Town of Plymouth, MA
Department of Marine & Environmental Affairs

Nutrient Management Data Report
Operational Monitoring Program
Data Report for 2017

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The surface water and groundwater monitoring conducted in the Eel River Watershed does not indicate negative impact from the Wastewater Treatment Facility in 2017, nor prior. The Wastewater Plant had three major sewer line breaks in the system in 2015-2016 and to the maximum extent possible the discharge was pumped and remediated. One of the breaks was north of Camelot Park and as indicated in the data, well A15 had a slight increase in nitrogen values during the October 2016 sampling event as well as in 2017. However, it the southern well only showed an increase in spring of 2017 and otherwise was average values. The increases in A15 may also be from private septic systems in the Hayden Hollow subdivision. As with previous years, the total nitrogen concentrations discharged into the infiltration basins are almost half the DEP permitted level of 10mg/L and minimal flow sent to the infiltration beds.

The Town continues to collect surface water, groundwater and biological samples in accordance with the Nutrient Management Plan. As indicated in this report, the Town has secured a substantial amount of open space land which will assist in preventing further nutrient loading into the watershed.

Section 1

Introduction of Nutrient Management Plan, WWTF, Town Projects

1.1 Nutrient Management Plan

As part of the Massachusetts Department of Environmental Protection (DEP) approval of Plymouth's Waste Water Treatment Facility (WWTF) Permit, SE# 1-677, a Nutrient Management Plan (NMP) was put in place. This plan was approved by DEP in January of 2001, *Town of Plymouth, Ma Nutrient Management Plan by Camp Dresser & McKee*. As part of the WWTF Permit the NMP consists of surface and groundwater monitoring within the Eel River Watershed in addition to the monitoring required by WWTF plant operations.

The NMP monitoring program consists of three parts; the baseline monitoring which occurred from May 1998 through February 2000; the interim monitoring which occurred from May 2000 through November 2001; the operational monitoring began following the operations of the WWTF in May 2002. As noted in Section 2.1 of the previous monitoring report, the Town and consultants have re-evaluated baseline and monitoring data to accurately represent pre-plant conditions, May 1998 to May 2002, as well as laboratory results which were reported in higher detection limits. Baseline laboratory results were generally reported in lower detection limits as compared with post WWTF results. Data issued Non-Detect (ND) values were numerically assigned half the detection limit for phosphorus and the calculation of Total Nitrogen. With higher detection values the total nitrogen value may appear higher although it was Non-Detect which can be misleading in representation and comparison of data results.

The NMP presents a methodology for monitoring changes in the Eel River system. Table 7-3 within the NMP, also below in Table 3, specifies action levels based on changes in water quality parameters. In addition to the monitoring, the NMP consists of controls and practices, known as the Base Management Plan, which the Town has and will continue to implement to reduce existing nutrient loads to the River and/or help minimize any future increases.

1.2 Purpose of the Nutrient Management Data Report

The purpose of the Nutrient Management Data Report is to present results of the operational monitoring program, compare data results to baseline conditions and defined action levels, evaluate whether changes have occurred and if so set forth a plan remediate the source. Specific action levels can be found in Table 3. The Data Report also allows for public updates on specific projects the Town is implementing within the watershed, Section 1.5.

1.3 Nutrient Management Monitoring

The baseline, interim and operational monitoring was previously conducted by Camp Dresser & McKee, Inc. until 2006. In 2006, the Town of Plymouth's Department of Public Works Environmental Management Division continued with the sampling events. As of October 2012 the Environmental Management Division has merged with Harbor Master and become the Department of Marine & Environmental Affairs. The monitoring program includes the measurement and analysis of multiple parameters for groundwater and surface water quality as well as harbor water quality and aquatic biological health.

The required surface water monitoring sites are listed in Table 1 with additional monitoring locations the Town monitors. Refer to the Surface Water Monitoring Section for further information.

Previous relevant reports include:

- Baseline Monitoring Program for the Eel River Watershed (May 1998), CDM.
- Preliminary Baseline Monitoring Data Report (October 1998), CDM
- Baseline Data Report, May 1990-February 2000, CDM
- Town of Plymouth, Nutrient Management Plan (July 2001), CDM
- Eel River Watershed Monitoring Data Report, May 1998-2001 (June 2002), CDM

- Eel River Watershed Nutrient Management Plan, Program Implementation Draft Update (April 2004), CDM
- Town of Plymouth, Operational Monitoring Program Data Report (March 2006), CDM
- Town of Plymouth, Operational Monitoring Program Data Report for 2006-2007 (August 2008), Town of Plymouth Department of Public Works Environmental Management Division
- Town of Plymouth, Nutrient Management Data Report, Operational Monitoring Program for 2008-2010 (April 2011), Town of Plymouth Department of Public Works Environmental Management Division
- Town of Plymouth, Nutrient Management Data Report, Operational Monitoring Program for 2011 (April 2012), Town of Plymouth Department of Public Works Environmental Management Division
- Town of Plymouth, Nutrient Management Data Report, Operational Monitoring Program for 2012 (September 2013), Town of Plymouth Department of Marine and Environmental Affairs
- Town of Plymouth, Nutrient Management Data Report, Operational Monitoring Program for 2013-2014 Town of Plymouth Department of Marine and Environmental Affairs
- Town of Plymouth, Nutrient Management Data Report, Operational Monitoring Program for 2015-2016, Town of Plymouth Department of Marine and Environmental Affairs

1.4 Waste Water Treatment Facility Discharge

The Town of Plymouth WWTF began operations in May 2002 per the Groundwater Discharge Permit SE#1-677 issued by DEP on June 25, 2000. The permit specifies a maximum 3.45MGD to the infiltration basins with an annual average of 0.75MGD. The maximum day design value of the treatment plant is 5.2MGD of which 1.75MGD is discharged to the ocean outfall. Below are averages per year of total nitrogen, flow to the infiltration basins and flow to the ocean outfall since the operation of the WWTF. As with previous years, the total nitrogen concentrations discharged into the infiltration basins 2017 were half the DEP permitted level of 10mg/L.

Table 1 – Yearly Average of Total Nitrogen and Flow

Yearly Average of Total Nitrogen (mg/L) to Infiltration Basins																
DATE	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Average	10.76	6.94	4.36	4.26	8.32	7.17	4.95	5.19	6.31	6.36	5.61	5.09	3.98	5.19	4.78	5.77
Yearly Average of Total Phosphorus (mg/L) to Infiltration Basins																
DATE	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Average	2.98	4.23	5.29	5.33	6.31	6.25	4.21	4.08	3.51	3.84	3.88	4.60	3.71	4.39	4.29	5.17
Yearly Average Flow (MGD) to Infiltration Basins																
DATE	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Average	0.038	0.174	0.173	0.141	0.173	0.124	0.198	0.108	0.193	0.276	0.117	0.115	0.124	0.101	0.729	0.061
Yearly Average Flow (MGD) to Ocean Outfall																
DATE	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Average	1.539	1.509	1.330	1.591	1.594	1.574	1.509	1.639	1.556	1.574	1.609	1.694	1.627	1.583	0.924	1.571

1.5 Department of Marine & Environmental Affairs, Base Management Plan and Projects within the Eel River Watershed

In May of 2005, the Environmental Management Division was created under the Department of Public Works to manage the Town's natural resource areas. As part of this management, the Eel River Watershed Nutrient Management Plan was undertaken by this Division. In October of 2012 the Environmental Management Division merged with Harbor Master to form its own Department known as the Department of Marine & Environmental Affairs. The Department of Marine & Environmental Affairs conducts the surface water and groundwater monitoring associated with the NMP and manages the biological monitoring conducted by a Consultant. The Department of Marine & Environmental Affairs reviews, compiles and generates the NMP Operational Monitoring Program Data Reports.

In addition, the Department of Marine & Environmental Affairs implements various projects within the watershed, most of which are part of the NMP Base Management Plan. The Base Management Plan consists of controls and practices the Town has and will continue to implement to reduce existing nutrient loads to the Eel River and/or to help minimize any future increases. The sections of the Plan include; Public Education Program, Buffer Strip, Stormwater BMPs, Source BMPs, Septic System Management, Use of Reclaimed Water, Lot Size and Open Space. The following is an outline of each section of the **Base Management Plan**:

Public Education Program – In response to this plan, the Town has: (a) implemented the Nutrient Management Plan Advisory Committee which consisted of various users, including land owners, farmers, and cranberry growers, to collaborate on the implementation of nutrient reduction techniques within the watershed; (b) involved the public in important watershed protection activities, such as the Eel River Trash Clean Up Day through the American Rivers Program and volunteer/public involvement in activities associated with the Eel River Headwaters River & Wetland Restoration Project; (c) created and updates the Department of Marine & Environmental Affairs website, which educates the public on the importance of protecting water quality and provides recreational links to trails within the Town including the Eel River Preserve. In 2014, through the Massachusetts Environmental Trust Grant Program the Town was able to implement the Plymouth Pond and Lakes Stewardship Program which included a substantial amount of ponds within the Eel River Watershed. Over 50 residents volunteered their time to collect both field and laboratory samples in 39 ponds. Data is being collaborated into a Pond Water Quality Atlas. This program initiated ongoing stewardship on a number of ponds.

Buffer Strip – Under this part of the NMP, the Town has protected over 300 acres of conservation land around the Eel River and its watershed. The protected areas include the Hoyt's Pond Conservation Area, the Eel River Preserve, the Russell Mill Pond Conservation Area, the Hayden Pond Conservation Area and the Herries Property. In 2011, the Town protected an additional 10 acres as open space and in 2012 the Town protected an additional 20 acres as open space. In 2014 the Town protected an additional 1.86acres off of Fuller Farm Road. The Town is currently appraising multiple properties in the Eel River Watershed totaling over 100acres of additional conservation land. The Town hopes to secure grant funding to purchase these properties in the near future.

The Town completed a draft of a Watershed Management Program General Bylaw for the Plymouth Harbor Watershed, which includes the Eel River Watershed. This Bylaw would allow for the protection of Plymouth's important natural resources such as water quality, drinking water supply, fish and wildlife habitat, eel grass habitat, shellfish, aesthetics and recreational uses. The goal of the Bylaw is to require mitigation for nutrient loading from land use changes and septic systems within the watershed. Such mitigation would include the use of advanced nutrient removal septic systems, as well as other best management practices. The Town will likely be implementing this or a similar Bylaw following the recommendation of the Department of Environmental

Protection's Massachusetts Estuaries Project for the Plymouth Harbor (including the Eel River Watershed) Total Maximum Daily Load Report.

Stormwater BMPs – The Town's Engineering Department has conducted a field inventory of catch basins and outfalls within the Eel River Watershed utilizing a GPS system. This has assisted the Town in implementing solutions to stormwater impacts within the Eel River system. For example, the Town implemented stormwater BMPs at the river crossing on Russell Mill Road to treat and reduce runoff from directly entering the river system. As part of the Eel River Headwaters Restoration Project, completed in 2010, the Town replaced two road crossing culverts, stormwater basin and created wetland infiltration areas for existing stormwater to be treated prior to entering the Eel River. In addition, the development area north of Warren Wells Brook was retrofitted with a constructed wetland stormwater treatment system in 2008-2009 under the Town's direction and oversight. In 2012 the Engineering Department conducted drainage improvements at East Russell Mills Road and cleaning improvements at River Street.

Source BMPs – The Town, with assistance of state and federal project partners, designed, permitted and implemented a 40 acre wetland and 1.75mile river restoration project known as the Eel River Headwaters Restoration Project. The project takes place on the Eel River Preserve where 40 acres of cranberry bogs and upland were acquired as well as on a portion of the Russell Mill Conservation Area. This area was manipulated over time for agricultural purposes, but it has now been taken out of agricultural production under the Towns stewardship. Nutrient loading to the Eel River from this project will be reduced by approximately 600lbs/yr of Nitrogen (CDM, 2005) and 500lbs/yr of Phosphorus (UMASS Amherst Cranberry Station). The Town has acquired over 2.5million dollars in funding and the restoration has been completed as of October 2010. The project has substantially improved fish passage and water quality through the removal of flow control structures and replacement of undersized culverts, restored 40 acres of wetland habitat including Atlantic white cedar swamps and reconfigured the Sawmill Dam to a natural river channel. For additional information on this project, see Eel River Headwaters Restoration Project description in this section below.

Septic System Management - The Town's Engineering Department and Board of Health have been updating a Town-wide septic inventory, which allows for the query and review of onsite septic system plans. The current inventory is available for municipal use in the Geographical Information System linked by parcel Id's. In 2008 the Town conducted a mailing to all residential properties within 100ft. of the Eel River notifying homeowners of the Town's zero interest septic upgrade loan program.

Use of Reclaimed Water – The Town completed a feasibility study, entitled "Plymouth South High/Middle School Water and Wastewater Alternatives Evaluation Final Report" (Sept. 2005, Tighe and Bond), analyzing the use of reclaimed water. Based on the results of the study, the Town has applied for funding sources, such as the State Revolving Fund, working with a developer where reclaimed water would be utilized to irrigate golf courses, ball fields and for toilet flushing within the development. Unfortunately the development fell through due to funding sources thereby eliminating the use of reclaimed water, however, the Town is willing to work with potential developers/partnerships in the future to accomplish this goal.

Lot Size – The Town has maintained the 3 acre lot size for rural residential development. Any development within 200ft. of the river is subject to the MA River Act and any work within 100ft. of the river or resource area is reviewed by the local Conservation Commission and Department of Environmental Protection. The Conservation Commission has increased the no-touch buffer zone from 25ft to 35ft in the Town's Wetland Protection Act Bylaw.

Open Space –In total, there are 3,360 acres of permanently protected open space within the Eel River Watershed. The Town received grant funding in 2017 and Town meeting approval to purchase a 43acre parcel adjacent to the Eel River, however it will be protected by Wildlands Trust. The Town has purchased 10.2 acres in the Eel River Watershed in 2017. In 2012, the Town protected an additional 20 acres of open space in the Eel River Watershed. In 2011, the Town protected 10 acres neighboring the Herries property. In addition, in 2010 the Town protected over 40acres adjacent to the Eel River Preserve known as the Herries property. In the winter of 2010, an additional 14.5 acres of open space was preserved north of Town Forest within the Eel River Watershed. In 2008 the Town protected 14 acres of land adjacent to Hayden Pond for conservation purposes, habitat and water quality preservation. In 2007 the Town protected 23 acres known as the Hoyt's Pond or College Pond Road property just south and connecting to the Eel River Preserve. The Eel River Preserve is a 130 acre parcel which connects with the 160 acres of the Russell Mill Pond Conservation Area. Through the Eel River Headwaters Restoration Project, and with funding assistance from the Town's Office of Community Development, two informational kiosks on the Sawmill Dam reconfiguration and Cranberry Bog/Wetland Habitat restoration efforts and history have been installed at the project site.

Overall, the work that the Town has performed under the NMP has been widely praised. The Town of Plymouth and project partners for the Eel River Headwaters Restoration received the National Award from Coastal America for preserving and restoring coastal resources and ecosystems. In addition, on January 10, 2008 the Executive Office of Energy and Environmental Affairs issued a press release describing the Town's extraordinary efforts to restore the headwaters of the Eel River. In the press release, Secretary Bowles states, "By providing vision and leadership for numerous open space and restoration projects, the Town of Plymouth continues to set a strong example of municipal action to protect the environment. With ambitious projects such as the Eel River, Plymouth has had extraordinary success pulling together diverse partners and funding sources for projects that benefit the community, the environment, and the region."

While the Base Management Plan will act to reduce and control nutrients in the watershed and prevent ecological harm in the Eel River, the NMP also lists additional control measures to restore the system in the event chemical and physical parameters produce an ecological change as described in Section 2.2.2. To date, there has not been evidence of this ecological change, however, the Town is committed to protecting the natural resources and has researched the viability of each of the control measures listed in the NMP. In 2007, the Town hired an engineering firm to complete the "Feasibility Study for Constructed Treatment Wetlands at the Plymouth WWTF, Stearns & Wheeler, LLC, June 2007." The Town has pursued funding opportunities for the implementation of the constructed wetlands, however, the current low flow and low input of nitrogen into the infiltration basins will not sustain a wetland community. The Town may actively pursue this option should the flow to the infiltration basins increase.

The following is a brief summary of additional projects in the Eel River Watershed the Town has conducted. For further information please visit the Department of Marine & Environmental Affairs webpage at www.plymouth-ma.gov.

Eel River Headwaters Restoration Project – Wetland & River Restoration

The Eel River Headwaters Restoration site is located within the Eel River Watershed, south of Russell Mill Pond. In 2005, the Town of Plymouth purchased 39.5 acres of bogs and 40 acres of upland at the headwaters of the Eel River, also known as the Eel River Preserve. In 2007 the Town purchased a 44 acre adjacent parcel that connects to Hoyts Pond, a coastal plain pond. The Hoyts Pond parcel, as well as the Eel River Preserve, connects with the additional 100+ acres of Town owned property north of Long Pond Road connecting to Russell Mill Pond.

In October of 2010 the Town of Plymouth, with the assistance of State & Federal Project Partner Agencies, have completed river and wetland restoration activities in the headwaters of the Eel River, the small spring-fed system which drains into historic Plymouth Harbor. This State & Federal Listed Priority Project included dredging to construct a sinuous stream channel 1.7 miles in length to reestablish natural conditions and enhance river continuity, filling of former artificial side channels, reconstruction of a re-connected floodplain, removal of dikes and water control structures, replacement of undersized culverts at Long Pond Road and a driveway to enhance fish passage, extensive wetland plantings including 17,000 Atlantic white cedar (AWC) trees, and re-establishment of rare wetland communities. Sawmill Pond Dam site has been re-configured to allow fish passage, and a restored river channel and floodplain has been reconstructed in the existing impoundment.

(Pre-restoration channel)

(Post-restoration channel)

(Bog 1 pre-restoration) ***(Bog 1 post-restoration***

(Bog 2 pre-restoration) ***(Bog 2 post-restoration)***

<u>Nutrient Management Model:</u> In the early spring of 2006, CDM completed the Nutrient Management Model for the Eel River Watershed. This model calculates the current loadings based off of MA GIS data and defined loading values for the watershed. It takes into account the current data values and calculates the percent reduction needed in each sub-watershed of the Eel River Watershed to reach the appropriated EPA value of 0.48mg/L of total nitrogen. DEP is also required by the Environmental Protection Agency to conduct a Total Maximum Daily Load model for Plymouth Harbor, which includes the Eel River Watershed. This TMDL model will be useful in the decision making process for implementation of projects.

<u>Cumulative Nitrogen Loading Determination for the Plymouth-Duxbury Harbor-Kingston Bay Embayment System in Support of Management and Restoration:</u> The Town of Plymouth has undertaken the responsibility of completing the nitrogen loading determination for the embayment systems pertaining to the seven communities. To date, all tasks have been completed other than the scenarios and final report (tasks 7 & 8). It is anticipated to be completed in 2017 for DEP and the Town to move forward with finalizing a Total Maximum Daily Load. With the finalized Massachusetts Estuaries Model, the seven communities will have significant information to plan properly for future development and infrastructure needs as well as restoration concepts for current land-use activities.

- Task 1 – Compilation & Review of Previous Studies
  Complete
- Task 2 – Cumulative Nitrogen Loading Determination
  Part 1 Complete, Part 2 Complete
- Task 3 – Stream/River Data Collection
  Complete
- Task 4 – Nitrogen Recycling collection
  Complete
- Task 5 – Assessment of Nutrient Related Health
  Finalized 2014
- Task 6 – Hydrodynamic Data Collection & Modeling
  Complete
- Task 7 – Water Quality Modeling
  Underway
- Task 8 – Nitrogen Loading Report
  Underway

Plymouth Harbor Watershed By-law: The Division worked with various consultants on a Nutrient Management Mitigation Program for the Plymouth Harbor Watershed which includes the Eel River. The goal of the by-law is to preserve and protect Plymouth Harbor & Eel River by regulating nutrients, and to manage nutrient inputs to protect public health, water quality, and the welfare of the residents of the Town through the preservation of the groundwater and surface water resources. A draft by-law was created by the Division and an article reserved for 2007 Town Meeting. However, preliminary discussions with DEP indicated it would be beneficial to implement the by-law following the release of the TMDL model. The model will specify which areas and what projects would most benefit the reduction in nutrients. Once the Plymouth Harbor

Embayment Study is complete the Town will review the best options for the implementation of the watershed by-law.

<u>Eel River Watershed Delineation</u>: In 2006, the Division assigned a consultant to delineate the Eel River Watershed based on the best available groundwater data. The previous watershed delineation was based on surface water and topography data that did not accurately depict the groundwater fed system. The consultant also delineated the entire Plymouth Harbor Watershed based on best available groundwater data. See Map 1 for Eel River & Plymouth Harbor Watershed. As part of the Plymouth Harbor Embayment System study noted above, the watershed for Plymouth Harbor was defined even further.

<u>Constructed Wetlands Feasibility Study at the WWTF Infiltration Basins</u>

The Division has utilized a consultant to conduct a feasibility study for constructing wetlands in the infiltration basin(s) at the WWTF to reduce nutrient loading in the groundwater. The feasibility study was completed in 2007 and consists of various tasks including inventory of site characteristics, evaluation of potential obstructions, wetland concept plans, alternatives analysis and final designs. The Town is evaluating the most appropriate method in reducing nutrient loading from the WWTF and researching funding for implementation. This project could potentially tie-in with the Reclaimed Water project for as a form of tertiary treatment.

<u>Reclaimed Water from the Wastewater Treatment Facility located in Camelot Park</u>

As part of the Massachusetts Environmental Policy (MEPA) process completed in 1997, which culminated in the construction of the new Town owned WWTF, reclaimed water re-use was evaluated as a means to reduce nutrient loading impacts to the Eel River Watershed from groundwater disposal of treated effluent at the WWTF and also reduce water usage. Two golf courses (Waverly Oaks and Crosswinds), the Plymouth South High School/Middle School campus, and the Forges Fields athletic facility have been identified as potential recipients of reclaimed water from the Town of Plymouth WWTF as part of the feasibility study, entitled "Plymouth South High/Middle School Water and Wastewater Alternatives Evaluation Final Report" (Sept. 2005, Tighe and Bond), analyzing the use of reclaimed water. Based on the results of the study, the Town has applied for funding sources, such as the State Revolving Fund, working with a developer where reclaimed water would be utilized to irrigate golf courses, ball fields and for toilet flushing within the development. Unfortunately the development has been on hold due to funding sources thereby eliminating the use of reclaimed water, however, the Town is willing to work with potential developers/partnerships in the future to accomplish this goal.

Section 2

Data Observations

2.1 Detection Limits and Baseline Averages

The surface and groundwater monitoring program was initiated in 1998 by Camp Dresser & McKee followed in 2006 by the newly created Environmental Management Division that continued the NMP monitoring. An important aspect of the monitoring program, as discovered in 2009, is the level of the detection limits. A detection limit is the laboratories lowest concentration at which an analyte can be detected in a sample and its concentration can be reported with a reasonable degree of accuracy and precision. In some cases a laboratory will utilize drinking water recommended limits as the reporting detection limit when in fact the method detected the analyte at lower limits. The initial program included very low detection limits (TP 0.05mg/L, TN analytes 0.001-0.2mg/L) and in 2006 the surface water and bi-annual well monitoring event the detection limits were much higher (TP 0.5mg/L, TN analytes 0.05-0.5mg/L). The detection limits are important as non-detect values are numerically assigned to half the detection limit for statistical analyses and analytes reported with higher detection limits would appear to have higher concentrations when in actuality they do not. For example, surface water location S-3A on 4/10/08 initially had a total nitrogen value of 0.723mg/L but with the re-issued lower detection limits the total nitrogen value was reduced substantially to 0.463mg/L. In 2009 the Town requested and received data re-issued with the lowest possible detection limit for nutrients as shown in the surface and groundwater tables in the attached Appendices. As of late 2009, the Town contracted with a laboratory offering the lowest detection limits in the area and therefore the there is an improvement in data representation as compared with baseline values. As noted above adding half the detection limit for non-detect values is important for statistical analysis. It is not common to add half the detection limit for calculating total nitrogen under a groundwater discharge permit (permit wells inner-outer).

However, for purposes of statistical analysis and comparison to baseline data the Nutrient Management Data Report calculates total nitrogen for the permit wells using half the detection limit.

As described a memorandum from Horsley Witten Group and attached as Appendix E:

> *Because, in the statistical analyses, non-detect (ND) values are treated numerically as half the detection limit (DL), DL's were identified for each parameter that could be held consistent for both baseline and post-WWTP conditions, in order to allow for a fair and consistent comparison. This involved looking at all detection limits used over the course of the sampling and arriving at a common value that could be numerically applied as half the detection limit to both baseline and post-WWTP data, while including as much as possible of both data sets. The lowest possible "common" DL's were selected that would allow for a consistent analysis from baseline to post WWTP conditions. In general, baseline DL's were lower than post-WWTP DL's and, therefore, baseline DL's had to be artificially raised to match the post-WWTP DL's. In some cases, the post WWTP DL's were simply far too high to provide meaningful data and those values cannot, therefore, be used for statistical comparison to baseline data. In some places groundwater DL's differ from surface DL's.*

The baseline water quality statistics includes surface water data from nine locations and groundwater data from twenty two monitoring wells. Baseline averages include all available pre-operation data 1998 to May of 2002. When the original baseline values were calculated in the Nutrient Management they did not include all pre-operation data. In most cases only two to three sample dates were utilized for the baseline calculations. These calculated baseline values can be found within this report as well as attached in Appendix E.

2.2 Surface Water Monitoring

Under the NMP, the Town monitors the following surface water locations five times per year: S-1, S-2B, S-3A, S-4A, S-5B, S-6A, however, as of November 2009 access has been denied to S-1. Following the completion of surface water sampling in 2012, access by the homeowner at S-2B has been denied for future sampling. The Town utilized location S-2C, downstream of the dam. Two harbor samples, S-7 & S-10, are collected two times per year in the summer. These locations are described below in surface water sampling locations. The surface water locations are monitored for field parameters, including temperature, specific conductivity, pH, dissolved oxygen and turbidity which are collected with a calibrated YSI 6600 unit. They are also monitored for analytical parameters including boron, chloride, total dissolved solids, ortho-phosphate, total phosphate, ammonia, nitrate, nitrite, total dissolved nitrogen, dissolved inorganic nitrogen and chlorophyll-a. Each sample is analyzed at a certified laboratory. In addition, Harbor locations S-7 and S-10 are monitored for the following analytical parameters: total kjeldahl nitrogen, total dissolved solids, ortho-phosphate, total phosphate, ammonia, nitrate, nitrite, total dissolved nitrogen, dissolved inorganic nitrogen, dissolved organic nitrogen, particulate organic carbon and particulate organic nitrogen which are analyzed at a certified laboratory. The field methodology for collecting surface water samples can be found in Appendix F.

2.2.1 Surface Water Sampling Locations

This section provides a description of locations and summary of monitoring data for the NMP required surface water locations S-2C, S-3A, S-4A, S-5B, S-6A. As noted in Table 2 as of November 2009 access has been denied to S-1. In addition access has been denied to S-2B, therefore, S-2C located downstream of Russell Mill Dam will replace this location.

Location S-1: This surface water station is located on Warren Wells Brook, a tributary to the Eel River, immediately downstream from a privately owned trout hatchery and approximately 0.5miles Southeast from the nearest WWTF infiltration basin. The trout hatchery also owns the small impoundment upstream from hatchery operations which has likely collected sediment inputs as impoundments do over time. The area upstream from the impoundment was retrofitted in 2008 by a private property owner to include a constructed wetland stormwater treatment system in Camelot Park. The location S-1 can potentially collect various water quality inputs including stormwater inputs from Camelot Park, trout hatchery operations, horse farm nutrient loading and failed septic systems. Figure II-2 titled “Downgradient Impact Areas from 0.75MGD or 1.25MGD Land Application Site A” in the Technical Advisory Committee

(TAC) Report (TAC Committee, 2000) indicates location S-1 is outside of both the 0.75MGD and 1.25MGD influence from the infiltration basins. As shown in Section 1.4, the 2015 average of less than 0.12MGD has been discharged into the infiltration basins, 2016 average increased to 0.729MGD due to sewer main repairs.

Location S-2B/C: S-2B surface water station is located in the Eel River at Russell Mill Pond approximately 0.5miles downstream from S-1 and approximately 1mile Southeast from the nearest WWTF infiltration basin. Russell Mill Pond is now the first impoundment from the headwaters of the Eel River since the removal of Sawmill Pond Dam in 2009-10. Originally CDM collected S-2B prior to the outlet of the Russell Mill Dam and shortly moved the location to the end of the dock at house number 24 on Russell Mills Road. Unfortunately, the owner has denied access for future sampling. The Town has replaced this location with S-2C downstream of the dam as previously sampled. Figure II-2 of the TAC Report (TAC, 2000) indicates this area is outside the area of influence of 0.75MGD from the infiltration basins but with the area of influence of 1.25MGD. As shown in Section 1.4, the 2015 average of less than 0.12MGD has been discharged into the infiltration basins, 2016 average increased to 0.729MGD due to sewer main repairs.

Location S-3A: This surface water station is located in the Eel River at Hayden Pond approximately 0.65miles downstream from S-2B/C and approximately 1mile east from the nearest WWTF infiltration basin. Hayden Pond is the second and last impoundment along the Eel River other than S-4A site at Howland Pond which is a tributary to the Eel River. The mouth of Hayden Pond receives direct stormwater input from Route 3 via a number of catch basins. To the east of Hayden Pond is 38 acres of agricultural land draining both surface runoff and via underground tile drains to the buffer of Hayden Pond. There is also an additional 13 acres of agricultural land to the west of Hayden, although there is a buffer, this area has been heavily fertilized in the past. Figure II-2 of the TAC Report (TAC, 2000) indicates this area is within either of the two areas of influence 0.75MGD or 1.25MGD from the infiltration basins. As shown in Section 1.4, the 2015 average of less than 0.12MGD has been discharged into the infiltration basins, 2016 average increased to 0.729MGD due to sewer main repairs.

Location S-4A: This surface water station is located in a tributary to the Eel River at Howland Pond. Downstream approximately 0.25miles is the confluence with the Eel River which is also 0.25miles downstream from location S-3A. This station is approximately 1.5miles east from the nearest infiltration basin and is not influenced by either a 0.75MGD or 1.25MGD discharge as shown in Figure II-2 of the TAC Report (TAC, 2000). Howland Pond is an impoundment bordered by over 60 acres of active agricultural land. This impoundment is subject to influence of agricultural activities discharging sediment as well as stream sediment transport. Figure II-2 of the TAC Report (TAC, 2000) indicates this station is outside of the influence of either 0.75MGD or 1.25MGD from the infiltration basins.

Location S-5B: This surface water station is located downstream of Eel River Basin and Warren Ave at the mouth of Plymouth Harbor, thereby receiving tidal influence. The station is approximately 1.25miles downstream from the confluence discussed at location S-4A above and 1.25miles Northeast of the nearest infiltration basin. Figure II-2 of the TAC Report (TAC, 2000) indicates this area is within either of the two areas of influence 0.75MGD or 1.25MGD from the infiltration basins. As shown in Section 1.4, the 2015 average of less than 0.12MGD has been discharged into the infiltration basins, 2016 average increased to 0.729MGD due to sewer main repairs.

Location S-6A: This surface water station is located downstream approximately 1mile from the headwaters of the Eel River. Prior to 2010 this station was located in the Sawmill Impoundment at the headwall of the dam. As of 2010, the dam has been removed and river restored as part of the Eel River Headwaters Restoration described in Section 1.5. The station is located 1 mile south of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is well outside of both the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location S-7 Harbor: This harbor location is closer to the outlet of the Eel River than S-10 also located in the harbor. The coordinates for this location: 70 38’23.59W 41 57’8.35”N

Location S-10 Harbor: Located in the harbor close to the jetty. The coordinates for this location: 70 39’12.32”W 41 57’41.86”N

Table 2

Surface Water Sampling Locations			
Location ID	**Description**	**Required by NMP**	**Schedule**
S-1	Russell Mill Pond Rd – prior to hatchery take left on dirt road. Bear right at fork and follow to water. NOTE: ACCESS DENIED AS OF NOVEMBER 2009	☑	5x/yr
S-2B	24 Russell Mill Pond Rd – Enos Property. From end of dock NOTE: ACCESS DENIED FOR FUTURE SAMPLING The Town has been denied access to sampling location, will utilize downstream location S-2C.	See S-2C	NA
S-2C	Off Russell Mill Pond Rd. Downstream of dam	☑	5x/yr
S-3A	Hayden Pond, upstream of fish ladder	☑	5x/yr
S-4A	Howland Pond, at Clifford Rd Bridge, u/s of dam	☑	5x/yr
S-5B	Downstream of Warren Avenue Bridge	☑	5x/yr
S-6A	The Nature Conservancy – at footbridge (prior to dam removal sample taken in Pond upstream of dam)	☑	5x/yr
S-7	In Harbor near Poverty Point. Note S-7 @ ebb tide taken within one hour of high slack tide per DEP. S-7 @ 2-4 HST taken 2-4 hours after high slack tide per EPA.	☑	2x/yr
S-10	In Harbor near jetty . Note S-10 @ ebb tide taken within one hour of high slack tide per DEP. S-10 @ 2-4 HST taken 2-4 hours after high slack tide per EPA.	☑	2x/yr
S-17	End of dock at 16 Eel River Circle	Not required	
S-4B	Downstream of Clifford Rd Bridge	Not required	
S-11	Upstream of Howland Pond. At outlet upstream of bridge	Not required	
S-15	At outlet of Forge Pond	Not required	
S-16	Inlet of Forges Pond off Old Sandwich Road near bog	Not required	
S-18	Outlet from lower bog off Old Sandwich Road	Not required	
S-19	Outlet from upper bog off Old Sandwich Road	Not required	
S-20	Pond south of Forge Pond	Not required	
S-3B	Downstream of Hayden Pond, directly downstream of bridge off Sandwich Rd. Across from 128 Sandwich Rd.	Not required	
S-2A	Russell Mill Pond –DEEP Location	Not required	
S-9A	Gilbert fish hatchery, upstream of hatchery near pump house in bog. NOTE: ACCESS DENIED AS OF NOVEMBER 2009	Not required	
S-6B	The Nature Conservancy – downstream of footbridge, between footbridge and outlet to Russell Mill Pond. Note: Dam removed at this location in 2010.	Not required	
S-12	Upstream of Long Pond Rd culvert (prior to 2010 taken at culvert outlet)	Not required	
S-13	Upstream of Bog 2 (as of 2010 restored to wetland) south of Long Pond Rd	Not required	
S-14	At headwaters – near tupelo tree, Bog 6 (as of 2010 restored to wetland)	Not required	

2.2.2 Chemical & Ecological Indicators for Surface Waters and Recommended Actions as described in the NMP 2001

The NMP presents a methodology for monitoring changes in the Eel River system. As described on page 7-3 of the NMP, total nitrogen has been chosen as an indicator of potential change because, like phosphorus, it is important for aquatic growth. As the NMP explains, "because nitrogen is not the limiting nutrient in the Eel River system, addition of nitrogen to surface water bodies is not expected to cause significant ecological changes. Therefore, nitrogen concentrations will be monitored in the eight wells surrounding the WWTF, but action levels and remedial actions are not defined for this parameter in the groundwater wells." If, however, it is determined that Total Nitrogen has changed in the surface waters (as compared to baseline conditions) and has resulted in a change in the biological system, response actions described in the NMP, and as described below, are required. Below are tables from the NMP describing the chemical and ecological indicators and recommended actions for surface waters.

Chemical Indicators for Surface Waters as Described in the NMP 2001

Table 3

Indicator	**Relevance**	**Expected Change**	**Comparison Level**	**Evaluation**	**Action**
			Monitor		
Boron	Indicator of wastewater plume	Increase with no harm	Average baseline conditions	None	None
			Monitor and Evaluate		
Total Nitrogen	Required nutrient for aquatic growth	Increase with no harm	Average Baseline Conditions	Check change in ecological indicators	See Recommended Actions
pH	Large changes may cause ecological shift	No change expected			
			Monitor and Act		
Total Phosphorus	Limiting nutrient for aquatic growth	No increase expected	Concentrations exceed baseline average & 95% exceedence level ** for 2 months in one season	See Action	See Recommended Actions
			Ecological Indicators		
Secchi Depth/ Turbidity	Measure of water clarity		Secchi depth <5% exceedence level for 2 months in one season		

Chlorophyll-a	Measure of algal abundance		Concentrations >95% exceedence level for 2 months in one season	Evaluate parameters to determine whether several indicators have changed systematically together.	See Recommended Actions
Macroinvertebrates (SC/CF ratio)	Indicates the dominant food source available		+/- 50% change in ratio over baseline		
Macrophytes (spatial coverage)	Habitat		+/- 25% change in areal coverage		

Recommended Actions from NMP 2001

Table 4

Indicator	Source	Available Actions
Total Phosphorus	WWTF	• Change Plant Operations • Upgrade plant to include phosphorus removal • Relocate discharge to Site 101
	Pinehills Development	Inform Pinehills Management of change
	Watershed	See Nutrient Management Plan – Possible Actions include: • Reduce P load from cranberry bogs and hatcheries • Identify and remediate failed septic systems • Limit use of fertilizers • Implement BMPs to reduce surface runoff
Total Nitrogen	WWTF	• Change Plant Operations • Upgrade nitrogen removal at plant • Relocate to Site 101
	Pinehills Development	Inform Pinehills Management of change
	Watershed	See NMP. Possible actions include: • Upgrade septics to include

		nitrogen removal • Limit Use of fertilizers • Implement BMPs to reduce surface runoff
pH	WWTF	Upgrade pH adjustment at plant

Recommended Actions

The monitoring data does not trigger any of the indicators noted in the Nutrient Management Plan from impacts of the Wastewater Facility. A private substantial wetland clearing in 2006 increased the total phosphorus in the eel river. Fortunately the water quality in the river recovered shortly thereafter but the wetland habitat was not replaced. In 2013-2014, at the Eel River Watershed Property, the Town worked closely with the farmer who was prepared to install a pipe directly into the river for irrigation as well as cut the buffer area. The Town was able to remove the pipe from the plan and instead proposed a small groundwater well away from the river as well as maintained the 200ft riverfront buffer. In 2016, the tributary to the Eel River, downstream from Forges and upstream from Howland Pond, was substantially cleared on the edges and the stream dredged. The Conservation Agent was notified.

2.2.3 Surface Water Monitoring Summary and Baseline Comparisons

The surface water data 2017 does not indicate WWTF impact or environmental impacts. There was an increase at S-2, however all but the last sample collected was under the baseline value. There have been significant decreases overall in total nitrogen at S-2 and S-6 since the Town completed the Eel River Headwaters Restoration Project. At S-2, downstream of Russell Mill Pond, baseline total nitrogen values are 0.90mg/L and in the last three years all but one sample was well below baseline conditions. As shown in the figures below, significant improvements in water quality at the restoration site and downstream have occurred.

Table 5 – Surface Water Comparisons

Location	Parameter	Calculated Baseline (Pre-Operational)	Operational Average thru 2016	2016 Average	Operational Average thru 2017	2017 Average
S-2	Total Nitrogen (TN) mg/L	0.900	0.589	0.335	0.592	0.639
S-3	Total Nitrogen (TN) mg/L	0.570	0.675	0.485	0.664	0.518
S-4	Total Nitrogen (TN) mg/L	0.240	0.630	0.428	0.620	0.487
S-5	Total Nitrogen (TN) mg/L	0.418	0.619	0.462	0.615	0.574
S-6	Total Nitrogen (TN) mg/L	0.639	0.701	0.413	0.686	0.493
S-2	Total Phosphorus (TP) mg/L	0.131	0.034	0.025	0.034	0.034
S-3	Total Phosphorus (TP) mg/L	0.025	0.041	0.028	0.040	0.023
S-4	Total Phosphorus (TP) mg/L	0.032	0.042	0.034	0.041	0.029
S-5	Total Phosphorus (TP) mg/L	0.027	0.046	0.051	0.044	0.030
S-6	Total Phosphorus (TP) mg/L	0.054	0.044	0.020	0.043	0.030
S-2	Boron mg/L	0.020	0.010	0.008	0.010	0.005
S-3	Boron mg/L	0.022	0.011	0.008	0.011	0.005
S-4	Boron mg/L	0.019	0.011	0.007	0.010	0.005
S-5	Boron mg/L	0.025	0.016	0.014	0.016	0.006
S-6	Boron mg/L	0.032	0.013	0.010	0.012	0.005
S-2	pH units	6.500	6.857	6.912	6.879	7.116
S-3	pH units	6.560	6.578	6.928	6.609	6.964
S-4	pH units	6.390	6.628	6.900	6.660	7.026
S-5	pH units	6.750	6.608	6.656	6.631	6.894
S-6	pH units	6.180	6.356	6.608	6.365	6.468
S-2	Chlorophyll-a	13.980	12.963	9.112	13.074	14.392
S-3	Chlorophyll-a	5.080	8.794	7.632	9.144	13.346
S-4	Chlorophyll-a	1.400	3.265	3.714	3.695	8.848
S-5	Chlorophyll-a	3.700	6.211	11.020	6.701	12.670
S-6	Chlorophyll-a	1.690	2.267	1.720	2.583	6.372

2.2.4 Surface Water Monitoring Total Nitrogen Figures

Figure 1

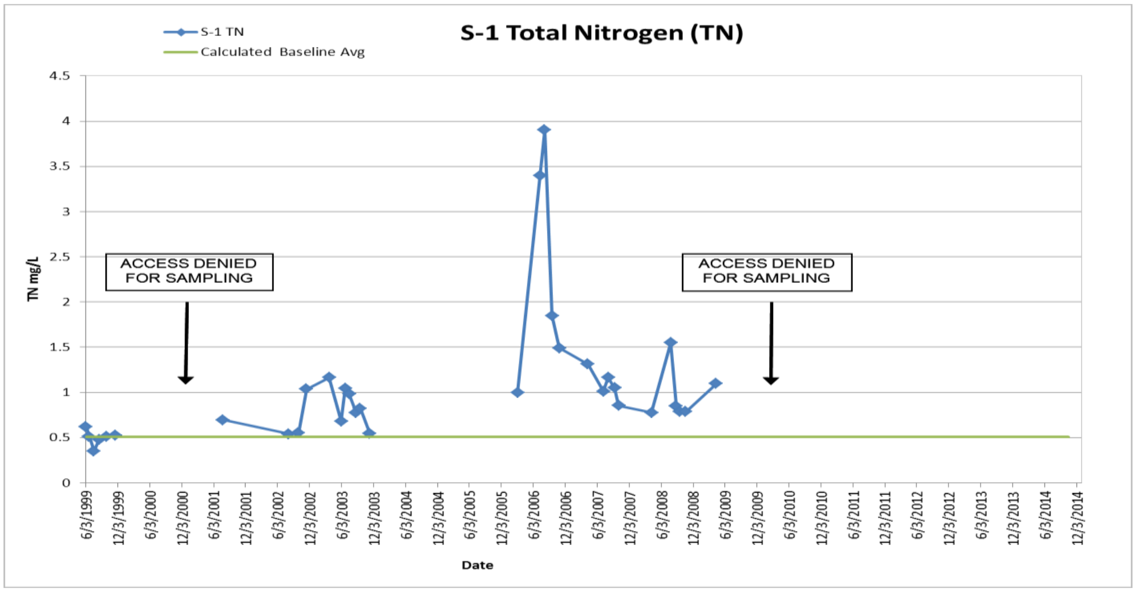


Figure 2

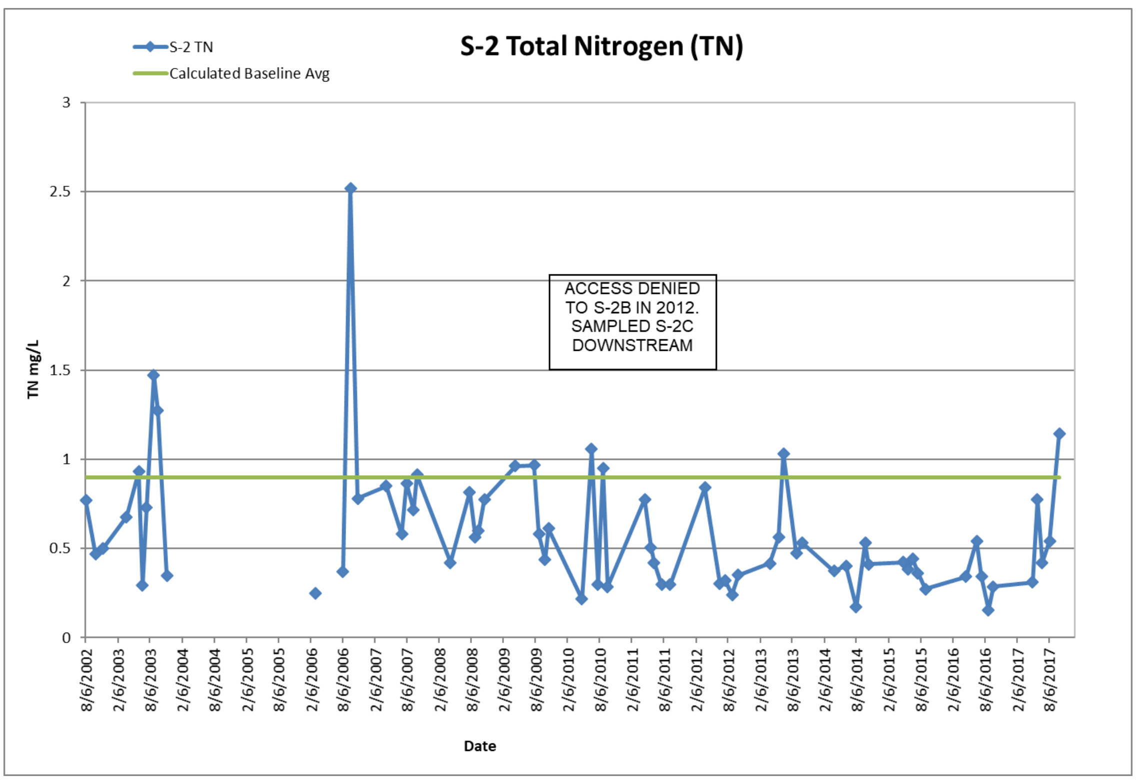


Figure 3

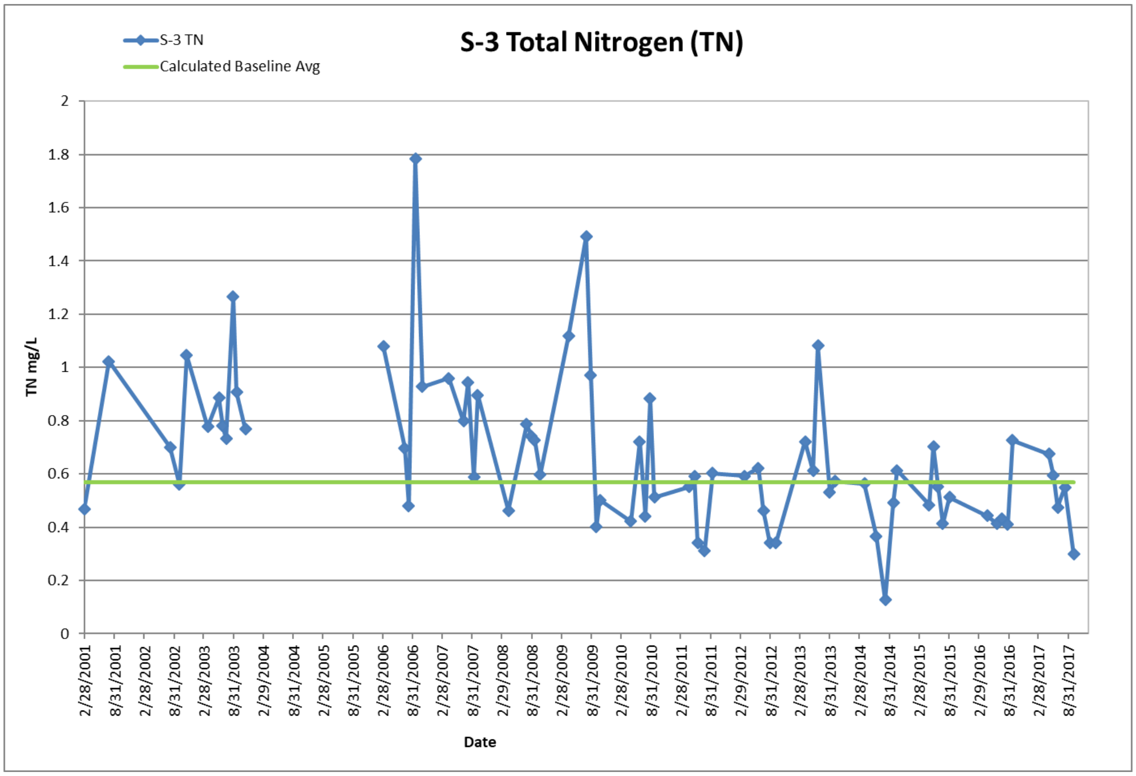


Figure 4

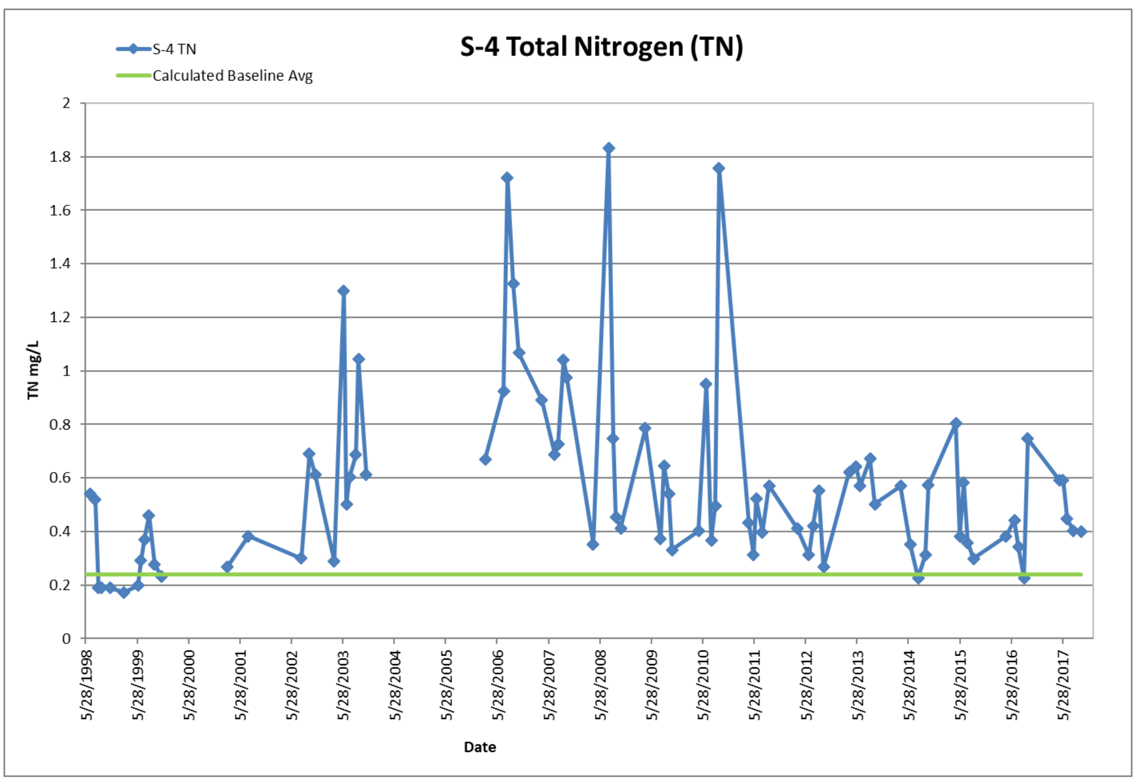


Figure 5

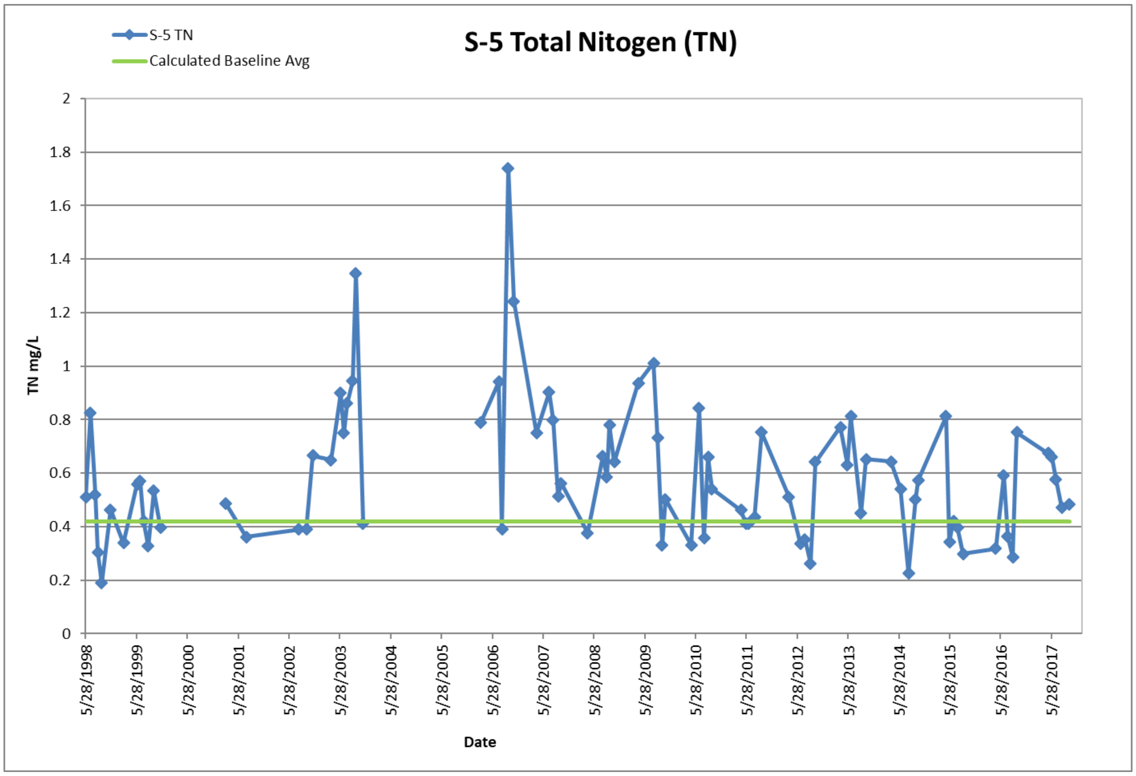
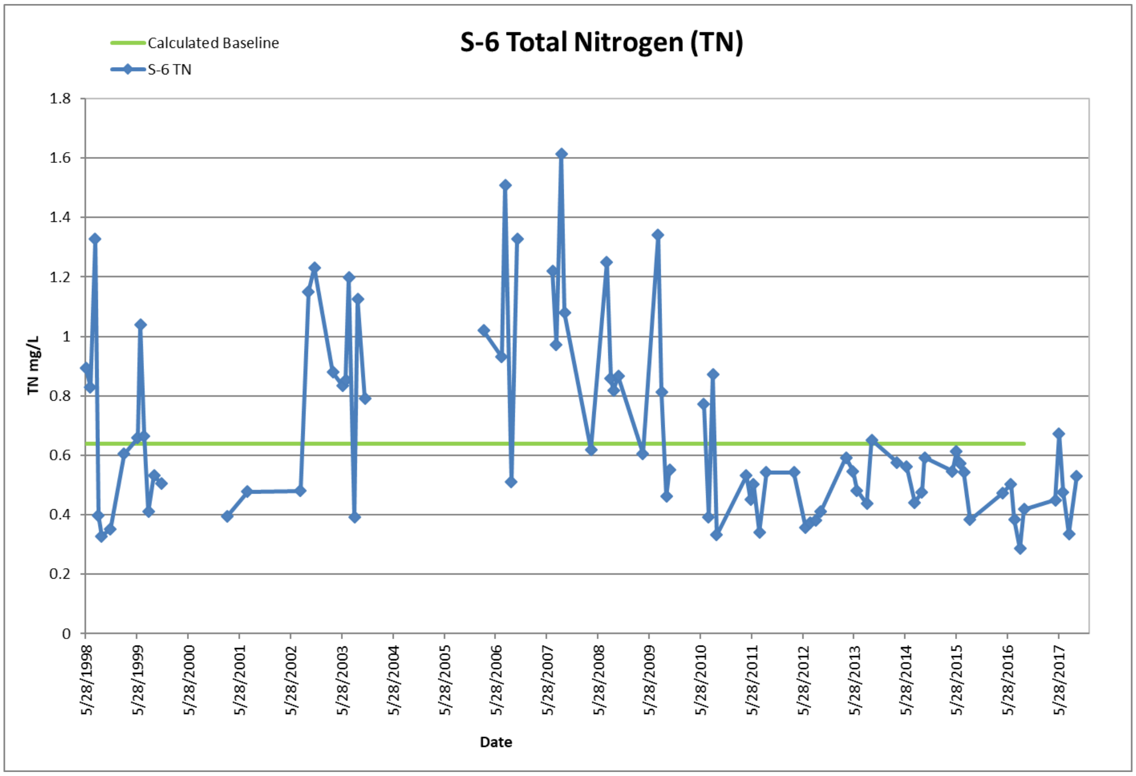


Figure 6



2.2.5 Surface Water Monitoring Nutrient Yearly Averages

Below are two tables depicting the pre and post WWTF operational yearly averages for both total phosphorus and total nitrogen at surface water stations. All data was utilized for total nitrogen averages. Total phosphorus averages excluded values where the field blank had a high detection as noted in Section 2.2.3.

Figure 7

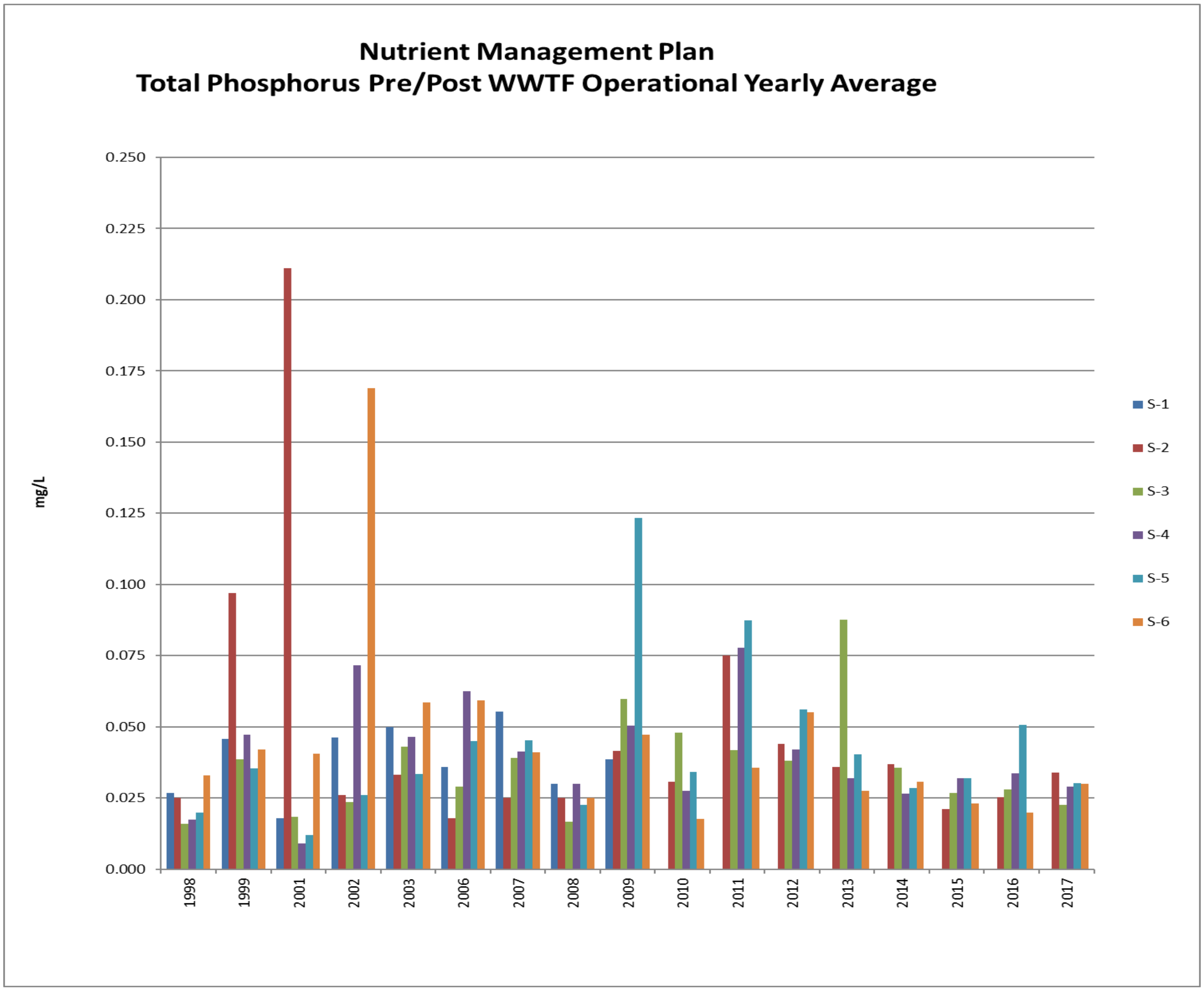
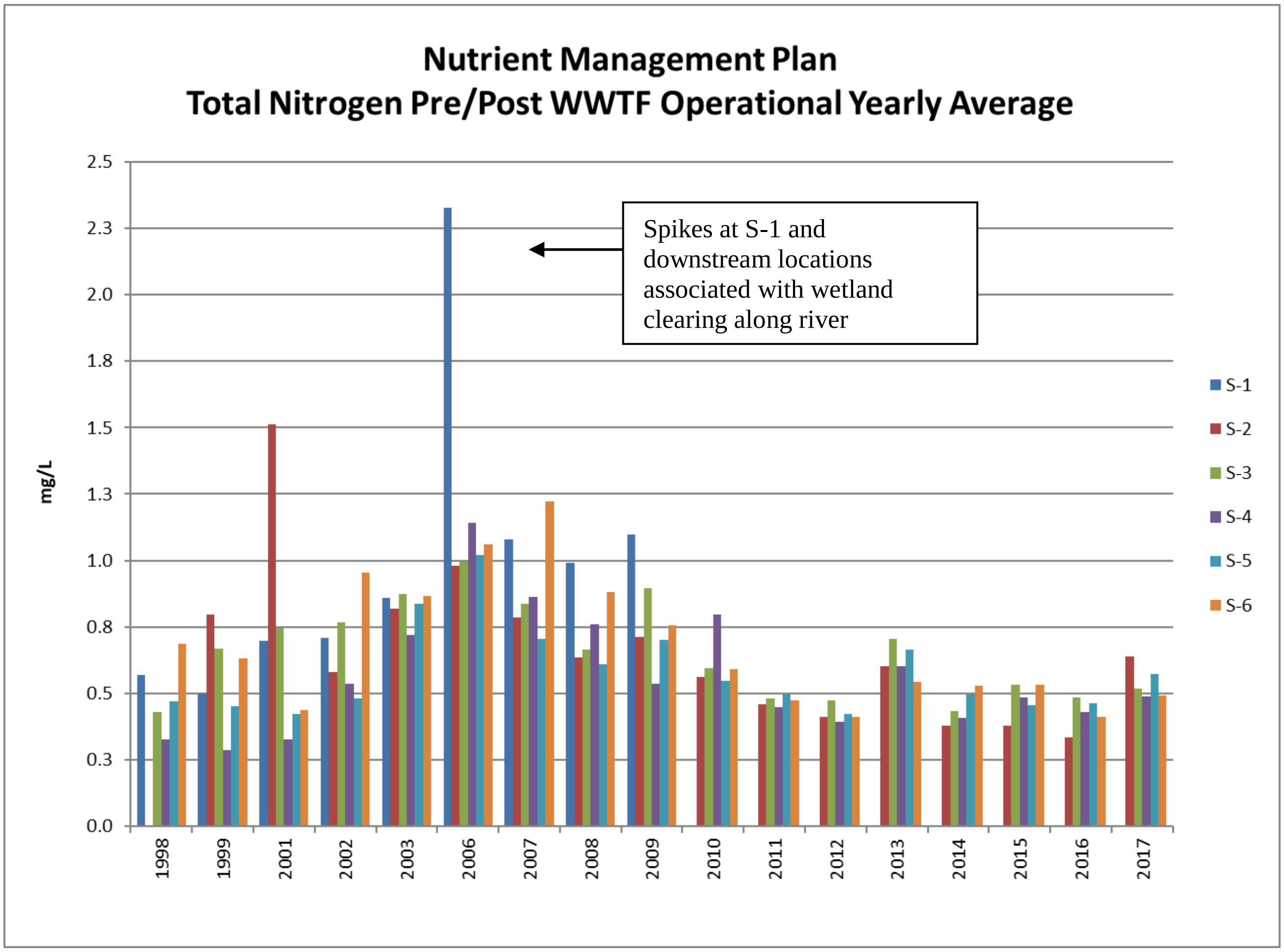


Figure 8



2.3 Groundwater Monitoring

Under the NMP, the Town monitors water levels in thirteen groundwater wells, eleven of which are monitored for field and laboratory analysis. The groundwater monitoring locations monitored two times per year include the following wells: A13, A15, A17, A21, 2SR, 2DR, 3S, 3D, 7SR, 5S and Bradford as described below. As of November 2009 access has been denied to the two well locations 3S & 3D. In the spring of 2011 sampling event an additional well, A19, sampled 2002-2004, will be added to compensate for the wells on private property the Town no longer has access to. A19 is located behind the treatment plant adjacent to the private property of 3S & 3D, thereby allowing the Town to accurately monitor any potential WWTF impacts in the groundwater. The groundwater wells are monitored for field parameters including temperature, specific conductivity, pH, dissolved oxygen and turbidity which are collected with a calibrated YSI 6600 unit. The wells are also monitored for analytical parameters including boron, chloride, copper, iron, mercury, VOC, total dissolved solids, ortho-phosphate, total phosphate, ammonia, nitrate, nitrite, total dissolved nitrogen, dissolved inorganic nitrogen, dissolved organic nitrogen and particulate organic nitrogen. Each sample is analyzed at a certified laboratory. The field methodology for collecting ground water samples can be found in Appendix G which references the EPA groundwater low stress purging and sampling procedures, EPA July 1996 Rev 2. As noted in the procedure, a two-well volume purge is conducted and sample is collected upon stabilization of field parameters.

2.3.1 Groundwater Monitoring Locations

Table 6

Groundwater Monitoring Locations			
Location ID	**Description**	**Inner/OuterWells/NMP**	**Schedule**
A9	Down gradient of Infiltration site, in wooded area	Inner (Permit)	Monthly
A10	Down gradient of Infiltration site, in wooded area	Inner (Permit)	Monthly
A11	Infiltration Basin Site	Inner (Permit)	Monthly
A16	Infiltration Basin Site	Inner (Permit)	Monthly
6S (R)	Down gradient of infiltration site	Outer (Permit)	Monthly
6D	Down gradient of infiltration site	Outer (Permit)	Monthly
1S	Down gradient of infiltration site	Outer (Permit)	Monthly
USGS 475 (R)	In cul-de-sac of Russell Mill Road	Outer (Permit)	Monthly
A13	DPW Parking Lot	NMP	2x/yr
A15	Before Hayden Hollow subdivision on Sandwich Rd	NMP	2x/yr
A17	Infiltration Basin Site near Odor Control	NMP	2x/yr
A21	On top of Russell Mill Pond Dam	NMP	2x/yr
2SR	Near culvert into Warren Wells Brook (Woods)	NMP	2x/yr
2DR	Near culvert into Warren Wells Brook (Woods)	NMP	2x/yr
3S	At Nickerson Property - near Hatchery NOTE: ACCESS DENIED AS OF NOVEMBER 2009	NMP	2x/yr
3D	At Nickerson Property - near Hatchery NOTE: ACCESS DENIED AS OF NOVEMBER 2009	NMP	2x/yr
A19	As of 2011 Replacement well for 3S/3D located in wooded area behind WWTF	NMP	2x/yr
7SR	In cul-de-sac of East Russell Mill Rd	NMP	2x/yr
5S	Nickerson Property - Off Russell Mills Road	NMP	2x/yr
Bradford	Town water supply well off Long Pond Road	NMP	2x/yr
472	Near Eel River Preserve Parking along Boot Pond Road	NMP (water level only)	WL Only
473	Near Eel River Preserve Parking along Boot Pond Road	NMP (water level only)	WL Only

Note: Locations 7SR & 5S were added to sampling program per DEP approval for 2007 sampling. Location A19 replaces 3S/3D

Location A13: This groundwater monitoring well is located in the Towns DPW Facility parking lot off Camelot Park Drive. The monitoring well is located 1,200ft NW of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is outside of both the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location A15: This groundwater monitoring well is located down gradient from the Hayden Hollow Subdivision off of Sandwich Road. The monitoring well is located 3,800ft NE of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is within both the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location A17/MW-7: This groundwater monitoring well is located at the WWTF near odor control. As shown in Figure II-2 of the TAC Report (TAC, 2000) the monitoring well is within the 1.25MGD influence of the infiltration basins and potentially the 0.75MGD influence.

Location A21: This groundwater monitoring well is located off of Russell Mills Road on top of the privately owned dam at Russell Mill Pond. The monitoring well name changed to A21-A when the property owner repaired the dam and the monitoring well was cut flush with the ground level. The monitoring well is located 5,000ft SE of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is outside of the 0.75MGD and within the 1.25MGD influence of the infiltration basins. **Monitoring well not sampled prior to plant operation, therefore baseline data is not available.**

Location 2SR: This groundwater monitoring well is located off of Camelot Park near Warren Wells Brook at the privately owned wetland stormwater system. The monitoring well is located 1,200ft SE of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is outside of both the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location 2DR: This groundwater monitoring well is located off of Camelot Park near Warren Wells Brook at the privately owned wetland stormwater system. The monitoring well is located 1,200ft SE of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is outside of both the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location 3S: This groundwater monitoring well is located at the Nickerson Hatchery near Warren Wells Brook. The monitoring well is located 2,100ft SE of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is outside of both the 0.75MGD and 1.25MGD influence of the infiltration basins. Between the winter 2006 and spring 2007 sampling event this well was damaged by a vehicle, however, adjacent 3D was able to be sampled. As of Fall 2009 the Town no longer has access to the property.

Location 3D: This groundwater monitoring well is located at the Nickerson Hatchery near Warren Wells Brook. The monitoring well is located 2,100ft SE of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is outside of both the 0.75MGD and 1.25MGD influence of the infiltration basins. As of Fall 2009 the Town no longer has access to the property.

Location 7SR: This groundwater monitoring well is located at the end of Old Russell Mills Road near Route 3. The monitoring well is located 2,100ft NE of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is within both the 0.75MGD and 1.25MGD influence of the infiltration basins. **Monitoring well not sampled prior to plant operation, therefore baseline data is not available.** This monitoring well was added to the sampling program in 2007.

Location 5S: This groundwater monitoring well is located off of Russell Mills Road heading toward the Nickerson Hatchery. The monitoring well is located 2,200ft SE of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is within the 1.25MGD influence and potentially either outside or just within the 0.75MGD influence of the infiltration basins. **Monitoring well not sampled prior to plant operation, therefore baseline data is not available.** This monitoring well was added to the sampling program in 2007.

Bradford Well: This municipal well site is located approximately 5,000ft SW of the nearest infiltration basin and as shown in Figure II-2 of the TAC Report (TAC, 2000) is not within the 1.25MGD or 0.75MGD influence of the infiltration basins. This site was chosen to reflect changes in the groundwater system on a watershed scale which are not associated with the WWTF.

Location A8/MW-11: This groundwater monitoring well is in the center of the existing group of infiltration basins and is therefore as shown in Figure II-2 of the TAC Report (TAC, 2000) within the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location A9: This groundwater monitoring well is in the area of proposed future infiltration basins and approximately 400ft NE from existing infiltration basins. As shown in Figure II-2 of the TAC Report (TAC, 2000) it is within the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location A10: This groundwater monitoring well is approximately 400ft SE from existing infiltration basins. As shown in Figure II-2 of the TAC Report (TAC, 2000) it is within the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location A11: This groundwater monitoring well is slightly south of existing infiltration basins in the southwest corner. As shown in Figure II-2 of the TAC Report (TAC, 2000) it is within the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location A16: This groundwater monitoring well is slightly south of route 3 and approximately 170ft from existing northeast infiltration bed. As shown in Figure II-2 of the TAC Report (TAC, 2000) it is within the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location 1S: This groundwater monitoring well is approximately 1000ft southeast from existing infiltration bed. As shown in Figure II-2 of the TAC Report (TAC, 2000) it is within the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location 6S(R): This groundwater monitoring well is approximately 300ft north of 1S and 1000ft southeast from existing infiltration basins. As shown in Figure II-2 of the TAC Report (TAC, 2000) it is within the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location 6D: This groundwater monitoring well is approximately 300ft north of 6S and 1000ft from existing infiltration basins. As shown in Figure II-2 of the TAC Report (TAC, 2000) it is within the 0.75MGD and 1.25MGD influence of the infiltration basins.

Location USGS475(R): This groundwater monitoring well is slightly south of route 3 and approximately 1,350ft from existing northeast infiltration bed. As shown in Figure II-2 of the TAC Report (TAC, 2000) it is within the 0.75MGD and 1.25MGD influence of the infiltration basins.

2.3.2 Groundwater Permit Compliance

Table 7

Groundwater Permit Compliance

Monitoring Group	*Wells*	*Permit Limit*
Adjacent Wells near WWTF site "inner wells"	A9, A10, A11, & A16	Any well >0.2mg/L of total phosphorus for either 3 consecutive months or 4 out of 6 consecutive months
Down-gradient Wells from WWTF site	1S,6SR,6D & USGS 475	Any well total phosphorus increase of >100% over established background concentrations for either 3 consecutive months or 4 out of 6 consecutive months.

"outer wells"		(Using all baseline data the average background concentration for these four outer wells is 0.07mg/L. The NMP Section 7.3 states 0.084mg/L through July 2001. Therefore an increase of 100% over the established background is 0.14mg/L)

As stated in Table 7-1 of the 2001 Nutrient Management Plan, total phosphorus has an action level while total nitrogen, boron and pH are to be monitored. Total phosphorus was chosen as an indicator because it is generally the limiting nutrient in the freshwater systems. As indicated in the NMP, phosphorus discharged into the infiltration basins is expected to be absorbed by the soil close to the facility and not migrate through the groundwater. To monitor possible phosphorus breakthroughs and prevention from traveling to surface waters, the permit limits were set both in the NMP and the groundwater discharge permit.

2.3.3 Bi-annual and Inner/ Outer Groundwater Monitoring Data Summary

There was one significant sewer main break in the Eel River Watershed at the end of 2015. Two others occurred outside of the Eel River Watershed in 2016. The forced main sewer breaks occurred due to corrosion in the pipes. The break in the Eel River Watershed occurred behind the Plymouth House of Correction along Route 3 on 12/19/2015 and discharged approximately 4 million gallons of sewage. The sewage was pumped and trucked to the Wastewater Treatment Facility for treatment. Since, the sewer force main has been replaced in its entirety. Well A15 had a slight increase in nitrogen values during the October 2016 sampling event, however, this may be due to the brief sewer line break that occurred south-west of this area. This increase in A15 was also observed in 2017, however it appears it may be on a downward trend. Well 7S which is south of A15 only showed an increase in the Spring of 2017 and otherwise was at average values. The Inner/Outer Groundwater Monitoring Wells did not meet or exceed thresholds stated in the *July 2001 Nutrient Management Plan Section 7.3.*

2.3.4 Bi-annual Groundwater Monitoring Data Comparisons and Total Nitrogen Figures

A13, A15, A17, A21, 2SR, 2DR, 3S, 3D (and 7SR, 5S as of 2007, A19 as of Nov 2010)

These locations were previously collected by Camp Dresser & McKee Inc. The Environmental Management Division began the monitoring in 2006.

Table 8 – Groundwater Comparisons

Location	Parameter	Calculated Baseline (Pre-Operational)	Operational Average thru 2016	2016 Average	Operational Average thru 2017	2017 Average
A13	Total Phosphorus (TP) mg/L	0.024	0.032	0.033	0.032	0.024
A15	Total Phosphorus (TP) mg/L	0.031	0.068	0.047	0.066	0.046
A17	Total Phosphorus (TP) mg/L	0.008	0.040	0.013	0.038	0.014
A21-A	Total Phosphorus (TP) mg/L	NA	0.046	0.076	0.049	0.083
2SR	Total Phosphorus (TP) mg/L	0.013	0.024	0.01	0.022	0.005
2DR	Total Phosphorus (TP) mg/L	0.026	0.057	0.048	0.057	0.038
7SR	Total Phosphorus (TP) mg/L	NA	0.023	0.009	0.021	0.005
5S	Total Phosphorus (TP) mg/L	NA	0.375	0.044	0.339	0.016
Bradford	Total Phosphorus (TP) mg/L	0.013	0.037	0.021	0.037	0.037
A13	pH units	4.92	5.11	8.65	5.10	4.83
A15	pH units	6.63	5.74	5.96	5.74	5.71
A17	pH units	5.18	5.28	6.49	5.28	5.21
A21-A	pH units	NA	6.06	6.16	6.06	turbid
2SR	pH units	5.96	4.80	4.98	4.81	4.96
2DR	pH units	5.62	5.67	6.42	5.66	5.43
7SR	pH units	NA	5.05	5.13	5.05	5.05
5S	pH units	NA	turbid	turbid	turbid	turbid
Bradford	pH units	5.93	NS	NS	NS	NS
A13	Boron mg/L	0.016	0.018	0.018	0.017	0.005
A15	Boron mg/L	0.038	0.014	0.016	0.013	0.005
A17	Boron mg/L	0.028	0.020	0.017	0.019	0.005
A21-A	Boron mg/L	NA	0.018	0.016	0.017	0.005
2SR	Boron mg/L	0.028	0.015	0.008	0.014	0.005
2DR	Boron mg/L	0.021	0.033	0.025	0.031	0.005
7SR	Boron mg/L	NA	0.009	<0.010	0.009	0.005
5S	Boron mg/L	NA	0.017	0.0115	0.015	0.005
Bradford	Boron mg/L	0.016	0.017	0.015	0.015	0.005
A13	Total Nitrogen mg/L	0.440	0.693	0.588	0.671	0.461
A15	Total Nitrogen mg/L	NA	1.656	2.059	1.773	3.057
A17	Total Nitrogen mg/L	2.690	1.953	1.667	1.988	2.376
A21-A	Total Nitrogen mg/L	NA	0.506	0.356	0.499	0.426
2SR	Total Nitrogen mg/L	1.090	1.189	1.027	1.278	2.172
2DR	Total Nitrogen mg/L	1.970	0.451	0.228	0.441	0.324
7SR	Total Nitrogen mg/L	NA	0.456	0.280	0.455	0.451
5S	Total Nitrogen mg/L	NA	0.728	0.503	0.724	0.682
Bradford	Total Nitrogen mg/L	0.195	0.643	0.320	0.608	0.279
A13	Total Dissolved Nitrogen mg/L	4.210	0.660	0.545	0.634	0.353
A15	Total Dissolved Nitrogen mg/L	3.610	1.493	1.950	1.602	2.800
A17	Total Dissolved Nitrogen mg/L	1.520	1.621	1.545	1.668	2.180
A21-A	Total Dissolved Nitrogen mg/L	NA	0.389	0.335	0.389	0.380
2SR	Total Dissolved Nitrogen mg/L	2.850	1.007	0.820	1.092	1.935
2DR	Total Dissolved Nitrogen mg/L	1.890	0.310	<0.2	0.295	0.125
7SR	Total Dissolved Nitrogen mg/L	NS	0.304	<0.1225	0.298	0.248
5S	Total Dissolved Nitrogen mg/L	NS	0.556	0.385	0.541	0.403
Bradford	Total Dissolved Nitrogen mg/L	0.170	0.372	<0.1425	0.350	<0.15

Figure 9

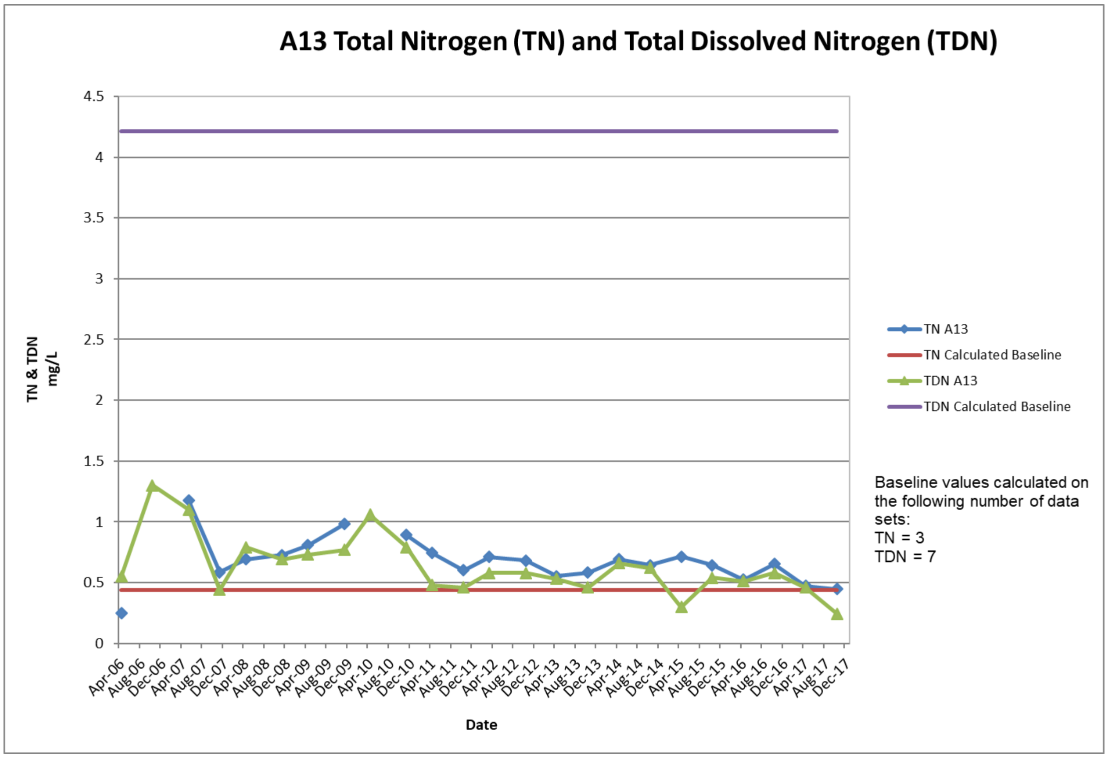
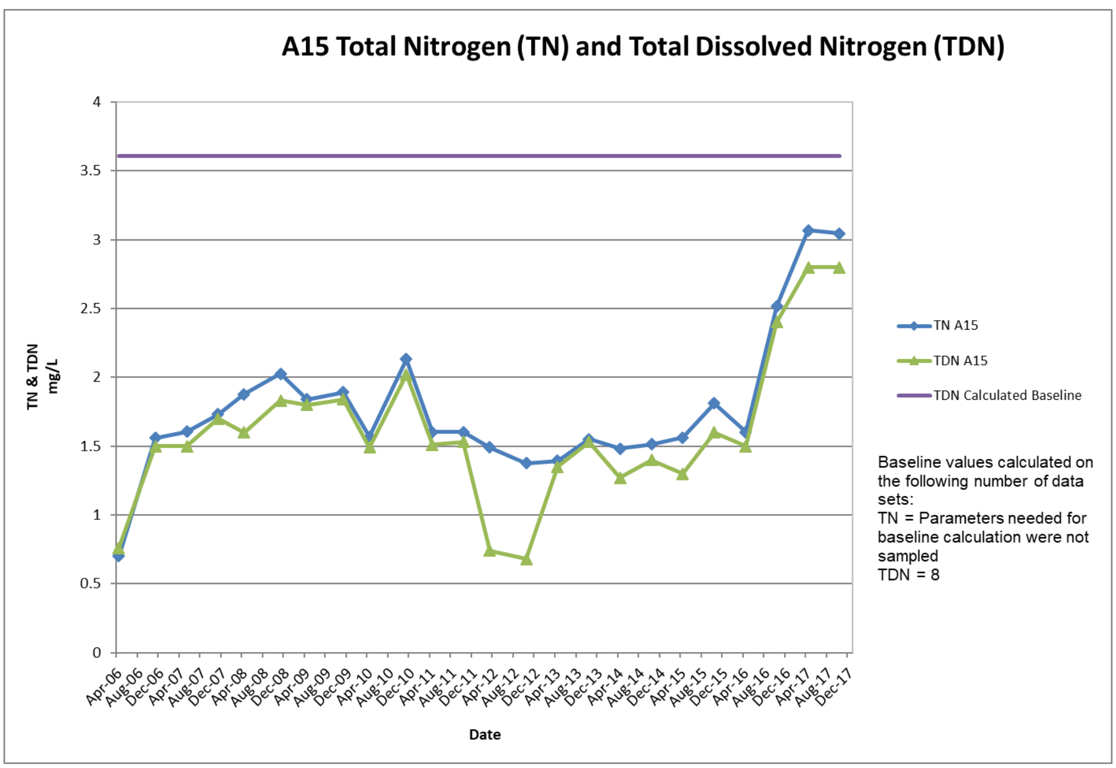


Figure 10



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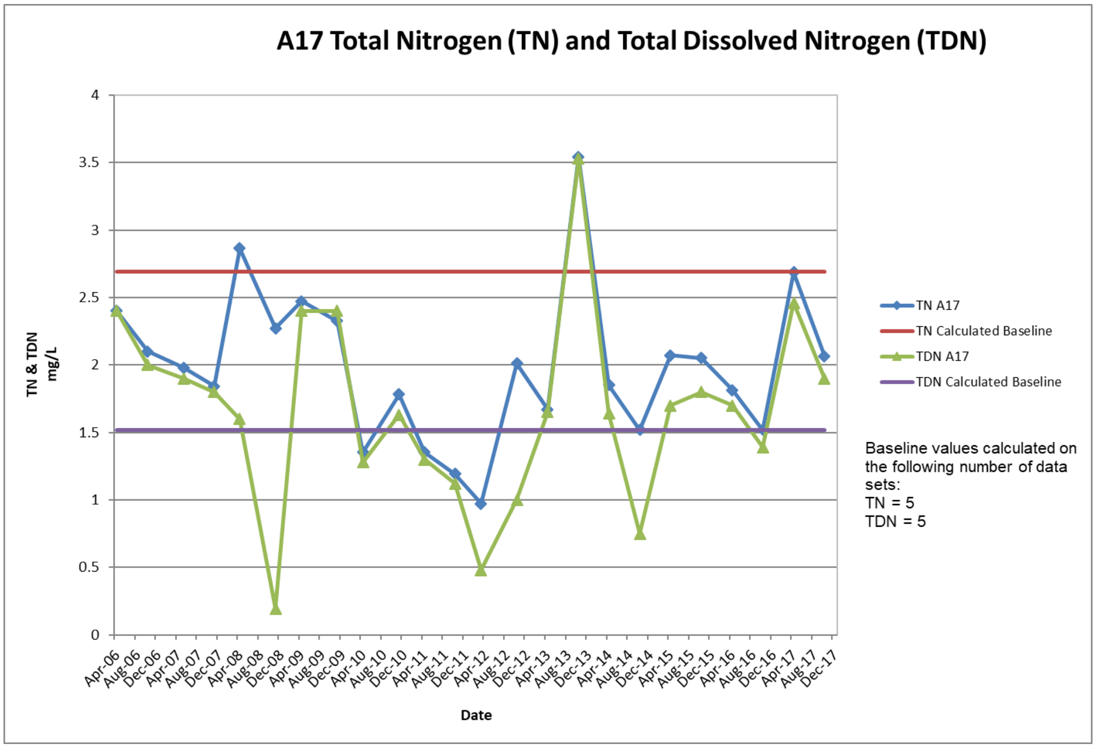

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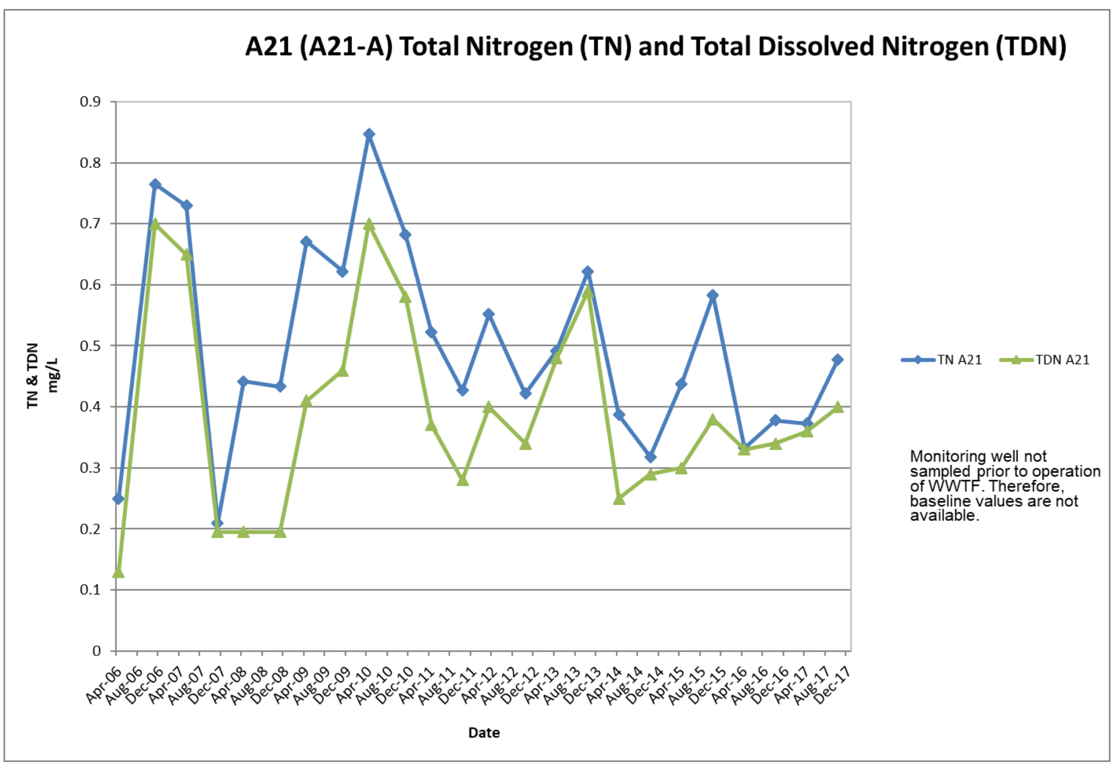

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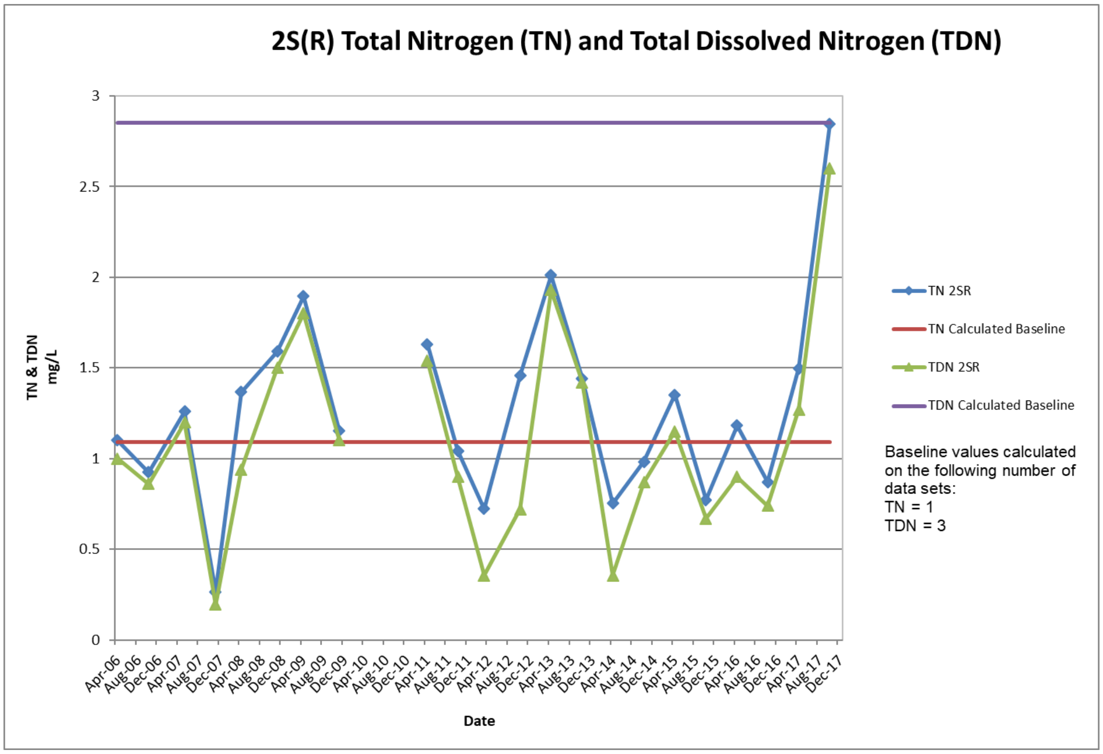

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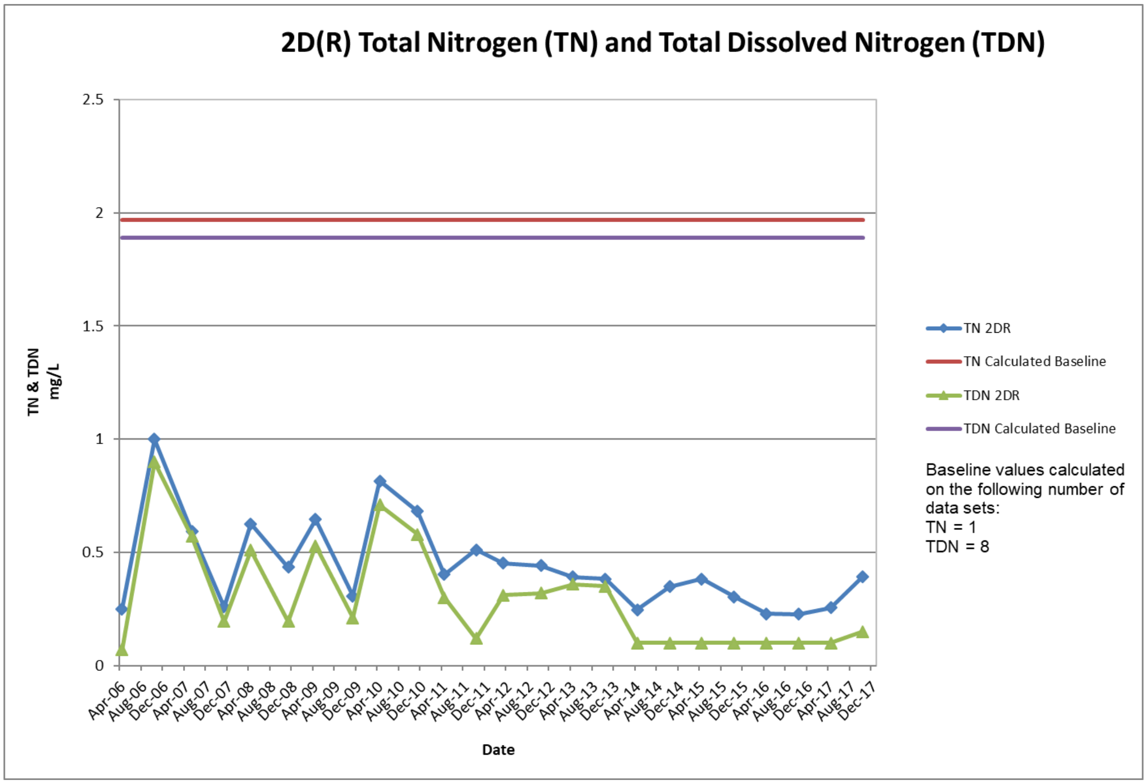

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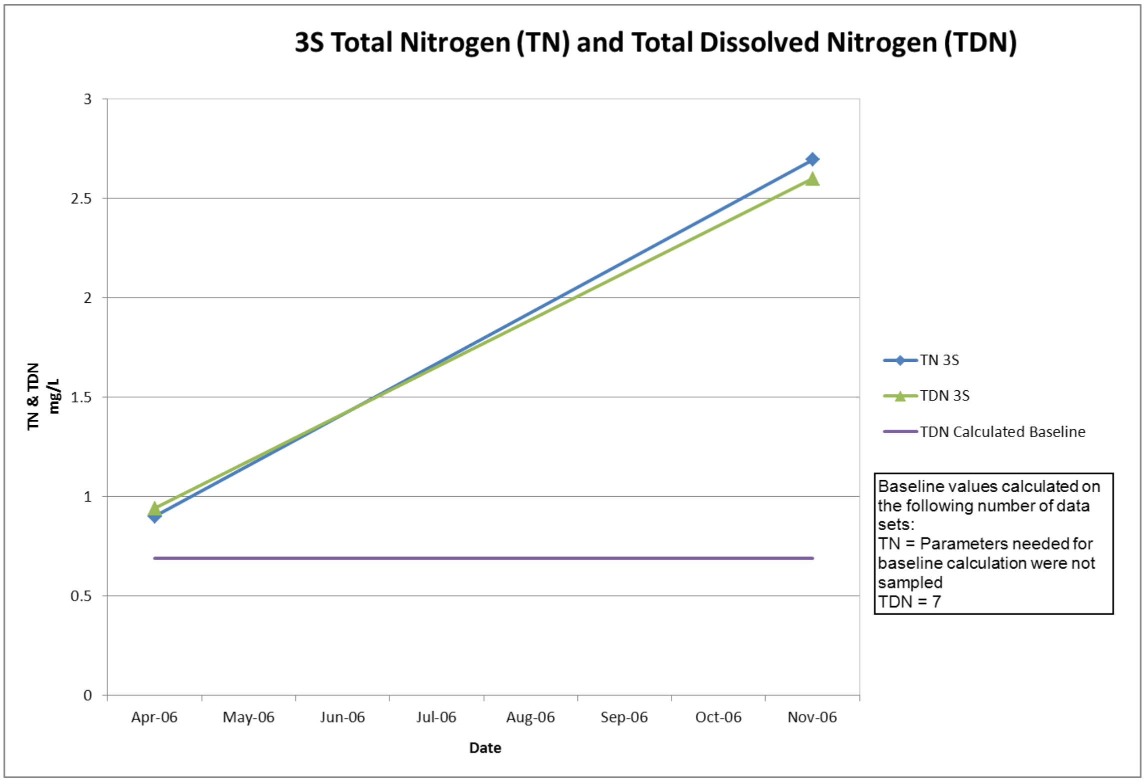

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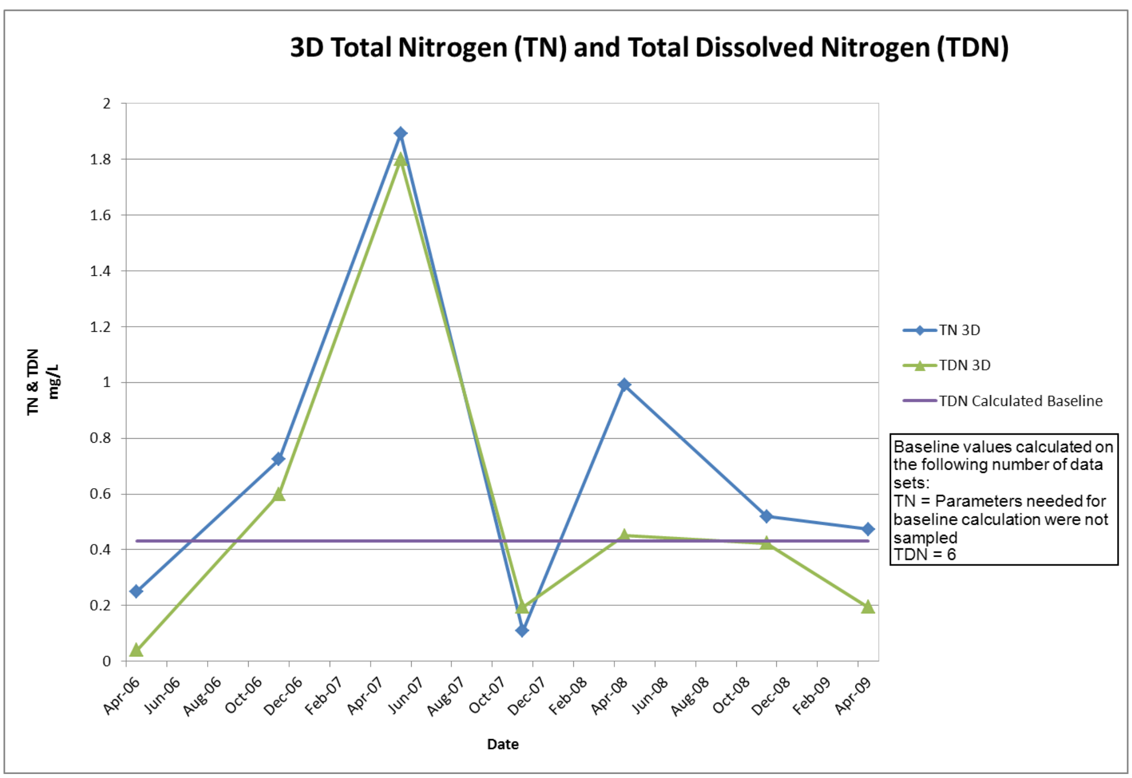

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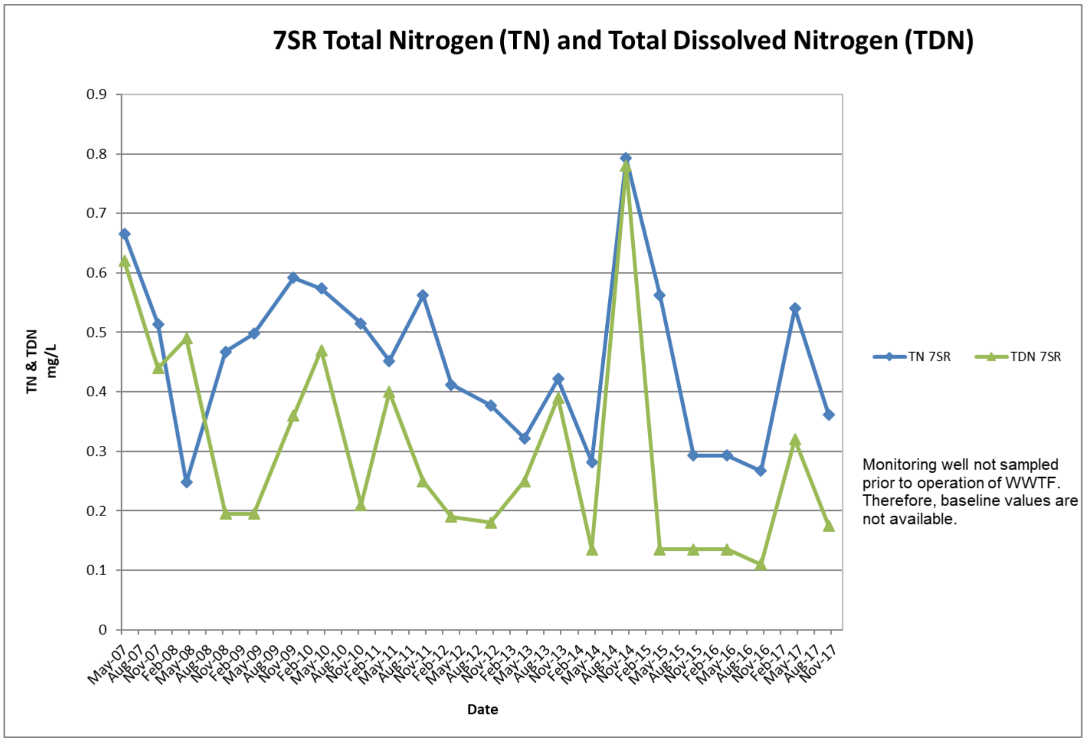

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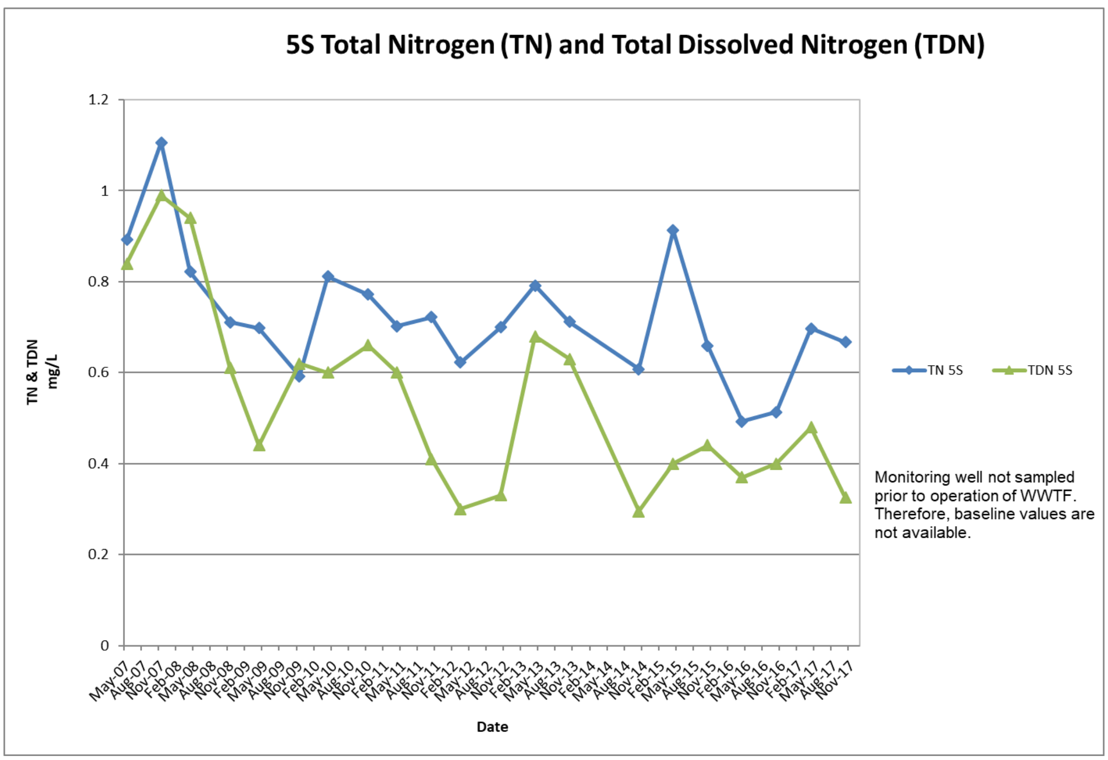

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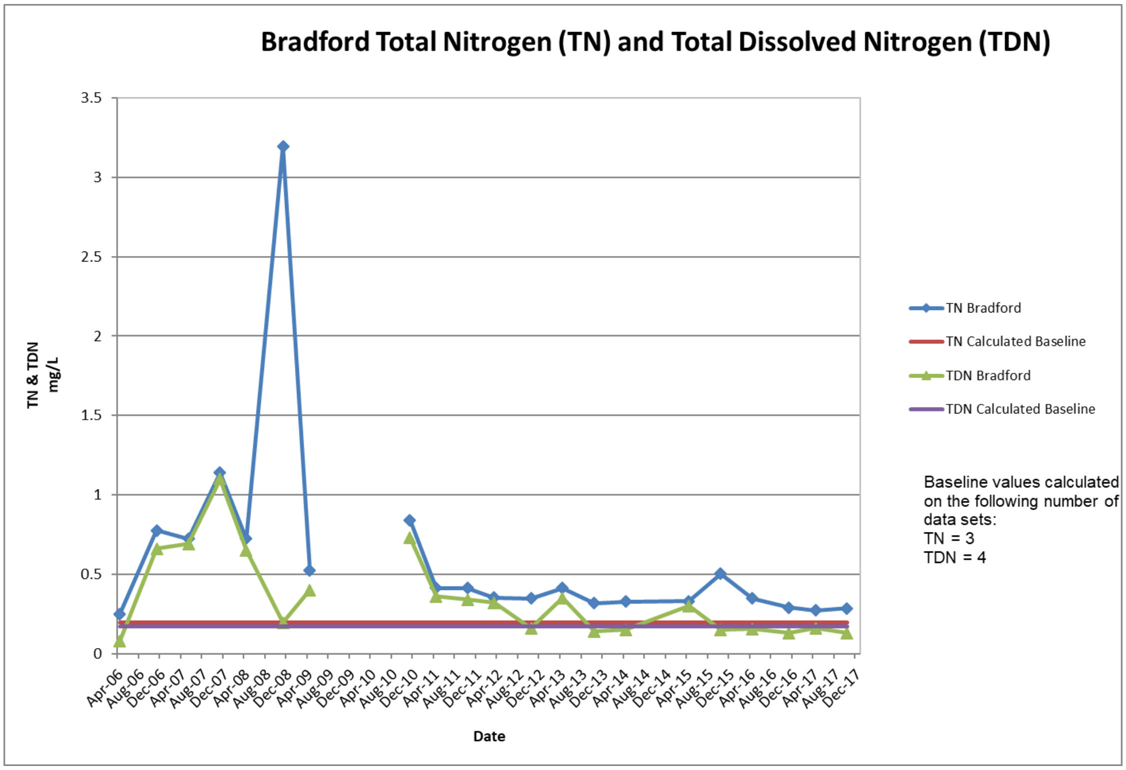


2.3.5 Inner and Outer Groundwater Monitoring Data Comparisons

A8, A9, A10, A11, A16, 1S, 6S(R), 6D, USGS 475(R)

As stated in the July 2001 Nutrient Management Plan Section 7.3: Eight monitoring wells are located near the WWTF for observing changes in the groundwater. The "inner wells" – A9, A10, A11 and A16 – are sited closest to the facility and would be the first to show any change caused by the treatment facility. The "outer wells" – 6SR, 6D, 1S and USGS 475(R)- are located further from the WWTF (down gradient of the property line) and would show a change later than the inner wells.

Four parameters, total phosphorus, total nitrogen, boron, and pH, were identified for monitoring groundwater changes proximal to the WWTF.

Table 9 – Inner and Outer Groundwater Comparisons

Location	Parameter	Calculated Baseline (Pre-Operational)	Operational Average thru 2016	2016 Average	Operational Average thru 2017	2017 Average
A8	Total Phosphorus (TP) mg/L	0.003	0.941	0.941	1.141	3.168
A9	Total Phosphorus (TP) mg/L	0.009	0.046	0.046	0.043	0.021
A10	Total Phosphorus (TP) mg/L	0.006	0.022	0.022	0.021	0.006
A11	Total Phosphorus (TP) mg/L	0.008	0.044	0.044	0.041	0.015
A16	Total Phosphorus (TP) mg/L	0.006	0.027	0.027	0.027	0.020
6S	Total Phosphorus (TP) mg/L	0.007	0.033	0.030	0.031	0.008
6D	Total Phosphorus (TP) mg/L	0.006	0.040	0.040	0.038	0.020
1S	Total Phosphorus (TP) mg/L	0.007	0.031	0.031	0.029	0.010
USGS475R	Total Phosphorus (TP) mg/L	0.039	0.061	0.061	0.057	0.018
A8	pH units	5.660	6.229	6.833	6.286	6.868
A9	pH units	6.000	5.450	6.723	5.527	6.293
A10	pH units	5.630	5.058	5.870	5.165	6.248
A11	pH units	5.390	5.386	7.693	5.415	5.708
A16	pH units	5.270	5.293	6.673	5.386	6.323
6S	pH units	5.420	5.403	6.673	5.518	6.673
6D	pH units	6.500	5.620	6.393	5.726	6.803
1S	pH units	5.460	5.504	6.570	5.578	6.317
USGS475R	pH units	5.320	5.600	6.563	5.666	6.328
A8*	Boron mg/L	0.024	0.164	0.243	0.171	0.247
A9	Boron mg/L	NA	0.098	0.104	0.099	0.105
A10	Boron mg/L	0.016	0.075	0.105	0.075	0.068
A11	Boron mg/L	0.017	0.053	0.066	0.052	0.034
A16	Boron mg/L	0.016	0.046	0.027	0.046	0.041
6S	Boron mg/L	0.015	0.038	0.017	0.036	0.010
6D	Boron mg/L	0.017	0.039	0.018	0.037	0.012
1S	Boron mg/L	0.029	0.042	0.017	0.039	0.009
USGS475R	Boron mg/L	0.024	0.042	0.042	0.040	0.022
A8	Total Nitrogen mg/L	1.230	3.840	4.709	3.878	4.289
A9	Total Nitrogen mg/L	1.135	3.365	4.061	3.431	4.160
A10	Total Nitrogen mg/L	0.750	3.118	2.959	3.057	2.388
A11	Total Nitrogen mg/L	1.090	2.138	2.879	2.123	1.965
A16	Total Nitrogen mg/L	0.860	0.817	1.959	0.877	1.544
6S	Total Nitrogen mg/L	0.195	0.386	0.216	0.367	0.159
6D	Total Nitrogen mg/L	0.195	0.939	1.166	0.921	0.732
1S	Total Nitrogen mg/L	0.360	0.278	0.139	0.257	<0.08
USGS475R	Total Nitrogen mg/L	0.195	1.421	2.496	1.500	2.308
*average excludes 2/2006						

As noted in Section 2.1 adding half the detection limit for non-detect values is important for statistical analysis. It is not common to add half the detection limit for calculating total nitrogen under a groundwater discharge permit (permit wells inner-outer). However, for purposes of statistical analysis and comparison to baseline data the Nutrient Management Data Report calculates total nitrogen for the permit wells using half the detection limit.

Figure 20

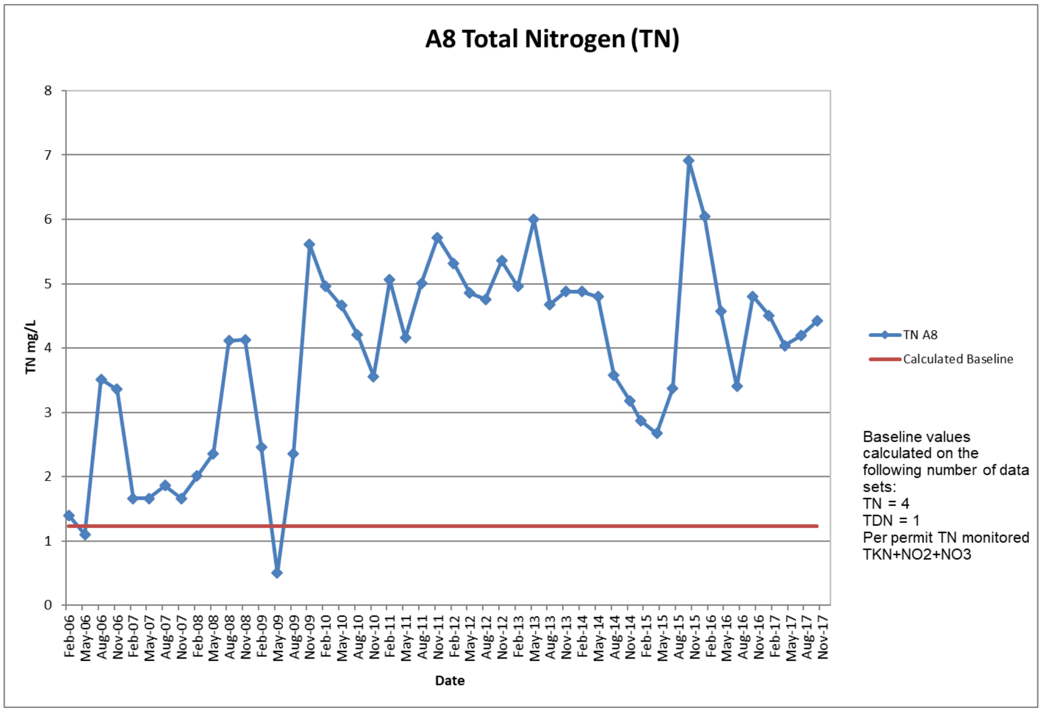


Figure 21

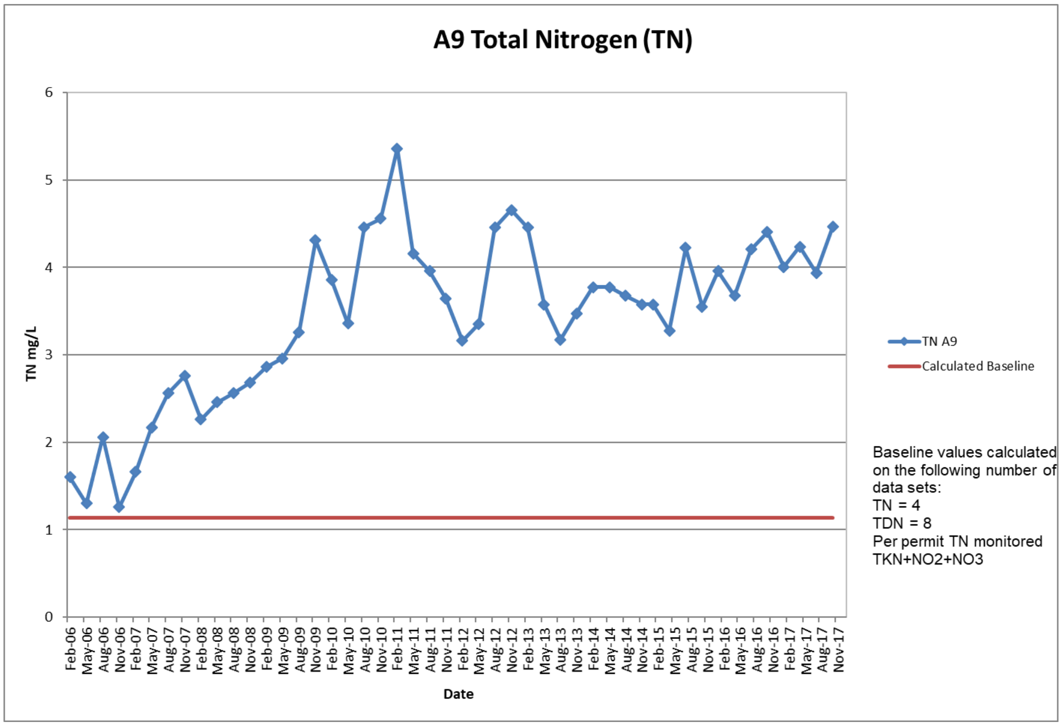
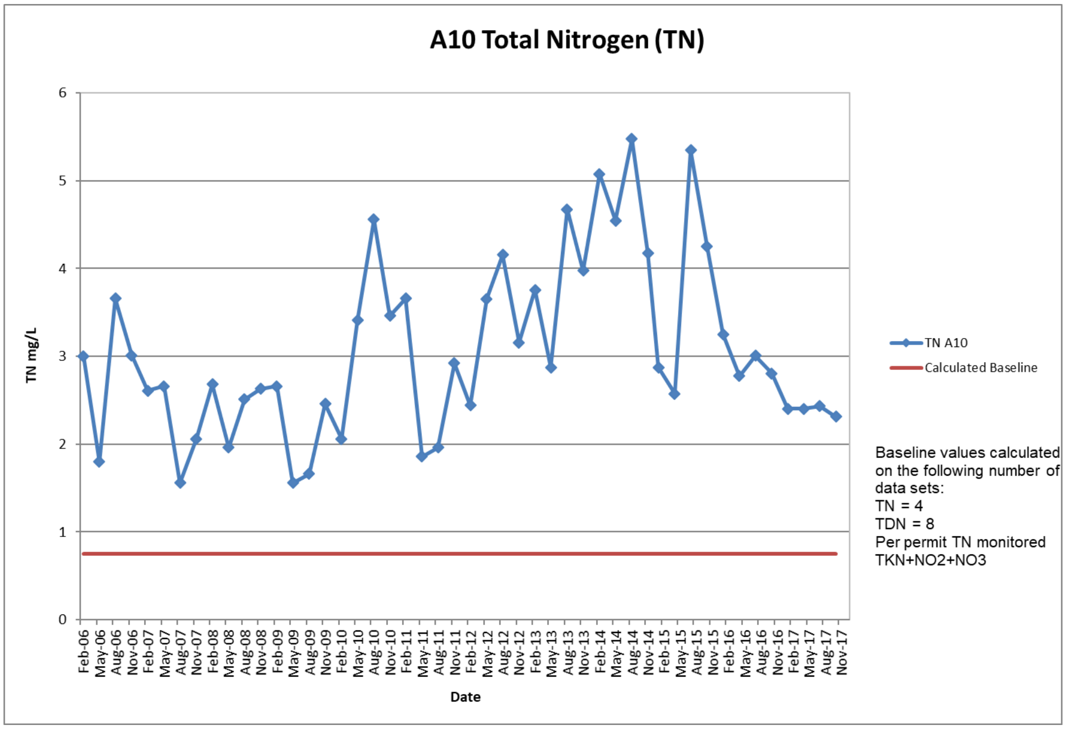


Figure 22



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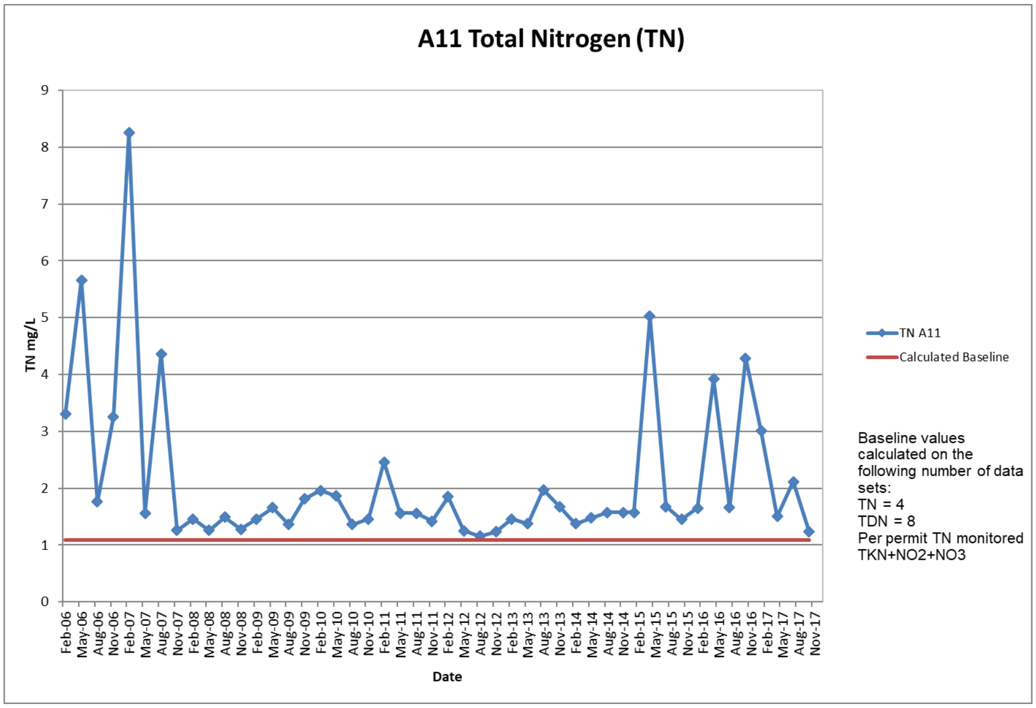
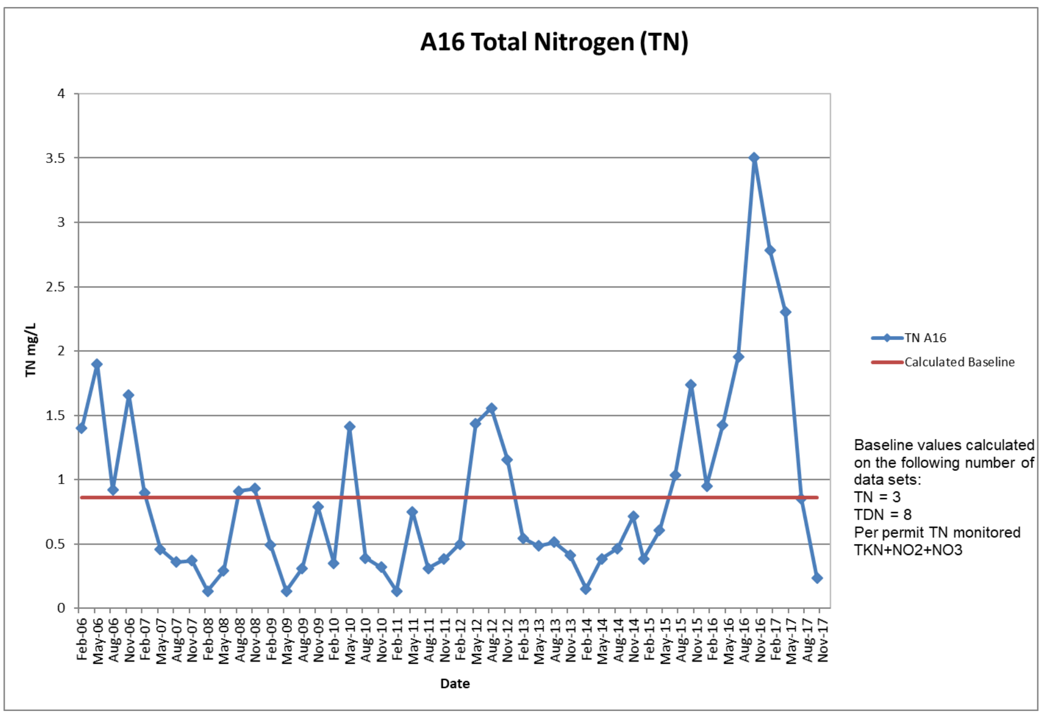


Figure 24



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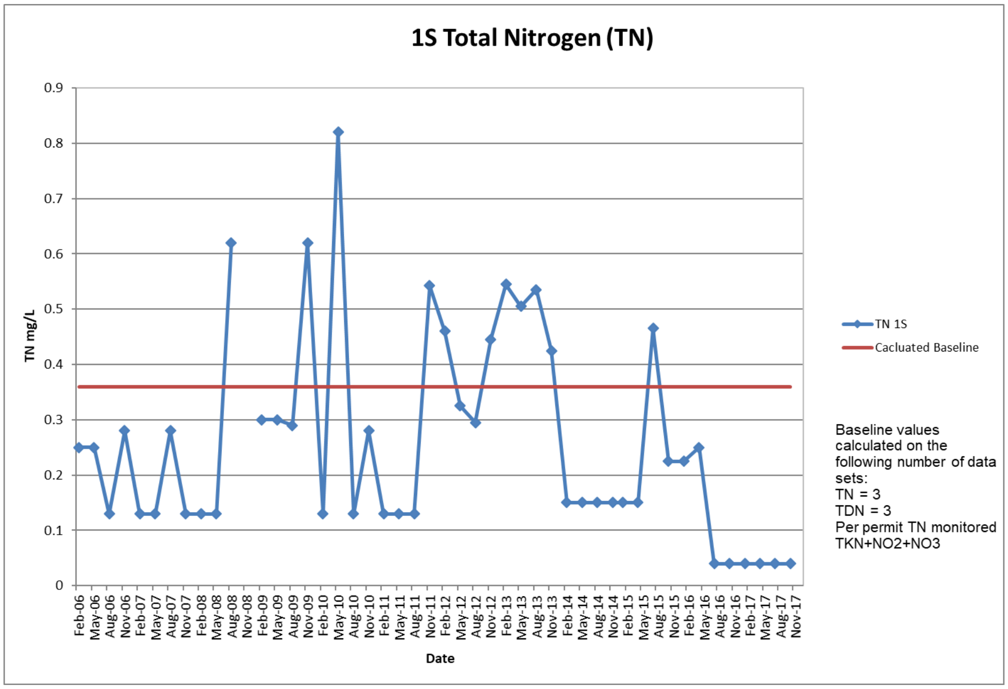

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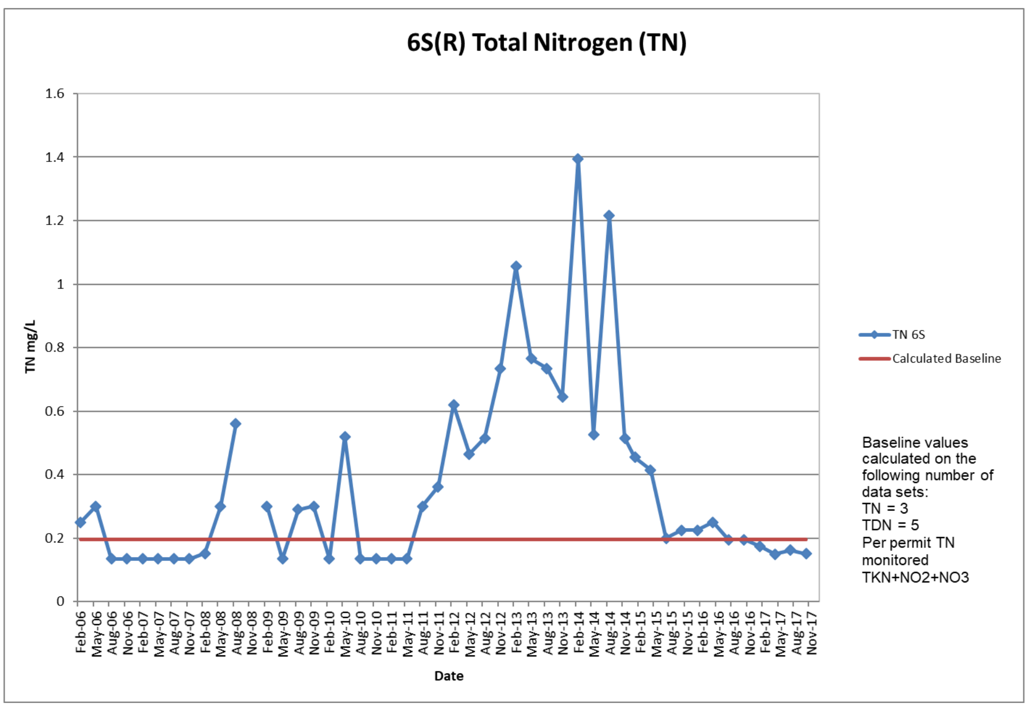

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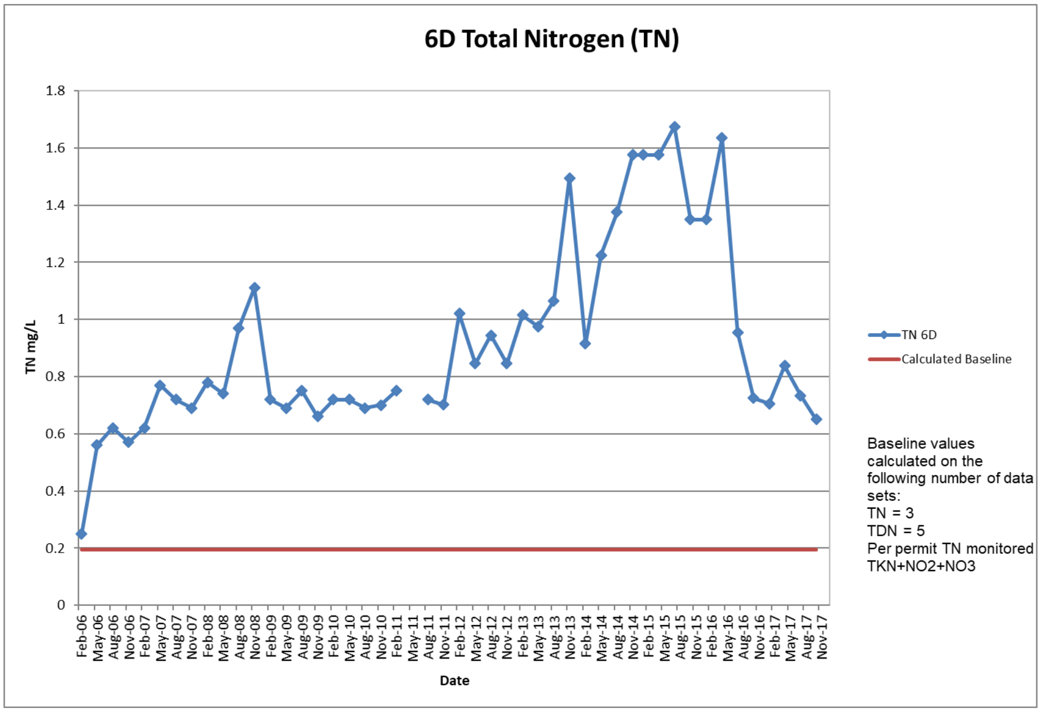
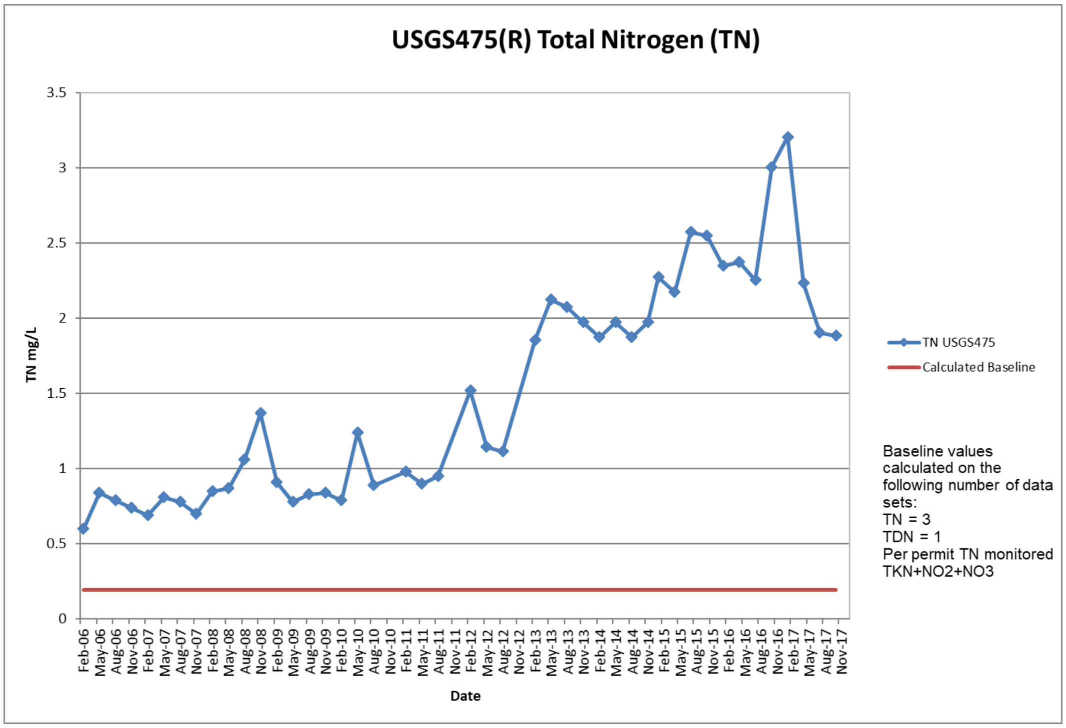


Figure 28



2.4 Biological Monitoring

The baseline biomonitoring program was performed in 1998, 1999 and 2001. Four pond stations were established and monitored during those years: Russell Mill Pond, Hayden Pond, Howland Pond and Eel River Pond (basin). All four ponds are man-made impoundments along the Eel River. The memoranda presenting the biomonitoring data and findings were presented as Appendix D of the June 2002 Eel River Watershed Monitoring Data Report.

The results of the operational biomonitoring of periphyton, macroinvertebrates, and plankton that was completed are attached in Appendix C. The following is a brief discussion of the data results compiled by the Town's Professional Consultant Limnologist/Biologist. Note from 1998-2012 Consultant was David Worden. Due to his passing the Town has now utilized the School of Marine Science and Technology as a Consultant.

2.4.1 Biological Monitoring Locations

Table 10

Biological Monitoring Locations			
Location ID	**Description**	**Macrophyte/ Phytoplankton**	**Macroinvertebrate/ Periphyton**
BM-1	Downstream of Russell Mill Pond, near hatchery		☑
BM-2	Downstream of Hayden Pond, near Sandwich Road		☑
BM-3	Near Forge Drive		☑
BM-4	Downstream of Sawmill Pond Dam		☑
Head 2 (not required)	In Eel River Preserve, Old Bog 4/5 Intersection		☑
Head 4 (not required)	In Eel River Preserve, Old Bog 1, d/s Long Pond Road		☑
Russell Mill Pond		☑	
Hayden Pond		☑	
Howland Pond		☑	
Eel River Basin		☑	

Note should be taken that at site BM-3 a wetland protection violation was reported to the Conservation Commission on 9/6/2016. Conservation Agent confirmed the river was dredged and widened. No formal enforcement action was taken.

2.4.2 Macroinvertebrate Data, 2017

Macroinvertebrate sampling was conducted on August 23, 2017 at the four stations selected for previous biomonitoring of lotic (running water) habitats composing the Eel River ecosystem. In addition the Head 2 and Head 4 locations were also sampled as part of the monitoring of the Eel River Headwaters Restoration Project. These stations consist of the following: BM-1 located downstream of Russell Millpond adjacent to a fish hatchery, BM-2 located upstream of the Old Sandwich Road Bridge crossing, BM-3a located upstream of the Forge Road crossing, and BM-4 located upstream of Russell Millpond and downstream of the dam removal site at the footbridge. Head 2 is located in the Eel River Preserve prior Bog 4/5 intersection and Head 4 is located downstream of Long Pond Road in prior Bog 1.

Methods

Sampling was conducted according to the multihabitat method of the Massachusetts DEP (December 1995) using an aquatic dip net. Substrates and instream structure providing microhabitat for aquatic invertebrates (cobble/gravel, submerged plants, woody debris/snags, etc) were sampled in proportion to their representation to form a composite sample at each sampling station. Analysis of the sample collected at each station entailed laboratory identification and enumeration of all organisms without subsampling. Collected organisms were identified to the lowest practical taxon, generally family or genus.

Data Analysis

Quantification of community structure observed in the sampling program is necessary if potential impacts to the system are to be detected in the future. Features of community structure quantified in this program consist of the following: richness (number of taxa), evenness (relative importance of taxa), number of EPT taxa (representatives of the pollution sensitive orders Ephemeroptera, Plecoptera and Trichoptera), relative abundance of major taxa (percent composition of the total community) and the relative abundance of functional feeding groups.

Community diversity has two components: richness and evenness. Richness is the most obvious component of diversity. The larger the number of taxa (species or genera) in a community, the greater the diversity. Evenness is the pattern of importance or dominance of taxa within a community. The more even or equitable the abundance of taxa are relative to each other, the greater is the diversity. Conversely, a community dominated by one or a few taxa, with other taxa being relatively rare, is less diverse. Evenness is quantified using the scaled standard deviation (scaled SD) value of Fager (1972) which uses the formula for that statistic to measure the variability in numbers of individuals per taxa. Scaled SD is a direct measure of the evenness component of diversity and allows comparison of samples with different numbers of taxa and individuals. Scaled SD values range from 0 to 1.0, with 0 representing extreme skew or unevenness in community structure (low diversity) and 1.0 representing complete evenness (maximum diversity).

Community measures involving tolerance values assigned to taxa, such as the Hilsenhoff Biotic Index and Lenat's Biotic Index, were omitted from analysis of the Eel River data due to their derivation from studies of communities inhabiting riffle habitat (stream reaches characterized by turbulent water flow). These measures are of questionable appropriateness for the Eel River which is a low-gradient system lacking riffles (as pointed out in previous reports). Additionally, tolerance values were developed as measures of the response of various taxa to diminished concentrations of dissolved oxygen resulting from organic pollution. Increased loading of organics to the Eel River, such as from a sewerage discharge, is not an impact anticipated in the design of this study.

Results

Results of macroinvertebrate sampling reinforce previous findings that show community composition corresponding predictably to the habitat characteristics of each sampling station (Appendix C). There is mix of increase and decrease in diversity as compared to previous years. Station BM-4 had little change prior to 2015, however, the community richness increased in 2015 and 2017.

The gravel substrate at station BM-1 consisted of larval flies and midges while the banks of the channel were abundant with amphipods. This is similar to previous years sampling results.

Caddisfiles were also present again at BM-1, BM-2 and BM-3 were both dominated by amphipods and BM-4 was abundant with files and midges. Head-2 had an abundance of amphipods while Head-4 was dominated by damselflies.

Measurements of community richness and EPT taxa have remained generally the same over the last couple of years. Evenness has also improved due to increased diversity where previous data indicated disproportionate representation by *Hydropsyche* as opposed to the relative scarcity of other taxa in the community. These caddisflies specialize in building particle-filtering nets and retreats on hard substrates. This organism had consistently dominated the community at BM-1, however, this has improved over the last few years. This year the specimen collection of hydrpsyche has increased, but is only half what it was in 2014.

Results from station BM-4 show colonization of this created habitat following the dam removal to be progressing such that a community now has fairly balanced representation by midges (Chironomidae), blackflies, mayflies (*Baetis* and *Stenonema*) and hydropsychid caddisflies as noted above. Within the Eel River Preserve at Head 2 there is a diverse habitat forming. The downstream site, Head 4, has been slightly slower in developing diversity, however in 2015 the community richness doubled and then remained the same in 2017.

Changes in composition and structure of the Eel River macroinvertebrate community and historical data reflect fluctuations in populations that are typical of macroinvertebrate communities. Over the last year, community richness increased and in some stations doubled. Numerous factors contribute to population dynamics within macroinvertebrate communities with extremes of flow, from drought conditions to flooding torrents, being the overriding factor. Other factors include competition, predation, type and availability of submerged substrates, and the dispersal of taxa through the oviposition behavior of aerial adult forms and by downstream “drift” of immature forms.

2.4.3 Periphyton Data, 2017

The artificial substrates were collected on June 2, 2017 and October 7, 2017. Slides recoverd in May were richly colonized with periphytic growth composed generally of diatoms as observed in previous years. Slides recovered in September were also composed of diatoms typical of periphyton. Location BM-3 had no organisms on the slide in the spring while Location BM-3 had no organisms on the slides in the Fall.

2.4.4 Secchi Transparency and Dominant Phytoplankton, 2017

Results of phytoplankton sampling and profile measurements recorded in the four ponds can be found in Appendix C. The phytoplankton community in Russell Mill Pond in the spring were dominated by *Asterionella* and *Tabellaria* thereby shifting to Rare in the fall. Hayden Pond had high densities of *Asterionella* and *Tintinnids* in the spring, similar to prior spring. which shifted to rare and occasional in the fall. *Asterionella* were abundant in Howland Pond in the spring and shifted to occasional in the fall. Eel River Basin in previous years had a different composition of phytoplankton then the other three systems, however, the spring had similar and abundant communities similar to the other systems. In the Fall the Eel River Basin was dominated by *Fragilaria and Fragilariopsis* which only one of was seen in the other system of Howland Pond.

Russell Mill Pond has a history of appearing particularly brown and turbid due to a bloom of the diatom *Asterionella.* Below the thermocline, the hypolimnion has been historically close to being anoxic due to intense microbial demand for oxygen. However, this spring, as with last spring, the anoxic condition did not occur on the sampling date. The clarity in Russell Mill Pond during the spring profile was 1.6m vs historically under 1m clarity.

As observed in previous years of monitoring, the outflow from Russell Mill Pond discharges tremendous amounts of *Asterionella* biomass and this was strongly evident in the phytoplankton communities of Hayden Pond and Eel River Basin located downstream. The water of these latter two ponds, especially Hayden Pond, had the same murky, brown appearance and microscopic analysis of samples showed *Asterionella* to be the dominant organism in both ponds. The phytoplankton communities observed in these two ponds often reflect the influence of very high productivity by phytoplankton in Russell Mill Pond and subsequent export of phytoplankton biomass downstream.

2.4.5 Macrophyte and Biomass Survey, 2017

Results of recent macrophytes surveys of the Eel River ponds document are generally consistent with observations from previous reports. Russell Mills Pond was very turbid when visited on June 1, 2017. Similar to last year, starwort and coontail were common along the southern edge of Russell Mill Pond, while common reed and Cattail were most common along the western edge. Invasive pondweed was dominant in Hayden Pond. The edges of Howland Pond were densely covered in purslane. Howland Pond also had an abundance of yellow waterlilies and large amounts of filamentous green algae. Naiad was beginning to grow as well. Eel River basin had an abundance of purslane, common reed and common cattail along the banks.