Hummock Pond
Annual Report
2007

Prepared for:
Marine and Coastal Resource Department
34 Washington Street
Nantucket, MA 02554

Prepared by:
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Introduction:

Hummock pond is a eutrophic coastal pond located on the southwest side of Nantucket Island. Hummock is approximately 2.3 miles long, running north to south with an average depth of 6ft. The watershed to pond ratio, at an average is 15:1. The pond is approximately 142 acres in size with a surface drainage basin of approximately 2,227 acres and a groundwater drainage basin of approximately 2,000 acres. Hummock Pond accumulates water during the winter and generally floods in the spring. Flooded conditions of Hummock Pond can reach Millbrook Swamp to Madaket Road. During flooded conditions, the surface area of the pond increases from 140 acres to approximately 425 acres (Kortman and Knoecklein 1994). Hummock Pond is opened to the sea twice per year to alleviate flooded conditions and to enhance marine fisheries. In addition, pond openings decrease nutrient concentrations and remove organic matter that accumulates in the pond from the bordering wetlands.

The surface drainage basin extends north and east of the head of Hummock. The basin encompasses Maxy's Pond, Crooked Lane, and one third of Sunset Hill. The surface divide extends south to Academy Hill School, "Five Corners", part of Prospect Cemetery, and encompasses Burnt Swamp. The surface divide then follows the configuration of the pond to Cisco Beach extending just north of Hummock Pond Road (Horsley, Witten and Heggemen 1990).The groundwater drainage basin starts north of Rams Pasture and follows in a northward direction reaching Capaum Pond. The divide stretches east to West Chester Street encompassing "No Bottom Pond" and to the southwest through Burnt Swamp, Rotten Pumpkin Pond, and Larrabee Swamp and to Cisco Beach. There are two soil types in the watershed that determine permeability and eroding capability. The northern section is classified as "Medisaprists-Barryland Variant association", consisting of organic mucky deposits, combined with outwash soils that are poorly drained. The southern section is classified as "Evesboro association" defined by gently sloping sandy soils that drain rapidly.

Accelerated eutrophication of the pond in recent years has lead to harmful blue-green algae blooms, and macro algae blooms. Dense mats of *Enteromorpho intestinalis* in the summers of '02, and '03 impeded navigation and raised concerns of local residents, as to the health of the pond. Because of this a more in depth and recent study was required. George Knoecklein of Northeast Aquatic Research, LLC, a limnological consultant for the Nantucket Marine and Coastal Resources Department, who had done previous studies on the pond was hired to complete a two year evaluation. In corroboration with Marine Dept. personnel Tracy Curley, and Keith Conant, Knoecklein investigated nutrient loading aspects, water quality, and the effectiveness of pond openings with respects to mitigating the ponds current problems. Copies of this report, Hummock Pond 2005 Monitoring Report, by Dr. Knoecklein can be obtained at the Nantucket Marine Department, 34 Washington St.

The School for Marine Science and Technology (SMAST), which is heading up the Massachusetts Estuaries Project for the Department of Environmental Protection will also be performing studies on the pond. 2007 investigations have been completed, and include sediment cores for nutrient analysis, stream gauging, and a bathymetry analysis. This work was completed with help from Marine Department personnel. This intensive study has generated volumes of data, which will be analyzed in 2008 with the goal of providing the Town of Nantucket a Total Maximum Daily Load (TMDL) scenario; similar to the reports done for Nantucket Harbor, Sesachacha Pond, and the Madaket Harbor / Long Pond system.

Methods:

Hummock Pond was monitored from April to November this year. Physical parameters include, temperature, dissolved oxygen, salinity, secchi disk depth, and water depth. Chemical parameters include nutrient concentrations of inorganic and organic components, Nitrate (NO3), Ammonia (NH3), Kjeldhal Nitrogen (TKN), Total Nitrogen (TN), and Total Phosphorous (TP). Nutrients were not analyzed in November due to monetary constraints. In 2004, 9 sampling sites were established for the Knoecklein study. Sites 1-6 remained the same, with a re-ordering of site 7, and the creation of sites 8, and 9. In 2007 sites 1, 3, 6, 7, and 8 were measured for physical parameters, additional water samples were collected for chemical constituents at sites 1, 3, and 7. The water samples are processed by Envirotech Laboratories located in Sandwich, MA. for the as for mentioned nutrient constituents.

Hummock water quality sampling stations are as follow: **Site 1:** is located at the foot of Hummock Pond. This site is closest to the ocean and generally remains brackish throughout the year. The average depth is approximately 9ft. The bottom sediment is sand. **Site 3:** is northward in a wider section of the pond. The water depth is approximately 6ft. The bottom sediment is sand and mud. **Site 6:** is located at the base of the northern bay. The average depth at this site is 4 ft., and the bottom is mud and detritus. **Site 7:** is located in the north head of hummock which is connected to the main body of the pond by a small winding tributary. The average depth at this site is 12 ft., and the bottom is a flocculent muddy surface approximately 6” deep covering a mud bottom. **Site 8:** is located at the northeast headwater of the northern bay, where there is an inlet from a sub-watershed to the northeast. The average depth is 4 ft., and the bottom is detritus, and flocculent mud. These locations are designated on **Map #1.**

Water Quality Monitoring Results:

Appendix A: contains all physical and chemical water quality data. **Appendix B:** contains the averages of A with corresponding charts. **Appendix C:** contains average monthly rainfall for 2006, as collected by the Nantucket Water Company.

Temperature and Dissolved Oxygen:

Temperature and dissolved oxygen are often closely related, and inversely proportional. The solubility of oxygen in water is very dependant on the temperature, and will decrease as temperature rises. Dissolved oxygen (D.O.) is also affected by nutrients, and the biological oxygen demand (BOD) of decaying plant or animal matter. As nutrients increase, phytoplankton and macro algae increase proportionately. These plants have a relatively short life cycle, and when they die and sink to the bottom, they are consumed by bacteria. These bacteria consume oxygen, and may lead to anoxic events. When this occurs, nutrients are released from the sediments, and a process known as "internal recycling" begins. The process of eutrophication may occur naturally, but at Hummock Pond it is accelerated by anthropogenic uses.

The temperature in Hummock Pond follows a well defined cyclical seasonal pattern, which is shown by the bell curve graph in figure 1. The pond is relatively isothermic because of its shallow condition and elongated shape, which allows it to be well mixed by wind driven waves. However because it is so long there are some differences between the foot and the head. These differences are also affected by surface water runoff, groundwater intrusion, and salinity gradients. The isolation of the northern head, its depth, and its kettle shape create the greatest variances. July and August are typically the months where temperatures reach their highest points. Fortunately in 2007 the main body of the pond did not go above 24ºC, or 75ºF (Appendix A, & Figure 1). This may decrease the solubility of oxygen in the water column, however it would not normally create an anoxic condition. The highest recorded temperatures occurred in the northern reaches of the pond at Site 7, and were just above 24ºC in august. For the most part there was limited stratification, with very subtle effects from a mild turnover during the winter, due to limited ice formation.

Dissolved oxygen (D.O.) concentrations are at maximum in the winter, due to cooler water temperatures. The main body of the pond experiences lower dissolved oxygen concentrations during the summer months where the concentrations typically range between 4 mg/l and 6 mg/l. D.O. conditions during the 2007 sampling period were better than most years, probably due to cooler temperatures and lack of precipitation that would normally bring a lot of nutrients to the pond. The lowest dissolved oxygen readings taken are associated with Site 7, and are related to the eutrophic conditions that exist there (Appendix A). The lowest recorded value throughout the main body of the pond occurred at the bottom at Site 1 in May after the ocean exchange had been met. This value of 4.05 mg/l was still not into a dangerous hypoxic level, and was probably related more to the salinity change at 9 feet. Site 7 shows a problematic condition throughout the sampling period. Initial bottom readings are in the hypoxic range, and by June they begin to show a trend toward a hyper eutrophic state (Appendix A, & Figure 2). By August bottom readings are 8.85 mg/l, coinciding with a massive blue green algae bloom throughout the water column; which also extends into the channel that connects the North Head with the Northern Bay. By September, bottom conditions have gone anoxic, 0.68 mg/l, as the full effect of the algae bloom takes hold. It is during these anoxic events that even more nutrients are released from sediments on the bottom, further exacerbating enriched conditions. As a consequence the algae bloom concentration increases, and lasts through to October; a duration of 3 months. Following the fall opening, and with the onset declining temperatures, D.O. conditions improve in November.

Figure 1: Average Temperature 2007

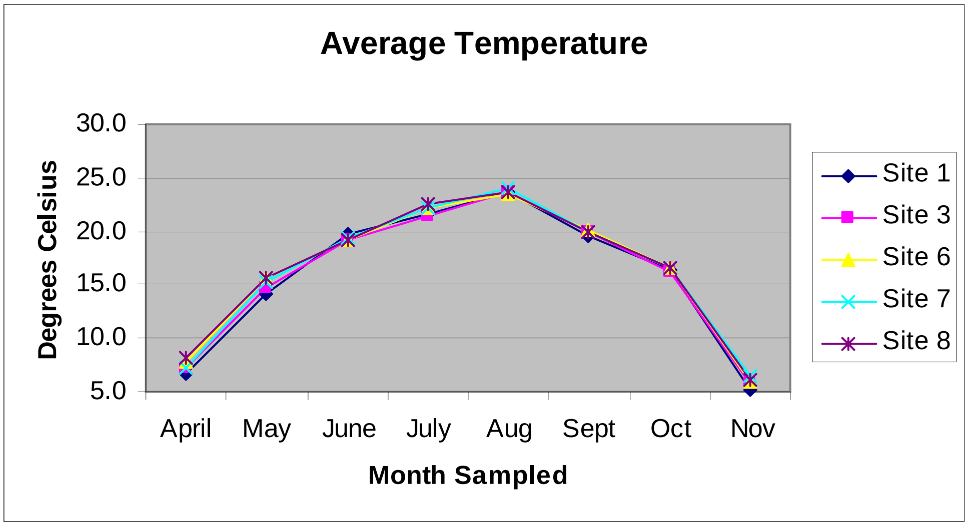
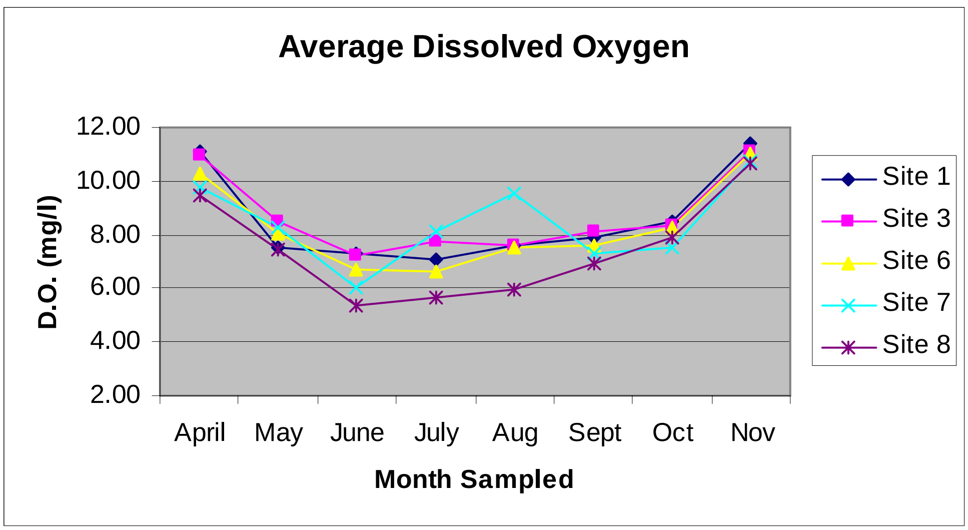


Figure 2: Average Dissolved Oxygen 2007



Salinity:

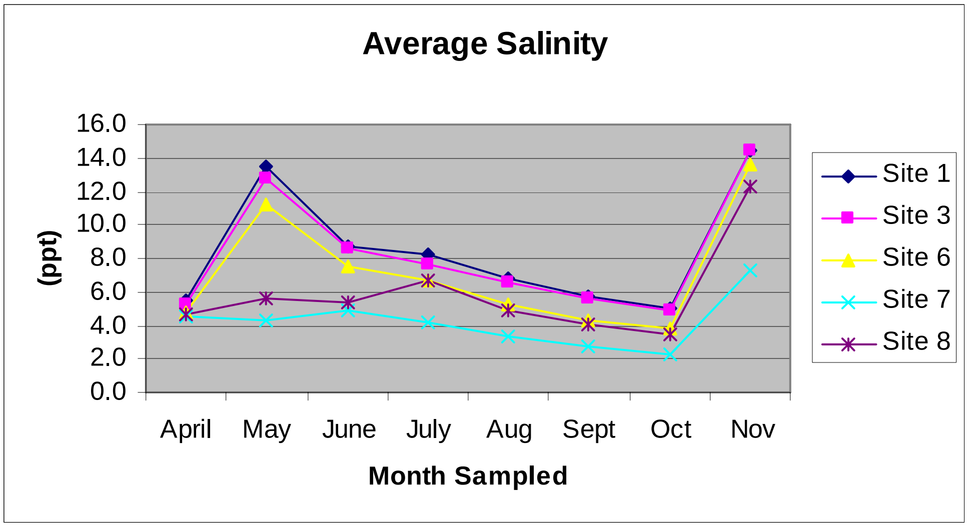
Hummock Pond has been designated to be maintained as a brackish water pond for fisheries migrations, mitigation of water quality and flood control by mechanically breaching the natural barrier beach to the ocean in the spring and fall. The 2007 spring opening occurred 4/20, and remained opened until 4/30, the fall opening occurred 10/26 and remained open until 11/2. Spring openings typically last longer than fall openings because of head waters accumulated during winter and spring precipitation. However, if a spring opening is not met for at least a week then water quality usually declines throughout the summer. During the spring opening, the ocean typically fills approximately half the pond (site 1 to site 6). Groundwater and surface water fill the head of the pond (site 6 to site 7, and 8). After an opening, mixing slows down and a salinity gradient develops in the pond forming a wedge. The foot of the pond retains the highest salinity while the head continues to become fresh from the constant input of groundwater. Hummock pond, located in the outwash plains, cannot maintain saline conditions due to the physical configuration of the pond, with respect to its watershed.

Hummock contained an average salinity of (4.9 ppt) in April prior to the spring pond opening. The pond increased in average salinity to 9 ppt after the opening. There were of course differences between the foot and the North head, prior to, and after the opening (Appendix A, & Figure 3). These differences were greatest (9.7 ppt) between the foot and head following the closure. As the pond began to seek equilibrium, a well defined salt wedge began to form at Sites 7, and 8 in June. The length of time the pond remains open to the ocean usually determines the initial salinity change in the pond. Salinity decreased throughout the summer as the pond filled with groundwater; this was delayed this year by the lack of precipitation over the summer. Site 8 actually showed a slight increase in salinity in July. Signs of freshening occurred first at Site 7 in May, and then Site 8 in June, as groundwater inputs from the northern watershed drive the recharge of the pond. The lowest salinity reading taken on the pond was at Site 7 throughout the water column in October, at (2.3 ppt).

The average pond salinity was 3.9 ppt in October prior to the fall opening. When the pond closed on 10/29, it closed on a low tide, however with a higher average salinity than the spring opening. A combined affect of this was higher salinities throughout the entire pond. Bottom measurements at the foot and the head were recorded at 14.4 ppt for Site 1, and 9 ppt for Site 7. Top to bottom differences were only, as much as 3 ppt (Site 7). The salinity in the pond was much greater after the fall opening of 2006, than the fall opening of 2007.

This extensive flushing should help to reduce nutrient levels in the pond, temporarily alleviating eutrophic conditions. If this is true, then water quality conditions for the summer of ’08 should be good, or at least better, and the pond should exhibit mesotrophic conditions. Blue-green algae blooms, and nuisance macro algae growth should also be minimized. However if this is not the case, then another form of remediation must be met in order to restore the ponds water quality. The success of openings can not be guaranteed, and the exportation of the nutrients which cause the problem, is not necessarily the best strategy. In fact the opening of a coastal pond to the ocean is very disruptive to the ecological community within. Following the last openings in 2006, where an excellent exchange of sea water was met, there was still a blue - green Algae bloom that lasted 3 months in 2007. This would indicate that opening the pond to the ocean is not enough to restore water quality. For, even in a record dry summer, 2007, the draw down of groundwater and turbidity of organics from openings led to high nutrient loading, and harmful algal blooms. Hopefully though, the openings will at least be beneficial to the herring population recovery; a species which has received a no fishing prohibition by the Division of Marine Fisheries until 2009.

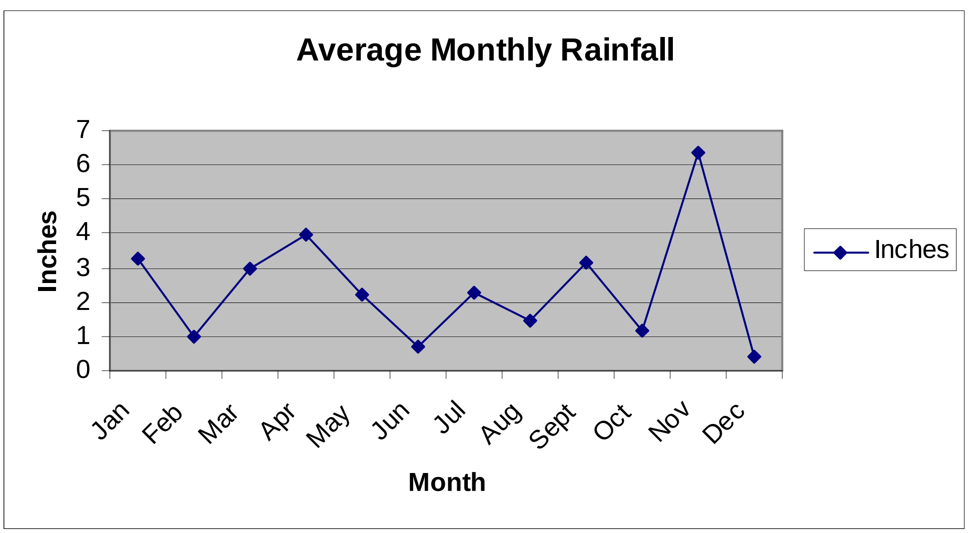
Figure 3: Average Salinity 2007



Rainfall:

Average rainfall was collected by the Nantucket Water Company, and shows record low precipitation for the summer, and low precipitation for the year (Appendix C, & Figure 4). As previously discussed rainfall directly affects volume and salinity in the ponds. It also affects the amount of nutrients that are carried in surface water and groundwater flow from watersheds to their associated water bodies. As anthropogenic uses increase, rainfall becomes an important factor in determining water quality.

Figure 4: Average Monthly Rainfall 2007



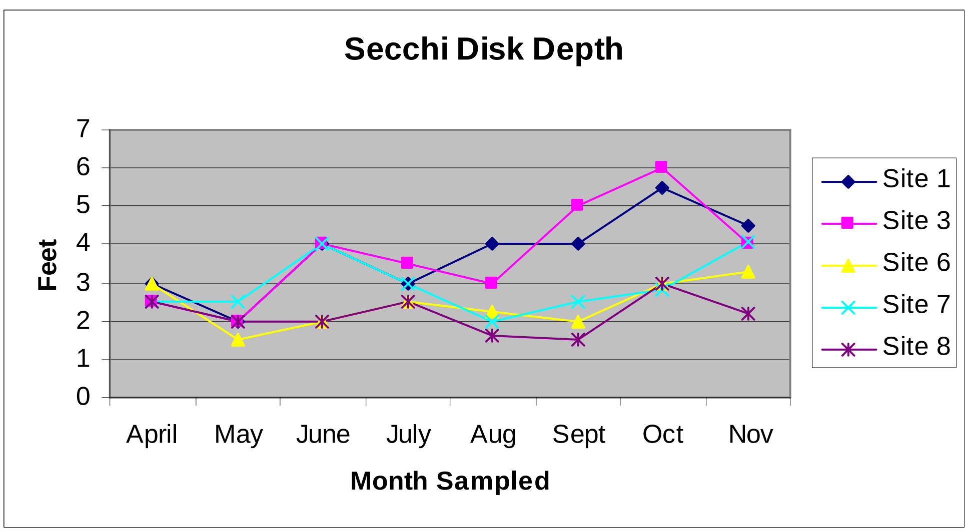
Total Rainfall = 28.89"
* December rainfall incomplete
Rainfall data supplied by Wannacomet Water Company

Secchi Disk Depth:

Secchi disk depth recordings are a quick helpful test in measuring water clarity. Water transparency will indicate the amount of phytoplankton, algae, and therefore nutrients available in the water column. The disc measures roughly one half the visible light penetrating the water column. When you combine this information with the bathymetry of any given water body, you can roughly define submerged aquatic vegetation boundaries. Because of Hummock Pond's average shallow depth, bathymetry, and poor water quality, it has a relative high abundance of submerged aquatic vegetation; some of which is undesirable. Secchi disk depth recordings reflect this condition, however this year they were better than most (Appendix A, & Figure 5). The salinity appears to be too low to effectively wipe out phragmities, and too low to support eel grass. Because of this however, the pond does support an abundant and diverse population of pond weeds. However, with nutrient levels as high as they are, Hummock has had problematic episodes of nuisance vegetation, and had deleterious phytoplankton blooms of blue-green algae which may dominate an ecosystem.

Average secchi disk depth recordings were (0.5 ft.) higher in 2007 than 2006, probably due to the lack of precipitation and associated nutrient loading. The 3 ft. average for most of the sampling period indicates a high level of phytoplankton production. Also in some shallow Sites, 3, 6, and 8 pond weeds were so thick they interfered with disk readings. Site 7 experienced its lowest reading in September at 1.5 ft. This was the result of a shift in phytoplankton communities, as blue-green algae became dominant June. The highest recordings were taken at Sites 3, and 1 in October; and measured to 6ft and 5.5ft respectively. This was most likely due to the lack of precipitation, the settling effect after the opening, and the cooling temperatures. These secchi disk depths for 2007 are still low however, and do not reflect an improvement in water quality.

Figure 5: Secchi Disk Depth 2007

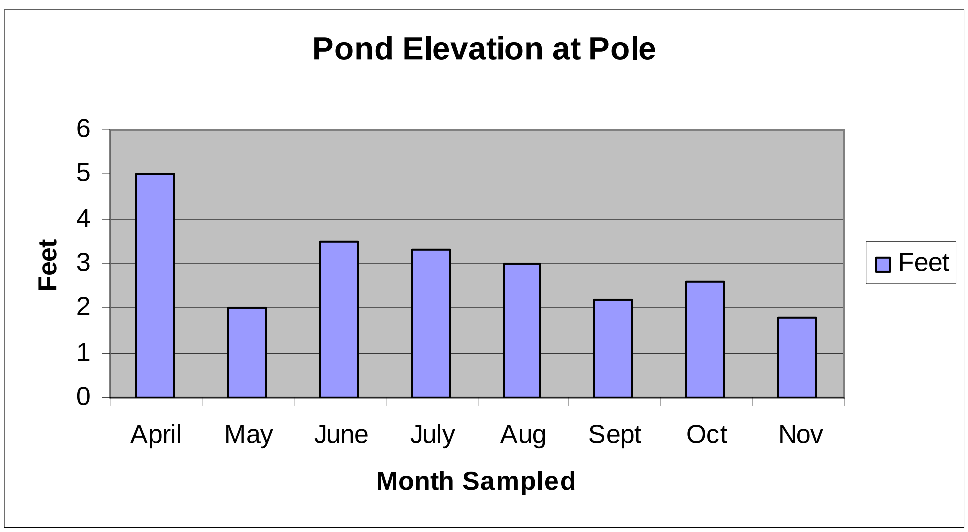


Pond Elevation:

Pond elevations were recorded on a pole between Sites 3, and 4 on the east side of the pond, at an abandoned floating dock location. The pole was chosen in 2004 for the 2 year Knoecklein (Northeast Aquatic Research) study. It was used in cross reference with topographical contours to measure pond volume with respects to mean sea level (MSL) elevation. With many years of data an average pond volume may be acquired with the use of the elevation at the pole. The 2005 report showed that the ponds surface area was 142 acres when the pole elevation was 3 ft., and this appears to be the average volume. At 5 ft. the pond would be at a somewhat flooded condition, with a surface area coverage of 267 acres. The base of the pole is approximately 0.5 ft. above mean low water sea level. This was determined by measurements taken 11/1/07, during the ’07 fall opening. So with a pole elevation of 2 ft., the surface of the pond would meet mean sea level.

When the pond was opened in April, it was approximately 5ft. (Appendix A, and Figure 6). The pond closed on a low tide, but was soon filled to 3.5 ft. with fresh groundwater from winter and spring precipitation. As precipitation dropped off in the summer so did elevation at the pole, approximately 2.2 ft by September. The pole elevation combined with salinity also shows that the pond is continually freshening, despite precipitation. As precipitation picked up in September, pond elevation rose slightly. However, after the fall opening, which closed on a low tide, the pond elevation was down again; just below 2 ft. in November. This shows the pond closures taking place at MSL, following both spring and fall openings.

Figure 6: Pond Elevation at Pole 2007



Nutrients:

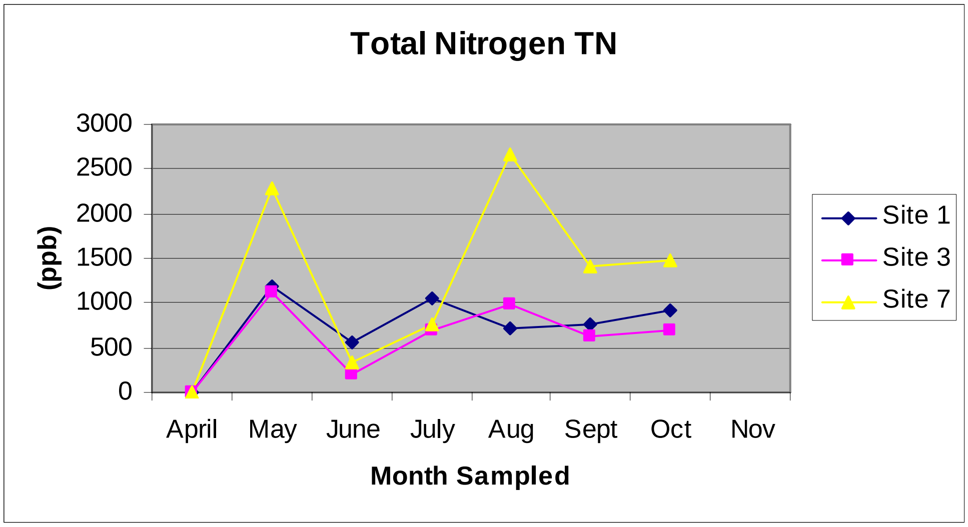
Nitrogen:

Nitrogen is the limiting nutrient in marine ecosystems, the quantity of which will dictate the health of any particular water body. Because Hummock is opened to the ocean it maintains a brackish water system for much of the year. Nitrogen which is accumulating in Hummock Pond may have a greater negative effect toward the foot of the pond than the head. Because of the ponds shape, there exists a higher saline condition at the foot, and a greater fresh water recharge at the head. Total nitrogen includes both organic and inorganic components. The Department of Environmental Protection for Massachusetts uses some standard classifications based on nitrogen thresholds to describe the health of many marine ecosystems. Hummock is now classified as an impaired, or eutrophic water body. Total nitrogen above 700 ppb is considered eutrophic. These standards can be found in the Estuaries Project Interim Report 2003, prepared by the School for Marine Science and Technology.

Total nitrogen when sampling began in April was very low, almost below a reportable limit. This may however have been due to colder temperatures, and an inactive environmental condition at this time. TN quickly reached exceedingly high levels after the spring opening in May, and may have been influenced by draw down effect of nutrient laden groundwater as well as increasing temperatures. Sites 1 and 3, were above 1,000 ppb and Site 7 was above 2,000 ppb TN (Appendix A, & Figure 7). Site 7 peaked in August with a reading of 2,670 ppb TN, in conjunction with the onset of the blue-green algae bloom. This reading is close to four times greater than the level suggested to be the limit to induce eutrophication in a marine system. And though Site 7 is predominantly fresh, this probably contributed to the anoxic conditions that occurred there in September and October. Anoxic events negatively affect an area because they allow for the re-release of nutrients from soils back into the water column. These nutrients then produce more harmful algae blooms in a never ending cycle toward etrophication, as bacteria consume the decaying algae on the bottom decreasing dissolved oxygen in a process known as biological oxygen demand (BOD), re-creating anoxic conditions on an annual cycle.

Also high at times were the various organic, and inorganic components of TN, such as Nitrate (NO_3), Kjeldhal Nitrogen (TKN), Ammonia (NH_3), and Organic Nitrogen (ON); see (Appendix B) for tables and figures. Eutrophic limits for these constituents are as follows; (NO_3) 70 ppb, (TKN) 700 ppb, (NH_3) 50 ppb, and (ON) 700 ppb. The large exchange that occurred in the fall opening was expected to decrease nitrogen levels for the summer of 2007, as long as pond temperatures remained cool, and anoxic events were avoided. This may be even more evident as the summer of 2007 was a record dry one, with little precipitation to carry nutrient rich surface water and groundwater from the watershed to the pond. However this was not the case, and would suggest that other means of controlling nitrogen levels must be met in order to ensure the future health of the pond.

Figure 7: Total Nitrogen 2007

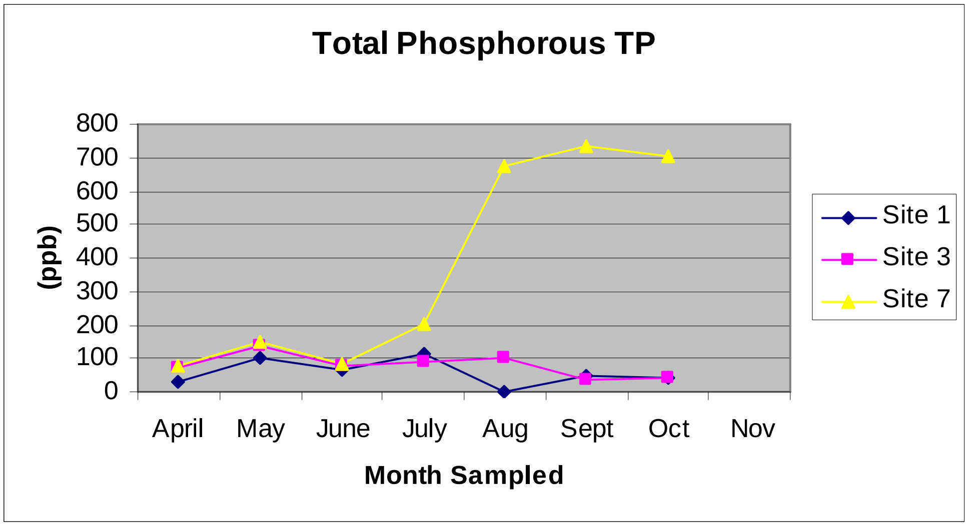


Total Phosphorus:

Hummock pond is predominantly a fresh water system because of its elongated shape, watershed area, and fresh water inputs on its northern end. The foot of the pond does remain brackish for much of the year though, and this does create some interesting dynamics. Total phosphorous (TP), is predominantly the limiting nutrient for plant growth in a fresh water system. However there is most likely a flip flopping of nutrient limiting conditions, because of salinity changes; based on nitrogen phosphorous ratios. This is usually the case in most coastal ponds that are opened to the ocean, and as previously discussed when this pond is transformed into a marine system, nitrogen becomes the limiting nutrient. Total phosphorous levels at or between 15-25 ppb, would be indicative of a mesotrophic system with good to fair water quality. Phosphorous levels rising above 50 ppb indicate eutrophic conditions.

The majority of water samples taken at Hummock for the summer of 2007 indicate eutrophic conditions with respects to phosphorous. All samples taken at Site 7 are above the impaired level. Two samples are 14 times the eutrophic limit, taken in, September and October; showing 733 ppb and 703 ppb (Appendix A, & Figure 8). Site 1, the area with the most saline conditions showed the lowest average TP for 2006. However the May and July readings at Sites 1 were high, double the eutrophic limit. Site 3 showed a higher average TP than Site 1, but varied dramatically from month to month. This may be related to influences from the Head of Hummock, as the flow of water appears to move from the head to the foot of the pond. The graph shows a sharp increase in TP at Site 7 with the onset of July, which coincides with peaking temperatures and hyper-eutrophic D.O. conditions; as well as declining salinities (Appendix A). By September periods of anoxia at site 7 result in a release of phosphorous from bottom sediments. This was visually seen from the physical presence of the blue-green algae bloom witnessed in the north head, which continued into October. Following the fall opening in October, it was predicted that the TP dropped off with the exchange to the ocean increasing salinities, and D.O. recordings, and falling temperatures. Also by the November sampling round the blue-green algae bloom had completely dissipated.

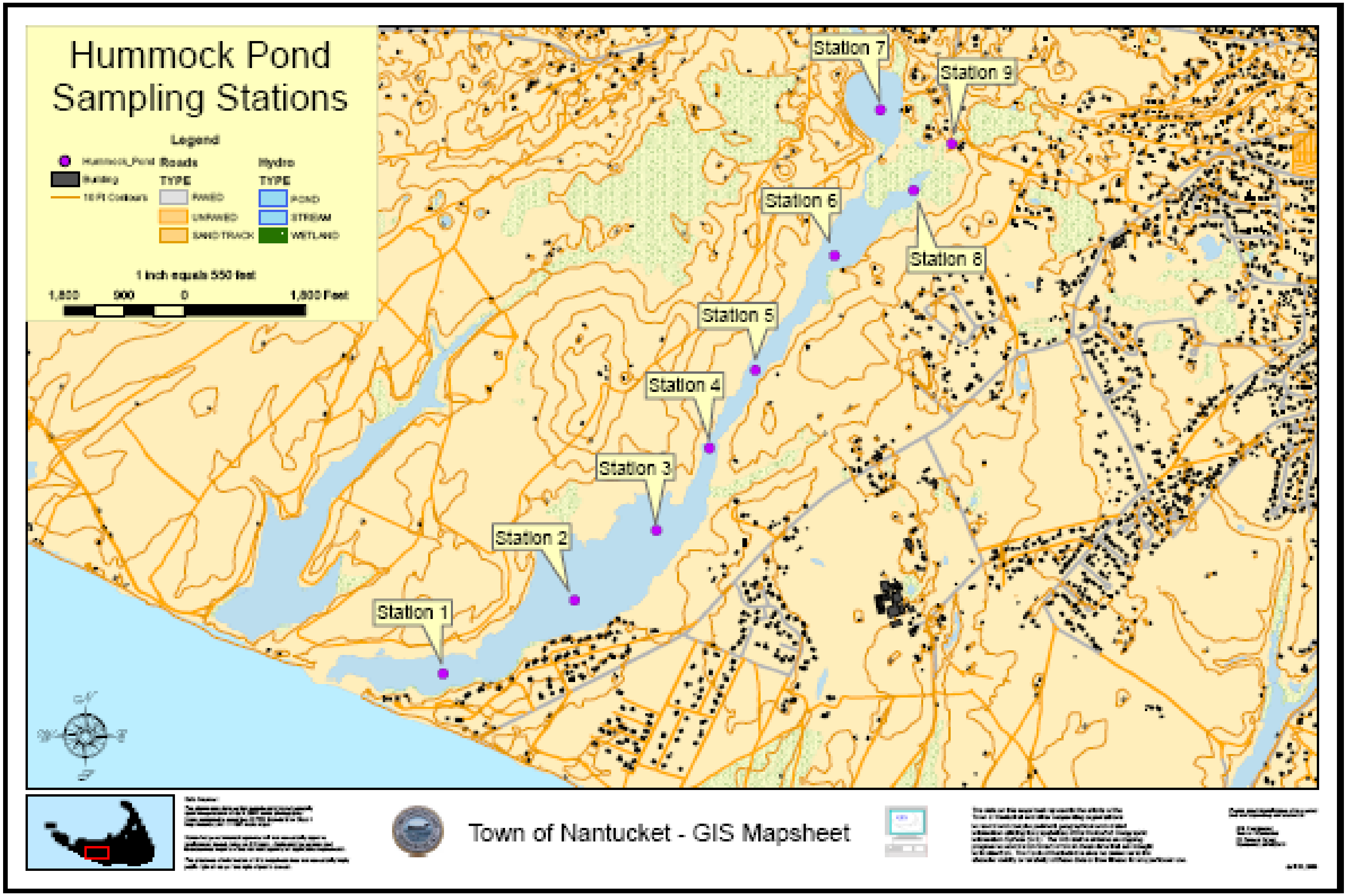
Figure 8: Total Phosphorous 2007



Conclusions:

The summary of results from the 2007 sampling period reveal that elevated levels of nutrients are occurring throughout Hummock pond. The highest concentrations of which are occurring in the northern head, which then affect lower portions of the pond. Nutrients are entering the pond from atmospheric deposition, septic and fertilizer inputs from the watershed, and internal recycling during anoxic events. The opening of the pond to flush nutrients does not appear to be a working solution, and the mitigation of nutrients in the form of sewer installation or changes in anthropogenic uses will not be resolved in the near future. In Knoecklein's 2005 report on Hummock, aeration is suggested as a possible solution to eliminate anoxia in the north head of Hummock in order to eliminate the recycling of nutrients during anoxic events. Also suggested is, the mechanical harvesting of weeds, a process that will have to be repeated as necessary. Both options should be considered, however the only long term solution is to mitigate nutrients in the watershed before they reach the pond.

The School for Marine Science and Technology (SMAST), is concluding their nutrient studies of the pond in cooperation with the Nantucket Marine Department. These studies will evolve into a more thorough Total Maximum Daily Load (TMDL) scenario, in accordance with the Massachusetts Estuaries Project, overseen by the Department of Environmental Protection. The comprehensive waste water treatment plan being evaluated by Earth Tech and the Nantucket Department of Public Works will also help come up with solutions to mitigate nutrient enrichment in Hummock. Until then, the opening of Hummock Pond, which may not definitively improve water quality will continue. Opening Hummock Pond for flood control and marine fisheries also needs as much attention as water quality monitoring. Their benefits and effectiveness need to be gauged quantitatively against their potential negative effects.


Hummock Pond
Sampling Stations
Legend
Roads
TYPE
PAVED
UNPAVED
SAND TRACK
Hydro
TYPE
POND
STREAM
WETLAND
1 inch equals 550 feet
1,800
900
0
1,800 Feet
Station 1
Station 2
Station 3
Station 4
Station 5
Station 6
Station 7
Station 8
Station 9
Town of Nantucket - GIS Mapsheet

Appendix A

Hummock Pond
2007
Physical and Chemical Data

Site 1: Foot of Pond
Site 3: Middle of Pond / Top of Main Body
Site 6: Northern Bay
Site 7: North Head
Site 8: North East Cove of Northern Bay

Temperature (º C)

Site 1	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	6.7	14.4	19.7	21.6	23.7	19.7	16.4	5.4
3	6.6	14.3	19.8	21.6	23.7	19.6	16.4	5.3
6	6.6	14.3	19.8	21.6	23.7	19.6	16.3	5.2
9	6.6	13.5	19.8	21.5	23.6	19.6	16.3	5.2
11	6.6		19.8	21.3	23.6			

Site 3	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	7.2	14.8	19.1	21.5	23.7	19.9	16.3	5.6
3	7.2	14.8	19.2	21.5	23.8	19.9	16.3	5.6
6	7.2	14.7	19.2	21.5	23.7	19.8	16.2	6
7	7.2	14.6	19.2	21.5	23.7		16.2	

Site 6	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	7.8	15.7	19.2	22.2	23.5	20.1	16.6	5.7
3	7.9	15.7	19.3	22.2	23.5	20	16.6	6.1
6	7.7	15.7	19.3	22.3	23.5	20	16.6	6.2

Site 7	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	7.3	15.6	19.4	22.2	24.1	20.1	16.7	6.1
3	7.3	15.6	19.4	22.2	24.1	20	16.6	6.1
6	7.3	15.5	19.3	22.2	24.1	19.9	16.5	6.7
9	7.3	15	19.5	22.1	24.1	19.9	16.4	6.5
12	7.3	14.6	19.1	22.1	24.1	19.7	16.4	7
13	7.2							

Site 8	4/12/2006	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	8.2	15.8	19.1	22.4	23.6	20	16.6	6
3	8.2	15.4	19.1	22.5	23.6	20	16.5	6.2
5	8.2							

Dissolved Oxygen (mg/l)

Site 1	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	11.12	8.67	7.31	7.47	7.61	7.97	8.68	11.53
3	11.15	8.64	7.25	7.27	7.57	7.89	8.68	11.42
6	11.14	8.65	7.27	7.26	7.61	7.91	8.67	11.45
9	11.16	4.05	7.31	7.12	7.62	7.75	7.88	11.35
11	10.94		7.32	6.23	7.51			

Site 3	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	11.12	8.58	7.3	8	7.7	8.09	8.46	11.13
3	10.96	8.57	7.24	7.94	7.62	8.09	8.39	11.2
6	10.95	8.42	7.23	7.65	7.6	8.08	8.37	11
7	10.84	8.35	7.16	7.47	7.49		8.25	

Site 6	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	10.36	8.07	6.79	7.1	7.6	7.63	8.32	11.05
3	10.34	8.01	6.71	7.08	7.54	7.6	8.27	11.02
6	10.06	8.01	6.56	5.67	7.41	7.59	8.24	10.94

Site 7	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	11.22	10.12	8.14	9.13	9.84	8.91	9.08	12.13
3	11.13	10.15	8.04	9.1	9.64	8.92	8.97	12.15
6	11.16	10.22	8.01	8.99	9.66	8.97	9.04	11.22
9	11.19	7.66	4.06	8.96	9.68	8.99	8.87	10.1
12	10.95	3.18	2.05	4.54	8.85	0.68	1.67	8.13
13	2.87							

Site 8	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	9.65	8.23	5.43	5.95	6.09	7.01	7.97	10.37
3	9.58	6.72	5.35	5.35	5.8	6.86	7.83	10.94
5	9.17							

Salinity (ppt)

Site 1	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	5.5	13	8.7	8.2	6.8	5.7	5	14.4
3	5.5	13	8.7	8.2	6.8	5.7	5	14.4
6	5.5	13.1	8.7	8.2	6.8	5.7	5	14.4
9	5.5	15	8.7	8.2	6.8	5.7	5	14.4
11	5.5		8.7	8.2	6.8			

Site 3	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	5.3	12.7	8.6	7.6	6.6	5.6	4.9	14.4
3	5.3	12.8	8.6	7.6	6.6	5.6	4.9	14.4
6	5.3	12.8	8.6	7.7	6.6	5.6	4.9	14.6
7	5.3	12.8	8.6	7.7	6.6			

Site 6	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	4.7	11.2	7.5	6.7	5.2	4.3	3.8	13.4
3	4.7	11.2	7.5	6.7	5.2	4.3	3.8	13.7
6	4.8	11.2	7.5	6.7	5.2	4.3	3.8	13.8

Site 7	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	4.5	3.6	4.4	4.2	3.3	2.7	2.3	6
3	4.5	3.6	4.4	4.2	3.3	2.7	2.3	6
6	4.5	3.6	4.4	4.2	3.3	2.7	2.3	6.7
9	4.5	4.7	5.3	4.2	3.3	2.7	2.3	8.6
12	4.5	5.7	5.8	4.3	3.4	3	2.3	9
13	4.5							

Site 8	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
0	4.6	4.1	5.43	6.7	4.9	4.1	3.5	11.3
3	4.6	7.1	5.35	6.7	4.9	4.1	3.5	13.4
5	4.6							

Secchi Disk Depth (ft.)

	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
Site 1	3	2	4	3	4	4	5.5	4.5
Site 3	2.5	2	4	3.5	3	5	6	4
Site 6	3	1.5	2	2.5	2.25	2	3	3.3
Site 7	2.5	2.5	4	3	2	2.5	2.8	4.1
Site 8	2.5	2	2	2.5	1.6	1.5	3	2.2

Pond Elevation at Pole (ft.)

	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
Feet	5	2	3.5	3.3	3	2.2	2.6	1.8

Nitrate (NO_3 ppb)

	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
Site 1	BRL	BRL	10	10	10	BRL	BRL	
Site 3	BRL	10	<10	BRL	10	BRL	BRL	
Site 7	BRL	BRL	130	BRL	10	BRL	10	

Ammonia (NH_3 ppb)

	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
Site 1	50	150	280	130	90	120	100	
Site 3	40	550	160	80	70	130	90	
Site 7	40	90	110	130	60	100	50	

Kjeldhal Nitrogen (TKN ppb)

	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
Site 1	BRL	1,190	560	1,050	700	770	910	
Site 3	BRL	1,120	210	700	980	630	700	
Site 7	BRL	2,800	210	770	2,660	1,400	1,470	

Organic Nitrogen (TKN - NH3 = ON ppb)

	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
Site 1	BRL	1,040	280	920	610	650	810	
Site 3	BRL	570	50	620	910	500	610	
Site 7	BRL	2,710	100	640	2,600	1,300	1,420	

Total Nitrogen (TN ppb)

	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
Site 1	<100	1,190	570	1,060	710	770	910	
Site 3	<100	1,130	210	700	990	630	700	
Site 7	<100	2,280	340	770	2,670	1,400	1,470	

Total Phosphorous (TP ppb)

	4/12/2007	5/9/2007	6/12/2007	7/3/2007	8/9/2007	9/25/2007	10/22/2007	11/20/2007
Site 1	32	104	63	112	BRL	46	42	
Site 3	70	135	80	87	99	37	41	
Site 7	78	147	82	204	673	733	703	

BRL = Below Reportable Limit
ND = Not Detected / Below Detectable Limit

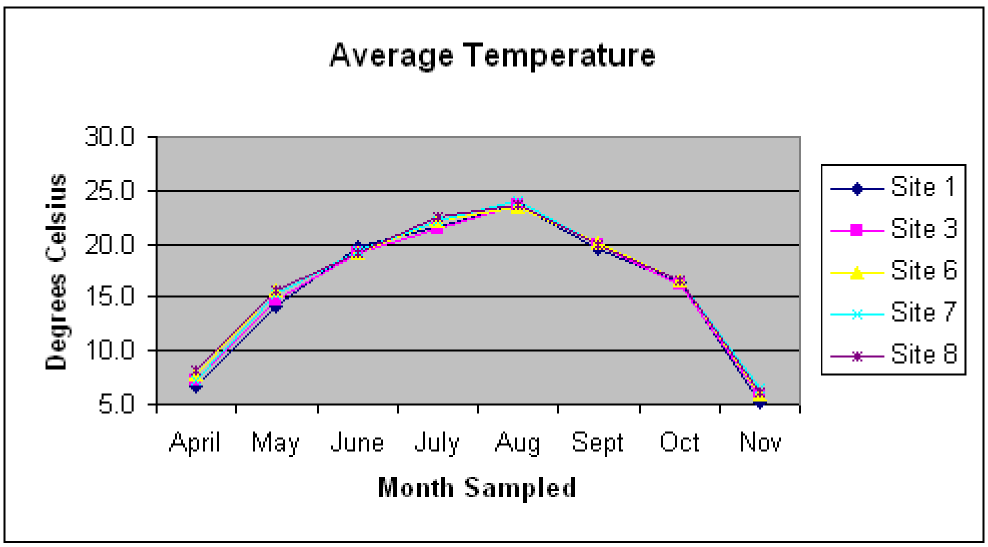
Appendix B

Hummock Pond 2007
Average Physical and Chemical Data with Charts

Site 1: Foot of Pond
Site 3: Middle of Pond / Top of Main Body
Site 6: Northern Bay
Site 7: North Head
Site 8: North East Cove of Northern Bay

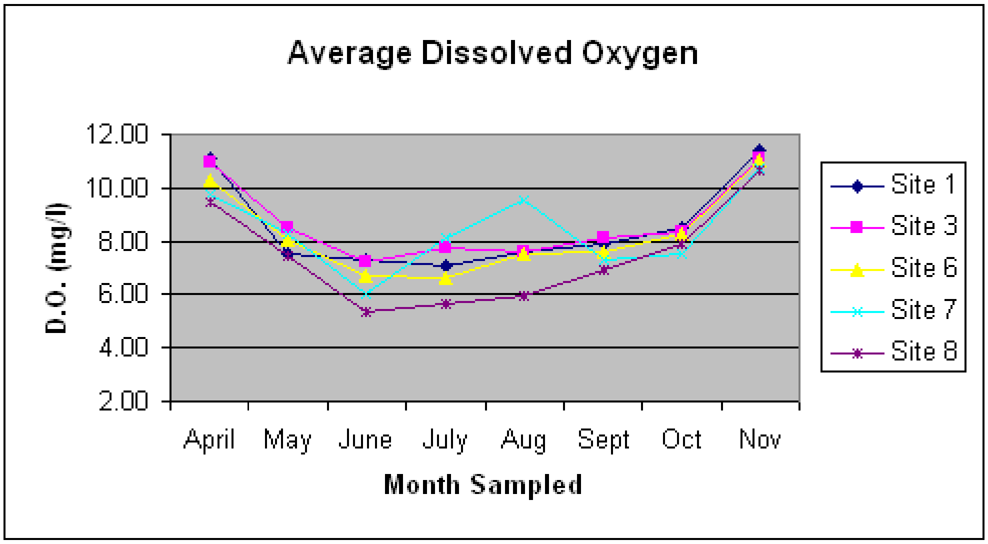
Temperature (º C)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	6.6	14.1	19.8	21.5	23.7	19.6	16.4	5.3
Site 3	7.2	14.7	19.2	21.5	23.7	19.9	16.3	5.7
Site 6	7.8	15.7	19.3	22.2	23.5	20.0	16.6	6.0
Site 7	7.3	15.3	19.3	22.2	24.1	19.9	16.5	6.5
Site 8	8.2	15.6	19.1	22.5	23.6	20.0	16.6	6.1



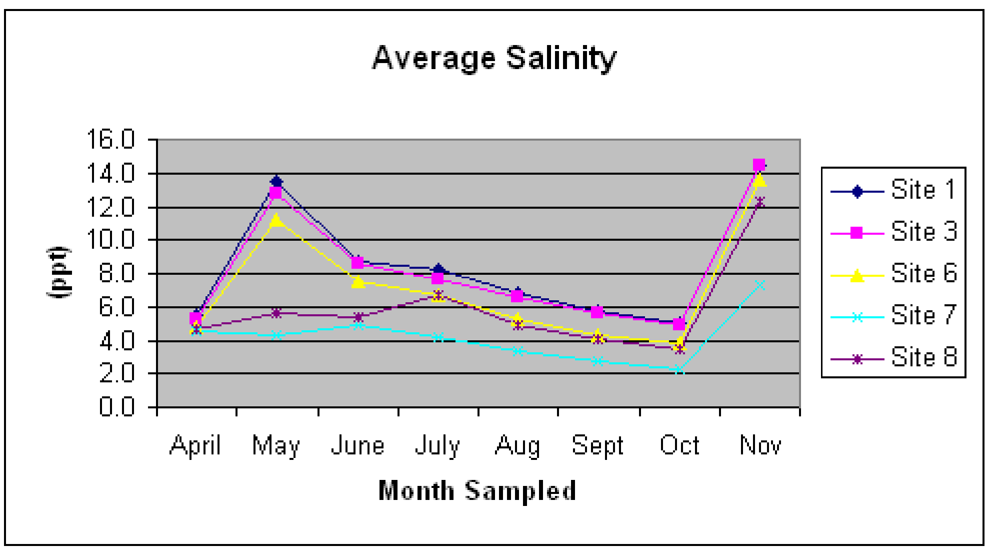
Dissolved Oxygen (mg/l)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	11.10	7.50	7.29	7.07	7.58	7.88	8.48	11.44
Site 3	10.97	8.48	7.23	7.77	7.60	8.09	8.37	11.11
Site 6	10.25	8.03	6.69	6.62	7.52	7.61	8.28	11.00
Site 7	9.75	8.27	6.06	8.14	9.53	7.29	7.53	10.75
Site 8	9.47	7.48	5.39	5.65	5.95	6.94	7.90	10.66



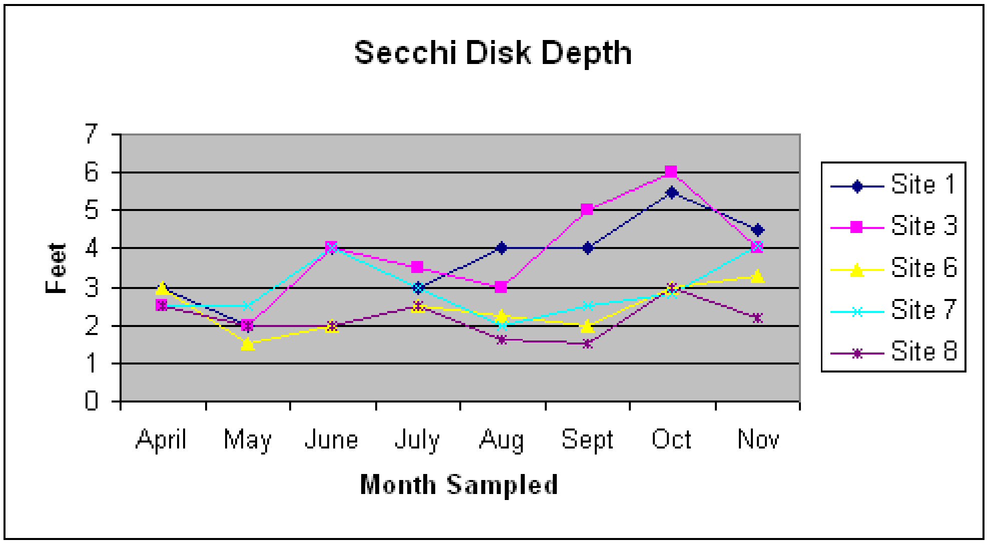
Salinity (ppt)

Site 1	April	May	June	July	Aug	Sept	Oct	Nov
Site 3	5.5	13.5	8.7	8.2	6.8	5.7	5.0	14.4
Site 6	5.3	12.8	8.6	7.7	6.6	5.6	4.9	14.5
Site 7	4.7	11.2	7.5	6.7	5.2	4.3	3.8	13.6
Site 8	4.5	4.2	4.9	4.2	3.3	2.8	2.3	7.3
	4.6	5.6	5.4	6.7	4.9	4.1	3.5	12.4



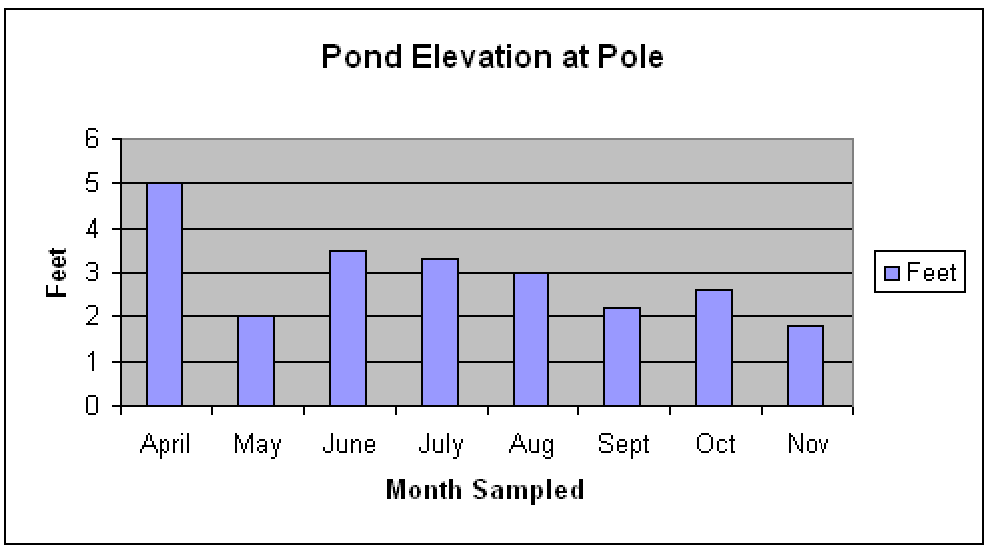
Secchi Disk
Depth (ft.)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	3	2	4	3	4	4	5.5	4.5
Site 3	2.5	2	4	3.5	3	5	6	4
Site 6	3	1.5	2	2.5	2.25	2	3	3.3
Site 7	2.5	2.5	4	3	2	2.5	2.8	4.1
Site 8	2.5	2	2	2.5	1.6	1.5	3	2.2



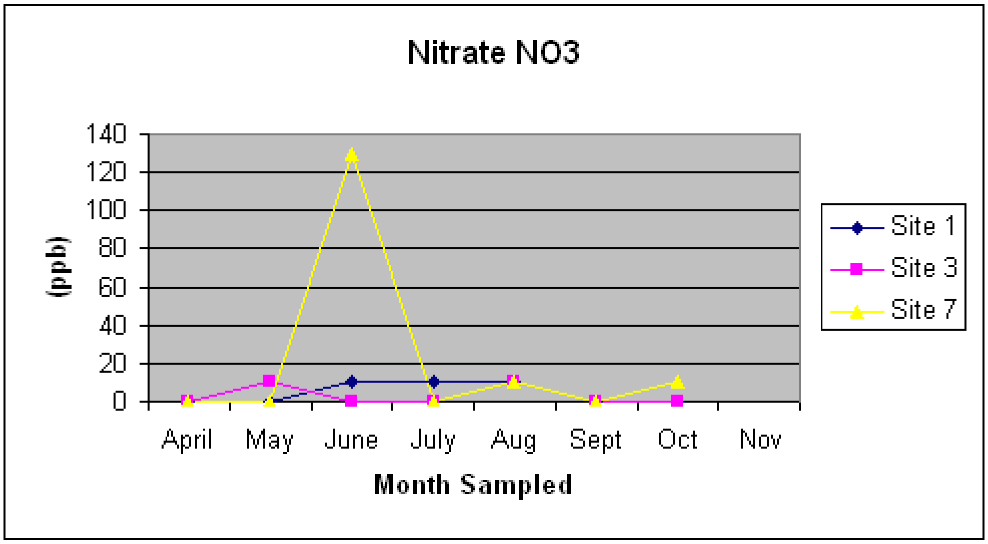
Pond Elevation at Pole (ft.)

	April	May	June	July	Aug	Sept	Oct	Nov
Feet	5	2	3.5	3.3	3	2.2	2.6	1.8



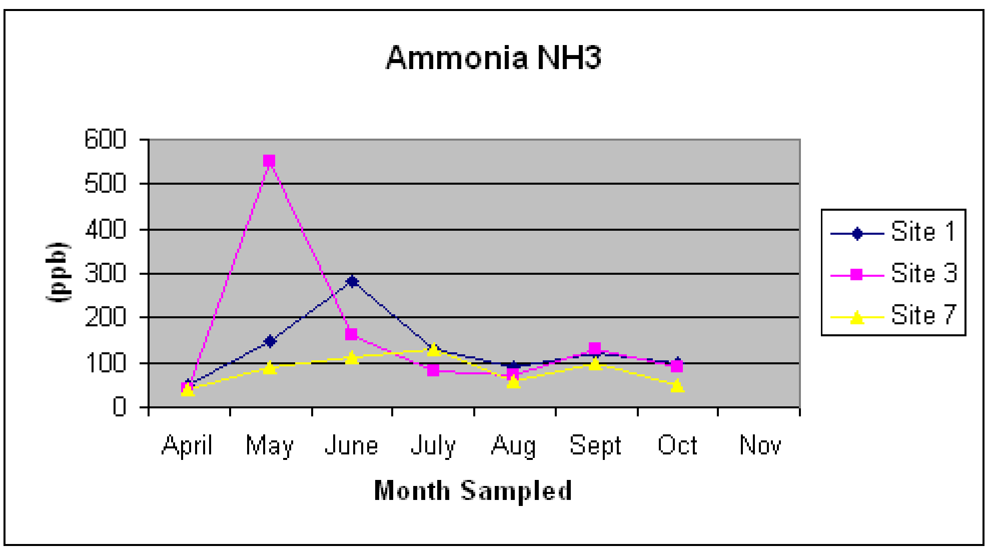
Nitrate (NO3 ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	BRL	BRL	10	10	10	BRL	BRL	
Site 3	BRL	10	<10	BRL	10	BRL	BRL	
Site 7	BRL	BRL	130	BRL	10	BRL	10	



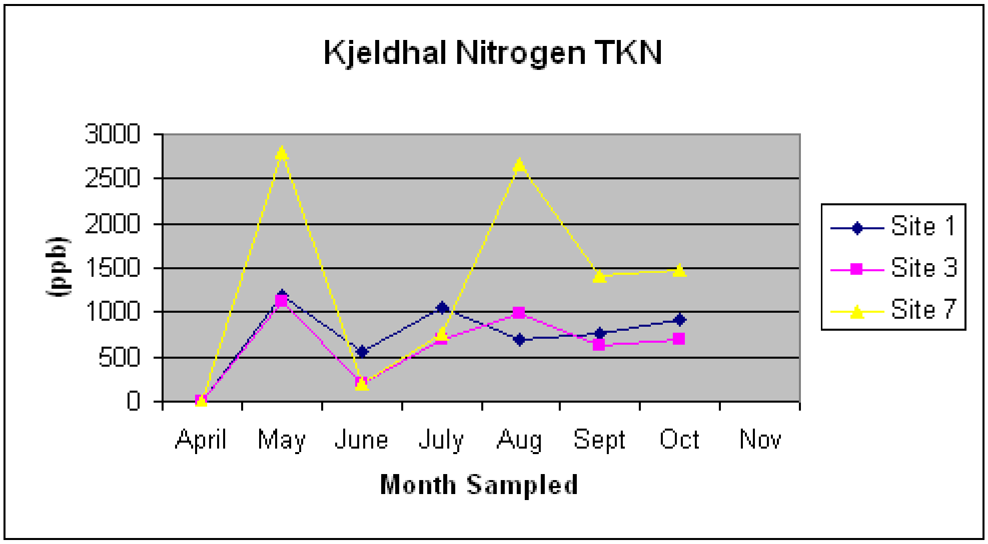
Ammonia
(NH_3 ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	50	150	280	130	90	120	100	
Site 3	40	550	160	80	70	130	90	
Site 7	40	90	110	130	60	100	50	



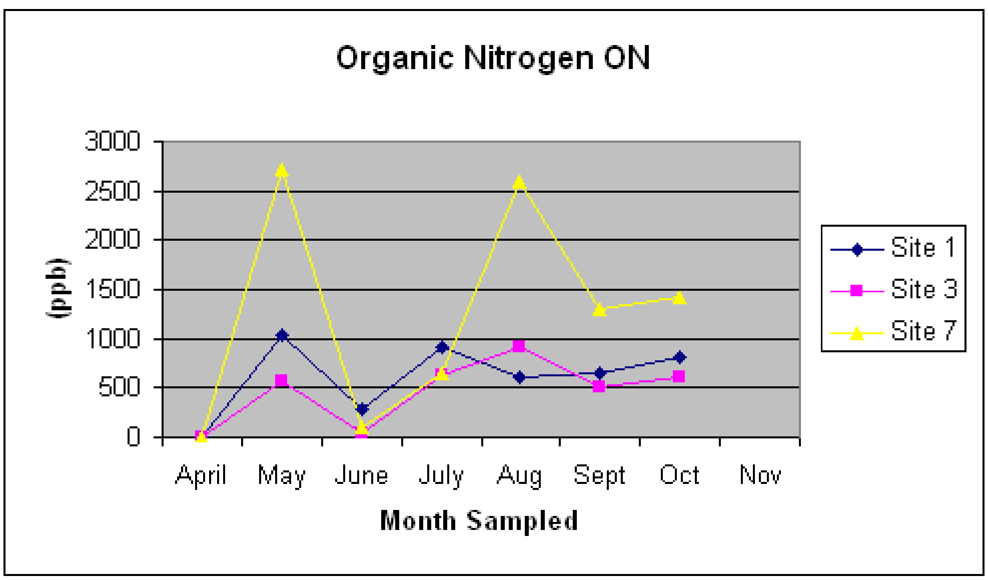
Kjeldhal Nitrogen (TKN ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	BRL	1,190	560	1,050	700	770	910	
Site 3	BRL	1,120	210	700	980	630	700	
Site 7	BRL	2,800	210	770	2,660	1,400	1,470	



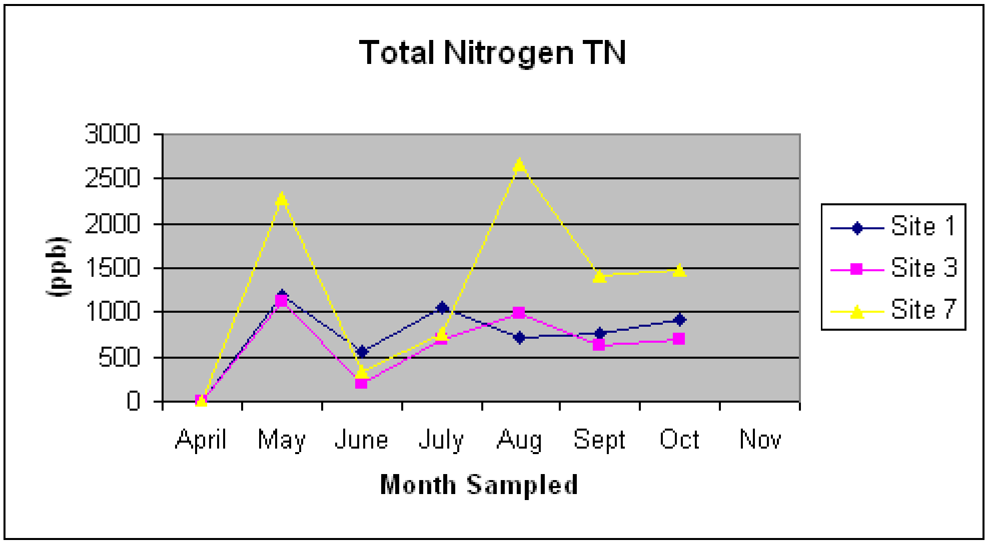
Organic Nitrogen (TKN - NH3 = ON ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	BRL	1,040	280	920	610	650	810	
Site 3	BRL	570	50	620	910	500	610	
Site 7	BRL	2,710	100	640	2,600	1,300	1,420	



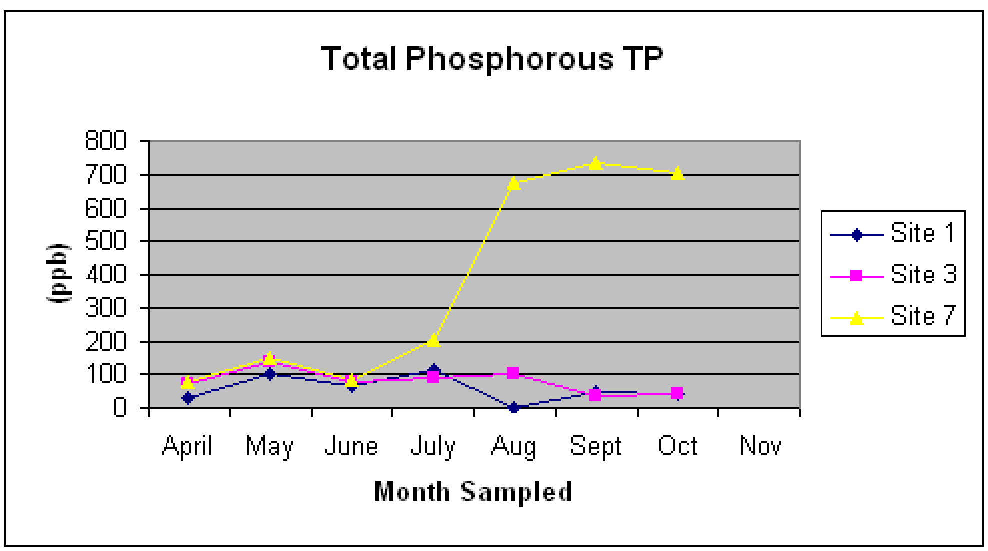
Total Nitrogen (TN ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	<100	1,190	570	1,060	710	770	910	
Site 3	<100	1,130	210	700	990	630	700	
Site 7	<100	2,280	340	770	2,670	1,400	1,470	



Total Phosphorous (TP ppb)

	April	May	June	July	Aug	Sept	Oct	Nov
Site 1	32	104	63	112	BRL	46	42	
Site 3	70	135	80	87	99	37	41	
Site 7	78	147	82	204	673	733	703	

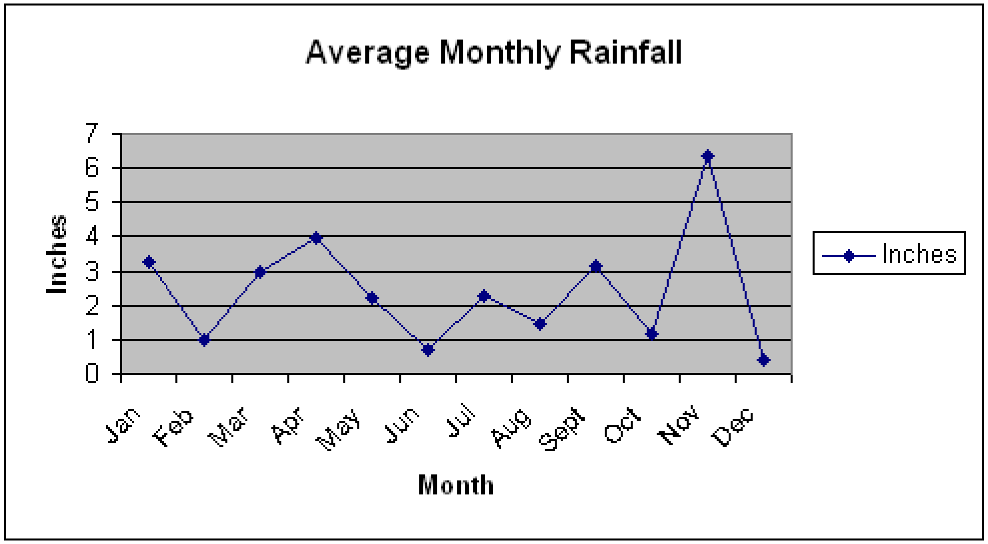


BRL = Below
Reportable
Limit
ND = Not Detected / Below
Detectable Limit

Appendix C

Average Monthly Rainfall
2007

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Inches	3.27	0.97	2.98	3.95	2.23	0.7	2.29	1.45	3.13	1.16	6.36	0.4



Total Rainfall: 28.89 "

December Rainfall Incomplete