Town of Plymouth, MA
Department of Public Works
Environmental Management Division

Operational Monitoring Program Data Report for 2006 and 2007

August 2008

Summary

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*, and is additional monitoring already set forth in the WWTF permit.

This additional 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. The baseline monitoring was conducted prior to the WWTF operation to document the existing conditions in the Eel River Watershed. The permit action levels as specified in Table 3 were created from the baseline monitoring results. The interim monitoring was also completed prior to the operations of the WWTF but was not included to evaluate the permit action levels but is utilized in the present evaluation to investigate trends in the monitoring program. The operational monitoring has been set forth to track and evaluate any changes in the Eel River system over time.

<u>Surface Water & Groundwater Monitoring Summary</u>

The Town Environmental Management Division conducted the 2006 & 2007 surface and groundwater monitoring for the Nutrient Management Plan. Veolia conducted the permit compliance inner/outer well monitoring.

As noted in Table 5, the total nitrogen and total phosphorus levels for the Eel River system have increased since the baseline average (1998-2000). Unfortunately, the Town has been unable to identify exactly what values were utilized to calculate the baseline averages by CDM as it seems some values may have been excluded in the calculations. The Towns evaluation of the data includes all concentration results. The overall increase in nutrients is a concern for the water quality in the Eel River as well as Plymouth Harbor. The Town is proactively identifying potential impacts and implementing appropriate mitigation measures to reduce these impacts. Mitigation efforts include; stormwater systems, river restoration, wetland restoration, removal of flow altering structures, river cleanups, preserving open space along the river, researching reclaimed water options from the WWTF. Many factors are associated with an increase in nutrients in waterbodies including; wastewater treatment facilities, septic systems, fertilizer use, stormwater runoff and development to name a few.

Many of the sampling locations maintained a consistent concentration of nutrients until the summer of 2006 when there was a wetland violation immediately adjacent to the river system. The data indicates a dramatic increase in nutrients at this location which is then apparent at the downstream locations. The groundwater data does not indicate an association with the overall increase in nutrients in the surface water. The wells located directly adjacent to the plant have at times indicated a higher level of nutrients, however, the downgradient wells are exponentially lower in concentrations.

At this time, the surface & groundwater data does not indicate an increase in nutrients from the WWTF. Other factors including the cranberry bogs, septic system failures, stormwater runoff and development appear to be impacting the overall water quality in the river system. However, the Town is actively pursuing reclaimed water options as well as tertiary treatments from the WWTF to reduce any potential impacts. The Town is also implementing projects, Section 1.5, to reduce the nutrient loading into the Eel River & Plymouth Harbor systems.

Biological Summary

The Towns Biologist/Limnologist Consultant has been performing the biological monitoring program from the onset of the baseline monitoring in 1998. Macroinvertebrate Communities, Periphyton, Plankton and Macrophyte analysis were conducted in 2006 & 2007. Overall, the biological conditions have remained similar to those collected during the baseline monitoring program. In 2006 the most notable change was the absence of the caddisfly *Cheumatopsyche* throughout the system. However, in 2007 it reappeared at stations BM-1 & BM-2. Another common caddisfly reappeared in 2007 as well, *Hydropsyche,* and was found at station BM-2. Also noted in both the 2006 & 2007 monitoring efforts, was a steady increase in specific conductance from locations BM-4 & BM-3A downstream throughout the system to the Eel River Basin. The most likely cause may be associated with road salting, especially at the crossing of Route 3 between BM-1 and Hayden Pond and the crossing of Clifford Road over the outlet of Howland Pond. Fanwort, *Cabomba caroliniana,* remains the only invasive alien macrophyte present in the

Eel River system and is restricted to Hayden Pond and the Eel River Basin. In general, the pond macrophyte communities were similar in composition, distribution, and density to observations documented in 2003 survey results with the exception of *Elodea* in Hayden Pond and Eel River Basin. Changes in macroinvertebrate community diversity reflect fluctuations in populations that are typical of these communities. Numerous factors contribute to population dynamics within macroinvertebrate communities including competition, predation, water regime, 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. Further information may be found in the Bilogical Monitoring Section 2.5.

Contents

Section 1

Introduction

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*, and consists of an additional monitoring program set forth in the WWTF permit for the Eel River Watershed.

The additional monitoring program consisted 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 June 2002. The baseline monitoring was conducted prior to the WWTF operation to document the existing conditions in the Eel River Watershed. The permit action levels as specified in Table 3 were created from the baseline monitoring results. The interim monitoring was also completed prior to the operations of the WWTF but was not included to evaluate the permit action levels but is utilized in the present evaluation to investigate trends in the monitoring program. The operational monitoring has been set forth to track and evaluate any changes in the Eel River system over time.

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. 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 Town created a more extensive surface water monitoring program in 2006 to evaluate the entirety of the Eel River Water System. The required surface water monitoring is listed in Table 1 with the additional monitoring locations. 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

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 beds 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.

The *Town of Plymouth, Ma Nutrient Management Plan by Camp Dresser & McKee January 2001,* states in the Executive Summary the following;

> *The WWTF will discharge 1.75MGD to the existing ocean outfall and discharge the remaining 1.25MGD to the infiltration beds at the facility. The initial flow to the infiltration beds will be limited to 0.75MGD; the flow will only be increased if there is a demonstrated need, if the Eel River System does not show any adverse impacts from the 0.75MGD discharge, and if DEP issues a new groundwater discharge permit at the higher discharge rate.*

The permit limit for nitrogen is 10mg/L with a total annual discharge to the infiltration beds of 0.75MGD. From June 2005 through May 2006 the average groundwater flow to the infiltration basins was 0.12MGD, with an average total nitrogen load of 4.02mg/L. During this same time period, the average flow to the ocean outfall was 1.623MGD bringing the total flow from the WWTF to 1.743MGD. From June 2006 through May 2007 the average groundwater flow to the infiltration basins was 0.14MGD, with an average total nitrogen load of 11.06mg/L. During this same time period, the average flow to the ocean outfall was 1.626MGD bringing the total flow from the WWTF to 1.766MGD. The increase in the average total nitrogen load from 2006-2007 is due to violations that were reported to DEP. Since then, the plant has been back in compliance. The average total nitrogen load from May 2007 through June 2008 was back down to 5.03mg/L. In the following section is a brief description of the Towns efforts in implementing reclaimed water which will greatly reduce future nutrient loading to the watershed as well as reduce water usage.

1.5 DPW Environmental Management Division and Projects within the Eel River Watershed

In May of 2005, the Environmental Management Division was created under DPW 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. The Division has incorporated additional monitoring of the Eel River System as described in Table 1.

Nutrient Management Model: 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.

Plymouth Harbor Watershed By-law: The Division worked with various consultants on a Nutrient Management Mitigation Program for the Plymouth Harbor Watershed which includes 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. The Town will continue to review the best options for the implementation of the watershed by-law.

Eel River Watershed Delineation: 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.

The Environmental Management Division is also involved in numerous projects within the Eel River Watershed. A few of these ongoing projects are briefly described below, however, updated information can be found on the Environmental Management Division webpage:

Eel River Headwaters Restoration Project – Wetland & River Restoration

Site Description: 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.

The restoration site consists of 39.5 acres of in-active cranberry bogs that were part of the Wetland Reserve Program through Natural Resource Conservation Service. The surrounding forest, upland and bogs were later purchased by the Town's Community Preservation Committee. The Eel River originates in this bog system and is a spring fed river that flows into Plymouth Harbor. Throughout the project site are numerous culverts and ditches which are obstructing flow. At the northern tip of the project site is the Sawmill Pond Dam which does not provide for fish passage.

Proposed Restoration Activities: The Eel River Headwaters Restoration project is a precedent setting restoration project converting abandoned cranberry bogs to wetland habitat, removing flow structures to restore river channel thereby creating coldwater stream habitat and reducing nutrients in both freshwater and coastal systems.

The primary objectives of this project are to provide fish passage, create wetland habitat, improve water quality in the Eel River and Plymouth Harbor through natural river channel restoration and wetland restoration. The bogs will be restored to a complex of natural wetlands including riparian wetlands, Atlantic white cedar swamp and scrub-shrub wetlands. Approximately 1.25 miles of natural river channel will be restored from the headwaters to Russell Mill Pond. The Town is also proposing the removal of the stone dam located upstream of Russell Mill Pond to improve water quality and provide fish passage.

The Division is working closely with project partners; Coastal Zone Management, Natural Resource Conservation Service, United States Fish & Wildlife Service, American Rivers and the Riverways Program. Together, project partners have raised almost 2million dollars for the restoration project. Final Design is complete for the wetland and river restoration and the dam removal final design is expected to be completed in 2008. The Town is currently working on the permitting stage of the project. Construction is expected to being late 2009 or early 2010.

Constructed Wetlands at the WWTF Infiltration Basins

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.

Reclaimed Water from the Wastewater Treatment Facility located in Camelot Park

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.

In 2007, the Town received initial approval to utilize 8million dollars of State Revolving Funds for the construction of a sewer and reclaimed water line between the Camelot Park WWTF and Plymouth South Middle/High School. The reclaimed water line will potentially service Forges

Field Recreational Facility, Plymouth South Middle/High School Recreational fields, Crosswinds & Waverly Oaks golf courses.

Reclaimed water use on these golf courses and athletic fields will positively impact the environment in respect to nutrient loading and groundwater recharge. By utilizing the reclaimed water on golf courses and athletic fields, fertilizer application will be reduced as the reclaimed water will contain a percentage of the appropriate nutrients. Also, a major influence for the use of reclaimed water in the watershed is the reduction in water with-drawl for irrigation use on ball fields and golf courses. Currently, Crosswinds Golf Course and Forges field athletic facility draft permit is for 43MGY. Waverly Oaks Golf Course has requested 65MGY in their Water Management Act Application. The utilization of reclaimed water on these facilities will greatly reduce the need for water with-drawl in the watershed. This project is on-going.

Section 2

Data Observations

2.1 Surface Water

Section 2.1.1 presents observations of the monitoring results for surface field measurements and analytical measurements from 2006 and 2007. The data presented in the first section is for the historical locations as defined in Table 1.

Surface Water Sampling Locations
Table 1

Location ID	Description	Required by NMP	Schedule
S-5B	Downstream of Warren Avenue Bridge	☑	5x/yr
S-17	End of dock at 16 Eel River Circle		1x/yr
S-4B	Downstream of Clifford Rd Bridge		1x/yr
S-4A	Howland Pond, at Clifford Rd Bridge, u/s of dam	☑	5x/yr
S-11	Upstream of Howland Pond. At outlet upstream of bridge		1x/yr
S-15	At outlet of Forge Pond		1x/yr
S-16	Inlet of Forges Pond off Old Sandwich Road near bog		1x/yr
S-18	Outlet from lower bog off Old Sandwich Road		1x/yr
S-19	Outlet from upper bog off Old Sandwich Road		1x/yr
S-20	Pond south of Forge Pond		1x/yr
S-3B	Downstream of Hayden Pond, directly downstream of bridge off Sandwich Rd. Across from 128 Sandwich Rd.		1x/yr
S-3A	Hayden Pond, upstream of fish ladder	☑	5x/yr
S-2A	Russell Mill Pond –DEEP Location		1x/yr
S-2C	Off Russell Mill Pond Rd. Downstream of dam		1x/yr

S-2B	24 Russell Mill Pond Rd – Enos Property. From end of dock	☑	5x/yr
S-1	Russell Mill Pond Rd – prior to hatchery take left on dirt road. Bear right at fork and follow to water.	☑	5x/yr
S-9A	Gilbert fish hatchery, upstream of hatchery near pumphouse in bog.		1x/yr
S-6B	The Nature Conservancy – downstream of dam. Between dam and outlet to Russell Mill Pond		1x/yr
S-6A	The Nature Conservancy – in Pond upstream of dam	☑	5x/yr
S-12	Downstream of bend after culvert along Long Pond Rd		1x/yr
S-13	Upstream of first bog south of Long Pond Rd		1x/yr
S-14	At headwaters – near tupelo tree, second to last bog		1x/yr
S-7	In Harbor near Poverty Point	☑	2x/yr
S-10	In Harbor near jetty	☑	2x/yr

2.1.1 Surface Water Data Observations

Field Measurements

<u>Temperature</u>

2006: During the operational monitoring period the temperature measured in the surface water ranged from 2.1 degrees Celsius to 23.36 degrees Celsius. The lower reading was collected at location S-3A on March 02, 2006 at 6:46AM. The higher reading was collected at location S-5B on August 7, 2006 at 8:07AM.

2007: During the operational monitoring period the temperature measured in the surface water ranged from 6.98 degrees Celsius to 24.31 degrees Celsius. The lower reading was collected at location S-4A on April 10, 2007 at 9:40AM. The higher reading was collected at location S-5B on August 06, 2007 at 8:13AM

<u>Specific Conductivity</u>

2006: During the operational monitoring period the specific conductivity measured in the surface water ranged from 63 us/cm to 164 us/cm. The lower reading was collected at location S-6A on October 30, 2006 at 11:05AM. The higher reading was collected at location S-9A on July 13, 2006 at 11:33AM.

2007: During the operational monitoring period the specific conductivity measured in the surface water ranged from 70 us/cm to 152 us/cm. The lower reading was collected at location S-4A on April 10, 2007 at 9:40AM. The higher reading was collected at location S-9A on August 06, 2007 at 11:02AM.

Dissolved Oxygen

2006: During the operational monitoring period the dissolved oxygen measured in the surface water ranged from 5.34 mg/L to 14.32 mg/L. The lower reading was collected at location S-3A on July 14, 2006 at 7:27AM. The higher reading was collected at location S-5B on March 02, 2006 at 6:05AM.

2007: During the operational monitoring period the dissolved oxygen measured in the surface water ranged from 5.07 mg/L to 15.78 mg/L. The lower reading was collected at location S-4A on September 12, 2007 at 8:48AM. The higher reading was collected at location S-5B on April 10, 2007.

pH

2006: During the operational monitoring period the pH measured in the surface water ranged from 5.69 S.U. (standard units) to 7.02 S.U. The lower reading was collected at location S-9A on August 07, 2006 at 10:57AM. The higher reading was collected at location S-2B on October 30, 2006 at 9:50AM.

2007: During the operational monitoring period the pH measured in the surface water ranged from 5.76 S.U to 7.09 S.U. The lower reading was collected at location S-9A on April 10, 2007 at 10:55AM.

Turbidity

2006: During the operational monitoring period the turbidity measured in the surface water ranged from 0.6 nephelometeric turbidity units (NTU) to 9.9 NTU. The lower reading was collected at location S-3A on September 19, 2006 at 12:40PM. The higher reading was collected at location S-6A on March 02, 2006 at 8:06AM.

2007: During the operational monitoring period the turbidity measured in the surface water ranged from 0 nephelometeric turbidity units (NTU) to 28.7 NTU. The lower reading of 0 NTU was collected at each of the locations in 2007. The higher reading was collected at location S-2B on August 06, 2007 at 10:42AM.

Laboratory Measurements

Boron

2006: During the operational monitoring period the boron measured in the surface water were typically below the 0.01 mg/L detection limit for surface water locations. A concentration of 0.026 mg/L was detected at location S-6A on July 13, 2006. Concentrations of boron at this location were also detected during the baseline conditions prior to the plant operation.

2007: During the operational monitoring period the boron measured in the surface water were typically below the 0.03 mg/L detection limit for surface water locations. A concentration of 0.0332 mg/L was detected at location S-5B on August 06, 2007. This is the first detection of boron at this location. Upstream there is a potential private septic issue that is being reviewed.

Chloride

2006: During the operational monitoring period the chloride concentrations in the surface water ranged from 0.75 mg/L to 43.9 mg/L. The lower concentration was detected at location S-9A on October 30, 2006. The higher concentration was detected at location S-5B, a tide influenced location, on September 19, 2006.

2007: During the operational monitoring period the chloride concentrations in the surface water ranged from 0.75 mg/L to 44.9 mg/L. The lower concentration was detected at location S-9A on September 12, 2007. The higher concentration was detected at location S-5B, a tide influenced location, on September 12, 2007.

Total Dissolved Solids

2006: During the operational monitoring period the total dissolved solids concentrations in the surface water ranged from 22 mg/L to 130 mg/L. The lower concentration was detected at location S-4A on March 6, 2006. The higher concentration was detected at location S-9A on August 07, 2006.

2007: During the operational monitoring period the total dissolved solids concentrations in the surface water ranged from 44 mg/L to 221 mg/L. The lower concentration was detected at location S-2B on August 06, 2007. The higher concentration was detected at location S-5B on October 04, 2007.

Chlorophyll-a

2006: During the operational monitoring period the chlorophyll-a concentrations in the surface water ranged from 0.3 ug/L to 150 ug/L. The lower concentration was detected at location S-9A on March 06, 2006. The higher concentration was detected at location S-4A on August 07, 2006. S-4A has historically been under 3 ug/L until 2006 when 3 sampling events during the summer months had high detection values (70-150 ug/L). S-4A is located in Howland Pond where, in recent years, there has been clearing of the vegetated buffer around the pond and upstream of the pond. This could be the reason for an increase in chlorophyll-a.

2007: During the operational monitoring period the chlorophyll-a concentrations in the surface water ranged from 0 ug/L to 11.2 ug/L. The lower concentration was detected at both locations S-1 and S-9A on September 12, 2007 and October 04, 2007 respectively. The higher concentration was detected at location S-3A on September 12, 2007.

Total Nitrogen

2006: During the operational monitoring period the total nitrogen concentrations in the surface water ranged from 0.37 mg/L to 3.39 mg/L. The lower concentration was detected at location S-2B on August 7, 2006. The higher concentration was detected at location S-1 on July 13, 2006. In July 2006 there was substantial clearing of wetlands directly around location S-1. On July 13, 2006, following the wetland clearing, the total nitrogen concentration was 3.39mg/L, then increased to 3.9mg/L in August, down to 1.54mg/L in September and then at 1.49mg/L in October. Prior to the July 2006 sampling event, the average total nitrogen concentration at S-1 was 0.830mg/L for the operational monitoring period. Downstream impacts are apparent in the data results. Therefore, the effects of wetland clearing on water quality are easily demonstrated in this incident.

2007: During the operational monitoring period the total nitrogen concentrations in the surface water ranged from 0.53 mg/L to 1.73 mg/L. The lower concentration was detected at location S-5B on September 12, 2007. The higher concentration was detected at location

S-6A on September 12, 2007. Location S-6A is in the immediate area of the Eel River Headwaters Restoration Project which will aid in nutrient reduction as outlined in Section 1.5.

Nitrate

2006: During the operational monitoring period the nitrate concentrations in the surface water ranged from <0.0050mg/L to 1.45mg/L. The lower concentration was detected at location S-4A at Howland Pond on July 13, 2006. The higher concentration was detected at location S-2B in Russell Mill Pond on September 19, 2006. As similarly noted above in the total nitrogen section, the impacts of the clearing of wetlands are noted downstream. On August 7, 2006 the nitrate level for S-2B was 0.06mg/L and on October 30, 2006 the level was <0.100.

2007: During the operational monitoring period the nitrate concentrations in the surface water ranged from <0.0257 mg/L to 0.471 mg/L. The lower concentration of non-detect was collected at locations S-2B for all sampling events excluding October 4, 2007. S-5B was also non-detect on August 06, 2007. The higher concentration was detected at location S-9A on April 10, 2007. The average nitrate concentration in 2007 for S-1 was 0.39 mg/L for 2007.

Nitrite

2006: During the operational monitoring period the nitrite concentrations in the surface water locations ranged from of <0.00100 mg/L to 0.0227 mg/L. The lower concentration of non-detect is found in many of the locations. The higher concentration was detected at location S-5B on September 19, 2006.

2007: During the operational monitoring period the nitrite concentrations in the surface water locations were under the detection limit of <0.022 mg/L.

Total Dissolved Nitrogen

2006: During the operational monitoring period the total dissolved nitrogen in the surface water ranged from <0.26 mg/L for most locations to 2.5 mg/L. The higher concentration was collected at location S-2B on September 19, 2006. This higher concentration could possibly be an outlier. The total dissolved nitrogen collected on August 7, 2006 was <0.26 mg/L and then following the September sampling round on October 30, 2006 the level was at 0.68 mg/L. The average concentration prior to the September 2006 sampling round was 0.396 mg/L. The higher concentration could also be attributed to the wetland clearing upstream a few months earlier.

2007: During the operational monitoring period the total dissolved nitrogen in the surface water ranged from 0.195 mg/L to 1.5 mg/L. The lower concentration was detected at location S-5B on September 12, 2007. The higher concentration was detected at location S-6A on September 12, 2007.

Total Phosphorus

2006: During the operational monitoring period the total phosphorus in the surface water ranged from 0.018 mg/L to 1 mg/L. The lower concentration was detected at location S-2B on July 13, 2006. The higher concentration was detected at location S-1 on August 7, 2006. This value is numerous deviations from the average detection at this site. However, this value may be associated with the wetland clearing as described in the Total Nitrogen section. Phosphorus binds to sediment and the increase could be associated with unstable bank sides following the clearing. July 13, 2006 the site had a detection of 0.036 mg/L and then on September 19, 2006 the value was below the detection limit of <0.132 mg/L.

2007: During the operational monitoring period the total phosphorus in the surface water ranged from <0.132 mg/L to 0.643 mg/L. The lower concentration was detected at all locations in 2007. The higher concentration was detected at location S-5B on April 10, 2007. It is unknown what this detection is associated with and it may be an outlier as all other concentrations at this location have been non-detect or below 0.06 mg/L.

Ortho-Phosphate

2006: During the operational monitoring period the ortho-phosphate in the surface water ranged from <0.01 mg/L to 0.0282 mg/L. The lower concentration was detected at locations S-9A and S-3A on August 07, 2006 for both locations. The higher concentration was detected at location S-6A on September 20, 2006.

2007: During the operational monitoring period the ortho-phosphate in the surface water ranged from <0.132 mg/L to 0.0639 mg/L. The lower concentration of non-detect was found at all locations. The higher concentration was detected at location S-2B on October 04, 2007. Previous concentrations for 2007 at location S-2B were below the detection limit.

2.2 Compliance Considerations

The discharge permit for the WWTF does not specify action levels for surface water parameters. However, Table 2 through Table 5 represent the action levels, averages, and exceedence levels for surface water locations as described in the Nutrient Management Plan, July 2001.

<table>
<tr><th colspan="6">Chemical Indicators for Surface Waters as described in the NMP 2001
TABLE 2</th></tr>
<tr><th>Indicator</th><th>Relevance</th><th>Expected Change</th><th>Comparison Level</th><th>Evaluation</th><th>Action</th></tr>
<tr><th colspan="6">Monitor</th></tr>
<tr><td>Boron</td><td>Indicator of wastewater plume</td><td>Increase with no harm</td><td>Average baseline conditions</td><td>None</td><td>None</td></tr>
<tr><th colspan="6">Monitor and Evaluate</th></tr>
<tr><td>Total Nitrogen</td><td>Required nutrient for aquatic growth</td><td>Increase with no harm</td><td rowspan="2">Average Baseline Conditions</td><td rowspan="2">Check change in ecological indicators</td><td rowspan="2">See Recommended Actions</td></tr>
<tr><td>pH</td><td>Large changes may cause ecological shift</td><td>No change expected</td></tr>
<tr><th colspan="6">Monitor and Act</th></tr>
<tr><td>Total Phosphorus</td><td>Limiting nutrient for aquatic growth</td><td>No increase expected</td><td>Concentrations exceed baseline average & 95% exceedence level ** for 2 months in one season</td><td>See Action</td><td>See Recommended Actions</td></tr>
</table>

Ecological Indicators					
Secchi Depth	Measure of water clarity		Secchi depth <5% exceedence level for 2 months in one season	Evaluate parameters to determine whether several indicators have changed systematically together.	See Recommended Actions
Chlorophyll-a	Measure of algal abundance		Concentrations >95% exceedence level for 2 months in one season		
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 Action from NMP 2001 TABLE 3		
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

Baseline Average and 95% Exceedence ** Levels for Surface Water Stations (NMP) from Table 7-5

TABLE 4

		S-1	S-2 (*S-2B*)	S-3 *(S-3A)*	S-4 *(S-4A)*	S-5 *(S-5B)*	S-6 *(S-6A)*
TN (mg/L)	Average	0.505	0.299	0.383	0.268	0.384	0.542
	95% Exceed.	0.780	0.936	0.982	0.640	0.743	1.048
TP (mg/L)	Average	0.035	0.019	0.028	0.024	0.028	0.041
	95% Exceed.	0.057	0.048	0.073	0.070	0.075	0.084
Boron (mg/L)	Average	0.013	0.017	0.014	0.010	0.019	0.011
	95% Exceed.	0.027	0.032	0.025	0.010	0.043	0.016
pH(SU)	Average	6.353	6.739	6.507	6.386	6.808	6.181
	95% Exceed.	7.225	7.545	7.184	7.111	7.401	7.549
Chlorphyll-a (mg/L)	Average	0.73	4.80	2.92	1.44	2.94	1.80
	95% Exceed.	2.26	27.60	12.04	6.03	21.67	8.98
Secchi (ft)	Average		6.02				
	95% Exceed.		3.17				

**Note: Definition of 95% Exceedence Level. Excerpt from Nutrient Management Plan, July 2001, section 7.22 Surface Water Action Levels.

The 95% exceedence is the value below which 95% of all samples are expected to occur. In other words, 19 out of 20 samples collected would fall below this value, and 1 sample would exceed it. This criteria was chosen based on methodology outlined in EPA's "Technical Support Document For Water Quality Based Toxics Controls" (March 1991). The 95% exceedence value was computed for each parameter and each sampling site, using the data set described above, averages, (excluding outliers). The data is assumed to have a log-normal distribution. The equation for the 95% exceedence value is: 95% exceedence value = exp(u + to) were u is the mean of the log-transformed data, o is the standard deviation of the log-transformed data, and t is the critical value from the t-distribution for a one-tailed test. Note that the 95% exceedence level is only computed once, using baseline data only. As additional data is collected, it will be compared against these values to help determine whether a change in a specified location for a specified parameter has occurred.

Baseline Average and 95% Exceedence ** Levels for Surface Water Stations (NMP) from Table 7-5
(Note: Averages for 2006 & 2007 include addition of half detection limit when value was non-detect)
BDL = below detection limit
TABLE 5

		S-1	**S-2B**	**S-3A**	**S-4A**	**S-5B**	**S-6A**
TN (mg/L)	Average	0.505	0.299	0.383	0.268	0.384	0.542
	95% Exceed.	0.780	0.936	0.982	0.640	0.743	1.048
	Operational Average 2006	2.3281	0.97163	0.98506	1.13292	1.023	1.05946
	Operational Average 2007	1.1772	0.91442	0.9828	0.9676	0.85327	1.3475
TP (mg/L)	Average	0.035	0.019	0.028	0.024	0.028	0.041
	95% Exceed.	0.057	0.048	0.073	0.070	0.075	0.084
*the initial detection limit was <0.5 thereby increasing the average	**Operational Average 2006**	0.2836	0.0455	0.179	0.1112	0.0964	0.0952
	Operational Average 2007	BDL	BDL	BDL	BDL	0.1814	BDL

Boron (mg/L)	Average	0.013	0.017	0.014	0.010	0.019	0.011
	95% Exceed.	0.027	0.032	0.025	0.010	0.043	0.016
	Operational Average 2006	BDL	BDL	BDL	BDL	BDL	0.0222
	Operational Average 2007	BDL	BDL	BDL	BDL	0.01864	BDL
pH(SU)	Average	6.353	6.739	6.507	6.386	6.808	6.181
	95% Exceed.	7.225	7.545	7.184	7.111	7.401	7.549
	Operational Average 2006	5.917	6.8683	6.4742	6.3414	6.6371	6.1014
	Operational Average 2007	6.38	6.772	6.446	6.2475	6.416	6.515
Chlorphyll-a (mg/L)	Average	0.73	4.80	2.92	1.44	2.94	1.80
	95% Exceed.	2.26	27.60	12.04	6.03	21.67	8.98
	Operational Average 2006	9.13	13.0	8.8	52.16	7.83	2.23
	Operational Average 2007	0.30	4.10	8.10	8.2	3.30	2.85

Section 2.2.1 Surface Water Data Comparison to Baseline Conditions

Total Nitrogen

The average total nitrogen for each of the sampling sites is above the baseline average as it was in the 2005 data report. In 2006 the Town incorporated additional monitoring sites along the Eel River to further evaluate potential impacts.

As stated in Section 2.1.1, there have been localized impacts to the increase in total nitrogen along the Eel River System. One of the impacts to the increase in total nitrogen is related to localized wetland clearing along Warren Wells Brook (S-1) and Howland Pond (S-4). Both of these violations were reported with the Department of Environmental Protection (DEP), however, no action was taken with Warren Wells Brook site. The Howland Pond violation is under an enforcement order through DEP. At the Warren Wells Brook site,S-1, the total nitrogen values spiked to 3.39mg/L and 3.9mg/L in July & August 2006 respectively during the violation time period. Prior to this violation, the operational average for S-1 was 0.830mg/L for total nitrogen. Downstream impacts of this violation are apparent in the data results. Location S-2B is located approximately 0.5miles downstream from S-1. The operational average prior to the impact of the violation was 0.696mg/L. In September of 2006 the level of total nitrogen had increased to 2.521mg/L. Even further downstream, 1.3miles from S-1, at Hayden Pond site S-3A the impact is apparent. The operational average prior to the impact of the violation was 0.821mg/L. In September of 2006 the level of total nitrogen had doubled to 1.743mg/L. It would be inaccurate to imply that there were not other potential impacts, however, this impact is quite apparent.

Another impact to the increase in total nitrogen in the past 8 years (from baseline in 1998) is septic system development or failure within the watershed. Wastewater systems account for approximately 80% of the total nitrogen load (Buzzards Bay Project, Nitrogen Management). The Town has developed a draft by-law to address this issue as outlined in Section 1.5. Camp Dresser and McKee conducted a study on Septic Systems in the *April 2004 Eel River Watershed Nutrient Management Plan Program Implementation Update* which utilized the best available data to determine septic systems within 500 ft of the Eel River. There were 408 parcels within the 500ft buffer, in which 274 parcels had buildings. Of the 274 parcels, 235 have septic systems. Of the 235 parcels with buildings and septic systems, data is available from the Health Department for only 119 parcels. Of these 119 parcels approximately 85 pre-date 1995 with 44 post 1995. Therefore, almost 50% of the septic systems within 500ft of the Eel River are most likely failed septics (cesspools) or older systems that may not be maintained. The Town is currently developing an updated septic system database which should be available in the near future to help target these systems. Currently, regulations only require failed systems to update if work is being conducted on the home or there is a public health threat.

Action Levels per Nutrient Management Plan (see Section 2.1.2): The Town is implementing watershed action levels as described below:

- *The Town is implementing two BMPs in 2008 that directly impact the Eel River. The first location is along Long Pond Road and involves culvert replacement for the Eel River as well as stormwater remediation. The second location is on Russell Mill Pond Road and will involve the installation of additional treatment systems for stormwater runoff, thereby, reducing the runoff from entering the river system.*
- *The Town has created an extensive restoration project that will greatly reduce nutrient loading to the Eel River. The Eel River Headwaters Restoration Project is unique as it includes both wetland and river restoration. See Section 1.5 for further information.*
- *The Town worked extensively on a Nutrient Watershed Management Plan in which within the Plymouth Harbor Watershed, development would be required to implement advanced nutrient removal septic systems. However, in discussions with DEP, it was stated that it would be best to wait for implementation until the TMDL is released. The Town is working with the state to complete the TMDL. See Section 1.5 for further information.*

Comparison of each of the locations to the baseline average and 95% exceedence level:

S-1: Prior to the violation discussed above, the operational average was at 0.830mg/L with values ranging from 0.54mg/L to 1.0mg/L. Following the violation, the average in 2007 was detected at 1.17mg/L. There have been documented impacts located upstream at a detention pond in which the Town initiated discussions and the development of a mitigation plan. The mitigation will include the treatment of stormwater entering the detention pond through the creation of a wetland treatment system. This work has been approved through the Conservation Commission, DEP & the Army Corp and will be taking place in 2008.

S-2B: It is important to note that the baseline average and 95% exceedence level CDM created is based on location S-2A (a deep sampling location taken from the center of the pond). S-2B is located from a homeowners dock, on the surface water, approximately 250ft north of S-2A. Sampling at location S-2B began in August of 2002, therefore there is not a "correct" baseline average to compare to. However, the total nitrogen ranges from 0.294mg/L to 1.473mg/L excluding the 2.521mg/L in August of 2006. It is also important to note that this location is within an artificial impoundment and overtime, will experience an increase in nutrients and biological activity. There is a considerable amount of biological observations and monitoring conducted on Russell Mill Pond, please see the Biological Section of this report for further information. Just upstream from Russell Mill Pond, at the Headwaters of the Eel River, the town is actively involved in a major wetland and river restoration project. This will greatly improve the water quality entering into Russell Mill Pond. It was estimated that approximately 614lbs/yr of nitrogen will be removed and 517lbs/yr of phosphorus will be removed from the wetland restoration portion of the project. Thus far the Town has raised approximately 1.8million dollars for the project. Please see Section 1.5 for further information.

S-3A: The operational averages are above the baseline average and at the 95% exceedence level. From discussions with CDM, it is important to note that a number of values were not included in the baseline average which may include;

June 29, 1998	0.712mg/L
August 04, 1998	0.77mg/L
June 03, 1999	2.114mg/L
June 22, 1999	0.721mg/L

These values were managed as outliers. However, it should be noted that the Town has included **all** values in the 2006 & 2007 averages with no outliers excluded. This location is also within an artificial impoundment which acts as a sink for nutrients and sediments. The Town is in the process of purchasing 13.6 acres which directly abuts the impoundment and preserving for open space. This will reduce potential future impacts of development around the pond.

S-4A: The operational averages are above the baseline average and the 95% exceedence level. Based on the data evaluation, values of total nitrogen began increasing in June of 2003, with a value of 1.299mg/L. The previous total nitrogen sample in March of 2003 was at 0.289mg/L. The increase in nutrients at this impoundment, Howland Pond, can be most likely attributed to a wetland clearing along the pond that DEP has an enforcement order on. Based on MaGIS aerial photography, the clearing took place between 2001 and 2005. A ditch was also created in the location of the clearing that collects a substantial amount of stormwater from the fields. Sediment is noticeable at the ditch exit and shortly downstream at the outlet of the Howland Pond Dam. The enforcement order placed by DEP includes the installation of 4 check dams along the ditch area to prevent sediment from entering Howland Pond. The investigation of wetland clearing is ongoing.

S-5B: The operational averages are above the baseline average and close to the 95% exceedence level. This location has some tidal influence as can be seen with the specific conductivity values from the field parameters. The total nitrogen values also show fluctuations. For instance, in 2006 August and September values were generally lower at 0.3918mg/L and 0.174mg/L respectively. In October of 2006 the value increased to 1.251mg/L. In September of 2007 the value was at 0.5311mg/L and increased to 1.064mg/L in October of 2007.

S-6A: The operational averages are above the baseline average and at or slightly above the 95% exceedence level. This location is approximately 1.25miles downstream from the headwaters of the Eel River and is also within the small Sawmill Pond impoundment. The headwaters of the Eel river meanders through un-natural ditches in the 40acre bog system, the area of the Headwaters Restoration project as discussed in Section 1.5. The bogs had been flooded for a number of years, and in 2006 as part of the restoration design efforts, the boards were released. There is a slight increase to the average of about 1mg/L in 2006 & 2007 from 0.8934mg/L pre 2006 operational average.

Total Phosphorus

The detection limit for total phosphorus during the 2006 & 2007 operational monitoring period started at <0.50mg/L for March 2006 and was lowered to <0.132mg/L for the remainder of the operational monitoring period. During the operational monitoring period a majority of the data results were below the detection limit.

Action Levels per Nutrient Management Plan (see Section 2.1.2): The Town is implementing two of the watershed action levels.

- *Reduce Phosphorus loading from cranberry bogs and hatcheries. The Towns Eel River Headwaters Restoration Project includes the restoration wetland habitat from existing cranberry bogs. It is estimated that approximately 614lbs/yr of phosphorus will be reduced* *by removing the cranberry bogs from production. The project also entails extensive river and wetland restoration that will further improve water quality. See section 1.5 for further details on the Eel River Headwaters Restoration Project.*

- *The Town is implementing two BMPs in 2008 that directly impact the Eel River. The first location is along Long Pond Road and involves culvert replacement for the Eel River as well as stormwater remediation. The second location is on Russell Mill Pond Road and will involve the installation of additional treatment systems for stormwater runoff, thereby, reducing the runoff from entering the river system.*

Comparison of each of the locations to the baseline average and 95% exceedence level:

S-1: The 2006 operational averages were above both the baseline average and the 95% exceedence level. This was mostly due to the detection of 1mg/L of total phosphorus on August 07, 2006 following the wetland clearing violation. Also, the addition of half the detection limit (0.50mg/L) increases the overall value of the total phosphorus average. Soil was deposited from the edges of the bank and the areas that were disturbed into Warren Wells Brook during the violation. This would account for the increase of total phosphorus in August of 2006, as phosphorus binds with soil particles. The following samples collected through 2007 were all below the detection limit, therefore, the area has somewhat stabilized.

S-2B: The 2006 operational average is above the baseline average and below the 95% exceedence level. The 2007 operational average were all below the detection limit. There were only two detections throughout the 2006 at this location; July 13, 2006 at 0.018mg/L and August 07,2006 at 0.032mg/L all other values were below the detection limit. It can be concluded that these values were detection and are in relation to the upstream wetland violation at S-1.

S-3A: The 2006 operational average is above the baseline average and the 95% exceedence level. The 2007 operational average were all below the detection limit. During the 2006 operational period there were three detections of total phosphorus; July 13, 2006 at 0.029mg/L and August 07, 2006 at 0.038mg/L and October 30, 2006 at 0.512mg/L. As stated above, the most likely contributor to the increases of total phosphorus in late 2006 can be associated with the wetland clearing at the upstream location S-1. As all following levels were below the detection limit as the disturbance subsided.

S-4A: The 2006 operational average was above the baseline average and the 95% exceedence level. The 2007 operational average was below the detection limit. See the above section on Total Nitrogen for this location for background on the wetland violation at Howland Pond. There were only two detections throughout the 2006 & 2007 operational monitoring period; July 13, 2006 at 0.034mg/L and August 07, 2006 at 0.14mg/L. All following levels were below the detection limit.

S-5B: The operational averages are above the baseline average and the 95% exceedence level. There were three detections throughout the operational monitoring periods; July 13, 2006 at 0.042mg/L and August 07, 2006 at 0.058mg/L and April 10, 2007 at 0.643mg/L. It is unclear why the level of total phosphorus increased in April of 2007. However, following results for the year were below the detection limit.

S-6A: The 2006 operational average was above the baseline average and the 95% exceedence level. The 2007 operational average was below the detection limit. There were two detections throughout the operational monitoring periods; July 13, 2006 at 0.036mg/L and August 07, 2006 at 0.058mg/L. Again, as is the case with the above sites, the averaging of the detection limits increases the operational average.

<u>Boron</u>

The detection limit for Boron during the operational monitoring period was 0.025mg/L. As the data results depict, most of the samples were below this detection limit. During the baseline conditions in 1998 onward, location S-6A had occasional detections of Boron. This parameter was included in the monitoring program to detect sewage effluent from the WWTF and or septic systems. Location S-6A is down gradient of the WWTF and has had detections of Boron up to 5 years prior to the operation of the plant. It is possible that the development south of Long Pond Road may be a contributor due to a failing septic system or older cess-pool systems.

Action Levels per Nutrient Management Plan (see Section 2.1.2): NONE

Comparison of each of the locations to the baseline average and 95% exceedence level:

S-1: The 2006 & 2007 operational averages are below both the baseline average and 95% exceedence level.

S-2B: The 2006 & 2007 operational averages are below both the baseline average and 95% exceedence level.

S-3A: The 2006 & 2007 operational averages are below both the baseline average and 95% exceedence level.

S-4A: The 2006 & 2007 operational averages are below both the baseline average and 95% exceedence level.

S-5A: The 2006 & 2007 operational averages are below both the baseline average and 95% exceedence level.

S-6A: The 2006 operational average is above the baseline average and 95% exceedence level. This is due to a detection of 0.026mg/L on July 13, 2006. See explanation above.

pH

The pH for the operational monitoring periods was collected with the Town owned YSI 6600 Water Quality Unit. Levels for all the locations were very close to the baseline average and did not exceed the 95% exceedence level.

Action Levels per Nutrient Management Plan (see Section 2.1.2): NONE

Comparison of each of the locations to the baseline average and 95% exceedence level:

S-1: The 2006 operational average is slightly below the baseline average but within the 95% exceedence level. The 2007 operational average is at the baseline average and does not exceed the 95% exceedence level.

S-2B: The 2006 & 2007 operational averages are slightly above the baseline average and do not exceed the 95% exceedence level.

S-3A: The 2006 & 2007 operational averages are slightly below the baseline average and do not exceed the 95% exceedence level.

S-4A: The 2006 & 2007 operational averages are at or slightly below the baseline average and do not exceed the 95% exceedence level.

S-5B: The 2006 & 2007 operational averages are below the baseline average and do not exceed the 95% exceedence level.

S-6A: The 2006 & 2007 operational averages are either at or slightly above the baseline average and do not exceed the 95% exceedence level.

Chlorophyll-a

The values for the 2006 & 2007 operational monitoring periods for chlorophyll-a fluctuated for each location. Chlorophyll-a is an indicator of the concentration of free-floating algae and can be a key indicator, along with nutrients, for the assessments of eutrophication in pond systems. It is important to note that all the ponds along the Eel River are man-made impoundments thereby acting as sinks for the collection of nutrients overtime.

Action Levels per Nutrient Management Plan (see Section 2.1.2): NONE

Comparison of each of the locations to the baseline average and 95% exceedence level:

S-1: The 2006 operational average is above the baseline average and the 95% exceedence level. The 2007 operational average is below the baseline average and the 95% exceedence level. See above explanations on wetland clearing at this location. There were three detections in 2006, the highest was following the wetland clearing with a level of 24mg/L on August 07, 2006.

S-2B: The 2006 operational average is above the baseline average and below the 95% exceedence level. The 2007 operational average is below the baseline average and the 95% exceedence level. These levels coincide with previous data collection even prior to the operational period.

S-3A: The 2006 & 2007 operational averages are both above the baseline average and below the 95% exceedence level. On March 06, 2006 the value was detected at 20mg/L with subsequent collection below 4mg/L.

S-4A: The 2006 operational average was above the baseline average and the 95% exceedence level. On August 07,2006 a value of 150mg/L was detected at this location. Total phosphorus and total nitrogen were both higher than normal during this sampling event. Field notes from the date of the collection indicate filamentous algae visible around bank side and the water clarity was poor. The value did decrease in subsequent sampling events, so this was more than likely an isolated event. See above total nitrogen section for details on Howland Pond violations that may have affected water quality.

S-5B: The 2006 & 2007 operational average was slightly above the baseline average and below the 95% exceedence level.

S-6A: The 2006 & 2007 operational average was slightly above the baseline average and below the 95% exceedence level.

Section 2.3 Harbor

Action levels for the harbor baseline data were not included in the January 2001 Nutrient Management Plan, although sampling in the harbor started in July 1999. However, the following section compares the operational monitoring data collected in the harbor with the baseline data as presented in the June 2002 Eel River Monitoring Data (Table C-10).

Two sampling sites are used for the harbor monitoring program in the Plymouth Harbor, S-7 & S-10, and see Table 6.

Plymouth Harbor Sampling TABLE 6						
Parameter	S-7 Baseline Average (1999-2002)	S-7 Operational Average 2006	S-7 Operational Average 2007	S-10 Baseline Average (1999-2002)	S-10 Operational Average 2006	S-10 Operational Average 2007
Total Nitrogen mg/L	0.356	0.407	0.478	0.373	0.321	0.520
Total Phosphorus mg/L	0.027	0.0345	<0.132	0.0353	0.0375	<0.132

For each of the harbor locations there was a slight increase in the operational monitoring period from the baseline average. As stated in this surface water section, there has been in increase in both total nitrogen and phosphorus within the Eel River Watershed. The harbor is also influenced by downtown Plymouth and Town Brook. The Town will continue to monitor and evaluate any increases in nutrients. The Town is working with the state in modeling the total maximum daily load for the harbor. This will be a valuable tool for the evaluation and control of nutrients.

Section 2.4 Groundwater

Table 7			
Groundwater Permit Compliance per NMP 2001 *Phosphorus*			
Monitoring Group	*Wells*	*Permit Limit*	*Observed Value 2006/2007*
Adjacent Wells near WWTF site "inner wells"	A9, A10, A11, & A16	Any well >0.2mg/L for either 3 consecutive months or 4 out of 6 consecutive months	2006 & 2007: All wells <0.2mg/L
Down-gradient Wells from WWTF site "outer wells"	1S,6SR,6D & USGS 475	Any well increase of >100% over established background concentrations for either 3 consecutive months or 4 out of 6 consecutive months. *note: the established background concentrations for these wells are not listed in the NMP, however, in section 7-3 it states that the average total phosphorus concentration is 0.084mg/L for the four outer wells.	2006: All wells below 0.084mg/L. 2007: All wells below 0.084mg/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.

Section 2.4 presents observations of the monitoring results for groundwater data from 2006. Appendix B includes the monitoring results for the 2006 & 2007 operational monitoring period.

2.4.1 Groundwater Data Observations

Groundwater Sampling Locations **Table 8**			
Location ID	**Description**	**Inner/OuterWells/NMP**	**Schedule**
A9	Down gradient of Infiltration site, in wooded area	Inner (Permit)	
A10	Down gradient of Infiltration site, in wooded area	Inner (Permit)	
A11	Infiltration Basin Site	Inner (Permit)	
A16	Infiltration Basin Site	Inner (Permit)	
6S (R)	Down gradient of infiltration site	Outer (Permit)	
6D	Down gradient of infiltration site	Outer (Permit)	
1S	Down gradient of infiltration site	Outer (Permit)	
USGS 475 (R)	In cul-de-sac of Russell Mill Road	Outer (Permit)	
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	NMP	2x/yr
3D	At Nickerson Property - near Hatchery	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.

2.4.2 <u>Bi-annual Groundwater Monitoring at locations: A13, A15, A17, A21, 2SR, 2DR, 3S, 3D (and 7SR, 5S as of 2007).</u>

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

Field Measurements

<u>Temperature</u>

2006: During the operational monitoring period the temperature measured in the ground water ranged from 7.75 degrees Celsius to 18.09 degrees Celsius. The lower reading was collected at location A21 on April 26, 2006 at 11:10AM. The higher reading was also collected at location A21 on November 01, 2006 at 12:30PM. The average temperature for the bi-annual monitoring wells in 2006 was 12.21 degrees Celsius.

2007: During the operational monitoring period the temperature measured in the ground water ranged from 9.98 degrees Celsius to 18.1 degrees Celsius. The lower reading was collected at location 2SR on May 9, 2007 at 9:10AM. The higher reading was collected at location A21 on November 14, 2007 at 2:20PM. The average temperature for the bi-annual monitoring wells in 2007 was 12.41 degrees Celsius.

<u>Specific Conductivity</u>

2006: During the operational monitoring period the specific conductivity measured in the groundwater ranged from 51 us/cm to 868 us/cm. The lower reading was collected at location 2SR on October 31, 2006 at 11:55AM. The higher reading was collected at location A13 on October 31, 2006 at 10:40AM. Historically, A13 has a higher specific conductivity level. With this value included, the average specific conductivity for the bi-annual monitoring wells in 2006 is 198us/cm. Without well A13, the average was 102us/cm.

2007: During the operational monitoring period the specific conductivity measured in the groundwater ranged from 39 us/cm to 650 us/cm. The lower reading was collected at location 2SR on November 15, 2007 at 10:15AM. The higher reading was collected at location 5S on May 8, 2007 at 2:20PM. This was the first time 5S has been sampled in a number of years. The water column was very shallow with a large amount of fine silt. A three-well volume purge was conducted due to the siltation. The average specific conductivity for the bi-annual monitoring wells was 206.65 us/cm, including the higher reading.

Dissolved Oxygen

2006: During the operational monitoring period the dissolved saturated oxygen measured in the groundwater ranged from 0.4% to 64.1%. The dissolved oxygen in mg/L measured in the groundwater ranged from 0.05mg/L to 7.01mg/L. The lower reading was collected at location 3D on November 1, 2006 at 11:20AM. The higher reading was collected at location A15 on April 26, 2006 at 9:50AM. The average dissolved oxygen content for the bi-annual monitoring wells was 2.61mg/L.

2007: During the operational monitoring period the dissolved saturated oxygen measured in the groundwater ranged from 0.5% to 106.8%. The dissolved oxygen in mg/L measured in the groundwater ranged from 0.05mg/L to 11.61mg/L. The lower reading was collected at location 2DR on November 15, 2007 at 10:55AM. The higher reading was collected at location 5S on November 16, 2007 at 8:40AM. The average dissolved oxygen content for the bi-annual monitoring wells was 4.99mg/L.

pH

2006: During the operational monitoring period the pH in groundwater ranged from 4.45 units to 6.92 units. The lower reading was collected at location A13 on October 31, 2006 at 10:40AM. The higher reading was collected at the Bradford well location on April 24, 2006 at 2:52PM. The average pH for the bi-annual monitoring wells was 5.51 units.

2007: During the operational monitoring period the pH in groundwater ranged from 4.51 units to 6.11 units. The lower reading was collected at location 5S on May 8, 2007 at 2:20PM. The higher reading was collected at location A21 on November 14, 2007 at 2:20PM. The average pH for the bi-annual monitoring wells was 5.18 units.

Turbidity

2006: During the operational monitoring period the turbidity in groundwater ranged from 0 NTUs to 1.8 NTUs. The lower reading of 0 NTUs was the case for the majority of the monitoring wells. The higher reading was collected at location A21 on April 26, 2006 at 11:10AM.

2007: During the operational monitoring period the turbidity in groundwater ranged from 0 NTUs to 32.6NTUs. The lower reading of 0 NTUs was the case for the majority of the monitoring wells. The higher reading was collected at location 5S on May 8, 2007 at 2:20PM. As stated above in the specific conductivity section, this was the first time 5S had been sampled in a number of years. The water column was very shallow with a large amount of fine silt. A three-well volume purge was conducted due to the siltation.

Laboratory Measurements

Total Phosphorus

2006: During the operational monitoring period the total phosphorus concentration in groundwater was non-detectable with the detection limits ranging from <0.132mg/L to <0.50mg/L. The average total phosphorus concentration was <0.163mg/L. On October 31, 2006 at location A17, total phosphorus was detected at 1.52mg/L. However, this was most likely due to an analytical error. The orthophosphate concentration on the same date was considerably low at 0.00540mg/L. When the well was tested again in 2007, the concentration of total phosphorus was non-detect.

2007: During the operational monitoring period the total phosphorus concentration in groundwater was mostly non-detectable with a detection limit of <0.132mg/L. There were three wells that had a detection of total phosphorus during the November 2007 sampling round as follows; 0.164mg/L at 7SR, 0.23mg/L at A15, 0.328mg/L at 5S. Previous sampling for 2006 & 2007 was non-detect.

Orthophosphate

2006: During the operational monitoring period the orthophosphate concentration in groundwater ranged from <0.0mg/L to 0.0492mg/L. The higher concentration was detected on November 1, 2006 at location A15. Note that the detection limit was lowered from 0.10 to 0.02. The average orthophosphate concentration was 0.029mg/L.

2007: During the operational monitoring period the orthophosphate concentration in groundwater ranged from <0.0257mg/L to 0.155mg/L. Most of the locations were non-detectable. The higher concentration was detected on November 16, 2007 at location A15.

Ammonia

2006: During the operational monitoring period the ammonia concentration in groundwater ranged from <0.130mg/L to 0.317mg/L. The average ammonia concentration was 0.100mg/L. The higher concentration was detected on October 31, 2006 at location A13. In April of 2006, the concentration at this location was <0.20mg/L.

2007: During the operational monitoring period the ammonia concentration in groundwater ranged from <0.130mg/L to 0.612mg/L. Most of the locations were non-detectable. The higher concentration was detected on May 08, 2007 at A13. In the November 2007 sampling round the concentration had decreased to 0.246mg/L.

Nitrate

2006: During the operational monitoring period the nitrate concentration in groundwater ranged from <0.10mg/L to 2.2mg/L. The average nitrate concentration was 0.553mg/L. The higher concentration was detected on April 24, 2006 at location A17. Previous data reports indicate that A17 has historically been above 1mg/L.

2007: During the operational monitoring period the nitrate concentration in groundwater ranged from <0.0257mg/L to 1.41mg/L. As in 2006, the higher concentration was detected at location A17 on May 08, 2007.

Nitrite

2006: During the operational monitoring period the nitrite concentration in groundwater was non-detect for all locations. The detection limit was 0.0100mg/L.

2007: During the operational monitoring period the nitrite concentration in groundwater was non-detect for all locations. The detection limit was 0.0220mg/L.

Total Nitrogen

2006: During the operational monitoring period the total nitrogen concentration in the groundwater ranged from <0.50mg/L to 2.695mg/L. The average concentration for total nitrogen was 1.33mg/L. The higher concentration was detected on November 1, 2006 at location 3S. This location has historically higher nitrogen levels as compared to other monitoring well locations. Unfortunately access was denied to conduct the baseline monitoring at 3S, therefore, only operational monitoring data is available.

2007: During the operational monitoring period the total nitrogen concentration in the groundwater ranged from 0.478mg/L to 2.239mg/L. The lower concentration was detected on November 16, 2007 at 3D. The higher concentration was detected on May 08, 2007 at A17.

Total Dissolved Solids

2006: During the operational monitoring period the total dissolved solids concentration in the groundwater ranged from 36mg/L to 516mg/L. The average concentration for total dissolved solids was 134.5mg/L. The lower concentration was detected on April 25, 2006 at location 2SR. The higher concentration was detected on October 31, 2006 at location A13. Location A13 groundwater monitoring notes indicated sedimentation in water during sampling activities.

2007: During the operational monitoring period the total dissolved solids concentration in the groundwater ranged from 31mg/L to 435 mg/L. The lower concentration was detected on May 09, 2007 at location 2DR. The higher concentration was detected on May 08, 2007 at location 5S. Location 5S has not been sampled since the baseline monitoring and sampling began again in 2007 as approved by DEP. The logbook field notes indicate silty-sand material in the well water in which a 3-well volume purge was conducted due to the erratic and high turbidity.

Chlorides

2006: During the operational monitoring period for the chloride concentration in the groundwater ranged from 6.2mg/L to 309mg/L. The average concentration for chloride was 43.59mg/L. The lower concentration was detected on April 25, 2006 at location 2SR. The higher concentration was detected on October 31, 2006 at location A13.

2007: During the operational monitoring period for the chloride concentration in the groundwater ranged from 5.82mg/L to 260mg/L. The lower concentration was detected on November 15, 2007 at location 2SR. The higher concentration was detected on May 08, 2007 at location 5S. See comment above in TDS section.

Boron

2006: During the operational monitoring period the boron concentration in the groundwater was non-detect. The detection values ranged from <0.01mg/L to <0.10mg/L.

2007: During the operational monitoring period the boron concentration in the groundwater was non-detect, with a detection value at <0.0300mg/L.

Copper

2006: During the operational monitoring period the copper concentration in the groundwater ranged from <0.00800mg/L to 0.0305mg/L. All wells were non-detect except for the raw line on the Bradford well with a concentration of 0.0305mg/L on November 1, 2006.

2007: During the operational monitoring period the copper concentration in the groundwater ranged from <0.0100mg/L to 0.0113mg/L. All of the wells were non-detect excluding a detection on May 08, 2007 at location 5S.

Mercury

2006: During the operational monitoring period the mercury concentration in groundwater was non-detect. The detection values ranged from <0.0002mg/L to <0.0005mg/L.

2007: During the operational monitoring period the mercury concentration in groundwater was non-detect, with a detection value of <0.0005mg/L.

Iron

2006: During the operational monitoring period the iron concentration in the groundwater ranged from <0.0600mg/L to 8.5mg/L. There was a value of 230mg/L detected at location A13 on April 24, 2006. Logbook notes indicated the initial purge water was silty and orange colored. When the well was tested again on October 13, 2006 the level was 8.5mg/L. The average concentration for iron was 1.45mg/L excluding the A13 level of 230mg/L.

2007: During the operational monitoring period the iron concentration in the groundwater ranged from <0.0600mg/L to 6.02mg/L. The higher concentration was detected on November 11, 2007 at location 5S.

Volatile Organic Compounds

2006: During the operational monitoring period the VOC concentration in the groundwater was below detectable limits expect for a value of 0.65ug/L of Cholorform at location A15 on April 26, 2006. The well was tested again on November 1, 2006 where the Chloroform was non-detect.

2007: During the operational monitoring period the VOC concentration in the groundwater was non-detect.

2.4.3 Inner & Outer Well Monitoring at locations: 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.

Total Phosphorus

2006: During the operational monitoring period the total phosphorus concentration in groundwater ranged from <0.005mg/L to 0.76mg/L. The average concentration was 0.02049mg/L with the 0.76mg/L included and 0.0128mg/L without the higher value included. The higher concentration was detected on August 30, 2006 at location USGS 475(R). However, by the next sampling round on October 26, 2006 the concentration had dropped to 0.041mg/L. Also, on August 30, 2006 the other wells did not exhibit any abnormal concentrations. Therefore, the 0.76mg/L is most likely an analytical error.

2007: During the operational monitoring period the total phosphorus concentration in groundwater ranged from <0.005mg/L to 0.18mg/L. The average concentration was 0.023mg/L. The higher concentration was detected on June 14, 2007 at A16.

Total Nitrogen

2006: During the operational monitoring period the total nitrogen concentration in groundwater ranged from 0.02mg/L to 5.4mg/L. The average concentration was 1.239mg/L. The lower concentration was detected on November 15, 2006 at location 1S. The higher concentration was detected on June 1, 2006 at A11. On August 31, 2006 the concentration at A11 was 1.5mg/L.

2007: During the operational monitoring period the total nitrogen concentration in groundwater ranged from 0.02mg/L to 4.1mg/L. The average concentration was 1.04mg/L. The higher concentration was detected on August 22, 2007 at A11. Location A11 is located adjacent to the infiltration beds, therefore, fluctuations in nitrogen concentrations are expected.

Boron

2006: During the operational monitoring period the boron concentration in groundwater ranged from non-detect, <0.1mg/L to 0.1mg/L. The higher concentration was detected on August 31, 2006 at A16.

2007: During the operational monitoring period the boron concentration in groundwater was non-detect at <0.1mg/L.

pH

2006: During the operational monitoring period the pH concentration in groundwater ranged from 4.35units to 5.45units. The average concentration was 4.90units. The lower concentration was detected on October 25, 2006 at A10. The higher concentration was detected on February 22, 2006 at 6D.

2007: During the operational monitoring period the pH concentration in groundwater ranged from 4.05units to 7units. The average concentration was 4.70 units, similar to the prior year. The lower concentration was detected on April 1, 2007 at A16. The higher concentration was detected on April 1, 2007 at USGS475(R). The pH value at USGS475(R) is usually around 5units, the higher value detected may be an analytical error especially when compared with pH values at other surrounding wells during this timeframe.

Section 2.5 Biological Monitoring

Biological Monitoring Locations
Table 9

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		☑
Russell Mill Pond		☑	
Hayden Pond		☑	
Howland Pond		☑	
Eel River Basin		☑	

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 in 2006 is attached in Appendix C. The following is a brief discussion of the data results.

2.5.1 Macroinverterbrate Data, 2006

The following information has been compiled from information provided by the Town's Consultant Limnologist/Biologist:

Macroinvertebrate sampling was conducted on September 16, 2006 at the four stations selected for previous biomonitoring of lotic (running water) habitats composing the Eel River ecosystem. These stations consist of the following: BM-1 located downstream of Russell Mill Pond adjacent to the Gilbert 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 Mill Pond and below the spillway of the impoundment know as "Sawmill Pond". Habitat characteristics of these sampling stations had not changed significantly since the monitoring effort in 2003.

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.

<u>Results</u>

Similar to previous results from the 2001-2003 monitoring period, results of macroinvertebrate sampling in 2006 document that community composition corresponds predictably to the habitat characteristics of each sampling station. Results can be found in Appendix C. However, some changes in community composition are evident, in comparison to 2001-2003, including absences of certain organisms, the appearance of organisms never observed previously, and organisms documented in the system, but appearing for the first time in certain sampling locations.

The most notable change was the absence of the caddisfly *Cheumatopsyche* throughout the system. Previously, this organism was consistently a significant component of the fauna, except in 2002 when it was absent from station BM-4. The absence of *Cheumatopsyche* contributed to reductions in community richness and EPT taxa richness at all stations except BM-4. Its absence may be the result of competitive exclusion by its congener *Hydropsyche* or from other causes and is likely only temporary. Historical data from 1999 document *Cheumatopsyche* present only at station BM-2.

The community at station BM-1 was dominated by hydropsychid caddisflies (*Hydrophsyche*) that specialize in building particle-filtering nets and retreats among gravel and cobble as well as pea clasms (*Pisidiidae*) that commonly inhabit these substrates. Both the caddisflies and clams are filter-feeders and their great abundance attests to a steady supply of fine particulate organic matter (FPOM) discharged from Russell Mill Pond located upstream. The caddisfly *Cheumatopsyche*, common at this station in evenness in 2006 register near the low end of the ranges documented in the 2001-2003 monitoring period.

At stations BM-2 and BM-3A, where submerged aquatic plants provide most of the substrate inhabited by macroinvertebrates, the communities were dominated by mayfly taxa (*Baetis* and *Stenonema*) that graze on periphyton associated with the plants and by blackfly larvae (*Simuliidae*) that live attached to the plants and filter food form the flowing water with special mouth parts. Also important at BM-2 and BM-3A were amphipods (*Gammarus*) that are detritivores commonly associated with aquatic plants.

At station BM-2, two specimens of giant water bug (genus *Belostoma*) were observed in 2006 for the first time in comparison to the historical database. Similarly, at station BM-3A, two specimens of dragonfly nymph of the genus *Boyeria* were observed for the first time in comparison to the historical database.

Notably absent at station BM-2 were any caddisflies, especially *Hydropsyche*. This organism was a significant component of the community in 2001 and 2002, but was absent in 2003 and continues to be absent in 2006. it is possible that these results are due to a coincidence of sampling rather that a real or permanent loss from the community, but future monitoring efforts should target whatever cobble/gravel microhabitat can be found to more closely investigate the status of caddisflies at this station.

Measurements of community richness at stations BM-2 and BM-3A were below the ranges documented in the 2001-2003 monitoring period, but community evenness registered well within the historical ranges.

The most noteworthy sampling result at station BM-4 was the presence of a stonefly (genus *Leuctra*) observed for the first time anywhere in the system since 1999 when two specimens were documented at station BM-1. Also, for the first time ever at station BM-4, a mayfly (genus *Stenonema*) was observed. *Stenonema* was commonly observed at station BM-2 and BM-3A, but never before at BM-4. The amphipod *Hyalella*, observed consistently at station BM-4 during 2001-2003, appears to have been replaced by the more common amphipod *Gammarus*. Finally, the caddisfly *Hydropsyche* was more prevalent at station BM-4 than previously documented in 2001-2003.

Observations of cranefly larvae (Tipulidae) were unique to station BM-4 which is consistent with data from the 2001-2003 monitoring period. Measurements of community richness and evenness at station BM-4 in 2006 register at the low end of the ranges documented in the 2001-2003 monitoring period, but EPT taxa richness was the highest recorded due to the appearance of the stonefly and mayfly.

Numbers of EPT taxa at the lotic sampling stations in 2006 ranged from one to four. This range would be low in communities from riffle habitat, but this is consistent with historical data (EPT taxa richness at all stations in the 2001-2003 database ranges from zero to six) and appears to be representative of a low-gradient system lacking riffles such as the Eel River.

Changes in community diversity at each station evident between 2006 results and the 2001-2003 database reflect fluctuations in populations that are typical of macroinvertebrate communities. Numerous factors contribute to population dynamics within macroinvertebrate communities including competition, predation, water regime, 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.

2.5.2 Periphyton Data, 2006

The following has been compiled from information provided by the Town's Consultant Limnologist/Biologist:

Periphyton data at locations BM-1, BM-2, BM-3a & BM-4 were collected in the spring and fall of 2006. Results of the data can be found in Appendix C . The artificial substrates collected in the spring were richly colonized with periphytic growth composed generally of diatoms as observed in previous years. *Spirogyra,* a common filamentous green alga, dominated substrates at BM-2 and the ciliate *Vorticella* was abundant on substrates at BM-1. The artificial substrates collected in the fall were also richly colonized with periphytic growth composed of diatoms. The ciliate *Vorticella* was abundant on substrates at BM-4. Shifts in relative abundance among taxa are evident in comparison to June of 2006 and to previous years as are gains and losses of a few rare taxa, but these changes reflect seasonal and inter-annual fluctuations in populations that are typical of periphyton communities.

2.5.3 Russell Mill Pond Water Column Profiles and Plankton Sampling, 2006

The following has been compiled from information provided by the Town's Consultant Limnologist/Biologist: (See Appendix C for data results)

<u>April 17, 2006:</u> The very high productivity of the pond, noted in previous years of monitoring, was again evident with Secchi transparency measuring only 4.5feet and the water appearing yellowish-brown due to high densities of the diatom *Asterionella* and other phytoplankton. Photosynthetic activity by phytoplankton is evident in the values of dissolved oxygen above saturation in the top four meters of the water column. However, beneath the thermocline, dissolved oxygen is rapidly being used up by microbial decomposition of sedimenting plankton.

<u>May 19, 2006</u> The profile of shows that dissolved oxygen is almost exhausted (less than 1ppm) in the hypolimnion (bottom two meters of the water column). This is due to the great productivity of this pond and the decomposition of sedimenting organic matter, mostly plankton, below the thermocline. The diatom *Asterionella*, dominant in April, has been surpassed by the diatom

Tabellaria. The export of plankton from Russell Mill Pond influences both ponds located downstream where these diatoms remain dominant. This influence of Russell Mill Pond on downstream pond plankton communities has been documented in previous years of monitoring. Howland Pond, located on the east branch of the system, is not influenced by Russell Mill Pond and has a plankton community of different composition (dominated by *Spirogyra* likely derived from benthic growth).

June 17, 2006 Productivity by phytoplankton remains very high with Secchi transparency now measuring only 3 feet and the water appearing turbid and yellowish-brown due to high densities of the diatoms *Asterionella* and *Tabellaria* and other phytoplankton. Intense photosynthetic activity by phytoplankton is evident in the over-saturation values of dissolved oxygens and elevated values of pH in the top two meters of the water column. However, dissolved oxygen beneath the thermocline has been nearly exhausted due to microbial decomposition of sedimenting plankton. The bottom two meters of the water column that remain relatively cold during the period of thermal stratification are almost devoid of oxygen.

July 15th & August 5th ,2006 During the sampling event the multiprobe profile data was lost due to instrument malfunction, another complete monitoring effort was conducted on August 5th to supplement the July data. Secchi transparency on July 15th had increased to 6.5 feet from previous measurements ranging from only 3 to 4.5 feet. This increase in water clarity indicates greatly reduced densities of phytoplankton. Microscopic analysis of the plankton sample showed the diatom *Asterionella* continued to be the dominant organism of a community that was relatively sparse in terms of the number of different taxa observed. By comparison, Secchi transparency on the August 5th supplementary monitoring date had decreased to 5 feet and the colonial chrysophyte *Dinobryon* and the filamentous cyanophyte *Oscillatoria* had supplanted *Asterionella* as dominant among a richer phytoplankton community. The profile data from August 5th is consistent with previous measurements that show over-saturation values of dissolved oxygen and elevated values of pH in the top two meters of the water column due to intense photosynthetic activity by phytoplankton. Conversely, dissolved oxygen beneath the thermocline was exhausted due to microbial decomposition of sedimenting plankton. The bottom two meters of the water column that remain relatively cold during the period of thermal stratification are likely devoid of oxygen despite the lack of zero values actually registered by the multiprobe. Additionally, a gradient of increasing conductivity from a depth of 3 meters to the bottom indicates the release of dissolved ions from the sediments under the reducing conditions that now dictate chemical processes in the anoxic hypolimnion.

August 31, 2006 The profile data is consistent with previous measurements that show over-saturation values of dissolved oxygen and elevated values of pH in the top two meter of the water column due to intense photosynthetic activity by phytoplankton. Conversely, dissolved oxygen beneath the thermocline was exhausted due to microbial decomposition of sedimenting plankton. Depressed dissolved oxygen concentrations now extend from the bottom up to within two meters of the pond surface. The bottom two meters of the water column are likely devoid of oxygen despite the lack of zero values actually registered by the multiprobe. This volume will be re-oxygenated later this fall when thermal stratification dissipates and the entire water column is mixed by wind energy acting on the surface during "turnover". A gradient of increasing conductivity now extends from a depth of 2 meters down to the bottom indicating a continuing release of dissolved ions from the sediments due to the reducing conditions that dictate chemical processes in the anoxic hypolimnion. Secchi transparency on August 31st had increased slightly to 5.5 feet from the previous measurement of 5 feet on August 5th. Microscopic analysis of the plankton sample showed the diatoms *Asterionella* and *Tabellaria* have re-established themselves as the dominant organisms of the phytoplankton community with the previous dominants observed August 5th (the colonial chrysophyte *Dinobryon* and the filamentous cyanophyte *Oscillatoria)* now only minor components of the community.

October 8, 2006 Profile data in this survey shows that the epilimnion has lost heat and cooled to around 14 degrees C and that there is less that 3 degrees difference between the surface and bottom of the water column. This weak remnant of thermal stratification structure will be dissipated by wind energy acting on the surface and the entire water column mixed during "turnover" later this month. Mixing has already re-oxygenated the water column down to a depth of 3 meters in contrast to previous profiles showing influence from anoxia in the hypolimnion extending up to within 2 meters of the surface. Higher conductivity values are also evident in surface waters as a result of homogenization with previously hypolimnetic waters laden with dissolved ions released from the sediments during the summer. Secchi transparency on October 8th had increased slightly to 6.5 feet from the previous measurement of 5.5 feet on September 16th. Microscopic analysis of the plankton sample showed the colonial chrysophyte *Synura* dominant over all the organisms. *Synura* occurs commonly among the plankton of lakes and ponds in New England and often achieves high densities in the fall as water temperatures cool.

<u>October 29, 2006</u> Profile data confirmed that turnover has occurred causing the entire water column to be homogenized and replenishing dissolved oxygen at depth. The previous profile on October 8th showed the hypolimnion still intact and completely anoxic. Secchi transparency on October 29th had decreased to 4.5 feet as a result of a bloom of the diatom *Asterionella* which likely was fueled by nutrients recycled form the hypolimnion during turnover. The colonial chrysophyte *Synura* also remained a major component of the plankton as observed previously on October 8th.

2.5.4 Secchi Transparency and Dominant Phytoplankton, 2006

Spring 2006: Results of multiprobe measurements recorded on May 19, 2006 are located in Appendix C. Results of Eel River Plankton sampling conducted on May 19, 2006 are located in Appendix C. The western branch of the Eel River (BM4, RMP, BM1, HAY, and BM2) have colder temperatures in the lotic (stream) locations despite receiving warmer discharge from upstream lentic (pond) locations. This indicates that the volume of cold groundwater seepage entering the channel is enough to counteract the heat gained by surface water while flowing through the ponds of the system.

In contrast to the alternation of temperatures between lotic and lentic habitats, there is a steady increase in specific conductance from locations BM4 and BM3a downstream throughout the system eventually to Eel River Basin. Specific conductance is a measure of the amount of ions dissolved in the water and the increasing downstream values indicate inputs of ions from multiple sources in the drainage area. The most significant loading of ions is likely derived from road salting, especially at the crossing of Route 3 between BM1 and Hayden Pond and the crossing of Clifford Road over the outlet of Howland Pond.

The profile of Russell Mill Pond shows that dissolved oxygen is almost exhausted in the hyplimnion (bottom two meters of the water column). This is due to the great productivity of this pond and the decomposition of sedimenting organic matter (mostly plankton) below the thermocline. The diatom *Asterionella*, dominant in April, has been surpassed by the diatom *Tabellaria*. The export of plankton from Russell Mill Pond influences both ponds located downstream (Hayden Pond and Eel River Basin) where these diatoms remain dominant. This influence of Russell Mill Pond on downstream pond plankton communities has been documented in previous years of monitoring. Howland Pond, located on the east branch of the system, is not influenced by Russell Mill Pond and has a plankton community of different composition (dominated by *Spirogyra* likely derived from benthic growth).

Dissolved oxygen values above saturation are again evident in the epilimnion of Russell Mill Pond as a consequence of photosynthetic activity by phytoplankton. Photosynthesis by the submerged aquatic plant Fanwort (*Cabomba caroliniana)* in Hayden Pond has similarly elevated dissolved oxygen above saturation levels. Values of hydrogen activity (pH) above the neutral value of 7.0 accompany the over-saturated dissolved oxygen values in both of these ponds. Photosynthesis results in the uptake of carbon dioxide dissolved in the water and this removal of carbon dioxide tends to increase the pH in the water column where photosynthetic activity is the greatest.

Fall 2006: Results of multiprobe measurements recorded on September 16, 2006 are located in Appendix C. Results of Eel River Plankton sampling conducted on September 16, 2006 are located in Appendix C. The pattern observed in the spring in the western branch of colder temperatures in the lotic stream locations despite receiving warmer discharge from upstream lentic locations is again evident. This indicates that the volume of cold groundwater seepage entering the channel continues to be enough to counteract the heat gained by surface water while flowing through ponds of the system.

Also consistent with May measurements is the pattern of steady increase in specific conductance from BM4 and BM3a downstream throughout the system eventually to the Eel River Basin except for a slight decrease between Hayden Pond and BM2 (115.5 down to 111.0 uS/cm). September values of specific conductance are slightly higher at all locations than recorded in May, likely a seasonal fluctuation related to lower flow rates typical of late summer.

The profile of Russell Mill Pond shows that the epilimnion has cooled and the thermocline no longer exhibits a steep gradient. The difference between temperatures at the surface and bottom of the water column is now less than 7 degrees Celcius indicating that fall “turnover” will likely take place next month. Turnover occurs when wind energy acting on the surface dissipates thermal stratification and mixes the entire water column. Hypolimnetic water, most of which has lacked oxygen since June, will be re-oxygenated at this time due to exposure to the atmosphere.

The diatoms *Asterionella* and *Tabellaria* remain dominant in Russell Mill Pond. Secchi transparency remained unchanged from the reading of 5.5 feet observed on August 31, 2006. As noted above, the export of plankton from Russell Mill Pond influences both ponds located downstream ponds, Hayden & Eel River Basin, where these diatoms remain dominant. This influence of Russell Mill Pond on downstream pond plankton communities has been documented over previous years of monitoring. Howland Pond, located on the east branch of the system, is not influenced by Russell Mill Pond and has a plankton community of different composition. However, Howland Pond currently supports a bloom of *Tabellaria* similar to the other ponds, but with *Asterionella* observed only rarely unlike the other ponds.

2.5.5 Macrophyte and Biomass Survey, 2006

The following information has been compiled from information provided by the Town’s Consultant Limnologist/Biologist:

Surveys of the four ponds were conducted on August 5, 2006 with supplementary observations recorded during the performance of other monitoring tasks throughout the summer. Map 6 depict the survey results for each pond. In general, the pond macrophyte communities were similar in composition, distribution, and density to observations documented in 2003 survey results with the exception of *Elodea* in Hayden Pond and Eel River Basin.

Fanwort (*Cabomba caroliniana)* remains the only invasive alien macrophyte present in the system and is still restricted to Hayden Pond and the Eel River Basin where it is a dominant component of these communities. There is no sign of other problematic aliens such as *Hydrilla,* Eurasian Water-milfoil (*Myriophyllum spicatum)*, or Water Chestnut (*Trapa natans*) in any of the ponds. *Elodea* is a common native species which is easily confused with *Hydrilla* and special attention was given to confirming the identification of *Elodea* in all four ponds.

In Hayden Pond, *Elodea* has expanded its distribution northward over the middle third of the basin and becomes so dense as to reach the surface and form a canopy. This expansion is mainly at the expense of Fanwort which still dominates the northern third of the pond basin. Interestingly, the opposite has occurred in the Eel River Basin where Fanwort has become dominant in the middle portion of the basin where formerly *Elodea* and Fanwort were co-dominant. Another notable feature in the Eel River Basin is the presence of scattered small patches of White Waterlily (*Nymphaea odorata)* widely distributed throughout the basin where none were observed previously. White Waterlily remains the dominant plant in Howland Pond, but small beds of *Decodon, Potamogeton,* and *Sparganium* previously rooted adjacent to the outlet were apparently removed during outlet reconstruction and the associated installation of rip-rap.

2.5.6 Macroinvertebrate Data, 2007

The following information has been compiled from information provided by the Town's Consultant Limnologist/Biologist:

Macroinvertebrate sampling was conducted on September 29 and 30, 2007 at the four stations selected for previous biomonitoring of lotic (running water) habitats composing the Eel River ecosystem. 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 below the spillway of an impoundment known as "Sawmill Pond" (adjacent to the Nature Conservancy Office). Habitat characteristics of these sampling stations remain essentially unchanged from those detailed in previous reports.

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. Sampling efforts were pursued until an estimated 100 organisms had been collected. 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; see below), 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 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 is 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 mostly 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.

<u>Results</u>

Results of macroinvertebrate sampling in 2007 reinforce previous findings that show community composition corresponding predictably to the habitat characteristics of each sampling station (Table 1). Some changes are evident in community composition in comparison to historical data, the most notable being the reappearance of two caddisfly genera and the absence of blackfly larvae at certain stations (see below). These changes reflect inter-annual fluctuations in populations that are typical of macroinvertebrate communities.

The reappearance of the hydropsychid caddisfly *Cheumatopsyche* at stations BM-1 and 2 was a significant change in 2007. This organism had been a significant component of the Eel River fauna in the sampling period 2001-03, but went undetected throughout the system in 2006. Another common caddisfly reappeared in 2007 after an absence, specifically at station BM-2. *Hydropsyche* (also in the family Hydropyschidae) was a significant component of the community at BM-2 in 2001 and 2002, but was absent in 2003 and 2006**.** The apparent absences and reappearances of these caddisfly genera may reflect actual population dynamics or be coincidental artifacts of sampling technique. In the case of *Hydropsyche* at station BM-2, optimal habitat for these organisms consists of coarse bed materials, such as cobble or gravel, and microhabitat of this type is very limited at this station.

Another significant change in 2007 was the absence of blackfly larvae (Simuliidae) at stations BM-2 and 3a. These organisms have consistently been important at these stations in previous years and are usually evident attached to aquatic vegetation. Blackfly larvae were abundant at station BM-4 attached to the ribbon-like leaves of Bur-reed (*Sparganium*) bent over in the current, so the lack of blackflies is especially perplexing at BM-3a where similar leaves of Bur-reed were vacant (other types of aquatic vegetation were uninhabited by blackfly larvae at station BM-2). However, it is likely that these results reflect only localized and temporary losses from the macroinvertebrate communities at these stations. Characteristics of the macroinvertebrate communities observed at each station in 2007 are discussed in the following paragraphs.

The community at station BM-1 was dominated by hydropsychid caddisflies (*Hydropsyche* and *Cheumatopsyche*) that specialize in building particle-filtering nets and retreats among gravel and cobble. Also important were pea clams (Pisidiidae) that inhabit these substrates and that are also common among the submerged roots of bank vegetation. Both the caddisflies and clams are filter-feeders and their great abundance attests to a steady supply of fine particulate organic matter (FPOM) discharged from Russell Millpond located upstream. At station BM-1, a specimen of viviparid snail (genus *Campeloma*) was observed in 2007 for the first time in comparison to historical data. Measurements of community richness, evenness, and EPT taxa at BM-1 register within the ranges documented in the historical database.

At stations BM-2 and BM-3a, where submerged aquatic plants provide most of the substrate inhabited by macroinvertebrates, the communities were dominated by amphipods (*Gammarus*) that are detritivores commonly associated with plants and by mayfly nymphs (*Baetis* and *Stenonema*) that graze on periphyton associated with aquatic plants. The caddisfly *Chimarra*, which is usually observed at station BM-3a, was absent in 2007. It also went undetected in 2002, but was subsequently collected in 2003 and 2006, so will likely reappear in future monitoring efforts. As discussed above, the absence of blackfly larvae (Simuliidae) at these stations is likely only a localized and temporary loss. At station BM-3a, in addition to the collected organisms, a young specimen of American Eel (*Anguilla rostrata*) and a small, unidentified crayfish (Crustacea, Decapoda) were captured in the net and released.

Measurements of community richness and EPT taxa at stations BM-2 and BM-3a were within the ranges documented in the historical database. Community evenness was within the historical range at BM-2, but registered at a new minimum of 0.33 at station BM-3a. This is due to the preponderance of amphipods as opposed to relative scarcity of other taxa in the community at BM-3a including minor representation by mayflies in comparison to BM-2.

The community at station BM-4 was dominated by the caddisfly *Hydropsyche* and by blackfly larvae (Simuliidae; mostly attached to leaves of *Sparganium* as noted previously). Specimens of dragonfly nymphs of the genus *Boyeria* were observed for the first time at BM-4 in comparison to the historical database, but these had been previously observed at station BM-3a in 2006. Also at station BM-4, a specimen of "riffle" beetle (genus *Dubiraphia*) was observed in 2007 for the first time in comparison to historical data.

The stonefly *Leuctra* was again represented at BM-4 by one specimen as in 2006. *Leuctra* was observed previously in 1999 at station BM-1 and is the only stonefly genus documented in the Eel River to date. The mayfly *Stenonema* was again observed at BM-4 after its first appearance at this station in 2006. Lastly, observations of cranefly larvae (Tipulidae) were unique to station BM-4 which is consistent with historical data.

Community richness registered at a new maximum of 14 taxa at station BM-4 although most of these taxa were represented by only one or a few specimens. Measurements of community evenness and EPT taxa at station BM-4 were within the ranges documented in the historical database.

Changes in composition and structure of the Eel River macroinvertebrate community between 2007 and historical data reflect fluctuations in populations that are typical of macroinvertebrate communities. 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.

Reference Cited: *Fager, E.W. 1972. Diversity: a sampling study. American Naturalist 106: 293 – 310.*

2.5.7 Periphyton Data, 2007

The following has been compiled from information provided by the Town's Consultant Limnologist/Biologist:

Periphyton data at locations BM-1, BM-2, BM-3a & BM-4 were collected in the spring and fall of 2007. Results of the data can be found in Appendix C. The artificial substrates collected in the spring were richly colonized with periphytic growth composed generally of diatoms and the green alga *Coleoachaete* in its typical prostrate growth form as observed in previous years. The artificial substrates collected in the fall were generally colonized by diatoms expect for station BM-3a where bacteria occupied most of the surfaces. Ascendancy by bacteria on artificial substrates is observed occasionally and does not necessarily indicate a change in water quality. Additional taxa were also significant at stations BM-1 and BM-2 consisting of the cyanophyte *Phormidium* and the green alga *Coleochaete* respectively.

2.5.8 Russell Mill Pond Water Column Profiles and Plankton Sampling, 2007

The following has been compiled from information provided by the Town's Consultant Limnologist/Biologist:

<u>April 29, 2007:</u> Results were very similar to those documented in April of 2006. The water appeared yellowish-brown due to high densities of the diatom *Asterionella* and other phytoplankton with Secchi transparency measuring only 5.5 feet (1.7 meters). Photosynthetic activity by phytoplankton is evident in the values of dissolved oxygen above saturation in the top four meters of the water column. However, beneath a depth of four meters, dissolved oxygen is rapidly being used up by microbial decomposition of sedimenting plankton. The deep stratum of water that remains relatively cold (hypolimnion) will soon become anoxic as documented during the period of thermal stratification last year.

<u>June 17, 2007:</u> Results continue to be very similar to those documented last year with photosynthesis by phoytoplankton causing surface water (epilimnion) to be supersaturated with dissolved oxygen and water below the thermocline (hypolimnion) becoming anoxic due to

decomposition. Secchi transparency had increased slightly from 4 feet to 4.5 feet since May. The diatom *Asterionella* continues to be the dominant organism among the plankton.

July 22, 2007: Results continue to be very similar to those documented last year with photosynthesis by phytoplankton causing surface water (epilimnion) to be supersaturated with dissolved oxygen and water below the thermocline (hypolimnion) becoming anoxic due to decomposition. Secchi transparency had increased slightly from 4.5 feet to 6.5 feet since June. Analysis of the plankton sample showed the community to have become quite diverse and no longer dominated by *Asterionella* or any other single organism. The prevalence of *Tintinnopsis* (a ciliate protozoan having a protective external case known as a test or lorica) is somewhat novel, not having been observed in the monitoring program previously, but is not indicative of any significant change in water quality.

August 26, 2007: Results continue to be very similar to those documented last year with photosynthesis by phytoplankton causing surface water (epilimnion) to be supersaturated with dissolved oxygen and water below the thermocline (hypolimnion) becoming anoxic due to decomposition. Secchi transparency remains limited due to high densities of phytoplankton. Analysis of the plankton sample showed a resurgence of the diatoms *Tabellaria* and *Asterionella.* The filamentous cyanophyte *Oscillatoria* remained a significant member of the community, but the ciliate protozoan *Tintinnopsis* had disappeared from the community since July.

2.5.9 Secchi Transparency and Dominant Phytoplankton, 2007

Spring 2007: Results of multiprobe measurements recorded on May 27, 2007 are located in Appendix C. Results of Eel River Plankton sampling conducted on May 27, 2007 are located in Appendix C. Similar to last year, there is generally an increase in specific conductance from headwater locations BM-4 and BM-3a downstream throughout the system eventually to Eel River Basin. This is evident in the figure which shows conductivity data from 2006 and the recent measurements arranged sequentially by location along the flow path from “headwaters” downstream to Eel River Basin including the western and southern branches. The diatom *Asterionella* was the dominant organism among all the ponds. In Russell Mill Pond, transparency has decreased from 5.5 feet to 4 feet since April and the hypolimnion has nearly been depleted of dissolved oxygen.

Fall 2007: Results of multiprobe measurements recorded on September 22, 2007 are located in Appendix C. Results of Eel River Plankton sampling conducted on September 22, 2007 are located in Appendix C. Similar to previous measurements, there is generally an increase in specific conductance from headwater locations BM4 and BM3a downstream throughout the system eventually to Eel River Basin. The diatoms *Asterionella* and *Tabellaria* were dominant among the plankton of all four ponds. Additionally, other organisms were significant in Russell Mill Pond and Hayden Pond including *Anabaena*, *Mallomonas*, and *Synura*. Secchi transparency increased from 6 feet to 8 feet since August in Russell Mill Pond.

2.5.10 Macrophyte and Biomass Survey, 2007

Observations of macrophytes in the four ponds were conducted throughout the summer in conjunction with other monitoring activities. Changes in the macrophyte communities were negligible from conditions documented last year and figures depicting survey results from 2006 are representative of current distributions and densities.

Fanwort (*Cabomba caroliniana*) remains the only invasive alien macrophyte present in the system and is still restricted to Hayden Pond and Eel River Basin where it is a dominant component of these communities. There is no sign of other problematic aliens such as *Hydrilla*, Eurasian Water-milfoil (*Myriophyllum spicatum*), or Water Chestnut (*Trapa natans*) in any of the ponds. *Elodea* is a common native species which is easily confused with *Hydrila* and special attention was given to confirming the identification of *Elodea* in all four ponds.