Town of Bluffton

May River Watershed Monitoring Program

File No. 05405

JUNE 2008

Prepared for:

TOWN OF BLUFFTON
POST OFFICE BOX 386
BLUFFTON, SC 29910

Prepared by:

BP BARBER
POST OFFICE BOX 1116
COLUMBIA, SOUTH CAROLINA 29202-1116

TABLE OF CONTENTS

List of Tables

Appendices

EXECUTIVE SUMMARY

In an effort to protect the May River, which has been designated by SCDHEC as an Outstanding Resource Water, the Town of Bluffton (Town) has implemented a monitoring program comprised of four main components: a Continuous Monitoring Program in the May River, a Stormwater Sampling Program, monitoring of runoff from the Palmetto Bluff development, and a Volunteer Monitoring Program.

The purpose of these monitoring programs is to obtain a comprehensive overview of the state of water quality in surface waters throughout the Town, particularly the quality of water in the May River and its drainage area. The fourfold program coupled with a new, more stringent stormwater ordinance, should provide the data and legal authority necessary to protect the quality of water in the May River.

The first component of this monitoring program is the Continuous Monitoring Program, which involves the deployment of three water quality sondes at three sites within the May River. These sondes monitor for a variety of water quality parameters, which are used as indicators of the overall state of water quality in the river. The ultimate goal of this monitoring effort was to establish baseline conditions in the May River, and analyze seasonal fluctuations and natural trends of various water quality parameters in the river. As future sampling programs are implemented, this data will provide a baseline with which data can be compared to determine if there are statistically significant variations of any of the parameters over time.

After a year-long deployment, the data has been analyzed, and a baseline of water quality in the May River has been established. In addition, the natural fluctuations of the conditions in the May River will allow for future monitoring results to be analyzed in context, and will allow for the discernment between natural fluctuations and statistically significant negative water quality changes that likely are the result of human activity and should be mitigated.

The purpose of the second component of the monitoring program, the Stormwater Sampling Program, is to monitor the ditches and tidal creeks to determine the potential pollutants from stormwater runoff that may ultimately enter the May River. Six sites were selected for sampling in stormwater ditches that flow into coves discharging to the May River. These six sites were chosen as a representative sample of various land uses. By identifying stormwater sampling sites that appear to contribute higher concentrations of pollutants to stormwater runoff, the Town will be provided with a basis to prioritize areas which they can move upstream for further sampling in order to ultimately determine the source or pollutants of concern.

The third component of this program is the monitoring of stormwater runoff at locations throughout the Palmetto Bluff development. This component has been undertaken due to the wide expanse of the May River shoreline occupied by Palmetto Bluff, and the potential for development to adversely impact the quality of stormwater runoff. There are two main goals of this sampling program: to determine the natural nutrient and fecal coliform levels present in stormwater runoff from this area by sampling at sites whose tributary areas are undeveloped, and to determine whether the development is increasing these natural loads by sampling at sites downstream of developed areas.

The fourth and final component of this comprehensive monitoring effort is the Volunteer Monitoring Program. This program was originally implemented in January of 2006 due to an overwhelming interest of the citizens of the Town to participate in the May River monitoring program. Volunteer data is useful as it illustrates general trends over time at each monitoring site. Due to the subjectivity of the monitoring process for many of the parameters, it is not appropriate to compare data from one site to another, nor to compare the volunteer data to any other data collected by the Town, such as that collected through the Continuous Monitoring Program. The program can, however, be used to identify overall trends at each individual site, and is a very useful program carried out by volunteers.

The following report discusses the results of the four components of the comprehensive May River Watershed Monitoring Program to date, and provides recommendations for the most effective continuation of the program.

INTRODUCTION

The Town of Bluffton (Town) is home to the May River, a tidally-influenced estuary that eventually empties into the Atlantic Ocean on the eastern coast of South Carolina. In 2001, the South Carolina Department of Health and Environmental Control (SCDHEC) designated the May River as an Outstanding Resource Water (ORW) due to its high level of water quality.

In an effort to maintain the high level of water quality of the May River, two water quality monitoring studies have been completed since 2002. A cooperative monitoring effort was undertaken in 2002-2003 primarily to establish baseline conditions of the May River. The results of this monitoring program were provided in a report to the Town in 2004 entitled *A Baseline Assessment of Environmental and Biological Conditions in the May River, Beaufort County, South Carolina* (Baseline Study). This monitoring program included continuous water quality monitoring, as well as an evaluation of the benthic community, nektonic community, sediment chemistry and toxicity for headwater tidal creeks.

The recommendations that stemmed from the May River Baseline Study, in addition to a strong desire among the citizens of Bluffton to protect the water quality of the May River, led to another water quality monitoring effort that began in 2005. The Town contracted with BP Barber and Hodgins Engineering and Consulting, LLC (HEC) to conduct a series of stormwater sampling events from July 2005-May 2006 at five sampling locations throughout the Town. The samples collected from these sites were analyzed for the following parameters: turbidity, ammonia, total Kjeldahl nitrogen (TKN), nitrate, nitrite, total phosphorus and fecal coliform.

In June of 2007, the Town passed a revised stormwater ordinance, which imposes, among other stipulations, strict monitoring requirements on operators of land disturbing activities. The use of Best Management Practices (BMPs) on construction sites and other land disturbing activities is also required to reduce the amount of sediment and pollutants that leave these sites, and ultimately enter the May River through the storm sewer system. The passing of this ordinance demonstrates the desire of the citizens of Bluffton to protect water quality, and is also a significant step toward minimizing contaminants from entering stormwater runoff, and ultimately the May River. The ordinance also includes language which provides the authority for an IDDE program, and the Town has a comprehensive map identifying all of the stormwater outfalls within the Town.

In an effort to continue building on the water quality data collected during the Baseline Study and the Stormwater Sampling Study, the Town purchased three YSI continuous monitoring sondes in 2006. The ultimate goal of this monitoring effort was to establish baseline conditions over a one-year period in the May River, and analyze seasonal fluctuations and natural trends of various water quality parameters in the river. As future sampling programs are implemented, this data will provide a baseline with which data can be compared to determine if there are statistically significant variations of any of the parameters over time.

The initial deployment of the sondes was in April 2007 at three locations within the May River: in the upper zone of the river near the community of Rose Dhu, in the middle zone of the river near Verdier Cove, and in the lower zone of the river near All Joy. The sondes analyze the water for specific water quality parameters every 15 minutes and record the data internally.

In addition to establishing a formal Continuous Monitoring Program in the May River, the Town continued the Stormwater Sampling Program carried out from 2005-2006. The original goal of the current Stormwater Sampling Program was to collect one sample per quarter at each site. The samples were collected in accordance with EPA's NPDES Storm Water Sampling Guidance Document, which states that samples should only be collected during an event resulting in 0.1 inches or more of rainfall, and the event must occur at least 72 hours from the previous event of 0.1 inches or greater.

The third component of this comprehensive monitoring program involves sampling stormwater runoff at locations throughout Palmetto Bluff. Palmetto Bluff is a private development located along the southern edge of the May River. This sampling effort has been undertaken due to the wide expanse of the May River shoreline occupied by Palmetto Bluff, and the recognition of the potential for development to adversely impact the quality of stormwater runoff, and subsequently receiving water bodies.

The fourth and final component of this comprehensive monitoring effort is the Volunteer Monitoring Program. This program was originally implemented in January of 2006 due to an overwhelming interest of the citizens of the Town to participate in the May River monitoring program. Volunteer data is useful as it illustrates general trends over time at each monitoring site. The program can be used to look at overall trends at each individual site, and is a very important component of the overall monitoring program.

MAY RIVER CONTINUOUS MONITORING PROGRAM

2.1 Background

The May River is an integral and highly-regarded component of the Town of Bluffton (Town). Residents value the river not only for its rich aesthetic value and for the beautiful wildlife for which it provides a home, but also for its recreational and economic value. In addition to boating, fishing and swimming, the May River is also utilized for oystering, crabbing, and other business ventures. The value placed on the May River by residents of Bluffton, as well as their intense desire to maintain the high level of water quality in the river, has led to various water monitoring programs.

As discussed in the *Introduction,* a cooperative monitoring effort was undertaken in 2002-2003 primarily to establish baseline conditions of the May River for particular parameters. The results of this monitoring program were provided in a report to the Town in 2004 entitled *A Baseline Assessment of Environmental and Biological Conditions in the May River, Beaufort County, South Carolina* (Baseline Study). Until this study, little quantitative water quality data existed for the May River. The entities commissioned by the Town to conduct the Baseline Study included the Marine Resources Research Institute of the South Carolina Department of Natural Resources (SCDNR), the United States Geological Survey (USGS) South Carolina District, and the National Oceanic and Atmospheric Administration's Center for Coastal Environmental Health and Biomolecular Research (NOAA-CCEHBR).

For the purpose of obtaining water quality data with respect to its relationship with the changing tide and meteorological conditions, USGS established three continuous monitoring stations within the May River. These stations monitored water quality and quantity parameters, including dissolved oxygen (DO), temperature, conductivity, water level and flow. A data set for each of these parameters was provided for comparison with the current continuous monitoring study, but this comparison includes both the incoming and outgoing tide data. In order to understand the land use impacts on water quality in the May River it is necessary to filter the data to include only the outgoing tide. Because the continuous data from the USGS monitoring stations is not filtered in this way, it is not possible to accurately compare the outgoing-tide-only data from the current Continuous Monitoring Program to the continuous data of the Baseline Study. A comparison was made instead with the seasonal grab sample results, discussed below. A comparison of continuous data to grab sample results is not ideal, but is necessary due to the lack of continuous data for outgoing tide with which to compare the current continuous monitoring data.

In addition to the three continuous monitoring stations, the Baseline Study also collected seasonal grab samples from tidal creeks and open water sites. The grab samples were analyzed for temperature, salinity, dissolved oxygen, pH and turbidity. The means of the parameters found in the seasonal grab samples collected at the open water sites located closest to each current sonde site were used for comparison with the current Continuous Monitoring Program. These means were estimated from bar graphs provided in the Baseline Study. It is important to note that, although the means provided in the Baseline Study provide a basis for a general comparison with the current Continuous Monitoring Program, the Baseline Study collected samples much less frequently than the Continuous Monitoring Program. This difference in sampling techniques makes only general comparisons of the data possible; no definitive conclusions can be drawn from the comparison of means of the current Program and the Baseline Study. While comparison of seasonal grab sample data against continuous monitoring is not ideal, it is the best data available to the town during this study. As the second year of continuous data is collected, the data from the current year of the Continuous Monitoring Program will provide the basis for comparison.

Summer semi-continuous data was also collected at open water sites. It would not be appropriate, however, to compare this data to the results of the current Continuous Monitoring Program, as the semi-continuous data of the Baseline Study was only collected for one 25-hour period at each site during the summer season and does not represent seasonal variations.

The recommendations of the Baseline Study provided the basis for the Continuous Monitoring Program that was implemented in April 2007. Recommendations related to the Continuous Monitoring Program are provided below:

- "Continuous monitoring of the May River provides a dynamic record of how the estuary is responding to changing hydrologic conditions. The Town of Bluffton should consult with the USGS regarding the value of continuing operation of one or more of the existing gauges and what parameters would be more useful to monitor."

- "The water quality parameters that appear to be the most important for consideration in monitoring based on the results of this study and other studies include DO, salinity, turbidity, chlorophyll-*a* (with HAB typing if problems occur), pH, nutrients, fecal coliforms (with typing if problems occur), and potentially total organic carbon and/or dissolved organic carbon."

The Baseline Study also noted that, in order "…to understand how parameters behave over time, it is necessary to analyze changes on various time scales such as hourly, daily, and seasonally." Based on the recommendations and conclusions from the Baseline Study, and after assessing the resources available to the Town, the Continuous Monitoring Program was implemented in order to continue the proactive assessment of water quality in the May River. Although the Town was limited in the number of parameters they were able to monitor for during this program, the majority of the recommended parameters were included.

In addition to evaluating the Baseline Study during the development of the current Continuous Monitoring Program, the *Beaufort County Stormwater Management Plan* (Plan) submitted on May 27, 2005 was also consulted to gain another perspective on the most effective route to take for future monitoring. This Plan recommended the implementation of a water quality monitoring program for Beaufort County, which would work toward achieving the following primary goals:

- "Establish baseline water quality via ambient sampling"
- "Identify seasonal trends and overall trends over time using long-term ambient sampling data"

The current Continuous Monitoring Program was developed following the recommendations from both the Baseline Study and the Plan, and utilizing the resources available to the Town in the most efficient manner possible. The intent of this program was to collect continuous data from the May River for a one-year period, in order to establish seasonal and overall trends of water quality parameters in the May River. This one-year monitoring period concluded in April 2008, and has provided a baseline of conditions in the May River as well as seasonal fluctuations with which future monitoring results can be compared.

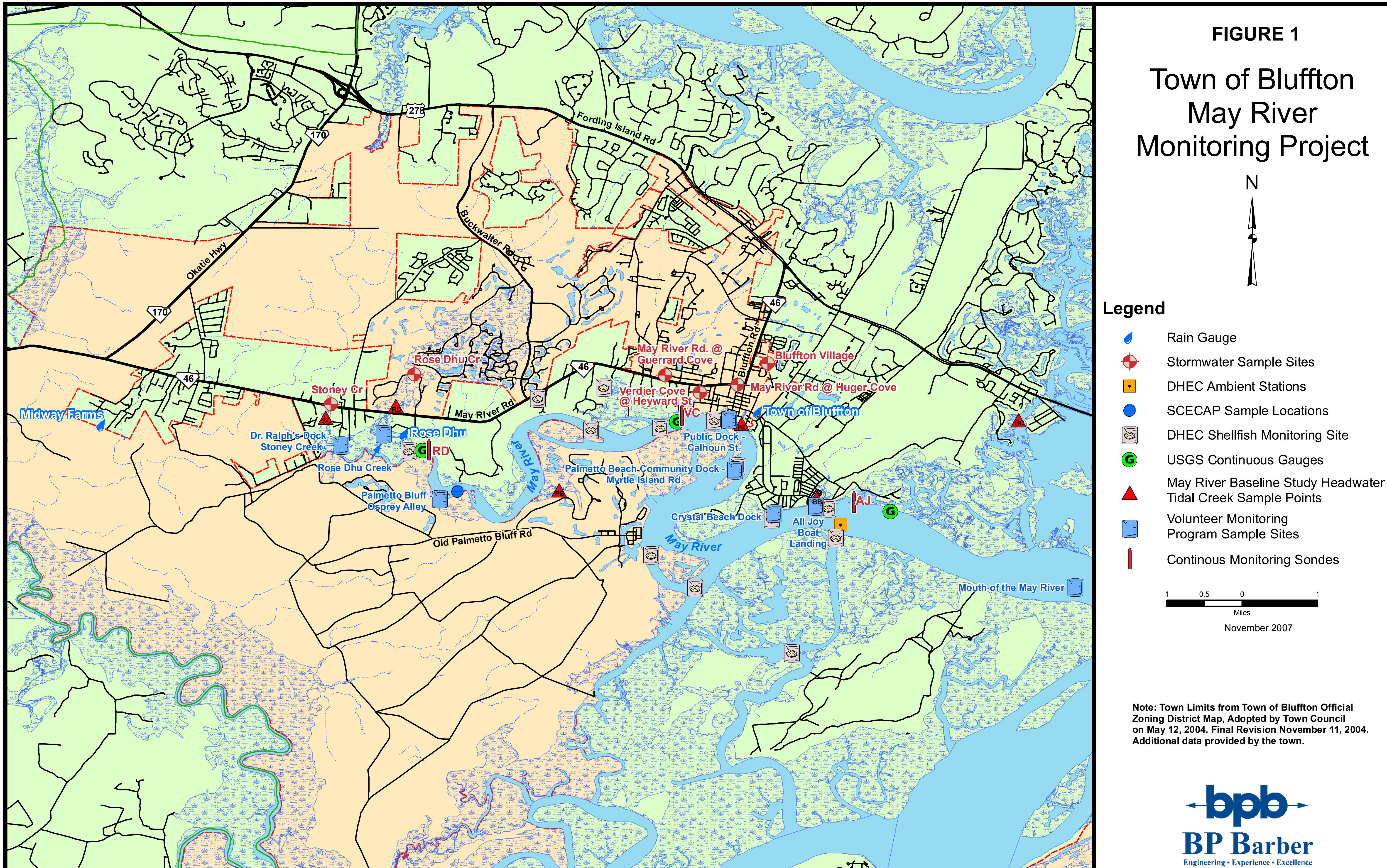
2.2 Continuous Monitoring Program Overview

As discussed in the *Introduction*, the Town purchased three continuous water quality monitoring sondes in 2006. Two of the sondes are YSI Model 6600 EDS with dissolved oxygen, conductivity, pH, turbidity, chlorophyll-*a*, temperature and vented depth sensors, and the third sonde is YSI Model 6920 with dissolved oxygen, conductivity, pH, turbidity, temperature and non-vented depth sensors.

The initial deployment of the sondes was in April 2007 at three locations within the May River: in the upper zone of the river near the community of Rose Dhu, in the middle zone of the river near Verdier Cove, and in the lower zone of the river near All Joy. The sondes were first collected for cleaning, calibration and maintenance on June 12, 2007. Following the June 12 cleaning, the sondes were initially collected, cleaned and calibrated approximately every two weeks. Due to severe fouling issues, the sonde cleaning frequency was increased to once weekly at the beginning of September; calibration was still only carried out once every two weeks. As colder temperatures arrived in late fall and early winter, it was possible for the cleaning frequency to return to once every two weeks. Figure 1 on the next page illustrates the

FIGURE 1

Town of Bluffton May River Monitoring Project



Note: Town Limits from Town of Bluffton Official Zoning District Map, Adopted by Town Council on May 12, 2004. Final Revision November 11, 2004. Additional data provided by the town.

BP Barber

Engineering • Experience • Excellence

approximate locations of all three sonde sites, as well as the six stormwater sampling sites, and eight volunteer monitoring sites.

Hodgins Engineering Consulting, LLC (HEC) processed the raw data from each deployment, overlaid precipitation data, and filtered the data so that only the outgoing tide was included in the analysis by BP Barber. There are no Federal or State standards for many of the parameters monitored for during this program; therefore, results were compared against a variety of sources to provide a general understanding of the state of the May River with respect to other estuarine environments in the southeastern United States. South Carolina Regulation 61-68 for Shellfish Harvesting Waters provides some numerical standards for a few of the parameters which were included in this monitoring program; the results of the current monitoring program were compared to these standards where applicable. Additional resources used for comparison purposes included a technical report published in 2004 by the South Carolina Estuarine and Coastal Assessment Program (SCECAP), as well as the Baseline Study completed in 2004.

A trend line has been added to all plots of the sonde data in order to demonstrate the trends and seasonal fluctuations which are naturally-occurring in the May River. Also, Table 1 below contains the approximate accuracy of each probe, as provided by the YSI User Manual. This data is provided to illustrate the level of accuracy that can be expected from the sonde data.

Table 1 - Sensor Specifications

Sensor	Accuracy
DO (%sat)	+/- 2% of the reading or 2% of air sat, whichever is greater
DO (mg/L)	+/- 2% of the reading or 0.2 mg/L, whichever is greater
pH	+/- 0.2 units
Turbidity	+/- 2% of the reading or 0.3 NTU, whichever is greater
Chlorophyll	No specification provided

2.3 Summary of Sonde Malfunctions and Probe Replacements

As with any type of technical equipment, there have been some issues with temporary sonde malfunctions during the past year. In addition, a few of the probes required replacing as they reached the end of their respective service lives. These issues have led to gaps in the data at each site. The trend lines that have been added to each graph demonstrate that the gaps have not been detrimental to the overall goal of the Continuous Monitoring Program of establishing seasonal fluctuations and trends. A summary of the sonde malfunctions, probe replacement and other issues that have led to data gaps is provided in the subsections that follow, arranged by site.

2.3.1 All Joy

The All Joy sonde was collected on September 26 and sent in to be evaluated by a YSI technician due to erratic chlorophyll-*a* and turbidity readings. The technician determined that the turbidity probe had flooded, which had subsequently caused malfunctions with the chlorophyll-*a* probe and the rest of the sonde. The turbidity probe was replaced, and the sonde was returned to the Town and redeployed on November 15, 2007. Although data was collected during the period September 5 through September 19, the accuracy of this data cannot be verified due to the fact that the sonde began having problems at some point during this period. In order to avoid potentially including faulty data in the analysis of water quality at this site, the data from September 5 through September 19 was not considered for the purpose of analysis. In addition, the All Joy sonde was with YSI Technical Support staff from September 19 through November 14, so there is no data from this time period to evaluate.

Another issue with the All Joy sonde was a sudden shift in dissolved oxygen (DO) concentrations that occurred on July 25. It was determined that the most likely cause of this shift was that a faulty or damaged membrane was placed on the DO probe during the calibration/cleaning process that took place on this date. Due to fact that the data from July 25 through September 19 does not follow the typical DO trend that has been established at the All Joy site, and the fact that there were no drastic changes in water temperature to have potentially been the cause of the shift, this data was removed for the purpose of analysis.

The conductivity probe at the All Joy site was reported in the second progress report to be having difficulty maintaining its calibration throughout many of the deployments. The issues with the conductivity probe were evident in many of the post-calibration conductivity levels, as well as in some of the calibration Conductivity Cell Constants which were out of range. For the purposes of this report, the conductivity data and thus the salinity data recorded from July 12 through September 19 is considered invalid and not representative of conditions at the All Joy site.

A YSI/AMJ sales representative was consulted regarding the drift in the conductivity readings at the All Joy site, and advised that sometimes it is necessary to clean this particular probe with a cleanser and wire brush rather than using only water. Since the sonde was received from YSI Technical Support and redeployed on November 14, the conductivity probe has been thoroughly cleaned according to the instructions provided by YSI each time it has been collected for calibration and cleaning. This appears to have corrected the drift problem with the All Joy sonde, leading to more consistent conductivity readings.

The All Joy sonde experienced some pH probe problems in the fourth quarter of monitoring. The probe began malfunctioning on January 16 and was removed from the sonde on January 30. It was determined that the probe had reached the end of its service life and a replacement was ordered. The replacement probe was received from YSI and installed on February 4. There was also an exclusion of pH data for the deployment from March 26 to April 10 due to readings that were unusually high during the deployment. A review of the pre-calibration and post-calibration records showed that the slopes for the probe were out of range during pre-calibration and that the readings had drifted by 5% during post calibration. The reason for these problems is unknown; however, the probe was recalibrated and functioned normally for the subsequent deployments.

The data gap from March 11 to March 27 is due to the All Joy sonde being deployed at Verdier Cove. The Verdier Cove sonde was malfunctioning during this time and the All Joy sonde was deployed at Verdier Cove.

2.3.2 Verdier Cove

No issue with the Verdier Cove sonde has caused a data gap for all parameters at the same time. Significant issues were encountered with the pH probe on the Verdier Cove sonde during this year-long monitoring program. It began returning very sporadic data, as well as having difficulty during the calibration process, around June 27. It was determined that the probe would need to be replaced, and one was ordered and installed on September 19. Upon consulting a YSI/AMJ sales representative, BP Barber was informed that the pH probes generally have the shortest service life of all the probes, typically lasting approximately one year before replacement is necessary. Because the pH probe had reached the end of its service life, the data from June 27 through September 19 was not evaluated. Due to the fact that the probe began malfunctioning after just two deployments of the Verdier Cove sonde, it was not immediately evident from either the calibration data or from looking at a graph of the data that the probe was malfunctioning; there was not sufficient baseline data to demonstrate that the readings were out of the ordinary.

When it was determined that the pH probe required replacing and a new probe was ordered, the replacement pH probe was slightly different than the initial probe, with a glass bulb that protruded from the tip of the probe. When the sonde was collected on October 24 after its second deployment with the new pH probe, it was discovered that the bulb had broken while in the May River. A replacement probe without the glass bulb was requested. While awaiting the new pH probe, the Verdier Cove sonde was redeployed with the pH probe with the broken bulb in order to protect the probe port from moisture.

The replacement pH probe still had not arrived when the sondes were collected on November 5, so the broken pH probe was replaced with the old pH probe for the subsequent deployment, again to protect the probe port. The new pH probe had arrived by the time the sondes were collected on November 14, and was replaced on the Verdier Cove sonde at that time. Communication problems between the probes and the sonde bulkhead were experienced during the calibration process that took place on November 14, and YSI technical support recommended returning the sonde to YSI to be evaluated. The Verdier Cove sonde was repaired and returned to the Town on January 24, and an unscheduled trip was made by BP Barber technicians to redeploy the repaired sonde.

After the installation of a new pH probe on January 24, the pH readings were accurate and stable; however, the slopes continued to be out of range during pre-calibration. When the sonde was pulled from the water on March 11 the pH readings were no longer accurate. After speaking with YSI Technical support, it was determined that the malfunction was caused by a problem within the sonde bulkhead and that the sonde needed to be sent to YSI Technical support. Initially it was decided that the sonde should be shipped immediately and therefore the All Joy sonde was deployed at Verdier Cove from March 11 to March 17. By March 17 the town had decided to wait until after the year-long study concluded in April to send the Verdier Cove sonde to YSI Technical support. The sonde was redeployed to Verdier Cove on March 17, but the pH data gathered from then until April 23 was deemed invalid.

There has also been a gap in the data collected at the Verdier Cove site that was not related to probe and/or sonde malfunction. This gap occurred from July 2 through July 12, and is attributed to the sonde memory reaching its capacity midway through this deployment.

In addition to the general problems with the sonde at Verdier Cove, and the problems with the pH probe, there were also some turbidity readings that were disregarded for the purpose of data analysis. This turbidity data was collected during the period from August 31 through September 19, and was omitted because the majority of the readings were unreasonably high, indicating an apparent parking problem of the probe wiper due to fouling of the sonde. Once it was determined that fouling at the Verdier Cove sonde site was causing the return of unreliable turbidity data, the sonde was repainted with anti-foul paint. This appears to have limited the amount of fouling and subsequently the parking problems of the turbidity probe, resulting in more consistent, reliable turbidity data.

As of May 20, the Verdier Cove sonde had been received by YSI Technical Support in order to resolve the internal bulkhead problems which are causing inaccurate pH readings.

2.3.3 Rose Dhu

Until the third quarter, there were only minor technical problems encountered with the Rose Dhu sonde. There are three brief data gaps at this site from September 14 through September 19, December 13 through December 19, and December 29 through January 3. The first gap began on September 14 at 5:16 p.m. and ended on September 19 at 6:01 p.m. The raw data and the calibration information were reevaluated, and the only potential cause of the gap that can be found is that the batteries expired prior to the collection of the sondes on September 19. This could not have been foreseen, as the battery life recorded during the August 22 calibration indicated that the sonde would have more than sufficient power for the subsequent deployment, and the sondes were not calibrated on September 5 when they were collected due to a lack of calibration standards.

The second data gap that occurred at the Rose Dhu site was from December 13 at 5:31 a.m. until December 19 at 12:31 p.m. This gap was caused by a lack of sufficient free memory space to hold all of the data through the end of the deployment beginning on November 28. There were 15 free memory days remaining on this date, but the next sonde collection had to be rescheduled for a later date, which led to the free memory running out prior to collection.

Another data gap occurred from December 29 at 7:46 a.m. until January 3 at 6:16 p.m. This again likely occurred due to the batteries expiring prior to the collection of the sondes. The batteries should not have expired; however, as the calibration process on December 19 indicated that there was at least 10.4 V of battery life remaining, which is above the recommended minimum voltage of 10 V that triggers replacement of the batteries. The procedure is being reevaluated to determine whether the batteries should be replaced more frequently, by increasing the trigger to 11V.

During the third quarter there were two issues with the pH probe at Rose Dhu. The first issue was a dataset from the deployment occurring from November 14 through November 28. Although the cause is uncertain at this point, the pH data from this entire deployment is significantly higher than the data collected during the deployments occurring both before and after it. This data also does not appear to follow the overall trend of pH established at this site. Because of these reasons, this data is considered invalid and was not included in the analysis.

The second issue with the pH probe is that it reached the end of its service life during the third quarter. A new pH probe was ordered from YSI in early February. The probe was received on March 5, and the sonde was redeployed with the new probe on March 11.

During the fourth quarter there were two data gaps at the Rose Dhu site both of which are attributable to batteries being depleted prior to the end of deployment. During the deployment from February 14 to February 27, the batteries died on February 23 causing a 4 day data gap. During the deployment lasting from March 26 to April 10, the batteries died hours after the sonde was deployed. Neither of these gaps could have been prevented, since, in both cases, the sonde indicated that battery voltage was adequate. A YSI sales representative was contacted regarding the problem. He recommended cleaning and drying the battery tubes as well as checking the turbidity port for water (water in this port can cause a power drain leading to decreased battery life). During post-calibration on April 23, water was found in the turbidity port. The port was dried and cleaned and the turbidity probe was fitted with a new o-ring. It is hoped that these improvements resolved the problem.

2.3.4 Summary of Sonde Issues

Table 2 on the next page provides a condensed summary of data gaps and exclusions, and their corresponding causes. This table is provided in order to aid in the clarification of which data was analyzed at each sonde site. If a parameter is not listed under a particular site, this indicates that there were no issues with that particular probe during the first year of the Continuous Monitoring Program.

Table 2 – Summary of Data Exclusion/Gaps

Summary of Data Excluded		
All Joy		
Parameter	*Dates of Data Excluded for Analysis/Dates of Data Gaps*	*Reason for Exclusion/Data Gap*
Entire Sonde	9/5/2007-9/19/2007	Data potentially invalid due to flooding of turbidity probe
	9/19/2007-11/14/2007	Sonde at YSI Technical Support
	3/11/2008-3/17/2008	All Joy sonde deployed at Verdier Cove site
DO	7/25/2007-9/19/2007	Suspected faulty/damaged membrane
Salinity	7/12/2007-9/19/2007	Conductivity probe was not maintaining its calibration well during this period
pH	1/30/2008-2/4/2008	pH probe malfunction
	3/26/2008-4/10/2008	pH probe malfunction
Verdier Cove		
Parameter	*Dates of Data Excluded for Analysis/Dates of Data Gaps*	*Reason for Exclusion/Data Gap*
Entire Sonde	7/2/2007-7/12/2007	Lack of memory space
	11/14/2007-1/24/2008	Sonde at YSI Technical Support
pH	7/12/2007-9/19/2007	Data invalid because pH probe had reached the end of its service life
	10/24/2007-11/14/2007	The bulb on the new pH probe was broken - awaiting new probe
	3/17/2008-4/23/2008	pH probe malfunction
Turbidity	8/31/2007-9/19/2007	Data omitted due to apparent parking problem

Table 2 – Summary of Data Exclusion/Gaps (Continued)

Rose Dhu		
Parameter	*Dates of Data Excluded for Analysis/Dates of Data Gaps*	*Reason for Exclusion/Data Gap*
Entire Sonde	9/14/2007-9/19/2007	Battery life expired
	12/13/2007-12/19/2007	Lack of memory space
	12/29/2007-1/3/2008	Battery life expired
	2/23/2008-2/27/2008	Battery life expired
	3/26/2008-4/10/2008	Battery life expired
pH	11/14/2007-11/28/2007	Cause unclear, data significantly outside of typical trends
	2/14/2008-3/11/2008	pH probe reached end of service life

2.4 Monitoring Results for Outgoing Tide

The monitoring results for each of the sonde sites are broken down by parameter in the sections below. In addition, the data used for comparison purposes is provided, and the implications of the data from the May River are discussed. All of the data analyzed in the following sections was filtered such that only outgoing tide data was considered. The reason for this is to isolate and identify land based impacts on parameters such as turbidity, temperature, and pH. Water going by the sonde is considered to behave as plug flow in the outgoing tide. It assumed that whatever flow goes past the sonde during incoming tide has already passed the sonde during outgoing tide. This perspective is advantageous in identifying what potential pollutants could be coming from the land (i.e. stormwater runoff, illicit discharges, etc.). Section 2.5 presents all of the valid data (both outgoing and incoming tide) which is advantageous to look at the overall aquatic health of the May River. As mentioned previously, the continuous outgoing tide data from the current monitoring programs is being compared with seasonal grab samples from the USGS Baseline study. This comparison is not ideal but is necessary due to a lack of continuous outgoing tide data with which to compare.

2.4.1 Dissolved Oxygen

Dissolved oxygen (DO) is one of the most critical components of any aquatic ecosystem. Fish, plants and other organisms require ample dissolved oxygen in the water in which they live in order to survive. Dissolved oxygen is also a major component in the decomposition of plant and animal matter. Due to the numerous manners in which dissolved oxygen is utilized in an aquatic ecosystem, the limited amount of DO present in the water has the potential to be exhausted.

Dissolved oxygen levels can be depleted, as discussed above, through naturally-occurring processes within an aquatic ecosystem. These levels are naturally replenished through the processes of reaeration and photosynthesis; thus, when an ecosystem is left unaffected by human activity, it goes through a continuous, self-sustaining cycle, in which dissolved oxygen is used and replenished. Human activities, unfortunately, can have a substantial impact on this natural cycle, which can cause DO levels to be depleted.

Failing septic systems leaching sewage into a water body have the potential to introduce a large amount of waste to the ecosystem, which consumes large quantities of DO in the process of decomposition. Additionally, human activity such as the fertilization of lawns and the use of phosphorus-containing detergents can add to the nutrient load of a water body when these chemicals enter stormwater runoff, or when they are used near a storm drain or surface water. Nutrients such as nitrogen and phosphorous can lead to excessive growth of algae and other plant matter within a water body. Although the presence of plants within a water body helps to replenish DO levels through the process of photosynthesis, excessive plant growth and decay causes more DO to be consumed through decomposition than is replenished through photosynthesis, thus significantly depleting DO concentrations.

According to Regulation 61-68, the concentration of dissolved oxygen (DO) in Shellfish Harvesting Waters should not drop below 4 mg/L, and the daily average should not be below 5 mg/L. The results of the Baseline Study indicated that "[s]imilar to many coastal systems, the May River is naturally low in dissolved oxygen. During the summer months, the minimum dissolved oxygen concentration was less than 4.0 mg/L for extended periods, and was generally higher in the lower zones of the river than in the upper zones of the system. Water temperature and dissolved oxygen are inversely related and highly correlated."

The results of the SCECAP monitoring program were also used for comparison with the current Continuous Monitoring Program. According to this report, "…the SCECAP data continue to suggest that lower DO concentrations in tidal creeks may be normal during the summer months compared to larger water bodies. When making regulatory decisions in such situations, the practice of considering natural background conditions seems appropriate. Even so, creek sites with mean DO levels < 3.0 mg/L may not fully support biological assemblages…" This report also states that, "[t]he average bottom DO concentration at the open water stations during the

2003-2004 survey was 5.2 mg/L, with approximately 90% of the state's open water habitat having an average DO > 4.0 mg/L."

One additional point made in the SCECAP report regarding the State regulations is that, "Occasional, short-term departures from these conditions [numeric criteria provided in Regulation 61-68] will not automatically result in adverse effects to the biological community. The standards also recognize that deviations from these criteria may occur solely due to natural conditions and that the aquatic community is adapted to such conditions. In such circumstances, the variations do not represent standards violations…" This information is included here to demonstrate that temporary deviances from the State standards do not necessarily indicate an immediate cause for concern, and are reflective of naturally-occurring conditions.

2.4.1.1 All Joy

The All Joy sonde site is considered to be an "open water" site, as it is located in one of the portions of the May River that is closest to confluence with the Calibogue Sound and furthest from the tidal headwater creeks. The DO concentrations at this site have consistently been higher than those at either the Verdier Cove or Rose Dhu sites, which are located further from the open ocean. This agrees with the finding of the Baseline Study that DO concentrations are generally higher in the lower zones of the river than in the upper zones. The All Joy site is located in close proximity to the sonde in the lower zone for the Baseline Study.

The average DO concentration at the All Joy site during this initial year of monitoring was 7.1 mg/L, which is well above the average bottom DO concentration at open water stations reported in the SCECAP technical report of 5.2 mg/L. This average is also well above the minimum daily average of 5.0 mg/L that is provided in Regulation 61-68. In analyzing the water temperature at the All Joy site and its correlation to the DO concentrations, it was noted that the DO concentrations and percent DO saturation are inversely related to the water temperatures. This is representative of the inverse relationship that is expected between temperature and DO concentration. Appendix A contains plots of all the data collected during the Continuous Monitoring Program.

2.4.1.2 Verdier Cove

The average DO concentration at the Verdier Cove site was 5.4 mg/L during this initial year of monitoring. This concentration is above the minimum daily average provided in Regulation 61-68 and slightly higher than the average bottom DO concentration at open water stations reported in the SCECAP technical report. Due to the fact that the Verdier Cove site cannot accurately be classified as either "open water" or "tidal headwaters," the average DO concentration being only slightly higher than the SCECAP average is not of concern. The middle portions of estuarine rivers are expected to have lower DO concentrations than portions closer to open water; thus, these DO concentrations are considered typical for the Verdier Cove site. In addition, the mean is well above 3.0 mg/L, below which the SCECAP report asserts biological assemblages may not be fully supported.

In addition, the inverse relationship between temperature and DO is evident at the Verdier Cove site. The lower DO concentrations occurred during the warmer months of summer, and once the sonde was redeployed after having been at YSI Technical Support, the DO concentrations and percent DO saturation increased dramatically due to the colder temperatures of January and February.

2.4.1.3 Rose Dhu

Shallow, tidal headwaters, such as those represented by the Rose Dhu site, typically have a much lower DO saturation capacity than deeper portions of an estuary that generally have lower water temperatures. In addition, tidal headwaters experience less flushing than portions of tidally-influenced waters which are closer to the ocean. The decreased flushing experienced in tidal headwaters allows for the build up of oxygen-consuming decaying plant and animal matter. Because of this, it is sometimes more practical to use a percent DO saturation criterion to determine if DO levels are "low." "Low" DO, or hypoxia, is defined in the Baseline Study as a percent saturation of less than 28%. The Baseline Study also noted that "[c]onditions of low DO (<28%), or hypoxia, naturally occur in headwater tidal creek habitats…"

The Rose Dhu site had an average percent DO saturation of 68%, with only 7% of the overall readings below the hypoxia limit of 28%. These percent DO saturation readings are significantly better than those found at the Rose Dhu site during the Baseline Study, which were an average percent DO saturation of 34%, with 43% of the readings below 28%. The overall average DO concentration at the Rose Dhu site was 5.2 mg/L.

Table 3 provides a general comparison of the mean DO concentrations in the upper, middle and lower zones of the May River during both the current Continuous Monitoring Program and the Baseline Study. The mean DO concentrations from the current Continuous Monitoring Program were calculated from all data points collected during the first year of monitoring, and the means of the Baseline Study were estimated from the graphs provided in the report of the results of the seasonal point sampling data. Although the data points from the Baseline Study were not collected on nearly the same frequency as the data points from the current sampling program, they still provide data for a rough comparison of the overall dissolved oxygen concentrations in the May River. It is important to note that the mean dissolved oxygen concentration at the Verdier Cove site is significantly lower than that reported in the Baseline Study. This can be attributed to the Verdier Cove sonde being out of the water for several weeks during the winter months, when DO concentrations would have been at their highest. Thus, the mean does not take into account a period of time when the DO concentrations would have been at their highest.

Table 3 - Dissolved Oxygen Comparison

Sampling Site	Dissolved Oxygen (mg/L) Mean	
	Current Study	Baseline
Rose Dhu (Upper Zone of May River)	5.25	5.27
Verdier Cove (Middle Zone of May River)	5.45	6.50
All Joy (Lower Zone of May River)	7.14	6.80

2.4.2 pH

Regulation 61-68 stipulates that at no time shall the pH of a Shellfish Harvesting Water fall below 6.5 or exceed 8.5. The Baseline Study compared its results to this range to determine if the pH values were acceptable. The SCECAP technical report noted that, "[f]or polyhaline waters, pH levels ≥ 7.4 are considered to be good. Values below 7.4 and above 7.1 pH units are considered to be fair…Values below 7.1 pH units…are considered to be poor pH conditions." The Baseline Study found that "[b]oth mean bottom water pH measurements and the instantaneous surface water quality samples in the May River were ≥ 7.4, indicating good water quality conditions." The lowest pH found during the Baseline Study occurred in the upper zone of the river, in a large tidal creek.

2.4.2.1 All Joy

At the All Joy site, the average pH reading from the initial year of this monitoring program was 7.7, and ranged from approximately 7.1 to 8.2 standard pH units. These values are within the range of 6.5 to 8.5, and fall within the "good" pH classification as determined by SCECAP. Overall the pH at this site appears to be within normal limits for an estuarine environment. In addition, the pH was plotted against the water temperature, and an inverse relationship between these two parameters was evident.

2.4.2.2 Verdier Cove

The average pH reading at the Verdier Cove site during the initial year of this monitoring program was 7.6, with an approximate range of 6.9 to 8.5 standard pH units. These values are within the range of 6.5 to 8.5, and the average pH value falls within the "good" pH classification as determined by SCECAP. This average pH value is also consistent with results of the Baseline Study, indicating that the pH at the Verdier Cove site is within normal limits for this section of the May River.

2.4.2.3 Rose Dhu

The average pH value at the Rose Dhu site during the first year of monitoring was 7.4, with an approximate range of 6.7 to 8.3 standard pH units. The average falls within the pH range that SCECAP classifies as "good." The range of values at this site also falls within the allowable range of 6.5 to 8.5. The pH values found at the Rose Dhu site are also consistent with the Baseline Study, which states that the lowest pH concentrations occurred near the headwaters of the May River.

An important note is that the range at this site is much wider than at the other two sonde sites; this can be attributed to the shallower water depth at this location, which allows for ambient air temperatures to have a more dramatic effect on water quality parameters. In addition, due to the shallow water in the headwaters, rainfall, which is naturally slightly acidic (average pH between 4.2 and 4.4), has more of an effect on the overall pH of the water of this region of the May River. The considerable dips in pH at this site typically occurred after significant rainfall events. In addition, the inverse temperature-pH relationship is apparent at this site.

Overall, the pH values at all three sites are considered typical and within normal ranges. There were also no severe fluctuations in any of the valid pH data. The average pH values at each site represent slightly basic waters, which is typical of estuarine environments. Table 4 provides a comparison of the mean pH values found during the first year of the Continuous Monitoring Program with the mean pH values provided in the Baseline Study. The means of the Baseline Study were estimated from the graphs provided in the report of the results of the seasonal point sampling data.

Table 4 - pH Comparison

Sampling Site	pH	
	Mean	
	Current Study	Baseline
Rose Dhu (Upper Zone of May River)	7.5	7.25
Verdier Cove (Middle Zone of May River)	7.7	7.6
All Joy (Lower Zone of May River)	7.8	7.5

*2.4.3 Chlorophyll-*a

Chlorophyll-*a* is a chemical that binds to the cells within algae and phytoplankton found in surface waters, and is an essential component in the process of photosynthesis. Chlorophyll-*a* is the most abundant form of chlorophyll, and is primarily responsible for the green color of plants. Monitoring for chlorophyll-*a* is a method used to determine the distribution and amount of phytoplankton present within a water body. The level of chlorophyll-*a* detected directly correlates to the amount of nutrients such as phosphorus and nitrogen present in an aquatic ecosystem, as they are the primary "building blocks" used during algal growth.

The potential adverse effect that excessive nutrient levels can have on DO concentrations within a water body was discussed in Section 2.4.1 above. The evaluation of the trends in the chlorophyll-*a* data from year to year will provide an indication of significant changes in the nutrient load to the May River. If there is a general upward trend in the chlorophyll-*a* data over the years, this may be indicative of the discharge of stormwater containing excessive nutrient concentrations.

Regulation 61-68 contains no criteria for chlorophyll-*a* concentrations in Shellfish Harvesting Waters. Values from the 2004 SCECAP technical report have been used for comparison purposes. The SCECAP technical report established the following classifications based on statistical analyses of data collected during the program. Chlorophyll-*a* concentrations are classified in the report as follows:

- Good – Chlorophyll-*a* concentrations less than 12 µg/L
- Fair – Chlorophyll-*a* concentrations less than 20 µg/L but greater than 12 µg/L
- High/Poor – Chlorophyll-*a* concentrations greater than 20 µg/L

Also for comparison, the Baseline Study referenced chlorophyll-*a* classifications established in a report finalized in 1999 entitled *National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries.* This report established the following classification ranges:

- Low – Chlorophyll-*a* concentrations less than 5 µg/L
- Medium – Chlorophyll-*a* concentrations less than 20 µg/L but greater than 5 µg/L
- High – Chlorophyll-*a* concentrations less than 60 µg/L but greater than 20 µg/L
- Hypereutrophic – Chlorophyll-*a* concentrations greater than 60 µg/L

The chlorophyll-*a* concentrations found in the May River were compared to both of the above classifications in order to determine generally how the May River compares to other estuarine systems.

2.4.3.1 All Joy

The overall chlorophyll-*a* concentrations at the All Joy site during the first year of monitoring were excellent, with 99.4% of the readings falling within the "Good" classification established by SCECAP. Comparing to the classifications provided in the Baseline Study, 71% of the readings fall within the "Low" classification, and 26% fall within the "Medium" classification.

There was a slight but definite upward shift in the data that occurred around the middle of July. The average chlorophyll-*a* concentration prior to this shift was approximately 4.9 μg/L, and after the shift was approximately 5.6 μg/L. The average chlorophyll-*a* concentration decreased to approximately 3.4 μg/L during November through January, indicating that the upward shift during the warmer months is seasonal, and naturally-occurring in the May River. The overall average chlorophyll-*a* concentration at the All Joy site during the first year of continuous monitoring was 4.5 μg/L, which falls into the best classification as defined by both SCECAP and the Baseline Study. There is also an inverse relationship between chlorophyll-*a* concentrations and water temperature.

2.4.3.2 Verdier Cove

The sonde deployed at Verdier Cove is not equipped with a chlorophyll-*a* probe. This sonde is an older model and only has one port available for an optical probe. It was determined that using this port for an optical turbidity probe would be more beneficial that using it for a chlorophyll-*a* probe.

2.4.3.3 Rose Dhu

At the Rose Dhu site, the chlorophyll-*a* concentrations were slightly higher than those at the All Joy site, with approximately 93% of the readings falling within the "Good" classification established by SCECAP. Comparing to the classifications provided in the Baseline Study, 32% of the readings fall within the "Low" classification, and 65% fall within the "Medium" classification. The higher chlorophyll-*a* concentrations at the Rose Dhu site are typical of shallow tidal headwaters which allow more sunlight penetration than deeper estuary sections. The greater exposure to sunlight aids in the process of photosynthesis and stimulates plant growth. Similarly to the All Joy site, there was a significant upward shift in the mean chlorophyll-*a* concentrations that occurred in mid to late July. The average chlorophyll-*a* concentration prior to the shift was approximately 6.4 μg/L, and after the shift was approximately 10.2 μg/L. The average concentration from October through January was 5.8 μg/L, again shifting back down from its peak during the summer months. The inverse relationship of chlorophyll-*a* concentrations to water temperature is again apparent. The overall average chlorophyll-*a* concentration at the Rose Dhu site during the first year of continuous monitoring was 6.7 μg/L which falls into the "Good" classification as defined by SCECAP and the "Medium" classification as defined by the Baseline Study.

Water temperature at the Rose Dhu station reached and maintained its peak of about 33^{o} C between August 9, 2007 and August 23, 2007. During this period when water temperature was at its maximum for the summer, the algae productivity was at its peak. Mean temperature was 32.4^{o}C, and mean chlorophyll-*a* was 11.8 μg/l. It is also noteworthy that the chlorophyll-*a* exhibited diurnal peaks and the peaks tracked closely with dissolved oxygen peaks.

The summertime increase in the chlorophyll-*a* concentrations at both the All Joy and Rose Dhu sites is typical of growing season conditions when plants thrive and growth rates increase, subsequently increasing the amount of decaying plant matter which consumes DO. The evaluation of the trends in the chlorophyll-*a* data from year to year will provide an indication of significant changes in the nutrient load to the May River. If there is a general upward trend in the chlorophyll-*a* data over the years, this may be indicative of the discharge of stormwater containing excessive nutrient concentrations. Because so much of the Rose Dhu drainage area is under the control of stormwater detention systems, continuous monitoring of these systems for chlorophyll-*a* and flow at their outfalls would be feasible should chlorophyll-*a* begin to increase at the Rose Dhu monitoring station.

A significant correlation between rainfall events and chlorophyll-*a* concentrations has not been established; thus plots of the chlorophyll-*a* concentrations versus rainfall are not provided in this report. Table 5 provides a comparison of the mean chlorophyll-*a* concentrations found during the Baseline Study and during the current Continuous Monitoring Program. The mean chlorophyll-*a* concentrations from the current Continuous Monitoring Program were calculated from all data points collected during the first three quarters, and the mean concentrations of the Baseline Study were estimated from the graphs provided in the report of the results of the seasonal point sampling data. It is important to note that, although the mean chlorophyll-*a* concentrations in the upper and lower zones of the river are higher than the means provided in the Baseline Study, the concentrations are still well within the "good" classification according to SCECAP, and within the "Medium" and "Low" classifications according to the Baseline Study. Also, as discussed previously, the apparent increase in chlorophyll-*a* concentrations from the Baseline Study to the current Program does not necessarily indicate that the water quality has been slightly degraded in the May River, it is likely the result in the significant differences in sampling frequency between the two programs.

Table 5 - Chlorophyll-*a* Comparison

Sampling Site	Chlorophyll-*a* Mean: Current Study	Chlorophyll-*a* Mean: Baseline
Rose Dhu (Upper Zone of May River)	6.7	5.7
All Joy (Lower Zone of May River)	4.5	4.1

2.4.4 Turbidity

Turbidity is a measure of the clarity of water (i.e., the amount of silt, sand, organic matter, plankton, etc., suspended in water). High levels of turbidity can be detrimental to the overall health of a water body, and are potentially harmful to marine life. High levels of turbidity can prevent sunlight from reaching much of the aquatic plant life typically growing well beneath the water surface. Sunlight is a driving force in the process of photosynthesis, which provides the surrounding aquatic ecosystem with much-needed dissolved oxygen. Without the use of appropriate sediment and erosion control measures, construction activity can introduce a substantial amount of silt, sand and sediment to stormwater runoff, increasing the turbidity of receiving waters.

The 2004 SCECAP technical report noted that, in comparison with many other states, South Carolina's estuarine waters are significantly more turbid. Turbidity can be attributed to several factors, such as the resuspension of the sediment from the estuary bottom due to tidal forces, and the introduction of sediment due to erosion occurring on developing land near water bodies.

According to regulation 61-68, the maximum State turbidity standard for Shellfish Harvesting Waters is 25 Nephelometric Turbidity Units (NTU). The 2004 SCECAP technical report went one step further in classifying turbidity levels within an estuary, as follows:

- Good – Turbidity levels less than or equal to 15 NTU
- Fair – Turbidity levels less than 25 NTU but greater than 15 NTU
- Poor – Turbidity levels greater than 25 NTU

2.4.4.1 All Joy

The turbidity levels at the All Joy site were excellent during the first year of this monitoring program, with an average value of approximately 4.7 NTU. More than 99% of the readings taken at this site were below the 25 NTU state standard, and 98.2% of the readings fell within the "Good" classification according to SCECAP.

2.4.4.2 Verdier Cove

Since the sonde at the Verdier Cove site was painted with a fresh coat of anti-foul paint at the beginning of the third quarter, and due to the colder temperatures of the winter months, fouling of this sonde has been greatly reduced, subsequently reducing the parking problems experienced at this site. The reduction in parking problems has greatly reduced the unreasonably high turbidity readings that have been recorded at Verdier Cove, thus making it possible to discern what true turbidity levels are at this location. Disregarding all turbidity readings over 100 NTU, and assuming slightly negative turbidity readings as zero, the average turbidity reading at the Verdier Cove site was 10.2 NTU, with 93.4% of the readings less than 25 NTU, and 87.3% of the readings falling into the "Good" classification according to SCECAP. There have been several turbidity spikes during the fourth quarter. It is believed that these spikes have been caused by fouling and which is supported by the observation of heavy aquatic growth on the sonde when it has been retrieved from the site following the last three deployments. The sonde, probes, and sonde guard were painted with a fresh coat of anti-fouling paint on April 23 in an attempt to address these fouling issues.

2.4.4.3 Rose Dhu

The overall turbidity at the Rose Dhu site has been good during the first year of this monitoring program, with an average level of 12 NTU. Approximately 89% of the readings were below the 25 NTU state standard, and 75% of the readings falling into the "Good" classification established by SCECAP. There was an upward shift in the turbidity data that occurred around July 25. Prior to this shift the average turbidity level was approximately 5.7 NTU, and after the shift the average was approximately 21.5 NTU. The shift correlates well with an upward shift in chlorophyll-*a* and DO data. The increased turbidity levels were potentially the result of the increased amounts of plant matter present in the water. This is further affirmed by the downward shift that occurred at the Rose Dhu site beginning at the start of November. From November 1 through April 23 the average turbidity reading was 6.28 NTU.

Table 6 provides a comparison of the mean turbidity levels found during the Baseline Study and during the current Continuous Monitoring Program. The mean turbidity levels from the current Continuous Monitoring Program were calculated from all data points collected during the first year of monitoring, and the mean concentrations of the Baseline Study were estimated from the graphs provided in the report of the results of the seasonal point sampling data.

Table 6 - Turbidity Comparison

Sampling Site	Turbidity (NTU)	
	Mean	
	Current Study	Baseline
Rose Dhu (Upper Zone of May River)	12	11
Verdier Cove (Middle Zone of May River)	10.2	14
All Joy (Lower Zone of May River)	4.7	11.5

2.4.5 Salinity

The specific conductivity was measured at each site in order to calculate the salinity levels in the May River. Salinity is mathematically derived from the specific conductivity data collected by the sonde. Typical salinity levels for sea water and fresh water are 20-35 parts per thousand (ppt) and 0-0.5 ppt, respectively. It follows that the salinity levels within the May River will range anywhere from 0-35 ppt; however, the salinity levels in the May River will most likely never be as low as those found in fresh water. This is due to the fact that there is not a significant source of fresh water being supplied to the river. The May River is an estuarine river and is thus brackish, with typical salinity values ranging from 10 to 35 ppt. One note regarding salinity is that significant rain events caused notable drops in the salinity levels at each of the sonde sites, due to the increase in the volume of freshwater.

There are no quantitative criteria in place to determine ranges of salinity that constitute stressful environments; thus, for the purpose of this report, the salinity values have been analyzed in relation to one another, and the potential causes for any significant changes (other than tidal changes) have been recorded. This will provide a baseline of data against which future salinity measurements can be compared.

Additionally, the Baseline Study noted that the mean salinity of open water and large tidal creek sites in the May River ranged from 23.3 ppt in the upper zone of the river, to 30.3 ppt in the lower zone of the river.

2.4.5.1 All Joy

The average salinity at All Joy was approximately 32 ppt during the first year of this monitoring program, and ranged from 27 to 34 ppt. This salinity range and average are in line with the mean salinity found in the lower zone of the river during the Baseline Study.

2.4.5.2 Verdier Cove

The average salinity at the Verdier Cove site during the first year of this monitoring program was 29 ppt, with a range of 20 to 34 ppt. This range is slightly wider than the range seen at the All Joy site, due to the fact that the middle portion of the estuary has less of a saltwater influence than the mouth of the river, and is more easily diluted with fresh water. The range of salinity values is still well within normal limits for an estuarine environment.

2.4.5.3 Rose Dhu

The average salinity at the Rose Dhu site during the first year of this monitoring program was 26 ppt, with a range of 10 to 34 ppt. Again, there is an increasing widening of the range of salinity levels as the monitoring moves toward the tidal headwaters, due to the decreasing saltwater influence, increasing fresh water influence, and decreasing water volumes. This range of salinities in tidal headwaters is normal, and the aquatic environment is adapted to living under these salinity conditions. The significant fluctuation in salinity in the upper zone of the river was also apparent in the results of the Baseline Study, which noted that "[t]his amount of fluctuation is not likely to represent stressful conditions for the estuarine biota present."

During the period June 11, 2007 to June 20, 2007, approximately 7.5 inches of rain fell on the watershed draining to the Rose Dhu site. Low tide salinity dropped below 16 ppt (27,840 µS/cm) on June 20, 2007, and stayed below that mark for just 12 days until July 2, 2007 when it recovered to greater than 16 ppt. The May River Baseline Study noted that after a 4.8-inch rainfall on June 19, 2002, the specific conductance values for the Pritchardville gauge decreased to 35,000 µs/cm and did not recover to the pre-event specific conductance levels until August 25, indicating a long retention time in the system (greater than 60 days) and limited flushing. A 2.4-inch rain event on April 7, 2003 decreased the specific conductance values at Pritchardville by greater than 20,000 µs/cm, and the system took approximately 30 days to recover to the pre-event specific conductance levels (Sanger, D.M., et.al. 2004). The researchers used these observations to suggest that Stoney Creek watershed had significant infiltrations which contributed to baseflow to the Creek for long periods after rain. Since the monitoring station referred to in the May River Baseline Study is about 500 feet closer to the open ocean than the Rose Dhu station, the current observations of salinity/conductivity can reasonably be compared with the Baseline Study. Thus the Summer 2007 data, by comparison to the 2002 and 2003 data, may indicate a reduction in the stormwater detention time in the watershed, and a change in overall infiltration in the watershed and an increase in the rate at which the Stoney Creek watershed drains.

Table 7 provides a comparison of the mean salinities found during the Baseline Study and during the current Continuous Monitoring Program. The mean salinities of the Baseline Study were estimated from the graphs provided in the report of the results of the seasonal point sampling data.

Table 7 - Salinity Comparison

Sampling Site	Salinity (ppt) Mean	
	Current Study	Baseline
Rose Dhu (Upper Zone of May River)	25.7	23.5
Verdier Cove (Middle Zone of May River)	29.4	29.0
All Joy (Lower Zone of May River)	31.9	30.3

2.4.6 Temperature

In addition to providing water quality information in and of itself, water temperature is used in the calculation of some of the other water quality parameters that are temperature dependent. According to South Carolina Regulation 61-68, the weekly average temperature of Shellfish Harvesting Waters shall not exceed 4°F (2.2°C) above natural conditions during the fall, winter or spring, and shall not exceed 1.5°F (0.8°C) above natural conditions during the summer as a result of the discharge of heated liquid.

The general trends of the water temperature at each site correlated closely with the trends of the ambient air temperature. The overall water temperatures at all three locations appear to be within normal limits.

Table 8 provides a comparison of the mean temperatures of the different zones of the May River found during the current Continuous Monitoring Program, and during the Baseline Study.

Table 8 - Temperature Comparison

Sampling Site	Temperature (°C)	
	Mean	
	Current Study	Baseline
Rose Dhu (Upper Zone of May River)	22.4	25.0
Verdier Cove (Middle Zone of May River)	23.4	24.8
All Joy (Lower Zone of May River)	21.1	22.5

2.4.7 Tannic Acid Event at Verdier Cove

There was a concern that improper sediment and erosion control on nearby construction sites was the cause of the plume, as this has been a recurring problem in this area. The grab samples were tested for turbidity, which would be indicative of a sediment control problem at a construction site, as well as for tannins and lignins, as they can cause a reddish-brown "tea" color when present in excessive concentrations. The laboratory results indicated a high level of tannins and lignins. The turbidity levels in the laboratory report were not greater than 4.1 NTU, which indicated that construction sites were not the origin of the plume.

Further investigation revealed that there is a fair amount of timberland that drains to Verdier Cove, which was the most likely origin of the plume. Timber and other types of tree bark contain tannins and lignins. In areas such as the timberlands that drain to Verdier Cove, tannins and lignins leach out into the stagnant water over time, turning the water a "tea" color. When a large rain event occurs, it flushes out the timberland, resulting in the discharge of water containing large amounts of tannins and lignins.

There was a large rain event on June 11 that produced more than 4 inches of rain. This rain event was significant enough to essentially flush out the water that had been stagnant in the timberland. Due to the retention time of the timberland, there was a delay of approximately five days before the May River saw the effects of this "flushing out."

Tannins and lignins typically do not have an adverse impact on water quality. They are acidic, however, and can thus potentially cause the pH of the receiving water body to be decreased slightly, which in turn causes heavy metals to become more toxic at lower concentrations. In this case, the pH did not appear to be impacted due to the introduction of tannins and lignins, fluctuating only slightly between approximately 7.5 and 7.7 standard pH units.

2.5 Monitoring Results for Incoming & Outgoing Tide

2.5.1 Continuous Monitoring Results versus Baseline Data

The monitoring results from the current continuous study are compared to the continuous data from the USGS Baseline study in Tables 9, 10, and 11 below. The parameters monitored during the USGS study included only temperature, specific conductivity, and dissolved oxygen. As mentioned previously, the continuous data from the USGS Baseline study includes both the incoming and outgoing tide and therefore the comparison with the current continuous data includes both the incoming and outgoing tide. Use of both the incoming and outgoing tidal data is ideal for making observations concerning the impact of water quality on aquatic life in the May River since organisms living in the river are subjected to both tides; however, this comparison is not ideal for making observations concerning land use and its implications on water quality. Graphs of the Baseline data versus the current continuous monitoring data by parameter and site can be found in Appendix B.

Table 9 – Monthly Parameter Averages All Joy vs. USGS Site 2035

Month	Temperature (°C)			Specific Conductivity (mS/cm)			Dissolved Oxygen (mg/L)		
	02 to 03	03 to 04	07 to 08	02 to 03	03 to 04	07 to 08	02 to 03	03 to 04	07 to 08
June	27.7	28.4	27.7	50.4	40.7	47.7	5.6	6.2	5.6
July	30.0	29.1	29.7	48.5	41.8	47.7	5.9	5.6	5.3
August	29.3	29.6	30.8	50.1	42.0	45.2	5.8	5.1	
September	27.9	27.1	28.5	45.2	45.1	42.6	5.9	5.6	
October	24.6	22.9		46.8	47.3		6.1	6.3	
November	18.1	20.0	16.3	45.8	47.0	49.8	7.9	7.4	7.4
December	11.5	11.7	15.1	44.6	46.1	50.4	10.0	9.5	7.7
January	9.4	10.6	11.6	43.6	45.8	50.1	10.4	9.7	8.7
February	11.4	10.3	14.2	45.3	45.5	48.8	10.3	10.1	8.5
March	16.5	15.7	17.0	42.9	45.5	47.2	8.7	9.3	7.6
April	20.2	20.1	19.8	39.1	46.6	49.0	7.5	7.6	6.6
May	25.3	25.8	24.3	41.4	45.9	48.8	6.5	6.7	6.2

Table 10 – Monthly Parameter Averages Verdier Cove vs. USGS Site 6720

Month	Temperature (°C)			Specific Conductivity (mS/cm)			Dissolved Oxygen (mg/L)		
	02 to 03	03 to 04	07 to 08	02 to 03	03 to 04	07 to 08	02 to 03	03 to 04	07 to 08
June	28.5	28.9	28.1	50.9	37.4	43.4	5.4	5.8	4.6
July	30.6	29.5	30.2	46.7	39.7	45.7	6.0	5.2	4.7
August	29.5	30.1	31.1	49.4	37.5	42.0	5.1	5.1	4.3
September	28.1	27.4	27.8	43.0	42.0	43.1	5.5	5.6	4.6
October	24.7	22.9	24.6	42.9	46.7	45.1	5.7	6.3	4.8
November	17.7	19.8	17.6	41.9	45.8	48.2	7.8	6.9	7.1
December	11.2	11.2		42.0	46.2		9.9	10.4	
January	9.2	10.8	10.4	41.8	45.0	46.1	10.6	10.6	9.2
February	11.8	10.9	14.6	42.9	44.6	47.8	10.0	10.0	6.7
March	17.2	16.7	17.4	39.4	45.7	44.3	8.6	8.8	7.6
April	20.7	20.9	20.2	36.1	46.6	46.6	7.5	7.8	4.8
May	26.1	26.5	21.0	38.4	45.7	47.8	6.3	6.1	5.4

Table 11 – Monthly Parameter Averages Rose Dhu vs. USGS Site 6711

Month	Temperature (°C)			Specific Conductivity (mS/cm)			Dissolved Oxygen (mg/L)		
	02 to 03	03 to 04	07 to 08	02 to 03	03 to 04	07 to 08	02 to 03	03 to 04	07 to 08
June	29.7	29.5	28.7	37.9	29.3	36.7	4.8	5.2	3.5
July	31.1	29.7	30.4	44.0	32.4	41.0	5.2	4.9	3.6
August	29.9	30.2	31.5	48.2	26.7	37.0	5.0	4.5	4.2
September	28.2	27.3	28.0	35.1	35.1	39.1	4.6	5.3	4.6
October	24.4	23.0	24.7	33.2	44.1	35.8	4.8	6.1	4.8
November	16.8	18.7	16.7	28.9	44.7	45.2	7.1	6.9	7.7
December	11.0	10.5	14.8	32.9	43.9	45.7	9.2	10.0	7.5
January	9.0	10.3	11.5	35.8	43.0	37.3	10.5	10.4	8.6
February	12.5	11.2	14.9	36.4	37.1	37.1	9.6	10.5	6.0
March	18.1	17.7	17.7	27.7	42.0	32.2	7.3	8.2	6.2
April	21.1	21.6	21.2	26.4	45.5	44.0	7.0	7.5	5.9
May	26.4	27.2	25.5	30.4	45.7	49.1	5.5	6.2	4.3

2.5.2 Continuous Monitoring Results for New Parameters

In order to comply with the recommendations from the USGS Baseline study the current continuous monitoring programs expanded the parameters being monitored continuously to include Salinity, DO%, Turbidity, Chlorophyll, and pH. The continuous monitoring of this expanded list of parameters is intended to work toward the goals of establishing baseline water quality and identifying seasonal and overall trends set by the *Beaufort County Stormwater Management Plan*. The results from the current continuous monitoring program for each of the new parameters can be found below in Tables 12, 13, 14, 15, and 16. The results are in the form of a monthly average for each parameter at each monitoring site. Graphs of this data by parameter and site can be found in Appendix B.

Table 12 – Monthly Salinity Averages for Continuous Monitoring Data by Site

Month	Salinity		
	RD	VC	AJ
April	31.2	31.9	31.2
May	32.1	31.2	31.9
June	23.2	27.9	31.0
July	26.1	29.5	30.1
August	23.3	26.8	
September	24.8	27.7	
October	22.6	29.2	
November	29.3	31.5	32.7
December	29.6		32.9
January	23.6	29.7	32.7
February	23.6	31.2	31.8
March	20.2	28.7	30.8

Table 13 – Monthly DO% Averages for Continuous Monitoring Data by Site

Month	DO %		
	RD	VC	AJ
April	72.9	88.5	94.3
May	62.7	77.3	89.0
June	51.8	68.4	84.6
July	54.8	74.0	82.7
August	65.5	67.8	
September	68.1	67.9	
October	65.3	67.8	
November	93.8	89.4	91.2
December	89.4		90.0
January	90.7	98.9	98.4
February	68.3	79.5	101.1
March	73.8	93.9	94.6

Table 14 – Monthly Turbidity Averages for Continuous Monitoring Data by Site

Month	Turbidity		
	RD	VC	AJ
April	6.7	9.5	9.7
May	6.1	7.7	7.0
June	9.0	34.0	6.3
July	12.7	30.2	4.2
August	30.5	46.2	6.6
September	24.2	10.2	7.8
October	19.3	8.3	
November	8.1	4.2	
December	5.1		3.4
January	4.7	2.3	5.5
February	6.8	3.1	2.7
March	8.0	4.4	4.4

Table 15 – Monthly Chlorophyll Averages for Continuous Monitoring Data by Site

Month	Chlorophyll	
	RD	AJ
April	7.8	5.2
May	6.1	5.9
June	11.2	4.5
July	9.7	5.0
August	11.4	6.0
September	9.7	4.0
October	6.2	
November	4.8	4.5
December	4.8	3.3
January	6.0	2.8
February	4.9	4.4
March	6.3	4.8

Table 16 – Monthly pH Averages for Continuous Monitoring Data by Site

Month	pH		
	RD	VC	AJ
April	7.5	7.7	7.8
May	7.4	7.5	7.7
June	7.1	7.3	7.6
July	7.3	7.5	7.6
August	7.3		7.7
September	7.4	7.9	7.6
October	7.3	7.5	
November	7.5		8.0
December	7.6		7.8
January	7.9		8.0
February	7.8		7.9
March	7.6		7.8

STORMWATER SAMPLING PROGRAM

3.1 Background

The Baseline Study provided recommendations related to the collection of stormwater samples in addition to a Continuous Monitoring Program. These recommendations are provided below:

- "Seasonal fecal coliform sampling of the May River system should be a major component of any sampling plan. SCDHEC currently monitors eight sites in the larger May River system, which should provide an adequate assessment of the larger water components. Additional sampling in the headwater systems should be included to better target upland sources. In addition, source tracking either by wastewater indicator analysis or MAR should be included to properly assess the source of bacteria observed."

- "Future studies of water quality, sediment quality, and biotic condition should concentrate on sampling tidal creeks since they represent a direct connection with the upland environment."

These recommendations led to the development and implementation of a Stormwater Sampling Program within the Town. Five sampling sites were selected for this initial stormwater sampling program, all located within tidal headwater creeks as recommended by the Baseline Study.

In addition to the recommendations stemming from the Baseline Study, the *Beaufort County Stormwater Management Plan* (Plan) submitted on May 27, 2005 was also consulted to gain another perspective on the most effective route to take for future monitoring. This Plan provided the following recommendations that apply to stormwater sampling.

- "Establish baseline water quality via ambient (grab) sampling"

- "Evaluate…wet weather…water quality in selected areas..."

In order to address these recommendations, the original stormwater sampling program involved the selection of five sampling sites in the tidal creeks of the May River. The five sampling locations were outfalls at Bluffton Village, Heyward Street, Rose Dhu Creek, Stoney Creek and New River Trail. Samples from these locations were analyzed for turbidity, nitrate, nitrite, total Kjeldahl nitrogen, ammonia, phosphorous and fecal coliform.

Samples were collected from each of these sites during eleven storm events, and the data was compiled. The data from this stormwater sampling program provides a general overview of the characteristics of stormwater discharging into May River tidal creeks. When the Town was evaluating the development of a new Continuous Monitoring Program, it was recommended that they continue collecting stormwater samples in order to better have the ability to begin isolating potential sources of certain pollutants. This led to the current Stormwater Sampling Program, described below.

3.2 Stormwater Sampling Program Overview

The current Stormwater Sampling Program is an extension of a program carried out from July 2005 to May 2006. When sampling sites were initially chosen for the current Program, the same five locations were selected in order to provide a continuation of data, and to determine any significant variations in the pollutant levels. Because it was initially chosen to get background data from an undeveloped site, the New River Trail sampling site was dropped for this study since it is still undeveloped, in order to concentrate on changing site conditions. Two additional sampling sites were also selected: May River Rd. @ Huger Cove and May River Rd. @ Guerrard Cove. These sites were chosen to provide preliminary data for a water quality model being developed by Applied Technology and Management (ATM). The locations of the six final sampling sites for this program are shown in Figure 1.

The original goal of the sampling program was to collect one sample per quarter at each site. Due to a lack of qualifying wet weather events during the limited sampling hours, it was not possible to meet this sampling schedule. Only two wet weather even samples were collected during this monitoring period. The first sample was collected on July 25, 2007, and the second sample was collected on February 18, 2008. The samples were collected in accordance with EPA's *NPDES Storm Water Sampling Guidance Document*, which states that samples should only be collected during an event resulting in 0.1 inches or more of rainfall, and the event must occur at least 72 hours after a previous event of 0.1 inches or greater. Although the Town was not required to comply with these requirements, as it was not regulated by an NPDES stormwater permit at the time, the sampling criteria is a good guide. The goal of sampling in accordance with these criteria was to capture the pollutant levels in the "first flush" of a storm event. That is, samples collected at the beginning of a rain event meeting the above criteria should theoretically contain the highest potential pollutant concentrations of any sample collected at a particular site.

The two samples that have been collected to date were collected on July 25, 2007 and February 18, 2008, as discussed above. The sample collected on July 25 was collected during a rain event totaling 0.1 inches, and that collected on February 18 was collected during a rain event of 1.05 inches. In both cases, the samples were stored in plastic bottles provided by TestAmerica Laboratories. The bottles contained the appropriate types and amounts of preservatives for each parameter for which the samples were tested. The samples were then sent to the TestAmerica

Laboratory located in Savannah, Georgia. The samples were each tested for ammonia, total Kjeldahl nitrogen (TKN), nitrates, nitrites, total phosphorous, turbidity, fecal coliform, and Escherichia coli (E. coli). The samples were also tested for Total Suspended Solids (TSS), in order to provide data for the water quality model developed by ATM. Due to the significant variation in rainfall between the two samples, a notable decrease in the parameters is noted for the second event. This is because there was a greater volume of water produced by the second event, resulting in the dilution of the samples, and subsequently a decrease in pollutant concentrations.

Sampling stormwater runoff is a relatively new concept, resulting in a significant lack of background data or any kind of water quality standards. Because of this, the results of the most recent stormwater sample collected within the Town were compared to results of the Nationwide Urban Runoff Program (NURP), which collected and analyzed stormwater samples from across the United States. The results were also compared with the average values of each parameter included in the 2005-2006 sampling program.

It is important to note that the values used here for comparison purposes are not standards, and are provided strictly to provide a general understanding of the potential indications of the grab sample results. Some of the parameters sampled during this study were not included in either the NURP or 2005-2006 study; in these cases, there is not a column for these values in the tables provided below. At this point, it is not possible to draw any conclusions from the data collected thus far; only general comparisons can be made.

3.3 Sampling Results

3.3.1 Nitrogen (TKN, Ammonia, Nitrate and Nitrite)

Total Kjeldahl nitrogen (TKN) is defined as the sum of organic and ammonia nitrogen. Both organic nitrogen and ammonia are naturally present in living organisms, and are thus found in sewage effluent, which is typically the primary source of TKN in surface waters. In addition, organic nitrogen and ammonia are common components of many types of fertilizers. When these fertilizers are applied in excess or too near the beginning of a rain event, there is the potential for a large portion of them to be introduced to storm water runoff and ultimately discharged into receiving streams.

Nitrates and nitrites are nitrogen-containing anionic compounds that are naturally-occurring in the environment. They are both products of the nitrification cycle that occurs within water bodies. Nitrite is also formed during the denitrification process. The nitrification process begins with the introduction of organic nitrogen to a water body; thus, the potential sources for nitrites and nitrates are the same as those for TKN. A summary table of the potential sources of the various types of nitrogen is provided in Table 17:

Table 17 - Potential Sources of Various Forms of Nitrogen

Nitrogen Form	Potential Sources
TKN	Failing septic tank, illicit sewer pipeline connection to stormwater pipeline, animal waste, sewer overflow during rain event, dead animal or plant matter, fertilizer, improper disposal of cleaners and other toxic household chemicals
Nitrites & Nitrates	Failing septic tank, illicit sewer pipeline connection to stormwater pipeline, animal waste, sewer overflow during rain event, fertilizer
Ammonia	Produced by chemical plants worldwide, fertilizer, used as a refrigerant in large industrial processes such as bulk icemaking and industrial food processing, used in cleaning agents and as a disinfectant
Total Organic Nitrogen	Failing septic tank, illicit sewer pipeline connection to stormwater pipeline, animal waste, sewer overflow during rain event, dead animal or plant matter, fertilizer, improper disposal of cleaners and other toxic household chemicals

Excessive nitrogen levels in its various forms can potentially lead to eutrophication of a water body, which is a condition of excessive plant growth and decay. As bacteria consume dead plant matter, which in turn consumes oxygen, the overall dissolved oxygen levels within the water body are diminished. If a water body is exposed to elevated nutrient levels for an extended period of time, it is possible for the rapid growth of phytoplankton and other plants to upset the ecosystem in that water body. The reduction of the introduction of nutrients to stormwater runoff should ultimately cause a reduction in the overall nutrient levels in the receiving water body, which in this case is the May River.

Tables 18, 19, 20, and 21 contain ammonia, TKN, nitrate and nitrite concentrations, and total nitrogen from the current Stormwater Sampling Program, respectively, as well as concentrations provided in the NURP report and those found during the 2005-2006 sampling program. At five of the six sampling sites, the ammonia concentrations in the samples collected on February 18 were lower than the concentrations in the samples collected on July 25. The ammonia concentrations in all samples collected during the current sampling program have been greater than the average ammonia concentrations found during the 2005-2006 study.

Overall, the TKN concentrations found in the two stormwater samples collected during this study have been comparable to those found in the NURP report and the 2005-2006 sampling study. There do not seem to be any significant variations from the results of either of these studies. Also, the TKN concentrations at five of the six sites were lower in the samples collected on February 18 than on July 25, which is consistent with the decrease seen in the ammonia concentrations from one sampling date to the next.

Nitrate and nitrite concentrations were provided separately in the lab report, but were combined here for comparison purposes. Nitrites were not detected above the method detection limit of

0.050 mg/L at any site during either sampling event; thus the sum of the nitrites and nitrates is simply equal to the nitrate concentrations of each sample. In addition, half of the samples were found to have nitrate concentrations below the detectable limit. Thus, half of the total samples collected had a total nitrate and nitrite concentration of less than 0.050 mg/L, and the remainder of the concentrations were comparable to those found during the 2005-2006 study which included eleven (11) wet weather events. These results indicate that nitrates and nitrites may not be the primary source of nitrogen that is introduced to stormwater runoff in the Town. Plots of the ammonia, TKN, and nitrate and nitrite concentrations, as well as the results of the previous 2005-2006 stormwater sampling program, are provided in Appendix C.

Table 18 – Ammonia Concentrations

Sampling Site	Ammonia (mg/L)			
	Current Program (1)			2005-2006 Sampling (2)
	7/25/2007	2/18/2008	Mean	
Bluffton Village	0.16	0.38	0.27	0.115
Verdier Cove at Heyward St	0.34	0.24	0.29	0.122
Rose Dhu Creek	0.76	0.24	0.5	0.078
Stoney Creek	0.29	0.24	0.265	0.108
May River Rd @ Huger Cove	0.54	0.27	0.405	N/A
May River Rd @ Guerrard Cove	1.1	0.34	0.72	N/A

(1) Four samples of current program

(2) Averages from the 2005-2006 Stormwater Sampling Program carried out in the Town

**NURP did not provide concentrations for ammonia

Table 19 – TKN Concentrations

Sampling Site	TKN (mg/L)				
	Current Program (1)			NURP (2)	2005-2006 Sampling (3)
	7/25/2007	2/18/2008	Mean		
Bluffton Village	1.6	0.68	1.14	1.5	0.52
Verdier Cove at Heyward St	1.9	1.1	1.5	1.5	1.21
Rose Dhu Creek	1.8	1.6	1.7	1.5	1.13
Stoney Creek	1.2	1.4	1.3	1.5	1.14
May River Rd @ Huger Cove	1.6	0.71	1.155	1.5	N/A
May River Rd @ Guerrard Cove	2.2	1.1	1.65	1.5	N/A

(1) Four samples of current program

(2) Site median EMC from NURP report (p. 6-43)

(3) Averages from the 2005-2006 Stormwater Sampling Program carried out in the Town

Table 20 – Nitrate and Nitrite Concentrations

Sampling Site	$NO_3 + NO_2$ as N (mg/L)			
	Current Program[1]			2005-2006 Sampling[2]
	7/25/2007	2/18/2008	Mean	
Bluffton Village	0.075	<0.050	0.075	0.15
Verdier Cove at Heyward St	0.12	<0.050	0.12	0.11
Rose Dhu Creek	<0.050	0.069	0.069	0.18
Stoney Creek	<0.050	<0.050	<0.050	0.13
May River Rd @ Huger Cove	0.35	0.087	0.2185	N/A
May River Rd @ Guerrard Cove	0.059	<0.050	0.059	N/A

(1) Four samples of current program

(2) Averages from the 2005-2006 Stormwater Sampling Program carried out in the Town

**NURP did not provide concentrations for nitrate/nitrite

Table 21 – Total Nitrogen Concentrations

Sampling Site	Total Nitrogen (Calculated) (mg/L)				
	Current Program[1]			NURP[2]	2005-2006 Sampling[3]
	7/25/2007	2/18/2008	Mean		
Bluffton Village	1.675	0.68	1.1775	2.18	0.669
Verdier Cove at Heyward St	2.02	1.1	1.56	2.18	0.11
Rose Dhu Creek	1.8	1.669	1.7345	2.18	1.306
Stoney Creek	1.2	1.4	1.3	2.18	1.27
May River Rd @ Huger Cove	1.95	0.797	1.3735	2.18	N/A
May River Rd @ Guerrard Cove	2.259	1.1	1.6795	2.18	N/A

(1) Four samples of current program

(2) Site median EMC from NURP report (p. 6-43)

(3) Averages from the 2005-2006 Stormwater Sampling Program carried out in the Town

3.3.2 Total Phosphorous

Phosphorous is an essential nutrient that fuels the growth and development of all aquatic life. Although naturally present in the environment, many human activities add a significant amount of phosphorous to surface waters, which can be detrimental to water quality. Similarly to nitrogen, phosphorous is found in both animal and plant waste, and is also a common constituent of many fertilizers. Phosphorous-containing detergents also contribute to the overall phosphorous load to surface waters.

At four of the six sampling sites, the concentrations found in samples collected on February 18 were lower than those found in samples collected on July 25. In general, the concentrations found in samples collected thus far have been comparable to those provided in the NURP report and found during the 2005-2006 sampling study.

A plot of the total phosphorous concentrations from the most recent stormwater samples, as well as the results of the previous 2005-2006 stormwater sampling program, is provided in Appendix B. Table 22 contains total phosphorous concentrations from the current Stormwater Sampling Program, as well as concentrations provided in the NURP report and those found during the 2005-2006 sampling program.

Table 22 – Phosphorous Concentrations

Sampling Site	TP (mg/L)				
	Current Program[1]			NURP[2]	2005-2006 Sampling[3]
	7/25/2007	2/18/2008	Mean		
Bluffton Village	0.49	<0.10	0.49	0.33	0.163
Verdier Cove at Heyward St	0.13	0.19	0.16	0.33	0.431
Rose Dhu Creek	0.34	0.32	0.33	0.33	0.238
Stoney Creek	0.97	0.26	0.615	0.33	0.34
May River Rd @ Huger Cove	0.61	0.16	0.385	0.33	N/A
May River Rd @ Guerrard Cove	0.11	0.18	0.145	0.33	N/A

(1) Four samples of current program

(2) Site median EMC from NURP report (p. 6-43)

(3) Averages from the 2005-2006 Stormwater Sampling Program carried out in the Town

3.3.3 Total Suspended Solids (TSS)

Total suspended solids (TSS) are defined as solids that float or are suspended in water or wastewater and are removable by filtration techniques. Some of the more common sources of TSS in water include material such as silt, decaying plant and animal matter, industrial wastes, and sewage.

All but one sample collected during the current monitoring study have been lower than the values provided in the NURP report. The one sample that was found to have a concentration greater than the NURP concentration was collected at the Rose Dhu sampling site. A plot of the TSS concentrations from the most recent stormwater sample is provided in Appendix C, and Table 23 contains TSS concentrations from the current Stormwater Sampling Program, as well as concentrations provided in the NURP report.

Table 23 – TSS Concentrations

Sampling Site	TSS (mg/L)			
	Current Program(1)			NURP(2)
	7/25/2007	2/18/2008	Mean	
Bluffton Village	18	0	9	100
Verdier Cove at Heyward St	16	17	16.5	100
Rose Dhu Creek	140	48	94	100
Stoney Creek	42	91	66.5	100
May River Rd @ Huger Cove	15	90	52.5	100
May River Rd @ Guerrard Cove	31	32	31.5	100

(1) Four samples of current program

(2) Site median EMC from NURP report (p. 6-43)

**TSS was not included in the 2005-2006 Stormwater Sampling Program carried out in the Town

3.3.4 Turbidity

As discussed above, one of the main reasons for analyzing stormwater samples for turbidity is to determine the impacts of construction on water quality. The turbidity levels found in the first two stormwater samples of this study were all lower than the average turbidity found during the 2005-2006 study. Also, although it is not appropriate to compare the turbidity levels found in stormwater samples to the 25 NTU state saltwater standard, it is helpful to use this value as a gauge of the magnitude of turbidity levels. Ten of the twelve total samples were found to have turbidity levels below 25 NTU.

These levels appear to be relatively low, and do not seem to indicate that any construction sites are contributing large amounts of sediment to runoff that discharges at these sample sites during sampling. Improperly controlled sediment at construction sites can sometimes lead to turbidity levels of 100 NTU or greater in stormwater runoff. A plot of the turbidity levels from the most recent stormwater samples, as well as the results of the previous 2005-2006 stormwater sampling program, is provided in Appendix C. Table 24 contains turbidity levels from the current Stormwater Sampling Program, as well as levels found during the 2005-2006 sampling program.

Table 24 – Turbidity

Sampling Site	Turbidity (NTU)			
	Current Program[1]			2005-2006 Sampling[2]
	7/25/2007	2/18/2008	Mean	
Bluffton Village	2.1	3.6	2.85	5.18
Verdier Cove at Heyward St	13	5.9	9.45	57.45
Rose Dhu Creek	17	10	13.5	23.82
Stoney Creek	18	29	23.5	40.23
May River Rd @ Huger Cove	23	19	21	N/A
May River Rd @ Guerrard Cove	28	18	23	N/A

(1) Four samples of current program

(2) Averages from the 2005-2006 Stormwater Sampling Program carried out in the Town

**NURP did not provide concentrations for nitrate/nitrite

3.3.5 Fecal Coliform

Fecal coliform is found in the intestinal track of all warm-blooded animals, and can be introduced to surface water in several different ways. Rather than testing the water directly for pathogens which can be costly, indicator organisms are used to assess the potential for fecal contamination. Failing septic tanks can potentially discharge sewage directly to a water body, or can allow sewage to come into contact with storm water that is subsequently discharged to a water body. In addition, a sewer line overflow during a rain event has the potential to introduce large amounts of fecal coliform to storm water runoff. Animal waste (both wildlife and pet) can also contribute fecal coliform to runoff if not properly disposed of. It is typical for storm drainage ditches and smaller tributaries to experience higher fecal values than expected in the open waters of the May River.

In the previous progress report, the fecal coliform results of five of the six samples collected on July 25 were "Too Numerous To Count (TNTC)." This does not necessarily mean that the fecal coliform count was extremely high; rather it has to do with the dilution factor used in the lab where the tests were run. If a sample is not diluted properly, it is not possible to count the colonies. By the time of this report the lab was able to estimate the results for five of the six samples previously reported as TNTC. The lab now estimates the fecal coliform counts for these five samples to be >400 CFU/100mL.

Fortunately, the lab was able to get actual fecal coliform counts for this most recent sample. The fecal coliform count ranged from 270 CFU/100mL to 5800 CFU/100mL. All these counts were lower than the median fecal coliform concentration provided in the NURP report; however there was a great amount of variability in the fecal coliform concentrations from one site to another. The Stoney Creek site had a fecal concentration about 20 times greater than the site with the lowest concentration. This may indicate that there is something in the watershed draining to

Stoney Creek that is contributing to an increased fecal coliform concentration at this site. Further samples will help to indicate whether this trend continues at Stoney Creek.

Additionally, the fecal coliform concentrations at the Rose Dhu Creek and May River Rd @ Guerrard Cove sites were significantly greater than concentrations at the other three sites. Future samples will be evaluated to determine if this is consistently the case at these sites.

A plot of the fecal coliform counts from the most recent stormwater samples, as well as the results of the previous 2005-2006 stormwater sampling program, is provided in Appendix C. Table 25 contains fecal coliform concentrations from the current Stormwater Sampling Program, as well as concentrations provided in the NURP report and those found during the 2005-2006 sampling program.

Table 25 – Fecal Coliform

Sampling Site	Fecal Coliform (CFU/100 mL)				
	Current Program[1]			NURP[2]	2005-2006 Sampling[3]
	7/25/2007	2/18/2008	Mean		
Bluffton Village	>400	500	>400	21000	776
Verdier Cove at Heyward St	>400	270	>400	21000	991
Rose Dhu Creek	>400	1400	>400	21000	1397
Stoney Creek	>400	5800	>400	21000	1478
May River Rd @ Huger Cove	>400	420	>400	21000	N/A
May River Rd @ Guerrard Cove	290	1100	695	21000	N/A

[1] Four samples of current program
[2] Site median EMC from NURP report (p. 6-43)
[3] Averages from the 2005-2006 Stormwater Sampling Program carried out in the Town

3.3.6 Escherichia coli (E. coli)

E. coli is a subset of fecal coliform. Of all the coliforms, only E. coli is generally not found growing and reproducing in the environment and is almost exclusive of fecal origin. Therefore, E. coli is considered to be the coliform bacteria that is the best indicator of fecal pollution and the presence of pathogens. Past studies have suggested that E. coli may be used to generally determine what portion of fecal coliform contamination can likely be attributed to human waste versus animal waste; however, recent studies have demonstrated that no indicator has been identified that is exclusive to humans due to die off rates, etc. E. coli can only indicate the presence of fecal contamination from a warm-blooded animal. Microbial source tracking is the only method that can positively identify the fecal source. Based on the resources available to the Town, using E. coli as a general indicator of human contamination is the most cost-effective option at this time; however, it will not be possible to positively state whether human sewage or animal waste is contaminating stormwater runoff. Additionally, the Town has opted to use thermal photography to attempt to locate failing septic tanks in order to supplement this effort. Town staff have also been trained and certified to inspect septic tanks.

While E. coli is a subset of fecal coliform, it is not appropriate to compare the ratio from the sampling event because the analysis involved two different methods as well as two different sample containers. The fecal coliform test involves diluting the sample to obtain results and may include background interference while the E. coli test is run with a full sample. Therefore, the E. coli results are more accurate than fecal since they have not been diluted; we will continue to evaluate the results but the E. coli test may be a better indicator of fecal contamination than the fecal coliform test.

The E. coli concentrations at all sampling sites are significantly greater in the samples collected on February 18 than they were in samples collected on July 25. Also, it is interesting to note that Stoney Creek has had the highest E. coli counts for both of the first two samples, and had the highest fecal coliform concentration in the second sample. In addition, the three sites with the highest fecal coliform counts are also the sites with the highest E. coli counts. A plot of the E. coli counts from the most recent stormwater samples is provided in Appendix C. Table 26 contains E. coli concentrations from the current Stormwater Sampling Program.

Table 26 – E. coli

Sampling Site	E. coli (CFU/100 mL)		
	Current Program[1]		
	7/25/2007	2/18/2008	Mean
Bluffton Village	150	660	405
Verdier Cove at Heyward St	14	390	202
Rose Dhu Creek	770	1000	885
Stoney Creek	2400	2400	2400
May River Rd @ Huger Cove	240	410	325
May River Rd @ Guerrard Cove	42	1700	871

(1) Four samples of current program

**NURP did not provide concentrations for e.coli

**E. coli was not included in the 2005-2006 Stormwater Sampling Program carried out in the Town

PALMETTO BLUFF MONITORING PROGRAM

4.1 Background

Palmetto Bluff is a private development located along the southern edge of the May River. Recognizing the potential for development to impact the River, officials at Palmetto Bluff have been conducting an extensive sampling program at numerous sites throughout the development. There are two main goals of this sampling program: to determine the natural nutrient and fecal coliform levels present in stormwater runoff from this area, and to determine whether the development (in this case the May River Golf Course) is increasing these natural loads. Palmetto Bluff retained the services of HSA Engineers and Scientists (HSA) to collect and analyze the grab samples.

Water quality monitoring at Palmetto Bluff has evolved over the past year to better address concerns about golf course runoff from the May River Golf Course Hole #7.

4.1.1 Overview of Monitoring Program

The following sections discuss the different components of the overall Palmetto Bluff Monitoring Program.

4.1.1.1 Stormwater Best Management Practice (BMP) Monitoring

Stormwater best management practices (BMPs) include retention ponds, detention ponds, catchments, constructed wetlands and any other technique implemented in order to provide some treatment for stormwater before it is discharged from an area. There are several such BMPs in place throughout the Palmetto Bluff development, two of which are included as part of the overall monitoring program in order to establish a baseline of water quality data for the BMPs (represented by Stations 3, 12 and 7).

The initial monitoring took place adjacent to May River Golf Hole #7, in a manmade catchment pond (Station 3) which releases its overflow into a drainage canal. The freshwater pond is designed to capture runoff from the golf course and upland areas, and provide time for pollutants to settle and filter out of the stormwater, prior to discharging into tidal creeks and the May River. The idea of the original testing was to gain an understanding of what, if any, nutrients were coming from the course. Station 12 is a rip rap drainage area which can only be sampled after heavy rainfall. This site was added to determine natural runoff loads prior to entering the catchment area.

Monitoring also occurs at the discharge from the large stormwater lagoon in the Palmetto Bluff Village (Station 7). The stormwater lagoon allows for the settling and filtration of pollutants similarly to Station 3; however, the lagoon contains a much larger volume of water and has a longer retention time, thus pollutant removal from this BMP is significantly higher than from Station 3. Monitoring at Station 7 provides nutrient and pollutant loads from another stormwater BMP system.

At this time there are no State or Federal regulations that provide numerical criteria for nutrients or other pollutants in freshwater or stormwater runoff. Stations 3, 12 and 7 provide good baseline data for stormwater best management practices; however, the more specific monitoring outlined below provides data for determining upland runoff, and runoff associated with Golf Hole #7.

4.1.1.2 May River Monitoring

Palmetto Bluff implemented additional monitoring in the May River directly north and south of the mouth of the Golf Hole #7 tidal creek (Stations 9 and 10) to more closely investigate if there are increased nutrients that may be associated with the golf course. Data indicate that there are not increased phosphorous or nitrogen levels at these locations.

Using in-stream qualitative results from the SCECAP report as a benchmark, data from the station closest to this hole showed consistently low nutrient loads, indicating there are not increases associated with the nearby golf course.

Palmetto Bluff has also monitored four locations in the May River (M1, M2, M3 and M4) since 2002. Stations M1 and M2 are located downstream of Palmetto Bluff and upstream of Palmetto Bluff, respectively. Stations M3 and M4 are located upstream of Palmetto Bluff and the Town of Bluffton, with M4 being the most upstream site. No updates to the data provided in the second progress report were available at the time this report was written. The data that has been available for previous reports indicates that the May River is an overall healthy aquatic ecosystem, and does not appear to have been adversely impacted by Palmetto Bluff. The data collected at sites M1 through M4 through August 2007 is included as Attachment 33.

4.1.1.3 Golf Hole #7

Questions still remained about the Golf Hole #7 drainage area, and what, if any, nutrients were coming from the catchment area into the tidal creek. Palmetto Bluff began monitoring at the mouth of the drain, where the freshwater from the catchment pond and upland enter the tidal creek (Station 1); in the main channel of the tidal creek just off the golf hole (Station 2); and downstream of the golf hole, halfway between the hole and the May River (Station 8).

At the same time, Palmetto Bluff chose a control site, a location similar in nature to the golf hole drainage area, but with no site development nearby (Station 6). This Station provides a clear benchmark of runoff, and naturally-occurring pollutant and nutrient loads. A statistical analysis was conducted for each water quality parameter between the control and stations 1 and 2. The results of this analysis are provided in Attachment 34. At this time, there are no statistically significant differences between the sites.

Most recently, they agreed to conduct an additional test (atrazine, which was recommended by Dr. Geoff Scott of NOAA) which will clarify whether the nutrients that are present are due to man-made causes or are natural. In this case, atrazine was not detected in any of the samples, thus providing further data that indicates that the nutrient levels in stormwater discharging from Palmetto Bluff are naturally-occurring. The complete lab report from the atrazine analysis is provided in Attachment 35. Attachment 36 contains fertilization records and soil sampling results discussed in the sections regarding phosphorous and nitrogen.

Figure 2 on the next page is a map illustrating the water quality monitoring locations at Palmetto Bluff discussed above. Points include data collected by HSA (S locations) and Shealy (M locations), as contracted by Crescent Resources. Locations include representative samples for the May River (9, 10, M1, M2, M3, M4), the May River Golf Course (1, 2, 8), Stormwater BMPs (i.e., freshwater grabs; 3, 7, 12), and a control (6).

4.1.2 Monitoring Summary and Results

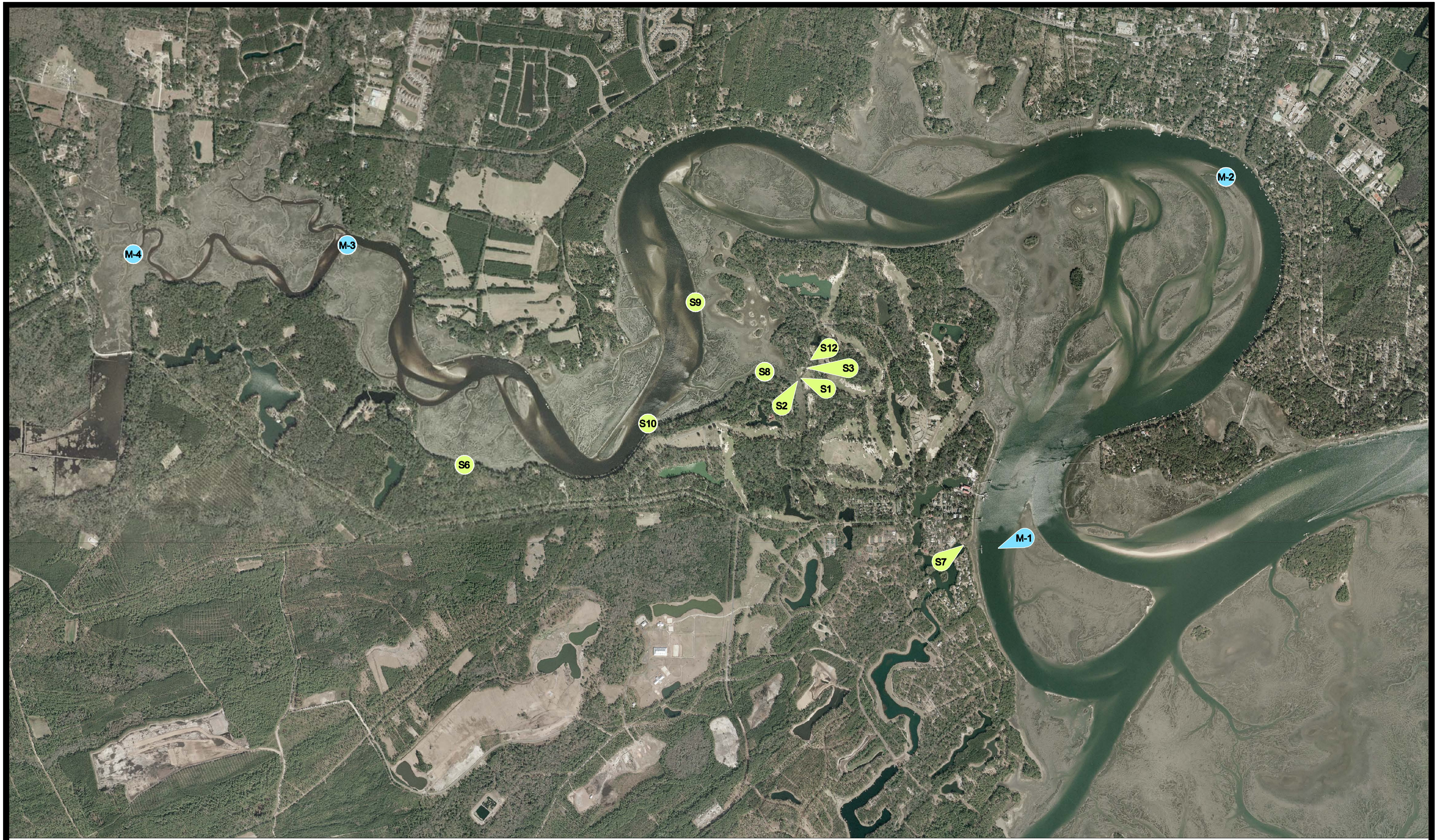
Comparative data and statistical analyses indicate that, at this time, there is no impact to the May River from the May River Golf Course. In fact, the nutrient and pollutant loads in runoff coming directly from the golf course into the adjacent creek are not significantly different from nutrient and pollutant loads in runoff from undeveloped areas.

4.1.2.1 Turbidity

The average turbidity levels detected at Stations 3 and 7 for the past year of sampling were 5.3 NTU and 3.2 NTU respectively. Only one sample was collected at station 12, with a turbidity of 12.9 NTU.

The samples collected within the tidal creeks, at Stations 1, 2 and 8, contained average turbidity levels of 7.3 NTU, 11 NTU and 5.1 NTU, respectively. These are comparable to the average turbidity readings at the control site, which was 7.0 NTU.

As sampling moved outward into the May River itself, at Stations 9 and 10, the turbidity levels greatly decreased from what was found in the tidal creeks. The average turbidity levels at Stations 9 and 10 were 3.8 NTU and 4.4 NTU, respectively.



SCALE IN FEET
1" = 2000'

0 1000 2000 3000 4000 8000

Printed: March 24, 2008

GPS COORDINATES - MARCH 2008

PALMETTO BLUFF

BLUFFTON, SOUTH CAROLINA

NORTH

All turbidity readings were below the state saltwater standard of 25 NTU. Although this limit does not directly apply to the sampling sites in this program, it is appropriate to use as a general comparison tool.

A summary of the average turbidity levels in samples collected from Palmetto Bluff is provided in Table 27. Appendix D contains a plot of the turbidity levels detected at Stations 1, 2, 3, 6, 7, 8, 9, 10 and 12.

Table 27 - Turbidity Concentrations

Station	Turbidity (NTU)
	Average
1	7.3
2	11.0
3	5.3
6	7.0
7	3.2
8	5.1
9	3.8
10	4.4
12	12.9

4.1.2.2 Total Phosphorous

The average phosphorous concentrations at Stations 3 and 7 were 0.378 mg/L and 0.042 mg/L, respectively. Only one sample was collected at station 12, with a phosphorous concentration of 0.230 mg/L.

Within the tidal creeks of Palmetto Bluff, at Stations 1, 2 and 8, the average phosphorous concentrations were 0.097 mg/L, 0.227 mg/L and 0.038 mg/L, respectively. Compared to the control site, which had an average phosphorous concentration of 0.067 mg/L, two of these concentrations are higher, particularly at Station 2. Statistical analyses indicate, however, that this increase is not statistically significant. Additionally, golf course fertilizer records show no phosphorous has been applied in 17 months, indicating that fertilizer is not the source of the phosphorous detected in grab samples. As discussed previously, Palmetto Bluff also collects soil samples for analysis (Attachment 36), which demonstrate that phosphorous is naturally abundant in the soils of the development.

As sampling moved further away from the upland and into the May River, phosphorous concentrations decreased significantly, to 0.038 mg/L at Stations 9 and 10. This concentration is equal to the concentration found at Station 8. All of the data collected to date appears to indicate that the phosphorous detected in samples from Palmetto Bluff are naturally-occurring, and are not being increased by activity from the golf course. The results of the atrazine tests further support this.

A summary of the average phosphorous concentrations in samples collected from Palmetto Bluff is provided in Table 28. Appendix D contains a plot of the total phosphorous concentrations detected at Stations 1, 2, 3, 6, 7, 8, 9, 10 and 12.

Table 28 - Phosphorous Concentrations

Station	Total Phosphorous (mg/L)
	Average
1	0.097
2	0.227
3	0.378
6	0.067
7	0.042
8	0.038
9	0.038
10	0.038
12	0.230

4.1.2.3 Total Nitrogen

Total Nitrogen is the sum of total Kjeldahl nitrogen (TKN) and nitrate and nitrite nitrogen. The average Total Nitrogen concentrations at Stations 3 and 7 were 1.08 mg/L and 0.185 mg/L, respectively. The sample collected at Station 12 was found to have a Total Nitrogen concentration of 0.230 mg/L.

At the sampling sites located within tidal creeks, Stations 1, 2 and 8, the Total Nitrogen concentrations were 0.548 mg/L, 0.373 mg/L and 0.497 mg/L, respectively. Compared to the control site, which had an average Total Nitrogen concentration of 0.537 mg/L, these averages appear to be comparable. In addition, the statistical analyses indicate that there is not a significant difference between the Total Nitrogen concentrations at the control site and those at Stations 1, 2 and 8. This information, in conjunction with the fertilization schedule provided by Palmetto Bluff which indicates no nitrogen has been applied to the golf course in seven months, indicates that the nitrogen in these samples is likely naturally-occurring. The results of the atrazine tests further support this.

The Total Nitrogen concentrations within the May River at Stations 9 and 10 were 0.454 mg/L and 0.595 mg/L, respectively.

A summary of the average nitrogen concentrations in samples collected from Palmetto Bluff is provided in Table 29. Appendix D contains a plot of the Total Nitrogen concentrations detected at Stations 1, 2, 3, 6, 7, 8, 9, 10 and 12.

Table 29 - Nitrogen Concentrations

Station	Total Nitrogen (mg/L)
	Average
1	0.548
2	0.373
3	1.080
6	0.537
7	0.185
8	0.497
9	0.454
10	0.595
12	0.230

4.1.2.4 Fecal Coliform

The average fecal coliform concentrations at the stormwater BMP stations, Stations 3 and 7, were 521 CFU/100mL and 237 CFU/100mL, respectively. The sample collected at Station 12 had a fecal coliform concentration of >400 CFU/100mL.

The tidal creek sampling sites, Stations 1, 2 and 8, had fecal coliform concentrations of 236 CFU/100mL, 830 CFU/100mL and 176 CFU/100mL, respectively. Compared to the control site, with an average fecal coliform concentration of 326 CFU/100mL, the concentration at Station 2 appears to be higher. However, there were no significant differences detected among the control, the May River Stations, and the golf course stations for fecal coliform levels. In addition, septic systems are not used throughout Palmetto Bluff, thus the presence of wildlife is likely the source of the fecal coliform. Further, there are only a couple of unoccupied houses under construction in this area; therefore, no pets are present to contribute to the fecal coliform load.

As sampling moved further into the May River, the fecal coliform concentrations decreased. At Stations 9 and 10 the average fecal coliform concentrations were 32 CFU/100mL and 256 CFU/100mL, respectively.

A summary of the average fecal coliform concentrations in samples collected from Palmetto Bluff is provided in Table 30. Appendix D contains a plot of the fecal coliform concentrations detected at Stations 1, 2, 3, 6, 7, 8, 9, 10 and 12.

Table 30 - Fecal Coliform Concentrations

Station	Fecal Coliform (CFU/100mL)
	Average
1	236
2	830
3	521
6	326
7	237
8	176
9	32
10	256
12	>400

4.1.2.5 Salinity

Salinity levels for Stations 9 and 10 are statistically different from the control (Station 6) and the stormwater (freshwater) BMP at golf hole #7 (Station 3). Further, Stations 1, 2, 8, and 6 are statistically different from the freshwater BMP at golf hole #7 (Station 3), indicating that salinity levels are maintained at the upland sections of the tidal creeks at the golf course and the control. Additionally, we have not observed any changes in natural salinity levels and fluctuations at individual stations over time. Monitoring of run-off potential will continue.

In other words, May River sampling locations (Stations 9 and 10) and tidal creek stations around the golf course (Stations 1, 2, and 8) continue to exhibit natural elevations in salinity levels relative to the freshwater BMP station (Station 3). Therefore, current data indicate that fresh water run-off from golf hole #7 is not altering the salinity levels in the tidal creek or the May River.

Salinity analysis results are presented in Appendix D. In addition, Appendix D contains a plot of the salinity levels at each station for reference purposes, and Table 31 contains a summary of the average salinity levels at each Station.

Table 31 - Salinity

Station	Salinity (ppt)
	Average
1	24.1
2	27.2
3	0.9
6	24.9
7	0.0
8	30.5
9	32
10	31.4
12	N/A

VOLUNTEER MONITORING PROGRAM

Due to an overwhelming interest of the citizens of the Town to actively participate in the May River monitoring program, a Volunteer Monitoring Program was implemented in January of 2006. Volunteer data is useful as it illustrates general trends over time at each particular site. Due to the subjectivity of the monitoring process for many of the parameters, it is not appropriate to compare data from one site to another, nor to compare the volunteer data to any other data collected by the Town, such as that collected through the Continuous Monitoring Program. The program can however be used to look at overall trends at each individual site and is a very useful program carried out by volunteers.

The eight sites that have been monitored as part of this program are labeled Mouth of May River, All Joy Landing, Crystal Beach, Palmetto Beach, Calhoun St. Dock, Palmetto Bluff/Osprey Alley, Rose Dhu Creek and Stoney Creek. All of these sites are shown on Figure 1. The parameters being monitored at these sites include water clarity, salinity, pH, air temperature, water temperature and dissolved oxygen. Volunteers have been instructed to monitor at their respective sites every Friday; the intent of this was to provide some consistency in the results. Tidal influences have not been taken into account in this monitoring program as the volunteers are not always able to sample at the same point in the tidal cycle. After collecting the data, volunteers are able to enter it on the South Carolina Oyster Restoration and Enhancement (SCORE) Program website. The SCORE Program is hosted by the South Carolina Department of Natural Resources (DNR).

Tables 32 and 33 contain the minimum, maximum and average values of each of the water quality parameters at each site. This data was collected from the SCORE website. Graphs of this data are provided in Appendix E. Some of the volunteers were able to monitor for dissolved oxygen and pH at a few of the sites, however this data is not available for all sites.

Table 32 - Volunteer Monitoring Data

Site #	Site Name	Water Clarity (cm)			Salinity (ppt)			pH		
		Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
1	Mouth of May River	37.3	54.6	43.6	29	48.4	34.1	N/A	N/A	N/A
2	All Joy Landing	32.5	260	75.6	24	35	30.8	7.6	7.9	7.7
3	Crystal Beach	7.5	120	60.4	24	46.5	31.2	N/A	N/A	N/A
4	Palmetto Beach	24	186	84	2.7	31	24.3	N/A	N/A	N/A
5	Calhoun St Dock	47.5	260	134.9	25	34	30	7	8.25	7.5
6	Palmetto Bluff/Osprey Alley	17	120	51.9	14	35	27.2	N/A	N/A	N/A
7	Rose Dhu	6.5	105	39	7.5	36	24.7	N/A	N/A	N/A
8	Stoney Creek	10.5	87	39.5	7.5	35	25.3	N/A	N/A	N/A

Table 33 - Volunteer Monitoring Data (Cont.)

Site #	Site Name	Air Temperature (°C)			Water Temperature (°C)			Dissolved Oxygen (mg/L)		
		Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
1	Mouth of May River	11.4	30	24.3	13.8	28.5	19.8	14.5	17.5	16
2	All Joy Landing	5	41	22.7	10	31.6	21.3	4.5	12.75	6
3	Crystal Beach	6	36	22.7	10.5	32.7	22.3	N/A	N/A	N/A
4	Palmetto Beach	13.8	32.7	23.6	13	31.3	25.1	N/A	N/A	N/A
5	Calhoun St Dock	13	33.5	22.4	10	32	22.4	4.5	9	6.3
6	Palmetto Bluff/Osprey Alley	4	33	21.1	9	33	22.2	6.1	6.1	6.1
7	Rose Dhu	7	35	22.2	9	33	22.2	3.2	27	7
8	Stoney Creek	3	35	22.2	8	32.5	22.6	3.7	5.3	4.5

CONCLUSIONS AND RECOMMENDATIONS

The data obtained through the 2007 Continuous Monitoring Program conducted in the May River has established baseline data for the May River in each distinct zone as well as seasonal fluctuations. With the conclusion of the 2007 Continuous Monitoring Program, the Town is now supplied with a comprehensive data set of several parameters in the May River for one full year. This comprehensive data set will be invaluable in providing insight into the baseline conditions of the river as well as seasonal trends and fluctuations.

The results of the two stormwater samples collected indicated that most of the pollutants present in runoff from the Town's drainage system are present in concentrations similar to those found in the NURP report and the previous stormwater sampling study conducted in the Town. The Town now has a data set with thirteen wet weather events for a limited number of sampling sites representative of local stormwater runoff. Additionally, the wet weather event sampling conducted by Palmetto Bluff is representative for this region as well.

The selection of a control site at Palmetto Bluff has provided nutrient and fecal data that is more appropriate to be used as a comparison with samples taken from other sampling sites around the development. In addition, the use of the data collected in the open water portions of the May River has proven helpful in determining the overall effects of Palmetto Bluff on the May River. Statistical analyses have also been performed by Palmetto Bluff staff on the data in order to determine whether the observed elevations were statistically significant and therefore considered biologically consequential. All data collected thus far seems to indicate that stormwater runoff discharging from Palmetto Bluff is not adversely impacting the May River. A baseline is continuing to be developed which will provide a more comprehensive overview of the quality of water discharging from Palmetto Bluff.

Volunteer Monitoring Program was implemented in January of 2006. Volunteer data is useful as it illustrates general trends over time at each particular site. Due to the subjectivity of the monitoring process for many of the parameters, it is not appropriate to compare data from one site to another, or to compare the volunteer data to any other datasets. The program can however be used to look at overall trends at each individual site and is a very useful program carried out by volunteers.

The results of all monitoring programs are positive and indicate that the May River is an overall healthy aquatic ecosystem. Now that the Town has made significant progress towards the recommendations set forth in the Baseline Study and the County Master Plan by: 1) conducting stormwater sampling in the tidal creeks and tributaries and 2) establishing a baseline and seasonal trends; it is recommended that the Town have all of the available datasets statistically analyzed to determine needs for future monitoring and determine if a water quality prediction model can be developed. During this study, it was determined that there are numerous additional datasets from various agencies. Recommendations were made to the Town to form a Technical Advisory Committee composed of all these agencies that have studied the May River area.

Long-term recommendations concerning future monitoring efforts will be made after the statistical analyses of all available data through the Technical Advisory Committee. Another initial recommendation is to evaluate the relationship between upland development patterns and water quality to determine if a predictive model can be developed. The strong desire of citizens of the Town, as well as officials of the Town and Palmetto Bluff, to work together to protect the high quality of water in the May River is essential to the success of this program. A cooperative effort among all entities which impact the May River is necessary in order to maintain the high level of water quality in the River.

Currently the Technical Advisory Committee is in the data inventory phase. Through a statistical analyses of the data, it can be determined if there have been significant changes in the condition of the May River since the Baseline Study. The evaluation should also address potential concerns noted in the continuous monitoring program such as the shorter salinity recovery period for heavy rain events in the headwaters as well as the lower DO during the summer months. To determine if a change is significantly different, consideration must be given to the range of values and deviation and must not be based solely on comparison of mean values. This statistical analysis will provide an assessment of the watershed and identify data gaps. From the watershed assessment, the Town could develop a watershed management plan which will identify stressor areas and outline management practices to protect the watershed.

The Town has already made great progress towards a watershed management plan. The Town has just finished a year-long process of collaboration with South Carolina Department of Health and Environmental Control's Office of Ocean and Coastal Resource Management (DHEC OCRM) in creating a Waterbody Management Plan, which incorporates many of the elements of a Waterbody Management Plan, but is much more narrowly focused, i.e. the May River and land immediately adjacent. "Considerable information and data had been collected on and about the environment, ecology, habitats, and physical parameters of the May River and its watershed. However, this information had not been previously consolidated and summarized in one document specific to the manner and extent in which people utilize the River. The Waterbody Management Plan for the May River provided an opportunity for the compilation and review of existing information from a variety of sources, and analysis based on goals and objectives established for the project. This analysis resulted in the identification of potential issues and conflicts between users, user groups, and the environmental conditions that were identified for protection. Ultimately the Waterbody Management Plan identified specific tasks and recommendations that should be implemented over the next five years that would be the most likely to achieve the various Project Goals and Objectives."

A watershed management plan is a strategic work plan for achieving water resource goals that provides assessment and management information for a watershed. It includes the analyses, actions, stakeholders, and resources related to development and implementation of the plan. The watershed planning process uses a series of cooperative, iterative steps to characterize existing conditions; identify and prioritize problems; define management objectives; and develop and implement protection or remediation strategies as necessary. The Town has initiated this watershed planning process by building relationships through the Technical Advisory Committee.

If the Town decides to expand the recently developed Waterbody Management Plan into a Watershed Management Plan, EPA has two important tools that may be utilized to assist with the development and implementation of a watershed plan to meet water quality standards and protect water resources. The *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* is designed to help with the watershed planning effort and is particularly useful for working with impaired or threatened waters. The *Watershed Plan Builder* is an online tool designed to help get started on developing a watershed plan by guiding through a series of questions designed to collect information about the watershed. The information provided would be the basis for a customized watershed plan outline. The outline includes recommended content to be included in the various sections of the watershed plan, as well as related data links and contact information. The outline can then be used to work through the watershed planning process with stakeholders to create a comprehensive watershed management plan.

It is also recommended that the Town continue the septic tank inspection program and prioritize the program using the stormwater sampling data, as well as the identified "hot spots". The stormwater sampling data indicates that the Town should focus on Stoney Creek, which has consistently been higher than the other sites. Additional sampling in the headwater systems should be included to better target upland sources. It is also important that flow data be collected during the wet weather sampling or some consideration be given to evaluating pollutant loading. The Town may also wish to consider a study of the benthic community to fully implement one of the recommendations of the May River baseline study.

The Town should develop and implement an Illicit Discharge Detection and Elimination (IDDE) program to complement the stormwater ordinance. The Town should complete an inventory of the stormwater outfalls, if not available, and conduct visual inspections of the outfalls during dry weather. Also, as "hot spots' are identified through the assessment, targeted sampling should be conducted to determine sources of potential pollution. Prioritization should be given to the headwaters based on available monitoring data.

For short-term recommendations prior to the completion of the statistical analyses, it is recommended that the Town:

1. Continue the continuous monitoring with the YSI sondes for a period of 5 days every other month to build on the ambient dataset. Discuss with USGS to evaluate if they can collect flow data in conjunction with this monitoring.

2. Continue to target stormwater sampling on a quarterly basis. Following the statistical analyses, some of the parameters may change. Consideration should be given to modifying the sites. It may be useful to add a reference site similar to New River Trail from the previous study which represents undeveloped water quality baseline data. It may also be useful to move the sites to collect data in areas not studied previously as well as possibly concentrate more in the headwaters area.

3. Encourage Palmetto Bluff to continue the expanded monitoring program they have implemented to provide useful data on controls, stormwater BMPs, tidal creeks and the May River.

4. Review the Volunteer Monitoring Program, establish if this need is meeting met by other sampling and determine if the volunteers' time could be better utilized through a modified monitoring program, dry weather screening through the IDDE program, etc. It will still be necessary for the volunteers to continue to observe the May River and inform the Town of any potential concerns.

REFERENCES

BP Barber and Associates, Inc., *Town of Bluffton May River Monitoring Program: Stormwater Sampling Study,* January 2007.

Bricker, S.B., C.G. Clement, D.E. Pirhalla, S.P. Orlando and D.R.G. Farrow. 1999. *National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries.* National Oceanic and Atmospheric Administration, National Ocean Service, Special Projects Office and the National Centers for Coastal Ocean Science. Silver Spring, MD, 71 p.

Chapra, Steven C, *Surface Water-Quality Modeling*, Boston: McGraw-Hill, 1997.

Sanger, D.M., et al., *A Baseline Assessment of Environmental and Biological Conditions in the May River, Beaufort County, South Carolina.* SC DNR, USGS, and NOAA, 2004.

South Carolina Department of Health and Environmental Control, Water Bureau, *Common Water Quality Indicators,* < http://www.scdhec.gov/environment/water/docs/surface.pdf>.

South Carolina Department of Health and Environmental Control, Water Bureau, *South Carolina Regulation 61-68: Water Classification and Standard,* June 2004.

Thomas & Hutton Engineering Co. and Camp Dresser McKee, Inc., *Beaufort County Stormwater Management Plan.* 2005.

United States Environmental Protection Agency, *Results of the Nationwide Urban Runoff Program: Volume I – Final Report*, December 1983.

Van Dolah, R.F, et al., *The Condition of South Carolina's Estuarine and Coastal Habitats During 2001-2002, Technical Report No. 100.* SCECAP, 2004.

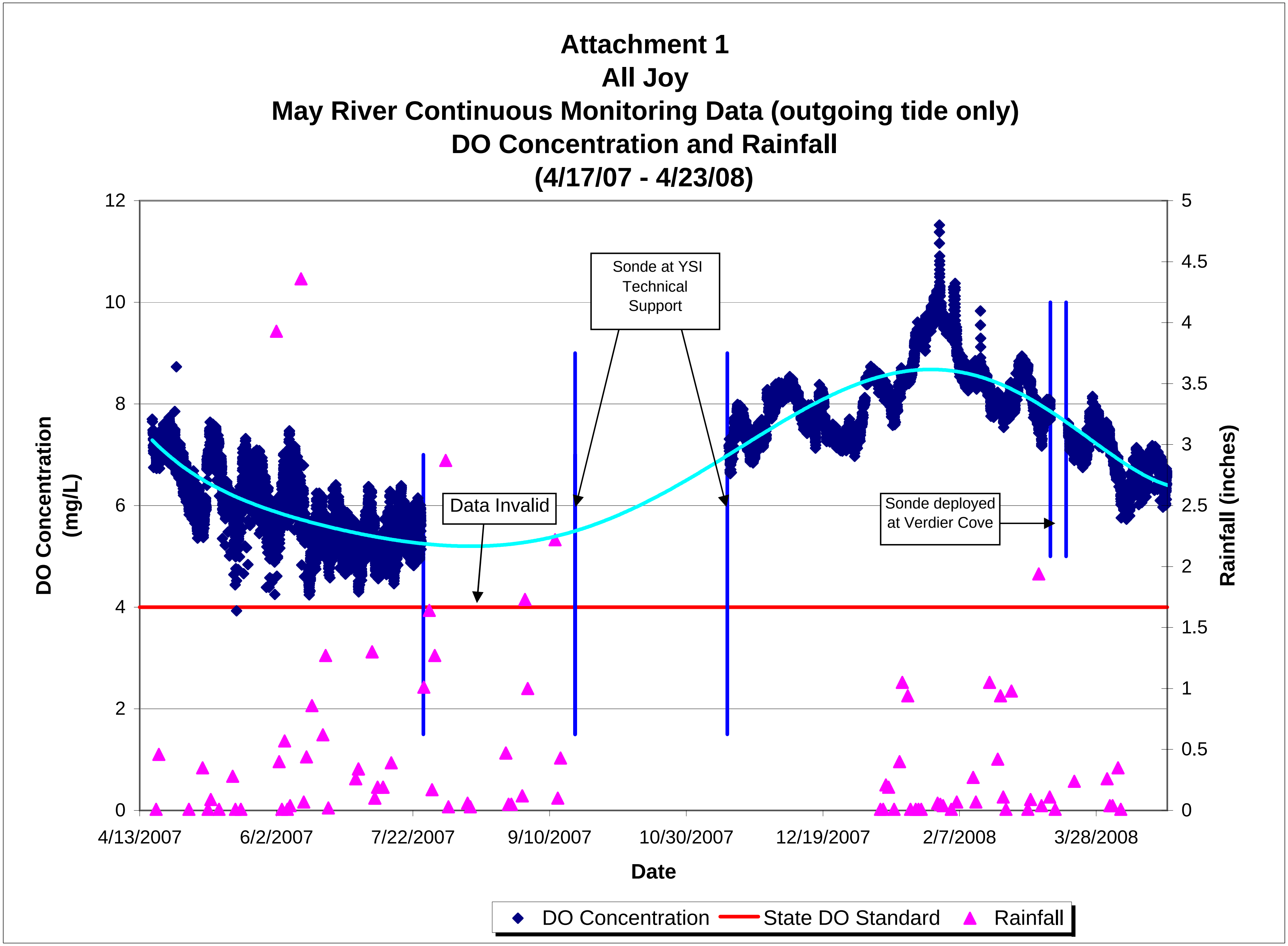
YSI Environmental, *The Basics of Chlorophyll Measurement,* 2005, <www.ysi.com>.

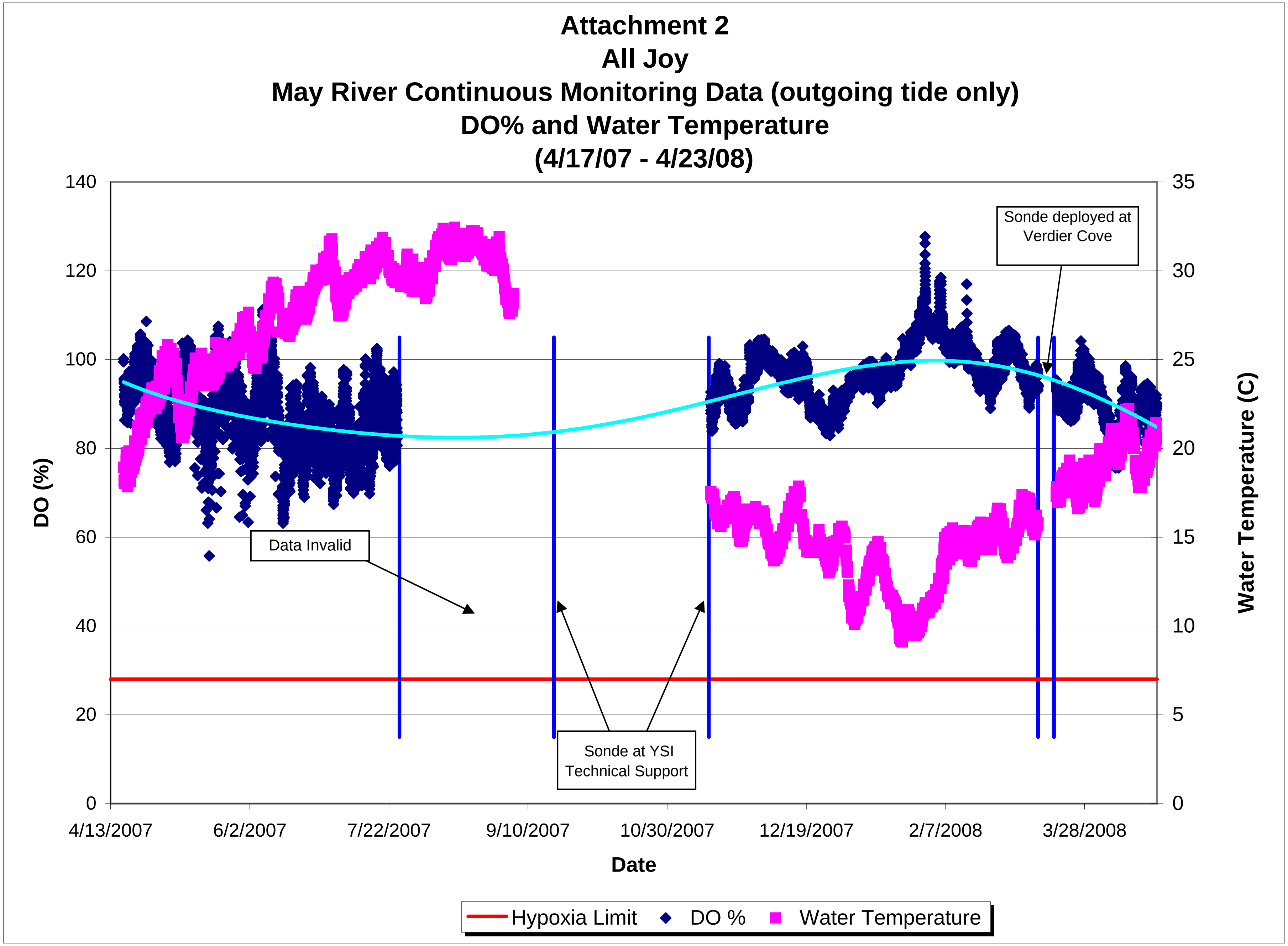
YSI Environmental, *6-Series Multiparameter Water Quality Sondes User Manual*, October 2006, <www.ysi.com.>.

South Carolina Department of Health and Environmental Control and the Town of Bluffton, *Waterbody Management Plan for the May River*, June 2008.

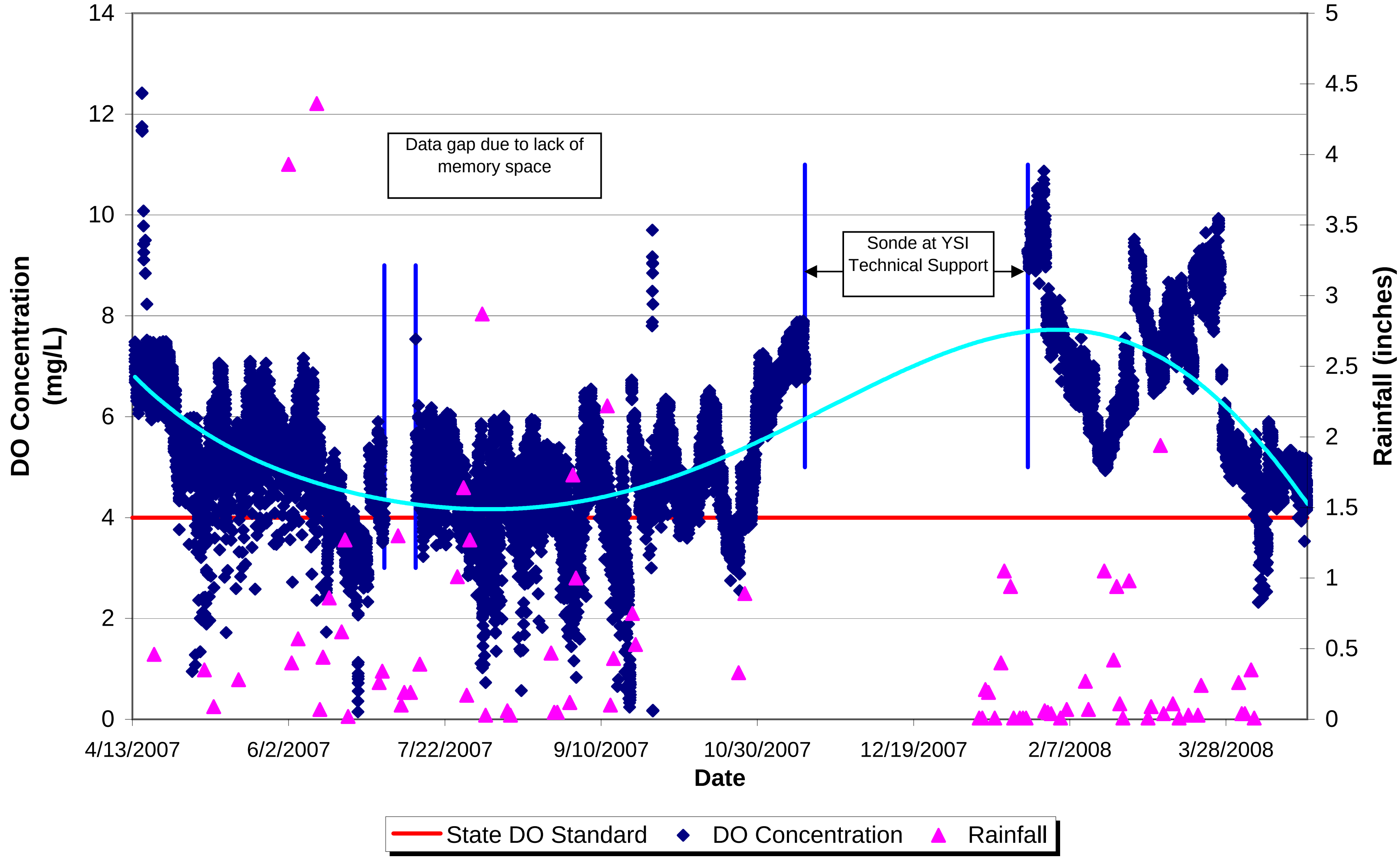
APPENDIX A

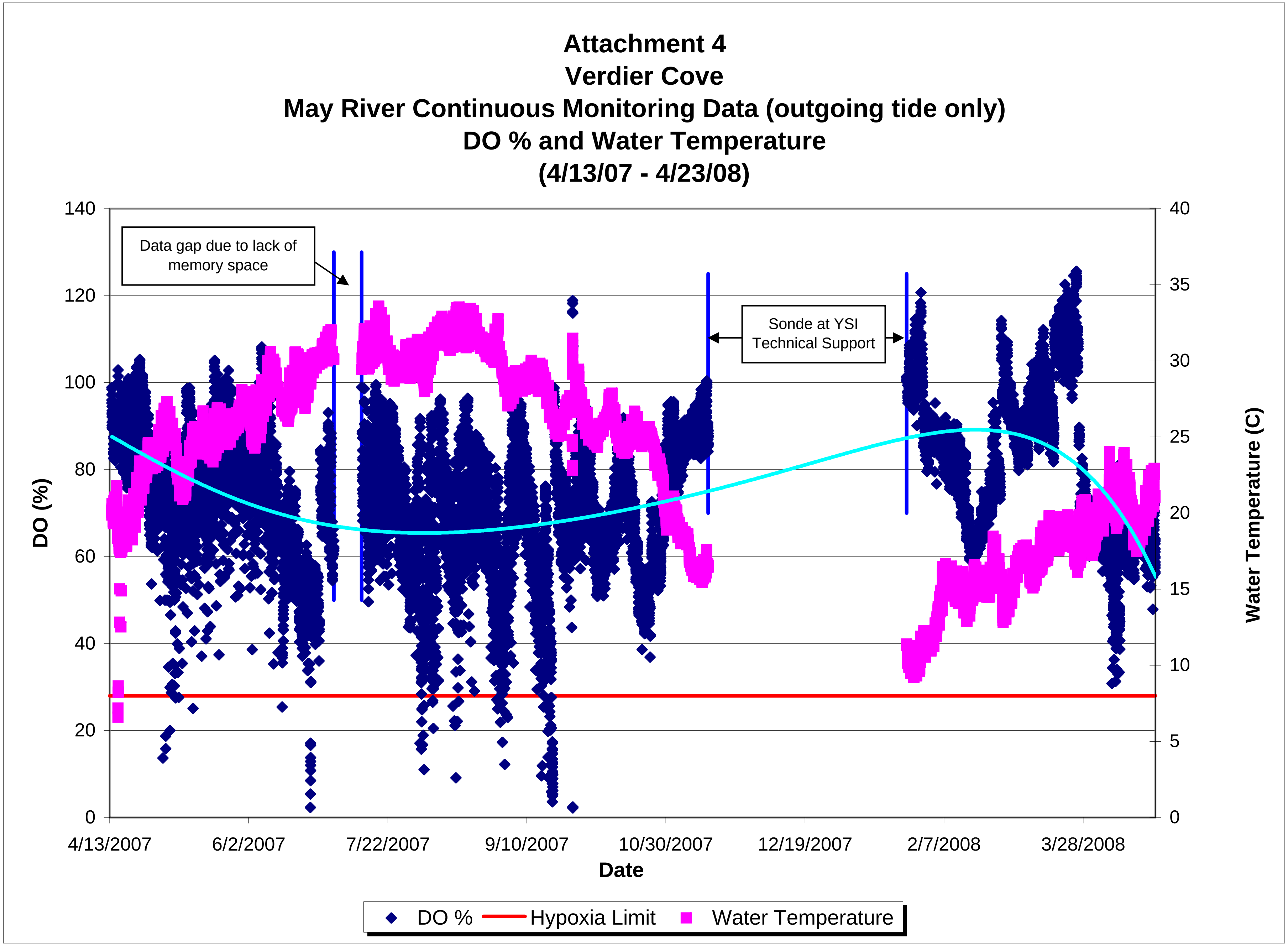
Continuous Monitoring Program Data


Attachment 1
All Joy
May River Continuous Monitoring Data (outgoing tide only)
DO Concentration and Rainfall
(4/17/07 - 4/23/08)
DO Concentration (mg/L)
Rainfall (inches)
Date
12
10
8
6
4
2
0
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Sonde at YSI Technical Support
Data Invalid
Sonde deployed at Verdier Cove
DO Concentration
State DO Standard
Rainfall


Attachment 2
All Joy
May River Continuous Monitoring Data (outgoing tide only)
DO% and Water Temperature
(4/17/07 - 4/23/08)
140
120
100
80
60
40
20
0
DO (%)
35
30
25
20
15
10
5
0
Water Temperature (C)
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Date
Data Invalid
Sonde at YSI Technical Support
Sonde deployed at Verdier Cove
Hypoxia Limit
DO %
Water Temperature

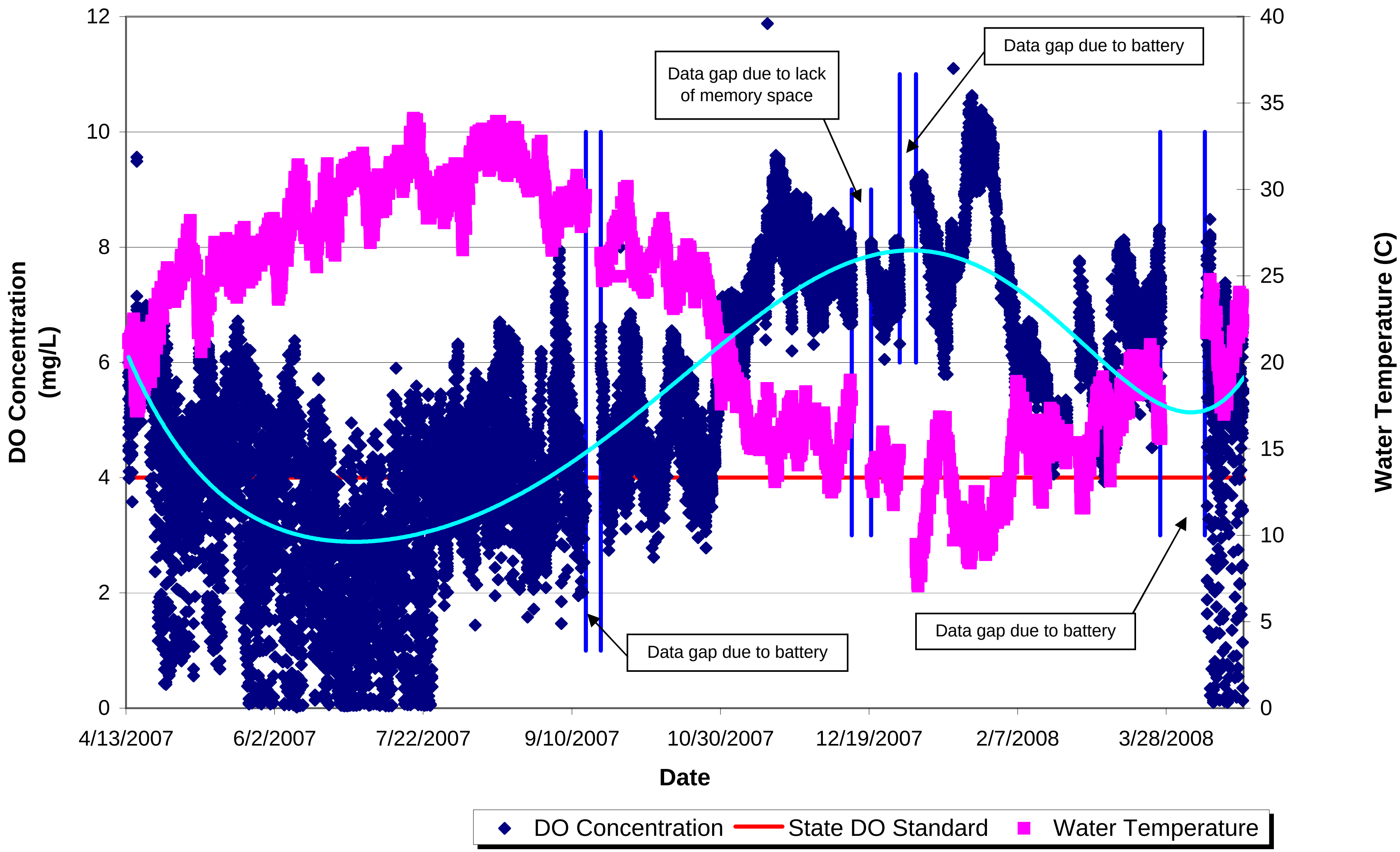
Attachment 3
Verdier Cove
May River Continuous Monitoring Data (outgoing tide only)
DO Concentration and Rainfall
(4/13/07 - 4/23/08)



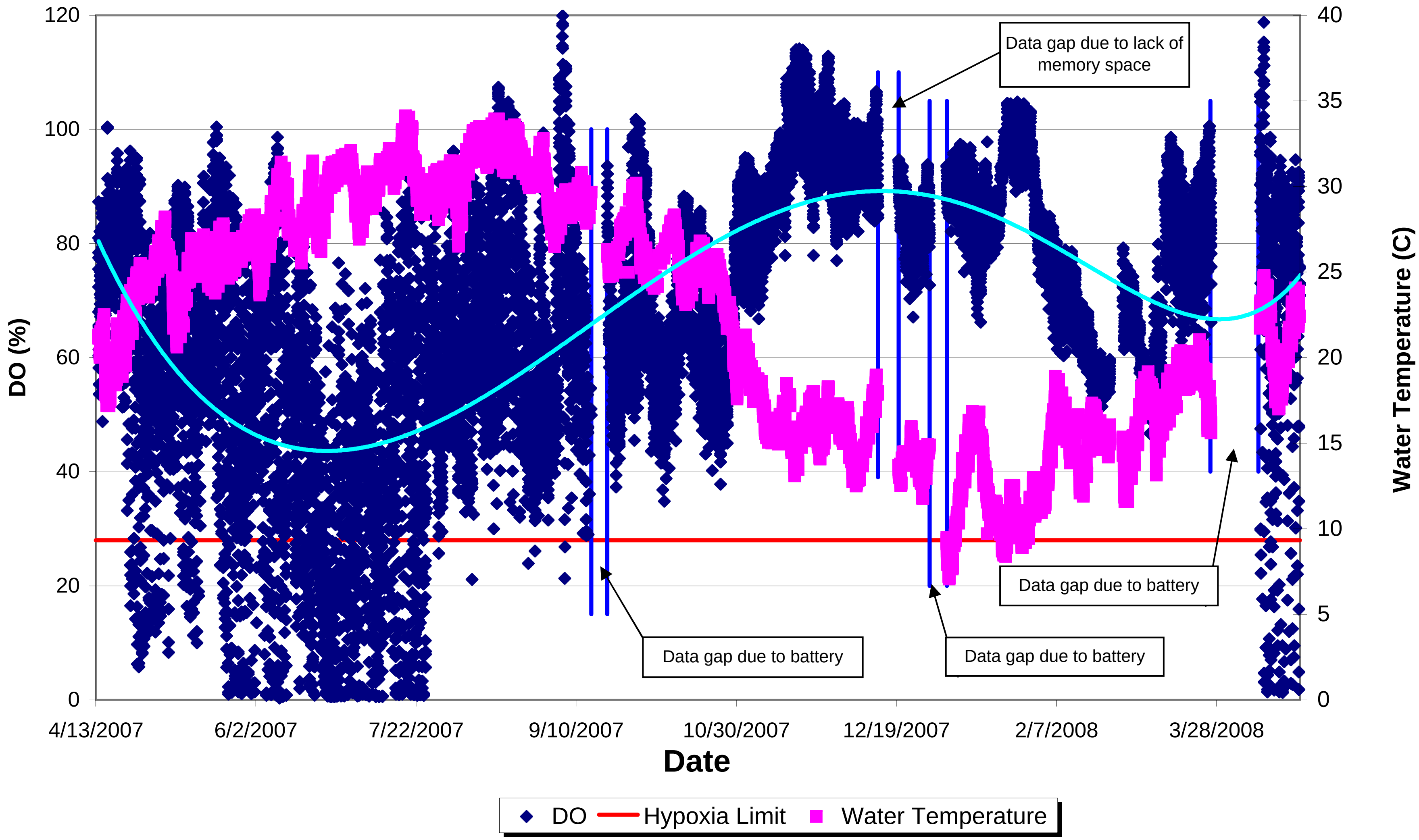


Attachment 4
Verdier Cove
May River Continuous Monitoring Data (outgoing tide only)
DO % and Water Temperature
(4/13/07 - 4/23/08)
Data gap due to lack of memory space
Sonde at YSI Technical Support
DO (%)
Water Temperature (C)
Date
140
120
100
80
60
40
20
0
40
35
30
25
20
15
10
5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
DO %
Hypoxia Limit
Water Temperature

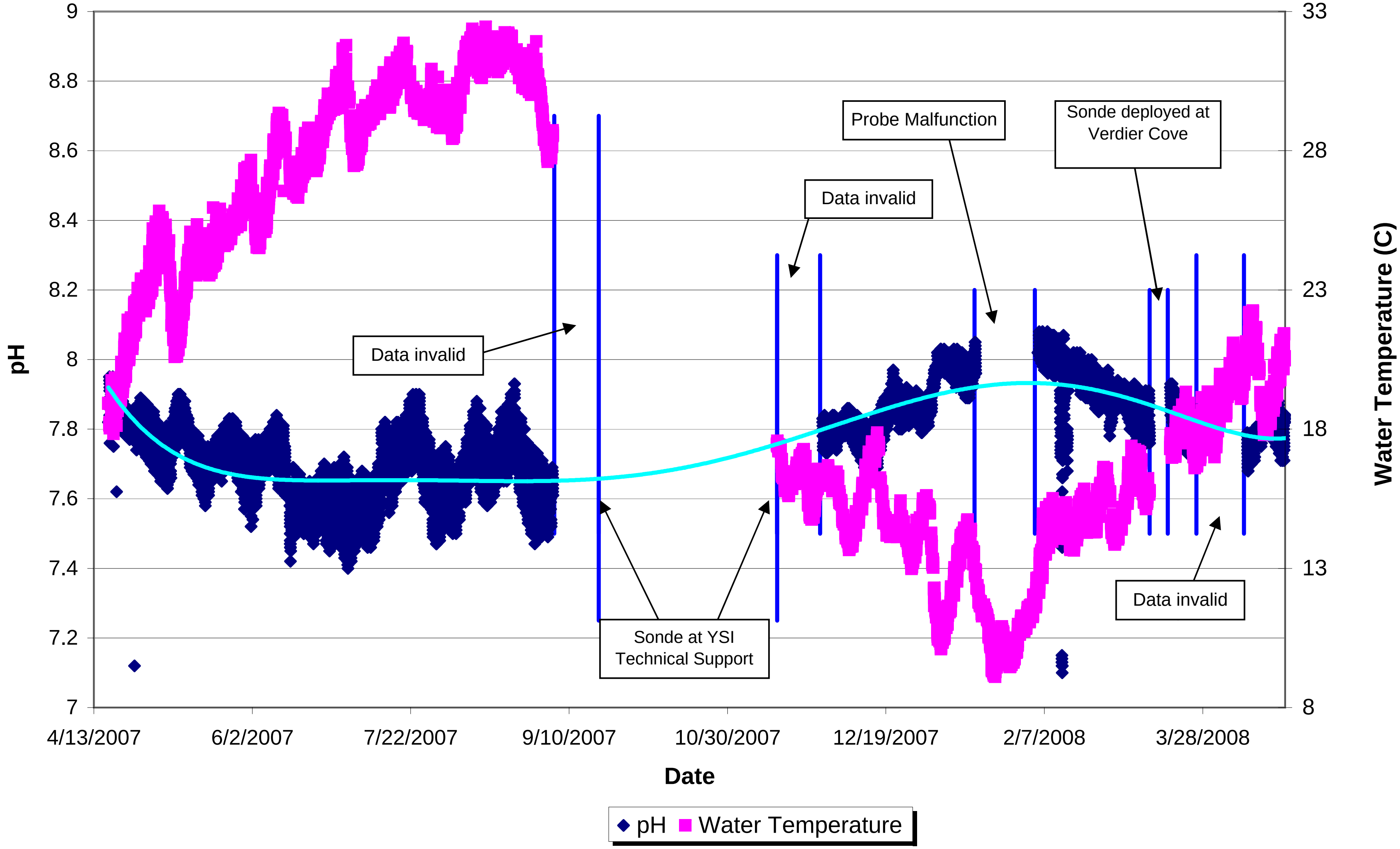
Attachment 5
Rose Dhu
May River Continuous Monitoring Data (outgoing tide only)
DO Concentration and Water Temperature
(4/13/07 - 4/23/08)



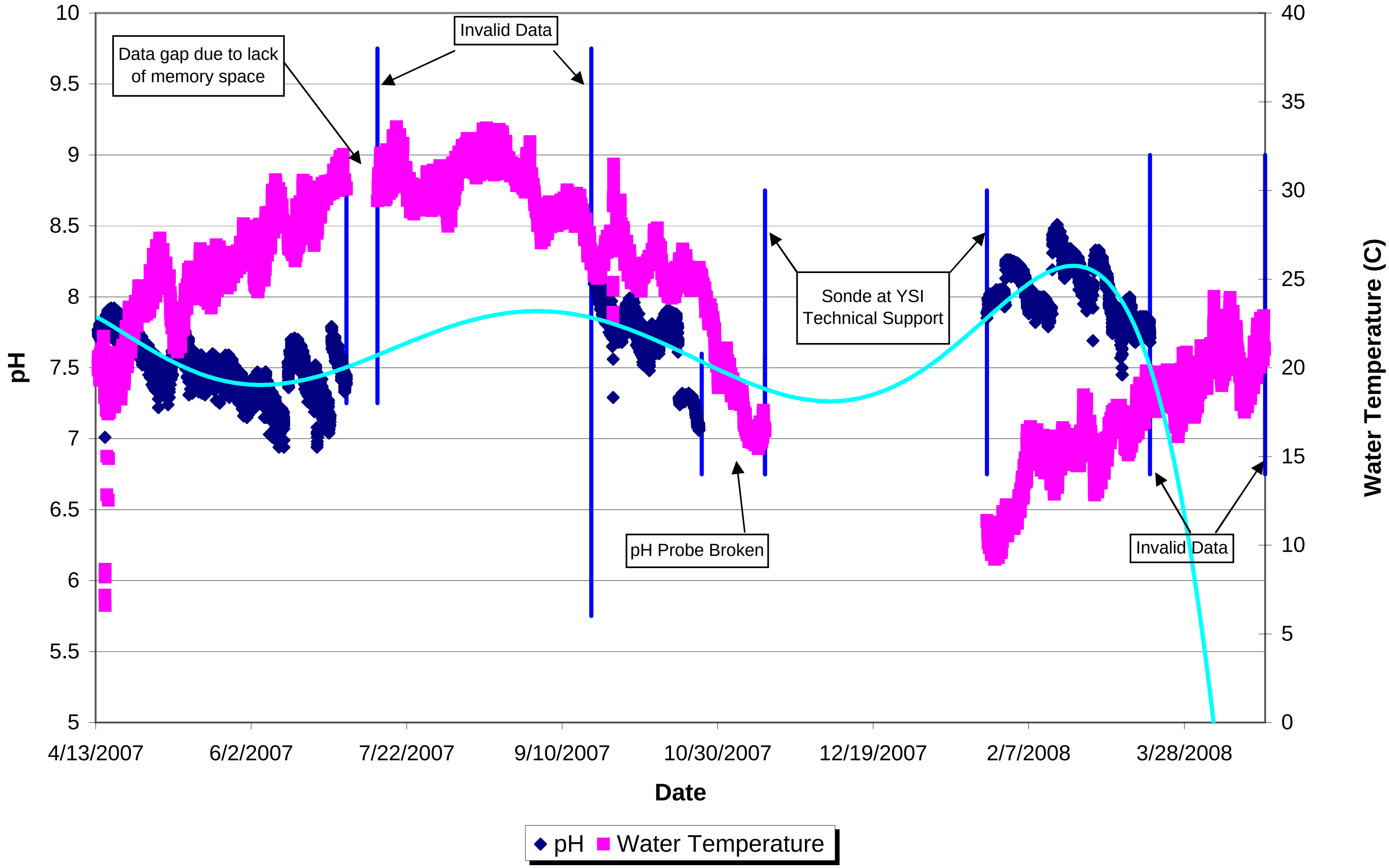
Attachment 6
Rose Dhu
May River Continuous Monitoring Data (outgoing tide only)
DO% and Water Temperature
(4/13/07 - 4/23/08)

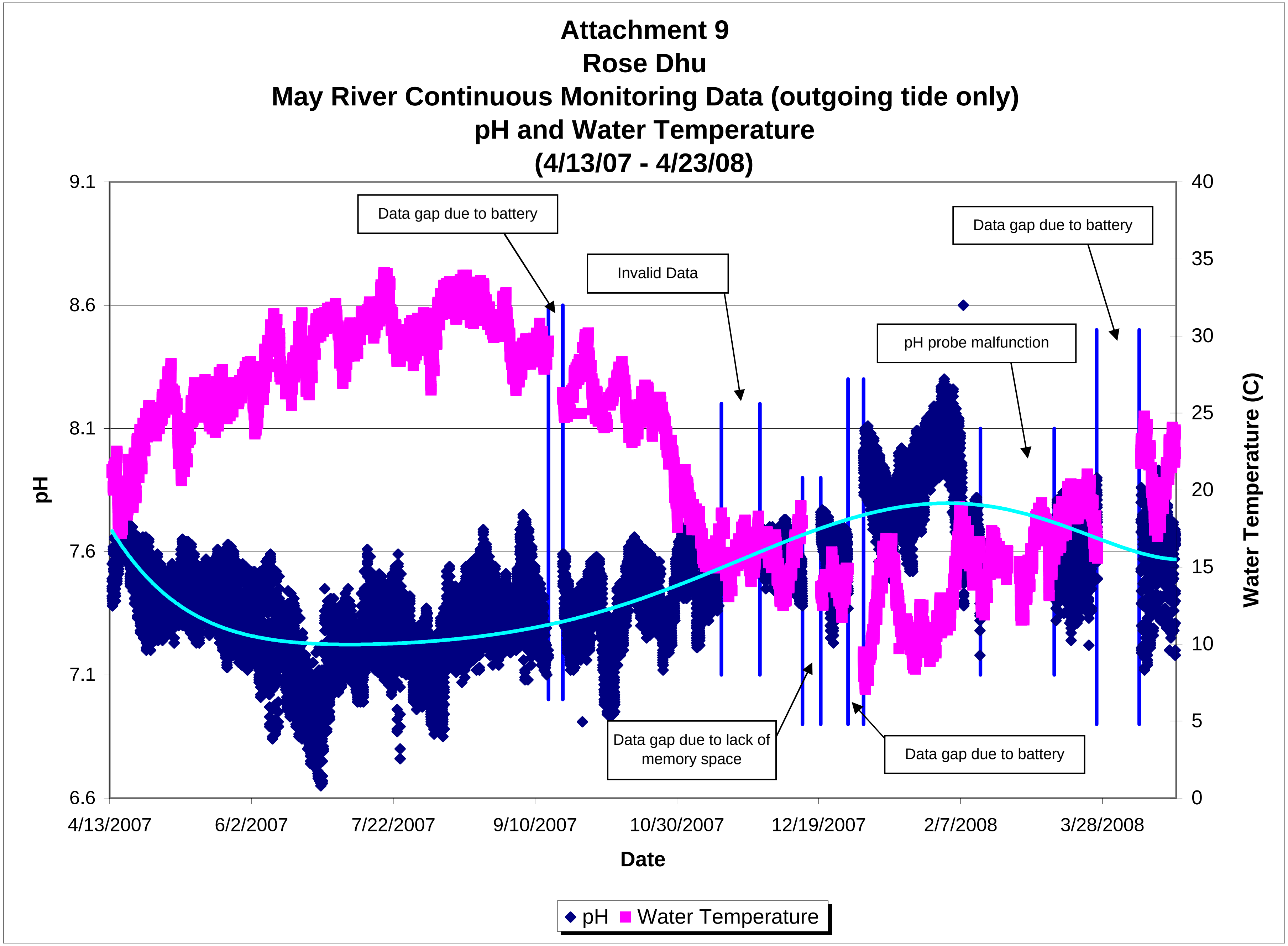


Attachment 7
All Joy
May River Continuous Monitoring Data (outgoing tide only)
pH and Water Temperature
(4/17/07 - 4/23/08)

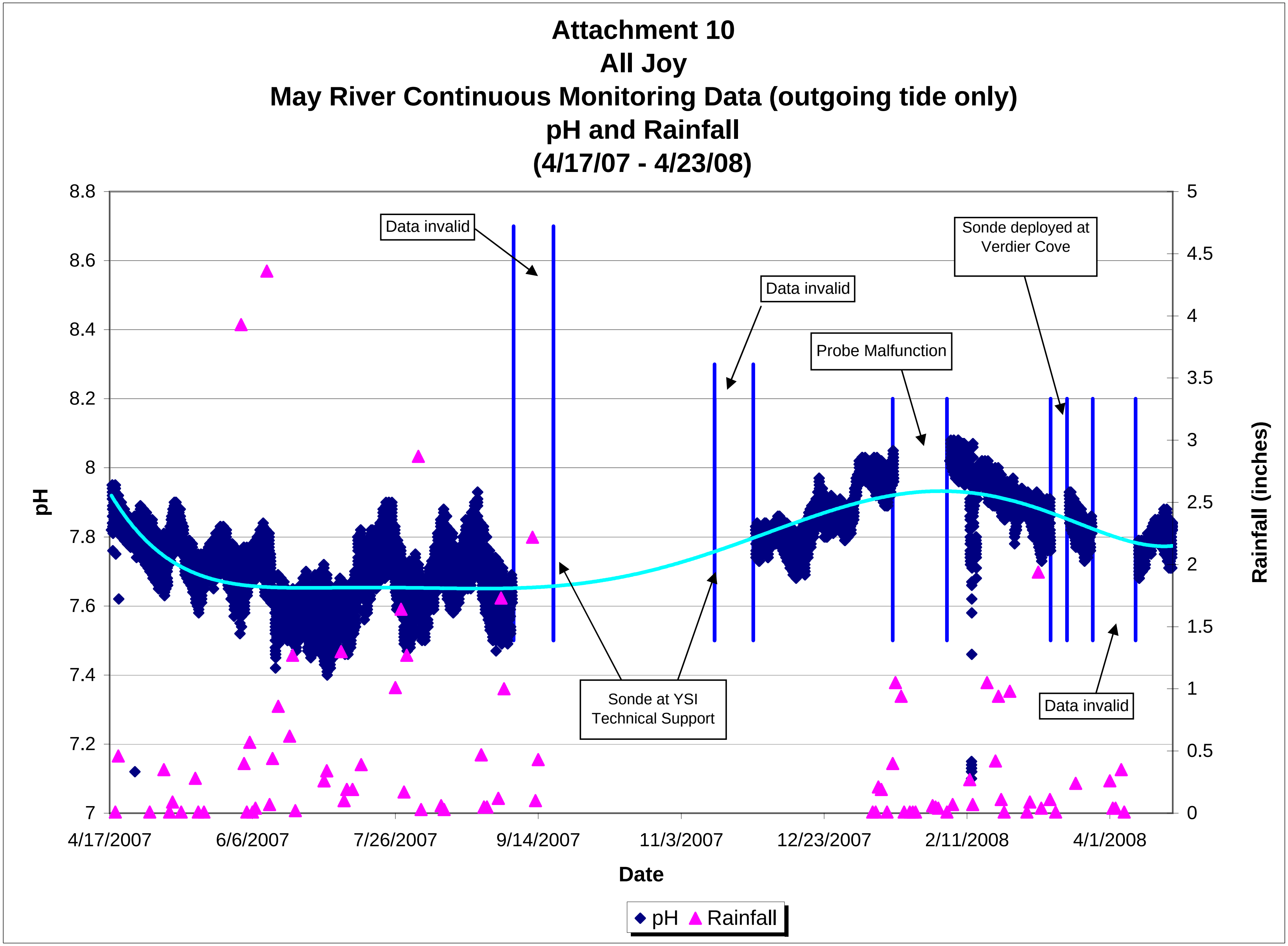


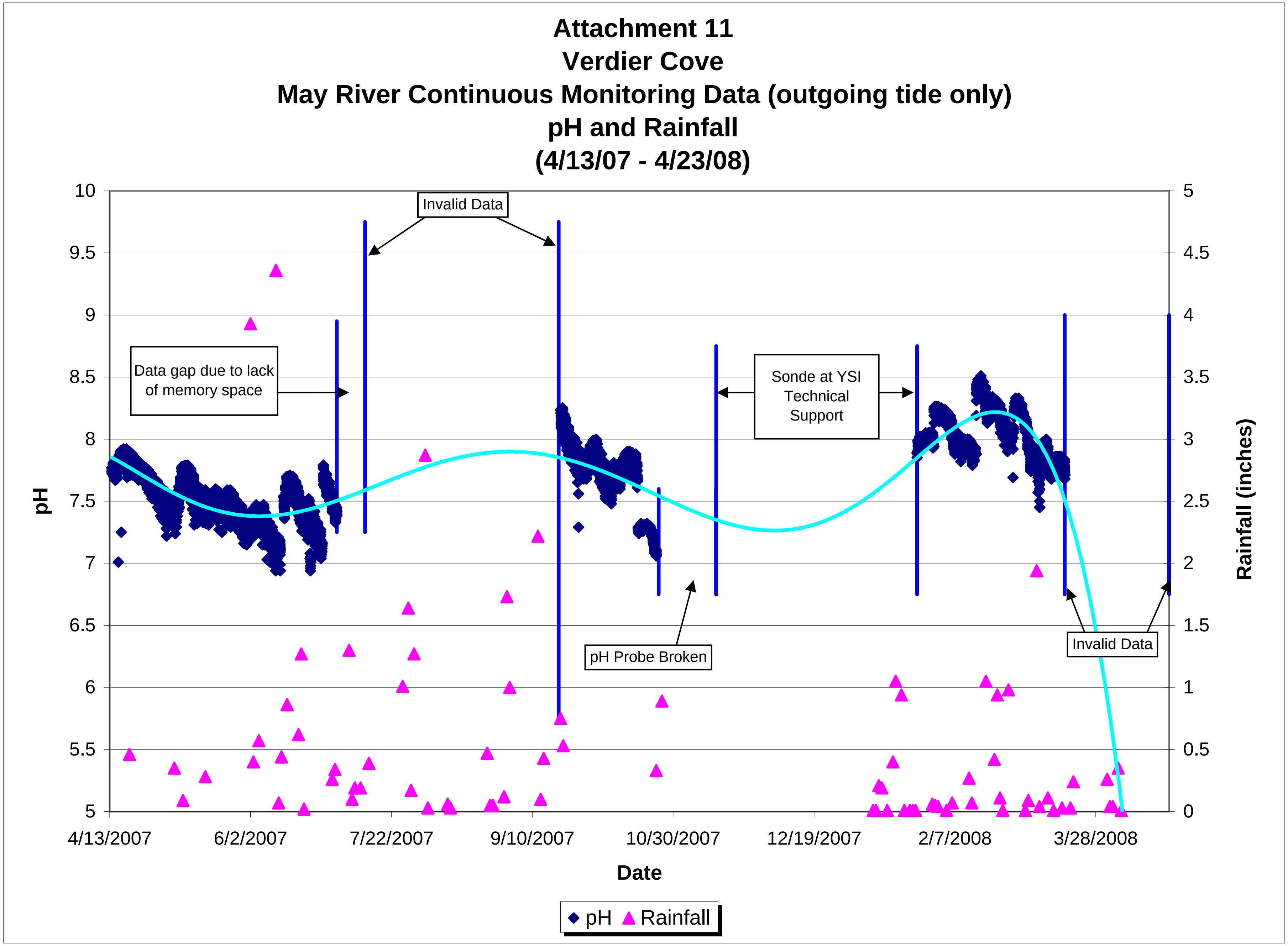
Attachment 8
Verdier Cove
May River Continuous Monitoring Data (outgoing tide only)
pH and Water Temperature
(4/13/07 - 4/23/08)





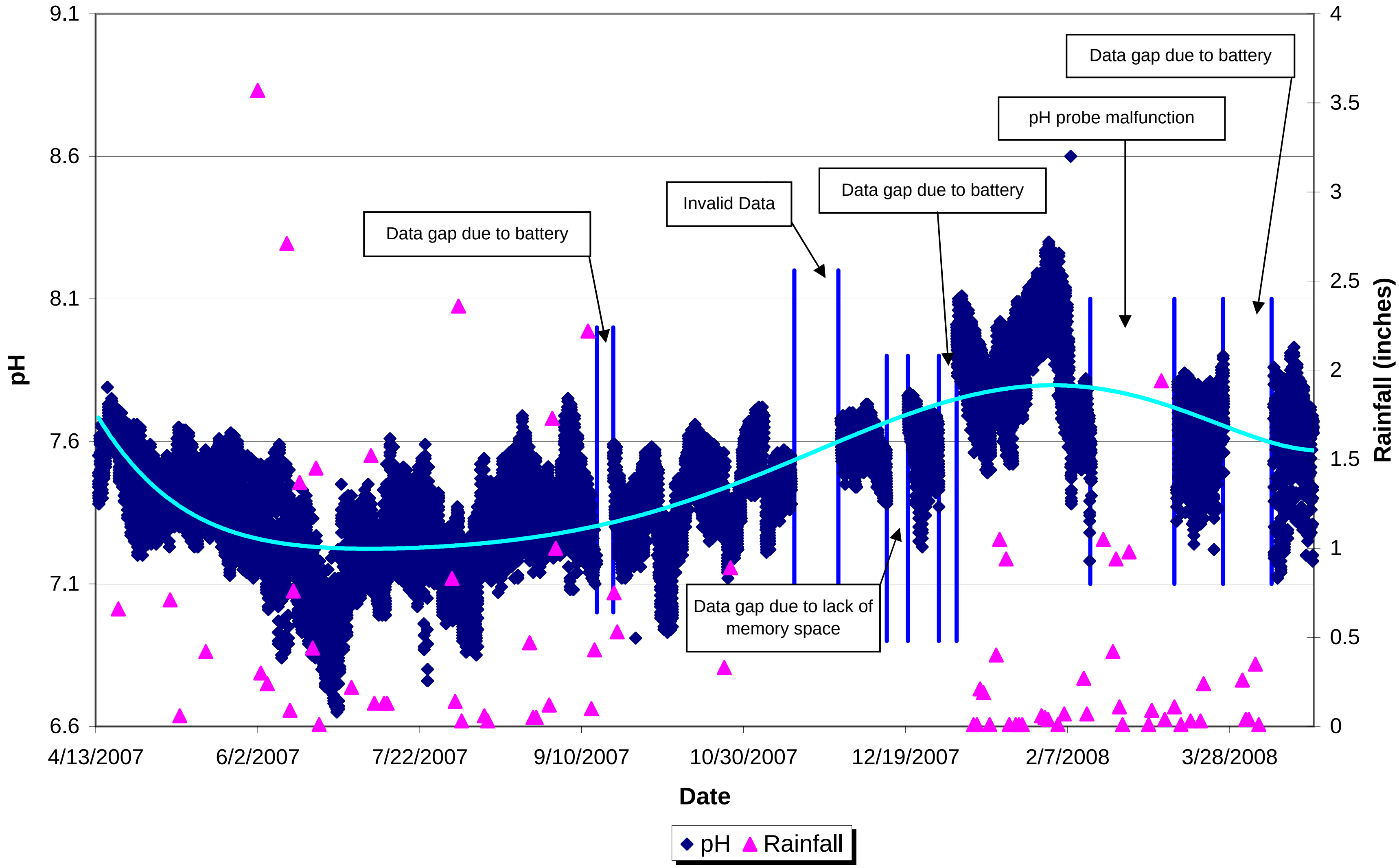
Attachment 9
Rose Dhu
May River Continuous Monitoring Data (outgoing tide only)
pH and Water Temperature
(4/13/07 - 4/23/08)
Data gap due to battery
Invalid Data
Data gap due to battery
pH probe malfunction
Data gap due to lack of memory space
Data gap due to battery
pH
Water Temperature (C)
Date
9.1
8.6
8.1
7.6
7.1
6.6
40
35
30
25
20
15
10
5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
pH
Water Temperature


Attachment 10
All Joy
May River Continuous Monitoring Data (outgoing tide only)
pH and Rainfall
(4/17/07 - 4/23/08)
pH
Rainfall (inches)
Date
8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
7.2
7
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4/17/2007
6/6/2007
7/26/2007
9/14/2007
11/3/2007
12/23/2007
2/11/2008
4/1/2008
Data invalid
Data invalid
Probe Malfunction
Sonde deployed at Verdier Cove
Sonde at YSI Technical Support
Data invalid
pH
Rainfall

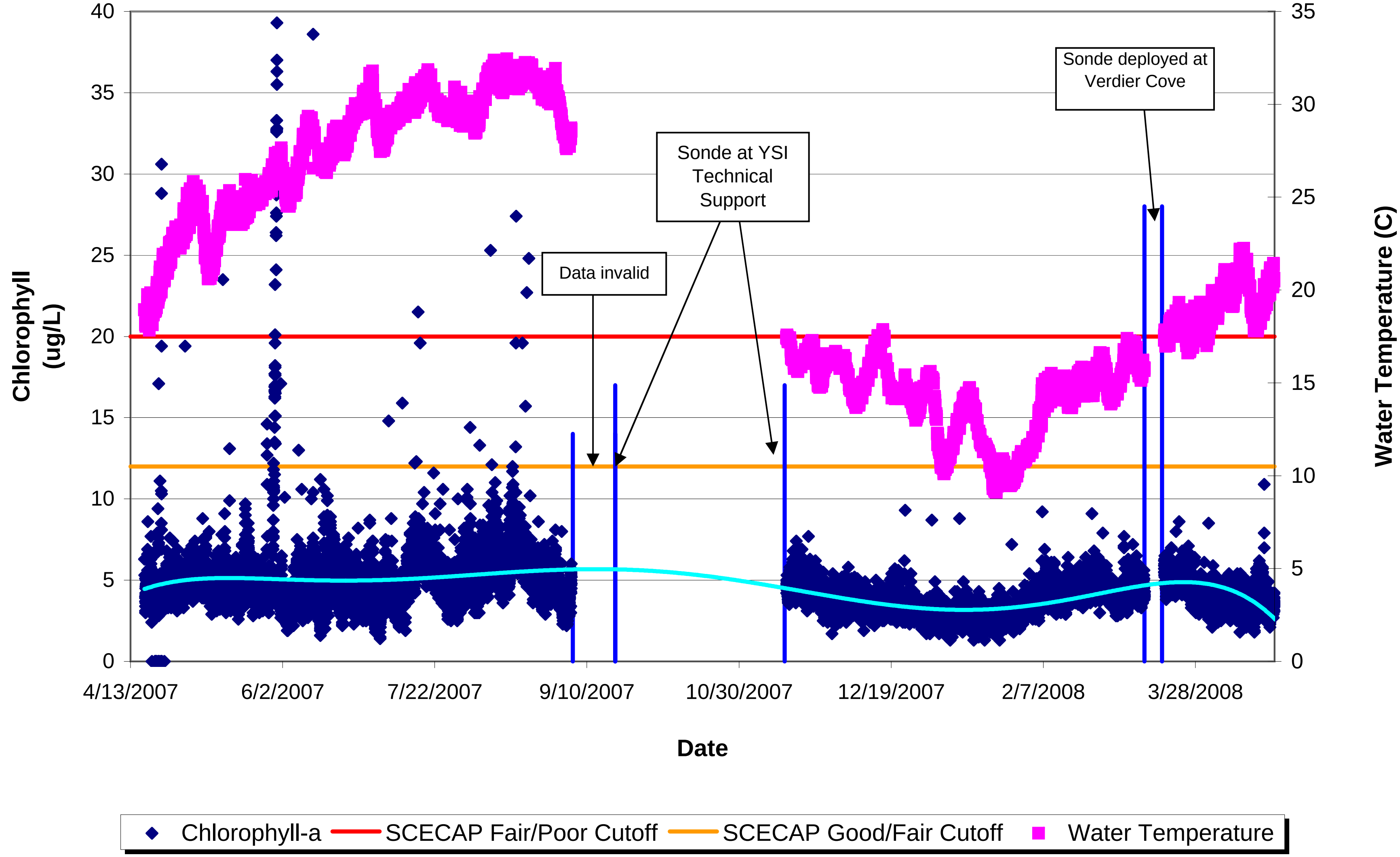


Attachment 11
Verdier Cove
May River Continuous Monitoring Data (outgoing tide only)
pH and Rainfall
(4/13/07 - 4/23/08)
Invalid Data
Data gap due to lack of memory space
Sonde at YSI Technical Support
pH Probe Broken
Invalid Data
pH
Rainfall (inches)
Date
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
pH
Rainfall

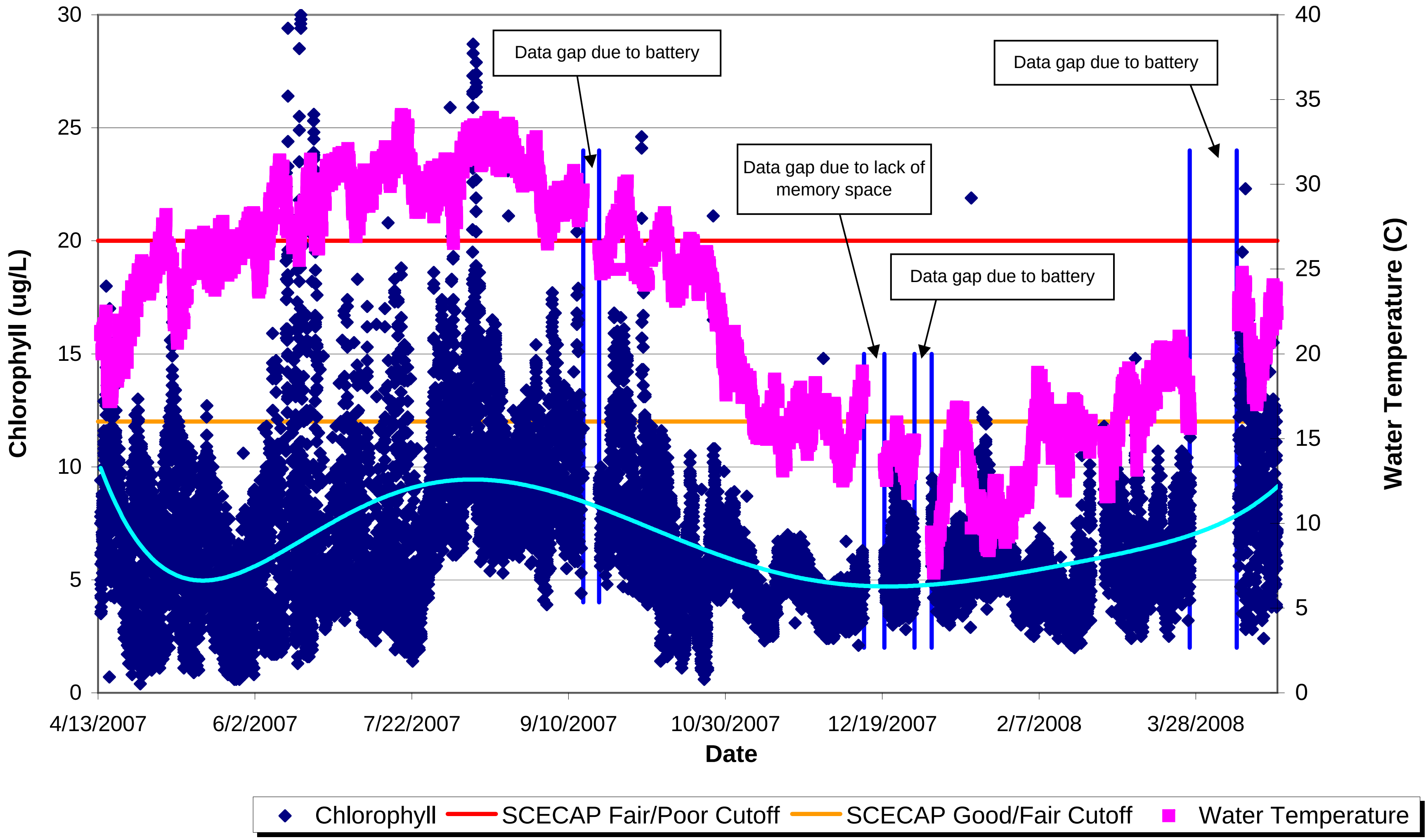
Attachment 12
Rose Dhu
May River Continuous Monitoring Data (outgoing tide only)
pH and Rainfall
(4/13/07 - 4/23/08)



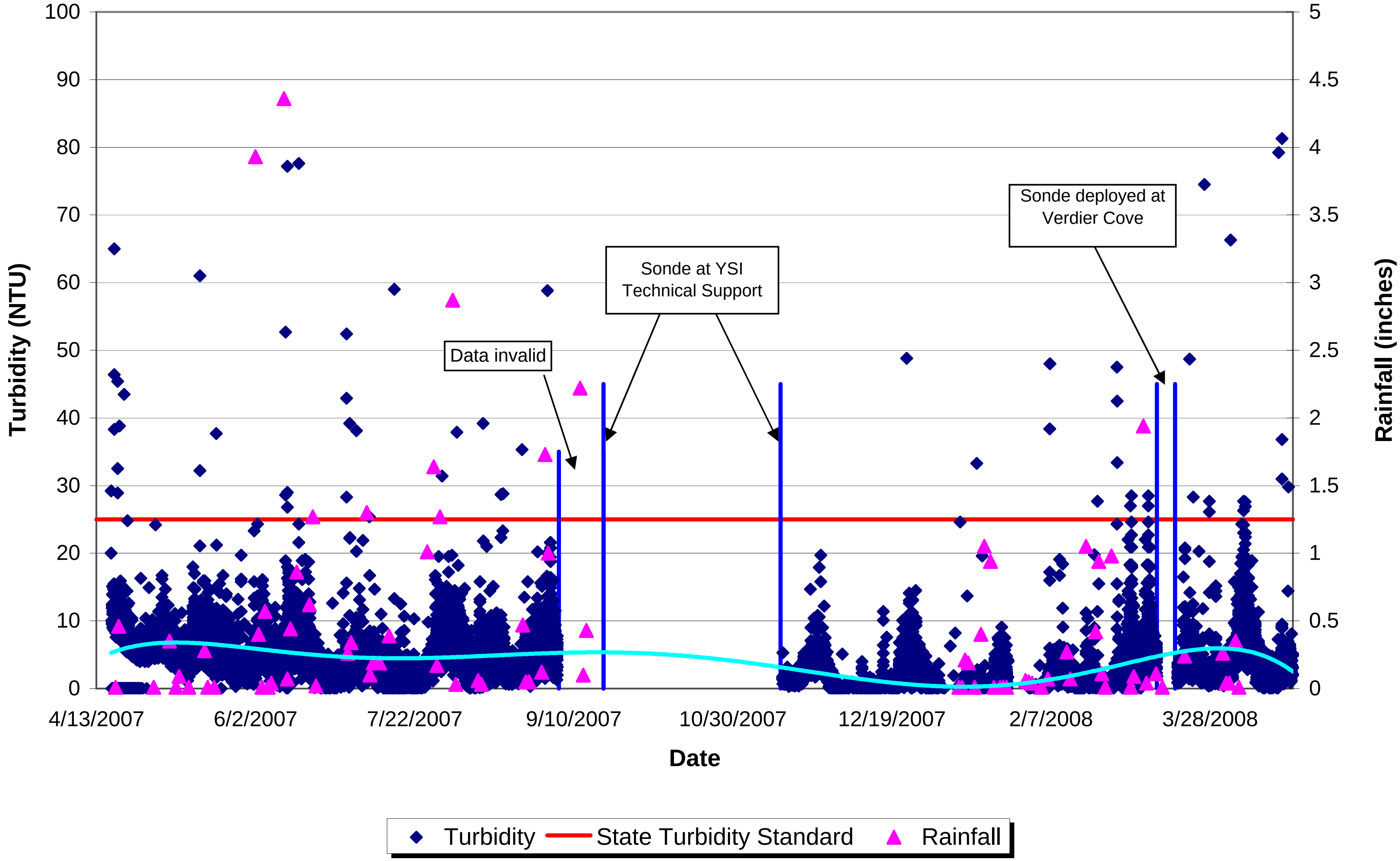
Attachment 13
All Joy
May River Continuous Monitoring Data (outgoing tide only)
Chlorophyll and Water Temperature
(4/17/07 - 4/23/08)

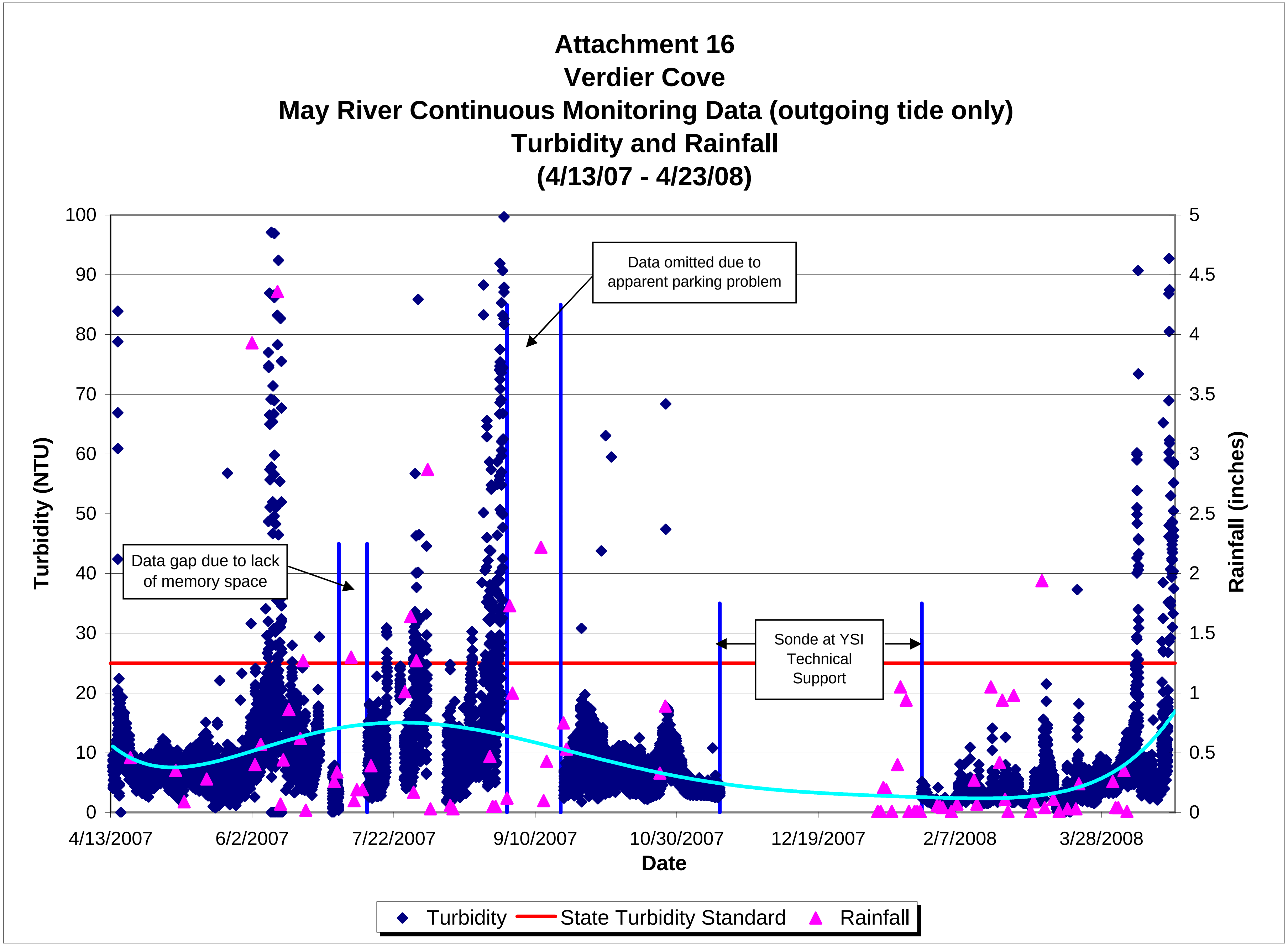


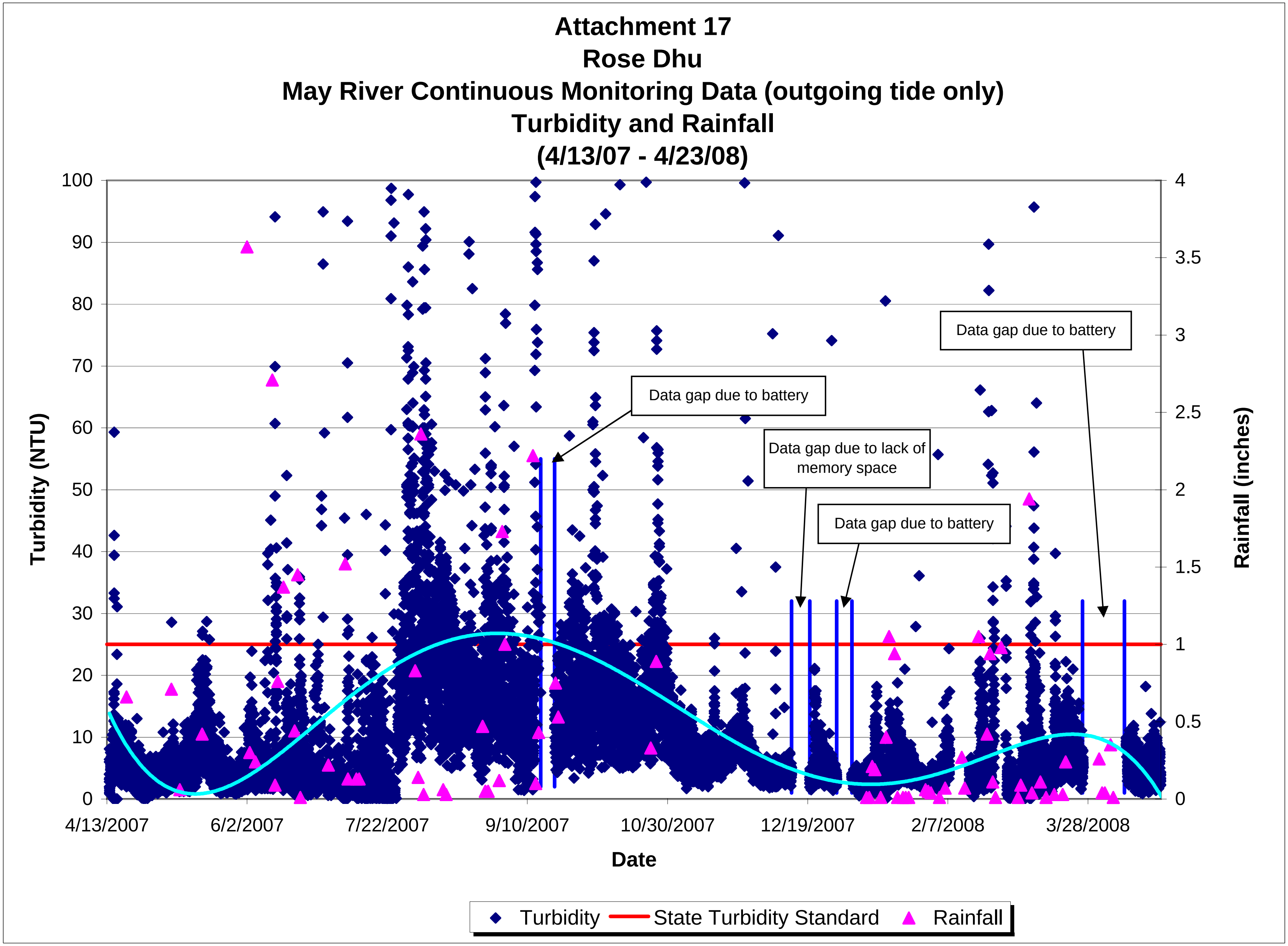
Attachment 14
Rose Dhu
May River Continuous Monitoring Data (outgoing tide only)
Chlorophyll and Water Temperature
(4/13/07 - 4/23/08)

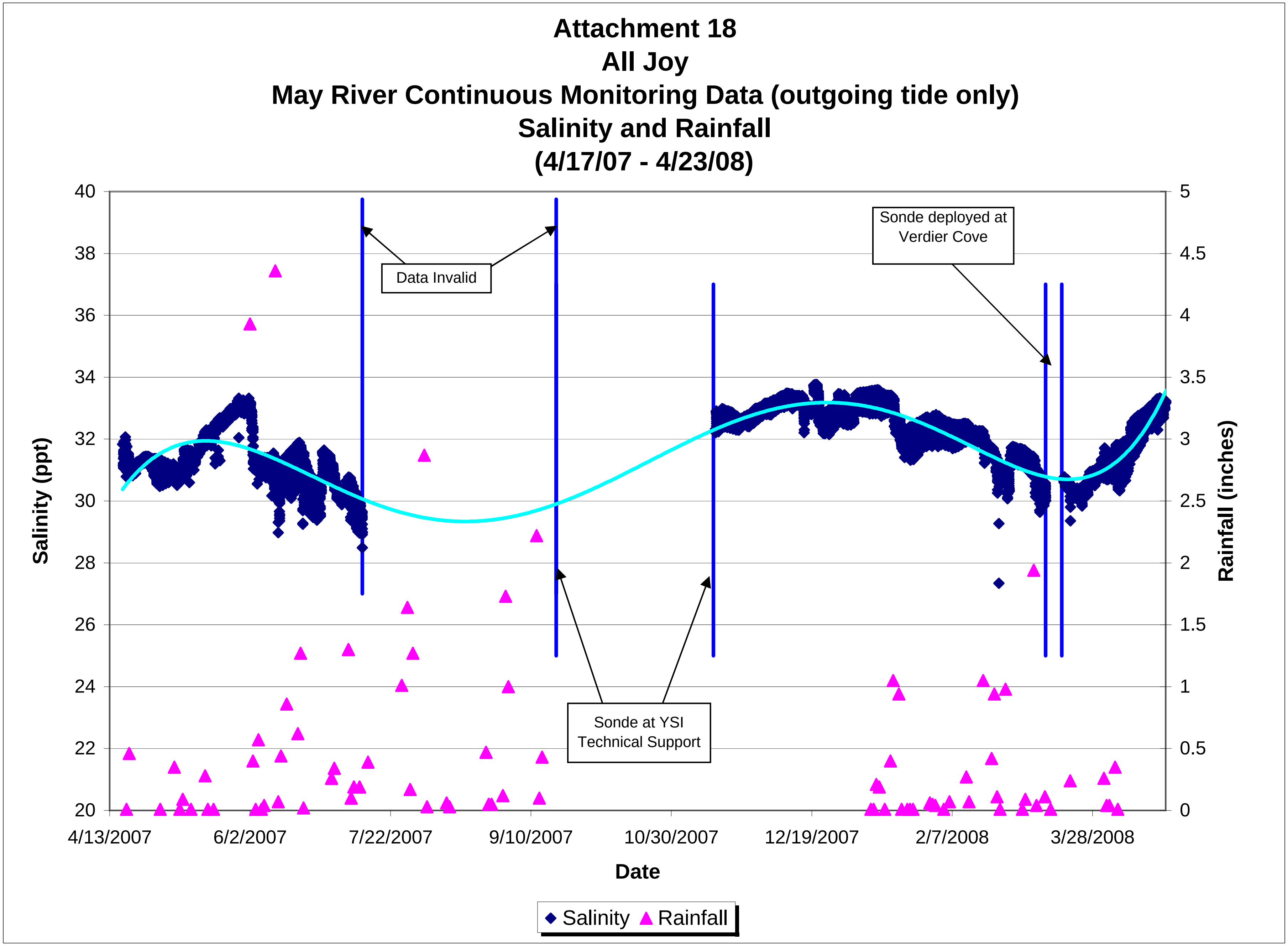


Attachment 15
All Joy
May River Continuous Monitoring Data (outgoing tide only)
Turbidity and Rainfall
(4/17/07 - 4/23/08)

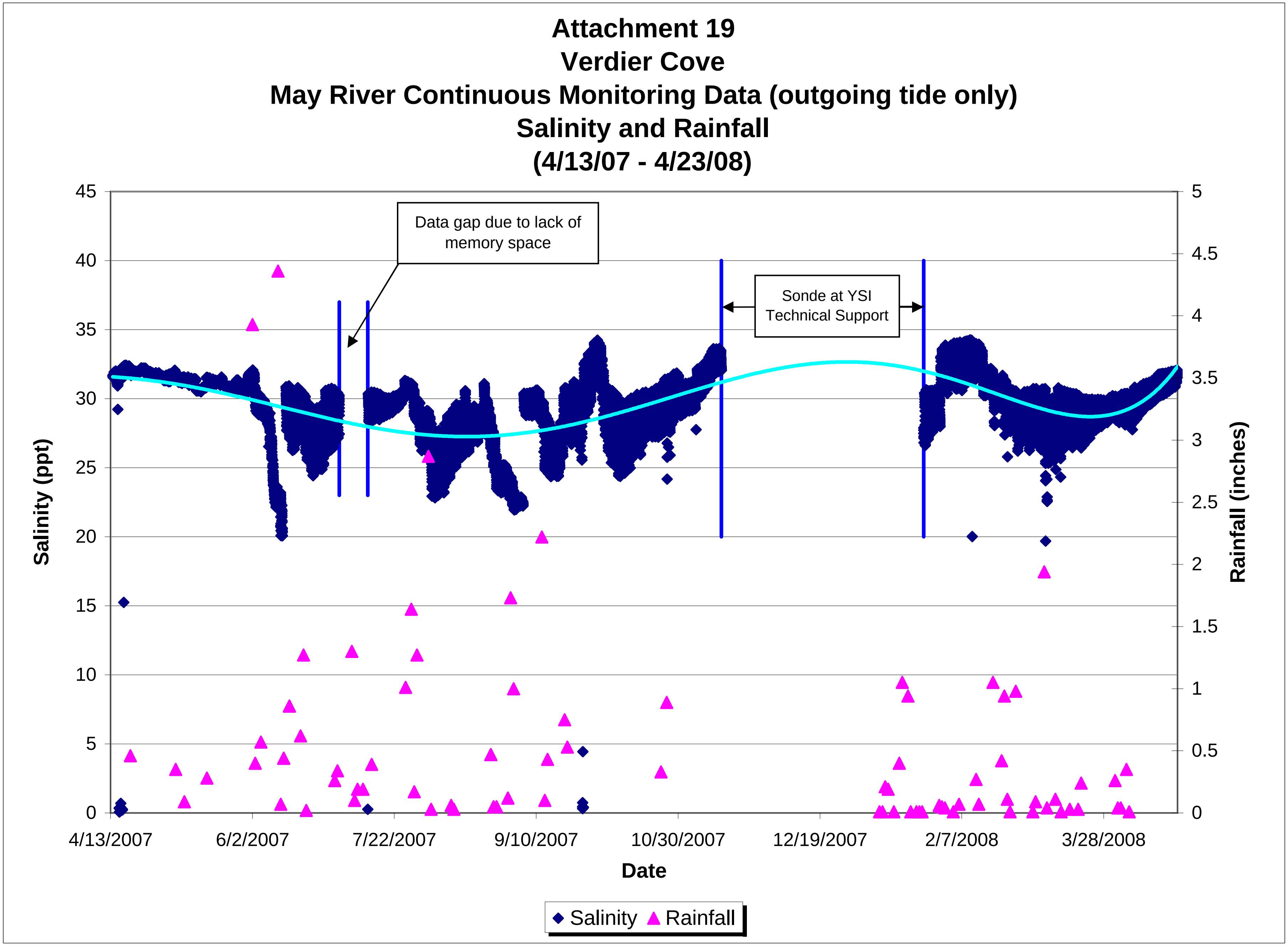



Attachment 16
Verdier Cove
May River Continuous Monitoring Data (outgoing tide only)
Turbidity and Rainfall
(4/13/07 - 4/23/08)
Turbidity (NTU)
Rainfall (inches)
100
90
80
70
60
50
40
30
20
10
0
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Data omitted due to apparent parking problem
Data gap due to lack of memory space
Sonde at YSI Technical Support
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Date
Turbidity
State Turbidity Standard
Rainfall

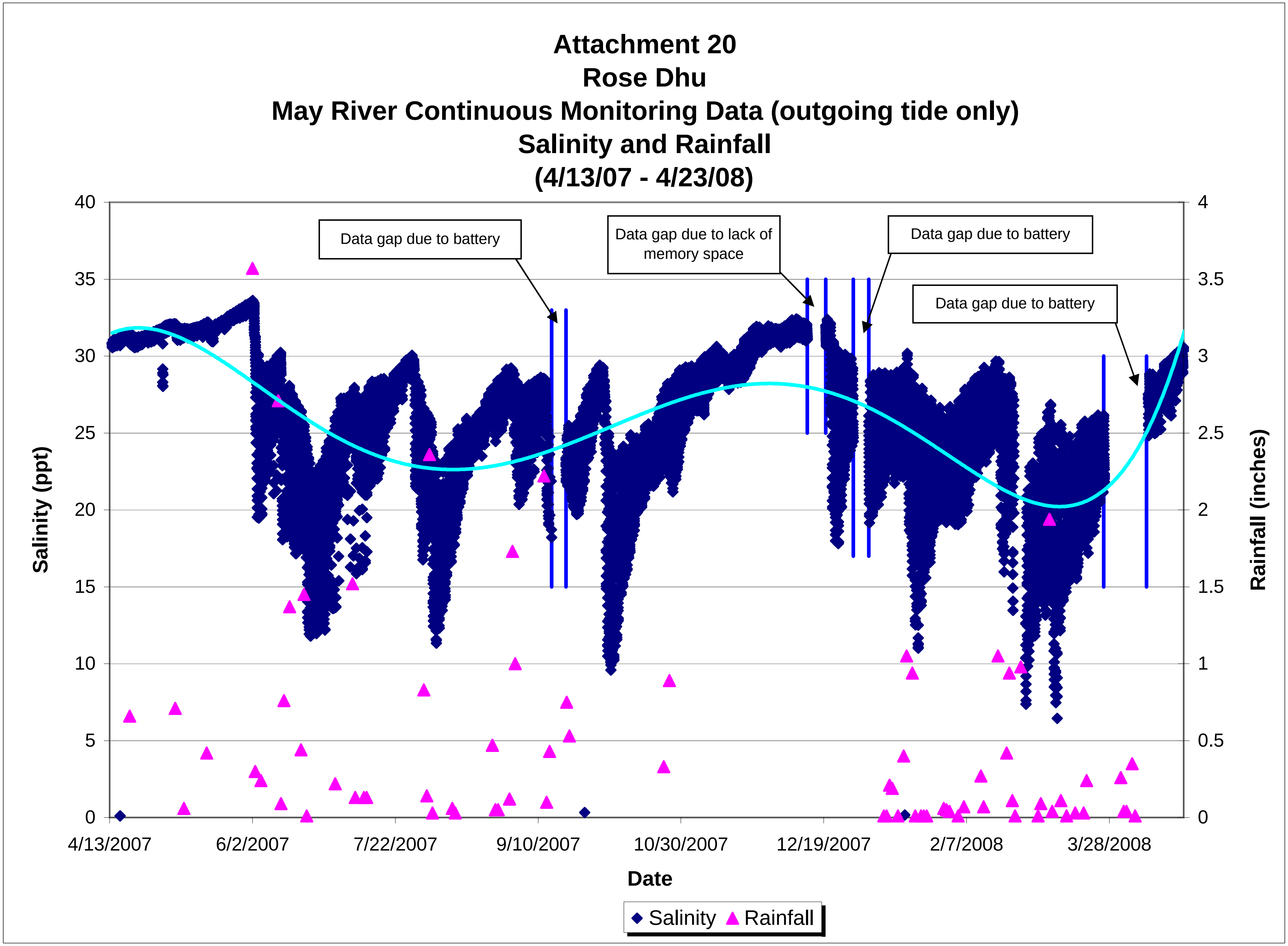

Attachment 17
Rose Dhu
May River Continuous Monitoring Data (outgoing tide only)
Turbidity and Rainfall
(4/13/07 - 4/23/08)
Turbidity (NTU)
Rainfall (inches)
Date
100
90
80
70
60
50
40
30
20
10
0
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Data gap due to battery
Data gap due to battery
Data gap due to lack of memory space
Data gap due to battery
Turbidity
State Turbidity Standard
Rainfall



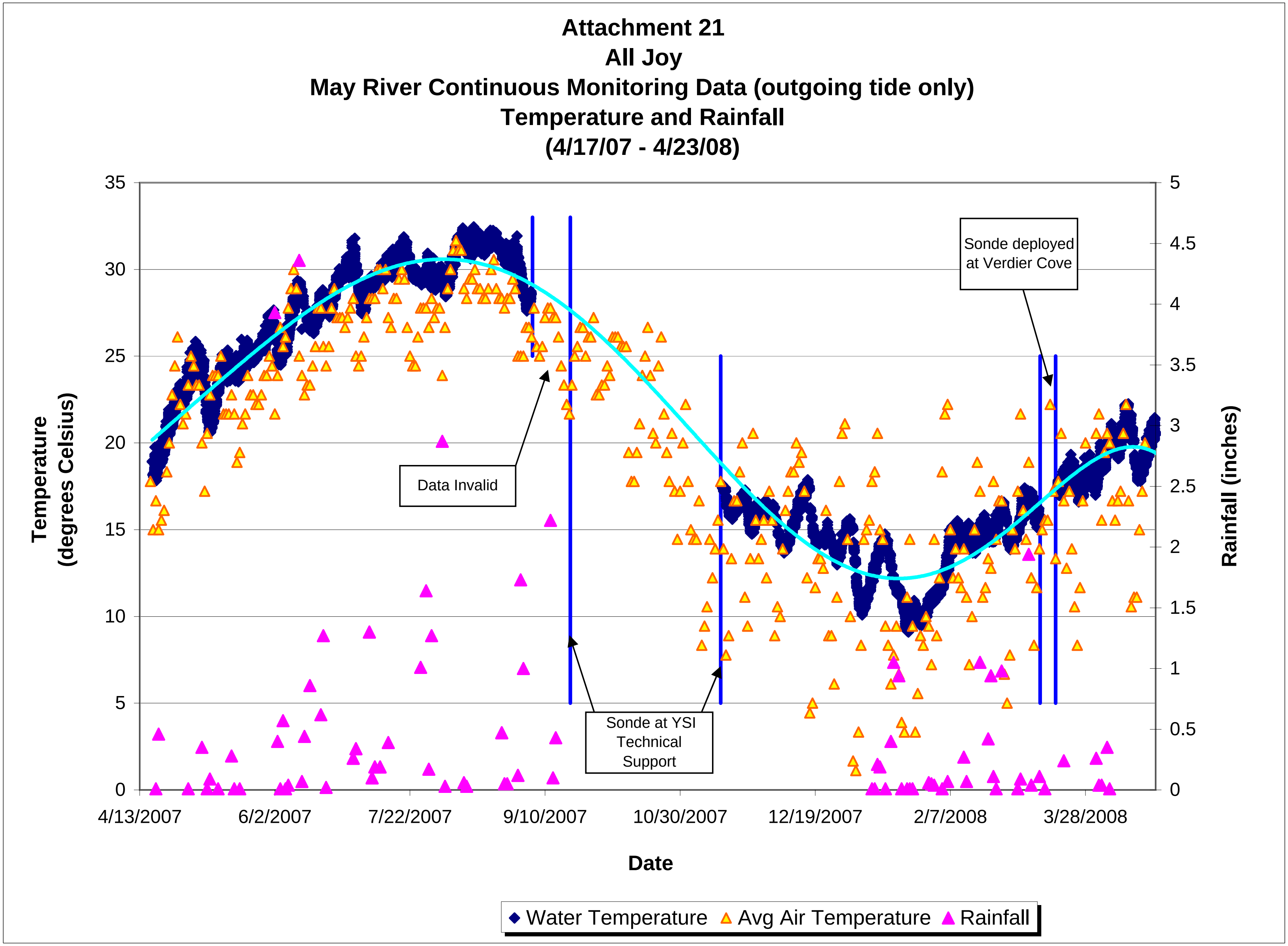
Attachment 18
All Joy
May River Continuous Monitoring Data (outgoing tide only)
Salinity and Rainfall
(4/17/07 - 4/23/08)
Salinity (ppt)
Rainfall (inches)
Date
Data Invalid
Sonde deployed at Verdier Cove
Sonde at YSI Technical Support
40
38
36
34
32
30
28
26
24
22
20
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Salinity
Rainfall



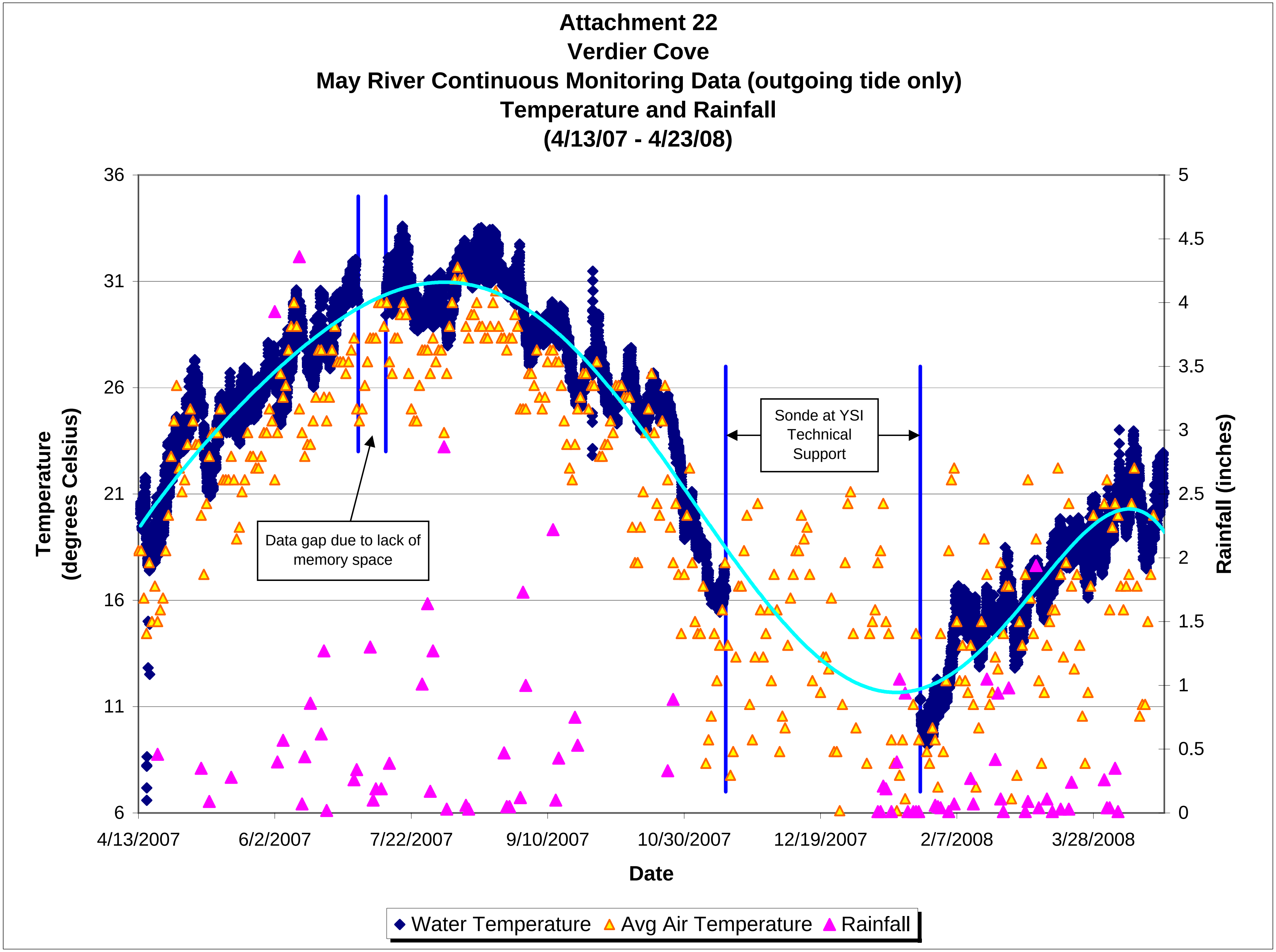
Attachment 19
Verdier Cove
May River Continuous Monitoring Data (outgoing tide only)
Salinity and Rainfall
(4/13/07 - 4/23/08)
Data gap due to lack of memory space
Sonde at YSI Technical Support
Salinity (ppt)
Rainfall (inches)
45
40
35
30
25
20
15
10
5
0
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Date
Salinity
Rainfall

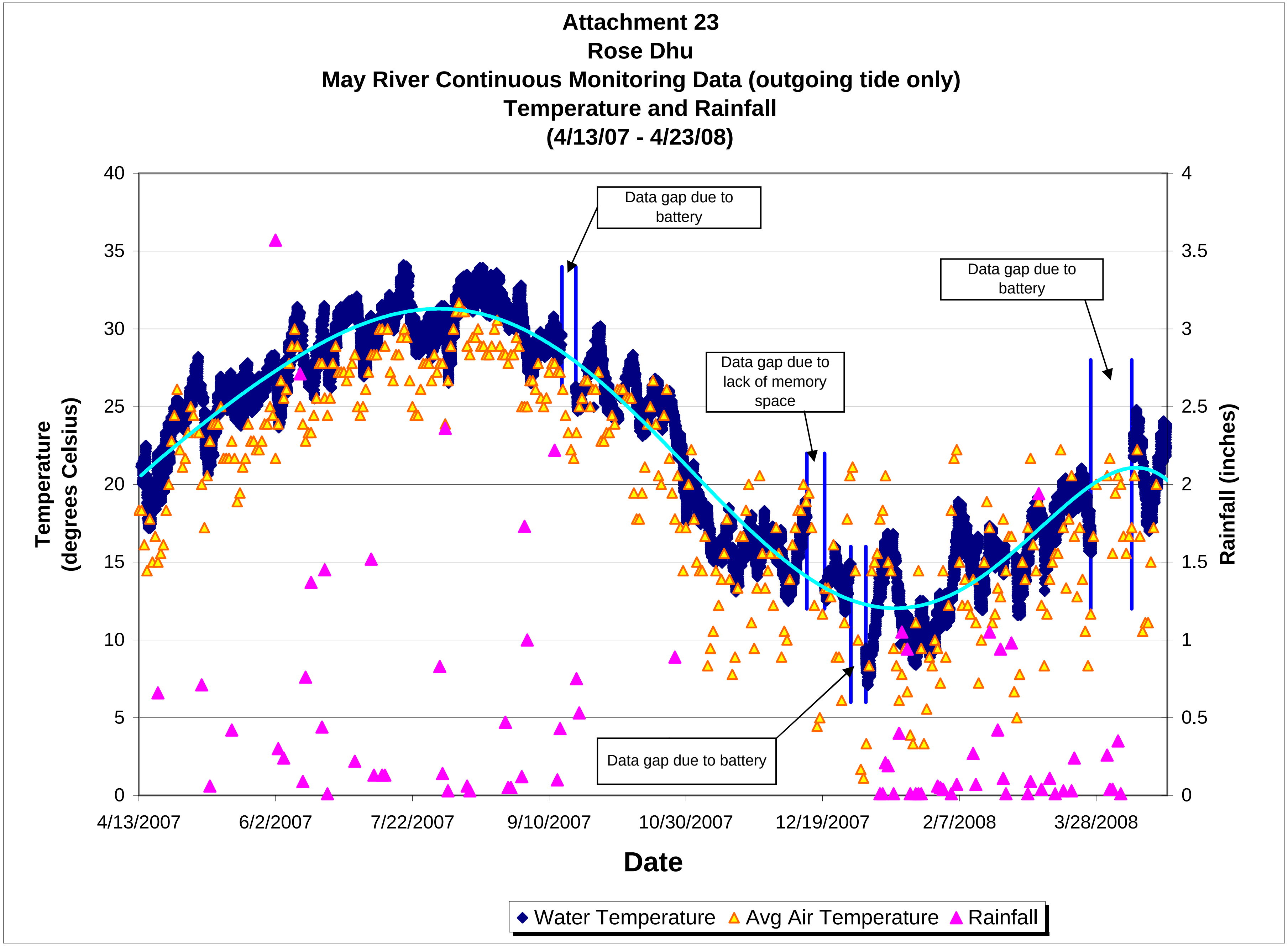


Attachment 20
Rose Dhu
May River Continuous Monitoring Data (outgoing tide only)
Salinity and Rainfall
(4/13/07 - 4/23/08)
Data gap due to battery
Data gap due to lack of memory space
Data gap due to battery
Data gap due to battery
Salinity (ppt)
Rainfall (inches)
40
35
30
25
20
15
10
5
0
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Date
Salinity
Rainfall



Attachment 21
All Joy
May River Continuous Monitoring Data (outgoing tide only)
Temperature and Rainfall
(4/17/07 - 4/23/08)
Temperature (degrees Celsius)
Rainfall (inches)
Date
35
30
25
20
15
10
5
0
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Data Invalid
Sonde at YSI Technical Support
Sonde deployed at Verdier Cove
Water Temperature
Avg Air Temperature
Rainfall


Attachment 22
Verdier Cove
May River Continuous Monitoring Data (outgoing tide only)
Temperature and Rainfall
(4/13/07 - 4/23/08)
Temperature
(degrees Celsius)
Rainfall (inches)
Date
36
31
26
21
16
11
6
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Data gap due to lack of memory space
Sonde at YSI Technical Support
Water Temperature
Avg Air Temperature
Rainfall

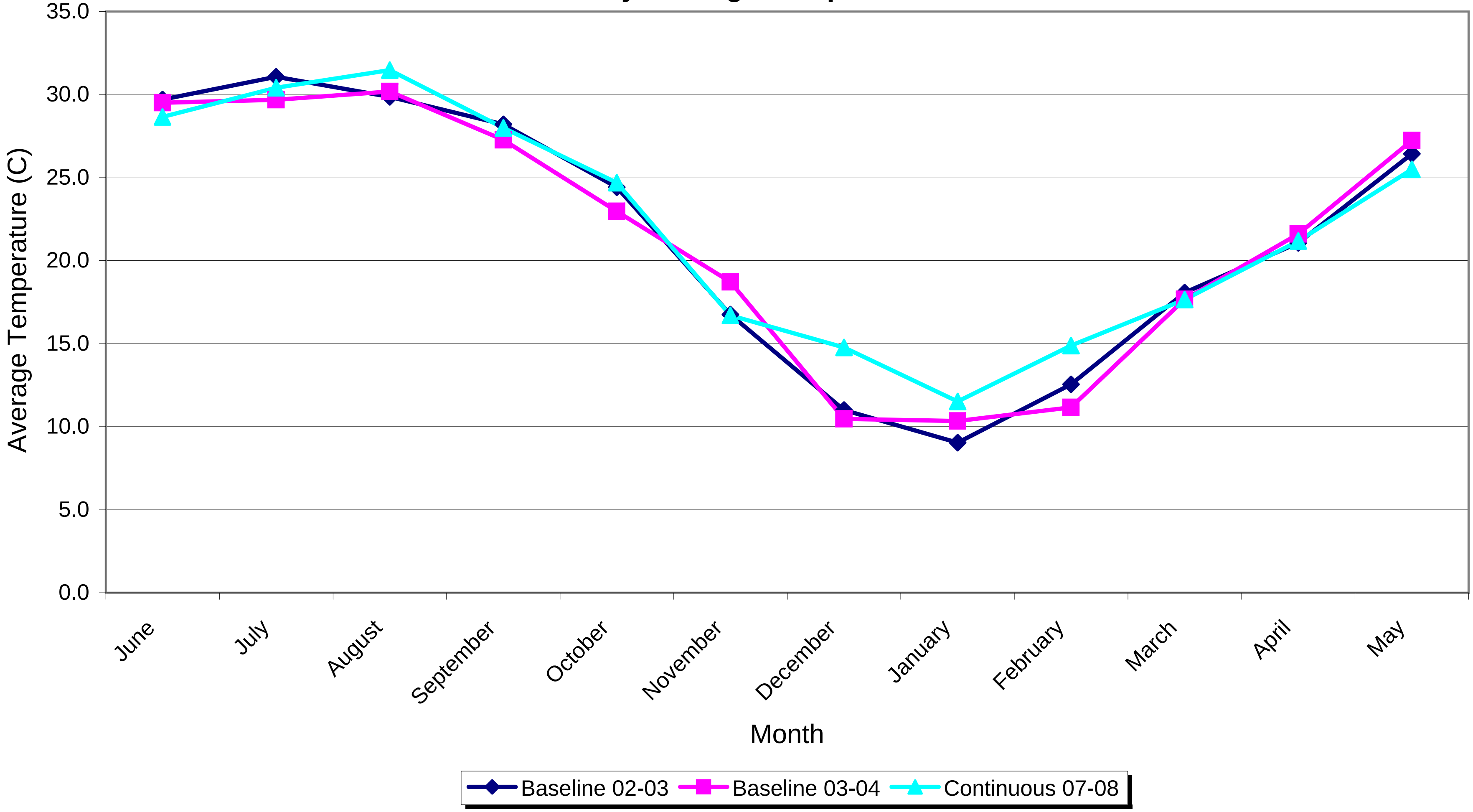


Attachment 23
Rose Dhu
May River Continuous Monitoring Data (outgoing tide only)
Temperature and Rainfall
(4/13/07 - 4/23/08)
Temperature
(degrees Celsius)
Rainfall (inches)
Date
Data gap due to battery
Data gap due to battery
Data gap due to lack of memory space
Data gap due to battery
40
35
30
25
20
15
10
5
0
4
3.5
3
2.5
2
1.5
1
0.5
0
4/13/2007
6/2/2007
7/22/2007
9/10/2007
10/30/2007
12/19/2007
2/7/2008
3/28/2008
Water Temperature
Avg Air Temperature
Rainfall

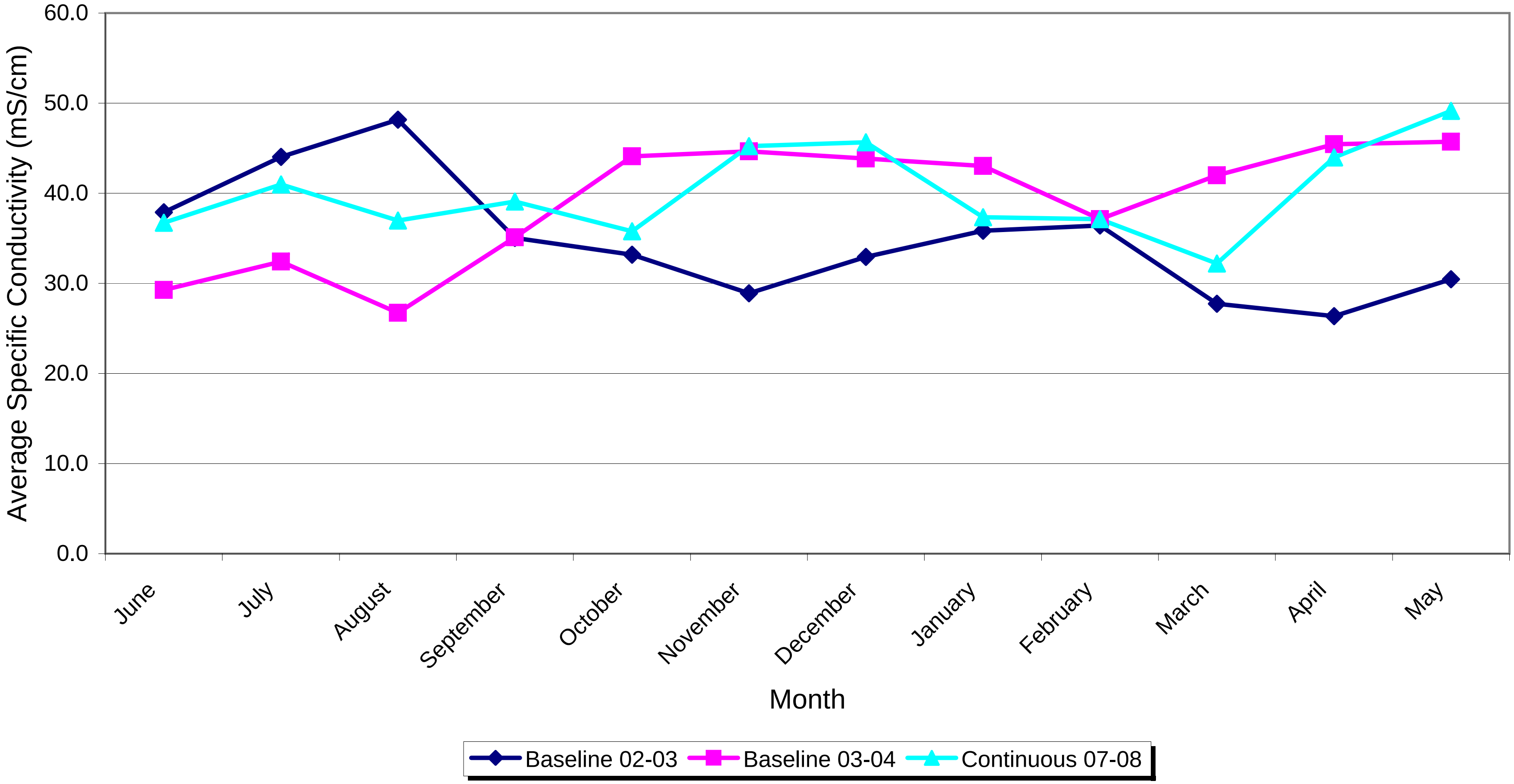
APPENDIX B

Baseline Comparison Data

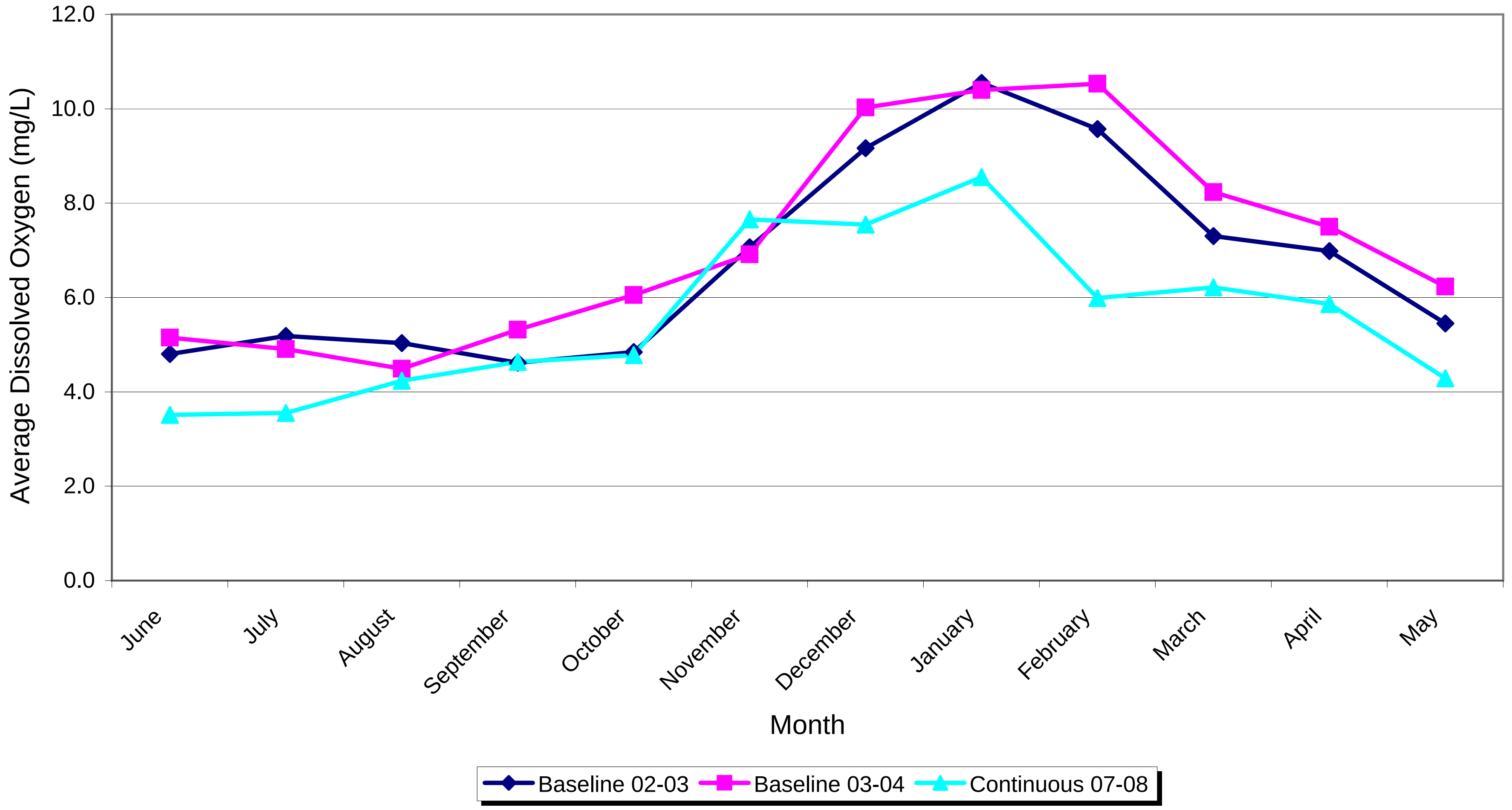
Attachment 24
Comparison of Current Continuous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
Rose Dhu Site vs. USGS Site 6711
Monthly Average Temperature



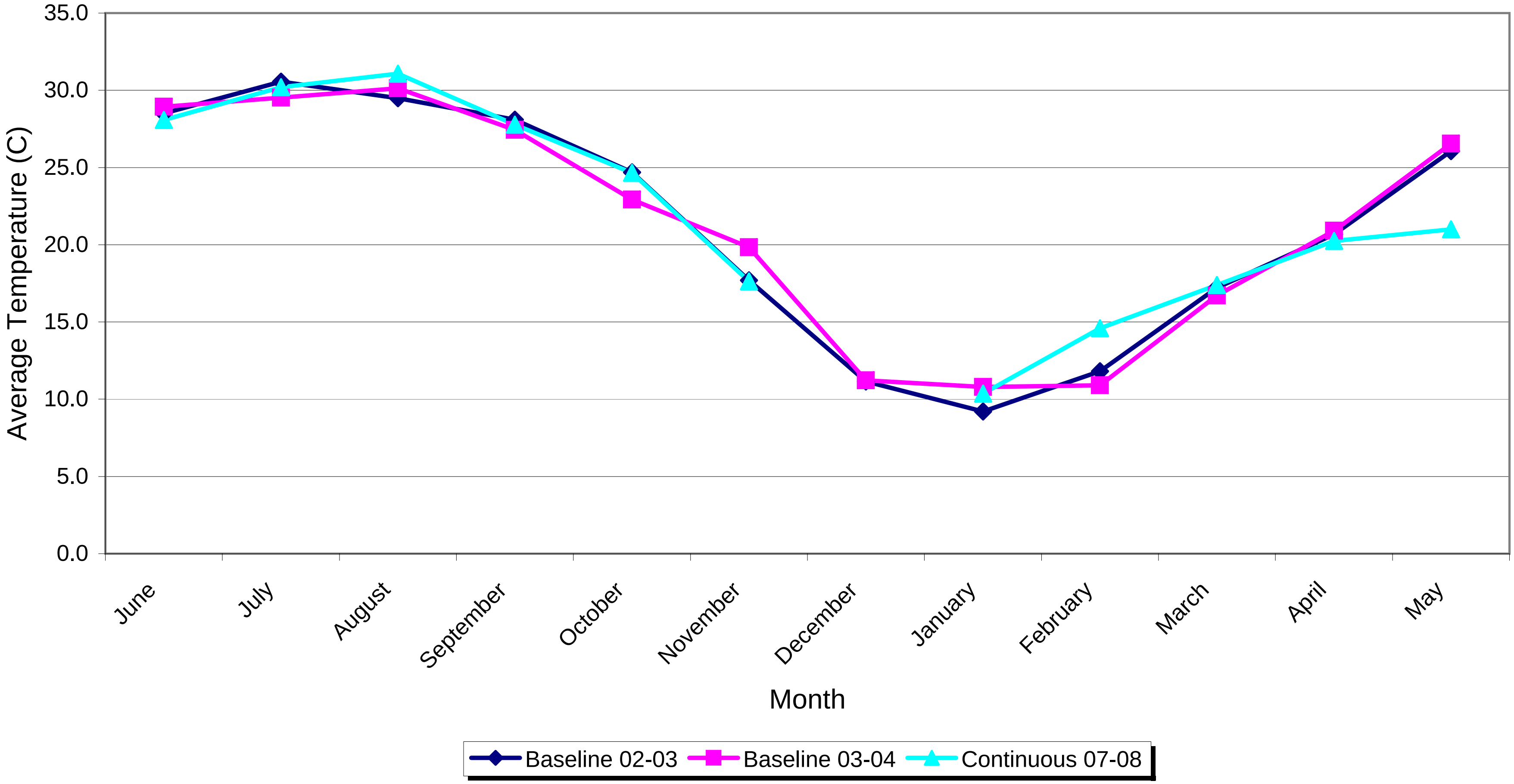
Attachment 25
Comparison of Current Continuous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
Rose Dhu Site vs. USGS Site 6711
Monthly Average Specific Conductivity



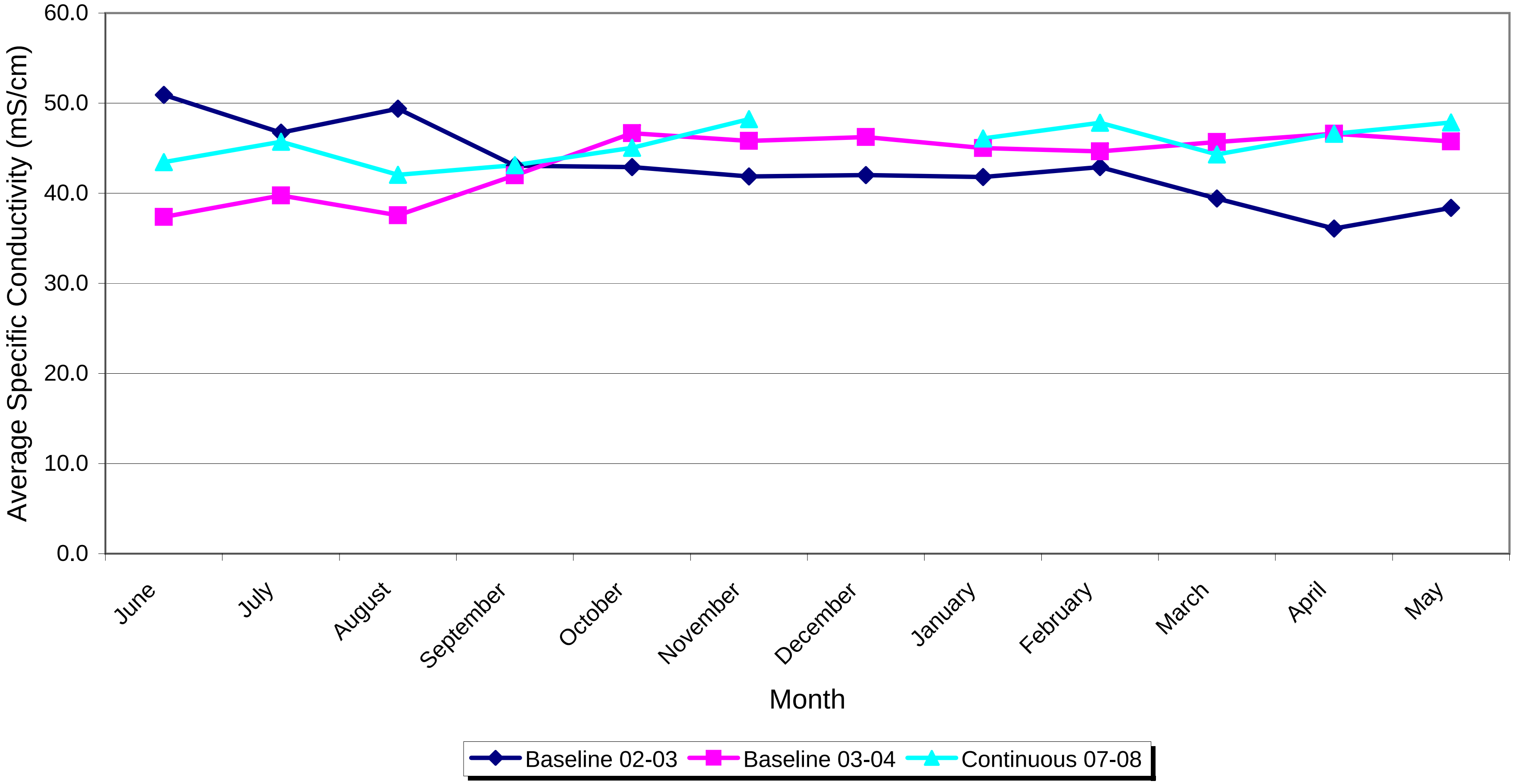
Attachment 26
Comparison of Current Continous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
Rose Dhu Site vs. USGS Site 6711
Monthly Average Dissolved Oxygen



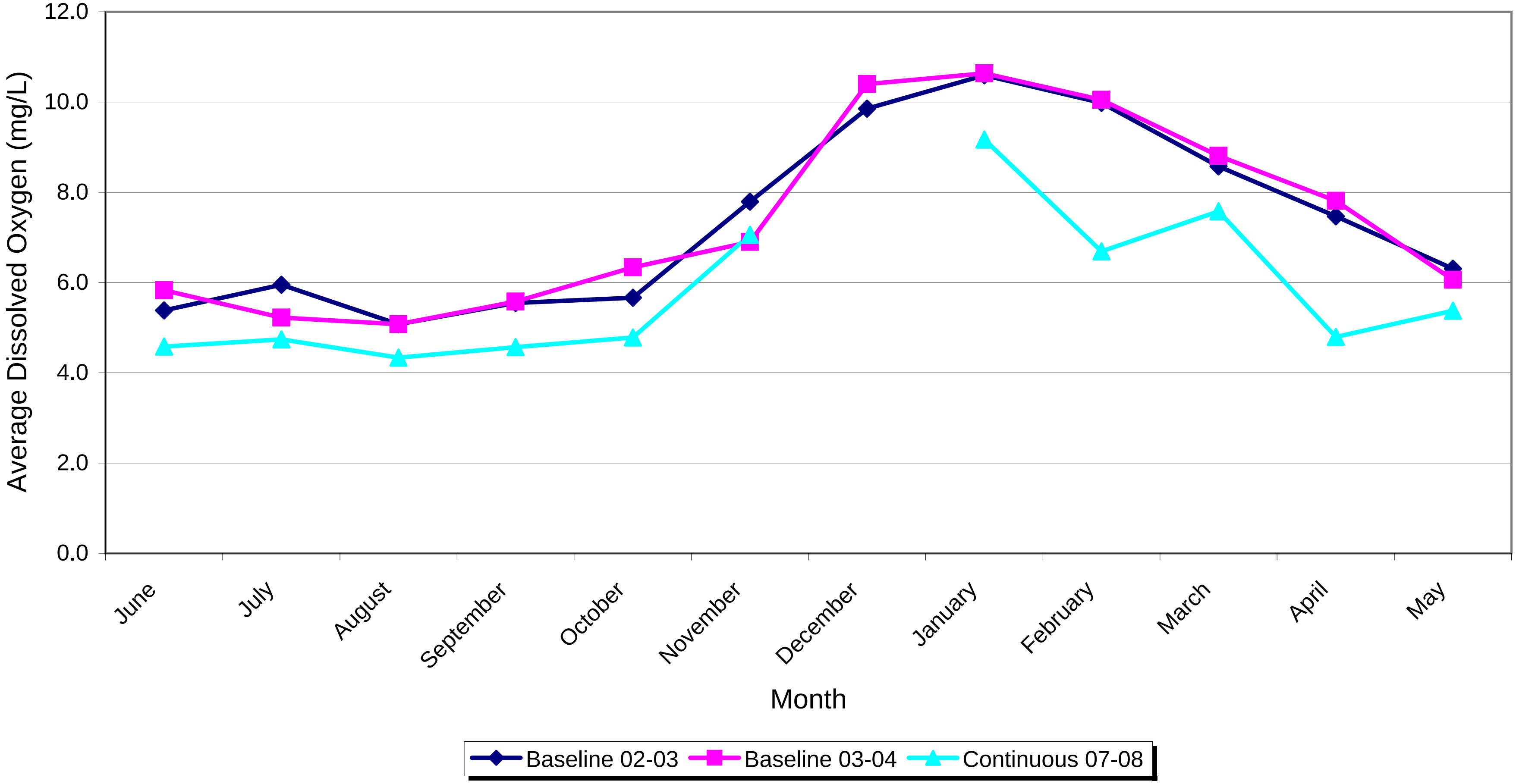
Attachment 27
Comparison of Current Continuous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
Verdier Cove Site vs. USGS Site 6720
Monthly Average Temperature



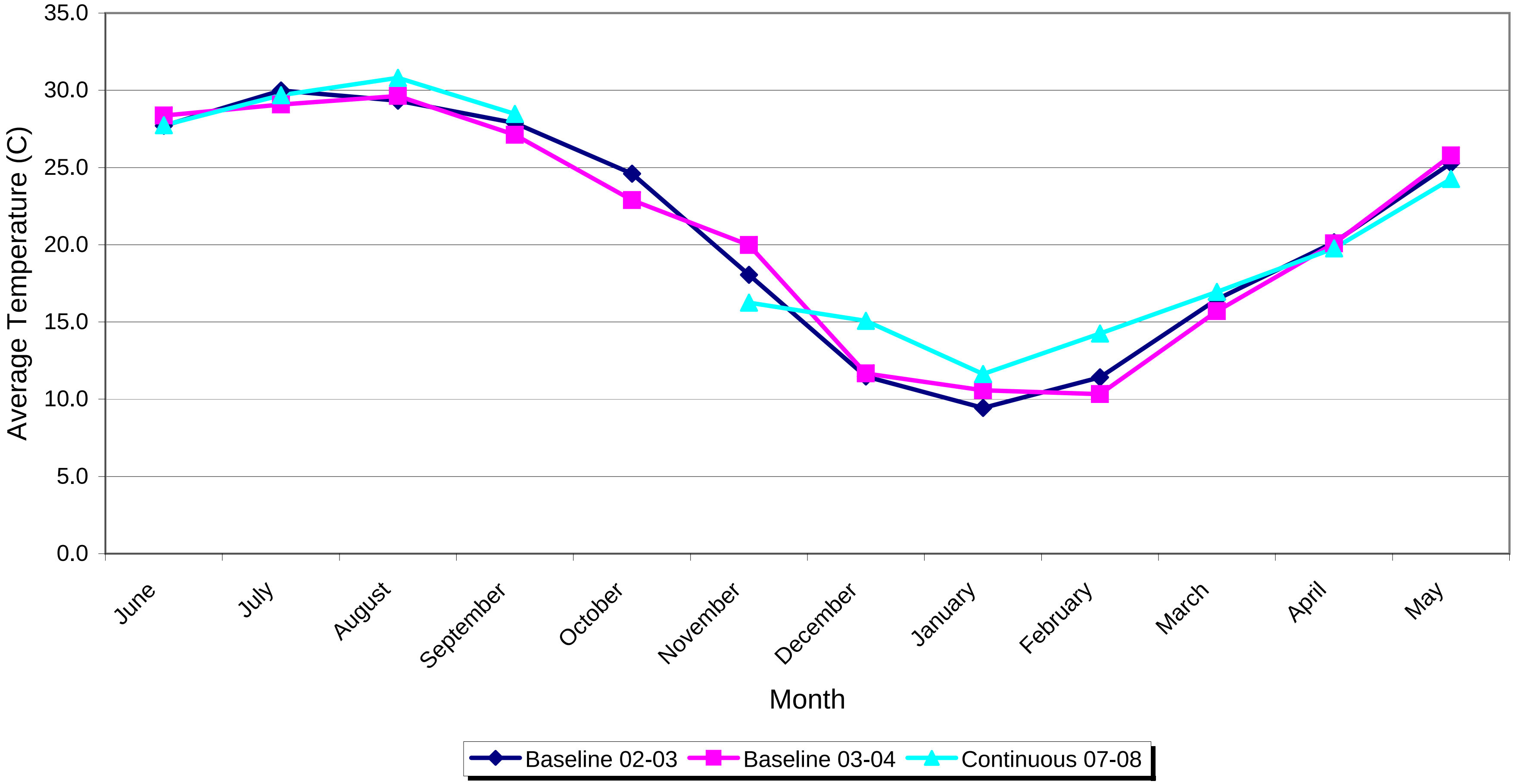
Attachment 28
Comparison of Current Continuous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
Verdier Cove Site vs. USGS Site 6720
Average Monthly Specific Conductivity



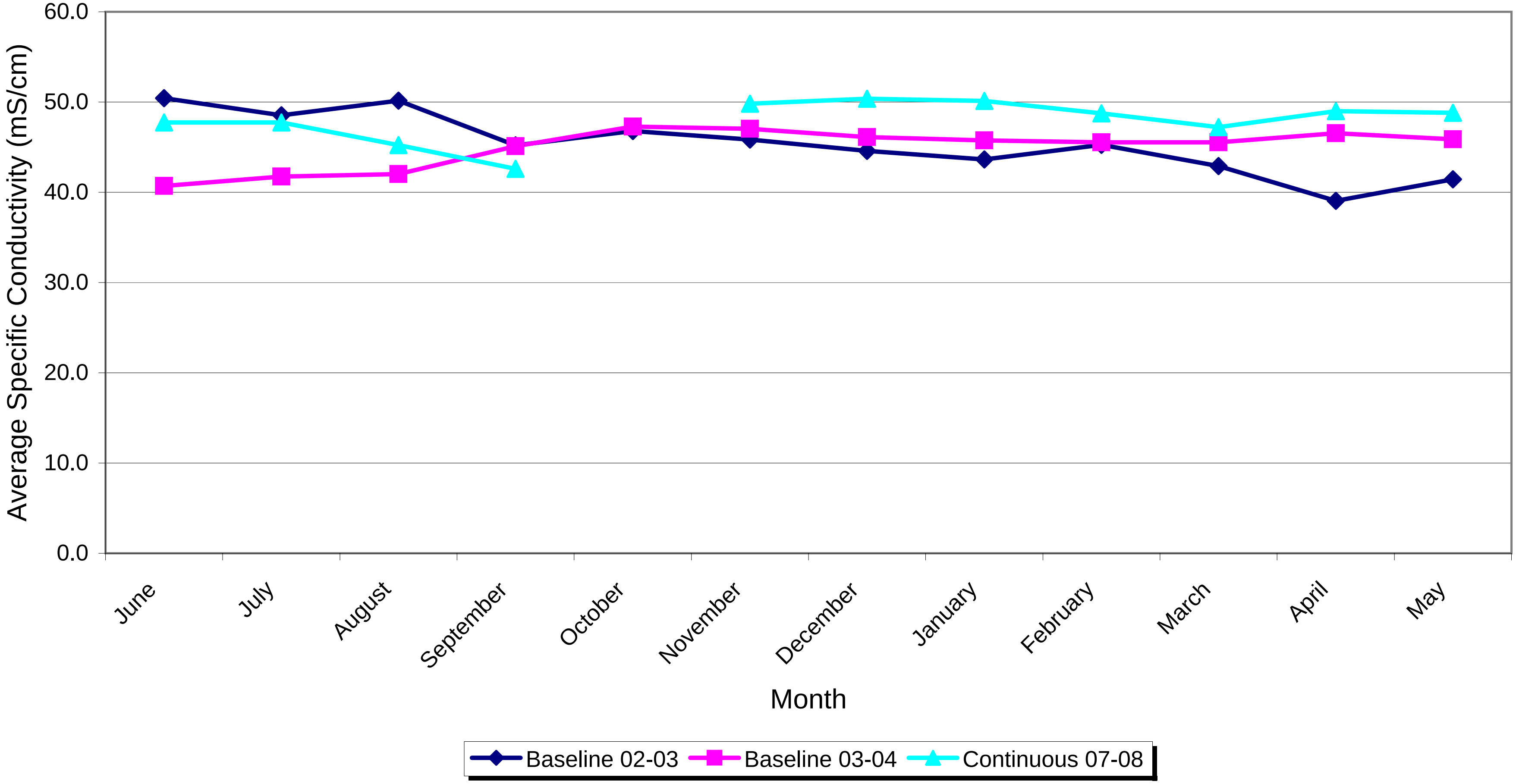
Attachment 29
Comparison of Current Continuous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
Verdier Cove Site vs. USGS Site 6720
Monthly Average Dissolved Oxygen



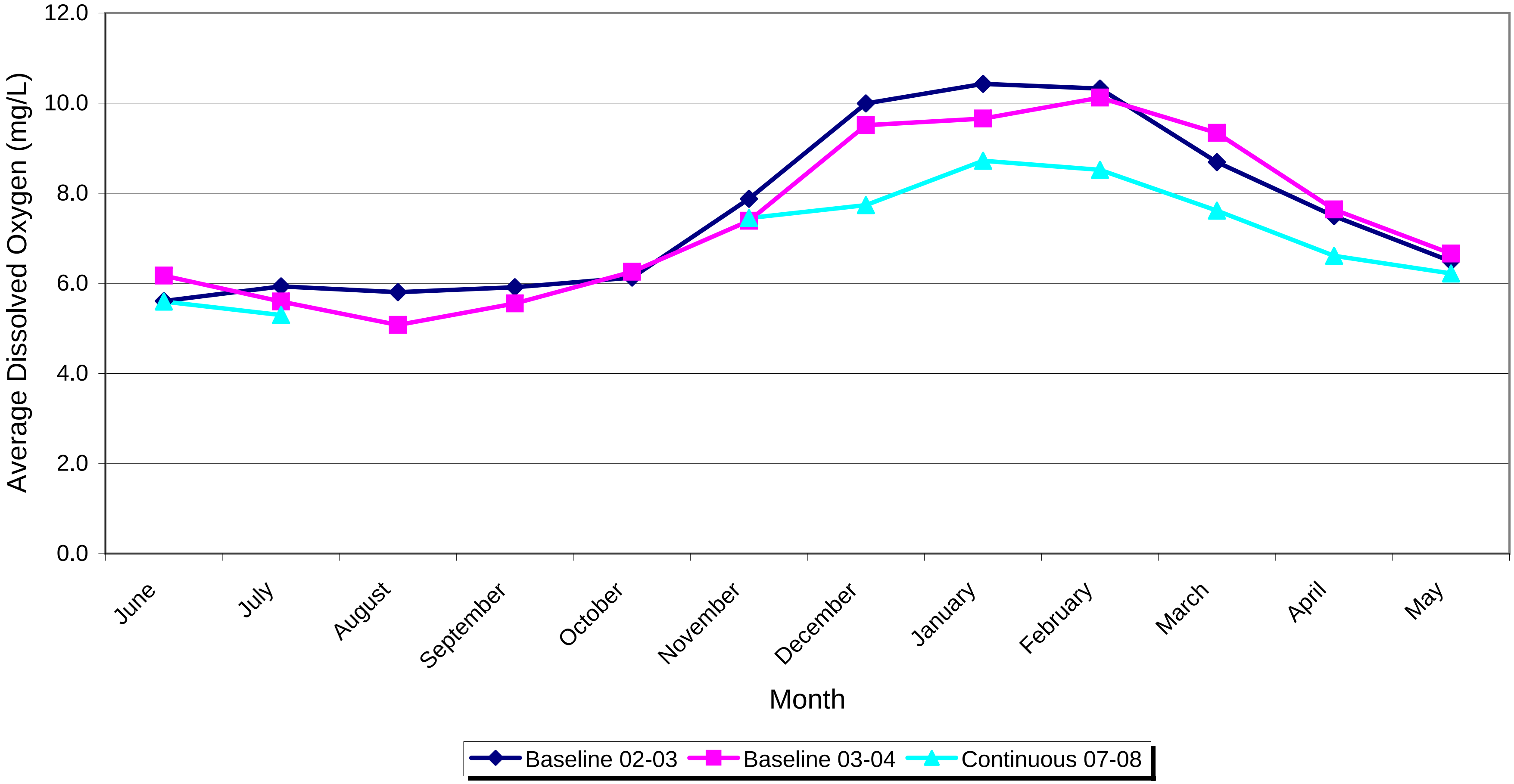
Attachment 30
Comparison of Current Continuous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
All Joy Site vs. USGS Site 2035
Monthly Average Temperature



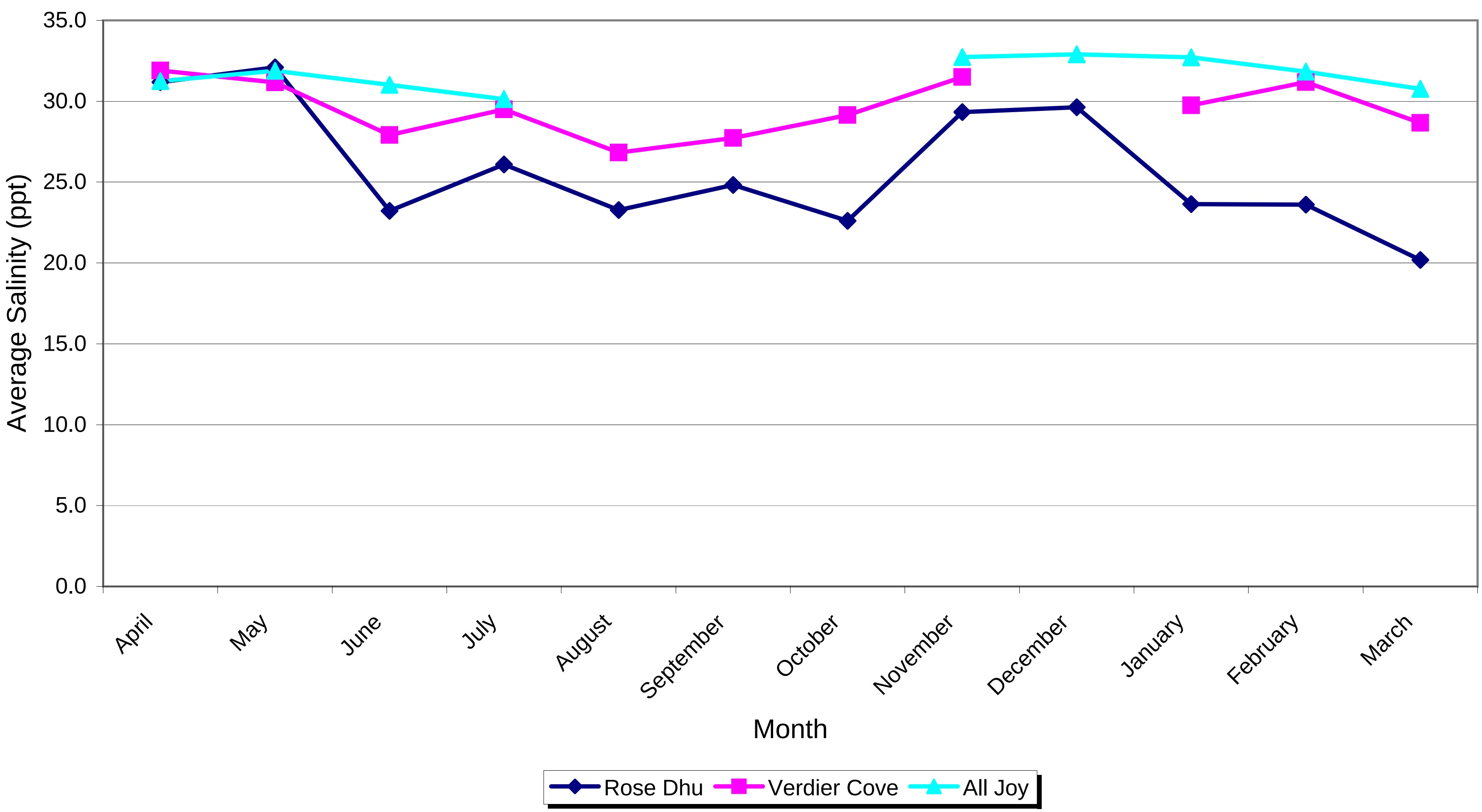
Attachment 31
Comparison of Current Continuous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
All Joy Site vs. USGS Site 2035
Monthly Average Specific Conductivity



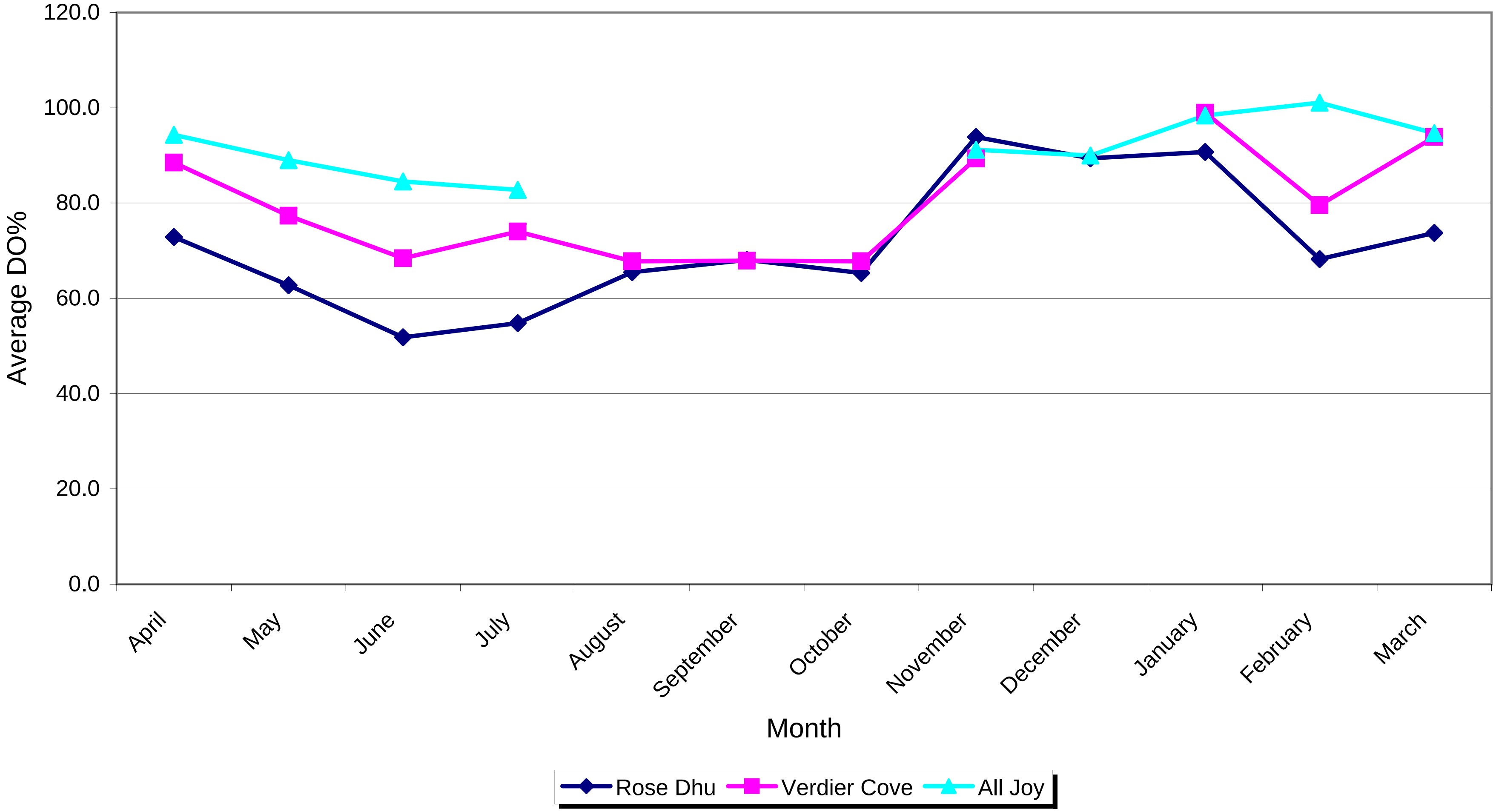
Attachment 32
Comparison of Current Continuous Monitoring Data to Baseline Study Data
(Incoming & Outgoing Tide)
All Joy Site vs. USGS Site 2035
Monthly Average Dissolved Oxygen



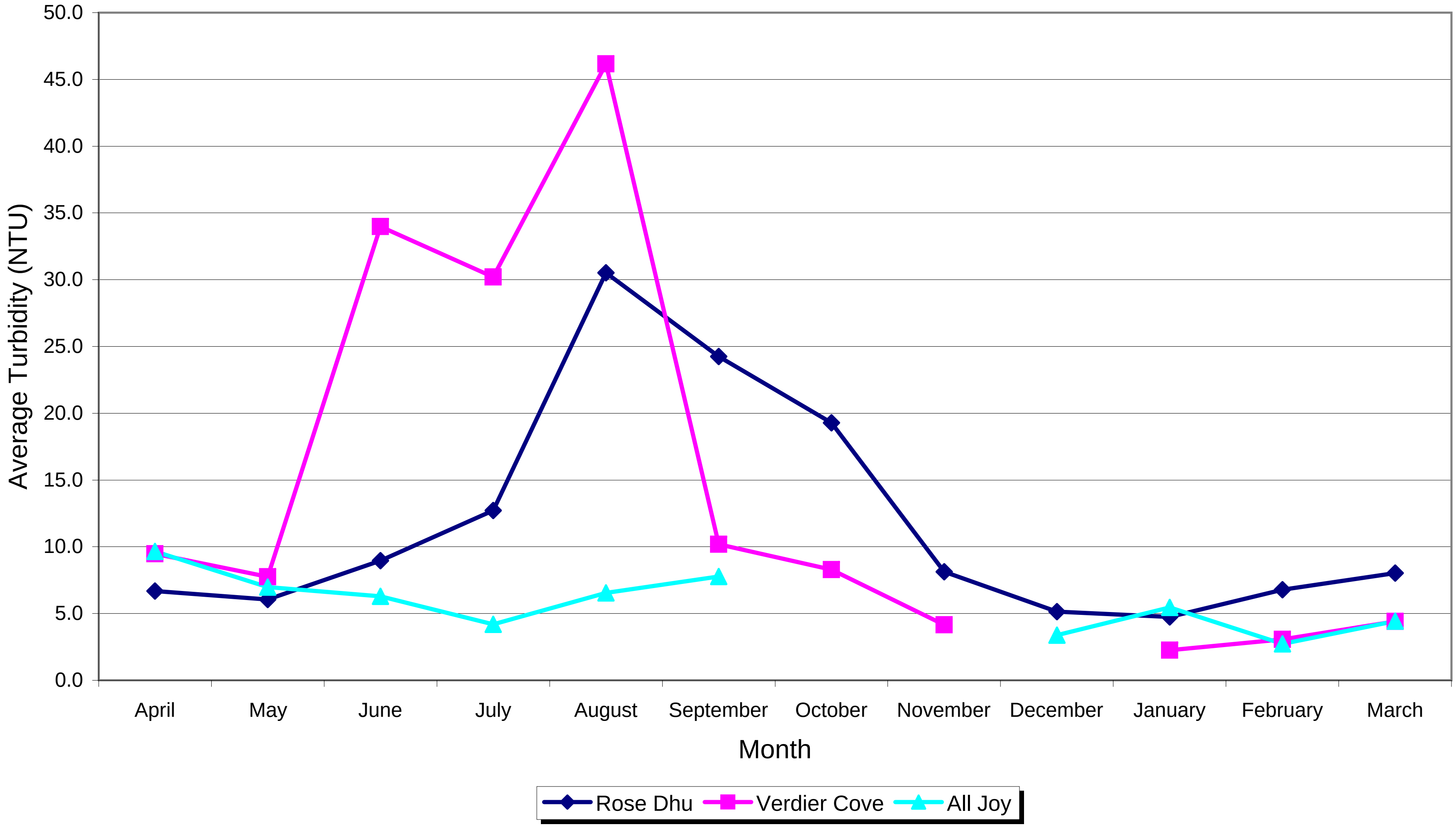
Attachment 33
May River Continuous Monitoring Data (Incoming & Outgoing Tide)
Monthly Average Salinity
April 2007 - March 2008



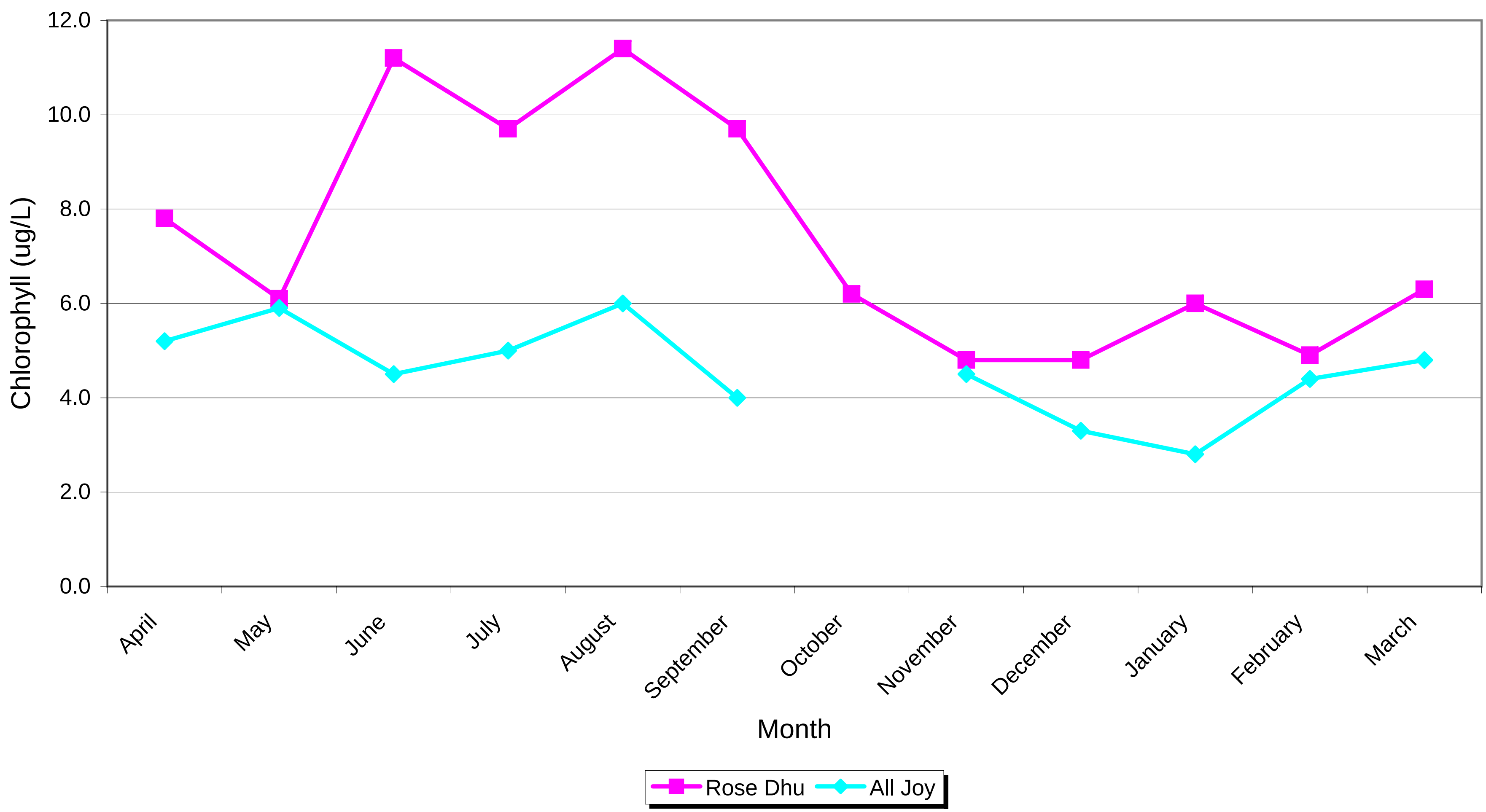
Attachment 34
May River Continuous Monitoring Data (Incoming & Outgoing Tide)
Monthly Average DO%
April 2007 - March 2008



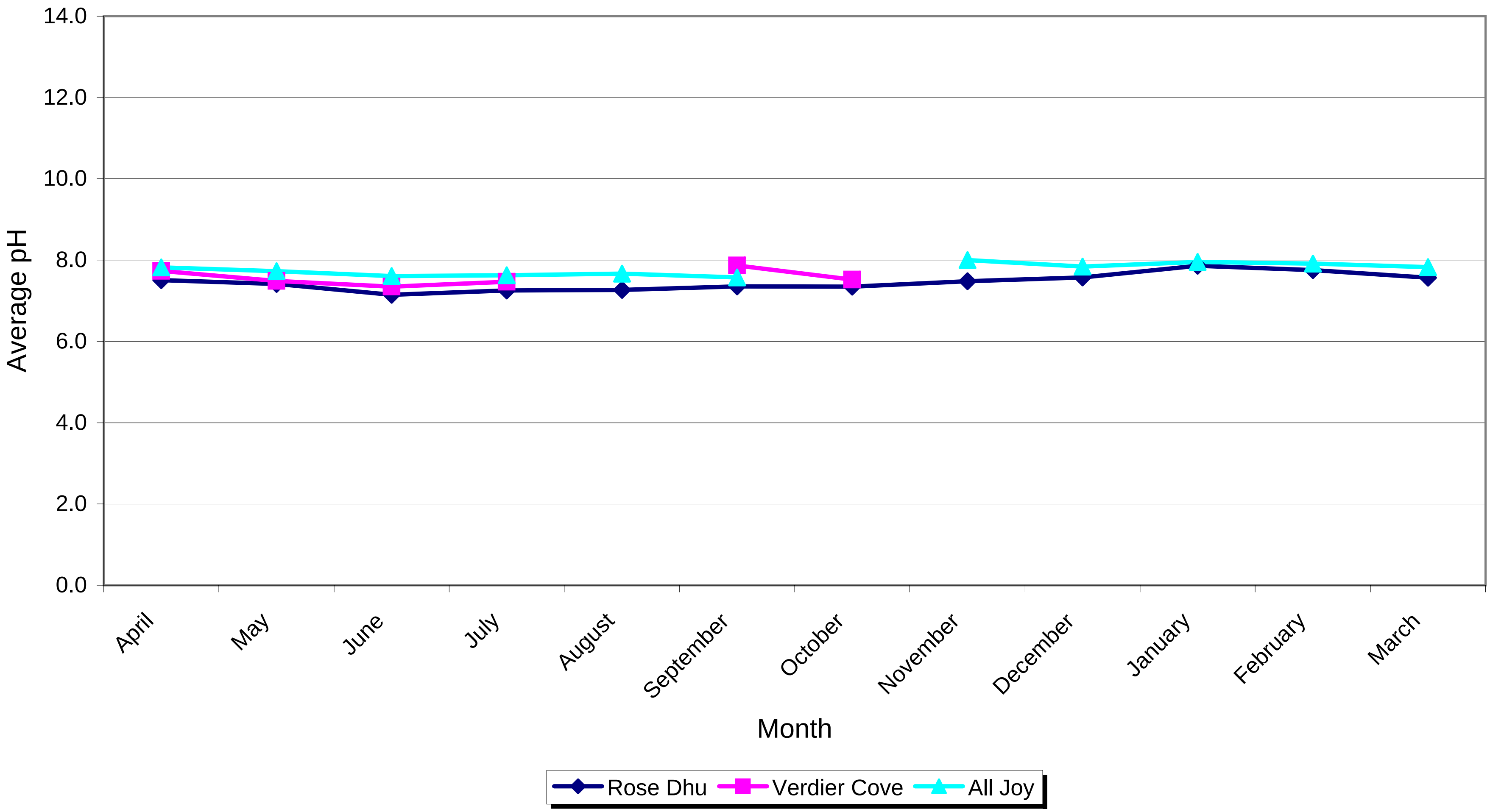
Attachment 35
May River Continuous Monitoring Data (Incoming & Outgoing Tide)
Monthly Average Turbidity
April 2007 - March 2008



Attachment 36
May River Continuous Monitoring Data (Incoming & Outgoing Tide)
Monthly Average Chlorophyll
April 2007 - March 2008

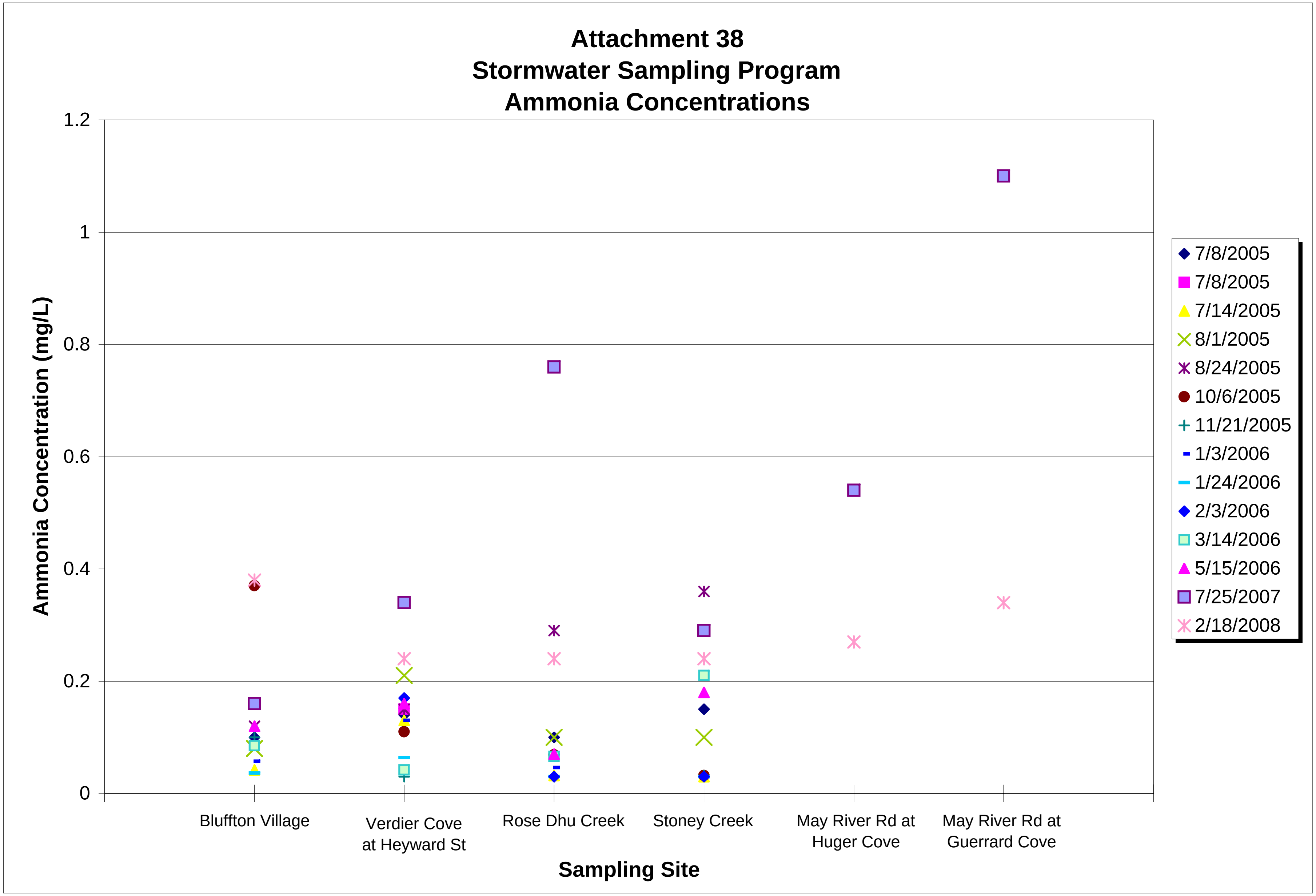


Attachment 37
May River Continuous Monitoring Data (Incoming & Outgoing Tide)
Monthly Average pH
April 2007 - March 2008

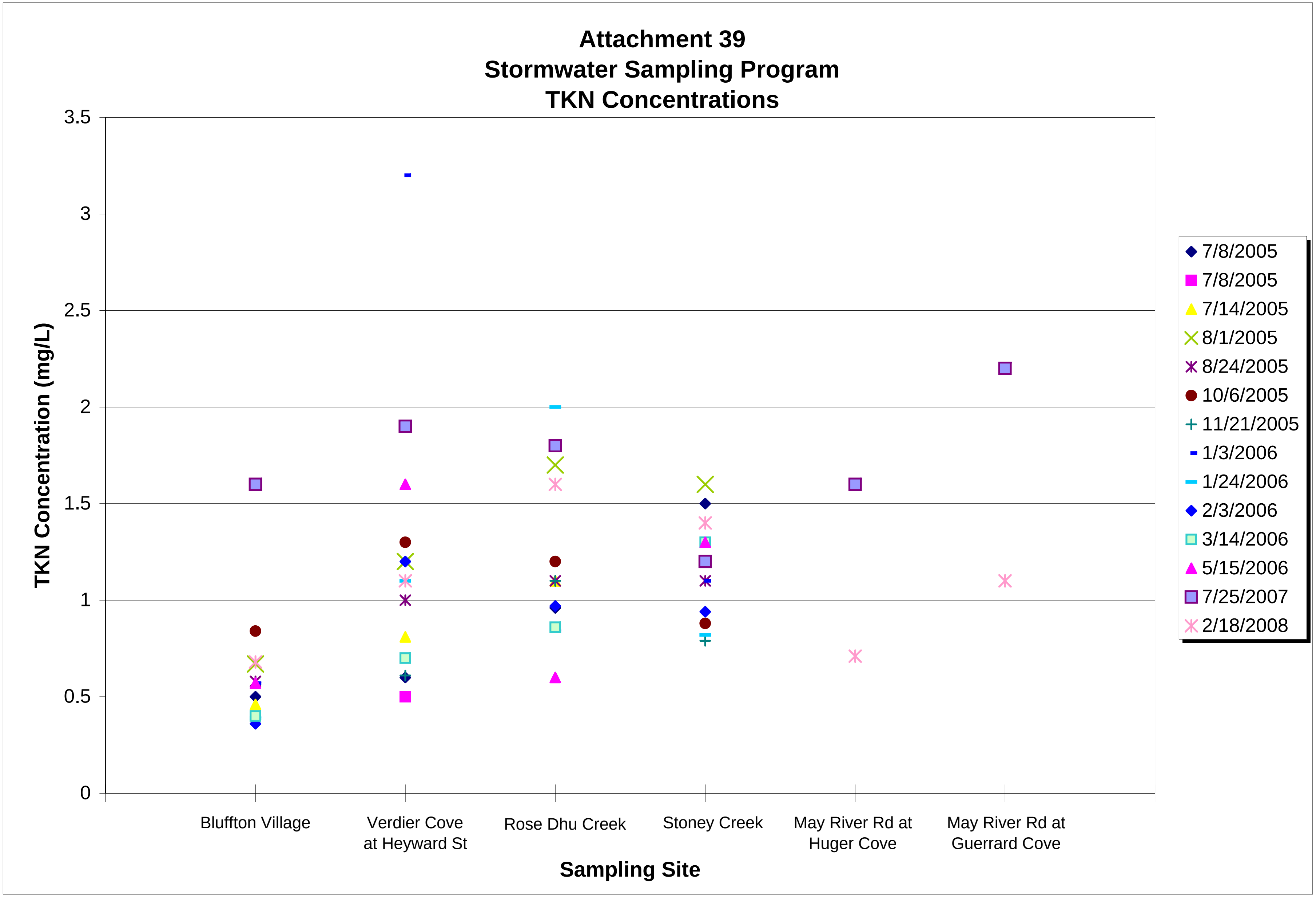


APPENDIX C

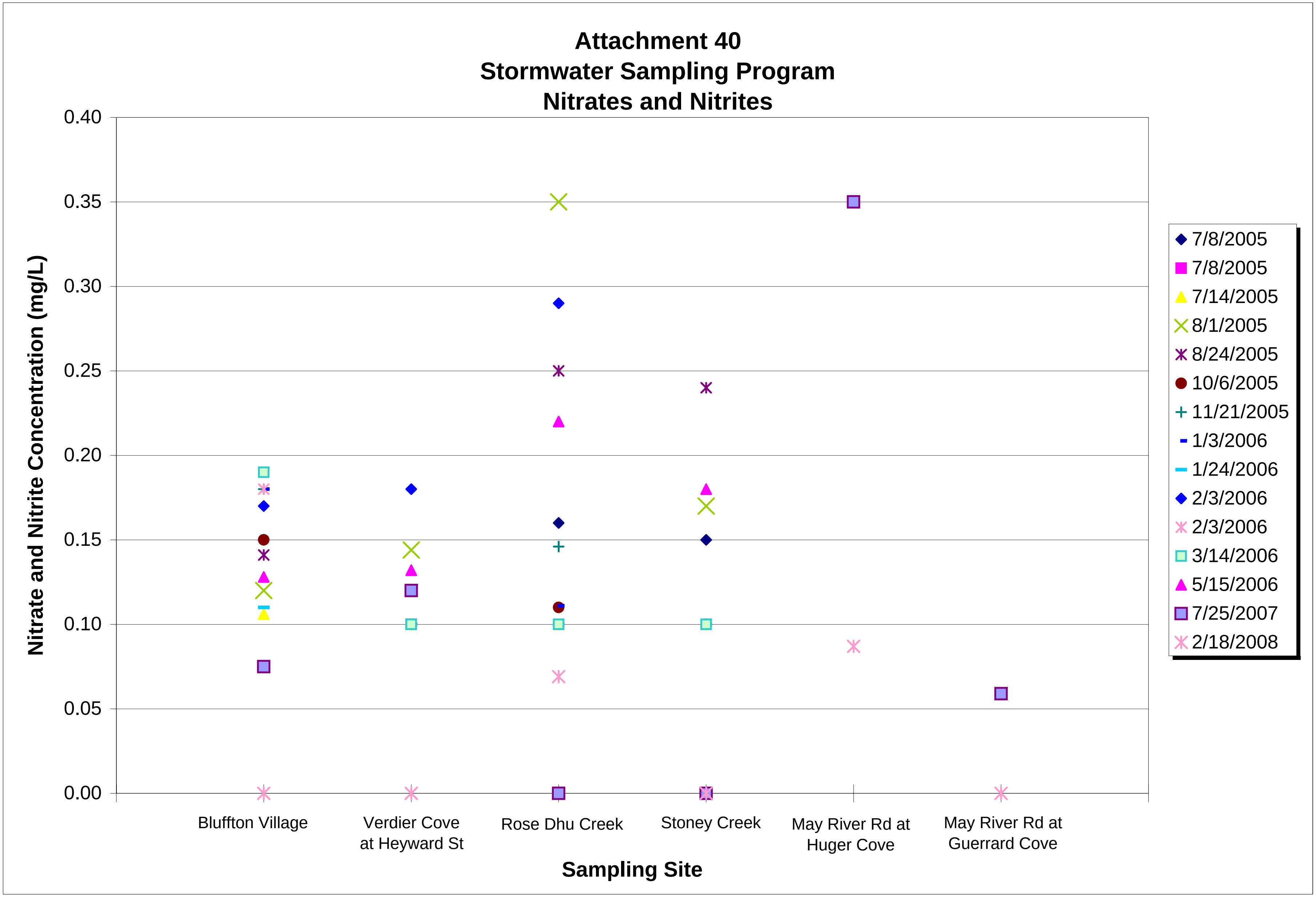
Stormwater Sampling Program Data

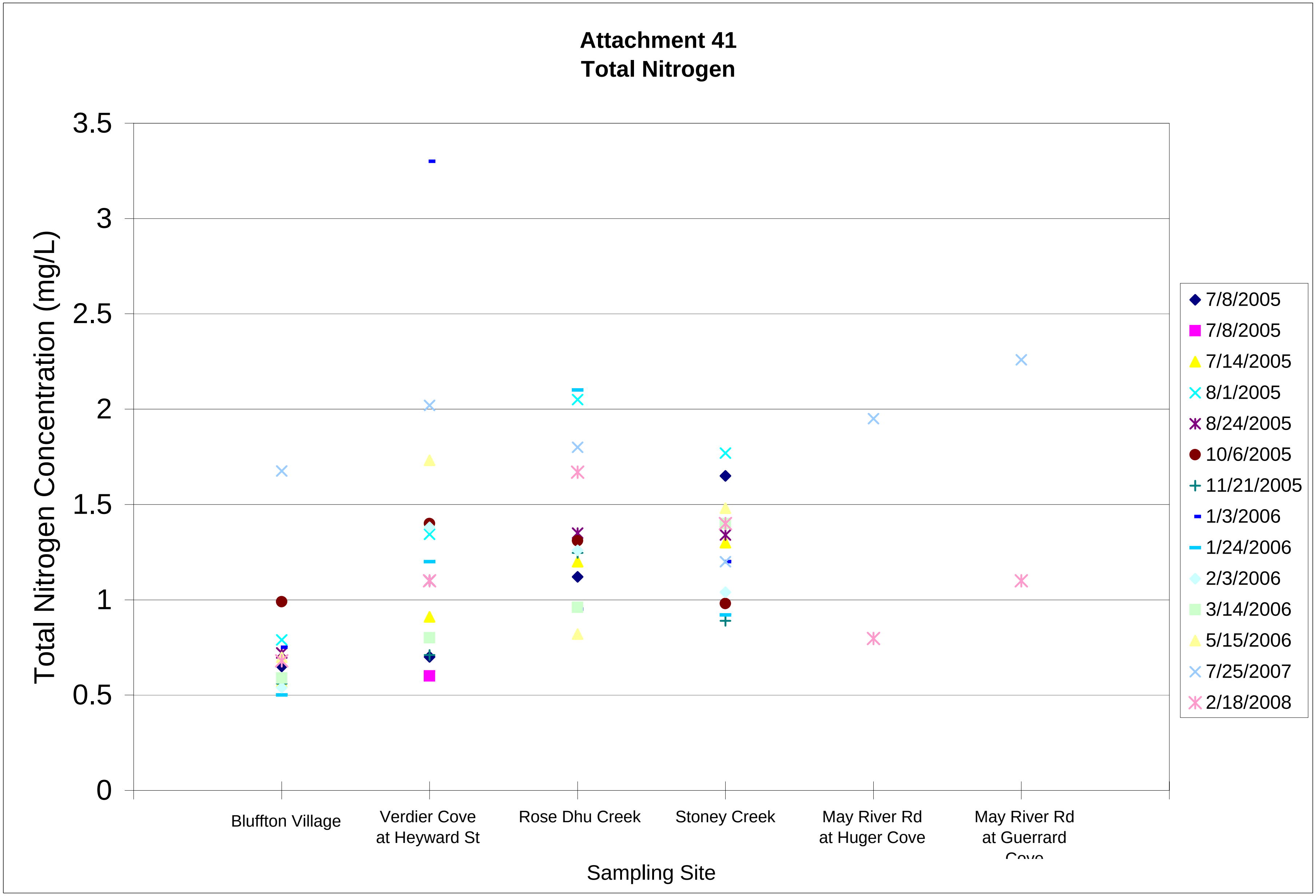


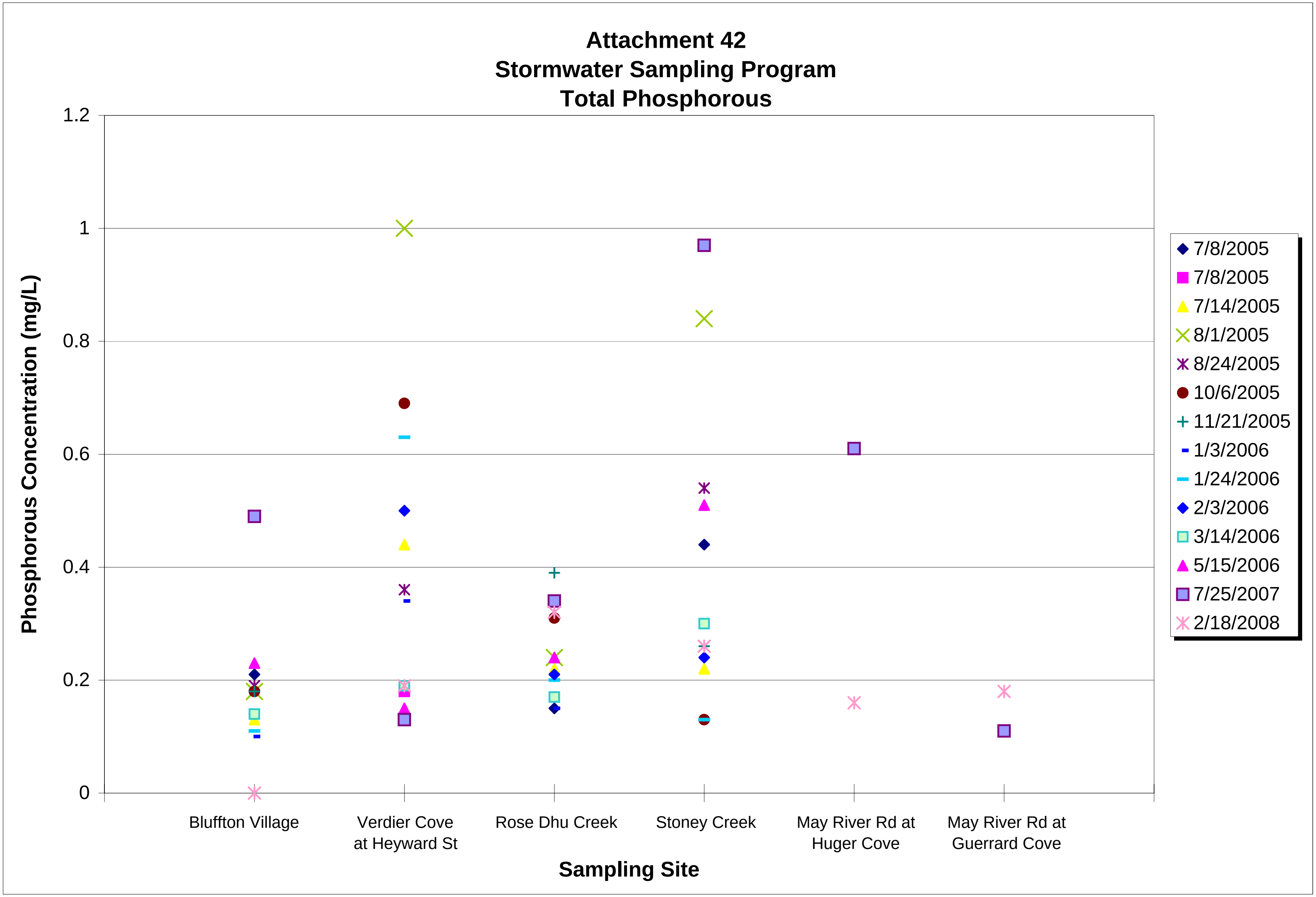
Attachment 38
Stormwater Sampling Program
Ammonia Concentrations
Ammonia Concentration (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard Cove
Sampling Site
7/8/2005
7/8/2005
7/14/2005
8/1/2005
8/24/2005
10/6/2005
11/21/2005
1/3/2006
1/24/2006
2/3/2006
3/14/2006
5/15/2006
7/25/2007
2/18/2008

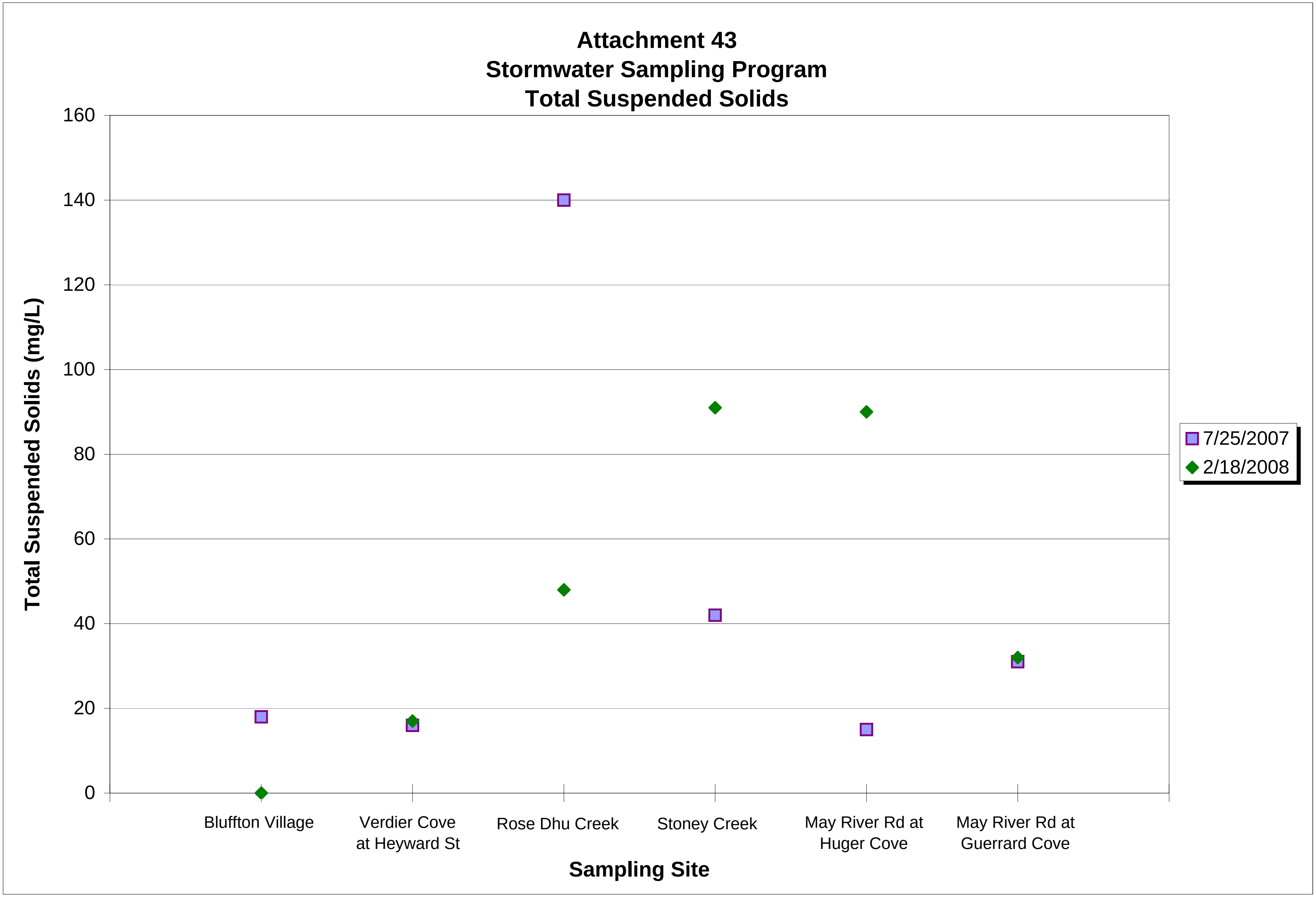


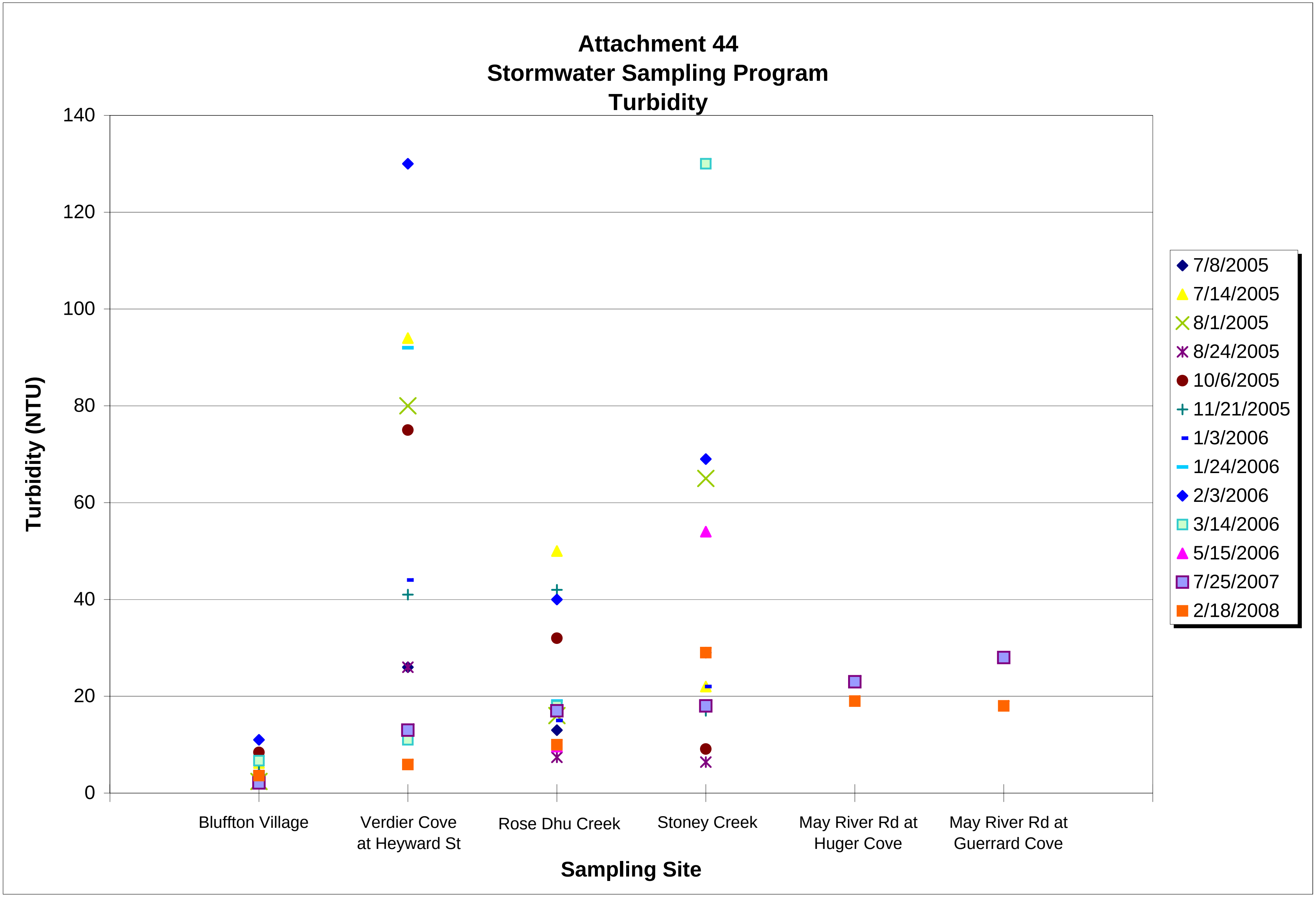
Attachment 39
Stormwater Sampling Program
TKN Concentrations
TKN Concentration (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard Cove
Sampling Site
7/8/2005
7/8/2005
7/14/2005
8/1/2005
8/24/2005
10/6/2005
11/21/2005
1/3/2006
1/24/2006
2/3/2006
3/14/2006
5/15/2006
7/25/2007
2/18/2008

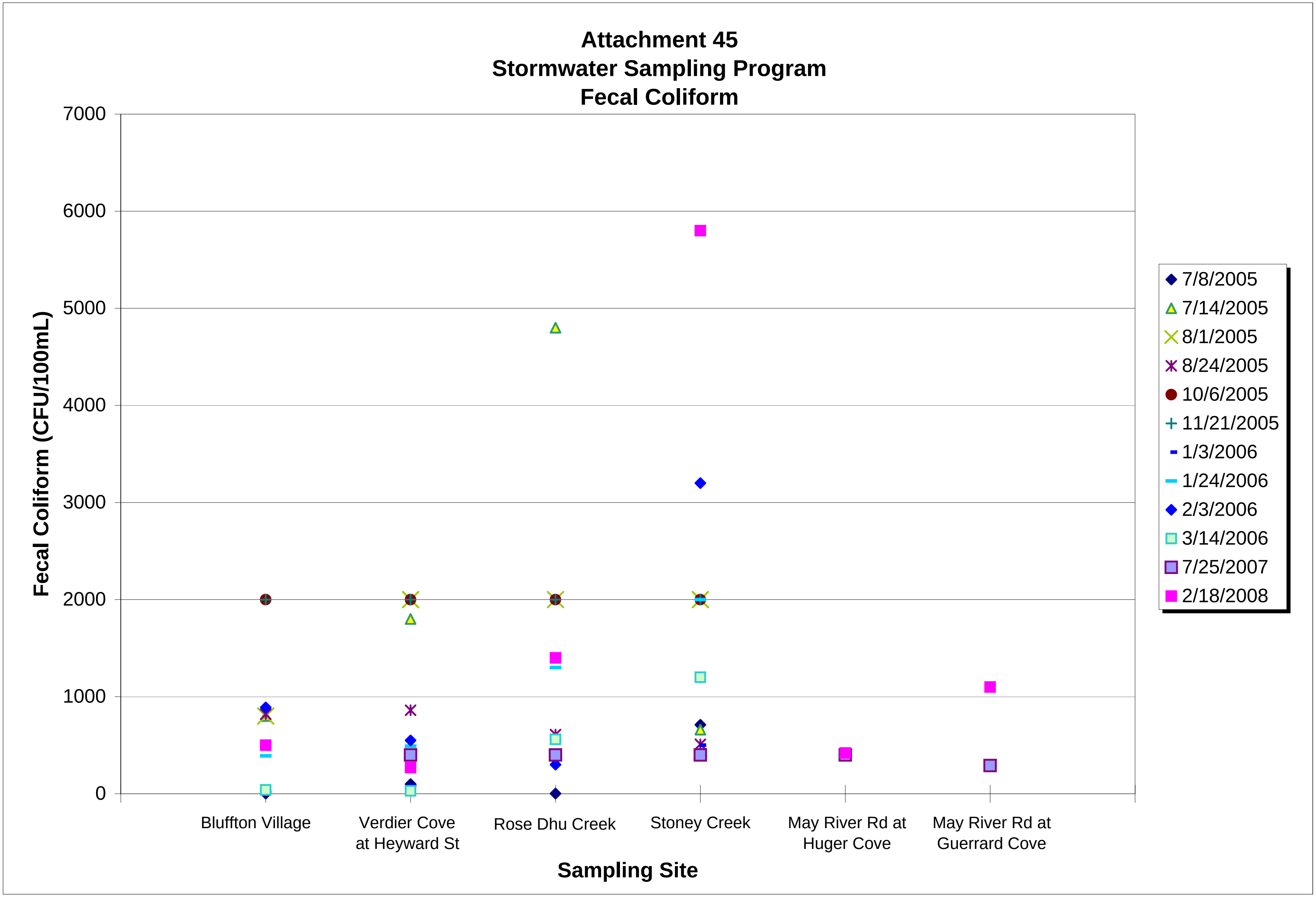

Attachment 40
Stormwater Sampling Program
Nitrates and Nitrites
Nitrate and Nitrite Concentration (mg/L)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard Cove
Sampling Site
7/8/2005
7/8/2005
7/14/2005
8/1/2005
8/24/2005
10/6/2005
11/21/2005
1/3/2006
1/24/2006
2/3/2006
2/3/2006
3/14/2006
5/15/2006
7/25/2007
2/18/2008

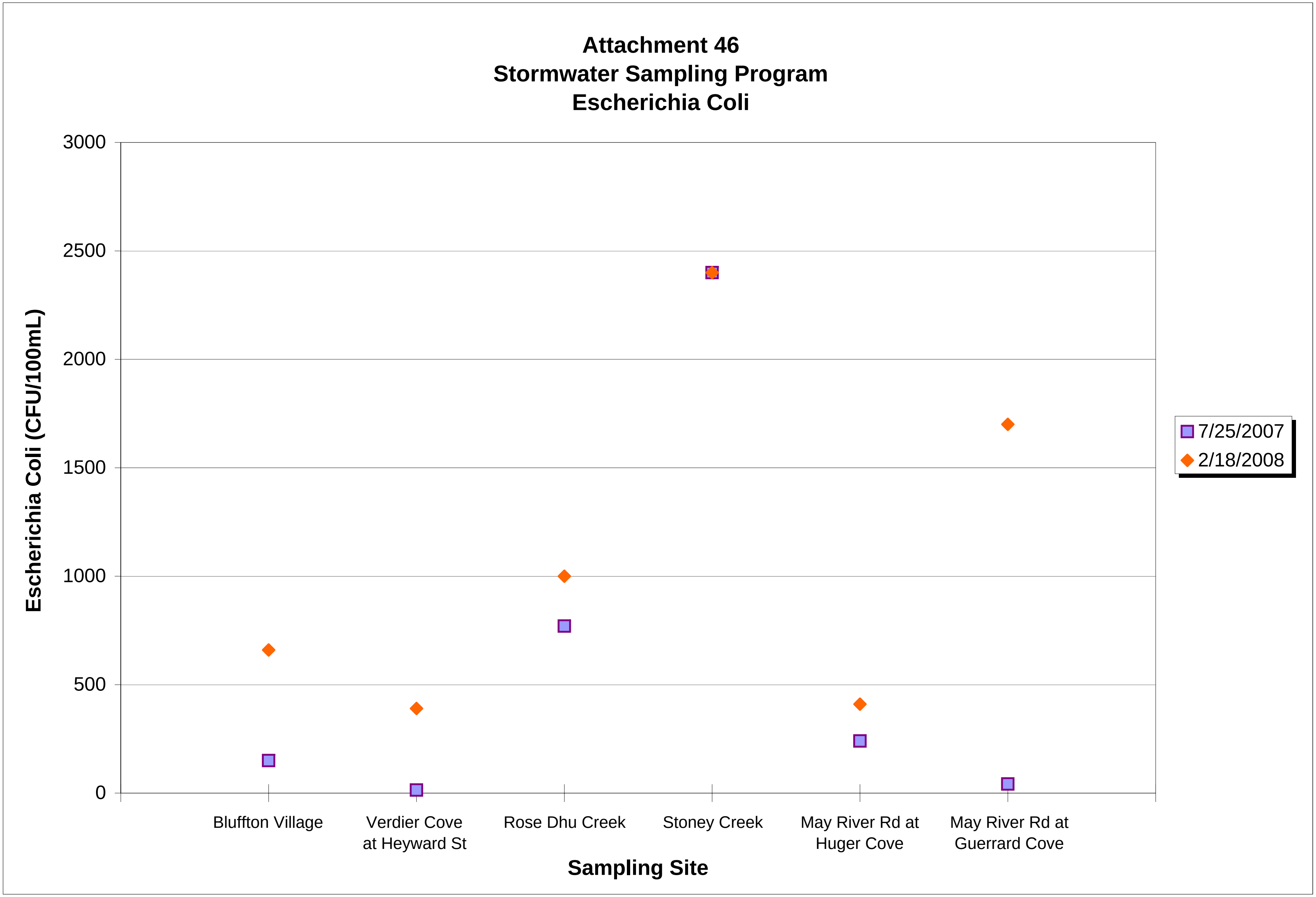

Attachment 41
Total Nitrogen
Total Nitrogen Concentration (mg/L)
3.5
3
2.5
2
1.5
1
0.5
0
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard
Sampling Site
7/8/2005
7/8/2005
7/14/2005
8/1/2005
8/24/2005
10/6/2005
11/21/2005
1/3/2006
1/24/2006
2/3/2006
3/14/2006
5/15/2006
7/25/2007
2/18/2008


Attachment 42
Stormwater Sampling Program
Total Phosphorous
Phosphorous Concentration (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard Cove
Sampling Site
7/8/2005
7/8/2005
7/14/2005
8/1/2005
8/24/2005
10/6/2005
11/21/2005
1/3/2006
1/24/2006
2/3/2006
3/14/2006
5/15/2006
7/25/2007
2/18/2008


Attachment 43
Stormwater Sampling Program
Total Suspended Solids
Total Suspended Solids (mg/L)
160
140
120
100
80
60
40
20
0
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard Cove
Sampling Site
7/25/2007
2/18/2008


Attachment 44
Stormwater Sampling Program
Turbidity
140
120
100
80
60
40
20
0
Turbidity (NTU)
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard Cove
Sampling Site
7/8/2005
7/14/2005
8/1/2005
8/24/2005
10/6/2005
11/21/2005
1/3/2006
1/24/2006
2/3/2006
3/14/2006
5/15/2006
7/25/2007
2/18/2008


Attachment 45
Stormwater Sampling Program
Fecal Coliform
Fecal Coliform (CFU/100mL)
7000
6000
5000
4000
3000
2000
1000
0
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard Cove
Sampling Site
7/8/2005
7/14/2005
8/1/2005
8/24/2005
10/6/2005
11/21/2005
1/3/2006
1/24/2006
2/3/2006
3/14/2006
7/25/2007
2/18/2008



Attachment 46
Stormwater Sampling Program
Escherichia Coli
Escherichia Coli (CFU/100mL)
3000
2500
2000
1500
1000
500
0
Bluffton Village
Verdier Cove at Heyward St
Rose Dhu Creek
Stoney Creek
May River Rd at Huger Cove
May River Rd at Guerrard Cove
Sampling Site
7/25/2007
2/18/2008

APPENDIX D

Palmetto Bluff Monitoring Data

Attachment 47
Sampling Data from Sites M1-M4
Palmetto Bluff

Station	DATE	TOC	TDS	TSS	BOD	TKN	NH3-N	NO3-N	TP	DP	F. Col	Cd	Cu	Pb	Zn	pH	DO	Sal.	Temp	TPH GRO	TPH DRO
ID		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	c/100 ml	mg/l	mg/l	mg/l	mg/l	SU	mg/l	ppt	°C	ug/l	ug/l
M1	19-Mar-02	ND	32000	25	ND	0.50	ND	0.044	0.028	0.019	4	ND	ND	ND	ND	7.90	6.40	25.0	22.0	ND	ND
M1	11-Jun-02	ND	37000	29	2.5	ND	ND	0.091	0.078	ND	6	ND	ND	ND	ND	7.70	5.80	25.0	29.0	ND	ND
M1	12-Aug-02	ND	37000	140	ND	1.10	ND	0.029	0.100	0.042	10	ND	ND	ND	ND	7.33	4.80	4.0	28.0	ND	ND
M1	8-Oct-02	ND	31000	23	ND	0.77	0.14	0.027	0.160	0.15	420	ND	ND	ND	ND	7.64	5.60	29.8	28.5	ND	ND
M1	6-Mar-03	ND	29000	9.8	ND	ND	ND	ND	0.041	0.025	2	ND	ND	ND	ND	7.70	8.12	22.7	15.0	ND	ND
M1	2-Jun-03	1.2	31000	17	ND	0.56	ND	ND	0.076	ND	<1	ND	ND	ND	ND	7.57	6.17	26.1	27.0	ND	ND
M1	14-Aug-03	1.2	28000	23	ND	0.57	ND	0.038	0.059	ND	ND	ND	ND	ND	ND	7.27	4.10	25.0	29.0	ND	150
M1	9-Oct-03	ND	32000	86	ND	0.51	ND	ND	0.046	0.041	<2	ND	ND	ND	ND	7.62	4.45	25.0	24.0	ND	110
M1	11-Mar-04	ND	31000	25	ND	ND	ND	ND	0.026	0.043	<2	ND	ND	0.0100	ND	7.62	8.70	21.3	15.0	ND	ND
M1	3-Jun-04	1.3	30000	20	ND	0.51	ND	ND	0.100	ND	6	ND	ND	ND	ND	7.67	5.80	21.5	28.0	ND	210
M1	19-Aug-04	1.2	34000	25	ND	1.00	ND	ND	0.057	ND	4	ND	ND	ND	ND	7.32	4.77	27.0	29.5	ND	160
M1	14-Oct-04	1.2	28000	52	ND	0.72	ND	0.040	0.072	0.034	<1	ND	ND	0.0100	ND	7.73	6.40	26.0	23.0	ND	ND
M1	2-Mar-05	ND	30000	20	ND	ND	ND	ND	ND	ND	<1.0	ND	ND	ND	ND	7.81	10.20	28.9	12.0	ND	ND
M1	9-Jun-05	1.1	26000	12	ND	0.54	ND	0.028	ND	ND	<2.0	ND	ND	ND	ND	7.37	7.50	25.0	29.0	280	ND
M1	11-Aug-05	1.4	25000	27	ND	0.50	0.20	ND	0.033	ND	50	ND	ND	ND	ND	7.39	6.80	18.9	30.0	ND	340
M1	6-Oct-05	ND	30000	28	ND	0.55	ND	ND	0.092	0.11	42	ND	ND	ND	ND	7.90	6.50	14.0	25.0	ND	ND
M1	20-Mar-06	ND	26000	15	2.2	0.54	ND	ND	0.044	0.038	6	ND	ND	0.0200	ND	7.83	8.20	28.0	16.0	ND	ND
M1	1-Jun-06	1.8	30000	14	ND	1.10	ND	0.140	0.088	0.086	3	ND	ND	ND	ND	6.78	6.26	24.9	30.0	ND	ND
M1	24-Aug-06	ND	32000	66	ND	0.79	0.13	ND	0.11	0.061	10	ND	ND	ND	0.023	7.47	5.81	33.2	30.0	ND	ND
M1	23-Oct-06	1.2	33000	25	ND	0.54	0.17	ND	0.068	0.065	<1.0	ND	ND	ND	ND	7.39	5.94	31.2	21.8	ND	ND
M1	7-Mar-07	ND	31000	10	ND	ND	ND	ND	0.039	0.042	6	ND	ND	ND	ND	6.93	9.39	19.5	15	ND	ND
M2	19-Mar-02	ND	36000	19	ND	0.72	ND	0.021	ND	0.024	ND	ND	ND	ND	ND	7.80	6.40	25.0	22.0	ND	ND
M2	11-Jun-02	ND	37000	28	ND	ND	ND	0.090	0.082	ND	2	ND	ND	ND	ND	7.63	5.80	28.0	28.0	ND	ND
M2	12-Aug-02	ND	37000	91	ND	0.75	ND	0.029	0.096	ND	8	ND	ND	ND	ND	7.42	5.20	10.0	28.0	ND	ND
M2	8-Oct-02	ND	30000	18	ND	0.61	ND	0.029	0.096	0.089	180	ND	0.0360	ND	ND	7.58	7.30	28.4	28.5	ND	ND
M2	6-Mar-03	ND	29000	20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.68	7.85	22.4	16.0	ND	ND
M2	2-Jun-03	1.2	32000	15	ND	ND	ND	ND	0.078	ND	<1	ND	ND	ND	ND	7.51	6.60	25.0	27.0	ND	ND
M2	14-Aug-03	1.3	27000	46	ND	0.74	ND	0.041	0.063	ND	4	ND	ND	ND	ND	6.99	4.50	24.0	29.0	ND	140
M2	9-Oct-03	1	32000	81	5.0	0.60	ND	0.130	0.053	0.032	150	ND	ND	ND	ND	7.56	4.35	25.0	24.0	ND	120
M2	11-Mar-04	ND	30000	16	ND	ND	ND	0.024	0.020	0.039	<2	ND	ND	0.0082	ND	7.76	8.60	21.0	15.0	ND	ND
M2	3-Jun-04	1.1	30000	32	ND	0.78	ND	0.028	0.088	ND	160	ND	ND	ND	ND	7.64	5.70	21.7	28.0	ND	260
M2	19-Aug-04	1.3	36000	26	ND	1.20	ND	ND	0.079	ND	<1	ND	ND	ND	ND	7.27	4.80	25.0	29.5	ND	180
M2	14-Oct-04	1.1	30000	19	ND	0.80	ND	0.030	0.067	ND	<1	ND	ND	0.0071	ND	7.59	7.00	26.0	23.0	ND	ND
M2	2-Mar-05	ND	30000	15	ND	ND	ND	ND	ND	ND	<1.0	ND	ND	ND	ND	7.77	10.20	28.0	12.5	ND	ND
M2	9-Jun-05	1.2	26000	13	ND	0.78	ND	0.020	0.060	ND	2	ND	ND	ND	ND	7.21	7.30	25.0	29.0	440	ND
M2	11-Aug-05	1.4	24000	29	ND	ND	0.170	ND	0.027	ND	22	ND	ND	ND	ND	7.42	7.60	18.6	30.0	ND	ND
M2	6-Oct-05	ND	30000	26	ND	0.51	ND	ND	0.220	0.064	80	ND	ND	ND	ND	7.88	6.45	13.0	25.0	ND	ND
M2	20-Mar-06	ND	26000	22	ND	ND	ND	ND	0.045	0.04	4	ND	ND	0.0230	ND	7.74	8.40	28.0	16.0	ND	ND
M2	1-Jun-06	1.3	30000	19	ND	ND	ND	0.130	0.089	0.08	3	ND	ND	ND	ND	7.30	6.31	25.8	30.0	ND	ND
M2	24-Aug-06	1.2	32000	66	ND	0.86	0.17	ND	0.12	0.060	32	ND	ND	ND	ND	7.43	5.86	32.2	30.0	ND	ND
M2	23-Oct-06	1.2	32000	33	ND	ND	0.28	ND	0.070	0.068	<1.0	ND	ND	ND	ND	7.35	5.54	31.0	21.9	ND	ND
M2	7-Mar-07	1.0	31000	9.3	ND	0.69	ND	ND	0.045	0.042	<1.0	ND	ND	ND	ND	7.33	9.68	19.6	15.0	ND	ND

Attachment 47
Sampling Data from Sites M1-M4
Palmetto Bluff

Station	DATE	TOC	TDS	TSS	BOD	TKN	NH3-N	NO3-N	TP	DP	F. Col	Cd	Cu	Pb	Zn	pH	DO	Sal.	Temp	TPH GRO	TPH DRO
ID		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	c/100 ml	mg/l	mg/l	mg/l	mg/l	SU	mg/l	ppt	°C	ug/l	ug/l
M3	19-Mar-02	ND	34000	18	2.7	0.57	ND	0.022	0.041	0.03	14	ND	ND	ND	ND	7.67	6.25	27.0	23.0	ND	ND
M3	11-Jun-02	ND	36000	30	3.2	ND	ND	0.092	0.100	ND	8	ND	ND	ND	ND	7.54	5.25	24.0	25.0	ND	ND
M3	12-Aug-02	ND	37000	31	ND	0.83	ND	0.029	0.062	0.039	<1	ND	ND	ND	ND	7.50	5.40	13.0	28.0	ND	ND
M3	8-Oct-02	ND	27000	33	ND	0.95	0.10	0.024	0.110	0.110	8	ND	ND	ND	ND	7.43	7.40	24.8	28.5	ND	ND
M3	6-Mar-03	1.7	23000	18	ND	ND	ND	ND	0.041	ND	13	ND	ND	ND	ND	7.41	7.85	17.4	16.0	ND	ND
M3	2-Jun-03	3.4	36000	26	ND	0.73	ND	ND	0.055	ND	20	ND	ND	ND	ND	7.06	6.11	16.0	27.0	ND	ND
M3	14-Aug-03	2.8	18000	31	ND	1.1	ND	0.046	0.069	ND	20	ND	ND	ND	0.028	6.73	5.10	16.0	30.0	ND	230
M3	9-Oct-03	1.2	30000	85	ND	0.59	ND	ND	0.066	0.036	12	ND	ND	ND	0.035	7.44	4.70	22.7	24.0	ND	150
M3	11-Mar-04	1	28000	27	ND	ND	ND	ND	0.050	0.035	<2	ND	ND	0.0100	ND	7.60	8.30	20.1	15.0	ND	ND
M3	3-Jun-04	1.6	32000	31	ND	0.58	ND	ND	0.036	ND	4	ND	ND	ND	ND	7.50	5.20	19.0	29.0	ND	280
M3	19-Aug-04	1.7	33000	66	2.4	0.97	ND	0.022	0.160	ND	<1	ND	ND	ND	ND	6.95	4.42	25.0	29.5	ND	270
M3	14-Oct-04	1.2	27000	10	ND	0.83	ND	0.029	0.096	ND	<1	ND	ND	0.0074	ND	7.29	6.30	26.0	23.0	ND	120
M3	2-Mar-05	1.0	28000	19	ND	ND	0.1	ND	0.026	ND	8	ND	ND	ND	ND	7.65	10.40	25.3	12.0	ND	ND
M3	9-Jun-05	2.0	22000	15	ND	0.56	ND	ND	0.088	ND	2	ND	ND	ND	ND	7.12	6.05	20.0	30.0	420	ND
M3	11-Aug-05	2.0	22000	28	ND	0.56	0.16	ND	0.011	ND	12	ND	ND	ND	ND	6.92	5.90	15.0	30.0	ND	ND
M3	6-Oct-05	1.2	27000	76	ND	0.64	ND	ND	0.27	0.068	160	ND	ND	ND	ND	7.68	6.20	11.0	25.0	ND	ND
M3	20-Mar-06	1.3	2400	11	ND	0.53	ND	ND	0.057	0.042	18	ND	ND	0.0180	ND	7.43	8.10	25.0	16.0	ND	ND
M3	1-Jun-06	ND	30000	19	ND	ND	ND	ND	0.058	0.087	1	ND	ND	ND	ND	7.48	5.70	27.0	29.0	ND	ND
M3	24-Aug-06	1.6	31000	49	ND	1.2	0.18	ND	0.13	0.071	22	ND	ND	ND	ND	7.32	5.76	36.7	30.0	ND	ND
M3	23-Oct-06	1.5	32000	43	ND	ND	0.18	ND	0.094	0.094	<1.0	ND	ND	ND	ND	7.24	5.89	30.1	21.7	ND	ND
M3	7-Mar-07	1.4	28000	11	ND	0.61	ND	ND	0.051	0.055	1	ND	ND	ND	ND	7.81	9.39	18.0	15.0	ND	ND
M4	19-Mar-02	ND	34000	23	3.2	0.85	ND	0.021	0.012	0.039	6	ND	ND	ND	0.028	7.47	6.30	25.0	23.0	ND	ND
M4	11-Jun-02	ND	38000	38	2.2	0.56	ND	0.092	0.13	ND	30	ND	ND	ND	ND	7.36	6.00	19.0	25.0	ND	ND
M4	12-Aug-02	ND	38000	40	ND	0.63	ND	0.028	0.054	0.049	<1	ND	ND	ND	ND	7.58	5.10	13.0	28.0	ND	ND
M4	8-Oct-02	ND	25000	52	ND	0.99	0.18	0.024	0.15	0.13	12	ND	ND	ND	ND	7.36	5.30	24.1	28.0	ND	ND
M4	6-Mar-03	28	18000	28	ND	0.69	ND	ND	0.043	ND	62	ND	ND	ND	ND	7.21	7.80	13.0	16.5	ND	ND
M4	2-Jun-03	5.6	14000	170	3.1	1.7	ND	ND	0.42	ND	52	ND	ND	ND	ND	6.49	5.58	11.9	26.5	170	ND
M4	14-Aug-03	4.2	14000	42	ND	1.1	0.13	0.044	0.11	0.037	ND	ND	0.0066	ND	0.026	6.56	4.40	12.0	29.5	ND	540
M4	9-Oct-03	1.3	30000	100	2.4	0.51	ND	ND	0.093	0.036	32	ND	ND	ND	0.025	7.17	4.50	19.8	24.0	ND	150
M4	11-Mar-04	1.1	26000	43	ND	ND	ND	ND	0.043	ND	4	ND	0.0054	ND	ND	7.53	8.80	15.3	14.0	ND	ND
M4	3-Jun-04	1.8	32000	36	2.6	ND	ND	ND	0.04	ND	18	ND	ND	ND	ND	7.44	5.10	14.0	29.0	ND	290
M4	19-Aug-04	1.9	32000	51	2.2	0.89	ND	ND	0.1	ND	16	ND	ND	ND	ND	6.69	4.77	24.0	29.5	ND	250
M4	14-Oct-04	1.7	28000	41	ND	0.88	ND	0.037	0.12	0.067	30	ND	ND	0.0049	ND	6.83	6.10	24.9	23.0	ND	130
M4	2-Mar-05	2.4	21000	14	ND	ND	0.13	0.075	0.04	0.02	48	ND	ND	ND	ND	7.34	9.70	19.3	11.0	ND	ND
M4	9-Jun-05	2.8	19000	25	ND	0.76	ND	ND	0.12	ND	20	ND	ND	ND	ND	7.01	8.00	17.0	30.0	350	ND
M4	11-Aug-05	2.7	19000	44	ND	1.1	0.17	ND	0.15	ND	38	ND	ND	ND	ND	6.88	6.00	14.0	30.0	ND	ND
M4	6-Oct-05	1.7	22000	68	ND	0.99	ND	ND	0.28	0.15	>400	ND	ND	0.0110	0.047	7.51	6.25	7.4	25.0	ND	ND
M4	20-Mar-06	1.7	22000	14	4.8	1.2	ND	ND	0.078	0.049	18	ND	ND	ND	ND	7.42	6.50	24.0	16.0	ND	210
M4	1-Jun-06	ND	29000	18	ND	ND	ND	ND	0.056	0.052	<1	ND	ND	ND	ND	7.55	6.18	26.4	29.0	ND	ND
M4	24-Aug-06	1.9	30000	47	2.0	0.54	0.10	ND	0.14	0.074	330	ND	ND	ND	ND	7.20	5.10	30.9	30.1	ND	ND
M4	23-Oct-06	1.7	31000	32	ND	ND	0.18	0.075	0.098	0.10	4	ND	ND	ND	ND	7.19	5.86	28.5	21.3	ND	ND
M4	7-Mar-07	1.9	26000	75	3.9	0.74	ND	ND	0.064	0.065	3	ND	ND	ND	ND	7.87	10.59	18.1	15.0	ND	ND

Pace Analytical®
www.pacelabs.com

Pace Analytical Services, Inc.
2225 Riverside Dr.
Asheville, NC 28804
(828)254-7176

Pace Analytical Services, Inc.
9800 Kincey Ave. Suite 100
Huntersville, NC 28078
(704)875-9092

CERTIFICATIONS

Project: PALMETTO BLUFF GOLF COURSE
Pace Project No.: 9215192

Charlotte Certification IDs

Florida/NELAP Certification Number: E87627
Kansas Certification Number: E-10364
Louisiana/LELAP Certification Number: 04034
North Carolina Drinking Water Certification Number: 37706
North Carolina Wastewater Certification Number: 12
North Carolina Field Services Certification Number: 5342
South Carolina Certification Number: 990060001
South Carolina Bioassay Certification Number: 990060003
Tennessee Certification Number: 04010
Virginia Certification Number: 00213

Asheville Certification IDs

Florida/NELAP Certification Number: E87648
Louisiana/LELAP Certification Number: 03095
New Jersey Certification Number: NC011
North Carolina Drinking Water Certification Number: 37712
North Carolina Wastewater Certification Number: 40
North Carolina Bioassay Certification Number: 9
Pennsylvania Certification Number: 68-03578
South Carolina Certification Number: 99030001
South Carolina Bioassay Certification Number: 99030002
Tennessee Certification Number: 2980
Virginia Certification Number: 00072

Eden Certification IDs

North Carolina Drinking Water Certification Number: 37738
Virginia Drinking Water Certification Number: 00424
North Carolina Wastewater Certification Number: 633

Pace Analytical®
www.pacelabs.com

Pace Analytical Services, Inc.
2225 Riverside Dr.
Asheville, NC 28804
(828)254-7176

Pace Analytical Services, Inc.
9800 Kincey Ave. Suite 100
Huntersville, NC 28078
(704)875-9092

SAMPLE ANALYTE COUNT

Project: PALMETTO BLUFF GOLF COURSE
Pace Project No.: 9215192

Lab ID	Sample ID	Method	Analysts	Analytes Reported	Laboratory
9215192001	**PB3**	EPA 8270	BET	7	PASI-C
9215192002	**PB2**	EPA 8270	BET	7	PASI-C
9215192003	**PB1**	EPA 8270	BET	7	PASI-C
9215192004	**PB6**	EPA 8270	BET	7	PASI-C

Pace Analytical Services, Inc.
2225 Riverside Dr.
Asheville, NC 28804
(828)254-7176

Pace Analytical Services, Inc.
9800 Kincey Ave. Suite 100
Huntersville, NC 28078
(704)875-9092

ANALYTICAL RESULTS

Project: PALMETTO BLUFF GOLF COURSE
Pace Project No.: 9215192

Sample: PB3 **Lab ID: 9215192001** Collected: 03/11/08 10:54

Parameters	Results	Units	Report Limit	DF
Atrazine	ND	ug/L	22.7	1

Sample: PB2 **Lab ID: 9215192002** Collected: 03/11/08 11:09

Parameters	Results	Units	Report Limit	DF
Atrazine	ND	ug/L	23.3	1

Sample: PB1 **Lab ID: 9215192003** Collected: 03/11/08 11:14

Parameters	Results	Units	Report Limit	DF
Atrazine	ND	ug/L	23.0	1

Sample: PB6 **Lab ID: 9215192004** Collected: 03/11/08 11:30

Parameters	Results	Units	Report Limit	DF
Atrazine	ND	ug/L	24.1	1

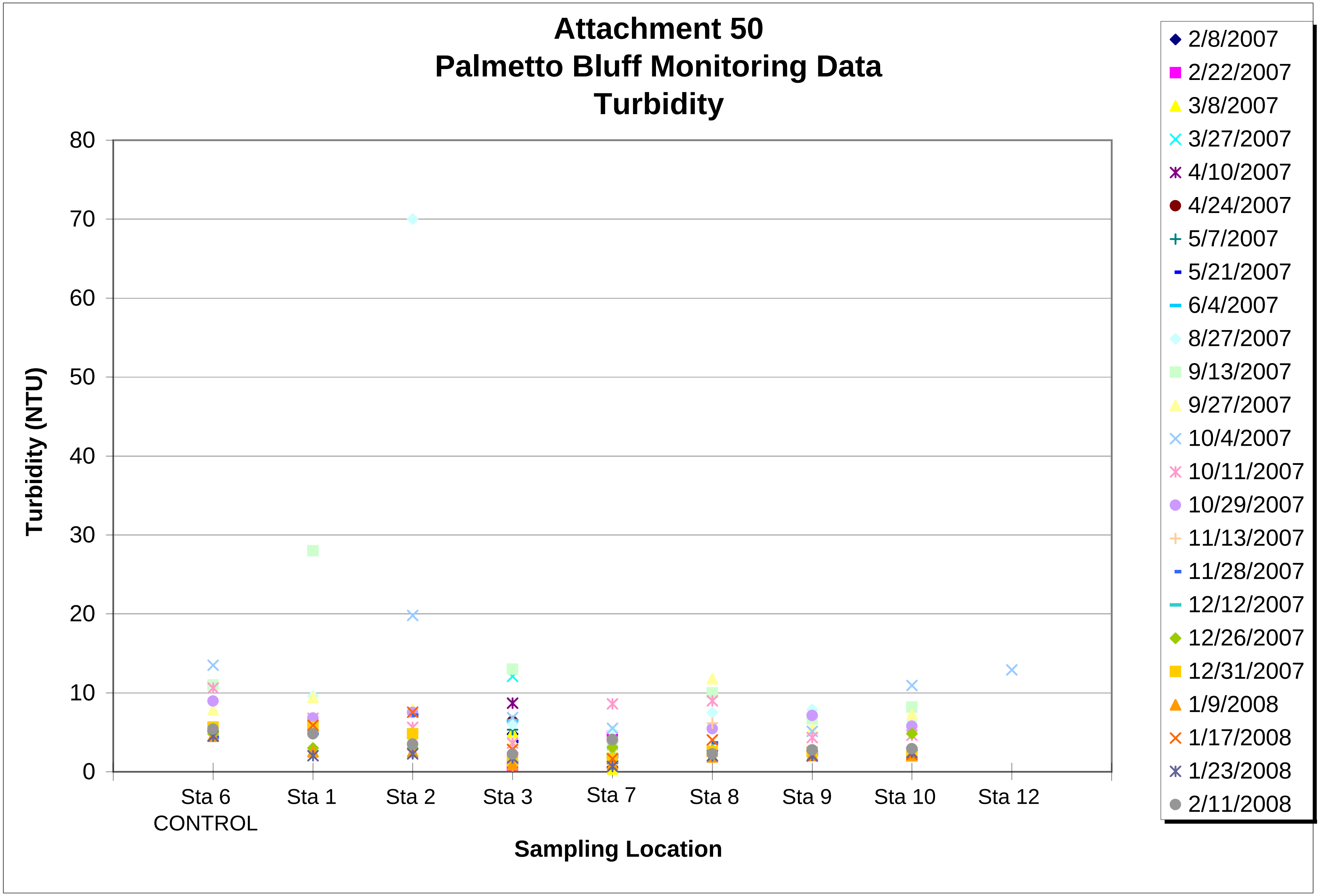
Attachment 49

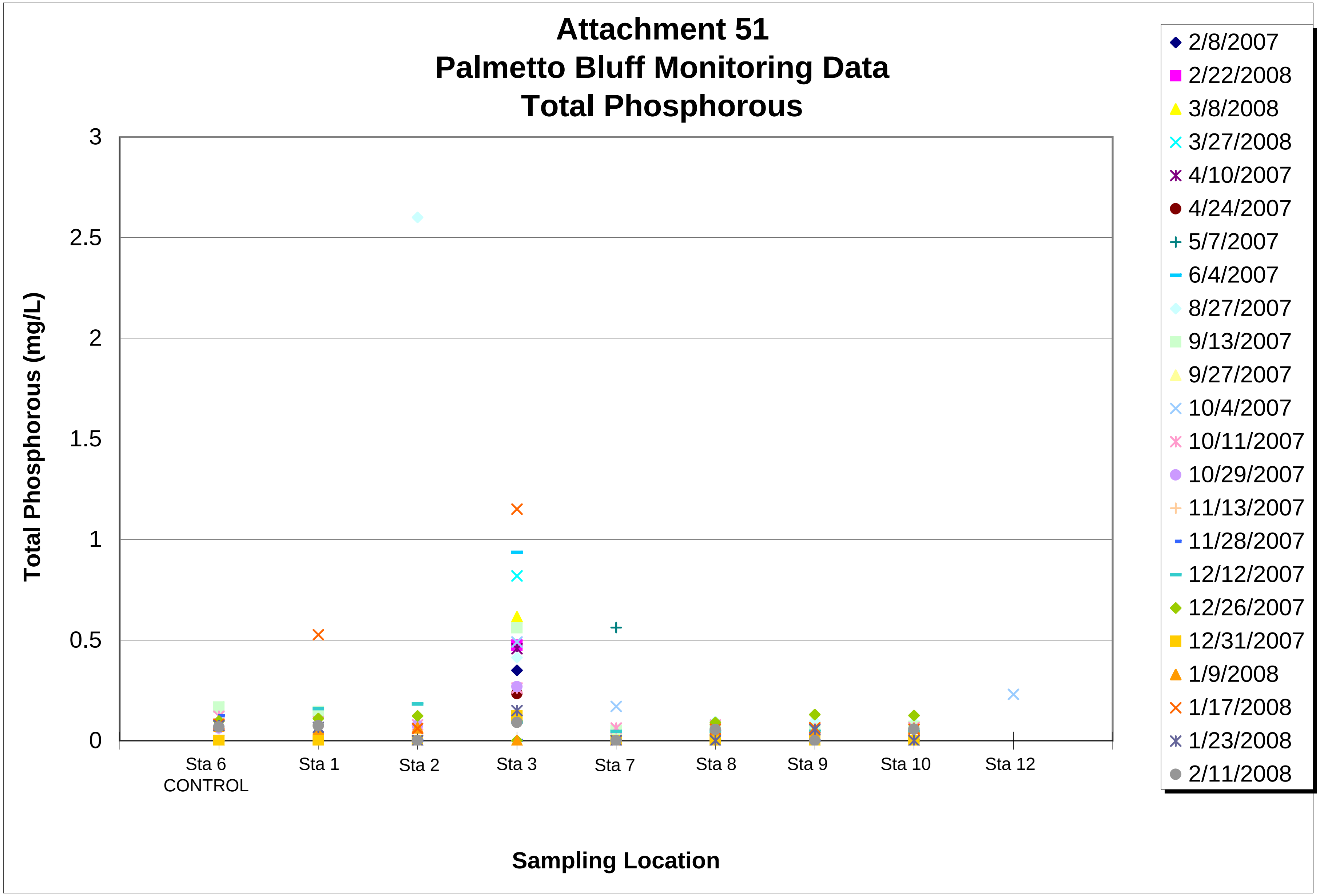
Soil Analysis Reports for May River Golf Club

Fertilizer Application made During 2007

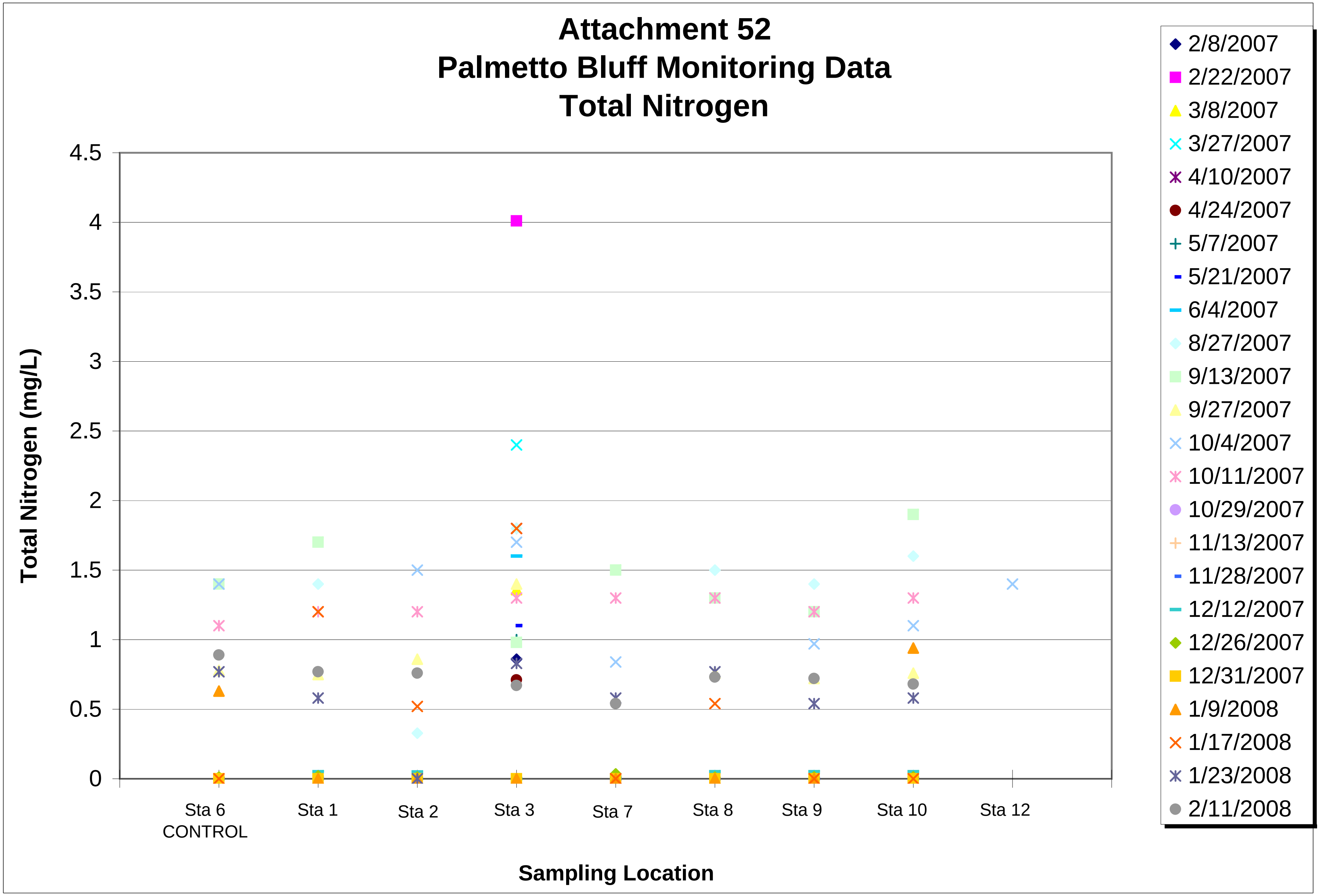
2/16/2007	**0-0-26 (NPK)**
4/1/2007	**10-0-11 (NPK)**
5/25/2007	**9-0-9 (NPK)**
8/24/2007	**0-0-23 (NPK)**

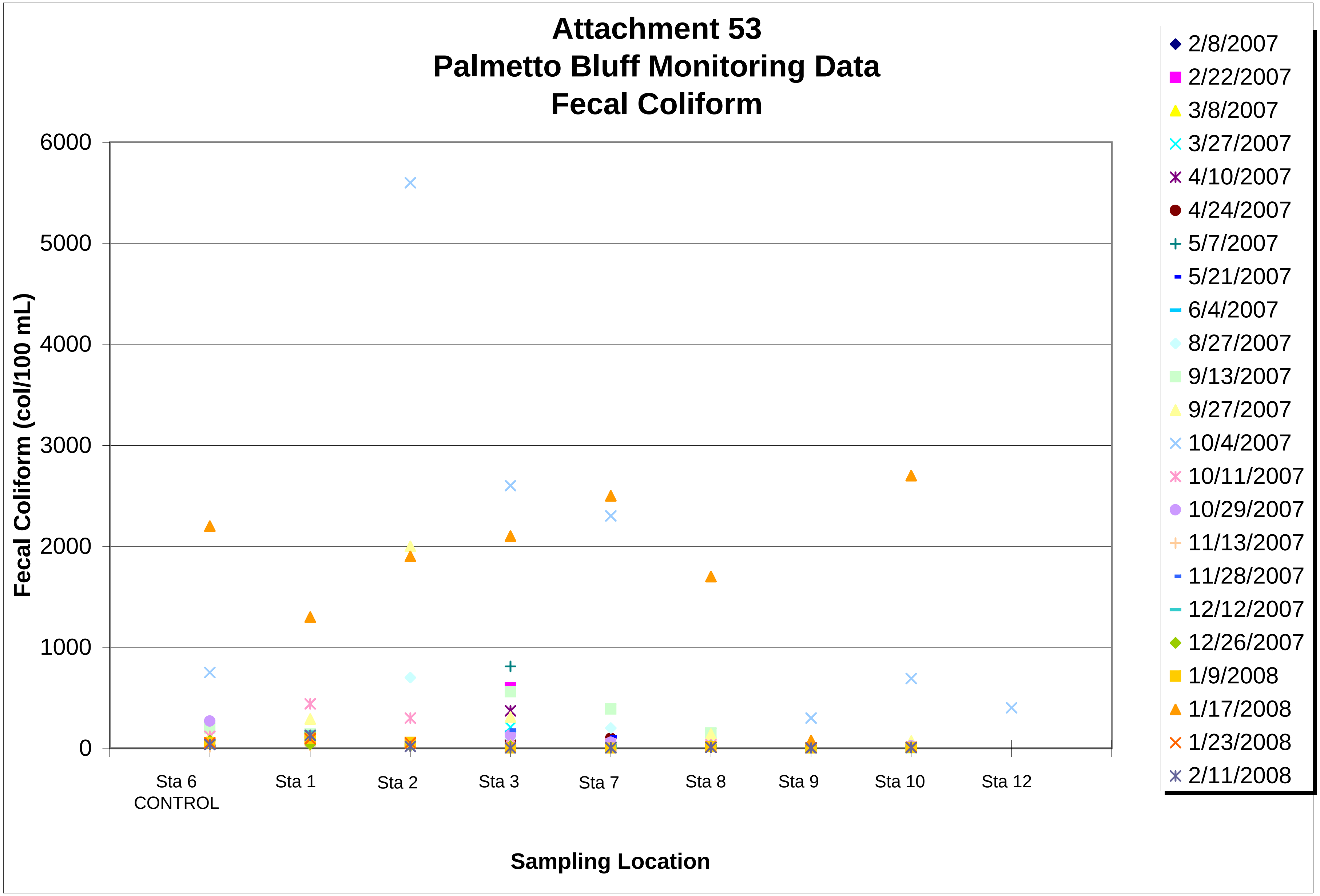
Sample Date 11/1/07		**Sample Date 5/19/07**		**Sample Date 1/16/07**	
Location	**Phosphorous**	**Location**	**Phosphorous**	**Location**	**Phosphorous**
Green #2	60 ppm	Fairway #1	113 ppm	Green #7	174 ppm
Green #13	65 ppm	Fairway #2	218 ppm	Green #1	240 ppm
Green #16	52 ppm	Fairway #3	137 ppm	Green #2	213 ppm
Green #17	76 ppm	Fairway #4	127 ppm	Green #4	161 ppm
Green #18	66 ppm	Fairway #5	175 ppm	Green #6	227 ppm
Tee #1	39 ppm	Fairway #7	88 ppm	Green #11	138 ppm
Tee #3	52 ppm	Fairway #8	206 ppm	Green #12	142 ppm
Tee #5	41 ppm	Fairway #9	192 ppm	Green #15	166 ppm
Tee #13	40 ppm	Fairway #10	140 ppm	Green #16	134 ppm
Tee #8	32 ppm	Fairway #11	341 ppm	Green #17	145 ppm
Tee #16	67 ppm	Fairway #12	133 ppm	Tee #7	158 ppm
Fairway #4	255 ppm	Fairway #13	155 ppm	Tee #1	199 ppm
Fairway #5	234 ppm	Fairway #14	290 ppm	Tee #4	202 ppm
Fairway #7	105 ppm	Fairway #15	110 ppm	Tee #5	171 ppm
Fairway #10	209 ppm	Fairway #16	240 ppm	Tee #10	154 ppm
Fairway #13	123 ppm	Fairway #17	174 ppm	Tee #13	101 ppm
Fairway #18	254 ppm	Fairway #18	126 ppm	Tee #15	145 ppm
				Tee #16	123 ppm
				Tee #17	167 ppm
				Tee #18	212 ppm


Attachment 50
Palmetto Bluff Monitoring Data
Turbidity
Turbidity (NTU)
80
70
60
50
40
30
20
10
0
Sta 6 CONTROL
Sta 1
Sta 2
Sta 3
Sta 7
Sta 8
Sta 9
Sta 10
Sta 12
Sampling Location
2/8/2007
2/22/2007
3/8/2007
3/27/2007
4/10/2007
4/24/2007
5/7/2007
5/21/2007
6/4/2007
8/27/2007
9/13/2007
9/27/2007
10/4/2007
10/11/2007
10/29/2007
11/13/2007
11/28/2007
12/12/2007
12/26/2007
12/31/2007
1/9/2008
1/17/2008
1/23/2008
2/11/2008



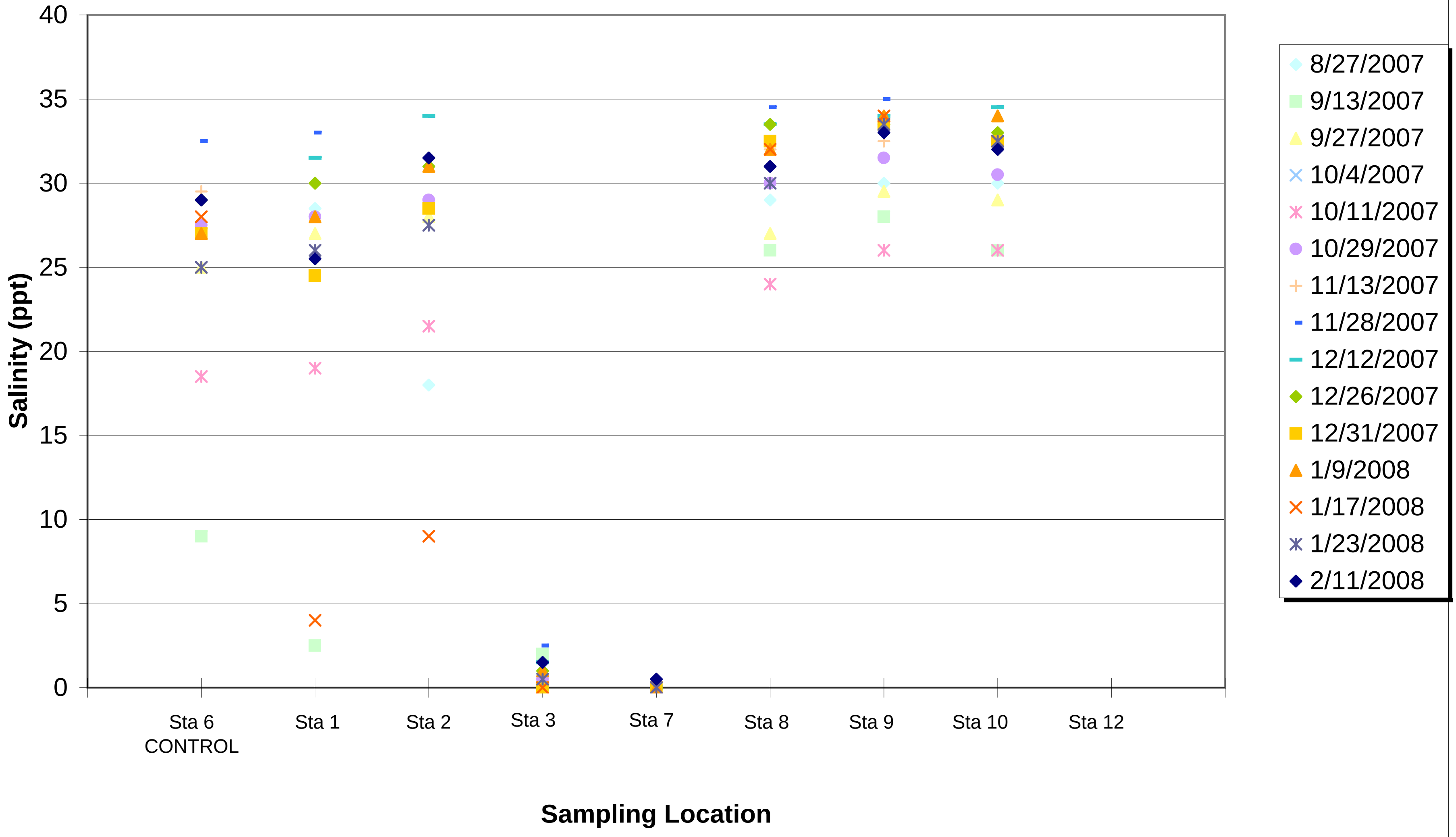
Attachment 51
Palmetto Bluff Monitoring Data
Total Phosphorous
Total Phosphorous (mg/L)
3
2.5
2
1.5
1
0.5
0
Sta 6 CONTROL
Sta 1
Sta 2
Sta 3
Sta 7
Sta 8
Sta 9
Sta 10
Sta 12
Sampling Location
2/8/2007
2/22/2008
3/8/2008
3/27/2008
4/10/2007
4/24/2007
5/7/2007
6/4/2007
8/27/2007
9/13/2007
9/27/2007
10/4/2007
10/11/2007
10/29/2007
11/13/2007
11/28/2007
12/12/2007
12/26/2007
12/31/2007
1/9/2008
1/17/2008
1/23/2008
2/11/2008


Attachment 52
Palmetto Bluff Monitoring Data
Total Nitrogen
Total Nitrogen (mg/L)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Sta 6 CONTROL
Sta 1
Sta 2
Sta 3
Sta 7
Sta 8
Sta 9
Sta 10
Sta 12
Sampling Location
2/8/2007
2/22/2007
3/8/2007
3/27/2007
4/10/2007
4/24/2007
5/7/2007
5/21/2007
6/4/2007
8/27/2007
9/13/2007
9/27/2007
10/4/2007
10/11/2007
10/29/2007
11/13/2007
11/28/2007
12/12/2007
12/26/2007
12/31/2007
1/9/2008
1/17/2008
1/23/2008
2/11/2008



Attachment 53
Palmetto Bluff Monitoring Data
Fecal Coliform
Fecal Coliform (col/100 mL)
6000
5000
4000
3000
2000
1000
0
Sta 6 CONTROL
Sta 1
Sta 2
Sta 3
Sta 7
Sta 8
Sta 9
Sta 10
Sta 12
Sampling Location
2/8/2007
2/22/2007
3/8/2007
3/27/2007
4/10/2007
4/24/2007
5/7/2007
5/21/2007
6/4/2007
8/27/2007
9/13/2007
9/27/2007
10/4/2007
10/11/2007
10/29/2007
11/13/2007
11/28/2007
12/12/2007
12/26/2007
1/9/2008
1/17/2008
1/23/2008
2/11/2008

Attachment 54
Palmetto Bluff Monitoring Data
Salinity



APPENDIX E

Statistical Analysis of Palmetto Bluff Data

Palmetto Bluff Water Quality Analyses
Conducted by Kimberly M. Andrews
March 2008

Sampling data included Sept. 2007 – Feb. 2008 for Stations 1, 2, 3, 6, 8, 9, and 10.

In order to pursue water quality trends on Palmetto Bluff in an objective and scientific manner, we proceeded with the appropriate statistical analysis. Analyses employed ANOVA (an analysis measuring significant differences in the variation of the data) in order to investigate whether the observed elevations were statistically significant and therefore considered biologically consequential. Variables of comparison were phosphorus, nitrogen, fecal coliform, and salinity. Table provided for referencing statistically significant values.

Phosphorus, Nitrogen, Fecal Coliform:

1) Stations 1, 2, and 3 were all compared against each other and individually against the control (Station 6). There were no significant differences among any of the stations. Of particular interest here, there are no significant differences between Stations 3 and 6 (p = . Although data appear to be high relative to the control, these elevations are not substantiated biologically.

2) When comparing Stations 1 and 2 (downstream from the stormwater catchment basin at Station 3) against the control at Station 6, there are no significant differences. Further, there are no significant differences substantiated when comparing Stations 1 and 2 against Station 3. Stations 1 and 2, being further down in the tidal creek, are representative of the quality of water delivered to the May River. As these levels are not significantly different from the control at Station 6 or the catchment basin, we can determine that golf course activities are not influencing water quality flow into the May River.

3) In referencing Chris Johnson’s data (May River Golf Course Superintendent) on 2006-2008 fertilization regimes, no phosphorus has been applied to the golf course since August 2006 (19 months) and the last application of nitrogen was June 2007 (9 months). Based on this time span, observed levels around Station 3 should not be attributed to these previous applications and therefore could only be based on natural levels.

4) Fecal levels were not significantly elevated at any of the sites examined in comparison to the control at Station 6. Perceived elevations are certainly attributed to wildlife usage of man-made freshwater sources, a resource that is incredibly limited on our landscape primarily dominated by brackish waters.

5) As per the request of the Town of Bluffton (via Kim Jones on 4 March 2008), atrazine tests were ordered (request submitted to HSA on 6 March 2008) for Stations 1, 2, 3, and 6.

Salinity:

6) Significant differences in salinity were detected in all comparisons of Station 3 with Stations 1, 2, and the control at Station 6. This trend is expected as Station 3 is simply a catchment basin and Stations 1, 2, and 6 are tidally influenced and more indicative of the characteristic hydrology on Palmetto Bluff. Additionally, as Stations 1 and 2 represent what is deposited in the May River, Stations 1 and 2 are more biologically representative and indicative of anthropogenic effects than the freshwater catchment at Station 3. Lastly, comparisons among Stations 3 and Station 6 are limited due to the significant differences in salinity which invalidate a direct comparison. Upon examination, the sampling point at Station 6 can not be adjusted farther upstream to achieve a freshwater control.

Table 1. ANOVA results comparing water quality indicator parameters among Stations and Palmetto Bluff's May River Golf Course. All analyses focusing on comparisons of Stations 1, 2, 3, with the control at Station 6 are presented here. Significant levels are determined at p = 0.05. Significant values are denoted with *.

Stations Compared		Test	p-value
1	2	P	0.5764
1	3	P	0.2086
2	3	P	0.1009
1	6	P	0.8302
2	6	P	0.1524
3	6	P	0.1242
1	2	N	0.6327
1	3	N	0.5531
2	3	N	0.2980
1	6	N	0.7264
2	6	N	0.7197
3	6	N	0.7199
1	2	FC	0.2378
1	3	FC	0.4111
2	3	FC	0.4434
1	6	FC	0.6943
2	6	FC	0.3275
3	6	FC	0.6844
1	2	Salinity	0.2259
1	3	Salinity	0.000001*
2	3	Salinity	<.0000001*
1	6	Salinity	0.5486
2	6	Salinity	0.3754
3	6	Salinity	<.0000001*

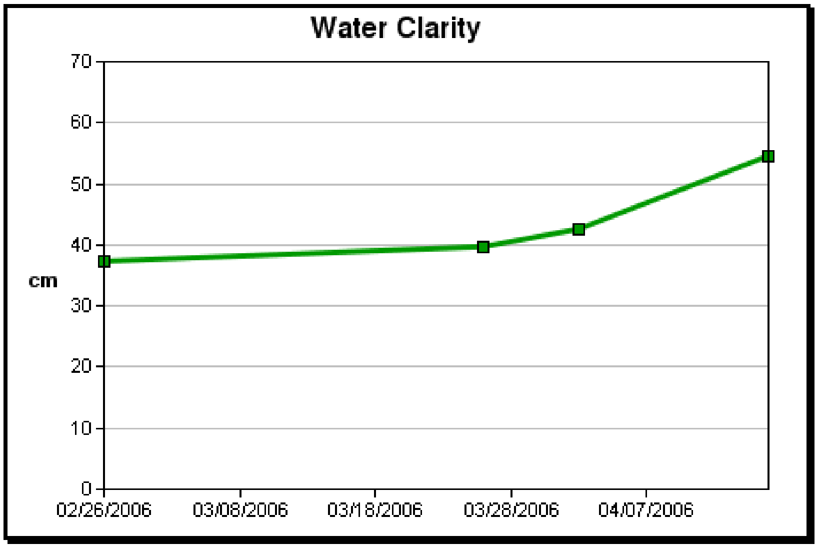
As more than 50 analyses were conducted thus far, analyses performed on Stations 8, 9, and with the control at Station 6 are not included. However, no significant differences were detected for any of the comparisons with these stations for phosphorus, nitrogen, or fecal coliform. Significance was detected only when comparing for differences in salinity between each of the stations and the control at Station 6.

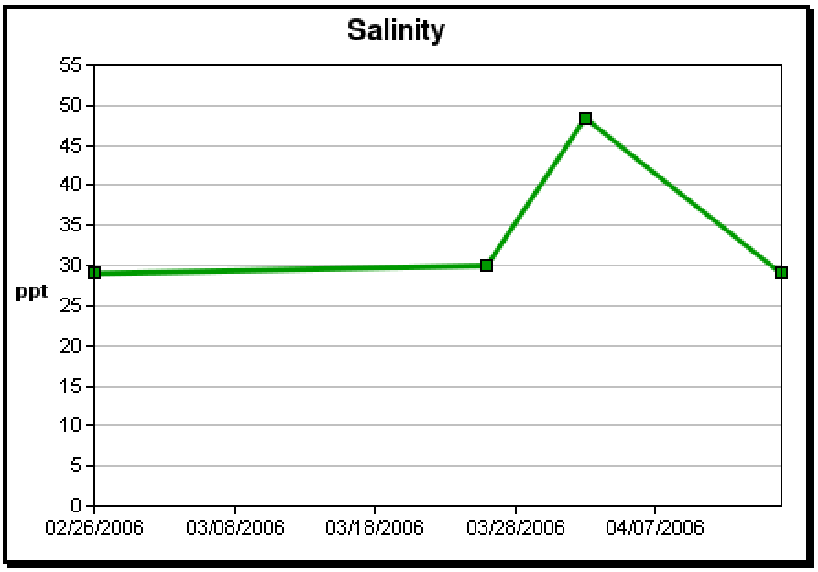
Please contact Kimberly Andrews, Science and Education Director with Palmetto Bluff Conservancy (kmandrews@crescent-resources.com) for additional information.

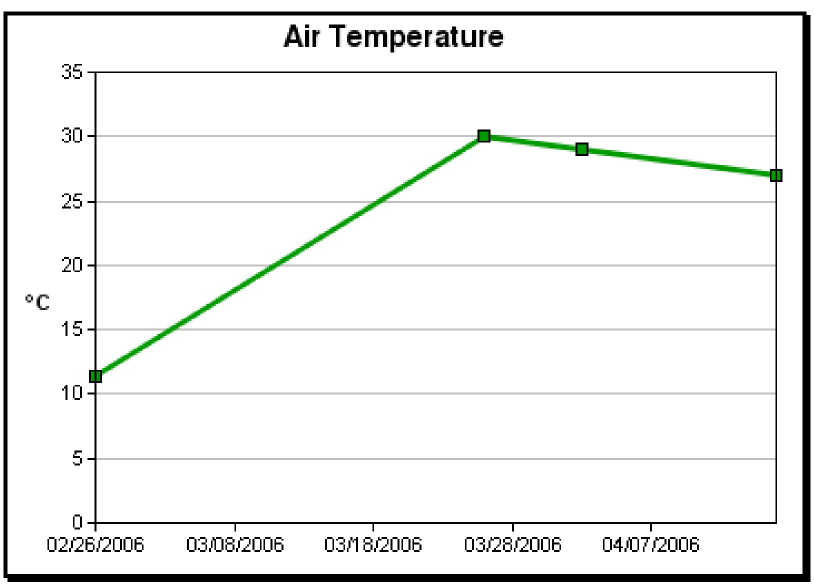
APPENDIX F

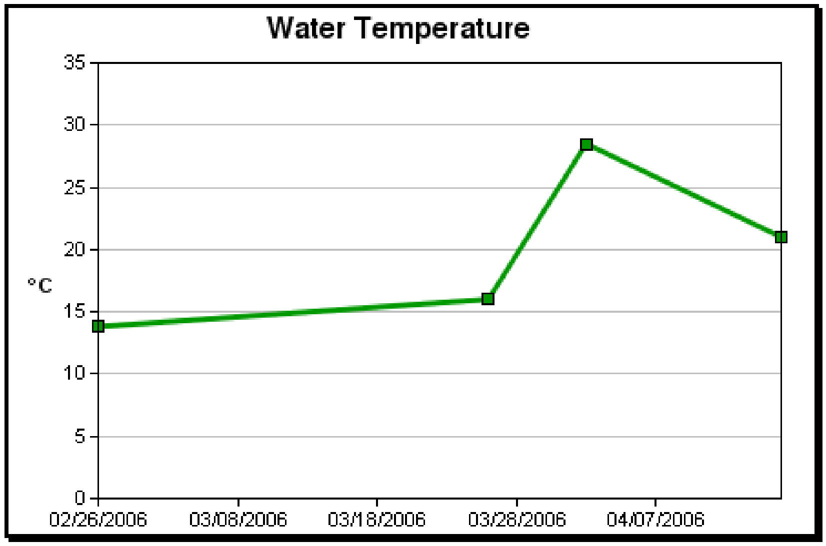
Volunteer Data

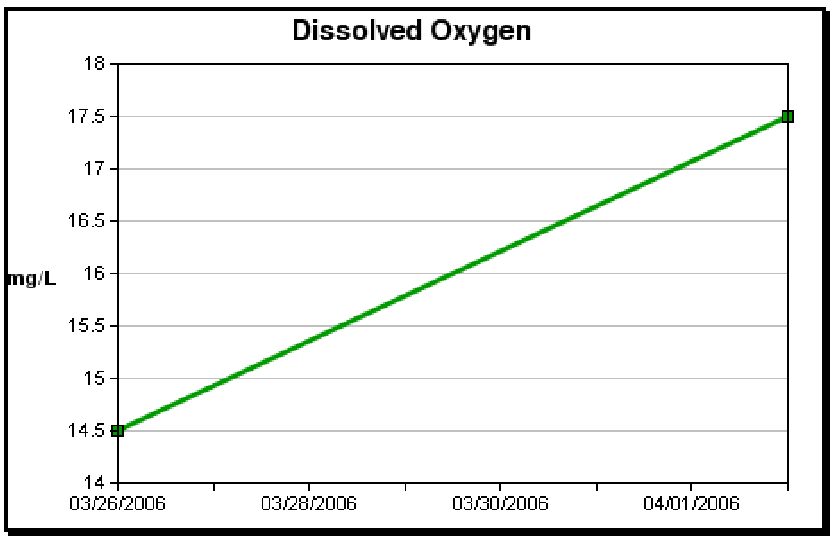
Site #1 – Mouth of May River



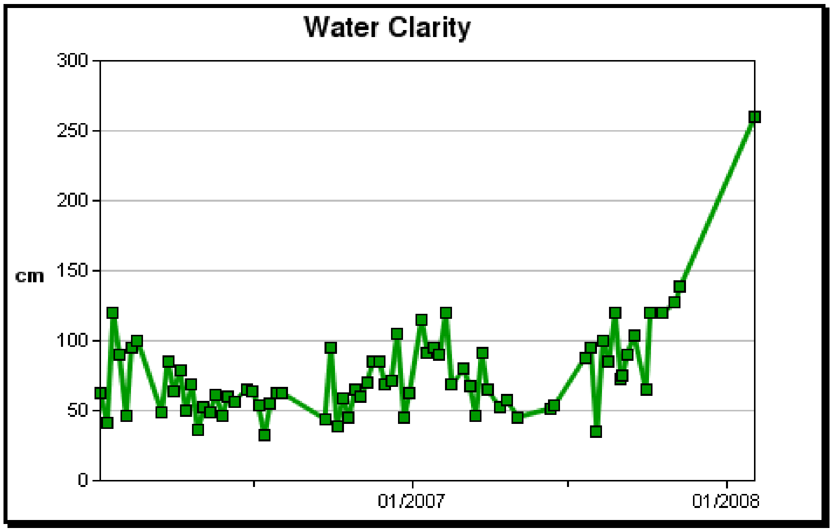


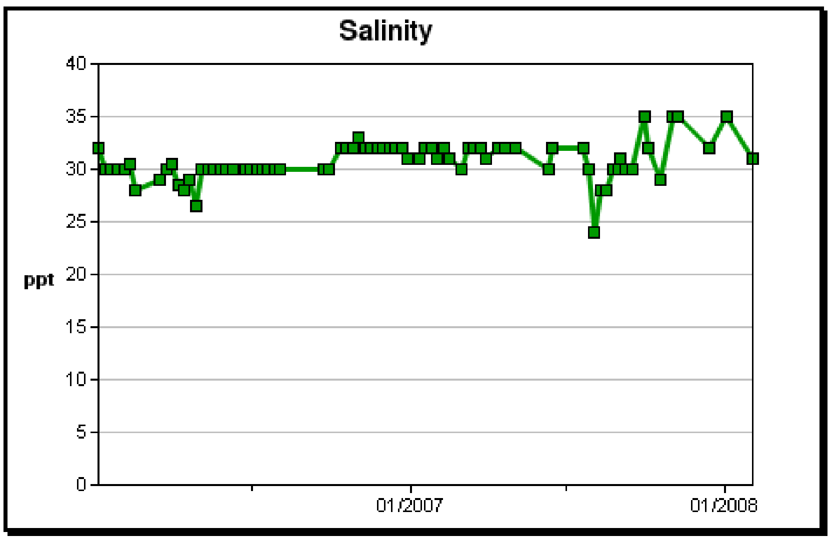


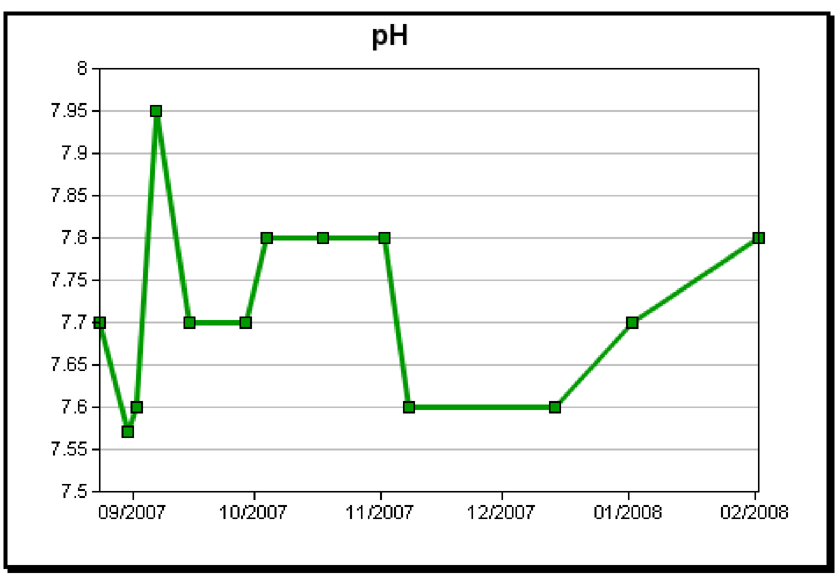

Water Temperature
35
30
25
20
°C
15
10
5
0
02/26/2006
03/08/2006
03/18/2006
03/28/2006
04/07/2006

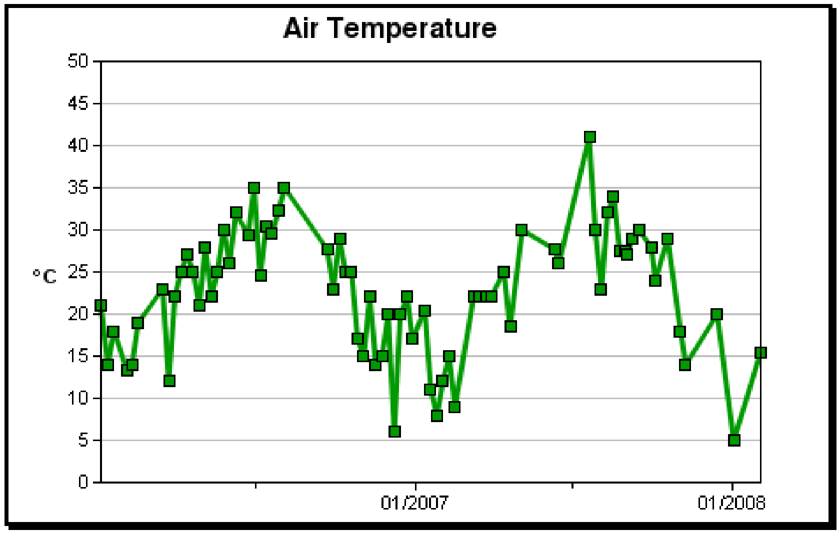

Dissolved Oxygen
18
17.5
17
16.5
mg/L
16
15.5
15
14.5
14
03/26/2006
03/28/2006
03/30/2006
04/01/2006

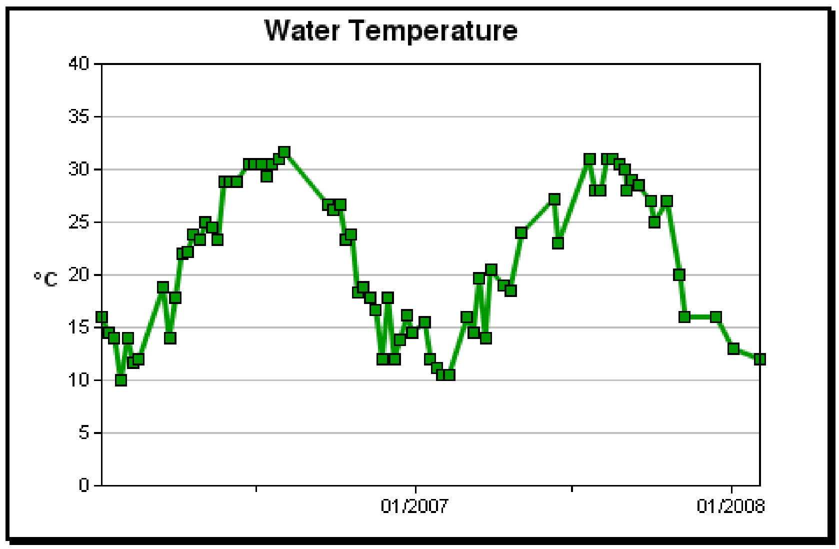
Site #2 – All Joy Landing

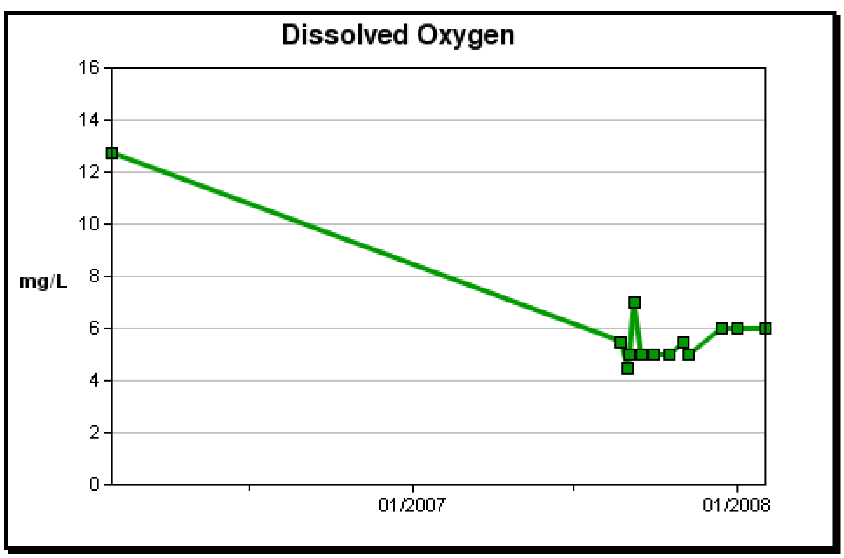




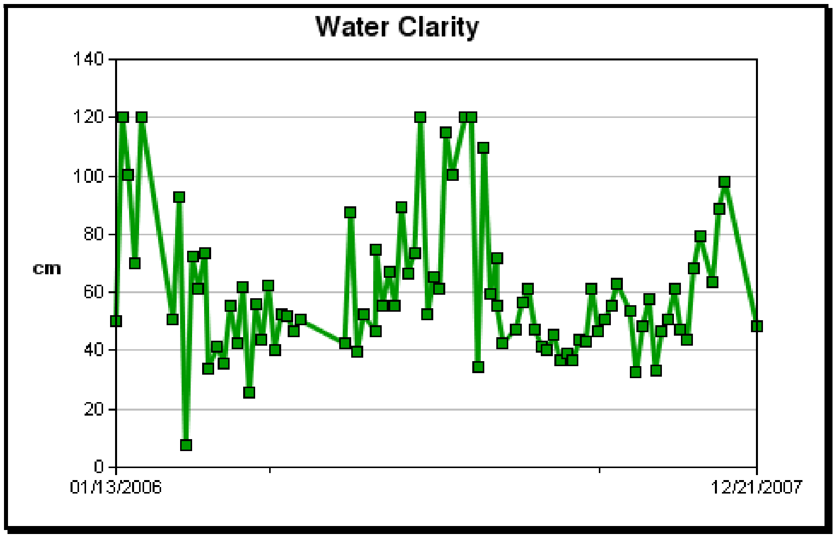


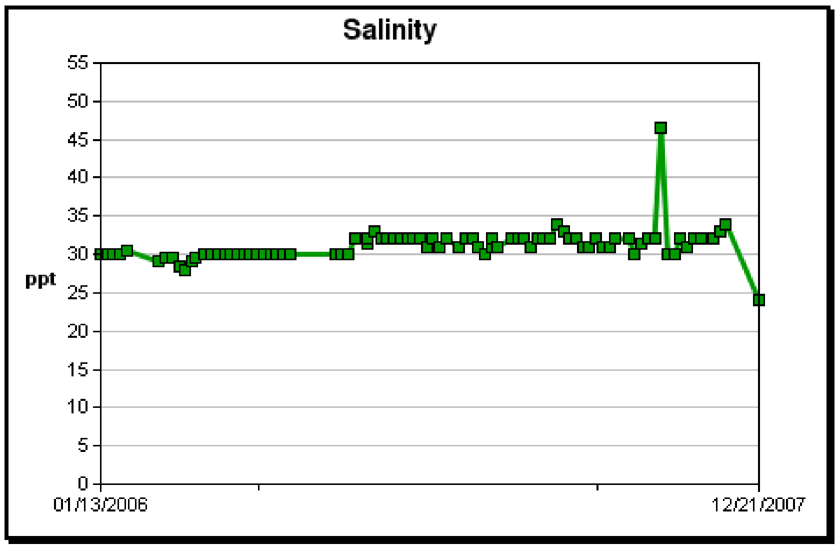

Air Temperature
°C
50
45
40
35
30
25
20
15
10
5
0
01/2007
01/2008

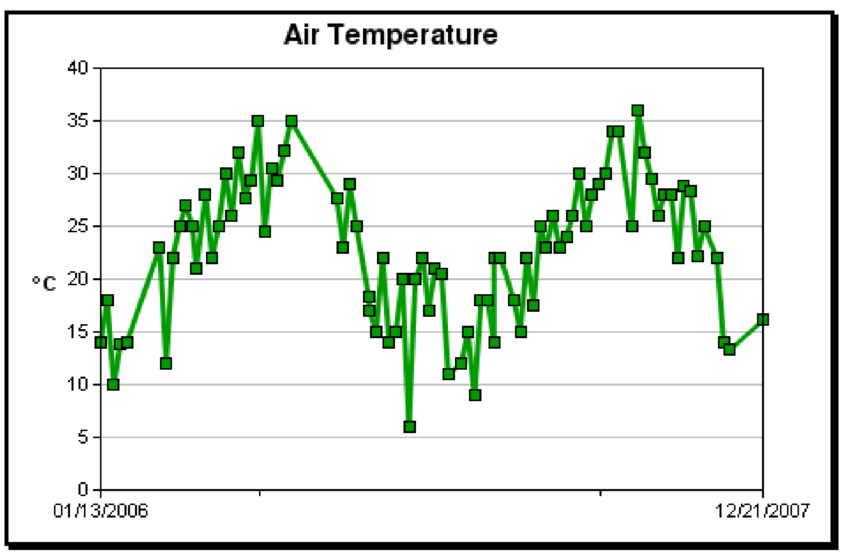

Water Temperature
°C
40
35
30
25
20
15
10
5
0
01/2007
01/2008

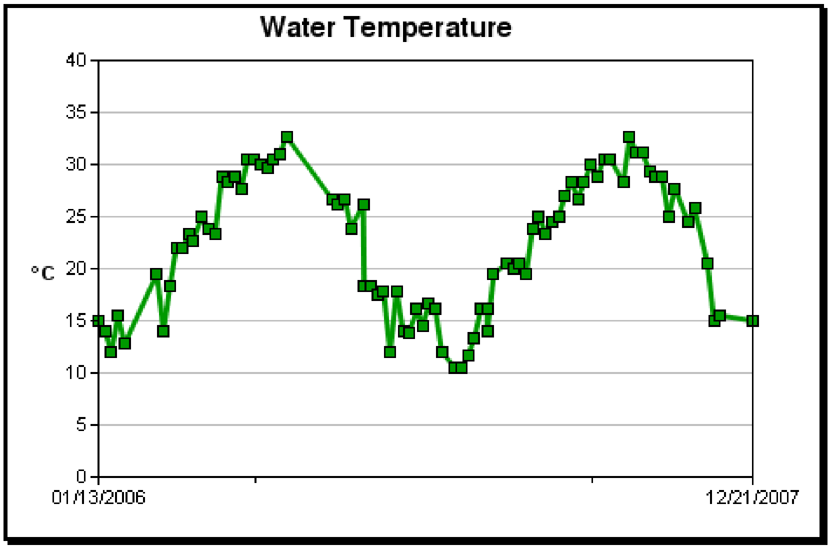

Dissolved Oxygen
mg/L
16
14
12
10
8
6
4
2
0
01/2007
01/2008

Site #3 – Crystal Beach

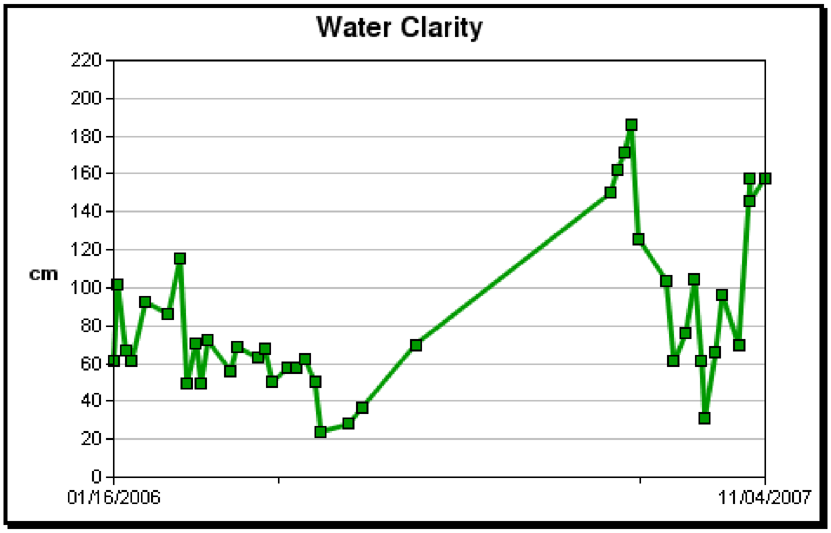


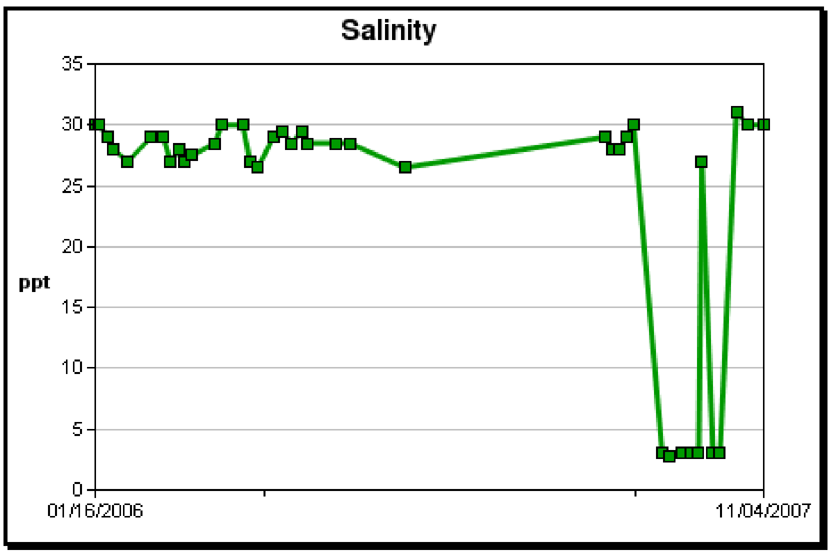


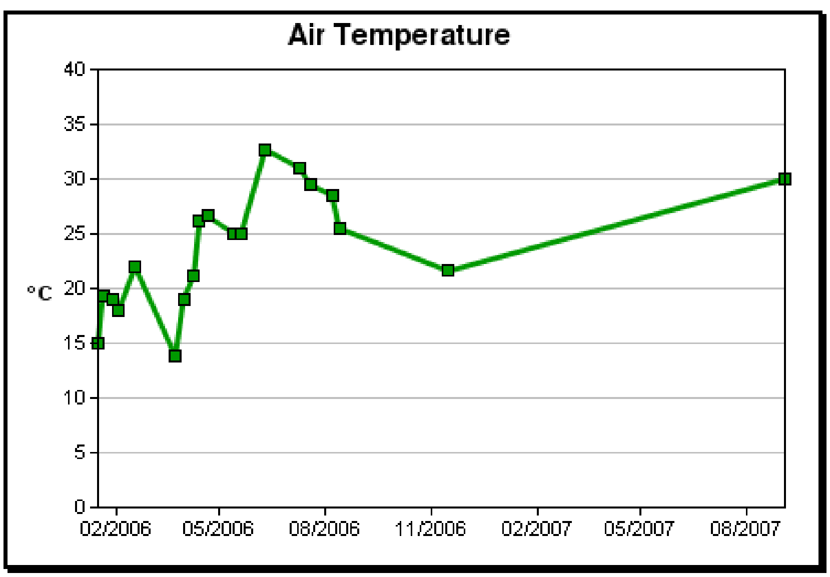


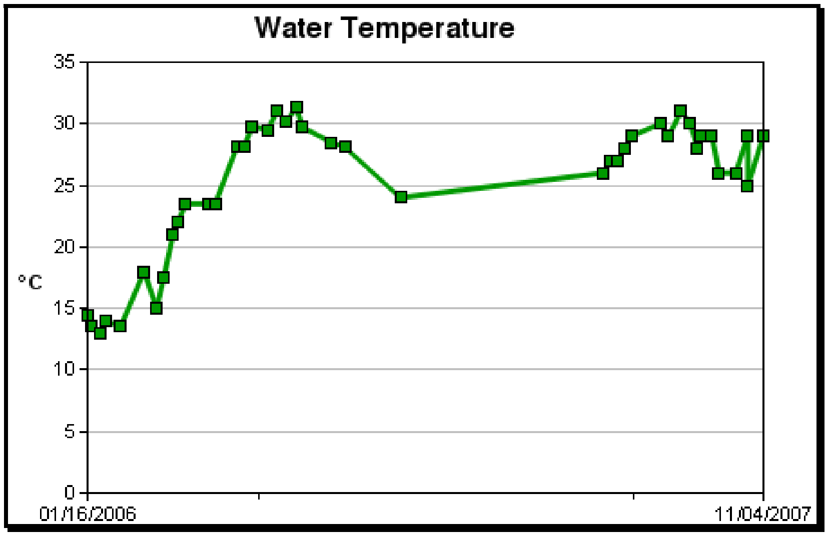

Water Temperature
40
35
30
25
20
15
10
5
0
°C
01/13/2006
12/21/2007

Site #4 – Palmetto Beach

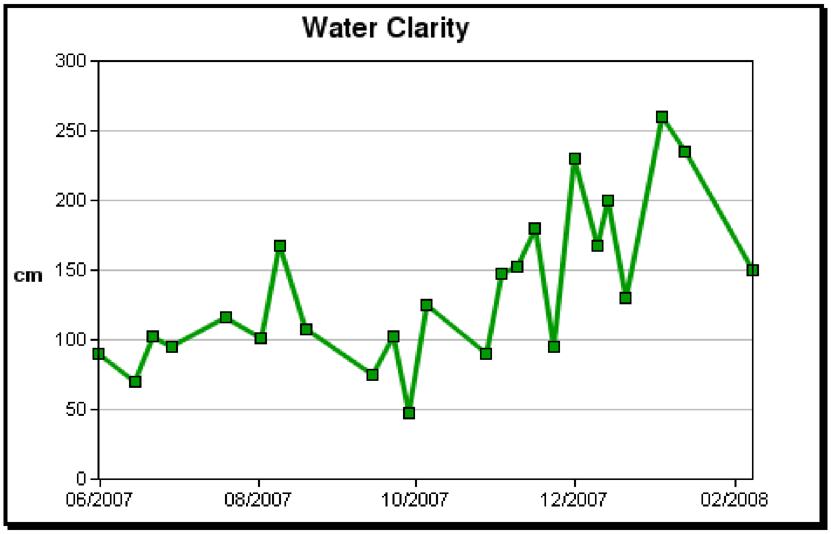


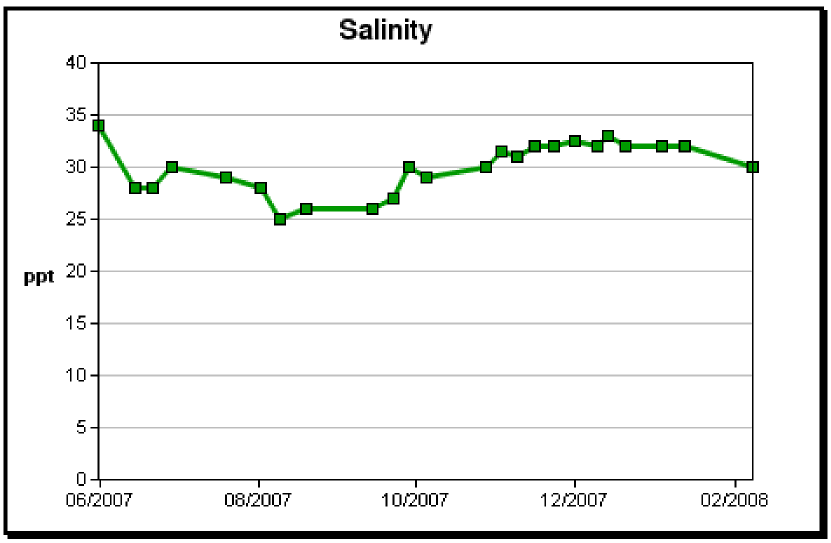


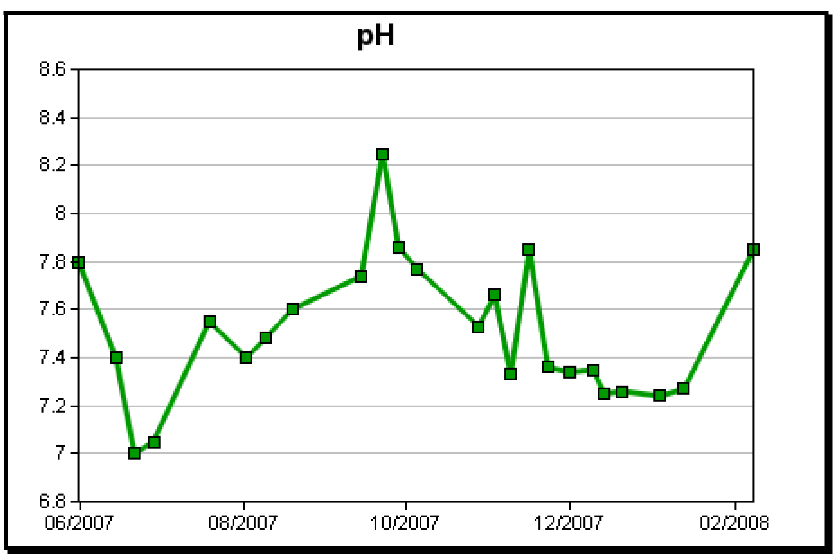


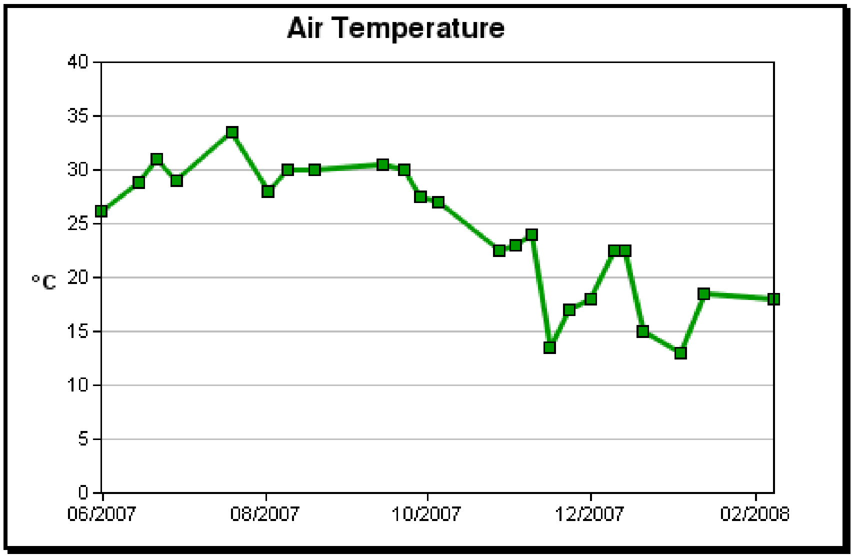

Water Temperature
35
30
25
20
15
10
5
0
°C
01/16/2006
11/04/2007

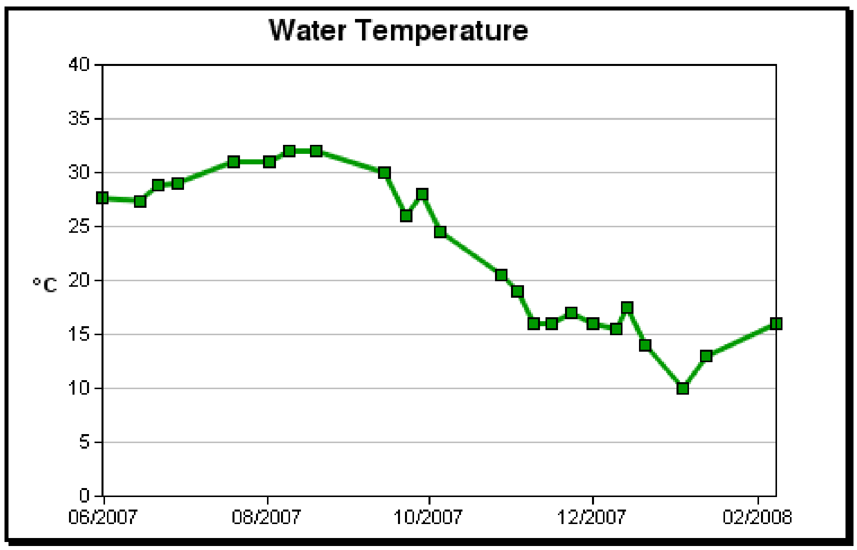
Site #5 – Calhoun St. Dock

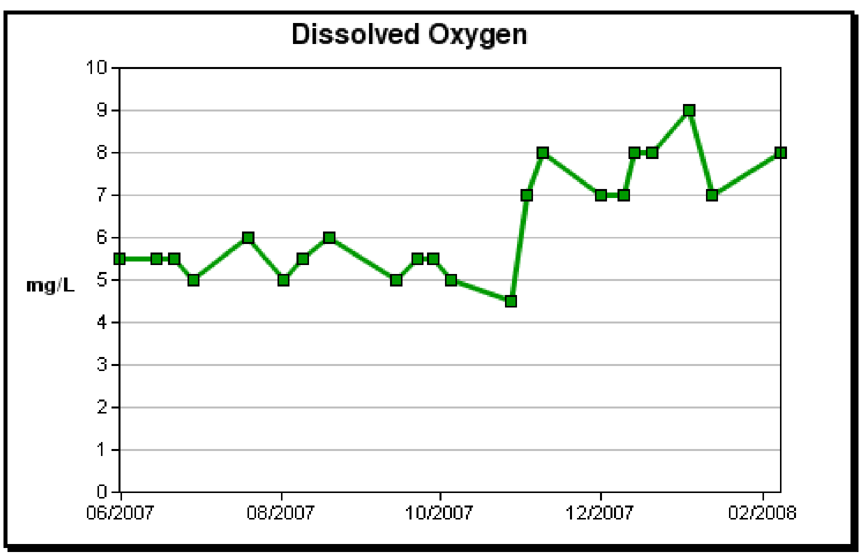




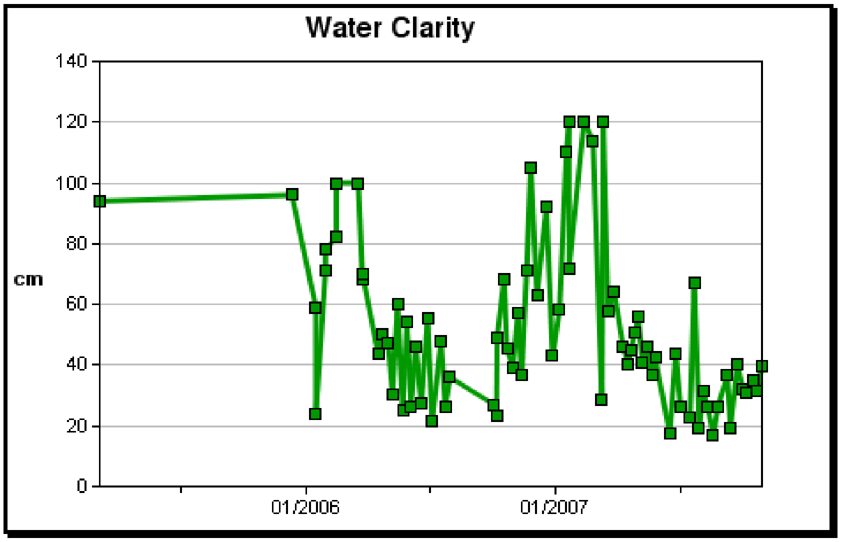


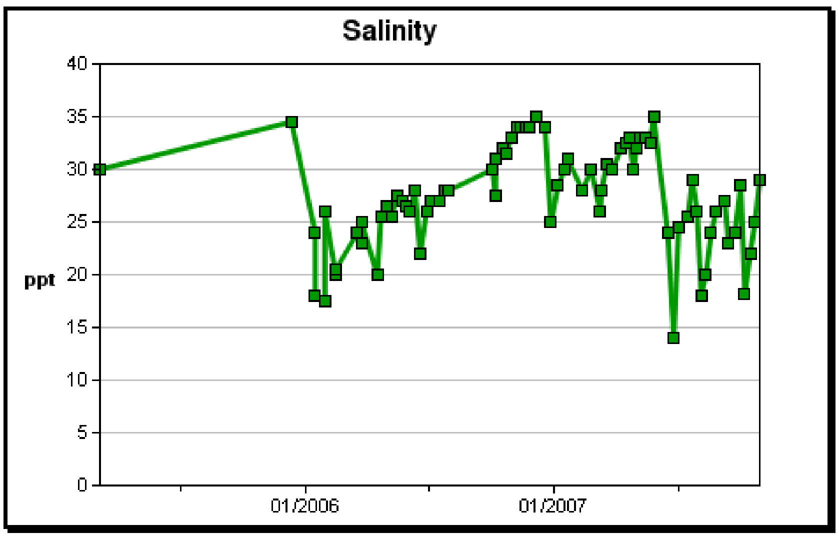

Air Temperature
°C
40
35
30
25
20
15
10
5
0
06/2007
08/2007
10/2007
12/2007
02/2008

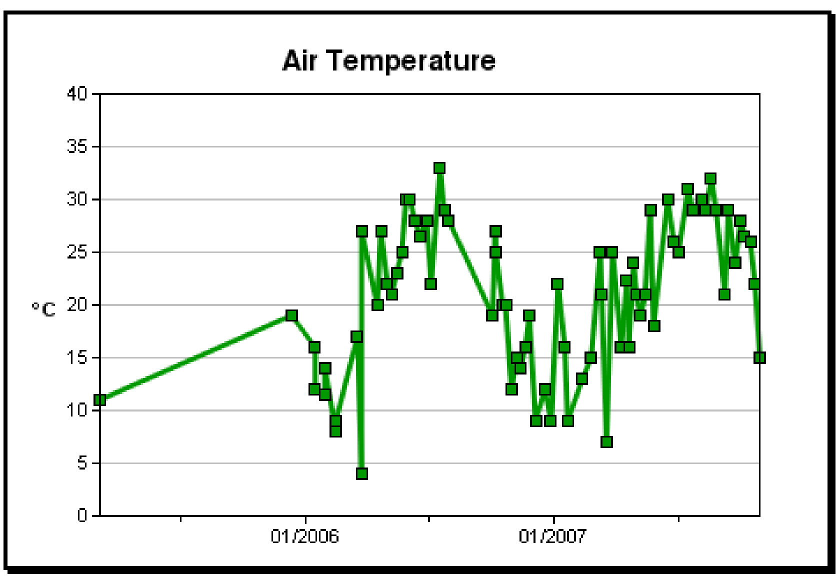

Water Temperature
°C
40
35
30
25
20
15
10
5
0
06/2007
08/2007
10/2007
12/2007
02/2008

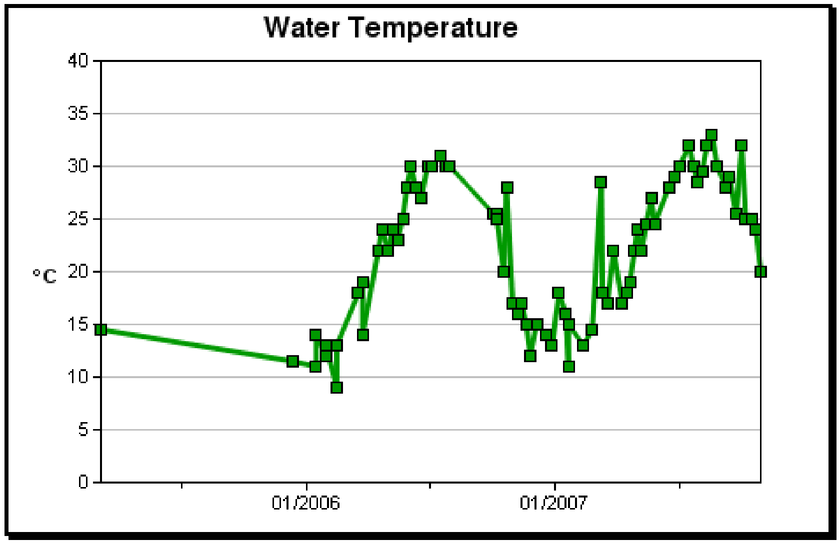

Dissolved Oxygen
mg/L
10
9
8
7
6
5
4
3
2
1
0
06/2007
08/2007
10/2007
12/2007
02/2008

Site #6 – Palmetto Bluff/Osprey Alley

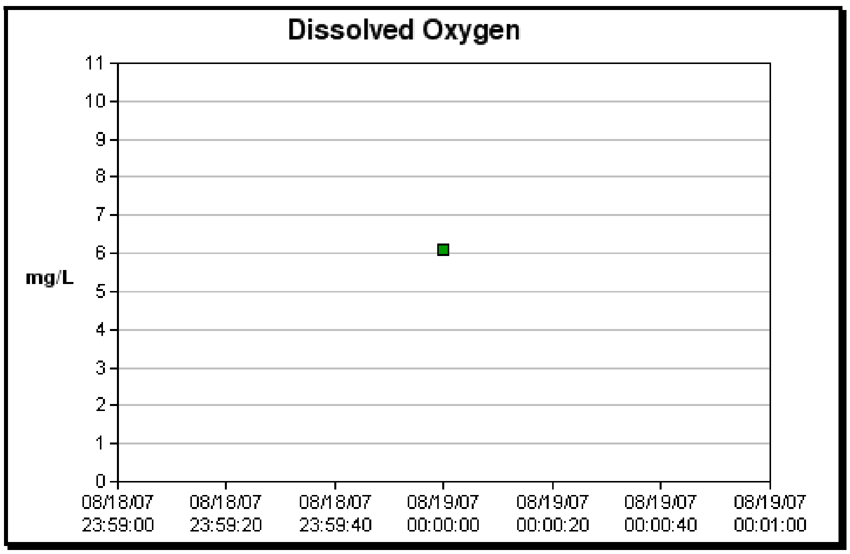






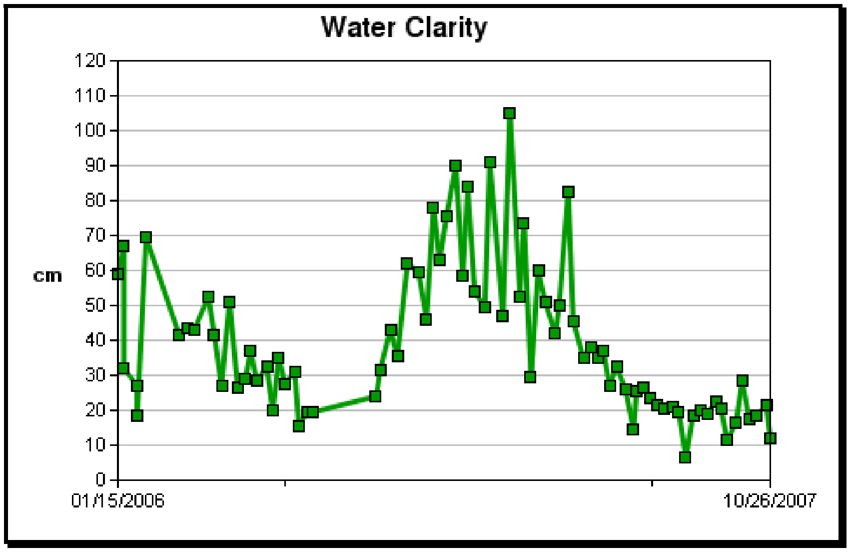


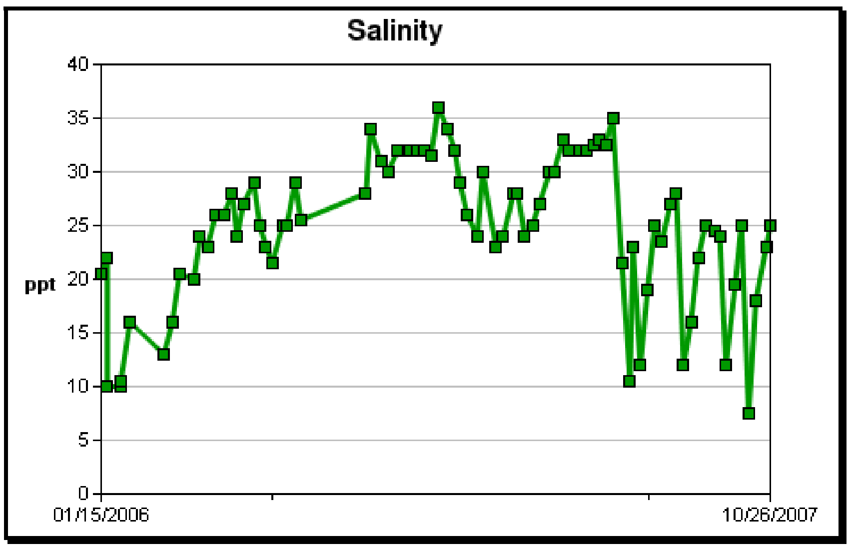
Water Temperature
40
35
30
25
°C 20
15
10
5
0
01/2006
01/2007

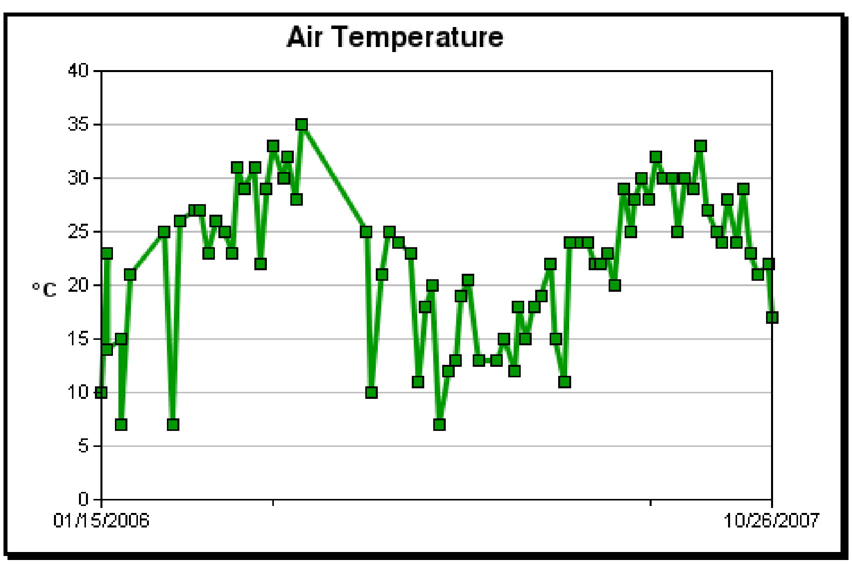


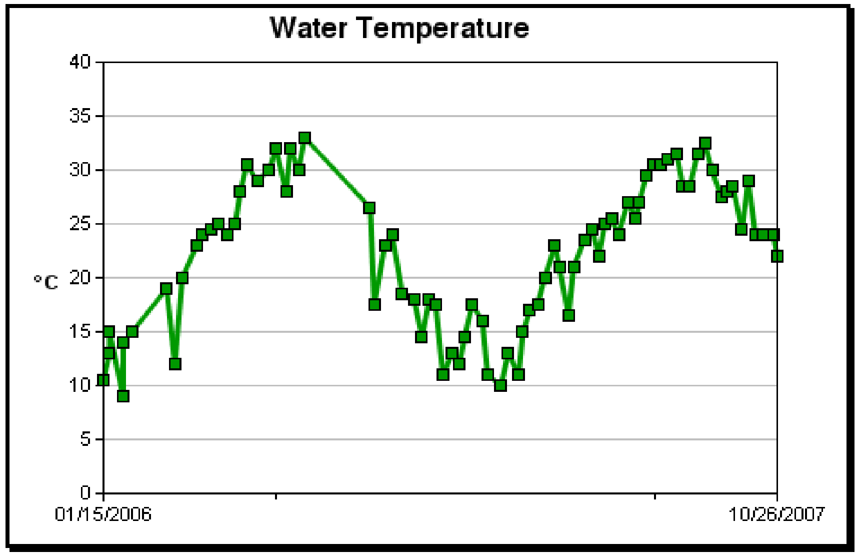
Dissolved Oxygen
11
10
9
8
7
6
mg/L
5
4
3
2
1
0
08/18/07 23:59:00
08/18/07 23:59:20
08/18/07 23:59:40
08/19/07 00:00:00
08/19/07 00:00:20
08/19/07 00:00:40
08/19/07 00:01:00

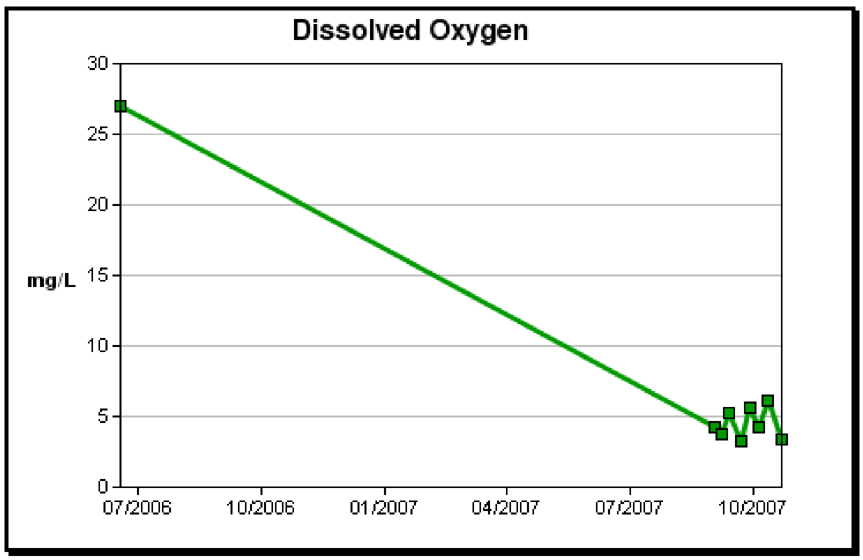
Site #7 – Rose Dhu Creek



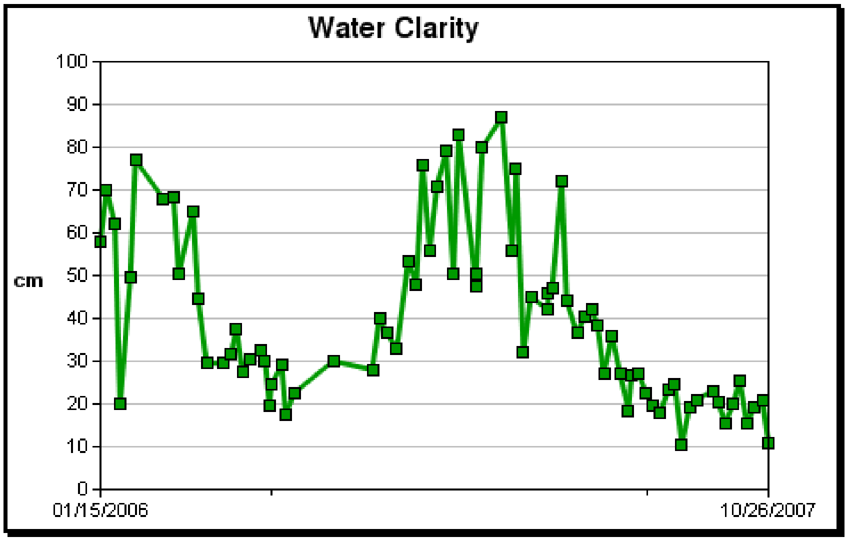


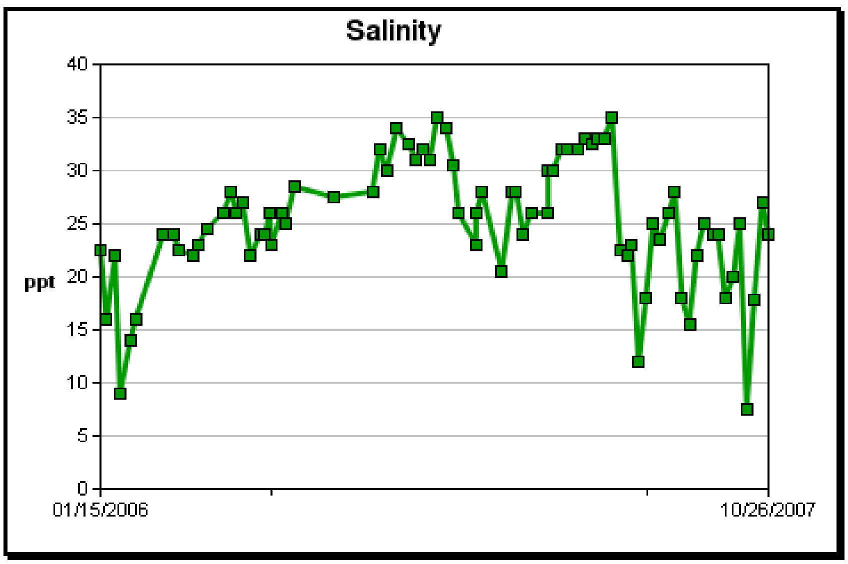


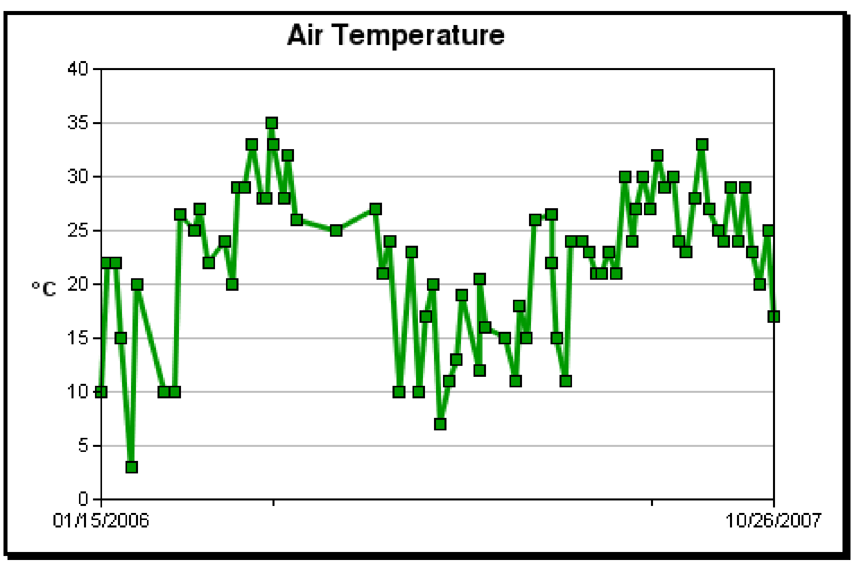

Water Temperature
°C
40
35
30
25
20
15
10
5
0
01/15/2006
10/26/2007

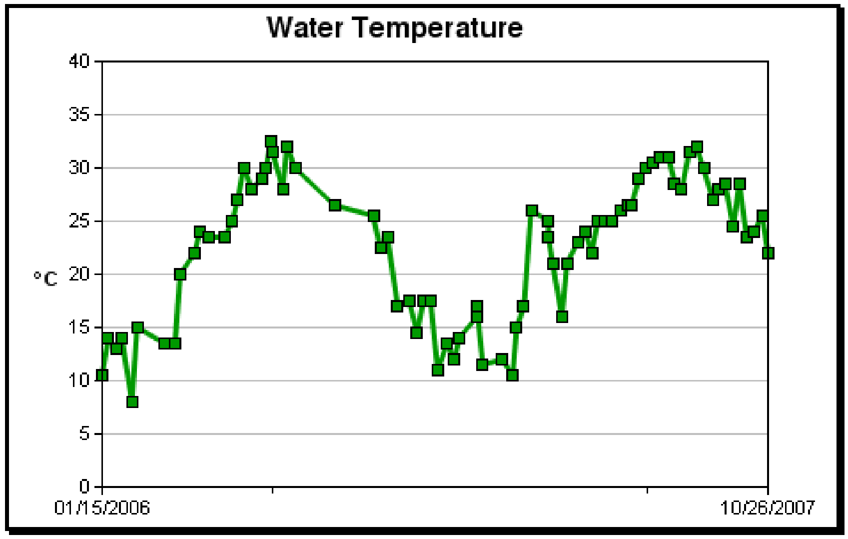

Dissolved Oxygen
mg/L
30
25
20
15
10
5
0
07/2006
10/2006
01/2007
04/2007
07/2007
10/2007

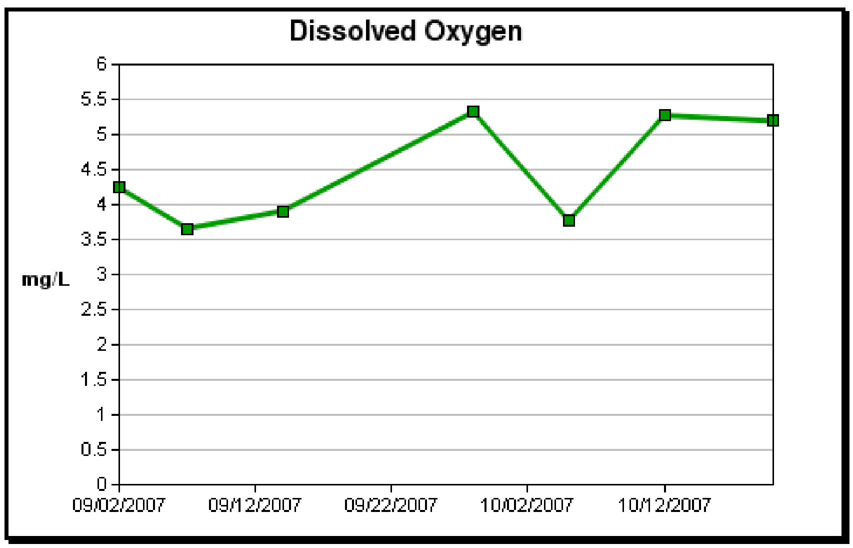
Site #8 – Stoney Creek








Water Temperature
40
35
30
25
°C
20
15
10
5
0
01/15/2006
10/26/2007


Dissolved Oxygen
6
5.5
5
4.5
4
3.5
mg/L
3
2.5
2
1.5
1
0.5
0
09/02/2007
09/12/2007
09/22/2007
10/02/2007
10/12/2007