Niantic River Watershed
Protection Plan

Watershed-wide Strategies to Prevent Nonpoint Source Pollution

Connecticut Department of Environmental Protection
Office of Long Island Sound Programs

September 2006

in cooperation with:
Town of East Lyme
Town of Montville
Town of Salem
Town of Waterford

Niantic River Watershed
Protection Plan

Watershed-wide Strategies to Prevent Nonpoint Source Pollution

Connecticut Department of Environmental Protection
Office of Long Island Sound Programs

September 2006

In cooperation with:

Town of East Lyme
Town of Montville
Town of Salem
Town of Waterford

NIANTIC RIVER WATERSHED PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

NIANTIC RIVER WATERSHED PLAN

1.0 FRONT MATTER

1.1 Acknowledgements

This planning project was made possible by a one-time grant from the National Oceanic and Atmospheric Association's (NOAA) Office of Ocean and Coastal Resource Management (OCRM). The Connecticut Department of Environmental Protection's (CTDEP) Office of Long Island Sound Programs (OLISP) and the Bureau of Water Protection and Land Reuse (BWPLR), in fulfillment of its obligations to administer the State of Connecticut's Coastal Nonpoint Source Pollution Control Program (CNP), developed in accordance with Section 6217 of the federal Coastal Zone Act Reauthorization Amendments (CZARA) of 1990, selected the Niantic River Watershed as the pilot area for the project.

The consulting team, led by Kleinschmidt Associates, would like to acknowledge the valuable contributions of the project steering committee to successfully complete this effort. Each member of this committee provided input and guidance, which enhanced the overall process. We would like to thank the following individuals and their organizations for their active participation on the project steering committee:

Marcia Balint, CTDEP OLISP
Colleen Bezanson, Town of Montville
Allison Branco, UCONN Avery Point, Marine Sciences
Mary Ann Chinatti, Town of Salem
Maureen Fitzgerald, Town of Waterford
John Gaucher, CTDEP OLISP
Fred Grimsey, Save the River, Save the Hills
Mary-Beth Hart, CTDEP OLISP
Kristal Kallenberg, CTDEP OLISP
Dr. Jim Kremer, UCONN Avery Point, Marine Sciences
Don Landers, East Lyme Harbor Management/Shellfish Commission
John Mullaney, USGS
Meg Parulis, Town of East Lyme
Sally Snyder, Town of Salem
Paul Stacey, CTDEP Nonpoint Source Program

Eric Thomas, CTDEP Watershed Management Program
Jamie Vaudrey, UCONN Avery Point, Marine Sciences
Tom Wagner, Town of Waterford

Other individuals offered their time, support and expertise to this project. We would like to acknowledge these people and organizations for their generous and valuable contributions: Jim Citak and Shannon Kelly of CT Department of Agriculture, Bureau of Aquaculture (CT DA/BA); CPT J. Muller and SSG D.J. Cherouny of the CT Army National Guard; Town of Waterford Public Schools; and University of Connecticut (UCONN) Nonpoint Education for Municipal Officials (NEMO).

1.2 Executive Summary

The Niantic River does not currently meet state water quality standards because of high levels of indicator bacteria and observed degradation of aquatic life. According to the State of Connecticut's *§303(d) List of Impaired Waters*, the Niantic River is not supporting activities such as shellfishing and swimming; the Niantic River's shellfish beds are closed after rain events of one inch or more. The *§303(d) List of Impaired Waters* states that the water quality of the Niantic River is not supporting the aquatic life known to inhabit the estuary. Symptoms of this condition include, algal blooms, seasonal variations in eelgrass populations, loss of scallop populations and changes to the fish communities. These ecological changes are thought to be linked to excessive nutrients, especially nitrogen, entering the river.

Bacteria and nitrogen enter the Niantic River from several sources. Historically, marine vessels, inadequately functioning septic systems and stormwater runoff have been cited as the primary sources of these and other pollutants to the Niantic River. As East Lyme and Waterford continue to extend domestic wastewater sewers to homes along the river, Salem and Montville enforce their surface water protection areas and marine vessels are prohibited to dump sanitary wastewater into the river, stormwater runoff has become the primary target for protecting the Niantic River. Stormwater runoff transports pollutants of the land into the many drainages and tributaries feeding the Niantic River.

This widespread, *nonpoint source pollution* is the greatest threat to the water quality and ecological health of the Niantic River.

The Niantic River Watershed Protection Plan was put together for the communities and advised by a Steering Committee with the vision to improve water quality throughout the watershed, eliminate shellfish bed closures, support fish and wildlife habitat and provide safe and healthy recreational areas. It is the commitment of the advisory committee that will make this plan a success. This plan takes a *watershed approach* to addressing the problems of nonpoint source pollution associated with the Niantic River, rather than a site specific approach. It considers the hydrologic, or watershed, boundaries of the Niantic River to characterize pollution sources and to develop strategies to address them. Through this scope, we examined the characteristics and land uses of the watershed to better understand the current and potential risk of nonpoint source pollution. Based on these risk assessments, it can then be determined what measures should be taken to decrease nonpoint source pollution to protect the Niantic River and its tributaries.

Examination of the watershed was facilitated by the use of aerial photography, Geographic Information Systems (GIS) and stormwater models. Existing land use and water quality reports for the watershed were also consulted. From these sources, several key findings about the Niantic River Watershed and nonpoint source pollution were identified.

Several recommendations are made throughout this report, in addition to many findings and results from various analyses that have been completed. The following is a summary of key findings, in addition to an outline of key recommendations for implementing various improvement plans within the watershed.

Key Project Findings

Data Assembly & Results	• Fifteen or more storm sewer outfalls discharge untreated runoff directly into the Niantic River. These outfalls collect runoff from several drainage areas of various sizes along the Niantic River shoreline.
	• As a watershed's imperviousness increases, the quality of its streams decreases – a relationship well-established in scientific literature. Five drainages of the Niantic River are currently covered by over 10% impervious surfaces such as roads, parking lots, sidewalks and roofs. At fully developed conditions (maximum development allowed by current planning and zoning regulations), ten drainages in the watershed will be covered by 10% or more imperviousness and one drainage will be over 30% impervious surface cover.
	• Stormwater modeling showed increased loading to the Niantic River from existing development, but drainages adjacent to the lower river are fairly developed with respect to the remainder of the watershed. Any areas that may be considered developable pose a risk for direct discharge to the lower river by increasing the pollutant loading through its tributaries.
	• Undeveloped areas further upstream in the watershed pose a great risk to increasing loads to town water supply reservoirs. Preservation of lands abutting receiving waterbodies is as much a key component to water quality protection as is stabilizing and treating existing development.
	• Tracked development of the watershed has steadily increased since monitoring using aerial images was implemented in 1985. Since that time, over a thousand acres of forest has been converted into either developed, barren or grassed lands.
Zoning	• Each of the towns are making great efforts to do their part in protecting the waters of their communities. A more effective approach may be to match wetland protection requirements for a consistent watershed wide approach to protecting water quality. For example, the towns of East Lyme and Waterford each have a 100-foot upland review for wetlands and watercourses, where the towns of Montville and Salem have different buffer areas.
Environmental	• Eelgrass populations plummeted in 1999, but experienced a rebound in 2003 and 2004. The future of the grass is still questionable and requires regular protection and monitoring. It is believed that continued growth of the eelgrass populations will also aid in restoring shellfish populations, although the increased predation by an overall increase in fish species may limit growth opportunities.
Monitoring	• Measurement of water quality throughout the watershed is not currently a standard practice. Improvements may be made through BMP and planning changes, but without practical measurement techniques, it becomes difficult to measure, monitor and adjust.
	• Monitoring and inspection programs, which are making great progress are underway in the Towns of Waterford and East Lyme, but the potential for future development is the greatest in the upper reaches of the watershed.

Key Recommendations

Zoning	• Town zoning should allow the use of non-traditional Best Management Practices by granting variances to standard subdivision or building requirements. Examples of waivers may include: o Curb requirements o Mandatory sidewalks o Pavement specifications o Density allowances o Building Low Impact Design (LID) techniques
	• Continue the establishment of open space preservation. Techniques for managing open space include: o Preservation of contiguous wildlife corridors o Maintain no-disturb buffers around wetlands and waterbodies
Management & Monitoring	• The Project Steering Committee should consider the formation of a watershed partnership or coalition. This body could be an ad hoc entity to regularly meet and collaborate on the implementation of specific aspects of the watershed plan, as mentioned. Or, the entity could be formed as a subcommittee of the Southeastern Connecticut Council of Governments, which may also assist in coordinating the body and implementing the plan.
	• Establish a full time watershed coordinator who would coordinate activities between all the towns. Such a position would supplement individual town stormwater utility districts.
	• Public monies should be used to purchase lands for preservation. This becomes even more prevalent in the case of protecting lands abutting the major reservoirs that are water supplies.
	• Development of a specific stormwater management utility. Such an entity would be responsible for implementing watershed water quality monitoring, post-construction inspections, street sweeping activities and stormwater retrofitting upgrades. Costs of equipment, monitoring and maintenance could be shared between the towns.
	• Avoid 'short-circuiting' of stormdrain discharges. Buffers may be placed along a stream, but a pipe discharging directly to the stream passes by the buffer without allowing for any attenuation or treatment of flows.
Educational	• Marinas in the Niantic River should be encouraged to become Certified Connecticut Clean Marinas to develop clean maintenance and operation activities. This also aids educating the boaters who use these marinas and the Niantic River.
	• Education is a key component to maintaining water quality. Certain educational programs are currently being implemented and should continue to be regularly provided for general residents, business owners, contractors, schoolchildren and town officials. Increased knowledge of good 'house-keeping' practices will only help to preserve water quality. Official education plans should be outlined and presented on an annual or bi-annual basis. Results from regular monitoring plans, development changes in the watershed and constantly changing technologies truly mandate a continual education program. Further discussions about implementing education plans may be found in Section 7.

A suite of watershed management options to address the study's key findings were developed. Land use and regulatory options were considered and discussed with the planners from the four watershed towns. Administrative and programmatic recommendations were included in the suite of options. These recommendations consist of educational activities, financial strategies and specific stormwater management measures. Where possible, management recommendations are assigned to specific areas of the watershed and associated with specific water quality targets. Together these items make up the Niantic River Watershed Protection Plan, which with the continued support of the stakeholders engaging the public, the communities and local organizations can work to protect and enhance the countless uses enjoyed by all in the watershed.

2.0 INTRODUCTION

This document was written with the intention of guiding the decisions of people working in government and business, as well as those property owners within in the watershed whose activities impact the quality of the Niantic River and its tributaries. It is meant to inform this general audience about known and suspected water quality issues and to recommend actions to address them. The most current and available science describes what we know about these issues and why they are important to all of us. Standard and innovative land use and water resource management practices provide techniques that equate to the best approaches for dealing with these issues.

To better under the genesis of this planning document, several key questions are addressed below.

2.1 Why is this plan needed?

The Niantic River does not meet State of Connecticut water quality standards. From the Golden Spur to the Amtrak Bridge, the use of the river for swimming, shellfish and other recreation is impaired because of excessive bacteria levels. Also, the river does not support the diversity and abundance of aquatic life expected to be found in the river. The cause of this impairment to aquatic life is not completely understood; however, there is a building body of scientific evidence that states that the river is overloaded with nutrients, primarily nitrogen. Nitrogen enriches the brackish Niantic River water, like fertilizer on a lawn, increasing algal and plant growth. Like bacteria, nutrients flow to the river with stormwater and are considered a problem of nonpoint source pollution.

Uses and enjoyment of the Niantic River are impacted by poor water quality and nonpoint source pollution. The water quality of the Niantic River is poor enough so that shellfishing and swimming are limited. Following one inch of rainfall, the State of Connecticut is required to close the shellfish beds of the Niantic River. Rain carries bacteria into the river where it is filtered by shellfish rendering them unsafe for consumption. Normally it would take 14 to 28 days for shellfish to cleanse themselves (depurate) so that potentially harmful bacteria are no longer a concern (until the next 1" rainstorm).

Changes in how we use and enjoy the Niantic River are linked to the overall health of the Niantic River ecosystem, which is also changing and maybe not for the better. Populations of marine plants and animals commonly found in the Niantic River have decreased over the past 4 decades (Millstone Environmental Laboratory (MEL), 2005). Beginning in the 1980s, a sharp decline in eelgrass (*Zostera marina*) was documented (Marshall, 1994) and in more recent years, eelgrass in the Niantic has shown annual variation (MEL, 2005). Scallops and winter flounder rely on eelgrass as nursery habitat and are practically missing from the Niantic River (Heck, *et al.*, 1995; MEL, 2005). Meanwhile, new species like green crabs and grubby, appear to be on the rise in the River (MEL, 2005).

Degraded water quality is thought to be an important driving force in these ecological changes. In particular, excessive nitrogen loading from nonpoint sources, predation, increased water temperatures and disease are all implicated are causes of this ecological situation (Marshall, 1994; CTDEP, 2002b; MEL, 2005). So, what can be driving these changes?

As time progresses, we become more certain of the causes of these *water quality impairments* and their relationship to ecosystem changes. Bacteria and nitrogen are the two greatest concerns for the quality of the Niantic River. Polluted runoff, illegal marine discharges and sewer line accidents are the most probable sources of bacteria to the Niantic (CT DA/BA, 2005). Nitrogen, polluted runoff, atmospheric deposition and groundwater inputs are critical water quality concerns for the Niantic River (Marshall, 1994; Mullaney, 2006; Stacey, 2004). For instance, we know that polluted runoff accounts for approximately half (50%) of the nitrogen inputs into the Niantic River. These inputs are the focus of this study. Atmospheric deposition of nitrogen accounts for approximately 10% of the nitrogen making its way to the river (Marine Biological Laboratory, 2006). The remaining nitrogen is most likely coming from septic systems through groundwater (Mullaney, 2006).

Significant investments have been made to control pollution to the Niantic River. East Lyme and Waterford have sewered many of the neighborhoods along the shores of the river to eliminate the risk of bacterial and nutrient pollution from septic systems. The Niantic boating community is being encouraged to observe the No Discharge Zone on river to control sewage from marine vessels. These efforts, combined with advances in stormwater management, offer hope that impacts from historic activities can be turned around. However, the impacts and management of nonpoint source pollution (*i.e.* polluted runoff and stormwater) remain.

The nature of nonpoint source pollution makes it extremely challenging to manage. It is decentralized (sources vary and are scattered), cumulative (pollution results not from one, voluminous event; rather, it occurs over time in regular, periodic rain/runoff events), and systematic (an entire hydrologic unit [watershed] is both the scope and scale of the problem). In the case of the Niantic River, pollution is transported to the mainstem via several smaller streams, each carrying pollutant loads emanating from sources somewhere else in the watershed. Hence, effectively managing nonpoint source pollution issues relies on an approach that is comprehensive and watershed-based, *i.e.* scaled according to the natural system to be managed.

Although watershed-based management plans have been recognized as the approach to dealing with nonpoint source pollution, they are not without their own set of challenges. For instance, watershed boundaries are not political boundaries, therefore several jurisdictions often have a stake in watershed management. The Niantic River Watershed includes portions of four towns – East Lyme, Montville, Salem, and Waterford. Therefore, watershed management relies on participation and execution from all four communities.

Watershed management boils down to *land use* management. By and large, land use planning and regulation, including the management of runoff (*i.e.* stormwater), lies with the municipalities. Current nonpoint source pollution problems are linked to historic development and stormwater management in these four communities. Like all coastal watershed communities in Connecticut, population and development pressure will continue to yield more full-time residents, housing and other developments, thereby increasing the potential for nonpoint source pollution problems. (NOAA, Spatial Trends in Coastal Socioeconomics (STICS), 2006).[1]

As the last remaining parcels of developable land are converted to commercial, trial, and residential uses, the quantity and quality of stormwater runoff can be expected to change. Therefore, it is central to this plan that polluted runoff be considered the greatest water quality management challenge for the Niantic River, primarily because it is considered the most *manageable* of all potential sources of pollution to the river. That is to say there is *real hope and possibility to prevent further degradation of the Niantic River and to restore it to an improved condition.* This plan is needed to establish a coherent and practical approach to dealing with nonpoint source pollution in the Niantic River Watershed.

The plan and the lessons learned from the planning process will assist the State of Connecticut to manage many of its coastal watersheds. The State of Connecticut's Coastal Nonpoint Source Pollution Control Program, developed in accordance with Section 6217 of the federal Coastal Zone Act Reauthorization Amendments of 1990, instigated this project with the hope that it will serve as a pilot study for other watersheds. The Niantic River Watershed was chosen because of its relatively manageable size; presence of known water quality issues; development pressure; active and participatory municipalities; and rich natural resources.

2.2 How was the plan developed?

The Niantic River Watershed Protection Plan was developed as a result of a research and planning project funded by the CTDEP's OLISP. The CTDEP OLISP and the BWPLR have received a one-time grant from NOAA's OCRM to develop a watershed protection plan for a small coastal watershed located within Connecticut's coastal nonpoint source pollution management area. The project was directed by a

[1] According to population statistics provided by NOAA, the coastal watersheds of New London County experienced population growth as follows: 230,348 (1970), 238,409 (1980), 254.957 (1990), 259,080 (2000), 266,466 (2004).

Steering Committee composed of representatives from the Towns of East Lyme, Montville, Salem, and Waterford; CTDEP (several offices); U.S. Geological Survey (USGS); UCONN; and Save the River, Save the Hills. A consulting team, led by Kleinschmidt Associates of Essex, Connecticut, was responsible for completing the project and drafting the plan. Figure 2.2-1 shows the project team organization.

The plan follows federal guidelines for a watershed management plan. Two documents, in particular, were consulted throughout the plan development process. The US Environmental Protection Agency (USEPA) issued in 2005 the *Draft Handbook for Developing Watershed Plans to Restore and Protect our Waters,*[2] which guides plan development according the nine key elements of a nonpoint source/watershed management plan (Table 2.2-1).

Table 2.2-1. The Nine Key Elements of a Watershed Plan

Key Element of a Watershed Plan	Plan Section
Identify causes and sources of pollution that need to be controlled	4.2 through 4.4
Determine load reductions needed	4.5.3
Develop management measures to achieve goals	6.1
Develop implementation schedule	7.3
Develop interim milestones to track implementation of management measures	6.2
Develop criteria to measure progress toward meeting watershed goals	6.2
Develop monitoring component	7.5
Develop information/education component	7.2
Identify technical and financial assistance needed to implement plan	7.1 and 7.4

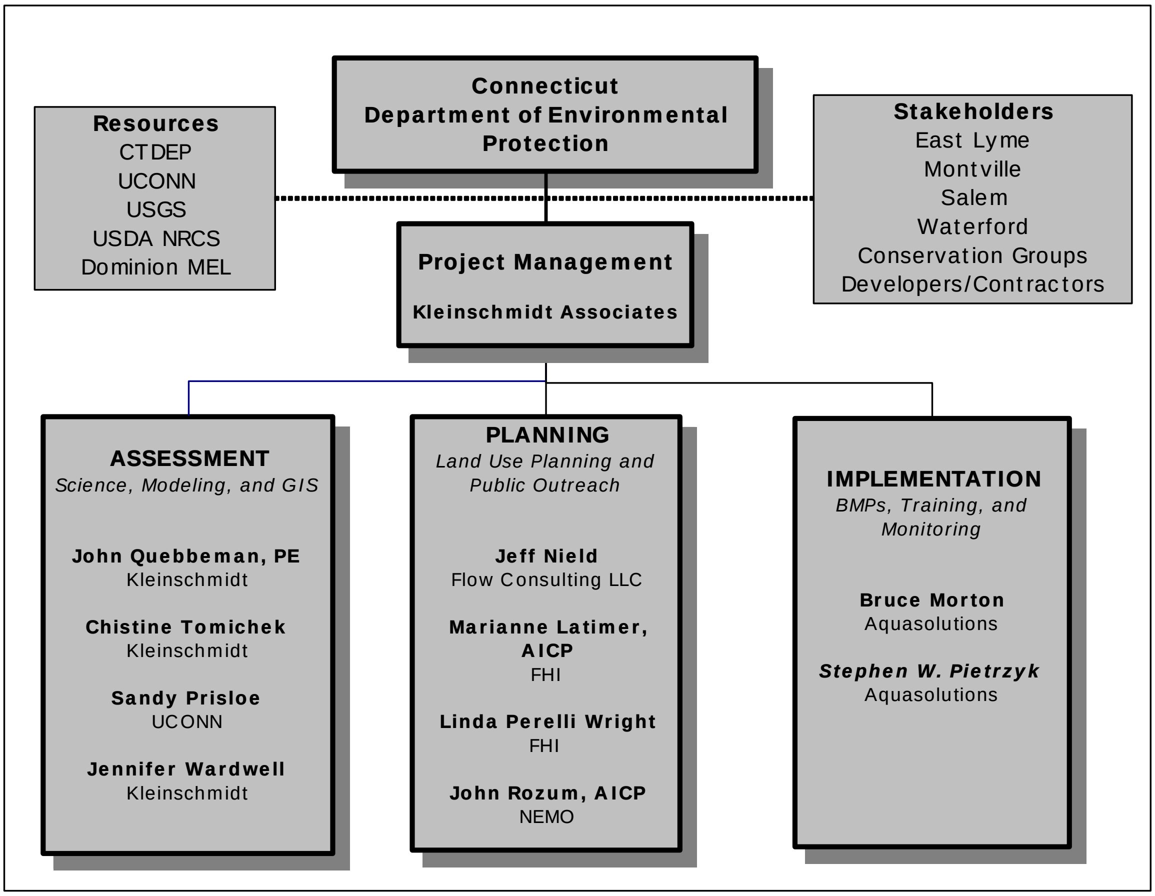
Also from USEPA, *Getting in Step: A Guide for Conducting Watershed Outreach Campaigns,*[3] was used as a reference to develop information and education (I/E) strategies for the Niantic River Watershed Protection Plan.

[2] http://www.epa.gov/owow/nps/watershed_handbook/pdf/handbook.pdf

[3] http://www.epa.gov/owow/watershed/outreach/documents/getnstep.pdf

The project consisted of several key components that led to the development of the plan. Part research project and part planning exercise, the Niantic River project relied on the input of scientists specializing in water quality and marine ecology, concerned citizens dedicated to preserving the Niantic River for future generations, and watershed managers tasked with managing governmental programs and policies dealing with the Niantic. The key steps take to develop the Niantic River Watershed Protection Plan are summarized below:

Figure 2.2-1. Project Team Organization



Step 1: **Describe the watershed** – This step was accomplished by gathering available physiographic, biological, and socioeconomic data about the Niantic River Watershed.

Step 2: **Identify existing water quality issues of concern** – Issues were identified by reviewing scientific literature and government documents, as well as talking with a wide range of watershed stakeholders.

Step 3: **Assess potential threats to the watershed and water quality** – The assessment of watershed threats consisted of several parts:

- Development of a 2004 land cover dataset
- Projection of future development/watershed land conversion by completing a future built-out analysis
- Estimation of current and future impervious surface coverage
- Analysis of the vulnerability of watershed lands to nonpoint source pollution

Step 4: **Identify watershed management priorities**, *i.e.* greatest potential and manageable threats.

Step 5: **Identify watershed management measures to minimize pollution** Implementation of land use regulations along with the corresponding Best Management Practices (BMPs), which address nonpoint source runoff and most importantly control nutrient levels reaching the Niantic River.

Step 6: **Estimate potential nonpoint source pollution reductions** from selected management measures, where applicable.

Step 7: **Develop monitoring, financial, and I/E recommendations** to implement the watershed plan.

2.3 How does this plan interact with other water quality protection and watershed management efforts?

This plan strives for a **consensus-driven**, **voluntary** and **regional** approach to improving the water quality of the Niantic River and its tributaries by managing nonpoint source pollution throughout the watershed. Ongoing planning, regulatory and research efforts are discussed in this document as the building blocks of future action. The plan should help coordinate and build upon ongoing efforts by offering management (*e.g.* communication and implementation) strategies to do so. It is also **prioritizes** efforts and actions that should be focused on in order to reach watershed management and water quality goals.

It should also be noted that the plan's recommendations are derived from current watershed assessments, *i.e.* they are original works of this study. The results of these assessments provide a scientific basis for the management recommendations included in the plan, which strive to affect land use decisions. Land use decisions on the local level, in particular, can be guided by the results and recommendations in this plan. In this regard, the plan will *strengthen* land use decision-making by informing the process with valuable scientific information.

It is important to recognize past and recent efforts to prevent pollution of the Niantic River and its tributaries. Many participants in this planning process expressed interest in learning if these efforts have made a difference in the water quality of the river so far and how this current effort will build on past successes. Below is a list of some of the water quality protection milestones that have been met in recent years:

- Infrastructural improvements (*e.g.* centralized wastewater treatment) in East Lyme and Waterford have decreased the potential impact of aging septic systems serving the shoreline neighborhoods of these towns.

- Town planning and zoning in the watershed has generally trended toward more protective stormwater management measures.

- Application for "No Discharge Zone" designation for the Connecticut coastline including the Niantic River decreases the risk of sewage discharge from marine vessels into the system.[4]

This study did not ascertain the effectiveness of these past efforts to improve the Niantic River. Water quality monitoring was not a facet of this project. With that, the study assumes that past efforts to decrease pollution sources are having a positive impact on the watershed and the river. This assumption has led to two important points to consider for the future of managing the watershed: 1) nonpoint sources of pollution are the greatest water quality management challenges and 2) the lack of water quality data for the Niantic River and its tributaries is greatly impeding how well we can account for past (and future) investments to improve them. On a positive note, several research and management efforts are underway that will increase our understanding of the water quality and ecological health of the river, which must be considered in a comprehensive management strategy for the watershed (Table 2.3-1).

---

[4] For No Discharge Zone designation for the CT coast from Eastern Point in Groton to Hoadley Point in Guilford refer to CFR 71 FR 27721, dated May 12, 2006.

Table 2.3-1. Current Research and Management Activities that are Important to Protection of the Niantic River and its Tributaries

Entity/Organization	Program/Project	Purpose/Expected Outcome/Status
Departments of Public Works East Lyme and Waterford	*Stormwater Management Program Plan Implementation*	Decrease in the volume and pollution of stormwater runoff into the Niantic River. Six stormwater management measures: 1) public education, 2) public involvement, 3) illicit discharge detection and elimination, 4) construction site stormwater runoff control, 5) post-construction stormwater management, and 6) municipal good housekeeping/pollution prevention. The Program Plan has been completed however funding for implementation is extremely limited.
Town of Waterford	*Jordan Cove Urban Watershed Monitoring Project*	A nonpoint source pollution management project in Jordan Cove (a watershed adjacent to the Niantic) that demonstrated many contemporary approaches to control nonpoint source pollution in a coastal watershed. Project is complete.
UCONN Marine Sciences Program at Avery Point Dr. James Kremer	*Nitrogen Loading Model*	This scientific study strives to quantify the effects of nitrogen loading on estuarine ecosystems like the Niantic River. Research in progress.
United States Geological Survey John Mullaney	*Study to Determine Nitrogen Discharge from Groundwater to the Niantic River*	▪ Determine pre-sewer nutrient concentrations in shallow and deep ground water based on two rounds of samples. ▪ Use dissolved gas concentrations to evaluate denitrification in the aquifer. ▪ Monitor post-sewer nitrate concentrations in ground water for one year. ▪ Estimate ground-water loads of nitrogen to the Niantic River before and after sewering. Research in progress.
CTDEP Nonpoint Source Pollution Program and Long Island Sound Study Paul Stacey	▪ *Development of a Nutrient Criteria for the Niantic River* ▪ *Development of a Total Maximum Daily Load (TMDL) for bacteria and nutrients in the Niantic River*	Set critical limits for bacteria and nutrient loadings to the Niantic River as the basis for water quality restoration activities. Research in progress.

2.4 Who should read this plan?

There are four categories of watershed plan stakeholders. The categories are defined by the role the stakeholders play in moving the plan forward. In Table 2.4-1, the stakeholder roles are defined by the questions listed in the left column and the stakeholders in the right column. Many of these stakeholders were involved in the planning process and others may play a minor role in plan implementation.

Table 2.4-1. Watershed Plan Stakeholders

<table>
<tr><td>Who is responsible for implementing the plan?</td><td colspan="2">Property Owners and Managers (e.g. Homeowners, Business-owners)
Developers, contractors and realtors
Local government:
• Directors of Department of Public Works – East Lyme, Montville, Salem, Waterford
• Directors of Planning – East Lyme, Montville, Salem, Waterford
• Environmental Planner/Wetland Officer – East Lyme, Montville, Salem, Waterford
• Zoning Officers
• East Lyme-Waterford Shellfish Commission
• Ledge Light Health District
• Save the River, Save the Hills
State agencies:
• CTDEP Bureau of Water Protection and Land Reuse – OLISP, Nonpoint Source Pollution Program, Coastal Management
• CTDEP Bureau of Natural Resources – Fisheries, Wildlife
• Connecticut Department of Transportation (ConnDOT)</td></tr>
<tr><td>Who is affected by the implementation of the plan?</td><td>Property owners
Anglers</td><td>Recreational users
Boaters</td></tr>
</table>

Who can provide information on the issues and concerns in the watershed?	Property owners Anglers Boaters Local government: • Boards of Selectman, planning, zoning, wetland commissions in East Lyme, Montville, Salem, Waterford. East Lyme-Waterford Shellfish Commission State agencies: • CT Department of Agriculture/Bureau of Aquaculture, CTDEP Bureau of Natural Resources
Who can provide technical and financial assistance in developing and implementing the plan?	State agencies and institutions: • CTDEP Bureau of Water Protection and Land Reuse – OLISP, Nonpoint Source Pollution Program, Coastal Management • CTDEP Bureau of Natural Resources – Fisheries, Wildlife • ConnDOT • CT Department of Agriculture/Bureau of Aquaculture, CTDEP Bureau of Natural Resources (DA/BA) • University of Connecticut Cooperative Extension Federal agencies: • NOAA, USEPA, USGS, USDA NRCS, USFWS

2.5 How is this plan organized?

Following this introductory section, the plan provides an overview of the Niantic River and its watershed (Section 3.0). It describes the Niantic River Watershed as an ecosystem with many remarkable characteristics, unique components and a wide range of uses. The results of the land cover analysis is presented to expand the description of the watershed using several robust datasets developed over the past two decades using digital photogrammetry and GIS.

Section 4.0 discusses the water quality concerns we are attempting to address with this management plan. We begin this discussion by describing the 'driving forces' behind this plan, which are both regulatory and non-regulatory. After completing a review of the nonpoint source pollution issues in the Niantic River Watershed, the plan presents the results of several assessments conducted as a part of this study.

The first assessment is one of future land use and impervious surface cover. These assessments help us predict future threats to the Niantic's water quality by examining future land use. Secondly, a watershed vulnerability assessment is presented, which helps us identify critical areas or high risk areas for nonpoint source pollution. Finally, the results of stormwater modeling are presented. These results include estimates of nonpoint source pollution generated from the watershed under various conditions, including the application of Best Management Practices to control stormwater and the pollutants it carries.

Section 5.0 summarizes the municipalities, agencies and organizations who currently manage the lands and waters in the watershed. Each of these stakeholders are, and will be, responsible for the implementation and enforcement of this plan.

Section 6.0 of the plan presents watershed management recommendations. The recommendations address specific water quality issues of concern. Each recommendation is assigned to a stakeholder(s) responsible for its implementation. Performance measures or indicators are provided for each management measure and strategy for monitoring implementation. Finally, financial options and strategies are discussed in order to address the concern of financing plan implementation.

The final section of the plan, Section 7.0, provides a strategy for an Implementation Program. The Organizational Structure, I/E, Outreach, Schedule, Financial Strategy and Monitoring Components are all presented to assist the Stakeholders in successfully implementing the Watershed Management recommendations presented here.

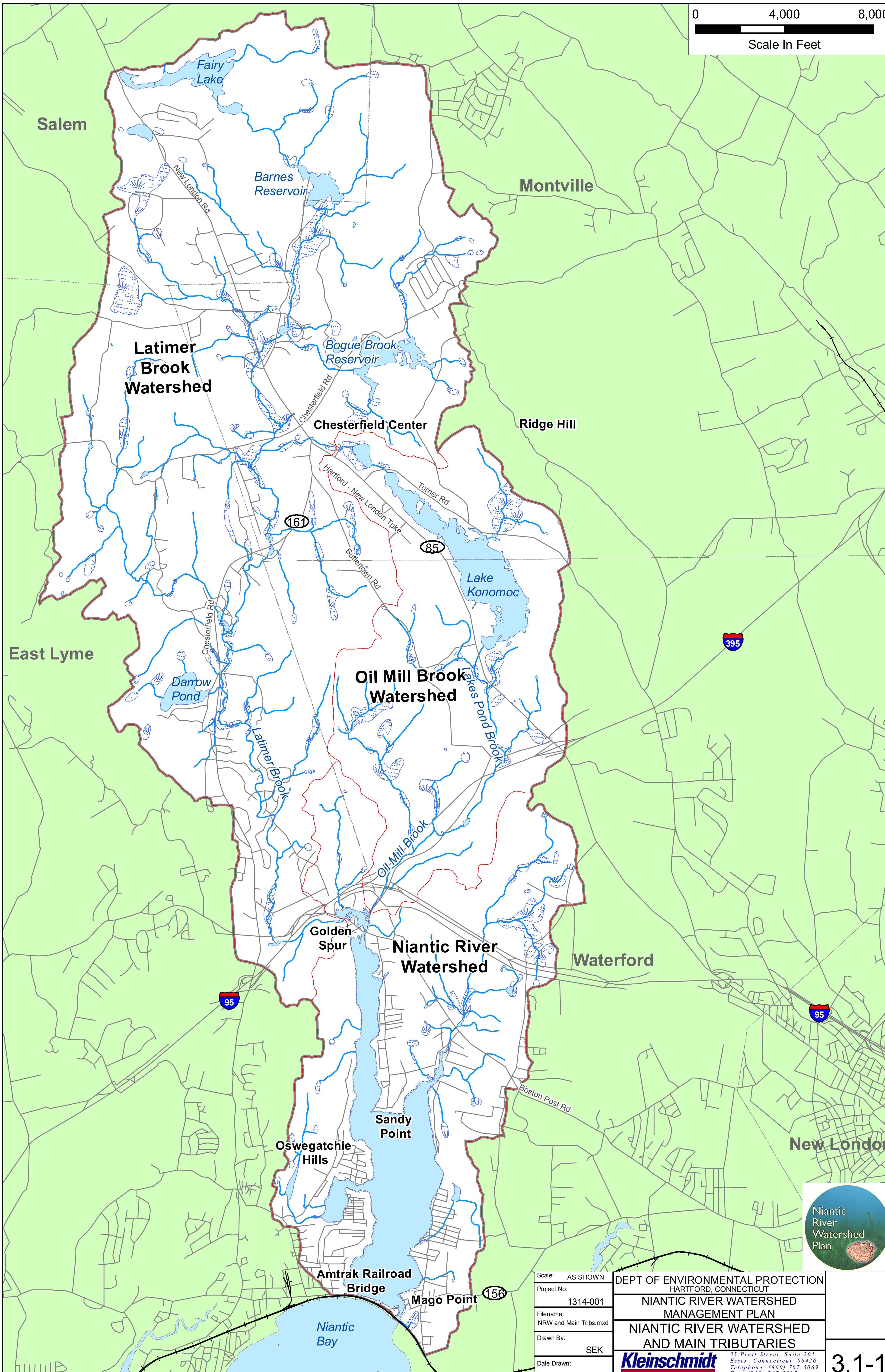
3.0 NIANTIC RIVER AND ITS WATERSHED

3.1 Overview

The Niantic River is an estuary. Freshwater drains from a small coastal watershed to a tidal embayment where fresh water mixes with the salt water of Long Island Sound. Most people relate to the Niantic River as a body of saltwater that provides access to the Sound and to the many marine resources it provides. However, the Niantic is part of larger hydrologic system that reaches miles inland to the Towns of Salem and Montville. The system we refer to is called its watershed.

The Niantic River drainage basin covers 31.3 square miles, or approximately 20,000 acres, and encompasses portions of four municipalities in southeastern Connecticut – East Lyme, Waterford, Salem, and Montville. The river extends from Route 1/Boston Post Road on the Waterford/East Lyme town line, an area known as Golden Spur, southward approximately three miles to its mouth at the Amtrak Railroad Bridge. The drainage basin consists of three subregional tributaries: the Niantic River and its main tributaries Latimer Brook and Oil Mill Brook. The river is also fed by several smaller unnamed tributaries (Figure 3.1-1).

Latimer Brook originates at Fairy Lake, located just east of the Route 82/Route 85 intersection (Salem Four Corners) and flows in a southerly direction, intersecting Barnes Reservoir just downstream of Fairy Lake. As it meanders south, the brook receives drainage from Bogue Brook Reservoir, located northeast of Chesterfield center, and then passes under Route 85 and Route 161, respectively. After crossing under Route 161, it parallels the roadway on the east until its ultimate discharge into the Niantic River at Golden Spur.



0
4,000
8,000
Scale In Feet
Fairy Lake
Salem
Barnes Reservoir
New London Rd
Montville
Bogue Brook Reservoir
Latimer Brook Watershed
Chesterfield Rd
Chesterfield Center
Ridge Hill
Hartford - New London Tpke
Turner Rd
161
85
Butlertown Rd
Lake Konomoc
Chesterfield Rd
395
East Lyme
Darrow Pond
Oil Mill Brook Watershed
Lakes Pond Brook
Latimer Brook
Oil Mill Brook
Golden Spur
Niantic River Watershed
Waterford
95
95
Boston Post Rd
Sandy Point
Oswegatchie Hills
New London
Niantic River Watershed Plan
Amtrak Railroad Bridge
Mago Point
156
Niantic Bay
Scale: AS SHOWN
Project No: 1314-001
Filename: NRW and Main Tribs.mxd
Drawn By: SEK
Date Drawn: 09-07-2006
DEPT OF ENVIRONMENTAL PROTECTION
HARTFORD, CONNECTICUT
NIANTIC RIVER WATERSHED MANAGEMENT PLAN
NIANTIC RIVER WATERSHED AND MAIN TRIBUTARIES
Kleinschmidt
Energy & Water Resource Consultants
35 Pratt Street, Suite 201
Essex, Connecticut 06426
Telephone: (860) 767-5069
Fax: (860) 767-5097
www.KleinschmidtUSA.com
3.1-1

The headwaters of Oil Mill Brook originate near Ridge Hill, located immediately north of Lake Konomoc and east of Route 85 in Montville. Lake Pond Brook flows south joining Oil Mill Brook before passing under Route 85 and Interstate 395, respectively. After briefly paralleling Interstate 395 on the south, Oil Mill Brook receives drainage from Willy's Meadow Brook located to the north of the Interstate 95/Interstate 395 Interchange. Oil Mill Brook then passes under Interstate 95 and discharges into the Niantic River at Golden Spur.

From Golden Spur south to Sandy Point, the Niantic River is approximately 1/4 mile wide. The East Lyme shoreline along this stretch is sparsely developed and consists mainly of cliffs and escarpments and steep wooded slopes with a few small pockets of narrow sandy beach. The area, known as Oswegatchie Hills, consists of over 700 acres of valuable land that offers great recreational potential because of its interesting terrain, and diverse wildlife. It is also one of the last large stretches of undeveloped waterfront land in Connecticut. The Waterford shoreline along this reach consists mainly of sandy beaches and gradual wooded slopes with moderate density residential development.

To the south of Sandy Point, the width of the Niantic River broadens to approximately ½ to ¾ mile and the density of both residential and commercial development gradually increases. From Mago Point to the Amtrak Railroad Bridge, the shoreline is a highly developed commercial shorefront. A large sand bar at the mouth of the river supports both the Amtrak rail corridor as well as Route 156, which both cross the river at its mouth. The sandbar constricts the mouth of the river, creating rapid currents during tidal exchanges with Niantic Bay. The bay side of the sand bar is characterized by a large beach and sand dunes.

3.2 The Niantic River Estuary

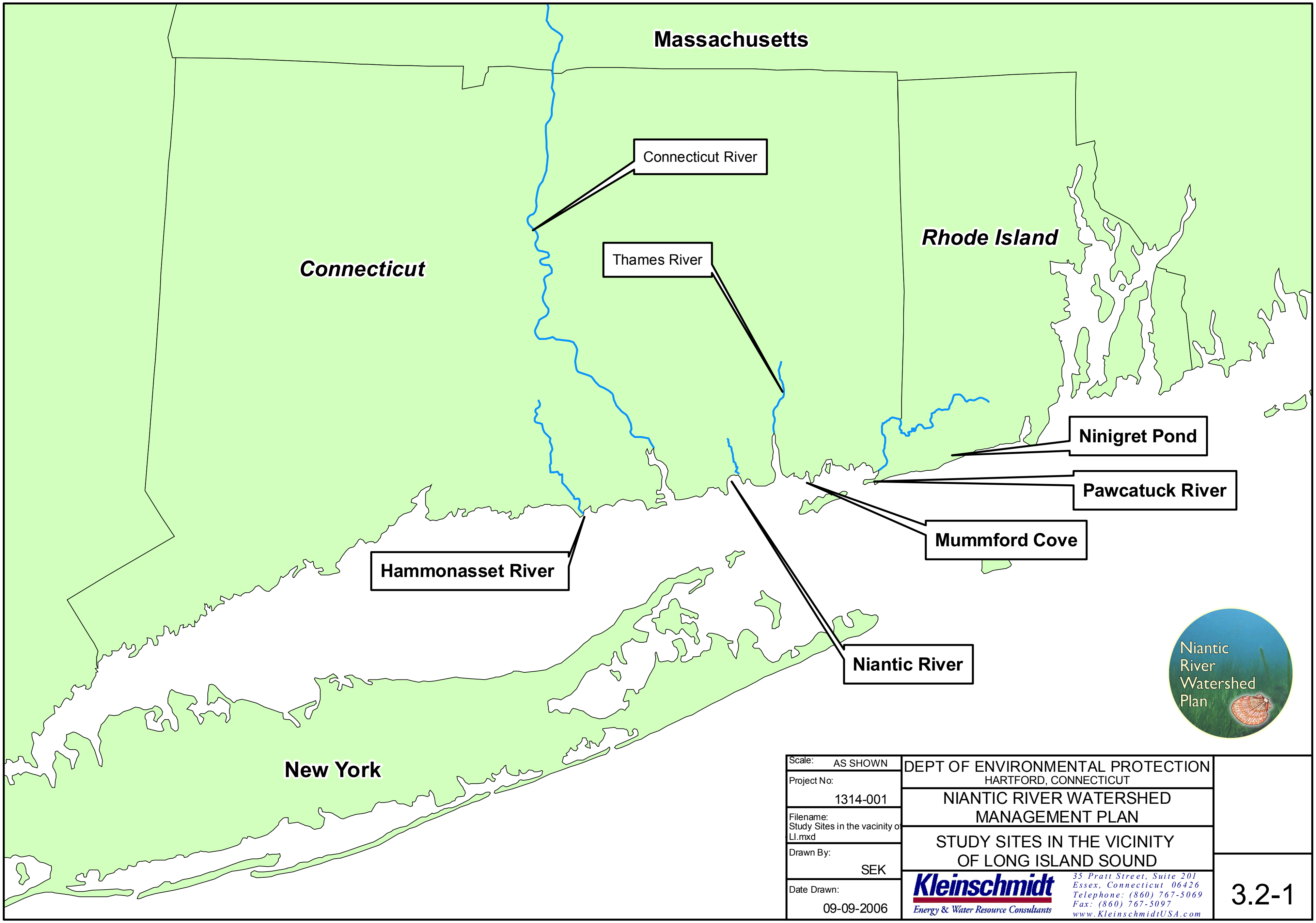
The Niantic River is a shallow marine estuary that was formed when sea level was at an elevation high enough to flood the low lying coastal valley. The river has historically supported healthy populations of shellfish, crustaceans, and finfishes and also provides excellent bird habitat as ospreys, herons, kingfishers, and cormorants may be observed at various times throughout the year.

In recent times, changes in river ecology believed to be associated with nitrogen loading include the loss of commercially important shellfish species, in addition to eelgrass stands and indicate a need for further water quality protection. Measures to protect water quality include land use and development controls to help reduce the influx of nonpoint source pollution. Additionally, the designation of the river and near-shore waters of Long Island Sound as a No Discharge Area may help eliminate potential sewage discharges from vessels, and eliminate another source of nutrient enrichment (CTDEP, 2005). Without the continued maintenance of existing water quality conditions, or attempts to reduce nonpoint source inputs, the health of the Niantic River ecosystem will deteriorate further.

3.2.1 Objectives

This overview is intended to provide a general discussion of the Niantic River aquatic ecosystem. The overview will synthesize historical and current research in an attempt to characterize the relationship between nutrient enrichment and effects on the receiving waters. Aspects of the Niantic River that are addressed include the primary producers (*e.g.* phytoplankton) and upper trophic levels including invertebrates and fishes. In addition to an examination of broader trends in the community, individual species are also discussed. Individual species were selected given their (1) critical importance from a habitat perspective, *e.g.* eelgrass; (2) properties as a control species, free from the effects of fishing and predation, *e.g.* the grubby (*Myoxocephalus aenaeus*), and (3) commercial significance, *e.g.* the bay scallop (*Argopecten irradians*) and winter flounder (*Pleuronectes americanus*). Of these species, eelgrass is considered a keystone species.

Where applicable, aspects of the Niantic River have been compared and contrasted with other nearby sites within Long Island Sound. The inter-site comparison was achieved with a 2001 – 2004 data set collected by UCONN under the auspices of Dr. Jim Kremer at five study sites. Sites investigated by UCONN included the Pawcatuck River, Mumford Cove, Ninigret Pond, and the Hammonasset River (Figure 3.2-1). Other data sets were culled from research conducted by Dominion Nuclear Connecticut (DNC) over the 1976 – 2004 timeframe, which also facilitated an assessment of trends in species abundance with time.



Scale: AS SHOWN

Project No: 1314-001

Filename: Study Sites in the vacinity of LI.mxd

Drawn By: SEK

Date Drawn: 09-09-2006

DEPT OF ENVIRONMENTAL PROTECTION
HARTFORD, CONNECTICUT

NIANTIC RIVER WATERSHED MANAGEMENT PLAN

STUDY SITES IN THE VICINITY OF LONG ISLAND SOUND

Kleinschmidt
Energy & Water Resource Consultants

35 Pratt Street, Suite 201
Essex, Connecticut 06426
Telephone: (860) 767-5069
Fax: (860) 767-5097
www.KleinschmidtUSA.com

3.2-1

3.2.2 Physical and Chemical Properties

3.2.2.1 Morphology and Bottom Sediments

The Niantic River estuary is a drowned valley that encompasses 790 acres and is separated from Long Island Sound by a sand bar leaving a narrow, 100 foot inlet at the east end for tidal exchange. The bar is presently bulk-headed and maintained and supports an Amtrak crossing and Route 156 (Marshall, 1994).

A tidal flat, or flood delta, has developed within the Niantic River estuary, which extends from the narrow inlet slightly less than one mile up the river. Slightly upstream of the tidal flat is a broad basin with typical water depths of 10 feet, although depths as great as 20 feet are reached further northward in the west branch of the Niantic. The maximum water depth in the river is 22 feet, with channel depths typically ranging between 10-13 feet (Marshall, 1994).

With respect to bottom substrate composition, the bottom sediments mirror the hydrologic regime such that well-sorted sands are observed in the high energy environment of the river channel, while finer grained silts and clays are observed in the more quiescent portions of the estuary. Organic material deposited in the low energy environment of the river basin has resulted in a muddy bottom that is highly unconsolidated (Marshall, 1994).

3.2.2.2 Tidal Exchange

The Niantic River and Bay system forms an inlet of Long Island Sound and is subject to the tidal dynamics of the Sound itself (Saila, 1976). Local tidal conditions in Long Island Sound are predominately semi-diurnal (two high tides and low tides per day) (Saila, 1976) that have a mean and maximum range of 2.6 and 3.2 feet, respectively. The tidal range in the Niantic River is 2.5 feet, which is two inches less than it is in Niantic Bay. Construction at the mouth of the Niantic River may have damped tidal oscillations and reduced circulation within the river (Marshall, 1994).

The residence time within the Niantic River, *i.e.*, the time it would take for water to enter into, pass through, and then exit the Niantic River system, is 25 days (Marshall, 1994) indicating high retention properties. During a study that modeled winter flounder larvae transport out of the Niantic River, it was predicted that 72% of the winter flounder larvae leaving the river at ebb tide would return to the river on the following flood tide (Saila, 1976). Thus, it can be seen that although flushing is rapid, the flushing rate is limited and retention times are long. In fact, these latter properties make the Niantic River an excellent fish nursery area.

The long retention times within the Niantic River are attributable to the morphology of Niantic Bay, which is a semi-enclosed basin. In addition, the flats within the Niantic River basin may also act to segregate waters of varying salinity during ebb and flood tides, such that more saline waters approaching from the Bay would flow along the bottom northward of the flats. Modeled current vectors during ebb and flood tides indicate that during the flood tide, flow is directed into two directions including (1) the Niantic River and (2) through the Bay and exiting past Black Point (Saila, 1976). During the ebb tide, water exits the Niantic River and flows along the Niantic Bay shoreline (Saila, 1976).

3.2.3 Freshwater Contribution

3.2.3.1 Surface Water

The Niantic River watershed area is small (31.3 square miles) and the volume of freshwater entering the estuary is low compared to tidal inputs. Freshwater input is limited to three major streams and runoff from the watershed and accounts for only 3% of the total tidal prism (Marshall, 1994). The main tributaries to the Niantic River include Latimer Brook and Old Mill Brook. The flow rate in Old Mill Brook is most likely similar to that observed in Latimer Brook, *i.e.* 3-20 cubic feet per second (cfs) (Saila, 1976).

In addition to tributaries discharging directly into the Niantic River, other freshwater inputs that can indirectly affect the Niantic River include the Thames and the massive Connecticut River, both of which discharge into Long Island Sound.

3.2.3.2 Groundwater

The discharge of ground water containing nutrients has been identified as a cause of water-quality degradation (Marshall, 1994). Based upon equations from Mazzaferro (1979), it is estimated that about 50% of the freshwater discharged to the Niantic River originates as ground water.

3.2.4 General Physicochemical Properties

3.2.4.1 Flow

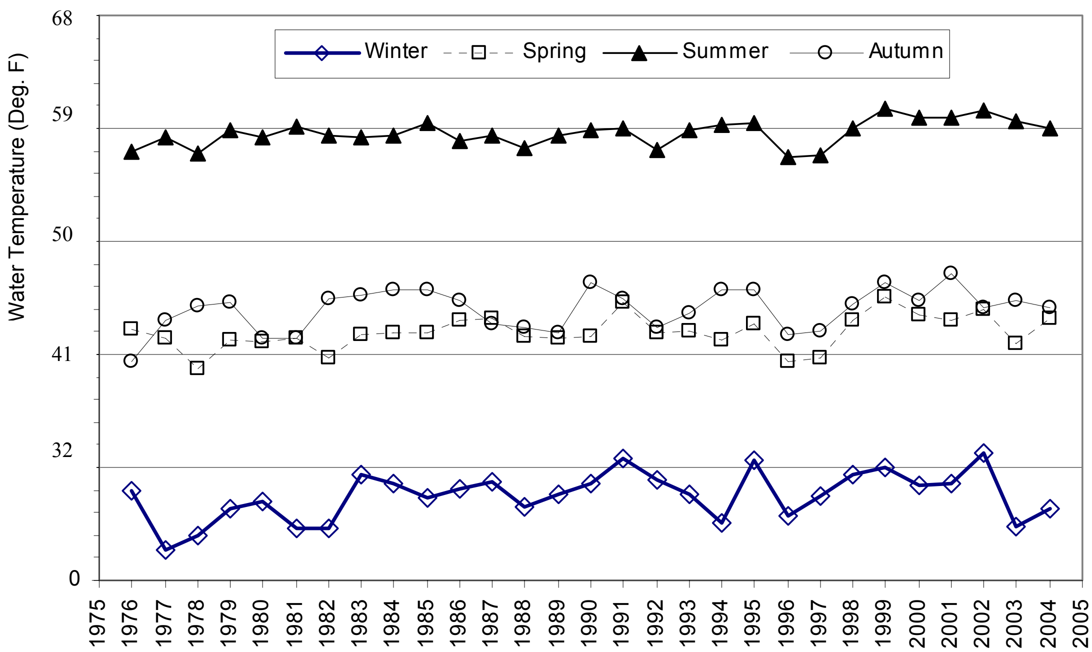
The general circulation in the Niantic River is influenced by surface water runoff, as well as tides, winds, and possibly density differences (Saila, 1976). Although tidal currents are reduced across the flood delta, currents are sufficient that a channel is maintained. Maximum current velocities within the Niantic system occur through the narrow mouth of the river and reach just over 3ft/sec, while in the upper Niantic River the tidal current is weak and currents only reach a maximum of 2/in/sec (Saila, 1976). Within the upper reaches of the Niantic, wind-related effects occur within the upper inch of the water column (Saila, 1976).

3.2.4.2 Temperature

Over 28 years of sampling (1976 – 2004), water temperatures within the Niantic River averaged 53.6 ºF (DNC, 2005). The Niantic River exhibits wide variation in temperature with an overall mean annual minimum temperature of 46.4 ºF and a maximum of 74.8 ºF. The highest overall water temperature measured during the 28 year study period was80.6 ºF, and was recorded during August, 1999. Since 1976, a significant and increasing trend was observed in mean annual water temperature (DNC, 2005). Keser *et al* (2003) demonstrated that from 1975 through 2000, a temperature increase of ~1.8 ºF (based upon annual means) and an increase of ~2.7 ºF (based upon daily means) was occurring in Niantic Bay.

Overall winter temperatures during the 28 year period sampled averaged 38.7 ºF; spring temperatures averaged 51.6 ºF; summer temperatures averaged 67.6 ºF; and autumn temperatures averaged 53.4 ºF (DNC, 2005) (Figure 3.2-2). Seasonal temperatures were most variable during the winter and least variable during the summer.

Figure 3.2-2. Seasonal mean water temperatures (1976-2004) calculated from mean daily water temperatures recorded in Niantic Bay



3.2.4.3 Salinity

Although some reduction of salinity is evident in the upper reaches of the Niantic River, salinities in the river generally approximate those observed in Niantic Bay and Long Island Sound waters. Maximum salinity within Niantic River during the summer is 30 parts per thousand (ppt), which drops to 20 ppt at the surface during times of freshwater inflow during the spring and periods of heavy surface water flow following storm events.

Long term salinity data collected by DNC in Niantic Bay indicate that surface salinities ranged from 28.5 - 31.9 ppt over the past 26 years. Salinities of the bottom waters were slightly higher and ranged from 28.7 to 32.0 ppt. Long term trends in salinity indicate that a decline in both surface and bottom salinity has occurred (DNC, 2005).

3.3 The Uses of the Niantic River

Historically, the river has served as an important economic asset to the surrounding human settlements. Dating back to the Nehantics – direct descendents of the original humans who arrived in the Americas an estimated 15-18,000 years ago[5], the river has sustained local populations by providing a natural resource base and transportation system to support thriving commerce, relationships, and lifestyle (Marshall, 1994 and MEL, 2006). Today, recreational uses of the Niantic River are more ubiquitous than commercial ones. River recreation includes sport fishing, clamming, crabbing, scalloping, pleasure boating, sailing, waterskiing, wake-boarding, tubing, kayaking, canoeing, swimming, and shoreline picnicking. Figure 3.3-1 shows the locations of the many places discussed throughout this section.

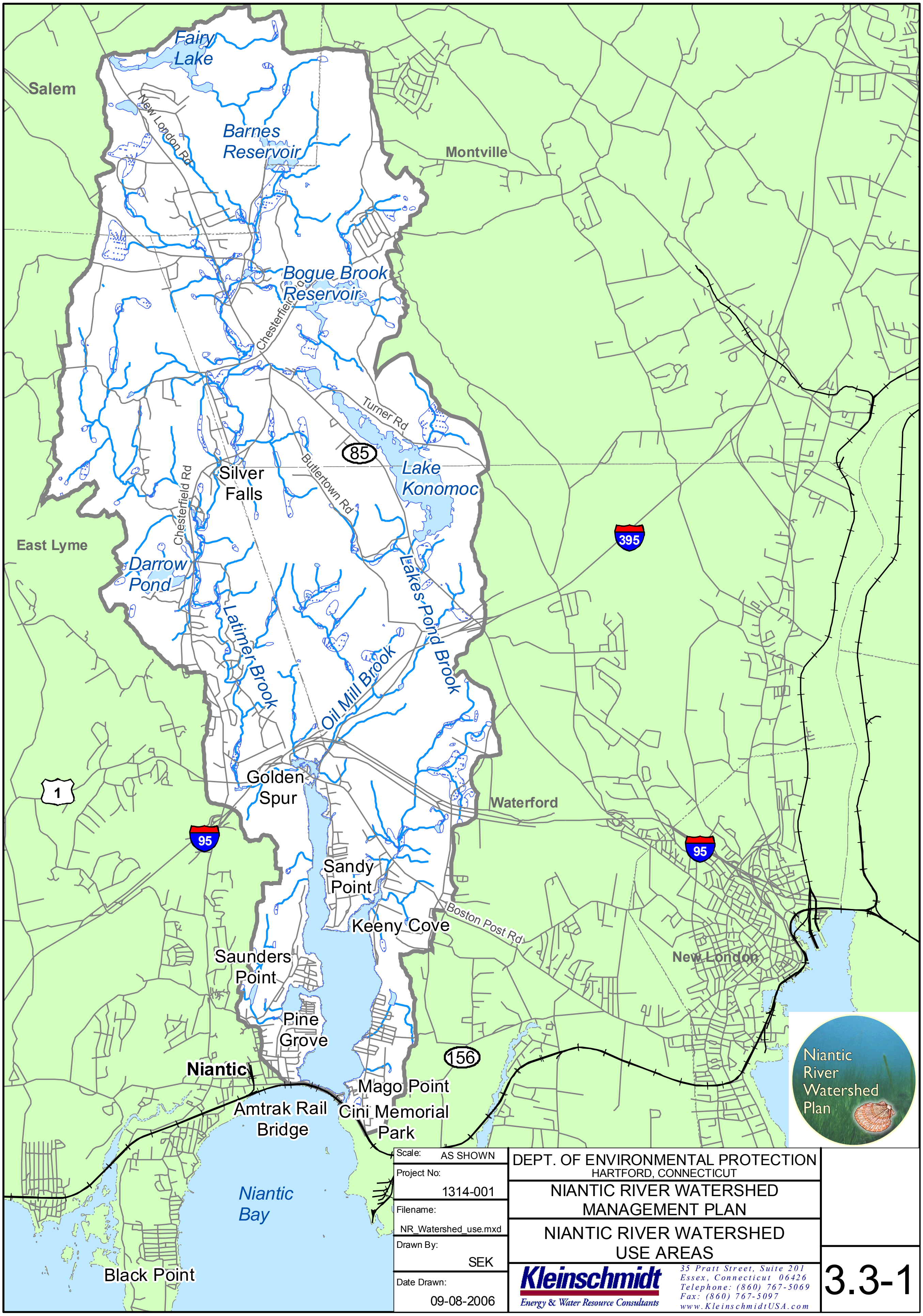
3.3.1 Fishing

With respect to sport fishing, the Niantic River is one of the most productive fishing areas on Long Island Sound. Anglers commonly land striped bass, which run through the narrow channel at the mouth of the river during the summer months. Winter flounder are another sought after fish that has historically inhabited the river, although the resident population has steadily decreased over the years (DNC, 2006). During the 2006 winter flounder season (April 1 – May 30), anecdotal reports indicated that anglers were "limiting out" (10 fish per person per day) on winter flounder on the Niantic River and shoreline dockowners were landing flounder from their docks (Don Landers, personal communication, 5/16/06).

Latimer Brook and Oil Mill Brook are also productive and popular recreational fishing areas. On Latimer Brook, a variety of fish can be caught, notably trout stocked by the state. Upstream to Silver Falls, anadromous fish such as searun brown trout and river herring are commonly seen. Fishing and taking of migratory river herring is not allowed in the state of Connecticut.

---

[5] Town of East Lyme, 'Niantic River Estuary Canoe/Kayak Trail'. www.eltownhall.com/maps/kayak%20trail.pdf



Scale:	AS SHOWN
Project No:	1314-001
Filename:	NR_Watershed_use.mxd
Drawn By:	SEK
Date Drawn:	09-08-2006

DEPT. OF ENVIRONMENTAL PROTECTION
HARTFORD, CONNECTICUT

NIANTIC RIVER WATERSHED
MANAGEMENT PLAN

NIANTIC RIVER WATERSHED
USE AREAS

Kleinschmidt
Energy & Water Resource Consultants
35 Pratt Street, Suite 201
Essex, Connecticut 06426
Telephone: (860) 767-5069
Fax: (860) 767-5097
www.KleinschmidtUSA.com

3.3-1

CTDEP Fisheries maintains a fish ladder and trap at the Latimer Brook Dam. This location at the head of the Niantic's tide is used by migratory fish such as river herring and sea-run brown trout. In 2006, the newly installed fish trap passed a documented 1,659 alewives and "many" trout (S. Gephardt, CTDEP, May 16, 2006). Latimer Brook, from the dam down to Golden Spur, is considered the most productive area to fish for sea-run brown trout in the State of Connecticut.

3.3.2 Shellfishing

The Niantic River shellfishery historically has been one of the most productive in Long Island Sound, especially with regard to the bay scallop (*Argopecten irradians*). A steady decline of the scallop population over the last two decades is consider to be related to the corresponding decrease in eelgrass beds in the river (Marshall, 1994). The bay scallop has not been completely eradicated from the river, but there are so few that the Waterford/East Lyme Shellfish Commission no longer issues shellfishing permits for them. In addition to the bay scallop, other important shellfish in the river include hard shell clams (*Mercenaria mercenaria*), soft shell clams (*Mya arenaria*), blue mussels (*Mytilus edulis*), and oysters (*Crassostrea virginica*). The blue crab (*Callinectes sapidus*) is the only crab found in the river that is actively sought after by recreational shellfisherman.

The CT DA/BA assigns and enforces shellfish classifications for the entire Connecticut shoreline. According to CT DA/BA mapping, shellfishing is prohibited in several areas within the Niantic River, including the reach north of Route 1 in the vicinity of Golden Spur, the area known as Shawandassee Pond adjacent to Niantic River Road in Waterford, and the area from Mago Point south to the Amtrak Railroad Bridge. The river is classified as Restricted Relay from Sandy Point north to Route 1, in the area known as Keeny Cove, all of Smith Cove with the exception of a small region that includes Three Belles Marina that is classified as Conditionally Restricted Relay, and two areas presently occupied by commercial marinas at the southern reach of the river near Route 156. The rest of the river, which generally includes a broad expanse from Sandy Point south to Route 156 excluding marina locations, is classified as Conditionally Approved.

The Waterford-East Lyme Shellfish Commission issues permits for recreational harvesting of clams, mussels, and oysters. In recent years, it annually approved 725 to 825 permits per year. It also has been involved in stocking programs for hard-shelled clams and scallops. Commercial shellfish activity in the river is limited to transplanting activities to depurate contaminated shellfish in clean beds and waters.

3.3.3 Boating and Watersports

There are a total of ten commercial marinas in the Niantic River, two anchorage areas located near Sandy Point and Keeny Cove, a number of small private individual docks scattered along the shoreline, and one state boat launch located in Waterford near Mago Point. The commercial marinas include five on the Niantic side of the river; Bayview Landing, Boats, Inc., Harbor Hill Marina, Port Niantic Marina, and Three Belles Marina; and five located on the Waterford side of the river; Black Hawk Dock, Mago Point Marina, Niantic Sport Fishing Dock, Capt. Johns Sport Fishing Center, and the Niantic Bay Marina. Three of the commercial marinas are open year round and offer sport fishing charters in Long Island Sound. The Niantic River is very active during the boating season.

The upper reaches of the river from Sandy Point northward is a favorite destination for waterskiers, wake-boarders, and tubers. Along this reach of the river you can also find boats anchored in the shallows as their owners and guests swim in the river or picnic on the nearby sandy shoreline. An organization known as *Save the River, Save the Hills* holds an annual Kayak Regatta as part of an event known as Niantic River Appreciation Day. Due to an increased interest in kayaking and canoeing, there has been a call for an increase in the number of nonmotorized vessel access points along the river, which will further enhance the public's recreational enjoyment of the river.

3.3.4 Shoreline Parks/Recreational Opportunities

There are a few parks and trails located along the shores of the Niantic River. A rather extensive trail system exists within the 700 acres of land known as Oswegatchie Hills on the East Lyme side of the river. These trails offer hiking opportunities as they connect Route 1 (Flanders) with the center of the Village of Niantic near Veterans Memorial Field and Pine Grove. The Niantic Public Access Trail is a one-half mile corridor connecting Smith Avenue in the Village of Niantic to the Niantic River Drawbridge and Cini Memorial Park. The path, which includes a wooden boardwalk on the north side of Route 156, offers numerous scenic views of the Niantic River. Cini Memorial Park is a waterfront park that occupies a small parcel of land that once supported the approach roadway to the old Niantic River swing bridge. The park offers views of the river and includes interpretive signs describing the river's shellfishery. It also provides access to the Niantic Bay Boardwalk's eastern terminus near the Amtrak Railroad bridge and the Niantic River Kayak Trail Launch[6]. According to the CTDEP, Cini Memorial Park is still being transformed to compliment the interesting maritime trade history of the river.

3.4 Land Use in the Niantic River Watershed

This section presents data and maps describing the land uses of the Niantic River Watershed. Table 3.4-1 estimates the land cover types for the watershed from 1985 to 2002. This section is intended to provide descriptive information about the watershed; natural resources and development patterns are shown to reflect changes over time. Later in this report, land use data will be analyzed and discussed in more detail as it relates to nonpoint source pollution.

---

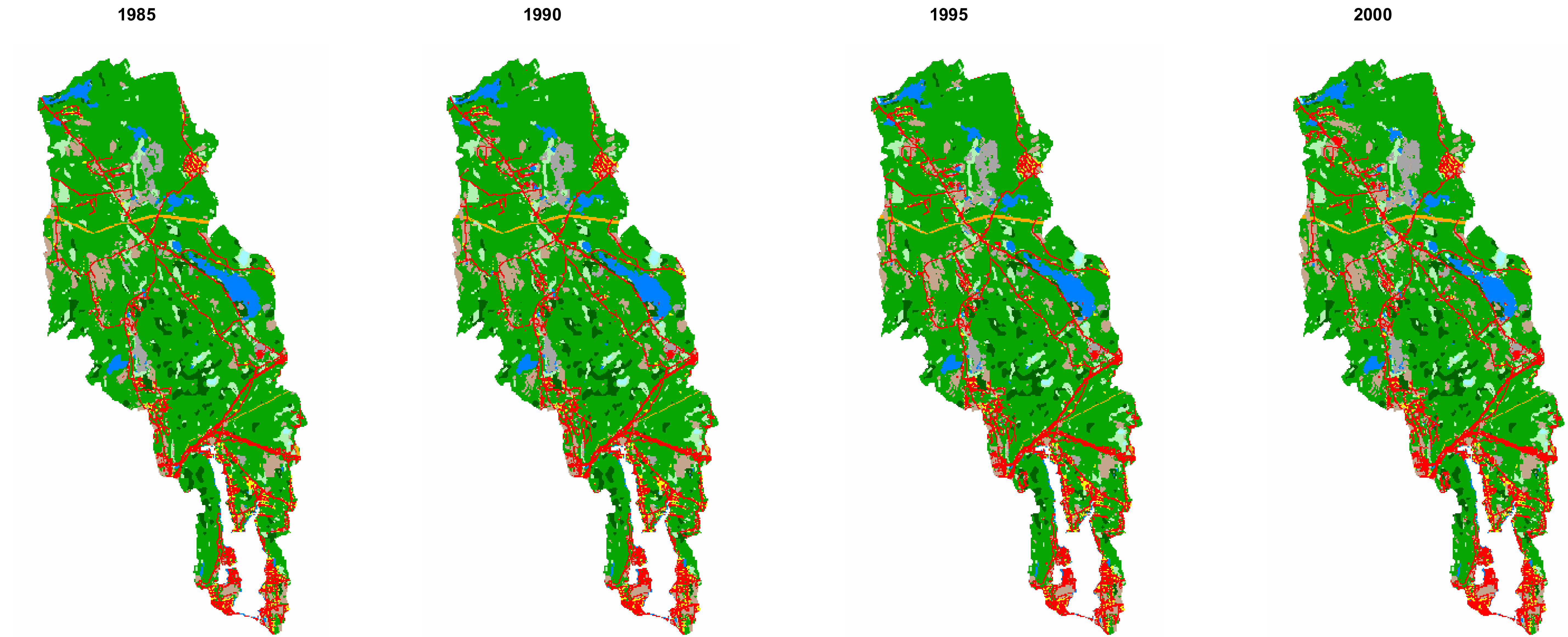
[6] To learn more about the Niantic River Kayak Trail visit http://www.eltownhall.com/Maps/Kayak%20Trail.pdf#search=%22Niantic%20River%20Kayak%20Trail%20Launch%22

Land uses for the Niantic River Watershed from 1985 to 2004 were analyzed as a part of this study. Data from 1985, 1990, 2000, and 2002 were obtained from the Center for Land Use Education and Research (CLEAR) at UCONN. 2004 aerial photography of the watershed was acquired through Southern New England Telephone (SNET). Interpretation of the aerial photographs was verified using existing natural resource GIS layers and field surveys. All of the study's land use maps reflect standardized land cover classifications (Anderson, *et al*, 1976). These land covers classify, "land capability, vulnerability to certain management practices, and potential for any particular activity or land value, either intrinsic or speculative." (Anderson, *et al.*, 1976).

Table 3.4-1. Summary and Comparison of Land Cover in the Niantic River Watershed, 1985 – 2002

Land Cover Class	1985 (acres)	%	1990 (acres)	%	1995 (acres)	%	2002 (acres)	%	Change 85 - 02 (acres)
Barren	347.8	1.8	409.2	2.2	509.9	2.7	538.9	2.8	191.1
Coniferous forest	916.7	4.8	902.1	4.8	879.7	4.6	868.0	4.6	-48.8
Deciduous forest	12,438.8	65.7	11,984.4	63.3	11,811.6	62.4	11,450.7	60.5	-988.1
Developed	1,950.4	10.3	2,252.7	11.9	2,335.4	12.3	2,518.7	13.3	568.3
Forested wetland	948.9	5.0	908.3	4.8	895.9	4.7	881.5	4.7	-67.4
Non-forested wetland	57.9	0.3	62.5	0.3	63.0	0.3	77.4	0.4	19.5
Other grasses and agriculture	1,210.4	6.4	1,329.1	7.0	1,362.4	7.2	1,535.8	8.1	325.5
Tidal wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Turf and grass	264.8	1.4	272.3	1.4	278.3	1.5	298.6	1.6	33.8
Utility right of way	120.1	0.6	115.8	0.6	115.5	0.6	113.7	0.6	-6.4
Water	668.1	3.5	687.8	3.6	672.5	3.6	641.2	3.4	-26.9
TOTAL	18,923.9		18,924.2		18,924.2		18,924.5		
Note: Water area of lower Niantic River is not included.									

Figure 3.4-1 provides a comparison of maps representing the Niantic River Watershed from 1985 and 2002. Maps are color-coded according to the land use classifications used to interpret aerial photography of the region (Anderson, *et al*, 1976). The legend provides the key to the land use information portrayed on each map. At this scale, it is difficult to compare the four maps and notice the subtle changes in land use over 17 years. However, on close inspection, new development (red) can be observed, especially along primary and secondary roads, where the red areas seem to swell. This represents a typical development pattern as more housing and commercial developments



- Developed
- Turf and grass
- Other grasses and agriculture
- Deciduous forest
- Coniferous forest
- Water
- Forested wetland
- Non-forested wetland
- Tidal Wetland
- Barren
- Utility right of way

clear

Niantic River Watershed Plan

Scale: AS SHOWN	DEPT OF ENVIRONMENTAL PROTECTION HARTFORD, CONNECTICUT
Project No: 1314-001	NIANTIC RIVER WATERSHED MANAGEMENT PLAN
Filename: LandUse_Comparison_1985-2000.mxd	LAND USE FOR THE NIANTIC RIVER WATERSHED 1985-2000
Drawn By: SEK	
Date Drawn: 09-07-2006	Kleinschmidt Energy & Water Resource Consultants 35 Pratt Street, Suite 201 Essex, Connecticut 06426 Telephone: (860) 767-5069 Fax: (860) 767-5097 www.KleinschmidtUSA.com

3.4-1

Data Sources: UCONN CLEAR, 2006

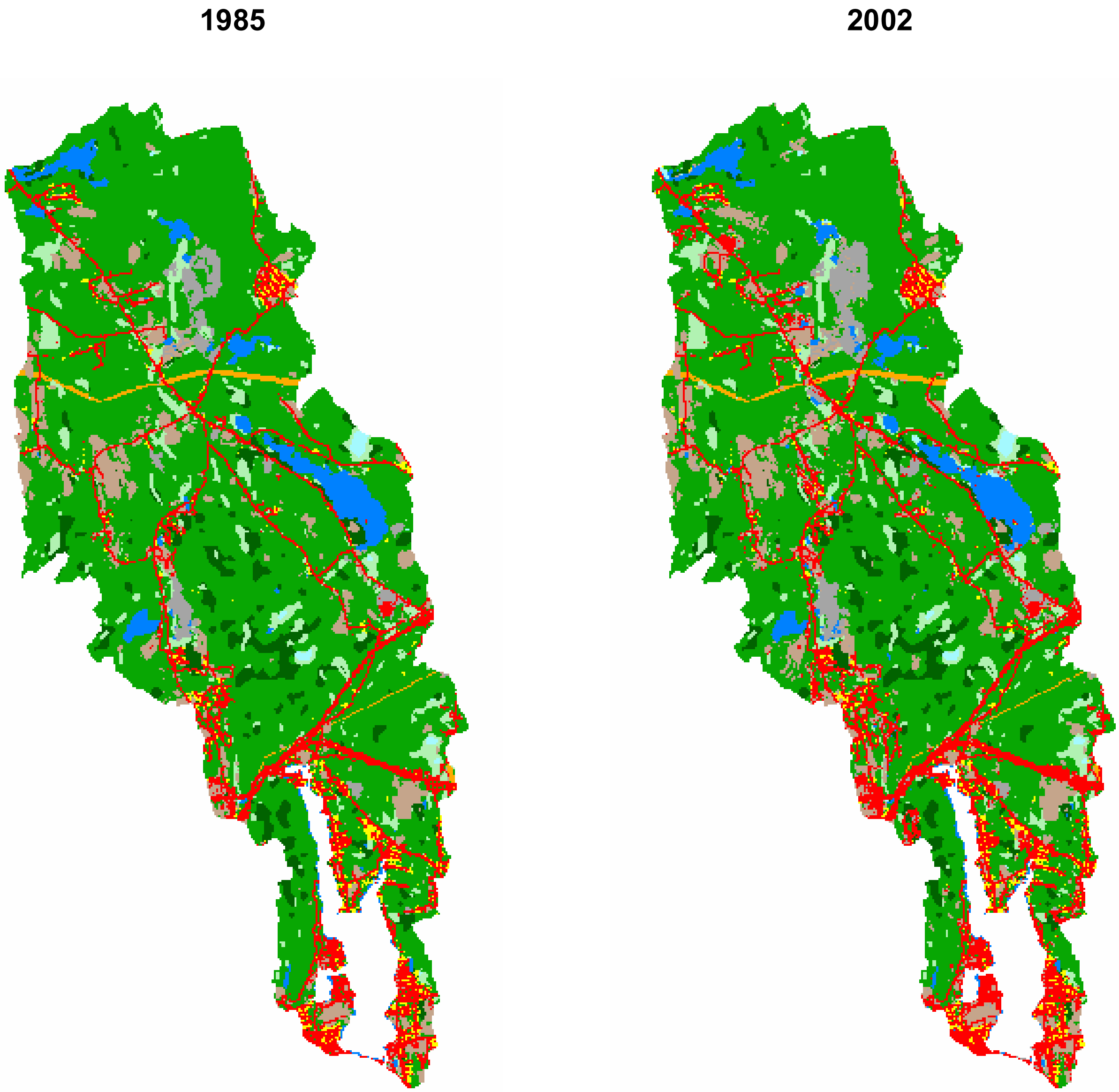
are added along existing roads. By 2002, the watershed is already less than 75% forested – the threshold at which changes in water yield and quality changes are measurable compared to an undisturbed watershed (Hornbeck et al, 1997).

The subtle land use changes illustrated by these maps highlight the incremental and cumulative characteristics of nonpoint source pollution. Generally, no one development will cause, in and of itself, the degradation of a stream. It is the cumulative impacts of *years* of development with which we are concerned. Development in the Niantic River Watershed has occurred and will occur incrementally over time. From year to year, changes in the landscape, as a result of development, are negligible with the possible exception of relatively large developments (*e.g.* "big box" retail outlets or road projects). But, after many years, landscape changes are obvious. The same holds true for nonpoint source pollution; the gradual development of the watershed will cause water quality concerns over time unless protective actions are taken.

Figure 3.4-2 illustrates more dramatic land cover changes in the Niantic River Watershed between 1985 and 2002. It is much easier to see where new development has occurred over 17 years compared to every five years. This characteristic of land use change is probable cause for nonpoint source pollution and related water quality problems.

3.4.1 Land Use Trends

The Niantic River Watershed exhibits a settlement pattern similar to other coastal watersheds in the Northeast United States. Older, denser development occurred along the coast in association with shipping and commercial centers while forestry and agriculture were the predominant land uses inland (Marshall, 1994 and Civco, *et. al.*, 2002). This land use pattern continues, by and large, with the exception that the upper portions of the watershed have converted back to forest land now that agricultural uses have diminished or are being developed for residential or commercial uses as a result of sprawl from the coastal areas. In the lower portions of the watershed – East Lyme and Waterford – new development



- Developed
- Turf and grass
- Other grasses and agriculture
- Deciduous forest
- Coniferous forest
- Water
- Forested wetland
- Non-forested wetland
- Tidal Wetland
- Barren
- Utility right of way

clear

Niantic River Watershed Plan

Scale: AS SHOWN	DEPT OF ENVIRONMENTAL PROTECTION HARTFORD, CONNECTICUT	
Project No: 1314-001	NIANTIC RIVER WATERSHED MANAGEMENT PLAN	
Filename: Land_Cover_ 1985and2002.mxd	COMPARISON OF LAND COVER FOR 1985 AND 2002	
Drawn By: SEK		
Date Drawn: 09-07-2006	Kleinschmidt Energy & Water Resource Consultants 35 Pratt Street, Suite 201 Essex, Connecticut 06426 Telephone: (860) 767-5069 Fax: (860) 767-5097 www.KleinschmidtUSA.com	3.4-2

is restricted to infill areas with the exception of Oswegatchie Hills in East Lyme. In the upper reaches of the watershed - Montville and Salem – there remain sizeable areas of land that could be developed.

Urbanization and population growth in the Niantic River Watershed are major driving forces for environmental change, especially nonpoint source pollution and its related water quality problems. We tend to assume that one can not happen without the other, *i.e.* population growth drives urbanization. However, the Long Island Sound Study (2006) found that along Connecticut's coastline, urban development is occurring at a much faster rate than population growth and is not necessarily dictated by population growth. More than likely, this trend is the result of the rise in the market for second, or seasonal homes, near the coast.

With the exception of the Connecticut River/Hartford corridor, coastal municipalities are the most urbanized and quickly urbanizing areas in Connecticut (CTDEP, 2006). In the Niantic River Watershed, this also seems to be true. Urbanization is occurring along with moderate increases in population (Table 3.4-2). As a result, the Connecticut coastline is becoming one of the mostly densely populated in the Northeast with population densities exceeding, on average, 125 persons per square mile (USEPA, 2005b).

Table 3.4-2. Recent Population Change in the Four Communities of the Niantic River Watershed

	1990	2000	2005	% Change (1990 – 2005)
East Lyme	15,340	18,118	18,459	***20.3%***
Montville	16,673	18,546	19,612	***17.6%***
Salem	3,310	3,858	4,094	***23.7%***
Waterford	17,930	18,940	19,152	***6.8%***
Source: US Census 1990, 2000; US Census Bureau, Population Estimates Program, 2006.				

3.4.1.1 Roads and Highways

Ground transportation constitutes a major land use in the Niantic River watershed. In 2004, approximately 440 acres of the watershed were dedicated to ground transportation (*e.g.* roads, highways, parking lots) (UCONN CLEAR, 2006). A considerable portion of this road surface is included in the federal highway system as Interstates 95 and 395. Also, making up this land use classification are extensive networks of local road and regional arteries.

Due to the nature of the use of roadways and the fact they are considered 100% impervious, they are always considered management concerns. New roads increase the impervious surface area of a watershed as well as the need for programmatic stormwater management. Managers of the Niantic River Watershed are confronted with a unique potential water quality issue resulting from the extension of Route 11 – a new transportation corridor slated for construction in the watershed.

3.4.1.2 Route 11 Extension

As of early June 2006, the extension of CT Route 11 is still a viable project. The Administrative Final Environmental Impact Statement in 1990 identified a preferred alternative known as "C/D". This alternative went forward in the most recent Draft Environmental Impact Statement as "92PD" (CTDEP, 1999). However, modifications to that, and other alternatives, were developed by an advisory committee, such that fourteen alternatives, plus the 'No-Build', were considered in the most recent environmental document (DEIS). That document, available in summary form on the ConnDOT website, does not identify a preferred alternative. However, according to Maguire Group Inc. (project engineering consultant), there is a Least Environmentally Damaging Preferred Alternative (LEDPA) identified by the US Army Corps of

Engineers (ACOE), although it is not certain that the other agencies prefer the LEDPA. Discussions will be ongoing for some time. Since the completion of the DEIS, further environmental studies were conducted for the corridor in summer of 2005 by Maguire Group Inc.

No specific stormwater measures have been proposed as mitigation for runoff from Route 11. It is likely that stormwater measures will follow the recent ConnDOT stormwater management plan for their highways. However, it is likely that curbs and catch basins are going to be heavily used due to the steep slopes along potential roadway cut and fill, will probably be proposed to capture the piped runoff.

The magnitude of potential impacts from the Route 11 Extension are shown in Figure 3.4-3 – Table ES-35 Comparison Matrix of Impacts by Alternative from the DEIS for Route 11. For each lettered alternative, a two-lane and a four-lane section were considered, with the parentheses indicating the lane configuration {(2) or (4)}. Of the build alternatives, wetland impacts range from 7 to 35 acres, floodplain impacts would range from 1.5 to 6.6 acres, and forest blocks would be fragmented.

For more information on the Route 11 Extension Project, contact the ConnDOT Office of Environmental Planning at (860) 594-2920.

Figure 3.4-3. Copy of the Table ES-35 Comparison Matrix of Impacts by Alternative from the DEIS for the Route 11 Extension

TABLE ES-35
COMPARISON MATRIX: OVERVIEW OF IMPACTS BY ALTERNATIVE

PROPOSED ALTERNATIVE	WETLANDS	NUMBER OF FOREST BLOCKS	FOREST BLOCK AREA	CLASS I & II LANDS	HIGH YIELD AQUIFERS	ENDANGERED SPECIES HABITAT	PRIME FARMLAND	FLOODPLAINS	HISTORIC/ ARCHAEOLOGICAL	STRUCTURES POTENTIALLY AFFECTED	AIR QUALITY *MICROSCALE ANALYSIS/ MESOSCALE ANALYSIS	NUMBER OF NOISE RECEPTORS EXCEEDING CRITERIA[1]	POTENTIAL/KNOWN HAZARDOUS WASTE/ CONTAMINATED SITES	COST[2] (MILLIONS)
NO BUILD	None	None	None	None	None	None	None	None	None/ None	None	*No CO violations	4	None	None
$W_{(4)}$	2.07 ha. (5.12 ac.)	>200 ha. - 2 50-200 ha. - 0	2.9 ha. (7.2 ac.)	Class I - 2.99 ha. (7.39 ac.) Class II- 0.52 ha. (1.28 ac.)	3.5 ha. (8.7 ac.)	None	0.32 ha. (0.78 ac.)	1.6 ha. (3.9 ac.)	17 properties/ Yes	32 dwellings 7 commercial 42 outbuildings 1 institutional	*No CO violations/ VOC & CO < No Build NO_x < No Build	4	20	$41.0
$W_{(4)}M$	1.52 ha. (3.77 ac.)	>200 ha. - 2 50-200 ha. - 0	1.4 ha. (3.5 ac.)	Class I - 2.47 ha. (6.06 ac.) Class II- 0.44 ha. (1.09 ac.)	1.8 ha. (4.3 ac.)	None	0.26 ha. (0.65ac.)	1.1 ha. (2.7 ac.)	17 properties/ Yes	25 dwellings 7 commercial 32 outbuildings 1 institutional	*No CO violations/ VOC & CO < No Build NO_x < No Build	4	20	$33.0
$W_{(2)}$	1.37 ha. (3.37 ac.)	>200 ha. - 2 50-200 ha. - 0	1.2 ha. (3.0 ac.)	Class I - 2.42 ha. (5.96 ac.) Class II- 0.46 ha. (1.15 ac.)	1.3 ha. (3.3 ac.)	None	0.18 ha. (0.45 ac.)	1.0 ha. (2.4 ac.)	17 properties/ Yes	17 dwellings 3 commercial 24 outbuildings	*No CO violations/ VOC & CO = No Build NO_x = No Build	4	20	$31.1
TSM	0.26 ha. (0.65 ac.)	None	None	None	0.2 ha. (0.5 ac.)	None	0.12 ha. (0.3 ac.)	0.2 ha. (0.5 ac.)	2 properties/ None	2 dwellings 3 commercial 2 institutional	*No CO violations/ VOC & CO = No Build NO_x = No Build	4	8	$1.7
TDM/TRANSIT	None	None	None	None	None	None	None	None	None/ None	None	*No CO violations/ VOC & CO = No Build NO_x = No Build	4	None	$1.4[3]
92PD	14.17 ha. (35.01 ac.)	>200 ha. - 2 50-200 ha. - 2	59.2 ha. (146.2 ac.)	None	1.6 ha. (4.1 ac.)	None	6.32 ha. (15.61 ac.)	2.7 ha. (6.6 ac.)	3 properties/ Yes	31 dwellings 16 commercial 34 outbuildings	*No CO violations/ VOC & CO < No Build NO_x > No Build	7	2	$255.6
$E_{(4)}$	14.27 ha. (35.26 ac.)	>200 ha. - 2 50-200 ha. - 3	63.8 ha. (157.6 ac.)	None	1.4 ha. (3.5 ac.)	None	6.32 ha. (15.61 ac.)	2.3 ha. (5.6 ac.)	3 properties/ Yes	22 dwellings 16 commercial 32 outbuildings	*No CO violations/ VOC & CO < No Build NO_x > No Build	7	2	$255.2
$E_{(2)}$	7.89 ha. (19.50 ac.)	>200 ha. - 2 50-200 ha. - 3	47.5 ha. (117.3 ac.)	None	0.5 ha. (1.1 ac.)	None	5.93 ha. (14.65 ac.)	1.2 ha. (3.0 ac.)	2 properties/ Yes	13 dwellings 20 outbuildings	*No CO violations/ VOC & CO < No Build NO_x > No Build	7	2	$154.7
$F_{(4)}$	11.62 ha. (28.72 ac.)	>200 ha. - 2 50-200 ha. - 4	68.3 ha. (168.7 ac.)	None	1.9 ha. (4.6 ac.)	None	34.49 ha. (85.23 ac.)	1.8 ha. (4.5 ac.)	3 properties/ Yes	29 dwellings 16 commercial 32 outbuildings 2 institutional	*No CO violations/ VOC & CO < No Build NO_x > No Build	7	3	$329.7
$F_{(2)}$	6.21 ha. (15.35 ac.)	>200 ha. - 2 50-200 ha. - 4	51.6 ha. (127.5 ac.)	None	0.8 ha. (2.1 ac.)	None	30.55 ha. (75.48 ac.)	0.7 ha. (1.6 ac.)	2 properties/ Yes	16 dwellings 15 outbuildings 2 institutional	*No CO violations/ VOC & CO < No Build NO_x > No Build	7	3	$213.1
$G_{(4)}$	13.23 ha. (32.69 ac.)	>200 ha. - 2 50-200 ha. - 4	68.3 ha. (168.7 ac.)	None	2.9 ha. (7.2 ac.)	None	25.58 ha. (63.19 ac.)	2.3 ha. (5.8 ac.)	3 properties/ Yes	38 dwellings 16 commercial 32 outbuildings 2 institutional	*No CO violations/ VOC & CO < No Build NO_x > No Build	7	3	$344.8
$G_{(2)}$	7.93 ha. (19.59 ac.)	>200 ha. - 2 50-200 ha. - 4	51.6 ha. (127.5 ac.)	None	1.1 ha. (2.6 ac.)	None	21.21 ha. (52.40 ac.)	1.0 ha. (2.4 ac.)	2 properties/ Yes	24 dwellings 16 outbuildings 2 institutional	*No CO violations/ VOC & CO < No Build NO_x > No Build	7	3	$224.6
$H_{(4)}$	4.40 ha. (10.87 ac.)	>200 ha. - 2 50-200 ha. - 3	38.1 ha. (94.1 ac.)	Class I - 2.98 ha. (7.36 ac.) Class II- 0.52 ha. (1.28 ac.)	3.0 ha. (7.3 ac.)	None	16.73 ha. (41.35 ac.)	1.2 ha. (3.0 ac.)	8 properties/ Yes	28 dwellings 1 commercial 36 outbuildings	*No CO violations/ VOC & CO < No Build NO_x > No Build	8	14	$113.6
$H_{(2)}$	3.0 ha. (7.41 ac.)	>200 ha. - 2 50-200 ha. - 3	28.8 ha. (71.1 ac.)	Class I - 2.41 ha. (5.95 ac.) Class II- 0.46 ha. (1.15 ac.)	1.0 ha. (2.5 ac.)	None	7.40 ha. (18.28 ac.)	0.6 ha. (1.5 ac.)	8 properties/ Yes	20 dwellings 25 outbuildings	*No CO violations/ VOC & CO < No Build NO_x > No Build	8	14	$81.9

1 = Does not include receptors already exceeding criteria (NAC) under existing conditions
2 = Construction cost; includes estimated ROW acquisition costs
3 = Cost of implementation for Route W only

4.0 WATER QUALITY OF THE NIANTIC RIVER AND ITS TRIBUTARIES

This section focuses on the water quality of the Niantic River and its tributaries. The section considers *existing* water quality issues of concern as well as *threats* to water quality or *potential* water quality issues of concern. *Existing* water quality issues have been documented. *Threats* or *potential* water quality issues have been identified by stakeholders, modeling, and land use analysis, but have not been verified with actual water quality monitoring. No actual water quality data collection occurred as a part of this planning effort. Additionally, this section of the report is primarily concerned with current conditions as they relate to the future of the watershed. Though a complete historical review of the ecological conditions in the watershed would provide a wealth of beneficial information in addressing future concerns of the health of the watershed it is beyond the scope of this work.

The primary sources of information used to determine the existing or known water quality issues of the Niantic River are the CTDEP/BWPLR and the CT DA/BA. The CTDEP/BWPLR is charged with regularly assessing the water quality of the State's waters, identifying threats, and developing remedial action. The CT DA/BA is responsible for implementing the National Shellfish Sanitation Program (NSSP). These two agencies produce regular assessments of the Niantic River that are readily available to the public.[7]

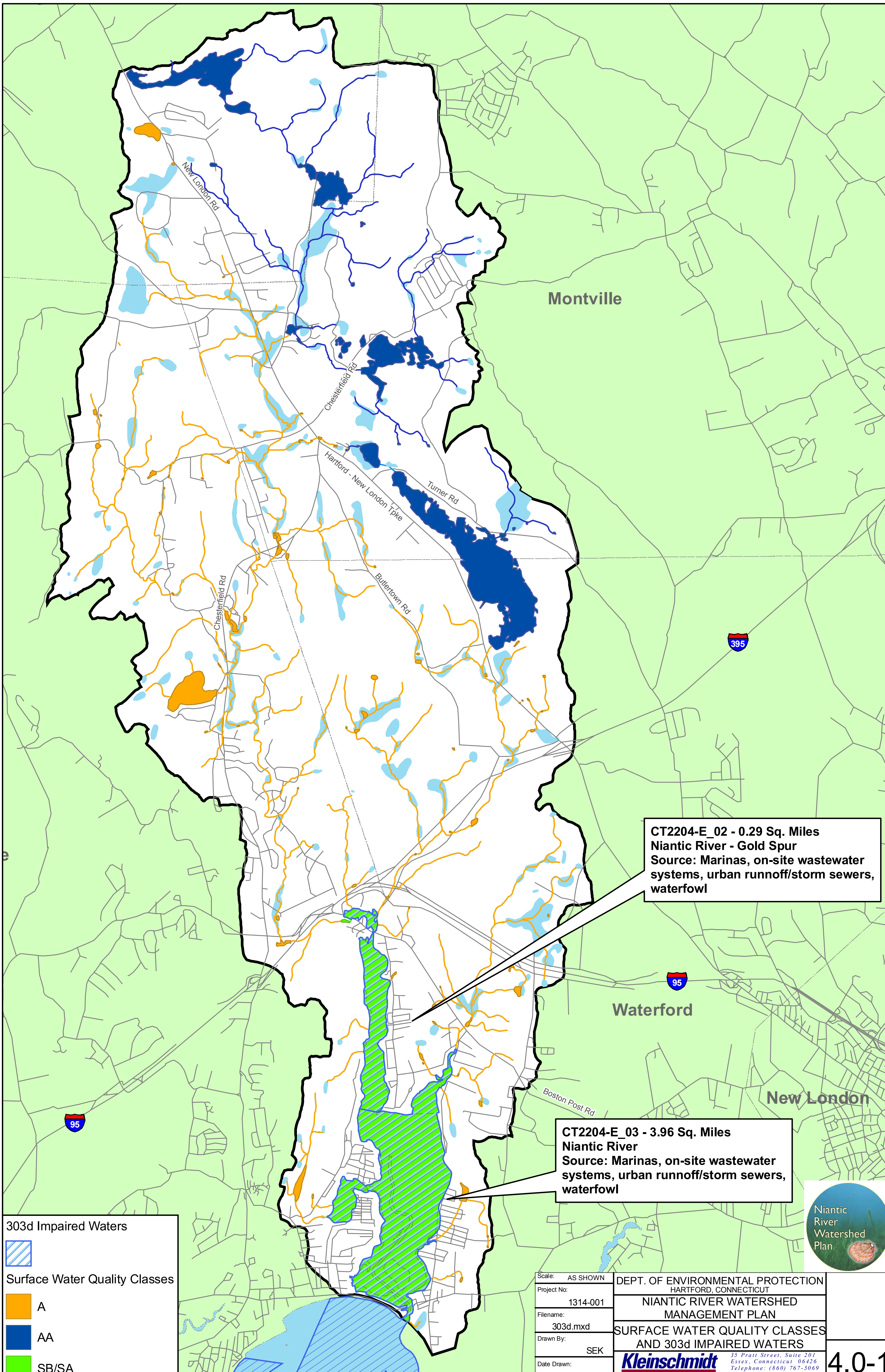
The CTDEP performs assessments of the State's waters on a regular basis according to a standard methodology referred to as the, Connecticut Consolidated Assessment and Listing Methodology (CALM). CALM describes the State's scientific approach to assessing Connecticut's waters for determining if they support their designated uses by comparing biological, chemical and physical data to the State's Water Quality Standards. These assessments result in biannual "Water Quality Reports to Congress" or "§305(b) Reports." Waters are assessed according to the State's water quality standards (CTDEP, 2002c). Waters found not supporting, or partially supporting, their uses are listed in a separate document referred to as, *Connecticut Waterbodies Not Meeting Water Quality Standards (Impaired Waters List or*

[7] For more information and contact directions visit the CTDEP BWPLR's Website: http://dep.state.ct.us/wtr/index.htm. The website for the CT DA/BA's Website is: http://www.ct.gov/doag/cwp/view.asp?a=1369&Q=259170.

§303(d) List). Once placed on the §303(d) List, CTDEP is required to develop a water quality restoration plan (*i.e.* total maximum daily load [TMDL] prescription) for it.

The Niantic River is classified as a Class SB/SA watercourse (Figure 4.0-1). Table 4.0 summarizes the water quality classifications and designated uses relevant to the Niantic River and its tributaries (CTDEP, 2002c) "SB/SA" presently may not be meeting SA Criteria or one or more designated uses. The water quality goal for these waters is achievement of Class SA criteria and attainment of Class SA designated uses. "SA" waters are designated for: habitat for marine fish, other aquatic life and wildlife; shellfish harvesting for direct human consumption; recreation; industrial water supply; and navigation (CTDEP, 2002c). SA Criteria from CT water quality standards are reproduced as Appendix C.

The freshwater tributaries flowing into the Niantic River are designated as Class A and AA. Class A waters, which represent the greater proportion of the streams in the watershed, have designated uses as potential water supplies; they are supportive of fish and wildlife habitat; recreational uses; and adequate for use as agricultural/industrial supplies. Class AA waters, which are limited to the reservoirs and their tributaries of the northern watershed in Salem and Waterford, have designated uses as 'existing or potential' water supplies. In fact, the Class AA waters of the Niantic Watershed are a part of the City of New London's public water supply system, which also serves populations of Montville and Waterford.



Scale: AS SHOWN	DEPT. OF ENVIRONMENTAL PROTECTION HARTFORD, CONNECTICUT
Project No: 1314-001	NIANTIC RIVER WATERSHED MANAGEMENT PLAN
Filename: 303d.mxd	SURFACE WATER QUALITY CLASSES AND 303d IMPAIRED WATERS
Drawn By: SEK	Kleinschmidt Energy & Water Resource Consultants 35 Pratt Street, Suite 201 Essex, Connecticut 06426 Telephone: (860) 767-5069 Fax: (860) 767-5097 www.KleinschmidtUSA.com
Date Drawn: 09-08-2006	4.0-1

Base data from CT DEP GIS (http://dep.state.ct.us/gis/index.htm) and USGS NHD (http://nhd.usgs.gov/).
303d and Surface Water Quality Classes data from CT DEP, 2004 and 2003.

Table 4.0. Surface Water Quality Classifications for the Niantic River and its Tributaries

Class	Comment	Use 1	Use 2	Use 3	Use 4	Use 5
A	Known, or presumed, to meet criteria which support designated uses	Potential drinking water supply	Fish and wildlife habitat	Recreational use	Agricultural or industrial supply	Other legitimate uses including navigation
AA	Known, or presumed, to meet criteria which support designated uses	Existing or proposed drinking water supply	Fish and wildlife habitat	Recreational use (may be restricted)	Agricultural or industrial supply	Other legitimate uses including navigation
SA	Uniformly excellent	Direct consumption of shellfish	Designated swimming	All other recreational uses		
SB/SA	Currently not meeting criteria for SA target	Shellfish for processing prior to consumption	Fish, shellfish, and wildlife habitat	Recreational use	industrial	Other legitimate uses including navigation

4.1 Overview of Coastal Nonpoint Source Pollutants and Their Impacts (Adapted from USEPA, 1993)

There are several pollutants that are expected to be found in nonpoint source pollution from urban and suburban landscapes. These pollutants are listed and described in Table 4.1-1.

Table 4.1-1. Nonpoint Source Pollutants, Characteristics and Impacts

Nonpoint Source Pollutants	Pollution Characteristics	Impacts
Sediments	• Produced by natural and anthropogenic erosion of streams. • Generated by particulates settled on impervious surfaces. • Constitutes the largest mass of pollutant loadings to surface waters. • Provide transport for other pollutants like nutrients and bacteria.	*Short term*: increased turbidity, reduced light penetration, decreased submerged aquatic vegetation (SAV), respiration impacts to fish and wildlife, reduced fecundity in fish. *Long term*: Smothered benthic habitat, siltation, channel shoaling, aesthetic impacts.
Nutrients	• Introduced to the watershed by the burning of fossil fuels, use of fertilizers and detergents and the deposit/disposal of human and animal wastes. • Phosphorus and nitrogen are the primary nutrients of concern.	• Eutrophication and low dissolved oxygen in marine ecosystems.
Oxygen-Demanding Substances	• Organic matter enters fresh and coastal waters and then is decomposed, depleting dissolved oxygen. • Organic matter is washed off impervious surfaces with runoff.	• Depletes dissolved oxygen. • Exacerbates the negative impacts of eutrophication.
Pathogens	• Associated with the feces of warm-blooded animals. • Elevated levels typically found in urban runoff. • Leading cause of water quality impairments in the United States.	• Beach and shellfish bed closures. • Contaminated drinking water sources.
Road Salts	• Primarily in northern climates. • Major pollutant in urban areas. • Produces high salt/chlorine concentrations in surface and ground water.	• Contaminated surface waters and ground water. • Toxic to benthic organisms. • Ecological effects pronounced in freshwater systems.
Petroleum hydrocarbons	• Derived from oil and other petroleum products. • Introduced into the watershed from vehicles. • Accumulates on impervious surfaces. • Bind to sediments and often collect in the benthic region.	• Toxic to aquatic life at high and low levels depending on compound. • Accumulate and persist in the benthic environment.
Heavy Metals	• Common in urban runoff: cadmium, chromium, copper, lead, and zinc. • Copper, lead, and zinc are the most prevalent in nonpoint source pollution from urban areas. • Deposit from vehicles and the atmosphere (particulate matter).	• Produce toxic effects on aquatic life. • Bioaccumulate in fish and marine mammals.
Toxics	• Various toxic compounds (USEPA "priority pollutants") can be found in urban runoff.	• Acute and chronic impacts to aquatic life.

4.2 Known Water Quality Issues in the Niantic River Watershed

The entire Niantic River from the Amtrak bridge to the Golden Spur is listed on the State's 303(d) List of Impaired Waters. It is listed because biological, chemical and physical data reveal that the river does not support several of its designated uses. The suspected causes and potential sources of these impairments, as well as other descriptive information, are summarized in Table 4.2-1. No TMDLs have been drafted for the Niantic River. (For explanations of the terms used in this table, please refer to Appendix B, Terms and Definitions).

Table 4.2-1. Niantic River Segments listed on the 2004 Connecticut Waterbodies Not Meeting Water Quality Standards (303(d) List)

Waterbody Segment ID	Waterbody Segment Name	Waterbody Segment Size (Sq. Miles)	Waterbody Location Description	Impaired Designated Use	Use Support Category	Cause (Potential Cause)	Tier	TMDL Priority	Potential Source
CT2204-E_02	Niantic Bay – upper bay and river_02	0.29	Niantic River, Gold Spur Area	Aquatic Life Support	Partial	Unknown	3	M	Marinas, Onsite wastewater systems (septic tanks), urban runoff/storm sewers, waterfowl
				Primary Contact – Recreation	Partial	Indicator Bacteria	2	L	
				Shellfishing	Not Supporting	Indicator Bacteria	2	L	
CT2204-E_03	Niantic Bay and offshore_03	3.96	Niantic River, Niantic Bay and offshore, excluding 0.2 sq. mi. near shore between Pond Point north to RR tracks, Niantic.	Aquatic Life Support	Partial	Unknown	3	M	Marinas, septic tanks, urban runoff/storm sewers, unknown sources, waterfowl
				Shellfishing	Not Supporting	Indicator Bacteria	2	L	

4.2.1 Pathogenic Bacteria

"Indicator bacteria" are reportedly the primary cause of impacts to human uses of the Niantic River. This cause indicates that water quality monitoring found pathogenic ("disease-causing") bacteria (*Escherichia coli* and Enterococci) in water samples in excess of the State's *Water Quality Criteria For Bacterial Indicators Of Sanitary Quality* (CTDEP, 2002c). Generally speaking, the presence of these bacteria indicates that fecal contamination by humans or wildlife has occurred and a potentially dangerous public health threat exists. Due in part to this result and the fact that the Niantic River is a popular shellfishing and recreation area, DA/BA conducts more in-depth investigations and assessments to determine the extent of the public health threat.

The CT DA/BA, working in conjunction with the East Lyme Health Department and the Ledge Light Health District (serving East Lyme and Waterford), is responsible for implementing the National Shellfish Sanitation Program (NSSP). CT DA/BA is required to classify shellfish growing waters in each town. Classifications result from a Comprehensive Evaluation Report, which includes a shoreline survey and water quality data every twelve (12) years, an Annual Assessment Report of shoreline changes and data analyses, and a Triennial Evaluation Report. These reports characterize pollution sources and their potential impact, analyses of seawater samples, recommended remedial actions for suspected issues, and classification recommendations. The CT DA/BA 'Shellfishing Area Classifications' are different from the water quality classifications mentioned above and are designated specifically for shellfish growing areas based on sanitary surveys of each area (CTDOAG, 2006).

The two most recent CT DA/BA assessments of the Niantic River are the *2003 Triennial Assessment for the Town of Waterford* and the *2003 Annual Assessment for the Town of East Lyme*. These reports provide the results of water quality sampling and pollution source investigations, as well as corrective measures, for the periods January 1, 2001 to December 31, 2003. However, pollution sources in the East Lyme Assessment only include those actively monitored for the 2003 calendar year (CT DA/BA, 2005a and 2005b). The purpose of the reports is to determine if the water quality is suitable to support the shellfish harvesting activity provided for by each area.

The Niantic River has four different shellfishing areas. From Sandy Point south to the Amtrak Bridge, there are two 'Conditionally Approved' shellfish growing areas. These areas are either "open" or "closed" for shellfish harvesting depending on recent precipitation (if there is 1 inch or more of rain, then the areas are closed). Smith Cove, Keeny Cove and the Niantic River north to Golden Spur, as well as the marina areas, are designated 'Restricted Relay' areas. These areas are where CT DA/BA allows shellfish to be taken, relayed or transported to Approved or Conditionally Approved Areas provided that the shellfish are not harvested for market or consumption prior to a minimum purification period of 14 consecutive days (CTDOAG, 2006). Shellfishing is prohibited at Mago Point, north of Golden Spur, and the upper portion of Keeny Cove.

These area classifications imply that the corresponding segments of the Niantic River are impacted by various sources of bacterial pollution. Based on a 3-year average (2001-2003), the Niantic River experienced 19 rain events of this amount per year. Should there not be any overlap between rain events, this number (1-inch of rainfall or greater) of rain events could equate to 19 potential closures, requiring a minimum of 14 days per closure, for a total of as many as 266 closure days.[8] Water quality sampling of the Niantic River in 2003 by the CT DA/BA (2005a and 2005b) verified that after certain rain events (greater than one inch) unsafe levels of bacteria have been found present in the water. Although some sampling results suggest that the "trigger rainfall event" could increase to 2 inches or greater, there are not enough monitoring data to support that change. Known sources of bacteria pollution are still present in the Niantic River Watershed that are cause for concern and action.

[8] Assumes no overlap between (4-day rain event).

The 2003 East Lyme and Waterford Assessments survey the Niantic River shoreline for possible pollution sources grouped into several categories. Outstanding sources of contamination along both sides of the river have contributions from extensive storm drains, marinas, wildlife, and domestic wastewater discharges. The 2003 surveys found that there are no agricultural activities, active sanitary landfills, refuse transfer stations, active septic sludge disposal lagoons or active dredge spoils disposal sites in East Lyme or Waterford that would impact shellfish growing areas (CT DA/BA, 2005a and 2005b).

4.2.1.1 Source Characterization – Storm Sewer Outfalls

Runoff, or stormwater, flows into the Niantic River and its tributaries through natural and manmade conveyances. Natural, vegetated conveyances (*i.e.* wetlands such as brooks and perennial streams) tend to attenuate the flow of stormwater and trap pollutants. Whereas, manmade conveyances (*e.g.* storm sewers) are made of impervious materials that directly convey untreated runoff into local wetlands, the river, or its tributaries without significantly attenuating flow or pollutant concentrations.

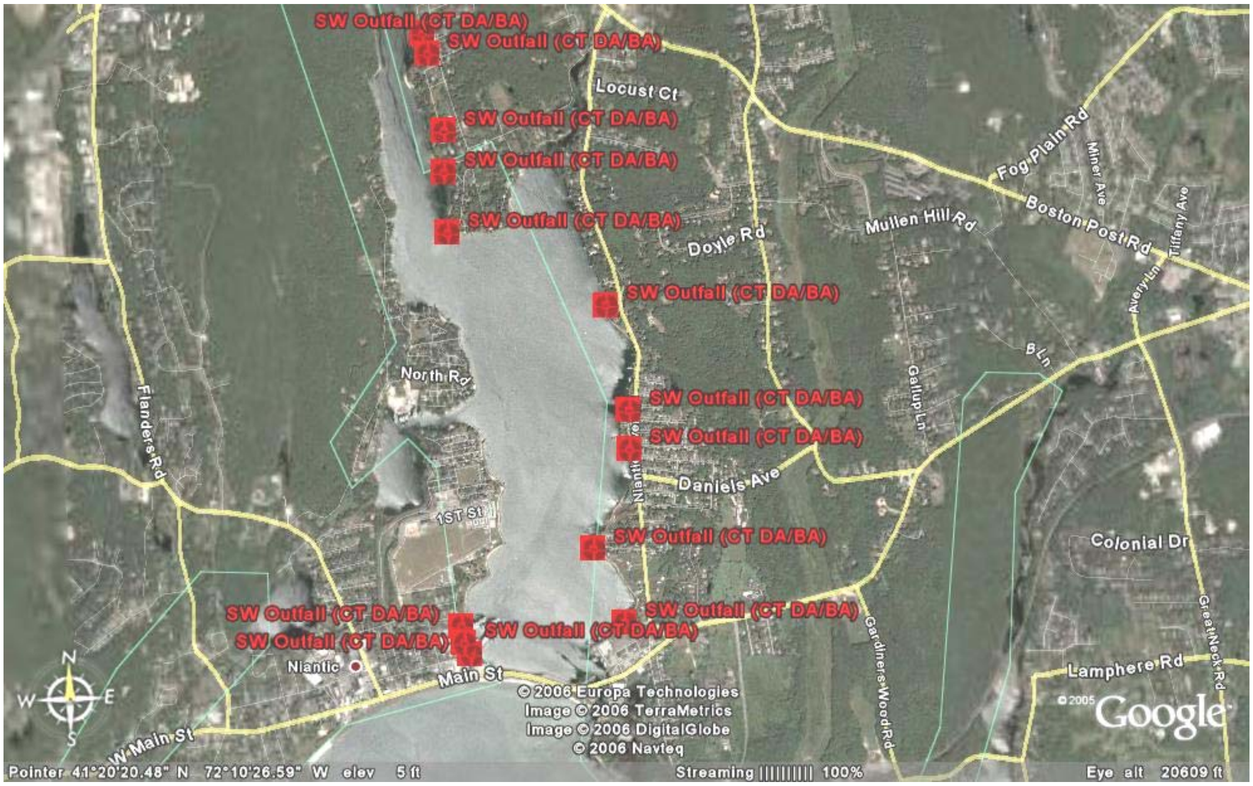
Although storm sewer outfalls are implicated as probable discharge locations of bacteria and nutrient loading to the Niantic River, limited information to quantify the problem exists at this time (Table 4.2-1). Presently, there are two data sources that locate storm sewer discharges throughout the watershed. CT DA/BA maps and describes storm sewer outfalls on the Niantic River, but not its tributaries. The towns of East Lyme, Montville and Waterford are responsible for mapping, assessing and monitoring their municipal separate storm sewer systems (MS4's).[9] Only the CT DA/BA data is available at this time.

[9] Please refer to '*General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems. Issuance Date: January 9, 2004*' from the State Of Connecticut DEP, Bureau of Water Protection and Land Reuse, Permitting, Enforcement and Remediation Division. The Town of Salem, due to its low population density, is exempt from filing for a NPDES Phase II permit for a municipal separate storm sewer system (MS4).

Niantic River shoreline surveys to identify potential bacteria pollution sources are conducted every twelve years by CT DA/BA. These surveys are currently the *only* regular field survey of pollution sources on the Niantic River. In 1995, CT DA/BA completed a Niantic River shoreline survey for East Lyme. It completed the remainder of the Niantic shoreline for the Town of Waterford's survey in 2000. Scheduled updates of the East Lyme survey is expected for 2007.

At the time this report was written, only results from the 2000 Waterford Shoreline Survey were available from CT DA/BA. A shoreline survey map was obtained illustrating the location of storm sewer outfalls in Waterford and a few in East Lyme, near the village of Niantic. Nine outfalls on the Waterford shoreline and three outfalls on the East Lyme side are illustrated on the shoreline maps. The approximate locations have been transposed onto the aerial photograph below, courtesy of Google Earth (Figure 4.2-1).

Figure 4.2-1. Approximated Locations of the Stormwater Outfalls along the Niantic River Shoreline in Waterford and the village of Niantic (East Lyme) according to the 2000 Waterford Shoreline Survey conducted by the CTDA/BA.



New data on stormwater outfalls in the watershed should be available within the next five years. East Lyme, Montville and Waterford are responsible for mapping the storm water outfalls under their MS4 permit as outlined in each municipality's stormwater management program plan. The Niantic River outfall locations will be verified upon full implementation of this plan. Outfalls along Latimer Brook and Oil Mill Brook will mostly likely be mapped when Montville implements its plan. The water quality of these outfalls should be evaluated during the implementation of the plans.

4.2.1.2 <u>Source Characterization – Marinas/Marine Vessels</u>

Sewage discharged from boats with a marine head (toilet) is a nonpoint source of pollution. It may contain pathogenic bacteria and viruses that infects shellfish rendering it unsuitable for human consumption and contaminates beaches making them unsafe for swimming. Bacteria pollution from vessel sewage discharge can particularly affect poorly flushed embayments and coves. Many marinas are located in these coastal features, which are also ideal shellfish habitats, swimming areas and fishing spots. Vessel sewage, like other pollutants, can be harmful to the environment even when partially treated (CTDEP, 2005).

On the Niantic River, vessel sewage discharges are suspected sources of pathogenic bacteria negatively impacting water quality and contributing to current impairments. No data exists quantifying the amount of sewage from vessels on the Niantic River. However, a recent study in support of the State's bid to designate an area of the Connecticut coastline, extending from Eastern Point in Groton to Hoadley Point in Guilford, as a No Discharge Area (NDA) approximated the number of vessels that pose a potential risk of sewage discharge.

As noted in Section 3.3.3, there are a total of eleven commercial marinas in the Niantic River, two anchorage areas located near Sandy Point and Keeny Cove, a number of small private individual docks scattered along the shoreline, and one state boat launch located in Waterford near Mago Point. Only one of these marinas, Port Niantic Marina, is involved in the State's Clean Marina Program.[10]

According to the CTDEP study, the approximate number of recreational vessels in the Niantic River is 7,200. This estimated number of vessels yields a potential 228 Type III marine sanitation devices (MSDs) in the Niantic River.[11] The number of commercial vessels in the

---

[10] Certified Connecticut Clean Marinas are recognized for implementing "practices which minimize the pollution from mechanical activities, painting and fiberglass repair, hauling and storing boats, fueling, facility management, emergency planning and boater education."

[11] Estimations include a relatively small number of vessels/MSDs locate in the Niantic Bay. Type III MSDs are holding tanks designed to prevent the overboard discharge of any sewage, treated or untreated. These holding tanks receive and store waste from marine toilets until it can be offloaded by a pumpout facility.

Niantic River is estimated at 300, including 154 permitted commercial fishing vessels (CTDEP, 2005c).

Effective May 12, 2006, the USEPA designated this area of Connecticut coastline, including the Niantic River, an NDA pursuant to the Clean Water Act, Section 312(f)(3) (USEPA, 2006). An NDA is a body of water in which the discharge of vessel sewage, both treated and untreated, is prohibited. This designation weighs heavily on the availability of marine pumpout facilities to service vessels with holding tanks. On the Niantic River, there are five locations where vessels may properly discharge their wastes and one pumpout boat that operates on weekends.

Implementation of the NDA could have immediate positive benefits for the Niantic River's water quality. We would expect that bacteria levels in the river would decrease, especially in the summer in and around the marina locations. Pinpointing the impact of effective NDA implementation is problematic because there remain many other bacteria sources on the river (*e.g.* wildlife, failing septic systems, and stormwater outfalls). However, future monitoring could compare historic water quality monitoring data of these locations from CT DA/BA to provide a measure of performance. Currently, success of the program is nationally measured in terms of the number of pumpouts and the volume of sewage pumped (USEPA, 2005c).

4.2.1.3 Source Characterization – Wildlife

The feces of various species of wildlife and domesticated animals wash away with runoff carrying bacteria to the Niantic River and its tributaries. Under certain circumstances, concentrations of bacteria from these sources can exceed water quality standards, thus resulting in localized and often chronic water quality problems. Management of these oft-times considered "background" levels of bacteria pollution can be challenging. Great strides have been made to discern between "natural" bacteria levels in the water from indigenous wildlife versus anthropomorphic sources related to wildlife and pets.

Many swan populations occupy the Niantic River with important consequence to water quality. Highest concentrations of swans are found in the upper sections of Keeny Cove (near Kiddies Beach), Waterford, Smith Cove and Golden Spur, East Lyme. Smaller concentrations populate the mouth of Latimer Brook, East Lyme. Population roosting areas impact on the river is exacerbated by significant rainfall events. Several species of migratory waterfowl also contribute to the bacterial pollution.

Dogs, cats, whitetail deer, raccoons and other mammals are potential sources of bacterial pollution throughout the Niantic River Watershed.

4.2.1.4 Source Characterization – Domestic Wastewater Discharges

Untreated domestic wastewater is a potential source of bacterial pollution in the Niantic River Watershed. Improperly designed, sited, and/or maintained on-site sewage disposal systems malfunction and discharge untreated sewage. Sewage from a failing system reaches a nearby stream, stormwater drain or the river in one of two ways. It often pools on the earth and runs off with rain water, or passes through the system untreated, contaminates groundwater and percolates into nearby surface waters.

Historically, failing on-site wastewater systems were documented as the primary sources of bacteria loading to the Niantic (CT DA/BA, 2005a & 2005b). On average, 2% of these systems are considered failing in a watershed (USEPA, 2005d). Within the last 15 years, most of East Lyme and Waterford have been connected to a centralized wastewater treatment facility. Only homes along Konomoc Avenue in Waterford and generally north of Interstate 395 rely on on-site wastewater disposal. In East Lyme, the Pine Grove sewer extension is underway and due for completion 2007, which leaves the community of Saunders Point to be the last unsewered neighborhood on the western shoreline of the Niantic.

There is no wastewater treatment facility discharge to the Niantic River or its tributaries. An extensive centralized sewer system services East Lyme and Waterford with the exception of few areas. The waste collected by this system is pumped to a treatment plant discharging to the Thames River in New London. In July 2004, East Lyme pumped 1.62 million gallons per day (MGD) and Waterford pumped 2.82 MGD to New London's treatment facility (CT DA/BA, 2005a & 2005b).

Any risk of water pollution to the Niantic River from this wastewater system results from the chance of a system failure such as breaks in the sewer line or malfunctioning pump station. East Lyme and Waterford maintain approximately ten public sewer pump-stations adjacent to the Niantic River (CT DA/BA, 2005a). Also, the main sewer crosses the mouth of the Niantic River near the Route 156 bridge. These systems are monitored by the Towns with periodic inspection reports provided to the State (DA/BA, 2005a).

4.2.2 Nutrient Nitrogen Loading

According to the draft 2006 303(d) List of Impaired Waters, the Niantic River is 'partially supporting' its designated use to provide suitable habitat for aquatic life. Although the cause of this impairment is listed as 'unknown', nutrient loading (primarily nitrogen) into the river, has been implicated as the primary pollutant of concern that has triggered changes to the Niantic River ecosystem (CTDEPT, 2004b).

It is well-understood that nitrogen inputs into coastal systems, particularly estuaries like the Niantic River, are on the rise and result in the eutrophication of these systems (Valiela, *et al.*, 1997; National Academy of Sciences (NAS), 1994; NAS, 2000). Eutrophication associated with nitrogen loading in estuaries is associated with periodic algal blooms. Algal blooms are often unsightly and considered a nuisance for water-based uses. Of serious concern, the algae eventually die and sink to the bottom where they decompose. The process of decomposition consumes oxygen and results in periodic hypoxia (low oxygen), an unsuitable condition for most marine life, or anoxia (no oxygen). Hypoxic conditions lead to fish kills and lifeless areas of coastal waters that cause marked alterations in ecological structure and function (NAS, 2000).

How the Niantic River ecosystem is responding to stressors like nitrogen is the subject of Section 4.3. Here we will concern ourselves with the problem of characterizing the sources of nitrogen in the Niantic River Watershed and address the question of each source's contribution of nitrogen to the system.

Surface runoff, including groundwater recharge, is considered a vehicle for nitrogen delivery to the Niantic River (Marshall, 1994; Stacey and Mullaney, 2004). Nitrogen, from nonpoint source pollution is the dominant and least easily controlled component of this form of coastal pollution (NAS, 2000). Emanating from the combustion of fossil fuels, fertilizer use, and wastewater, nitrogen enters a watershed via atmospheric pollution, direct application [of fertilizer] and domestic wastewater discharge. Precipitation and runoff transport accumulated nitrogen compounds, such as nitrate [NO_3^-] and ammonium [NH_4^+], into nearby streams carrying it thus to coastal rivers or estuaries.

Nitrogen, as a component of domestic wastewater effluent, is flushed underground where it mixes with groundwater. Groundwater reserves the nitrogen-laden effluent and ultimately transports it to nearby surface waters as recharge. Whether carried by groundwater or surface water, some use or "uptake" of the nitrogen occurs, which can make estimating these sources a more complex task. For example, Mullaney, *et al.* (2002), noted that instream losses of nitrogen from uptake by biota, storage of nitrogen in the streambed and impoundment sediments, volatilization of ammonia nitrogen, and denitrification confound the problem of estimating nitrogen contributions via surface water.

It is expected that nitrogen (in various forms) be present in the watershed because of land uses and other sources (*i.e.* atmosphere, runoff, or wastewater). The quantity and transport of it to Niantic River is currently being examined by several other investigations. Until these investigations are complete, our understanding of the fate and transport of nitrogen in the Niantic River Ecosystem will remain limited. Table 4.2-2 provides a snapshot of three key research efforts that are in various stages of completion.

Table 4.2-2. Current Research Efforts investigating the Role, Fate, and Transport in the Niantic River Ecosystem

UCONN Marine Sciences Program at Avery Point Dr. James Kremer	*Nitrogen Loading Model*	This scientific study strives to quantify the effects of nitrogen loading on estuarine ecosystems like the Niantic River.
USGS John Mullaney	*Study to Determine Nitrogen Discharge from Groundwater to the Niantic River*	▪ Determine pre-sewer nutrient concentrations in shallow and deep ground water based on two rounds of samples. ▪ Use dissolved gas concentrations to evaluate denitrification in the aquifer. ▪ Monitor post-sewer nitrate concentrations in ground water for one year. ▪ Estimate ground-water loads of nitrogen to the Niantic River before and after sewering.
CTDEP Nonpoint Source Pollution Program and Long Island Sound Study Paul Stacey	▪ *Development of a Nutrient Criteria for the Niantic River* ▪ *Development of a Total Maximum Daily Load (TMDL) for bacteria and nutrients in the Niantic River*	Set critical limits for bacteria and nutrient loadings to the Niantic River as the basis for water quality restoration activities.

4.3 Niantic River Ecosystem: Biological Properties And Ecological Interactions

4.3.1 Nutrients and Primary Productivity

In marine waters, nitrogen is typically the nutrient that limits algal primary production (Valiela, 1984). Consequently, the addition of nitrogen to coastal waters from anthropogenic sources can increase the growth and abundance of algae (Lapointe & O'Connell, 1989). Excessive algal production causes, either directly or indirectly, most of the adverse changes in coastal ecosystems (Costa *et al.*, 1999). In general, the response of coastal ecosystems to nitrogen loading are most pronounced in systems with restricted water exchange, although stratified estuaries and estuaries where the photic zone extends to the bottom are also heavily impacted (Costa *et al.*, 1999).

Primary producers have evolved different strategies to exploit heterogeneity in nutrient supply and exhibit marked differences with respect to the ability to retain nutrients (Worm & Sommer, 2000). Specifically, microalgae and filamentous macroalgae have a relatively high surface area to volume ratio, and as such, will uptake macronutrients and grow rapidly, yet possess low nutrient storage capacity (Pedersen & Borum, 1996; in Worm & Sommer, 2000). Perennial canopy-forming macroalgae on the other hand, possess low surface area to volume ratios, and will uptake nutrients and grow slowly, yet exhibit higher nutrient storage capacities (Pedersen & Borum, 1996; in Worm & Sommer, 2000).

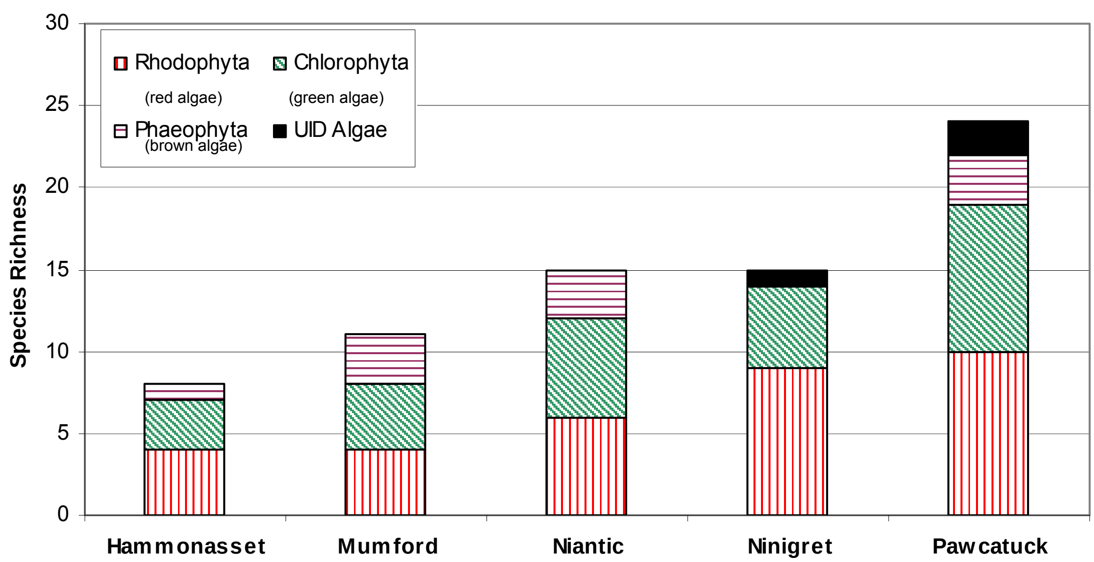
The differences in architecture will result in a variable response to nutrient inputs that may be apparent at fine spatial scales, *e.g.* embayment. Ultimately, the particular macroalgal assemblage at a site may mirror local conditions with respect to the return interval, duration; and concentration of the nutrient input.

4.3.1.1 The Macroalgal Community

The macroalgae data presented in this section were obtained from a raw data set collected by UCONN during May-November from 2001 to 2004 under the auspices of Dr. Jim Kremer (Vaudrey & Kremer, unpublished data).

A total of 39 species of macroalgae were identified at five sites and included a suite of Rhodophyta (red algae), Phaeophyta (brown algae), Chlorophyta (green algae), and three unidentified (UID) macroalgal species (Vaudrey & Kremer, unpublished data) (Figure 4.3-1). The macroalgal community at the Niantic River site was represented by fifteen species. In general, green and red algae dominate at all of the sites, with much fewer examples of brown algae.

Figure 4.3-1. Cumulative species richness by phylum across each of the five University of Connecticut study sites



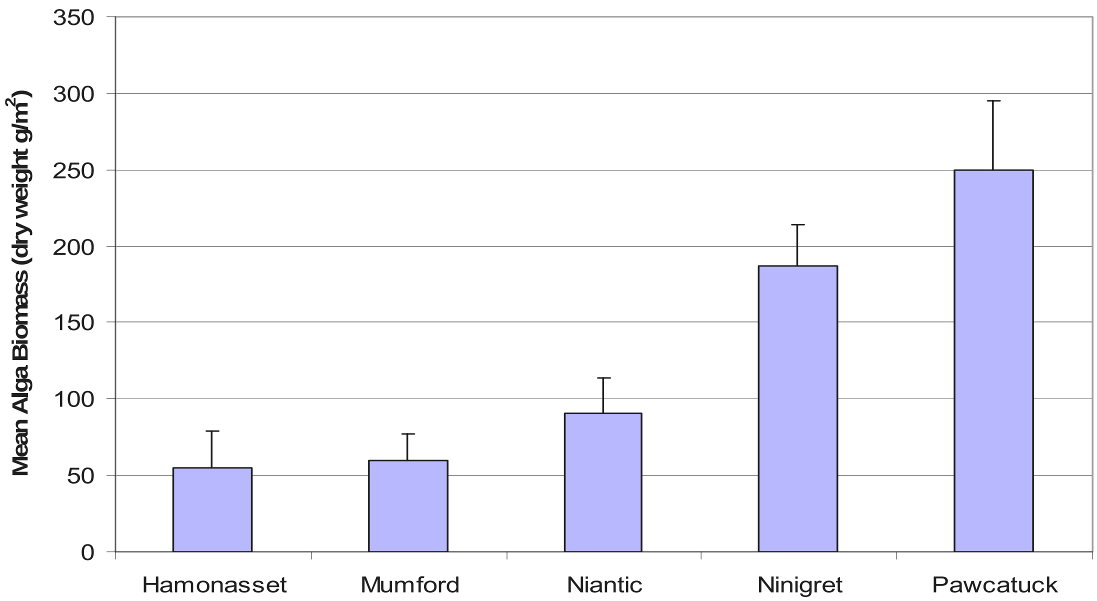
With respect to nutrient requirements and tolerance of nutrient enriched environments, *Gracilaria tikvahiae*, a genus of red algae, is often found in areas undergoing eutrophication, and exhibits rapid growth, elevated nitrogen uptake rates, and high tissue nitrogen storage capacity. Furthermore, *Gracilaria tikvahiae* can tolerate the indirect effects of nitrogen loading, including anoxia (Peckol & Rivers, 1995). *Polysiphonia* is another commonly occurring genus of red algae that exhibits rapid growth and is an opportunistic species that displaces native algae. Macroalgae with rapid nutrient uptake such as *Spyridia* are dominant in eutrophic environments with high nutrient supplies, but tend to be absent from low nutrient habitats. *Spyridia* can readily accumulate dissolved nitrogen, although accumulated nitrogen reserves decline quickly.

The green algae genus *Ulva lactuca* was the most prevalent of the green algae genera, occurring at all of the sites sampled although *Laminaria* also occurred frequently. *Ulva* as a genus is often epiphytic, thrives in nitrogen rich environments, uptake rates are particularly high, and grows rapidly. However, *Ulva* has very little ability to store nitrogen in its tissues and is often out-competed by species that have longer nutrient retention times. *Chaetomorpha*, another genus of green algae, is light dependent, utilizes more nutrients, and also reduces nutrient flux. Additionally, water turbulence can benefit *Chaetomorpha* by increasing the amounts of available ammonium (NH_4+), nitrate (NO_3^-), and phosphate (PO_4^-). The occurrence of *Enteromorpha* is governed by the availability of nitrogen and the genus is presently being investigated for its uses as treatment of secondary municipal sewage. When nitrogen is limited, *Codium* can appear sickly and bleached with a coat of fine hairs that increase the absorptive area. This species can also utilize nitrogen in many forms such as nitrate, nitrite, ammonium, and urea, albeit at low concentrations.

Brown algae were observed at four of the five study sites. Of five brown algae species, *Ectocarpus* is present along the entire eastern coast of the United States and is tolerant of elevated metals concentrations.

With respect to mean macroalgal biomass observed at each of the sites (dry weight g/m^2), the mean biomass at the Niantic site fell in the middle of the five sites sampled (Figure 4.3-2).

Figure 4.3-2. Summary of mean macroalgal biomass (dry weight g/m2) +1SE at each of the five study sites



Data Source : Vaudrey & Kremer, unpublished data

4.3.1.2 Eelgrass (Zostera Marina)

Eelgrass stands play a pivotal role in the maintenance of a healthy estuarine and coastal ecosystem. The stands form the basis of primary production that supports both epiphytic communities ("air plants", or plants not requiring soil) and species occurring at higher trophic levels (Short *et al*, 2002). Historically, eelgrass stands within the Long Island Sound system have been reduced due to the episodic occurrence of a wasting disease, which was attributed to the slime mold *Labyrinthula*

(Short *et al*, 1986). Studies conducted during the 1990s suggest that the loss of eelgrass may be attributable to nitrogen enrichment (Short & Burdick, 1996), although competitive interactions with other macroalgae have been implicated as well (Short *et al*, 1991; Short & Burdick, 1996). Ultimately, the effects of nutrient enrichment serve to increase competition between eelgrass and macroalgae.

Within the Niantic River, eelgrass stands have experienced frequent die-offs and the largest decline in population characteristics of any locality that presently supports eelgrass (DNC, 2005). Following a massive die-off in 1999, the Niantic River population exhibited a recovery in 2004, although the species is still under constant threat. Continued threats to eelgrass populations in the Niantic River include nutrient input from domestic septic systems, disease, increased turbidity, competitive interactions with macroalgae and herbivory. In addition, local water temperatures have increased by as much as 2.7 ºF since 1976 (DNC, 2005). This trend may also be exacerbating unfavorable conditions for *eelgrass*.

4.3.1.2.1 <u>Autecology</u>

Eelgrass spreads through its root system, with primary nutrient uptake occurring via sediment through the roots. Although nutrients within the water column may enter the plant via absorption, this is a relatively insignificant pathway for nutrient uptake. Substrate requirements for eelgrass occur over a broad range of sediment particle sizes that include coarse sands/gravels and fine silts and clays. In a similar manner to many plants, it can persist in a wide variety of habit types. For example, it has been observed that eelgrass occurring in the wave mixed zone possess shorter, broader leaves, grow in dense stands and produce dense rhizome clusters, whereas plants growing in less turbulent environments are taller, have broader, longer leaves and are more widely spaced, with less dense rhizome networks (Costa, 1988). This pattern simply reflects the ability of eelgrass to overcome shear forces by anchoring in the sediment, along with altering its architecture to minimize turbulence. The maximum depth at which eelgrass (and macroalgae) can grow is determined largely by light attenuation and spectral quality, which are mediated by absorption (by chlorophyll *a*) and scattering (by suspended solids, Dissolved Organic Matter, etc.) (Spence, 1982).

The euphotic zone is the surface layer of the water column where photosynthetically active radiation (PAR) is sufficient to maintain phytoplankton populations (Spence, 1982; Hader *et al.*, 1998). At high densities, phytoplankton can absorb more than 75% of PAR (Spence, 1982). In general, the blue and red wavelengths are the most used by chlorophyll *a*. The lower bound of the euphotic zone is that depth where gross daily photosynthetic carbon fixation balances phytoplankton respiratory losses over a single day and only 1% of PAR penetrates (Hader *et al*, 1998). Ultimately, the least absorbed wavelength by chlorophyll *a* (green) might be used to define the "bottom" of the euphotic zone (Spence, 1982).

4.3.1.2.2 Physicochemical Environment

With regard to the physicochemical environment, benchmark criteria for water quality parameters that would promote suitable eelgrass habitat within Long Island Sound have been developed. The suggested criteria were presented within the Eelgrass Habitat Restoration Technical Manual for variables including chlorophyll *a*, light attenuation, and total suspended solids, *etc.* (Table 4.3-2).

Table 4.3-1. Suggested water quality criteria for eelgrass

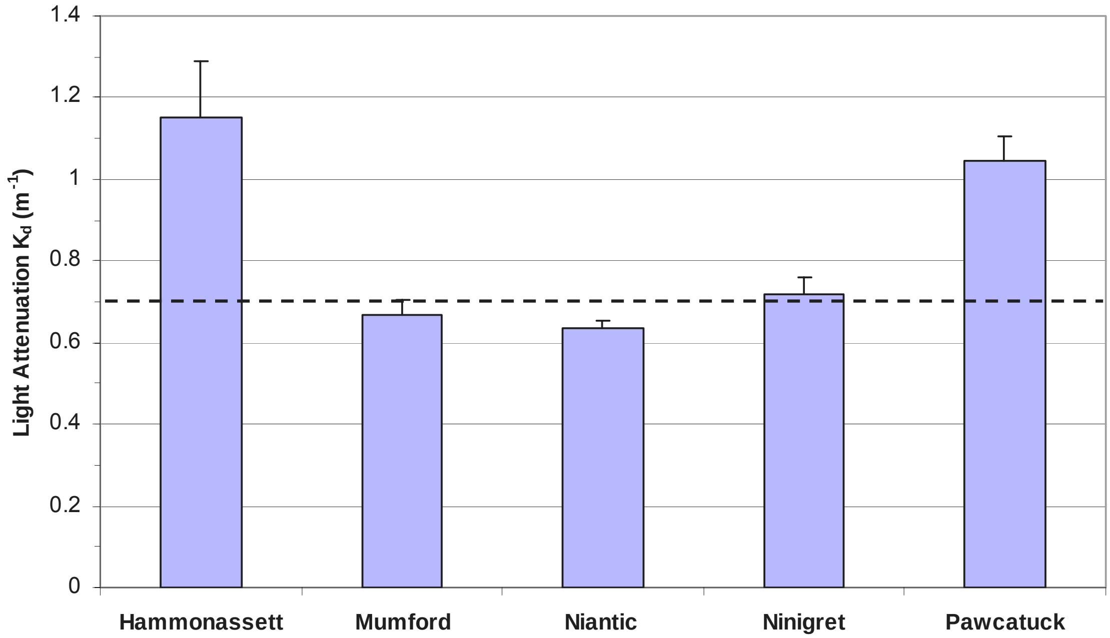
Parameter	Suggested Threshold
Light Attenuation coefficient K_d (m^{-1})	<0.7
Total Suspended Solids TSS (mg/L)	<30.0
Chlorophyll *a* (ug/L)	<5.5
Dissolved inorganic nitrogen (mg/L)	<0.03
Dissolved inorganic phosphorus (mg/L)	<0.02
Sediment Organic Matter (%)	<3.0
Secchi Depth (m)	>0.7

[a]: Parameters are based upon environmental data collected at three eelgrass sites in Long Island Sound over 18 months (Koch *et al*, 1994).

Based upon the data collected by the UCONN, both the Niantic and the Mumford sites are below the suggested upper bound for K_d (0.7) (Figure 4.3-3) (Figure 4.3-4).

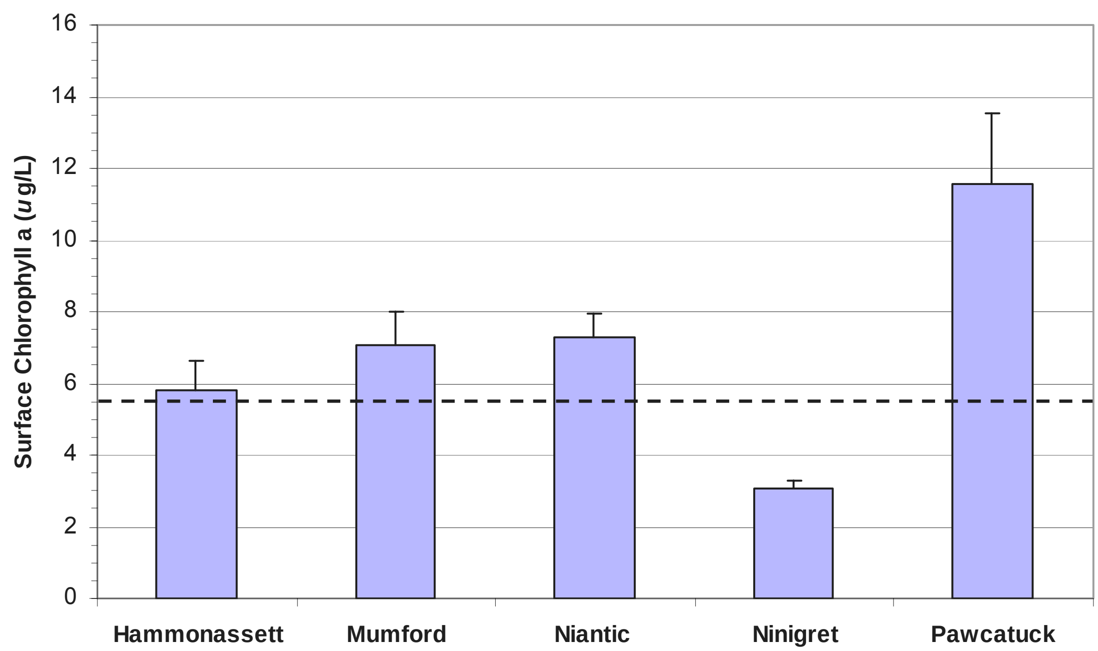
In order to determine if chlorophyll *a* concentrations increased within the Niantic River during the 2001-2004 UCONN sample period, a time series analysis was conducted (Gilbert, 1987). The results indicate that mean chlorophyll *a* concentrations within the Niantic River system increased slightly over this time period (Figure 4.3-5) and that the increase in surface chlorophyll *a* is significant, as is the increase in bottom chlorophyll.

Figure 4.3-3. Summary of mean light attenuation (m-1) at each of the five University of Connecticut study sites +1SE



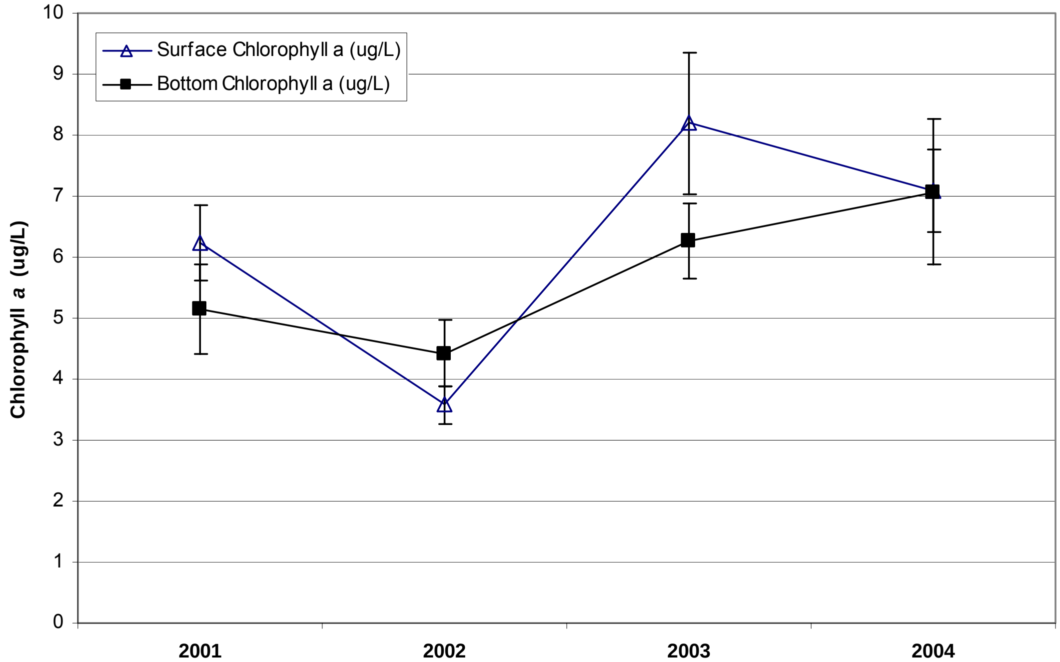
Data Source: Vaudrey & Kremer, unpublished data

Figure 4.3-4. Summary of mean surface chlorophyll a concentrations (ug/L) at each of the five University of Connecticut study sites +1SE



Data Source: Vaudrey & Kremer, unpublished data)

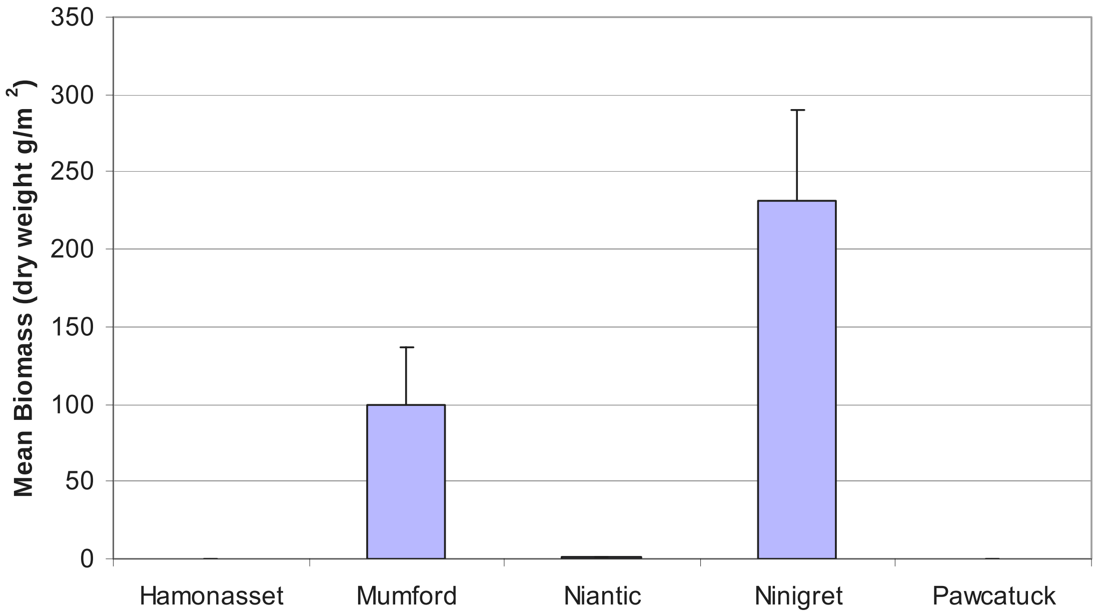
Figure 4.3-5. Mean surface and bottom chlorophyll a concentrations (ug/L) ±1SE over a four year period in the Niantic River system



Data Source: University of Connecticut (Vaudrey & Kremer, unpublished data)

During the 1985 – 2005 timeframe, the DNC has monitored aspects of eelgrass abundance in the Niantic River including shoot density, shoot length, and standing crop, in addition to sediment characteristics. Based upon the results, shoot density (no./m^2) has been largely static with time, although shoot length (cm) appears to have exhibited a slight decrease (DNC, 2005). Mean monthly standing crop (dry weight g/m^2) has also declined over the 20-year study period. With respect to the data collected by UCONN during the 2001-2004 study of the Niantic and four other sites, mean *eelgrass* biomass is lowest at the Niantic River site (Figure 4.3-6).

Figure 4.3-6. Summary of mean Eelgrass biomass (dry weight g/m2) +1SE at each of the five study sites



Data Source : Vaudrey & Kremer, unpublished data

Within the Niantic River itself, a 25cm (~10 inches) thick mat of the red algae *Agardhiella subulata* covered the sediment surface and the lower portions of the eelgrass beds shortly before the massive die-off of Niantic river eelgrass stands in 1999. Ultimately, the increase in algal decomposition induced anoxic conditions and elevated ammonium levels within the bed, which led to the gradual die-off. In spite of the frequent die-back, eelgrass populations within the Niantic River had rebounded by 2003, and by 2004 patchy eelgrass stands were once again established in the Niantic River.

The analysis of percent carbon and nitrogen (CHN), in addition to stable nitrogen isotopes in eelgrass and macroalgal tissue indicates that aquatic macrophytes in the Niantic River are experiencing what is referred to as the "luxury uptake" of nitrogen (Vaudrey & Kremer, unpublished data). The increased storage of N without a concomitant influence on biomass production is demonstrative of luxury consumption, and was mirrored in the higher than typical carbon nitrogen ratios in Niantic River macrophytes (Vaudrey & Kremer, unpublished data).

4.3.1.3 Summary of Primary Productivity

The composition of the macroalgal community within the Niantic River indicates that species tolerant of both metals loading (*Ectocarpus*) and nutrient loading (*Ulva*, *Gracilaria*, *Enteromorpha,* etc.) are present. The Niantic River might be considered one of the least nutrient-enriched sites included in the UCONN study. Both surface and bottom chlorophyll *a* concentrations have increased over the 2001-2004 timeframe within the Niantic River, which is also somewhat suggestive of increased nutrient inputs. Ultimately, in the presence of increasing macronutrient concentrations, it is likely that the Niantic River macroalgal community will shift to increasingly favor those algal species that are more effective at macronutrient uptake and retention.

Based upon data collected by DNC over the past 20 years, complete die-offs/low abundance of eelgrass within the Niantic River occurred in 1985, 1986, 1988, 1992, 1994, 1999, 2000, and 2001. The loss of eelgrass within the Niantic River has been observed to occur in response to smothering by epiphytic blue mussels, pulses of sedimentation which coincided with the catastrophic 1999 die-off (DNC, 2005) and competitive interactions with macroalgae. Elevated water temperatures have also been implicated and were present during the 1999 die-off, the effects of which are heightened during concentrations of elevated inorganic nutrients in the water column (DNC, 2005). In summation, the eelgrass beds within the Niantic River are uniquely susceptible to the effects of macronutrient enrichment, *i.e.* nitrates, phosphates, ammonium, given the long residence times in the Niantic River, and the proximity to agricultural runoff and domestic septic systems.

4.4 The Fish Community and Macroinvertebrates

The analysis of the Niantic River fish community presented in this section is largely based upon a longitudinal demersal data set that spanned the years 1976 – 2004 (DNC, 2005). The data were collected every other week for the past 30 years within the Niantic River estuary channel by DNC researchers. All catch data were expressed in units of catch per unit effort (CPUE). Some members have been standardized to proportion catches fouled by macroalgae and detritus (DNC, 2005).

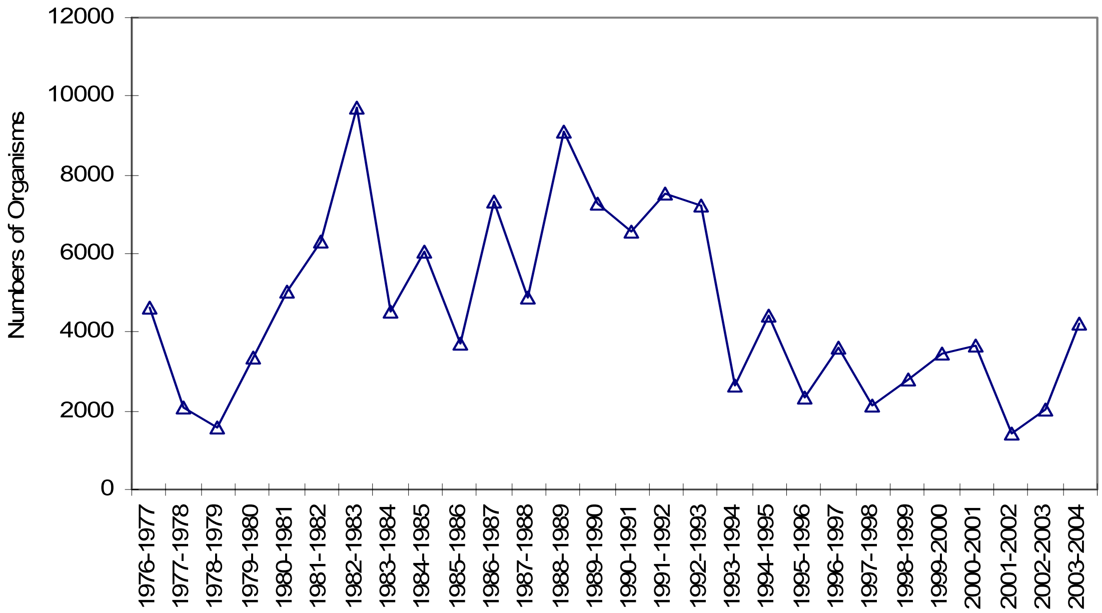
Data presented in the 2006 report "Monitoring the Marine Environment of Long Island Sound at Millstone Power Station" (DNC, 2006) have also been included in this section. This data set includes macroinvertebrates, *e.g.* green crab along with fishes collected from the Niantic River.

In addition to the community level analysis, specific organisms examined within the Niantic river include grubby, winter flounder and bay scallop. The grubby was selected given its properties as a good indicator species for natural variation (no fishing pressure and little predation), while the winter flounder and bay scallop were selected given their significance as commercially and recreationally important species.

4.4.1 Community Level Trends in the Niantic River

Over the entire 28 year period, a total of 129,649 individuals across 84 fish taxa were recorded in the Niantic River (DNC, 2005) (Figure 4.4-1). Winter flounder was the most frequently captured fish with 80,344 individuals collected. Overall, the top five taxa accounted for 81.5% of the total catch including: winter flounder (61.9%), silversides (7.4%), grubby (5.9%) windowpane (3.3%), and summer flounder (2.9%). Numbers of organisms plummeted in 1993-1994 which appears to have coincided with an eelgrass die-off in 1992. Since 1992-1993, the numbers of organisms have remained low relative to the period of peak abundance seen in the 1980s.

Figure 4.4-1. Numbers of fishes caught in trawl samples



Bay scallops were most abundant from 1976 – 1987, while northern pipefish was most abundant from 1980 – 1998. Fishes including tautog and scup were collected at increasingly greater numbers from 1999-2004 (DNC, 2006) (Figures 4.4-2 and 4.4-3, respectively).

Figure 4.4-2. Numbers of tautog collected in Niantic River trawl samples

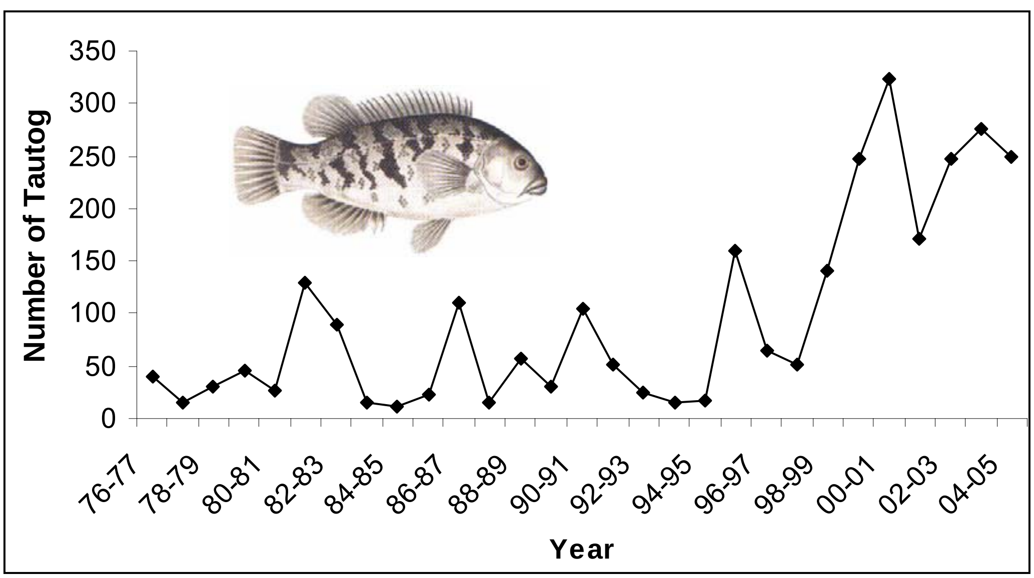
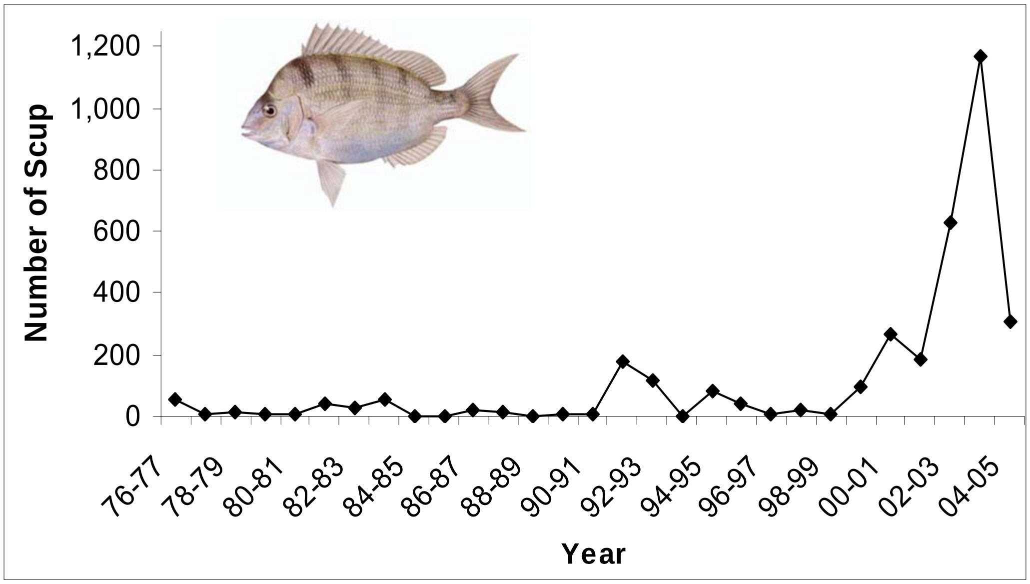
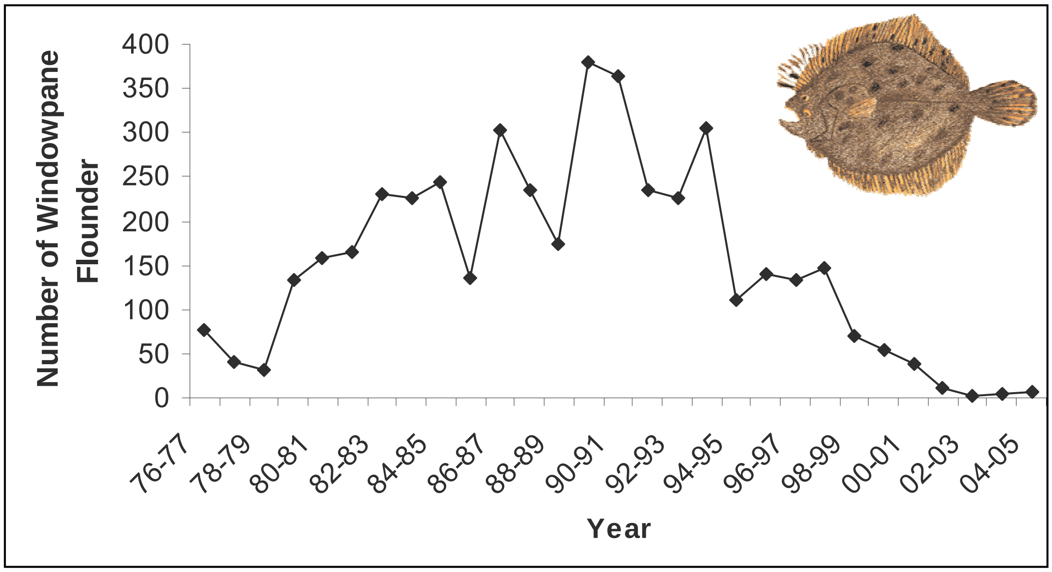


Figure 4.4-3. Numbers of scup collected in Niantic River trawl samples



In a comparison of species collected during 1976-1979 and 1999-2004, stark differences in species composition were observed (DNC, 2006). The differences are attributable to a pronounced decrease in bay scallop and a recent increases in predatory species such as the green crab, along with fishes such as scup, striped searobin, Atlantic menhaden, and spotted hake. Changes in species abundance were also observed from 1988-2004, which were manifested as an increase in the abundance of scup, and decreases in threespine stickleback, Atlantic rock crab, and American lobster, along with a sharp decrease in windowpane flounder abundance (Figure 4.4-4).

Figure 4.4-4. Numbers of windowpane flounder collected in Niantic River trawl samples



4.4.2 Grubby (Myoxocephalus aenaeus)

This section examines the trends in the behavior of benthic fishes that are known to utilize eelgrass beds during spawning and focuses specifically on the grubby (*Myoxocephalus aenaeus*) over the time period 1976-2004 (DNC, 2005).

The size of the grubby population could be, at least in part, linked with perturbations in spawning habitat such as the loss of eelgrass beds within the Niantic River. Declines in other benthic fishes that favor eelgrass beds have been observed in the Niantic River including juvenile winter flounder and the oyster toadfish.

The DNC grubby data collected from 1976-2004 indicate that there are more grubbies in the Niantic River than in Niantic Bay (Table 4.4-1). This result is similar to the findings by Roseman *et al*, 2005.

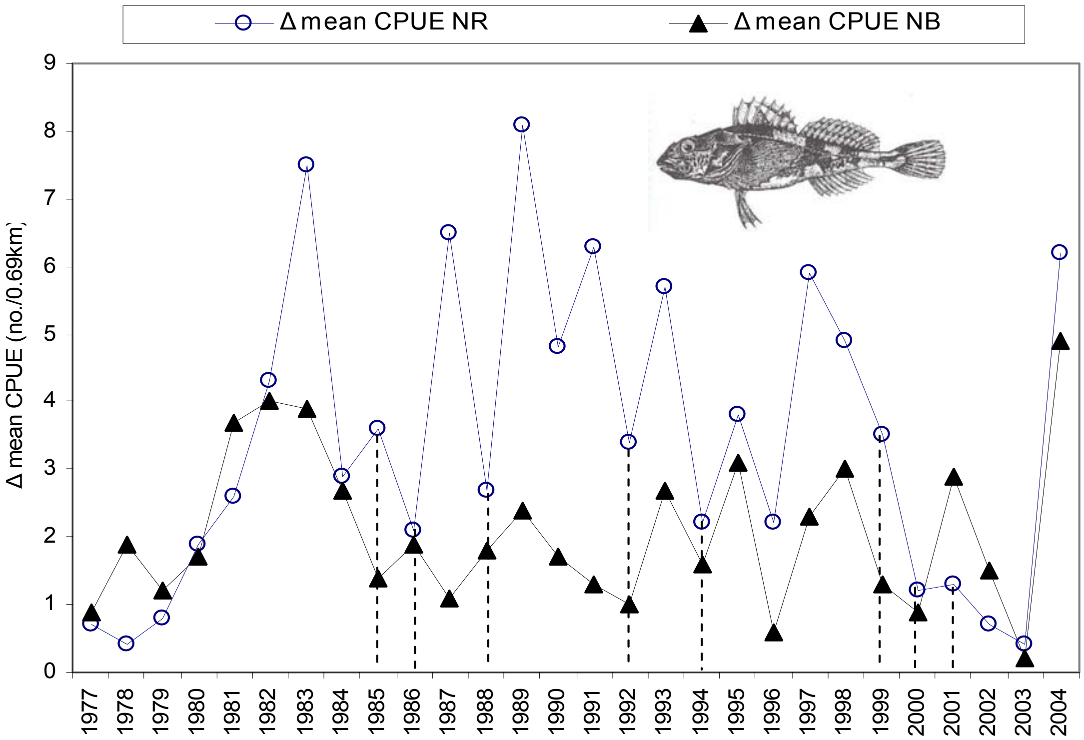
Table 4.4-1. Summary of mean grubby CPUE values in the Niantic River and the Niantic Bay (1976-2004)

	Niantic River	Niantic Bay
Number of Samples	28	28
Range	0.4 - 8.1	0.2 - 4.9
Δ mean CPUE	3.45	2.05
Standard Deviation	2.26	1.14
Mean 95% Confidence Interval	1.47	0.81

Data Source: DNC, 2005

In order to explore the possibility that variability in eelgrass biomass may explain the variability in grubby abundance within the Niantic River, abundance data were plotted against known eelgrass die-off events. Based upon data collected over the past 20 years, die-offs of eelgrass occurred in 1985, 1986, 1992, 1994, and 1999 (indicated by vertical dashed lines), while low abundance events occurred in 1988, 2000, and 2001 (Figure 4.4-5). Grubby abundance fluctuates a great deal during the period around the die-offs. The grubby is a short-lived species that matures in one year, so a fairly acute response to changes in habitat properties might be expected.

Figure 4.4-5. Annual mean change of grubby catch per unit effort (CPUE) within the Niantic River and Niantic Bay (1976-2004)



Data Source: DNC, 2005

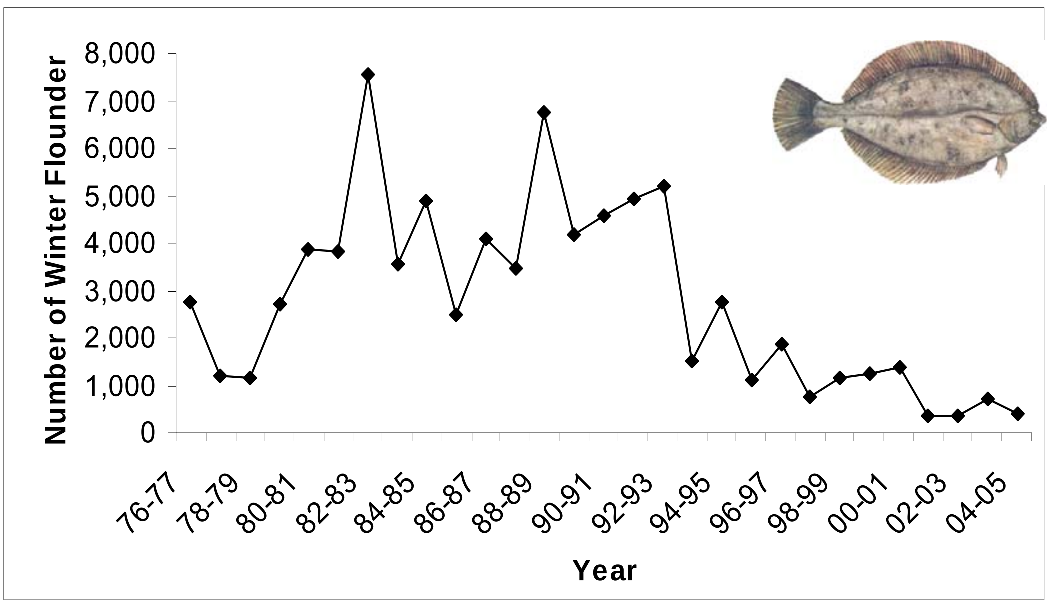
4.4.3 Winter Flounder (Pleuronectes americanus)

The winter flounder is an important commercial and sport fish in Connecticut and a dominant member of the local fish community. The abundance of this fish has been observed to be cyclical and population size fluctuates widely. Most adult winter flounder enter nearshore waters in late autumn/early winter and spawn nocturnally in the upper portions of estuaries during late winter/early spring when water temperatures range from 33.8º F – 50º F and salinities that range from 10–35‰ (Bigelow & Schroeder, 1953). Following metamorphosis, most young-of-the-year (YOY) winter flounder settle or move into shallow inshore waters. Densities can be highest in bare patches adjacent to eelgrass beds, although habitat use by young winter flounder is somewhat variable (Goldberg *et al.*, 2002).

Larval winter flounder have been sampled within the Niantic River since 1983 (DNC, 2006). In most years sampled, variability in the numbers of winter flounder larvae has been less noticeable in Niantic Bay than in the Niantic River. Furthermore, the abundance of larvae within the Niantic River was on the order of two to six times greater than in Niantic Bay. More recently however, the differences in larvae abundance have not been as conspicuous (DNC, 2006). It is likely that the greater abundance of winter flounder larvae in the Niantic River is attributable to the presence of suitable spawning areas.

Adult winter flounder have been sampled within the Niantic River since 1976 (DNC, 2006). The abundance of adult winter flounder has decreased from peaks observed during the 1980s and 1990s (Figure 4.4-6).

Figure 4.4-6. Numbers of winter flounder collected in Niantic River trawl samples



A more intensive sampling of winter flounder adults occurring during their spawning season (February-April) has been conducted in the Niantic River since 1983. As adult winter flounder abundance decreased throughout the 1990's, adults appeared to concentrate into small areas of the Niantic River, including the upper portions (DNC, 2006).

Along the eastern shoreline of the Niantic River, ripe males were encountered more frequently than females, indicating that these portions of the river are most likely serving as spawning sites (DNC, 2006). Furthermore, large adults were also common in shallow areas, which suggests that most spawning takes place where water depths are not as great (DNC, 2006). In general, few winter flounder of any size have been found in the Niantic River navigational channel during the past decade and most have been observed in the upper portions during their spawning season. Over the past decade, the abundance of winter flounder spawners in the Niantic River has remained at a relatively low level and has more or less mirrored larger trends observed in Long Island Sound (Gottschall *et al.*, 2005).

4.4.4 Macroinvertebrates (Bay Scallop)

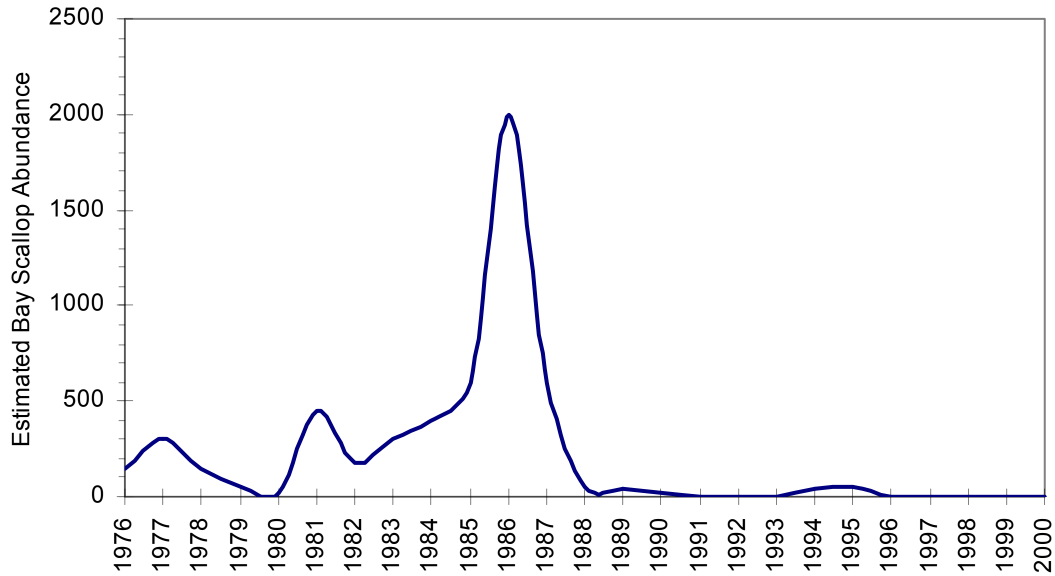
Over the last several decades, there has been a marked decline in the population abundance of bay scallop (*Argopecten irradians*) in nearshore waters and estuaries of the northeastern United States. Losses of habitat, deterioration of water quality, and harmful algal blooms have probably contributed to this decreased abundance (Goldberg *et al*, 2000). Apparently, bay scallops will generally only spawn once in their 18-22 month lifespan and this life history strategy increases the possibility of limited recruitment when year-class survival is poor. From this, it is clear that even slight perturbations to habitat properties may have serious consequences for this sensitive species.

Very young scallops <10mm (or 3/8 inch) apparently cannot tolerate highly silted substrates and will attach themselves to epibenthic surfaces until reaching 11 mm (or 1/2 inch) and then drop to the bottom until most scallops are 31 mm (or 1 1/4 inch) in size (Garcia-Esquivel & Bricelj, 1993), a strategy that probably improves their survival rate. Beds of eelgrass are apparently preferred as settlement locations. Young bay scallops grow faster in slower moving currents and since eelgrass beds tend to slow normal water currents (through increased surface area), availability of these plants may enhance growth rates. In instances where an eelgrass bed has become disturbed, bay scallops will emigrate out of the damaged eelgrass bed and re-attach to blades in adjacent and undisturbed beds (Garcia-Esquivel & Bricelj, 1993). This study also indicated that those bay scallops that emigrated remained in the adjacent beds, even after the damaged bed had recovered (Garcia-Esquivel & Bricelj, 1993). This response has also been observed in the Niantic River, whereby bay scallops were observed migrating out of Niantic River eelgrass beds that had become deplete of oxygen as a result of thick mats of decomposing *Agardhiella subulata*, invasive species of reg algae (Goldberg *et al*, 2000; DNC, 2005).

In the case of the Niantic River, and the extremely patchy and random nature of eelgrass biomass within the system, it seems probable that a population of bay scallops emigrating out of a disturbed bed might not actually encounter a suitable patch. In fact, the risk of predation by green crab (*Carcinus maenus*) or starfish for example, would only be increased as the small juvenile scallops move across broad expanses of unsuitable habitat, thus increasing mortality. During times of a low standing crop of eelgrass within the Niantic River, predation efficiency would most likely be increased (Prescott, 1990). Therefore, a decrease in eelgrass biomass even over a timeframe of a few weeks could markedly increase the mortality of small juveniles (Garcia-Esquivel & Bricelj, 1993).

Within the Niantic River, the abundance of bay scallops was at a peak in 1986, after which time the population plummeted (Figure 4.4-7). Presently, the species persists at low levels in the Niantic River and the small population size is mirrored in the low abundance of scallop landings over the past 10 years (Faber, Waterford East Lyme Shellfish Commission (WELSCO), pers. comm.; as cited in Goldberg *et al.*, 2000).

Figure 4.4-7. Niantic River bay scallop abundance taken from trawl data collected from 1976 – 2000



Data Source: DNC, 2001

Pilot studies directed at the restoration of bay scallop populations in the Niantic River have only met with mixed results, although these early attempts do show some promise (Goldberg *et al*, 2000).

4.4.5 Summary

The numbers of different species in the Niantic River has increased in recent times, although the overall numbers of fishes have exhibited a dramatic reduction. Unfortunately, the increase in diversity has come at the expense of important fishes that were once numerically dominant including the highly valuable winter flounder.

The grubby is a good control species to use in an assessment of a response to variability in habitat properties. Based upon the evidence at hand, the grubby population size is more variable in the Niantic River than in Niantic Bay. A qualitative relationship between grubby abundance and eelgrass is suggested by alternating depressed grubby numbers during times of low eelgrass abundance and die-offs, followed by a rebound in grubby numbers as the eelgrass becomes re-established. Based upon research conducted by Roseman *et al.* (2005), grubby may be using the Niantic River preferentially to spawn. This relationship is based upon the fact that larger, more reproductively mature grubby were observed in the Niantic River. Under the assumption that the grubby use eelgrass beds preferentially during spawning, it might be expected that the abundance and total length of grubby within the Niantic River during times of low eelgrass abundance may decrease.

The abundance of winter flounder larvae in the Niantic River has been considerably more variable than observed in Niantic Bay. Furthermore, the numbers of larvae have been higher in the Niantic River than in Niantic Bay and this is most likely attributable to the presence of suitable spawning habitat, particularly along the eastern shoreline of the Niantic River. It is worth noting however, that the difference in the numbers of winter flounder larvae observed both in the Niantic River and Niantic Bay have not been pronounced. With respect to adult winter flounder, their abundance has decreased from peaks observed in the1980s and 1990s. Over the past decade, the abundance of winter flounder spawners in the Niantic River has remained at a relatively low level and has mirrored larger trends observed in Long Island Sound.

The bay scallop has exhibited a dramatic reduction in population size and is most likely the least resilient organism to changes in habitat properties, *e.g.* eelgrass cover. Given the dependence of early developmental stages on eelgrass beds, stochasticity in the abundance of eelgrass, and the inability to locate suitable eelgrass patches may have increased the likelihood of predation. In addition to reduced recruitment in response to decreased availability of suitable habitat, the increase in predation may have at least partially contributed to the recent reduction in bay scallop.