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GREEN INFRASTRUCTURE

2012 Phyto-Technology Demonstration Project

July 2013

Test Cells newly planted in June 2012

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Test Cells and drain tubes, July 2012

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Abstract

Cape Cod is a Massachusetts coastal community facing significant impacts to its sole source aquifer and impaired coastal water quality as a result of overabundant nutrients from wastewater, fertilizers, and stormwater. This phyto-technology demonstration project was a component in the ongoing evaluation of green infrastructure to treat wastewater for nitrogen-sensitive coastal waters and phosphorus-sensitive fresh surface waters. The project evaluated phyto-technology's ability to remediate nitrogen and phosphorus by dosing approximately 45 tree cuttings with secondarily treated effluent and monitoring the results over a six month period. **An average of 82% nitrogen removal and 65% total phosphorus removal were reported.** Extrapolating from the data collected, the study found that at the rate of dosing and planting scheme dictated, **approximately 631 tree cuttings of this type could treat one pound of Nitrogen annually.**

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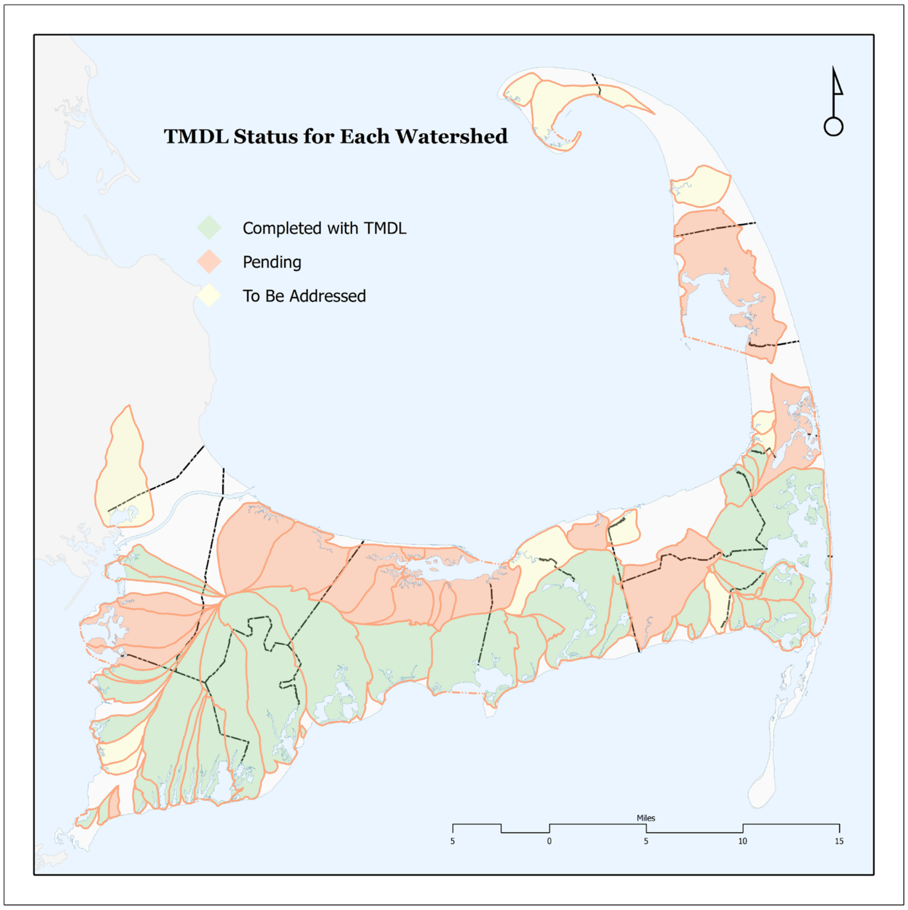

Figure 1: TMDL Status by Watershed (CCC, 2012)

ABOUT THE REGION

Cape Cod, a.k.a. Barnstable County, is a peninsula covering approximately 412 square miles located at the easternmost point of Massachusetts. It consists of 15 incorporated towns and 560 miles of coastline. The majority of the coastline is developed, except for the Cape Cod National Seashore, designated as a national park by President John F. Kennedy in 1961, which covers over 43,000 acres of ponds, woods, and beachfront and nearly 40 miles of seashore in the towns of Provincetown, Truro, Wellfleet, Eastham, Orleans, and Chatham. The entire region is considered by the US census to be the "Barnstable Town Metropolitan Statistical Area." The Cape Cod Commission (CCC) is the Regional Planning Agency (RPA).

Introduction

THE WATER QUALITY PROBLEM ON CAPE COD

The geology of Cape Cod consists primarily of sandy well-drained soils deposited by glaciers during the last deglaciation. The groundwater stored within these deposits is the source of drinking water for Cape Cod,which was designated by the EPA in 1982 as a Sole Source Aquifer. The aquifer has of six separate lenses, feeds water to numerous fresh water ponds, and ultimately discharges to the surrounding marine waters. Approximately 85% of the more than 156,000 homes on Cape Cod presently use individual septic systems, which are regulated under Title 5 of the State Environmental Code. **Nitrogen** from the wastewater in the septic systems has traveled through the soils and severely impaired coastal water quality, resulting in excess algae production, the formation of algal mats, the formation of anoxic areas, and the loss of eel grass and shellfish, often resulting in noxious conditions. The federal Clean Water Act requires, through State-mandated Total Maximum Daily Loads (TMDL's, or prescribed nutrient limits), that Cape Cod communities reduce the nitrogen load through the provision of wastewater treatment and sewers. Based on the studies to date, approximately 40% of the existing housing must be sewered (CCC, 2010).

Just as nitrogen is the contaminant of concern in Cape Cod's coastal waters, **phosphorus** is impacting Cape Cod's freshwater systems. Cape Cod has nearly 994 ponds covering nearly 11,000 acres. These ponds range in size from less than an acre to 735 acres; with the 21 biggest ponds having nearly half of the total Cape-wide pond acreage. Typically, the ponds lack a surface water inlet or outlet. Instead, the sandy sides of these ponds allow a steady inflow and outflow of water to and from the adjacent aquifer. The pond surfaces generally fluctuate up and down in response to the seasonal rise and fall of the water table, giving us a window into the aquifer. As part of the regional aquifer system, the ponds are linked to drinking water and coastal estuaries, as well as any pollutants added to the aquifer (CCC, 2012).

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The estimated regional cost for the necessary infrastructure is approximately $3-$6 billion dollars that would be implemented over the next 20-30 years (CCC, 2013). This cost will create an unsustainable financial burden for many individuals and families and overwhelming fiscal impacts for the towns to construct, operate, and maintain this infrastructure. Cape Cod Commission (CCC) staff and consultants have collected information, or are in the process of generating reports, on alternative and conventional treatment approaches, technologies, and costs. The region needs to identify a mosaic of solutions that are effective and affordable. Different technologies will be appropriate depending on specific circumstances such as the amount of nitrogen to be removed, the density of existing or expected development, the location of existing infrastructure and the approach desired.

Ongoing work includes identifying case studies, nitrogen removal capacity, and total capital and operation and maintenance costs, where available, as well as siting and land use criteria for implementation of each approach. Where case studies are not available, the Commission will provide siting criteria for selecting pilot project sites for new technologies and approaches (CCC, 2012).

As of the writing of this paper, the Cape Cod Commission is leading the effort to update the 1978 Section 208 Area-wide Water Quality Management Plan for Cape Cod. More information on the plan may be found at: http://www.capecodcommission.org.

PHYTO-TECHNOLOGY FOR WASTEWATER TREATMENT

As a component of this Section 208 update, Cape Cod Commission staff have investigated a number of green infrastructure technologies that could be utilized with other, more conventional wastewater treatment systems to capture and treat wastewater at sites throughout the Cape. Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier built environments. This work includes the development of a green infrastructure siting tool, which utilizes a matrix of siting criteria to determine sites that are eligible for green technology. The screening tool is currently in development. Table 4 of the Appendix lists some of the prominent technologies that CCC is researching.

In a traditional phytoremediation approach, plants have been used to uptake hydrofluorocarbons and heavy metals at brownfield sites through

phytoextraction [1] and **rhizodegredation**[2] (Figure 2). In this way, plants have also been used in Low Impact Development (LID) best management practices such as rain gardens. These accepted practices have led to the concept of expanding the use of phyto-technologies to treat groundwater and wastewater. The use of phyto-technology for wastewater treatment is in an early stage, and there is little North American research about its use in coastal communities such as Cape Cod. Because of this, regulators have yet to permit the practice as an acceptable form of wastewater treatment to meet established TMDLs.

The benefits of phyto-technologies expand beyond water quality improvements. In a triple bottom-line evaluation (an evaluation of the cultural, environmental, and economic impacts), it is apparent that phyto technology could benefit the Cape by contributing to its open space and recreational opportunities, serve as an alternative fuel source, and work with other technologies to enhance their effectiveness at a low cost. This demonstration project was implemented to test the hypothesis that the processes of phytoextraction and rhizodegredation can treat nitrogen and phosphorus from effluent in Cape Cod's native soil.

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1 The use of plants to remove dangerous elements or compounds from soil or water

2 Degradation of contaminants in the area of soil surrounding the roots

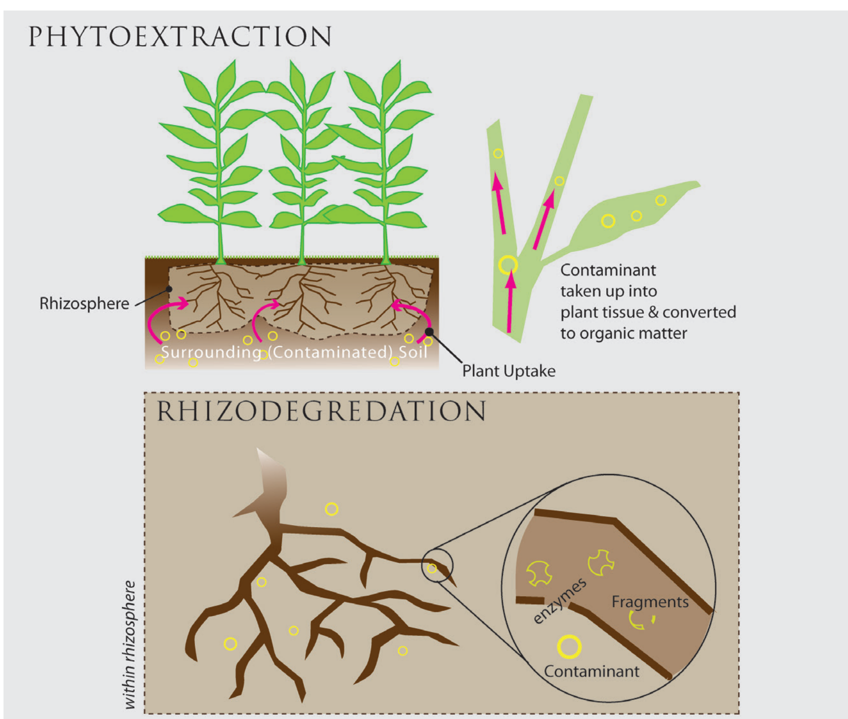

Figure 2: Phytoextraction & Rhizodegredation, CCC 2013

PLANT TYPES USED IN PHYTO-TECHNOLOGY

Many species of plants have been used in phyto-technology projects including "*Salix* species (hybrid poplars, cottonwoods, and willow), grasses (rye, Bermuda grass, sorghum, fescue, bullrush), legumes (clover, alfalfa, and cowpeas), aquatic plants (parrot feather, duckweed, arrow-root, cattail, pondweed), and hyperaccumulators for metals (sunflowers, Indian mustard, and *Thlaspi spp.*)" (Shnoor, 1997). Poplars and willows are by far the most popular plants used for phyto-technology because of their deep and prolific roots, ability to process large amounts of water, and fast growth. "Poplars and willows have been used extensively in Europe as a vegetative filter for cleaning polluted drainage water from agricultural land and for wastewater treatment and soil remediation combined with biomass production for energy use" (Westphal and Isebrands 2001). This study utilized a mixture of hybrid poplar (*Populus*) and Black Willow (*Salix nigra*) cuttings, which were deeply planted (each cell was 3.5 feet deep) and closely spaced (five to a 2.25-square-foot area).

Figure 3: Populus deltoides hybrid (top), Salix nigra (bottom)

Poplar (*Populus spp.*) is a deciduous, dioecious plant in the Willow (Salix) family. It is known to adapt to difficult conditions including both arid conditions and floods, stemming from its origin as a riparian plant accustomed to ephemeral stream conditions. Hybrid poplars, such as those used in this study (*Populus deltoids* x *nigra*) are considered to be ideal for phyto technology as they "grow very quickly, becoming 40-50 feet within a few years; take up large quantities of water, exerting hydraulic control at the site; are hardy and survive limited periods of soil anoxia; can be grown from a small cutting of another tree" (Flokstra, 2010). Because of the plants aggressive growth habit, researchers for this study chose to utilize male specimens only.

Black willow (*Salix nigra*) is prolific throughout the United States and has a shaggy, shrub-like growth habit. It is accustomed to riparian soils and inundated environments and is fast growing with a short life span. "As a phytoremediation plant since 1992, black willow has been documented as having been used in remediation projects within the United States at contaminated locations" (USEPA, 2000).

Project Background

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This pilot phyto-technology demonstration project was carried out by the Cape Cod Commission in Summer-Fall 2012 to assess the viability of utilizing a phyto-technology approach to wastewater treatment on Cape Cod. The project, consisting of nine test cells filled with indigenous substrate and planted with poplars and willow cuttings, was constructed on a low budget in partnership with the Town of Barnstable and the University of Massachusetts Dartmouth School for Marine Sciences and Technology (SMAST) laboratory (http://www.umassd.edu/smast/).

The project was sited at the Hyannis Water Pollution Control Facility (WPCF), provided as an in-kind service by the Town of Barnstable Department of Public Works. The facility houses primary and secondary wastewater treatment tanks, laboratory facilities, and disposal beds. The project cells were situated on the grated decking suspended above the secondary effluent tanks (Figure 5) where a feeder hose was connected to the irrigation system dosing the tree plantings with nitrogen rich effluent at an average of 5-7 mg/L. This setup also allowed for excess effluent from the cell's drain tubes to flow directly back into the tanks below.

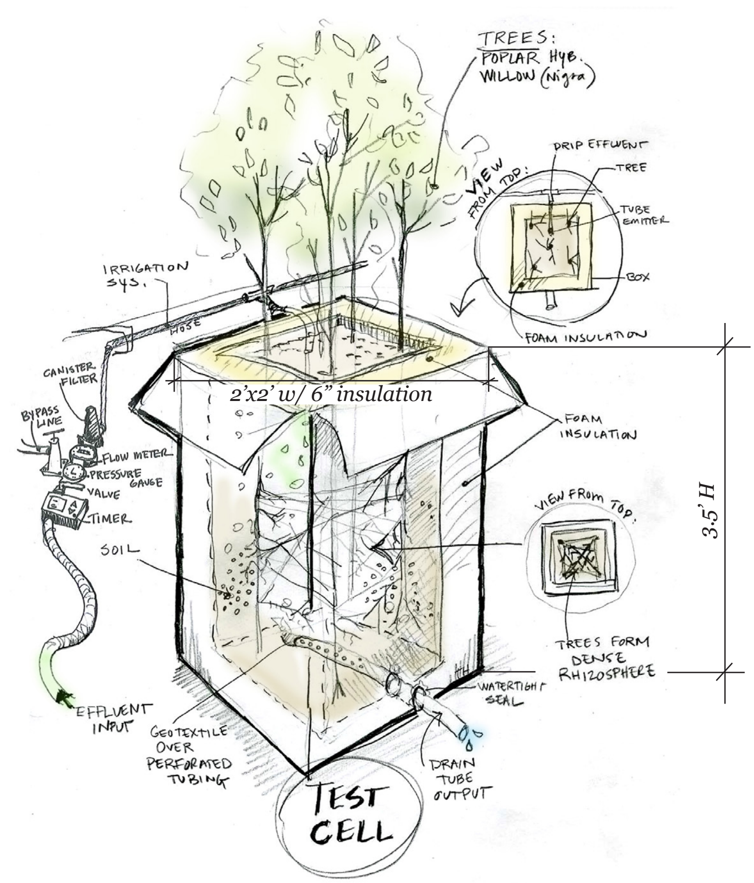

Figure 4: Schematic of test cell, (CCC 2012 adapted from Ecolotree)

Following initial installation and plant establishment in June 2012, the project began sampling via collection canisters in August 2012, and completed in December 2012. Phyto technology of this kind has been implemented on varying scales by bioengineering firms throughout the globe for *in situ* treatment of contaminated soil. In this study, the system worked to facilitate the uptake of nutrients from effluent distributed via drip irrigation.

Materials and Methods

The project setup consisted of nine “test cells,” following experimental models established by a leading phyto technology bioengineering group, Ecolotree (based out of Iowa), in other demonstration project locations. The cells consisted of re-purposed insulated corrugated cardboard boxes, outfitted with a perforated PVC drain tube wrapped in geotextile and caulked into place at the invert of each cell (Figure 4). Upon the recommendation from Cape Cod Commission staff hydrologists, the nine cells were then filled with substrate meant to mimic the soil conditions of Cape Cod where this technology might eventually be used. Two cells, each with varying soil types were filled as followed: unwashed native sand mixed with clay and minerals; Cape Cod “bankfill”—a mixture of sand, clay, and aggregate found deep below the surface; cleaned play sand like that found in wastewater effluent disposal beds; and the final three were filled with Perlite (an ultralight lava rock) meant to represent a control condition of ideal rooting substrate. The soil chemistry of each of these substrates is found in Table 2 of the Appendix.

Figure 5: Test Cell location on decking over treatment tank (top); Plant cuttings and materials ready to install (bottom)

Once the cells were filled with substrate, cuttings were planted five to a cell in order to create a dense rhizosphere. Once planted, the trees were watered twice a day with a small dose of effluent distributed via a simple drip irrigation system on a timer. This effluent water then cycled through the test cell container, eventually reaching the drainage point, where it was sampled.

INSTALLATION AND MONITORING

An Ecolotree staff assistant worked with the Cape Cod Commission to implement installation in June 2012. Installation consisted of test cell preparation, setup of irrigation components and drain tubes, the filling of each cell with substrate mix, and planting refrigerated willow and poplar cuttings provided by the vendor. After this initial setup, CCC staff

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oversaw the ongoing maintenance of the irrigation system and monitored tree growth until the optimal root growth was achieved prior to water sampling, in August 2012. Water quality samples were then obtained via catchment basins attached to the cell drain tubes on a twice-monthly basis from late August 2012 to December 2012.

A monitoring and maintenance program was established to ensure that the system operated properly. Visits to the site to check tree growth and health were done at twice-weekly intervals from June to September and at each sampling event from September to December. A monitoring log is included in the Appendix. Effluent dosages to the cells were measured periodically and the system adjusted as needed. As the weather grew colder, the trees lost their leaves, and leaves were removed from the cells to avoid a buildup of leaf matter. Additionally, a layer of organic native hardwood mulch was applied and the irrigation controllers, hoses and emitters were wrapped in insulating material in mid-November to assist in maintaining optimal soil temperature.

NUTRIENT SAMPLING PROCEDURE

The test cells were dosed with effluent treated to secondary treatment[3] levels for which data was readily available. From the drain tubes of the test cells, water samples were collected by placing plastic containers under the each tube. The containers were placed on Tuesday mornings and samples were collected on Thursdays to allow for residence time[4]. Samples were then transferred into sterilized plastic containers provided by the analysis lab (UMASS Dartmouth SMAST). A duplicate sample was collected from one cell each time to ensure that the analysis process was being done correctly. These samples were eventually analyzed against data obtained from the Water Pollution Control Facility to determine nutrient removal rates.

Nutrients analyzed included: nitrite, total kjeldahl nitrogen (TKN), total nitrogen, phosphorus, particulate N, dissolved organic nitrogen and

3 Secondary wastewater treatment follows the primary treatment process. Secondary treatment removes or reduces contaminants or growths that are left in the wastewater from the primary treatment process. Usually biological treatment is the most effective type of treatment on bacteria, or contaminant, growth at this stage.

4 The average amount of time that a particle spends in a particular system. This measurement varies directly with the amount of substance that is present in the system. A universal equation is used to calculate residence time.

specific conductivity[5]. The first samples were taken on August 30,2012 and the last were collected December 20th, 2013.

Results

The majority of the trees took root well but a total of nine poplar cuttings and three willows never rooted. Through the monitoring period tree growth progressed normally. In mid-August most of the Poplar trees showed signs of *Marssonia* leaf spot[6]; it was decided that no treatment was necessary for this project, as the leaves would soon drop off due to natural seasonal change (Figure 6).

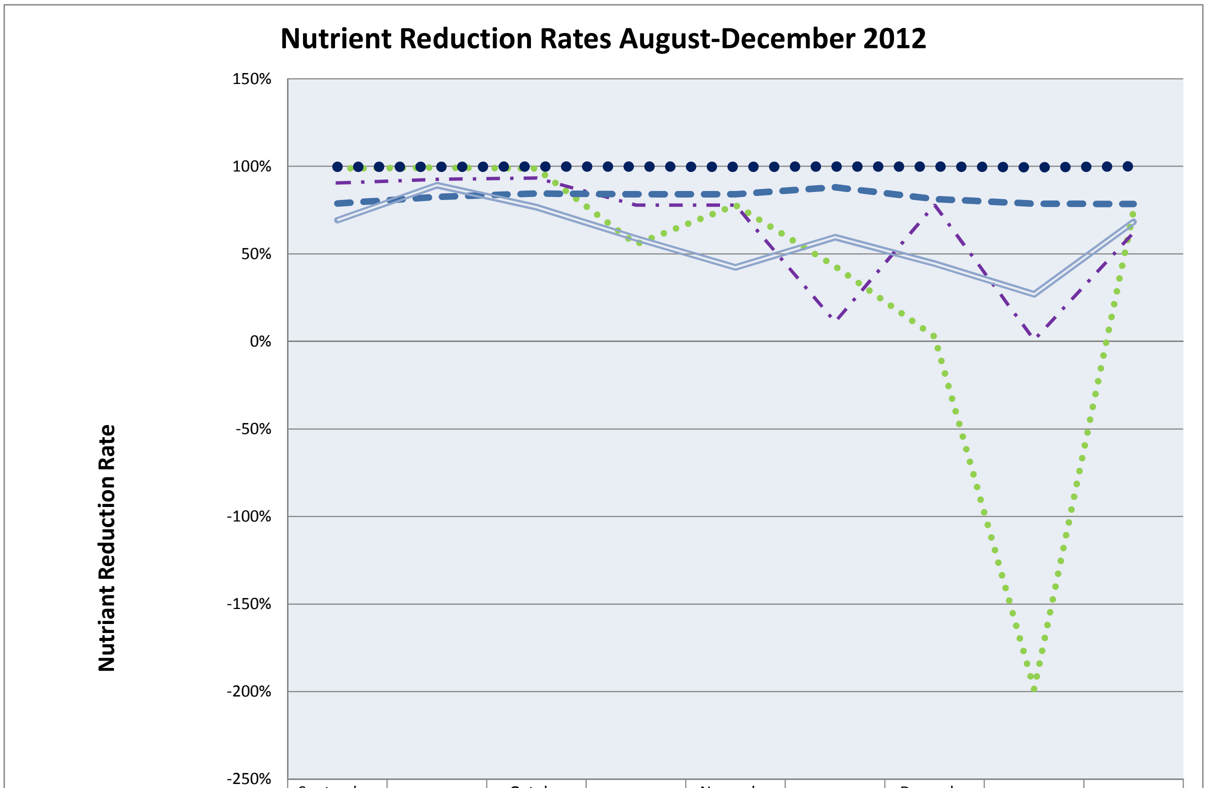
Figure 6: Poplar leaves

The experimental design was not without complications. Unexplained variations in dosage amounts to some cells occurred several times. The system was inspected, with no signs of what could cause this problem, although it appeared to be an anomaly with the timer/flow meter setup. The treatment plant switched aeration tanks towards the end of October, changing the pressure within the system, which had a short-term effect on dosage amounts. This did not end up affecting sampling. A set dose of one liter to each cell three times a day was established and remained for the rest of the project. All filters and tubes were checked weekly and cleaned as needed. Algae buildup in some of the feed tubes was cleaned regularly with pipe cleaners and distilled water. Some of the drain tubes required re-caulking to avoid leakages once sampling began. Issues with the timer led to replacing it with a new one as well as relocating the large canister filter to the beginning of the delivery system. This lessened the chance for debris to clog any portions of the line that were previously in front of it, which is a possible reason for the problems experienced with the first timer. As the trees became established in the cells, the dosage amounts and frequency were adjusted according to instructions from the vendor.

Influent data from the Barnstable Water Pollution Control Facility (WPCF) lab (Table 6, Appendix) was collected and compiled with effluent data from UMASS SMAST, as seen in Table 4 (Appendix). Across the

5 The sampling table (Appendix, Table 4) lists NH3 in the influent from the wastewater facility and NH4 from the effluent from SMAST. This could be due to different pH levels, as ammonia/ammonium are both present at relative percentages based on pH.

6 Marsonnia leaf spot is a common fungal disorder that occurs in Poplar trees , often following periods of intense rain. In intense cases, trees may lose their leaves altogether, which did not occur.



	September		October		November		December		
Po4 Reduction Rates	99%	99%	99%	56%	78%	43%	3%	-199%	75%
TP Reduction Rates	90%	93%	93%	78%	78%	11%	78%	1%	62%
TN Reduction Rates	79%	82%	84%	84%	84%	88%	81%	79%	78%
NH3/NH4 Reduction Rates	69%	89%	77%	59%	42%	59%	44%	27%	68%
NO2+NO3 Reduction Rates	100%	100%	100%	100%	100%	100%	100%	99%	100%

Figure 7: Nutrient Reduction Rates for PO4, TP,TN,NH3, NO2, NO3 for Project Period

board, the project resulted in reductions of all nutrients, including an average total nitrogen reduction of 82%.

TOTAL NITROGEN REMOVAL

Nitrogen removal rates were fairly consistent throughout the project, as reflected in Figure 8. The average of 82% removal for all test cells reflects a fluctuation from 78% to 88%. The highest removal efficiency of 88% was observed in late October, when trees had lost their leaves and the average high/low temperatures were 64° and 49° respectively, with about three inches of precipitation during the 30-day period. The lowest nitrogen removal efficiency was 78%, at the outset of the project when plants were getting established and the completion, when temperatures lowered to an average low of 49 degrees Fahrenheit.

NITROGEN REMOVAL BY SUBSTRATE

There was little difference in the nitrogen removal efficiency based on substrate, which fell in the range of 75-90% as shown in Figure 9. A significant dip noted in the removal rate for the washed sand cells on September 27 was due to a faulty sample.

TOTAL PHOSPHORUS REMOVAL

Total phosphorus removal reflected more fluctuation, particularly on the 11/8/12 sampling event and 12/6/12 sampling event. These outliers were examined in relation to weather data and monitoring logs. Several factors may have influenced the fluctuation, including the loss of leaves (leaves were removed from boxes rather than allowed to decompose), the application of native hardwood (pine-oak) mulch, a change in air temperature, and “Super storm” Sandy. The mulch had the greatest ability to increase phosphorus levels by way of the introduction of organic material, and thus may have polluted the sample. It may also be considered that these influences reflect conditions in the native ecology of Cape Cod that would be present if the project were to be implemented in the field.

PHOSPHORUS REMOVAL BY SUBSTRATE

The results for phosphorus removal by substrate also varied much more than that of nitrogen removal, reflecting significant differences between substrates in processing phosphorus. Native sand appeared to have the greatest phosphorus-removal efficiencies, with an average over the nine

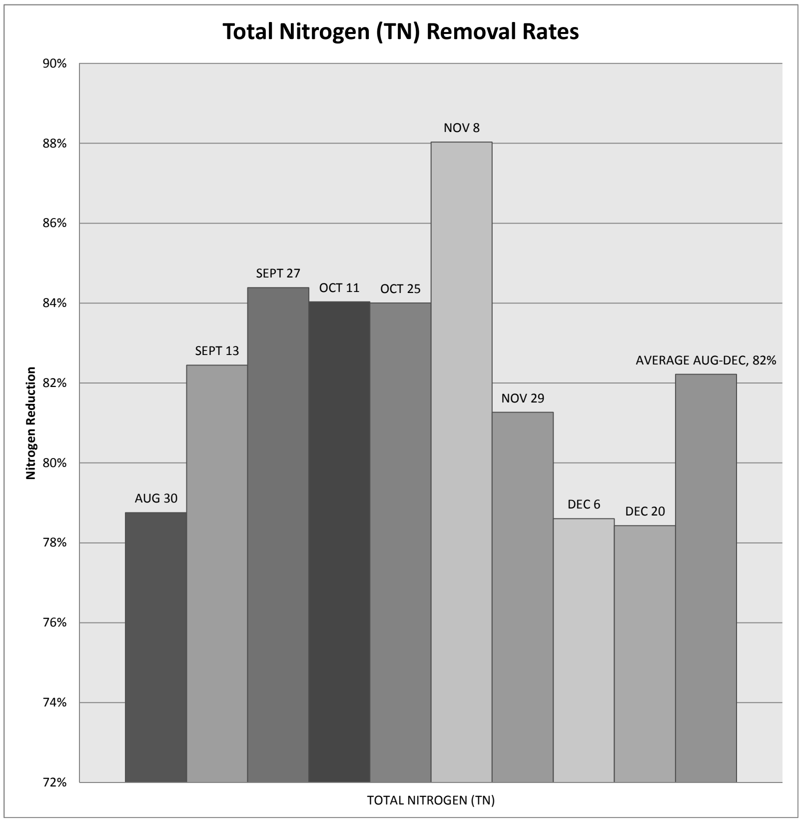


Figure 8: Nitrogen Reduction Rates for Project Period

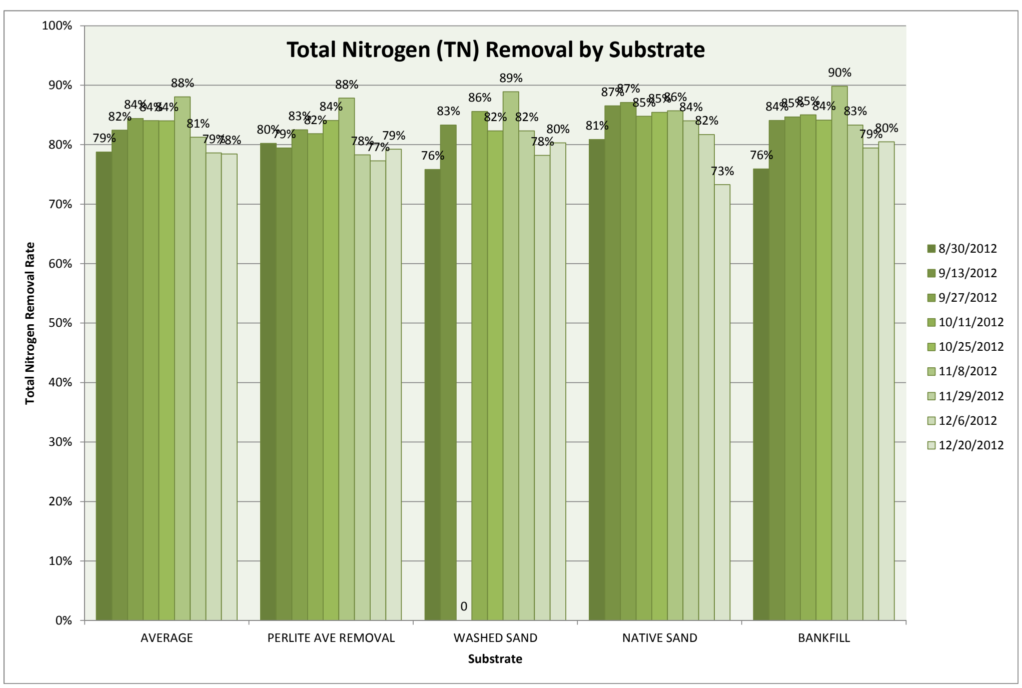


Figure 9: Nitrogen Removal by Substrate

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sampling events of 95% removal. This may be partially due to the fact that native sand had the lowest presence of phosphorus at the outset, reflected in the soil sample table in the Appendix. This also reflects the research on sand-filtration methods for phosphorus removal, where sand acts to “physically siev(e) suspended particulates and the associated pollutants from the water” (Erickson, 2005). The native sand appeared to fare better at this than the washed sand, which had an average removal rate of 56%. However, this number reflects several anomalies, including a period when no sample was collected, as well as a very low rate on 11/29/12, perhaps due to the addition of organic mulch, mentioned earlier.

Perlite had the lowest overall average phosphorus removal (35%), which reflects a fluctuation between very high removal rates at the outset and very low rates in November and December. This could be the result of a P-sorption[7] increase at the outset, and decrease after the application of organic matter. Perlite is a form of volcanic rock, which is documented to have the “greatest P-sorption of all soil types due to the presence of large amounts of aluminum and iron dioxide in kaolin clays” (University of Hawaii, 2013).

Conclusions

For a short-term demonstration project, this experiment captured some valuable data that may be utilized in future planning, as well as increased the visibility of green infrastructure on Cape Cod. Most notably, the project’s average **nitrogen removal rate of 82%** indicates the potential applicability of phyto-technology for *in situ* wastewater treatment.

This data indicates that the processes of phytoextraction and rhizodegredation worked to remove Nitrogen as hoped. The series of equations in Figure 12 extrapolated this data to deduce that at the dosing rate and planting configuration used in this study, **approximately 631 trees could treat one pound of Nitrogen annually.** Planning studies indicate that the average household utilizing Title 5 regulated septic on Cape Cod produces over **10 lbs** of nitrogen annually (CCC, 2013); in order to treat this volume of nitrogen in household effluent at the dosing levels of this study[8] approximately 6,300 cuttings /one eighth of an acre would need to be planted, at a dense spacing of one cutting every foot. At a

7 P-sorption occurs when the orthophosphates, H2PO4- and HPO42- bind tightly to soil particles.

8 There was a fluctuation between 15 and 20 Liters per day, so for the purposes of the equation an average of 18 Liters per day was used.

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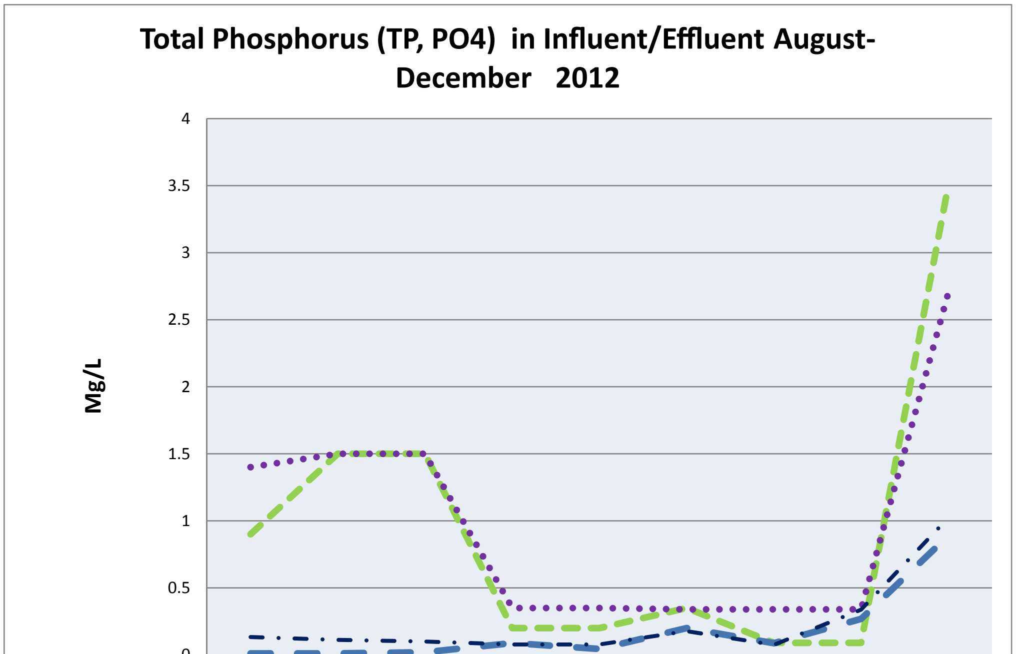

	September		October		November		December		
Po4 Influent	0.9	1.5	1.5	0.2	0.2	0.35	0.09	0.09	3.5
Po4 Effluent	0.01	0.011	0.020	0.09	0.04	0.20	0.09	0.27	0.89
Total P Influent	1.4	1.5	1.5	0.35	0.35	0.34	0.34	0.34	2.7
Total P Effluent	0.13	0.113	0.100	0.08	0.08	0.18	0.08	0.34	1.02

Figure 11: Total Phosphorus in Mg/L for Project Period

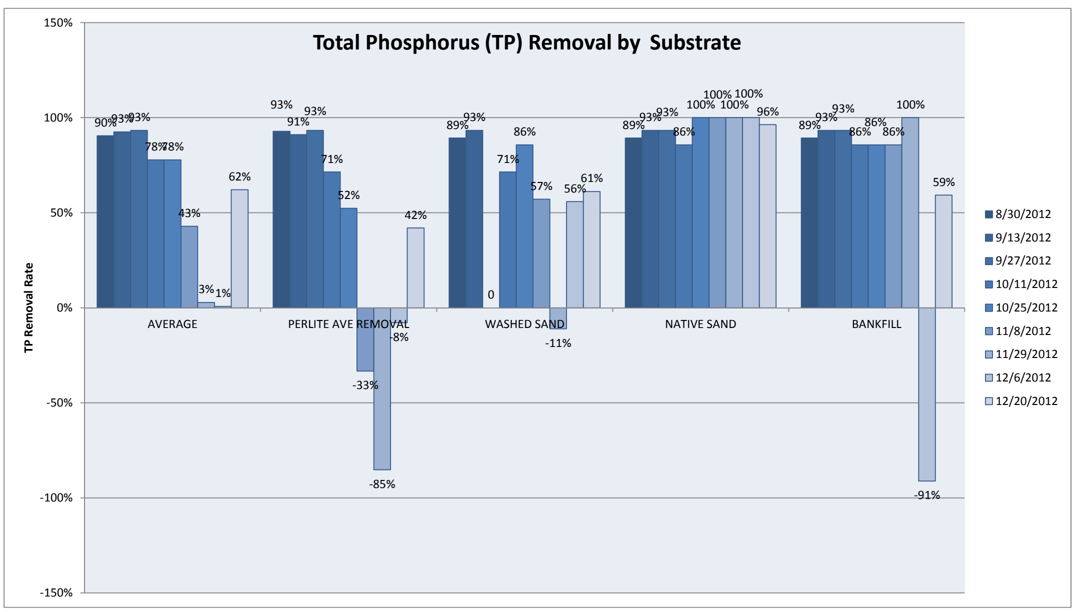

Figure 12: Total Phosphorus Reduction Rates by Substrate

higher dosing rate or alternative planting design, nitrogen removal efficiencies may be inversely impacted.

If phyto-technology of this type was utilized regionally to treat wastewater, plantings of poplar and willow on this scale could equate to creating an agricultural monoculture[9]. It would be important to consider these tree species are not native to Cape Cod, and their introduction could have a significant impact on the Cape Cod ecosystem. A native species with the same characteristics – deep and prolific roots, little space needed, a quick growth rate, and the ability to process a large amount of water daily – could be substituted. Native pussy willow (*Salix discolor*) or Black gum (*Nyssa sp.*) may be good candidates; additional research and experimentation would need to be done to determine appropriate plant species with similar characteristics.

Constants
a = 18 L (average daily dose of L/cell/day for 9 cells)
*b = 45 Trees (5 trees/cell * 9 cells)*
c = 2.25 SF (Square footprint of each cell)
d = 6 mg/L (average dose of TN influent)
e = 82% (Average TN reduction rate)
f = 453592 (conversion factor of mg to lbs)
g = Annual TN removed (see below)
h = annual TN/year/tree (see below)
i= # of trees to treat 1lb N annually

Solve for "g"	Annual TN removed for entire project?		
	g = (a*d)*e	88.56	mg/day
	g=	32324.4	mg/year

Solve for "h"	Annual TN removed per tree, in lbs?		
	h= g/b	718.32	mg/year/tree
	h =	0.0015836	lb/year/tree

Solve for "i"	To treat 1 lb of TN per year, how many trees?		
	1(lb N)=i(h)	631	trees

Solve for "j"	Spatial recommendation for this many trees?		
	j=(c/5)*i	284.16	SF

Figure 12: Equations utilized to extrapolate data

Also of note is the demonstrated ability of native sand to assist in the remediation of phosphorus. However, fluctuations in phosphorus removal efficiencies are inexplicable at this scale, and it is recommended that additional care be taken in any future study to collect more frequent and numerous samples, as well as to protect the surface area to disallow for any pollution of the experiment.

In order to overcome regulatory barriers to utilizing phyto-technology of this kind on a larger scale, it is recommended that additional, larger-scale pilot projects be implemented at a certified test center, such as the Massachusetts Alternative Septic Systems Test Center. For this project, it is recommended to utilize a control planting group with plantings or varying type dosed with effluent, all in native sand.

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9 The cultivation or growth of a single crop or organism.

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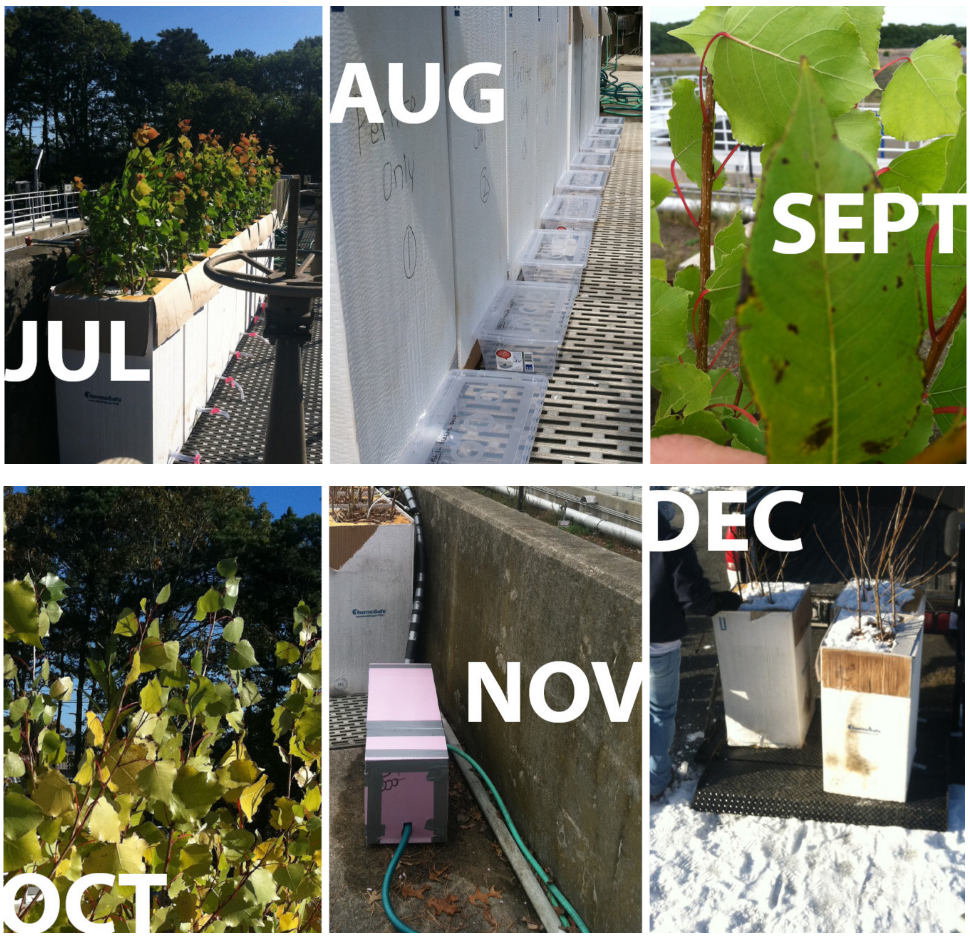

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TABLE 1: GREEN INFRASTRUCTURE SITING MATRIX

	GI – Wastewater									BMPs – Stormwater					
	Constructed Wetlands (end-of-pipe for disposal)	Permeable Reactive Barriers	Phytoremediation		Stormwater Treatment Wetlands	Regenerative Stormwater Conveyance	Biofiltration Strips	Bioretention	Advanced Biofiltration	Infiltration	Green roof[1]	Permeable Pavement	Bioswales	Stormwater Disconnection	Gravel Wetland
Impaired watershed															
Floodplain: V zone															
Floodplain: A zone															
SLOSH															
350 ft buffer to vernal pool															
100 ft buffer to wetland															
USGS zone of contribution															
Zone II's															
Direct discharge potential															
Soils: disturbed															
Soils: well drained															
Soils: poorly drained													x[2]		
Cranberry bog															
Within open space: agricultural															
Within open space: protected															
Within open space: recreation															
Within open space: government															
Tidal restriction															
Density: wastewater flow/grid cell?															
Intertidal area															
Adjacent to open space: agricultural															
Adjacent to open space: protected															
Adjacent to open space: recreation															
Adjacent to open space: government															
Underground utilities															
Wellhead protection areas															
DEP wetlands															
Forest protection areas															
Endangered species habitat															
Depth to groundwater > 4'															
Depth to groundwater < 4'															
Proximity to golf courses, athletic fields															
Proximity to roads															
Impervious areas															
Proximity to schools, community centers, churches															

Notes

Land ownership and depth to groundwater will be applied after the screening analysis has been completed.

positive siting criteria (desirable for project siting)

characteristic which may be a constraint for siting (to be applied later)

[1] Green roofs have a significantly different set of siting criteria from other stormwater LID techniques

[2] Although bioswales can be designed to function as infiltration BMPs, those mentioned here are designed as water quality BMPs

The siting criteria matrix consists of multiple GIS-based data layers (termed "siting criteria") along the vertical axis and a collection of potential GI and LID practices on the horizontal axis. The practices identified have been selected based on their high nitrogen removal efficiencies and represent a range of practices that are applicable in a wide variety of conditions.

TABLE 2: SOIL SAMPLING DATA

Site: **Cape Cod Commission**
Location: **Cape Cod, MA**
Project #: **2012.07**
Sampling date: **6/21/2012**
Sampled by: **Cape Cod Commission**

Legend:
Bold = very low/low
Italic = very high
Normal = sufficient

Sample ID		BFILL	NSND	SAND
Lab		22093	22094	22095
Agronomic Properties:				
Texture	N/A			
	% Sand Silt Clay			
Soil pH	N/A	7.4	7.5	*8.9*
Organic matter	%	**1.4**	**0.4**	**0.4**
Cation exchange capacity	meq/100 g	**4.4**	**0.7**	**2.3**
Essential Macronutrients:				
Phosphorus	mg/kg	15	**2**	**3**
Potassium	mg/kg	**59**	**14**	**17**
Magnesium	mg/kg	84	**30**	**45**
Sulfur	mg/kg	5	**3**	5
Calcium	mg/kg	**695**	**70**	**329**
Essential Micronutrients:				
Iron	mg/kg	*33*	12	18
Manganese	mg/kg	13	10	10
Boron	mg/kg	**0.1**	**0.1**	**0.1**
Copper	mg/kg	0.7	**0.5**	0.6
Zinc	mg/kg	**0.6**	**0.2**	**0.3**
Non-essential Elements:				
Sodium	mg/kg	**17**	**10**	**43**

TABLE 3: PROJECT LOGBOOK

Month	Date	Perlite Cell 1	Perlite Cell 2	Perlite Cell 3	Washed sand Cell 4	Washed sand Cell 5	Native Sand Cell 6	Native Sand Cell 7	Bank Fill Cell 8	Bank Fill Cell 9	Notes/Maintenance
JUNE	6/14/2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Installed cells, planted trees, set up irrigation system to dose at 3L per cell per day to establish (irrigating at 2xday)
	6/15/2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Checked drain tubes and noted leakage.
	6/18/2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dry drain tubes: 1, 7, 9; Leaking drain tubes 2-8; Turned off water in prep for recaulking of drain tubes on 6/19/12
	6/19/2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Recaulked drain tubes
	6/20/2012	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Minor leaking on irrigation tubes 3 and 8. Reprogrammed irrigation timer for 2x day: 9am-9pm
	6/21/2012	Leaves present on poplars; drain leakage, drain OK; New emitter tube	drain leakage, drain OK;	Leaves present on poplars; New emitter tube	drain OK	drain leakage, drain OK;	Leaves present on poplars; New emitter tube	drain leakage, drain OK; New emitter tube	Leaves present on poplars	Leaves present on poplars	Unseasonably hot temperatures (upper 90's). Drainage leaking on cells 1,2,5,7; all drainage tubes working (water present).Checked Water timer (dosing too long) and reset; cleaned filters, installed new emitter tubes
	6/28/2012	Leaves present on 2 poplar, 1 willow.some leakage on drain, drain OK	Leaves present on 3 poplar, Willow dead. Some leakage on drain, drain OK	Leaves present on 3 poplar, some leakage on drain, drain OK	Leaves present on 3 poplar, drain OK	Leaves present on 1 poplar, 1 Willow, drain OK	Leaves present on 3 poplars; no leaks; drain ok	Minor bud on polar, willow leaf; no leaks, drain OK	Leaves present on 2 polar, willow DEAD. No leaks, Drain OK	All 5 trees leafing out!! No leaks, Drain OK	Dosing at average of 0.29 L/dose/cell
JULY	7/3/2012	Leaves present on all trees; Drain tube leakage, drain ok	Leakage on drain tube, drain ok; Leaves on 3 poplars	Leakage on drain tube, drain ok, 3 poplars have leaves	Leakage on drain tube, drain brown, 3 poplars have leaves	Drain tube brown, willow and 3 poplars have leaves	Everything has leaves and no drain leakage	Drain tube leakage, 3 poplars and willow have leaves	Drain tube brown, 2 poplars have leaves	Everything has leaves, drain ok	Tightened all effluent tubes to reduce leaking - no significant leaking after tightening.
	7/10/2012	Drain/feed tubes ok, 2 dead poplars; best of all willows	Feed tube ok, Drain tube leaking heavily; willow and 1 poplar on right dead; others small but ok	Feed/drain tubes ok; poplar rear right dead; willow stareting to leaf out	Feed/drain tubes ok; poplar rear right dead; willow starting to leaf out	Feed/drain tubes ok; poplar rear left dead	Drain tube ok; emitter tube clogged with debris; best all around cell, all alive with leaves	Feed/drain tubes ok; one poplar and willow ok; rest deadish	Drain tube ok; emitter tube needs replacing; willow and 2 poplar on right dead	Feed/drain tube ok; all trees good; poplars on right small but ok	Tested flow rates. Some leakage as noted. All ok.
	7/11/2012		Drain tube leaking				Cleared out feed tube debris		Changed out broked connection for feed tube		Changed out broken fitting for feed tube on cell 8; cleared out feed tube of debris on cell 6; checked all connections and tightened as needed; set new dosing time for 2 minutes
	7/19/2012	Same as 7/10; checked flow=850ml	Drain tube leaking	HEAVY LEAKAGE FROM DRAIN TUBE	Same as 7/10; checked flow=950ml	Same as 7/10	Feed tube clogged again; checked flow=2000ml	Same as 7/10	Tree health same as 7/10; feed tube connection is ok(per fix on 7/11	Same as 7/10; checked flow=1000ml	Cell 6 is getting double the amount of water as the rest; inspected feed tube set-up, found nothing out of the ordinary, Check tree health; measured flow to trees(cell 6=too much)
	7/20/2012		Drain tube leaking	Leakage from drain tube		Leakage from drain tube	HEAVY leakage from drain tube	Moderate leakage from drain tube			Large fluctuation in watering, need to reset timer/flow meter. Changed the orifice plate in cell 6.
	7/23/2012		Leakage from drain tube					Leakage from drain tube			Replaced/reset clock; reconfigured irrigation to place canister filter at the beginning of line; adjusted flow diaphragm to deliver 1000ml/2min; measured flow
	7/25/2012										Checked irrigation timer, ran manually to check flow out of emitters; set timer for afternoon to check.
	7/26/2012	Leakage from drain tube	Moderate leakage from drain tube					Leakage from drain tube			Need to recaulk drain tubes; measured flows in cells.
	7/27/2012										Checked and cleaned all filters
	7/30/2012	Leakage from drain tube	Leakage from drain tube		Leakage from drain tube	Leakage from drain tube		Leakage from drain tube			Turned off system to allow dry time in order to re-caulk around drain tubes for proper collection of samples.
	7/31/2012										Recaulked cells 1,2,4,5,& 7
AUGUST	8/1/2012										Turned system back on
	8/1/2012										Re-caulking seems to have worked; only minor leakage, could be from rain event.Set up collection container for sample collection; set clock to dose at 3L twice a day.
	8/2/2012										Container had about 3L each; this could be due to the recent rain event, recheck on 8/3.
	8/3/2012										Containers again had 3L each
	8/6/2012										Water was turned off through the weekend after checking filters on Friday 8/3; there was still a little more than a liter collected.
	8/7/2012	Just over 1L collected	Just over 1L collected	0L collected?	Just under 1L collected	1L collected	1/2L collected	About 2L collected	Just over 1L collected	0L collected ?	Very inconsistent sample amounts on all cells. When containers where removed to inspect, it appeared that all were providing water from drain tube.
	8/8/2012	Cardboard was soaked 5in up all the way around cell									Checked collection amounts(All had 3L); measured flow.
	8/9/2012	No soakage around bottom									Cell 1 only had 1L; the rest had at least 2L
	8/13/2012										Flow was slow; actually stopped momentarilly then restarted.Checked collection amounts; cleaned/checked all filters
	8/14/2012	Less than 1L	More than 1L	Less than 1L	Less than 1L	Less than 1L	More than 1L	More than 1L	More than 1L	0 liters collected	Reset the system to deliver 1.5L(each cell) twice a day. Cell 1 is receiving exactly this amount while cell 9 get slightly more(200-300mL) due to the set up of system.
	8/15/2012	2L								1L	Cells 2-8 had at least 3L collected each. The flow rate was still a little over(100-300mL) the 1.5L desired, made adjustment to diaphragm/pressure. Leakage all around cell 1, cell 6&7 little leak around drain tube.
	8/16/2012										Flow rate good; collection amounts the same as 8/15
	8/17/2012										Same as 8/15-8/16

TABLE 3: PROJECT LOGBOOK | 2 OF 2

		Perlite	Perlite	Perlite	Washed sand	Washed sand	Native Sand	Native Sand	Bank Fill	Bank Fill	
Month	**Date**	**Cell 1**	**Cell 2**	**Cell 3**	**Cell 4**	**Cell 5**	**Cell 6**	**Cell 7**	**Cell 8**	**Cell 9**	**Notes/Maintenance**
	8/20/2012										*Washed bins out with soap and water, triple rinse with distilled water(per Lab recommendation)*
	8/21/2012									*0 liters collected*	*Clock broke when removing filter; cell 9 had no sample, tried to clean out drain tube gently with coat hanger*
	8/22/2012	*In- 1600ml Out- 1L*	*In- 1550ml Out- +1L*	*In- 1800ml Out- -1L*	*In- 1750ml Out- -1L*	*In- 1850ml Out- 0L*	*In- +3000ml Out- 3L*	*In- 2100ml Out- +1L*	*In- 1800ml Out- +1L*	*In- +3000ml Out- 3L*	*Cell 5 is delivering a lttle more than desired but did not provide a sample; cells 6&9 delivered too much and provided more than necessary for sampling.*
	8/23/2012	*In- 1550ml Out- 1600ml*	*In- 1550ml Out- 750ml*	*In- 1450ml Out- 950ml*	*In- 1300 Out- 0ml*	*In- 1450ml Out- 0ml*	*In- 3250ml Out- 0ml*	*In- 1700 Out- 0ml*	*In- 1750ml Out- 1300ml*	*In- 1700ml Out- 0ml*	*There is much inconcistancy in the amount being delivered; there is inconcistancy in amounts draining, this could be due to residence times of different soil types*
	8/23/2012										*All cells are now dosing at between 950ml and 1100ml; Adjusted flow to deliver approx. 2L twice a day*
	8/24/2012	*In- 1600ml Out- 1700*	*In- 2000ml Out 1400ml*	*In- 1700ml Out- 800ml*	*In- 1800ml Out- 700ml*	*In- 1800ml Out- 500ml*	*In- 4100ml Out- 3100ml*	*In- 2000ml Out- 1750ml*	*In- 1800ml Out- 1550ml*	*In- 2500ml Out- 0ml*	*Still variable amounts delivered and collected.*
	8/27/2012	*In-950ml*	*In-1050ml*	*In-950ml*	*In-1000ml*	*In-950ml Out-650ml*	*In-2200ml*	*In-1000ml*	*In-850ml*	*In-1400ml Out-750ml*	*All cells accept 5 & 9 collected at least 3L. Most cells dosing the correct amount.*
	8/27/2012	*In-1000ml*	*In-1100ml*	*In-1000ml*	*In-1000ml*	*In-1050ml*	*In-2250ml*	*In-1100*	*In-950ml*	*In-1400ml Out-750ml*	*These doses were not introduced to cells; they were collected for measuring purposes only. Per direction from Lab the flow rates were adjusted to dose 1L every 8 hrs, we are dosing at 3xday for 4 minutes, producing the amounts recorded.*
	8/28/2012										*Noticed immediately that dosage was too high. Stopped program and made adjustments.*
	8/28/2012	*In-1000ml*	*In- 1100ml*	*In- 1100ml*	*In- 1100ml*	*In- 1100ml*	*In- 2600ml*	*In-1200ml*	*In- 1100ml*	*In 1650ml*	*Ran program for proper time/flow amounts*
	8/30/2012			*Used for duplicate sample*							*Intitiated water sampling; Collected samples for testing*
SEPTEMBER	*9/11/2012*	*2 poplars rt rear dead*	*1 poplar frt rt, willow dead*	*Rt rear poplar dead*	*Rt rear poplar dead; Biggest specimens*	*Lt rear poplar dead; Biggest specimens*	*All trees alive and well; very full*	*2 rt poplars, willow dead*	*2 rt poplars dead*	*All trees alive and well*	*Canister filter was very dirty, needs to be cleaned every week;*
	9/13/2012				*Little less than 1L collected*			*No sample collected*		*Little less than 1L collected*	*Sampling Event. Cell 7 did not produce any effluent for sampling ; cells 4 and 9 produced a little less than 1L*
	9/18/2012	*In- 1100ml; spots on leaves; poplar leaves slightly lighter than last week; major algae in dosing tube; minor leakage around base pf cell*	*In- 1100ml; spots on leaves; poplar slightly lighter than last week; very little algae in dosing tube*	*In-1100ml; spots on leaves; poplar slightly lighter than last week; very little algae in dosing tube; dosing hose popped out of ground*	*In- 1100ml; spotting on leaves; Poplar leaves slightly lighter than last week; quite a few leaves fallen off into cell; minor leakage around base of cell*	*In- 1300ml; minor spotting on leaves; Poplar leaves slightly lighter than last week; quite a few leaves fallen off into cell; minor leakage around base of cell*	*In- 2800ml; minor spotting on leaves; poplar leaves slightly lighter than last week;*	*In- 1100ml; minor spotting on leaves; poplar leaves; minor leakage around base of cell*	*In- 1200ml; minor spotting on leaves; poplar leaves slightly lighter than last week; very little algea in dosing tube*	*In- 700ml; minor spotting on leaves; poplar leaves slightly lighter than last week*	*Cell 9 not dosing as much as it should; cell6 still dosing too much; cell3 tube released; all willows still dark green but do exibit some spotting(see pics); Set up collection contatiners(to test amounts out for Thursday, not sampling this week); cleaned all filter; cleaned out algae(?) from delivery hose for all cells; tested dosing amounts*
	9/20/2012	*Same leaf spots; no difference in color change; no more apparent leakage*	*Same leaf spots; no difference in color change*	*Same leaf spots; no difference in color change*	*Same leaf spots; no difference in color change; no more apparent leakage*	*Same minor leaf spots; no difference in color change; no more apparent leakage*	*Same minor leaf spots; no difference in color change*	*Same minor leaf spots; no difference in color change*	*Same minor leaf spots; no difference in color change*	*Same minor leaf spots; no difference in color change*	*All cells provided plenty of effluent for testing, rain event (9/18-9/19) ; spots on most likely diagnosis is Marssonina Leaf Spot; no treatment is being recommended for this project*
	9/25/2012				*End of feeding tube clogged with sand, cleaned it out*						*Can see new buds at bases of leaves; leaf spots not any worse than last week; Set out containers for sampling; cleaned all filters*
	9/27/2012	*Used for duplicate sample*			*No sample collected; collection container was moved*	*No sample collected; collection container was moved*	*Feed tube was out of ground*			*No sample collected*	*Some of the feed tubes may need to be shortened, they are too curved and when the water pressure increases they release from the cell; Collected samples; washed all containers and sampling instruments*
OCTOBER	*10/2/2012*										*Poplar leaves are getting lighter; cleaned all filters.*
	10/11/2012		*Used for duplicate sample*								*Trees losing leaves; checked dosing, did not deliver water possibly due to running of hoses at plant. They are going to be running for few days while switching aeration tanks.*
	10/18/2012										*Too much flow into some of the cells; Iadjusted the flow rate diapragm ; need to calibrate the system.Cleaned all filters; checked flow to cells*
	10/23/2012										*Check flow rates, check all filters, emmitters and hoses*
	10/23/2012										*Flow rates reflect pressure changes at the treatment plant due to the aeration tank swich. Trees are all rapidly losing leaves but appear healthy otherwise.*
	10/25/2012				*Used for duplicate sample*						*Collected samples*
	10/30/2012										*Checked trees after* ***Hurricane sandy*** *; not many leaves left but all seem to have made it through storm unharmed*
NOVEMBER	*11/8/2012*					*Used for duplicate sample*					*Trees have very few leave. Collected samples.*
	11/13/2012										*Put organic bark mulch around trees to insullate for the colder months*
	11/15/2012										*Overflow hose had been disconnected, system did not run without it,water to cells questionable. Began to install the housing around irrigation system for insulation.*
	11/20/2012										*Cells 5 and 6 dosing more than desired. No leaves left on trees.Tested dosing; recalibrated system; cleaned all filters*
	11/20/2012										*May need to get a can of foam insulation to plug a few gaps in box. Constructed insulating box around valve portion of system*
	11/29/2012						*Used for duplicate sample*	*No sample collected*			*Collected water samples. Cell 1 had just under desired amount, took 600cc sample and got most of the liter sample; Cell 7 did not have anything for a sample.*
DEC	*12/4/2012*										*Cleaned collection containers, placed them out for sampling on Thursday, Dec. 6*
	12/20/2013										*No data collected. Last sampling event.*

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TABLE 4: NUTRIENT ANALYSIS | 1 OF 3

					TEST CELLS (9 in total, 5 plants per Cell: 1 Black Willow, 4 Hyb.Poplar)																	
		SAMPLING DATE	mg/L READING	AVERAGE	Perlite Cell 1	Perlite Cell 2	Perlite Cell 3	PERLITE AVERAGE	PERLITE AVE REMOVAL	Washed Sand Cell 4	Washed Sand Cell 5	WASHED SAND AVERAGE	WASHED SAND	Native Sand Cell 6	Native Sand Cell 7	NATIVE SAND AVERAGE	NATIVE SAND	Bank Fill Cell 8	Bank Fill Cell 9	BANK FILL AVERAGE	BANKFILL	Notes
AUGUST	***Influent Readings***** - mg/L																					
	Ammonium-NH3	8/20/2012	0.13																			
	NOx = Nitrate+Nitrite	8/20/2012	4.22																			
	Total Kjehldahl Nitrogen-TKN	8/20/2012	1.74																			
	Total Nitrogen-TN	8/20/2012	5.96																			
	Ortho-Phosphorus-PO4	8/1/2012	0.9																			
	Total Phosphorus-TP	8/1/2012	1.4																			
	Effluent Readings - mg/L	8/30/2012					*DUP*															
	Ammonium-NH4***	8/30/2012	0.04	**69%**	0.04	0.02	0.03	0.03	**77%**	0.04	0.14	0.09	**31%**	0.03	0.02	0.025	**81%**	0.02	0.02	0.02	**85%**	
	NOx = Nitrate+Nitrite	8/30/2012	0.01	**100%**	0.01	0.01	0.01	0.01	**92%**	0.01	0.02	0.015	**88%**	0.01	0.01	0.01	**92%**	0	0.05	0.025	**81%**	
	Total Kjehldahl Nitrogen-TKN****	8/30/2012	1.25	**28%**	0.98	1.21	1.32	1.17	**33%**	NS	1.42	1.42	**18%**	1.01	1.25	1.13	**35%**	1.02	1.79	1.405	**19%**	
	Total Nitrogen-TN	8/30/2012	1.27	**79%**	0.99	1.22	1.33	1.18	**80%**	NS	1.44	1.44	**76%**	1.02	1.26	1.14	**81%**	1.03	1.84	1.435	**76%**	NS-Bottle Broken
	Ortho-Phosphorus-PO4	8/30/2012	0.01	**99%**	0.02	0.04	0.01	0.02	**97%**	0.01	0.01	0.01	**99%**	0	0	0	**100%**	0.01	0	0.005	**99%**	
	Total Phosphorus-TP	8/30/2012	0.13	**90%**	0.1	0.1	0.1	0.10	**93%**	0.1	0.2	0.15	**89%**	0.1	0.2	0.15	**89%**	0.1	0.2	0.15	**89%**	
	Particulate N-PON	8/30/2012	0.21	**NA**	0.2	0.22	0.21	0.21	**NA**	NS	0.13	0.13	**NA**	0.15	0.44	0.295	**NA**	0.12	0.2	0.16	**NA**	
	Dissolved Organic N-DON	8/30/2012	1.00	**NA**	0.74	0.97	1.08	0.93	**NA**	0.96	1.15	1.055	**NA**	0.83	0.79	0.81	**NA**	0.88	1.57	1.225	**NA**	
	Weather Data	**AUG 8/1-8/31:Total PRECIP =5.0"; Average HIGH temp = 80F; Average LOW temp = 66F**																				
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																					
SEPTEMBER	***Influent Readings***** - mg/L																					
	Ammonium-NH3	9/4/2012	0.15																			
	NOx = Nitrate+Nitrite	9/4/2012	3.45																			
	Total Kjehldahl Nitrogen-TKN	9/4/2012	1.82																			
	Total Nitrogen-TN**	9/4/2012	5.27																			
	Ortho-Phosphorus-PO4	9/6/2012	1.5																			
	Total Phosphorus-TP	9/6/2012	1.5																			
	Effluent Readings - mg/L	9/13/2012												*DUP*								
	Ammonium-NH4***	9/13/2012	0.016	**89%**	0.02	0.02	0.02	0.02	**87%**	0.02	0.02	0.02	**87%**	0.01	NS	0.01	**93%**	0.01	0.01	0.01	**93%**	NS-No Sample Taken
	NOx = Nitrate+Nitrite	9/13/2012	0.011	**100%**	0.01	0.01	0.03	0.02	**89%**	0.01	0.01	0.01	**93%**	0.01	NS	0.01	**93%**	0	0.01	0.005	**97%**	
	Total Kjehldahl Nitrogen-TKN****	9/13/2012	0.913	**50%**	0.9	1.04	1.26	1.07	**41%**	0.82	0.91	0.865	**52%**	0.7	NS	0.7	**62%**	0.84	0.83	0.835	**54%**	
	Total Nitrogen-TN	9/13/2012	0.925	**82%**	0.91	1.05	1.29	1.08	**79%**	0.83	0.93	0.88	**83%**	0.71	NS	0.71	**87%**	0.84	0.84	0.84	**84%**	
	Ortho-Phosphorus-PO4	9/13/2012	0.011	**99%**	0.01	0.03	0.01	0.02	**99%**	0.01	0.01	0.01	**99%**	0.01	NS	0.01	**99%**	0.01	0	0.005	**100%**	
	Total Phosphorus-TP	9/13/2012	0.113	**93%**	0.1	0.1	0.2	0.13	**91%**	0.1	0.1	0.1	**93%**	0.1	NS	0.1	**93%**	0.1	0.1	0.1	**93%**	
	Particulate N-PON	9/13/2012	0.105	**NA**	0.11	0.14	0.23	0.16	**NA**	0.08	0.07	0.075	**NA**	0.05	NS	0.05	**NA**	0.08	0.08	0.08	**NA**	
	Dissolved Organic N-DON	9/13/2012	0.791	**NA**	0.77	0.88	1.01	0.89	**NA**	0.72	0.82	0.77	**NA**	0.64	NS	0.64	**NA**	0.75	0.74	0.745	**NA**	
	Weather Data	**SEP 9/1-9/30: Total PRECIP =6.47"; Average HIGH temp = 72F; Average LOW temp = 57F**																				
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																					
SEPTEMBER	***Influent Readings***** - mg/L																					
	Ammonium-NH3	9/18/2012	0.1																			
	NOx = Nitrate+Nitrite	9/18/2012	4.55																			
	Total Kjehldahl Nitrogen-TKN	9/18/2012	1.4																			
	Total Nitrogen-TN**	9/18/2012	6																			
	Ortho-Phosphorus-PO4	9/6/2012	1.5																			
	Total Phosphorus-TP	9/6/2012	1.5																			
	Effluent Readings - mg/L	9/27/2012																				
	Ammonium-NH4***	9/27/2012	0.023	**77%**	0.01	0.02	0.01	0.01	**87%**	NS	NS	NS	**NA**	0.02	0.01	0.015	**85%**	0.07	NS	0.07	**30%**	
	NOx = Nitrate+Nitrite	9/27/2012	0.010	**100%**	0.01	0.01	0	0.01	**93%**	NS	NS	NS	**NA**	0.03	0.01	0.02	**80%**	0	NS	0	**100%**	
	Total Kjehldahl Nitrogen-TKN****	9/27/2012	0.930	**34%**	0.95	1.02	1.17	1.05	**25%**	NS	NS	NS	**NA**	0.76	0.76	0.76	**46%**	0.92	NS	0.92	**34%**	
	Total Nitrogen-TN	9/27/2012	0.937	**84%**	0.95	1.03	1.17	1.05	**83%**	NS	NS	NS	**NA**	0.78	0.77	0.775	**87%**	0.92	NS	0.92	**85%**	
	Ortho-Phosphorus-PO4	9/27/2012	0.020	**99%**	0.02	0.03	0.02	0.02	**98%**	NS	NS	NS	**NA**	0.02	0.02	0.02	**99%**	0.01	NS	0.01	**99%**	
	Total Phosphorus-TP	9/27/2012	0.100	**93%**	0.1	0.1	0.1	0.10	**93%**	NS	NS	NS	**NA**	0.1	0.1	0.1	**93%**	0.1	NS	0.1	**93%**	
	Particulate N-PON	9/27/2012	0.073	**NA**	0.07	0.1	0.1	0.09	**NA**	NS	NS	NS	**NA**	0.03	0.08	0.055	**NA**	0.06	NS	0.06	**NA**	
	Dissolved Organic N-DON	9/27/2012	0.833	**NA**	0.87	0.9	1.06	0.94	**NA**	NS	NS	NS	**NA**	0.71	0.67	0.69	**NA**	0.79	NS	0.79	**NA**	
	Weather Data	**SEP 9/1-9/30: Total PRECIP =6.47"; Average HIGH temp = 72F; Average LOW temp = 57F**																				
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																					
OCTOBER	***Influent Readings***** - mg/L																					
	Ammonium-NH3	10/1/2012	0.1																			
	NOx = Nitrate+Nitrite	10/1/2012	3.83																			
	Total Kjehldahl Nitrogen-TKN	10/1/2012	0.84																			
	Total Nitrogen-TN**	10/1/2012	4.37																			
	Ortho-Phosphorus-PO4	10/3/2012	0.2																			
	Total Phosphorus-TP	10/3/2012	0.35																			
	Effluent Readings - mg/L	10/11/2012				*DUP*																
	Ammonium-NH4***	10/11/2012	0.04	**59%**	0.02	0.04	0.02	0.03	**73%**	0.05	0.08	0.065	**35%**	0.05	0.02	0.035	**65%**	0.02	0.07	0.045	**55%**	
	NOx = Nitrate+Nitrite	10/11/2012	0.01	**100%**	0.01	0.01	0.01	0.01	**90%**	0.01	0	0.005	**95%**	0.01	0	0.005	**95%**	0.01	0.02	0.015	**85%**	
	Total Kjehldahl Nitrogen-TKN****	10/11/2012	0.70	**17%**	0.87	0.73	0.85	0.82	**3%**	0.5	0.75	0.625	**26%**	0.58	0.73	0.655	**22%**	0.39	0.91	0.65	**23%**	
	Total Nitrogen-TN	10/11/2012	0.70	**84%**	0.88	0.73	0.77	0.79	**82%**	0.51	0.75	0.63	**86%**	0.59	0.74	0.665	**85%**	0.39	0.92	0.655	**85%**	
	Ortho-Phosphorus-PO4	10/11/2012	0.09	**56%**	0.1	0.1	0.1	0.10	**50%**	0.1	0	0.05	**75%**	0	0	0	**100%**	0.4	0	0.2	**0%**	
	Total Phosphorus-TP	10/11/2012	0.08	**78%**	0.1	0.1	0.1	0.10	**71%**	0.1	0.1	0.1	**71%**	0.1	0	0.05	**86%**	0.1	0	0.05	**86%**	
	Particulate N-PON	10/11/2012	0.06	**NA**	0.06	0.06	0.07	0.06	**NA**	0.04	0.03	0.035	**NA**	0.05	0.07	0.06	**NA**	0.07	0.05	0.06	**NA**	
	Dissolved Organic N-DON	10/11/2012	0.60	**NA**	0.79	0.63	0.76	0.73	**NA**	0.41	0.64	0.525	**NA**	0.48	0.64	0.56	**NA**	0.3	0.79	0.545	**NA**	
	Weather Data	**OCT 10/1-10/31: Total PRECIP =3.14"; Average HIGH temp = 64F; Average LOW temp = 49F**																				
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																					

TABLE 4: NUTRIENT ANALYSIS | 2 OF 3

				TEST CELLS (9 in total, 5 plants per Cell: 1 Black Willow, 4 Hyb.Poplar)																	
		SAMPLING DATE	mg/L READING	AVERAGE	Perlite Cell 1	Perlite Cell 2	Perlite Cell 3	PERLITE AVERAGE	PERLITE	Washed Sand Cell 4	Washed Sand Cell 5	WASHED SAND AVERAGE	WASHED SAND	Native Sand Cell 6	Native Sand Cell 7	NATIVE SAND AVERAGE	NATIVE SAND	Bank Fill Cell 8	Bank Fill Cell 9	BANK FILL AVERAGE	BANKFILL
OCTOBER	***Influent Readings***** - mg/L																				
	Ammonium-NH3	10/15/2012	0.1																		
	NOx = Nitrate+Nitrite	10/15/2012	4.08																		
	Total Kjehldahl Nitrogen-TKN	10/15/2012	0.9																		
	Total Nitrogen-TN**	10/15/2012	4.98																		
	Ortho-Phosphorus-PO4	10/3/2012	0.2																		
	Total Phosphorus-TP	10/3/2012	0.35																		
	Effluent Readings - mg/L	10/25/2012								*DUP*											
	Ammonium-NH4***	10/25/2012	0.06	**42%**	0.03	0.04	0.05	0.04	**60%**	0.07	0.04	0.055	**45%**	0.09	0.06	0.075	**25%**	0.09	0.05	0.07	**30%**
	NOx = Nitrate+Nitrite	10/25/2012	0.01	**100%**	0.01	0.01	0.01	0.01	**90%**	0.01	0.02	0.01	**90%**	0.04	0.01	0.03	**70%**	0.02	0	0.01	**90%**
	Total Kjehldahl Nitrogen-TKN****	10/25/2012	0.78	**13%**	0.7	0.68	0.97	0.78	**13%**	0.85	0.88	0.865	**4%**	0.69	0.7	0.695	**23%**	0.99	0.57	0.78	**13%**
	Total Nitrogen-TN	10/25/2012	0.80	**84%**	0.72	0.69	0.97	0.79	**84%**	0.86	0.9	0.88	**82%**	0.73	0.72	0.725	**85%**	1.01	0.57	0.79	**84%**
	Ortho-Phosphorus-PO4	10/25/2012	0.04	**78%**	0.2	0.1	0.1	0.13	**33%**	0	0	0	**100%**	0	0	0	**100%**	0	0	0	**100%**
	Total Phosphorus-TP	10/25/2012	0.08	**78%**	0.2	0.2	0.1	0.17	**52%**	0.1	0	0.05	**86%**	0	0	0	**100%**	0.1	0	0.05	**86%**
	Particulate N-PON	10/25/2012	0.04	**NA**	0.03	0.04	0.04	0.04	**NA**	0.03	0.04	0.035	**NA**	0.04	0.06	0.05	**NA**	0.08	0.04	0.06	**NA**
	Dissolved Organic N-DON	10/25/2012	0.68	**NA**	0.64	0.6	0.88	0.71	**NA**	0.75	0.8	0.775	**NA**	0.56	0.58	0.57	**NA**	0.82	0.48	0.65	**NA**
	Weather Data	**OCT 10/1-10/31: Total PRECIP =3.14"; Average HIGH temp = 64F; Average LOW temp = 49F**																			
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																				
NOVEMBER	***Influent Readings*** - mg/L																				
	Ammonium-NH3	10/31/2013	0.1																		
	NOx = Nitrate+Nitrite	10/31/2013	4.11																		
	Total Kjehldahl Nitrogen-TKN	10/31/2013	1.82																		
	Total Nitrogen-TN**	10/31/2013	5.94																		
	Ortho-Phosphorus-TP	10/3/2013	0.35																		
	Total Phosphorus-PO4	10/3/2013	0.2																		
	Effluent Readings - mg/L										*DUP*										
	Ammonium-NH4***	11/8/2012	0.04	**59%**	0.04	0.02	0.03	0.03	**70%**	0.02	0.045	0.0325	**68%**	0.09	0.04	0.065	**35%**	0.05	0.03	0.04	**60%**
	NOx = Nitrate+Nitrite	11/8/2012	0.01	**100%**	0.01	0.01	0	0.01	**93%**	0	0.01	0.005	**95%**	0.01	0.01	0.01	**90%**	0	0.01	0.005	**95%**
	Total Kjehldahl Nitrogen-TKN****	11/8/2012	0.70	**61%**	0.67	0.71	0.76	0.71	**61%**	0.59	0.72	0.655	**64%**	0.85	0.82	0.835	**54%**	0.67	0.54	0.605	**67%**
	Total Nitrogen-TN	11/8/2012	0.71	**88%**	0.67	0.73	0.77	0.72	**88%**	0.59	0.73	0.66	**89%**	0.87	0.83	0.85	**86%**	0.67	0.54	0.605	**90%**
	Ortho-Phosphorus-TP	11/8/2012	0.20	**43%**	0.6	0.4	0.4	0.47	**-33%**	0	0.3	0.15	**57%**	0	0	0	**100%**	0.1	0	0.05	**86%**
	Total Phosphorus-PO4	11/8/2012	0.18	**11%**	0.5	0.4	0.3	0.40	**-100%**	0	0.2	0.1	**50%**	0.2	0	0.1	**50%**	0	0	0	**100%**
	Particulate N-PON	11/8/2012	0.04	**NA**	0.03	0.04	0.03	0.03	**NA**	0.03	0.025	0.0275	**NA**	0.03	0.04	0.035	**NA**	0.11	0.02	0.065	**NA**
	Dissolved Organic N-DON	11/8/2012	0.62	**NA**	0.6	0.65	0.7	0.65	**NA**	0.54	0.65	0.595	**NA**	0.73	0.74	0.735	**NA**	0.51	0.49	0.5	**NA**
	Weather Data	**OCT 10/1-10/31: Total PRECIP = 3.14"; Average HIGH temp = 64F; Average LOW temp = 49F | NOV 11/1-11/30: Total PRECIP = 2.81"; Average HIGH temp = 51; Average LOW temp = 37I**																			
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																				
NOVEMBER	***Influent Readings*** - mg/L																				
	Ammonium-NH3	11/19/2012	0.10																		
	NOx = Nitrate+Nitrite	11/19/2012	2.88																		
	Total Kjehldahl Nitrogen-TKN	11/19/2012	1.26																		
	Total Nitrogen-TN**	11/19/2012	4.13																		
	Ortho-Phosphorus-TP	11/7/2012	0.09																		
	Total Phosphorus-PO4	11/7/2012	0.34																		
	Effluent Readings - mg/L	11/29/2012												*DUP*							
	Ammonium-NH4***	11/29/2012	0.06	**44%**	0.04	0.08	0.03	0.05	**50%**	0.1	0.06	0.08	**20%**	0.075	NS	0.075	**25%**	0.01	0.05	0.03	**70%**
	NOx = Nitrate+Nitrite	11/29/2012	0.01	**100%**	0.01	0.01	0.01	0.01	**90%**	0.02	0	0.01	**90%**	0	NS	0	**100%**	0	0	0	**100%**
	Total Kjehldahl Nitrogen-TKN****	11/29/2012	0.77	**39%**	0.82	0.9	0.97	0.90	**29%**	0.78	0.65	0.715	**43%**	0.655	NS	0.655	**48%**	0.63	0.73	0.68	**46%**
	Total Nitrogen-TN	11/29/2012	0.77	**81%**	0.82	0.9	0.97	0.90	**78%**	0.8	0.66	0.73	**82%**	0.66	NS	0.66	**84%**	0.64	0.74	0.69	**83%**
	Ortho-Phosphorus-TP	11/29/2012	0.09	**3%**	0.3	0.1	0.1	0.17	**-85%**	0	0.2	0.1	**-11%**	0	NS	0	**100%**	0	0	0	**100%**
	Total Phosphorus-PO4	11/29/2012	0.08	**78%**	0.3	0.1	0.1	0.17	**51%**	0	0.1	0.05	**85%**	0	NS	0	**100%**	0	0	0	**100%**
	Particulate N-PON	11/29/2012	0.02	**NA**	0.02	0.02	0.02	0.02	**NA**	0.01	0.01	0.01	**NA**	0.01	NS	0.01	**NA**	0.02	0.01	0.015	**NA**
	Dissolved Organic N-DON	11/29/2012	0.70	**NA**	0.76	0.8	0.92	0.826667	**NA**	0.67	0.58	0.625	**NA**	0.57	NS	0.57	**NA**	0.6	0.67	0.635	**NA**
	Weather Data	**NOV 11/1-11/30: Total PRECIP = 2.81"; Average HIGH temp = 51; Average LOW temp = 37F**																			
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																				
DECEMBER	***Influent Readings*** - mg/L																				
	Ammonium-NH3	11/28/2013	0.10																		
	NOx = Nitrate+Nitrite	11/28/2013	2.74																		
	Total Kjehldahl Nitrogen-TKN	11/28/2013	1.25																		
	Total Nitrogen-TN**	11/28/2013	3.99																		
	Ortho-Phosphorus-PO4	11/7/2013	0.09																		
	Total Phosphorus-TP	11/7/2013	0.34																		
	Effluent Readings - mg/L	12/6/2012																*DUP*			
	Ammonium-NH4***	12/6/2012	0.07	**27%**	0.09	0.11	0.01	0.07	**-30%**	0.03	0.14	0.085	**15%**	0.03	NS	0.03	**70%**	0.025	0.15	0.0875	**13%**
	NOx = Nitrate+Nitrite	12/6/2012	0.02	**99%**	0.02	0.01	0.02	0.02	**83%**	0.02	0.01	0.015	**85%**	0.01	NS	0.01	**90%**	0	0.03	0.015	**85%**
	Total Kjehldahl Nitrogen-TKN****	12/6/2012	0.89	**29%**	0.89	0.98	0.8	0.89	**29%**	0.7	1.01	0.855	**32%**	0.71	NS	0.71	**43%**	0.815	1.23	1.0225	**18%**
	Total Nitrogen-TN	12/6/2012	0.85	**79%**	0.9	1	0.82	0.91	**77%**	0.72	1.02	0.87	**78%**	0.73	NS	0.73	**82%**	0.81	0.83	0.82	**79%**
	Ortho-Phosphorus-PO4	12/6/2012	0.27	**-199%**	0.3	0.3	0.5	0.37	**-307%**	0	0.1	0	**100%**	0	NS	0	**100%**	0.05	0.9	0.475	**-428%**
	Total Phosphorus-TP	12/6/2012	0.34	**1%**	0.3	0.3	0.5	0.37	**-8%**	0.1	0.2	0.15	**56%**	0	NS	0	**100%**	0.1	1.2	0.65	**-91%**
	Particulate N-PON	12/6/2012	0.02	**NA**	0.02	0.02	0.03	0.02	**NA**	0.02	0.02	0.02	**NA**	0.01	NS	0.01	**NA**	0.025	0.03	0.0275	**NA**
	Dissolved Organic N-DON	12/6/2012	0.80	**NA**	0.78	0.85	0.76	0.796667	**NA**	0.65	0.85	0.75	**NA**	0.67	NS	0.67	**NA**	0.765	1.05	0.9075	**NA**
	Weather Data	**NOV 11/1-11/30: Total PRECIP = 2.81"; Average HIGH temp = 51; Average LOW temp = 37F | DEC 12/1-11/31: Total PRECIP = 11.72"; Average HIGH temp = 49; Average LOW temp = 34F**																			
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																				

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THIS PAGE IS BEST VIEWED AT 11x17 LANDSCAPE ORIENTATION

TABLE 4: NUTRIENT ANALYSIS | 3 OF 3

					TEST CELLS (9 in total, 5 plants per Cell: 1 Black Willow, 4 Hyb.Poplar)																
		SAMPLING DATE	mg/L READING	AVERAGE	Perlite Cell 1	Perlite Cell 2	Perlite Cell 3	PERLITE AVERAGE	PERLITE	Washed Sand Cell 4	Washed Sand Cell 5	WASHED SAND AVERAGE	WASHED SAND	Native Sand Cell 6	Native Sand Cell 7	NATIVE SAND AVERAGE	NATIVE SAND	Bank Fill Cell 8	Bank Fill Cell 9	BANK FILL AVERAGE	BANKFILL
DECEMBER	***Influent Readings*** - mg/L																				
	Ammonium-NH3	**12/10/2013**	0.1																		
	NOx = Nitrate+Nitrite	**12/10/2013**	2.929																		
	Total Kjehldahl Nitrogen-TKN	**12/10/2013**	1.26																		
	Total Nitrogen-TN**	**12/10/2013**	4.19																		
	Ortho-Phosphorus-TP	**12/5/2013**	3.5																		
	Total Phosphorus-PO4	**12/5/2013**	2.7																		
	Effluent Readings - mg/L	**12/20/2012**																	*DUP*		
	Ammonium-NH4***	**12/20/2012**	0.03	**68%**	0.03	0.02	0.04	0.03	**70%**	0.05	0.01	0.03	**70%**	0.04	0.03	0.035	**65%**	0.03	0.035	0.0325	**68%**
	NOx = Nitrate+Nitrite	**12/20/2012**	0.00	**100%**	0	0	0	0.00	**100%**	0	0	0	**100%**	0	0	0	**100%**	0.01	0.005	0.0075	**100%**
	Total Kjehldahl Nitrogen-TKN****	**12/20/2012**	0.84	**33%**	0.89	0.84	0.86	0.86	**31%**	0.85	0.79	0.82	**35%**	0.86	NS	0.86	**32%**	0.79	0.825	0.8075	**36%**
	Total Nitrogen-TN	**12/20/2012**	0.90	**78%**	0.9	0.84	0.87	0.87	**79%**	0.86	0.79	0.825	**80%**	0.87	1.37	1.12	**73%**	0.8	0.835	0.8175	**80%**
	Ortho-Phosphorus-PO4	**12/20/2012**	0.89	**75%**	1.3	1.4	1.7	1.47	**58%**	0.7	1	0.85	**76%**	0	0	0	**100%**	0.9	1	0.95	**73%**
	Total Phosphorus-TP	**12/20/2012**	1.02	**62%**	1.3	1.4	2	1.57	**42%**	1	1.1	1.05	**61%**	0	0.2	0.1	**96%**	1	1.2	1.1	**59%**
	Particulate N-PON	**12/20/2012**	0.07	**NA**	0.02	0.02	0.03	0.02	**NA**	0.02	0.03	0.025	**NA**	0.02	0.41	0.215	**NA**	0.03	0.02	0.025	**NA**
	Dissolved Organic N-DON	**12/20/2012**	0.80	**NA**	0.84	0.8	0.79	0.81	**NA**	0.78	0.75	0.765	**NA**	0.8	0.93	0.865	**NA**	0.73	0.77	0.75	**NA**
	Weather Data	**DEC 12/1-11/31: Total PRECIP = 11.72"; Average HIGH temp = 49; Average LOW temp = 34F**																			
	DUP : Duplicate sample, number average of 2; **Phosphorus tests once per month (>7 days prior), others taken 10-14 days prior to effluent reading***influent test-NH3, effluent test-NH4 ****TKN=PON+DON+NH4																				

PROJECT OVERALL (AUG-DEC)	**PROJECT AVERAGES**			
	Influent Readings - mg/L	**8/20-12/20**	**AVE mg/L**	**AVE % reduction**
	Ammonium-NH3	**8/20-12/20**	0.11	
	NOx = Nitrate+Nitrite	**8/20-12/20**	3.64	
	Total Kjehldahl Nitrogen-TKN	**8/20-12/20**	1.37	
	Total Nitrogen-TN**	**8/20-12/20**	4.98	
	Ortho-Phosphorus-TP	**8/20-12/20**	0.93	
	Total Phosphorus-PO4	**8/20-12/20**	0.96	
	Effluent Readings - mg/L			
	Ammonium-NH4***	**8/20-12/20**	0.04	**59%**
	NOx = Nitrate+Nitrite	**8/20-12/20**	0.01	**100%**
	Total Kjehldahl Nitrogen-TKN****	**8/20-12/20**	0.86	**34%**
	Total Nitrogen-TN	**8/20-12/20**	0.87	**82%**
	Ortho-Phosphorus-PO4	**8/20-12/20**	0.18	**39%**
	Total Phosphorus-TP	**8/20-12/20**	0.23	**65%**
	Particulate N-PON	**8/20-12/20**	0.07	**NA**
	Dissolved Organic N-DON	**8/20-12/20**	0.76	**NA**

TABLE 5: UMASS SMAST DATA | 1 OF 2

Coastal Systems Group
SMAST
Umass Dartmouth
706 Rodney French Blvd
New Bedford, Ma 02747

Key

- NA=Not Applicable
- NES = Not Enough Sample
- NS = No Sample
- NC = No Chain Of Custody
- ND = No Data, samples being processed
- BDL = Below Detection Limit

Weather Conditions:		24 hour Precipitation	
1	Clear	1	None
2	Partly Cloudy	2	Light
3	Overcast	3	Heavy
4	Fog/Haze		
5	Drizzle		
6	Fog/Haze		

Sample ID	Depth	QA/QC	Date	PO4 (uM)	PO4 (mg/L)	TP (uM)	TP (mg/L)	NH4 (uM)	NH4 (mg/L)	NOX (uM)	NOX (mg/L)	DIN (uM)	DIN (mg/L)	DON (uM)	DON (mg/L)	TDN (uM)	TDN (mg/L)	POC (uM)	POC (mg/L)	PON (uM)	PON (mg/L)	C/N Ratio	TON (uM)	TON (mg/L)	TN (uM)	TN (mg/L)	
TC1			8/30/2012	0.6	0.02	4.6	0.1	2.7	0.04	0.73	0.01	3.47	0.05	52.71	0.74	56.18	0.79	85.24	1.02	14.24	0.20	5.99	66.95	0.94	70.42	0.99	
TC2			8/30/2012	1.2	0.04	4.7	0.1	1.7	0.02	0.45	0.01	2.12	0.03	69.00	0.97	71.13	1.00	91.45	1.10	15.63	0.22	5.85	84.63	1.19	86.76	1.22	
TC3		SAMPLE	8/30/2012	0.2	0.01	4.2	0.1	1.9	0.03	0.99	0.01	2.93	0.04	71.78	1.01	74.72	1.05	85.76	1.03	13.71	0.19	6.26	85.49	1.20	88.42	1.24	
TC3		FD	8/30/2012	0.2	0.01	4.2	0.1	2.1	0.03	0.84	0.01	2.96	0.04	81.62	1.14	84.58	1.18	101.35	1.22	16.31	0.23	6.22	97.93	1.37	100.89	1.41	
TC4			8/30/2012	0.4	0.01	4.3	0.1	2.6	0.04	0.56	0.01	3.12	0.04	68.60	0.96	71.73	1.00	NS	NS	NS	NS	NS	NS	NS	NS	NS	bottle borken on arriva
TC5			8/30/2012	0.3	0.01	4.9	0.2	10.1	0.14	1.41	0.02	11.52	0.16	82.03	1.15	93.55	1.31	67.46	0.81	9.23	0.13	7.31	91.26	1.28	102.78	1.44	
TC6			8/30/2012	0.1	0.00	4.8	0.1	2.2	0.03	0.71	0.01	2.91	0.04	58.95	0.83	61.86	0.87	69.73	0.84	10.63	0.15	6.56	69.58	0.97	72.49	1.02	
TC7			8/30/2012	0.1	0.00	7.8	0.2	1.5	0.02	0.37	0.01	1.86	0.03	56.41	0.79	58.27	0.82	277.43	3.33	31.53	0.44	8.80	87.94	1.23	89.81	1.26	
TC8			8/30/2012	0.3	0.01	3.8	0.1	1.4	0.02	0.34	0.00	1.75	0.02	62.80	0.88	64.55	0.90	60.63	0.73	8.86	0.12	6.84	71.66	1.00	73.41	1.03	
TC9			8/30/2012	0.1	0.00	5.9	0.2	1.7	0.02	3.25	0.05	4.92	0.07	111.95	1.57	116.87	1.64	90.17	1.08	14.20	0.20	6.35	126.15	1.77	131.07	1.84	
TC1			9/13/2012	0.5	0.01	3.6	0.1	1.4	0.02	0.47	0.01	1.84	0.03	54.94	0.77	56.78	0.80	56.05	0.67	7.94	0.11	7.06	62.89	0.88	64.72	0.91	
TC2			9/13/2012	0.9	0.03	4.4	0.1	1.3	0.02	0.45	0.01	1.73	0.02	62.83	0.88	64.55	0.90	67.88	0.82	10.33	0.14	6.57	73.16	1.02	74.89	1.05	
TC3			9/13/2012	0.3	0.01	8.0	0.2	1.7	0.02	2.42	0.03	4.13	0.06	72.08	1.01	76.21	1.07	122.99	1.48	16.08	0.23	7.65	88.16	1.24	92.29	1.29	
TC4			9/13/2012	0.4	0.01	4.3	0.1	1.2	0.02	0.56	0.01	1.74	0.02	51.45	0.72	53.19	0.75	48.28	0.58	5.97	0.08	8.09	57.42	0.80	59.16	0.83	
TC5			9/13/2012	0.3	0.01	4.1	0.1	1.7	0.02	0.41	0.01	2.13	0.03	58.83	0.82	60.96	0.85	42.17	0.51	5.30	0.07	7.96	64.14	0.90	66.26	0.93	
TC6		SAMPLE	9/13/2012	0.4	0.01	1.8	0.1	0.6	0.01	0.63	0.01	1.28	0.02	47.13	0.66	48.41	0.68	25.37	0.30	3.43	0.05	7.40	50.55	0.71	51.84	0.73	
TC6		FD	9/13/2012	0.4	0.01	1.7	0.1	0.6	0.01	0.41	0.01	1.06	0.01	44.05	0.62	45.12	0.63	25.19	0.30	3.33	0.05	7.58	47.38	0.66	48.44	0.68	
TC8			9/13/2012	0.4	0.01	3.6	0.1	0.7	0.01	0.26	0.00	1.00	0.01	53.69	0.75	54.69	0.77	42.27	0.51	5.42	0.08	7.80	59.11	0.83	60.10	0.84	
TC9			9/13/2012	0.2	0.00	3.3	0.1	0.8	0.01	0.51	0.01	1.33	0.02	53.05	0.74	54.39	0.76	40.10	0.48	5.46	0.08	7.34	58.52	0.82	59.85	0.84	
TC1			9/27/2012	0.5	0.02	2.6	0.1	0.9	0.01	0.41	0.01	1.34	0.02	62.91	0.88	64.25	0.90	33.74	0.41	5.12	0.07	6.58	68.03	0.95	69.38	0.97	
TC1			9/27/2012	0.5	0.02	2.8	0.1	0.7	0.01	0.55	0.01	1.25	0.02	60.61	0.85	61.86	0.87	33.54	0.40	4.83	0.07	6.95	65.44	0.92	66.69	0.93	
TC2			9/27/2012	0.9	0.03	3.4	0.1	1.4	0.02	0.76	0.01	2.13	0.03	64.22	0.90	66.34	0.93	51.60	0.62	7.04	0.10	7.33	71.26	1.00	73.39	1.03	
TC3			9/27/2012	0.6	0.02	3.7	0.1	0.6	0.01	0.34	0.00	0.95	0.01	75.56	1.06	76.51	1.07	54.42	0.65	7.10	0.10	7.67	82.66	1.16	83.61	1.17	
TC6			9/27/2012	0.6	0.02	1.7	0.1	1.3	0.02	1.98	0.03	3.29	0.05	50.49	0.71	53.79	0.75	19.20	0.23	2.22	0.03	8.65	52.71	0.74	56.01	0.78	
TC7			9/27/2012	0.6	0.02	1.8	0.1	0.9	0.01	0.50	0.01	1.39	0.02	47.62	0.67	49.01	0.69	40.95	0.49	5.92	0.08	6.92	53.53	0.75	54.92	0.77	
TC8			9/27/2012	0.4	0.01	2.5	0.1	4.9	0.07	0.17	0.00	5.11	0.07	56.16	0.79	61.26	0.86	30.84	0.37	4.24	0.06	7.28	60.39	0.85	65.50	0.92	
TC1			10/11/2012	2.1	0.1	3.7	0.1	1.5	0.02	1.03	0.01	2.49	0.03	56.04	0.79	58.54	0.82	31.71	0.38	4.15	0.06	7.64	60.20	0.84	62.69	0.88	
TC2		SAMPLE	10/11/2012	2.7	0.1	4.7	0.1	2.3	0.03	0.35	0.00	2.61	0.04	51.00	0.71	53.60	0.75	31.40	0.38	4.62	0.06	6.79	55.62	0.78	58.22	0.82	
TC2		FD	10/11/2012	2.7	0.1	4.6	0.1	2.5	0.04	0.37	0.01	2.88	0.04	38.82	0.54	41.70	0.58	32.05	0.38	4.72	0.07	6.79	43.54	0.61	46.41	0.65	
TC3			10/11/2012	4.1	0.1	5.9	0.2	1.1	0.02	0.22	0.00	1.35	0.02	54.57	0.76	55.92	0.78	32.93	0.40	4.83	0.07	6.82	59.40	0.83	60.75	0.85	
TC4			10/11/2012	0.5	0.0	2.4	0.1	3.6	0.05	0.74	0.01	4.29	0.06	29.28	0.41	33.57	0.47	19.65	0.24	2.58	0.04	7.63	31.85	0.45	36.15	0.51	
TC5			10/11/2012	0.3	0.0	1.8	0.1	5.8	0.08	0.26	0.00	6.09	0.09	45.77	0.64	51.86	0.73	16.96	0.20	1.94	0.03	8.72	47.71	0.67	53.80	0.75	
TC6			10/11/2012	0.5	0.0	2.0	0.1	3.8	0.05	0.41	0.01	4.21	0.06	34.29	0.48	38.50	0.54	30.41	0.37	3.41	0.05	8.93	37.70	0.53	41.91	0.59	
TC7			10/11/2012	0.7	0.0	1.3	0.0	1.5	0.02	0.30	0.00	1.85	0.03	45.95	0.64	47.80	0.67	33.65	0.40	4.87	0.07	6.91	50.82	0.71	52.66	0.74	
TC8			10/11/2012	0.4	0.0	2.0	0.1	1.2	0.02	0.38	0.01	1.55	0.02	21.75	0.30	23.30	0.33	38.84	0.47	4.87	0.07	7.98	26.62	0.37	28.17	0.39	
TC9			10/11/2012	0.3	0.0	1.4	0.0	4.8	0.07	1.60	0.02	6.40	0.09	56.20	0.79	62.60	0.88	23.46	0.28	3.25	0.05	7.22	59.45	0.83	65.85	0.92	
TC1			10/25/2012	5.7	0.2	6.7	0.2	2.3	0.03	0.57	0.01	2.86	0.04	45.80	0.64	48.67	0.68	17.53	0.21	2.47	0.03	7.11	48.27	0.68	51.13	0.72	
TC2			10/25/2012	3.7	0.1	5.2	0.2	2.6	0.04	0.54	0.01	3.16	0.04	43.18	0.60	46.34	0.65	21.18	0.25	3.08	0.04	6.89	46.26	0.65	49.42	0.69	
TC3			10/25/2012	2.0	0.1	3.4	0.1	3.5	0.05	0.97	0.01	4.43	0.06	62.53	0.88	66.96	0.94	20.42	0.25	2.58	0.04	7.92	65.11	0.91	69.54	0.97	
TC4		SAMPLE	10/25/2012	0.4	0.0	1.7	0.1	4.5	0.06	0.79	0.01	5.26	0.07	49.79	0.70	55.05	0.77	14.73	0.18	1.95	0.03	7.57	51.74	0.72	57.00	0.80	
TC4		FD	10/25/2012	0.4	0.0	1.7	0.1	5.9	0.08	0.41	0.01	6.35	0.09	57.41	0.80	63.76	0.89	15.78	0.19	2.17	0.03	7.26	59.58	0.83	65.94	0.92	
TC5			10/25/2012	0.3	0.0	1.5	0.0	2.8	0.04	1.13	0.02	3.96	0.06	57.19	0.80	61.15	0.86	19.99	0.24	2.79	0.04	7.17	59.98	0.84	63.94	0.90	
TC6			10/25/2012	0.5	0.0	1.5	0.0	6.3	0.09	2.99	0.04	9.32	0.13	39.92	0.56	49.25	0.69	22.31	0.27	2.87	0.04	7.78	42.79	0.60	52.11	0.73	
TC7			10/25/2012	0.3	0.0	1.1	0.0	4.1	0.06	0.73	0.01	4.85	0.07	41.64	0.58	46.49	0.65	27.89	0.33	4.63	0.06	6.03	46.27	0.65	51.12	0.72	
TC8			10/25/2012	0.5	0.0	2.2	0.1	6.3	0.09	1.75	0.02	8.08	0.11	58.29	0.82	66.38	0.93	40.56	0.49	6.05	0.08	6.70	64.35	0.90	72.43	1.01	
TC9			10/25/2012	0.1	0.0	1.4	0.0	3.9	0.05	0.34	0.00	4.25	0.06	33.96	0.48	38.21	0.54	20.36	0.24	2.60	0.04	7.83	36.56	0.51	40.81	0.57	
TC1			11/8/2012	17.6	0.5	19.7	0.6	2.7	0.04	0.40	0.01	3.12	0.04	42.64	0.60	45.76	0.64	22.78	0.27	2.37	0.03	9.62	45.01	0.63	48.13	0.67	
TC2			11/8/2012	12.3	0.4	13.3	0.4	1.7	0.02	0.75	0.01	2.43	0.03	46.52	0.65	48.96	0.69	23.14	0.28	2.86	0.04	8.09	49.39	0.69	51.82	0.73	
TC3			11/8/2012	11.0	0.3	11.3	0.4	2.4	0.03	0.35	0.00	2.72	0.04	50.01	0.70	52.73	0.74	21.19	0.25	2.38	0.03	8.89	52.39	0.73	55.11	0.77	
TC4			11/8/2012	0.4	0.0	1.2	0.0	1.3	0.02	0.29	0.00	1.63	0.02	38.33	0.54	39.96	0.56	22.82	0.27	2.29	0.03	9.96	40.62	0.57	42.25	0.59	
TC5		SAMPLE	11/8/2012	8.0	0.2	8.3	0.3	3.2	0.05	0.42	0.01	3.66	0.05	53.22	0.75	56.88	0.80	16.83	0.20	2.08	0.03	8.08	55.30	0.77	58.96	0.83	
TC5		FD	11/8/2012	8.1	0.2	8.3	0.3	3.1	0.04	0.45	0.01	3.59	0.05	39.01	0.55	42.60	0.60	15.58	0.19	1.66	0.02	9.36	40.68	0.57	44.27	0.62	
TC6			11/8/2012	0.3	0.0	1.0	0.0	6.6	0.09	0.97	0.01	7.57	0.11	52.42	0.73	59.99	0.84	18.71	0.22	2.24	0.03	8.35	54.66	0.77	62.23	0.87	
TC7			11/8/2012	0.2	0.0	1.1	0.0	2.8	0.04	0.92	0.01	3.72	0.05	52.93	0.74	56.65	0.79	21.21	0.25	2.70	0.04	7.87	55.63	0.78	59.35	0.83	
TC8			11/8/2012	0.2	0.0	3.5	0.1	3.4	0.05	0.31	0.00	3.71	0.05	36.54	0.51	40.25	0.56	58.39	0.70	7.91	0.11	7.38	44.45	0.62	48.16	0.67	
TC9			11/8/2012	0.1	0.0	0.9	0.0	1.8	0.03	0.50	0.01	2.31	0.03	34.74	0.49	37.05	0.52	11.44	0.14	1.23	0.02	9.28	35.97	0.50	38.29	0.54	

THIS PAGE IS BEST VIEWED AT 11x17 LANDSCAPE ORIENTATION

TABLE 5: UMASS SMAST DATA | 2 OF 2

Sample ID	Depth	QA/QC	Date	PO4 (uM)	PO4 mg/L	TP (uM)	TP mg/L	NH4 (uM)	NH4 mg/L	NOX (uM)	NOX mg/L	DIN (uM)	DIN mg/L	DON (uM)	DON mg/L	TDN (uM)	TDN mg/L	POC (uM)	POC mg/L	PON (uM)	PON mg/L	C/N Ratio	TON (uM)	TON mg/L	TN (uM)	TN mg/L
TC1			11/29/2012	10.8	0.3	11.2	0.3	2.5	0.04	0.49	0.01	3.04	0.04	54.04	0.76	57.09	0.80	13.08	0.16	1.16	0.02	11.32	55.20	0.77	58.24	0.82
TC2			11/29/2012	3.8	0.1	4.8	0.1	5.8	0.08	0.36	0.01	6.21	0.09	56.98	0.80	63.18	0.89	11.63	0.14	1.39	0.02	8.39	58.36	0.82	64.57	0.90
TC3			11/29/2012	3.8	0.1	4.8	0.1	1.8	0.03	0.44	0.01	2.27	0.03	66.00	0.92	68.26	0.96	11.30	0.14	1.20	0.02	9.43	67.20	0.94	69.46	0.97
TC4			11/29/2012	0.5	0.0	1.6	0.0	7.3	0.10	1.41	0.02	8.71	0.12	47.80	0.67	56.51	0.79	8.36	0.10	0.80	0.01	10.41	48.60	0.68	57.31	0.80
TC5			11/29/2012	4.1	0.1	4.9	0.2	4.6	0.06	0.30	0.00	4.90	0.07	41.44	0.58	46.34	0.65	8.96	0.11	1.03	0.01	8.72	42.47	0.59	47.37	0.66
TC6		SAMPLE	11/29/2012	0.4	0.0	0.7	0.0	8.3	0.12	0.22	0.00	8.51	0.12	40.45	0.57	48.96	0.69	7.73	0.09	0.71	0.01	10.84	41.16	0.58	49.67	0.70
TC6		FD	11/29/2012	0.2	0.0	0.6	0.0	2.5	0.03	0.27	0.00	2.73	0.04	40.71	0.57	43.44	0.61	7.29	0.09	0.76	0.01	9.62	41.47	0.58	44.20	0.62
TC8			11/29/2012	0.4	0.0	1.2	0.0	1.0	0.01	0.32	0.00	1.29	0.02	42.73	0.60	44.02	0.62	12.95	0.16	1.70	0.02	7.62	44.43	0.62	45.72	0.64
TC9			11/29/2012	0.8	0.0	1.4	0.0	3.3	0.05	0.30	0.00	3.57	0.05	48.00	0.67	51.57	0.72	9.31	0.11	1.03	0.01	9.06	49.02	0.69	52.60	0.74
TC1			12/6/2012	9.5	0.3	10.1	0.3	6.1	0.09	1.15	0.02	7.25	0.10	55.35	0.78	62.60	0.88	13.42	0.16	1.70	0.02	7.90	57.05	0.80	64.30	0.90
TC2			12/6/2012	10.1	0.3	10.4	0.3	8.2	0.11	0.80	0.01	8.97	0.13	60.89	0.85	69.86	0.98	12.59	0.15	1.52	0.02	8.30	62.41	0.87	71.38	1.00
TC3			12/6/2012	16.5	0.5	17.5	0.5	1.0	0.01	1.21	0.02	2.21	0.03	54.58	0.76	56.80	0.80	14.95	0.18	1.90	0.03	7.86	56.49	0.79	58.70	0.82
TC4			12/6/2012	0.9	0.0	2.3	0.1	2.4	0.03	1.15	0.02	3.55	0.05	46.57	0.65	50.12	0.70	10.44	0.13	1.22	0.02	8.53	47.80	0.67	51.34	0.72
TC5			12/6/2012	4.5	0.1	4.9	0.2	10.1	0.14	0.52	0.01	10.66	0.15	60.36	0.85	71.02	1.00	11.86	0.14	1.56	0.02	7.59	61.92	0.87	72.59	1.02
TC6			12/6/2012	0.4	0.0	1.6	0.0	2.2	0.03	0.98	0.01	3.21	0.05	48.07	0.67	51.28	0.72	8.05	0.10	1.02	0.01	7.89	49.09	0.69	52.30	0.73
TC8		SAMPLE	12/6/2012	1.5	0.0	2.4	0.1	1.8	0.03	0.35	0.00	2.20	0.03	53.73	0.75	55.92	0.78	14.08	0.17	1.86	0.03	7.58	55.59	0.78	57.78	0.81
TC8		FD	12/6/2012	1.7	0.1	2.4	0.1	1.8	0.02	0.27	0.00	2.03	0.03	55.35	0.78	57.38	0.80	13.69	0.16	1.92	0.03	7.12	57.27	0.80	59.30	0.83
TC9			12/6/2012	29.3	0.9	40.0	1.2	10.9	0.15	1.79	0.03	12.68	0.18	74.64	1.05	87.33	1.22	13.26	0.16	1.81	0.03	7.32	76.45	1.07	89.14	1.25
TC1			12/20/2012	43.0	1.3	43.2	1.3	2.2	0.03	0.16	0.00	2.39	0.03	60.21	0.84	62.60	0.88	19.52	0.23	1.54	0.02	12.68	61.75	0.87	64.14	0.90
TC2			12/20/2012	43.7	1.4	43.9	1.4	1.2	0.02	0.29	0.00	1.44	0.02	56.81	0.80	58.25	0.82	16.83	0.20	1.75	0.02	9.63	58.56	0.82	59.99	0.84
TC3			12/20/2012	54.1	1.7	63.9	2.0	3.1	0.04	0.25	0.00	3.31	0.05	56.68	0.79	59.99	0.84	20.07	0.24	1.81	0.03	11.10	58.48	0.82	61.80	0.87
TC4			12/20/2012	21.0	0.7	32.2	1.0	3.6	0.05	0.10	0.00	3.68	0.05	56.02	0.78	59.70	0.84	17.79	0.21	1.49	0.02	11.91	57.52	0.81	61.19	0.86
TC5			12/20/2012	32.5	1.0	34.1	1.1	1.0	0.01	0.16	0.00	1.13	0.02	53.34	0.75	54.47	0.76	20.39	0.24	2.23	0.03	9.15	55.57	0.78	56.70	0.79
TC6			12/20/2012	0.5	0.0	1.4	0.0	3.1	0.04	0.10	0.00	3.25	0.05	57.18	0.80	60.43	0.85	18.23	0.22	1.72	0.02	10.60	58.90	0.83	62.14	0.87
TC7			12/20/2012	0.6	0.0	5.0	0.2	2.4	0.03	0.12	0.00	2.57	0.04	66.10	0.93	68.67	0.96	198.78	2.39	29.02	0.41	6.85	95.13	1.33	97.70	1.37
TC8			12/20/2012	30.2	0.9	32.9	1.0	2.4	0.03	0.43	0.01	2.79	0.04	52.26	0.73	55.05	0.77	22.76	0.27	2.35	0.03	9.69	54.61	0.77	57.40	0.80
TC9		SAMPLE	12/20/2012	31.4	1.0	37.8	1.2	2.8	0.04	0.41	0.01	3.16	0.04	53.06	0.74	56.22	0.79	14.69	0.18	1.52	0.02	9.65	54.58	0.76	57.74	0.81
TC9		FD	12/20/2012	33.7	1.0	37.2	1.2	2.3	0.03	0.35	0.00	2.63	0.04	57.36	0.80	59.99	0.84	15.57	0.19	1.68	0.02	9.27	59.04	0.83	61.67	0.86

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TABLE 6: BARNSTABLE WPCF DATA| JULY

Jun-12	DO mg/l	pH	Temp°C	Cl Resid mg/l	SS mg/l	Alk P	Alk F	NH_3 P mg/l	NO_3 P mg/l	TKN P mg/l	NH_3 F mg/l	NO_3 F mg/l	NO_2 F mg/l	TKN F mg/l	Total-N F mg/l	Contact Detention Time (hours)
1	5.28	6.92	21.4	0.62	<0.1											1.06
2	5.25	6.96	22.8	0.67	<0.1											1.06
3	5.63	6.65	21.2	0.68	<0.1											1.02
4	5.63	6.86	20.7	0.79	<0.1	175	108	32.8	0.572	40.34	1.99	1.05	0.138	3.36	4.55	1.04
5	5.95	6.74	20.4	0.43	<0.1											1.01
6	6.15	6.79	21.3	0.65	<0.1	206	105	36.5	0.630	44.27	0.26	3.21	0.136	2.52	5.87	1.02
7	5.65	6.84	21.8	0.43	<0.1						0.96	2.46				1.03
8	5.63	6.71	22.0	0.34	<0.1						1.21	2.57				1.39
9	6.91	6.96	21.9	0.39	<0.1											1.01
10	5.94	6.85	22.7	0.38	<0.1											1.04
11	6.01	6.58	22.6	0.47	<0.1	168	91	35.1	0.477	41.78	0.10	3.43	0.063	0.9	4.39	1.01
12	5.90	6.81	21.7	0.44	<0.1											1.02
13	6.08	6.71	21.9	0.58	<0.1	208	101	36.9	0.580	44.86	0.15	3.84	0.204	2.01	6.05	0.96
14	6.06	6.77	21.9	0.41	<0.1											1.00
15	6.17	6.73	22.0	0.30	<0.1						0.62	3.35				1.03
16	5.52	6.97	22.5	0.33	<0.1											1.02
17	5.50	6.78	22.5	0.42	<0.1											1.05
18	5.46	6.67	22.2	0.35	<0.1	171	91	37.6	0.837	45.30	0.14	3.73	0.150	2.58	6.46	1.04
19	5.95	6.66	22.6	0.32	<0.1											1.01
20	5.71	6.78	23.5	0.25	<0.1	190	89	35.7	0.678	45.58	1.00	3.87	0.294	3.7	7.86	1.02
21	5.88	6.87	24.6	0.20	<0.1						0.17	4.21	0.193	2.59	6.99	1.02
22	5.59	6.67	24.2	0.18	<0.1						0.30	4.48	0.248	2.66	7.39	1.01
23	5.83	7.03	24.7	0.22	<0.1											1.01
24	5.85	6.98	24.5	0.25	<0.1											1.08
25	5.79	6.86	23.7	0.29	<0.1	176	72	36.5	0.786	44.69	0.14	4.31	0.105	2.94	7.35	0.99
26	5.31	6.91	23.7	0.38	<0.1											0.96
27	5.62	6.92	23.4	0.15	<0.1	195	96	35.0	0.556	42.73	0.22	4.23	0.196	3.22	7.64	0.99
28	5.55	6.83	24.4	0.18	<0.1											0.99
29	5.79	6.79	24.3	0.37	<0.1											0.94
30	5.94	7.04	25.3	0.46	<0.1											0.92
AVG	**5.78**	**6.82**	**22.7**	**0.40**	**<0.1**	**186**	**94**	**35.8**	**0.640**	**43.69**	**0.56**	**3.44**	**0.173**	**2.65**	**6.46**	**1.02**

Jun-12	Chloride mg/l	Sodium mg/l	BOD P mg/l	BOD F mg/l	F. Coliform col/100ml	Total P mg/l	Ortho-P mg/l	pH P	pH F	VOC F	TOC F
1											
2											
3											
4	72	84	211	8.56	12			7.37	7.47	X	11
5											
6	81	87	243	9.03	25	0.6	0.3	7.55	7.40		
7											
8											
9											
10											
11	88	70	200	3.80	4			7.09	7.12		
12											
13	110	98	236	6.21	38			7.38	7.20		
14											
15											
16											
17											
18	85	87	236	10.46				7.13	7.22		
19					15						
20	112	100	240	10.43	7			7.37	7.34		
21											
22											
23											
24											
25	91	81	224	10.48	67			7.30	7.11		
26											
27	81	82	227	5.28	96			7.41	7.23		
28											
29											
30											
AVG	**90**	**86**	**227**	**8.03**	**33**	**0.6**	**0.3**	**7.33**	**7.26**		**11.00**

TABLE 6: BARNSTABLE WPCF DATA| AUGUST

Jul-12	DO mg/l	pH	Temp°C	Cl Resid mg/l	SS mg/l	Alk P	Alk F	NH_3 P mg/l	NO_3 P mg/l	TKN P mg/l	NH_3 F mg/l	NO_3 F mg/l	NO_2 F mg/l	TKN F mg/l	Total-N F mg/l	Chlorine Contact Detention Time (hours)
1	6.13	6.99	25.7	0.19	<0.1											0.98
2	5.49	6.50	25.2	0.09	<0.1	176	88	37.5	0.639	44.69	0.136	4.37	0.069	2.66	7.10	0.95
3	5.60	6.95	25.1	0.46	<0.1											0.94
4	6.09	7.10	25.4	0.50	<0.1											0.91
5	5.79	6.94	24.3	0.35	<0.1	194	105	35.0	0.614	46.09	0.104	4.48	0.084	2.94	7.50	0.88
6	5.83	6.94	25.5	0.50	<0.1											0.90
7	5.83	7.09	25.4	0.42	<0.1											0.88
8	5.91	7.12	25.3	0.48	<0.1											0.96
9	5.90	6.92	25.6	0.49	<0.1											0.99
10	5.83	7.08	26.0	0.37	<0.1	165	92	38.7	0.618	43.99	0.169	3.79	0.076	1.40	5.27	0.93
11	5.77	6.77	25.3	0.12	<0.1											0.94
12	5.81	6.89	25.5	0.54	<0.1	194	91	33.9	0.598	44.83	0.182	3.43	0.069	1.40	4.90	0.97
13	5.63	6.89	25.2	0.65	<0.1											0.89
14	5.65	6.92	25.6	0.38	<0.1											0.88
15	5.82	6.85	26.0	0.50	<0.1											0.94
16	5.63	6.93	25.9	0.75	<0.1	163	83	38.6	0.569	41.75	0.159	3.96	0.052	1.96	5.97	0.89
17	5.76	6.91	26.7	0.53	<0.1											0.91
18	5.41	6.93	26.8	0.31	<0.1	194	95	34.4	0.486	43.43	0.153	3.18	0.042	1.68	4.90	0.89
19	5.85	6.98	25.8	0.34	<0.1											1.70
20	5.46	7.00	24.5	0.49	<0.1						<0.1	3.63	0.062	1.82	5.51	0.85
21	5.85	7.10	25.5	0.38	<0.1											0.85
22	5.58	7.09	25.7	0.43	<0.1											0.87
23	5.78	6.81	25.8	0.57	<0.1	183	105	37.0	0.526	43.99	0.164	2.74	0.054	2.38	5.17	0.88
24	5.27	6.91	25.9	0.41	<0.1											0.90
25	5.56	7.68	25.3	0.30	<0.1	179	101	35.8	0.429	43.99	0.120	1.67	0.092	1.82	3.58	0.90
26	5.61	6.90	25.6	0.58	<0.1											0.89
27	5.39	6.93	25.6	0.44	<0.1						0.160	1.89	0.053	2.52	4.46	0.91
28	5.23	7.06	25.7	0.15	<0.1											0.87
29	5.14	7.08	25.6	0.57	<0.1											0.90
30	5.61	6.83	25.3	0.60	<0.1	179	103	36.3	0.705	41.47	0.216	2.64	0.033	1.40	4.07	0.91
31	5.55	6.97	24.8	0.42	<0.1											0.84
AVG	**5.67**	**6.97**	**25.5**	**0.43**	**<0.1**	**181**	**96**	**36.4**	**0.576**	**43.80**	**0.156**	**3.25**	**0.062**	**2.00**	**5.31**	**0.93**

Jul-12	Chloride mg/l	Sodium mg/l	BOD P mg/l	BOD F mg/l	F. Coliform col/100ml	Total P mg/l	Ortho-P mg/l	pH P	pH F	VOC F	TOC F
1											
2	97	88			56			7.19	7.46		
3											
4											
5	85	93	245	5.63	48	0.4	0.1	7.24	7.07		9.3
6			270	6.10							
7											
8											
9	104	85	247	7.04	10			7.17	7.54		
10											
11	97	86	255	5.88	142			7.24	7.41		
12											
13											
14											
15											
16	90	84	219	5.83	34			7.19	7.62		
17											
18	101	86	227	4.39	50			7.35	7.61		
19											
20											
21											
22											
23	89		244	5.13	69			7.08	7.52		
24											
25	104		270	4.58	56			7.15	7.42		
26											
27											
28											
29											
30	108		212	4.50	33			7.13	7.48		
31											
AVG	**97**	**87**	**243**	**5.45**	**55**	**0.4**	**0.1**	**7.19**	**7.46**		**9.30**

TABLE 6: BARNSTABLE WPCF DATA| SEPTEMBER

Aug-12	DO mg/l	pH	Temp°C	Cl Resid mg/l	SS mg/l	Alk P	Alk F	NH_3 P mg/l	NO_3 P mg/l	TKN P mg/l	NH_3 F mg/l	NO_3 F mg/l	NO_2 F mg/l	TKN F mg/l	Total-N F mg/l	Chlorine Contact Detention Time (hours)
1	5.66	6.80	25.1	0.41	<0.1	188	109	35.5	0.551	42.03	0.218	1.35	0.039	1.82	3.21	0.89
2	5.67	7.00	26.3	0.34	<0.1											0.88
3	5.84	6.90	26.2	0.21	<0.1						0.106	1.50				1.25
4	6.25	7.07	26.7	0.23	<0.1											0.87
5	5.96	7.08	26.5	0.45	<0.1											0.89
6	5.65	6.94	26.8	0.52	<0.1	190	120	37.0	0.680	42.31	0.293	1.14	0.029	2.52	3.69	0.91
7	5.21	6.98	26.0	0.30	<0.1											0.91
8	5.68	6.70	26.6	0.35	<0.1	192	111	35.0	0.668	44.55	0.202	1.04	0.025	2.24	3.31	0.89
9	5.88	6.79	26.8	0.50	<0.1											0.89
10	5.58	6.41	26.1	0.18	<0.1											0.82
11	5.30	7.06	26.4	0.18	<0.1											0.84
12	5.54	7.03	26.2	0.20	<0.1											0.90
13	5.70	6.49	26.7	0.28	<0.1	164	84	37.3	0.504		0.163	2.40	0.099			0.85
14	5.71	6.94	26.3	0.25	<0.1					52.36	0.123	3.20	0.072	1.54	4.81	0.83
15	5.66	7.01	26.7	0.17	<0.1	188	93	33.5	0.498	43.01	0.145	3.30	0.074	2.38	5.75	0.83
16	5.60	7.01	26.5	0.30	<0.1											0.81
17	5.95	7.06	26.9	0.26	<0.1											0.83
18	5.37	7.05	25.9	0.26	<0.1											0.82
19	5.50	7.06	26.0	0.29	<0.1											0.89
20	5.78	6.79	26.2	0.32	<0.1	171	96	35.6	0.735	43.91	0.130	4.17	0.050	1.74	5.96	0.93
21	6.02	6.92	26.3	0.30	<0.1											0.92
22	5.76	7.03	26.4	0.21	<0.1	200	111	33.5	0.840	42.09	0.121	3.01	0.048	1.60	4.66	0.92
23	5.74	6.94	26.4	0.27	<0.1											0.90
24	5.37	6.94	26.4	0.30	<0.1											0.90
25	6.34	7.11	26.4	0.25	<0.1											0.92
26	5.64	7.05	26.0	0.29	<0.1											0.97
27	5.72	6.92	26.3	0.32	<0.1	180	107	34.5	0.511	42.59	0.126	4.56	0.034	2.80	7.39	0.97
28	5.30	7.01	25.9	0.27	<0.1											0.97
29	5.52	6.92	26.0	0.35	<0.1	199	101	34.4	0.593	42.03	0.129	3.55	0.061	2.80	6.41	0.99
30	5.96	6.99	25.9	0.52	<0.1											0.95
31	5.70	5.92	25.5	0.54	<0.1											0.91
AVG	**5.70**	**6.90**	**26.3**	**0.31**	**<0.1**	**186**	**104**	**35.1**	**0.620**	**43.88**	**0.160**	**2.66**	**0.053**	**2.16**	**5.02**	**0.91**

Aug-12	Chloride mg/l	Sodium mg/l	BOD P mg/l	BOD F mg/l	F. Coliform col/100ml	Total P mg/l	Ortho-P mg/l	pH P	pH F	VOC F	TOC F
1	111	100	229	6.43	42	1.4	0.9	7.28	7.48		13
2											
3											
4											
5											
6	105	92	239	6.38	6			7.20	7.61		
7											
8	99	82	262	5.11	18			7.29	7.44		
9											
10											
11											
12											
13	100	85			46			7.30	7.54		
14			226	4.32							
15			207	4.78	39			7.39	7.54		
16	107	96									
17											
18											
19											
20	96	95	214	4.75	34			7.13	7.45		
21											
22	101	96	214	3.66	57			7.45	7.14		
23											
24											
25											
26											
27	104	94			88			7.24	7.62		
28			170	2.68							
29	106	100	167	invalid	23			7.35	7.31		
30											
31											
AVG	**103**	**93**	**214**	**4.76**	**39**	**1.4**	**0.9**	**7.29**	**7.46**		**13.00**

TABLE 6: BARNSTABLE WPCF DATA| OCTOBER

Sep-12	DO mg/l	pH Final	Temp°C	Cl Resid mg/l	SS mg/l	Alk P	Alk F	NH_3 P mg/l	NO_3 P mg/l	TKN P mg/l	NH_3 F mg/l	NO_3 F mg/l	NO_2 F mg/l	TKN F mg/l	Total-N F mg/l	Chlorine Contact Detention Time (hours)
1	6.07	7.19	26.3	0.39	<0.1											0.95
2	6.31	7.15	26.3	0.44	<0.1											1.01
3	5.22	7.12	25.0	0.45	<0.1											1.05
4	5.72	7.01	25.7	0.45	<0.1	188	99	30.8	0.633	43.68	0.146	3.39	0.058	1.82	5.27	1.08
5	5.87	6.91	25.9	0.49	<0.1											0.96
6	5.47	6.97	26.0	0.48	<0.1	187	116	35.1	0.549	43.59	0.122	3.03	0.088	3.92	7.04	1.05
7	5.92	6.99	26.0	0.48	<0.1											1.01
8	5.90	6.80	26.5	0.01	<0.1											1.00
9	5.64	5.25	25.7	0.38	<0.1											1.08
10	5.65	7.15	24.9	0.47	<0.1	191	115	32.2	0.852	41.19	0.155	4.33	0.062	1.96	6.35	1.03
11	5.41	7.24	23.8	0.48	<0.1											1.06
12	6.07	7.20	25.0	0.51	<0.1	198	103	35.2	0.658	42.03	0.122	3.93	0.046	2.52	6.50	1.08
13	5.91	7.11	23.7	0.55	<0.1											1.06
14	5.81	7.10	24.4	0.48	<0.1											1.05
15	5.66	7.18	24.6	0.39	<0.1											1.06
16	5.69	7.15	24.2	0.45	<0.1											1.14
17	5.82	7.11	23.5	0.45	<0.1											1.09
18	5.78	7.15	24.1	0.37	<0.1	179	97	37.7	0.563	42.28	<0.1	4.51	0.040	1.40	5.95	1.07
19	5.96	7.11	24.4	0.49	<0.1		89				<0.1	3.99				1.03
20	5.77	7.15	23.6	0.55	<0.1	195	101	34.8	0.627	41.72	0.104	3.20	0.044	1.68	4.92	1.13
21	6.57	7.10	23.1	0.48	<0.1											1.06
22	6.06	7.16	23.5	0.45	<0.1											1.06
23	5.96	7.15	24.0	0.52	<0.1											1.16
24	5.94	7.06	22.8	0.38	<0.1	169	99	33.2	0.781	41.72	<0.1	3.81	0.020	2.52	6.35	1.14
25	6.11	7.08	23.7	0.42	<0.1											1.11
26	5.90	7.03	23.3	0.46	<0.1	195	97	35.9	0.563	44.24	<0.1	3.79	0.033	1.68	5.50	1.11
27	6.16	7.02	23.8	0.47	<0.1											1.08
28	5.59	7.07	22.9	0.51	<0.1											1.02
29	6.22	7.20	23.7	0.45	<0.1											1.05
30	6.21	7.14	22.0	0.32	<0.1											1.02
AVG	**5.88**	**7.04**	**24.4**	**0.44**	**<0.1**	**188**	**102**	**34.4**	**0.653**	**42.56**	**0.130**	**3.78**	**0.049**	**2.19**	**5.99**	**1.06**

Sep-12	Chloride mg/l	Sodium mg/l	BOD P mg/l	BOD F mg/l	F. Coliform col/100ml	Total P mg/l	Ortho-P mg/l	pH P	pH F	VOC F	TOC F
1											
2											
3											
4	97	93	317	4.22	36			7.18	7.61		
5											
6	108	110	222	5.70	TNTC	1.5	1.5	7.32	7.62		10
7											
8											
9											
10	97	92	229	5.95	26			7.12	7.58		
11											
12	100	99	223	3.38	8			7.43	7.57		
13											
14											
15											
16											
17	97	92	232	4.58	11			7.23	7.45		
18									7.36		
19	91	89	231	3.15	26			7.44	7.45		
20											
21											
22											
23											
24	97		291	6.17	72			7.05	7.40		
25											
26	95		251	4.08	64			7.44	7.40		
27											
28											
29											
30											
31											
AVG	**98**	**96**	**250**	**4.65**	**35**	**1.5**	**1.5**	**7.28**	**7.49**		**10**

TABLE 6: BARNSTABLE WPCF DATA| NOVEMBER

October	DO mg/l	pH	Temp°C	Cl Resid mg/l	SS mg/l	Alk P	Alk F	NH_3 P mg/l	NO_3 P mg/l	TKN P mg/l	NH_3 F mg/l	NO_3 F mg/l	NO_2 F mg/l	TKN F mg/l	Total-N F mg/l
1	5.73	6.99	21.8	0.36	<0.1	165	81	29.2	0.485	37.97	<0.1	3.80	0.030	0.98	4.81
2	5.88	7.10	23.2	0.47	<0.1										
3	6.04	7.41	23.3	0.48	<0.1	183	76	28.7	0.631	38.80	<0.1	3.52	0.009	0.84	4.37
4	5.81	7.08	23.3	0.36	<0.1										
5	6.00	6.88	23.7	0.46	<0.1										
6	5.57	7.11	23.7	0.38	<0.1										
7	5.45	7.12	23.1	0.35	<0.1										
8	6.60	7.07	22.0	0.48	<0.1										
9	5.83	7.16	21.9	0.46	<0.1										
10	6.01	7.08	22.3	0.41	<0.1	153	73	26.9	2.580	37.18	<0.1	3.52	0.009	2.15	5.68
11	6.21	7.10	21.2	0.32	<0.1										
12	6.45	7.06	20.9	0.35	<0.1	180	72	33.9	0.362	42.51	<0.1	3.78	0.010	1.18	4.97
13	6.57	7.11	20.2	0.36	<0.1										
14	6.43	7.14	20.3	0.46	<0.1										
15	6.72	7.14	21.4	0.34	<0.1	188	96	37.4	0.522	42.51	<0.1	4.07	0.006	0.90	4.98
16	6.69	6.84	21.6	0.37	<0.1										
17	6.48	7.04	21.0	0.43	<0.1	203	91	33.9	0.592	42.37	<0.1	3.52	0.008	0.90	4.43
18	6.57	7.03	21.2	0.34	<0.1										
19	6.19	7.16	21.0	0.44	<0.1										
20	6.30	7.16	21.8	0.35	<0.1										
21	6.51	7.15	21.4	0.41	<0.1										
22	6.25	6.90	20.7	0.49	<0.1	168	92	36.0	0.632	41.61	<0.1	3.84	0.007	1.12	4.97
23	6.97	6.97	20.5	0.40	<0.1										
24	6.20	6.92	20.2	0.42	<0.1	194	81	35.7	0.683	42.45	<0.1	3.24	0.005	1.4	4.65
25	6.76	6.94	20.3	0.57	<0.1										
26	6.50	6.95	20.0	0.16	<0.1										
27	6.89	7.09	19.8	0.40	<0.1										
28	7.11	7.03	20.0	0.50	<0.1										
29	6.08	6.95	19.9	0.65	<0.1	171	88	35.3	0.680	42.59	<0.1	3.76	0.008	0.98	4.75
30	6.28	6.97	20.5	0.63	<0.1										
31	6.26	6.91	20.5	0.70	<0.1	179	85	28.1	0.528	38.67	<0.1	4.11	0.011	1.82	5.94
AVG	**6.30**	**7.05**	**21.4**	**0.43**	**<0.1**	**178**	**84**	**32.5**	**0.770**	**40.67**	**#DIV/0!**	**3.72**	**0.010**	**1.23**	**4.96**

October	Chloride mg/l	Sodium mg/l	BOD P mg/l	BOD F mg/l	F. Coliform col/100ml	Total P mg/l	Ortho-P mg/l	pH P	pH F	VOC F	TOC F
1	90	80	264	4.19	TNTC			7.25	7.64		
2											
3	91	83	219	3.51	23	0.35	0.20	7.67	7.54	X	8.5
4											
5											
6											
7											
8											
9	89	83	288	3.82	14			6.96	7.55		
10											
11	92	88	249	3.38	119			7.44	7.24	X	
12											
13											
14											
15	97	86	355	4.46	24			7.43	7.31		
16											
17	107	89	306	4.47	26			7.53	7.17	X	
18											
19											
20											
21											
22	96	86	221	1.88	29			7.25	6.99		
23											
24	95	86	195	3.94	14			7.48	7.41	X	
25											
26											
27											
28											
29	95		247	4.19	8			7.30	7.36		
30											
31	96		194	3.22	161			7.43	7.28		
AVG	**95**	**85**	**254**	**3.71**	**46**	**0.35**	**0.20**	**7.37**	**7.35**		**8.50**

TABLE 6: BARNSTABLE WPCF DATA| DECEMBER

Nov-12	DO mg/l	pH	TempºC	Cl Resid mg/l	SS mg/l	Alk P	Alk F	NH_3 P mg/l	NO_3 P mg/l	TKN P mg/l	NH_3 F mg/l	NO_3 F mg/l	NO_2 F mg/l	TKN F mg/l	Total-N F mg/l
1	6.04	6.63	20.3	0.65	<0.1										
2	6.13	6.95	18.2	0.48	<0.1										
3	6.31	7.05	19.2	0.53	<0.1										
4	6.28	7.05	18.7	0.70	<0.1										
5	6.43	6.90	17.6	0.61	<0.1	173	92	32.4	0.963	41.47	<0.1	2.90	0.006	1.96	4.87
6	7.03	6.93	18.1	0.75	<0.1										
7	6.50	6.98	16.8	0.75	<0.1	191	95	36.3	0.559	43.15	<0.1	2.46	0.003	0.84	3.30
8	6.36	6.92	17.3	0.70	<0.1										
9	6.84	6.87	17.4	0.68	<0.1										
10	7.14	7.02	17.5	0.33	<0.1										
11	6.75	6.98	17.6	0.51	<0.1										
12	6.29	7.00	18.4	0.51	<0.1										
13	6.60	6.90	18.5	0.74	<0.1	190	84	29.9	0.475	42.03	<0.1	3.10	0.002	1.40	4.50
14	6.80	6.88	17.8	0.62	<0.1										
15	6.77	6.94	17.3	0.75	<0.1	194	97	33.5	0.591	43.71	<0.1	3.31	0.010	1.68	5.00
16	6.86	6.96	17.3	0.51	<0.1										
17	7.03	7.09	17.7	0.49	<0.1										
18	6.90	7.02	17.8	0.45	<0.1										
19	7.17	6.93	17.6	0.53	<0.1	169	97	28.0	1.670	37.94	<0.1	2.87	0.007	1.26	4.13
20	7.03	6.79	17.3	0.67	<0.1	190	104	30.2	1.080	40.46	<0.1	2.27	0.013	1.26	3.54
21	6.64	7.04	17.4	0.51	<0.1										
22	7.11	7.68	18.3	0.49	<0.1										
23	7.26	7.06	18.1	0.63	<0.1										
24	7.21	7.00	17.9	0.59	<0.1										
25	7.17	7.05	16.7	0.61	<0.1										
26	6.71	7.06	16.5	0.51	<0.1	181	84	41.8	7.170	47.80	<0.1	3.39	0.003	1.18	4.57
27	6.71	7.00	16.3	0.45	<0.1										
28	6.77	7.03	16.0	0.71	<0.1	202	100	40.6	0.695	46.76	<0.1	2.73	0.012	1.25	3.99
29	7.03	6.99	15.6	0.58	<0.1										
30	6.95	6.97	15.5	0.51	<0.1										
AVG	**6.76**	**6.99**	**17.6**	**0.59**	**<0.1**	**186**	**94**	**34.1**	**1.650**	**42.92**	**#DIV/0!**	**2.88**	**0.007**	**1.35**	**4.24**

Nov-12	Chloride mg/l	Sodium mg/l	BOD P mg/l	BOD F mg/l	F. Coliform col/100ml	Total P mg/l	Ortho-P mg/l	pH P	pH F	VOC F	TOC F
1											
2											
3											
4											
5	111	87			8			7.30	7.24		
6											
7	100	85	197	4.13	2	0.34	0.09	7.22	7.44		8.2
8			217	2.90							
9											
10											
11											
12											
13	99	84	217	2.90	<1			7.35	7.40		
14											
15	93	86	301	3.42	1			7.33	7.49		
16											
17											
18											
19	97	90	374	3.45	<1			7.48	6.90		
20	104	89	299	3.32	4			7.40	7.51		
21											
22											
23											
24											
25											
26	88		216	4.42	<1			7.40	7.41		
27											
28	93		221	3.52	1			7.28	7.41		
29											
30											
AVG	**98**	**87**	**255**	**3.51**	**3**	**0.34**	**0.09**	**7.35**	**7.35**		**8.20**