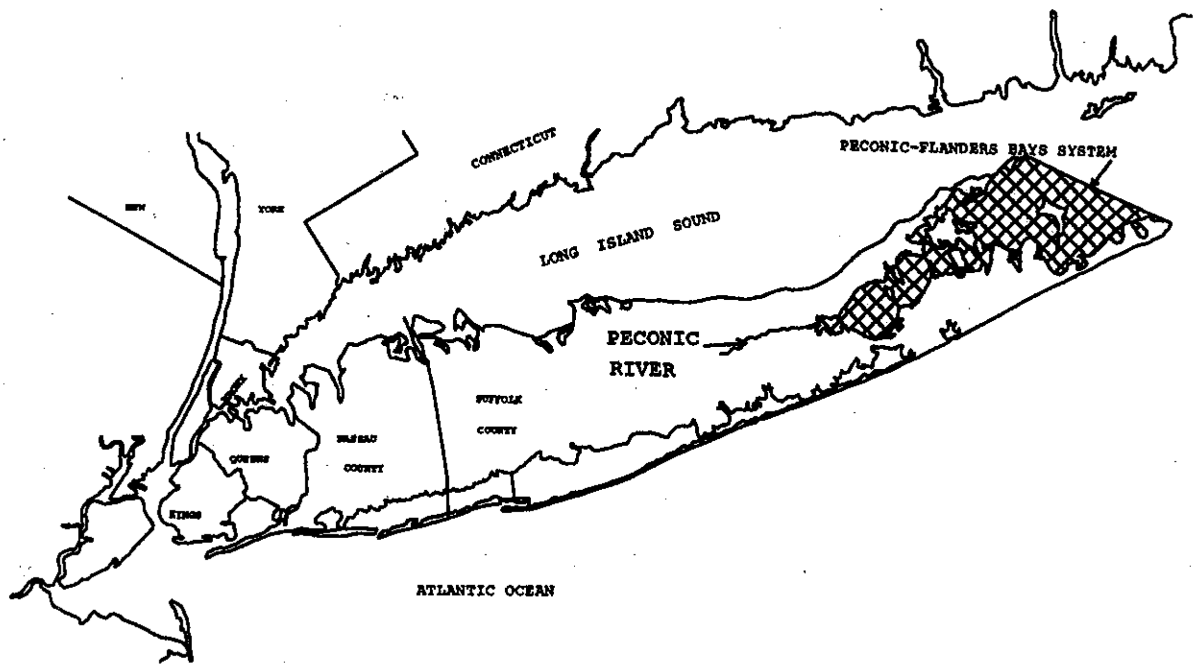
BROWN TIDE COMPREHENSIVE ASSESSMENT AND MANAGEMENT PROGRAM

SUMMARY



Robert J. Gaffney
County Executive

Mary E. Hibberd, M.D., M.P.H.
Commissioner

SUFFOLK COUNTY
DEPARTMENT OF HEALTH SERVICES

November, 1992

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November, 1992

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MESSAGE FROM THE COUNTY EXECUTIVE

I am pleased to present the summary of the Brown Tide Comprehensive Assessment and Management Program (BTCAMP).

As you are aware, the Brown Tide crisis has dramatically illustrated the need to take steps to ensure the permanent protection of the Peconic Estuary system. The Brown Tide has decimated the nationally significant scallop population and caused numerous other adverse natural resource and aesthetic impacts, threatening the livelihoods of the East End baymen and the local tourism-based economy.

This study clearly demonstrates the commitment of Suffolk County to the protection of the Peconic Estuary system resources. Over four years of intensive efforts were dedicated to BTCAMP, which was funded with $200,000 of federal grant monies and more than $1.3 million of Suffolk County contributions. This funding, although substantial, is a small price to pay for the preservation of Peconic Estuary water quality and natural resources.

The program, which was conducted by Suffolk County Department of Health Services, was supported by three consulting firms and numerous researchers. In addition, the management of BTCAMP was a cooperative effort among all levels of government and included strong and active citizen participation. I have no doubt that BTCAMP will serve as a model and forerunner for other marine surface water quality protection programs. In fact, largely due to BTCAMP efforts and a nomination document prepared by the Suffolk County Department of Health Services, the Peconic Estuary has recently been designated a nationally significant estuary by its acceptance into the federal National Estuary Program. With this acceptance, the Peconic Estuary joined only seventeen other estuaries in this program, qualifying for additional funding for further management, research, and demonstration projects.

I trust that, as you read the summary, you will share my concerns regarding the threats to the Peconic Estuary resources. The study has clearly demonstrated the need for management to preserve this invaluable resource, which has recently been designated by the Nature Conservancy as one of the "Last Great Places" in the western hemisphere. With your support, we can effectively proceed with implementation of the detailed program recommendations, leaving our treasured legacy intact for generations to come.

ROBERT J. GAFFNEY
Suffolk County Executive

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Brown Tide Comprehensive Assessment and Management Program

EXECUTIVE SUMMARY

The Brown Tide is an algal bloom caused by a particularly small and previously unknown species (Aureococcus anophagefferens). Adverse impacts caused by the Brown Tide include the virtual eradication of the nationally significant bay scallop population and the decimation of Peconic Estuary eelgrass beds. In response to the Brown Tide problem, the Suffolk County Department of Health Services (SCDHS) initiated the Brown Tide Comprehensive Assessment and Management Program (BTCAMP) in 1988.

BTCAMP was undertaken with two distinct objectives. The first objective was to research the causes and impacts of the Brown Tide, identifying any appropriate remedial actions and defining those areas which require further study. The second objective was to investigate more conventional water quality problems affecting local bay areas so that corrective actions to minimize any present or future water quality problems could be identified and evaluated.

The study has concentrated on the "Peconic Estuary System," including the groundwater-contributing areas to the Peconic River and the entire Flanders/Peconic Bays system. Study efforts have particularly focused on the western Peconics (i.e., Flanders Bay and its tributaries), the most stressed portion of the system. There has also been a general examination of the other marine waters where the Brown Tide has occurred, including Shinnecock Bay, Moriches Bay and eastern Great South Bay.

The final management plan was supported by a comprehensive series of tasks including monitoring of the bays, assessment of the sources of pollutant loading to the bays (e.g., stormwater runoff, sewage treatment plants, groundwater inflow), analysis of land use in the area surrounding the bays, and computer modelling of water movement and quality in the bays. In addition, input from County-funded research projects has been vital to the success of the management program.

The findings, conclusions, and recommendations of the study are discussed in the following extended summary and are distilled in Table 2. In brief, BTCAMP found that, although all algal growth requires the macronutrients nitrogen and phosphorus, the Brown Tide is apparently not triggered by these conventional macronutrients. However, the Brown Tide may be caused by other factors which include meteorological patterns and specific chemicals (chelators, specific organic nutrients, certain metals). The study recommends further laboratory and field research regarding not only these chemicals, but also other factors related to Brown Tide subsidence; areas of interest include viruses, and the relationship between zooplankton grazing and dimethyl sulfide. Brown Tide impacts on shellfish (toxic, mechanical, and poor nutritional aspects) also should be explored further.

BTCAMP also addressed conventional water quality parameters. The L.I. 208 Study marine surface water quality guideline was refined to 0.5 mg/l for the tidal portions of the Peconic River and Flanders Bay. The nitrogen guideline is exceeded in the western, tidal portions of the Peconic Estuary, and dissolved oxygen concentrations occasionally dip to unacceptably low levels at discreet locations, such as in the tidal Peconic River and Meetinghouse Creek. However, the system generally has not demonstrated characteristics of advanced eutrophication in terms of conventional nutrients and D.O. depletion. This evidence indicates that the system currently may be near the limits of the factors of safety incorporated in the determination of the nitrogen guideline. Water quality in the freshwater portions of the Peconic River and in the main bays system east of Flanders Bay is generally excellent with respect to nitrogen.

Based on extensive monitoring and mathematical modelling of impacts of management alternatives, BTCAMP recommends the general policies of "no net increase" of direct nitrogen loading to surface waters and "no substantial degradation of groundwater" in the Peconic River and Flanders Bay groundwater-contributing areas. These areas are poorly flushed and have demonstrated environmental sensitivity to increased pollutant loading. A "no degradation of surface water quality" policy is recommended for the eastern Peconic system.

Specific recommendations include a minimum zoning of two acres per unit in the Peconic River region to protect the excellent surface water quality in the river, which is dependent on groundwater quality; the river directly impacts surface water quality in Flanders Bay. A long-range recommendation of upgrading the Riverhead STP is designed to decrease future surface water total nitrogen levels to concentrations near the marine surface water quality nitrogen guideline. Also, further improvements in Meetinghouse Creek water quality, if effected in conjunction with Riverhead STP upgrading, would provide additional system-wide water quality benefits in terms of nitrogen guideline attainment.

Coliform sampling and modelling indicate that pollution control efforts should be focused on prevention of additional coliform loading. Stormwater runoff remediation should occur primarily on a site-specific basis, where feasible, rather than on a system-wide scale.

Many other pollutant sources were also considered in BTCAMP, including duck farms, hazardous material discharges, fertilizer and sanitary system pollution, landfills, marinas and boating, and atmospheric deposition. Areas of concern were identified (e.g., pesticides in surface waters and potential North Sea landfill contamination of Fish Cove) and areas for further study were recommended.

Brown Tide Comprehensive Assessment and Management Program
SUMMARY

1) INTRODUCTION

The Peconic system is an interconnected series of shallow coastal embayments at the eastern end of Long Island, New York (see Figure 1), that have been plagued with an unusual algal bloom which has been popularly dubbed the "Brown Tide." Because of the devastating impacts of this bloom on the estuarine resources of the Peconic system, the Suffolk County Department of Health Services (SCDHS) initiated the Brown Tide Comprehensive Assessment and Management Program (BTCAMP) in 1988.

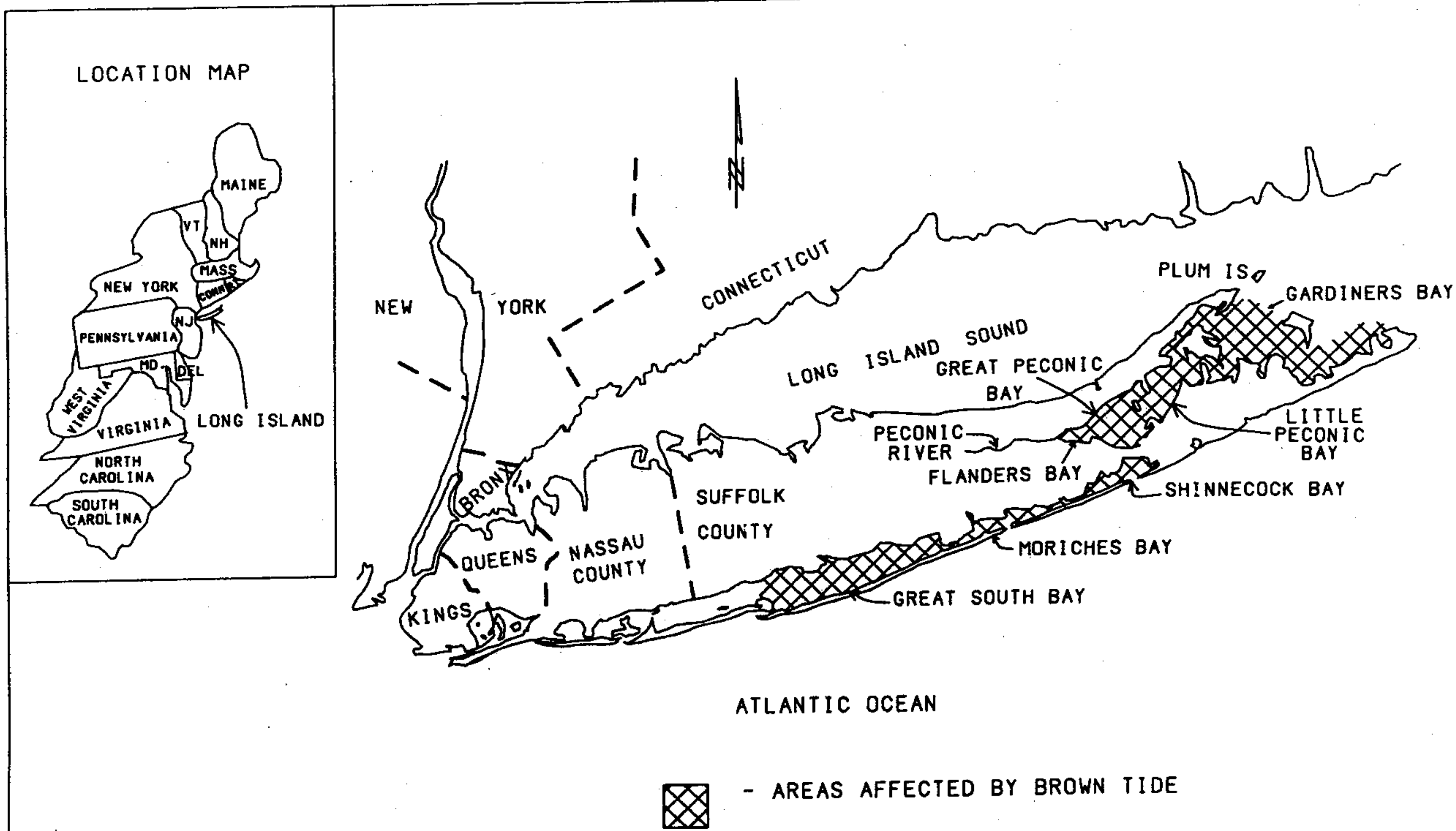
A) Study Area

The study area for BTCAMP (see Figure 2) was delineated as the groundwater-contributing area to the Flanders-Peconic Bays system and includes over 110,000 acres of land. In the westernmost portion of the system, the study area boundary was defined as the area of influence in which a shallow flow groundwater regime contributes groundwater to the Peconic River and its tributaries (the "Peconic River groundwater-contributing area," west of Cross River Drive). East of the Peconic River, the North and South Fork groundwater divides were utilized as study area boundaries. Although BTCAMP comprehensively assessed the entire Peconic Estuary system, the primary study efforts (e.g., land use analysis, sampling) were more heavily focused on the Peconic River and Flanders Bay Regions (approximately 30,000 acres of land) due to limited study resources, the environmental sensitivity and poor flushing of these areas (56 day average flushing time for Flanders Bay), and the adverse environmental impacts which they have sustained.

The surface waters of the Peconic Estuary system are comprised of over 100 distinct bays, harbors, embayments and tributaries which span a total area of over 100,000 acres. Between the Peconic River at the western end of the system and Gardiners Bay to the east, the marine surface waters (not including Gardiners Bay) encompass an area of approximately 80 square miles (over 50,000 acres). The average depth of the major bays in this area ranges from 5.0 feet in Flanders Bay to 21.0 feet in Little Peconic Bay, with a maximum depth of 95 feet in Shelter Island Sound. Gardiners Bay, the easternmost body of water in the study area, has a surface area of approximately 75 square miles.

B) Brown Tide Spacial and Temporal Occurrence

The Brown Tide bloom persisted in high concentrations in the Peconic system for extended periods in 1985, 1986, 1987, and 1988. It also occurred in eastern Great South Bay, Moriches Bay, and Shinnecock Bay during this period. Peak Brown Tide cell counts in the Peconic system often exceeded 1 million cells per milliliter (ml), as compared with a normal, mixed phytoplankton assemblage concentration which would typically range from 100 to 100,000 cells per ml. After virtually disappearing, elevated Brown Tide cell counts were observed in July of 1990 in West Neck Bay, a sheltered water body off Shelter Island, and in western Shinnecock and eastern Moriches Bays. Brown Tide also reappeared in high concentrations in Shinnecock and Moriches Bays in the fall of 1990 and persisted into the winter. Another intense bloom of Brown Tide began in the Peconic Estuary system in May, 1991 and persisted at high levels through July, 1991; a Moriches and Shinnecock Bays bloom of Brown Tide also began in May, but persisted through December 1991. In the summer of 1992, brown tide reappeared in high concentrations in West Neck Bay, Coecles Harbor, Great South Bay, Shinnecock Bay, and Moriches Bay. Bloom conditions have been consistently most severe in Flanders and West Neck Bays; bloom dynamics in the main Peconic Estuary system often have been radically different from conditions in West Neck Bay and South Shore Bays. The devastating effects of the Brown Tide are discussed below in the "Resource Overview" and in the "Summary of Findings, Conclusions, and Recommendations."



BROWN TIDE COMPREHENSIVE ASSESSMENT AND MANAGEMENT PROGRAM (BTCAMP)

FIGURE 1. LOCATION MAP OF AREAS AFFECTED BY BROWN TIDE

NO SCALE

SOURCE: SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES

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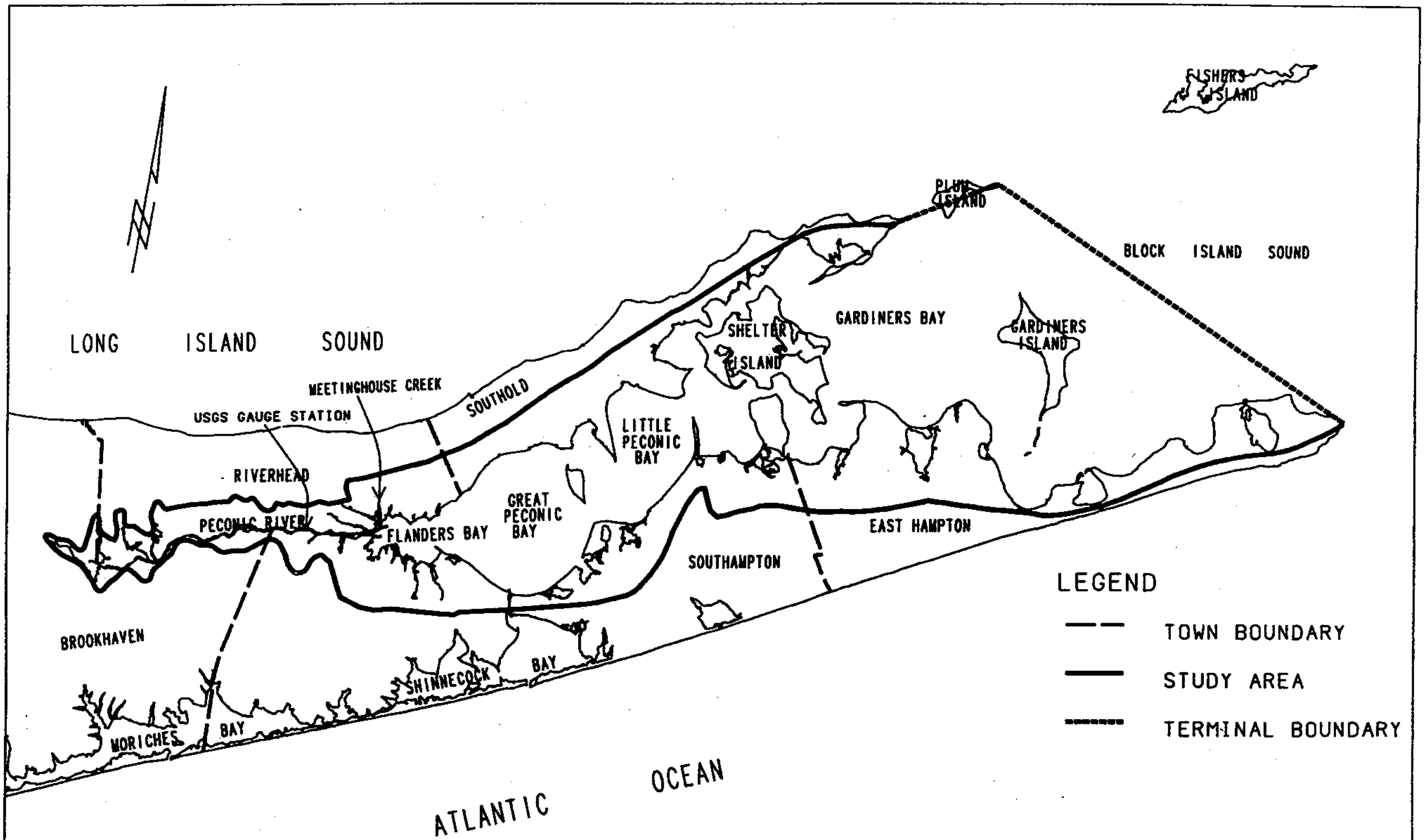

BROWN TIDE COMPREHENSIVE ASSESSMENT AND MANAGEMENT PROGRAM (BTCAMP)

FIGURE 2: STUDY AREA - PECONIC ESTUARY SYSTEM

NO SCALE

SOURCE: SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES

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C) BTCAMP Approach

BTCAMP is a multi-year study which provided for a comprehensive program of specialized research activities, extensive bay monitoring, management and evaluation of data (e.g., land use, sources of contamination, groundwater), and state-of-the-art mathematical computer modelling.

1. Research

BTCAMP benefitted from the research efforts of numerous individuals and organizations. The State University of New York at Stony Brook, Marine Sciences Research Center (SUNY MSRC) has contributed heavily to BTCAMP with extensive laboratory studies of Brown Tide characteristics and its effects on the bay scallop population. MSRC research also has included eelgrass population study. Other BTCAMP researchers include Dr. Jonathan Garber (sediment/water column flux studies); Dr. Joseph Schubauer and Dr. Douglas Capone (nutrient inflow via groundwater discharge); the Woods Hole Oceanographic Institute (immunofluorescent procedures for the study of the Brown Tide); and Pace University of New York City (satellite-based remote sensing of the brown tide phenomenon). Institutions which were instrumental in BTCAMP monitoring efforts were Long Island University at Southampton (historical bay water quality monitoring data), Suffolk County Community College (laboratory and facility support), and Brookhaven National Laboratory (deployment of fluorometers to collect continuous chlorophyll and temperature data).

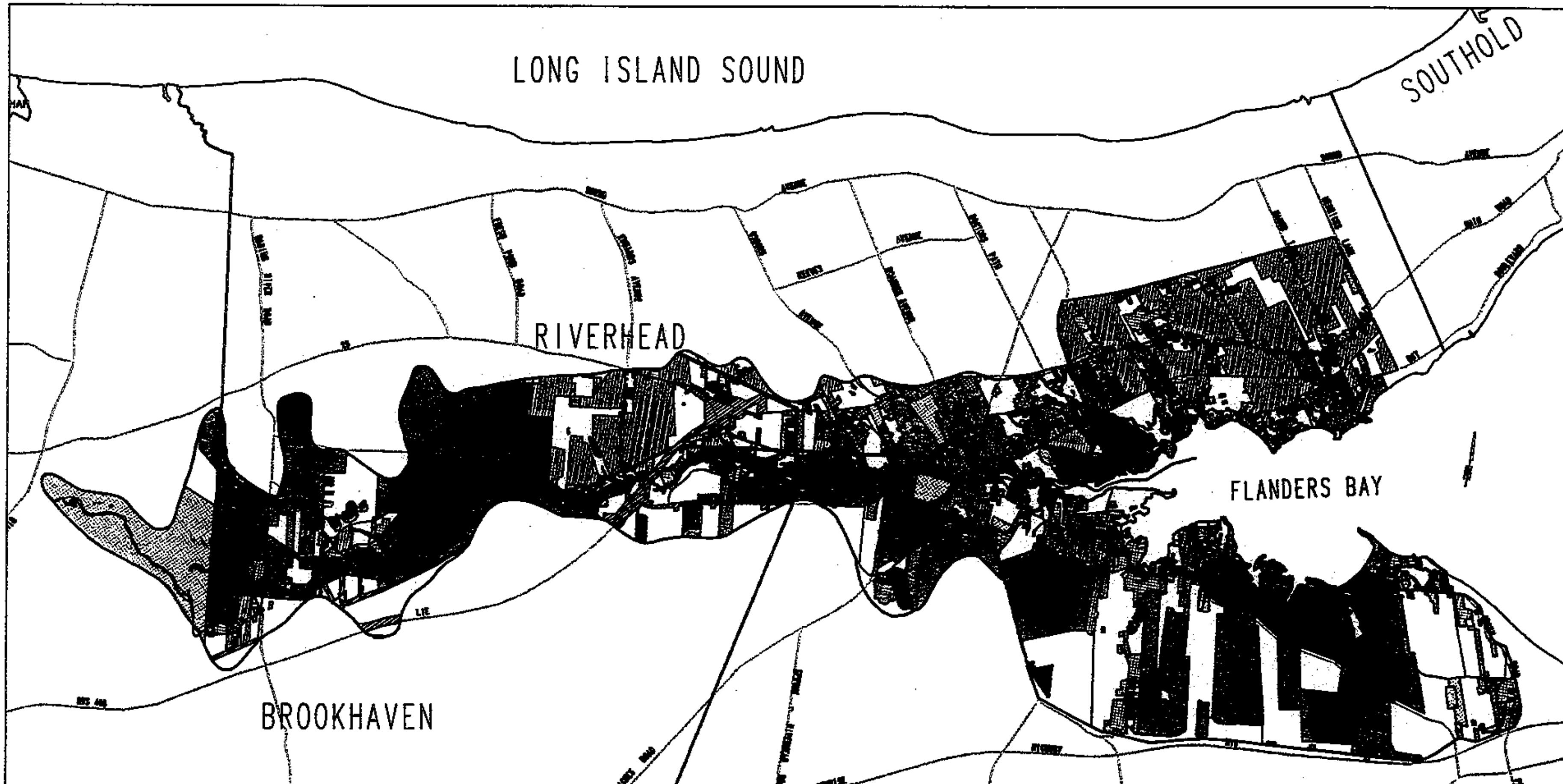
2. Monitoring, Land Use and Data Analysis

SCDHS conducted an extensive surface water and point source monitoring program. Between January, 1988 and June, 1990, over 4,400 marine water quality samples were collected and analyzed by the SCDHS pursuant to Brown Tide study. Samples were examined for a broad spectrum of physical, chemical, and biological data. The sampling program included frequent, periodic sampling at a number of stations as well as occasional sampling runs immediately preceding and subsequent to wet weather events at select stations and point sources. In addition, routine point source monitoring occurred for the Riverhead sewage treatment plant (see infra Figure 6), Meetinghouse Creek (see supra Figure 2), and the Peconic River (see supra Figure 2). Other sampling activities included two comprehensive wet-weather runs to assess the impacts of stormwater runoff on the Peconic River.

Raw land use data were provided by the Long Island Regional Planning Board (LIRPB) following aerial photograph analysis and field surveys. The data were subsequently computer-digitized by LIRPB and SCDHS staff. The products of these efforts for the groundwater-contributing and stormwater runoff-contributing areas to the Peconic River and Flanders Bay system are contained in Figures 3 and 4, respectively. The digitized maps facilitated tabulation of land use data (see Table 1), which was used directly to generate estimates of pollution, such as on-lot sanitary waste disposal and fertilizer pollution loading. The land use data was also evaluated in conjunction with other information such as groundwater and surface water quality data to explore the relationship between land use and environmental conditions in specific areas. A tremendous amount of information, including an assessment of over 10,000 groundwater samples, was compiled and generated in analyzing pollutant loading conditions in the study area. The results of this analysis are contained in the "Summary of Findings, Conclusions, and Recommendations."

3. Modelling

A state-of-the-art mathematical computer model of the Peconic estuary system was developed by the consultant, Tetra-Tech, which enhanced the United States Environmental Protection Agency (USEPA) "WASP4" model and renamed it "WASP5." This model is a system of coupled hydrodynamic and water quality models which can be used to examine circulation, water quality, and eutrophication; in BTCAMP, the calibrated model was verified with current data and was utilized to predict the impacts of various management alternatives.



BROWN TIDE COMPREHENSIVE ASSESSMENT
AND MANAGEMENT PROGRAM
(BTCAMP)

Legend for 1988 Land Use

- Low density residential (<= 1 d.u./acre)
- Medium density residential (> 1 d.u. to < 5 d.u./acre)
- High density residential (>= 5 d.u./acre)
- Commercial
- Industrial
- Institutional
- Open Space-Recreational
- Agriculture
- Vacant
- Transportation & Recharge Basin
- Utilities
- Waste Handling - Management
- Surface Waters

NO SCALE

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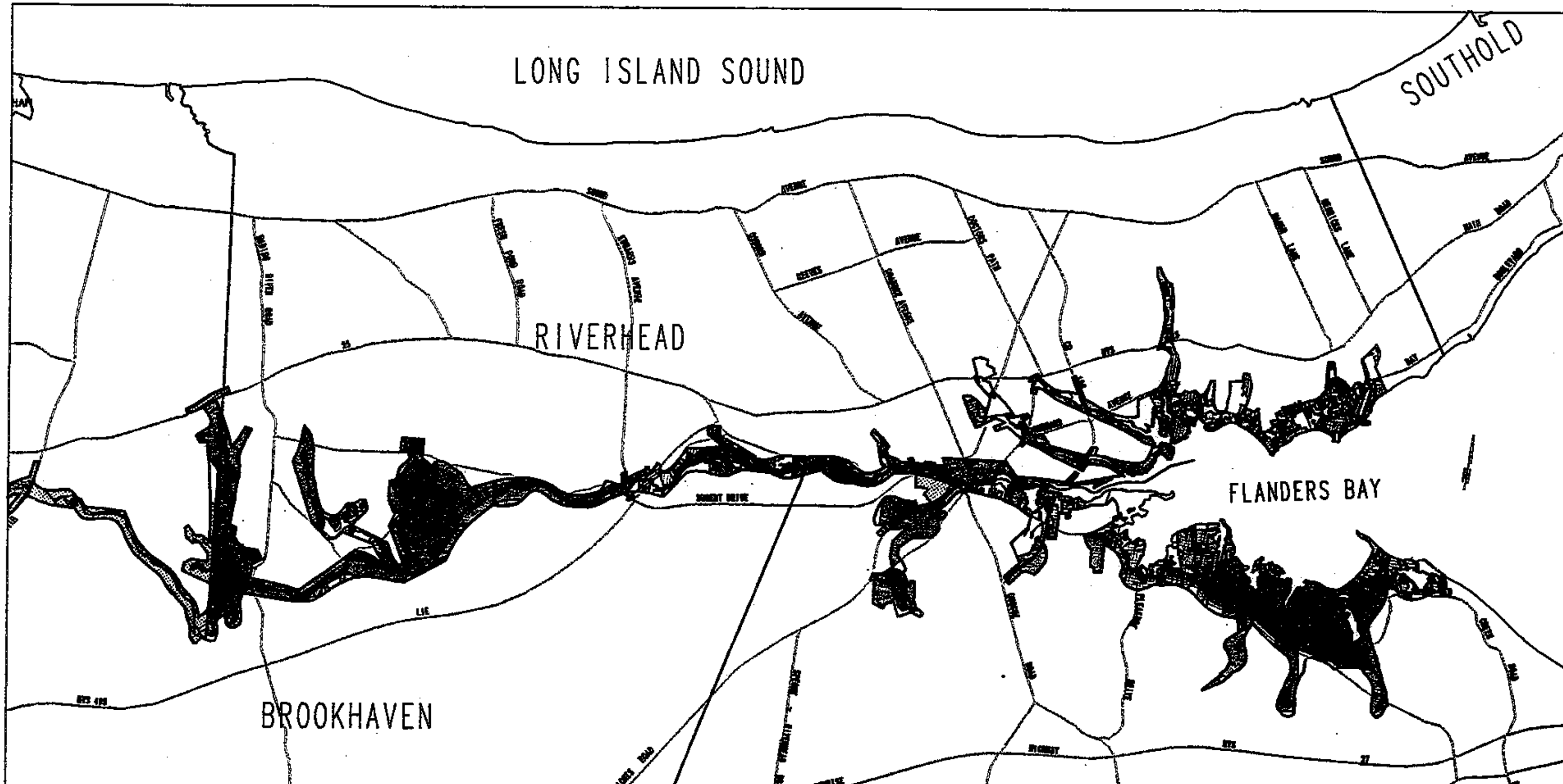
FIG. 3: 1988 Land Use
Peconic River/Flanders Bay
Groundwater Contributing Area



BROWN TIDE COMPREHENSIVE ASSESSMENT
AND MANAGEMENT PROGRAM
(BTCAMP)

FIG. 4: 1988 Land Use
Peconic River/Flanders Bay
Stormwater Runoff Contributing Area

Legend for 1988 Land Use

- Low density residential (<= 1 d.u./acre)
- Medium density residential (> 1 d.u. to < 5 d.u./acre)
- High density residential (>= 5 d.u./acre)
- Commercial
- Industrial
- Institutional
- Open Space-Recreational
- Agriculture
- Vacant
- Transportation & Recharge Basin
- Utilities
- Waste Handling - Management
- Surface Waters

NO SCALE

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TABLE 1
Land Uses in Peconic Estuary Study Area (1988)

LAND USE	WESTERN AREA * Acres (%)	EASTERN AREA ** Acres (%)
Low Density Residential (less than or equal to 1 unit/acre)	1,383 (5)	6,181 (7)
Medium Density Residential (greater than 1 to less than 5 units/acre)	2,707 (9)	6,675 (8)
High Density Residential (greater than or equal to 5 units/acre)	302 (1)	2,788 (3)
Commercial	595 (2)	2,484 (3)
Industrial	1,533 (5)	1,365 (2)
Institutional	1,424 (5)	2,144 (3)
Open Space - Recreational	8,286 (27)	18,936 (23)
Agriculture	3,736 (12)	8,968 (11)
Vacant	8,613 (29)	30,925 (37)
Transportation & Recharge Basin	736 (2)	3,136 (4)
Utilities	165 (1)	--- ---
Waste Handling - Management	56 (0)	--- ---
Surface Waters	678 (2)	--- ---
ALL LAND USES	**30,214** (100)	**83,602** (100)

* Includes Peconic River and Flanders Bay planning areas.
** Includes Great Peconic Bay, Little Peconic Bay, Shelter Island Sound, Gardiners Bay, and Western Block Island Sound areas.
NOTE: Western study area estimates were generated by rigorous aerial photograph study and field verifications. Eastern study area projections are crude estimates which should be refined by future study.

The hydrodynamic program utilized in this study is a two-dimensional model which simulates water movement due to tides, winds, and unsteady inflows. The eutrophication version, which can simulate total biomass eutrophication conditions (i.e., phytoplankton growth/death, nutrient cycles, sediment interaction, and dissolved oxygen), is being used for this study. The structure of the mathematical model is based on a set of equations representing transport, biological, chemical, and sediment/benthos submodels. The transport submodel is externally computed on a subtidal time scale with a link-node hydrodynamic model. The sediment/benthos submodel is empirically represented as temperature dependent biological and geochemical boundary forcing functions of nutrient and oxygen mass fluxes across the sediment-water interface. The linear and nonlinear interactions between the biological and chemical submodels are designed to represent the major dynamic processes that reflect natural and anthropogenic loading of carbon and nutrients.

The BTCAMP "WASP5" computer model of the Peconic Bays system is an improvement over the model applied in the 1976 LI 208 Study, with new parameters added and major flaws discovered and rectified. The improvements in "WASP5" over "WASP4" include greater coverage, an atmospheric deposition source loading term, and a multi-species phytoplankton submodel. The "WASP5" model also incorporates the impacts of zooplankton grazing on nutrient recycling and includes a multi-seasonal simulation spanning an entire year.

2) GOALS

The general goals of BTCAMP are as follows:

A) To research the causes and impacts of the Brown Tide, identify any appropriate remedial actions, and define those areas which require further study.

B) To investigate more conventional water quality problems impacting local bay areas so that corrective actions to minimize any present or future water quality problems could be identified and evaluated. Primary parameters of concern are coliform bacteria, which is an indicator organism that is used as the standard to certify shellfish areas and regulate beaches, and nitrogen, which, in excessive concentrations, is often associated with cultural eutrophication (i.e., excessive algal blooms, dissolved oxygen depletion, etc).

   In achieving this goal, existing monitoring data was evaluated, extensive additional data was obtained, point and non-point sources of pollution were identified and assessed, and land use data was compiled by LIRPB and was analyzed in relation to pollution sources and groundwater and surface water quality data. This information subsequently was used to refine the L.I. 208 Study marine surface water quality nitrogen guideline and to formulate and evaluate management alternatives so that appropriate mitigation measures could be recommended in a final, comprehensive management plan.

C) To establish a mechanism for assessing the progress of implementation of BTCAMP recommendations, addressing potential future environmental problems, identifying additional applicable programs and funding sources, etc.

3) RESOURCE OVERVIEW

The Peconic Estuary system, designated by the Nature Conservancy as one of the "Last Great Places" in the western hemisphere, consists of over 100 distinct bays, harbors, embayments and tributaries and drains an area of approximately 110,000 acres. The drainage area to the Peconic Estuary is rich with rolling farmland, scenic beaches, and lush woodlands and wetlands. The population of the East End Towns of 115,000 persons, as estimated in 1989, swells to over 280,000 in the summertime.

The study area has numerous locally and nationally significant resources which are at risk, including its value as a fishery. In 1982, bay scallop catches from the Peconic System accounted for approximately 28% of the United States landings of this species and commercial fishery dockside landings were worth $7.3 million (1982 dollars). By 1987 and 1988, after the onset of the Brown Tide bloom, the pre-Brown Tide scallop harvest of 150,000 to 500,000 pounds per year had dropped to only about 300 pounds per year. Other important shellfish which were apparently adversely impacted by the Brown Tide include clams and blue mussels. In addition, the oyster business was worth about $3.4 million annually in 1982 before its value plummeted to less than $10,000 per year in 1987. Long-term impacts of the bloom on shellfish habitats and reproduction are unknown.

There is also evidence that the Peconic Bays estuary is very important as a nursery and spawning ground for the coastal fisheries, including weakfish and numerous other commercially valuable finfish. The potential for devastating long-range effects of the Brown Tide on local fisheries is illustrated by the loss of eelgrass resulting from reduced light penetration in the water column; eelgrass is important habitat for certain finfish as well as shellfish. Although the dockside value of commercial fishery landings is significant, it is much smaller than the actual revenues generated by other water-related activities, including businesses, restaurants, marinas, and other institutions which cater to sportfishermen, boaters, and bathers who utilize the Peconic system. Annual direct boater revenues are estimated to be over 200 million dollars (Association of Marine Industries).

From a natural resources standpoint, the Peconic area possesses a plethora of diverse and beautiful habitats and species. Over 3,600 acres of tidal wetlands, as well as numerous important freshwater wetlands, provide wildlife habitat, offer a buffer against pollutants, and afford recreational opportunities and scenic open space. In addition to wetlands, 15 rare ecosystems as designated in the "Priority listings of rare and natural communities with occurrences on Long Island" (New York Natural Heritage Program, December 1986) occur within the study area. These ecosystems vary in degree of rarity from rare in New York State to globally rare, such as the dwarf pine plains. In all, thirty-five natural and man-influenced vegetative communities occur within an eighth of a mile from the banks of the Peconic River alone.

In recognizing the importance of the habitats present in the Peconic estuary area, state and local agencies have listed no fewer than thirty-seven geographic areas as critical environmental areas because of the exceptional or unique characteristics that make the area environmentally important. In addition, over forty areas in the region have been designated as significant coastal fish and wildlife habitats by the Secretary of State pursuant to the recommendations of the New York State Department of Environmental Conservation (NYSDEC) under the New York State Coastal Management Program. The Peconic Bay habitats are by far the largest and most diverse concentration of habitats when compared to any other segment of New York State's 3,200 miles of coastal area which extends through 23 coastal counties.

A number of nationally and locally threatened and endangered species use the important habitats which exist in the Peconic Estuary study area. These species include the federally endangered loggerhead, leatherback, and green turtles as well as the federally endangered Kemp's Ridley turtle, which reportedly uses the Peconic system as a nursery. Other threatened and endangered species which utilize the Peconic Estuary system include the piping plover and the roseate tern, which are also federally listed species, and the least tern, common tern, northern harrier, red-shouldered hawk, osprey, tiger salamander, buck moth, and mud turtle. "Special concern" species birds that are probable nesters in the Peconic system include the least bittern, barn owl, common nighthawk, eastern bluebird, vesper sparrow, and grasshopper sparrow. "Special concern" reptiles and amphibians include the spotted salamander, blue spotted salamander, hognose snake, and diamondback terrapin. Numerous rare and endangered insects, such as the coastal barrens buck moth, also occur in the Peconic Estuary study area.

Because of its extraordinary value, a significant amount of acreage in the Peconic system has been set aside as parkland for a variety of reasons which include active and passive recreation, nature preserve, and groundwater protection. Major State and County parks wholly or partially within the Peconic drainage area encompass over 5,000 acres. In all, approximately one-fourth of the 110,000 acres in the drainage area of the Peconic system is currently in open space and recreational land use.

Recreational facilities within the Peconic/Flanders Bays system include 30 public bathing beaches (i.e., beaches with permits which are routinely sampled). The Peconic region also includes six campgrounds and 16 golf courses, 10 of which are open to the public. Thousands of boat berths are contained in the 69 marinas in the Peconics, and fourteen public boat launches are also available for boating enthusiasts. Hiking, biking, scuba diving, and numerous other active and passive activities are enjoyed by the area's residents and visitors.

4) PROJECT PARTICIPATION/ADMINISTRATION

BTCAMP is headed by the Suffolk County Department of Health Services. Assistance has been provided by LIRPB, NYSDEC, USEPA and the Cornell Cooperative Extension Service. In addition, a consulting team consisting of three firms, Dvirka & Bartilucci Consulting Engineers, Tetra-Tech, Inc. and Creative Enterprises of Northern Virginia, Inc., was retained to assist the County. The project has been a cooperative effort among all levels of government, with an active management committee comprised of state, federal, and local government officials as well as citizen representatives.

The universities which have contributed to BTCAMP include the State University of New York at Stony Brook, Long Island University, Suffolk County Community College, and Pace University. Other institutions which have participated in the study included the Chesapeake Biological Laboratory, the Woods Hole Oceanographic Institute, and Brookhaven National Laboratory.

The BTCAMP Citizens Advisory Committee (CAC), a/k/a The Peconic Bay Task Force, a/k/a Save the Bays, Inc., is comprised of representatives from marine related industry, environmental and civic organizations, baymen, boaters, sports fishermen and other interested citizens. The CAC has made significant contributions to BTCAMP by assuring public involvement in the study, preparing educational materials, and setting up the series of Save the Bays Conferences. Of special note are the booklet "Clear Water - A Guide to Reducing Water Pollution" and the video entitled "Save Our Bays."

Several civic organizations and environmental groups have also been active in the protection of the natural resource of the Peconic Bays system. These organizations include the Group for the South Fork, the North Fork Environmental Council, the Nature Conservancy, the League of Women Voters of Riverhead/Southold, and Southold 2000. Members of these groups serve on the Board of "Save the Peconic Bays, Inc.," in addition to conducting their own environmental stewardship programs. In addition, the Green Seal Program has conducted shellfish relay and transplant programs.

5) PROJECT COST

Commitment to the Peconic Estuary resource was well illustrated by the local funding for BTCAMP, which greatly exceeded the required 25% local match for $200,000 of Federal 205(j) funds. Over one million dollars in SCDHS in-kind services and approximately $350,000 of Suffolk County Capital funds were ultimately provided for the BTCAMP study. *[205(j) refers to the federal "Water Quality Act of 1987" Sec. 205(j)--"Water Quality Management Planning." These are funds provided by USEPA and administered by NYSDEC.]*

The project was well worth the investment for a number of reasons. BTCAMP has contributed substantially to the store of scientific knowledge regarding the Brown Tide organism, and has developed a comprehensive characterization of Peconic Estuary water quality which will be useful in perpetuity. In addition, the study has assessed the impacts of a wide variety of pollutant sources, evaluated numerous management alternatives, and recommended a set of specific actions which should be taken to ensure the permanent integrity of the Peconic system from a conventional nutrient perspective. The monitoring, modelling, and land use evaluations performed in BTCAMP will undoubtedly serve as models for future studies. Finally, and most practically, the cost of the study has been extremely small in relation to cost of implementation of many management possibilities. For example, the cost of system-wide stormwater runoff mitigation and sewage treatment plant upgradings would be on the order of tens of millions of dollars. Therefore, the prioritization of resource allocation presented in BTCAMP is of the utmost importance in maximizing environmental benefits from limited available resources.

6) REPORT STRUCTURE

Sections 1 through 5 of BTCAMP essentially provide a comprehensive characterization of the Peconic Estuary system and its groundwater-contributing area (collectively designated as the "study area"). These sections of the report form the basis for subsequent sections which analyze environmental conditions and pollutant contribution, evaluate management alternatives, and recommend a management plan. Section 1 of BTCAMP is an introduction which sets forth the purposes and priorities of the study, defines and describes the study area, and discusses the BTCAMP planning approach, previous water quality studies, and related planning efforts. The natural resources and processes which are highlighted above in the "Resource Overview" are addressed in detail in Section 2. Section 3 explores surface water quality in detail, presenting data and analysis regarding water quality conditions and trends and, in so doing, reflecting the tremendous amount of site-specific sampling which has been performed for the Peconic Estuary system. Brown Tide is discussed in Section 4, which treats the organism's spacial and temporal appearances as well as its biology, impacts, and related research efforts. Section 5 undertakes an extensive analysis of groundwater quality in the study area to be used to substantiate subsequent qualitative and quantitative analyses of pollutant loading and to provide data for the computer model of the system.

Section 6 of BTCAMP presents the extensive pollutant assessment efforts which were performed to provide a basis for computer model inputs and the management alternatives evaluation. The resulting findings, conclusions, and recommendations are presented in Section 7; a summary of this section is presented below. Section 7 also contains the alternatives evaluation, computer modelling results, and an implementation plan for the recommendations. Finally, Section 8 is a summary of the invaluable efforts of the BTCAMP CAC as a vehicle for public input, project guidance, and public education.

7) SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATIONS

The following is a narrative summary of the findings, conclusions, and recommendations contained in Section 7. Following the narrative is a summary of the information in tabular format (Table 3); proposed additional research and investigation projects are subsequently summarized on Table 4.

A) Summary of Findings and Conclusions

1. Brown Tide and Natural Resources Impacts

The Brown Tide is an algal bloom which has appeared in the Peconic/Flanders and South Shore bays systems. It is caused by a particularly small and previously unknown species (Aureococcus anophagefferens) and can persist for unusually long periods of time over large areas. The bloom is recurring in nature, and has to date been unpredictable in onset, duration, and cessation.

Although advances have been made regarding the identification and characterization of the Brown Tide organism and its growth needs, the causal factors related to the Brown Tide bloom are not known. The input of conventional macronutrients such as nitrogen and phosphorus apparently do not trigger the onset of the Brown Tide blooms. Chemicals which have been implicated by research as potential contributors to Brown Tide's pervasiveness include specific organic nutrients, chelators such as citric acid, and trace metals such as iron, selenium, vanadate, arsenate and boron. Additionally, viruses are suspected to be a critical agent in ending the growth cycle of the Brown Tide, while acrylic acid and dimethyl sulfide (DMS), which may be produced by the Brown Tide, may be toxic to the zooplankton population which would graze on Aureococcus. Preliminary SCDHS sampling results show a correlation between elevated dimethyl sulfide (DMS) concentrations in surface waters and the Brown Tide bloom. Finally, there may be a relationship between meteorological and climatological factors and the Brown Tide.

The Brown Tide has had devastating effects on natural resources in the Peconic Estuary system. The abundant Peconic Bay scallop population was virtually eradicated by the onset of the Brown Tide; the causes of this impact may be related to toxic, mechanical, and/or poor nutritional aspects of the Brown Tide organism. In addition, the eelgrass beds which are critical to the regional importance of the Peconic Estuary as a shellfish and finfish spawning and nursery area were decimated, probably due to reduced light penetration caused by the Brown Tide bloom density. Other shellfish which declined during Brown Tide blooms include oysters and possibly blue mussels. Hard clams also appear to have been adversely affected during the bloom; long-term impacts on shellfish are unknown.

2. Conventional Water Quality

a. Nutrients

While total nitrogen inputs from point sources to Flanders Bay have decreased by 53% between 1976 and 1990 (see Table 2), significant improvements in Flanders Bay water quality with respect to nitrogen concentrations have not been observed in this time period. In contrast to nitrogen, apparent improvements in water quality with respect to phosphorus have been noted in conjunction with a 77% decrease in total phosphorus loading to Flanders Bay in this time frame. This phenomenon may be partially explained by the even higher degree of reduction of phosphorus input (77% reduction compared with 53% nitrogen reduction). However, the reliability of an explanation of historical impacts is hampered by the absence of a fundamental understanding of the temporal response of sediment flux (i.e., chemical exchange between sediments and water column) to variations in point sources. Nevertheless, the analysis of current conditions for the purpose of assessing future management alternatives is considered to be reliable in that the analysis is based on a state-of-the-art model which has been calibrated and verified utilizing a plethora of existing data. The existing nitrogen inputs into the Peconic system are graphically summarized in Figure 5.

Actual historical decreases in nutrient loading to the Peconic River and Flanders Bay are certainly much more dramatic than observed between 1976 and 1990, since most of the numerous duck farms which discharged to the Peconic River and Flanders Bay had already gone out of business by 1976. Records indicate that Peconic Estuary duck farming began around 1900, and that 21 duck farms were in business in the estuarine system in 1938. In addition to discharging heavy organic and nutrient loads, these facilities undoubtedly did not utilize the waste treatment systems of settling and chlorination which would be required to reduce pathogen discharge. In 1938, dissolved oxygen levels of 0 and 0.1 mg/l were reported in the Peconic River headwaters and tidal areas, respectively. Other historic industries in 1938 included a laundry facility which discharged to the Peconic River. Earlier accounts from the 1800's identify several additional industries, including numerous fish-processing plants throughout the estuarine system and several mills (grist mill, saw-mill, fulling mill, woolen mill, etc.) and an iron forge on the Peconic River. Although historical water quality data prior to 1976 is scarce, it would appear that conditions in the Peconic Estuary system, in terms of dissolved oxygen, nutrients, and other contaminants, have improved significantly since the cessation of industrial discharges to the estuary.

Based on an analysis of data specific to Flanders Bay which relates Flanders Bay diurnal dissolved oxygen (D.O.) ranges to chlorophyll-a concentrations and then correlates chlorophyll-a concentrations to nitrogen levels, the L.I. 208 Study marine water quality guideline of 0.4 mg/l total nitrogen should be modified to 0.5 mg/l for Flanders Bay and the tidal portions of the Peconic River so that a water quality standard of 5.0 mg/l dissolved oxygen may be maintained in these areas. Although this analysis is a

TABLE 2
Point Source Nutrient Concentrations and Loadings
1976 vs. 1988-1990 *

TOTAL NITROGEN AND PHOSPHORUS CONCENTRATIONS

	Number of Samples (5/88-3/90)	Average Total Nitrogen (mg/l)		Average Total Phosphorus (mg/l)		Avg Flow (mgd)	
		1976	1988-90	1976	1988-90	1976	1988-90
PECONIC RIVER GAUGE	68	1.0	0.5	0.16	0.11	23.3	32.1
MEETINGHOUSE CREEK**	127	53.0	15.0	13.0	1.2	2.1	2.9
RIVERHEAD STP	68	19.0	23.0	5.1	3.0	0.7	0.7

TOTAL NITROGEN AND PHOSPHORUS LOADINGS

	Number of Samples (5/88-3/90)	Average Total Nitrogen (lb/day)		Average Total Phosphorus (lb/day)		Avg Flow (mgd)	
		1976	1988-90	1976	1988-90	1976	1988-90
PECONIC RIV. GAUGE	68	190	130	31	30	23.3	32.1
MEETINGHOUSE CREEK**	127	930	360	230	28	2.1	2.9
RIVERHEAD STP	68	120	140	31	17	0.7	0.7
OTHER SOURCES ***	7	200	44	63	8	---	---
TOTAL LOADING ****		1440	680	350	80		

NOTES

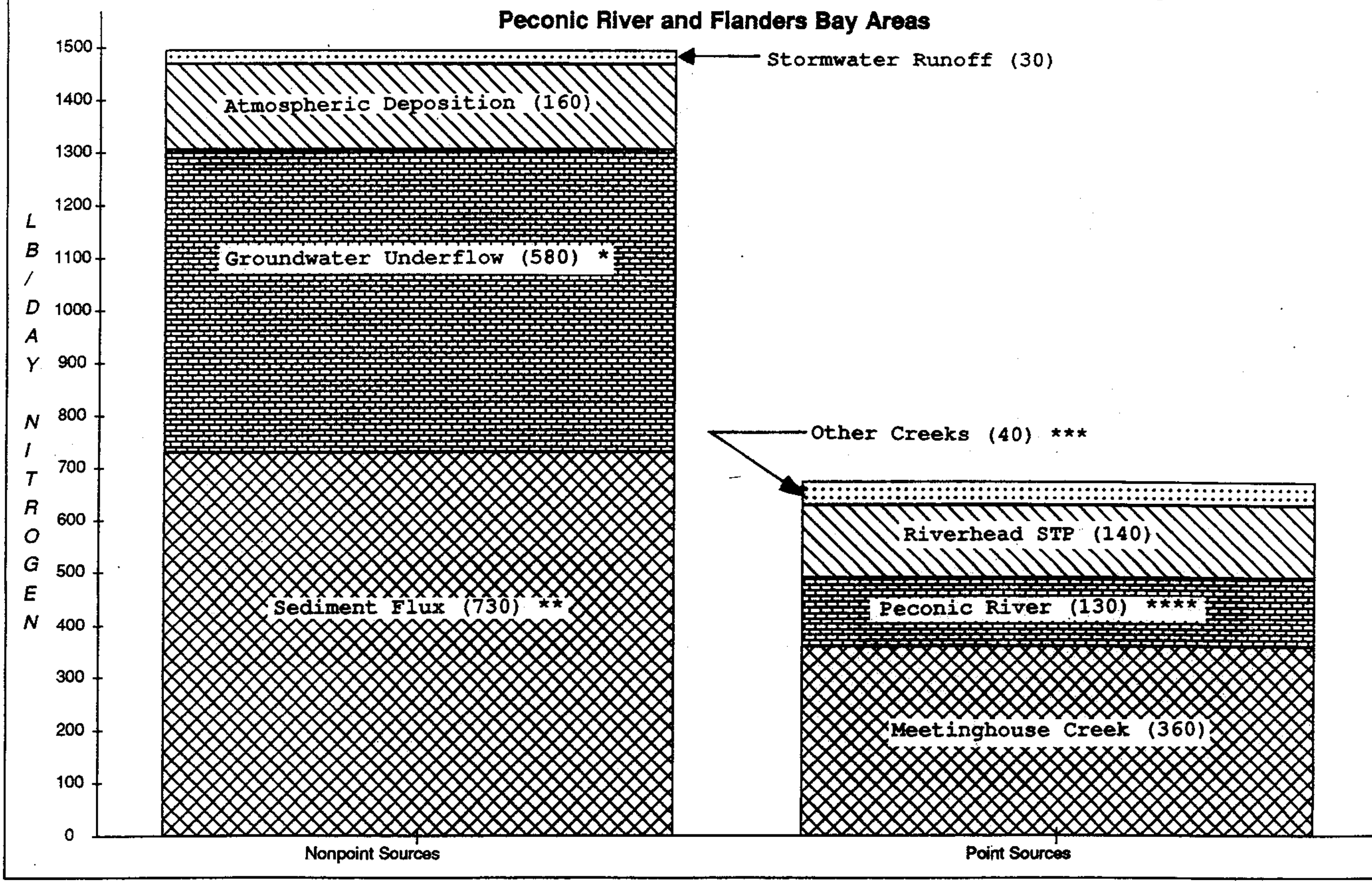
* 1976 data limited to three sampling dates in July, August, and September as noted in 1976 Tetra-Tech Water Quality Modeling Report.

** 4.5 cfs assumed for Meetinghouse Creek based on limited flow data. Only low tide samples used for Meetinghouse Creek; 1976 estimates of 930 pounds per day is higher than estimates of 600 pounds per day as contained in LI 208 Section G., p. 61. Current Meetinghouse Creek sampling as reflected in this table began on April, 1987.

*** Includes Terry's Creek, Sawmill Creek, Little River, White Brook, Birch Creek, Mill Creek, Hubbard Creek, and Broad Cove Duck Farm.

**** Minor arithmetic deviations in total loadings as the sum of individual loads are due to round-off of presented intermediate numbers.

BTCAMP FIGURE 5 - Point and Nonpoint Source Nitrogen Loading



Note: Based on Peconic River/Flanders Bay data [1987-1990]
*   Includes groundwater contribution downstream of (east of) Peconic River USGS gauge station.
**   Year-round average. Summertime sediment flux is approx. 2,400 pounds per day.
*** Includes Terry's, Sawmill, Birch, Mill, and Hubbard Creeks; Little River; and White Brook.
**** Includes flow upstream of (west of) USGS gauge station.

technical refinement of the nitrogen guideline based on an extensive analysis of existing data, major pollution abatement efforts still would be required to attain the guideline regardless of the refinement, since actual surface water total nitrogen concentrations are well in excess of the guideline in the eastern Peconic River and western Flanders Bay during summer conditions. Typical non-creek total nitrogen concentrations are as high as 0.8 mg/l (and occasionally slightly higher) as determined by both computer modelling and sampling of Flanders Bay.

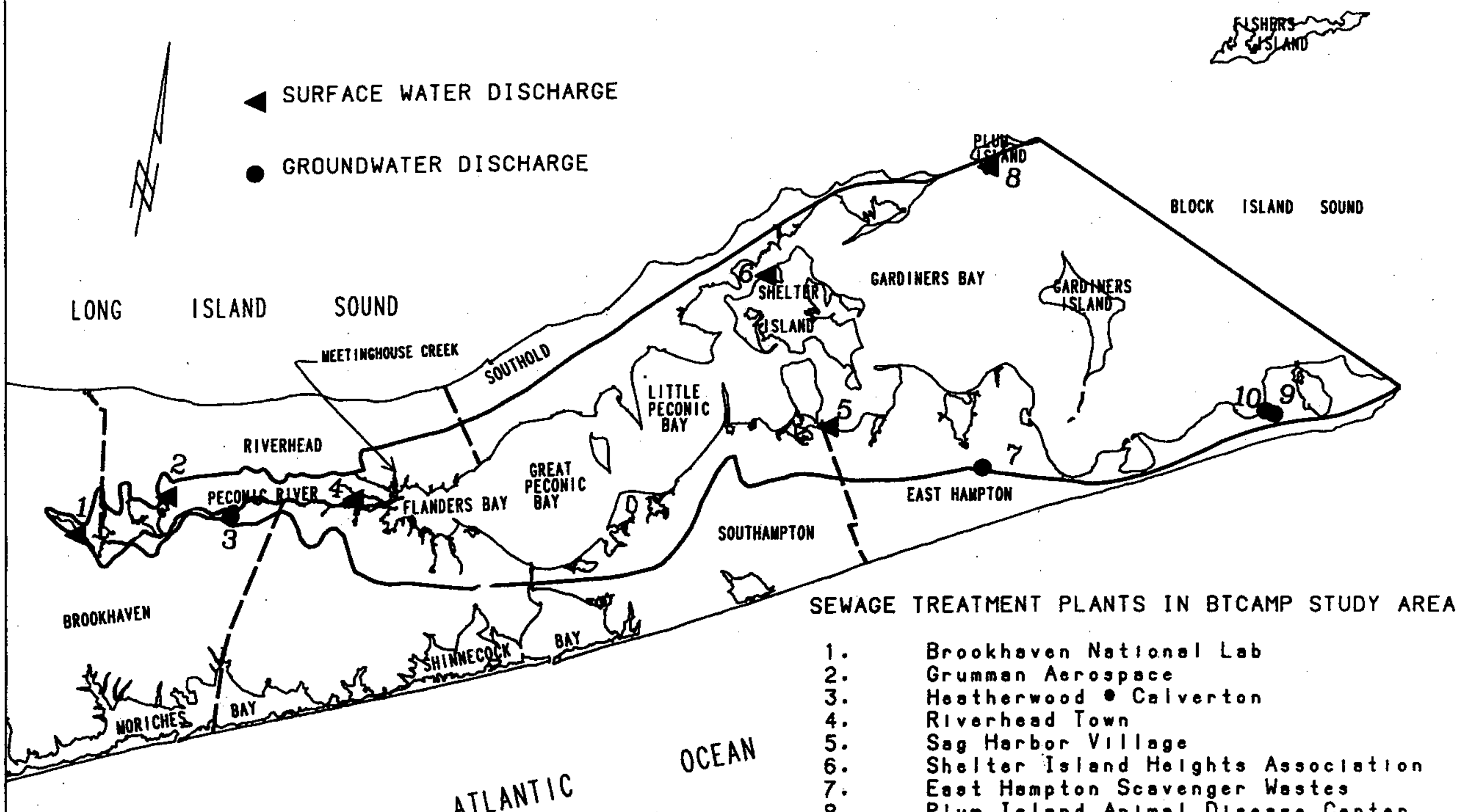
The nitrogen guideline is exceeded in the western portions of the Peconic Estuary, and dissolved oxygen concentrations occasionally dip to unacceptably low levels (i.e., less than 5 mg/l) at discreet locations, such as in the tidal Peconic River and Meetinghouse Creek. However, the system generally has not demonstrated characteristics of advanced eutrophication in terms of conventional nutrients and D.O. depletion. This evidence indicates that the Flanders Bay system currently may be near the limits of the factors of safety incorporated in the determination of the nitrogen guideline, indicating that the system could experience serious eutrophication and water quality degradation problems if pollutant loading were to increase. The most significant of all of the nitrogen loadings in terms of impact on the estuarine system has thus far been found by mathematical and computer modelling techniques to be the Peconic River and the Riverhead STP due to the concentrated nature of the discharge at a location near the mouth of the Peconic River, a poorly-flushed area of the Peconic Estuary system. With respect to the nitrogen guideline, water quality in surface waters east of Flanders Bay is generally excellent.

The location of sewage treatment plants in the Peconic system are presented in Figure 6. Based on modelling and monitoring, the Riverhead sewage treatment plant is by far the most significant sewage treatment plant (STP) in terms of nitrogen loading to the Peconic Estuary system (0.7 mgd and 140 pounds per day total nitrogen, of which 7 pounds per day are attributable to the scavenger waste treatment facility; scavenger waste is the material pumped from septic systems and cesspools). Grumman and Brookhaven National Laboratory, although discharging significantly less nutrients, are also of concern because they discharge directly into the environmentally sensitive Peconic River.

Based on modelling and monitoring, the other major point source discharges to the Flanders Peconic Bays system include the Peconic River and Meetinghouse Creek. Average total nitrogen loading from the Peconic River, as measured at the USGS (United States Geologic Survey) gauge station (see supra Figure 2 for locations), was 130 pounds per day, but the range of nitrogen loading for any given day was between 20 pounds per day (4/24/89) and 500 pounds per day (10/4/89) between December, 1988 and March, 1990. Peconic River surface water average total nitrogen loading appears to have decreased by about 60 pounds per day between 1976 and 1988-1990; this decrease could be attributable to the elimination of duck farming activity along the River as well as a decrease in Grumman flows in this time period. However, such observations over a limited time period are not definitive, since nitrogen loading from the river is variable and is heavily dependent on flow and, thus, temporal climatological trends. Significant improvements were observed in Meetinghouse Creek, where, due to the cessation of direct discharges from the Corwin Duck Farm, nitrogen loading decreased from 930 to 360 pounds per day between 1976 and 1988-1990.

Modelling indicates that at existing discharge rates, improvements in wastewater treatment and disposal at the Riverhead STP would result in a reduction of summertime surface water total nitrogen concentrations to near the 0.5 mg/l guideline throughout the tidal areas of the Peconic Estuary system (with the exception of small creeks, tributaries, etc., which could have locally elevated nitrogen concentrations). These operational improvements could be in the form of a groundwater discharge containing 10 mg/l total nitrogen, a surface water discharge relocated to central or eastern Flanders Bay, or a surface water discharge at the existing location with an effluent nitrogen concentration of 4 mg/l.

In determining the most viable alternative to handle short-term and long-term sewage collection, treatment, and disposal needs, cost concerns would have to be analyzed in conjunction with environmental impacts including, but not limited to, benefits to surface water quality, disturbance and



SEWAGE TREATMENT PLANTS IN BTCAMP STUDY AREA

1. Brookhaven National Lab
2. Grumman Aerospace
3. Heatherwood • Calverton
4. Riverhead Town
5. Sag Harbor Village
6. Shelter Island Heights Association
7. East Hampton Scavenger Wastes
8. Plum Island Animal Disease Center
9. Manor • Montauk
10. Rough Riders • Montauk

BROWN TIDE COMPREHENSIVE ASSESSMENT AND MANAGEMENT PROGRAM (BTCAMP)

FIGURE 6: SEWAGE TREATMENT PLANTS IN THE PECONIC ESTUARY SYSTEM

NO SCALE

SCURCE: SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES

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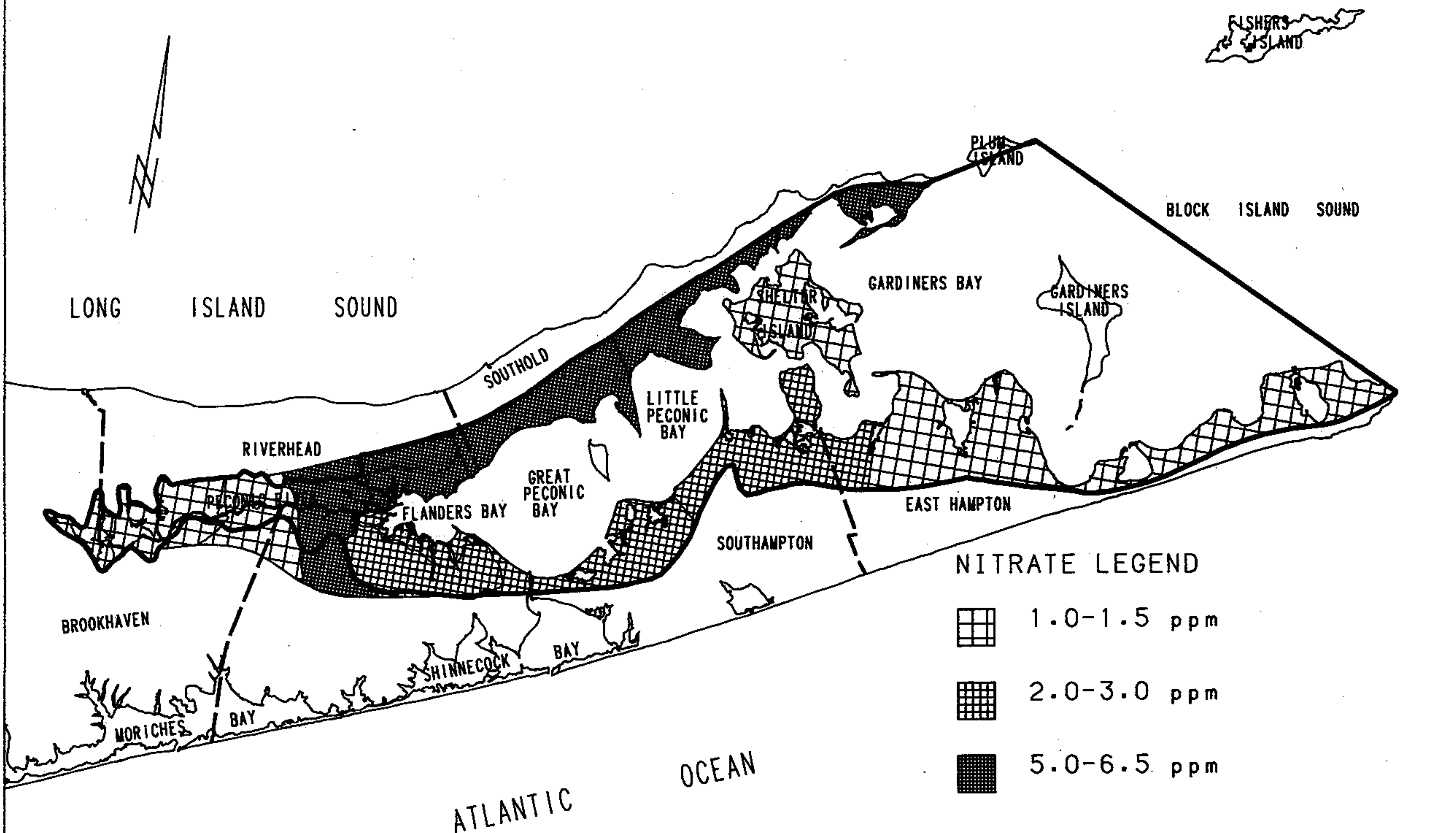
destruction of natural resources, and impacts on open shellfish beds and bathing beaches, etc. From a natural resources and surface water quality perspective, groundwater recharge would be the most desirable alternative for the Riverhead STP due to the additional filtration of effluent through soil and the elimination of the potential of surface water contamination during upset conditions. Modelling indicates that groundwater recharge would also result in the opening of currently closed shellfish beds.

In 1990, the Town's consultant estimated that accommodating significant expansion in the Riverhead STP's service area to include new developments (e.g., western portion of Route 58 corridor) could increase future flow to the facility to a level of 2 to 3 mgd. Currently, the Riverhead STP has obtained a SPDES permit modification to allow for an increase in facility flow, subject to reevaluation upon consideration of the findings of this study. However, modelling indicates that increases in STP nitrogen contribution from an increase in discharge at existing treatment conditions would cause further degradation of surface water in terms of elevated nitrogen concentrations. This degradation could result in adverse impacts on a system which is apparently already near its safe nutrient assimilation capacity. The potential for future, greater STP expansions further highlights the need for prudent, long-range pollution control strategies.

It should be noted that this summary, and the report in general, presents Riverhead STP discharge conditions at 0.7 mgd and 23 mg/l total nitrogen (140 pounds per day total nitrogen). Initially, when the study began, the facility reported a discharge of 1.06 mgd and 23 mg/l total nitrogen. On discovering faulty flow measurement, the facility revised the flow estimate to 0.7 mgd in the summer of 1991; the model was re-verified, and the report was appropriately modified. At the final writing of the report, the facility was discharging 0.64 mgd at 25 mg/l total nitrogen (134 pounds per day total nitrogen). Given the variability in discharge rate, the negligible difference between 134 and 140 pounds per day total nitrogen loading, and the difficulty in revising the entire report, 140 pounds per day of nitrogen loading from the Riverhead STP is generally presented in the report unless otherwise noted. However, for the sake of thoroughness, the modelling consultant did re-run the verification and cumulative impact graphic using latest available conditions (134 pounds per day nitrogen loading from Riverhead STP; see infra Figure 7 for cumulative impact graphic). The current conditions indicate that the impacts of increasing the facility's flow to its maximum current capacity of 1.3 mgd are that significant increases of up to 0.2 mg/l total nitrogen will occur through several kilometers of the system (see Section 7.6 of the full report). Section 7 contains more detailed information regarding modelling impacts and results.

The elimination of Corwin Duck Farm's direct discharge to Meetinghouse Creek substantially improved water quality in the creek with respect to nutrients such as nitrogen, but nitrogen (15 mg/l total nitrogen as compared with less than 2 mg/l in other local creeks) and coliform concentrations in the creek remain elevated. Despite the quantitative significance of Meetinghouse Creek nitrogen loading, modelling runs indicate that a substantial reduction of the creek's nitrogen concentrations (15 to 2 mg/l total nitrogen) would result in only moderate improvements in system-wide water quality (about 0.05 mg/l maximum system-wide total nitrogen reduction as compared with 0.2 mg/l improvement associated with Riverhead STP upgrading) due to the creek's location in a better-flushed location than the Peconic River and Riverhead STP. These improvements would be more significant on a system-wide scale if they were effected in concert with other pollution abatement efforts, such as the elimination of the Riverhead STP surface water discharge; such a combination of nitrogen source reductions would improve total nitrogen to below 0.5 mg/l throughout the open bays system.

In light of the low nitrogen concentrations (0.5 mg/l average) and the dubious feasibility of further significant improvements in Peconic River water quality, mitigation of existing conditions west of the USGS gauge station does not appear to be a priority. However, the substantial potential for future development in the study area (34% of 15,900 acres in the Peconic River area are developable as of 1989) highlights the need for pollution prevention in the Peconic River region, despite the great amount of open space and recreational land uses (26% of 15,900 acres in 1989) in this region. Since the land use statistics were compiled, recent acquisitions have decreased the amount of developable land in the



NOTE: Montauk and Shelter Island regions have less than 25 samples

BROWN TIDE COMPREHENSIVE ASSESSMENT AND MANAGEMENT PROGRAM (BTCAMP)

FIGURE 7: PRIVATE WELL AVERAGE TOTAL NITROGEN CONCENTRATIONS
PECONIC RIVER/FLANDERS BAY GROUNDWATER CONTRIBUTING AREA

NO SCALE

SOURCE: SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES

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Peconic River groundwater-contributing area. These acquisitions have certainly been helpful in safeguarding groundwater and surface water quality, but represent a relatively small portion of the developable land and do not detract from the priority nature of the continuing need for management. Other acquisitions have been proposed as part of the draft Special Groundwater Protection Area (SGPA) plan.

The intensity of land usage in given areas is directly related to nitrogen loading, which in turn correlates with the degradation of groundwater quality. Nitrogen loading rates from non-sewered medium density residential land use (the most prevalent residential land use in the study area; as defined by L.I.R.P.B., greater than 1 unit to less than five units per acre) and agricultural land use are roughly equivalent; both residential and agricultural land uses are responsible for substantial nitrogen loading in the Peconic River and Flanders Bay regions, resulting in elevated groundwater nitrogen concentrations in eastern Peconic River and North Flanders Bay areas (see Figure 7).

The high degree of open space in the Peconic River watershed, which has not undergone drastic land use changes between 1976 and 1988, has undoubtedly spared the river system from the adverse impacts of anthropogenic pollution in recent years. However, modelling analysis (Cornell, 1983) and field sampling (L.I. 208 Study, Comprehensive Water Resources Management Plan) have indicated that a development density of 1.0 unit per acre (less than or equal to 1 unit per acre is defined as low density) would result in an average groundwater nitrogen concentration of about 4.0 mg/l, which is well in excess of the existing Peconic River surface water nitrogen concentration of 0.5 mg/l. A density of 0.5 units per acre (i.e., two-acre zoning) would result in a nitrogen recharge concentration of approximately 2.6 mg/l; additional benefits could be realized through the use of fertilizer controls or even lower densities.

Current modelling projects that Flanders Bay nitrogen concentrations are quite sensitive to Peconic River nitrogen loading increases (1.0 mg/l Peconic River average nitrogen concentration would elevate Flanders Bay nitrogen concentrations by approximately 0.2 mg/l). BTCAMP did not specifically utilize a sophisticated model which interactively relates groundwater degradation to surface water quality on a localized basis throughout the length of the Peconic River, since the river was treated as a point source and groundwater underflow was considered east of the Peconic River USGS gauge station. However, the 1976 L.I. 208 study did utilize such modelling and determined that slight changes in groundwater quality have significant impacts on Peconic River surface water nitrogen concentrations. Thus, more stringent land use controls for the Peconic River area are warranted in light of the substantial amount of vacant and developable land in this environmentally sensitive region. Land use controls would also result in additional benefits in terms of natural resources protection.

From a purely quantitative perspective, groundwater nitrogen contribution (approximately 580 pounds per day east of [downstream of] Peconic River USGS gauge station) appears to be extremely significant. However, evidence such as surface water quality data, computer modelling analysis, and groundwater infiltration sampling indicate that groundwater nitrogen contribution is not having a significant adverse impact on the Peconic River and Flanders Bay system. Additionally, the portions of the study area east of Flanders Bay do not appear to be negatively impacted by groundwater nitrogen contribution due to greatly increased flushing from the seaward boundary of the system as well as a much lower rate of groundwater infiltration into the system. Although mitigation of existing groundwater conditions does not appear to be an imperative priority with respect to water quality improvement, the prevention of substantial future degradation to existing groundwater quality is an important goal, especially in the Peconic River groundwater-contributing area.

Sediment flux is the chemical exchange between the sediment and the water column. Summertime sediment flux nitrogen contribution, which is approximately 2,350 pounds per day, is greater than all other point and non-point sources of nitrogen contribution combined; however, this estimate is based on limited data and should not be considered as an absolute quantification of nitrogen loading from sediment. Changes in point source loading resulting from the implementation of management alternatives would eventually change the sediment flux rate of oxygen and nutrients, potentially resulting in significant water quality improvements. More monitoring and study would be needed to better characterize the dynamics of the relationship between pollution contribution and sediment flux and to document actual short-term and long-term water quality benefits which would be associated with pollutant abatement measures.

Relative to overall point and non-point source nitrogen loads to the Peconic River and Flanders Bays system (estimated at 3,800 pounds per day total nitrogen during summertime conditions), stormwater runoff, which contributes approximately 30 pounds per day of nitrogen, does not appear to be a significant source with respect to nutrient loading.

A graphic illustration of the modelling results of cumulative pollution control alternative analysis with respect to nitrogen concentrations is presented in Figure 8. The nitrogen profiles are plotted along a system transect extending from the westernmost tidal reaches of the system (at the Peconic River) eastward to Gardiners Bay. The base case is representative of existing average total nitrogen concentrations in the system.

b. Coliforms

As of 1990, 3,053 acres of shellfish beds are closed in the Peconic system; these areas are generally situated in partially enclosed embayments and near shore locations or are located adjacent to STP discharges. Stormwater runoff is the largest and most significant source of total and fecal coliform loading to the Peconic River and Flanders Bay. Stormwater runoff coliform loading is correlated with the intensity of land use, with land use and pollutant loading analysis indicating that the North and South Forks, with substantial acreage in residential land use, each contribute a greater overall coliform load than the less intensively developed Peconic River watershed. The Riverhead STP and duck farming activity have also historically contributed substantial coliform loadings. Additional localized sources of coliform pollution may include wildlife waste and improperly installed, or poorly functioning, sanitary systems. There also exists concern regarding potential coliform pollution stemming from marinas and boating activities, especially in constrained and poorly-flushed water bodies.

Modelling indicates that the system-wide benefits from decreased stormwater runoff coliform loading (movement of open shellfish area boundary approximately an additional 0.5 km westward with a 50% loading decrease) are relatively insubstantial with respect to the massive efforts that would be required to reduce existing coliform loading. Therefore, management efforts should be focused on prohibiting any action which would result in a substantial increase in stormwater runoff coliform loading to the Peconic Estuary system. There may, however, be local areas that would benefit by decreasing runoff; these areas should be subject to more detailed analysis.

The Riverhead STP total coliform contribution was estimated to approach that of the stormwater runoff contribution in the 1988-1990 period. Riverhead has instituted STP chlorination improvements in the spring of 1991 which the Town of Riverhead consultant reports have resulted in marked reductions in the amount of coliform discharged. Modelling indicates that the elimination of the Riverhead STP surface water coliform loading could move the open shellfish area boundary on the order of an additional 1 km westward. If the Riverhead STP were to convert to a groundwater discharge, the potential for direct surface water pollution during upset conditions would be eliminated, and, thus, additional shellfish beds might be opened.

Meetinghouse Creek continues to contribute substantial coliform loading in wet and dry weather despite the cessation of direct duck farm discharge to the creek. A modelling assessment of Meetinghouse Creek coliform loading impacts shows that improvements in Meetinghouse Creek coliform concentrations would result in localized water quality benefits but would be of little system-wide water quality significance. It must be emphasized that, at one time, duck farming discharges to the Peconic River and Flanders Bay undoubtedly contributed a much greater coliform load due to the nature

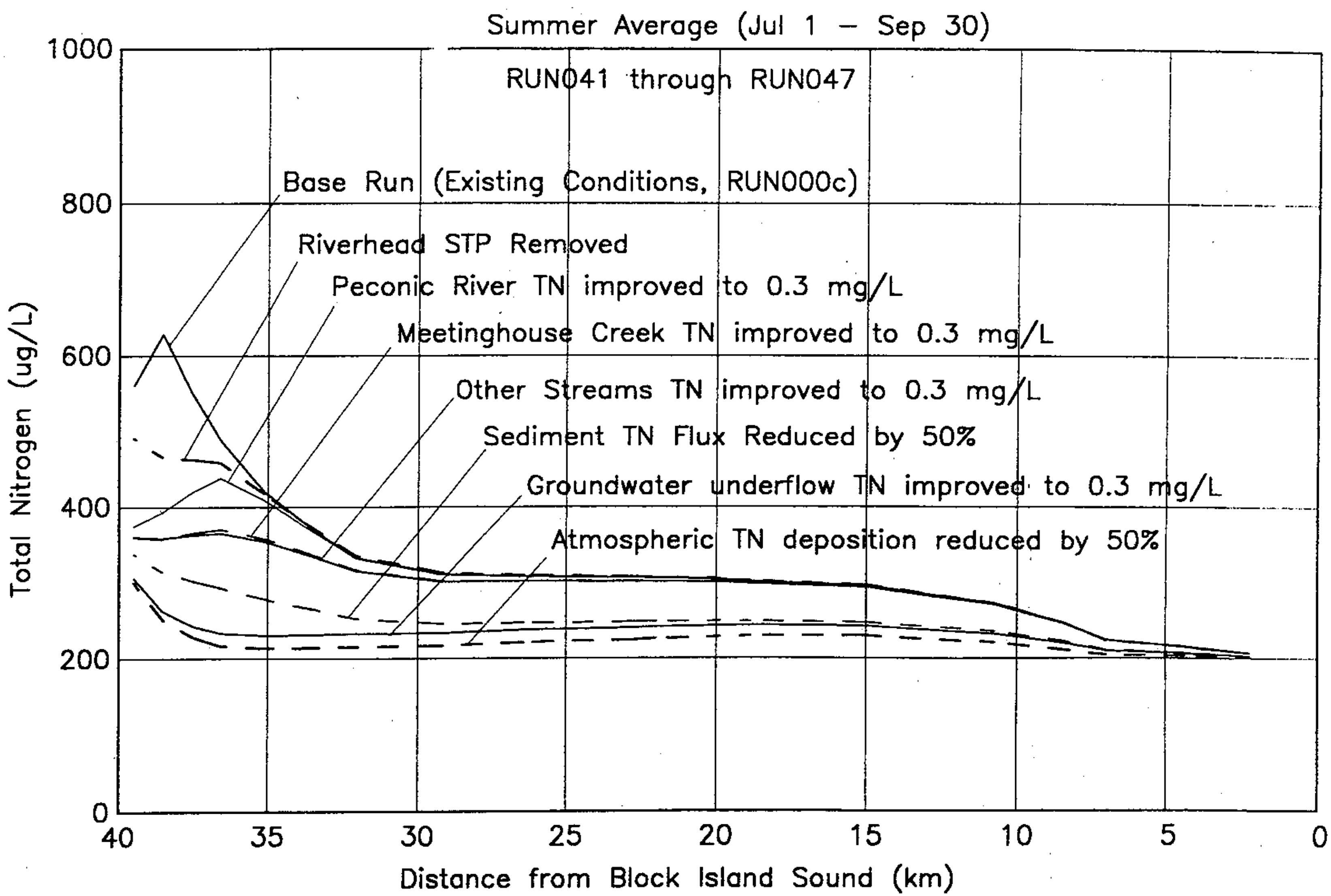


FIGURE 8: COMPUTER MODELLING MANAGEMENT ALTERNATIVES ANALYSIS: CUMULATIVE TOTAL NITROGEN IMPROVEMENTS

and extent of the historical duck farming activity, which had substantially subsided by the 1970's and, with the exception of the Corwin Duck Farm, totally ceased in the 1980's.

c. Other Pollutants

In general, there is no evidence of extensive surface water organic chemical contamination problems or surface water impacts in the Peconic Estuary system. However, there has been enough evidence of organic chemical, pesticide, and landfill-related pollution in the study area to warrant monitoring, study, and, in some cases, remedial investigations (e.g., North Sea Landfill and Rowe Industries sites). Organic chemicals have been sporadically detected in groundwater; pesticide contamination of groundwater throughout the North Fork resulting from agricultural practices is common (see Figure 9), and pesticides have been detected in low concentrations in surface waters of East Creek. In addition, the North Sea landfill (see location on Figure 10) has generated a plume of contaminants which reportedly includes ammonia, iron, manganese, volatile organic compounds, cadmium, and lead. This plume has reached the surface waters of the Peconic system. In terms of industrial discharges, waste disposal practices at Brookhaven National Laboratory (BNL) have resulted in significant contamination of groundwater; numerous hazardous materials leaks and spills have also been reported throughout the study area and at Grumman and BNL. However, potential pollution of surface waters from these industrial sources of pollution has not been documented, except at the Rowe Industries site in Sag Harbor, where a significant plume of organic chemical contamination has reached its discharge boundary at Sag Harbor Cove. The impacts of this plume are currently unknown. Finally, oil and gasoline, marine paints, floatables, and other debris are boating-related pollution sources which may warrant future evaluation in the Peconic Estuary system.

Acid rain has traditionally been a concern with respect to depressing the pH of freshwater ecosystems. In the context of the BTCAMP study of a marine environment, acid rain is not a primary concern with respect to direct impact on surface water pH due to the buffering capacity of the marine system. However, acid rain may directly impact the fresh waters in the study area and may have indirect impacts on marine waters related to the solubility and transport of contaminants through the sediments. In addition, due to increasing emissions of nitrogen oxides to the atmosphere on a national level over the last three decades, the amount of nitrogen reaching waters from precipitation has been recognized as a significant contributor of contaminants to surface waters. The modelling consultant has estimated that the atmospheric deposition of nitrogen to the Peconic River and Flanders Bay surface water system is 160 pounds per day (wetfall and dry deposition); this estimate is approximately 5% of the overall non-point source loading to the system.

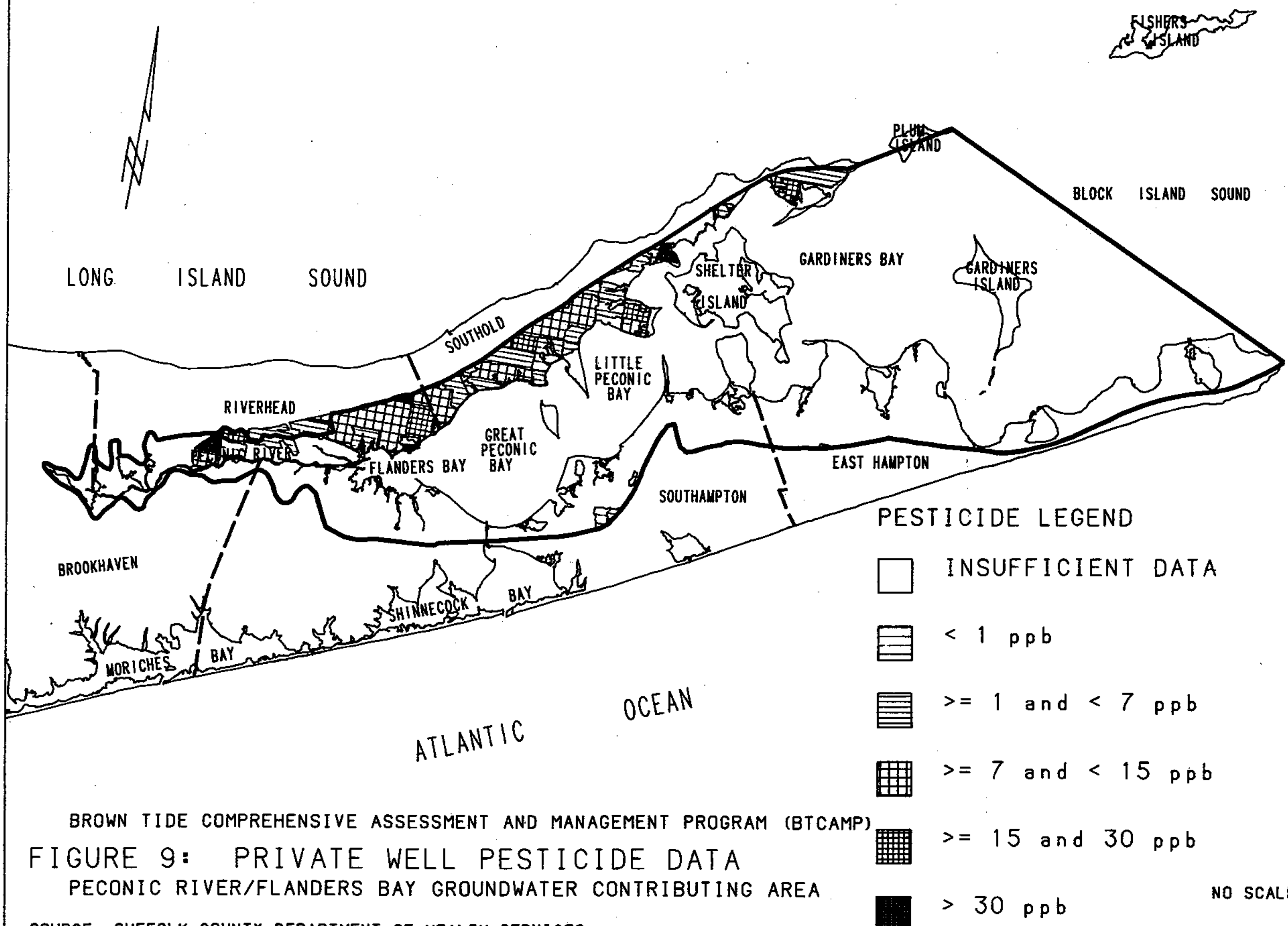
3. Other Natural Resources

Although BTCAMP focuses primarily on the causes and effects of the Brown Tide as well as other conventional water quality parameters, the wealth of other natural resources which are present in the groundwater-contributing area to the Peconic Estuary must be acknowledged. The ecological significance of the area is manifested in its extensive, high-quality wetlands, its New York Natural Heritage Program rare ecosystems, its significant coastal fish and wildlife habitats, and its nationally and locally threatened and endangered species.

The protection of these resources is, of course, of paramount concern. While some resources, such as wetlands, serve to protect surface water quality, other resources may be impacted by water quality management and land use decisions and structural and non-structural control. Thus, natural resources should be protected and, where feasible, enhanced when major water quality-related management decisions are contemplated. In addition, a Peconic Estuary-specific natural resource inventory and management plan should be pursued for the Peconic Estuary system.

4. Implementation

The implementation of the recommendations would best proceed as a cooperative effort between all levels of government with the support and guidance of the private citizenry. The agencies and

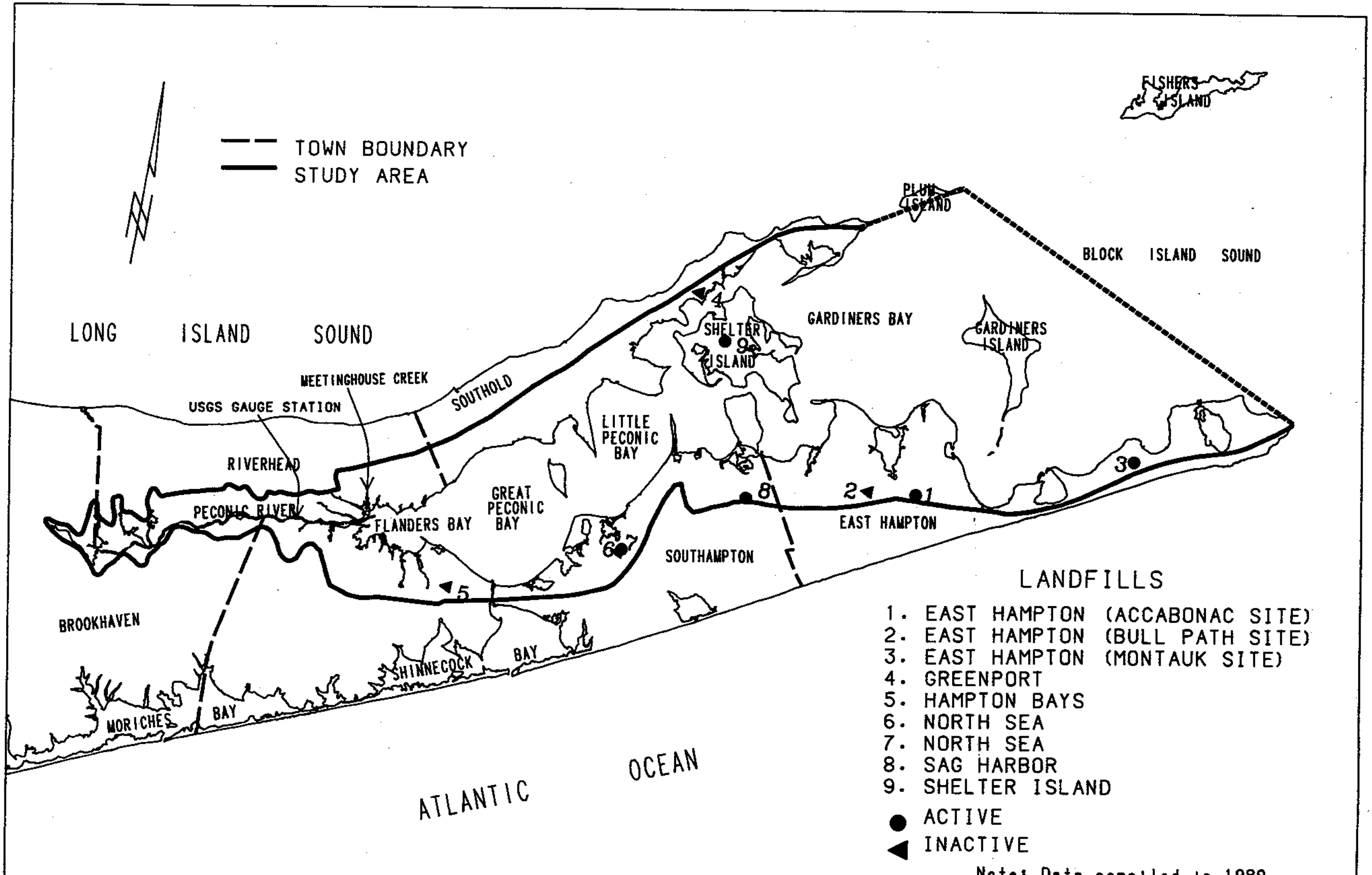


BROWN TIDE COMPREHENSIVE ASSESSMENT AND MANAGEMENT PROGRAM (BTCAMP)

FIGURE 9: PRIVATE WELL PESTICIDE DATA

PECONIC RIVER/FLANDERS BAY GROUNDWATER CONTRIBUTING AREA

SOURCE: SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES



BROWN TIDE COMPREHENSIVE ASSESSMENT AND MANAGEMENT PROGRAM (BTCAMP)

FIGURE 10: ACTIVE AND INACTIVE LANDFILLS IN THE PECONIC AREA

SOURCE: SUFFOLK COUNTY DEPARTMENT OF HEALTH SERVICES

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organizations which are charged with the implementation program are already well established. The immediate goals of implementation are effecting specific recommendations related to mitigation, remediation, public education, and further study. The implementation program also would be most effective with mechanisms to re-convene the BTCAMP management committee to periodically assess the progress of the implementation of BTCAMP recommendations as well as to address future environmental problems and potential additional programs and funding sources.

B) Summary of Recommendations

1. Prevention of Degradation - Peconic River and Flanders Bay

Incremental point and non-point source pollution of surface waters and substantial groundwater degradation should be prohibited in the poorly flushed and environmentally stressed tidal portions of the Peconic River and western Flanders Bay areas.

a) In relation to STP expansion, no net increase in quantities of nitrogen discharge should be allowed to the surface waters of the Peconic River from Grumman, Brookhaven National Laboratory, and the Riverhead sewage treatment plants (STP's); other new or incremental discharges resulting in additional nitrogen loading should also be prohibited. In the case of Riverhead STP flow increases, "no net increase" may be achieved by a groundwater discharge of incremental process flow which has been denitrified (optimally to 4 mg/l) to ensure that no significant groundwater degradation and subsequent surface water impacts occur. In the alternative, the facility could denitrify the incremental flow plus a portion of the existing flow and discharge the entire effluent stream at the current outfall, provided that the total quantity (i.e., pounds per day) of nitrogen discharged does not exceed current nitrogen discharge levels. Of the two "no net increase" alternatives, the groundwater recharge of incremental flow is preferable from a nitrogen and/or other contaminant (e.g., coliform) standpoint due to the additional filtration of effluent through soil as well as the reduced potential of surface water contamination from upset conditions.

b) To prevent future, substantial degradation of groundwater and, subsequently, Peconic River surface water, developable residential land in the Peconic River groundwater-contributing area should be upzoned to a minimum of two acres. Developable commercial, industrial, and institutional land uses should be controlled such that the nitrogen impacts on groundwater are comparable to that of two-acre residential zoning. Additional natural resource protection could be attained by even more stringent land use controls, such as three to five acre zoning. It should be noted that the Wild, Scenic, and Recreational River (WSRR) act administered by NYSDEC limits residential development to 4 acres per unit in "scenic" areas and 2 acres per unit in "recreational" areas. Much of the Peconic River groundwater-contributing area is regulated under the WSRR program, with the "scenic" area extending from the headwaters of the river to the railroad bridge west of Edwards Avenue and the "recreational" designation applying to the remainder of the freshwater river area.

c) Zoning controls should be implemented in conjunction with other land use management techniques, including cluster development, transfer of development rights, and programs related to preservation, acquisition, and enhancement of land. The highest possible standards should be utilized in the review of development plans in the river region, including requiring open space dedications, maximum practicable setbacks from the river, and natural landscaping techniques to minimize turf areas and fertilizer use.

d) In general, the construction of additional groundwater-discharging sewage treatment plants in the groundwater-contributing area to the Peconic River is contrary to the recommended large-lot zoning policy, which is designed to prevent substantial groundwater degradation for surface water protection purposes. No new groundwater-discharging treatment facility should be considered unless it replaces and upgrades an older facility. However, in special circumstances, groundwater-discharging sewage treatment plants may be considered, subject to the following conditions:

i) Best available technology is utilized (e.g., denitrification to 4 mg/l);

ii) The proposed project is associated with significant groundwater, natural resources, and/or surface water quality benefits; and

iii) Additional environmental analysis and/or modelling indicate that the adverse impacts on the Peconic River system will be negligible.

e) Best management practices, such as low-maintenance lawns, slow-release nitrogen fertilizers, modification of fertilizer application rates, and fertilizer use restrictions should be promoted, especially in the Peconic River watershed.

2. Nutrient Pollution Abatement - Peconic River and Flanders Bay

To attain the recommended marine surface water quality total nitrogen guideline of 0.5 mg/l for Flanders Bay, prudent pollution abatement strategies for the Peconic River and Flanders Bay are warranted where feasible, and should be pursued.

a) Although adverse impacts of pollution are apparent in certain localized surface water segments, there appears to be no imminent, critical threat of nutrient over-enrichment to the system-wide surface water quality of the Peconic Estuary system. However, as a long-range management goal, the Riverhead STP should be upgraded so that the nitrogen guideline can be attained and adequate system-wide surface water quality could be assured. Such an approach affords the Town the ability to study economic, social, and environmental impacts associated with long-term growth and sewering needs, and to fairly apportion upgrading costs among developments which connect to the system and expand the service area.

The long-range facility upgrade could incorporate a groundwater discharge containing 10 mg/l total nitrogen, a surface water discharge relocated to central or eastern Flanders Bay at current nitrogen discharge levels (approximately 23 mg/l total nitrogen), or a surface water discharge at the existing location with an effluent nitrogen concentration of 4 mg/l. Further study would be required to adequately weigh the costs and impacts associated with each treatment alternative. For example, there may be significant adverse environmental impacts associated with the relocation of the outfall discharge to central or eastern Flanders Bay. From BTCAMP's pollution control and natural resources perspective, groundwater recharge is the most desirable alternative.

b) Monitoring of pollution at Meetinghouse Creek should be continued and remediation should be effected when technologically, economically, and environmentally feasible.

3. Pollution Control - Eastern Study Area

Pollution to the eastern portions of the Peconic Estuary system should be controlled such that existing water quality in the bays east of Flanders Bay is maintained. In tributaries and small embayments, pollution sources and facilities such as Sag Harbor Village STP require additional evaluation to determine localized impacts and potential remedial measures.

4. Stormwater Runoff and Coliform Control

a) Stormwater runoff remediation efforts should be evaluated and undertaken on a site-specific basis pursuant to localized studies which demonstrate technological, economic, and environmental feasibility.

b) On a system-wide basis, any action which would result in a substantial increase in stormwater runoff coliform loading to the Peconic Estuary system should be strictly prohibited. Proposals for new development within the stormwater runoff-contributing area to the Peconic Estuary system should be reviewed under the strictest scrutiny. In addition to on-site stormwater runoff containment requirements, vegetative buffers and sediment and erosion control plans should be considered as part of the approval process, with enforcement through the issuance and revocation of permits.

5. Boating and Marina Controls

a) The Suffolk County law (Resolution #946-88) which mandates the SCDHS to undertake investigation of potential nuisances at marinas should be implemented in the Peconic Estuary system so that marine pollution data could be obtained; to date, this law has not been implemented due to SCDHS staffing limitations. These data could be utilized to specifically identify boating and marina problems and management needs and to conduct an informed evaluation of the feasibility of potential control alternatives. Until such an evaluation occurs, the highest possible standard of review for marina projects should be employed to assure minimal adverse environmental impacts from marina construction and operation.

b) Greater use of shore-based toilets, holding tanks on boats, and existing and additional pump-out stations should be promoted, especially in areas with heavy boat traffic or in environmentally sensitive areas. The implementation of other measures, such as designation of "no discharge zones" and enforcement for non-compliance with discharge regulations, may also increase usage of pump-out facilities.

6. Natural Resources

a) Restoration and monitoring of natural resources which have been adversely impacted by the Brown Tide should occur in conjunction with other pollution control measures outlined in this section. Examples of potential priority restoration and monitoring targets should be scallop reseeding and eelgrass replanting.

b) Water quality management decisions should be accompanied by the maximum practicable level of protection and enhancement of affected natural resources, based on a comprehensive analysis of available data and the selection of the most protective resource management alternative which is feasible from social, economic, and technological perspectives.

c) A Peconic Estuary-specific natural resource inventory and management plan should be pursued for the Peconic Estuary system. Several suggestions regarding management were made in the *Workshop for the Development of a Research Program for the Peconic Bay Responsive to Management Needs* report (MSRC et al, November, 1991) which points out that, from a natural resources perspective, management information for the

Peconic Estuary appears to be relatively limited. Selected areas of concern are outlined as follows:

-Characterization of shellfish resources and other related components of the Peconic system (e.g., submerged aquatic vegetation, sediment type, etc.), further evaluation of brown tide impacts on various shellfish species, and assessment of success of prior shellfish reseeding and vegetation restoration programs.

-Determination of the abundance and distribution of finfishery resources through trawl and plankton surveys, followed by mapping of habitats, quantification of nursery value, and analysis of interaction of finfisheries with brown tide.

-Management of critical habitat for rare and endangered species, placing priority on existing knowledge of habitat to maximize species protection. Issues requiring investigation include, but are not limited to, the feeding habits and boat-related mortality of the Kemp's Ridley turtle in east end waters, the forage fish food sources to rare and endangered birds, and the habitat requirements of the eastern mud turtle in the Peconic Estuary system.

7. Further Monitoring and Research

a) Monitoring of water quality and Brown Tide in the Peconic Estuary and South Shore bays systems should be continued. The refinement of the marine surface water nitrogen guideline of 0.5 mg/l for Flanders Bay and tidal portions of the Peconic River also should be pursued.

b) Theories relating to the onset and persistence of the Brown Tide should be researched further; this research should have greater emphasis on field studies. Chemicals which should be further investigated include specific organic nutrients, which may be required for rapid growth of the Brown Tide and might even serve as additional energy sources; chelators (chemicals that combine with metals making them nontoxic to organisms and/or available for growth) such as citric acid; and trace metals such as iron, selenium, vanadate, arsenate and boron. In addition, theories that physical factors such as meteorological and climatological patterns (e.g., wind, rainfall) may be responsible for the onset and/or persistence of the Brown Tide should be further evaluated. Finally, research concerning the organism's physiology should be continued.

c) Research on the impacts of the Brown Tide on shellfish should be continued. This research would focus on the potential for the Brown Tide's toxic, poor nutritional, and/or mechanical inhibition of scallop growth and reproduction. The potential toxicity of acrylic acid and dimethyl sulfide (DMS), which may be produced by the Brown Tide, to shellfish larvae should also be examined. In addition, other mechanisms which may be responsible for the adverse impacts on shellfish should be examined, including the poor retention of small particles by shellfish feeding apparatus, structural features of Aureococcus which impair digestion by filter feeders, inefficient feeding and low absorption at high algal concentrations, and insufficient nutritive quality of Aureococcus to shellfish.

d) Factors related to the control and subsidence of the Brown Tide bloom have been theorized and should be researched. One such theory is that acrylic acid produced by the Brown Tide adversely affects the viability of a zooplankton population which would graze on and limit the Brown Tide. The role of viruses in the subsidence of the Brown Tide has also been hypothesized and should be investigated.

e) Sediment flux sampling should be continued and expanded, and the dynamics of the relationship between pollution contribution and sediment flux should be studied. One goal of future sediment flux study is to document ultimate water quality benefits which would be associated with pollutant abatement measures such as Riverhead STP upgrading and Meetinghouse Creek remediation. Changes in point source loading resulting from the implementation of management alternatives would eventually change the sediment flux rate of oxygen and nutrients; allowing additional pollution into the Peconic River/Flanders Bay system would further exacerbate the potential for system-wide cultural eutrophication. Conversely, the benefits of recommended pollution control measures, when considered independently of sediment flux, generally bring water quality to levels near (but not necessarily below) the nitrogen guideline. Thus, additional benefits realized from sediment flux pollution abatement might result in additional water quality improvements, which could ensure eventual nitrogen guideline attainment. Therefore, the general need to obtain additional sediment flux information does not affect other management recommendations made in this report.

f) The computer model of the estuarine system should be improved to include a sediment submodel which predicts benthic fluxes as a function of sedimentary particulate organic matter decay along with the mass transport and kinetics of dissolved nutrients. Other recommendations include adding model parameters (when available) to run a Brown Tide model, improving understanding of zooplankton distribution and grazing rates, coupling WASP5 with a more sophisticated model to account for gyres, incorporating hourly model simulations to improve diurnal dissolved oxygen prediction, and considering the addition of multiple vertical layers in the Peconic River to account for known vertical gradients of salinity.

g) Surveys of shellfish and finfish resources in the Peconic system should be continued, and Brown Tide impacts on shellfish should be monitored.

h) Groundwater monitoring programs and the study of potential surface water impacts of groundwater should be continued, especially in areas with known contamination such as the North Sea Landfill, the Rowe Industries site, Brookhaven National Laboratory, Grumman and East Creek. More study regarding the extent and potential impacts of hazardous materials contamination should be conducted. These programs should incorporate surface water and sediment monitoring, where appropriate, and should consider potential surface water impacts as important factors in future management decisions.

Just prior to BTCAMP report publication, USEPA announced that no further federal action at the North Sea landfill site is necessary. Under a consent decree with USEPA, the Town of Southampton is addressing the source of contamination. A USEPA press release (October 6, 1992) notes that the North Sea Landfill does not pose a significant threat to public health and environment via groundwater contamination, based on a program of remedial action. This program also calls for further monitoring of groundwater, air, benthic ammonia flux in Fish Cove, and hard clam recruitment

i) Monitoring of the direct and indirect impacts of acid rain should be conducted.

8. Public Education

Preservation and enhancement of Peconic River water quality should be promoted through information and public participation programs, such as the workshops which have been sponsored by the BTCAMP Citizens' Advisory Committee (CAC) regarding pollution sources such as fertilizers, animal wastes, and sanitary systems. Boater education efforts should also be expanded, and public awareness of stormwater runoff and groundwater pollution problems should be heightened. Additionally, "Stop Throwing Out Pollutants" programs should be continued and, where possible, enhanced as a means to foster public education and to help to reduce the amount of household hazardous materials which pollute the environment.

9. Implementation

A few of the more important implementation roles, priorities, and responsibilities are noted as follows.

a) Research activities may be conducted by a wide array of institutions, many of which have already participated in BTCAMP. Funding for further research activities should be provided by all levels of government, including federal, state, county, and town government.

b) Monitoring of groundwater and surface waters should continue as it was conducted during BTCAMP, with SCDHS providing most BTCAMP-related monitoring and laboratory services and NYSDEC contributing with sampling pursuant to programs such as shellfish area testing and finfish management. In addition, NYSDEC and EPA are responsible for conducting and/or overseeing many related sampling programs, such as Superfund and landfill remedial investigation programs. Outside consultants and laboratories may be retained for site-specific sampling programs (e.g., sediment sampling).

c) Point source and sewage treatment plant recommendations should be implemented by NYSDEC and SCDHS through the State Pollutant Discharge Elimination System (SPDES) permit process. It would be the responsibility of Riverhead Town to weigh economic, social, and environmental impacts related to various alternatives in formulating a long-range sewage treatment plant expansion and upgrading program which is acceptable to the State. Recently, Riverhead Town has announced that it will voluntarily impose a "no net increase of nitrogen discharge" policy on its sewage treatment plant (STP) in order to be consistent with BTCAMP recommendations. The cost for the required denitrification will be borne by the projects which result in new connections. In committing to this policy, the Town has taken an important step toward ensuring non-degradation of Peconic Estuary surface water quality.

d) Meetinghouse Creek pollution should be addressed by NYSDEC and the Corwin Duck Farm with the assistance and guidance of SCDHS and the Soil Conservation Service (SCS) regarding guidelines for future pollution abatement.

e) Peconic River land use regulations fall within the province of the Towns' regulatory authority, and should be implemented by the Towns of Riverhead, Brookhaven, and Southampton. In addition, all towns in the study area should consider land use studies and reforms to protect localized surface water quality conditions and natural resources.

f) Stormwater runoff should be addressed at the Town level at the subdivision review stage and by State, County, and Town governments when concerning roadways in their respective jurisdictions. Local investigations and pilot remediation projects should be cooperative efforts between all levels of government.

g) Local government master plans, zoning codes and land use regulatory policies should be reviewed to determine the extent to which they are consistent with BTCAMP recommendations. Appropriate changes in land use programs should be proposed in those instances where inconsistencies and conflicts are found.

h) Public education should be continued by the Citizens' Advisory Committee (a.k.a. "Save the Bays"), which has been an invaluable resource in terms of disseminating information by way of newsletters, a video and an accompanying booklet. The CAC should also continue conducting public information conferences such as the two "State of the Bays" conferences conducted in 1988 and 1990 as well as the four successful "Save the Bays" workshops co-produced with Cornell Cooperative Extension Marine Program, which has been, and should continue to be, instrumental in educating the public in a broad range of environmental issues.

i) In terms of program responsibilities, the agencies and organizations charged with the recommended implementation program are already well established. A general summary of priorities which have been set in BTCAMP is as follows:

-Many of the priorities identified in BTCAMP should be implemented immediately, especially those in the sensitive Peconic River corridor (e.g., "no net increase" policy for STP's in the Peconic River area).

-The report also has attempted to define those activities which are important management concerns because of potential for long-term water quality enhancement, but which are not immediate priorities due to current cost of mitigation and the lack of an immediate threat to system-wide water quality. Examples of this class of "long-range" management concerns include Meetinghouse Creek pollution abatement and mitigation of existing pollution from the Riverhead STP.

-Land use controls in the Peconic River area are a relatively short-term goal which cannot be implemented instantaneously due to the need for new land use regulations at the local level. Two-acre zoning is of paramount importance, while more restrictive zoning will result in additional natural resource benefits. An assessment of development review procedures by Towns should occur immediately to ensure consistency with BTCAMP recommendations.

-System-wide stormwater runoff mitigation is not a pressing priority, and should proceed in the future on a site-specific basis as resources allow.

-The monitoring efforts and public education are existing, continuing programs.

j) In terms of project costs, BTCAMP did not present highly detailed, site-specific economic information regarding the various alternatives; such evaluation is beyond the scope of BTCAMP and is better left to subsequent studies. However, a consideration of economic factors has been an integral part of the management process of weighing costs of management measures with projected benefits. Economic aspects of some of the major study components are summarized as follows:

-In some areas, such as maintaining existing monitoring programs, no significant, incremental operating costs will be needed.

-Riverhead Town is in the process of generating preliminary estimates for the cost of STP upgrades. Preliminary reports indicate that the cost of the entire plant upgrade will be on the order of millions of dollars. With this cost factor in mind, the immediate "no net increase" Riverhead STP recommendation was made based on the pressing environmental need to prevent any further degradation to the system. The long-range upgrade recommendation was carefully crafted to allow managed growth in the Town, with incoming developments bearing the cost of a phased denitrification program.

-USEPA has performed preliminary analyses regarding the cost of sediment remediation at Meetinghouse Creek which indicate that as much as 250,000 cubic yards would require removal at $3 to $9 per cubic yard (assuming a convenient disposal site), based on conversations with NYSDEC regarding historical dredging experience. In light of the high cost of remediation and the relatively small system-wide water quality benefits associated with creek remediation, Meetinghouse Creek is not a pressing management priority. However, monitoring and potential mitigation should be pursued based on continuing evaluation of alternative management technologies (e.g., plantings, covering of sediments, etc.).

-BTCAMP has essentially affirmed the findings of the Long Island Segment of the Nationwide Urban Runoff Program ("L.I. NURP") which asserted that "on an areawide basis, the opportunities for preserving the quality of currently certified or certifiable waters far exceed those for improving the quality of conditionally certified or uncertified waters." BTCAMP found that, on a system-wide basis, major reductions of stormwater runoff would result in marginal benefits in terms of open shellfishing areas. NURP found that annual costs associated with a 50% overland runoff control to the Great South Bay system were over 1 million dollars a year (1982 dollars; capital amortized at 10% over 20 years plus operation and maintenance costs). Although the economics of remediation for the Flanders/Peconic Bay system were not specifically treated in NURP, the difficulty and expense in system-wide remediation, coupled with the uncertainty of effectiveness due to a number of variables, make system-wide remediation inadvisable at this time. However, further site-specific investigations should be pursued to assess value of localized remediation.

-Regarding land use controls, no initial capital costs are incurred; however, economic implications certainly are associated with upzonings. From BTCAMP's perspective, reasonable recommendations have been set forth which balance pressing environmental needs with socio-economic factors. Although a "no development" policy would virtually guarantee excellent Peconic River surface water quality, such a plan would be unduly onerous; thus, two-acre zoning (or its equivalent based on nitrogen loading) was selected as a minimum upzoning recommendation because of its groundwater benefits which would ensure the integrity of groundwater and Peconic River surface water quality. Additional natural resources protection could be obtained by even larger-lot zoning. Of course, the ultimate decisions regarding land use have been left to the Towns.

8) Project Acceptance and Future Management

Response to drafts of the BTCAMP report has generally been positive. Revisions to the report have been made to conform to comments, where practicable.

Public participation also was an integral component of the management process. Several presentations were provided to the Citizens' Advisory Committee to apprise citizens of project progress as well as to solicit input. The study's findings, conclusions, and recommendations were finalized in draft tabular form and were presented publicly in October, 1991. After distribution of the full Summary document, an open public hearing was advertised and held in April, 1992 to once again present the major aspects of the study and solicit further input.

SCDHS has convened numerous Management Committee meetings throughout the project. The final Management Committee meeting was held in April, 1992, at which time attendees all approved of the substance of the report's contents as presented in this Summary. The BTCAMP Management Committee believes that this summary accurately reflects the management and research efforts that have been performed pursuant to BTCAMP. Through extensive participation from numerous governmental and private organizations and individuals, the study has effectively pursued the research of the Brown Tide organism while independently exploring and evaluating an expansive array of management techniques for conventional water quality concerns. All who have worked on this project feel privileged to have contributed in some small measure to the management of such an invaluable resource, and are grateful for the general level of support received in the process from both the public and private sectors.

Future Brown Tide Management Committee meetings should be held periodically to identify and address environmental problems, additional programs and funding sources, and progress of implementation of BTCAMP recommendations. The recently announced inclusion of the Peconic Estuary in the National Estuary Program represents a vehicle for further management of the Peconic Estuary system.

9) Concluding Statement

Although BTCAMP's management focus primarily has been on conventional surface water quality issues, the comprehensive nature of the study hopefully has imparted a broader sense of the natural resources, recreational opportunities, and commercial value associated with the system. Through remarkably good fortune, the resources in the study area seem to have survived the onslaught of human-related degradation which has plagued so much of the Northeast. Fortunately, many of the estuarine system's exceptional resources remain intact, and may be preserved through prudent planning.

Despite the general optimism regarding quality of the Peconics, the data indicate that localized water quality problems exist and significant portions of the western main bays system is at the threshold of significant degradation. Thus, the estuarine system is at a crossroads. Careless exploitation will lead to increasingly irreversible degradation, contributing to the demise of a once-pristine ecosystem. Thus, although mitigation is an important factor in BTCAMP, the preservation of resources must also be of paramount concern to ensure the preservation of our legacy for future generations.

Brown Tide Comprehensive Assessment and Management Program

TABLE 3 - SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

TOPIC	FINDINGS / CONCLUSIONS	RECOMMENDATIONS
I. BROWN TIDE	1. The Brown Tide is an algal bloom of a particularly small and previously unknown species (*Aureococcus anophagefferens*) which has appeared in the Flanders/ Peconic and South Shore bays systems. 2. The Brown Tide bloom is recurring in nature, and has to date been unpredictable in onset, duration, and cessation, often persisting for unusually long periods of time over large areas. 3. Advances have been made regarding the identification and characterization of the Brown Tide and its growth needs. Although all algal growth requires macronutrients, conventional macronutrients such as nitrogen apparently do not trigger the onset of the Brown Tide blooms. Chemicals which have been implicated by research as potential contributors to Brown Tide's pervasiveness include specific organic nutrients, chelators such as citric acid, and trace metals such as iron, selenium, vanadate, arsenate and boron. 4. Viruses are suspected to be an agent in ending the growth cycle of the Brown Tide. Acrylic acid and dimethyl sulfide, which may be produced by the Brown Tide organism, may be toxic to zooplankton which would graze on the Brown Tide. Meteorological and climatological factors may also affect the Brown Tide. 5. The abundant Peconic Bay scallop population was virtually eradicated by the toxic, mechanical, and/or poor nutritional aspects of the Brown Tide. In addition, the eelgrass beds, which are a critical shellfish and finfish spawning and nursery area, were decimated, probably due to reduced light penetration caused by the Brown Tide. Other shellfish apparently affected during Brown Tide blooms include oysters, clams, and blue mussels.	1. Monitoring of water quality and Brown Tide concentrations in the Peconic Estuary and South Shore bays systems should be continued. 2. Theories relating to the onset and persistence of the Brown Tide should be further researched; this research should have greater emphasis on field studies. Areas of research should include specific organic nutrients; chelators such as citric acid; trace metals such as iron, selenium, vanadate, arsenate, and boron; and meteorological and climatological factors. Laboratory research regarding the organism's physiology also should be continued. 3. Surveys and research on the toxic, mechanical, and/or poor nutritional impacts of the Brown Tide on shellfish should be continued. 4. Factors related to the control and subsidence of the Brown Tide, such as viruses and dimethyl sulfide/ acrylic acid production, should be researched. 5. Restoration and monitoring should occur for Brown Tide-impacted natural resources; potential priority targets are scallops and eelgrass.
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II. OTHER ENVIRONMENTAL CONCERNS		
1. MARINE SURFACE WATER QUALITY	1. Based on analysis of Flanders Bay data which relates total nitrogen (TN) concentrations to chlorophyll-a and chlorophyll-a to diurnal dissolved oxygen (D.O.) variations, a surface water total nitrogen concentration limit of 0.5 mg/l will ensure a minimum dissolved oxygen of 5.0 mg/l. 2. Portions of the western Peconic system contravene the TN guideline (typical TN levels as high as 0.8 mg/l), and occasionally experience depressed D.O., but apparently not exhibit advanced eutrophication in terms of conventional nutrients. The system may be near the limits of the factor of safety incorporated in the TN guideline. 3. Water quality in the eastern Peconics is excellent with respect to nitrogen concentration. 4. Data indicate that nitrogen concentrations in Flanders Bay have not changed significantly between 1976 and 1988. Prior to 1976, numerous industries (extensive duck farms, milling, fish processing, iron forge, etc.) probably contributed to degraded conditions as compared with 1976.	1. The general L.I. 208 Study marine surface water quality nitrogen guideline of 0.4 mg/l should be modified to 0.5 mg/l total nitrogen for Flanders Bay and the tidal portions of the Peconic River. 2. All new or incremental nitrogen loading should be prohibited if it discharges to surface waters, or results in substantial groundwater degradation, in the environmentally stressed region of the tidal Peconic River and western Flanders Bay. 3. As a long range goal, pollution abatement should occur so that the nitrogen guideline can be attained in the tidal portions of the Peconic River and Flanders Bay. 4. Pollution to the eastern portions of the Peconic Estuary system should be controlled so that existing water quality in the bays east of Flanders Bay is maintained. In small embayments, pollution sources require evaluation to assess localized impacts and potential remediation. 5. Surface water modelling and monitoring should continue.

BTCAMP TABLE 3 - SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS (cont.)

TOPIC	FINDINGS / CONCLUSIONS	RECOMMENDATIONS
2. MAJOR POINT SOURCES		
A. Sewage Treatment Plants ("STP's")	1. Because of the quantity and location of its discharge at the poorly-flushed mouth of the Peconic River, the Riverhead sewage treatment plant (0.7 mgd, 140 pounds per day total nitrogen discharge, of which 7 pounds per day are attributable to the scavenger waste facility) is by far the most significant sewage treatment plant in terms of nitrogen loading. 2. Improvements in wastewater treatment and disposal at the Riverhead STP would result in a reduction of summertime surface water total nitrogen concentrations to near the 0.5 mg/l guideline in the western Peconic system. 3. Elimination of the Riverhead STP surface water coliform loading could move the open shellfish area boundary on the order of an additional 1 km westward. 4. Previous efforts at sampling and modelling impacts of the Grumman and Brookhaven National Laboratory STP's have been limited. However, both of these facilities are environmental concerns because they discharge directly into the environmentally sensitive Peconic River. 5. Other STP's discharging to surface waters are not a threat to system-wide water quality because of their remote locations with respect to the western Peconics and their low nitrogen loading rates. However, localized impacts (e.g., Sag Harbor) may require further investigation.	1. In relation to sewage treatment plant expansion, no net increase in quantities of nitrogen discharged to surface waters should be allowed from Grumman, Brookhaven National Lab, and Riverhead STP's. 2. Pollution from other sewage treatment plants in the study area should be controlled such that existing water quality in the surface waters east of Flanders Bay is maintained. 3. As a long-range management goal, the Riverhead STP should be upgraded so that the surface water quality nitrogen guideline can be attained. 4. The long-range Riverhead STP upgrade may be in the form of a groundwater discharge (10 mg/l total N), a relocated surface water discharge at central or eastern Flanders Bay (approx. 23 mg/l total N), or a surface water discharge at the existing location (4 mg/l total N); environmental impacts of alternatives would require assessment before selection. From BTCAMP's pollution control and natural resources perspective, groundwater recharge is the most desirable alternative. 5. SPDES permits should be modified to require monthly reporting of effluent nitrogen concentrations for Peconic River-discharging STP's and quarterly reporting for all other surface water-discharging STP's.
B. Peconic River	1. Water quality in the Peconic River is excellent with respect to nitrogen concentration (approximately 0.5 mg/l at USGS gauge upstream of Riverhead STP). 2. Despite excellent water quality, as a result of its high flow, the Peconic River contributes substantial nitrogen (avg.of 130 pounds per day, range of 20 to 500 pounds per day) to an environmentally stressed area. 3. The high degree of open space in the Peconic River watershed (26% of 15,900 acres in 1989) has spared the river from excessive pollution in recent years; the area's land use did not change drastically between 1976 and 1988. 4. Substantial potential exists for future development in the Peconic River area (34% of acreage developable in 1989). 5. Mathematical modelling and sampling have established that increased development intensity adversely impacts groundwater quality. L.I. 208 Study modelling indicates that slight changes in groundwater quality have significant impacts on Peconic River nitrogen concentrations; as per current modeling, Flanders Bay nitrogen concentrations are very sensitive to Peconic River loadings. 6. The relationship between land use and surface water quality, coupled with the amount of developable land in the study area, highlights the need for stringent development controls to prevent degradation of Peconic River and Flanders Bay. An additional benefit of land use controls would be the added protection of invaluable natural resources of the study area.	1. Throughout the entire Peconic River groundwater-contributing area, new or incremental nitrogen loading should be prohibited if it discharges to surface waters or results in substantial groundwater degradation. 2. New groundwater-discharging sewage treatment plants in the Peconic River area generally should be avoided. New groundwater-discharging plants should be considered only if best available denitrification technology is used; the proposed project is associated with significant groundwater, natural resources, and/or surface water quality benefits; and additional analysis shows that impacts on the Peconic River system will be negligible. 3. Developable residential land in the Peconic River groundwater-contributing area should be upzoned to a minimum of two acres per unit. Additional natural resource protection could be attained by even more stringent land use controls, such as three to five acre zoning. 4. Commercial, industrial, and institutional land uses should be controlled so that the impact on groundwater with respect to nitrogen contribution is comparable to that of two-acre residential zoning. 5. Zoning controls should be implemented in conjunction with other land use management techniques, including cluster development, transfer of development rights, and programs related to land preservation, acquisition, and enhancement. 6. In addition to the land use controls noted above,

BTCAMP TABLE 3 - SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS (cont.)

TOPIC	FINDINGS / CONCLUSIONS	RECOMMENDATIONS
2. MAJOR POINT SOURCES (cont.)		
B. Peconic River (cont.)		Peconic River development plans should be reviewed utilizing the strictest practicable standards, which would include the requiring of open space dedications, maximum practicable setbacks from the river, and natural landscaping to minimize fertilizer use.
C. Meetinghouse Creek	1. The elimination of Corwin Duck Farm's direct discharge to Meetinghouse Creek substantially improved water quality in the creek with respect to nutrients such as nitrogen, but nitrogen (15 mg/l as compared with less than 2 mg/l in other local creeks) and coliform concentrations in the creek remain elevated. 2. Current total nitrogen loading from Meetinghouse Creek is approximately 360 pounds per day. 3. Substantial reduction of Meetinghouse Creek nitrogen contribution (15 to 2 mg/l total N) would result in only moderate improvements in system-wide water quality (due to the creek's location in a better-flushed area, only about 0.05 mg/l total nitrogen reduction as compared with 0.2 mg/l improvement associated with Riverhead STP upgrading). 4. Meetinghouse Creek improvements would have more system-wide significance if they were effected in concert with other pollution abatement efforts. 5. Improvements in Meetinghouse Creek coliform concentrations would result in only localized benefits.	1. Monitoring and remedial investigation of pollution at Meetinghouse Creek should be continued and remediation should be effected when technologically, economically, and environmentally feasible. 2. The evaluation of the effectiveness of on-site duck waste containment and treatment processes at the Corwin Duck Farm should be continued. 3. Sediment flux study should be conducted in Meetinghouse Creek to quantify actual impacts of sediment flux on water quality and to evaluate effectiveness of potential remedial measures.
3. MAJOR NON-POINT SOURCES		
A. Sediment Flux (i.e., chemical exchange between sediment and water column)	1. Summertime sediment flux nitrogen contribution, estimated to be 2,400 pounds per day, is greater than all other sources of nitrogen contribution combined. 2. Changes in point source loading resulting from the implementation of management alternatives would eventually change the sediment flux rate, potentially resulting in significant water quality improvements. 3. More monitoring and study is needed to better characterize the dynamics of the relationship between pollution contribution and sediment flux.	1. Sediment flux sampling should be continued and expanded. 2. The dynamics of the relationship between pollution contribution and sediment flux should be studied so that ultimate short and long-term benefits associated with pollution abatement could be better documented. 3. The computer model of the estuarine system should be upgraded to include an improved sediment submodel.
B. Stormwater Runoff	1. Stormwater runoff, which contributes approx. 30 pounds per day of nitrogen, does not appear to be a significant input with respect to nutrient loading. 2. As of 1990, 3,053 acres of shellfish beds are closed in the Peconic system; these areas are generally situated in semi-enclosed embayments and near shore locations or are located adjacent to STP discharges. 3. Stormwater runoff is the largest and most significant	1. On a system-wide basis, any action which would result in a substantial increase in stormwater runoff coliform loading to the Peconic Estuary system should be strictly prohibited. 2. Stormwater runoff remediation efforts should be undertaken on a site-specific basis pursuant to localized studies which demonstrate technological, economic, and environmental feasibility.

BTCAMP TABLE 3 - SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS (cont.)

TOPIC	FINDINGS / CONCLUSIONS	RECOMMENDATIONS
3. MAJOR NON-POINT SOURCES (cont.)		
B. Stormwater Runoff (cont.)	source of total and fecal coliform loading to the Peconic River and Flanders Bay. Other localized sources may include wildlife waste and sanitary systems. 4. Based on pollutant loading analysis and land use data, stormwater runoff coliform loading is correlated with land use intensity, with the North and South Flanders Bay areas, due to substantial residential acreage, each contributing a much greater coliform load than the less intensively developed Peconic River watershed 5. Modelling indicates that the benefits from decreased stormwater runoff coliform loading do not justify the costs of system-wide remediation. However, localized benefits might be realized from site-specific remediation.	3. Proposals for new development within the stormwater runoff-contributing area to the Peconic Estuary system should be reviewed under the strictest scrutiny. In addition to on-site stormwater runoff containment requirements, vegetative buffers and sediment and erosion control plans should be considered as part of the approval process, with enforcement through the issuance and revocation of permits. 4. With respect to sources such as domestic animal waste and fertilizers, best management practices and public awareness should be promoted.
C. Groundwater Underflow	1. North Flanders Bay, North Fork and eastern Peconic River regions have groundwater nitrogen concentrations which are substantially elevated (5 to 7 mg/l). 2. Western and central Peconic River, with their vast expanses of open space, have relatively low total nitrogen concentrations (1 to 1.5 mg/l) indicating excellent groundwater quality. 3. Pesticide contamination of private water supply wells is common in the eastern Peconic River, North Flanders Bay and North Fork regions (6.4 to 14.4 ppb avg.), where agricultural chemical usage was historically prevalent. Detectable pesticide levels in East Creek (up to 8 ppb) indicate that pesticide contamination has, to some degree, reached surface waters of the study areas. 4. The intensity of land usage in given areas is directly related to nitrogen loading and groundwater quality degradation. Both residential and agricultural land uses are responsible for substantial nitrogen loading in the Peconic River and Flanders Bay regions; medium-density residential and agricultural land uses have similar nitrogen loading rates. 5. The apparent significance of groundwater nitrogen contribution (approx. 580 pounds per day east of USGS gauge) is tempered by surface water quality data, computer modelling, and groundwater infiltration sampling which indicate that groundwater nitrogen contribution is not having a significant impact on study area surface waters. 6. Although mitigation of existing groundwater conditions does not appear to be a priority with respect to surface water quality improvement, the prevention of substantial future degradation to existing groundwater quality is an important goal, especially in the Peconic River area.	1. Substantial degradation of existing groundwater quality should be prevented, especially in the Peconic River area (see II.2.B., "Peconic River"). 2. Groundwater monitoring programs and the study of surface water impacts of groundwater should be continued, especially with respect to areas with known contamination (see II.4.A., "Landfills," and II.4.B., "Hazardous Materials"); estimation of groundwater inflow and its pollutant contribution to surface waters should be performed for the areas east of Flanders Bay and further refined in the western study area. Pesticide contamination related to agricultural practices is an area of special concern which warrants further monitoring and evaluation. 3. Best management practices, such as low-maintenance lawns, slow-release nitrogen fertilizers, modification of fertilizer application rates, and sanitary system maintenance should be promoted through public education. 4. Additional controls, such as fertilizer use restrictions, should be promoted in the Peconic River watershed.
4. OTHER SOURCES OF POLLUTION		
A. Landfills	1. The plume of contaminants which emanates from the North Sea landfill reportedly includes ammonia, iron, manganese, volatile organic compounds, lead, and	1. Investigations, remedial actions, and monitoring at the North Sea Landfill should be conducted with full consideration of surface water impacts.

BTCAMP TABLE 3 - SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS (cont.)

TOPIC	FINDINGS / CONCLUSIONS	RECOMMENDATIONS
4. OTHER SOURCES OF POLLUTION (cont.)		
A. Landfills (cont.)	cadmium. 2. With the exception of Shelter Island, the other eight landfills in the study area are classified as potential environmental hazards.	2. Monitoring of the surface waters and sediments of Fish Cove should be continued. 3. Monitoring of other landfills in the study area should consider potential surface water impacts.
B. Hazardous Materials	1. Activities at Brookhaven National Lab and Grumman have resulted in groundwater contamination and subsequent remediation efforts. 2. Surface water impacts from existing industrial discharges have not been documented. 3. The inactive Rowe Industries facility is the source of a significant plume of organic chemical contamination which has reached its discharge boundary at Sag Harbor Cove, with unknown impacts. 4. There are no reports of surface water impacts resulting from accidental spills and leaks in the study area. 5. Household hazardous materials are a potential and largely undocumented source of pollution.	1. Groundwater monitoring programs at Rowe Industries, Brookhaven National Laboratory, Grumman, and other sites of present and historical discharges should be continued. In general, the relatively small store of data regarding hazardous materials impacts on surface waters should be expanded. 2. Where appropriate, monitoring and remedial investigations of hazardous material-contaminated sites should incorporate surface water and sediment monitoring with full consideration of surface water impacts incorporated in management decisions. 3. "Stop Throwing Out Pollutants" programs should be continued and enhanced to foster public education and reduce household hazardous material pollution.
C. Marinas and Boating	1. Sanitary waste discharges from boating activities are site-specific and not well documented, but are suspected of contributing to surface water coliform loading, especially in environmentally sensitive waterways with poor flushing. 2. The implementation of the Suffolk County law (Res. 946-88) to investigate potential nuisances at marinas would be a useful first step in addressing the need to better understand and manage the contribution of marinas and boating to surface water pollution. 3. Oil and gasoline, marine paints, and debris are marine pollution sources which may warrant future evaluation.	1. The Suffolk County law mandating the investigation of potential nuisances at marinas should be implemented. 2. Greater use of shore-based toilets, holding tanks on boats, and existing and additional pump-out stations should be promoted, especially in areas with heavy boat traffic or in environmentally sensitive areas. 3. Implementation of other measures, such as designation of "no discharge zones" and enforcement for non-compliance with discharge regulations, may also increase usage of pump-out facilities and should be considered, especially in environmentally sensitive areas. 4. Marina projects should be scrutinized under the most environmentally sensitive standards of review. 5. Public education should be an integral component of boater-related surface water protection programs. 6. The impacts of oil and gasoline, marine paints, and floatables and other debris should be investigated.
D. Atmospheric Deposition	1. Atmospheric deposition of nitrogen to surface water systems is approximately 160 pounds per day (wetfall and dry deposition); this estimate is approximately 5% of the system's overall (summertime) non-point source loading. 2. Modelling indicates that changes in regional air quality would have limited impact on the system's marine waters. 3. Although acid rain is not a primary concern with respect to direct impact on marine surface water pH due to the	1. Monitoring of the direct and indirect impacts of acid rain on the surface waters of the study area should be conducted and studied, where appropriate.

BTCAMP TABLE 3 - SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS (cont.)

TOPIC	FINDINGS / CONCLUSIONS	RECOMMENDATIONS
4. OTHER SOURCES OF POLLUTION (cont.)		
D. Atmospheric Deposition (cont.)	buffering capacity of the marine system, acid rain may directly impact the fresh waters in the study area and may indirectly impact marine waters by affecting the solubility/transport of material through sediments.	
5. NATURAL RESOURCES	1. The ecological significance of the Peconic Estuary is manifested in its rare ecosystems, nationally and locally threatened and endangered species, species diversity, and extensive wetlands and wildlife habitats. 2. Natural resources may be impacted by water quality management decisions. 3. From a natural resources persepective, management information for the Peconic Estuary appears to be relatively limited.	1. All water quality management decisions should be accompanied by the maximum practicable level of protection and enhancement of natural resources. 2. A comprehensive, Peconic Estuary-specific natural resources inventory/management plan should be pursued.
6. IMPLEMENTATION	1. The implementation of BTCAMP recommendations would best proceed as a cooperative effort between all levels of government with the support and guidance of the private citizenry. 2. The implementation program would be most effective with mechanisms to re-convene the BTCAMP Management Committee to periodically assess the progress of implementation of BTCAMP recommendations, to address potential future environmental concerns, and to identify funding sources for additional monitoring, research, and remediation.	1. Implementation of regulatory and/or remediation recommendations should be conducted by parties that have current responsibilities and should be enacted/enforced by the agencies with current jurisdiction over the subject matter of given recommendations. For example, the STP recommendations should be enforced by NYSDEC and SCDHS through the SPDES permit process, with STP owners responsible for compliance. Meetinghouse Creek pollution should be addressed by NYSDEC and the Corwin Duck Farm with the assistance and guidance of SCDHS and the Soil Conservation Service (SCS). Land use regulations fall within the province of the Towns' regulatory authority, and stormwater runoff should be addressed at the appropriate governmental level. 2. To ensure consistency with this study's recommendations, all local regulations, plans, policies, and practices should be reviewed and, where necessary, amended. 3. In the case of non-regulatory issues, implementation should be conducted by organizations which are qualified in given areas of concern. Funding for research should be provided by all levels of government, and public education should be continued by the Citizens' Advisory Committee (a.k.a. "Save the Bays") and groups such as the Cornell Cooperative Extension. Future Brown Tide Management Committee meetings should be held periodically to assess the progress of implementation, address potential future environmental problems, and identify and pursue funding sources for further monitoring, study, remediation, etc. 4. Monitoring of groundwater and surface waters should be continued by SCDHS with respect to BTCAMP-type monitoring and NYSDEC and USEPA, where appropriate (e.g., shellfish program and finfish, superfund sites, etc.). Local investigations and pilot remediation projects should be cooperative intergovernmental efforts.

Table 4
BTCAMP - Proposed Peconic Estuary System Research and Investigation Projects

The following outline is a summary of the additional major research and investigation projects recommended by the draft Brown Tide Comprehensive Assessment and Management Program report. $100,000 of Suffolk County capital funds have recently been appropriated for Brown Tide-related research.

BROWN TIDE
* ONSET AND PERSISTENCE
  - -Chemicals such as specific organic nutrients, chelators (e.g., citric acid), and trace metals (e.g., iron, selenium, vanadate, arsenate and boron).
  - -Physical factors such as meteorological and climatological patterns.
  - -Research concerning the organism's physiology.
  - -Greater emphasis on field studies.
* IMPACTS ON SHELLFISH
  - -Toxic impacts (e.g, potential toxicity of acrylic acid and dimethyl sulfide, which may be produced by the Brown Tide, to shellfish larvae).
  - -Mechanical inhibition of scallop growth and reproduction (e.g., poor retention of small particles by shellfish feeding apparatus, structural features of Aureococcus which impair digestion by filter feeders).
  - -Nutritive quality of Aureococcus to shellfish.
* CONTROL AND SUBSIDENCE
  - -Investigation of zooplankton which would graze on and limit the Brown Tide (e.g., impacts of dimethyl sulfide and acrylic acid produced by the Brown Tide on the viability of a zooplankton population).
  - -Role of viruses in the subsidence of the Brown Tide.

SEDIMENT FLUX
- -Continuation and expansion of sampling.
- -Study of dynamics of the relationship between pollution contribution and sediment flux.
- -Improvement of computer model of the estuarine system to include a sediment submodel which predicts benthic fluxes as a function of sedimentary particulate organic matter decay along with the mass transport and kinetics of dissolved nutrients.

NATURAL RESOURCES
- -Surveys of shellfish and finfish resources.
- -Restoration and monitoring of Brown Tide-impacted natural resources (e.g., eelgrass and scallops).
- -Preparation of a Peconic Estuary-specific natural resources inventory and management plan.

STORMWATER RUNOFF
- -Investigation of the efficacy of localized stormwater runoff control measures.
- -Refinement of assessments of stormwater runoff pollution contribution and impacts on surface waters, especially in areas east of Flanders Bay.

GROUNDWATER INFLOW
- -Site-specific investigation of surface water impacts of groundwater inflow, especially in areas with known contamination such as the North Sea Landfill, the Rowe Industries site, Brookhaven National Laboratory, and East Creek.
- -Continuation of monitoring programs.
- -Refinement of assessments of groundwater inflow and impacts on surface waters, especially in areas east of Flanders Bay.
- -Study of the extent and potential impacts of hazardous materials.

SURFACE WATER QUALITY
- -Continuation of water quality monitoring.
- -Further refinement of nitrogen guideline.