# CAPE COD POND AND LAKE ATLAS

*FINAL REPORT*
*MAY 2003*



Cape Cod P.A.L.S.
Pond and Lake Stewards

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# Cape Cod Pond and Lake Atlas

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# EXECUTIVE SUMMARY

Cape Cod is blessed with abundant waters, both fresh and salt. During the past ten years, significant strides have been made to assess the water quality status and impacts on coastal estuary waters, but a comparable effort had not been initiated to assess pond and lake water quality. In 1999, the Cape Cod Commission, in coordination with a number of other organizations, set a goal of developing a network of citizens and organizations concerned with the quality of Cape Cod ponds. A limited number of ponds had been studied extensively in the 1980's and regional sampling of ponds had been done a couple of times, but these regional assessments had generally focussed on the larger ponds and had not provided a comprehensive picture of pond water quality on Cape Cod. With funding from the state Executive Office of Environmental Affairs, the cooperation and free laboratory services provided by the School of Marine Science and Technology (SMAST) at UMASS-Dartmouth, subsequent funding from the Community Foundation of Cape Cod, and the grass-roots enthusiasm of volunteer water quality samplers and other concerned citizens, the Cape Cod Pond and Lake Stewardship (PALS) program was initiated and nurtured to achieve the goal of better understanding the status of Cape Cod ponds.

This Pond and Lake Atlas is a status report on the PALS program. It documents the outreach and education activities leading to the creation of the PALS program, reviews water quality data collected by volunteers during the 2001 PALS Snapshot from over 190 ponds, uses this data to develop Cape Cod-specific indicators of pond impacts, reviews data collected in previous studies, and details further efforts necessary to move pond protection and remediation forward on the Cape.

Cape Cod has nearly 994 ponds covering nearly 11,000 acres. These ponds range in size from less than an acre to 735 acres; with the 21 biggest ponds having nearly half of the total Cape-wide pond acreage. Approximately 40% of the ponds are less than an acre. Prior to the creation of this Pond Atlas, a complete count of all the ponds on Cape Cod had not been accomplished. Of the 994 ponds, only 176 have maximum depth measurements and only 89 have bathymetric information, which is important for understanding water quality information.

As part of the overall PALS program, SMAST provided laboratory services at no cost to towns or volunteers for the 2001 PALS Snapshot of pond water quality. Volunteers collected dissolved oxygen and temperature profiles, clarity readings, and 421 water quality samples from 195 ponds between August 15 and September 30. Samples were analyzed for chlorophyll *a*, alkalinity, pH, total nitrogen, and total phosphorus. This information is the most comprehensive dataset on Cape Cod ponds.

This dataset was used to provide a general assessment of pond water quality on Cape Cod. The authors reviewed existing tools for evaluating pond ecosystem nutrient levels, including Carlson's Trophic Status Index and USEPA's ecoregion nutrient thresholds, and applied USEPA's nutrient threshold calculation methodology to develop Cape Cod-specific nutrient thresholds. These tools were used to look at the general status of ponds on town by town basis and select number of individual ponds.

The review of current USEPA nutrient thresholds and Cape Cod nutrient thresholds suggest that the water quality in Cape Cod ponds is significantly impacted by surrounding development. Review of 2001 dissolved oxygen concentrations and comparison of 1948 and 2001 dissolved oxygen concentrations suggest that many of these pond ecosystems are not only impacted, but also seriously impaired. Based on information in this Atlas, between 74 and 93% of the Cape's ponds are impacted by surrounding development or uses. Based largely on

dissolved oxygen information, approximately 45% of all the ponds and 89% of the deepest ponds are impaired.

Although these measures indicate significant ecological problems, most of the ponds still provide the majority of uses that most Cape Codders desire. Bacterial testing of ponds show that these ponds generally provide healthy conditions for swimming. Fishing and boating are still popular and recent property values and sales show that demand for pondfront properties is only increasing.

But even some these uses are impacted by ecological problems. Occasional large fish kills or algal blooms are due to excessive nutrients. Regular stocking of deep ponds sustains trout fisheries, but trout generally do not have adequate habitats to make it through a summer due to lack of oxygen cold waters of deeper ponds. More nutrients generally favor bass fishing, but half of the eighteen pond tested for mercury now have health warnings about consumption of fish tissue.

Because the appearance of these ponds is shaped by what the users observe from the surface, actions to correct these ecological impairments will depend on community and state priorities. Active discussion of ecological management strategies for these ponds may lead to refinement of pond users' expectations for habitat and recreation.

The PALS Program offers the opportunity to concerned citizens (Pond and Lake Stewards (PALS)) to gather meaningful ecological and use information that can later be used to influence future funding priorities and provide data to scientists that can be used in later assessments of remedial water quality options. The PALS Program currently has a number of monitoring components (Snapshots and more frequent town programs) that are developing information that will be useful for better understanding the regional status, as well as the status of individual ponds. The networking components of the PALS program encourage the sharing of experiences among all PALS.

In order to encourage and sustain the nascent network of PALS on Cape Cod the following are recommended as future steps:

1. Continue the PALS Snapshots of pond water quality
2. Recruit volunteer coordinators, volunteers, and other PALS in each town
3. Encourage towns to acquire necessary sampling equipment
4. Encourage towns to initiate summer pond sampling programs
5. Provide sufficient personnel to train volunteer monitors, develop monitoring locations, provide regular feedback to volunteers to ensure protocols are followed during sampling season
6. Provide qualified personnel to review and analyze sampling data
7. Provide adequate funding to have annual or semi-annual PALS gatherings for outreach, education, and technical transfer
8. Provide adequate long-term funding to remediate impairments
9. Ensure that pond water quality is thoroughly considered in town comprehensive wastewater assessments

# Table of Contents

Cape Cod Pond and Lake Atlas
May, 2003



<u>Town by Town Atlas Sections</u>

# Individual Ponds in Town by Town Atlas Sections

| Barnstable | Map | WQ Review |
|---|---|---|
| Bearse | X | X |
| Eagle | X | X |
| Garretts | X | X |
| Hamblin | X | X |
| Hathaway | X | X |
| Israel | X | |
| Joshuas | X | X |
| Long (MM) | X | X |
| Long (C'ville) | X | X |
| Lovells | X | X |
| Mary Dunn | X | |
| Micah | X | X |
| Middle | X | X |
| Muddy | X | |
| Red Lilly | X | |
| Shallow | X | |
| Shuabel | X | X |
| Wequaquet | X | X |
| **Bourne** | | |
| Flax | X | X |
| Queen Sewell | X | |
| **Brewster** | | |
| Blueberry | X | X |
| Canoe | X | X |
| Cliff | X | X |
| Elbow | X | X |
| Flax | X | X |
| Higgins | X | X |
| Little Cliff | X | X |
| Long | X | X |
| Lower Mill | X | X |
| Rafe | X | |
| Seymour | X | X |
| Sheep | X | X |
| Smalls | X | |
| Upper Mill | X | |
| Walkers | X | |

| Chatham | Map | WQ Review |
|---|---|---|
| Black - East | X | X |
| Emery | X | X |
| Goose | X | X |
| Lovers | X | X |
| Mill | X | X |
| Ryders | X | |
| Schoolhouse | X | X |
| Stillwater | X | X |
| White | X | X |
| **Dennis** | | |
| Fresh | X | X |
| Scargo | X | X |
| **Eastham** | | |
| Great | X | X |
| Herring | X | X |
| **Falmouth** | | |
| Ashumet | X | |
| Coonamessett | X | |
| Crooked | X | |
| Deep | X | X |
| Fresh | X | |
| Grews | X | |
| Jenkins | X | |
| Mares | X | |
| Round | X | |
| Round(2) | X | |
| **Harwich** | | |
| Hinckleys | X | X |
| John Joseph | X | X |
| Sand | X | |
| Skinequit | X | X |
| West Reservoir | X | |

| Mashpee | Map | WQ Review |
|---|---|---|
| Johns | X | X |
| Mashpee Wakeby | X | X |
| Santuit | X | X |
| **Orleans** | | |
| Baker | X | X |
| Crystal | X | X |
| Pilgrim | X | X |
| **Provincetown** | | |
| Clapps | X | X |
| **Sandwich** | | |
| Hoxie | X | |
| Lawrence | X | |
| Peters | X | X |
| Pimlico | X | X |
| Shawme | X | |
| Snake | X | X |
| Spectacle | X | |
| **Truro** | | |
| Great | X | X |
| Round (East) | X | X |
| Round (West) | X | X |
| Ryder | X | X |
| Slough | X | X |
| **Wellfleet** | | |
| Duck | X | X |
| Dyer | X | |
| Gull | X | X |
| Kinnacum | X | X |
| Long | X | X |
| **Yarmouth** | | |
| Dennis | X | X |
| Long | X | X |

# List of Figures and Tables

Cape Cod Pond and Lake Atlas
May, 2003

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# I. INTRODUCTION

Cape Cod is a land of water. If one were to fly over Cape Cod on a sunny spring day, nearly a 1,000 surface water bodies would reflect back, like black diamonds in the land surface. These water bodies, many of which disappear as water levels drop throughout the summer, cover nearly 11,000 acres of Cape Cod.

Generally, these lakes and ponds are depressions left in the land surface after the glaciers that formed Cape Cod about 12,000 years ago retreated to the north. The glaciers left large chunks of ice that were surrounded and covered by the sands carried by the glacial meltwater as it flowed to the south. As these chunks of ice melted, the landscape above them collapsed forming large depressions called "kettle holes". As precipitation fell and the Cape's aquifer system developed, the water table eventually rose to fill these kettle hole depressions and create the hundreds of ponds we see on Cape Cod today.

Typical kettle hole ponds or lakes lack streams flowing into or out of them. Instead, the sandy sides of these ponds allow a steady inflow and outflow of groundwater to and from the adjacent aquifer. The pond surfaces generally fluctuate up and down in response to the seasonal rise and fall of the water table, giving us a "window" into the aquifer.

But there are a wide variety of ponds on the Cape: shallow or deep, with streams or without, surrounded by houses or with a largely pristine shoreline, near the coast or inland at the top of the aquifer. Although some folks would even like to see a better distinction between "ponds" and "lakes", all of these surface water bodies are considered in this Atlas and "lake" and "pond" will be used interchangeably throughout. Most of them share one common feature, however: little was known about their condition and characteristics. This Atlas presents new information, reviews old information, and provides a basis for Cape Cod to move forward with protection and remediation of these resources.

### *A. How ponds function*

Lake and pond ecosystems are controlled by interactions among physical features and internal chemical interactions. Physical features include the surface shape of the lake, surrounding topography, bathymetry, and watershed size. Chemical interactions occur between and among the plants and animals in the lake and the sediments, water, and constituents in the water. Outside factors such as strength and direction of wind, air and water temperature, groundwater and surface water inflows and outflows also play important roles in how a given ecosystem functions.

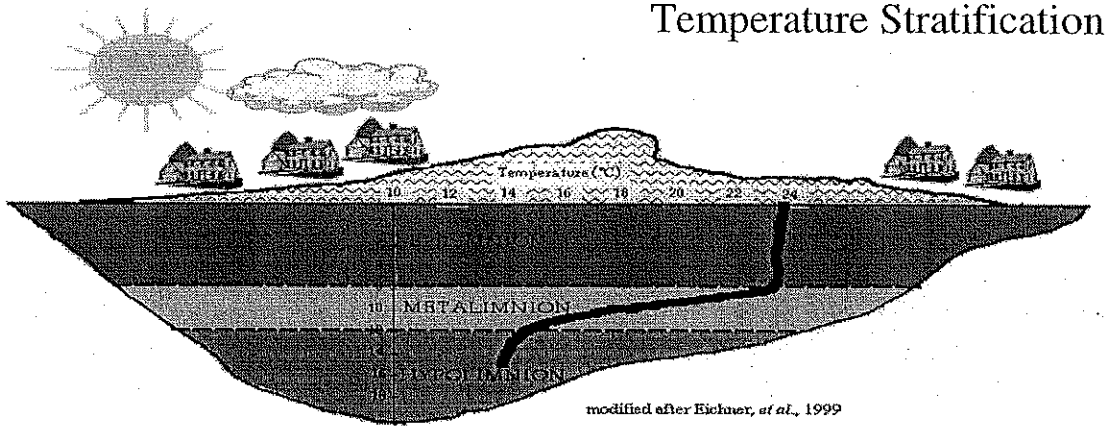
The ecosystems of Cape Cod kettle ponds change throughout the seasons of the year and from year to year depending on all of the factors above, but temperature changes are a key factor for every pond, especially for deeper ponds. Beginning in early spring, air and water temperatures begin to rise as the days become longer. If the winds are strong enough to keep the lake well mixed, the warming of the water is consistent and the same temperature can be measured throughout the water column. But usually, at some point, the warming is too rapid and the winds are not strong enough to maintain mixing, and cooler bottom waters are separated from warmer upper waters. This process is called **stratification** and generally occurs in ponds that are 9 meters or deeper.

The upper, warmer waters continue to warm as the year moves into the summer. This upper layer of water is called the **epilimnion** and can usually reach between 24 and 27°C (75 to 80°F). The cooler, bottom waters generally maintain a temperature close to the overall temperature of the lake just prior to the onset of stratification (usually 10 to 15°C or 50 to 60°F).

This lower layer is called the **hypolimnion**. The transition zone between these two layers, where temperature changes rapidly with changes in depth, is called the metalimnion (**Figure 1**).

Figure 1.

Generalized Pond Temperature Stratification




As temperatures cool in the fall, the stratification begins to weaken because the temperature in the epilimnion begins to drop and the temperature difference between the upper and lower layers becomes smaller. Eventually the normal winds disrupt the stratification and the lake returns to a well mixed water column again.

A variety of species utilize the temperature and water quality differences between the layers during stratification. The cooler waters can hold more **dissolved oxygen**, so fish such as trout, which generally require high oxygen and cooler temperatures, spend more of their time in the hypolimnion. The sediments at the bottom of the hypolimnion are rich in nutrients and usually support catfish and other bottom feeding fish, as well as worms and other creatures living in the sediments. Since rooted aquatic plants and floating algae need light for photosynthesis, they are generally found only in the epilimnion.

In shallower ponds, the total volume of the lake is smaller and less wind energy is necessary to keep the lake well mixed. In these ponds, the water column tends to be well mixed throughout the summer and temperature differences remain small between surface and bottom waters.

Although temperature is a key determinant in the amount of oxygen dissolved in lake water, some lakes will have low oxygen conditions in their deeper, cooler waters. This occurs because there is so much organic material (*e.g.*, dead algae or other plant material) in the sediments of the lake, that the bacteria decomposing or breaking down the material is taking oxygen out of the lake water above the sediments. These bacteria respire just like humans and take in oxygen and produce carbon dioxide. If there are sufficient organic materials in the pond, the bacterial population can create **anoxic** conditions (*i.e.*, usually defined as dissolved oxygen concentrations less than 1 part per million (ppm)). Since fish also need oxygen from the water, anoxic conditions will cause them to swim to areas where oxygen is more plentiful. However, if they are a cool water fish, like trout, their habitat has effectively disappeared. If anoxic conditions occur rapidly, all the fish in that portion of the lake can be killed. Anoxic or low

oxygen (*i.e.*, hypoxic) conditions can occur in any lake, regardless of depth. Shallow lakes can have well mixed conditions, but if the organic load in the sediments is sufficient, oxygen concentrations can be low.

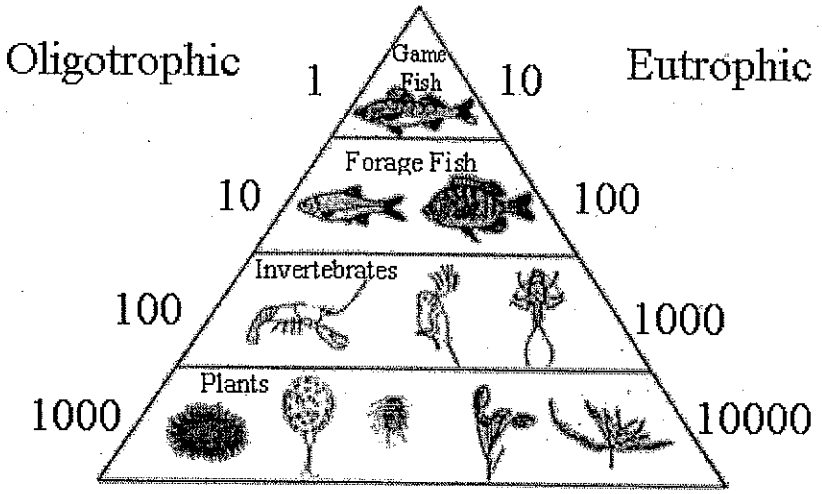
Plants in ponds can be free-floating algae (*i.e.*, phytoplankton) or rooted aquatic plants. As the population of plants grows and dies over a series of years, the leftover plant material or detritus falls to the bottom of ponds and is degraded by bacteria. This material usually gathers in the deepest portions of pond and continues to degrade. The accumulation of this material forms the sediments. In ponds with stream inputs, the streams can also be sources of sediment materials.

When low oxygen conditions occur in sediments, the chemical characteristics of many of the compounds found in the sediments can also be altered. Nutrients, like phosphorus, can be released from the sediments into the water above the sediments. If these nutrients are made available to algae in well lit, upper waters, they can prompt algal blooms.

Sediments in the bottom of Cape Cod ponds are generally the result of plant growth in the pond. Nutrients enter ponds from their watershed; mostly from the properties abutting the pond. Watersheds can be expanded by stormwater structures on nearby roads or parking areas that pipe stormwater runoff and accompanying nutrients into the watershed.

Since available nutrients determine the amount of plant growth in a pond and plants form the base of ecosystems, the amount and types of dominant plants generally determines the total amount of other organisms there will the pond. The total weight or mass of all organisms in a lake is usually characterized as the lake's **trophic status** and is often related to the amount of phosphorus or total amount of a particular plant or animal (Figure 2). Lakes are often grouped into categories based on how much plant growth is occurring. **Oligotrophic** lakes have low nutrient inputs and consequently have relatively little plant growth. **Eutrophic** lakes have higher nutrient inputs and significantly more plant growth. Scientist have attempted to use water quality monitoring information (nutrient concentrations, Secchi disk measurements, etc.) to establish ranges for various measurements that correspond to these trophic categories. Some of these classification schemes have included additional labels, such as **mesotrophic** (*i.e.*, middle trophic, between oligotrophic and eutrophic) or **hypereutrophic** (*i.e.*, more than eutrophic).

Figure 2. Relative Phosphorus Mass at Lake Trophic Levels




Modified after McComas (1993)

Ponds with more nutrients will support more diverse ecosystems, which generally means more variety of plants, fish, and other animals. However, too many nutrients can preclude certain species from growing in their preferred

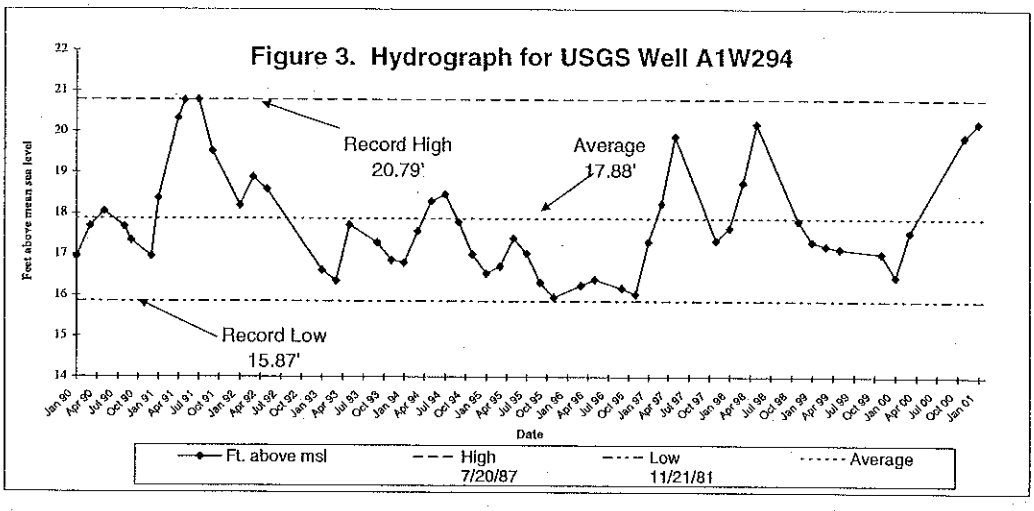
portion of a pond. As mentioned previously, trout prefer colder water that is usually found in the hypolimnion of stratified lakes, but too many nutrients can produce too much decaying plant matter or detritus in the sediments and lead to anoxic conditions. Since trout need oxygen to survive, they cannot live in their preferred, colder portion of the lake. Because of this relationship, more oligotrophic ponds tend to be better fisheries for trout.

Phosphorus is the key nutrient in ponds and lakes because it is usually more limited in freshwater systems than nitrogen. Typical plant organic matter contains phosphorous, nitrogen, and carbon in a ratio of 1 P:7 N:40 C per 500 wet weight (Wetzel, 1983). Therefore, if the other constituents are present in excess, phosphorus, as the limiting nutrient can theoretically produce 500 times its weight in algae. Because it is more limited, 90% or more of the phosphorus occurs in organic forms (plant and animal tissue or plant and animal wastes) and any available inorganic phosphorus (mostly orthophosphate ($PO_4^{-3}$)) is quickly reused by the biota in the lake (Wetzel, 1983). Much research has been directed towards trying to determine the most important phosphorus pool for determining the overall productivity of lake ecosystems, but to date most of the work has found that a measure of total phosphorus is the best predictor of productivity of lake ecosystems (Vollenweider, 1968).

While the pond ecosystems on Cape Cod are similar to pond ecosystems seen in other parts of the country, there are niches within Cape pond ecosystems that are somewhat unique. Two of these niches are the naturally low pH (acidic) condition of Cape Cod's waters and the water table fluctuation zone around Cape Cod ponds. Because the Cape is largely composed of sand carried and deposited here by the glaciers, there are no carbonate-based rocks (*e.g.*, limestone) available to provide carbon to buffer the natural acidity of rainwater. Water in equilibrium with the carbon dioxide in the atmosphere has an acidic pH of 5.65; pH above 7 is basic, below 7 is acidic. As precipitation falls on the Cape, it may pick up some buffering capacity as it moves through the root zone of plants as it recharges the aquifer. Available groundwater data generally shows pH on Cape Cod between 6 and 6.5; Frimpter and Gay (1979) sampled groundwater from 202 wells on Cape Cod and found a median pH of 6.1. The plants and animals in Cape Cod ponds have developed in this low pH, acidic environment.

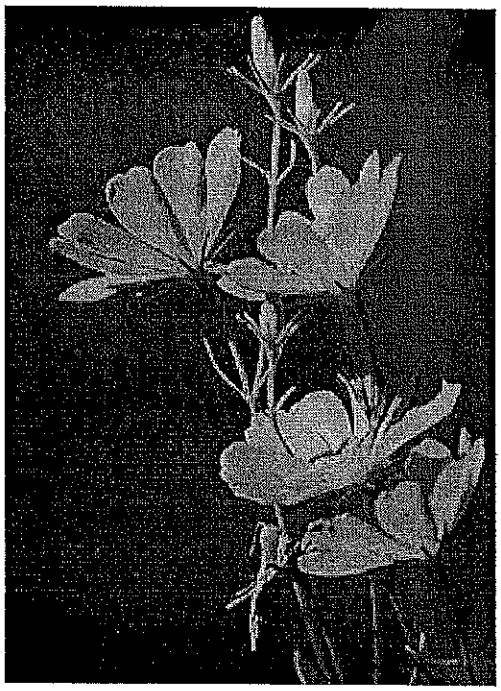
Water level fluctuations have also played a significant role in the pond ecosystems that have developed on Cape Cod. Groundwater levels rise and fall throughout the years, based on seasonal and annual precipitation trends. Water levels can fluctuate up to 6 feet in the interior portions of the Cape (Figure 3), with declining fluctuations closer to the coastline (Frimpter and Belfit, 2001). In the winter and spring, there is little evaporation, plants are dormant, and most of the precipitation reaches the aquifer causing the water table level to rise. From May to November, plants capture most available precipitation and transpire the water back to the atmosphere during photosynthesis. As a result, little precipitation during this period reaches the water table and, consequently, the water levels decline.

In general, water levels in kettle ponds are similar to levels in the surrounding groundwater. Changes in the water table level can be seen directly by looking at a kettle pond. This is most noticeable by looking at the size of the shoreline beaches. The beaches become larger during times of low water and become smaller and sometimes disappear altogether during years with above average precipitation. The size of the beach is also directly related to the nearshore bathymetry (or bottom elevations) of the pond.




The fluctuations of the water levels creates a fairly unique ecological niche and certain plants on the Cape have evolved to take advantage of these cycles. The globally rare Plymouth gentian (Sabatia kennedyana) is a plant that lives within the area of the fluctuating water levels (Figure 4). In ponds where the water level has been low for a period of years, scrub pine and scrub oak trees will invade the area of historic fluctuations, but when the water level comes back up, the inundation kills these invaders and the gentian and other similar species utilizing this area continue to thrive.

Figure 4. – Plymouth Gentian



### *B. How do we use and manage ponds*

Over the years, the ecosystems of many of Cape Cod's ponds have been altered in either planned or unplanned ways by human activities. These alterations have included the enhancement or creation of herring runs, construction of spillways or weirs to try to control water levels, removal of water for cranberry bog irrigation, addition of trout or bass by agencies and/or individuals to create a population for fishing, construction of public water supply wells near ponds that alter how water levels fluctuate, and the increased addition of nutrients from houses and roads built close to ponds. The ecosystems have adapted to these changes, but often pondshore residents and other users of the ponds have not been pleased with the changes.

Over the past few years, more attention has been focussed on pond issues, largely one would assume because more people are living on Cape Cod and, consequently, more demands

are being placed on the pond resources. Local Cape Cod newspapers have described concerns over rising and falling water levels, algal blooms, and fish kills. Public debates about permitting of public drinking water supply and golf course irrigation wells and their impact on nearby pond levels and discussions about conflicts between swimmers and watercraft users have also generated newspaper articles. The public attention has often led to the creation of watershed or pond associations by concerned citizens and subsequent management action by a town agency to resolve the issues of concern.

In order to understand what management options can be used on ponds, some understanding of the legal issues surrounding some of the options is necessary. Ponds of a certain area are "waters of the Commonwealth of Massachusetts" and, therefore, are owned by the public. The area of these "Great Ponds" is either 20 acres or 10 acres depending on which portion of Massachusetts General Law is reviewed (Chapter 131, Section 1 or Chapter 91, Section 35, respectively). In 1933, the legislature designated 164 Great Ponds on Cape Cod. Analysis of 1994 aerial photos reviewed for this Atlas show 165 ponds of 10 acres or more on Cape Cod.

Because these ponds are public resources, substantial activities on, in, or near them, including adopting local bylaws, generally require some sort of public notice and discussion by a government agency, like a local conservation commission or the state Department of Environmental Management. For example, the building of a new permanent dock requires a Chapter 91 license from the local conservation commission, but depending on the impact could also be reviewed by the state Department of Environmental Protection. This need for public participation in the review of changes to the characteristics (*e.g.*, pond levels) or use (*e.g.*, horsepower limitations on watercraft) of ponds generally ensures that decisions regarding ponds are subject to public discussion.

However, much of the public concerns about ponds are the result of decisions that occurred long before the current regulatory system was developed. In the past, road stormwater structures often discharged directly into ponds, septic systems for seasonal homes were built 10 to 20 feet from the pond shoreline to save on excavation costs, and natural pondshore vegetation was destroyed in order to extend lawns or improve access to the pond. Much of the current concerns raised about Cape Cod ponds, especially in the area of water quality, are the result of impacts caused by decisions like these made in the during the past 50 years.

As the study of lakes, the field of limnology, has advanced, science has provided details about the impacts of these decisions and, more importantly, translation of the science into potential activities to repair and prevent impairments of lake ecosystems. Some local bylaws have required naturally vegetated buffers to decrease or eliminate nutrient-laden stormwater or lawn runoff. Alum or other sequestering agents has been added to ponds to cover the sediments and prevent internal regeneration of nutrients from pond sediments. Plant harvesters have been developed to remove excessive growth of aquatic vegetation and the nutrients which could be released from them as they decay. Chemists have developed herbicides that target specific invasive plant species. Some state regulations and laws have required the production of detergents with lowered amounts of phosphorus.

In order to determine which of these activities are most appropriate for a given problem, scientist have to gain a better understanding of a particular lake and the problem. This information is obtained through a refined assessment of the pond. In order to conduct such a study, funds need to be provided to hire someone who is appropriately trained to gather or direct

the gathering of the information to complete the characterization. Since the ponds are public resources, obtaining funding usually has to occur through a town or state agency.

Finding funding for these assessments is usually an obstacle to their completion. Town budgets are usually more constrained than state budgets for obtaining funds for pond assessments. Current state programs providing funding for a lake assessment are: 1) the Department of Environmental Management (DEM) Lake and Ponds Program, 2) the Department of Environmental Protection (DEP) Section 604(b) Water Quality Management Planning Grant Program, 3) the DEP Section 319 Nonpoint Source Competitive Grant Program, and 4) the DEP Section 104(b)(3) Water Quality and Wetland Program. The DEP listed sources are federal funds directed to DEP for administration of the Clean Water Act. Most lake assessments completed on Cape Cod were funded under Section 314 of the Clean Water Act, which currently does not have a budget at the federal level.

Each of the available funding programs has criteria that may limit its potential use for completing lake assessments. Among the criteria that are reviewed for applications under the DEM program are: 1) a maximum of 50% of the total project cost, up to $25,000 will be provided by DEM, 2) public access to the pond must be available to any resident of the Commonwealth, and 3) the body of water must be publicly owned. The DEP 604(b) Program requirements include that proposed projects support current DEP assessment priorities and that the project meets federal affirmative action procurement requirements. The 604(b) program does not require a match and eligible respondents include regional planning agencies, councils of governments, conservation districts, counties, cities and towns, and other substate planning agencies and interstate agencies. The DEP 319 Program focuses on implementation of assessment recommendations, includes a requirement for a 40% non-federal match, and is available to any interested Massachusetts public or private organization. Funding under the 104(b)(3) program is available on a competitive basis to state environmental agencies and requires a non-federal match of 25% of the total project cost. Recent examples of the use of state funding for lake projects on the Cape include: 1) the Management Study of Long Pond, Brewster and Harwich (ENSR, 2001), funded using 604b grant funds through the Cape Cod Commission and 2) the Baker Pond Water Quality Assessment, Orleans (Eichner, *et al.*, 2001), funded using DEM Lake and Pond Program funds.

Lake assessments may be completed to address any number of problems. There are a number of management issues that are somewhat related, but often have their own special concerns. Four of these issues are briefly discussed below.

*1. Land Use*

As the study of lakes and their water quality has advanced, the impact of nearby land uses on pond water quality has been clearly established. Sand has an iron coating that naturally binds phosphorus, so the Cape has a relative advantage for dealing with phosphorus loads coming from septic systems, lawns, and runoff. However, if the phosphorus flows directly into a lake, the filtering capacity of our sands are negated.

Humans annually produce about 2 pounds of phosphorus, which is reduced between 50 and 90% by sand around leachfields of conventional Title 5 septic systems (MEDEP, 1989; McComas, 1993). However, once all the phosphorus binding sites are occupied, the phosphorus can flow with the groundwater and eventually discharge into a pond (Robertson, *et al.*, 1998).

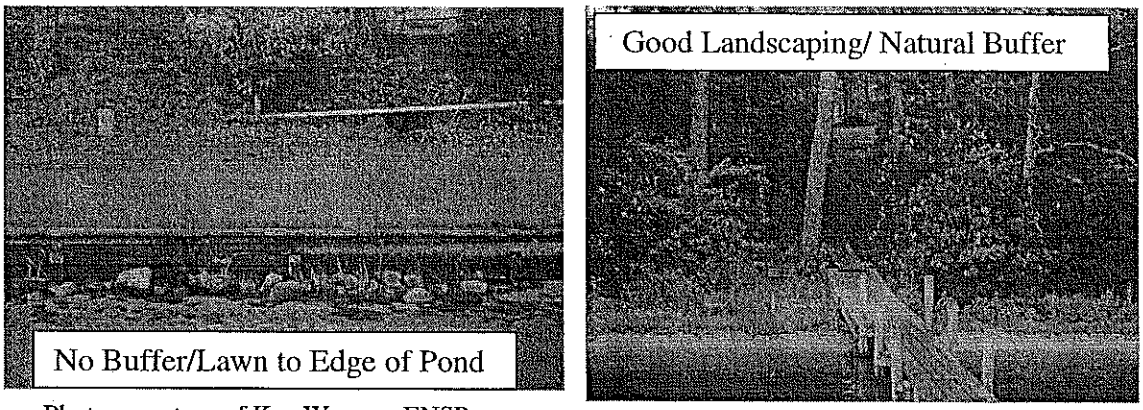
In order to address this, a number of recommendations have been made regarding leachfield setbacks from pond shores to maximize the adsorption of phosphorus and minimize

the amount getting into ponds. Through the Clean Lakes Program, USEPA recommended a 100 meter setback for leachfields. This recommendation has been translated into 300 ft setbacks, which has been incorporated into the county's Regional Policy Plan (CCC, 1991, 1996, 2002) and a number of the town's Local Comprehensive Plans.

Although the circumstances of each lake are different, usually a greater concern for phosphorus entering ponds is lawn fertilizers. Conventional fertilizers contain the nutrients nitrogen, phosphorus, and potassium, the ratio of which is usually shown on the packaging (e.g., 14-3-6, which would be 14 parts nitrogen, 3 parts phosphorus, 6 parts potassium). Using this example ratio, about 0.26 pounds of phosphorus would be applied annually to a 5,000 $ft^2$ lawn. This load is roughly equivalent to the load expected from one septic system. If a higher phosphorus ratio fertilizer is utilized and the load is not utilized by the grass or runs off the lawn in a rainstorm, the load from a lawn can easily surpass the load from a septic system.

In order to address these potential ecological problems, management recommendations for near shore lawns have included avoiding or limiting phosphorus containing fertilizers, designing steeper slopes to encourage runoff infiltration, winding paths to shore, limiting lawn areas, and maintaining natural vegetated buffers between lawn areas and pondshores. Figure 5 shows examples of good and poor shoreline landscaping practices.

Figure 5. Nearshore Landscaping and Buffers




Photos courtesy of Ken Wagner, ENSR

Road runoff is another source of nutrients entering ponds. As mentioned previously, ponds are often a low point in the topography, so past road design included runoff directly into ponds or down steep banks to ponds. Although there are still some problems areas, towns have included better treatment of stormwater as a key design component in parking lot and road design, DEP has adopted a stormwater design policy (DEP, 1997), which includes best management practices, and towns have been encouraging Mass Highway to address runoff to surface waters on state roads.

Together, these land use management practices have led to greater protection of pond water quality. However, altering existing development to address these practices often creates difficulties that are expensive or hard to implement. In addition, historic activities on or near lakes, often with very high nutrient loads (*e.g.*, keeping large numbers of domesticated duck and geese on Hamblin Pond in Barnstable) have often left a legacy of excessive nutrients.

Establishing options to improve or protect water quality is part of pond management plans, which establish usually establish a number of decisions that could be taken in or around a

pond and their associated costs (*e.g.*, ENSR, 2001). Development of these plans allows communities to make reasoned decisions about management of these resources rather than the past practices that did not consider pond water quality in land use decisions.

*2. Fisheries*

Ponds have been actively managed for fisheries far longer than any other pond management concerns. Given that many of the ponds on the Cape have neither a stream inlet or outlet, it is possible that many of these ponds had no fish in them during their early development and only developed fisheries as a result of man's intervention. Common fish currently found in Cape Cod ponds include perch (yellow and white), brown bullhead, pumpkinseed, bass (largemouth and smallmouth), banded killifish, American eel, and alewife.

The Massachusetts Division of Fish and Wildlife in the Department of Fisheries, Wildlife and Environmental Law Enforcement is responsible fish management on Cape Cod, which includes regular stocking and fishing licenses (see www.state.ma.us/dfwele/dfw/dfw_toc.htm). Current efforts in support of sport fishing in freshwater ponds have included stocking of trout and bass.

Of course, focussing on only one aspect of pond management has in the past led to decisions that, in retrospect, do not support good pond ecosystem function. In order to maintain active sport fisheries, past DFW activities have included applying poison (*e.g.*, rotenone and toxaphene) to ponds in concentrations designed kill the entire fish population in order to "reclaim" them for trout fisheries. Hathaway Pond in Barnstable, for example, has been "reclaimed" seven times: 1952, 1956, 1962, 1967, 1969, 1971 and 1973. Other fisheries activities have included applying fertilizer (1956-1957, Edmunds Pond in Bourne) and digging of herring runs (1867, Lake Wequaquet in Barnstable). DFW staff are currently involved in an effort to document the fisheries management history of ponds that are now actively managed. Because of the long history of management of many of the Cape's ponds, individual pond assessments should always include a review of DFW files.

*3. Watersheet Management*

Pond surfaces are used for many activities: fishing, swimming, and a variety of different types of boating. Some of these uses will necessarily conflict with others (*e.g.*, swimmers and boaters). Over a period of time, most lake communities and states have adopted "watersheet" regulations that strive to avoid these conflicts; for example, boaters needing to keep a specified distance from swimmers. Another example of these types of regulations are the horsepower restrictions that many Cape towns on specified ponds. Recent conflicts on the Cape have also arisen over the use of personal watercraft (*i.e.*, jetskis). As the population on the Cape continues to grow, it is likely that additional conflicts will develop over the use of pond surfaces.

## II. Cape Cod Pond and Lake Stewards (PALS)

The Cape Cod Pond and Lake Stewards (PALS) program is working to bring the management and water quality concerns together with pond-specific information and includes: 1) involving motivated citizens in the collection of water quality information and advocacy for the ponds that they care about, 2) government environmental agencies and universities providing technical assistance to correctly collect and interpret the water quality and pond watershed information and consider various pond management scenarios, and 3) non-governmental agencies providing citizens with organizational assistance to form lake associations and other

stewardship entities. The production of this Atlas is a significant milestone in an effort to develop a public stewardship program for the ponds of Cape Cod.

A grant to initiate this program was provided to the Cape Cod Commission by the Massachusetts Executive Office of Environmental Affairs via the Massachusetts Watershed Initiative (MWI). Partners with the Commission in this grant include: the School of Marine Science and Technology at UMASS-Dartmouth, the Compact of Cape Cod Conservation Trusts, the Cape Cod National Seashore, the Association for the Preservation of Cape Cod, the Community Foundation of Cape Cod, the Waquoit Bay National Estuarine Research Reserve, and Cape Cod Community College.

One of the most visible projects under the PALS program have been the "Ponds in Peril" workshops. Three of these workshops, which were held in Dennis (May 2001), Sandwich (November 2001), and Harwich (May 2002), included briefings on pond specific assessments, volunteer pond monitoring, potential funding opportunities, and lake and pond management strategies. Each of the workshops was very well attended and provided opportunities for those concerned about their own pond to learn from experts, share their experiences, and discuss stewardship activities with folks from other ponds. It is hoped that more of these meetings will be possible in the future.

These workshops also served as a touchstone for the recruiting of pond monitors and volunteer coordinators. Enthusiastic volunteers were encouraged to begin collecting Secchi depth information. One hundred Secchi disks were made and distributed by the Cape Cod Commission (Figure 6). Data reporting postcards were distributed with the disks and data was returned to the Commission. Data from this effort was included in the Great North American Secchi Dip-In, which involves over 25,000 volunteers in 41 states and 3 provinces of Canada and is coordinated through Kent State University and the North American Lake Management Society (http://dipin.kent.edu/).

Figure 6. PALS Secchi Disks

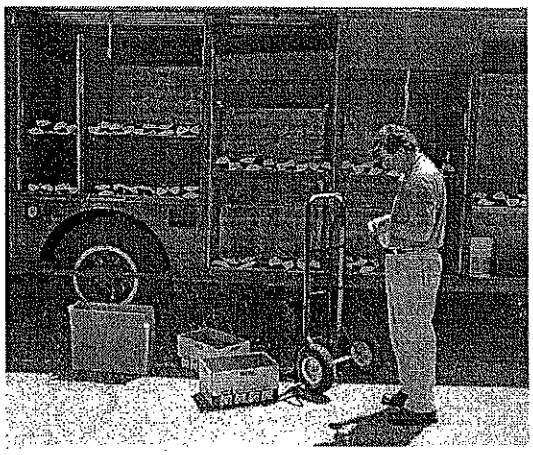


Photo by Ed Eichner, CCC

The combination of the pond meetings and the Secchi measurement activities tapped into citizen concerns about the water quality in their ponds. Through the efforts of state Senator Henri Rauschenbach and the University of Massachusetts - Dartmouth, the PALS program was allowed to channel the citizen enthusiasm into an even more ambitious activity: the 2001 PALS Water Quality Snapshot. The 2001 PALS Snapshot included the sampling of 195 ponds and was coordinated by the Cape Cod Commission and the School of Marine Science and Technology (SMAST) at the University of Massachusetts at Dartmouth. The 2001 PALS Snapshot data are the basis for the regional review of Cape Cod ponds and lakes that is included in this Atlas.

During the development of these efforts, many other Cape Cod pond-related activities, loosely fitting under the PALS umbrella, also spurred further regional and community discussions and activities related to pond management and water quality monitoring. The activities included:

1. The Commission obtained a special grant from the US Environmental Protection Agency to measure mercury concentrations in fish tissue in eight ponds (Michaud, 2001).
2. The Commission provided funding to the Town of Dennis Water Quality Advisory Committee to purchase pond monitoring equipment.
3. Commission staff assisted the Town of Orleans in the completion of monitoring reports for Baker Pond (Eichner, *et al.*, 2001) and Crystal Lake (Orleans Water Quality Task Force, 2001).
4. Under a DEP grant to the Commission, the towns of Brewster and Harwich completed a management plan for Long Pond (ENSR, 2001) to investigate the cost and feasibility of various techniques to improve water quality. An alum treatment was identified as an appropriate activity to reduce in-lake nutrient loads. Subsequently, the 2002 state environmental bond bill passed containing $200,000 to assist the towns in paying for this treatment.
5. The Cape Cod National Seashore Laboratory obtained a grant from the Community Foundation of Cape Cod to provide pond water quality analysis services to Outer Cape towns.
6. The Compact of Cape Cod Conservation Trusts began a project to identify and prioritize parcels around ponds for water quality, wildlife habitat, and recreation purposes.
7. The Cape Cod National Seashore released its Kettle Pond Atlas (Portnoy, *et al.*, 2001a) and accompanying collection of water quality monitoring data from 1975 to 1999 (Portnoy, *et al.*, 2001b).
8. The Community Foundation of Cape Cod creating the Agua Fund program to fund freshwater monitoring activities.
9. An alum treatment to reduce in-lake nutrient loads in Ashumet Pond in Falmouth and Mashpee was successfully completed in September 2001 by the Air Force Center of Environmental Excellence.

All of these activities have brought pond water quality and management issues into sharper focus for Cape Cod. This atlas builds on these activities and provides both a regional and local basis to help understand where Cape communities should prioritize future efforts.

The funding for this Atlas and the projects leading to its production came from a number of sources. As mentioned previously, the initial funding was provided via MWI funds from the MA Executive Office of Environmental Affairs. Subsequent funding was provided by Community Foundation of Cape Cod. The water quality analyses that form the base of the pond reviews in this Atlas could not have been completed without funding from the University of Massachusetts at Dartmouth, School of Marine Science and Technology to provide new water quality information. Aside from providing the funding for this Atlas, these funds and the efforts of all involved have created a better informed citizenry with better opportunities to make more informed decisions about land uses and wastewater treatment that may impact pond water quality.

### *A. Regional Pond Water Quality Analysis*

The 2001 PALS Water Quality Snapshot dataset is the most comprehensive regional water quality assessment of Cape Cod pond water quality ever created. In order to maximize the use of this dataset, additional information about each individual pond also needs to be considered along with the water quality information. This additional information includes: physical

features of the ponds (*e.g.*, size, depth, watershed), historic water quality data, and current and past land use information. Continuation of the PALS program offers the opportunity to address the protection of all Cape Cod ponds by bringing together all the pertinent information for each individual pond.

*1. Past Reviews*

A handful of Cape Cod ponds have been subject to so-called "diagnostic feasibility studies," where water quality data is combined with physical data to review potential options to address water quality problems (*e.g.*, ENSR, 2001; BEC, 1993). However, regional reviews of Cape-wide pond water quality have been even more limited.

During July and August 1948, the state Division of Fisheries and Game (DFG) collected depth, dissolved oxygen, temperature, pH, methyl orange alkalinity, plankton, and transparency data for 51 Cape Cod ponds. The data is presented in DFG (1948), but is not interpreted save for whether "trout water" is available.

During 1969, J.A. McCann completed an inventory of all ponds and lakes in Barnstable County over five acres or identified on US Geological topographic maps. This inventory includes the review of aerial photographs taken during the spring of 1965 and concludes that there are 356 ponds, 206 of which could be classified as Great Ponds (>10 acres). This review includes classification of access, mean and maximum depth, whether the pond was stocked, land use of the shoreline, and a subjective evaluation of use, but does not contain water quality data except for some limited Secchi readings. No interpretation or synthesis of the information is presented.

During the mid-1970's, Environmental Management Institute (EMI, 1976) was hired to complete a special study of the Cape Cod ponds in support of the 208 Wastewater Management Study (CCPEDC, 1978). This study included sampling of 152 ponds from a helicopter between September 2 and September 6, 1975. The report also mentions "winter" sampling January 20 and April 13, 1976, but it is unclear whether this sampling also involved use of a helicopter. Standard sampling procedure for the helicopter sampling included: 1) hovering above the pond and taking a color photograph, 2) landing at a sampling point and collecting a dissolved oxygen and temperature profile to the bottom, and 3) collecting a water sample one foot below the surface. Samples were analyzed for ammonia-nitrogen, nitrate-nitrogen, ortho-phosphorus, sodium, calcium, potassium, iron, manganese, mercury, magnesium, copper, arsenic, selenium, cadmium, chromium, lead, zinc, nickel, chlorophyll a, chloride, pH, conductivity, and alkalinity.

Limited data review is provided in the EMI (1976) report, but the helicopter sampling method calls into question how representative the sampling results are. Based on airflow calculations at www.bellhelicopter.textron.com, a 3,000 pound helicopter with a 33.3 ft rotor (a Bell model 206 helicopter) would force 1,450,000 $ft^3$ of air per minute through the rotor while hovering (Figure 7). Given the density of air, 58.5 tons of air per minute would be forced down onto the lake surface while the helicopter hovered. This mass would displace an equivalent mass of water. In smaller lakes, the displacement could cause significant mixing and introduction of oxygen throughout the volume of water when the sampling would occur. In larger lakes, the displacement would be a smaller percentage of the volume of the lake, but the localized oxygenation might still be a cause for concern since many of the chemicals analyzed from the pond samples are sensitive to changes in oxygen concentrations (*e.g.*, higher oxygen concentrations cause ammonia-nitrogen to be converted to nitrate-nitrogen). It is unclear how much the sampling method might have impacted the water quality results in the 1976 study.

Figure 7. Helicopter Impact on Lake Surface

From: www.bellhelicopter.textron.com,

Ahrens and Siver (2000) collected samples at 1 m depth from 60 ponds three times between October 1996 and July 1998. Secchi disk depths and 1 m increment profiles of specific conductivity were also collected in the field. Water samples were analyzed for pH, alkalinity, total phosphorus, total nitrogen, sulfate ($SO_4^-$), potassium($K^+$), sodium ($Na^+$), calcium ($Ca^{+2}$), magnesium ($Mg^{+2}$), and chlorophyll-*a*. Analysis of the sampling results looks at the ponds Cape-wide and by various portions of the Cape (i.e., "Forearm, Bicep, Elbow, and Provincetown"). This analysis generally focussed on the acidity, ionic balance, and trophic characteristics and found that: 1) the percentage of acidic lakes on Cape Cod was greater than other regions in eastern North America, 2) that sodium and chloride (*i.e.*, the constituents of table salt) were the dominant cation and anion species, and 3) that Forearm (Wellfleet and Truro) lakes were generally the least productive, although differences between the regions were "slight". Ahrens and Siver (2000) concluded the analysis with the following: "The lakes of Cape Cod are rather unique and different from lakes in other regions in the eastern U.S. They are very acidic, poorly buffered, oligotrophic, and have high sodium, chloride, and magnesium concentrations."

*2. 2001 PALS Water Quality Snapshot*

Between August 15 and September 30, 2001, volunteers collected 421 water quality samples from 195 ponds; at least one pond was sampled in each of the fifteen Cape Cod towns. This sampling followed a sampling protocol developed jointly by the Cape Cod Commission and the School of Marine Science and Technology (SMAST) at the University of Massachusetts at Dartmouth. The collected samples were analyzed at the SMAST lab for: 1) pH, 2) alkalinity, 3) chlorophyll *a*, 4) phaeophytins, 5) total phosphorus, and 6) total nitrogen. The Commission provided logistical support for the effort, including: developing the lists of ponds to sample, ensuring adequate training of volunteers, locating sampling points, distributing sample bottles, transporting collected samples, and recruiting town coordinators. Volunteers also collected dissolved oxygen and temperature profiles at each pond, as well as a Secchi disk depth measurement. A field sampling sheet from the 2001 sampling season is included in Appendix A. SMAST also provided funding for by a 2002 Snapshot; the results of which should be available in Spring 2003.

The Commission and SMAST built on the volunteer network developed as a result of the Secchi Dip-In program and recruited town coordinators to assist in the timing of sample collection. A variety of coordination arrangements with towns were developed in support of the Snapshot; some towns use town staff, some use citizens, and some use both town staff and citizens. These town coordinators have developed into the backbone of the sampling portions of the on-going PALS effort, including the 2002 PALS Snapshot and town-based summer long sampling programs. Table 1 lists the current town pond monitoring coordinators.

Field sampling protocol during the Snapshot sampling involved first finding the deepest point in the pond or lake. Selected ponds have bathymetric maps available from the state Division of Fisheries and Wildlife (see http://www.state.ma.us/dfwele/dfw/dfw_pond.htm) or from previous assessment studies. A bathymetric map generally allowed volunteers to more quickly narrow their potential area of sampling, but the final sampling location was located using a variety of methods including: a sonar depth finder, Secchi disks lowered to the bottom, and marked buoys for selected towns with regular pond sampling programs (*e.g.*, Orleans).

Table 1. Current PALS Town Coordinators

| Town | Citizen Coordinator | Town Staff |
|---|---|---|
| Barnstable | | Dale Saad |
| Bourne | | |
| Brewster | Jane Johnson | Bob Mant |
| Chatham | | Bob Duncanson |
| Dennis | Dick Armstrong | |
| Eastham | Sandy Bayne | Henry Lind |
| Falmouth | | |
| Harwich | Frank Sampson | Heinz Proft |
| Mashpee | Jim Hanks | |
| Orleans | Judy Scanlon | |
| Provincetown | | |
| Sandwich | | Jo Anne Buntich |
| Truro | | |
| Wellfleet | | |
| Yarmouth | | |

note: most of the ponds in Wellfleet, Truro and Provincetown are within the Cape Cod National Seashore. These ponds have been sampled during the PALS Snapshots through the efforts of Krista Lee, John Portnoy, and Jon Budreski of the National Park Servic

note2: Ponds in Bourne and Falmouth were sampled during the PALS Snapshots through the efforts of Tony Williams of the Coalition for Buzzards Bay.

Once the sampling location was established, a Secchi disk reading was made and a temperature/dissolved oxygen profile was collected at 1 meter increments. Volunteers then used a Niskin or Van Dorn sampler to collect a whole water sample at various depths depending on the total depth of the pond. In ponds of 1 m or less, one or two 0.5 m depth samples were collected. In ponds less than 9 meters deep, a sample was collect just below the surface (0.5 m) and one meter above the bottom. In ponds with a total depth of approximately 9 meters, three samples were collected (0.5 m below the surface, 3 m down, and 1 m above the bottom). In ponds with a total depth of greater than 9 meters, four samples were collected: just below the surface (0.5 m), 3 m down, 9 m down, and 1 m above the bottom. Samples were collected in 1 liter dark plastic bottles, which had been previously been acid washed. No preservatives were used. Samples were placed in a cooler with ice or ice packs following collection and were delivered to the laboratory either the same day or the following morning. Table 2 shows the parameters tested from the collected PALS samples at the SMAST laboratory, along with the methods and their respective detection limits.

Table 2. – PALS Sample SMAST Laboratory Analytical Methods

| **Analyte** | **Method** | **Detection Limit** | **Reference** |
|---|---|---|---|
| pH | Potentiometric | NA | Standard Methods, 1995 |
| Alkalinity | Titrimetric | 0.5 mg/L | Standard Methods, 1995 |
| Chlorophyll a/ Phaeophytin | Acetone Extraction/Fluorometry | 0.1 µg/L | Standard Methods, 1995, Parsons *et al.* 1989 |
| Total Nitrogen | Persulfate Digestion/ Cadmium Reduction/Colorimetry | 0.1 µM | Standard Methods, 1995, D'Elia *et al.*, 1977 |
| Total Phosphorus | Boiling Acid Digestion/Colorimetry | 0.1 µM | Standard Methods, 1995, Murphy and Riley, 1962 |

**a. Physical Characteristics**

In order to prepare the PALS sampling lists for volunteers and provide a structure for organizing existing information about the ponds, Commission staff and AmeriCorps volunteers began to gather physical information about the ponds. An unique numbering system for all the freshwater bodies on the Cape was developed; summaries of pond characteristics are included in separate town by town sections at the back of the Atlas. Although water quality is a defining feature of how well pond ecosystems are functioning, physical characteristics of the pond, including its depth, surface area, nearby topography, recharge area, and sediment thickness, also play an important role.

Using a Spring 1994 aerial photo, Commission GIS staff digitized all the surface water features on the Cape. Each water body was assigned a unique number and the area for each surface water body was determined. The numbering system consists of a two letter town code and a unique number for each pond (*e.g.*, SA-431 is Lawrence Pond in Sandwich). This information was then combined in a database with available depth information, including depths determined during the 2001 PALS Snapshot.

Development of this information allowed Commission staff to review the areas of all the Cape's fresh surface waters (Figure 8). Based on this information, there are 994 surface waters on Cape Cod with a total area of 10,453 acres. Forty-four percent (44%) of the 994 ponds on the Cape are less than one acre in area; little is known about these ponds and their functions. Since some of these surface waters likely dry up during low water conditions or even every summer, it raises the question of whether these surface waters are ponds or not.

In order to try to answer this question, dictionaries and available limnology and ecology texts were reviewed for definitions of what constitutes a lake. As mentioned previously, Massachusetts law defines "Great Ponds" and the common practice in the Commonwealth has been to use "lake" and "pond" interchangeably. Merriam-Webster On-line (www.m-w.com) defines a lake as "a considerable inland body of standing water" and defines a pond as "a body of water usually smaller than a lake." The North American Lake Management Society (www.nalms.org) defines a lake as "a considerable body of inland water or an expanded part of a river" and a pond as "a body of water smaller than a lake, often artificially formed." These definitions allude to size being a defining characteristic, but do not clarify a dividing line that could be used to separate "ponds" from "lakes." Review of limnology texts (*e.g.*, Wetzel (1983) and Horne and Goldman (1994)) do not offer definitions of lakes. G.E. Hutchinson (1957) treatise on limnology defined 75 different lake types. Given all of this information, the authors suggest that all 994 fresh surface waters should be regarded as "ponds" or "lakes" until a better definition is provided.

Only three ponds of less than one acre were sampled during the 2001 Snapshot with maximum depths of 0.2, 0.87, and 2 meters. Additional aerial photography during various water table conditions might help to clarify how ephemeral many of these small surface waters are. The combined area of these 442 surface waters, however, is less than 2% of the total freshwater surface area on Cape Cod.

In contrast, the 21 largest ponds on the Cape make up 48% of the total freshwater surface area (see Figure 8). Since these large ponds represent the largest proportion of the total pond area, the average pond area is 10.5 acres, but the large number of small ponds causes the median pond area to be only 1.3 acres.

Figure 8.

# Cape Cod Ponds: Area and Number

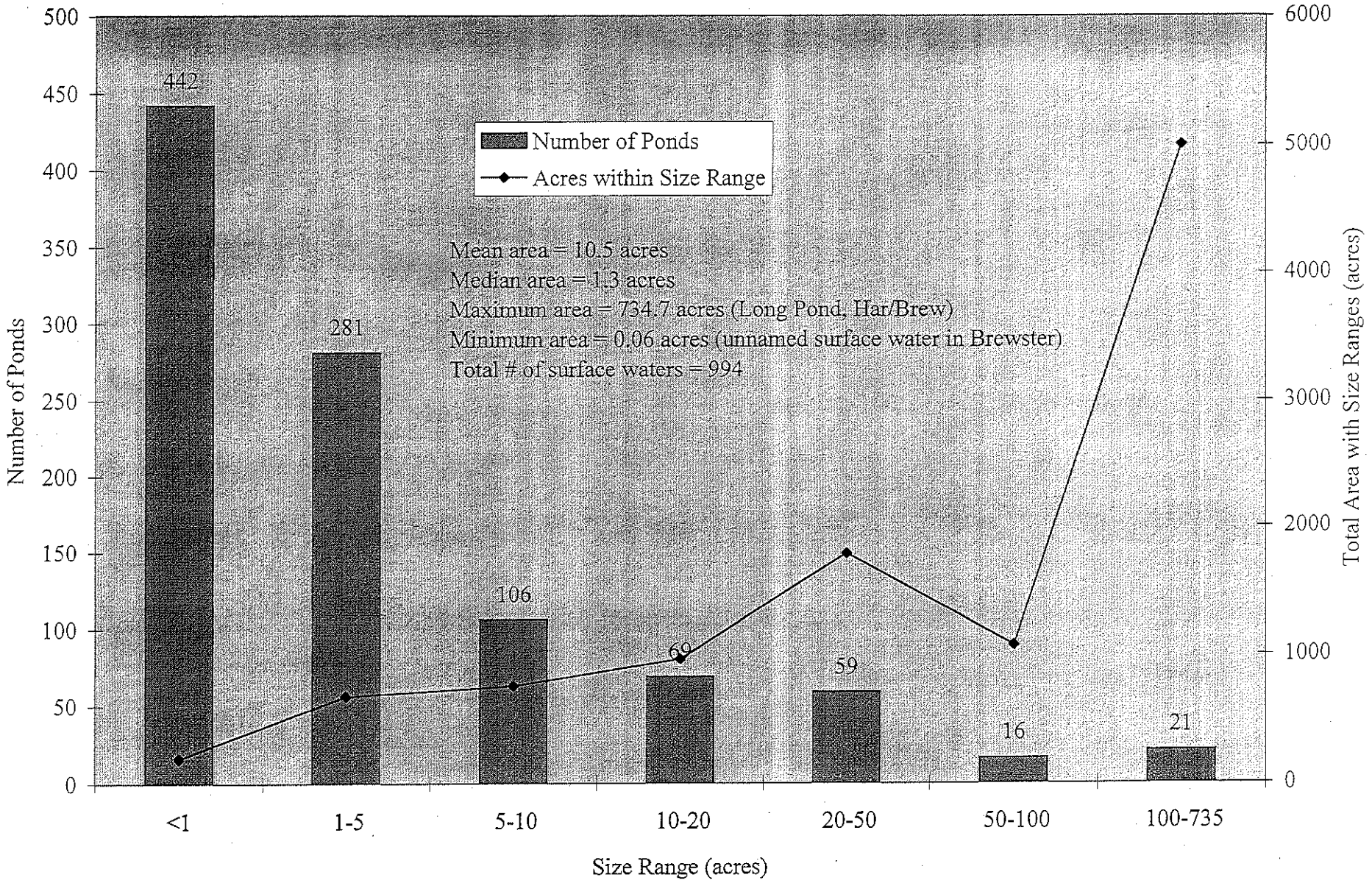


Figure 9 reviews the same information by town. Barnstable and Falmouth have the greatest number of ponds with 184 and 142, respectively. The largest total area is in Brewster with 2,028 acres of ponds, followed by Barnstable with 1,892 acres. Mashpee has the largest average pond size with 28.8 acres for its 56 ponds, including the large ponds of Mashpee-Wakeby (726 acres), Johns (338 acres), Ashumet (218 acres), and Santuit (171 acres).

Figure 10 combines the areal information with available information about maximum depth. Maximum depth was used because pond-wide bathymetric information is available for only approximately 80 ponds, while the number of ponds with available depth maximum depth readings is 176 ponds. Many of the maximum depth readings are only available because one was collected at the time of the 2001 Snapshot sampling. Because the Snapshot is the source of much of the data, the mean depth (5.88 meters) and median depth (4.08 meters) are likely skewed higher to reflect larger, more easily accessible ponds. Based on this information, the 23% of ponds have a maximum depth between 1 to 3 meters and the thirteen deepest ponds (15-29 m deep) occupy the largest surface area (2,443 acres).

**b. 2001 PALS Snapshot Water Quality Results**

At most of the PALS workshops, folks approached Commission, SMAST, and other expert staff and commonly asked a version of the following question: "Is my pond ok?" That question has driven much of the research that has occurred in the field of limnology, or lake science, for over 100 years. With the collection of the 2001 Snapshot data, we have a better opportunity to answer that question, but we also have to understand the range of what constitutes a "healthy" pond ecosystem.

As mentioned previously, G.E. Hutchison (1957) defined over 75 different types of ponds. The results from Figures 8 and 10 indicate the fairly wide range of physical characteristics of Cape Cod ponds, so even with a common climate and geologic setting, one would expect to see a range of what is "ok." In order to better answer the question, the authors reviewed the answers that have been developed in other areas of the country.

Project staff begin by reviewing available trophic indices and current efforts to define "unimpacted" ponds. An "index" is a method of assigning a numerical rank to a pond based on a series of parameters. In this fashion, scientists often group lakes into various trophic categories (*e.g.*, oligotrophic, mesotrophic, eutrophic, etc.). Staff then reviewed various efforts to define "reference" lakes or lakes that are "pristine" or unimpacted by human development.

One of the better known trophic classification strategies is the one developed by Carlson (1977). The trophic state of a pond is the total amount of living biological material (*i.e.*, biomass) in the ecosystem. Carlson's strategy looks at a simpler measure of algal biomass and relates it to separate measures of total phosphorus, chlorophyll a, and Secchi disk depth. Carlson designed the system to utilize one or another of the measures to classify the trophic state index (TSI) of a pond or lake on a scale of 0 to 100 (Carlson and Simpson, 1996). The equations for producing the various TSI values and the likely ecosystem characteristics are presented in Table 3.

Subsequent evaluation of Carlson's Index has found that one measure or another is better for use at various times of year (e.g., total phosphorus may be better than chlorophyll at predicting summer trophic state), but the best predictor of algal biomass is chlorophyll concentrations (Carlson, 1983). Subsequent uses of the Carlson Index by other investigators have included combining and averaging the various TSI values. Carlson (1983) regards this as a misuse of the indices and states "There is no logic in combining a good predictor with two that are not."

Figure 9.

# Number and Area of Ponds by Town

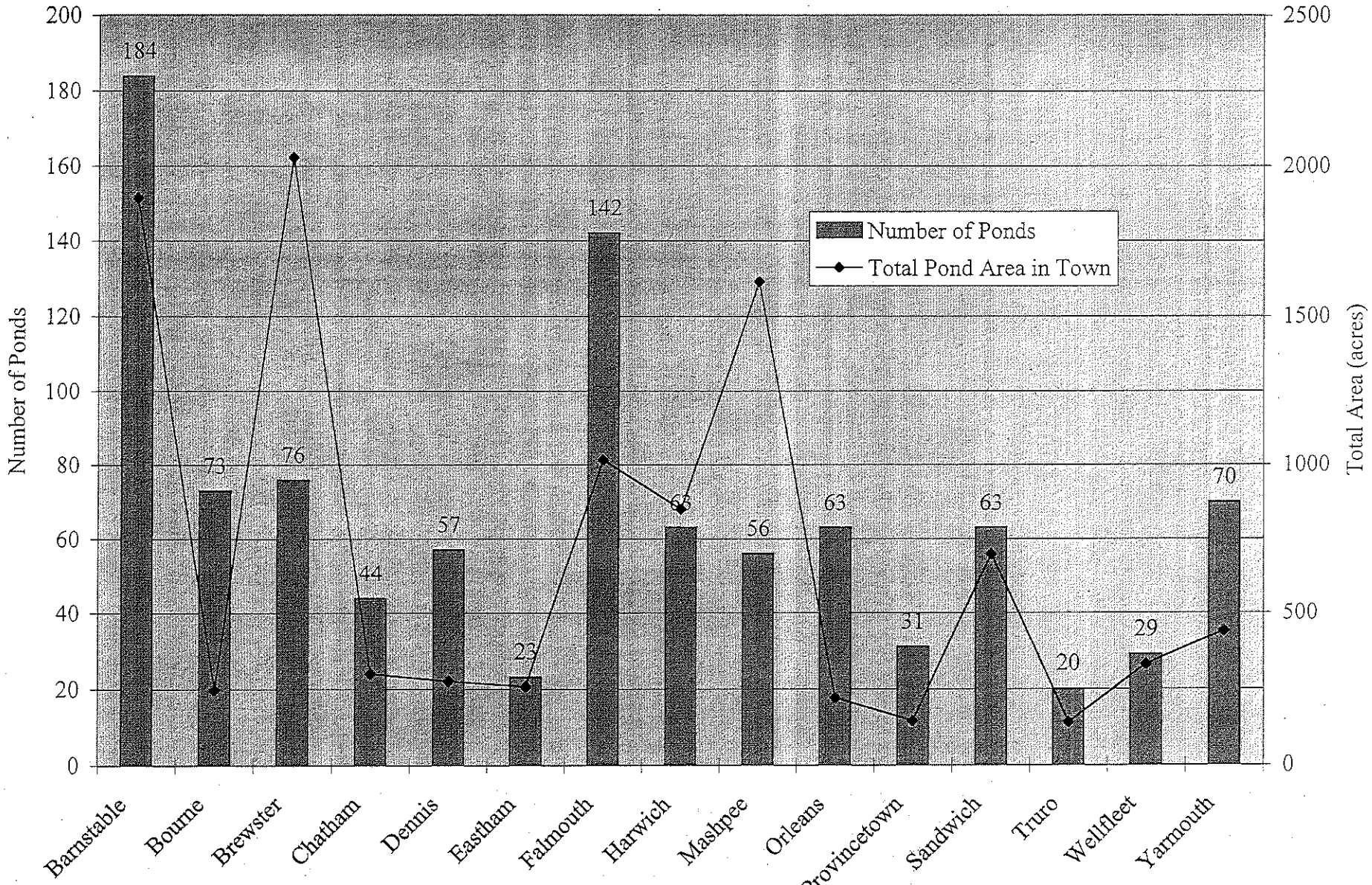
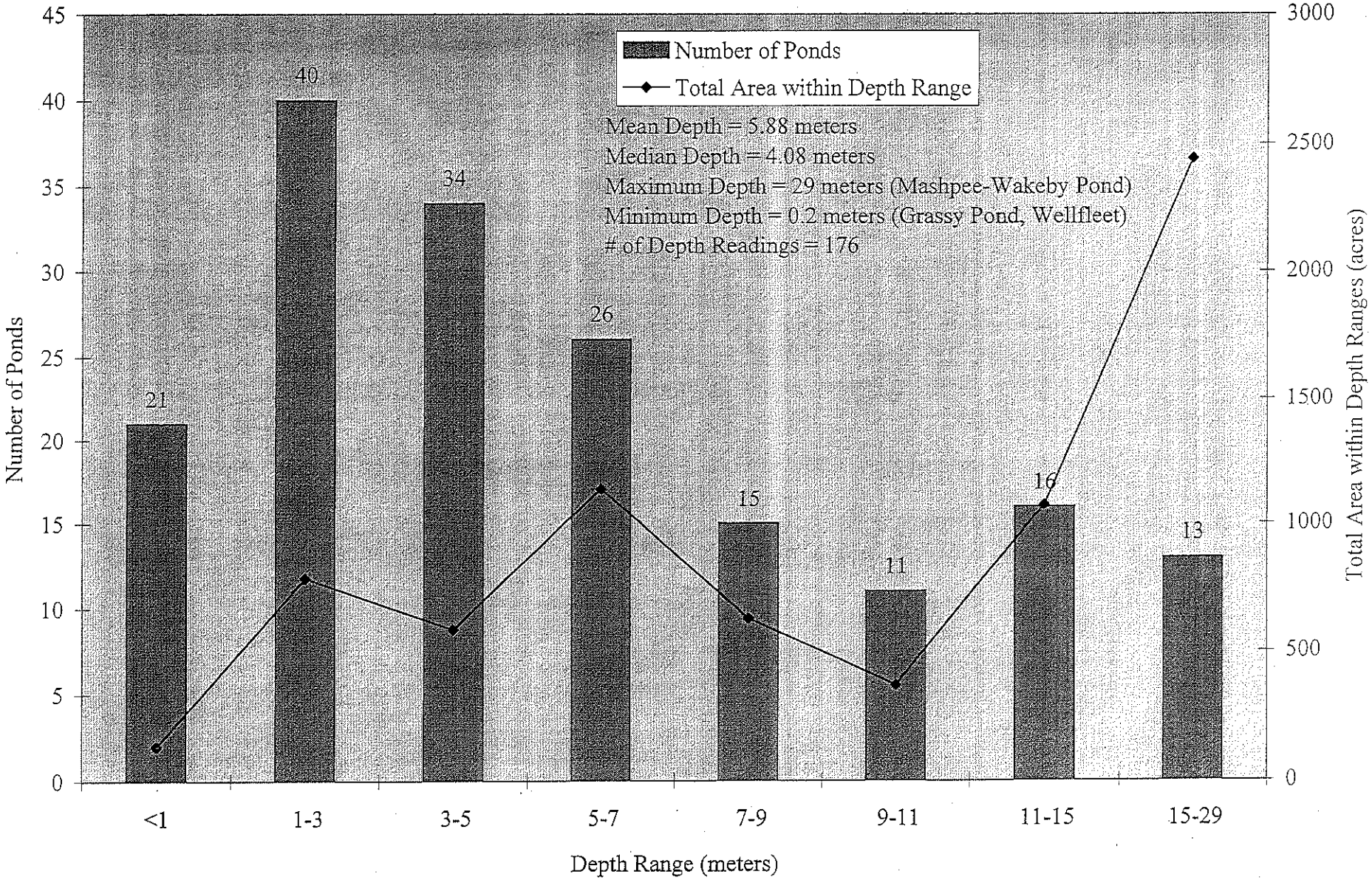


Figure 10.

# Cape Cod Ponds: Depth and Number



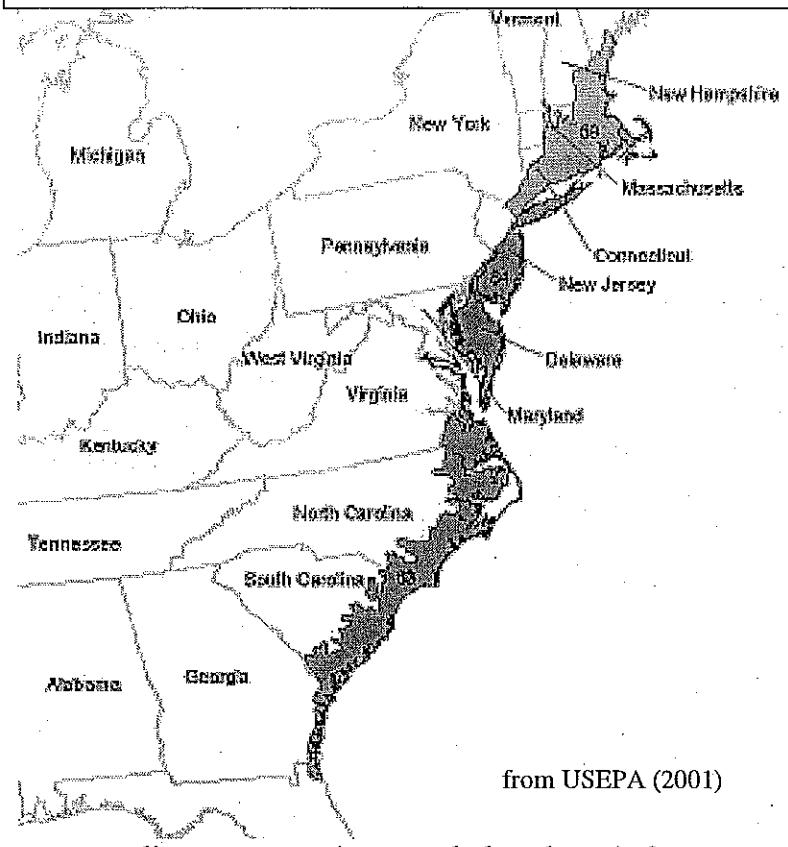

Depth information from 2001 Snapshot
Areas based on CCC GIS interpretation of 1994 aerial photo

| Table 3. – Carlson Trophic State Index (TSI) | | | | | |
|---|---|---|---|---|---|
| TSI Calculations | | | | | |
| TSI(SD) = 60 - 14.41 ln(SD) | | | SD = Secchi disk depth (meters) | | |
| TSI(CHL) = 9.81 ln(CHL) + 30.6 | | | CHL = Chlorophyll a concentration (µg/L) | | |
| TSI(TP) = 14.42 ln(TP) + 4.15 | | | TP = Total phosphorus concentration (µg/L) | | |
| TSI values and likely pond attributes | | | | | |
| TSI Values | Chl a (µg/L) | SD (m) | TP (µg/L) | Attributes | Fisheries & Recreation |
| <30 | <0.95 | >8 | <6 | Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion | Salmonid fisheries dominate |
| 30-40 | 0.95-2.6 | 8-4 | 6-12 | Hypolimnia of shallower lakes may become anoxic | Salmonid fisheries in deep lakes only |
| 40-50 | 2.6-7.3 | 4-2 | 12-24 | Mesotrophy: Water moderately clear; increasing probability of hypolimnetic anoxia during summer | Hypolimnetic anoxia results in loss of salmonids. |
| 50-60 | 7.3-20 | 2-1 | 24-48 | Eutrophy: Anoxic hypolimnia, macrophyte problems possible | Warm-water fisheries only. Bass may dominate. |
| 60-70 | 20-56 | 0.5-1 | 48-96 | Blue-green algae dominate, algal scums and macrophyte problems | Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating. |
| 70-80 | 56-155 | 0.25-0.5 | 96-192 | Hypereutrophy: (light limited productivity). Dense algae and macrophytes | |
| >80 | >155 | <0.25 | 192-384 | Algal scums, few macrophytes | Rough fish dominate; summer fish kills possible |
| after Carlson and Simpson (1996);<br>Carlson TSI developed in algal dominated, northern temperate lakes | | | | | |

Although the Carlson indices were developed for use in northern temperate lakes and do not work well in lakes where macrophytes (i.e., rooted aquatic plants) dominate the ecosystem, project staff used the chlorophyll *a* concentrations from the 2001 Snapshot as one measure of the general trophic state of the Cape's lakes and ponds (see following sections). Further detailed pond by pond analysis of other measures (*e.g.*, total phosphorus, dissolved oxygen, macrophyte cover, etc.) need to be evaluated to assess the trophic status of an individual lake. It should also be further noted that higher Carlson values do not necessarily mean that the water quality in a pond is "poor"; although water quality and biomass levels are linked, higher biomass levels are valuable for warm water fisheries (*e.g.*, bass) and may be appropriate for shallow, more naturally productive pond ecosystems.

Where the Carlson indices try to establish the trophic level of a pond, the US Environmental Protection Agency (USEPA) has recently been working to characterize "reference" or "unimpacted" conditions in lakes and ponds. This effort, which is being pursued in order to satisfy regulatory provisions under the federal Clean Water Act, is focussed on developing reference criteria for various nutrients in lakes and reservoirs (USEPA, 2000). USEPA has refined this work by dividing the United States into various "ecoregions" and comparing only ponds and lakes only within these ecologically similar settings. Cape Cod, for example, is located within Ecoregion 14 ("Eastern Coastal Plain'), which extends along the Atlantic Ocean coast from southern Maine to northern Florida and subecoregion 84 ("Atlantic Coastal Pine Barrens"), which includes Nantucket, Martha's Vineyard, southern New Jersey, Long Island, and portions of Plymouth (Figure 11).

Figure 11. – USEPA Subecoregions within Ecoregion 14

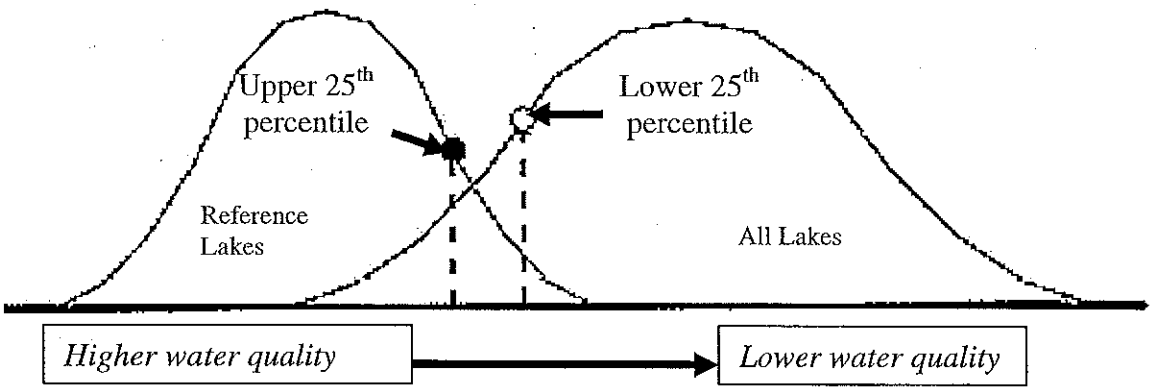



from USEPA (2001)

The USEPA method for determining reference conditions utilizes one of two methods depending on the amount and quality of the data that is available (USEPA, 2001). One method is to determine the upper 25$^{th}$ percentile (75$^{th}$ percentile) of a water quality parameter (*e.g.*, total phosphorus) from measurements collected only from reference or unimpacted lakes (Figure 12). This method is preferred by USEPA because it is likely associated with minimally impacted water quality conditions. USEPA's other method is used when unimpacted lakes have not been adequately identified. This method determines the lower 25$^{th}$ percentile of a particular parameter from all sampling data from lakes within a region. Limited analysis comparing the two methods seems to indicate that results from the two methods are similar (USEPA, 2001).

By selecting a threshold value for various parameters, USEPA is trying to identify ponds that are "minimally impacted by human activities" and provide states with guidance values in the development of numeric standards for surface water regulations to "protect against nutrient overenrichment from cultural eutrophication" (USEPA, 2001). In other words, USEPA is trying to define what "natural" conditions might be expected in ponds in the various ecoregions. By doing this, USEPA is also defining what might be appropriate targets for remediating impacted ecosystems.

Figure 12. USEPA Methods for setting reference condition thresholds




Source: USEPA, 2000

USEPA has recently released reference values for lakes and reservoirs within the entire Ecoregion 14, including Subecoregion 84, which contains Cape Cod (USEPA, 2001). The data collection for this analysis found 92 lakes had been sampled in subecoregion 84 between 1990 and 1999 and this data was analyzed to develop reference values for Secchi depth, total phosphorus, total nitrogen, and chlorophyll *a* (Table 4). The available data included sampling in all four seasons and USEPA determined that the most frequently sampled season in Subecoregion 84 had less than 10 samples for three of the parameters and 33 samples for total phosphorus (see Table 4). These reference values were developed using the lower 25th percentile of all the available data.

In contrast to the dataset available to USEPA, the dataset available from the 2001 Cape Cod Pond Water Quality Snapshot comes from 195 lakes with over 150 surface samples for each of the parameters considered. Because the Cape Cod dataset is more extensive than the subecoregion dataset used by USEPA, concerns were raised that the USEPA criteria may not accurately reflect conditions in Cape Cod ponds. In order to explore this question, atlas authors reviewed the 2001 PALS Snapshot data using both of the USEPA (2000) criteria methodologies: 1) the lower 25th percentile of all water quality data and 2) the upper 25th percentile of the unimpacted ponds.

Table 4. USEPA Ecoregion 14 Reference Information

| | Ecoregion 14 | Subecoregion 84 |
|---|---|---|
| # of lakes | 647 | 92 |
| # of lake stations | 910 | 100 |

| Nutrient Parameters Considered | # of records in | | Reference Thresholds | |
|---|---|---|---|---|
| | Ecoregion 14 | Subecoregion 84 | Ecoregion 14 | Subecoregion 84 |
| Secchi depth | 14,581 | 79 | 4.5 m | 2 m |
| chlorophyll *a* | 5,977 | 73 | 2.1 µg/L | 6 µg/L* |
| total nitrogen (TN) | 925 | 1 | 0.32 mg/L | 0.41 mg/L* |
| total phosphorus (TP) | 12,386 | 106 | 8 µg/L | 9 µg/L |

*fewer than 4 lakes used to develop threshold
Source: USEPA, 2001

Table 5 presents the results from applying both methods to the 2001 Cape Cod PALS data. The differences between the lower 25th percentile reference conditions determined by USEPA and the ones determined using the 2001 PALS Snapshot data are: 0.4 µg/l (chlorophyll *a*), 2 µg/l (total phosphorus) and 0.01 mg/l (total nitrogen). The TN difference is within the precision range expected by the laboratory method (Standard Methods, 1999), indicating that the difference between the two criteria is not significant. Differences between the TP and chlorophyll a concentrations are large enough to have two distinct readings in a lab, but for the purposes of this comparison are relatively small. Because of concerns about having the Secchi readings skewed by measurements were the disk rested on the bottom, Secchi depth was not included in this analysis. Overall, the differences between the USEPA Ecoregion 14 reference criteria and Cape Cod-specific reference criteria determined using the USEPA lower 25th percentile method are negligible.

Table 5. – Reference Criteria for Cape Cod Ponds based on 2001 PALS Snapshot

| | | chl *a* | TN | TP | pH |
|---|---|---|---|---|---|
| Category | Measure | µg/L | mg/L | µg/L | |
| 2001 Snapshot (All ponds) | # of ponds sampled | 191 | 184 | 175 | 193 |
| 2001 Snapshot (All ponds) | Median | 3.6 | 0.44 | 16 | 6.28 |
| 2001 Snapshot (All ponds) | Lower 25th percentile | 1.7 | 0.31 | 10 | 5.62 |
| USEPA Ecoregion 14 | Lower 25th percentile | 2.1 | 0.32 | 8 | * |
| 4 List Ponds (8 ponds) | upper 25th percentile | 1.0 | 0.16 | 7.5 | 5.19 |
| 3 List Ponds (26 ponds) | upper 25th percentile | 1.1 | 0.22 | 7.7 | 5.24 |

* not used in USEPA nutrient criteria determination
USEPA (2001) is source of USEPA concentrations
All Cape Cod measures based on results from 2001 PALS Snapshot surface water samples.
Highlighted rows list criteria used in analyses throughout Pond Atlas

Atlas authors then reviewed the 2001 Snapshot data using the USEPA methodology for determining reference criteria that looks at the upper 25th percentile of the most unimpacted (or reference) ponds. In order to use this method, the review started by determining which Cape Cod ponds could be characterized as "unimpacted." In order to accomplish this, project staff first reviewed the 2001 Snapshot data to determine which ponds are within the lower 25th percentile for each of the criteria measures. This analysis resulted in a list of 101 ponds with at least one parameter result within the lower 25th percentile of one of the four measures (TP, TN, CHL-a, and pH). The list of these ponds was then cross-referenced to see how many of the ponds were on two of the lists (49 ponds), three of the lists (26 ponds), and all four lists (8 ponds). The eight ponds on all four lists are: Hathaway (South) and Micah in Barnstable, Slough and Pine in Brewster, Flax in Dennis, Slough in Truro, and Duck and Spectacle in Wellfleet. Based on this analysis, these are the least impacted ponds on Cape Cod among those measured during the 2001 Snapshot.

The upper 25th percentile was then determined from the available data from these eight ponds. This analysis resulted in measures shown in Table 5. This data was then combined with the data from the 18 other ponds with three measures within the lower 25th percentiles and the upper 25th percentile was determined again (see Table 5).

The resulting concentrations based on the 8 ponds for total nitrogen, chlorophyll *a*, and total phosphorus are 52, 59, and 75%, respectively, of the criteria concentrations determined using all the 2001 Snapshot data. The corresponding percentages using the three-list ponds are 71, 65, and 77%, respectively. Interestingly, the reference criteria for total phosphorus from this methodology is roughly equivalent to the USEPA Ecoregion 14 criterion, while the total nitrogen and chlorophyll *a* concentrations are roughly half of the USEPA criteria.

It is clear from this analysis that further data collection could help to refine these concentrations, but it is unclear how appropriately the upper 25$^{th}$ percentile method criteria reflect "unimpacted" ponds on Cape Cod. Given the rapid population increases and land development over the past 40 years on the Cape, it may be difficult to accurately characterize any pond on Cape Cod as "unimpacted." The above method to identify the least impacted pond is reasonable, but alternative methods might result in different criteria. At this point, the 2001 PALS Snapshot data is the most comprehensive dataset available for Cape Cod ponds and is an appropriate basis for determining nutrient criteria.

The following sections discuss each of the water quality parameters measured during the 2001 PALS Snapshot and their importance in assessing whether a pond ecosystem is impacted or impaired. Included in this discussion are town-by-town comparisons of the 2001 Snapshot results to the Cape Cod reference criteria developed using both USEPA development methods. Since the Snapshot database is larger than the dataset used by USEPA for the Subecoregion that contains Cape Cod, the authors feel that it is more appropriate to consider Cape Cod data when assessing which criteria should apply.

**i. Phosphorus**

Phosphorus is a nutrient; typical plant organic matter contains phosphorous, nitrogen, and carbon in a ratio of 1 P: 7 N: 40 C per 500 wet weight (Wetzel, 1983). Therefore, if the other constituents are present in excess, phosphorus, as the limiting nutrient can theoretically produce 500 times its weight in algae. Because it is usually the most limited nutrient in lakes, 90% or more of the total mass of phosphorus in a lake usually occurs in organic forms (plant and animal tissue or plant and animal wastes) and any available inorganic phosphorus (mostly orthophosphate ($PO_4^{-3}$)) is quickly reused by the biota in the lake (Wetzel, 1983). Because all phosphorus forms may be made available to stimulate plant growth most studies of lakes focus on total phosphorus concentrations (Vollenweider, 1968). Total phosphorus (TP) includes ortho-phosphorus and all phosphorus bound in organic matter, including algae.

USEPA currently recommends a reference threshold of 8 µg/l TP for Cape Cod's ecoregion, while use of the USEPA nutrient criteria methods to review the 2001 PALS Snapshot data results in a reference threshold of 10 µg/l when all data is considered and 7.5 µg/l when only "unimpacted" ponds are considered (see Table 5). Carlson's TSI classifies lakes with TP concentrations up to 12 µg/L as the lowest nutrient or oligotrophic ponds (see Table 3). Most Cape Cod lakes have low phosphorus concentrations due to the lack of phosphorus in the surrounding glacially-derived sands.

Aherns and Siver (2000) sampling of 60 Cape Cod lakes in 1997 and 1998 found a mean TP concentration in surface waters of 0.014 ppm (14 µg/l). This concentration would place the "average" Cape Cod lake in the oligotrophic to mesotrophic range based on 200 lakes measured throughout the world (Wetzel, 1983), the mesotrophic range based on Carlson's index (see Table 3) and would place it above the Cape Cod and USEPA Ecoregion "impacted" thresholds.

Figure 13 presents the comparison of the Cape Cod reference criteria for total phosphorus with the 2001 Snapshot surface water results by town. During the 2001 Snapshot sampling, 175 surface water TP samples were collected. The average of TP concentration of these samples is 27.2 µg/l (or 0.0272 ppm), while the median is 16.4 µg/l. Town results show how many pond's surface water TP concentrations are below the reference concentration (7.5 µg/l) based only on data from unimpacted ponds, above the reference concentration (10 µg/l) based on data from all the ponds, and how many are between these two concentrations. For example, Mashpee volunteers collected surface TP samples from 18 ponds, 17 of which were impacted (*i.e.*, TP concentration greater than 10 µg/L) (see Figure 13). Overall, 16% of the pond had concentrations that would be considered unimpacted (TP<7.5 µg/l), 74% would be considered impacted (TP>10 µg/l), and 10% could be considered either impacted or unimpacted depending on which USEPA method was used to develop the threshold. Individual pond results are included in the town-specific sections of this Atlas.

Regardless of which methodology is used, this analysis indicates that a minimum of 74% of the ponds sampled during the 2001 PALS Snapshot have been impacted by human development. This finding then raises the issue of whether these impacts are impairments that require reductions in the phosphorus concentrations. All of the PALS data would need to be brought together for individual ponds along with additional monitoring in order to evaluate whether the "impacts" are causing ecosystem-wide problems like increasing tendencies toward algal blooms and fish kills or whether the impacts are prompting just enough plant growth to create good bass fisheries. Certainly, based on this analysis, at least three-quarters of the pond ecosystems on Cape Cod have been altered from what they would otherwise be without human influence.

**ii. Nitrogen**

Nitrogen is one of the primary nutrients in surface water systems (phosphorus and potassium being the other two). Nitrogen switches between a number of chemical species (nitrate, nitrite, ammonium, nitrogen gas, and organic nitrogen) depending on a number of factors, including dissolved oxygen, pH, and biological uptake (Stumm and Morgan, 1981). Nitrate-nitrogen is the fully oxidized form of nitrogen, while ammonium-nitrogen is the fully reduced (*i.e.*, low oxygen) form. Inorganic nitrogen generally enters ponds in the nitrate-nitrogen form, is incorporated into algae forming organic nitrogen, and then is converted back to inorganic forms (nitrate- and ammonium-nitrogen) in the waste from algae or organisms higher up the food chain or by bacteria decomposing dead algae in the sediments. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen and ammonium forms. Total nitrogen (TN) is generally reported as the addition of TKN and nitrate-nitrogen concentrations.

Nitrogen is not usually the limiting nutrient in ponds, but ecosystem changes during the course of a year or excessive phosphorus loads can create conditions where it is the limiting nutrient. In very productive or eutrophic lakes, algae that can extract nitrogen directly from the atmosphere, which is approximately 75% nitrogen gas, often have a strong competitive advantage and tend to dominate the pond ecosystem. These blue-green algae, more technically known as cyanophytes, are generally indicators of excessive nutrient loads.

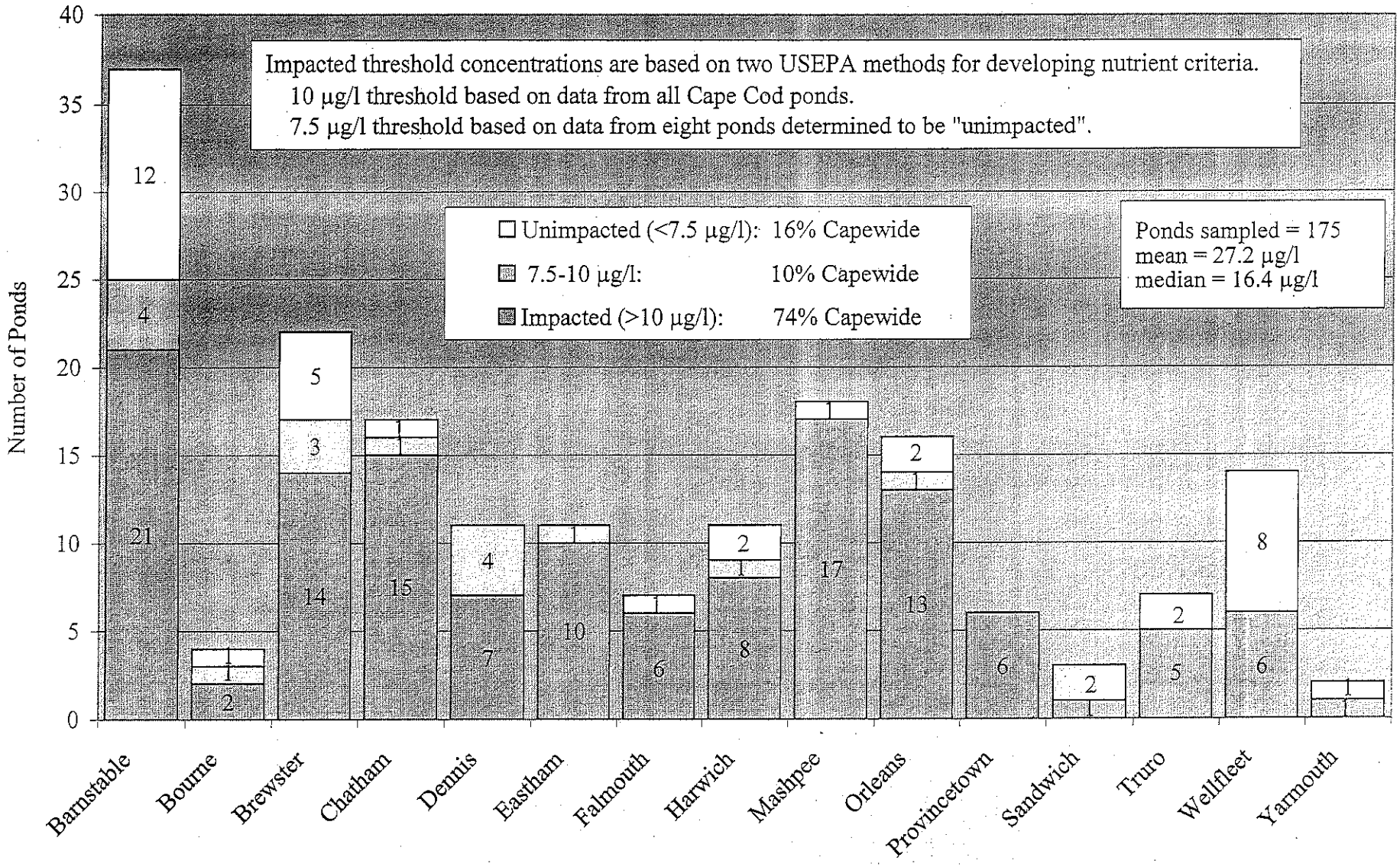
USEPA currently recommends a reference threshold of 0.32 mg/l (or 0.32 ppm) TN for Cape Cod's ecoregion, while use of the USEPA nutrient criteria methods to review the 2001 PALS Snapshot data results in a reference threshold of 0.31 mg/l when all data is considered and 0.16 mg/l when only "unimpacted" ponds are considered (see Table 5). Aherns and Siver (2000)

Figure 13.

# Total Phosphorus in Cape Cod Ponds: Comparison to Cape Cod Impacted Threshold

Surface Samples (0.5 or 1 m)

August 15 to September 30, 2001



sampling of 60 Cape Cod lakes in 1997 and 1998 found a mean TN concentration in surface waters of 0.249 ppm. This concentration places the "average" Cape Cod lake solidly in the oligotrophic range based on 200 lakes measured throughout the world (Wetzel, 1983), characterizes it as "impacted" if the threshold from only unimpacted ponds of Cape Cod is considered, and would characterize it as "unimpacted" if the threshold using all Cape Cod pond data is considered (see Table 5). For comparison, the average groundwater nitrate-nitrogen in over 5,000 private wells sampled throughout Cape Cod, roughly an approximation of average aquifer nitrogen concentrations, is 0.23 ppm (CCC files).

Figure 14 presents the comparison of the Cape Cod reference criteria for TN with the 2001 Snapshot surface water results by town. During the 2001 Snapshot sampling, 184 surface water TN samples were collected. The average of concentration of these samples is 0.58 mg/l (or 0.58 ppm), while the median is 0.44 mg/l. Town results show how many pond's surface water TN concentrations are below the reference concentration (0.16 mg/l) based only on data from unimpacted ponds, above the reference concentration (0.31 mg/l) based on data from all the ponds, and how many are between these two concentrations. For example, Barnstable volunteers and staff collected surface total nitrogen samples from 34 ponds, 28 of which were impacted (*i.e.*, TN concentration greater than 0.31 mg/L)(see Figure 14). Overall, 7% of the ponds had concentrations that would be considered unimpacted (TN<0.16 mg/l), 75% would be considered impacted (TN>31 mg/l), and 18% could be considered either impacted or unimpacted depending on which USEPA method was used to develop the threshold. Individual pond results are included in the town-specific sections of this Atlas.

**iii. Secchi Depth/Total Depth**

An approximate evaluation of transparency, or light penetration, of water can be made using a Secchi disc (Figure 15). Fluctuations in Secchi depths are generally linked to fluctuations in concentrations of plankton or inorganic particles and has been linked through a variety of analyses to trophic status of lakes (*e.g.*, Carlson, 1977). Observed Secchi disc transparencies range from a few centimeters in very turbid lakes to over 40 m in a few clear lakes (Wetzel, 1983). Secchi depth is also related to the overall depth of a pond; if the pond is relatively shallow, the disk may be visible on the bottom even with significant algal densities.

The 1948 Massachusetts DFG Fisheries Report transparency results from fifty-one Cape Cod ponds averaged 18.4 ft (5.6 m) and ranged between 1 ft (0.3 m) in Pilgrim Lake in Truro and 34 ft (10.4 m) in Long Pond in Wellfleet. The Aherns and Siver (2000) survey of sixty Cape Cod lakes and ponds found Secchi depths ranged between 0.31 m in Duck Pond in Provincetown to 9.35 m in Sheep Pond in Brewster; thirty-six percent of the lakes had a mean Secchi depth greater than 5.0 m. USEPA (2001) currently has a reference threshold of 1.2 meters for ponds within Ecoregion 14, which includes Cape Cod (see Table 5).

Although the staff has concerns about the skewing of the relationship between Secchi depth and total depth, which are discussed below, staff developed a Cape Cod reference criterion for Secchi readings using both USEPA reference criteria methods based on data collected during the 2001 PALS Snapshot. Since higher Secchi readings are more indicative of good water quality, the USEPA method looks at the upper 25$^{th}$ percentile (i.e., the 75$^{th}$ percentile) of all data. The reference criterion (3.8 m) using all the 2001 PALS data is slightly shallower than the criterion (4.5 m) developed by USEPA for the ecoregion that contains Cape Cod. The lower 25$^{th}$ percentile reference criteria based on data from the least impacted ponds on the Cape is 6.8 m.

Figure 14.

# Total Nitrogen in Cape Cod Ponds: Comparison to Cape Cod Impacted Threshold

Surface Samples (0.5 or 1 m depth)

August 15 to September 30, 2001

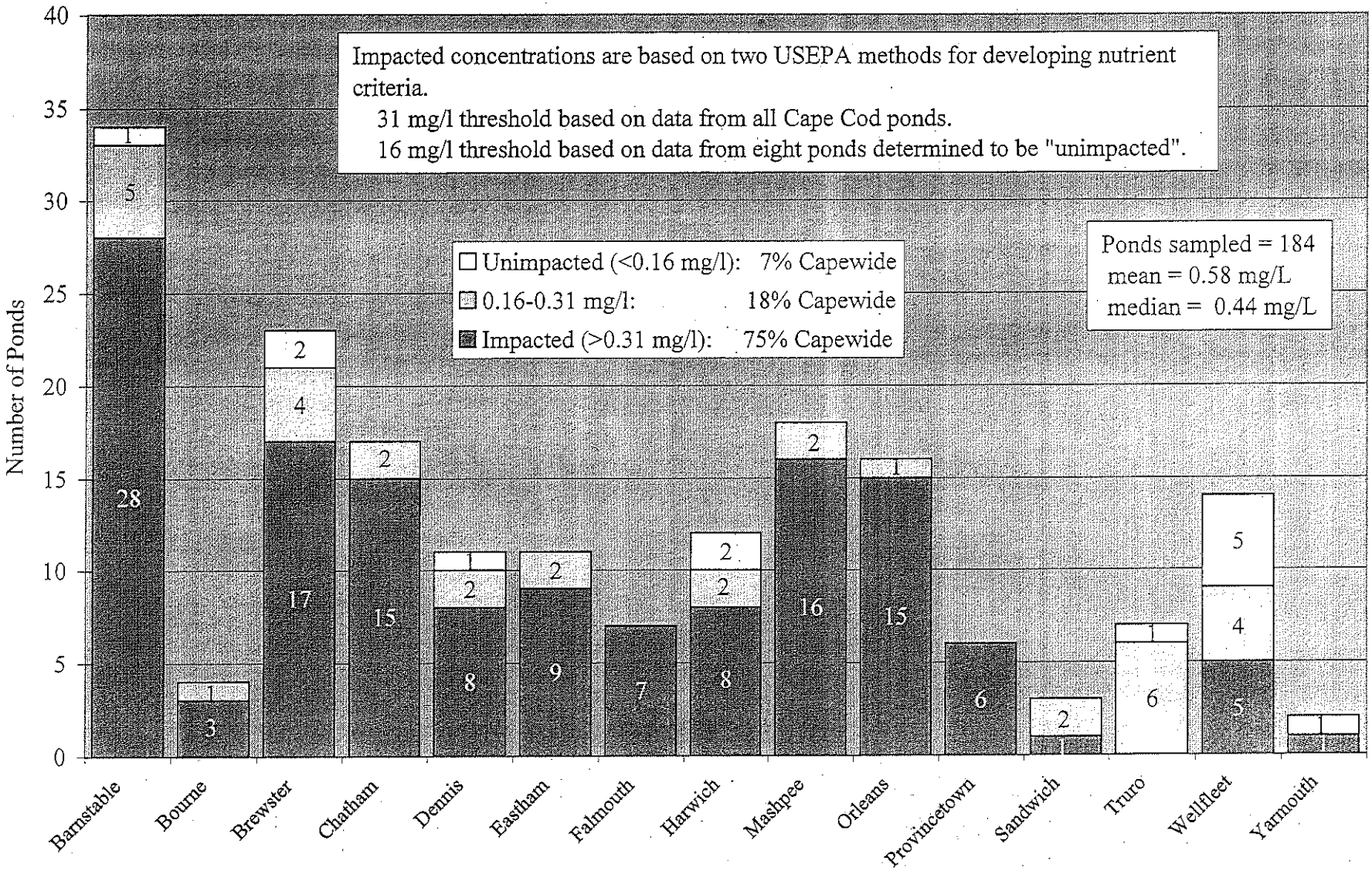
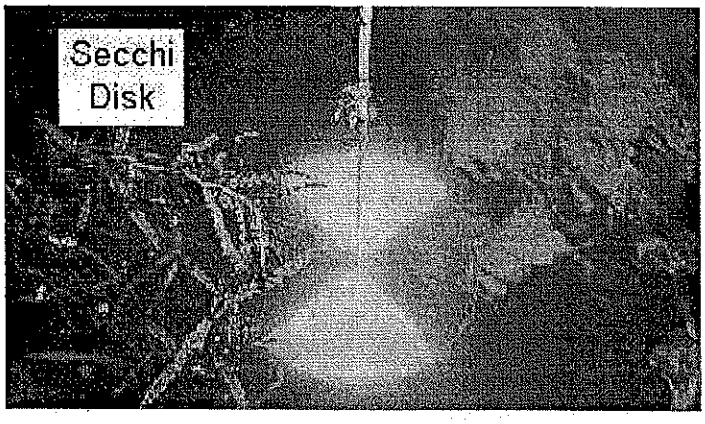


Figure 15. – Secchi Disk




From: www.epa.state.il.us/water/conservation-2000/volunteer-lake-monitoring/secchi-disk.jpg

Figure 16 presents the comparison of the 2001 Snapshot results to the Cape Cod reference criteria. During the 2001 Snapshot sampling, 192 Secchi depth readings were collected. The average of depth of these readings is 2.66 m (or 8.7 ft), while the median is 2.26 m. Town results show how many pond's Secchi depth readings are above the reference depth (6.8 m) based only on data from unimpacted ponds, below the reference depth (3.8 m) based on data from all the ponds, and how many are between these two depths. For example, Brewster volunteers collected Secchi depth readings from 25 ponds, 20 of which had Secchi depths of less than 3.8 m (12.5 ft) (see Figure 16). As would be expected by the method used to develop the reference criterion, the analysis shows that about a three-quarters (75%) of the ponds on Cape Cod have been "impacted" by human activities. Individual pond results are included in the town-specific sections of this Atlas.

Secchi readings present a bit of problem because in many shallow ponds, the Secchi disk can be seen on the bottom of the pond. In these ponds, the measurement is not limited by the clarity of the water, but by the depth of the pond and, because of this, the clarity reading can be skewed by these results. For example, among Secchi readings included in the lower 25$^{th}$ percentile (*i.e.*, supposedly the most impacted ponds), the Secchi disk was resting on the bottom in half of the 48 results. If these ponds were deeper, conceivably they would have deeper Secchi readings. Even among the least impacted ponds (*i.e.*, ponds in the upper 25$^{th}$ percentile), 8 of the 49 readings were instances where the Secchi disk was resting on the bottom.

Because depth is so important when considering Secchi readings, total depths of the ponds must also be part of the evaluation of the Secchi readings from the 2001 PALS Snapshot. Figure 17 shows Secchi depth information as a percentage of total depth. As shown in Figure 17, 56 of the 192 ponds (29%) sampled during the 2001 Snapshot had clear enough water that the Secchi disk could be seen on the bottom of the pond. The range of depths for these ponds is from 0.2 m (Grassy Pond, Wellfleet) to 7.2 m (Flax Pond, Dennis).

Conversely, this finding also indicates that 71% of the sampled ponds have materials in their waters that impact light transmission. This percentage may be a better measure of how many ponds on Cape Cod have been "impacted". All these ponds have Secchi depths that indicate that light cannot reach the bottom, which, in turn, indicates that rooted aquatic plants are unlikely to grow on the areas of the bottoms of these pond below the Secchi depth.

The issues surrounding the use of Secchi depth readings in shallow ponds presents difficulties for regional aggregation of ponds data, but Secchi depth remains as an important measure for clarity fluctuations in deeper ponds. Of course, any detailed pond assessment should include all available information and not rely strictly on one measure.

Figure 16.

# Secchi Depth in Cape Cod Ponds: Comparison to Cape Cod Impacted Threshold

August 15 to September 30, 2001

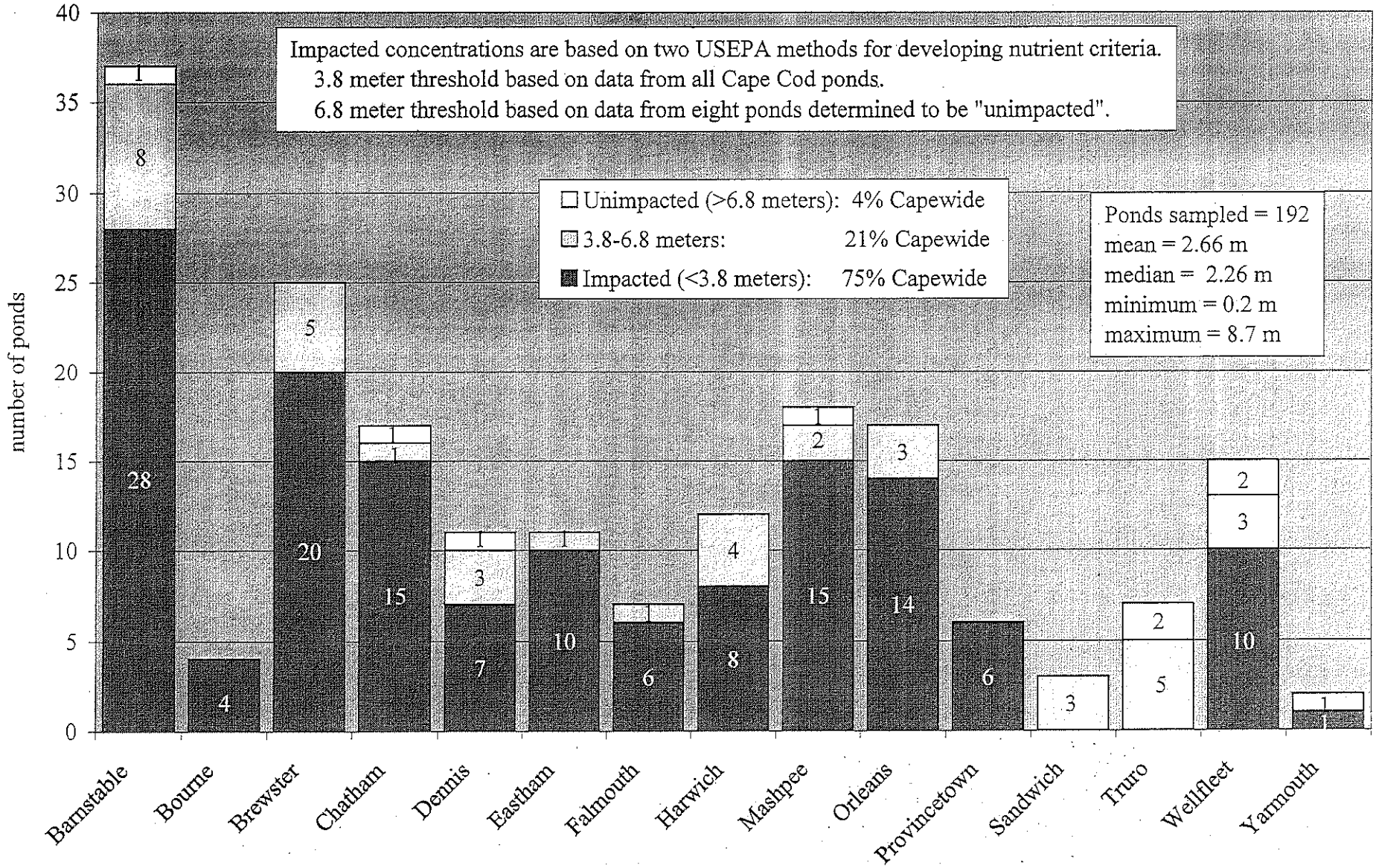
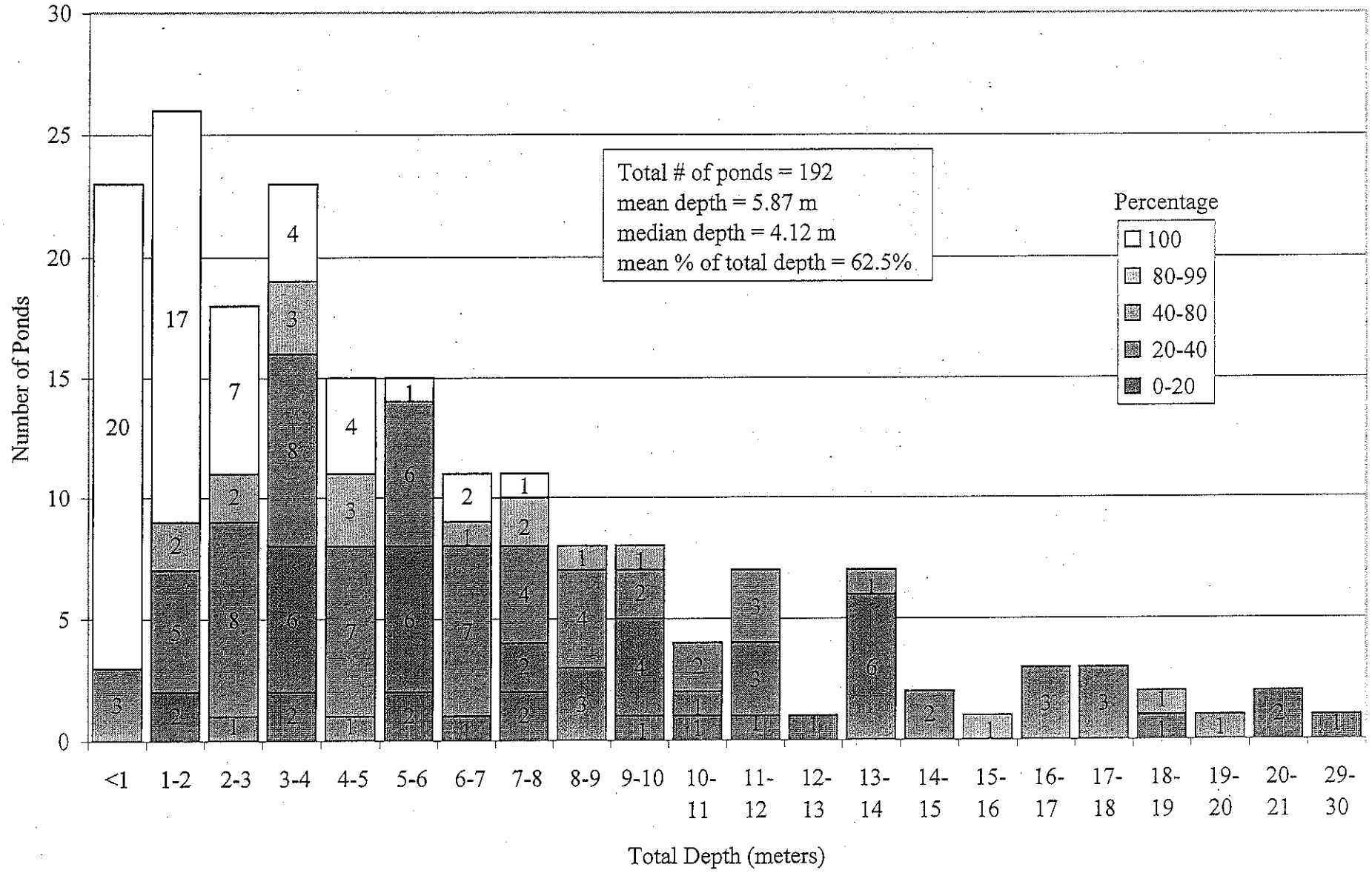


Figure 17.

# Secchi Depth as a Percentage of Total Depth

August 15 to September 30, 2001



**iv. Chlorophyll a**

Chlorophyll is the primary photosynthetic pigment in plants, both algae and macrophytes (*i.e.*, any aquatic plants larger than microscopic algae, including rooted aquatic plants). Because of its prevalence, measurement of chlorophyll can be used to estimate how much algae is present. Chlorophyll *a* (CHL-a) is a specific pigment in the chlorophyll family and plays a primary role in photosynthesis (USEPA, 2000).

USEPA (2001) cites a reference threshold of 2.1 µg/l chlorophyll *a* for ponds within Cape Cod's ecoregion, while use of the USEPA nutrient criteria methods to review the 2001 PALS Snapshot data results in a reference threshold of 1.7 µg/l when all data is considered and 1.0 µg/l when only "unimpacted" ponds are considered (see Table 5). Aherns and Siver (2000) survey of sixty Cape Cod lakes and ponds found the mean CHL-a concentration to be 3.07 µg/L with a range of 0.51 to 19.25 µg/L.

Figure 18 presents the comparison of the Cape Cod reference criterion for chlorophyll *a* with the 2001 Snapshot results by town. During the 2001 Snapshot sampling, 191 CHL-a samples were collected. The average of concentration of these samples is 8.44 µg/L with a range from 0.01 to 102.9 µg/L. Town results in Figure 18 show how many pond's surface water CHL-a concentrations are below the reference concentration (1.0 µg/l) based only on data from unimpacted ponds, above the reference concentration (1.7 µg/l) based on data from all the ponds, and how many are between these two concentrations. For example, volunteers from National Park Service at Cape Cod National Seashore collected surface CHL-a samples from seven ponds in Truro, four of which had concentrations that in the unimpacted category, one with a concentration in the impacted category, and two with concentrations between the two reference concentrations (see Figure 18). Overall, 73% of the ponds sampled during the 2001 PALS Snapshot had surface CHL-a concentrations in the impacted category. Additional pond by pond analysis of chlorophyll *a* and all other parameters would help gauge the severity of these impacts. Individual pond results are included in the town-specific sections of this Atlas.

Since CHL-a is the primary constituent for the application of the Carlson (1977) Trophic State Index (TSI), Atlas authors also used the Carlson Index to evaluate the 2001 PALS Snapshot data. This evaluation shows that 38% of the 191 ponds with surface chlorophyll *a* concentrations are in the oligotrophic category (TSI range of <30 – 40), 34% are in the mesotrophic category (TSI range of 40-50), 26% are in the eutrophic category (TSI range of 50-70) and 3% are in the hypereutrophic category (TSI range of 70 – 80). When these values are broken down by region, the percentage of oligotrophic ponds is: 35% of the Sagamore lens ponds, 37% of the Monomoy lens ponds, and 47% of the Outer Cape ponds. Figure 19 has the CHL-a TSI results grouped by town.

**v. Dissolved Oxygen and Temperature**

As mentioned in the above discussion, lake ecosystems are controlled by interactions among the physical, chemical and biological factors within the lake. The availability of oxygen determines distributions of various species; some require higher concentrations, while others are more tolerant of occasional low oxygen concentrations. Oxygen concentrations also determine the solubility of many inorganic elements; higher concentrations of phosphorus, nitrogen, and iron, among other constituents, occur in the hypolimnion when anoxic conditions convert bound, solid forms into soluble forms that are then released into the water column. Temperature negatively interacts with oxygen concentrations (*i.e.*, higher temperature water holds less

Figure 18.

# Chlorophyll a in Cape Cod Ponds: Comparison to Cape Cod Impacted Threshold

Surface Samples (0.5 or 1 m)

August 15 to September 30, 2001

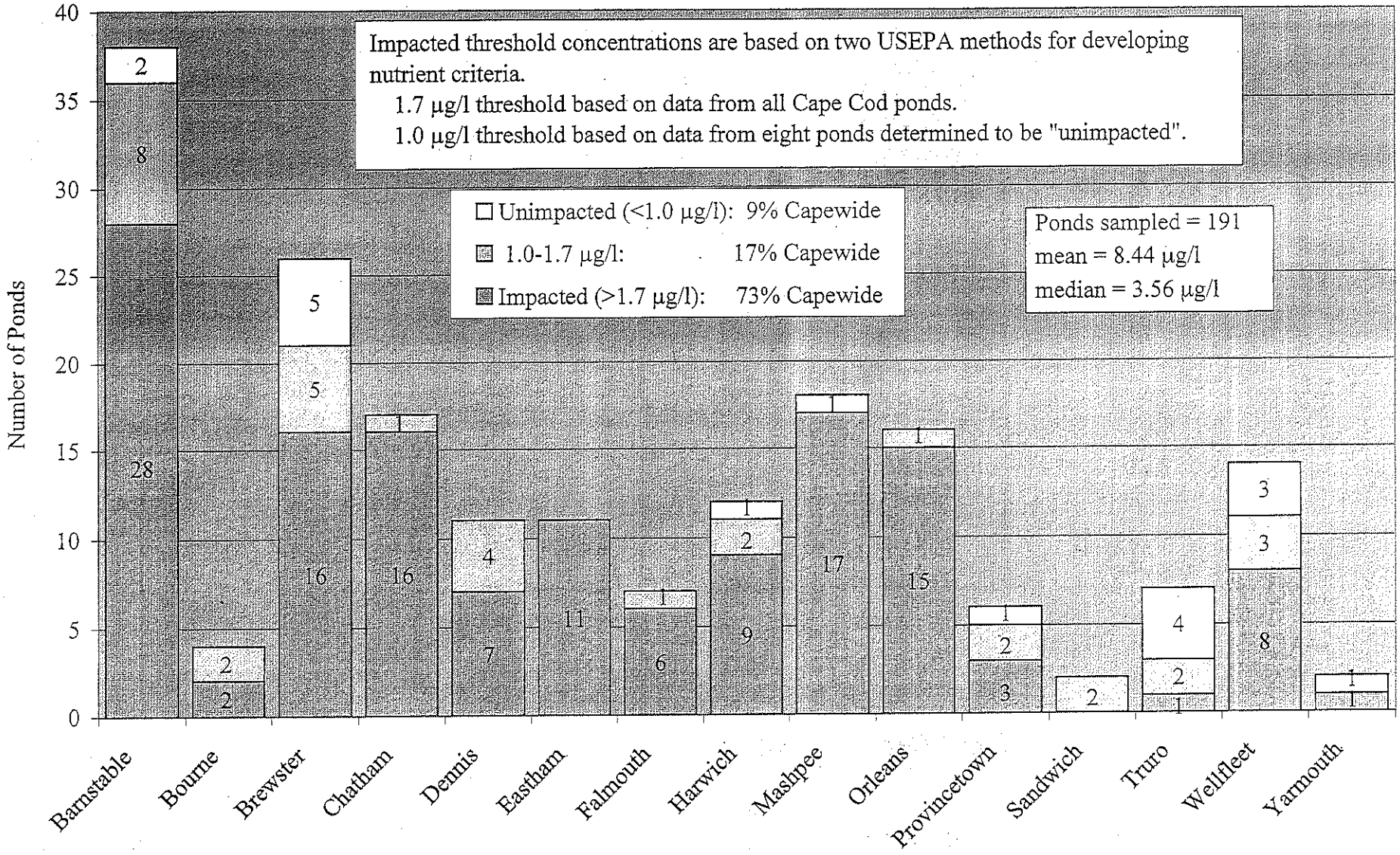
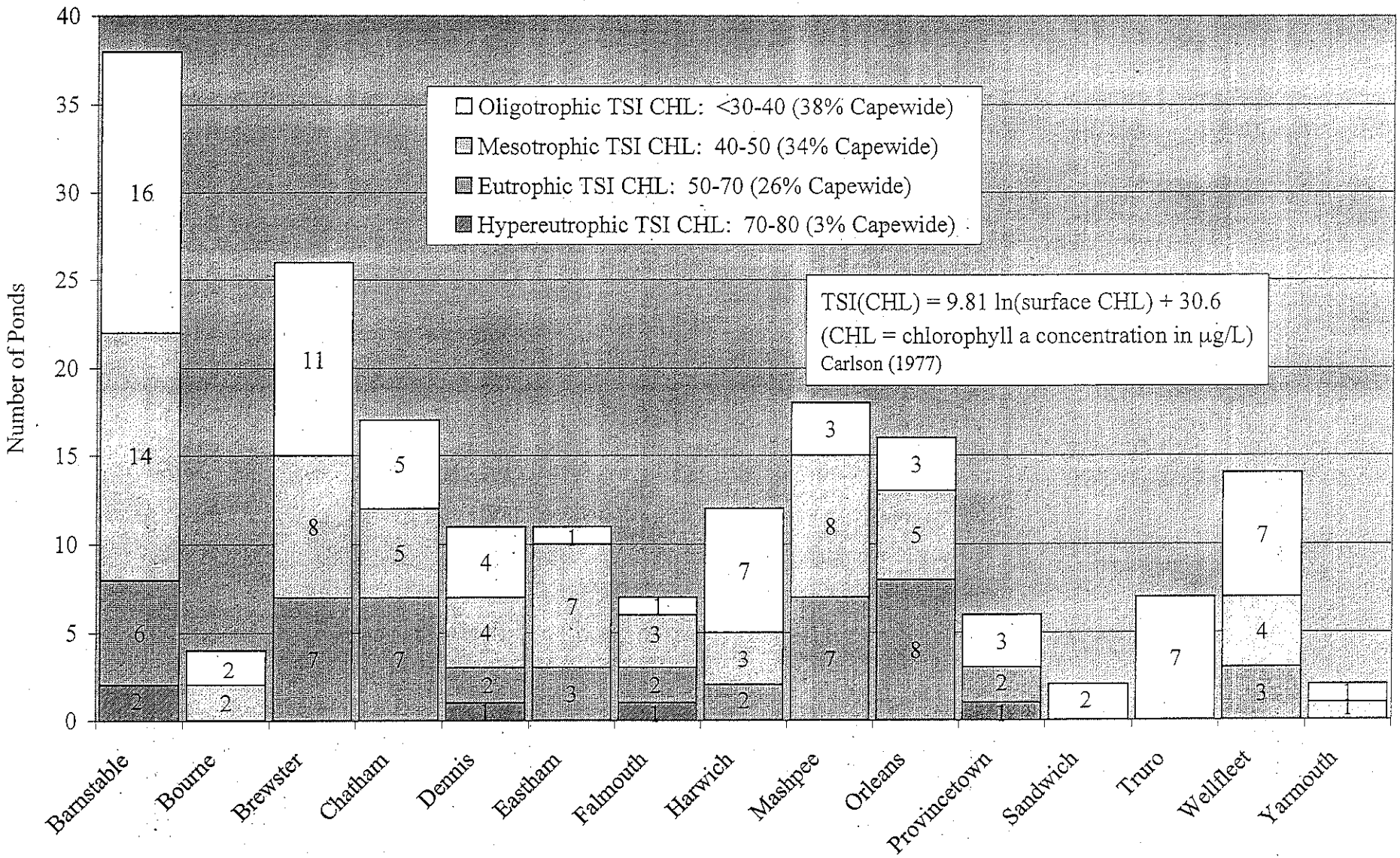


Figure 19.

# Carlson Chlorophyll Trophic Status Index (TSI)

## Cape Cod 2001 Snapshot Ponds: Surface Samples

August 15 to September 30, 2001



dissolved oxygen) and the formation of thermal layers (*i.e.*, stratification) in deeper lakes does not allow hypolimnetic waters to interact with the atmosphere.

Biological interactions can also impact DO concentrations. Since one of the main byproducts of photosynthesis is oxygen; a vigorous algal population can produce DO concentrations that are greater than the concentrations that would be expected based simply on temperature interactions. These instances of "supersaturation" usually occur in lakes with high nutrient concentrations, since the algal population would need readily available nutrients in order to thrive. In some lakes, algal populations can cause oxygen maxima deeper in the pond, at or near the metalimnion, where the algae can utilize higher phosphorus concentrations leaking through from the hypolimnion, while still having adequate, albeit low, light for photosynthesis.

The discussion of dissolved oxygen and temperature reinforces the consideration of depth in the characterization of lake ecosystems. Consideration of depth-related impacts contrasts with the USEPA reference methodology, save for Secchi depth. As discussed in the above Secchi section, depth considerations present a number of challenges when considering reference conditions. Although USEPA had DO information available, it chose not to include DO in the reference criteria. However, given the importance of oxygen in the survival of aquatic species, DO is a preeminent measure to consider in gauging the status of pond and lake ecosystems.

Whereas Secchi depth focuses on the upper portions of the water column, most of the focus in DO discussions is on the deepest (or hypolimnetic) waters of ponds. DO concentrations in the deepest parts of lakes are a function of the amount of oxygen consumption by bacteria in the sediments as they decompose organic matter deposited in the sediments and the temperature of the water. Higher oxygen demand by the bacteria will reduce the oxygen concentrations, which is balanced somewhat by the increased ability of lower temperature water to hold more dissolved oxygen. Oxygen concentrations in surface waters will be the result of temperature, oxygen demand from the sediments, and how well winds mix oxygen into the waters from the atmosphere. DO concentrations in hypolimnetic waters will usually be determined by the oxygen content of the water at the time of stratification minus whatever bacterial consumption occurs; if bacteria consume all the oxygen, it cannot be replenished because the thermal layering prevents these waters from being replenished by the atmosphere.

Figure 20 shows DO concentrations at the deepest measuring point in ponds measured during the 2001 Snapshot sampling. Measurements in Figure 20 are further divided into those from ponds that should stratify (depth >9 meters) and those not likely to stratify (depth ≤9 meters). Of the 151 non-stratifying ponds, 35 (or 23%) had anoxic conditions in their deepest waters. Of the 35 stratifying ponds, 28 (or 80%) had anoxic conditions in their deepest waters. Overall, 34% of the ponds measured during the 2001 Snapshot sampling had anoxic conditions and 45% had deep water with concentrations that would be a concern for fish survival (≤4 ppm).

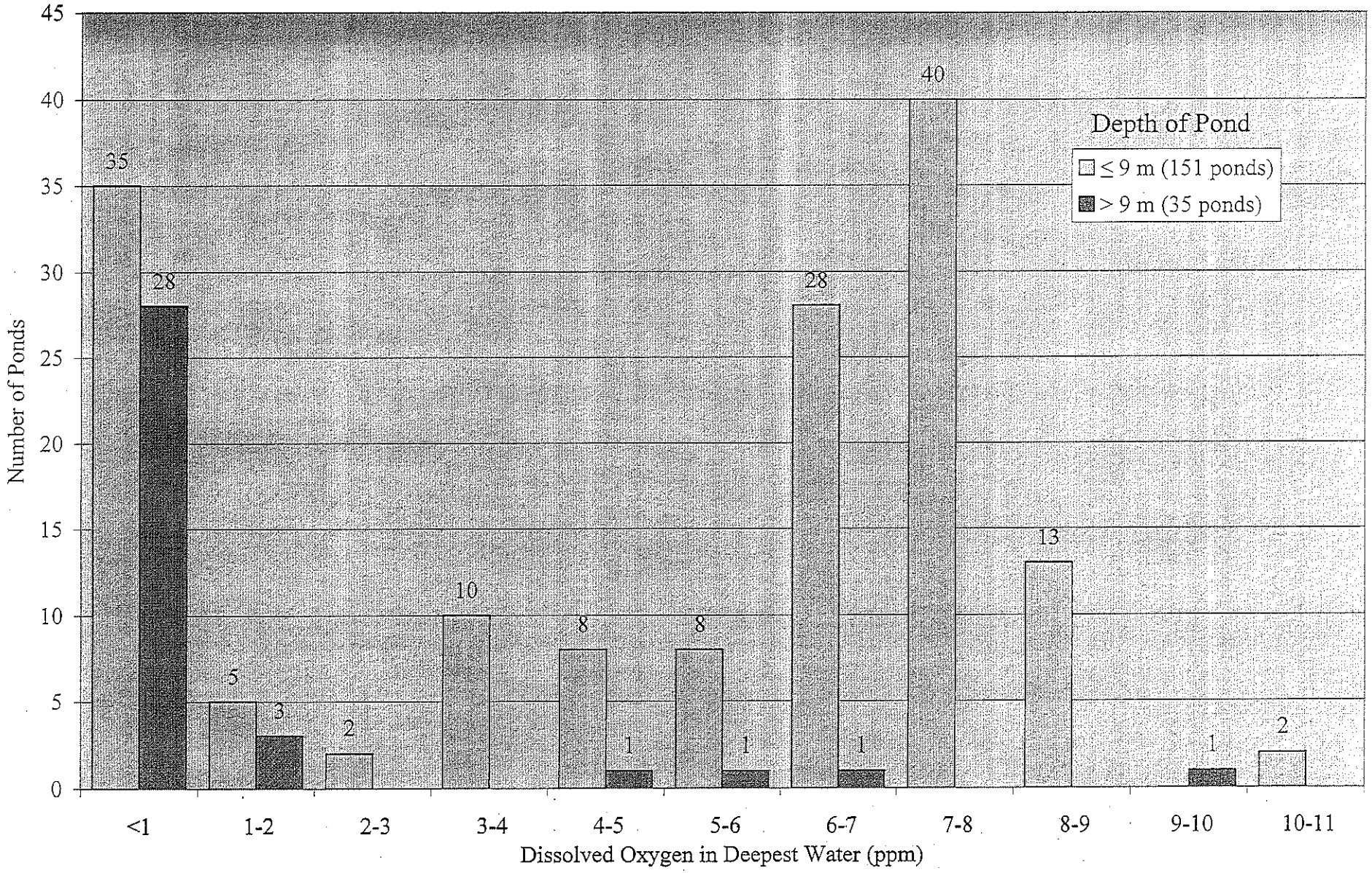
**vi. pH and Alkalinity**

pH is a measure of acidity; pH values less than 7 are considered acidic, while pH values greater than 7 are considered basic. pH is the negative log of the hydrogen ion concentration in water (*e.g.*, water with a $H^+$ concentration = $10^{-6.5}$ has a pH of 6.5). pH is determined by the interaction of all of the ions with carbon species, like carbon dioxide, carbonate, and bicarbonate, having the most direct effect (Stumm and Morgan, 1981). The pH of rainwater, in equilibrium with carbon dioxide in the atmosphere, is 5.65. Photosynthesis takes carbon dioxide and hydrogen ions out of the water causing pH to increase, so more productive lakes will tend to have higher pH measurements. Alkalinity is a measure of the compounds that shift pH toward

Figure 20.

# Cape Cod Ponds: Deepest Dissolved Oxygen by General Stratification Depth

August 15 to September 30, 2001



more basic values, is mostly determined by the concentrations of bicarbonate, carbonates, and hydroxides, and is a measure of the capacity of waters to buffer acidic inputs. Consequently, pH and alkalinity are linked values.

Since the sand deposited as Cape Cod during the last glacial period does not have carbonate minerals, Cape soils have low alkalinity and little capacity to buffer the naturally acidic rainwater that falls on the Cape. Aherns and Siver (2000) found an average pH of 6.1 with a range of 4.4 to 8 and an average alkalinity of 1.95 mg/L as $CaCO_3$ in the 60 ponds they measured in 1997 and 1998. The median pH among the 18 lakes sampled on Cape Cod as part of the Acid Rain Monitoring Program was 5.95. Median pH concentration in 20 ponds monitored in Cape Cod National Seashore is 5.1, while the median alkalinity concentration is 0.22 mg/L as $CaCO_3$ (Portnoy, *et al.*, 2001b).

USEPA chose not to include pH or alkalinity as values for the development of reference criteria, likely because lower pH and alkalinity measures are not necessarily indicative of unimpacted ecosystems. Extremely low pH values would be associated with acid rain impacts. Values of 6 to 8 are generally acceptable pH values in state water quality standards, but it is unclear what a "natural" range on Cape Cod is.

The average surface pH of 193 ponds sampled in the 2001 Snapshot is 6.16 with a range of 4.38 to 8.92, while the average alkalinity is 7.21 mg/L as $CaCO_3$ with a range of 0 to 92.1. If the USEPA (2000) lower 25$^{th}$ percentile reference condition method is applied to all the 2001 Snapshot surface water data, the Cape Cod reference pH threshold is 5.62 and the reference alkalinity threshold is 1.55 mg/L as $CaCO_3$. Figure 21 shows the application of the Cape Cod pH reference threshold to the 2001 Snapshot results by town.

Within the towns in Figure 21 the percentage of ponds above the reference threshold varies widely. In most of the Outer Cape towns, where most of the ponds are located within the Cape Cod National Seashore, the percentage of ponds below the threshold approaches or exceeds 50% of the ponds measured, led by Provincetown with all six ponds with pHs less than 5.625. In contrast, 82% (9 of 11) ponds in Eastham, which are all located outside of the National Seashore, are above the threshold. In other towns, the percentage of ponds above the threshold range from 54% (Dennis) to 100% (Bourne, Falmouth, Sandwich). Application of the alkalinity reference condition results in essentially the same percentages.

Since acid rain is a concern in many lakes on the Cape because of the limited alkalinity, pH values in lakes can also be lower than the 5.65 expected based on simple equilibrium with atmospheric carbon dioxide. This is especially important for the lakes that are largely unimpacted by nutrients from surrounding land use because the counteracting influences of photosynthesis is not available to buffer the pH-lowering inputs from acid rain. When the ponds are grouped into three regions, those in the Sagamore lens, those in the Monomoy lens, and those on the outer Cape, the percentage of sampled ponds with surface water pH's less than 5.65 are 15%, 23%, and 50%. This analysis shows that half of the ponds sampled on the outer Cape have pH's that may be indicative of acid rain impacts; refined analysis of individual ponds and other measures would be required to further clarify the impacts.

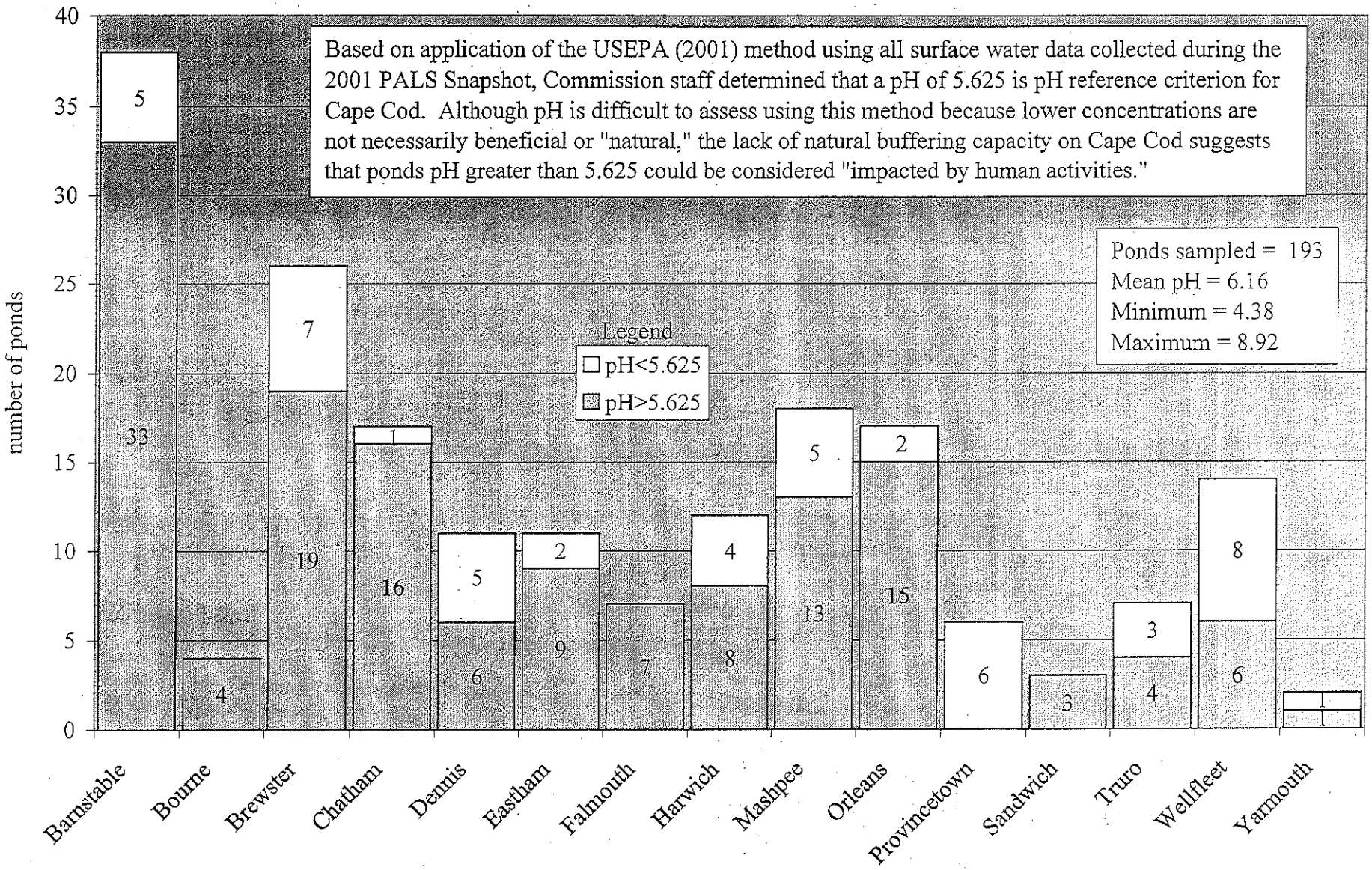
### *B. Other Cape Cod Pond Monitoring*

The PALS Snapshots are one aspect of the monitoring that is underway to better characterize the condition of Cape Cod ponds. Other monitoring projects have included: mercury in fish tissue, water levels, and Secchi disk depths. Each of these projects are briefly discussed below.

Figure 21.

# pH in Cape Cod Ponds: Comparison to Cape Cod Reference Criteria

Surface Samples only



*1. Mercury*

Mercury is a naturally occurring element that is often released into the atmosphere by burning of fossil fuels. Mercury is also neurotoxin that can concentrate in fish to levels that are of health concern for humans that eat them. Studies of lake pH levels and concentrations of mercury in fish have shown that low pH/acidic conditions generally favor high mercury concentrations (*e.g.*, Greenfield, *et al.* (2001), MADEP (1997)). Given the generally low pH of most Cape Cod ponds (see above), this relationship has raised concerns about the safety of consuming fish caught in these ponds.

Currently, Massachusetts Department of Public Health lists 111 ponds and lakes in the commonwealth with various forms of fish consumption advisories, mostly related to mercury impacts (see http://www.state.ma.us/dph/beha/fishlist.htm for the entire list). Nine of these ponds are located within Barnstable County. A total of 18 Cape Cod ponds have been tested for mercury contamination by either MADEP, the Cape Cod Commission or the National Park Service.

Three of the nine ponds were included on the advisory list following fish tissue testing by the Cape Cod Commission during the summer of 2001 under a grant from USEPA (Michaud, 2001). This testing also indicated a number of ponds with fish that had mercury concentrations above health thresholds, but the sample sizes were too small for the issuance of health advisories. Given the high percentage of advisories issued for the number of ponds tested and the relationship between low pH and high mercury concentrations in fish tissue, the Commission has been encouraging DEP and DPH to conduct additional testing.

*2. Pond Water Levels*

As mentioned previously, pond water levels on Cape Cod generally fluctuate with groundwater levels. The Cape Cod Commission has been gathering groundwater levels from a regional network of 60 to 65 wells since the early 1970's. This monitoring supports US Geological Survey (USGS) programs and provides the data necessary for groundwater separation calculations required in the state septic system regulations (310 CMR 15: Title 5). The historic database of groundwater levels is an important resource for management of the water on Cape Cod.

Pond water level monitoring, up until recently, had not received similar support. Volunteers from the Association for the Preservation of Cape Cod (APCC) gathered monthly water level reading on a dozen Cape ponds between May and September since 1973. In 1985, the DEP instituted water withdrawal permitting for public supply wells, which required suppliers with wells near ponds to monitor pond levels. In 1994, the Cape Cod Commission began the monitoring of 24 ponds in the Monomoy Lens with a volunteer "Adopt-a Pond" program. Each of these programs ran into problems with maintaining staff gauges and finding volunteers.

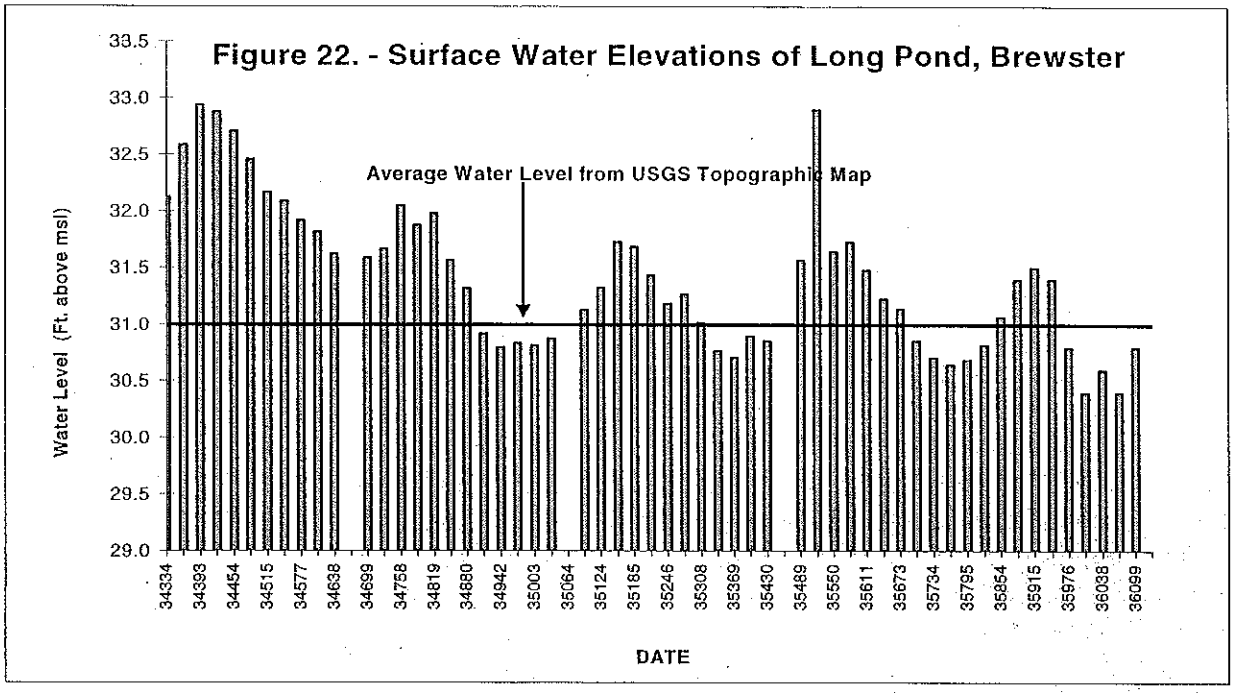
In order to provide a more reliable method of pond water level measurements, the Commission contracted with the USGS in 1997 to install stilling wells adjacent to 12 ponds. These wells connect with the surface waters providing a permanent water level measuring without the need for gauge replacement or resurveying. However, these gauges have been subject to some of the same vandalism and maintenance concern as the staff gauges. In the spring of 2002, APCC requested that the Cape Cod Commission add the seven remaining ponds measured by APCC volunteers to the larger pond network coordinated by the Commission.

Currently, water levels in 29 ponds are monitored in the Cape Cod Water Level Network (Table 6). Most of the levels are collected by volunteers and the data collection, network

maintenance, and database support is provided by the Cape Cod Commission. Another 14 ponds are monitored by various public drinking water suppliers as a condition of water withdrawal permits.

| Table 6. Summary of Surface Water Level Monitoring - Cape Cod, 1973-2002 | | | | |
|---|---|---|---|---|
| APCC Pond Monitoring | Water District Pond Monitoring | Adopt a Pond Program | USGS Stilling Wells | Cape Cod Water Level Network |
| **Start - 6/73** | **1985 -1998** | **Start – 5/94** | **Start – 10/97** | **August 2002** |
| Ashumet (FA) | Flintrock (BA) | Blueberry (BR) | Bakers (OR) | Blueberry (BR) |
| Crocker (FA) | Halfway (YA) | Cliff (BR)* | Flax (HA) | Little Cliff (BR) |
| Great (TR) | Hog (SA) | Elbow (BR)* | Flax (BR) | Long (BR) |
| Gull (WE) | Horse (YA) | Higgins (BR)* | Hathaway (BA) | Ruth (BR) |
| Horseleech (TR) | Israel (BA) | Little Cliff (BR) | Little Cliff (BR) | Upper Mill (BR) |
| Jemima (EA)* | Lewis (BA) | Long Pond (BR) | Run (DE) | Cobbs (BR) |
| Ryder (TR) | Long (FA) | Lower Mill (BR)* | Upper Mill (BR) | Griffiths (BR) |
| Snake (SA) | Lovers (CH) | Ruth (BR) | Wash (OR) | Flax (BR) |
| Spectacle (SA) | Mary Dunn (BA) | Walkers (BR)* | Wequaquet (BA) | Bakers (DE) |
| White (CH) | Rafes (BR) | Cobbs (BR) | White (CH) | Run (DE) |
| | Robins (HA) | Griffiths (BR) | | Aunt Edies (HA) |
| | Sandy (YA) | Flax (BR) | | Flax (HA) |
| | White (DE) | Bakers (DE) | | John Joseph (HA) |
| | Crooked (FA) | Run (DE) | | Long (HA) |
| | | Aunt Edies (HA) | | Bakers (OR) |
| | | Flax (HA) | | Crystal (OR) |
| | | John Joseph (HA) | | Pilgrim (OR) |
| | | Long (HA) | | Uncle Harveys (OR) |
| | | Olivers (HA)* | | Wash (OR) |
| | | Bakers (OR) | | White (CH) |
| | | Cedar (OR)* | | Wequaquet (BA) |
| | | Crystal (OR) | | Hathaway (BA) |
| | | Pilgrim (OR) | | Crocker (FA) |
| | | Uncle Harveys (OR) | | Spectacle (SA) |
| | | Wash (OR) | | Snake (SA) |
| | | White (CH) | | Great (TR) |
| | | | | Horseleech (TR) |
| | | | | Ryder (TR) |
| * Discontinued | | | | Gull (WE) |

Beginning in the spring of 2003, the Commission hope to replace all surfaces gauges used throughout the Cape to improve data consistency. Data for all the wells is reported monthly by volunteers and is entered into a computer database and periodically reported to the USGS. Figure 22 presents an example pond hydrograph.

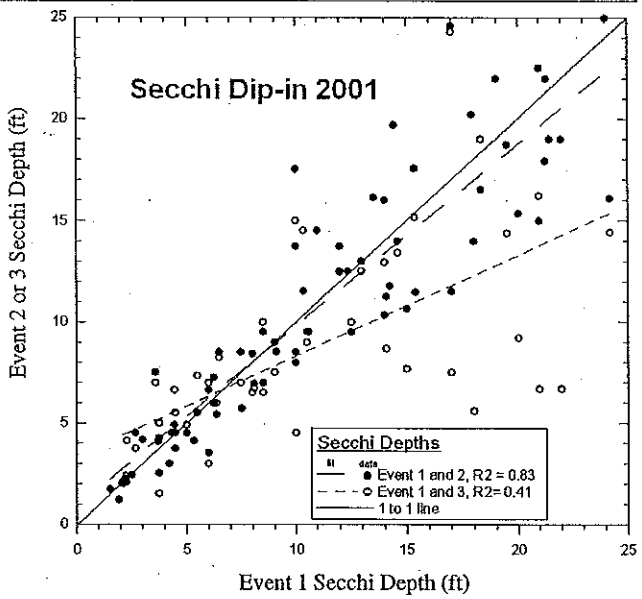



*3. PALS Secchi Disk Monitoring*

As mentioned previously, at the first "Ponds in Peril" workshop in May 2001, prospective Pond and Lake Stewards (PALS) were encouraged to begin collecting Secchi disk readings. Over 100 Secchi disks were distributed free of charge to volunteers along with postage-paid, preaddressed postcards for reporting of results. Cape Cod Commission staff coordinated these activities and ensured that each pond had only one sampler. Samples were collected in early July, late July, and early August.

A total of 66 volunteers participated in the first measurement of 107 ponds. Repeat measurements scheduled for late July and early August were made for 83 and 65 ponds, respectively, with 55 and 45 volunteers participating for each measurement event. Results collected between June 29 and July 14 were submitted to the Great North American Secchi Dip-In, which is coordinated through Kent State University (http://dipin.kent.edu/) and the North American Lake Management Society. Results for all three measurement events were presented at the second "Ponds in Peril" workshop.

Figure 23. 2001 Secchi Dip-In: Comparison of Results




Water clarity generally declined by a larger magnitude between the first and third measurement events as compared to the decline observed between the first and second events (Figure 23). Overall, more than half of the ponds experienced reduced water clarity.

*4. CCNSS Supported Monitoring*

In 2002, Cape Cod National Seashore (CCNS) received funding from the Community Foundation of Cape Cod to support pond sampling throughout the summer for a number of towns. Orleans, Eastham, Brewster, and Dennis extended the volunteer networks developed during the 2001 PALS Snapshot and collected samples from 54 ponds at various intervals between late May and mid-November. Samples were analyzed at the CCNS's North Atlantic Coastal Laboratory for total nitrogen, total phosphorus, nitrate-nitrogen, ortho-phosphorus, and chlorophyll *a*. Field data collection included Secchi depth readings and temperature and dissolved oxygen profiles. Sample collection depths generally mirrored the protocol developed for the PALS Snapshot sampling. The laboratory results were made available in early 2003, so analysis and interpretation of the data has not occurred at the time this is being written. The CCNS has secured funding from the state Coastal Zone Management program to continue the pond sampling program during the summer of 2003.

This sampling also supplements the regular pond monitoring that the CCNS conducts for the ponds within the CCNS boundaries. Summaries of sampling conducted in CCNS ponds are included in Portnoy, *et al.* (2001a and 2001b).

*5. Invasive/Exotic Species*

The state Department of Environmental Management (DEM) has recently initiated a "Weed Watchers" program to use trained citizen volunteers to monitor ponds for invasive species. Exotic invasive species are species that are not native to an ecosystem whose introduction causes economic or environmental harm. Among the more notable examples of invasive species are zebra mussels, which are native to Asia, grow with such vigor that they are altering nutrient dynamics throughout the Great Lakes, clog municipal drinking water intakes, and are estimated to have the potential to cause $3.1 billion worth of damage (OTA, 1993).

In Cape Cod ponds, aquatic plants are usually the primary invasive species concern. Given that the pond ecosystems on Cape Cod are relatively rare in the United States, there are a number of species that are correspondingly rare and likely to be threatened by exotic invasive species. Bakers Pond in Orleans is part of a group of five pilot ponds located throughout Massachusetts where volunteers received training to identify and monitor exotic invasive species.

A recent example of an invasive aquatic plant was the detection and treatment of hydrilla (*Hydrilla verticillata*) in Long Pond in Barnstable. Hydrilla is of tropical Asian origin, but has shown a high level of adaptability. According Langeland (1996), hydrilla was first discovered in the United States in 1960 at two Florida locations and it spread throughout the state very rapidly; covering 20,000 ha by 1988 with a jump to 40,000 ha in 43% of the public lakes by 1995 (Figure 24). Long Pond was the first identification of hydrilla in Massachusetts and DEM and the town responded rapidly to address the potential threat.

Hydrilla was identified in early 2002. By June, the state and the town has appropriated approximately $50,000, selected a herbicide contractor, and completed the application. Sonar®, which has an active ingredient called fluridone, was applied on June 6 and the concentration was reinforced on July 11. Sonar® acts by inhibiting photosynthesis and has been show to be fairly selective in low concentrations for the control of other aquatic invasives (Madsen, *et al.*, 2002).

Given the potential rapid spread, extensive impact, and number of pond ecosystems that could be impacted on the Cape, public education and assistance is necessary to ensure that exotic invasives do not gain a foothold on Cape Cod.

Figure 24. Hydrilla at Wakulla Springs, Florida

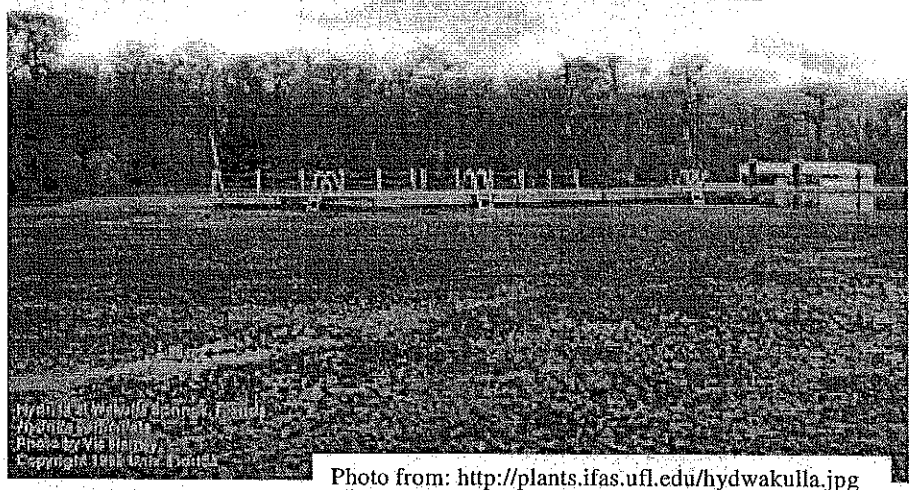


Photo from: http://plants.ifas.ufl.edu/hydwakulla.jpg

*6. Safe Swimming Beaches*

Since Cape Cod ponds are used extensively for swimming, ensuring that waters are safe for swimming is an important pond management consideration. In 2001, Massachusetts adopted the Beaches Bill, which required regular testing of all public and semi-public bathing beaches. State regulations to implement the law are contained 105 CMR 445 and require weekly bacterial testing. The Barnstable County Department of Health and Environment conducts most of the laboratory analyses for Cape towns and maintains the results on a portion of their website (www.barnstablecountyhealth.org/bsgeneralinfo.htm).

Review of 2001 and 2002 testing shows that beaches at Cape Cod ponds are safe for swimming. Of the 1,112 samples collected from 83 pond beaches tested in 2001, 15 samples (or 1.5%) exceeded the limit of 235 E. coli colony forming units allowed per 100ml sample. In 2002, 928 samples were collected from 74 pond beaches and 10 (or 1.1%) exceeded the limit. Between the two years, only two samples persisted beyond one day and no tested ponds had consistent exceedences. Table 7 lists the ponds sampled.

Table 7.

# Cape Cod Freshwater Beaches Bacterial Testing

2001-2002

| POND | TOWN | 2001 # Samp | 2001 # Fail | 2002 # Samp | 2002 # Fail |
|---|---|---|---|---|---|
| Garretts Pond | BAR | 13 | 0 | 13 | 0 |
| Wequaquet Town | BAR | 13 | 0 | 14 | 1 |
| Wequaquet Yacht | BAR | 13 | 0 | 13 | 0 |
| Gooseberry Pond | BAR | 13 | 0 | 13 | 0 |
| Shallow Pond | BAR | 13 | 0 | 14 | 1 |
| Long Pond | BAR | 13 | 0 | 13 | 0 |
| Hathaway Pond | BAR | 13 | 0 | 13 | 0 |
| Mystic Lake Town | BAR | 13 | 0 | 4 | 0 |
| Mystic Lake Race Ln | BAR | 13 | 0 | 13 | 0 |
| Middle Pond | BAR | 13 | 0 | 13 | 0 |
| Hamblin Pond | BAR | 14 | 1 | 13 | 0 |
| Shubael Pond | BAR | 13 | 0 | 13 | 0 |
| Lovells Pond | BAR | 13 | 0 | 13 | 0 |
| Joshua's Pond | BAR | 13 | 0 | 13 | 0 |
| Crystal Lake | BAR | 11 | 1 | | |
| Bearses Pond | BAR | 13 | 0 | 14 | 1 |
| Queen Sewell | BOU | 13 | 0 | 13 | 0 |
| Picture Lake | BOU | 13 | 0 | 13 | 0 |
| Slough pond | BRE | 14 | 1 | 13 | 0 |
| Upper Mill Pond | BRE | 12 | 0 | 13 | 0 |
| Long Pond | BRE | 12 | 0 | 13 | 0 |
| Sheep Pond | BRE | 12 | 0 | 13 | 0 |
| Seymour Pond | BRE | 12 | 0 | 13 | 0 |
| Blueberry Pond | BRE | 9 | 0 | | |
| Greenland Pond | BRE | 9 | 0 | | |
| Round Pond | BRE | 1 | 0 | | |
| Elbow Pond | BRE | 1 | 0 | | |
| Princess | DEN | 12 | 0 | 14 | 1 |
| Scargo | DEN | 12 | 0 | 13 | 0 |
| Flax Pond | DEN | 12 | 0 | 13 | 0 |
| Long Pond (Depot St) | EAS | 14 | 0 | 13 | 0 |
| Herring Pond | EAS | 14 | 0 | 13 | 0 |
| Wiley Park | EAS | 14 | 0 | 13 | 0 |
| Minister Pond | EAS | 14 | 0 | 13 | 0 |
| Great Pond | EAS | 14 | 0 | 13 | 0 |
| Grews Pond | FAL | 12 | 0 | 10 | 0 |
| Ashumet Pond (right of landing) | FAL | | | 1 | 0 |
| Ashumet Pond (Landing) | FAL | | | 13 | 2 |
| Coonamessett Pond | FAL | 1 | 0 | | |
| Buck Pond | HAR | 13 | 0 | 13 | 0 |
| Sand Pond | HAR | 13 | 0 | 13 | 0 |
| Robbins Pond | HAR | 13 | 0 | 13 | 0 |
| Hinkley's Pond | HAR | 13 | 0 | 13 | 0 |
| Long Pond 1(Cahoon St) | HAR | 13 | 0 | 13 | 0 |
| Long pond 2 | HAR | 13 | 0 | 13 | 0 |
| Long Pond 3 (Rte 124) | HAR | | | 13 | 0 |
| Seymour Pond | HAR | 13 | 0 | 13 | 0 |
| Aunt Edies Pond | HAR | 8 | 1 | | |
| John Josephs Pond | HAR | 7 | 0 | | |
| Hawksnest Pond | HAR | | | 3 | 0 |
| Skinequit Pond | HAR | | | 13 | 0 |
| Fells Pond | MAS | 13 | 0 | 13 | 0 |
| Dean's Pond | MAS | 14 | 1 | | |
| Ashumet Pond N | MAS | 11 | 0 | | |
| Ashumet Fisherman's Cove | MAS | 13 | 0 | | |
| Ashumet Pond S | MAS | 9 | 0 | | |
| Johns Pond | MAS | 13 | 0 | 13 | 0 |
| John's Pond (Briarwood) | MAS | 13 | 0 | 13 | 0 |
| John's Pond (N) | MAS | 13 | 0 | 13 | 0 |
| Santuit Pond | MAS | 13 | 0 | 13 | 0 |
| Wakeby (Camp Farley) | MAS | 12 | 0 | 13 | 0 |
| Wakeby Attaquin | MAS | 13 | 0 | 15 | 1 |
| Wakeby (Pickerel Cove) | MAS | 1 | 0 | | |
| Crystal Lake | ORL | 13 | 0 | 13 | 0 |
| Pilgrim Lake | ORL | 13 | 0 | 13 | 0 |
| Bakers Pond | ORL | 13 | 0 | 13 | 0 |
| Shawme Pond | SAN | 12 | 3 | | |
| Hoxie Pond | SAN | 12 | 0 | 13 | 0 |
| Lawrence Pond | SAN | 13 | 1 | 13 | 0 |
| Triangle Pond | SAN | 12 | 0 | 13 | 0 |
| Spectacle Pond | SAN | 12 | 0 | 15 | 2 |
| Wakeby Pond | SAN | 12 | 0 | 10 | 0 |
| Pimlico Pond | SAN | 12 | 0 | 13 | 0 |
| Peter's Pond | SAN | 12 | 0 | 13 | 0 |
| Snake Pond | SAN | 12 | 0 | 13 | 0 |
| Long Pond | WEL | 13 | 0 | 13 | 0 |
| Gull Pond | WEL | 13 | 0 | 13 | 0 |
| Higgins Pond | WEL | 13 | 0 | 13 | 0 |
| Herring Pond | WEL | 13 | 0 | 13 | 1 |
| Dyer Pond | WEL | 13 | 0 | 13 | 0 |
| Great Pond | WEL | 13 | 0 | 12 | 0 |
| Duck Pond | WEL | 13 | 0 | 12 | 0 |
| Spectacle Pond | WEL | | | 11 | 0 |
| Turtle Pond | WEL | 1 | 0 | | |
| Flax Pond | YAR | 18 | 1 | 12 | 0 |
| Long Pond (Lyman) | YAR | 20 | 3 | 13 | 0 |
| Long Pond (Indian Mem. Dr.) | YAR | 18 | 1 | 13 | 0 |
| Little Sandy Pond | YAR | 19 | 1 | 13 | 0 |
| Dennis Pond | YAR | 19 | 0 | 13 | 0 |

= not tested

failure is 235 or more of E. coli colony forming units per 100ml sample

source of data: Barnstable County Department of Health and Environment

towns not listed have samples tested by other laboratories

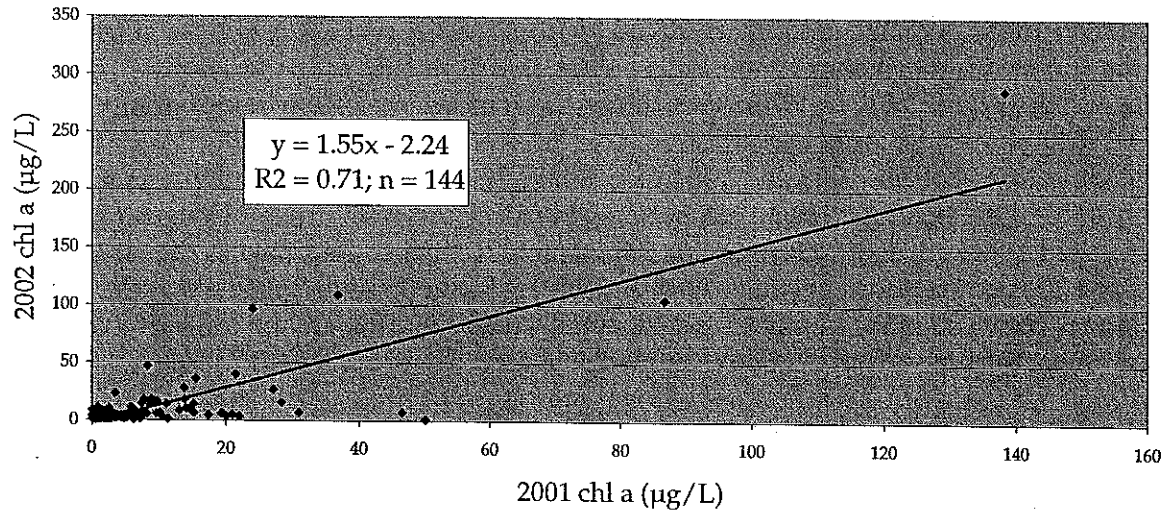
## III. Overall Regional Condition of Cape Cod Ponds

Cape Cod is blessed with nearly 11,000 acres of fresh water ponds. As with all of the Cape's waters, the strong attraction this blessing creates has brought an ever increasing population to their shores. It is clear from the previously discussed comparisons to individual measures of available standards that the impacts of this increase in population have been observed in most of Cape Cod's ponds.

Data from the 2001 PALS Snapshot was used to develop Cape Cod-specific nutrient criteria using a methodology developed by USPEPA. This review of nutrient criteria for total phosphorus (TP), total nitrogen (TN), and chlorophyll a (CHL-a) indicates that only 7 to 16% of the Cape's ponds are "unimpacted" by human activities.

Because the 2001 PALS Snapshot data is only indicative of one year's water quality and the Snapshot is designed to assess these ponds during what is likely to be their worst water quality conditions, additional, longer term data is necessary to evaluate how representative the Snapshot data is of general ecological conditions in Cape Cod ponds. Although the 2002 PALS Snapshot data has only recently been made available and further review is warranted, a simple comparison between 2001 and 2002 data set should help to address this issue. Figure 25 presents the comparison between chlorophyll a concentrations in surface samples in 2001 and 2002 and shows a fairly good consistency ($R^2 = 0.71$) between the two years. Further comparisons between other variables measured during the PALS Snapshots should help to understand the expected variability in some of the measures used and continuation of the PALS Snapshot monitoring will help to clarify the year to year variability in the ponds' conditions. In addition, sampling programs that collect samples throughout the year or throughout the summer would help to clarify seasonal variability, the development of the conditions observed during the PALS Snapshot season, and variability during the summer.

**Figure 25. Comparison of 2001 and 2002 PALS Chlorophyll a Surface Concentrations**




While nutrient criteria can be used to assess whether ponds are ecologically "impacted", questions still remain whether "impacted" is necessarily the same as "impaired." Low oxygen

conditions are a well-defined habitat impairment; recent efforts have better defined the level of impairment, including quantifying impairment of fish breeding success in low oxygen conditions (*e.g.*, Wu, *et al.*, 2003).

Because this is a well-defined impairment, the Atlas authors reviewed deep DO concentrations to assess how many of the ponds might be classified as "impaired.' This analysis indicates 23% of the "shallow" ponds had anoxic conditions in their deepest waters, while 34% had hypoxic (≤4 ppm DO) conditions. Shallow ponds are defined as those with a maximum depth of 9 m or less; 151 of these ponds were measured during the 2001 PALS Snapshot. When the 35 deepest ponds (maximum depth of greater than 9 m) are evaluated, 80% had anoxic conditions in their deepest waters and 89% had hypoxic conditions. Overall, 34% of the ponds (68 of 186) measured during the 2001 Snapshot sampling had anoxic conditions and 45% (83 ponds) had hypoxic conditions. These ponds could reasonably be considered "impaired."

Some might debate that a number of the ponds, especially the deeper ponds, naturally have anoxic or hypoxic conditions in their deeper waters. In order to try to address this issue, dissolved oxygen readings in the same ponds in both 1948 and 2001 were compared. The PALS Snapshot data is the source of the 2001 data. MADFG (1948) is the source of the 1948 data and contains DO data for 51 ponds collected between July 6 and August 26, 1948.

The focus of the 1948 data is generally on trout fisheries, so DO profiles are usually not continuous. In addition, the 1948 depths were measured in feet, while the PALS depths were measured in meters. Data were generally matched to within one meter of depth readings in the two years, although some bottom readings were up to 2 m off. Readings collected in 41 ponds in 2001 are matched by comparable 1948 readings; a total 156 matched readings are available. The average difference in depth over 156 readings is 0.057 m.

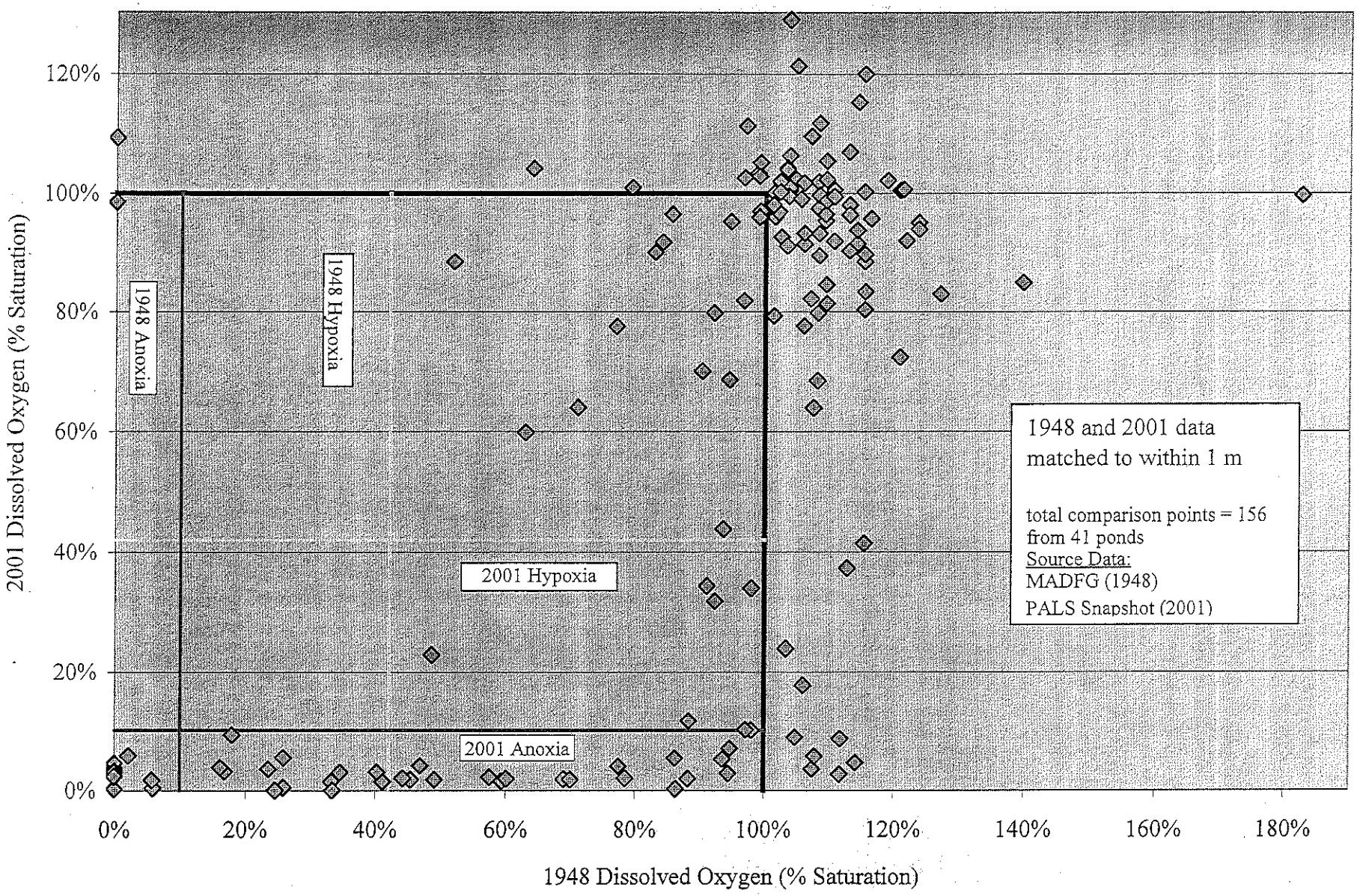
In order to minimize temperature-related DO differences and allow a better comparison between the 1948 and 2001 datasets, concentration data was converted to percent saturation. In the temperature range observed in both 1948 and 2001 (10 to 24°C), a 4 ppm DO concentration (*i.e.*, a hypoxic threshold) is between 36 and 48% saturation, while a concentration of 1 ppm (*i.e.*, an anoxic threshold) is between 9 and 12% saturation. The following analysis used the average of 42% DO saturation as a hypoxia threshold and 10% saturation as an anoxia threshold.

The comparison of the DO saturation values shows 76% of the matched readings are lower in 2001 than 1948. Average percent saturation in 1948 is 83%, while it is 60% in 2001. In 1948, 17 of the 156 readings had anoxic saturation values of 10% or less, while in 2001 51 readings were anoxic (Figure 26). In 1948, 30 readings had hypoxic saturation values of 42% or less, while in 2001, 62 readings were hypoxic.

This comparison between 1948 and 2001 data generally shows that water quality in a approximately 75% of the ponds reviewed has been degraded. Thirty-two of the 41 ponds (78%) reviewed developed hypoxic conditions between 1948 and 2001. Thirty-four (34) of the ponds (83%) developed anoxic conditions between 1948 and 2001. These findings suggest that the low DO concentrations observed in the ponds are not "natural" conditions, but are the reflection of 50 years worth of impacts from surrounding development and use.

Figure 26.

# Comparison of 1948 and 2001 Dissolved Oxygen in Cape Cod Ponds and Lakes



## IV. Summary and Next Steps

The review of current USEPA nutrient thresholds, Cape Cod nutrient thresholds, dissolved oxygen concentrations, and comparison of 1948 and 2001 dissolved oxygen concentrations suggest that the water quality in Cape Cod ponds is impacted by surrounding development and, in many cases, is impaired by the same development. Based on information in this Atlas, between 74 and 93% of the Cape's ponds are impacted by surrounding development or uses. Based largely on dissolved oxygen information, approximately 45% of all the ponds and 89% of the deepest ponds are impaired.

Because many of these impairments are not readily observed from the surface, the extent of the impairment is often seen only when there is a fish kill or an algal bloom. Actions to correct these impairments will depend on community and state priorities.

Although the ecological comparisons show significant impairments of pond ecosystems, bacterial testing of ponds show that these ponds generally provide healthy conditions for swimming. Concerns have also been raised about eating fish from selected ponds and about conflicts among various users (*e.g.*, jetskis), but recent measurements of property values and sale of pondfront properties have shown significant upward trends. Active discussion of management strategies for these ponds may lead to refinement of pond users' expectations for habitat and recreation.

Gathering additional water quality readings in these ponds can serve dual purposes of providing concerned citizens (Pond and Lake Stewards (PALS)) with information to influence future funding priorities and provide data to scientists that can be used in later assessments of remedial options. The PALS program currently has a number of monitoring components (Snapshots and more frequent town programs) that are developing information that will be useful for better understanding the regional status, as well as the status of individual ponds. The networking components of the PALS program encourage the sharing of experiences among all PALS.

In order to reinforce and encourage the nascent network of PALS on Cape Cod, the following are recommended as future steps:

1. Continue the PALS Snapshots of pond water quality
2. Recruit volunteer coordinators, volunteers, and other PALS in each town
3. Encourage towns to acquire necessary sampling equipment
4. Encourage towns to initiate summer pond sampling programs
5. Provide sufficient personnel to train volunteer monitors, develop monitoring locations, provide regular feedback to volunteers to ensure protocols are followed during sampling season
6. Provide qualified personnel to review and analyze sampling data
7. Provide adequate funding to have annual or semi-annual PALS gatherings for outreach, education, and technical transfer
8. Provide adequate long-term funding to remediate impairments
9. Ensure that pond water quality is thoroughly considered in town comprehensive wastewater assessments

## V. Cape Cod Pond Trivia

| *Largest* | | town | acres |
|---|---|---|---|
| 1 | Long | Brew/Harw | 743 |
| 2 | Mashpee-Wakeby | Mashpee | 729 |
| 3 | Wequaquet | Barnstable | 654 |
| 4 | Great Herring | Bourne | 373 |
| 5 | Johns | Mashpee | 338 |

Source: CCC GIS Dept

| *Deepest* | town | ft |
|---|---|---|
| Mashpee-Wakeby | Mashpee | 95 |
| Cliff | Brewster | 84 |
| Ashumet | Falmouth | 84 |
| Long | Brew/Harw | 72 |
| Long | Falmouth | 66 |

Source: PALS 2001 Snapshot & DFW files

| *Most Common Names* | | *Unique Names* |
|---|---|---|
| # | name | Flying Squirrel |
| 10 | Mill | Cat Swamp Pond |
| 9 | Long | Widger Hole |
| 8 | Flax | Chigger Pond |
| 7 | Grass or Grassy | Pinkwink Pond |
| 6 | Round | Doanes Bog Pond |
| 6 | Lily | Canawa Pond |

| *# of Ponds* | | |
|---|---|---|
| Town | total | >10 ac |
| Barnstable | 184 | 27 |
| Bourne | 73 | 7 |
| Brewster | 76 | 22 |
| Chatham | 44 | 7 |
| Dennis | 57 | 6 |
| Eastham | 23 | 5 |
| Falmouth | 142 | 23 |
| Harwich | 63 | 20 |
| Mashpee | 56 | 9 |
| Orleans | 63 | 4 |
| Provincetown | 31 | 3 |
| Sandwich | 63 | 10 |
| Truro | 20 | 4 |
| Wellfleet | 29 | 8 |
| Yarmouth | 70 | 10 |
| TOTAL | 994 | 165 |

Source: CCC GIS Dept

| *Water Quality (from 2001 PALS Snapshot)* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| measure | unit | depth | **high** | Pond Name | Town | **low** | Pond Name | Town |
| **Secchi** | m | overall | 8.7 | Goose | Chatham | 0.2 | Lake Elizabeth | Barnstable |
| **pH** | | surface | 8.92 | Doanes Bog Pond | Wellfleet | 4.38 | Hathaway | Barnstable |
| | | overall | 8.92 | Doanes Bog Pond | Wellfleet | 4.38 | Hathaway | Barnstable |
| **DO** | mg/L | surface | 13.84 | Cedar | Orleans | 0.77 | Red Brook-upper | Falmouth |
| | mg/L | overall | 13.84 | Cedar | Orleans | 0.03 | Long Pond (18-22 m) | Brewster |
| **Alkalinity** | mg/L* | surface | 92 | Fresh | Falmouth | <0.5 (detection limit) | | |
| | mg/L* | overall | 590 | Hinckley (4 m) | Harwich | <0.5 (detection limit) | | |
| **Chl-a** | µg/L | surface | 86 | Schoolhouse | Brewster | <0.1 (detection limit); 4 ponds | | |
| | µg/L | overall | 138 | Canawa (1 m) | Mashpee | <0.1 (detection limit) | | |
| **TP** | µg/L | surface | 235 | Oyster | Falmouth | <3.1 (detection limit); 12 ponds | | |
| | µg/L | overall | 1291 | Cedar (3 m) | Orleans | <3.1 (detection limit) | | |
| **TN** | mg/L | surface | 5.96 | Clapps-Round | Provincetown | 0.06 | Slough | Truro |
| | mg/L | overall | 5.96 | Clapps-Round | Provincetown | 0.04 | Snake (6 m) | Sandwich |

*measured as mg CaCO3/L

## VI. References

Ahrens, T.D., and P.A. Siver. 2000. Trophic conditions and water chemistry of lakes on Cape Cod, Massachusetts, USA. *Lake and Reservoir Management.* 16(4): 268-280.

American Public Health Association, American Water Works Association, and Water Environment Federation. 1995. Standard Methods for the Examination of Water and Wastewater, 19th edition. Washington, DC.

Baystate Environmental Consultants, Inc. January, 1987. Diagnostic/Feasibility Study for the Management of Great Pond, Eastham, MA. Prepared for the Town of Eastham and the Massachusetts Division of Water Pollution Control. East Longmeadow, MA.

Baystate Environmental Consultants, Inc. December, 1991. A Diagnostic/Feasibility Study for the Management of Herring Pond, Eastham, MA. Prepared for the Town of Eastham and the Massachusetts Division of Water Pollution Control. East Longmeadow, MA.

Baystate Environmental Consultants, Inc. July, 1993. Diagnostic/Feasibility Study of Hamblin Pond, Barnstable, MA. Prepared for the Town of Barnstable Conservation Department.

Canfield, D.E., Jr., C.D. Brown, R.W. Bachmann and M.V. Hoyer. Volunteer Lake Monitoring: Testing the Reliability of Data Collected by the Florida LAKEWATCH Program. *Lake and Reservoir Management.* 18(1): 1-9.

Cape Cod Planning and Economic Development Commission. 1978. Final Environmental Impact Statement and 208 Water Quality Management Plan for Cape Cod. Barnstable County. Barnstable, MA.

Cape Cod Commission. 1991. Regional Policy Plan. Cape Cod Commission, Barnstable County. Barnstable, MA.

Cape Cod Commission. 1996. Regional Policy Plan. Cape Cod Commission, Barnstable County. Barnstable, MA.

Cape Cod Commission. 2002. Regional Policy Plan. Cape Cod Commission, Barnstable County. Barnstable, MA.

Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography.* 22: 361-369.

Carlson, R.E. 1983. Discussion on "Using differences among Carlson's trophic state index values in regional water quality assessment", by Richard A. Osgood. *Water Resources Bulletin.* 19: 307-309.

Carlson, R.E. and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods.* North American Lake Management Society. 96 pp. (summarized at http://dipin.kent.edu/tsi.htm#A).

D'Elia, C.F., P.A. Stuedler and N. Corwin. 1977. Determination of total nitrogen in aqueous samples using persulfate digestion. *Limnology and Oceanography.* 22: 760-764.

Eichner, E.M., T.C. Cambareri. V. Morrill, and B. Smith. 1998. Lake Wequaquet Water Level Study, Final Report. Cape Cod Commission, Water Resources Office, Barnstable, MA.

Eichner, E.M., V. Morrill, B. Smith, and K. Livingston. 1999. Long Pond Water Quality Assessment, Final Report. Cape Cod Commission, Water Resources Office, Barnstable, MA.

Eichner, E.M., J. Scanlon, G. Heufelder, and J. Wood. 2001. Baker Pond Water Quality Assessment. Prepared for Town of Orleans and MA Department of Environmental Management. Cape Cod Commission. Barnstable, MA.

ENSR International. 2001. Management Study of Long Pond, Brewster and Harwich, Massachusetts. Willington, CT.

Environmental Management Institute. 1976. Final Report, Water Quality Assessment, Cape Cod, 1976. Prepared for Area Wide Wastewater Management Program, Cape Cod Planning and Economic Development Commission, Barnstable County, Massachusetts. Marion, MA.

Frimpter, M.H. and G.C. Belfit. 1992. Estimation of High Ground-Water Levels for Construction and Land Use Planning, A Cape Cod Example – Updated 1991. Cape Cod Commission Technical Bulletin 92-001. Prepared in cooperation with the US Geological Survey, Water Resources Division. Cape Cod Commission. Barnstable, MA.

Frimpter, M.H. and F.B. Gay. 1979. Chemical Quality of Ground Water on Cape Cod, Massachusetts. Water Resources Investigations 79-65. US Geological Survey. Boston, MA.

Godfrey, P.J., M.D. Mattson, M-F Walk, P.A. Kerr, O.T. Zajicek, and A. Ruby, III. 1996. The Massachusetts Acid Rain Monitoring Project: Ten Years of Monitoring Massachusetts Lakes and Streams with Volunteers. Water Resources Research Center, University of Massachusetts – Amherst. Publication No. 171. Available at: www.umass.edu/tei/wrrc/pdf/ARMfinalrpt.PDF

Greenfield, B.K., Hrabik, T.R., Harvey, C.J., and Carpenter, S.R. 2001. Predicting mercury levels in yellow perch: Use of water chemistry, trophic ecology, and spatial traits. *Canadian Journal of Fisheries and Aquatic Sciences.* 58(7): 1419-1429.

Hazardous Waste Remedial Actions Program. 1994. Ashumet and Johns Ponds, 1994 Annual Report. Installation Restoration Program, Air National Guard. Oak Ridge, TN.

Horne, A.J. and C.R. Goldman. 1994. *Limnology.* 2nd edition. McGraw-Hill Co., New York, New York.

Hutchinson, G.E. 1957. A treatise on limnology in *Geography, Physics and Chemistry*, Vol. I. John Wiley & Sons, New York, New York.

Jacobs Engineering Group, Inc. 1998. Final Ecological Quarterly Data Summary Report, Fall 1997. Air Force Center for Environmental Excellence/Massachusetts Military Reservation, Installation Restoration Program. Otis ANGB, MA.

Langeland, K.A. 1996. Hydrilla verticillata (L.F.) Royle (Hydrocharitaceae), "The Perfect Aquatic Weed". *Castanea.* 61: 293-304. Available at: plants.ifas.ufl.edu/hydcirc.html

Madsen, J.D., K.D. Getsinger, R.M. Stewart and C.S. Owens. Whole Lake Fluridone Treatments for Selective Control of Eurasian Watermilfoil: II. Impacts on Submersed Plant Communities. *Lake and Reservoir Management.* 18(3): 181-190.

Maine Department of Environmental Protection. 1989. Phosphorus Control in Lake Watersheds: A Technical Guide to Evaluating New Development.

Massachusetts Department of Environmental Protection. 1997. Fish Mercury Distribution in Massachusetts Lakes. Office of Research and Standards and Office of Watershed Management. Available at: www.state.ma.us/dep/ors/files/fish_hg.pdf.

Massachusetts Department of Environmental Protection. 1998. Stormwater Management Policy. Available at: www.state.ma.us/dep/brp/stormwtr/files/2103ch.pdf).

Massachusetts Division of Fisheries and Game. 1948. Fisheries Report – Lakes of Plymouth, Berkshire and Barnstable Counties.

Mattson, M.D., P.J. Godfrey, R.A. Barletta, and A. Aiello. 1997. Draft Generic Environmental Impact Report: Eutrophication and Aquatic Plant Management in Massachusetts. Massachusetts Department of Environmental Protection and Department of Environmental Management.

McCann, J.A. 1969. An Inventory of the Ponds, Lakes, and Reservoirs of Massachusetts, Barnstable County. Water Resources Research Center, University of Massachusetts – Amherst. Publication No. 10-1.

McComas, S. 1993. *Lake Smarts: The First Lake Maintenance Handbook.* Terrene Institute and US Environmental Protection Agency. Washington, DC.

Michaud, S. 2001. Cape Cod Commission letter report to US Environmental Protection Agency regarding Evaluation of Mercury Occurrence in Freshwater Fish on Cape Cod.

Murphy, J. and J.P. Riley. 1962. A modified single solution method for determination of phosphate in natural waters. *Analytica Chimica Acta.* 27: 31-36.

Office of Technology Assessment. 1993. *Harmful Non-Indigenous Species in the United States, OTA-F-565.* US Congress, Office of Technology Assessment. Washington, DC. Available at: http://www.wws.princeton.edu/cgi-bin/byteserv.prl/~ota/disk1/1993/9325/932501.PDF.

Orleans Water Quality Task Force. 2001. Baseline Water Quality Study for Crystal Lake, Orleans, MA. Final Report, FY2000, Department of Environmental Management Lakes and Ponds Grant.

Parsons, T.R., Y. Maita and C. Lalli. 1989. Manual of Chemical and Biological Methods for Seawater Analysis. Pergamon Press. Oxford, England.

Portnoy, J.W., M.G. Winkler, P.R. Sanford, and C.N. Farris. 2001a. Kettle Pond Data Atlas. Paleoecology and Modern Water Quality. Cape Cod National Seashore. National Park Service, US Department of the Interior. Wellfleet, MA.

Portnoy, J.W., M.G. Winkler, P.R. Sanford, and C.N. Farris. 2001b. Kettle Pond Data Atlas. Compendium of Water Quality Monitoring, 1975-1999. Cape Cod National Seashore. National Park Service, US Department of the Interior. Wellfleet, MA.

Robertson, W.D., S.L. Schiff, and C.J. Ptacek. 1998. Review of Phosphate Mobility and Persistence in 10 Septic System Plumes. *Ground Water*. 36(6): 1000-1010.

Scanlon, J. and G. Meservey. 2001. 3 Ponds Study, Orleans, MA: Crystal Lake, Pilgrim Lake, and Baker's Pond.

Strahler, A.N. 1966. *A Geologist's View of Cape Cod*. The Natural History Press. Garden City, NY.

Stumm, W. and J.J. Morgan. 1981. *Aquatic Chemistry*. John Wiley & Sons, Inc., New York, NY.

U.S. Environmental Protection Agency. 2000. Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs. First Edition. EPA-822-B00-001. US Environmental Protection Agency, Office of Water, Office of Science and Technology. Washington, DC.

U.S. Environmental Protection Agency. 2001. Ambient Water Quality Criteria Recommendations. Information Supporting the Development of State and Tribal Nutrient Criteria for Lakes and Reservoirs in Nutrient Ecoregion XIV. EPA 822-B-01-011. US Environmental Protection Agency, Office of Water, Office of Science and Technology, Health and Ecological Criteria Division. Washington, DC.

Vollenweider, R.A. 1968. Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication. Paris, Rep. OECD, DAS/CSI/68.27.

Wetzel, R. G. 1983. *Limnology*. Second Edition. CBS College Publishing, New York, NY.

Wu, R.S.S., B.S. Zhou, D.J. Randall, N.Y.S. Woo, and P.K.S. Lam. 2003. Aquatic Hypoxia is an Endocrine Disruptor and Impairs Fish Reproduction. *Environmental Science and Technology*. 37(6): 1137-1141.

# Appendix A

# Cape Cod Pond Snapshot
# Field Sampling Sheet

LAKE AND POND SAMPLING DATA SHEET
Cape Cod 2002 Pond Sampling/Stewardship Program

CAPE COD COMMISSION

LAKE/POND NAME: _____

TOWN: _____ Sample Collector: _____

Date:_____ Time: _____ (AM or PM)

**Observations (write in or circle as appropriate):**

Water Color: _____ (blue, brown, green, blue/green, red/orange, white, etc)

Weather (circle):

1. Cloudless, 2. Pt. Cloudy, 3 Overcast, 4. Rain, 5. Fog/Haze, 6. Drizzle, 7. Intermit. Rain

Wind (circle):

1. Calm, 2. Light Breeze, 3. Steady Wind, 4. Strong Wind

| **Plants on Pond (check conditions):** | Over 50% | 25% to 50% | 10% to 25% | up to 10% | less than 1% or None |
|---|---|---|---|---|---|
| Waterlilies coverage of pond surface: | | | | | |
| Floating Algae on pond surface: | | | | | |
| Emergent Grasses/Sedges of surface: | | | | | |
| Other plant #1_____: | | | | | |
| Other plant #2_____: | | | | | |
| Other Notes: | | | | | |

TOTAL DEPTH: _____meter

SECCHI READING: Disappearing: _____ meter Reappearing: _____ meter

DISSOLVED OXYGEN/TEMPERATURE PROFILE

Meter Manufacturer: _____ Model# _____

Record DO/Temp profile in one-meter increments except for the first surface reading which is taken at 0.5 m. If the pond is very shallow (3 meters or less), record readings at 0.5 meter increments.

| Depth (m) | Temp (°C) | Dissolved Oxygen (mg/l) | Depth (m) | Temp (°C) | Dissolved Oxygen (mg/l) | Depth (m) | Temp (°C) | Dissolved Oxygen (mg/l) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

LAKE/POND NAME: _____

TOWN: _____ Sample Collector: _____

WATER QUALITY SAMPLING

!! FILL BOTTLE TO TOP and RECORD BOTTLE #'s !!

| Pond greater than 9 meters deep | |
|---|---|
| Sampling Depth | Bottle Number/Label |
| a. just below the surface | |
| b. 3 m down | |
| c. 9 m down | |
| d. 1 m above the bottom | |

In ponds approximately 9 m deep, collect three samples (just below the surface, 3 m down, and 1 m above the bottom).

| Pond less than 9 meters deep | |
|---|---|
| Sampling Depth | Bottle Number/Label |
| a. just below the surface | |
| b. 1 m above the bottom | |

In ponds approximately 1 m deep, please collect two samples just below the surface

TIME SAMPLING COMPLETED: _____ (AM or PM)

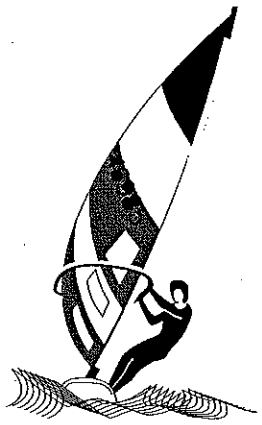
All water samples must be kept cold, in a cooler with ice packs, and delivered to the Cape Cod Commission offices the same day (prior to 3:30 PM)!

**CAPE COD COMMISSION OFFICES, 3225 MAIN ST., BARNSTABLE (on 6A in Barnstable Village, across from the Post Office).**

SAMPLE SIGNOFFS

| | **Signature** | **Received** | **Delivered** |
|---|---|---|---|
| | | **Date/Time** | **Date/Time** |
| Pond Monitor | | | |
| Sampling Coordinator | | | |
| Cape Cod Commission | | | |
| SMAST | | | |

# BARNSTABLE PONDS



Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
Pond 2001 Water Quality Summary Table
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:

Bearse Pond
Eagle Pond
Garretts Pond
Hamblin Pond
Hathaway Pond
Joshua Pond
Long Pond (Centerville)
Long Pond (Marstons Mills)
Lovells Pond
Micah Pond
Middle Pond
Mystic Pond
Shuabel Pond
Wequaquet Lake

Map Only:

Israel Pond
Mary Dunn Pond
Muddy Pond
Red Lily Pond
Shallow Pond

# Town of Barnstable Atlas Summary

**Total Land Area (sq. miles)**: 60.17

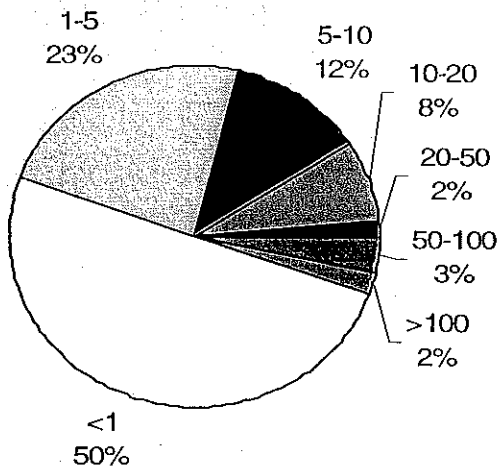
**Total Area of Ponds (acres)**: 1892 acres

**Total # of Ponds**: 184

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 92 |
| 1-5 acres: | 43 |
| 5-10 acres: | 22 |
| 20-50 acres: | 3 |
| 50-100 acres: | 6 |
| >100 acres: | 4 |

**# of Barnstable Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 38 |
| # of impacted ponds | |
| Chlorophyll a: | 28 |
| Total Nitrogen: | 28 |
| Total Phosphorus: | 21 |

**2001 Secchi Dip-In**

| | |
|---|---|
| # of ponds dipped: | 15 |
| # of volunteers: | 7 |

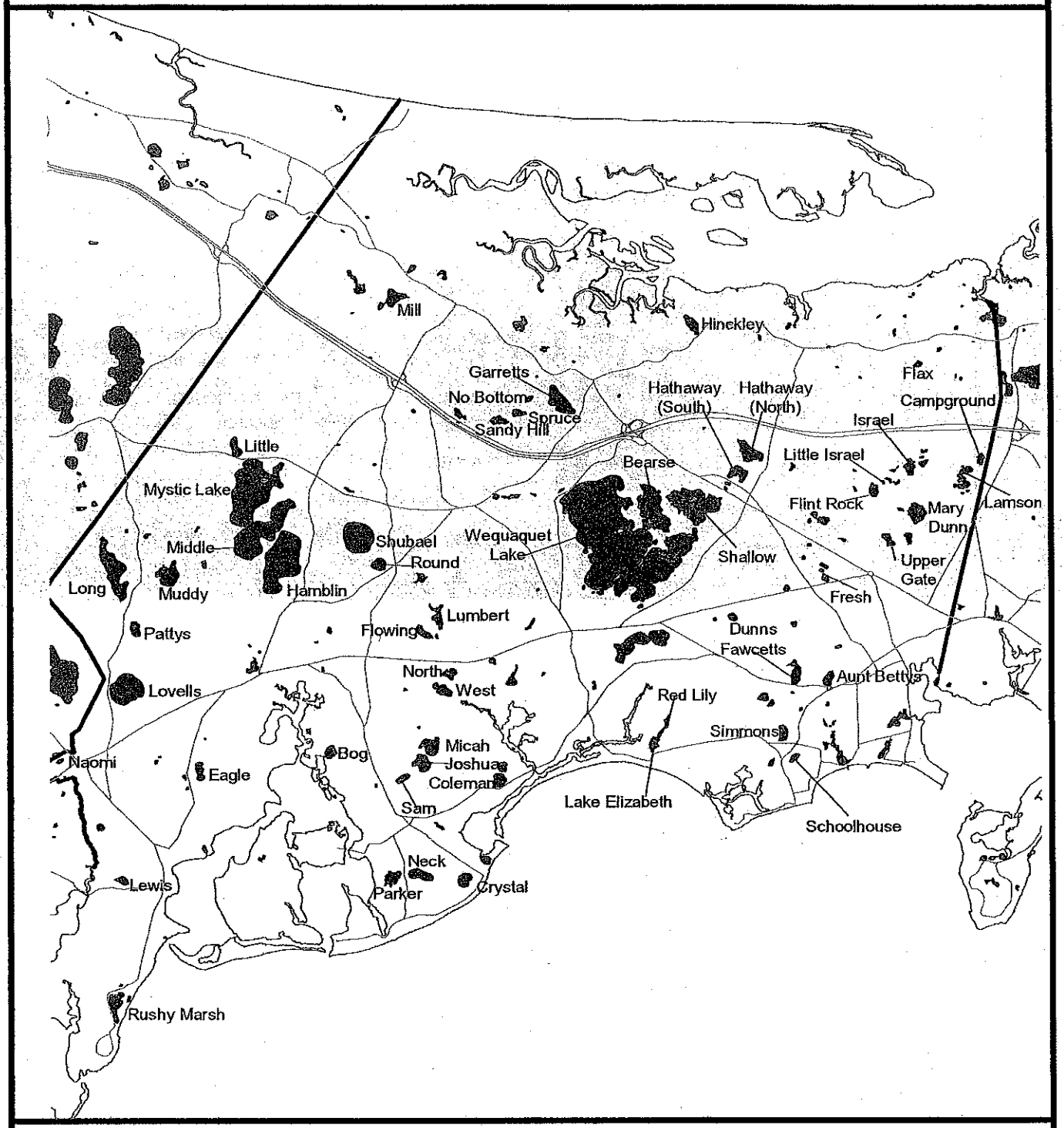
**Coordinator**:

| | |
|---|---|
| Town Staff: | Dale Saad |
| Citizen: | |

**Pond Groups**:

Barnstable Water Watchers
Wequaquet Lake Protective Association
Barnstable Land Trust
Cotuit Waders
Indian Pond Association
Garretts Pond
Three Bays Preservation

# BARNSTABLE NAMED PONDS

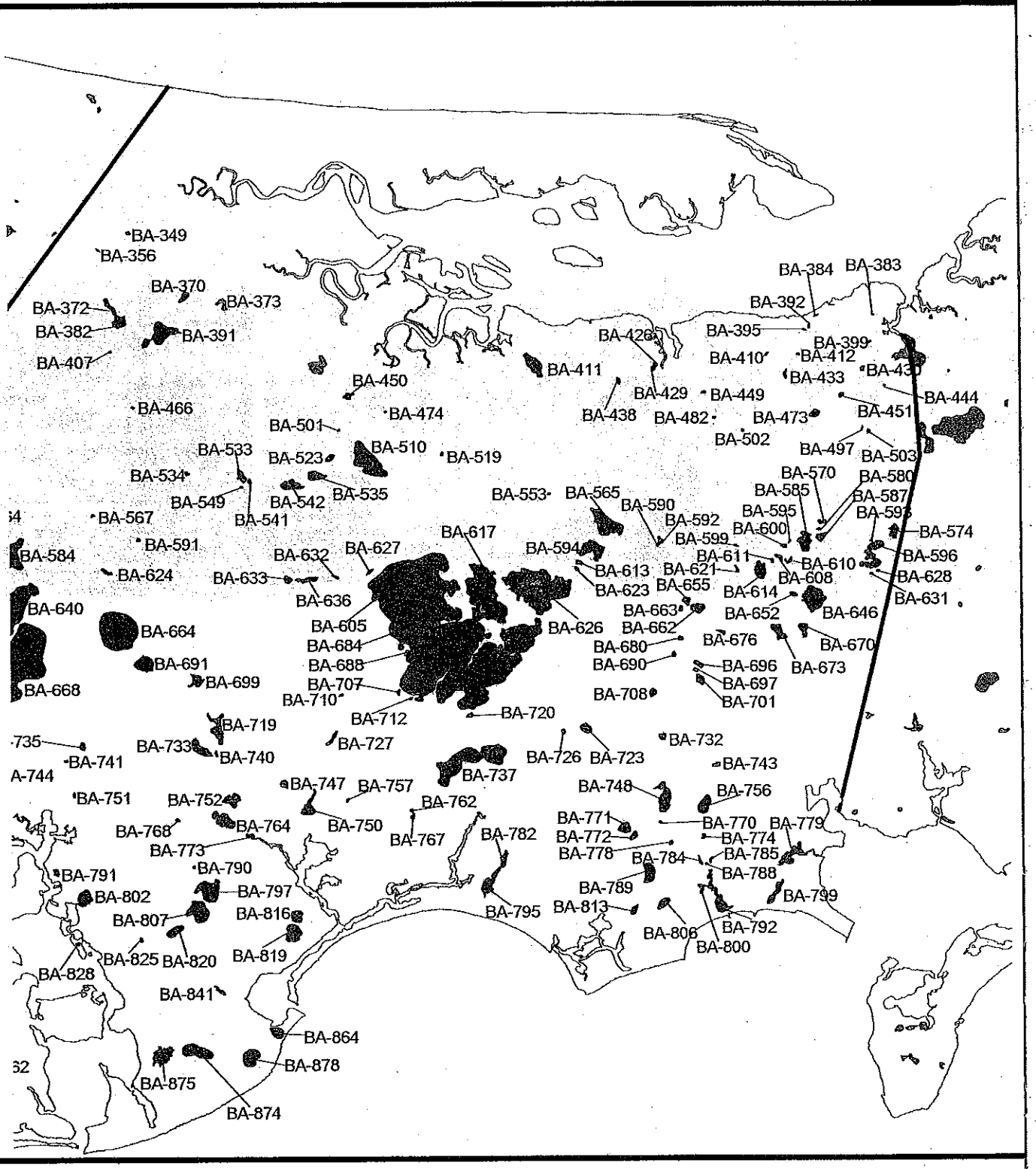



N

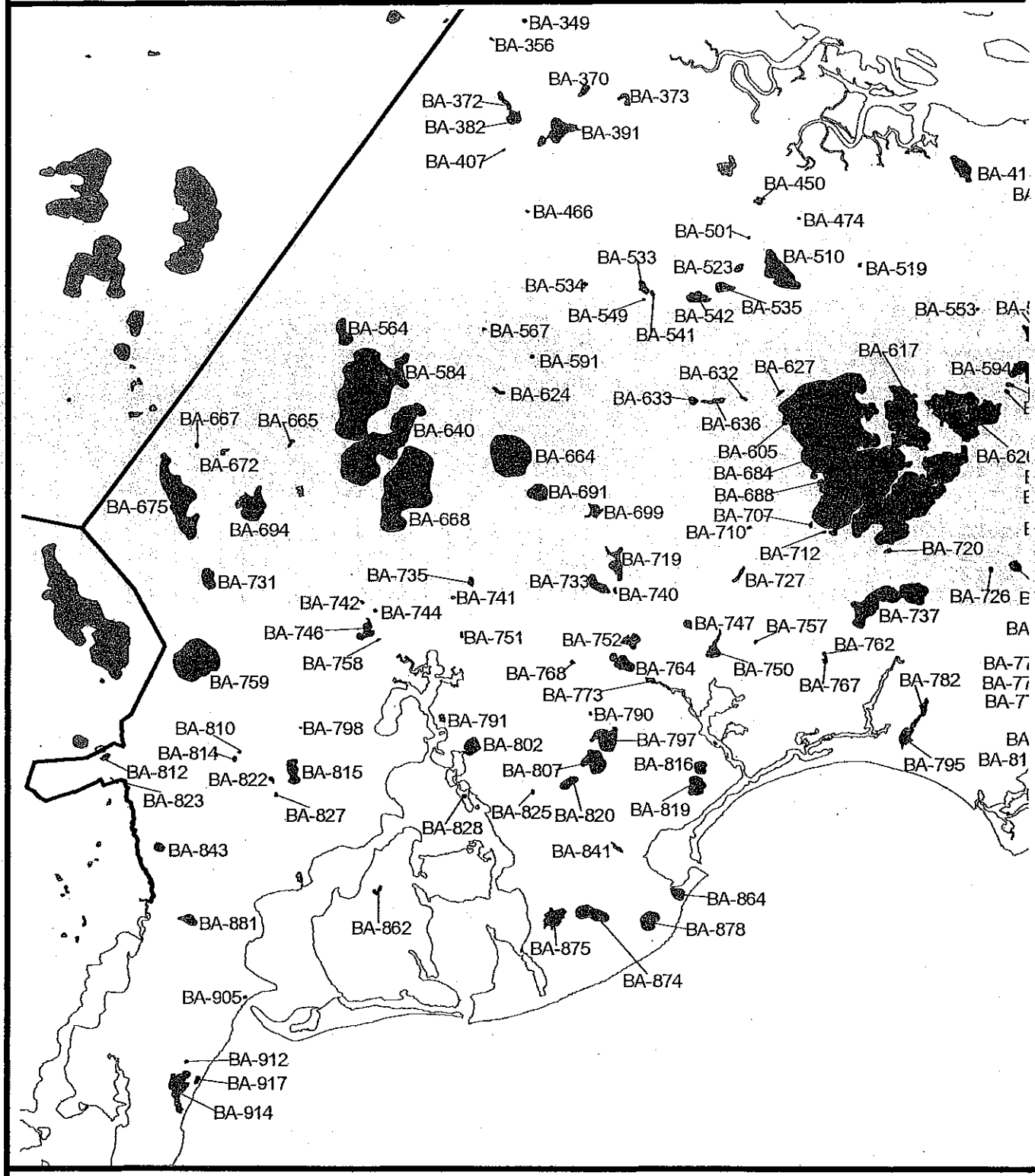
1 0 1 2 3 Miles

CAPE COD COMMISSION

# GIS ID'S FOR BARNSTABLE (East) PONDS

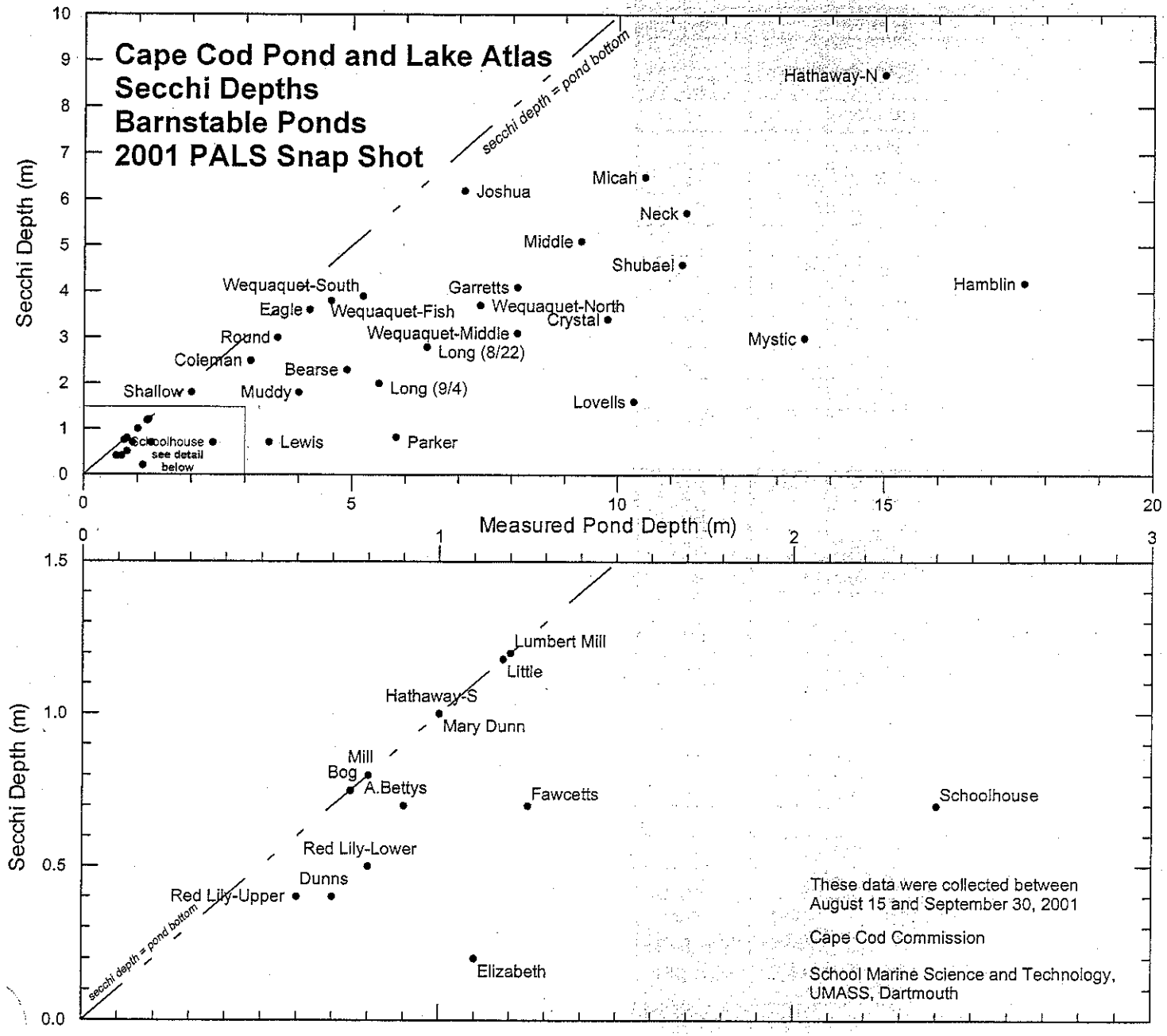


# GIS ID'S FOR BARNSTABLE (West) PONDS



# Barnstable 2001 PALS Water Quality Snapshot Summary

| | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | ug/l | unimpacted (<1.0 ug/l) | at risk (1-1.7 ug/l) | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk (0.16-0.31 mg/l) | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk (7.5-10 ug/l) | impacted (>10 ug/l) |
| Aunt Bettys Pond | 86.83 | | | x | 0.73 | | | x | 24.78 | | | x |
| Bearse Pond | 6.95 | | | x | 0.41 | | | x | 21.37 | | | x |
| Bog Pond | 6.72 | | | x | 1.53 | | | x | 59.77 | | | x |
| Coleman Pond | 3.9 | | | x | 0.44 | | | x | 17.34 | | | x |
| Crystal Pond | 2.86 | | | x | 0.39 | | | x | 7.43 | x | | |
| Dunns Pond | 19.03 | | | x | 1.76 | | | x | 205.64 | | | x |
| Eagle Pond | 1.37 | | x | | 0.37 | | | x | BDL | x | | |
| Fawcetts Pond | 5.77 | | | x | 0.70 | | | x | 11.46 | | | x |
| Garretts Pond | 1.87 | | | x | 0.22 | | x | | 4.96 | x | | |
| Hamblin Pond | 2.26 | | | x | 0.27 | | x | | BDL | x | | |
| Hathaway Pond (North) | 1.47 | | x | | 0.32 | | | x | 4.96 | x | | |
| Hathaway Pond (South) | 0.79 | x | | | 0.23 | | x | | 8.05 | | x | |
| Joshua Pond | 1.98 | | | x | 0.13 | x | | | BDL | x | | |
| Lake Elizabeth | 11.3 | | | x | 0.65 | | | x | 41.19 | | | x |
| Lewis Pond | 7.31 | | | x | 0.67 | | | x | 20.44 | | | x |
| Little Pond | 1.07 | | x | | 0.38 | | | x | 7.43 | x | | |
| Long Pond August 22 | 11.58 | | | x | 0.45 | | | x | 4.03 | x | | |
| Long Pond September 4 | 5.79 | | | x | 0.46 | | | x | 14.87 | | | x |
| Lovells Pond | 2.69 | | | x | 0.37 | | | x | 14.87 | | | x |
| Lumbert Mill Pond | 6.17 | | | x | 1.55 | | | x | BDL | x | | |
| Mary Dunn Pond | 1.14 | | x | | 0.38 | | | x | 11.46 | | | x |
| Micah Pond | 1.19 | | x | | 0.18 | | x | | 3.41 | x | | |
| Middle Pond | 1.38 | | x | | 0.37 | | | x | 8.05 | | x | |
| Mill Pond | 1.67 | | x | | 0.68 | | | x | missing | | | |
| Muddy Pond | 9.12 | | | x | 0.75 | | | x | 34.38 | | | x |
| Mystic Lake | 4.3 | | | x | 0.26 | | x | | 11.46 | | | x |
| Neck Pond | 1.35 | | x | | 0.44 | | | x | BDL | x | | |
| Parker Pond | 7.7 | | | x | 1.00 | | | x | 13.94 | | | x |
| Red Lily Pond Lower Basin | 3.31 | | | x | 1.44 | | | x | 8.05 | | x | |
| Red Lily Pond Upper Basin | 2.5 | | | x | | | | | 14.87 | | | x |
| Round Pond | 0.85 | x | | | 0.36 | | | x | 8.05 | | x | |
| Schoolhouse Pond | 86.83 | | | x | 1.50 | | | x | 181.17 | | | x |
| Shallow Pond | 3.56 | | | x | 0.48 | | | x | 14.87 | | | x |
| Shubael Pond | 2.03 | | | x | 0.36 | | | x | 4.96 | x | | |
| Wequaquet Lake South Basin | 2.33 | | | x | | | | | 17.96 | | | x |
| Wequaquet Lake-Fish Pond | 3.01 | | | x | | | | | 14.87 | | | x |
| Wequaquet Lake-Middle Basin | 3.55 | | | x | 0.39 | | | x | 17.96 | | | x |
| Wequaquet-North Basin | 3.72 | | | x | | | | | 14.87 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Barnstable Ponds
2001 PALS Snap Shot
Secchi Depth (m)
Measured Pond Depth (m)
secchi depth = pond bottom
Hathaway-N
Micah
Joshua
Neck
Middle
Shubael
Hamblin
Wequaquet-South
Garretts
Eagle
Wequaquet-Fish
Wequaquet-North
Crystal
Round
Wequaquet-Middle
Mystic
Long (8/22)
Coleman
Bearse
Shallow
Muddy
Long (9/4)
Lovells
Schoolhouse
see detail
below
Lewis
Parker
Lumbert Mill
Little
Hathaway-S
Mary Dunn
Mill
Bog
A.Bettys
Fawcetts
Schoolhouse
Red Lily-Lower
Dunns
Red Lily-Upper
Elizabeth
These data were collected between
August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology,
UMASS, Dartmouth

# BARNSTABLE POND DATABASE

| Pond Name | CCC GIS ID | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aunt Bettys Pond | BA-756 | 96005 | 7.1 | N | | 15 | 4 | informal | | wq | wq |
| Bearse Pond | BA-617 | 96012 | 66.8 | Y | 22,012 | 24 | 18 | pubnoramp | | sd,wq | wq |
| Ben's Pond | | | | | | 8 | | | O | | |
| Bog Pond | BA-802 | 96023 | 7.2 | N | | 5 | | | O | | wq |
| Campground Pond | BA-574 | | 3.5 | N | | 30 | | | | | |
| Coleman Pond | BA-819 | 96041 | 9.9 | N | | 5 | | | | wq | |
| Crooked Pond | | | | | | 25 | | | | | |
| Crystal Lake | BA-878 | 96051 | 10.1 | N | | 10 | | informal | | wq | wq |
| Duck Pond | | 96067 | | | | 29 | | | | | |
| Dunns Pond | BA-723 | 96069 | 3.6 | N | | 31 | | | | wq | |
| Eagle Pond | BA-815 | 96072 | 8.5 | Y | 2,440 | 18 | 15 | informal | | sd,wq | wq |
| Fawcetts Pond | BA-748 | 96083 | 11.9 | N | | 18 | | abutter | O | wq | wq |
| Flax Pond | BA-473 | 96086 | 2.4 | N | | 25 | | | | | |
| Flint Rock Pond | BA-614 | 96092 | 6.3 | N | | 35 | | | | | |
| Flowing Pond | BA-733 | | 7.2 | N | | | | | | | |
| Fresh Pond | BA-701 | 96100 | 2.7 | N | | 25 | | | | | |
| Garretts Pond | BA-510 | 96103 | 27.9 | Y | 9,057 | 38 | 28 | pubnoramp | O | sd,wq | wq |
| Hamblin Pond | BA-668 | 96126 | 115.4 | Y | 107,431 | 42 | 63 | pubramp,gravel | I | sd,wq | wq |
| Hathaway Pond (North) | BA-565 | 96129 | 20.9 | Y | 16,446 | 33 | 56 | pubramp | | sd,wq | sd,wq |
| Hathaway Pond (South) | BA-594 | 96130 | 12.6 | N | | 33 | 6 | informal | | sd,wq | |
| Hinckley Pond | BA-411 | 96139 | 10.3 | N | | 11 | 16 | informal | O | | |
| Hyannis Airport Pond | | 96147 | | | | 26 | | | | | |
| Israel Pond | BA-585 | 96150 | 8.1 | Y | 372 | 35 | 2 | none | | | |
| Joshua Pond | BA-807 | 96159 | 14.7 | N | 6,387 | 11 | 38 | pubnoramp | | wq | wq |
| Lake Elizabeth | BA-795 | 96080 | 6.3 | N | | 10 | | informal | O,HR | wq | wq |
| Lamson Pond | BA-596 | 96164 | 12.3 | N | | 31 | | informal | | | |
| Lewis Pond (airport) | BA-670 | | | | | 23 | | | | | |
| Lewis Pond | BA-881 | 96167 | 4.6 | N | | 5 | | | O | | wq |
| Little Israel Pond | BA-608 | 96173 | 1.1 | N | | 35 | | informal | | | |
| Little Pond | BA-564 | 96176 | 9.7 | N | | 53 | | informal | | | wq |

# BARNSTABLE POND DATABASE

| Pond Name | CCC GIS ID | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Long Pond | BA-675 | 96181 | 54.8 | N | 14,757 | 26 | 22 | pubramp | I,O | wq | wq |
| Long Pond | BA-737 | 96184 | 51.0 | Y | 17,201 | 51 | 15 | informal | | wq | wq |
| Lovells Pond | BA-759 | 96185 | 55.5 | Y | 35,211 | 38 | 37 | pubramp,cartop | I,O | sd,wq | wq |
| Lumbert Pond | BA-719 | 96189 | 9.7 | N | | 55 | | | I,O | wq | wq |
| Mary Dunn Pond | BA-646 | 96193 | 18.0 | Y | 1,952 | 26 | 9 | none | | sd,wq | |
| Micah Pond | BA-797 | 96197 | 16.0 | N | 7,779 | 12 | 41 | informal | | wq | wq |
| Middle Pond | BA-640 | 96198 | 104.6 | Y | 59,977 | 44 | 35 | pubramp | I,O,HR | sd,wq | wq |
| Mill Pond | BA-391 | 96204 | 16.7 | N | | 11 | 5 | | O | | wq |
| Mill Pond | BA-746 | | 6.0 | N | | 15 | | | I,O | | wq |
| Muddy Pond | BA-694 | 96216 | 24.6 | N | | 45 | 14 | public | | wq | wq |
| Mystic Lake | BA-584 | 96218 | 148.4 | Y | 91,822 | 44 | 40 | pubnoramp | O | sd,wq | sd,wq |
| Naomi Pond | BA-812 | | 1.4 | N | | | | | | | |
| Neck Pond | BA-874 | 96219 | 13.6 | N | | 6 | | informal | | | wq |
| No Bottom Pond | BA-523 | 96222 | 1.8 | N | | 35 | | | | | wq |
| North Pond | BA-752 | 96225 | 5.8 | N | | 5 | | | | | |
| North Pond | BA-816 | 96323 | 4.9 | N | | | | | | | |
| Parker Pond | BA-875 | 96238 | 10.9 | N | | 5 | | none | | | wq |
| Pattys Pond | BA-731 | 96240 | 8.3 | N | | 44 | | none | | | |
| Red Lily Pond | BA-782 | 96257 | 4.5 | Y | 402 | 10 | 6 | informal | O | wq | wq |
| Round Pond | BA-691 | 96262 | 9.8 | N | | 35 | 14 | pubnoramp | | sd,wq | wq |
| Rushy Marsh Pond | BA-914 | 96266 | 16.0 | N | | 5 | | | | | |
| Sam Pond | BA-820 | 96274 | 5.1 | N | | 15 | | | | | |
| Sandy Hill Pond | BA-542 | 96276 | 6.6 | N | | 45 | | | | | |
| Schoolhouse Pond | BA-806 | 96282 | 3.6 | N | | 6 | | | | sd,wq | sd,wq |
| Shallow Pond | BA-626 | 96285 | 78.4 | Y | | 34 | 7 | informal | | wq | wq |
| Shubael Pond | BA-664 | 96293 | 55.1 | Y | | 43 | 41 | pubramp,gravel | | sd,wq | wq |
| Simmons Pond | BA-789 | 96295 | 7.8 | N | | 8 | | | | | |
| Sinnott | | | | | | | | | I,O | | |
| Spruce Pond | BA-535 | 96308 | 5.0 | N | | 35 | | | | | |
| Three Ponds | | | | | | | | | | | |

# BARNSTABLE POND DATABASE

| Pond Name | CCC GIS ID | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Gate Pond | BA-673 | | | | | 26 | | | | | |
| Weathervane Pond | | | | | | | | | | | |
| Wequaquet Lake | BA-605 | 96333 | 596.3 | Y | | 34 | 32 | pubramp,concrete | O,HR | sd,wq | wq |
| West Pond | BA-764 | 96187 | 10.1 | N | | | | | | | |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

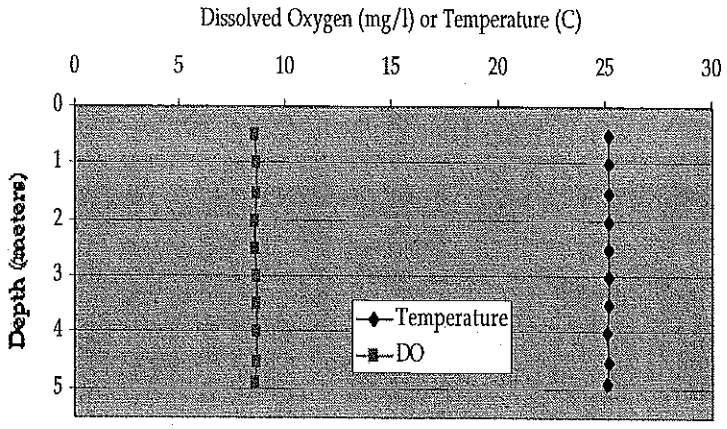
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County,McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Bearse Pond
## Barnstable
## BA-617

Acreage: 65
Maximum Depth: 18 ft
2001 Secchi Dip: 7.5 ft
Lake Association: Wequaquet Lake Protective Association




Dissolved Oxygen and Temperature
Bearse Pond, 8/29/01

OVERVIEW

Bearse Pond is located in the Town of Barnstable. It is connected to Lake Wequaquet by a surface water channel known as Snow's Cove, located on the southwestern shore of the pond. Groundwater flows into the lake along its northern shores, while flow out of the pond occurs along its southern shores and through the surface water connection to Lake Wequaquet. Bathymetry for the pond was developed by the Massachusetts Division of Fisheries and Wildlife in 1993 (see map for Wequaquet Lake). The pond is surrounded by residential development on all sides and supports boating, swimming, fishing and icefishing. Public access is provide via a town right of way, however there is no boat ramp access.

WATER QUALITY

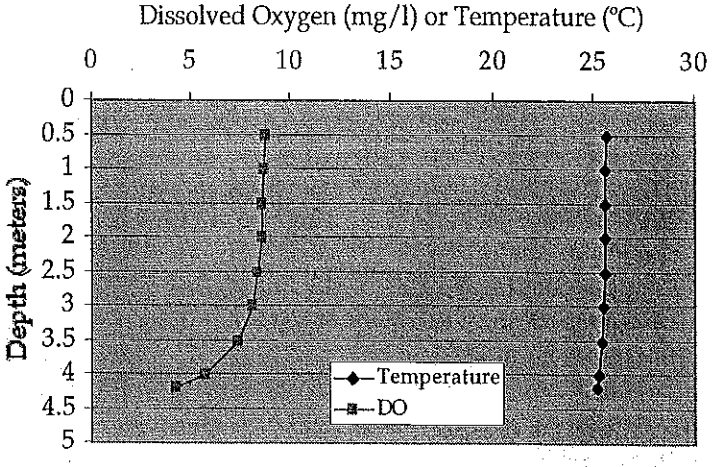
Water quality sampling was conducted in 1983, 1984, 1989, 2001 and 2002. Water quality trends indicate a shift from oligotrohic to oligothrphic/mesotrophic conditions. Dissolved oxygen and temperature profiles from 2001 PALS sampling (shown above) indicate a well mixed, well oxygenated water column. Pond clarity was observed to a depth of 2.3 meters. Bearse Pond has been treated to limit the growth of fanwort.

Total phosphorus and chlorophyll *a* concentrations are more than double Cape Cod "impacted" thresholds and suggest a productive algal population. The Carlson TSI value based on the surface chlorophyll *a* concentration places Bearse Pond at the high end of the mesotrophic category. The Wequaquet Lake Protective Association gathers water quality data from Spring through Fall. It is recommended that the town consider combining all existing data together with additional targetted data collection to complete a characterization of this pond and evaluate whether the observed conditions are likely to worsen. Overall, Bearse Pond presents as an impacted pond with relatively high nutrient concentrations.

| August 29, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.62 | 6.95 | 4.4 | 21.4 | 0.41 |
| 4 | 6.62 | 6.75 | 4.5 | 27.9 | 0.41 |

# Eagle Pond
## Barnstable
## BA-815

Acreage: 10
Maximum Depth: 15 ft
2001 Secchi Dip: 11.8 ft
Lake Association: None




Dissolved Oxygen and Temperature
Eagle Pond, 8/21/01

OVERVIEW

Eagle Pond is located in the village of Cotuit, just east of Putnam Avenue. Groundwater flow enters the pond from the north and west shores of the pond and discharges along the south and east shores. This relatively small pond has only informal access across a large undeveloped private property. There is no development around the moderately sloped shoreline.

WATER QUALITY

The 2001 PALS Snapshot appears to be the first water quality sampling of Eagle Pond. Results from the dissolved oxygen and temperature profiles (see above) indicate well mixed warm water with good oxygen saturation except for a slight DO decline near the sediments. TP and chlorophyll a concentrations are less than current Cape Cod "impacted" thresholds, while TN concentrations exceed the TN "impacted" threshold. A Carlson TSI based on the surface chlorophyll concentration places the lake in the lower half of the oligotrophic with some deep anoxia category.

These relatively low concentrations are reflective on the lack of shoreline development around the pond. Additional dissolved oxygen monitoring and water quality sampling on an annual basis are recommended to document any changes in water quality. Based on the available data, Eagle Pond presents as a relatively clean, largely unimpacted lake.

| August 21, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.52 | 1.37 | 3.1 | BDL | 0.37 |
| 3 | 6.54 | 1.54 | 2.8 | 5.0 | 0.35 |

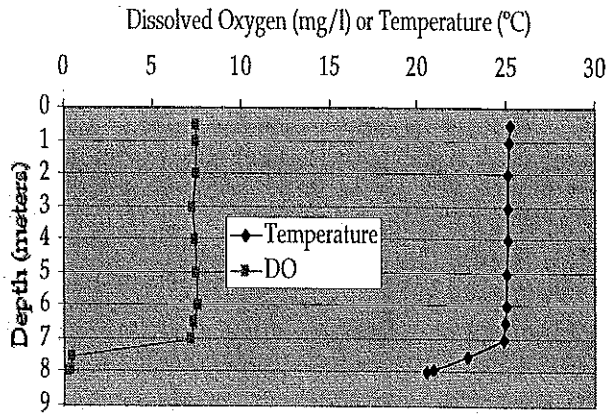
BDL = Below Detection Limit

# Garretts Pond

## Barnstable

## BA-510

Acreage: 24
Maximum Depth: 28 ft
2001 Secchi Dip: 13.5 ft
Lake Association: Garretts Pond Watchers




Dissolved Oxygen and Temperature
Garretts Pond, 8/27/01

OVERVIEW

Garretts Pond is located in West Barnstable, off of Route 6A near the intersection of Church Street. Groundwater enters the pond from the southern and westerly shores. The pond discharges water to groundwater along the northern and eastern shores. There is a narrow outlet that discharges surface water to Brickyard Creek, which flows into Barnstable Harbor, on the northern tip of the pond. The pond has steep shoreline along the southern end of the pond, and moderately steep shoreline around the remainder of the pond. Much of the shoreline is developed and includes some cottages on the eastern shore and many larger homes on the western shore. It is a popular spot for boating, swimming, fishing and icefishing. Public access is provided as a town owned right of way off Oak Street, but there is no boat ramp.

WATER QUALITY

Water quality sampling was conducted by the state Division of Fisheries and Game in August 1969, when the pond quality was characterized as acidic, infertile conditions with excellent transparency (24 ft at a measuring point with a 25 ft depth). Dissolved oxygen was 98% saturation at depth of 10 feet, 90% at a depth of 20 ft. The pond was resampled in 1980 and considered mesotrophic based on the results. The pond was sampled again in the 2001 PALS Snapshot, the results of which are presented below.

The PALS temperature profile (shown above) shows a clear thermal stratification at a depth of 7 meters (23 ft). Above this depth, the temperature and dissolved oxygen profiles indicate well mixed and well oxygenated water. At 7.5 m (24.6 ft) and below, the water is anoxic, likely due to oxygen demand by bacteria decomposing the sediments.

A Carlson TSI based on the surface chlorophyll *a* concentration places the pond in the oligotrophic category. TP and TN concentrations are below current Cape Cod "impacted" thresholds, while the chlorophyll concentrations are at or above the Cape Cod chlorophyll threshold. The lack of oxygen deep in the pond is a cause for concern. It is recommended that annual monitoring of the pond continue and that a characterization of nutrient loads to and within the lake be considered by the town in the future; more frequent DO profiles would help gauge whether the deep anoxic conditions should be addressed. Garrents Pond presents as a realtively clean lake with uncertain deep water quality concerns.

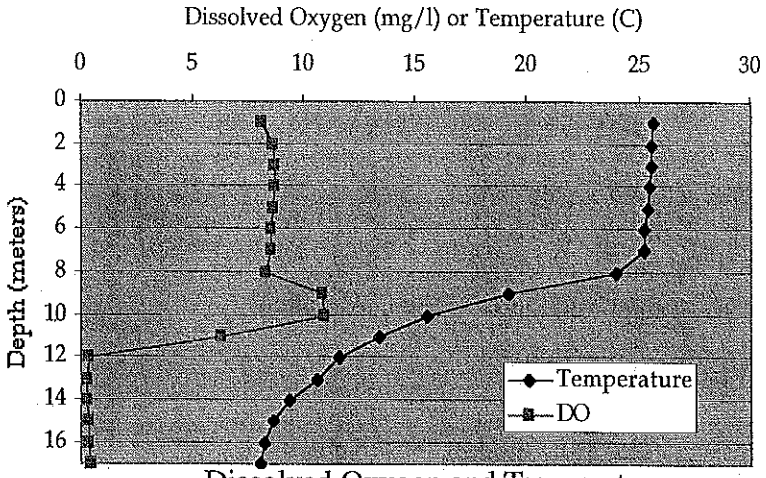
| August 27, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 5.95 | 1.87 | 1.8 | 5.0 | 0.22 |
| 3 | 6.06 | 3.06 | 1.9 | 5.0 | 0.26 |
| 7 | 6.04 | 2.99 | 1.8 | 5.0 | 0.28 |

# Hamblins Pond

## Barnstable

## BA-668

Acreage: 115
Maximum Depth: 63 ft
2001 Secchi Dip: 13.8 ft
Lake Association:
Indian Pond Association



Dissolved Oxygen and Temperature
Hamblin Pond, 8/22/01

OVERVIEW

The pond is located wholly within the Town of Barnstable and just to the south of Mystic Lake and Middle Pond. The pond is entirely groundwater fed with flow coming in on the north and discharging along the south. The pond has approximately 20 residences along it waterfront, is abutted by and is the source of water for a 4 to 5 acre cranberry bog, and has public access from town-owned conservation land, which contains a beach, boat launch, and associated parking areas and a number of hiking trails. The lake watershed has a long history of agricultural use, including a large duck farm with approximately 10,000 Muscovy ducks operated between the 1920's and 1950's at the southern end of the pond (Baystate Environmental Consultants, 1993). The duck farm and the associated wastes are thought to be the cause of the water quality impairments, which were addressed by the 1995 alum treatment. There is a ten horsepower limit on outboard motors enforced by the Town of Barnstable.

WATER QUALITY

Water quality readings seem to indicate an improved but still impaired system; the temperature and dissolved oxygen profiles collected for the 2001 PALS Snapshot (shown above) show a small trout habitat, but anoxic conditions in the deeper waters limit the habitat. These conditions also indicate that occassional algal blooms could occur as high phosphorus concentrations in deep water are mixed back into the upper water column. The temperature profile collected on 8/22/01 do not indicate a well defined hypolimnion with temperature readings continuing to decline with depth below 8 m; dissolved oxygen conditions become anoxic below 12 m. These conditions are an improvement from those observed prior to the alum treatment, which had anoxic conditions below 7 m, including a profile collected in 1948. A Carlson TSI based on the surface chlorophyll concentration indicates that this pond would fall into the upper portion of the oligotrophic with some bottom anoxia category. TN and chlorophyll concentrations exceed current Cape Cod impacted" thresholds, while TP exceeds its threshold only near the sediments. Although the alum application improved water quality conditions, Hamblin Pond is clearly impacted with impaired water quality at depth. With this in mind, it is recommended that existing and Snapshot monitoring of this pond continue and, if conditions warrant it, the town may want to consider another alum treatment.

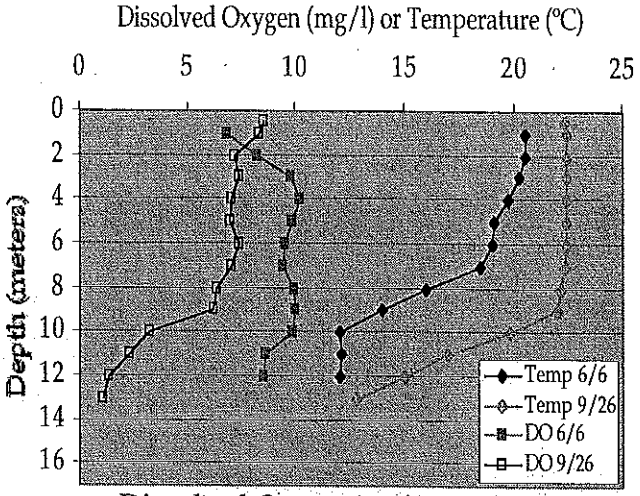
| August 22, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.99 | 2.26 | 3.6 | BDL | 0.27 |
| 3 | 6.95 | 2.13 | 3.5 | BDL | 0.28 |
| 9 | 6.9 | 2.11 | 3.5 | BDL | 0.24 |
| 17 | 6.64 | 12.20 | 23.7 | 258.3 | 1.81 |

# Hathaway Pond

## Barnstable

## BA - 565

Acreage: 21
Maximum Depth: 57 ft
2001 Secchi Dip: 28.5 ft (6/6/01)
Lake Association: none




Dissolved Oxygen and Temperature
Hathaway Pond, 2001

OVERVIEW

The pond is located wholly within the Town of Barnstable. Groundwater flows into the lake from the north and water flows out of the lake via groundwater on its southern end. Bathymetry for the pond was developed by the state Division of Fisheries and Wildlife. The pond is surrounded by town-owned conservation land, which contains a popular beach and associated parking areas and a number of hiking trails.

WATER QUALITY

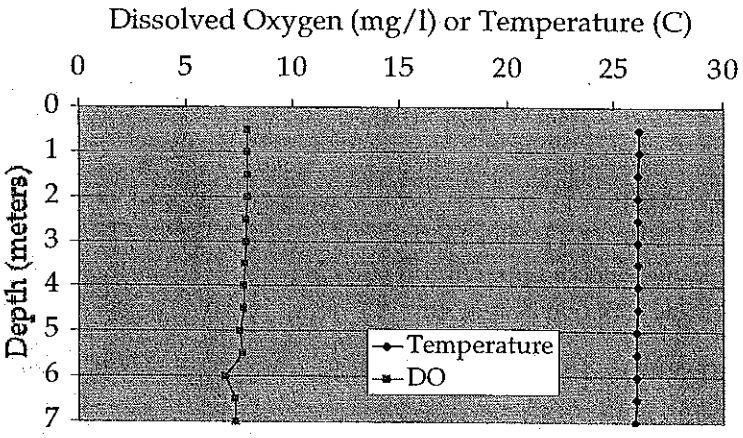
Hathaway Pond was sampled in July 1948 and September 2001. The dissolved oxygen profile collected in 1948 had saturated (*i.e*, high) concentrations throughout the water column, as compared to the 2001 DO profiles (shown above) that show hypoxic concentrations (< 4 ppm) below 10 m late in the summer.

Chlorophyll, TP, and TN concentrations from the 2001 PALS Snapshot (shown below) are generally at or below current Cape Cod "impacted" thresholds, except for the deep concentrations which exceed all thresholds. A Carlson TSI based on surface chlorophyll concentration collected during the 2001 PALS Snapshot categorizes Hathaway Pond as oligiotrophic with some deep anoxia.

Dissolved oxygen conditions in September raise some concerns about deep water habitat and phosphorus regeneration, but additional dissolved oxygen profiles could clarify how much of the summer these conditions exist. Low oxygen conditions are a habitat impairment for trout, which are annually stocked in the Spring, and regeneration of phosphorus could prompt algal blooms. Secchi clarity in September was 8.7 m (67% of the sampling depth) indicating good clarity throughout the epliminion. It is recommended that the town consider regular dissolved oxygen monitoring to evaluate the extent and duration of the hypoxic conditions. Given that Hathaway Pond is surrounded by municipal land, undeveloped save for a town beach, impacts observed over the past 50 years are likely due to recreational use of the pond and should occur rather slowly, but additional monitoring could help to clarify how much of a concern the late summer readings are. Overall, Hathaway Pond presents as a realtively clean, largely unimpacted lake that has experienced some impacts over the last 50 years.

| September 26, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 5.67 | 1.47 | 0.9 | 5.0 | 0.32 |
| 3 | 5.83 | 1.12 | 1.4 | 14.9 | 0.27 |
| 9 | 5.73 | 0.90 | 1.5 | 9.9 | 0.28 |
| 13 | 5.63 | 4.18 | 2.7 | 24.8 | 0.37 |

# Joshua Pond
## Barnstable
## BA-807




Dissolved Oxygen and Temperature
Joshua Pond, 8/21/01

Acreage: 14.7
Maximum Depth: 23 ft
2001 Secchi Dip: 20.3 ft
Lake Association: None

OVERVIEW

Joshua Pond is located amongst ensely wooded municipal land in the village of Osterville. Groundwater flow enters the pond from the northwest. The pond discharges surface vater to groundwater along the southeast shore. There are no surface water outlets from Joshua Pond. ıccess to the pond is obtained via a pathway crossing Town of Barnstable conservation property or at a mall municipal beach on the southern shore. Recreational uses include swimming, fishing, and icefishing.

WATER QUALITY

Joshua Pond was sampled in 1960, 1980-1981, and 2001-2002 with water quality results generally ıdicating excellent water quality, low biological productivity, and an oligotrophic status. The dissolved xygen and temperature profiles collected in both August 1980 for the town Conservation Commission and ıugust 2001 as part of the PALS Snapshot sampling indicate well oxygenated, warm water with an absence f temperature stratification. The relative Secchi disk depth from 2001 places Joshua Pond among the top ıree in terms of water clarity on Cape Cod among ponds with overall depths 7 meters (23 ft) or deeper. A 'arlson TSI based on a surface chlorophyll *a* concentration places the pond in the oligotrophic category. lutrient concentrations collected at the same time support this characterization; TN and TP concentrations re below the current Cape Cod "impacted" thresholds. These nearly pristine conditions are a reflection of ıe lack of shoreline development around the pond. Overall, Joshua Pond presents as a realtively clean, ırgely unimpacted lake.

| August 21, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 4.96 | 1.98 | 0.4 | BDL | 0.13 |
| 6 | 4.98 | 1.99 | 0.3 | BDL | 0.24 |

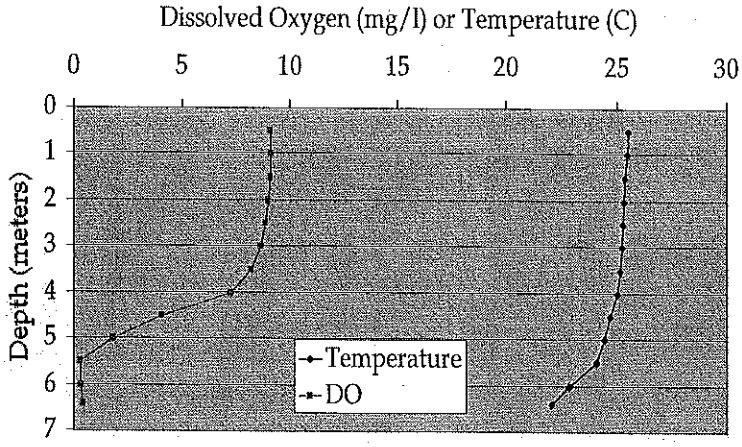
BDL = Below Detection Limit

# Long Pond (Centerville)

## Barnstable

## BA-737

Acreage: 50
Maximum Depth: 22 ft
2001 Secchi Dip: 9.2 ft
Lake Association:
Committee for the Preservation of Long Pond




Dissolved Oxygen and Temperature
Long Pond, 8/22/01

OVERVIEW

Long Pond is located in the village of Centerville. Surface flows into and out of the pond occur during higher groundwater conditions; coming in from a Wequaquet Lake herring run and discharging to the Centerville River. Groundwater flows into the pond along its northern shores and discharges along the southern shores. There is a boat ramp located on Piney Pont Drive and a town beach on the eastern end off of Pine Street. Recreational uses included boating, swimming and fishing. Long Pond is surrounded by densely developed single family homes.

WATER QUALITY

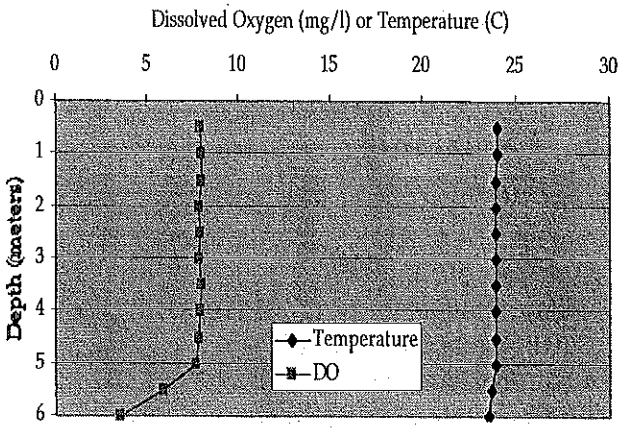
Water quality samples were collected from Long Pond in 1948, 1981, 1983, and 2001-2002. Earlier reports based on 1981 conditions report borderline mesotrophic/eutrophic conditions. In 1983, algae counts were low and wild iris and water lilies were abundant and the trophic status was listed as oligo/mesotrophic. Results from the 2001 PALS Snapshot sampling (shown below) indicate neutral acidity, moderate water clarity, and signs of impairment. All concentrations, except TP, are greater than Cape Cod "impacted" thresholds. A Carlson TSI based on the surface chlorophyll concentration places the pond in the middle of the eutrophic category.

The anoxic conditions below 5.5 meters (see above) are consistent with excessive organic loads in the sediments and the more than doubling of TP concentrations with depth indicate that phosphorus is being released from the sediments. The relatively low TP concentrations are consistent with the extensive rooted plant growth that exists in Long Pond, including the exotic, invasive plant, Hydrilla. Long Pond is the only pond in Massachusetts where hydrilla has been identified; an herbicide was applied to the pond during the summer of 2002. It is recommended that the town consider additional characterization of nutrient loads into and within the lake. Overall, Long Pond presents as an impacted pond with water quality problems.

| August 22, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 7.11 | 11.58 | 7.3 | 4.0 | 0.45 |
| 5 | 6.74 | 11.41 | 8.4 | 10.8 | 0.52 |

# Long Pond
# (Marston Mills)
## Barnstable
## BA-675

Acreage: 55
Maximum Depth: 18 ft
2001 Secchi Dip: 6.6 ft
Lake Association: None




Dissolved Oxygen and Temperature
Long Pond, 9/4/01

OVERVIEW

Long Pond is located in the village of Marstons Mills, west of Santuit Road. The pond is groundwater fed from the northeast and has no surface water outlet. Surface water from the pond flows to groundwater along the east and south shoreline. Approximately 50% of the eastern shoreline is protected by conservation land. Most of the shoreline has high banks, some portions have moderate slopes. Wetlands surround the southern tip of the pond. The reminder of the shoreline is developed with single family homes. Recreational uses of the pond include swimming and limited fishing. Public access to the pond is informal across conservation property.

WATER QUALITY

Long Pond was apparently first sampled in August 1948 by the Division of Fisheries and Game and was again sampled in September 2001 as part of the PALS Snapshot. In 1948, dissolved oxygen and temperature profiles were collected as well as measurements of pH, alkalinity, and transparency. The 2001 temperature profile indicates no thermal stratification and the dissolved oxygen profile generally indicates saturated oxygen conditions except for depressed concentrations below the 5 meter depth. This drop in DO concentrations was not observed in 1948.

A Carlson TSI based on the surface chlorophyll *a* concentration places Long Pond in the mesotrophic category. Concentrations of TP, TN, and chlorophyll from samples collected during the 2001 PALS Snapshot (see below) all exceed current Cape Cod "impacted" thresholds. The lack of oxygen deep in the pond suggests that impacts are occurring to the pond, that conditions have worsened since 1948, and that current algal growth will allow these conditions to worsen. It is recommended that annual monitoring of the pond should continue and that the town consider conducting more refined monitoring and a characterization of current and future nutrient loads. Overall, Long Pond presents as an impacted lake with existing water quality concerns.

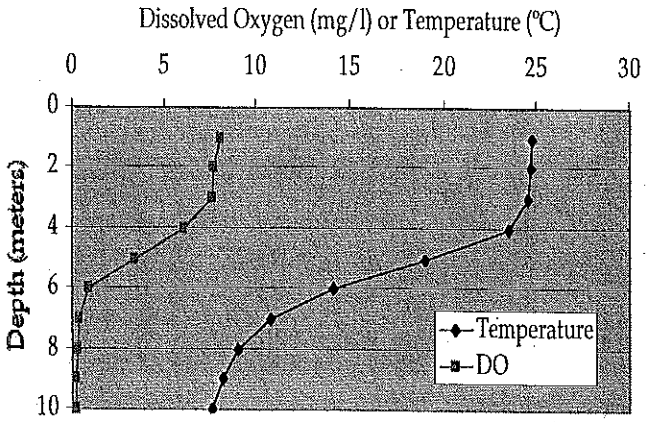
| September 4, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.32 | 5.79 | 9.5 | 14.9 | 0.46 |
| 4.5 | 6.49 | 5.84 | 9.6 | 11.5 | 0.47 |

# Lovells Pond

## Barnstable

## BA-759

Acreage: 55.5
Maximum Depth: 37 ft
2001 Secchi Dip: 5.2 ft
Lake Association: None




Dissolved Oxygen and Temperature
Lovells Pond, 8/16/01

OVERVIEW

Lovells Pond is located in the village of Cotuit, north of Route 28 and east of Newtown Road. The pond is primarily recharged by groundwater flow from the north and west shoreline, and contributes surface water to groundwater via the south and eastern shorelines. The pond also receives limited surface water from a small brook draining from a cranberry bog on the northwest shore and discharges surface water through a pipe to the Little River. Several large cranberry bogs surround Lovells Pond in addition to recently developed single family homes. Several large contiguous pieces of land, owned by municipal water suppliers abut the northern shoreline. The pond is heavily used for swimming, fishing and icefishing. It is stocked by the Massachusetts Division for Fisheries and Wildlife. Public access to Lovells Pond is provided via a boat ramp off of Newton Road and a small beach on the south shore.

WATER QUALITY

Lovells Pond was sampled in 1948, 1980, and again in 1982 with a shift noted from oligotrophic to borderline oligotrophic/mesotrophic status. A description of the pond in 1993 noted a distinctive greenish color. In 1948, the DO profile had a concentration of 9 ppm at 35 ft (10.5 m) and transparency was noted to 23 ft. In contrast, the 2001 PALS Snapshot dissolved oxygen results (see above) note that anoxic conditions exist below 23 ft and the Secchi reading was limited to 5.2 ft.

A Carlson TSI based on the surface chlorophyll *a* concentration places the pond on the boundary between the mesotrophic and oligotrophic categories. All water quality concentrations collected during the 2001 Snapshot (see below) exceed the current Cape Cod "impacted" thresholds with the deep concentrations clearly reflecting the impacts of the anoxic conditions are having on the pond sediments.

More refined monitoring is recommended to characterize the time necessary to establish the anoxic conditions observed in August 2001, measure nutrients in the sediments, and determine whether the system has significant phosphorus bound in rooted plant materials. The town and the state may want to consider a more detailed assessment to establish potential measures to restore this pond to 1948 conditions. Lovells Pond presents as a impacted lake with existing water quality concerns.

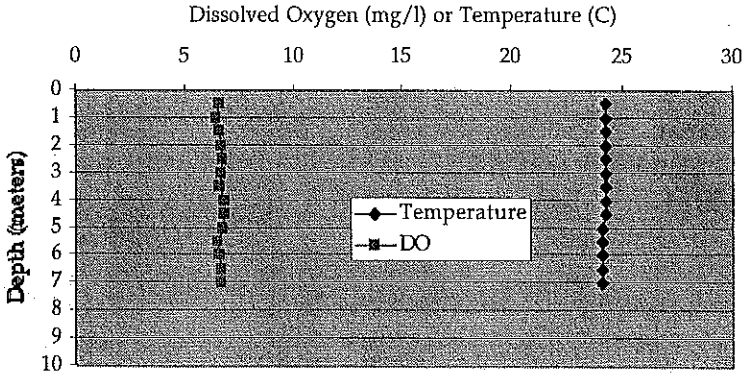
| August 16, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.89 | 2.69 | 1.8 | 14.9 | 0.37 |
| 3 | 6.99 | 3.03 | 1.9 | 21.4 | 0.49 |
| 9.2 | 6.72 | 19.60 | 2.6 | 27.9 | 0.74 |

# Micah Pond

## Barnstable

## BA-797

Acreage: 16
Maximum Depth: 41 ft
2001 Secchi Dip: 21 ft
Lake Association: None




Dissolved Oxygen and Temperature
Micah Pond, 9/6/01

OVERVIEW

Micah Pond is located in the village of Osterville, near the intersection of Pond Road and Bumps River Road. This classic kettlehole pond has one controlled outlet to a cranberry bog. Groundwater flows into the pond from the northern shoreline and the pond discharges to groundwater along the southern shores. The pond shoreline is entirely surrounded by undeveloped public land, which contains a number of walking trails. Public access to the pond is informal across conservation lands. Recreational activities include fishing and swimming.

WATER QUALITY

Micah Pond was sampled in 1960, 1980, 2001, and 2002. Although the water quality results generally indicating very good water quality, low biological productivity, and an oligotrophic status, some of the dissolved oxygen profiles have hypoxia (depressed concentrations) in the deeper portion of the pond. In 1960, DO in the bottom sample was 3.2 ppm and in 1980 anoxic (<1 ppm) concentrations were detected below 10.5 m (35 ft). The 2001 profile did not collect data beyond 7 m.

Beyond this concern, TN, TP, Secchi, and chlorophyll *a* readings collected during the 2001 PALS Snapshot are generally less than Cape Cod "impacted" thresholds and are at or less than thresholds developed for reference or unimpacted ponds. A Carlson TSI based on a surface chlorophyll *a* concentration places the pond on the boundary between oligiotrophic and oligotrophic with some deep anoxia categories.

During the development of the Cape Cod thresholds, Micah Pond was identified as one of the eight reference ponds for Cape Cod; Micah Pond was selected as one of the Cape Cod reference ponds because all of its surface water quality measures are in the lowest 25th percentile among all ponds measured during the 2001 PALS Snapshot. Another measure indicative of its relatively unimpacted condition is its Secchi depth, which was in the upper 95th percentile among all the ponds sampled during the 2001 PALS Snapshot. These nearly pristine conditions are a reflection of the lack of shoreline development around the pond. Overall, Micah Pond presents as a realtively clean, largely unimpacted lake.

| September 6, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 5.40 | 1.19 | 1.0 | 3.4 | 0.18 |
| 3 | 5.37 | 1.24 | 0.9 | BDL | 0.16 |
| 9.5 | 5.38 | 0.47 | 1.1 | BDL | 0.13 |

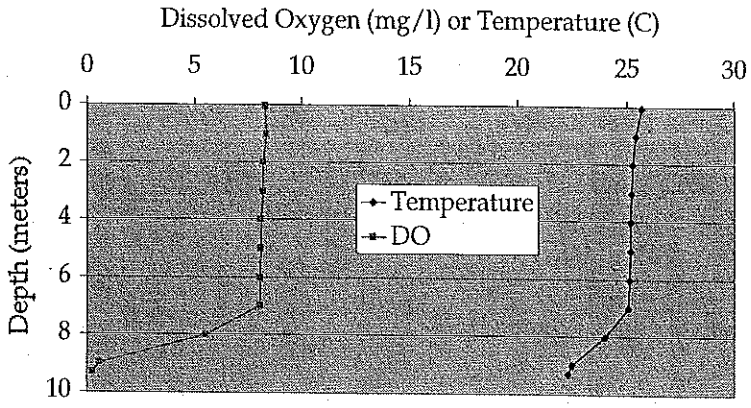
BDL = Below Detection Limit

# Middle Pond

## Barnstable

## BA-640

Acreage: 108
Maximum Depth: 35 ft
2001 Secchi Dip: 16.7 ft
Lake Association:
Indian Pond Association
Wheeler Road Association




Dissolved Oxygen and Temperature
Middle Pond, 8/16/01

OVERVIEW

Middle Pond is located in the Town of Barnstable. As the name implies, it is situated midway between Mystic Lake and Hamblins Pond. Groundwater recharge to the pond is from the northwest, largely from groundwater that has passed through Mystic Lake. The pond discharges surface water to groundwater along a narrow strip of shoreline adjacent to Hamblins Pond The pond also receives surface flow from Mystic Pond via a shallow channel and discharges surface water via an anadromous fish run to the Marstons Mills River. The shoreline is mapped as a priority habitat for rare species within wetlands by the Association to Preserve Cape Cod. The shoreline is well developed with single family homes, including seasonal and year-round homes. Public access is via a boat ramp off of Mystic Drive at the south end of the lake. Recreational uses include swimming, fishing, boating and icefishing.

WATER QUALITY

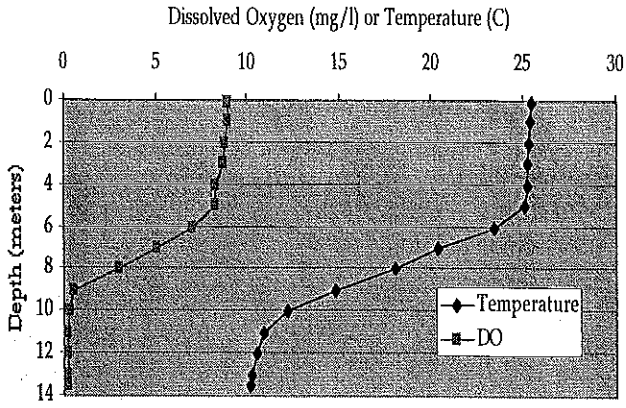
Various parameters have been measured in Middle Pond in 1948, 1975, 1980, 2001, and 2002. Dissolved oxygen (DO) readings collected on August 9, 1948 and August 27, 1980 show well saturated conditions from the surface to the bottom; these profiles are similar to the one collected during the 2001 PALS Snapshot (shown above), although the 2001 profile shows some anoxia near the bottom. Transparency in 1948 was 22 ft, 19.8 in 1980, and 16.7 ft in 2001; without additional readings it is difficult to discern whether this is a real trend or the natural range of fluctuation in Secchi disk readings. Phosphorus concentrations generally are in the same range throughout the years; total phosphorus data from the 2001 Snapshot (see below) is just above the Cape Cod "impacted" threshold (7.5 µg/l). A Carlson TSI based on the surface chlorophyll concentration indicates that this pond is in the lower portion of the oligotrophic with some bottom anoxia category.

Middle Pond appears to have changed little over the past 50 years, although the appearance of bottom anoxia and the Secchi readings may signal more recent nutrient loads. Given the pond's location in the groundwater system, it is somewhat protected from upgradient nutrients by Mystic Lake. Further evaluation of nutrient interactions between the three lakes in the "Indian Ponds" complex (Mystic, Middle, and Hamblin) is recommended as part of the development of a comprehensive management strategy for the complex. Development of this strategy should include more refined water quality sampling throughout the summer months, sediment sampling, and better definition of the pond watersheds. Overall, Middle Pond presents as a largely unimpacted pond with some concerns about deep anoxia.

| August 16, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.92 | 1.38 | 1.6 | 8.1 | 0.37 |
| 3 | 6.89 | 1.39 | 1.6 | 5.0 | 0.26 |
| 8 | 6.87 | 1.66 | 1.6 | 8.1 | 0.22 |

# Mystic Lake
## Barnstable
## BA-584

Acreage: 149
Maximum Depth: 40 ft
2001 Secchi Dip: 10 ft
Lake Association:
Indian Ponds Association




Dissolved Oxygen and Temperature
Mystic Lake, 8/21/01

OVERVIEW

Mystic Lake is located in the Town of Barnstable. It is the largest of the three "Indian Ponds" and is situated north of Middle Pond and Hamblins Pond. As the northern-most pond, Mystic Lake has the largest watershed and captures most of the nutrients from the three pond watershed before discharging groundwater to the southeast and Middle Pond. Mystic Lake is also directly connected to Middle Pond by a small channel. The shoreline is mapped as a priority habitat for rare species within wetlands by the Association to Preserve Cape Cod. The shoreline is well developed with single family homes, including seasonal and year-round homes. Public access is via a boat ramp off Race Lane. Recreational uses include swimming, fishing, boating and icefishing.

WATER QUALITY

Various parameters have been measured in Mystic Lake in 1948, 1975, 1980, 2001, and 2002. Temperature readings collected on 8/9/48 show a well-mixed, well-oxygenated upper layer extending to a depth of 25 ft (7.6 m) with cooler waters beneath (bottom temperature was 56°F (13.3°C)). Dissolved oxygen (DO) concentrations fall to 4.4 parts per million (ppm) at 35 ft (10.7 m) and are anoxic (<1 ppm) at 40 ft (12.2 m). DO concentrations on 8/27/80 are similar, but anoxic conditions begin at 35 ft. DO conditions measured during the 2001 PALS Snapshot (shown above) are, in turn, somewhat worse with anoxic conditions beginning at 9 m.

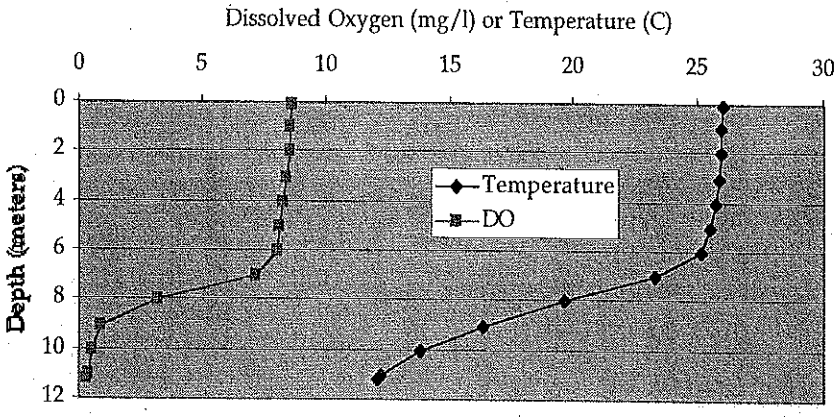
Nutrient and chlorophyll *a* concentrations collected during the 2001 PALS Snapshot (shown below) are generally consistent with the observed DO impairments. All total phosphorus (TP) readings are above the Cape Cod "impacted" threshold; shallower readings are twice the threshold. The deepest sample has a TP concentration 20 times the surface concentrations; this is consistent with TP regeneration from the sediments normally observed in lakes with deep anoxic waters. The surface chlorophyll *a* concentration is more than four times its threshold; a Carlson TSI based on this concentration indicates that this pond is in the middle portion of the mesotrophic category.

Water quality in Mystic Lake appears to have worsened over the past 50 years. It is recommended that the town consider a water quality assessment of the Mystic Lake, including a more refined monitoring program to evaluate DO, nutrient, and chlorophyll *a* concentrations throughout the summer, a sediment characterization, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to continue to worsen. This assessement could be part of the development of a comprehensive management strategy for the three ponds in the "Indian Ponds" complex (Mystic, Middle, and Hamblin). Overall, Mystic Lake presents as an impacted pond with deep anoxia.

| August 21, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.42 | 4.3 | 5.4 | 11.6 | 0.26 |
| 3 | 6.78 | 3.40 | 6.4 | 14.9 | 0.28 |
| 9 | 6.76 | 6.49 | 9.3 | 14.9 | 0.29 |
| 12.5 | 6.39 | 10.80 | 34.4 | 296.4 | 1.74 |

# Shubael Pond
## Barnstable
## BA-664

Acreage: 56
Maximum Depth: 41 ft
2001 Secchi Dip: 15.1 ft
Lake Association
Sand Shores Association




Dissolved Oxygen and Temperature
Shubael Pond, 8/20/01

OVERVIEW

Shubael Pond is located in the village of Marstons Mills. Shubael Pond is a round, kettlehole pond with a moderate to steeply sloping shoreline. Groundwater flows into the pond from the northwest. The pond contributes surface flow to groundwater along the southeast shoreline. The area surrounding the pond is well developed with single family homes. Public access is provided via a gravel boat ramp off Shubael Pond Drive and Willamantic Drive. The pond is extensively used for fishing, boating and swimming. The pond is routinely stocked with trout by the Massachusetts Division of Fisheries and Wildlife.

WATER QUALITY

Shubael Pond has been sampled in 1980, 2001, and 2002, with dissolved oxygen and temperature profiles only available during the 2001 and 2002 samples. Chlorophyll a and TN concentrations from the 2001 PALS snapshot (see below) are above current Cape Cod "impacted" thresholds, while TP concentrations are below the TP threshold. A Carlson TSI based on a surface chlorophyll *a* concentration places the pond in the oligotrophic with some deep anoxia category.

Without historic DO profiles it is difficult to assess whether the anoxia in the bottom of the pond has occurred historically or is of more recent occurence; additional DO monitoring on a biweekly schedule during the summer is recommended to resolve whether the anoxia develops at the onset of stratification or whether it only occurs during the late summer. It is also recommended that annual monitoring of the pond continue and that a characterization of nutrient loads to and within the lake be considered in the future to resolve whether conditions are likely to worsen. Overall, Shubael Pond presents as a impacted pond with water quality concerns that need additional monitoring to resolve.

| August 20, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.47 | 2.03 | 0.7 | 5.0 | 0.36 |
| 3 | 6.42 | 1.86 | 0.7 | * | 0.34 |
| 10 | 6.42 | 7.63 | 0.9 | 5.0 | 0.34 |

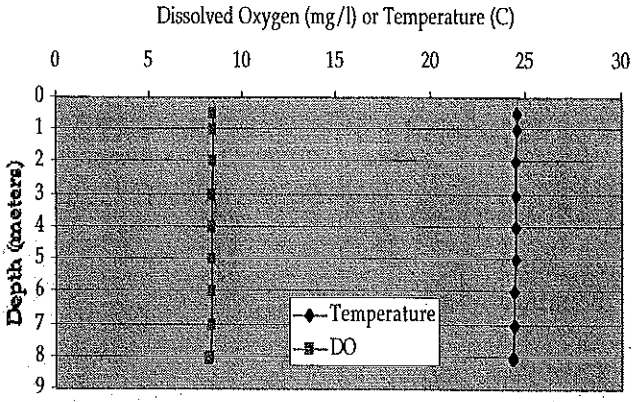
* = value appears to be outlier; inconsistent with other values/parameter readings

# Wequaquet Lake

## Barnstable

## BA-605

Acreage: 596
Maximum Depth: 32 ft
2001 Secchi Dip: 12 ft
LakeAssociation: Wequaquet Lake Protective Association




Dissolved Oxygen and Temperature
Wequaquet Lake, 8/29/01

OVERVIEW

Wequaquet Lake is the largest lake in the Town of Barnstable and the third largest lake on Cape Cod. It is centrally located west of Route 132 and south of Route 6. The pond is recharged from groundwater flow from the north and west. The pond discharges to groundwater along the south, southwest, southeast, and eastern shorelines. In addition the pond supplies surface water to a dam controlled herring run leading into Long Pond during average to high groundwater conditions. Water levels were evaluated through a Cape Cod Commission study in 1998.

Most of the shoreline is moderately sloped, but areas with shallow slopes are occasionally flooded. The shoreline is densely developed with year round and seasonal homes. The pond is used extensively for recreation including icefishing, boating, swimming, water-skiing, sailing and fishing. A public boat ramp and bathing beach are located off of Shootflying Hill Road.

WATER QUALITY

The pond was sampled in 1948, 1980 (when it was categorized as oligotrophic), 1989 (when it was categorized as borderline oligotrophic/mesotrophic), 2001, and 2002. Four sets of samples were collected from the lake during the 2001 PALS Snapshot. Results from both the 1948 and 2001dissolved oxygen and temperature profiles indicate well mixed warm water with good oxygen saturation and no apparent impacts in the intervening years. The Carlson TSI based on 2001 surface chlorophyll concentrations places the lake on the line between the oligotrophic and mesotrophic categories. Nutrient concentrations generally are slightly higher than Cape Cod "impacted" thresholds, while chlorophyll concentrations are generally more than double the Cape Cod threshold. Given Lake Wequaquet's relatively shallow depth, nutrient additions will be mixed into the entire water column creating opportunities for algal growth. It is recommended that the town consider additional characterization of nutrient loads into and within the lake. Overall, Lake Wequaquet presents as a realtively clean, but impacted lake.

| | August 29, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|---|
| | Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| | meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| North Basin | 0.5 | 6.69 | 3.72 | 3.6 | 14.9 | 0.32 |
| | 6 | 6.55 | 4.3 | 3.7 | 13.0 | 0.40 |
| Middle Basin | 0.5 | 6.69 | 3.55 | 3.5 | 18.0 | 0.39 |
| | 4 | 6.64 | 3.05 | 3.6 | 18.0 | 0.35 |
| | 7 | 6.56 | 3.75 | 3.5 | 34.4 | 0.39 |
| South Basin | 0.5 | 6.51 | 2.33 | 2.9 | 18.0 | 0.38 |
| | 4 | 6.51 | 2.31 | 2.9 | 18.0 | 0.33 |
| Fish Pond/NW | 0.5 | 6.57 | 3.01 | 0.7 | 14.9 | 0.36 |
| | 3.5 | 6.49 | 2.82 | 0.7 | 34.4 | 0.53 |


400 0 400 800 Feet

## Eagle Pond Barnstable (BA-815)

**Bathymetry Source:**
**Bathymetric Map of Eagle Pond, Cotuit (1993)**
**Romark Limnological Assessments, Inc.**

Town owned land
300' buffer
Bathymetry in feet

N
W E
S


1000 0 1000 2000 Feet

## Garretts Pond Barnstable (BA-510)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
300' Buffer Zone
Bathymetry

N
W E
S


## Hamblin's Pond
## Barnstable
## (BA-668)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet
300' Buffer Zone

N
W E
S

2000 0 2000 4000 Feet

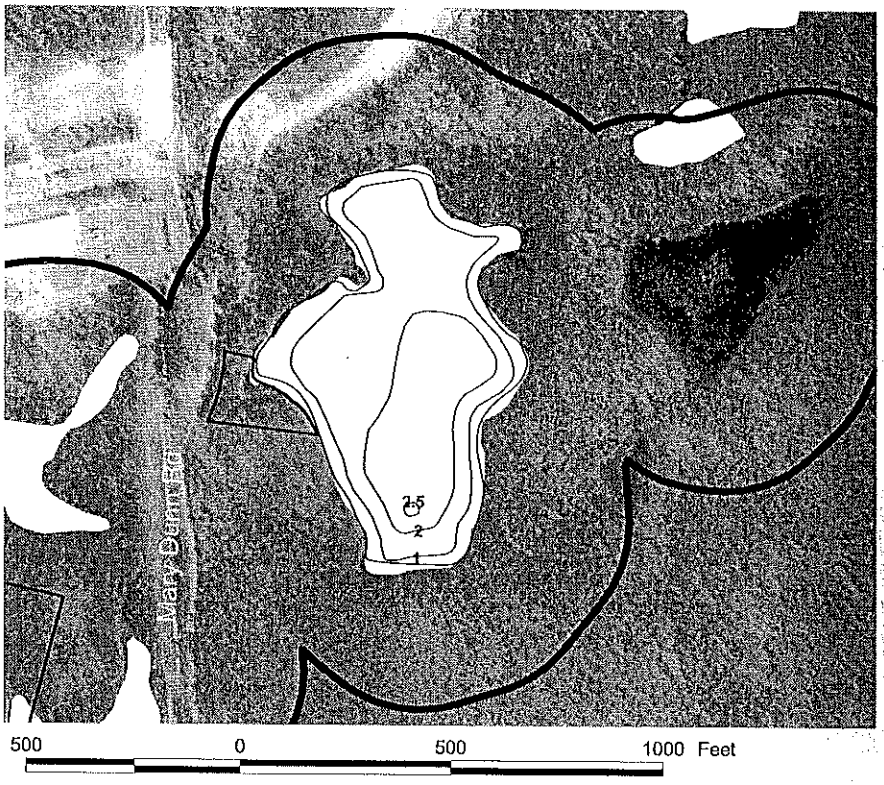

## Hathaway's Pond
## Barnstable
## (BA-565)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet
300' Buffer Zone
Town owned land

N
W E
S

800 0 800 1600 Feet

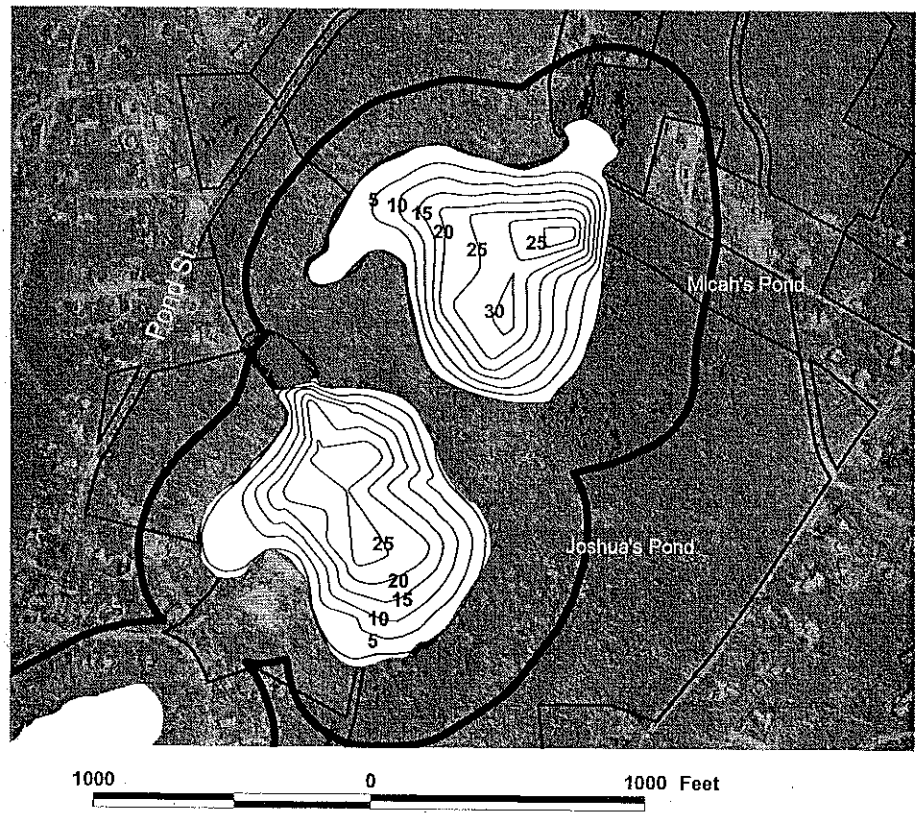



## Israel Pond
## Barnstable
## (BA-585)

Bathymetry Source:
IEP, Inc. September 1990

300' buffer
Town owned land
Bathymetry in feet

N
W
E
S

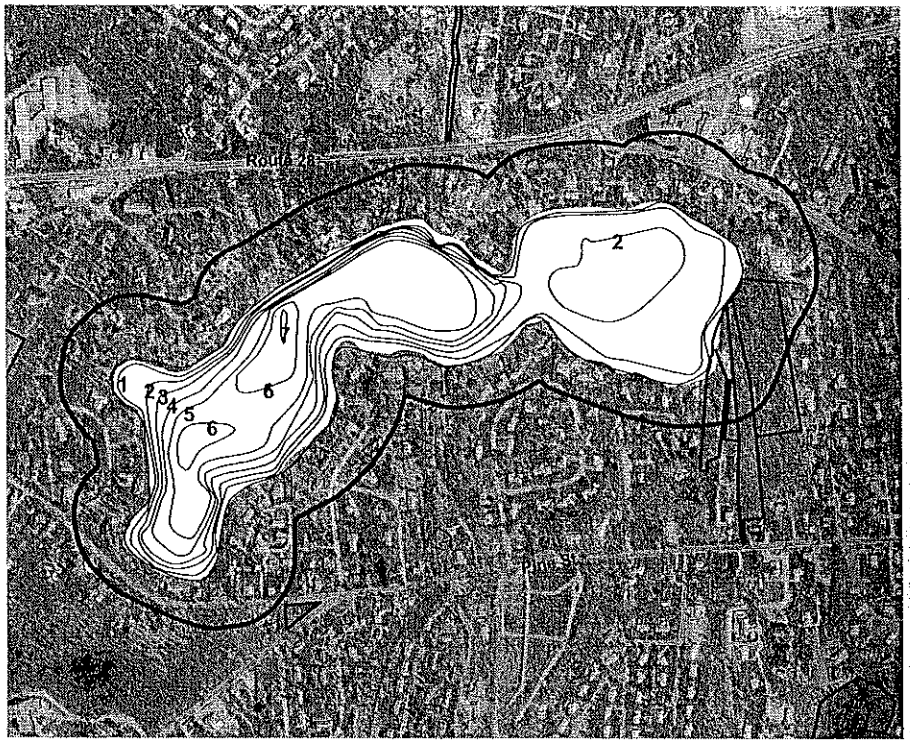



## Joshua (BA-807)
## and
## Micah's Ponds (BA-797)
## Barnstable

Bathymetry Source:
Division of Fish and Wildlife

300' Buffer Zone
Bathymetry in feet
Town owned land

N
W
E
S



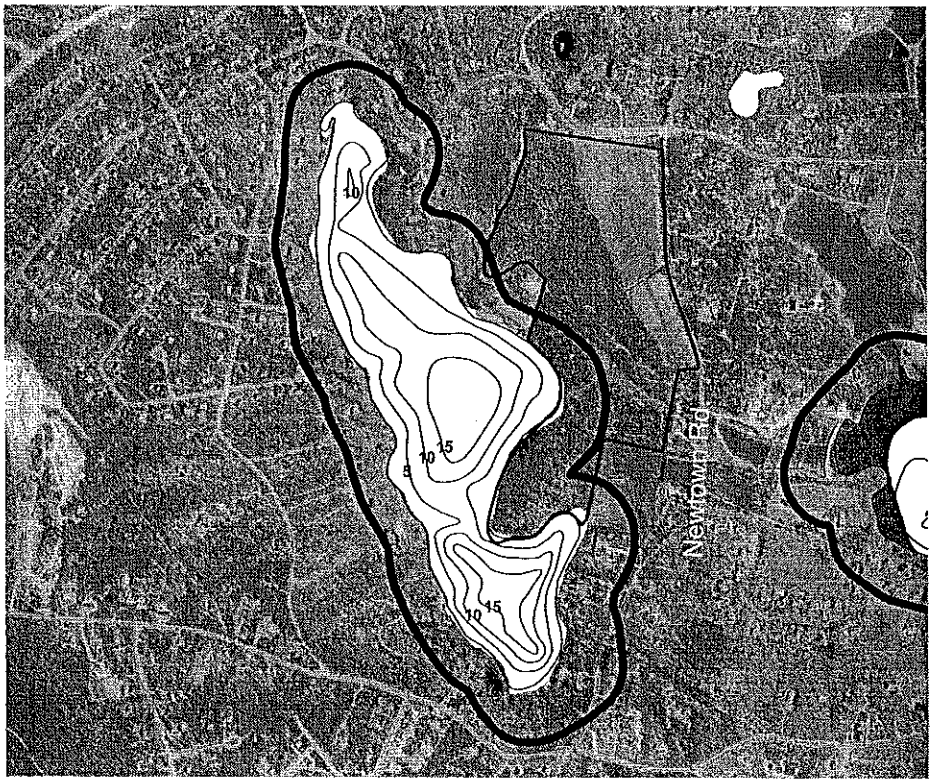

600 0 600 1200 1800 Feet

## Long Pond Centerville Barnstable (BA-737)

Bathymetry Source:
IEP, Inc. and KV Associates

Town owned land
300' buffer
Bathymetry in meters

N
W E
S



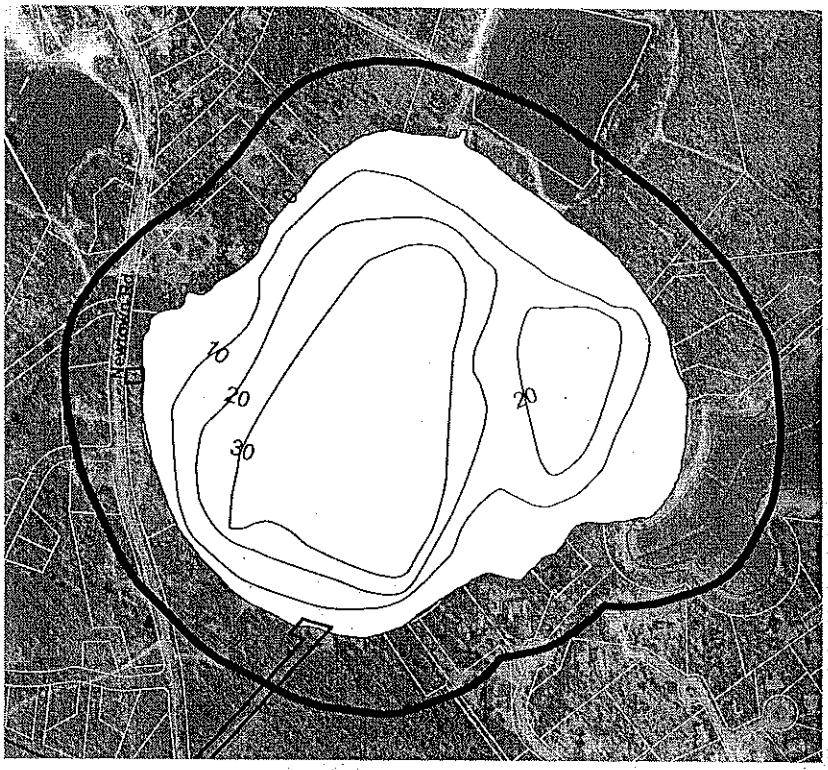

500 0 500 1000 1500 2000 2500 Feet

## Long Pond Marstons Mills Barnstable (BA-675)

Bathymetry Source:
Division of Fish and Wildlife

300' buffer
Town owned land
Bathymetry in feet

N
W E
S



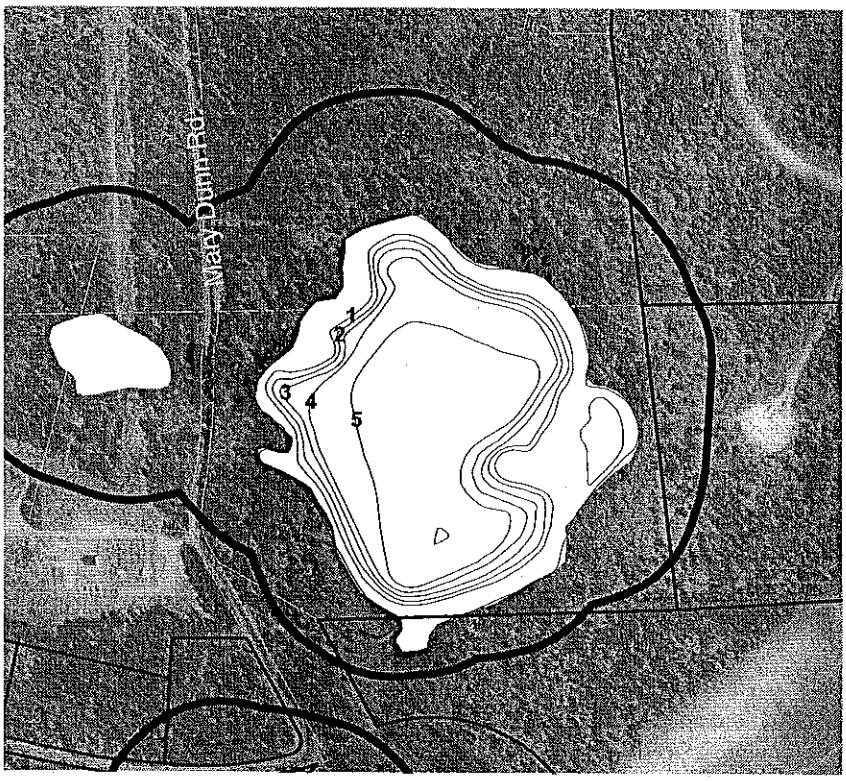

## Lovells Pond
## Barnstable
## (BA-759)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet
300' Buffer Zone

N
W E
S

900 0 900 1800 Feet




## Mary Dunn Pond
## Barnstable
## (BA-646)

**Bathymetry Source:**
**IEP, 1990 EIR Independance Park**

Town owned land
Bathymetry in feet
300' Buffer Zone

N
W E
S

700 0 700 1400 Feet


900 0 900 1800 2700 Feet

## Middle Pond Barnstable (BA-640)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet
Town owned land

300' Buffer Zone

N
W E
S


700 0 700 1400 Feet

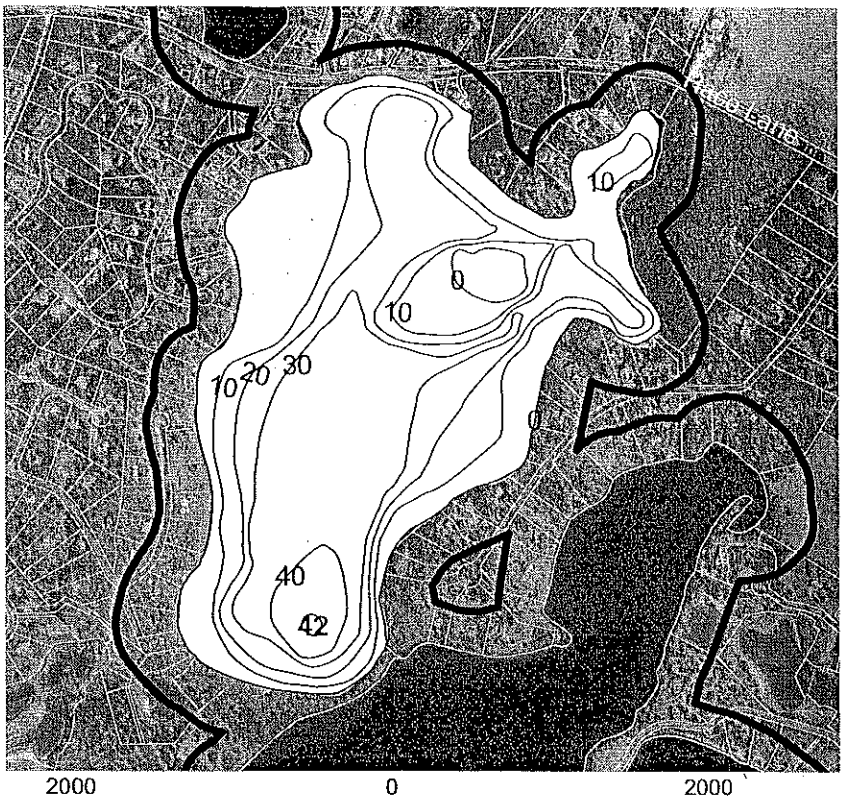
## Muddy Pond Barnstable (BA-694)

**Bathymetry Source:**
**Unknown**

Bathymetry in feet

300' Buffer Zone

N
W E
S




## Mystic Pond
## Barnstable
## (BA-584)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet

300' Buffer Zone

N
W E
S

2000 0 2000 4000 Feet


## Red Lily Pond
## Barnstable
## (BA-782)

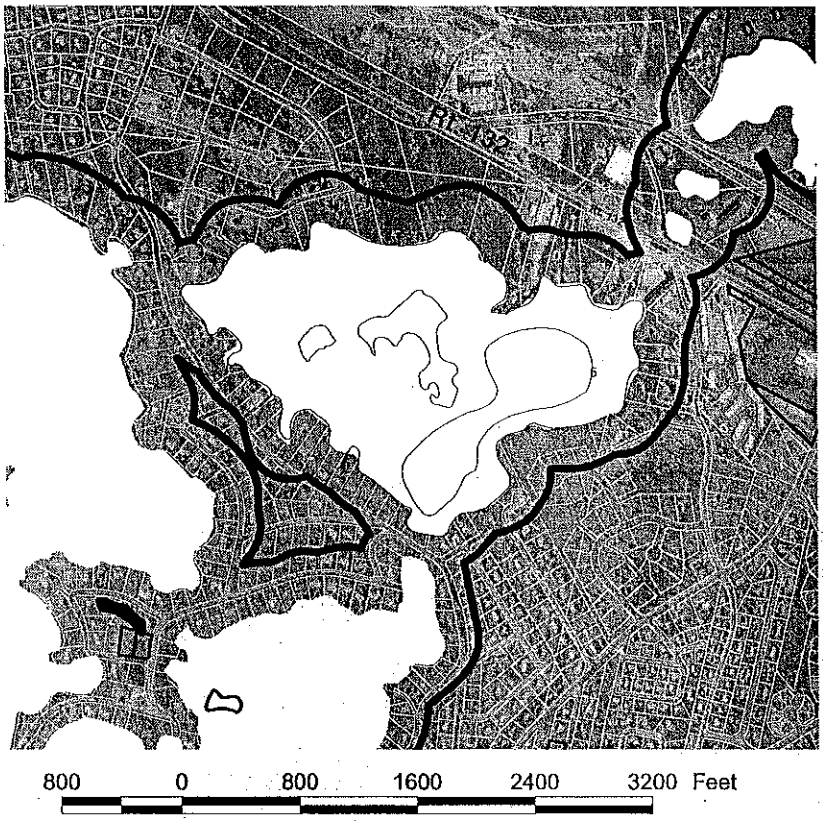
**Bathymetry Source:**
**Baseline Water Quality Studies of Selected Lakes and Ponds in the Cape Cod Drainage Area 1983, DEQE**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

600 0 600 1200 Feet



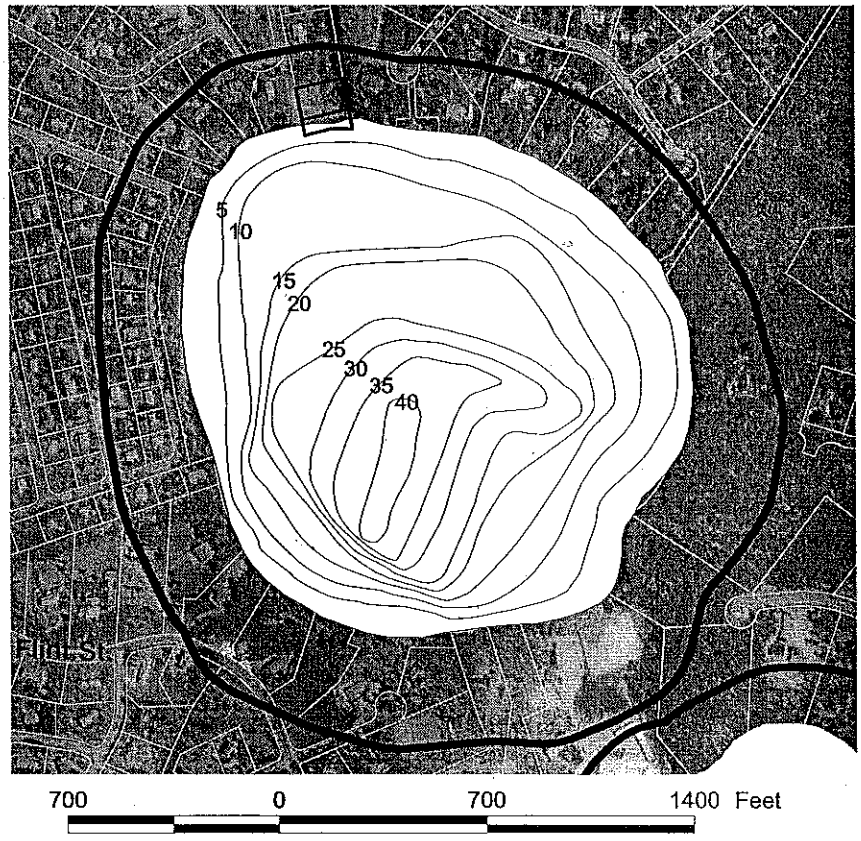

## Shallow Pond Barnstable (BA-626)

**Bathymetry Source:**
**MA DEQE 1983**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S



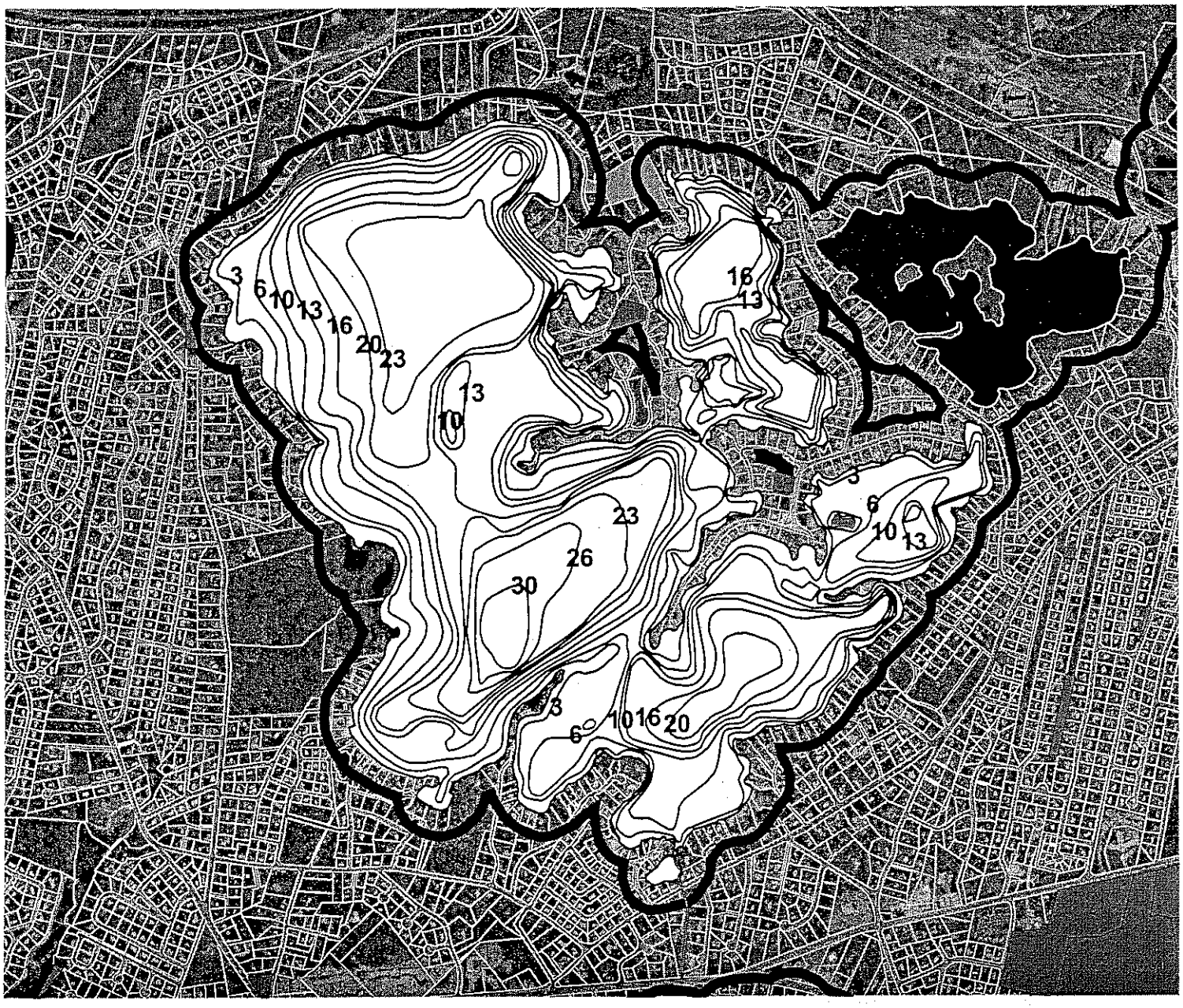

## Shubael Pond Barnstable (BA-664)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land.shp
Bathymetry in feet

300' Buffer Zone

N
W E
S




# Wequaquat Lake (BA-605) and Bearse Pond (BA-617)

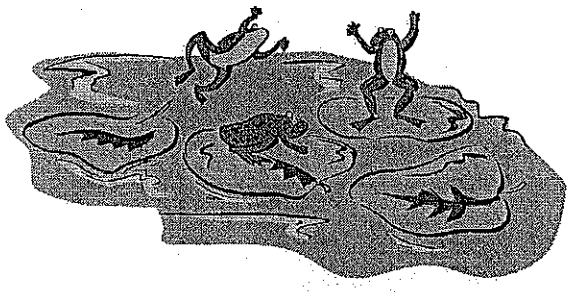
**Bathymetry Source:**
**Department of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zones

N
W
E
S

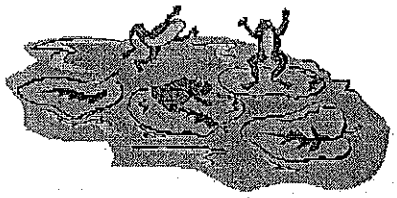
# BOURNE PONDS



Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

| With Map and Description: | Map Only: |
| --- | --- |
| Flax Pond | Queen Sewell |

# Town of Bourne Atlas Summary



**Total Land Area (sq. miles):** 41.02

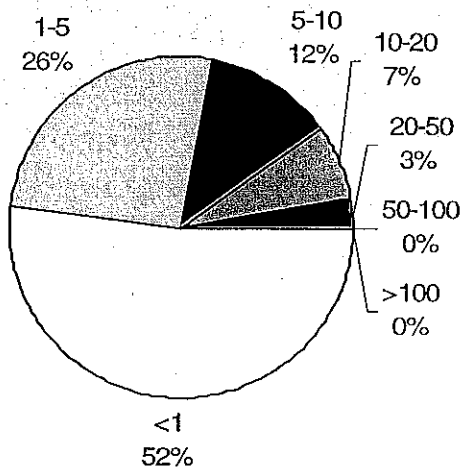
**Total Area of Ponds (acres):** 247

**Total # of Ponds:** 73

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 38 |
| 1-5 acres: | 19 |
| 5-10 acres: | 9 |
| 10-20 acres: | 5 |
| 20-50 acres: | 2 |
| 50-100 acres: | |
| >100 acres: | |

**Number of Bourne Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 4 |
| # of impacted ponds | |
| Chlorophyll a: | 2 |
| Total Nitrogen: | 3 |
| Total Phosphorus: | 2 |

**2001 Secchi Dip-In**

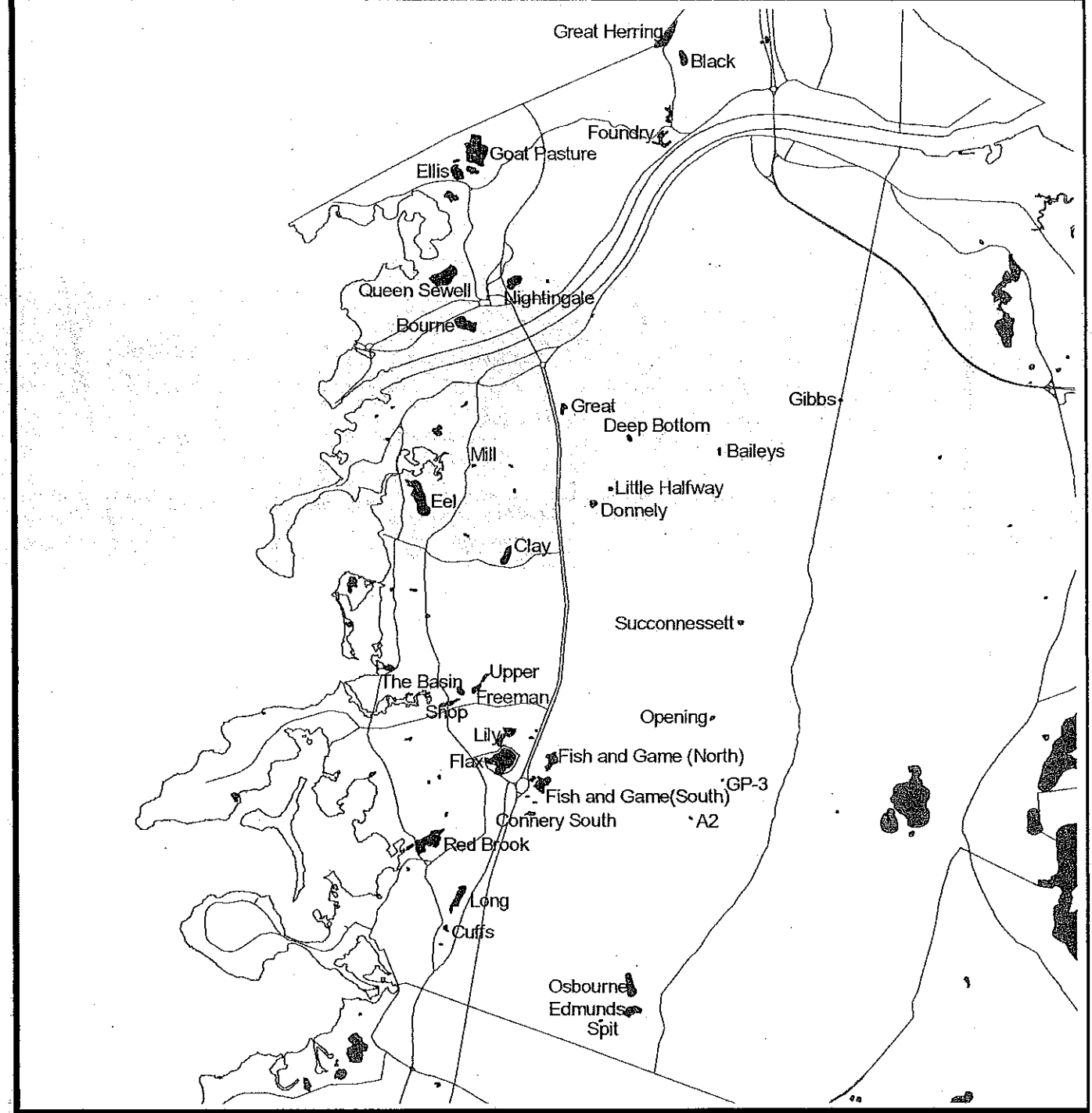
| | |
|---|---|
| # of ponds dipped: | 2 |
| # of volunteers: | 1 |

**Coordinator:**

Ponds in Bourne were sampled during the PALS Snapshots through the efforts of Tony Williams of the Coalition for Buzzards Bay.

**Pond Groups:** Coalition for Buzzards Bay

# BOURNE
# NAMED PONDS



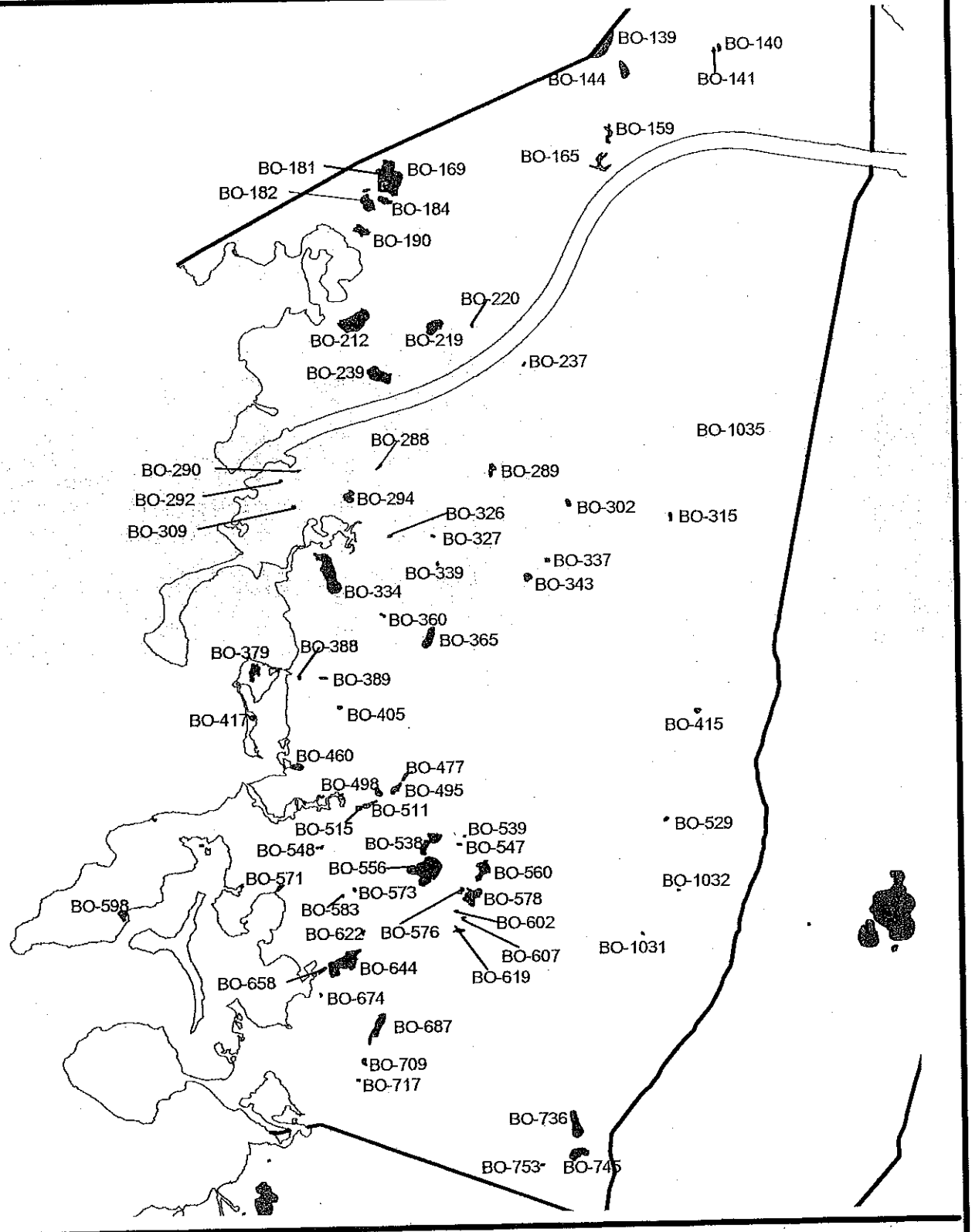

N

1 0 1 2 Miles

COUNTY OF BARNSTABLE * MASSACHUSETTS *

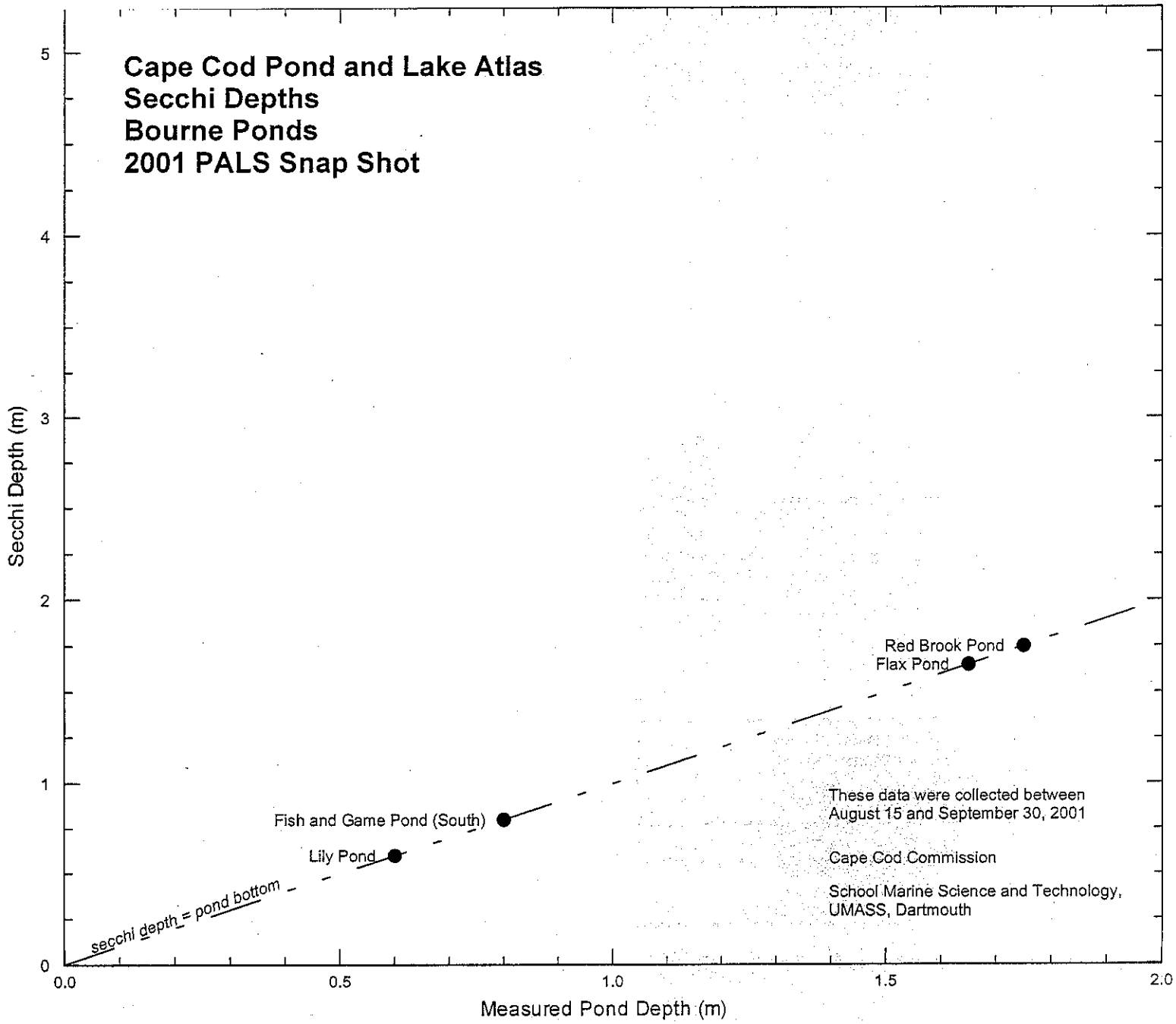
CAPE COD COMMISSION

# GIS ID'S FOR BOURNE PONDS



# Bourne 2001 PALS Water Quality Snapshot Summary

| | Chlyorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk (1-1.7 ug/l) | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk (0.16-0.31 mg/l) | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk (7.5-10 ug/l) | impacted (>10 ug/l) |
| **Fish and Game Pond (South)** | 2.895 | | | x | 0.84 | | | x | 9.76 | | x | |
| **Flax Pond** | 1.005 | | x | | 0.37 | | | x | 13.32 | | | x |
| **Lily Pond** | 1.34 | | x | | 0.57 | | | x | 21.06 | | | x |
| **Red Brook Pond** | 3.66 | | | x | 0.25 | | x | | 4.65 | x | | |


Cape Cod Pond and Lake Atlas
Secchi Depths
Bourne Ponds
2001 PALS Snap Shot
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
0.0
0.5
1.0
1.5
2.0
Red Brook Pond
Flax Pond
Fish and Game Pond (South)
Lily Pond
secchi depth = pond bottom
These data were collected between
August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology,
UMASS, Dartmouth

# BOURNE POND DATABASE

| Name | CCC GIS ID | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A2 Pond | BO-1031 | | 0.2 | | | | | | | | |
| Bennett Pond | | 96014 | | | | 8 | | none | | | |
| Baileys Pond | BO-315 | | 0.7 | N | | | | | | | |
| Black Pond | BO-144 | 95013 | 4.4 | N | | 18 | | private | | | |
| Bourne Pond | BO-239 | 95016 | 10.6 | N | | | | town | | | |
| Fish and Game Pond (South) | BO-578 | 96030 | 7.6 | N | | 46 | | MMR | | | |
| Fish and Game Pond (North) | BO-560 | | 6.3 | N | | 48 | | MMR | | | |
| Clay Pond | BO-365 | 96038 | 5.5 | N | | 33 | | pubnoramp | | | |
| Connery South Pond | BO-619 | | 1.1 | N | | | | | | | |
| Cuffs Pond | BO-709 | 96052 | 0.9 | N | | | | none | I,O | | |
| Deep Bottom Pond | BO-302 | 96056 | 1.1 | N | | | | MMR | | | |
| Donnely Pond | BO-343 | 96063 | 1.9 | N | | | | MMR | | | |
| Edmunds Pond | BO-745 | 96074 | 6.2 | N | | 52 | 8 | MMR | | | |
| Eel Pond | BO-334 | 96075 | 20.0 | N | | | | pubramp | O | | |
| Ellis Pond | BO-182 | 96081 | 6.5 | N | | 19 | | private | I,O | | |
| Flax Pond | BO-556 | 96087 | 23.0 | Y | 2,671 | 36 | 6 | pubramp | | | |
| Foundry Pond | BO-165 | 96095 | 4.2 | N | | | 4 | none | I,O,HR | | |
| Freeman Pond | BO-495 | 96096 | 2.2 | N | | | 3 | 4PondConsArea | I,O | | |
| Gibbs Pond | BO-1035 | | 0.4 | N | | | | | | | |
| Goat Pasture Pond | BO-169 | 96104 | 23.1 | N | | 24 | 5 | informal | I,O | | |
| GP-3 Pond | BO-1032 | | 0.2 | N | | | | | | | |
| Great Herring Pond | BO-139 | 94050 | 11.1 | N | | 34 | 37 | pubramp,gravel | HR | | |
| Great Pond | BO-289 | 96116 | 1.9 | N | | 34 | | informal | | | |
| Lily Pond | BO-538 | 96169 | 7.4 | N | | 37 | 5 | pubnoramp | | | |
| Little Halfway Pond | BO-337 | 96172 | 0.7 | N | | | | MMR | | | |
| Long Pond | BO-687 | 96178 | 7.5 | N | | 27 | | none | I,O | | |
| Mill Pond | BO-326 | | 0.4 | N | | 25 | | none | | | |
| Mill Pond | BO-515 | 96205 | 0.9 | N | | | | 4PondConsArea | I,O | | |

# BOURNE POND DATABASE

| Name | CCC GIS ID | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nightingale Pond | BO-219 | 96221 | 7.0 | N | | 8 | 11 | pubnoramp | | | |
| Opening Pond | BO-529 | | 0.6 | N | | | | | | | |
| Osbourne Pond | BO-736 | 96232 | 8.3 | N | | 53 | 5 | MMR | | | |
| Queen Sewell Pond | BO-212 | 96253 | 17.3 | Y | 7657.9 | 4 | 28 | pubramp | | | |
| Red Brook Pond | BO-644 | 96256 | 17.1 | N | | 10 | 10 | TownConsArea | O | | wq |
| Shop Pond | BO-511 | 96292 | 1.8 | N | | 25 | | 4PondConsArea | I,O | | |
| Spit Pond | BO-753 | | 0.3 | N | | | | | | | |
| Succonnessett Pond | BO-415 | | 1.0 | N | | | | | | | |
| The Basin | BO-498 | | 1.9 | N | | | | | | | |
| Upper Pond | BO-477 | 96325 | 1.1 | N | | | | 4PondConsArea | O | | |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

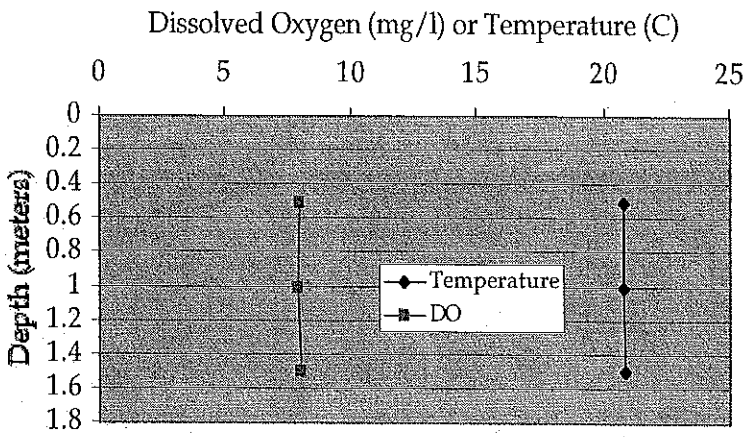
GIS #'s assigned by Cape Cod Commision GIS 200. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Flax Pond
# (Picture Lake)
## Bourne
## BO-556

Acreage: 23
Maximum Depth: 6 ft
2001 Secchi Dip: 6 ft
Lake Association: none




Dissolved Oxygen and Temperature
Flax Pond, 2001 PALS Snapshot

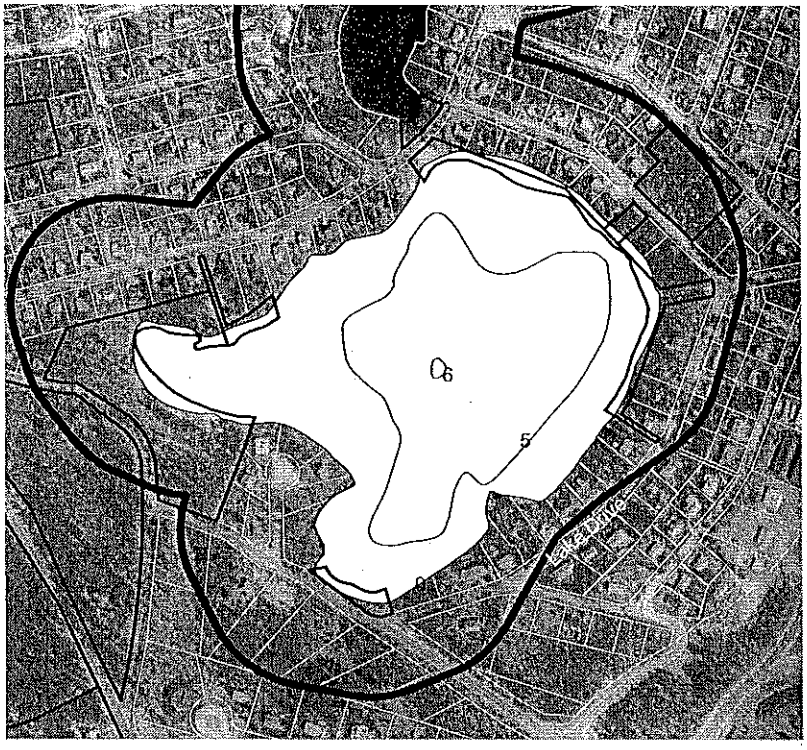
OVERVIEW

Flax Pond, which is also known as Picture Lakek, is located west of Route 28, General MacArthur Boulevard and the Otis Air Force Base rotary. This shallow kettlehole pond is recharged by groundwater flow from the east and contributes surface flow to groundwater along the west shoreline. The shoreline is well developed with single family homes. Limited amounts of open space are provided as a pond buffer around the east and western ends of the pond. Public access is available at two ponts on the west shore, off of County Road through a town park and beach area. Recreational activites include swimming and fishing. According to the state Division of Fish and Wildlife, the pond has a history of being a good largemouth bass pond.

WATER QUALITY

The 2001 PALS Snapshot data appears to be the first water quality sampling of Flax Pond. As a shallow pond, wind should keep the water column well mixed and water quality should be homogeneous. Temperature and dissolved oxygen profiles display homogeneous conditions, as do the results from the duplicate water quality samples collected (shown below). The chlorophyll *a* and TP concentrations are below current Cape Cod "impacted" thresholds, while the TN concentrations slightly exceed the TN threshold. A Carlson TSI based on a surface chlorophyll *a* concentration places the pond at the top of the oligotrophic category. Overall, Flax Pond presents as a realtively clean, largely unimpacted lake.

| 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.47 | 1.04 | 6.1 | 5.3 | 0.37 |
| 0.5 | 6.74 | 0.97 | 6.2 | 5.3 | 0.37 |




700 0 700 1400 Feet

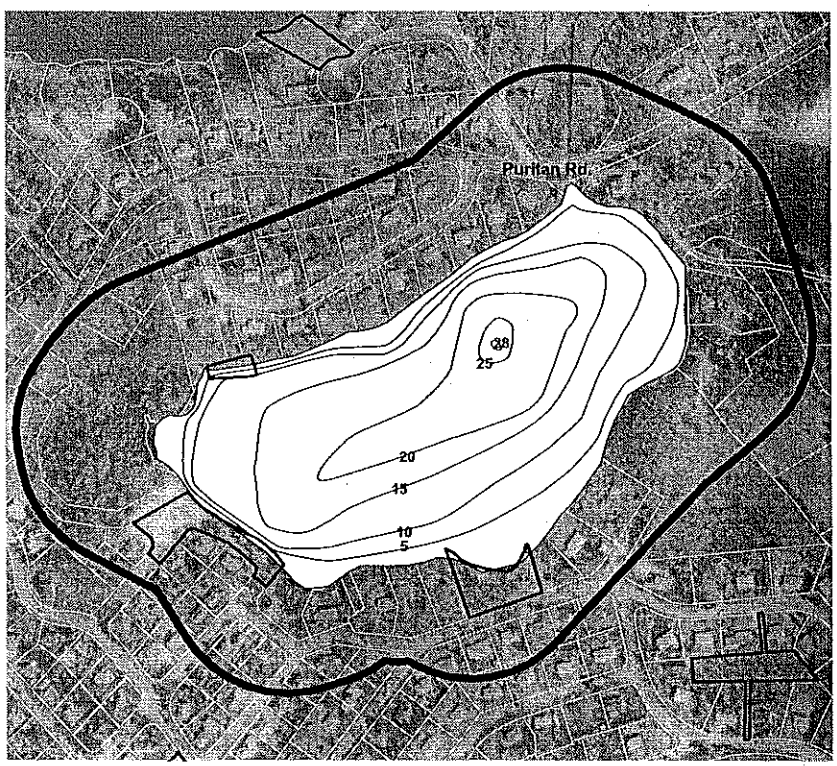
## Flax Pond
## Bourne
## (BO-556)

**Bathmetry Source:**
**Division of Fish and Wildlife**

Bourne town owned parcels
Bathymetry in feet

300' Buffer Zone

N
W E
S




500 0 500 1000 Feet

## Queen Sewell Pond
## Bourne
## (BO-212)

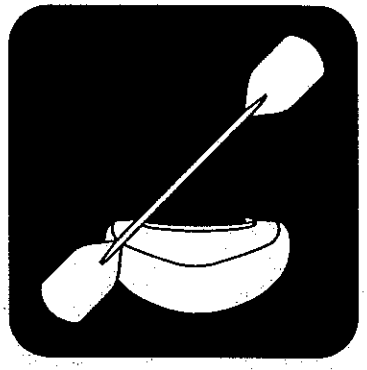
**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

# BREWSTER PONDS



Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
Pond 2001 Water Quality Summary Table
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:

Blueberry Pond
Canoe Pond
Cliff Pond
Elbow Pond
Flax Pond
Higgins Pond
Little Cliff Pond
Long Pond
Lower Mill Pond
Seymour Pond
Sheep Pond

Map Only:

Rafe Pond
Ruth Pond
Smalls Pond
Upper Mill/ Walkers

# Town of Brewster Atlas Summary

**Total Land Area (sq. miles):** 22.5

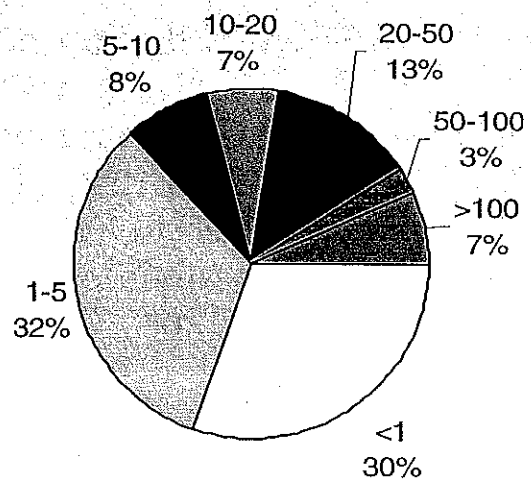
**Total Area of Ponds (acres):** 2028

**Total # of Ponds:** 76

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 23 |
| 1-5 acres: | 25 |
| 5-10 acres: | 6 |
| 10-20 acres: | 5 |
| 20-50 acres: | 10 |
| 50-100 acres: | 2 |
| >100 acres: | 5 |

**Number of Brewster Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 26 |
| # of impacted ponds | |
| Chlorophyll a: | 16 |
| Total Nitrogen: | 15 |
| Total Phosphorus: | 12 |

**2001 Secchi Dip-In**

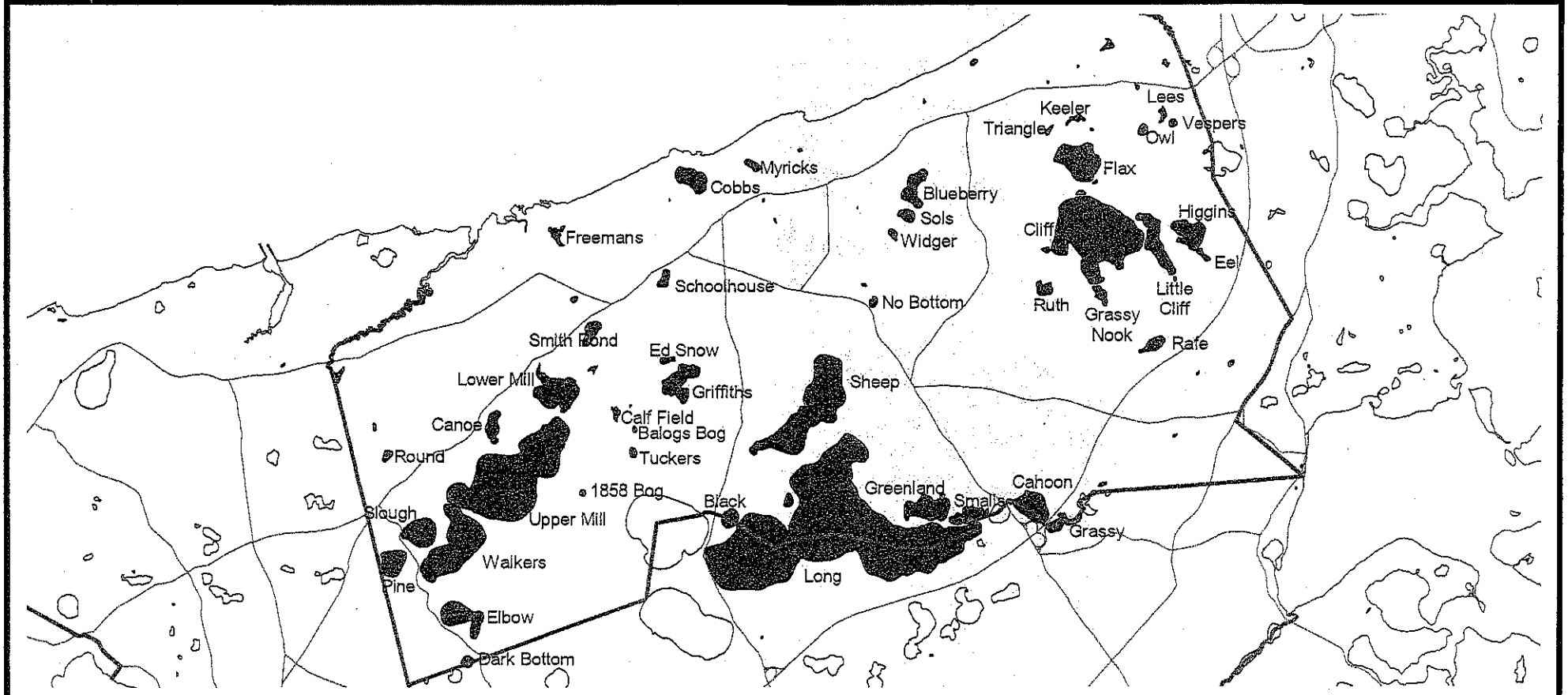
| | |
|---|---|
| # of ponds dipped: | 20 |
| # of volunteers: | 11 |

**Coordinator:**

| | |
|---|---|
| Town staff: | Bob Mant |
| Citizen: | Jane Johnson |

**Pond Groups:** Brewster Pond Monitoring Group
Canoe Pond Association
Long Pond Watershed Association

# BREWSTER NAMED PONDS

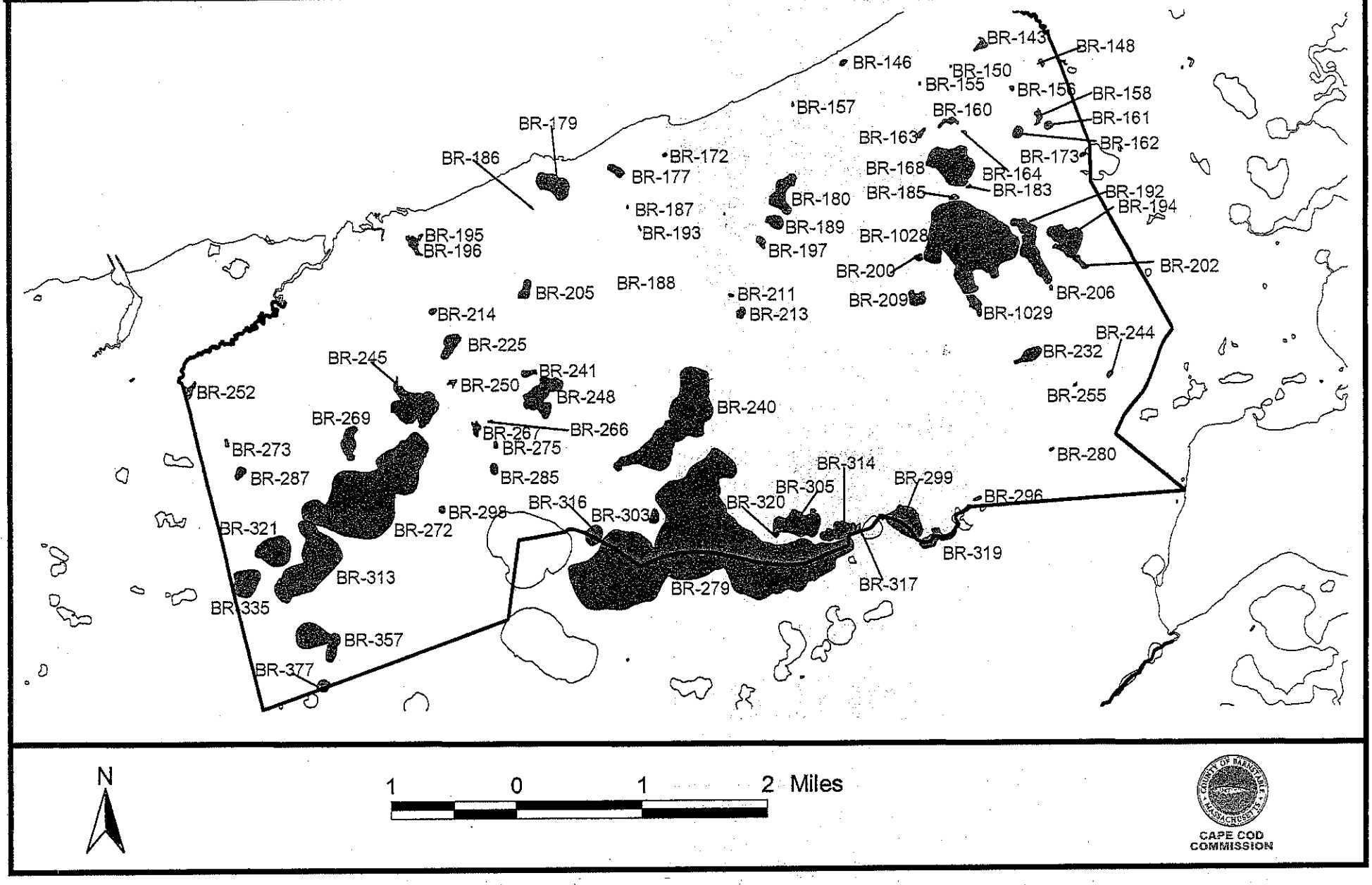



N

1 0 1 2 Miles

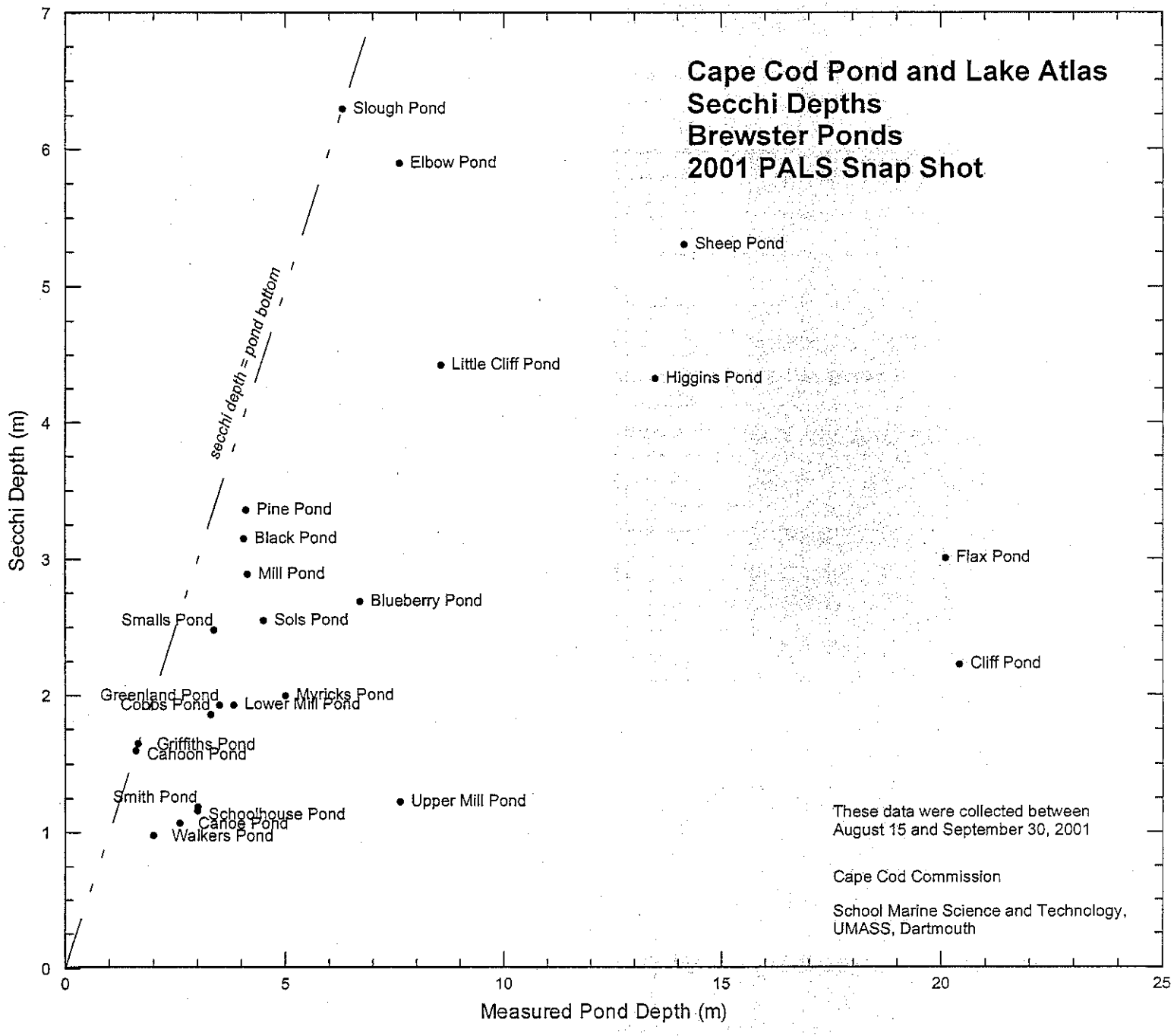
CAPE COD COMMISSION

# GIS ID'S FOR BREWSTER PONDS



# Brewster 2001 PALS Water Quality Snapshot Summary

| Name | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk 1-1.7 ug/l | **impacted (>1.7 ug/l)** | mg/l | unimpacted (<0.16 mg/l) | at risk 0.16-0.31 mg/l | **impacted (>0.31 mg/l)** | ug/l | unimpacted (<7.5 ug/l) | at risk 7.5-10 ug/l | **impacted (>10 ug/l)** |
| Black Pond | 0.01 | x | | | | | | | | | | |
| Blueberry Pond | 2.77 | | | x | 0.35 | | | x | 10.84 | | | x |
| Cahoon Pond | 1.16 | | x | | 0.47 | | | x | 4.65 | x | | |
| Canoe Pond | 13.65 | | | x | 0.57 | | | x | 26.63 | | | x |
| Cliff Pond | 5.83 | | | x | 0.42 | | | x | | | | |
| Cobbs Pond | 7.15 | | | x | 0.72 | | | x | 14.25 | | | x |
| Elbow Pond | 1.29 | | x | | 0.22 | | x | | 7.74 | | x | |
| Flax Pond | 4.59 | | | x | 0.31 | | | x | 7.74 | | x | |
| Greenland Pond | 2.66 | | | x | 0.37 | | | x | 14.25 | | | x |
| Griffiths Pond | 6.78 | | | x | 0.33 | | | x | 14.25 | | | x |
| Higgins Pond | 1.68 | | x | | 0.25 | | x | | 7.74 | | x | |
| Little Cliff Pond | 1.11 | | x | | 0.22 | | x | | 4.65 | x | | |
| Long Pond | 13.71 | | | x | 0.50 | | | x | 16.72 | | | x |
| Lower Mill Pond | 28.32 | | | x | 0.57 | | | x | 41.04 | | | x |
| Mill Pond | 2.45 | | | x | 0.32 | | | x | 20.44 | | | x |
| Myricks Pond | 7.04 | | | x | 0.52 | | | x | 11.46 | | | x |
| Pine Pond | 0.33 | x | | | 0.11 | x | | | 4.65 | x | | |
| Schoolhouse Pond | 10.3 | | | x | 0.83 | | | x | 12.70 | | | x |
| Seymour Pond | 4.84 | | | x | 0.39 | | | x | 26.63 | | | x |
| Sheep Pond | 1.12 | | x | | 0.20 | | x | | 6.19 | x | | |
| Slough Pond | 0.65 | x | | | 0.12 | x | | | 4.65 | x | | |
| Smalls Pond | 0.02 | x | | | | | | | | | | |
| Smith Pond | 12.18 | | | x | 0.90 | | | x | 39.33 | | | x |
| Sols Pond | 0.04 | x | | | | | | | | | | |
| Upper Mill Pond | 14.27 | | | x | 0.47 | | | x | 33.14 | | | x |
| Walkers Pond | 15.53 | | | x | 0.67 | | | x | 52.03 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Brewster Ponds
2001 PALS Snap Shot
Secchi Depth (m)
Measured Pond Depth (m)
secchi depth = pond bottom
Slough Pond
Elbow Pond
Sheep Pond
Little Cliff Pond
Higgins Pond
Pine Pond
Black Pond
Mill Pond
Flax Pond
Blueberry Pond
Smalls Pond
Sols Pond
Cliff Pond
Greenland Pond
Myricks Pond
Cobbs Pond
Lower Mill Pond
Griffiths Pond
Canoon Pond
Smith Pond
Upper Mill Pond
Schoolhouse Pond
Canoe Pond
Walkers Pond
These data were collected between
August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology,
UMASS, Dartmouth

# BREWSTER POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bakers Pond | | | | | | | | public | | | |
| 1858 Bog | BR-298 | | 1.3 | N | | | | | | | |
| Balogs Bog | BR-275 | | 0.9 | N | | | | | | | |
| Black Pond | BR-316 | 96017 | 10.6 | N | | 35 | | informal | | wq | wq |
| Blueberry Pond | BR-180 | 96022 | 21.3 | Y | 7,718 | 25 | 24 | informal | | sd,wq | sd,wq |
| Cahoon Pond | BR-299 | 96028 | 32.8 | N | | 31 | 14 | none | | sd,wq | wq |
| Calf Field Pond | BR-267 | | 3.0 | N | | 32 | | private | | | |
| Canoe Pond | BR-269 | 96031 | 13.6 | N | | 27 | 20 | private | O | sd,wq | |
| Cedar Lake | | 96032 | | | | | | | | | |
| Cliff Pond | BR-1028 | 96039 | 201.9 | Y | 224,282 | 26 | 84 | state park,concrete ramp | | wq | wq |
| Cobbs Pond | BR-179 | 96040 | 23.0 | N | | 11 | 12 | private | O | sd,wq | wq |
| Dark Bottom Pond | BR-377 | | 4.7 | N | | | | private | | | |
| Ed Snow Pond | BR-241 | | 3.0 | N | | 30 | | | | | |
| Eel Pond | BR-202 | 96076 | 3.0 | N | | 20 | | state park | | | |
| Elbow Pond | BR-357 | 96077 | 36.3 | N | | 30 | 31 | pub access | | sd,wq | sd, wq |
| Flax Pond | BR-168 | 96091 | 51.2 | Y | 44,904 | 24 | 72 | state park | | wq | wq |
| Freemans Pond | BR-196 | 96097 | 5.2 | N | | 6 | | thr swamp | O | | |
| Grassy Nook Pond | BR-1029 | 96109 | 6.7 | N | | 26 | 3 | state park | | | |
| Grassy Pond | BR-319 | 96110 | 13.1 | N | | 32 | | isolated | I,O | | |
| Greenland Pond | BR-305 | 96119 | 36.6 | N | | 31 | 18 | private | | sd,wq | wq |
| Griffiths Pond | BR-248 | 96122 | 32.3 | N | | 33 | 15 | pay access | | sd,wq | sd,wq |
| Higgins Pond | BR-194 | 96136 | 28.5 | Y | 28,216 | 24 | 66 | state park | | wq | wq |
| Keeler Pond | BR-160 | 96160 | 3.1 | N | | 25 | | state park | | | |
| Lees Pond | BR-158 | | 2.7 | N | | 25 | | private | | | |
| Little Cliff Pond | BR-192 | 96170 | 34.5 | Y | 13,748 | 25 | 34 | state park,concrete ramp | | wq | wq |
| Littlefields Pond | HA-387 | | | | | 29 | | | | | |
| Long Pond | BR-279 | 96183 | 734.7 | Y | 618,029 | 31 | 66 | none | 0,HR | sd,wq | wq |
| Lower Mill Pond | BR-245 | 96188 | 50.4 | N | | 25 | 13 | informal | I | sd,wq | sd,wq |
| Upper Mill Pond | BR-272 | 96324 | 257.4 | Y | 142,526 | 26 | 29 | pubaccess | I,O | wq | wq |
| Mud Pond | | | | | | | | private | | | |
| Myricks Pond | BR-177 | 96217 | 4.6 | N | | 10 | | private | | wq | wq |

# BREWSTER POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **No Bottom Pond** | BR-213 | | 2.9 | N | | 31 | | private | | sd | |
| **Owl Pond** | BR-162 | 96233 | 3.6 | N | | 24 | | private | | sd | |
| **Pine Pond** | BR-335 | 96248 | 23.3 | N | | 29 | | informal | | wq | wq |
| **Rafe Pond** | BR-232 | 96254 | 9.1 | N | | 28 | 18 | informal | | | |
| **Round Pond** | BR-287 | 96263 | 3.5 | N | | 30 | | none | | | |
| **Ruth Pond** | BR-209 | 96267 | 7.5 | N | | 27 | 18 | in state park | | | |
| **Schoolhouse Pond** | BR-205 | 96280 | 6.2 | N | | 23 | | pubramp, cartop | | sd,wq | sd,wq |
| **Sheep Pond** | BR-240 | 96289 | 147.7 | Y | 152,503 | 37 | 60 | pubramp,concrete | | sd,wq | |
| **Slough Pond** | BR-321 | 96299 | 31.6 | N | | 28 | 20 | pubramp,cartop | | sd,wq | sd,wq |
| **Smalls Pond** | BR-314 | 96300 | 17.7 | Y | 3,363 | 35 | | private | | sd,wq | wq |
| **Smith Pond** | BR-225 | 96301 | 11.0 | N | | 27 | | private | | sd,wq | |
| **Sols Pond** | BR-189 | 96271 | 6.7 | N | | 25 | | private | | | wq |
| **Triangle Pond** | BR-163 | | 1.6 | N | | | | | | | |
| **Tuckers Pond** | BR-285 | | 2.7 | N | | 34 | | private | | sd,wq | |
| **Vespers Pond** | BR-161 | 96328 | 2.1 | N | | 24 | | state park | | sd,wq | |
| **Walkers Pond** | BR-313 | 96331 | 103.2 | Y | 14,064 | 26 | 7 | pubramp | O | sd,wq | sd,wq |
| **Widger Hole** | BR-197 | 96339 | 2.8 | N | | 27 | | private | | sd,wq | |
| **Mill Pond** | HA-310 | | | | | 30 | | | | | sd,wq |
| **Mud Pond** | HA-300 | 96215 | | | | 34 | | | O | | |
| **Seymour Pond** | HA 306 | 96284 | | | | 29 | 38 | pubaccess | O,HR | | wq |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

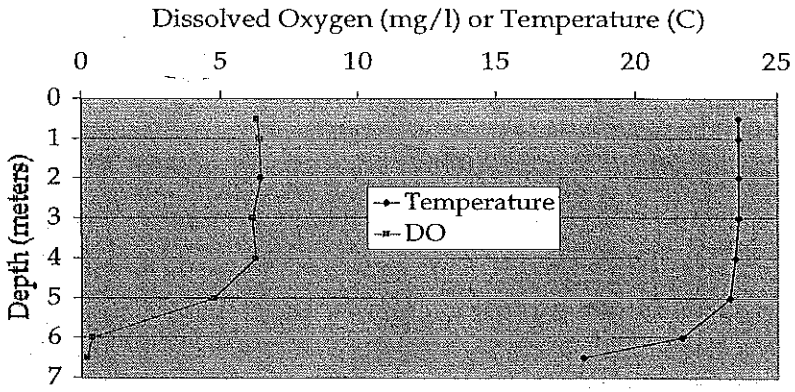
Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Blueberry Pond

## Brewster

## BR-180

Acreage: 21.3
Maximum Depth: 22 ft
2001 Secchi Dip: 8.8 ft
Lake Association: none




Dissolved Oxygen and Temperature
Blueberry Pond, 9/4/01

OVERVIEW

Blueberry Pond is located on the north side of Brewster, south of Route 6A and west of Millstone Road. The pond is fed by groundwater recharge from the south and discharges surface water to groundwater along the northern end of the pond. There are no surface water outlets or inlets to this pond. A public beach is accessible off of Blueberry Pond Drive. Recreational uses including swimming and fishing, although the pond is not stocked.

WATER QUALITY

Samples have been collected from Blueberry Pond in 1984 (four times) and during the 2001 PALS Snapshot (results shown below). All the summer dissolved oxygen and temperature profiles indicate some stratification deeper in the pond (below 5 m in the 2001 Snapshot profiles shown above) with an accompanying decline in dissolved oxygen concentrations. The TN and TP concentrations from the 2001 Snapshot (shown below) are just above the current Cape Cod "impacted" thresholds, while the chlorophyll *a* concentrations 63 to 91% higher than the respective threshold. The Carlson TSI based on the surface chlorophyll *a* concentration places the pond on the oligotrophic/mesotrophic line. The lack of oxygen deep in the pond suggests that impacts are occurring to the pond; the extent of the 1984 data is inadequate to assess whether conditions have been relatively stable over the past 17 years. It is recommended that annual monitoring of the pond continue and that collection of more frequent dissolved oxygen and temperature profiles and a characterization of nutrient loads to and within the lake be considered in the future to better assess whether conditions are likely to worsen. Blueberry Pond presents as a realtively unimpacted lake with existing water quality concerns.

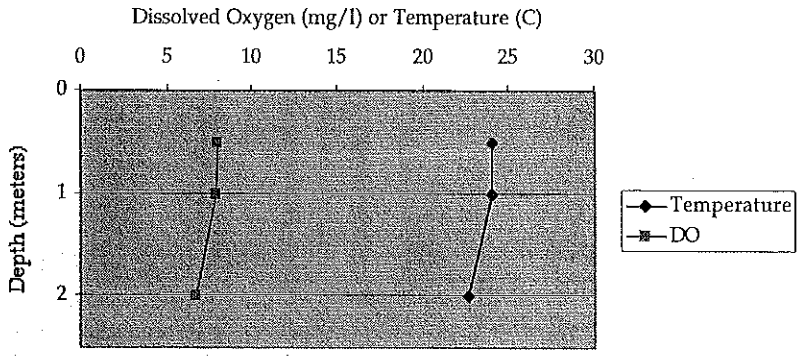
| September 4, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.16 | 2.77 | 3.0 | 10.8 | 0.35 |
| 5.7 | 6.07 | 3.24 | 3.2 | 10.8 | 0.34 |

# Canoe Pond

## Brewster

## BR-269

Acreage: 13.6
Maximum Depth: 8.5 ft
2001 Secchi Dip: 3.5 ft
Lake Association:
Canoe Pond Association




Dissolved Oxygen and Temperature
Canoe Pond, 9/6/01

OVERVIEW

The pond is located wholly within the Town of Brewster, south of Setucket Road and west of Canoe Pond Drive. Water table mapping in the area is incomplete, but groundwater is interpreted to flow into the west and potentially the east sides of the pond. The pond discharges water to groundwater on the north side. Canoe Pond has an outlet at its southern end into Upper Mill Pond. Canoe Pond is surrounded by private land on the west side and residential development on the east side. There is no public access to the pond.

WATER QUALITY

The 2001 PALS Snapshot data appears to be the first water quality sampling of Canoe Pond. As a shallow pond, wind should keep the water column well mixed and water quality should be homogeneous. Temperature and dissolved oxygen profiles generally display homogeneous conditions, as do the results from the water quality samples collected (shown below). The chlorophyll *a*, TP, and TN concentrations are above current Cape Cod "impacted" thresholds. A Carlson TSI based on a surface chlorophyll *a* concentration places the pond in the middle of the eutrophic category. Given these results and the noting of fairly extensive water lillies and pickeral weed, as well as floating algae, observed during the 2001 Snapshot, it is clear that Canoe Pond is impacted. It is recommended that a plant survey of both rooted and floating and sediment sampling be considered in the future to better determine available nutrient loads within the pond. In addition, it is recommended that a review of existing and future nutrient loads also be conducted in concert with regular water quality sampling. Overall, Canoe Pond presents as a nutrient impacted pond with current water quality concerns and undetermined future concerns.

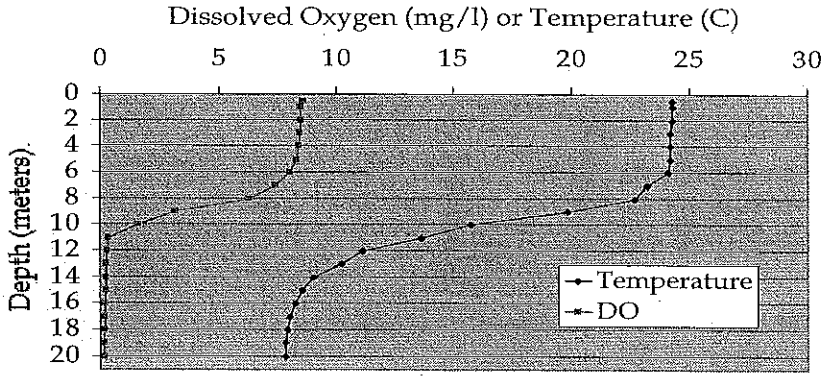
| September 6, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.65 | 13.65 | 13.6 | 26.6 | 0.57 |
| 2 | 6.57 | 13.89 | 13.6 | 23.5 | 0.59 |

# Cliff Pond

## Brewster

## BR-1028

Acreage: 202
Maximum Depth: 85 ft
2001 Secchi Dip: 7.3 ft
Lake Association: None




Dissolved Oxygen and Temperature
Cliff Pond, 9/11/01

OVERVIEW

Cliff Pond is located within Nickerson State Park, Brewster. The pond is recharged from groundwater entering the pond from the south/southwest and contributes surface water to groundwater to the north/northeast. There are no surface water inlets or outlets for Cliff Pond. The shoreline is completely undeveloped, with the exception of several bath houses for seasonal camping use. During the summer season, tent and trailer camping near the pond is very popular. Many visitor use the park for day visits. There are several public access points including a cement boat ramp on the south shore, and a number of public beaches. Recreational uses include boating, waterskiing, swimming, fishing and icefishing.

WATER QUALITY

Temperature and dissolved oxygen profiles exist for Cliff Pond in the following years: 1948, 1976, 2001 (shown above), and 2002. On 8/16/48, temperature stratification began around 30 ft (9.1m) with a relatively sharp thermocline of about 10 ft, below which temperatures were between 52 (near the bottom) and 57 °F (at 45 ft (13.7m)). In 1948, DO concentrations fell with depth; declining from 7.2 ppm at 50 ft to 1.4 ppm at 80 ft. On 9/11/01, anoxic conditions exist throughout the deeper waters of Cliff Pond (from the bottom up to 11 m) and into the thermocline. Comparison of the two profiles seem to indicate that impacts over the last 50 years have created worse water quality conditions in Cliff Pond.

Water quality samples have been collected from Cliff Pond in 1997, 2001, and 2002. Surface and near surface total nitrogen, total phosphorus, and chlorophyll a concentrations collected in the 2001 PALS Snapshot (see below) confirm the DO impacts discussed above; all concentrations exceed current Cape Cod "impacted" limits. The Carlson TSI value based on the surface chlorophyll *a* concentration is 48, which is the high end of the mesotrophic range. The high concentrations of nutrients deep in the pond show that significant nutrient amounts are available from the pond sediments. Given the location of the pond within Nickerson State Park, further characterization of this pond, including additional water quality monitoring, is recommended to evaluate the source of these nutrients and assess whether the current conditions are likely to worsen. Overall, Cliff Pond presents as a nutrient impacted pond with current water quality concerns and undetermined future concerns.

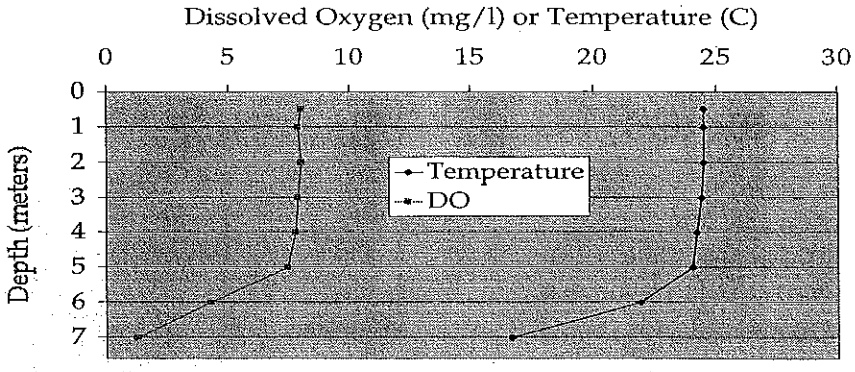
| September 11, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.24 | 5.83 | 2.0 | missing | 0.42 |
| 3 | 6.25 | 7.10 | 2.1 | 13.9 | 0.45 |
| 9 | 5.8 | 2.84 | 2.6 | 13.9 | 0.43 |
| 19.5 | 6.3 | 1.01 | 14.2 | 177.5 | 0.88 |

# Elbow Pond

## Brewster

## BR-357

Acreage: 36
Maximum Depth: 31 ft
2001 Secchi Dip: 19.3 ft
Lake Association: None




Dissolved Oxygen and Temperature
Elbow Pond, 9/401

OVERVIEW

Elbow Pond is located in the south west corner of Brewster, north of Route 6 and east of Airline Road. The pond is located at a natural groundwater divide, and is recharged by groundwater flow from the east. The pond contributes surface water to groundwater through its north, west and southern shores. The shoreline is essentially undeveloped, with the exception of several single family homes. There are several sizable cranberry bogs and town owned pieces of land adjacent to the pond. Limited recreational use include swimming and boating. The pond is stocked by the Massachusetts Division of Fisheries. Public access is available off of Slough Pond Road.

WATER QUALITY

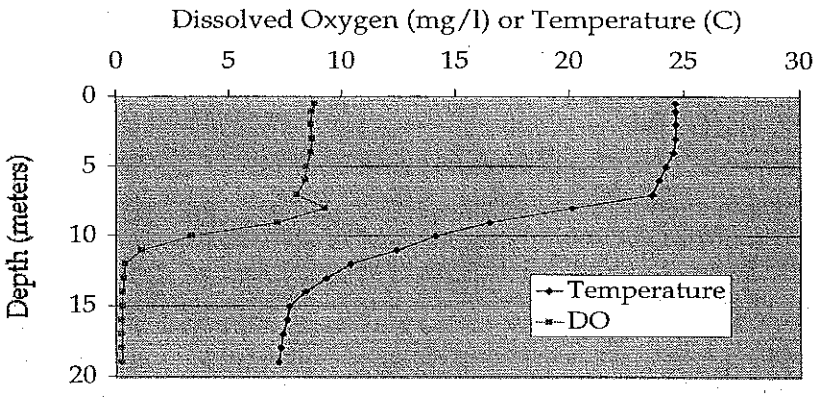
The 2001 PALS Snapshot appears to be the first complete water quality sampling of Elbow Pond, although a 1952 fish survey noted that transparency was 20 ft. As a relatively shallow pond, wind should keep the water column well mixed and water quality should be homogeneous. The 2001 dissolved oxygen and temperature profiles show well mixed conditions down to 5 m, but both DO and temperature decline below that depth indicating DO consumption due to bacterial consumption of sediment materials. The low DO conditions lead to release of nutrients into the deep waters (as indicated in the data shown below). Even with this release, the surface concentrations of chlorophyll *a*, total phosphorus, and total nitrogen are below current Cape Cod "impacted" thresholds. A Carlson TSI based on a surface chlorophyll *a* concentration places the pond at the lower end of the oligotrophic with some deep anoxia category. Given the low DO conditions in the deeper waters, it is recommended that annual sampling continue and more refined sampling should be considered to evaluate the potential for these conditions to degrade the overall condition of the pond. Overall, Elbow Pond presents as a realtively clean lake with some existing water quality concerns.

| September 4, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.04 | 1.29 | 1.6 | 7.7 | 0.22 |
| 6.6 | 5.90 | 2.65 | 4.5 | 23.5 | 0.40 |

# Flax Pond

## Brewster
## BR-168

Acreage: 51
Maximum Depth: 70 ft
2001 Secchi Dip: 9.9 ft
Lake Association: None




Dissolved Oxygen and Temperature
Flax Pond, 9/11/01

OVERVIEW

Flax Pond is located in Nickerson State Park, just north of Cliff Pond. The Pond is recharged with groundwater from the south and discharges surface water to groundwater along the northern shoreline. The shoreline is completely undeveloped, with the exception of several bath houses for seasonal camping use. Recreational uses include canoeing, swimming, fishing and icefishing. There are several public access points including a number of public beaches. Cartop boats and canoes can be launched after a short carry down a steep slope next to the public beach on the eastern shore. The pond is stocked with brook, brown and rainbow trout, but also contains smallmouth bass, brown bullheads, golden shiners and banded killifish.

WATER QUALITY

Flax Pond has temperature and dissolved oxygen profiles for 1948, 2001, and 2002, with water quality analyses available for 2001 and 2002 from the PALS Snapshots. The 8/17/48, profiles show temperature stratification began around 30 ft (9.1m) with a thermocline of about 20 ft and a hypolimnion below 50 ft with temperatures were between 50 and 54 °F. The DO profile has the lowest concentration at the deepest measured depth (3 ppm @ 70 ft (21.3m)). In contrast, the 2001 PALS profiles (shown above) show anoxic conditions below 12 m (in the lower portion of the thermocline). Comparison of these profiles seem to indicate that impacts over the last 50 years have created worse water quality conditions in Flax Pond.

The 2001 PALS water quality results (shown below) reflect the impacts of the low DO concentrations deep in the pond. Surface total nitrogen and total phosphorus concentrations are below the current Cape Cod "impacted" thresholds, while the chlorophyll *a* concentration is more than double its threshold; deep nutrient concentrations are at least five times surface concentrations. The Carlson TSI value based on the surface chlorophyll *a* concentration is 45, which is the middle of the mesotrophic range. Given the location of the pond within Nickerson State Park, further characterization of this pond, including additional water quality monitoring, is recommended to evaluate the sediment nutrient loads, likely sources of the nutrients in the sediment, the length of time anoxic conditions exist in the pond, and assess whether the current conditions are likely to worsen. Overall, Flax Pond presents as a nutrient impacted pond with current water quality concerns and undetermined future concerns.

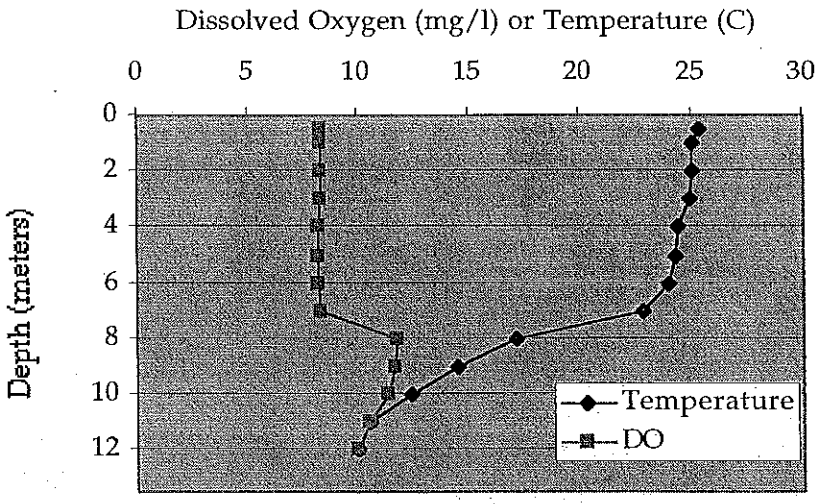
| September 11, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.75 | 4.59 | 4.0 | 7.7 | 0.31 |
| 3 | 6.62 | 4.57 | 3.6 | 10.8 | 0.38 |
| 9 | 6.18 | 2.15 | 5.1 | 10.8 | 0.42 |
| 19 | 6.61 | 1.28 | 27.9 | 105.9 | 1.60 |

# Higgins Pond

## Brewster

## BR-194

Acreage: 28.51
Maximum Depth: 66 ft
2001 Secchi Dip : 14.2 ft
Lake Association:




Dissolved Oxygen and Temperature
Higgins Pond, 9/11/01

OVERVIEW

Higgins Pond is located in ckerson State Park, to the east Cliff Pond and Little Cliff nd. The Pond is recharged ex- isively from groundwater re- arge from the west and dis- arges surface water to groundwater along the eastern shoreline. The shoreline is completely undeveloped. ere is one main access point from a steep, rutted dirt road approaching the northwest corner of the pond. e pond also can be accessed from a dirt road off Bakers Pond Road for cartop boat and canoe launching. creational use is limited primarily to fishing and icefishing. The pond's deep, cold, well oxygenated ters are ideal for trout. In 1987 it was designated as a catch and release only pond and stocked with the miscamme strain of brook trout which grow up to 8 pounds. No bait is allowed to be used in this pond.

WATER QUALITY

Higgins Pond was sampled in 1948, 2001, and 2002. In 1948, the August 16 temperature and dissolved ygen (DO) profiles showed thermal stratification between 30 and 35 ft and hypoxic DO concentrations (< ppm) at 60 ft and below. In 2001, the September 11 profiles show thermal stratification beginning around ft (7 m) and superstaturated DO concentrations (>100%) at 9 m with a decline to saturated conditions and ar-saturated conditions below. Chlorophyll a concentrations at 9 m are at least twice those in shallower mples (see below) suggesting that photoplankton below the Secchi depth (4.33 m) are photosynethically ive.

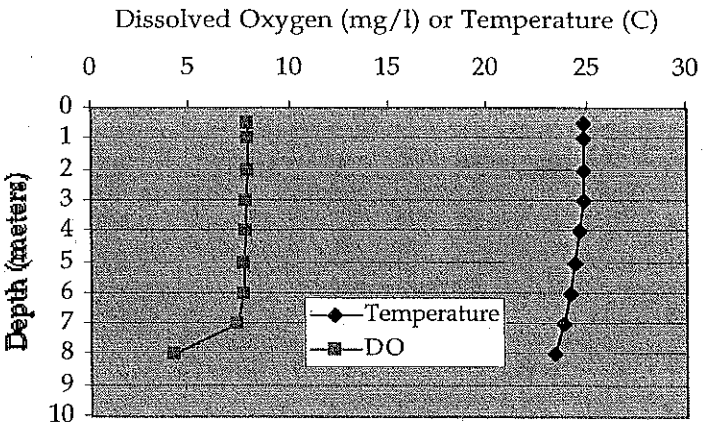
Most of the 2001 PALS concentrations for chlorophyll *a*, TP, and TN (except for the two deepest lorophyll *a* and the 9 m TP)(see below) are less than the current Cape Cod "impacted" thresholds. The rlson TSI based on the surface chlorophyll *a* concentrations places the lake in the lower portion of the igotrophic with some anoxia" category. Higgins Pond presents as a clean, nearly unimpacted pond, with apparent improvement in water quality over the last 50 years. Further evaluation of historic land uses ound Higgins Pond is recommended to attempt to determine the cause of the 1948 impairment and whether establishment of Nickerson State Park and the relatively difficult access of this pond has allowed this nd to "cleanse" itself. Annual monitoring of this pond is also encouraged to watch for any water quality anges.

| September 11, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.68 | 1.68 | 3.3 | 7.7 | 0.25 |
| 3 | 6.5 | 1.43 | 3.5 | 7.7 | 0.21 |
| 9 | 6.28 | 3.82 | 3.7 | 10.8 | 0.26 |
| 12.5 | 6.09 | 2.12 | 3.5 | 7.7 | 0.21 |

# Little Cliff Pond

## Brewster
## BR-192

Acreage: 34.5
Maximum Depth: 33 ft
2001 Secchi Dip: 14.5 ft
Lake Association: None




Dissolved Oxygen and Temperature
Little Cliff Pond, 9/11/01

OVERVIEW

Little Cliff Pond is located within Nickerson State Park, Brewster, just east of Cliff Pond and just west of Higgins Pond. The pond is recharged from groundwater entering the pond from the southwest and contributes surface water to groundwater to the northeast. The shoreline around Little Cliff Pond is undeveloped, with the exception of a paved boat ramp on the western shore. Recreational uses are limited to canoeing, fishing and icefishing. The pond is stocked with trout. Smallmouth bass and other species are also present.

WATER QUALITY

Little Cliff Pond was sampled in 1948, 2001, and 2002. In 1948, the August 16 temperature and dissolved oxygen (DO) profiles showed little thermal stratification, although there was a ten degree F difference between surface and 34 ft and DO concentrations were generally high with the lowest (7.8 ppm) recorded at 34 ft. The 2001 profile is very similar with little temperature or DO variation, although DO declines to 4.2 ppm at 8 m (26 ft).

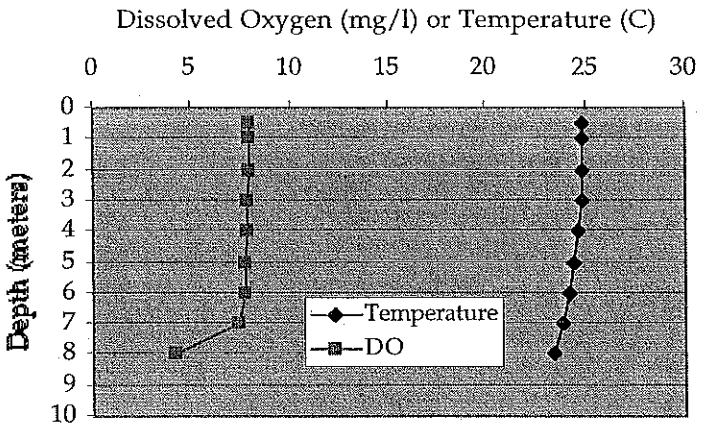
All of the 2001 PALS concentrations for chlorophyll *a*, TP, and TN (see below) are less than the current Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the lake at the lower boundary of the "oligotrophic with some anoxia" category. The change in deep DO suggests that even with an undeveloped shoreline that impacts from human activities in Nickerson State Park have had an impact on the pond ecosystem over the last 50 years. Although the impacts are relatively minor, it is recommended that annual monitoring should continue and that development of a lake management plan for Little Cliff Pond be considered. Overall, Little Cliff Pond presents as a relatively clean, nearly unimpacted pond.

| September 11, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.14 | 1.11 | 2.1 | 4.6 | 0.22 |
| 3 | 6.16 | 1.19 | 2 | 4.6 | 0.21 |
| 7.5 | 6.03 | 1.13 | 2 | 4.6 | 0.22 |

# Little Cliff Pond

## Brewster
## BR-192

Acreage: 34.5
Maximum Depth: 33 ft
2001 Secchi Dip: 14.5 ft
Lake Association: None




Dissolved Oxygen and Temperature
Little Cliff Pond, 9/11/01

OVERVIEW

Little Cliff Pond is located within Nickerson State Park, Brewster, just east of Cliff Pond and just west of Higgins Pond. The pond is recharged from groundwater entering the pond from the southwest and contributes surface water to groundwater to the northeast. The shoreline around Little Cliff Pond is undeveloped, with the exception of a paved boat ramp on the western shore. Recreational uses are limited to canoeing, fishing and icefishing. The pond is stocked with trout. Smallmouth bass and other species are also present.

WATER QUALITY

Little Cliff Pond was sampled in 1948, 2001, and 2002. In 1948, the August 16 temperature and dissolved oxygen (DO) profiles showed little thermal stratification, although there was a ten degree F difference between surface and 34 ft and DO concentrations were generally high with the lowest (7.8 ppm) recorded at 34 ft. The 2001 profile is very similar with little temperature or DO variation, although DO declines to 4.2 ppm at 8 m (26 ft).

All of the 2001 PALS concentrations for chlorophyll *a*, TP, and TN (see below) are less than the current Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the lake at the lower boundary of the "oligotrophic with some anoxia" category. The change in deep DO suggests that even with an undeveloped shoreline that impacts from human activities in Nickerson State Park have had an impact on the pond ecosystem over the last 50 years. Although the impacts are relatively minor, it is recommended that annual monitoring should continue and that development of a lake management plan for Little Cliff Pond be considered. Overall, Little Cliff Pond presents as a relatively clean, nearly unimpacted pond.

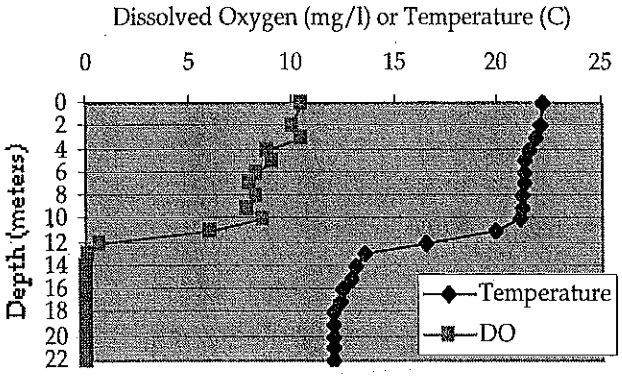
| September 11, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.14 | 1.11 | 2.1 | 4.6 | 0.22 |
| 3 | 6.16 | 1.19 | 2 | 4.6 | 0.21 |
| 7.5 | 6.03 | 1.13 | 2 | 4.6 | 0.22 |

# Long Pond

## Harwich/Brewster

## BR - 279

Acreage: 734.7
Maximum Depth: 66 ft
2001 Secchi Dip: 9 ft
Lake Association: Long Pond Watershed Association, Inc.




Dissolved Oxygen with depth
Long Pond, 9/24/01

OVERVIEW

Long Pond is the largest great pond on Cape Cod covering over 740 acres and split between the Towns of Brewster and Harwich. Groundwater flows into the lake along almost its entire perimeter, flowing out only on the west edge near the herring run and potentially near Cahoon Pond on the east. Long Pond has been the subject of a Cape Cod Commission water quality assessment (Eichner, *et al.*, 1999) and a lake managment plan, completed by ENSR (2001). ENSR estimated that only two undeveloped parcels existed along the shoreline in October 2000; approximately 92 cesspools or leachfields exist within 200 ft of the shoreline. There are numerous access points on Long Pond including three boat ramps and three public beaches. The pond has been stocked with smallmouth bass, brown bullhead and striped bass over the years and fisheries surveys were conducted in 1980 and 1992.

WATER QUALITY

Long Pond regularly experiences water quality problems that threaten the environmental health and the enjoyment of the pond by town residents. A large algal bloom occurred on the lake during 1996 and a significant fish kills (> 100 fish) have occurred in 1997 and 2001. The lake was sampled in 1948, for pH as part of Acid Rain Monitoring Project during the 1980s, and annually by town of Brewster staff and citizen volunteers since 1997, including at least temperature and DO profiles every two weeks during summer months. All water quality parameters measured during the 2001 PALS Snapshot (see below) exceed current Cape Cod "impacted" thresholds.

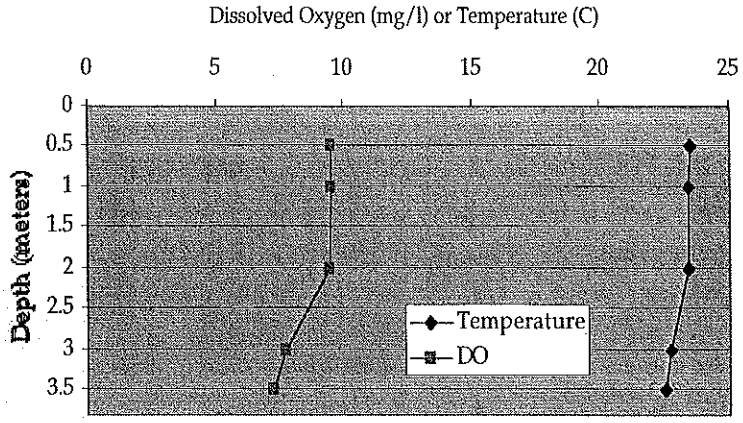
The 1948 DO profile had anoxic conditions below 45 ft (13.7 m) suggesting that Long Pond has had water quality problems for at least 50 years. The more intensive data collection at Long Pond has confirmed that once thermal stratification of the lake occurs in late May or early June, high dissolved oxygen demand in the sediments depletes oxygen to anoxic (<1 ppm) levels in the hypolimnion that persist until the stratification erodes in October. The high oxygen demand causes the release of phosphorus from the sediments of the lake and some of this phosphorus leaks into the warmer upper layer prompting algal blooms. ENSR (2001) recommended application of alum to block the release of phosphorus and improve dissolved oxygen in the colder lower waters.

| September 24, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.48 | 13.71 | 2.8 | 16.7 | 0.50 |
| 3 | 6.25 | 16.90 | 2.63 | 21.7 | 0.55 |
| 9 | 6.67 | 11.76 | 3 | 21.7 | 0.50 |
| 21 | 6.25 | 5.51 | 3.3 | 335.4 | 2.80 |

# Lower Mill Pond

## Brewster
## BR-245

Acreage: 50.4
Maximum Depth: 13 ft
2001 Secchi Dip: 6 ft
Lake Association: None




Dissolved Oxygen and Temperature
Lower Mill Pond, 9/6/01

OVERVIEW

Lower Mill Pond is located just south of Route 6A near the intersection of Setucket and Stony Brook Road. The pond is recharged by groundwater flow from the south and by a surface outlet from Upper Mill Pond. The pond is dammed at its northern tip, where it discharges to a herring run (Stony Brook). An historic grist mill is also operated at this dam site. A town park has been developed incorporating the mill and herring run. The shoreline is moderately developed, with informal access across town owned land. Recreational uses includes fishing and boating.

WATER QUALITY

Lower Mill Pond was sampled in 1962, 2001, and 2002. The 1962 sampling, which was part of a fisheries survey, consisted of one dissolved oxygen (DO) reading and a temperature profile, which found the pond with little temperature difference throughout its water column. The 2001 PALS temperature profile (shown above) is similar to the 1962 profile, while the 2001 PALS DO profile shows a modest decline with depth.

All of the 2001 PALS concentrations for chlorophyll *a*, TP, and TN in Lower Mill Pond (see below) exceed the current Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the lake in at the lower range of the "eutrophic with blue-green algae dominance" category. Although Lower Mill Pond has high concentrations of nutrients, its shallow bathymetry allows it to remain well oxygenated and the limited DO information seems to suggest that available wind has sufficent energy to offset the oxygen demand in the sediments. It is recommended that the town consider a more refiined monitoring program to evaluate the depth of the sediments, their nutrient content, and DO, nutrient, and chlorophyll *a* concentrations throughout the summer. In addition, this program should be accompanied by a land use assessment of properties around the pond, as well as an assessment of whether water quality conditions are likely to worsen. Overall, Lower Mill Pond presents as an impacted pond with current water quality concerns.

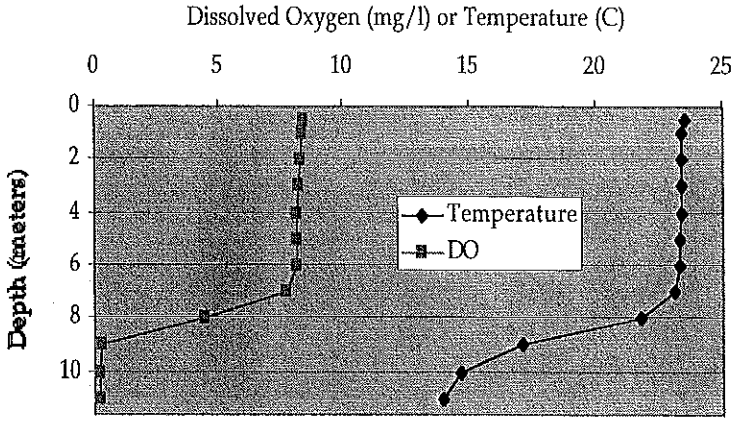
| September 6, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.85 | 28.32 | 3.5 | 36.2 | 0.55 |
| 3 | 6.35 | 21.68 | 3.6 | 55.1 | 0.64 |

# Seymour Pond

## Brewster/Harwich

## HA-306

Acreage: 181
Maximum Depth: 38 ft
2001 Secchi Dip: 8 ft
Lake Association: None




Dissolved Oxygen and Temperature
Seymour Pond, 9/9/01

OVERVIEW

Seymour Pond is located west of Route 124 and Long Pond and straddles the Harwich/ Brewster town line. The pond is situated on a groundwater divide, so it discharges surface water to the groundwater along all but its western shore. It is connected to abutting wetland areas and cranberry bogs and the pond also discharges to a herring run connected to Hinkley Pond and the Herring River. Shoreline development is relatively sparse. Public access is provided across a town beach or along the Cape Cod Rail Trail. Recreational uses include boating, fishing and swimming. The pond is stocked with small mouth bass and contains abundant quantities of yellow and white perch.

WATER QUALITY

Seymour Pond was sampled in 1948, 1970, 2001, and 2002. In 1948, the August 17 temperature profile shows little thermal stratification, although there was a 7°F difference between surface and the deepest reading (35 ft), while the dissolved oxygen (DO) concentrations were generally high with the lowest (4.8 ppm) recorded at 35 ft. In 1970, the temperature profile was similar to the 1948 profile, but the August 19 DO profile had concentrations of 2 ppm and less below 32 ft. The 2001 temperature profile is different from the other two with a well mixed upper 7 m (23 ft) with rapidly decreasing temperatures below; the pond is not deep enough to form a true hypolimnion. The 2001 DO profile has anoxic concentrations (i.e., DO <1 ppm) at 9 m (29.5 ft).

Seymour Pond was sampled by both Brewster and Harwich volunteers during the 2001 PALS Snapshot (see below). All of the chlorophyll *a*, TP, and TN concentrations exceed the current Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations from both sampling events places the lake in the middle of the "mesotrophic" category. From a review of the historic DO profiles, it is clear that water quality within Seymour Pond has become progressively worse over the last 50 years. It is recommended that the towns consider a water quality assessment of the Seymour Pond, including a more refined monitoring program to evaluate DO, nutrient, and chlorophyll *a* concentrations throughout the summer, a sediment characterization, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to continue to worsen. Overall, Seymour Pond presents as an impacted pond with current water quality problems.

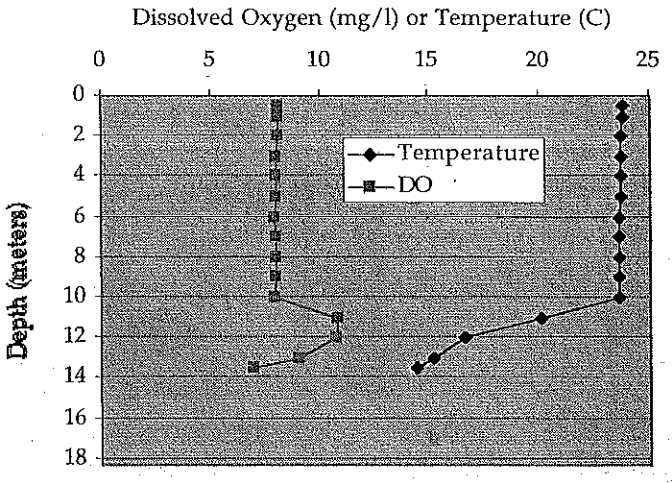
| September 6, 2001 PALS Brewster Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.04 | 4.84 | 2.1 | 26.6 | 0.39 |
| 3 | 6.04 | 4.00 | 1.8 | 26.6 | 0.37 |
| 9 | 6.10 | 6.09 | 10.8 | 36.2 | 0.53 |
| 11.5 | 6.47 | 6.79 | 41.3 | 110.6 | 2.92 |
| September 14, 2001 PALS Harwich Snapshot Results | | | | | |
| 0.5 | 6.08 | 5.38 | 2.5 | 21.7 | 0.41 |
| 6 | 6.09 | 4.50 | | 21.7 | 0.33 |

# Sheep Pond

## Brewster

## BR-240

Acreage: 147.7
Maximum Depth: 63 ft
2001 Secchi Dip: 17.4 ft
Lake Association: Sheep Pond Beach Association




Dissolved Oxygen and Temperature
Sheep Pond, 9/6/01

OVERVIEW

Sheep Pond is located to the north of Long Pond, midway between Routes 124 and 137. . The pond is recharged by groundwater flow from the north and discharges surface water to groundwater to the south. The southeast shoreline is developed with single family homes, while the majority of the northwestern shoreline is undeveloped. Recreational uses include swimming, boating (up to three horsepower), fishing and icefishing. Public access is provided off of Fishermans Landing Road, where there is a paved boat ramp. The pond is stocked with trout including brook, brown and rainbow species. Occasionally, stocks of Atlantic salmon are added.

WATER QUALITY

Sheep Pond was sampled in 1948, 1980, between 1988 and 1989 as part of a diagnostic/feasibility (D/F) study (IEP, 1993), 2001, and 2002. In 1948, the August 18 temperature profile shows gradual thermal stratification with a 9°F difference between surface and the deepest reading (55 ft). The dissolved oxygen (DO) concentrations in 1948 were generally high with the lowest (4.4 ppm) recorded at 55 ft. In 1980, the July 30 temperature profile showed a well mixed epilimnion above 9 m (29.5 ft) and a gradual cooling to 16 m (52.5 ft) without a well defined hypolimnion. The accompanying DO profile had a hypoxic concentration (<4 ppm) at 15 m and an anoxic concentration (<1 ppm) at 16 m. The D/F study had anoxic conditions below 14 m from the beginning of July until mid-August. The September 2001 DO profile had no anoxic waters and had supersaturated (>100%) DO conditions at 11 and 12 m (see above).

All of the TN, three of the TP and three of the chlorophyll *a* concentrations from the 2001 PALS Snapshot (see below) are less than the current Cape Cod "impacted" thresholds; the 9 m TP and the deep chlorophyll *a* concentrations exceed their respective thresholds. The Carlson TSI based on the surface chlorophyll *a* concentration places the lake at the bottom of the "oligiotrophic with some deep anoxia" category. The review of available DO profiles appears to indicate that Sheep Pond has changed little over the last 50 years, although it is unclear whether the deep anoxia was occuring 50 years ago. Given that a D/F study was completed with a goal of water quality preservation, it is recommended that the town review the step s proposed in the D/F study and assess the extent of implementation. In addition, it is recommended that annual monitoring of the pond continue. Overall, Sheep Pond presents as a relatively clean, largely unimpacted pond.

| September 6, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.37 | 1.12 | 2.7 | 6.2 | 0.20 |
| 3 | 6.32 | 0.79 | 2.7 | 9.3 | 0.20 |
| 9 | 6.35 | 1.31 | 2.7 | 13.9 | 0.20 |
| 13.5 | 6.05 | 3.63 | 4.5 | 4.6 | 0.27 |

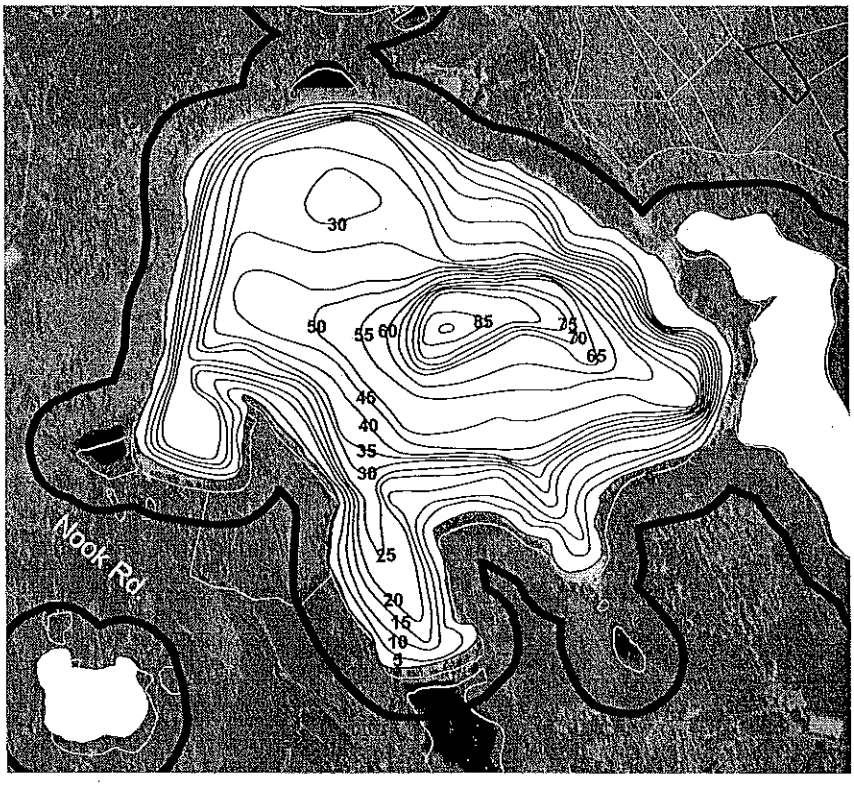

## Blueberry Pond
## Brewster
## (BR-180)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet
300' Buffer Zone

N
W E
S

1000 0 1000 2000 Feet



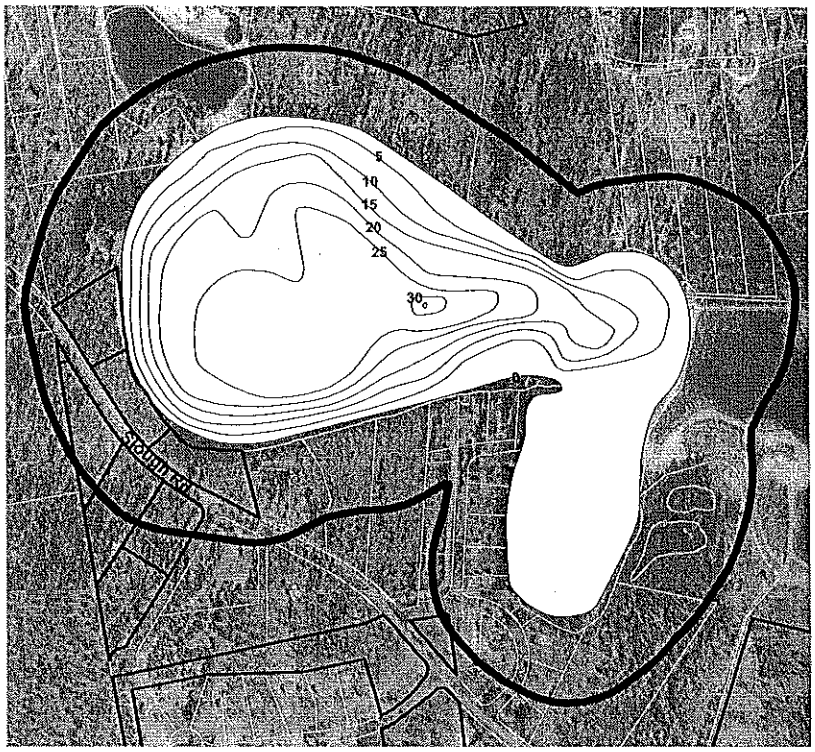

## Cliff Pond
## Brewster
## (BR-1028)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Brewster town owned parcels
Bathymetry in feet
300' Buffer Zone

N
W E
S

2000 0 2000 4000 Feet




600 0 600 1200 Feet

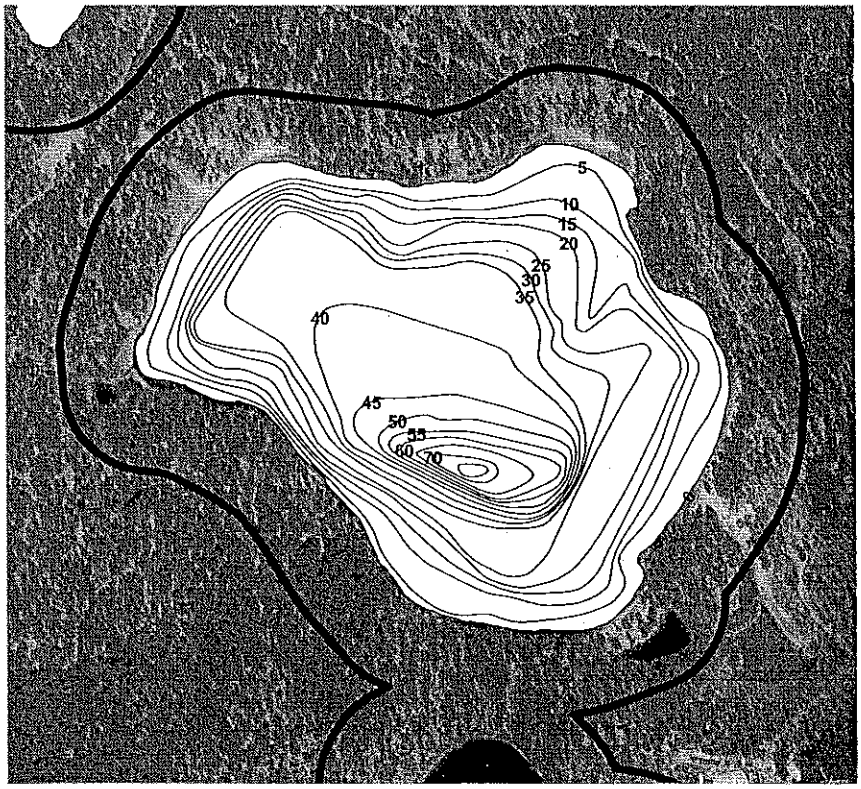
## Elbow Pond Brewster (BR-357)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S




900 0 900 1800 Feet

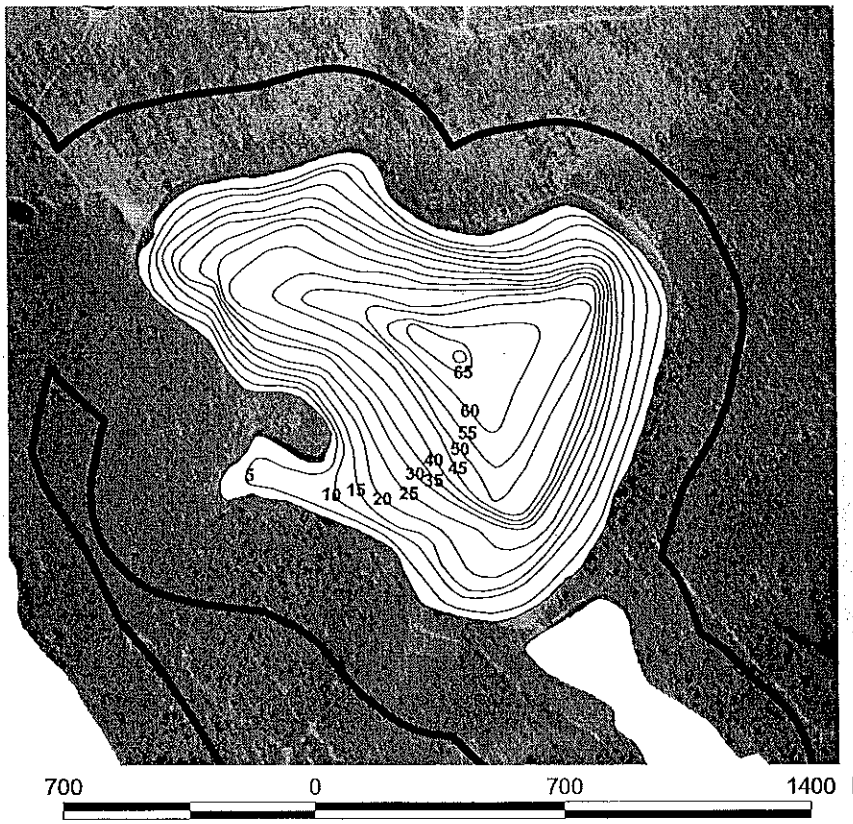
## Flax Pond Brewster (BR-168)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Brewster town owned.shp
Bathymetry in feet

300' Pond Buffer

N
W E
S

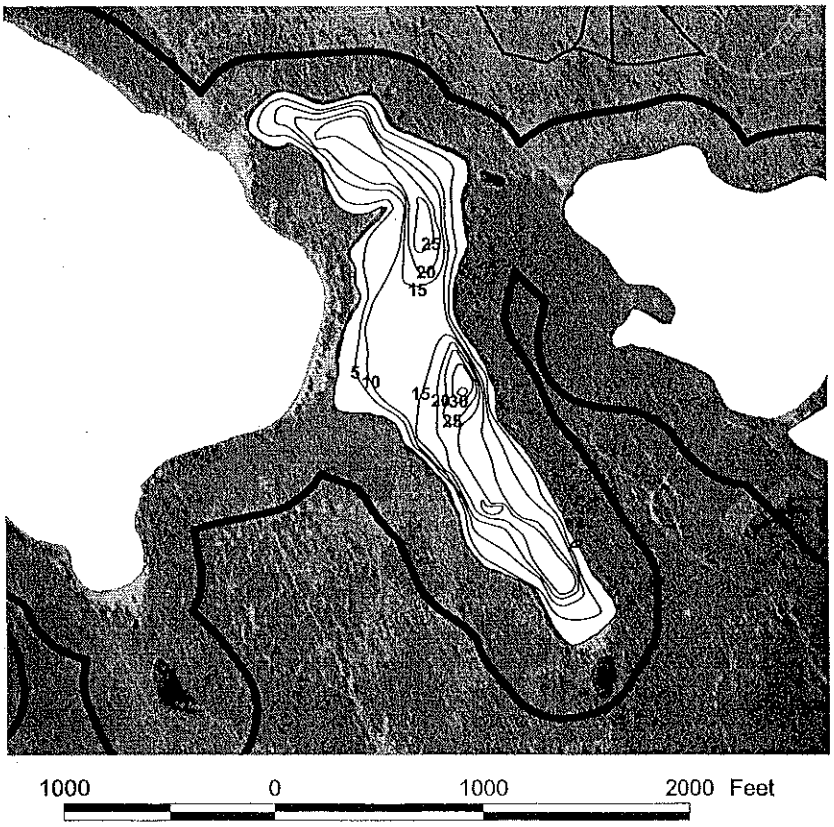



## Higgins Pond Brewster (BR-194)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Brewster town owned.shp
Bathymetry in feet
300' Pond Buffer

N
W E
S




## Little Cliff Pond Brewster (BR-192)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Brewster town owned parcels
Bathymetry in feet
300' Buffer Zone

N
W E
S


# Long Pond
# Brewster/Harwich
# (BR-279)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned property
Town owned property
Bathymetry in feet

300' Buffer Zone

N
W
E
S

4000 0 4000 8000 Feet


600 0 600 1200 1800 2400 Feet

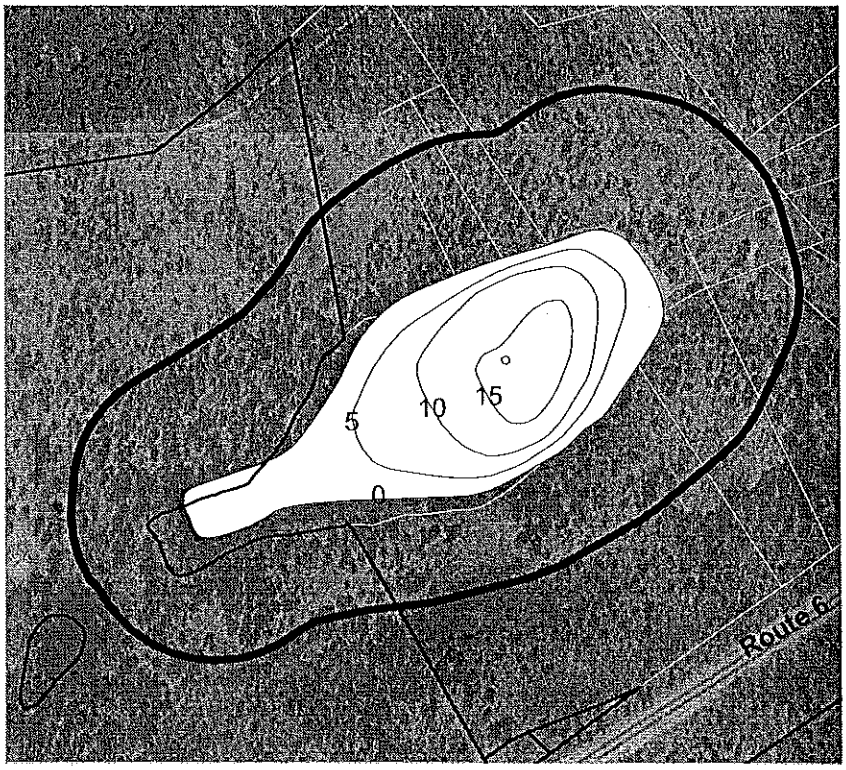
## Lower Mill Pond Brewster (BR-245)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S




600 0 600 1200 Feet

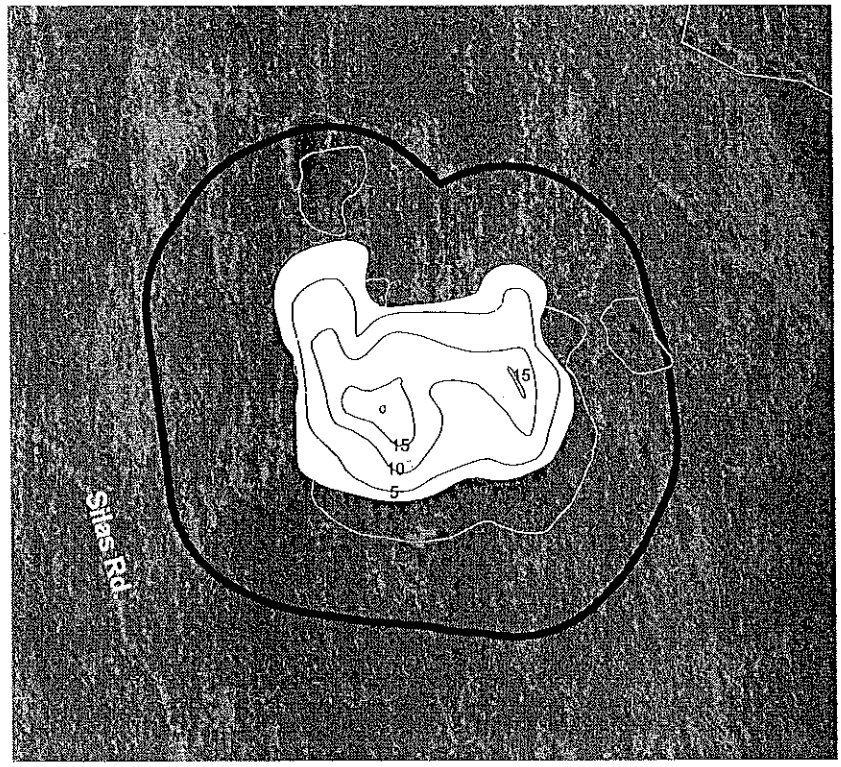
## Rafe Pond Brewster (BR-232)

**Bathymetry Source:**
**University of Massachusetts**

Brewster town owned parcels
Bathymetry in feet

300'Buffer Zone

N
W E
S




## Ruth Pond
## Brewster
## (BR-209)

**Bathymetry Source:**
**University of Massachusetts**

Brewster town owned parcels

Bathymetry in feet

300' Buffer Zone

N
W E
S

600 0 600 1200 Feet


## Seymour Pond
## Brewster/Harwich
## (HA-306)

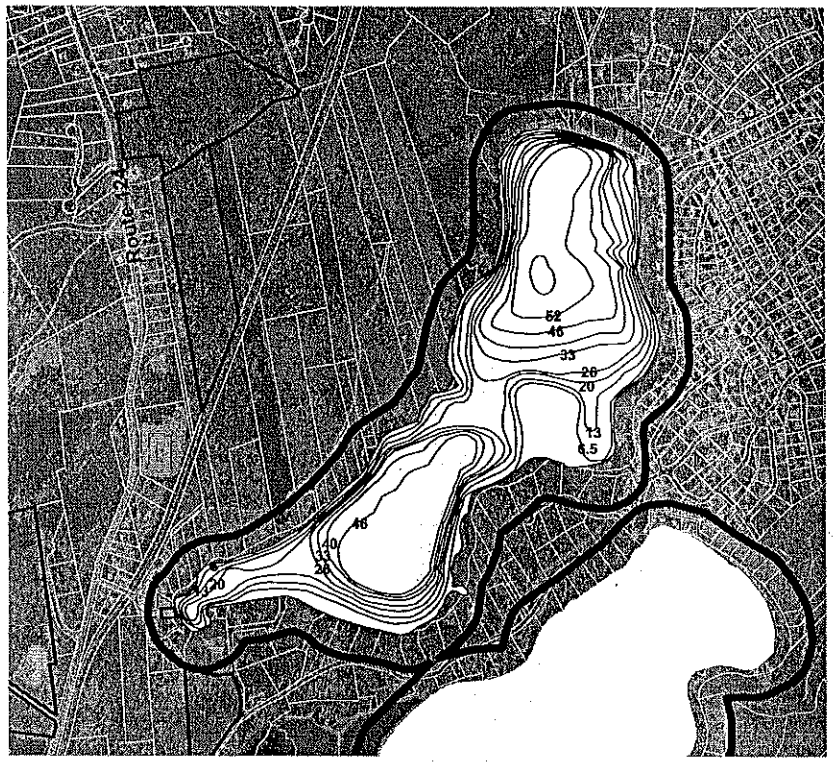
**Bathymetry Source:**
**Division of Fish and Wildlife**

Brewster town owned parcels
Bathymetry in feet

300' Buffer Zone

N
W E
S

1000 0 1000 2000 3000 Feet



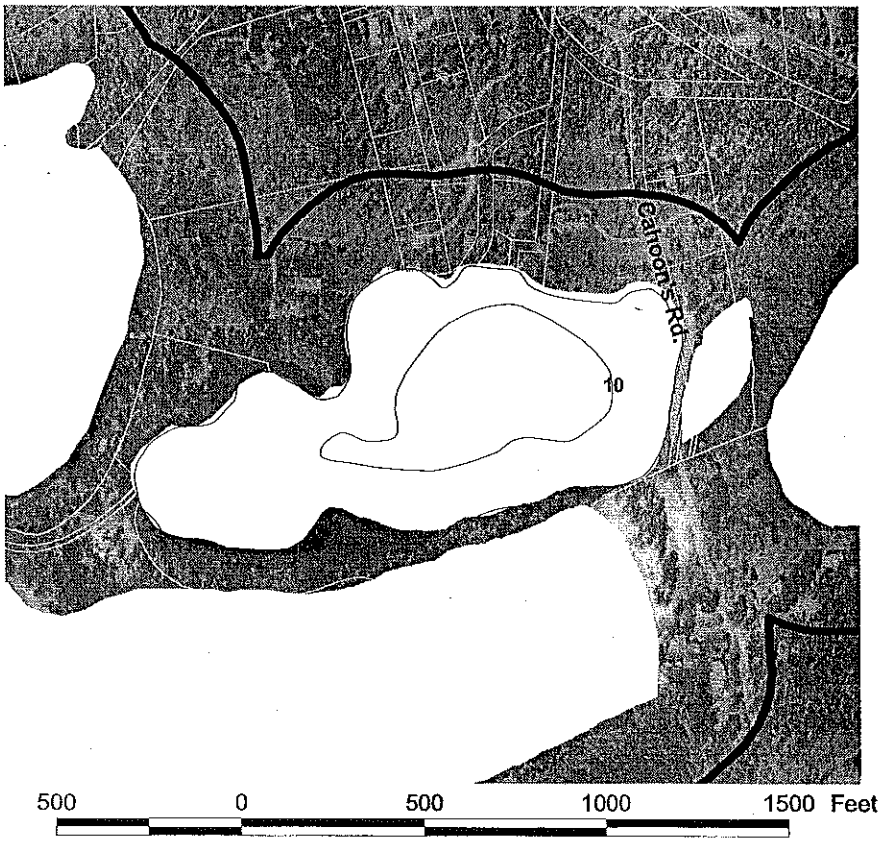

## Sheep Pond Brewster (BR-240)

**Bathymetry Source:**
**IEP**

**Brewster town owned parcels**
**Bathymetry in feet**

**300' Buffer Zone**

N
W E
S




## Smalls Pond Brewster (BR-314)

**Bathymetry Source:**
**Division of Fish and Wildlife**

**Town owned land**
**Bathymetry in feet**

**300' Buffer Zone**

N
W E
S


# Upper Mill/Walkers Brewster (BR-272/313)

**Bathymetry Source:**
**Division of Fish and Wildlife**

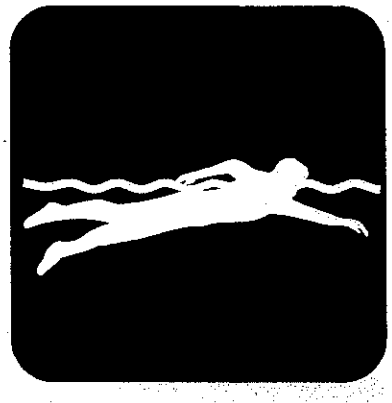
**Brewster town owned parcels**
**Bathymetry in feet**

**300' Buffer Zone**

N
W
E
S

3000 0 3000 6000 Feet

# CHATHAM PONDS



Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
Pond 2001 Water Quality Summary Table
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

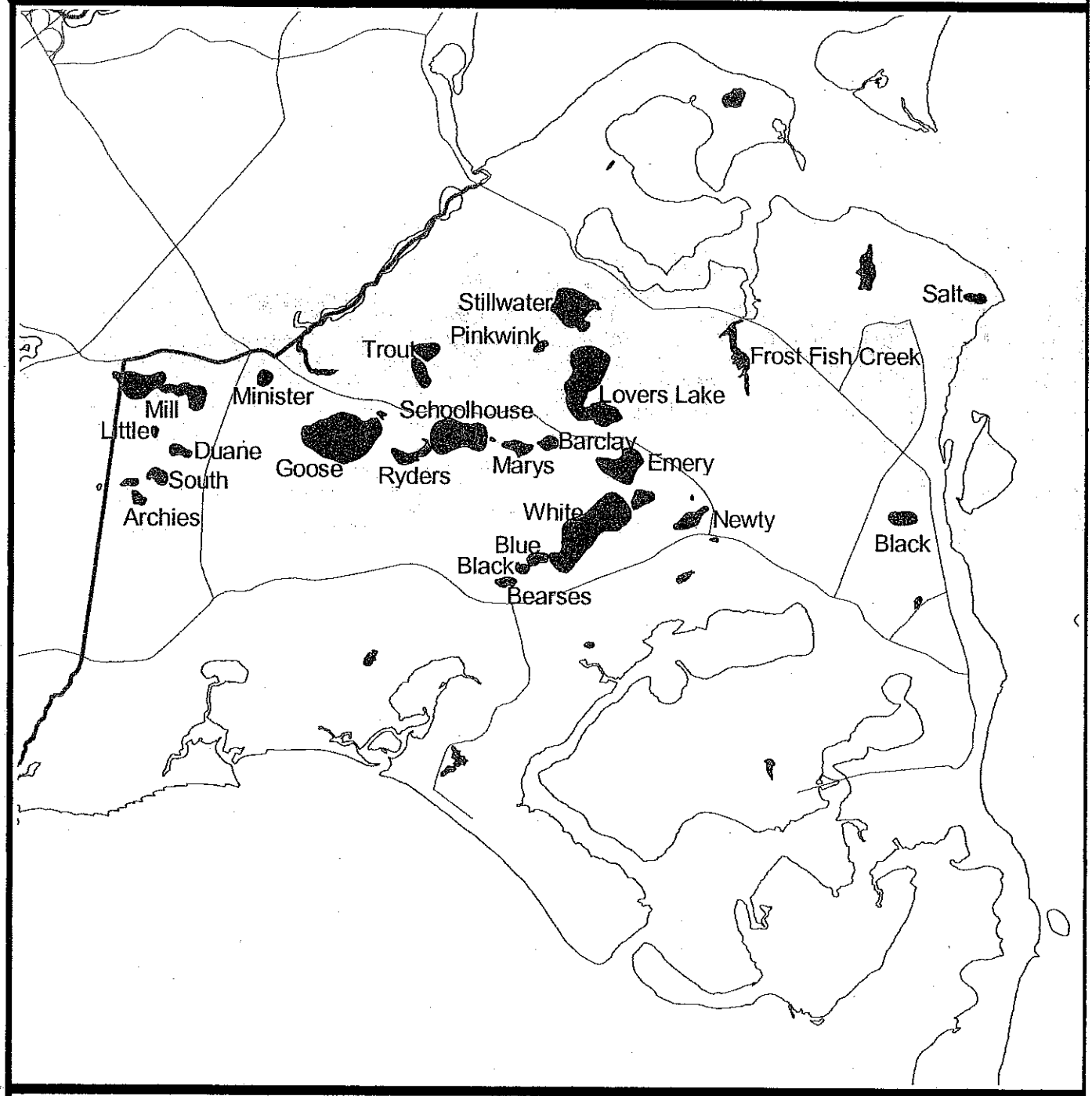
With Map and Description:

Black Pond- East
Emery Pond
Goose Pond
Lovers Pond
Mill Pond
Schoolhouse Pond
Stillwater Pond
White Pond

Map Only:

Ryders Pond

# CHATHAM
# NAMED PONDS

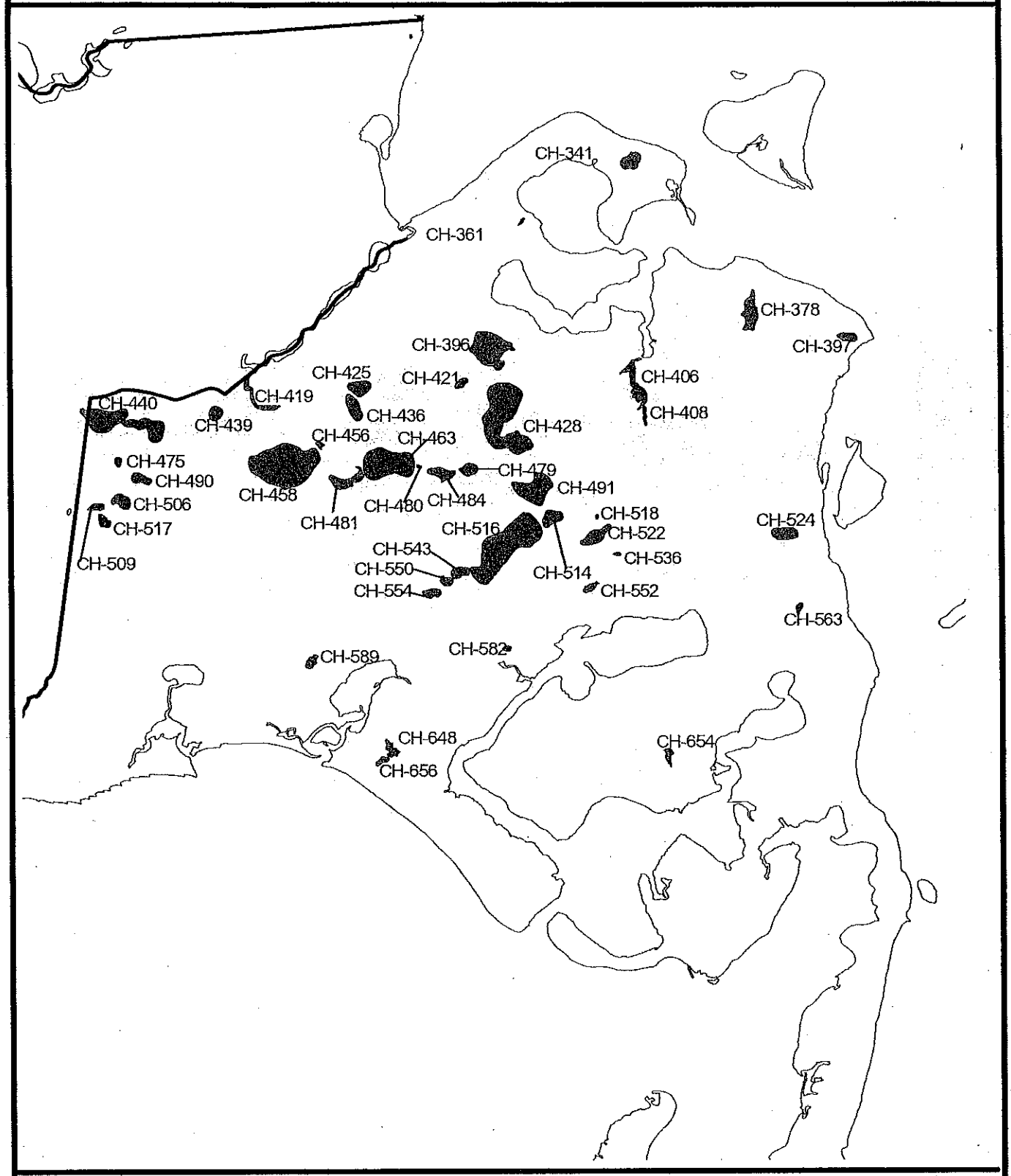



N

1 0 1 Miles

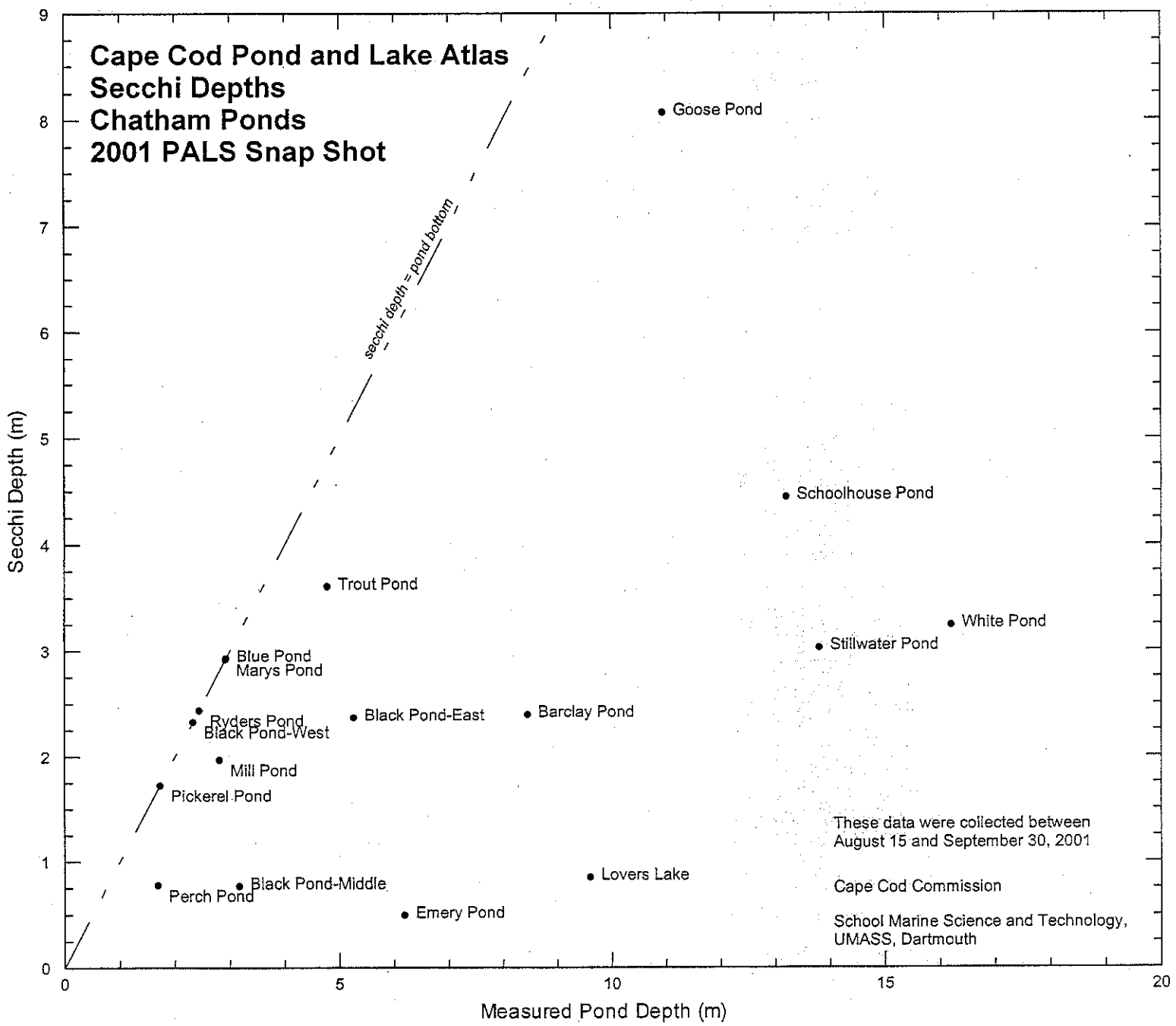
CAPE COD COMMISSION

# GIS ID'S FOR CHATHAM PONDS



# Chatham 2001 PALS Water Quality Snapshot Summary

| | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | ug/l | unimpacted (<1.0 ug/l) | at risk 1-1.7 ug/l | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk 0.16-0.31 mg/l | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk 7.5-10 ug/l | impacted (>10 ug/l) |
| Barclay Pond | 3.34 | | | x | 0.37 | | | x | 18.27 | | | x |
| Black Pond | 6.89 | | | x | 0.57 | | | x | 20.13 | | | x |
| Black Pond | 8.84 | | | x | 0.58 | | | x | 18.27 | | | x |
| Black Pond-Middle | 19.31 | | | x | 0.96 | | | x | 49.86 | | | x |
| Blue Pond | 2.09 | | | x | 0.46 | | | x | 16.72 | | | x |
| Emery Pond | 21.89 | | | x | 1.43 | | | x | 54.82 | | | x |
| Goose Pond | 1.83 | | | x | 0.28 | | x | | BDL | x | | |
| Lovers Lake | 46.63 | | | x | 0.90 | | | x | 35.00 | | | x |
| Marys Pond | 1.09 | | x | | 0.46 | | | x | 21.68 | | | x |
| Mill Pond | 8.85 | | | x | 0.46 | | | x | 20.13 | | | x |
| Perch Pond | 7.23 | | | x | 0.68 | | | x | 74.64 | | | x |
| Pickerel Pond | 2.03 | | | x | 0.50 | | | x | 21.68 | | | x |
| Ryders Pond | 2.92 | | | x | 0.54 | | | x | 20.13 | | | x |
| Schoolhouse Pond | 3.72 | | | x | 0.28 | | x | | 10.22 | | | x |
| Stillwater Pond | 8.25 | | | x | 0.44 | | | x | 15.18 | | | x |
| Trout Pond | 2.46 | | | x | 0.32 | | | x | 13.32 | | | x |
| White Pond | 2.71 | | | x | 0.37 | | | x | 8.36 | | x | |


Cape Cod Pond and Lake Atlas
Secchi Depths
Chatham Ponds
2001 PALS Snap Shot
secchi depth = pond bottom
Goose Pond
Schoolhouse Pond
Trout Pond
White Pond
Stillwater Pond
Blue Pond
Marys Pond
Ryders Pond
Black Pond-West
Black Pond-East
Barclay Pond
Mill Pond
Pickerel Pond
Lovers Lake
Perch Pond
Black Pond-Middle
Emery Pond
These data were collected between August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology, UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
6
7
8
9
0
5
10
15
20

# CHATHAM POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max Depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | Monitoring ** 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Archies Pond | CH-517 | | 2.0 | N | | | | | | | |
| Barclay Pond | CH-479 | | 3.0 | N | | 10 | | TCA | | wq | wq |
| Bearses Pond | CH-554 | 96011 | 2.3 | N | | 14 | | informal | | | |
| Black Pond | CH-524 | 96019 | 5.0 | N | | 24 | 16 | private | | wq | wq |
| Black Pond | CH-550 | 96016 | 1.7 | N | | 14 | | informal | | sd,wq | wq |
| Black Pond, East | | | | | | | 18 | | | | wq |
| Blue Pond | CH-543 | 96021 | 3.0 | N | | 14 | 13 | informal | | sd,wq | wq |
| Duane Pond | CH-490 | 96064 | 2.9 | N | | 18 | | TCA | | | |
| Emery Pond | CH-491 | 96082 | 14.1 | N | | 16 | 21 | private | I | sd,wq | wq |
| Frost Fish Creek | CH-408 | | 7.8 | N | | | | | | | |
| Goose Pond | CH-458 | 96106 | 41.2 | Y | 33847 | 15 | 52 | fish landing | | sd,wq | wq |
| Hospital Pond | | 96145 | | | | | | federal | | | |
| Little Pond | | | | | | 25 | | private | | | |
| Lovers Lake | CH-428 | 96186 | 37.7 | N | | 13 | 36 | TCA | O,HR | sd,wq | wq |
| Marys Pond | CH-484 | | 4.2 | N | | 10 | | TCA | | wq | wq |
| Mill Pond | CH-440 | 96200 | 23.5 | N | | 20** | 16 | well | I | wq | wq |
| Minister Pond | CH-439 | 96209 | 2.8 | N | | 20 | | TCA | | | wq |
| Monomoy Point Big Pond | | 96210 | | | | 2 | | federal | | | |
| Monomoy Point Little Pond | | 96211 | | | | 3 | | federal | | | |
| Newty Pond | CH-522 | 96220 | 5.5 | N | | 23 | | private | | wq | |
| Pickerel Pond | | | | | | 15 | | private | | | |
| Pinkwink Pond | CH-421 | | 1.5 | N | | 15 | | private | | | |
| Ryders Pond | CH-481 | 96269 | 5.7 | N | | 15 | 15 | TCA | | sd,wq | sd,wq |
| Salt Pond | CH-397 | | 2.4 | N | | 5 | | Cons.Foundation | O | | |
| Schoolhouse Pond | CH-463 | 96281 | 22.8 | Y | 14177 | 13 | 47 | Town | | sd,wq | sd,wq |
| South Pond | CH-506 | | 3.5 | N | | 18 | | TCA | | | |

# CHATHAM POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max Depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stillwater Pond** | CH-396 | 96309 | 18.7 | N | | 8 | 51 | TCA | I,O,HR | sd,wq | wq |
| **Trout Pond** | CH-425 | | 4.9 | N | | 15 | | private | | sd,wq | wq |
| **White Pond** | CH-516 | 96337 | 40.5 | N | | 14 | 59 | pubramp | | sd,wq | sd,wq |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

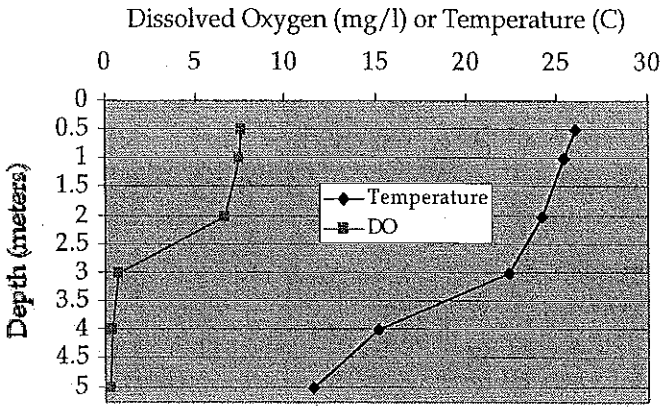
Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Black Pond-East

## Chatham

## CH-524

Acreage: 5
Maximum Depth: 17 ft
2001 Secchi Dip: 7.8 ft
Lake Association: None




Dissolved Oxygen and Temperature
Black Pond- East, 8/28/01

OVERVIEW

Black Pond-East is located at the eastern edge of Chatham close to Aunt Lydias Cove. This pond is perched above the regional water table, as evidenced by the 24 foot pond elevation only 2,000 feet from the ocean. Because it is perched, the pond is recharged primarily from precipitation and other perched groundwater that may exist in the vicinity of Black Pond. The shoreline is well developed on the east and north side, and there are some wetland areas to the south and the east. Recreational uses are limited to pond abutters.

WATER QUALITY

Black Pond-East has been sampled in 2000, 2001, and 2002. Temperature and dissolved oxygen (DO) profiles were collected by the Town of Chatham staff in 2000 and for each of the PALS Snapshot events in 2001 (shown above) and 2002. The temperature profiles in 2000 and 2001 are similar with gradually declining temperatures with increasing depth. Both DO profiles have concentrations near saturation in the upper 2 m, but anoxic concentrations (<1 ppm) at 3 m and below.

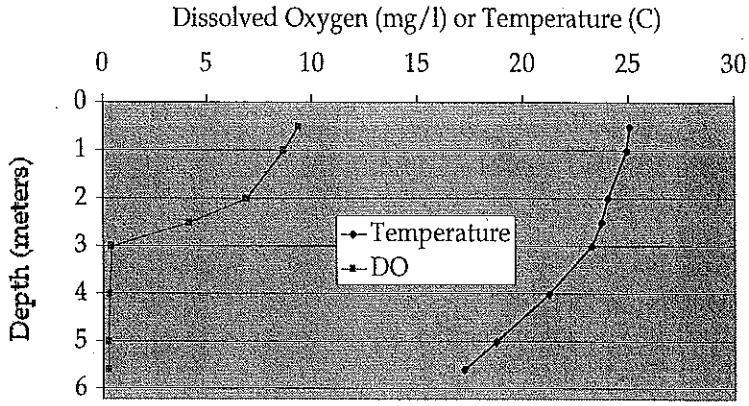
All of the chlorophyll *a*, TP, and TN concentrations measured in Black Pond-East during the 2001 PALS Snapshot (see below) exceed the current Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond on the mesotrophic side of the mesotrophic/eutrophic category boundary, while the chloropyll *a* concentration at 2.5 m would place the pond in the hypereutrophic category.

The DO and nutrient information seem to indicate that during summer conditions, the sediments in Black Pond-East are releasing nutrients into the water column, which are in turn prompting extensive algal growth. It is recommended that the town continue annual monitoring of the pond and that the town consider a more refined assessment of the pond ecosystem in the near future. This assessment should include a characterization of nutrient loads to and within the lake, more refined monitoring, sediment characterization, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to continue to worsen. Black Pond-East presents as an impacted pond with existing water quality problems.

| August 27, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.44 | 6.89 | 4.8 | 20.1 | 0.57 |
| 2.5 | 6.34 | 123.31 | 5.1 | 21.7 | 0.64 |
| 4.5 | 6.2 | 4.18 | 11.7 | 87.6 | 0.74 |

# Emery Pond
## Chatham
## CH-491

Acreage: 14.1
Maximum Depth: 20 ft
2001 Secchi Dip: 1.6 ft
Lake Association: None




Dissolved Oxygen and Temperature
Emery Pond, 8/28/01

OVERVIEW

Emery Pond is located north of the Chatham Airport and south of Queen Anne Road. The pond is located across a natural groundwater divide, receiving recharge from the west and discharging surface water to groundwater along the north, south and east shoreline. The shoreline is lightly developed with single family homes. There is no public access to Emery and recreational use is limited.

WATER QUALITY

Emery Pond has been sampled in 2000, 2001, and 2002. Temperature and dissolved oxygen (DO) profiles were collected by the Town of Chatham staff in 2000 and for each of the PALS Snapshot events in 2001 and 2002. The October 2000 temperature and DO profiles show generally well-mixed conditions throughout the water column. In contrast, the August 2001 profiles (shown above) show a temperature profile with gradually declining temperatures with increasing depth and a DO profile with concentrations near saturation in the upper 2 m, but anoxic concentrations (<1 ppm) at 3 m and below.

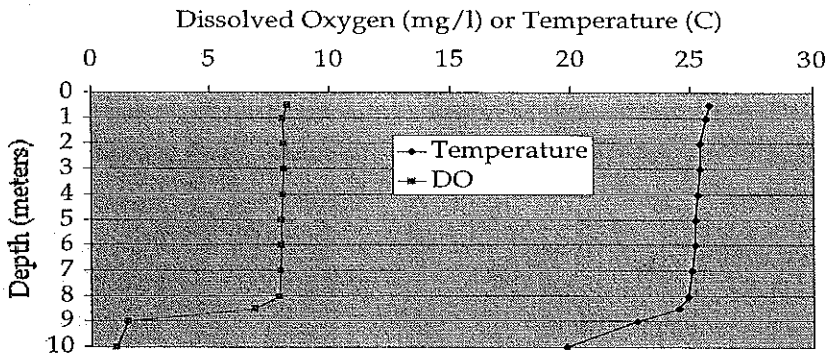
All of the chlorophyll *a*, TP, and TN concentrations measured in Emery Pond during the 2001 PALS Snapshot (see below) exceed the current Cape Cod "impacted" thresholds; the nutrient concentrations are 3 to 5 times higher, while the chlorophyll concentrations are more than 10 times the threshold. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond on boundary between eutrophic and eutrophic with blue-green algae dominance categories.

The DO and nutrient information seem to indicate that during summer conditions, the sediments in Emery Pond are releasing nutrients into the water column (deep nutrient concentrations 2 to 5 times shallow concentrations), which are in turn prompting extensive algal growth (chlorophyll *a* concentrations). It is recommended that the town continue annual monitoring of the pond and that the town consider a more refined assessment of the pond ecosystem in the near future. This assessment should include a characterization of nutrient loads to and within the lake, more refined monitoring, sediment characterization, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to continue to worsen. Emery Pond presents as an impaired pond with existing water quality problems.

| August 28, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 7.85 | 21.89 | 10.3 | 54.8 | 1.43 |
| 3 | 6.53 | 34.93 | 1.8 | 41.5 | 1.12 |
| 5 | 6.45 | 23.19 | 31.3 | 246.2 | 2.66 |

# Goose Pond
## Chatham
## CH-458

Acreage: 41.25
Maximum Depth: 52 ft
2001 Secchi Dip: 26 ft
Lake Association: None




Dissolved Oxygen and Temperature
Goose Pond, 8/28/01

OVERVIEW

Goose Pond is the largest freshwater Pond is Chatham, located south of Queen Anne Road and east of Route 137. The shoreline is wooded and undeveloped, and the pond bottom is sandy. Two municipal tracts of land protect the north west shoreline, where a fishermans landing is located. Recreational uses include swimming and fishing. The pond is stocked with various trout species, including brook, brown and rainbow. Other species include small mouth bass, banded killifish, golden shiners, yellow perch, brown bullhead and mummichogs.

WATER QUALITY

DO and temperature profiles have been collected in Goose Pond in 1948, 1954, 1955, 1957, 1982, 1993, 2000, 2001, and 2002. Most of these profiles are similar to the 2001 PALS Snapshot (shown above), which shows a well mixed water column with DO concentrations near saturation to approximately 8 m with a sharp thermocline and cooler waters with impacted DO concentrations and anoxic conditions below that. Although the deepest waters have always had anoxia, review of the profiles seems to indicate that high oxygen, cool waters (*i.e.*, trout waters) are occurring less frequently during the summer.

Other monitoring parameters collected during the 2001 Snapshot generally show relatively low impacts: nutrient and chlorophyll a concentrations are all relatively close to current Cape Cod "impacted" thresholds and Secchi depth is second deepest of the ponds sampled during the 2001 Snapshot. The Carlson TSI based on 2001 surface chl a concentration places the lake in the oligiotrophic category with occasional deep anoxia.

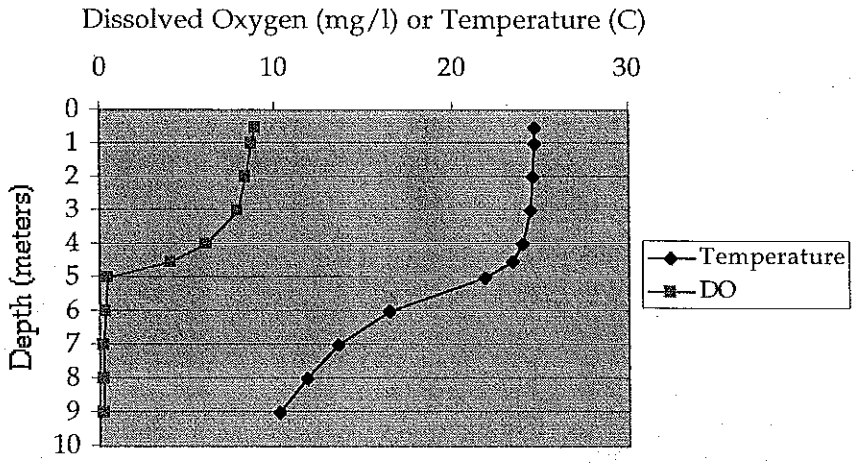
It is recommended that annual monitoring of the pond should continue and that consideration be given to conducting more refined DO monitoring throughout the summer to characterize the development of the anoxic conditions. If these conditions occur at the onset of stratification, the town may want to consider a more refined characterization of the pond. At this point, Goose Pond presents as a relatively unimpacted pond with concerns about extent and frequency of anoxia in the bottom waters.

| August 28, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.53 | 1.83 | 2.5 | BDL | 0.28 |
| 3 | 6.36 | 2.07 | 2.3 | 3.4 | 0.26 |
| 8 | 6.32 | 1.66 | 2.4 | 10.2 | 0.25 |
| 10 | 6.03 | 2.86 | 6.2 | 11.8 | 0.30 |

BDL = Below Detection Limit

# Lovers Lake
## Chatham
## CH-428

Acreage: 37.7
Maximum Depth: 31 ft
2001 Secchi Dip: 2.8 ft
Lake Association: None




Dissolved Oxygen and Temperature
Lovers Lake, 8/28/01

OVERVIEW

Lovers Lake is located mid-way between Old Comers Road and Queen Anne Road, just south of Ryders Cove. Groundwater recharges the pond from the south. The pond discharges surface water to the ground along the north shore as well to a small stream that flows to Stillwater Pond. The south and western shores are developed with single family homes. The west and north shores are undeveloped. Land ownership includes some conservation property and a municipal water supply. There is no public access to the pond, and recreational uses is limited to boating and fishing.

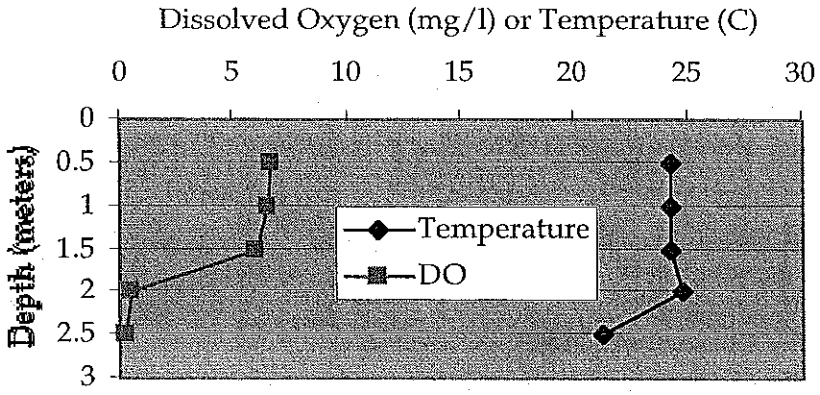
WATER QUALITY

Temperature and dissolved oxygen profiles have been collected in 2000, 2001, and 202. Profiles show gradual temperature drop below 5 to 7 meters, with a well mixed epilimnion. Profiles also have anoxic concentrations for a minimum of 40% of the water column and seem to indicate that the deep low conditions are impacting the upper well mixed waters. The high total phosphorus concentrations observed in the deep waters seem to indicate that phosphorus is being released from the sediments and the high surface chlorophyll a concentration (top 5% of all surface readings during the 2001 PALS Snapshot) seems to indicate that this phosphorus is being transfered to the epiliminion and prompting extensive algal growth. This hypothesis is consistent with the relatively shallow Secchi depth, high surface pH and TP concentration, but would need to be confirmed by additional sampling. The high chlorophyll a concentration results in a Carlson TSI ranking near the line between eutrophic with blue green algal dominance and hypereutrophic. It is recommended that annual monitoring of the pond continue and that a characterization of nutrient loads to and within the lake, including more refined monitoring, be considered in the future. Lovers Lake presents as a highly impacted pond with significant water quality problems.

| August 28, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 8.07 | 46.63 | 17.7 | 35.0 | 0.90 |
| 3 | 7.93 | 24.99 | 18.3 | 26.6 | 0.76 |
| 9 | 6.47 | 3.76 | 64.8 | 130.7 | 1.99 |

# Mill Pond
## Chatham
## CH-440

Acreage: 23.5
Maximum Depth: 9 ft
2001 Secchi Dip: 6.5 ft
Lake Association: none




Dissolved Oxygen and Temperature
Mill Pond, 8/29/01

OVERVIEW

Mill Pond is located in the northwest corner of Chatham, near the intersection of Queen Anne Road and Route 137. The pond receives groundwater recharge from the north west and discharging surface water to groundwater at the east end on Mill Pond . The shoreline is lightly developed with single family homes. Several large tracts of undeveloped land and municipal property border Mill Pond. There is no public access to Mill Pond and recreational use is limited.

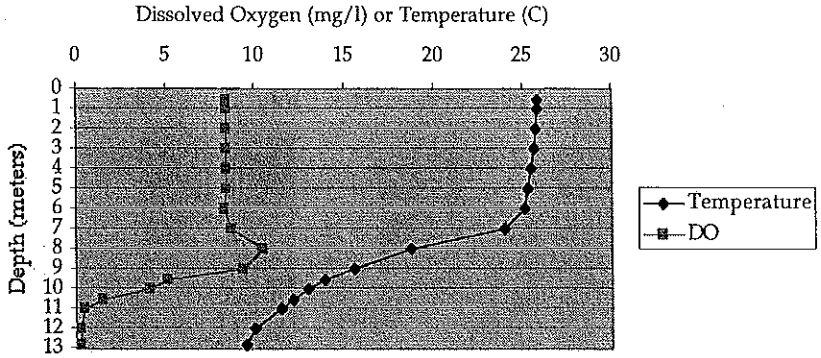
WATER QUALITY

Temperature and dissolved oxygen profiles have been collected in 2000, 2001, and 2002. Because the pond is relatively shallow, there should be relatively little temperature or dissolved oxygen change with depth. August profiles in both 2000 and 2001 show anoxic or near anoxic concentrations (<1 ppm DO) at 2 m and below. Both chlorophyll a and total phosphorus concentrations are relatively low, but clearly impacted. The surface chlorophyll a concentration results in a Carlson TSI ranking in the eutrophic category, although the field observation of significant water lily coverage raises questions about the applicability of the Carlson index, which was developed for algal dominated pond ecosystems. High water clarity and relatively low TP concentrations are consistent with most of the nutrients being bound up in the lillies, but additional characterization and monitoring would be necessary to confirm this hypothesis. It is recommended that annual monitoring of the pond continue and that a characterization of nutrient loads to and within the lake, including more refined monitoring and plant characterization, be considered in the future. Mill Pond presents as an impacted pond with some water quality concerns.

| August 29, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.57 | 8.85 | 9.6 | 20.1 | 0.46 |
| 2 | 6.38 | 11.44 | 10.0 | 21.7 | 0.54 |

# Schoolhouse Pond
## Chatham
## CH-463

Acreage: 22.8
Maximum Depth: 47 ft
2001 Secchi Dip: 14.6 ft
Lake Association: None




Dissolved Oxygen and Temp/erature
Schoolhouse Pond, 8/28/01

OVERVIEW

Schoolhouse Pond located south of Queen Anne Road and east of Sam Ryder Road. The shoreline is moderately developed with single family homes. Groundwater recharges the pond from the southwest. Surface water from the pond discharges to groundwater along its northeast shoreline. Recreational uses include swimming and fishing. A town beach on the western shore connects Schoolhouse Pond with Ryder Pond. The pond is stocked with various trout including brook, brown and rainbow. Other species include small mouth bass, chain pickerel, pumpkinseed sunfish, American eel, yellow perch, brown bullhead and abundant banded killifish.

WATER QUALITY

Temperature, DO, and Secchi depth readings are available for Schoolhouse Pond in 1975, 1980, 2000, 2001, and 2002. All the available temperature profiles show stratification starting between 7 and 8 m with a gradual lowering of temperature with depth, but without the formation of a true hypolimnion. The 2000 and 2001 profiles show DO concentrations generally decreasing with depth once the stratification level is reached, usually attaining anoxic conditions in the deepest water. The 2001 Snapshot profile also indicates a DO "bulge" at 8 m, likely due to impacts from algal photosynthesis. Secchi readings are generally between 4 and 5 m (27 to 40% of total depth). The Carlson TSI based on 2001 surface chl a concentrations places the lake in the mesotrophic category. Surface TP and TN concentrations from the 2001 PALS Snapshot are relatively low (at or below the Cape Cod "impacted" thresholds), but the very high TP, TN, alkalinity, and chlorophyll a concentrations observed in the deepest sample suggest that significant nutrients are contained in the sediments. These nutrients are released when anoxic conditions occur in the deeper portion of the lake. The lack of oxygen deep in the pond suggests that impacts are occurring to the pond. It is recommended that annual monitoring of the pond should continue and that consideration be given to conducting more refined monitoring and a characterization of current and future nutrient loads, as well as the rooted plant and algal population of the pond. Schoolhouse Pond presents as an impacted lake with existing water quality concerns.

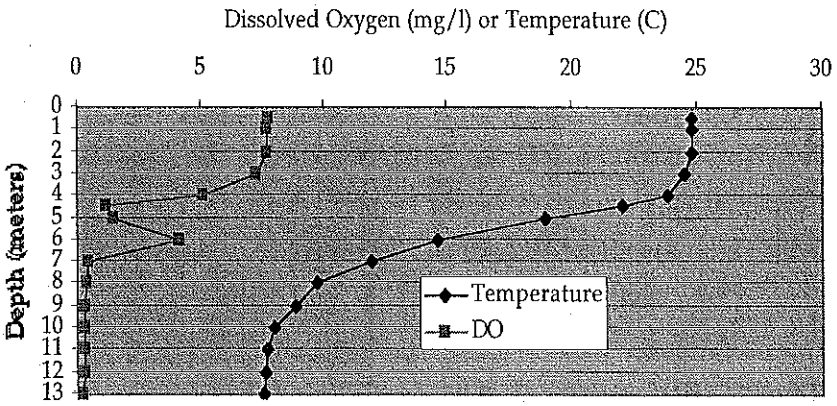
| August 28, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.39 | 3.72 | 4.6 | 10.2 | 0.28 |
| 3 | 6.51 | 3.47 | 4.5 | 8.4 | 0.33 |
| 9 | 6.3 | 4.49 | 6.4 | 11.8 | 0.36 |
| 12 | 6.13 | 72.45 | 17.9 | 51.4 | 1.00 |

# Stillwater Pond

## Chatham

## CH-396

Acreage: 18.7
Maximum Depth: 45 ft
2001 Secchi Dip: 9.9 ft
Lake Association: None




Dissolved Oxygen and Temperature
Stillwater Pond, 8/28/01

OVERVIEW

Stillwater Pond is located north of Old Comers Road and east of Training Field Road. The pond is recharged by groundwater from the southwest and by a surface water inlet from Lovers Lake. The pond discharges surface water to groundwater along its northern shoreline and to a herring run that leads to Ryder Cove. The shoreline is moderately developed with single family homes. Recreational uses include boating and fishing.

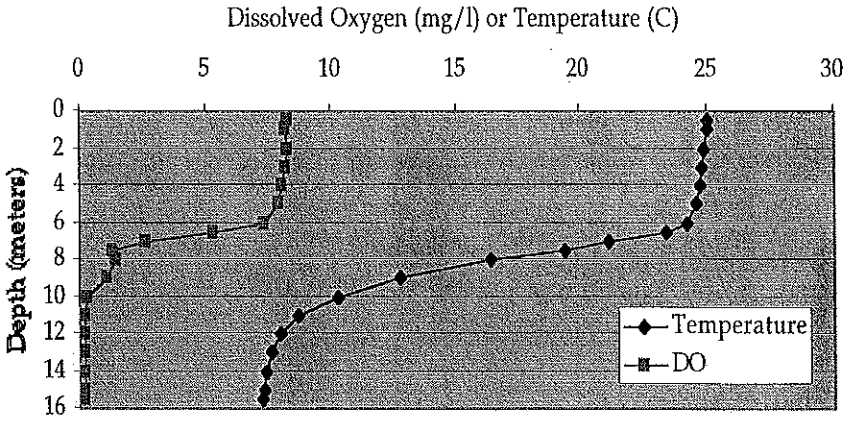
WATER QUALITY

Temperature and dissolved oxygen profiles have been collected in 2000, 2001, and 2002. Profiles show gradual temperature drop below 4 to 5 meters, with a well mixed epilimnion. Profiles also have anoxic concentrations for a minimum of 40% of the water column. The 2001 PALS Snapshot profile (shown above) also shows an area of higher than expected DO at 6 meters, which is likely due photosynthetic algae floating lower in the water column. The observed anoxic conditions appear to be releasing significant phosphorus loads back into the water column, although it appears that is not reaching the epilimnion of the pond based on the slightly impacted surface chlorophyll a concentration. The deep TN concentration is the fourth highest among all the ponds sampled during the 2001 Snapshot, while the deep TP concentration is the fifth highest. The relatively low surface chlorophyll a concentration results in a Carlson TSI ranking near the line between mesotrophic and eutrophic, although the deep water conditions readily indicate that significant nutrients are available within the pond. It is recommended that annual monitoring of the pond continue and that a characterization of nutrient loads to and within the lake, including more refined monitoring, be considered in the future. Stillwater Pond presents as a highly impacted pond with significant water quality problems.

| August 28, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.97 | 8.25 | 16.4 | 15.2 | 0.44 |
| 3 | 6.51 | 4.92 | 16.3 | 13.3 | 0.45 |
| 8 | 6.54 | 6.17 | 35.6 | 71.2 | 1.51 |
| 12.5 | 5.94 | 3.65 | 48.2 | 325.5 | 2.40 |

# White Pond
## Chatham
## CH-516

Acreage: 40.5
Maximum Depth: 56 ft
2001 Secchi Dip: 10.6 ft
Lake Association: None




Dissolved Oxygen and Temperature
White Pond, 8/28/01

OVERVIEW

White Pond located southeast of the Chatham Municipal Airport. Groundwater recharges the pond from the northwest. Surface water from White Pond discharges to groundwater along its southeast shoreline. A surface channel connects White Pond to Blue Pond at the southwest corner during high groundwater conditions. The shoreline is moderately developed with single family homes. Recreational uses include swimming, boating and fishing. Public access is provided by small town beach and boat ramp on the north shore.

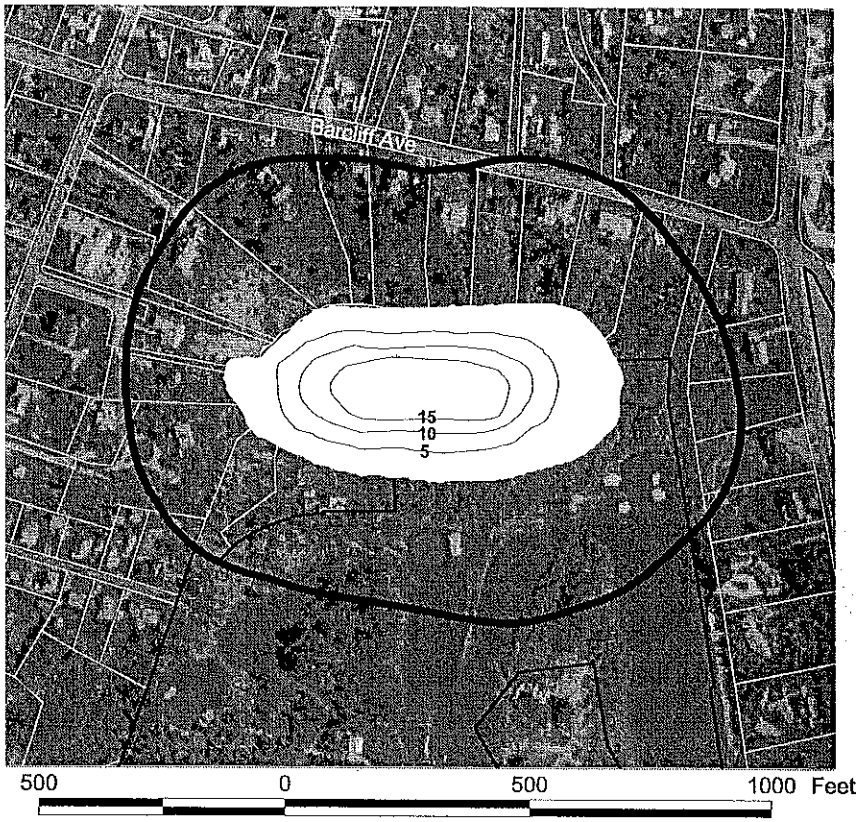
WATER QUALITY

Temperature and dissolved oxygen profiles have been collected on White Pond in 1948, 2000, 2001, and 2002, while a temperature profile alone was collected in 1911. All the temperature profiles are relatively consistent with three well-defined layers and bottom temperatures in the 7 to 12 °C (45 to 54 °F) range. The 1948 DO profile shows some lower concentrations deeper within the pond, but lowest concentration is 2.6 ppm observed at 55 ft (16.8 m). This profile contrasts with the 2001 PALS Snapshot (shown above), which has anoxic conditions below 10 m (32 ft).

Chlorophyll *a* and TN concentrations in the upper water column exceed current Cape Cod "impacted" thresholds, while TP concentrations are just below the TP threshold (shown below); nutrient concentrations increase significantly at the bottom of the pond (the deep TN concentration is the third highest among the 417 samples collected during the 2001 Snapshot sampling, while the deep TP is the eleventh highest of 410 TP samples). The low surface chlorophyll *a* concentration results in a Carlson TSI ranking near the line between oligotrophic and mesotrophic, although the deep water conditions indicate that significant nutrients are available within the pond.

Lack of oxygen in the deep, cool waters is a significant impairment for trout populations. It is recommended that annual monitoring of the pond continue and that a characterization of nutrient loads to and within the lake, including more refined monitoring, be considered in the future. White Pond presents as an impacted pond with water quality problems that has suffered degradation over the last 50 years.

| August 28, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.65 | 2.71 | 9.2 | 8.4 | 0.37 |
| 3 | 6.66 | 3.00 | 9.4 | 8.4 | 0.40 |
| 9 | 6.84 | 3.93 | 13.1 | 8.4 | 0.35 |
| 15 | 7.3 | 5.10 | 51.2 | 223.3 | 2.78 |



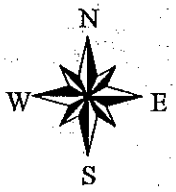

## Black Pond Chatham (CH- 524 )

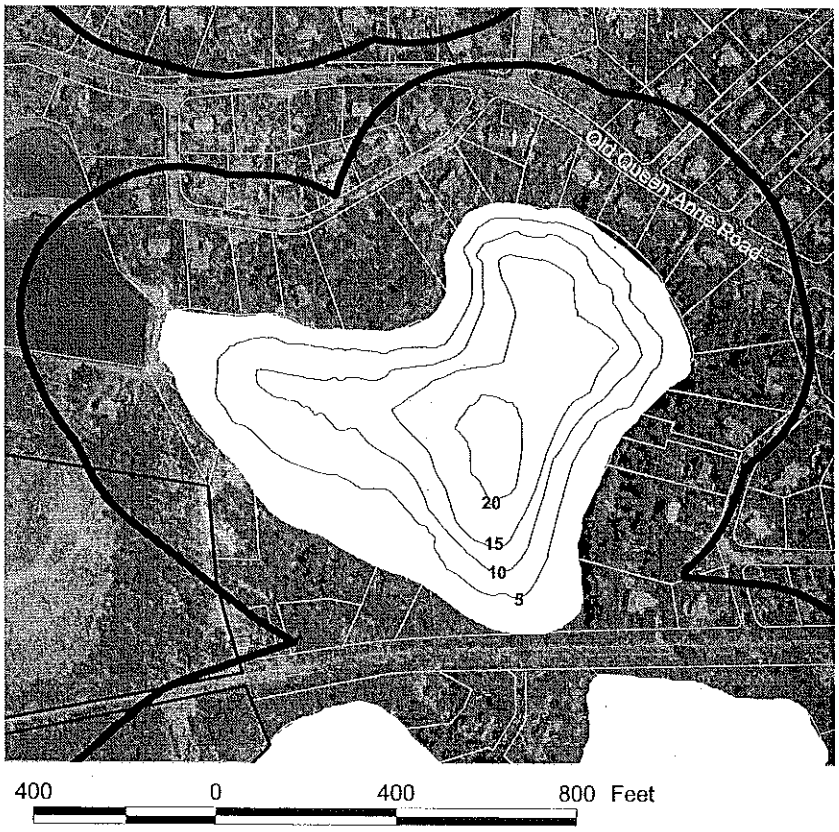
Bathymetry Source:
Chatham Water Quality Lab
Applied Science Assoc., 2000

Bathyemetry in feet

Town owned properties

300' Buffer Zone



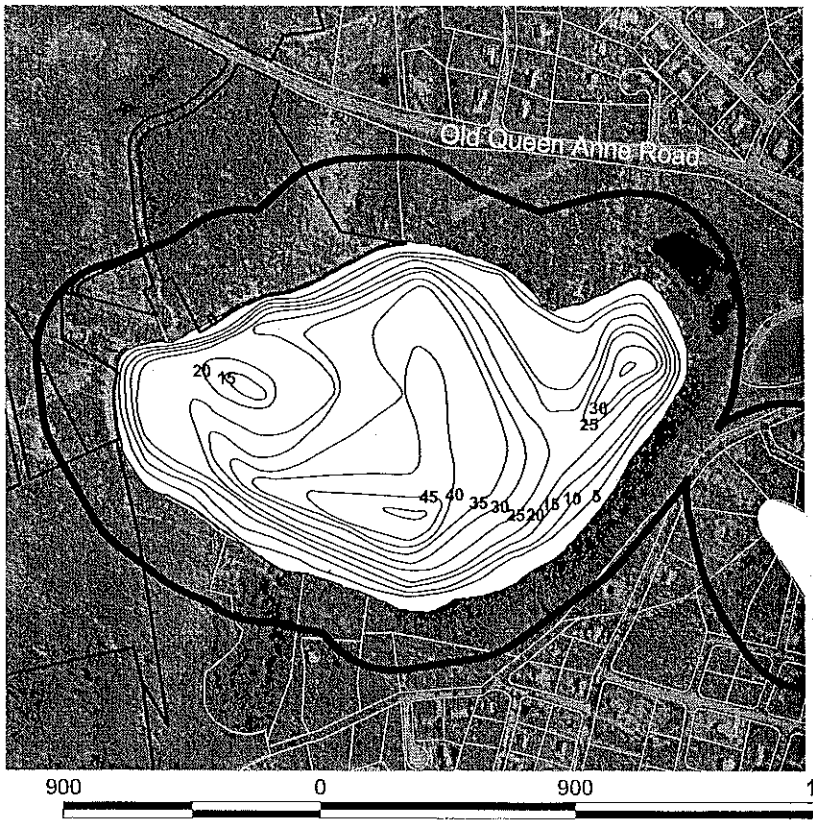

## Emery Pond Chatham (CH-491)

Bathymetry Source:
Chatham Water Qualtiy Lab
Applied Science Association,2000

Town owned land

Bathymetry In feet

300' Buffer Zone



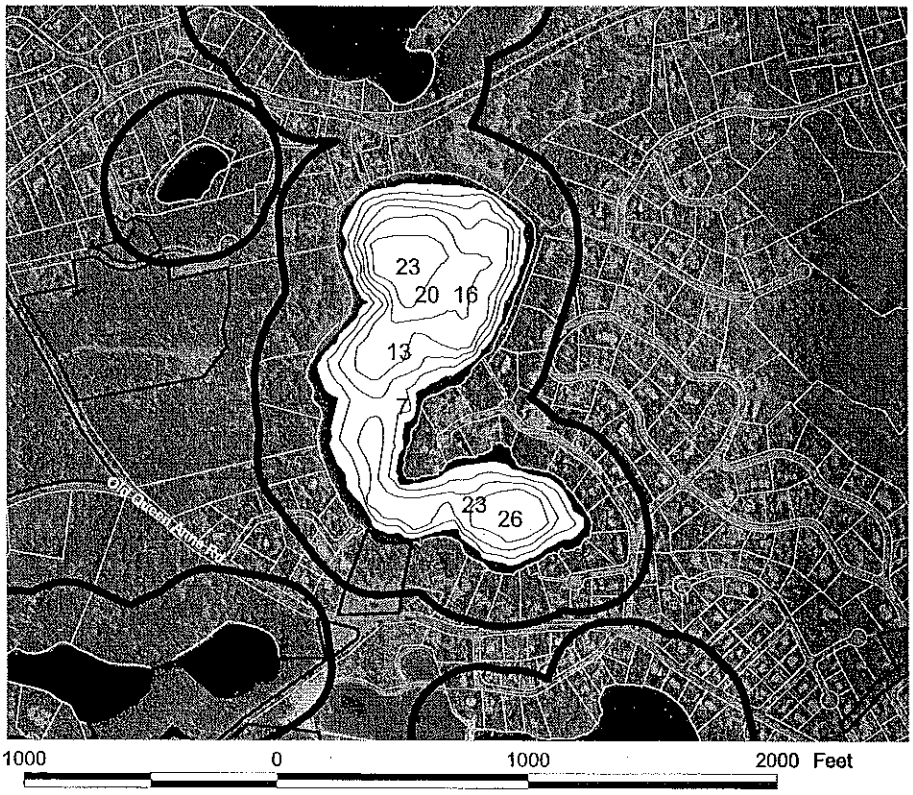

## Goose Pond Chatham (CH-458)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Chatham town owned parcels
Bathymetry in feet

300' Buffer Zones

N
W E
S

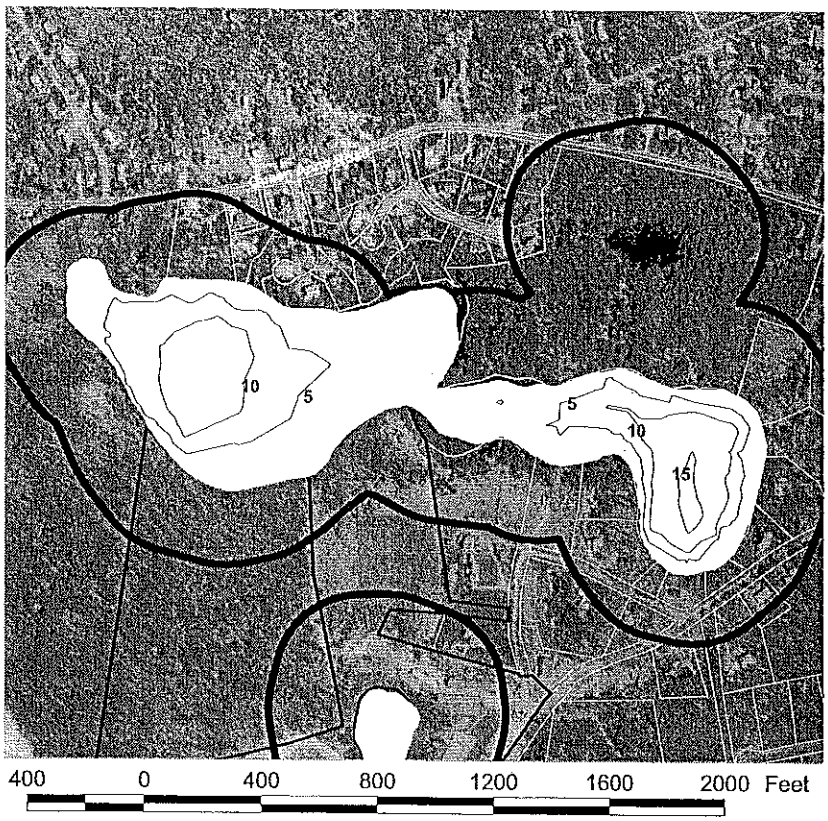



## Lovers Lake Chatham (CH-428)

**Bathymetry Source:**
**Chatham Water Quality Lab**

Bathymetry in Feet
Chatham town owned parcels.
300' Buffer Zone

N
W E
S

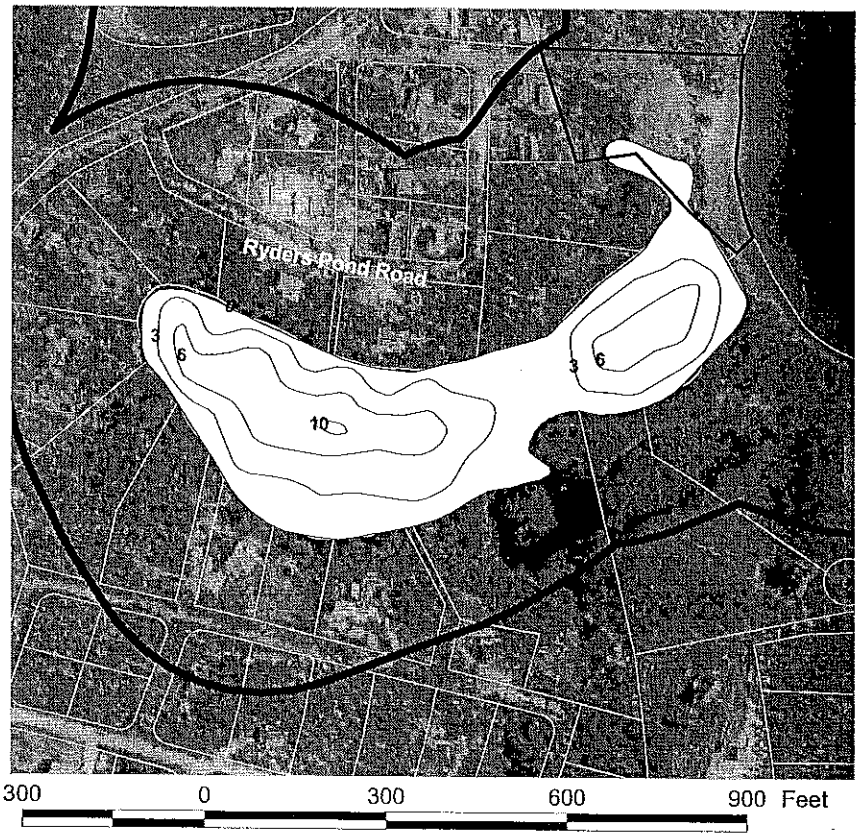



## Mill Pond Chatham (CH-440)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet
Town owned land
300' Buffer Zone

N
W E
S

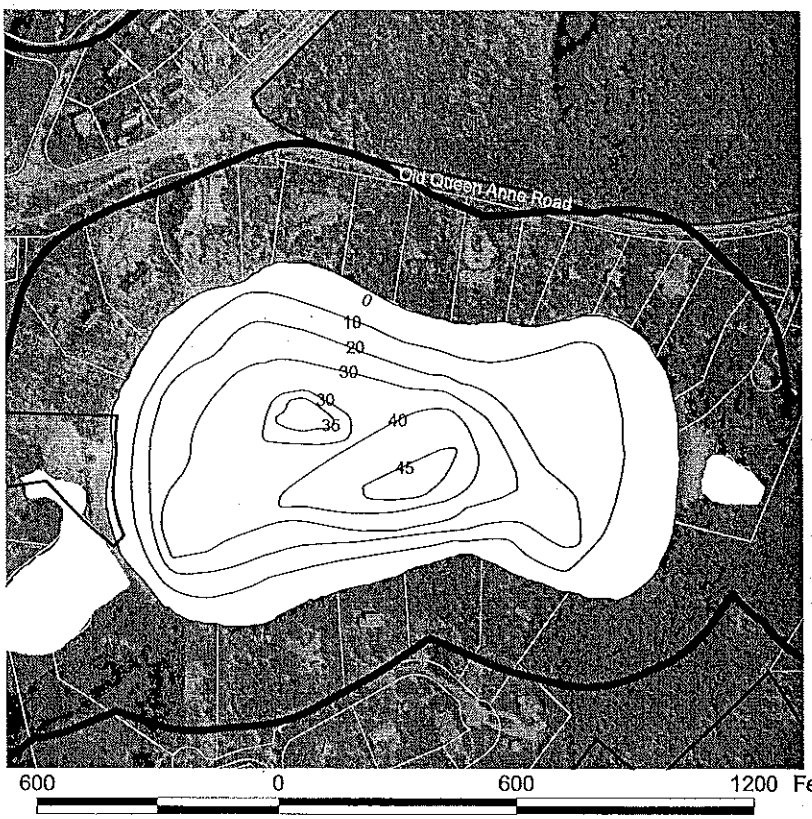



## Ryders Pond Chatham (CH-481)

**Bathymetry Source;**
**Chatham Water Quality Lab**

Town owned land
Bathymetry in feet
300' Buffer Zone

N
W E
S



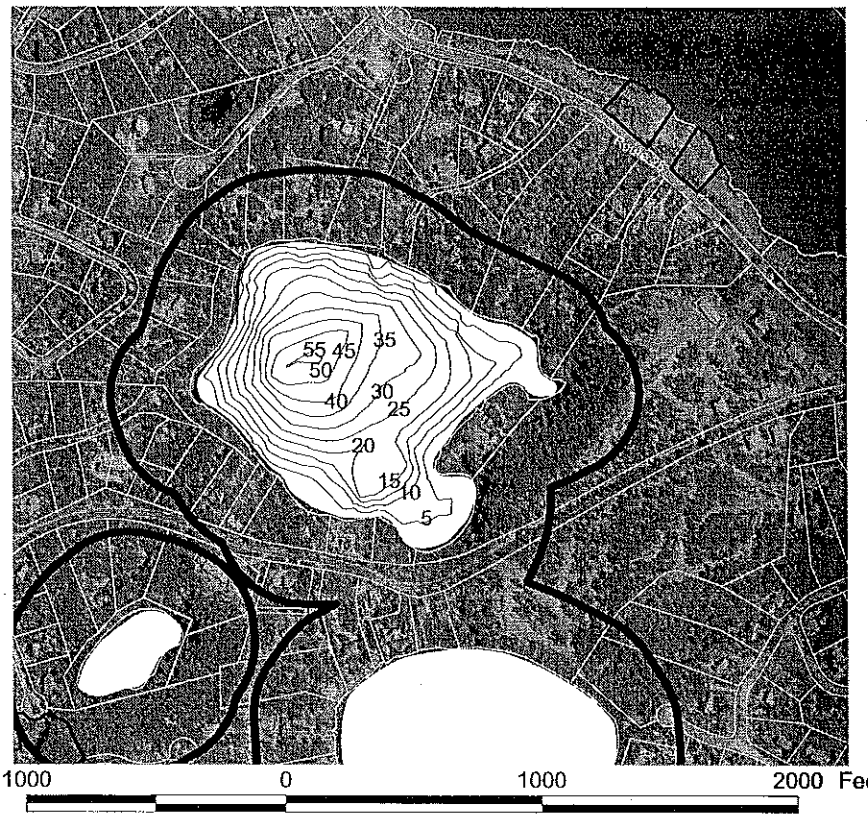

## Schoolhouse Pond
## Chatham
## (CH-463)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Chatham town owned parcels
Bathymetry in feet

300' Buffer Zone

N
W E
S




## Stillwater Pond
## Chatham
## (CH-396)

**Bathymetry Source:**
**Chatham Water Quality Lab**

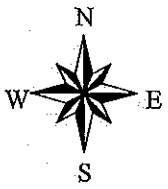
Bathymetry in feet
Chatham town owned parcels
300' Buffer Zone

N
W E
S

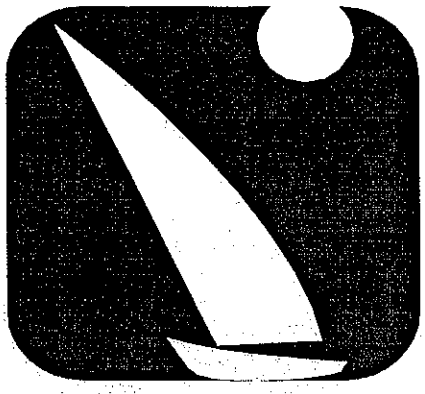

# White Pond
# Chatham
# (CH-516)

**Bathymetry Source:**
**Chatham Water Quality Lab**
**Applied Science Assoc.**

Bathymetry in feet
Town owned land
300' Buffer Zone



# DENNIS PONDS

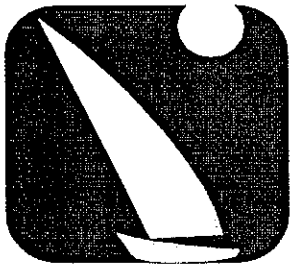


Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:

Fresh Pond
Scargo Lake

# Town of Dennis Atlas Summary



**Total Land Area (sq. miles):** 20.66

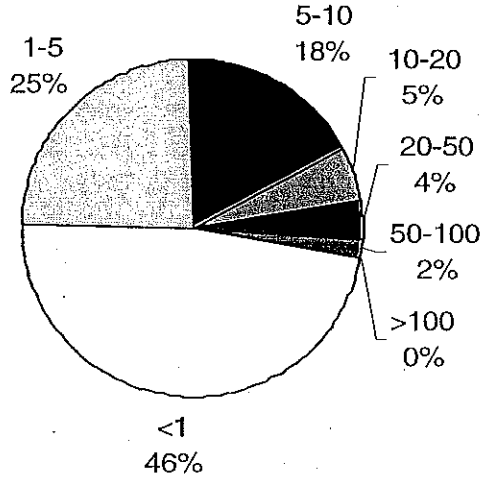
**Total Area of Ponds (acres):** 275

**Total # of Ponds:** 57

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 27 |
| 1-5 acres: | 14 |
| 5-10 acres: | 10 |
| 10-20 acres: | 3 |
| 20-50 acres: | 2 |
| 50-100 acres: | 1 |
| >100 acres: | 0 |

**Number of Dennis Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 11 |
| # of impacted ponds | |
| Chlorophyll a: | 7 |
| Total Nitrogen: | 8 |
| Total Phosphorus: | 7 |

**2001 Secchi Dip-In**

| | |
|---|---|
| # of ponds dipped: | 16 |
| # of volunteers: | 5 |

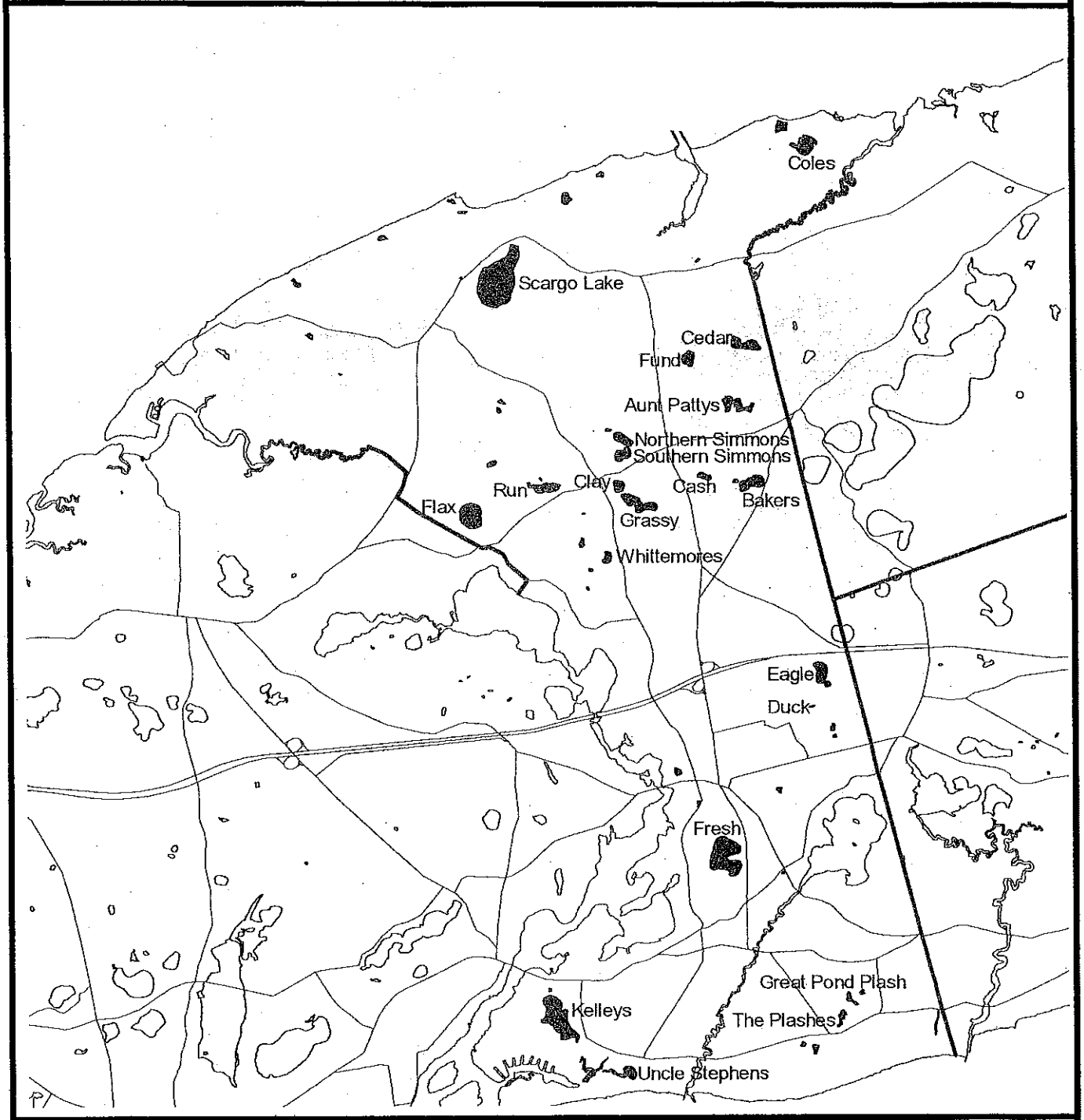
**Coordinator:**

Town Staff:

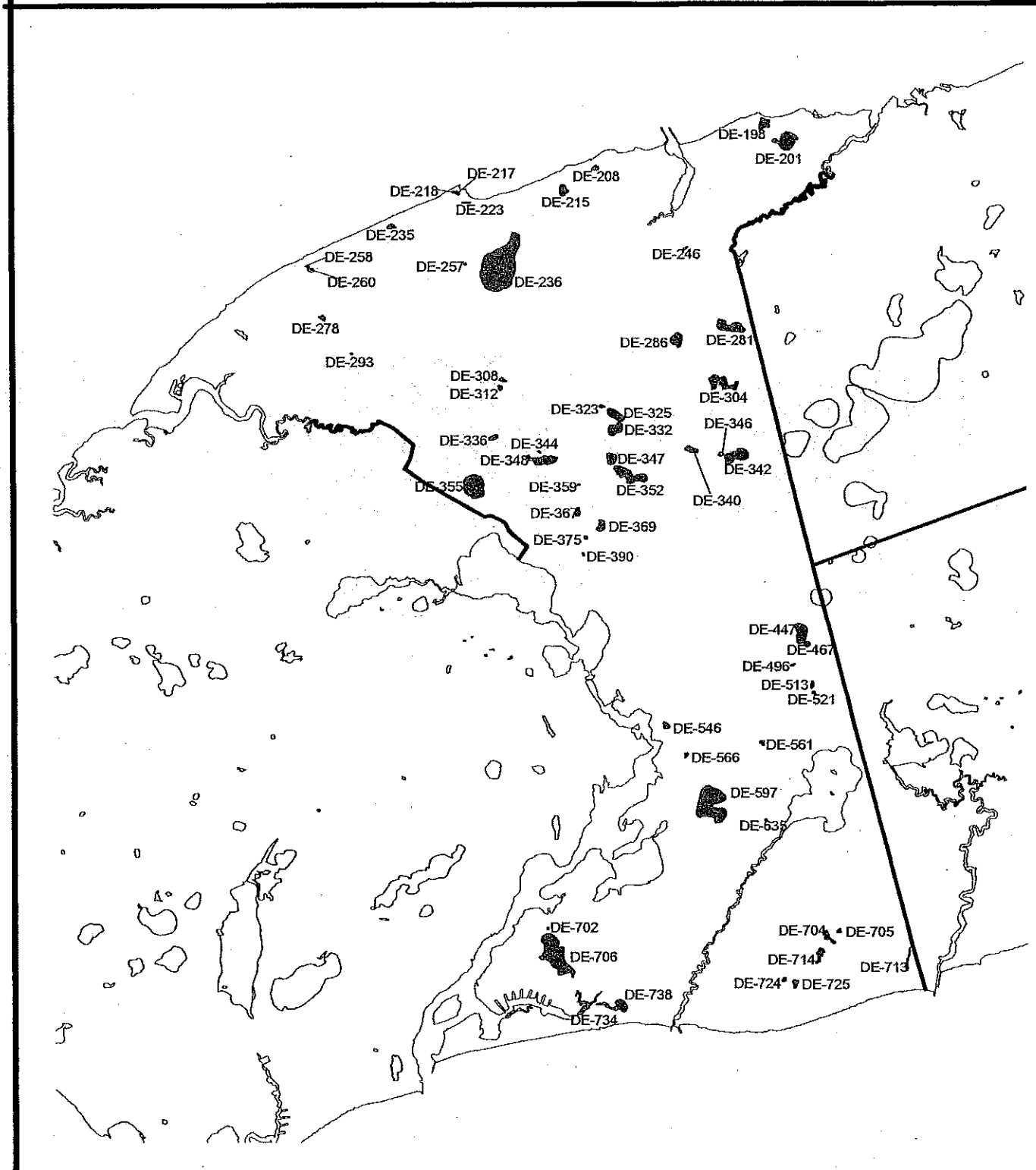
Citizen: Bill Boothe, Seth Crowell

**Pond Groups:** Water Quality Advisory Committee

# DENNIS
# NAMED PONDS



# GIS ID'S FOR DENNIS PONDS



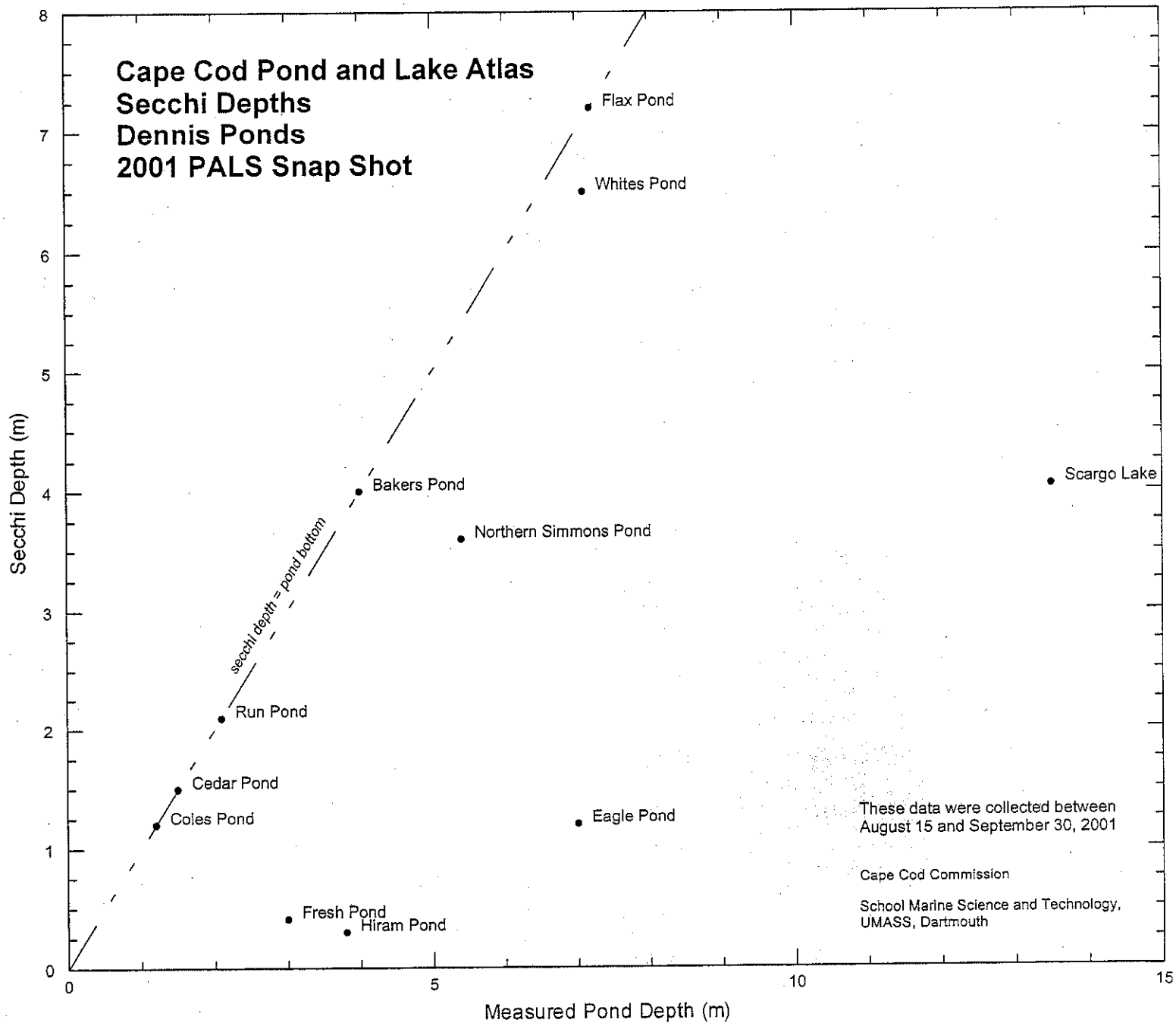

N

1 0 1 2 Miles

CAPE COD COMMISSION

# Dennis 2001 PALS Water Quality Snapshot Summary

| Name | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk (1-1.7 ug/l) | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk (0.16-0.31 mg/l) | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk (7.5-10 ug/l) | impacted (>10 ug/l) |
| Bakers Pond | 1.11 | | x | | 0.20 | | x | | 7.74 | | x | |
| Cedar Pond | 5.86 | | | x | 0.53 | | | x | 17.34 | | | x |
| Coles Pond | 102.9 | | | x | 0.61 | | | x | 48.93 | | | x |
| Eagle Pond | 4.3 | | | x | 0.42 | | | x | 14.25 | | | x |
| Flax Pond | 1.14 | | x | | 0.08 | x | | | 7.74 | | x | |
| Fresh Pond | 45.82 | | | x | 1.18 | | | x | 74.33 | | | x |
| Hiram Pond | 44 | | | x | 0.91 | | | x | 50.48 | | | x |
| Northern Simmons Pond | 1.6 | | x | | 0.49 | | | x | 14.25 | | | x |
| Run Pond | 3.31 | | | x | 0.41 | | | x | 7.74 | | x | |
| Scargo Lake | 3.19 | | | x | 0.38 | | | x | 10.84 | | | x |
| Whites Pond | 1.45 | | x | | 0.18 | | x | | 7.74 | | x | |


Cape Cod Pond and Lake Atlas
Secchi Depths
Dennis Ponds
2001 PALS Snap Shot
Flax Pond
Whites Pond
Bakers Pond
Scargo Lake
Northern Simmons Pond
secchi depth = pond bottom
Run Pond
Cedar Pond
Coles Pond
Eagle Pond
Fresh Pond
Hiram Pond
These data were collected between August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology, UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
6
7
8
0
5
10
15

# DENNIS POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Aunt Pattys Pond | DE-304 | 96007 | 9.06 | N | | 30 | | thr wellfld | | | |
| Bakers Pond | DE-342 | 96009 | 9.51 | N | | 29 | 19 | townconsarea | | sd,wq | |
| Cash Pond | DE-340 | | 2.53 | N | | 35 | | thr wellfld | | sd | |
| Cedar Pond | DE-281 | 96034 | 9.39 | N | | 32 | | townconsarea | | sd,wq | sd |
| Clay Pond | DE-347 | 96037 | 3.86 | N | | 22 | | thr wellfld | | sd,wq | |
| Coles Pond | DE-201 | 96042 | 11.17 | N | | 6 | | informal | O | sd | sd |
| Duck Pond | DE-496 | 96065 | 0.37 | N | | 15 | | | | | |
| Eagle Pond | DE-447 | 96071 | 7.99 | N | | 25 | 24 | off LoveLn. | O | sd,wq | wq |
| Flax Pond | DE-355 | 96090 | 17.01 | N | | 30 | 29 | townconsarea | | sd,wq | |
| Fresh Pond | DE-597 | 96101 | 31.56 | N | | 7 | 8 | townconsarea | O | sd,wq | sd |
| Fund Pond | DE-286 | 96102 | 5.21 | N | | 31 | | thr D.Pines GC | | sd | |
| Grassy Pond | DE-352 | 96112 | 11.77 | N | | 23 | | thr wellfld | | | |
| Great Pond Plash | DE-705 | | 1.88 | N | | | | | | | |
| Kelleys Pond | DE-706 | 96162 | 29.80 | N | | 5 | 30 | townconsarea | O | | |
| Northern Simmons | DE-325 | 96296 | 5.65 | N | | 22 | | thr wellfld | | sd,wq | wq |
| Run Pond | DE-348 | 96265 | 8.14 | N | | 25 | | thr wellfld | | wq | |
| Scargo Lake | DE-236 | 96279 | 59.29 | Y | 41,194 | 12 | 48 | pubramp | O,HR | sd,wq | |
| Southern Simmons | DE-332 | | 5.66 | N | | 23 | | off N.Simmons | | sd,wq | |
| The Plashes | DE-714 | | 2.40 | N | | 5 | | townconsarea | O | sd | |
| Uncle Stephens Pond | DE-738 | 96322 | 6.72 | N | | 2 | | | | | |
| Weir Creek | DE-734 | | 5.52 | N | | | | | | | |
| Whittemores Pond | DE-369 | | 2.89 | N | | | | | | | |
| White Pond | | 96338 | | | | 27 | | abutter | | sd | |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

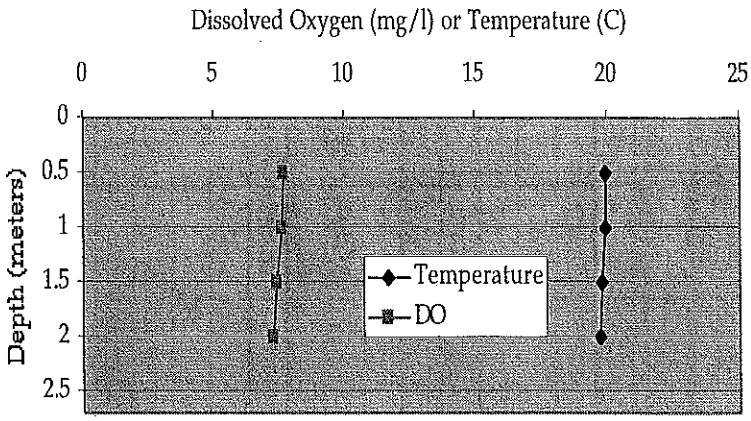
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot

# Fresh Pond
## Dennis
## DE-597

Acreage: 31.6
Maximum Depth: 9 ft
2001 Secchi Dip: 1.3 ft
Lake Association: none




Dissolved Oxygen and Temperature
Fresh Pond, 9/21/01

OVERVIEW

Fresh Pond is located just north and west of the intersection of Routes 134 and 28. The pond is recharged by groundwater flow from the north and east and discharges surface water to groundwater along the southern and western shorelines. Fresh Pond also discharges surface water though a outlet that runs to the Bass River. The shoreline is surrounded by conservation area and wetlands. Public access to the pond is available across the conservation area off of Route 134. Recreational use on Fresh Pond includes walking trails, boating, fishing, and skating.

WATER QUALITY

Fresh Pond was sampled in 1980, 2001, and 2002. As would be expected in a shallow, fairly large pond, the 2001 temperature and dissolved oxygen (DO) profiles show a well-mixed, well-oxygenated water column. However, the nutrient concentrations are very high; TN concentrations are at least three times higher than the current Cape Cod "impacted" threshold and TP concentrations are at least six times higher. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond on the upper portion of the "eutrophic with blue-green algae dominance" category.

The very low pH and lack of alkalinity, as well as field observations noting "tea colored" water, suggest that water quality in the pond may be influenced of peat moss, which lowers pH as it decays. Surface waters with peat are often labeled as "swamps" or "bogs".

The town Water Quality Advisory Committee collected more refined data from Fresh Pond during the summer of 2002; it is recommended that the town consider a water quality assessment of the pond, including a review of this more refined data, a land use assessment of shoreline and watershed properties, and characterization of whether the conditions of this pond are reflective of natural conditions. Overall, Fresh Pond presents as an impacted pond with current water quality problems, but uncertainty about some of its characteristics suggest that final characterization should await more refined analysis.

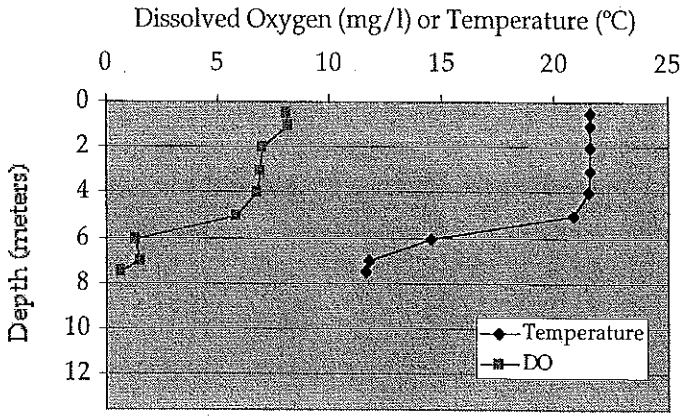
| September 21, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 4.50 | 45.82 | BDL | 74.3 | 1.18 |
| 2 | 4.41 | 39.96 | BDL | 69.4 | 1.10 |
| BDL = Below Detection Limit (ALK DL = 0.5 mg/L) | | | | | |

# Scargo Lake

## Dennis

## DE-236

Acreage: 59
Maximum Depth: 44 ft
2001 Secchi Dip: 13.2 ft
Lake Association: None?




Dissolved Oxygen and Temperature
Scargo Lake, 9/21/01

OVERVIEW

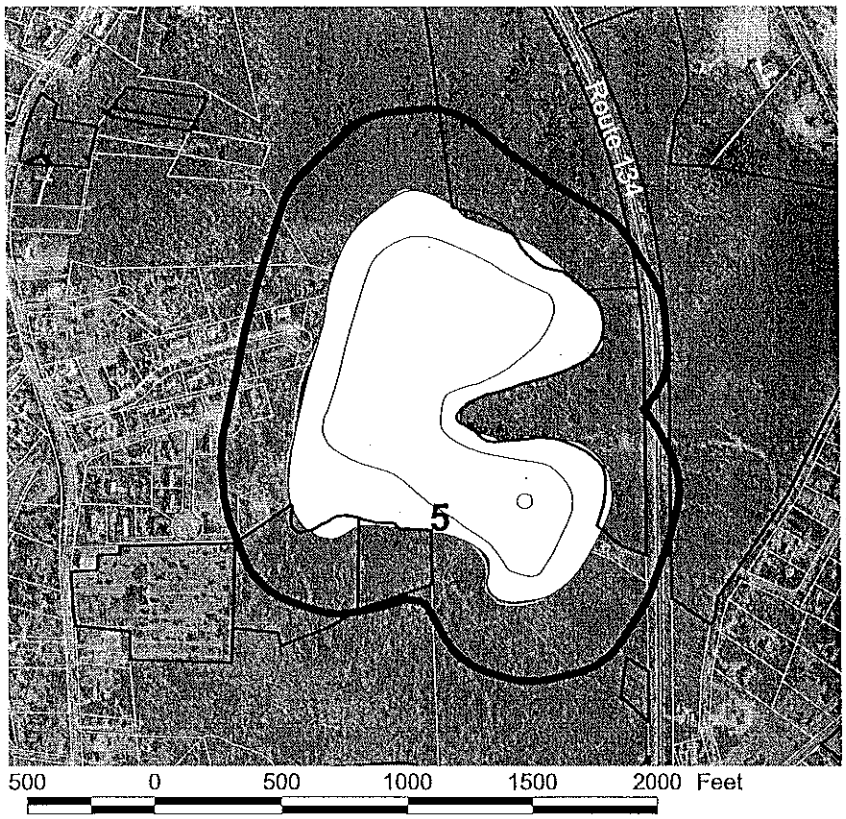
Scargo Lake is located on the north side of Dennis, just south of Rt 6A. The lake is recharged by groundwater flow from the south and discharges surface flow to the groundwater along the northern shoreline. There is also a herring run leading to Sesuit Creek at the northern end of the lake. The shoreline is moderatly developed with single family homes and cottages. A large public beach area and boat ramp are located on the eastern shoreline. Recreational activites include fishing, boating and swimming.

WATER QUALITY

Scargo Lake was sampled in 1948, 1982, 2001, and 2002. In 1948, the August 18 temperature profile indicated a well-mixed upper layer (*i.e.*, epilimnion) to 30 ft with waters approximately 10°F cooler below 35 ft. The dissolved oxygen (DO) profile had near saturation concentrations in the epiliminion and deeper concentrations beginning at 6 ppm and declining to anoxic (<1 ppm) conditions at the bottom. In August 1982, anoxic conditions existed below 11 m (36.1 ft) with some oxygen between the epiliminon and the cooler waters. The 2001 PALS Snapshot profile (shown above) shows further worsening of DO conditions with limited deep readings showing anoxic conditions existing at the bottom of the epiliminion. All but one of the chlorophyll *a*, TP, and TN concentrations measured in Scargo Lake exceed Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond on the mesotrophic side of the mesotrophic/oligotrophic with some bottom anoxia category boundary.

The review of DO profiles shows a gradual decline in deep DO concentrations in Scargo Lake with current conditions having no cold water fishery and release of nutrients from the sediments. Although additional monitoring would help to clarify how long this condition exists during the summer, it appears that water quality in Scargo Lake has become more impaired over the last 50 years and consideration of information from other ponds discussed in this Pond Atlas suggests that the 1948 conditions were impaired as well. The town Water Quality Advisory Committee collected more refined data during the summer of 2002; it is recommended that the town consider a water quality assessment of the Scargo Lake, including a review of this more refined data and include a sediment characterization, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to continue to worsen. Overall, Scargo Lake presents as an impacted pond with current water quality problems.

| September 21, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.12 | 3.19 | 6.2 | 10.8 | 0.38 |
| 3 | 6.23 | 3.25 | 6.9 | 14.2 | 0.29 |
| 9 | 5.99 | 12.24 | 8.1 | 10.8 | 0.33 |
| 12.5 | 5.97 | 16.93 | 8.3 | 30.0 | 0.48 |



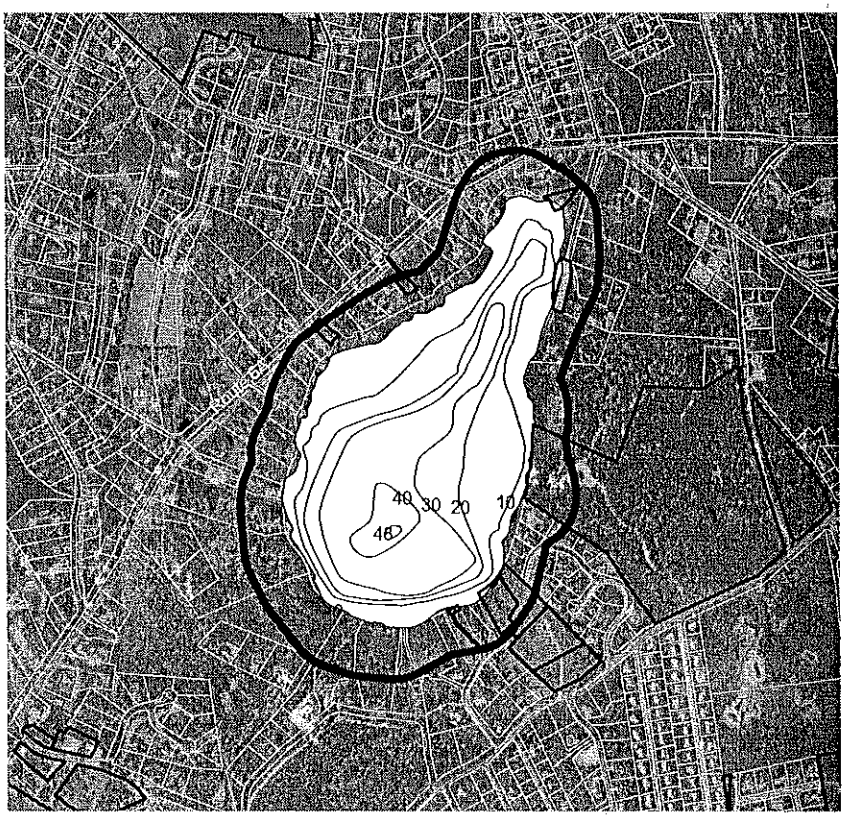

## Fresh Pond
## Dennis
## (DE-597)

**Bathmetry Source**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S




## Scargo Lake
## Dennis
## (DE-236)

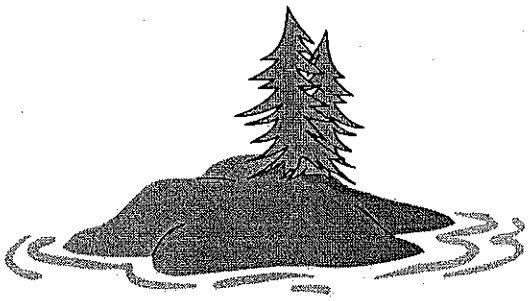
**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

# EASTHAM PONDS

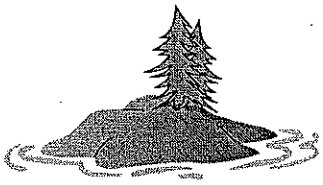


Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:

Great Pond
Herring Pond

# Town of Eastham Atlas Summary



**Total Land Area (sq. miles):** 14.25

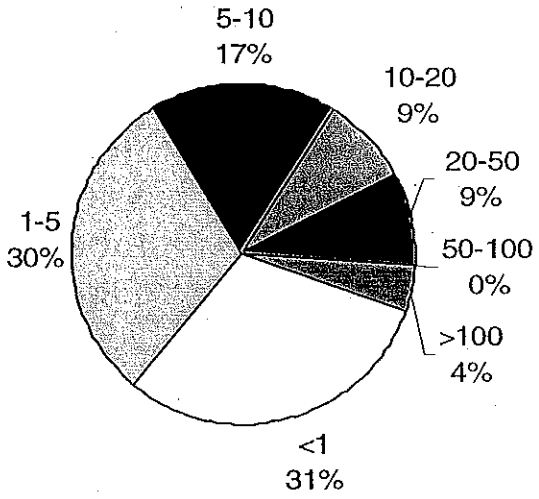
**Total Area of Ponds (acres):** 258

**Total # of Ponds:** 23

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 7 |
| 1-5 acres: | 7 |
| 5-10 acres: | 4 |
| 10-20 acres: | 2 |
| 20-50 acres: | 2 |
| 50-100 acres: | 0 |
| >100 acres: | 1 |

**Number of Eastham Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 11 |
| # of impacted ponds | |
| Chlorophyll a: | 11 |
| Total Nitrogen: | 9 |
| Total Phosphorus: | 10 |

**2001 Secchi Dip-In**

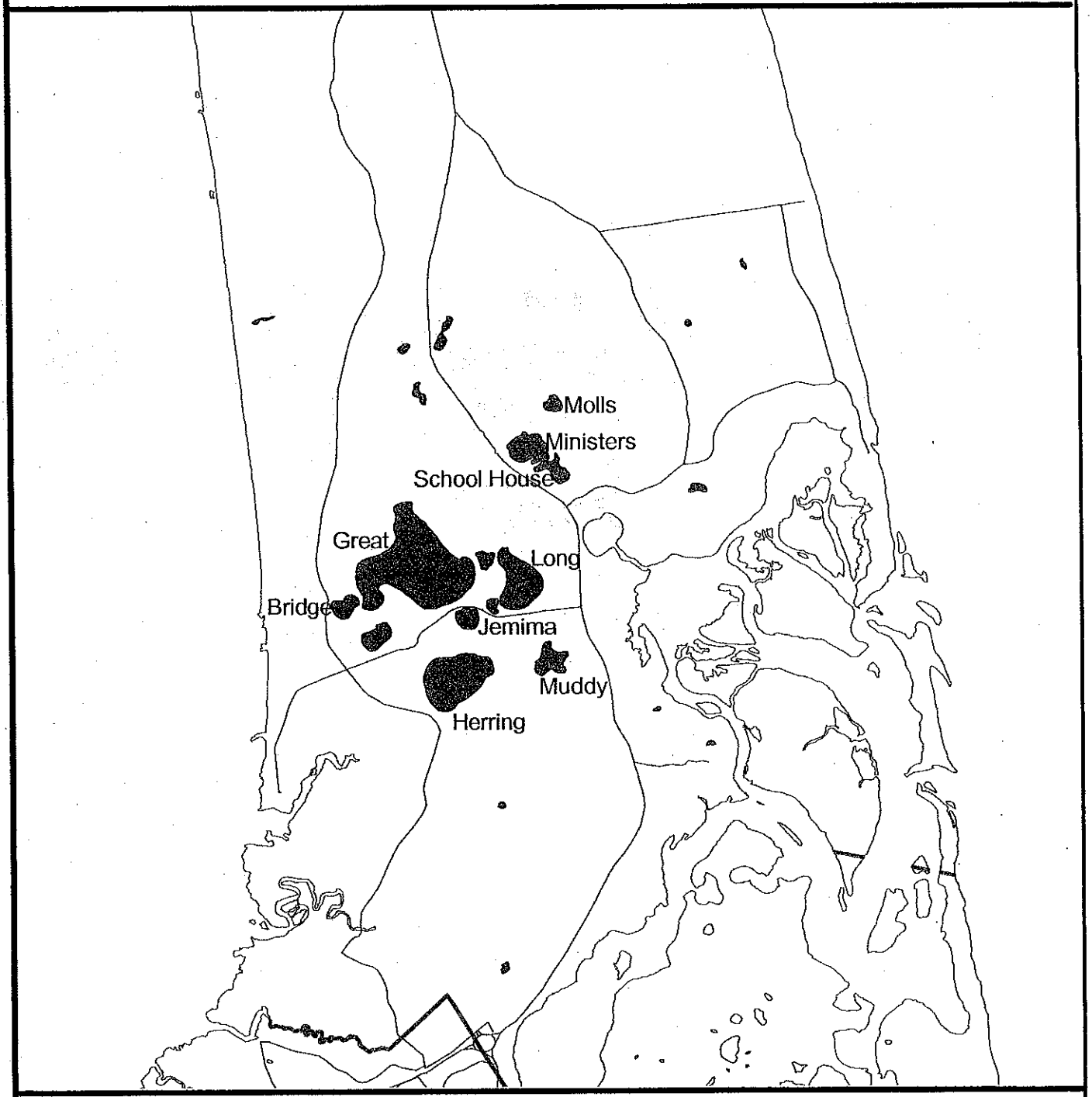
| | |
|---|---|
| # of ponds dipped: | 4 |
| # of volunteers: | 4 |

**Coordinator:**

| | |
|---|---|
| Town staff: | Henry Lind |
| Citizen: | Sandy Bayne |

**Pond Groups:** National Park Service
Eastham Pond Monitoring Group

# EASTHAM
# NAMED PONDS

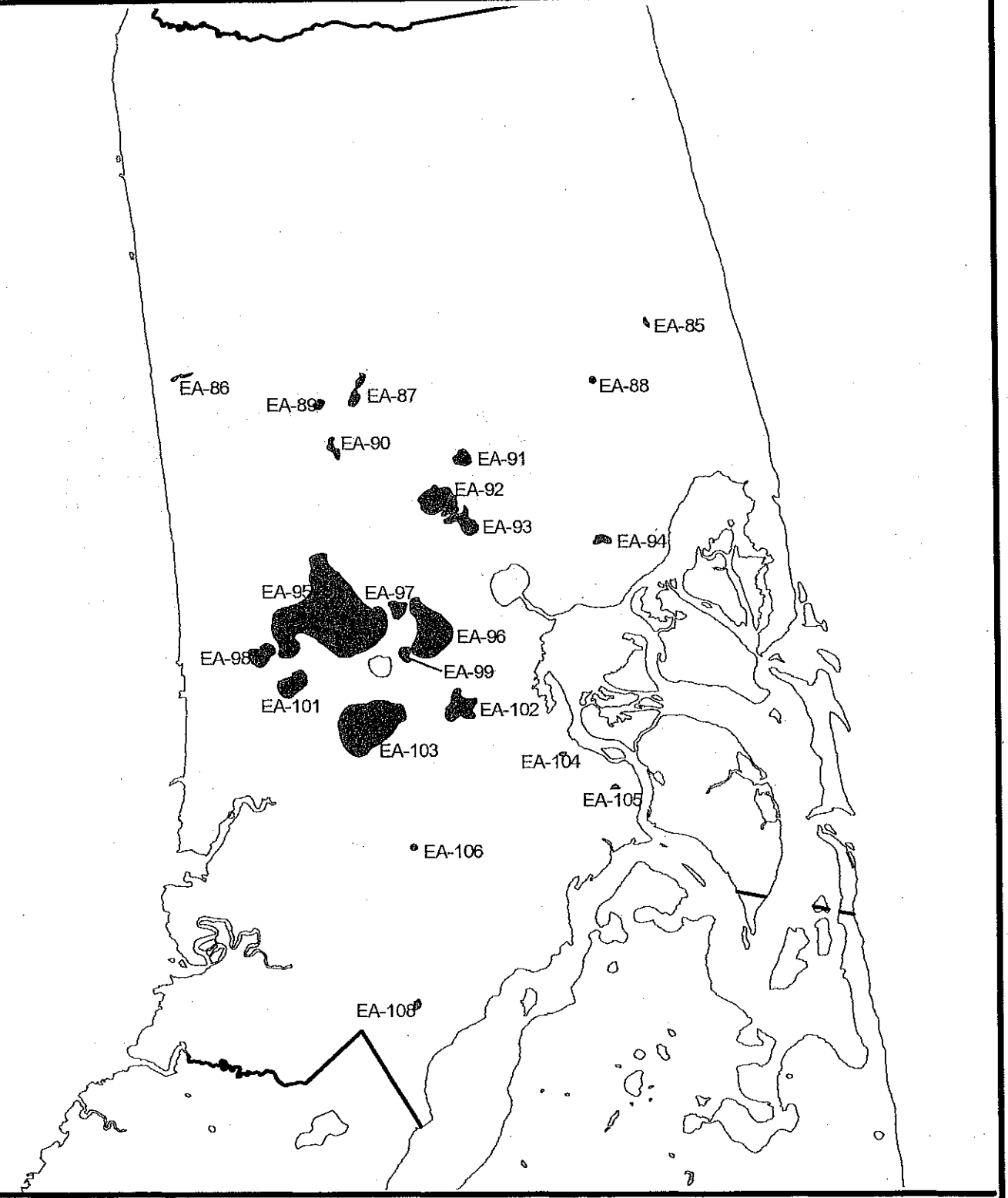



N

0.6 0 0.6 1.2 Miles

CAPE COD COMMISSION

# GIS ID'S FOR EASTHAM PONDS




N

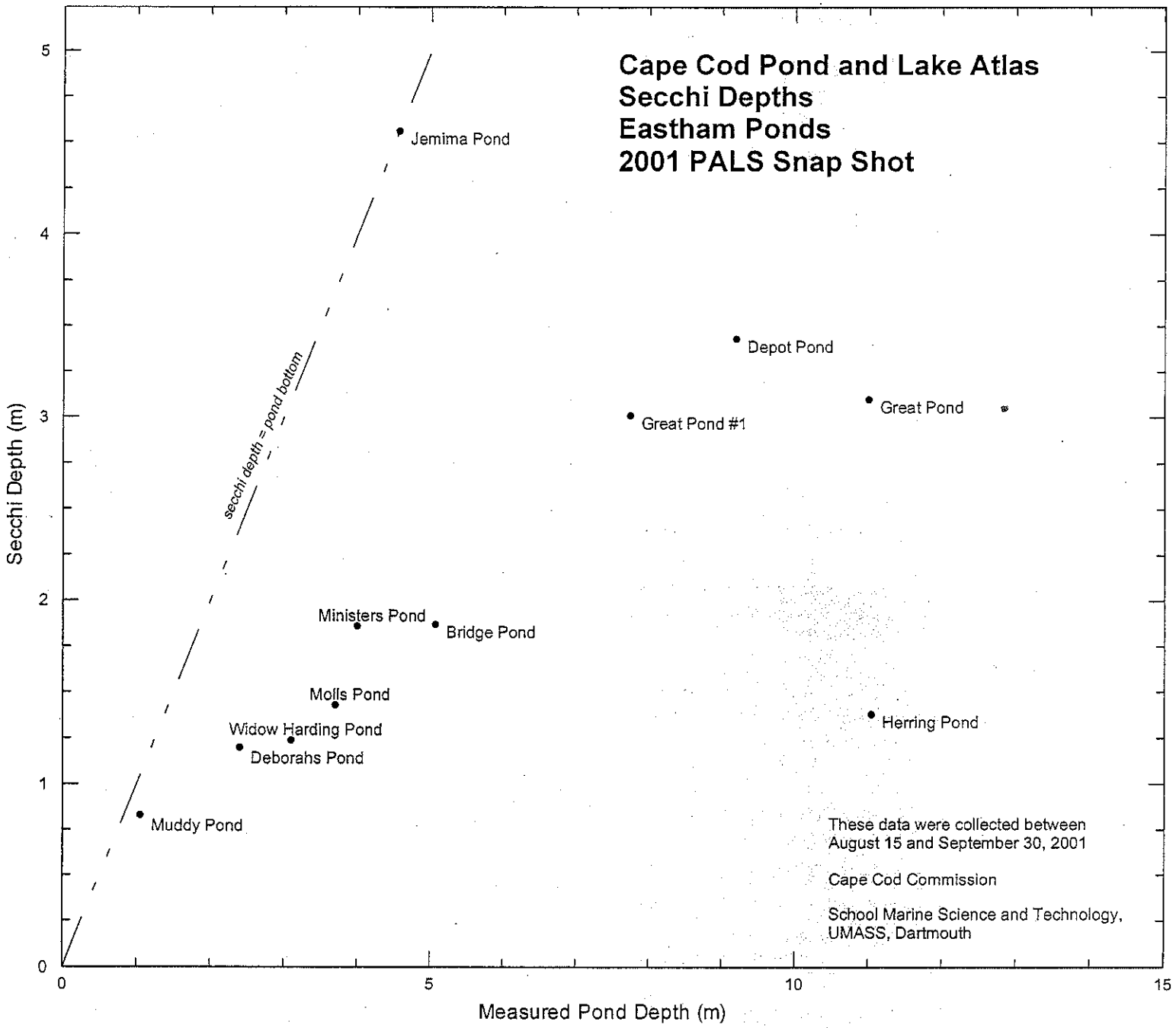
1 0 1 Miles

COUNTY OF BARNSTABLE MASSACHUSETTS

CAPE COD COMMISSION

# Eastham 2001 PALS Water Quality Snapshot Summary

| Name | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk 1-1.7 ug/l | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk 0.16-0.31 mg/l | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk 7.5-10 ug/l | impacted (>10 ug/l) |
| Bridge Pond | 7.15 | | | x | 0.41 | | | x | 20.44 | | | x |
| Deborahs Pond | 4.13 | | | x | 0.60 | | | x | 12.70 | | | x |
| Depot Pond | 3.99 | | | x | 0.32 | | | x | 13.32 | | | x |
| Great Pond | 5.29 | | | x | 0.40 | | | x | 16.72 | | | x |
| Great Pond #1 | 3.92 | | | x | 0.38 | | | x | 16.72 | | | x |
| Herring Pond | 15.18 | | | x | 0.55 | | | x | 23.23 | | | x |
| Jemima Pond | 2.05 | | | x | 0.29 | | x | | 9.29 | | x | |
| Ministers Pond | 8.55 | | | x | 0.57 | | | x | 26.63 | | | x |
| Molls Pond | 5.28 | | | x | 0.27 | | x | | 10.84 | | | x |
| Muddy Pond | 2.64 | | | x | 0.49 | | | x | 10.84 | | | x |
| Widow Harding Pond | 20.86 | | | x | 0.59 | | | x | 83.62 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Eastham Ponds
2001 PALS Snap Shot
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
0
5
10
15
secchi depth = pond bottom
Jemima Pond
Depot Pond
Great Pond
Great Pond #1
Ministers Pond
Bridge Pond
Molls Pond
Widow Harding Pond
Deborahs Pond
Herring Pond
Muddy Pond
These data were collected between August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology, UMASS, Dartmouth

# EASTHAM POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (Feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bridge Pond** | EA-98 | | 6.7 | N | | 8 | | | | sd,wq | sd,wq |
| **Deborahs Pond** | EA-97 | | 3.7 | N | | 10 | | | | wq | |
| **(Little) Depot Pond** | EA-99 | | 2.3 | N | | | | | | wq | wq |
| **Great Pond** | EA-95 | 96115 | 109.7 | N | 46,263 | 8 | 36 | publanding | | wq | sd,wq |
| **Bridge Pond** | | 96132 | | | | 8 | | | | | |
| **Herring Pond** | EA-103 | 96133 | 44.2 | Y | 25,147 | 7 | 35 | publanding | | sd,wq | sd,wq |
| **Jemima Pond** | EA-100 | 96154 | 6.4 | N | | 5 | | pubramp | | | sd,wq |
| **Long Pond/ Big Depot Pond** | EA-96 | 96061 | 27.9 | N | | 10 | 31 | none | | sd | sd |
| **Muddy Pond** | EA-102 | 96175 | 10.5 | N | | 10 | | | | | sd,wq |
| **Ministers Pond/ School House Pond** | EA-92 | 96208 | 14.6 | N | | 14 | 16 | publanding | | wq | sd,wq |
| **Molls Pond** | EA-91 | | 3.4 | N | | 14 | | | | wq | sd,wq |
| **School House Pond** | EA-93 | | 6.8 | N | | | | | | | sd |
| **Widow Harding Pond** | EA-101 | 96340 | 8.7 | N | | 9 | | | | sd | sd,wq |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

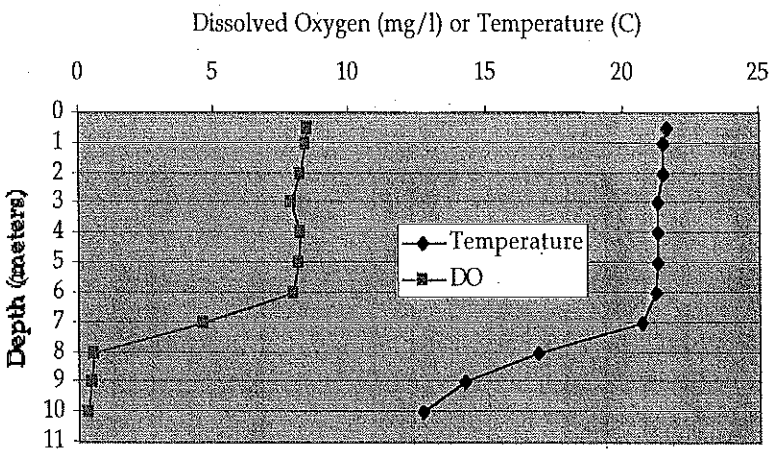
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Great Pond
## Eastham
## EA-95

Acreage: 109.7
Maximum Depth: 36 ft
2001 Secchi Dip: 10.9 ft
Lake Association: None




Dissolved Oxygen and Temperature
Great Pond, 9/20/01

OVERVIEW

Great Pond is located midway between Cape Cod Bay and Salt Pond, west of Route 6 and east of Herring Brook Road. The Pond is recharged by groundwater flow from the north and east and discharges surface water to groundwater along its southern and western shores. Surface water flows into the pond from a small unammed pond east of Great Pond and a surface water outlet is located at the southwest corner of the pond discharging to a small pond and then to Herring Brook. The shoreline is lightly developed with seasonal and year-round single family homes. Public access is provided at a beach at Wiley Park, off of Herring Brook Road and at a boat ramp off of Great Pond Road. Recreational activities include swimming, fishing and boating.

WATER QUALITY

Great Pond was sampled in 1948, 1985-1986, 1997-1998, and 2001-2002. In 1948, the August 20 temperature profile indicated a well-mixed upper layer (*i.e.*, epilimnion) to 20 ft with waters 5 to 13°F cooler below 25 ft. The dissolved oxygen (DO) readings indicate depressed concentrations beginning at 10 ft with anoxic (<1 ppm) concentrations below 25 ft. The 2001 PALS profiles (shown above) show deep low oxygen conditions extending into the epilimnion. These conditions would allow nutrients regenerated from the sediments to mix into the epilimnion and prompt algal growth. Great Pond was the subject of a diagnostic/feasability study in 1987 by Baystate Environmental Consultants.

All water quality readings collected during the 2001 PALS Snapshot (see below) exceed the Cape Cod "impacted" thresholds. A Carlson TSI based on the surface chlorophyll concentration places the pond in the middle of the mesotrophic category.

Although the 1987 diagnostic/feasability study did not recommend any remedial activity, it is clear that Great Pond has impaired water quality and is significantly impacted compared to Cape Cod reference ponds. This impairment has apparently existed for more than 50 years. During the summers of 2001 and 2002, volunteers have collected additional water quality data, including nutrient analyses completed by the National Park Service. It is recommended that the Town consider revisiting the 1987 study using the newly collected data. Overall, Great Pond presents as an impacted pond with current water quality problems.

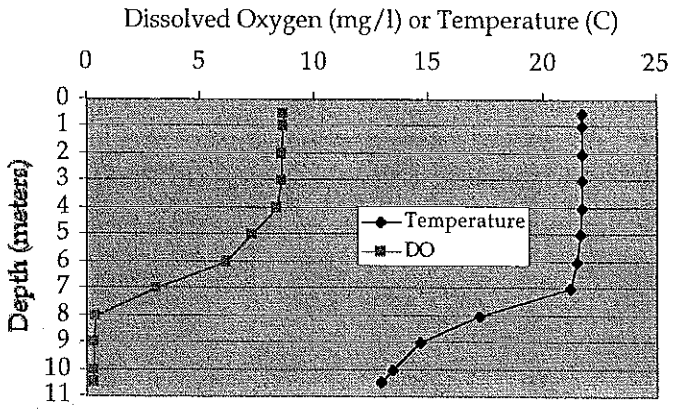
| September 20, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.58 | 5.29 | 11.0 | 16.7 | 0.40 |
| 3 | 6.47 | 6.97 | 10.9 | 18.3 | 0.39 |
| 9 | 6.31 | 12.81 | 25.5 | 28.2 | 0.62 |
| 10 | 6.32 | 6.64 | 28.2 | 30.0 | 0.94 |

# Herring Pond

## Eastham

## EA-103

Acreage: 44.2
Maximum Depth: 36 ft
2001 Secchi Dip: 4.5 ft
Lake Association: None




Dissolved Oxygen and Temperature
Herring Pond, 9/18/01

OVERVIEW

Herring Pond is located midway between the Herring River and Salt Pond, west of Route 6 and east of Herring Brook Road. The pond is recharged by groundwater flow from the north and east and discharges surface water to groundwater along its southern and western shores. There is a herring run connected to the pond at the southwest corner of the pond discharging surface water to the Herring River. The shoreline is well developed with single family homes. Public access is provided at a boat ramp on Herring Brook Road, near the herring run. Recreational activities include swimming, fishing and boating.

WATER QUALITY

Herring Pond was sampled in 1948, 1988-1999, and 2001-2002. In 1948, the August 26 temperature profile indicated a well-mixed upper layer (*i.e.*, epilimnion) to 25 ft with waters 7 to 10°F cooler below 30 ft. The dissolved oxygen (DO) profile had near saturation concentrations in the epiliminion and deeper concentrations beginning at 5.2 ppm and declining to anoxic (<1 ppm) conditions at the bottom. The 2001 PALS Snapshot profile (shown above) shows anoxic conditions rising to 8 m (26 ft) or within a meter of the bottom of the epilimnion. Herring Pond was the subject of a diagnostic/feasability study in 1991 by Baystate Environmental Consultants; the study does not present any DO or temperature profiles.

All of the chlorophyll *a*, TP, and TN concentrations measured in Herring Pond exceed the Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond in the middle of the eutrophic category.

The comparison of the 1948 and 2001 PALS profiles show a worsening of water quality in Herring Pond. The deep anoxia is releasing nutrients from the sediments (see 10 m TP and TN concentrations below) and the weak temperature stratification likely allows these nutrients to leak into the epilimnion, prompting algal growth (see high chlorophyll *a* concentrations). Although additional monitoring would help to clarify how long the anoxia exists during the summer, it appears that water quality in Herring Pond has become more impaired over the last 50 years and consideration of information from other ponds discussed in this Pond Atlas suggests that the 1948 conditions were impaired as well. During the summers of 2001 and 2002, volunteers have collected additional water quality data, including nutrient analyses completed by the National Park Service. It is recommended that the Town consider revisiting the 1991 study using the newly collected data. Overall, Herring Pond presents as an impacted pond with current water quality problems.

| September 18, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 8.57 | 15.18 | 26.6 | 23.2 | 0.55 |
| 3 | 8.67 | 15.44 | 26.8 | 26.6 | 0.58 |
| 9 | 6.64 | 11.09 | 41.2 | 53.0 | 0.56 |
| 10 | 6.51 | 14.89 | 43.3 | 112.4 | 1.05 |

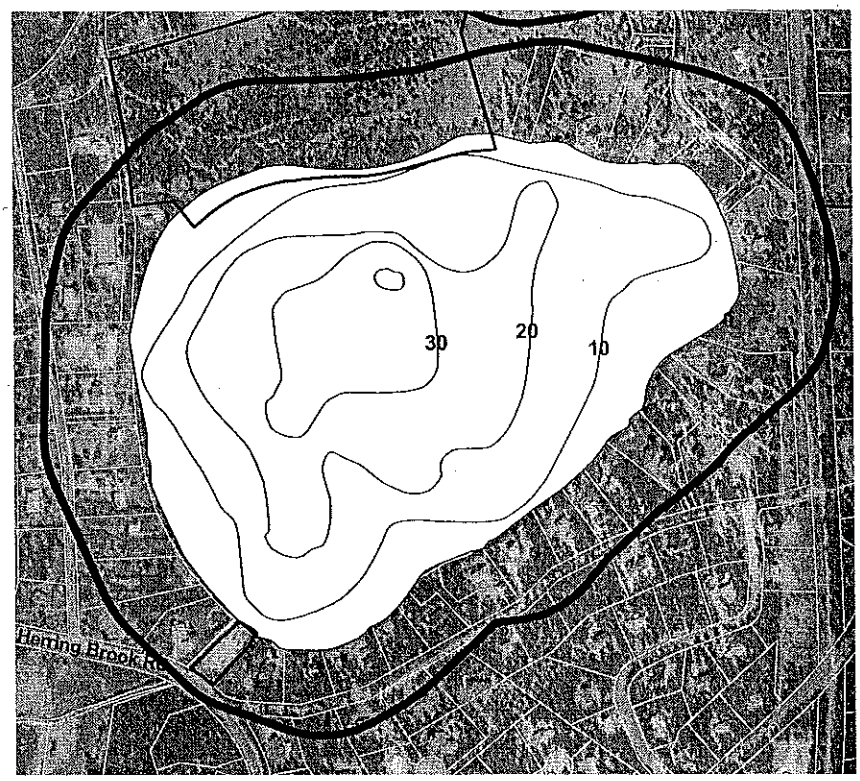

## GreatPond Eastham (EA-95)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet
Town owned land
300' Buffer Zone

N
W E
S

2000 0 2000 4000 Feet




## Herring Pond Eastham (EA-103)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet
300' Buffer Zone

N
W E
S

800 0 800 1600 Feet

# FALMOUTH PONDS

Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

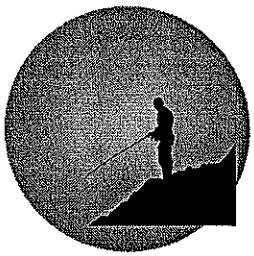
With Map and Description:

Deep Pond

Map Only:

Ashumet Pond
Coonamessett Pond
Crooked Pond
Fresh Pond
Grews Pond
Jenkins Pond
Mares Pond
Round Pond
Round (2) Pond

# Town of Falmouth Atlas Summary



**Total Land Area (sq. miles):** 44.25

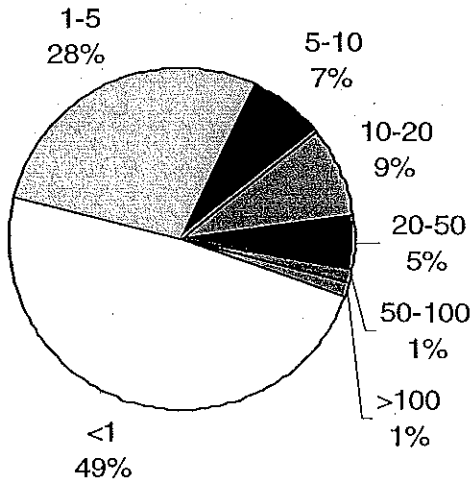
**Total Area of Ponds (acres):** 1016

**Total # of Ponds:** 141

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 68 |
| 1-5 acres: | 40 |
| 5-10 acres: | 10 |
| 10-20 acres: | 12 |
| 20-50 acres: | 7 |
| 50-100 acres: | 2 |
| >100 acres: | 2 |

**Number of Falmouth Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 7 |
| # of impacted ponds | |
| Chlorophyll a: | 6 |
| Total Nitrogen: | 7 |
| Total Phosphorus: | 6 |

**Secchi Dip-In**

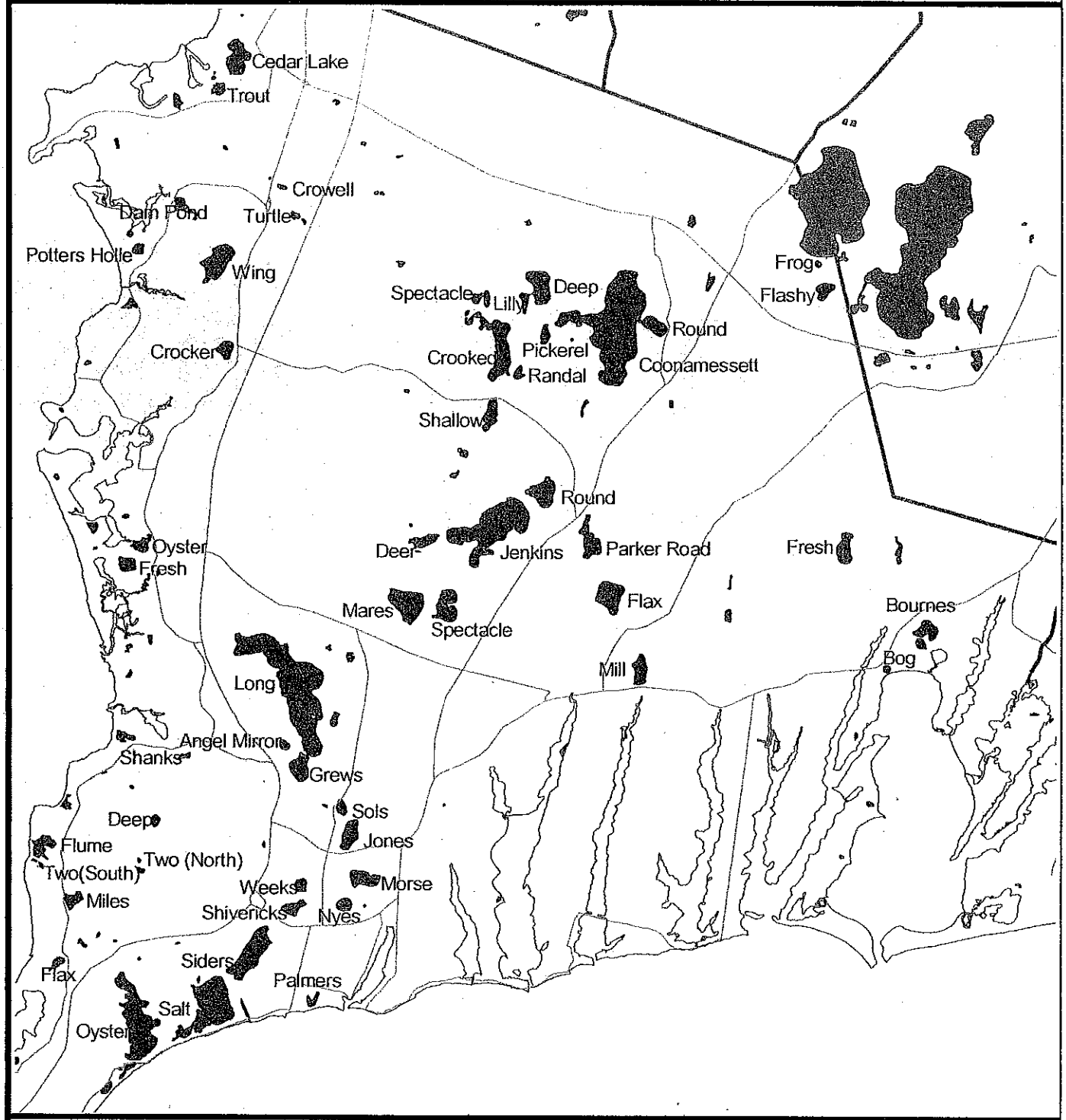
| | |
|---|---|
| # of ponds dipped: | 7 |
| # of volunteers: | 6 |

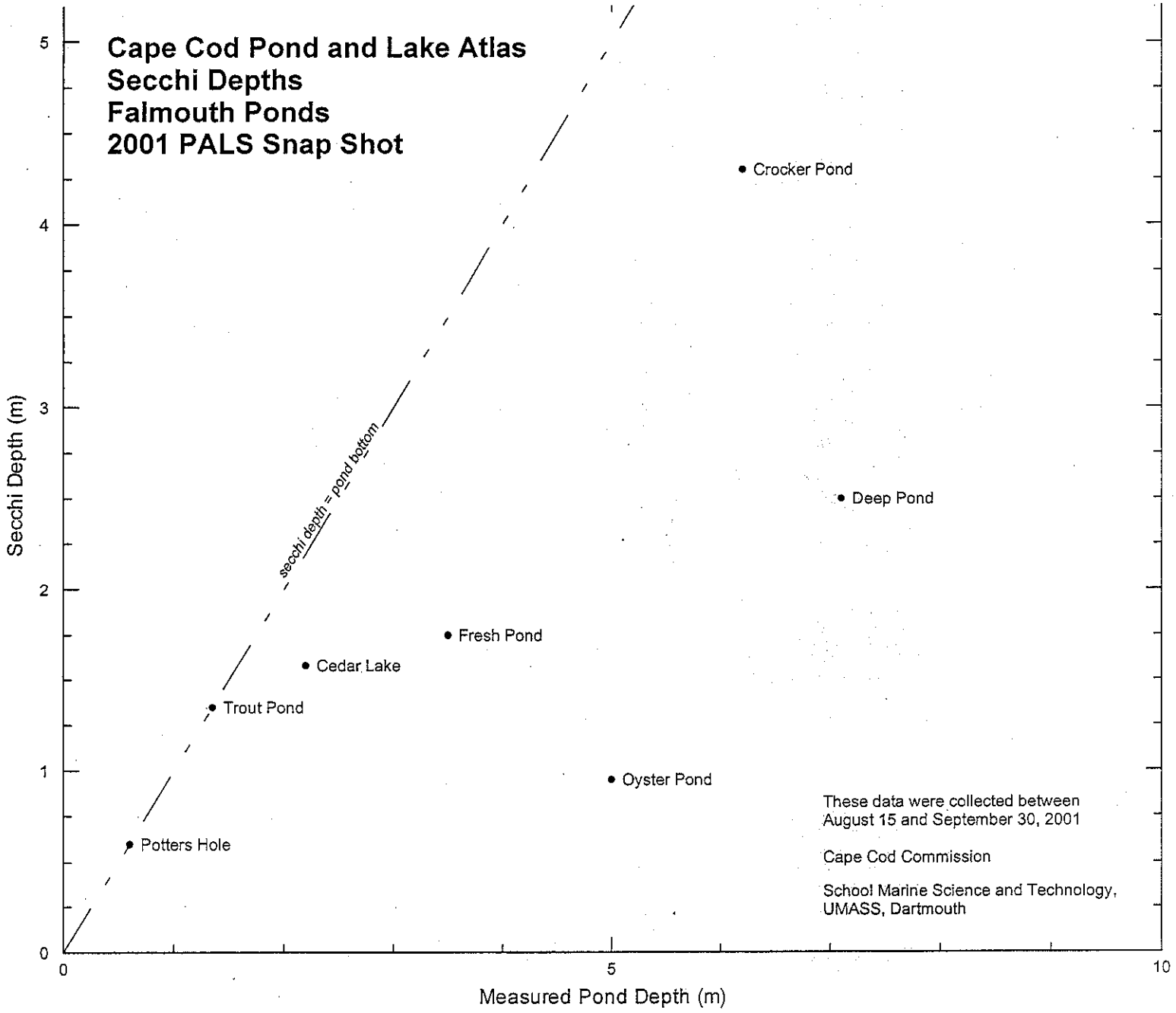
**Coordinator:**

The ponds in Falmouth were sampled during the PALS Snapshots through the efforts of Tony Williams of the Coalition for Buzzards Bay.

**Pond Groups:** Coonamesset Pond Association

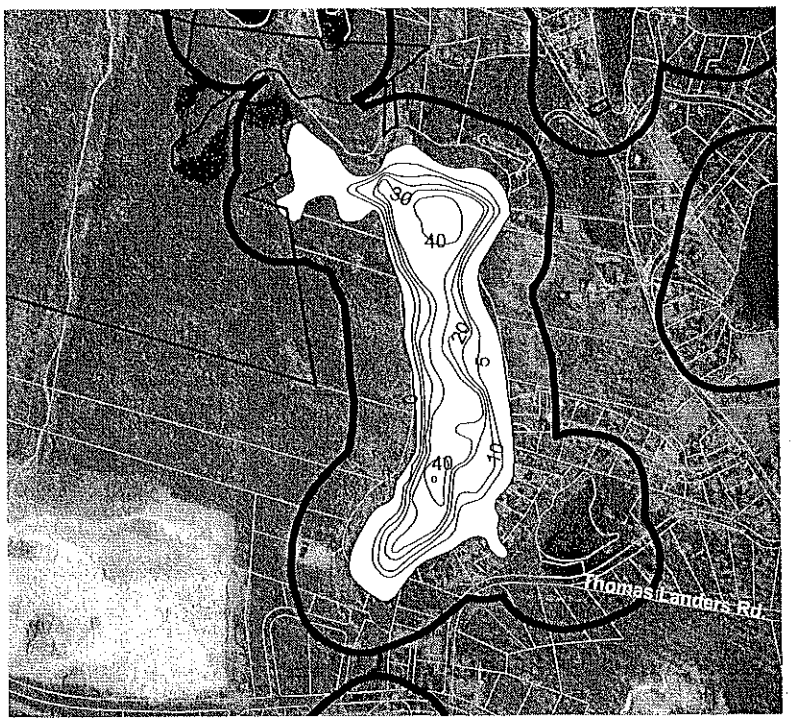
# FALMOUTH NAMED PONDS




Cape Cod Pond and Lake Atlas
Secchi Depths
Falmouth Ponds
2001 PALS Snap Shot
Secchi Depth (m)
Measured Pond Depth (m)
secchi depth = pond bottom
Crocker Pond
Deep Pond
Fresh Pond
Cedar Lake
Trout Pond
Oyster Pond
Potters Hole
These data were collected between August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology, UMASS, Dartmouth
0
1
2
3
4
5
0
5
10

# FALMOUTH POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Angel Mirror Pond | FA-958 | | 2.7 | N | | | | | | | |
| Bog Pond | FA-944 | 96024 | 3.0 | N | | 10 | | | I,O | | |
| Bournes Pond | FA-941 | 96026 | 10.3 | N | | 5 | 18 | none | O | | |
| Caleb Pond | | 96029 | | | | 2 | | none | I,O | | |
| Cedar Lake | FA-761 | 96344 | 20.7 | N | | 9 | 10 | Town | | sd | wq |
| Coonamessett Pond | FA-855 | 96043 | 161.9 | Y | 96,473 | 33 | 34 | Town | O,HR | sd | sd |
| Coonamessett River Reservoir | | 96044 | | | | 14 | | Town | HR | | |
| Crocker Pond | FA-893 | | 7.5 | N | | 15 | | | | | |
| Crooked Pond | FA-884 | 96047 | 34.3 | N | | 30 | 42 | Town | | sd | |
| Crowell Pond | FA-826 | | 1.2 | N | | | | | | | |
| Dam Pond | FA-832 | 96054 | 6.2 | N | | 5 | | | | | |
| Deep Pond | FA-857 | 96058 | 21.3 | Y | 9,227 | 35 | 28 | Town | | | |
| Deep Pond | FA-974 | | 2.7 | N | | | | | | | |
| Deer Pond | FA-925 | 96059 | 8.8 | N | | 17 | | Town | | | |
| Flashy Pond | FA-860 | 96111 | 7.8 | N | | 39 | | | | | |
| Flax Pond | FA-937 | | 22.4 | N | | 11 | 30 | Town | O | | |
| Flax Pond | FA-1004 | | 3.4 | N | | | | | | | |
| Flume Pond | FA-976 | 96093 | 11.0 | N | | 5 | | informal | | | |
| Fresh Pond | FA-924 | 96099 | 13.5 | N | | 19 | 22 | informal | O | | |
| Fresh Pond | FA-933 | | 7.3 | N | | | | | | | |
| Frog Pond | FA-850 | | 1.1 | N | | 45 | | | | | |
| Grews Pond | FA-962 | 96121 | 14.3 | Y | 8,467 | 11 | 42 | Town | | | |
| High School Pond | | | | | | 5 | | | | | |
| Jenkins Pond | FA-918 | 96155 | 89.0 | Y | | 19 | 51 | pubramp | | sd | sd |
| Jones Pond | FA-975 | 96158 | 12.9 | N | | 6 | | informal | O | | |
| Lilly Pond | FA-868 | | 4.0 | N | | | | | | | |
| Long Pond | FA-942 | | 145.7 | N | | 11 | 70 | none | | | |




1000 0 1000 2000 Feet

## Crooked Pond
## Falmouth
## (FA-884)

**Bathymetry source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet
300' Buffer Zone

N
W E
S

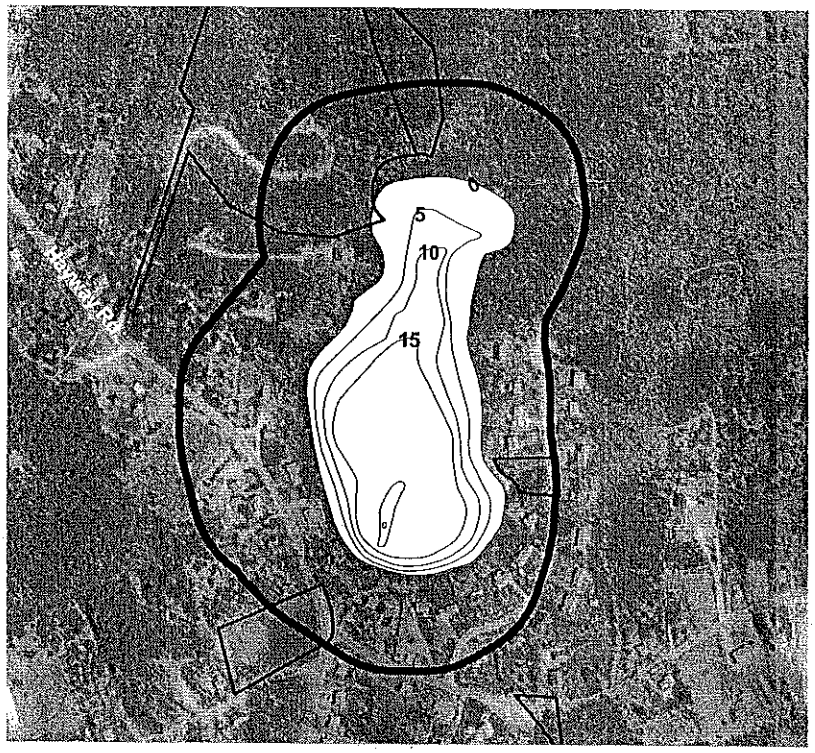

900 0 900 1800 Feet

## Deep Pond
## Falmouth
## (FA-857)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet
300' Buffer Zone

N
W E
S




## Fresh Pond
## Falmouth
## (FA-924)

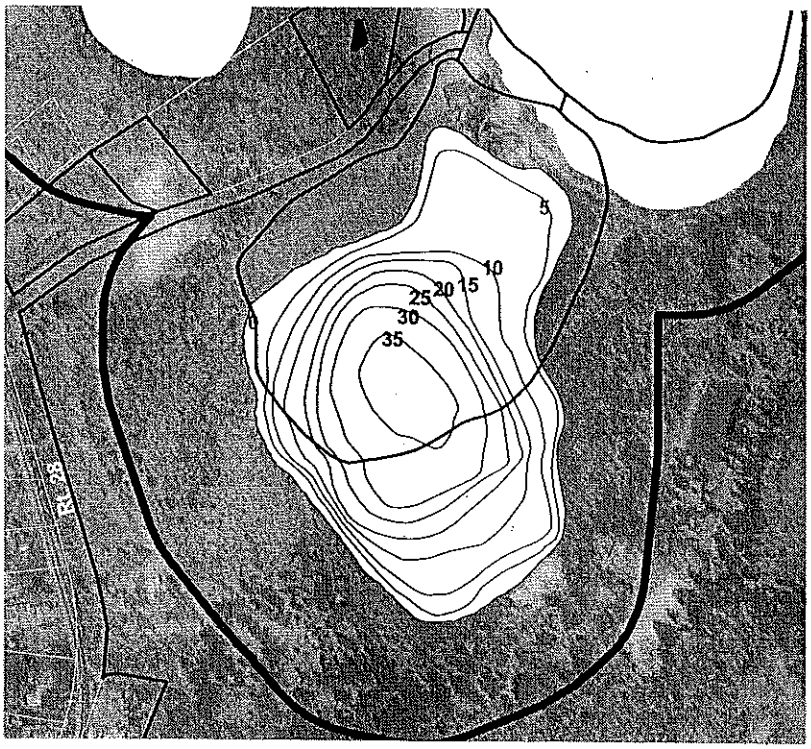
**Bathymetry Source:**
**Division of Fish and Wildlife**

Town Owned Land
Bathymetry in feet

300' Buffer Zone

N
W E
S

800 0 800 1600 Feet




## Grews Pond
## Falmouth
## (FA-962)

**Bathymetry Source:**
**Division of Fish and Wildlife**

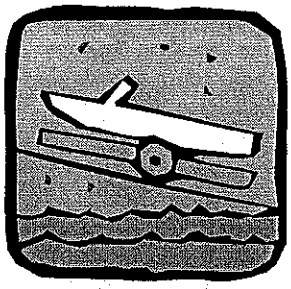
Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

600 0 600 1200 Feet

# Town of Harwich Atlas Summary



**Total Land Area (sq. miles):** 20.93

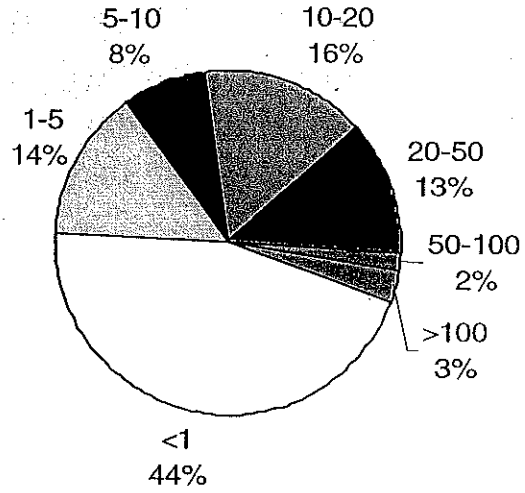
**Total Area of Ponds (acres):** 850

**Total # of Ponds:** 63

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 29 |
| 1-5 acres: | 9 |
| 5-10 acres: | 5 |
| 10-20 acres: | 10 |
| 20-50 acres: | 8 |
| 50-100 acres: | 1 |
| >100 acres: | 1 |

**Number of Harwich Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 12 |
| # of impacted ponds | |
| Chlorophyll a: | 9 |
| Total Nitrogen: | 8 |
| Total Phosphorus: | 9 |

**2001 Secchi Dip-In**

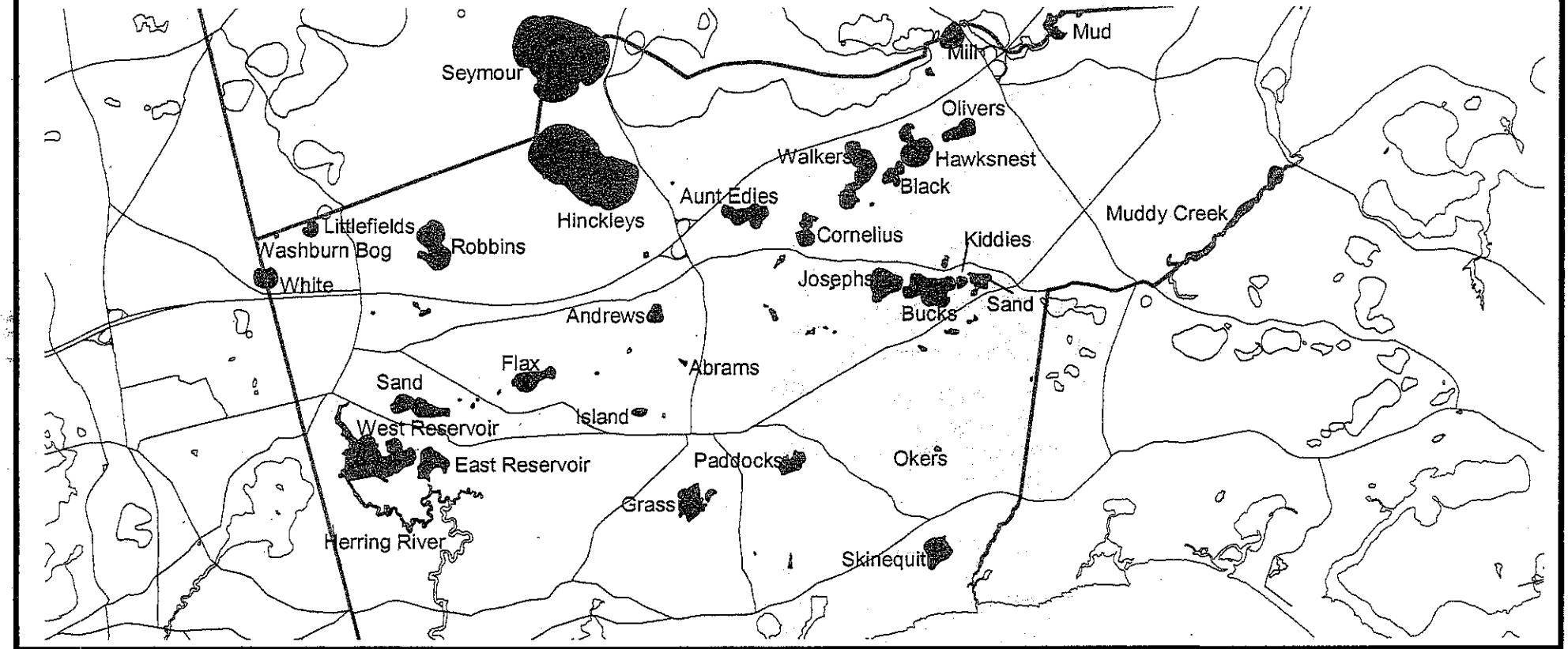
| | |
|---|---|
| # of ponds dipped: | 9 |
| # of volunteers: | 8 |

**Coordinator:**

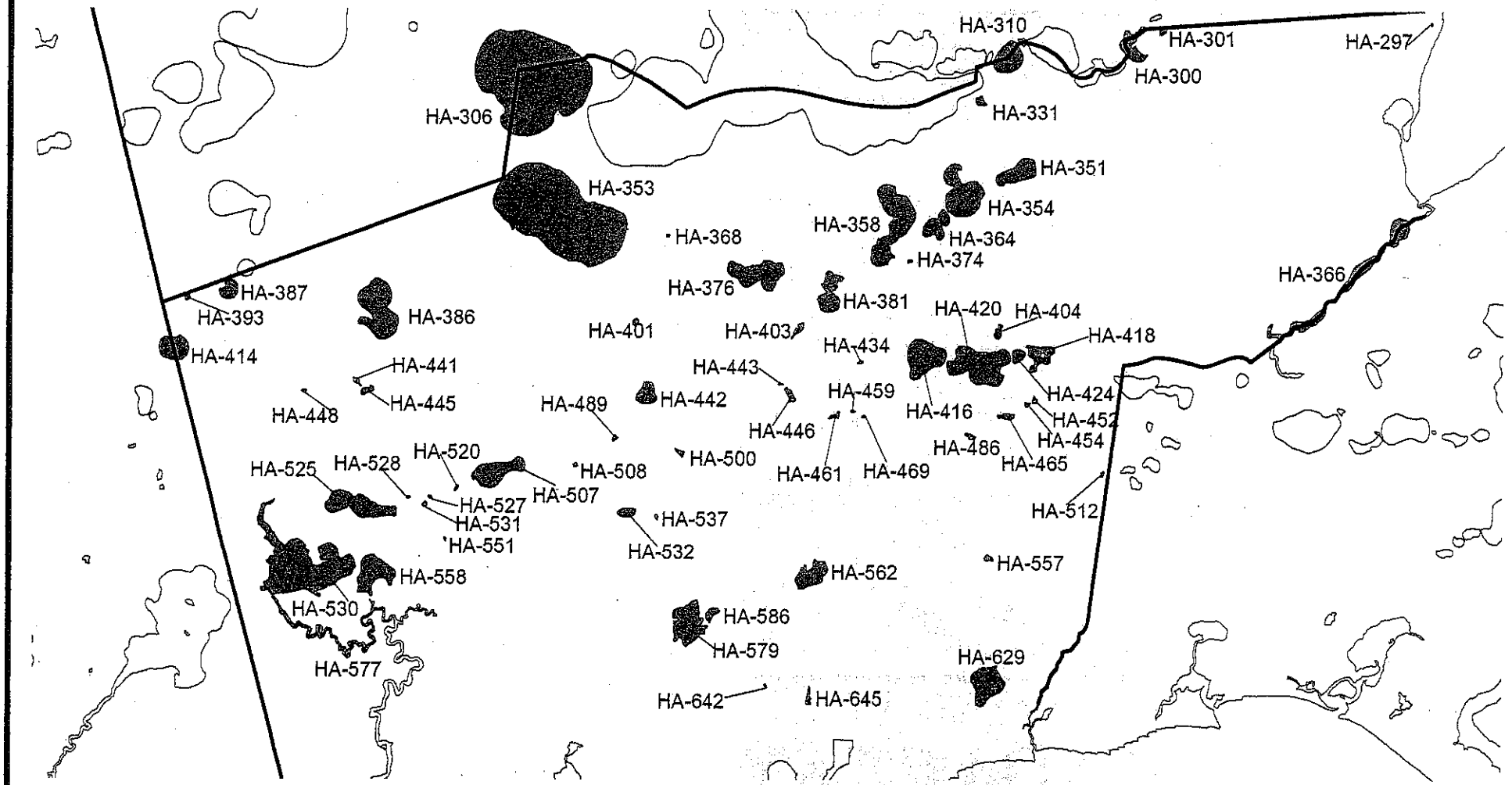
| | |
|---|---|
| Town staff: | Heinz Proft |
| Citizen: | Frank Sampson |

**Pond Groups:** Harwich SMWQC
Long Pond Watershed Association
Great Sand Lakes Association

# HARWICH NAMED PONDS



# GIS ID'S FOR HARWICH PONDS



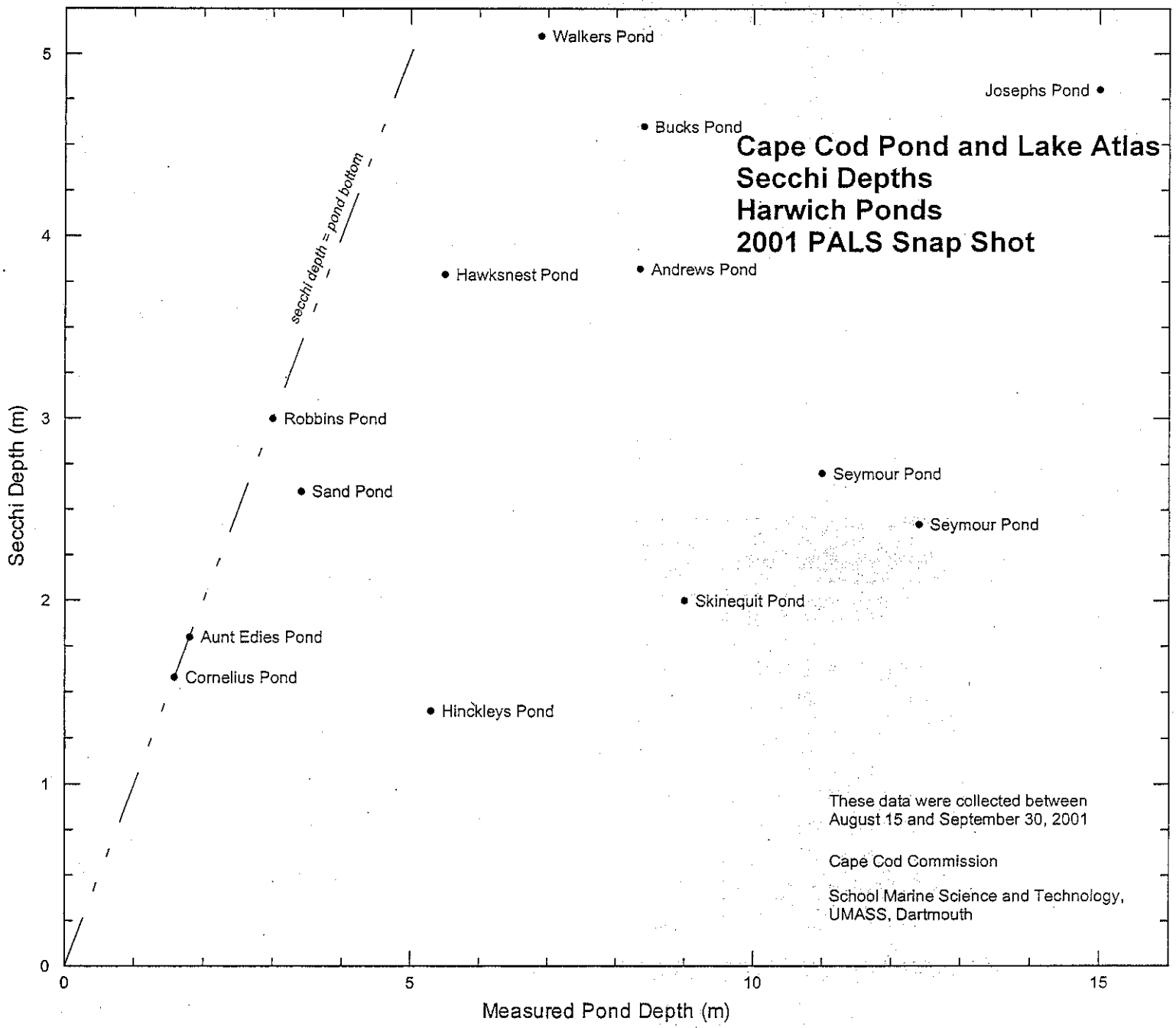

N

1 0 1 Miles

CAPE COD COMMISSION

# Harwich 2001 PALS Water Quality Snapshot Summary

| | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | ug/l | unimpacted (<1.0 ug/l) | at risk 1-1.7 ug/l | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk 0.16-0.31 mg/l | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk 7.5-10 ug/l | impacted (>10 ug/l) |
| Andrews Pond | 3.41 | | | x | 0.60 | | | x | 10.22 | | | x |
| Aunt Edies Pond | 2.54 | | | x | 0.21 | | x | | 10.22 | | | x |
| Bucks Pond | 2.35 | | | x | 0.30 | | x | | 8.36 | | x | |
| Cornelius Pond | 2.185 | | | x | 0.34 | | | x | 20.75 | | | x |
| Hawksnest Pond | 2.59 | | | x | 0.13 | x | | | BDL | x | | |
| Hinckleys Pond | 9.57 | | | x | 0.45 | | | x | 30.04 | | | x |
| Josephs Pond | 1.66 | | x | | 0.33 | | | x | 11.77 | | | x |
| Robbins Pond | 1.13 | | x | | 0.34 | | | x | 6.81 | x | | |
| Sand Pond | 6.17 | | | x | 0.38 | | | x | 15.18 | | | x |
| Seymour Pond | 5.38 | | | x | 0.41 | | | x | 21.68 | | | x |
| Skinequit Pond | 7.35 | | | x | 0.40 | | | x | 30.04 | | | x |
| Walkers Pond | 0.89 | x | | | 0.11 | x | | | BDL | x | | |


Cape Cod Pond and Lake Atlas
Secchi Depths
Harwich Ponds
2001 PALS Snap Shot
Walkers Pond
Josephs Pond
Bucks Pond
Andrews Pond
Hawksnest Pond
secchi depth = pond bottom
Robbins Pond
Sand Pond
Seymour Pond
Seymour Pond
Skinequit Pond
Aunt Edies Pond
Cornelius Pond
Hinckleys Pond
These data were collected between August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology, UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
0
5
10
15

# HARWICH POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Abrams Pond | HA-500 | | 0.7 | N | | | | | | | |
| Andrews Pond | HA-442 | 96002 | 6.7 | N | | 27 | | private/abutter | | sd,wq | wq |
| Aunt Edies Pond | HA-376 | 96006 | 22.0 | N | | 22 | 7 | abutter | | wq | sd,wq |
| Black Pond | HA-364 | 96018 | 9.2 | N | | 32 | | informal | | | |
| Bucks Pond | HA-420 | | 34.3 | N | | 30 | | town/abutter | | wq | wq |
| Cornelius Pond | HA-381 | 96045 | 12.5 | N | | 32 | 7 | informal | I,O | sd,wq | sd,wq |
| Dias Pond | | | | | | | | | | | |
| East Reservoir | HA-558 | | 18.4 | N | | | | | | | |
| Flax Pond | HA-507 | 96089 | 17.3 | N | | 20 | | informal | I | sd | wq |
| Grass Pond | HA-579 | 96108 | 20.4 | N | | 9 | 3 | informal | O | | wq |
| Hawksnest Pond | HA-354 | 96131 | 27.3 | N | | 32 | | none | | sd,wq | wq |
| Herring River | HA-577 | | 16.6 | N | | | | | | sd | |
| Hinckleys Pond | HA-353 | 96140 | 174.2 | Y | 73,654 | 28 | 28 | informal/town | I,O,HR | wq | wq |
| Island Pond | HA-532 | 96149 | 2.9 | N | | 25 | | none | | | |
| Josephs Pond | HA-416 | | 21.8 | Y | 18,621 | 30 | 55 | informal | | wq | wq |
| Kiddies Pond | HA-424 | | 2.8 | N | | | | | | | |
| Littlefields Pond | HA-387 | | 5.4 | N | | 29 | | | | | |
| Mill Pond | HA-310 | | 13.8 | N | | 30 | | | | sd | |
| Mud Pond | HA-300 | 96215 | 9.8 | N | | 34 | | | O | | |
| Muddy Creek | HA-366 | | 30.0 | N | | | | | | | |
| Okers Pond | HA-557 | | 0.8 | N | | | | | | | |
| Olivers Pond | HA-351 | 96231 | 13.2 | N | | 31 | | informal | | | |
| Paddocks Pond | HA-562 | 96236 | 11.8 | N | | 14 | | | | | |
| Robbins Pond | HA-386 | 96259 | 33.1 | N | | 29 | 12 | informal/town | | wq | wq |
| Sand Lake | HA-418 | | 8.2 | N | | | | | | wq | |
| Sand Pond | HA-525 | 96275 | 23.0 | N | | 13 | 25 | informal/town | I | sd | wq |
| Seymour Pond | HA-306 | 96284 | 181.9 | Y | 77,528 | 29 | 38 | pubaccess | O,HR | wq | |
| Skinequit Pond | HA-629 | 96297 | 18.0 | Y | 9,314 | 8 | 32 | informal | | sd,wq | sd |
| Walkers Pond | HA-358 | 96330 | 35.6 | N | | 32 | 27 | pubramp | O | sd,wq | sd,wq |
| Washburn Bog Pond | HA-393 | | 0.6 | N | | | | | | | |

# HARWICH POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **West Reservoir** | HA-530 | 96135 | 75.5 | Y | 10,657 | 7 | 6 | pubramp | O,HR | | |
| **White Pond** | HA-414 | 96338 | 12.1 | N | | 27 | | abutter | HR | | |
| **Black Pond** | | 96017 | | | | 35 | | informal | | | |
| **Cahoon Pond (BushBeachPond)** | | 96028 | | | | 31 | 14 | none | | | |
| **Grassy Pond** | | 96110 | | | | 32 | | isolated | I | | |
| **Long Pond** | | 96183 | | | | 31 | 66 | none | I,O,HR | | |
| **Round Pond/ Dark Bottom** | | 96263 | | | | 30 | | none | | | |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

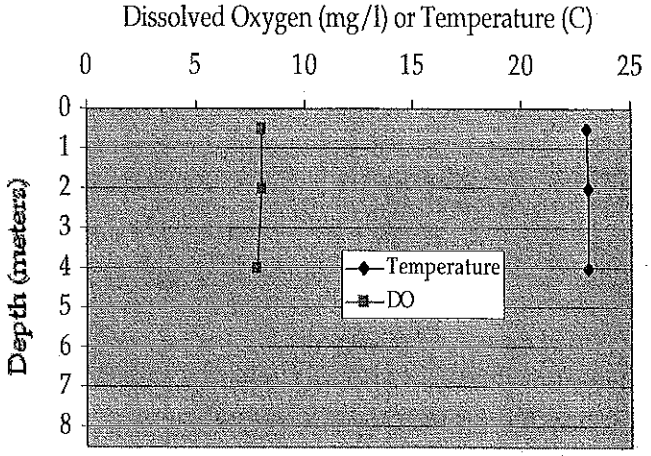
Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Hinckleys Pond

## Harwich

## HA-353

Acreage: 174.2
Maximum Depth: 28 ft
2001 Secchi Dip: 4.6 ft




Dissolved Oxygen and Temperature
Hinckleys Pond, 9/14/01

OVERVIEW

Hinckleys Pond, also known as Pleasant Lake, is located a half mile northwest of the Route 6/Route 124 interchange and a Harwich town beach is located just west of Route 124. The pond is recharged by groundwater flow from the northeast and discharges surface flow to the groundwater along the southern shoreline, as well as recieving surface flow from Long Pond via the Herring River and discharging surface water into the Herring River. The pond shoreline is developed with residential homes, cranberry bogs and a beach. Access to the pond is from a dirt road on the western side of pond, south of a cranberry bog and the pond has a six horsepower limit on outboard motors. According to DFW, Hinckleys Pond is an excellent warm water fishery.

WATER QUALITY

Water quality sampling of Hinkelys Pond was conducted in 1948, 1989, 2001, and 2002. In 1948, the August 17 temperature profile had well-mixed conditions throughout the water column (3°F difference between top and bottom). Two dissolved oxygen (DO) readings were taken, both of which were near saturation, again confirming well-mixed conditions with no observed DO demand by the sediments. By July 1989, a bottom DO reading was down to 69% saturation, while readings collected by Harwich pond volunteers during the summer of 2001 found anoxic concentrations (< 1 ppm) in two consecutive readings at 6 and 7 m depths during August. The profiles shown above were not collected over the deepest portion of the pond.

All of the chlorophyll *a*, TP, and TN concentrations measured in Hinckleys Pond during the 2001 PALS Snapshot (see below) exceed the Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond in the lower portion of the eutrophic category.

A comparison of the historical data with more recent water quality indicates that Hinckleys Pond has become impaired over the last 50 years. Town volunteers have been gathering data on the pond for the past two summers; it is recommended that the town consider a water quality assessment of the Hinckleys Pond, including a review of this more recent data and include a sediment characterization, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to continue to worsen. Overall, Hinckleys Pond presents as an impaired pond with current water quality problems.

| September 14, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.33 | 9.57 | 5.6 | 30.0 | 0.45 |
| 4 | 6.29 | 9.24 | * | 33.1 | 0.44 |

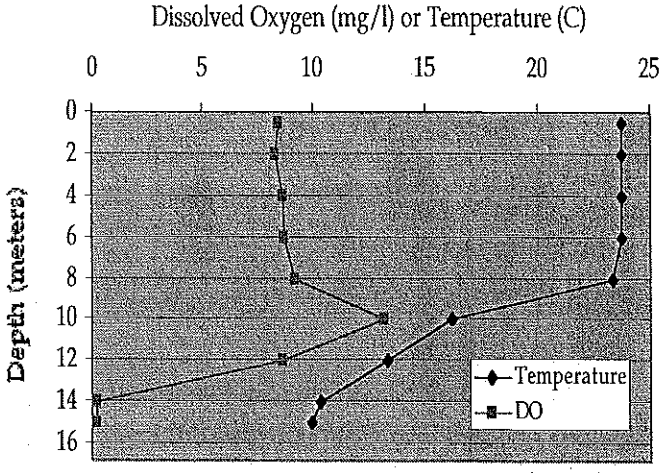
* = value appears to be outlier; inconsistent with other values/parameter readings

# John Joseph Pond

## Harwich

## HA-416

Acreage: 21.8
Maximum Depth: 55 ft
2001 Secchi Dip: 15.7 ft
Lake Association: Great Sand Lakes Assoc.




Dissolved Oxygen and Temperature
John Joseph Pond, 9/14/01

OVERVIEW

John Joseph Pond is located at the intersection of John Joseph and Queen Anne Roads. The pond is recharged from groundwater flowing from the north and discharges surface flow to groundwater along its southern shore. The pond shoreline is well developed with year round and seasonal single family homes. A public beach access is provided off of Lakeside Terrace. Recreational uses include swimming, boating and fishing

WATER QUALITY

John Joseph Pond was sampled in 1989, 2001, and 2002. The temperature and dissolved oxygen (DO) profiles from 1989 and 2001 are very similar with a well-mixed upper layer (i.e. epiliminion), gradual temperature decline with depth below the epilimnion, a supersaturated DO "bulge"just below the epilimnion and anoxic DO concentrations (<1 ppm) near the bottom of the pond. Two other DO profiles collected by town volunteers during August 2001 show that the anoxic conditions persisted for at least six weeks.

Water quality samples collected during the 2001 PALS Snapshot (see below) show that surface concentrations for TP and TN exceed Cape Cod "impacted" thresholds, while chlorophyll *a* is less than its threshold. Concentrations of these parameters increase with increasing depth with the deepest readings at least two to five times those observed at the surface. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond in the middle of the oligotrophic with some bottom anoxia category.

The anoxic conditions in the bottom of the pond are causing the release of nutrients back into the water column, which with the lack of strong deep stratification allows these nutrients to seep into the epilimnion. This relationship is the likely cause of the DO bulge near the bottom of the epilimnion, where algae can reproduce and photosynthesize in the low light conditions (Secchi readings of up to 7.6 m have been recorded). Based on information from other ponds reviewed in this Atlas, this anoxia is an impairment that has likely developed over the past 50 years. It is recommended that the town consider a water quality assessment of John Joseph Pond, including a more refined monitoring program to evaluate DO, nutrient, and chlorophyll *a* concentrations throughout the summer, a review of citizen collected data, a sediment characterization, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to worsen. Overall, John Joseph Pond presents as an impacted pond with current water quality problems.

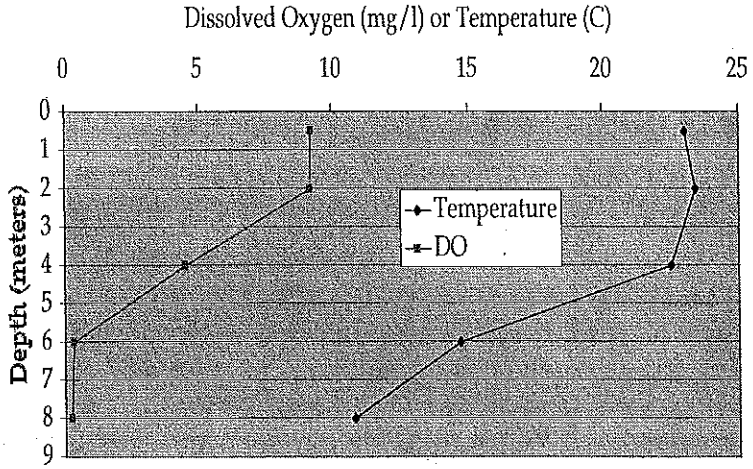
| September 14, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.62 | 1.66 | 5.1 | 11.8 | 0.33 |
| 3 | 6.64 | 1.22 | 5.3 | 5.3 | 0.33 |
| 9 | 6.45 | 2.62 | 5.4 | 5.3 | 0.42 |
| 15 | 6.19 | 3.34 | 19.7 | 36.5 | 1.69 |

# Skinequit Pond

## Harwich

## HA-629

Acreage: 18
Maximum Depth: 32 ft
2001 Secchi Dip: 6.6 ft
Lake Association: None




Dissolved Oxygen and Temperature
Skinequit Pond, 9/12/01

OVERVIEW

Skinequit Pond is south of Route 28 in South Harwich. This pond is recharged from groundwater flowing from the north and discharges surface flow to groundwater along its southern shore. The pond shoreline is well developed with single family homes. Recreational uses include swimming, boating and fishing

WATER QUALITY

Skinequit Pond was sampled in 1989, 2001, and 2002. The 1989 and 2001 temperature profiles show a well-mixed upper layer (*i.e.* epiliminion) down to approximately 4 m with a gradual decline in temperature with increasing depth. Both dissolved oxygen (DO) profiles show anoxic concentrations (<1 ppm) below 6 m with depressed concentrations mixed into the lower portions of the epilimnion.

All of the chlorophyll *a*, TP, and TN concentrations collected during the 2001 PALS Snapshot (see below) exceed the Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentration places the lake on the eutrophic side of the line between the eutrophic and mesotrophic categories. Care should be taken in using the Carlson TSI for Skinequit Pond because the IEP, Inc. (1989) characterization indicated extensive rooted plant populations and Carlson's index was developed for ponds with limited rooted plant populations.

Skinequit Pond is overloaded with organic materials; bacterial respiration during the consumption of the materials is consuming all the deep oxygen in the pond. The respiration is so active that it is seeping into the portions of the water column that are regularly mixed (*i.e.* the epiliminion). The lack of oxygen is also causing the release of sediment nutrients into the water column, which can then prompt the growth of more algae and rooted plants that can, in turn, create more sediment organics. This cycle would need to be broken in order for water quality to improve in Skinequit Pond. It is recommended that the town consider a water quality assessment of the Skinequit Pond, including a more refined monitoring program to evaluate DO, nutrient, and chlorophyll *a* concentrations throughout the summer, a review of citizen collected data, a sediment and plant characterization, and a land use assessment of shoreline and watershed properties. Overall, Skinequit Pond presents as an impaired pond with current water quality problems.

| September 12, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 7.41 | 7.35 | 15.6 | 30.0 | 0.40 |
| 8 | 6.94 | 58.74 | 48.7 | 310.6 | 2.24 |


## Hinkley's Pond
## Harwich
## (HA-353)

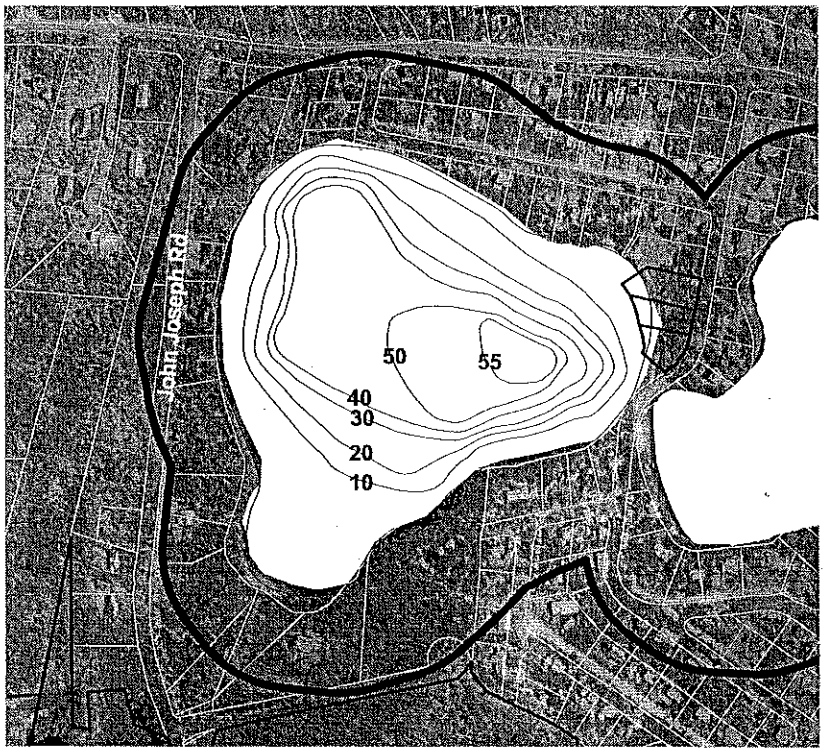
**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

1000 0 1000 2000 3000 Feet




## John Joseph's Pond
## Harwich
## (HA-416)

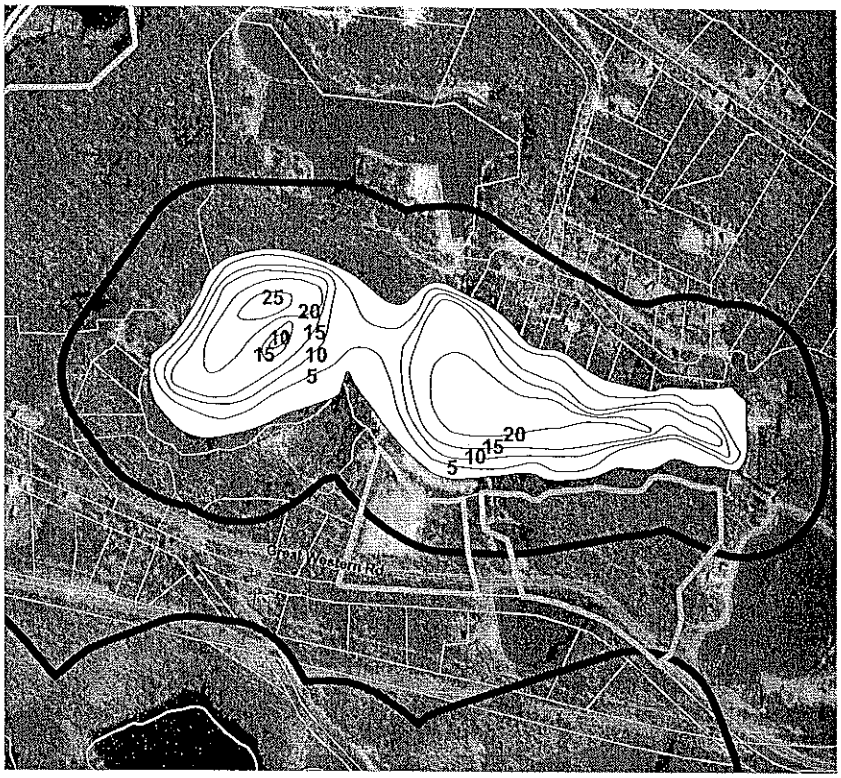
**Bathymetry Source:**
**Unknown**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

700 0 700 1400 Feet




500 0 500 1000 1500 2000 Feet

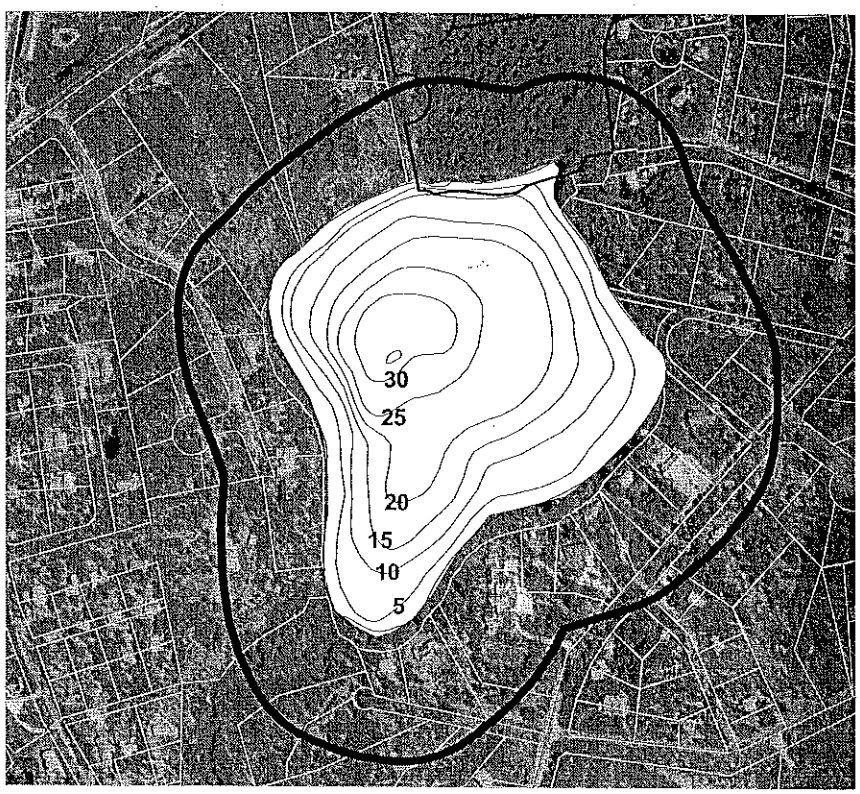
## Sand Pond
## Harwich
## (HA-525)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S




700 0 700 1400 Feet

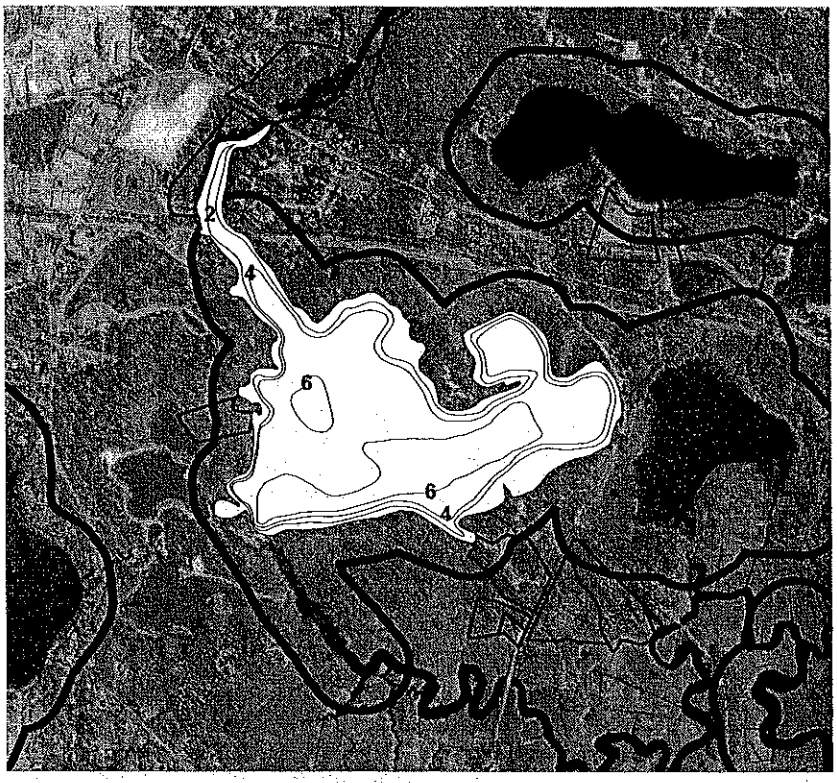
## Skinequit Pond
## Harwich
## (HA-629)

**Bathymetry Source:**
**Unknown**

Bathymetry in feet
Town owned land

300' Buffer Zone

N
W E
S




# West Reservoir
# Harwich
# (HA-530)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet

Town owned land

300' Buffer Zone

N
W E
S

1000 0 1000 2000 3000 4000 Feet

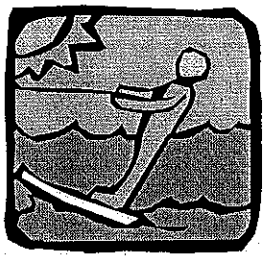
# MASHPEE PONDS

Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:

Mashpee Wakeby Pond
John's Pond
Santuit Pond

# Town of Mashpee Atlas Summary



**Total Land Area (sq. miles):** 23.86

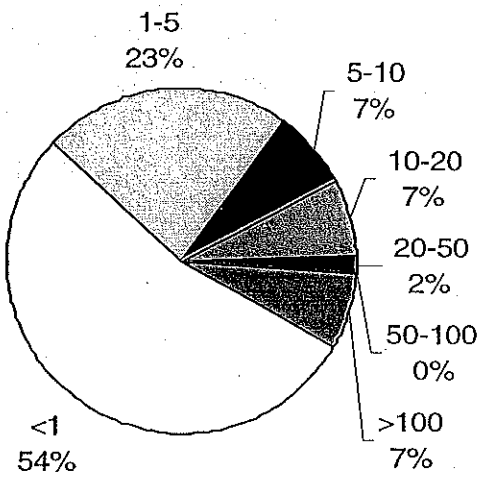
**Total Area of Ponds (acres):** 1614

**Total # of Ponds:** 56

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 30 |
| 1-5 acres: | 13 |
| 5-10 acres: | 4 |
| 10-20 acres: | 4 |
| 20-50 acres: | 1 |
| 50-100 acres: | 0 |
| >100 acres: | 4 |

**Number of Mashpee Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 18 |
| # of impacted ponds | |
| Chlorophyll a: | 17 |
| Total Nitrogen: | 16 |
| Total Phosphorus: | 17 |

**2001 Secchi Dip-In**

| | |
|---|---|
| # of ponds dipped: | 2 |
| # of volunteers: | 3 |

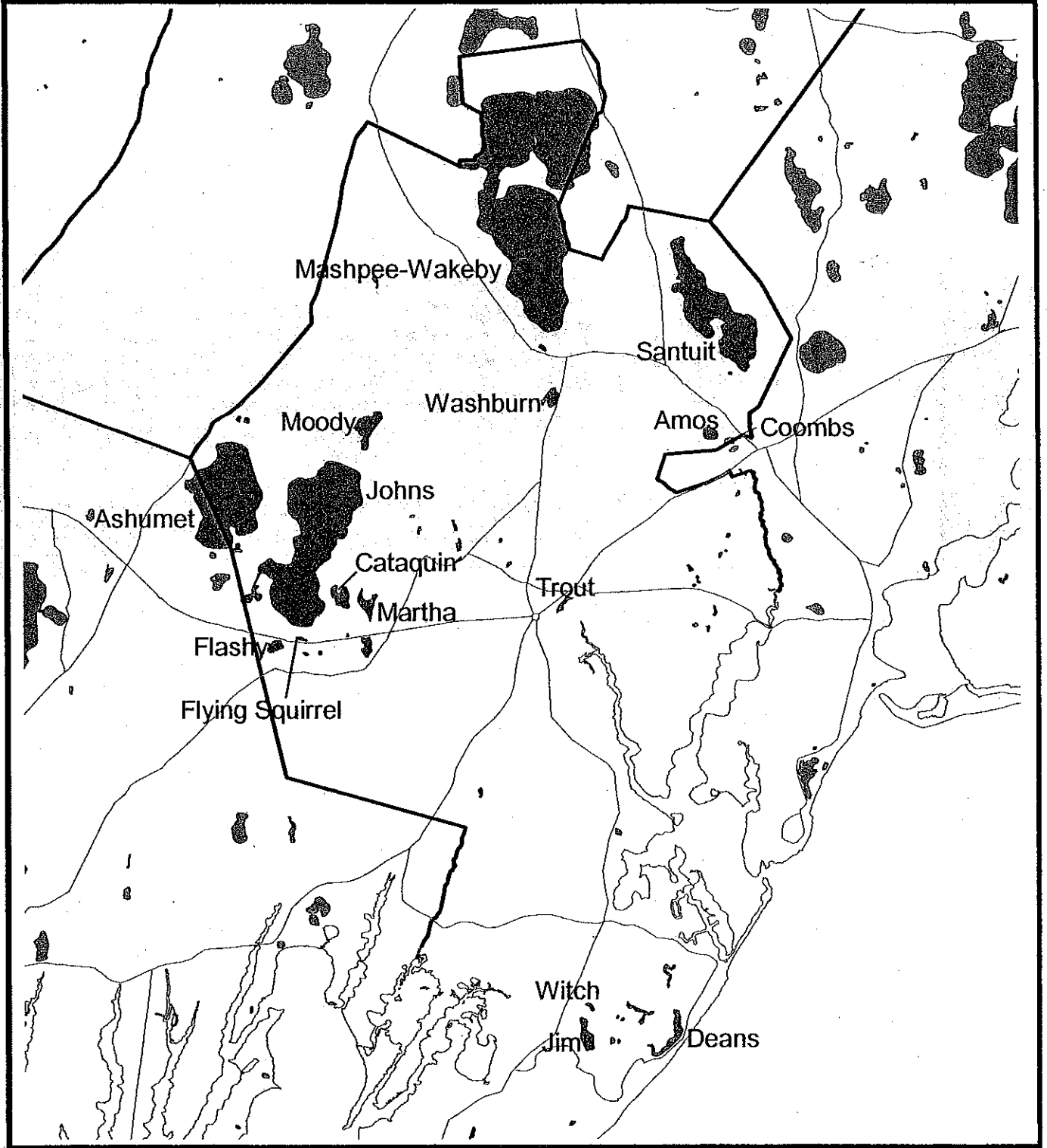
**Coordinator:**

Town staff:

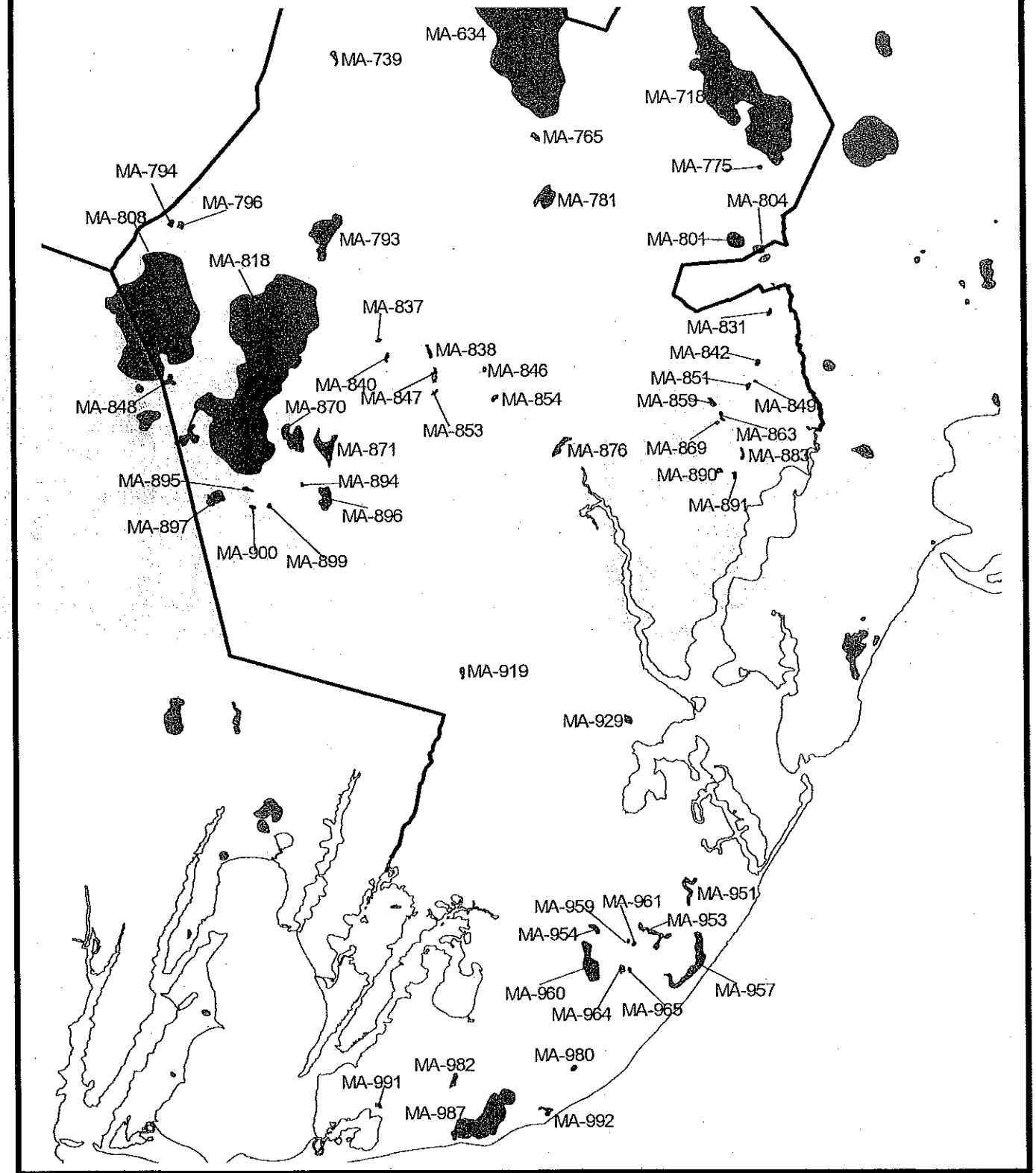
Citizen: Jim Hanks

**Pond Groups:** Mashpee Environmental Coalition
Ashumet Valley Property Owners

# MASHPEE NAMED PONDS

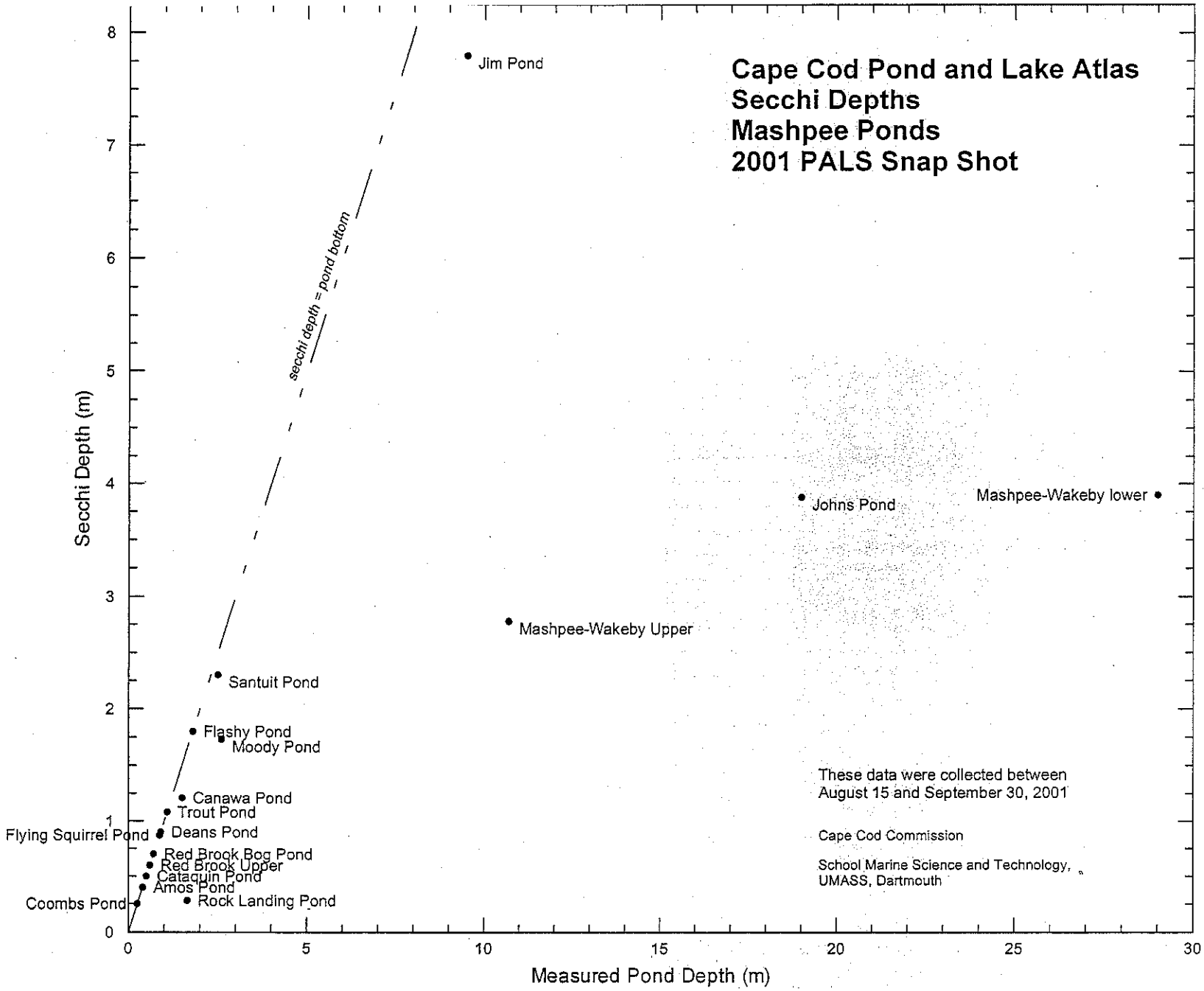


# GIS ID'S FOR MASHPEE PONDS



# Mashpee 2001 PALS Water Quality Snapshot Summary

| Name | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk 1-1.7 ug/l | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk 0.16-0.31 mg/l | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk 7.5-10 ug/l | impacted (>10 ug/l) |
| Amos Pond | 0.61 | x | | | 1.46 | | | x | 46.76 | | | x |
| Canawa Pond | 12.91 | | | x | 0.44 | | | x | 23.85 | | | x |
| Cataquin Pond | 11.07 | | | x | 0.91 | | | x | 33.45 | | | x |
| Coombs Pond | 17.05 | | | x | 1.39 | | | x | 63.02 | | | x |
| Deans Pond | 2.78 | | | x | 0.73 | | | x | 23.69 | | | x |
| Flashy Pond | 3.89 | | | x | 0.56 | | | x | 21.99 | | | x |
| Flying Squirrel Pond | 3.395 | | | x | 0.57 | | | x | 20.44 | | | x |
| Grassy Pond | 3.405 | | | x | 0.54 | | | x | 20.44 | | | x |
| Jim Pond | 2.34 | | | x | 0.27 | | x | | 53.27 | | | x |
| Johns Pond | 3.67 | | | x | 0.32 | | | x | 4.03 | x | | |
| Mashpee-Wakeby Upper | 6.34 | | | x | 0.34 | | | x | 72.78 | | | x |
| Moody Pond | 6.42 | | | x | 0.51 | | | x | 17.34 | | | x |
| Red Brook Bog Pond | 4.58 | | | x | 0.59 | | | x | 40.11 | | | x |
| Red Brook Upper | 13.03 | | | x | 0.31 | | x | | 33.45 | | | x |
| Rock Landing Pond | 30.99 | | | x | 1.07 | | | x | 61.32 | | | x |
| Santuit Pond | 2.23 | | | x | 0.65 | | | x | 17.34 | | | x |
| Trout Pond | 20.01 | | | x | 1.06 | | | x | 22.14 | | | x |
| Washburn Pond | 15.16 | | | x | 0.92 | | | x | 43.51 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Mashpee Ponds
2001 PALS Snap Shot
Secchi Depth (m)
Measured Pond Depth (m)
secchi depth = pond bottom
Jim Pond
Johns Pond
Mashpee-Wakeby lower
Mashpee-Wakeby Upper
Santuit Pond
Flashy Pond
Moody Pond
Canawa Pond
Trout Pond
Flying Squirrel Pond
Deans Pond
Red Brook Bog Pond
Red Brook Upper
Cataquin Pond
Amos Pond
Coombs Pond
Rock Landing Pond
These data were collected between
August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology,
UMASS, Dartmouth

# MASHPEE POND DATABASE

| Name | CCC GIS ID | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Amos Pond | MA-801 | 96001 | 5.6 | N | | 36 | | | | wq | |
| Ashumet Pond | MA-808 | 96004 | 218.3 | Y | 167,395 | 55 | 84 | pubramp,concrete | O,HR | | |
| Cataquin Pond | MA-870 | | 10.5 | N | | 38 | | | | wq | |
| Coombs Pond | MA-804 | | 2.1 | N | | | | | | wq | |
| Deans Pond | MA-957 | 96055 | 12.6 | N | | 5 | | | | wq | wq |
| Flashy Pond | MA-897 | 96084 | 5.0 | N | | 35 | | | | wq | |
| Flat Pond | MA-987 | 96085 | 39.3 | N | | 5 | 6 | none | | | |
| Flat Pond, Little | | 96171 | | | | 5 | | | | | |
| Flying Squirrel Pond | MA-895 | | 0.7 | N | | 5 | 6 | informal | | wq | |
| Jehu Pond | | 96153 | | | | 5 | | informal | | | |
| Jim Pond | MA-960 | 96156 | 10.6 | N | | 38 | 65 | pubramp,concrete | I,O,HR | wq | wq |
| Johns Pond | MA-818 | 96157 | 337.7 | Y | 223,181 | 38 | | informal | | | |
| Johns Pond (West) | | 96334 | | | | 33 | | | | | |
| Lily Pond | MA-992 | | 1.3 | N | | | | | | | |
| Martha Pond | MA-871 | 96192 | 8.7 | N | | 45 | 13 | abutter | O | | |
| Mashpee-Wakeby | MA-634 | 96194 | 725.8 | Y | 638,786 | | | | | sd | sd,wq |
| Moody Pond | MA-793 | 96212 | 19.2 | N | | 32 | 5 | informal | | wq | wq |
| Old Barnstable Road | | 96229 | | | | 5 | | | | | |
| Pine Tree Corner | | 96249 | | | | 43 | 11 | pubramp | O | | |
| Santuit Pond | MA-718 | 96277 | 170.5 | Y | 25,215 | 5 | | | | sd,wq | sd,wq |
| Trout Pond | MA-876 | | 2.6 | N | | | | | | wq | wq |
| Washburn Pond | MA-781 | | 7.9 | N | | | | | | wq | |
| Witch Pond | MA-954 | 96343 | 1.2 | N | | 44 | 65 | pubramp,concrete | | | |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

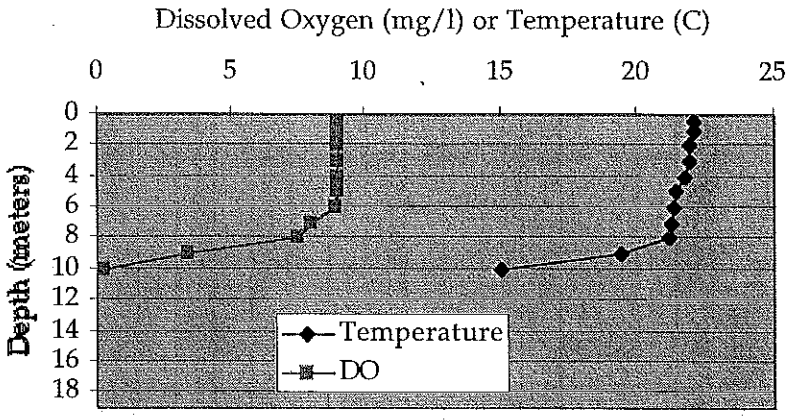
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Johns Pond
## Mashpee
## MA-818

Acreage: 337.7
Maximum Depth: 62 ft
2001 Secchi Dip: 12.7 ft
Lake Association: None




Dissolved Oxygen and Temperature
Johns Pond, 2001

OVERVIEW

Johns Pond is located in western Mashpee just southeast of Ashumet Pond and the Massachusetts Military Reservation (MMR). A public paved boat ramp with an accompanying small parking lot is located on the northwest corner of the pond off of Hooppole Road. The pond drains into the Childs and Quashnet Rivers. Fisheries surveys conducted during 1991 and 1992 recorded 11 species present and the pond is stocked annually in the spring and fall with brook and rainbow trout.

WATER QUALITY

Johns Pond was sampled in 1948, 1980, 1993, 1994, 1998, 2001, and 2002. The 7/23/48 temperature profile showed stratification around 35 ft, with depressed dissolved oxygen (DO) concentrations below 50 ft and a minimum DO concentration of 6.4 ppm. In 8/13/80 and the summer of 1994, temperature stratification occurred around 30 ft and DO concentrations less than 1 ppm (*i.e.*, anoxic conditions) were measured below 36 ft. The 2001 PALS readings are consistent with the 1980 and 1994 samplings, but DO and temperature concentrations were not measured below 10 m (33 ft). Surface TP concentrations from the 2001 PALS snapshot (see below) are below the current Cape Cod "impacted" threshold, while the chlorophyll *a* and TN concentrations exceed their thresholds. A Carlson TSI based on a surface chlorophyll *a* concentration places the pond in the middle of the mesotrophic category.

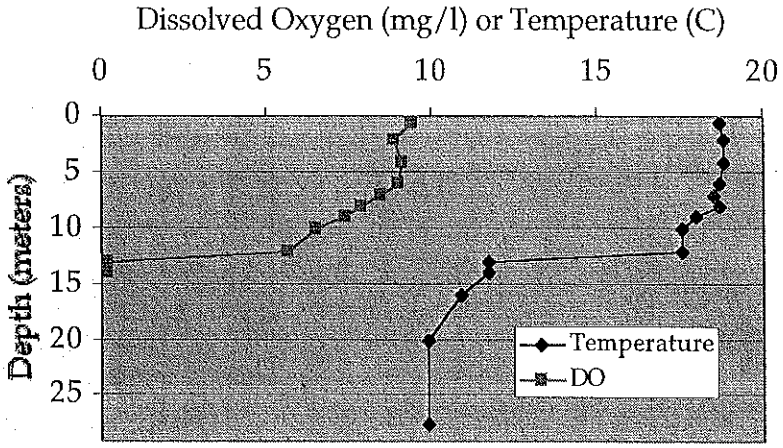
Although the surface concentrations do not indicated impacts, it is clear from a comparison of historic and recent DO profiles that deep water quality has become impaired over the last 50 years. The rise in TN, TP, and alkalinity concentrations observed in the deep samples (see below) are consistent with anoxic conditions allowing sediment -bound nutrients to be released into overlying waters. Monitoring from MMR studies (HAZWRAP, 1994) suggests that anoxic conditions develop early in the summer, but additional DO monitoring on a biweekly schedule during the summer or two is recommended to resolve how persistent the anoxia is. It is also recommended that annual monitoring of the pond continue, and that more refined monitoring and a characterization of nutrient loads to and within the lake be considered in the future. Johns Pond presents as an impacted lake with existing water quality problems.

| 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.8 | 3.67 | 8.0 | 4.0 | 0.32 |
| 3 | 6.75 | 3.20 | 8.0 | 4.0 | 0.36 |
| 9 | 6.43 | 6.65 | 8.1 | 7.4 | 0.32 |
| 18 | 6.44 | 3.85 | 26.7 | 26.9 | 1.20 |

# Mashpee/Wakeby Pond

## Mashpee, Sandwich
## MA-634

Acreage: 725.8
Maximum Depth: 83 ft
2001 Secchi Dip: 9 ft
Lake Association: None




Dissolved Oxygen and Temperature
Mashpee/Wakeby Pond, 2001

OVERVIEW

Mashpee Wakeby Pond is composed of two connected kettlehole basins located in both Mashpee and Sandwich, east of Route 130. The northern basin is deeper with a maximum depth of 95 ft, while the upper basin has a maximum depth of 65 ft. Shallows between the two basin have a maximum depth of approximately 20 ft. The pond is recharged by groundwater flow from the northwest and contributes surface flow to groundwater along its eastern shoreline. A controlled surface water outlet and herring run connects to the Mashpee River at the southern tip. The shoreline is heavily developed with seasonal and year-round single family homes, several town beaches and summer camps. Public access is available at the Sandwich town beach at the Ryder Property , and at the Mashpeepublic beach and boat ramp, north of Route 130. The pond is stocked with brook, brown and rainbow trout twice a year. Other species include large and smallmouth bass, chain pickeral and white catfish.

WATER QUALITY

The lake was sampled in 1948, 1980, 2001, and 2002. The 7/29/48 temperature profile showed stratification around 30 ft, with depressed DO concentrations below 40 ft and a minimum DO concentration of 2.6 ppm. In both 1980 and 2001, DO concentrations of less than 1 ppm (*i.e.*, anoxic conditions) were measured below 45 ft. Surface chlorophyll *a*, TP, and TN concentrations from the 2001 PALS snapshot (see below) are all above the current Cape Cod "impacted" thresholds, with the TP concentration nearly ten times the threshold. A Carlson TSI based on a surface chlorophyll *a* concentration places the pond at the high end of the mesotrophic category.

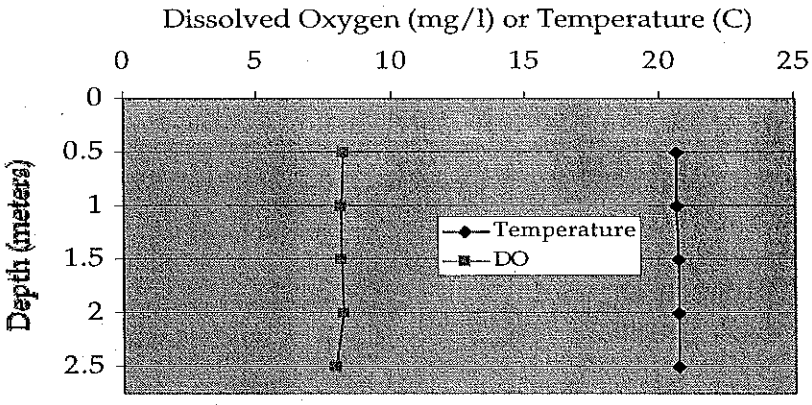
It is clear from a comparison of historic and recent DO profiles that deep water quality has become more impaired over the last 50 years. Additional DO monitoring on a biweekly schedule during the summer is recommended to resolve whether the anoxia develops at the onset of stratification or whether it only occurs during the late summer. It is also recommended that annual monitoring of the pond continue, and that more refined monitoring be considered in the future, along with a characterization of nutrient loads to and within the lake. Mashpee Wakeby Pond presents as an impacted lake with existing water quality problems.

| 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 1 | 6.89 | 6.34 | 12.6 | 72.8 | 0.34 |
| 2 | 6.51 | 6.72 | 12.4 | 14.1 | 0.34 |
| 9 | 6.40 | 2.96 | 12.4 | 10.8 | 0.35 |
| 14 | 6.26 | 7.40 | 25.3 | 149.6 | 0.60 |
| 26 | 6.41 | 0.04 | 30.6 | 370.1 | 1.52 |

samples also collected at: 4, 5, 6, 8, and 10 m

# Santuit Pond
## Mashpee
## MA-718

Acreage: 170.5
Maximum Depth: 9 ft
2001 Secchi Dip: 7.5 ft
Lake Association: None




Dissolved Oxygen and Temperature
Santuit Pond, 2001

OVERVIEW

Santuit Pond is relatively shallow and is located about a mile north of Route 28 and east of Route 130 in northeastern Mashpee. Public access is a town right-of-way, dirt ramp at the end of Hornbeam Street, which is off Sandwich/Cotuit Road. The last fisheries survey in 1979 recorded nine species, including: largemouth bass, chain pickerel, golden shiner, yellow perch, pumpkinseed, alewife, brown bullhead, white sucker and white perch.

WATER QUALITY

The lake was sampled in 1948, 1980, 2001, and 2002. All the profiles show consistent temperatures from top to bottom, as would be expected in a shallow pond. The 1948 and 2001 profiles show dissolved oxygen (DO) concentrations near saturation, while the 1980 profile has anoxic conditions at a depth of 2 m. Surface chlorophyll *a* and TP concentrations from the 2001 PALS snapshot (see below) are above current Cape Cod "impacted" thresholds, while the TN concentration is twice its current threshold. A Carlson TSI based on a surface chlorophyll *a* concentration places at the upper end of the oligotrophic with deep anoxia category.

Santuit Pond presents as a shallow, slightly nutrient enriched pond with some water quality concerns that could be resolved with additional monitoring. Additional regular monitoring throughout a summer either by volunteers or through the use of continuous monitoring instrument would be necessary to determine what conditions are necessary to achieve the anoxic conditions observed in 1980. Given the clarity nearly to the bottom and the high TN concentrations, the ecosystem in Santuit Pond would rapidly respond to any additions of phosphorus. It is recommended that the town consider regular monitoring, as well as a land use assessment to determine whether additional phosphorus loads are likely in the future.

| 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.48 | 2.23 | 10.8 | 17.3 | 0.65 |
| 1.5 | 6.54 | 2.71 | 11.1 | 18.9 | 0.46 |


2000 0 2000 4000 6000 Feet

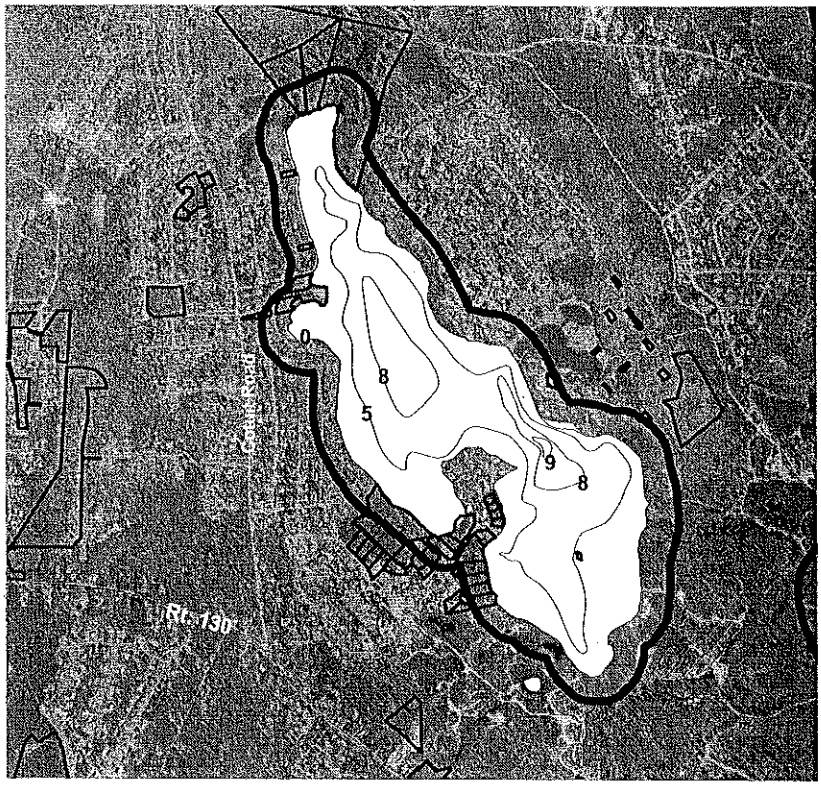
## John's Pond Mashpee (MA-818)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S



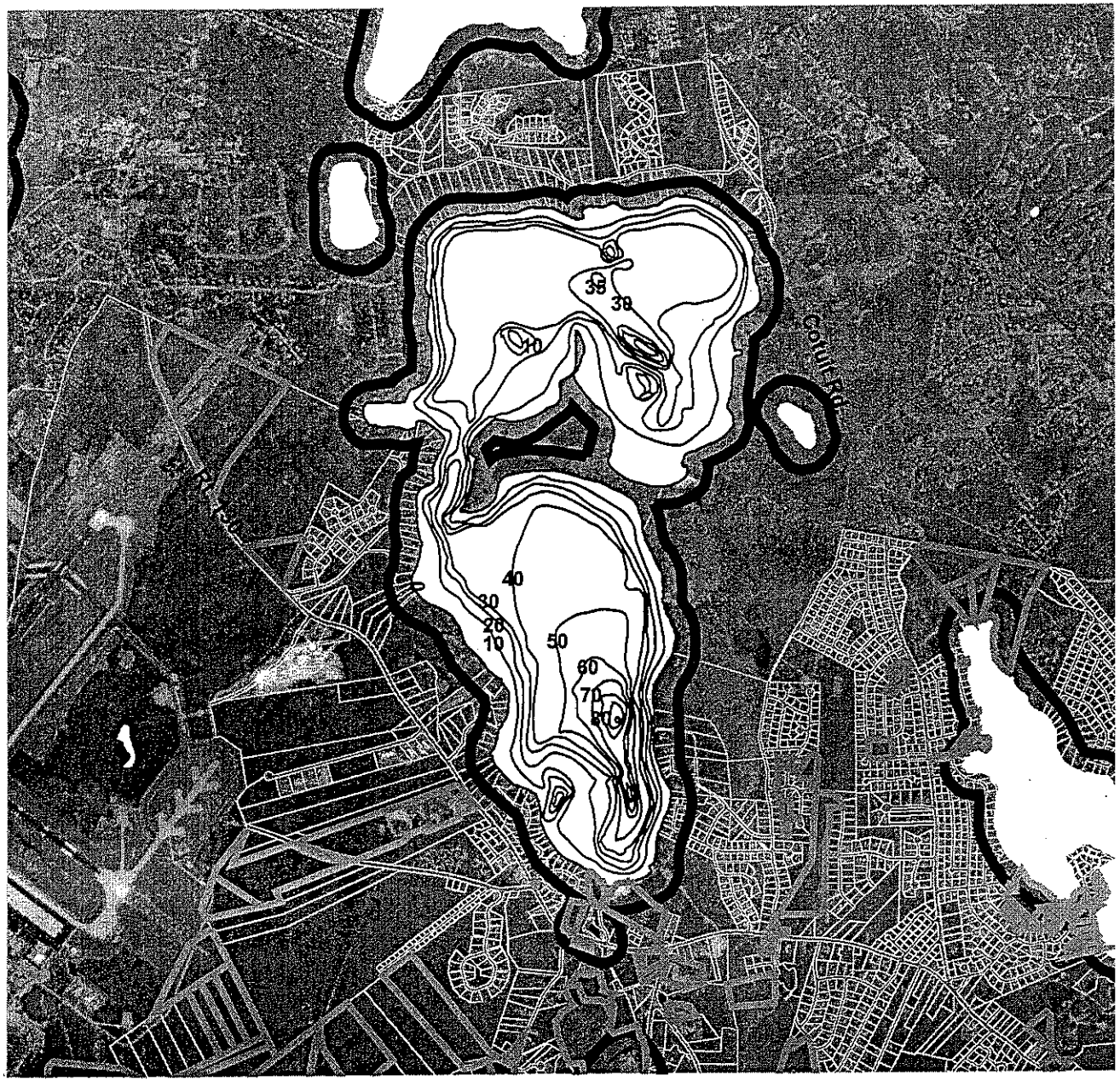

2000 0 2000 4000 Feet

## Santuit Pond Mashpee (MA-718)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet
Town owned land
300' Buffer Zone

N
W E
S




# Mashpee-Wakeby Pond
# Mashpee/Sandwich
# (MA-634)

**Bathymetry Source:**
**Division of Fish and Wildlife**

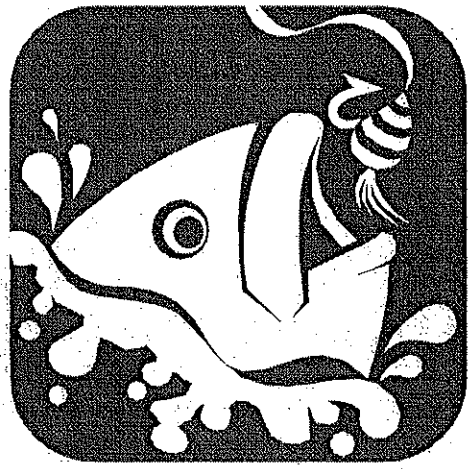
Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

5000 0 5000 10000 Feet

# ORLEANS PONDS



Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:

Baker's Pond
Crystal Lake
Pilgrim Pond

# Town of Orleans Atlas Summary

**Total Land Area (sq. miles):** 13.94

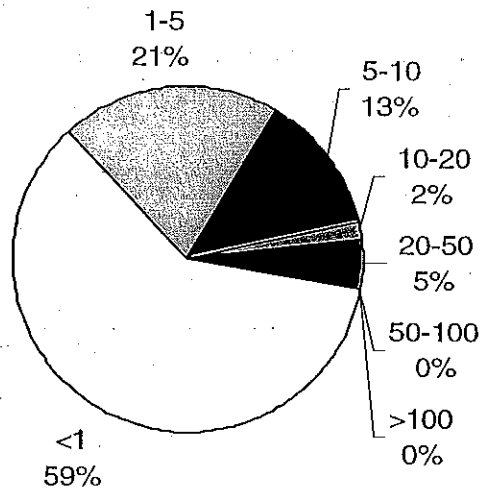
**Total Area of Ponds (acres):** 220

**Total # of Ponds:** 63

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 38 |
| 1-5 acres: | 13 |
| 5-10 acres: | 8 |
| 10-20 acres: | 1 |
| 20-50 acres: | 3 |
| 50-100 acres: | 0 |
| >100 acres: | 0 |

**Number of Orleans Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 17 |
| # of impacted ponds | |
| Chlorophyll a: | 15 |
| Total Nitrogen: | 15 |
| Total Phosphorus: | 13 |

**2001 Secchi Dip-In**

| | |
|---|---|
| # of ponds dipped: | 10 |
| # of volunteers: | 6 |

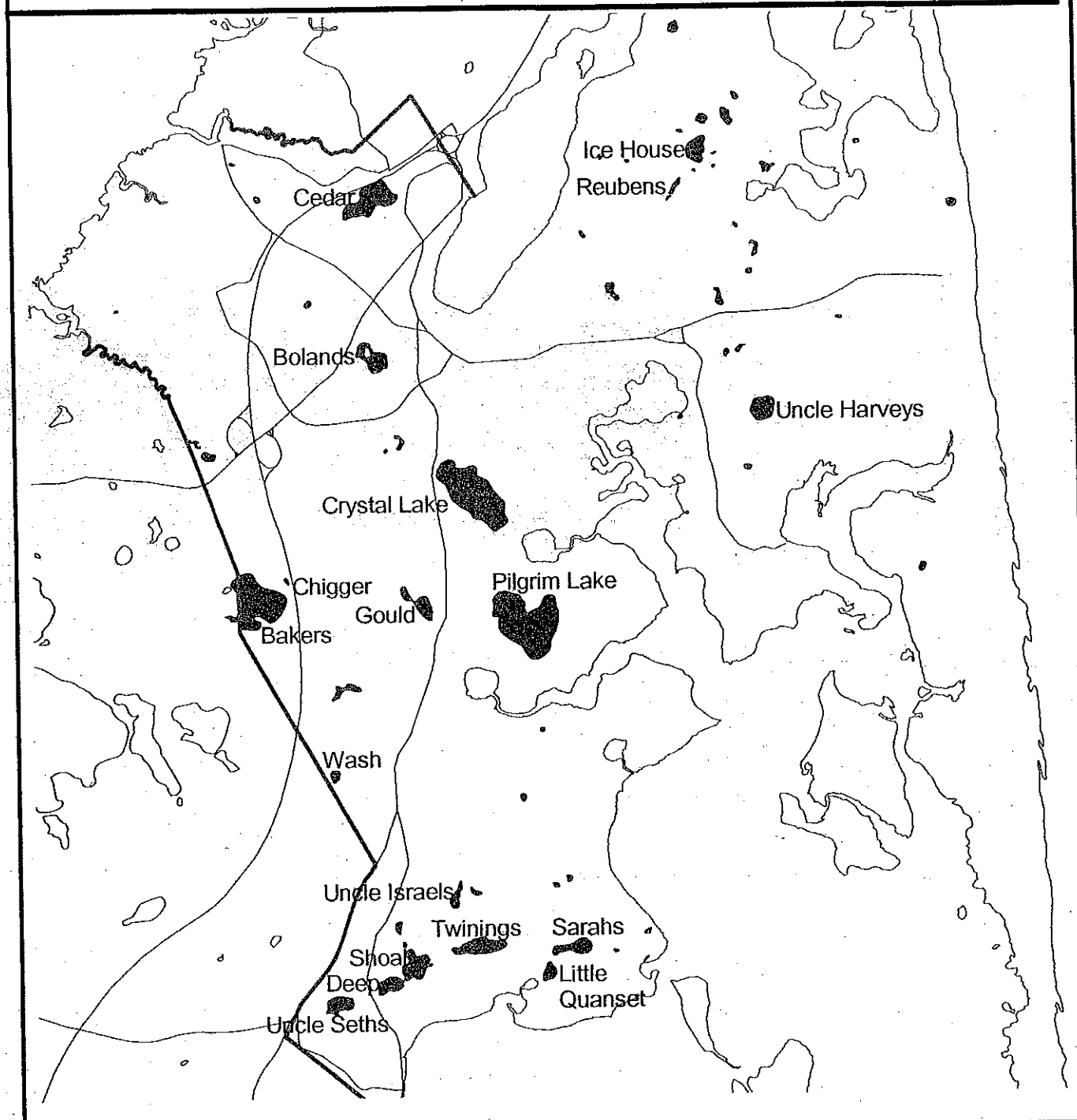
**Coordinator:**

Town staff:

Citizen: Judy Scanlon

**Pond Groups:** Orleans Water Quality Task Force
Friends of Crystal Lake
Friends of Bakers Pond
Friends of Pilgrim Lake

# ORLEANS
# NAMED PONDS



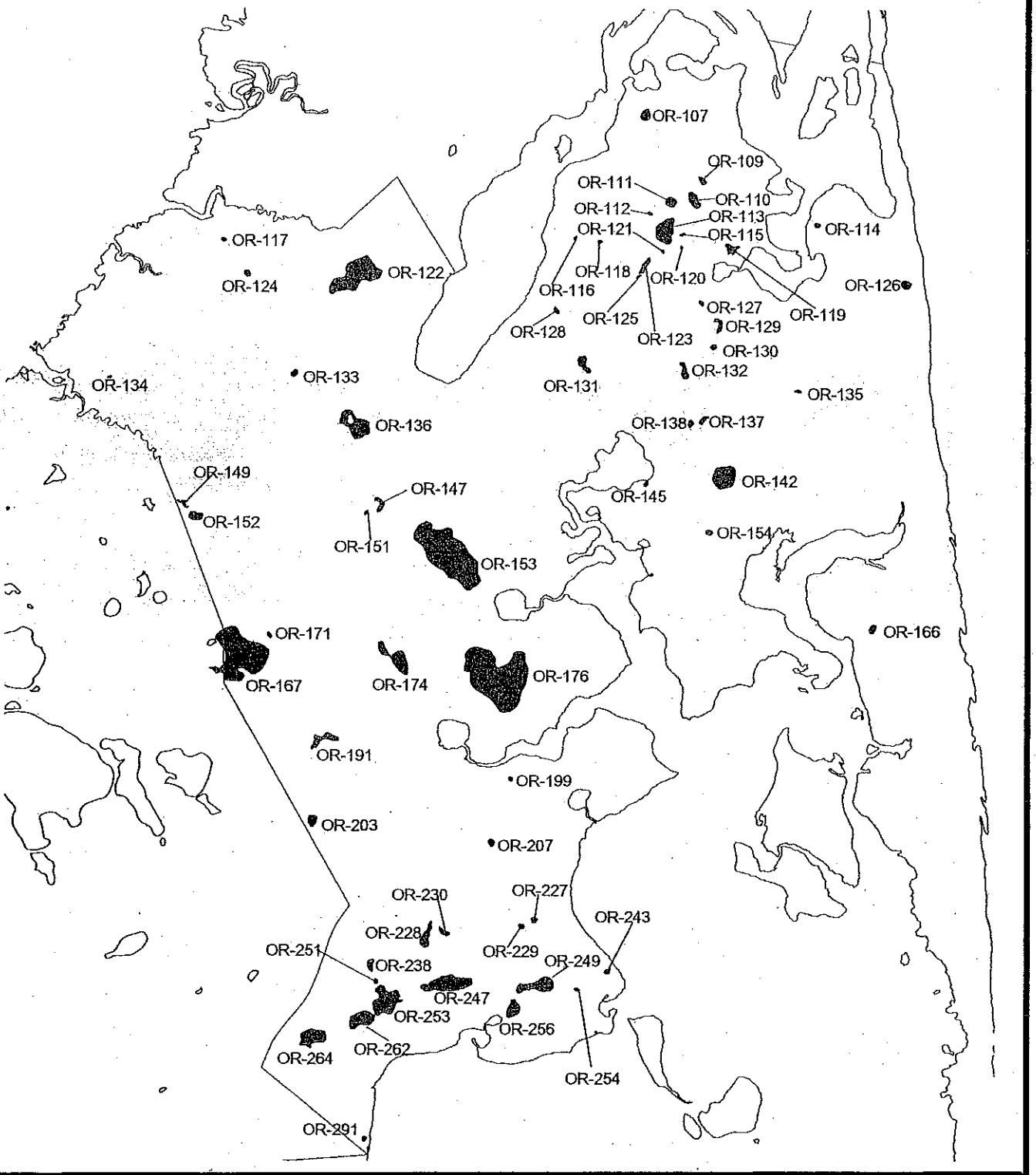

N

1 0 1 Miles

COUNTY OF BARNSTABLE MASSACHUSETTS

CAPE COD COMMISSION

# GIS ID'S FOR ORLEANS PONDS



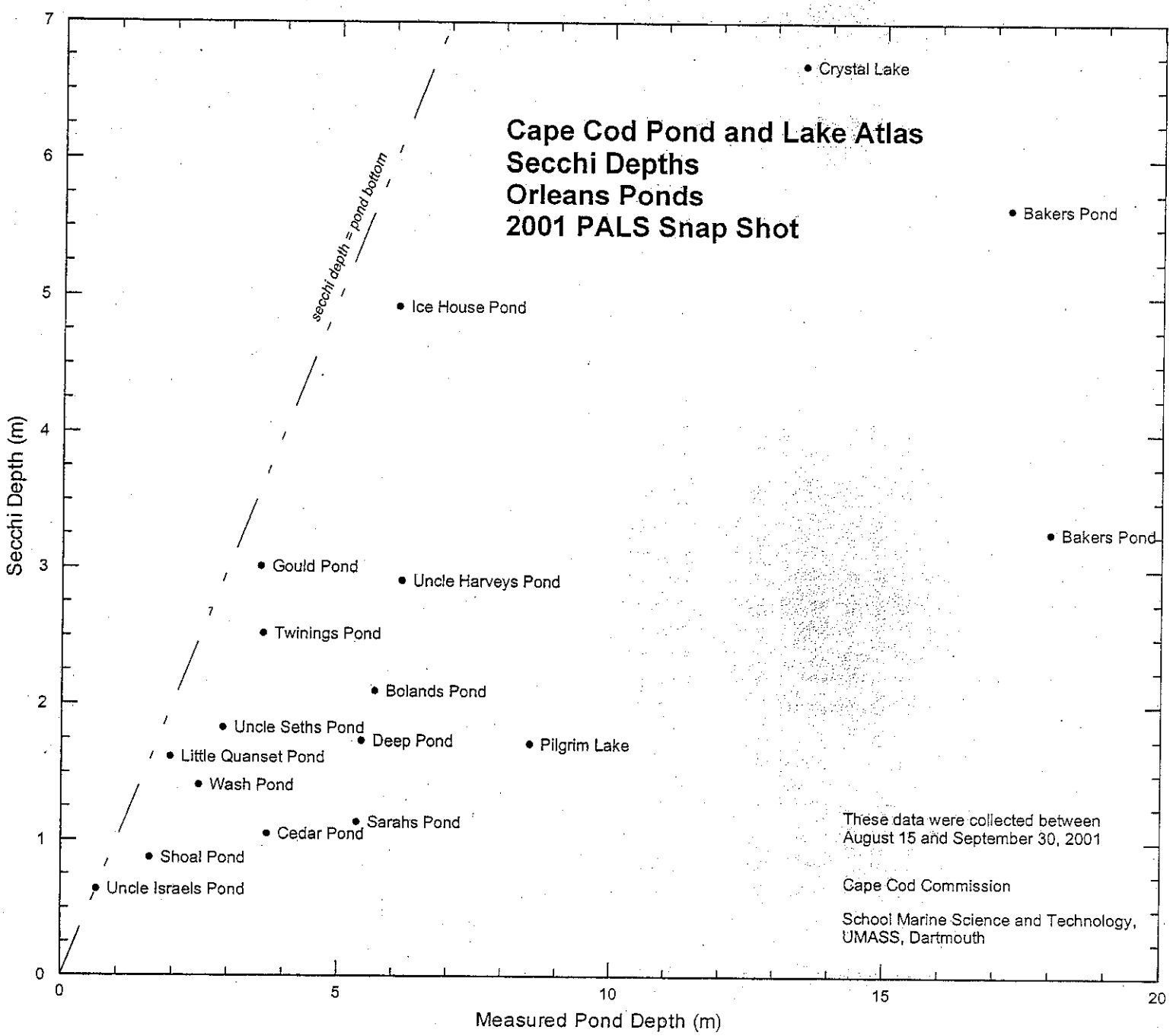

N

1 0 1 Miles

CAPE COD COMMISSION

# Orleans 2001 PALS Water Quality Snapshot Summary

| Name | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk 1-1.7 ug/l | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk 0.16-0.31 mg/l | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk 7.5-10 ug/l | impacted (>10 ug/l) |
| Bakers Pond | 1.44 | | x | | 0.43 | | | | 1.55 | x | | |
| Bolands Pond | 4.78 | | | x | 0.68 | | | x | 45.53 | | | x |
| Cedar Pond | 13.79 | | | x | 1.43 | | | x | 86.41 | | | x |
| Crystal Lake | 1.87 | | | x | 0.29 | | x | | 8.05 | | x | |
| Deep Pond | 11.08 | | | x | 0.60 | | | x | 16.41 | | | x |
| Gould Pond | 2.06 | | | x | 0.41 | | | x | 16.41 | | | x |
| Ice House Pond | 3.29 | | | x | 0.42 | | | x | 13.01 | | | x |
| Little Quanset Pond | 23.92 | | | x | 0.77 | | | x | 60.39 | | | x |
| Pilgrim Lake | 15.17 | | | x | 0.56 | | | x | 13.01 | | | x |
| Sarahs Pond | 17.35 | | | x | 1.01 | | | x | 27.56 | | | x |
| Shoal Pond | 10.08 | | | x | 0.73 | | | x | 27.56 | | | x |
| Twinings Pond | 10.29 | | | x | 0.45 | | | x | 16.41 | | | x |
| Uncle Harveys Pond | 5.71 | | | x | 0.51 | | | x | 6.50 | x | | |
| Uncle Israels Pond | 36.85 | | | x | 1.32 | | | x | 78.04 | | | x |
| Uncle Seths Pond | 4.19 | | | x | 0.57 | | | x | 26.01 | | | x |
| Wash Pond | 4.92 | | | x | 0.79 | | | x | 16.41 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Orleans Ponds
2001 PALS Snap Shot
secchi depth = pond bottom
Crystal Lake
Bakers Pond
Ice House Pond
Bakers Pond
Gould Pond
Uncle Harveys Pond
Twinings Pond
Bolands Pond
Uncle Seths Pond
Deep Pond
Pilgrim Lake
Little Quanset Pond
Wash Pond
Sarahs Pond
Cedar Pond
Shoal Pond
Uncle Israels Pond
These data were collected between August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology, UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
6
7
0
5
10
15
20

# ORLEANS POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bakers Pond | OR-167 | 96008 | 29.3 | Y | 17,973 | 21 | 54 | pubramp,cartop | | sd,wq | sd,wq |
| Bolands Pond | OR-136 | 96025 | 7.3 | N | | 15 | | school | | sd,wq | wq |
| Cedar Pond | OR-122 | 96033 | 16.1 | N | | 8 | 10 | informal | HR | sd,wq | wq |
| Chigger Pond | OR-171 | | 0.3 | N | | | | | | | |
| Crystal Lake | OR-153 | 96050 | 38.2 | Y | 26,537 | 15 | 44 | pubramp | O | sd,wq | wq |
| Deep Pond | OR-262 | 96057 | 4.7 | N | | 19 | | private | | sd,wq | wq |
| Gould Pond | OR-174 | 96107 | 5.5 | N | | 16 | | watershed | | wq | wq |
| Ice House Pond | OR-113 | 96148 | 5.7 | N | | 49 | | informal | | wq | wq |
| Little Quanset Pond | OR-256 | | 2.6 | N | | | | | | | wq |
| Old Swamp Pond | OR-191 | 96335 | | | | 20 | | watershed | | | |
| Pilgrim Lake | OR-176 | 96246 | 44.7 | Y | 18,034 | 8 | 28 | beach | O,HR | sd,wq | wq |
| Reubens Pond | OR-123 | | 1.0 | N | | | | | | | wq |
| Sarahs Pond | OR-249 | 96278 | 5.6 | N | | 12 | | private | | wq | wq |
| Shoal Pond | OR-253 | 96291 | 8.6 | N | | 19 | | private | | sd,wq | wq |
| Twinings Pond | OR-247 | 96317 | 9.1 | N | | 17 | 14 | ConsComm | | sd,wq | wq |
| Uncle Harveys Pond | OR-142 | 96319 | 7.0 | N | | 8 | | ConsComm | | sd,wq | wq |
| Uncle Israels Pond | OR-228 | 96320 | 2.1 | N | | 15 | | private | | wq | wq |
| Uncle Seths Pond | OR-264 | 96321 | 5.4 | N | | 23 | | private | | sd,wq | wq |
| Wash Pond | OR-203 | | 1.3 | N | | 15 | | watershed | | wq | wq |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

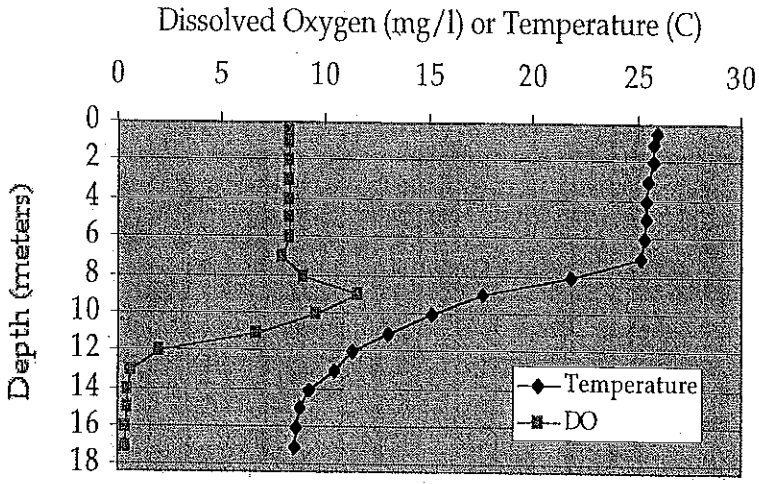
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Bakers Pond
## Orleans/Brewster
## OR-167

Acreage: 29.3
Maximum Depth: 60 ft
2001 Secchi Dip: 10.7 ft
Lake Association:
Friends of Bakers Pond




Dissolved Oxygen and Temperature
Bakers Pond, 8/27/01

OVERVIEW

Bakers Pond is located to the west of Route 6, just south of Exit 12 on the Orleans/ Brewster town line. The pond is recharged from groundwater flowing from the west and north and discharges surface flow to groundwater along its east shore. The pond shoreline is sparsley developed with single family homes. A public beach access is provided on the eastern shore. Recreational uses include swimming, boating and fishing. The pond is stocked with trout each spring and fall.

WATER QUALITY

Baker Pond was sampled in 1948, 2001, and 2002. In 1948, the August 19 temperature profile indicated a well-mixed upper layer (i.e., epilimnion) to 35 ft with waters 7 to 10°F cooler below 35 ft. The dissolved oxygen (DO) profile had near saturation concentrations in the epiliminion and deeper concentrations beginning at 7.8 ppm at 45 ft and declining to hypoxic (<4 ppm) conditions at the bottom. From late 2000 through 2001, Baker Pond was the subject of a town-initiated water quality study (Eichner, *et al.*, 2001). The monitoring during this study found anoxic concentrations (<1 ppm DO) in the deeper waters once thermal stratification was achieved (mid-June) and these conditions existing until turnover in mid-November; late summer conditions are shown above in the 2001 PALS Snapshot profiles.

Surface water chlorophyll *a* and TP concentrations measured in Baker Pond are less than the current Cape Cod "impacted" thresholds, while surface TN and all parameter concentrations at depth exceed these thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond at the lower end of the oligotrophic with some bottom anoxia category, but this is contrasted by conflicting classifications for Secchi depth and TP Carlson TSI's, which place the pond in the mesotrophic and oligiotrophic categories, respectively.

The water quality study concluded that additional sampling, including sediments and stormwater from nearby roads, including Route 6, was necessary to better understand Baker Pond's water quality. It is clear from reviewing the DO profiles that this pond is impaired and has worsened over the past 50 years. The Town of Orleans Water Quality Task Force collected more refined data during the summer of 2002; it is recommended that the town consider a revised water quality assessment of the Baker Pond, including a review of this more refined data and include a sediment characterization and stormwater sampling and a forecast of whether water quality is likely to continue to worsen. Overall, Baker Pond presents as an impacted pond with current water quality problems.

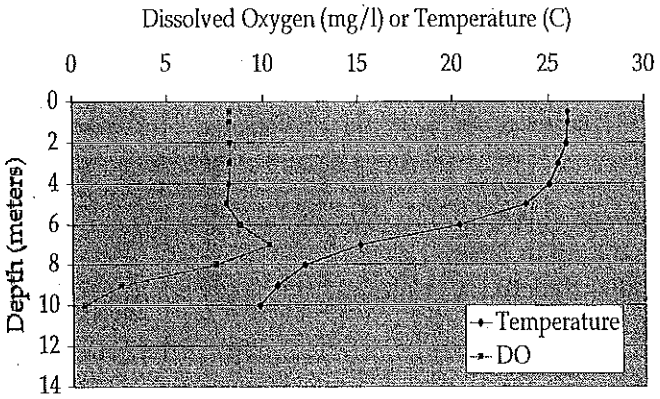
| August 27, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.27 | 1.44 | 2.0 | 1.5 | 0.43 |
| 15 | 6.02 | 7.68 | 5.4 | 37.5 | 0.62 |

# Crystal Lake

## Orleans

## OR-153

Acreage: 38
Maximum Depth: 44 ft
2001 Secchi Dip: 21.9 ft
Lake Association:
Friends of Crystal Lake




Dissolved Oxygen and Temperature
Crystal Lake, 8/28/01

OVERVIEW

Crystal Lake is located southeast of the intersection of Pond Road and Route 28. This lake is recharged with groundwater flowing from the west and discharges surface flow to groundwater along its northeast and east shore. On the northeast shore an intermittent stream discharges into the pond from a wetland area and a surface outlet drains into a cranberry bog ultimately leading into the tidal Kescayogansset Pond. The lake shoreline is moderately developed with single family homes. Public access is provided by a paved boat ramp on the northwest end and a small public beach on the southeast shore. Recreational uses include swimming, boating and fishing. The lake is stocked with trout each spring and fall.

WATER QUALITY

Crystal Lake was sampled in 1948, 2001, and 2002. In 1948, the August 19 temperature profile indicated a well-mixed upper layer (*i.e.*, epilimnion) to 18 ft with waters 8 to 15°F cooler below 20 ft. The dissolved oxygen (DO) profile had near saturation concentrations in the epiliminion and deeper concentrations beginning at 9.2 ppm at 25 ft and declining to anoxic (<1 ppm) conditions at the bottom (38 and 42 ft readings). Between May and November 2000, Crystal Lake was the subject of a town-initiated water quality study (OWQTF, 2001). The monitoring during this study found anoxic concentrations (<1 ppm DO) in the deepest waters about a month following the beginning of thermal stratification (early-June) with a progressively thicker, deep anoxic layer as summer progressed. The 2001 PALS Snapshot profiles (shown above) show an anoxic layer of approximately 4 m (13.1 ft) at the bottom of the lake, which is close to the maximum observed during 2000.

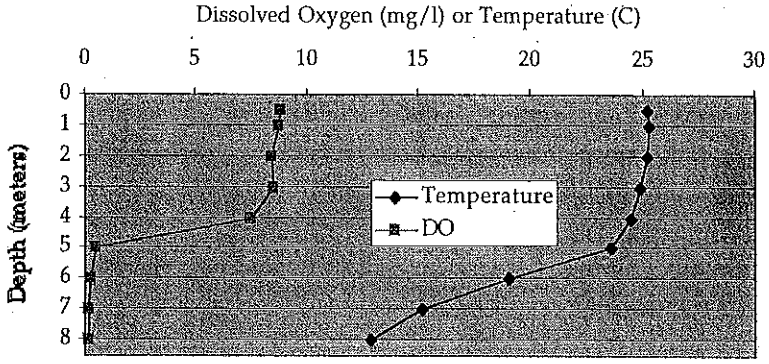
Chlorophyll *a*, TP, and TN concentrations measured in the upper three samples from Crystal Lake are generally less than or slightly above current Cape Cod "impacted" thresholds, while the nutrient concentrations at depth exceed these thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond at the middle of the oligotrophic with some bottom anoxia category.

The water quality study concluded that additional sampling, including sediments and stormwater from nearby roads, including Route 6, was necessary to better understand Crystal Lake's water quality. It is clear from reviewing the DO profiles that this pond is impaired, has worsened over the past 50 years, and consideration of information from other ponds discussed in this Pond Atlas suggests that the 1948 conditions were impaired as well. The Orleans Water Quality Task Force collected more refined data during the summer of 2002; it is recommended that the town consider a revised water quality assessment of the Crystal Lake, including a review of this more refined data and include a sediment characterization and stormwater sampling and a forecast of whether water quality is likely to continue to worsen. Overall, Crystal Lake presents as an impacted pond with current water quality problems.

| August 28, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.24 | 1.87 | 2.3 | 8.1 | 0.29 |
| 3 | 6.27 | 1.18 | 2.6 | 8.1 | 0.32 |
| 9 | 5.83 | 1.29 | 3.1 | 13.0 | 0.26 |
| 12.5 | 6.25 | 1.36 | 12 | 73.4 | 0.59 |

# Pilgrim Lake
## Orleans
## OR-176

Acreage: 44.7
Maximum Depth: 28 ft
2001 Secchi Dip: 5.8 ft
Lake Association:
Friends of Pilgrim Lake




Dissolved Oxygen and Temperature
Pilgrim Lake, 8/28/01

OVERVIEW

Pilgrim Lake is located east of oute 28 and south of Monument Road. The lake is recharge by groundwater flow from the west and ischarges surface flow to the groundwater along the north, south, and east shorelines. There is a herring run ading to the tidal Kescayogansett Pond at the northern end of the lake. The shoreline is lightly developed ith single family homes and cottages. A large public beach area and boat ramp are located on the northeast ore. Recreational activites include fishing, boating and swimming.

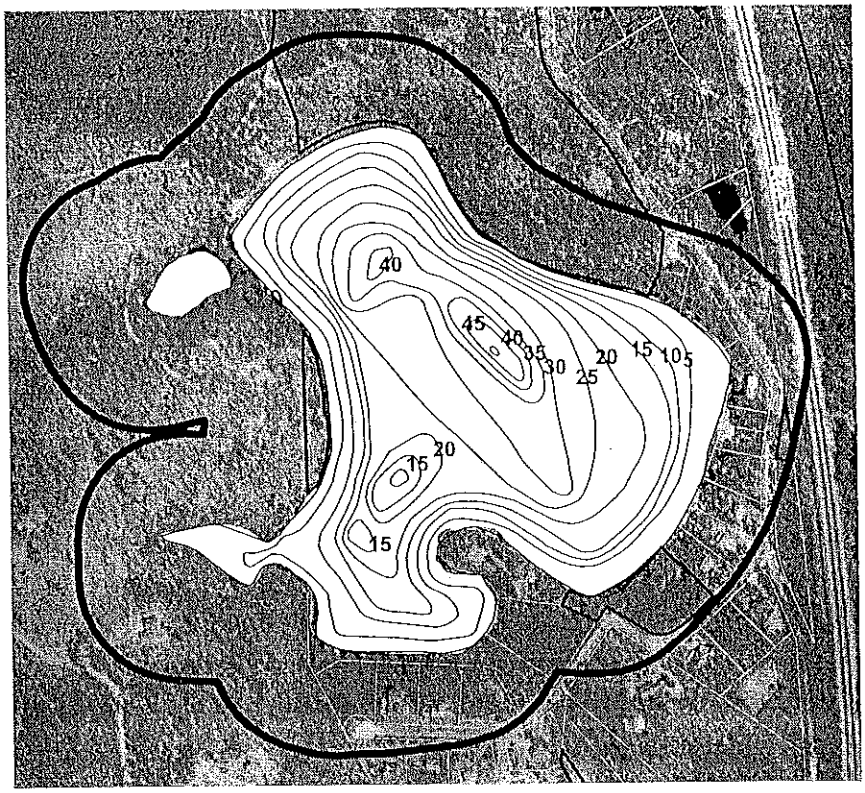
WATER QUALITY

Pilgrim Lake was sampled in 1980, 2001, and 2002. In 1980, the July 29 temperature and dissolved oxygen O) profiles indicated a well-mixed water column with a slight drop in temperature at the bottom of the lake. etween 2000 and 2001, Pilgrim Lake was part of a town-initiated water quality study (Scanlon and Meservey, 001). Profiles collected showed the onset of thermal stratification in early June with a well-mixed upper layer (*e.g.*, ilimnion) to 3 m followed by a gradual deeping of the layer to 5 m as the summer progressed. Below the ilimnion, there was a gradual lowering of temperature with depth, but without the formation of a true ypolimnion. Deep dissolved oxygen concentrations declined with the onset of stratification, attaining a 1.5 m thick layer of anoxic water on the bottom of the lake from July through September. In an apparent orsening, the 2001 PALS Snapshot profile (see above) shows a ~3.5 m layer of anoxic water on the bottom.

All the chlorophyll *a*, TP, and TN concentrations measured during the 2001 PALS Snapshot (shown below) xceed the current Cape Cod "impacted" thresholds, with the deep TP being the second highest recorded during the napshot. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond at the middle of the utrophic category.

The water quality study concluded that additional sampling, including sediments, was necessary to better nderstand Pilgrim Lake's water quality. It is clear from reviewing the DO profiles that this pond is impaired and at this impairment appears to have occurred over the past 20 years. The Orleans Water Quality Task Force ollected more refined data during the summer of 2002; it is recommended that the town consider a revised water uality assessment of the Pilgrim Lake, including a review of this more refined data and include a sediment charac-rization, a land use assessment of shoreline and watershed properties, clarification of differences between 2000 nd 2001 results, and a forecast of whether the water quality problems are likely to continue to worsen. Overall, ilgrim Lake presents as an impacted pond with current water quality problems.

| August 28, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.72 | 15.17 | 10.9 | 13.0 | 0.56 |
| 7.5 | 6.18 | 5.62 | 24.6 | 455.3 | 0.59 |




700 0 700 1400 Feet

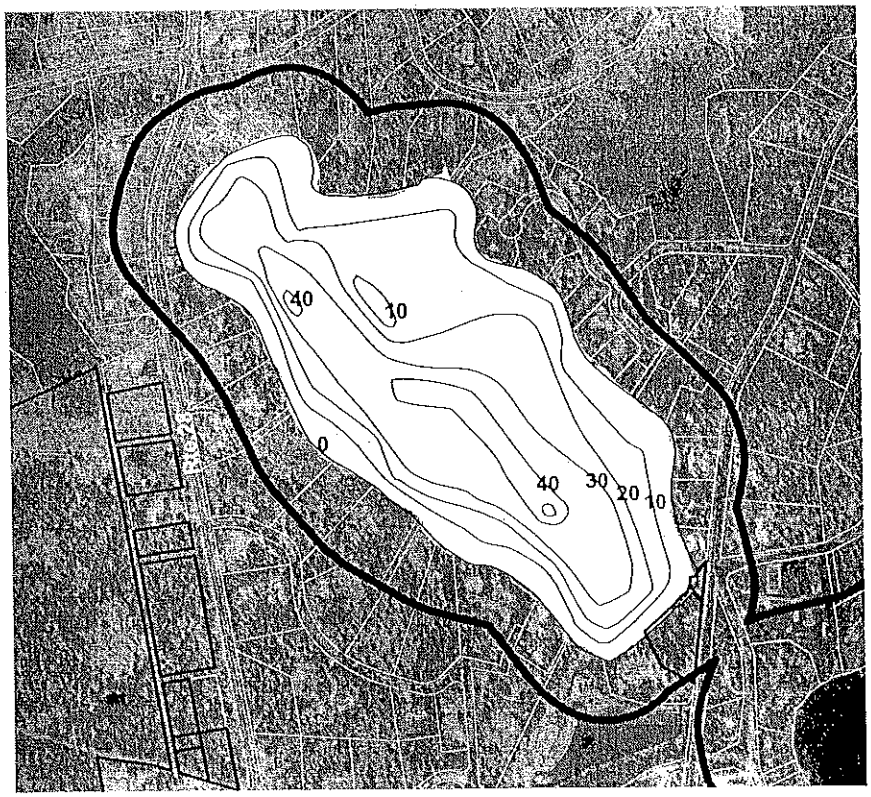
## Baker's Pond
## Orleans
## (OR-167)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S




1000 0 1000 2000 Feet

## Crystal Lake
## Orleans
## (OR-153)

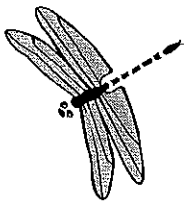
**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

# PROVINCETOWN PONDS

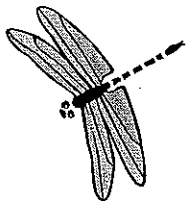


Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

Description Only:

Clapps Pond

# Town of Provincetown Atlas Summary



**Total Land Area (sq. miles):** 8.35

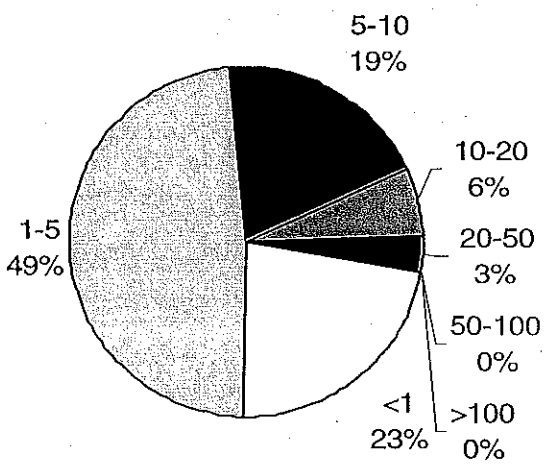
**Total Area of Ponds (acres):** 145

**Total # of Ponds:** 31

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 7 |
| 1-5 acres: | 15 |
| 5-10 acres: | 6 |
| 10-20 acres: | 2 |
| 20-50 acres: | 1 |
| 50-100 acres: | 0 |
| >100 acres: | 0 |

**Number of Provincetown Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 6 |
| # of impacted ponds | |
| Chlorophyll a: | 3 |
| Total Nitrogen: | 6 |
| Total Phosphorus: | 6 |

**Secchi Dip-In**

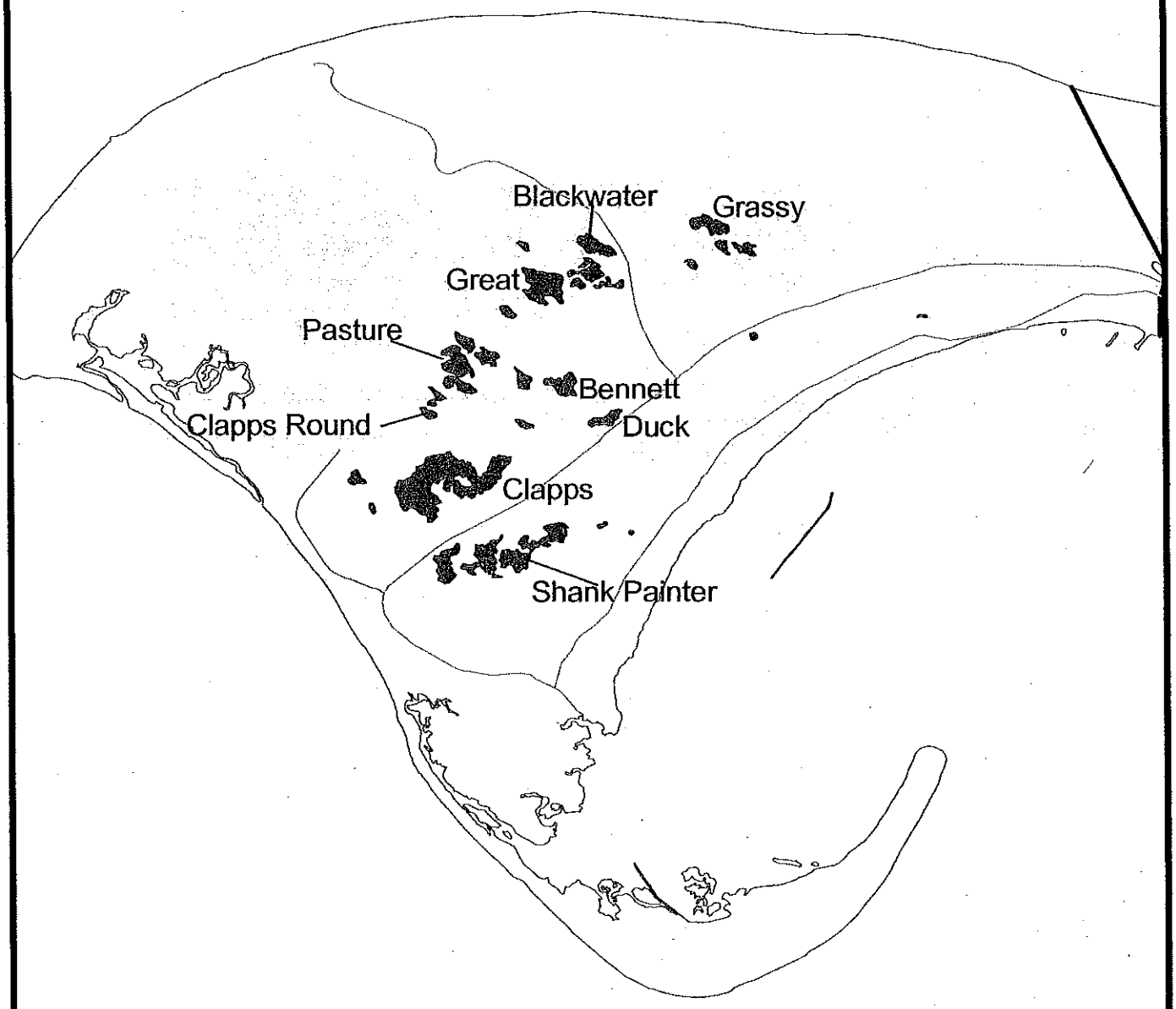
| | |
|---|---|
| # of ponds dipped: | 3 |
| # of volunteers: | 3 |

**Coordinator:**

Most of the ponds in Provincetown are within the National Seashore. These ponds have been sampled through the efforts of Krista Lee, John Portnoy, and Jon Budreski of the National Park Service.

**Pond Groups:** National Park Service

# PROVINCETOWN NAMED PONDS

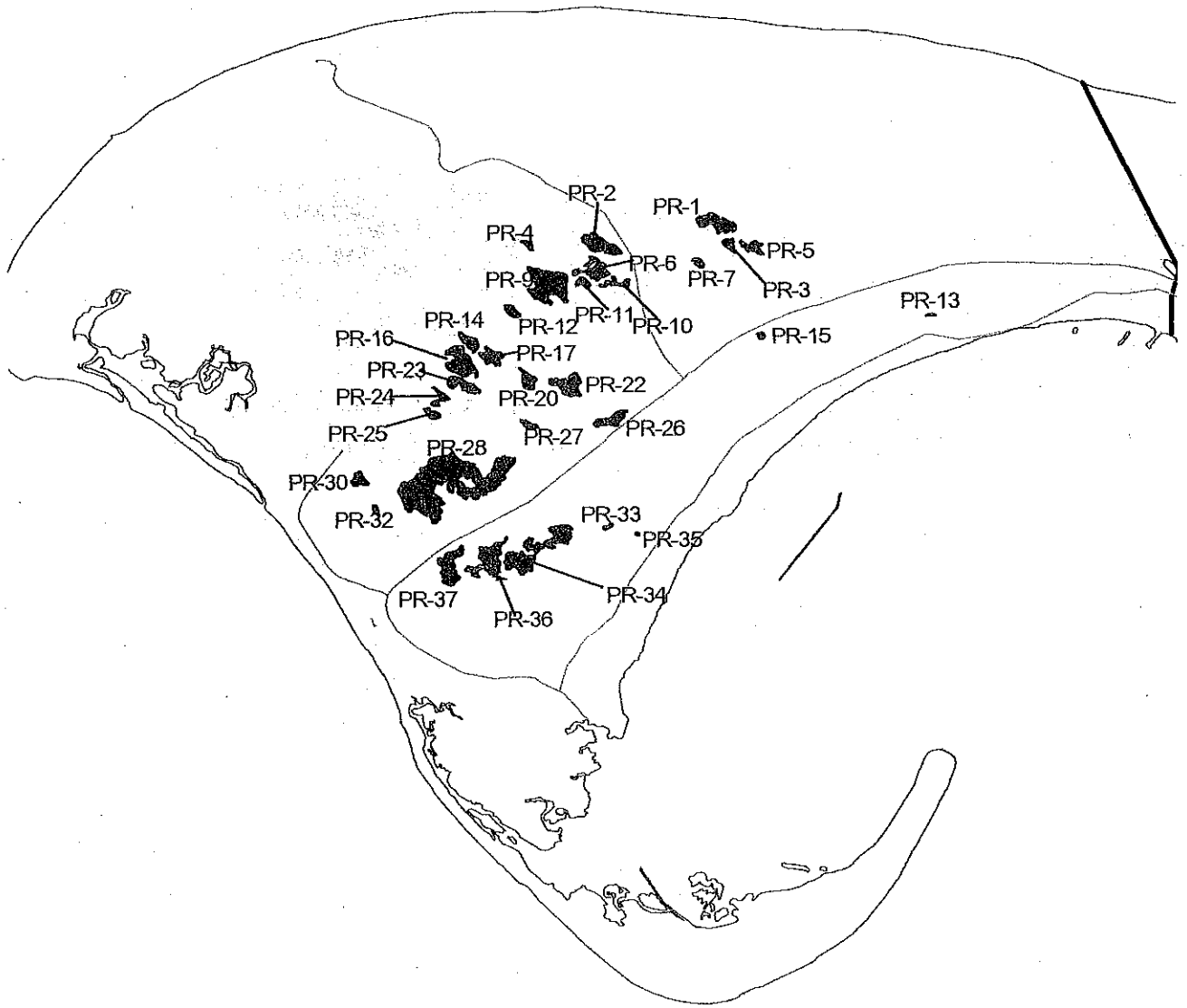



N

1 0 1 Miles

CAPE COD COMMISSION

# PROVINCETOWN GIS ID'S



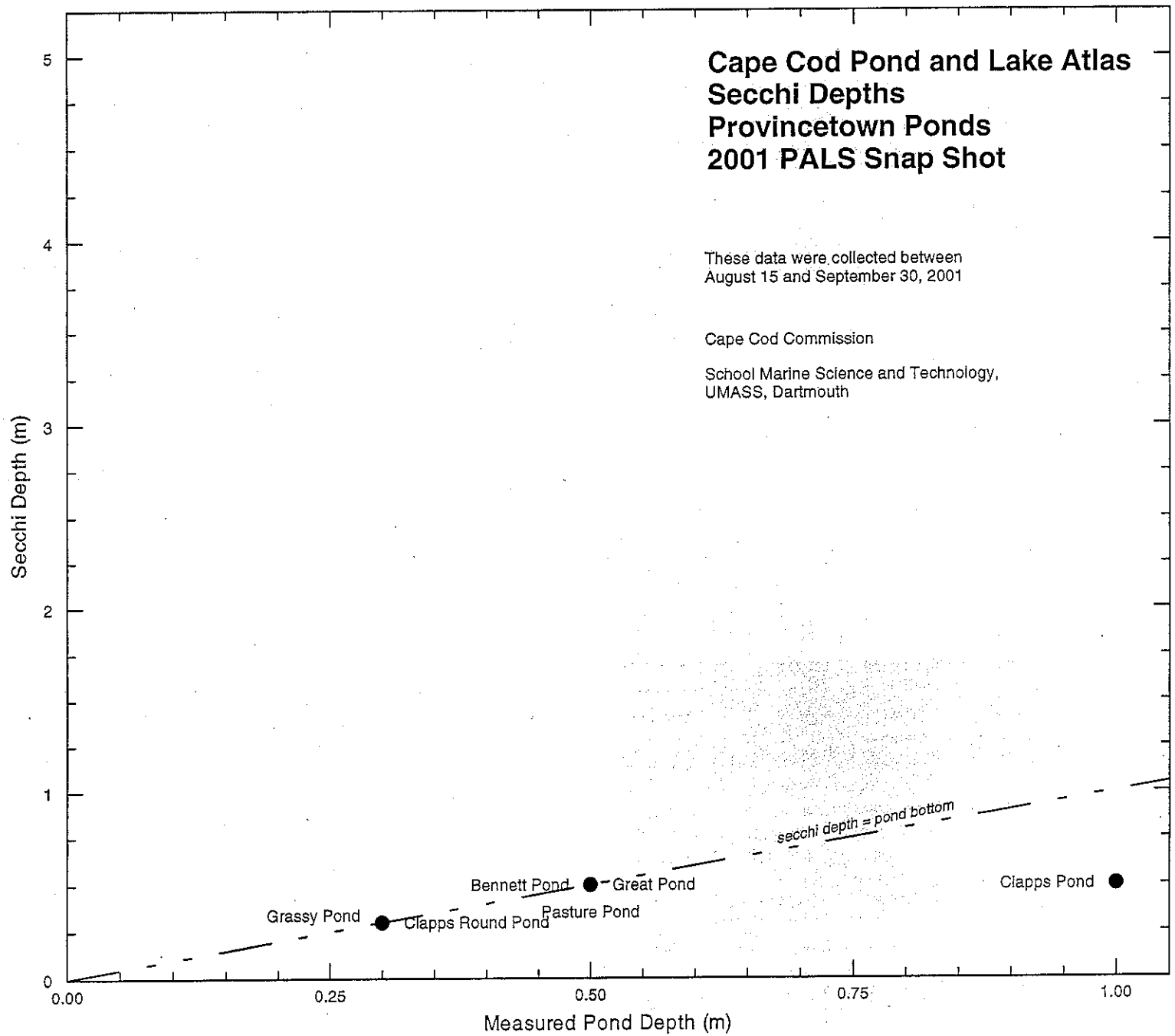

N

1 0 1 Miles

CAPE COD COMMISSION

# Provincetown 2001 PALS Water Quality Snapshot Summary

| | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | ug/l | unimpacted (<1.0 ug/l) | at risk (1-1.7 ug/l) | **impacted (>1.7 ug/l)** | mg/l | unimpacted (<0.16 mg/l) | at risk (0.16-0.31 mg/l) | **impacted (>0.31 mg/l)** | ug/l | unimpacted (<7.5 ug/l) | at risk (7.5-10 ug/l) | **impacted (>10 ug/l)** |
| Bennett Pond | 1.09 | | x | | 0.64 | | | x | 30.04 | | | x |
| Clapps Pond | 8.21 | | | x | 0.89 | | | x | 70.92 | | | x |
| Clapps Round Pond | 72.83 | | | x | 5.96 | | | x | 224.53 | | | x |
| Grassy Pond | 1.37 | | x | | 0.65 | | | x | 26.63 | | | x |
| Great Pond | 50.14 | | | x | 1.64 | | | x | 227.63 | | | x |
| Pasture Pond | 0.71 | x | | | 0.58 | | | x | 20.44 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Provincetown Ponds
2001 PALS Snap Shot
These data were collected between
August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology,
UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
0.00
0.25
0.50
0.75
1.00
secchi depth = pond bottom
Bennett Pond
Great Pond
Clapps Pond
Grassy Pond
Clapps Round Pond
Pasture Pond

# PROVINCETOWN POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bennett Pond** | PR-22 | 96013 | 5.4 | N | | 4 | 6 | CCNS | | wq | wq |
| **Blackwater Pond** | PR-2 | | 5.6 | N | | 3 | 4 | pubramp | | | |
| **Clapps Pond** | PR-28 | 96035 | 43.7 | N | | 5 | 3 | CCNS | | wq | sd,wq |
| **Clapps Round Pond** | PR-25 | 96036 | 1.5 | N | | 5 | 3 | west half town | | sd,wq | |
| **Duck Pond** | PR-26 | 96066 | 3.4 | N | | 5 | 3 | CCNS | | sd | sd |
| **Grassy Pond** | PR-1 | 96113 | 5.6 | N | | 4 | 3 | CCNS | | wq | wq |
| **Great Pond** | PR-9 | 96118 | 12.4 | N | | | 3 | PtownConsTr. | | wq | wq |
| **Jimmy's Pond** | | | | | | 4 | | | | | |
| **Little Bennett Pond** | PR-20 | 96347 | | | | 5 | 3 | CCNS | | | |
| **Pasture Pond** | PR-16 | 96239 | 7.4 | N | | 3 | 3 | none | | wq | wq |
| **Shank Painter Pond** | PR-34 | 96287 | 13.1 | N | | 3 | 3 | none | | sd | sd |
| **West Shank Painter Pond** | PR-37 | 96336 | | | | | | | | | |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

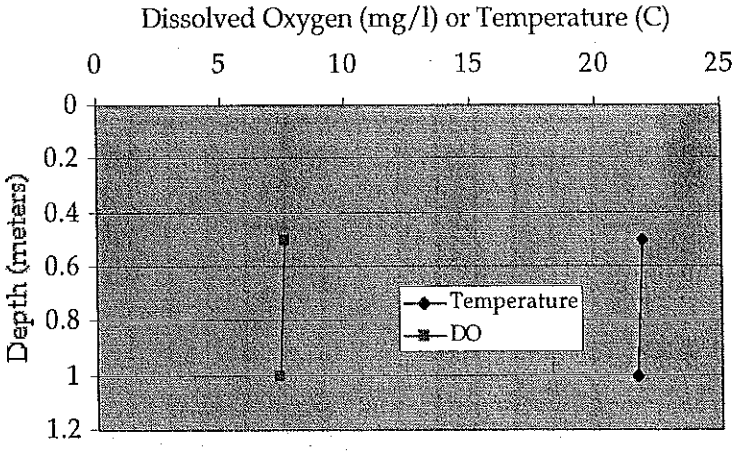
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Clapps Pond
## Provincetown
## PR-28

Acreage: 44
Maximum Depth: 4 ft
2001 Secchi Dip: 1.6 ft
Lake Association: none




Dissolved Oxygen and Temperature
Clapps Pond, 2001

OVERVIEW

Clapps Pond is located in the Town of Provincetown, north of Route 6, and straddling the Cape Cod National Seashore boundary. Groundwater flows into the lake from the north and pond water flows back into the groundwater along the southern shore. The shoreline is undeveloped and access is provided by a dirt road off Route 6 through the MA Division of Fisheries and Wildlife Clapps Pond Access and Wildlife Management Area. The last fisheries survey (1981) noted dense weeds and a sparse fish population with four species recorded: chain pickerel, brown bullhead, largemouth bass and pumpkinseed.

WATER QUALITY

Clapps Pond is similar to many of the Provincetown ponds, shallow (1 m or less in depth), very acidic (pH readings generally between 4 and 5.5 and little alkalinity), and containing moderate to high concentrations of nutrients. These ponds are much younger than most of the rest of the Cape's ponds, forming after the growth of the Provincelands during the last 3,500 years (Strahler, 1966) and might be more properly classified as swamps or bogs. The low pH is likely due to the influence of peat moss, which lowers pH as it decays.

Because these ponds are so different from most of the others sampled during the 2001 PALS Snapshot and the associated development of Cape Cod nutrient criteria, comparison to the current Cape Cod "impacted" thresholds is not appropriate. The Carlson TSI based on the surface chlorophyll *a* concentration places Clapps Pond at the bottom of the eutrophic category, but again this may be more reflective of the natural condition of the Clapps Pond ecosystem rather than the result of human impacts. Since these systems are rather unique on Cape Cod, it is recommended that annual monitoring, at a minimum, continue and that more refined monitoring be considered.

| September 6, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 5.33 | 8.21 | 1.3 | 70.9 | 0.89 |

# SANDWICH PONDS

Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:
Peter's Pond
Pimlico Pond
Snake Pond

Map Only:
Hoxie Pond
Lawrence Pond
Shawme Pond
Spectacle Pond

# Town of Sandwich Atlas Summary

**Total Land Area (sq. miles):** 42.61

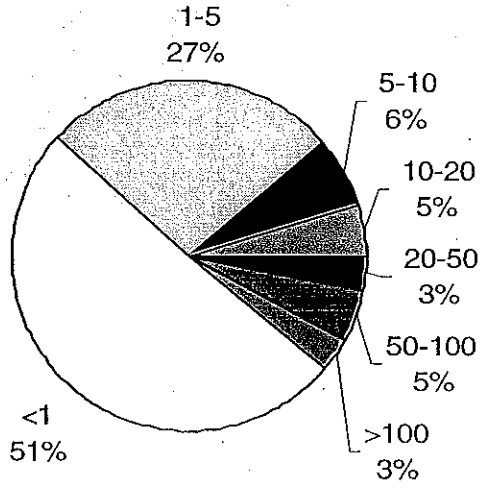
**Total Area of Ponds (acres):** 698

**Total # of Ponds:** 63

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 32 |
| 1-5 acres: | 17 |
| 5-10 acres: | 4 |
| 10-20 acres: | 3 |
| 20-50 acres: | 2 |
| 50-100 acres: | 3 |
| >100 acres: | 2 |

**Number of Sandwich Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 3 |
| # of impacted ponds | |
| Chlorophyll a: | 0 |
| Total Nitrogen: | 1 |
| Total Phosphorus: | 1 |

**2001 Secchi Dip-In**

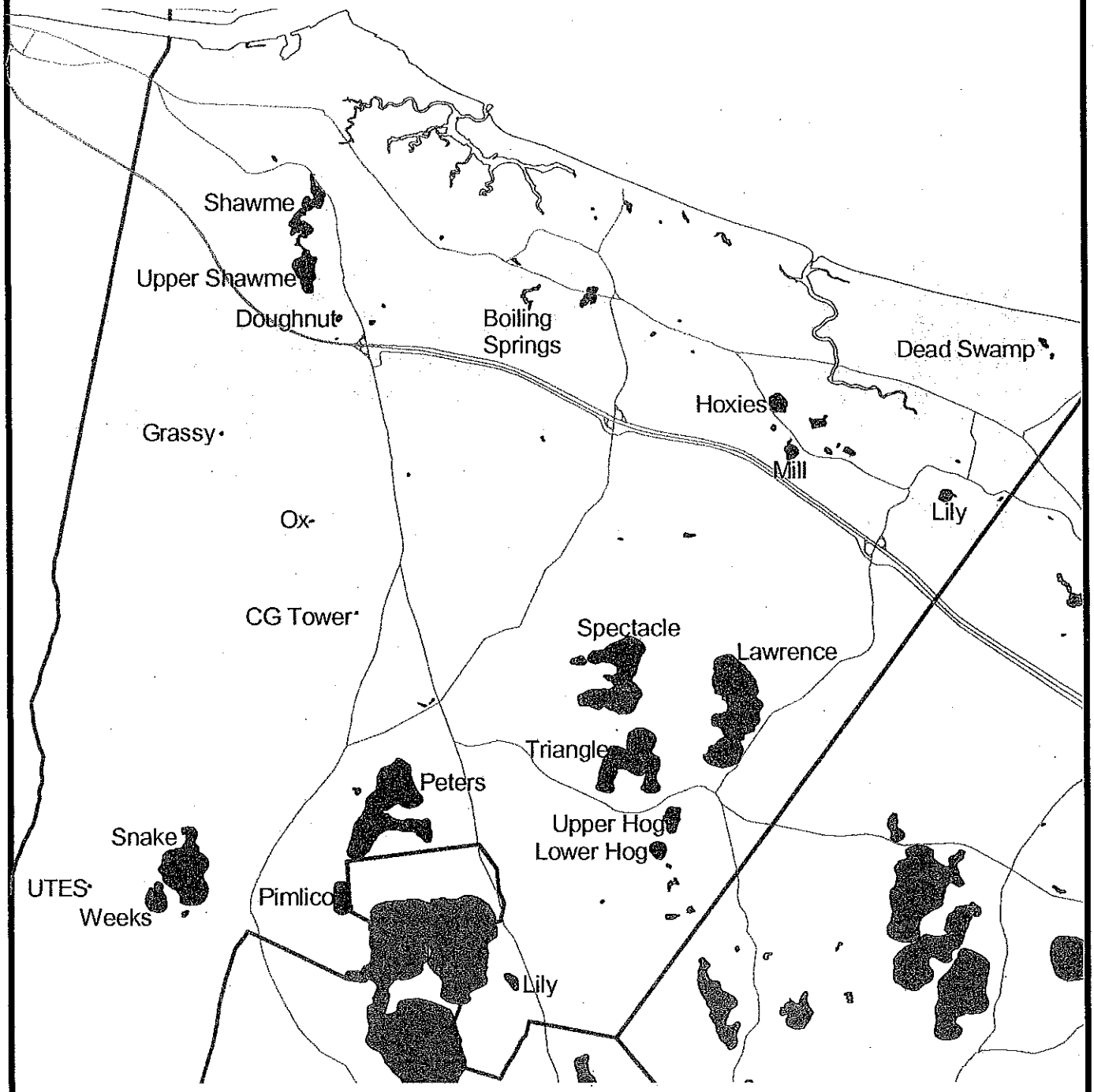
| | |
|---|---|
| # of ponds dipped: | 4 |
| # of volunteers: | 3 |

**Coordinators:**

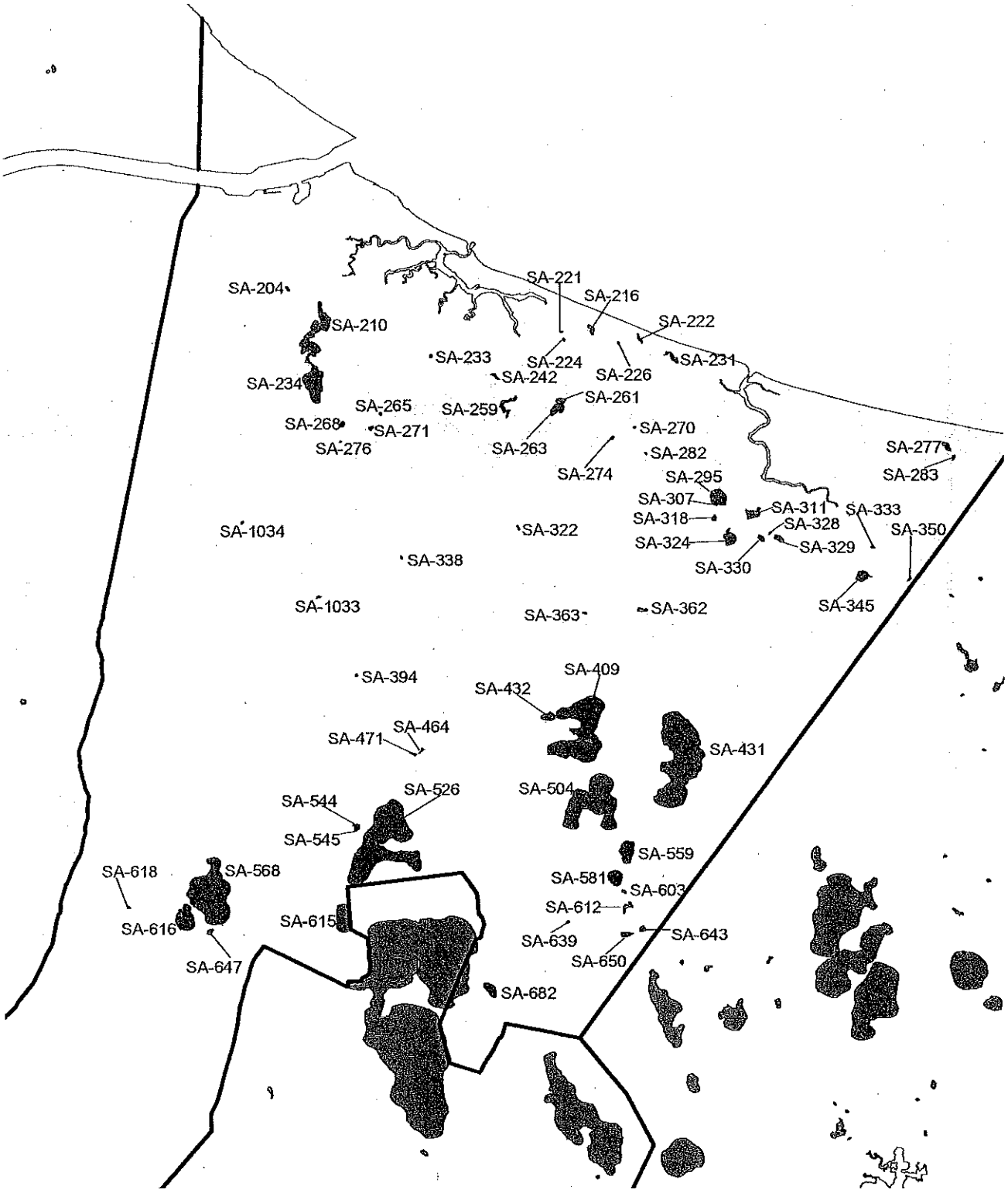
Town staff: Jo Anne Buntich
Citizen:

**Pond Groups:** Shawme Pond Watershed Association, Inc.
Sandwich Pond Monitoring Group

# SANDWICH NAMED PONDS



# GIS ID'S FOR SANDWICH PONDS



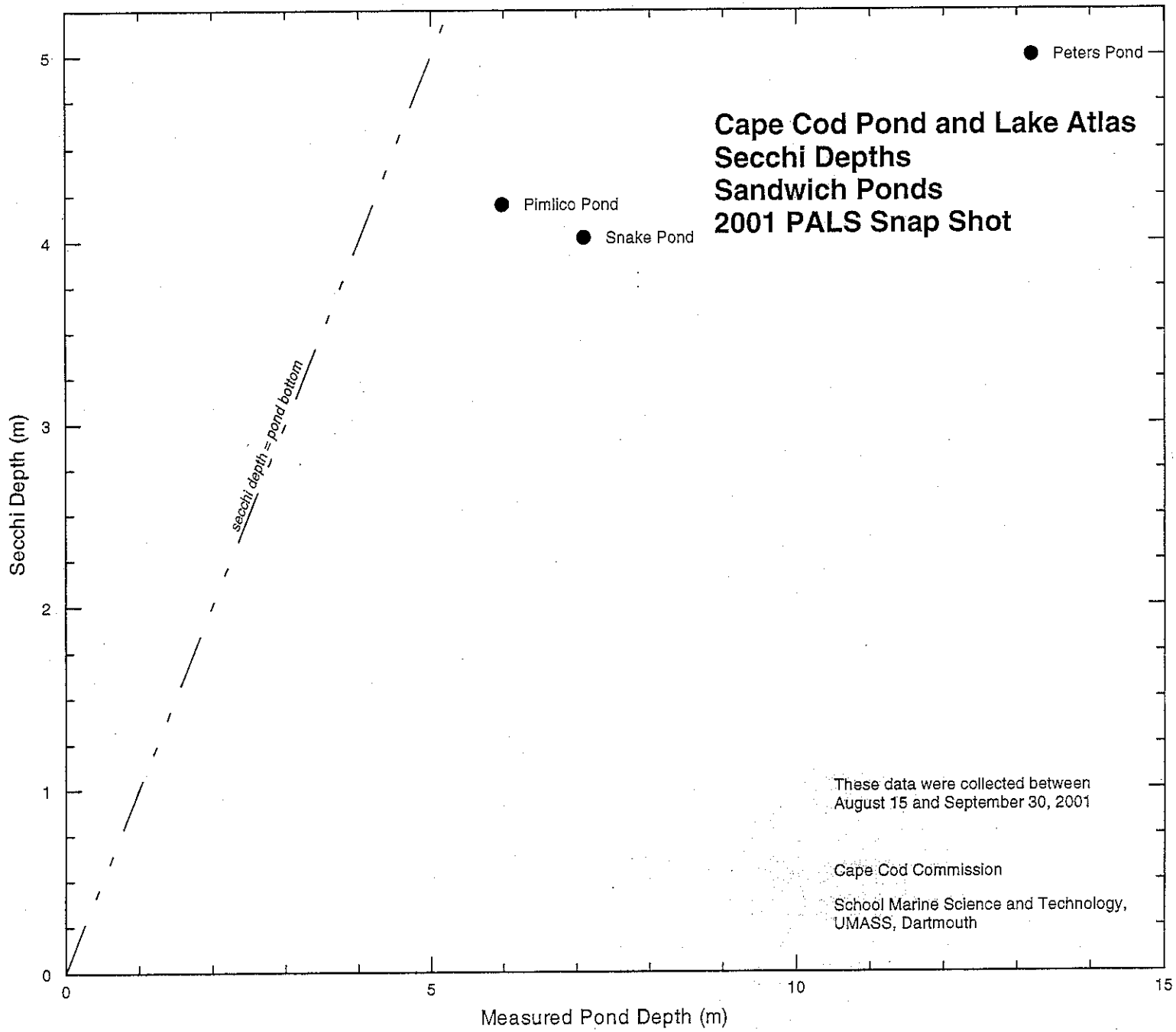

N

1 0 1 Miles

CAPE COD COMMISSION

# Sandwich 2001 PALS Water Quality Snapshot Summary

| | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | ug/l | unimpacted (<1.0 ug/l) | at risk (1-1.7 ug/l) | **impacted (>1.7 ug/l)** | mg/l | unimpacted (<0.16 mg/l) | at risk (0.16-0.31 mg/l) | **impacted (>0.31 mg/l)** | ug/l | unimpacted (<7.5 ug/l) | at risk (7.5-10 ug/l) | **impacted (>10 ug/l)** |
| Peters Pond | 1.67 | | x | | 0.29 | | x | | 8.05 | | x | |
| Pimlico Pond | | | | | 0.32 | | | x | 8.36 | | x | |
| Snake Pond | 1.36 | | x | | 0.16 | | x | | 11.77 | | | x |


Peters Pond
Pimlico Pond
Snake Pond
Cape Cod Pond and Lake Atlas
Secchi Depths
Sandwich Ponds
2001 PALS Snap Shot
secchi depth = pond bottom
These data were collected between
August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology,
UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
0
5
10
15

## SANDWICH POND DATABASE

| Name | CCC GIS ID | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Boiling Springs Pond | SA-259 | | 3.7 | N | | | | | | | |
| CG Tower Pond | SA-394 | | 0.2 | N | | | | | | | |
| Dead Swamp Pond | SA-277 | | 1.8 | N | | 40 | | | | | |
| Doughnut Pond | SA-268 | | 0.9 | N | | | | | | | |
| Goodspeed Cemetary | | 96105 | | | | 55 | | informal | | | |
| Grassy Pond | SA-1034 | | 0.3 | N | | | | | | | |
| Lower Hog Pond | SA-581 | 96141 | 7.8 | N | | 65 | 26 | none | | | |
| Upper Hog Pond | SA-559 | 96142 | 11.3 | N | | 65 | 20 | private | | | |
| Hoxies Pond | SA-295 | 96146 | 8.8 | Y | 4,036 | 15 | 37 | informal | O | | sd |
| Lawrence Pond | SA-431 | 96165 | 133.8 | Y | 59,016 | 61 | 27 | informal | | sd | wq |
| Lily Pond | SA-345 | | 4.8 | N | | | | | | | |
| Lily Pond | SA-682 | | 5.1 | N | | | | | | | |
| Mill Pond | SA-324 | | 5.7 | N | | | | | | | |
| Nye Pond | | 96228 | | | | 35 | 32 | none | O | | sd |
| Old Quaker Meeting House Pond | | 96230 | | | | 15 | 5 | informal | | | |
| Ox Pond | SA-1033 | | 0.3 | N | | | | | | | |
| Peters Pond | SA-526 | 96244 | 130.6 | Y | 109,135 | 67 | 57 | pubramp,concrete | | sd,wq | sd,wq |
| Pimlico Pond | SA-615 | 96247 | 16.4 | Y | 6,524 | 63 | 25 | pubramp | | wq | sd,wq |
| Shawme Lake | SA-210 | 96288 | 25.5 | N | 2,606 | 16 | 16 | informal | I,O | | sd |
| Upper Shawme Lake | SA-234 | 96326 | 23.0 | N | 4,847 | 24 | 24 | pubnoramp | O | | sd |
| Snake Pond | SA-568 | 96302 | 83.5 | Y | 37,016 | 68 | 33 | pubnoramp | | sd,wq | sd,wq |
| Spectacle Pond | SA-409 | 96307 | 97.1 | Y | 55,303 | 63 | 43 | informal | | sd | sd,wq |
| Triangle Pond | SA-504 | 96313 | 83.1 | N | | 62 | 30 | informal | | | sd,wq |
| UTES Pond | SA-618 | | 0.2 | N | | | | | | | |
| Weeks Pond | SA-616 | 96332 | 16.1 | N | | 65 | 15 | informal | | | |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

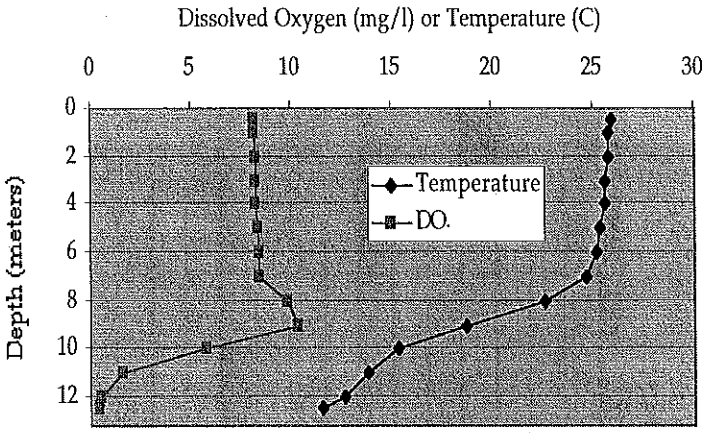
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Peters Pond
## Sandwich
## SA-526

Acreage: 130.6
Maximum Depth: 54 ft
2001 Secchi Dip: 16.6 ft
Lake Association: None




Dissolved Oxygen and Temperature
Peters Pond, 8/29/01

OVERVIEW

Peters Pond is located between Cotuit oad and Route 130, just south of Quaker leeting House Road. The pond is re-arged by groundwater flow from the west id discharges surface water to groundwa-r on the south and east shores. The shoreline is well developed with single family homes, a seasonal mpground, and a gravel mining operation. Public access is provided at a paved boat ramp off of John wer Road and a town right-of-way over a beach area at the southern end of the pond. The pond is heavily ocked in the spring and fall with brook, borwn and rainbow trout. In addition to fishing, swimming and oating are popular recreational activities.

WATER QUALITY

Peters Pond was sampled in 1948, 1997, 1998, 2001, and 2002. In 1948, the August 3 temperature profile ows a well mixed upper layer (*i.e.*, epilimnion) to 30 ft, with a 7°F difference between 30 and 35 ft readings. issolved oxygen (DO) concentrations are generally near satuartion, although concentrations decline from 9.2 ppm 40 ft to 4 ppm at 52 ft (near the bottom). The 2001 PALS temperature profile (shown above) has a well mixed yer to 7 m (23 ft) with a gradual decline in temperature with increasing depth., while the DO is near saturation in e epilimnion below which a slight "bulge" occurs, followed by a rapid decline to anoxic concentrations (<1 ppm) the deepest waters.

The surface TP and TN concentrations collected during the 2001 PALS Snaphot are at or just below Cape Cod mpacted" thresholds, while the chlorophyll *a* concentration exceeds its threshold; all the deep readings exceed the rrent thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the lake in the middle the "oligiotrophic with some deep anoxia" category.

A comparison of the 1948 and 2001 DO profiles shows that Peters Pond has become impaired over the last 50 ars. This impairment is generally associated with the deeper waters, but the 2001 temperature profile has a latively weak stratification, so the higher deep nutrient concentrations reflecting sediment regeneration would be le to seep into the epilimnion. The DO "bulge" is coincident with this seepage depth and is likely due to algae riving utilizing the higher nutrients concentrations. It is recommended that the towns consider a water quality sessment of the Peters Pond, including a more refined monitoring program to evaluate DO, nutrient, and chloro-yll *a* concentrations throughout the summer, a sediment characterization, a land use assessment of shoreline and atershed properties, and a forecast of whether water quality is likely to continue to worsen. Overall, Peters Pond esents as an impacted pond with current water quality problems.

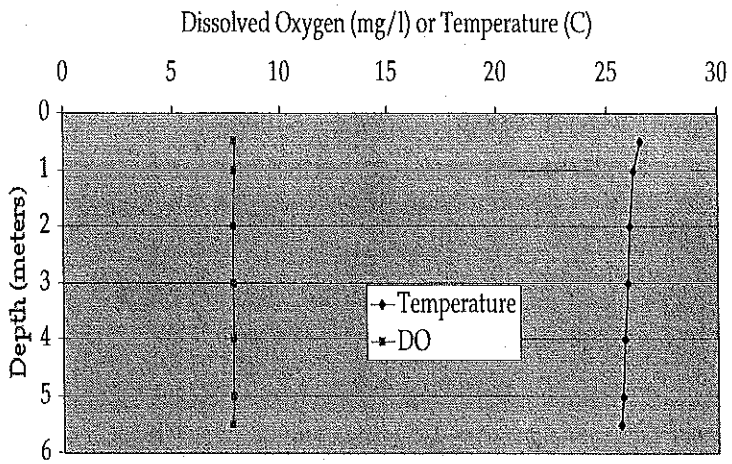
| August 29, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.86 | 4.67 | 11.6 | 8.1 | 0.29 |
| 12 | 6.43 | 19.75 | 14.9 | 27.9 | 0.40 |

# Pimlico Pond

## Sandwich

## SA-615

Acreage: 16.4
Maximum Depth: 25 ft
2001 Secchi Dip: 13.8 ft
Lake Association: None




Dissolved Oxygen and Temperature
Pimlico Pond, 8/29/01

OVERVIEW

Pimlico Pond is located between Cotuit Road and Route 130, just south of Pimlico Pond Road. The pond is recharged by groundwater flow from the northwest and discharges surface water to groundwater on the south and east shores. The shoreline is lighlty developed with single family homes located on the western shore. Public access is provided at an unimproved boat ramp off Pimlico Pond Road. The pond is stocked in the spring with brook, brown and rainbow trout, however the warm waters cannot sustain trout populations over the year.

WATER QUALITY

Pimlico Pond was sampled in the 2001 and 2002 PALS Snapshots. From a review of available documents, these appear to be the first water quality samples collected from Pimlico Pond. The temperature and dissolved oxygen profiles (shown above) are indicative of well mixed conditions throughout the water column.

All of the chlorophyll *a*, TP, and TN concentrations collected during the 2001 PALS Snapshot (see below), except for the deep TP concentrations are at or just below the Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentration places the lake solidly in the oligotrophic category.

Pimilico Pond is an excellent example of the limitations of relying only on water quality information when assessing whether a pond is impacted or not. Field observations at the time of the 2001 sampling found that the bottom of Pimilico Pond is covered with a lush growth of aquatic plants. These plants are storing and likely consuming most of the nutrients that are in or flowing into the pond. Because of this, chlorophyll a concentrations, which are a measure of free floating algae are extremely low. Pimlico Pond has made a transition from the usual Cape Cod pond, algal-dominated ecosystem to an ecosystem dominated by rooted plants. Restoration of this pond to a more typical pond ecosystem would likely require removal of most of the plants and perhaps some of the sediments. Before such an undertaking, it is recommended that the town consider a more refined pond assessment including: a more refined monitoring program to evaluate DO, nutrient, and chlorophyll *a* concentrations throughout the summer, a sediment characterization, a characterization of the extent of rooted plant extent, total mass, and nutrient mass, a land use assessment of shoreline and watershed properties, and a forecast of expected benefits of various restoration activities.

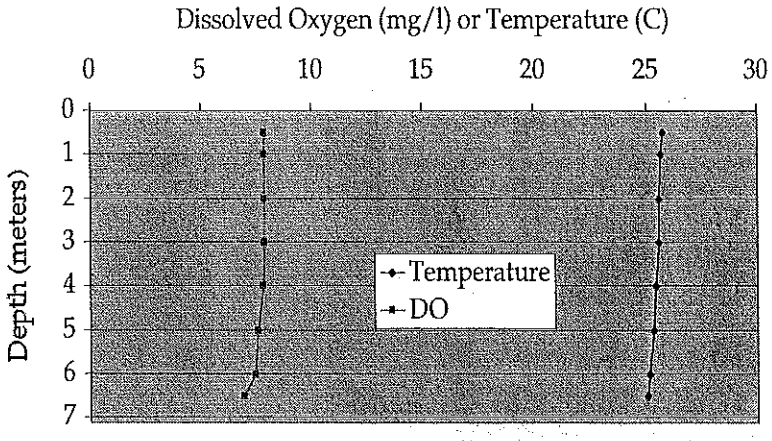
| August 29, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.68 | 0.15 | 4.3 | 8.4 | 0.32 |
| 5 | 6.57 | 1.33 | 4.3 | 11.8 | 0.30 |

# Snake Pond

## Sandwich

## SA-568

Acreage: 83.5
Maximum Depth: 33 ft
2001 Secchi Dip: 13.2 ft
Lake Association: None




Dissolved Oxygen and Temperature
Snake Pond, 8/29/01

OVERVIEW

Snake Pond is located near the Sandwich/Bourne townline west of Route 130 and north of Snake Pond Drive. The pond is recharged by groundwater flow from the north, and contributes surface water to groundwater along the southern shore. The shoreline is well developed with a large town beach, a seasonal summer camp and single family homes. The pond is used extensively for fishing, swimming and boating.

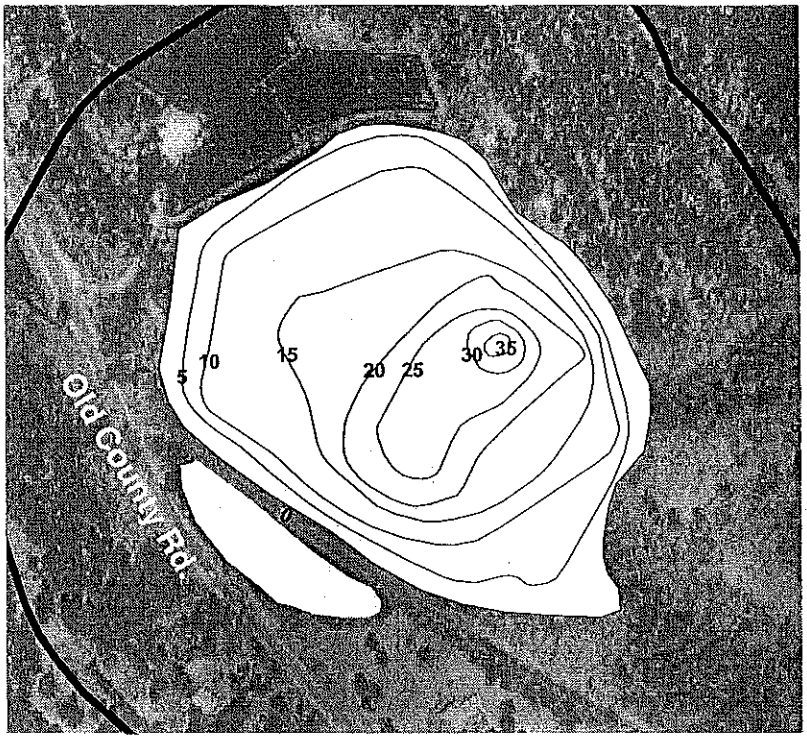
WATER QUALITY

Snake Pond was sampled in 1948, 1980, 1997, 2001, and 2002. In 1948, the August 3 temperature profile shows a well mixed upper layer (*i.e.*, epilimnion) to 30 ft, with a 7°F difference between 30 and 35 ft readings. Dissolved oxygen (DO) concentrations are generally near satuartion, although concentrations decline from 9.2 ppm at 40 ft to 4 ppm at 52 ft (near the bottom). The August 1997 profiles (Jacobs Engineering Group, 1998) generally matches the 1948 profile, while the 1980 and 2001 profiles did not take place over the deepest spot in the lake, so both show well mixed, saturated DO throughout the water column.

The chlorophyll a and TN concentrations collected during the 2001 PALS Snaphot are below the Cape Cod "impacted" thresholds, while the TP concentrations exceed its threshold. The Carlson TSI based on the surface chlorophyll *a* concentrations places the lake in the middle of the "oligiotrophic with some deep anoxia" category.

Water quality in Snake Pond appears to have changed little over the past 50 years. The only potential cause for concern is the slightly elevated TP concentrations. It is recommended that annual water quality sampling of Snake Pond continue in order to monitor this concern. Overall, Snake Pond presents as a realtively clean, largely unimpacted lake.

| August 29, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.63 | 1.36 | 2.9 | 11.8 | 0.16 |
| 6 | 6.64 | 1.87 | 2.9 | 11.8 | 0.04 |




200 0 200 400 600 800 Feet

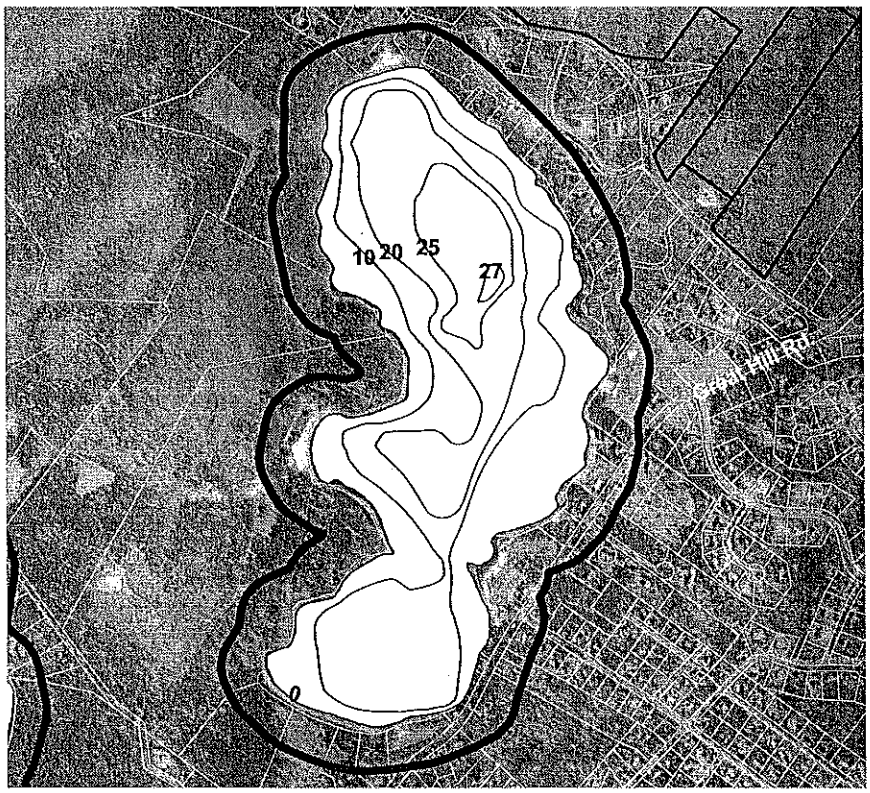
## Hoxie Pond
## Sandwich
## (SA-295)

**Bathymetry Source**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S




1000 0 1000 2000 Feet

## Lawrence Pond
## Sandwich
## (SA-431)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Pond Buffer

N
W E
S


## Peter's Pond
## Sandwich
## (SA-526)

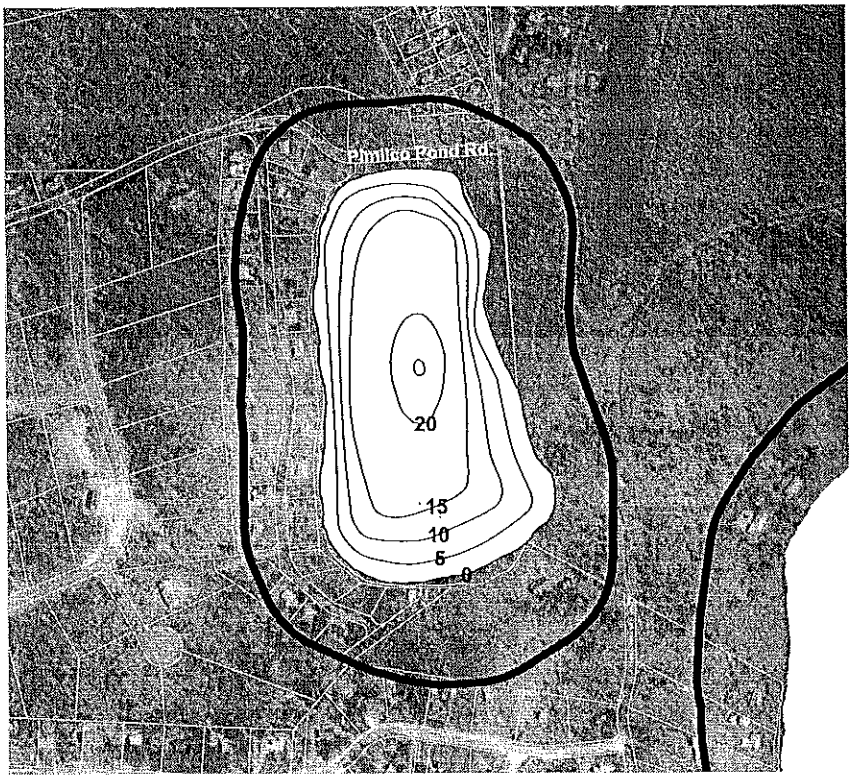
**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

2000 0 2000 4000 Feet




## Pimlico Pond
## Sandwich/Mashpee
## (SA-615)

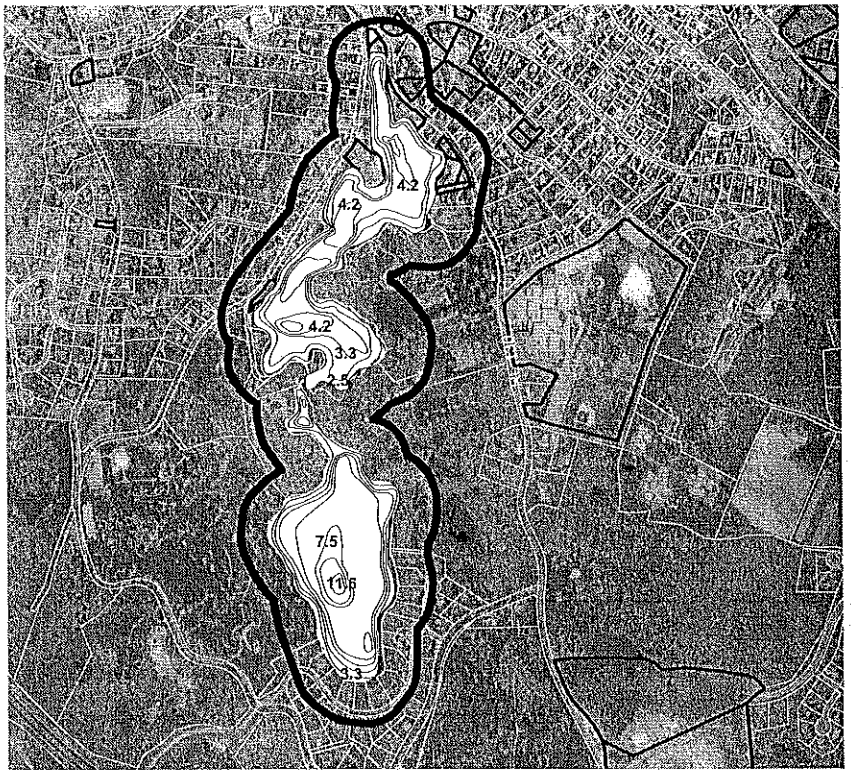
**Bathymetry Source:**
**Division of Fish and Wildlife**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W E
S

600 0 600 1200 1800 Feet




## Upper and Lower Shawme Ponds Sandwich (SA-210/234)

**Bathymetry Source:**
**Division of Fish and Wildlife**

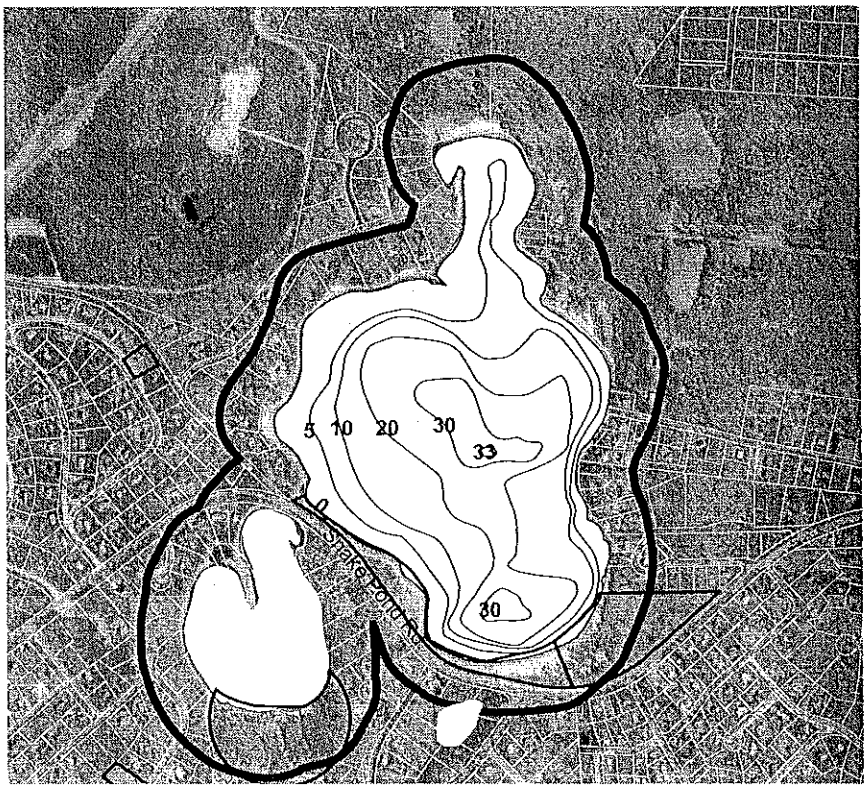
**Bathymetry in feet**

**Town owned land**

**300' Buffer Zone**

N
W E
S

2000 0 2000 4000 Feet




## Snake Pond Sandwich (SA-568)

**Bathymetry Source:**
**Division of Fish and Wildlife**

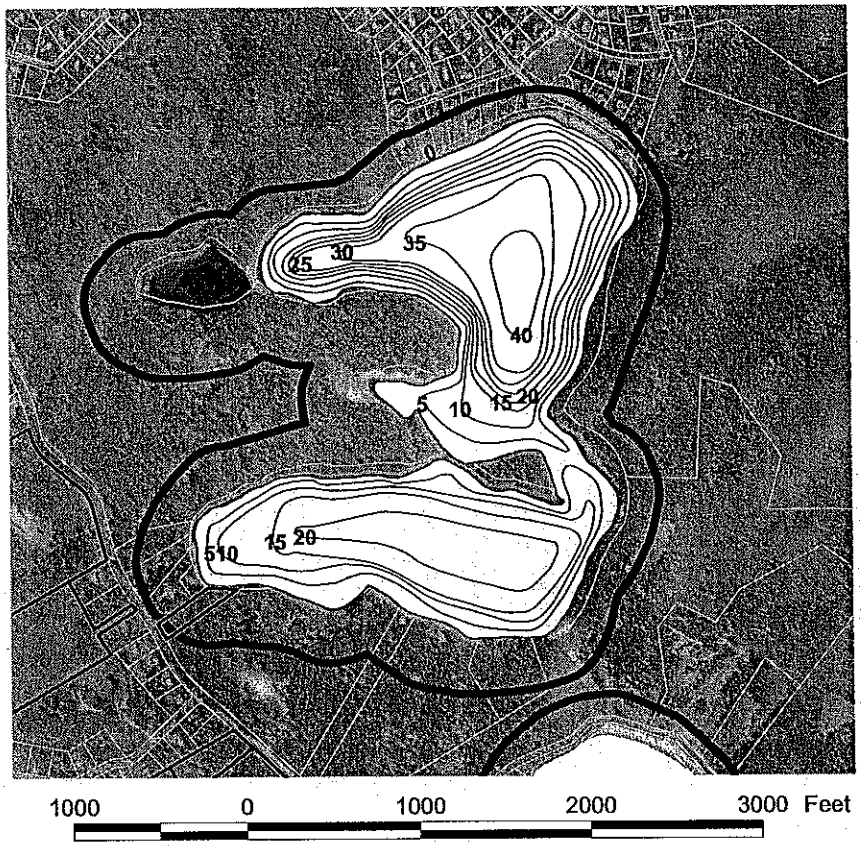
**Town owned land**

**Bathymetry in feet**

**300' Buffer Zone**

N
W E
S

1000 0 1000 2000 3000 Feet



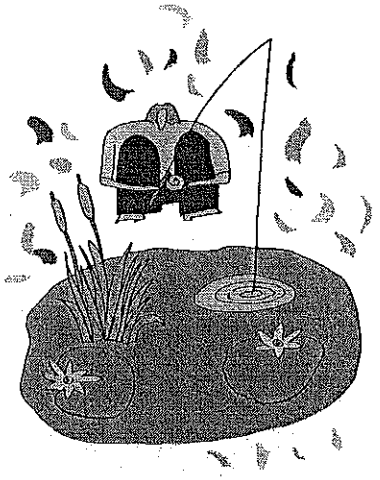

## Spectacle Pond
## Sandwich
## (SA-409)

**Bathymetry Source:**
**Division of Fish and Wildlife**

- Sandwich townowned.shp
- Town owned land
- Bathymetry in feet
- 300' Buffer Zone

N
W E
S

# TRURO PONDS

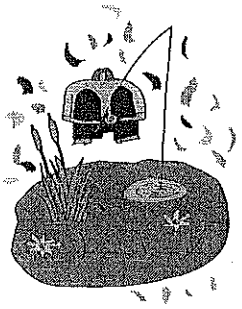


Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:

Great Pond
Round Pond (east)
Round Pond (west)
Ryder Pond
Slough Pond

# Town of Truro Atlas Summary



**Total Land Area (sq. miles):** 35

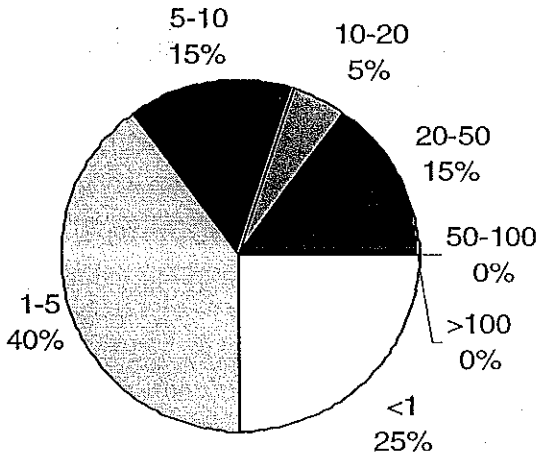
**Total Area of Ponds (acres):** 140

**Total # of Ponds:** 20

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 5 |
| 1-5 acres: | 8 |
| 5-10 acres: | 3 |
| 10-20 acres: | 1 |
| 20-50 acres: | 3 |
| 50-100 acres: | 0 |
| >100 acres: | 0 |

**Number of Truro Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 7 |
| # of impacted ponds | |
| Chlorophyll a: | 1 |
| Total Nitrogen: | 0 |
| Total Phosphorus: | 5 |

**2001 Secchi Dip-In**

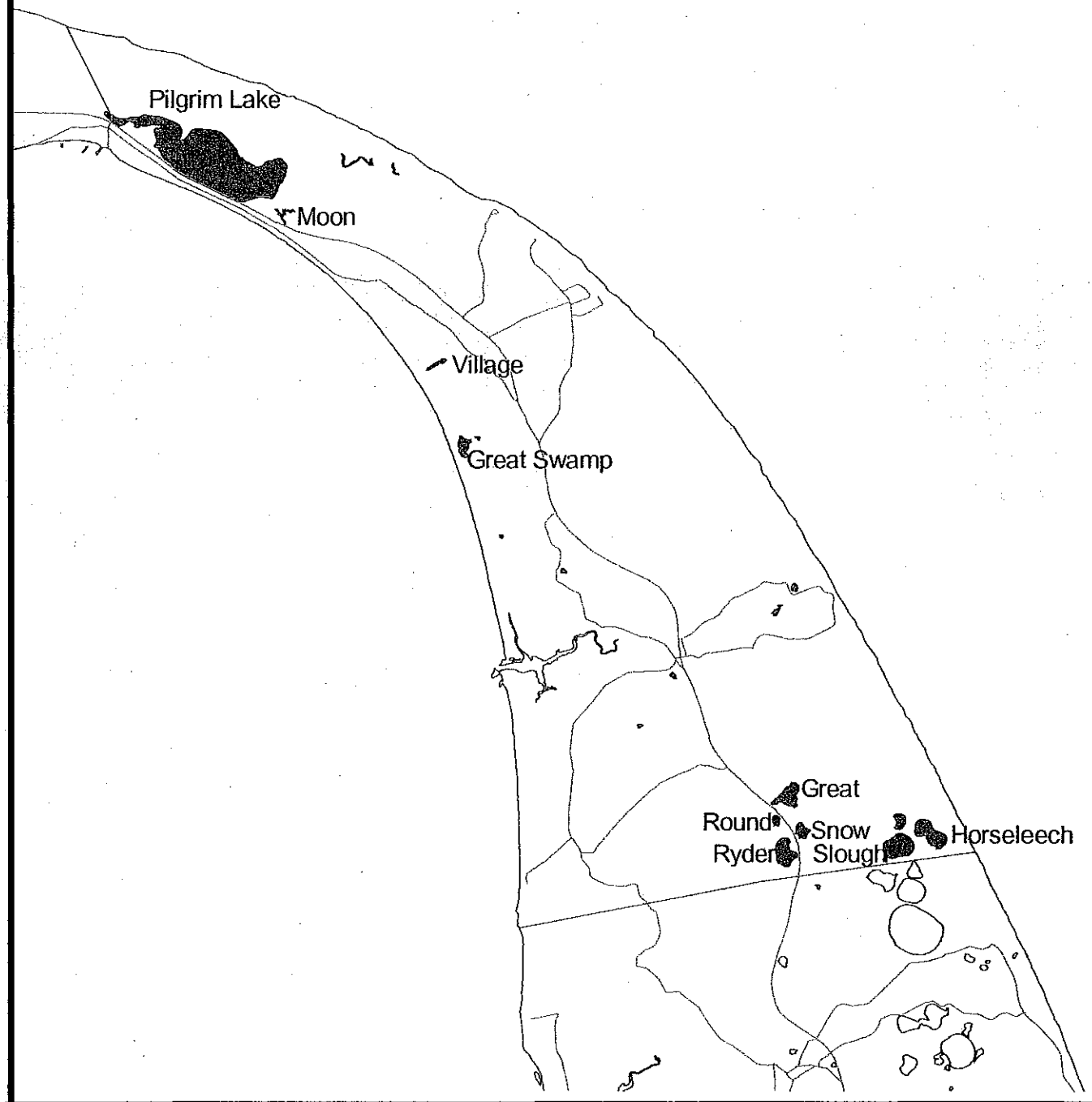
| | |
|---|---|
| # of ponds dipped: | 5 |
| # of volunteers: | 1 |

**Coordinators:**

Most of the ponds in Truro are located within the National Seashore. They have been sampled during the PALS Snapshots through the efforts of Krista Lee, John Portnoy, and Jon Brudreski of the National Park Service.

**Pond Groups:** National Park Service

# TRURO
# NAMED PONDS



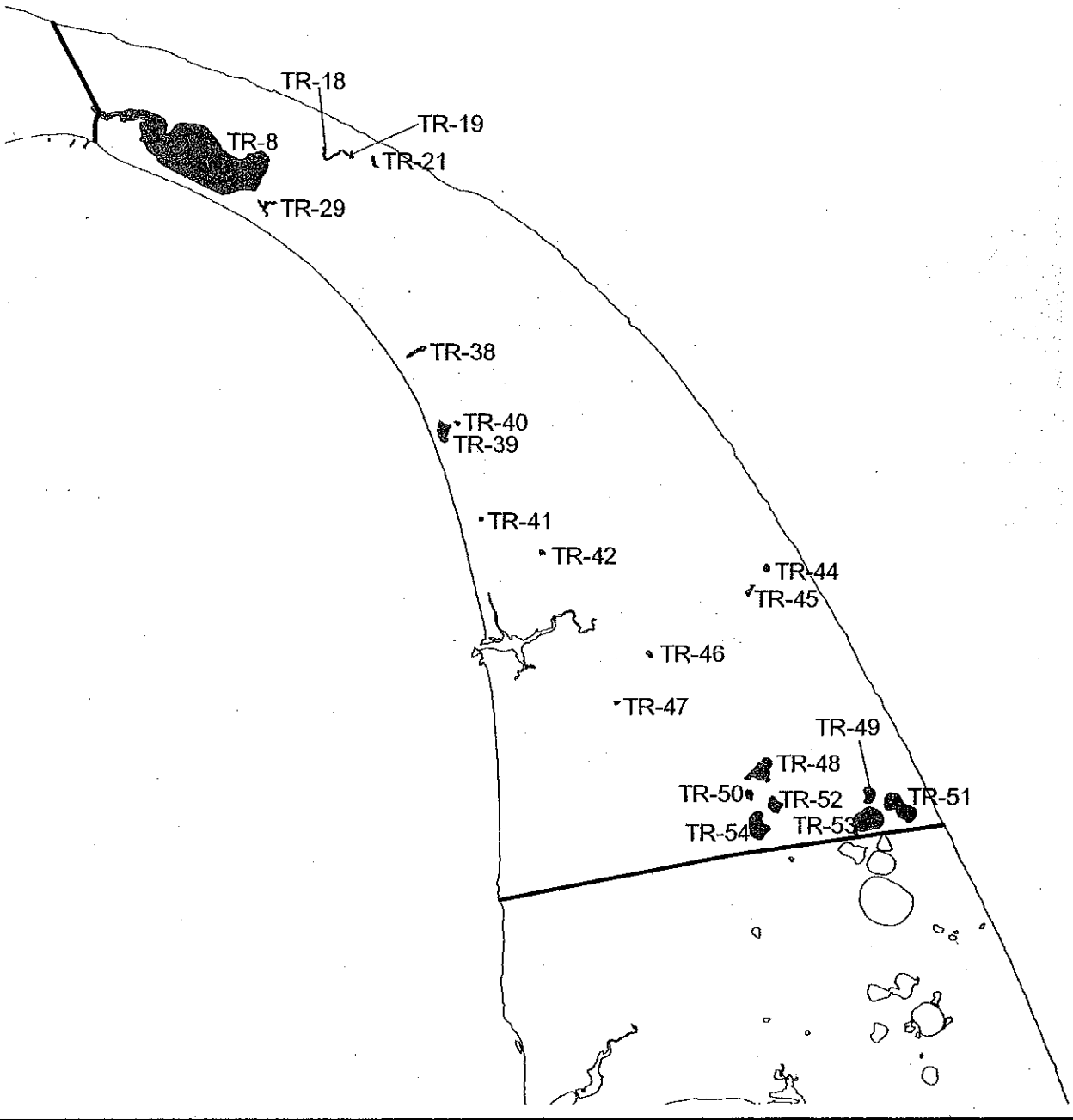

N

1 0 1 2 Miles

COUNTY OF BARNSTABLE MASSACHUSETTS

CAPE COD COMMISSION

# GIS ID'S FOR TRURO PONDS



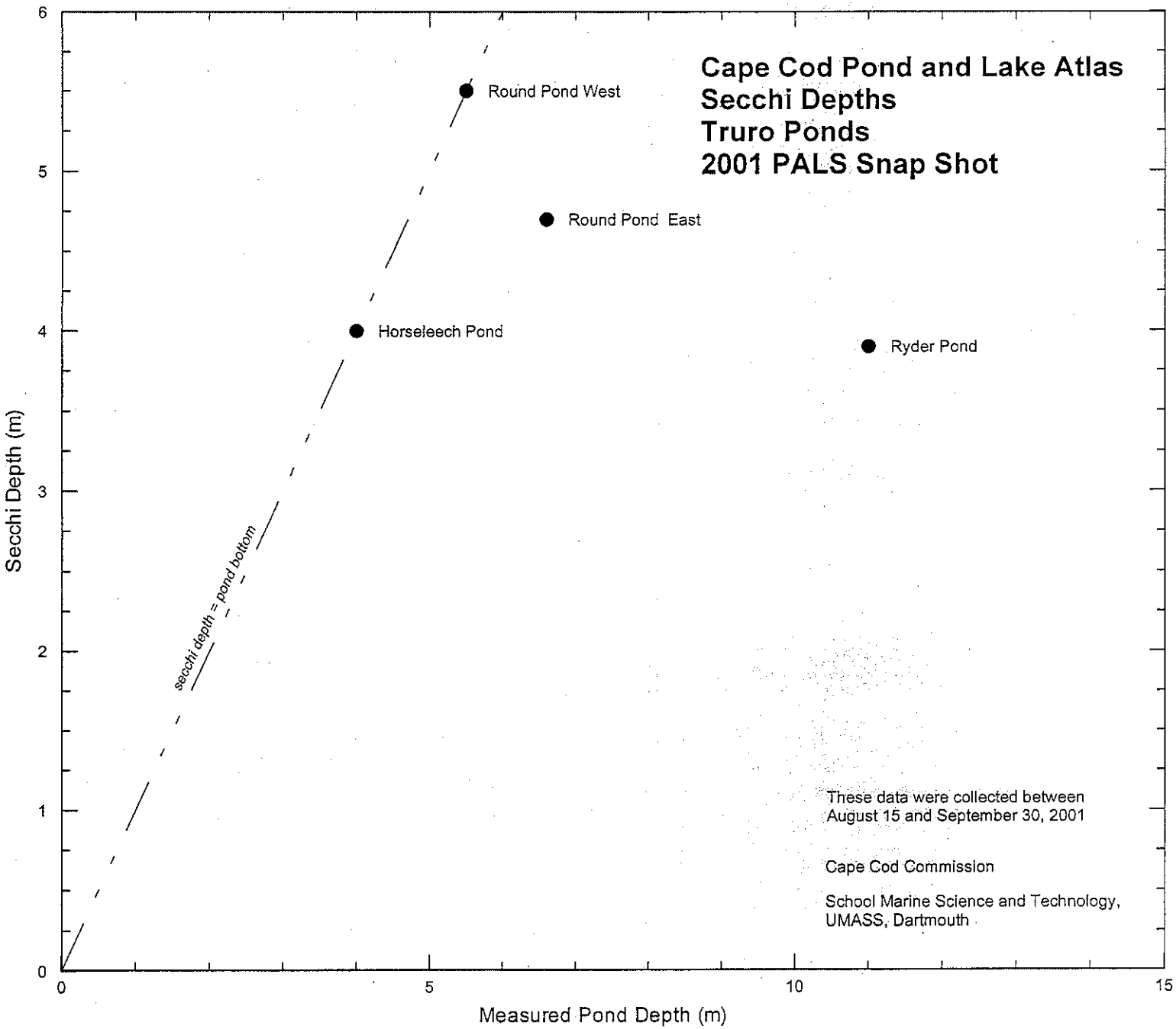

N

1 0 1 2 Miles

CAPE COD COMMISSION

# Truro 2001 PALS Water Quality Snapshot Summary

| Name | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk (1-1.7 ug/l) | impacted (>1.7 ug/l) | mg/l | unimpacted (<0.16 mg/l) | at risk (0.16-0.31 mg/l) | impacted (>0.31 mg/l) | ug/l | unimpacted (<7.5 ug/l) | at risk (7.5-10 ug/l) | impacted (>10 ug/l) |
| Great Pond | 0.67 | x | | | 0.25 | | x | | 10.84 | | | x |
| Horseleech Pond | 0.39 | x | | | 0.22 | | x | | 7.43 | x | | |
| Round Pond East | 1.88 | | | x | 0.18 | | x | | 10.84 | | | x |
| Round Pond West | 1.43 | | x | | 0.18 | | x | | 10.84 | | | x |
| Ryder Pond | 1.66 | | x | | 0.21 | | x | | 10.84 | | | x |
| Slough Pond | 0.97 | x | | | 0.06 | x | | | 7.43 | x | | |
| Snow Pond | 0.34 | x | | | 0.21 | | x | | 14.25 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Truro Ponds
2001 PALS Snap Shot
Round Pond West
Round Pond East
Horseleech Pond
Ryder Pond
secchi depth = pond bottom
These data were collected between
August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology,
UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
6
0
5
10
15

# TRURO POND DATABASE

| Name | CCC GIS ID | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | Monitoring ** 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Great Pond** | TR-48 | 96114 | 18.7 | N | | 9 | 35 | town,CCNS,priv | | sd,wq | sd,wq |
| **Great Swamp Pond** | TR-39 | | 9.0 | Y | 4,838 | | | | | | |
| **Horseleech Pond** | TR-51 | 96144 | 26.2 | N | | 6 | 16 | CCNS/private | | sd,wq | sd,wq |
| **Moon Pond** | TR-29 | 96213 | 2.3 | N | | 5 | | CCNS | | | |
| **Pilgrim Lake** | TR-8 | | 318.0 | N | | | | | | | |
| **Round Pond** | TR-49 | 96261 | 7.3 | Y | 3,491 | 6 | 34 | CCNS/private | | wq | wq |
| **Round Pond** | TR-50 | 96260 | 2.9 | N | | 9 | 30 | CCNS | | wq | wq |
| **Ryder Pond** | TR-54 | 96268 | 20.7 | N | | 9 | 30 | CCNS/private | | sd,wq | sd,wq |
| **Slough Pond** | TR-53 | 96298 | 30.3 | N | | 6 | 25 | CCNS | | sd,wq | sd,wq |
| **Snow Pond** | TR-52 | 96303 | 7.7 | N | | 8 | 26 | informal | | sd,wq | sd,wq |
| **Village Pond** | TR-38 | 96329 | 2.9 | N | | 5 | 5 | Town | | | |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

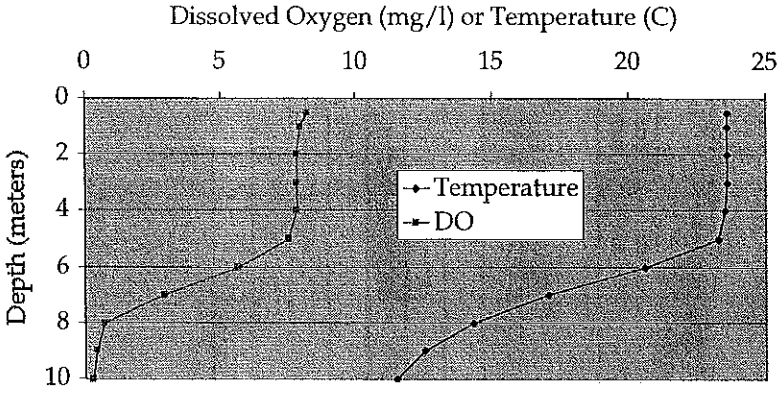
Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Great Pond

## Truro

## TR-48

Acreage: 18.7
Maximum Depth: 35 ft
2001 Secchi Dip: 26 ft
Lake Association: None




Dissolved Oxygen and Temperature
Great Pond, 9/5/01

OVERVIEW

Great Pond is located east of Route 6, mile north of the Wellfleet/Truro town line the Cape Cod National Seashore. The ond is recharged by groundwater flow from the northeast and discharges surface water to groundwater to the south nd west. There are several residential homes located adjacent to the pond. Public access is provided at the outhwestern end of the pond via a dirt path. Recreational activities include swimming, fishing and small boat use. he pond is stocked with brook trout by the MA Division of Fish and Wildlife. Other fish species include brown ullhead, banded killifish, pumpkinseed sunfish smallmouth bass and yellow perch.

WATER QUALITY

Various parameters have been measured in Great Pond in 1973, 1975-1976, 1978, and 1982--2002. The arliest dissolved oxygen (DO) profile for Great Pond was apparently collected in February 1984 by the National ark Service; review of profiles since then generally show deep anoxic concentrations (<1 ppm) developing in June, rogressively rising up to the bottom of the epilimnion (i.e., usually around the 7 m depth) in late summer/early fall, nd then returned to high oxygen levels by turnover late in the fall. Since comprehensive DO data does not exist efore 1990, it is impossible to ascertain if the generally observed concentrations have worsened or improved over ie last 50 years.

All the water quality readings collected during the 2001 PALS Snapshot (see below) except for the deepest utrient concentrations are less than the Cape Cod "impacted" thresholds. The surface concentrations are consistent ith previous NPS sampling. The higher deep concentrations are likely due to the anoxic conditions causing the elease of nutrients usually bound in the sediments. A Carlson TSI based on the surface chlorophyll concentration laces Great Pond in the oligiotrophic category.

Water quality conditions in Great Pond appear to have been fairly stable for the past decade; although the ottom anoxia will likely cause surface water quality to be impaired on occasion. Water quality results from other 'ape Cod ponds show that the anoxia is generally a condition that has developed during the last century, which uggests that a more refined review of available data be combined into a water quality assessment of the Great Pond help understand how the water quality problems in the pond have developed. This review should include a view of available sediment data, a land use assessment of historic shoreline and watershed properties, develop- ient of a water budget, and a forecast of whether the observed water quality problems are likely to worsen. Overall, reat Pond presents as an impacted pond with existing water quality problems.

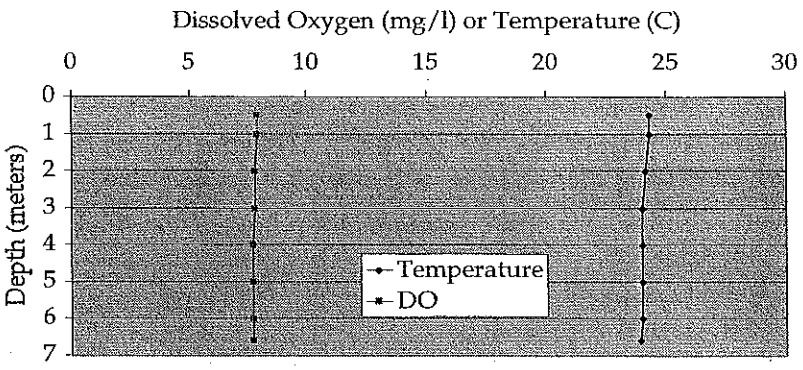
| September 5, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 5.67 | 0.67 | 1.5 | 10.8 | 0.25 |
| 3 | 6.01 | 0.60 | 1.5 | 7.7 | 0.21 |
| 9 | 5.71 | 0.75 | 4.9 | 14.2 | 0.36 |

# Round Pond (East)

## Truro

## TR-49

Acreage: 7.3
Maximum Depth: 34 ft
2001 Secchi Dip: 15 ft
Lake Association: None




Dissolved Oxygen and Temperature
Round Pond (East), 9/5/01

OVERVIEW

Round Pond (East) is located in the Cape Cod National Seashore, approximately a mile east of Route 6 just over the Wellfleet/Truro town. Round Pond is the northernmost pond is a string of ponds including Gull, Higgins, Herring, Slough, and Horseleech Pond. The pond receives groundwater recharge from the northwest and contributes surface water to groundwater along its southeast shoreline. Development is limited to a single residential home on the south shore. Public access is limited to dirt trails and footpaths. Recreational activities include fishing and ice skating.

WATER QUALITY

Various parameters have been measured in Round Pond (East) in 1975-1976 and 1984-2002. The earliest dissolved oxygen (DO) profile for Round Pond (East) was apparently collected in May 1993 by the National Park Service; review of available profiles since then generally show well mixed temperature and DO throughout the water column, although limited summer profiles generally show hypoxic (<4 ppm) to anoxic (<1 ppm) concentrations near the bottom. The 2001 PALS profiles (shown above) reflect a well mixed, well oxygenated water column; these conditions are common in shallower ponds where winds are strong enough to maintain these conditions.

Water quality readings collected during the 2001 PALS Snapshot (see below) are generally just above the Cape Cod "impacted" thresholds, except for total nitrogen and pH which are below the thresholds. A Carlson TSI based on the surface chlorophyll concentration places the pond in the oligiotrophic with some bottom anoxia category.

Because Round Pond (East) is located within the National Seashore, nutrients released from the sediments during the periods of bottom anoxia will be the most significant source of nutrients to the organisms in the pond. Given this situation, it is likely that water quality in Round Pond (East) will remain fairly stable unless recreational uses of the pond increase. The National Park Service may want to consider conducting a summer algal survey to establish a baseline. Round Pond (East) presents as a relatively clean, slightly impacted pond.

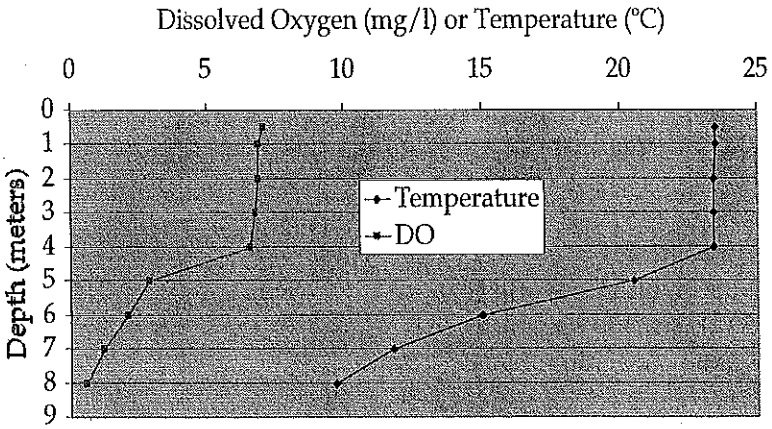
| September 5, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 5.46 | 1.88 | 0.9 | 10.8 | 0.18 |
| 6 | 5.56 | 2.99 | 1.0 | 14.2 | 0.20 |

# Round Pond (West)

## Truro

## TR-50

Acreage: 2.9
Maximum Depth: 30 ft
2001 Secchi Dip: 18 ft
Lake Association: none




Dissolved Oxygen and Temperature
Round Pond (West), 9/5/01

OVERVIEW

Round Pond (West) is located in the Cape Cod National Seashore, adjacent to the west side of Route 6 and just over the Wellfleet/Truro town. The pond receives groundwater recharge from the northeast and contributes surface water to groundwater along its southwest shoreline. There is no development around the pond and no public access.

WATER QUALITY

Various parameters have been measured in Round Pond (West) in 1955-1957, 1975-1976, 1978, and 1982-2002. The earliest dissolved oxygen (DO) profile for Round Pond (West) was apparently collected in August 1955 by the Massachusetts Division of Fisheries and Game. Further review of DFW files show that the pond was extensively managed with at least four poison applications in the early 1960's to "reclaim" the pond for trout additions; trout were added to the pond every year between 1955 and 1962. Review of available summer DO and temperature profiles since the mid-1950's, including the 2001 PALS Snapshot data shown above, generally show a well mixed upper layer *(i.e.*, epilimnion) to a depth of 4 m with declining temperature and DO below 4 m. Comparison of the 1950's DO profiles to more recent ones show a slight increase in the thickness of the bottom hypoxic layer (concentrations < 4 ppm), but the profiles are fairly consistent over the past 45 years.

Water quality readings collected during the 2001 PALS Snapshot (see below) are at or just below the Cape Cod "impacted" thresholds, except for the deep readings which are likely increased by bottom anoxia (<1 ppm DO concentrations) causing regeneration of nutrients usually bound in the sediments. A Carlson TSI based on the surface chlorophyll concentration places the pond in the oligiotrophic with some bottom anoxia category.

A review of historic dissolved oxygen profiles suggest that water quality conditions within Round Pond (West) have been relatively stable and are likely to remain so given the pond's location within the National Seashore. Water quality conditions are impacted with low DO conditions releasing nutrients back into the water column during the summer and causing a habitat impairment for the deeper portions of the pond. Given that review of ponds with similar depths show DO concentrations greater than 8 ppm down to depths of at least 8 m, the National Park Service may want to consider addressing this impairment following a more comprehensive review of all the available pond data. Round Pond (West) presents as a relatively clean pond with impaired deep waters.

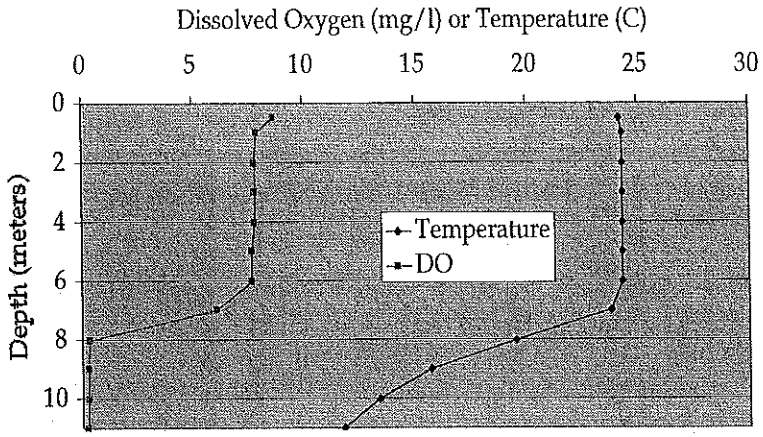
| September 5, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 4.88 | 1.43 | BDL | 10.8 | 0.18 |
| 3 | 4.90 | 1.04 | BDL | 9.3 | 0.19 |
| 7 | 4.67 | 8.00 | BDL | 87.0 | 0.52 |
| BDL = Below Detection Limit (ALK DL = 0.5 mg/L) | | | | | |

# Ryder Pond

## Truro

## TR-54

Acreage: 20.7
Maximum Depth: 30 ft
2001 Secchi Dip: 13 ft
Lake Association: None




Dissolved Oxygen and Temperature
Ryder Pond, 9/5/01

OVERVIEW

Ryder Pond is located in the Cape Cod National Seashore, west of Route 6 just over the Wellfleet/Truro townline. The pond receives groundwater recharge from the northeast and contributes surface water to groundwater along its southwest shoreline. There is no development around the pond and no public access.

WATER QUALITY

Various parameters have been measured in Ryder Pond in 1975-1976, 1978, and 1983-2002. The earliest dissolved oxygen (DO) profile for Ryder Pond was apparently collected in Feburary 1984 by the National Park Service; review of available summer profiles since then generally show well mixed temperature and DO to between 5 and 7 m depth with bottom anoxic DO concentrations (<1 ppm) that begin at 10 m early in the summer and rising to 8 to 9 m by the end of the summer. The September 5 PALS profile shown above is fairly typical for early September. Some winter profiles also show persistent bottom anoxia.

Water quality readings collected during the 2001 PALS Snapshot (see below) are generally close to the Cape Cod "impacted" thresholds, except for the deep readings which are likely increased by bottom anoxia (<1 ppm DO concentrations) causing regeneration of nutrients usually bound in the sediments. A Carlson TSI based on the surface chlorophyll concentration places the pond in the middle of the oligiotrophic with some bottom anoxia category.

A review of historic dissolved oxygen profiles suggest that water quality conditions within Ryder Pond have been relatively stable and are likely to remain so given the pond's location within the National Seashore. Water quality conditions are impaired by anoxic DO conditions releasing nutrients back into the water column during the summer and causing a habitat impairment for the deeper portions of the pond. Given that review of ponds with similar depths show DO concentrations greater than 8 ppm down to depths of at least 8 m, the National Park Service may want to consider addressing this impairment following a more comprehensive review of all the available pond data. Ryder Pond presents as a relatively clean pond with impaired deep waters.

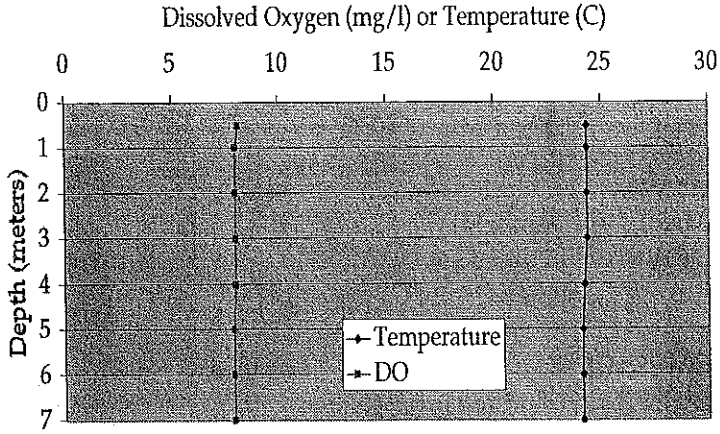
| September 5, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 5.95 | 1.66 | 1.4 | 10.8 | 0.21 |
| 3 | 5.79 | 1.66 | 1.4 | 14.2 | 0.19 |
| 9 | 5.83 | 24.75 | 5.6 | 23.5 | 0.30 |
| 10 | 5.84 | 21.71 | 5.7 | 30.0 | 0.32 |

# Slough Pond

## Truro

## TR-53

Acreage: 30.3
Maximum Depth: 25 ft
2001 Secchi Dip: 16 ft
Lake Association: None




Dissolved Oxygen and Temperature
Slough Pond, 9/5/01

OVERVIEW

Slough Pond is located in the Cape Cod National Seashore, east of Route 6 just over the Wellfleet/Truro town. Slough Pond is part of a string of ponds including Gull, Higgins, Herring, Round, and Horseleech Pond. The pond receives groundwater recharge from the northwest and contributes surface water to groundwater along its southeast shoreline. The shoreline is lightly developed with single family seasonal homes. There is no public access.

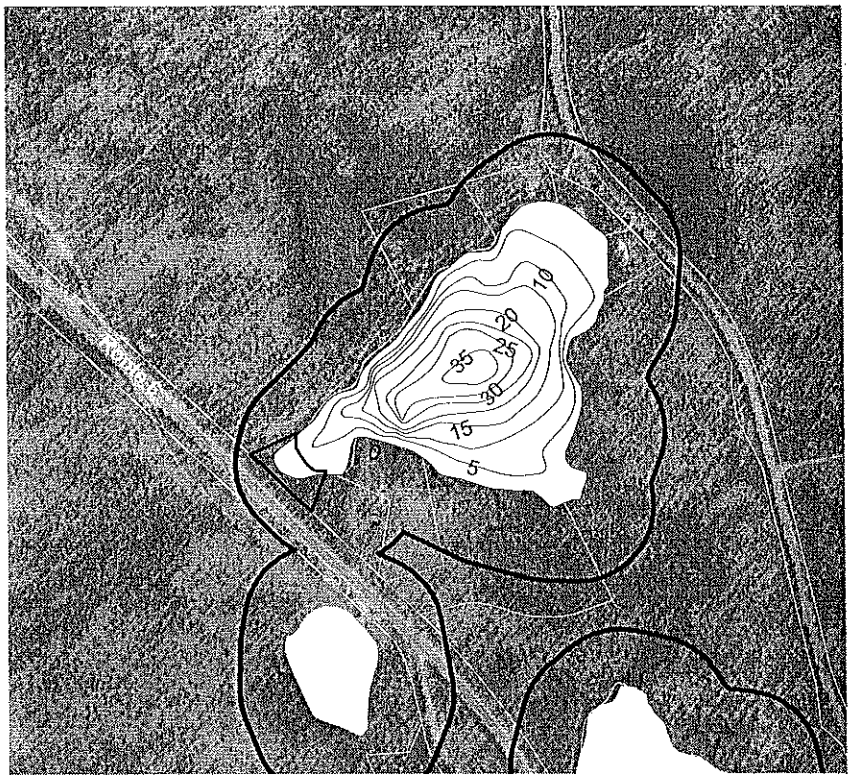
WATER QUALITY

Various parameters have been measured in Slough Pond in 1952, 1975-1976, 1978, 1982, and 1984-2002. The earliest dissolved oxygen (DO) profile for Slough Pond was apparently collected in August 1990 by the National Park Service; review of available profiles since then generally show well mixed temperature and DO throughout the water column with an occasional hypoxic (<4 ppm) concentration near the bottom. The DO and temperature PALS profiles shown above reflect a well mixed, well oxygenated water column; these conditions are common in shallower ponds where winds are strong enough to maintain these conditions and sediment biodegradation is limited. These profiles are fairly typical for the profiles collected in Slough Pond throughout the summer with lower temperatures and higher DO concentrations observed during the winter.

Water quality readings collected during the 2001 PALS Snapshot (see below) are at or below the Cape Cod "impacted" thresholds, including the thresholds developed from the unimpacted or reference ponds. During the development of the Cape Cod thresholds, Slough Pond was identified as one of the eight reference ponds for Cape Cod. A Carlson TSI based on the surface chlorophyll concentration places the pond on the boundary between the oligotrophic and oligiotrophic with some bottom anoxia categories.

Slough Pond was selected as one of the Cape Cod reference ponds because all of its surface water quality measures are in the lowest 25th percentileamong all ponds measured during the 2001 PALS Snapshot. Historic DO profiles and Secchi readings over the past decade have been relatively stable. Slough Pond presents as a clean, largely unimpacted lake.

| September 5, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 4.96 | 0.97 | 0.4 | 7.4 | 0.06 |
| 6 | 4.97 | 1.58 | 0.4 | 9.0 | 0.07 |



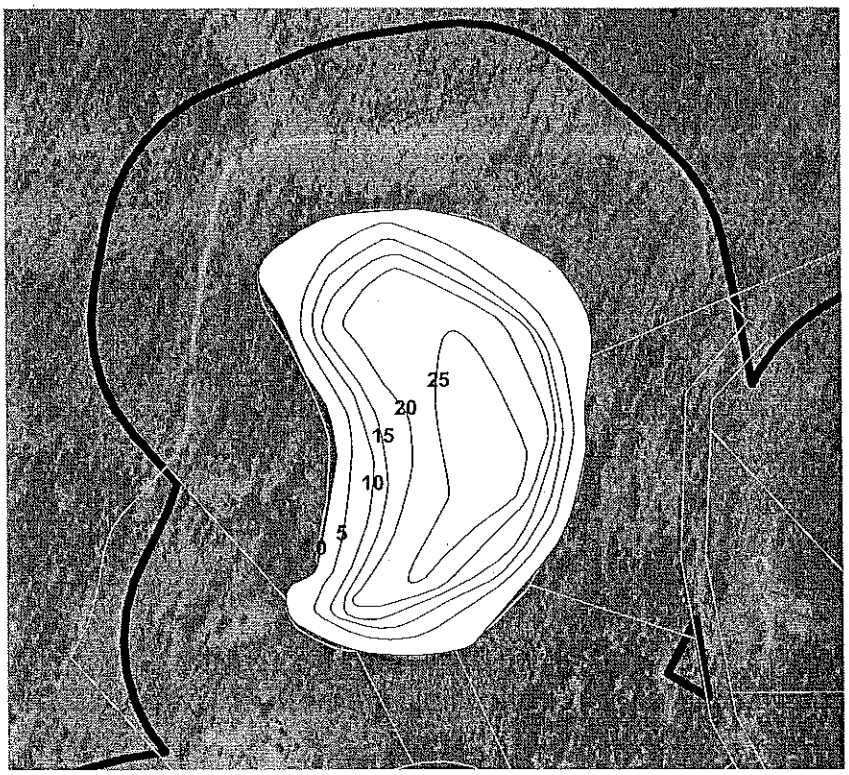

1000 0 1000 2000 Feet

## Great Pond Truro (TR-48)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet
Town owned land
300' Buffer Zone

N
W E
S




200 0 200 400 600 Feet

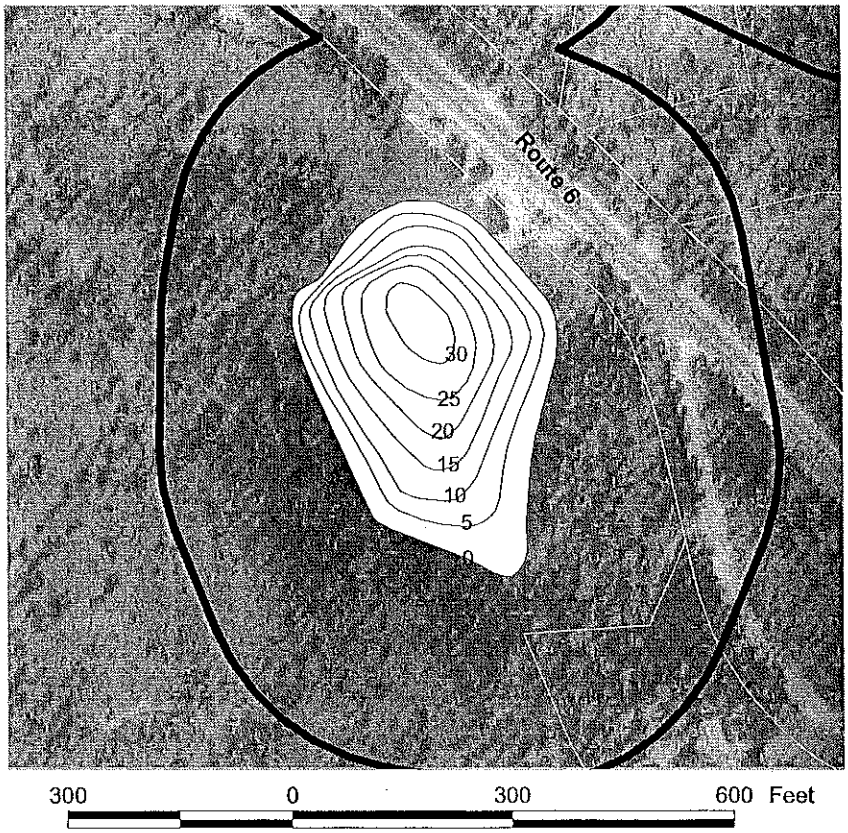
## Round Pond East Truro (TR-49)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet

300' Buffer Zone

N
W E
S



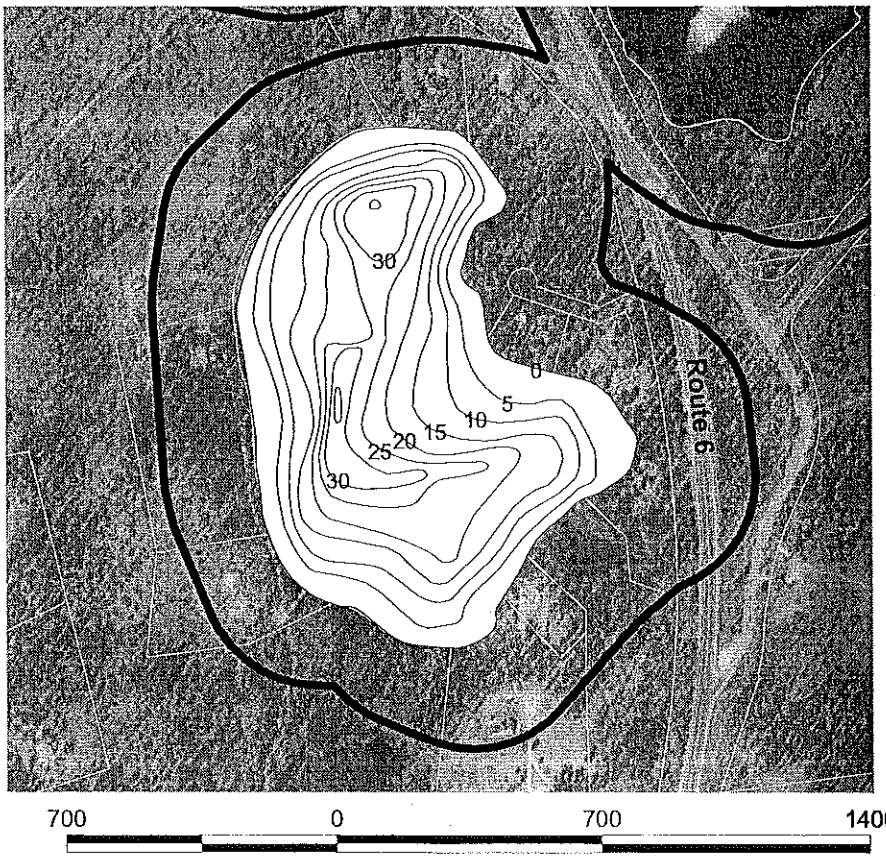

## Round Pond West
## Truro
## (TR-50)

**Bathymetry Source:**
**Unknown**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W
E
S



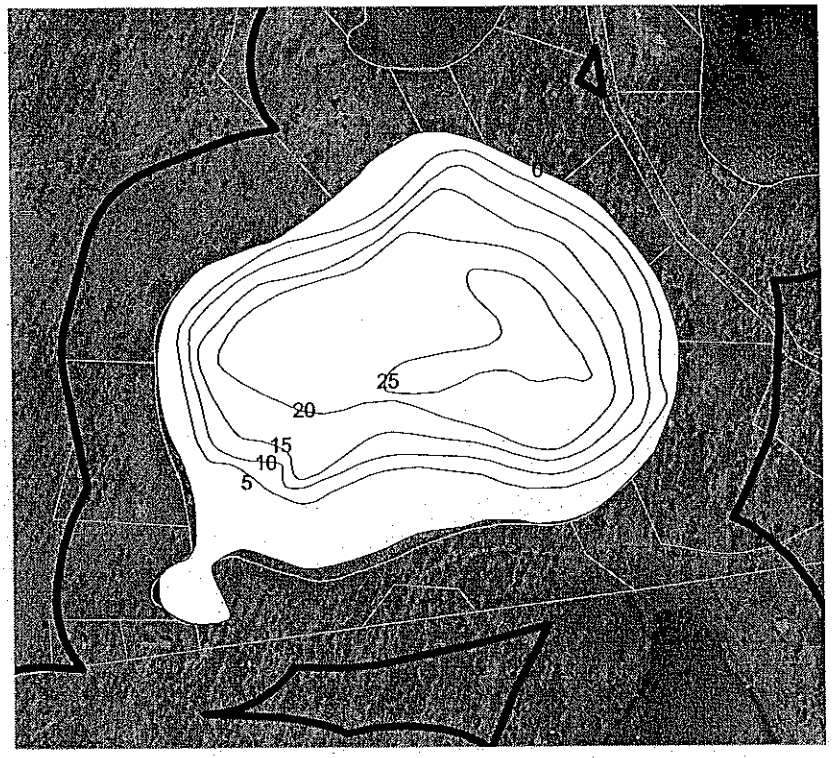

## Ryder Pond
## Truro
## (TR-54)

**Bathymetry Source:**
**National Park Service**

Town owned land
Bathymetry in feet

300' Buffer Zone

N
W
E
S




500 0 500 1000 1500 Feet

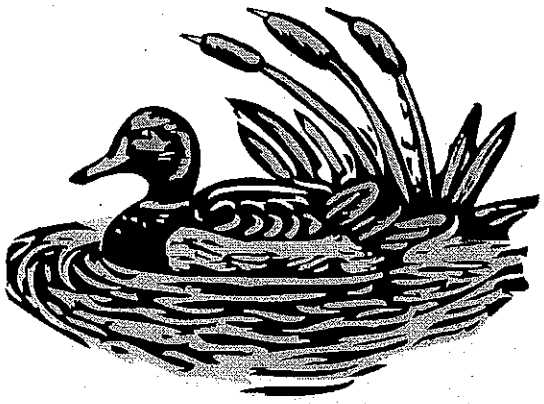
## Slough Pond
## Truro
## (TR-53)

**Bathymetry Source:**
**Division of Fish and Wildlife, 1952**

Town owned land
Bathymetry in feet
Slough Pond
300' Buffer Zone

N
W E
S

# WELLFLEET PONDS



Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

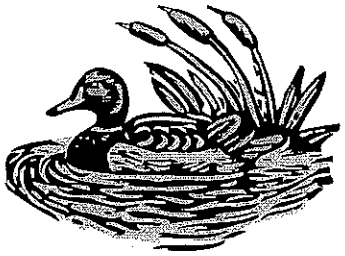
With Map and Description:

Duck Pond
Gull Pond
Kinnacum Pond
Long Pond

Map Only:

Dyer Pond

# Town of Wellfleet Atlas Summary



**Total Land Area (sq. miles):** 20.47

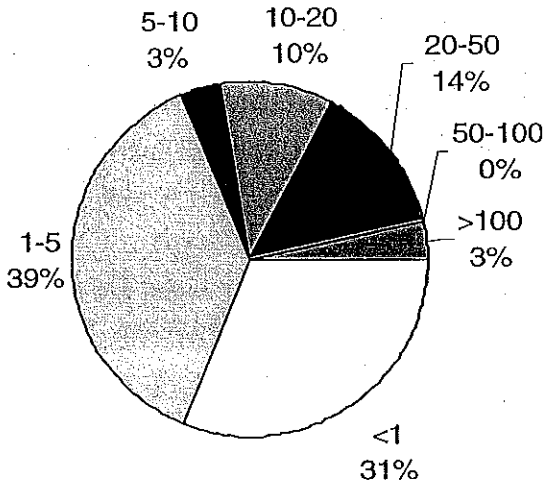
**Total Area of Ponds (acres):** 330

**Total # of Ponds:** 29

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 9 |
| 1-5 acres: | 11 |
| 5-10 acres: | 1 |
| 10-20 acres: | 3 |
| 20-50 acres: | 4 |
| 50-100 acres: | 0 |
| >100 acres: | 1 |

**Number of Wellfleet Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 14 |
| # of impacted ponds | |
| Chlorophyll a: | 1 |
| Total Nitrogen: | 5 |
| Total Phosphorus: | 6 |

**2001 Secchi Dip-In**

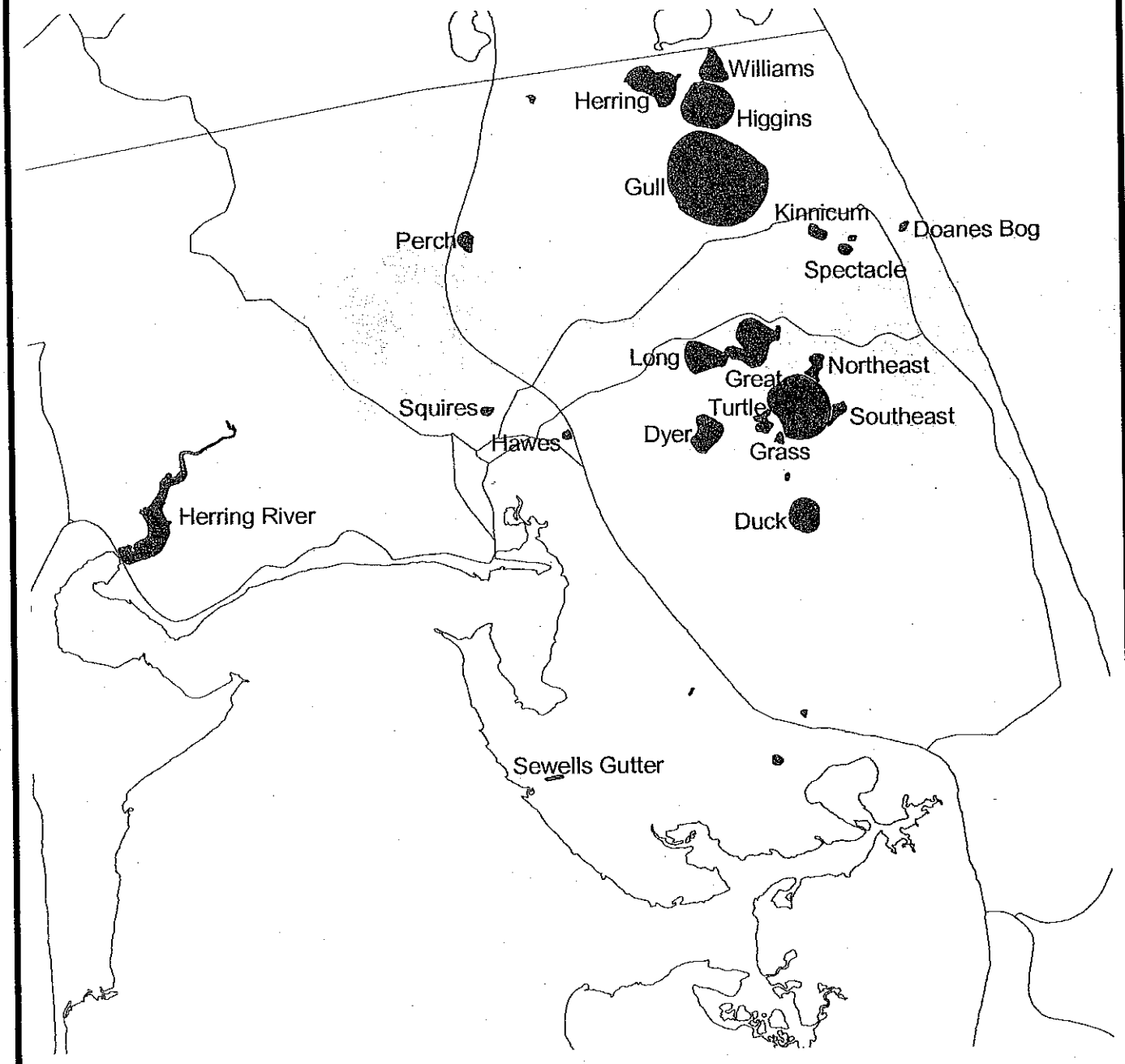
| | |
|---|---|
| # of ponds dipped: | 11 |
| # of volunteers: | 2 |

**Coordinators:**

Most of the ponds in Wellfleet are located within the National Seashore. They have been sampled during the PALS Snapshots through the efforts of Krista Lee, John Portnoy, and Jon Brudreski of the National Park Service.

**Pond Groups:** National Park Service

# WELLFLEET NAMED PONDS

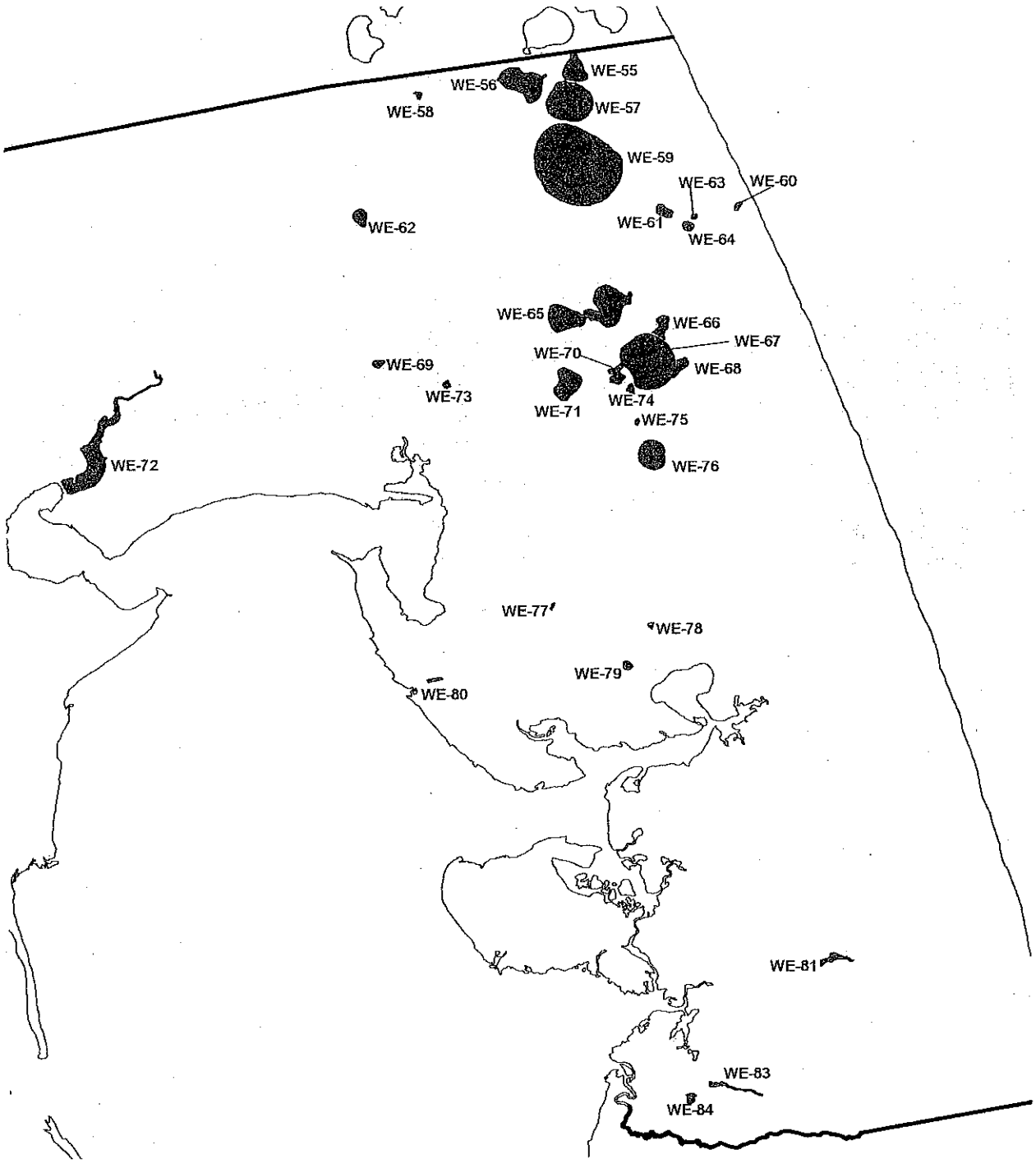



N

1 0 1 Miles

CAPE COD COMMISSION

# GIS ID'S FOR WELLFLEET PONDS



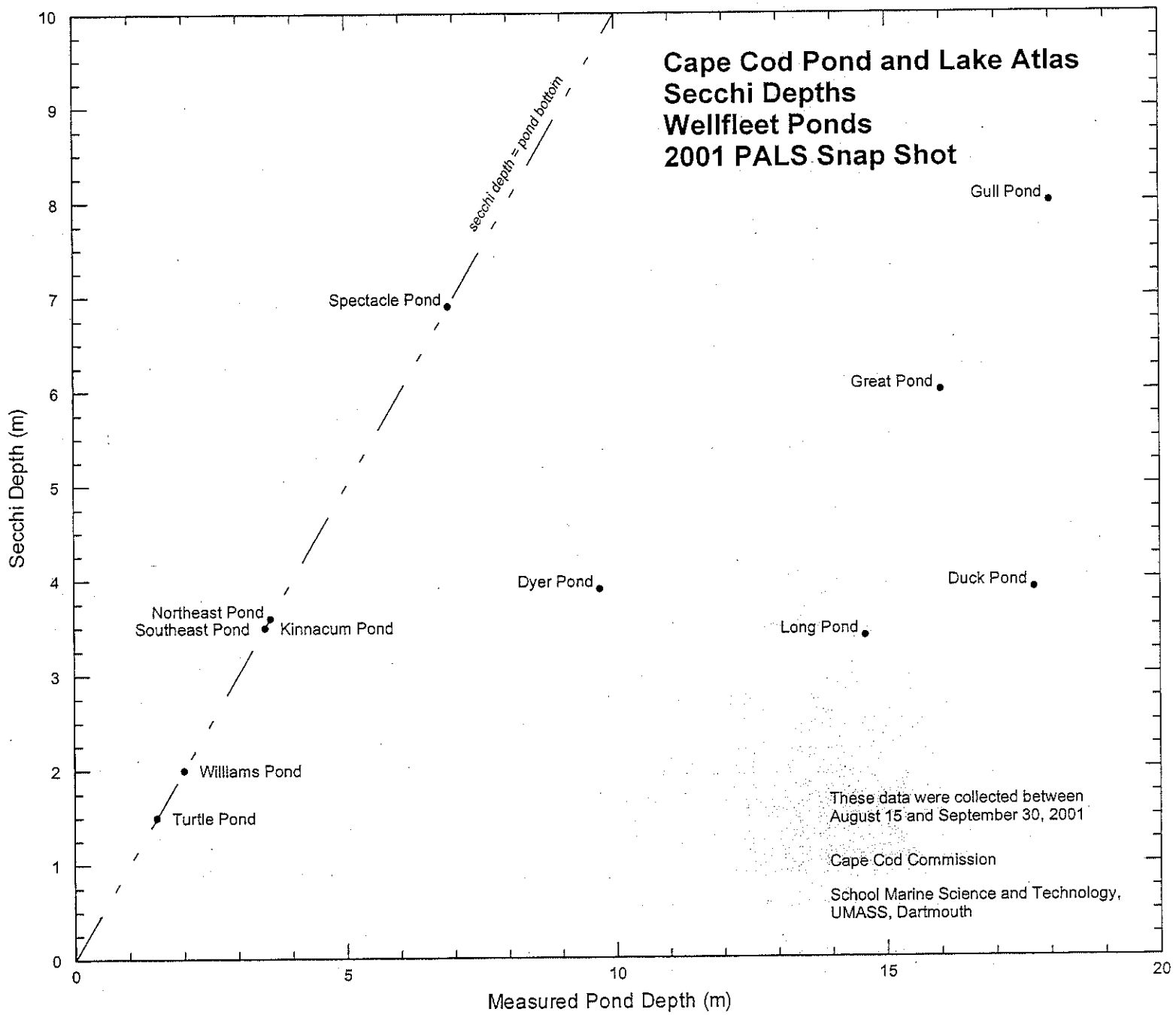

N

0.4 0 0.4 0.8 Miles

CAPE COD COMMISSION

# Wellfleet 2001 PALS Water Qualtiy Snapshot Summary

| Name | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk (1-1.7 ug/l) | **impacted (>1.7 ug/l)** | mg/l | unimpacted (<0.16 mg/l) | at risk (0.16-0.31 mg/l) | **impacted (>0.31 mg/l)** | ug/l | unimpacted (<7.5 ug/l) | at risk (7.5-10 ug/l) | **impacted (>10 ug/l)** |
| Doanes Bog Pond | 13.08 | | | x | 1.33 | | | x | 28.80 | | | x |
| Duck Pond | 0.32 | x | | | 0.16 | x | | | 4.03 | x | | |
| Dyer Pond | 3.43 | | | x | 0.14 | x | | | 4.03 | x | | |
| Grassy Pond | 2.42 | | | x | 1.01 | | | x | 30.35 | | | x |
| Great Pond | 1.14 | | x | | 0.08 | x | | | BDL | x | | |
| Gull Pond | 1.1 | | x | | 0.27 | | x | | 4.03 | x | | |
| Herring Pond | 14.03 | | | x | 0.58 | | | x | 41.81 | | | x |
| Higgins Pond | 3.37 | | | x | 0.30 | | x | | 10.84 | | | x |
| Kinnacum Pond | 9.65 | | | x | 0.39 | | | x | 13.94 | | | x |
| Long Pond | 2.83 | | | x | 0.13 | x | | | 5.88 | x | | |
| Northeast Pond | 1.045 | | x | | 0.25 | | x | | BDL | x | | |
| Southeast Pond | 0.54 | x | | | 0.20 | | x | | BDL | x | | |
| Spectacle Pond | 0.77 | x | | | 0.16 | x | | | 4.03 | x | | |
| Williams Pond | 3.74 | | | x | 0.49 | | | x | 13.94 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Wellfleet Ponds
2001 PALS Snap Shot
secchi depth = pond bottom
Gull Pond
Spectacle Pond
Great Pond
Dyer Pond
Duck Pond
Northeast Pond
Southeast Pond
Kinnacum Pond
Long Pond
Williams Pond
Turtle Pond
These data were collected between August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology, UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20

# WELLFLEET POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | Monitoring ** 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Doanes Bog Pond | WE-60 | | 0.8 | N | | | | | | wq | wq |
| Duck Pond | WE-76 | 96068 | 12.7 | Y | 8,447 | 8 | 55 | CCNS,town,priv | | sd,wq | sd,wq |
| Dyer Pond | WE-71 | 96070 | 11.6 | N | | 8 | 36 | CCNS,priv | | sd,wq | sd,wq |
| Grass Pond | WE-74 | | 0.9 | N | | | | | | wq | |
| Great Pond | WE-67 | 96117 | 44.5 | N | | 8 | 56 | CCNS,town,priv | | sd,wq | sd,wq |
| Gull Pond | WE-59 | 96123 | 106.8 | Y | 116,842 | 6 | 64 | CCNS,town,priv | O,HR | sd,wq | sd,wq |
| Hawes Pond | WE-73 | | 0.8 | N | | | | | | | |
| Herring Pond | WE-56 | 96134 | 19.1 | N | | 6 | 7 | CCNS,town,priv | I,O,HR | sd,wq | sd,wq |
| Herring River | WE-72 | | 29.5 | N | | | | | | | |
| Higgins Pond | WE-57 | 96137 | 28.0 | N | | 6 | 20 | CCNS,town,priv | I,O,HR | sd,wq | sd,wq |
| Kinnicum Pond | WE-61 | 96163 | 2.9 | N | | 7 | 7 | private | | wq | wq |
| Long Pond | WE-65 | 96179 | 36.7 | Y | 18,919 | 8 | 50 | CCNS,town,priv | | sd,wq | sd,wq |
| Northeast Pond | WE-66 | 96226 | 4.0 | N | | 8 | | CCNS,priv | | | wq |
| Perch Pond | WE-62 | 96243 | 3.4 | N | | 5 | | | | sd | |
| Sewells Gutter | WE-80 | | 0.8 | N | | | | | | | |
| Southeast Pond | WE-68 | 96305 | 2.6 | N | | 8 | 13 | CCNS,private | | sd,wq | wq |
| Spectacle Pond | WE-64 | 96306 | 1.7 | N | | 5 | 25 | CCNS | | sd,wq | wq |
| Squires Pond | WE-69 | | 1.3 | N | | | | | | | |
| Turtle Pond | WE-70 | 96316 | 3.8 | N | | 8 | 7 | CCNS,private | | wq | wq |
| Williams Pond | WE-55 | 96341 | 8.8 | N | | 6 | 7 | CCNS,private | HR | sd,wq | wq |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

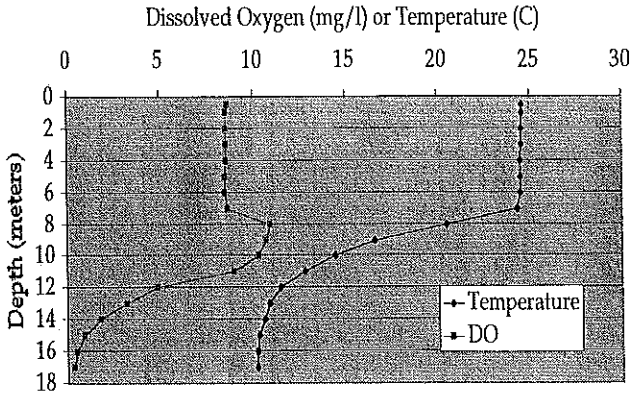
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Duck Pond
## Wellfleet
## WE-76

Acreage: 12.7
Maximum Depth: 55 ft
2001 Secchi Dip: 13 ft
Lake Association: None



Dissolved Oxygen and Temperature
Duck Pond, 2001

OVERVIEW

Duck Pond is located in the Cape Cod National Seashore east of Old County Road. Duck Pond is located near the top of a natural regional groundwater divide, so its watershed is relatively small. It discharges surfacewater to groundwater mostly along its eastern shoreline. The shoreline surrounding Duck Pond is undeveloped with the exception of one summer home. Public access to a small beach is limited to a footpath on the west shore, that originates at a small parking area.

WATER QUALITY

Various parameters have been measured in Duck Pond in 1956-1957, 1975-1978, and 1980--2002. The earliest dissolved oxygen (DO) profile for Duck Pond was apparently collected in mid-July 1990 by the National Park Service; review of profiles since then generally show deep anoxic concentrations (<1 ppm) developing in mid-August, progressively rising up to 12 m in late summer/early fall, and then returned to high oxygen levels by turnover late in the fall. Since DO data do not exist before 12 years ago, it is impossible to ascertain if the generally observed concentrations have worsened or improved over the last 50 years. Review of the more extensive Secchi disk dataset suggests that transparency has declined over the last 50 years; mid-1950's summer readings were generally near 15 m (50 ft) with a low of 10 m (33 ft), while summer readings between 1999 and 2001 fluctuate between 3.15 and 7.32 m with an average of 5.2 m.

Nutrient concentrations from the 2001 PALS Snapshot (shown below) are less than Cape Cod nutrient thresholds, but chlorophyll a concentrations below the surface exceed the Cape Cod "impacted" threshold. These concentrations along with the "bulge" in the DO profile suggest that a vigorous algal population is surviving in the upper layer (i.e., epilimnion) of Duck Pond. Lake with a DO bulge usually have internal nutrient loading from bottom sediments during summer stratification. A Carlson TSI based on the surface chlorophyll a concentration places the pond in the oligotrophic category, but use of the 3 m concentration places the pond in the mesotrophic category.

Duck Pond is interesting because the low nutrient concentrations do not seem to balance the chlorophyll a concentrations and the bottom anoxia. Because of its relatively undeveloped shoreline, it is recommended that the full extent of all the available monitoring information be combined into a water quality assessment of the Duck Pond to help understand how the water quality problems in the pond have developed. This review should include a review of available sediment data, a land use assessment of historic shoreline and watershed properties, development of a water budget, and a forecast of whether the observed water quality problems are likely to worsen. Overall, Duck Pond presents as an impacted pond with some existing water quality problems.

| September 4, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 4.79 | 0.32 | BDL | 4.0 | 0.16 |
| 3 | 4.8 | 4.26 | BDL | 5.9 | 0.13 |
| 9 | 5.07 | 4.10 | 0.5 | 7.4 | 0.13 |
| 16.5 | 4.66 | 1.06 | BDL | 7.4 | 0.05 |

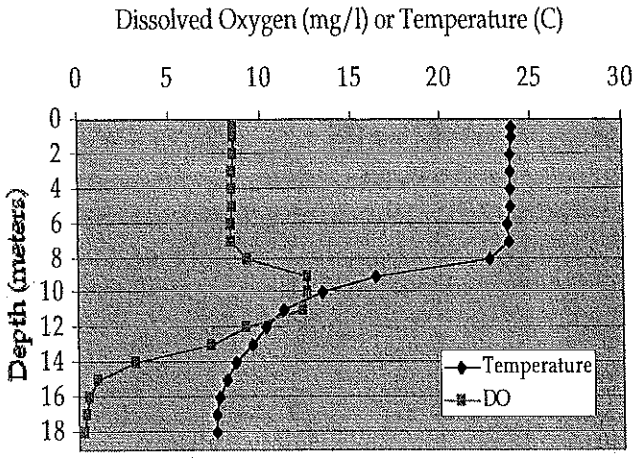
BDL = Below Detection Limit (ALK DL = 0.5 mg/L)

# Gull Pond

## Wellfleet

## WE-59

Acreage: 107
Maximum Depth: 62 ft
2001 Secchi Dip: 26.2 ft
Lake Association: None




Dissolved Oxygen and Temperature
Gull Pond, 9/4/01

OVERVIEW

Gull Pond is located in the Cape Cod National Seashore and the northeastern corner of Wellfleet. Gull Pond is locate at the top of the groundwater divide discharging surface water to groundwater along the east and west shores. Gull Pond is the southern-most pond in a chain of interconnected ponds that connect to the Herring River. Gull Pond discharges surface water via a small inlet to Higgins Pond. The shoreline surrounding Gull Pond is lightly developed with approximately 25, mostly seasonal homes and cottages. A town beach is located on the western shoreline. Recreational uses including swimming, fishing, icefishing, and boating (no outboards allowed). The pond is stocked annually with rainbow, brown and brook trout; the pond is one of seven in the state designated as a Special Brown Trout Water.. Other species include smallmouth bass and sea-run alewife.

WATER QUALITY

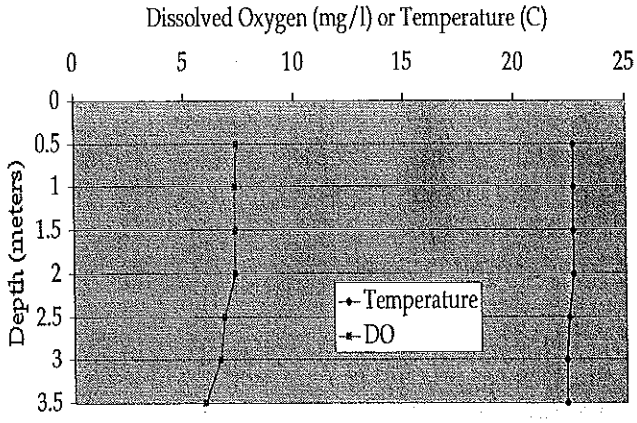
Various parameters have been measured in Gull Pond in 1948 and 1975-2002. In 1948, the August 24 temperature profile shows a well mixed upper layer (*i.e.*, epilimnion) to 30 ft, with a 8°F difference between 30 and 35 ft readings. Dissolved oxygen (DO) concentrations are above or near satuartion down to 45 ft with a rapid decline between 45 and 50 ft and anoxic concentrations (<1 ppm) at 60 and 65 ft. The 2001 PALS temperature profile (shown above) is similar to the 1948 profile, but the DO profile shows anoxic concentrations beginning at 16 m (52 ft). Cape Cod National Seashore DO profiles since 1988 have shown that deep anoxic conditions generally begin in June and the layer thickens throughout the summer. A 2-4 m layer of cool, well oxygenated water usually rests on the anoxic layer providing a habitat for trout. Surface nutrient levels collected during the 2001 PALS Snapshot (see below) generally reflect low productivity , except the high nutrient concentrations in deep samples caused by the anoxia releasing the nutrients from the sediments. A Carlson TSI based on the surface chlorophyll *a* concentration generally reflects the low nutrients and places the lake in the lower portion of the oligotrophic with deep anoxia category .

It is unclear without further review of the existing data how much the deep low DO conditions vary from year to year; there are some indications that they have worsened over the past 50 years. It is recommended that the full extent of all the available monitoring information be combined into a water quality assessment of the Gull Pond, including a review of available sediment data, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to worsen. Overall, Gull Pond presents as an impacted pond with existing water quality problems.

| September 4, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.31 | 1.1 | 4.5 | 4.0 | 0.27 |
| 3 | 6.53 | 1.26 | 4.3 | 7.4 | 0.30 |
| 9 | 6.29 | 2.00 | 4.6 | 7.4 | 0.27 |
| 17 | 6.25 | 0.00 | 17 | 51.4 | 1.12 |

# Kinnacum Pond
## Wellfleet
## WE-61

Acreage: 2.9
Maximum Depth: 11.5 ft
2001 Secchi Dip: 11.5 ft




Dissolved Oxygen and Temperature
Kinnicum Pond, 2001

OVERVIEW

Kinnacum Pond is located in the Cape Cod National Seashore west of Ocean View Drive and south of Gross Hill Road. Kinnacum Pond receives groundwater recharge from the west and northwest and discharges surfacewater to groundwater along the east and southeast shoreline. The shoreline is largely undeveloped and there is no public access.

WATER QUALITY

Various parameters have been measured in Kinnacum Pond in 1975-1976, 1978, 1982-1983, and 1985-2002. The 2001 PALS temperature profile (shown above) has a well mixed water column with consistent dissolved oxygen (DO) and temperature readings from the surface to the bottom. Historic DO profiles occassionally show anoxic conditions up to 2 m in depth.

All of the TP, TN, and chlorophyll *a* concentrations collected during the 2001 PALS Snapshot (shown below) exceed Cape Cod "unimpacted" thresholds. Surface TP and chlorophyll *a* concentrations are generally consistent with National Park Service monitoring results (Portnoy, *et al*, 2001a). The Carlson TSI based on the surface chlorophyll *a* concentration places the lake in the lower end of the eutrophic category, while the TP concentration places it in the mesotrophic category. Observations collected during the PALS Snapshot indicated that approximately 20% of the pond surface was covered with water lillies and another 10% was covered with emergent grasses. These observations suggest that the Carlson indices, which were developed for algae-dominated pond ecosystems, may not be appropriate in assessing Kinnicum Pond.

The extent of the rooted plants and lillies, the higher chlorophyll a concentrations, and the occasional extensive anoxia suggest that Kinnacum Pond is a very productive ecosystem. This suggestion is somewhat suprising given the minimal existing development around the pond and its groundwater-only flow hydrology. It is recommended that additional characterization of the plant communities, sediments, and shoreline materials be considered along with a more thorough review of the historic Cape Cod National Seashore data to help understand how Kinnacum Pond has become so productive. Overall, Kinnacum Pond presents as a highly productive, clear pond with occasional water quality problems.

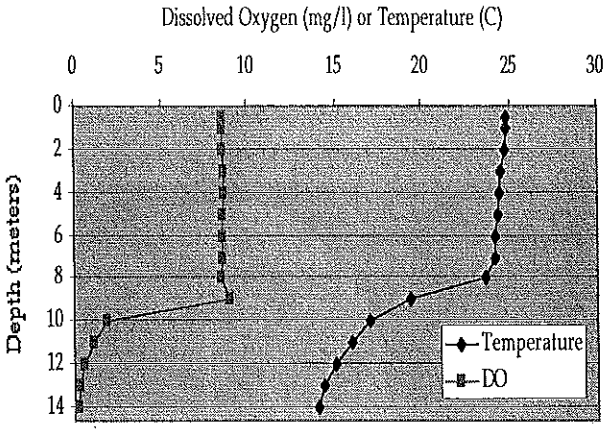
| September 6, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 4.81 | 9.65 | 0.0 | 13.9 | 0.39 |
| 2.5 | 4.86 | 4.81 | 0.3 | 13.9 | 0.41 |

# Long Pond

## Wellfleet

## WE-65

Acreage: 36.7
Maximum Depth: 49 ft
2001 Secchi Dip: 11.2 ft
Lake Association: None




Dissolved Oxygen and Temperature
Long Pond, 9/5/01

OVERVIEW

Long Pond is located in the Cape Cod National Seashore south of Long Pond Road. Long Pond is locate at the top of the groundwater divide discharging surface water to groundwater along the east and west shores. The shoreline surrounding Long Pond is moderately developed with mostly seasonal homes and cottages. A town beach is located on the western shoreline that is heavily used in the summer months. Recreational uses including swimming and fishing.

WATER QUALITY

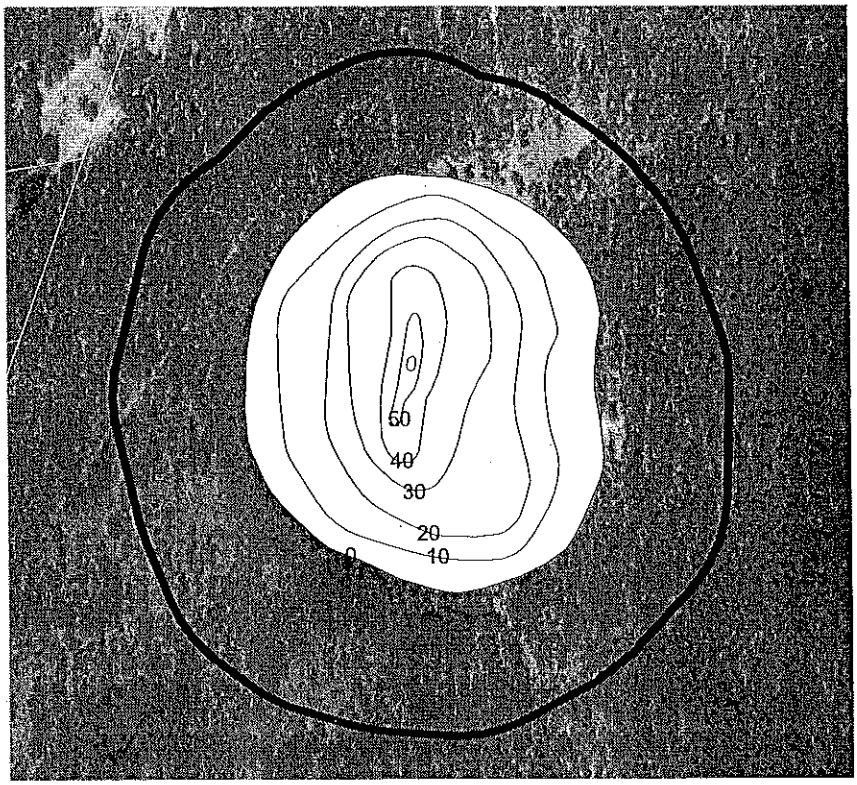
Various parameters have been measured in Long Pond in 1948, 1970-1971, 1973, 1975, 1976, 1980, and 1983-2002. In 1948, the August 24 temperature profile shows a well mixed upper layer (*i.e.*, epilimnion) to 30 ft, with a 6°F difference between 30 and 35 ft readings. Dissolved oxygen (DO) concentrations are generally near saturation, although concentrations decline from 8 ppm at 40 ft to 0 ppm at 48 ft (near the bottom). The 2001 PALS temperature profile (shown above) has a well mixed layer to 8 m (26 ft) with a gradual decline in temperature with increasing depth., while the DO is near saturation in the epilimnion to 9 m, below which concentrations fall rapidly with anoxic concentrations (<1 ppm) below 12 m (39 ft). Historic DO profiles collected by the National Park Service during the late 1990's generally indicate that anoxia begins in mid to late July and eventually occupies all the deep waters.

The TP and TN concentrations (shown below) in the upper three samples are below Cape Cod "unimpacted" thresholds, while all the chlorophyll *a* concentrations exceeds its threshold; all the deep readings exceed the current thresholds. Surface TP and chlorophyll *a* concentrations are generally consistent with National Park Service monitoring results (Portnoy, *et al*, 2001a). The Carlson TSI based on the surface chlorophyll *a* concentration places the lake on the mesotrophic side of the boundary between the mesotrophic and oligotrophic with deep anoxia categories.

The review of DO profiles seems to show that water quality in Long Pond has become more impaired over the last 50 years and consideration of information from other ponds discussed in this Pond Atlas suggests that the 1948 conditions were impaired as well. The release of nutrients from the sediments and the general lack of an oxic layer between the anoxic waters and the eplimnion suggest that Long Pond may experience periodic algal blooms. It is recommended that the full extent of the available monitoring information be combined into a water quality assessment of the Long Pond, including a review of available sediment data, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to worsen. Overall, Long Pond presents as an impacted pond with current water quality problems.

| September 5, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 4.76 | 2.83 | BDL | 5.9 | 0.13 |
| 3 | 4.81 | 4.45 | BDL | 7.4 | 0.14 |
| 9 | 4.88 | 3.90 | BDL | 5.9 | 0.11 |
| 13.5 | 6.26 | 9.10 | 11.4 | 20.4 | 0.47 |

BDL = Below Detection Limit (ALK DL = 0.5 mg/L)



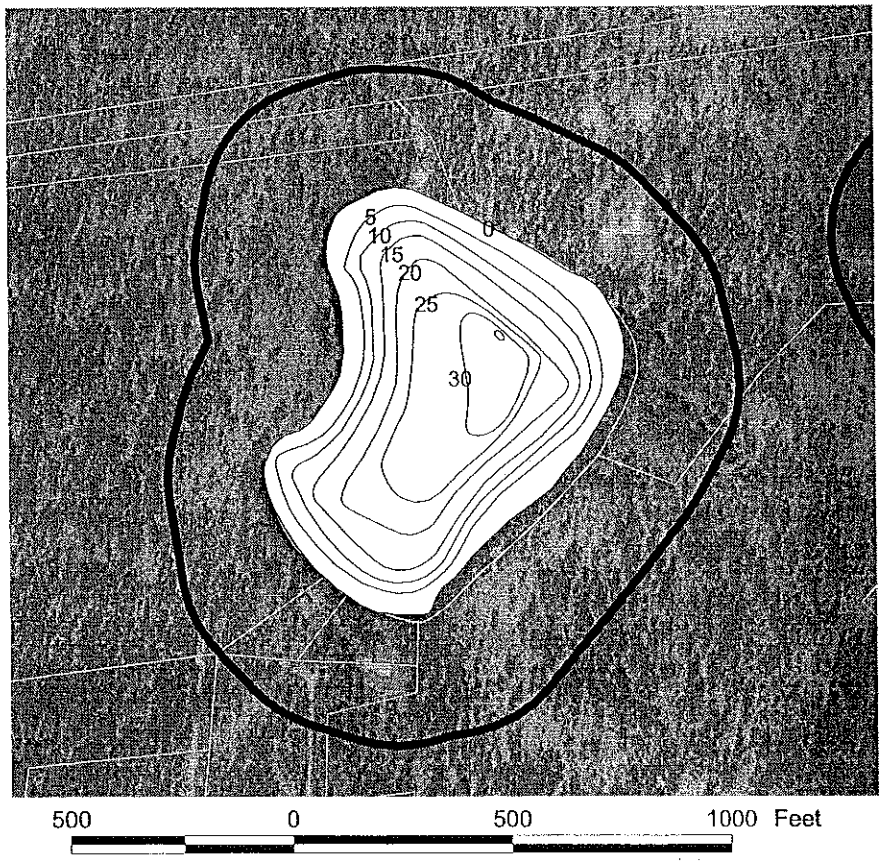

## Duck Pond Wellfleet (WE-76)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet

300' Buffer Zone

N
W E
S



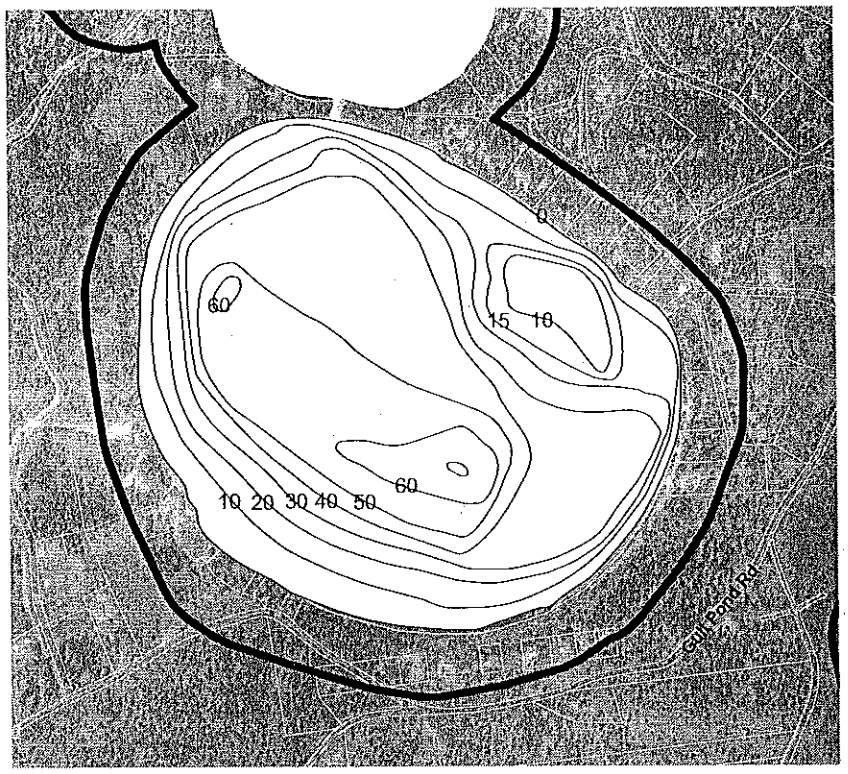

## Dyer Pond Wellfleet (WE-71)

**Bathymetry Source:**
**Unknown**

Bathymetry in feet

300' Buffer Zone

N
W E
S




1000 0 1000 2000 Feet

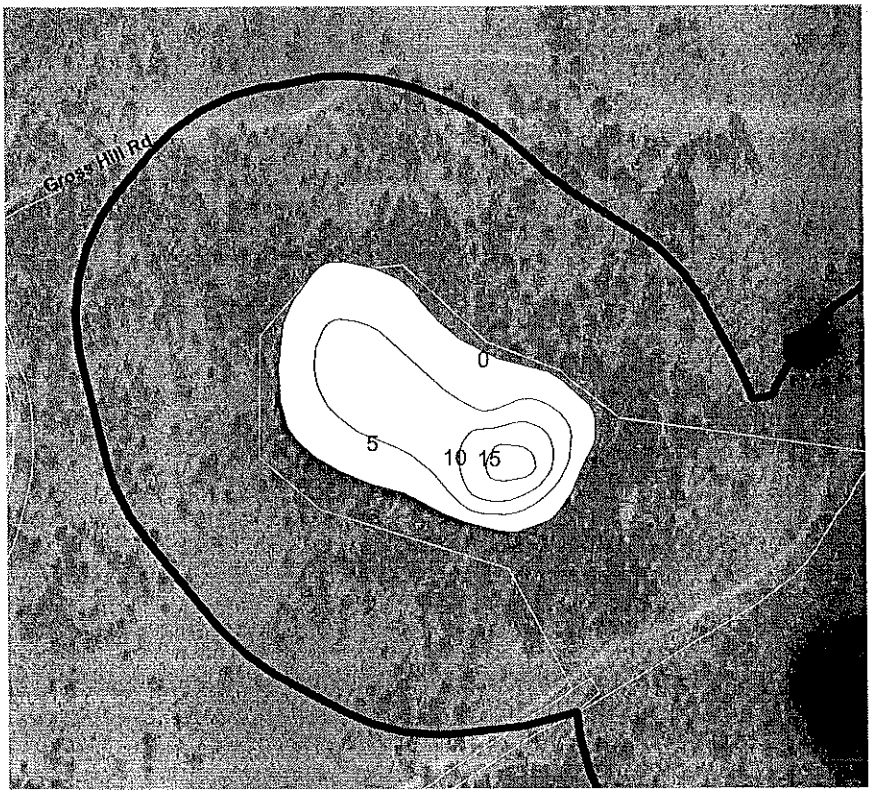
## Gull Pond Wellfleet (WE-59)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet

300' Buffer Zone

N
W E
S




300 0 300 600 Feet

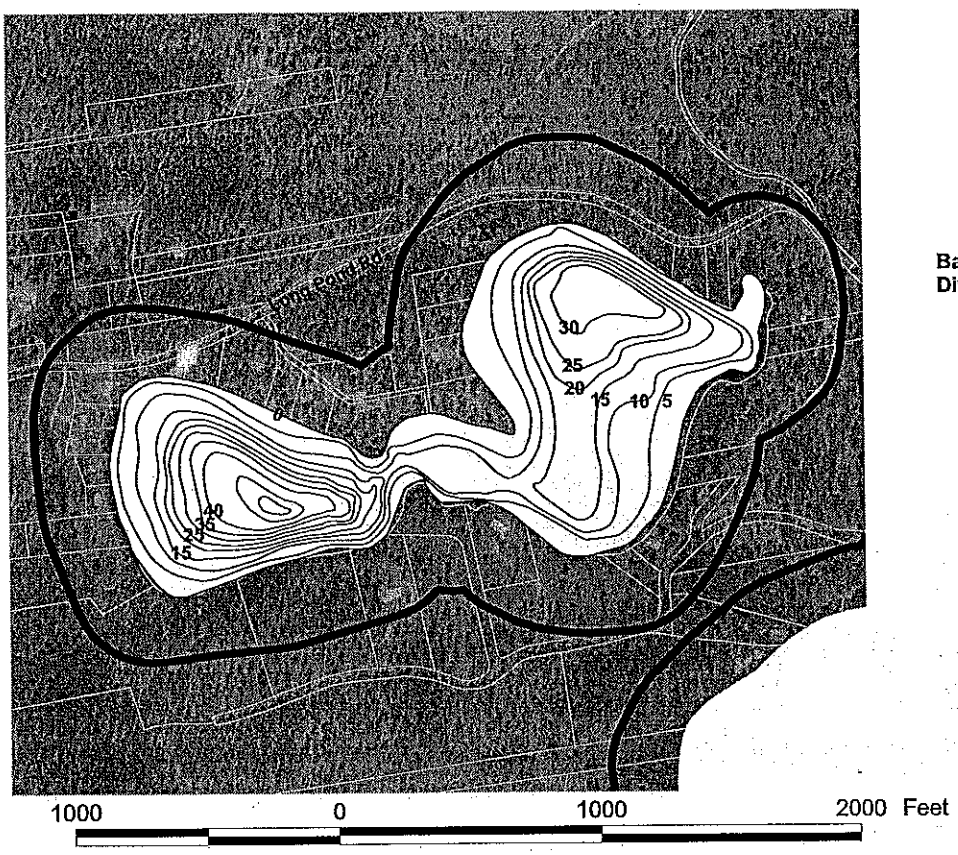
## Kinnacum Pond Wellfleet (WE-61)

**Bathymetry Source:**
**Unknown**

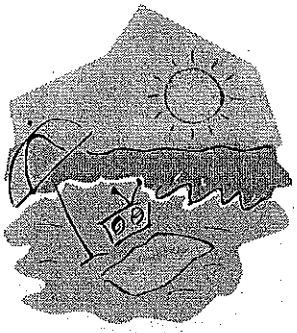
Bathymetry in feet

300' Buffer Zone

N
W E
S


Long Pond
Wellfleet
(WE-65)
Bathymetry Source:
Division of Fish and Wildlife
Bathymetry in feet
300' Buffer Zone
N
W
E
S
30
25
20
15
10
5
0
40
35
25
15
1000
0
1000
2000 Feet

# YARMOUTH PONDS

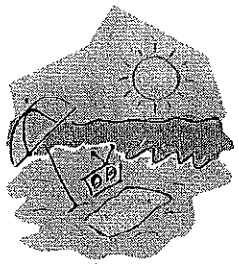


Town Atlas Summary
Pond with Names Map
Pond GIS Number Map
2001 PALS Water Quality Snapshot Summary
Pond Secchi Depth Graph
Pond with Names Town Database
Pond Maps

With Map and Description:

Dennis Pond
Long Pond

# Town of Yarmouth Atlas Summary



**Total Land Area (sq. miles):** 24.13

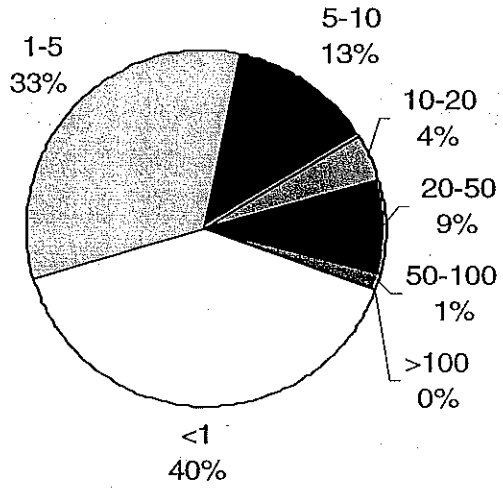
**Total Area of Ponds (acres):** 440

**Total # of Ponds:** 70

**# of Ponds by size (acres)**

| | |
|---|---|
| <1 acres: | 28 |
| 1-5 acres: | 23 |
| 5-10 acres: | 9 |
| 10-20 acres: | 3 |
| 20-50 acres: | 6 |
| 50-100 acres: | 1 |
| >100 acres: | 0 |

**Number of Yarmouth Ponds by Size in Acres**




**2001 PALS Water Quality Snapshot**

| | |
|---|---|
| # of ponds sampled: | 2 |
| # of impacted ponds | |
| Chlorophyll a: | 1 |
| Total Nitrogen: | 1 |
| Total Phosphorus: | 1 |

**2001 Secchi Dip-In**

| | |
|---|---|
| # of ponds dipped: | 3 |
| # of volunteers: | 2 |

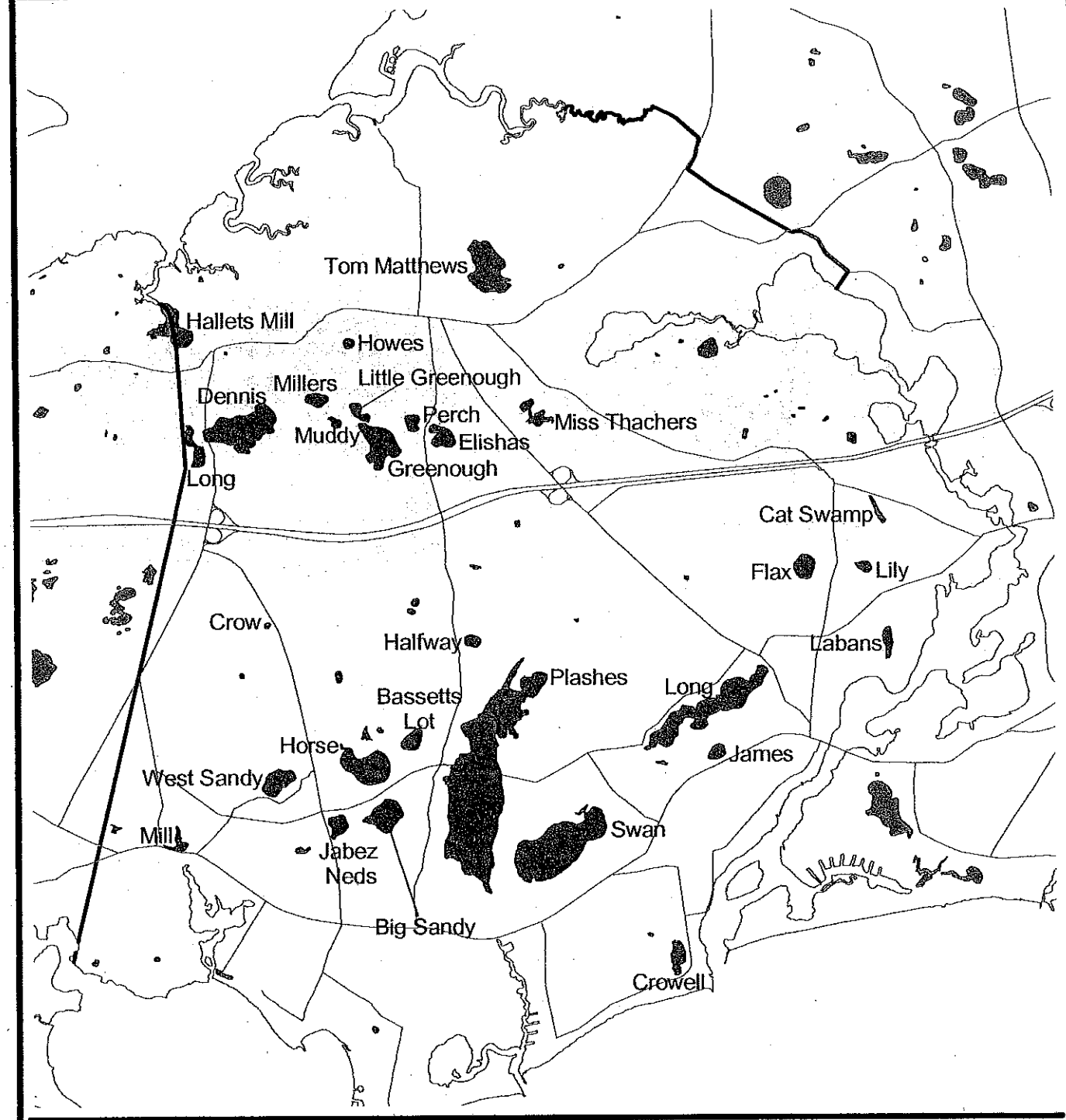
**Coordinators:**

Town staff:

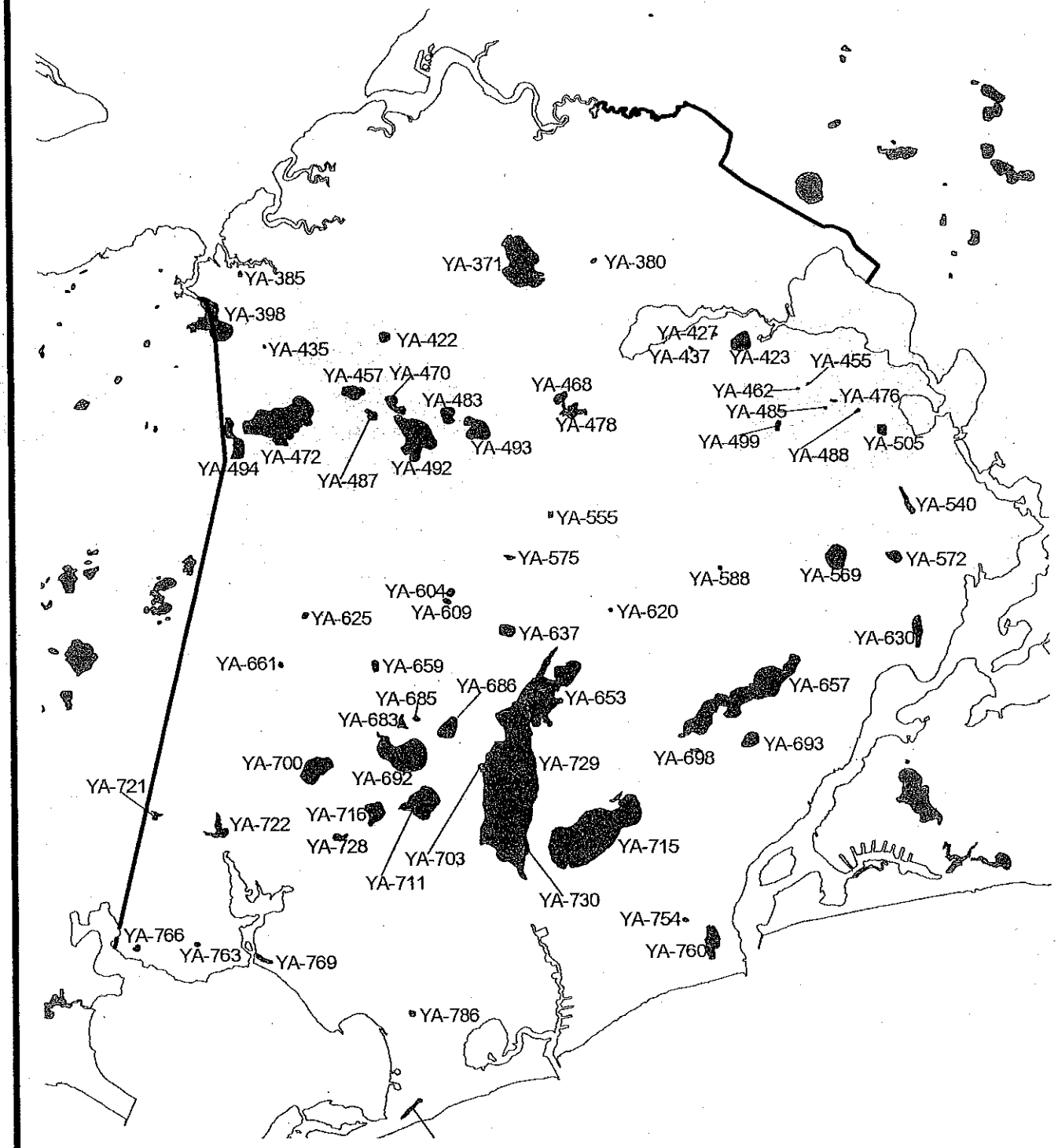
Citizen:

**Pond Groups:**

# YARMOUTH NAMED PONDS



# GIS ID'S FOR YARMOUTH PONDS



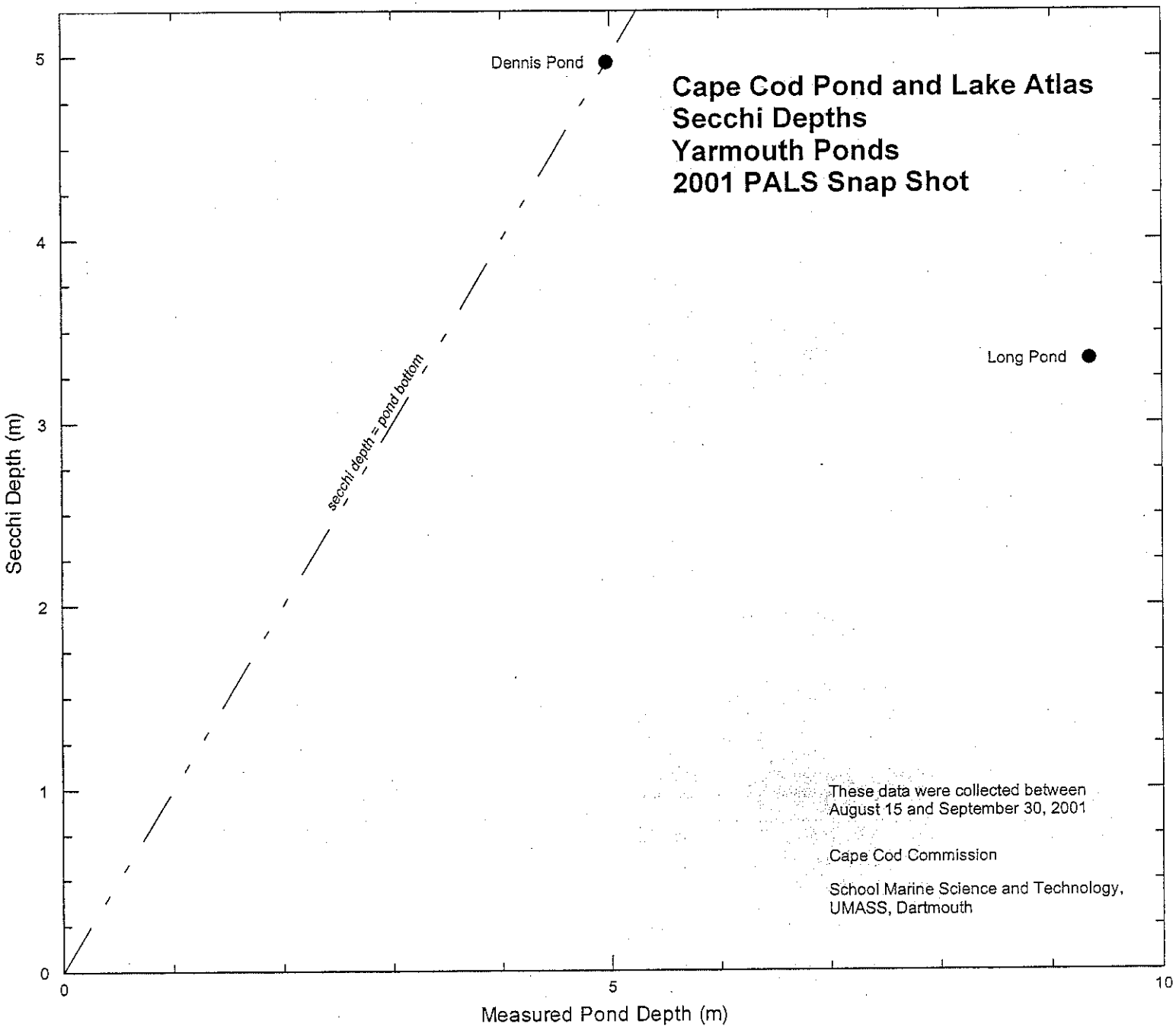

N

1 0 1 Miles

CAPE COD COMMISSION

# Yarmouth 2001 PALS Water Quality Snapshot Summary

| Name | Chlorophyll a | | | | Total Nitrogen | | | | Total Phosphorus | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ug/l | unimpacted (<1.0 ug/l) | at risk (1-1.7 ug/l) | **impacted (>1.7 ug/l)** | mg/l | unimpacted (<0.16 mg/l) | at risk (0.16-0.31 mg/l) | **impacted (>0.31 mg/l)** | ug/l | unimpacted (<7.5 ug/l) | at risk (7.5-10 ug/l) | **impacted (>10 ug/l)** |
| Dennis Pond | 0.42 | x | | | 0.16 | x | | | BDL | x | | |
| Long Pond | 4.78 | | | x | 0.51 | | | x | 11.77 | | | x |


Cape Cod Pond and Lake Atlas
Secchi Depths
Yarmouth Ponds
2001 PALS Snap Shot
Dennis Pond
Long Pond
secchi depth = pond bottom
These data were collected between August 15 and September 30, 2001
Cape Cod Commission
School Marine Science and Technology, UMASS, Dartmouth
Secchi Depth (m)
Measured Pond Depth (m)
0
1
2
3
4
5
0
5
10

# YARMOUTH POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bassetts Lot Pond | YA-686 | 96010 | 7.2 | N | | 17 | 20 | thr wellfield | | | sd |
| Big Sandy Pond | YA-711 | 96015 | 19.4 | N | | 15 | 20 | thr subdv | I | | |
| Cat Swamp Pond | YA-540 | | 2.5 | N | | 15 | | golf course | | | |
| Crow Pond | YA-625 | | 0.7 | N | | | | | | | |
| Crowell Pond | YA-760 | 96048 | 8.2 | N | | 5 | | | | | |
| Dennis Pond | YA-472 | 96060 | 47.8 | Y | 13,267 | 25 | 18 | TOWN | | wq | wq |
| Elishas Pond | YA-493 | 96079 | 10.2 | N | | 9 | 20 | town | O | sd | |
| Flax Pond | YA-569 | 96088 | 9.5 | N | | 9 | 20 | Rec. Area | | | |
| Greenough Pond | YA-492 | 96120 | 26.4 | N | | 20 | 25 | Boy Sct Cmp | | sd | |
| Great Island Pond | | | | | | 9 | | subdv open sp | | | |
| Halfway Pond | YA-637 | 96124 | 3.9 | N | | 19 | | private | | | |
| Hallets Mill Pond | YA-398 | | 20.6 | N | | | | | | | |
| Horse Pond | YA-692 | 96143 | 30.3 | N | | 16 | 19 | informal | O | | sd,wq |
| Howes Pond | YA-422 | | 2.2 | N | | 25 | 15 | private | | | |
| Jabez Neds Pond | YA-716 | 96151 | 7.5 | N | | 11 | 20 | | O | | |
| James Pond | YA-693 | 96152 | 4.7 | N | | 5 | 30 | St. Police HQ | | | |
| Labans Pond | YA-630 | | 5.1 | N | | 4 | 20 | golf course | O,HR | | |
| Lily Pond | YA-572 | 96168 | 3.1 | N | | 7 | 24 | private | | | |
| Little Greenough Pond | YA-470 | | 4.5 | N | | 20 | | in Boy Sct Cmp | | | |
| Little Sandy Pond | | 96177 | | | | 10 | 26 | Buck Island Rd. | I,O,HR | | |
| Long Pond | YA-494 | 96182 | 8.3 | N | | 25 | 25 | Willow St. | | wq | |
| Long Pond | YA-657 | 96180 | 60.5 | Y | 15,735 | 5 | 30 | pubramp,concrete | I,O,HR | | wq |
| Tom Matthews Pond | YA-371 | 96195 | 35.6 | N | | 7 | 5 | Gun Club | O,HR | | |
| Mill Pond | YA-722 | 96206 | 4.4 | N | | 15 | 5 | Rt. 28 town Mill | I,O,HR | | |
| Millers Pond | YA-457 | 96207 | 5.8 | N | | 22 | 20 | Botanic trails | | | |
| Miss Thachers Pond | YA-478 | | 5.0 | N | | 9 | 8 | | HR | | |
| Muddy Pond | YA-487 | | 2.1 | N | | 20 | 20 | in Boy Sct Cmp | | | |
| North Dennis Road Pond | | 96224 | | | | 5 | | | | | |
| Perch Pond | YA-483 | 96242 | 4.5 | N | | 19 | 20 | townconsland | | | |
| Plashes Pond | YA-653 | 96250 | 44.5 | N | | 15 | 6 | TOWN | O | sd | sd |
| Swan Pond | YA-715 | | 87.9 | N | | | | | | | |

# YARMOUTH POND DATABASE

| Name | CCC GIS id | PALIS | Acres | Bathy-metry | Volume (ft3) | Altitude (ft. above msl) | Max depth (feet) | Access | Tributaries (I,O,HR)* | Monitoring ** 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Reservoir** | | 96258 | | | | 7 | | public | I,O | | |
| **West Sandy Pond** | YA-700 | | 13.7 | N | | | | | | | sd |

*I-inlet, O- outlet, HR- herring run
**sd-secchi dip, wq-water quality

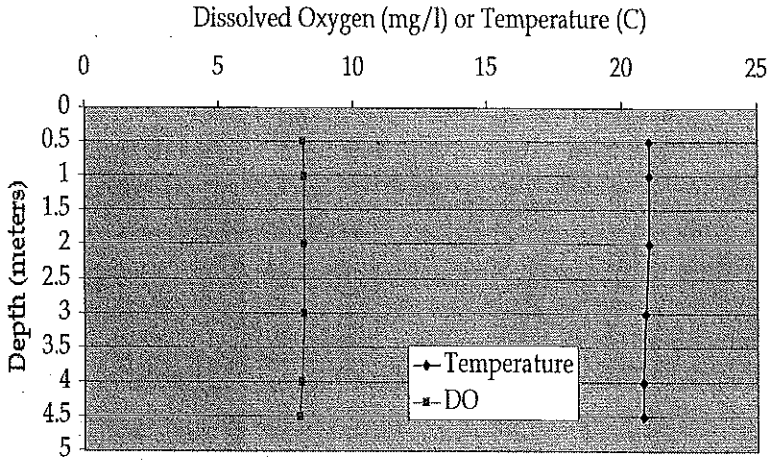
GIS #'s assigned by Cape Cod Commision GIS 2001. Ponds without GIS#'s are either in an adjoining town or have a duplicate name.

PALIS #'s from A Pond and Lake information system for Massachusetts. Publ.No. 108. Massachusetts Water Resources Research Center, Umass, Amherst, MA 1985.

Pond data are either from the Massachusetts Division of Fisheries and Wildlife website, www.state.ma.us/dfwele, An Inventory of the Ponds, Lakes, and Reservoirs of Mass, Barnstable County, McCann, 1969 or measurements taken during the 2001 PALS snapshot.

# Dennis Pond
## Yarmouth
## YA-472

Acreage: 47.8
Maximum Depth: 16 ft
2001 Secchi Dip: 16 ft
Lake Association: None




Dissolved Oxygen and Temperature
Dennis Pond, 9/28/01

OVERVIEW

Dennis Pond is located north of Route 6 on the east side of Willow Street. This shallow kettle pond is recharged by groundwater flow from the south and west and discharges surface water to groundwater along its north and east shore. There are no surface water outlets. The shoreline is undeveloped. Public access is provided at a town beach off of Summer Street. Recreational activities include swimming and fishing. The number of fish species is limited, but perch and pickerel populations are fairly abundant.

WATER QUALITY

Dennis Pond was sampled in 1948, 2001, and 2002. In 1948, the July 12 temperature and dissolved oxygen (DO) readings indicated a well-mixed lake with similar readings at the surface and near the bottom. The Secchi disc could be seen on the bottom of the pond. In 2001, similar conditions exist.

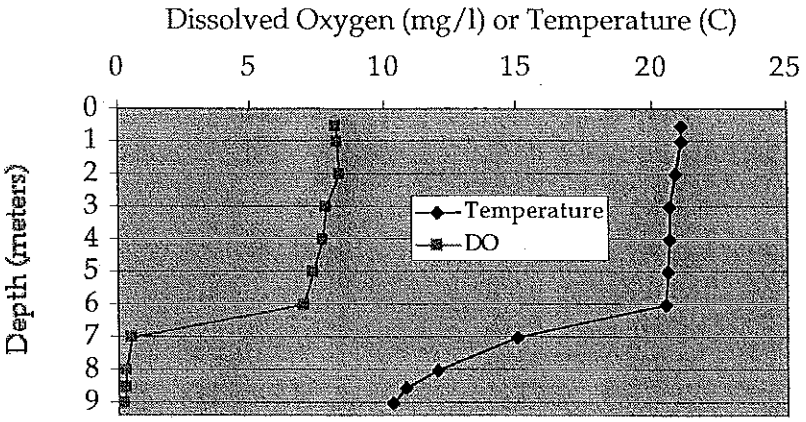
All of the 2001 PALS concentrations for chlorophyll *a*, TP, and TN (see below) are less than the current Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations categorizes the lake as oligotrophic. Comparison of Dennis Pond nutrient and Secchi readings to the other ponds sampled during the 2001 PALS Snapshot places Dennis Pond among the 34 least impacted ponds on Cape Cod. Given that the shoreline is undeveloped and little change in clarity has been observed over the past 50 years, Dennis Pond presents as an unimpacted pond with no apparent water quality problems.

| September 28, 2001 PALS Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 4.77 | 0.42 | 0.0 | BDL | 0.16 |
| 4 | 4.74 | 0.28 | 0.0 | BDL | 0.15 |

BDL = Below Detection Limit (<3.1 µg/L)

# Long Pond
## Yarmouth
## YA-657

Acreage: 60.5
Maximum Depth: 30 ft
2001 Secchi Dip: 11 ft
Lake Association: None




Dissolved Oxygen and Temperature
Long Pond, 9/28/01

OVERVIEW

Long Pond is located just north of Route 28 and west of Station Avenue. Long Pond is recharged by groundwater flow from the north and northwest and discharges surface water to groundwater along its south and southeast shore. The pond is connected to the Parker River by a herring run. The shoreline is heavily developed with year round homes. Public access includes a town beach and concrete boat ramp located on the southwest shore. Recreational activities include swimming and fishing. The pond is stocked annually with trout.

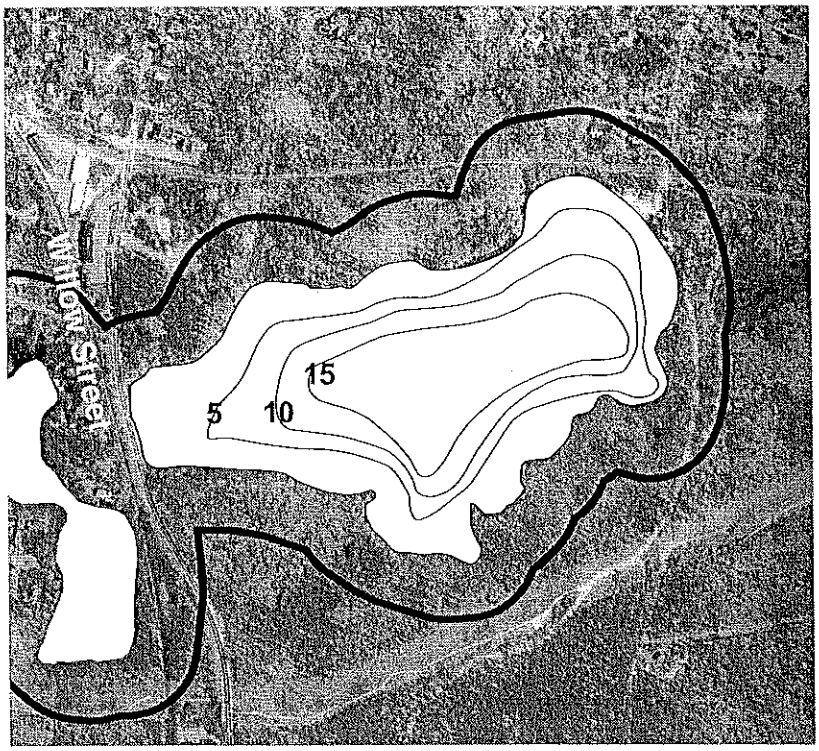
WATER QUALITY

The 2001 and 2002 PALS Snapshot sampling events appear to be the first water quality samples collected from Long Pond. The 2001 temperature profile shows a well mixed epilimnion to 6 m below which the temperature gradually declines. The dissolved oxygen (DO) profile reflects the well mixed conditions to 6 m, but deeper than 6 m DO concentrations become anoxic (<1 ppm).

All of the chlorophyll *a*, TP, and TN concentrations measured in Long Pond exceed the current Cape Cod "impacted" thresholds. The Carlson TSI based on the surface chlorophyll *a* concentrations places the pond in the middle of the mesotrophic category.

Given that low DO conditions exist at the bottom of the epilimnion, the high nutrient concentrations observed in the deepest samples are likely mixing into the epilimnion and creating opportunities for occasional algal blooms. The deep portions of the pond are impaired by the lack of oxygen and the lack of oxygen appears to be prompting the nutrient release from the sediments. Review of historic information from other ponds reviewed in the Pond Atlas suggest that the current conditions are a reflection of impacts from shoreline development over the last 50 years. It is recommended that the town consider a water quality assessment of the Long Pond, including a more refined monitoring program to evaluate DO, nutrient, and chlorophyll *a* concentrations throughout the summer, a sediment characterization, a land use assessment of shoreline and watershed properties, and a forecast of whether water quality is likely to continue to worsen. Overall, Long Pond presents as an impacted pond with current water quality problems.

| September 28, 2001 Snapshot Results | | | | | |
|---|---|---|---|---|---|
| Depth | pH | Chlorophyll a | Alkalinity | Total Phosphorus | Total Nitrogen |
| meters | | µg/L | as mg CaCO3/L | µg/L | mg/L |
| 0.5 | 6.71 | 4.78 | 12.5 | 11.8 | 0.51 |
| 3 | 6.60 | 6.81 | 12.8 | 11.8 | 0.52 |
| 8.5 | 6.23 | 3.50 | 13.9 | 33.1 | 0.74 |




700 0 700 1400 2100 Feet

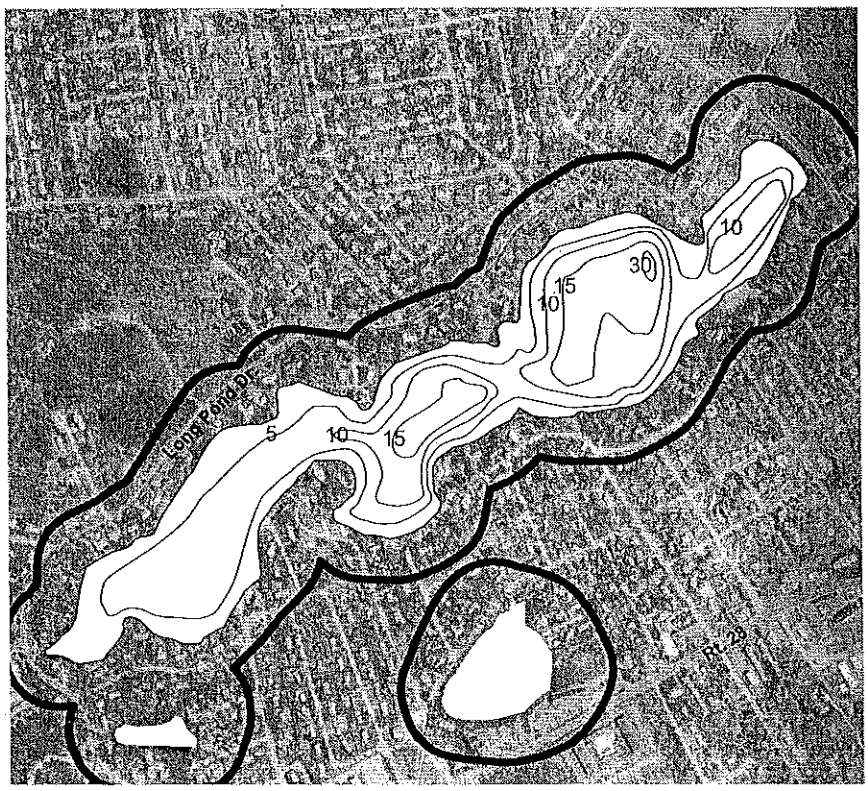
## Dennis Pond
## Yarmouth
## (YA-472)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet

300' Buffer Zone

N
W E
S




1000 0 1000 2000 Feet

## Long Pond
## Yarmouth
## (YA-657)

**Bathymetry Source:**
**Division of Fish and Wildlife**

Bathymetry in feet

300' Buffer Zone

N
W E
S