Canalwatch Volunteer Program
5-Year Nutrient Analysis
2005-2009

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This report is intended to provide a general overview of Canalwatch data in different areas of the City. While it is useful as a screening tool, the data set is not sufficient to determine causes of patterns or trends in the data.

For regulatory purposes, professionally-collected data sets should be consulted because they contain a wider variety of parameters that are consistently sampled over long periods of time.

Background on the Canalwatch Program

Cape Coral's most well-known feature is its 400-mile network of canals. Residents value the waterfront living and recreation provided by these waterways. Canals also serve to provide stormwater treatment, irrigation water, and wildlife habitat. Water quality affects and is affected by all of these functions.

Canalwatch is a volunteer water sampling program comprised of local residents and coordinated by the City's Environmental Resources Section (ERS). The goals of the program are to educate citizens about water quality issues, establish relationships between residents and the City's environmental staff, and increase community members' ownership of our common resources.

Canalwatch is unique in that volunteers sample in their own backyards. This allows residents to engage with the water quality and ecological processes of their own canal. When a volunteer signs up, they are assigned a site number based on their location in the City. If they move or decide to stop participating for other reasons, their site is retired. Due to this setup, there is a high amount of volunteer – and site – turnover.

The Canalwatch volunteer program was founded in 1995. By the end of 2009, volunteers had taken a total of 5,162 samples from 186 sites.

Methods

Upon joining the program, Canalwatch volunteers receive an initial one-hour training on water quality and sampling methods. To collect a water sample, volunteers rinse a 250-mL plastic bottle three times with canal water, dumping downstream of where they will collect the sample, then fill it to the shoulder. Volunteers bring their samples to Environmental Resources staff, then receive a pre-cleaned bottle to use for the following month's sampling. Staff biologists are also available at the drop-off point to answer any questions, especially from new volunteers, and address any concerns.

Samples are kept cold until they are received by the Cape Coral Environmental Laboratory, where they are analyzed within 28 days according to methods from APHA (1989) using a WestCo auto-analyzer. Nutrients analyzed by the lab are nitrite (NO_2), nitrate (NO_3), ammonia (NH_3), total kjeldahl nitrogen (TKN), total nitrogen (TN), and phosphate (TPO_4).

Table 1: Analytes and their detection limits

Analyte	MDL	units
NO2	0.05	mg/L
NO3	0.05	mg/L
NH3	0.1	mg/L
TKN	0.1	mg/L
TPO4	0.05	mg/L

Nutrient data analyzed for this study are detection frequencies and concentrations for NH_3, TPO_4, and TKN. NO_2 was not detected in any samples in the study period. NO_3 is not included due to data that did not pass QA/QC checks. Because NO_3 is a component of TN, the latter is also excluded here.

Over the 5 years of this analysis, 2797 samples were received from 129 sites. Twenty sites were active for the entire 5 years of the study period. Of these, 15 are included here for analysis. Sites were chosen based on number of samples received over the study period. Location was also a factor; if multiple sites were close to each other on the same canal, the one with the most samples over the study period was chosen to represent the area.

In working with the data, all values below the detection limit for an analyte were set to half that analyte's detection limit. Graphs were made using Excel, and statistical analyses were performed using SYSTAT. Non-parametric statistical methods are generally appropriate for the analysis of water quality data, which tends to be non-normally distributed and may contain outliers (Helsel and Hirsch, 2002). Chi-square analyses were used to test for differences in categorical data (i.e. whether an analyte was detected or not). When a nutrient was detected in >50% of samples for a region, additional tests could be run. Kruskal-Wallis tests were used to test for differences in concentration between seasons. If no seasonal effect was detected for a region, a Mann-Kendall analysis was used to test for trends over the 5-year study period. If a seasonal effect was found, a Seasonal Kendall trend test was used.

Grouping of Sites

Sites were divided into six regions (figure 1):

- **FW-G**: Freshwater, Alligator Slough and its tributaries. Gator Slough lies along the northern border of Cape Coral and receives some inflows from Charlotte County. Sites 43A, 85C, and 88B.
- **FW-N**: Freshwater North of Pine Island Road, excluding Gator Slough. Sites 35A, 48A, and 52B.
- **FW-S**: Freshwater South of Pine Island Road. There is more development south of Pine Island Road, which could cause differences in water quality. Sites 26C and 28D.
- **SW-N**: Saltwater North of Pine Island Road. Both sites in this group are in the North Spreader system, though they are at opposite ends. The boat lift at the south end of the North Spreader system was removed in 2008. Sites 58E and 90A.
- **SW-SE**: Saltwater in southeast Cape Coral, with strong river influences. Sites 19D, 21D, and 22C.
- **SW-SS**: Saltwater in southwest Cape Coral; in or near the South Spreader Canal and with less influence from the river and possibly some influence from Matlacha Pass. Sites 67A and 72A.

Definition of Rainy and Dry Seasons

County-wide, monthly rainfall data from 2005-2009 was downloaded from Lee County's website. The data indicated that the rainy months were June through September (average rainfall 8.88 inches) and dry months were October through May (average rainfall 1.89 inches). This is a different division than other studies have used (Duffey et al. 2007 and City of Sanibel 2009, both of which included October in the rainy season) but seems to be a natural division in the data (figure 2a). Average annual rainfall over the study period was 50.68 inches. Rainfall was highest in 2005, an active hurricane season, and lowest in 2007 (figure 2b).

Because Canalwatch samples are taken the first Wednesday of every month, they are a reflection of conditions during the prior month. Therefore, Canalwatch samples that represent the rainy season are July through October, and dry season samples are November through June.

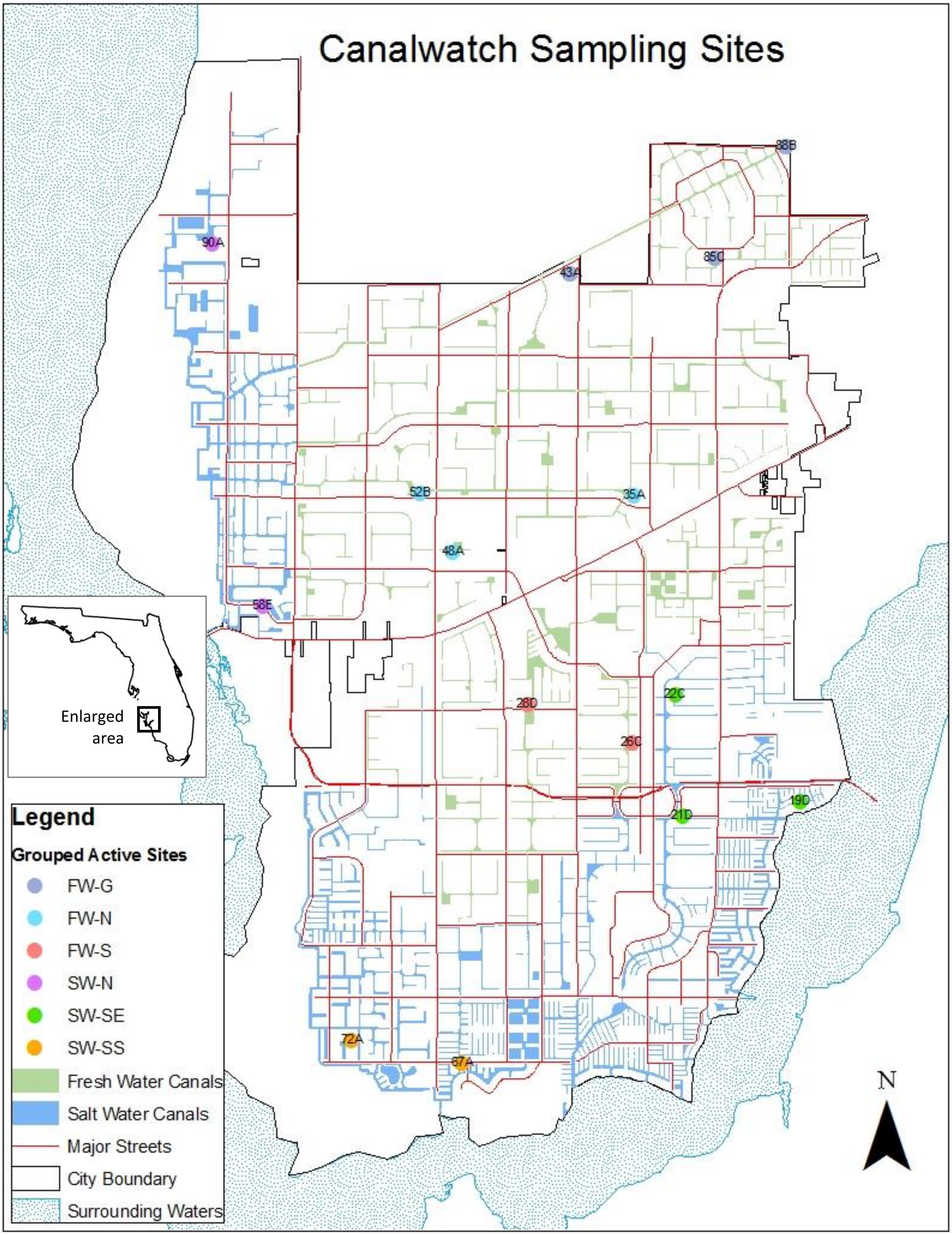

Figure 1: Sites included in this analysis.

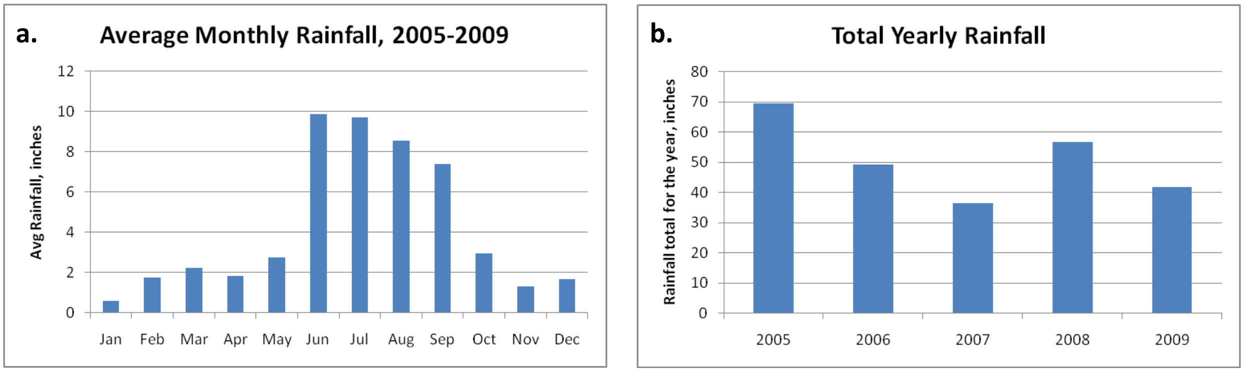

Figure 2: (a) Average monthly rainfall during the study period; (b) Total yearly rainfall.

Results and Discussion

NH_3 - Ammonia

NH_3 was below detection more than 50% of the time, so concentrations could not be statistically analyzed for trends. However, the frequency with which NH_3 was detected in the different regions and different seasons was assessed.

Table 2: Overall detection frequency of NH_3

NH3	Overall detection by region		
	# detectable	# samples	% detectable
FW-G	37	151	24.50
FW-N	43	153	28.10
FW-S	38	96	39.58
FW Overall	**118**	**400**	**29.50**
SW-N	43	100	43.00
SW-SE	95	159	59.75
SW-SS	37	93	39.78
SW Overall	**175**	**352**	**49.72**

NH_3 was detected in approximately 50% of saltwater samples, much more often than in the 30% of freshwater samples (table 2; figure 3). The area with the fewest detectable NH_3 levels was FW-G. The area with the most detectable NH_3 levels was SW-SE.

Detection frequency dropped at all sites in 2009. The largest drops in detection over the study period were in SW-SS, FW-S, and FW-N, although FW-N's largest drop was between 2006 and 2008 (figure 3).

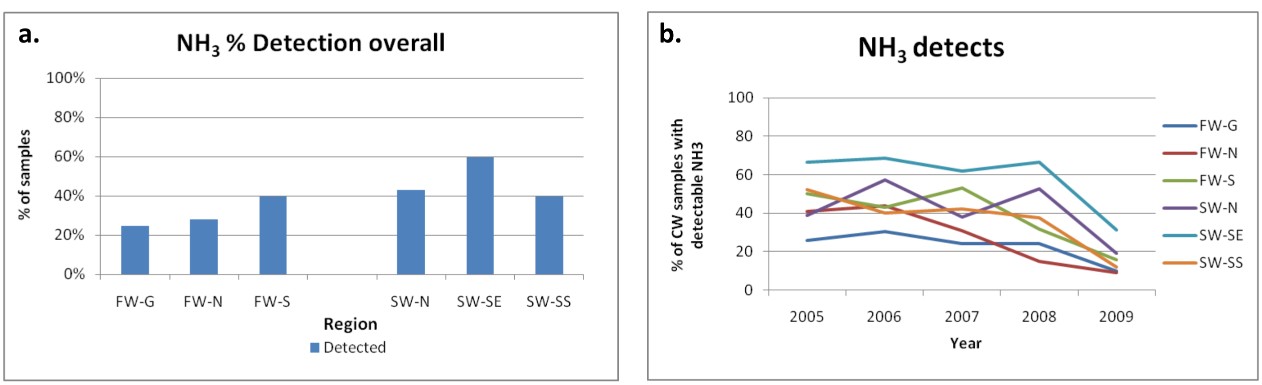

Figure 3: Detection frequency of NH_3 by region, (a) overall and (b) by year.

NH_3 was detected more often in the dry season than in the rainy season in all regions except FW-G (table 3; figure 4). This tendency was most pronounced in FW-S, followed by SW-SE and SW-SS.

However, seasonal differences in detection frequency were not statistically significant (using chi-square tests) for any region.

Because NH_3 was detected in more than 50% of samples collected from SW-SE, analyses were run on concentrations in this region. A Kruskal-Wallis test showed no significant seasonal effect on concentration (p=0.592), so a two-tailed Mann-Kendall was used to test for change over time. No significant trend was detected over the 5-year period (p=0.061; figure 5).

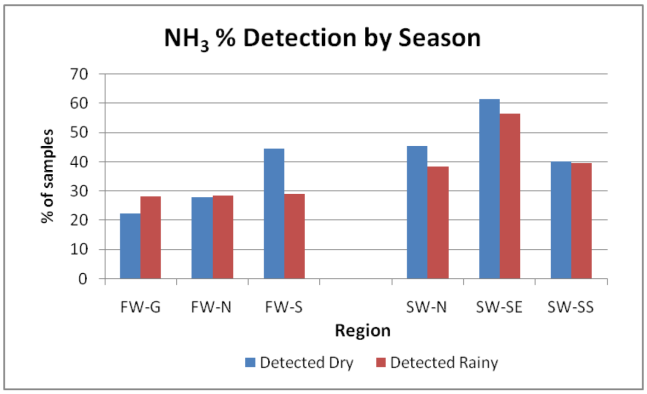

Figure 4: Detection frequency of NH3 by region and season.

Table 3: Detection frequency of NH3 by region and season.

NH3	Dry Season, 2005-2009 combined			Rainy Season, 2005-2009 combined		
	# detectable	# samples	% detectable	# detectable	# samples	% detectable
FW-G	21	94	22.34	16	57	28.07
FW-N	29	104	27.88	14	49	28.57
FW-S	29	65	44.62	9	31	29.03
FW Overall	**79**	**263**	**30.04**	**39**	**137**	**28.47**
SW-N	30	66	45.45	13	34	38.24
SW-SE	64	104	61.54	31	55	56.36
SW-SS	24	60	40.00	13	33	39.39
SW Overall	**118**	**230**	**51.30**	**57**	**122**	**46.72**

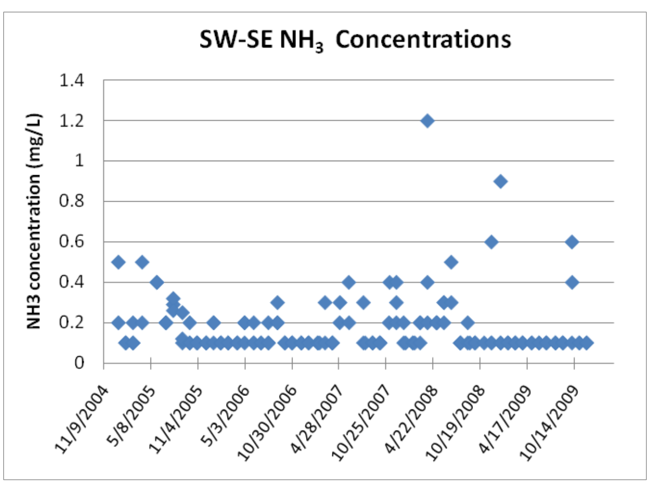

Figure 5: NH3 concentrations in the SW-SE region during the study period.

TPO_4 – Phosphate

TPO_4 was below detection in most regions more than 50% of the time, so concentrations could not be statistically analyzed for trends. However, the frequency with which TPO_4 was detected in the different regions and seasons was assessed.

TPO_4 was detected over three times more often in saltwater canals than in freshwater canals (table 4; figure 6). FW-N had the lowest detection frequency, followed by SW-N. SW-SE had the highest amount of samples with detectable TPO_4. In this region, TPO_4 ranged up to 0.35 mg/L.

TPO_4 was detected most frequently in the SW-SE canals in all years, followed by the SW-SS canals. Detection in SW-N was comparable to (and even lower than some of) the freshwater sites. Detection frequency increased in 2009 in most regions.

Table 4: Overall detection frequency of TPO_4 by region.

TPO4	Overall detection by region		
	# detectable	# samples	% detectable
FW-G	29	159	18.24
FW-N	12	156	7.69
FW-S	24	100	24.00
FW Overall	**65**	**415**	**15.66**
SW-N	14	104	13.46
SW-SE	131	165	79.39
SW-SS	51	95	53.68
SW Overall	**196**	**364**	**53.85**

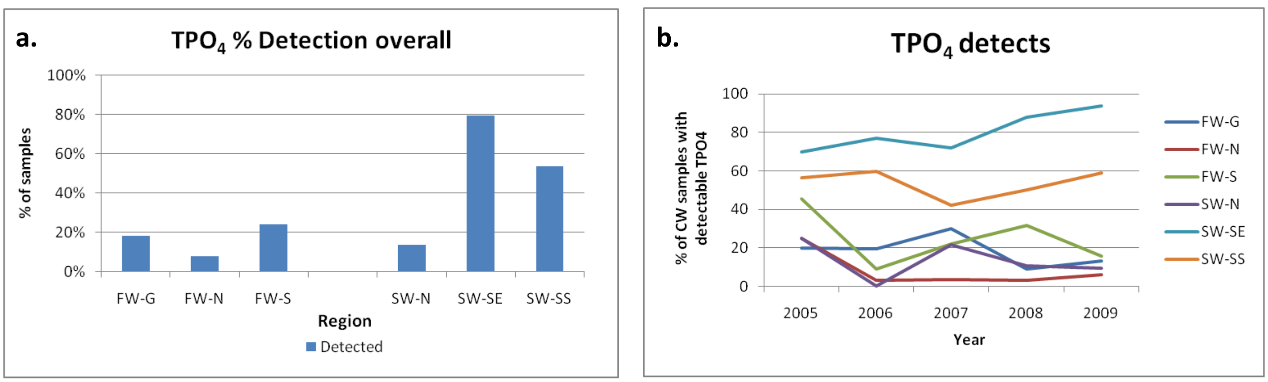

Figure 6: Detection frequency of TPO_4 by region, (a) overall and (b) by year.

TPO_4 was detected more often during the rainy season than during the dry season (table 5; figure 7). Chi-square tests showed this seasonal effect on detection frequency to be statistically significant in three of the six regions: FW-G (p=0.003), SW-SE (p=0.006), and SW-SS (p=0.002).

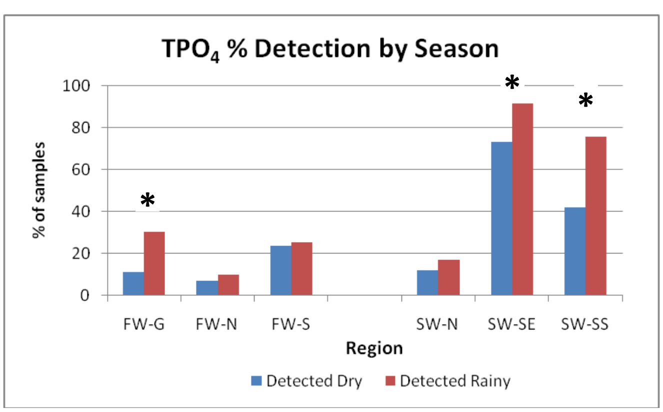

Figure 7: Detection frequency of TPO_4 by region and season. An asterisk (*) denotes a significant difference between seasons.

Table 5: Detection frequency of TPO4 by region and season.

TPO4	Dry Season, 2005-2009 combined			Rainy Season, 2005-2009 combined		
	# detectable	# samples	% detectable	# detectable	# samples	% detectable
FW-G	11	99	11.11	18	60	30.00
FW-N	7	105	6.67	5	51	9.80
FW-S	16	68	23.53	8	32	25.00
FW Overall	**34**	**272**	**12.50**	**31**	**143**	**21.68**
SW-N	8	68	11.76	6	36	16.67
SW-SE	79	108	73.15	52	57	91.23
SW-SS	26	62	41.94	25	33	75.76
SW Overall	**113**	**238**	**47.48**	**83**	**126**	**65.87**

SW-SE had the highest rate of detection, at 74% in the dry season and 91% in the rainy season. A Kruskal-Wallis test showed a significant seasonal effect on TPO_4 concentration in this region (p=0.000), so a two-tailed Seasonal Kendall analysis was used to test for concentration change over time. No significant trend was detected (p=0.440; figure 8).

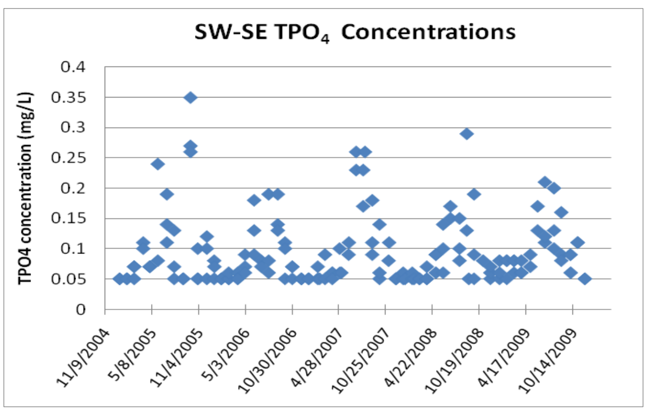

Figure 8: TPO_4 concentration in the SW-SE region during the study period.

TKN – Total Kjeldahl Nitrogen

Median TKN was generally higher in SW canals than in FW canals. Data from SW-SE were consistently among the highest values, and that from FW-N was consistently among the lowest (figure 9). There was no statistically significant seasonal effect in any region (table 6).

TKN spiked in all regions in 2007, the driest year of the study period. Median concentrations for all groups were higher at the end of the study period than at the beginning. There was a statistically significant increase in TKN concentration in two freshwater regions (FW-G, p=0.024; and FW-S, p=0.029), but nowhere else.

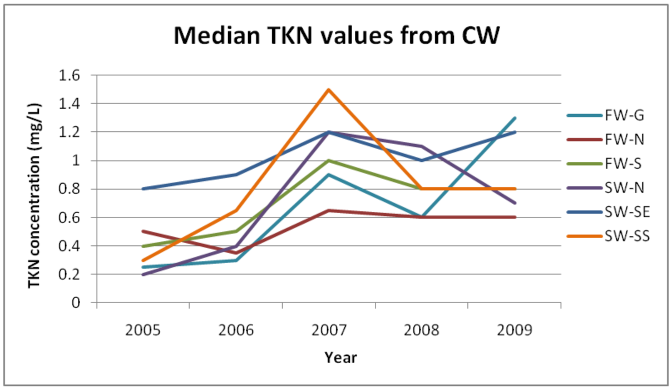

Figure 9: Median TKN values by region and year.

Table 6: Median TKN concentrations by region and season.

TKN	Dry Season, 2005-2009 combined					Rainy Season, 2005-2009 combined				
	median	min	max	st. dev.	n	median	min	max	st. dev.	n
FW-G	0.6	0.1	4.7	0.89	95	0.7	0.1	14	1.86	57
FW-N	0.6	0.1	3	0.71	105	0.5	0.1	1.9	0.33	49
FW-S	0.7	0.1	6.4	1.30	68	0.7	0.1	1.3	0.35	31
FW-Overall	**0.6**	**0.1**	**6.4**	**0.96**	**268**	**0.6**	**0.1**	**14**	**1.25**	**137**
SW-N	0.7	0.1	3.1	0.78	65	0.7	0.1	1.5	0.36	34
SW-SE	1.1	0.1	4.2	0.97	108	1	0.1	8.2	1.13	55
SW-SS	0.85	0.1	3.8	0.87	60	0.7	0.1	10.3	1.75	33
SW-Overall	**0.9**	**0.1**	**4.2**	**0.90**	**233**	**0.8**	**0.1**	**10.3**	**1.20**	**122**

Comparisons to Typical Water Quality Values

The state of Florida does not currently have numeric standards for nitrogen and phosphorus concentrations in surface waters. The federal Environmental Protection Agency is developing numeric nutrient criteria for the state, but as of this writing, the criteria are not yet finished.

The Florida Department of Environmental Protection compiles water quality data from across the state and periodically releases reports of typical water quality values. Values used here (Hand et al. 2009) cover the years 2000-2008 and are updated values from those used in Friedemann and Hand 1989, *Typical Water Quality Values for Florida's Lakes, Streams, and Estuaries*. These reports provide percentile distributions of each water quality parameter for several different types of water bodies: blackwaters, coastal waters, estuaries, lakes, springs, and streams. If data is at the 10th percentile, for example, only 10% of Florida's waters have lower values. The 50th percentile is the median. It should be noted that this data spans the entire state, including two climatic regions and five biogeographic regions (Duffey et al. 2007).

Hand et al. (2009) define the estuary category as "saltwater transitional areas ranging from near fresh water to pure salt water, usually beginning at the mouths of coastal rivers." Because Cape Coral's saltwater canals are connected to tidal systems, here they are compared to Hand et al.'s estuary values (tables 7 and 8). Freshwater canals are closed systems, with very little flow, and are compared to lake values. Hand et al. (2009) define the lake category as "freshwater reservoirs with longer residence times than streams. Some wide, slow-moving streams, such as the Lower St. John's River, are classified as lakes due to their long residence times and wind-driven currents."

To estimate the different regions' water quality status relative to 'typical' Florida values, percentile distributions are grouped as follows: ≤30 = below average; 31-69 = average; ≥70 = higher than average (Duffey et al. 2007; City of Sanibel 2009).

Table 7: Canalwatch median nutrient values as compared to Typical Water Quality distributions (Hand et al. 2009); time trend and seasonality results are also shown. bd means that <50% of samples in a region had detectable concentrations of an analyte, so comparisons to typical values could not be made for that region.

Parameter	Region	Median	Percentile	Compared to	Status	Trend Results	Seasonality
NH3	FW-G	bd	n/a	Lake	n/a	n/a	None
	FW-N	bd	n/a	Lake	n/a	n/a	None
	FW-S	bd	n/a	Lake	n/a	n/a	None
	SW-N	bd	n/a	Estuary	n/a	n/a	None
	SW-SE	0.1	90	Estuary	Higher than Average	No Trend	None
	SW-SS	bd	n/a	Estuary	n/a	n/a	None
TPO4	FW-G	bd	n/a	Lake	n/a	n/a	Rainy>Dry
	FW-N	bd	n/a	Lake	n/a	n/a	None
	FW-S	bd	n/a	Lake	n/a	n/a	None
	SW-N	bd	n/a	Estuary	n/a	n/a	None
	SW-SE	0.07	50	Estuary	Average	No Trend	Rainy>Dry
	SW-SS	bd	n/a	Estuary	n/a	n/a	Rainy>Dry
TKN	FW-G	0.65	35	Lake	Average	Increasing	None
	FW-N	0.5	20	Lake	Lower than Average	No Trend	None
	FW-S	0.7	45	Lake	Average	Increasing	None
	SW-N	0.7	50	Estuary	Average	No Trend	None
	SW-SE	1	85	Estuary	Higher than Average	No Trend	None
	SW-SS	0.7	50	Estuary	Average	No Trend	None

Table 8: Typical Florida Water Quality Percentile Distributions for Estuaries and Lakes (Hand 2008).

	NH_4		TP		TKN	
Percentile	**Estuary**	**Lake**	**Estuary**	**Lake**	**Estuary**	**Lake**
10	0.010	0.008	0.014	0.009	0.410	0.430
20	0.015	0.010	0.028	0.012	0.500	0.519
30	0.020	0.012	0.042	0.015	0.560	0.610
40	0.026	0.015	0.055	0.020	0.633	0.695
50	0.034	0.017	0.073	0.023	0.695	0.816
60	0.044	0.020	0.095	0.028	0.780	0.935
70	0.050	0.023	0.133	0.035	0.860	1.060
80	0.064	0.034	0.165	0.053	0.949	1.290
90	0.087	0.059	0.230	0.095	1.105	1.700
No. of waterbodies	**384**	**787**	**396**	**968**	**372**	**721**

Summary

Nutrients were consistently detected most often, and generally at the highest concentrations, in the SW-SE region, saltwater canals near the Caloosahatchee River. SW-SS, in or near the South Spreader system, was generally the second highest region in detection frequency and concentration. The other regions were fairly similar to each other, with freshwater regions exhibiting some variability between seasons. SW-N, the North Spreader region, was generally more similar to the freshwater sites than to the other saltwater sites in this study.

NH_3: NH_3 was detected more often in saltwater than freshwater canals, with SW-SE having the highest detection frequency of any region. In four regions (FW-S, SW-N, SW-SE, and SW-SS) it was detected slightly more often in the dry season than in the rainy season, although this was not statistically significant.

TPO_4: TPO_4 was detected more often in saltwater than freshwater canals. SW-SE had the highest detection frequency, followed by SW-SS. The other regions had similar detection frequencies. TPO_4 was detected more often in the rainy season than the dry season in all regions; this was statistically significant in three of the regions (FW-G, SW-SE, and SW-SS).

TKN: TKN concentrations were highest in the SW-SE region. Concentrations did not differ significantly between seasons. In two regions (FW-G and FW-S), TKN concentrations significantly increased over the study period.

Differences among saltwater canals and between saltwater and freshwater regions are likely due to a combination of varying population densities and differing tidal influences. The contributions of each of these factors are worthy of further study.

Acknowledgements

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