# Interim Phosphorus Reduction Strategy for Connecticut Freshwater Non-Tidal Waste-Receiving Rivers and Streams Technical Support Document

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## Introduction

Macro nutrients, such as nitrogen and phosphorus, are an essential component of plant and animal nutrition and are naturally occurring in aquatic systems. However, excessive inputs of nutrients from human sources such as discharges from industrial and municipal water pollution control facilities (WPCF) or runoff from urban and agricultural lands can alter primary productivity in aquatic systems and result in impairment to both recreational and aquatic life uses in Connecticut's water resources. Excessive loading of nutrients from anthropogenic sources causes or contributes to accelerated eutrophication, often termed 'cultural eutrophication.' Eutrophication is a process that increases the level of primary production leading to algal blooms, including blooms of noxious cyanobacteria, reduction in water clarity, alteration of habitat and in extreme cases depletion of oxygen, fish kills, and other impairments to aquatic life. Eutrophication is a slow natural process that occurs within a water body, but human activity greatly speeds up the process primarily thorough the addition of excess nutrients.

Excessive nutrient enrichment of surface waters is a widespread issue throughout the United States and the world. Connecticut has identified 21freshwater water bodies on the 2012 Impaired Waters List according to section 303(d) of the Clean Water Act (CT DEEP, 2012) where nutrient enrichment is specifically listed as a contributing cause of the impairment. These waters are primarily lakes that were assessed as impaired due to frequent algal blooms resulting from anthropogenic inputs of nutrients that threaten or impair aquatic life support or recreational designated uses. However, nutrients likely cause or contribute to other water body impairments that are not currently listed specifically for nutrients. Several water bodies have been identified as impaired for aquatic life uses caused by unknown pollutants where high yields of anthropogenic nutrient loading occur (Figure 1). The high yield of phosphorus in many of these water bodies is due to loading from municipal or industrial WPCFs discharging directly to the water bodies.

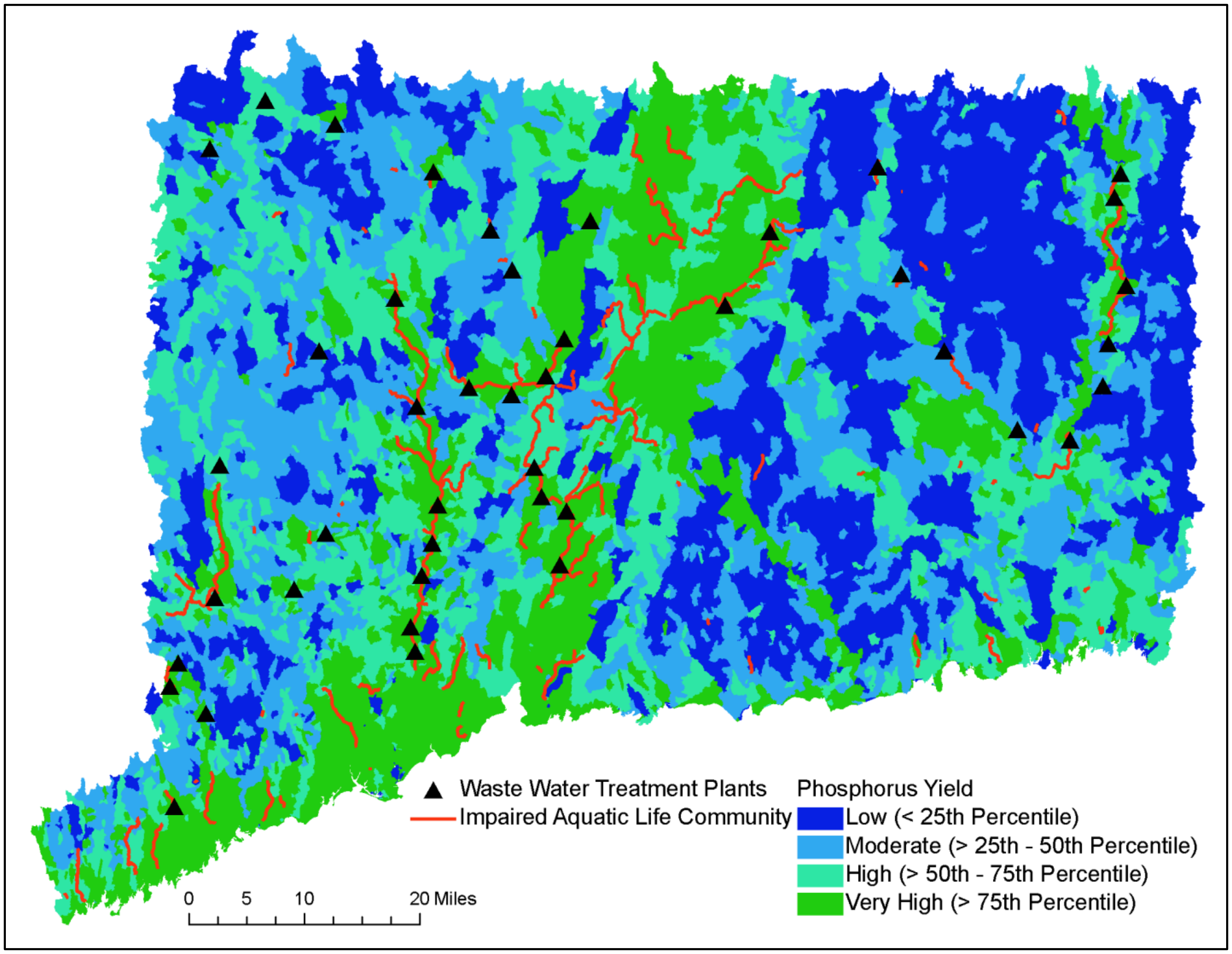


**Figure 1. Statewide phosphorus yields calculated using SPARROW (Moore et al., 2011). Aquatic life impairments based on assessments for the 2012 impaired waters list.**

As a result of the high percentage of water bodies listed for nutrient-related impairments in the U.S. according to section 303(d) of the Clean Water Act, the U.S. EPA has targeted nutrient pollution reduction a priority and have encouraged states to accelerate reduction of nutrients by prioritizing watersheds on a state-wide basis and setting load-reduction goals while developing numeric nutrient criteria for adoption into state water quality standards (Grubbs, 2001; Grumbles, 2007; Stoner, 2011). In addition, Federal regulations 40 C.F.R. § 122.44(d) indicate that entities issuing permits under the National Pollutant Discharge Elimination System (NPDES) program are required to determine whether a given point source discharge causes or has the reasonable potential to cause or contribute to an in-stream excursion above a narrative or numeric criteria within a state water quality standard. If a discharge is found to cause or contribute to an excursion of a water quality criterion, NPDES regulations implementing sections 301(b)(1)(C) of the Clean Water Act provide that a permit must contain effluent limits to achieve state water quality standards. In order to protect Connecticut water resources and be consistent with U.S. EPA guidance and federal regulations, the CT Department of Energy and Environmental Protection (DEEP) identified freshwater non-tidal waste receiving streams as a high priority for nutrient loading reductions due to the high phosphorus yields in these water bodies and potential to contribute to water quality impairments.

The Connecticut Water Quality Standards (WQS) (CT DEEP, 2013) incorporate narrative standards and criteria for nutrients with no numeric criteria. These narrative policy statements direct DEEP to impose discharge limitations or other reasonable controls on point and non point sources of nutrients which have the potential to contribute to the impairment of any surface water to ensure maintenance and attainment of existing and designated uses, restore impaired waters, and prevent excessive anthropogenic inputs of nutrients or impairment of downstream waters.

In the absence of numeric criteria for phosphorus, DEEP developed the methodology described below based on the narrative criteria and policy statements in the WQS to meet the pressing need to issue NPDES permits and be protective of the environment. These methods were approved by the United States Environmental Protection (EPA) in a letter dated October 26, 2010 as an interim strategy to establish water quality based phosphorus limits in non-tidal freshwater for industrial and municipal WPCFs NPDES permits until the Department has established numeric nutrient criteria in the CT WQS. The interim strategy is based on best available information at a state-wide level using methods to identify phosphorus enrichment levels in waste receiving rivers and streams that adequately protects aquatic life uses. This strategy results in overall reductions up to 95% of the current watershed load once the strategy is fully implemented.

*Phosphorus, healthy streams, and Connecticut's Water Quality Standards*

The contribution of phosphorus to eutrophication and aquatic life impairments is difficult to measure directly because phosphorus is a natural element required for biological processes and the effects on the stream vary over time and space. Streams exhibit varying levels of productivity and diversity along longitudinal and lateral dimensions of the river network (Cardinale et al., 2005; Thorp et al., 2006; Vannote et al., 1980). Primary producers in streams include photosynthesizing organisms like algae and macrophytes. The biomass of primary producers may vary greatly throughout a season, from year to year and from one stream reach to another. This natural variation may also result from changes in light availability, temperature and predation due to grazer activity.

This methodology focuses on the contribution of phosphorus loading to cultural eutrophication and its effects on the biological condition of the stream rather than a single numeric criterion value. Threshold based management, or targeting a specific nutrient concentration could impart an unintended consequence of decreasing ecological diversity in rivers and streams if phosphorus was treated like a toxic pollutant (Figure 2). The management approach used for toxic pollutants is based on quantal endpoints that are ineffective for pollutants like nutrients because the ecological impacts of nutrients often occur long before organisms are killed or impaired (Becker, 2013). This approach uses diatoms as a biological endpoint and instead of a having a single threshold, uses anthropogenic phosphorus loading compared to natural levels of phosphorus to drive management activity.

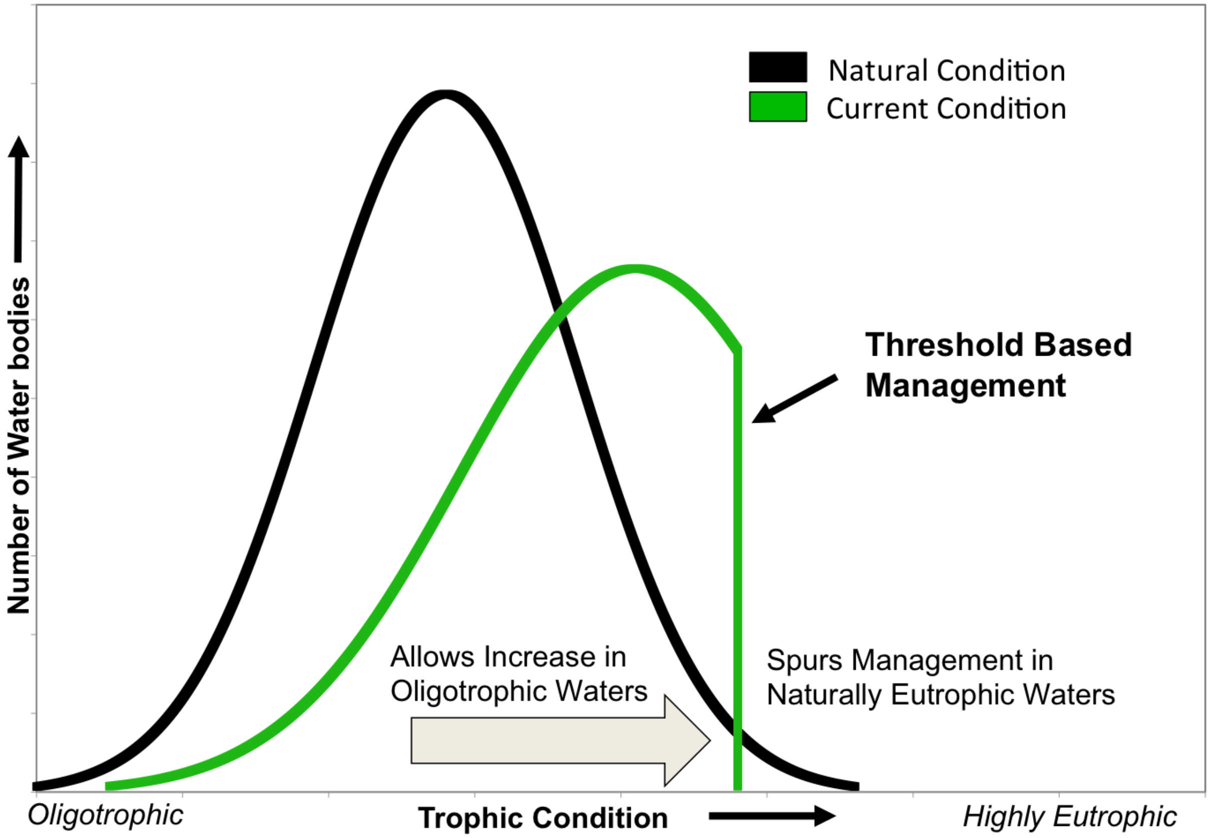


**Figure 2. Example of threshold-based approach applied to nutrients using a hypothetical distribution. The black line shows the 'naturally' varying distribution of nutrients in the aquatic environment. The green line shows the current distribution with a threshold criterion applied. (Paul Stacey, Personal Communication, 2010)**

Several studies (Danielson, 2009a; Kelly et al., 1998; Potapova and Charles, 2007; Potapova et al., 2004; Winter and Duthie, 2000) have shown that algal species composition provide a reliable indicator of trophic status in rivers and streams. Diatoms, a collection of microalgae in the Bacillariophyta group, are widely recognized and used as indicators of river and stream water quality (Kelly et al., 2008; Pan et al., 1996; Patrick, 1949; Stevenson and Pan, 1999). Several state agencies have identified the effectiveness of diatom trophic indices in aiding the development of nutrient criteria (Danielson, 2009b; Ponader et al., 2007). Studies conducted using CT data have also identified the importance of incorporating diatom responses in the development of nutrient criteria (Smucker et al., 2013). Diatom composition has also been used extensively in Europe as measure of trophic conditions (Kelly et al., 2008; 1998). Lavoie et al. (2008) found that species composition of diatoms is more likely to reflect actual stream conditions than assessment of water chemistry or algal biomass because they integrate the effects of stressors over time and space. Once it enters the stream, phosphorus can be found in the water column, taken up by aquatic organisms or attached to sediment in the water.

Current efforts to manage cultural eutrophication in freshwater in CT are focused on phosphorus because phosphorus is typically found to be the primary limiting nutrient in freshwater systems (Correll, 1998). This means that the level of phosphorus is a limiting factor of biological productivity in streams. In-stream concentrations of phosphorus measured in surface water grab samples (e.g. mg/L) are often used in nutrient criteria studies (U.S. EPA, 2000a). However, phosphorus loads exported to a stream (e.g. lb/ac/yr) may better reflect that the addition of phosphorus over time and space (U.S. EPA SAB, 2010) because stream trophic conditions are affected by the addition of phosphorus over time rather than any one single concentration of phosphorus.

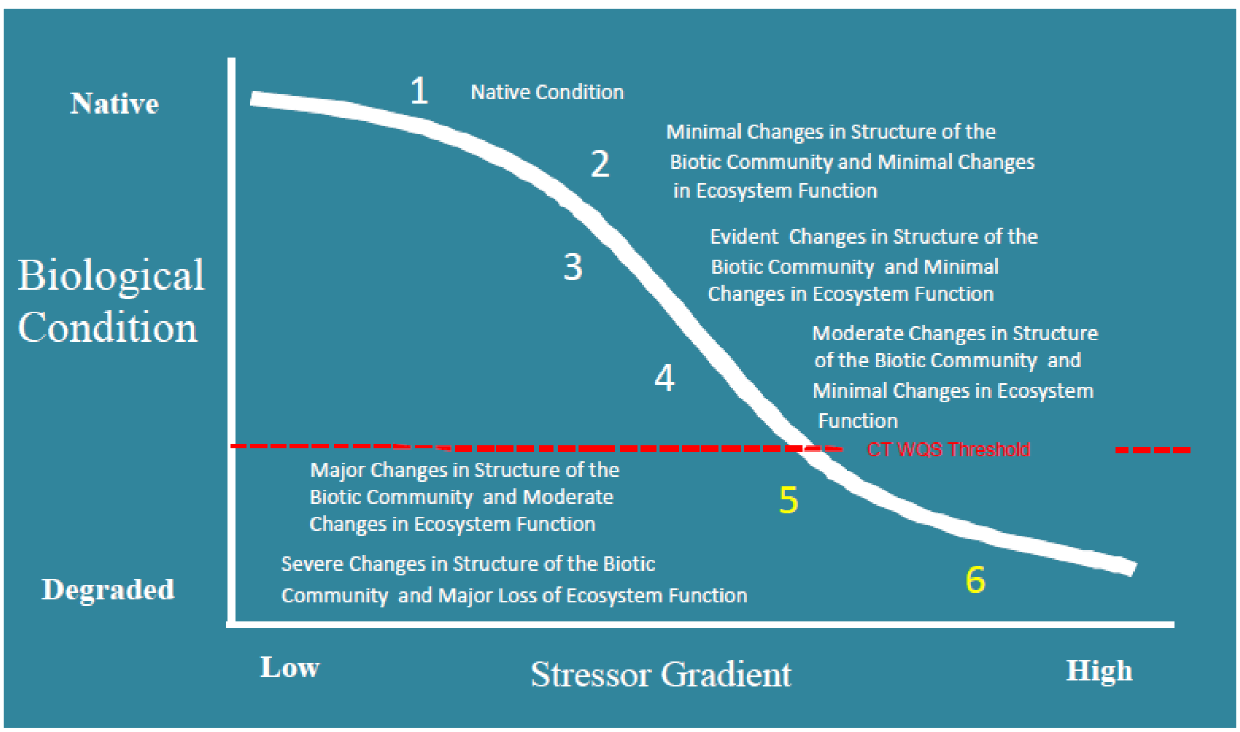


**Figure 3: The Biological Condition Gradient (BCG) modified from Davies and Jackson (2006) and applied the CT WQS. The BCG was developed to serve as a common scientific framework that describes how biological communities and ecological attributes change in response to increasing levels of stressors.**

The analysis described below is designed to identify where major changes occur in the biological condition of rivers and streams in response to phosphorus. The CT WQS (2013) state that water quality is insufficient when major deviations from the natural condition have occurred in the structure of the biotic community (Figure 3) along the biological condition gradient (Davies & Jackson, 2006). The biological condition gradient illustrates the relationship between the amount of stress in the environment and its effect on biological communities. Major changes are defined as markedly diminished sensitive taxa; conspicuously unbalanced distribution of major groups from that expected; organism conditions showing signs of physiological stress; ecosystem function showing reduced complexity and redundancy; and increased build-up or export of unused materials. Specifically, the analysis identifies changes in trophic condition as indicated by changes in the diatom biological community in response to anthropogenic phosphorus loadings. The analysis includes 4 steps: 1) Identify where diatom community samples were collected across the State; 2) Estimate the seasonal anthropogenic phosphorus loadings at those samples site; 3) Identify changes in the diatom community in response to phosphorus loadings; and 4) Identify loading reductions needed in waste-receiving stream to meet CT WQS biological condition goals.

**Methods**

*Study Area and Sampling Data*

Periphyton samples were collected from natural substrates as part of the CT DEEP ambient water quality monitoring program. Periphyton is a complex mixture of microscopic algae (including diatoms), bacteria and fungi that grows on the bottom substrate of a river or stream. It includes the collection of eplithic diatoms. Eplithic diatoms grow on hard relatively inert substrates that are typically bigger than most algae, such as gravel, pebble, cobble and boulder (Stevenson, 1996). Samples were collected in wadable riffle or run sections of the stream. Periphyton surveys were conducted at 85 sites across the State in July and August from 2002 – 2004 using an integrated approach that combined probabilistic and targeted monitoring designs (Wahle, 2003). Stein and Bernstein (2008) demonstrated that an integrated approach provides a more complete assessment of conditions to support water quality management.

Probabilistic designs draw sampling stations randomly from an area or region and are used by the U.S. EPA and states to provide statistically valid assessments of water quality and designated use attainment for spatially diverse regions. Targeted sites focus on describing and quantifying impacts, tracking trends and assessing compliance with regulatory guidelines or limits. Of the 85 sites, 59 were selected using a probabilistic sampling design and 26 selected using a targeted approach. At each site, 15 rocks were randomly selected throughout a 150 m stream reach in riffle and run habitats. Periphyton was removed from within a 5.1 $cm^2$ area on each rock and composited into one sample. Five ml of the periphyton sample were filtered onto a 47 mm diameter glass fiber filter with a 0.7 µm pore size for chlorophyll *a* analysis. The remaining sample was preserved and sent to a laboratory for diatom taxonomic identification. Diatom samples were processed using acid to remove organic material before mounting on slides using NAPHRAX™. Diatoms were identified to the lowest practical taxonomic level, typically species or lower, and at least 600 valves were enumerated per sample. For the analysis taxon identified below the species level were truncated to the species level. The chlorophyll *a* samples were frozen and sent to a separate lab for quantification using EPA fluorometric method 445.0/AERP 12 and aTurner Design Fluorometer TD-700.

At each site, a surface water chemistry sample was also collected. Nitrogen was determined as $NO_2 + NO_3$ (subsequently referred to as $NO_x$) using a cadmium reduction technique and an autoanalyzer for colorimetric measurements (EPA method 353.2). Total phosphorus was determined using the colorimetric EPA methods 365.1 and 365.4, which used persulfate and acid digestion. Turbidity was determined by nephelometry using EPA method 180.1.

In some cases, site locations may have been sampled more than once for two reasons: 1) a site was sampled in multiple years or 2) field replicates for samples were collected during the same year to adhere to quality control procedures. In these cases taxa counts were averaged. Taxa abundance was calculated at the species level and any taxa identified at a higher level than species were removed. Rare taxa were defined as those occurring in less than 5% of the samples and were removed from further analysis.

*Estimates of Seasonal Phosphorus Loadings*

Phosphorus enrichment levels were estimated using a metric called an enrichment factor (EF) (Becker & Dunbar, 2009). An EF is a unitless metric that provides an estimate of the level of anthropogenic phosphorus loading to river and streams. An EF value of 1 would mean that there was no anthropogenic phosphorus loading because current loading is equal to the forested condition. Higher EF values indicate a greater contribution of anthropogenic phosphorus. Phosphorus loadings were used instead of the single grab phosphorus chemistry samples because trophic conditions are affected by the addition of phosphorus over time rather than any one point-in-time single concentration of phosphorus. The EF is calculated by dividing the estimated total seasonal (April through October) phosphorus load by an estimated ‘natural’ total phosphorus load for any given point along a river or stream (**Equation 1**). The critical ‘growing’ season (April through October) is targeted for management because this is the time period when phosphorus is more likely to be taken up by sediment and biomass due to low flows, longer periods of sunlight and warmer conditions.

$$\textbf{Enrichment Factor (EF)} = \frac{\textbf{Total NPDES Load} \left(\textbf{lbs}/\textbf{day}\right) + \textbf{Land Cover Load}\left(\textbf{lbs}/\textbf{day}\right)}{\textbf{Forested Condition Load} \left(\textbf{lbs}/\textbf{day}\right)}$$

**Equation 1. Enrichment Factor Calculation**

The total current phosphorus load is calculated by adding the total upstream NPDES discharge load to the total upstream land cover load. Phosphorus loads from NPDES discharges were estimated using the flow and phosphorus concentration data from daily monitoring and nutrient analysis reports submitted to the Department from the facilities during April through October, 2001 - 2007. The land cover and ‘natural’ loads were estimated using land cover export coefficients for urban, agricultural and undeveloped land cover developed by Becker & Dunbar (2009). Land cover export coefficients estimate the average phosphorus export from a given area of land cover type to the river. The land cover export coefficients used for this analysis were within the ranges observed in a recent USGS study within the Northeastern United States (Trench et al., 2012) (Table 1) and generally consistent with the mean phosphorus export observed at sites across New England.

**Table 1. Phosphorus export coefficients from Becker & Dunbar (2009) compared to average exports observed in Trench et al. (2012) with a drainage area less than 640,000 Acres (1000 SqMi) without municipal treatment discharges in New England (n = 9) and all throughout the Northeastern U.S. (n = 43).**

| **Source** | **Undeveloped (lb/ac/yr)** | **Urban (lb/ac/yr)** | **Agriculture (lb/ac/yr)** |
|---|---|---|---|
| Becker & Dunbar (2009) ***export coefficient used in this study*** | **0.038** | **0.158** | **0.721** |
| Trench et al (2012) New England Sites ***mean*** *(n, range)* | **0.07** *(n= 5, 0.05 – 0.1)* | **0.13** *(n= 3, 0.08 – 0.22)* | **0.77** *(n= 1, NA)* |
| Trench et al (2012) All Northeastern Sites ***mean*** *(n, range)* | **0.09** *(n=15, 0.02 – 0.22)* | **0.72** *(n= 10, 0.08 – 2.34)* | **0.77** *(n=6, 0.09 – 2.19)* |

The total land cover phosphorus load was calculated by multiplying the specified land cover type area (i.e. urban, agriculture or forest) in the upstream drainage basin by the export coefficient and adding all three together. The 'natural' phosphorus load was calculated by multiplying the entire upstream drainage area by the forest export coefficient.

The total upstream drainage basin was delineated for each of the sampling points using the Arc Hydro extension (version 1.4) for ArcGIS (ESRI ArcMap version 9.3.1). Land cover areas were calculated for each of the export coefficient categories in each basin using condensed land cover category grids derived from the University of Connecticut Center for Land Use Education and Research (CLEAR) dataset (Version 1) as described in Becker & Dunbar (2009). NPDES discharges were identified in each basin using GIS point coverage data from CT DEEP. Seven sites were eliminated from the analysis where the majority of the basin was out of state and land cover data or out of state NPDES data was not available leaving 78 sites for further analysis.

*Identifying changes in the diatom community in response to phosphorus loadings*

Threshold Indicator Taxa ANnalysis TITAN (Baker and King, 2010) was used to identify change points in the diatom species response to phosphorus loadings and community level phosphorus loading thresholds by considering aggregate changes across species. The TITAN method integrates information on the occurrence, abundance, and directionality of taxa responses (Baker and King, 2010) using indicator value (IndVal) scores (Dufrêne and Legendre, 1997). The IndVal scores are calculated and used to associate individual taxa with either a positive or negative response across the observed continuous gradient, in this case a phosphorus enrichment gradient. The TITAN method identifies the point at which the maximum IndVal of the taxon occurs across the observed gradient as the observed change point and assigns the taxa to either a positive or negative partition. Evidence for a diatom community thresholds to phosphorus loadings is identified by synchronous taxa response. The TITAN method standardizes the observed IndVal as z scores and sums the z scores of each individual taxon within each partition for every candidate change point across the observed phosphorus gradient. This standardization ensures that both common and uncommon species contribute equally to the community change analysis (Baker and King, 2010). The largest sums for each positive and negative partition are identified as observed community-level change points. TITAN was written in the programming language R and the code is available as a supplement to Baker and King (2010).

Bootstrap re-sampling was used to estimate uncertainty and identify significant indicator taxa by providing measures of indicator purity and reliability. Indicator purity provides information on the proportion of agreement between the observed change-point response direction (negative or positive) and the bootstrap replicates. Indicator reliability provides an estimate of how significantly different the dataset is from a random distribution. Individual taxa were considered significant if at least 95% of the bootstrap runs indicated the same response direction as the observed response (i.e. high purity) and at least 95% of the bootstrap runs were significantly different from a random distribution at $p \leq 0.05$ (i.e. high reliability). Bootstrap replicates were also used to develop empirical confidence limits around the community level change points. Bootstrap replicates were run 500 times and used to define enrichment thresholds for Connecticut streams. The 95% sum z+ from the 500 bootstrap replicates was used to define the upper most limit where CT WQS are met for the biological community. This approach was chosen because it represents a saturated threshold, beyond which major deviations from the natural condition have occurred in the structure of the biotic community. Beyond this point, an altered community structure is sustained and little change in the biological community is observed.

For comparison non-parametric change point analysis (nCPA) was also run (King & Richardson, 2003, Qian et al., 2003). nCPA and TITAN are similar analyses, however TITAN uses IndVal scores instead of deviance reduction to identify change points. nCPA identifies an aggregate, community level, dissimilarity response, while TITAN incorporates taxon-specific responses. nCPA identifies a point along the independent-variable gradient that produces the greatest reduction in deviance. nCPA uses bootstrap re-sampling with replacement (500 permutations) to estimate uncertainty in the change point values and produces cumulative probability plots for comparison based on the frequency distribution of change points. nCPA was also run using R version 2.10 (R Development Core Team http://www.R-project.org) and source code provided in Baker & King (2010).

*Application to Waste Receiving Streams*

The locations of NPDES facilities that discharge phosphorus into freshwaters and their receiving waters were identified using the CT DEEP municipal facilities GIS layer and through personal communication with CT DEEP NPDES permitting staff. The upstream EF and the seasonal phosphorus loading contribution from upstream NPDES facilities to the EF were estimated at multiple points downstream of NPDES facilities. The locations for EF analysis downstream of NPDES facilities were defined as stream segment points using the USGS 1:24,000 National Hydrography Dataset (NHD) stream line developed for CT. The Arc Hydro extension in ArcGIS was used to delineate the watershed at each stream segment location and calculate the land cover category areas and NPDES phosphorus loading contributions used to estimate the current EF as described above. In basins that extended out of state where CLEAR data was not available, land cover areas were estimated using the 2001 National Land Cover Dataset (Homer et al., 2004). Out of state NPDES facilities were identified through personal communication with U.S. EPA Region 1 staff and loads were estimated using the phosphorus concentration limits and design flows allocated in facility permits.

In-stream loading reductions needed to meet the maximum allowable EF target necessary to achieve WQS identified by the TITAN analysis at each of the stream segment locations were determined by subtracting the current EF from the WQS target EF. The needed reductions were applied to the NPDES facilities waste load allocation to ensure the target EF was met throughout the stream. In cases where the current NPDES facilities phosphorus load already met the target EF, a cap at the current waste load allocation was applied to ensure future anti-degradation.

**Results**

The 78 sites for analysis were distributed throughout the State (Figure 3, Table2) and represented a range of human disturbance (percent impervious cover 1.46 – 13.64 %), drainage area (0.45 – 259.25 square miles) and enrichment levels (1.2 to 76 EF).

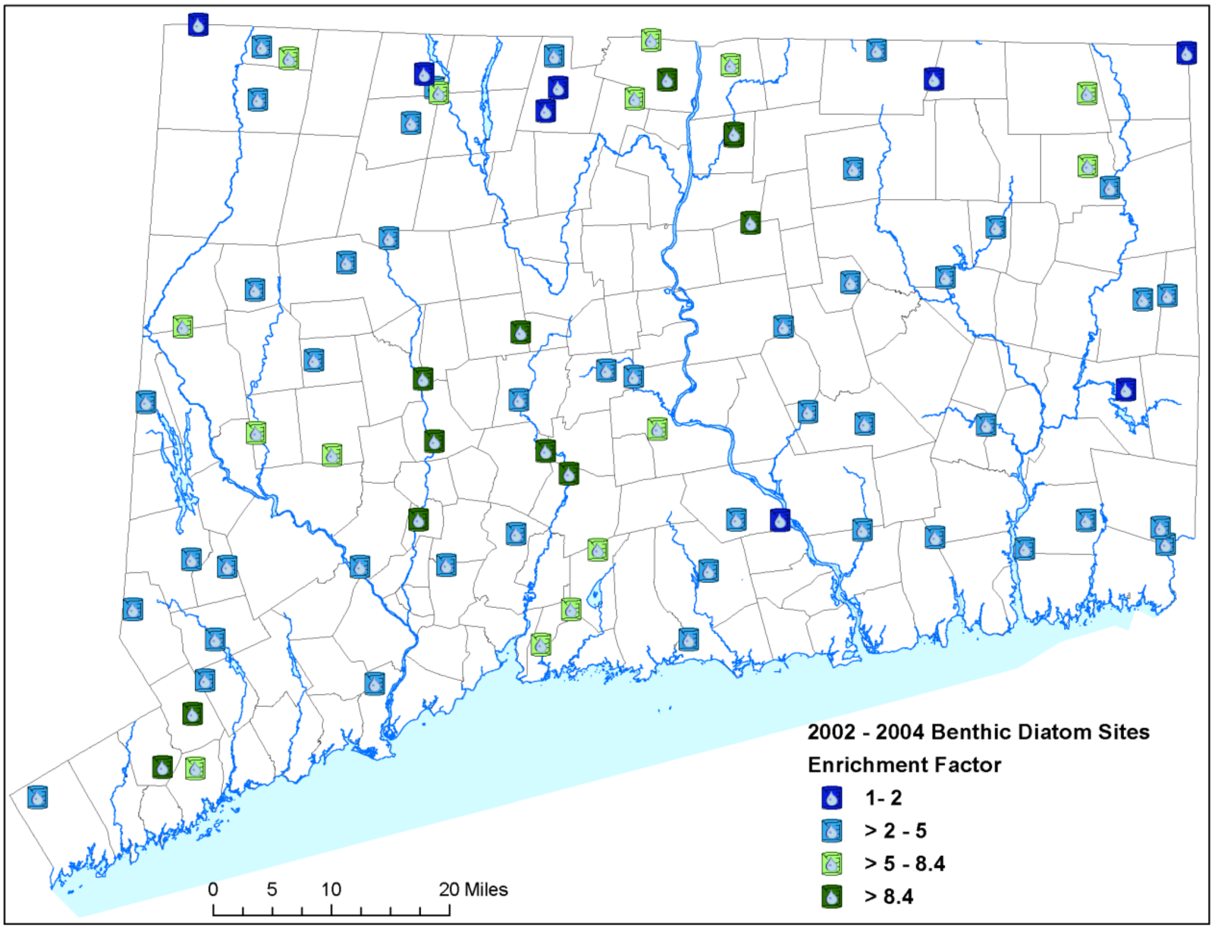


**Figure 4. Site locations of where benthic diatom community and nutrient chemistry data were collected from 2002 - 2004. The phosphorus enrichment factor was estimated at each site using land cover data and phosphorus data submitted to CT DEEP from 2002 - 2007 by NPDES permit dischargers.**

**Table 2: The 78 Sites used in the analysis along with their drainage area ($mi^2$), percent impervious cover (IC) in the upstream drainage area and enrichment factor.**

| ID | Stream Name | Location | Municipality | Area ($mi^2$) | Percent IC | Enrichment Factor |
|---|---|---|---|---|---|---|
| 22 | Broad Brook | upstream USGS gage at Route 191 | East Windsor | 15.54 | 4.93 | 9.3 |
| 28 | Coginchaug River | downstream Route 66 | Middletown | 37.29 | 5.11 | 6.24 |
| 69 | Farm River | downstream Totoket Road | North Branford | 12.87 | 5.33 | 6.32 |
| 77 | Five Mile River | under Old Norwalk Road | New Canaan | 5.07 | 13.64 | 35.14 |
| 163 | Mattabesset River | downstream Berlin Street | Cromwell | 45.28 | 11.62 | 4.38 |
| 178 | Muddy Brook | downstream Route 168 (Main Street) | Suffield | 19.43 | 4.74 | 8.93 |
| 189 | Natchaug River | downstream North Bear Hill Road | Chaplin | 73.1 | 2.81 | 2.83 |
| 191 | Naugatuck River | upstream Frost Bridge Echo Lake Rd and Route 262 | Watertown | 137.39 | 4.31 | 13.44 |
| 192 | Naugatuck River | behind Fire Station | Beacon Falls | 259.26 | 8.47 | 49.77 |
| 216 | Naugatuck River | at Palmer Bridge Street | Torrington | 52.84 | 6.43 | 3.17 |
| 236 | Norwalk River | upstream Perry Avenue | Norwalk | 32.81 | 9.84 | 6.49 |
| 267 | Pequabuck River | adjacent USGS Gage upstream of Central Avenue | Bristol | 45.69 | 10.34 | 76.04 |
| 288 | Quinnipiac River | downstream small dam behind water company building on Syndall Street | Cheshire | 76.2 | 10.72 | 41.56 |
| 316 | Salmon River | downstream 0.7 miles RR bridge | Colchester | 82.42 | 4.62 | 3.9 |
| 317 | Sandy Brook | opposite Grange Hall off Riverton Road | Colebrook | 36.98 | 2.18 | 2.02 |
| 319 | Saugatuck River | downstream Route 107 & Route 53 Junction | Redding | 20.81 | 3.88 | 2.62 |
| 325 | Shepaug River | downstream 100 meters Wellers Bridge Road (Route 67) | Roxbury | 132.29 | 3.31 | 5.99 |
| 336 | Still River | adjacent USGS gage off Robertsville Road | Colebrook | 85.55 | 3.21 | 5.81 |
| 337 | Still River | downstream Triangle Street | Danbury | 30.9 | 11.31 | 3.4 |
| 340 | Stony Brook | upstream South Grand Street | Suffield | 10.53 | 3.74 | 7.2 |
| 424 | Mattabesset River | upstream Lower Lane and Belcher Brook Mouth | Berlin | 9.92 | 8.19 | 4.24 |
| 488 | Eightmile River | downstream 100 meters Prospect Street | Southington | 14.15 | 8.45 | 3.32 |
| 573 | Blackberry River | Behind Elm Knoll Farm at second tractor crossing | North Canaan | 38.85 | 2.7 | 5.01 |
| 574 | Blackberry River | adjacent well field south of Route 7 crossing | North Canaan | 43.04 | 2.81 | 4.97 |
| 607 | Shunock River | upstream Route 49 | North Stonington | 16.45 | 3.49 | 4.2 |
| 739 | Muddy Brook | Upstream of private bridge Number 1600 Route 187 | Suffield | 8.22 | 4.44 | 7.57 |
| 740 | Mountain Brook | adjacent old logging road | Granby | 0.86 | 2.07 | 1.47 |
| 742 | Indian Meadow Brook | between Route 44 crossing and end of Loomis Street | Winchester | 4.43 | 2.77 | 2.75 |
| 743 | Sandy Brook | 250 meters upstream second bridge crossing on Sandy Brk Rd from Rte 8 | Colebrook | 34.51 | 2.15 | 1.99 |
| 744 | Lake Waramaug Brook | at farm Bridge crossing number 21 route 341 | Warren | 4.51 | 3.18 | 2.48 |

| ID | Stream Name | Location | Municipality | Area ($mi^2$) | Percent IC | Enrichment Factor |
|---|---|---|---|---|---|---|
| 745 | Bull Mountain Brook | upstream Camp Flat Rd and Mud Pond Rd intersection | Kent | 1.99 | 3.14 | 5.59 |
| 746 | Sawmill Brook | at confluence with spring lake outfall | Sherman | 1.66 | 2.03 | 2.6 |
| 748 | Naugatuck River | at RR crossing DS of Mad River Confluence | Waterbury | 205.95 | 8.19 | 10.18 |
| 749 | Limekiln Brook | upstream Rockwell Road | Bethel | 3.98 | 8.21 | 4.17 |
| 750 | Bladdens River | upstream Sanford Road | woodbridge | 1.74 | 5.57 | 2.82 |
| 751 | East Branch Byram River | downstream John Street | Greenwich | 2.46 | 5.34 | 3.43 |
| 752 | Pumpkin Ground Brook | upstream cutspring rd | stratford | 3.4 | 11 | 2.96 |
| 753 | Norwalk River | adjacent Wilton Jr High/ Middle School | Wilton | 18.17 | 9.25 | 8.81 |
| 755 | Neck River | upstream Green Hill Rd | Madison | 4.94 | 7.65 | 2.27 |
| 756 | Pond Meadow Brook | Adjacent to Abner Lane (at yellow road marker with dep id) | Killingworth | 6.26 | 3.56 | 2.45 |
| 757 | Beaver Meadow Brook | adjacent to Beaver Meadow Road | Haddam | 0.46 | 3.92 | 2.36 |
| 758 | Flat Brook | at #30 Finley Hill Rd | Marlborough | 2.09 | 4.42 | 3.97 |
| 759 | Shunock River | upstream route 184 | North Stonington | 14.74 | 3.18 | 4.18 |
| 760 | Flat Brook | upstream Baldwin Hill Road | Ledyard | 1.38 | 7.78 | 2.81 |
| 761 | Latimer Brook | between Brook Bend cul-de-sac and Robin Drive cul-de-sac | East Lyme | 9.99 | 3.51 | 2.93 |
| 762 | Bentley Brook | at Gifford Lane | Bozrah | 1.52 | 3.14 | 3.2 |
| 763 | Rocky Brook | adjacent to East Thompson Road | Thompson | 4.83 | 1.78 | 1.23 |
| 765 | Skungamaug River | downstream Old Cathole Road | Tolland | 6.18 | 3.82 | 3.23 |
| 766 | Stickney Hill Brook | upstream Brown road | Union | 2.28 | 2.11 | 1.92 |
| 778 | Mashamoquet Brook | adjacent route 101 | pomfret | 28.86 | 3.18 | 4.77 |
| 779 | Hop River | adjacent route 6 at andover auto parts | andover | 58.83 | 4.17 | 3.88 |
| 780 | Sages Ravine Brook | 500 feet upstream route 41 | Salisbury | 3.4 | 1.46 | 1.27 |
| 789 | Ekonk Brook | between buildings 6 & 7 at condos Gorman Street | Plainfield | 5.31 | 2.91 | 4.94 |
| 906 | Freshwater Brook | behind last parking lot 9 Moody Road | Enfield | 7.39 | 10.67 | 7.54 |
| 907 | East Branch Salmon Brook | immediately above small pond Woodhaven Riding Facility #160 rte 189 | Granby | 5.02 | 2.79 | 2.57 |
| 908 | Still Brook | Upstream Whispering Pine Lane | Stafford | 2.6 | 3.1 | 3.39 |
| 909 | North Running Brook | upstream dirt road farm rd below child hill farm property | Woodstock | 1.86 | 3.8 | 8.07 |
| 910 | Hollenbeck River | Adjacent to Rte 63 at SNET pole #856 | Canaan | 22.75 | 2.1 | 2.42 |
| 911 | Beach Brook | adjacent to bend Upstream 100 meters cabin off broad hill road | Granby | 1.19 | 1.63 | 1.89 |
| 913 | Wappaquia Brook | at old bridge off RTE 169 on Wappaquia Brook Farm | Pomfret | 3.63 | 4 | 7.35 |
| 915 | Bantam River | Upstream Confluence with West Branch Bantam River | Litchfield | 10.55 | 2.69 | 4.53 |
| 916 | Hockanum River | behind #440 Rte 83 (Odessey School) | Manchester | 49.12 | 9.86 | 27.42 |

| ID | Stream Name | Location | Municipality | Area (mi$^2$) | Percent IC | Enrichment Factor |
|---|---|---|---|---|---|---|
| 917 | Sawmill Brook | upstream Meadowbrook Lane | Mansfield | 3.49 | 2.97 | 3.73 |
| 920 | Cabin Brook | Upstream Cabin Road | Colchester | 1.48 | 10.74 | 4.45 |
| 921 | Crooked Brook | DS Rte 201 | Griswold | 1.65 | 2.52 | 1.87 |
| 922 | Pomperaug River | at Access Rd United Water Company behind Unitarian Church | Southbury | 64.09 | 3.86 | 6.08 |
| 923 | Mill River | at first pull-off DS Tuttle Road | Hamden | 22.02 | 8.87 | 3.56 |
| 924 | Clark Creek | Upstream RTE 82 Culvert | Haddam | 2.51 | 2.13 | 1.2 |
| 925 | Seth Williams Brook | Behind Apartment buildings 10-11 | Ledyard | 4.32 | 4.16 | 3.51 |
| 926 | Titicus River | behind track Ridgefield High School | Ridgefield | 5.08 | 10.72 | 3.16 |
| 927 | Fivemile Brook | 50 meters US mouth At old dam structure | Oxford | 1.9 | 4.89 | 3.03 |
| 928 | Farm River | Upstream of dirt farm road Schantz farm # 1775 Middletown Ave | North Branford | 3.6 | 7.86 | 5.31 |
| 930 | Eightmile River | 150 meters downstream Confluence with East branch eightmile R. (rte 156) | Lyme | 43.21 | 3.14 | 2.99 |
| 931 | West Branch Saugatuck River | at end of Whiporwill Lane | Weston | 1.73 | 4.36 | 2.5 |
| 932 | Farm River | at end of dirt rd off Gloria Place | East Haven | 19.3 | 9.65 | 5.63 |
| 933 | Wood Creek | upstream Paddy Hollow Road | Bethlehem | 2.53 | 3.32 | 4.31 |
| 1111 | Quinnipiac River | upstream Oak Street | Wallingford | 97.55 | 11.59 | 52.32 |
| 1475 | Broad Brook | end of Brookside Drive 500 feet DS Broad Brook Mill Pond | East Windsor | 13.59 | 4.94 | 8.99 |

Broad ranges of nutrient chemistry grab sample values were observed among the 78 sites (Figure 5, Table 3). The values in this study for Total Phosphorus, Total Nitrogen and Turbidity were generally in the same ranges as those observed in a 5-year statewide monitoring study conducted from 2006 – 2010 that included 963 samples collected under ambient conditions (CT DEEP, 2011) (Table 3).

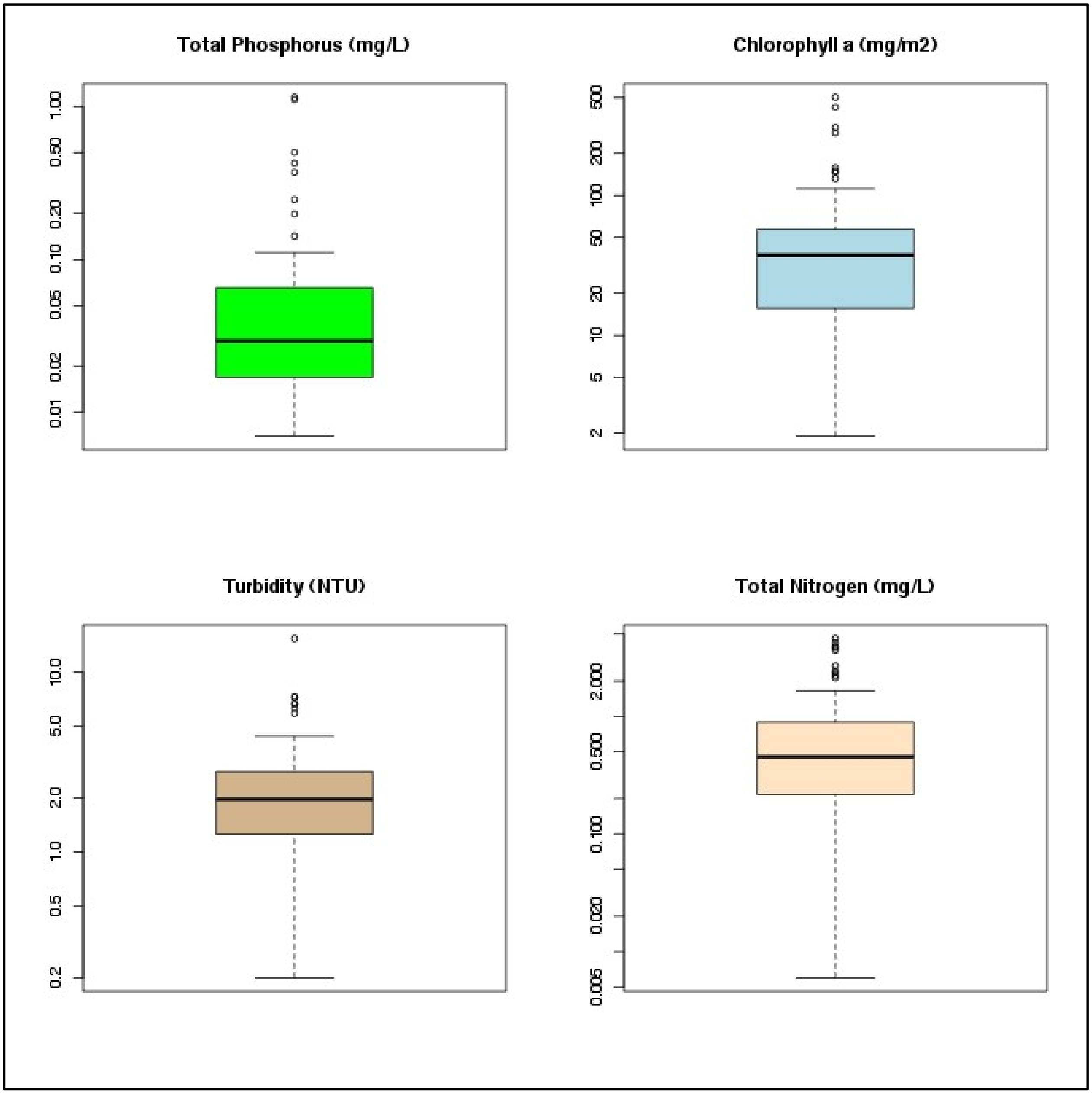


**Figure 5: Boxplots of water chemistry ranges observed in chemistry samples collected at the 78 study sites.**

**Table 3: The minimum (Min), median, mean and maximum (Max) values observed in this study (n = 78) from chemistry grab samples as compared to values observed in a state-wide study conducted from 2006 - 2010 (n = 963) (CT DEEP 2011). Note that chlorophyll a values were not available as part of the state-wide study.**

| | Study | Total Phosphorus (mg/L) | Total Nitrogen (mg/L) | Turbidity (NTU) | Chlorophyll *a* ($mg/m^2$) |
|---|---|---|---|---|---|
| Min | This Study (n = 78) | 0.007 | 0.006 | 0.2 | 1.903 |
| | Statewide (n = 963) | 0.002 | 0.008 | 0.1 | NA |
| Median | This Study (n = 78) | 0.029 | 0.454 | 1.967 | 37.38 |
| | Statewide (n = 963) | 0.021 | 0.571 | 1.3 | NA |
| Mean | This Study (n = 78) | 0.086 | 0.838 | 2.449 | 59.506 |
| | Statewide (n = 963) | 0.06 | 0.7986 | 2.27 | NA |
| Max | This Study (n = 78) | 1.15 | 4.585 | 15.4 | 504.096 |
| | Statewide (n = 963) | 1.558 | 6.93 | 29.2 | NA |

A total of 400 diatom species occurred at the sites. Two hundred fifty-seven occurred in less than 5% of the samples and were removed from the analysis. A total of 143 diatom species were used in the analysis (Table 5). Fifty species were categorized as "decreasers" in response to increasing phosphorus enrichment, while 93 species were categorized as "increasers" in response to increasing phosphorus enrichment. The diatom community change point for decreasers (sum z-) was 1.9 EF with a range from 1.9 to 4.3 for the $5^{th}$ and $95^{th}$ confidence intervals, respectively. The diatom community change point for increasers (sum z+) was 6.16 with a range from 4.5 to 8.4 for the $5^{th}$ and $95^{th}$ confidence intervals, respectively. Sixteen decreaser taxa and 41 increaser taxa out of 143 total taxa were identified as significant. The overall community change point using nCPA was 5.715 with a range of 2.8 to 6.4 for the $5^{th}$ and $95^{th}$ confidence intervals, respectively.

Frequency and abundance of decreaser species sharply declined between the 2 and 4 EF range, with a decline among all significant decreaser species around 6 EF, while increaser species became more prevalent between 6 EF and 8 EF, suggesting a community shift across the phosphorus gradient (Figure 6A & 6B). The upper limit representing a saturated threshold, beyond which major deviations from the natural condition have occurred in the structure of the biotic community, was defined as 8.4 EF.

**Table 4: Threshold Indicator Taxa Analysis (TITAN) community-level thresholds estimated from diatom species responses to phosphorus enrichment (EF). The observed change point (CP) corresponds to the value of the x resulting in the largest sum of indicator value (IndVal) z-scores among all negative (z-) and positive (z+) taxa, respectively. Percentages (5%, 50%, 95%) correspond to change points from 500 bootstrap replicates and represent uncertainty around the CP.**

| Method | CP | 5% | 50% | 95% |
|---|---|---|---|---|
| TITAN sum (z-) | 1.90 | 1.90 | 2.31 | 4.27 |
| TITAN sum (z+) | 6.16 | 4.49 | 5.89 | 8.44 |
| nCPA | 5.72 | 2.76 | 5.15 | 6.43 |

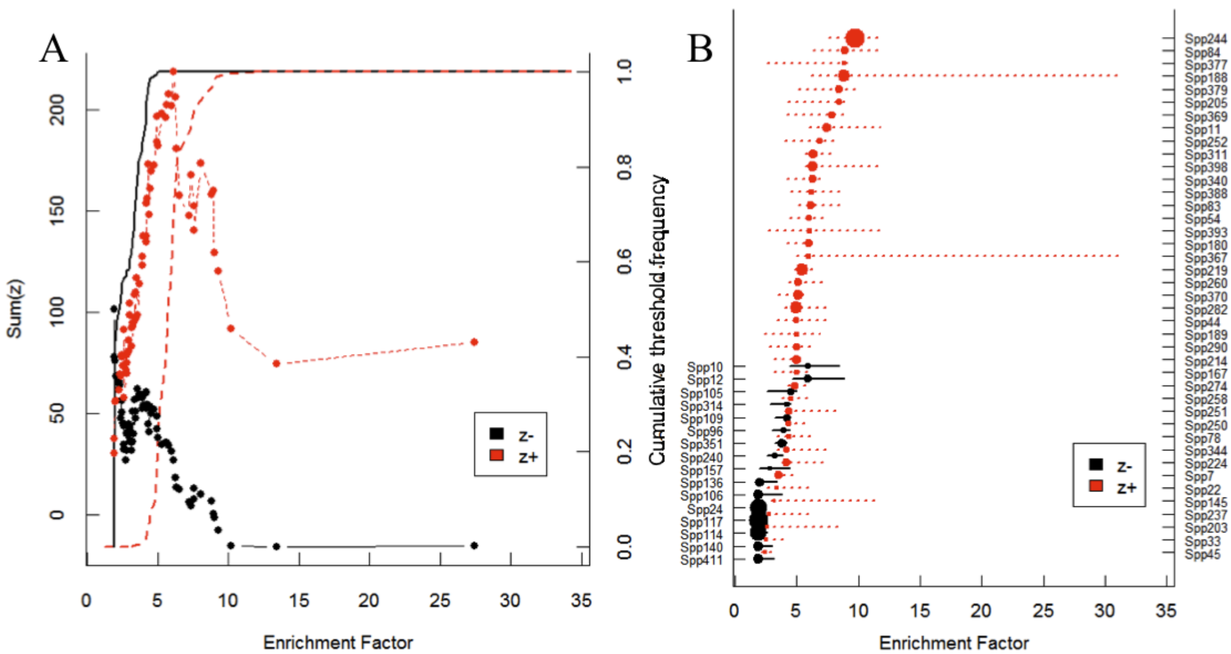


**Figure 6. Threshold Indicator Taxa ANalysis (TITAN) outputs. (A) sum (z) scores for decreasers (black circles) and increasers (red circles) across the phosphorus enrichment gradient. Vertical lines are cumulative frequency distributions of change points for negative (solid) and positive (dashed) indicator species across 500 replicate runs. (B) Significant species (purity ≥ 0.95, reliability ≥ 0.95, p < 0.05) in response to increasing (z+) or decreasing (z-) phosphorus enrichment. The circle size represents z-scores and horizontal lines overlapping each circle cover the 5th and 95th percentiles among 500 replicate runs.**

**Table 5: Threshold Indicator Taxa Analysis (TITAN) changes points of diatom species in response to phosphorus enrichment factor. The observed changes points (CP) corresponds to the value resulting in the largest indicator value (IndVal) z-scores for each taxon either as an increase (+) or decrease (-) to the phosphorus enrichment gradient. Percentiles (5%, 50%, 95%) correspond to change points from 500 bootstrap replicates. Purity is the mean proportion of correct response direction (z- or z+) assignments; reliability (Rel) is the mean proportion of P-values <0.05 among 500 bootstrap iterations.**

| ID | Species | ± | CP | 5% | 50% | 95% | IndVal | P-value | z-score | Purity | Rel |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spp10 | Achnanthidium caledonicum | z- | 5.89 | 3.525 | 5.89 | 8.955 | 70.11 | 0.004 | 4.99 | 0.982 | 0.982 |
| Spp101 | Eunotia diodon | z- | 1.9 | 1.9 | 1.9 | 4.065 | 49.39 | 0.004 | 8.75 | 0.974 | 0.898 |
| Spp104 | Eunotia flexuosa | z- | 4.485 | 1.945 | 3.93 | 12.231 | 20.7 | 0.024 | 2.32 | 0.906 | 0.82 |
| Spp105 | Eunotia formica | z- | 4.485 | 2.135 | 3.885 | 5.15 | 39.51 | 0.004 | 5.14 | 1 | 1 |
| Spp106 | Eunotia implicata | z- | 1.9 | 1.9 | 1.995 | 4.165 | 65.64 | 0.004 | 7.91 | 0.99 | 0.984 |
| Spp109 | Eunotia meisteri | z- | 4.18 | 3.09 | 4.165 | 4.64 | 35.71 | 0.004 | 5.25 | 1 | 1 |
| Spp114 | Eunotia paludosa | z- | 1.9 | 1.9 | 1.945 | 2.975 | 82.8 | 0.004 | 12.68 | 0.998 | 0.994 |
| Spp117 | Eunotia praerupta | z- | 1.9 | 1.9 | 1.945 | 2.435 | 99.85 | 0.004 | 14.97 | 1 | 0.996 |
| Spp12 | Achnanthidium exiguum | z- | 5.89 | 4.267 | 6.405 | 8.955 | 80.7 | 0.004 | 6.6 | 0.998 | 0.998 |
| Spp126 | Fragilaria capucina | z- | 2.385 | 1.9 | 2.485 | 7.815 | 29.91 | 0.164 | 1.02 | 0.612 | 0.404 |
| Spp136 | Fragilariforma virescens | z- | 1.945 | 1.9 | 1.995 | 4.065 | 56.42 | 0.004 | 6.95 | 0.988 | 0.96 |
| Spp138 | Frustulia crassinervia | z- | 4.18 | 2.435 | 3.635 | 4.64 | 16.67 | 0.012 | 3.05 | 0.988 | 0.842 |
| Spp139 | Frustulia erifuga | z- | 4.18 | 2.485 | 3.93 | 5.605 | 8.31 | 0.224 | 0.97 | 0.758 | 0.322 |
| Spp140 | Frustulia krammeri | z- | 1.9 | 1.9 | 1.995 | 3.80425 | 65.37 | 0.004 | 8.14 | 0.99 | 0.962 |
| Spp149 | Gomphonema acuminatum | z- | 3.385 | 2.60375 | 3.385 | 4.85025 | 12.01 | 0.02 | 2.51 | 0.94 | 0.644 |
| Spp152 | Gomphonema angustatum | z- | 4.21 | 2.775 | 3.93 | 5.89 | 23.65 | 0.016 | 2.79 | 0.794 | 0.73 |
| Spp153 | Gomphonema angustum | z- | 6.28 | 1.945 | 3.365 | 5.72375 | 8.47 | 0.28 | 0.57 | 0.558 | 0.254 |
| Spp157 | Gomphonema clavatum | z- | 2.805 | 1.945 | 2.805 | 4.95175 | 21.85 | 0.008 | 3.3 | 0.992 | 0.904 |
| Spp162 | Gomphonema gracile | z- | 4.485 | 2.385 | 4.165 | 7.435 | 9.68 | 0.292 | 0.58 | 0.696 | 0.32 |
| Spp171 | Gomphonema pumilum | z- | 8.435 | 1.945 | 4.41 | 8.435 | 25.76 | 0.048 | 1.51 | 0.618 | 0.342 |
| Spp174 | Gomphonema sphaerophorum | z- | 3.185 | 1.995 | 3.09 | 5.44 | 16.53 | 0.012 | 3.3 | 0.906 | 0.73 |
| Spp176 | Gomphonema truncatum | z- | 1.9 | 1.9 | 1.945 | 4.6655 | 31.54 | 0.012 | 2.77 | 0.822 | 0.628 |
| Spp182 | Karayevia clevei | z- | 4.18 | 2.605 | 3.93 | 7.435 | 18.25 | 0.092 | 1.47 | 0.858 | 0.608 |
| Spp183 | Karayevia laterostrata | z- | 7.265 | 1.9 | 4.34 | 7.265 | 12.9 | 0.252 | 1.03 | 0.592 | 0.172 |
| Spp190 | Meridion circulare | z- | 3.385 | 1.945 | 3.635 | 8.435 | 30.36 | 0.108 | 1.33 | 0.616 | 0.428 |
| Spp193 | Navicula angusta | z- | 1.9 | 1.9 | 1.9 | 6.16 | 45.95 | 0.008 | 4.96 | 0.862 | 0.716 |
| Spp210 | Navicula erifuga | z- | 3.41 | 2.385 | 3.9075 | 9.8335 | 10.17 | 0.24 | 0.68 | 0.506 | 0.34 |
| Spp226 | Navicula notha | z- | 4.845 | 2.135 | 4.27 | 5.605 | 24.08 | 0.02 | 2.96 | 0.976 | 0.884 |
| Spp23 | Amphora pediculus | z- | 4.27 | 2.435 | 3.265 | 6.84 | 8.45 | 0.288 | 0.72 | 0.79 | 0.412 |
| Spp233 | Navicula radiosa | z- | 2.68 | 2.52775 | 3.385 | 6.16 | 8.08 | 0.356 | 0.22 | 0.564 | 0.254 |
| Spp24 | Amphora veneta | z- | 1.9 | 1.9 | 1.945 | 2.485 | 83.1 | 0.004 | 13.43 | 0.998 | 0.988 |
| Spp240 | Navicula schmassmanni | z- | 3.265 | 2.48375 | 3.265 | 4.07 | 26.53 | 0.008 | 4.87 | 1 | 0.99 |
| Spp249 | Navicula tenelloides | z- | 2.815 | 2.435 | 3.635 | 7.815 | 13.32 | 0.2 | 0.91 | 0.596 | 0.368 |

| ID | Species | ± | CP | 5% | 50% | 95% | IndVal | P-value | z-score | Purity | Rel |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spp28 | Aulacoseira alpigena | z- | 4.18 | 2.485 | 3.8 | 4.485 | 11.9 | 0.048 | 2.57 | 0.98 | 0.67 |
| Spp293 | Nitzschia palustris | z- | 3.465 | 2.805 | 3.93 | 7.435 | 8.3 | 0.292 | 0.43 | 0.692 | 0.36 |
| Spp300 | Nitzschia recta | z- | 8.87 | 2.485 | 3.8 | 7.265 | 16.42 | 0.156 | 0.71 | 0.49 | 0.17 |
| Spp314 | Nupela lapidosa | z- | 4.21 | 2.53 | 4.165 | 4.845 | 32.23 | 0.008 | 4.15 | 1 | 0.978 |
| Spp351 | Planothidium stewartii | z- | 3.8 | 2.975 | 3.635 | 4.21 | 48.38 | 0.004 | 6.72 | 1 | 1 |
| Spp356 | Psammothidium bioretii | z- | 4.845 | 2.68 | 3.495 | 8.955 | 10.47 | 0.124 | 0.78 | 0.684 | 0.348 |
| Spp361 | Psammothidium marginulatum | z- | 1.9 | 1.9 | 1.945 | 4.21 | 32.88 | 0.016 | 6.15 | 0.968 | 0.76 |
| Spp364 | Psammothidium subatomoides | z- | 4.27 | 3.18375 | 4.165 | 5.72375 | 42.52 | 0.008 | 3.81 | 0.934 | 0.9 |
| Spp378 | Sellaphora rectangularis | z- | 1.9 | 1.9 | 2.435 | 6.84 | 22.86 | 0.056 | 3.07 | 0.812 | 0.58 |
| Spp380 | Stauroforma exiguiformis | z- | 3.885 | 2.605 | 4.165 | 20.42 | 15.36 | 0.16 | 0.86 | 0.576 | 0.344 |
| Spp382 | Stauroneis kriegeri | z- | 4.21 | 2.48375 | 4.065 | 6.28 | 14.11 | 0.076 | 1.69 | 0.872 | 0.524 |
| Spp411 | Tabellaria flocculosa | z- | 1.9 | 1.9 | 1.995 | 3.41 | 92.69 | 0.004 | 8.04 | 1 | 1 |
| Spp6 | Achnanthes oblongella | z- | 3.385 | 2.805 | 3.41 | 4.985 | 12.03 | 0.044 | 1.74 | 0.95 | 0.614 |
| Spp63 | Cymbella ehrenbergii | z- | 1.9 | 1.9 | 3.385 | 4.985 | 26.67 | 0.072 | 2.58 | 0.99 | 0.762 |
| Spp74 | Diadesmis confervacea | z- | 2.68 | 1.9 | 3.1725 | 31.275 | 13.44 | 0.112 | 1.07 | 0.622 | 0.364 |
| Spp96 | Epithemia turgida | z- | 3.93 | 2.875 | 3.8 | 4.845 | 39.16 | 0.004 | 4.91 | 0.984 | 0.976 |
| Spp97 | Eucocconeis laevis | z- | 1.9 | 1.9 | 2.305 | 5.15 | 56.97 | 0.004 | 6.22 | 0.942 | 0.888 |
| Spp11 | Achnanthidium deflexum | z+ | 7.435 | 5.715 | 7.815 | 20.42 | 64.64 | 0.004 | 7.65 | 1 | 0.998 |
| Spp13 | Achnanthidium minutissimum | z+ | 31.275 | 2.4325 | 8.955 | 31.275 | 41.1 | 0.032 | 2.35 | 0.86 | 0.666 |
| Spp132 | Fragilaria sepes | z+ | 3.01 | 3.01 | 3.885 | 31.275 | 11.32 | 0.044 | 1.52 | 0.456 | 0.276 |
| Spp134 | Fragilaria vaucheriae | z+ | 1.995 | 1.9 | 2.53 | 8.45675 | 58.25 | 0.048 | 2.16 | 0.88 | 0.78 |
| Spp137 | Frustulia amphipleuroides | z+ | 3.16 | 2.605 | 3.525 | 7.44075 | 19.62 | 0.024 | 2.04 | 0.956 | 0.764 |
| Spp143 | Frustulia vulgaris | z+ | 2.135 | 2.385 | 3.635 | 7.815 | 27.54 | 0.14 | 1.13 | 0.356 | 0.146 |
| Spp144 | Geissleria acceptata | z+ | 2.945 | 3.09 | 4.485 | 6.16 | 9.09 | 0.104 | 0.9 | 0.79 | 0.33 |
| Spp145 | Geissleria decussis | z+ | 3.16 | 2.605 | 3.385 | 20.42 | 32.31 | 0.016 | 3.04 | 0.986 | 0.916 |
| Spp164 | Gomphonema kobayasii | z+ | 5.44 | 2.435 | 5.605 | 20.42 | 30.84 | 0.02 | 2.76 | 0.84 | 0.726 |
| Spp166 | Gomphonema micropus | z+ | 8.87 | 1.9 | 3.465 | 9.73 | 12.53 | 0.104 | 1.56 | 0.45 | 0.31 |
| Spp167 | Gomphonema minutum | z+ | 4.95 | 2.975 | 4.485 | 11.8 | 46.17 | 0.004 | 4.37 | 0.998 | 0.994 |
| Spp168 | Gomphonema olivaceoides | z+ | 2.945 | 3.09 | 6.16 | 31.275 | 9.09 | 0.22 | 0.88 | 0.73 | 0.402 |
| Spp170 | Gomphonema parvulum | z+ | 9.135 | 1.945 | 4.115 | 11.8 | 64.09 | 0.04 | 2.06 | 0.968 | 0.838 |
| Spp18 | Amphipleura pellucida | z+ | 6.03 | 2.8035 | 5.44 | 7.435 | 26.62 | 0.02 | 3.07 | 0.94 | 0.82 |
| Spp180 | Hippodonta capitata | z+ | 6.03 | 3.345 | 5.15 | 7.435 | 54.66 | 0.004 | 6.62 | 1 | 0.996 |
| Spp188 | Mayamaea atomus | z+ | 8.87 | 5.14175 | 8.955 | 31.275 | 61.61 | 0.004 | 10.09 | 1 | 1 |
| Spp189 | Melosira varians | z+ | 4.985 | 2.305 | 4.485 | 7.815 | 53.21 | 0.004 | 4.1 | 0.996 | 0.99 |
| Spp197 | Navicula canalis | z+ | 6.84 | 3.265 | 6.84 | 31.275 | 17.14 | 0.008 | 3.41 | 0.93 | 0.75 |
| Spp198 | Navicula capitatoradiata | z+ | 4.34 | 2.815 | 4.64 | 6.28 | 21.3 | 0.02 | 2.89 | 0.902 | 0.728 |
| Spp203 | Navicula cryptocephala | z+ | 2.605 | 2.46 | 2.815 | 9.8335 | 50.73 | 0.012 | 3.45 | 0.99 | 0.962 |

| ID | Species | ± | CP | 5% | 50% | 95% | IndVal | P-value | z-score | Purity | Rel |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spp204 | Navicula cryptotenella | z+ | 1.9 | 1.9 | 2.435 | 7.485 | 77.45 | 0.004 | 3.22 | 0.89 | 0.824 |
| Spp205 | Navicula cryptotenelloides | z+ | 8.435 | 4.16 | 6.405 | 11.8 | 29.5 | 0.008 | 5.44 | 1 | 0.97 |
| Spp214 | Navicula gregaria | z+ | 4.95 | 2.975 | 4.64 | 5.89 | 76.39 | 0.004 | 8.25 | 1 | 1 |
| Spp219 | Navicula lanceolata | z+ | 5.44 | 4.41 | 5.715 | 7.265 | 71.23 | 0.004 | 10.31 | 1 | 1 |
| Spp22 | Amphora montana | z+ | 3.385 | 2.485 | 3.93 | 6.405 | 49.46 | 0.004 | 3.63 | 1 | 0.99 |
| Spp222 | Navicula menisculus | z+ | 3.385 | 2.605 | 4.27 | 20.42 | 20.27 | 0.016 | 2.43 | 0.972 | 0.818 |
| Spp224 | Navicula minima | z+ | 4.165 | 3.525 | 4.9675 | 7.815 | 68.86 | 0.004 | 6.63 | 1 | 1 |
| Spp227 | Navicula peregrina | z+ | 6.28 | 2.975 | 6.16 | 20.96275 | 13.6 | 0.064 | 2.28 | 0.814 | 0.544 |
| Spp229 | Navicula perminuta | z+ | 2.385 | 2.435 | 4.065 | 6.86125 | 10.45 | 0.456 | 0.33 | 0.558 | 0.234 |
| Spp231 | Navicula praeterita | z+ | 2.58 | 2.605 | 4.065 | 7.846 | 9.68 | 0.372 | 0.62 | 0.58 | 0.3 |
| Spp237 | Navicula rhynchocephala | z+ | 2.775 | 2.485 | 2.815 | 6.405 | 35.59 | 0.008 | 3.14 | 0.978 | 0.954 |
| Spp238 | Navicula rostellata | z+ | 6.16 | 2.775 | 5.44 | 7.846 | 36.19 | 0.004 | 3.23 | 0.974 | 0.898 |
| Spp242 | Navicula schroeterii | z+ | 7.435 | 4.6215 | 7.815 | 11.8 | 24.71 | 0.004 | 5.59 | 0.95 | 0.87 |
| Spp244 | Navicula subminuscula | z+ | 9.73 | 7.435 | 8.955 | 20.42 | 87.25 | 0.004 | 16.79 | 1 | 1 |
| Spp250 | Navicula tripunctata | z+ | 4.34 | 3.885 | 4.64 | 6.28 | 27.7 | 0.004 | 5.2 | 0.996 | 0.97 |
| Spp251 | Navicula trivialis | z+ | 4.34 | 4.05825 | 4.95 | 11.8 | 29.37 | 0.004 | 5.72 | 0.998 | 0.99 |
| Spp252 | Navicula veneta | z+ | 6.84 | 3.8 | 6.28 | 9.135 | 27.38 | 0.008 | 5.27 | 1 | 0.952 |
| Spp258 | Nitzschia acidoclinata | z+ | 4.485 | 3.385 | 4.845 | 6.42675 | 27.15 | 0.004 | 4.68 | 0.996 | 0.968 |
| Spp26 | Astartiella bahusiensis | z+ | 8.955 | 3.185 | 7.815 | 20.42 | 28.23 | 0.012 | 5.05 | 0.962 | 0.8 |
| Spp260 | Nitzschia amphibia | z+ | 5.15 | 4.17925 | 5.44 | 8.87 | 69.64 | 0.004 | 7.16 | 1 | 1 |
| Spp268 | Nitzschia capitellata | z+ | 2.875 | 2.875 | 3.885 | 31.275 | 10.71 | 0.144 | 0.85 | 0.776 | 0.348 |
| Spp270 | Nitzschia dissipata | z+ | 2.385 | 1.995 | 2.875 | 7.55 | 43.8 | 0.064 | 1.67 | 0.814 | 0.686 |
| Spp274 | Nitzschia fonticola | z+ | 4.845 | 4.18 | 4.95 | 7.2735 | 52.34 | 0.004 | 5.81 | 1 | 0.998 |
| Spp276 | Nitzschia frustulum | z+ | 2.605 | 2.67625 | 4.115 | 31.275 | 18.03 | 0.076 | 1.43 | 0.88 | 0.624 |
| Spp279 | Nitzschia heufleriana | z+ | 3.09 | 2.815 | 3.8 | 11.8 | 13.46 | 0.096 | 1.51 | 0.92 | 0.576 |
| Spp282 | Nitzschia inconspicua | z+ | 4.985 | 3.885 | 4.95 | 8.435 | 75.21 | 0.004 | 10.4 | 1 | 1 |
| Spp285 | Nitzschia liebethruthii | z+ | 8.955 | 2.875 | 8.87 | 31.275 | 25.43 | 0.024 | 4.32 | 0.844 | 0.696 |
| Spp286 | Nitzschia linearis | z+ | 2.775 | 2.875 | 4.18 | 6.03 | 11.86 | 0.08 | 1.14 | 0.556 | 0.298 |
| Spp29 | Aulacoseira ambigua | z+ | 8.435 | 3.265 | 6.405 | 11.8 | 27.14 | 0.04 | 2.67 | 0.96 | 0.874 |
| Spp290 | Nitzschia palea | z+ | 4.95 | 2.485 | 4.41 | 7.815 | 70.3 | 0.004 | 5.83 | 1 | 1 |
| Spp303 | Nitzschia sigmoidea | z+ | 31.275 | 2.77025 | 9.73 | 31.275 | 35.83 | 0.024 | 3.44 | 0.786 | 0.596 |
| Spp305 | Nitzschia sociabilis | z+ | 6.16 | 2.775 | 4.41 | 20.42 | 18.81 | 0.02 | 2.42 | 0.886 | 0.702 |
| Spp309 | Nitzschia supralitorea | z+ | 3.635 | 3.09 | 4.64 | 8.955 | 25.43 | 0.04 | 2.32 | 0.914 | 0.798 |
| Spp311 | Nitzschia tubicola | z+ | 6.28 | 5.605 | 6.405 | 8.435 | 26.32 | 0.004 | 7.56 | 0.996 | 0.96 |
| Spp315 | Opephora olsenii | z+ | 8.955 | 2.945 | 8.435 | 31.275 | 23.86 | 0.028 | 3.59 | 0.878 | 0.704 |
| Spp317 | Parlibellus protracta | z+ | 7.55 | 3.8725 | 7.55 | 20.42 | 26.63 | 0.008 | 5.11 | 0.972 | 0.868 |
| Spp328 | Pinnularia subcapitata | z+ | 3.385 | 3.16 | 3.9075 | 7.56325 | 10.87 | 0.084 | 2.01 | 0.94 | 0.512 |

| ID | Species | ± | CP | 5% | 50% | 95% | IndVal | P-value | z-score | Purity | Rel |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spp33 | Brachysira vitrea | z+ | 2.53 | 2.435 | 2.805 | 5.44 | 39.68 | 0.012 | 3.07 | 0.986 | 0.956 |
| Spp338 | Planothidium delicatulum | z+ | 6.03 | 3.885 | 6.16 | 31.275 | 22.43 | 0.008 | 4.42 | 0.966 | 0.864 |
| Spp339 | Planothidium dubium | z+ | 8.435 | 2.67625 | 7.6825 | 31.275 | 23.81 | 0.072 | 1.66 | 0.738 | 0.62 |
| Spp340 | Planothidium frequentissimum | z+ | 6.28 | 3.88075 | 5.605 | 7.56325 | 65.97 | 0.004 | 6.84 | 1 | 1 |
| Spp341 | Planothidium granum | z+ | 6.84 | 4.267 | 7.265 | 8.955 | 22.87 | 0.004 | 6.11 | 0.982 | 0.866 |
| Spp342 | Planothidium hauckianum | z+ | 4.34 | 3.01 | 5.0675 | 31.275 | 14.1 | 0.016 | 2.68 | 0.922 | 0.73 |
| Spp344 | Planothidium lanceolatum | z+ | 4.18 | 2.68 | 5.15 | 8.435 | 56.2 | 0.004 | 5.58 | 1 | 0.998 |
| Spp350 | Planothidium rostratum | z+ | 6.03 | 2.435 | 5.715 | 9.135 | 30.75 | 0.032 | 2.48 | 0.92 | 0.726 |
| Spp354 | Platessa hustedtii | z+ | 31.275 | 1.995 | 4.845 | 31.275 | 19.73 | 0.116 | 2.19 | 0.574 | 0.296 |
| Spp365 | Psammothidium ventralis | z+ | 11.8 | 1.9925 | 3.525 | 31.275 | 14.63 | 0.18 | 0.29 | 0.54 | 0.314 |
| Spp366 | Pseudostaurosira brevistriata | z+ | 2.945 | 2.875 | 3.635 | 31.275 | 12.73 | 0.128 | 1.66 | 0.868 | 0.49 |
| Spp367 | Pseudostaurosira parasitica | z+ | 5.89 | 4.27 | 6.405 | 31.275 | 23.98 | 0.008 | 4.55 | 0.972 | 0.918 |
| Spp368 | Pseudostaurosira subsalina | z+ | 8.955 | 3.185 | 7.55 | 20.42 | 26.79 | 0.012 | 4.18 | 0.902 | 0.768 |
| Spp369 | Reimeria sinuata | z+ | 7.815 | 3.88075 | 7.265 | 9.135 | 89.83 | 0.004 | 5.87 | 1 | 1 |
| Spp370 | Rhoicosphenia abbreviata | z+ | 5.15 | 3.345 | 4.34 | 5.715 | 78.29 | 0.004 | 8.89 | 1 | 1 |
| Spp377 | Sellaphora pupula | z+ | 8.87 | 2.46 | 6.405 | 9.73 | 52.41 | 0.016 | 3.63 | 0.988 | 0.978 |
| Spp379 | Sellaphora seminulum | z+ | 8.435 | 4.985 | 7.265 | 20.42 | 83.29 | 0.004 | 7.09 | 1 | 1 |
| Spp388 | Staurosira construens | z+ | 6.16 | 2.605 | 6.405 | 8.955 | 57.01 | 0.004 | 4.07 | 0.976 | 0.954 |
| Spp391 | Staurosirella leptostauron | z+ | 8.955 | 2.435 | 7.815 | 31.275 | 19.81 | 0.064 | 1.97 | 0.742 | 0.524 |
| Spp393 | Staurosirella pinnata | z+ | 6.03 | 2.46 | 6.28 | 20.42 | 50.82 | 0.004 | 4.15 | 0.974 | 0.942 |
| Spp396 | Surirella amphioxys | z+ | 9.73 | 1.995 | 7.55 | 20.96275 | 20.35 | 0.084 | 1.85 | 0.616 | 0.424 |
| Spp398 | Surirella brebissonii | z+ | 6.28 | 5.44 | 7.265 | 20.42 | 31.58 | 0.004 | 8.85 | 0.996 | 0.982 |
| Spp404 | Synedra acus | z+ | 2.815 | 2.945 | 4.165 | 9.73 | 8.77 | 0.3 | 0.75 | 0.612 | 0.178 |
| Spp407 | Synedra rumpens | z+ | 9.135 | 1.945 | 3.41 | 11.8 | 45.65 | 0.236 | 0.56 | 0.444 | 0.26 |
| Spp409 | Synedra ulna | z+ | 1.945 | 1.9 | 2.46 | 11.8 | 63.38 | 0.02 | 2.69 | 0.932 | 0.866 |
| Spp44 | Cocconeis neothumensis | z+ | 4.985 | 3.21 | 4.985 | 8.955 | 36.81 | 0.004 | 5.66 | 1 | 0.998 |
| Spp45 | Cocconeis pediculus | z+ | 2.485 | 1.995 | 2.5075 | 3.525 | 77.15 | 0.004 | 3.5 | 0.958 | 0.908 |
| Spp52 | Cyclostephanos tholiformis | z+ | 9.135 | 2.305 | 6.16 | 31.275 | 17.46 | 0.072 | 1.41 | 0.586 | 0.38 |
| Spp54 | Cyclotella distinguenda | z+ | 6.03 | 3.18375 | 5.715 | 7.55 | 56.67 | 0.004 | 5.33 | 0.998 | 0.992 |
| Spp68 | Cymbella naviculiformis | z+ | 1.995 | 2.135 | 4.115 | 9.135 | 24.29 | 0.252 | 0.92 | 0.694 | 0.41 |
| Spp7 | Achnanthes pseudoswazi | z+ | 3.525 | 3.185 | 3.93 | 4.985 | 75.92 | 0.004 | 6.88 | 1 | 1 |
| Spp78 | Diatoma tenuis | z+ | 4.34 | 3.16 | 4.845 | 6.405 | 37.02 | 0.004 | 4.5 | 0.998 | 0.99 |
| Spp83 | Diploneis parma | z+ | 6.16 | 4.64 | 6.28 | 9.73 | 39.32 | 0.004 | 6.83 | 0.996 | 0.99 |
| Spp84 | Discostella pseudostelligera | z+ | 8.955 | 5.605 | 8.435 | 20.42 | 52.63 | 0.004 | 7.41 | 0.998 | 0.984 |
| Spp86 | Encyonema brehmii | z+ | 9.135 | 2.385 | 7.265 | 20.42 | 53.96 | 0.04 | 2.27 | 0.682 | 0.586 |
| Spp91 | Encyonema prostratum | z+ | 31.275 | 2.45875 | 6.22 | 31.275 | 58.81 | 0.02 | 2.86 | 0.978 | 0.896 |

**Application: Reductions in CT Waste-Receiving Streams**

Forty-five NPDES facilities were identified as discharging phosphorus to non-tidal freshwaters in CT. Forty-three are WPCFs and two are industrial plant discharges. The 45 facilities discharge to 20 rivers and streams across the state (Figure 7). The drainage basin size below the facilities ranged from 0.67 square miles below the Ridgefield Main WPCF in Ridgefield Brook to 1080.85 square miles below the New Milford WPCF in the Housatonic River.

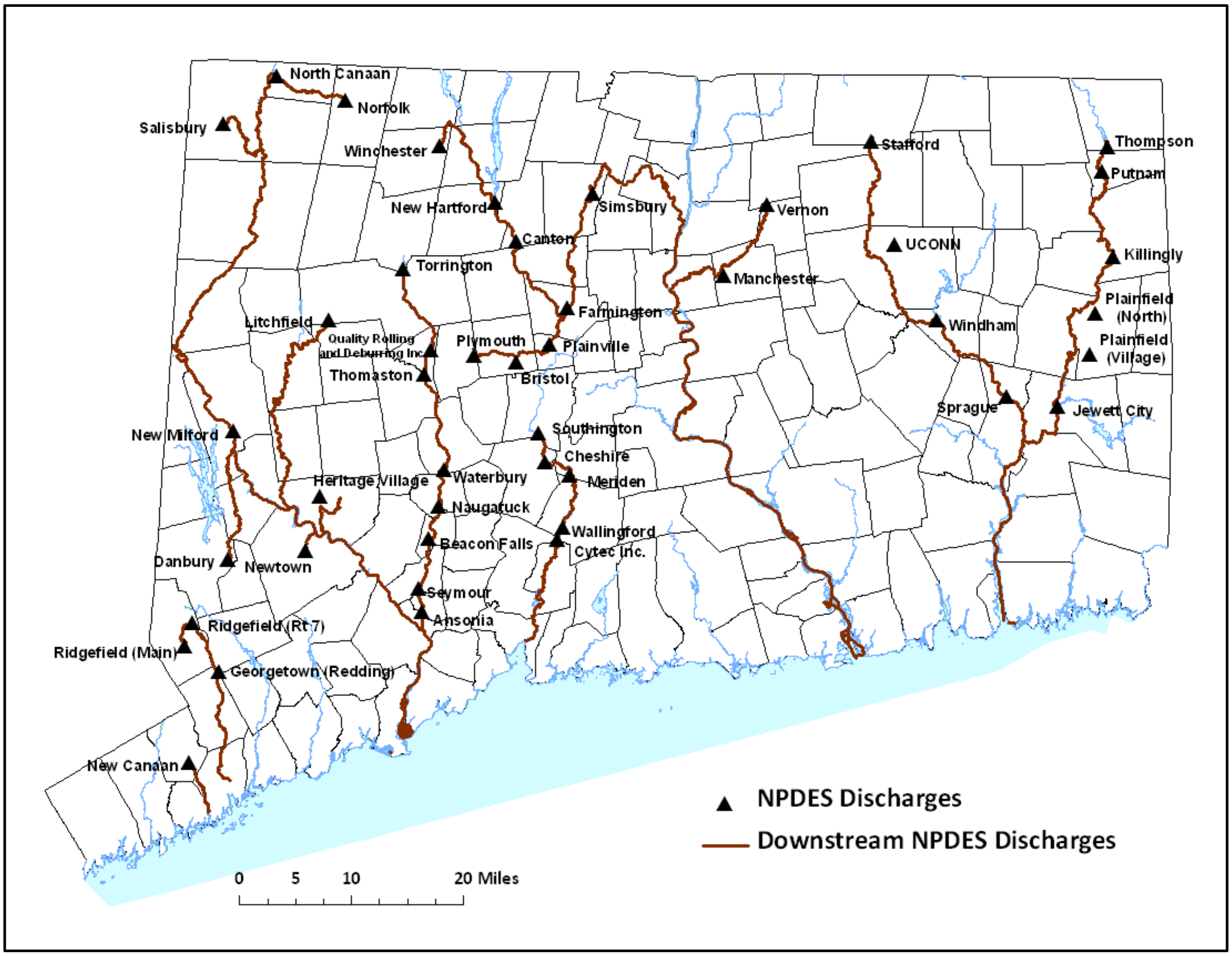


**Figure 7: Locations of the 45 NPDES facilities and waste receiving streams included in the analysis**

**Table 6: Comparison of observed phosphorus yields in the Trench et al. (2011) study compared to this analysis at available USGS gaging stations with watersheds primarily within CT.**

| USGS Station | Drainage Area (SqMi) | Years of Record | Min (Lbs/SqMi) | Mean (Lbs/SqMi) | Median (Lbs/SqMi) | Max (Lbs/SqMi) | This Study |
|---|---|---|---|---|---|---|---|
| SHETUCKET RIVER AT SOUTH WINDHAM, Conn. | 408 | 11 | 68 | 110 | 110 | 150 | 126 |
| HOCKANUM RIVER NEAR EAST HARTFORD, Conn. | 73.4 | 11 | 730 | 1000 | 1000 | 1200 | 1003 |
| QUINNIPIAC RIVER AT WALLINGFORD, Conn. | 115 | 11 | 550 | 1000 | 1100 | 1500 | 1121 |
| NAUGATUCK RIVER AT BEACON FALLS, Conn. | 260 | 11 | 720 | 1200 | 1300 | 1600 | 1195 |
| NORWALK RIVER AT WINNIPAUK, Conn. | 33 | 11 | 64 | 130 | 120 | 220 | 158 |

Phosphorus loadings and EFs were estimated using land cover export coefficients and NPDES facilities data as described above at multiple points in waste receiving streams. The estimated phosphorus yields in waste-receiving streams in this study fell within the range of estimated phosphorus yields in a recent USGS study (Trench et al., 2011) using 11 years of data at available USGS gage stations (Table 6). The estimated yields generally approximated the mean and median yields observed in the study. The EFs in the 20 waste receiving streams ranged from 3.3 below the New Hartford WPCF in the Farmington River to 138 below the Ridgefield WPCF in Ridgefield Brook. The Naugatuck River had the largest estimated phosphorus load of 955.01 lbs/day below the Ansonia WPCF discharge where an estimated 92.16 % of the in-stream load is attributed to NPDES discharges (Table 7).

**Table 7: Estimated In-Stream Phosphorus Load (lbs/day) and EF at the discharge point of each NPDES facility and the estimated percent contribution of sources to that load.**

| NPDES | Watershed | Estimated In-Stream Phosphorus Load (lbs/day) at Discharge Point | EF | Estimated Percent Contribution to Phosphorus Load at Discharge Point | | | |
|---|---|---|---|---|---|---|---|
| | | | | % NPDES | % Forest | % Urban | % Ag |
| LITCHFIELD WPCF | Bantam River Watershed | 27.11 | 9.5 | 48.21 | 7.22 | 5.27 | 39.3 |
| NORFOLK SEWER DISTRICT | Blackberry River Watershed | 5.8 | 7.2 | 59.8 | 11.23 | 5.87 | 23.09 |
| NORTH CANAAN WPCF | Blackberry River Watershed | 19.1 | 6.3 | 40.32 | 12.29 | 6.09 | 41.3 |
| SALISBURY WPCF | Factory Brook Watershed | 8.97 | 19.8 | 79.63 | 3.62 | 2.94 | 13.81 |
| WINSTED WPCF | Farmington River Watershed | 26.74 | 9.4 | 74.92 | 8.6 | 6.46 | 10.02 |
| NEW HARTFORD WPCF | Farmington River Watershed | 67.34 | 3.3 | 45.96 | 27.14 | 9.18 | 17.72 |
| CANTON WPCF | Farmington River Watershed | 103.53 | 4.3 | 53.85 | 20.56 | 7.75 | 17.85 |
| FARMINGTON WPCF | Farmington River Watershed | 543.55 | 18.3 | 87.4 | 4.53 | 3 | 5.06 |
| SIMSBURY WPCF | Farmington River Watershed | 642.03 | 19.5 | 87.39 | 4.13 | 3.16 | 5.31 |
| NEW CANAAN WPCF | Fivemile River Watershed | 11.72 | 35.5 | 89.2 | 0.96 | 7.14 | 2.7 |
| VERNON WPCF | Hockanum River Watershed | 82.19 | 46.5 | 87.83 | 1.19 | 2.02 | 8.95 |
| MANCHESTER WATER & SEWER | Hockanum River Watershed | 205.54 | 42.4 | 88.83 | 1.08 | 3.98 | 6.1 |
| New Milford WPCF | Housatonic River Main Stem Watershed | 381.28 | 5.3 | 20.84 | 14.2 | 6.68 | 58.29 |
| DANBURY WPCF | Limekiln Brook Watershed | 82.21 | 89.8 | 95.5 | 0.6 | 1.62 | 2.28 |
| TORRINGTON WPCF | Naugatuck River Watershed | 76.24 | 21 | 84.9 | 3.57 | 3.14 | 8.39 |
| QUALITY ROLLING AND DEBURRING INC. | Naugatuck River Watershed | 87.87 | 13.1 | 74.28 | 5.67 | 4.96 | 15.09 |
| THOMASTON WPCF | Naugatuck River Watershed | 113.31 | 15.5 | 77.62 | 4.71 | 4.29 | 13.39 |
| WATERBURY WPCF | Naugatuck River Watershed | 679.21 | 49 | 92.44 | 1.33 | 2.07 | 4.16 |
| NAUGATUCK WPCF | Naugatuck River Watershed | 849.15 | 52.2 | 92.78 | 1.22 | 2.04 | 3.96 |
| BEACON FALLS WPCF | Naugatuck River Watershed | 860.29 | 48.7 | 92.5 | 1.32 | 2.17 | 4.01 |
| SEYMOUR WPCF | Naugatuck River Watershed | 909.68 | 45.4 | 91.99 | 1.43 | 2.32 | 4.27 |
| ANSONIA WPCF | Naugatuck River Watershed | 955 | 46.2 | 92.16 | 1.39 | 2.31 | 4.13 |
| RIDGEFIELD MAIN WPCF C/O OMI | Norwalk River Watershed | 6.14 | 137.9 | 97.63 | 0.41 | 1.13 | 0.82 |
| RIDGEFIELD RTE 7 C/O OMI | Norwalk River Watershed | 6.83 | 24.2 | 87.65 | 2.23 | 7.34 | 2.77 |
| REDDING WPCF | Norwalk River Watershed | 9.73 | 9.9 | 72.66 | 6.62 | 12.93 | 7.79 |
| PLYMOUTH WPCF | Pequabuck River Watershed | 32.06 | 30.9 | 89.33 | 2.26 | 2.85 | 5.56 |

| NPDES | Watershed | Estimated In-Stream Phosphorus Load (lbs/day) at Discharge Point | EF | Estimated Percent Contribution to Phosphorus Load at Discharge Point | | | |
|---|---|---|---|---|---|---|---|
| | | | | % NPDES | % Forest | % Urban | % Ag |
| BRISTOL WPCF | Pequabuck River Watershed | 229.04 | 75.4 | 95.17 | 0.74 | 1.97 | 2.12 |
| PLAINVILLE WPCF | Pequabuck River Watershed | 312.44 | 95.5 | 96.12 | 0.56 | 1.65 | 1.66 |
| SOUTHBURY HERITAGE VILLAGE WPCF | Pomperaug River Watershed | 39.39 | 7.8 | 27.74 | 8.06 | 7.12 | 57.08 |
| NEWTOWN WPCF | Pootatuck River Watershed | 10.87 | 7.33 | 36.87 | 8.25 | 13.38 | 41.5 |
| THOMPSON WPCF | Quinebaug River Watershed | 43.4 | 5.8 | 40.9 | 11.88 | 14.94 | 32.27 |
| PUTNAM WPCF | Quinebaug River Watershed | 123.59 | 5.7 | 36.75 | 12.7 | 11.37 | 39.18 |
| KILLINGLY WPCF | Quinebaug River Watershed | 197.19 | 6.5 | 43.64 | 11.29 | 9.47 | 35.59 |
| PLAINFIELD NORTH WPCF | Quinebaug River Watershed | 237.29 | 6.4 | 43.77 | 11.21 | 9.34 | 35.69 |
| PLAINFIELD WPCF | Quinebaug River Watershed | 266.99 | 6.4 | 42.82 | 11.17 | 9.12 | 36.89 |
| GRISWOLD WPCA | Quinebaug River Watershed | 292.29 | 6.2 | 41.01 | 11.65 | 9.26 | 38.09 |
| SOUTHINGTON WPCF | Quinnipiac River Watershed | 114.6 | 30.8 | 87.26 | 1.66 | 5.51 | 5.57 |
| CHESHIRE WPCF | Quinnipiac River Watershed | 206.96 | 44.9 | 90.94 | 1.11 | 3.83 | 4.12 |
| MERIDEN WPCF | Quinnipiac River Watershed | 336.24 | 52.7 | 92.15 | 0.9 | 3.47 | 3.48 |
| WALLINGFORD WATER & SEWER | Quinnipiac River Watershed | 486.43 | 66.2 | 93.54 | 0.67 | 2.95 | 2.85 |
| CYTEC INDUSTRIES INC. | Quinnipiac River Watershed | 506.9 | 67.6 | 93.6 | 0.65 | 2.89 | 2.87 |
| SPRAGUE WPCF | Shetucket River Watershed | 161.39 | 5.2 | 33.51 | 14.53 | 9.91 | 42.05 |
| STAFFORD WPCA | Willimantic River Watershed | 17.6 | 5 | 48.93 | 16.35 | 10.5 | 24.21 |
| UCONN WPCF | Willimantic River Watershed | 53.4 | 7.3 | 60.56 | 10.85 | 7.73 | 20.85 |
| WILLIMANTIC WPCF | Willimantic River Watershed | 101.8 | 6.8 | 50.12 | 11 | 8.47 | 30.41 |

An 8.4 EF was identified in the TITAN analysis as a saturation threshold, beyond which major deviations from the natural condition have occurred in the structure of the biotic community. This threshold was identified by the Department as the maximum allowable EF target necessary to achieve WQS in waste receiving streams. The Department is requiring a reduction in current phosphorus loads from NPDES facility discharges to those streams with an EF greater than 8.4. The reductions at these facilities will ensure that an 8.4 EF is maintained throughout the stream so that water quality management goals are achieved and aquatic life uses are met (Table 8). The required load reductions will be incorporated into the facility NPDES permits when they are up for renewal. Those facilities discharging to streams with an EF below 8.4 will be required to maintain their current phosphorus load to ensure anti-degradation. Any increases in flow at the facilities in the future will require that the facilities reduce their phosphorus concentration. Compliance schedules may be incorporated into the permit to allow for planning, design, financing and construction of any treatment facilities necessary to achieve performance levels. The minimum performance concentration limit was set at 0.1 mg/L based on available technology to achieve phosphorus reductions at the time of the analysis. Permit limits for WPCFs that require a reduction below 0.1 mg/L to achieve 8.4 EF were set at a loading of 0.1 mg/L times their current flow rate and will be re-evaluated during the next permit cycle.

**Table 8: The current average phosphorus load (lbs/day) and the phosphorus load after reductions are met, as well as the proposed performance limit needed to meet reductions at the 45 NPDES facilities.**

| NPDES | Watershed | Current Average Phosphorus Load (lbs/day) 2001 - 2007 | Phosphorus Load After Reductions to meet EF goal (lbs/day) | Proposed Performance Limit (mg/L) |
|---|---|---|---|---|
| LITCHFIELD WPCF | Bantam River Watershed | 13.07 | 9.97 | 2.39 |
| NORFOLK SEWER DISTRICT | Blackberry River Watershed | 3.45 | 3.45 | Cap |
| NORTH CANAAN WPCF | Blackberry River Watershed | 4.29 | 4.29 | Cap |
| SALISBURY WPCF | Factory Brook Watershed | 7.14 | 1.97 | 0.62 |
| WINSTED WPCF | Farmington River Watershed | 20.03 | 17.16 | 1.49 |
| NEW HARTFORD WPCF | Farmington River Watershed | 10.92 | 10.92 | Cap |
| CANTON WPCF | Farmington River Watershed | 24.8 | 24.8 | Cap |
| FARMINGTON WPCF | Farmington River Watershed | 119.01 | 70.11 | 2 |
| SIMSBURY WPCF | Farmington River Watershed | 85.99 | 46.95 | 2.5 |
| NEW CANAAN WPCF | Fivemile River Watershed | 10.45 | 1.47 | 0.19 |
| VERNON WPCF | Hockanum River Watershed | 72.19 | 4.56 | 0.14 |
| MANCHESTER WATER & SEWER | Hockanum River Watershed | 110.4 | 13.21 | 0.25 |
| New Milford WPCF | Housatonic River Main Stem Watershed | 5.76 | 5.76 | Cap |
| DANBURY WPCF | Limekiln Brook Watershed | 78.51 | 7.55 | 0.1 |
| TORRINGTON WPCF | Naugatuck River Watershed | 64.73 | 17.29 | 0.4 |
| QUALITY ROLLING AND DEBURRING INC. | Naugatuck River Watershed | 0.54 | 0.53 | 0.7 |
| THOMASTON WPCF | Naugatuck River Watershed | 22.68 | 7.35 | 1 |
| WATERBURY WPCF | Naugatuck River Watershed | 539.92 | 34.26 | 0.2 |
| NAUGATUCK WPCF | Naugatuck River Watershed | 159.97 | 16.43 | 0.4 |
| BEACON FALLS WPCF | Naugatuck River Watershed | 7.91 | 2.67 | 1 |
| SEYMOUR WPCF | Naugatuck River Watershed | 41.09 | 7.54 | 0.7 |
| ANSONIA WPCF | Naugatuck River Watershed | 43.32 | 11.92 | 0.7 |
| RIDGEFIELD MAIN WPCF | Norwalk River Watershed | 5.99 | 0.52 | 0.1 |
| RIDGEFIELD RTE 7 * | Norwalk River Watershed | 0 | 1 | 1 |
| REDDING WPCF | Norwalk River Watershed | 1.08 | 1.08 | Cap |
| PLYMOUTH WPCF | Pequabuck River Watershed | 28.64 | 4.38 | 0.5 |
| BRISTOL WPCF | Pequabuck River Watershed | 189.33 | 7.48 | 0.1 |
| PLAINVILLE WPCF | Pequabuck River Watershed | 82.35 | 3.49 | 0.2 |

| NPDES | Watershed | Current Average Phosphorus Load (lbs/day) 2001 - 2007 | Phosphorus Load After Reductions to meet EF goal (lbs/day) | Proposed Performance Limit (mg/L) |
|---|---|---|---|---|
| SOUTHBURY HERITAGE VILLAGE WPCF | Pomperaug River Watershed | 10.92 | 10.92 | Cap |
| NEWTOWN WPCF | Pootatuck River Watershed | 4.01 | 4.01 | Cap |
| THOMPSON WPCF | Quinebaug River Watershed | 6.29 | 2.1 | 0.7 |
| PUTNAM WPCF | Quinebaug River Watershed | 19.69 | 8.41 | 0.7 |
| KILLINGLY WPCF | Quinebaug River Watershed | 40.64 | 18.23 | 0.7 |
| PLAINFIELD NORTH WPCF | Quinebaug River Watershed | 17.82 | 3.86 | 0.7 |
| PLAINFIELD WPCF | Quinebaug River Watershed | 10.51 | 2.51 | 0.7 |
| GRISWOLD WPCA | Quinebaug River Watershed | 5.52 | 2.92 | 0.7 |
| SOUTHINGTON WPCF | Quinnipiac River Watershed | 100 | 7.53 | 0.2 |
| CHESHIRE WPCF | Quinnipiac River Watershed | 88.2 | 4.06 | 0.2 |
| MERIDEN WPCF | Quinnipiac River Watershed | 121.64 | 8.71 | 0.1 |
| WALLINGFORD WATER & SEWER | Quinnipiac River Watershed | 145.16 | 8.95 | 0.2 |
| CYTEC INDUSTRIES INC. | Quinnipiac River Watershed | 19.44 | 1.49 | 0.1 |
| SPRAGUE WPCF | Shetucket River Watershed | 3.11 | 3.11 | Cap |
| STAFFORD WPCA | Willimantic River Watershed | 8.61 | 8.61 | Cap |
| UCONN WPCF | Willimantic River Watershed | 23.76 | 23.76 | Cap |
| WILLIMANTIC WPCF | Willimantic River Watershed | 18.63 | 18.63 | Cap |

* Current phosphorus loading data was not available for the Ridgefield Rte. 7 WPCF at the time the analysis was conducted.

The Quinnipiac River, an urbanized waste-receiving stream located south central portion of CT (Figure 8), is provided as a detailed example. The Quinnipiac contains 4 municipal WPCFs (Southington, Cheshire, Meriden & Wallingford) and one industrial (Cytec, Inc.) discharge of phosphorus (Figure 8). The EF was calculated at 52 points in the Quinnipiac River downstream of NPDES facilities (Figure 8).

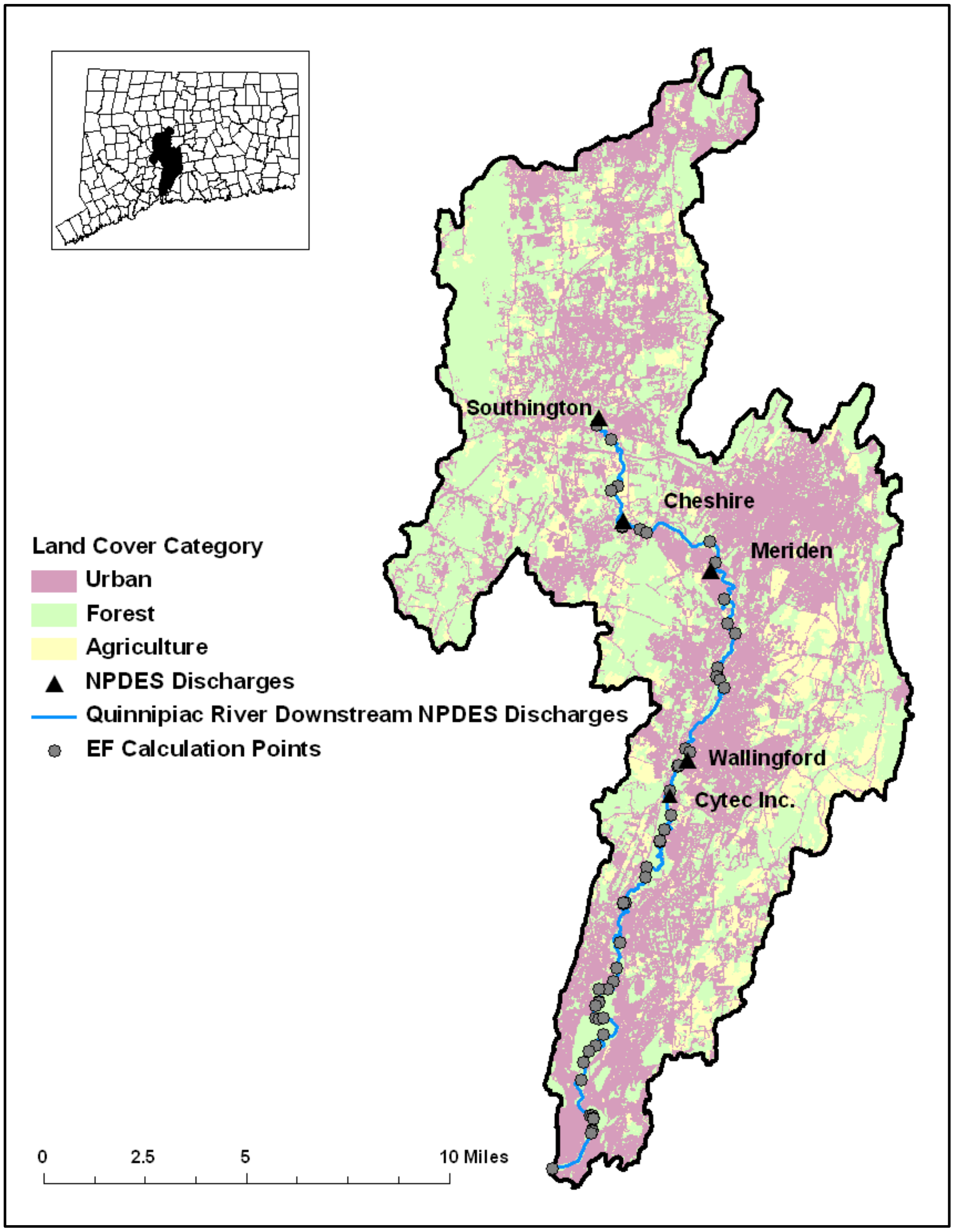


**Figure 8: Quinnipiac River Watershed Land Cover and Points for Analysis**

The in-stream phosphorus load at the most downstream discharge point, Cytec Inc., is an estimated 108,479 lbs / season while the estimated load under 'natural' conditions is 1,605 lbs / season making the EF 67.6 (i.e. 108,479 / 1,605 = 67.6). The in-stream EF below the facilities ranges from 30.8 below the Southington WPCF to 67.6 below the Cytec Inc. discharge in Wallingford. Loading reductions at each of the plants were made to ensure an 8.4 EF throughout the river (Table 9). Note that in the in-stream EF required to meet CT WQS is lower than an 8.4 EF below the Southington, Cheshire, Meriden and Wallingford WPCFs (Table 9). These reductions are needed to ensure downstream protection of an 8.4 EF consistently throughout the river. The Appendix contains details of loading reductions and permit requirement for all facilities discharging to a freshwater non-tidal waste-receiving stream in CT by watershed.

**Table 9: Reductions needed at NPDES facilities discharging to the Quinnipiac River to achieve EFs consistent with CT WQS**

| NPDES | Flow (MGD) | Current NPDES Load (lbs/day) | Required NPDES Load (lbs/day) | Percent Load Reduction Needed | Current In-Stream EF At Discharge | Required In-Stream EF At Discharge |
|---|---|---|---|---|---|---|
| SOUTHINGTON WPCF | 4.51 | 100 | 7.53 | 92.50% | **30.8** | **6** |
| CHESHIRE WPCF | 2.43 | 88.2 | 4.06 | 95.40% | **44.9** | **6.6** |
| MERIDEN WPCF | 10.44 | 121.64 | 8.71 | 92.80% | **52.7** | **7.3** |
| WALLINGFORD WATER & SEWER | 5.36 | 145.16 | 8.95 | 93.80% | **66.2** | **8.3** |
| CYTEC INDUSTRIES INC. | 1.79 | 19.44 | 1.49 | 92.30% | **67.6** | **8.4** |

**Future Work**

Ongoing study in CT rivers and streams (Becker, 2012) is currently being conducted to refine this approach through additional data collection and by expanding the methodology to include non-waste receiving streams. The current approach provides for a major statewide advancement in the level of phosphorus control that is expected to meet all freshwater designated uses in waste-receiving streams. The adaptive nature of Connecticut's strategy allows for revisions to permit limits in future permit cycles without delaying action that we know needs to be taken today. It also provides an opportunity to monitor and research the responsiveness of the aquatic systems to these initial steps to manage phosphorus from NPDES permitted sources.

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# Appendix. Enrichment Factor Watershed Analysis Overview and Limits for NPDES Facilities Discharging to Freshwater Rivers and Streams

# Nutrient Enrichment Analysis Watershed Overview

**Last Updated: 7 Nov. 2011**

## INTRODUCTION

**A geo-spatial modeling analysis was conducted in the following watersheds below facilities discharging phosphorus to assess the level of nutrient enrichment in the river. The goal of the Connecticut interim nutrient management strategy is to achieve or maintain an enrichment factor (EF) of 8.4 or below throughout a watershed. An EF represents the ratio of the total seasonal phosphorus load (April through October) at the point of complete mixing downstream of a National Pollutant Discharge Elimination System (NPDES) discharge to that load calculated for the same location from a fully forested upstream watershed with no point discharges. The total current load includes the current load from the NPDES facility and any additional NPDES facilities upstream plus the load from current land use export.**

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left({}^{\text{lbs}}/_{\text{day}}\right) + \text{Land Cover Load}\left({}^{\text{lbs}}/_{\text{day}}\right)}{\text{Forested Condition Load}\left({}^{\text{lbs}}/_{\text{day}}\right)}$$

**The EF quantifies the cumulative influence of anthropogenic activity (point and non point) on current phosphorus loads. The goal of an 8.4 EF represents a threshold at which a significant change is seen in stream algal communities indicating highly enriched conditions and impacts to aquatic life uses. The analysis was conducted using stream algae collected in rivers and streams throughout CT under varying enrichment conditions. The approach targets the critical 'growing' season (April through October) when phosphorus is more likely to be taken up by sediment and biomass because of low flow and warmer conditions. During winter months aquatic plants are dormant and flows are higher providing constant flushing of phosphorus through aquatic systems with a less likely chance that it will settle out into the sediment. Limiting the phosphorus export from industrial and municipal facilities offers a targeted management strategy for achieving aquatic life designated uses within a waterbody.**

# Nutrient Enrichment Analysis Watershed Overview

## Bantam River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| LITCHFIELD WPCF | CT0100803 | LITCHFIELD | 0.80 | AS, Nitr, DNitr,UV |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| LITCHFIELD WPCF | 0.50 | 3.29 | 13.07 | **2.39** | 9.97 |

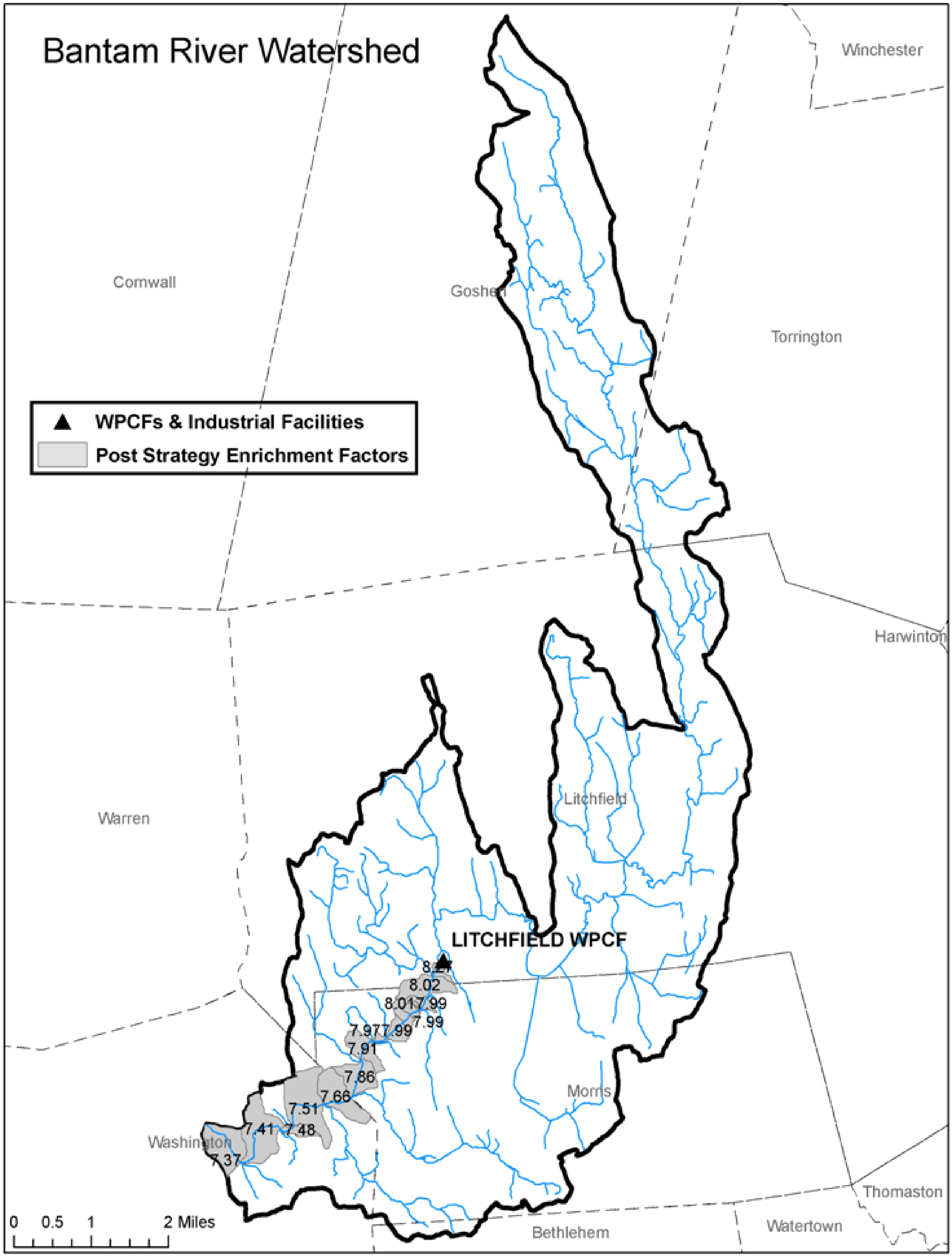
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left(\text{lbs}/_{\text{day}}\right) + \text{Land Cover Load}\left(\text{lbs}/_{\text{day}}\right)}{\text{Forested Condition Load}\left(\text{lbs}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| LITCHFIELD WPCF | 13.07 | 14.04 | 2.86 | **9.50** | 9.97 | **8.40** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Blackberry River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| NORFOLK SEWER DISTRICT | CT0101231 | NORFOLK | 0.35 | AS, EA, DChlor, SFilt |
| NORTH CANAAN WPCF | CT0100064 | CANAAN | 0.40 | AS, UV |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| NORFOLK SEWER DISTRICT | 0.31 | 1.70 | 3.45 | **Cap** | 3.45 |
| NORTH CANAAN WPCF | 0.32 | 1.88 | 4.29 | **Cap** | 4.29 |

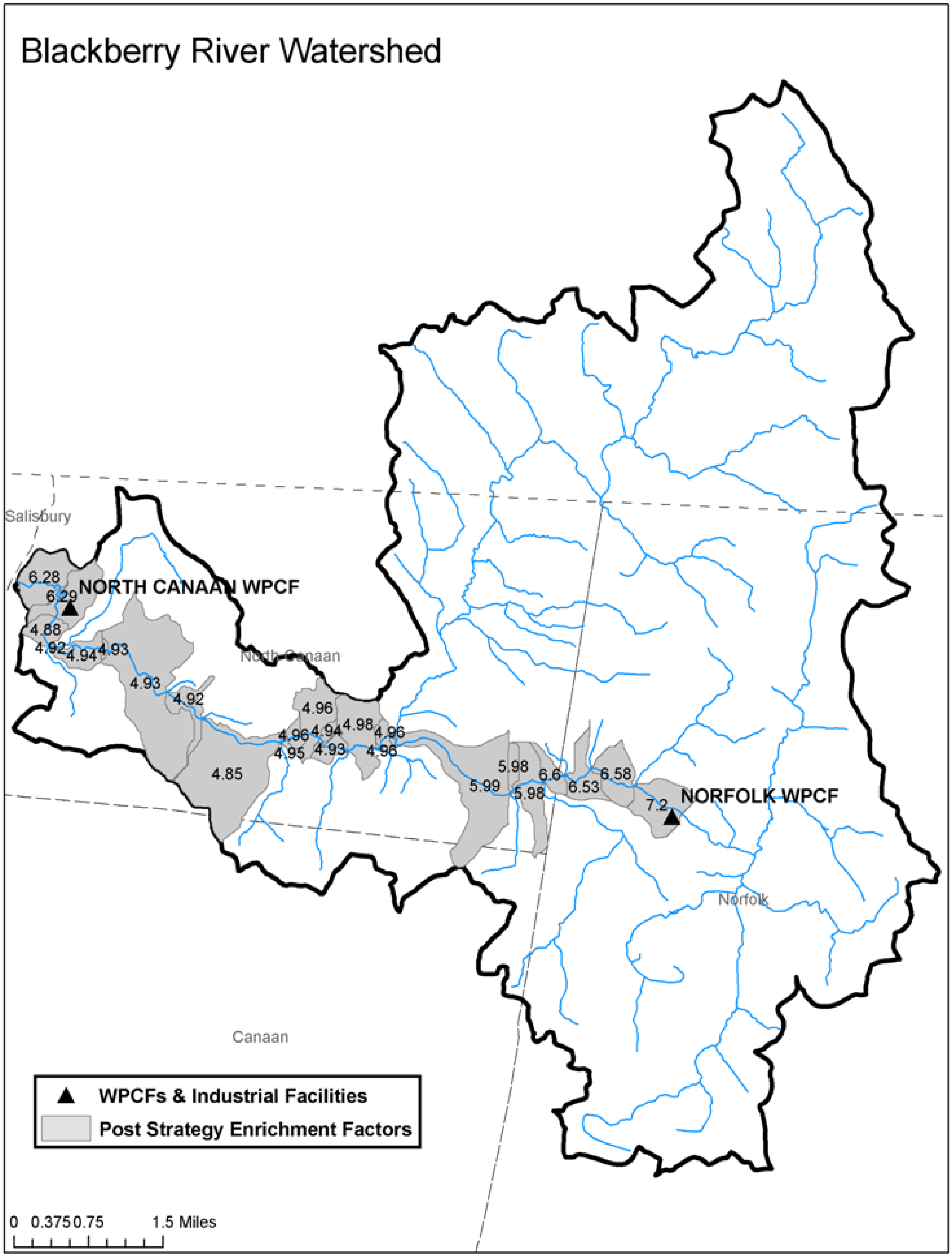
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load } \left(\text{lbs}/_{\text{day}}\right) + \text{ Land Cover Load} \left(\text{lbs}/_{\text{day}}\right)}{\text{Forested Condition Load } \left(\text{lbs}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| NORFOLK SEWER DISTRICT | 3.45 | 2.33 | 0.80 | **7.20** | 3.45 | **7.20** |
| NORTH CANAAN WPCF | 7.74 | 11.40 | 3.04 | **6.30** | 7.74 | **6.30** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Factory Brook Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| SALISBURY WPCF | CT0100498 | SALISBURY | 0.67 | AS, SFilt, UV |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| SALISBURY WPCF | 0.38 | 2.40 | 7.14 | **0.62** | 1.97 |

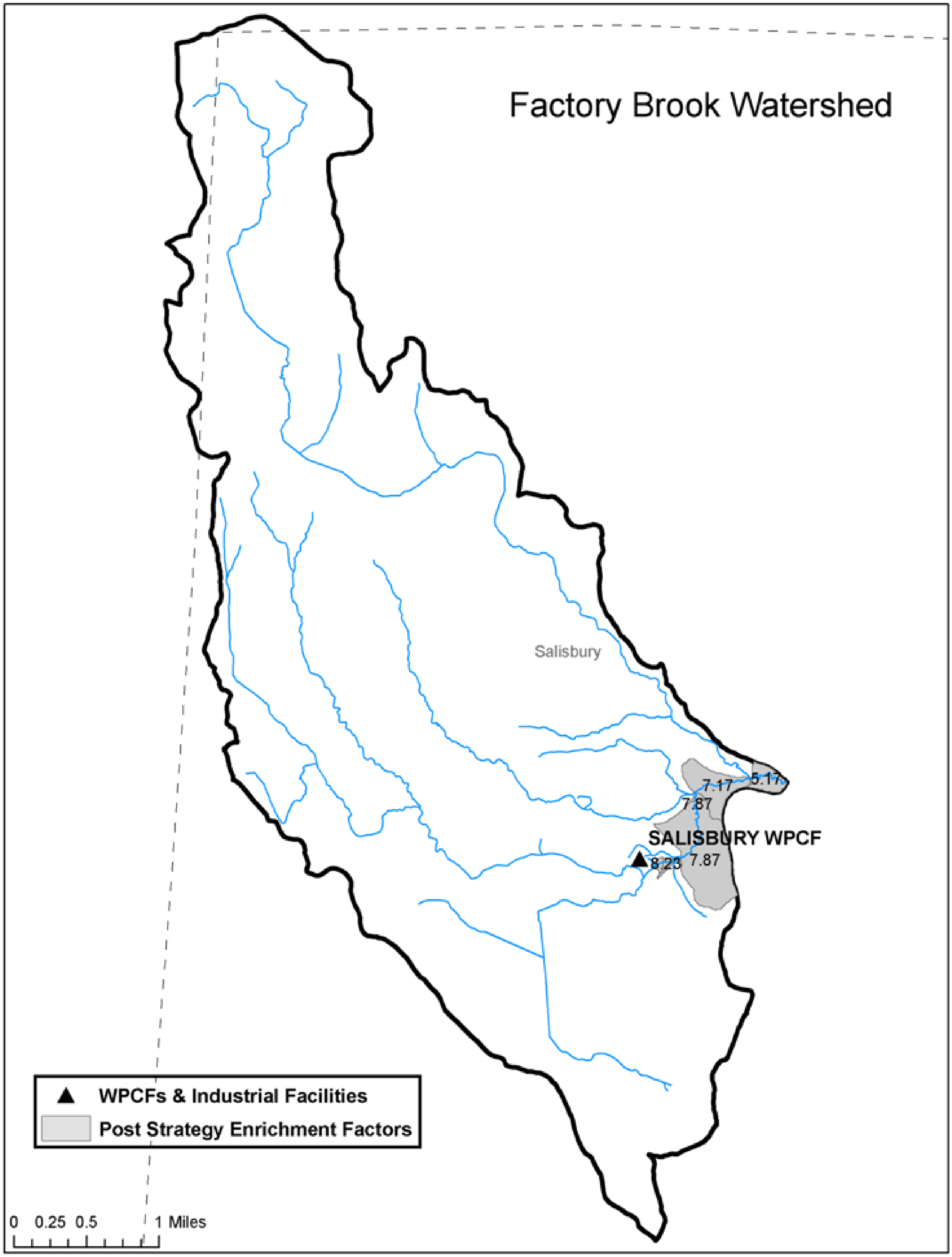
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left(\text{lbs}/\text{day}\right) + \text{Land Cover Load}\left(\text{lbs}/\text{day}\right)}{\text{Forested Condition Load}\left(\text{lbs}/\text{day}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| SALISBURY WPCF | 7.14 | 1.83 | 0.45 | **19.80** | 1.97 | **8.40** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Farmington River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| PLYMOUTH WPCF | CT0100463 | TERRYVILLE | 1.75 | AS, AdvTr, Nitr, DNitr, UV |
| WINSTED WPCF | CT0101222 | WINSTED | 3.50 | AS, AdvTr, Nitr, DChlor |
| BRISTOL WPCF | CT0100374 | BRISTOL | 10.75 | AS, AdvTr, Nitr, UV |
| PLAINVILLE WPCF | CT0100455 | PLAINVILLE | 3.80 | RBC, SFilt, UV, AdvTr, Nitr |
| NEW HARTFORD WPCF* | CT0100331 | NEW HARTFORD | 0.40 | AS, EA |
| CANTON WPCF | CT0100072 | CANTON | 0.80 | RBC, SFilt, TFilt, UV |
| FARMINGTON WPCF | CT0100218 | FARMINGTON | 5.65 | AS, TFilt, AdvTr, Nitr, DNitr, DChlor |
| SIMSBURY WPCF | CT0100919 | SIMSBURY | 2.85 | AS, OD, Nitr, DNitr, UV |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| PLYMOUTH WPCF | 1.05 | 3.47 | 28.64 | **0.5** | 4.38 |
| WINSTED WPCF | 1.38 | 1.87 | 20.03 | **1.49** | 17.16 |
| BRISTOL WPCF | 8.96 | 2.62 | 189.33 | **0.1** | 7.48 |
| PLAINVILLE WPCF | 2.09 | 5.08 | 82.35 | **0.2** | 3.49 |
| NEW HARTFORD WPCF* | 0.40 | 3.27 | 10.92 | **Cap** | 10.92 |
| CANTON WPCF | 0.60 | 5.44 | 24.80 | **Cap** | 24.80 |
| FARMINGTON WPCF | 4.20 | 3.55 | 119.01 | **2** | 70.11 |
| SIMSBURY WPCF | 2.25 | 4.57 | 85.99 | **2.5** | 46.95 |

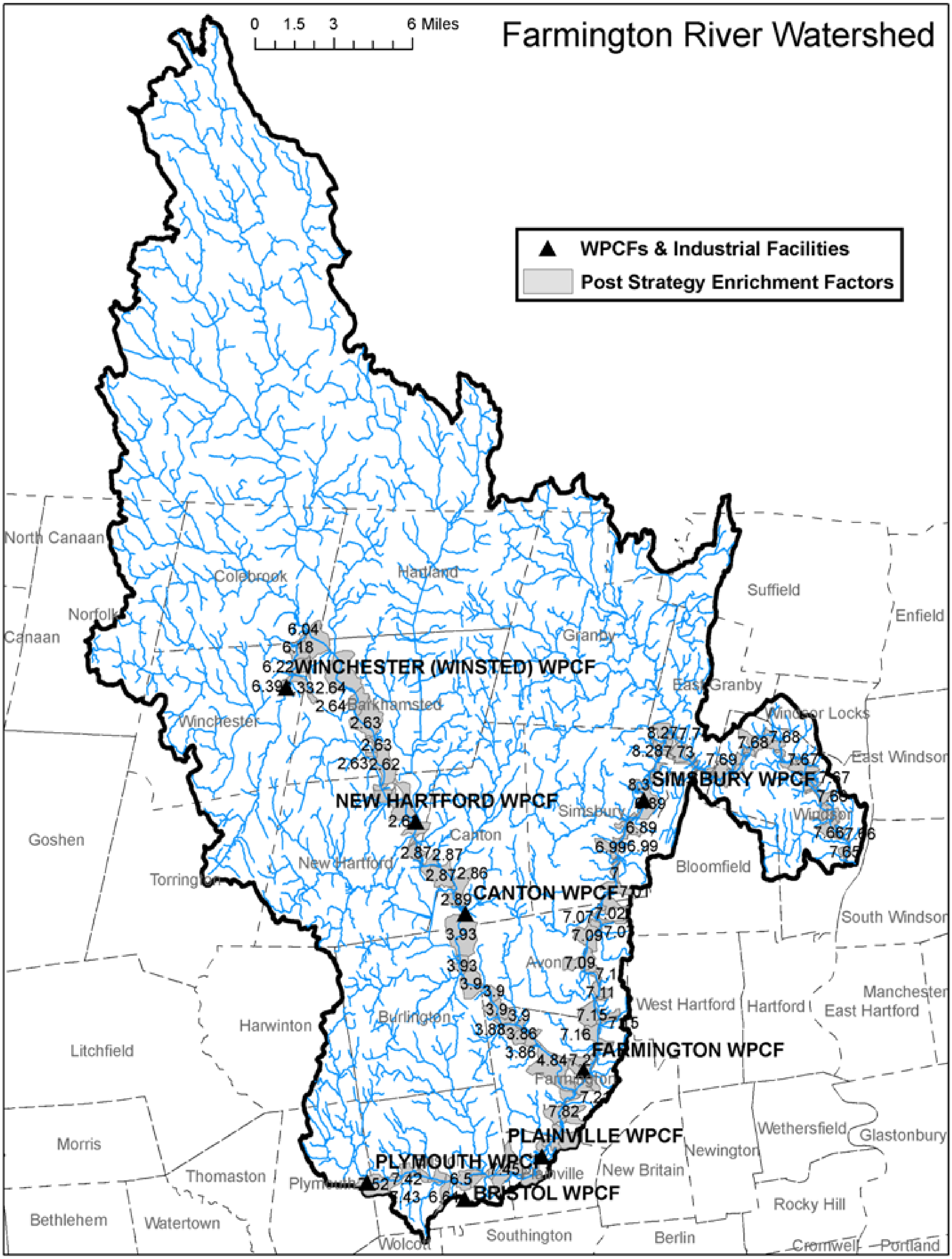
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left({}^{\text{lbs}}/_{\text{day}}\right) + \text{Land Cover Load}\left({}^{\text{lbs}}/_{\text{day}}\right)}{\text{Forested Condition Load}\left({}^{\text{lbs}}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| PLYMOUTH WPCF | 28.64 | 3.42 | 1.04 | **30.90** | 4.38 | **7.50** |
| WINSTED WPCF | 20.03 | 6.70 | 2.85 | **9.40** | 17.16 | **8.40** |
| BRISTOL WPCF | 217.97 | 11.07 | 3.04 | **75.40** | 11.86 | **7.60** |
| PLAINVILLE WPCF | 300.32 | 12.13 | 3.27 | **95.50** | 15.35 | **8.40** |
| NEW HARTFORD WPCF* | 30.95 | 36.38 | 20.15 | **3.30** | 28.08 | **3.20** |
| CANTON WPCF | 55.75 | 47.77 | 23.94 | **4.30** | 52.88 | **4.20** |
| FARMINGTON WPCF | 475.08 | 68.46 | 29.75 | **18.30** | 138.34 | **7.00** |
| SIMSBURY WPCF | 561.07 | 80.96 | 32.97 | **19.50** | 185.29 | **8.10** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Fivemile River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| NEW CANAAN WPCF | CT0101273 | NEW CANAAN | 1.70 | AS, OD, EA, AdvTr, Nitr, DNitr, UV |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| NEW CANAAN WPCF | 0.93 | 1.42 | 10.45 | **0.19** | 1.47 |

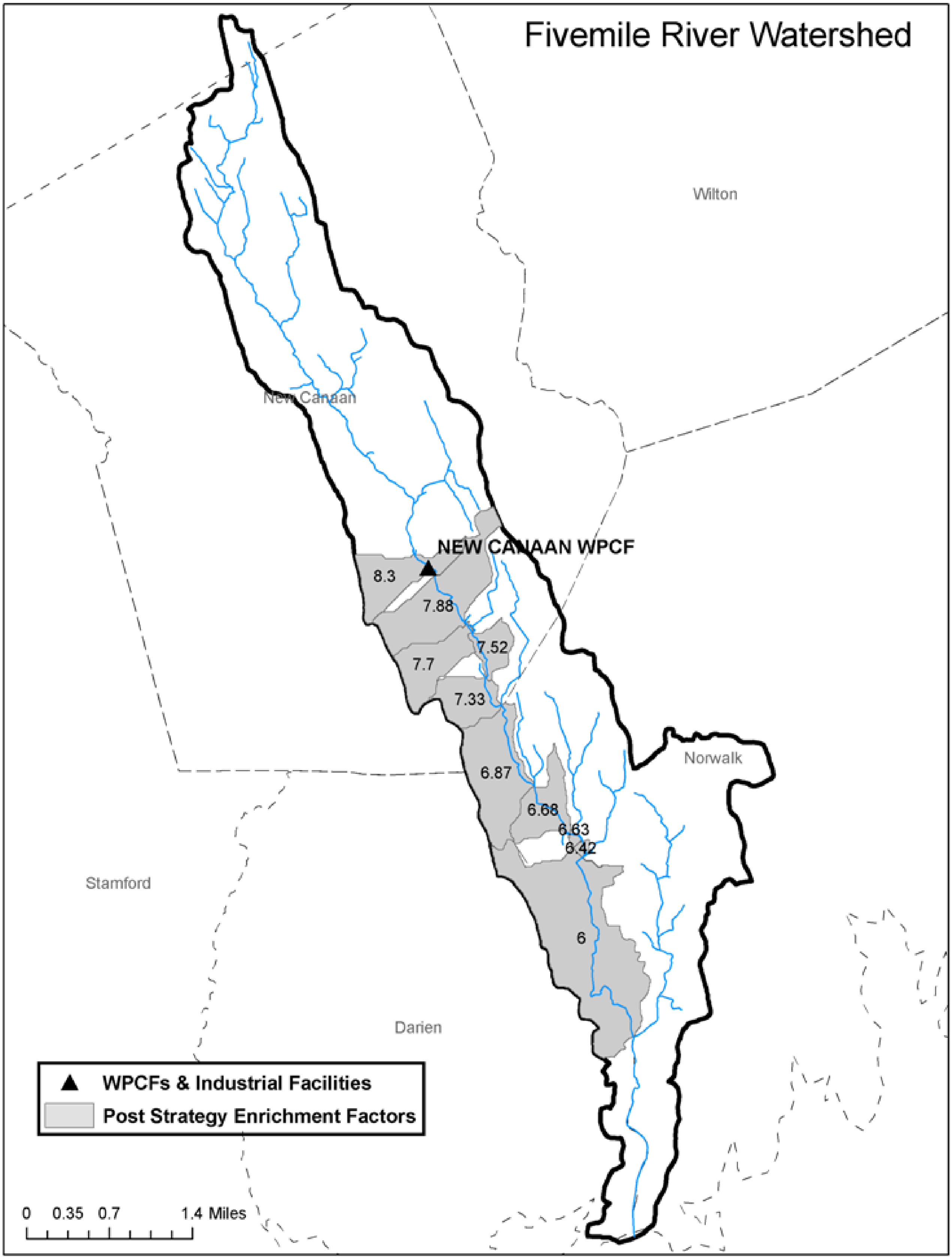
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load} \left({}^{\text{lbs}}/_{\text{day}}\right) + \text{Land Cover Load} \left({}^{\text{lbs}}/_{\text{day}}\right)}{\text{Forested Condition Load} \left({}^{\text{lbs}}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| NEW CANAAN WPCF | 10.45 | 1.26 | 0.33 | **35.50** | 1.47 | **8.30** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Hockanum River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| VERNON WPCF | CT0100609 | VERNON | 7.10 | PAC, AdvTr, Nitr, SFilt, DChlor |
| MANCHESTER WATER & SEWER | CT0100293 | MANCHESTER | 8.25 | AS, AdvTr, Nitr, UV |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| VERNON WPCF | 3.90 | 2.30 | 72.19 | **0.14** | 4.56 |
| MANCHESTER WATER & SEWER | 6.33 | 2.15 | 110.40 | **0.25** | 13.21 |

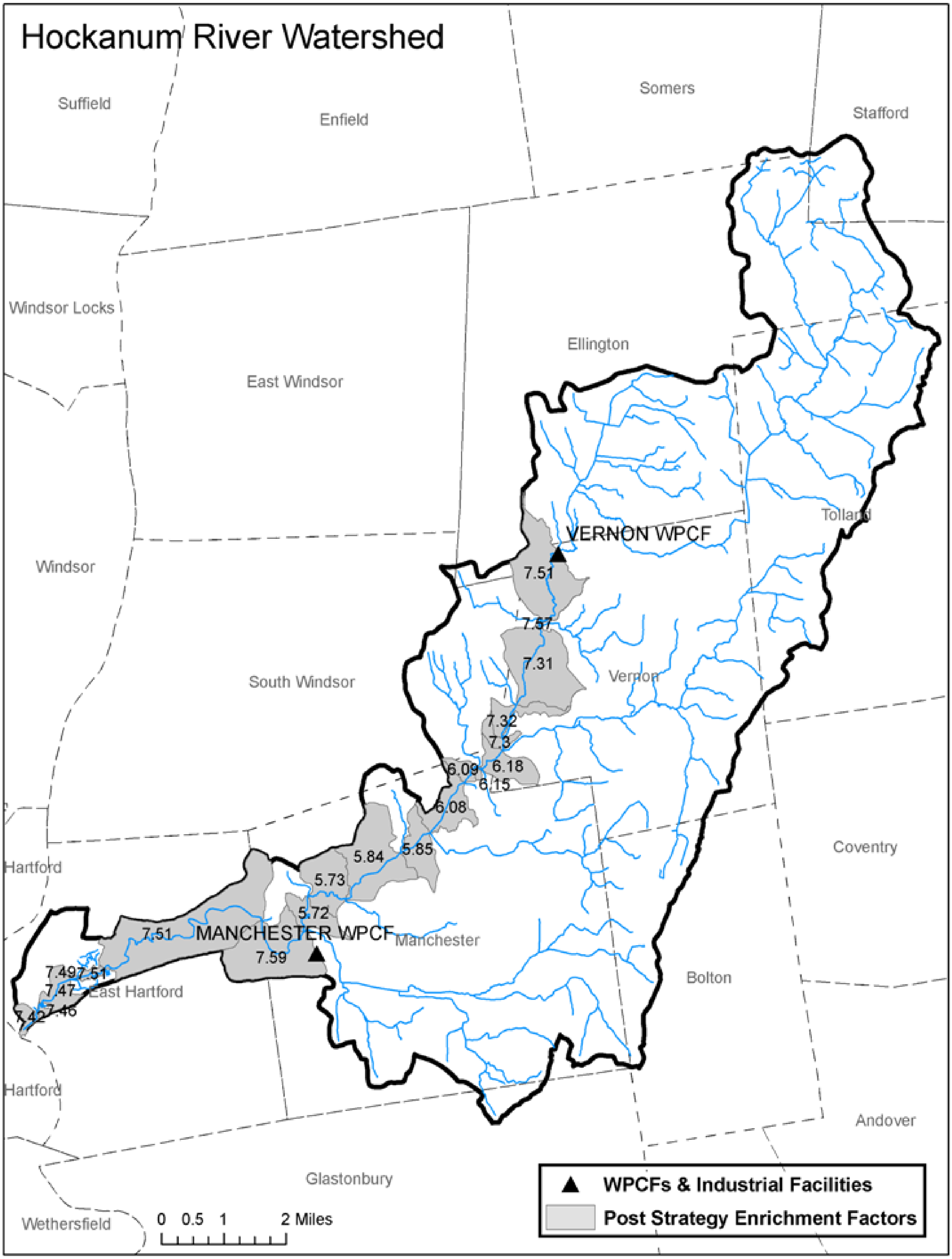
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load } \left(\frac{\text{lbs}}{\text{day}}\right) + \text{ Land Cover Load} \left(\frac{\text{lbs}}{\text{day}}\right)}{\text{Forested Condition Load } \left(\frac{\text{lbs}}{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| VERNON WPCF | 72.19 | 10.00 | 1.77 | **46.50** | 4.56 | **8.20** |
| MANCHESTER WATER & SEWER | 182.59 | 22.96 | 4.85 | **42.40** | 17.77 | **8.40** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Housatonic River Main Stem Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| New Milford WPCF* | CT0100391 | NEW MILFORD | 1.02 | AS, AdvTr, PRem |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration,
OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification
DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| New Milford WPCF* | 0.69 | 1.00 | 5.76 | **Cap** | 5.76 |

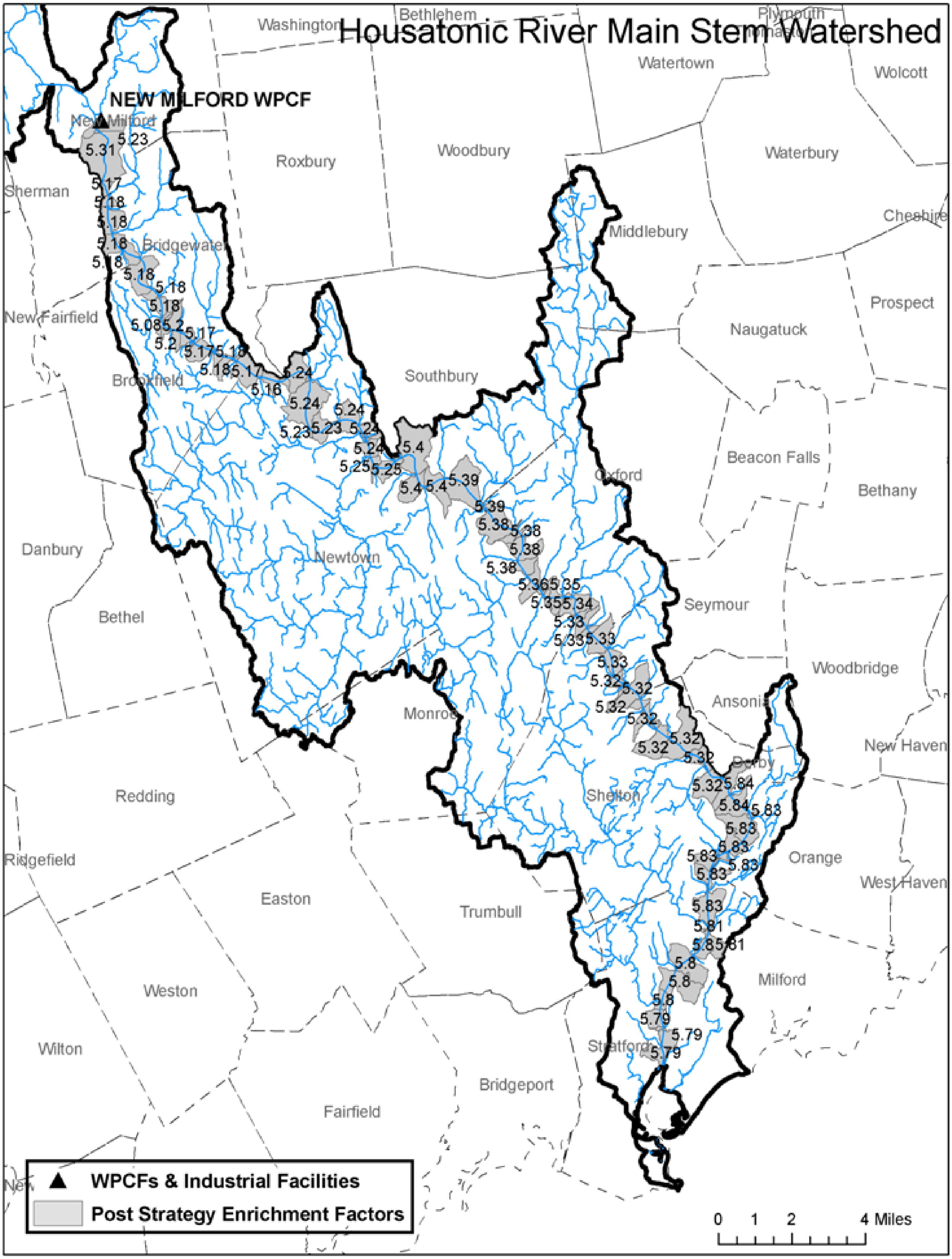
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left(^{\text{lbs}}/_{\text{day}}\right) + \text{Land Cover Load}\left(^{\text{lbs}}/_{\text{day}}\right)}{\text{Forested Condition Load}\left(^{\text{lbs}}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| New Milford WPCF* | 79.49 | 301.85 | 71.87 | **5.30** | 79.49 | **5.30** |

## Nutrient Enrichment Analysis Watershed Overview

### Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Limekiln Brook Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| DANBURY WPCF | CT0100145 | DANBURY | 15.50 | AS, TFilt, AdvTr, Nitr, DNitr, PRem, DChlor |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| DANBURY WPCF | 9.05 | 1.04 | 78.51 | **0.1** | 7.55 |

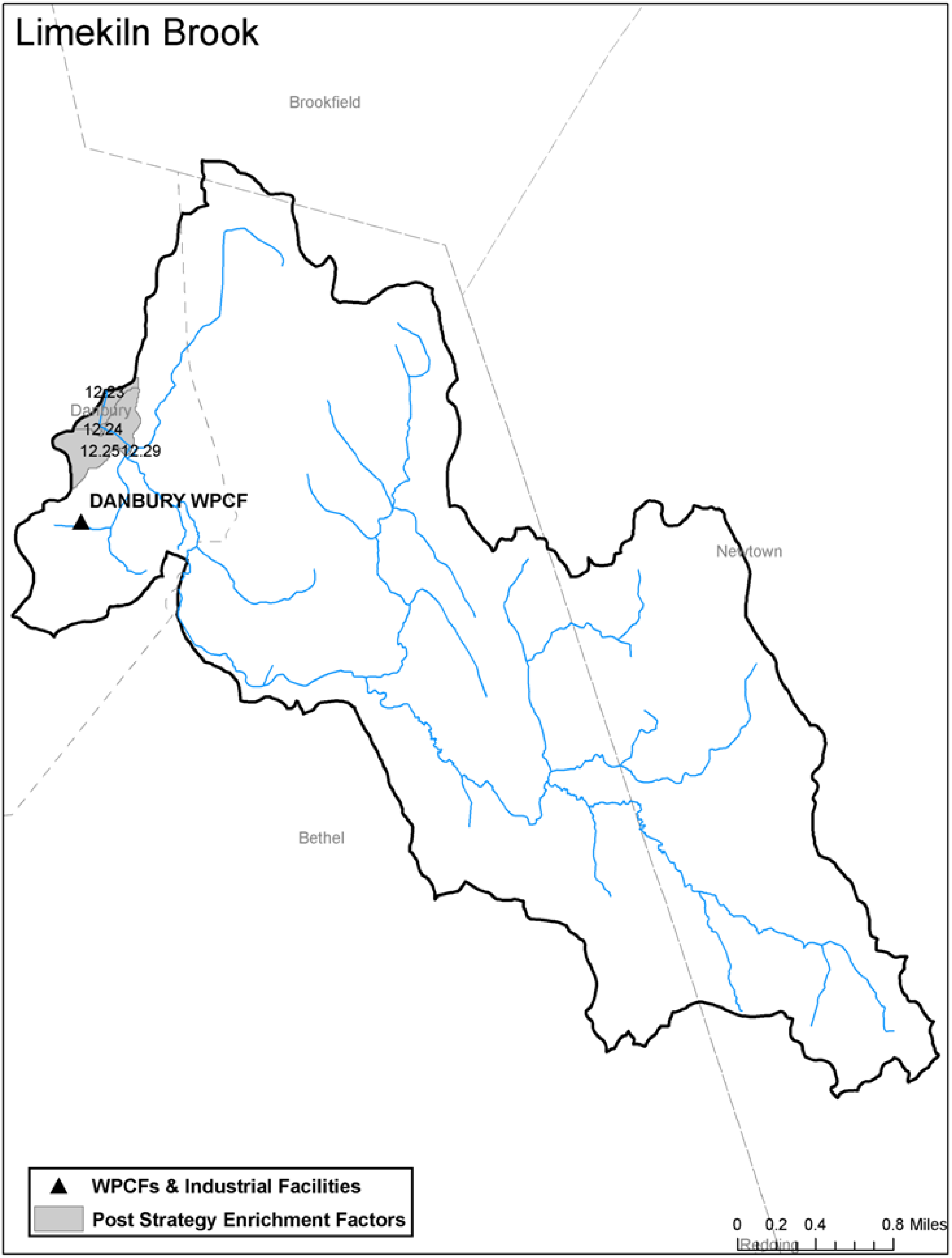
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load } \left(\text{lbs}/_{\text{day}}\right) + \text{ Land Cover Load} \left(\text{lbs}/_{\text{day}}\right)}{\text{Forested Condition Load } \left(\text{lbs}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| DANBURY WPCF | 78.51 | 3.70 | 0.92 | **89.80** | 7.55 | **12.30** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Naugatuck River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| TORRINGTON WPCF | CT0100579 | TORRINGTON | 7.00 | AS, AdvTr, Nitr, DNitr, DChlor |
| QUALITY ROLLING AND DEBURRING INC. | CT0025305 | THOMASTON | | |
| THOMASTON WPCF | CT0100781 | THOMASTON | 1.38 | SBR, AdvTr, UV, Nitr, DNitr |
| WATERBURY WPCF | CT0100625 | WATERBURY | 27.00 | AS, AdvTr, Nitr, DNitr, UV |
| NAUGATUCK WPCF | CT0100641 | NAUGATUCK | 10.30 | AS, AdvTr, Nitr, DNitr, DChlor |
| BEACON FALLS WPCF | CT0101061 | BEACON FALLS | 0.71 | AS, UV |
| SEYMOUR WPCF | CT0100501 | SEYMOUR | 2.93 | AS, Nitr, DNitr, DChlor |
| ANSONIA WPCF | CT0100013 | ANSONIA | 3.50 | AS, DChlor |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| TORRINGTON WPCF | 5.18 | 1.68 | 64.73 | **0.4** | 17.29 |
| QUALITY ROLLING AND DEBURRING INC. | 0.09 | 0.70 | 0.54 | **0.7** | 0.53 |
| THOMASTON WPCF | 0.88 | 3.29 | 22.68 | **1** | 7.35 |
| WATERBURY WPCF | 20.52 | 3.19 | 539.92 | **0.2** | 34.26 |
| NAUGATUCK WPCF | 4.92 | 4.30 | 159.97 | **0.4** | 16.43 |
| BEACON FALLS WPCF | 0.32 | 3.19 | 7.91 | **1** | 2.67 |
| SEYMOUR WPCF | 1.29 | 3.98 | 41.09 | **0.7** | 7.54 |
| ANSONIA WPCF | 2.04 | 2.89 | 43.32 | **0.7** | 11.92 |

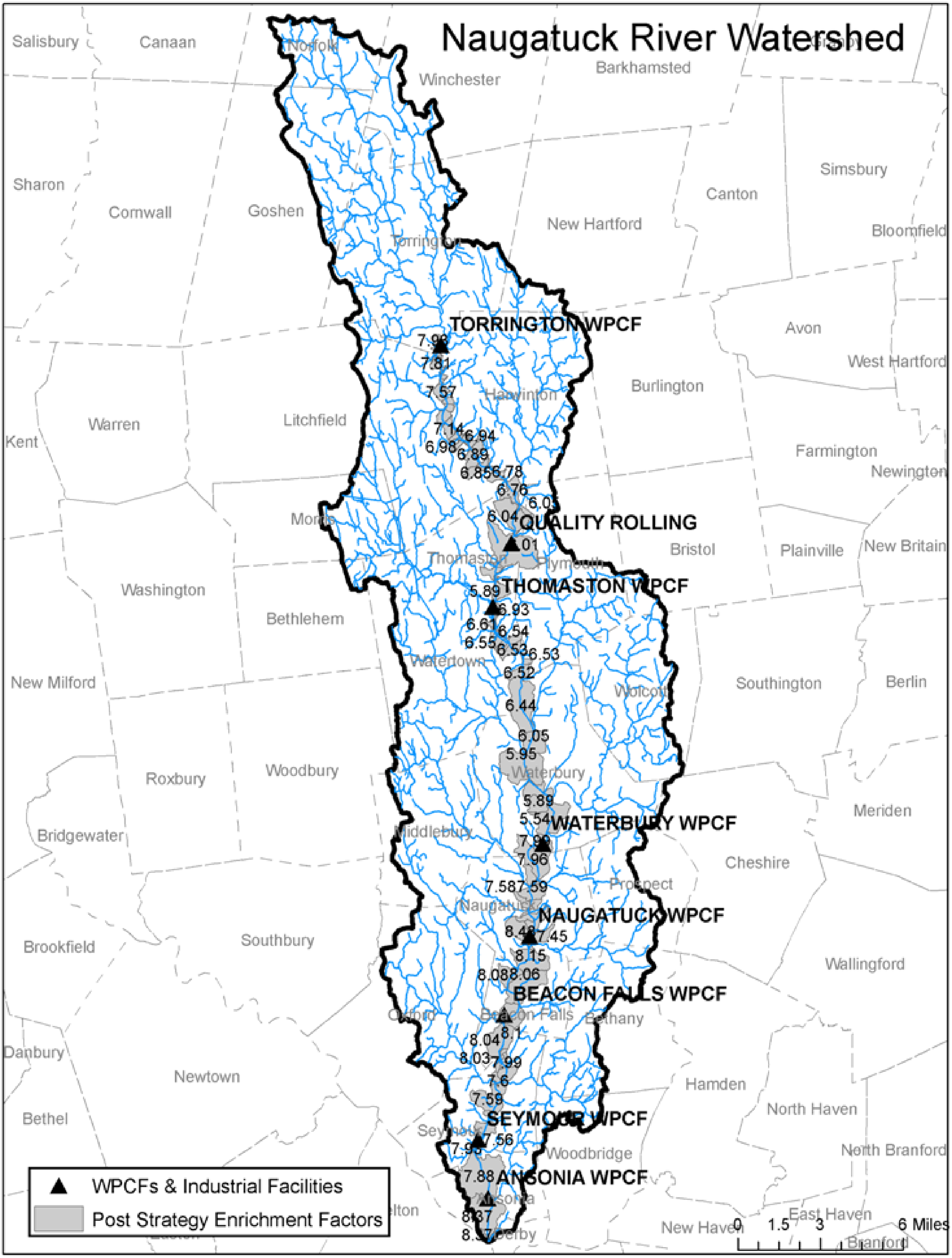
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load} \left({}^{\text{lbs}}/_{\text{day}}\right) + \text{Land Cover Load} \left({}^{\text{lbs}}/_{\text{day}}\right)}{\text{Forested Condition Load} \left({}^{\text{lbs}}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| TORRINGTON WPCF | 64.73 | 11.52 | 3.63 | **21.00** | 17.29 | **7.90** |
| QUALITY ROLLING AND DEBURRING INC. | 65.27 | 22.60 | 6.72 | **13.10** | 17.82 | **6.00** |
| THOMASTON WPCF | 87.95 | 25.36 | 7.29 | **15.50** | 25.17 | **6.90** |
| WATERBURY WPCF | 627.87 | 51.35 | 13.87 | **49.00** | 59.42 | **8.00** |
| NAUGATUCK WPCF | 787.84 | 61.32 | 16.26 | **52.20** | 75.85 | **8.40** |
| BEACON FALLS WPCF | 795.75 | 64.55 | 17.66 | **48.70** | 78.52 | **8.10** |
| SEYMOUR WPCF | 836.84 | 72.85 | 20.05 | **45.40** | 86.06 | **7.90** |
| ANSONIA WPCF | 880.16 | 74.85 | 20.65 | **46.20** | 97.98 | **8.40** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Norwalk River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| RIDGEFIELD MAIN WPCF C/O OMI | CT0100854 | RIDGEFIELD | 1.00 | AS, AdvTr, Nitr, DNitr, PRem, Sfilt, UV |
| RIDGEFIELD RTE 7 C/O OMI* | CT0101451 | RIDGEFIELD | 0.12 | RBC, UV, Nitr |
| REDDING WPCF | CT0101770 | REDDING | 0.25 | SBR, UV, AdvTr, Nitr, DNitr |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| RIDGEFIELD MAIN WPCF C/O OMI | 0.62 | 1.38 | 5.99 | **0.1** | 0.52 |
| RIDGEFIELD RTE 7 C/O OMI* | 0.12 | | 0.00 | **1** | 1.00 |
| REDDING WPCF | 0.05 | 3.38 | 1.08 | **Cap** | 1.08 |

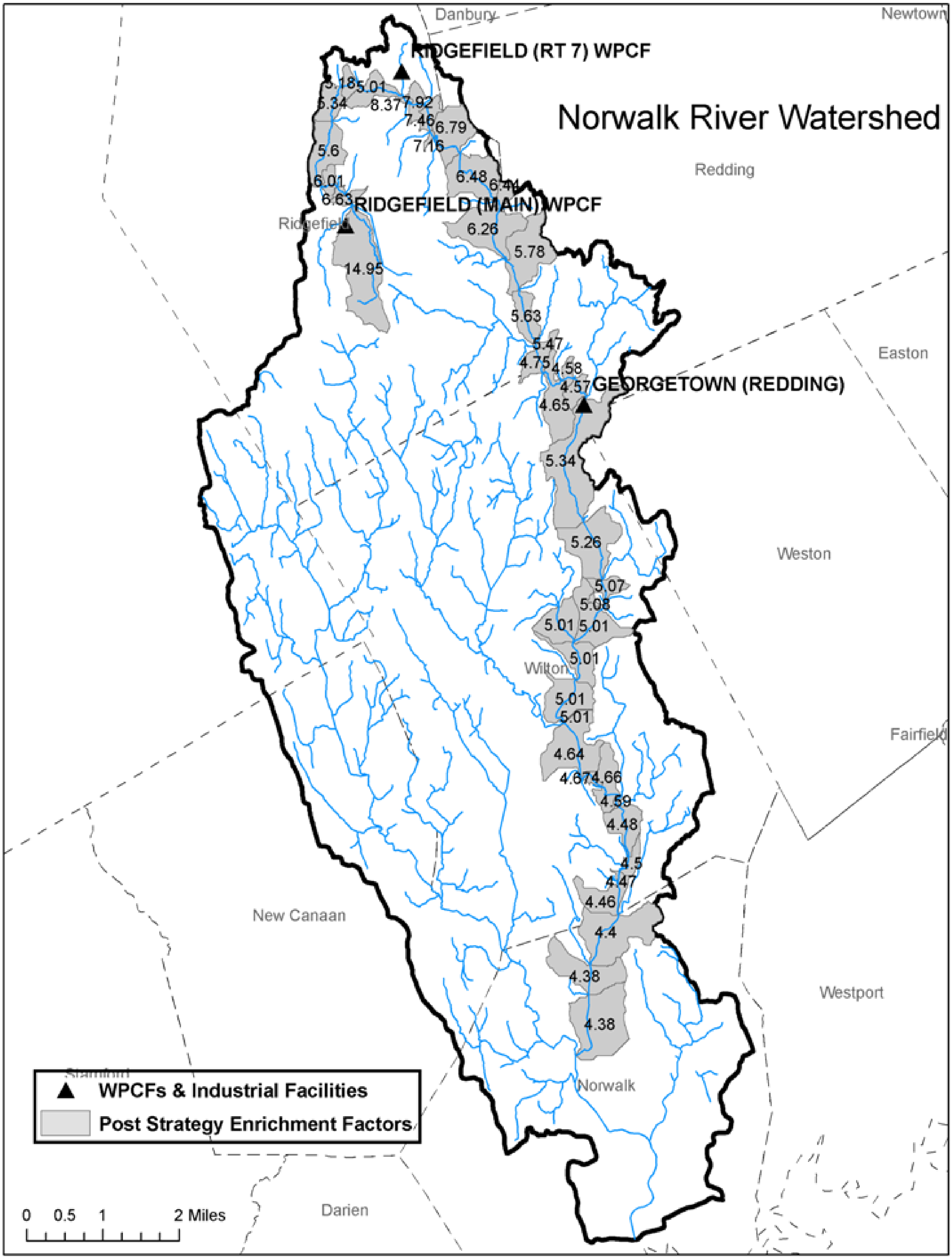
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left(\text{lbs}/_{\text{day}}\right) + \text{Land Cover Load}\left(\text{lbs}/_{\text{day}}\right)}{\text{Forested Condition Load}\left(\text{lbs}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| RIDGEFIELD MAIN WPCF C/O OMI | 5.99 | 0.15 | 0.04 | **137.90** | 0.52 | **15.00** |
| RIDGEFIELD RTE 7 C/O OMI* | 5.99 | 0.84 | 0.28 | **24.20** | 1.52 | **8.40** |
| REDDING WPCF | 7.07 | 2.66 | 0.99 | **9.90** | 2.60 | **5.30** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Pomperaug River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| SOUTHBURY HERITAGE VILLAGE WPCF* | CT0101133 | SOUTHBURY | 0.78 | AS, Nitr, DNitr, PRem |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| SOUTHBURY HERITAGE VILLAGE WPCF* | 0.66 | 0.96 | 10.92 | **Cap** | 10.92 |

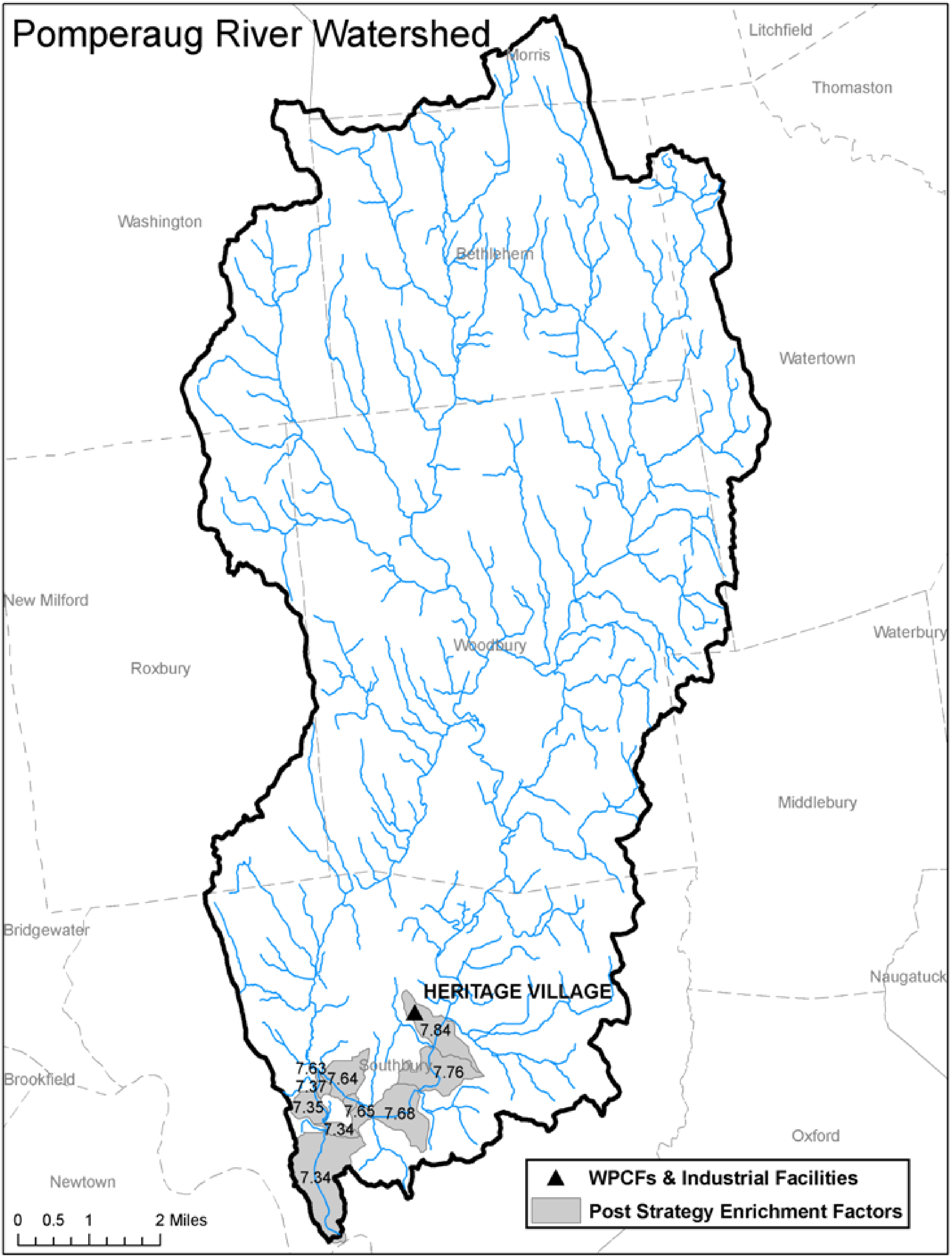
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left({}^{\text{lbs}}/_{\text{day}}\right) + \text{Land Cover Load}\left({}^{\text{lbs}}/_{\text{day}}\right)}{\text{Forested Condition Load}\left({}^{\text{lbs}}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| SOUTHBURY HERITAGE VILLAGE WPCF* | 10.92 | 28.47 | 5.03 | **7.80** | 10.92 | **7.80** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Pootatuck River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| NEWTOWN WPCF | CT0101788 | NEWTOWN | 0.93 | AS, OD, EA, UV,AdvTr, PRem, Nitr, DNitr |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| NEWTOWN WPCF | 0.48 | 0.52 | 4.01 | **Cap** | 4.01 |

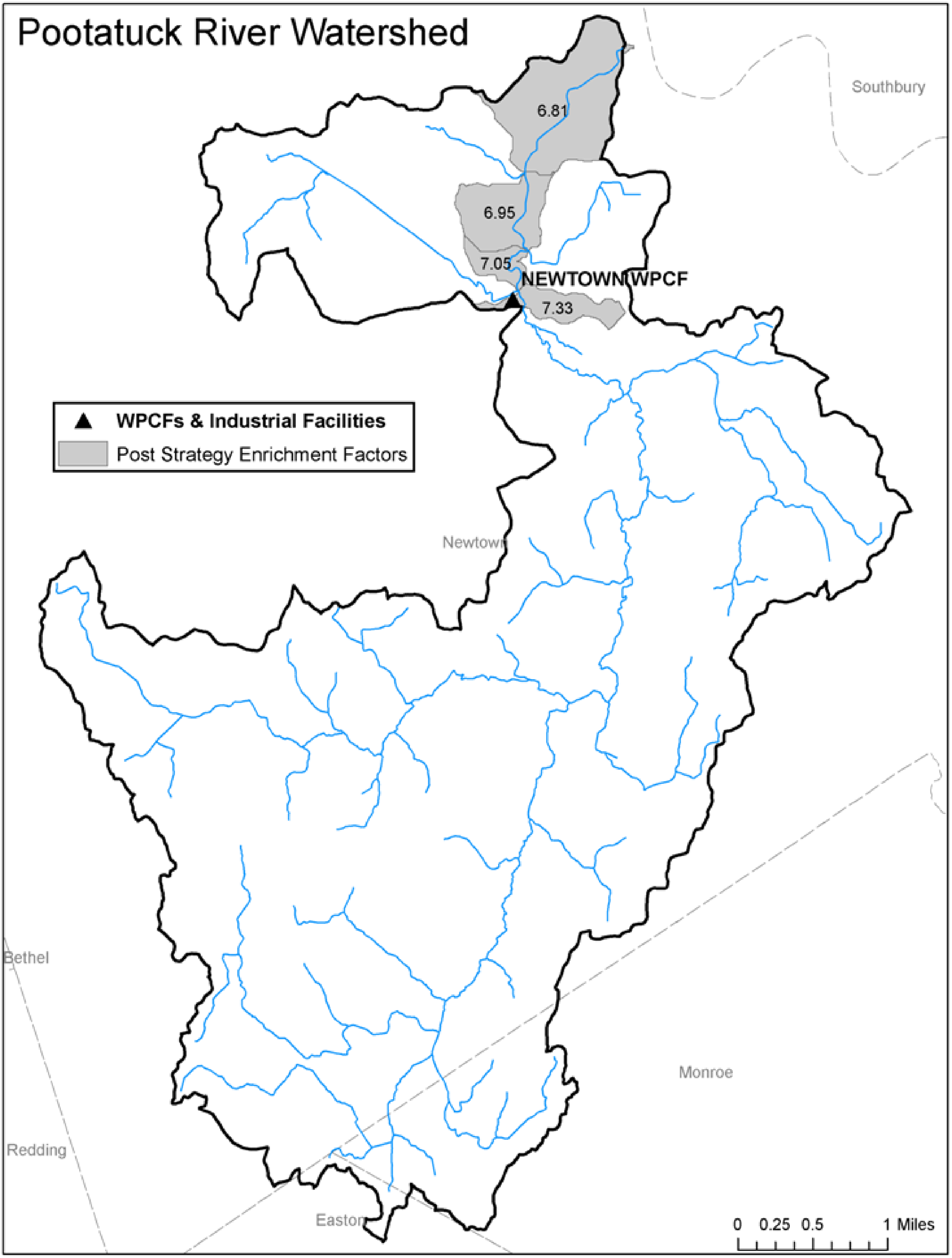
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left(\text{lbs}/_{\text{day}}\right) + \text{Land Cover Load}\left(\text{lbs}/_{\text{day}}\right)}{\text{Forested Condition Load}\left(\text{lbs}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| NEWTOWN WPCF | 4.01 | 6.86 | 1.48 | **7.33** | 4.01 | **7.33** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Quinebaug River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| THOMPSON WPCF | CT0100706 | THOMPSON | 1.36 | AS, DChlor |
| PUTNAM WPCF | CT0100960 | PUTNAM | 2.91 | AS, DChlor |
| KILLINGLY WPCF | CT0101257 | DANIELSON | 8.00 | AS, DChlor, TFilt |
| PLAINFIELD NORTH WPCF | CT0100447 | PLAINFIELD | 1.08 | AS, DChlor |
| PLAINFIELD WPCF | CT0100439 | PLAINFIELD | 0.71 | AS, EA, DChlor |
| GRISWOLD WPCA | CT0100269 | JEWETT CITY | 0.50 | AS, OD,PRem, UV, (Nitr, DNitr capable) |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| THOMPSON WPCF | 0.36 | 2.32 | 6.29 | **0.7** | 2.10 |
| PUTNAM WPCF | 1.44 | 1.80 | 19.69 | **0.7** | 8.41 |
| KILLINGLY WPCF | 3.12 | 1.58 | 40.64 | **0.7** | 18.23 |
| PLAINFIELD NORTH WPCF | 0.66 | 3.52 | 17.82 | **0.7** | 3.86 |
| PLAINFIELD WPCF | 0.43 | 3.13 | 10.51 | **0.7** | 2.51 |
| GRISWOLD WPCA | 0.50 | 2.11 | 5.52 | **0.7** | 2.92 |

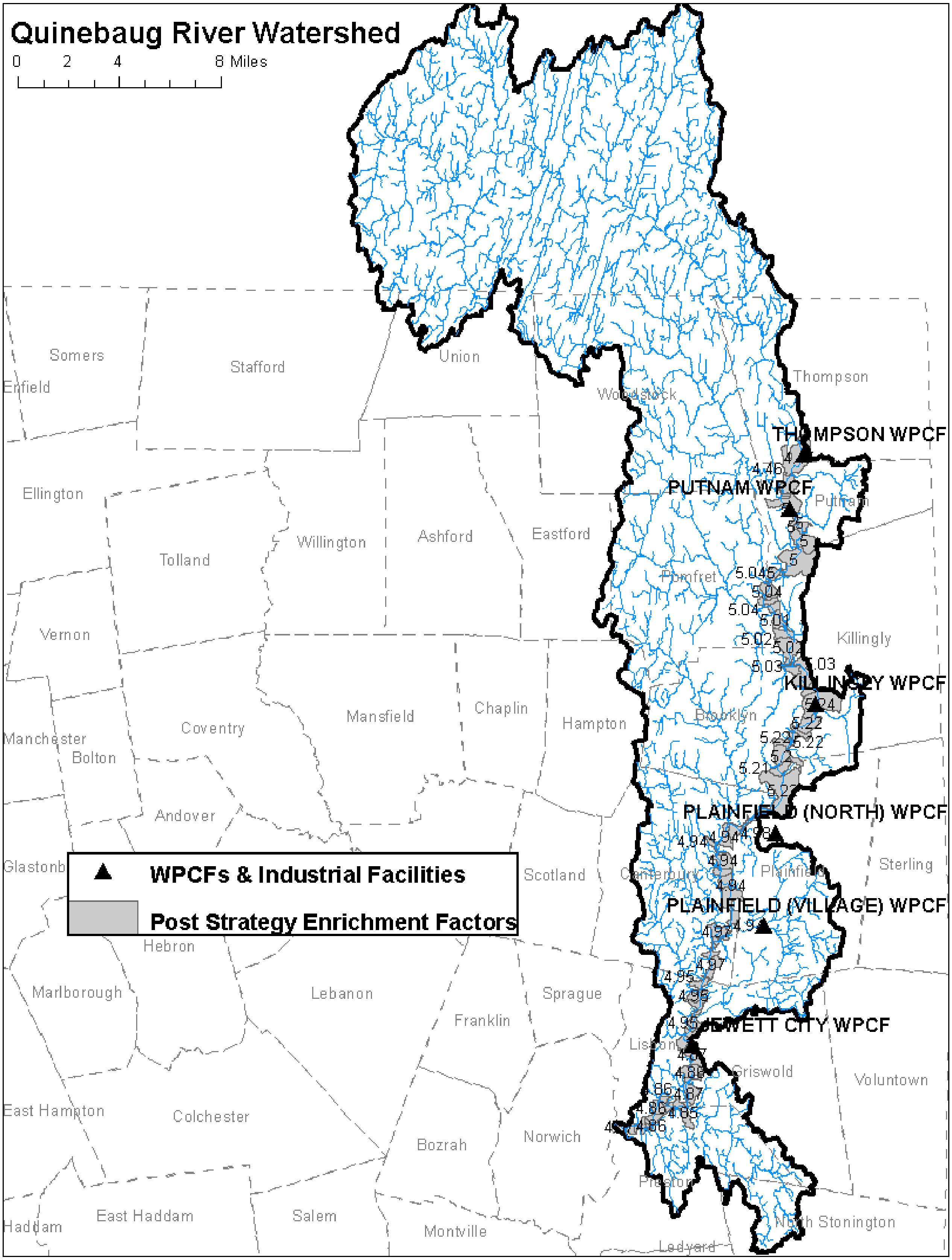
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load} \left(\frac{lbs}{day}\right) + \text{Land Cover Load} \left(\frac{lbs}{day}\right)}{\text{Forested Condition Load} \left(\frac{lbs}{day}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| THOMPSON WPCF | 6.29 | 25.65 | 7.45 | **5.80** | 2.10 | **5.30** |
| PUTNAM WPCF | 25.98 | 78.18 | 21.60 | **5.70** | 10.52 | **5.00** |
| KILLINGLY WPCF | 66.62 | 111.14 | 30.42 | **6.50** | 28.75 | **5.20** |
| PLAINFIELD NORTH WPCF | 84.44 | 133.45 | 37.22 | **6.40** | 32.60 | **5.00** |
| PLAINFIELD WPCF | 94.95 | 152.67 | 41.70 | **6.40** | 35.12 | **5.00** |
| GRISWOLD WPCA | 100.47 | 172.44 | 47.25 | **6.20** | 38.04 | **4.90** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Quinnipiac River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| SOUTHINGTON WPCF | CT0100536 | SOUTHINGTON | 7.40 | AS, AdvTr, TFilt, UV, Nitr |
| CHESHIRE WPCF | CT0100081 | CHESHIRE | 3.50 | AS, Nitr, DNitr, DChlor |
| MERIDEN WPCF | CT0100315 | MERIDEN | 11.60 | AS, AdvTr, DChlor, Nitr, DNitr |
| WALLINGFORD WATER & SEWER | CT0100617 | WALLINGFORD | 8.00 | RBC, UV, Nitr, DNitr, AdvTr |
| CYTEC INDUSTRIES INC. | CT0000086 | WALLINGFORD | | |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| SOUTHINGTON WPCF | 4.51 | 2.74 | 100.00 | **0.2** | 7.53 |
| CHESHIRE WPCF | 2.43 | 4.61 | 88.20 | **0.2** | 4.06 |
| MERIDEN WPCF | 10.44 | 1.47 | 121.64 | **0.1** | 8.71 |
| WALLINGFORD WATER & SEWER | 5.36 | 3.46 | 145.16 | **0.2** | 8.95 |
| CYTEC INDUSTRIES INC. | 1.79 | 1.31 | 19.44 | **0.1** | 1.49 |

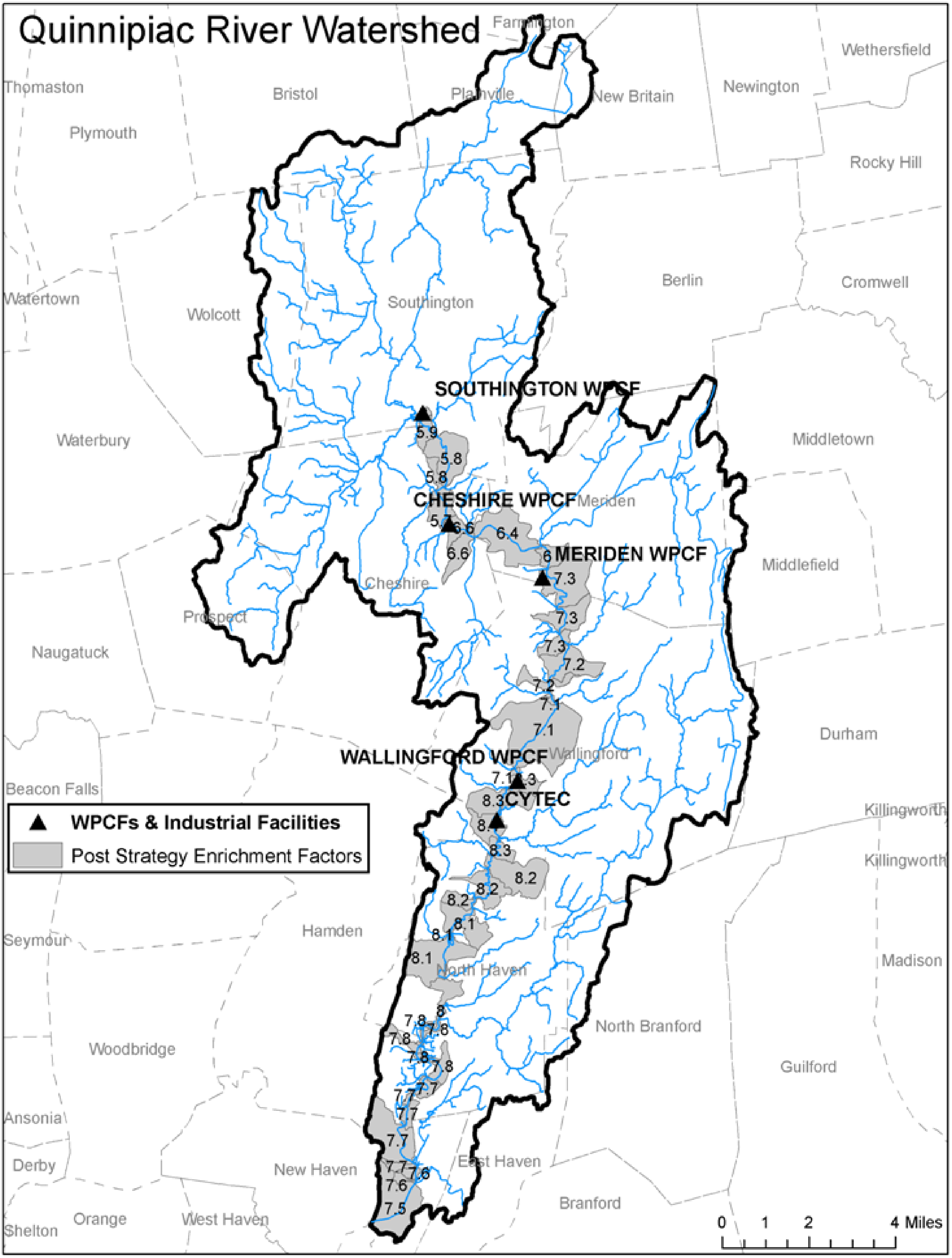
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left({}^{\text{lbs}}/_{\text{day}}\right) + \text{Land Cover Load}\left({}^{\text{lbs}}/_{\text{day}}\right)}{\text{Forested Condition Load}\left({}^{\text{lbs}}/_{\text{day}}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| SOUTHINGTON WPCF | 100.00 | 14.61 | 3.72 | **30.80** | 7.53 | **6.00** |
| CHESHIRE WPCF | 188.20 | 18.77 | 4.61 | **44.90** | 11.59 | **6.60** |
| MERIDEN WPCF | 309.84 | 26.41 | 6.38 | **52.70** | 20.30 | **7.30** |
| WALLINGFORD WATER & SEWER | 455.00 | 31.45 | 7.34 | **66.20** | 29.25 | **8.30** |
| CYTEC INDUSTRIES INC. | 474.44 | 32.47 | 7.50 | **67.60** | 30.74 | **8.40** |

## Nutrient Enrichment Analysis Watershed Overview

### Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Shetucket River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| SPRAGUE WPCF | CT0100978 | Baltic | 0.40 | AS, EA |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| SPRAGUE WPCF | 0.17 | 2.68 | 3.11 | **Cap** | 3.11 |

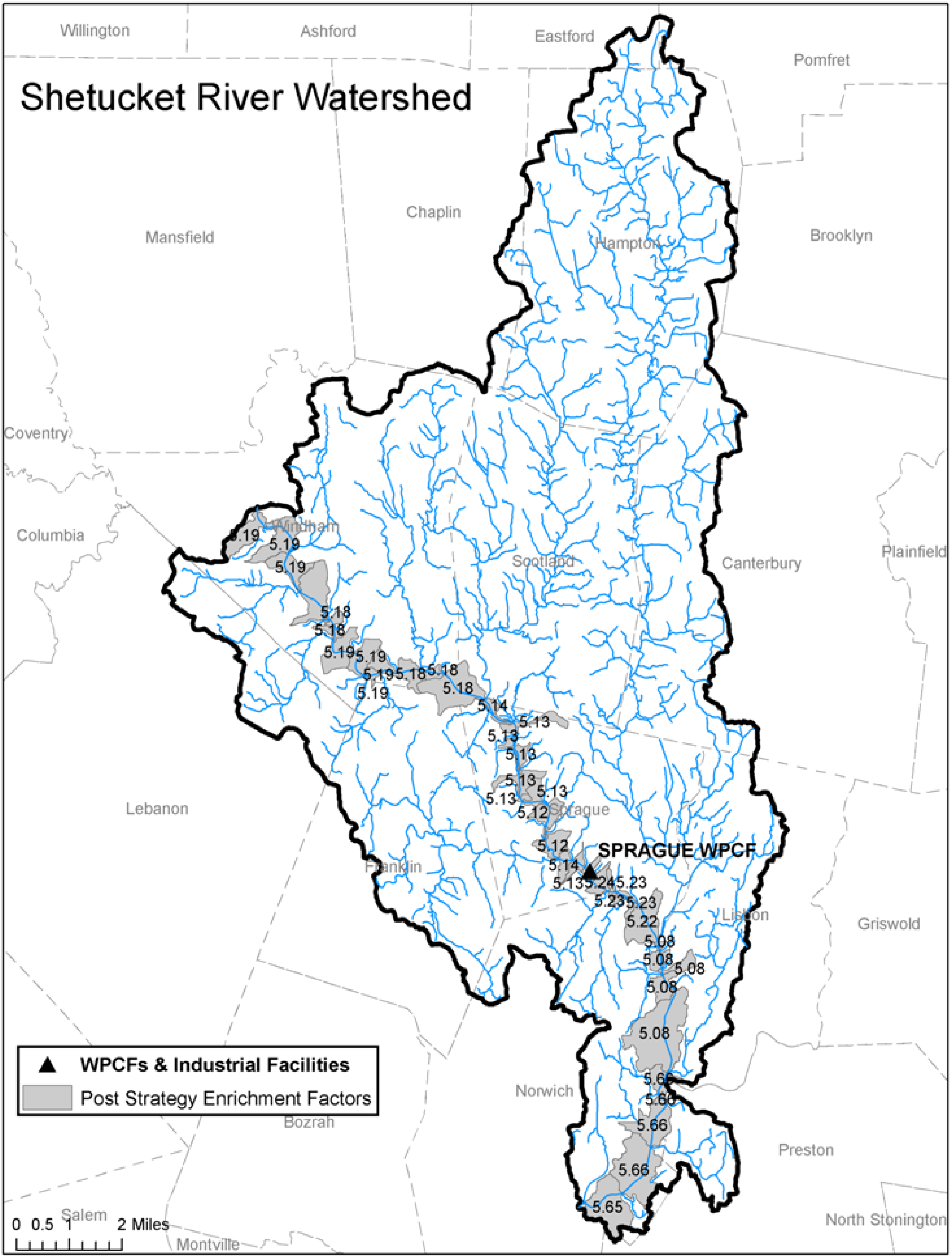
### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left(\text{lbs}/\text{day}\right) + \text{Land Cover Load}\left(\text{lbs}/\text{day}\right)}{\text{Forested Condition Load}\left(\text{lbs}/\text{day}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| SPRAGUE WPCF | 54.11 | 107.31 | 30.83 | **5.20** | 54.11 | **5.20** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors



# Nutrient Enrichment Analysis Watershed Overview

## Willimantic River Watershed

### Facility Overview

| NPDES | NPDES# | Town | Design Flow | Type of Treatment* |
|---|---|---|---|---|
| STAFFORD WPCA | CT0101214 | STAFFORD SPRINGS | 2.00 | AS, UV, Anthracite Filters |
| UCONN WPCF | CT0101320 | STORRS | 3.00 | AS, ADvTr, OD, Nitr, DNitr, DChlor |
| WILLIMANTIC WPCF | CT0101001 | WILLIMANTIC | 5.50 | AS, DChlor |

* AS = activated sludge, RBC = rotating biological contractor system, SBR = sequencing batch reactor system, EA = extended aeration, OD = oxidation ditch, DChlor = dechlorination, UV = ultraviolet disinfection, AdvTr = advanced treatment, Nitr = nitrification DNitr = denitrification, PRem = phosphorous removal, PAC = powdered activated carbon system, Sfilt = sand filter, TFilt = trickling filter

### Current and Proposed Seasonal Phosphorus Treatment

| NPDES | Current Average Flow (MGD) 2001 - 2007 | Current Average Concentration (mg/L) 2001 - 2007 | Current Average Load (lbs/day) 2001 - 2007 | Proposed Performance Limit (mg/L) | Proposed Permit Load (lbs/day) |
|---|---|---|---|---|---|
| STAFFORD WPCA | 1.49 | 0.71 | 8.61 | **Cap** | 8.61 |
| UCONN WPCF | 1.27 | 2.45 | 23.76 | **Cap** | 23.76 |
| WILLIMANTIC WPCF | 2.42 | 0.95 | 18.63 | **Cap** | 18.63 |

### Enrichment Factor at Point of Discharge

$$\text{Enrichment Factor (EF)} = \frac{\text{Total NPDES Load}\left(\text{lbs}/\text{day}\right) + \text{Land Cover Load}\left(\text{lbs}/\text{day}\right)}{\text{Forested Condition Load}\left(\text{lbs}/\text{day}\right)}$$

| NPDES | Upstream NPDES Load (lbs/day) | Estimated Land Use Export Load (lbs/day) | Forested Condition Load (lbs/day) | Current EF | Proposed Upstream NPDES Load (lbs/day) | Proposed EF |
|---|---|---|---|---|---|---|
| STAFFORD WPCA | 8.61 | 8.99 | 3.54 | **5.00** | 8.61 | **5.00** |
| UCONN WPCF | 32.37 | 21.06 | 7.36 | **7.30** | 32.37 | **7.30** |
| WILLIMANTIC WPCF | 51.00 | 50.78 | 14.89 | **6.80** | 51.00 | **6.80** |

# Nutrient Enrichment Analysis Watershed Overview

## Post Strategy Implementation Enrichment Factors