A Final Report

On the

Surface Water Monitoring and Flow Data Collection Study

For the

Cameron County Special Study

Prepared by

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of the

The Nueces River Authority

In Cooperation with the

Texas Commission on Environmental Quality

For the

Clean Rivers Program

Effective Period January 2004 through August 2005

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List of Acronyms

BOD	Biochemical Oxygen Demand
CFS	Cubic Feet per Second
DO	Dissolved Oxygen
FM	Farm to Market Road
NRA	Nueces River Authority
NPS	Non-Point Source
NTU	Nephelometric Turbidity Units
TCEQ	Texas Commission on Environmental Water Quality
TKN	Total Kjeldahl Nitrogen
TDS	Total Dissolved Solids
TOC	Total Organic Compounds
TSS	Total Suspended Solids
VSS	Volatile Suspended Solids

Executive Summary

Due to concerns of a significant water pollution problem caused by non-point source (NPS) pollution, the Nueces River Authority (NRA) in cooperation with the Texas Commission on Environmental Quality (TCEQ) and the Clean Rivers Program entered a contractual agreement to conduct a special study to monitor water quality originating from the Green Valley Farms colonia in Cameron County, Texas. The Green Valley Farms colonia is a largely undeveloped 2,000 acre tract where wastewater is treated primarily by using septic/soil absorption systems. During flood events, septic/soil absorption systems become inundated with water and fail to function properly. Polluted runoff from the Green Valley Farms colonia eventually makes its way to the Arroyo Colorado. In large flood events, a portion of the runoff diverts to the Resaca De Los Fresnos.

In an effort to characterize the quality of water originating from the Green Valley Farms colonia, NRA conducted monthly monitoring at one site collecting routine conventional parameters, field data, and flow from January 2004 through August 2005. Analyses for Biochemical Oxygen Demand (BOD), Orthophosphate-phosphorus, and Total Kjeldahl Nitrogen (TKN) were added to further assess water quality. In addition, NRA was slated to collect runoff during 4 high flow events but only two events occurred during the study period. Laboratory results from sampling events indicated elevated bacteria concentrations at all flow regimes.

Introduction

Cameron County, the southernmost county in Texas, is bordered on the north by Willacy County, on the south by Mexico, on the east by the Gulf of Mexico, and on the west by Hidalgo County. Located in the Rio Grande Plains region of South Texas, Cameron County was founded with the signing of the Treaty of Guadalupe-Hidalgo on July 4, 1848. Much of the economy and population growth in its early years was based on the trade industry. Later, agriculture, oil and gas production and the tourism industry were included as major economic providers.

By 2000, Cameron County had a population of 335,227 persons ranking it 11th out of the 254 counties in Texas. Cameron County has been experiencing above average growth (8.3%) compared with the State average (6.1%) between 2000 and 2003. The per capita income averaged $10,960 with 33.1% of the residents living below the poverty line. Due to population increases and low income levels, Cameron County, like many counties in the border area, has witnessed the development of settlements known as *colonias*. Colonias are distinguished from standard housing in that they lack one or more forms infrastructure including municipal drinking and wastewater treatment tie-in, trash pickup, electricity and paved roads. Due to this lack of infrastructure, colonias are often a source of NPS pollution.

NPS pollution is the leading cause of water pollution in the United States. NPS pollution is derived from many diffuse sources in the environment and largely occurs as storm water moves over land picking up and transporting natural and human-made pollutants to receiving waters. Sources of NPS pollution generally include fertilizers, herbicides, pesticides, toxic chemicals, bacteria from faulty septic systems and naturally occurring animal wastes. Common water quality concerns associated with NPS pollution generally include elevated bacteria levels, nutrient enrichment, increased BOD, and elevated Chlorophyll-a and Pheophytin-a levels.

In Cameron County, a significant water pollution problem, caused by NPS pollution, has been attributed to runoff from the Green Valley Farms colonia and surrounding agricultural areas. During heavy rain events, soils become saturated and septic/soil absorption systems fail to function properly. Contaminated runoff flows from the colonia and associated agricultural land into a man-made ditch that drains into the Arroyo Colorado tidal segment (2201) and eventually the Laguna Madre. The Arroyo Colorado has been identified in the latest state approved 305(d) report and is listed in the state approved 303(d) list for depressed dissolved oxygen (DO). During large flood events, a portion of this water diverts to the Resaca De Los Fresnos which flows into the Laguna Atascosa and through the Laguna Atascosa National Wildlife Refuge.

The purpose of the Cameron County Special Study is to provide hydrological data and flow to monitor the effects of high and low flow conditions on the quality of water flowing in the drainage ditch that intersects FM 510. Originally conceived as a constructed wetland project between the TCEQ, NRA, and the Cameron County Drainage District #3, funding for construction of the wetland was not secured. Data will be retained for state records pending future Best Management Plan projects.

Water Quality Monitoring follows protocol in accordance with the latest version of the TCEQ's *Surface Water Quality Monitoring Procedures* (2003).

Study Area

Cameron County is 140 miles (225 km) south of Corpus Christi in the Rio Grande Plains region of South Texas (Figure 1). The county covers 905 square miles (2,344 square kilometers), with an elevation ranging from sea level to 60 feet (18 meters). The climate in Cameron County is classified as subtropical and subhumid (short, mild winters and long, hot, and humid summers). Average temperatures range from 50°F to 69° (10°C to 21°) in January and 75°F to 94°(24°C to 34°) in July. Annual precipitation rates for Cameron County average approximately 26 in per yr (66 cm per yr). Most precipitation occurs in early fall and coincides with tropical storm activity or in late spring due to frontal systems (Texas Department of Water Resources, 1982).

One site was chosen for monitoring and given the station identification number 18196. The site is approximately 300 yards upstream from the crossing at FM 510 and upstream from a municipal drinking water treatment plant that was under construction during the study period (January 2004 through August 2005). Initial project plans proposed monitoring before the construction of a storm water retention pond and therefore identified a site just downstream of the proposed pond. However, the retention pond did not get approved and the project was suspended as of August 2005.

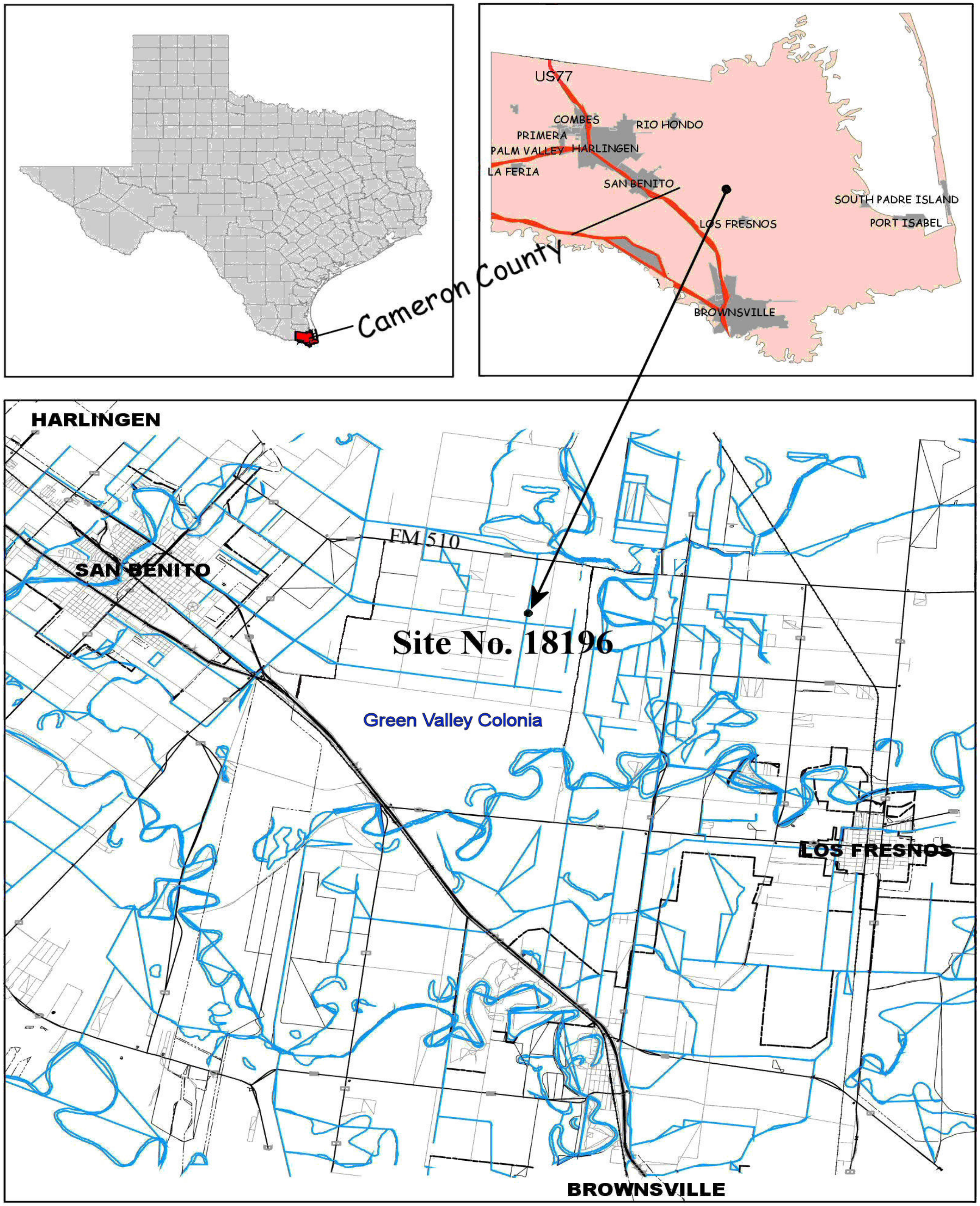

Figure 1. Map of the Cameron County Special Study Sampling Site

The Green Valley Farms colonia is a 2,000 acre tract that is approximately 20% developed and served by septic/soil absorption systems. The area of the affected watershed encompasses approximately 10.5 square miles (27.2 square kilometers) and is located within the boundary of the 100 year flood plain.

During moderate flooding events, storm water flows into a man-made ditch (Figure 2) that drains into the upper portion of the Arroyo Colorado Tidal Segment (2201), and eventually to the Laguna Madre. During large flooding events, a portion of the storm water diverts to the Resaca De Los Fresnos which flows through the Laguna Atascosa National Wildlife Refuge via the Laguna Atascosa.

Figure 2. Photograph of Drainage Ditch off FM 510

Materials and Methods

Site 18196 was monitored once a month beginning in January 2004 and concluded in August 2005 for a total of 20 months. Surface waters were monitored using a Hydrolab Minisonde® 4a and Surveyor ® 4a Data Display to measure depth, temperature, DO (mg/L and % saturation), pH, specific conductance, and salinity. Hydrolab data collection was taken as defined in the TCEQ *Surface Water Quality Monitoring Procedures* (2003). In addition, field data collected included transparency, air temperature, wind speed and direction.

Stream flow measurements taken during periods of normal and low flow conditions were made using a Marsh-McBirney Model 2000 Flo-Mate (Figure 3). Operation of the Flo-Mate followed guidelines provided in accordance with the TCEQ *Surface Water Quality Monitoring Procedures* (2003).

Figure 3. Photograph of Stream flow Measurement Process

Due to deep water and rapid current velocities, flow data from the high flow events were determined by approximation. Current velocities were calculated based on the velocity of floating debris. A tag line was strung out approximately 30 feet (9 meters) parallel to the bank and the time for debris to travel the length of the tag line was recorded. This process was repeated 3 times and the average was recorded. To record cross sectional area, a picture was taken at the time of monitoring. This picture noted the level of the drainage relative to a pipe and wooden structure that crossed the drainage just upstream from the sampling location. The water level and cross-sectional area were then calculated using the elevation of these structures relative to the streambed on a subsequent visit.

Results

Data gathered during much of the study period were primarily collected during a region-wide drought. Rainfall estimates from January through July 2005 remained well below average with deficits ranging from 3-9 inches (8-23 cm) below normal. Stream flow values were consistently recorded in the 1-4 cfs range for much of the study period (Figure 4). Flow, during this time, was primarily dominated by the workings of Cameron County Irrigation District #2 and coincided with the needs of the farming community.

High flow events were infrequent with only two being recorded during the 20 month study period. The first and largest magnitude event was monitored on March 17th 2004 recording 146 cfs (Figures 5 and 6). There was extensive flooding in the area with many areas inundated with standing water. Storm water could be seen flowing in culverts that drained into the drainage ditch.

Figure 4. Photograph of Drainage Ditch off FM 510 during Low Flow Conditions

Figure 5. Photograph of the High Flow Event from March 2004 looking South


Figure 6. Photograph of the High Flow Event from March 2004 looking North

A second high flow event occurred on July 21st 2005 and coincided with the passage of Hurricane Emily just south of Brownsville (Figures 7 and 8). The precipitation associated with this storm was not conducive to large-scale flooding in the area and was, instead, dominated by periods of intermittent but widespread rainfall. Precipitation on the order of 2 to 4 inches was reported throughout the study area. Discharge to the drainage was approximately 40 cfs.

Figures 9 through 28 are graphs of the values of each of the measured parameters, plotted against flow, over the course of the study.

Figure 7. Photograph of the High Flow Event from July 2005 looking South

Figure 8. Photograph of the High Flow Event from July 2005 looking North

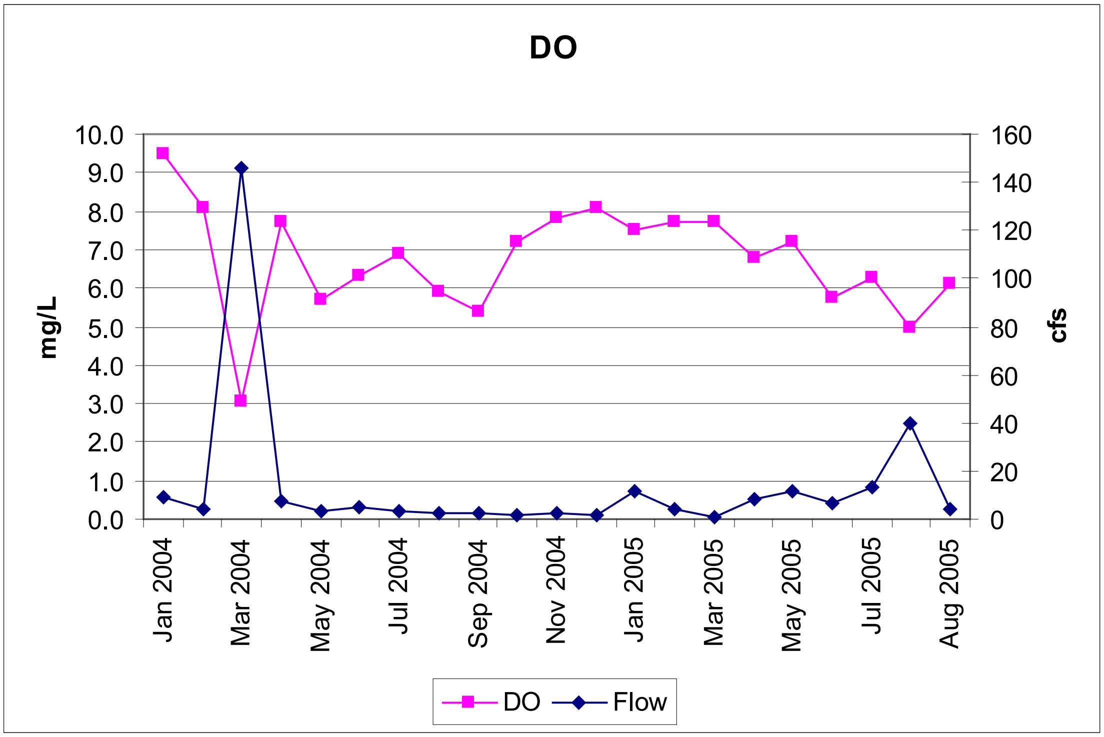

Figure 9. Dissolved Oxygen (mg/L) and Flow (cfs) versus time (months)

DO levels, with the exception of the March 2004 high flow event did not reflect hypoxic conditions. The downward trend observed in summer months is most likely associated with rising temperatures and the relative nature of oxygen saturation in water.

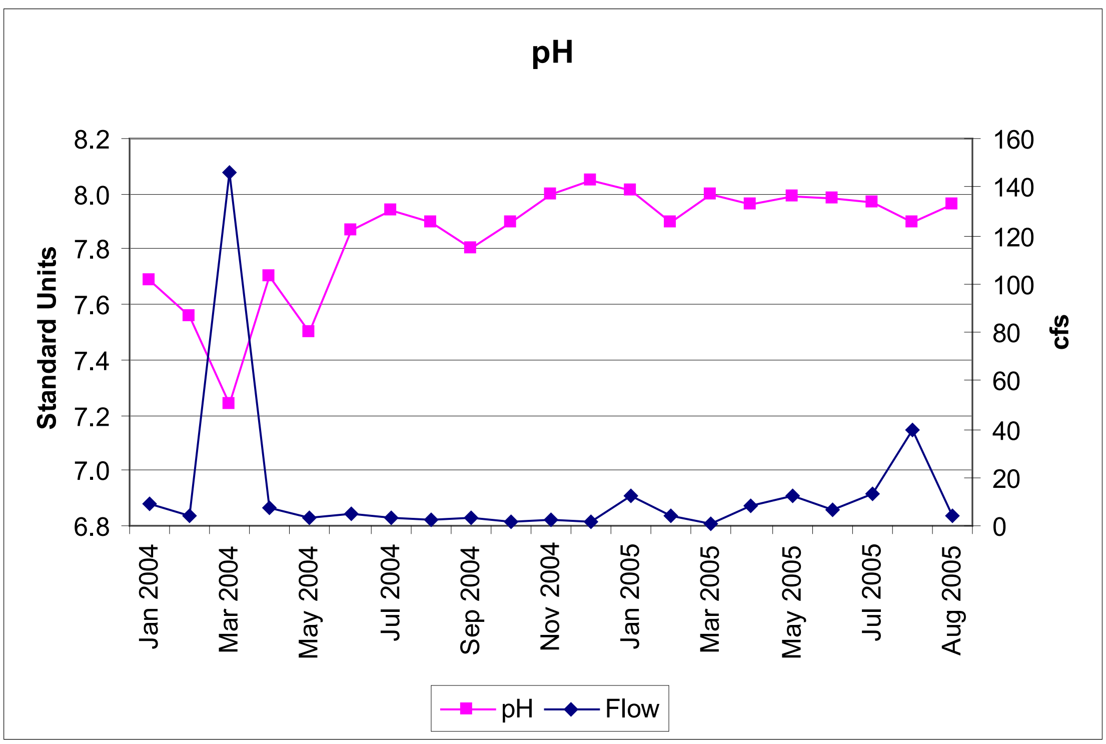

Figure 10. pH and Flow (cfs) versus time (months)

pH units reflected a less alkaline nature during the high flow event as was attributed to the slightly acidic pH of rain water.

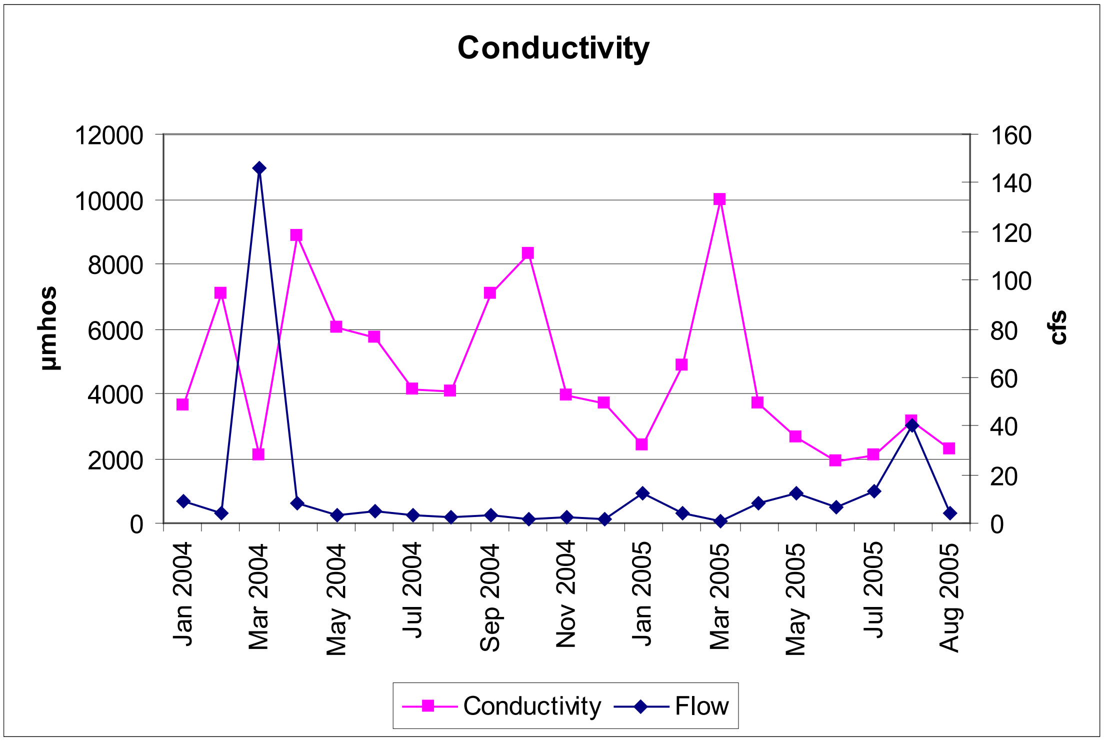

Figure 11. Conductivity (µmhos) and Flow (cfs) versus time (months)

Conductivity values reflected an inverse proportion to flow ranging from 1887 µmhos during the 146 cfs event and 9962 µmhos during record low of 0.6 cfs.

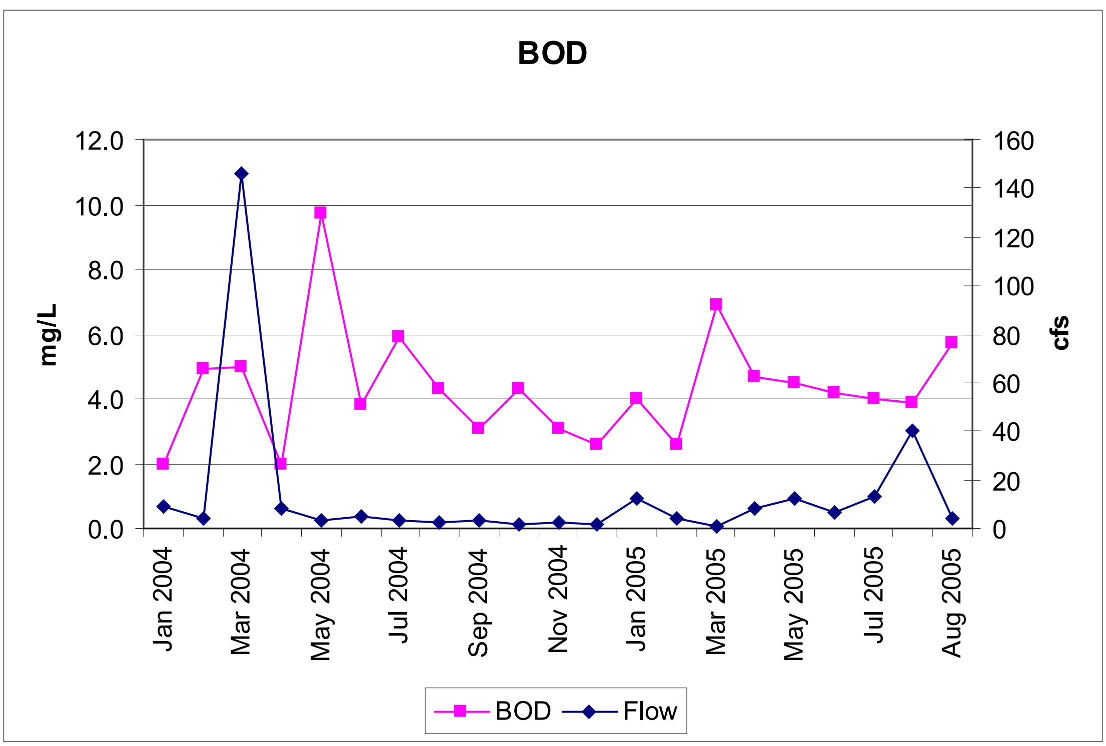

Figure 12. Biochemical Oxygen Demand (mg/L) and Flow (cfs) versus time (months)

BOD ranged from 2.0 to 9.7 mg/L indicating moderate oxygen demand.

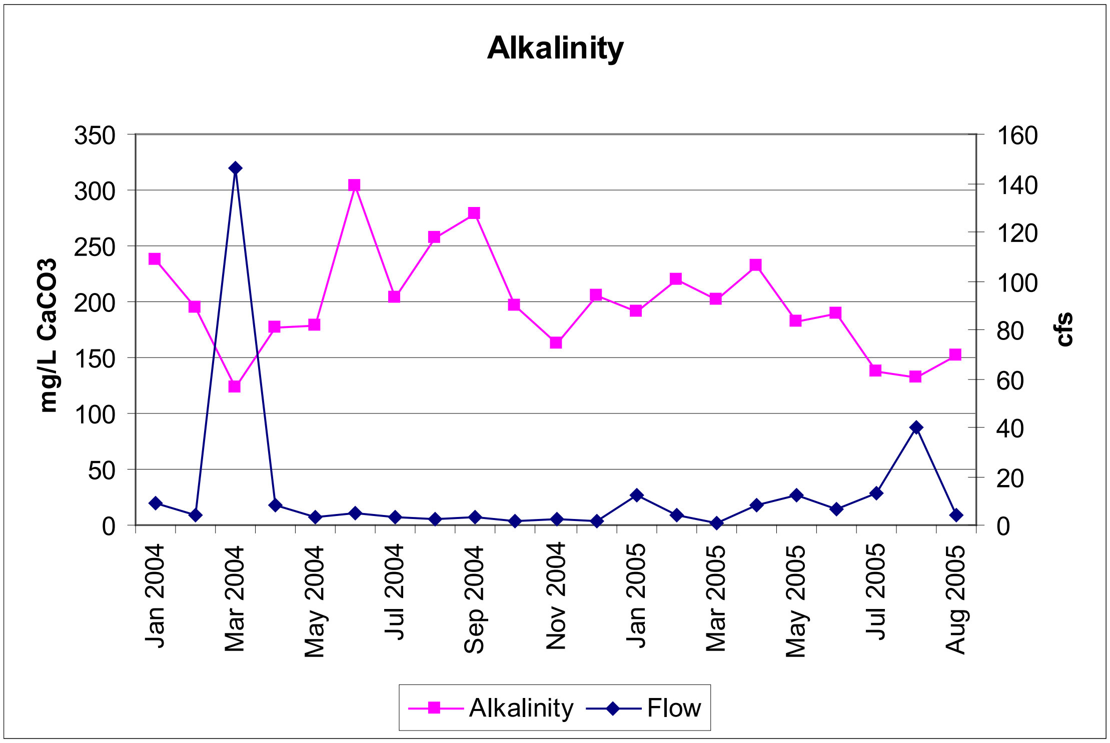

Figure 13. Alkalinity (mg/L $CaCO_3$) and Flow (cfs) versus time (months)

Alkalinity values reflect a fairly stable concentration with the exception of the high flow event where a value of 124 mg/L $CaCO_3$. The high value was 303 mg/L $CaCO_3$.

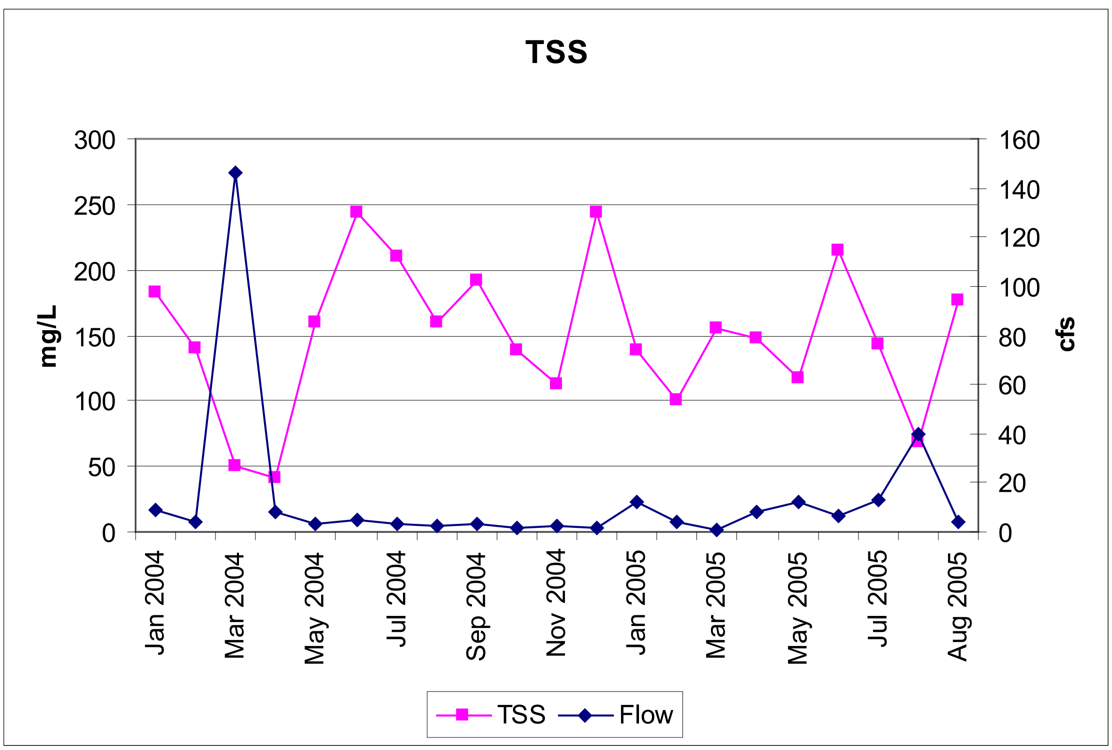

Figure 14. Total Suspended Solids (mg/L) and Flow (cfs) versus time (months)

Total Suspended Solids (TSS) concentrations were generally inversely proportional to flow; the range was 41 to 244 mg/L.

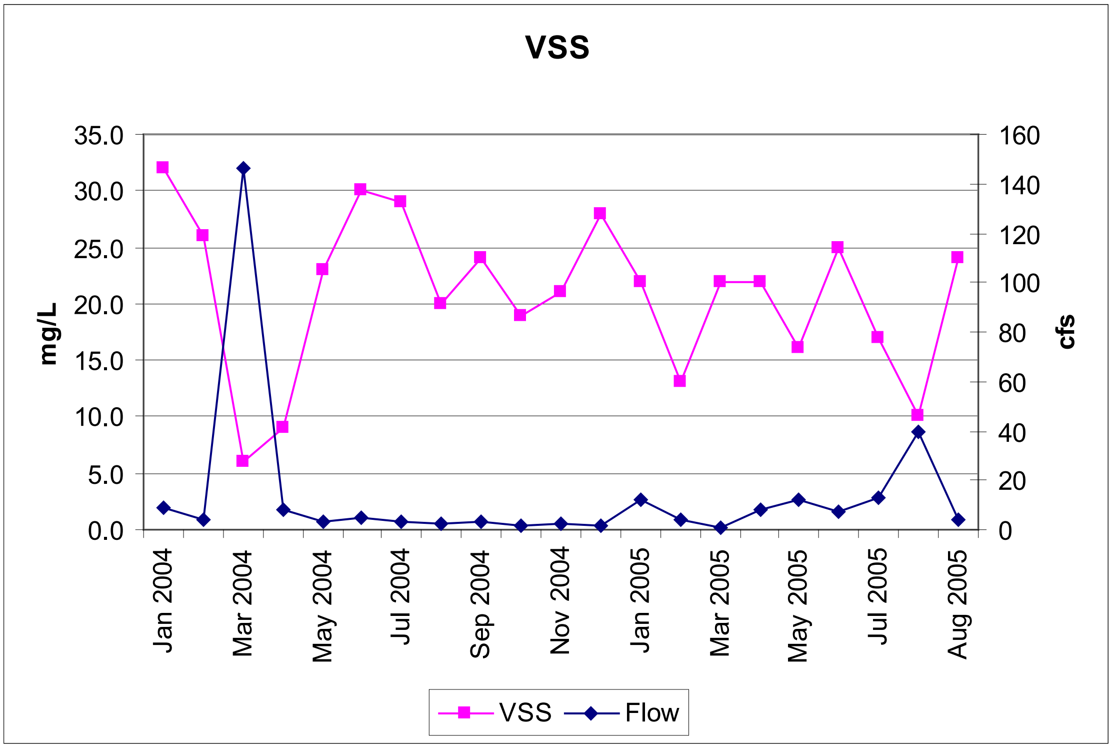

Figure 15. Volatile Suspended Solids (mg/L) and Flow (cfs) versus time (months)

The chart for Volatile Suspended Solids (VSS) values nearly perfectly mirrored TSS values indicating an inverse proportion with flow.

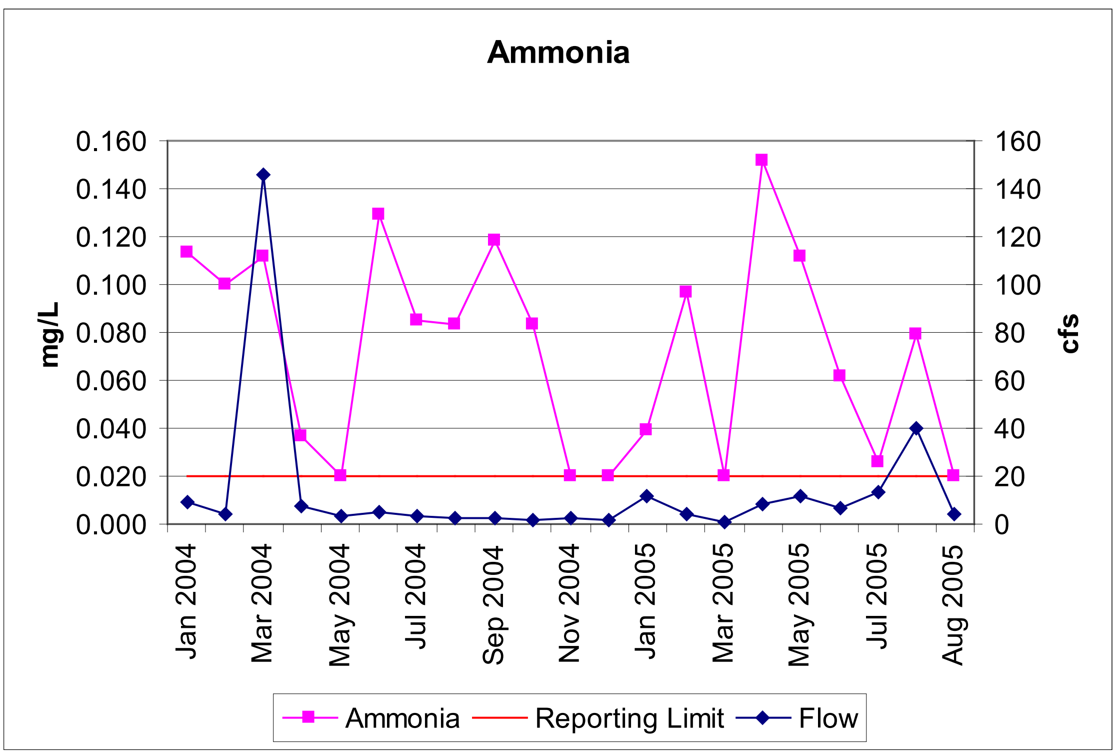

Figure 16. Ammonia (mg/L) and Flow (cfs) versus time (months)

Ammonia concentrations ranged from undetectable (<0.02 mg/L) to 0.152 mg/L. Highest values of Ammonia were recorded in April 2004.

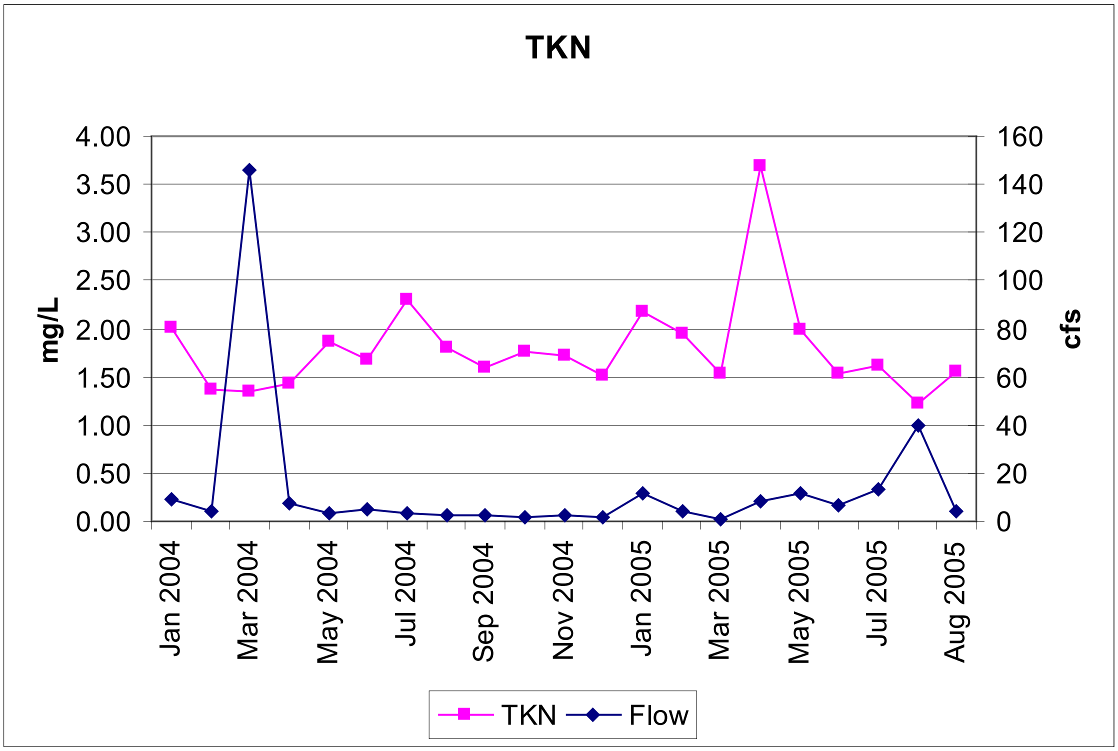

Figure 17. Total Kjeldahl Nitrogen (mg/L) and Flow (cfs) versus time (months)

TKN values ranged from 1.23 to 3.68mg/L.

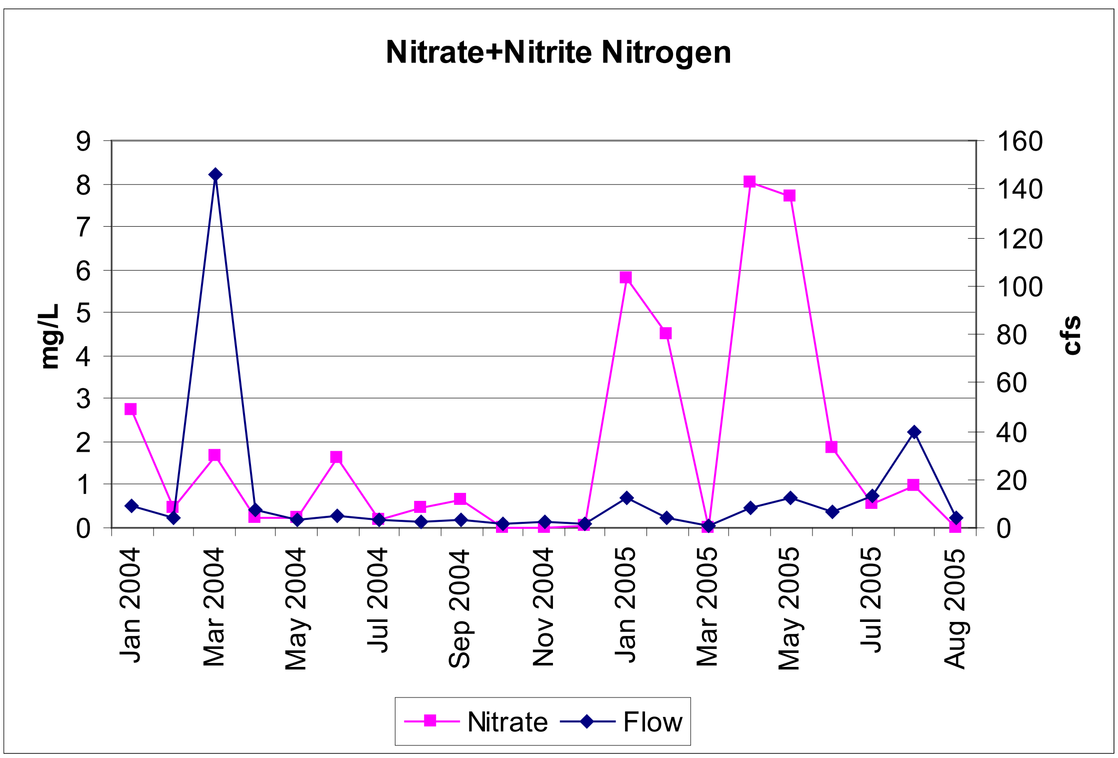

Figure 18. Nitrate+Nitrite Nitrogen (mg/L) and Flow (cfs) versus time (months)

Nitrate+Nitrite Nitrogen ranged from undetectable (< 0.02 mg/L) to 8.034mg/L. Highest values of Nitate+Nitrite Nitrogen were recorded in April 2004.

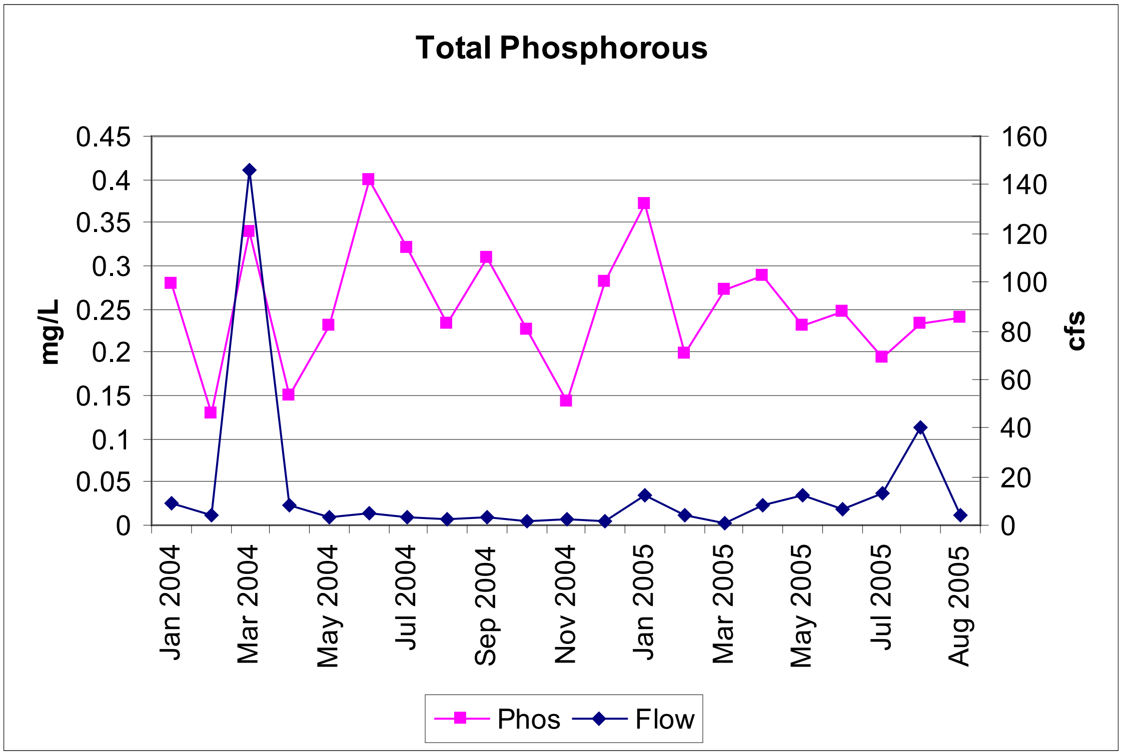

Figure 19. Total Phosphorus (mg/L) versus Flow (cfs) versus time (months)

Total Phosphorus ranged from 0.13 to 0.40 mg/L with no discernable relation to flow.

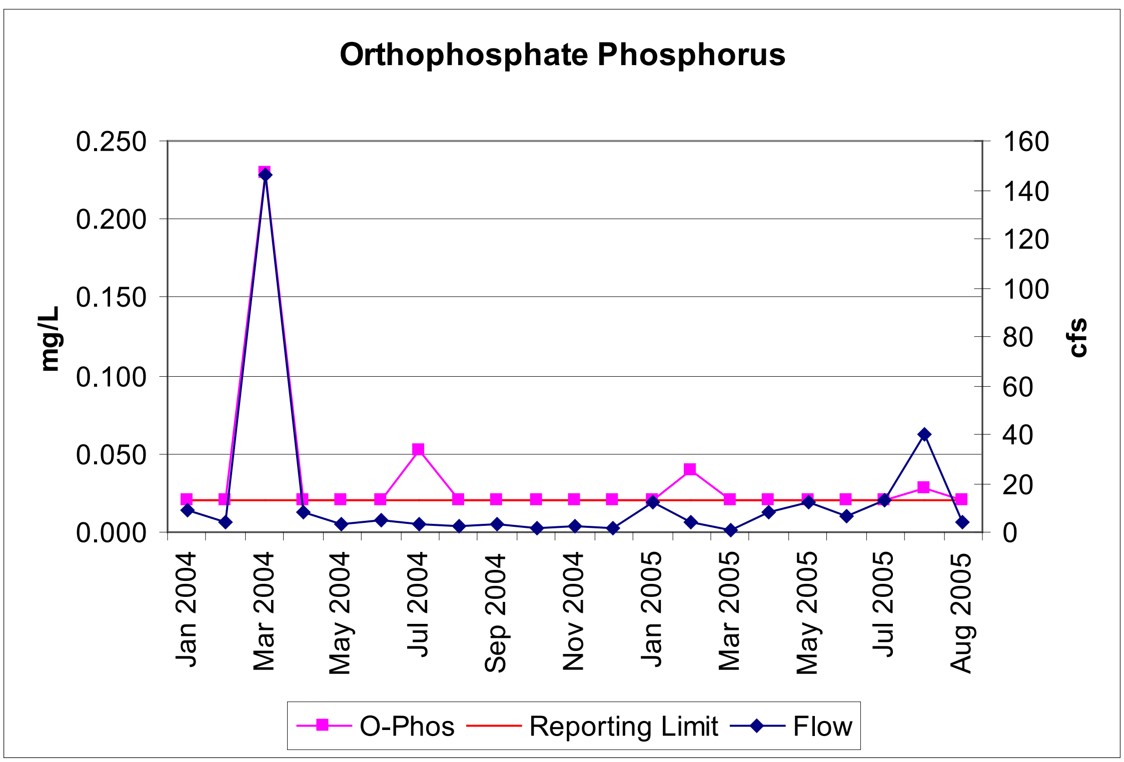

Figure 20. Orthophosphate Phosphorus (mg/L) and Flow (cfs) versus time (months)

Orthophosphate Phosphorus levels ranged from undetectable (<0.02 mg/L) for much of the study period to 0.229 mg/L during the March 2004 high flow event.

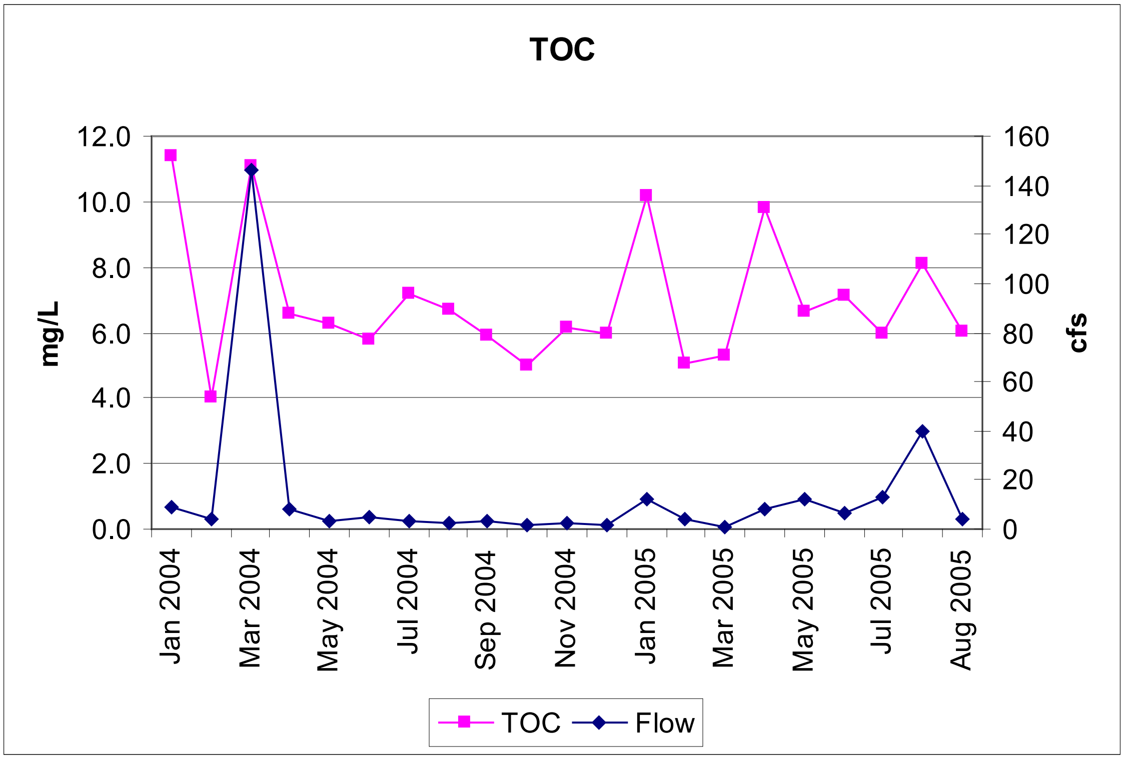

Figure 21. Total Organic Carbon (mg/L) and Flow (cfs) versus time (months)

Total Organic Carbon (TOC) ranged from 4.0 to 11.4 mg/L and generally seems to be flow dependent with the exception of the January 2004 data.

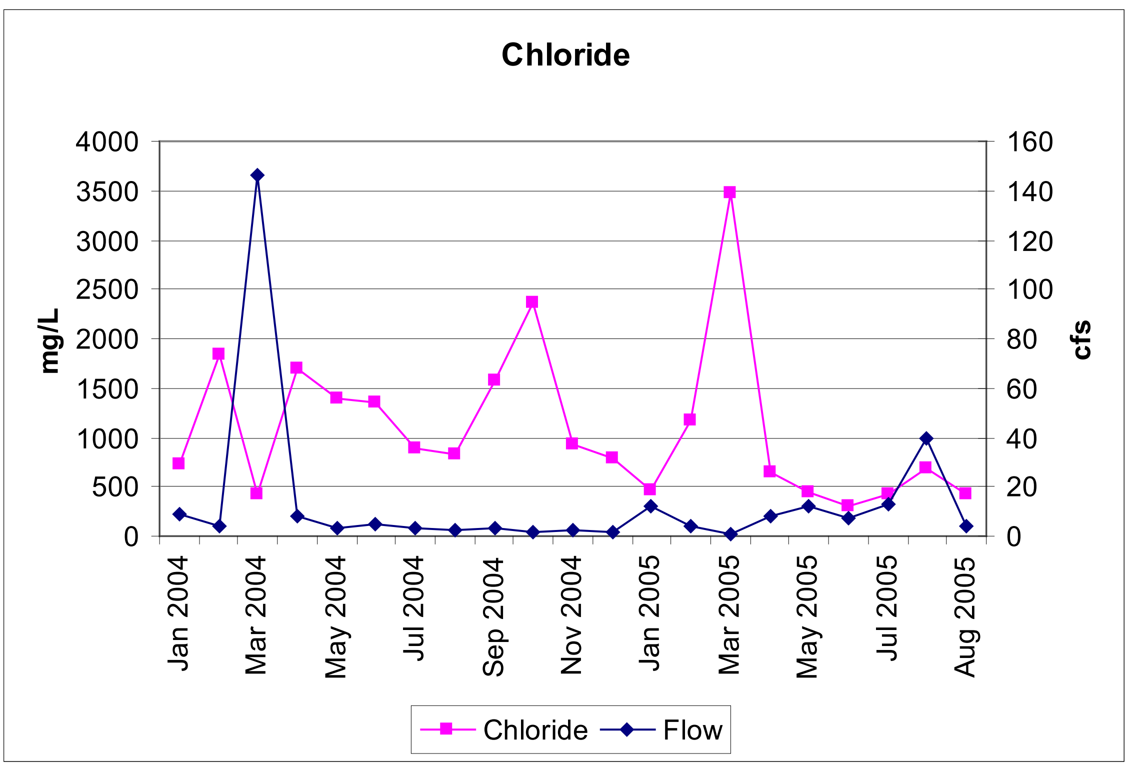

Figure 22. Chloride (mg/L) Flow (cfs) versus time (months)

Chloride values ranged from 301 to 3480 mg/L and appear inversely proportional to flow.

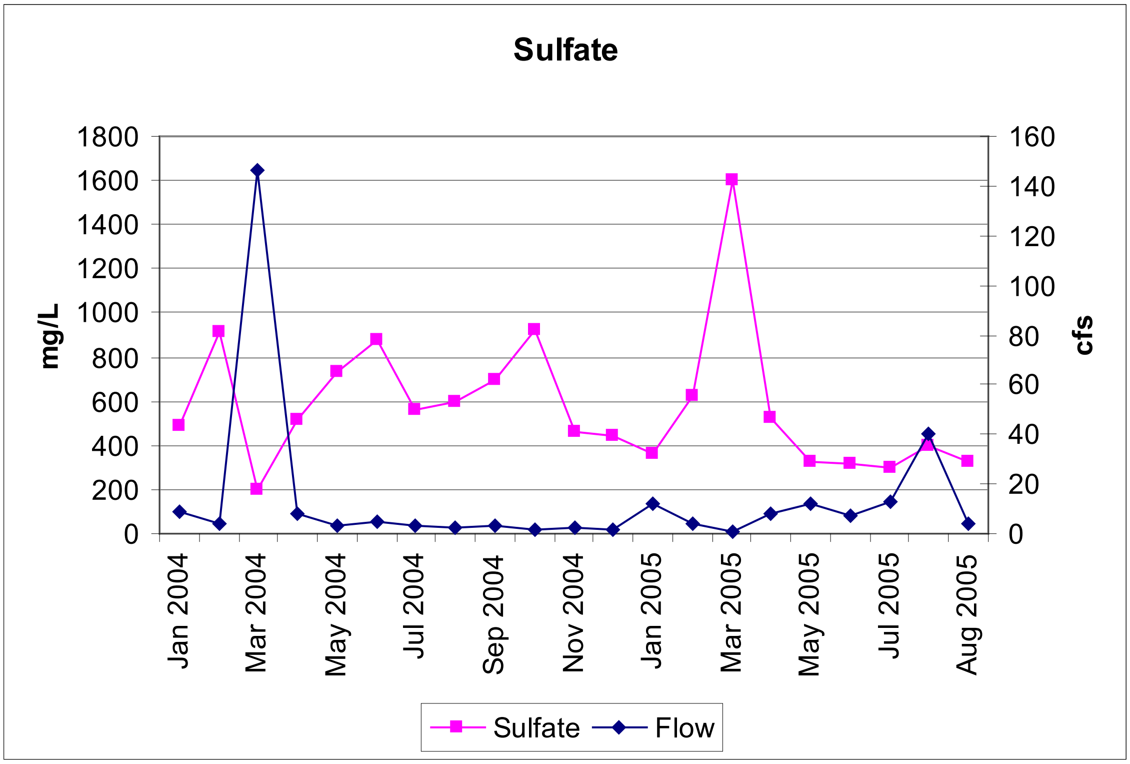

Figure 23. Sulfate (mg/L) and Flow (cfs) versus time (months)

Sulfate values ranged from 199 to 1600 mg/L and appear inversely proportional to flow.

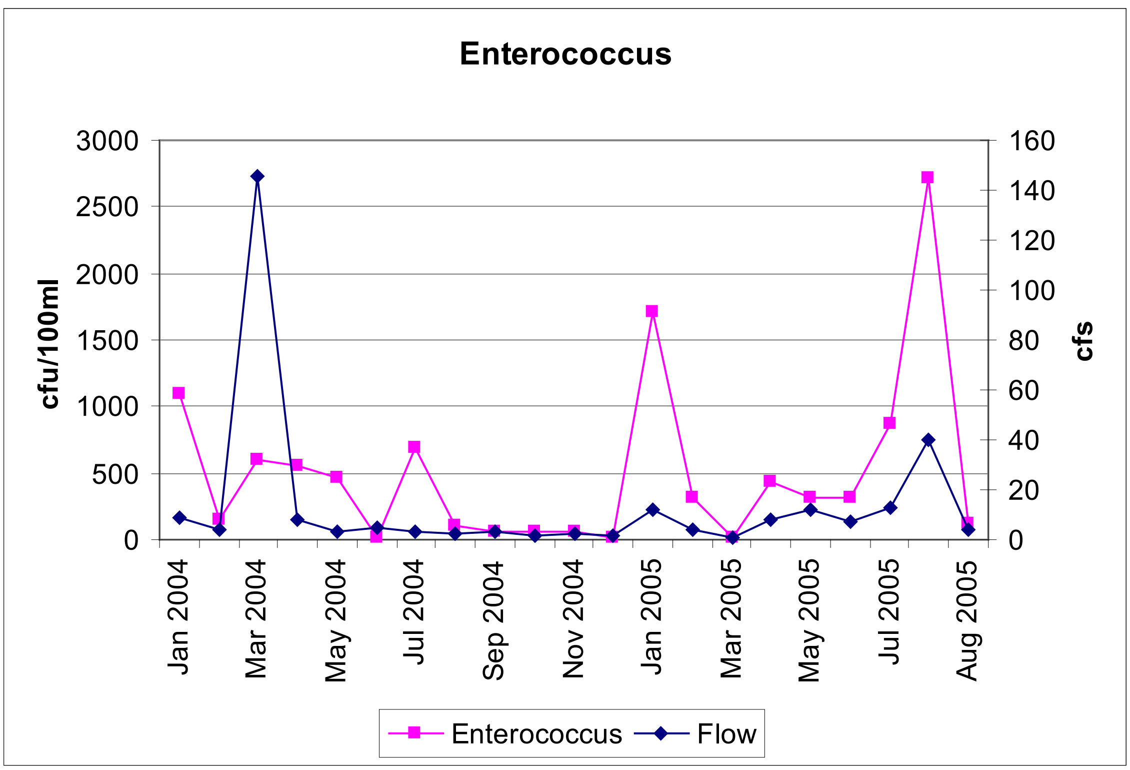

Figure 24. Enterococcus (colony forming units) and Flow in cfs versus time (months)

Enterococcus values ranges from 12 to 2710 colony forming units. Most abundant colony counts coincided with the high flow event in June 2005.

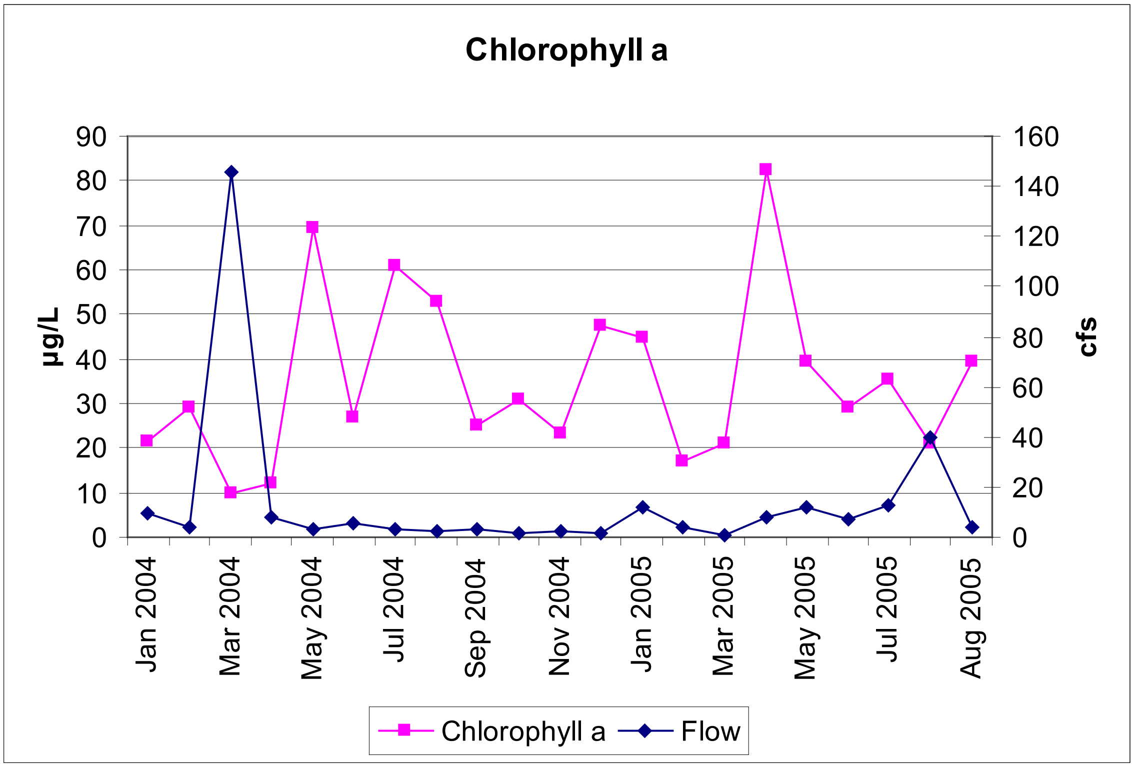

Figure 25. Chlorophyll-a (µg/L) and Flow (cfs) versus time (months)

Chlorophyll-a concentrations ranged from 9.8 to 82.3 µg/L. Concentrations above 30 µg/L indicate elevated concentrations.

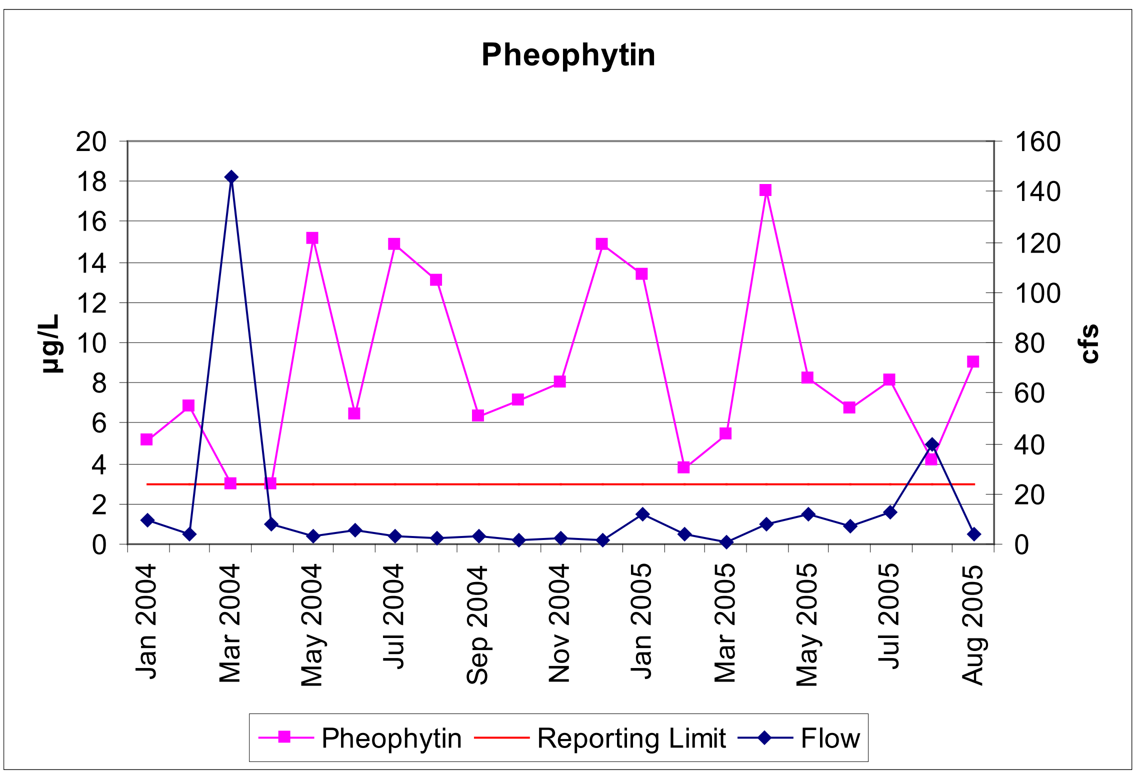

Figure 26. Pheophytin-a (µg/L) and Flow (cfs) versus time (months)

Pheophytin-a ranged from non detect (< 3 µg/L) to 17.5 µg/L indicating high concentration of degrading Chlorophyll-a compounds.

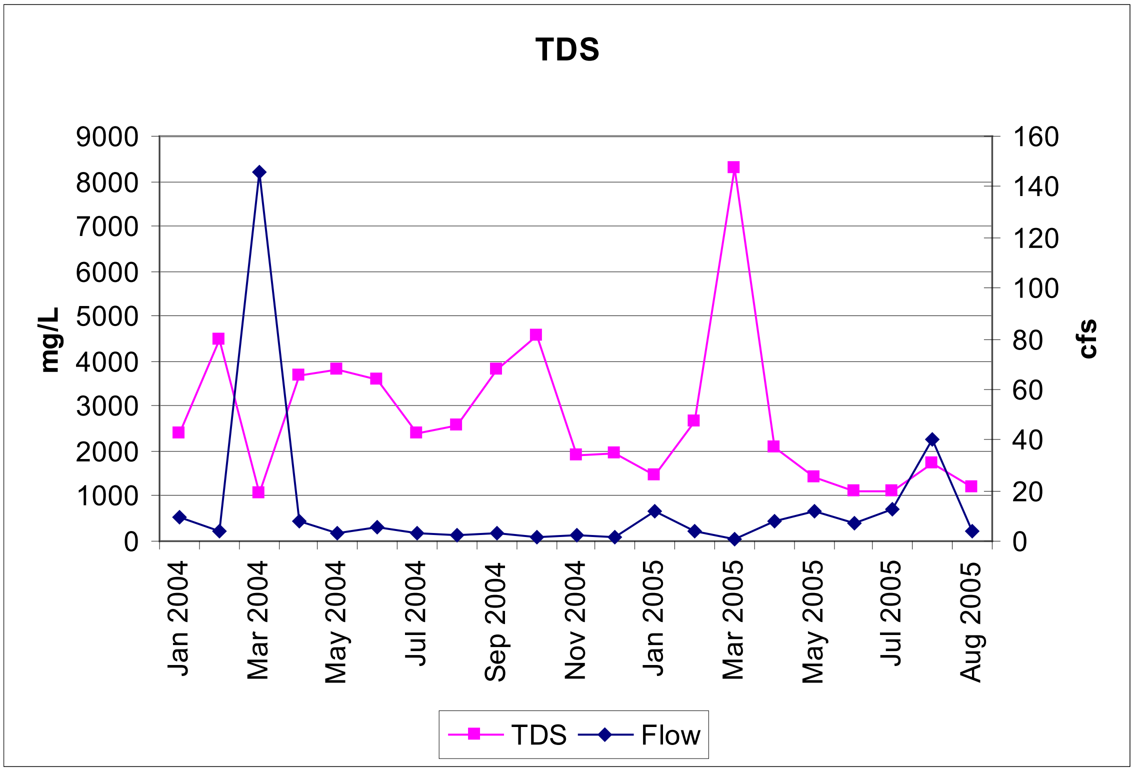

Figure 27. Total Dissolved Solids (mg/L) and Flow (cfs) versus time (months)

Total Dissolved Solids (TDS) ranged from 1070 to 8310 mg/L and inversely proportional to flow.

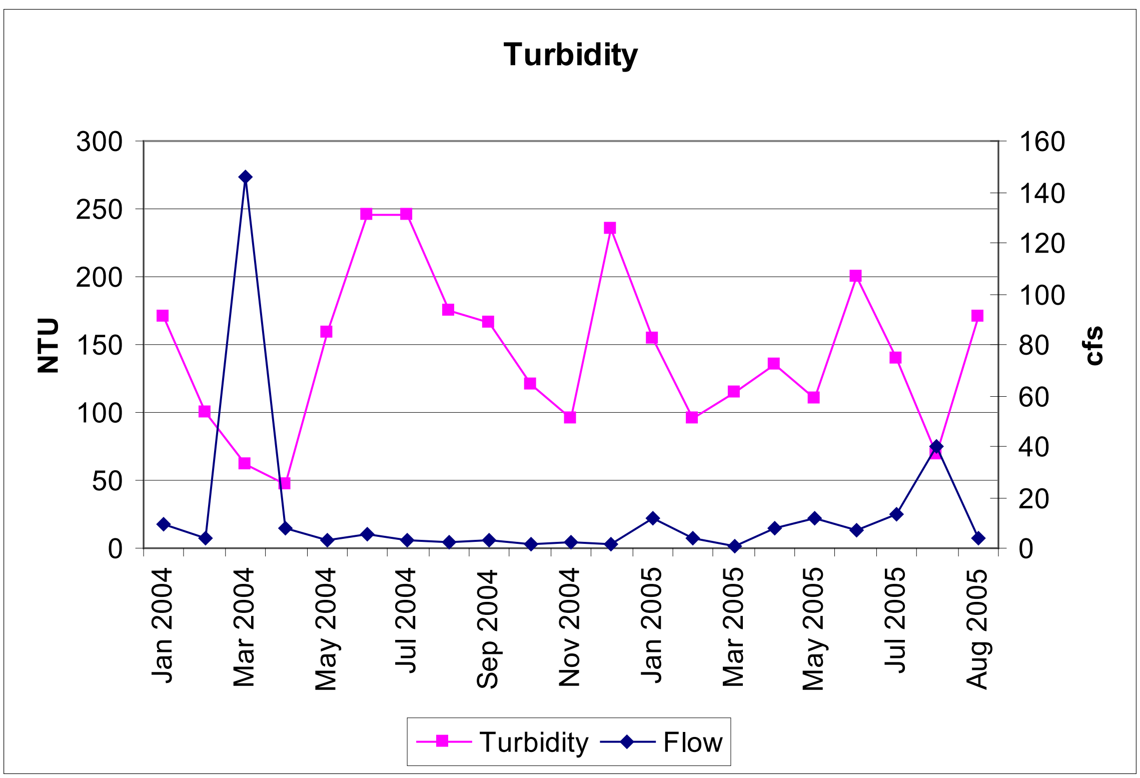

Figure 28. Turbidity (NTU) and Flow (cfs) versus time (months)

Turbidity ranged from 47.7 to 245 NTUs.

Discussion

For the Cameron County Special Study, much of the study period reflected low flow conditions. Severe to extreme drought conditions persisted across Deep South Texas with the region averaging between 3 to 9 inches (8 to 23 cm) below normal for the year (January 2005 through July 2005). The lowest flow measurement recorded was 0.6 cfs in March 2005. TDS, Sulfate, and Chloride measurements spiked during this time whereas Nitrate-nitrite nitrogen, TKN, Ammonia, Chlorophyll-a, and Pheophytin-a concentrations reflected depressed concentrations.

In April and May 2005, moderate flows measured in the drainage were associated with the workings of the Cameron County Irrigation District #2. Due to the lack of major precipitation events, irrigation waters were channeled through the drainage system for irrigation purposes. Nitrate-nitrite nitrogen, TKN, Ammonia, Chlorophyll-a, and Pheophytin-a all recorded maximum values of the study period during this time. Elevated concentrations of Chlorophyll-a and the degradation component Pheophytin-a were likely the result of elevated nitrogen concentrations during this time.

High flow events recorded during the study period occurred in March 2004 and July 2005 recording 146 cfs. Data gathered for the March event coincided with lowest concentrations of DO, Alkalinity, TSS, VSS, Sulfate, Chlorophyll-a and Pheophytin-a. pH data collected was the least basic of the study period and associated with the slightly acidic nature of rainwater. Orthophosphate phosphorus levels spiked during the March event. Enterecoccus colonies were reported as > 600 colony forming units. Although it was a high concentration, sampling occurred on the second day of the high flow event and the findings were simply reported at > 600 colony forming units. Laboratory staff were asked to report subsequent data to reflect a more accurate count.

The high flow event in July 2005 followed the landfall of Hurricane Emily just south of Brownsville and recorded 40 cfs in the drainage ditch. Precipitation associated with this storm was not conducive to large-scale flooding in the area and was, instead, dominated by periods of intermittent but widespread rainfall. Enterococcus colonies were the highest measured during the study period at 2710 colony forming units. Monitoring was conducted one day after landfall of Hurricane Emily. Evidence of standing water and flooded fields was minimal during this event.

Literature Cited

Texas Natural Resource Conservation Commission. 2003. Surface Water Quality Monitoring Procedures Manual. No. GI-252.

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