EXHIBIT 44 (AR J.12)

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Methodology and Assessment Results related to Eelgrass and Nitrogen in the Great Bay Estuary for Compliance with Water Quality Standards for the New Hampshire 2008 Section 303(d) List

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Executive Summary

The New Hampshire Department of Environmental Services (DES) developed an assessment methodology for determining compliance with water quality standards for biological integrity (Env-Ws 1703.19) using eelgrass (*Zostera marina*) cover in the Great Bay Estuary as an indicator. DES reviewed eelgrass cover data from 1948 to 2005. Eight regions of the estuary were found to have significant eelgrass loss based upon the degree of historic loss or recent declining trends accounting for natural variability. One region, Great Bay, was found to be threatened for significant eelgrass loss. Impairments for biological integrity (Env-Ws 1703.19) will be added to the State of New Hampshire 2008 Section 303(d) List for these regions. For four tributaries, DES determined that there should also be impairments for nitrogen per the narrative standard, Env-Ws 1703.14. In these four assessment units, there were impairments for chlorophyll-a, which is a primary symptom of excessive nitrogen in estuarine waters. The assessment methodology and results were peer-reviewed by national and regional experts in this field.

Introduction

On March 24, 2008, the Department of Environmental Services (DES) received comments from the Conservation Law Foundation (CLF) on the State of New Hampshire's Draft 2008 Section 303(d) List. CLF's comments included the following:

> (a) Significant eelgrass declines in the Piscataqua River and Little Bay demonstrate that these waters are impaired (or threatened).
> (b) Eelgrass declines within Great Bay, particularly in light of system-wide eelgrass declines and nitrogen loading trends, demonstrate that Great Bay is an impaired (or threatened) water body.
> (c) Eelgrass declines within the Squamscott, Lamprey, and Oyster Rivers, particularly in light of system-wide eelgrass declines and nitrogen loading trends, demonstrate that these waters are impaired (or threatened).

CLF contends that the loss of eelgrass constitutes a violation of Env-Ws 1703.19 (Biological and Aquatic Community Integrity) and that the major cause of impairment should be identified as excessive nitrogen loading and that, as such, these assessment units should also be listed as impaired for Env-Ws 1703.14 (narrative nutrient criteria). CLF further requests that because of potential light attenuation impacts, DES should also consider identifying suspended solids as an additional potential cause.

CLF provided a number of sources of data on eelgrass and estuarine water quality to support their comments. The primary data source was the State of the Estuaries Report (NHEP, 2006) from the New Hampshire Estuaries Project (NHEP). CLF also cited reports from Dr. Fred Short from the University of New Hampshire (UNH).

The eelgrass data were not included in the Draft Section 303(d) List because DES had not established a methodology with numeric thresholds for determining attainment of the aquatic life use based on changes in eelgrass habitat. In response to the comments from CLF, DES has researched this question, focusing on four main points.

- The regulatory authority under New Hampshire law by which DES can consider eelgrass habitat loss to be a water quality standard violation.
- Precedents by other states for placing estuaries on 303(d) lists based on eelgrass loss.
- An assessment methodology for eelgrass habitat data that is based on sound scientific principles and is transferable to other biological data.
- A methodology for using the narrative nutrient standard (Env-Ws 1703.14) to determine nitrogen impairments in tidal waters.

Regulatory Authority

Regulatory authority to consider eelgrass habitat loss to be a water quality violation would be governed by the narrative water quality standard for biological and aquatic community integrity, Env-Ws 1703.19. This regulation states:

> (a) The surface waters shall support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.
> (b) Differences from naturally occurring conditions shall be limited to non-detrimental differences in community structure and function.

Eelgrass (*Zostera marina*) is the base of the estuarine food web in the Great Bay Estuary. Healthy eelgrass beds filter water and stabilize sediments (Short and Short, 1984) and provide habitat for fish and shellfish (Duarte, 2001; Heck et al., 2003). While eelgrass is only one species in the estuarine community, the presence of eelgrass is critical for the survival of many species. Maintenance of eelgrass habitat should be considered critical in order to "maintain a balanced, integrated, and adaptive community of organisms". Loss of eelgrass habitat would change the species composition of the estuary resulting in a detrimental difference in community structure and function. In particular, if eelgrass habitat is lost, the estuary will likely be colonized by macroalgae species which do not provide the same habitat functions as eelgrass (Short et al., 1995; Hauxwell et al., 2003; McGlathery et al, 2007). Therefore, DES believes that significant losses of eelgrass habitat would not meet the narrative standard of Env-Ws 1703.19 and create a water quality standard violation for biological integrity.

Eelgrass is sensitive to water clarity (Short et al., 1995). Cultural eutrophication from excess nitrogen, and suspended sediments in estuaries cause phytoplankton blooms, periphyton growth on eelgrass leaves, and light attenuation from non-algal particles (Short et al., 1995; Hauxwell et al., 2003; McGlathery et al, 2007). DES has not developed numeric criteria for the protection of eelgrass for nitrogen or suspended solids. For nitrogen, DES can use the narrative standard for nutrients, Env-Ws 1703.14, to evaluate impairments. The narrative standard for estuarine waters, which are Class B, states:

> (b) Class B waters shall contain no phosphorus or nitrogen in such concentrations that would impair any existing or designated uses, unless naturally occurring.

Until numeric criteria are available, DES must interpret the narrative standard using a weight-of-evidence approach. DES does not have water quality criteria for suspended solids. Therefore, development of impairment assessment methodology for this parameter was not pursued.

The NHEP Technical Advisory Committee is leading an effort to develop numeric nutrient criteria for nitrogen and suspended solids for the protection of eelgrass as the main indicator of aquatic life health in the Great Bay Estuary. The committee hopes to produce recommendations by the end of 2008.

Precedents from Other States

DES contacted the other coastal states in New England for their policies on assessing eelgrass loss in terms of water quality standards. One New England state has made impairment decisions for estuaries based on eelgrass habitat loss. The Massachusetts Department of Environmental Protection (MA DEP) considers an estuary to be impaired if there has been a significant eelgrass loss based on the best professional judgment of the assessor (MA DEP, 2007). MA DEP has not established numeric thresholds for significant eelgrass loss. In the Massachusetts approach, eelgrass habitat maps from as far back as 1951 are compared to more recent maps. If the eelgrass habitat loss is easily noticeable to the assessor, MA DEP will consider that estuary to be impaired for eelgrass loss. MA DEP began this practice for the 2006 assessment cycle. Eelgrass assessments are made for estuaries being studied by the Massachusetts Estuaries Project for which there are numeric nutrient criteria as well as for other estuaries for which both historic and current eelgrass data are available but numeric nutrient criteria have not been established. If there is a pattern of loss and there is a weight of evidence that the loss is due to nutrients, the water body segment is listed as impaired by excess nutrients. The weight of evidence approach includes additional data indicating low dissolved oxygen, high phytoplankton chlorophyll *a,* high nitrogen concentrations, and/or organically enriched benthic habitat. If there are no additional data or information available for the "weight of evidence" approach, the assessment staff determine that the water body segment impairment is habitat alteration. Therefore, there is a precedent within New England for states to add assessment units to their 303(d) lists for significant eelgrass loss and to consider the cause of the impairment to be nitrogen without having numeric nutrient criteria.

New Hampshire Assessment Methodology

DES uses a standardized approach to assessments to ensure that impairment decisions are made with credible indicators and use support criteria. This standardized approach is described in the DES Comprehensive Assessment and Listing Methodology or CALM (NH DES, 2008). The CALM for the 2008 303(d) list does not contain indicators or use support criteria for eelgrass. Therefore, DES developed a peer-reviewed methodology to use indicators and use support criteria for eelgrass, which is based on sound scientific principles and is equally credible to the indicators already in the CALM.

Eelgrass Indicator

There are three indicators of eelgrass habitat in the Great Bay Estuary:

(1) Synoptic surveys of eelgrass cover using aerial imagery. Dr. Fred Short at UNH has completed these surveys for at least portions of the Great Bay Estuary every year from 1986 to 2005. The eelgrass cover maps are ground truthed by annual boat visits to sites in the estuary. The advantage of this data source is that it is collected using standardized procedures that are published in the scientific literature (Short and Burdick, 1996) and an approved Quality Assurance Project Plan. The current survey results can be readily

compared to historic information on eelgrass presence between 1948 and 1981 which was compiled by The Nature Conservancy for the Great Bay Estuarine Restoration Compendium (Odell et al., 2006). The NHEP uses this information as an environmental indicator in its State of the Estuaries Report. The deadline for data submittals for the 2008 Section 303(d) List was December 2007. The most recent data on eelgrass in the Great Bay Estuary that were submitted by the deadline are from 2005. Maps of eelgrass cover in 2006 and 2007 have been or will be generated in 2008. These data will be considered for the 2010 Section 303(d) List.

(2) Estimates of eelgrass biomass throughout the Great Bay Estuary. These estimates are made from the synoptic survey data for cover and estimates of eelgrass density. The advantage of this data source is that it provides information on changes between healthy "dense" eelgrass beds and less healthy "sparse" beds. The disadvantage of this data source is that the error in the biomass estimates is larger than for the eelgrass cover indicator. The magnitude of this error has not yet been quantified. The NHEP uses this information as a supporting variable in its State of the Estuaries Report.

(3) Time series studies of eelgrass cover, biomass, and other metrics at specific locations over multiple years. Dr. Fred Short maintains research sites in the Lower Piscataqua River and Little Bay where he has monitored eelgrass habitat intensively over multiple years. The advantage of this data source is that more detailed and accurate information is available for the sites being studied. The disadvantage of this data source is that the results may only be representative of the areas being studied, not the whole estuary.

Based on the advantages and disadvantages of the various data sources above, DES feels that eelgrass cover (1) is an appropriate indicator for water quality impairment determinations. This indicator is collected using accepted and standardized protocols and is ground truthed annually. Current eelgrass cover data can also be compared to maps of historic eelgrass cover (compiled from various sources from 1948 to 1981) to determine long-term habitat losses. MA DEP has set a precedent for making 303(d) impairments using loss of eelgrass cover. While eelgrass biomass estimates (2) are useful as a supporting variable, DES, at this time, believes that this data source is too uncertain to be appropriate as a water quality criterion. DES has requested information from UNH to determine the magnitude of error associated with the biomass calculations. Should the error be less than expected, DES will reconsider its position on the use of biomass as an indicator in the future. Similarly, the time series studies (3) provide useful information but do not represent a large enough area to be used as a water quality criterion. Loss of eelgrass at one location may be offset by gains in some other location. Therefore, it is more appropriate to use total eelgrass cover as the indicator for the assessment.

Use Support Criteria for Eelgrass Indicator

When setting use support criteria in the CALM, DES aims to satisfy several goals: consistency with water quality standards; adherence to sound scientific and statistical principles; and consistency between different indicators and water body types. After a review of the available data and the manner in which it is being assessed by MA DEP, DES considers two methods to be appropriate for assessing eelgrass cover data.

(1) If there are reliable historic and current maps of eelgrass cover for an area, DES will use the percent decline from the historic level to determine impairments. A region will be considered to have significant eelgrass loss if the change from historic levels is >20%. This threshold value was determined from natural variability observed in recent eelgrass cover in Great Bay, which will be discussed in the following section. A higher threshold is not needed to account for error in the maps of historic eelgrass populations, because these maps likely underestimate eelgrass coverage during pristine conditions (see chronology of eelgrass changes in the Results and Discussion section). To avoid spurious impairments from one year of data, the median eelgrass cover from the last three years of data (in this case, 2003-2005) will be compared to the historic eelgrass cover. The historic eelgrass cover will be the maximum cover observed in the assessment zone from any one of the historic maps of eelgrass distribution.

(2) If sufficient data from annual surveys are available, DES will evaluate recent trends in the eelgrass cover indicator. Trends will be evaluated using linear regression of eelgrass cover in a zone versus year. The assessment zone will be considered to have significant eelgrass loss if there is a statistically significant ($p<0.05$), decreasing trend that shows a loss of 20% of the resource with 95% confidence (i.e., the 95th percentile upper confidence limit of the regression for the most recent date is less than 20% of the maximum value of the cover over the time series). Statistical procedures for estimating prediction intervals for individual estimates from Helsel and Hirsh (1992) will be used. DES selected 20% as the threshold for "significant loss" based on the natural variability in eelgrass cover that has been observed in Great Bay. For the period between 1990 and 1999, eelgrass cover in Great Bay was relatively healthy and stable. The relative standard deviation of the eelgrass cover during this period was 6.5%. Assuming that the variability in eelgrass cover in Great Bay is representative of other locations, DES chose three relative standard deviations (3 x 6.5 = 20%) as an appropriate threshold for non-random change from reference conditions.

DES will consider a zone to be impaired if either of the two methods indicates significant eelgrass loss. In the EPA Assessment Database, impairments due to significant eelgrass loss will be coded as "Estuarine Bioassessments". For assessment zones with significant eelgrass loss, DES will review available records for dredging and mooring fields to identify potential impacts to eelgrass from these activities.

Use Support Criteria for Nutrients

The estuarine eutrophication model used by the National Oceanic and Atmospheric Administration relates external nutrient inputs to primary and secondary symptoms of eutrophication (Bricker et al., 2007). Elevated chlorophyll-a concentrations and proliferation of macroalgae are primary symptoms of eutrophication, while low dissolved oxygen, loss of submerged aquatic vegetation (e.g., eelgrass), and harmful algal blooms are secondary symptoms. This approach is consistent with the conceptual model of coastal eutrophication presented by Cloern (2001). Therefore, the most direct link between nutrient inputs to an estuary and eutrophic effects is for chlorophyll-a concentrations in the water and macroalgae growth.

DES evaluates chlorophyll-a concentrations in the estuary to determine support of the primary contact recreation designated use. More than 1,800 chlorophyll-a results from tidal waters were evaluated for the 2008 Section 303(d) List. Assessment units were considered to be impaired if more than ten percent of the chlorophyll-a samples in the assessment unit had concentrations higher than 20 ug/L, or if any two readings within an assessment unit exceeded 40 ug/L (NH DES, 2008). The tidal portions of four tributaries to the Great Bay Estuary were listed as impaired for chlorophyll-a in the draft 2008 Section 303(d) List for New Hampshire: the Squamscott River, Lamprey River, Oyster River, and the Salmon Falls River.

Several studies of macroalgae were completed in the Great Bay Estuary in the 1980s. Mathieson and Hehre (1986) documented the distribution of different macroalgae species throughout the tidal shoreline of New Hampshire, including the Isles of Shoals. Chock and Mathieson (1983) and Hardwick-Witman and Mathieson (1983) studied the species composition at particular locations in the estuary. These studies provide a baseline macroalgae species in the estuary. There have been reports of increases in the abundance of different species of nuisance macroalgae by researchers at UNH, but the studies from the 1980s have not been repeated to document the changes. It is not possible to determine impairments of designated uses or water quality standards based on the available data. In 2008, the NHEP received a grant from EPA to use hyperspectral imagery to quantify nuisance macroalgal cover (multiple *Ulva* species, *Gracilaria* [e.g. *G. tikvahiae*], epiphytic red algae [e.g., ceramialean red algae] and detached/entangled *Chaetomorpha* populations) using a standard, synoptic method. Once this study is completed, it may be possible to determine trends in macroalgae and to use this as an indicator of impairment in future assessments.

The primary symptoms of eutrophication are useful as a means to detect eutrophication before secondary symptoms develop. Phytoplankton blooms (as measured by chlorophyll-a concentrations) subsequently lead to low dissolved oxygen due to respiration of organic matter (Cloern, 2001). Cultural eutrophication from increased nitrogen loads to estuaries has been shown to be a major cause of seagrass disappearance worldwide (Burkholder et al., 2007; Short and Wyliie-Escheverria, 1996). Excess nitrogen contributes to eelgrass loss by promoting the proliferation of epiphytes and ephemeral macroalgal species on and around seagrasses and by increasing phytoplankton blooms which decrease water clarity (Short et al., 1995; Hauxwell et al., 2001; Hauxwell et al., 2003). However, eelgrass can be lost due to other factors such as disease (Muehlstein et al., 1991), sedimentation, and construction of boat moorings, docks or other structures.

Therefore, for the 2008 Section 303(d) List, DES will consider estuarine assessment units to be impaired for nutrients per Env-Ws 1703.14 if there is an impairment for one of the primary symptoms of eutrophication. A quantitative assessment methodology is only available for chlorophyll-a concentrations in water. The impairments will be specifically for nitrogen because nitrogen is the limiting nutrient in estuaries (Howarth and Marino, 2006).

Results and Discussion

DES applied the assessment methodology to the eelgrass cover data for all sections of the Great Bay Estuary. Historical eelgrass cover maps were available from the Great Bay Estuarine Restoration Compendium (Odell et al., 2006) for all areas except the upper reaches of the Piscataqua River, Portsmouth Harbor and Little Harbor. Recent eelgrass cover maps are available for all areas between 1996 and 2005. For the Great Bay, Lamprey River, Squamscott River, and Winnicut River, eelgrass cover has been mapped annually since 1986. Eelgrass is not known to have been present in the Cocheco or Salmon Falls Rivers. These tidal tributaries were only evaluated for nitrogen impairments.

DES has 43 assessment units to cover the Great Bay Estuary that are coincident with the National Shellfish Sanitation Program growing areas. Great Bay itself consists of five different assessment units. In terms of eelgrass habitat it makes sense to evaluate eelgrass cover on aggregates of assessment units covering contiguous areas in order to reduce variability from small shifts in the locations of eelgrass beds. Therefore, DES aggregated the eelgrass cover data into thirteen areas: Winnicut River, Squamscott River, Lamprey River, Oyster River, Bellamy River, Cocheco River, Salmon Falls River, Great Bay, Little Bay, Upper Piscataqua River, Lower Piscataqua River, Portsmouth Harbor/Little Harbor, and Sagamore Creek. The assessment units associated with each of these areas are shown in Table 1. For the Piscataqua River and Portsmouth Harbor zones, the eelgrass cover on both the New Hampshire and Maine sides of the river were included in the totals. Eelgrass in the tidal creeks along the Maine side of the Piscataqua River was not included in the totals. The boundaries of each of the aggregated assessment zones are shown in Figure 1.

Information on the historic distribution of eelgrass cover is available from local maps and the scientific literature. Each of the data sources for the historic distribution of eelgrass are discussed in the following approximate chronology.

> The **pre-colonial distribution** of eelgrass cover in the Great Bay Estuary is unknown. In Buzzards Bay, the coverage of eelgrass in 1600 was estimated to be at least two times greater than the coverage in 1985 (Costa, 2003).
>
> In **1931-1932**, there was a massive die off of eelgrass in both North America and Europe due to 'wasting disease' caused by an infestation of the slime mold, *Labryinthula zostera* (Godet et al., 2008). Nearly all of the eelgrass beds along the east coast of the United States were lost during this outbreak. Beds in low salinity areas (e.g., tributaries) survived and helped to repopulate the coasts (Short et al., 1986). Jackson (1944) reported that the loss of eelgrass in the Great Bay

Estuary released large quantities of silt into the water and affected shellfish, fish, and waterfowl populations.

In **1948**, S. Bradley Krochmal completed a survey of eelgrass in the Great Bay Estuary and its tributaries for a University of New Hampshire M. Sc. thesis on smelt populations (Krochmal, 1949). Aerial photography was not used to map the eelgrass beds. The thesis does not explicitly state the methods used but it is presumed that shore and boat surveys were employed based upon the text.

In 1948, eelgrass populations were just beginning to recover from the 1931 wasting disease outbreak. Costa (2003) reported that the greatest rates of eelgrass recovery in Buzzards Bay occurred in the 1950s and 1960s. Eelgrass beds in France had hardly recovered by the 1950s (Godet et al., 2008). Therefore, the distribution of eelgrass in the Great Bay Estuary in 1948 represents a population in recovery. Much of the eelgrass was concentrated in the low salinity areas in the tidal tributaries, which is expected because the beds in low salinity areas survived the wasting disease. Regarding eelgrass in Great Bay, Krochmal (1949) states, "*Zostera* can be found only on the side sheltered from the prevailing northwesterly winds. The best development is found at the mouths of the Exeter, Lamprey, and Oyster Rivers."

The thesis contains a carefully drawn 1:64,000 scale map of eelgrass presence. Eelgrass presence on the map is denoted by three different density symbols, "P", "S", and "C". The density code "P" is for "isolated patches" of eelgrass. Eelgrass densities of "S" ("scattered") and "C"("common") refer to eelgrass cover greater than or equal to 25 percent of the substrate. The lowest density of eelgrass that is mapped with current methods using aerial photography is 10 to 30 percent cover of substrate. Therefore, to be reasonably consistent with current methods, only the eelgrass beds mapped in the "scattered" or "common" density codes will be used for comparisons to current data.

The boundaries of the eelgrass beds were digitized by The Nature Conservancy by creating polygons that surround groups of the same density symbols on the map. Because the bed boundaries were not actually shown on the map, the polygons created through the digitizing process should be considered approximate. Moreover, with a 1:64,000 map, the width of a line on the page covers approximately 100 feet of actual land surface. Digitizing this scale map introduces additional uncertainty in the area estimates for typical eelgrass beds on the order of 10 to 20 percent.

The map shows the complete extent of eelgrass in the Winnicut, Squamscott, Lamprey, Oyster Rivers, Great Bay and Little Bay. The map also covers the lower part of the Bellamy River and the lower part of the Upper Piscataqua River. In addition to the map, the thesis contains narrative summaries of conditions in the Cocheco River, Salmon Falls River, and Piscataqua River. The author makes frequent references to discharges of raw sewage and industrial wastes to the rivers. Therefore, conditions during this mapping period were far from pristine.

In **1962**, the Maine Geologic Survey mapped eelgrass beds on the Maine side of the Piscataqua River as part of the Coastal Maine Geologic Environment survey (ME DEP, 1962). The beds were mapped from aerial photography and checked by field visits to some sites. This survey covered a relatively small portion of the Great Bay Estuary. However, the eelgrass beds on the Maine side of the river were not mapped by any other sources until 1996. Therefore, this historic dataset provides useful information.

In **1980-1981**, the New Hampshire Fish and Game Department completed an inventory of natural resources in the Great Bay Estuary (NH FGD, 1981). Eelgrass populations in the Great Bay, Little Bay, and portions of the Piscataqua River were assessed using boat and diver surveys. The surveys did not cover any of the tidal tributaries to Great Bay or Little Bay.

The inventory was completed in response to the "T/V New Concord" oil spill in 1979 which released 25,000 gallons of No.6 fuel oil into the estuary. In Buzzards Bay, the eelgrass populations completed their recovery from the 1931 wasting disease outbreak in the 1980s (Costa, 2003). If the trajectory of recovery in Great Bay was similar, the distribution of eelgrass in 1980-1981 is useful for documenting the recolonization of eelgrass in Great Bay, Little Bay, and the Piscataqua River. Eelgrass was largely absent from these areas in the 1948 survey.

The boundaries of the eelgrass beds were drawn on NOAA charts and then represented on a small scale map in the report (1:64,000). As with the 1948 dataset, digitizing from a map of this scale introduces error on the scale of 10-20% in area estimates for typical size eelgrass beds. The uncertainty from transferring eelgrass bed boundaries from the NOAA charts to the report map is unknown.

In **1984**, there was a recurrence of wasting disease in the Great Bay Estuary. The disease virtually eliminated the eelgrass beds in Little Bay and the Piscataqua River (Short et al., 1986). Paradoxically, the distribution of eelgrass in Great Bay increased in 1984 relative to 1981. The 1984 map was created from aerial photography and ground truth surveys by the University of New Hampshire. This map has not been digitized and, therefore, could not be used in this analysis.

In **1988-1989**, eelgrass populations in the Great Bay Estuary were again decimated due to an infestation of wasting disease (Muehlstein et al., 1991). The coverage of eelgrass in the Great Bay fell to 15 percent of normal levels (NHEP, 2006). By 1990, the eelgrass cover in Great Bay had rebounded to pre-infestation levels.

In **1995**, a small wasting disease outbreak decreased the biomass of eelgrass in the Great Bay (NHEP, 2006).

The datasets from 1948, 1962, and 1980-1981 were collected before the current monitoring program using aerial photography began in 1986. Therefore, these datasets are considered to be "historic". However, the preceding chronology shows that none of the historic data sources represent pristine, pre-colonial distribution of eelgrass in the Great Bay Estuary. The eelgrass populations in the estuary have been nearly wiped out by wasting disease on several occasions, most notably in 1931. The historic maps from 1948, 1962, and 1980-1981 illustrate the eelgrass cover in various stages of recovery from the 1931 wasting disease pandemic and impacts due to discharges of untreated sewage, industrial waste, and oil. Therefore, the three maps of historic eelgrass beds should be considered to represent the minimal extent of eelgrass historically.

Figure 2 shows the eelgrass beds mapped by each of the historical data sources. Figure 3 shows the presence of eelgrass from the most recent (2005) survey. The acreage of eelgrass cover in each zone over time is summarized in Table 2. The results for each zone are discussed below.

Winnicut River

The historic maps of eelgrass do not show eelgrass cover in the Winnicut River. Linear regression of eelgrass cover from 1990 to 2005 detected a significant decreasing trend at the 0.05 significance level (Figure 4). The trend indicates that at least 48% of the eelgrass cover in this assessment unit was lost as of 2005. The trend was evaluated for the 1990-2005 period because the eelgrass populations in the whole estuary were devastated in 1988-1989 due to an infestation of the slime mold, *Labryinthula zostera*, commonly called "wasting disease" (Muehlstein et al., 1991). Including data from before 1990 would have prevented detection of any trends since the wasting disease episode. Per the assessment methodology, the Winnicut River should be considered impaired for significant eelgrass loss. The cause of the eelgrass loss is unknown. Dredging is not a possible cause as there are no records of major dredging operations in Winnicut River (USACE, 2005). There are no major mooring fields in this assessment zone. There were insufficient data to determine if there were any chlorophyll-a violations in this zone. Since there are no known chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

Squamscott River

The historic maps of eelgrass in the Squamscott River show 42.1 acres of habitat in 1948. Median eelgrass cover for the 2003-2005 period was 0 acres. Therefore, 100% of the eelgrass cover in this area has been lost. The cause of the eelgrass loss is unknown. Dredging is not a possible cause as the last channel dredge occurred in 1911 (USACE, 2005). There are no major mooring fields in this assessment zone. The Squamscott River is also impaired for chlorophyll-a. Seven of the 91 chlorophyll-a samples in this assessment zone were greater than the water quality criterion for primary contact recreation (20 ug/L). Three of these samples had a chlorophyll-a concentration greater than 40 ug/L (Magnitude of Exceedence criterion). Per the assessment methodology, the Squamscott River should be considered impaired for significant eelgrass loss and nutrients (nitrogen).

Lamprey River

The historic maps of eelgrass in the Lamprey River show 53.4 acres of habitat in 1948. Median eelgrass cover for the 2003-2005 period was 0 acres. Therefore, 100% of the eelgrass cover in this area has been lost. The cause of the eelgrass loss is unknown. Dredging is not a possible cause as the last channel dredge occurred in 1903 (USACE, 2005). There are no major mooring fields in this assessment zone. The Lamprey River is also impaired for chlorophyll-a. Three of the 110 chlorophyll-a samples in this assessment zone were greater than the water quality criterion for primary contact recreation (20 ug/L). Two of these samples had a chlorophyll-a concentration greater than 40 ug/L (Magnitude of Exceedence criterion). Per the assessment methodology, the Lamprey River should be considered impaired for significant eelgrass loss and nutrients (nitrogen).

Oyster River

The historic maps of eelgrass in the Oyster River show 182.5 acres of habitat in 1948. Median eelgrass cover for the 2003-2005 period was 0 acres. Therefore, 100% of the eelgrass cover in this area has been lost. The cause of the eelgrass loss is unknown. Dredging is not a possible cause as the channel has not been dredged (PDA, 2006). There are only a few small mooring fields in this assessment zone. There is also a chlorophyll-a impairment in the Oyster River. Nine of the 98 chlorophyll-a samples in this assessment zone were greater than the water quality criterion for primary contact recreation (20 ug/L). Six of these samples had a chlorophyll-a concentration greater than 40 ug/L (Magnitude of Exceedence criterion). Per the assessment methodology, this assessment unit should be considered impaired for significant eelgrass loss and nutrients (nitrogen).

Bellamy River

The historic maps of eelgrass in the Bellamy River show 66.9 acres of habitat in 1948 and 36.0 acres in 1980-1981. Median eelgrass cover for the 2003-2005 period was 0 acres. Therefore, 100% of the eelgrass cover in this area has been lost. The cause of the eelgrass loss is unknown. Dredging is not a possible cause as the last channel dredge occurred in 1896 (USACE, 2005). There are only a few small mooring fields in this assessment zone. Per the assessment methodology, the Bellamy River should be considered impaired for significant eelgrass loss. Available chlorophyll-a data indicate compliance with the chlorophyll-a criterion in this zone. Since there are no chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

Great Bay

The historic maps of eelgrass in the Great Bay show 263.9 acres of habitat in 1948 and 1217.4 acres in 1980-1981. Median eelgrass cover for the 2003-2005 period was 2,043.3 acres. Therefore, the eelgrass cover in this area has expanded relative to the historic data sources; the change relative to the pre-colonial distribution of eelgrass is unknown. Linear regression of eelgrass cover from 1990 to 2005 did not detect a significant trend at the 0.05 significance level. The trend was evaluated for the 1990-2005 period because the eelgrass populations in the whole estuary were devastated in 1988-1989 due to an infestation of the slime mold, *Labryinthula zostera*, commonly called "wasting disease" (Muehlstein et al., 1991). Therefore, per the assessment methodology, Great Bay should not be considered impaired for significant eelgrass loss. Available chlorophyll-a data indicate compliance with the chlorophyll-a criterion in this zone. Since there are no chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

The Clean Water Act allows for water bodies to be listed as "threatened," which generally means that the listing agency has cause to believe that the water body may well be impaired by the next listing cycle. Preliminary data for eelgrass in 2006 and 2007 in this assessment zone indicate a downward trend since 2005. This trend may be sufficient to result in significant eelgrass loss for the 2010 303(d) List. Therefore, the Great Bay should be listed as "threatened" on the 2008 303(d) List. An additional reason to consider the eelgrass habitat in the Great Bay to be threatened is the absence of eelgrass from the tributaries which served as refuges during past wasting disease outbreaks.

Little Bay

The historic maps of eelgrass in the Little Bay show 76.5 acres of habitat in 1948 and 408.7 acres in 1980-1981. Median eelgrass cover for the 2003-2005 period was 14.2 acres. Therefore, 97% of the eelgrass cover from 1980-1981 in this area has been lost. The cause of the eelgrass loss is unknown. Short et al. (1986) attributed the loss of eelgrass in Little Bay between 1981 and 1984 to a wasting disease outbreak. Dredging is not a possible cause as major dredging has not occurred in this assessment zone (USACE, 2005). There are several large mooring fields in this assessment zone. The mooring fields near Dover Point and the Bellamy River seem to overlap with potential and current eelgrass habitat. Per the assessment methodology, Little Bay should be considered impaired for significant eelgrass loss. Available chlorophyll-a data indicate compliance with the chlorophyll-a criterion in this zone. Since there are no chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

Upper Piscataqua River

The historic maps of eelgrass in the Upper Piscataqua River show 62.0 acres of habitat on the New Hampshire side of the river in 1948, 17.7 acres on the Maine side of the river in 1962, and 42.2 acres on the New Hampshire side in 1980-1981. Combining the acreages from the New Hampshire and Maine sides of the river in 1948 and 1962, respectively, the historic coverage of eelgrass in this zone was 79.7 acres. Median eelgrass cover for the 2003-2005 period was 0.7 acres. Therefore, 99% of the eelgrass cover in this area has been lost. The cause of the eelgrass loss is unknown. Short et al. (1986) attributed the loss of eelgrass in the Piscataqua River between 1981 and 1984 to a wasting disease outbreak. Dredging is not a possible cause as major dredging has not occurred in this assessment zone (USACE, 2005). There are several large mooring fields in this assessment zone that seem to overlap with potential eelgrass habitat. Per the assessment methodology, the Upper Piscataqua River should be considered impaired for significant eelgrass loss. Available chlorophyll-a data indicate compliance with the chlorophyll-a criterion. Since there are no chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

Lower Piscataqua River

The historic maps of eelgrass in the Lower Piscataqua River show 41.9 acres of habitat on the Maine side of the river in 1962 and 86.6 acres of habitat on the New Hampshire side in 1980-1981. Combining the acreages from the Maine and New Hampshire sides of the river in 1962 and 1980-1981, respectively, the historic coverage of eelgrass in this zone was 128.4 acres. Median eelgrass cover for the 2003-2005 period was 24.2 acres. Therefore, 81% of the eelgrass cover in this area has been lost. The cause of the eelgrass loss is unknown. Short et al. (1986) attributed the loss of eelgrass in the Piscataqua River between 1981 and 1984 to a wasting disease outbreak. Significant dredging operations have occurred in this assessment zone between 1956 and 2000 (USACE, 2005). This assessment zone is used frequently by large ships. There are several large mooring fields in this assessment zone that seem to overlap with potential and current eelgrass habitat. Per the assessment methodology, the Lower Piscataqua River should be considered impaired for significant eelgrass loss. Available chlorophyll-a data indicate compliance with the chlorophyll-a criterion. Since there are no chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

Portsmouth Harbor and Little Harbor

The historic maps of eelgrass do not cover Portsmouth Harbor and Little Harbor. Comparisons between historic and current eelgrass cover were not possible. Linear regression of eelgrass cover from 1996 to 2005 did not detect a significant decreasing trend at the 0.05 significance level. Per the assessment methodology, this assessment unit should not be considered impaired for significant eelgrass loss. Available chlorophyll-a data indicate compliance with the chlorophyll-a criterion. Since there are no chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

Sagamore Creek

The historic maps of eelgrass do not cover Sagamore Creek. Comparisons between historic and current eelgrass cover were not possible. Linear regression of eelgrass cover from 1996 to 2005 did not detect a significant decreasing trend at the 0.05 significance level. Per the assessment methodology, this assessment unit should not be considered impaired for significant eelgrass loss. There are insufficient data to determine if there are any chlorophyll-a violations in this zone. Since there are no known chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

Cocheco River

Eelgrass is not known to have been present in the Cocheco River. The historic sources did not map and current eelgrass maps do not show eelgrass in this zone. Available chlorophyll-a data indicate compliance with the chlorophyll-a criterion. Since there are no chlorophyll-a impairments in this zone, an impairment for nutrients per Env 1703.14 is not justified.

Salmon Falls River

Eelgrass is not known to have been present in the Salmon Falls River. The historic sources did not map and current eelgrass maps do not show eelgrass in this zone. However, the Salmon Falls River is impaired for chlorophyll-a. Six of the 52 chlorophyll-a samples in this assessment zone were greater than the water quality criterion for primary contact recreation (20 ug/L). None of the samples had chlorophyll-a concentrations greater than 40 ug/L (Magnitude of Exceedence criterion). Per the assessment methodology, the Salmon Falls River should be considered impaired for nutrients (nitrogen).

Peer Review of Methodology

Description of the Peer Review Process

DES organized a two step scientific peer review to validate the science and data used in this assessment methodology. First, on May 30, 2008, DES distributed a draft of the methodology to the Technical Advisory Committee for the New Hampshire Estuaries Project. This group met on June 10, 2008, to discuss the draft methodology (minutes available). DES revised the methodology based on comments received at that meeting. Second, on June 20, 2008, DES distributed the revised methodology to local and regional experts. The peer-review panel consisted of the NHEP Technical Advisory Committee, EPA, NOAA, state governments in New England, National Estuary Programs in New England, National Estuarine Research Reserves in New England, potentially affected municipalities in New Hampshire and Maine, and interested non-governmental organizations. Comments were requested by July 11, 2008. On July 2, 2008, DES staff met with representatives from potentially affected municipalities to review the proposal and answer questions.

Peer Review Comments and DES Responses

DES received comments from the following organizations or individuals:

1. Joe Costa, Buzzards Bay National Estuary Program
2. Steve Halterman, Massachusetts Department of Environmental Protection
3. Kathy Mills, Great Bay National Estuarine Research Reserve
4. Jim Latimer, U.S. Environmental Protection Agency
5. Phil Colarusso, U.S. Environmental Protection Agency
6. Pete Richardson, Watershed resident
7. Dave Cedarholm, Town of Durham
8. Tom Irwin, Conservation Law Foundation

9. Russell Dean and Jennifer Perry, Town of Exeter
10. Ray Konisky, The Nature Conservancy
11. Chris Nash, DES Shellfish Program
12. John Bohenko, City of Portsmouth
13. Tim Visel, Sound School Regional Vocational Aquaculture Center

DES paraphrased the comments *that suggested changes to the methodology* from each letter, grouped the comments by subject area, and provided responses in the paragraphs below. Numbers at the end of each comment correspond to the list of people above and denote which person provided the comment. Comments that supported the proposed methodology or suggested editorial changes have not been summarized, although these comments were reviewed and considered by DES staff.

<u>Massachusetts DEP Methodology</u>

- The MA DEP approach to assessing eelgrass loss was incorrectly represented. If there is a pattern of loss and there is a weight of evidence that the loss is due to nutrients, the water body segment is listed as impaired by excess nutrients. The weight of evidence approach includes additional data indicating low dissolved oxygen, high phytoplankton chlorophyll *a,* high nitrogen concentrations, and/or organically enriched benthic habitat. If there are no additional data/information available for the "weight of evidence" approach, the assessment staff determine that the water body segment impairment is habitat alteration. MA DEP has not yet had to set a minimum "significant" loss "threshold" for this impairment category. (2, 8, 10)

Response: The citation to MA DEP method was changed.

<u>Eelgrass Biomass Indicator</u>

- The methodology should include eelgrass biomass declines as an indicator of impairment. The density of eelgrass is a significant factor in determining the health and viability of eelgrass. (5, 8)
- The variability in the eelgrass biomass indicator should be quantified. (5)

Response: DES believes that there is much more variability in the eelgrass biomass indicator than the eelgrass cover indicator. On June 20, 2008, DES requested data from UNH on variability and quality assurance protocols related to this indicator. UNH has not yet provided sufficient data to complete an assessment of the uncertainty for the biomass indicator. If the uncertainty in this indicator is acceptably low, DES will consider this indicator for the assessment methodology for the 2010 303(d) list.

<u>Threshold for Significant Eelgrass Loss</u>

- The 40% threshold for significant eelgrass loss (relative to historical eelgrass coverage) is too high. (4, 5, 8, 10)
- The threshold should be changed to 10% (8) or 20% (5, 10).
- The same threshold for eelgrass cover loss should be used whether the loss is measured relative to historic maps or relative to recent trends. (5, 8)

Response: The threshold for historical losses was changed to 20% assuming that the historical data can be validated. The threshold for significant loss relative to recent trends remained at 20% to be consistent.

<u>Averaging Period/Anomalous Years</u>

- DES should exclude from trend analyses any eelgrass data for years during which there is significant eelgrass loss due to events not associated with water quality conditions (e.g., wasting disease, dredging, storms). (3)
- DES should not to average eelgrass cover data for the most recent four years as a measure of "current conditions". This practice has the potential to mask significant trends, as well as to delay needed action. (8, 10)

Response: For assessing changes from historical datasets to current conditions, the averaging period was shortened to three years. The median value was used instead of the average to discount an anomalous year. For assessing trends using the current monitoring data, the data from all years were weighted equally.

<u>Ruppia</u>

- DES should remove *Ruppia maritima* from its calculations of eelgrass cover and biomass. *Ruppia* (widgeon grass) is an annual plant that may colonize areas of eelgrass loss; counting it as healthy eelgrass habitat is not an appropriate method. (8, 10)

Response: *Ruppia* coverage was removed from all calculations.

<u>Eelgrass Trend Methods</u>

- DES should focus on eelgrass trends and, when a downward trend beyond the natural variation is observed, list the assessment unit as impaired. (8)
- DES should use Great Bay eelgrass cover data for 1996 – the year with the greatest recorded acreage of cover – as the reference point for assessing more recent annual data and trends. (8)

Response: The methodology for assessing current eelgrass data already uses trends with thresholds for impairment set at levels beyond the range of natural variation. The methodology already uses the maximum eelgrass coverage within the period for trend analysis to calculate percent loss.

<u>Data for Report</u>

- DES should include the draft 2006 eelgrass cover data in the analysis for the 2008 303(d) list. (8)

Response: UNH has not provided a final report for the 2006 eelgrass mapping survey. DES has received raw data from 2006. However, there were questions about the polygon attributes which UNH has not answered. DES has quality assurance requirements for data used for 305(b) assessments. Given that the 2006 data would best be characterized as "draft", they do not meet these quality assurance requirements. DES will use eelgrass data from 2006 and subsequent years that are final by December 31, 2009, for the 2010 303(d) List.

Indicators for Nitrogen Impairments

- Nitrogen impairments should be assigned to an assessment unit if any of the primary or secondary eutrophication symptoms are present (e.g., low dissolved oxygen, algal blooms, increasing nitrogen concentrations, and eelgrass loss not explained by other causes). (5, 8)

Response: DES will propose numeric water quality criteria for nutrients in estuarine assessment units by December 31, 2008. This proposal will include a methodology for determining impairments when various primary or secondary symptoms of eutrophication occur. DES expects significant input from the NHEP Technical Advisory Committee and other stakeholders on this proposal. DES believes that determining nitrogen impairments based on phytoplankton blooms (chlorophyll-a) for the 2008 303(d) List is an appropriate first step in this process. The new criteria will be used for the 2010 303(d) List.

Historical Eelgrass Coverage Datasets

- Source citations for historical eelgrass maps should be added. (3, 11)
- The historical eelgrass maps should not have been aggregated. The results from each survey should be presented individually. (9, 12)
- In the summaries for each river, state a time frame for the historic maps to give readers a sense of how far back in time the comparison extends. (3)

Response: The historical maps from 1948, 1962, and 1980 have been presented separately on figures and tables. The methods and applicable area for each historical survey have been described.

“Threatened” Listing for Great Bay

- The Clean Water Act allows for water bodies to be listed as "threatened," which generally means that the listing agency has cause to believe that the water body may well be impaired by the next listing cycle. Given the preliminary eelgrass data for 2006 and 2007, DES should list the Great Bay as threatened for significant eelgrass loss on the 2008 303(d) list. (5, 8)

Response: Preliminary data for eelgrass in 2006 and 2007 indicate a downward trend since 2005. This trend may be sufficient to result in significant eelgrass loss for the 2010 303(d) List. Therefore, DES agrees that Great Bay should be listed as “threatened” on the 2008 303(d) List for Aquatic Life Use Support.

Eelgrass Loss Due to Storms or Dredging or Other Causes

- In areas where significant eelgrass loss has been observed, DES should research non-water quality factors which have the potential to destroy eelgrass beds, such as storms, dredging, erosion, docks, grazing, ice scour, wasting disease, and boat moorings. These factors may account for part or all of eelgrass loss in certain areas of the Great Bay Estuary. (7, 9, 11, 12)

Response: DES has not attributed causes for any of the impairments for significant eelgrass loss. The impairment is merely a reflection that historical eelgrass beds are no longer present or current eelgrass beds are declining faster than natural variability. DES agrees that all relevant factors should be investigated in areas with significant eelgrass loss. DES does not currently have the resources to complete these investigations but can contribute relevant data. Information on dredging and mooring fields has been added to this report to assist with the investigations.

<u>Nitrogen Effects on Eelgrass</u>

- Heck and Valentine (2007) argue that cascading trophic effects from the loss of predator species are equally important to nutrient inputs. (9)
- The cause and effect link between nitrogen concentrations and eelgrass has not clearly been established. (12)

Response: Eelgrass loss is not presumed to be related to nitrogen. Nitrogen impairments for the 2008 cycle are based exclusively on elevated chlorophyll-a concentrations, a primary symptom of cultural eutrophication. DES may develop a relationship between nitrogen and eelgrass as part of the numeric water quality criteria for nutrients in estuarine assessment units.

<u>Chlorophyll-a Impairments</u>

- Details on the chlorophyll-a concentrations in the Squamscott River, Lamprey River, Oyster River, and the Salmon Falls River should be included in the report. (7)

Response: This information has been added to the summaries for each assessment area.

<u>Additional Research</u>

- DES should investigate historical changes in nitrogen loading and eelgrass loss using ^{210}Pb-dated sediment cores using USGS methods (see http://sofia.usgs.gov/workshops/waterquality/ligninphenol/). (9)

Response: It is not possible complete this research in time for the 2008 303(d) List deadline but DES will consider this idea for future studies.

Conclusions and Recommendations

1. There has been significant eelgrass loss in several sections of the Great Bay Estuary. Due to the importance of eelgrass for the ecosystem of the estuary, the loss of this habitat constitutes a water quality impairment under Env-Ws1703.19. The specific zones and assessment units that will be considered impaired for Aquatic Life Use Support due to "Estuarine Bioassessments" in the 2008 Section 303(d) List are as follows (Figure 5):

Assessment Zone	DES Assessment Unit ID
WINNICUT RIVER	NHEST600030904-01
SQUAMSCOTT RIVER	NHEST600030806-01
OYSTER RIVER	NHEST600030902-01-01
	NHEST600030902-01-02
	NHEST600030902-01-03
	NHEST600030904-06-17
BELLAMY RIVER	NHEST600030903-01-01
	NHEST600030903-01-02
LAMPREY RIVER	NHEST600030709-01
LITTLE BAY	NHEST600030904-06-10
	NHEST600030904-06-11
	NHEST600030904-06-12
	NHEST600030904-06-13
	NHEST600030904-06-14
	NHEST600030904-06-15
	NHEST600030904-06-16
UPPER PISCATAQUA RIVER	NHEST600031001-01-01
	NHEST600031001-01-02
	NHEST600031001-01-03
LOWER PISCATAQUA RIVER	NHEST600031001-02

2. The Great Bay should be listed as threatened for significant eelgrass loss. Preliminary data for eelgrass in 2006 and 2007 in this assessment zone indicate a downward trend since 2005. This trend may be sufficient to result in significant eelgrass loss for the 2010 303(d) List. The specific zones and assessment units that will be considered threatened for Aquatic Life Use Support due to "Estuarine Bioassessments" in the 2008 Section 303(d) List are as follows (Figure 5):

Assessment Zone	DES Assessment Unit ID
GREAT BAY	NHEST600030904-02
	NHEST600030904-03
	NHEST600030904-04-02
	NHEST600030904-04-03
	NHEST600030904-04-04
	NHEST600030904-04-05
	NHEST600030904-04-06

3. Violations of the narrative standard for nutrients, Env-Ws 1703.14, were evident in four assessment units. In these four assessment units, there were impairments for chlorophyll-a, which is a primary symptom of excessive nitrogen in estuarine waters. The specific assessment units that will be considered impaired for Primary Contact Recreation due to nutrients (specifically nitrogen) in the 2008 Section 303(d) List are as follows (Figure 6):

Assessment Zone	**DES Assessment Unit ID**
LAMPREY RIVER	NHEST600030709-01
SQUAMSCOTT RIVER	NHEST600030806-01
OYSTER RIVER	NHEST600030902-01-03
SALMON FALLS RIVER	NHEST600030406-01

4. UNH should provide DES with the requested information to determine the magnitude of error associated with the biomass calculations.

5. Aerial imagery for future eelgrass cover assessments should be georectified. The older imagery should be archived at NH GRANIT to document the source of the 1986 to 2005 eelgrass cover maps.

6. Metadata records for the historic maps of eelgrass cover should be created and these data sources should be archived at NH GRANIT.

7. The NHEP Technical Advisory Committee should continue to develop numeric nutrient criteria for the Great Bay Estuary.

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Tables

Table 1: Assessment units in each zone of the estuary

GROUP NAME	AUID	DESCRIPTION
BELLAMY RIVER	NHEST600030903-01-01	BELLAMY RIVER NORTH
	NHEST600030903-01-02	BELLAMY RIVER SOUTH
COCHECO RIVER	NHEST600030608-01	COCHECO RIVER
GREAT BAY	NHEST600030904-02	GREAT BAY PROHIB SZ1
	NHEST600030904-03	GREAT BAY PROHIB SZ2
	NHEST600030904-04-02	CROMMENT CREEK
	NHEST600030904-04-03	PICKERING BROOK
	NHEST600030904-04-04	FABYAN POINT
	NHEST600030904-04-05	GREAT BAY
	NHEST600030904-04-06	ADAMS POINT SOUTH
LAMPREY RIVER	NHEST600030709-01	LAMPREY RIVER
LITTLE BAY	NHEST600030904-06-10	ADAMS POINT MOORING FIELD SZ
	NHEST600030904-06-11	ADAMS POINT TRIB
	NHEST600030904-06-12	U LITTLE BAY (SOUTH)
	NHEST600030904-06-13	LOWER LITTLE BAY
	NHEST600030904-06-14	LOWER LITTLE BAY MARINA SZ
	NHEST600030904-06-15	LOWER LITTLE BAY GENERAL SULLIVAN BRIDGE
	NHEST600030904-06-16	ULITTLE BAY (NORTH)
LOWER PISCATAQUA RIVER	MEEST600031001-02	LOWER PISCATAQUA RIVER
	NHEST600031001-02	LOWER PISCATAQUA RIVER
OYSTER RIVER	NHEST600030902-01-01	OYSTER RIVER (JOHNSON CR)
	NHEST600030902-01-02	OYSTER RIVER (BUNKER CR)
	NHEST600030902-01-03	OYSTER RIVER
	NHEST600030904-06-17	OYSTER RIVER MOUTH
PORTSMOUTH HARBOR	MEEST600031001-11	UPPER PORTSMOUTH HARBOR-ME
AND LITTLE HARBOR	MEOCN000000000-02-18	ATLANTIC OCEAN
	NHEST600031001-05	BACK CHANNEL
	NHEST600031001-08	WENTWORTH-BY-THE-SEA
	NHEST600031001-11	UPPER PORTSMOUTH HARBOR-NH
	NHEST600031002-02	LITTLE HARBOR
	NHOCN000000000-02-18	ATLANTIC OCEAN
SAGAMORE CREEK	NHEST600031001-03	UPPER SAGAMORE CREEK
	NHEST600031001-04	LOWER SAGAMORE CREEK
SALMON FALLS RIVER	MEEST600030406-01	SALMON FALLS RIVER
	NHEST600030406-01	SALMON FALLS RIVER
SQUAMSCOTT RIVER	NHEST600030806-01	SQUAMSCOTT RIVER
UPPER PISCATAQUA RIVER	MEEST600031001-01-01	UPPER PISCATAQUA RIVER
	MEEST600031001-01-02	UPPER PISCATAQUA RIVER
	MEEST600031001-01-03	UPPER PISCATAQUA RIVER-SOUTH-ME
	NHEST600031001-01-01	UPPER PISCATAQUA RIVER-NORTH
	NHEST600031001-01-02	DOVER WWTF SZ
	NHEST600031001-01-03	UPPER PISCATAQUA RIVER-SOUTH
WINNICUT RIVER	NHEST600030904-01	WINNICUT RIVER

EXHIBIT 44 (AR J.12)

Table 2: Eelgrass cover in different zones of the Great Bay Estuary (acres)

Year	Winnicut River	Squamscott River	Lamprey River	Oyster River	Bellamy River	Great Bay	Little Bay	Upper Piscataqua River*	Lower Piscataqua River*	Portsmouth Harbor and Little Hbr*	Sagamore Creek
Pre-Colonial	??	??	??	??	??	??	??	??	??	??	??
1931-1932	Approx. 0	Approx. 0	Approx. 0	Approx. 0	Approx. 0	Approx. 0	Approx. 0	Approx. 0	Approx. 0	Approx. 0	Approx. 0
1948	0.0	42.1	53.4	182.5	66.9	263.9	76.5	62.0	a	a	a
1962	a	a	a	a	a	a	a	17.7	41.9	a	a
1980-1981	a	a	a	a	36.0	1217.4	408.7	42.2	86.6	a	a
1986	2.2	0.0	0.0	a	a	2015.2	a	a	a	a	a
1987	2.2	0.0	0.0	a	a	1685.7	a	a	a	a	a
1988	0.0	0.0	0.0	a	a	1187.5	a	a	a	a	a
1989	0.0	0.0	0.0	a	a	312.6	a	a	a	a	a
1990	15.9	0.0	0.0	a	a	2024.2	a	a	a	a	a
1991	23.4	0.0	0.0	a	a	2255.8	a	a	a	a	a
1992	7.3	0.0	0.0	a	a	2334.4	a	a	a	a	a
1993	6.9	0.0	0.0	a	a	2444.9	a	a	a	a	a
1994	13.8	0.0	0.0	a	a	2434.3	a	a	a	a	a
1995	7.8	0.0	0.0	a	a	2224.9	a	a	a	a	a
1996	7.6	0.0	0.0	14.0	0.0	2495.4	32.7	1.6	31.2	315.7	1.8
1997	7.5	0.0	0.0	a	a	2297.8	a	a	a	a	a
1998	10.0	0.0	0.0	a	a	2387.8	a	a	a	a	a
1999	10.2	0.0	0.0	0.0	0.0	2119.5	26.2	0.5	11.4	294.1	3.0
2000	0.0	0.0	0.0	0.0	0.0	1944.5	7.5	1.6	11.4	321.3	0.9
2001	4.1	0.0	0.0	0.0	0.0	2388.2	10.9	2.0	20.4	319.5	2.2
2002	3.5	0.0	0.0	0.0	0.0	1791.8	4.3	0.5	17.2	332.0	2.3
2003	3.5	0.0	2.2	0.0	0.0	1620.9	14.2	2.9	32.1	324.8	2.2
2004	4.2	0.0	0.0	0.0	0.8	2043.3	12.8	0.7	20.1	291.1	2.5
2005	9.2	0.0	0.0	0.0	0.0	2201.2	25.8	0.4	24.2	283.3	6.1
2003-2005 median	4.2	0.0	0.0	0.0	0.0	2043.3	14.2	0.7	24.2	291.1	2.5
Percent Change: Historic to '03-'05 Med	NA	-100%	-100%	-100%	-100%	68%	-97%	-99%	-81%	NA	NA
Significant Decrease Since 1990	Yes (-48%)	NA	NA	NA	NA	No	NA	NA	NA	No	No
Listing	Impaired	Impaired	Impaired	Impaired	Impaired	None	Impaired	Impaired	Impaired	None	None

a = not mapped NA = not analyzed * The 1948 and 1980-1981 surveys only covered the NH side of the river. The 1962 survey only covered the ME side.

* The acreages for 1996-2005 include beds from both the NH and ME sides of the river but not the tidal creeks along the Maine shore.

EXHIBIT 44 (AR J.12)

Figures

Figure 1: Eelgrass assessment zones

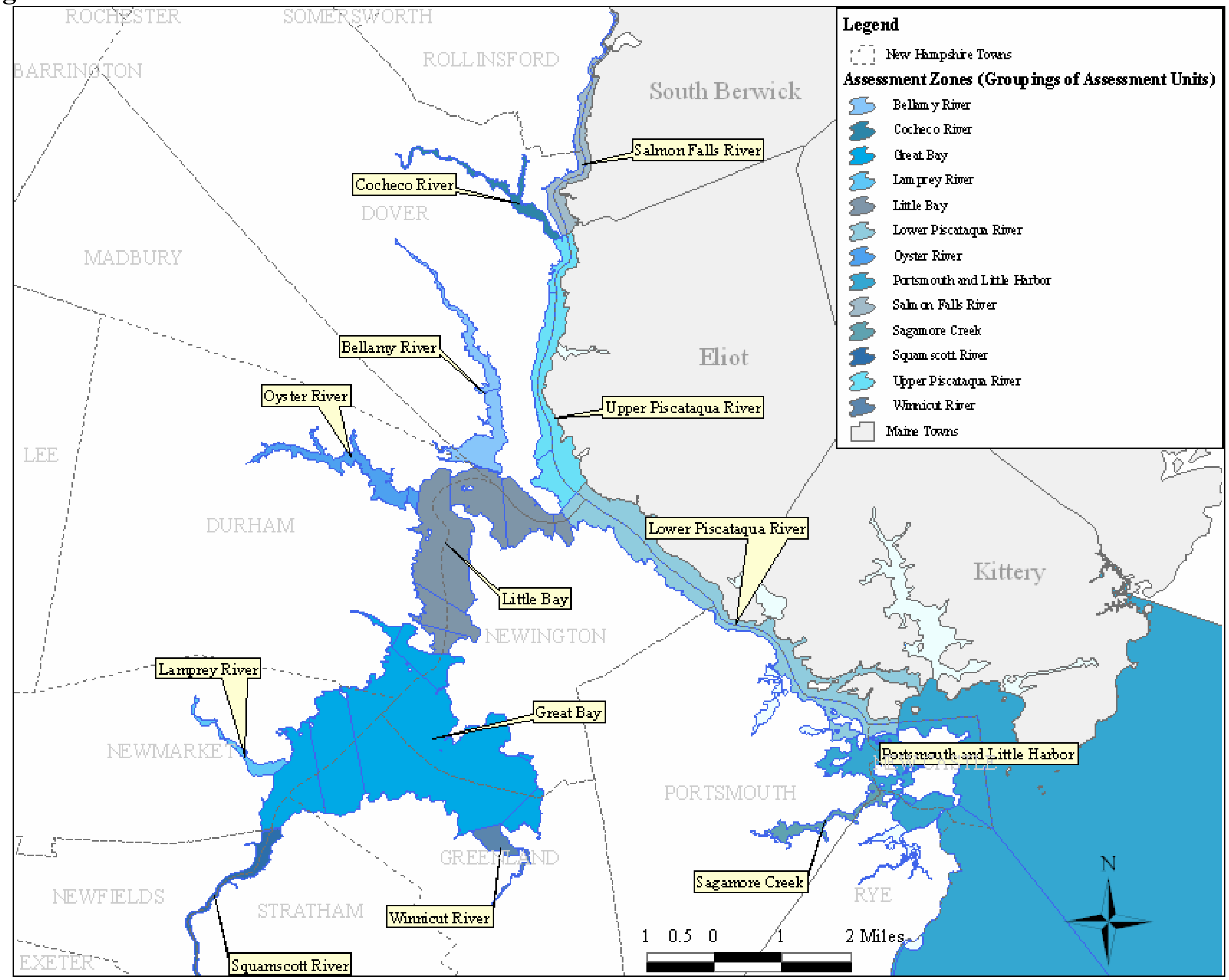

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Figure 2: Historic eelgrass cover from surveys completed between 1948 and 1981

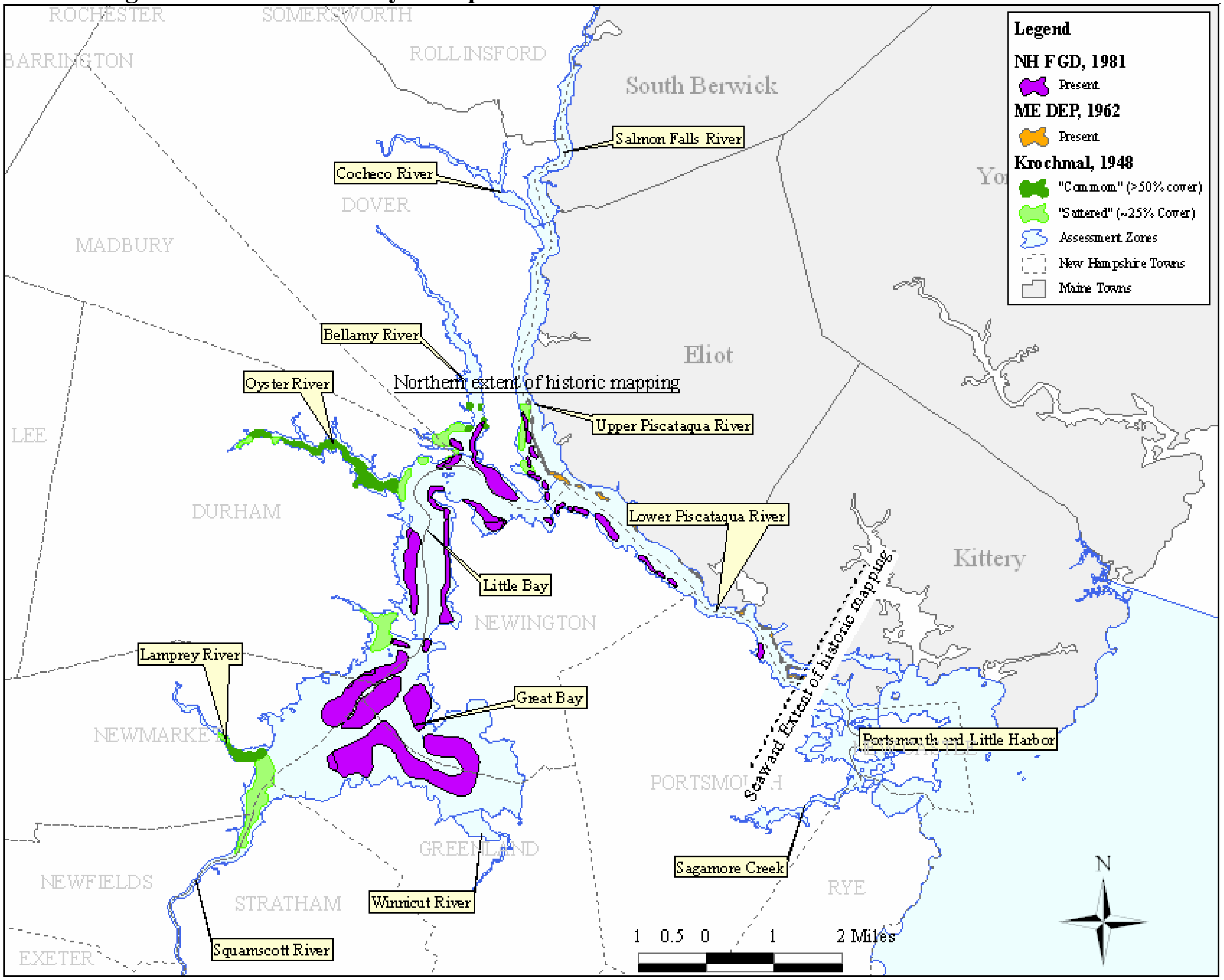

Figure 3: Eelgrass cover in 2005

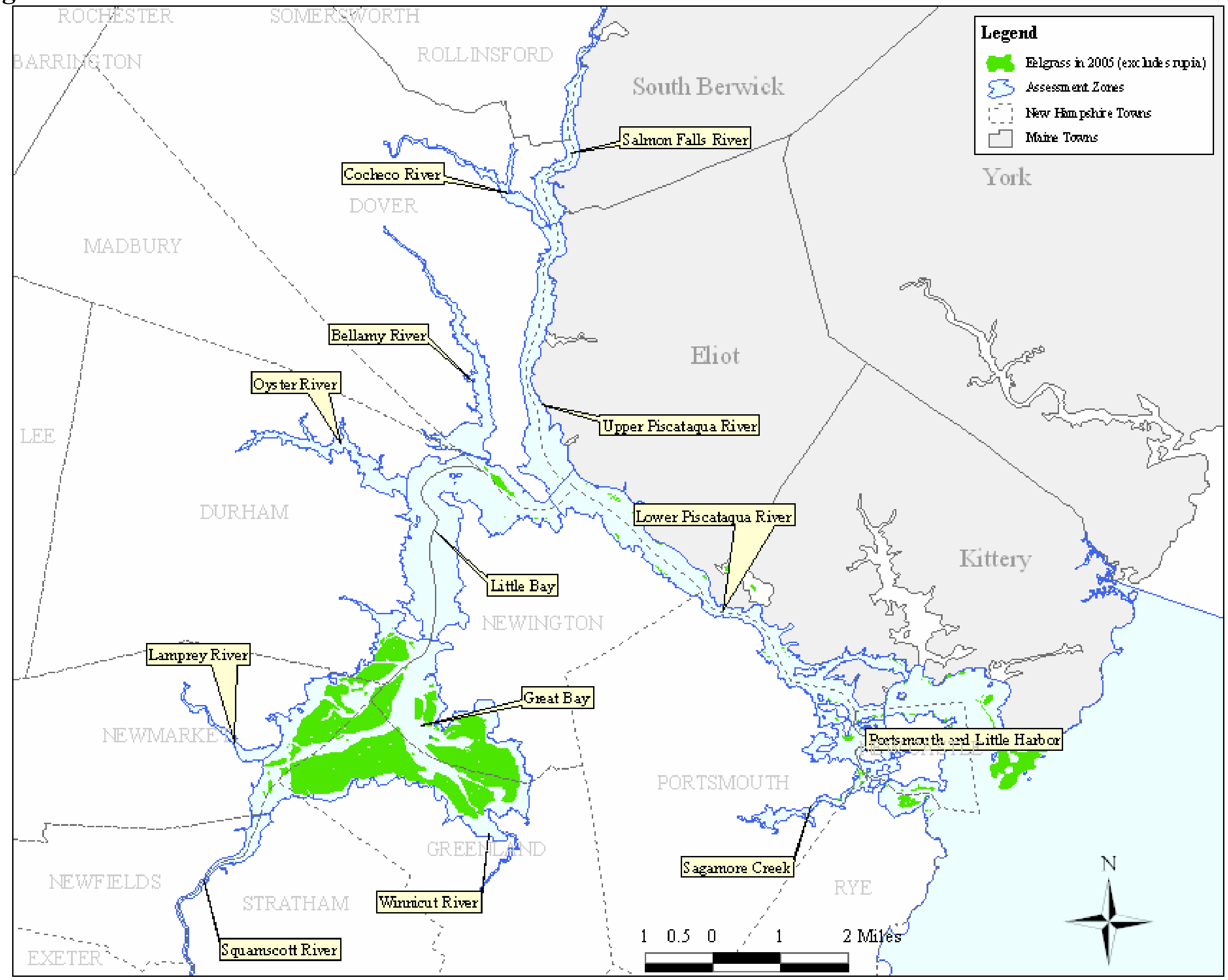

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Figure 4: Trend in eelgrass cover in the Winnicut River

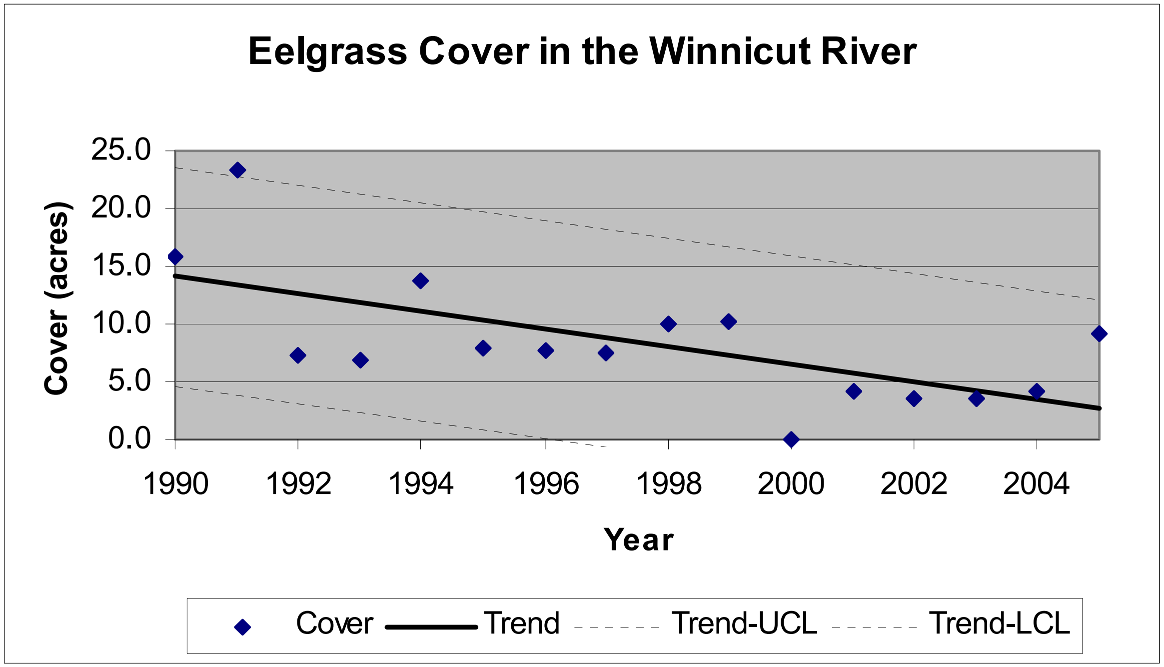

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Figure 5: Final eelgrass assessment for significant eelgrass loss

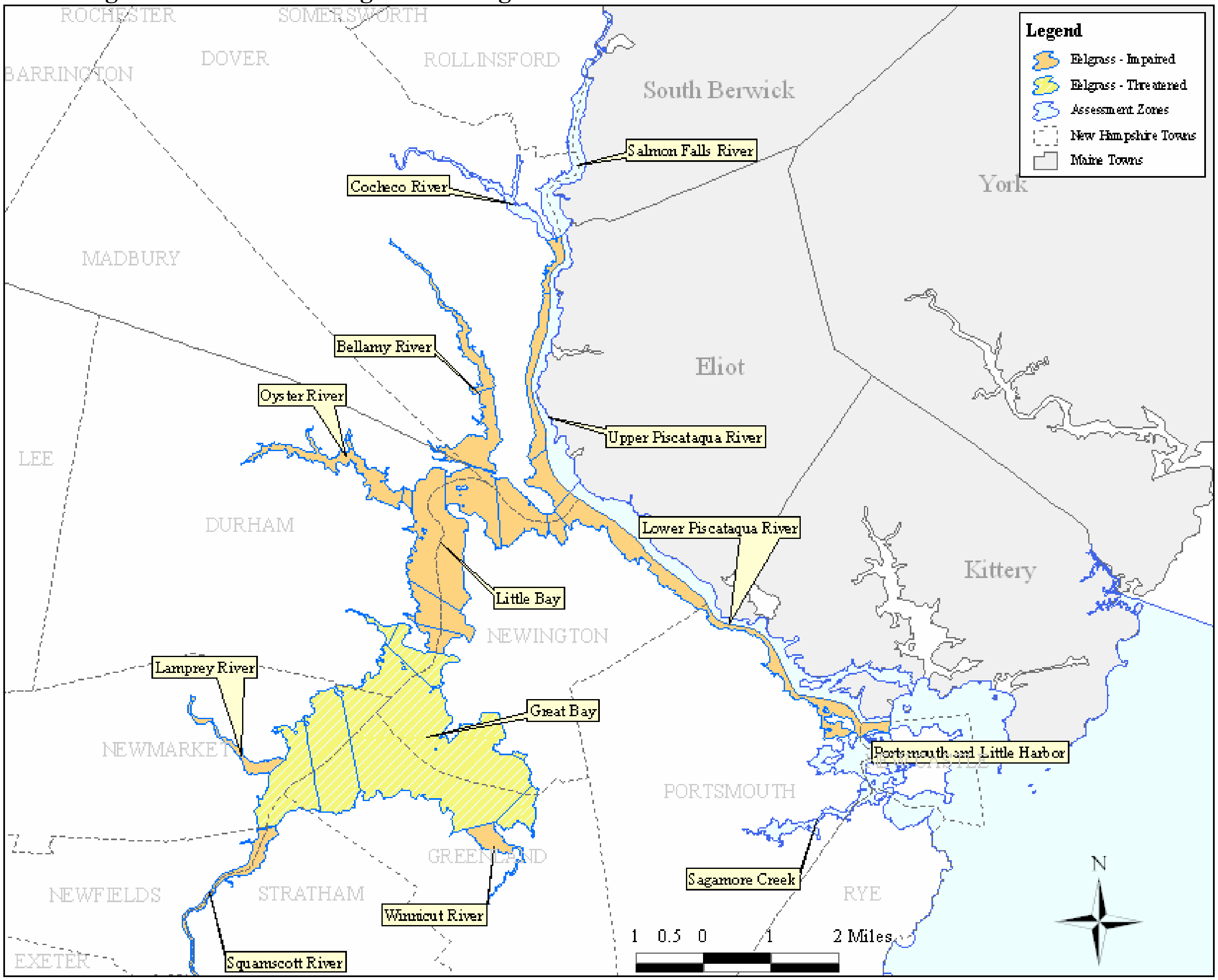

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Figure 6: Impairments for nitrogen