Report on Nutrient Synoptic Surveys in the Lower Patapsco River Watershed, Howard County, Maryland, March 2004 as part of a Watershed Restoration Action Strategy.

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Landscape and Watershed Analysis
Management Studies
March, 2005

Acknowledgements

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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.

Cover photo: Sucker Branch at Park Dr. by Niles Primrose

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Executive Summary

A nutrient synoptic survey was conducted during March, 2004 in the Lower Patapsco watershed as part of the Lower Patapsco WRAS. Samples were analyzed from 37 sites throughout the watershed. Nitrate/nitrite concentrations were found to be excessive in one subwatershed, high in one, moderately elevated in twenty-two others, and baseline in the remaining thirteen subwatersheds. Instantaneous nitrate/nitrite yields were found to be excessive in four subwatersheds, high in five, moderate in nine, and baseline in the remaining eighteen, with one not calculated. High concentrations of orthophosphate were found in four subwatersheds, moderate concentrations in four, and the remaining twenty-nine below baseline. Orthophosphate yields were found to be below baseline in thirty-six subwatersheds, with one uncalculated. The two subwatersheds with excessive or high nitrate/nitrite concentrations also had high yields and could be associated with a sewer line down the stream valley. The elevated orthophosphate concentrations appear to be associated with phosphorus rich soils in systems that had fine suspended sediment loads lingering in the water column. No subwatershed had elevated orthophosphate yields. No significant anomalies were found in the insitu measurements of dissolved oxygen, or temperature. Insitu specific conductivity values were generally high, with 21 subwatersheds having values greater than 400 mmohs/cm. Five additional sites were over 300 mmohs/cm, and the remaining 9 where less than 300 mmohs/cm. The high specific conductivities appear to be associated with road salts from major highway systems in these subwatersheds.

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Introduction

A nutrient synoptic survey was conducted during March, 2004 in the Howard County portion of the Lower Patapsco watershed as part of the Lower Patapsco Watershed Restoration Action Strategy.

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 (Table 1) 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 benchmark, 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.

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.

METHODS

Water Chemistry Sampling

Synoptic water chemistry samples were collected in early spring throughout the watershed. Sampling was halted for a minimum of 24 hours after rainfall events totaling more than .25 inches. 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 selected sites at the time of 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.

RESULTS

A nutrient synoptic survey was conducted during March, 2004 in the Lower Patapsco watershed as part of the Lower Patapsco WRAS. Samples were analyzed from 37 sites throughout the watershed. Sampling site locations are noted in Table 2 and mapped with subwatersheds in Figure 1. Dissolved nutrient concentrations and yields from all sites are noted in Table 3. Nitrate/nitrite concentrations were found to be excessive in one subwatershed, high in one, moderately elevated in twenty-two others, and baseline in the remaining thirteen subwatersheds (Figure 2). Instantaneous nitrate/nitrite yields were found to be excessive in four subwatersheds, high in five, moderate in nine, and baseline in the remaining eighteen, with one not calculated (Figure 3). High concentrations of orthophosphate were found in four subwatersheds, moderate concentrations in four, and the remaining twenty-nine below baseline (Figure 4). Orthophosphate yields were found to be below baseline in thirty-six subwatersheds, with one uncalculated Figure 5). No subwatershed had elevated orthophosphate yields. No significant anomalies were found in the insitu measurements of pH, dissolved oxygen, or temperature (Table 4). Insitu specific conductivity values were generally high, with 21 subwatersheds having values greater than 400 mmohs/cm. Five additional sites were over 300 mmohs/cm, and the remaining 9 where less than 300 mmohs/cm (Figure 6).

Table 2. Lower Patapsco Watershed WRAS March, 2004
Sampling Site Locations

Site	LOCATION	lat	long
0	Deep Rn at Rt 103	39.18097	76.75146
1	Deep Rn at Rt 1	39.17504	76.77502
2	UT* to Deeo Rn at Rt 103	39.19551	76.78236
3	Deep Rn at Mayfield Woods Middle School	39.19551	76.78236
4	UT to Deep Rn at Wesley La	39.19912	76.77879
5	Deep Rn at Old Montgomery Rd	39.20970	76.77318
6	Shallow Rn at Athol Rd	39.19039	76.73996
7	UT to Shallow Rn at Loudon Ave	39.19267	76.73046
9	Shallow Rn at Troy Hill corp center	39.19253	76.75349
10	UT to Shallow Rn at Troy Hill corp center	39.19253	76.75349
11	UT to Shallow Rn off Karas Way	39.20167	76.75144
12	UT to Shallow Rn off Karas Way	39.20167	76.75144
13	Rockburn Br at River Rd	39.22602	76.72014
14	Rockburn Br at Belmont Woods Rd	39.21790	76.74083
15	Rockburn Br in Rockburn Br park	39.22307	76.75732
16	UT to Patapsco at River Rd	39.24173	76.74963
17	Bonnie Br at Bonnie Br Rd	39.25033	76.76777
18	Bonnie Br at Gawan Dr	39.23691	76.78204
19	UT to Tiber Br off New Cut Rd	39.26144	76.79810
20	Tiber Br off New Cut Rd	39.26726	76.80025
21	Hudson Br at Emory St	39.26726	76.80025
22	Hudson Br at Frederick Rd	39.27088	76.81909
23	Sucker Br at Park Dr	39.27708	76.79475
24	Sucker Br at Rogers Ave	39.28751	76.80965
25	UT to Patapsco at Daniels Rd	39.31376	76.81568
26	UT to Patapsco at Carrie Way/Furrow Ave	39.30596	76.84000
27	UT to Patapsco in park south of Greenhaven Ct		
28	UT to Patapsco in park north of Greenhaven Ct		
29	UT to Patapsco in park south of Greenclover Dr		
30	Davis Br in park from Greenclover Dr		
31	Davis Br at Rt 99	39.31492	76.88026
32	Deep Rn off Hanover Rd	39.19007	76.72154
33	UT to Patapsco at Levering Ave	39.21703	76.70937
34	UT to Patapsco nr Clover Dr		
35	UT to Patapsco nr Grooms La		
36	Deep Rn off Hanover Rd	39.18948	76.72070
	*UT= unnamed tributary		

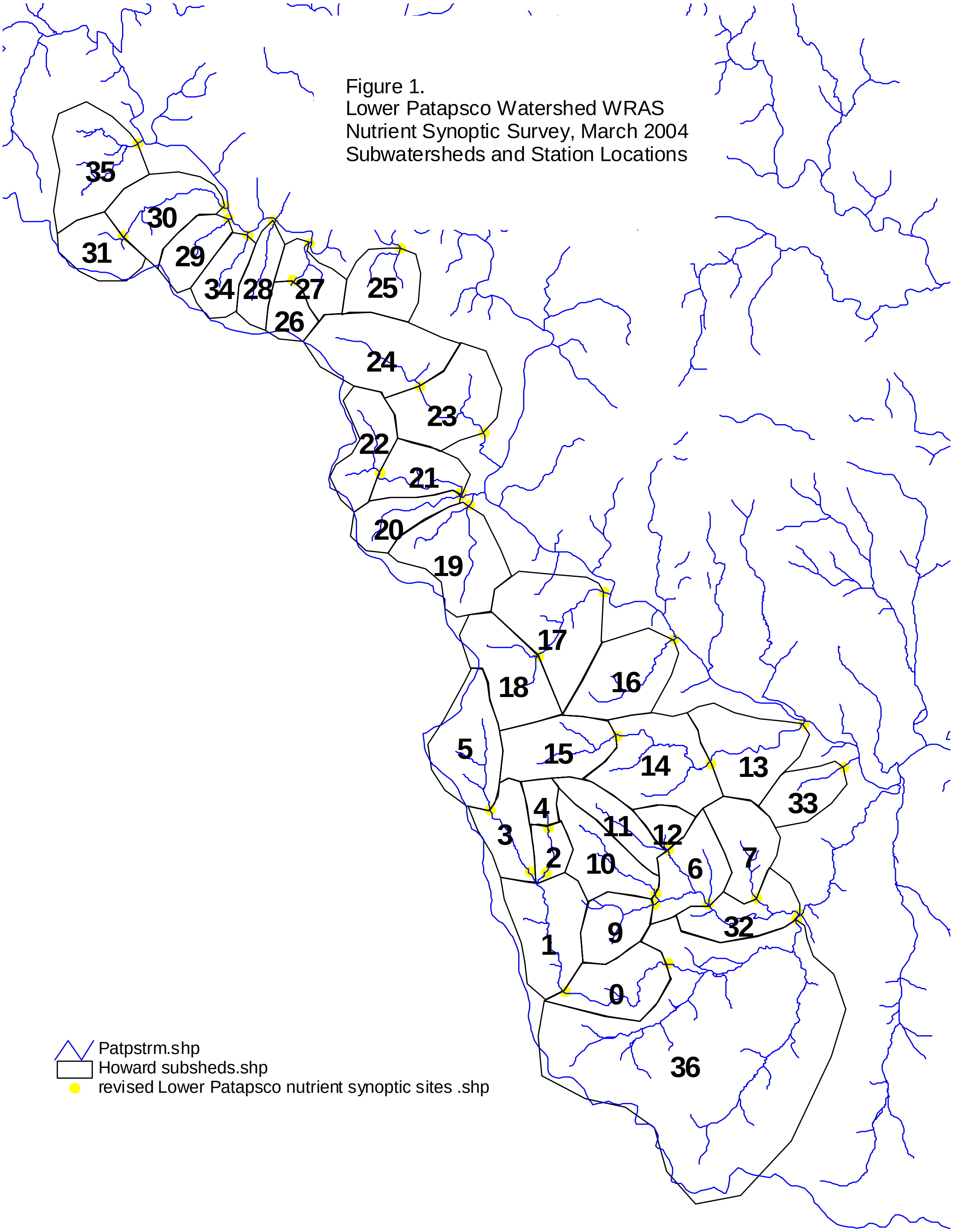
Figure 1.
Lower Patapsco Watershed WRAS
Nutrient Synoptic Survey, March 2004
Subwatersheds and Station Locations
35
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16
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33
4
11
12
3
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10
6
7
32
9
1
0
36
Patpstrm.shp
Howard subsheds.shp
revised Lower Patapsco nutrient synoptic sites .shp

Table 3. Lower Patapsco Watershed WRAS March, 2004
Dissolved Nutrient Concentrations and Yields

			Concentrations				Yields	
			PO4	NO2+NO3	Area	Discharge	PO4	NO2+NO3
Site	Date	Time	mg P/l	mg N/l	hectares	L/sec	Kg/h/day	Kg/h/day
0	03/29/04	915	0.001	0.680	1142	87	0.000007	0.004501
1	03/29/04	1000	0.001	0.860	905	68	0.000007	0.005596
2	03/29/04	1335	0.001	0.440	128	8	0.000006	0.002496
3	03/29/04	1325	0.001	1.180	454	104	0.000020	0.023312
4	03/29/04	1405	0.001	0.440	60	6	0.000008	0.003735
5	03/29/04	1420	0.001	1.440	290	25	0.000007	0.010784
6	03/29/04	1150	0.001	0.510	819	68	0.000007	0.003657
7	03/29/04	1120	0.001	0.420	171	10	0.000005	0.002153
9	03/29/04	1210	0.008	0.190	162	19	0.000080	0.001896
10	03/29/04	1220	0.002	0.490	224	17	0.000013	0.003221
11	03/29/04	1635	0.002	0.170	150	4	0.000005	0.000404
12	03/29/04	1360	0.002	1.160	68	23	0.000059	0.034142
13	03/29/04	1545	0.002	1.070	947	104	0.000019	0.010120
14	03/29/04	1520	0.004	1.100	645	54	0.000029	0.007992
15	03/29/04	1500	0.003	1.350	258	41	0.000041	0.018590
16	03/30/04	1030	0.015	1.32	284	74	0.000338	0.029707
17	03/30/04	900	0.004	1.14	667	49	0.000025	0.007208
18	03/30/04	945	0.002	0.97	278	8	0.000005	0.002439
19	03/30/04	1245	0.004	0.81	333	24	0.000025	0.004977
20	03/30/04	1120	0.004	1.20	154	7	0.000016	0.004808
21	03/30/04	1115	0.002	1.33	362	39	0.000018	0.012249
22	03/30/04	1410	0.002	1.29	196	48	0.000042	0.027385
23	03/30/04	1310	0.001	1.26	673	49	0.000006	0.007905
24	03/30/04	1340	0.002	1.42	363	33	0.000016	0.011106
25	03/30/04	1440	0.008	1.66	187	26	0.000095	0.019812
26	03/30/04	1505	0.006	5.01	94	5	0.000027	0.022443
27	04/05/04	915	0.006	3.080	220	36	0.000084	0.043022
28	04/05/04	945	0.004	1.530	120	31	0.000090	0.034379
29	04/05/04	1105	0.016	1.180	138	15	0.000155	0.011441
30	04/05/04	1120	0.017	1.110	420	82	0.000286	0.018679
31	03/30/04	1530	0.004	2.10	164	13	0.000027	0.014028
32	03/29/04	1040	0.001	0.430	1793	94	0.000005	0.001952
33	03/29/04	1600	0.002	1.090	149	7	0.000008	0.004477
34	04/05/04	1045	0.003	2.120	130	26	0.000051	0.036148
35	04/05/04	1230	0.012	1.410	333	72	0.000224	0.026369
36	03/29/04	1100	0.003	0.880	3246	285	0.000023	0.006680

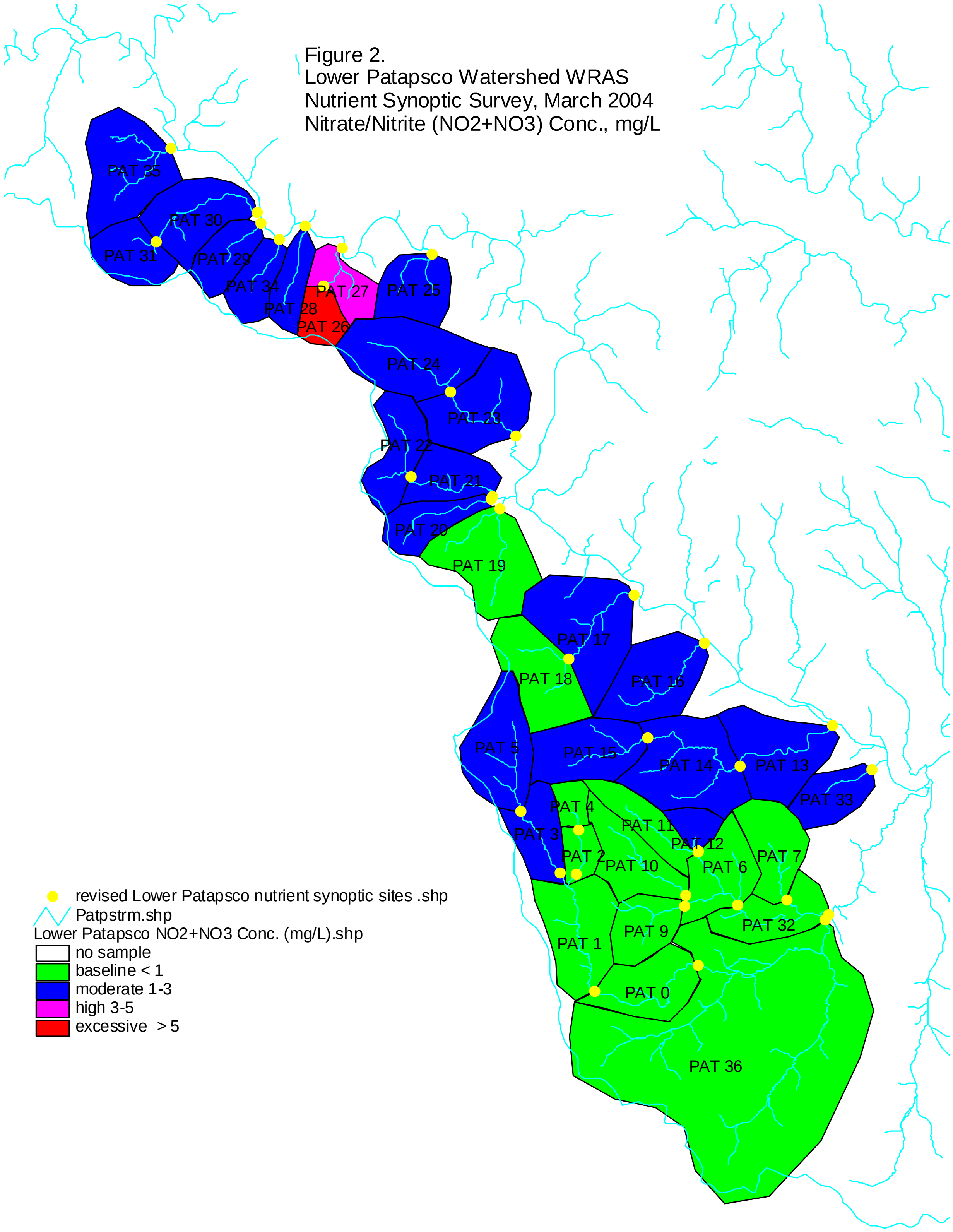


Figure 2.
Lower Patapsco Watershed WRAS
Nutrient Synoptic Survey, March 2004
Nitrate/Nitrite (NO2+NO3) Conc., mg/L

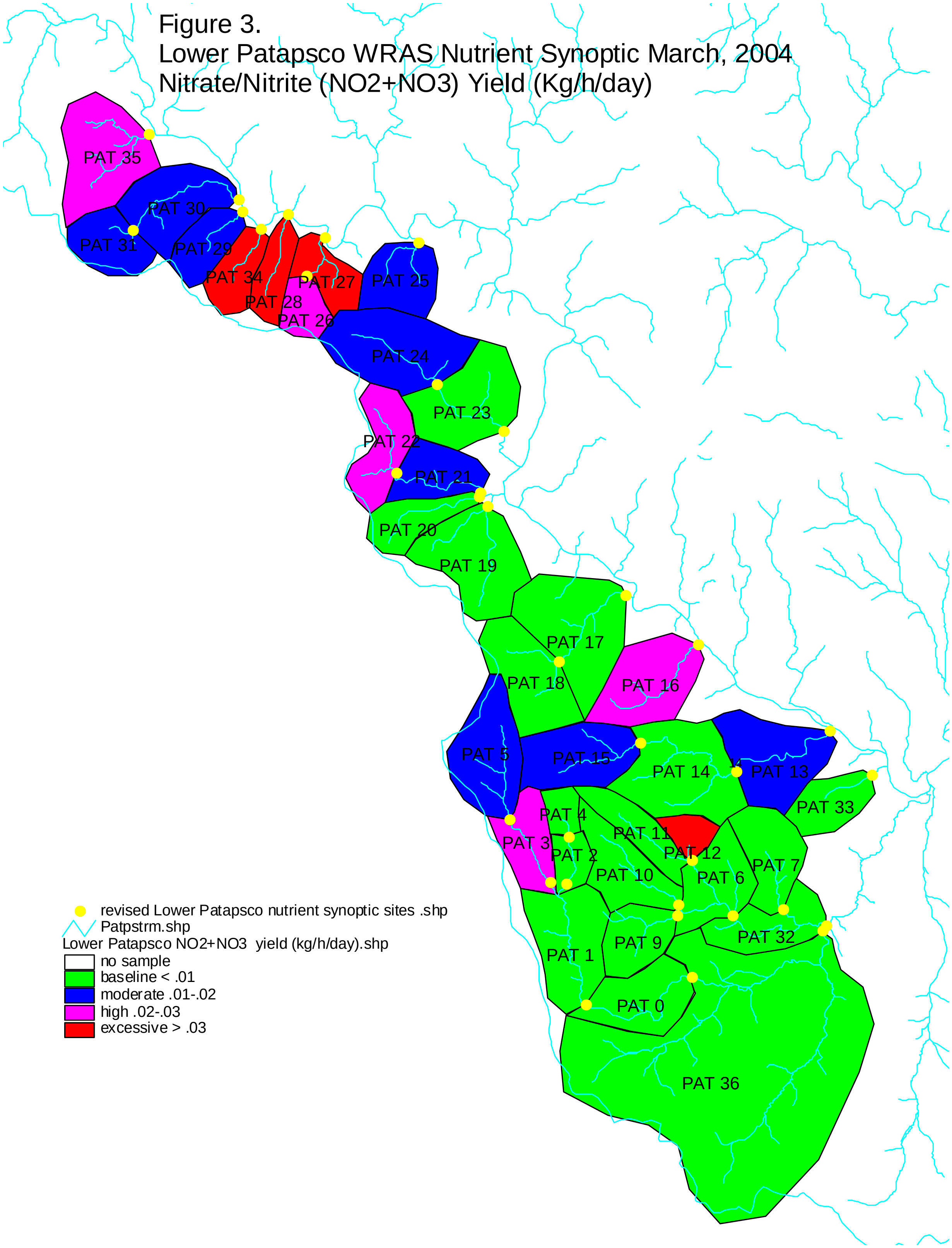
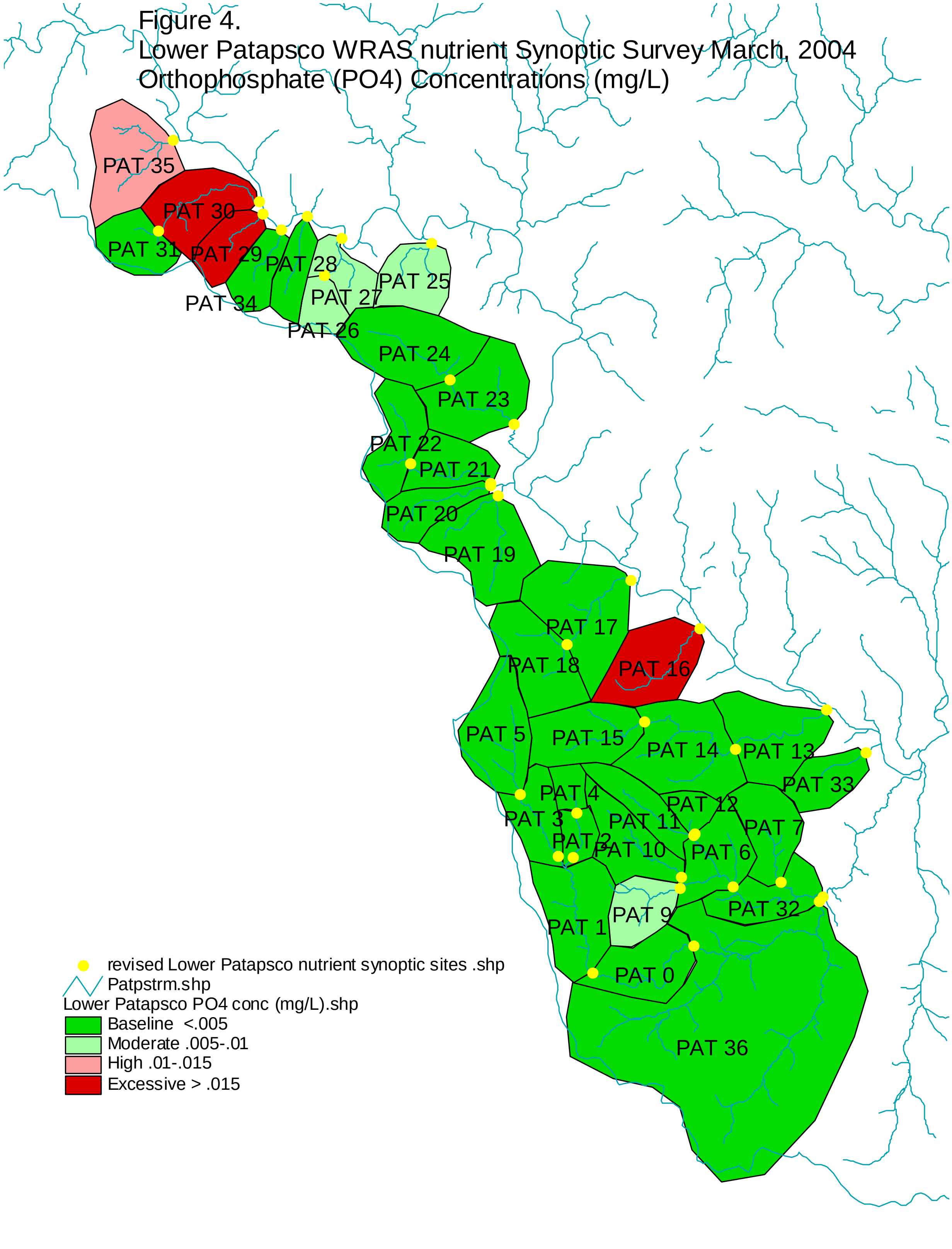


Figure 3.
Lower Patapsco WRAS Nutrient Synoptic March, 2004
Nitrate/Nitrite (NO2+NO3) Yield (Kg/h/day)

Figure 4.
Lower Patapsco WRAS nutrient Synoptic Survey March, 2004
Orthophosphate (PO4) Concentrations (mg/L)



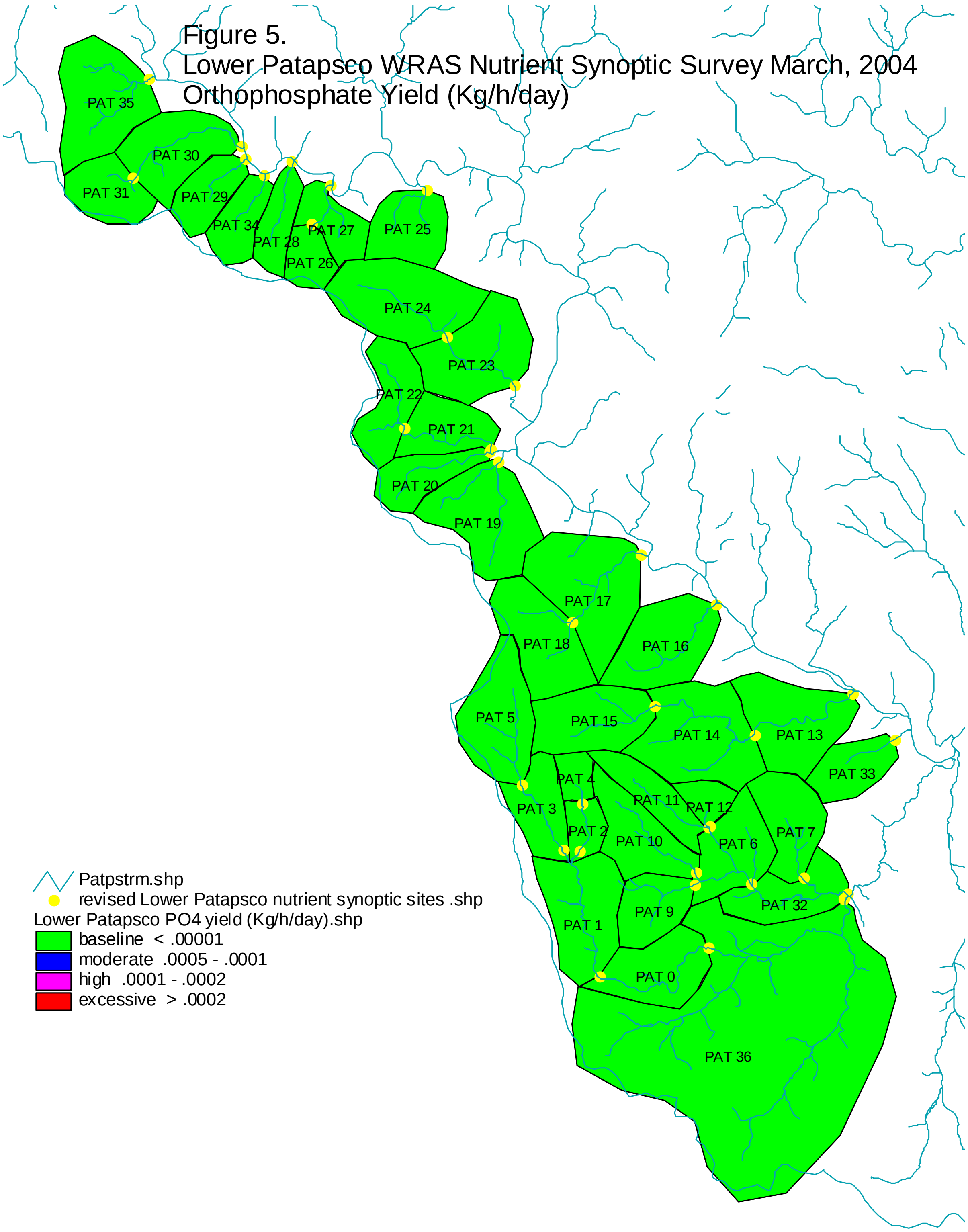


Figure 5.
Lower Patapsco WRAS Nutrient Synoptic Survey March, 2004
Orthophosphate Yield (Kg/h/day)
PAT 35
PAT 30
PAT 31
PAT 29
PAT 34
PAT 28
PAT 27
PAT 26
PAT 25
PAT 24
PAT 23
PAT 22
PAT 21
PAT 20
PAT 19
PAT 17
PAT 18
PAT 16
PAT 5
PAT 15
PAT 14
PAT 13
PAT 33
PAT 4
PAT 3
PAT 11
PAT 12
PAT 2
PAT 10
PAT 6
PAT 7
PAT 9
PAT 32
PAT 1
PAT 0
PAT 36
Patpstrm.shp
revised Lower Patapsco nutrient synoptic sites .shp
Lower Patapsco PO4 yield (Kg/h/day).shp
baseline < .00001
moderate .0005 - .0001
high .0001 - .0002
excessive > .0002

Table 4. Lower Patapsco WRAS Nutrient Synoptic Survey March, 2004
Insitu Water Quality Parameters

Site	date	time	temp	pH	cond	do
0	29-Mar-04	915	10.64	8.06	640	12.50
1	29-Mar-04	1000	11.05	7.79	642	10.98
2	29-Mar-04	1335	13.49	7.71	700	9.98
3	29-Mar-04	1325	13.91	7.82	567	10.28
4	29-Mar-04	1405	12.78	7.48	695	9.50
5	29-Mar-04	1420	13.30	7.76	596	10.10
6	29-Mar-04	1150	13.18	8.03	528	10.96
7	29-Mar-04	1120	11.99	8.34	548	13.74
9	29-Mar-04	1210	13.99	7.88	703	11.74
10	29-Mar-04	1220	13.22	7.57	475	10.23
11	29-Mar-04	1635	12.73	7.39	614	9.96
12	29-Mar-04	1630	12.15	7.72	277	10.33
13	29-Mar-04	1545	12.02	8.00	319	10.38
14	29-Mar-04	1520	12.50	7.67	227	10.20
15	29-Mar-04	1500	13.13	7.47	278	10.04
16	30-Mar-04	1020	7.59	7.72	191	11.87
17	30-Mar-04	900	7.38	8.11	341	11.29
18	30-Mar-04	945	7.49	7.45	323	11.10
19	30-Mar-04	1240	8.33	8.16	412	11.05
20	30-Mar-04	1120	8.13	8.10	608	11.35
21	30-Mar-04	1115	7.96	8.31	797	11.64
22	30-Mar-04	1410	9.27	8.20	918	12.50
23	30-Mar-04	1310	8.45	8.16	661	10.50
24	30-Mar-04	1340	8.70	8.14	718	11.64
25	30-Mar-04	1440	8.63	8.27	270	11.64
26	30-Mar-04	1505	9.24	7.41	458	10.76
27	05-Apr-04	915	3.65	7.27	303	12.50
28	05-Apr-04	940	4.09	7.32	221	12.05
29	05-Apr-04	1105	6.70	7.16	170	11.20
30	05-Apr-04	1120	5.90	6.95	137	11.50
31	30-Mar-04	1530	11.11	8.12	326	12.06
32	29-Mar-04	1040	12.15	7.74	543	11.88
33	29-Mar-04	1600	11.23	7.84	566	9.50
34	05-Apr-04	1045	7.10	7.56	283	6.90
35	05-Apr-04	1230	7.11	7.34	156	11.21
36	29-Mar-04	1100	11.75	7.66	504	11.15

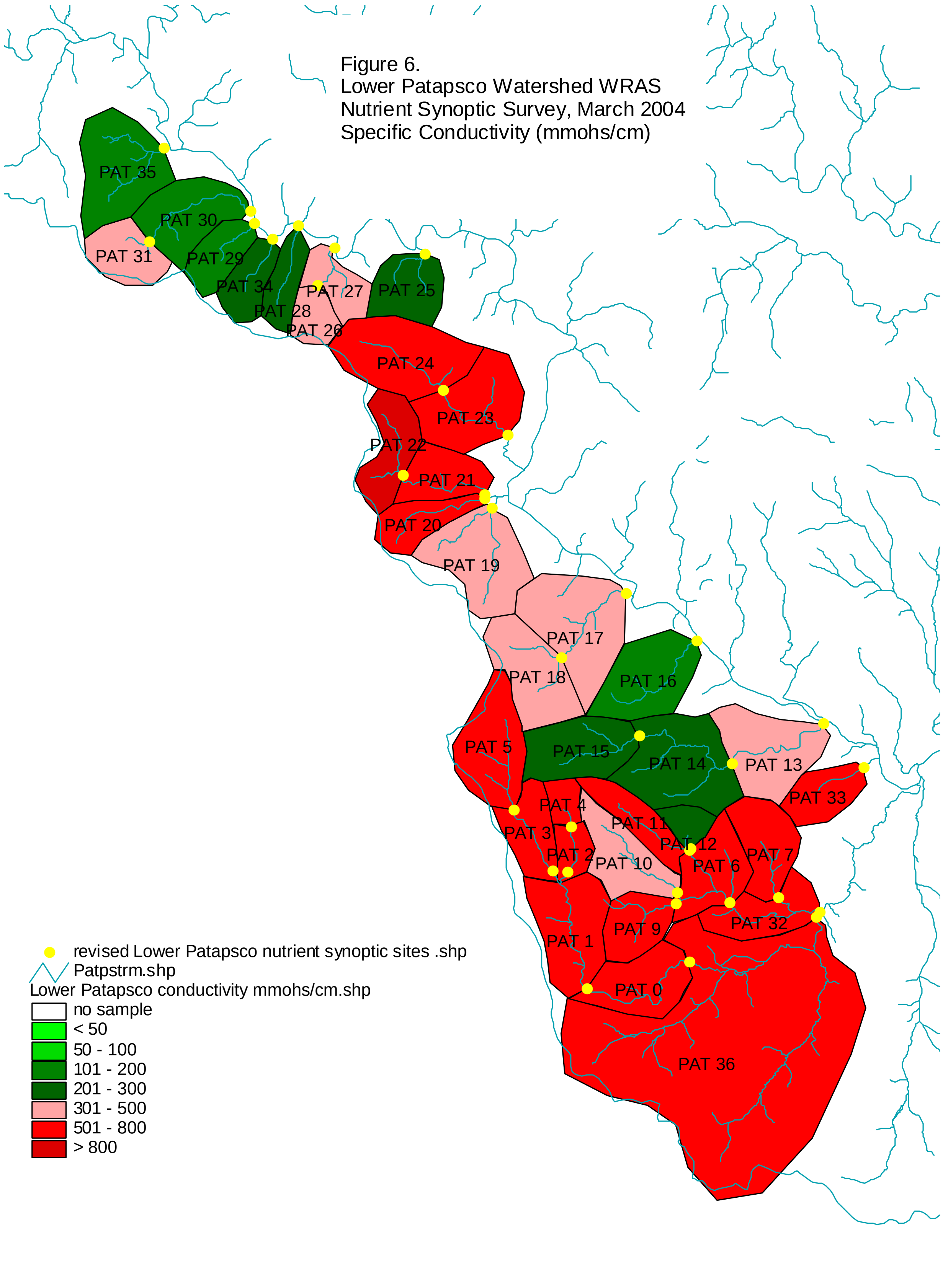


Figure 6.
Lower Patapsco Watershed WRAS
Nutrient Synoptic Survey, March 2004
Specific Conductivity (mmohs/cm)
PAT 35
PAT 30
PAT 31
PAT 29
PAT 34
PAT 28
PAT 27
PAT 26
PAT 25
PAT 24
PAT 23
PAT 22
PAT 21
PAT 20
PAT 19
PAT 17
PAT 18
PAT 16
PAT 5
PAT 15
PAT 14
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PAT 6
PAT 7
PAT 9
PAT 32
PAT 1
PAT 0
PAT 36
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Patpstrm.shp
Lower Patapsco conductivity mmohs/cm.shp
no sample
< 50
50 - 100
101 - 200
201 - 300
301 - 500
501 - 800
> 800

Discussion

Nutrients concentrations in watersheds dominated by urban and suburban land use are generally relatively low as illustrated in the nutrient synoptic averages from around the state shown in Table 5. Exceptions to this rule are large developments not serviced by a central sewer system, or sewered areas with failing infrastructure. This latter exception may be the cause for the elevated nitrate/nitrite concentrations within subwatersheds number 26 and 27. Elevated nitrate/nitrite yields are somewhat more prevalent, especially in the area west of Ellicott City. The majority of the watersheds with elevated yields and low concentrations are above the fall line where underlying bedrock would be closer to the surface. This would tend to elevate groundwater discharge relative to coastal plain watersheds with deeper soils. The relatively wet winter and spring would have contributed to this effect.

Table 5. Annual & Spring Nutrient Concentration Averages from Other Nutrient Synoptic Surveys

Mg/L	Piney	German Br.	Pocomoke	Lower Patapsco	Western Branch	Lower Patuxent	Lower Monocacy	Liberty
NO2+NO3 Spring	3.742	3.832	3.734	**1.25**	0.214	0.439	1.731	3.410
NO2+NO3 Annual	4.823	4.704	2.384					
PO4 Spring	0.800	0.043	0.028	**0.004**	0.005	0.012	0.019	0.004
PO4 Annual	1.177	0.067	0.022					

As noted previously, orthophosphate generally travels bound to sediment. The watersheds with elevated orthophosphate concentrations also had construction activity and sediment control facilities that could be contributing suspended sediment loads to the streams.

The significantly elevated specific conductivity in many of the subwatersheds appears to be the result of road salts moving into the surface aquifer. All of these subwatersheds have heavy road networks. Supplemental sampling in November, 2004 found specific conductivities remained elevated in those subwatersheds that had previously been high, and the conductivity correlated well with measures of chloride (Table 6).

Table 6. Lower Patapsco WRAS
Supplemental Insitu Water Quality and Chloride Concentrations Nov., 2004

Date	Time	Sample	Cl (mg/L)	temp	pH	cond	do
11/8/2004	900	Pat 0	86.1	9.6	7.8	511	9.7
11/8/2004	915	Pat 1	100.3	9.4	7.95	567	9.7
11/8/2004	940	Pat 2	124.7	9.5	7.72	628	9.6
11/8/2004	950	Pat 3	81.9	9.3	7.9	506	10
11/8/2004	1020	Pat 4	128.4	10.2	7.4	630	6.2
11/8/2004	1050	Pat 5	76.1	9.6	7.6	483	8.7
11/8/2004	1115	Pat 21	143.7				
11/8/2004	1125	Pat 22	79.3				

Conclusion

Nutrients do not appear to be a significant problem in the Lower Patapsco watershed at this time. Further investigations should be conducted in subwatersheds number 26 and 27 to determine the source of the elevated nitrate/nitrite found there. Road salt does appear to be causing a water quality impact in a major portion of the Lower Patapsco watershed. Salt spills in or near streams have been implicated in fish kills, but little data is available on the significance of impacts to freshwater stream biota from groundwater contaminated with chronic low level salt concentrations. Impacts to roadside vegetation from excessive salt are well documented.

Literature Cited

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