Watershed Plan for the Upper Broad Creek Watershed

Town of Hilton Head Island, SC

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Additionally, the modeling work and technical analysis referenced in this report was performed by Woolpert, Inc.

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Executive Summary

Note: At the time that the 319 grant funding this study was awarded in 2013, Broad Creek was listed on the 303(d) as having impairment for fecal coliform bacteria. However, that impairment was removed with the publication of the 2014 303(d) list. Although the impairment has been removed, this plan acts as though the impairment still exists.

Broad Creek is a major tidal river that is generally considered to be the most important natural resource on Hilton Head Island. Broad Creek is used for shellfish harvesting, recreation, and also provides important marsh and aquatic habitat for many species. In the mid-1990s, water quality in Broad Creek became a public issue following closings of multiple shellfish harvesting areas. Since those closures, water quality in Broad Creek has followed a general trend of improvement; however, as recently as 2012, there were water quality monitoring stations in the upper portions of Broad Creek that still had impairments due to bacteria levels.

This document takes a detailed look at water quality in the upper portion of the Broad Creek watershed. The plan examines potential sources and causes of impairment for three primary pollutants of concern: bacteria, nitrogen, and phosphorus. Water quality monitoring data and computer models were used to analyze these pollutants and to estimate annual loadings. The Town reviewed opportunities for a variety of management measures, ultimately choosing ten proposed projects that could have a significant impact on pollutant loadings into Broad Creek.

Background and Watershed Characterization

Broad Creek is a major tidal river system for Hilton Head Island, South Carolina. It lies in a north-easterly direction and nearly splits the island in half. The Broad Creek watershed is very large – comprising anywhere from 37% to 54% of the entire island's upland area, depending on where the transition between Broad Creek and Calibogue Sound is determined to be. Broad Creek is generally considered to be the most important natural resource on Hilton Head Island. It provides numerous benefits to the area including shellfish habitat and harvesting opportunities, recreational activities for residents and visitors, and critical saltwater marsh and aquatic habitat for many species including several endangered species.

Interest in improving the water quality in Broad Creek originally grew out of numerous closures of Beaufort County shellfish harvesting areas in 1995. In response to the closures, local citizen groups organized and encouraged the cleanup of polluted waters. At the Town level, a commitment to restoring Broad Creek was formalized first in the 1999 Comprehensive Plan and then in much greater detail in the 2002 Broad Creek Management Plan. The 2002 plan was a comprehensive analysis of the entire Broad Creek watershed including land use, water quality, wildlife, recreation, and aesthetics.

This plan document focuses on water quality in the headwaters, or upper, portion of the Broad Creek watershed. At the time that this study began, in 2013, this section of Broad Creek was listed on the South Carolina 303(d) list, with impairment due to fecal coliform levels. However, in 2014, the fecal coliform standard was attained in Broad Creek, and the waterbody was removed from the 303(d) list of impaired waters. Although the impairment is no longer applicable, this plan works under the assumption that the impairment still exists. Regardless of the current impairment status of Broad Creek, this watershed based plan outlines management measures that, when implemented, can help reduce pollutant loadings into Broad Creek, ultimately keeping it off of the impaired waters list.

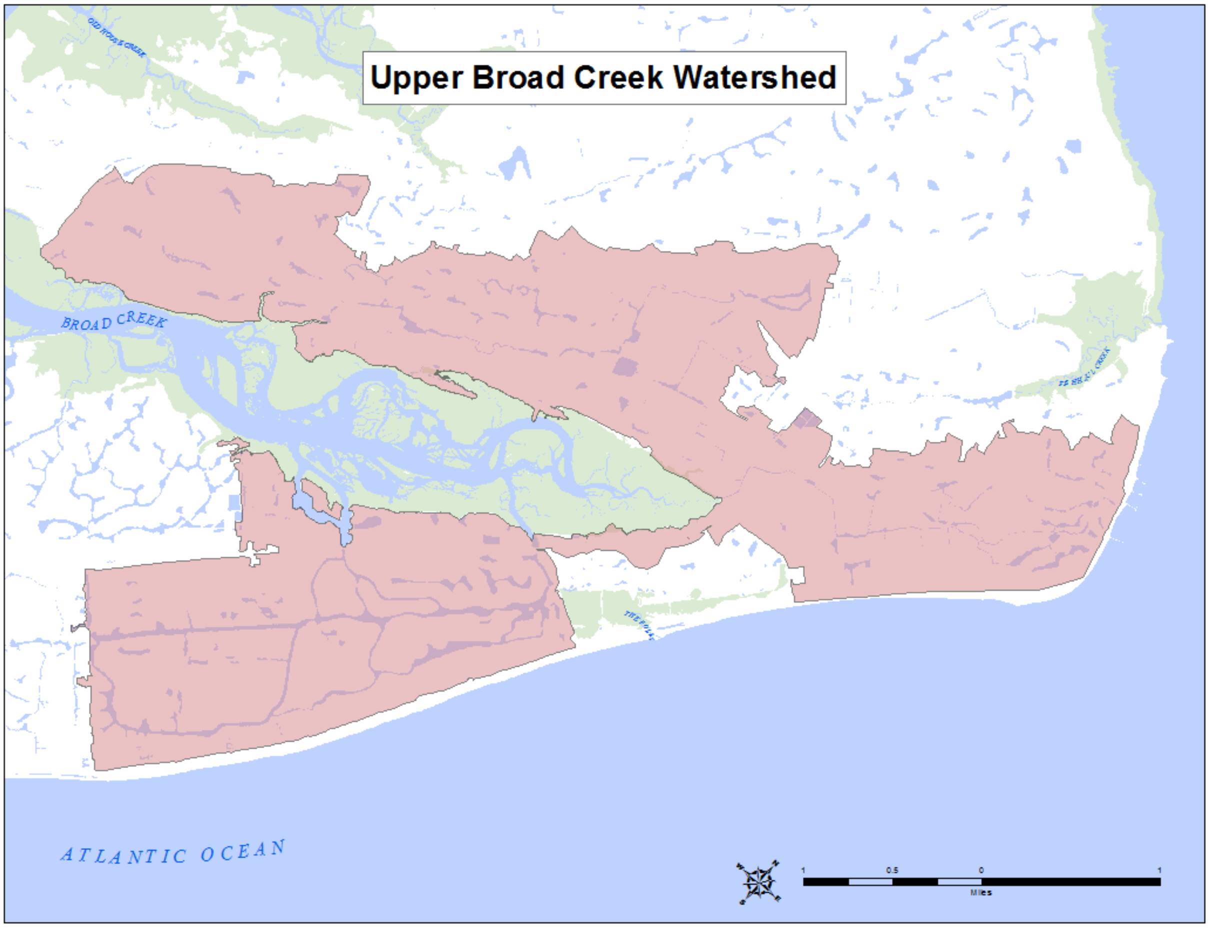


Figure 1: Map of the watershed boundary. The area of the watershed is approximately 5,385 acres.

Land Use

The Upper Broad Creek Watershed, as defined for this study, is approximately 5,385 acres. An analysis of land uses in the watershed revealed that the majority of land uses fall into open space, golf course, or single family residential categories (See Figure 2). While land uses that are traditionally associated with higher pollutant loadings (e.g., industrial, commercial) do not make up a large percentage of the watershed, they tend to be located in clusters that may need to be further investigated as potential hot spots.

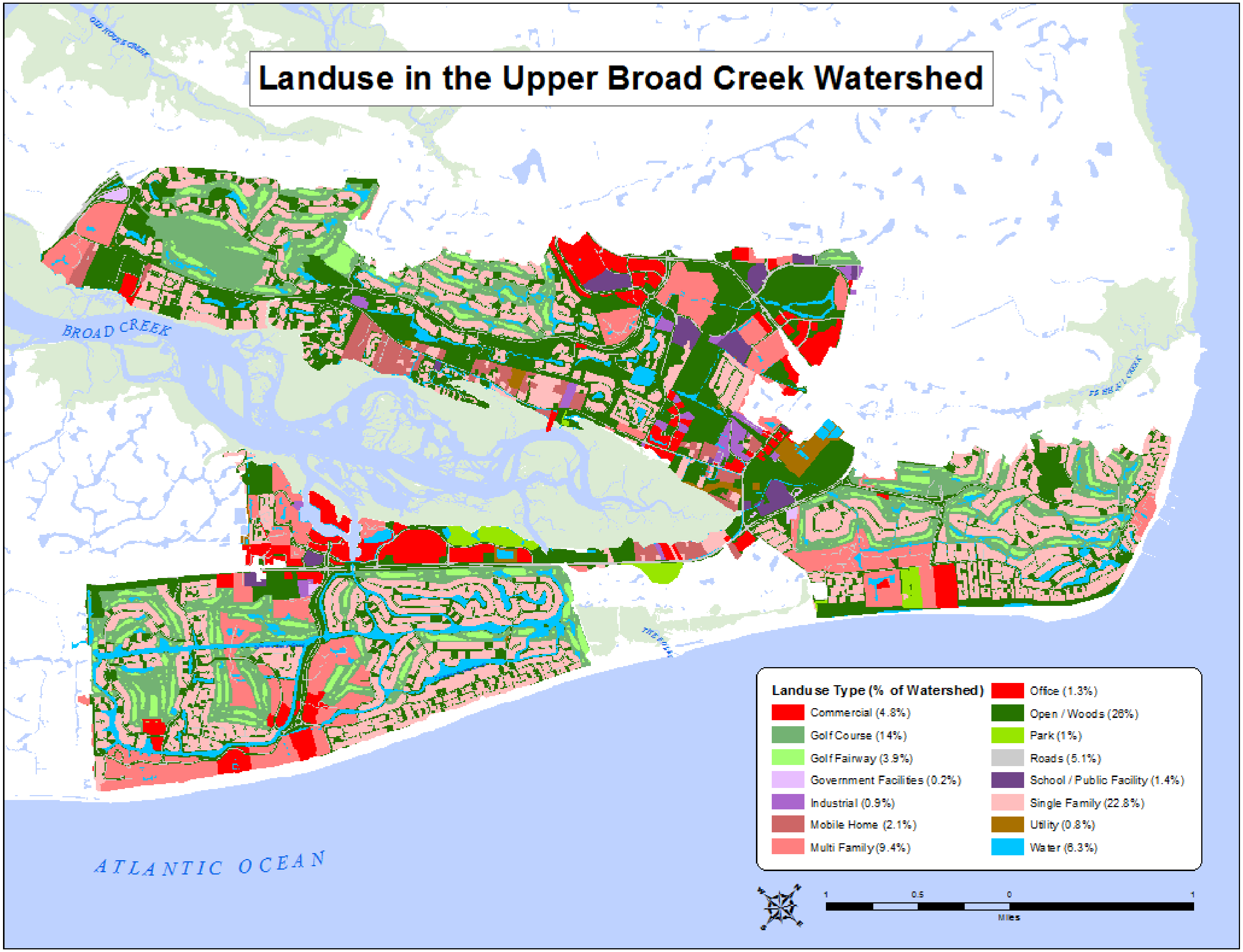


Figure 2: Map showing the land uses within the Upper Broad Creek watershed. Residential and Open/Golf Course uses make up the majority of the watershed.

Identifying Pollution Sources and Causes

Pollutants of Concern

The primary pollutant of concern for this study is fecal coliform bacteria, due to the impairment and 303(d) listing for Broad Creek; however, the Town also has an interest in nutrient levels (phosphorus and nitrogen), not only in Broad Creek itself, but also in the surface waters and tributaries that ultimately drain to it.

Potential Sources

Fecal coliform bacteria in Broad Creek likely come from three potential sources: failing septic systems, pet waste, and wildlife. Excess nutrient loadings can originate from some of the same sources as bacteria, such as failing septic systems and pet waste. Aside from those common sources, a major source of both phosphorus and nitrogen could be excess fertilizer applications on residential and commercial properties as well as golf courses – all land uses that comprise significant portion of the Upper Broad Creek watershed.

Table 1: Potential sources of fecal coliform bacteria and nutrient pollution in Broad Creek

Pollutant	Potential Sources	Affected Uses
Fecal Coliform Bacteria	Failing septic systems, wildlife, pet waste	Shellfish Harvesting (303d impairment), Recreation (no listed impairment)
Nutrients (Phosphorus and Nitrogen)	Excess fertilizer application (residential lawns, commercial properties and golf courses), pet waste, failed septic systems, increased impervious surfaces, bank erosion	Aquatic Life (no listed impairment)

Septic Systems

Human sources of fecal bacteria pollution generally come from sanitary sewer overflows or septic tank failures. There is a wastewater treatment plant within the study area, but there have not been any known overflows or spills associated with it recently; therefore, human sources of fecal bacteria in Broad Creek are most likely due to failed septic tank systems in the watershed.

Within the project study area, there are 142 parcels that do not have sewer service and 210 separate buildings/and structures on those lots (See Figure 3). These areas without sewer service are potentially hot spot sources of fecal coliform bacteria.

Although these properties served by septic systems may be important sources of several pollutants into Broad Creek, the Town did not conduct an in-depth analysis of annual loadings from these properties and potential loading reductions due to management measures. One of the reasons this plan doesn't include an in-depth analysis of this pollution source is that the Town of Hilton Head Island is not responsible for providing sanitary sewer services within its limits. Sewer service on the island is provided by three different public service districts, and all of the properties served by privately-owned septic systems in the watershed are within the service area of Hilton Head Public Service District #1 (HHPSD). Furthermore, the Town and the HHPSD have partnered to produce a master sewer plan, designed to bring sanitary sewer service to all the remaining unserved parcels in their service district by 2020. The Town has and will continue to provide funding to achieve this goal, and the HHPSD oversees the implementation of the plan. To date, the Town has dedicated over 3 million dollars in funding for the implementation of the plan. Since there is already an action plan in place to address these potential pollution sources, this study does not include modeling to specifically estimate loadings from septic tanks, nor does it include any proposed management measures beyond the existing sewer master plan to specifically address pollution from septic tanks.

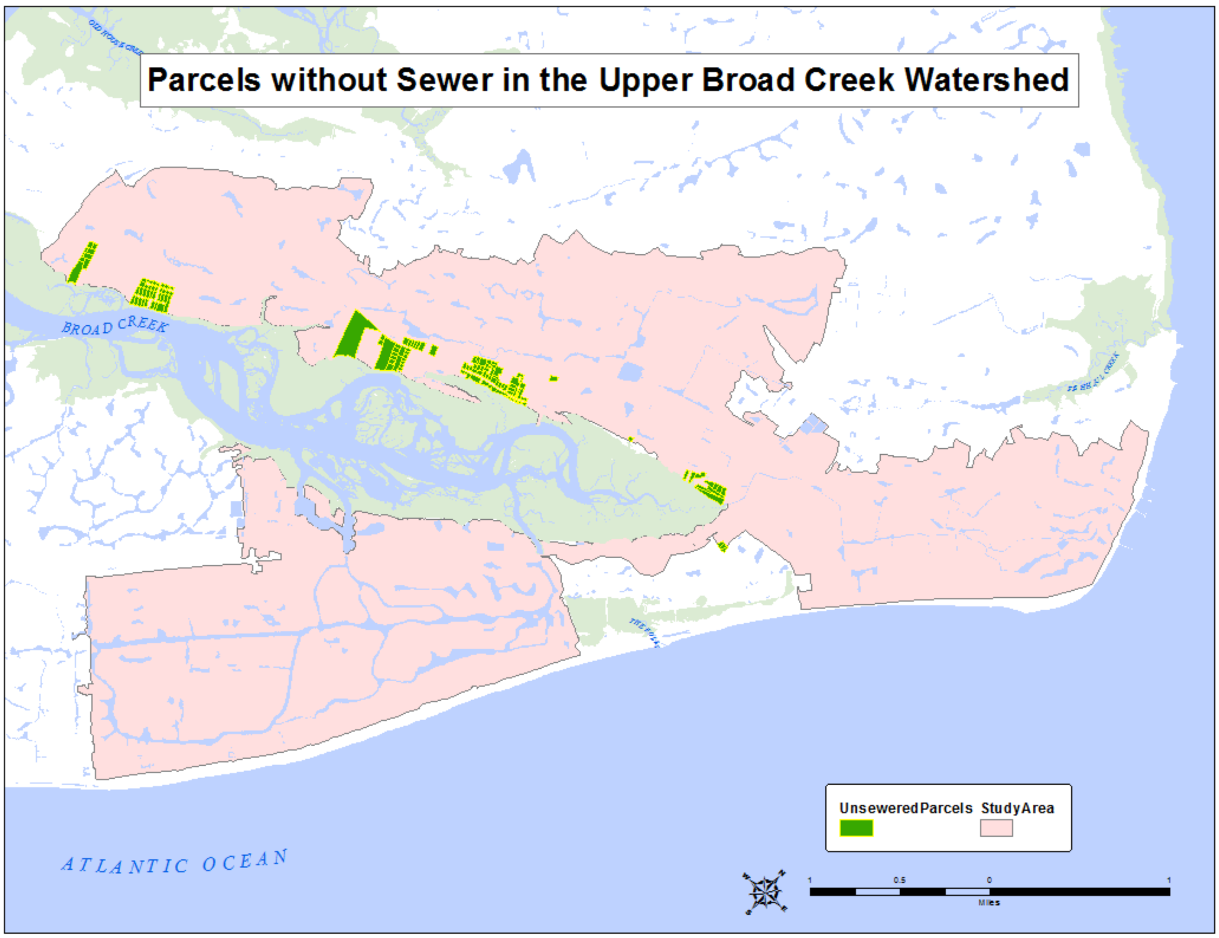


Figure 3: Locations of parcels without sewer service in the study area.

Pet Waste

The Town is not particularly concerned about pollutant loadings from wildlife, since those levels are generally considered to be background pollution levels, and there are very few practical options for managing wildlife to reduce pollutant loadings (the major exception being relocation of invasive species like Canadian Geese that have inhabited a stormwater pond).

Pet waste is a bit more of a concern than wildlife, due to the concentration of residential properties in the watershed. In addition to physical BMPs, loadings from pet waste can potentially be reduced through education and outreach initiatives that attempt to change behaviors of pet owners.

Using statistics provided by the American Veterinary Medical Association (AMVA, 2012), Town staff estimated pet ownership numbers for single family households within the study area. Using an estimate of 3,200 Single Family or Mobile Home buildings within the watershed, staff calculated that there are 1,792 pet-owning households in the study area and 1,869 dogs and 2,042 cats among those households. According to the EPA, a typical dog produces up to 274 pounds of waste a year (Carolina Clear, 2015). If no dog owners picked up after their pets, those estimates extrapolate to over 500,000 pounds of waste per year generated by dogs in the watershed. This highlights the importance of addressing uncontrolled pet waste as a management measure to improve water quality.

Fertilizer Application

Fertilizer applications associated with residential lawns and golf courses are potentially significant sources of phosphorus and nitrogen pollution. Within the study area, there are 2978 single-family residential parcels, totaling 1258 acres with an average size of 0.42 acres. In addition to the residential parcels, there are 210 acres of golf course fairways, which is generally short grass that is heavily fertilized and often located adjacent to surface waters. See Figure 2 for a map showing the locations of residential properties and golf courses.

Water Quality Monitoring

Since 1999, the Town has had a water quality monitoring program that involves taking grab samples from various locations around the island on a regular basis. The Town's monitoring data is strictly for non-regulatory purposes and does not include an approved Quality Assurance Project Plan (QAPP); however, the data can provide good insight on surface water conditions and can be useful when planning for public education or targeting areas for more detailed study.

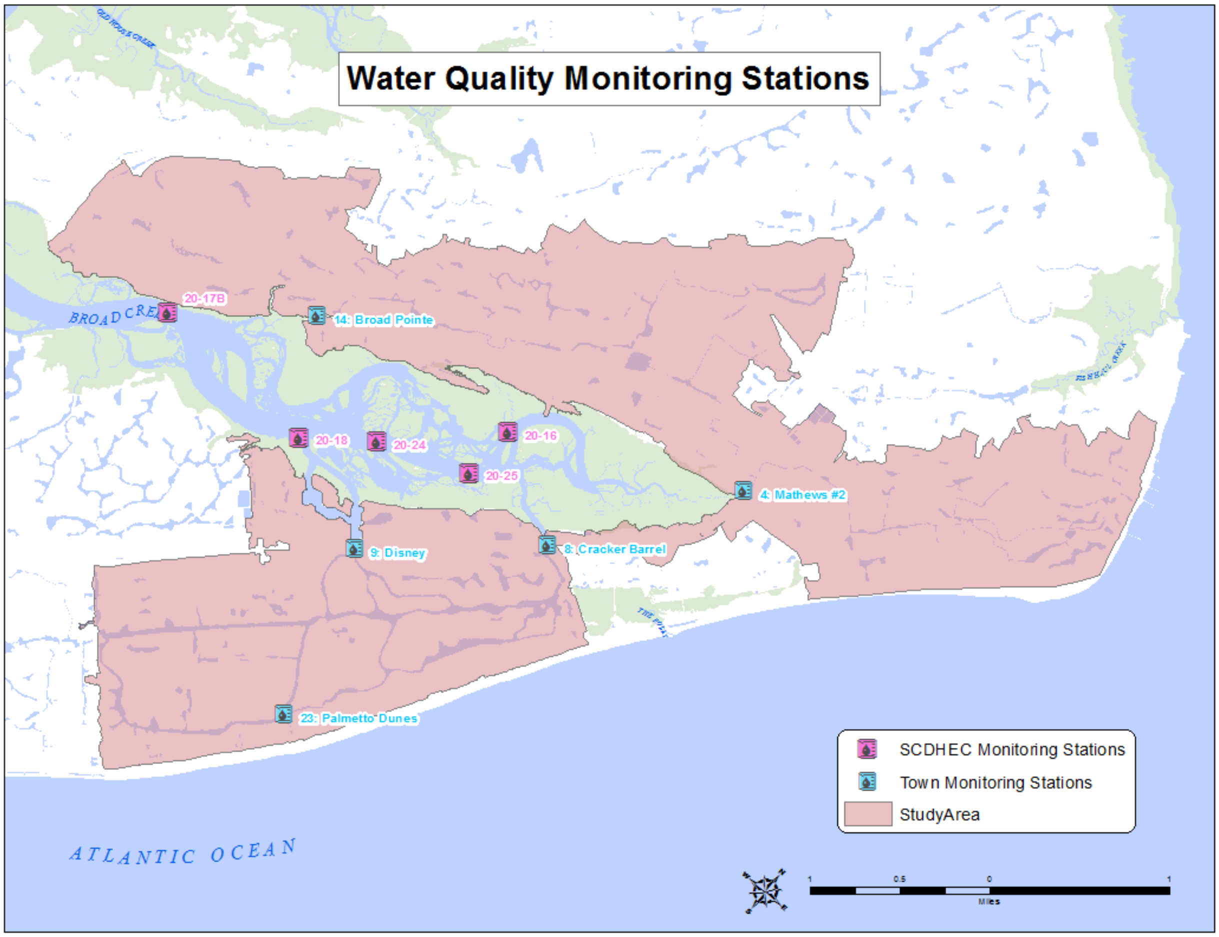


Figure 4: Map of water quality monitoring/sampling locations in the study area.

Obviously, Broad Creek is classified as a saltwater waterbody; however, an interesting observation based on Town monitoring data is the fluctuation of salinity levels at the Town's five sampling locations in the study area. Tide levels and rainfall amounts certainly affect salinity levels of samples, particularly at the Broad Pointe and Mathews 2 stations. Most surprising, perhaps, are the salinity levels at the Palmetto Dunes sampling location, especially when compared to Broad Pointe and Mathews 2, which are both closer in distance to Broad Creek. This can probably be explained by the fact that the Palmetto Dunes canal system is fed and flushed on a monthly basis, via tide gates that open to Broad Creek. All of these locations can be classified as either saltwater or brackish, with no true freshwater locations. This has some management implications for the Town, as water quality standards and guidelines typically have differences for saltwater and freshwater waterbodies.

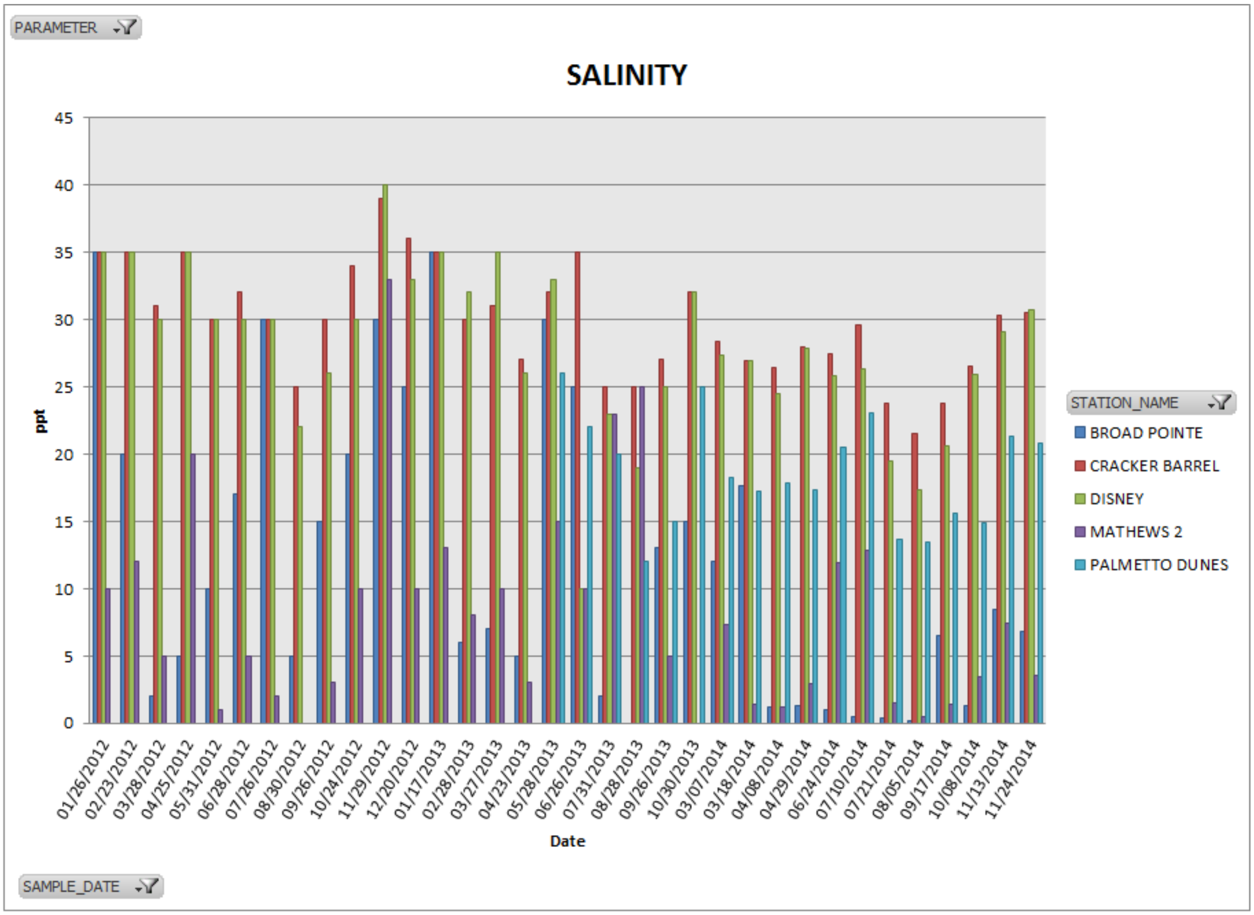


Figure 5: Salinity levels at Town sampling locations.

The charts below (Figures 6-9) show the results of Town water quality monitoring at five locations within the study area. Given the brackish nature of the water at all of these locations, it seems appropriate to compare the pollutant levels of samples to the state standards and guidelines available for saltwater, rather than freshwater.

State water quality standards are generally based on the designated use of a particular waterbody. Broad Creek is classified as shellfish harvesting waters (SFH) – a designation that carries some of the strictest standards, particularly for fecal coliform bacteria. If a waterbody meets the SFH standards, it is considered safe to use for commercial shellfish operations, as well as a host of recreational activities. The state standard for fecal coliform bacteria levels in shellfish harvesting waters is a maximum of 43 CFU/100mL for a single sample (SCDHEC, 2014).

During the three-year time period from January 2012 - December 2014, each of these locations had samples with fecal coliform levels that exceeded the single sample limit at least once. For both the Broad Pointe and Mathews 2 sampling locations, the majority of samples contained fecal coliform levels that exceeded the single sample limit for SFH waters, usually at extreme levels. The Palmetto Dunes location, which is the furthest distance from Broad Creek (and has only been sampled since May 2013), also exceeded the SFH limit for the majority of the samples. Interestingly, the Cracker Barrel and Disney sampling sites, which are located at the inlet and outlet of the Palmetto Dunes canal system, fared much better against the standard.

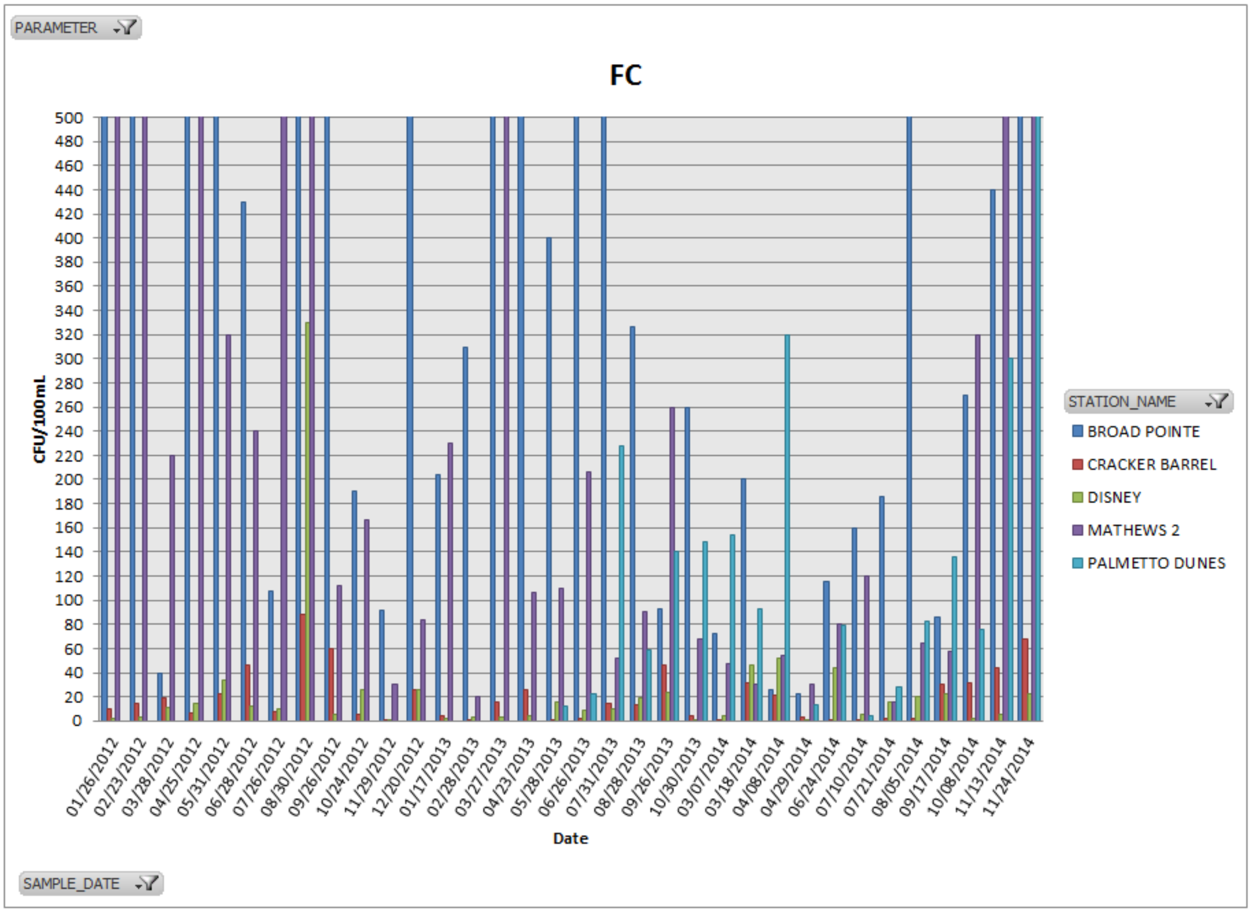


Figure 6: Fecal coliform bacteria levels for Town sampling locations.

For nutrients, the state has standards for lakes over 40 acres that are dependent on the ecoregion. For lakes less than 40 acres there are only narrative criteria. The state standard for nitrogen for lakes in the Coastal Plains region is 1.50 mg/L, and the standard for phosphorus is 0.09 mg/L (SCDHEC, 2014). While these standards are meant to apply to large freshwater lakes, rather than brackish lagoons and open channels, they may still offer some guidance for the Town.

A look at the sampling data for nitrogen shows that only a few samples taken during the three-year period exceeded the state lake standard; however, phosphorus levels exceeded the state lake standard for the majority of the samples taken.

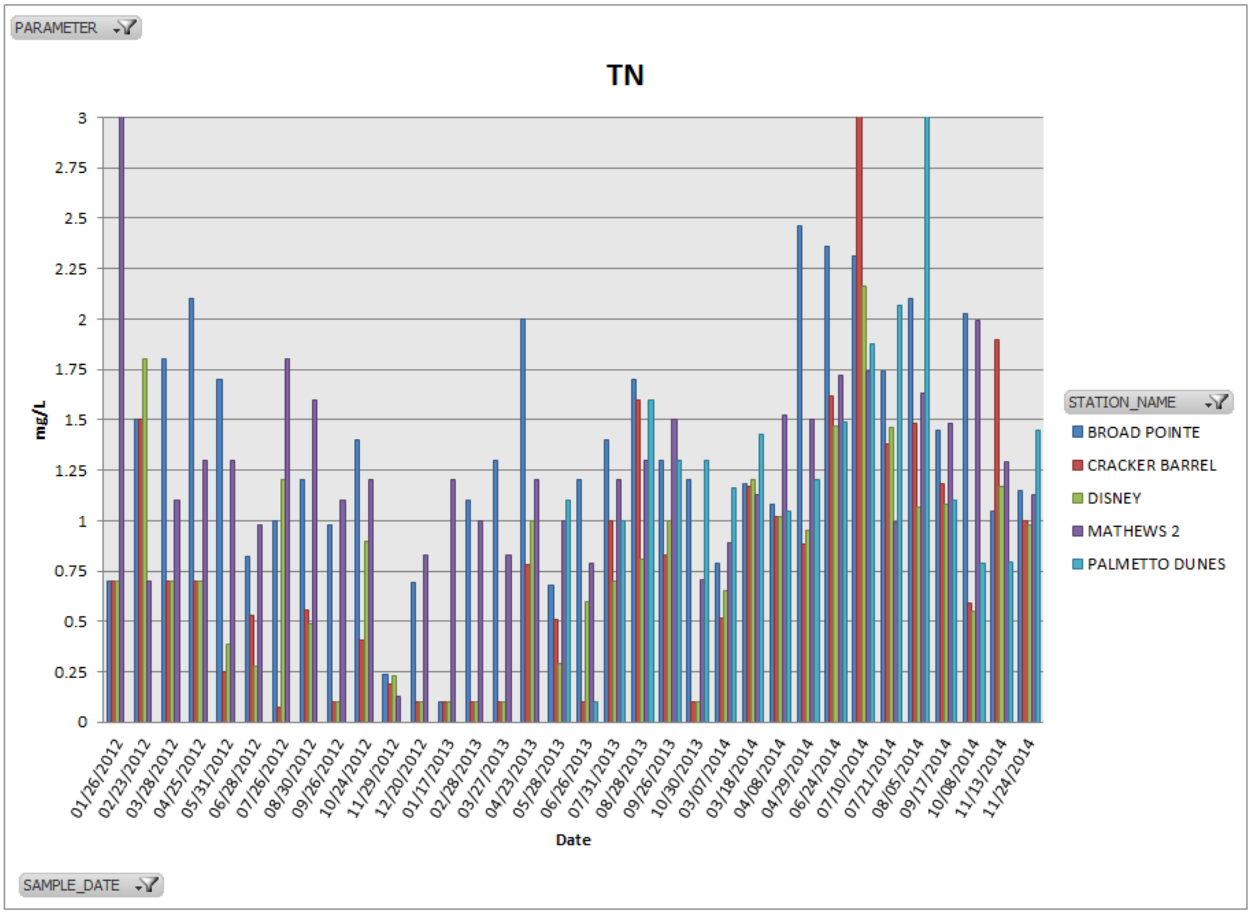


Figure 7: Total nitrogen levels at Town sampling locations.

The main concern regarding nutrient pollution is eutrophication – a process by which a body of water reaches a high concentration of nutrients. A high nutrient concentration in water promotes excessive algae growth, and as those algae die and decompose the water is depleted of available oxygen. This state of depleted oxygen, known as hypoxia, can cause other organisms in the water, such as fish, to die. Phosphorus is generally considered to be the limiting factor in eutrophication of freshwater, whereas nitrogen is considered to be the limiting factor in saltwater environments. Since the waters in this study area range from brackish to saltwater, the generally low nitrogen levels may be the reason that there have not been any observed algal blooms. As the sampling data for dissolved oxygen show, none of these areas are approaching hypoxic states, even though there have been instances of dissolved oxygen levels below the state threshold. None of this is to say that the Town should not be concerned with the elevated phosphorus levels in the water. It is simply an observation that the high concentrations of phosphorus have not yet led to a state of eutrophication.

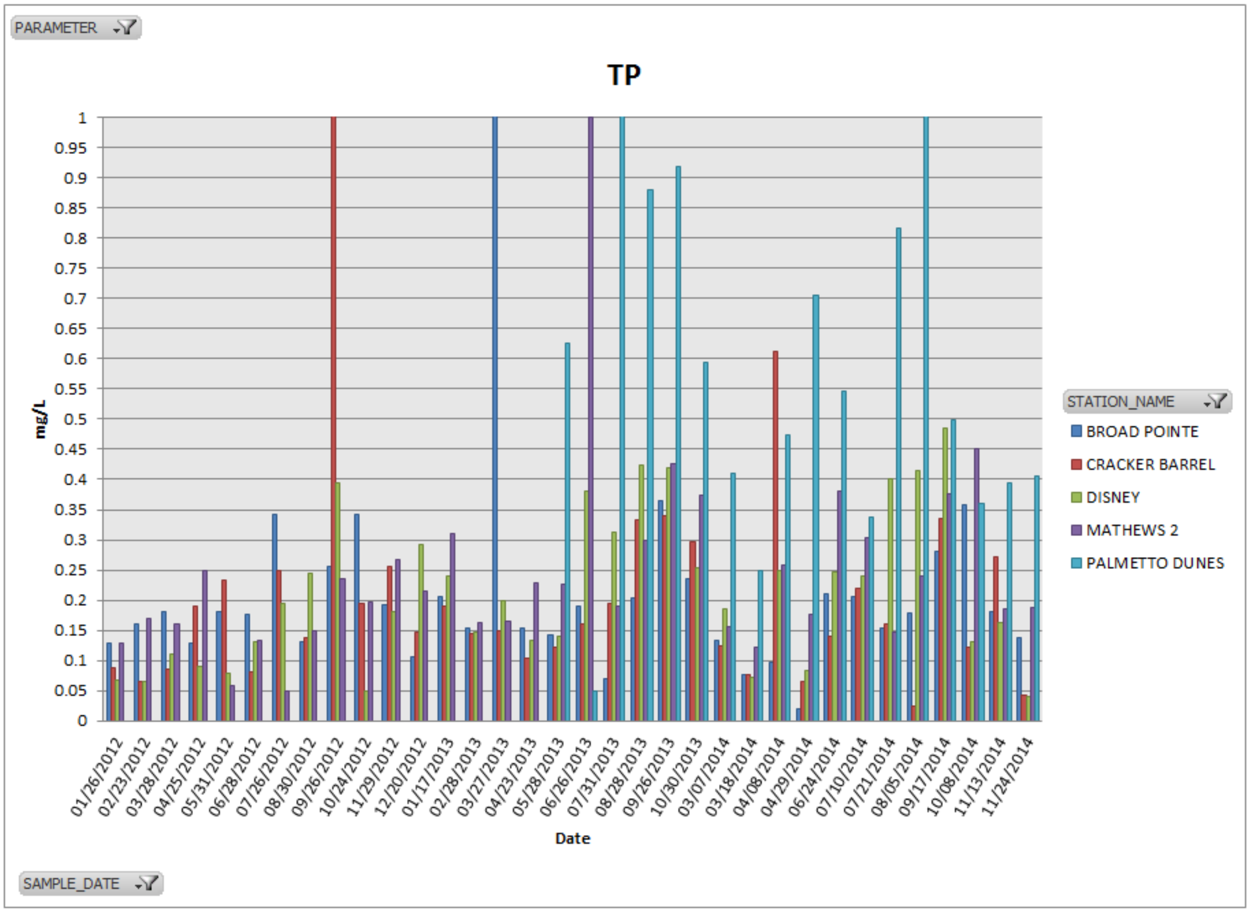


Figure 8: Total phosphorus levels at Town sampling locations.

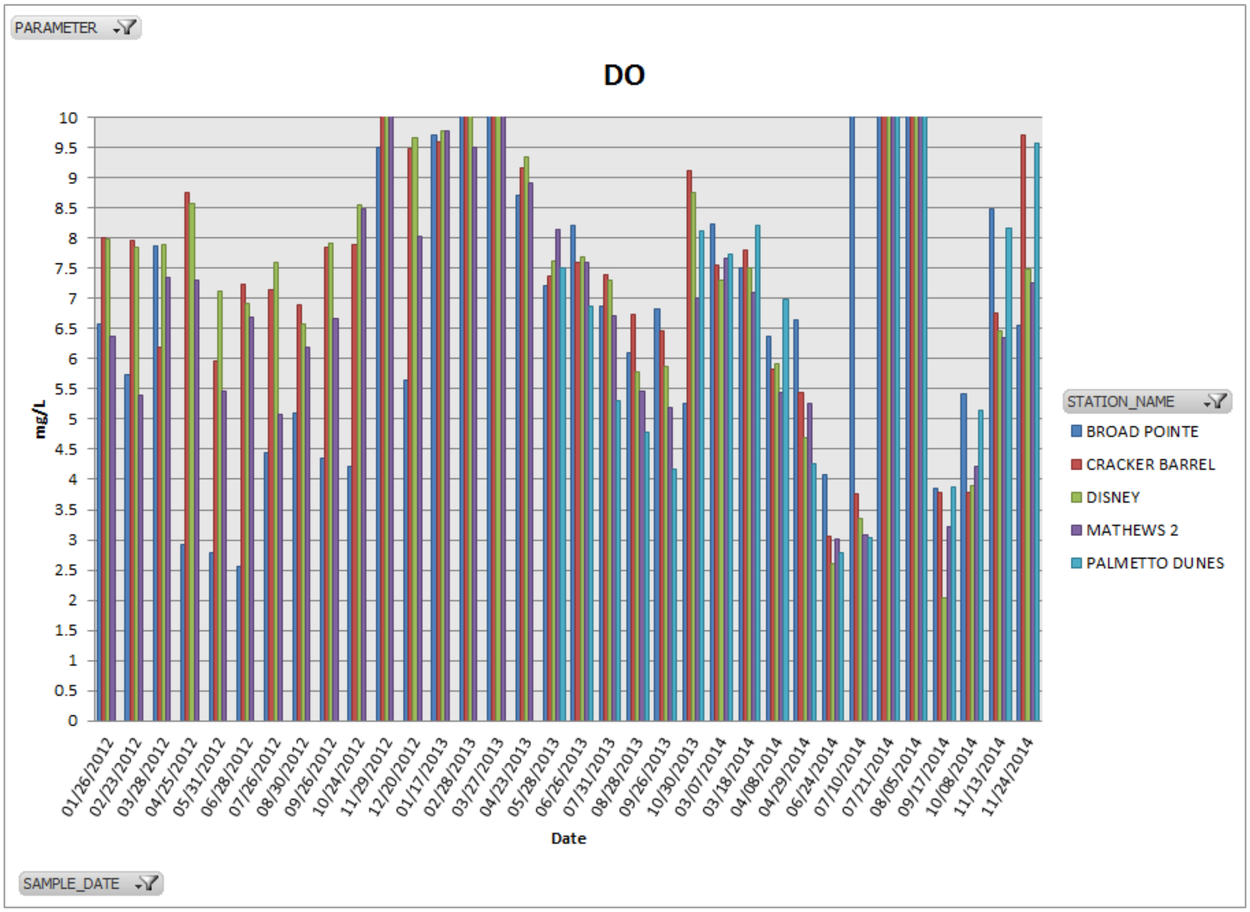


Figure 9: Dissolved oxygen levels at Town sampling locations.

Water Quality Modeling to Estimate Loadings from Stormwater Runoff

To assist with estimating pollutant loadings from stormwater runoff in the study area, the Town hired a consultant, Woolpert Inc., to develop water quality models with the Integrated Design, Evaluation, and Assessment of Loadings (IDEAL) software program. The IDEAL model is suitable for both small, individual construction projects and large watersheds with hundreds of sub-basins and BMPs. The model simulates rainfall/runoff events with land use-based loading for sediment, nitrogen, phosphorus, and bacteria, using local historical hydrologic data. Conveyances can be hydraulically routed or translated. BMPs include both hydraulics and treatment processes. Treatment routines are state-of-the art and are based on complex physical, chemical, and biological processes. The process-based calculations allow for precise modeling of BMPs even in series, as is often the case in relatively flat coastal areas like Hilton Head Island. While there are other methods of accounting for BMPs' water quality treatment, like the Coastal LID Design Guide, IDEAL is the only one that calculates a unique trapping efficiency for each BMP.

For this study, event mean concentrations (EMCs) were modeled at the subbasin level. For estimating annual loadings, these subbasins were aggregated into *systems* based on common outfalls to Broad Creek. The only exception to this approach was inside the Palmetto Dunes community, for which EMCs and annual loadings were modeled at the subbasin level. The reason for this is that all the upland areas within Palmetto Dunes drain to a central canal system, which flows throughout the entire community and ultimately discharges to Broad Creek. Due to this unique system, the Palmetto Dunes canal – rather than Broad Creek – was considered to be the receiving waterbody for the IDEAL model in that area. The decision to treat the canal as the receiving waters is supported by the water quality data discussed in the previous section, as pollutant levels – especially for phosphorous and fecal coliform – are typically higher at the sampling location within Palmetto Dunes than they are at the outlets where the system empties into Broad Creek.

The modeling results tend to reveal a pattern showing relatively high event mean concentrations of fecal coliform, nitrogen, and phosphorus at the subbasin level; however, estimated annual loadings into receiving waters (Broad Creek and the Palmetto Dunes canal) at the system scale tend to be relatively low (see Figures 10-12). This pattern can be explained by the fact that most stormwater runoff in the study area is already being treated by a significant network of existing ponds and other BMPs.

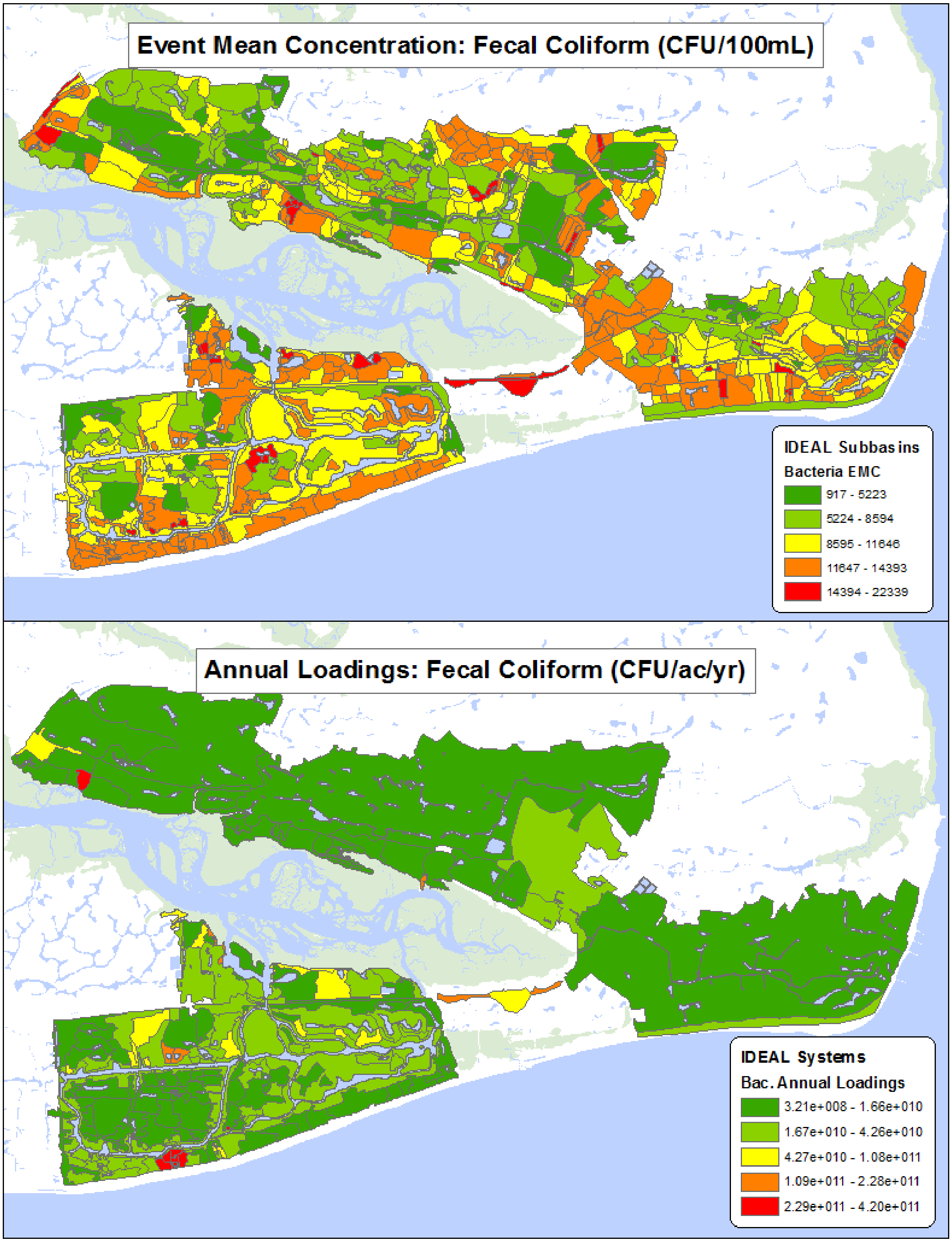


Figure 10: IDEAL modeling results for fecal coliform. Top map shows event mean concentrations at the subbasin level. Bottom map shows annual loadings at a system scale.

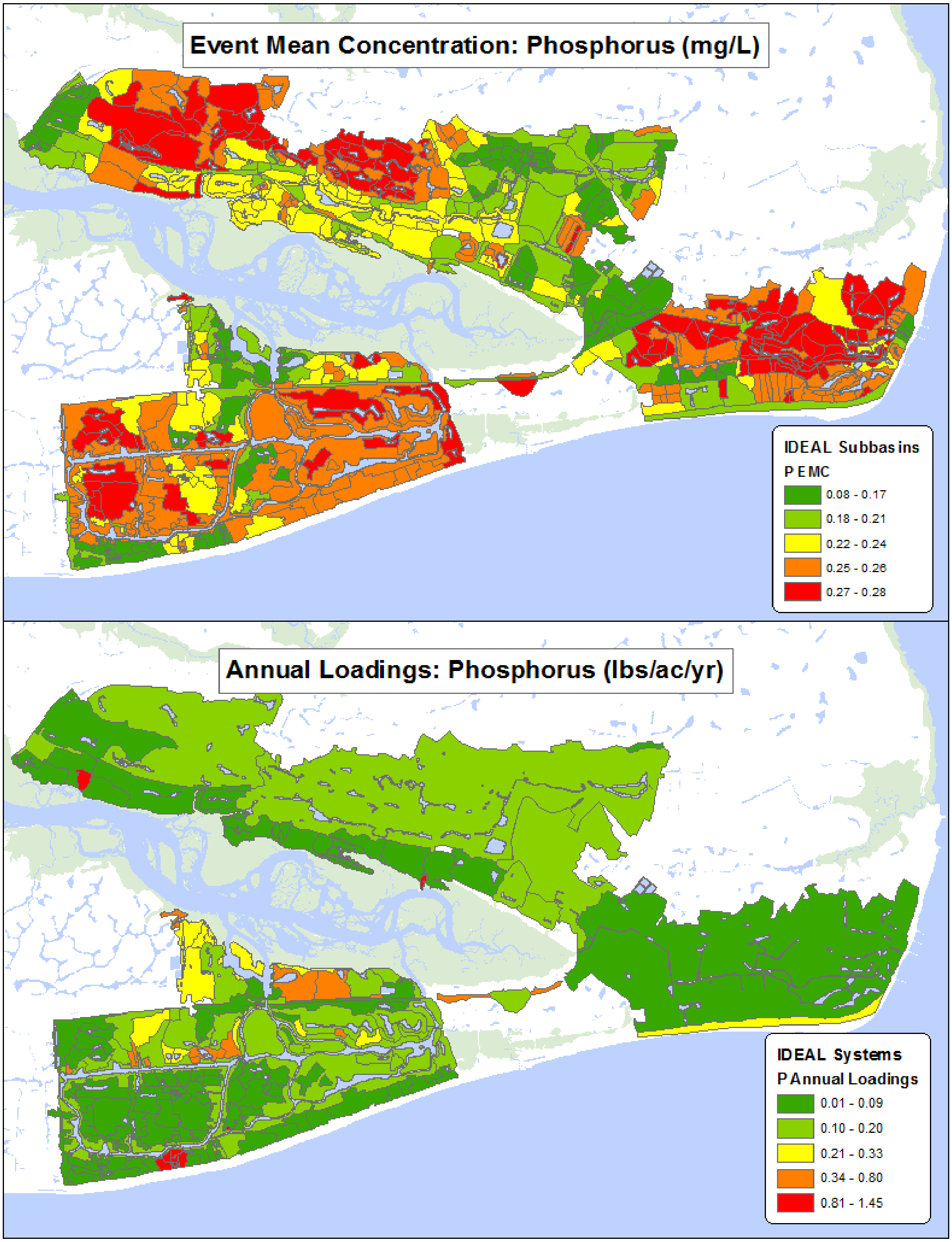


Figure 11: IDEAL modeling results for total phosphorus. Top map shows event mean concentrations at the subbasin level. Bottom map shows annual loadings at a system scale.

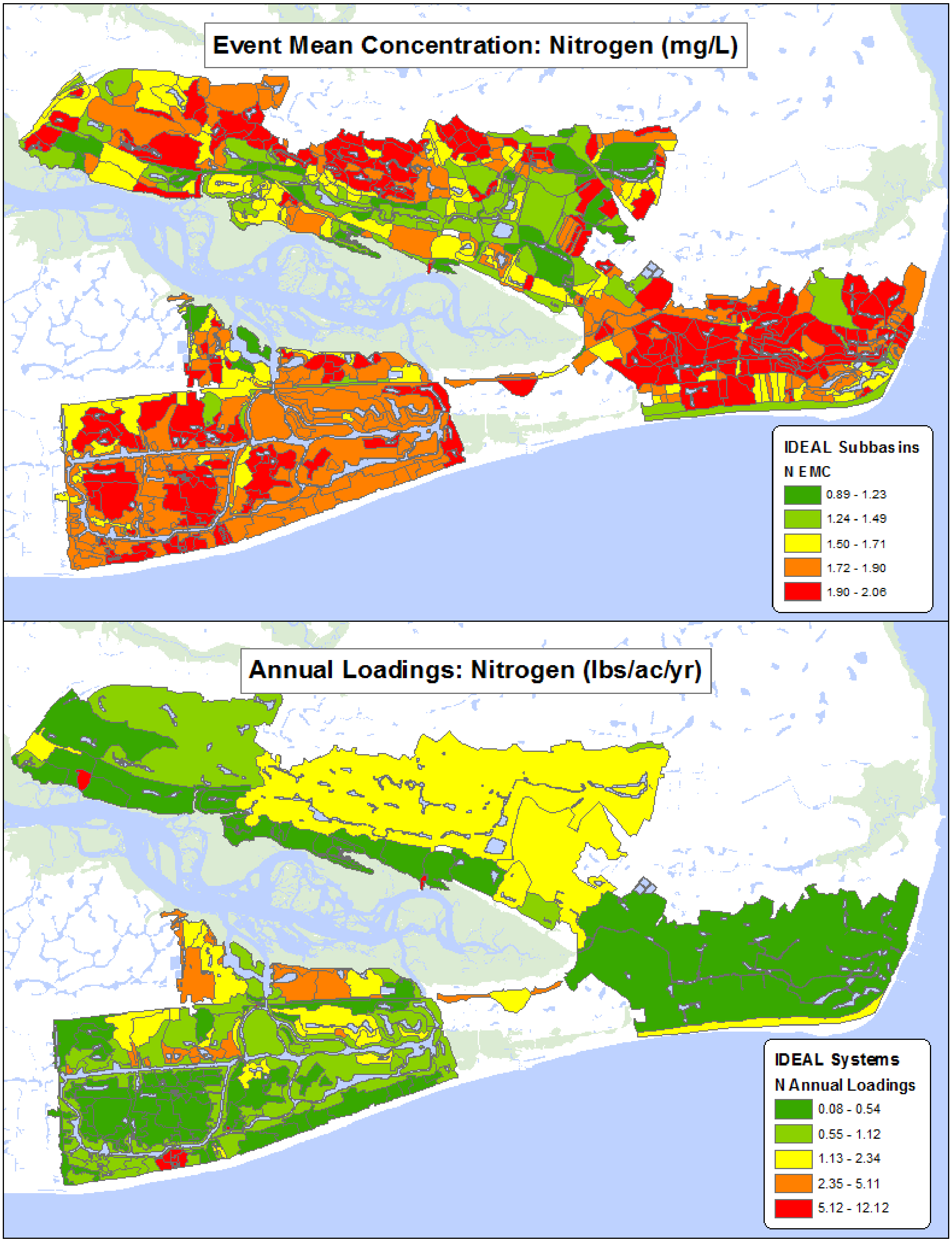


Figure 12: IDEAL modeling results for total nitrogen. Top map shows event mean concentrations at the subbasin level. Bottom map shows annual loadings at a system scale.

Proposed Management Measures

Evaluation of Best Management Practices

As part of this study, thirty-seven (37) potential best management practice (BMP) locations were identified in areas with the highest pollution potential. Ultimately, these 37 sites were prioritized and narrowed down to ten (10) potential projects that had the most promise for being effective implementations.

The criteria used for prioritizing potential BMPs were:

- *Contribution to bacteria problems* – including proximity to Broad Creek, existing treatment measures, and the loading rate. This variable was strongly considered and ended up significantly narrowing down the list of potentially effective BMPs, as much of the study area already drains to existing ponds before entering Broad Creek. Other pollutants like nutrients and sediment are also important to the Town, but the impairment in Broad Creek is due to fecal coliform levels. Therefore, the Town prioritized BMPs based on their potential bacteria removal efficiencies.
- *Available land area* – only considered the possibly of locating BMPs in currently open, pervious areas to avoid disturbing existing structures, pavement or trees. The amount of tree cover on the island made this a significant limiting factor.
- *Drainage area* – drainage area size was considered, as larger drainage areas increase the potential positive water quality impacts of BMPs.
- *Feasibility* – BMPs were only considered in locations that would not require extensive modifications to existing drainage networks and infrastructure.
- *Property ownership* – publicly owned properties present the fewest obstacles to BMP construction, while private property may be subject to negotiations with the landowner and possible purchase of the land. While both public and private properties were considered for potential sites, priority was given to public properties.

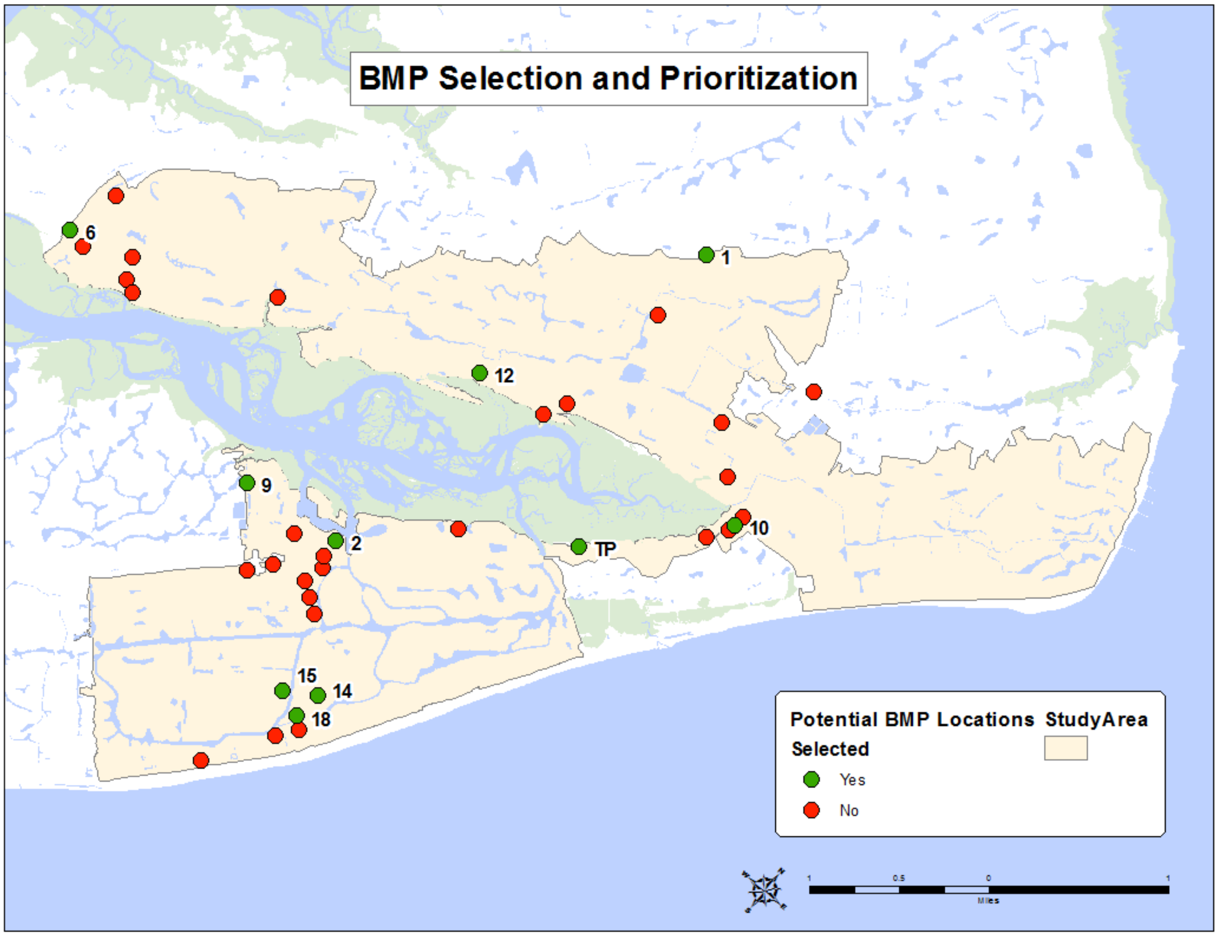


Figure 13: Map showing locations of potential BMP locations. 10 out of 37 potential sites were chosen for detailed evaluation.

The ten selected sites were then modeled with IDEAL to estimate their impacts on pollutant reduction. Several sites were modeled for different types of BMPs as well. A summary table of these results can be found below in Table 2, and detailed descriptions for each proposed BMP can be found in Appendix A of this report. Although fecal coliform is the primary pollutant of concern for this study, total nitrogen and total phosphorus loading reductions were also estimated for each of the proposed BMPs.

The majority of these BMPs show significant opportunities to remove bacteria and nutrients from stormwater runoff. Only sites 1 and 9 show minimal opportunities for improvement.

Table 2: Table showing modeled annual load reductions from proposed BMPs.

Site ID	BMP Description	Existing Annual Load, lbs or CFU			Annual Removal by Proposed BMP, lbs or CFU			Percent Reduction		
		TN	TP	Bacteria	TN	TP	Bacteria	TN	TP	Bacteria
1	Bio-swale	1,257	164.7	7.90E+12	3	0.26	1.10E+10	<1%	<1%	<1%
2	Bioretention Cell	9.6	0.92	3.00E+11	3.8	0.45	1.20E+11	39%	49%	39%
6	Bio-swale	31.5	3.03	1.00E+12	4.1	0.43	2.00E+11	13%	14%	20%
9	Wet Pond Riser	122.6	13.96	2.00E+12	0.3	0.03	3.00E+09	<1%	<1%	<1%
10	Filtrexx check dams	78.7	9.28	2.70E+12	55.1	8.7	2.70E+12	70%	94%	99%
12	Filtrexx Check Dams	4	0.6	1.10E+11	1.5	0.35	7.30E+10	38%	58%	66%
14*	Bioretention Cell (BRC)	1.7	0.1	6.10E+10	1.7	0.1	6.10E+10	99%	99%	99%
15*	Distributed BRCs	40.8	2.41	1.60E+12	34.6	2.0	1.35E+12	85%	85%	84%
18*	2 Filterra units	5.4	0.57	2.60E+11	2.1	0.31	2.25E+11	39%	55%	87%
TP	Bioretention Cells	31.8	3.33	1.30E+12	30.5	3.1	1.29E+12	96%	94%	99%

**For the 3 BMPs in Palmetto Dunes, the canal system is treated as the receiving waterbody.*

Table 3: BMPs ranked by bacteria removal potential.

Area	Site ID	BMP Description	Annual Pollutant Removal		
			TN (lbs)	TP (lbs)	Bacteria (CFU)
Port Royal	10	Filtrexx Check Dams	55.1	8.7	2.70E+12
Palmetto Dunes*	15	Distributed Bioretention Cells	34.6	2	1.40E+12
Port Royal	TP	Bioretention Cells	30.5	3.1	1.30E+12
Palmetto Dunes*	18	Filterra Inlet Filters	2.1	0.31	2.30E+11
Indigo Run	6	Bio-swale	4.1	0.43	2.00E+11
Shelter Cove	2	Bioretention Cell	3.8	0.45	1.20E+11
Indigo Run	12	Filtrexx Check Dams	1.5	0.35	7.30E+10
Palmetto Dunes*	14	Bioretention Cell	1.7	0.1	6.10E+10
Indigo Run	1	Bio-swale	3	0.26	1.10E+10
Shelter Cove	9	Wet Pond Riser	0.3	0.03	3.00E+09

Implementation Plan

Costs and Technical/Financial Assistance

Cost Analysis

Estimated installation costs for the ten BMPs that were evaluated are available in the table below. During the design phase for each of these projects, the Town will also need to estimate recurring maintenance costs to keep the BMPs functioning as intended.

Table 4: Installation costs for the 10 evaluated BMPs.

Site	Installation Cost Estimate
ID 01	$15,000
ID 02	$26,000
ID 06	$12,000
ID 09	$8,000
ID 10	$7,000 initially $94,000 for 15 years
ID 12	$6,000 initially, $64,000 for 15 years
ID 14	$45,000
ID 15	$169,000
ID 18	$21,000
ID TP	$265,000

Technical Assistance

Prior to actually constructing any of the proposed BMPs, the Town will need accurate surveys and geotechnical analyses to determine site specific soils and water table levels. The Town has professional engineers on staff that can produce detailed construction plans, and it also has on-call contracts with drainage engineering firms if necessary. Designers should also consult with landscape architects to determine appropriate plantings for bioswales and bioretention areas and to develop landscape maintenance plans.

The Town could also use the technical expertise of its water quality monitoring contractor to help develop and implement a monitoring plan that will effectively assess the performance of the BMPs once constructed.

Financial Assistance

The Town anticipates that the majority of funding for implementation of this plan will come from its Stormwater Utility Fund – an enterprise account funded by annual stormwater utility fees charged to property owners. The stormwater utility has an annual budget of approximately $3.5 million, much of which currently goes toward repairs and maintenance on privately-owned drainage systems for which the Town has taken over maintenance responsibilities. Most of the proposed BMPs have construction costs that should be able to be worked into the stormwater project budget over the next several years. A few of the proposed BMPs have fairly significant construction costs, and it would likely be several years before the Town would be able to fit those into the budget without additional external funding.

One option for external funding is the SC DHEC 319 Grant program, which offers grants specifically for implementing approved watershed plans. With the completion and approval of this watershed plan, the Town becomes eligible to apply for matching grant funds to implement all or portions of the plan. One thing to keep in mind with grant funding is that Broad Creek, as of 2014, is no longer on the impaired waters list. This does not necessarily disqualify the Town for eligibility, as DHEC will consider projects for which the purpose is to preserve and protect water quality in unimpaired watersheds. However, historically the 319 grant program has focused on remediation projects in impaired watersheds, and it is possible that a Town grant proposal would receive less priority than proposals in watersheds with impairments.

The state revolving fund (SRF) – a loan program for water resources projects, including stormwater and nonpoint source projects – is also another funding option worth exploring. The SRF program offers low-interest loans to municipalities and utilities for upgrading or improving water/wastewater/stormwater infrastructure. The Town could look into using SRF funds for funding one or several of the proposed BMP construction projects evaluated in this plan.

Information and Education Component

Many of the proposed management measures in this plan are projects that will involve the construction of physical BMPs, as well as ongoing maintenance. However, it is unlikely that structural measures alone can provide the long-term water quality benefits that the Town seeks. Therefore, the Town should develop an educational outreach program that can complement the structural practices by promoting behavioral changes among residents, visitors, and other stakeholders.

One key group of stakeholders that will play an important role in the successful implementation of this plan is homeowner associations. Several of the proposed BMPs are located within the limits of planned unit development communities, so educating their homeowners on the need for and potential benefits of these projects will be critical. Without buy-in from these homeowner associations, some of these proposed projects may not be feasible.

The BMPs that are proposed to be constructed as part of this plan can themselves play an important role in the Town's education outreach program. Several of the proposed locations are adjacent to major roads on the island or are in areas that receive a high number of visitors during the summer season. The Town should consider taking advantage of these high-visibility projects and establish them as educational pilots. Signs could help explain to residents and visitors pollution issues and how these BMPs attempt to address those issues. Similarly, the Town could point to these projects as examples of the types of practices it would like to see private developers and contractors implement on future projects.

Outside of the structural BMPs proposed for this plan, the Town should develop outreach materials and campaigns that address two behavioral issues that could be significant contributors to bacterial pollution – residential pet waste and failing septic systems. The Town should consider distributing educational materials that educate residents on the potential environmental impacts of pet waste. Additionally the Town could consider promoting the installation of pet waste stations along its large network of public pathways, as well as near lagoons and ponds on residential and hotel properties.

In regards to the issue of failing septic systems, the Town and the Hilton Head Public Service District (which provides sanitary sewer services in the study area) have partnered to layout a path for providing sanitary sewer service to the PSD's entire service area over the next several years. However, in the meantime, the Town should consider an outreach program that targets property owners with septic systems and educates them on issues like regular maintenance of the system and how to detect potential problems. The Town may also want to consider establishing a program that provides technical, and possibly financial, assistance to property owners with septic systems that are in need of repair but do not have the resources to do so.

Schedule and Milestones

In light of the fact that the most likely source of funding for implementing this plan is the Town's Stormwater Utility Fund, the Town should have a goal to include one or more of the proposed BMPs each budget year over the next several years. Currently, most of the stormwater utility funds go towards maintaining older drainage systems for which the Town has taken over maintenance responsibilities; however, as some of these existing maintenance issues get repaired the Town hopes to have more funds available to use for watershed improvement projects.

The Town's fiscal year runs from July 1 – June 30, and at the time of this report budgeting is already well underway for fiscal year 2017 (July 1, 2016 – June 30, 2017). Therefore, any actions taken during FY17 will likely be at the planning level: developing educational/outreach program and materials, reaching out to stakeholders/property owners for BMPs proposed on private property, discussions with SCDOT for BMPs proposed in state rights-of-way, and preliminary engineering designs. Starting in Fiscal Year 2018, the Town should be able to start adding one or more of the proposed projects into its budget on an annual basis. The table below provides a proposed schedule for completing the BMPs proposed in this plan.

Table 5: Schedule and milestones for plan implementation.

Schedule	
Fiscal Year	Milestone
2017	Develop outreach/educational program
	Research/apply for funding opportunities
	Reach out to private property owners for potential project buy-in
2018	Purchase & Install Filtrexx Check Dams (Projects: 10 & 12)
	Begin implementing updated WQ Monitoring strategy. Amend contracts and obtain equipment as needed.
	Begin planning/design for Project TP, apply for any external funding
2019	Projects 2, 9, 18 (On existing Town property or property with Town easement)
	Construct Project TP
	Evaluate educational and outreach program effectiveness
2020-2021	Evaluate feasibility of remaining projects (those completely on private property or SCDOT rights-of-way)
	Evaluate overall project implementation
	Determine if pollutants are being reduced by BMPs

Evaluation Criteria

It is impossible to judge the success of a plan without coming up with indicators for measuring success. Naturally, the most important metric for measuring the success of this plan is whether or not Broad Creek can remain off the 303(d) list of impaired waters. Since most of the management measures proposed in this plan are physical BMPs, one evaluation metric should be an annual assessment of progress made towards installation of these BMPs. Additionally, once BMPs have been installed they should be evaluated for pollutant removal function (see monitoring strategy).

Another criterion for evaluation should focus on trends in water quality samples that the Town collects. 3 current sampling locations had well-under 50% of samples meeting the standards for fecal coliform, and all five sampling locations in the study area had fewer than 25% of samples meeting the guidelines for phosphorus levels. Since nitrogen levels generally met the standards during the sampling period, the focus should be on increasing the percentage of samples that meet the standards or guidelines for fecal coliform and phosphorus. A good aspirational goal would be for 80+% of Town water quality samples to meet or exceed the state standards or guidelines; however, with the percentages of samples meeting these limits being extremely low for fecal coliform and phosphorus, a reasonable intermediate goal might be achieving compliance with the standards on 50% or more of samples.

Monitoring Strategy

The goal of the Town's monitoring strategy associated with this plan should have two goals: to assess whether pollutant levels are dropping in Broad Creek and to assess the pollutant removal effectiveness of individual BMP installations. There is a need for ambient water quality monitoring in Broad Creek as well as screening at stormwater outfall locations. Currently, SC DHEC conducts ambient water quality monitoring at several stations in Broad Creek. The Town, with the help of a consulting firm, conducts water quality monitoring at stormwater outfalls and a few upstream locations during both wet and dry weather.

The primary pollutants that need to be considered for monitoring are fecal coliform bacteria, nitrogen, and phosphorus. Some other parameters such as dissolved oxygen, chlorophyll a, and pH could also provide useful information about the health of the waters. Currently, the Town's water quality monitoring program assesses about twenty parameters, but it may be worth evaluating the need to continue to analyze all of these on a regular basis. By focusing on a few primary parameters, the Town could potentially save laboratory analysis costs and divert funds to start monitoring at more locations. The Town should also weigh the costs and benefits of purchasing some water quality testing equipment to conduct some sampling in-house while still outsourcing some sampling and analysis, particularly for bacteria.

References

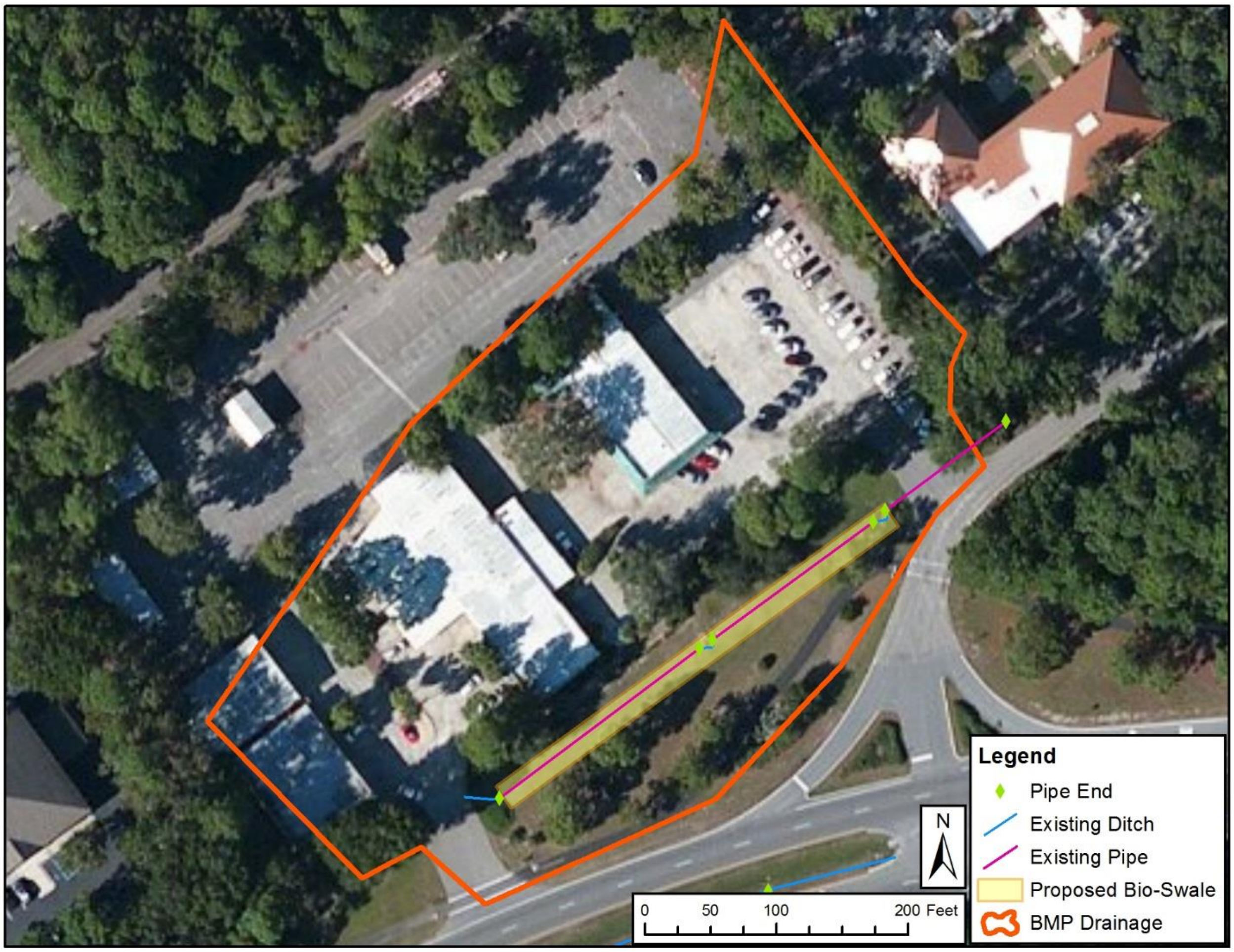
American Veterinary Medical Association (AVMA), 2012. "U.S. Pet Ownership Statistics". https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx

Carolina Clear, 2015. "Pet Waste". http://www.clemson.edu/public/carolinaclear/consortiums/lcsc_home/pet_waste.html

South Carolina Department of Health and Environmental Control (SCDHEC), 2014. "R.61-68, Water Classifications & Standards. http://www.scdhec.gov/agency/docs/water-regs/r.61-68.pdf

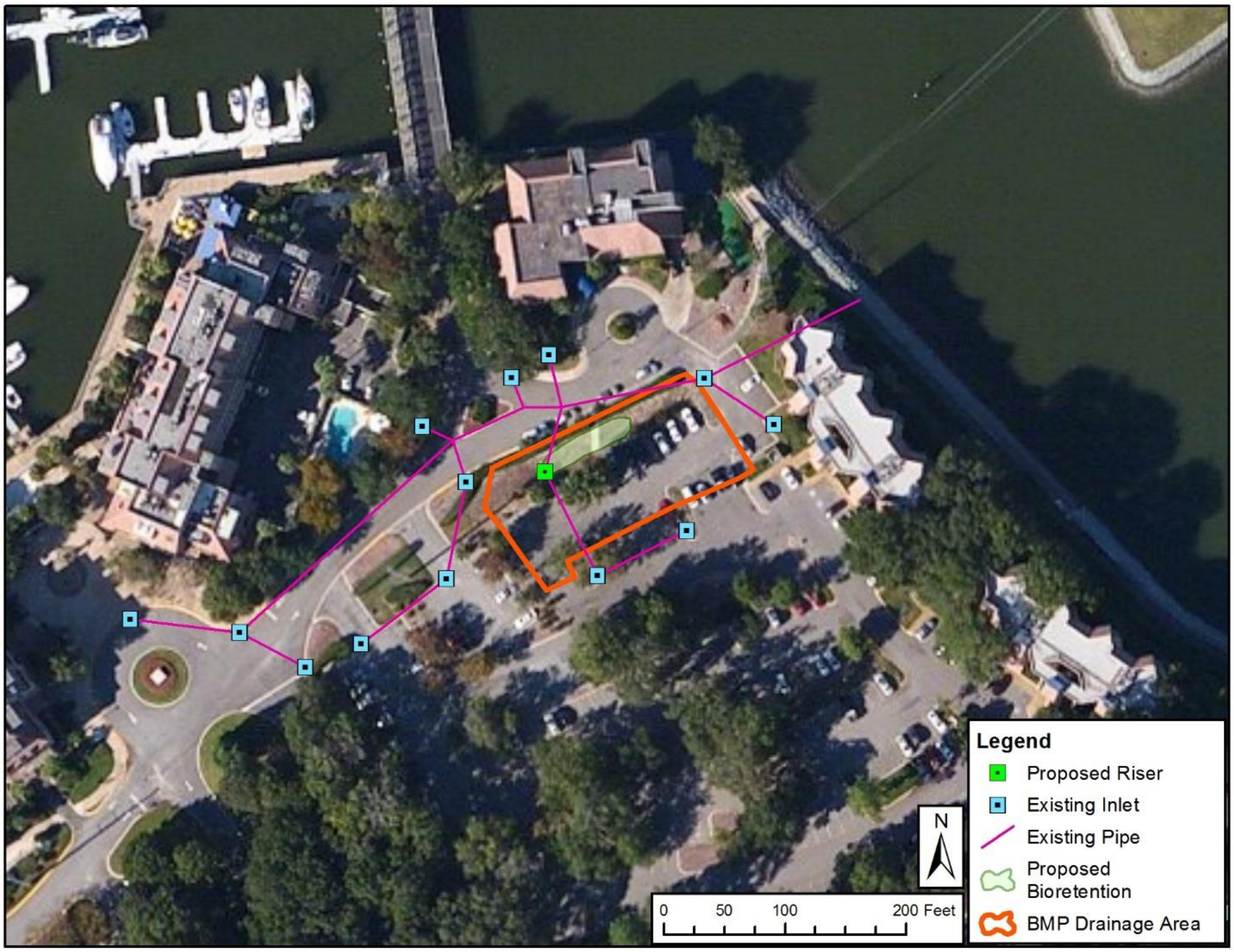
APPENDIX A: BMP CUT SHEETS

Location ID 01: Automobile Place Bio-Swale Design		
Existing: Subbasin is 3.3 acres with 76% impervious surface at the intersection of Automobile Pl and William Hilton Pkwy. Lot was formerly a car dealership. Runoff discharges through pipe to the East.	Sediment Reduction	31%
	Nitrogen Reduction	13%
	Phosphorus Reduction	13%
Proposed Design: Remove two pipes and excavate to create a Bio-Swale that is 365 feet long and 20 feet wide.	Bacteria Reduction	12%
	Estimated Cost = $15,000	
Additional Notes		
A Dry Pond was also considered- see other cut sheets. Bioretention was not modeled here because there is not enough available head for an effective underdrain.		



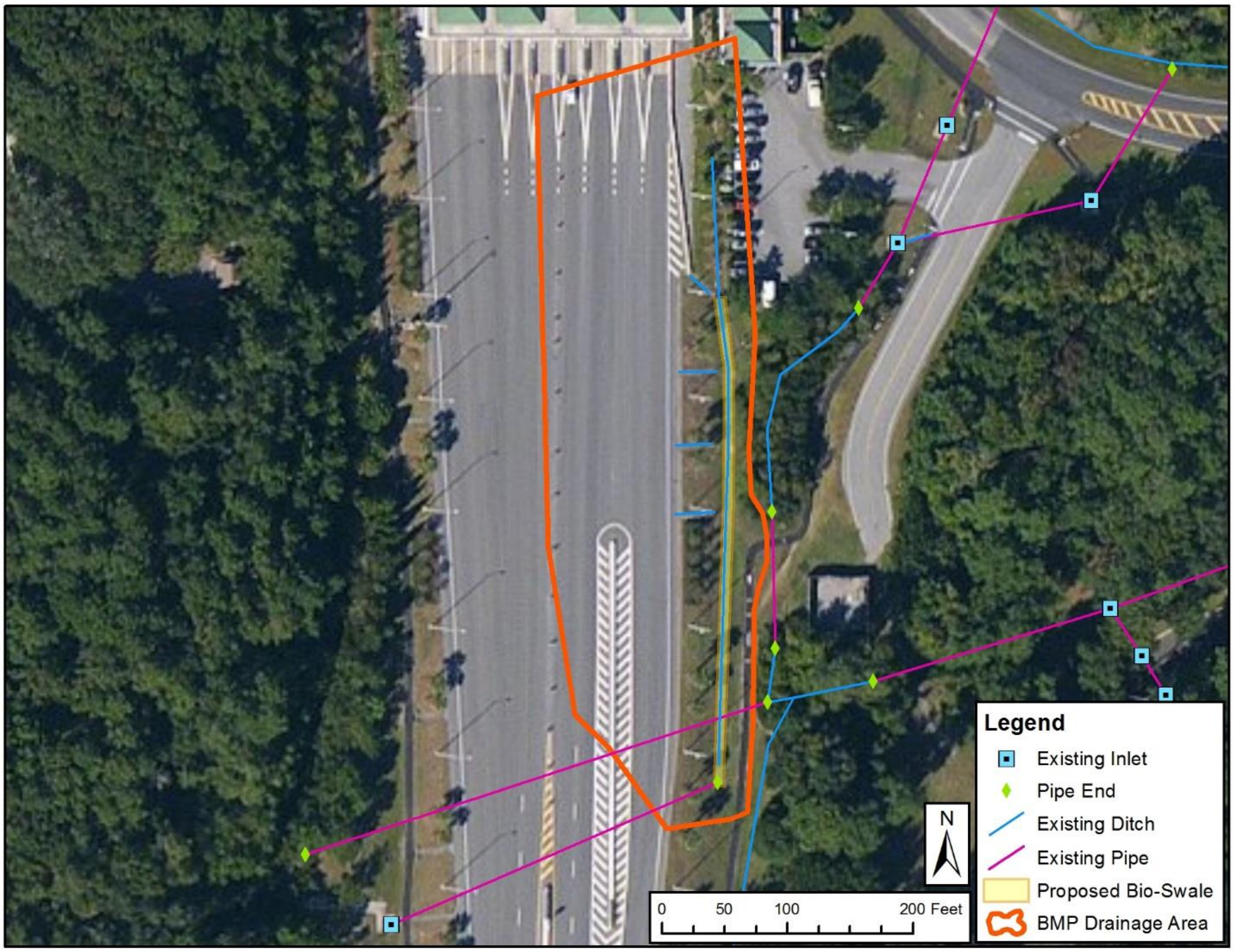
Total Annual Removal and Unit Cost of Removal		
Parameter	**Amount Removed Annually**	**Unit Cost**
Sediment	817 lbs	$18 per lb
TN	3.8 lbs	$4,000 per lb
TP	0.26 lbs	$57,000 per lb
Bacteria	9.3×10^{10} CFU	$162 per 10^9 CFU

Location ID 02: Harbourside Lane Bioretention Design		
Existing: Subbasin is 0.3 acres with 65% impervious surface in a parking lot at the end of Harbourside Ln. Runoff currently sheet flows to an inlet and discharges through existing pipe to Broad Creek.	Sediment Reduction	>99%
	Nitrogen Reduction	>99%
	Phosphorus Reduction	>99%
Proposed Design: Replace existing inlet with 1.5 foot high riser. Excavate and add media to create 0.03 ac bioretention cell in parking lot median. Replace pedestrian sidewalk with elevated walkway.	Bacteria Reduction	>99%
	Estimated Cost = $26,000	
Additional Notes		
BMP drainage area limited by existing infrastructure which bypasses proposed bioretention area.		



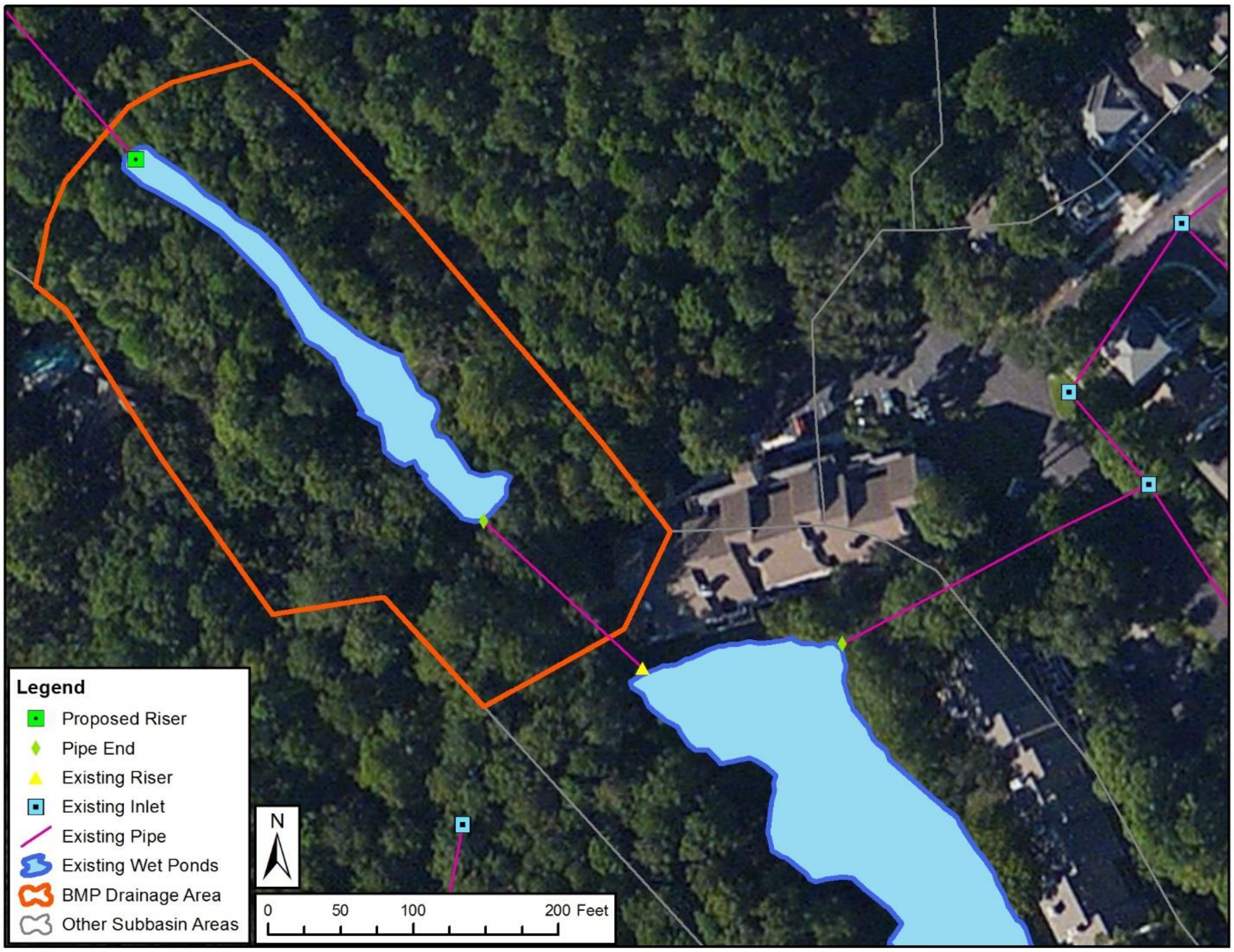
Total Annual Removal and Unit Cost of Removal		
Parameter	**Amount Removed Annually**	**Unit Cost**
Sediment	217 lbs	$120 per lb
TN	3.8 lbs	$6,900 per lb
TP	0.45 lbs	$58,000 per lb
Bacteria	1.2×10^{11} CFU	$226 per 10^9 CFU

Location ID 06: Cross Island Parkway Bio-Swale Design		
Existing: Subbasin is 1.5 acres with 67% impervious surface located at the Cross Island Pkwy toll plaza. Runoff currently flows from the road into a ditch and then a pipe that discharges on the West side of the road.	Sediment Reduction	38%
	Nitrogen Reduction	27%
	Phosphorus Reduction	27%
Proposed Design: Excavate existing channel to create a Bio-Swale that is 385 feet long and 8 feet wide.	Bacteria Reduction	26%
	Estimated Cost = $12,000	
Additional Notes		
A Dry Pond was also considered- see other cut sheets. Bioretention was not modeled here because there is not enough available head for an effective underdrain.		



Total Annual Removal and Unit Cost of Removal		
Parameter	**Amount Removed Annually**	**Unit Cost**
Sediment	418 lbs	$29 per lb
TN	4.1 lbs	$2,900 per lb
TP	0.43 lbs	$28,000 per lb
Bacteria	2.0×10^{11} CFU	$59 per 10^{9} CFU

Location ID 09: Yacht Cove Drive Wet Pond Riser Retrofit Design		
Existing: Subbasin is 1.5 acres with 8% impervious surface at the end of Yacht Cove Dr. Existing wet pond receives water from upstream pond and other subbasins and ponds. Total contributing drainage area is 43.4 acres.	Sediment Reduction	8%
	Nitrogen Reduction	<1%
	Phosphorus Reduction	<1%
Proposed Design: Pond currently has a flashboard riser without boards to restrict flow. Riser will be replaced with a rectangular riser with a 4 inch orifice located at a stage of 1 foot.	Bacteria Reduction	<1%
	Estimated Cost = $8,000	
Additional Notes		
This pond is on land owned by THHI. The large pond immediately upstream improves water quality to the extent that it limits the potential water quality impact of a retrofit to this pond (lower initial pollutant loads entering this pond makes further reductions more difficult).		



Total Annual Removal and Unit Cost of Removal		
Parameter	**Amount Removed Annually**	**Unit Cost**
Sediment	86 lbs	$93 per lb
TN	0.3 lbs	$27,000 per lb
TP	0.03 lbs	$270,000 per lb
Bacteria	3.0×10^9 CFU	$2,700 per 10^9 CFU

Location ID 10: Mathews Drive Outfall Filtrexx Check Dam Design		
Existing: Subbasin is 10.5 acres with 46% impervious surface at the intersection of Folly Field Rd/Mathews Dr and William Hilton Pkwy. System discharges through ditch to outfall.	Sediment Reduction	12%
	Nitrogen Reduction	70%
	Phosphorus Reduction	94%
Proposed Design: A series of three Filtrexx check dams in the channel. Each check dam is a pyramid made of three 12" diameter Filtrexx Envirosoxx with pollutant removing media.	Bacteria Reduction	99%
	Estimated Initial Cost = $7,000 **Estimated Cost for 15 Years = $94,000**	
Additional Notes		
Life expectancy of Filtrexx check dams varies but averages 6 months. Unit costs were adjusted for the table below to simulate the cost of replacement for 15 years, similar to the lifespan of other BMPs in this analysis. Cost for each replacement is estimated to be $3,000.		

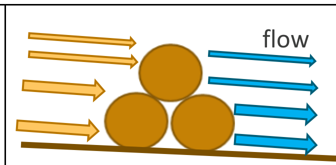
Total Annual Removal and Unit Cost of Removal			
Parameter	**Amount Removed Annually**	**Unit Cost**	**Adjusted Unit Cost (for 15 Years)**
Sediment	635 lbs	$11 per lb	$148 per lb
TN	55.1 lbs	$127 per lb	$1,700 per lb
TP	8.7 lbs	$806 per lb	$10,800 per lb
Bacteria	$2.7x10^{12}$ CFU	$3 per 10^9 CFU	$35 per 10^9 CFU

Location ID 12: Marshland Road Outfall Filtrexx Check Dam Design

Existing: Subbasin is 17.4 acres with 12% impervious surface along Marshland Rd between Aiken Pl and Joyce Ln. System discharges through ditch to outfall.

Sediment Reduction	11%
Nitrogen Reduction	55%
Phosphorus Reduction	84%
Bacteria Reduction	99%

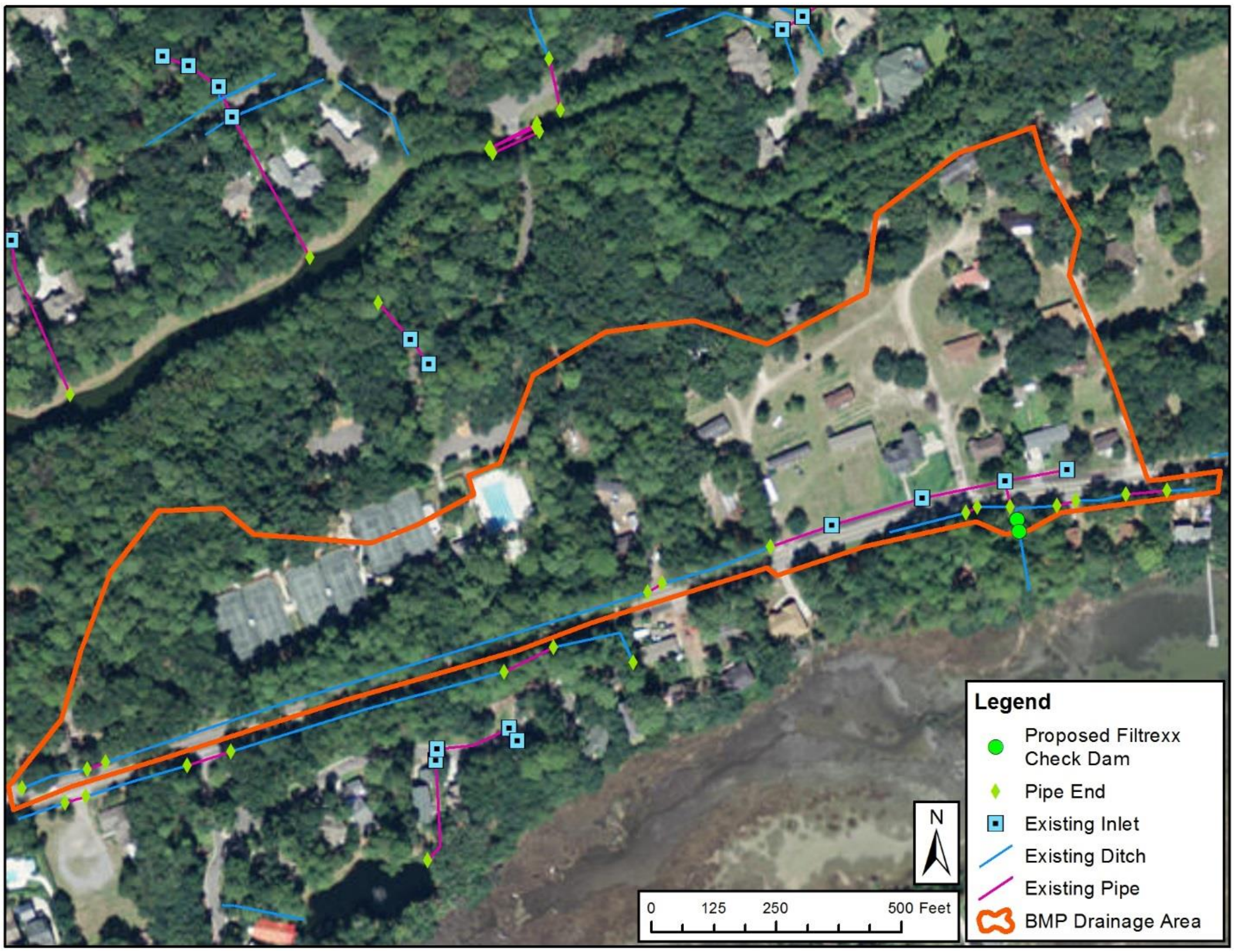
Proposed Design: A series of two Filtrexx check dams in the channel. Each check dam is a pyramid made of three 12” diameter Filtrexx Envirosoxx with pollutant removing media.



Estimated Initial Cost = $6,000
Estimated Cost for 15 Years = $64,000

Additional Notes

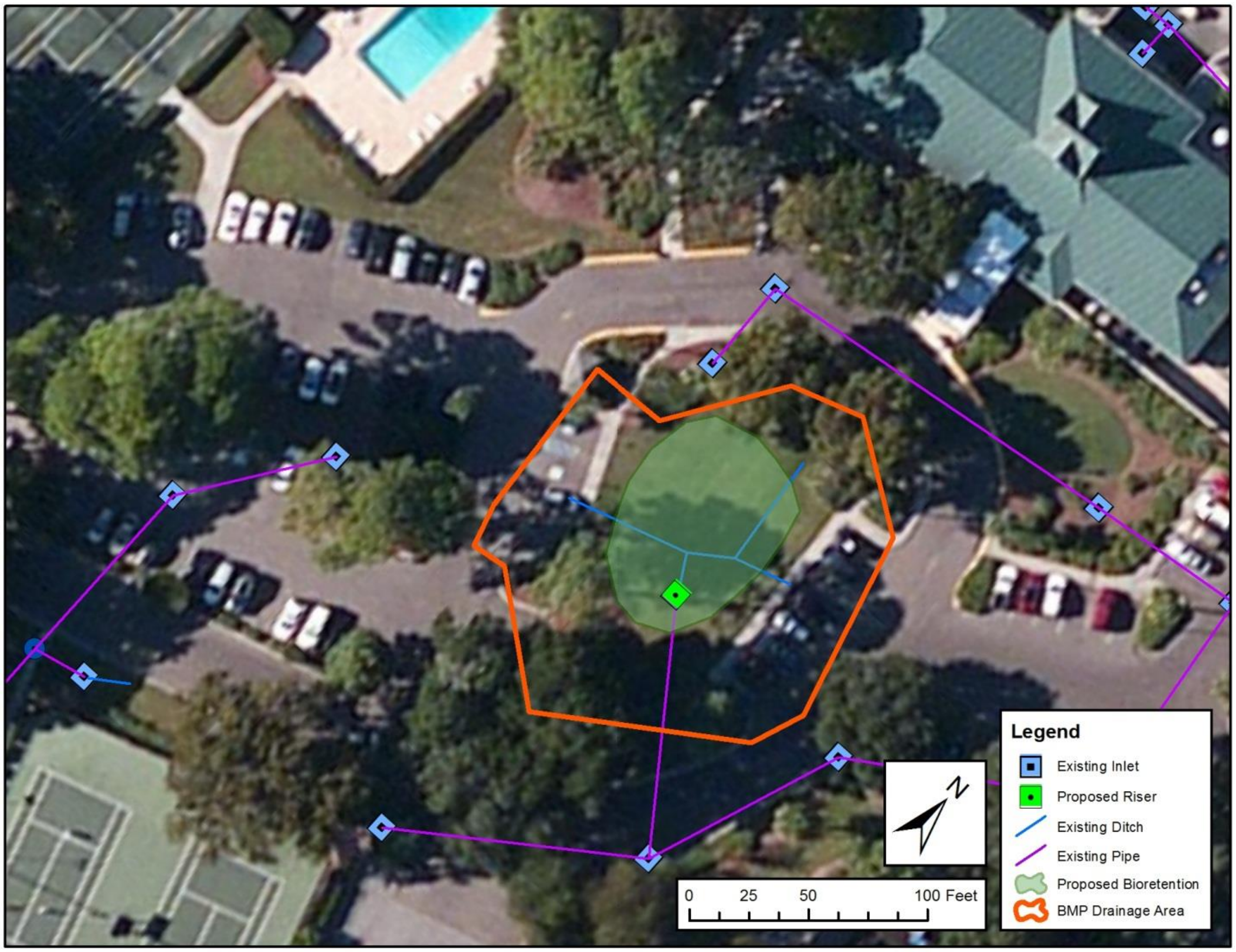
Life expectancy of Filtrexx check dams varies but averages 6 months. Unit costs were adjusted for the table below to simulate the cost of replacement for 15 years, similar to the lifespan of other BMPs in this analysis. Cost for each replacement is estimated to be $2,000.



Total Annual Removal and Unit Cost of Removal

Parameter	Amount Removed Annually	Unit Cost	Adjusted Unit Cost (for 15 Years)
Sediment	113 lbs	$53 per lb	$570 per lb
TN	1.5 lbs	$3,900 per lb	$42,000 per lb
TP	0.35 lbs	$17,000 per lb	$184,000 per lb
Bacteria	7.3×10^{10} CFU	$83 per 10^{9} CFU	$880 per 10^{9} CFU

Location ID 14: Trent Jones Lane Parking Lot Island Bioretention Design		
Existing: Subbasin is 0.3 acres with 34% impervious surface in a golf course parking lot. There is an existing grate inlet and pipe draining the parking lot island.	Sediment Reduction	99%
	Nitrogen Reduction	99%
	Phosphorus Reduction	99%
Proposed Design: Replace grate inlet with and excavate 0.07 acre bioretention cell with two feet of soil media. Riser is 1.5 feet high.	Bacteria Reduction	99%
	Estimated Cost = $45,000	
Additional Notes		
Small drainage area because of existing stormwater infrastructure. Lower cost is possible if existing riser can be used.		



Total Annual Removal and Unit Cost of Removal		
Parameter	**Amount Removed Annually**	**Unit Cost**
Sediment	123 lbs	$366 per lb
TN	1.68 lbs	$26,800 per lb
TP	0.10 lbs	$450,000 per lb
Bacteria	$6.1x10^{10}$ CFU	$735 per 10^9 CFU

Location ID 15: Carnoustie Road Tennis Facility Bioretention Design

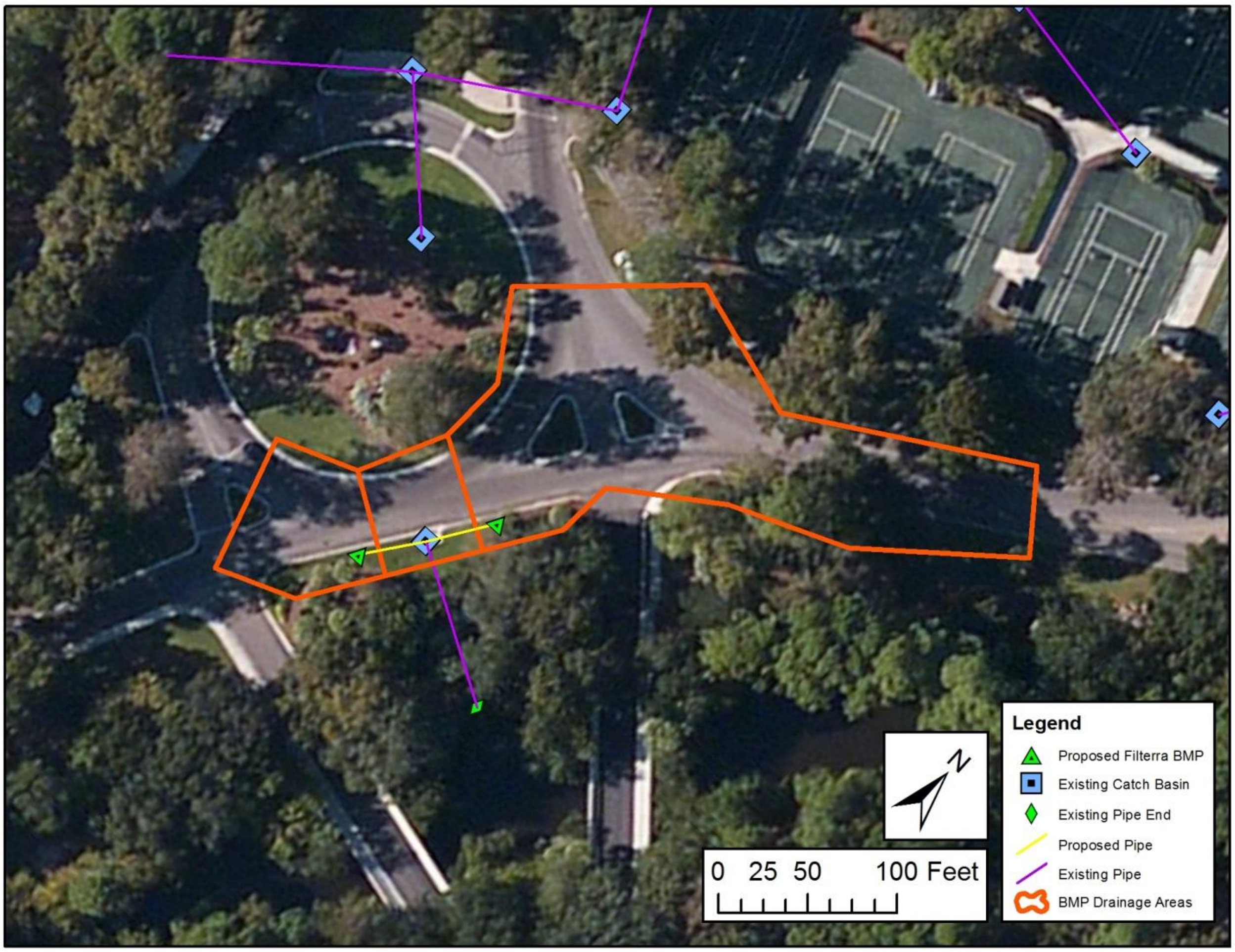
Existing: Subbasin is 2.9 acres with 60% impervious surface consisting of tennis courts, parking lot, and sidewalks. Experiences high clay loads from the tennis courts.	Sediment Reduction	85%
	Nitrogen Reduction	85%
	Phosphorus Reduction	85%
Proposed Design: 0.22 acres of bioretention at four locations within the subbasin. Assume 2/3 of subbasin area is routed to bioretention and treated.	Bacteria Reduction	84%
	Estimated Cost = $169,000	

Additional Notes

Bioretention cell locations and sizes are approximate. This is a conceptual estimate- there is no guarantee all the drainage area shown can be directed to BMPs without major changes to drainage structures.

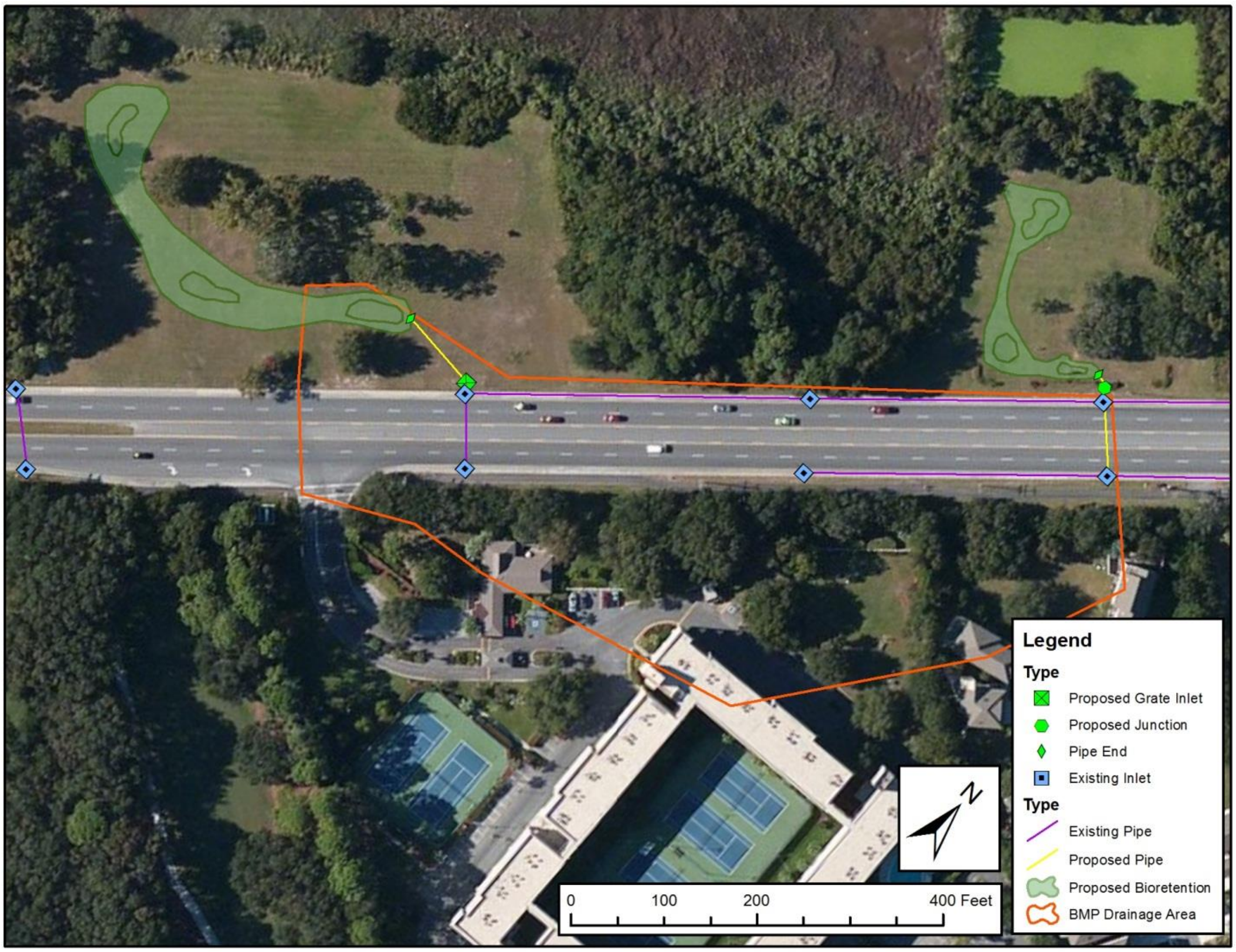
Total Annual Removal and Unit Cost of Removal		
Parameter	**Amount Removed Annually**	**Unit Cost**
Sediment	2625 lbs	$64 per lb
TN	34.5 lbs	$4,900 per lb
TP	2.0 lbs	$83,000 per lb
Bacteria	$1.4x10^{12}$ CFU	$122 per 10^9 CFU

Location ID 18: Ocean Lane Traffic Circle Filterra BMP Design		
Existing: Subbasin is 0.6 acres with 60% impervious surface consisting of roadway and surrounding area. Runoff drains through existing catch basin and pipe to outfall.	Sediment Reduction	30%
	Nitrogen Reduction	39%
	Phosphorus Reduction	55%
Proposed Design: Install two Filterra BMPs to treat runoff before it reaches existing catch basin and outfall.	Bacteria Reduction	87%
	Estimated Cost = $21,000	
Additional Notes		
Plantings in Filterra units may be limited by line-of-sight restrictions.		



Total Annual Removal and Unit Cost of Removal		
Parameter	**Amount Removed Annually**	**Unit Cost**
Sediment	120 lbs	$175 per lb
TN	2.1 lbs	$10,000 per lb
TP	0.31 lbs	$67,000 per lb
Bacteria	2.3×10^{11} CFU	$93 per 10^9 CFU

Location ID TP: William Hilton Parkway Bioretention Design		
Existing: Subbasin is 4 acres with 50% impervious surface including William Hilton Parkway and surrounding properties. Road has existing catch basins and concrete pipe.	Sediment Reduction	99%
	Nitrogen Reduction	96%
	Phosphorus Reduction	94%
Proposed Design: Modeled plans provided by town showing series of dry ponds. Included new pipe crossing road and replaced catch basins to route additional flow to the ponds.	Bacteria Reduction	99%
	Estimated Cost = $265,000	
Additional Notes		
Plans provided for these BMPs labeled them as bioretention but did not specify media, riser, or underdrain. This design assumed a 1-foot depth of soil media, and an underdrain.		



Total Annual Removal and Unit Cost of Removal		
Parameter	**Amount Removed Annually**	**Unit Cost**
Sediment	2211 lbs	$120 per lb
TN	30.5 lbs	$8,700 per lb
TP	3.1 lbs	$85,000 per lb
Bacteria	1.3×10^{12} CFU	$204 per 10^9 CFU

APPENDIX B:
FULL-SIZE WATER QUALITY CHARTS

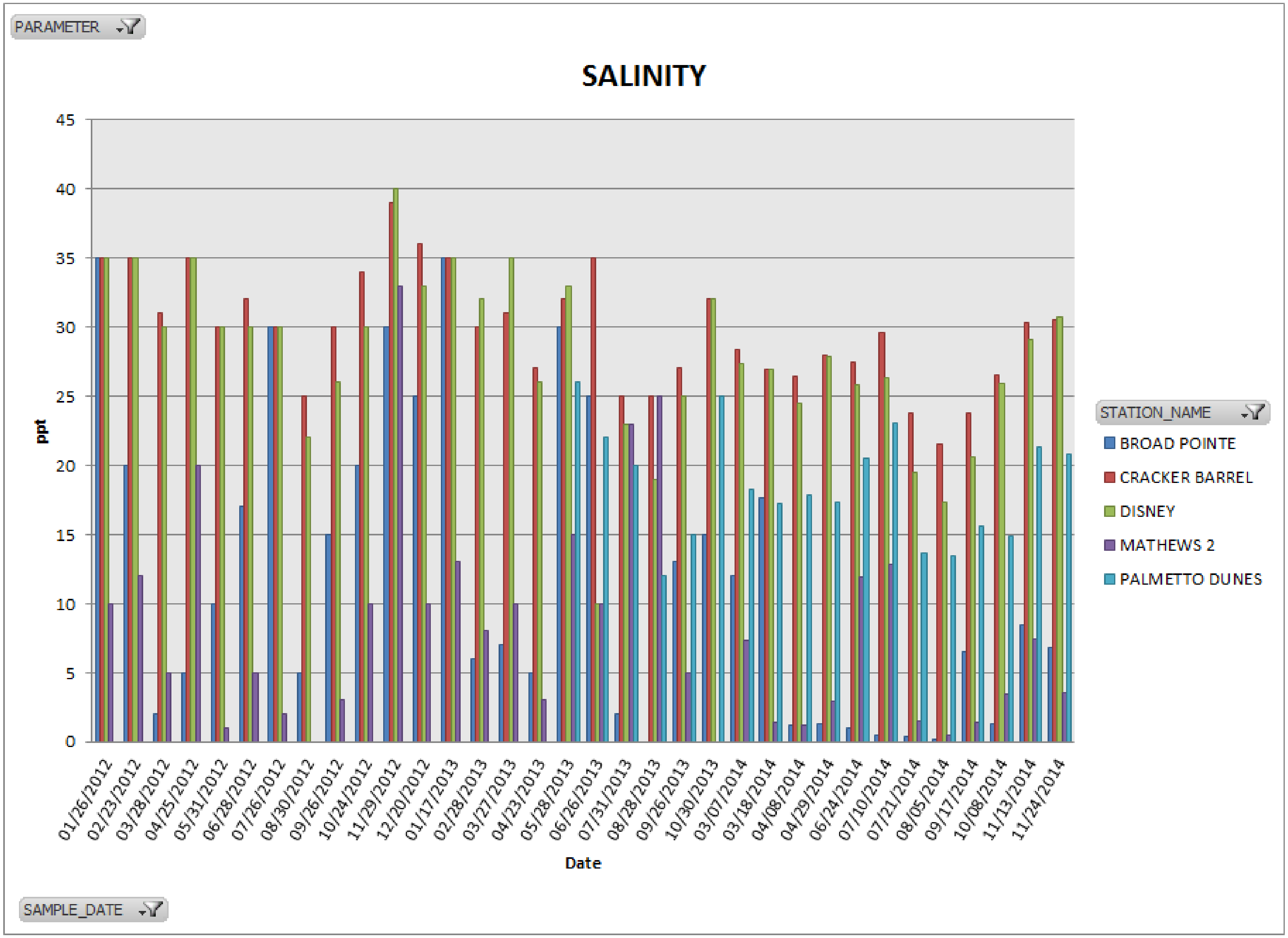


Figure 1: Salinity levels at Town sampling locations.

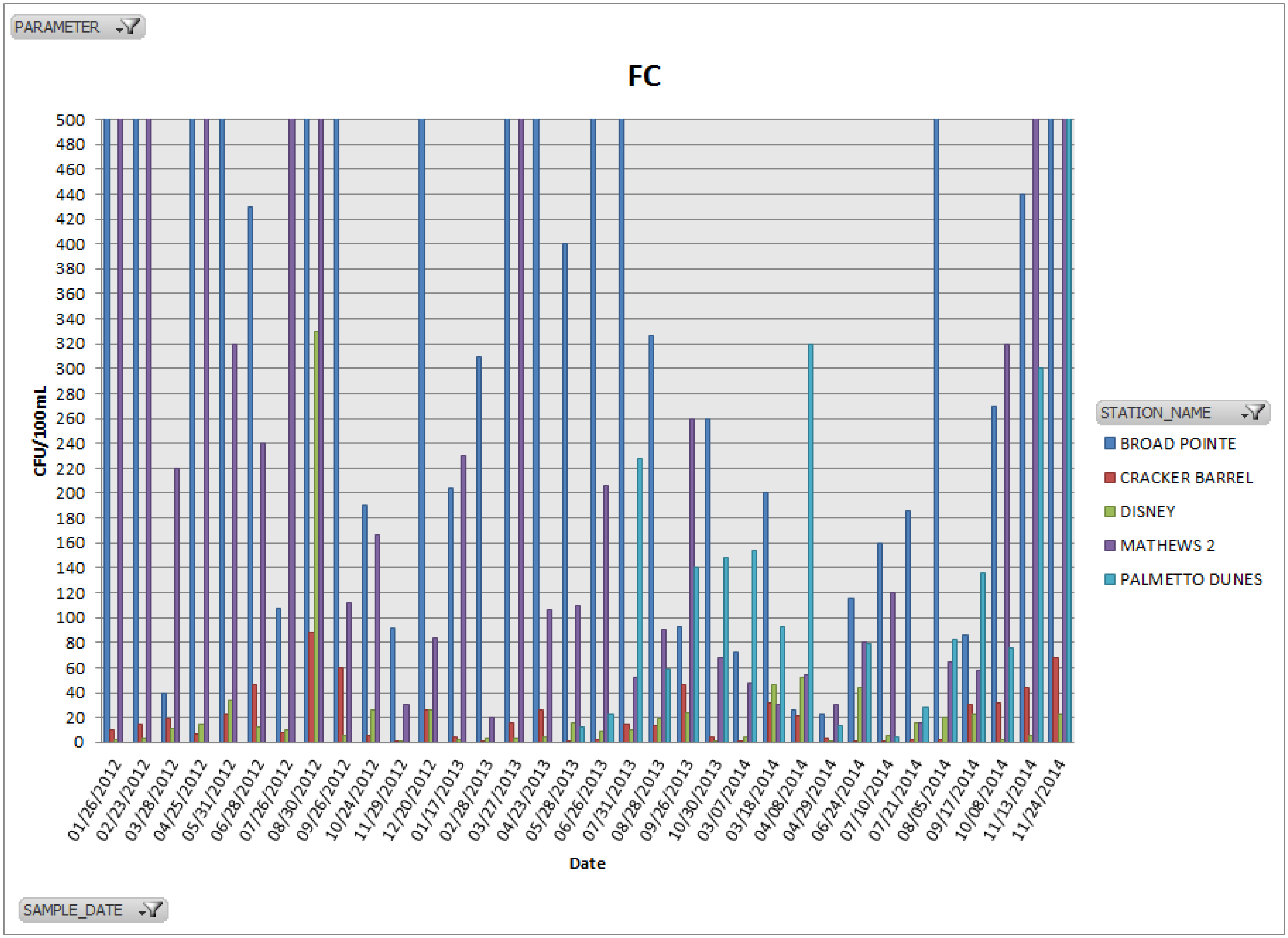


Figure 2: Fecal coliform bacteria levels for Town sampling locations.

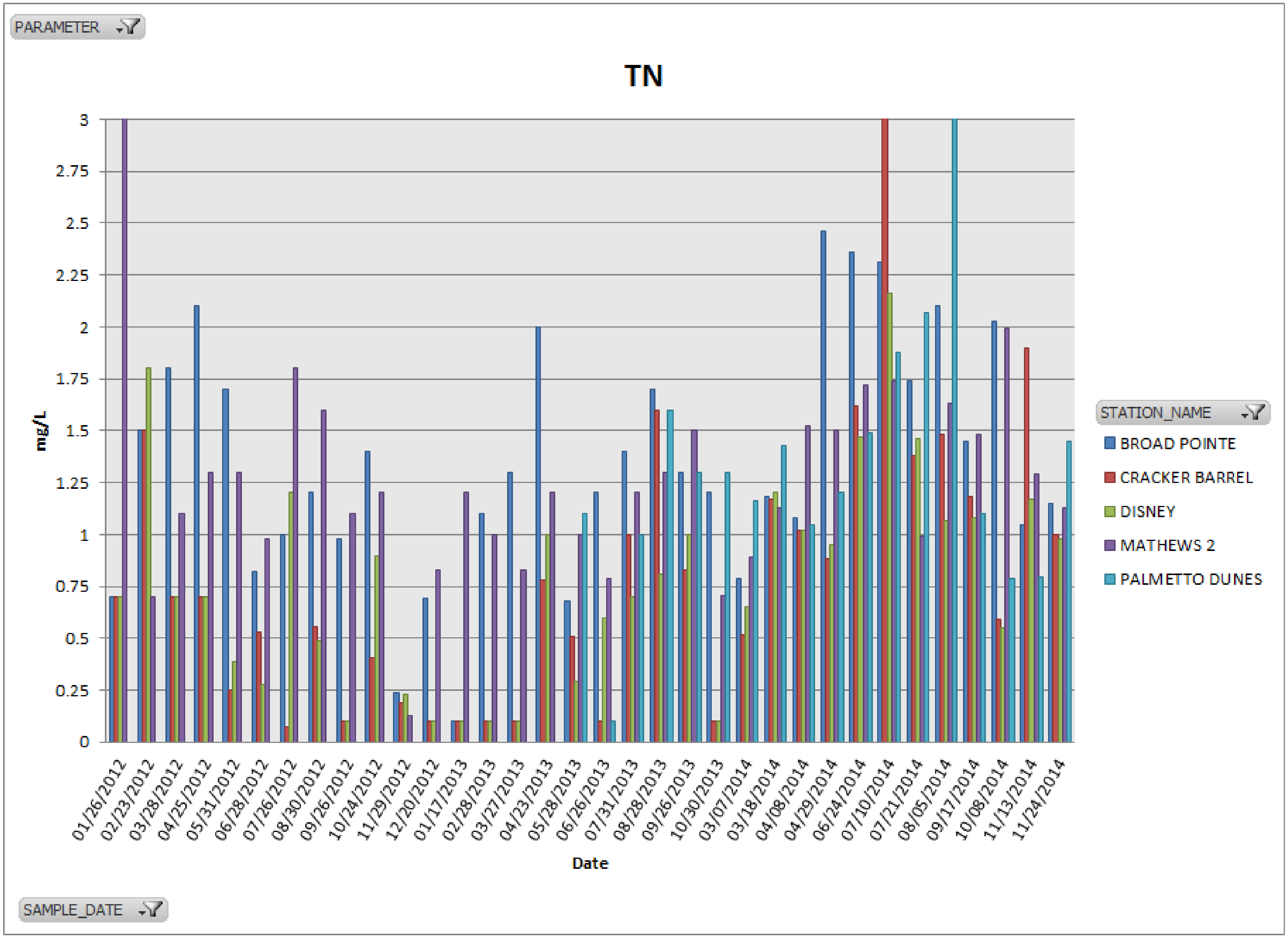


Figure 3: Total nitrogen levels at Town sampling locations.

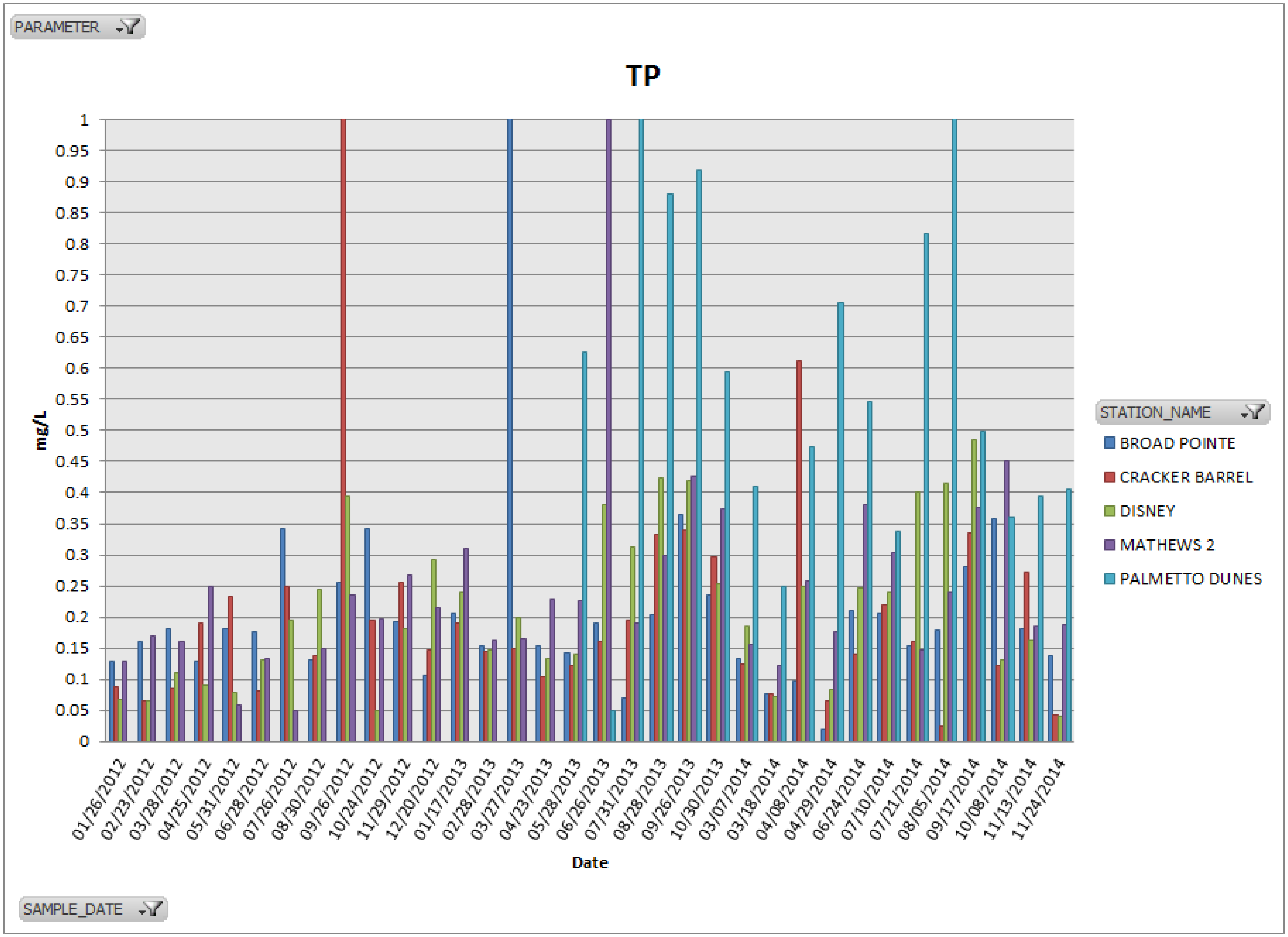


Figure 4: Total phosphorus levels at Town sampling locations.

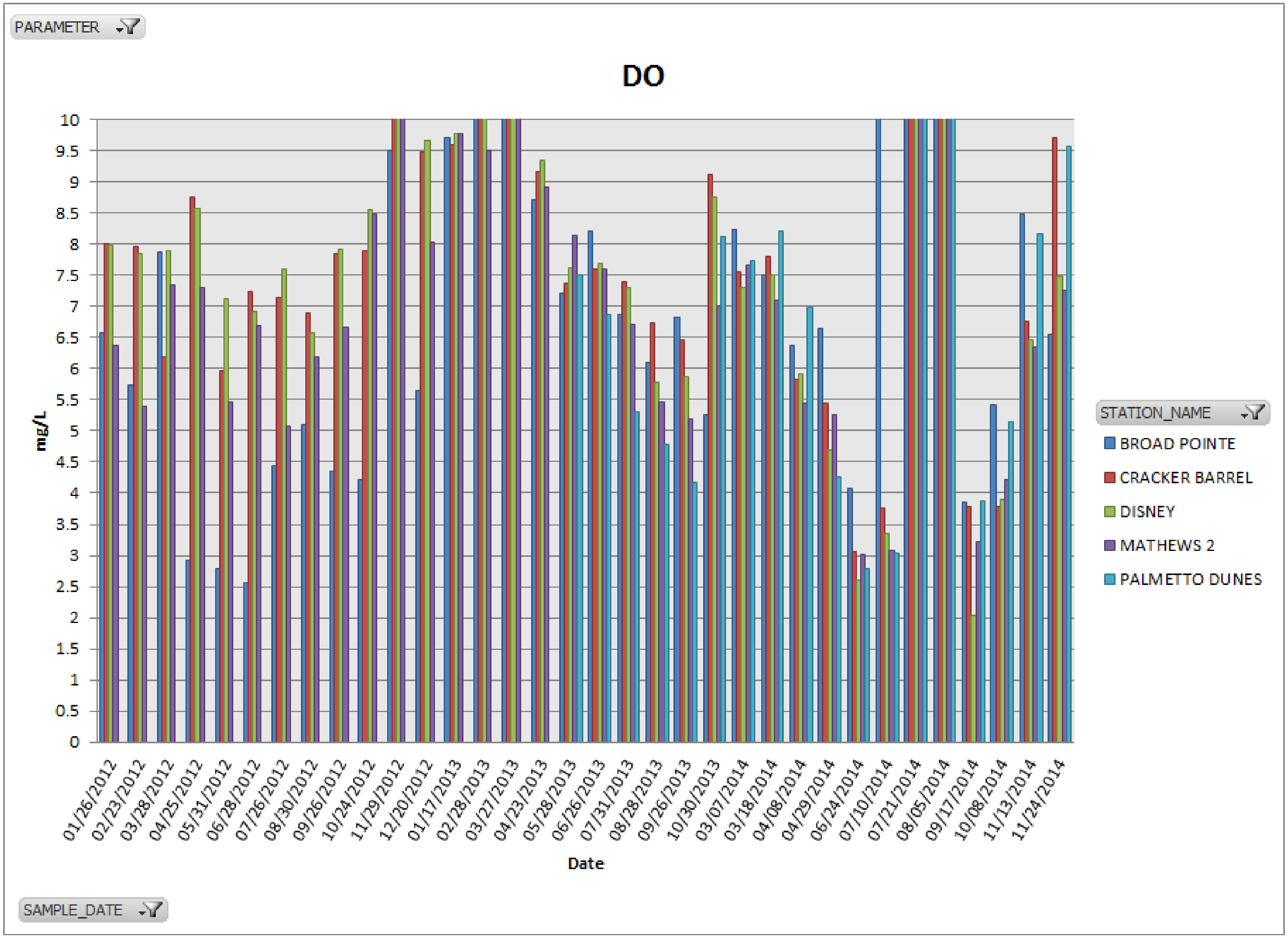


Figure 5: Dissolved oxygen levels at Town sampling locations.