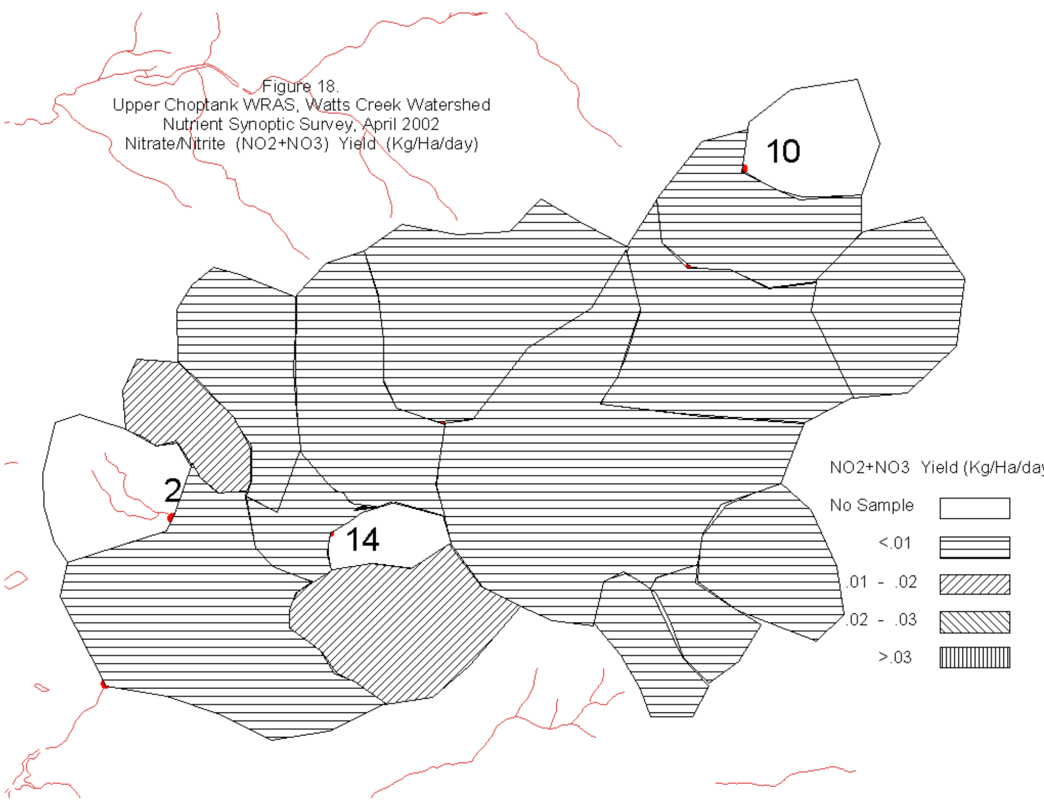


Figure 18.
Upper Choptank WRAS, Watts Creek Watershed
Nutrient Synoptic Survey, April 2002
Nitrate/Nitrite (NO2+NO3) Yield (Kg/Ha/day)
10
2
14
NO2+NO3 Yield (Kg/Ha/day
No Sample
<.01
.01 - .02
.02 - .03
>.03

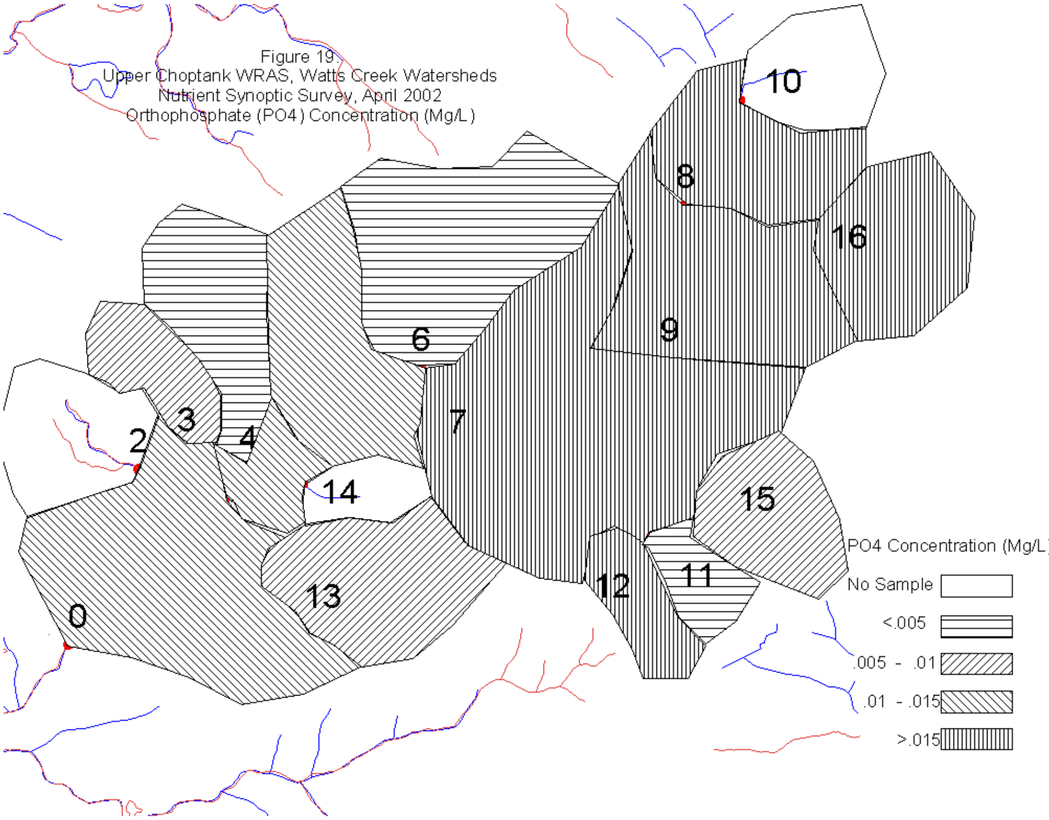


Figure 19
Upper Choptank WRAS, Watts Creek Watersheds
Nutrient Synoptic Survey, April 2002
Orthophosphate (PO4) Concentration (Mg/L)
10
8
16
6
9
3
2
4
7
14
15
13
0
12
11
PO4 Concentration (Mg/L)
No Sample
<.005
.005 - .01
.01 - .015
>.015

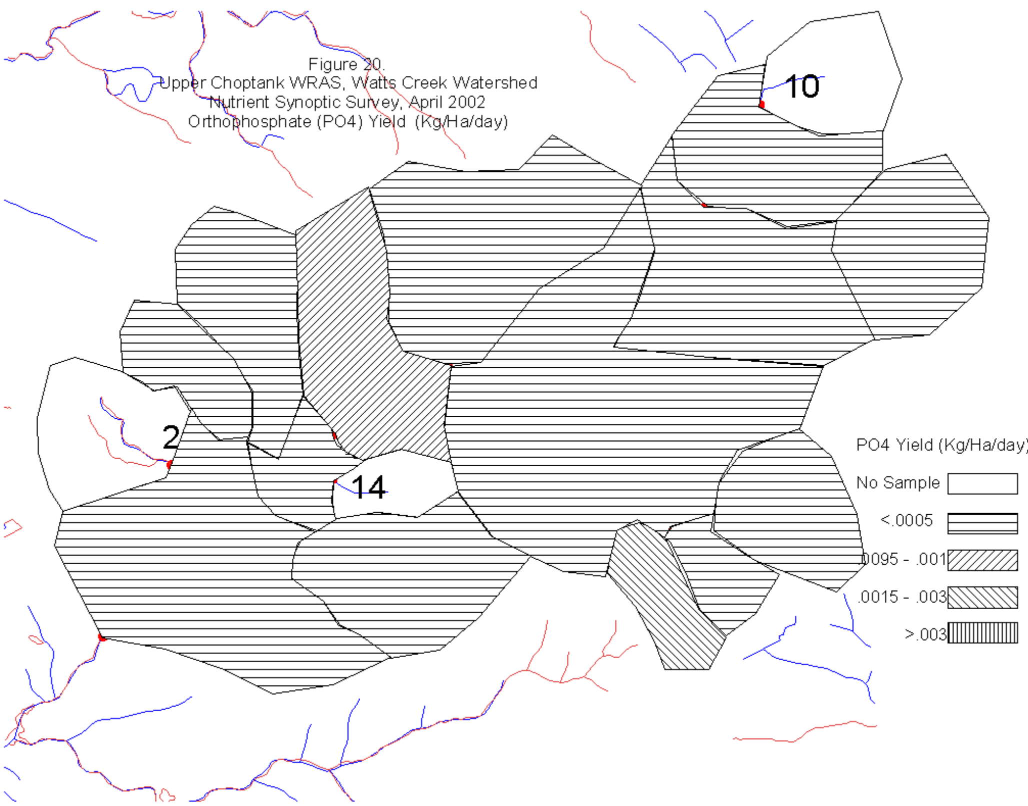


Figure 20
Upper Choptank WRAS, Watts Creek Watershed
Nutrient Synoptic Survey, April 2002
Orthophosphate (PO4) Yield (Kg/Ha/day)
10
2
14
PO4 Yield (Kg/Ha/day)
No Sample
<.0005
0095 - .001
.0015 - .003
>.003

Table14. Watts Creek Watershed In Situ Water Quality

			InSitu Hydrolab Readings			
DATE	STATION	TIME	Temp.	pH	Cond.	DO
04/02/02	Watts Creek 0	945	10.44	6.78	0.133	10.81
04/02/02	Watts Creek 01	1035	9.98	6.63	0.117	11.57
04/02/02	Watts Creek 02	.	.	.	.	.
04/02/02	Watts Creek 03	1020	11.21	6.55	0.113	10.54
04/02/02	Watts Creek 04	1110	12.97	6.53	0.099	11.70
04/02/02	Watts Creek 05	1120	11.84	6.65	0.115	11.25
04/02/02	Watts Creek 06	1215	13.45	6.16	0.121	9.90
04/02/02	Watts Creek 07	1230	14.42	6.55	0.113	10.73
04/02/02	Watts Creek 08	1310	16.25	6.41	0.128	14.35
04/02/02	Watts Creek 09	1255	13.20	6.66	0.134	9.30
04/02/02	Watts Creek 10	.	.	.	.	.
04/02/02	Watts Creek 11	1405	14.59	5.79	0.084	9.42
04/02/02	Watts Creek 12	1410	18.74	6.36	0.174	12.90
04/02/02	Watts Creek 13	1055	10.59	6.54	0.138	9.73
04/02/02	Watts Creek 14	.	.	.	.	.
04/02/02	Watts Creek 15	1350	13.55	6.00	0.066	5.72
04/02/02	Watts Creek 16	1330	17.69	6.40	0.105	14.67

Long Branch

Long Branch is a small first order stream running through Caroline Country Club golf course. Two sites were sampled on this stream (Table 15, Figure 21). As shown in Table 16 and Figure 22, nitrate/nitrite concentrations were baseline in the upper portion of the watershed and in the low end of the moderate range below the golf course. Watershed yields of nitrate/nitrite were baseline, and were among the lowest of any watershed sampled in the Choptank drainage (Figure 23). Orthophosphate concentrations and yields followed the same pattern as the nitrate/nitrite, with moderate concentrations at the outlet and baseline yields throughout the watershed (Figures 24 & 25).

In situ water quality readings from Long Branch indicated marginally low pH at site 1 as the only significant anomaly (Table 17). The drainage upstream of this station is heavily wooded and poorly drained, promoting organic acidity from leaf litter. The ponds on the golf course, with extensive algal growth, tend to buffer the lower pH coming from up stream.

Table 15. Synoptic Sampling Sites in Long Branch Watershed, March 2002

Station	Road Crossing	Latitude	Longitude	Sample Type**
Long Br. 0	Pealiquor Rd.	38.84400	-75.84686	N.B
Long Br. 1	Hickory Pl.	38.84364	-75.83669	N

**(Benthic, Nutrient)

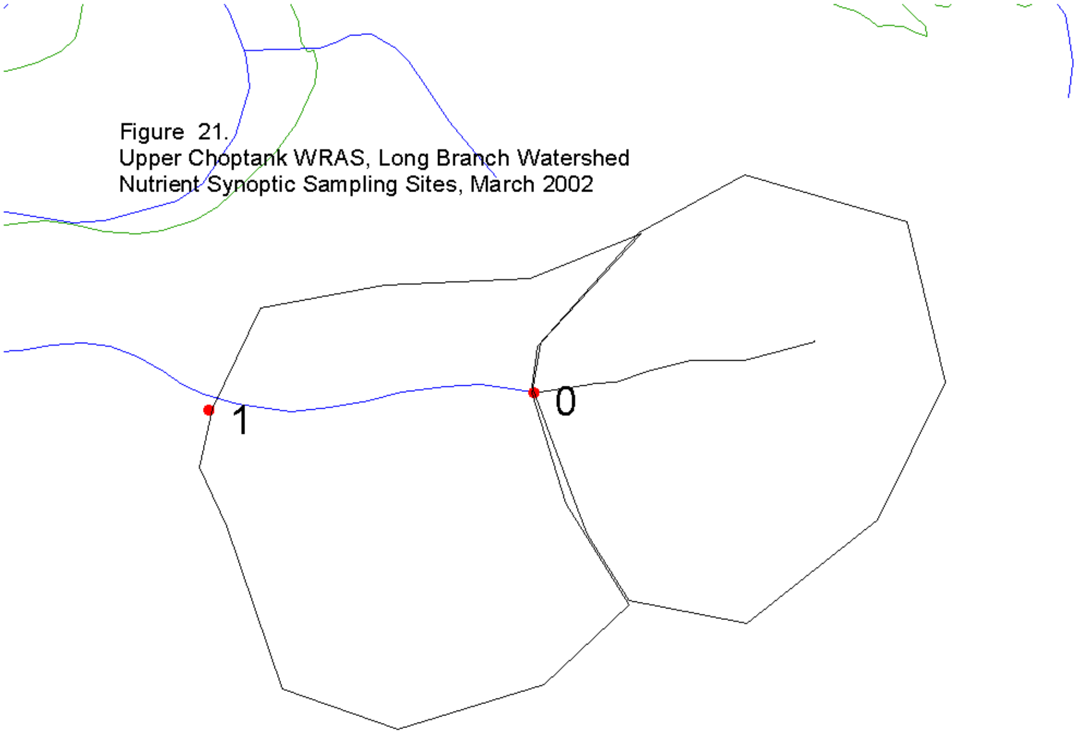


Figure 21.
Upper Choptank WRAS, Long Branch Watershed
Nutrient Synoptic Sampling Sites, March 2002

Table 16. Long Branch Nutrient Synoptic Results, March 2002

DATE	STATION	Concentration PO4 (mg P/L)	Concentration NO23 (mg N/L)	Discharge (L/s)	Daily Loads PO4 (kg/day)	Daily Loads NO23 (kg/day)	Area Hectares	Nutrient Yields/Hectare PO4 (kg/day/ha)	Nutrient Yields/Hectare NO23 (kg/day/ha)
03/29/02	Long Br. 0	0.008	0.80	7.68	0.01	0.53	72	0.000074	0.007367
03/29/02	Long Br. 1	0.003	1.94	1.57	0.00	0.26	163	0.000003	0.001617

Figure 22.
Upper Choptank WRAS, Long Branch Watershed
Nutrient Synoptic Survey, March 2002
Nitrate/Nitrite (NO2+NO3) Concentration (Mg/L)

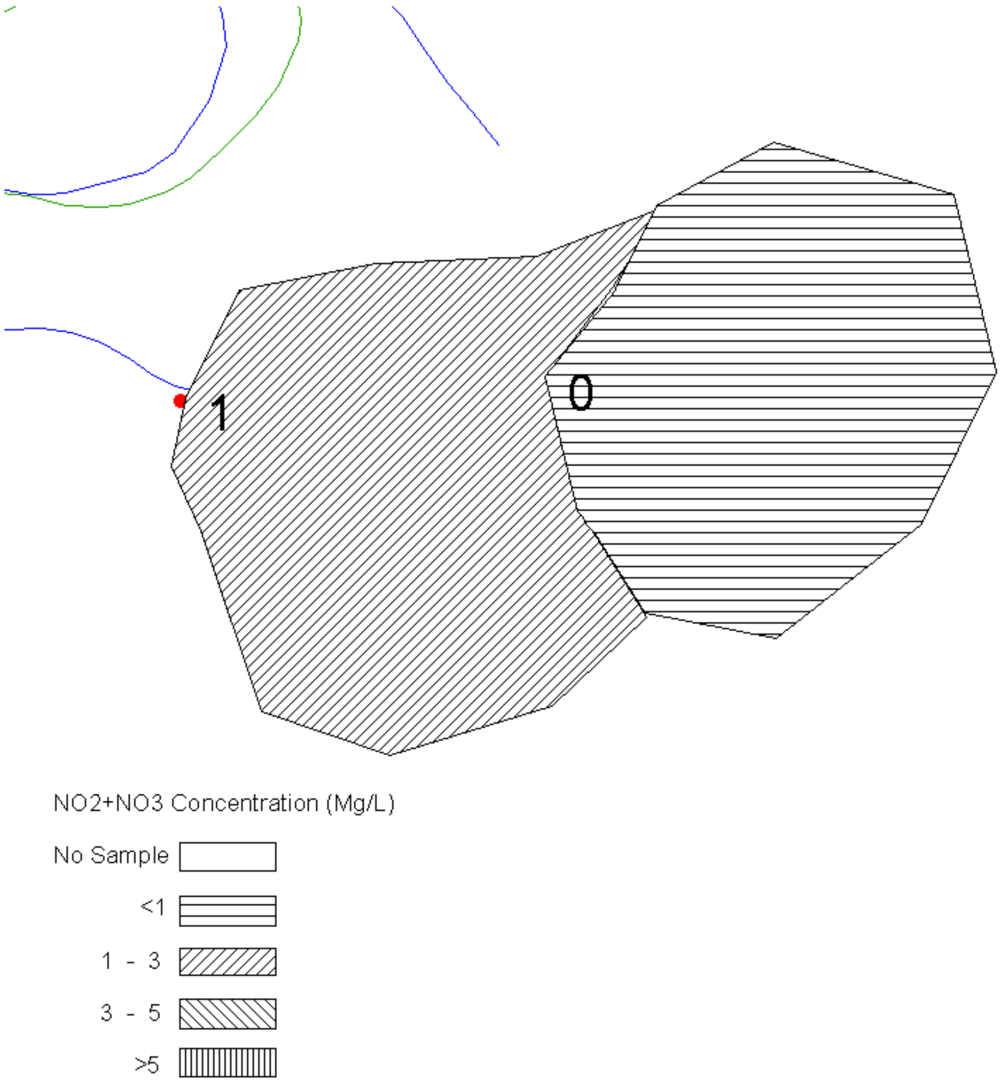


Figure 23.
Upper Choptank WRAS, Long Branch Watershed
WRAS Nutrient Synoptic Survey, March 2002
Nitrate/Nitrite (NO2+NO3) Yield (Kg/Ha/day)

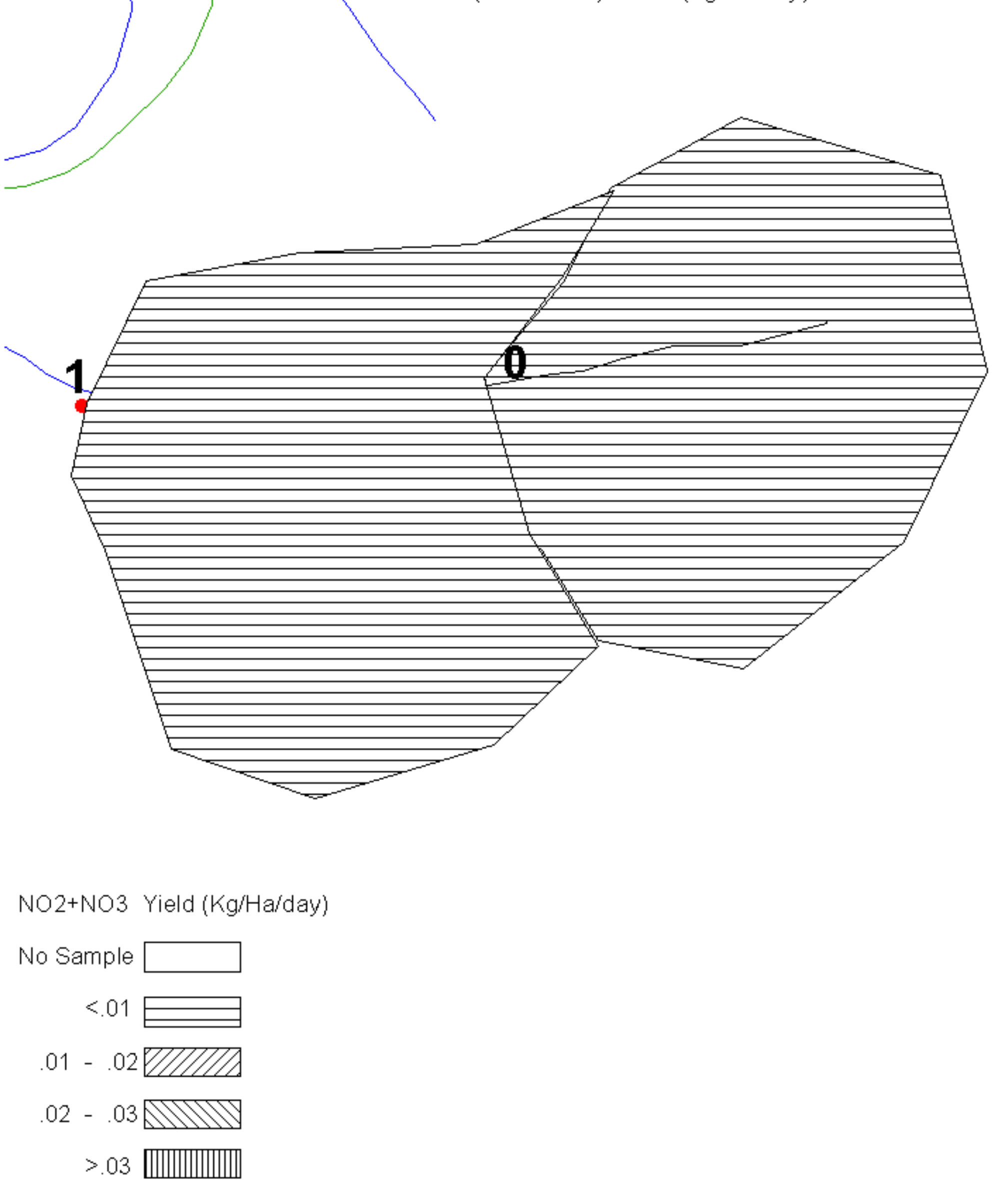


Figure 24.
Upper Choptank WRAS, Long Branch Watershed
Nutrient Synoptic Survey, March 2002
Orthophosphate (PO4) Concentration (Mg/L)

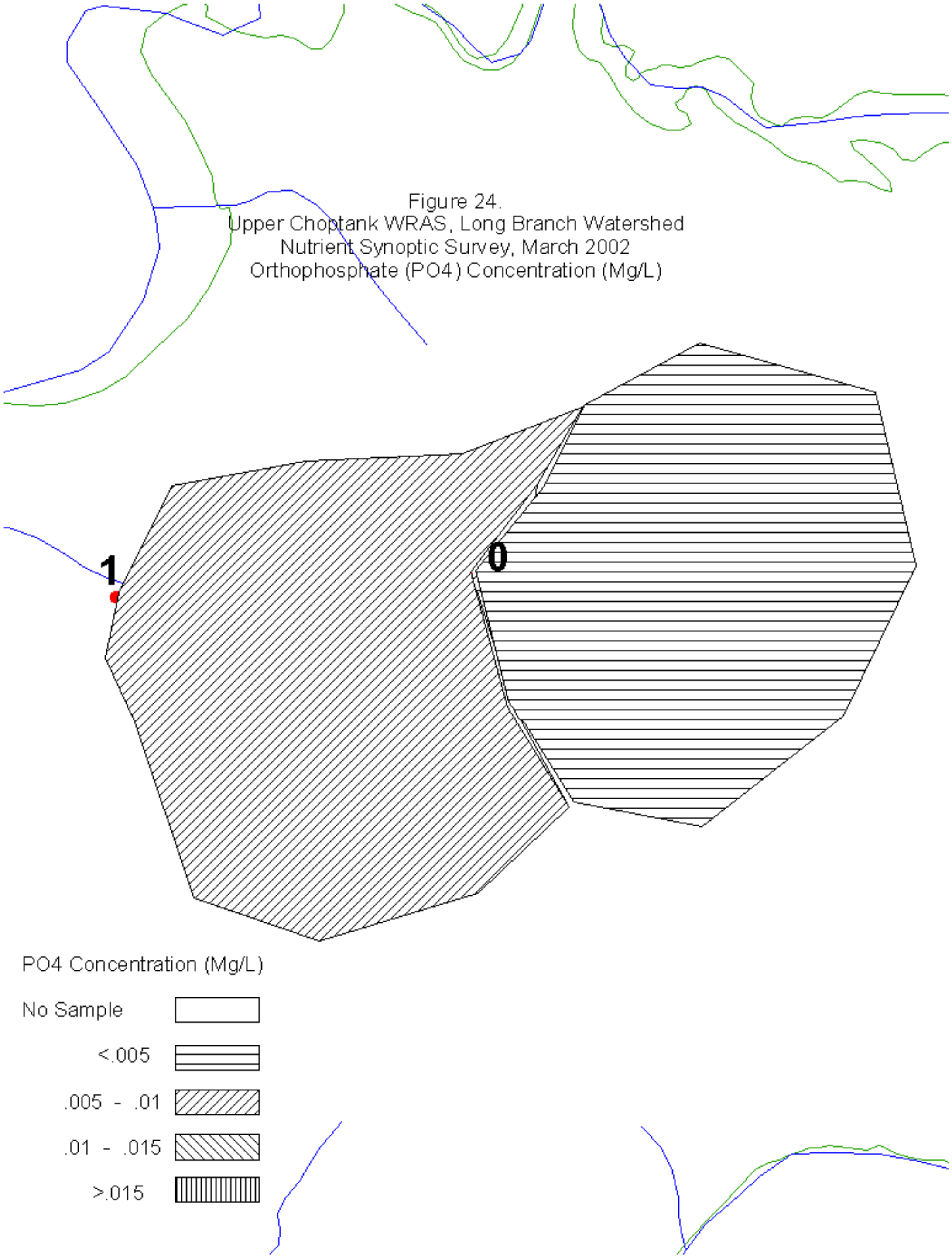


Figure 25.
Upper Choptank WRAS, Long Branch Watershed
Nutrient Synoptic Survey, March 2002
Orthophosphate (PO4) Yield (Kg/Ha/day)

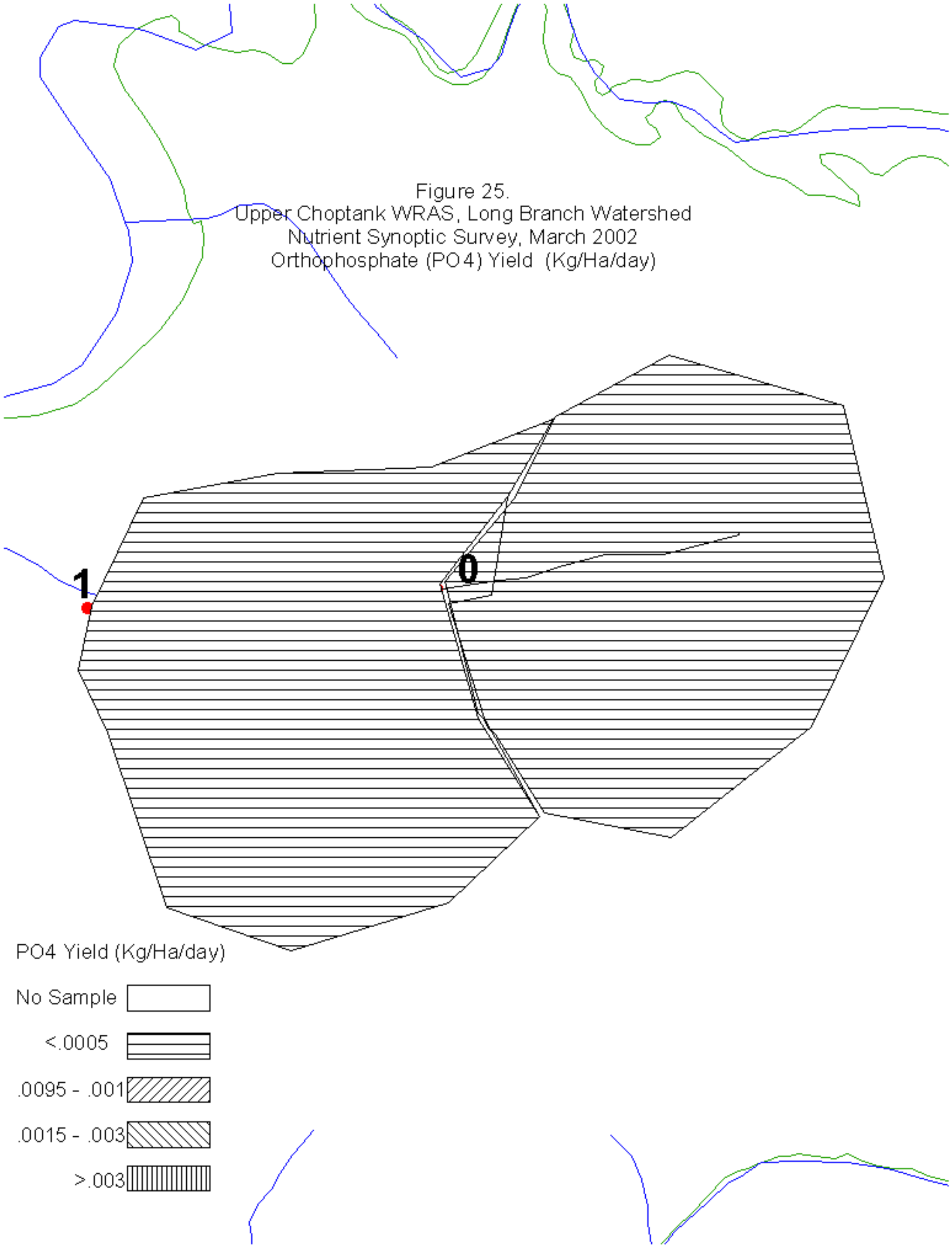


Table 17. Long Branch Watershed In Situ Water Quality

			InSitu Hydrolab Readings			
DATE	STATION	TIME	Temp.	pH	Cond.	DO
03/29/02	Long Br. 0	950	11.32	6.32	0.136	11.94
03/29/02	Long Br. 1	930	9.57	5.64	0.097	9.53

Little Creek

A total of 8 potential sampling sites were identified in the Little Creek watershed (Table 18, Figure 26). Two of the small head water streams were dry (08), or had ponded water present but no flow (03).

Table 18. Synoptic Sampling Sites in Little Creek Watershed, March 2002

Station	Road Crossing	Latitude	Longitude	Sample Type**	Note
Little Creek 01	Marsh Creek Rd.	38.74086	-75.96839	N	
Little Creek 02	Marsh Creek Rd.	38.74086	-75.96839	N.B	
Little Creek 03	Marsh Creek Rd.	.	.	.	No Flow
Little Creek 04	Marsh Creek Rd.	38.73581	-75.96267	N	
Little Creek 05	Bethlehem Rd.	38.73447	-75.95600	N	
Little Creek 06	Bethlehem Rd.	38.73967	-75.95219	N	
Little Creek 07	Bethlehem Rd.	38.74356	-75.94711	N	
Little Creek 08	Rt 331				Dry

**(Benthic, Nutrient)

The nitrate/nitrite concentrations in Little Creek ranged from extremely low to extremely high. The majority of the watershed was baseline at less than 1 mg/L. Two subwatersheds were in the low end of the moderate category, and one subwatershed was the highest found among all Choptank samples (Table 19, Figure 22). Potential sources for the high nitrate/nitrite concentrations were not obvious at the time of sampling. Run off from stock piled or freshly applied poultry litter during a rain event several days prior to sampling could have contributed. The extremely low flow at this site resulted in a baseline yield for the watershed (Figure 23). A flushing rain event could produce higher yields at the watershed outlet. The moderate concentration at site 2 translated into a moderate yield from this side of the watershed as well.

Table 19. Little Creek Nutrient Synoptic Results, March 2002

DATE	STATION	Concentration PO4 (mg P/L)	Concentration NO23 (mg N/L)	Discharge (L/s)	Daily Loads PO4 (kg/day)	Daily Loads NO23 (kg/day)	Area Hectares	Nutrient Yields/Hectare PO4 (kg/day/ha)	Nutrient Yields/Hectare NO23 (kg/day/ha)
03/29/02	Little Creek 01	0.008	16.30	0.00	0.00	0.00	257	0.000000	0.000000
03/29/02	Little Creek 02	0.014	1.42	30.20	0.04	3.71	274	0.000133	0.013523
03/29/02	Little Creek 03	.	.	0.00	.	.	10	.	.
03/29/02	Little Creek 04	0.004	0.82	0.60	0.00	0.04	22	0.000009	0.001936
03/29/02	Little Creek 05	0.010	0.06	6.08	0.01	0.03	182	0.000029	0.000173
03/29/02	Little Creek 06	0.004	0.03	4.41	0.00	0.01	49	0.000031	0.000235
03/29/02	Little Creek 07	0.019	1.90	1.82	0.00	0.30	47	0.000064	0.006379

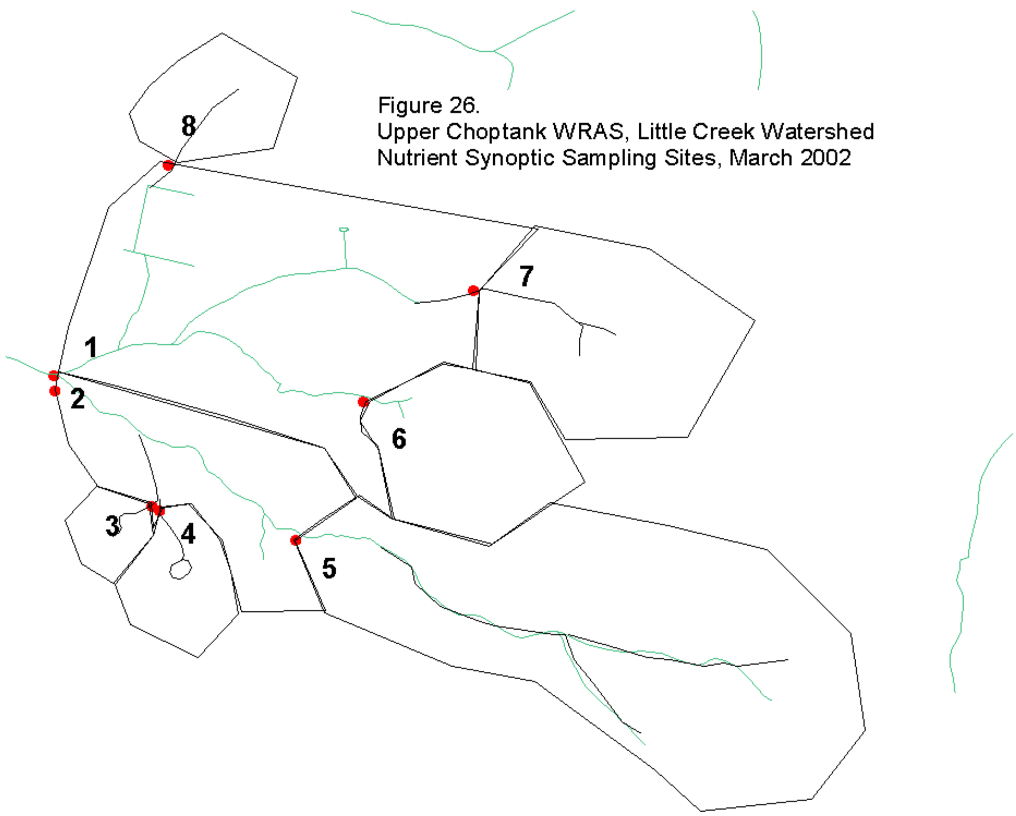


Figure 26.
Upper Choptank WRAS, Little Creek Watershed
Nutrient Synoptic Sampling Sites, March 2002

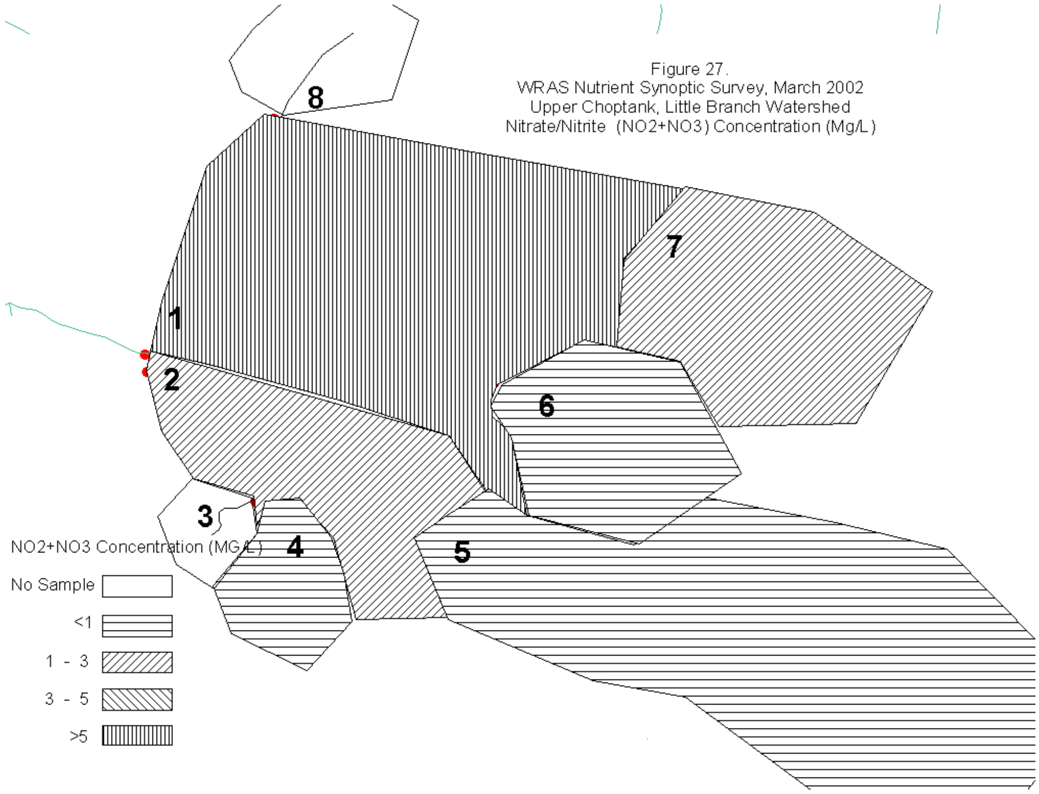


Figure 27.
WRAS Nutrient Synoptic Survey, March 2002
Upper Choptank, Little Branch Watershed
Nitrate/Nitrite (NO2+NO3) Concentration (Mg/L)
1
2
3
4
5
6
7
8
NO2+NO3 Concentration (MG/L)
No Sample
<1
1 - 3
3 - 5
>5

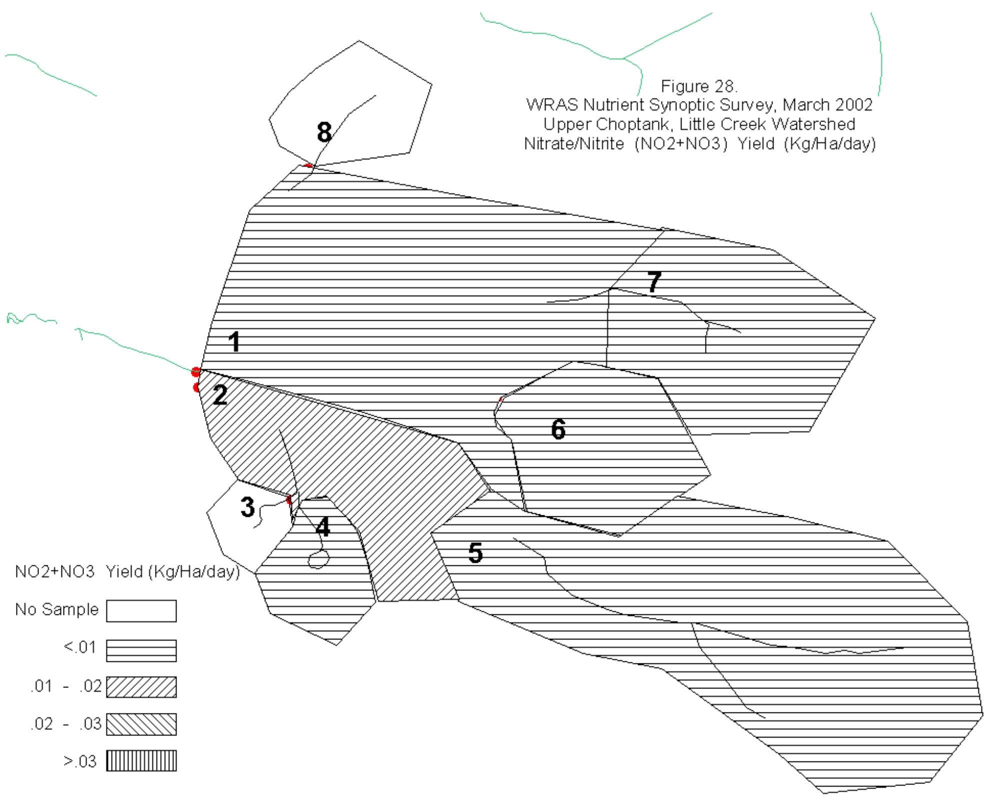


Figure 28.
WRAS Nutrient Synoptic Survey, March 2002
Upper Choptank, Little Creek Watershed
Nitrate/Nitrite (NO2+NO3) Yield (Kg/Ha/day)
1
2
3
4
5
6
7
8
NO2+NO3 Yield (Kg/Ha/day)
No Sample
<.01
.01 - .02
.02 - .03
>.03

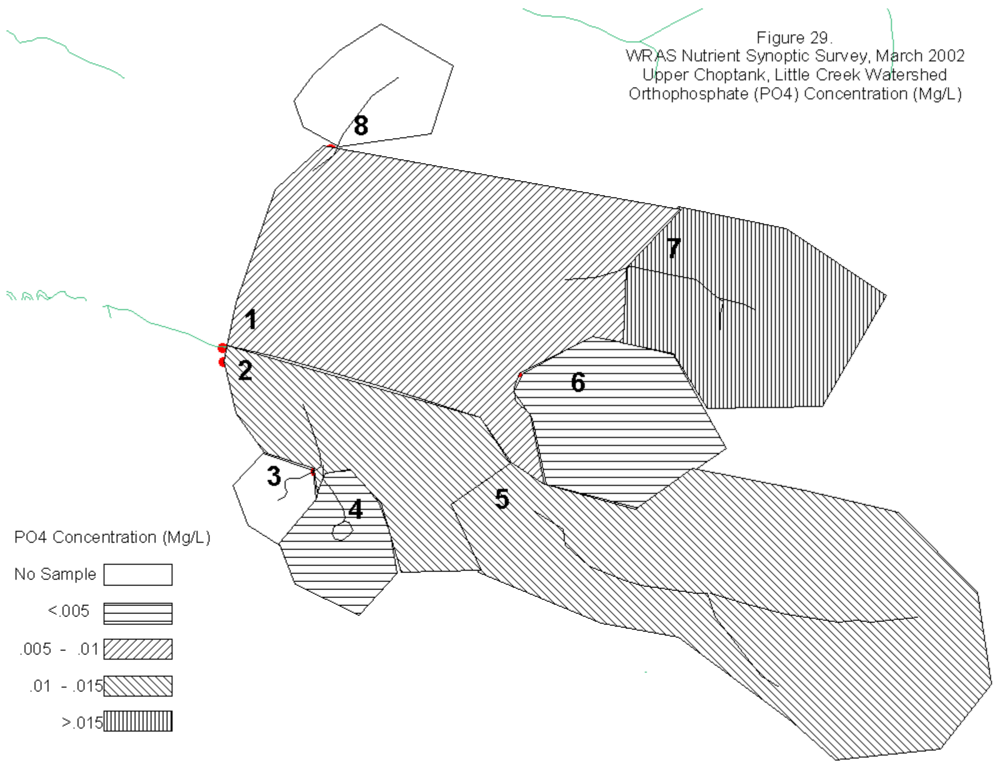


Figure 29.
WRAS Nutrient Synoptic Survey, March 2002
Upper Choptank, Little Creek Watershed
Orthophosphate (PO4) Concentration (Mg/L)
8
7
1
2
6
3
4
5
PO4 Concentration (Mg/L)
No Sample
<.005
.005 - .01
.01 - .015
>.015

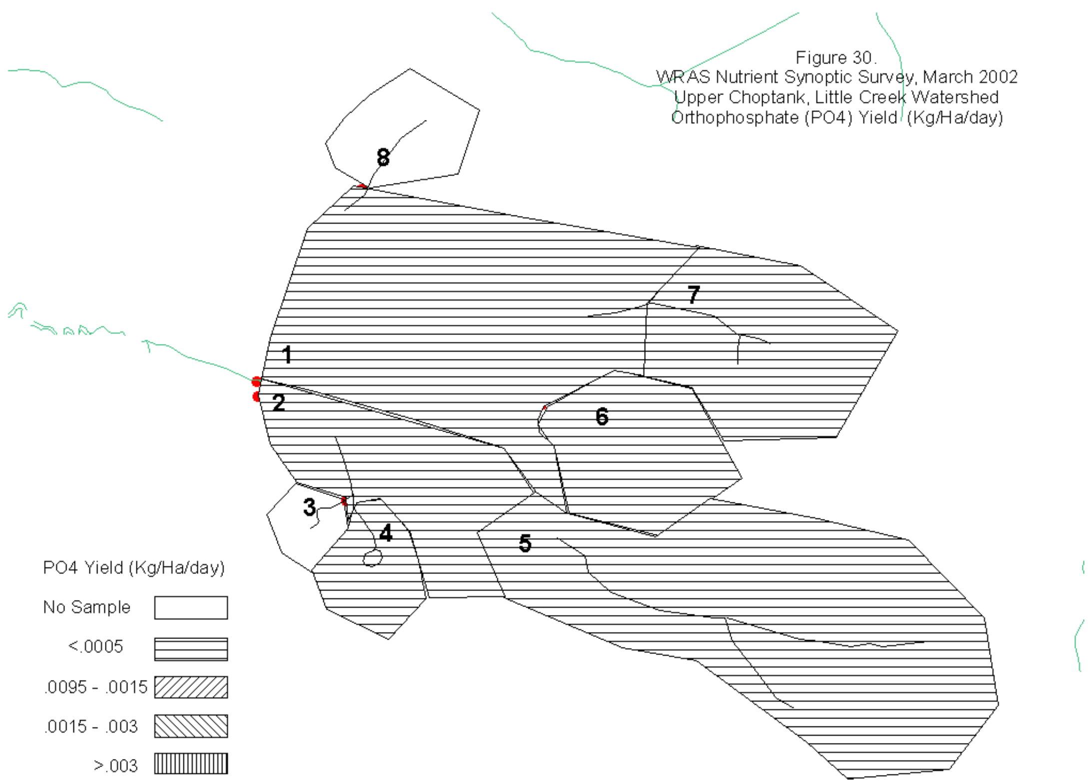


Figure 30.
WRAS Nutrient Synoptic Survey, March 2002
Upper Choptank, Little Creek Watershed
Orthophosphate (PO4) Yield (Kg/Ha/day)
8
7
1
2
6
3
4
5
PO4 Yield (Kg/Ha/day)
No Sample
<.0005
.0095 - .0015
.0015 - .003
>.003

The in situ water quality readings from Little Creek found several anomalies (Table 20). The elevated specific conductivity at site 1 correlates with the extremely high nitrate/nitrite concentrations found at this site and could be indicative of inputs from a concentrated fertilizer source. The very low pH values at sites 5 and 6 are most likely due to organic sources. Both of these watersheds are heavily wooded and poorly drained, promoting standing water in leaf and pine needle litter that would become acidified. The rainfall event prior to sampling would have flushed some of this acidic water into the actively flowing water.

Table 20. Little Creek Watershed In Situ Water Quality

			InSitu Hydrolab Readings			
DATE	STATION	TIME	Temp.	pH	Cond.	DO
03/29/02	Little Creek 01	1230	16.59	6.59	0.510	14.13
03/29/02	Little Creek 02	1240	14.48	6.93	0.210	11.25
03/29/02	Little Creek 03	.	.	.	.	.
03/29/02	Little Creek 04	1305	14.75	6.40	0.215	7.55
03/29/02	Little Creek 05	1320	13.64	3.88	0.100	7.83
03/29/02	Little Creek 06	1330	13.98	3.81	0.089	6.13
03/29/02	Little Creek 07	1345	14.74	6.06	0.171	12.55

Talbot County Watersheds

A total of 18 sample sites were identified in the targeted watersheds of Talbot County (Table 21). Fourteen were in the Kings Creek watershed, and four others were in or near the Miles Creek watershed (Figure 31). One site was not sampled due to access problems, and the site on Miles Creek did not have a discharge measurement taken due to excessive depth of the stream at the sampling site.

Nutrient concentrations were elevated throughout the Talbot sites (Table 22). Nitrate/nitrite concentrations were excessive in 3 subwatersheds, and moderate or high in all but one of the others (Figure 32). The 3 subwatersheds noted as excessive, also translated to excessive yields (Figure 33). Two of these sites (10 & 12) were in the upper portion of the Beaverdam watershed, but the yield at the watershed outlet was considered baseline. A concentration of poultry houses in this upper watershed area could have contributed to these findings. Several other small subwatershed systems had moderate or high yields. A rain event the day prior to sampling would have increased discharges, thus boosting yields. The apparent anomalies in the discharges on some of the streams, more upstream than downstream, were due to sampling on two successive days after the rain event. The higher discharges on the first sampling day would have moved out of the system before sampling on the second day.

The high number of subwatersheds having excessive orthophosphate concentrations reflects the effect of increased suspended sediment in the streams due to the rain event (Figure 34). Only two of the subwatersheds translated their concentrations to elevated yields (Figure 35). These excessive orthophosphate concentrations and yields indicate soil phosphorus levels are relatively high.

Table 21. Synoptic Sampling Sites in Talbot County Watersheds, March 2002

Station	Road Crossing	Latitude	Longitude	Sample Type**	
T 0	Galloway Rn. at MD 328	38.79292	-76.03392	N.B	
T 01	Wootenaux Cr. at MD 328	38.79656	-75.02553	N.B	
T 02	Wootenaux Cr. at Chapel Rd.	.	.	N	
T 03	UT* to Kings Cr. at Black Dog Alley	.	.	N	
T 04	Kings Cr. at Mullet Branch Rd.	.	.	N	
T 05	Galloway Rn at Chapel Rd.	.	.	N	
T 06	UT to Kings Cr.at MD 328	.	.	N	
T 07	UT to Kings Cr.at MD	.	.	N	
T 08	UT to Beaverdam Br. at MD 328	.	.	N	
T 09	Beaverdam Br. at MD 328	38.81150	-75.97025	N.B	
T 10	Beaverdam Br. at Miller Rd.	38.83336	-75.98878	N.B	
T 11	UT to Beaverdam Br. at Miller Rd.	.	.	N	
T 12	Beaverdam Br. at Chapel Rd.	.	.	N	chicken litter odor
T 13	UT to Beaverdam Br. at Chapel Rd.	.	.	N	
T 14	UT to Choptank at Barkers Landing Rd.	.	.	.	No access No sample
T 15	UT to Miles Cr at Deep Branch Rd.	38.68975	-76.01903	N.B	
T 16	Miles Cr at Wrights Mill Rd.	.	.	N	4'+ deep no flow detected at sides.
T 17	Bollingbroke Cr at Beaver Dam Rd.	38.63069	-76.04153	N	

* Unnamed tributary
**(Benthic, Nutrient)

Table 22. Talbot Watersheds Nutrient Synoptic Results, March 2002

DATE	STATION	Concentration PO4 (mg P/L)	Concentration NO23 (mg N/L)	Discharge (L/s)	Daily Loads PO4 (kg/day)	Daily Loads NO23 (kg/day)	Area Hectares	Nutrient Yields/Hectare PO4 (kg/day/ha)	Nutrient Yields/Hectare NO23 (kg/day/ha)
03/30/02	T 0	0.028	4.13	11.36	0.03	4.05	421	0.000065	0.009631
03/30/02	T 01	0.030	1.25	44.39	0.12	4.79	973	0.000118	0.004926
03/29/02	T 02	0.040	0.87	62.65	0.22	4.71	705	0.000307	0.006680
03/29/02	T 03	0.043	1.38	25.42	0.09	3.03	444	0.000213	0.006827
03/29/02	T 04	0.036	1.61	198.47	0.62	27.61	2182	0.000283	0.012655
03/29/02	T 05	0.034	2.44	8.72	0.03	1.84	88	0.000292	0.020931
03/29/02	T 06	0.273	4.25	6.35	0.15	2.33	180	0.000830	0.012920
03/29/02	T 07	0.008	6.60	27.06	0.02	15.43	389	0.000048	0.039643
03/29/02	T 08	0.011	1.73	11.06	0.01	1.65	309	0.000034	0.005354
03/30/02	T 09	0.019	2.11	48.02	0.08	8.75	1364	0.000058	0.006416
03/30/02	T 10	0.033	5.13	32.57	0.09	14.44	377	0.000246	0.038317
03/29/02	T 11	0.019	2.05	63.41	0.10	11.23	404	0.000257	0.027782
03/29/02	T 12	0.049	5.25	33.07	0.14	15.00	271	0.000516	0.055328
03/29/02	T 13	0.029	1.27	28.55	0.07	3.13	210	0.000341	0.014942
03/29/02	T 14	.	.	.	.	.	166	.	.
03/30/02	T 15	0.007	4.65	11.16	0.01	4.48	250	0.000027	0.017962
03/29/02	T 16	0.006	2.20	.	.	.	1378	.	.
03/30/02	T 17	0.004	2.04	11.94	0.00	2.10	403	0.000010	0.005227

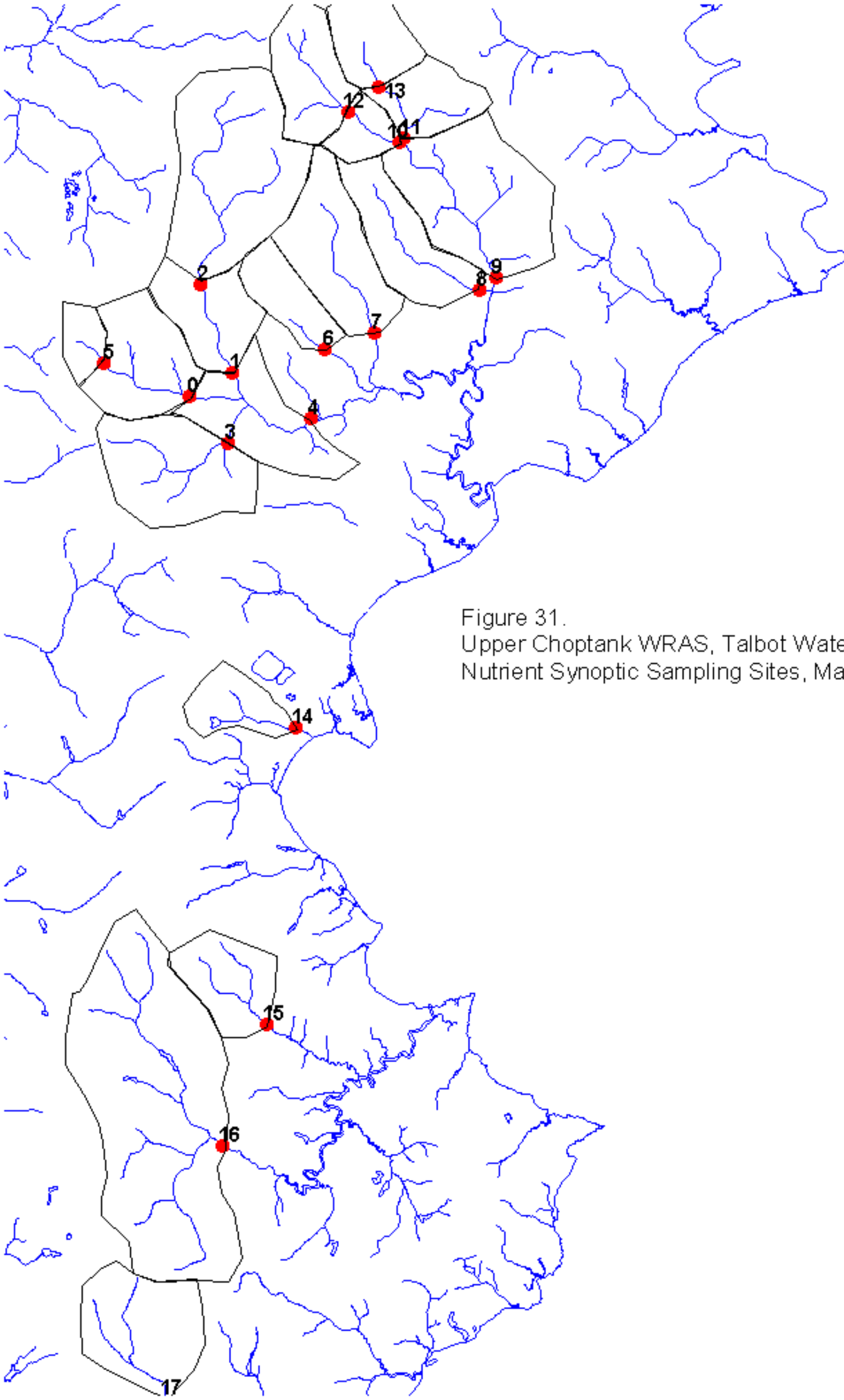


Figure 31.
Upper Choptank WRAS, Talbot Watersheds
Nutrient Synoptic Sampling Sites, March 2002

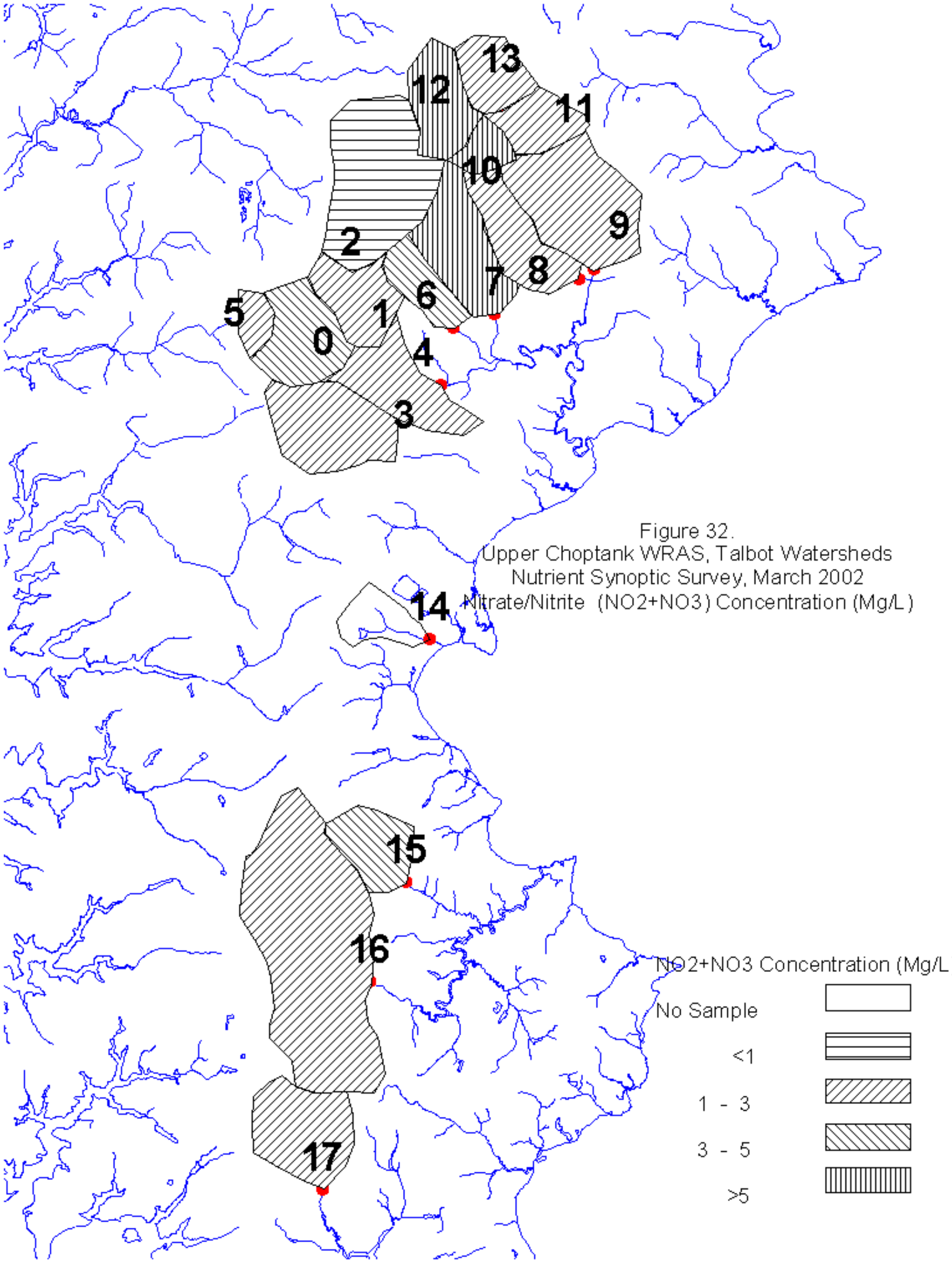


Figure 32.
Upper Choptank WRAS, Talbot Watersheds
Nutrient Synoptic Survey, March 2002
Nitrate/Nitrite (NO2+NO3) Concentration (Mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
NO2+NO3 Concentration (Mg/L)
No Sample
<1
1 - 3
3 - 5
>5

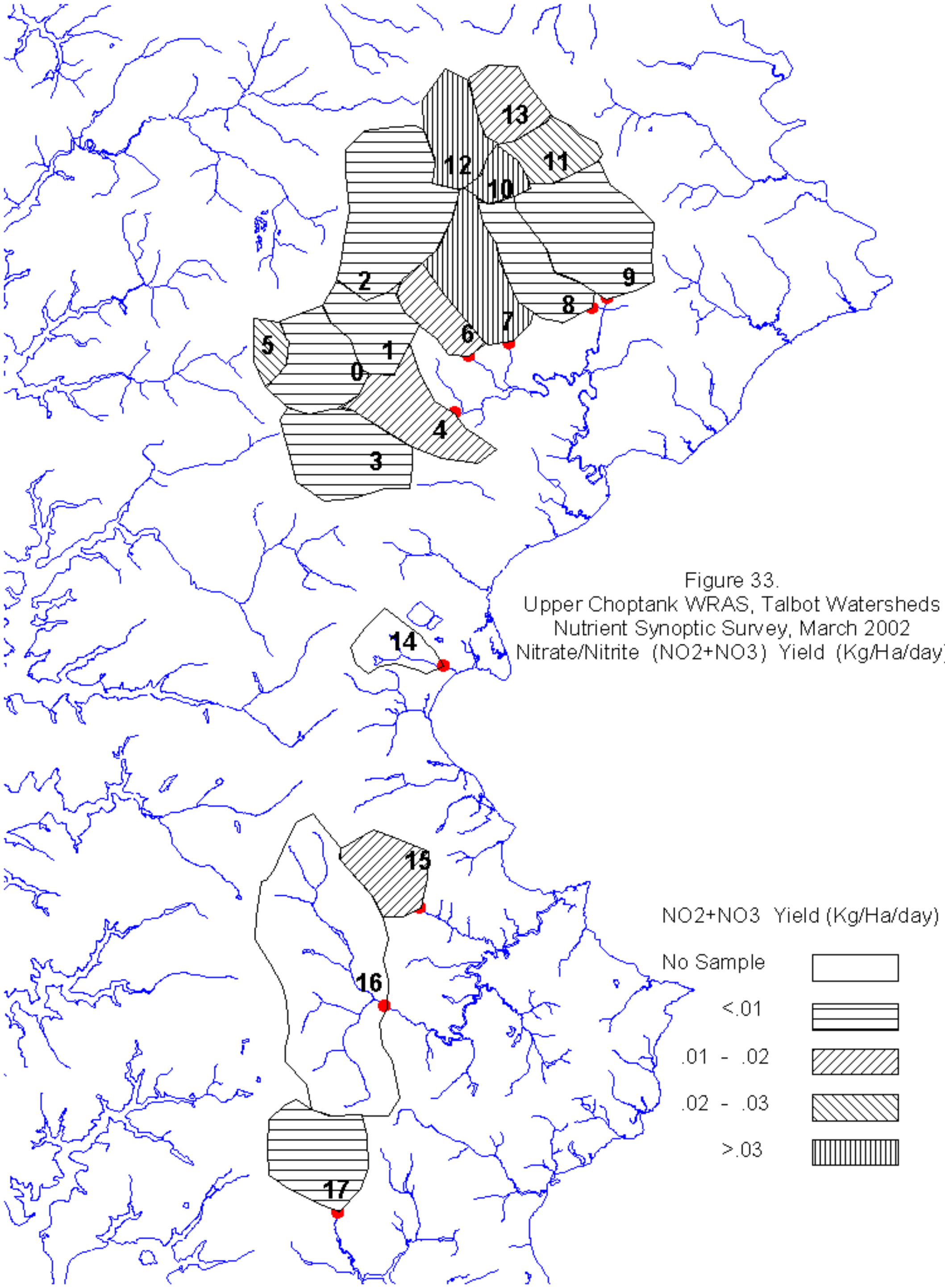


Figure 33.
Upper Choptank WRAS, Talbot Watersheds
Nutrient Synoptic Survey, March 2002
Nitrate/Nitrite (NO2+NO3) Yield (Kg/Ha/day)

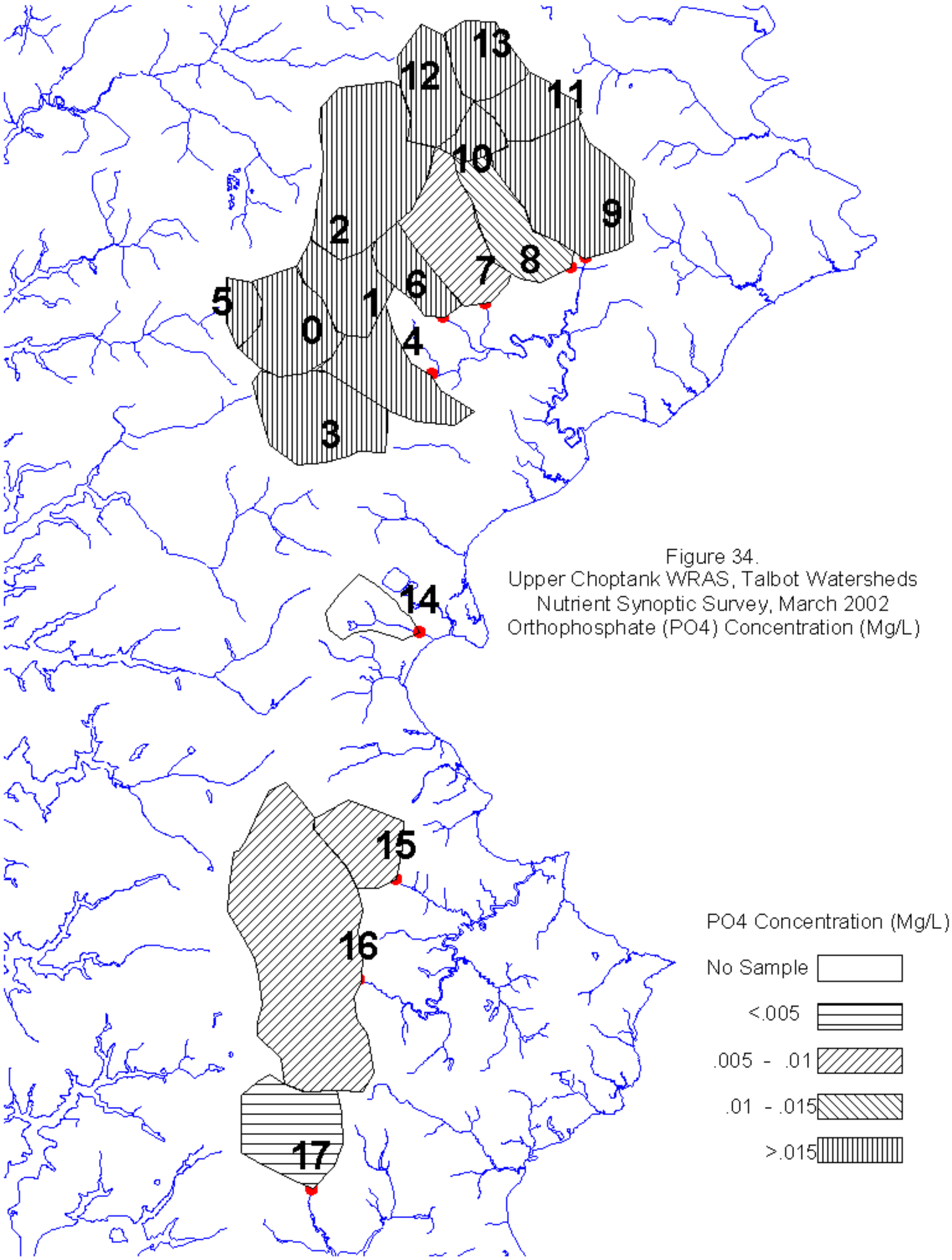


Figure 34.
Upper Choptank WRAS, Talbot Watersheds
Nutrient Synoptic Survey, March 2002
Orthophosphate (PO4) Concentration (Mg/L)

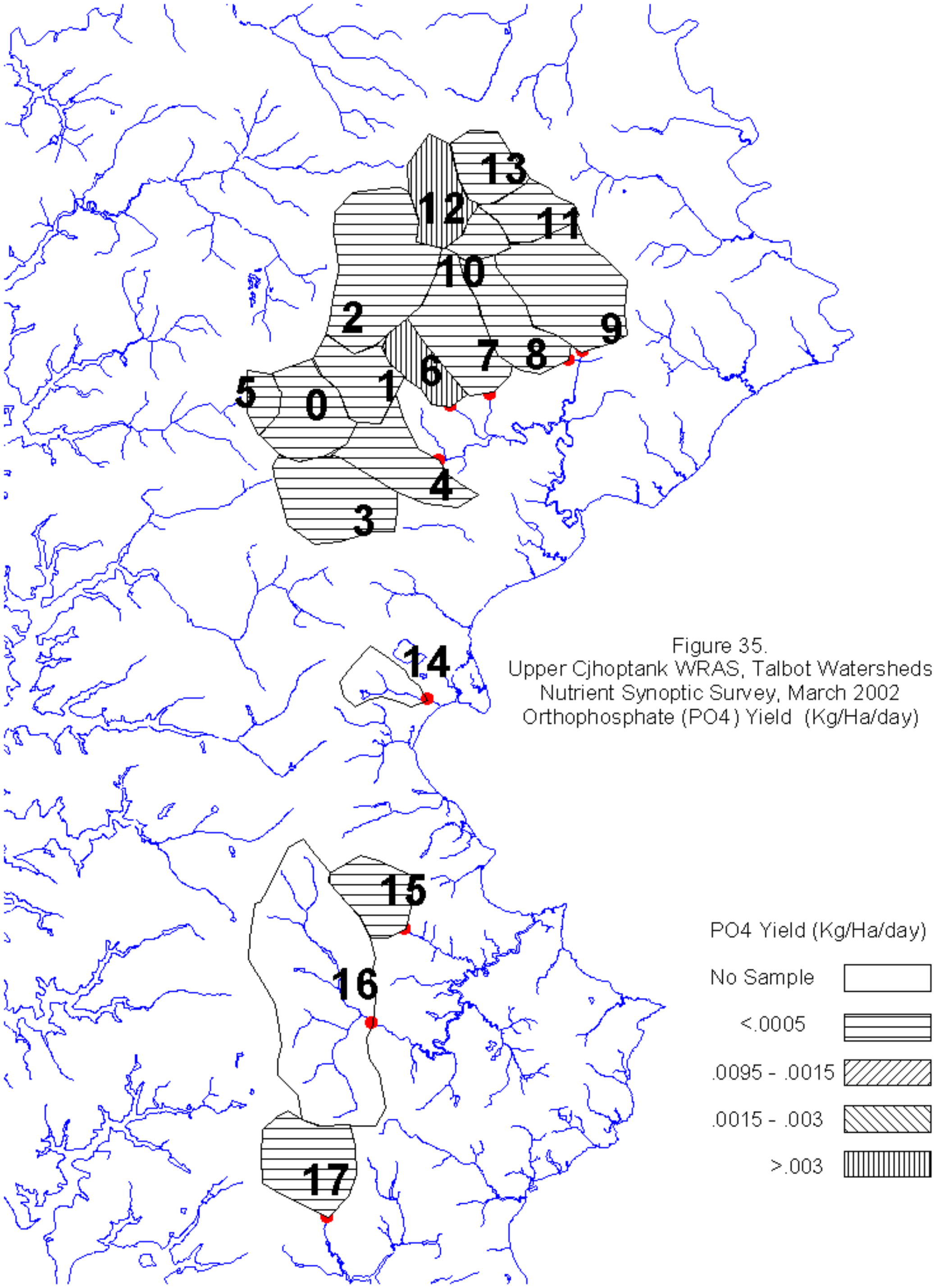


Figure 35.
Upper Cjhoptank WRAS, Talbot Watersheds
Nutrient Synoptic Survey, March 2002
Orthophosphate (PO4) Yield (Kg/Ha/day)

The in situ water quality readings from the Talbot County watersheds found no anomalous values (Table 23).

Table 23. Talbot Watersheds In Situ Water Quality

			InSitu Hydrolab Readings			
DATE	STATION	TIME	Temp.	pH	Cond.	DO
03/30/02	T 0	915	11.95	6.79	0.250	10.56
03/30/02	T 01	855	12.47	6.72	0.182	9.45
03/29/02	T 02	1020	9.40	.	0.143	9.66
03/29/02	T 03	915	8.48	6.90	0.207	10.16
03/29/02	T 04	1250	12.05	.	0.177	7.96
03/29/02	T 05	955	10.57	7.80	0.233	7.27
03/29/02	T 06	1220	13.28	.	0.253	6.15
03/29/02	T 07	1210	12.56	7.63	0.174	9.18
03/29/02	T 08	1155	12.15	7.88	0.146	9.60
03/30/02	T 09	820	11.50	6.86	0.184	9.62
03/30/02	T 10	1315	15.63	7.03	0.220	11.53
03/29/02	T 11	1125	10.77	.	0.124	10.65
03/29/02	T 12	1045	10.53	7.64	0.217	8.08
03/29/02	T 13	1105	11.46	7.81	0.121	9.01
03/29/02	T 14	.	.	.	.	.
03/30/02	T 15	1420	16.74	6.69	0.200	10.00
03/29/02	T 16	1345	14.12	7.37	0.189	9.33
03/30/02	T 17	1400	17.56	6.51	0.163	8.54

Untargeted Upper Choptank Watersheds

An additional 19 sample site were located through out the upper Choptank watershed, generally outside of the targeted watersheds described above, to help provide a more complete picture of the water quality. The road crossings are noted in Table 24, and the sites are mapped in Figure 36. Site 14 was too deep to do a successful discharge measurement.

Six watersheds in this group had excessive nitrate/nitrite concentrations, three were considered high, and six more had moderate concentrations (Table 25, Figure 37). The remaining three sites sampled were baseline. The two highest concentrations were from a small watershed in Talbot County (8), and Fowling Creek in Caroline County (13). The Talbot site was draining agricultural ground with reduced buffer and what appeared to be stock piled poultry litter in the headwaters. The Fowling Creek site has a fertilizer handling facility at stream side on Nagle Rd.. Sources of nitrate/nitrite in the remaining watersheds were not readily apparent. These high concentrations translated into five watersheds with excessive yields, two with high yields, and three with moderate yields (Figure 38). Fowling Creek was one of the watersheds with an excessive yield.

Table 24. Synoptic Sampling Sites in Untargeted Watersheds, March/April 2002

Station	Road Crossing	Latitude	Longitude	Sample Type**
Misc. 0	Tidy Island Cr. At Sandy Bend Rd.(DE)	39.11018	-75.72823	N
Misc. 18	Beaverdam Ditch at Strauss Ave.(DE)	39.11547	-75.74228	N
Misc. 01	Coolspring Br at Henderson Rd.	39.08882	-75.75970	N
Misc. 02	Oldtown Br at MD 313	39.02270	-75.78758	N.B
Misc. 03	Gravelly Run at Drapers Mill Rd.	38.99540	-75.78192	N.B
Misc. 04	UT* to Forge at Rt 480	38.95397	-75.83122	N
Misc. 05	Forge at Rt 480	38.95417	-75.82936	N
Misc. 06	Spring Br. At MD 313	38.94339	-75.81292	N
Misc. 07	Church Br at MD 313	38.91119	-75.81817	N
Misc. 08	UT to Choptank at MD 328	38.88267	-75.84981	N
Misc. 09	UT to Choptank at 2nd St., Denton	38.87486	-75.83506	N
Misc. 10	Herring Rn at Sennett Rd.	38.85158	-75.81042	N
Misc. 11	Williston Lake at MD 16	38.82761	-75.84667	N
Misc. 12	Robins Cr. At MD 16	38.81242	-75.86325	N
Misc. 13	Fowling Cr. at Wilkins Branch Rd.	38.79447	-75.87442	N
Misc. 14	Hog Cr at Hog Creek Rd.	38.77506	-75.92369	.
Misc. 15	Crowberry Cr at Tanyard Rd.	38.76253	-75.94067	N
Misc. 16	Marsh Cr at Havercamp Rd.	38.71339	-75.93872	N
Misc. 17	Hunting Cr at Kraft Rd.	38.71511	-75.88483	N

*Unnamed Tributary
**(Benthic, Nutrient)

Numerous untargeted watersheds had elevated orthophosphate concentrations (Figure 39). The majority (10) were in the moderate category, and four were considered high. No watersheds had elevated orthophosphate yields (Figure 40).

The insitu water quality from these streams fell well within the ranges found throughout the watershed (Table 26).

Table 25. Untargeted Watersheds Nutrient Synoptic Results, March/April 2002

		Concentration			Daily Loads		Area	Nutrient Yields/Hectare	
DATE	STATION	PO4	NO23	Discharge	PO4	NO23	Hectares	PO4	NO23
		(mg P/L)	(mg N/L)	(L/s)	(kg/day)	(kg/day)		(kg/day/ha)	(kg/day/ha)
04/04/02	Misc 18	0.005	0.16	340.75	0.15	4.71	686	0.000214	0.006863
04/04/02	Misc 0	0.010	0.91	177.64	0.15	13.97	1332	0.000115	0.010484
04/04/02	Misc. 01	0.002	0.25	49.90	0.01	1.08	538	0.000016	0.002004
04/04/02	Misc. 02	0.003	1.71	87.21	0.02	12.89	979	0.000023	0.013168
04/04/02	Misc. 03	0.011	2.91	355.43	0.34	89.36	2666	0.000127	0.033524
04/03/02	Misc. 04	0.012	5.38	49.35	0.05	22.94	682	0.000075	0.033639
04/03/02	Misc. 05	0.008	2.90	98.43	0.07	24.66	4172	0.000016	0.005911
04/05/02	Misc. 06	0.003	4.54	95.41	0.02	37.42	1580	0.000016	0.023682
04/05/02	Misc. 07	0.005	5.29	346.60	0.15	158.41	2769	0.000054	0.057213
03/29/02	Misc. 08	0.013	7.70	11.77	0.01	7.83	324	0.000041	0.024197
03/29/02	Misc. 09	0.005	1.50	19.95	0.01	2.58	301	0.000029	0.008597
03/29/02	Misc. 10	0.010	2.31	144.82	0.13	28.90	1485	0.000084	0.019466
03/29/02	Misc. 11	0.003	3.94	255.12	0.07	86.85	2291	0.000029	0.037902
03/29/02	Misc. 12	0.006	1.85	76.20	0.04	12.18	1146	0.000034	0.010631
03/29/02	Misc. 13	0.008	7.65	120.83	0.08	79.87	1461	0.000057	0.054653
03/29/02	Misc. 14	.	.	100.78	.	.	1222	.	.
03/29/02	Misc. 15	0.005	3.77	13.68	0.01	4.46	248	0.000024	0.017964
04/02/02	Misc. 16	0.008	5.70	89.06	0.06	43.86	938	0.000066	0.046779
04/02/02	Misc. 17	0.005	5.66	127.69	0.06	62.44	1547	0.000036	0.040372

Table 26. Untargeted Watersheds In Situ Water Quality

			InSitu Hydrolab Readings			
DATE	STATION	TIME	Temp.	pH	Cond.	DO
04/04/02	Misc 18	1310	14.37	6.82	0.167	16.53
04/04/02	Misc 0	1330	13.79	7.51	0.202	16.55
04/04/02	Misc. 01	1245	14.66	6.25	0.102	12.91
04/04/02	Misc. 02	1220	12.03	6.15	0.145	12.69
04/04/02	Misc. 03	1425	13.36	7.09	0.152	12.70
04/03/02	Misc. 04	1125	17.33	.	0.151	9.38
04/03/02	Misc. 05	1200	15.04	.	0.155	9.62
04/05/02	Misc. 06	1300	11.25	6.37	0.108	12.20
04/05/02	Misc. 07	1240	11.72	6.45	0.142	12.60
03/29/02	Misc. 08	1455	16.39	6.80	0.215	13.18
03/29/02	Misc. 09	1435	13.89	6.85	0.223	10.53
03/29/02	Misc. 10	1415	13.22	6.86	0.134	12.25
03/29/02	Misc. 11	1015	11.28	6.79	0.149	13.30
03/29/02	Misc. 12	1035	10.02	6.48	0.123	11.10
03/29/02	Misc. 13	1055	11.25	6.62	0.210	12.08
03/29/02	Misc. 14	1130	11.80	6.69	0.190	12.70
03/29/02	Misc. 15	1150	12.33	6.71	0.152	11.96
04/02/02	Misc. 16	905	8.61	6.90	0.186	9.60
04/02/02	Misc. 17	830	8.90	6.83	0.176	11.93

Figure 36.
Upper Choptank WRAS, Untargeted Watersheds
Nutrient Synoptic Sampling Sites, March /April 2002

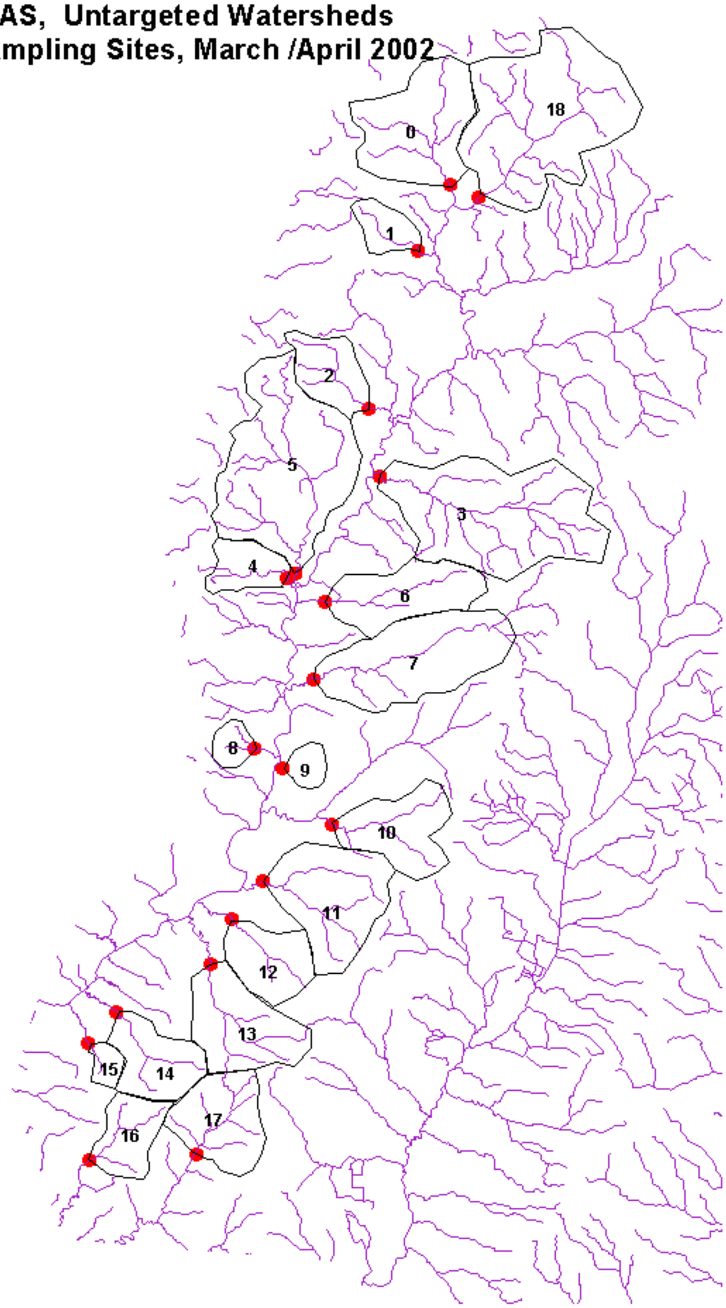
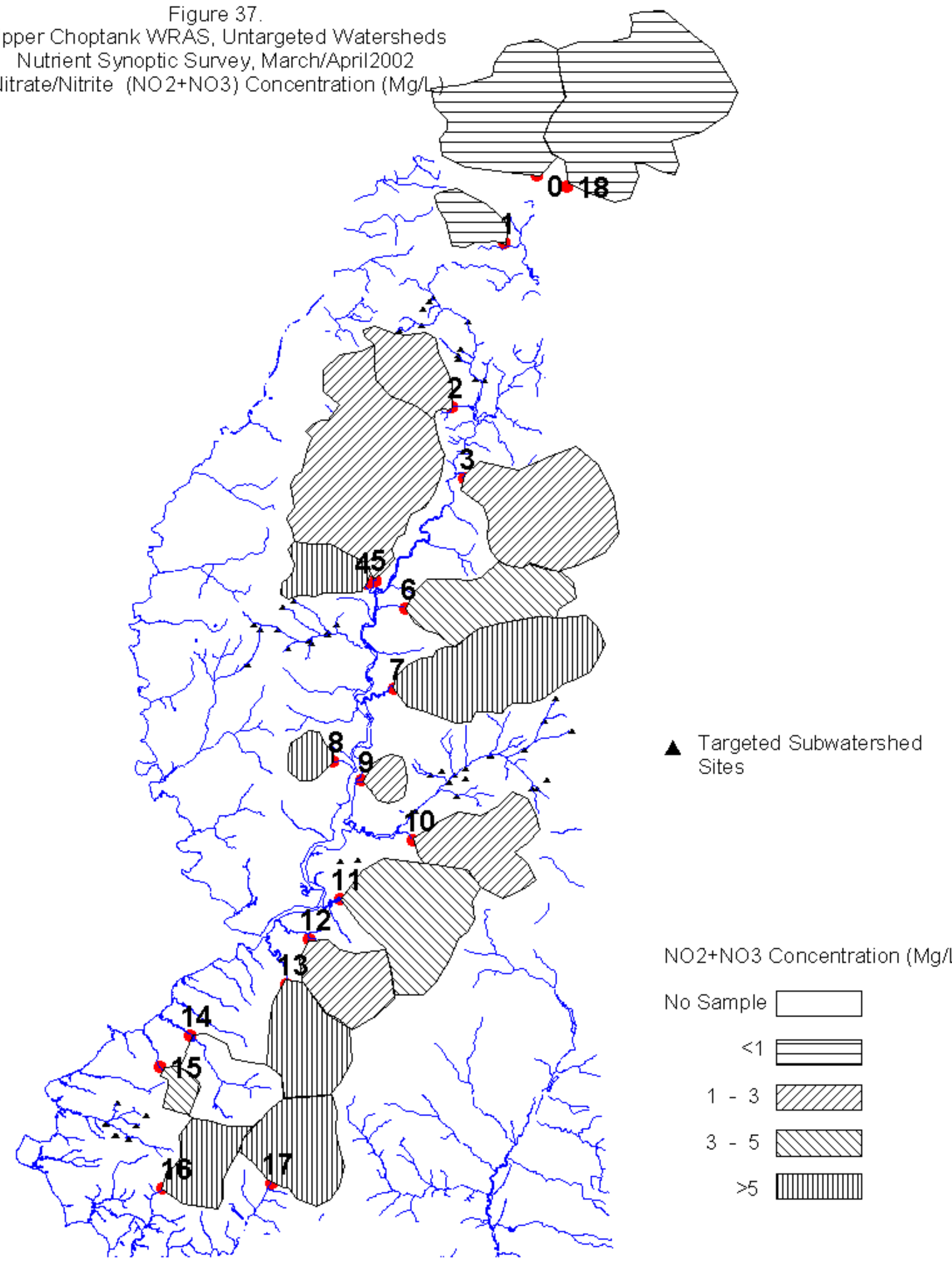


Figure 37.
Upper Choptank WRAS, Untargeted Watersheds
Nutrient Synoptic Survey, March/April2002
Nitrate/Nitrite (NO2+NO3) Concentration (Mg/L)



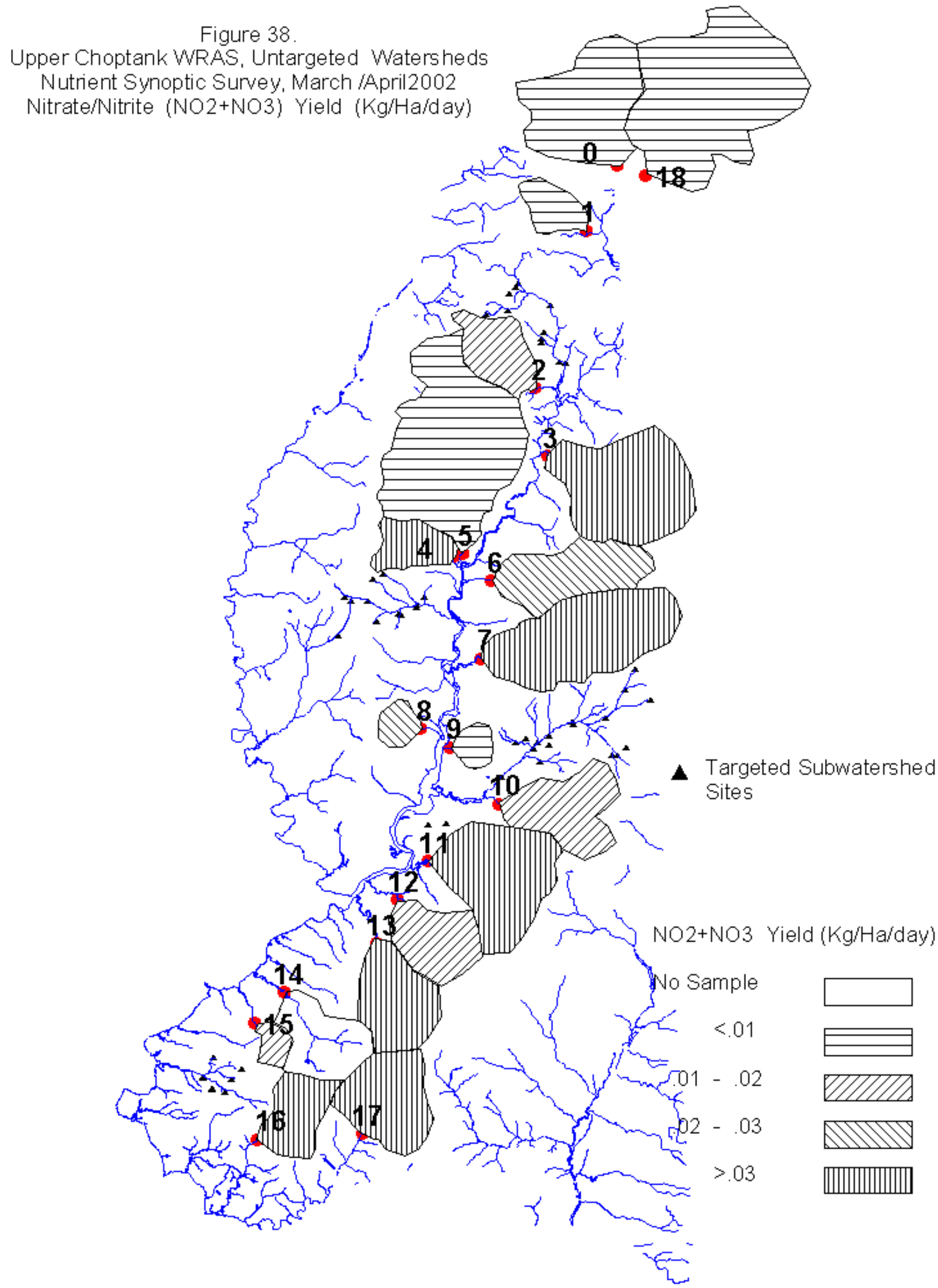


Figure 38.
Upper Choptank WRAS, Untargeted Watersheds
Nutrient Synoptic Survey, March /April2002
Nitrate/Nitrite (NO2+NO3) Yield (Kg/Ha/day)
0
18
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Targeted Subwatershed Sites
NO2+NO3 Yield (Kg/Ha/day)
No Sample
<.01
.01 - .02
.02 - .03
>.03

Figure 39.
Upper Choptank WRAS, Untargeted Watersheds
Nutrient Synoptic Survey, March /April2002
Orthophosphate (PO4) Concentration (Mg/L)

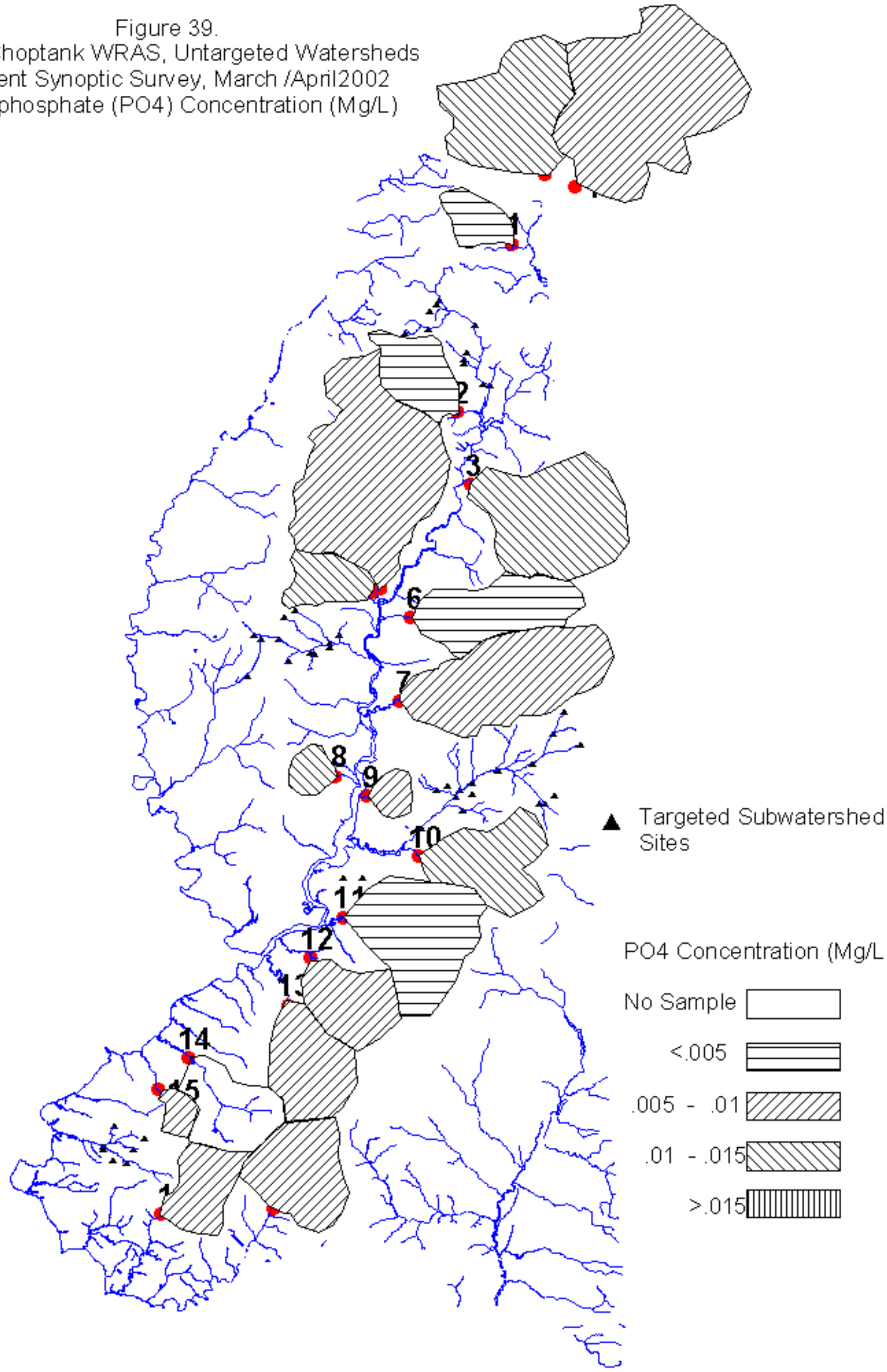
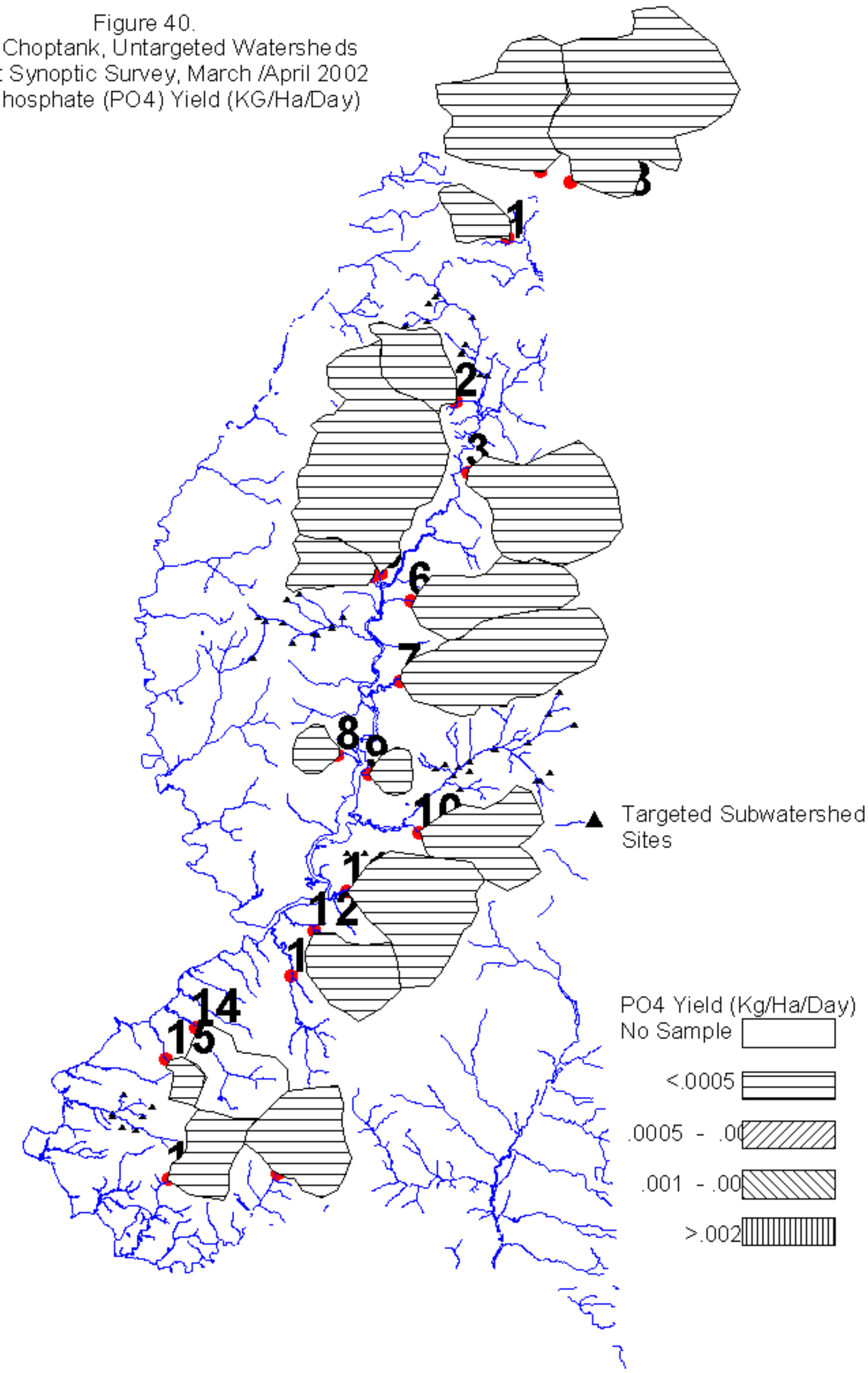


Figure 40.
Upper Choptank, Untargeted Watersheds
Nutrient Synoptic Survey, March /April 2002
Orthophosphate (PO4) Yield (KG/Ha/Day)



Macroinvertebrate sampling

Benthic macroinvertebrate samples were collected at 14 sites throughout the upper Choptank watershed, with at least one in each targeted subwatershed and several in untargeted subwatersheds (Figure 41). An Index of Biotic Integrity was calculated from the collected samples and a habitat score calculated for each site (Table 25).

The poor macroinvertebrate community at the Broadway Branch site appears to be due to the absence of some critical habitat features. The riparian area was dominated by grasses, with only scattered shrubby trees, and the in stream substrate was at best small gravel and sand. The absence of significant trees and canopy created a lack of woody debris, leaf litter, and root mat. All factors important for food and habitat. The limited variety of gravel sizes and amount of a gravel also reduced available habitat and food resources. Water quality did not appear to be a significant factor in the poor macroinvertebrate community. These results are in line with historic (1990 through 1996) sampling from this site (Primrose, personal communication). These same problems were more extreme in Chicken Branch, and were coupled with possible water quality impacts to support a very poor macroinvertebrate community. As with Broadway Branch, the historic data was similar.

Forge Branch and Watts Creek 0 followed their historical results of fair and good macroinvertebrate communities, and supporting and comparable habitats respectively. The habitat around the Forge Branch site was scored lower on riparian vegetation and reduced variability in channel substrate. The Watts Creek site is one of the best macroinvertebrate and habitat sites on the Eastern Shore. The habitat at the Watts Creek 5 site, although comparable to a reference, suffered from elevated sediment loads that tend to reduce macroinvertebrate community diversity. Water quality does not appear to be a factor at these three sites.

Long Branch and Little Creek, with impacted macroinvertebrate communities and good habitat, have probable water quality problems. Nutrient concentrations found at these sites are below what might be impacting these streams. Long Branch may be impaired from episodic low pH levels and/or long term turf management activities on the Caroline Country Club golf course. Possible sources of water quality impacts to Little Creek 2 were not obvious when driving through the watershed. The low pH values in the headwaters could translate downstream during rain events, helping to maintain a depressed macroinvertebrate community.

Talbot site 1 fell into the same category as the previous two sites, comparable habitat but significantly impaired macroinvertebrate communities. No obvious sources for water quality impairment were observed upstream of this site during the sampling. The habitat at Talbot 9 was marginally in the supporting category. Riparian areas were excellent, but in stream macroinvertebrate habitat was very reduced. Riffles were absent, only small patches of gravel were available within long runs, root mats were very small, and woody debris was restricted to one small debris pile within the 75 meter sampling reach. These habitat limitations could account for the poor macroinvertebrate community. Historic sampling during the 1990s found similar impacts due to ponding behind numerous beaverdams.

The remaining Talbot sites and the two untargeted had macroinvertebrate communities in line with their habitat quality. Historic data from the two untargeted sites found no significant changes in macroinvertebrate communities or habitat assessments.

Figure 41.
Upper Choptank WRAS
Macroinvertebrate Synoptic Survey, March 2002

Table 27. Upper Choptank Watershed Benthic IBI Calculations

site	# Taxa/ score	# EPT taxa score	% Ephem score	% Tanytarsini of total chir score	Beck index score	# scraper taxa score	% clingers score	total score	IBI score/ #metrics	IBI rating	Habitat Rating
Broadway 2	19/3	2/1	2/3	5/3	3/1	3/3	0/1	15	2.14	poor	supporting
Chicken 2	19/3	0/1	0/1	.2/1	2/1	2/3	0/1	11	1.57	very poor	part supporting
Forge 1	18/3	5/5	22/5	0/1	2/1	3/3	60/3	21	3.00	fair	supporting
Watts 0	23/3	9/5	41/5	6/3	4/3	5/5	75/5	29	4.14	good	comparable
Watts 5	23/3	9/5	29/5	0/1	6/3	5/5	1/3	25	3.57	fair	comparable
Long 1	14/3	2/1	0/1	0/1	0/1	4/3	69/5	15	2.14	poor	comparable
Little 2	17/3	0/1	0/1	0/1	0/1	3/3	57/3	13	1.86	very poor	comparable
Talbot 0	24/3	4/3	59/5	7/3	3/1	3/3	59/3	21	3.00	fair	supporting
Talbot 1	18/3	3/3	24/5	0/1	1/1	1/1	60/3	17	2.43	poor	comparable
Talbot 9	19/3	4/3	7/3	3/3	2/1	3/3	52/3	19	2.71	poor	supporting
Talbot 10	19/3	4/3	26/5	15/5	2/1	3/3	81/5	25	3.57	fair	supporting
Talbot 15	24/3	4/3	6/3	3/3	1/1	3/3	69/5	21	3.00	fair	supporting
Untargeted 3	24/3	9/5	35/5	0/1	10/3	4/3	75/5	25	3.57	fair	comparable
Untargeted 4	19/3	9/5	52/5	22/5	6/3	5/5	91/5	31	4.43	good	comparable

The historic sampling during the 1990s mentioned above was part of a state wide water quality monitoring effort using macroinvertebrates as indicators. All accessible third order tributaries to the Choptank (19 sites) were sampled every other year from 1990 through 1996. Streams that regularly came up as severely impacted were Beaverdam Ditch, Bolingbroke Creek, Fowling Creek, Oldtown Branch, and Chicken Branch. Streams that were regularly considered good were Engle Ditch, Gravelly Branch, Herring Run, Watts Creek, and Mill Creek.

Literature Cited

Chesapeake Bay and Watershed Programs, Monitoring and Non-Tidal Assessment, 1998. *Development of a Benthic Index of Biotic Integrity for Maryland Streams*. CBWP-MANTA – EA-98-3

Frink, Charles R.. 1991. *Estimating Nutrient Exports to Estuaries*. Journal of Environmental Quality. 20:717-724.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, R.M. Hughes. 1989. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish*. United States Environmental Protection Agency. EPA/440/4-89/001

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