Technical Memorandum

Westport River Watershed Alliance Ponds Monitoring Project Summer 2012

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Re: Summary of Water Quality Monitoring Activities in Cockeast Pond, Adamsville Pond, Forge Pond as undertaken by the Coastal Systems Program, School for Marine Science & Technology at the University of Massachusetts – Dartmouth and the Westport River Watershed Alliance. Period of Performance: July 25 – September 25, 2012

Date: June 30, 2013

Overview: The water quality monitoring project detailed below was designed to extend the previous (2008, 2009, 2010, and only Cockeast in 2011) collection of baseline nutrient related water quality data that is required to assess the nutrient related health of Forge, Adamsville and Cockeast Ponds in the Town of Westport. Sampling was undertaken to evaluate the annual variations in the water quality of the 3 ponds based on summer sampling only. Summer is the critical management period, as water quality conditions in ponds and estuaries are generally at their lowest point of the year.

The sampling project is a joint effort between WRWA and SMAST. Summer 2012 sample collection was conducted by WRWA with technical assistance and analysis by the Coastal Systems Program within the School for Marine Science and Technology (SMAST), University of Massachusetts, Dartmouth. The work included water quality sampling at the previously established monitoring sites. Multi-year monitoring is essential for proper assessment, since inter-annual variations in aquatic systems are common (resulting from differences in rainfall, temperature, light intensity {cloudy versus sunny days}). A low-intensity, long-term program provides a more accurate measurement of typical conditions and the amount of variation in each parameter. Equally important, it allows evaluation of changes in pond water quality due to changing activities within the associated watershed. The baseline water quality monitoring assesses the present health of these ponds and their need for protection/restoration, and also provides the pond information needed to enhance the MEP evaluation of nitrogen mitigation and analysis of the Westport River estuary system.

The Technical Memorandum is organized as follows:

1. Overview of Forge Pond, Adamsville Pond and Cockeast Pond water quality monitoring
2. Summary of Sampling Approach
3. Results of Sampling Measurements
    - Summary of 2012 Water Quality Results for Forge Pond Sampling
    - Summary of 2012 Water Quality Results for Adamsville Pond Sampling
    - Summary of 2012 Water Quality Results for Cockeast Pond Sampling
    - Comparison of 2008, 2009, 2010, 2012 with 2011 for Cockeast Pond
4. Pond Trophic Status

Summary of Sampling Approach in Forge Pond, Adamsville Pond and Cockeast Pond:

The Westport River Watershed Alliance (WRWA) Pond Water Quality Monitoring Project was continued in the summer of 2012 following the previously developed protocols and sampling locations to ensure comparability. The 2012 program included a total of three (3) sampling events, once in July, once in August and once in September. The sampling stations and depths were as follows:

- Forge Pond
    - Water column at 1 Mid-pond station. Samples were collected at surface and bottom depth (Figure 1).
- Adamsville Pond
    - Water column at 1 Mid-pond station. Samples were collected at surface and bottom depths (Figure 2).
- Cockeast Pond
    - Water column at 1 station. Samples in the north basin (Station 2) were collected at surface and bottom depths. In previous years samples were also collected in the south basin (Station 1), however gradients between the sites were minimal and the south basin station was dropped (Figure 3).

Figure 1 – Aerial photograph of Forge Pond depicting the location at which nutrient samples were collected.

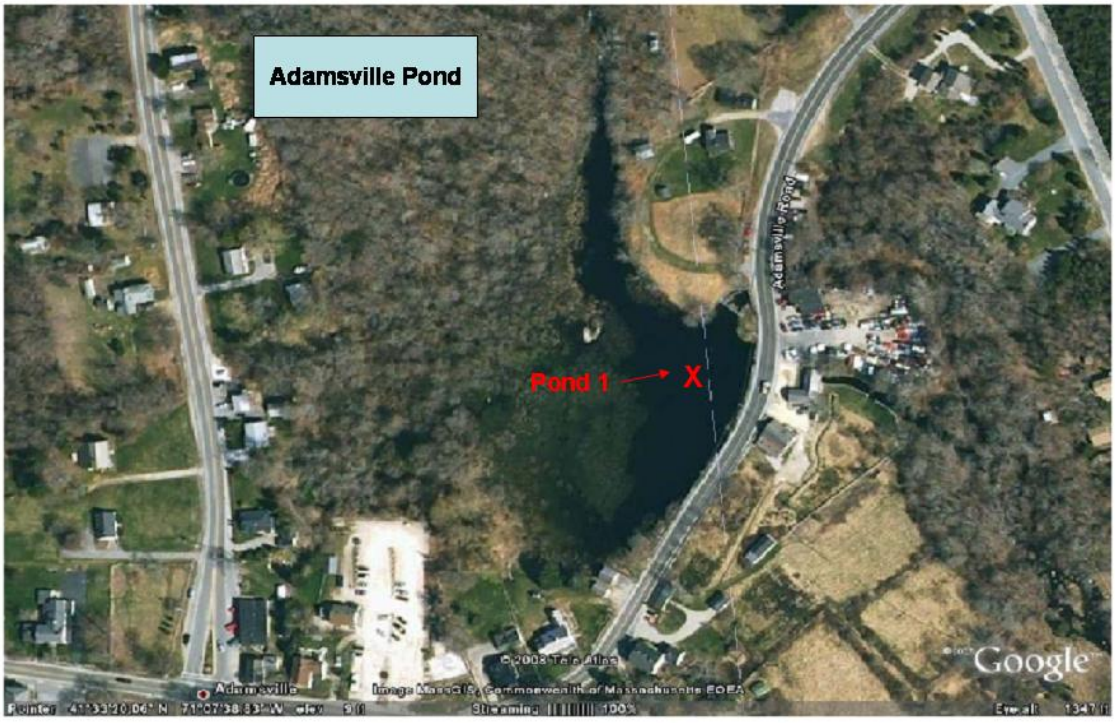


Figure 2 – Aerial photograph of Adamsville Pond depicting the location at which nutrient samples were collected.

Figure 3 – Aerial photograph of Cockeast Pond depicting the 2 locations at which nutrient samples have been collected. Samples were only collected at Station #2 in 2012.

Nutrient samples collected at each sampling station were assayed at the Coastal Systems Program Analytical Facility at SMAST. All samples were analyzed for ammonium (NH4), nitrate+nitrite (NO3+NO2), Dissolved Organic Nitrogen (DON), Particulate Organic Nitrogen (PON), ortho-phosphate (PO4), Particulate Organic Carbon (POC), Total Phosphorus (TP), Chlorophyll a, Pheophytin a, pH and alkalinity. Over the 2012 season, a total of 6 samples were collected from Forge Pond, 6 samples were collected from Adamsville Pond and 6 samples were collected from Cockeast Pond. In addition, one field duplicate was collected from Cockeast Pond and two were collected from Forge Pond for QA purposes.

Summary of 2012 Water Quality Results for Forge Pond, Adamsville and Cockeast Ponds:

Total nitrogen levels showed enrichment of the watercolumn in each of the ponds monitored. Forge Pond showed slightly lower, 0.78 mg N L^{-1} and Adamsville Pond, 1.27 mg N L^{-1}, slightly higher, than Cockeast Pond, 0.92 mg N L^{-1}. Although the dominant forms of nitrogen entering streams and ponds is typically nitrate and ammoniuim (DIN), organic forms of nitrogen (DON, PON) dominate the watercolumn nitrogen pool of all 3 ponds. This results from the transformation of inorganic forms to organic forms by aquatic plants, algae and phytoplankton. However there remains significant inorganic nitrogen in Forge and Adamsville Ponds, 0.17 mg N L^{-1}, 0.18 mg N L^{-1}, and to a lesser extent in Cockeast, 0.055 mg N L^{-1}, which account for 22%, 14% and 6% of their respective total nitrogen pools.

DON was the dominant form of nitrogen in all 3 ponds. The average DON concentration in the water column of Forge Pond across the 3 sampling dates was 0.50 mg/L, approximately 65% of the TN pool in pondwaters (Tables 1,2,3). Similarly, Adamsville and Cockeast have DON average levels of 0.66 mg N L^{-1} and 0.66 mg N L^{-1}, respectively, accounting for 52% and 72% of their respective total nitrogen pools. The remaining nitrogen pool, PON, was comprised primarily of phytoplankton and some organic detritus and boosted the organic nitrogen pool in Forge, Adamsville and Cockeast Ponds to 78%, 86% and 94% of their respective total nitrogen pools.

The dominance of organic nitrogen is fairly typical of surface freshwater systems, particularly lakes and ponds or when the watershed includes wetland areas. Dissolved organic nitrogen, a by-product of the decomposition of plant material, enters from the upland stream and pond sediments and is not readily available to plants or bacteria and tends to remain in the water column until transported out in outflowing water. In contrast, the inorganic nitrogen released during plant decay or that enters in groundwater, surface water, or rainfall is readily available to algae, phytoplankton and plants. It is rapidly taken up and converted to organic nitrogen within streams, ponds and estuaries. The PON within these ponds is primarily a result of this uptake and growth by phytoplankton. The predominance of organic forms within each pond indicates that these transformations are occurring. A coupled land-use analysis such as that prepared by the MEP is needed for definitive evaluation of nutrient sources, total load to each pond, and the rate of water turnover (flushing) within each pond.

While nitrogen is critical in determining the health of down gradient estuaries and is an important nutrient in pond productivity, phosphorus appears to be the immediate nutrient causing the eutrophic conditions in the fully freshwater ponds, Forge Pond and Adamsville Pond. The ratio of N/P can be used as an approximate gauge of the relative importance of N and P to the nutrient related health of an aquatic system. While this is a more robust analysis in salt water compared to freshwater systems, generally N/P ratios less than 16 indicate that the nutrient to manage is nitrogen. The molar ratio of TN/TP in both freshwater ponds indicates a potential need for phosphorus management, with Forges Pond TN/TP being 52 and Adamsville Pond being 34. In contrast, for salt ponds, like Cockeast Pond (10-13 ppt), the molar ratio DIN/DIP

(dissolved inorganic N and P) is sometimes used for the evaluation (ratio = 61). However, the concentrations of the nutrients also need to be taken into account. In the case of the freshponds, the DIN and DIP levels are sufficient to presently support significant phytoplankton growth. However, in Cockeast Pond the nitrogen levels are low and the inorganic phosphorus levels very low. Therefore, it appears from this preliminary analysis that both nitrogen and phosphorus inputs will result in increased phytoplankton growth.

These results are consistent with the high phytoplankton biomass (as chlorophyll a) in Forge and Adamsville Ponds, 11 ug L^{-1} (blooms to 38 ug L^{-1}) and 18 ug L^{-1} (blooms to 47 ug L^{-1}), respectively, compared to the low levels in Cockeast Pond, <3 ug L^{-1} (Tables 1,2,3).

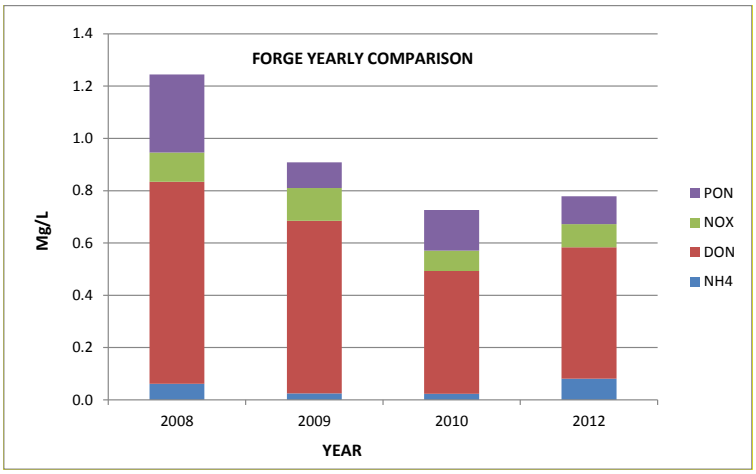
Comparison of 2012 Data with 2008, 2009 and 2010 Data

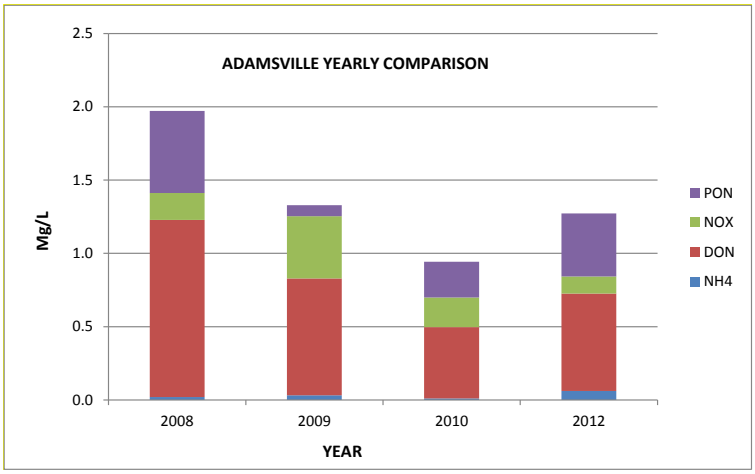
In Adamsville Pond, TN showed a general decrease from approximately 1.9 mg/L in 2008 to 1.3 in 2009 to 0.9 mg/L in 2010 and then an increase back up to 1.3 mg/L 2012. While the 2008, 2010, and 2012 values are means of several samplings, the 2009 value is a result of a single sample, as is the case for 2009 values for Forge and Cockeast Ponds as well. Consequently, this trend should be interpreted with caution. DON is the dominant N form all 4 years with DIN and PON making up a smaller portion of the TN pool (Figure 4). TP has varied from 0.068-0.098 mg/L with no clear trend over the 4 years of sampling (Table 2 and 2009 and 2010 Tech Memo).

In Cockeast Pond, TN values at both sampling stations are variable over the 5 sampling years, decreasing from approximately 1.2 mg/L in 2008 to 0.8 mg/L (Sta. 1) and 0.9 mg/L (Sta. 2) in 2009 and then increasing to approx. 1.1 mg/L at both Stations in 2010 and 2011, and decreasing to 0.92 mg/L in 2012 (Figure 4, Table 3 and 2009, 2010 and 2011 Tech Memo). For all 5 years, DON dominates all other forms of N with DIN making up a very small fraction of TN (Figure 4). TP values varied around approximately 0.02 mg/L at both stations in 2008 and 2009 but increased to 0.05 mg/L (Sta. 1) and 0.06 mg/L (Sta. 2) in 2010 and then decreased down0.05 mg/L in 2011 to 0.03 mg/L in 2012 (Table 3, 2009, 2010, 2011 tech memo).

In Forge Pond, there is a trend in TN values over the 4 sampling years, decreasing from approximately 1.2 mg/L in 2008 to 0.9 mg/L in 2009 to 0.7 mg/L in 2010 with a slight increase in 2012 to 0.78 mg/L in 2012 (Figure 4, Table 1 and 2009 and 2010 Tech Memo). For all 4 years, DON is the dominant form of N, with DIN and PON in smaller portions (Figure 4). TP varies between approximately 0.03 and 0.06 mg/L over the 4 years of sampling (Table 1 and 2009 and 2010 Tech Memo).

Annual rainfall data (New Bedford) from 2008-2012 show a general decrease over this period from 59.5 inches in 2008 to 56.4 inches in 2009 to 46.1 inches in 2010 to 54.5 inches in 2011 to 37.4 inches in 2012 (Northeast Regional Climate Center). Such a trend could have an influence on the general decrease in N in Adamsville and Forge Ponds over the same period but doesn't correlate with the variable levels of nitrogen in Cockeast Pond (Figure 4). Prior to the sampling period in each of the 4 years, rainfall amounts (New Bedford, Jan-July) were approximately 28 inches in 2008, 31 inches in 2009, about 30 inches in 2010, about 28 inches in 2011 and about 20 inches in 2012 (Northeast Regional Climate Center). Consequently, it is not clear whether or not rainfall had a major influence on the differences between N levels during the 5 sampling years.





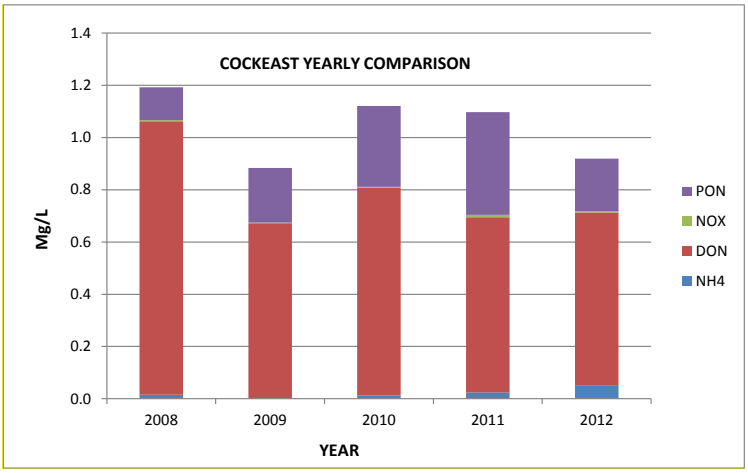


Figure 4. Comparison of water column Nitrogen concentrations from 2008, 2009, 2010, 2011 (Cockeast only) and 2012 in Adamsville, Cockeast and Forge Ponds. 2008 values (mg/L) are means of 4 monthly samplings, June-September; 2009 values are from a single sampling in September and 2010 & 2012 values are means of 3 samplings, July-September.

Pond Trophic Status:
Based upon the summer 2012 survey results it is possible to conduct a basic assessment of the nutrient related health of the 3 Westport Ponds. The assessment uses Total Phosphorus, Chlorophyll-*a* pigment levels and water clarity (secchi depth), all of which are interrelated parameters that focus on nutrient enrichment. The index of choice is the Carlson Trophic State Index, which is based upon comparisons to a large number of U.S. lakes and ponds (Table 4)[1]. Cockeast Pond was included in this assessment as it appears to be sensitive to phosphorus addition, like freshwater ponds. The data used in the index was the average over the sampling period from the mixed layer of each pond. While the index needs to be used with other biotic indicators, it does provide a general assessment tool where calculated index levels are correlated with different Trophic States:

- TSI >50: Eutrophic (highly nutrient enriched)
- TSI 40-50: Mesotrophic (moderately nutrient enriched)
- TSI <40: Oligotrophic (low level of nutrient enrichment)

It appears that Forge Pond, Cockeast Pond and Adamsville Pond are continuing to show clear signs of eutrophication (Table 5). Eutrophic conditions are those that exist under high nutrient inputs and are typified by algal and phytoplankton blooms, low water clarity and sometimes low oxygen in bottom waters. Nutrient enrichment can be seen in the poor water clarity. Forge Pond and Adamsville Pond generally had Secchi depths of 1 meter or less, while Cockeast Pond showed an average value of 1.3 meters. A moderately enriched pond would support Secchi depths of 2-4 meters. The "cloudiness" of the water column is mainly caused by phytoplankton growth, measured by Chlorophyll-*a* concentrations which ranged from a low of 2.3 ug/L in Cockeast to a high of 17.54 ug/L at Adamsville (Tables 1-3). The highest average Chlorophyll-*a* value (Adamsville Pond) results in the lowest Secchi Depth reading (Table 5). Phosphorus is the nutrient primarily responsible for phytoplankton growth in freshwater lakes and ponds. TP levels in all 3 ponds are high with average concentrations of 0.033 mg/L in Forge Pond, 0.084 mg/L in Adamsville Pond and 0.029 mg/L in Cockeast Pond (Tables 1, 2, 3). These concentrations correlate with the high levels of Chlorophyll-*a* and result in low water clarity. These 3 indicators together yield the high TSI values in Table 5 and the resulting Eutrophic status in all 3 water bodies.

In comparing the 2010 (2011-Cockeast only) Trophic State with 2012, both Adamsville Pond and Forge Pond remain classified as Eutrophic while Cockeast Pond continues to vary between Eutrophic (2010, 2011) to a Meso/Eutrophic State (2009, 2012).

[1] http://www.epa.gov/bioiweb1/aquatic/carlson.html

Recommendations:
We recommend that a full sampling schedule (3-4 sampling events) be undertaken in 2013. This schedule allows for the continuation of tracking the health of the ponds. WRWA should also begin to plan for a management level assessment of these ponds that will consider all the collected data and will bring it into context with watershed delineation/land use info, water and nutrient budgets. In addition, an analysis of the hydrodynamics of Cockeast Pond coupled to water quality should be considered to evaluate the efficiency of the present tidal inlet. It is likely that tidal flushing is a primary control on the water quality and habitat health of this small coastal pond, which periodically appears to freshen significantly.

ACKNOWLEDGMENTS

The Coastal Systems Program Technical Team would like to take the opportunity to thank the Westport River Watershed Alliance for its commitment to advancing environmental stewardship in southeastern Massachusetts and its proactive attitude in seeking analyses on aquatic systems in need of protection or restoration. The marriage of advocacy with science helps to ultimately advance the greater good and WRWA is a true champion in that regard. In particular, the assistance of Matt Patrick, Roberta Carvalho, and Betsy White is much appreciated. We would also like to acknowledge the support of the Town of Westport Massachusetts Estuaries Project Committee, who are examining the variety of nitrogen management alternatives (including using restoration of freshwater habitats) for the overall restoration of the Westport River Estuary.

FORGE POND													
	PO4	TP	NH4	Nox	DIN	DON	TDN	POC	PON	TON	TN	Chla	Salinity
Date	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ppt)
7/25/2012	0.0	0.04	0.15	0.13	0.28	0.60	0.88	1.28	0.15	0.75	1.03	26.66	0.1
7/25/2012	0.0	0.04	0.15	0.12	0.26	0.58	0.84	1.36	0.17	0.74	1.01	8.65	0.1
7/25/2012	0.0	0.04	0.16	0.14	0.30	0.39	0.69	1.03	0.14	0.53	0.82	37.68	0.1
8/22/2012	0.0	0.03	0.08	0.10	0.18	0.63	0.81	1.03	0.11	0.75	0.93	2.78	0.1
8/22/2012	0.0	0.03	0.06	0.10	0.16	0.69	0.85	1.06	0.11	0.80	0.97	4.00	0.1
9/25/2012	0.0	0.03	0.02	0.04	0.06	0.39	0.45	0.71	0.06	0.45	0.51	2.81	0.1
9/25/2012	0.0	0.03	0.02	0.06	0.07	0.43	0.51	0.59	0.05	0.48	0.56	2.36	0.1
9/25/2012	0.0	0.03	0.02	0.02	0.05	0.30	0.35	0.64	0.07	0.37	0.41	2.09	0.1
AVERAGE	**0.009**	**0.033**	**0.081**	**0.089**	**0.169**	**0.503**	**0.672**	**0.962**	**0.107**	**0.610**	**0.779**	**10.878**	**0.100**

Table 1. Summary of nutrient concentrations for samples collected in Forge Pond.

ADAMSVILLE POND													
	PO4	TP	NH4	Nox	DIN	DON	TDN	POC	PON	TON	TN	Chla	Salinity
Date	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ppt)
7/25/2012	0.0	0.09	0.13	0.11	0.24	0.54	0.78	4.07	0.72	1.26	1.50	9.36	0.1
7/25/2012	0.0	0.08	0.07	0.16	0.23	0.68	0.91	3.64	0.65	1.33	1.56	6.42	0.1
8/22/2012	0.1	0.10	0.04	0.19	0.23	0.93	1.16	1.09	0.14	1.07	1.30	7.54	0.1
8/22/2012	0.1	0.10	0.05	0.19	0.24	1.05	1.29	0.61	0.06	1.11	1.35	1.40	0.1
9/25/2012	0.0	0.07	0.04	0.02	0.05	0.35	0.40	2.36	0.41	0.76	0.81	33.59	0.1
9/25/2012	0.0	0.07	0.03	0.04	0.07	0.43	0.51	3.60	0.60	1.03	1.11	46.92	0.1
AVERAGE	**0.028**	**0.084**	**0.062**	**0.117**	**0.178**	**0.664**	**0.842**	**2.563**	**0.430**	**1.094**	**1.273**	**17.539**	**0.100**

Table 2. Summary of nutrient concentrations for samples collected in Adamsville Pond. Concentration is in milligrams/liter.

COCKEAST POND													
	PO4	TP	NH4	Nox	DIN	DON	TDN	POC	PON	TON	TN	Chla	Salinity
Date	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	(ppt)
7/25/2012	0.0	0.03	0.03	0.00	0.04	0.82	0.85	1.13	0.19	1.01	1.04	3.19	10.6
7/25/2012	0.0	0.03	0.05	0.00	0.06	0.73	0.79	1.30	0.23	0.96	1.01	2.81	10.6
8/22/2012	0.0	0.03	0.04	0.01	0.05	0.70	0.75	0.97	0.15	0.85	0.90	1.19	11.4
8/22/2012	0.0	0.03	0.03	0.01	0.04	0.71	0.75	1.07	0.17	0.88	0.91	1.42	11.3
8/22/2012	0.0	0.02	0.07	0.00	0.07	0.70	0.77	0.98	0.16	0.86	0.93	1.48	11.4
9/25/2012	0.0	0.03	0.10	0.01	0.10	0.77	0.88	1.44	0.21	0.98	1.08	3.19	13.4
9/25/2012	0.0	0.03	0.02	0.00	0.03	0.22	0.24	2.04	0.30	0.52	0.54	3.04	13.4
AVERAGE	**0.002**	**0.029**	**0.050**	**0.005**	**0.055**	**0.663**	**0.718**	**1.274**	**0.201**	**0.865**	**0.919**	**2.332**	**11.729**

Table 3. Summary of nutrient concentrations for samples collected in Cockeast Pond.

TSI	Secchi Depth (m)	Epilimnion Total P (ug/L)	Epilimnion Chlorophyll *a* (ug/L)	Trophic State
0	63.98	0.75	0.04	Oligotrophic
10	32.00	1.5	0.12	Oligotrophic
20	16.00	3	0.34	Oligotrophic
30	7.99	6	0.94	Oligotrophic
40	3.99	12	2.6	Mesotrophic
50	2.01	24	6.4	Eutrophic
60	1.01	48	20	Eutrophic
70	0.49	96	56	Eutrophic
80	0.24	192	154	Eutrophic
90	0.12	384	427	Eutrophic
100	0.06	768	1183	Eutrophic

Table 4. The Carlson Trophic Status Index (TSI) scores for Secchi Depth, Total Phosphorus and Chlorophyll a.

Pond	Secchi (m)	Secchi TSI	Chl a (ug/L)	Chl a TSI	TP (ug/L)	TP TSI	2012 Trophic State	2011 Trophic State	2010 Trophic State	2009 Trophic State
Forge	0.98	60	10.89	55	33	55	**Eutrophic**	**N/A**	**Eutrophic**	**Meso/Eutrophic**
Cockeast	1.28	60	2.3	40	29	55	**Meso/Eutrophic**	**Eutrophic**	**Eutrophic**	**Meso/Eutrophic**
Adamsville	0.73	65	17.54	60	84	65	**Eutrophic**	**N/A**	**Eutrophic**	**Eutrophic**

Table 5. Assessment of Trophic State of Forge Pond, Cockeast Pond and Adamsville Pond within the Town of Westport, based upon average values of summer 2012 surveys.