Report on Nutrient Synoptic Surveys in the Upper Chester River Watershed, Kent and Queen Anne's Counties, Maryland, March 2004 as part of a Watershed Restoration Action Strategy.

Maryland Department of Natural Resources
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MARYLAND
DEPARTMENT OF
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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: Unicorn Br at Hacketts Corner. Rd. by Niles Primrose

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Executive Summary

A nutrient synoptic survey was conducted during March, 2004 in the Upper Chester watershed as part of the Upper Chester WRAS. Samples were analyzed from 82 sites throughout the watershed. Nitrate/nitrite concentrations were found to be excessive in twenty-eight subwatersheds, high in thirteen, moderately elevated in twenty-six others, and baseline in the remaining fifteen subwatersheds. Instantaneous nitrate/nitrite yields were found to be excessive in twenty-nine subwatersheds, high in six, moderate in thirteen, and baseline in the remaining 36, with one not calculated. Excessive concentrations of orthophosphate were found in eight subwatersheds, high concentrations in thirteen, moderate concentrations in twenty-seven, and the remaining thirty-four below baseline. Orthophosphate yields were found to be moderate in one watershed, and baseline in the remaining eighty, with one uncalculated. The majority of the elevated nitrate/nitrite concentrations and/or yields appear to be associated with animal and row crop agriculture in the Red Lion Branch, Unicorn Branch and Chesterville Branch watersheds. The elevated nitrate/nitrite levels in the Forman Branch watershed appear to be associated with a community on well and septic. The elevated orthophosphate concentrations were concentrated in the Red Lion and Andover Branches and appear to be associated with phosphorus rich soils in systems that had fine suspended sediment loads lingering in the water column. Only one subwatershed in the Cypress Creek watershed had elevated orthophosphate yields. All others were below baseline. No significant anomalies were found in the insitu measurements of dissolved oxygen, or temperature. The upper portion of the Cypress Creek watershed had low specific conductivity (<100 mmohs/cm), with two subwatersheds in this drainage having extremely low conductivity (<50 mmohs/cm) indicative of streams with low buffering capacity. Depressed ph values (<6.5) followed the low conductivity indicative of streams susceptible to acid deposition degradation.

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Introduction

A nutrient synoptic survey was conducted during March, 2004 in the Upper Chester watershed as part of the Upper Chester 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 Upper Chester watershed as part of the Upper Chester WRAS. Samples were analyzed from 82 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 twenty-eight subwatersheds, high in thirteen, moderately elevated in twenty-six others, and baseline in the remaining fifteen subwatersheds (Figure 2). Instantaneous nitrate/nitrite yields were found to be excessive in twenty-nine subwatersheds, high in six, moderate in thirteen, and baseline in the remaining 36, with one not calculated (Figure 3). Sewell Branch was the one yield not calculated because the stream was too deep to complete an accurate discharge measurement. Excessive concentrations of orthophosphate were found in eight subwatersheds, high concentrations in thirteen, moderate concentrations in twenty-seven, and the remaining thirty-four below baseline (Figure 4). Orthophosphate yields were found to be moderate in one watershed, and baseline in the remaining eighty, with one uncalculated as noted above (Figure 5). Temperature, dissolved oxygen, pH, and specific conductivity values are noted for all sites in Table 4. No significant anomalies were found in the insitu measurements of dissolved oxygen, or temperature. The upper portion of the Cypress Creek watershed had low specific conductivity (<100 mmohs/cm), with two subwatersheds in this drainage having extremely low conductivity (<50 mmohs/cm) (Figure 6). Depressed ph values (<6.5) followed the low conductivity (Figure 7).

Table 2. Upper Chester WRAS Nutrient Synoptic - March, 2004
Sampling Site Locations

*UT = unnamed tributary

Site	Location	lat	long
UC 42	Hambleton Cr at Schrader Rd	39.18086	76.209
UC 43	Hambleton Cr at Rt 213	39.18191	76.0608
UC 46	Rosin Cr at Round Top Rd	39.21375	76.1946
UC 47	Foreman Br at Rt 544	39.21106	75.98334
UC 48	UT* to Foreman Br at Hoffecker Rd	39.20448	75.95773
UC 49	Forman Br at Hoffecker Rd	39.20389	75.96338
UC 50	UT to Foreman Br at Hoffecker Rd	39.20409	75.97655
UC 51	Foreman Br at Bowers Rd	39.15923	75.95576
UC 53	UT to Foreman Br at Bowers Rd	39.201	75.9562
UC 54	UT to Chester off Farm Rd from Double Cr Rd	39.2288	75.97132
UC 55	UT to Chester off farm rd from Double Cr Rd	39.22932	75.96349
UC 56	UT to Chester at Rt 544	39.2216	75.94535
UC 57	Pearl Cr at Rt 544	39.22568	75.93124
UC 58	UT to Pearl Cr at Pine Tree Rd	39.22218	75.92823
UC 60	Pearl Cr at Pondtown Rd	39.20569	75.92911
UC 61	Red Lion Br at Rt 544	39.2354	75.90425
UC 62	Red Lion Br at Red Lion Br Rd	39.22004	75.89954
UC 63	UT to Red Lion at Red Lion Br Rd	39.2286	75.89368
UC 65	UT to Red Lion at Coleman Rd	39.20243	75.88728
UC 66	Red Lion at Coleman Rd	39.20092	75.89683
UC 67	UT to Red Lion at Dudleys Crnr Rd	39.20154	75.90231
UC 68	UT to Red Lion at Dudleys Crnr Rd	39.18364	75.89256
UC 69	Red Lion at Rt 300	39.18418	75.89438
UC 70	Red Lion at Roe Rd	39.1729	75.89819
UC 71	UT to Red Lion at Roe Rd	39.1729	75.89819
UC 72	Red Lion at Del Foxx Rd	39.15184	75.90335
UC 73	UT to Red Lion at Roe Rd	39.16686	75.86926
UC 74	UT to Red Lion at Rt 313	39.16885	75.86028
UC 75	UT to Red Lion at Barclay Rd	39.14469	75.83744
UC 76	UT to Red Lion at Tavern Rd	39.1572	75.84821
UC 77	UT to Red Lion at Barclay Rd	39.1449	75.86632
UC 79	UT to Chester at Rt 544	39.24082	75.89604
UC 80	Unicorn Br at Rt 313	39.25016	75.86116
UC 81	Unicorn Br at Hacketts Crnr Rd	39.2317	75.85571
UC 83	UT to Unicorn at Sudlersville Cemetary Rd	39.2093	75.8418

UC 84	Unicorn at Sudlersville Cemetary rd	39.20341	75.84692
UC 85	Chapel Br Ditch at Cedar tree La	39.20221	75.84964
UC 86	Chapel Br Ditch at Rt 300	39.18855	75.85064
UC 87	Unicorn at Rt 300	39.19132	75.83343
UC 88	UT to Unicorn at Race Track Rd	39.16878	75.82792
UC 89	Unicorn at Race Track Rd	39.17006	75.81781
UC 90	Unicorn at Church Rd	39.14885	75.8068
UC 91	UT to Unicorn at Duhamel Crnr rd	39.16951	75.81576
UC 92	UT to Unicorn at Duhamel Crnr Rd	39.18494	75.82698
UC 93	Andover Br at Peacock Crnr Rd	39.24627	75.82022
UC 94	UT to Andover at High Bridge Rd	39.23897	75.8181
UC 95	UT to Andover at Baxter Rd	39.22481	75.81307
UC 96	UT to Andover at Blanco Rd	39.23861	75.80358
UC 97	Andover at Blanco rd	39.23927	75.7891
UC 98	UT to Andover at Bolton Woods Rd	39.21872	75.78495
UC 99	Andover Br at Stulltown Rd	39.21901	75.76871
UC 100	Gravelly Rn at Stulltown Rd	39.21845	75.76115
UC 101	UT to Andover at Rt 300	39.19319	75.77821
UC 102	Andover at Rt 300	39.19164	75.77401
UC 103	Andover at Pete Everett Rd	39.17718	75.77961
UC 104	Andover at Church Rd	39.16195	75.77859
UC 105	Sewell Br at farm rd off Rt 291	39.24771	75.76766
UC 107	UT to Andover at Rt 291	39.25739	75.83241
UC 110	Cypress Br at Walnut Tree Rd	39.28931	75.79134
UC 111	UT to Cypress at Walnut Tree Rd	39.29096	75.81863
UC 112	UT to Cypress at Big Stone Rd	39.25827	75.80961
UC 113	UT to Cypress at Big Stone Rd	39.28421	75.77551
UC 114	Cypress at Big Stone Rd	39.29499	75.76866
UC 115	UT to Cypress at Md Line Rd	39.30144	75.7802
UC 116	UT to Cypress at Walnut Tree Rd	39.2906	75.7977
UC 117	UT to Cypress at Md Line Rd	39.30495	75.81023
UC 118	Little Mill Pond at Galena Rd	39.27112	75.83794
UC 119	Little Mill Pond at Carroll Clarke Rd	39.29583	75.83728
UC 120	Mills Br at Rt 291	39.26504	75.86784
UC 121	Mills Br at Chesterville Bridge Rd	39.27574	75.86876
UC 122	UT to Mills Br at Dudley Chance Rd	39.29628	75.86543
UC 123	Mills Br at Lambston Forest Rd	39.30422	75.8735
UC 124	UT to Mill at farm la off Lambston Forest Rd	39.30059	75.8806
UC 125	UT to Chester at farm rd off Rt 291	39.24925	75.98663
UC 126	Chesterville Br at Rt 291	39.25777	75.93922
UC 127	Chesterville Br at Morgnec Rd	39.27442	75.93963
UC 128	Chesterville Br at Grove Rd	39.28891	75.92868
UC 129	UT to Chester at Rt 291	39.257	75.94702
UC 131	UT to Chester at Rt 291	39.25639	75.98312
UC 134	UT to Gravelly at Rt 300	39.19925	75.75345
UC 135	Gravelly at Lion Hope Rd	39.20456	75.74342
UC 137	Sewell Br at Sewell Br Rd	39.24694	75.74902

Figure 1. Upper Chester WRAS Nutrient Synoptic, March 2004, Sampling Sites and Subwatersheds

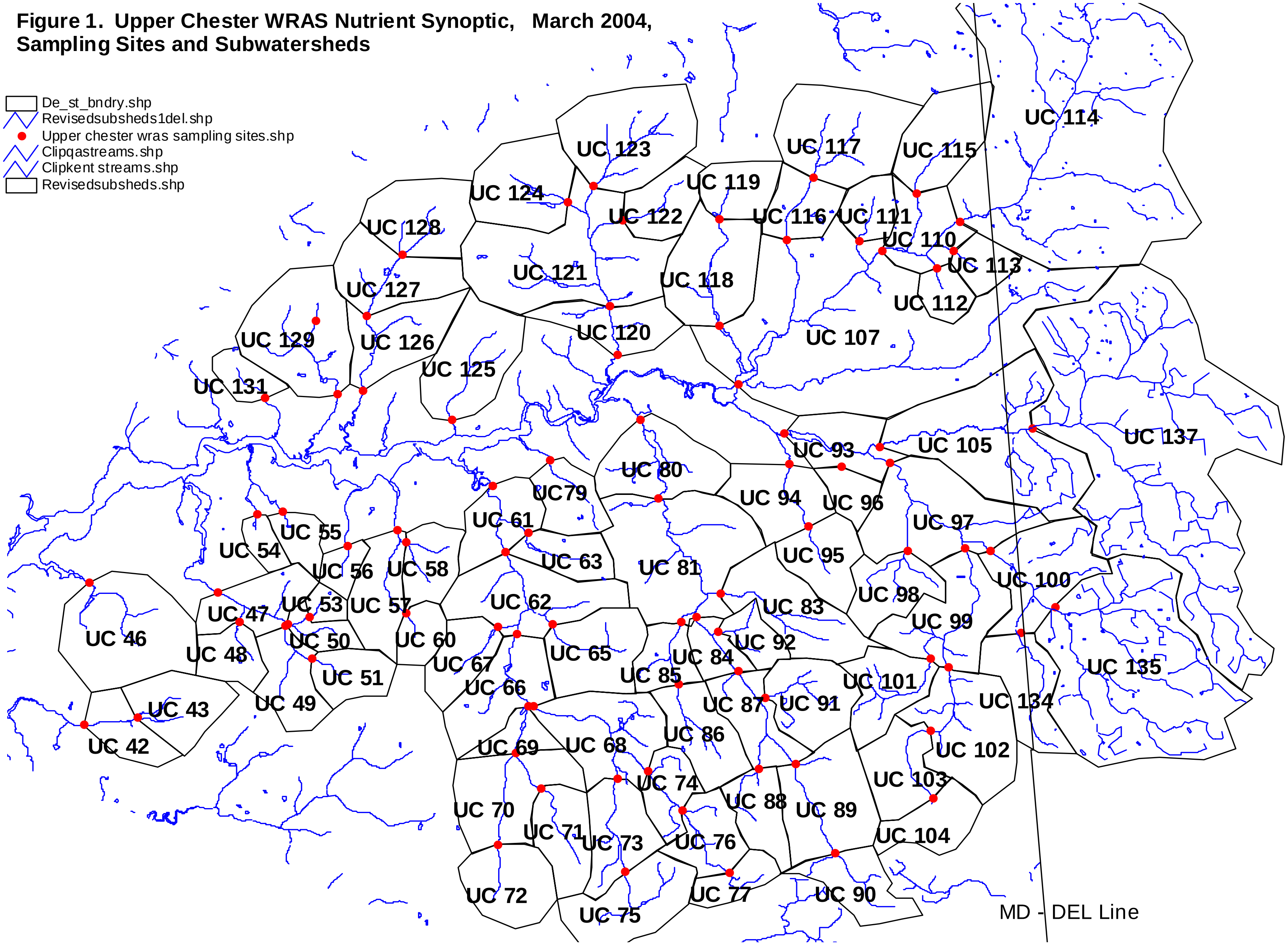
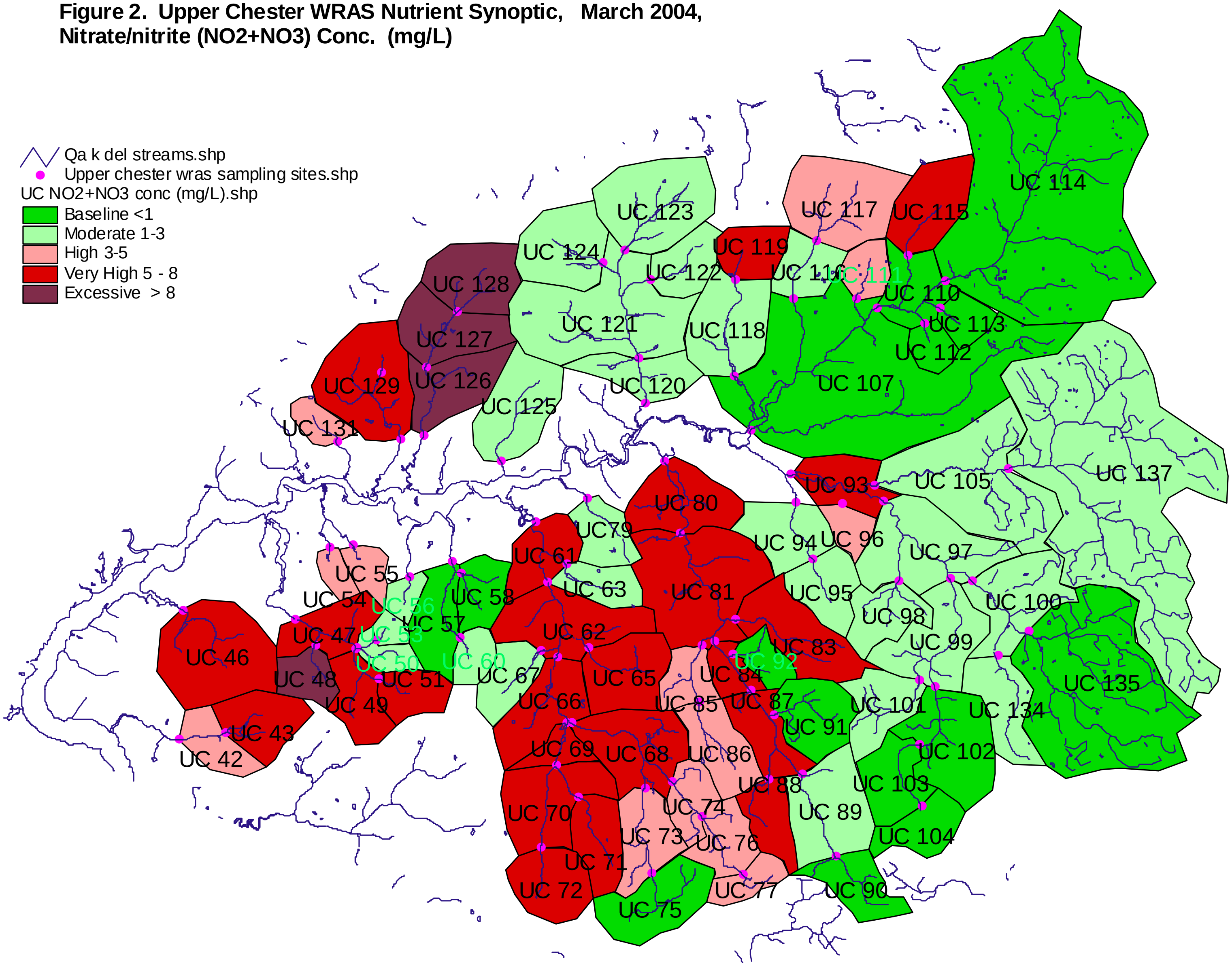


Table 3. Upper Chester WRAS Nutrient Synoptic - March, 2004
Dissolved Nutrient Concentrations and Yields

Station	Date	Watershed Area (H)	Discharge L/sec	PO4 mg/L	NO2+NO3 mg/L	PO4 kg/h/day	NO2+NO3 kg/h/day
UC 42	11-Mar-04	605	48.46	0.004	3.110	0.000028	0.021524
UC 43	11-Mar-04	322	8.55	0.001	5.020	0.000002	0.011516
UC 46	11-Mar-04	686	72.69	0.003	6.020	0.000027	0.055153
UC 47	11-Mar-04	1445	152.81	0.003	6.060	0.000027	0.055371
UC 54	11-Mar-04	155	3.43	0.002	3.590	0.000004	0.006861
UC 55	11-Mar-04	185	3.84	0.002	4.680	0.000004	0.008396
UC 48	11-Mar-04	321	6.83	0.002	10.300	0.000004	0.018925
UC 49	11-Mar-04	500	96.02	0.003	7.870	0.000050	0.130585
UC 53	11-Mar-04	96	10.52	0.004	1.830	0.000038	0.017257
UC 51	11-Mar-04	236	19.60	0.004	5.770	0.000029	0.041461
UC 50	11-Mar-04	263	16.67	0.004	2.410	0.000022	0.013200
UC 56	11-Mar-04	115	6.39	0.002	1.790	0.000010	0.008557
UC 57	11-Mar-04	777	63.89	0.003	0.900	0.000021	0.006394
UC 58	11-Mar-04	284	15.61	0.003	0.190	0.000014	0.000902
UC 60	11-Mar-04	265	15.07	0.002	1.120	0.000010	0.005500
UC 61	11-Mar-04	5823	987.70	0.012	5.230	0.000176	0.076647
UC 63	11-Mar-04	226	11.70	0.006	1.280	0.000027	0.005728
UC 62	11-Mar-04	5299	625.96	0.014	5.430	0.000143	0.055420
UC 67	11-Mar-04	277	15.33	0.006	1.050	0.000029	0.005027
UC 66	11-Mar-04	4137	527.74	0.022	5.780	0.000242	0.063705
UC 65	11-Mar-04	348	24.53	0.005	6.270	0.000030	0.038198
UC 77	12-Mar-04	179	41.17	0.015	3.530	0.000299	0.070269
UC 72	12-Mar-04	344	33.20	0.017	6.410	0.000142	0.053470
UC 71	12-Mar-04	512	82.00	0.010	6.130	0.000138	0.084847
UC 70	12-Mar-04	1188	40.19	0.020	7.830	0.000058	0.022885
UC 73	12-Mar-04	954	87.44	0.009	4.430	0.000071	0.035081
UC 74	12-Mar-04	742	41.13	0.004	4.230	0.000019	0.020258
UC 76	12-Mar-04	444	37.92	0.004	3.030	0.000030	0.022357
UC 75	12-Mar-04	598	14.70	0.007	0.310	0.000015	0.000658
UC 68	12-Mar-04	2356	234.59	0.035	5.080	0.000301	0.043703
UC 69	12-Mar-04	1320	153.73	0.012	6.330	0.000121	0.063693
UC79	15-Mar-04	284	6.75	0.003	2.010	0.000006	0.004125
UC 80	15-Mar-04	4950	843.00	0.004	5.850	0.000059	0.086078
UC 81	15-Mar-04	4446	557.49	0.006	6.780	0.000065	0.073454
UC 83	15-Mar-04	574	45.56	0.011	6.010	0.000075	0.041212
UC 84	15-Mar-04	2268	217.14	0.005	5.180	0.000041	0.042849
UC 85	15-Mar-04	583	83.89	0.008	4.550	0.000099	0.056570
UC 87	15-Mar-04	1966	165.03	0.004	7.390	0.000029	0.053597
UC 86	15-Mar-04	308	21.60	0.009	3.300	0.000055	0.019990
UC 88	15-Mar-04	287	14.89	0.008	6.590	0.000036	0.029546
UC 89	15-Mar-04	938	3.82	0.004	1.120	0.000001	0.000394

UC 90	15-Mar-04	327	13.46	0.013	0.500	0.000046	0.001778
UC 91	15-Mar-04	379	6.89	0.008	0.240	0.000013	0.000377
UC 92	15-Mar-04	180	21.47	0.007	0.860	0.000072	0.008852
UC 96	15-Mar-04	347	128.05	0.012	4.970	0.000383	0.158587
UC 93	15-Mar-04	12969	785.77	0.003	7.270	0.000016	0.038057
UC 94	14-Mar-04	488	4.47	0.012	2.090	0.000009	0.001652
UC 95	14-Mar-04	290	14.54	0.004	2.680	0.000017	0.011627
UC 98	15-Mar-04	416	21.71	0.008	1.260	0.000036	0.005678
UC 99	15-Mar-04	2090	163.56	0.013	2.260	0.000088	0.015281
UC 100	15-Mar-04	3479	178.08	0.018	1.090	0.000080	0.004821
UC 97	15-Mar-04	6768	548.64	0.013	2.080	0.000091	0.014568
UC 101	22-Mar-04	423	31.09	0.009	2.280	0.000057	0.014466
UC 102	22-Mar-04	1109	136.00	0.010	0.770	0.000106	0.008159
UC 103	22-Mar-04	545	157.61	0.011	0.220	0.000275	0.005497
UC 104	22-Mar-04	189	24.49	0.007	0.050	0.000079	0.000561
UC 105	22-Mar-04	5542	414.60	0.015	1.380	0.000097	0.008920
UC 112	22-Mar-04	126	141.31	0.005	0.600	0.000483	0.057936
UC 113	22-Mar-04	196	9.65	0.002	0.030	0.000008	0.000127
UC 135	22-Mar-04	2493	208.03	0.009	0.840	0.000065	0.006056
UC 134	23-Mar-04	450	43.28	0.017	1.930	0.000141	0.016043
UC 137	23-Mar-04	4415	too deep	0.010	1.600	0.000000	0.000000
UC 110	23-Mar-04	5295	547.86	0.009	0.270	0.000080	0.002414
UC 116	23-Mar-04	1040	14.75	0.004	2.930	0.000005	0.003591
UC 111	23-Mar-04	182	120.87	0.009	4.910	0.000516	0.281559
UC 119	23-Mar-04	228	6.83	0.006	5.400	0.000015	0.013948
UC 117	23-Mar-04	674	46.09	0.009	4.090	0.000053	0.024148
UC 115	23-Mar-04	542	78.67	0.005	5.070	0.000063	0.063535
UC 114	23-Mar-04	4215	64.34	0.004	0.010	0.000005	0.000013
UC 107	23-Mar-04	9023	487.68	0.007	0.340	0.000033	0.001588
UC 118	23-Mar-04	770	1275.85	0.008	2.040	0.001145	0.292046
UC 120	24-Mar-04	2920	164.65	0.007	1.160	0.000034	0.005651
UC 126	24-Mar-04	1325	216.57	0.003	8.700	0.000042	0.122859
UC 129	24-Mar-04	558	19.96	0.004	5.320	0.000012	0.016448
UC 131	24-Mar-04	134	14.04	0.003	4.810	0.000027	0.043486
UC 127	24-Mar-04	910	117.56	0.003	9.130	0.000033	0.101908
UC 128	24-Mar-04	643	36.68	0.002	11.700	0.000010	0.057670
UC 121	24-Mar-04	2573	131.57	0.007	1.100	0.000031	0.004860
UC 122	24-Mar-04	253	13.85	0.004	2.010	0.000019	0.009519
UC 123	24-Mar-04	661	26.60	0.007	1.230	0.000024	0.004279
UC 124	24-Mar-04	503	6.87	0.003	1.570	0.000004	0.001851
UC 125	24-Mar-04	525	4.24	0.001	1.510	0.000001	0.001053

Figure 2. Upper Chester WRAS Nutrient Synoptic, March 2004, Nitrate/nitrite (NO2+NO3) Conc. (mg/L)



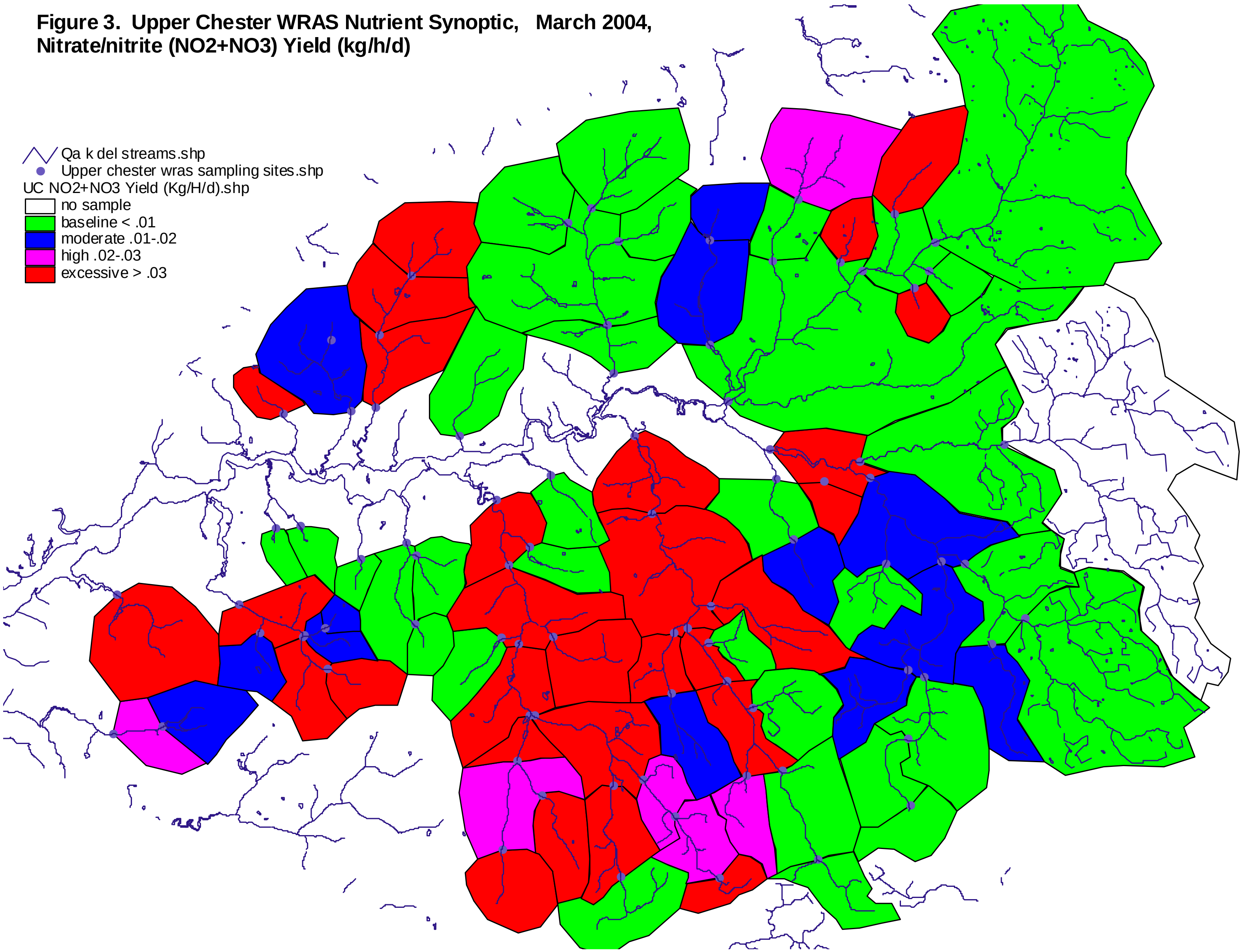


Figure 3. Upper Chester WRAS Nutrient Synoptic, March 2004, Nitrate/nitrite (NO_2+NO_3) Yield (kg/h/d)

Figure 4. Upper Chester WRAS Nutrient Synoptic, March 2004, Orthophosphate (PO4) Conc. (mg/L)

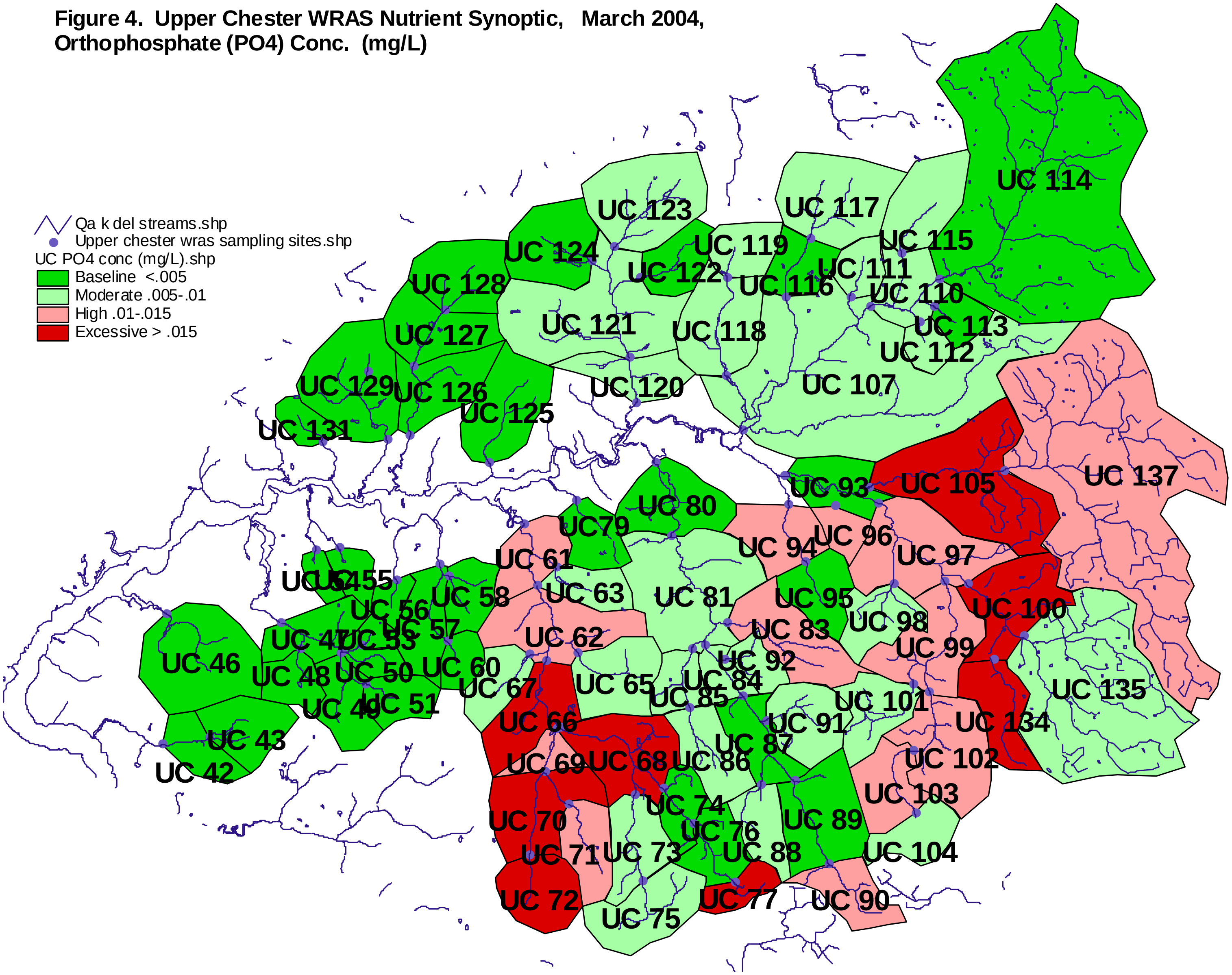


Figure 5. Upper Chester WRAS Nutrient Synoptic, March 2004, Orthophosphate (PO4) Yield (kg/h/d)

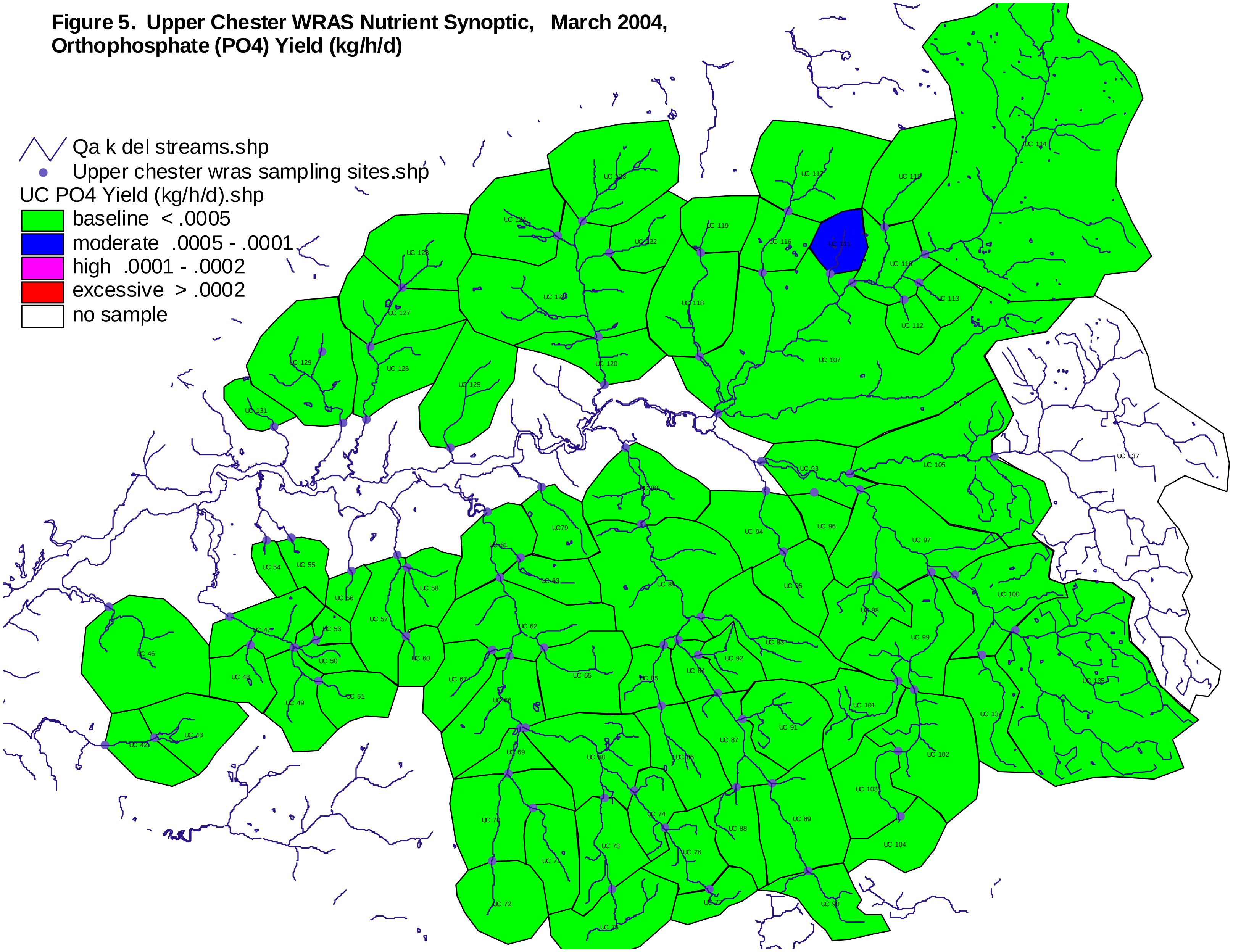


Table 4. Upper Chester WRAS Nutrient Synoptic - March, 2004. Insitu Water Quality

Station	Date	Time	Discharge L/sec	Temp ©	pH	Cond micromohs/cm	D.O. (mg/L)
UC 42	11-Mar-04	810	48.46	6.1	7.25	171	10.36
UC 43	11-Mar-04	830	8.55	10.67	6.66	163	7.12
UC 46	11-Mar-04	915	72.69	5.2	7.1	179	10.51
UC 47	11-Mar-04	950	152.81	6.36	7.02	155	11.7
UC 54	11-Mar-04	1035	3.43	6.26	6.15	142	13.35
UC 55	11-Mar-04	1100	3.84	6.74	6.3	168	11.29
UC 48	11-Mar-04	1120	6.83	6.91	5.98	193	10.57
UC 49	11-Mar-04	1130	96.02	9.74	6.34	163	10.95
UC 53	11-Mar-04	1200	10.52	9.15	6.32	90	10.72
UC 51	11-Mar-04	1215	19.60	9.81	6.37	150	11.01
UC 50	11-Mar-04	1250	16.67	8.63	6.75	146	10.98
UC 56	11-Mar-04	1315	6.39	8.81	5.85	124	10.52
UC 57	11-Mar-04	1330	63.89	8.74	5.72	82	10.63
UC 58	11-Mar-04	1355	15.61	9.25	5.64	71	9.86
UC 60	11-Mar-04	1415	15.07	10.39	5.47	74	9.7
UC 61	11-Mar-04	1445	987.70	9.87	7.21	183	11.49
UC 63	11-Mar-04	1510	11.70	11	6.91	206	10.1
UC 62	11-Mar-04	1525	625.96	9.81	7.19	188	11.31
UC 67	11-Mar-04	1600	15.33	8.89	6.64	118	11.11
UC 66	11-Mar-04	1620	527.74	9.61	7	195	11.48
UC 65	11-Mar-04	1640	24.53	9.98	6.95	147	11.3
UC 77	12-Mar-04	815	41.17	7.55	6.28	177	7.25
UC 72	12-Mar-04	855	33.20	8.03	6.81	204	10.34
UC 70	12-Mar-04	915	82.00	7.52	6.83	225	11.91
UC 71	12-Mar-04	920	40.19	7.09	6.8	206	10.14
UC 73	12-Mar-04	1000	87.44	8.33	6.57	167	9.99
UC 74	12-Mar-04	1025	41.13	8.26	6.36	150	10.1
UC 76	12-Mar-04	1045	37.92	8.85	6.47	156	9.9
UC 75	12-Mar-04	1105	14.70	7.1	6.18	177	10.2
UC 68	12-Mar-04	1130	234.59	8.93	6.54	168	11.09
UC 69	12-Mar-04	1155	153.73	9.21	7	219	12.46
UC 94	14-Mar-04	1445	128.05	12.51	6.24	149	10.99
UC 93	14-Mar-04	1510	785.77	8.57	6.9	153	11.08
UC79	15-Mar-04	920	6.75	6.72	6.04	143	10.7
UC 80	15-Mar-04	940	843.00	8.3	6.5	150	10.67
UC 81	15-Mar-04	955	557.49	8.37	6.42	164	10.33
UC 83	15-Mar-04	1025	45.56	8.14	6.35	135	11.02
UC 84	15-Mar-04	1045	217.14	8.54	6.4	152	10.23
UC 85	15-Mar-04	1120	83.89	9.95	6.33	181	11.45
UC 87	15-Mar-04	1145	165.03	10.21	6.48	145	10.72
UC 86	15-Mar-04	1205	21.60	12.15	6.11	164	11.25
UC 88	15-Mar-04	1235	14.89	11.15	5.72	82	8.26
UC 89	15-Mar-04	1305	3.82	11.31	6.53	111	12.34
UC 90	15-Mar-04	1330	13.46	12.1	6.62	134	9.03

UC 91	15-Mar-04	1405	6.89	16.35	6.62	77	12.12
UC 92	15-Mar-04	1415	21.47	12.75	5.85	190	12.28
UC 96	15-Mar-04	1535	4.47	11.42	5.76	84	10.09
UC 95	15-Mar-04	1555	14.54	11.71	5.47	67	8.68
UC 98	15-Mar-04	1610	21.71	13.03	6.5	167	10.78
UC 99	15-Mar-04	1630	163.56	11.39	6.91	167	10.62
UC 100	15-Mar-04	1655	178.08	11.23	7.04	171	9.5
UC 97	15-Mar-04	1720	548.64	10.48	7.09	165	10.3
UC 101	22-Mar-04	800	31.09	3.03	6.73	168	11.9
UC 102	22-Mar-04	825	136.00	4.27	6.33	102	10.3
UC 103	22-Mar-04	845	157.61	5.32	6.19	89	10.13
UC 104	22-Mar-04	900	24.49	5.57	6.12	90	10.6
UC 105	22-Mar-04	950	414.60	5.43	6.51	142	10.6
UC 112	22-Mar-04	1030	141.31	5.67	6.97	89	10.63
UC 113	22-Mar-04	1100	9.65	4.59	4.37	49	11.5
UC 135	22-Mar-04	1135	208.03	5.72	6.32	159	11.63
UC 134	23-Mar-04	800	43.28	1.5	6.42	125	10.82
UC 137	23-Mar-04	840	too deep	4.3	6.49	179	10.8
UC 110	23-Mar-04	900	547.86	3.76	6.34	77	10.3
UC 116	23-Mar-04	930	14.75	3.56	6.18	111	11.75
UC 111	23-Mar-04	945	120.87	4.03	6.38	154	10.2
UC 119	23-Mar-04	1015	6.83	5.33	5.96	153	8.5
UC 117	23-Mar-04	1030	46.09	4.26	6.32	125	9.35
UC 115	23-Mar-04	1050	64.34	4.88	4.84	39	11.83
UC 114	23-Mar-04	1115	487.68	5.96	5.67	82	10.15
UC 107	23-Mar-04	1200	1275.85	6.72	6.29	108	11.21
UC 118	23-Mar-04	1230	78.67	8.33	6.43	175	10.8
UC 120	24-Mar-04	810	164.65	5.14	7.01	223	10.92
UC 126	24-Mar-04	845	216.57	6.91	6.75	190	9.06
UC 129	24-Mar-04	915	19.96	7.35	6.67	167	12.1
UC 131	24-Mar-04	955	14.04	7.63	5.95	171	10.81
UC 127	24-Mar-04	1025	117.56	9.73	6.7	197	12.54
UC 128	24-Mar-04	1050	36.68	9.39	6.37	204	12.04
UC 121	24-Mar-04	1125	131.57	8.29	7.04	220	11.04
UC 122	24-Mar-04	1150	13.85	9.85	6.4	167	10.54
UC 123	24-Mar-04	1210	26.60	9.14	6.27	209	9.87
UC 124	24-Mar-04	1245	6.87	10	6.47	266	10.4
UC 125	24-Mar-04	1345	4.24	12.9	6.4	164	9.79

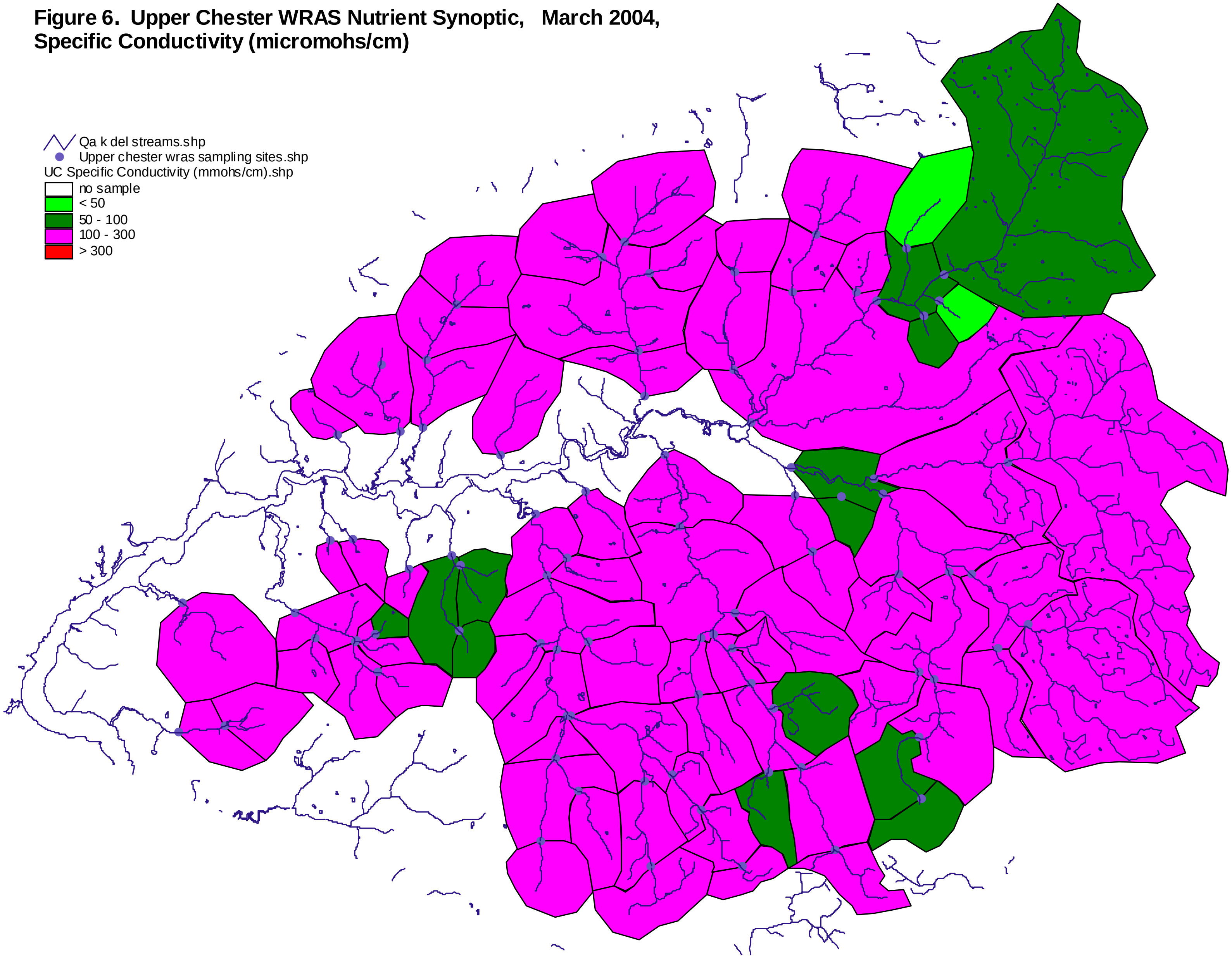
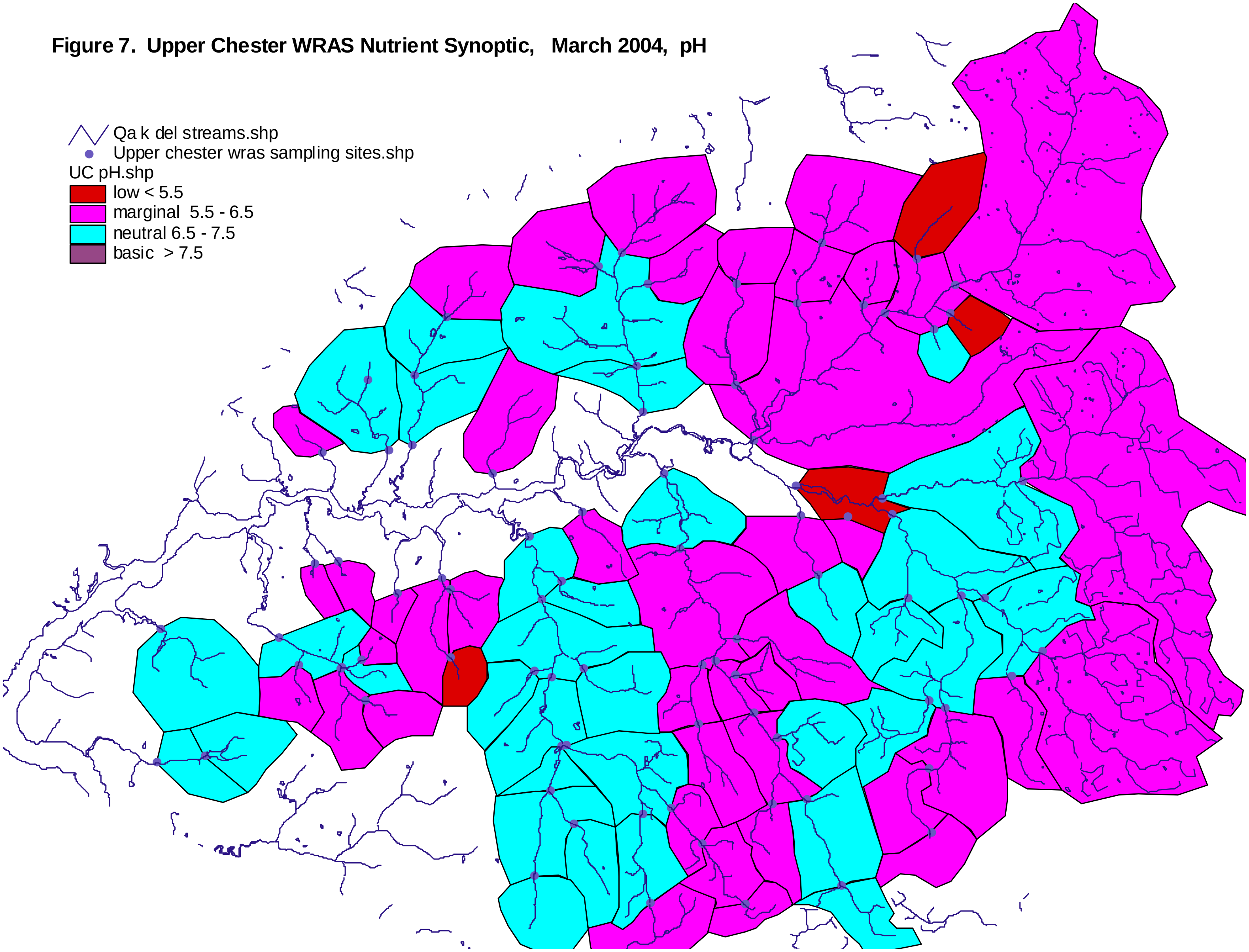


Figure 6. Upper Chester WRAS Nutrient Synoptic, March 2004, Specific Conductivity (micromohs/cm)

Figure 7. Upper Chester WRAS Nutrient Synoptic, March 2004, pH



DISCUSSION

The majority of the elevated nitrate/nitrite concentrations and yields in the Foreman Branch, Red Lion Branch and Unicorn Branch watersheds appear to be associated with row crop agriculture and/or concentrations of septic. The upper Forman Branch subwatershed has a small residential community on well and septic immediately upstream of a sampling site (UC 48) that appears to be contributing to the excessive nitrate/nitrite levels. Animal agriculture appears to be the primary cause of the excessive nitrate/nitrite concentrations within the Chesterville Branch watershed. Pastureland in the Chesterville Branch watershed visible from Rt 291 showed animal access to the stream. The well-drained soils in these watersheds are very efficient at moving nutrients from the surface to the shallow groundwater and then to surface water. Alternatively, many of the watersheds with low and baseline nitrate/nitrite concentrations and yields have a high proportion of hydric soils. This association could be due to less agriculture in these watersheds, or denitrification of ground water from anoxic/hypoxic soil water conditions.

The elevated orthophosphate concentrations were most prevalent in Red Lion and Andover Branches. As noted previously, orthophosphate generally travels bound to sediment particles. The three sites with the highest orthophosphate concentrations (UC 68, UC 100, and UC 134) were all noted as being very muddy. Even fine suspended sediment loads lingering in the water column days after a rain event can elevate orthophosphate concentrations due to phosphorus rich soils in a watershed. Hypoxic or anoxic conditions in the surface water or stream bottom sediments will also create free orthophosphate. One or more of these conditions existed in the Red Lion and Andover Branches watersheds due to eroding stream banks, biological activity, and/or slow flow conditions. Only one subwatershed had elevated orthophosphate yields, UC 111 in the Cypress Creek watershed. This sample site was immediately downstream of a beaver dam and had a relatively high discharge in relation to the watershed area resulting in a 'moderate' yield. All other yields were below baseline, indicating that orthophosphate is not a significant problem during baseflow conditions. The numerous watersheds with high orthophosphate concentrations would argue that storm flows would produce significant phosphorus loadings at the watershed outlets.

The very low specific conductivity and pH values in several of the upper Cypress Creek subwatersheds appeared to be naturally occurring due to tannic acid in water draining wooded wetlands. Streams exhibiting such low conductivity and pH are indicative of poorly buffered systems susceptible to impacts from acid deposition. The prevalence of depressed pH values the in headwaters of Andover Branch, Foreman Branch, and Pearl Creek, and throughout Unicorn Branch tend to match the distribution of hydric and other poorly drained soils in these watersheds. High organic content in these types of soils in forests and wetlands create a reducing environment that propomtes low pH.

A comparison of the 2004 synoptic data with data from a 1998 synoptic survey from Unicorn Branch and Cypress Creek found both similarities and differences. Nitrate/nitrite concentrations from 1998 where similar, with generally low concentrations in Cypress and elevated concentrations in Unicorn (Figure 8). Orthophosphate concentrations were high in both watersheds in 1998 compared to those found in 2004 (Figure 9). A comparison of discharges from the two surveys found 1998 to have considerably higher volumes. Elevated discharges would produce lower nitrate/nitrite concentrations through dilution and higher orthophosphate concentrations due to higher suspended sediment loads. Specific conductivity and pH values were very similar between surveys.

The results from both the 1998 and present survey confirmed findings from a previous nutrient study done in the Chester River watershed by the U.S. Fish and Wildlife Service and MDE in 1992-3 (Boward 1966). Forman, Red Lion, Unicorn and Chesterville Branches have been and remain major contributors to the nutrient load of the Chester River.

Comparison of the average nitrate/nitrite and orthophosphate concentrations in the upper Chester with other eastern and western shore watershed synoptics finds it is very similar to all but the heavily forested upper Monocacy (Table 5).

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

Mg/L	Piney	German Br.	Pocomoke	**Upper Chester**	Middle Chester	**Upper Monocacy**	Liberty
NO2+NO3 Spring	3.742	3.832	3.734	**3.538**	4.87	1.731	3.410
NO2+NO3 Annual	4.823	4.704	2.384				
PO4 Spring	0.800	0.043	0.028	**0.007**	0.012	0.019	0.004
PO4 Annual	1.177	0.067	0.022				

While macroinvertebrates were not collected for this WRAS survey, cursory examination during the 2004 synoptic, and sampling done from 1990 through 1996, noted that Foreman Branch, Unicorn Branch, and Red Lion Branch clearly supported the best macroinvertebrate communities in the watershed (Primrose, pers. com., Boward, 1996). These same streams also had some of the highest nutrient concentrations and yields. All of these streams have excellent stands of SAV in the summer and areas with good to excellent macroinvertebrate habitat. In contrast, Chesterville Branch had equally high nutrients, but lacked the habitat quality necessary to support a high quality macroinvertebrate community. The macroinvertebrate community quality appears to reflect the quality of the in-stream and riparian habitat, not necessarily the ambient nutrient concentrations. There is undoubtedly an enhancement of the macroinvertebrate community due to the increased primary production from dissolved nutrient, but adequate and suitable habitat has to be available for the macroinvertebrates to take advantage of the increased food source. A large majority of the Chester tributaries had habitat that was considered moderately impaired judged by qualitative habitat assessment methods.

CONCLUSION

Well drained soils, abundant in the upper Chester watershed, promote movement of nitrate/nitrite from surface application or septic input of nutrients to ground water and ultimately to surface water and the Chester River mainstem. Short stopping this nutrient transport requires action at the source, such as cover crops and denitrifying septic systems. The considerable number of subwatersheds with elevated orthophosphate concentrations during base flow would translate to elevated yields during storm events. Cover crops would help reduce sheet flow from fields, and stream bank stabilization would help reduce riparian erosion. Reduction of the sediment load carried by these streams would also accrue a significant benefit to the aquatic biota through in-stream habitat improvement.

Figure 8. Upper Chester WRAS - Limited Synoptic Survey, March 1998.
Nitrate/nitrite (NO2+NO3) mg/L

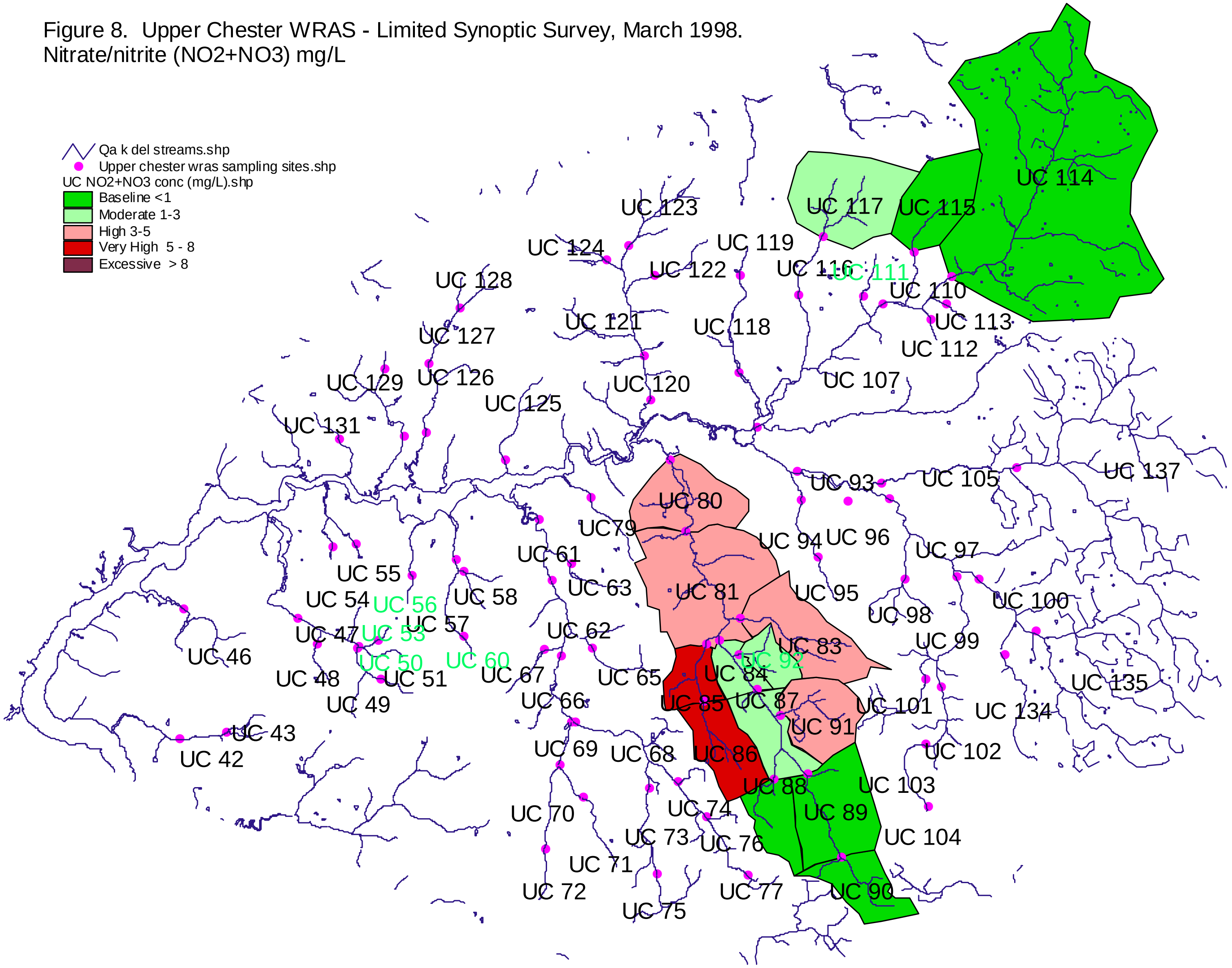
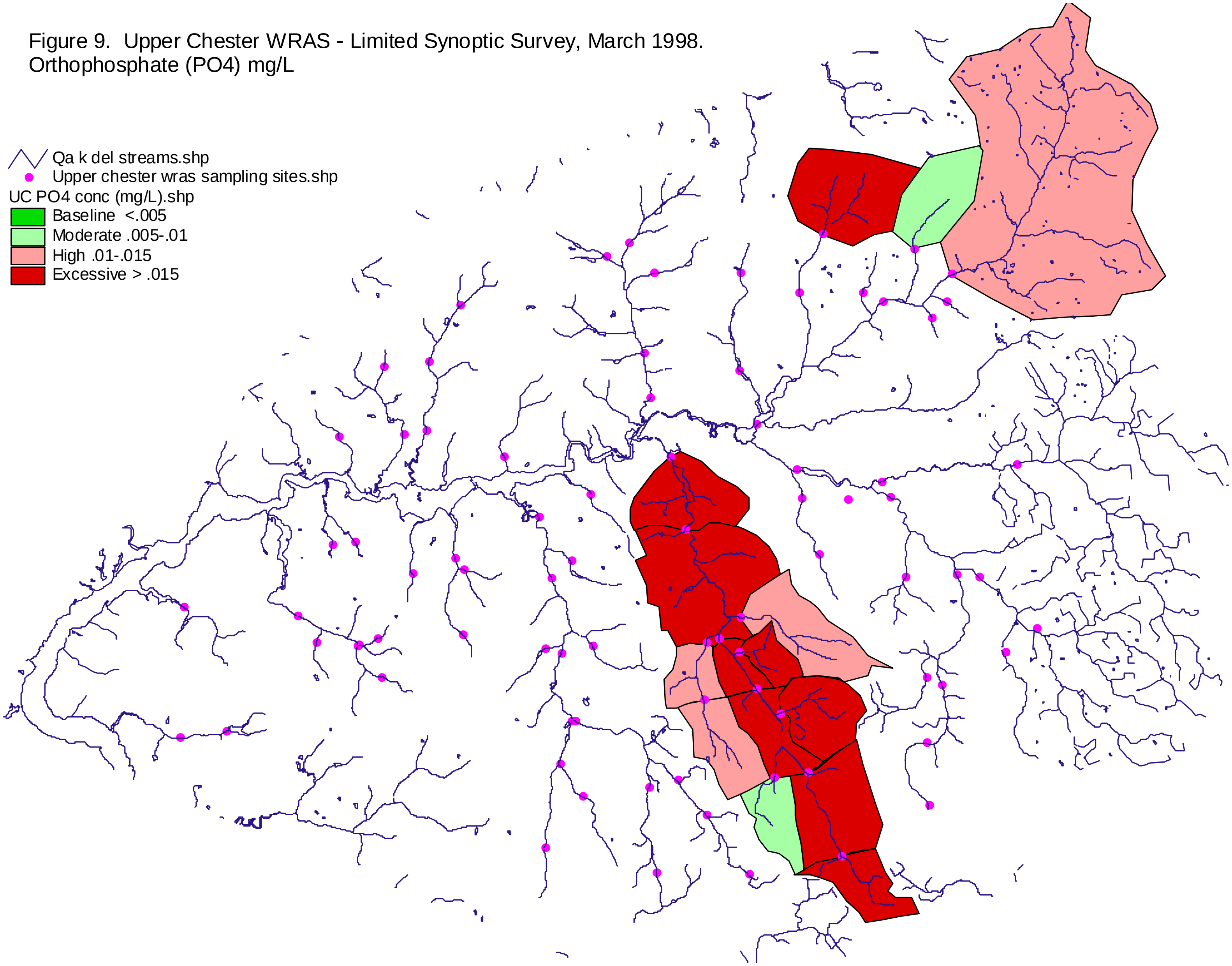


Figure 9. Upper Chester WRAS - Limited Synoptic Survey, March 1998.
Orthophosphate (PO4) mg/L



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