DEPARTMENT OF PLANNING
AND ENVIRONMENTAL PROTECTION

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LONG AND SHORT-TERM WATER QUALITY CHANGES AT SITE #15, NEW RIVER AT ANDREWS AVENUE, FORT LAUDERDALE, FL

ENVIRONMENTAL MONITORING
DIVISION

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EXECUTIVE SUMMARY

This report summarizes the data obtained from a study of changes in water quality at the Broward County Department of Planning and Environmental Protection's (DPEP) surface water quality monitoring Site #15 located on the New River at Andrews Avenue in Fort Lauderdale, Florida during July 29, 1999 through February 7, 2000. The purpose of the study was to 1) determine nearly continuous (measured every 15 minutes) changes in physical water quality parameters, 2) determine the differences in physical and chemical water quality between ebb and flood tides, and 3) determine changes in physical, chemical and microbiological water quality parameters during ebb tide over an extended period of time. The findings of this study may have implications for the DPEP's surface water quality monitoring program.

Three different monitoring regimens were applied over the course of this study; fine time-scale monitoring, tidal monitoring and long time-scale monitoring. Fine time-scale monitoring consisted of measurements taken every 15 minutes over a 43-day period. Tidal monitoring involved collecting samples 4 times a day at mid-ebb and mid-flood tides over a period of 11 days. Long time-scale monitoring involved the collection of samples once a week during the ebb tide over a period of 10 weeks.

The fine time-scale monitoring regimen indicated that physical parameters are greatly influenced by tidal action at this site. Maximum values for temperature & turbidity and minimum values for pH, conductivity & dissolved oxygen occurred at low tide.

Water management practices also had a measurable impact on the physical water quality parameters at this site. The major sources of fresh water flow to the New River are Water Conservation Areas (WCA) 2B and 3A through the South Florida Water Management District Sewell Lock on the North New River Canal via the South Fork of the New River. When water was released from the WCA, dissolved oxygen, conductivity and pH levels as measured at Site #15 were depressed and their tidally-driven cyclic nature was damped. Water levels at Site #15 were also affected by these practices.

The tidal monitoring portion of this study revealed statistical differences between ebb and flood tide were observed for TKN and nitrite+nitrate concentrations (higher during flood) but not for ammonia or total phosphorus.

During the long-term monitoring regimen of this study, water quality was found to be highly variable. Rainfall, which was rare during the monitoring period, was found to have a measurable impact on water quality with respect to some parameters. Intense rain events resulted in spikes in total Kjeldahl nitrogen, total nitrogen and fecal coliform levels while prolonged periods of less intense rainfall seemed to result in general elevations in nitrite+nitrate, orthophosphate and total phosphorus levels.

The implications of this study on the surface water quality monitoring program are that worst-case water quality conditions for TKN and nitrite+nitrate may be expected during flood tide while tidal considerations are not significant for ammonia or total phosphorus. The high variability observed

over the 100 day long-term monitoring regimen suggests that quarterly monitoring may not provide an adequate indication of ambient water quality and that the sampling frequency could be increased to improve the reliability of the data. Sampling to best represent ambient conditions should be scheduled to avoid heavy rain events if possible.

I. INTRODUCTION

This report summarizes the data obtained from a study of changes in water quality at DPEP's surface water quality monitoring Site #15 (see Figure 1) located on the New River at Andrews Avenue in Fort Lauderdale, Florida during July 29, 1999 through February 7, 2000. The purpose of the study was to 1) determine nearly continuous (measured every 15 minutes) changes in physical water quality parameters, 2) determine the differences in physical and chemical water quality between ebb and flood tides, and 3) determine changes in physical, chemical and microbiological water quality parameters during ebb tide over an extended period of time.

Three different monitoring regimens were applied over course of this study; fine time-scale monitoring, tidal monitoring and long time-scale monitoring. Fine time-scale monitoring consisted of measurements taken every 15 minutes over a 43-day period. The parameters measured during this regimen included temperature, turbidity, conductivity, pH, dissolved oxygen and tidal stage. Tidal monitoring involved collecting samples 4 times a day at mid-ebb and mid-flood tides over a period of 11 days. The parameters measured during this regimen were ammonia, nitrite+nitrate, total Kjeldahl nitrogen and total phosphorus. Long time-scale monitoring involved the collection of samples once a week during the ebb tide over a period of 10 weeks. The parameters measured during this regimen included ammonia, nitrite+nitrate, total Kjeldahl nitrogen, orthophosphate, total phosphorus, chlorophyl and fecal coliform. Rainfall, as an average reading taken from 3 meteorological stations within or adjacent to the New River drainage basin was also available for correlation with the physical, chemical and microbiological data.

Figure 1
Location of Site #15 on the New River

II. METHODOLOGY

Monitoring Regimens

From July 29 to September 10, 1999 discrete measurements of temperature, specific conductance, turbidity, pH and dissolved oxygen were recorded every 15 minutes using a Hydrolab DataSonde 4a multiprobe and data logger (sonde) (Hydrolab Corp, Austin, TX). This instrument is totally self-contained and is capable of recording the listed parameters unattended for periods of up to two weeks. The sonde was secured to a piling under the bridge on the north side of the river channel at a point such that the sensors would remain below the surface throughout the tide cycle. The approximate high tide depth of the channel at this point was 15 feet. Following the initial calibration and deployment, the instrument was serviced and re-calibrated twice during the monitoring period; once on August 12, 1999 at 12:15 PM (sample sequence #1346) and again on August 27, 1999 at 11:30 AM (sample sequence #2783).

From August 20 to September 9, 1999 samples were collected at mid-outgoing and mid-incoming tides over several days using an autosampler. An American Sigma, Streamline 800SL autosampler (American Sigma, Medina, NY) was used to collect discrete samples for ammonia, nitrite+nitrate, total phosphorus and total Kjeldahl nitrogen. The autosampler bottles contained sulfuric acid as a preservative.

From November 9, 1999 to February 7, 2000 weekly grab samples were collected during the outgoing tide. The grab samples were collected approximately 2 feet sub-surface and tested for conductivity, dissolved oxygen, ammonia, nitrite+nitrate, total phosphorus and total Kjeldahl nitrogen, fecal coliform, orthophosphate, and chlorophyll *a*.

Analytical Methods

The physical parameters were measured in the field using the Surveyor 3 multi-parameter water quality logging system. Temperature was measured by a linear thermistor with calibration traceable to a National Bureau of Standards thermometer. pH was measured by a glass electrode and sealed reference with refillable flowing junction. Conductivity was measured by a six-electrode cell with automatic temperature compensation. Turbidity was measured by a nephelometric sensor.

The chemical and microbiological parameters were measured in the laboratory using methods published by the Environmental Protection Agency (USEPA, 1983) and the American Public Health Association (Greenberg et al, 1992). Orthophosphate was measured by an automated sequential flow analyzer (SFA) using the method of ascorbic acid reduction. Total phosphorus was also measured by SFA and ascorbic acid reduction after all forms of phosphorus in the sample were converted to orthophosphate by acid digestion on an aluminum block. Ammonia was measured by SFA by the method of indophenol blue which is formed by the reaction of ammonia with alkaline phenol and hypochlorite. Nitrite plus nitrate was measured by SFA using cadmium reduction of nitrate to nitrite and measurement of the resulting nitrite by diazotizing with sulfanilamide and coupling with N-(1-naphthyl)-ethylenediamine dihydrochloride to form a highly colored azo dye which was measured colorimetrically. Total Kjeldahl nitrogen was measured by converting all organic nitrogen forms to ammonia by mercury-catalyzed acid digestion on an aluminum block and subsequent measurement of ammonia by SFA using the salicylate-hypochlorite method. Chlorophyll *a* was measured by fluorometry after isolating pigment-bearing bodies from the water by filtration through a 0.45 micron membrane filter and extracting with acetone. Fecal coliform was measured by the membrane filter technique.

Tables 1 and 2 below specify the methodologies used in the study and their associated data quality objectives. The methods in the tables refer to Standard Methods (Greenberg et al, 1992) and Environmental Protection Agency (USEPA, 1983). The data in Table 1 and Table 2 are EMD laboratory-determined detection and acceptance limits.

TABLE 1
Methods and Data Quality Objectives for Physical Measurements

Parameter	Method	Detection Limit	Precision, RPD	Accuracy
Dissolved oxygen	EPA 360.1	0.05 mg/L	0-5.3%	99.0-101.0%
Turbidity	EPA 180.1	0.1 NTU	0-29.7%	77.3-116.6%
Specific conductance	EPA 120.1	1 umho/cm	0-0.9%	91.7-113.9%
Salinity	SM2520B	0.025 ppt	0-2.1%	79.3-108.7%
pH	EPA 150.1	NA	0-2.8%	97.6-100.4%
Temperature	EPA 170.1	NA	0-4.0%	95.0-105.0%

TABLE 2
Methods and Data Quality Objectives for Chemical and Microbiological Measurements

Parameter	Method	Detection Limit	Precision, RPD	Accuracy
ammonia	EPA 350.1	0.015 mg/L	0-12.7%	91.3-110.6%
nitrite+nitrate	EPA 353.2	0.005 mg/L	0-13.3%	90.6-110.8%
total phosphorus	EPA 365.4	0.010 mg/L	0-21.9%	92.7-105.4%
total Kjeldahl nitrogen	EPA 351.2	0.131 mg/L	0-46.8%	87.6-111.9%
fecal coliform	SM9222D	2 c/100ml	0-0.3%	NA
orthophosphate	EPA 365.1	0.003 mg/L	0-5.4%	96.8-105.9%
chlorophyll *a*	SM10200H	0.05 mg/m^3	0-17.0%	77.6-129.8%

Statistical Calculations

Data were examined for outliers before calculating statistics or plotting data. When values were reported as “BDL”, a value equal to one-half the method detection limit was used in the calculations. All statistical calculations were performed using SigmaStat statistical software (Jandel, 1995).

III. RESULTS

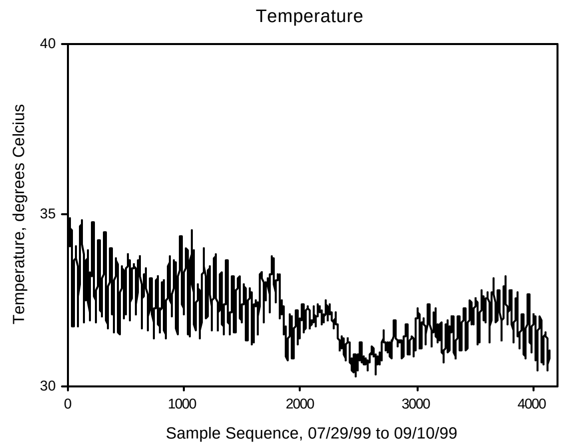
Fine time-scale monitoring

During the fine time-scale monitoring period, physical parameter measurements were recorded every 15 minutes. These data will be depicted individually and as daily averages. The changes that occurred during one tidal cycle are also presented.

Fine time-scale monitoring, readings every 15 minutes

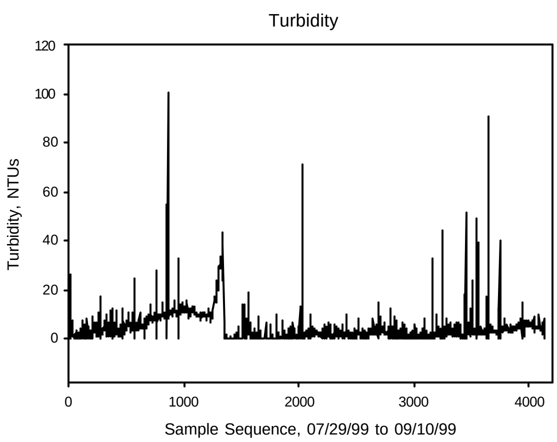
Figures 2-6 below depict the results of the physical parameter measurements taken every 15 minutes during the period of July 29 to September 9, 1999.

Figure 2



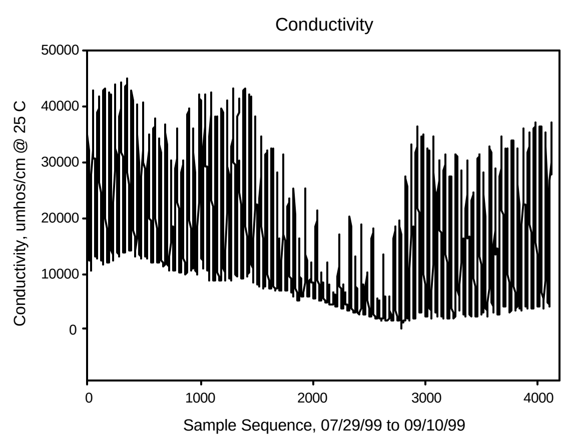
Temperature ranged from 30.3 to 34.9 degrees Celsius (C) and averaged 32.2 C with a median value of 32.0 C.

Figure 3



Turbidity ranged from 0.0 to 101 NTU and averaged 4.0 NTU with a median value of 2.4 NTU. The spurious, extremely high turbidity readings were considered anomalous, possibly due to an occasional stick or leaf passing the probe and not indicative of general water turbidity at the moment.

Figure 4



Conductivity ranged from 281 to 44,924 micromhos/cm and averaged 15,499 micromhos/cm with a median value or 12,083 micromhos/cm.

Figure 5

pH ranged from 7.2 to 7.9 units with average and median values of 7.5 units.

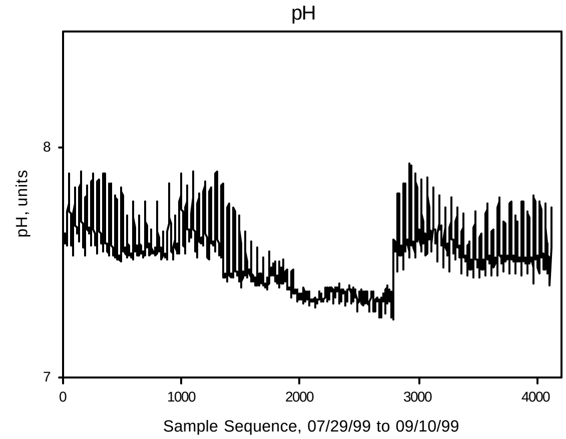
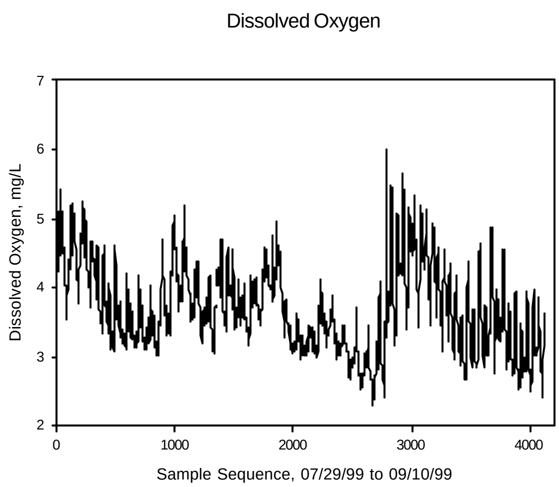


Figure 6



Dissolved oxygen ranged from 2.3 to 6.0 mg/L and averaged 3.7 with a median value of 3.6 mg/L.

Figure 7

A chart of probe depth, Figure 7, is provided to illustrate the tide cycle.

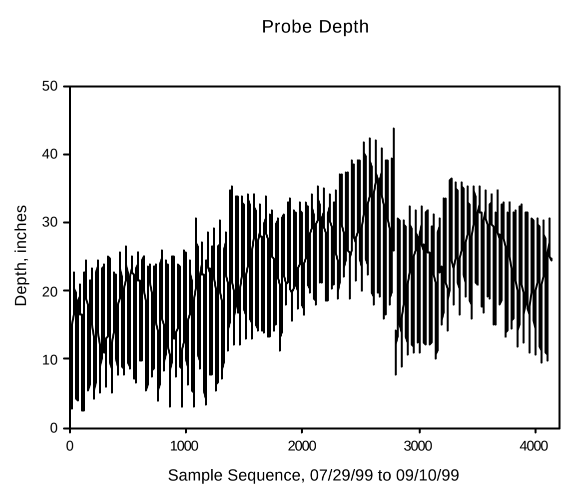
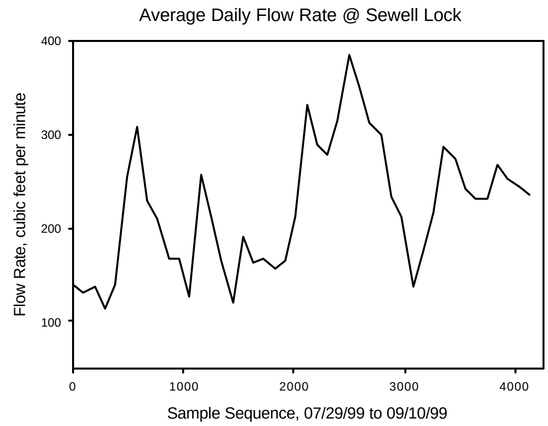


Figure 8

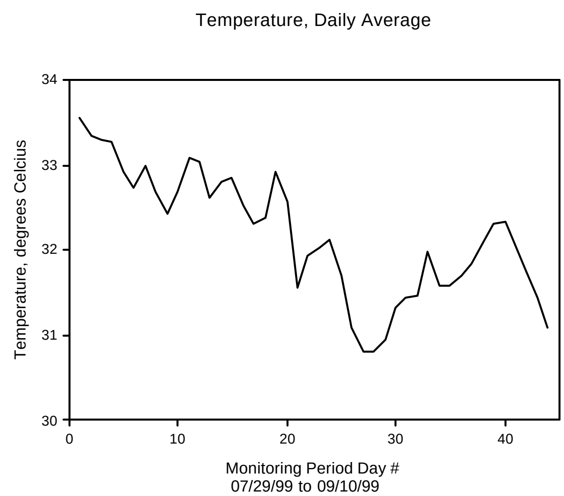


With the exception of turbidity, the data exhibited a cyclic nature due to tidal influences. Some of the parameters, specifically temperature, pH, dissolved oxygen, and conductivity also showed a fairly distinct depression during the central portion of the monitoring period. This depression is likely due to increased flow of water from the WCA. These flows, as measured at Sewell Lock are depicted as daily averages during the monitoring period in Figure 8.

Fine time-scale monitoring, expressed as daily averages

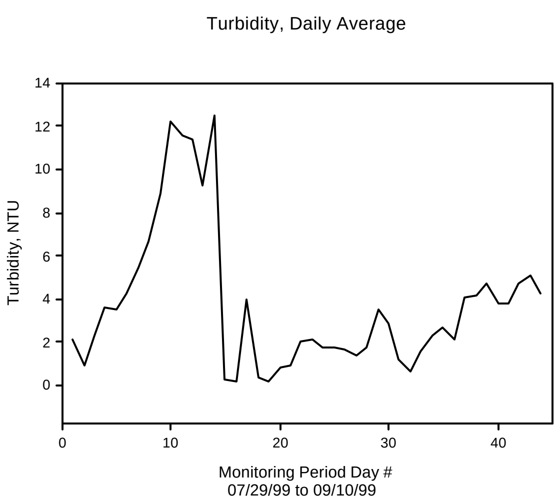
Figures 9 to 13 illustrate the changes in temperature, turbidity, pH, dissolved oxygen, and conductivity over the period of July 29, 1999 to September 10, 1999 expressed and depicted as daily averages.

Figure 9



Temperature ranged from 30.8 to 33.6 degrees C and averaged 32.2 C with a median value of 32.2 C.

Figure 10



Turbidity ranged from 0.2 to 12.5 NTU and averaged 3.8 NTU with a median value of 2.8 NTU.

pH ranged from 7.33 to 7.68 units with an average value of 7.54 units and a median value of 7.56.

Figure 11

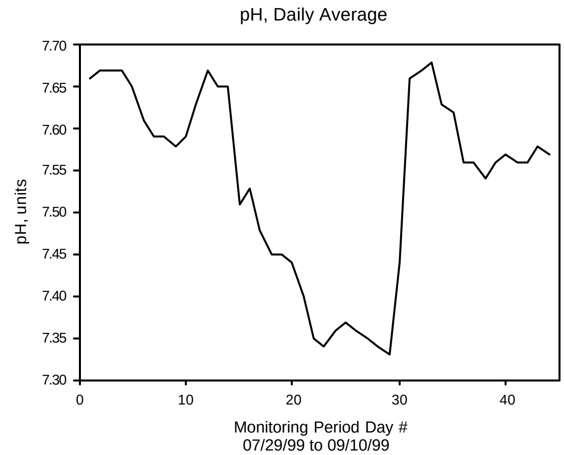
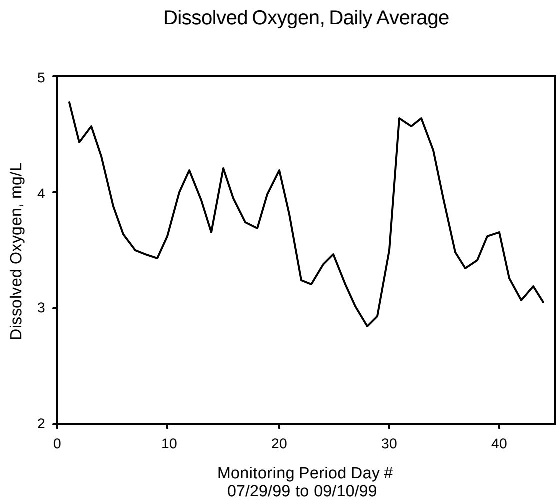
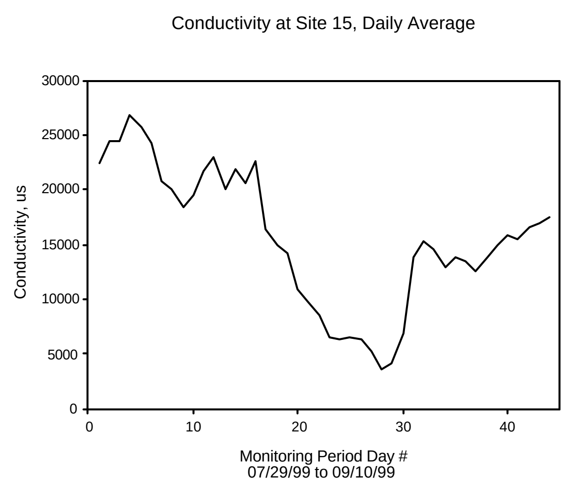


Figure 12



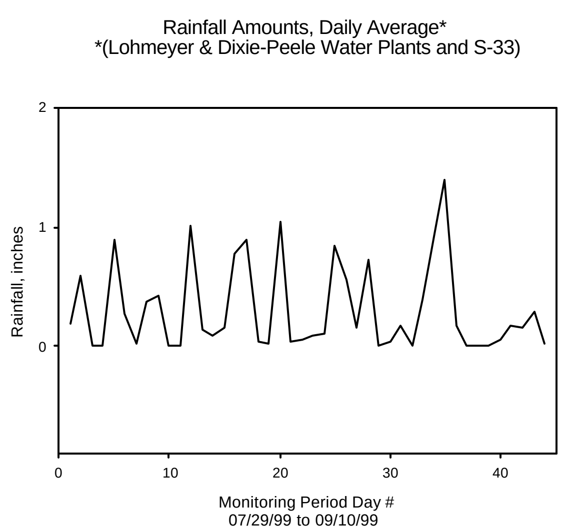
Dissolved oxygen ranged from 2.8 to 4.8 mg/L and averaged 3.7 with a median value of 3.6 mg/L.

Figure 13



Conductivity ranged from 3,656 to 26,763 micromhos/cm and averaged 15,573 micromhos/cm with a median value or 15,401 micromhos/cm.

Figure 14



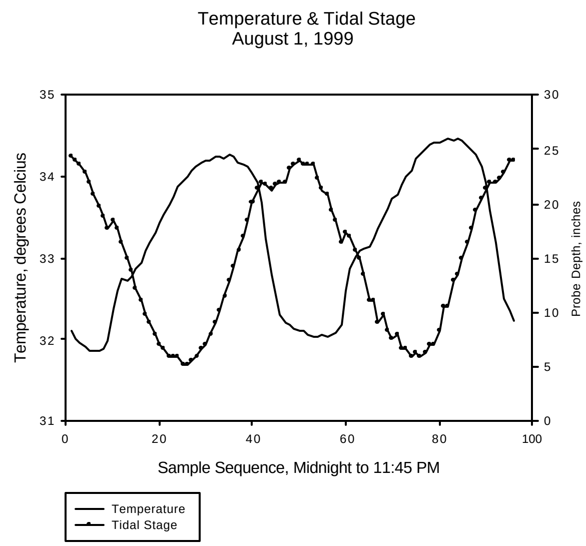
Average daily rainfall during this period, as measured at 3 locations in the vicinity of the drainage basin, is depicted in Figure 14.

While the averaging of the data over a 24 hour period eliminated the cyclic appearance of the data, the depressed values for temperature, pH, dissolved oxygen and conductivity during the high flow period at the Sewell Lock were still apparent. There was no apparent correlation between rainfall and the average parameter concentrations.

<u>Fine time-scale monitoring; detail over the tidal cycle</u>

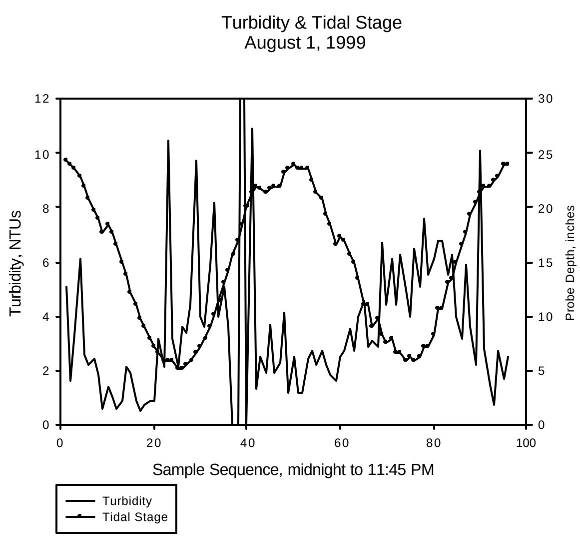
Figures 15 to 19 depict changes in the measurements of temperature, turbidity, pH, dissolved oxygen and conductivity over the tidal cycle (as indicated by probe depth). A chart of probe depth and predicted tide height, Figure 20, is also provided to establish the accuracy of the software used to predict tide stage at this location.

Figure 15



In general, maximum water temperature occurred near low tide. Water flowing from the shallower western areas is of a darker color which enhances its absorption of solar energy and contributing to increased temperatures.

Figure 16



Turbidity was also generally higher at low tide. This suggests that suspended matter, whether it be flotsam and jetsam or algae, is moving east from the western areas.

Figure 17

pH values rose in unison with tide height due to the higher alkalinity of sea water.

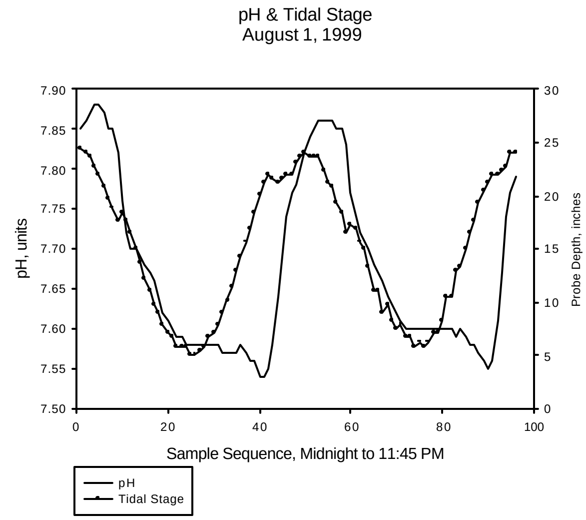
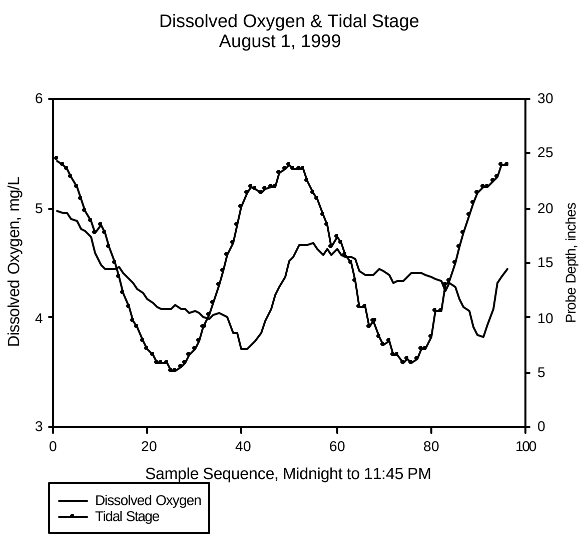


Figure 18

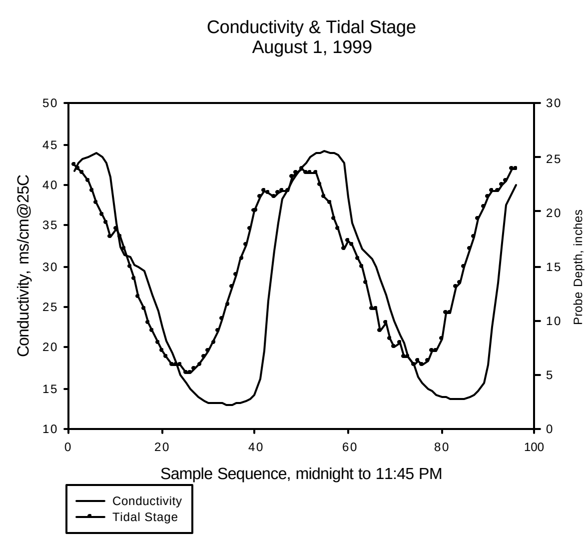


Dissolved oxygen levels reached a maximum just after high tide and decreased steadily with the outgoing tide reaching their minimum values a short time after low tide.

Dissolved oxygen levels also tend to rise and fall in sync with daylight due to the oxygen-producing photosynthetic activities of phytoplankton.

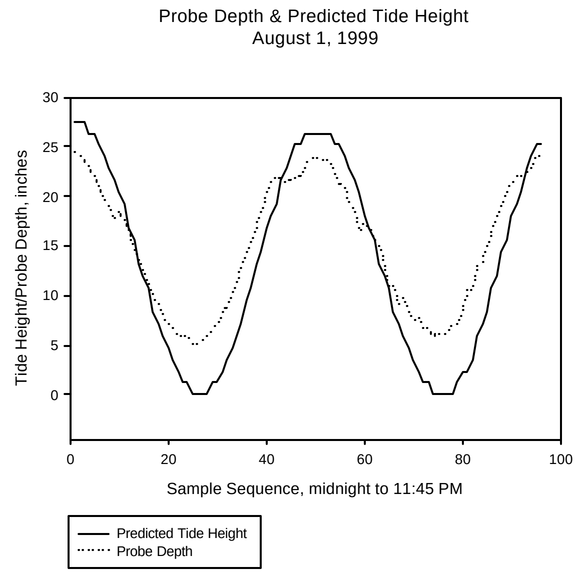
Figure 19

Conductivity values reached maximums shortly after the high tide as would be expected as saline coastal water moves in from the east.



The chart of probe depth versus predicted tide height indicate that tidal predictions at this site are very close to actual tide stage.

Figure 20

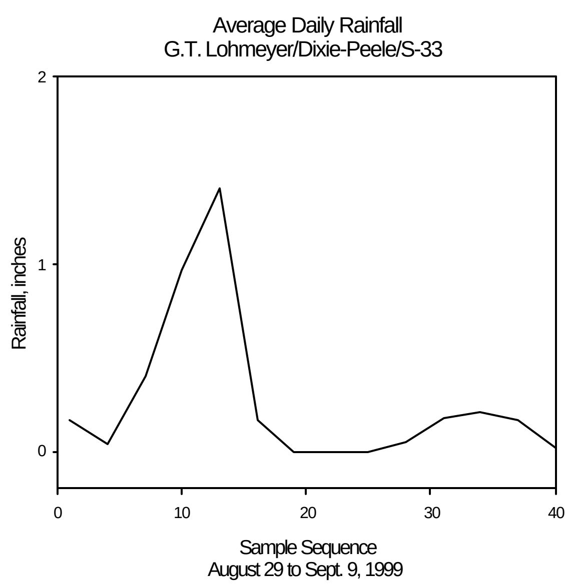


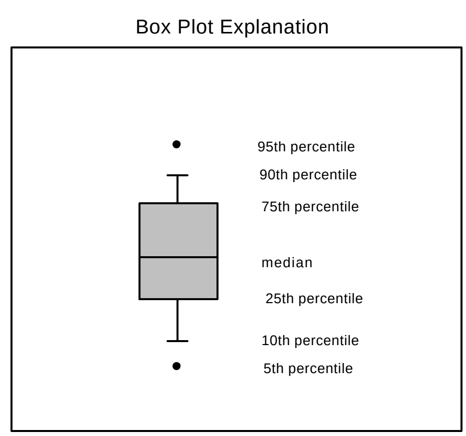
Tidal Monitoring; ebb versus flood tide

Figures 23 through 30 depict differences in water quality between incoming and outgoing tide with respect to chemical parameters (ammonia, TKN, nitrite+nitrate and TP). A chart, Figure 21, of average daily rainfall as recorded at three different stations in the vicinity of the basin is also provided. Box plots of ebb and flood tide data are provided to help visualize any differences between ebb and flood tide concentrations. Figure 22 illustrates the features of the box plots.

Figure 21

Figure 22





Although the autosampler was programmed to collect samples at the mid-point between high and low tides, actual sampling time varied somewhat from ideal but ebb tide samples were always collected during outgoing flow and flood tide samples were always collected during incoming flow.

During ebb tide, ammonia ranged from 0.036 to 0.194 mg/L with a mean (+/-1 standard deviation) of 0.113±0.047 mg/L and a median of 0.100 mg/L. During the flood tide, ammonia ranged from 0.067 to 0.202 mg/L with a mean of 0.127±0.034 mg/L and a median of 0.125 mg/L. There was not a statistically significant difference between ebb and flood tide ammonia concentrations (á=0.05) although the power of the performed test (0.118) was below the desired power of 0.800. The lack of significant difference should be interpreted cautiously.

Figure 23

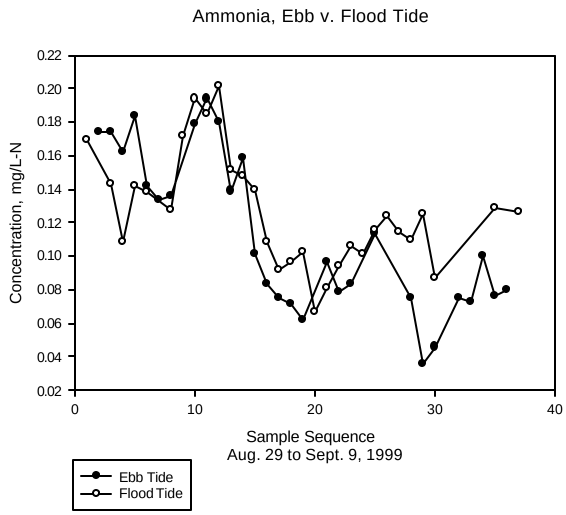
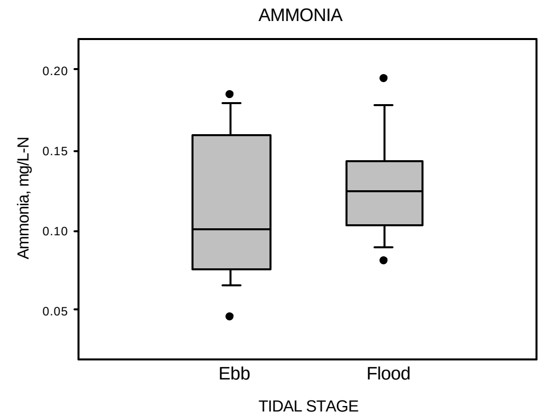


Figure 24



During ebb tide, total Kjeldahl nitrogen (TKN) ranged from 0.850 to 1.690 mg/L with a mean of 1.250±0.199 mg/L and a median of 1.240 mg/L. During the flood tide, TKN ranged from 1.110 to 1.810 mg/L with a mean of 1.481±0.196 mg/L and a median of 1.510 mg/L. The mean concentration elevation of TKN during the flood tide over the ebb was found to be statistically significant (P=<0.001). The power of the performed test with á=0.05 was 0.996.

Figure 25

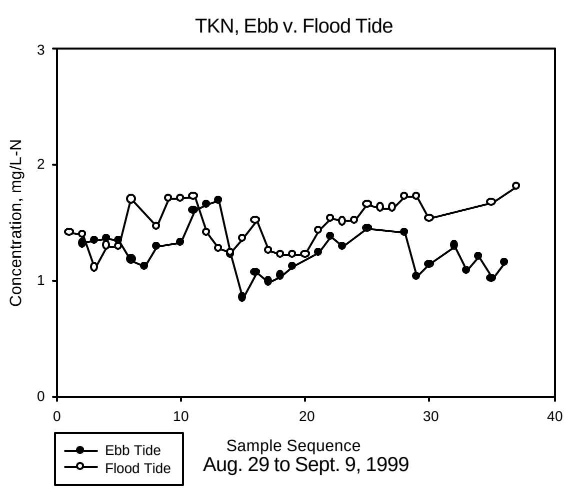
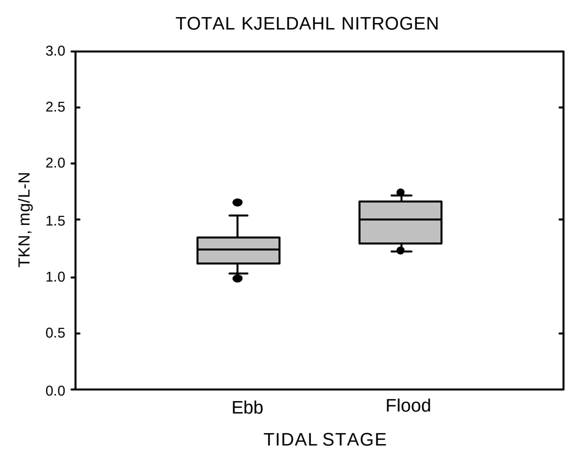


Figure 26



During ebb tide, nitrite+nitrate concentration ranged from 0.002 to 0.406 mg/L with a mean of 0.241±0.084 mg/L and a median of 0.265 mg/L. During the flood tide, nitrite+nitrate ranged from 0.002 to 0.418 mg/L with a mean of 0.283±0.101 mg/L and a median of 0.300 mg/L. The data failed the normality test (P=<0.001) so the Mann-Whitney Rank Sum Test was applied. The mean nitrite+nitrate concentration elevation during flood tide over the ebb tide was found to be statistically significant (P=0.001).

Figure 27

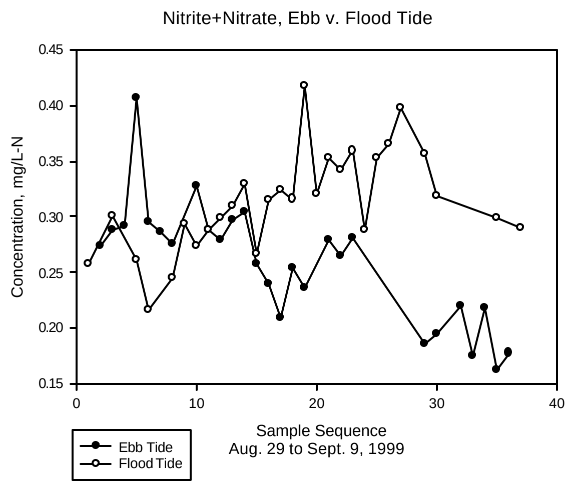
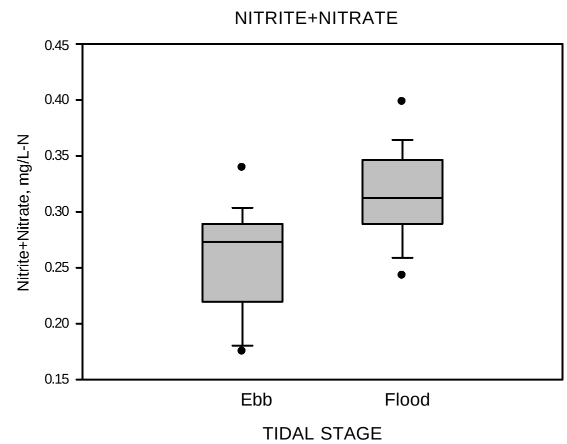


Figure 28



During ebb tide, total phosphorus (TP) ranged from 0.005 to 0.072 mg/L with a mean of 0.033±0.026 mg/L and a median of 0.031 mg/L. During the flood tide, TP ranged from 0.005 to 0.083 mg/L with a mean of 0.035±0.028 mg/L and a median of 0.039 mg/L. The data failed the normality test (P=<0.001) so the Mann-Whitney Rank Sum Test was applied. This test indicated that there was not a statistically significant difference between ebb and flood tide TP concentrations (P=0.853).

Figure 29

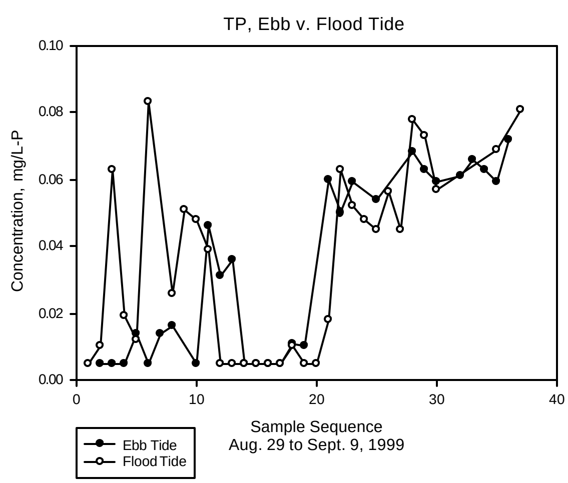
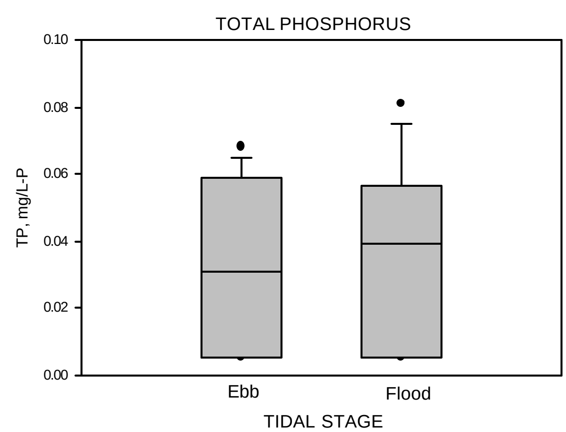


Figure 30



Long time-scale monitoring; weekly grab samples during ebb tide
Figures 31 through 40 depict water quality over the period of November 9, 1999 to February 7, 2000 with respect to conductivity, dissolved oxygen, ammonia, TKN, nitrite+nitrate, total nitrogen, orthophosphate, total phosphorus, chlorophyll *a* and fecal coliform. A chart of average rainfall during this time period, Figure 41, is also provided. Thirteen grab samples were collected during this period during the ebb tide.

The physical parameters measured during the long time-scale monitoring period were conductivity and dissolved oxygen. Conductivity ranged from 16,100 to 27,500 micromhos/cm with a mean ($\pm$1 standard deviation) of 21,584$\pm$3,541 mg/L and a median of 22,400 micromhos. Conductivity is a measure of the ability of water to conduct an electrical current and is directly related to the amount of dissolved solids in the water. Since Site #15 is tidal, conductivity readings were generally high. Dissolved oxygen ranged from 4.88 to 6.54 mg/L with a mean of 5.78$\pm$0.56 mg/L and a median of 5.75 mg/L. Dissolved oxygen is required to support marine life. The Broward County standard for surface water is no reading less than 4.0 mg/L. All readings were acceptable.

Figure 31

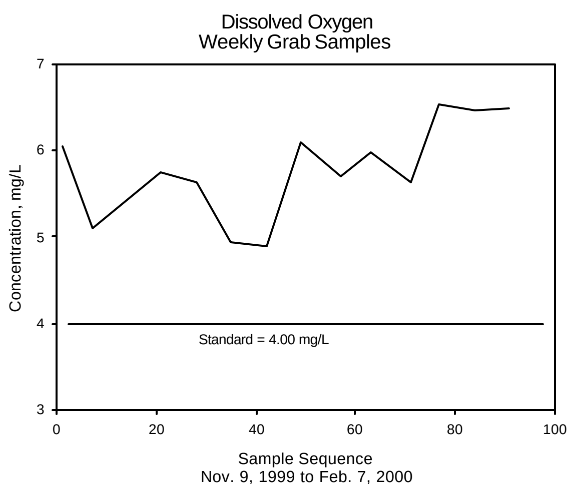
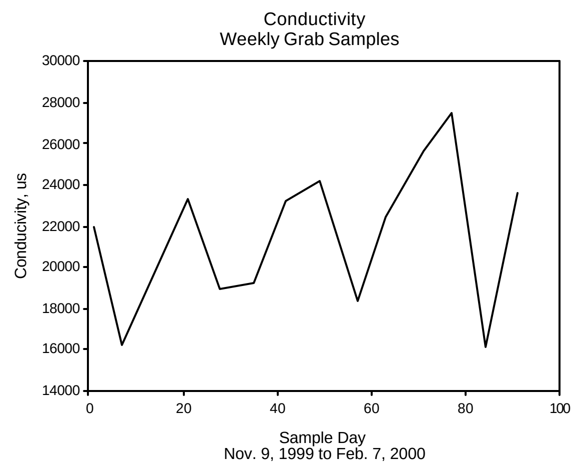


Figure 32



Nitrogen forms measured during this period were ammonia, total Kjeldahl nitrogen (TKN) and nitrite+nitrate. Total nitrogen is computed by adding the nitrite+nitrate and TKN concentrations. Excessive nitrogen levels can cause undesirable algae blooms. Ammonia ranged from 0.016 to 0.068 mg/L with a mean of 0.038$\pm$0.016 mg/L and median of 0.038 mg/L. TKN ranged from 0.794 to 1.790 mg/L with a mean of 1.121$\pm$0.322 mg/L and median of 1.010 mg/L. Nitrite+nitrate ranged from 0.192 to 0.528 mg/L with a mean of 0.281$\pm$0.087 mg/L and a median of 0.268 mg/L. Total nitrogen ranged from 1.15 to 2.01 mg/L with a mean of 1.40$\pm$0.30 mg/L and a median of 1.29 mg/L. The Broward County standard for total nitrogen in marine surface water is 1.50 mg/L. Three of the thirteen values (23.0%) recorded during the weekly monitoring period exceeded the standard.

Figure 33

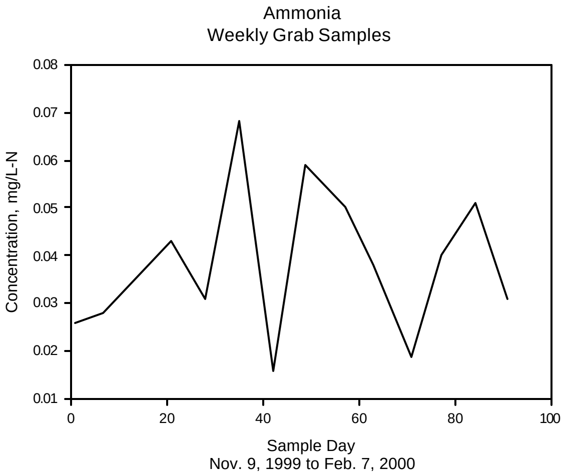


Figure 34

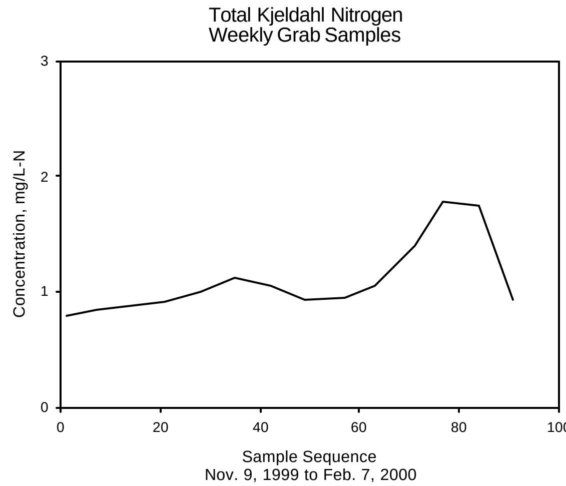


Figure 35

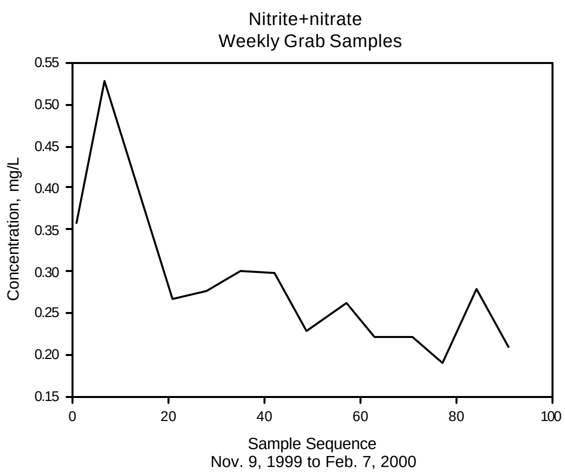
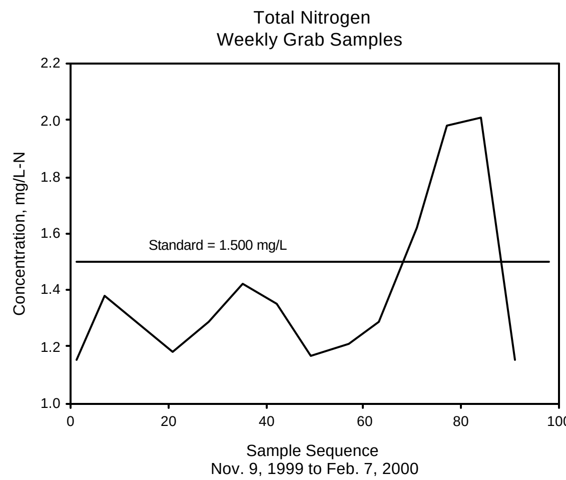


Figure 36



Phosphorus forms measured during this period were orthophosphate and total phosphate. These two phosphorus forms are distinguished analytically by their ability to react with analytical reagents. Orthophosphate is the most bio-available and reacts directly with analytical reagents. Total phosphorus includes organically-bound phosphorus that is not immediately bio-available. Analytically, it requires digestion with strong acid before it will react with reagents. Orthophosphate ranged from 0.023 to 0.066 mg/L with a mean of 0.041±0.008 mg/L and a median of 0.040 mg/L. Total phosphorus ranged from 0.024 mg/L to 0.075 mg/L with a mean of 0.044±0.015 mg/L and a median of 0.038 mg/L. The Broward County standard for total phosphorus in marine surface water is 0.050 mg/L. Four of the thirteen values (30.8%) recorded during the weekly monitoring exceeded the standard.

Figure 37

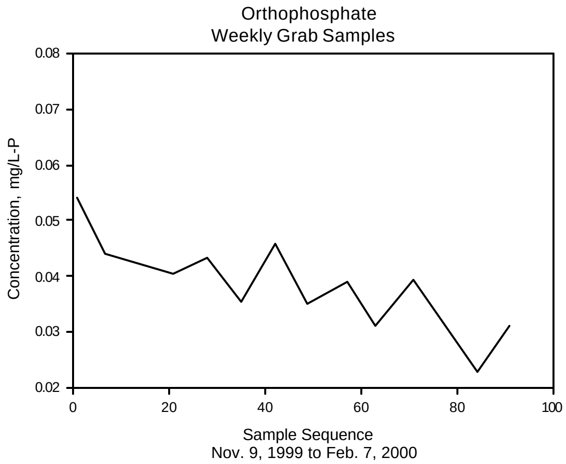


Figure 38

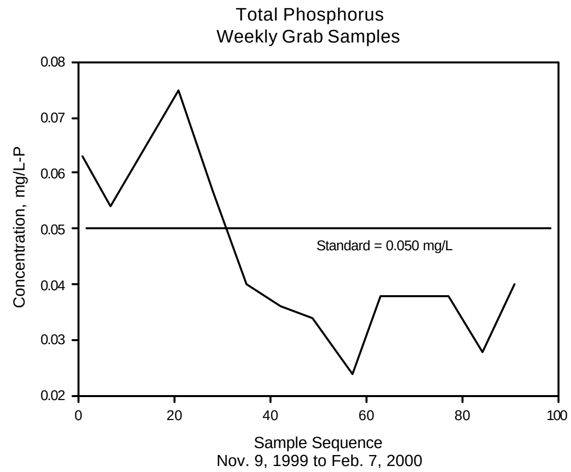
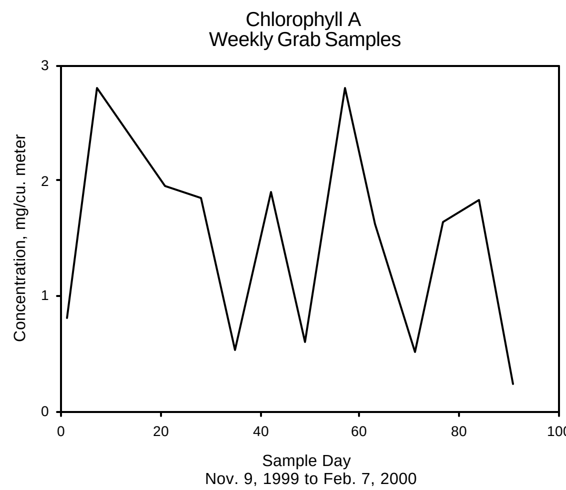
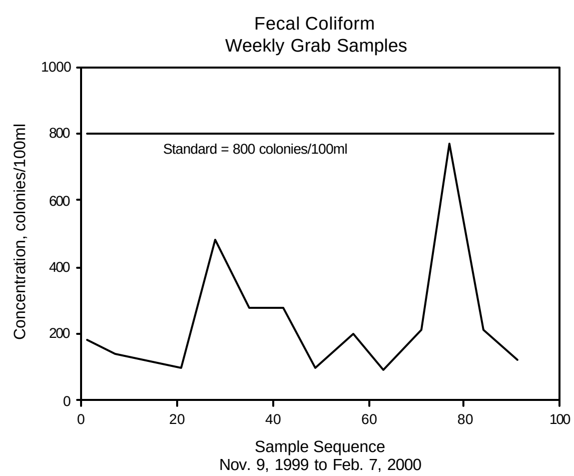


Figure 39



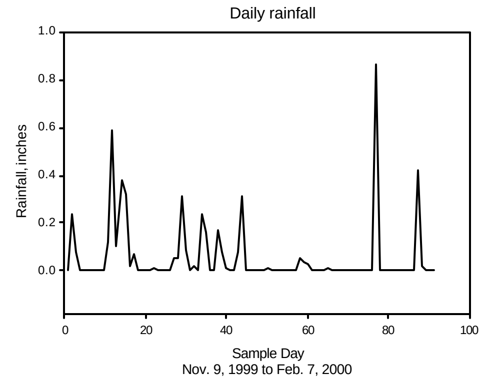
Chlorophyll *a* ranged from 0.240 to 2.800 mg/m^3 with a mean of 1.470 mg/m^3 and a median of 1.650 mg/m^3. The concentration of photosynthetic pigments is used extensively to estimate phytoplankton biomass (Rott, 1980) and in conjunction with nutrient measurements, is useful for evaluating the health and productivity of a water body.

Figure 40



Fecal coliform ranged from 93 to 770 colonies/100ml with a mean of 243 colonies/100ml and a median of 200 colonies/100ml. The Broward County standard for fecal coliform in surface water is tri-level; (a) 200 colonies/100ml for monthly average, (b) 400 colonies/100ml for 10% of the samples and (c) 800 colonies/100ml in any sample. None of the samples failed the one-time standard of 800 colonies/100mls. The monthly average standard of 200 colonies/100ml was exceeded in December 1999 (285 colonies/100ml) and January 2000 (297 colonies/100ml). If the entire monitoring period is considered, the 10% of samples standard of 400 colonies/100ml was also exceeded (15% of samples).

Figure 41



The long-term monitoring regimen also revealed some interesting relationships between rainfall and water quality with respect to nutrients. Single, intense rain events seemed to result in spikes in total Kjeldahl nitrogen, total nitrogen and fecal coliform levels while prolonged periods of less intense rainfall seemed to result in general elevations in nitrite+nitrate, orthophosphate and total phosphorus levels.

The time period of this portion of the monitoring was during the "dry" season. The chart of average rainfall, Figure 41, indicates that average rainfall exceeded ½ inch on only two occasions (sample days 12 & 77). Frequent, less intense rain events, however were more common during the earlier period of the regimen.

During one of the heavy rainfall events (January 24, 2000; sample sequence #77) the daily rainfall amount was 0.84 inches. The charts of TKN, TN and fecal coliform, Figures 34, 36 and 40 respectively indicate maximum values occurred at that time. This suggests that these parameters are most susceptible to elevation due to storm water runoff. Ammonia, nitrite plus nitrate, total phosphorus and chlorophyll *a* did not seem to be greatly affected by this amount of rain.

In contrast to the effects of intense rain events, frequent, low intensity rainfall that occurred during the earlier part of this monitoring period seems to have resulted in general elevations in nitrite+nitrate orthophosphate and total phosphorus (see Figures 35, 37 and 38 respectively). Ambient levels of these parameters showed a trend toward lower levels later on as the frequency of rain events diminished. The mechanism of this phenomenon is not immediately apparent and warrants further study.

IV. DISCUSSION AND CONCLUSIONS

The fine time-scale monitoring regimen indicates that physical parameters are greatly influenced by tidal action at this site. Maximum values for temperature & turbidity and minimum values for pH & dissolved oxygen occurred at low tide. The extremely high turbidity readings that were observed were considered anomalous, possibly due to an occasional stick or leaf passing the probe and not indicative of general water turbidity at the moment. Conductivity maximums occurred at high tide.

Water management practices had a noticeable impact on the physical water quality parameters at this site. A major source of fresh water flow to the New River is from WCA 2B and 3A through the South Florida Water Management District Sewell Lock on the North New River Canal via the South Fork of the New River (DPEP, 2001). When flows from the WCA are high, dissolved oxygen, conductivity and pH levels are depressed and their tidally-driven cyclic nature is damped. Water levels at Site #15 are also affected by these practices. The observation of extreme variation in salinity likely influences the biological communities as well.

Statistical differences between ebb and flood tide were observed for TKN and nitrite+nitrate but not for ammonia or total phosphorus. Mean TKN levels were 18% higher during flood tide. Mean nitrite+nitrate levels were 17% higher during flood tide. The finding of higher nitrite+nitrate and TKN concentrations during the flood tide was unexpected and counter-intuitive because saline water from the east would be expected to be lower in TKN and nitrite+nitrate than fresh water from the west. Figures 42 and 43 indicate that with the exception of Site #16, sites west of Site #15 tend to be higher in nitrite+nitrate and TKN, however, statistical differences only existed between Site #15 and Site #38 which is located near Port Everglades on the Intracoastal Waterway. Site #16 is located in the North Fork of the New River that historically has depressed dissolved oxygen levels that would not be conducive to oxidized forms of nitrogen. Furthermore, the major source of water to the New River is from the South Fork so water quality impacts at Site #15 from the North Fork would be minimal. Possibly, samples collected during ebb and flood tides are more indicative of water that arrived at the sampling point during the previous tidal cycle and thus not truly representative of eastern or western water. Samples collected at dead low or dead high may yield different results. Future studies of this phenomenon should include finer time-scale measurements supplemented by simultaneous conductivity measurements to reveal any correlation between the concentration flux and tide change.

Figure 42

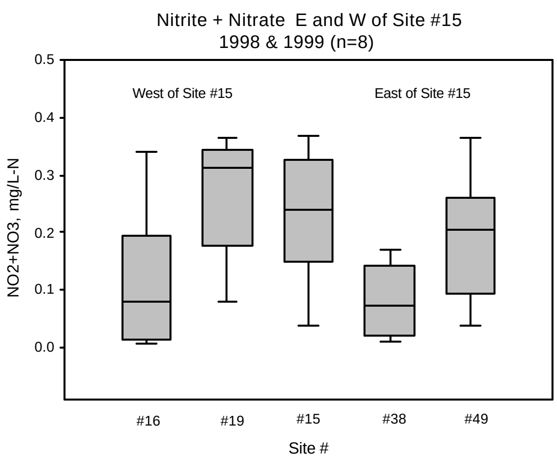


Figure 43

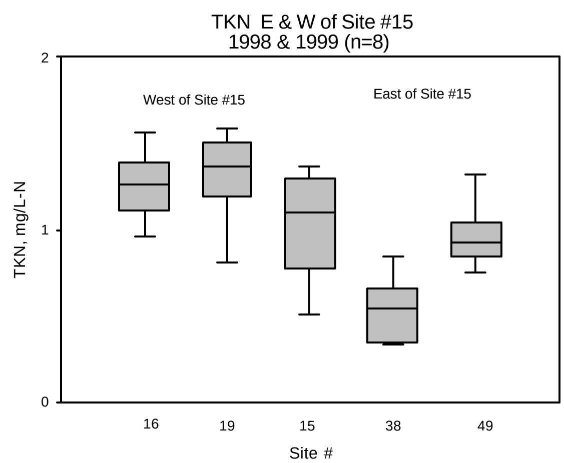
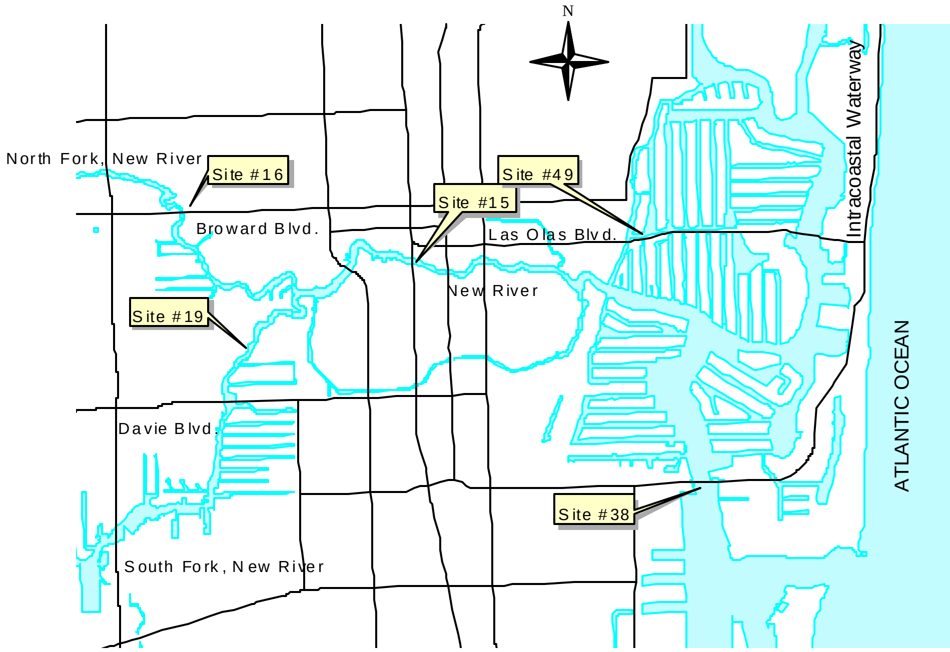


Figure 44
Monitoring Sites E & W of Site #15



The long-term monitoring regimen also revealed some interesting trends in water quality with respect to some parameters. Intense rain events seemed to result in spikes in total Kjeldahl nitrogen, total nitrogen and fecal coliform levels while prolonged periods of less intense rainfall seemed to result in general elevations in nitrite+nitrate, orthophosphate and total phosphorus levels. nutrients.

Each of the regimens employed in this study provided valuable information. These results suggest, however, that additional useful information might be obtained by combining two or more of the regimens investigated in this study simultaneously.

The implications of this study on the surface water quality monitoring program are that worst-case water quality conditions for TKN and nitrite+nitrate would be experienced during flood tide while tidal considerations are not significant for ammonia or total phosphorus. The high variability observed over the 100 day long-term monitoring regimen suggests that quarterly monitoring may not provide an accurate indication of ambient water quality and that the sampling frequency could be increased to improve the reliability of the data. During the dry season, water quality will be noticeably impacted by rainfall events in the vicinity of 1 inch or more. Sampling for ambient water quality should be scheduled to avoid these events if possible.

The DPEP will consult with other water quality research groups (e.g., U.S.E.P.A., South Florida Water Management District, etc.) to determine optimum, cost-effective sampling frequency.

V. LITERATURE CITED

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10. SUPPLEMENTARY NOTES

11. ABSTRACT

This report summarizes the data obtained from a study of changes in water quality at DPEP's surface water quality monitoring Site #15 located on the New River at Andrews Avenue in Fort Lauderdale, Florida during July 29, 1999 through February 7, 2000. The purpose of the study was to 1) determine nearly continuous (measured every 15 minutes) changes in physical water quality parameters, 2) determine the differences in physical and chemical water quality between ebb and flood tides, and 3) determine changes in physical, chemical and microbiological water quality parameters during ebb tide over an extended period of time.

The fine time-scale monitoring regimen indicates that physical parameters are greatly influenced by tidal action at this site. Maximum values for temperature & turbidity and minimum values for pH & dissolved oxygen occurred at low tide. Conductivity maximums occurred at high tide.

Water management practices also have a measurable impact on the physical water quality parameters at this site. When water was released from the WCA, dissolved oxygen, conductivity and pH levels as measured at Site #15 were depressed and their tidally-driven cyclic nature is damped.

Statistical differences between ebb and flood tide were observed for TKN and nitrite+nitrate concentrations (higher during flood) but not for ammonia or total phosphorus.

During the long-term monitoring regimen of this study, water quality was found to be highly variable. Intense rain events seemed to result in spikes in total Kjeldahl nitrogen, total nitrogen and fecal coliform levels while prolonged periods of less intense rainfall seemed to result in general elevations in nitrite+nitrate, orthophosphate and total phosphorus levels.

The implications of this study on the surface water quality monitoring program are that worst-case water quality conditions for TKN and nitrite+nitrate would be experienced during flood tide while tidal considerations are not significant for ammonia or total phosphorus. The high variability observed over the 100 day long-term monitoring regimen suggests that quarterly monitoring may not provide an adequate indication of ambient water quality and that the sampling frequency could be increased to improve the reliability of the data. Sampling to best represent ambient conditions should be scheduled to avoid heavy rain events if possible.

12. KEY WORDS
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Tidal

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