C-11653
Quarterly Progress Report #2
(August - October 2003)

Land Application of Residuals and Chicken Manure in the Lake Okeechobee Watershed: Phosphorus Considerations

March 8, 2004

UNIVERSITY OF FLORIDA

Department of Soil and Water Science, Gainesville, FL 32611

Southern DataStream

Southern DataStream, Inc. PO Box 1577, Labelle, FL 33975

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A. SAMPLING AND PROJECT EVENTS

The dates of sampling events are provided in Table 1 along with the status of each sample set relative to the UF-ARL laboratory reporting of results.

Table 1. Water quality sampling dates , vial numbers and status of laboratory results.

QUARTER	DATE		OPO4			TDPO4			TAL			TPO4		
			Start	End	n	Start	End	n	Start	End	n	Start	End	n
Q1	19-Mar	Shallow	181	239	58	240	298	58	299	357	58			
Q1	19-Mar	Deep	358	416	58	417	475	58	476	534	58			
Q1	13-Jun	Deep	595	654	59	775	834	59	1050	1109	59			
Q1	24-Jun	Shallow	535	594	59	715	774	59	990	1049	59			
Q1	27-Jun	Deep	1170	1229	59	1350	1409	59	1625	1684	59			
Q1	17-Jul	Deep	1805	1864	59	1985	2044	59	2260	2319	59			
Q1	26-Jul	Grab	1865	1890	25	2045	2070	25	2320	2345	25	1895	1920	25
Q1	26-Jul	Composite										2075	2090	15
Q1	28-Jul	Composite										2091	2102	11
Q2	6-Aug	Composite										2346	2374	28
Q2	9-Aug	Grab	2480	2538	58	2660	2718	58	2915	2973	58	2539	2596	57
Q2	10-Aug	Grab	4525	4528	3	5525	5528	3	6525	6528	3	3344	3347	3
Q2	10-Aug	Composite						0				2985	3067	82
Q2	12-Aug	Grab pre-storm	4500	4524	24	5500	5524	24	6500	6524	24	3319	3343	24
Q2	13-Aug	Grab post-storm	3095	3150	55	3151	3206	55	3207	3262	55	3263	3318	55
Q2	14-Aug	Grab	4529	4587	58	5529	5587	58	6529	6587	58	3402	3460	58
Q2	19-Aug	Deep	4601	4660	59	5601	5660	59	6601	6660	59			
Q2	19-Aug	Shallow	4661	4720	59	5661	5720	59	6661	6720	59			
Q2	19-Aug	Grab	4721	4773	52	5721	5773	52	6721	6773	52	3474	3526	52
Q2	22-Aug	Composite										3585	3676	91
Q2	27-Aug	Grab	4774	4830	56	5774	5830	56	6774	6830	56	3527	3583	56
Q2	5-Sep	Grab	4832	4889	57	5832	5889	57	6832	6889	57	3677	3734	57
Q2	5-Sep	Composite			0							3741	3826	85
Q2	19-Sep	Deep	4906	4965	59	5890	5949	59	6890	6949	59			
Q2	30-Sep	Grab	7060	7117	57	8060	8117	57	9060	9117	57	3837	3894	57
Q2	3-Oct	Shallow	7000	7059	59	8000	8059	59	9000	9059	59			
Q2	20-Oct	Deep	7256	7315	59	8240	8299	59	9240	9299	59			
Q3	10-Nov	Shallow	7124	7183	59	8120	8179	59	9120	9179	59			
Q3	10-Nov	Deep	7196	7255	59	8180	8239	59	9180	9239	59			
Q3	17-Dec	Shallow	7322	7381	59	8306	8365	59	9306	9365	59			
Q3	22-Dec	Deep	7382	7441	59	8366	8425	59	9366	9425	59			
Q3	20-Jan	Deep	7442	7501	59	8426	8485	59	9426	9485	59			
Q4	18-Feb	Deep	7502	7561	59	8486	8545	59	9486	9545	59			
					1446			**1446**			**1446**			**756**

Received from ARL
Not Received
Pending
Not requested

TOTAL: 5094

As of the date of this report, over 5000 water samples have been collected and submitted to the laboratory for analysis. Five data sets from Quarter 2 are still being reviewed by the laboratory and have not been released.

In addition to the water sampling dates shown in Table 1, other project tasks and events include the following:

August 1 - Maintenance of samplers (pumps fixing, insect killing, CU maintenance)

August 6 - Maintenance of samplers (power units, pumps, insect elimination, CU maintenance)

August 8 – Samplers maintenance (replacing hoses, filters)

August 8 - 50 cows in the field as stored temporarily by ranch

August 9 – erosion bypass on some plots

August 12 – field maintenance and troubleshooting

August 12 – grass sampling

August 19 – retire old batteries; remove weeds from B and C

August 23 – restoration of eroded ditches

August 27 – soda apple removing, instruments maintenance

September 6 – GPS data collected

September 9 – weed removal B, C, 80 cows in the field, back gate removed from hinges.

September 30 – soda apple cutting

October 17 – started mowing and harvesting

October 31 – ended mowing and harvesting

B. GROUND WATER QUALITY

Shallow ground water samples were collected on August 19 and October 3 from wells that extend to a depth of 3 feet. Deep ground water samples were collected on August 19, September 19, and October 3 from wells that extend to a depth of 10 feet. Concentration results for ortho-phosphorus, total dissolved phosphorus and total aluminum plus time series graphs, treatment effect graphs, and block effect graphs for the shallow wells are provided in Tables 2-3 and Figures 1-33. Results for the deeper wells are shown in Tables 4-5 and Figures 34-66.

These results show that P movement to the ground water is greatest for the commercial fertilizer and chicken manure (Figures 13-14). This movement of phosphorus to the shallow ground water appears to be lower on plots, which received the WTR alum residuals (Figures 19-20, 25-26). The addition of alum residuals does not appear to elicit elevated levels of aluminum in the shallow ground water (Figures 24 and 27). Phosphorus concentrations in the shallow ground water of Block B show a disproportionate increase as compared to Blocks A and C. Also, a single sample from B15 on June 24 with unusually high phosphorus content is affecting the calculations of mean values for the chicken manure treatment. This is the cause of the low treatment mean appearing extremely large compared to the high treatment mean concentration (Figures 22-23, 55-56, and 58-59). The plot treatments show no apparent effect on deep ground water quality.

These results lead to variety of observations and questions:

Q: Why is ground water ortho-P higher in Low-P compared to High-P treated plots for both sources?
A: This may be related to the background P level in the soil. However, since soil samples were not collected from the plots prior to initiating the treatments, this possible explanation cannot be evaluated.

Q: Why do graph trends show higher ground water ortho-P than total dissolved P concentrations?
A: There is clearly a problem with the analysis of either the ortho-P or total-P. This lab issue must be investigated and resolved.

Q: Why is total aluminum in Boca-treated plots higher where alum residuals were not added?
A: the probable explanation is that the aluminum levels are all actually quite low and quite similar. Any differences between treatments are probably just natural variation.

Q: Where is all the aluminum in commercial fertilizer-treated plots coming from?
A: Again, the aluminum levels and variations observed appear to be natural and relatively low, not the result of our treatments.

Q: Why is the amount of P that leached into ground water the same for low and high P-treatments?
A: This suggests that fertilizer amount at these particular levels is not a significant environmental level.

Q: Why is there more TDPO4 in low-P than high-P treated plots?
A: This is the result of very few data points. Time will tell if this observation holds up.

Q: Why is there more P leaching into ground water from low-P than high-P treated plots?
A: Again, this is the result of very few data points. We must see if this anomaly continues.

Q: How would be the effect of blocking on the measured parameters different between shallow and deep ground water?
A: The shallow ground water is more affected by ground surface slope. Block A represents the higher, flatter portion of the pasture, while block C is the lower portion of the steeply sloped pasture and block B is the transition zone. The water table dynamics differ in these zones and therefore the nutrient content might also tend to vary.

Q: Why is more P coming off the control plots than P-amended plots?
A: There are only three control plots. Two are located at the ends of the blocks. This observation may simply be an artifact of the particular plots selected as controls.

Shallow Well Samples Results

Table 2. OPO4 concentrations (µg/L) as measured in shallow ground water wells between Aug 19 and Oct 3, 2003.

ID	19-Aug	3-Oct	Fertilizer	P Level	Alum
A1	91	862	Chicken	Low	w/Alum
A2	180	808	Boca	High	w/Alum
A3	904	1,038	Commercial	Low	w/Alum
A4	125	437	Pompano	High	w/Alum
A5	110	389	Chicken	Low	x/Alum
A6	76	592	Boca	High	x/Alum
A7	88	207	Pompano	Low	w/Alum
A8	2,951	2,824	Commercial	Low	x/Alum
A9	240	1,110	Chicken	High	w/Alum
A10	313	1,555	Pompano	Low	x/Alum
A11	351	550	Commercial	High	w/Alum
A12	22	191	Chicken	High	x/Alum
A13	250	885	Boca	Low	w/Alum
A14	3,636	5,267	Boca	Low	x/Alum
A15	2,328	4,653	Commercial	High	x/Alum
A16	34	1,913	Pompano	High	x/Alum
A17	1,245	1,728	NULL	NULL	NULL
B1	153	431	Chicken	Low	w/Alum
B2	9	231	Pompano	High	w/Alum
B3	2,471	1,895	Commercial	Low	w/Alum
B4	6	64	Boca	High	w/Alum
B5	12	24	Chicken	High	w/Alum
B6	14	24	Pompano	Low	w/Alum
B7	640	914	Boca	Low	w/Alum
B8	512	749	Pompano	Low	x/Alum
B9	2,188	1,989	Commercial	High	w/Alum
B10	1,409	82	Boca	High	x/Alum
B11	693	743	Commercial	Low	x/Alum
B12	1,537	2,996	Pompano	High	x/Alum
B13	1,011	1,946	NULL	NULL	NULL
B14	4,930	3,924	Boca	Low	x/Alum
B15	2,083	4,574	Chicken	Low	x/Alum
B16	12,753	8,520	Commercial	High	x/Alum
B17	1,104	3,277	Chicken	High	x/Alum
C1	4	10	Boca	Low	w/Alum
C2	4	24	Pompano	Low	w/Alum
C3	239	590	Chicken	Low	w/Alum
C4	2,224	2,597	Pompano	Low	x/Alum
C5	57	785	Boca	Low	x/Alum
C6	751	862	Chicken	Low	x/Alum
C7	2,465	1,091	Boca	High	w/Alum
C8	2,297	442	Commercial	Low	w/Alum
C9	162	302	Pompano	High	w/Alum
C10	918	624	Chicken	High	w/Alum
C11	1,761	946	Commercial	Low	x/Alum
C12	1,044	1,488	Boca	High	x/Alum
C13	77	104	Commercial	High	w/Alum
C14	404	742	Chicken	High	x/Alum
C15	4,814	6,570	Commercial	High	x/Alum
C16	379	2,025	Pompano	High	x/Alum
C17	352	401	NULL	NULL	NULL

Table 3. Total Aluminum concentrations (mg/L) as measured in shallow ground water wells between Aug 19 and Oct 3, 2003.

ID	19-Aug	3-Oct	Fertilizer	P Level	Alum
A1	0.8	0.4	Chicken	Low	w/Alum
A2	0.2	0.2	Boca	High	w/Alum
A3	0.4	0.3	Commercial	Low	w/Alum
A4	0.4	0.3	Pompano	High	w/Alum
A5	0.4	0.2	Chicken	Low	x/Alum
A6	0.1	0.3	Boca	High	x/Alum
A7	0.5	0.5	Pompano	Low	w/Alum
A8	0.4	0.2	Commercial	Low	x/Alum
A9	0.4	0.5	Chicken	High	w/Alum
A10	0.3	0.3	Pompano	Low	x/Alum
A11	0.2	0.3	Commercial	High	w/Alum
A12	0.7	0.4	Chicken	High	x/Alum
A13	0.4	0.3	Boca	Low	w/Alum
A14	0.3	0.3	Boca	Low	x/Alum
A15	0.5	0.6	Commercial	High	x/Alum
A16	0.3	0.3	Pompano	High	x/Alum
A17	0.5	0.5	NULL	NULL	NULL
B1	0.4	0.2	Chicken	Low	w/Alum
B2	0.6	0.4	Pompano	High	w/Alum
B3	1.0	0.9	Commercial	Low	w/Alum
B4	0.9	0.6	Boca	High	w/Alum
B5	0.5	0.5	Chicken	High	w/Alum
B6	0.3	0.4	Pompano	Low	w/Alum
B7	0.3	0.4	Boca	Low	w/Alum
B8	0.5	0.8	Pompano	Low	x/Alum
B9	0.9	0.5	Commercial	High	w/Alum
B10	0.9	0.7	Boca	High	x/Alum
B11	1.0	1.4	Commercial	Low	x/Alum
B12	0.7	0.4	Pompano	High	x/Alum
B13	0.3	0.2	NULL	NULL	NULL
B14	0.4	0.2	Boca	Low	x/Alum
B15	0.3	0.2	Chicken	Low	x/Alum
B16	0.4	0.4	Commercial	High	x/Alum
B17	0.5	0.4	Chicken	High	x/Alum
C1	0.7	0.7	Boca	Low	w/Alum
C2	1.4	0.5	Pompano	Low	w/Alum
C3	1.1	0.7	Chicken	Low	w/Alum
C4	0.6	0.5	Pompano	Low	x/Alum
C5	0.3	0.2	Boca	Low	x/Alum
C6	0.6	0.3	Chicken	Low	x/Alum
C7	0.4	0.3	Boca	High	w/Alum
C8	0.6	0.2	Commercial	Low	w/Alum
C9	0.2	0.0	Pompano	High	w/Alum
C10	0.3	0.1	Chicken	High	w/Alum
C11	0.5	0.5	Commercial	Low	x/Alum
C12	1.0	0.7	Boca	High	x/Alum
C13	1.0	0.6	Commercial	High	w/Alum
C14	0.7	1.3	Chicken	High	x/Alum
C15	0.4	0.1	Commercial	High	x/Alum
C16	0.2	0.1	Pompano	High	x/Alum
C17	0.5	0.3	NULL	NULL	NULL

Shallow Well Samples Time Series

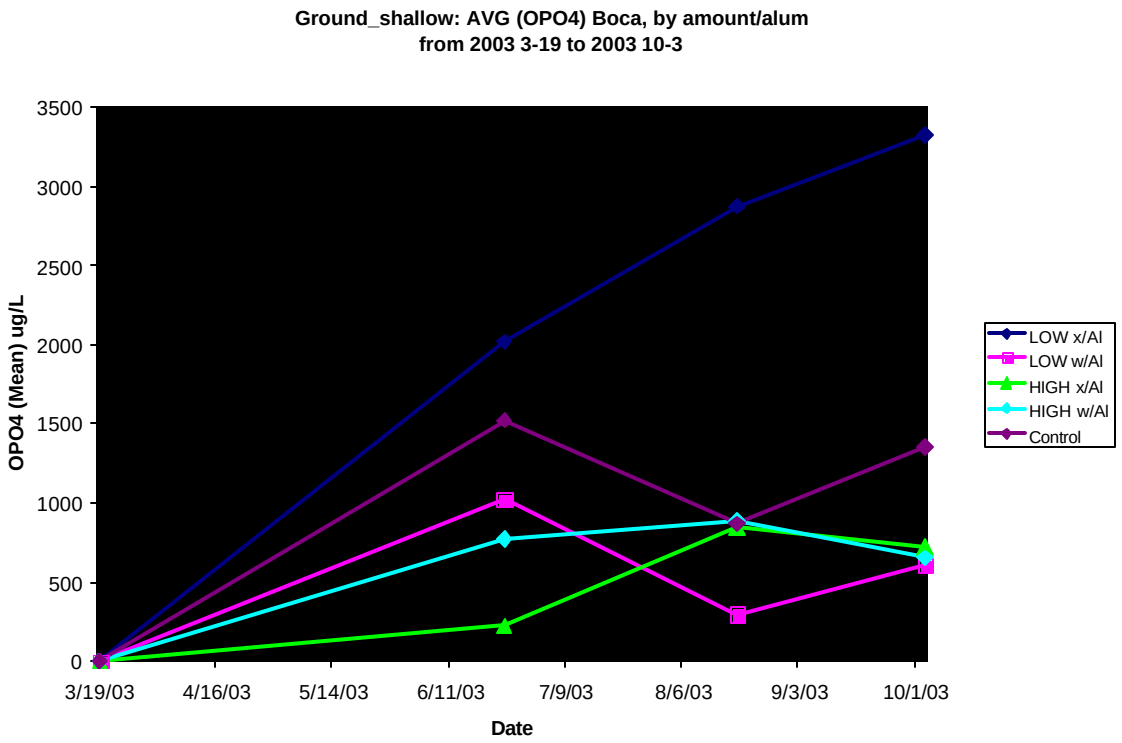

Figure 1. Mean ortho-phosphorus concentrations in shallow ground water wells for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

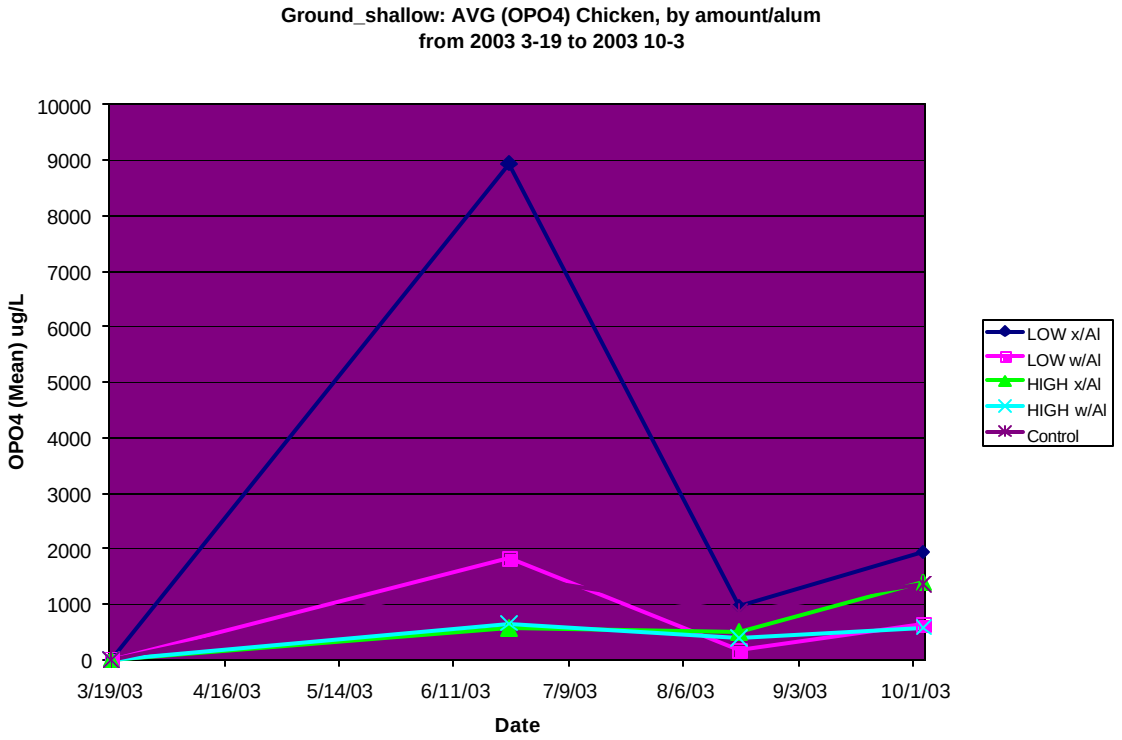

Figure 2. Mean ortho-phosphorus concentrations in shallow ground water wells for chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

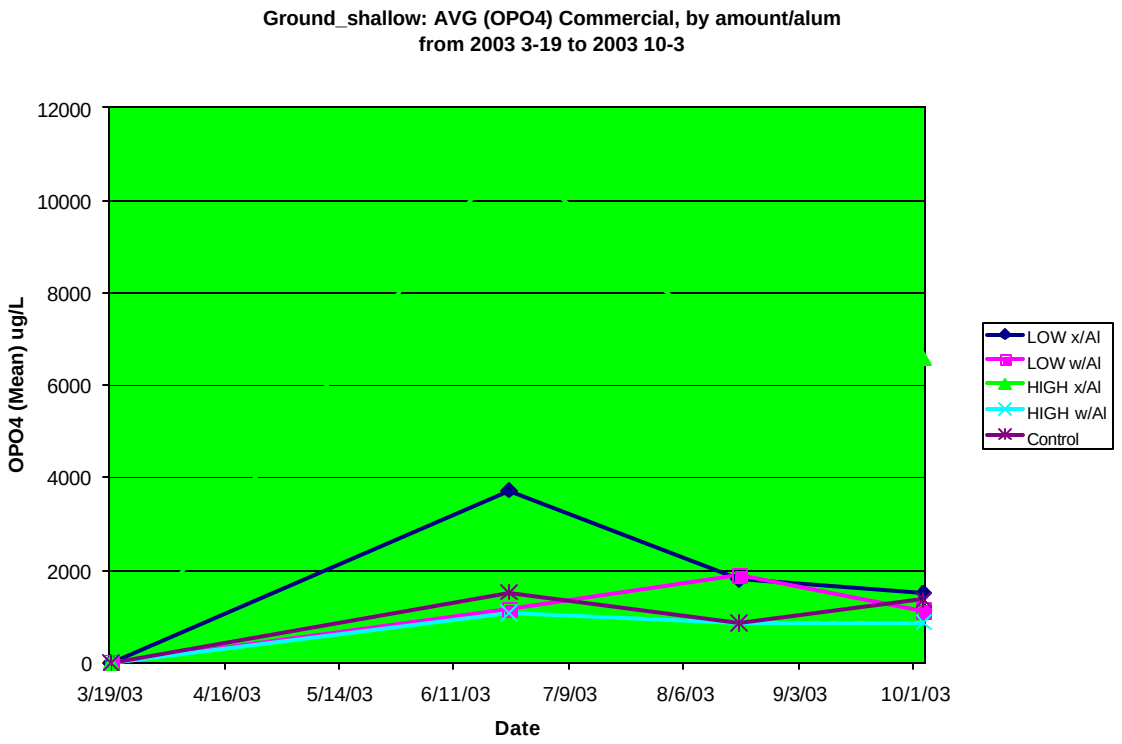

Figure 3. Mean ortho-phosphorus concentrations in shallow ground water wells for commercial fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

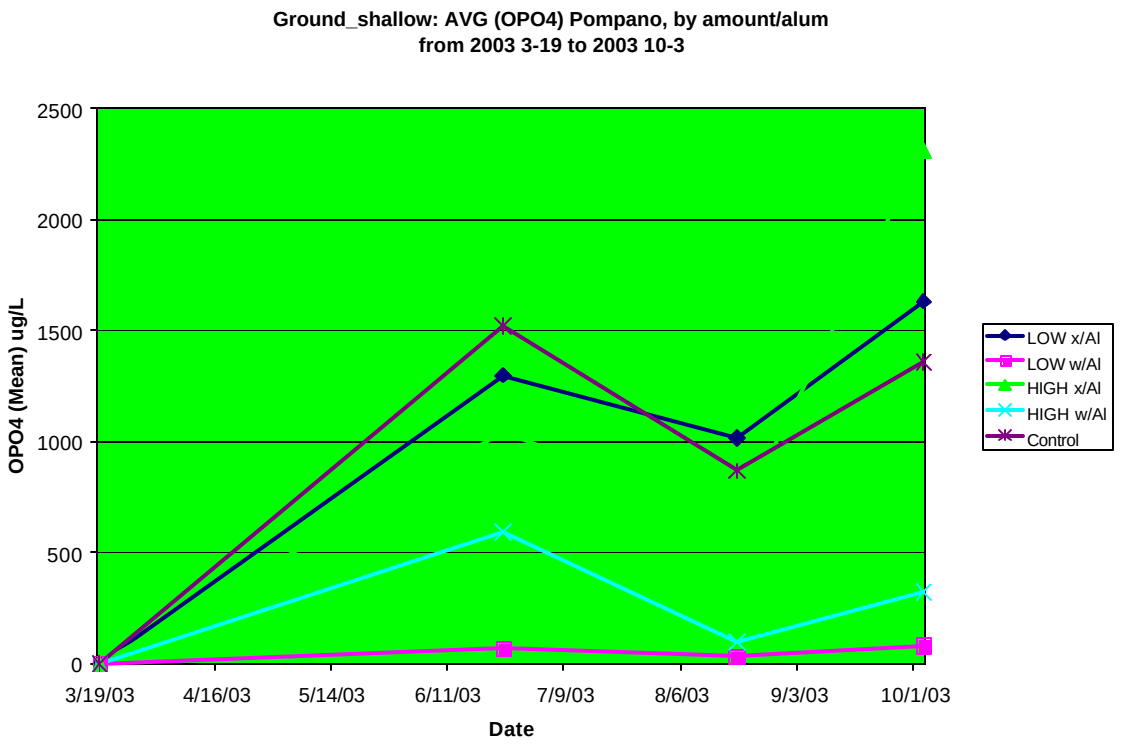

Figure 4. Mean ortho-phosphorus concentrations in shallow ground water wells for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

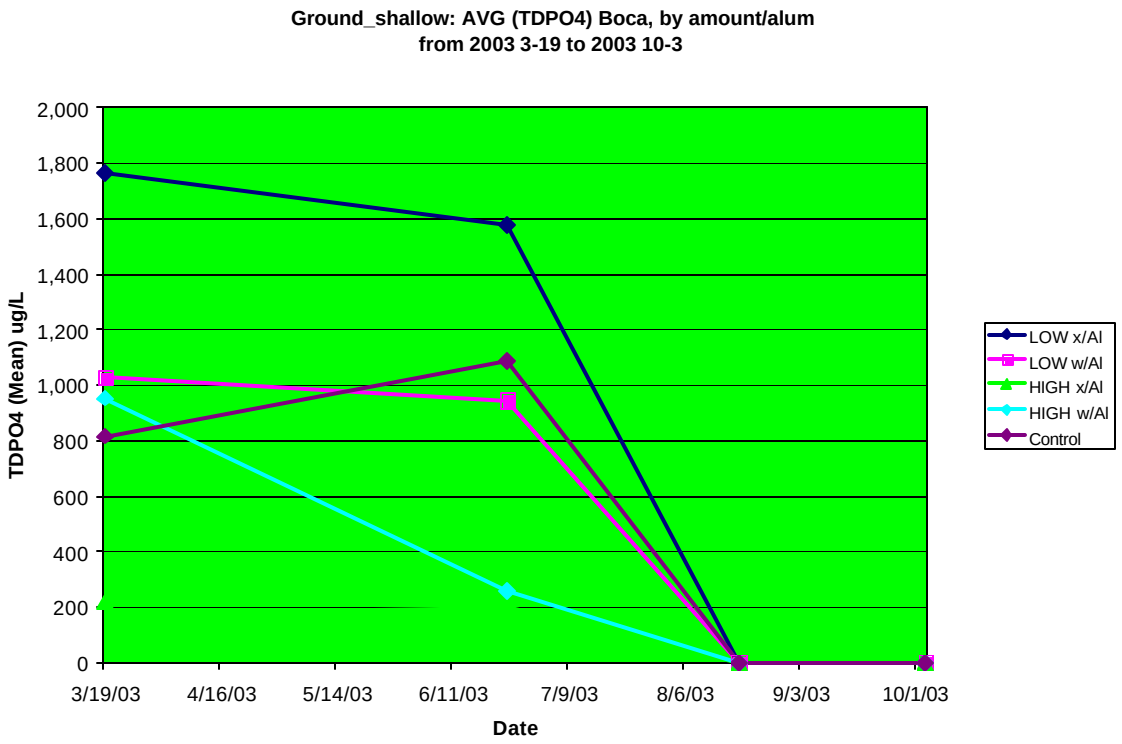

Figure 5. Mean total dissolved phosphorus concentrations in shallow ground water wells for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

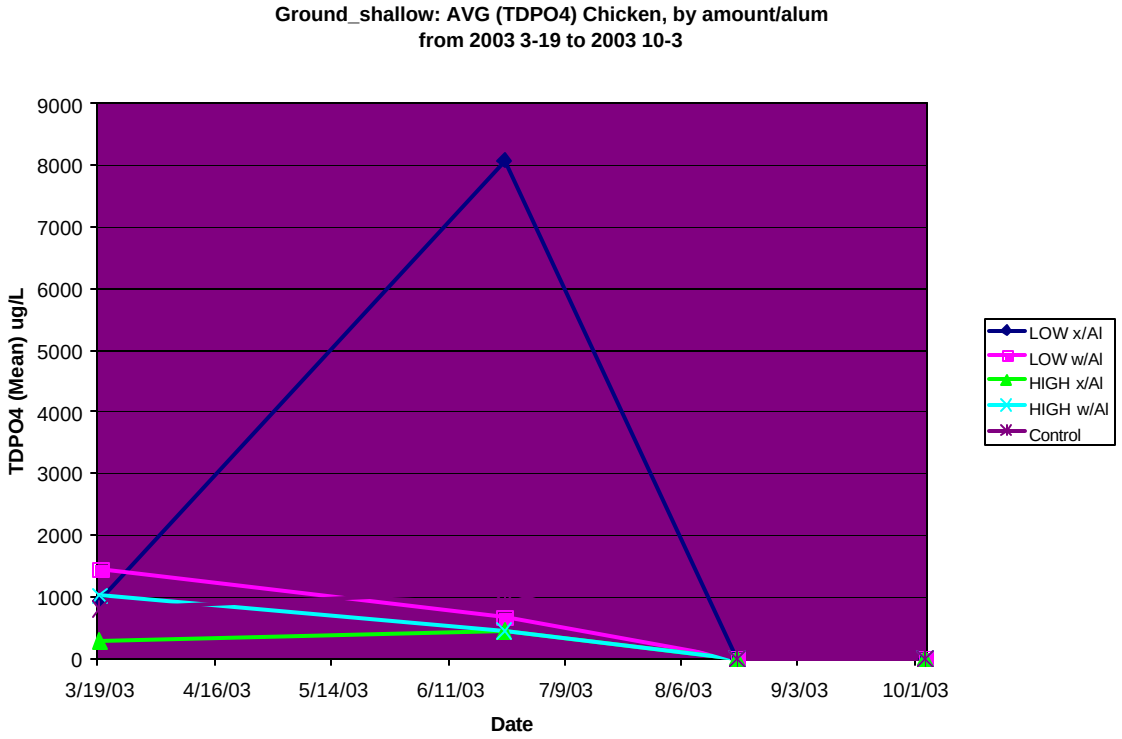

Figure 6. Mean total dissolved phosphorus concentrations in shallow ground water wells for chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

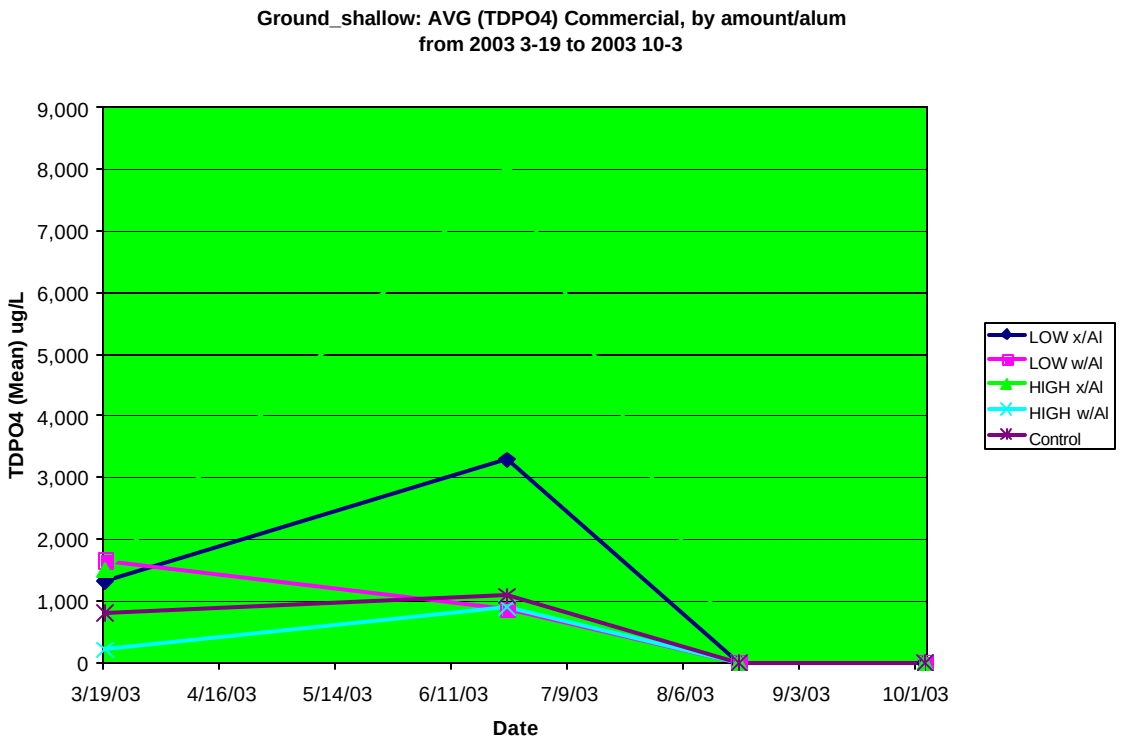

Figure 7. Mean total dissolved phosphorus concentrations in shallow ground water wells for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

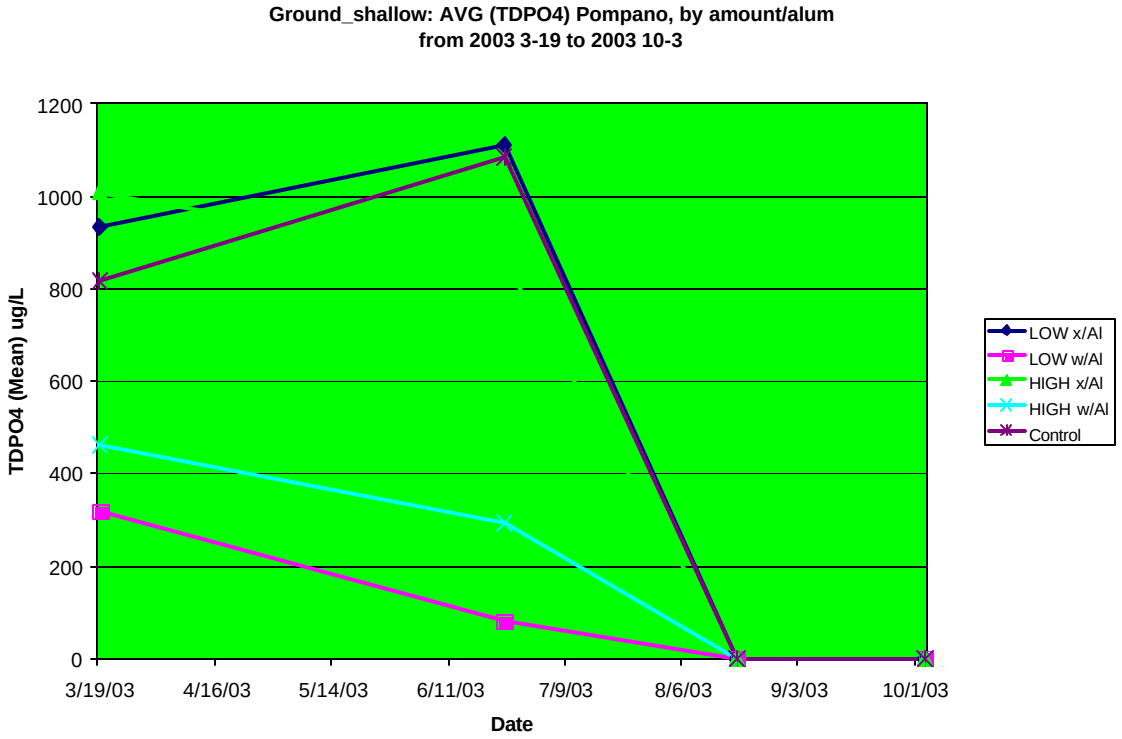

Figure 8. Mean total dissolved phosphorus concentrations in shallow ground water wells for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

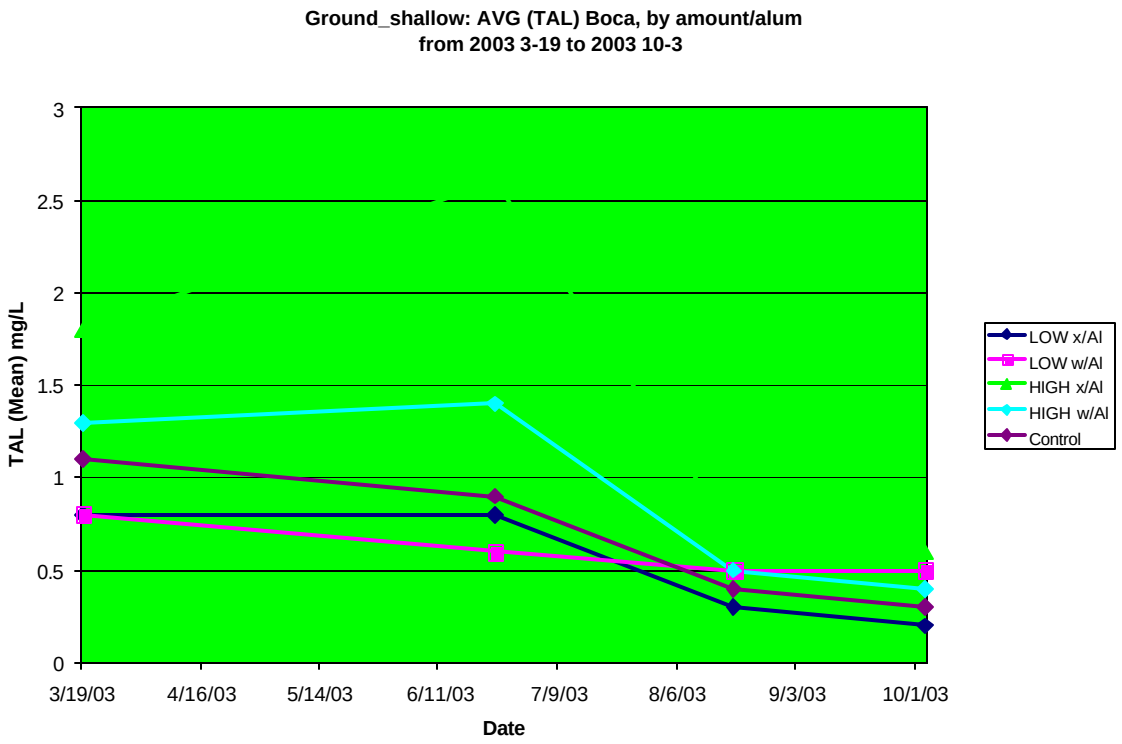

Figure 9. Mean total aluminum concentrations in shallow ground water wells for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

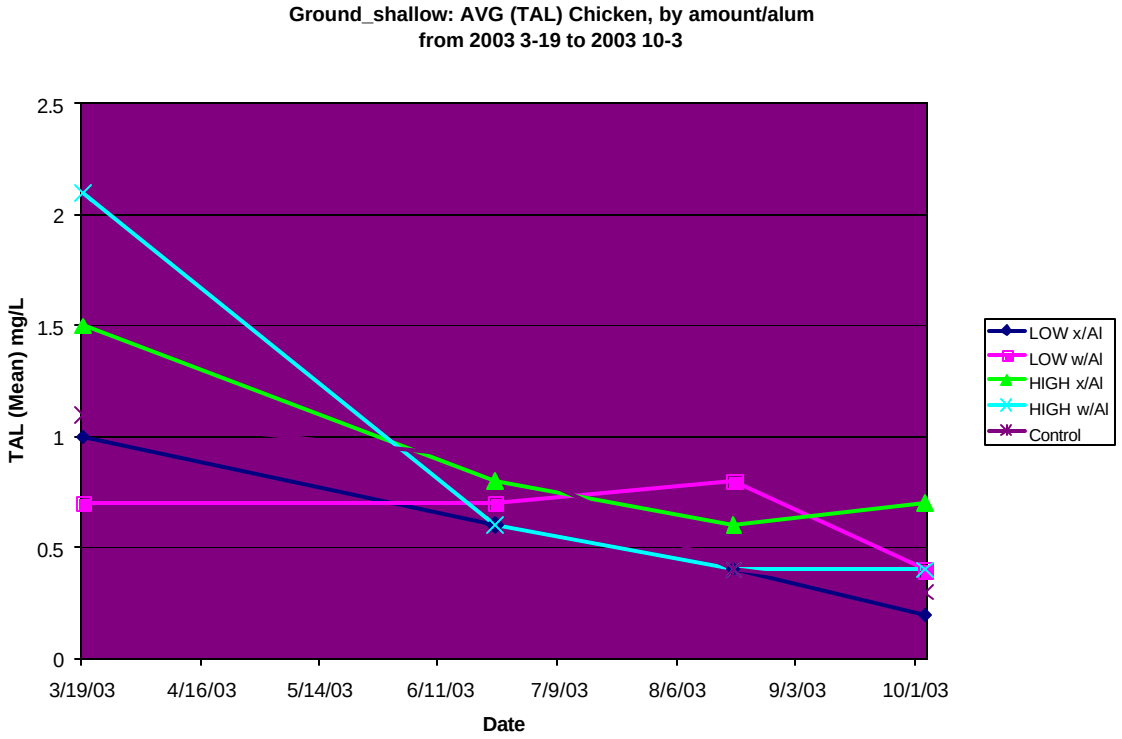

Figure 10. Mean total aluminum concentrations in shallow ground water wells for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

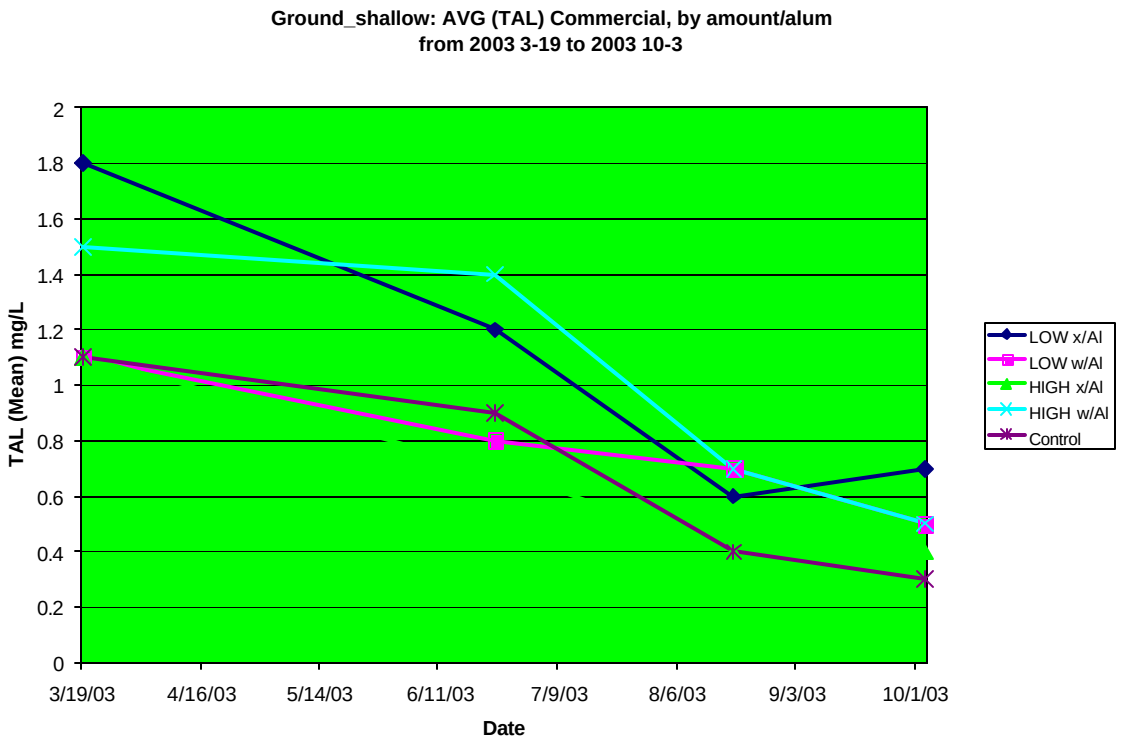

Figure 11. Mean total aluminum concentrations in shallow ground water wells for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

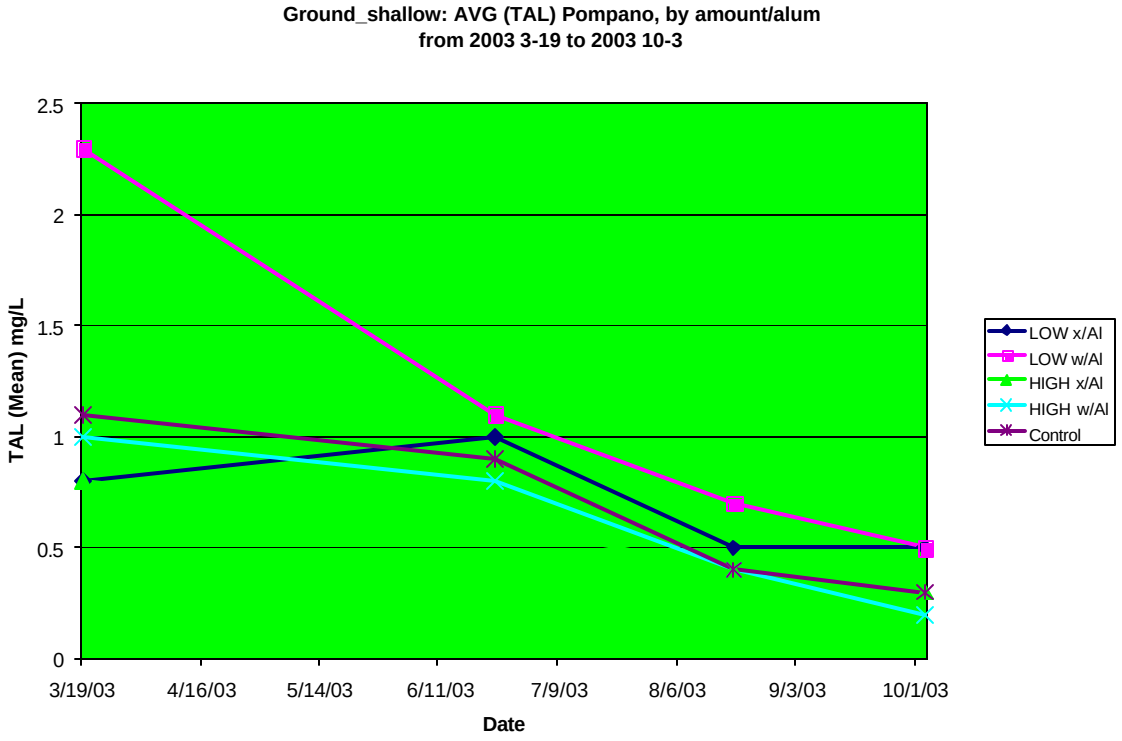

Figure 12. Mean total aluminum concentrations in shallow ground water wells for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 3, 2003.

Shallow Well Samples Treatment Effects

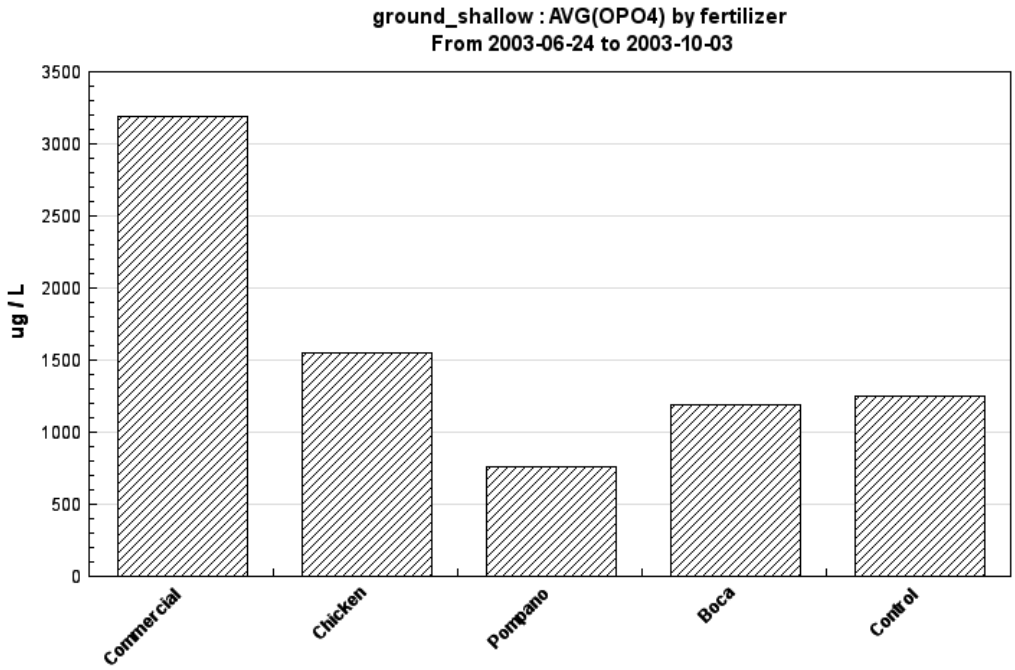

Figure 13. Mean ortho-phosphorus concentration by fertilizer source as measured in shallow ground water wells between June 24 and October 3, 2003.

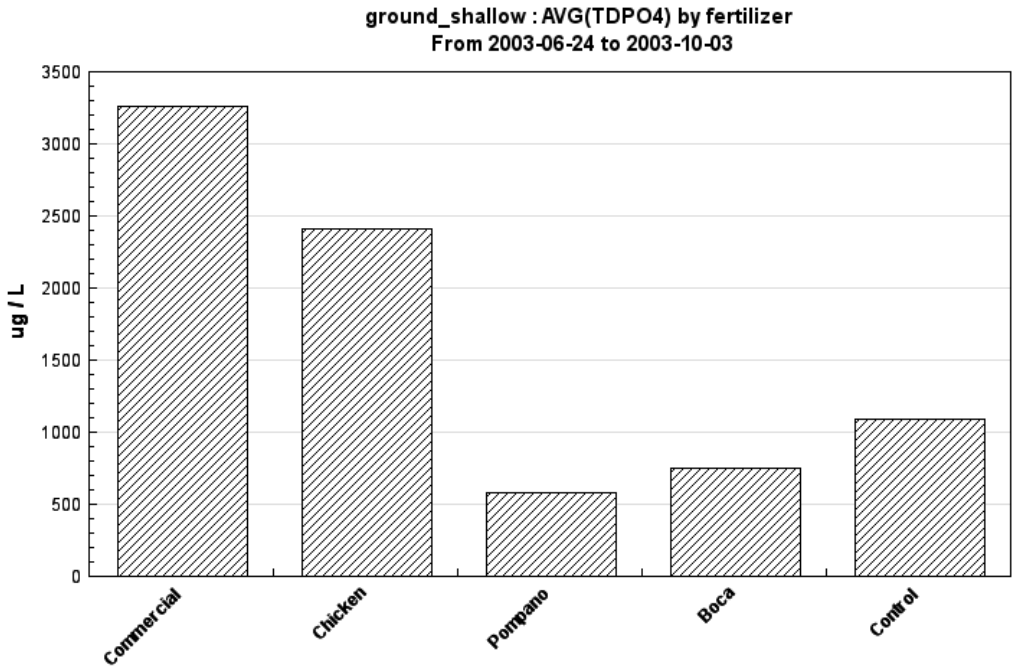

Figure 14. Mean total dissolved phosphorus concentration by fertilizer source as measured in shallow ground water wells between June 24 and October 3, 2003.

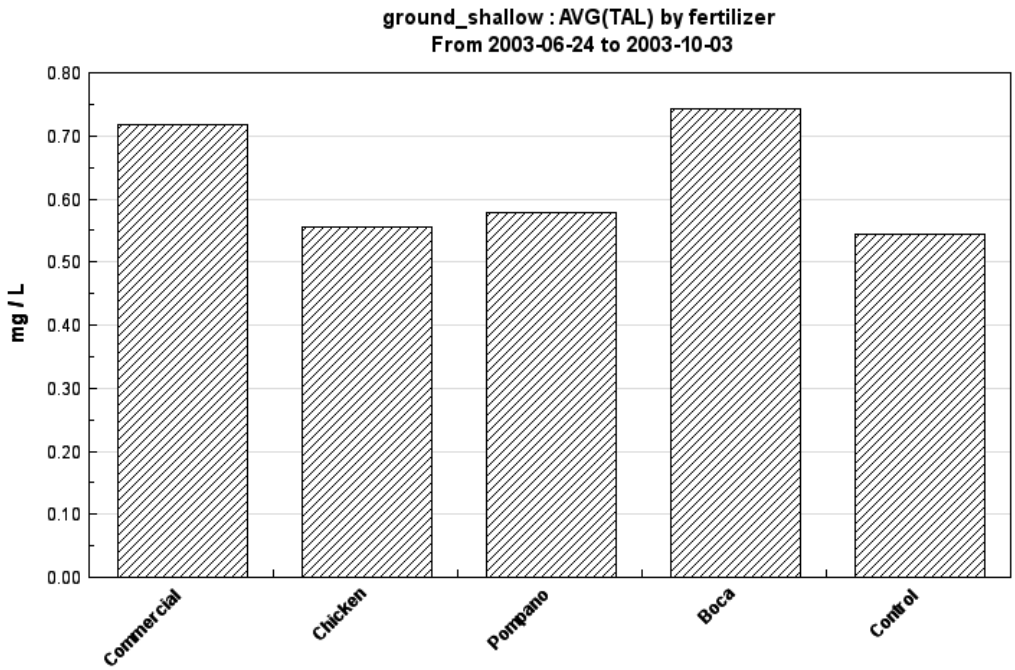

Figure 15. Mean total aluminum concentration by fertilizer source as measured in shallow ground water wells between June 24 and October 3, 2003.

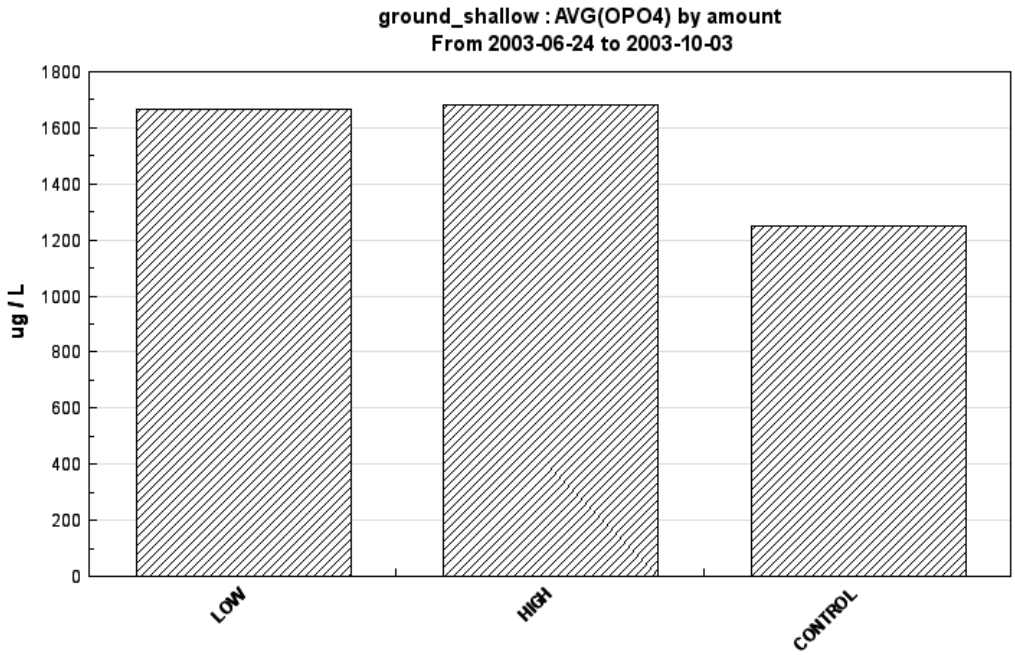

Figure 16. Mean ortho-phosphorus concentration by amount as measured in shallow ground water wells between June 24 and October 3, 2003.

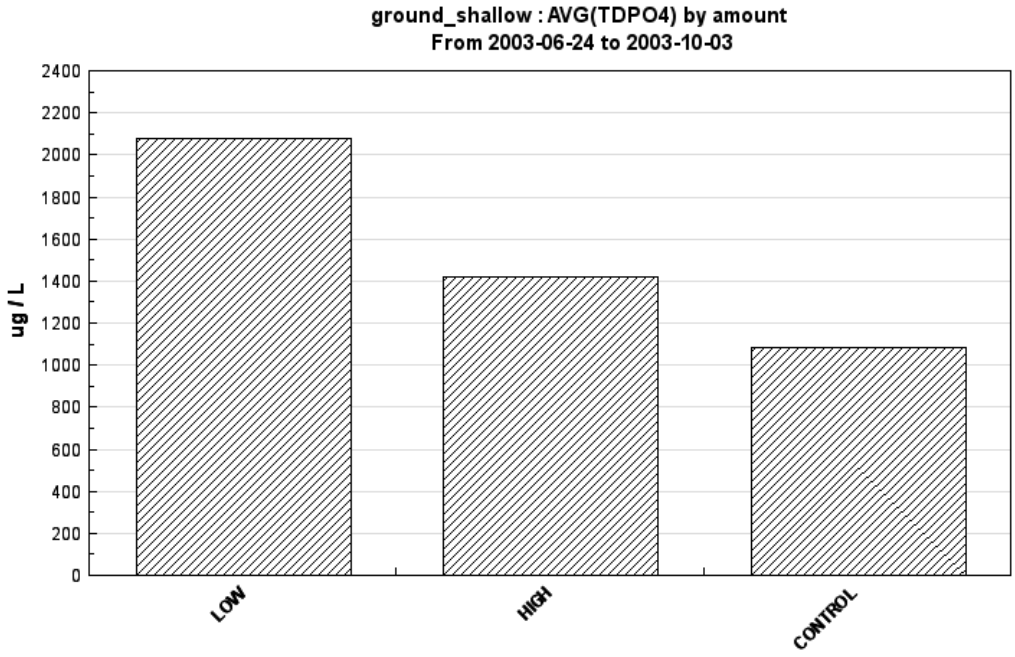

Figure 17. Mean total dissolved phosphorus concentration by amount as measured in shallow ground water wells between June 24 and October 3, 2003.

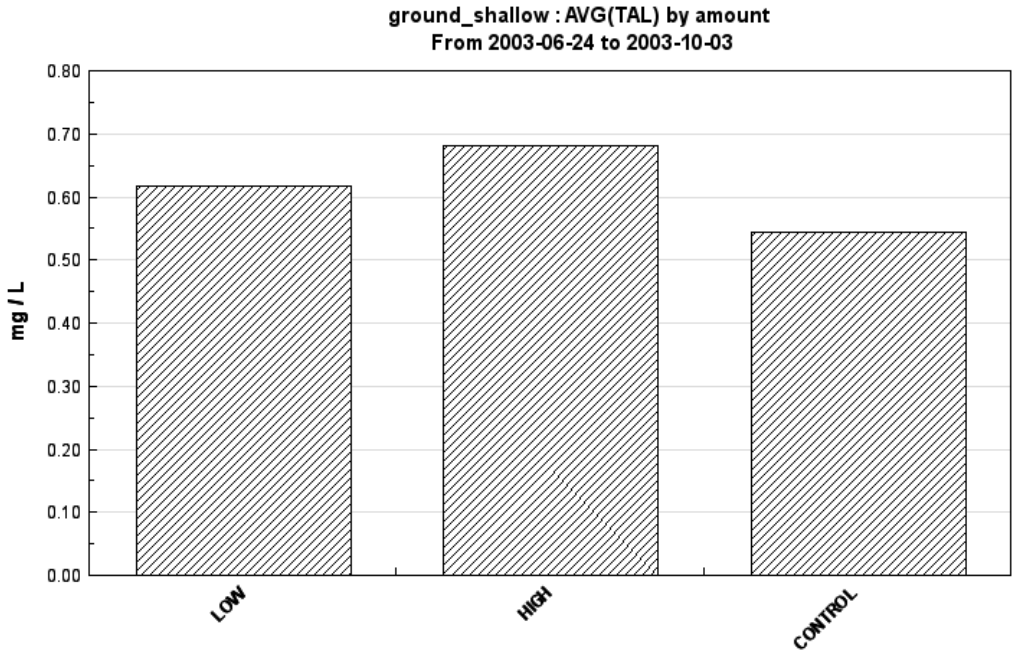

Figure 18. Mean total aluminum concentration by amount as measured in shallow ground water wells between June 24 and October 3, 2003.

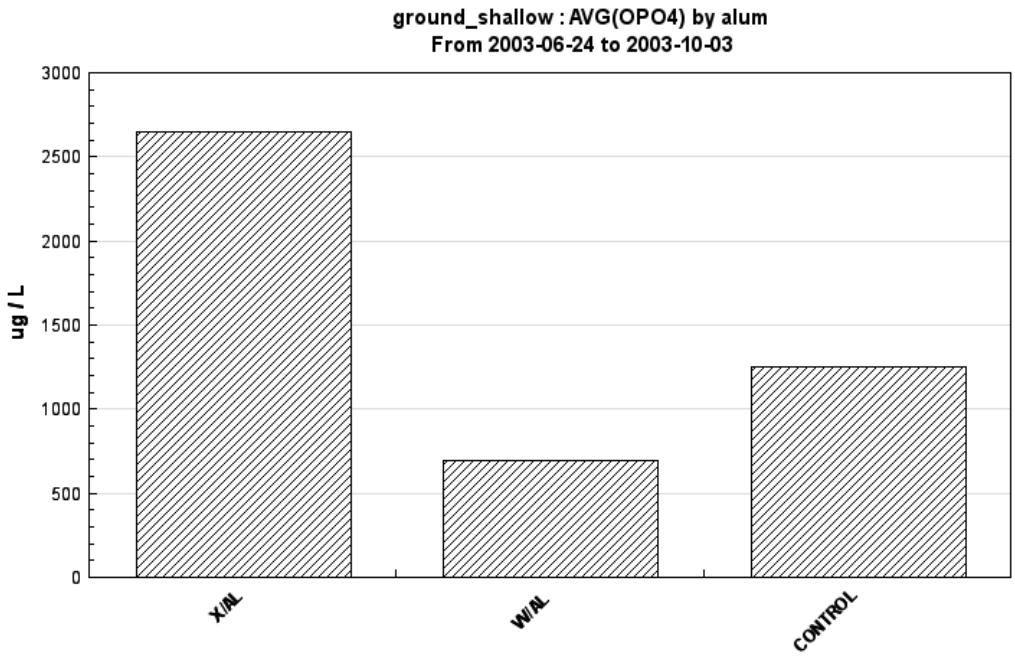

Figure 19. Mean ortho-phosphorus concentration by WTR amendment (alum) as measured in shallow ground water wells between June 24 and October 3, 2003.

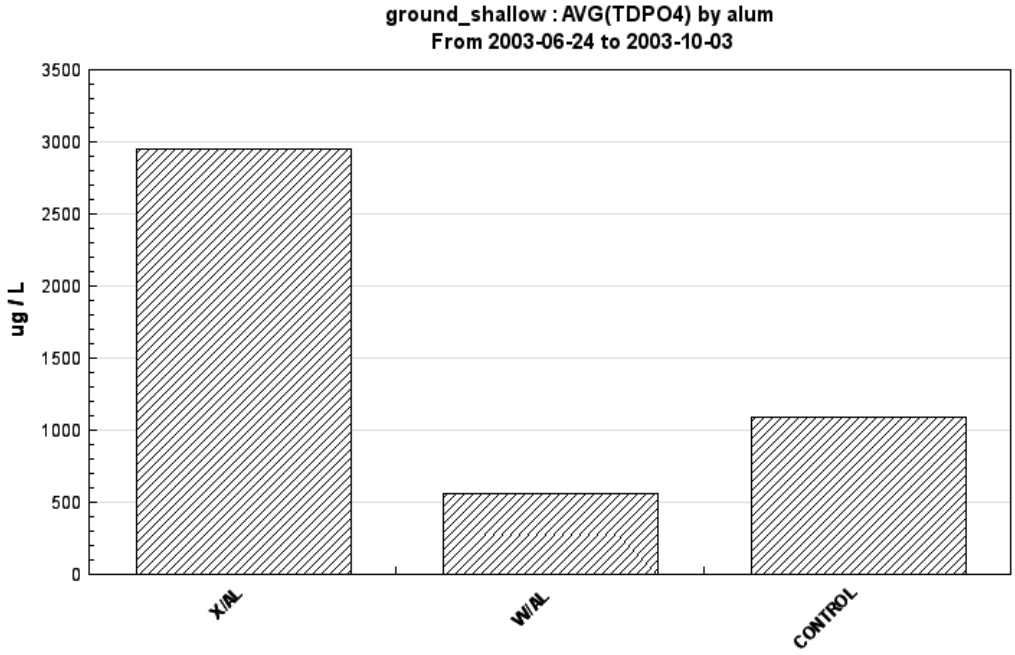

Figure 20. Mean total dissolved phosphorus concentration by WTR amendment (alum) as measured in shallow ground water wells between June 24 and October 3, 2003.

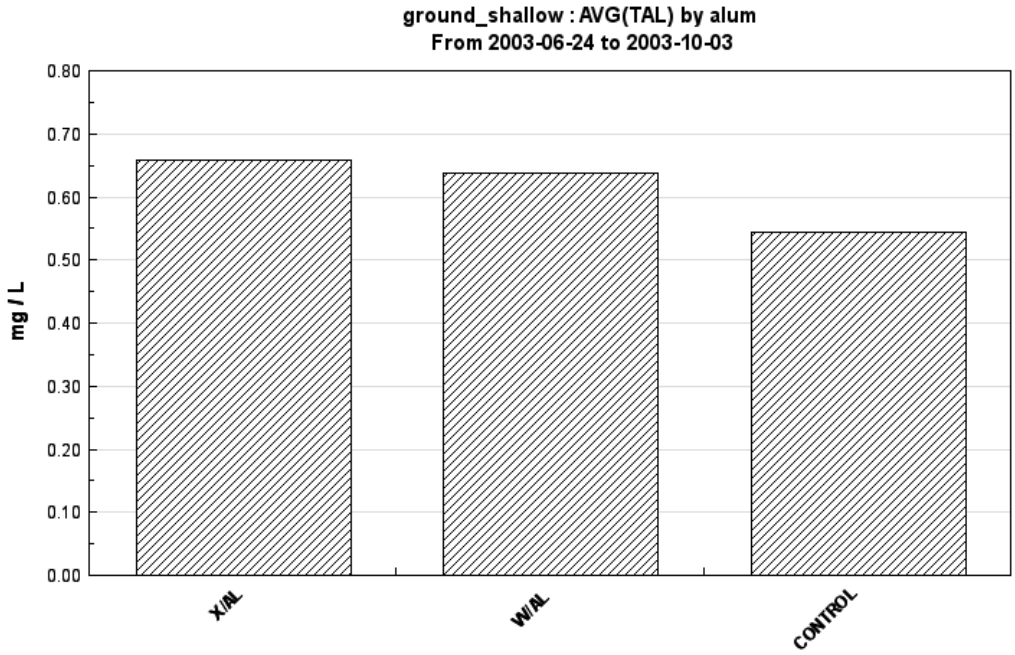

Figure 21. Mean total aluminum concentration by WTR amendment (alum) as measured in shallow ground water wells between June 24 and October 3, 2003.

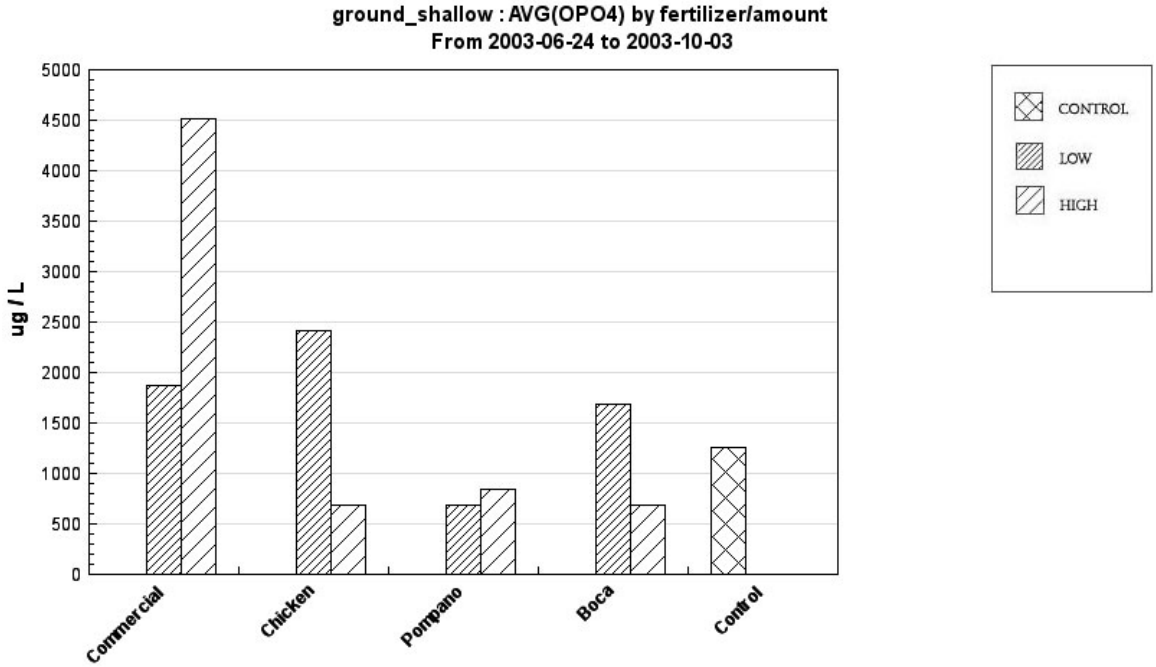

Figure 22. Mean ortho-phosphorus concentration by fertilizer source and amount as measured in shallow ground water wells between June 24 and October 3, 2003.

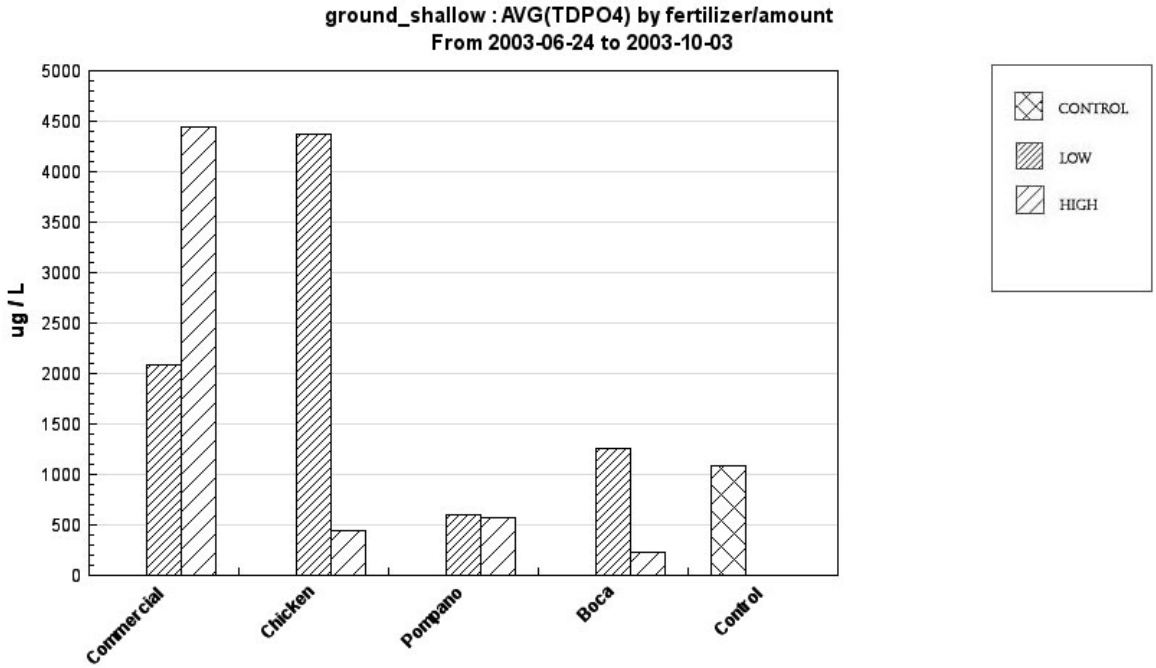

Figure 23. Mean total dissolved phosphorus concentration by fertilizer source and amount as measured in shallow ground water wells between June 24 and October 3, 2003.

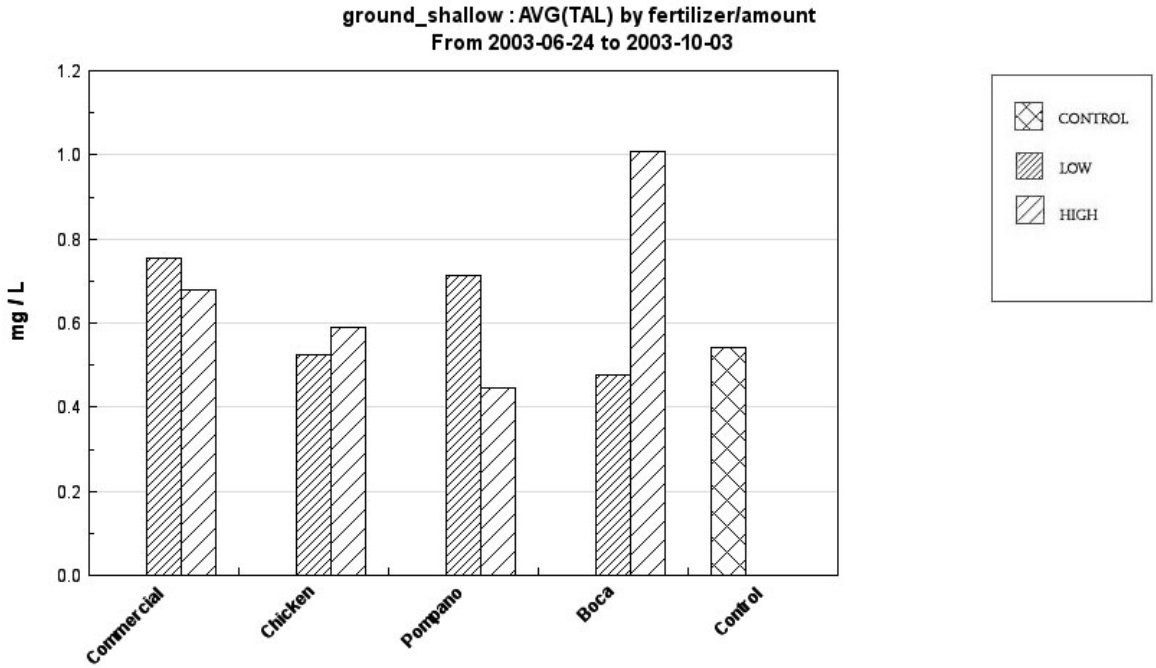

Figure 24. Mean total aluminum concentration by fertilizer source and amount as measured in shallow ground water wells between June 24 and October 3, 2003.

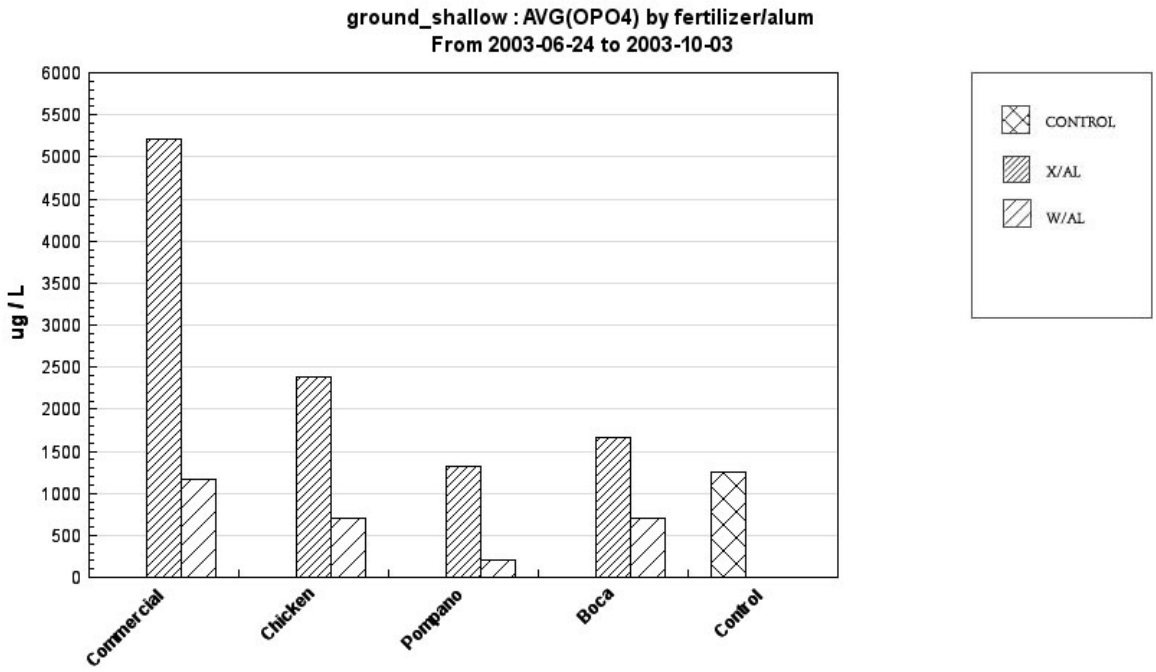

Figure 25. Mean ortho-phosphorus concentration by fertilizer source and WTR amendment (alum) as measured in shallow ground water wells between June 24 and October 3, 2003.

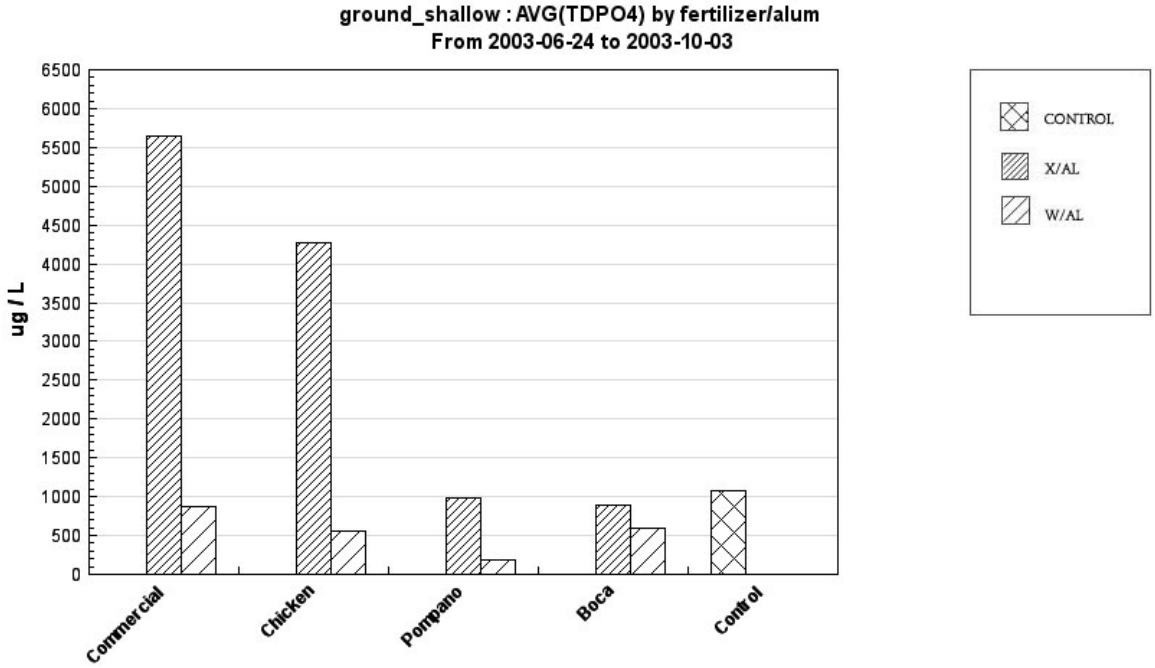

Figure 26. Mean total dissolved phosphorus concentration by fertilizer source and WTR amendment (alum) as measured in shallow ground water wells between June 24 and October 3, 2003.

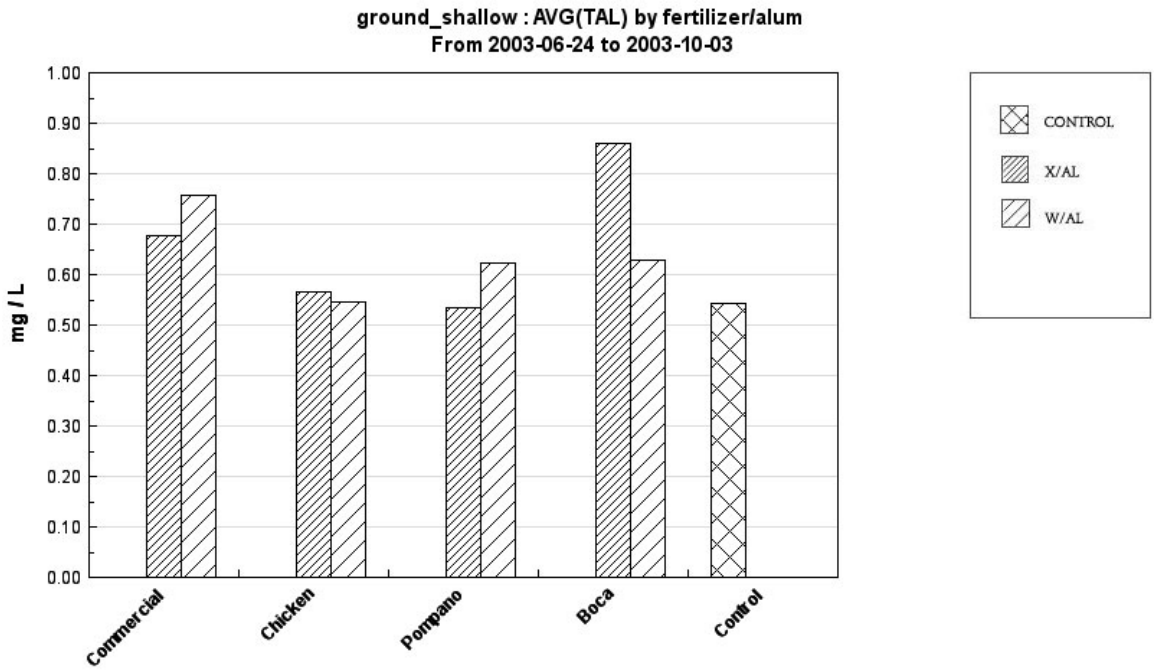

Figure 27. Mean total aluminum concentration by fertilizer source and WTR amendment (alum) as measured in shallow ground water wells between June 24 and October 3, 2003.

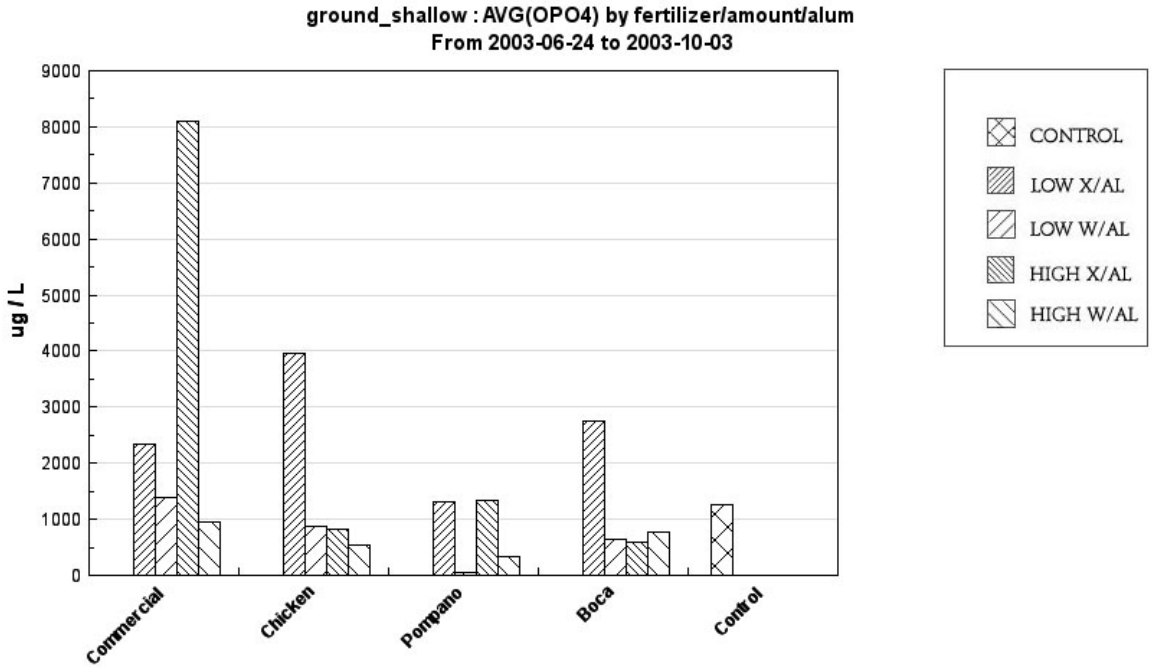

Figure 28. Mean ortho-phosphorus concentration by fertilizer source, amount and WTR amendment (alum) as measured in shallow ground water wells between June 24 and October 3, 2003.

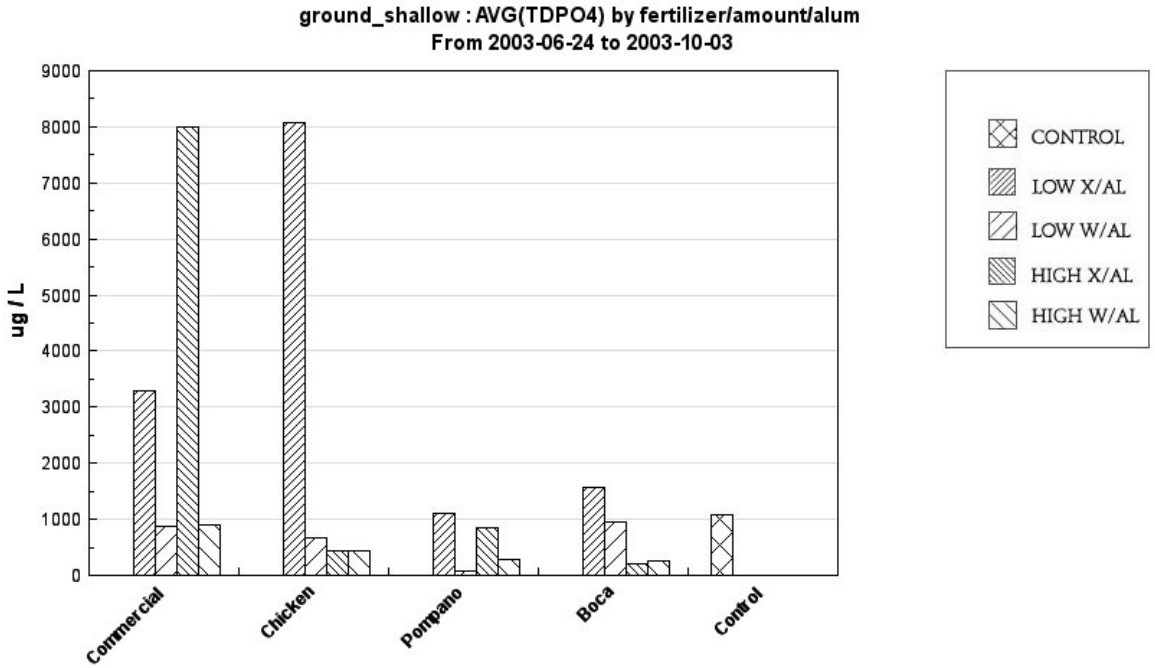

Figure 29. Mean total dissolved phosphorus concentration by fertilizer source, amount and WTR amendment (alum) as measured in shallow ground water wells on between June 24 and October 3, 2003.

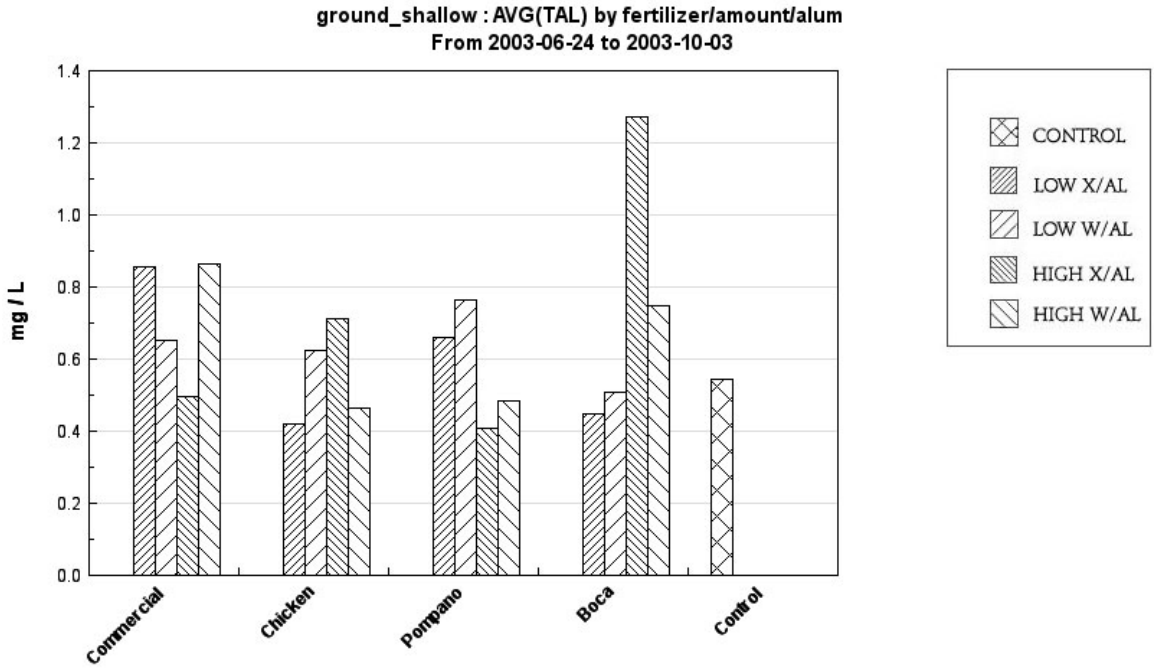

Figure 30. Mean total aluminum concentration by fertilizer source, amount and WTR amendment (alum) as measured in shallow ground water wells between June 24 and October 3, 2003.

Shallow Well Samples Block Effects

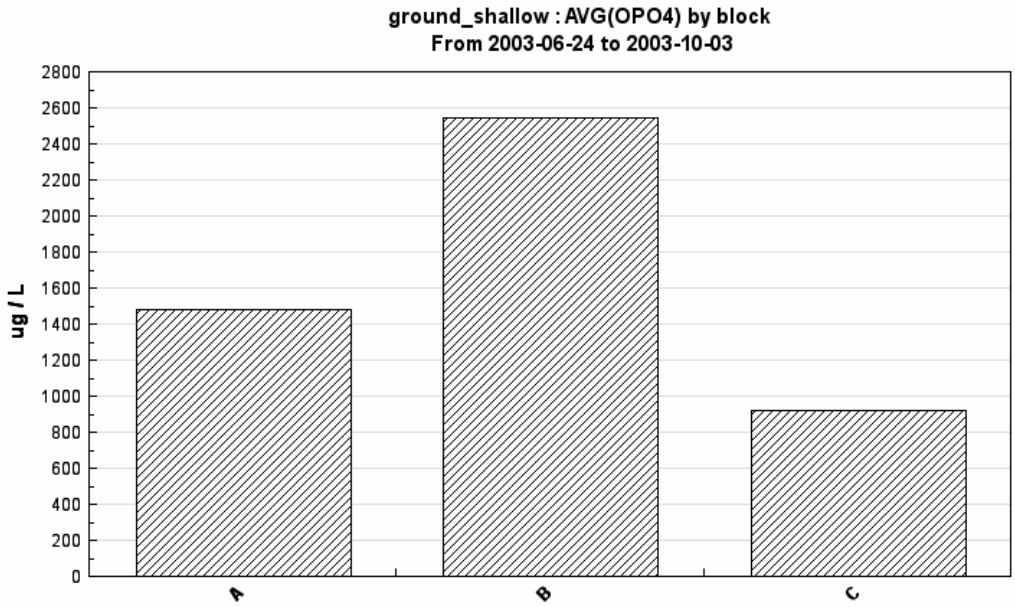

Figure 31. Mean ortho-phosphorus concentrations by block as measured in shallow ground water wells between June 24 and October 3, 2003.

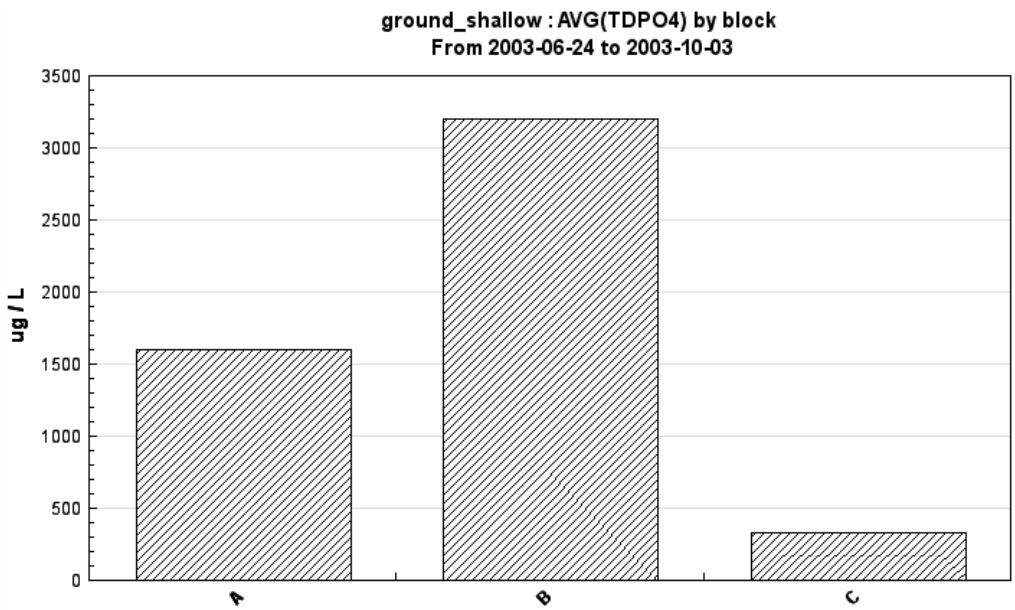

Figure 32. Mean total dissolved phosphorus concentrations by block as measured in shallow ground water wells between June 24 and October 3, 2003.

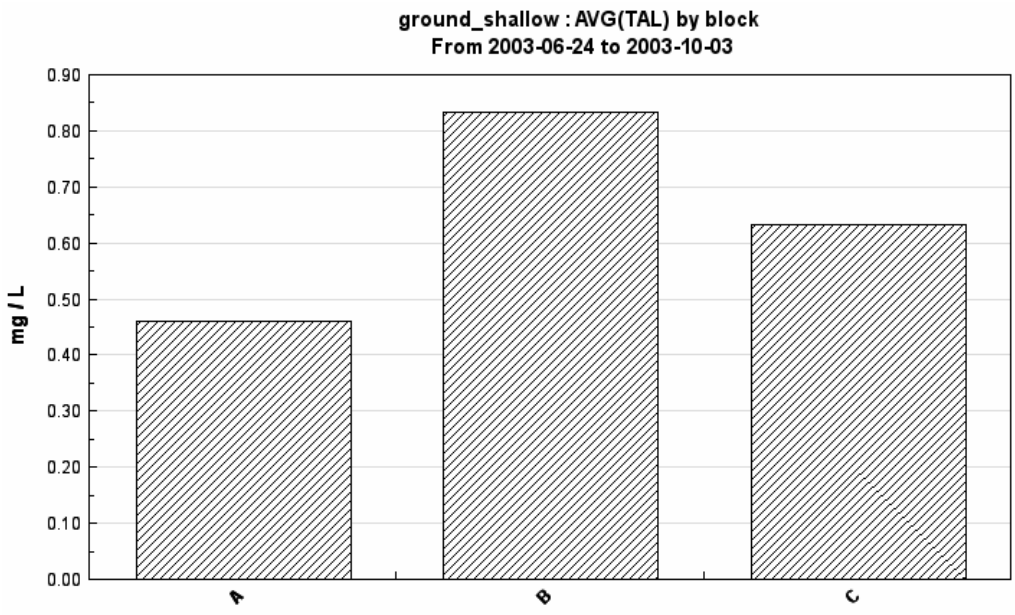

Figure 33. Mean total aluminum concentrations by block as measured in shallow ground water wells between June 24 and October 3, 2003.

Deep Well Samples Results

Table 4. OPO4 concentrations (µg/L) as measured in deep ground water wells between Aug 19 and Oct 20, 2003.

ID	19-Aug	19-Sep	20-Oct	Fertilizer	P Level	Alum
A1	7,287	4,590	3,419	Chicken	Low	w/Alum
A2	4,150	2,420	2,570	Boca	High	w/Alum
A3	1,693	1,147	2,328	Commercial	Low	w/Alum
A4	1,425	1,506	2,374	Pompano	High	w/Alum
A5	2,449	1,141	5,166	Chicken	Low	x/Alum
A6	1,647	1,250	1,403	Boca	High	x/Alum
A7	288	320	3124	Pompano	Low	w/Alum
A8	1,395	1,230	1,418	Commercial	Low	x/Alum
A9	655	711	2479	Chicken	High	w/Alum
A10	2,728	1,910	2,682	Pompano	Low	x/Alum
A11	575	785	838	Commercial	High	w/Alum
A12	1,923	1,265	2,336	Chicken	High	x/Alum
A13	1,685	1,992	3,722	Boca	Low	w/Alum
A14	890	1,671	1,594	Boca	Low	x/Alum
A15	3,153	1,908	2,354	Commercial	High	x/Alum
A16	1,740	1,471	2,304	Pompano	High	x/Alum
A17	4,922	4,575	2,985	*NULL*	*NULL*	*NULL*
B1	116	270	2078	Chicken	Low	w/Alum
B2	18	2	1129	Pompano	High	w/Alum
B3	10	3	2138	Commercial	Low	w/Alum
B4	11	2	1226	Boca	High	w/Alum
B5	7	3	1665	Chicken	High	w/Alum
B6	14	9	921	Pompano	Low	w/Alum
B7	529	1,404	5,161	Boca	Low	w/Alum
B8	681	946	1666	Pompano	Low	x/Alum
B9	19	21	4028	Commercial	High	w/Alum
B10	25	27	3392	Boca	High	x/Alum
B11	675	1,415	1,545	Commercial	Low	x/Alum
B12	1,268	1,621	3,714	Pompano	High	x/Alum
B13	2,404	1,313	1,852	*NULL*	*NULL*	***NULL***
B14	3,540	8,299	4,433	Boca	Low	x/Alum
B15	529	1,531	4,398	Chicken	Low	x/Alum
B16	7,275	5,199	5,426	Commercial	High	x/Alum
B17	1,218	991	816	Chicken	High	x/Alum
C1	6	21	990	Boca	Low	w/Alum
C2	12	2	1866	Pompano	Low	w/Alum
C3	17	13	3719	Chicken	Low	w/Alum
C4	15	22	6555	Pompano	Low	x/Alum
C5	499	2,370	1,071	Boca	Low	x/Alum
C6	58	66	1436	Chicken	Low	x/Alum
C7	810	906	1512	Boca	High	w/Alum
C8	1,445	1,061	1,210	Commercial	Low	w/Alum
C9	167	561	2425	Pompano	High	w/Alum
C10	379	250	2731	Chicken	High	w/Alum
C11	69	100	1313	Commercial	Low	x/Alum
C12	19	2	2136	Boca	High	x/Alum
C13	9	2	2863	Commercial	High	w/Alum
C14	58	90	3102	Chicken	High	x/Alum
C15	76	424	2835	Commercial	High	x/Alum
C16	433	406	2991	Pompano	High	x/Alum
C17	705	487	146	*NULL*	*NULL*	***NULL***

Table 5. Total Aluminum concentrations (mg/L) as measured in deep ground water wells between Aug 19 and Oct 20, 2003.

ID	19-Aug	19-Sep	20-Oct	Fertilizer	P Level	Alum
A1	1.8	0.7	0.5	Chicken	Low	w/Alum
A2	2.5	1.3	2.2	Boca	High	w/Alum
A3	2.2	1.0	1.9	Commercial	Low	w/Alum
A4	2.5	0.6	2.9	Pompano	High	w/Alum
A5	3.9	1.2	4.7	Chicken	Low	x/Alum
A6	1.7	0.8	2.3	Boca	High	x/Alum
A7	0.8	0.0	0.8	Pompano	Low	w/Alum
A8	0.6	0.6	1.1	Commercial	Low	x/Alum
A9	2.2	1.2	2.3	Chicken	High	w/Alum
A10	1.4	0.5	1.4	Pompano	Low	x/Alum
A11	0.8	0.2	1.2	Commercial	High	w/Alum
A12	1.7	0.4	1.1	Chicken	High	x/Alum
A13	1.6	0.0	1.9	Boca	Low	w/Alum
A14	0.9	0.0	1.3	Boca	Low	x/Alum
A15	1.4	0.5	0.9	Commercial	High	x/Alum
A16	0.8	0.9	1.5	Pompano	High	x/Alum
A17	0.9	0.1	0.8	*NULL*	*NULL*	*NULL*
B1	0.8	0.6	1.7	Chicken	Low	w/Alum
B2	1.1	1.6	1.9	Pompano	High	w/Alum
B3	1.0	0.4	0.7	Commercial	Low	w/Alum
B4	0.5	0.0	0.6	Boca	High	w/Alum
B5	0.6	0.0	0.3	Chicken	High	w/Alum
B6	0.4	0.1	0.7	Pompano	Low	w/Alum
B7	1.3	0.3	1.9	Boca	Low	w/Alum
B8	1.6	1.5	2.9	Pompano	Low	x/Alum
B9	1.7	0.0	0.5	Commercial	High	w/Alum
B10	0.5	0.0	0.4	Boca	High	x/Alum
B11	1.1	0.8	2.2	Commercial	Low	x/Alum
B12	1.8	0.1	1.5	Pompano	High	x/Alum
B13	2.5	0.3	2.5	*NULL*	*NULL*	*NULL*
B14	1.9	0.1	1.5	Boca	Low	x/Alum
B15	1.4	0.1	1.4	Chicken	Low	x/Alum
B16	0.6	0.0	1.7	Commercial	High	x/Alum
B17	0.9	0.7	0.9	Chicken	High	x/Alum
C1	0.6	0.0	0.0	Boca	Low	w/Alum
C2	0.4	0.0	0.0	Pompano	Low	w/Alum
C3	0.8	0.0	0.4	Chicken	Low	w/Alum
C4	0.6	0.0	0.8	Pompano	Low	x/Alum
C5	1.3	0.2	1.2	Boca	Low	x/Alum
C6	1.1	0.8	1.4	Chicken	Low	x/Alum
C7	0.9	0.0	1.1	Boca	High	w/Alum
C8	0.5	0.0	0.4	Commercial	Low	w/Alum
C9	0.1	0.0	0.1	Pompano	High	w/Alum
C10	0.6	0.0	0.7	Chicken	High	w/Alum
C11	1.9	1.3	1.9	Commercial	Low	x/Alum
C12	1.7	0.8	1.9	Boca	High	x/Alum
C13	0.5	0.0	0.4	Commercial	High	w/Alum
C14	1.6	0.2	0.4	Chicken	High	x/Alum
C15	1.1	0.5	1.4	Commercial	High	x/Alum
C16	1.7	0.4	1.1	Pompano	High	x/Alum
C17	1.7	0.2	1.2	*NULL*	*NULL*	***NULL***

Deep Well Samples Time Series

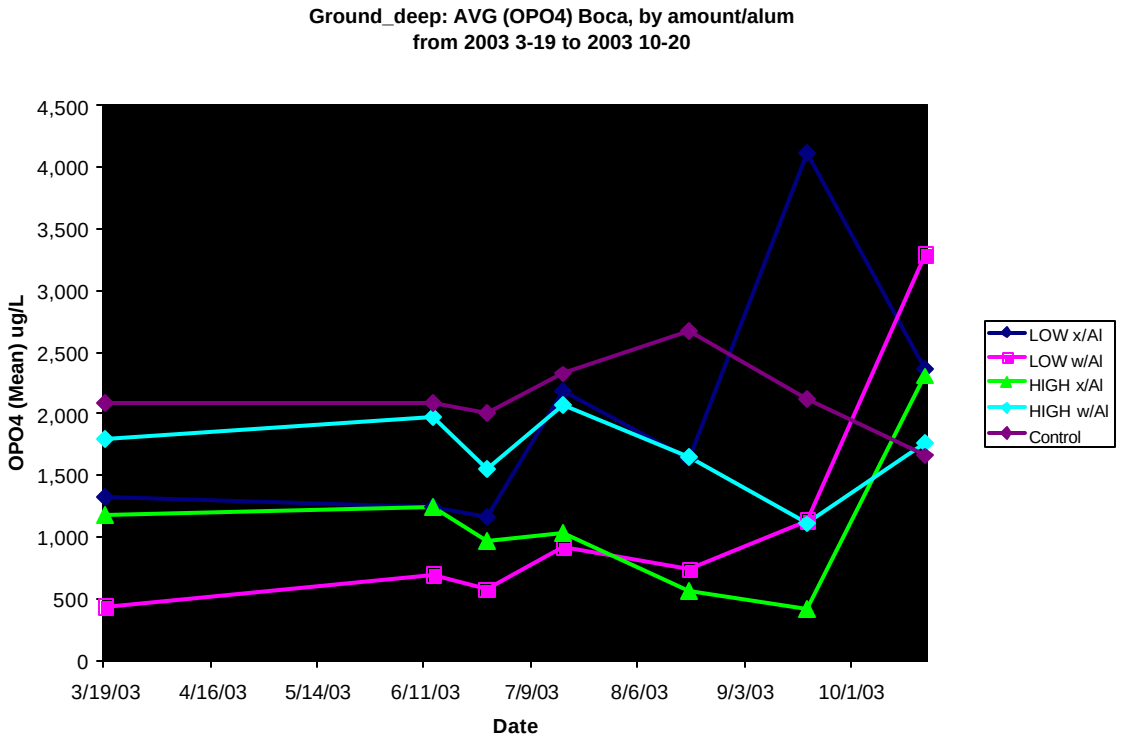

Figure 34. Mean ortho-phosphorus concentrations in deep ground water wells for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

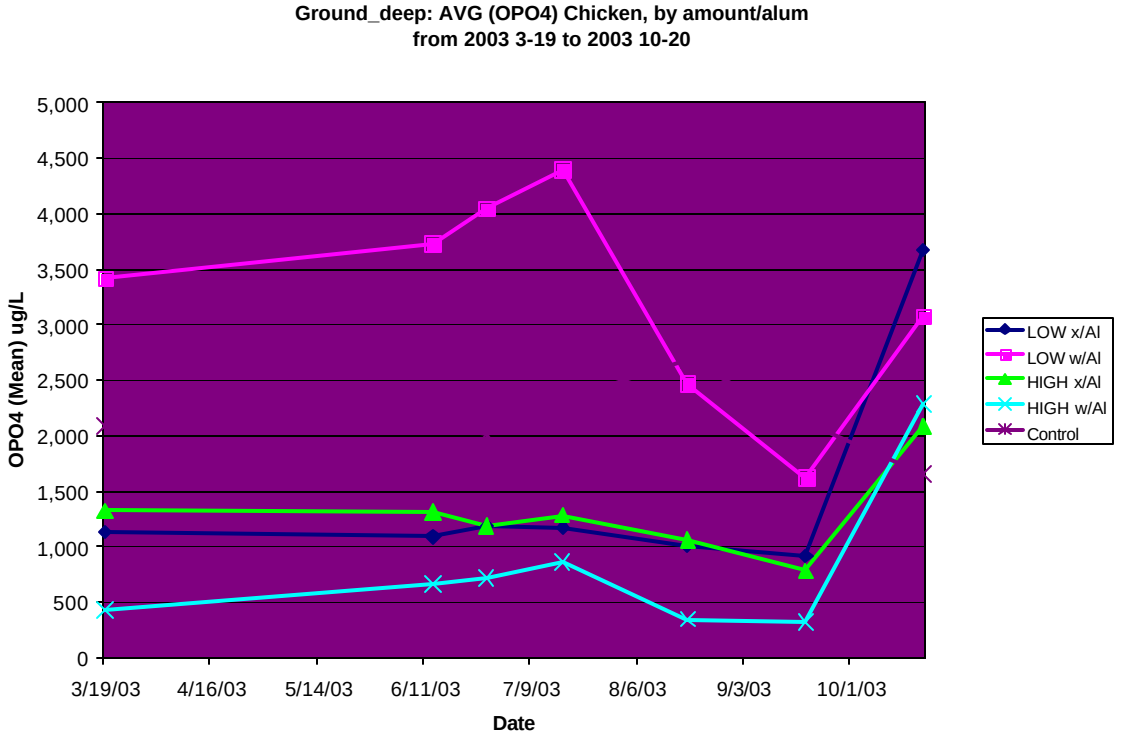

Figure 35. Mean ortho-phosphorus concentrations in deep ground water wells for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

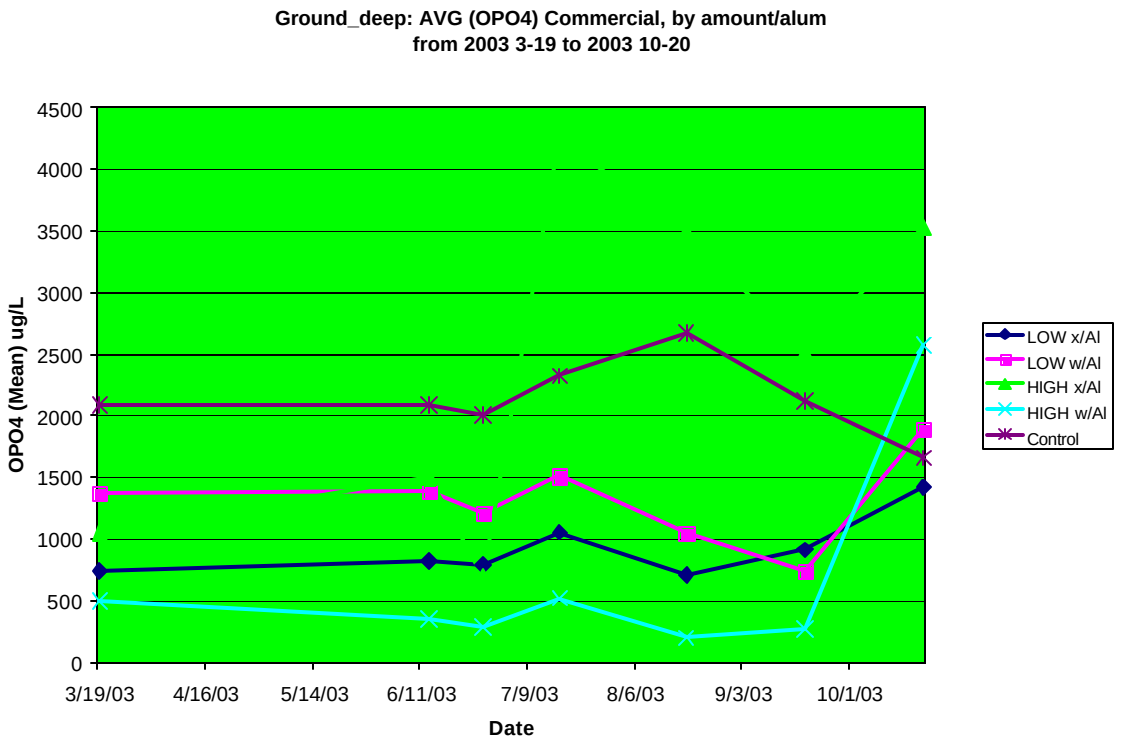

Figure 36. Mean ortho-phosphorus concentrations in deep ground water wells for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

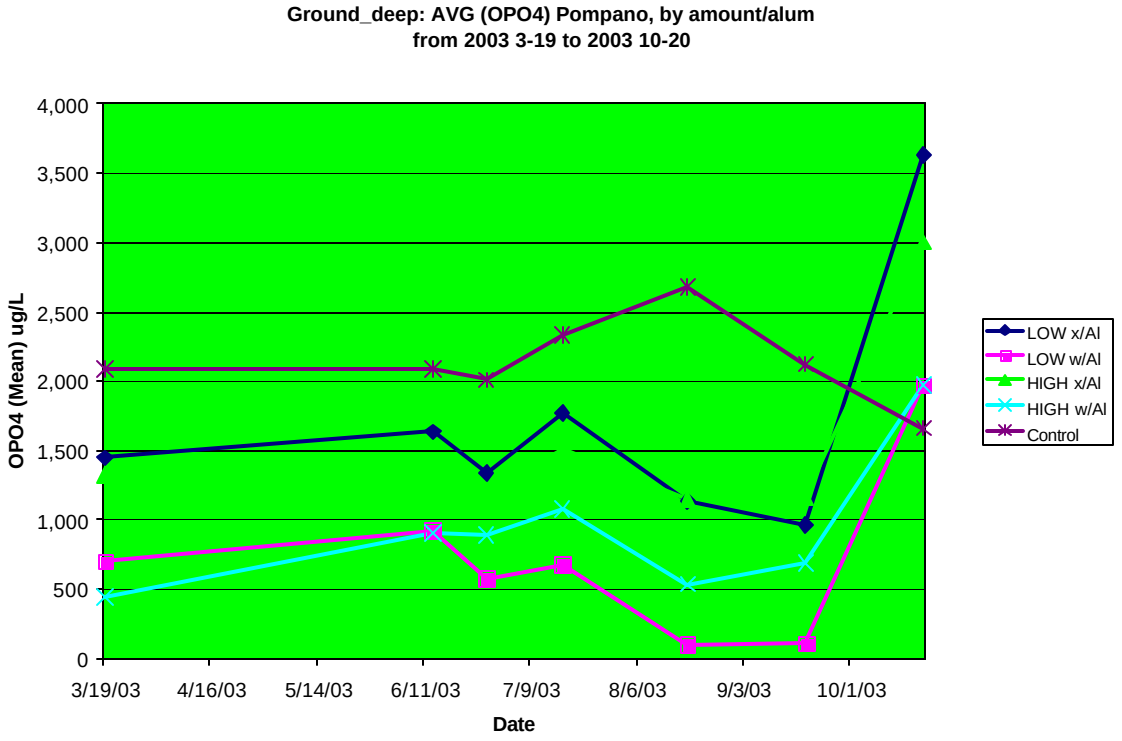

Figure 37. Mean ortho-phosphorus concentrations in deep ground water wells for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

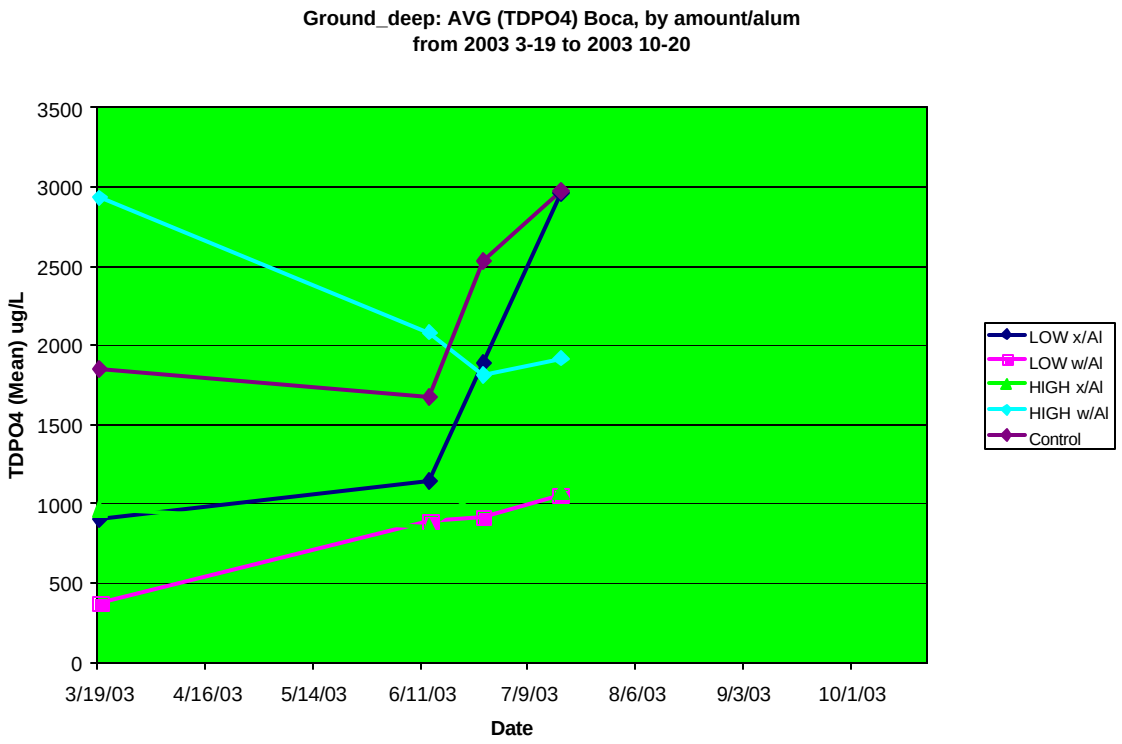

Figure 38. Mean total dissolved phosphorus concentrations in deep ground water wells for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

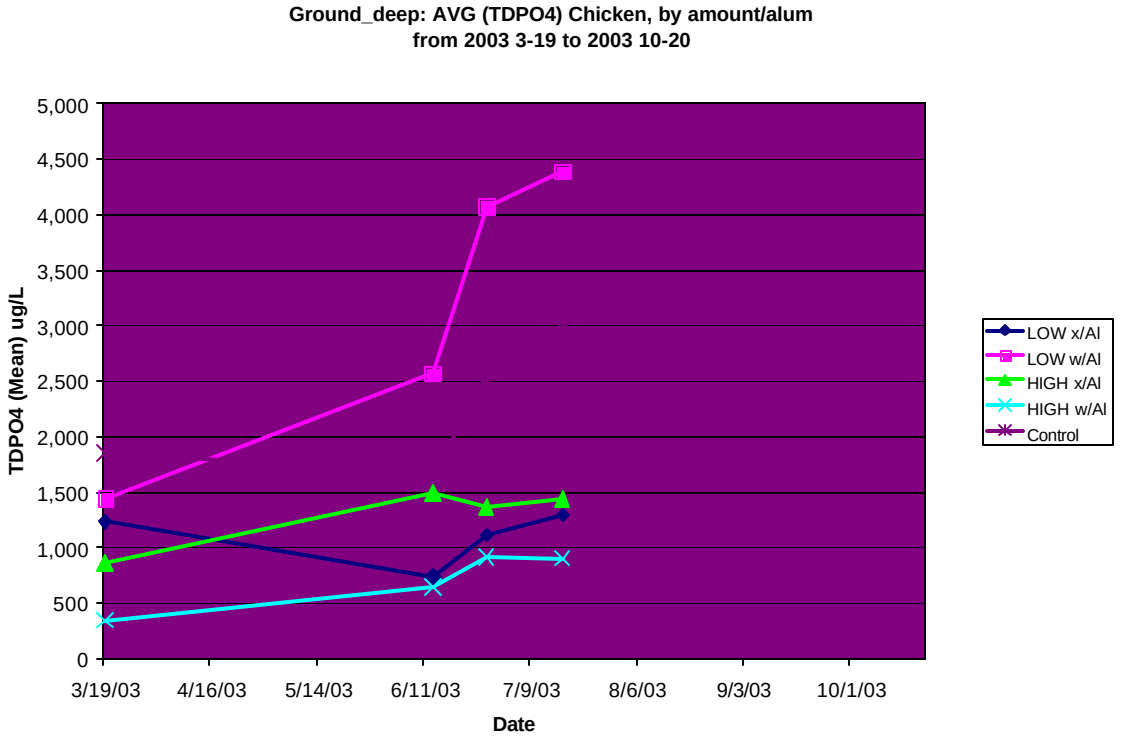

Figure 39. Mean total dissolved phosphorus concentrations in deep ground water wells for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

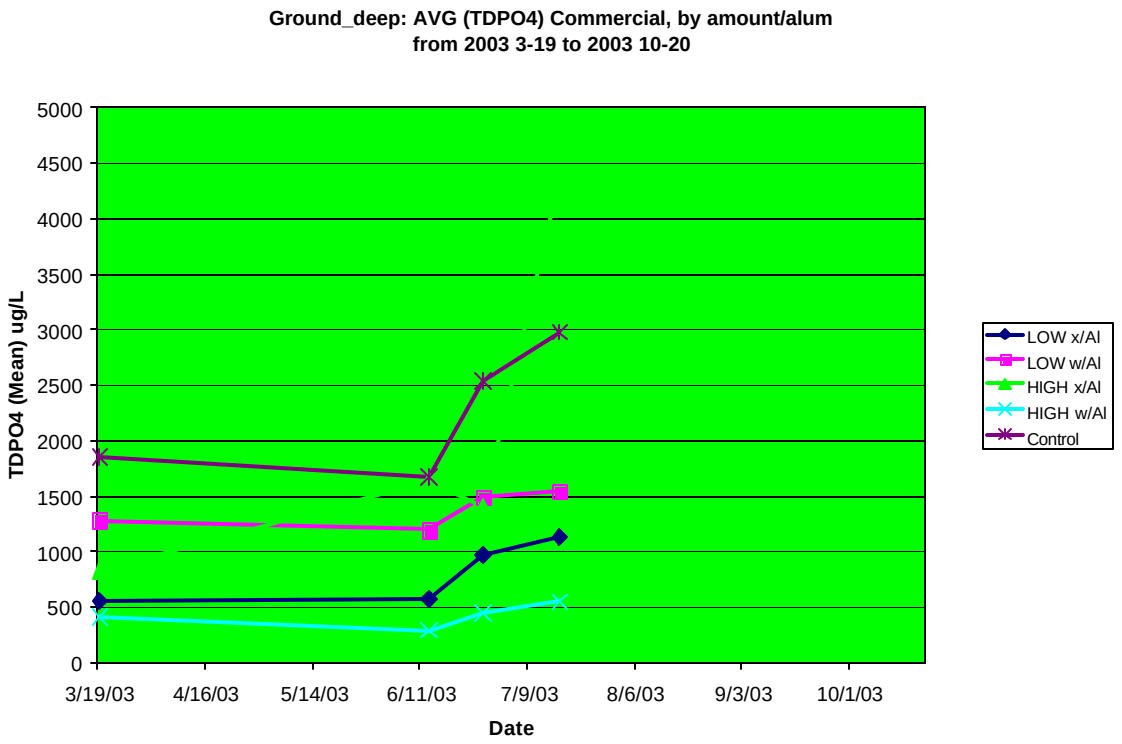

Figure 40. Mean total dissolved phosphorus concentrations in deep ground water wells for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

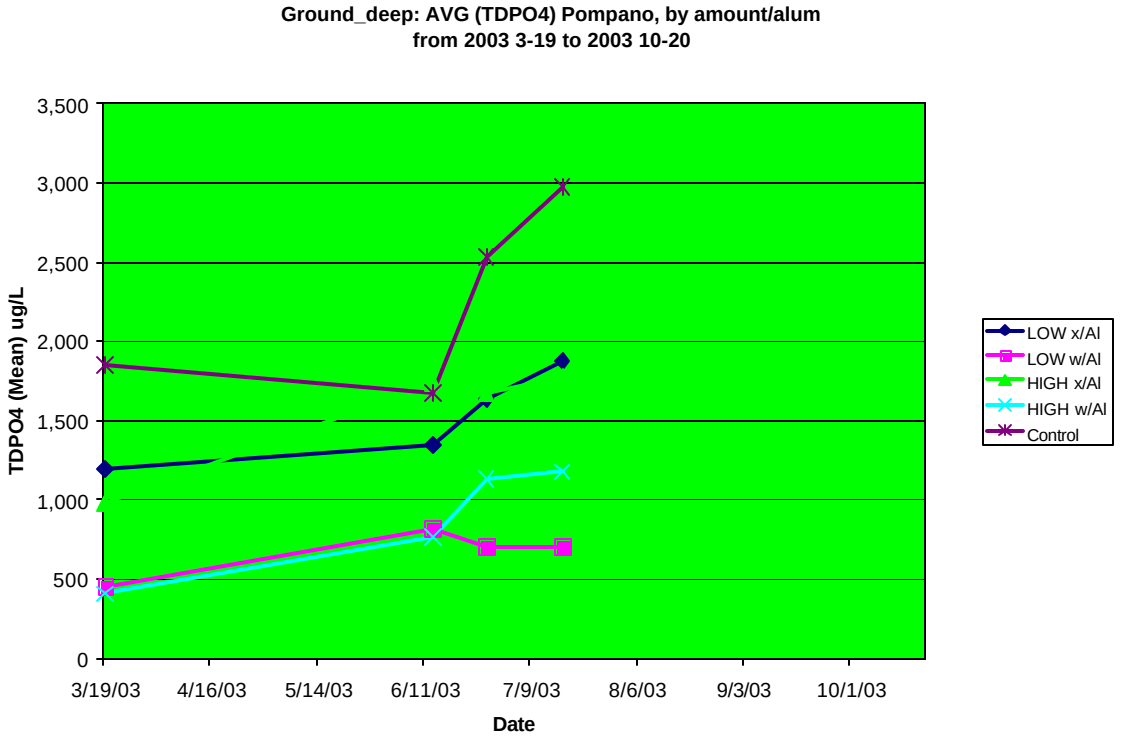

Figure 41. Mean total dissolved phosphorus concentrations in deep ground water wells for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

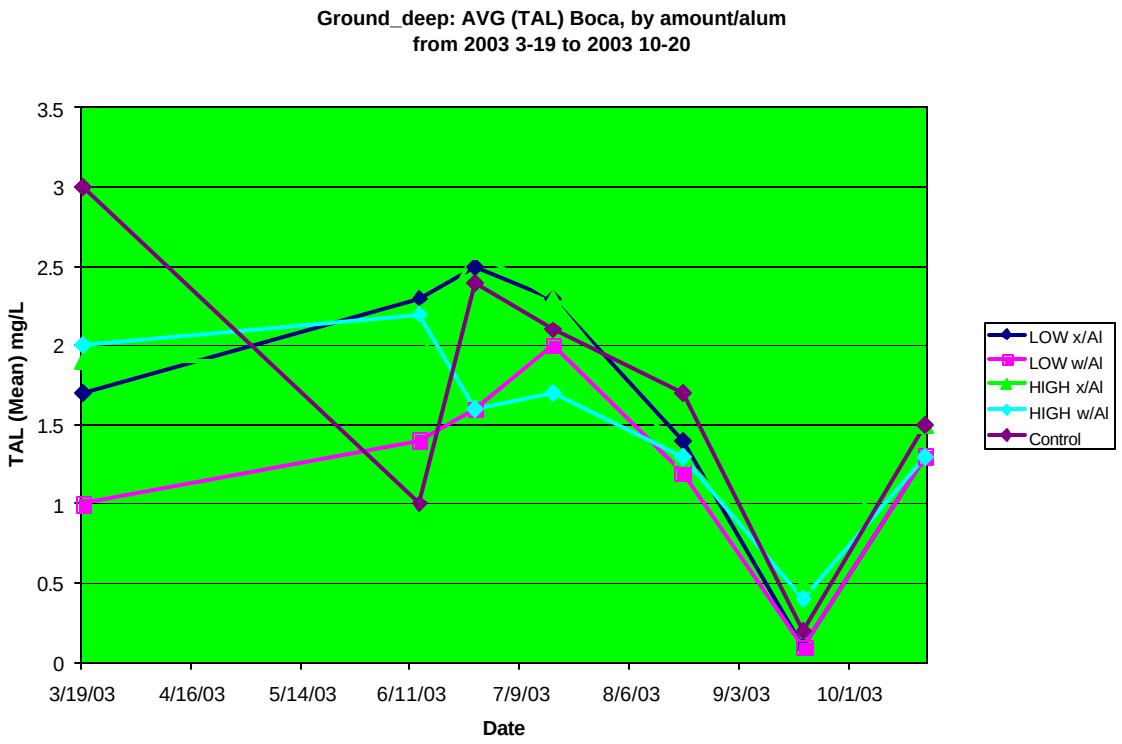

Figure 42. Mean total aluminum concentrations in deep ground water wells for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

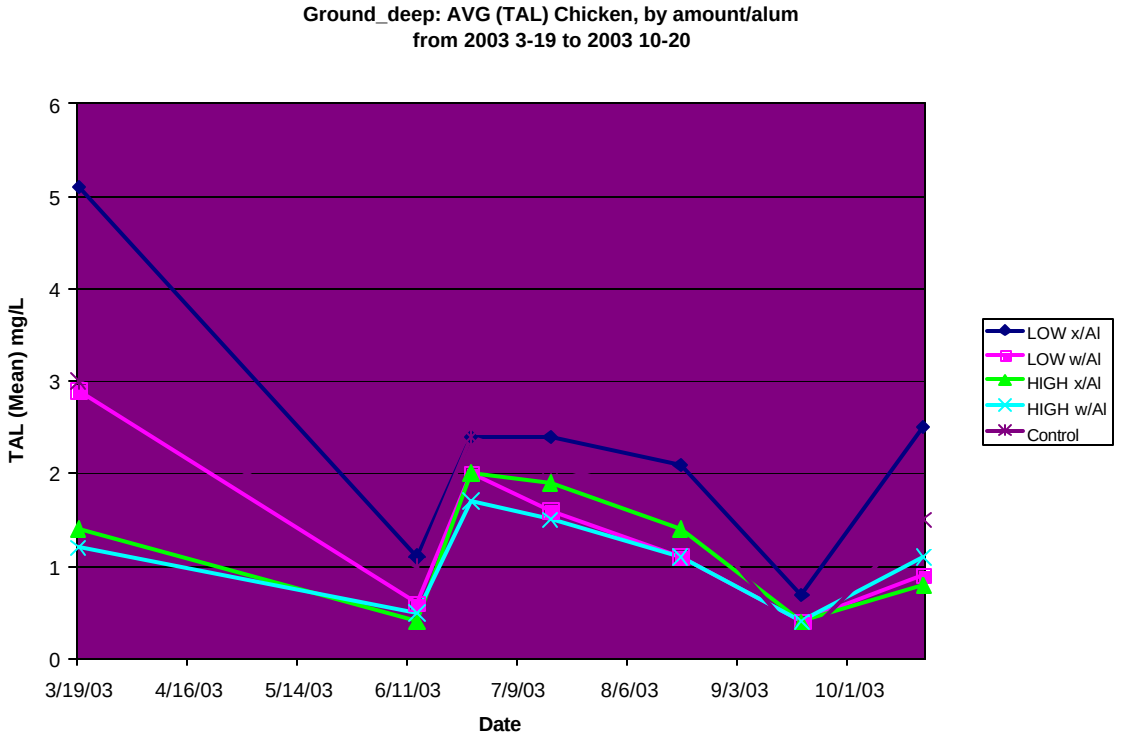

Figure 43. Mean total aluminum concentrations in deep ground water wells for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

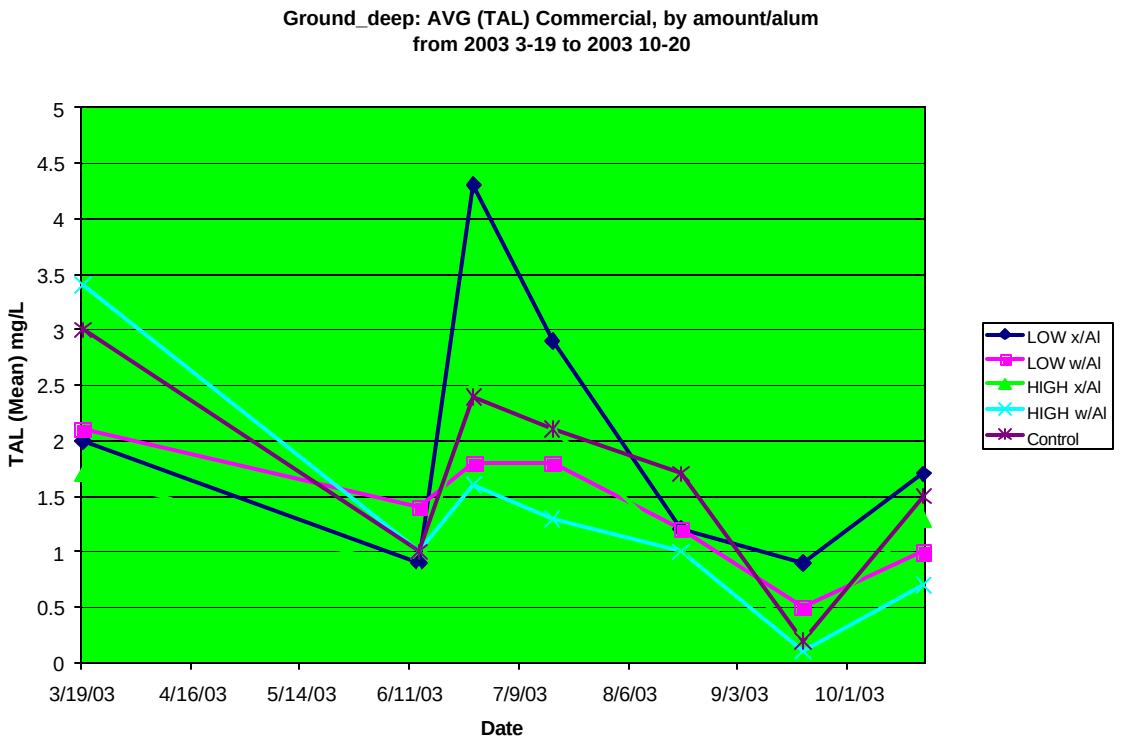

Figure 44. Mean total aluminum concentrations in deep ground water wells for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

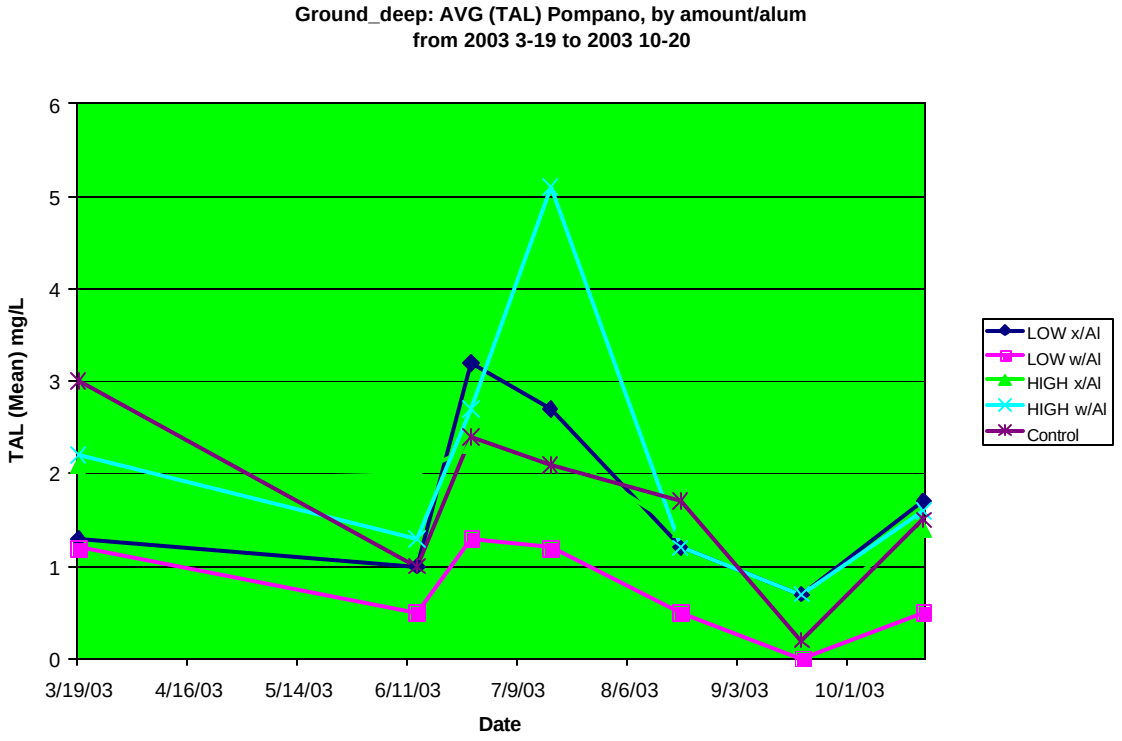

Figure 45. Mean total aluminum concentrations in deep ground water wells for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between March 19 and October 20, 2003

Deep Well Samples Treatment Effects

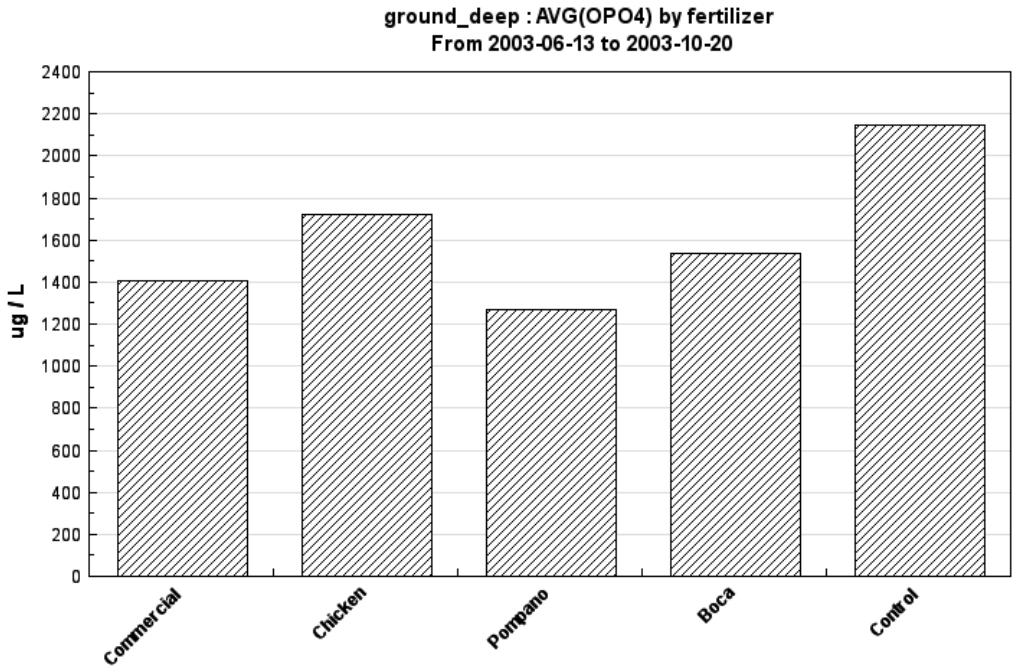

Figure 46. Mean ortho-phosphorus concentration by fertilizer source as measured in deep ground water wells between June 13 and October 20, 2003.

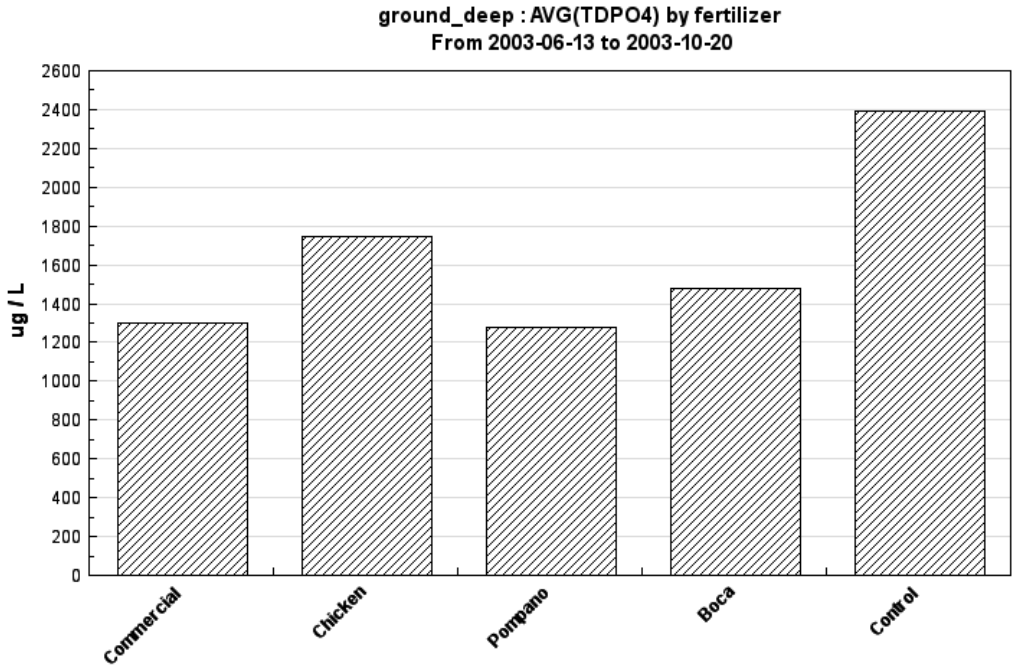

Figure 47. Mean total dissolved phosphorus concentration by fertilizer source as measured in deep ground water wells between June 13 and October 20, 2003.

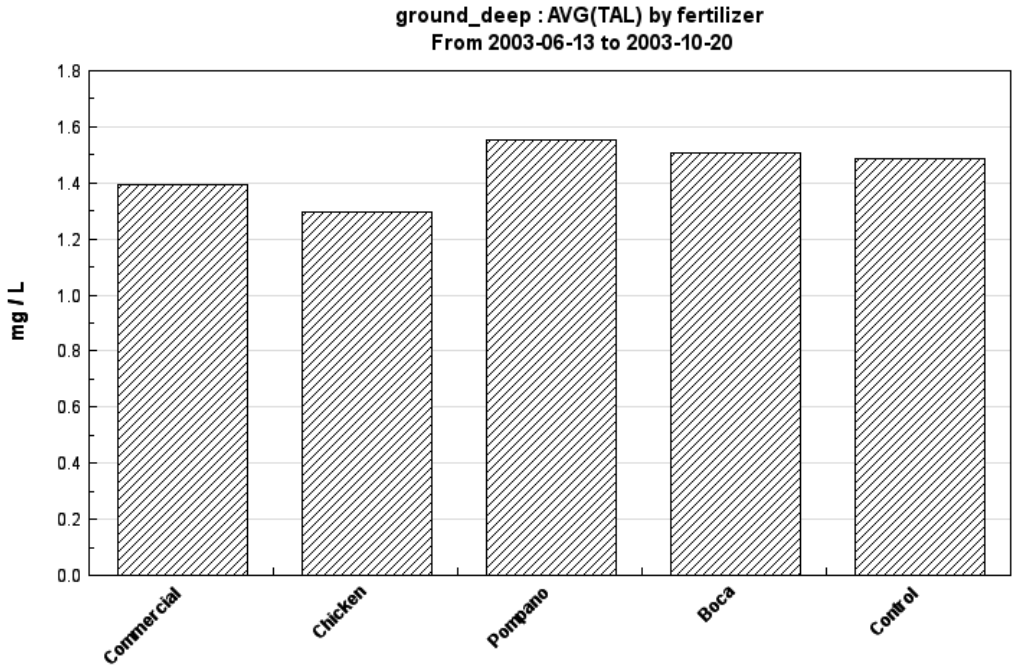

Figure 48. Mean total aluminum concentration by fertilizer source as measured in deep ground water wells between June 13 and October 20, 2003.

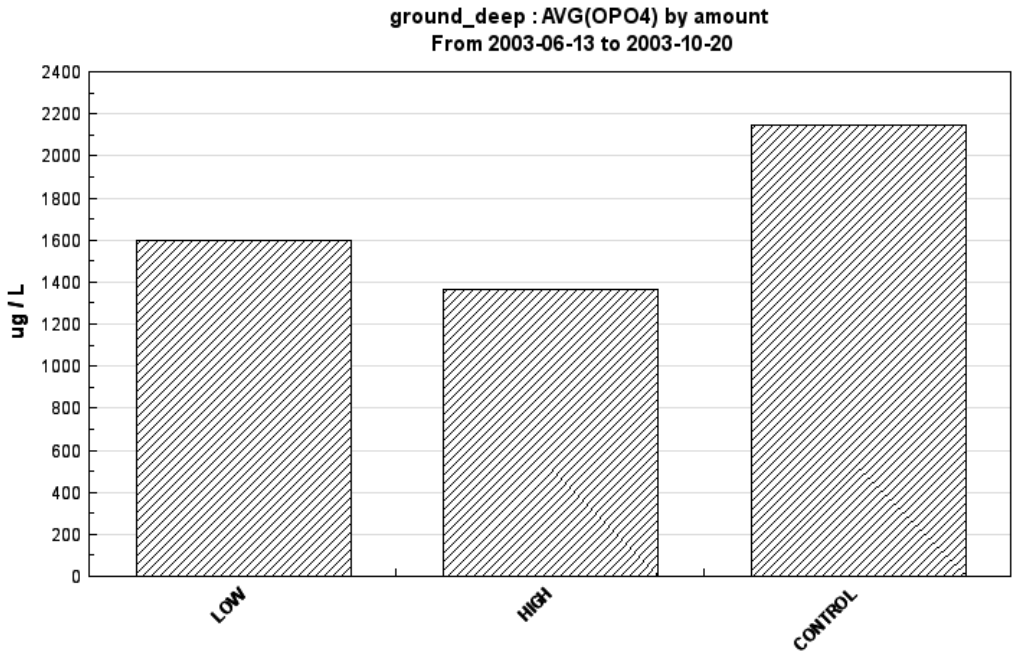

Figure 49. Mean ortho-phosphorus concentration by amount as measured in deep ground water wells between June 13 and October 20, 2003.

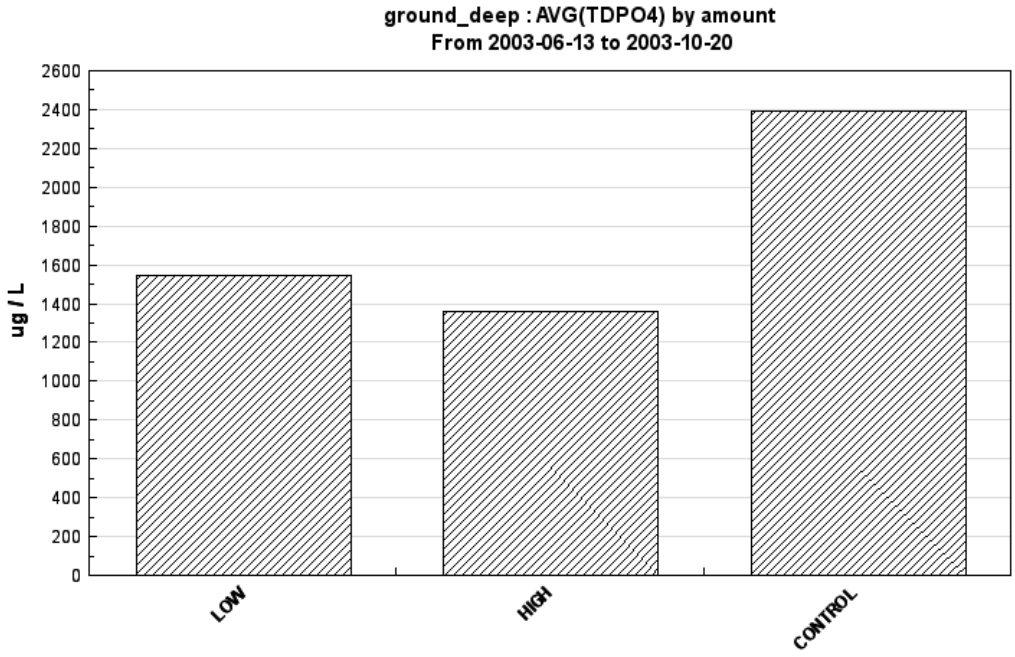

Figure 50. Mean total dissolved phosphorus concentration by amount as measured in deep ground water wells between June 13 and October 20, 2003.

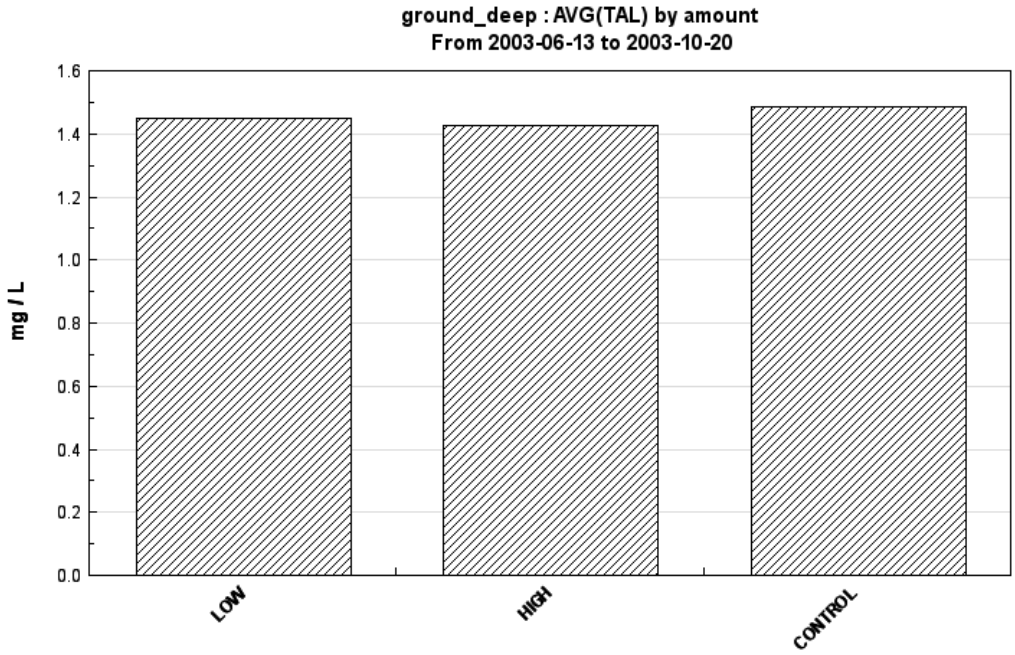

Figure 51. Mean total aluminum concentration by amount as measured in deep ground water wells between June 13 and October 20, 2003.

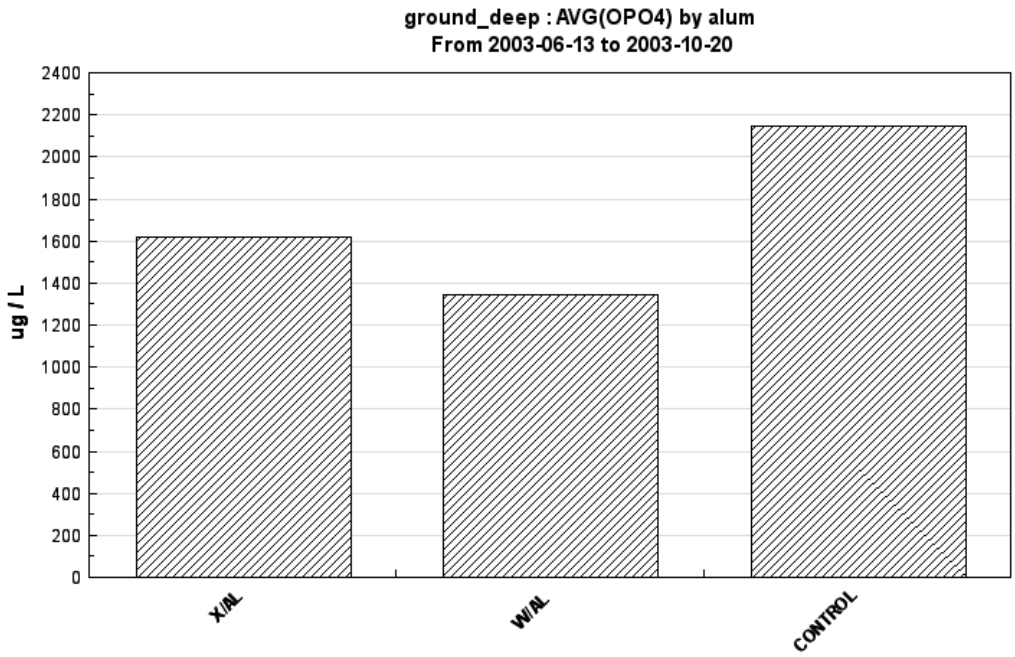

Figure 52. Mean ortho-phosphorus concentration by WTR amendment (alum) as measured in deep ground water wells between June 13 and October 20, 2003.

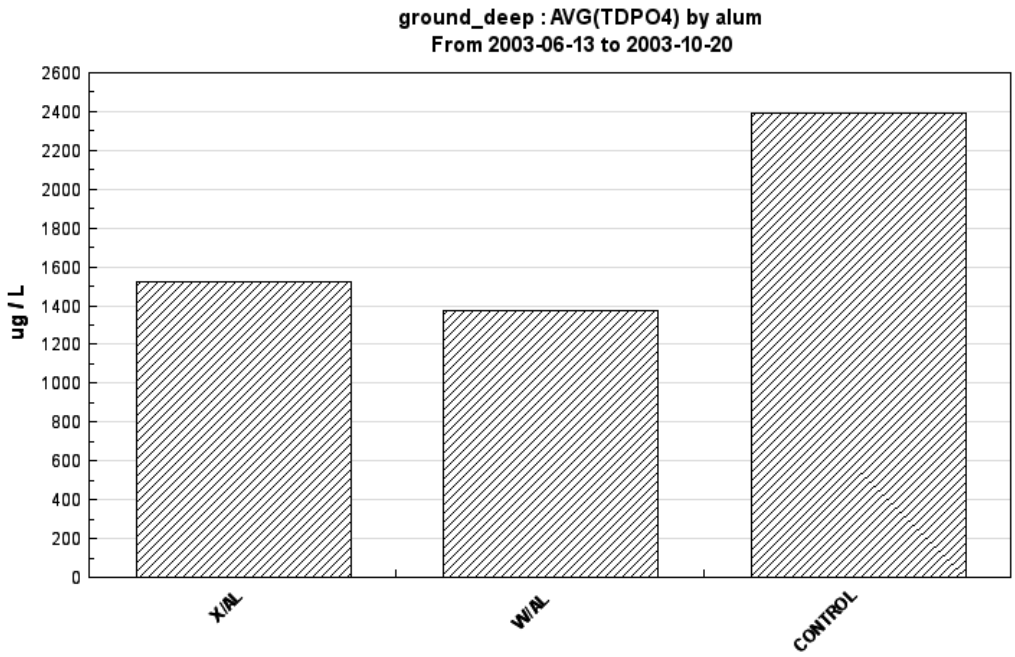

Figure 53. Mean total dissolved phosphorus concentration by WTR amendment (alum) as measured in deep ground water wells between June 13 and October 20, 2003.

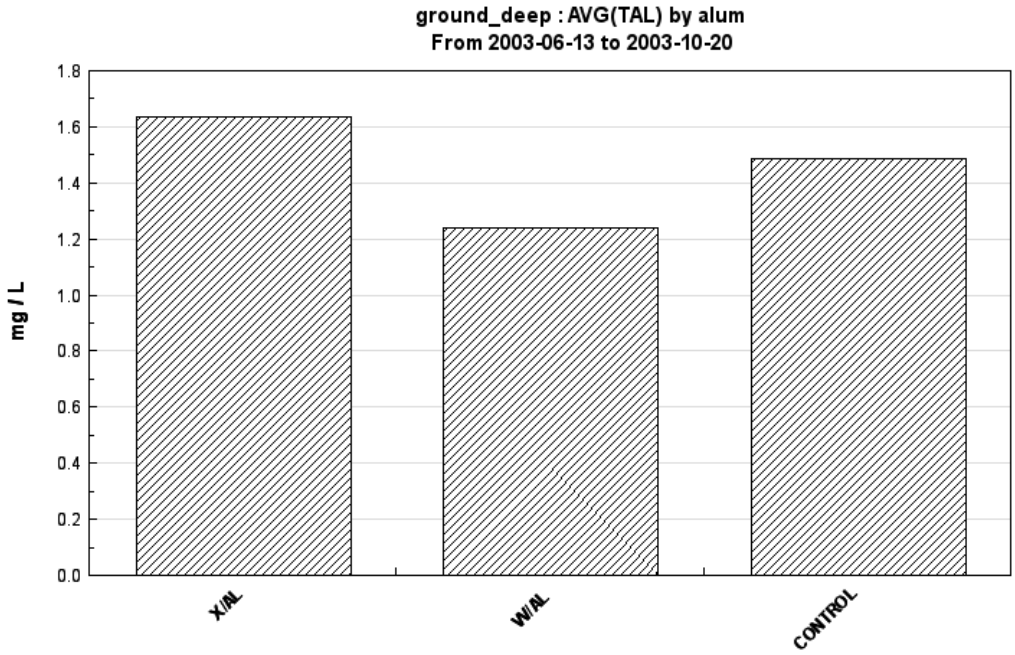

Figure 54. Mean total aluminum concentration by WTR amendment (alum) as measured in deep ground water wells between June 13 and October 20, 2003.

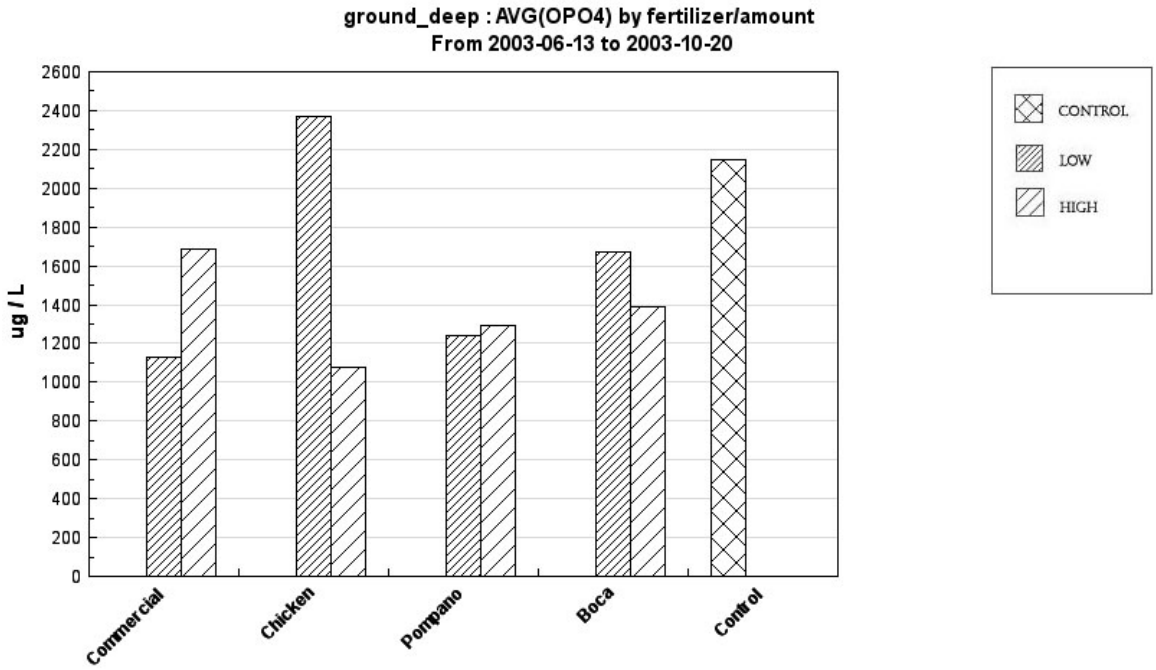

Figure 55. Mean ortho-phosphorus concentration by fertilizer source and amount as measured in deep ground water wells between June 13 and October 20, 2003.

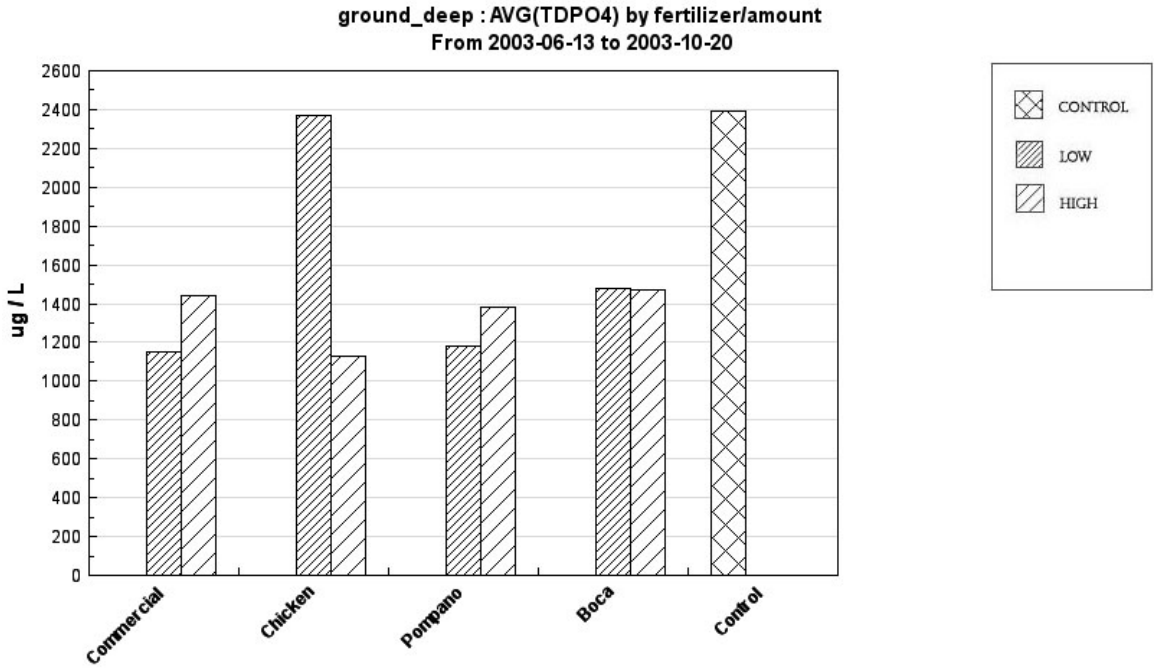

Figure 56. Mean total dissolved phosphorus concentration by fertilizer source and amount as measured in deep ground water wells between June 13 and October 20, 2003.

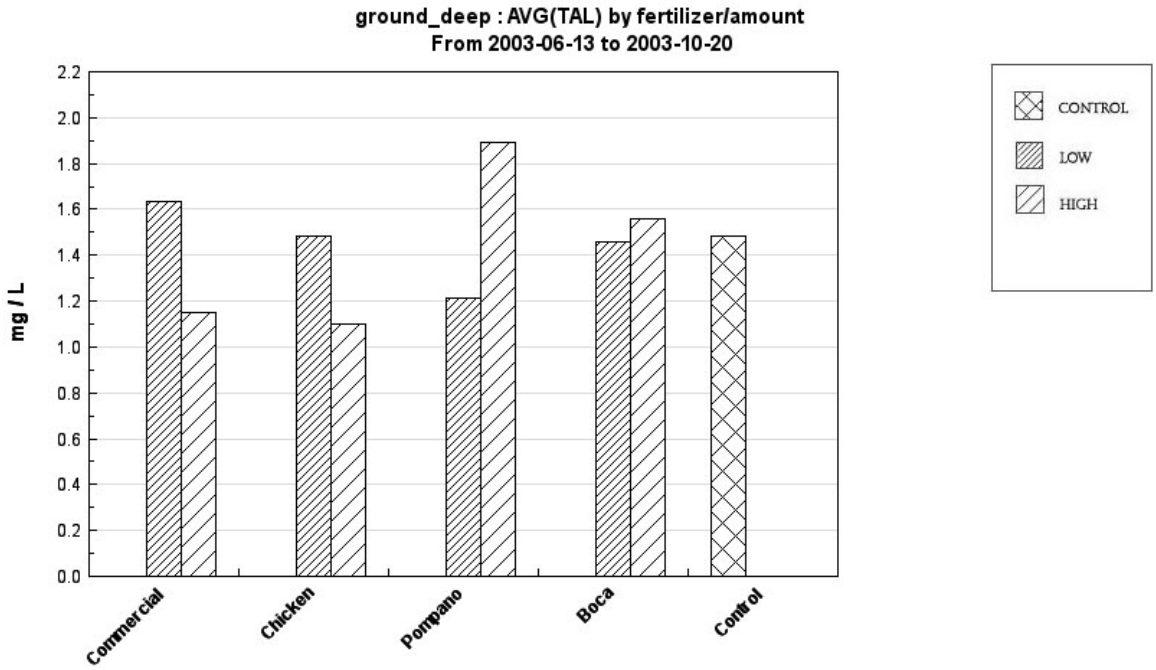

Figure 57. Mean total aluminum concentration by fertilizer source and amount as measured in deep ground water wells between June 13 and October 20, 2003.

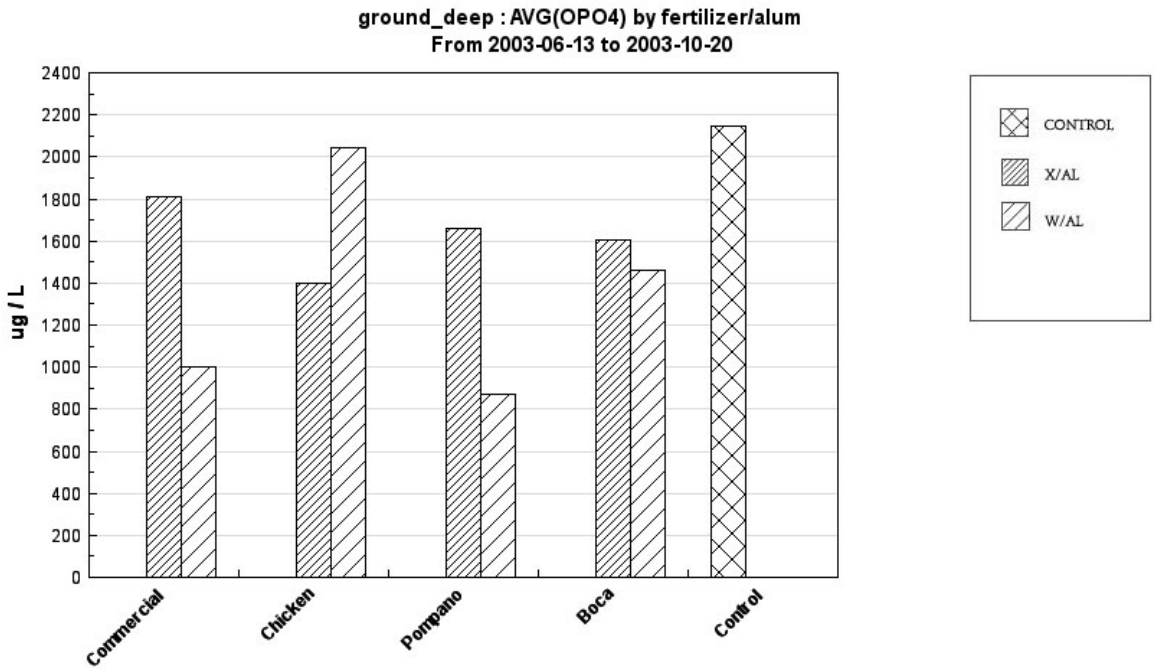

Figure 58. Mean ortho-phosphorus concentration by fertilizer source and WTR amendment (alum) as measured in deep ground water wells between June 13 and October 20, 2003.

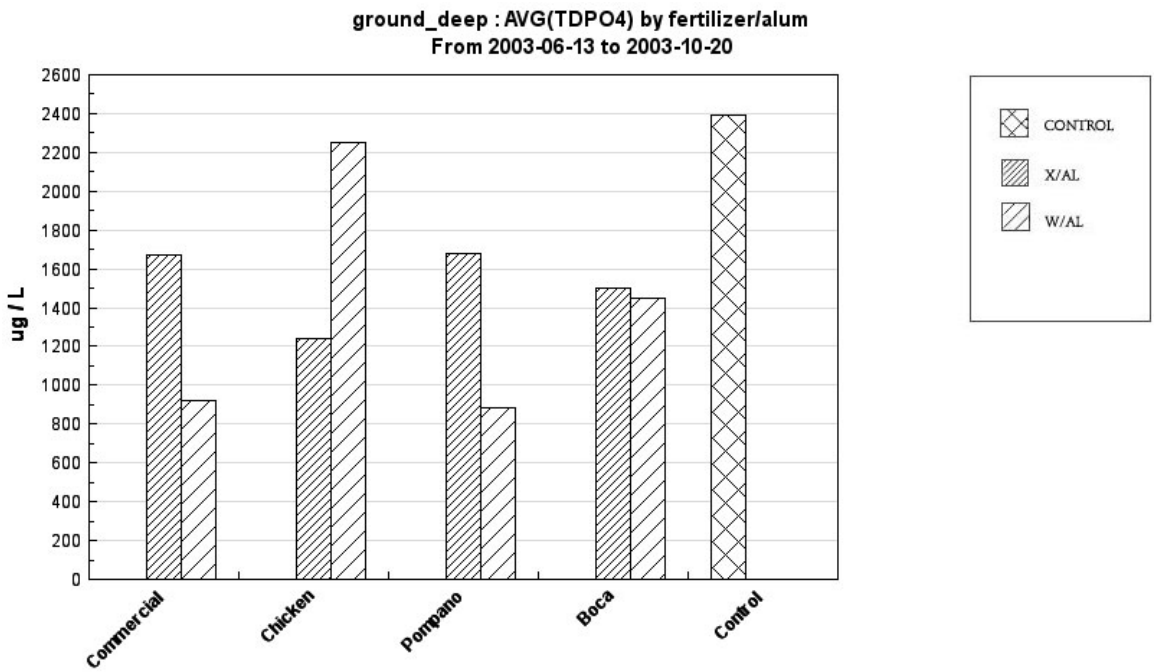

Figure 59. Mean total dissolved phosphorus concentration by fertilizer source and WTR amendment (alum) as measured in deep ground water wells between June 13 and October 20, 2003.

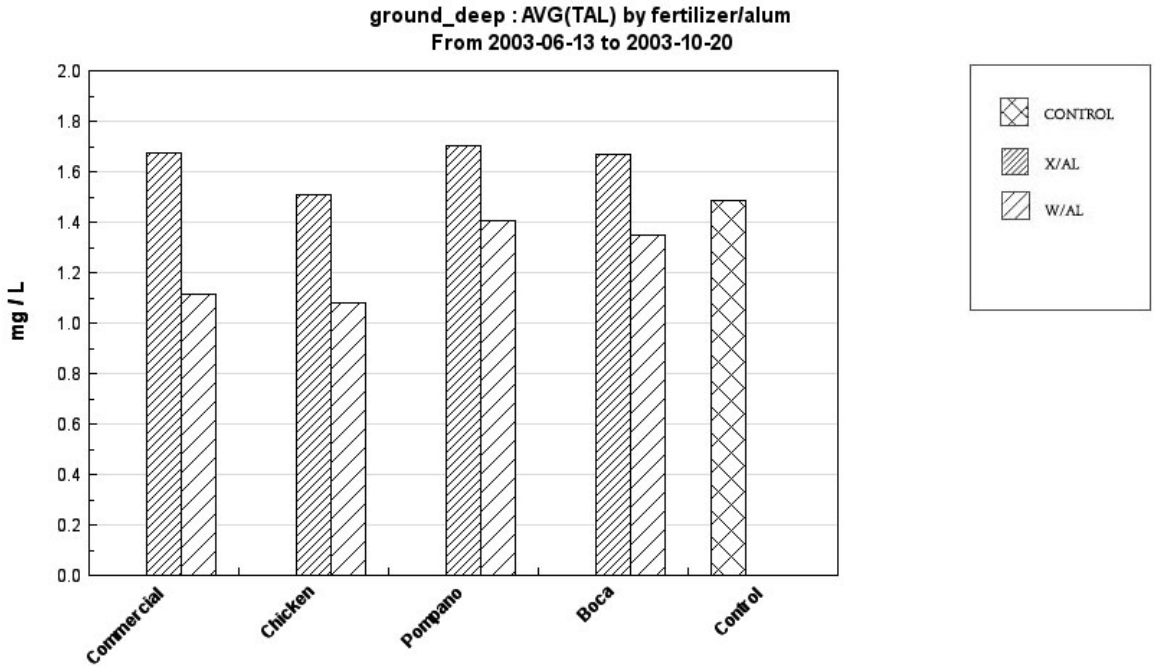

Figure 60. Mean total aluminum concentration by fertilizer source and WTR amendment (alum) as measured in deep ground water wells between June 13 and October 20, 2003.

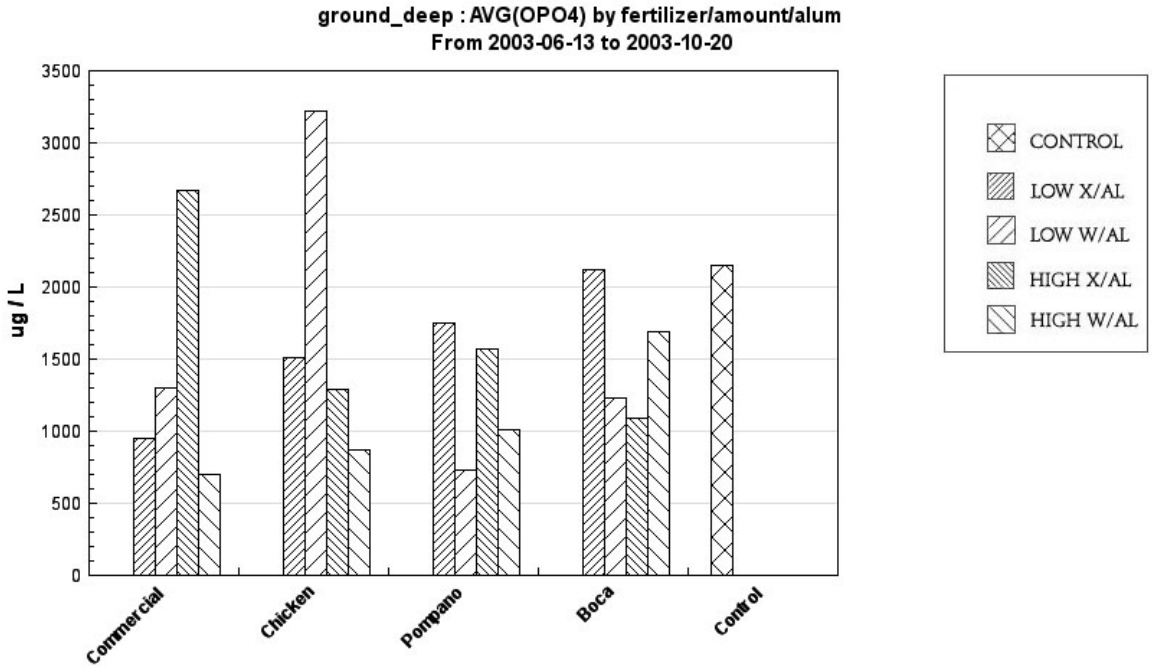

Figure 61. Mean ortho-phosphorus concentration by fertilizer source, amount and WTR amendment (alum) as measured in deep ground water wells between June 13 and October 20, 2003.

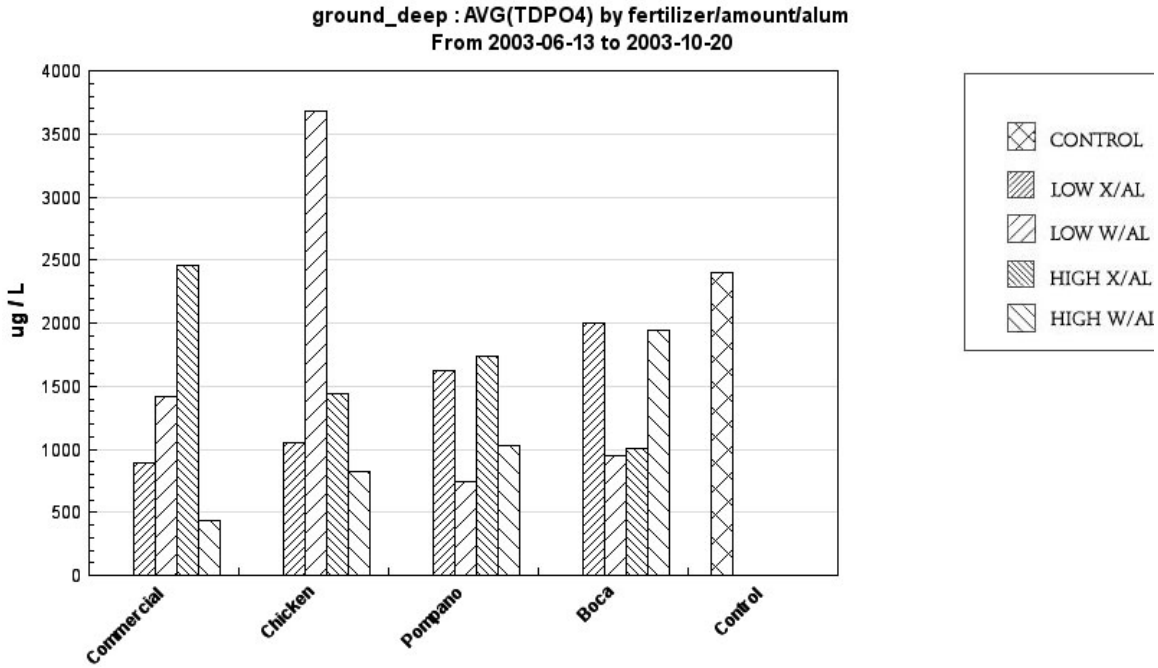

Figure 62. Mean total dissolved phosphorus concentration by fertilizer source, amount and WTR amendment (alum) as measured in deep ground water wells on between June 13 and October 20, 2003.

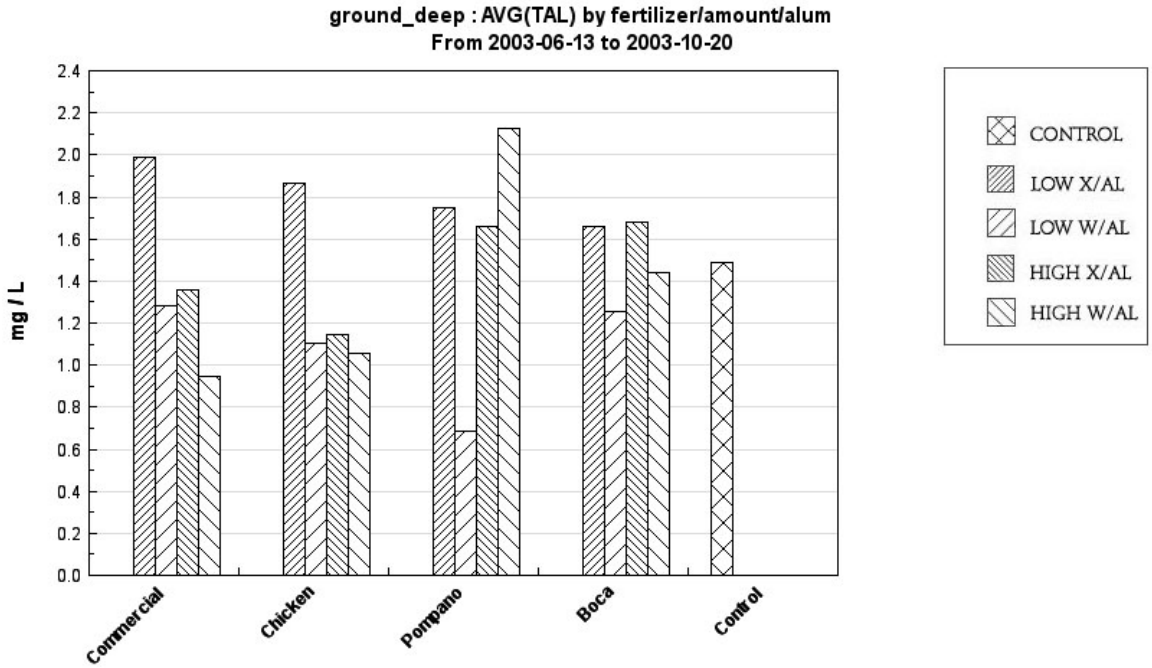

Figure 63. Mean total aluminum concentration by fertilizer source, amount and WTR amendment (alum) as measured in deep ground water wells between June 13 and October 20, 2003.

Deep Well Samples Block Effects

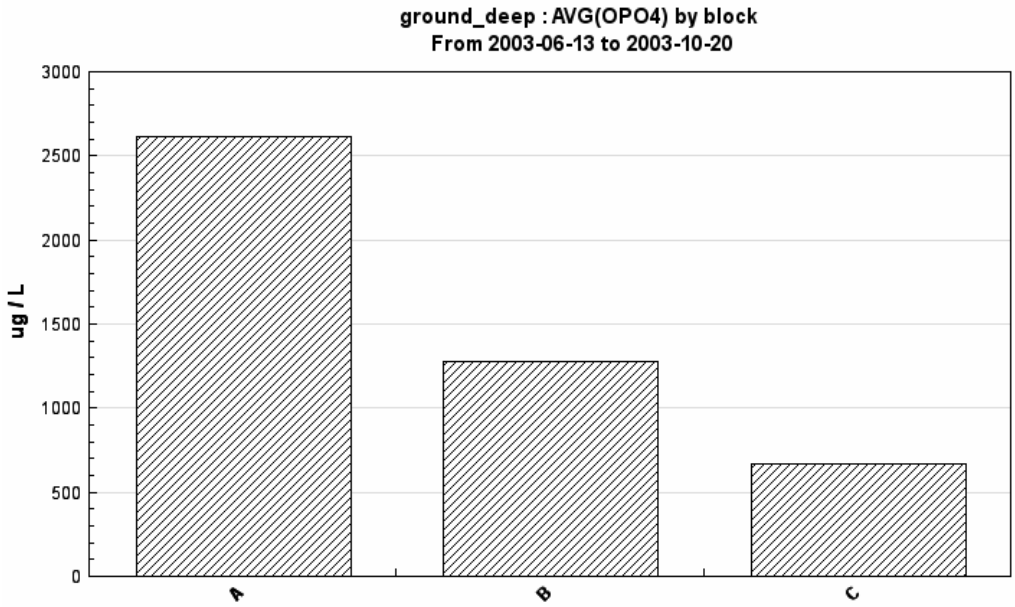

Figure 64. Mean ortho-phosphorus concentrations by block as measured in deep ground water wells between June 13 and October 20, 2003.

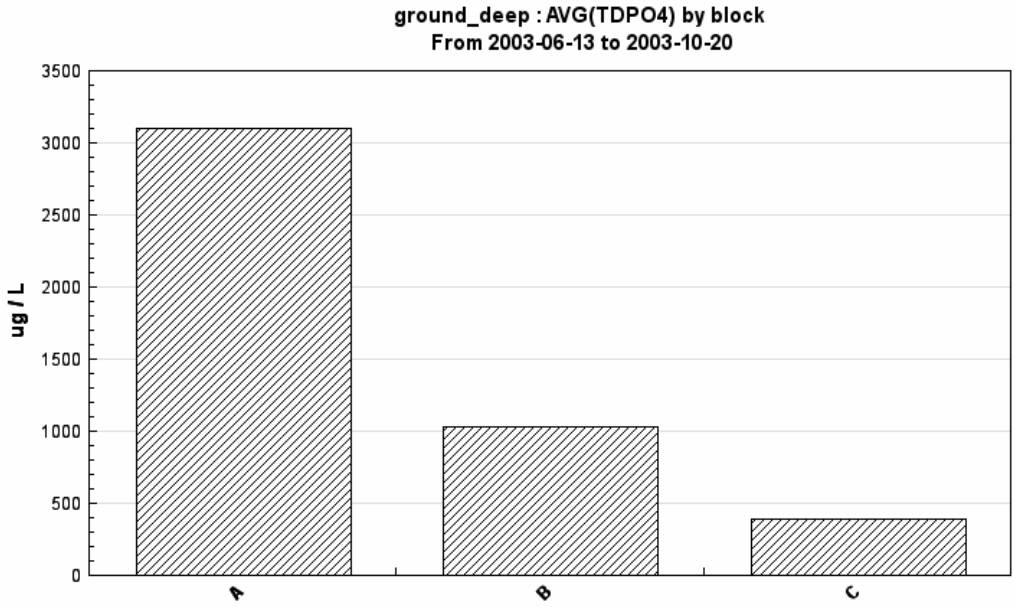

Figure 65. Mean total dissolved phosphorus concentrations by block as measured in deep ground water wells between June 13 and October 20, 2003.

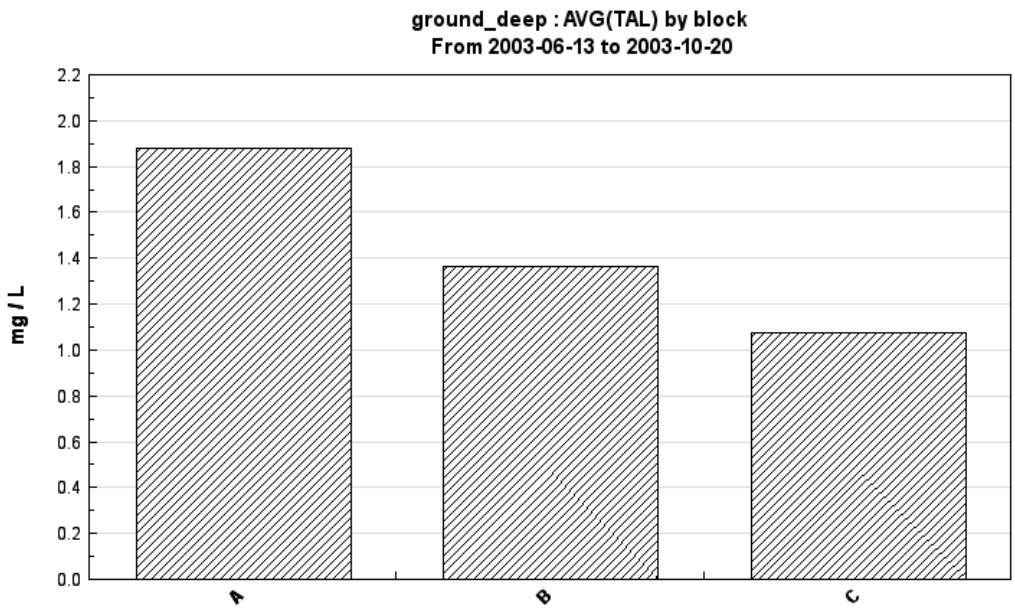

Figure 66. Mean total aluminum concentrations by block as measured in deep ground water wells between June 13 and October 20, 2003.

C. SURFACE WATER QUALITY

Surface water grab samples were collected on August 9, 12, 13, 19 and September 3 from the exit of the sampler flumes at the discharge point of each plot. Composite samples were collected from the automatic samplers on August 6, 10, 22, and September 5. The grab samples were tested for ortho-phosphorus, total dissolved phosphorus, total phosphorus and total aluminum. The composite samples were tested for total phosphorus only. Results for surface water grab samples are shown in Tables 6-9 and Figures 67-110. Results for surface water composite samples are shown in Table 10 and Figures 111-121.

No clear effect from the fertilizer type on surface water quality is apparent in these results. However, the WTR amendment may be causing a reduction in the P concentrations while also increasing the aluminum concentrations in the surface runoff (Figures 91-92 and 101-104). The WTR effect on P seems more pronounced on the Boca plots. The WTR appears to hold down otherwise highly elevated P concentrations in surface water from these plots. The amount of fertilizer does not appear to have a significant effect on surface water P concentrations in runoff (Figures 87-89 and 96-97). However, the expected effect may be masked by the relatively high background concentrations in both surface and ground water on this pasture. The use of the WTR amendment does not appear to have a significant effect on aluminum (Figures 91-92). The composite samples seem to exhibit lower total phosphorus concentrations than the grab samples. Interestingly, the treatment plots exhibit a mean TP concentration lower than the control plots. This suggests that an in-situ preservative may be required for the automatic samplers.

Grab Samples Results

Table 6. OPO4 concentrations (µg/L) as measured in surface water grab samples between Aug 9 and Sep 30, 2003.

ID	9-Aug	12-Aug	13-Aug	19-Aug	27-Aug	5-Sep	Fertilizer	P Level	Alum
A1	2809	1099	1323	1635	1596	1415	Chicken	Low	w/Alum
A2	1179	N/A	992	741	507	1907	Boca	High	w/Alum
A3	664	N/A	579	1153	84	1486	Commercial	Low	w/Alum
A4	886	N/A	502	1051	705	1007	Pompano	High	w/Alum
A5	564	N/A	808	886	426	846	Chicken	Low	x/Alum
A6	714	1687	1217	1390	439	2386	Boca	High	x/Alum
A7	1257	406	600	1003	809	1641	Pompano	Low	w/Alum
A8	1438	N/A	948	1044	576	1034	Commercial	Low	x/Alum
A9	603	488	624	806	631	1217	Chicken	High	w/Alum
A10	2363	850	954	791	754	1231	Pompano	Low	x/Alum
A11	1025	N/A	822	1757	1420	926	Commercial	High	w/Alum
A12	1080	1069	950	1957	627	1276	Chicken	High	x/Alum
A13	404	2016	426	1268	403	711	Boca	Low	w/Alum
A14	934	N/A	2119	2138	2884	1635	Boca	Low	x/Alum
A15	1850	1413	1281	1660	666	3120	Commercial	High	x/Alum
A16	595	N/A	1576	2298	945	739	Pompano	High	x/Alum
A17	871	1312	1159	1277	2008	884	*NULL*	*NULL*	*NULL*
B1	885	1006	891	1311	399	797	Chicken	Low	w/Alum
B2	1473	945	863	1466	514	1208	Pompano	High	w/Alum
B3	3601	1288	1213	875	646	1575	Commercial	Low	w/Alum
B4	1136	1020	1078	1330	939	853	Boca	High	w/Alum
B5	1779	N/A	1300	1454	691	2094	Chicken	High	w/Alum
B6	623	N/A	879	1181	591	1356	Pompano	Low	w/Alum
B7	2633	N/A	1767	1503	479	1923	Boca	Low	w/Alum
B8	1561	1144	925	790	1021	4200	Pompano	Low	x/Alum
B9	762	N/A	1099	1373	744	1164	Commercial	High	w/Alum
B10	1053	N/A	1717	2130	1171	6500	Boca	High	x/Alum
B11	899	N/A	1381	1158	990	1470	Commercial	Low	x/Alum
B12	456	N/A	613	1055	666	1250	Pompano	High	x/Alum
B13	973	N/A	980	607	731	1382	*NULL*	*NULL*	*NULL*
B14	2733	N/A	1151	1047	1153	2467	Boca	Low	x/Alum
B15	561	N/A	1051	860	768	949	Chicken	Low	x/Alum
B16	1491	1893	1792	1434	818	1645	Commercial	High	x/Alum
B17	2610	N/A	1649	1458	1441	2171	Chicken	High	x/Alum
C1	1085	563	848	1364	339	683	Boca	Low	w/Alum
C2	630	N/A	527	756	840	508	Pompano	Low	w/Alum
C3	1340	672	513	954	660	1155	Chicken	Low	w/Alum
C4	1141	N/A	2140	1430	1042	2508	Pompano	Low	x/Alum
C5	476	N/A	2819	1312	876	1970	Boca	Low	x/Alum
C6	1919	N/A	1516	873	574	1049	Chicken	Low	x/Alum
C7	371	N/A	936	1411	702	427	Boca	High	w/Alum
C8	365	N/A	435	697	683	343	Commercial	Low	w/Alum
C9	561	N/A	421	616	368	293	Pompano	High	w/Alum
C10	873	N/A	697	771	831	306	Chicken	High	w/Alum
C11	446	N/A	853	1011	330	1302	Commercial	Low	x/Alum
C12	669	2304	1901	2295	4622	1864	Boca	High	x/Alum
C13	671	N/A	592	381	311	522	Commercial	High	w/Alum
C14	670	N/A	1245	1407	1160	1070	Chicken	High	x/Alum
C15	2102	1884	1200	2011	946	3121	Commercial	High	x/Alum
C16	565	1232	1219	1362	2368	1246	Pompano	High	x/Alum
C17	500	N/A	1279	1111	658	1433	*NULL*	*NULL*	*NULL*

Table 7. TDPO4 concentrations (µg/L) as measured in surface water grab samples between Aug 9 and Sep 5, 2003

ID	9-Aug	12-Aug	13-Aug	19-Aug	27-Aug	5-Sep	Fertilizer	P Level	Alum
A1	2809	1099	1323	1635	1596	1415	Chicken	Low	w/Alum
A2	1179	N/A	992	741	507	1907	Boca	High	w/Alum
A3	664	N/A	579	1153	84	1486	Commercial	Low	w/Alum
A4	886	N/A	502	1051	705	1007	Pompano	High	w/Alum
A5	564	N/A	808	886	426	846	Chicken	Low	x/Alum
A6	714	1687	1217	1390	439	2386	Boca	High	x/Alum
A7	1257	406	600	1003	809	1641	Pompano	Low	w/Alum
A8	1438	N/A	948	1044	576	1034	Commercial	Low	x/Alum
A9	603	488	624	806	631	1217	Chicken	High	w/Alum
A10	2363	850	954	791	754	1231	Pompano	Low	x/Alum
A11	1025	N/A	822	1757	1420	926	Commercial	High	w/Alum
A12	1080	1069	950	1957	627	1276	Chicken	High	x/Alum
A13	404	2016	426	1268	403	711	Boca	Low	w/Alum
A14	934	N/A	2119	2138	2884	1635	Boca	Low	x/Alum
A15	1850	1413	1281	1660	666	3120	Commercial	High	x/Alum
A16	595	N/A	1576	2298	945	739	Pompano	High	x/Alum
A17	871	1312	1159	1277	2008	884	*NULL*	*NULL*	*NULL*
B1	885	1006	891	1311	399	797	Chicken	Low	w/Alum
B2	1473	945	863	1466	514	1208	Pompano	High	w/Alum
B3	3601	1288	1213	875	646	1575	Commercial	Low	w/Alum
B4	1136	1020	1078	1330	939	853	Boca	High	w/Alum
B5	1779	N/A	1300	1454	691	2094	Chicken	High	w/Alum
B6	623	N/A	879	1181	591	1356	Pompano	Low	w/Alum
B7	2633	N/A	1767	1503	479	1923	Boca	Low	w/Alum
B8	1561	1144	925	790	1021	4200	Pompano	Low	x/Alum
B9	762	N/A	1099	1373	744	1164	Commercial	High	w/Alum
B10	1053	N/A	1717	2130	1171	6500	Boca	High	x/Alum
B11	899	N/A	1381	1158	990	1470	Commercial	Low	x/Alum
B12	456	N/A	613	1055	666	1250	Pompano	High	x/Alum
B13	973	N/A	980	607	731	1382	*NULL*	*NULL*	*NULL*
B14	2733	N/A	1151	1047	1153	2467	Boca	Low	x/Alum
B15	561	N/A	1051	860	768	949	Chicken	Low	x/Alum
B16	1491	1893	1792	1434	818	1645	Commercial	High	x/Alum
B17	2610	N/A	1649	1458	1441	2171	Chicken	High	x/Alum
C1	1085	563	848	1364	339	683	Boca	Low	w/Alum
C2	630	N/A	527	756	840	508	Pompano	Low	w/Alum
C3	1340	672	513	954	660	1155	Chicken	Low	w/Alum
C4	1141	N/A	2140	1430	1042	2508	Pompano	Low	x/Alum
C5	476	N/A	2819	1312	876	1970	Boca	Low	x/Alum
C6	1919	N/A	1516	873	574	1049	Chicken	Low	x/Alum
C7	371	N/A	936	1411	702	427	Boca	High	w/Alum
C8	365	N/A	435	697	683	343	Commercial	Low	w/Alum
C9	561	N/A	421	616	368	293	Pompano	High	w/Alum
C10	873	N/A	697	771	831	306	Chicken	High	w/Alum
C11	446	N/A	853	1011	330	1302	Commercial	Low	x/Alum
C12	669	2304	1901	2295	4622	1864	Boca	High	x/Alum
C13	671	N/A	592	381	311	522	Commercial	High	w/Alum
C14	670	N/A	1245	1407	1160	1070	Chicken	High	x/Alum
C15	2102	1884	1200	2011	946	3121	Commercial	High	x/Alum
C16	565	1232	1219	1362	2368	1246	Pompano	High	x/Alum
C17	500	N/A	1279	1111	658	1433	*NULL*	*NULL*	*NULL*

Table 8. TPO4 concentrations (µg/L) as measured in surface water grab samples between Aug 9 and Sep 30, 2003.

ID	9-Aug	11-Aug	12-Aug	13-Aug	19-Aug	22-Aug	27-Aug	5-Sep	30-Sep	Fertilizer	P Level	Alum
A1	1668	N/A	4038	1786	839	2,401	1,819	1,744	1,596	Chicken	Low	w/Alum
A2	1172	N/A	N/A	1549	471	1,559	1,526	2083	976	Boca	High	w/Alum
A3	860	N/A	N/A	1,705	1,170	1,293	1,320	2605	756	Commercial	Low	w/Alum
A4	453	N/A	N/A	562	533	1,055	1,334	1,364	1,001	Pompano	High	w/Alum
A5	425	N/A	N/A	3101	842	1665	875	2110	793	Chicken	Low	x/Alum
A6	2188	N/A	2,208	1,976	1,229	2,009	3,199	6,780	1,399	Boca	High	x/Alum
A7	861	N/A	781	1204	779	1126	961	1515	546	Pompano	Low	w/Alum
A8	808	N/A	N/A	1623	539	2,056	1,751	1,166	1,187	Commercial	Low	x/Alum
A9	913	688	705	1371	478	1200	752	683	902	Chicken	High	w/Alum
A10	600	N/A	716	1788	725	1,874	1,018	1,414	1,024	Pompano	Low	x/Alum
A11	1807	N/A	N/A	2,146	1,191	2,338	1,596	1071	920	Commercial	High	w/Alum
A12	424	N/A	472	2,150	1,270	1,651	1363	755	908	Chicken	High	x/Alum
A13	2943	N/A	851	1,754	1,034	1293	972	1030	965	Boca	Low	w/Alum
A14	1452	N/A	N/A	1,567	1,466	2,529	2,311	1583	N/A	Boca	Low	x/Alum
A15	590	N/A	975	2,612	2,039	1,347	1,192	1136	N/A	Commercial	High	x/Alum
A16	591	N/A	N/A	2,119	1,033	1,706	1264	573	485	Pompano	High	x/Alum
A17	1,451	1,055	1488	2489	865	3,097	1,950	1,298	1,175	*NULL*	*NULL*	*NULL*
B1	1568	N/A	587	2,141	1,435	1496	801	1031	561	Chicken	Low	w/Alum
B2	865	N/A	702	1,228	1280	968	729	434	579	Pompano	High	w/Alum
B3	790	N/A	1082	747	920	2198	734	683	N/A	Commercial	Low	w/Alum
B4	1762	N/A	1,127	1,719	1,868	1229	794	915	N/A	Boca	High	w/Alum
B5	756	N/A	N/A	1,046	1,338	3256	995	1989	949	Chicken	High	w/Alum
B6	1830	N/A	N/A	1,607	1,301	1,048	1,070	2359	836	Pompano	Low	w/Alum
B7	1194	N/A	N/A	1029	803	1270	961	1474	905	Boca	Low	w/Alum
B8	1230	N/A	724	1817	605	2,115	1,023	1174	450	Pompano	Low	x/Alum
B9	5362	N/A	N/A	1970	739	1,637	1167	810	440	Commercial	High	w/Alum
B10	2332	N/A	N/A	5,407	1,582	3,837	3,862	8031	186	Boca	High	x/Alum
B11	2510	N/A	N/A	1,673	1,268	2198	860	1260	479	Commercial	Low	x/Alum
B12	3312	N/A	N/A	1619	622	1,671	1,203	1329	810	Pompano	High	x/Alum
B13	4269	N/A	N/A	1590	499	3,404	1,405	1239	680	*NULL*	*NULL*	*NULL*
B14	1685	N/A	N/A	3,264	1,113	2,675	2,322	6151	569	Boca	Low	x/Alum
B15	4149	N/A	N/A	1727	901	2,560	2,272	1610	723	Chicken	Low	x/Alum
B16	5480	N/A	2,217	4,300	1,306	1,879	1,370	3295	628	Commercial	High	x/Alum
B17	4210	N/A	N/A	3,081	1,054	1,838	2,703	2205	612	Chicken	High	x/Alum
C1	1887	589	453	1375	779	2114	623	932	513	Boca	Low	w/Alum
C2	1417	N/A	N/A	1916	615	2260	803	681	762	Pompano	Low	w/Alum
C3	1154	1,221	1,544	1,171	1,039	1,923	1,103	1,039	1,510	Chicken	Low	w/Alum
C4	799	N/A	N/A	3445	933	3,895	1,513	2187	948	Pompano	Low	x/Alum
C5	878	N/A	N/A	1,873	1,059	3,501	2,294	1004	847	Boca	Low	x/Alum
C6	1046	N/A	N/A	1785	973	2,660	1,184	1078	411	Chicken	Low	x/Alum
C7	403	N/A	N/A	374	406	1,854	1752	926	966	Boca	High	w/Alum
C8	951	N/A	N/A	1307	648	1904	445	984	1,136	Commercial	Low	w/Alum
C9	915	N/A	N/A	1188	438	1629	544	264	1,012	Pompano	High	w/Alum
C10	1243	N/A	N/A	1398	653	1,716	1203	364	781	Chicken	High	w/Alum
C11	1783	N/A	N/A	871	1,593	2,870	2,116	1447	599	Commercial	Low	x/Alum
C12	797	N/A	1,881	3,298	1,539	4,892	2,647	2,174	1,649	Boca	High	x/Alum
C13	1084	N/A	N/A	475	466	3748	728	373	1,711	Commercial	High	w/Alum
C14	1353	N/A	N/A	2130	981	3,344	1,833	1431	974	Chicken	High	x/Alum
C15	920	N/A	741	1,710	1,550	1,305	1,751	1076	395	Commercial	High	x/Alum
C16	742	N/A	1,321	2,195	1,237	3,607	2,261	1171	283	Pompano	High	x/Alum
C17	22	N/A	N/A	1887	962	2,911	1,306	2005	504	*NULL*	*NULL*	*NULL*

Table 9. Total Aluminum concentrations (mg/L) as measured in surface water grab samples between Aug 9 and Sep 30, 2003.

ID	9-Aug	11-Aug	12-Aug	13-Aug	19-Aug	27-Aug	5-Sep	30-Sep	Fertilizer	P Level	Alum
A1	0.4	N/A	0.3	0.1	0.2	0.1	0.4	0	Chicken	Low	w/Alum
A2	0.5	N/A	N/A	0.1	0.2	0.1	0.5	0	Boca	High	w/Alum
A3	0.4	N/A	N/A	0.1	0.1	0.1	0.3	0.2	Commercial	Low	w/Alum
A4	0.4	N/A	N/A	0.1	0.2	0.2	0.4	0	Pompano	High	w/Alum
A5	0.5	N/A	N/A	0.1	0.2	0.2	0.3	0	Chicken	Low	x/Alum
A6	0.4	N/A	0.2	0.2	0.2	0.2	0.5	0	Boca	High	x/Alum
A7	0.5	N/A	0.2	0.2	0.2	0.2	0.5	0.1	Pompano	Low	w/Alum
A8	0.5	N/A	N/A	0.1	0.3	0.1	0.6	0	Commercial	Low	x/Alum
A9	0.5	0.2	0.6	0.2	0.2	0.2	0.5	0	Chicken	High	w/A lum
A10	0.5	N/A	0.2	0.2	0.2	0.2	0.4	0.1	Pompano	Low	x/Alum
A11	0.4	N/A	N/A	0.2	0.2	0.3	0.3	0	Commercial	High	w/Alum
A12	0.4	N/A	0.2	0.2	0.2	0.2	0.5	0	Chicken	High	x/Alum
A13	0.4	N/A	0.2	0.2	0.2	0.3	0.4	0.2	Boca	Low	w/Alum
A14	0.4	N/A	N/A	0.1	0.2	0.2	0.3	0	Boca	Low	x/Alum
A15	0.4	N/A	0.4	0.2	0.2	0.2	0.4	0	Commercial	High	x/Alum
A16	0.3	N/A	N/A	0.2	0.3	0.2	0.4	0	Pompano	High	x/Alum
A17	0.4	0.2	0.2	0.2	0.2	0.2	0.3	0	*NULL*	*NULL*	*NULL*
B1	0.8	N/A	0.2	0.2	0.2	0.2	0.4	0.3	Chicken	Low	w/Alum
B2	1.1	N/A	0.5	0.2	0.3	0.2	0.9	0.5	Pompano	High	w/Alum
B3	1	N/A	0.5	0.2	0.5	0.3	0.5	0.5	Commercial	Low	w/Alum
B4	0.8	N/A	0.3	0.2	0.2	0.2	0.6	0	Boca	High	w/Alum
B5	0.6	N/A	N/A	0.2	0.2	0.2	0.4	0	Chicken	High	w/Alum
B6	0.4	N/A	N/A	0.2	0.1	0.2	0.4	0	Pompano	Low	w/Alum
B7	0.5	N/A	N/A	0.2	0.2	0.2	0.6	0	Boca	Low	w/Alum
B8	0.6	N/A	0.2	0.1	0.2	0.2	0.4	0	Pompano	Low	x/Alum
B9	0.7	N/A	N/A	0.2	0.2	0.4	0.6	0	Commercial	High	w/Alum
B10	0.6	N/A	N/A	0.2	0.2	0.2	0.4	0	Boca	High	x/Alum
B11	0.4	N/A	N/A	0.2	0.2	0.2	0.3	0	Commercial	Low	x/Alum
B12	0.3	N/A	N/A	0.2	0.2	0.2	0.3	0	Pompano	High	x/Alum
B13	0.4	N/A	N/A	0.3	0.2	0.2	0.4	0	*NULL*	*NULL*	*NULL*
B14	0.4	N/A	N/A	0.2	0.2	0.2	0.4	0	Boca	Low	x/Alum
B15	0.5	N/A	N/A	0.3	0.3	0.2	0.4	0	Chicken	Low	x/Alum
B16	0.5	N/A	0.2	0.3	0.2	0.2	0.5	0	Commercial	High	x/Alum
B17	0.4	N/A	N/A	0.2	0.2	0.2	0.4	0	Chicken	High	x/Alum
C1	1	0.2	0.3	0.3	0.3	0.2	0.6	0	Boca	Low	w/Alum
C2	0.9	N/A	N/A	0.4	0.2	0.3	0.6	0.1	Pompano	Low	w/Alum
C3	0.7	0.2	0.2	0.2	0.3	0.2	0.5	0	Chicken	Low	w/Alum
C4	0.6	N/A	N/A	0.2	0.2	0.2	0.6	0	Pompano	Low	x/Alum
C5	0.6	N/A	N/A	0.3	0.2	0.2	0.4	0	Boca	Low	x/Alum
C6	0.5	N/A	N/A	0.1	0.2	0.2	0.5	0	Chicken	Low	x/Alum
C7	0.5	N/A	N/A	0.3	0.2	0.2	0.4	0	Boca	High	w/Alum
C8	0.4	N/A	N/A	0.2	0.2	0.2	0.4	0.2	Commercial	Low	w/Alum
C9	0.7	N/A	N/A	0.1	0.2	0.2	0.4	0	Pompano	High	w/Alum
C10	0.4	N/A	N/A	0.2	0.3	0.2	0.4	0.1	Chicken	High	w/Alum
C11	0.7	N/A	N/A	0.2	0.3	0.2	0.5	0	Commercial	Low	x/Alum
C12	0.7	N/A	0.3	0.1	0.3	0.1	0.3	0.2	Boca	High	x/Alum
C13	0.4	N/A	N/A	0.2	0.2	0.2	0.3	0	Commercial	High	w/Alum
C14	0.5	N/A	N/A	0.2	0.2	0.2	0.6	0	Chicken	High	x/Alum
C15	0.6	N/A	0.2	0.2	0.3	0.2	0.4	0	Commercial	High	x/Alum
C16	0.5	N/A	0.3	0.2	0.3	0.1	0.5	0	Pompano	High	x/Alum
C17	0	N/A	N/A	0.2	0.2	0.2	0.5	0	*NULL*	*NULL*	*NULL*

Grab Samples Time Series

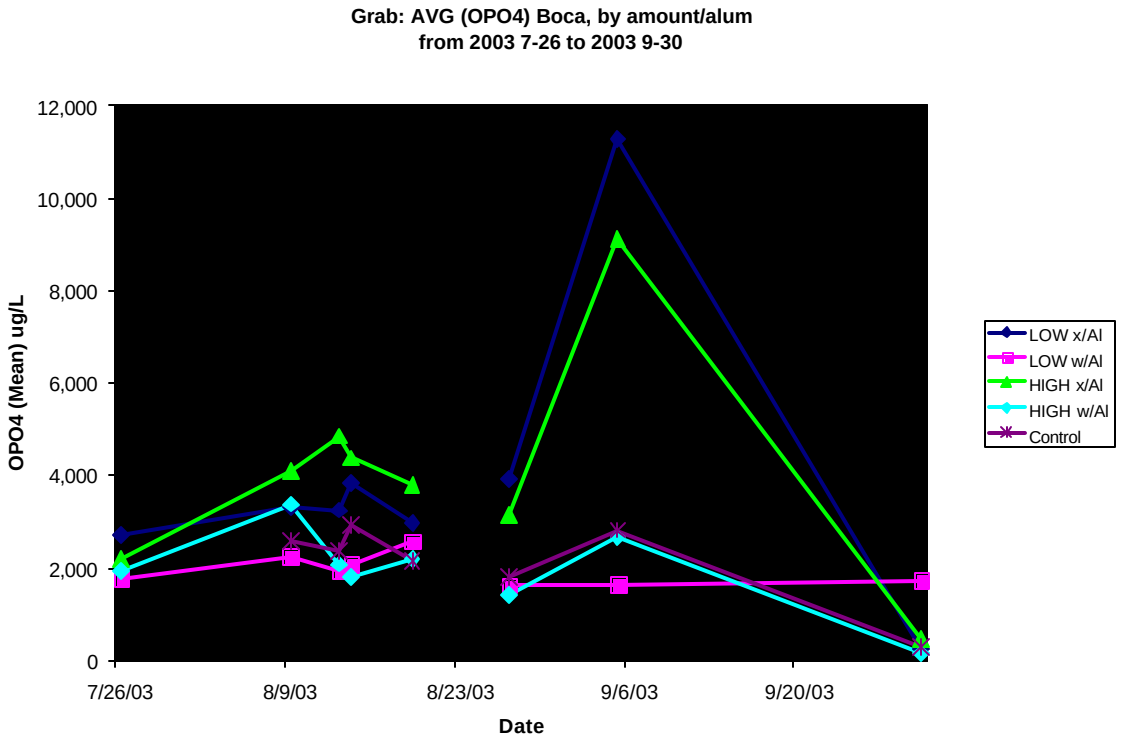

Figure 67. Mean ortho-phosphorus concentrations in surface water grab samples for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

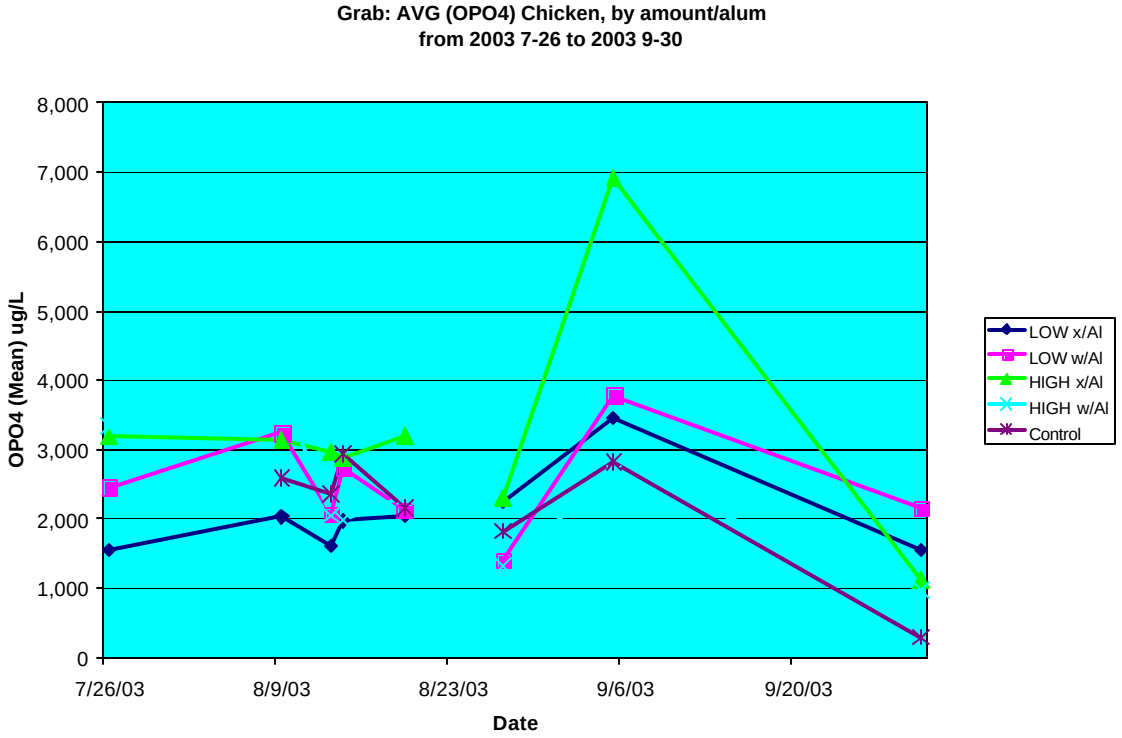

Figure 68. Mean ortho-phosphorus concentrations in surface water grab samples for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

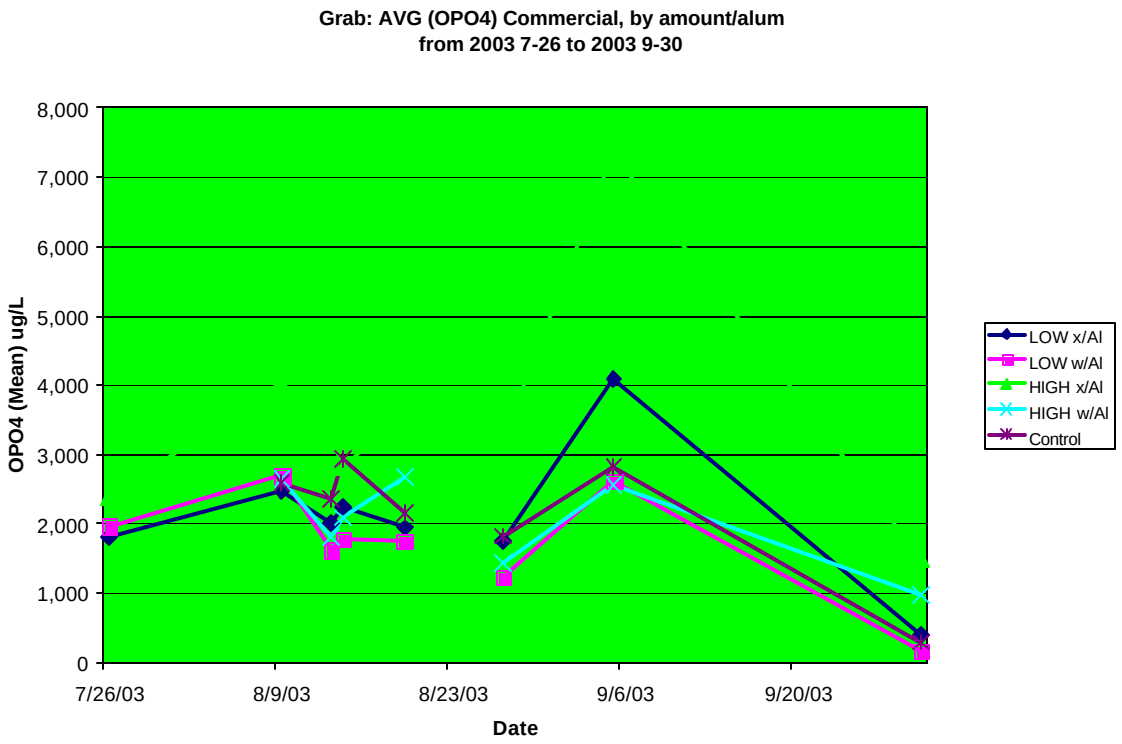

Figure 69. Mean ortho-phosphorus concentrations in surface water grab samples for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

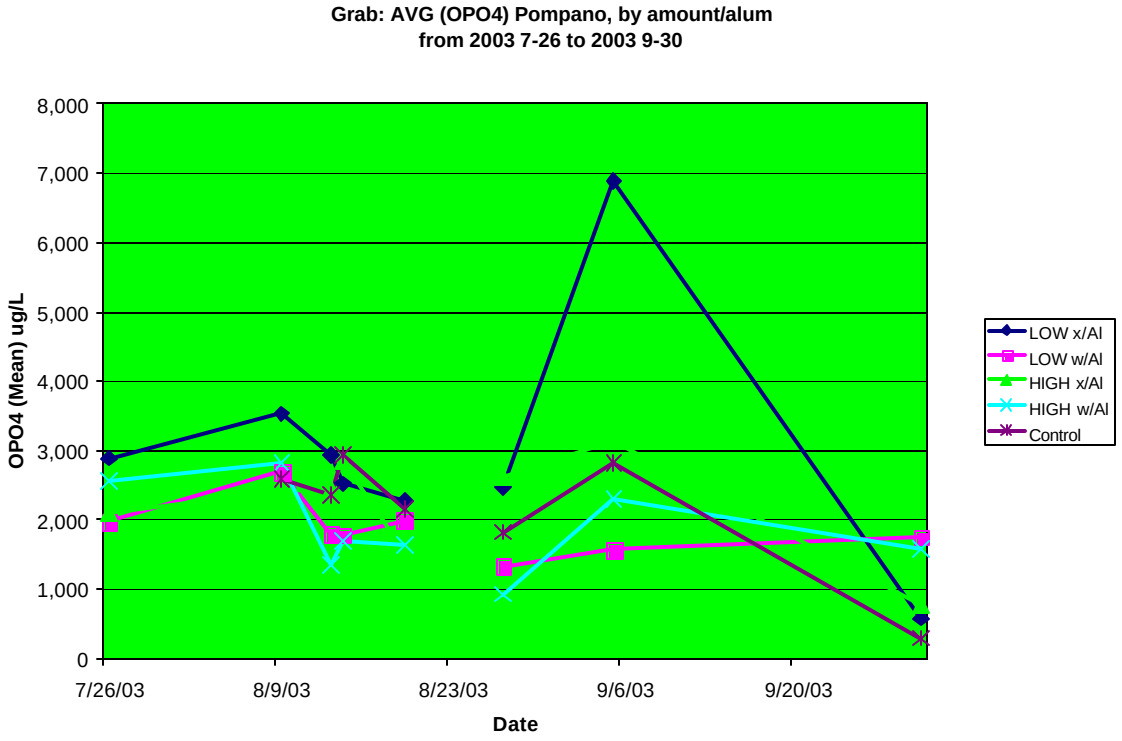

Figure 70. Mean ortho-phosphorus concentrations in surface water grab samples for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

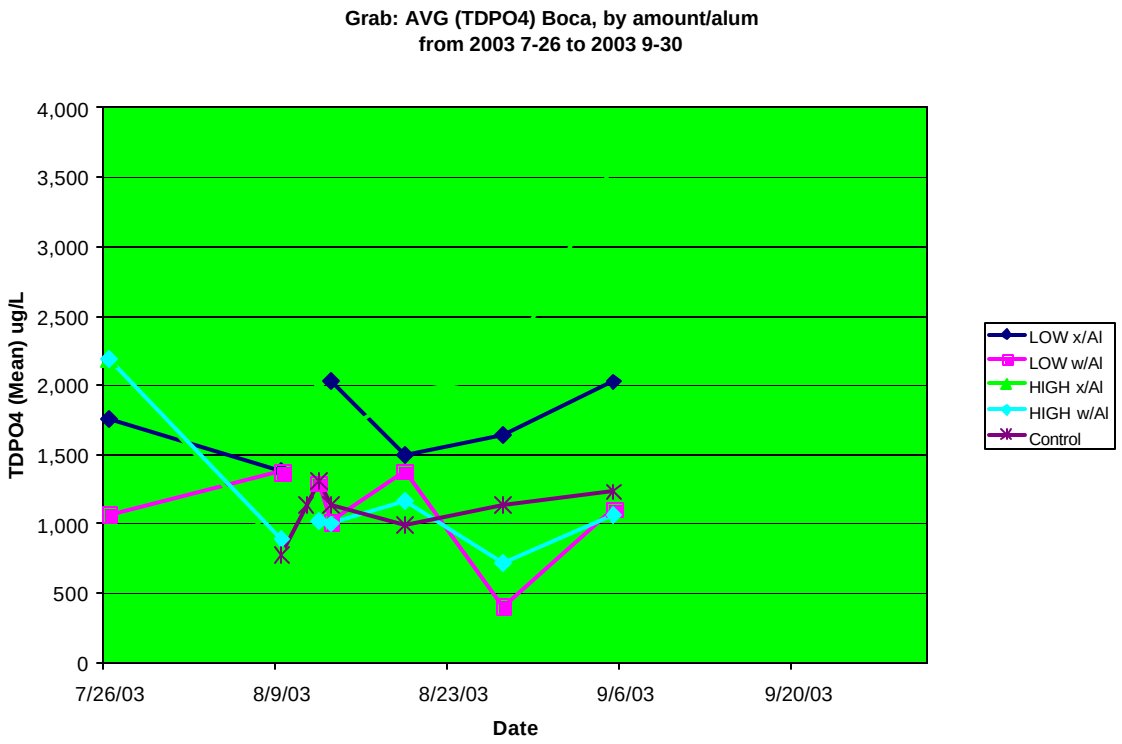

Figure 71. Mean total dissolved phosphorus concentrations in surface water grab samples for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

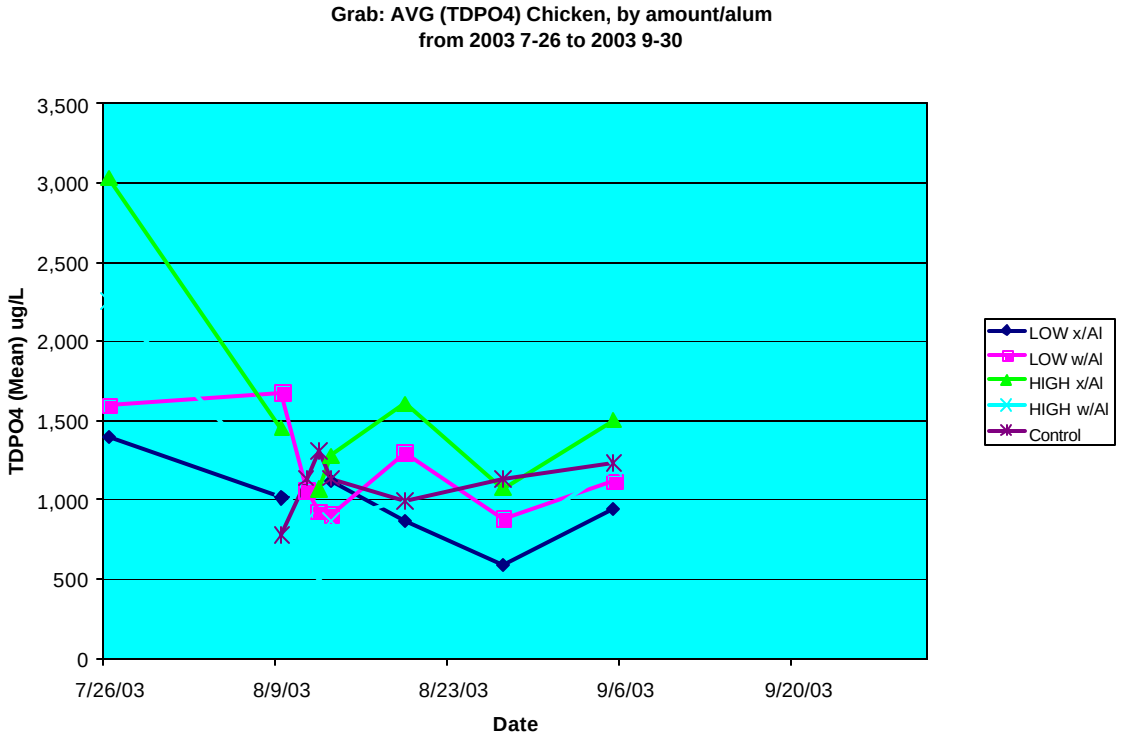

Figure 72. Mean total dissolved phosphorus concentrations in surface water grab samples for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

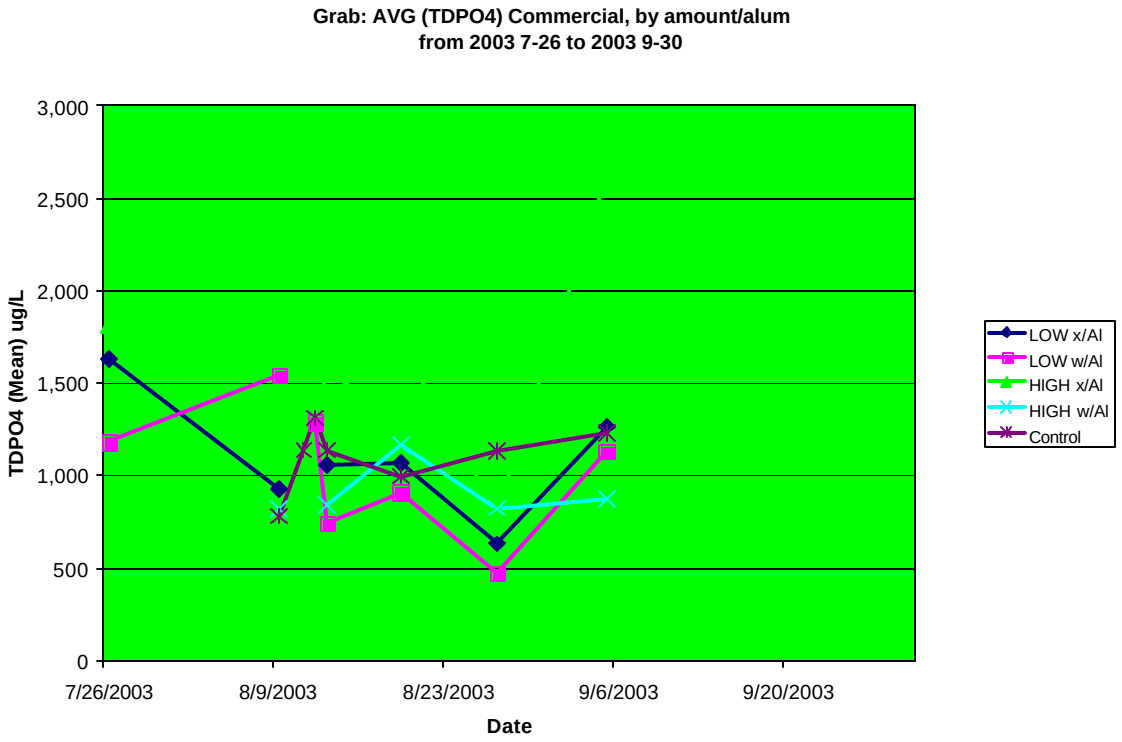

Figure 73. Mean total dissolved phosphorus concentrations in surface water grab samples for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

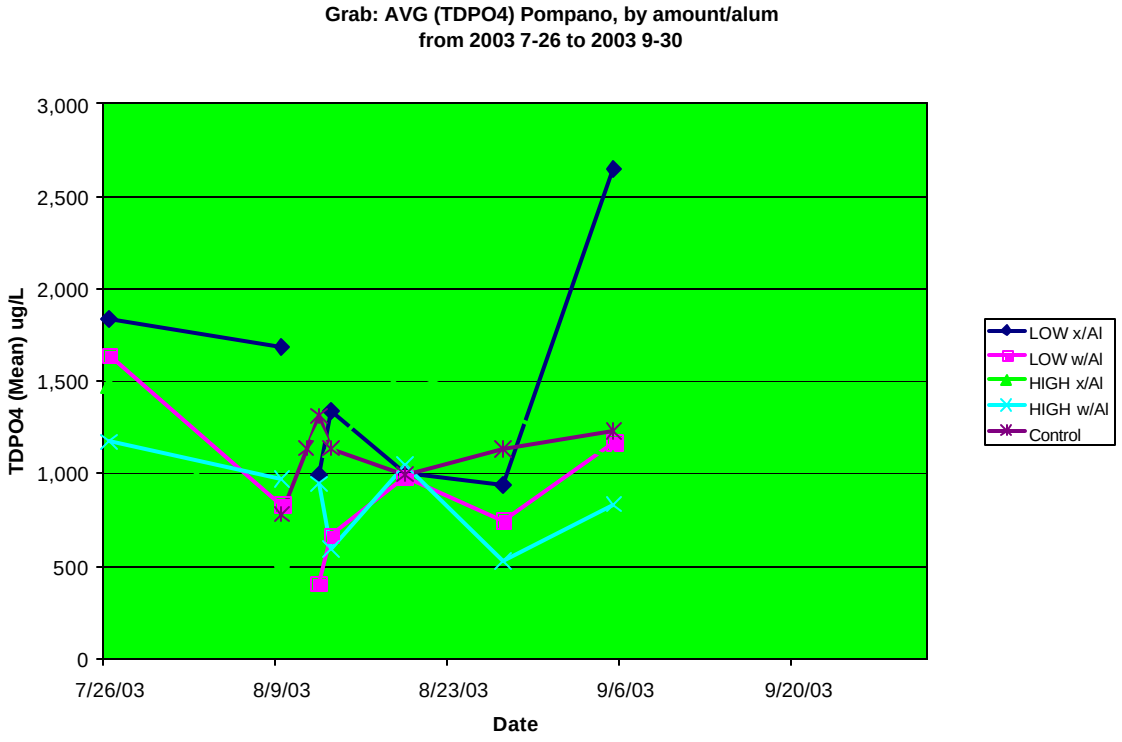

Figure 74. Mean total dissolved phosphorus concentrations in surface water grab samples for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

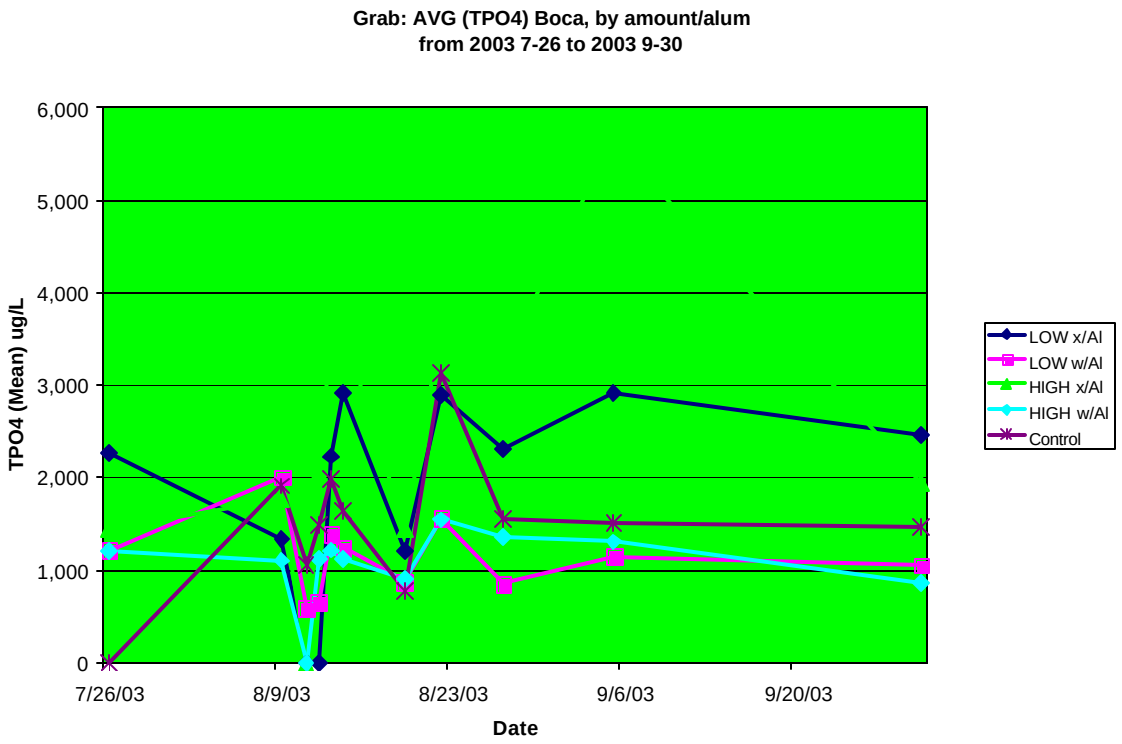

Figure 75. Mean total phosphorus concentrations in surface water grab samples for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

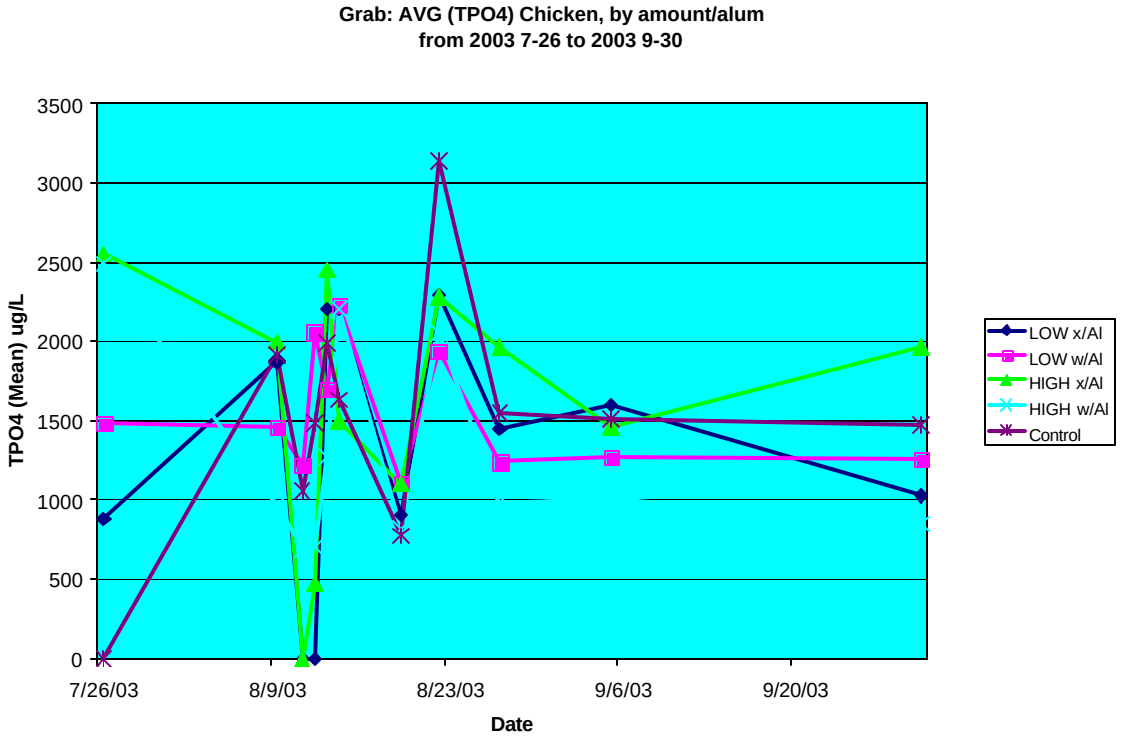

Figure 76. Mean total phosphorus concentrations in surface water grab samples for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

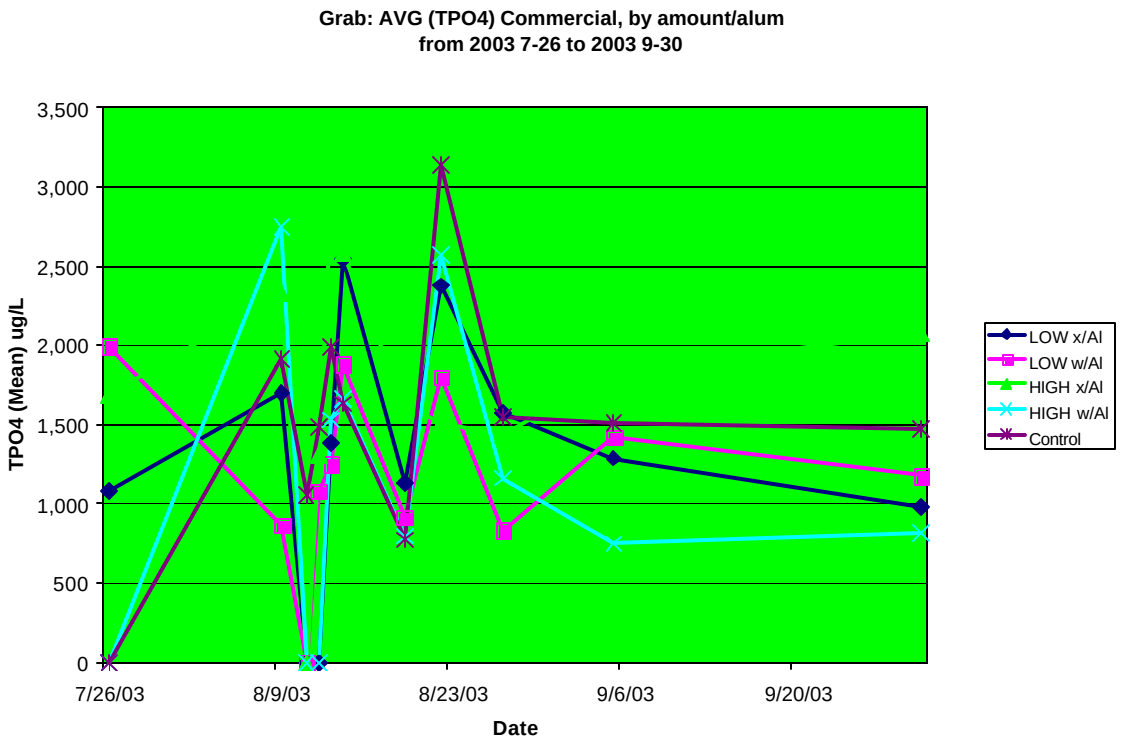

Figure 77. Mean total phosphorus concentrations in surface water grab samples for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

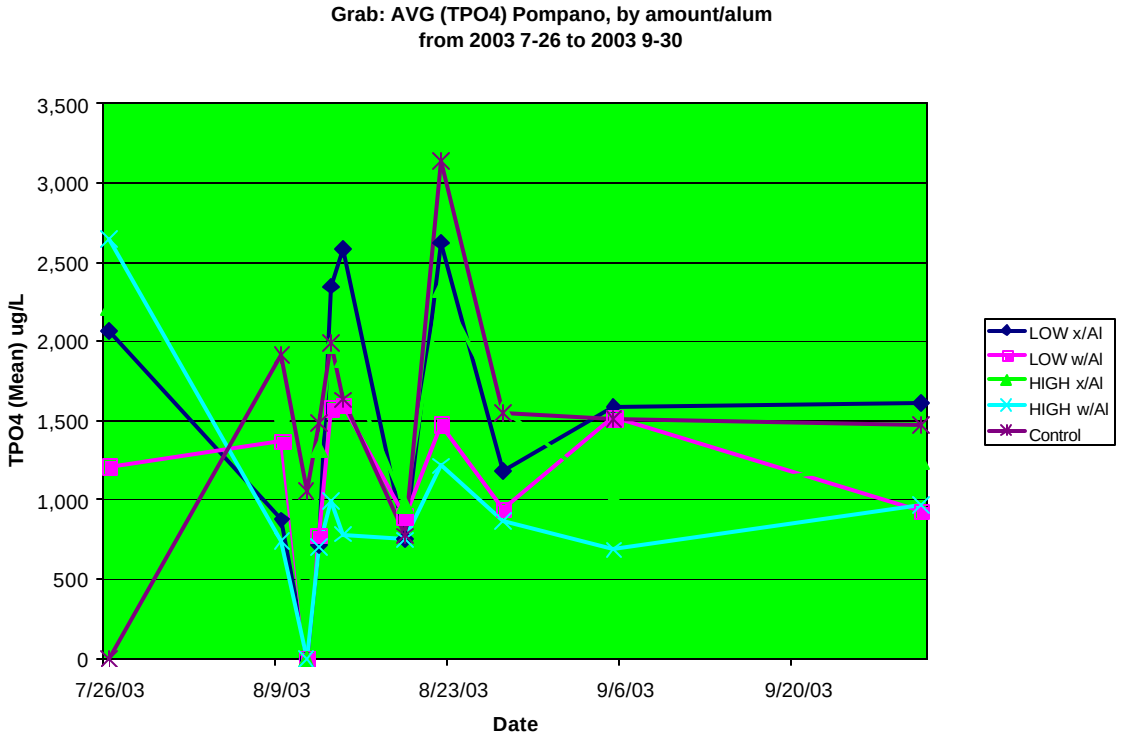

Figure 78. Mean total phosphorus concentrations in surface water grab samples for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

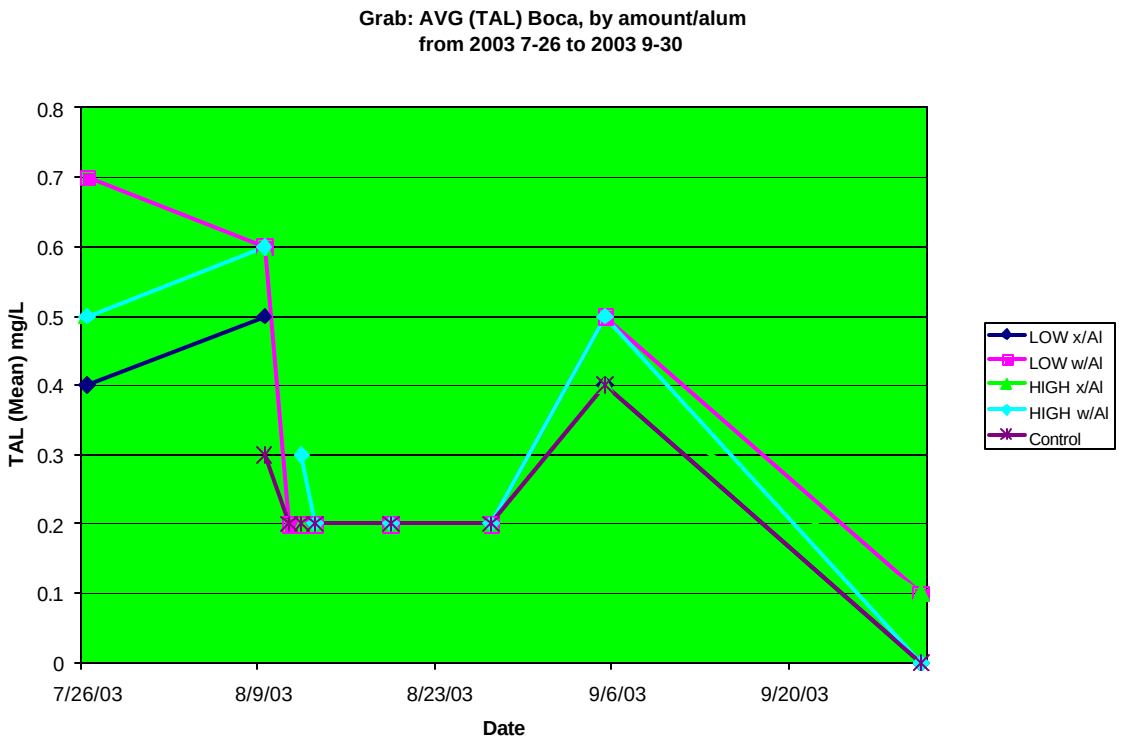

Figure 79. Mean total aluminum concentrations in surface water grab samples for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

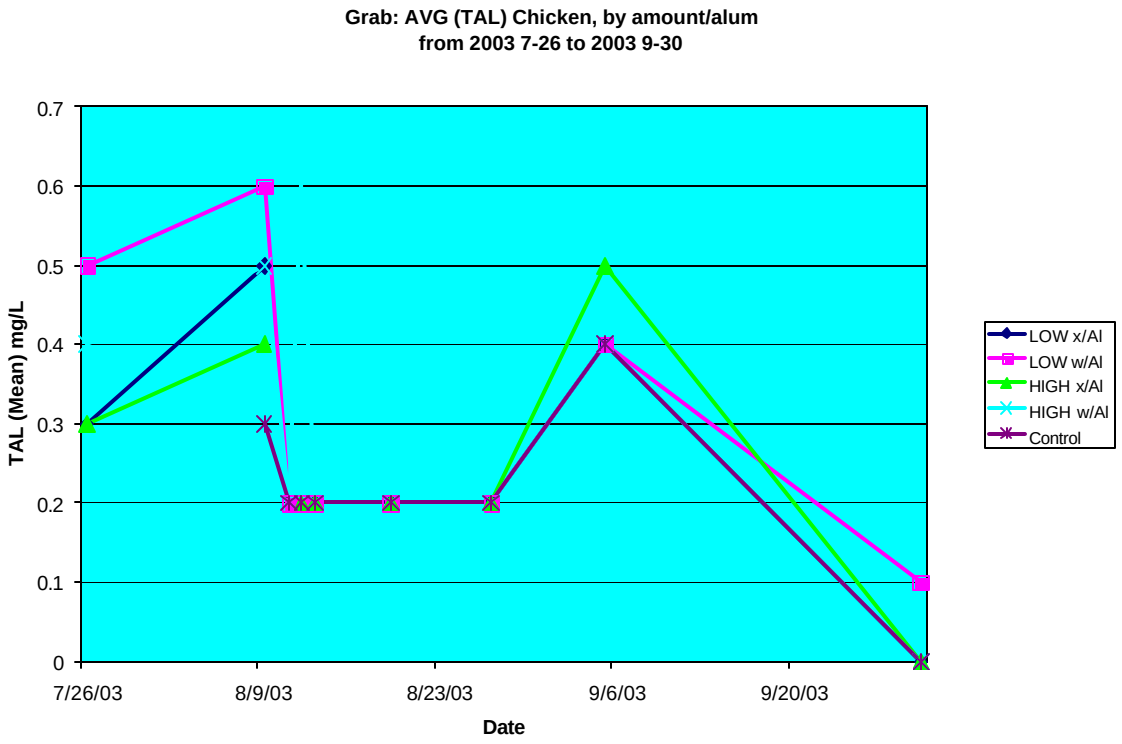

Figure 80. Mean total aluminum concentrations in surface water grab samples for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

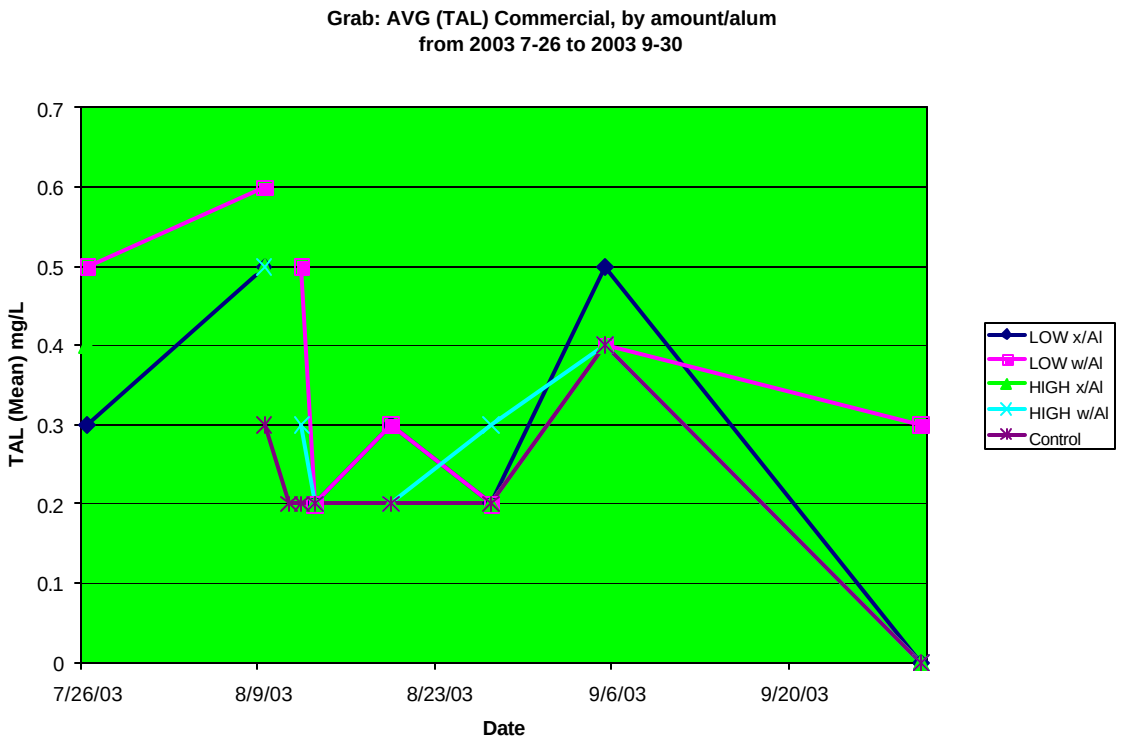

Figure 81. Mean total aluminum concentrations in surface water grab samples for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

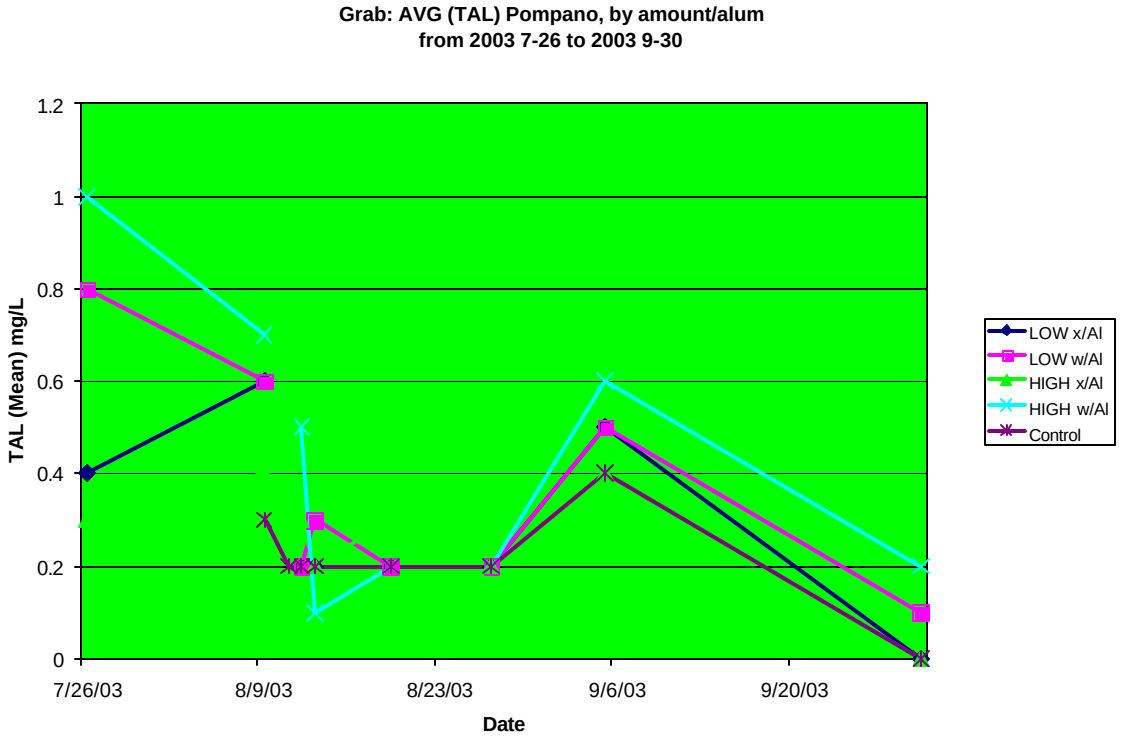

Figure 82. Mean total aluminum concentrations in surface water grab samples for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and September 30, 2003.

Grab Samples Treatment Effects

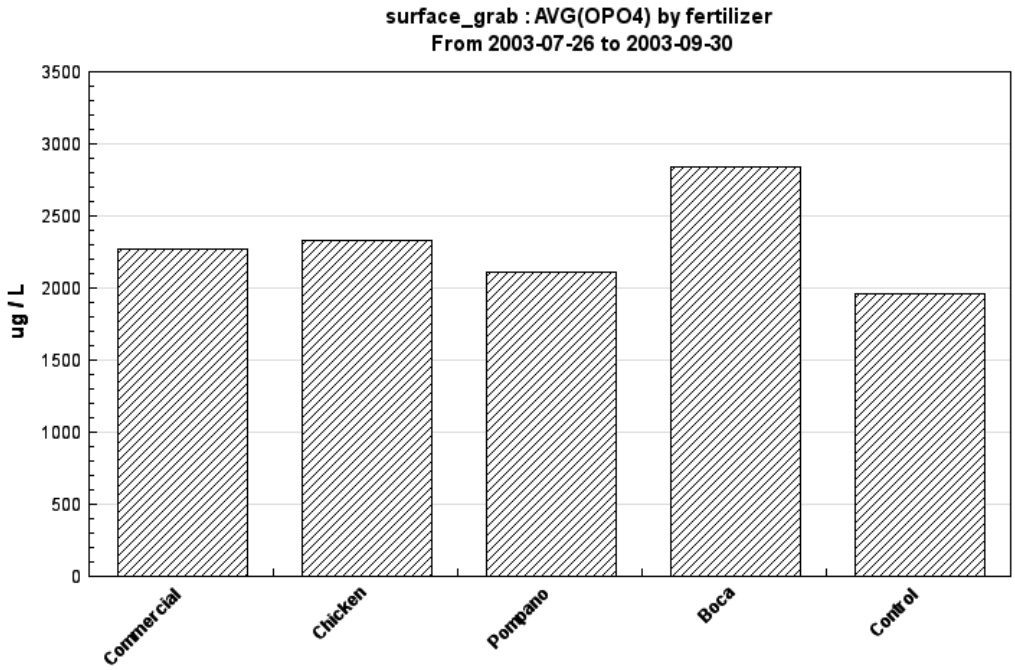

Figure 83. Mean ortho-phosphorus concentration by fertilizer source as measured in surface water grab samples between July 26 and September 30, 2003.

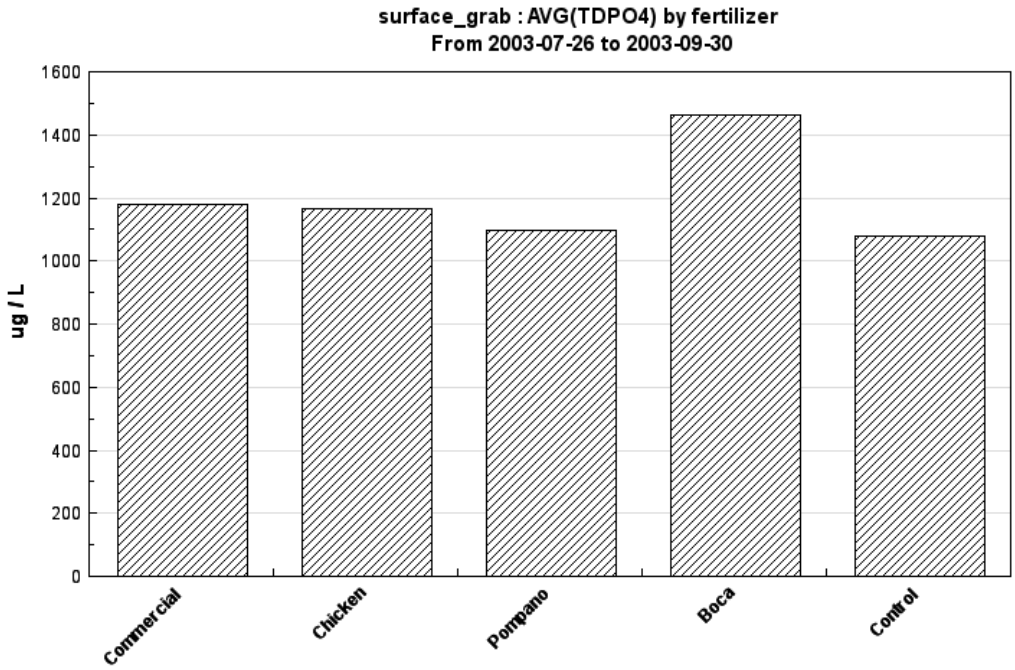

Figure 84. Mean total dissolved phosphorus concentration by fertilizer source as measured in surface water grab samples between July 26 and September 30, 2003.

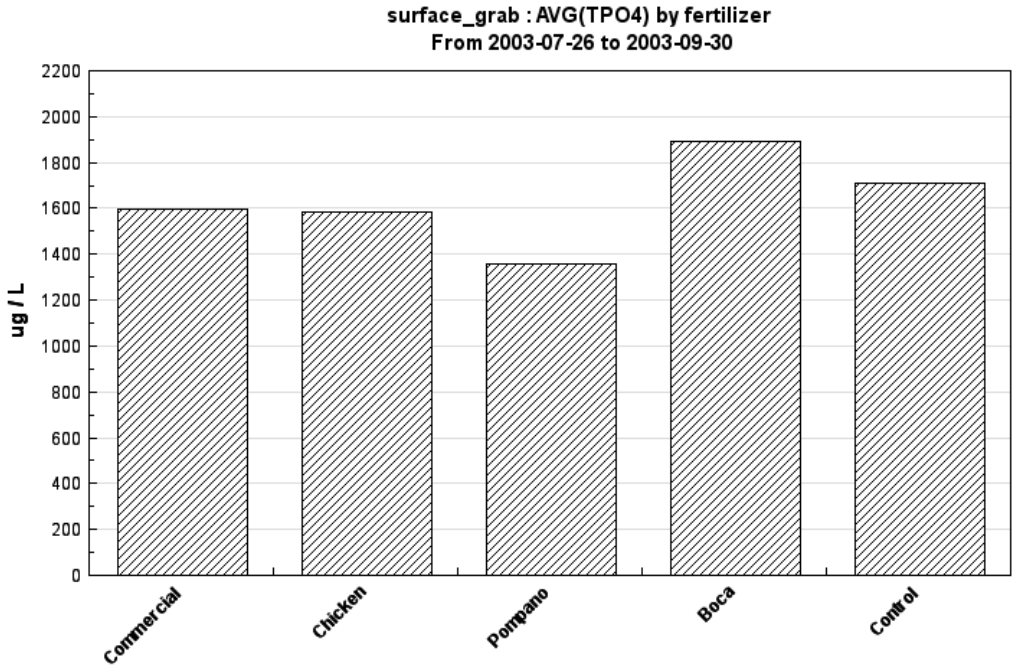

Figure 85. Mean total phosphorus concentration by fertilizer source as measured in surface water grab samples between July 26 and September 30, 2003.

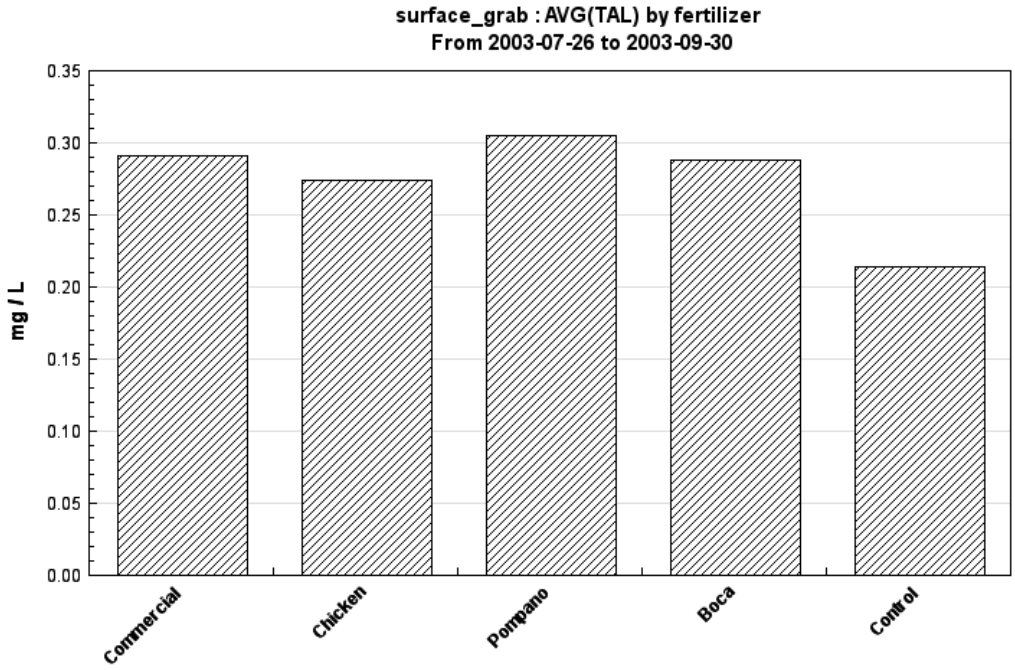

Figure 86. Mean total aluminum concentration by fertilizer source as measured in surface water grab samples between July 26 and September 30, 2003.

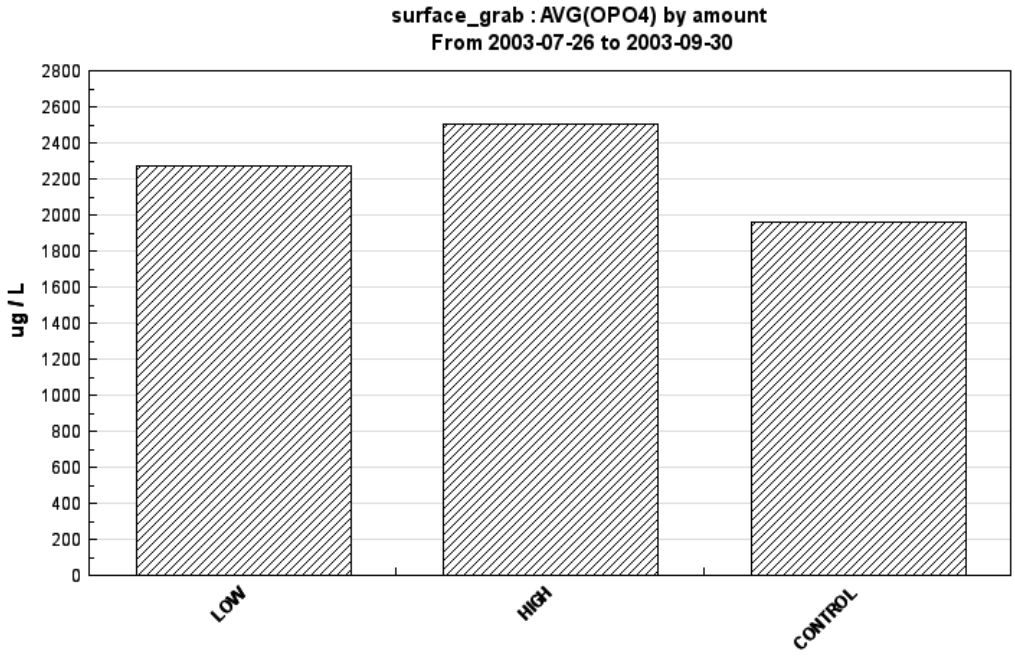

Figure 87. Mean ortho-phosphorus concentration by amount as measured in surface water grab samples between July 26 and September 30, 2003.

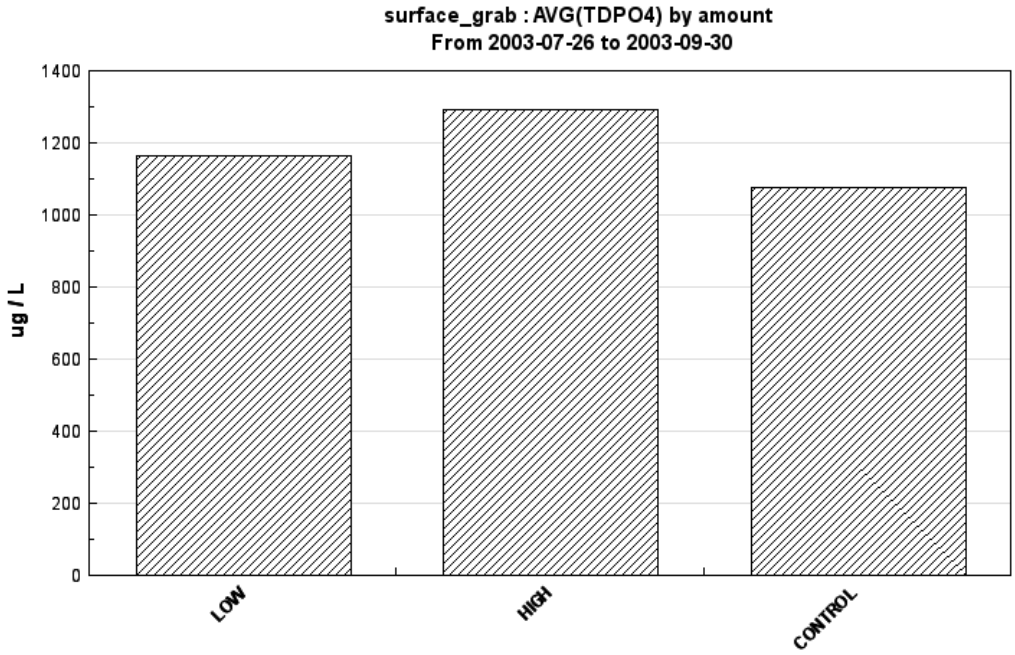

Figure 88. Mean total dissolved phosphorus concentration by amount as measured in surface water grab samples between July 26 and September 30, 2003.

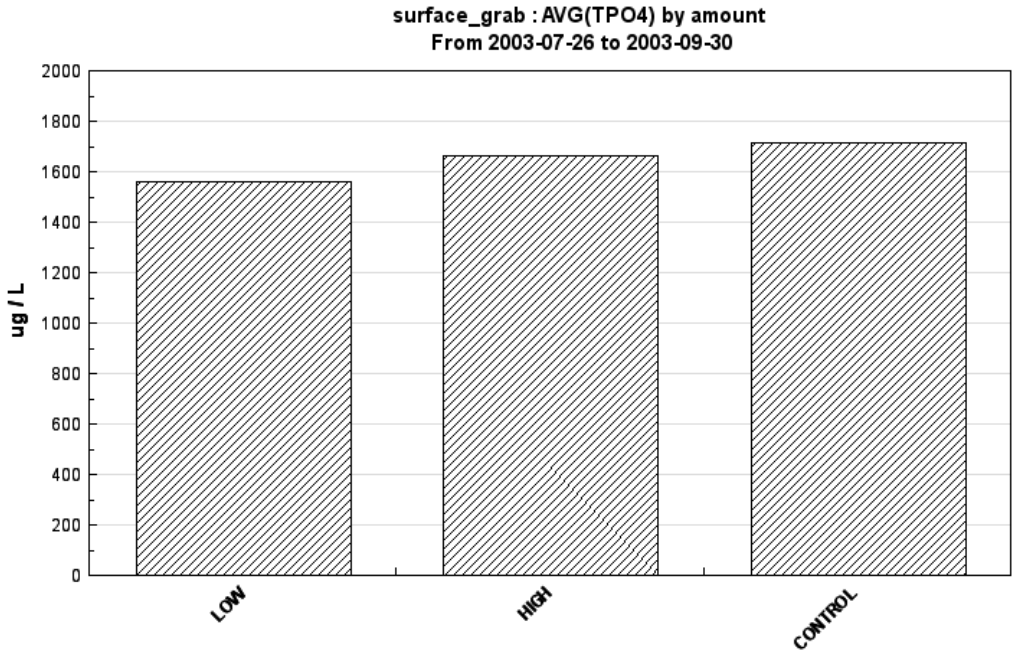

Figure 89. Mean total phosphorus concentration by amount as measured in surface water grab samples between July 26 and September 30, 2003.

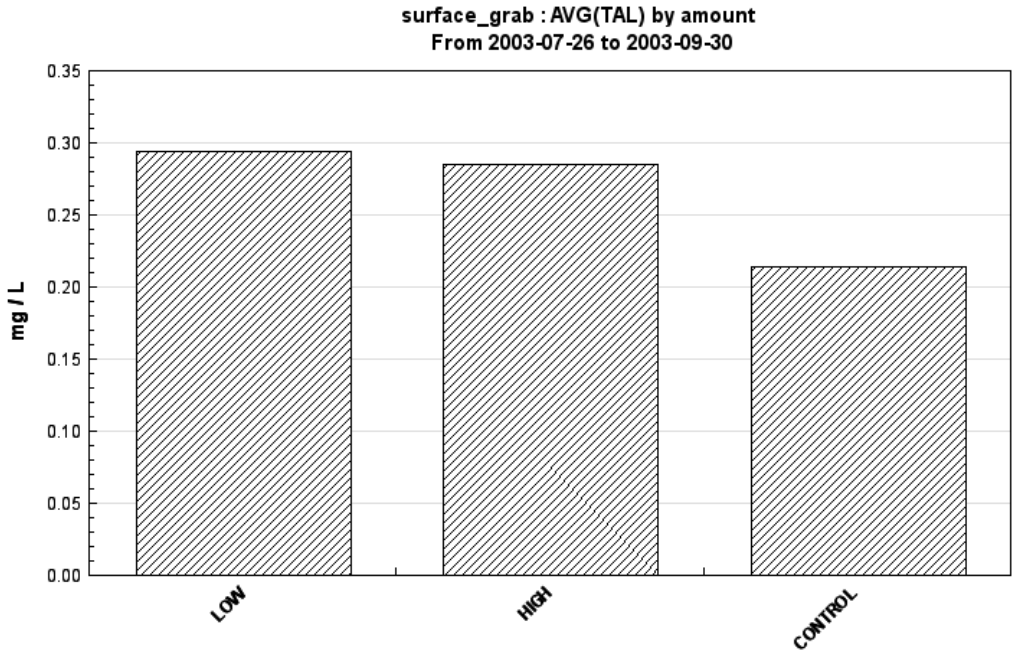

Figure 90. Mean total aluminum concentration by amount as measured in surface water grab samples between July 26 and September 30, 2003.

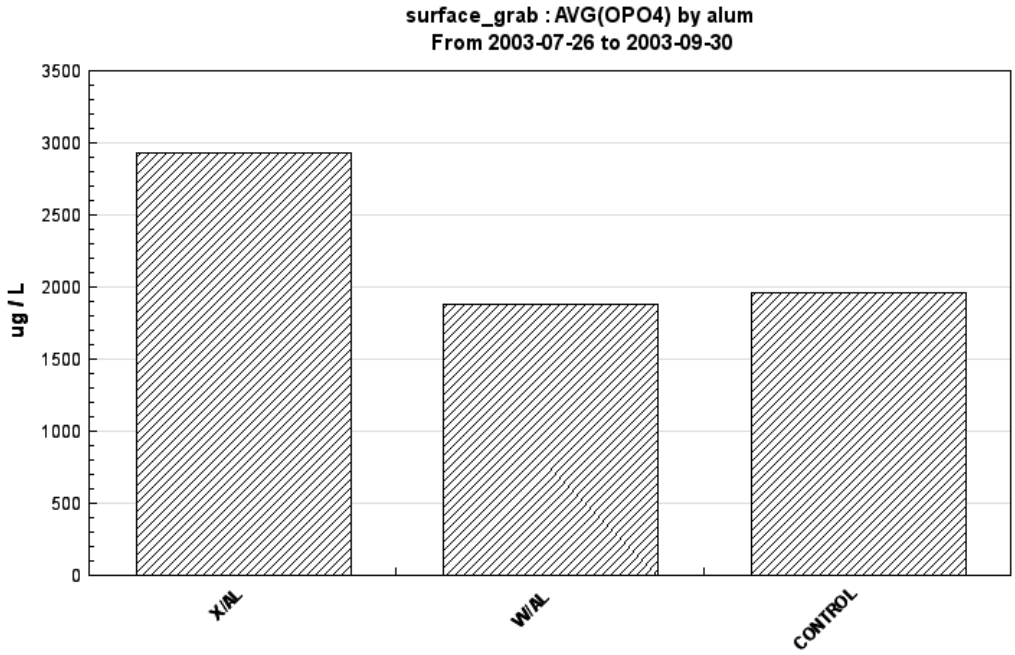

Figure 91. Mean ortho-phosphorus concentration by WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

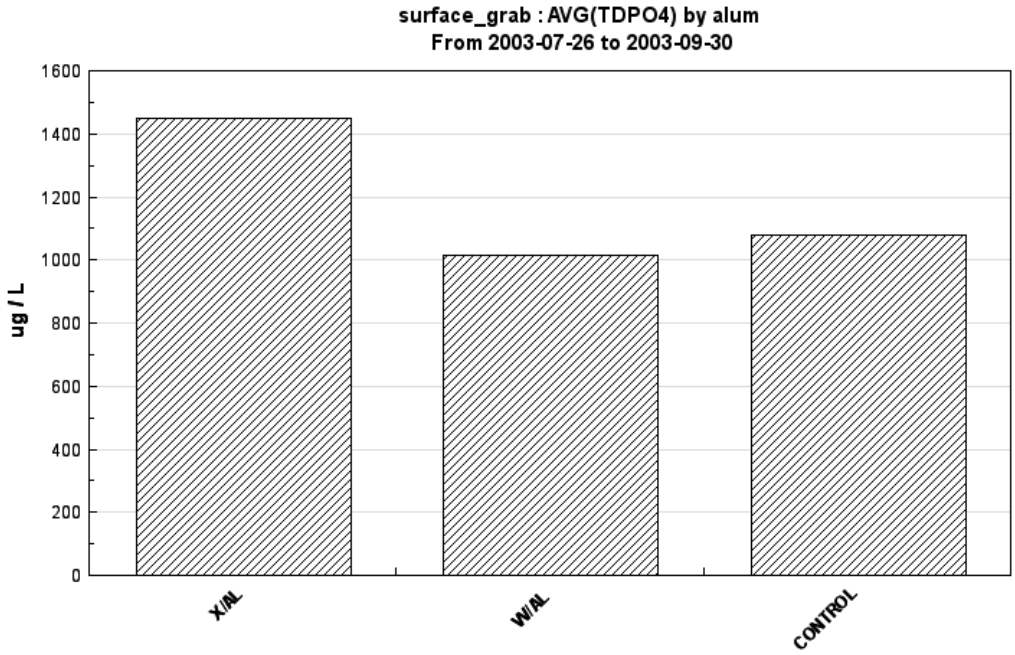

Figure 92. Mean total dissolved phosphorus concentration by WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

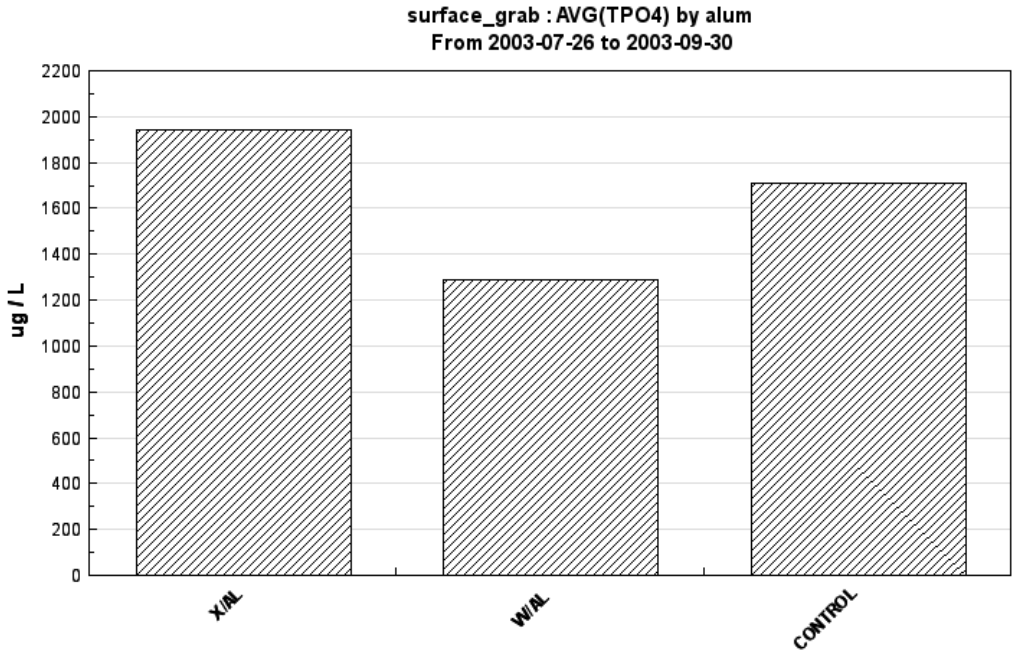

Figure 93. Mean total phosphorus concentration by WTR amendment (alum) source as measured in surface water grab samples between July 26 and September 30, 2003.

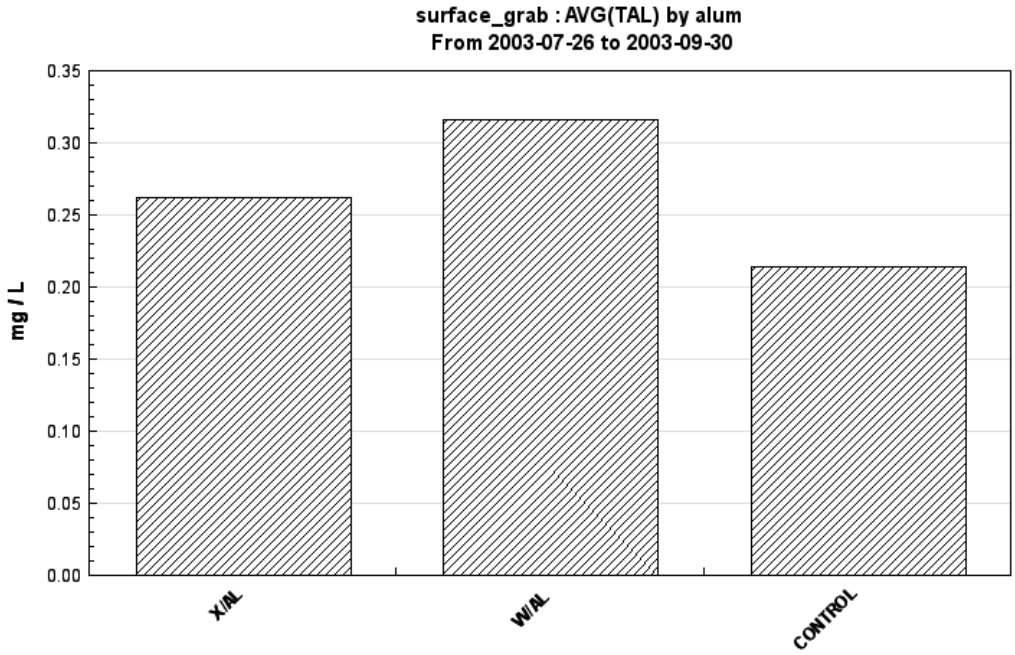

Figure 94. Mean total aluminum concentration by WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

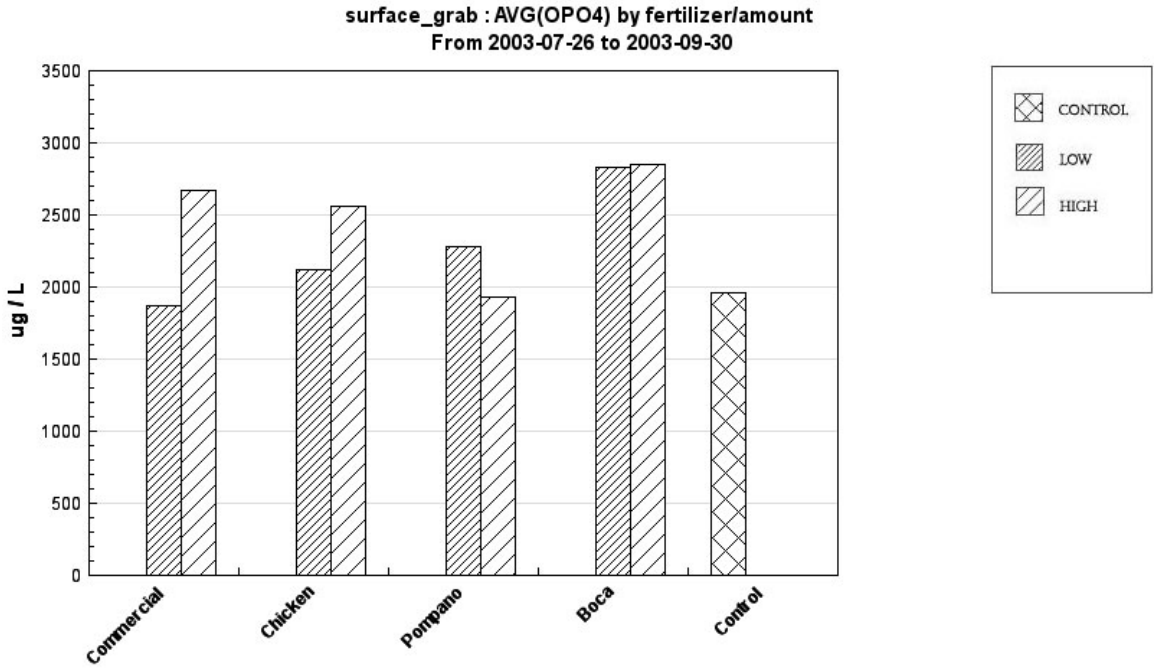

Figure 95. Mean ortho-phosphorus concentration by fertilizer source and amount as measured in surface water grab samples between July 26 and September 30, 2003.

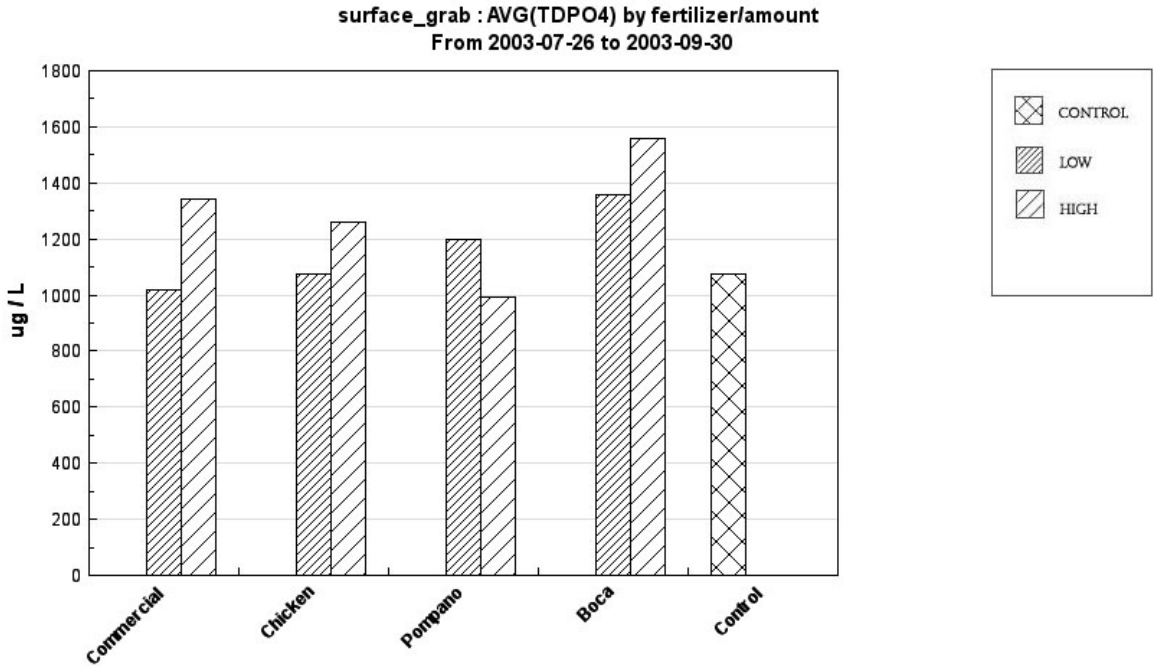

Figure 96. Mean total dissolved phosphorus concentration by fertilizer source and amount as measured in surface water grab samples between July 26 and September 30, 2003.

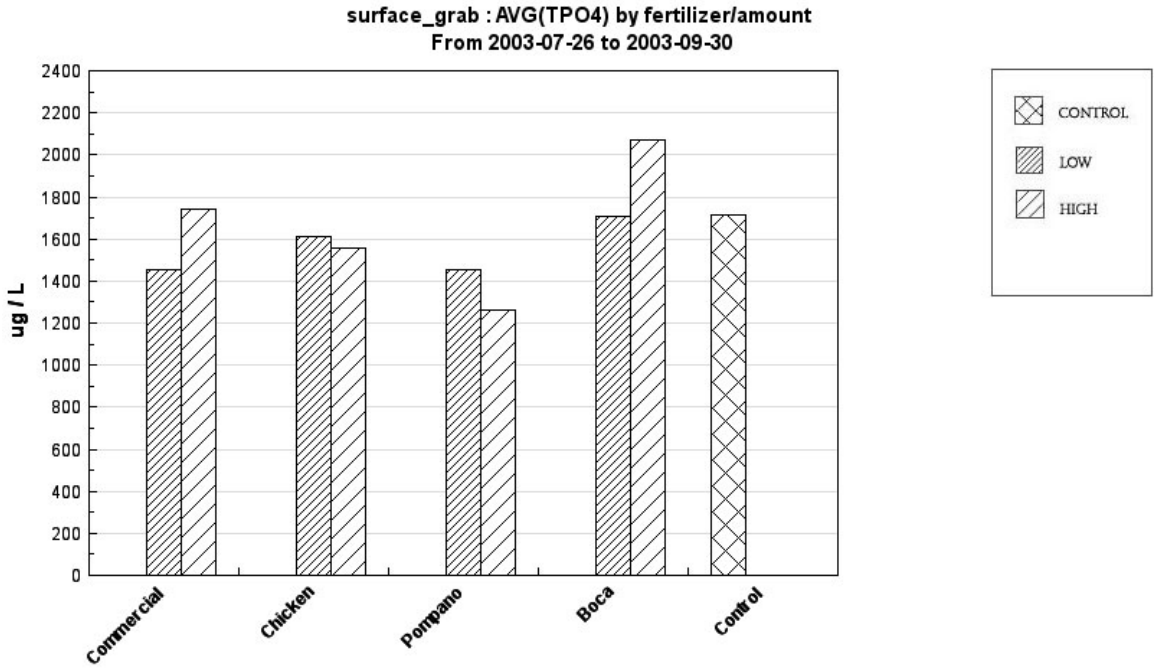

Figure 97. Mean total phosphorus concentration by fertilizer source and amount as measured in surface water grab samples between July 26 and September 30, 2003.

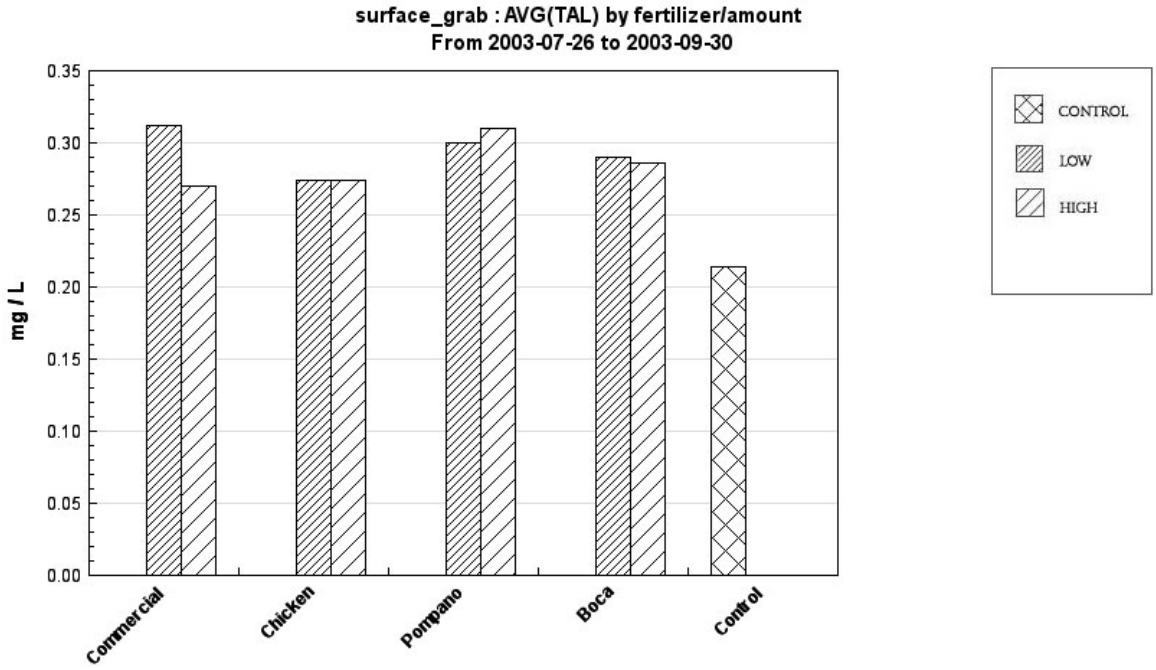

Figure 98. Mean total aluminum concentration by fertilizer source and amount as measured in surface water grab samples between July 26 and September 30, 2003.

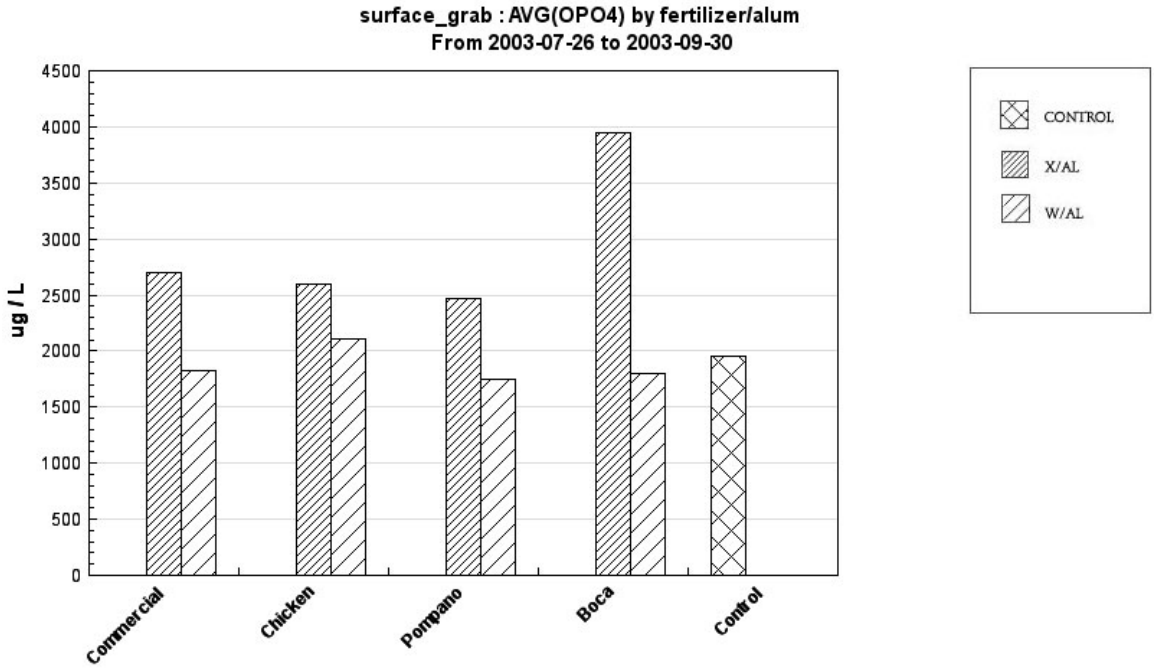

Figure 99. Mean ortho-phosphorus concentration by fertilizer source and WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

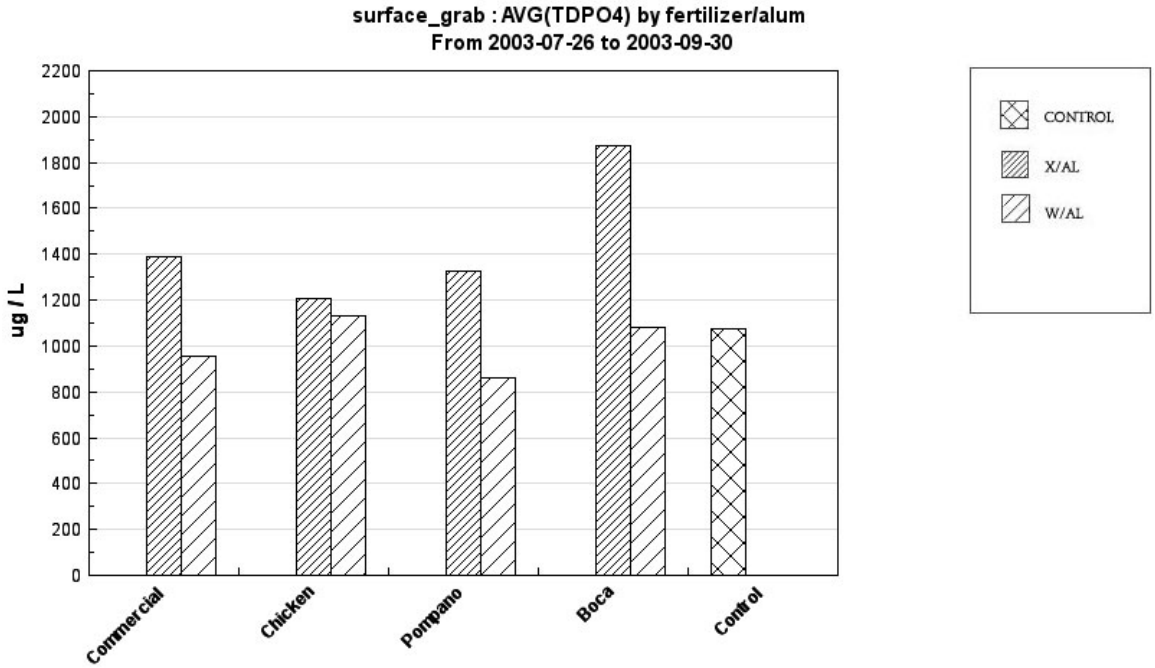

Figure 100. Mean total dissolved phosphorus concentration by fertilizer source and WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

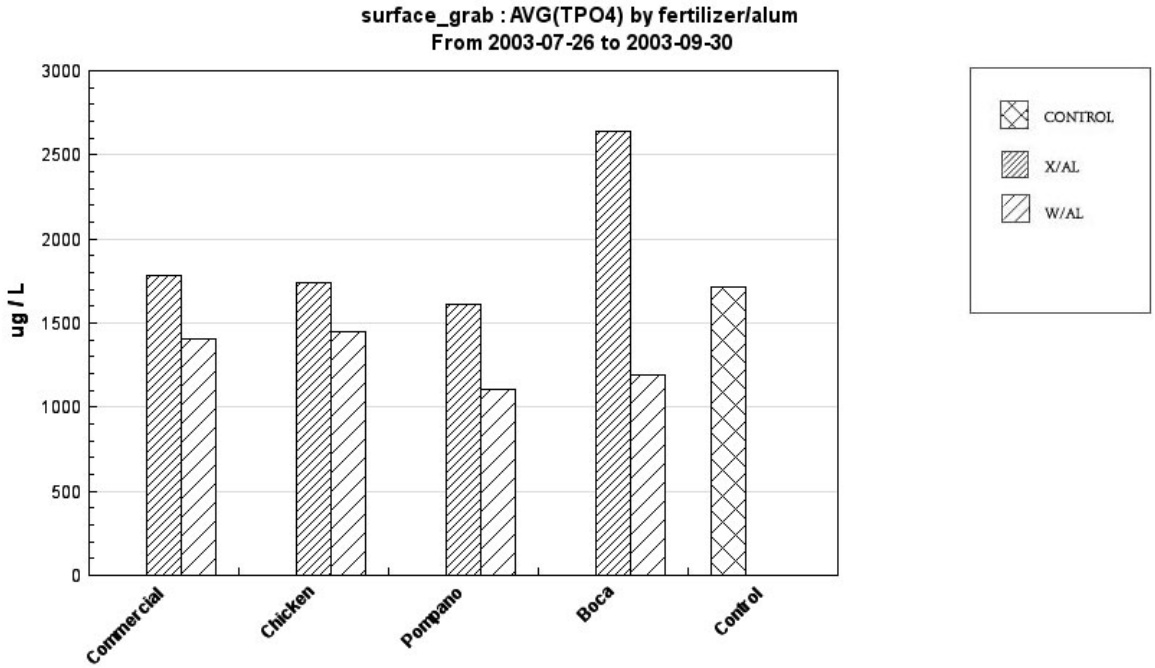

Figure 101. Mean total phosphorus concentration by fertilizer source and WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

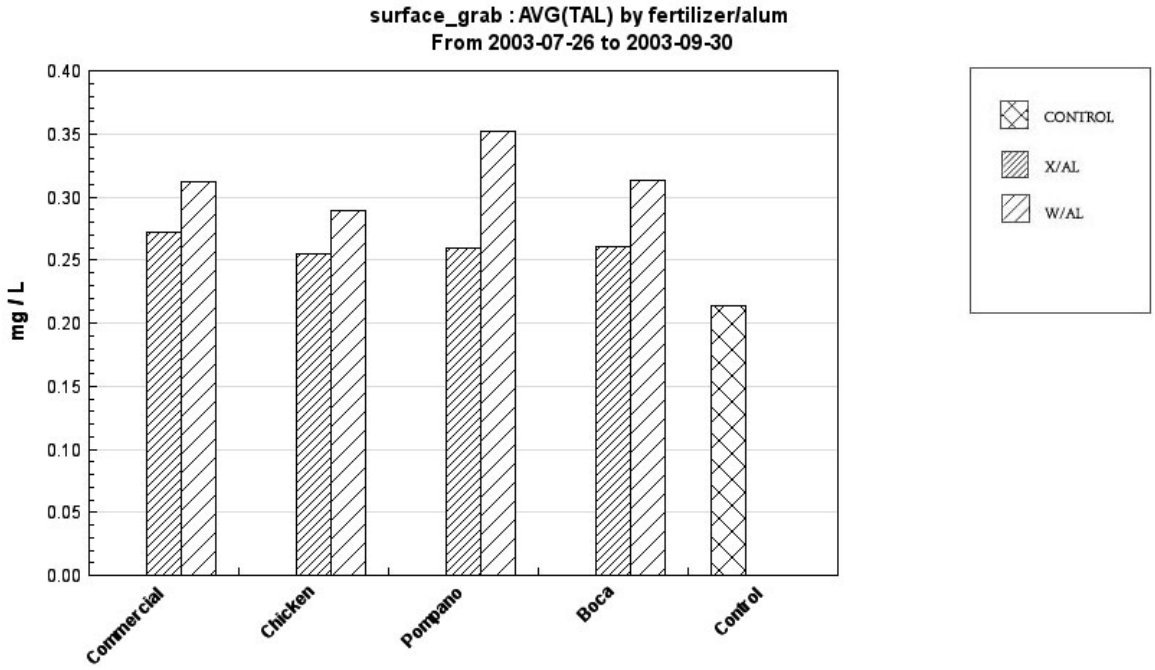

Figure 102. Mean total aluminum concentration by fertilizer source and WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

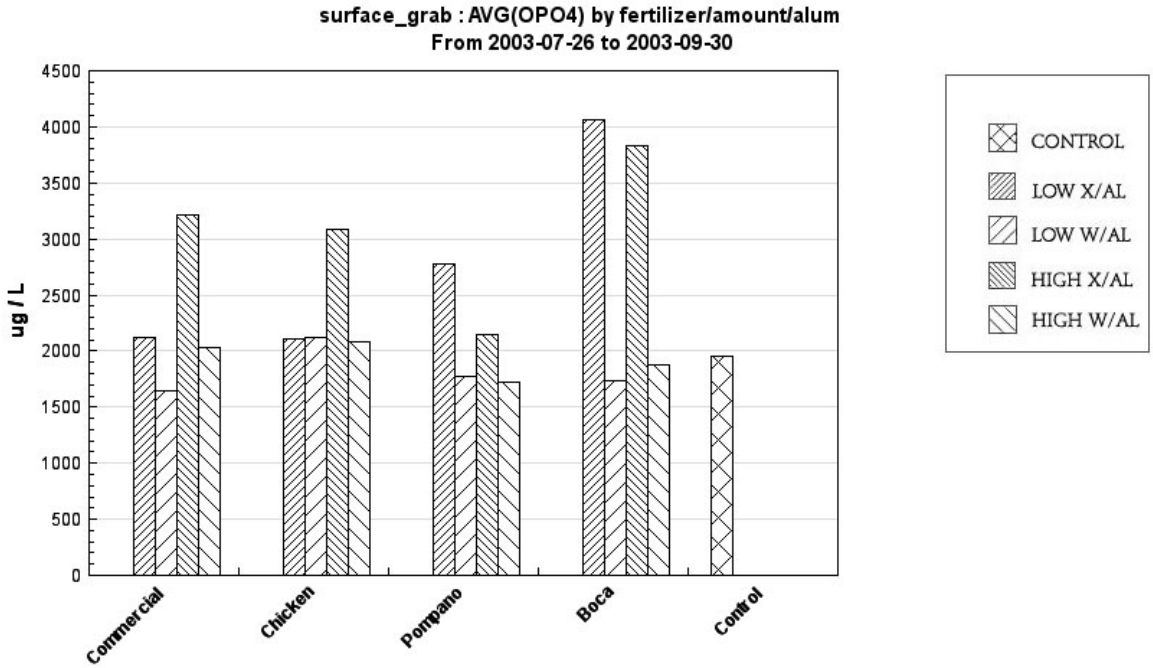

Figure 103. Mean ortho-phosphorus concentration by fertilizer source, amount and WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

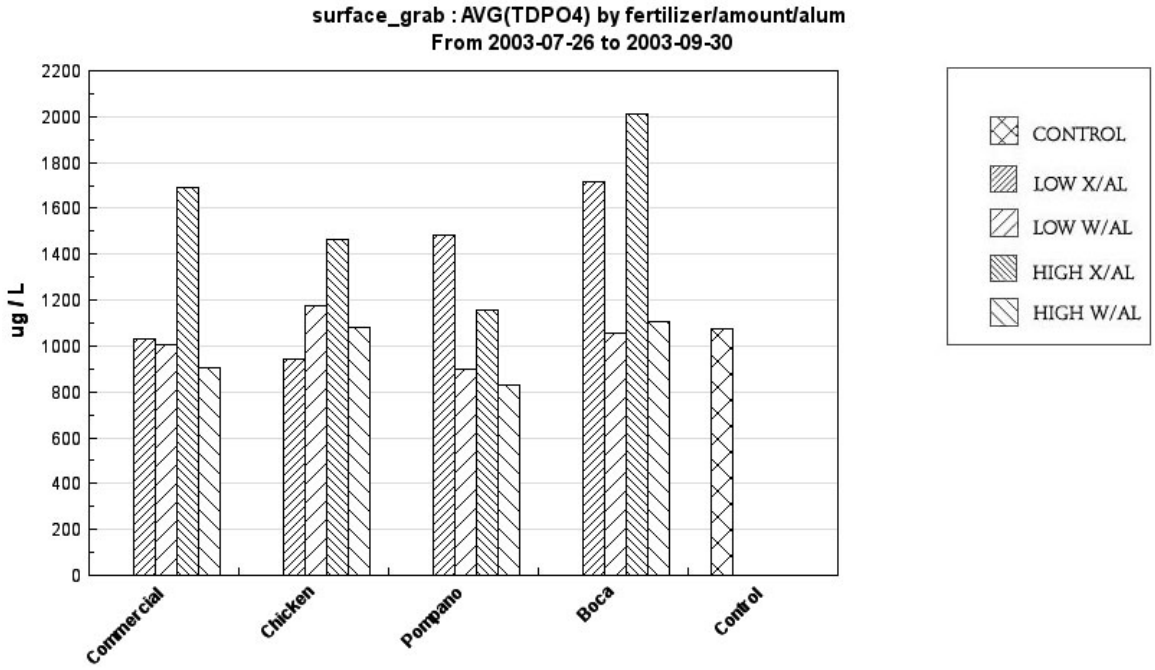

Figure 104. Mean total dissolved phosphorus concentration by fertilizer source, amount and WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

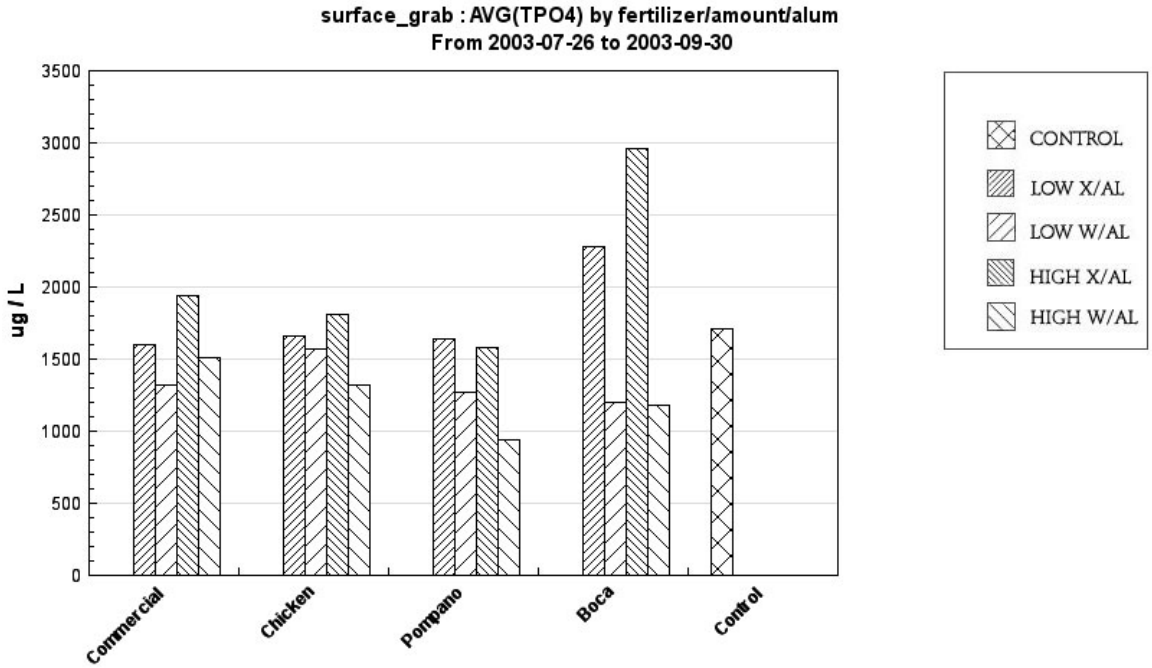

Figure 105. Mean total phosphorus concentration by fertilizer source, amount and WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

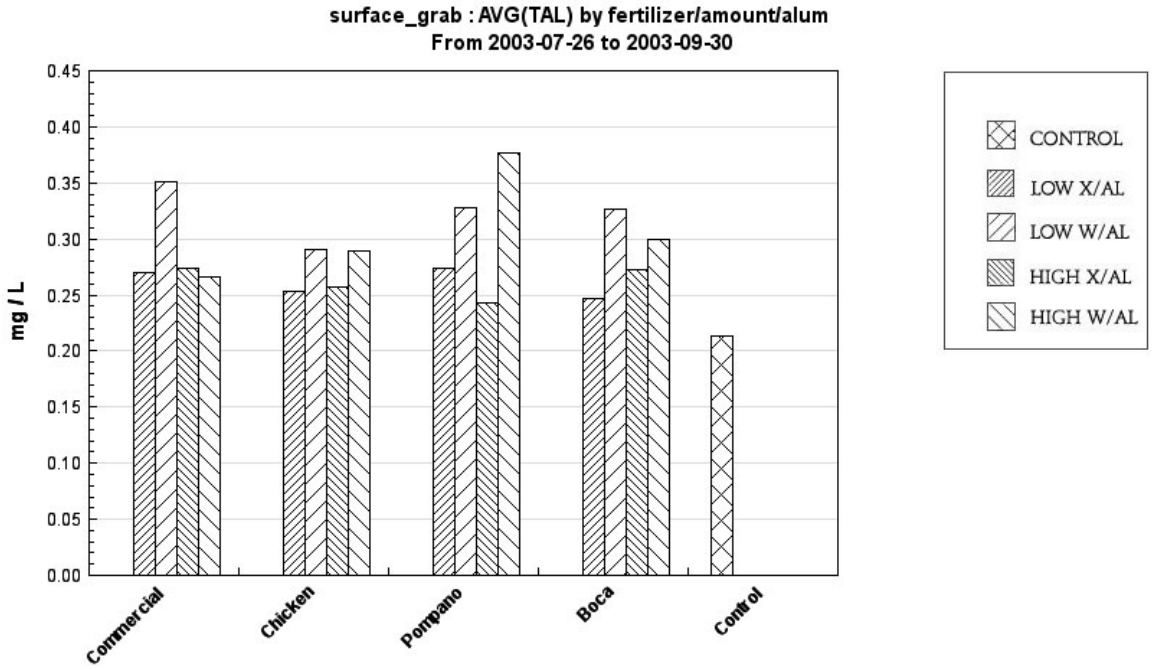

Figure 106. Mean total aluminum concentration by fertilizer source, amount and WTR amendment (alum) as measured in surface water grab samples between July 26 and September 30, 2003.

Grab Samples Block Effects

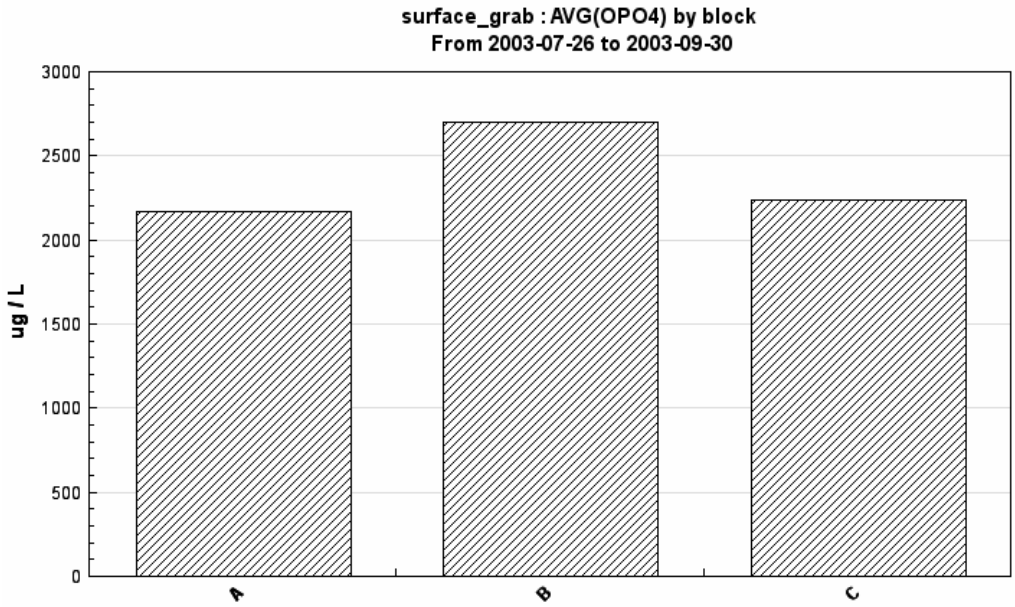

Figure 107. Mean ortho-phosphorus concentrations by block as measured in surface water grab samples between July 26 and September 30, 2003.

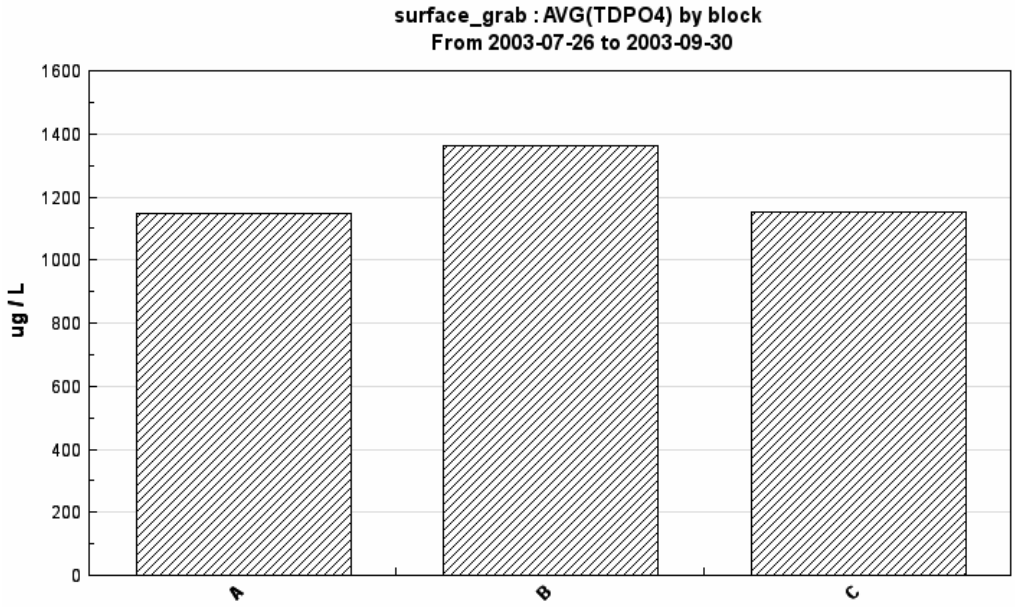

Figure 108. Mean total dissolved phosphorus concentrations by block as measured in surface water grab samples between July 26 and September 30, 2003.

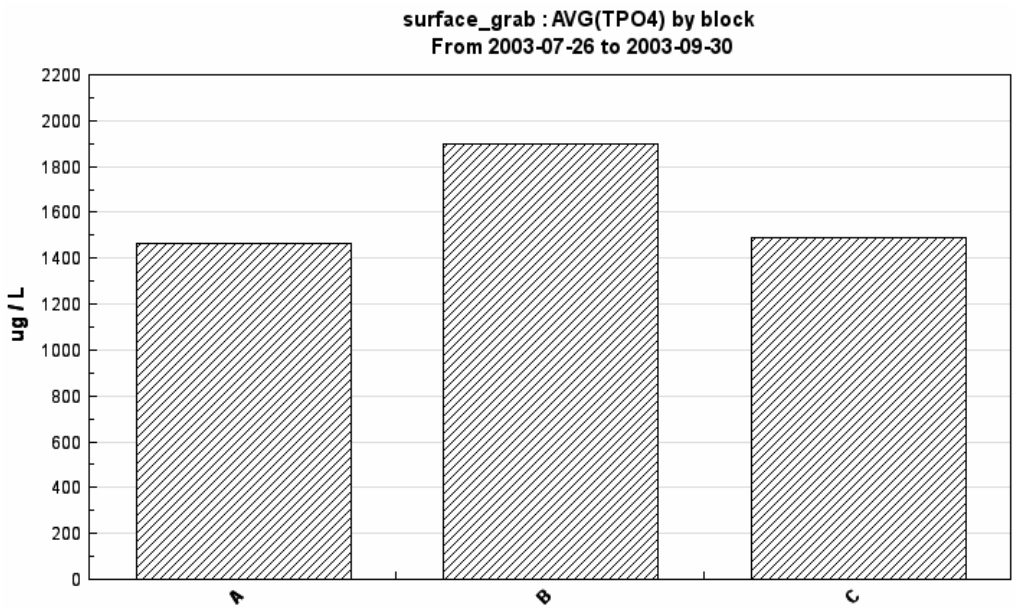

Figure 109. Mean total phosphorus concentrations by block as measured in surface water grab samples between July 26 and September 30, 2003.

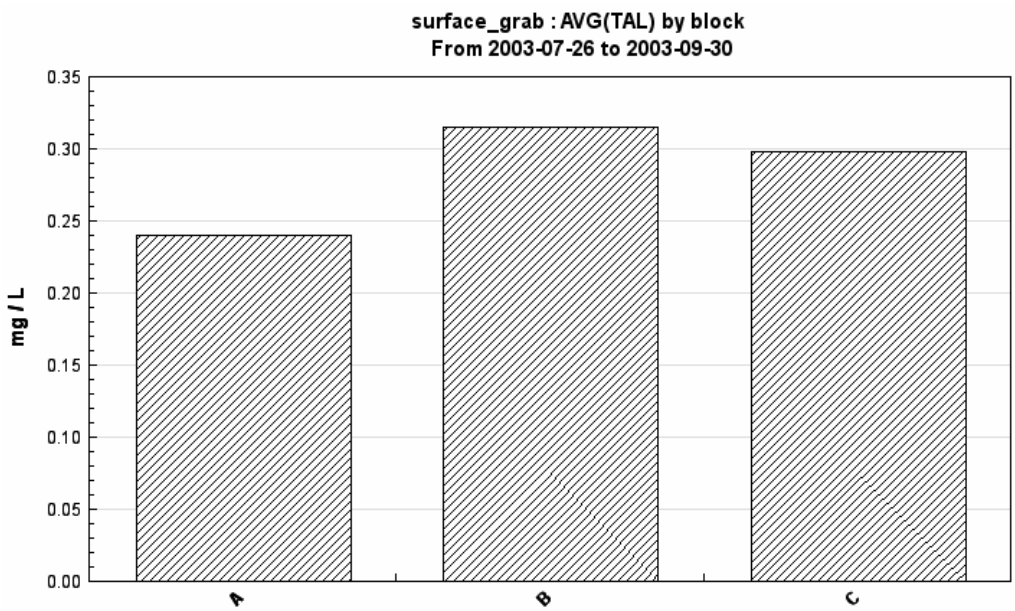

Figure 110. Mean total aluminum concentrations by block as measured in surface water grab samples between July 26 and September 30, 2003.

Composite Samples Results

Table 10. TPO4 concentrations (µg/L) as measured in surface water composite samples between Aug 6 and Sep 5, 2003.

ID	6-Aug	10-Aug	22-Aug	5-Sep	Fertilizer	P Level	Alum
A1	N/A	611	N/A	1135	Chicken	Low	w/Alum
A2	5,332	1,562	N/A	1070	Boca	High	w/Alum
A3	53	344	N/A	1066	Commercial	Low	w/Alum
A4	N/A	911	N/A	1356	Pompano	High	w/Alum
A5	772	436	N/A	1021	Chicken	Low	x/Alum
A6	2,027	N/A	N/A	2326	Boca	High	x/Alum
A7	N/A	589	N/A	838	Pompano	Low	w/Alum
A8	N/A	1,292	N/A	1371	Commercial	Low	x/Alum
A9	N/A	537	1021	1137	Chicken	High	w/Alum
A10	528	531	N/A	1050	Pompano	Low	x/Alum
A11	N/A	415	N/A	1451	Commercial	High	w/Alum
A12	N/A	954	N/A	1487	Chicken	High	x/Alum
A13	N/A	1,295	N/A	1921	Boca	Low	w/Alum
A14	N/A	898	N/A	1828	Boca	Low	x/Alum
A15	841	N/A	N/A	1555	Commercial	High	x/Alum
A16	N/A	481	N/A	N/A	Pompano	High	x/Alum
A17	N/A	924	1050	1901	*NULL*	*NULL*	*NULL*
B1	1,159	886	N/A	699	Chicken	Low	w/Alum
B2	798	938	N/A	923	Pompano	High	w/Alum
B3	1,849	580	1572	1717	Commercial	Low	w/Alum
B4	1,880	1,409	N/A	980	Boca	High	w/Alum
B5	550	1,433	N/A	2220	Chicken	High	w/Alum
B6	N/A	1,301	N/A	1926	Pompano	Low	w/Alum
B7	2,262	459	N/A	1343	Boca	Low	w/Alum
B8	609	689	N/A	2024	Pompano	Low	x/Alum
B9	N/A	702	N/A	1096	Commercial	High	w/Alum
B10	702	1,442	N/A	2574	Boca	High	x/Alum
B11	N/A	259	N/A	1445	Commercial	Low	x/Alum
B12	N/A	1,099	N/A	1325	Pompano	High	x/Alum
B13	N/A	1,272	N/A	1798	*NULL*	*NULL*	*NULL*
B14	N/A	600	N/A	2583	Boca	Low	x/Alum
B15	32	N/A	N/A	2052	Chicken	Low	x/Alum
B16	1,526	998	N/A	2168	Commercial	High	x/Alum
B17	N/A	1,903	N/A	1412	Chicken	High	x/Alum
C1	713	503	1822	637	Boca	Low	w/Alum
C2	310	1,244	986	901	Pompano	Low	w/Alum
C3	1,231	733	N/A	750	Chicken	Low	w/Alum
C4	N/A	430	1377	1565	Pompano	Low	x/Alum
C5	1,274	966	N/A	2412	Boca	Low	x/Alum
C6	N/A	1,032	1,324	1178	Chicken	Low	x/Alum
C7	1,152	471	N/A	1018	Boca	High	w/Alum
C8	1,169	409	N/A	936	Commercial	Low	w/Alum
C9	2,377	244	757	626	Pompano	High	w/Alum
C10	N/A	902	N/A	671	Chicken	High	w/Alum
C11	308	736	N/A	853	Commercial	Low	x/Alum
C12	N/A	1,358	1,091	2233	Boca	High	x/Alum
C13	N/A	704	1751	657	Commercial	High	w/Alum
C14	N/A	1,877	N/A	1511	Chicken	High	x/Alum
C15	804	744	1527	2829	Commercial	High	x/Alum
C16	969	N/A	N/A	2539	Pompano	High	x/Alum
C17	3,926	N/A	N/A	1472	*NULL*	*NULL*	*NULL*

Composite Samples Time Series

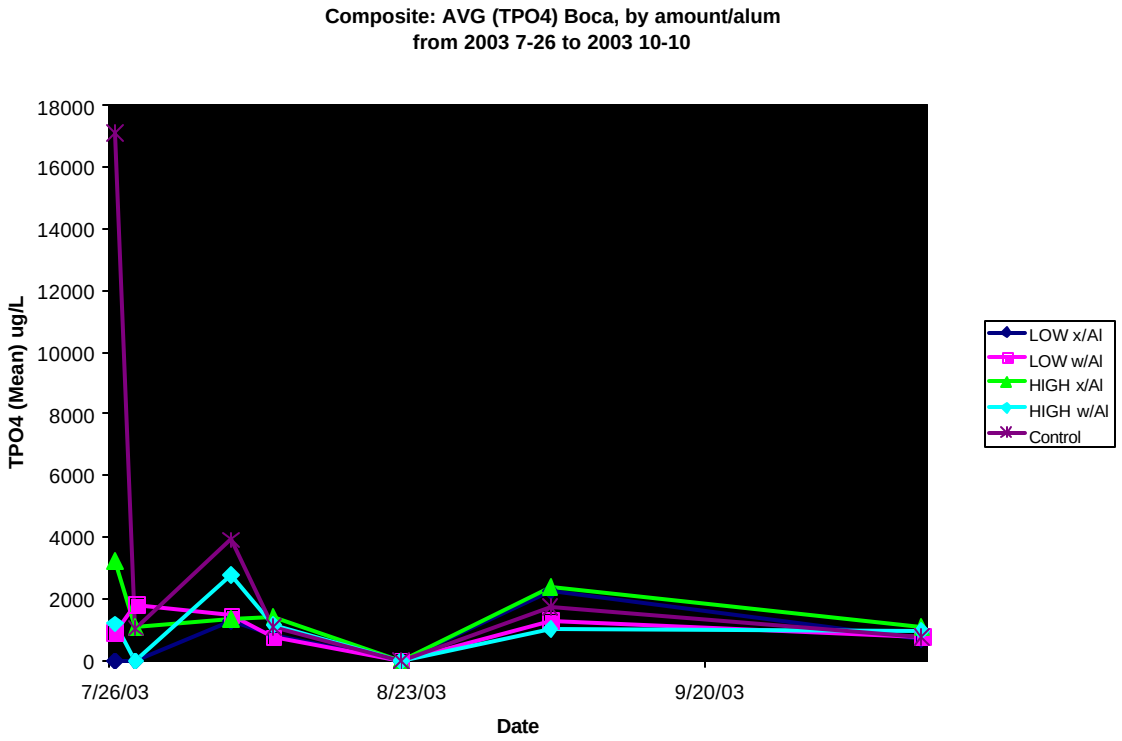

Figure 111. Mean total phosphorus concentrations in surface water composite samples for Boca fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and October 10, 2003.

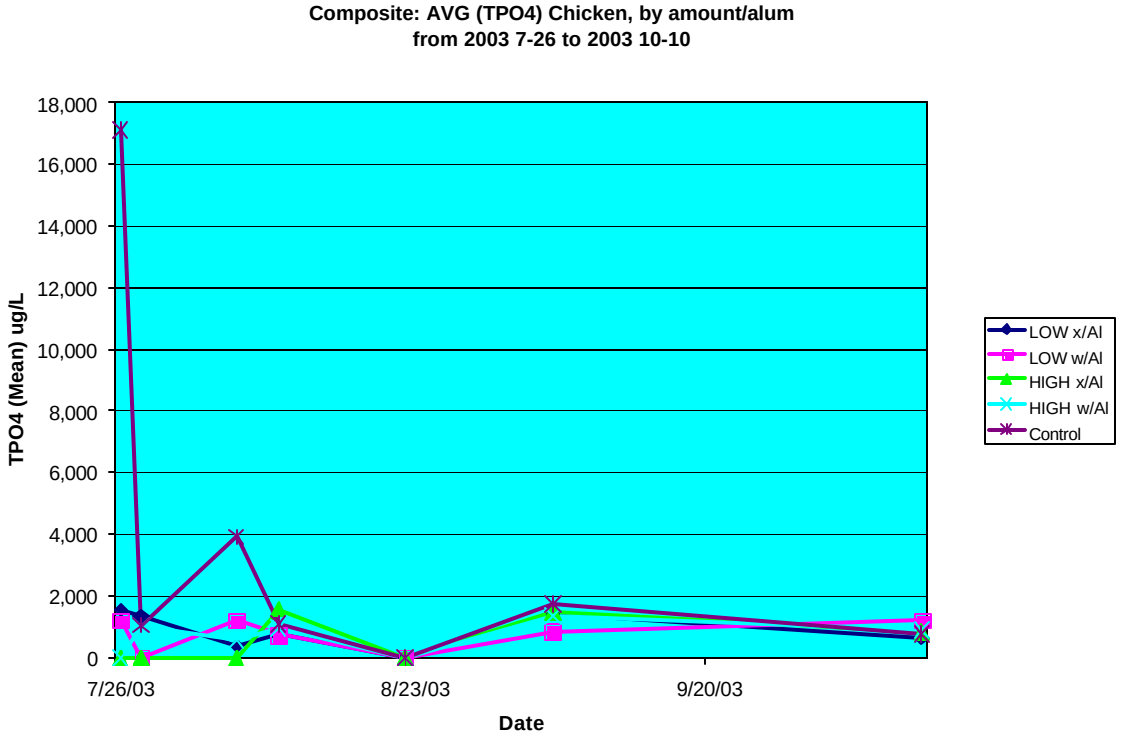

Figure 112. Mean total phosphorus concentrations in surface water composite samples for Chicken manure fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and October 10, 2003

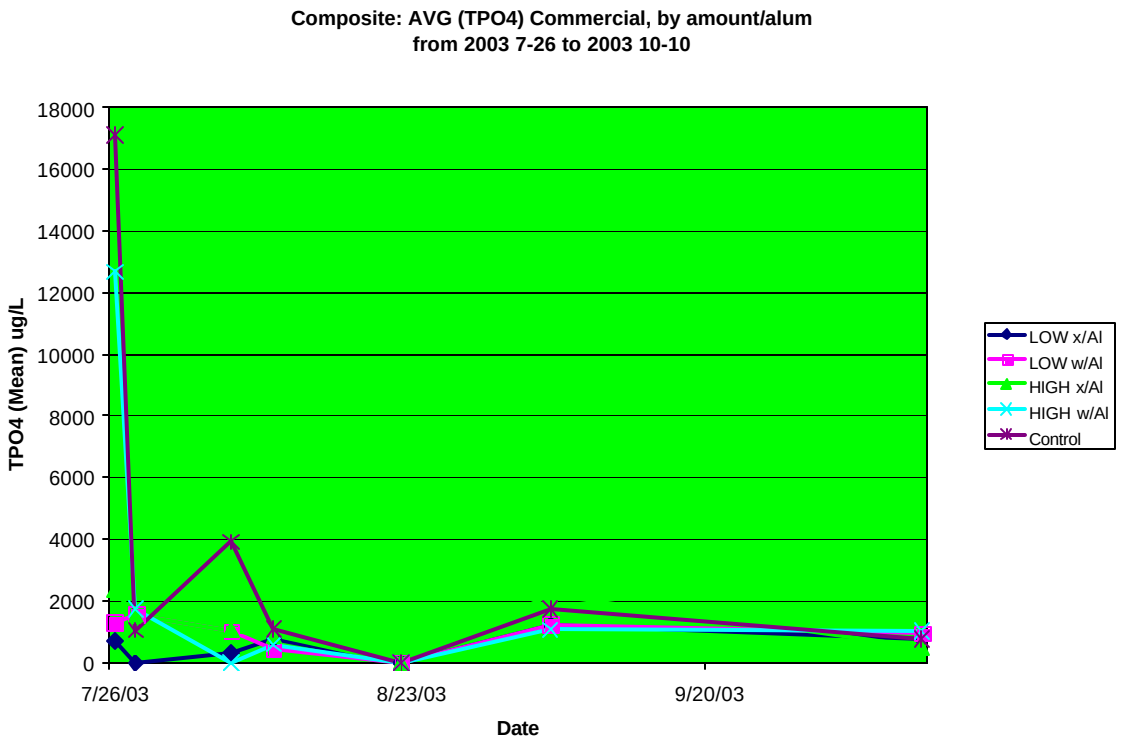

Figure 113. Mean total phosphorus concentrations in surface water composite samples for Commercial fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and October 10, 2003.

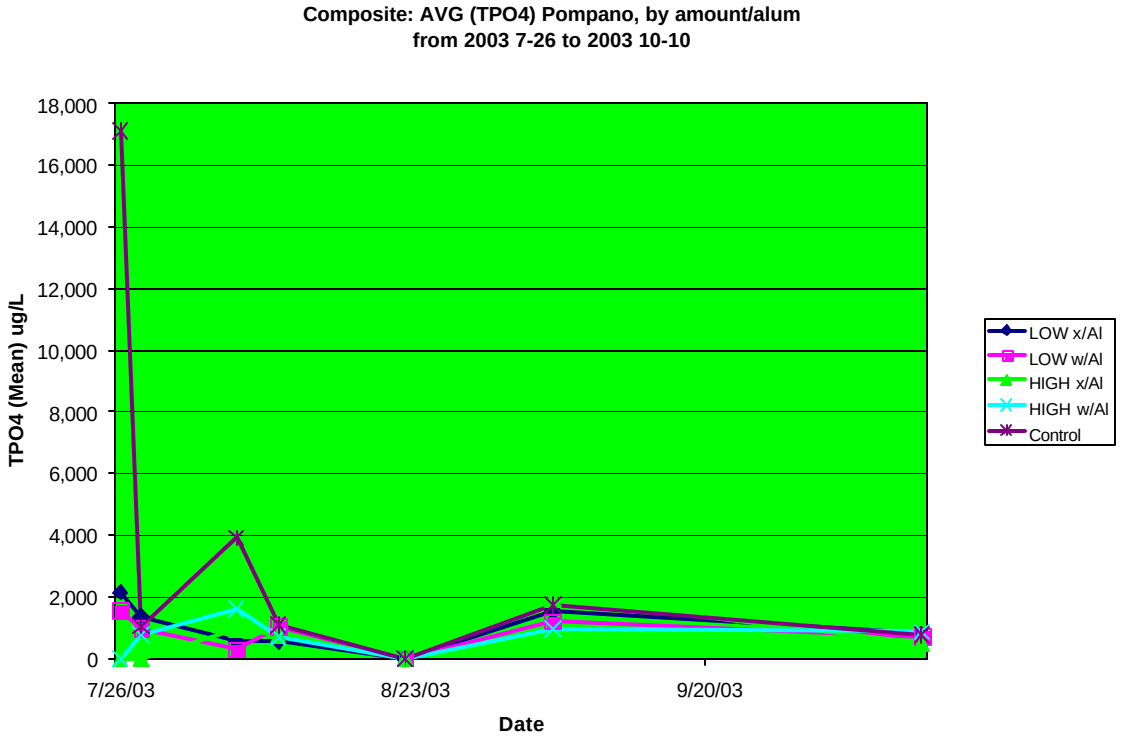

Figure 114. Mean total phosphorus concentrations in surface water composite samples for Pompano fertilizer source by fertilizer amount and WTR amendment (alum) between July 26 and October 10, 2003.

Composite Samples Treatment Effects

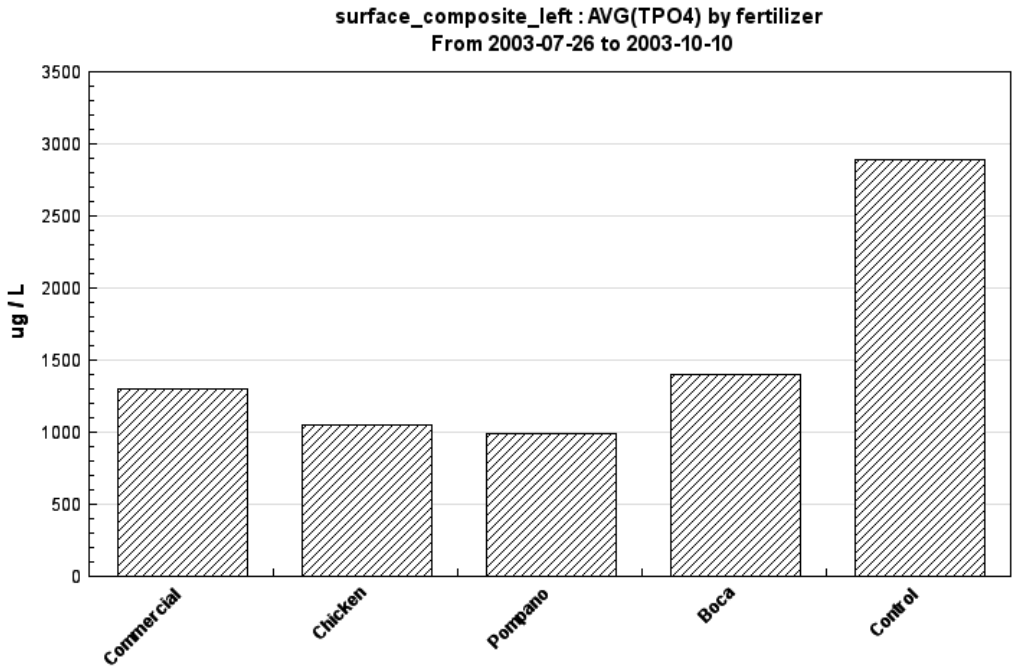

Figure 115. Mean total phosphorus concentration by fertilizer source as measured in surface water composite samples between July 26 and October 10, 2003.

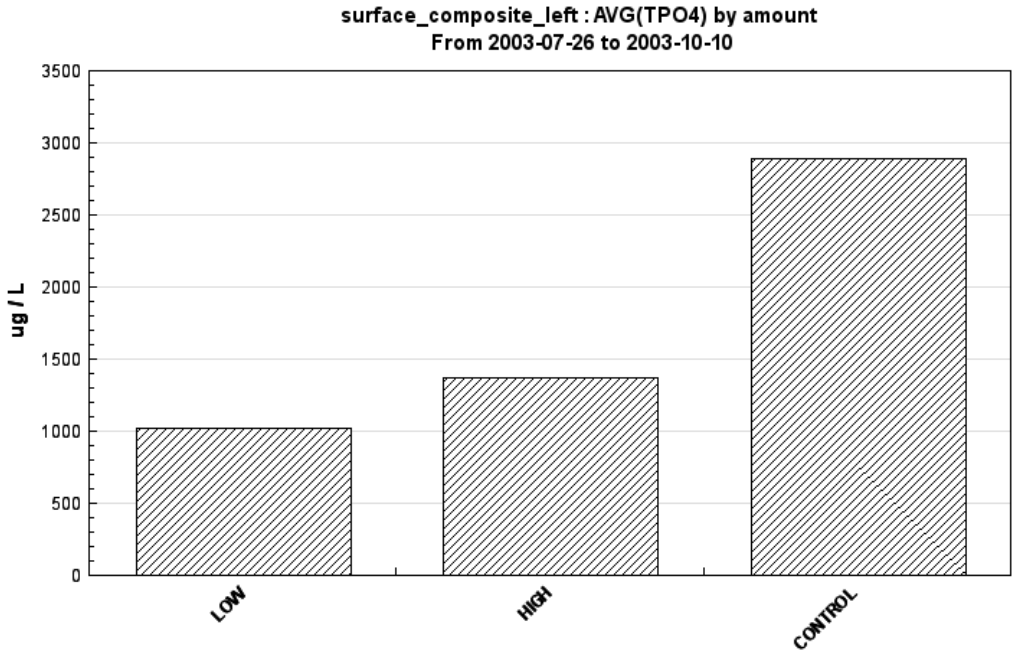

Figure 116. Mean total phosphorus concentration by amount as measured in surface water composite samples between July 26 and October 10, 2003.

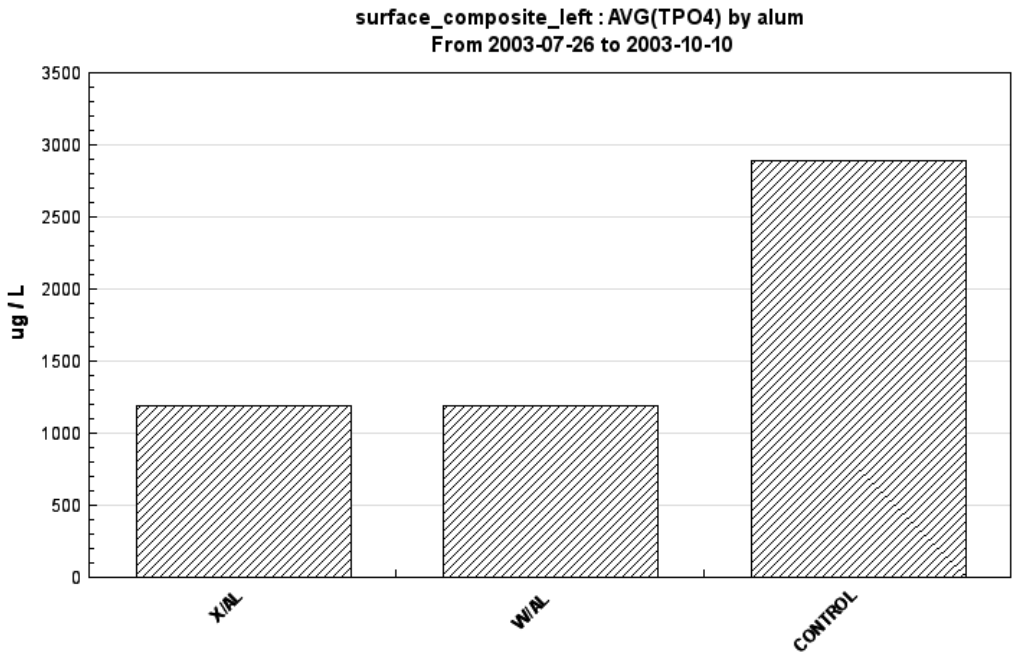

Figure 117. Mean total phosphorus concentration by WTR amendment (alum) as measured in surface water composite samples between July 26 and October 10, 2003.

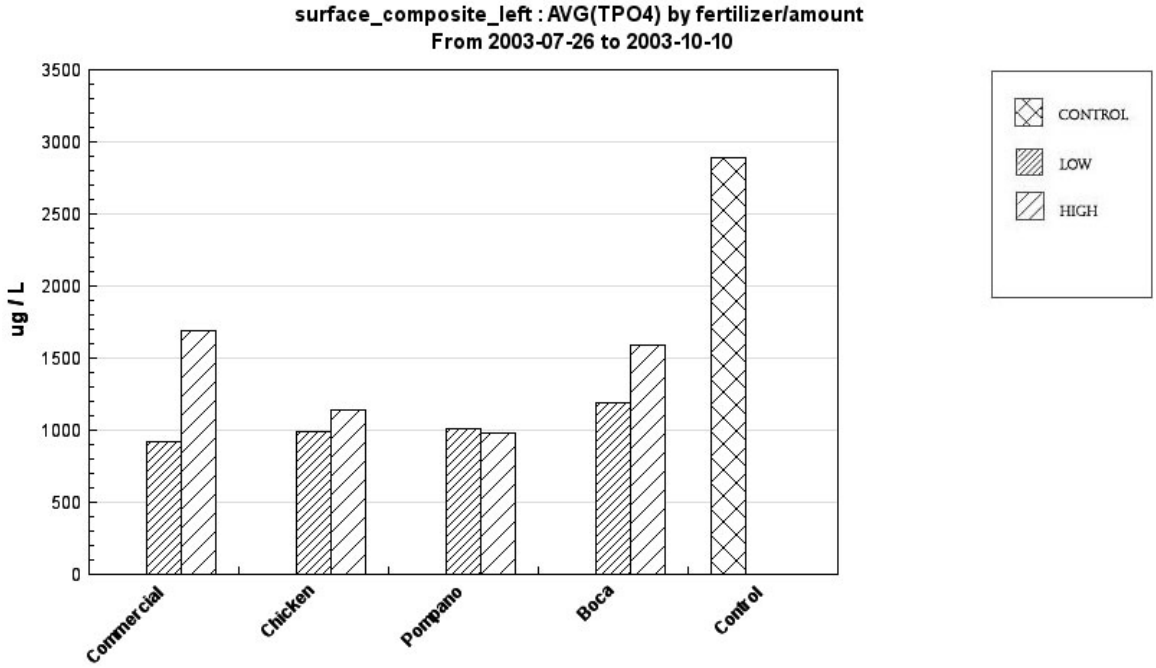

Figure 118. Mean total phosphorus concentration by fertilizer source and amount as measured in surface water composite samples between July 26 and October 10, 2003.

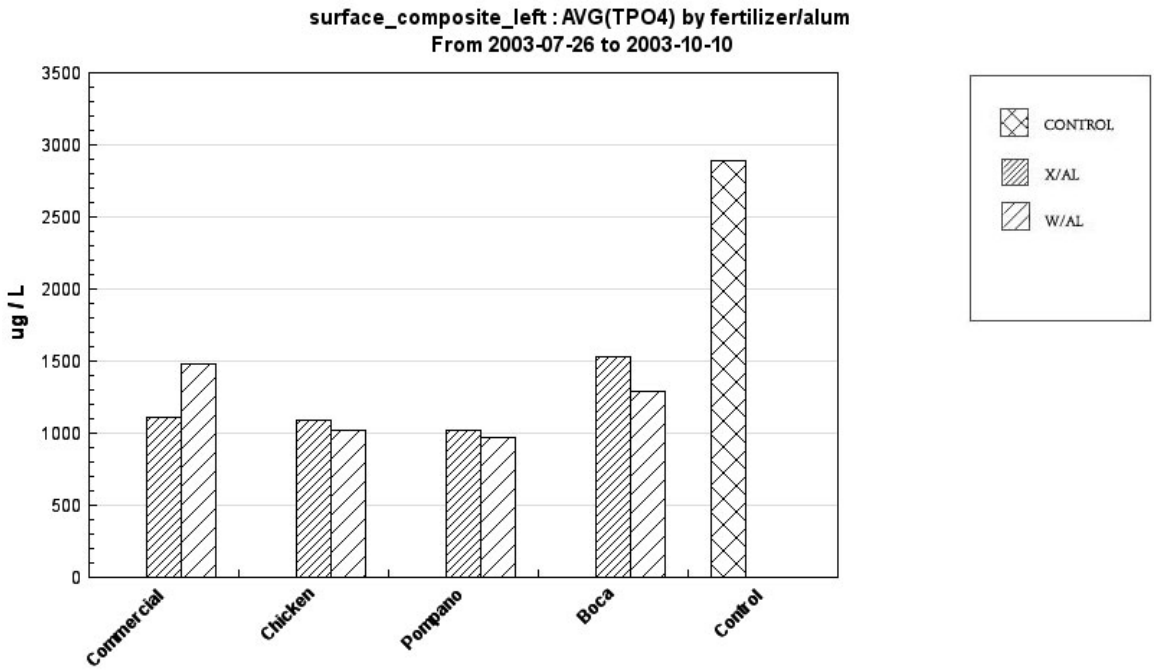

Figure 119. Mean total phosphorus concentration by fertilizer source and WTR amendment (alum) as measured in surface water composite samples between July 26 and October 10, 2003.

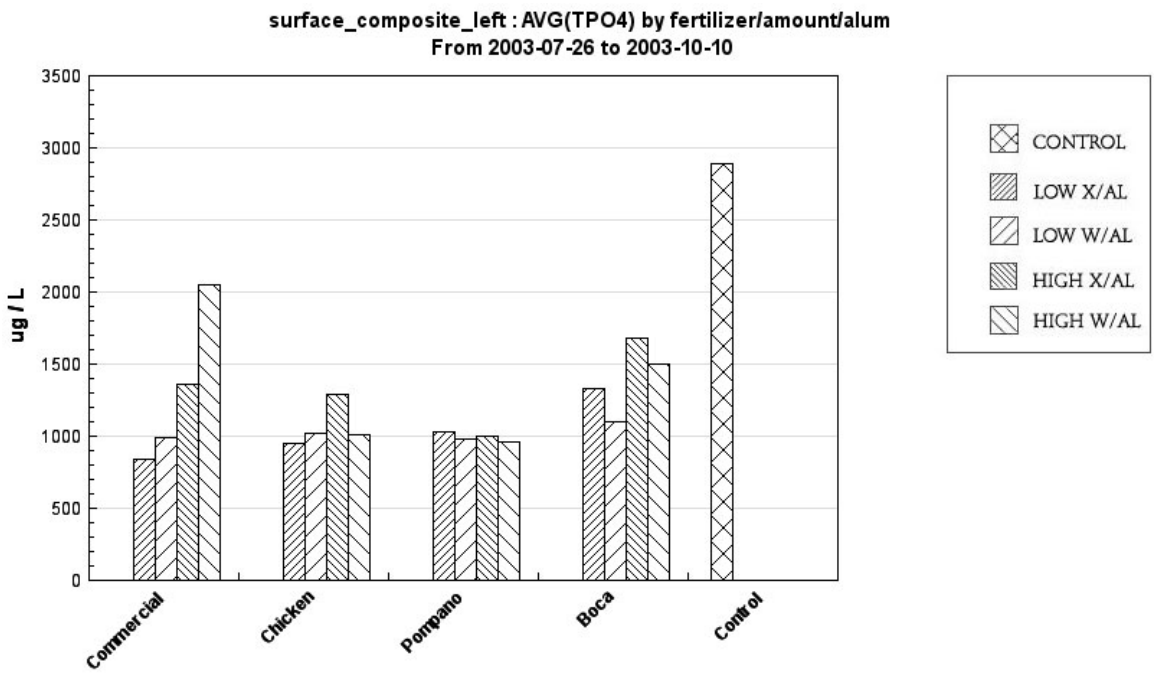

Figure 120. Mean total phosphorus concentration by fertilizer source, amount and WTR amendment (alum) as measured in surface water composite samples between July 26 and October 10, 2003.

Composite Samples Block Effects

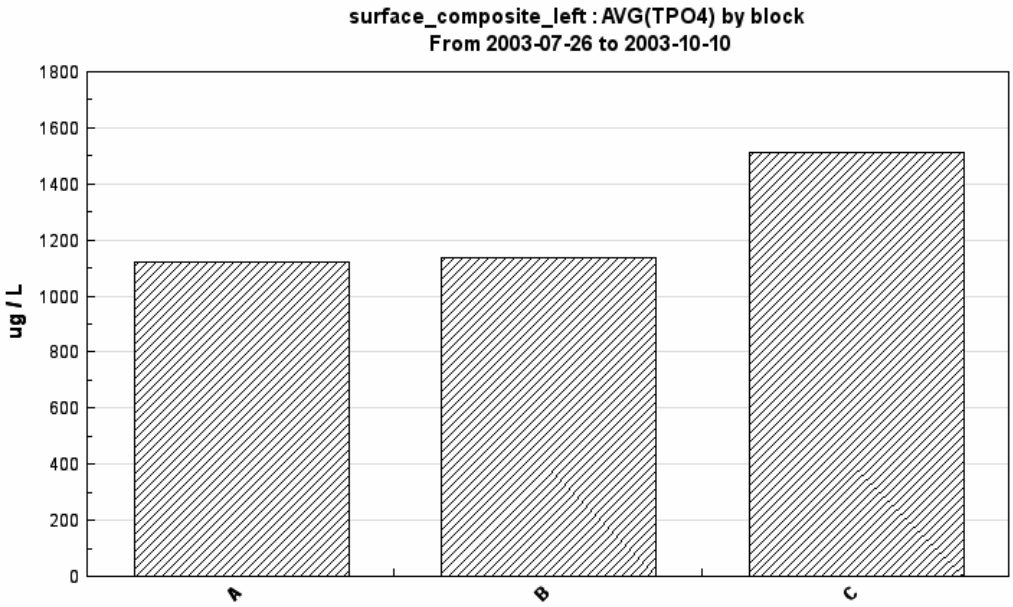

Figure 121. Mean total phosphorus concentrations by block as measured in surface water composite samples between July 26 and October 10, 2003.

D. PROBLEMS & CORRECTIVE ACTIONS

Sampling Equipment

Maintenance of the large number of instruments and samplers continues to represent a formidable challenge. The control units fail periodically requiring repairs. Insects invade the samplers introducing organic debris that tends to clog the sampler holes. Hoses and filters require cleaning and replacement. Pumps also fail from time to time if the control circuits get jammed in the on position. Erosion around the samplers was a problem in the early period of the runoff season but these situations were fixed by a shovel brigade. The solar panels originally purchased for the project experienced a high failure rate. Approximately 5 more failed during quarter 2 and were replaced.

Many of the batteries purchased for this project are failing to hold a proper charge. The batteries have a limited life and the extension of the project pushed the battery limits. A major reason for the battery failures was the lack of cycling. The 51 batteries sit unused but charged at the site for most months of the year and then are used sporadically during the brief runoff events. During the first year (2002) that these units were in the field they were not called upon to deliver significant power because of the lack of runoff. Therefore, a battery cycling system is being produced that will provide an automated way to exercise the batteries. In the short-term this problem is being addressed by purchasing replacement batteries to cover the failed units. However, an automated power drain system has been designed and tested and 55 units are being produced for the project samplers.

Farm Operations

Access to farm operations services continues to be another area of difficulty. On August 8 the rancher experienced some sort of farm emergency and therefore stored 50 cows in the project area for a few days. This caused damage to some of the equipment and deposition of wastes in certain areas, particularly in the plots nearest the main entrance and in the plots at the opposite corner of the pasture. Problems with invasive cows continued once the cows became familiar with the pasture and appeared to be intentionally seeking ways to enter the pasture whereas previously they showed no particular interest in our area. On September 9, a rear gate was found lifted off its hinges and a herd of 80 cows were in the field. They were chased out. Tasks such as treatment and manual removal of tropical soda apple plants are another labor intensive challenge. Grass cutting and removal from the plots was a problem. However, a system of directional cutting of the plots with a blowing mower followed by use of a forklift like extension on the front of a vehicle proved to be a slow but effective way to push the grass to the outside of the plots.

Ground Water Sampling

The logistics of ground water sampling is always a challenge but this is being addressed as improved methods and tools are continuing to evolve. The pump carts seem to be working well but high suspended solids in the water from some of the wells slows the filtering process at the well. This is being solved by the use of dual pumps and filters to speed up the process. Problems with the ortho-phosphorus results coming out higher than the total dissolved phosphorus remains a problem. To address this issue, the IFAS lab is examining its methods and our particular matrix to determine the source of the error. We have also purchased a field test system for ortho-P to help provide immediate P analysis in the field to supplement the IFAS lab results. Improved containers for cooling and storage of samples have been purchased and will be used in the next quarter. The field lab is providing a more sheltered location to process the samples.

E. ACTIVITIES PLANNED FOR NEXT QUARTER

Activities planned for the winter of 2003-2004 include the basic monthly ground water sampling, supplemental ground water sampling during periods of heavy rain, surface water grab sample collection, surface water automatic sample collection, soil sample collection, vegetation sample collection, and maintenance of the automatic water samples. Given the challenges of managing the large volumes of data produced by this project, work is being done to develop an on-line database that will serve as the water quality data storage location as well as provide a capability for immediate calculation and graphical/tabular display of summary graphics. This system will allow project cooperators to review results and draw preliminary conclusions at their own convenience.