



The Cape Cod Freshwater Strategy

PONDS AND LAKES



CAPE COD
COMMISSION

CAPE COD FRESHWATER STRATEGY: PONDS AND LAKES

2025

Prepared by Cape Cod Commission staff

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The maps and graphics in this document are for planning purposes only. They are not adequate for legal boundary definition, regulatory interpretation, or parcel level analysis.



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CAPE COD FRESHWATER STRATEGY: PONDS AND LAKES

Table of Contents

■ EXECUTIVE SUMMARY	4
■ INTRODUCTION	11
■ ABOUT CAPE COD PONDS.....	16
■ DEFINING THE PROBLEM.....	23
■ REGIONAL PLANNING CONTEXT	35
■ DESIGNING THE FRESHWATER STRATEGY	40
■ EXPANDED DATA COLLECTION AND ANALYSIS	54
■ STRATEGIES	62
■ RECOMMENDATIONS.....	66
■ TAKING ACTION	81

An aerial photograph of a calm pond with a dense forest of green trees along its shoreline. A small, light-colored building is visible on the shore. The water reflects the sky and the surrounding greenery. The image is used as a background for the slide, with a dark blue gradient overlay on the left side where the text is placed.

Executive Summary

Water quality in Cape Cod's ponds and lakes is declining due to the impacts of decades of human activity, with these effects exacerbated by climate change. The Freshwater Strategy equips local and regional stakeholders with the data, information, and resources necessary to take action to protect and restore these essential water resources.

Recognizing the importance of Cape Cod's ponds and lakes and the critical threats they face, the Cape Cod Commission launched the Cape Cod Freshwater Initiative in 2022. The Initiative is a science-based, information-driven planning process to engage stakeholders and enable action to protect and restore Cape Cod's freshwater ponds and lakes.

Cape Cod's 890 ponds are a defining element of the region's identity; these dynamic natural systems provide critical ecological functions and serve as popular destinations widely recognized as key contributors to the local and regional economy. Though Cape Cod's ponds and lakes share a similar geologic history, each is distinguished by its geomorphology and natural species composition. Ponds and lakes are connected to estuarine and marine ecosystems via ground and surface water; provide habitat for fish, wildlife, and aquatic vegetation, including many rare species; and support complex food webs and rare natural communities. They attract visitors and make Cape Cod a desirable place to live for year-round and seasonal residents. An analysis of the local and regional economic impacts of ponds revealed that homeowners and visitors are willing to pay a premium to live or rent near clean, healthy ponds.

Freshwater challenges are complex but may be considered in three broad categories. Foremost, human activity and development has led to impacts to pond water quality from septic systems, fertilizers, and stormwater runoff. As most Cape Cod ponds and lakes are directly connected to groundwater, poor pond water quality can impact groundwater, drinking water, and downstream coastal bays and estuaries. Threats to pond health are directly related to the land use activities within pond buffers and contributing watersheds, and include inputs of excess nutrients (nitrogen and phosphorus), pollutants, algal blooms, erosion, invasive and nuisance species, and climate change.

Also contributing to pond protection and management challenges is limited availability and access to pond data. While towns, pond groups and non-profit entities have been collecting data and examining ponds for decades, access to and analysis of pond water quality data has been limited; compounding this problem, much of the data has not been collected on a consistent and consecutive schedule.

Finally, while the Massachusetts Wetlands Protection Act and other regulations provide important protections for ponds, permitting process and requirements can become a barrier to advancing pond projects. Jurisdiction and responsibility for implementing pond management actions are not always clear.

Coordinated action at the regional scale is needed to address the many challenges freshwater ponds face.

Recognized for decades as a key component of the region, ponds and lakes have been identified as a priority for action within many regional planning documents. The Cape Cod Regional Policy Plan and many of the Commission's planning studies and initiatives highlight the importance of ponds and lakes as an essential part of the Cape's ecology, economy, and landscape, and prioritize protection and restoration of the region's natural environment as an essential strategy in maintaining the quality of life on Cape Cod.

The Freshwater Strategy is the result of extensive data collection, research, and stakeholder engagement. Commission staff convened stakeholders including municipal staff, local committee and board representatives, business representatives, pond groups and associations, and others to identify areas of focus and priorities; and technical working and end-user groups to inform strategy identification and tool development. Commission staff conducted research on past pond assessments, as well as management strategies employed, to better understand freshwater challenges within the region and

beyond. Additionally, the Commission contracted with economic and legal specialists to examine the economic impacts and legal and jurisdictional issues associated with ponds and lakes. Tools and resources to support implementation of the Freshwater Strategy include fact sheets on strategies, economic analysis findings, a communications toolkit, freshwater pond buffer guidance, a pond prioritization framework, pond profiles, findings of a GIS analysis of pond buffers and watersheds, a restoration projects data viewer, and an expanded Water Quality Data Portal that includes pond data and trend analyses.



Tools and Resources

Tools and resources to support implementation of the Freshwater Strategy



Freshwater Strategies Database

Including fact sheets and an online viewer for a range of approaches for addressing pond water quality



Pond Buffer Guidance

Practical strategies for installing or enhancing native pond shore buffers, including best practices, planting plans, extensive native species lists, and other resources



Economic Analysis Findings

Quantifying how pond water quality impacts property values, the regional economy, and public perceptions



Communications Toolkit

Key messages and resources to improve access to accurate, science-based information about ponds



Pond Profiles

A snapshot view of regional and town-by-town pond information



Restoration Projects Data Viewer

Identifies pond management strategies implemented across Cape Cod to help inform further action



Pond Prioritization Framework

Model framework to help prioritize freshwater ponds for planning, management, and resources



Water Quality Data Portal

Expanded to include freshwater pond data and trend analyses



Analysis of Pond Characteristics

GIS analysis of pond buffers and watersheds that identified stress scores and phosphorus hotspots

A key component of the Freshwater Initiative was the dedication of funds toward the implementation of the Regional Pond Monitoring Program, resulting in collection of consistent, standardized data from representative ponds across Cape Cod. With the new and historic data collected and made available through the Water Quality Data Portal, users may explore changing water quality conditions in ponds over time. Through the Freshwater Initiative, the Commission and partners initiated two remote sensing projects: the Commission partnered with the National Oceanic and Atmospheric Administration to pair field-measured Secchi disk data with satellite reflectance data; and with the University of Rhode Island, University of Minnesota, and the Association to Preserve Cape Cod to correlate other field data with satellite imagery to examine and understand changing conditions in more ponds than could be feasibly visited in the field.

While there are dozens of different strategies that municipalities, pond organizations, and others can employ to ensure healthier and well protected ponds, certain actions surfaced as necessary and impactful approaches for the region. The following key recommendations have the potential to improve the region's understanding of ponds and lakes, support improved freshwater habitats and water quality, and enable local regional action.

Cape Cod's ponds and lakes are in jeopardy. The Freshwater Initiative provided the opportunity for a dedicated planning process to better understand the challenges ponds face and identify impactful solutions. The Freshwater Strategy equips local and regional stakeholders with the data, information, and resources necessary to take action to protect and restore these essential water resources.

Key Recommendations

Necessary and impactful approaches to advance freshwater priorities throughout the region



Maintain and expand funding for the Regional Pond Monitoring Program



Develop a regional funding program for town projects



Improve access to state and federal grant funds



Prioritize ponds for action



Promote best practices and universally beneficial strategies



Integrate freshwater ponds into municipal water resource planning



Utilize pond buffer guidance



Develop model wetland bylaws and orders of conditions



Streamline wetland permitting to facilitate restoration of pond shore buffers



Expand regional monitoring and laboratory capacity



Enhance understanding of groundwater interactions and address data gaps



Improve consistent communication and outreach for varied pond users



Foster appreciation and respect for Cape Cod's ponds

Introduction

Cape Cod's ponds and lakes are fragile.

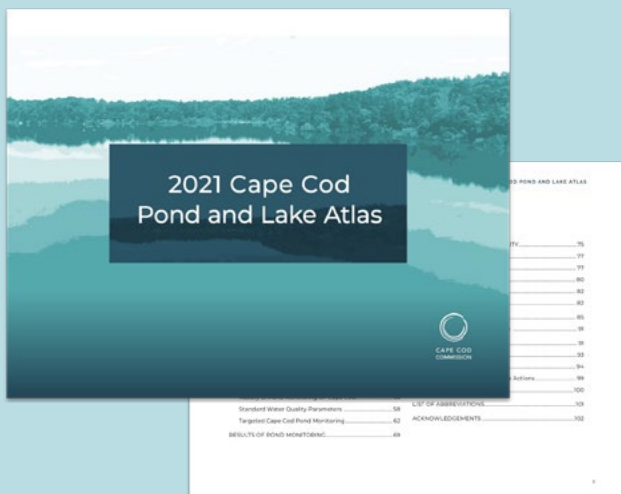
For decades, the Cape Cod Commission (Commission), along with stakeholders from across the region, has recognized the health of freshwater resources as a regional priority. Impacted by decades of human activity and development and exacerbated by climate change, water quality is declining in many Cape Cod ponds and lakes.



Cape Cod has a long history of prioritizing water resources and coming together as a region to collaborate and plan to address large-scale economic and environmental challenges. In 2015, an update to the region's Area Wide Water Quality Management Plan (208 Plan) provided a framework for addressing coastal water quality impairments caused by land use and development. It identified that nutrient loading not only impacted coastal water quality, but pond water quality as well, and identified the need to take action to address freshwater quality

impairments. More importantly, the 208 Plan provided a framework for regional water resources planning that can be leveraged and built upon to restore degraded freshwater ponds and protect those not yet impacted.

The 2018 Cape Cod Regional Policy Plan (RPP) also identified the health of Cape Cod's freshwater ponds and lakes as a key challenge facing the region. It called for an update to the Cape Cod Pond and Lake Atlas (an action that was completed in 2021) and efforts to update and



REGIONAL POLICY PLAN RECOMMENDED ACTION

Update and Expand Understanding of Fresh Water Resources Data

Compile available fresh water resources water quality data into a regional database.

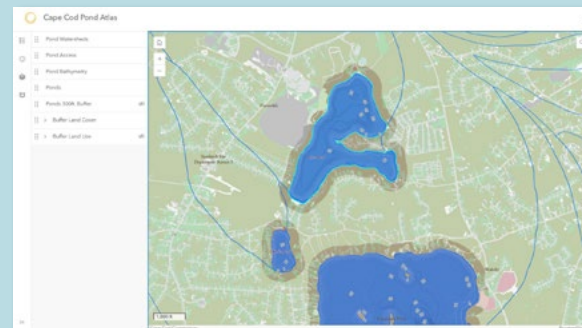
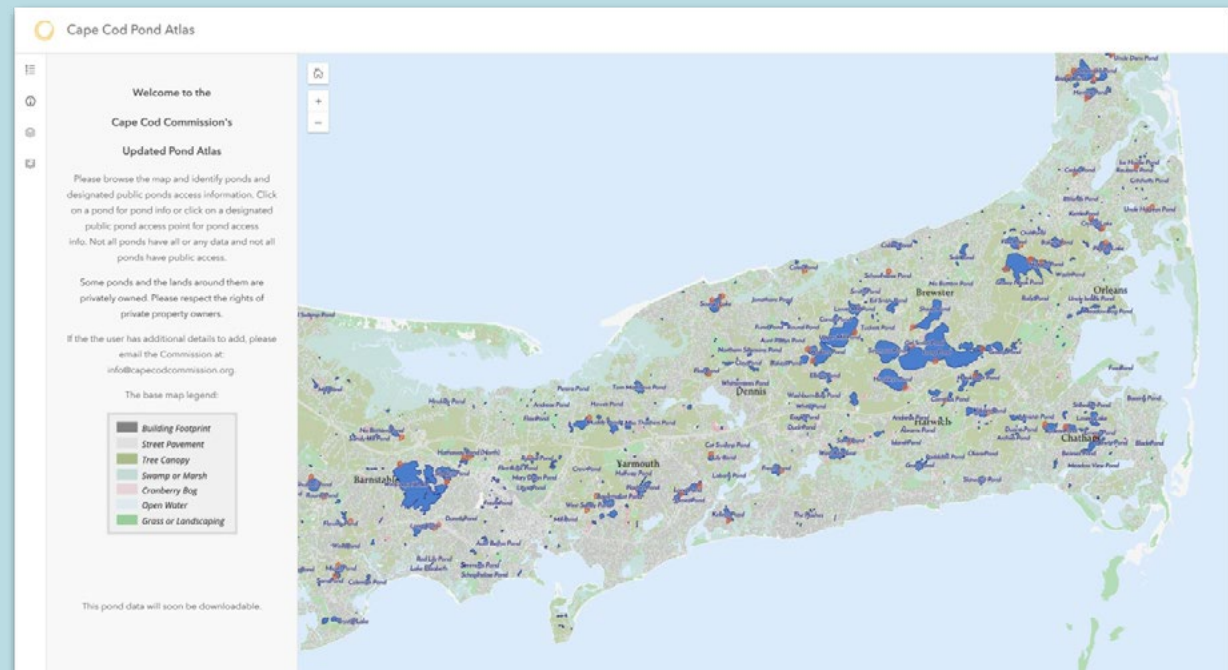
*Seek funding to update the **Cape Cod Ponds and Lakes Atlas** to reflect current water quality data collected by the Ponds and Lakes Stewardship Program.*

Cape Cod Pond and Lake Atlas Viewer

The Cape Cod Pond Viewer serves as a companion to the Cape Cod Pond and Lake Atlas and can be used to explore Cape Cod's ponds, and the challenges they face.

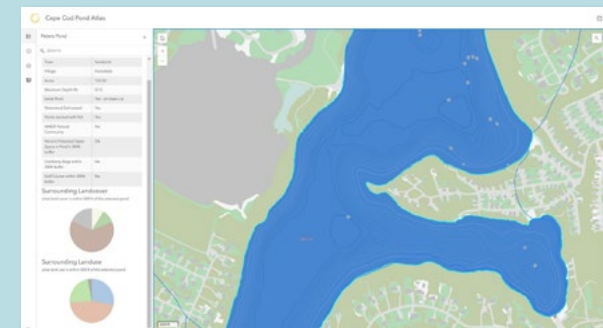
The viewer includes pond characteristics, information about public access points, and surrounding land use characteristics for those with available data.

Explore online at:
cccom.link/pond-atlas



MAP LAYERS

Available map layers include access points, pond watershed delineations, bathymetry data, 300 ft. pond buffer area, and other pond and surrounding land use characteristics.



POND CHARACTERISTICS

The Info Panel shows individual pond related characteristics including acreage, depth, and more. Users can also explore surrounding land cover and land use summaries within a 300 ft. pond buffer area.

expand the region's understanding of freshwater resources by compiling available water quality data into a regional database.

Recognizing the importance of Cape Cod's ponds and lakes and the critical threats they face, the Cape Cod Commission launched the Cape Cod Freshwater Initiative in 2022. The Initiative is a science-based, information-driven planning process to engage stakeholders and enable action to protect and restore Cape Cod's freshwater ponds and lakes. The data and information in the

2021 Cape Cod Pond and Lake Atlas served as the basis for the Initiative, which has resulted in the expansion of existing data sources, identification of new resources, and recommendations to advance efforts and enable action locally and regionally. This Freshwater Strategy provides an overview of the work performed under the Freshwater Initiative and defines a path forward for Cape Cod to support healthy, functioning freshwater ecosystems.



STRATEGY ELEMENTS

Cape Cod Freshwater Initiative

A science-based, information-driven planning process that will engage stakeholders and enable action to protect and restore Cape Cod's freshwater ponds



Pond and Lake Atlas Update

Completing an update to the 2003 Atlas to serve as a resource for updated pond information



Physical Characteristics

Assessing factors influencing water quality changes and identifying potential water quality degradation drivers



Data Management and Analysis

Developing freshwater monitoring database, processing scripts for trend analyses, and accessible user interface



Remote Sensing

Using satellite-derived imagery and existing pond water quality data to quantify changes in pond characteristics



Strategies Database

Developing a pond-specific strategies database with a range of approaches for addressing pond water quality



Engagement and Outreach

Engaging stakeholders to support development of decision-support tools and guidance documents



Economic Analysis

Quantifying how pond water quality impacts property values, the regional economy, and public perceptions



Legal and Jurisdictional Analysis

Reviewing federal and state laws on freshwater ponds and identifying opportunities for local and regional action



Regional Monitoring Program

Expanding pond monitoring to collect data necessary to support management decisions and track performance



Ongoing Data Management and Analysis

Maintaining accessible pond monitoring datasets via web-based interface



An aerial photograph of a pond with a small, tree-covered island in the center. The water is a deep blue, and the surrounding land is covered in dense green forest. The sky is a pale blue with some light clouds.


About Cape Cod Ponds

A defining element of the region's identity.

Cape Cod's 890 ponds and lakes are a defining element of the region's identity. These dynamic natural systems provide critical ecological functions and serve as popular destinations widely recognized as key contributors to the local and regional economy. Nearly 84% of year-round residents and second homeowners agree that ponds and lakes are important to the Cape Cod economy; more than 90% agree they are important to the environment.¹

¹ *Cape Cod Freshwater Initiative Economic Analysis*, p. 6-7, ERG, Inc, April 2024. capecodcommission.org/our-work/freshwater-economic-analysis

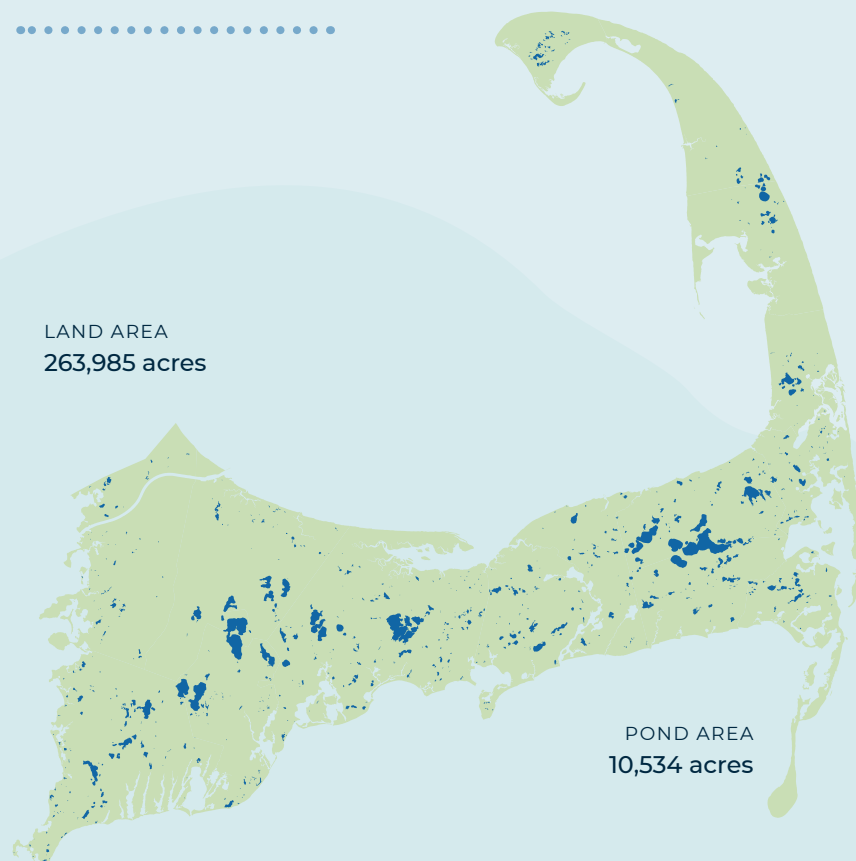
Cape Cod's ponds and lakes formed about 12,000 years ago, during the last stage of the Wisconsin glaciation. As glaciers retreated, large chunks of ice were left behind. As the ice melted, the landscape above them collapsed, forming large depressions, or kettles. Where these depressions dip below the groundwater table, they fill with water creating kettle hole ponds. The 2021 Pond and Lake Atlas describes in more detail pond connections to groundwater.



While glacial kettle hole pond formation is not exclusive to Cape Cod, the concentration of hundreds of these ponds in such a small geographic area is unique globally.



Cape Cod Ponds by the Numbers



CAPE COD PONDS AND LAKES

Explore more data about Cape Cod ponds and lakes in the Pond Atlas Viewer at: cccom.link/pond-atlas

890
PONDS

166
10+ Acre
Ponds

395
Named
Ponds

LARGEST PONDS by area

1. Long Pond
Brewster and Harwich (743 acres)
2. Mashpee-Wakeby Pond
Mashpee and Sandwich (736 acres)
3. Wequaquet Lake
Barnstable (673 acres)

DEEPEST PONDS with data available

1. Cliff Pond
Brewster (88 ft.)
2. Ashumet Pond
Mashpee (84 ft.)
3. Flax Pond
Brewster (75 ft.)

27 

Fish Stocked
Ponds

107 


Ponds Adjacent to
Cranberry Bogs

22 

Ponds that Cross
Town Boundaries

96 

Ponds with
Public Access*

30% 

Protected Open Space
within pond 300ft buffer

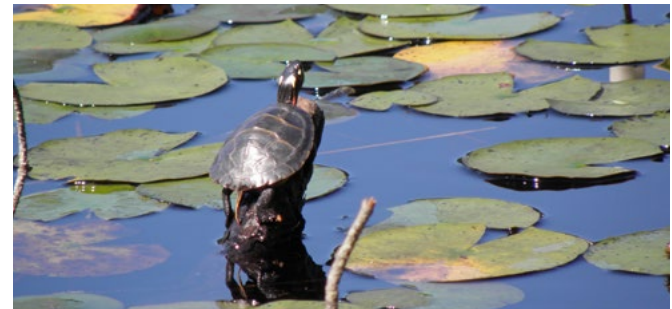
14% 

Impervious Surfaces
within pond 300ft buffer

**Includes public beaches, boat ramps, and launches*

Cape Cod's numerous and diverse ponds range in size from less than an acre to 735 acres. The 21 largest ponds make up nearly half of the total Cape-wide pond acreage. Approximately 40% of Cape Cod ponds are less than an acre and 166 are designated as "great ponds" of 10 acres or more.

Though Cape Cod's ponds and lakes share a similar geologic history, each is distinguished by its geomorphology and natural species composition. Ponds have different depths, surface areas, and volumes. Some ponds have stream connections, but most do not. Pond watersheds are different in terms of size, extent, pattern of development, and topography. Some ponds and their watersheds are, or have been, managed; others are stocked with fish or support different fish communities based on their depth, water temperature, and connectivity to the ocean.



Cape Cod's diverse ponds vary greatly - each with its own species composition, ecological characteristics, surrounding development patterns, and levels of use.

Ponds are an important part of the Cape Cod ecosystem. They are connected to estuarine and marine ecosystems via ground- and surface water; provide habitat for fish, wildlife, and aquatic vegetation, including many rare species; and support complex food webs and rare natural communities.

Ponds are also important to the economy. It is estimated that the region's ponds see between 1.3 and 1.7 million visits annually.² They attract visitors and make Cape Cod a desirable place to live for year-round and seasonal residents. Residents and visitors use ponds for recreational activities such as swimming, boating, and fishing. Homeowners and visitors value clean ponds and are willing to pay a premium to live or rent near them.³ They provide a sense of place, and many enjoy them simply for their aesthetics.

² *ibid.*, p. 41

³ *ibid.*, p. 22

Cape Cod's ponds and lakes are dynamic natural systems that contribute to the region's identity



HABITAT



RECREATION



SENSE OF PLACE



ECONOMY



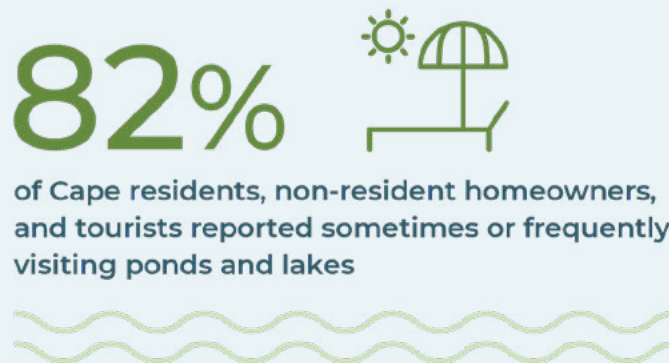
Freshwater Initiative Economic Analysis Key Findings

THE PRESENCE AND QUALITY OF FRESHWATER PONDS AND LAKES HAS A SIGNIFICANT IMPACT ON THE CAPE COD ECONOMY AND TOURISM.

Ponds are a valued natural resource for residents and visitors alike. The Freshwater Initiative Economic Analysis, conducted by Eastern Research Group (ERG), provides necessary data to understand the impact of freshwater quality on property and rental values, pond visitation, spending, public perceptions, and attitudes.

Explore online at:
capecodcommission.org/freshwater

Cape Cod ponds and lakes are popular destinations.



1.3 to 1.7 million
Estimated visits to Cape Cod ponds and lakes annually



66% of visits come between the Months of June and August

Cape residents and non-resident homeowners value clean ponds.

91% 

either “agree” or “strongly agree” that **ponds and lakes are important to the Cape Cod environment**, and they are willing to pay a premium to live near them.

Homes near a pond with clear water will sell or rent for more than similar homes near a pond with algal issues.

Sales price premium of **\$22,300 more** 
(5% more than the median home sales price)

Weekly rental increase of nearly **\$200 more** 
(8% more than the median weekly rental value)

Freshwater Initiative Economic Analysis Key Findings

THE PRESENCE AND QUALITY OF FRESHWATER PONDS AND LAKES HAS A SIGNIFICANT IMPACT ON THE CAPE COD ECONOMY AND TOURISM.

Ponds and lakes with good water quality have a valuable impact and contribution to the Cape Cod economy.

84%

of Cape residents and non-resident homeowners either "agree" or "strongly agree" that **ponds and lakes are important to the Cape Cod economy**



660 to 830 jobs annually can be attributed to spending associated with visits to lakes and ponds



\$70 - \$89 million

of the region's GDP is associated with visits to lakes and ponds

Visitors **spend an average of \$50** locally per visit

People prefer to visit ponds and lakes with clean water and clean beaches.



Visitors are **1.8 TIMES** more likely to visit a pond that

rarely or never has bacterial issues than a pond with issues every summer.



Visitors are **2.5 TIMES** more likely to visit a pond that has **little to no litter** than a pond with a noticeable amount of litter.



Visitors are **1.2 TIMES** more likely to visit a pond that has **signs about recent water testing** than one with no sign.

Cape residents and non-resident homeowners support targeted pond improvements.



The **most impaired** ponds and lakes, the ones with the **highest support** for improvement, and the **most used/visited** should be prioritized.



Cape residents and non-resident owners also overwhelmingly indicated that pond improvement projects with **ecosystem benefits** should be prioritized.

A photograph of a pond with a wooden dock and a building reflected in the water. The water is calm, showing clear reflections of the surrounding environment. The dock is made of wooden planks and extends into the water. The building is a multi-story structure with a light-colored facade and a dark roof. The overall scene is peaceful and scenic.

Defining the Problem

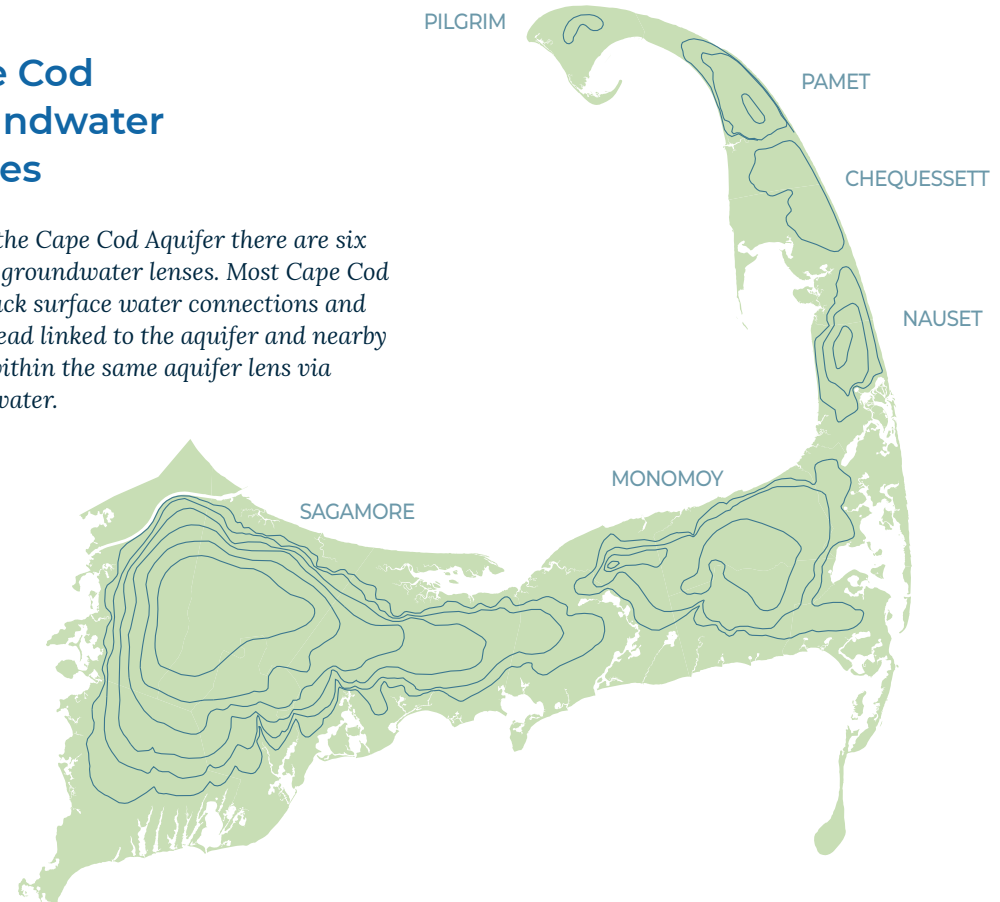
Freshwater challenges are complex.

Human activity and development has led to excessive inputs of nutrients (nitrogen and phosphorus) to ponds from septic systems, fertilizers, and stormwater runoff, which impacts water quality. The buildup of excess nutrients has led to a proliferation of algae that thrives in nutrient-rich and warm waters. Excessive algae growth and subsequent decomposition depletes oxygen, damaging freshwater ecosystems, and certain toxic algae threatens the health and safety of humans, pets, wildlife, and aquatic life. As most Cape Cod ponds and lakes are directly connected to groundwater, activities within the pond watershed or its buffers may impact the pond, and thereby impact pond water quality, the aquifer, drinking water supplies, and downstream coastal bays and estuaries.

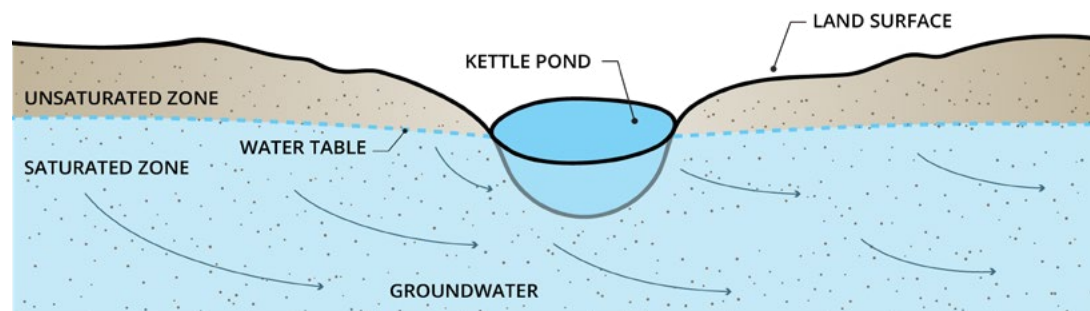
While each of Cape Cod's ponds and lakes are unique, they face shared pressures and stressors that are exacerbated by climate change. Most ponds on the Cape lack surface water connections, and are, instead, directly connected through groundwater to the aquifer, drinking water supplies, and other nearby ponds within the same aquifer lens. Ponds within the same aquifer lens may be similarly impacted by precipitation, drought, and larger scale changes to the landscape and hydrology. Understanding the status of water quality, the unique challenges each of the ponds face, and the potential management approaches for addressing pond health is hampered by a lack of high-quality data.

Cape Cod Groundwater Lenses

Within the Cape Cod Aquifer there are six distinct groundwater lenses. Most Cape Cod ponds lack surface water connections and are instead linked to the aquifer and nearby ponds within the same aquifer lens via groundwater.



The interaction of groundwater with kettle ponds is a key aspect of hydrology in glacially formed landscapes like Cape Cod. Precipitation moves through the unsaturated zone—where soil contains mostly air—before reaching the saturated zone below, where soil is saturated with water. Groundwater in the saturated zone can flow into or out of the pond through the pond bottom.



The Freshwater Initiative launched a dedicated effort to study, monitor, research and analyze the causes of declining pond water quality across the region. Commission staff and partners approached this work hypothesizing that there are land use activities or regional drivers of change causing decline in pond water quality. While data and information collected to date indicate that there are many known contributing factors to changing pond conditions in the region, there is no single factor, or combination of factors, that stands out as a primary cause. Each pond is unique and managing changing conditions requires a targeted approach to address specific management goals.

While individual ponds require in-depth analysis to understand their unique conditions, there are several key findings from this work that identify more widespread causes and solutions for the region's most stressed ponds. Key findings, described in more detail throughout this document, include a decrease in dissolved oxygen due to

increasing water temperatures and phosphorus levels in ponds throughout the region, potential for more frequent harmful algal blooms, impacts from impervious surface and stormwater runoff adjacent to ponds, continued challenges determining the role of

septic systems relative to other sources (e.g. stormwater and fertilizer) on pond phosphorus levels, and a lack of awareness of pond sensitivity evidenced by the overuse of ponds and the surrounding buffer areas.



Threats to Pond Health

The health of a pond is directly related to the land use within, and the condition of, its watershed. Over the past 50 years, Cape Cod has seen a significant increase in its year-round population, from approximately 100,000 people in 1970 to almost 230,000 people in 2020. The population of the region doubles during the warmer months with seasonal residents and visitors. These population increases have led to direct and indirect adverse impacts on freshwater bodies. Threats to ponds and lakes from increased human uses and activities are described in detail in the Cape Cod Pond and Lake Atlas and include:



EXCESS NUTRIENTS (mainly nitrogen and phosphorus) enter ponds through on-site septic system effluent and stormwater. Septic effluent flows through groundwater to ponds, while stormwater flows over the ground, picking up nutrients on the way, to ponds. Over time excess nutrients can lead to eutrophication (increased plant and algae growth).



POLLUTANTS such as pathogens, pesticides, toxic metals, and chemicals including PFAS and other emerging contaminants, enter ponds through wastewater, stormwater, or groundwater and contribute to poor water quality. Pollutants may also impact fish and pose a threat to humans who consume contaminated fish.



ALGAL BLOOMS form under eutrophic conditions and may negatively impact the use of ponds. Some blooms can produce toxins which may be harmful to people, pets, and wildlife. Blooms may also lead to low dissolved oxygen levels, harming aquatic life.



EROSION is the natural process of land being worn down and moved by wind or water. Erosion can be exacerbated by human actions, from development to recreating around ponds, increasing sediment runoff. Sediment in ponds results in increased turbidity and poor water clarity and is also a source of phosphorus.



INVASIVE AND NUISANCE SPECIES can negatively impact pond ecosystems and recreational access. Invasive species are not native to local ecosystems and disrupt food webs and pond ecology. Invasive species can outcompete native species, dominating the water body and reducing biodiversity and recreational opportunities. Once invasive species are introduced, managing and controlling them is a significant challenge.

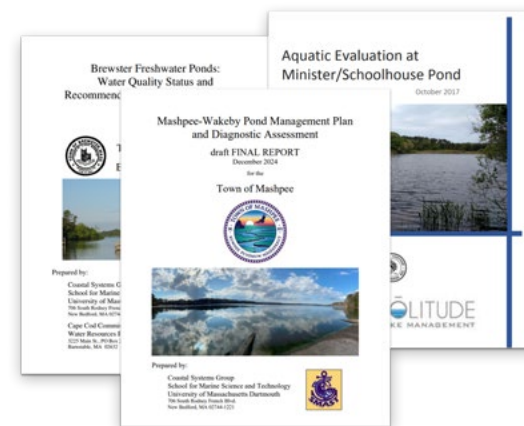


CLIMATE CHANGE has led to increased air and water temperatures, more intense rain events, and prolonged droughts. These effects of climate change exacerbate and magnify the impacts of the other threats to pond health.

The first concerted effort to understand the condition of Cape Cod's ponds took place in 2001 with the formation of the Pond and Lake Stewardship (PALS) Program. The 2001 PALS Snapshot water quality data informed development of the 2003 Cape Cod Pond and Lake Atlas, which identified that between 73% and 93% of monitored ponds showed signs of human impact and approximately 45% of all ponds and 89% of the deepest ponds monitored had conditions unfavorable for fish survival and were determined to be impaired. The 2003 Atlas also found that dissolved oxygen concentrations collected during 2001 PALS monitoring were lower than dissolved oxygen measurements collected by the Massachusetts Department of Fish and Wildlife in 1948,⁴ which suggested that the low dissolved oxygen concentrations observed in the ponds were not “natural” conditions but the reflection of decades of impacts from surrounding development and land use. The 2003 Atlas recognized the importance of ongoing monitoring of pond water quality and the PALS Program continues to collect data on an annual basis.

Since 2001, approximately 80 town-wide or pond-specific studies have been conducted by towns across the Cape, using a combination of data collected by the PALS Program, independent town monitoring, and supplemental monitoring. The reports summarize background information on the pond(s) and the status of water quality and include recommendations for improvement to pond monitoring or pond health. They provide data and information to characterize water quality challenges and insight into potential strategies for restoration and protection. Many of the ponds studied have been identified as impaired. Since its inception in 2019, the Association to Preserve Cape Cod's State of the Waters Report has consistently concluded that over one-third of ponds graded based on available data have “unacceptable” water quality.⁵

Pond ecology is influenced by many factors including nutrient loading, temperature, and pH. Cape Cod's ponds have generally become less acidic, with increases in alkalinity, since passage of the Clean Air Act. Alkalinity is a measure of the ability of a pond



POND PLANS

Since 2001, approximately 80 town-wide or pond-specific studies have been conducted by towns across the Cape.

to neutralize acids and bases. An increase in alkalinity means a pond is better able to provide more stable water chemistry, which in turn provides a healthier environment for aquatic plants and animals. However, ongoing changes in temperature and nutrient loading have created unstable and stressful conditions for pond life. Since 2001, temperatures in ponds in the Sagamore and Monomoy lenses have increased between

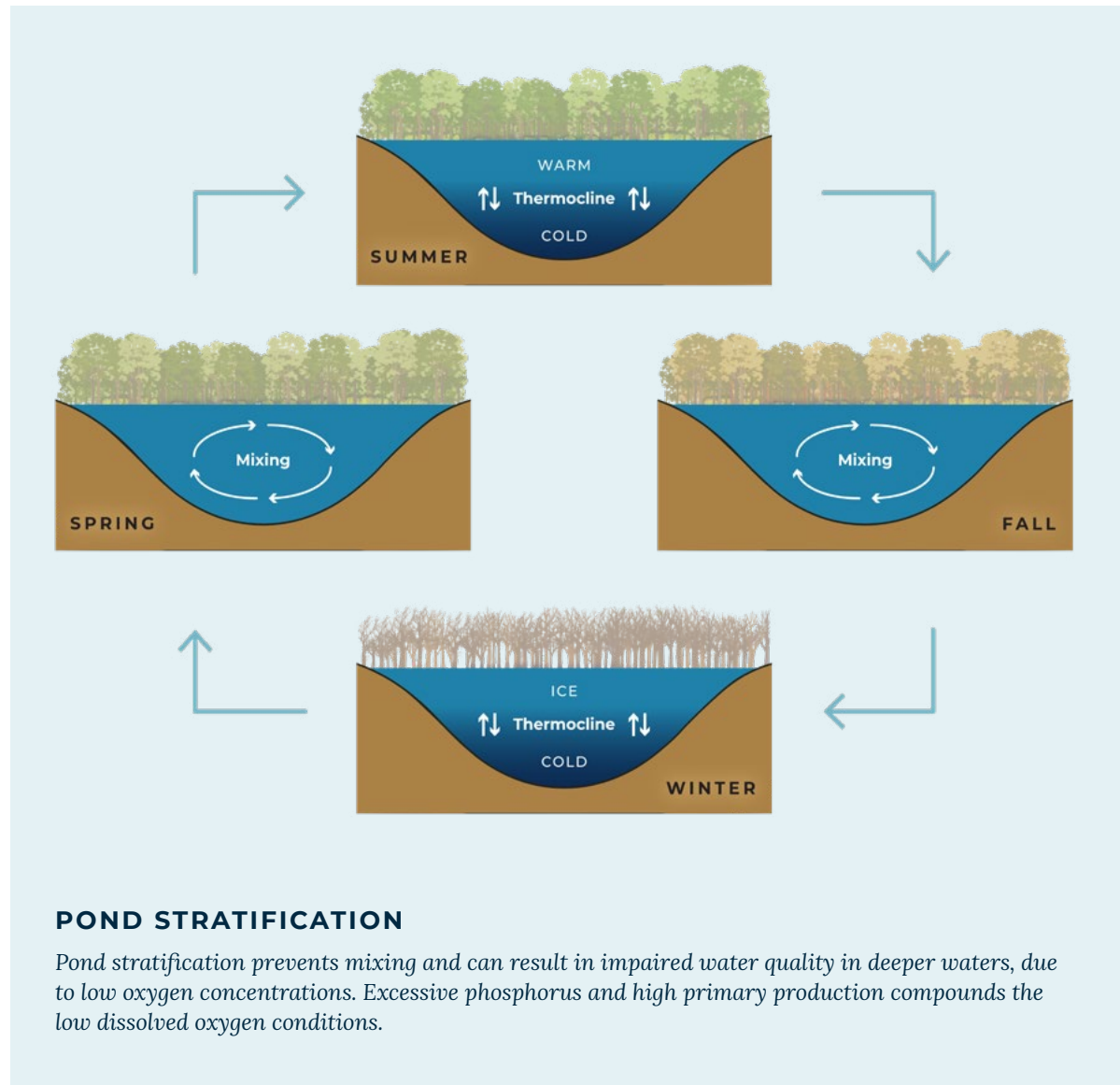
4 Massachusetts Division of Fisheries and Game. 1948. Fisheries Report – Lakes of Plymouth, Berkshire and Barnstable Counties.

5 State of the Waters, Association to Preserve Cape Cod. <https://capecodwaters.org/>.

3.1- and 4.8-degrees Fahrenheit.⁶ Higher water temperatures, particularly warmer winter pond temperatures, impact the timing, duration, and depth of pond stratification. Stronger and longer stratification of ponds can lead to extended low or no oxygen conditions in deeper waters, impacting aquatic life and altering the cycling of nutrients within a pond.

Together, nitrogen and phosphorus support an abundance of plant growth and influence overall pond ecology. Even though the Clean Air Act resulted in reductions of atmospheric nitrogen deposition, nitrogen levels in ponds across the region are increasing. Similarly, and with more direct adverse effects, phosphorus levels in ponds have increased in every lens but the Pamet. Increasing levels of phosphorus in ponds is particularly concerning as it can remain cycling within a pond system indefinitely and have a lasting impact on pond biology. Many of the pond assessments conducted by towns highlight concerns about internal

⁶ Cape Cod Regional Pond Data Analysis, capecodcommission.org/freshwater



loading, or the remobilization of phosphorus from the sediment and its subsequent availability in the water, which further exacerbates eutrophication. In recent years, cyanobacteria have become increasingly visible in Cape Cod ponds. Cyanobacteria monitoring suggests that a combination

of excess nutrients and increasing water temperatures results in poor water quality and harmful algal blooms.

Feedback from stakeholders, including municipal natural resources and conservation professionals, natural resources consultants, pond associations, and pond abutters, has helped to identify the wide range of factors contributing to the decline

in the region's ponds. Limited awareness or concern regarding sensitivity of Cape Cod ponds results in human behaviors that negatively impact pond health.

Increased development brings impervious surfaces and managed landscapes that redirect stormwater into ponds, carrying pollutants and nutrients. Visitors to ponds can introduce invasive species, cause




WHAT IS CYANOBACTERIA?

Cyanobacteria (also known as blue-green algae) are photosynthetic microorganisms in freshwater that can rapidly form harmful blooms. Some produce cyanotoxins, posing risks to humans and animals.



DEVELOPMENT IMPACTS

14% of the land area within the 300-foot buffer of Cape Cod ponds are impervious surfaces. These surfaces increase the rate of stormwater runoff, carrying pollutants and nutrients, and causing erosion. Along developed pond shorelines runoff directly enters the water.

14% 
Impervious Surfaces
 within pond 300 ft. buffer

displacement of wildlife and plants, trample rare or endangered species, and destroy surrounding pond buffers.

Other more structural factors contribute to challenges with pond management. A lack of data limits understanding of the unique conditions in each of the region's ponds, as well as identification of potential solutions. Lack of clear ownership or responsibility for management, complicated by multiple permitting requirements, can prevent initiation of restoration or preservation projects. Limited municipal staff capacity and sources of funding for projects have influenced natural resources management priorities at the local level.

Limited Data Collection and Access

Cape Cod towns, the Barnstable County Department of Health and Environment (BCDHE), the Cape Cod National Seashore, the PALS program, and many non-profit entities have been monitoring ponds for

decades. While some monitoring programs, such as that of the National Seashore, are consistent, others vary. Comprehensive review and assessment of Cape Cod's overall pond health has been limited by a lack of accessible high-quality data.⁷

The annual PALS Snapshot monitoring has continued every year since 2003 through the collaboration of local, county, state, and university programming. With additional monitoring sponsored by towns, pond organizations, and the National Seashore, these programs have collectively contributed more than 1,800 water quality samples

from over 230 ponds across the Cape. Field monitoring has been conducted by National Seashore staff, town staff, and a large network of town-based volunteers. Laboratory analyses of collected water samples are provided by the University of Massachusetts Dartmouth's School for Marine Science and Technology (SMST), the Center for Coastal Studies (CCS), and the North Atlantic Coastal Laboratory (NACL) at the Cape Cod National Seashore (CCNS). Recently, increased quality and frequency of data collection has supported more detailed assessments of pond water quality, provided baseline information, and garnered

PARAMETERS COMMONLY ASSESSED

While the primary suite of parameters measured include water temperature, total depth, Secchi disk depth, dissolved oxygen, pH, alkalinity, chlorophyll a, phaeophytin, total phosphorus, and total nitrogen, parameters vary by organization and program and can make comparisons and long-term trend analyses challenging.

*A Secchi disk is used to measure transparency depth.
Photo: United States Geological Survey.*



⁷ A thorough discussion of the scope and history of freshwater quality monitoring may be found in the Cape Cod Pond and Lakes Atlas: <https://www.capecodcommission.org/our-work/ponds-and-lakes/>

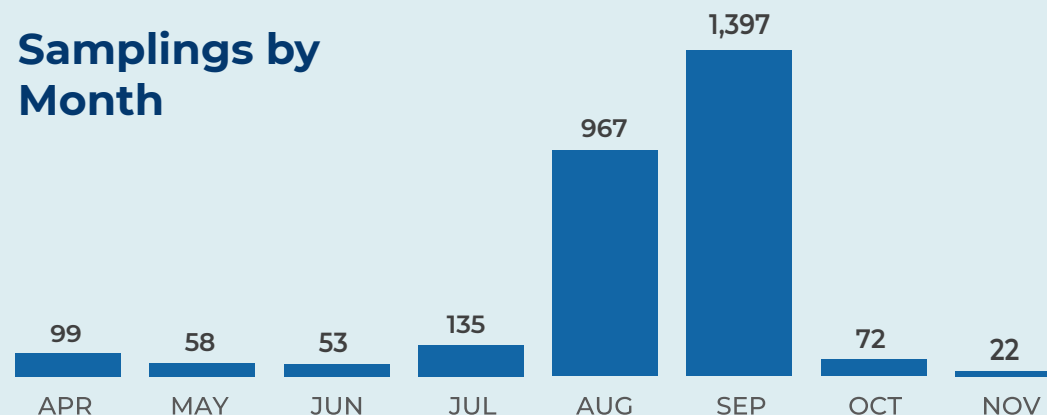
insight into seasonal and long-term trends. Many towns expanded their own municipal monitoring programs, enabling completion of lake and pond assessments.

The vast majority of historical monitoring has occurred in the months of August and September, allowing for evaluation of how physical characteristics (e.g., temperature) and water quality characteristics (e.g., nutrient measurements) change from year to year during the late summer/early fall sampling period. Information about pond conditions in the spring and how those conditions change throughout the summer is extremely limited.

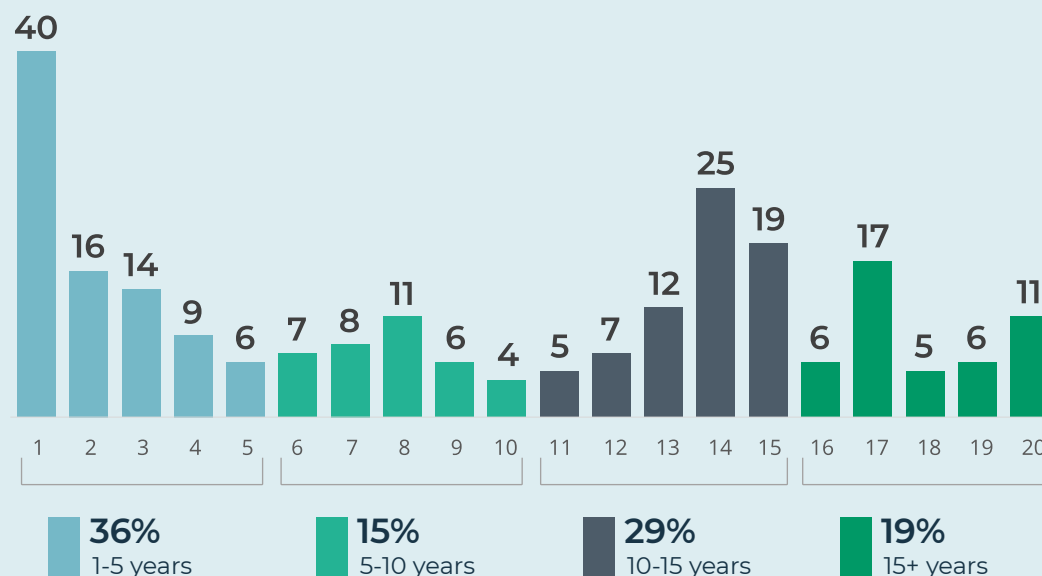
The ponds monitored through the PALS Program change over time and from year to year, which has led to significant variation in the number of data points or the length of data record for individual ponds.⁸ Historic snapshot monitoring, at its peak, measured approximately 20% of the region's ponds on an annual basis. Nearly half of monitored ponds have between 5 and 15 years of data; approximately 20% have data records longer

⁸ Approximately 230 ponds have been monitored by multiple programs over the past 23 years.

Samplings by Month



Ponds by Number of Years Sampled



than 15 years; and approximately 35% have limited data (<5 years). The total number of ponds monitored at any point in time collectively represents just 26% of Cape Cod's 890 ponds.

Water quality monitoring is also conducted for public health reasons.⁹ BCDHE has conducted monitoring for E.coli at freshwater bathing beaches across the Cape for over 30 years. E. coli is an indicator species, whose presence may serve as an indicator of other organisms, viruses, and conditions that have the potential to cause illness. These harmful organisms are present in stormwater runoff, as well as animal and human waste. More recently, pond monitoring has expanded to include sampling for cyanobacteria and surveillance for harmful algal blooms. In 2021, the Association to Preserve Cape Cod (APCC) and BCDHE partnered to expand the County's bacteria sampling to include cyanobacteria monitoring given its potential to degrade water quality and produce toxins. Today, approximately 100 ponds are monitored for the presence of cyanobacteria. To date however, differences in timing and

frequency of monitoring have made it difficult to establish connections between public health monitoring results and water quality data. Going forward, the ability to compare beach closure data with other water quality parameters and watershed characteristics may provide insight into addressing issues that lead to beach closures.

While the large data set generated by the PALS Program, along with data collected through pond-specific studies and other local and regional monitoring efforts, provides an opportunity to gather insights about the region's ponds, it offers limited ability to detect trends with confidence. The inconsistencies in data collection, whether due to locations changing from year to year or individual ponds having longer or shorter data records, make it challenging to calculate trends at a subregional or regional scale. The lack of a comprehensive source of readily available pond data has been identified as hampering the region's ability to evaluate changes in water quality and anticipate challenges, such as harmful algal blooms. Expanded and consistent pond water quality

monitoring and analysis, at larger spatial and temporal scales, is necessary to inform management.

Complex Permitting and Jurisdiction

The current regulatory environment in Massachusetts provides important protections for ponds, adjoining wetlands, and associated wildlife and plant habitat. But permitting requirements, including the time and cost of preparing pond assessments, engineered plans, and other permitting documents, can become a barrier to advancing pond projects. Implementing strategies to protect, manage and restore freshwater ponds often requires permitting through local, state and federal agencies. The regulatory landscape includes interrelated permits, reporting requirements, and planning processes. Access to funds may be hindered by the disparate timelines of the permitting process and those of grant and loan programs.

⁹ Pursuant to the Massachusetts Department of Public Health's Minimum Standards for Bathing Beaches (105 CMR 445.000), freshwater ponds with public and semi-public bathing beaches must be monitored weekly during the bathing season for fecal bacteria to ensure that water remains safe for swimming.

Additionally, the applicable jurisdiction and ensuing responsibility are not always clear. In some cases, abutters and pond users are interested in taking action, but lack the authority to do so. Where smaller ponds are owned by multiple private entities, there must be consensus about taking action, what action to take, and the source of funding. Ponds greater than 10 acres in size may be designated by the state as great ponds,¹⁰ requiring the Commonwealth to be involved in any permitting activities.

The responsibility for taking management action within a pond depends on ownership and can be complex. Ponds can be owned by private parties or a government entity; however, shore front property owners do not automatically have ownership rights in a pond. If a pond is privately owned, private owners can enact and enforce rules and regulations governing the use of the pond; these use regulations extend to the municipality. If a municipality wants a private pond for public use, it would either need to purchase it, or negotiate public access rights from the private owners, including access for management activities. In all

GREAT POND DESIGNATION IN MASSACHUSETTS

For the purposes of public access, the Massachusetts Department of Environmental Protection (MassDEP) presumes that all ponds greater than 10 acres are great ponds, though some ponds greater than 10 acres in size are not on the state's list of great ponds (last updated in 2017).¹ Where access (right-of-way) does not exist to a great pond, Mass General Law Chapter 91 provides a process to petition for access. Great pond status assures public access to the pond and that certain use rights are protected.

¹ Massachusetts Great Ponds List, <https://www.mass.gov/doc/massachusetts-great-ponds-list>



cases, regardless of who is initiating the management action, engaging stakeholders in the planning process is necessary for a successful outcome.

“Great pond” status will also influence management, as great ponds are held in trust by the state for the public. The public

access rights to great ponds initially allowed for free fishing and fowling and were later extended by the courts to include boating, bathing, skating, and taking water or ice for domestic or agricultural purposes. Towns may initiate management actions on great ponds subject to permitting approvals. In cases where management action is

¹⁰ M.G.L. Chapter 91, Section 35. <https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXIV/Chapter91/Section35>

necessary or desired, collaboration between local and state entities will be necessary to determine the responsible parties.

Regardless of pond ownership or great pond status, ponds that require monitoring and/or management action where more than one owner is involved will benefit from engaging all abutters to the pond, as well as town staff and elected and appointed leaders. Different towns may have differing capacities to commit staff time to planning and permitting pond management activities, but unless a

pond is wholly owned by one entity, it is best to engage town staff early on to determine the appropriate local process.

The complexity associated with understanding and managing Cape Cod's diverse freshwater ponds warrants new resources and requires a dedicated, regional approach. Reversing declining pond water quality is a long-standing regional priority; however, due to competing priorities, a lack of data and information, and the sheer number of freshwater resources to address,

among other challenges, the region has had a limited ability to take action to both protect and restore ponds. While each pond is unique and presents its own management challenges, it is necessary to identify opportunities to work collaboratively as a region to establish programs and develop strategies that support local management, project implementation, and broader protection of freshwater ponds and lakes.



An aerial photograph of a coastal area, likely Cape Cod, showing a mix of green land, blue water, and some buildings. The image is overlaid with a semi-transparent teal color that covers the left side and top, creating a background for the text.

Regional Planning Context

Interconnected resources and recommendations.

The Cape Cod Commission's various planning studies and initiatives examine the impacts of changing land use patterns, including identifying impacts on the region's freshwater resources and how that affects other aspects of life on Cape Cod. Freshwater pond challenges and considerations are incorporated into all regional planning initiatives.

The Regional Policy Plan

The [Cape Cod Regional Policy Plan \(RPP\)](#) has long recognized the importance of Cape Cod’s freshwater resources. The 2018 RPP articulates a growth policy that focuses growth in centers of activity and areas supported by adequate infrastructure, while guiding it away from areas that must be protected for ecological, historical, or other reasons. The water resources goal of the 2018 RPP is to maintain a sustainable supply of high quality untreated drinking water and protect, preserve, or restore the

ecological integrity of Cape Cod’s fresh and marine surface water resources. It recognizes freshwater quality as a key challenge facing the region, noting surface water quality in Cape Cod ponds has been significantly impacted by surrounding development.

While the RPP provides an overarching framework and comprehensive vision for growth across Cape Cod, the Commission addresses specific regional issues through focused planning efforts including the Area Wide Water Quality Management Plan, Climate Action Plan, Regional Transportation



Plan, Regional Housing Strategy, Comprehensive Economic Development Strategy, and now this Freshwater Strategy.

REGIONAL POLICY PLAN WATER RESOURCES GOAL AND OBJECTIVES

GOAL	OBJECTIVES	
To maintain a sustainable supply of high quality untreated drinking water and protect, preserve or restore the ecological integrity of fresh and marine surface waters.	1.	Protect and preserve groundwater quality
	2.	Protect, preserve and restore fresh water resources
	3.	Protect, preserve and restore marine water resources
	4.	Manage and treat stormwater to protect and preserve water quality
	5.	Manage groundwater withdrawals and discharges to maintain hydrologic balance and protect surface and groundwater resources

Cape Cod Pond and Lake Atlas

In 2021, the Commission fulfilled a recommended action in the 2018 RPP and published an updated [Atlas](#), along with a [Pond Viewer](#). The updated Atlas provides an account of implementation of the 2003 Atlas recommendations, progress made, and gaps identified. It also summarizes information on current pond science, monitoring, and management. In addition, the Atlas identifies next steps for moving pond monitoring, remediation projects, and conservation efforts forward on Cape Cod. The 2021 Pond and Lake Atlas provided the basis for the Freshwater Initiative.

Area Wide Water Quality Management Plan

Cape Cod's [Area Wide Water Quality Management Plan](#) (208 Plan), developed pursuant to Section 208 of the Clean Water Act, was certified by Massachusetts Governor Charlie Baker and approved by the United States Environmental Protection Agency in 2015. The 208 Plan addresses the degradation of Cape Cod's water resources from excessive nutrients, recognizing that septic systems are the primary source of the nitrogen that degrades coastal water quality. It established a framework to restore coastal water quality that local, regional, state, and federal partners continue to use to advance wastewater management efforts

and regulatory reforms today. In addition, the 208 Plan highlights the importance of considering ponds in watershed planning, as ponds provide natural attenuation of nitrogen in groundwater and act as "nitrogen filters." Ongoing data collection, analysis, and interpretation are imperative to successful implementation of the 208 Plan and are specific recommendations of the certified and approved plan.

Climate Action Plan

Climate change exacerbates threats and impacts to Cape Cod's freshwater ponds. Algal blooms have been documented in dozens of ponds throughout Cape Cod and are anticipated to increase as the climate warms. The [Cape Cod Climate Action Plan](#)



seeks to mitigate the causes and adapt to the impacts of climate change. Finalized in 2021, the Climate Action Plan recognizes that dedicated and immediate action is necessary to slow the effects of climate change and improve the region's resiliency to its impacts. A priority strategy identified in the Climate Action Plan is to reduce emissions by increasing protected open space and natural habitats by enhancing carbon storage and sequestration in forests, wetlands, and soils.¹¹ Adding local efforts to global climate action has the potential to reduce the impacts of climate change on the region's natural resources.

Regional Transportation Plan

The region's transportation infrastructure has both shaped, and been shaped by, the development patterns of the region. It must continue to evolve to meet the needs of future generations, respond to climate change, and support more compact and mixed-use development in appropriate locations.

The [Cape Cod 2024 Regional Transportation Plan](#) (RTP) envisions a multi-modal transportation system that supports the environmental and economic vitality of the region through infrastructure investment

that focuses on safety, livability, sustainability, resiliency, equity, and preservation of the character that makes Cape Cod special.

The RTP acknowledges that ensuring Cape Cod's environment is sustainable and resilient in the long term is paramount and that any threat to the Cape Cod environment is a threat to the overall vitality of the region. It includes a specific goal to maintain, protect, and enhance the natural environment and reduce greenhouse gas emissions. Two objectives aimed at achieving this goal are to minimize negative impacts of the transportation system on the natural environment and improve stormwater management and treatment to improve fresh and marine water resources.¹²

¹¹ *Cape Cod Climate Action Plan*, p. 143, Cape Cod Commission, July 2021.

¹² *Cape Cod 2024 Regional Transportation Plan*, p. 20, Cape Cod Commission, July 2023. See Goal 2: Maintain, Protect, and Enhance the Natural Environment and Reduce Greenhouse Gas Emissions.



Regional Housing Strategy

The region must address challenges associated with the built environment in a way that protects and restores water and natural resources to ensure a vibrant year-round community and economy. The [Cape Cod Regional Housing Strategy](#) includes policies and strategies for housing development and redevelopment to address housing supply, affordability, and availability challenges while protecting sensitive natural resources. It includes a series of guiding principles intended to promote diverse housing opportunities in appropriate locations and consistent with the Cape Cod character. The guiding principles include protecting natural and cultural resources, addressing climate change and coastal resiliency, and prioritizing redevelopment and reuse to ensure that the provision of housing is not at odds with protecting natural resources and ensuring their continued natural functions.¹³

Comprehensive Economic Development Strategy

The [2024 Cape Cod Comprehensive Economic Development Strategy](#) (CEDS) recognizes that the quality of the environment is inextricably linked with the regional economy and quality of life on Cape Cod. High quality natural systems, including freshwater ponds, draw people to Cape Cod. Protecting these resources is imperative to achieving the region's sustainable economic development goals. The 2024 CEDS Action Plan includes investing in water quality and wastewater infrastructure, including continuing to enhance data collection and reporting on fresh and coastal water quality.¹⁴ The CEDS acknowledges these actions are critical to understanding the changing environment, building support for appropriate management of water resources, and for developing a long-term funding strategy for consistent monitoring.

¹³ *Housing Cape Cod: The Regional Strategy*, p. 9, Cape Cod Commission, 2024.

¹⁴ *2024 Cape Cod Comprehensive Economic Development Strategy*, p. 63, Cape Cod Commission, June 2024.

Designing the Freshwater Strategy

**Informed and guided by extensive data,
research, and engagement.**

The Freshwater Strategy has been informed and guided by extensive data collection, research, and robust stakeholder engagement conducted throughout the Freshwater Initiative, with an end goal of better enabling action to support overall health of freshwater ponds on Cape Cod.



Data were assembled to establish a baseline understanding of ponds and lakes in the region. Research was conducted to better define the importance of freshwater resources and identify potential restoration, management, and policy strategies and approaches. Stakeholders provided a more holistic picture of pond threats and observed impairments and highlighted challenges with pond management. Stakeholders also informed and provided feedback on impactful recommendations and resources.

Outreach and Engagement

Commission staff convened various stakeholder and technical working groups to guide development of the Freshwater Strategy. The outreach and engagement process included municipal meetings, subregional stakeholder working groups, a technical advisory group, and end user groups to support development of decision-support tools and guidance documents. In total, more than 350 stakeholders were engaged in the Freshwater Initiative.

MUNICIPAL MEETINGS

Beginning in February 2023, Cape Cod Commission staff met with town staff from across Cape Cod to better understand local concerns and provide an overview of the Freshwater Initiative. The meetings were an opportunity to describe the regional context for freshwater planning, and to discuss goals, priorities, challenges, tools, resources and support needed, and identify stakeholders. Town staff widely expressed an interest in the Regional Pond Monitoring Program and provided insight into local priorities for monitoring. Town staff also highlighted the importance of incorporating freshwater pond management efforts into other local and regional water and wastewater management planning, as well as communicating the mutual benefits of stormwater improvements and wastewater management to freshwater ponds and estuaries.

Town staff noted that funding can be difficult to access and there are limited funding sources and contractors available to support pond work. They also noted their own limitations with staff and volunteer capacity to monitor, report, permit, enforce, and provide education on freshwater ponds.



Pond Network

Coalition of pond groups, associations, and pond water quality monitors designed to connect, collaborate, and share resources



Technical Advisory Groups

Technical experts advised on elements such as the water quality improvement strategies database



Community Outreach and Input

Engaged the broader community to better understand public perception, awareness, and priorities



Stakeholder Engagement

Broad stakeholder representation to understand priorities, potential solutions, and build consensus on a framework for action

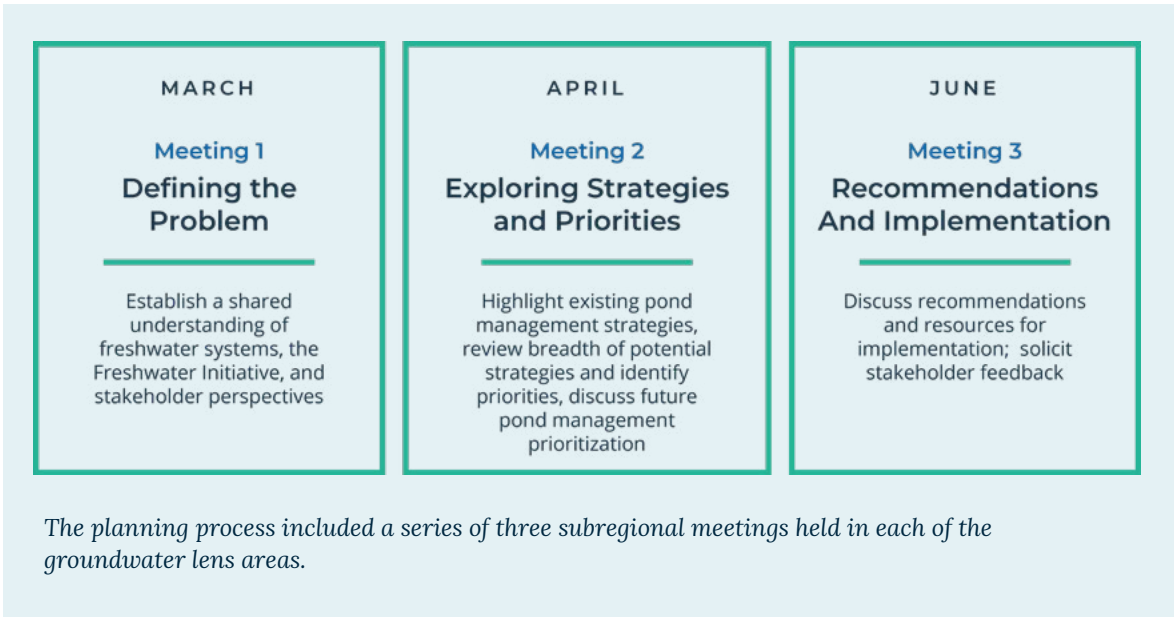
Commission staff convened various stakeholder and technical working groups to guide development of the Freshwater Strategy.

Town staff consistently identified the need for improved communications and outreach, especially for reaching seasonal populations and new homeowners.

SUBREGIONAL STAKEHOLDER WORKING GROUPS

The planning process also included subregional meetings with stakeholders to develop a framework for identifying and implementing pond management strategies. Stakeholder meetings were organized by groundwater lens (Sagamore lens, Monomoy lens, and Outer Cape lenses) with each group meeting three times between March and June 2024. Participants included representatives from municipalities, pond groups and associations, non-profits, and state and federal government agencies, among others.

Stakeholders shared feedback on the top threats to ponds, important qualities of ponds, and resources needed to support pond health. They discussed their experience researching and implementing pond management strategies, considerations for selecting strategies, and important criteria



to consider when prioritizing ponds for study and action. Stakeholders also provided feedback on draft recommendations. They placed specific emphasis on recommendations related to ongoing regional monitoring, ensuring ponds are included in local water resources planning processes, and developing and committing to consistent education and communication about the importance of, impacts to, and management strategies for freshwater ponds. The feedback and perspectives informed identification of priority recommendations included in this strategy.

END USER AND ADVISORY GROUPS

Issue-specific end user and advisory groups were convened to inform development of tools, resources, and guidance documents. Technical advisors representing government, academia, consultants, and non-profits provided expertise and perspectives on freshwater pond strategies and reviewed and offered feedback on the database of restoration, remediation, and management approaches developed. A group of end users, including representatives from government agencies, research and

nonprofit organizations, pond groups, and others, provided insight and feedback into the development of the Water Quality Data Portal, identifying potential uses of the tool, sharing insight on important parameters and analyses, and discussing key features of the interface. A separate group of end users, including conservation agents, pond association members, and ecological landscaping professionals supported development of the Freshwater Pond Buffer Guidance. The group provided feedback on conceptual landscape plans, native plant lists, and broader guidance provided in the document.

PONDS NETWORK

Local pond organizations are prevalent on Cape Cod. Whether they are organized around a single or multiple ponds, each organization is comprised of dedicated volunteers conducting educational outreach, advocacy efforts, and data collection. The [Cape Cod Ponds Network](#) is a collaboration between the Commission and APCC that provides a forum for pond



The Cape Cod Ponds Network pictured at the 2023 OneCape Summit.

groups throughout the region to connect, collaborate, share resources, and discuss and advance solutions and strategies.

The Cape Cod Ponds Network was initially convened in June 2022 and meets quarterly. The network is targeted towards pond stewardship and includes over 40 pond organizations, but meetings are open to any interested parties. Meeting topics have

included establishing network objectives; sharing information on recent pond projects and events; communications, outreach, and engagement; organizing a pond association; regional pond monitoring; pond fisheries; and Freshwater Initiative updates.

COMMUNICATIONS TOOLKIT

Stakeholders consistently identified the need to improve resident and visitor understanding about pond health challenges and the importance of modifying human activities and behavior along pond shores and within pond buffers and watersheds. In response, Commission staff prepared a communications toolkit with resources to help communicate concepts about pond health and management to target audiences. The Communications Toolkit defines terms, identifies audiences, and provides key messages and other resources to improve access to accurate, science-based information about ponds.

The Toolkit is available at:
cccom.link/fws-comms

Research

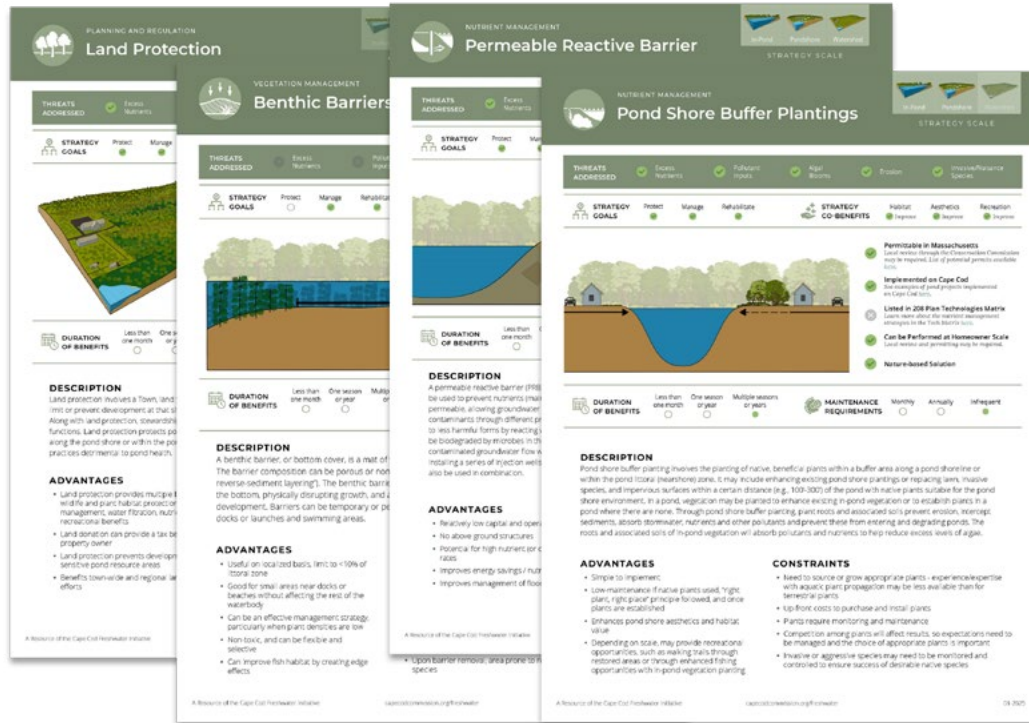
To guide development of the Freshwater Strategy, Commission staff conducted research on past pond assessments and studies as well as the strategies they employed, in order to better understand freshwater challenges throughout Cape Cod, the Commonwealth, and the country. Additionally, the Commission contracted with the Eastern Research Group, Inc. to conduct an economic analysis to better understand the impact of freshwater ponds on the local and regional economy. The Commission also worked with a legal team to conduct an analysis of the legal and jurisdictional landscape governing pond protection, remediation, restoration and management.

STRATEGIES RESEARCH

To ensure existing local efforts and planning were incorporated into the regional planning process, and to better understand the impact of pond restoration and protection projects implemented on Cape Cod, Commission staff reviewed and compiled local pond reports. These reports serve as models for other towns or pond organizations looking

to develop their own plans. Staff solicited information and feedback regarding pond restoration projects from the reports, as well as directly from town staff and pond organizations, and developed a [Pond Restoration Projects Viewer](#), which identifies pond-specific challenges, strategies, and results of projects employed on Cape Cod.

The review of local pond reports informed development of a database of strategies that could be utilized on Cape Cod. Commission staff conducted further research utilizing existing guidance documents, such as Massachusetts' [Practical Guide to Lake Management](#), New York's [Diet for a Small Lake](#), and scientific literature, to understand and document strategies employed elsewhere in the Commonwealth and the country. Staff, with assistance from a group of technical advisors, developed a pond-specific strategies database that includes a range of technologies, regulatory and voluntary options, and management approaches for protecting and restoring pond water quality. To ensure the information in the database is accessible, Commission staff also developed a fact sheet for each of the strategies.



Strategy fact sheets were developed to provide a visual presentation for the array of management approaches identified in the strategies database. In addition to the strategy details, each fact sheet includes a custom illustration that highlights key concepts of the approach and applicable implementation examples. Explore all the freshwater strategy fact sheets at: capecodcommission.org/our-work/pond-strategies

ABOUT THE STRATEGIES TECHNICAL ADVISORY GROUP

Commission staff convened a group of technical advisors knowledgeable about current and innovative freshwater pond protection, management, and restoration strategies to inform and provide insight and feedback on the strategies database. The group met several times during the spring and summer of 2023. Advisors represented government, academia, consultants, and non-profits. The group shared feedback on strategies that are most applicable to Cape Cod's ponds, permitting requirements, and viability. Advisors emphasized that pond management is a long-term process requiring a science-based approach, combination of techniques, ongoing monitoring, and adaptive management. Advisors also suggested highlighting nature-based solutions and solutions that improve climate resilience, which are often a priority for funding.

ECONOMIC ANALYSIS

To better understand and quantify the importance of Cape Cod's ponds to the economy, the Commission contracted with the Eastern Research Group, Inc. to conduct an [economic analysis](#). The analysis quantifies the impact of proximity to clean freshwater lakes and ponds on property values and rental prices, estimates the impact of freshwater quality on the regional economy, and assesses the willingness to pay for key freshwater pond features. The economic analysis also provides an increased understanding of the impact of ponds and lakes, and their respective water quality, on pond visitation, spending, and public perceptions about freshwater resources. Key findings of the economic analysis indicate that Cape Cod ponds and lakes are popular destinations; people prefer to visit ponds and lakes with clean water and clean beaches; Cape residents and non-resident homeowners value clean ponds and support targeted pond improvements; and lakes and ponds are recognized as important to the Cape Cod economy. These results will inform decisions about future freshwater restoration and preservation efforts.

LEGAL AND JURISDICTIONAL ANALYSIS

Commission staff engaged the legal firm Hemenway and Barnes, LLP, to provide an overview of the statutory and regulatory framework governing freshwater ponds and water quality in the region. Their review addressed interrelated federal and state permits, reporting requirements, planning processes, and grant and loan programs, as well as the local and regional regulatory framework for freshwater resources on Cape Cod. Aspects of the analysis are reflected throughout the Strategy and informed development of the recommendations. Additional information and resources to support an understanding of the regulatory landscape, including a list of municipal bylaws and ordinances relevant to freshwater ponds, are available at: capecodcommission.org/freshwater.

REGULATION

As described previously, permitting and jurisdiction over freshwater ponds is complex. The jurisdictional framework related to freshwater ponds begins with the federal [Clean Water Act](#) (CWA), administered by the United States Environmental Protection Agency (EPA) and the Army Corps of Engineers (USACE). The CWA was designed to eliminate pollution of all Waters of the United States (WOTUS) which include freshwater ponds, their tributaries, and adjacent wetlands. Through the states, the CWA establishes water quality standards and provides water pollution control grants. In Massachusetts, standards are established and grants administered through the Massachusetts Department of Environmental Protection (MassDEP). MassDEP also administers Title 5 regulations governing the siting, construction, and expansion of on-site sewage treatment and disposal systems. Total Maximum Daily Loads (TMDLs) may be established for certain pollutants affecting impaired ponds or lakes. Water quality certification (Section 401 of the CWA) is needed for certain permits and is issued by MassDEP. National Pollution Discharge

Elimination System (NPDES) permits are needed for any surface discharge into WOTUS, particularly stormwater discharges, including from Municipal Separate Storm Sewer Systems (MS4s).

The Massachusetts [Wetlands Protection Act](#) (WPA) protects wetlands (including ponds) and the public interests they serve. Public interests include flood control, prevention of pollution and storm damage (including from stormwater), and protection of public and private water supplies, groundwater supply, fisheries, land containing shellfish, and wildlife habitat. These public interests are protected by requiring a careful review of proposed work that may alter wetlands. MassDEP oversees administration of the law, develops regulations and policies, and provides technical assistance to local conservation commissions who administer the WPA. Local conservation commissions may also establish their own local wetlands protection bylaws for the purpose of providing more substantive protection.

In addition to the WPA, other state laws apply to ponds. Massachusetts' [Chapter 91](#) law applies to great ponds – ponds that, in their natural state, contain more than ten acres of land. Chapter 91 holds, in trust for the public, title to land under great ponds, regulates activities in and around great ponds, and preserves public use rights. Where a pond is a designated habitat for threatened or endangered species under the [Massachusetts Endangered Species Act](#), any project impacting such habitat is subject to review by the Natural Heritage and Endangered Species Program. In addition, the [Massachusetts Environmental Policy Act](#) (MEPA) provides for public review of the potential environmental impacts of projects that otherwise require state approval or benefit from state financial assistance, including certain larger projects subject to permitting under the WPA.

Depending on the pond, or pond watershed, and the scope and scale of the freshwater pond strategy being implemented, additional reviews by local boards, committees and departments, as well as other regional, state, and federal agencies, may be required (see [Pond Strategies Permitting](#)).

FRESHWATER POND BUFFER GUIDANCE

Pond shore buffers play a critical role in the health of Cape Cod's ponds. One of the strategies identified through the Freshwater Initiative to help protect and restore pond health is to install or enhance natural pond shore buffers with native plants. Homeowners, pond associations, and municipalities with properties bordering freshwater ponds seek guidance and local examples of landscaping and other best practices to help protect and preserve ponds. To help meet this identified need, Commission staff worked with a consultant

to develop [guidance for pond shore buffers](#) that will aid in educating residents and homeowners, increase community acceptance and implementation of appropriate pond shore practices, and support local conservation commission review and approval of restorative pond shore projects.

The guidance includes basic information on landscape installation and maintenance best practices landowners can undertake to preserve and protect freshwater ponds, as well as information on the importance of vegetated buffers to freshwater ponds,

a description of Cape Cod freshwater pond shore native plant communities, a list of native plants and where to source them, and planting plans for a variety of pond shore landscapes found on Cape Cod. The guidelines provide concise, user-friendly, visually inspiring freshwater pond shore buffer guidelines to assist Cape Cod pond shore property owners and municipalities in their efforts to protect freshwater pond ecosystems and pond water quality.

ABOUT THE POND BUFFER GUIDANCE END USER GROUP

To aid in the development of the pond buffer guidance, the Commission convened a group of end users including conservation agents, pond association members, and ecological landscaping professionals to review and provide feedback on drafts of conceptual landscape plans, native plant lists, and narrative guidance. The end users were asked about the level of detail in the concept plans and whether the plans adequately represent the various types of freshwater pond shores generally encountered on Cape Cod based on characteristics like slope, sun exposure, and soil conditions. Participants also provided insight on which plant lists they typically refer to in their community or work and their thoughts on incorporating species that may not be native to Cape Cod, but may be native to the broader region and be very beneficial to wildlife. The end users also commented on the outline for designing, installing, and maintaining a pond buffer and offered feedback on best practices to be included in the guide.

Cape Cod Freshwater Pond Buffer Guidance

The pond buffer guidance offers practical strategies for installing or enhancing native pond shore buffers. It includes best practices, planting plans, extensive native species lists, and resources to empower homeowners to make environmentally responsible choices.

View the guide at: cccom.link/pond-buffer-guidance

BEST PRACTICES, PLANTING PLANS, AND RESOURCES

THE IMPORTANCE OF VEGETATED BUFFERS

CAPE COD FRESHWATER POND BUFFER GUIDANCE

A HEALTHY VEGETATED BUFFER HAS:

NO DEVELOPMENT

Ideal buffers are devoid of structures, impervious surfaces, non-biodegradable materials, and other site disturbances.

DENSE LAYERS OF NATIVE PLANTS

• Overstory (Tall Trees and Shrubs)
• Understory (Small Trees and Shrubs)
• Groundcovers & Herbaceous Plants (Low Shrubs, Ferns, Perennials & Grasses)

SPECIES DIVERSITY

• A range of native plants that provide flowers, seeds, and fruit at different times to support wildlife throughout all four seasons.

• A mix of evergreen and deciduous plants (deciduous plants lose their leaves in winter; evergreens have green leaves all year round).

NATURAL LITTER

• Fallen leaves and needles act as natural mulch, protecting plant roots and sheltering insects and small animals that over-winter on Cape Cod. They also add valuable nutrients back into the soil.

• Snags, fallen trees, and dead stumps provide wildlife habitat for aquatic and terrestrial wildlife species, as well as insects and fungi which are all part of a healthy freshwater wetland ecosystem.

MAINTENANCE FREE ZONE

Unless under special conditions with a wetland permit:

• No fertilizers, herbicides or pesticides
• No removal of trees or other vegetation
• No pruning or removal of limbs

ELEMENTS OF A VEGETATED BUFFER

Ideally, all development is kept outside of the buffer, and the entire buffer is filled with dense layers of native vegetation. Development includes buildings, driveways and parking areas, decks, patios, swimming pools and accessory structures, walkways, utilities, drainage structures and septic systems. Turf lawns, vegetable gardens and highly manicured ornamental planting beds that may contain fertilizers and other chemicals should also remain outside of the buffer zone. Fences should not be placed in buffer areas unless they are designed with large enough space for wildlife to be able to move through without getting trapped.

Septic systems and leaching fields should be placed as far away from the pond as possible, ideally 300 feet or more from the pond. Plantings above septic areas should be of herbaceous plant material such as grasses and wildflowers. Woody trees and shrubs should not be planted above or immediately adjacent to septic areas, as their roots can interfere with the system's ability to properly function.

Draining wood is not near freshwater ponds as part of a healthy ecosystem. (Photo by Regis Toner)

SECTION THROUGH A POND BUFFER



THE IMPORTANCE OF VEGETATED BUFFERS

CAPE COD FRESHWATER POND BUFFER GUIDANCE

WHY CHOOSE NATIVE PLANTS?

ADAPTED TO LOCAL REGIONS

Native Cape Cod species have adapted to their unique environment, including cold winters, poor soil conditions, strong winds, salt spray and periods of drought and flooding.

LOW MAINTENANCE

Since our native plants are adapted to this region, as long as they are located in places best suited for their needs, they require less attention than many exotic plants. Once established, native plants require:

• **Little or No Fertilizer and Pesticides**
Decreases the amount of chemicals and herbicides from entering our waterbodies and reduces annual maintenance costs.

• **Minimal Maintenance**
Less time and energy spent mowing, weeding, or watering.

• **Little or No Irrigation**
Conserves water, making our fresh water resources more available, as well as reducing water bills.

AMBIENT AND CULTURAL VALUE

Native plants are an integral part of the historic and natural aesthetic of our local landscapes. They provide woodland flowers in spring, wildflowers meadows in summer, and brilliant color in fall. The abundance of berries and fruit native plants produce are critical food sources for local and migratory birds.

EROSION & STORMWATER CONTROL

The deep and complex roots of our native plants are well-designed to co-exist with other native plants to form a dense matrix of root systems that can retain soils, as well as filter and absorb stormwater runoff more efficiently than a monoculture of non-native plants.

CRITICAL TO NATIVE WILDLIFE

Native plants are essential components of local wildlife habitats.

• **Host Plants for Native Pollinators**
While adult pollinators can often feed on non-native flowers, most insects evolved alongside specific plants that feed their larvae. If their host plants are missing from their habitats, the larvae will not survive into adulthood.

• **Support for the Native Food Web**
By hosting pollinators and insect populations, native plants are an integral part of the native food web. While adult birds can eat seeds and fruit from a variety of plants, most require thousands of insects to feed their young. Small animals that eat native plants, worms and fruit in turn feed predators like foxes and owls.

• **Shelter for a Variety of Wildlife**
Native plants have co-evolved with the native wildlife over thousands of years, forming symbiotic relationships that support each other. They often co-exist in a rich matrix of different plant types that has the potential to feed and shelter an equally diverse selection of wildlife.

NATIVE PLANTS ARE A CRITICAL SOURCE OF FOOD, COVER, AND NESTING HABITAT FOR LOCAL WILDLIFE. SOME SPECIES DEPEND EXCLUSIVELY ON SPECIFIC PLANTS WITHIN REGIONAL AND LOCAL ECOSYSTEMS FOR SURVIVAL.



The Red-Bellied Sapsucker (pictured) and other species that rely on native plants for food and shelter. **The Red-Bellied Sapsucker** (pictured) and other species that rely on native plants for food and shelter. **The Red-Bellied Sapsucker** (pictured) and other species that rely on native plants for food and shelter.

CAPE COD FRESHWATER POND BUFFER GUIDANCE

CONCEPT #1

Existing Site Conditions:

• Building is completely in the buffer zone.
• A healthy tree canopy (mostly shade trees).
• Understory consists of native groundcovers with no significant shrub material and no area of turf lawn.
• Soil is moist but well-drained with organic matter.

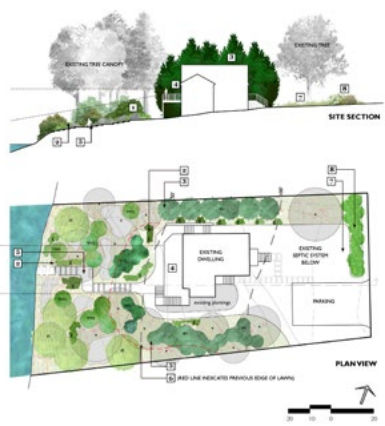
Site Goals:

1. Establish understory layers by planting shrubs to help control erosion and provide seasonal interest. Focus on areas where existing groundcovers are sparse.
2. Supplement bare soil areas with additional groundcovers.
3. Provide shade-colored evergreen plantings near to the house to provide privacy between neighbors.
4. Preserve a direct view from road (see floor plan).
5. Provide steps to the water and a small bench area the works with existing vegetation and topography.
6. Remove turf lawn from the back yard area.
7. Plant native play space in the front yard (consider using low alternatives with a "no mow" house or native groundcovers).
8. Provide a small planting strip between the street and front yard as a first line of defense for stormwater runoff.

Suggested Plants:

Small trees (15-25' Ht.)
American hornbeam (Cornus alternifolia)
Osage orange (Hog hornbeam)
Alder (Betula)
Evergreen screening (trees or shrubs)
Red cedar (Juniperus)
Boxwood (Buxus)
Medium-Tall Shrubs (6-10' Ht.)
Celtis occidentalis (Common Hackberry)
Cornus alternifolia (American Hornbeam)
Boxwood (Buxus)
Medium-Low Shrubs (4-6' Ht.)
Caulophthorus (Panicum)
Rugosa rose (Rosa rugosa)
Rosa pratincola (Sweet rose)
Groundcover / Green Muck (less than 3' Ht.)
Coral bells (Hebe)
Dwarf mondo grass (Liriodendron)
Purple meadow grass (Hesperis matronalis)

APPENDIX A: EXAMPLE PLANTING STRATEGIES FOR RESTORING VEGETATED BUFFERS



APPENDIX B: PLANT LISTS AND ADDITIONAL RESOURCES

CAPE COD FRESHWATER POND BUFFER GUIDANCE

WOODY SHRUBS NATIVE TO CAPE COD



Upper left: The guidance outlines the importance of vegetated buffers to ponds and key components of a healthy buffer.

Upper right: The guide highlights the benefits of selecting native plants for pond buffers and the negative impacts of invasive plant species.

Lower left: The guide presents 11 concept plans, representative of typical conditions of pond shore properties on Cape Cod, showing different planting strategies for residences within buffers to freshwater ponds.

Lower right: An extensive list of native trees, shrubs, and groundcovers is included in the guidance with representative photos and details on size, shape, sun and soil requirements, color and bloom time, and wildlife benefits.

POND PRIORITIZATION FRAMEWORK

The stakeholder engagement process highlighted the gap between resources available for freshwater pond planning and management and the number of ponds requiring attention. A model pond prioritization framework was suggested as a systematic and transparent way to support the distribution of limited municipal resources over time and help provide justification for grant applications and funding requests. Several existing examples of criteria used to prioritize water bodies for scientific study, funding, or management were identified. Commission staff reviewed local municipal pond prioritization criteria where they exist, preferred characteristics of ponds to prioritize for improvement from the Economic Analysis Public Perception Survey,¹⁵ and MassDEP's TMDL 2.0 document.¹⁶ As

freshwater planning varies substantially from town to town in terms of the number of water bodies to manage, level of previous study, and local priorities, a compilation of relevant prioritization criteria was compiled as a resource to support prioritization at the local level. Municipal and other pond decision-makers can utilize the [list of criteria](#), as appropriate for their community, and apply them to multiple water bodies.

Baseline Data

Commission staff and consultants collected and analyzed existing data and information to better understand pond characteristics and surrounding land uses, the status of freshwater quality, and potential internal and external drivers of water quality degradation. To support access to consistent and expanded data and analysis on the health

of freshwater ponds, Commission staff also partnered with APCC, National Oceanic and Atmospheric Administration (NOAA), and others to develop new programs and approaches for collecting and analyzing data necessary to support management decisions moving forward.

POND PROFILES

To provide context for ponds at the local and regional scale, Commission staff developed [pond profiles](#) for each of the 15 Cape Cod towns and for Barnstable County. The profiles include a snapshot of regional and town-by-town pond information, including freshwater pond characteristics, monitoring efforts, water quality impairments, surrounding land use and watershed details, as well as related town actions and strategies, and existing local pond organizations.

¹⁵ *Cape Cod Freshwater Initiative Economic Analysis*, p. 54-107, ERG, Inc, April 2024. <https://capecodcommission.org/our-work/freshwater-economic-analysis>

¹⁶ [Massachusetts Vision 2.0: Clean Water Act Section 303\(d\) and Total Maximum Daily Load Development](#)

Barnstable County Ponds Profile

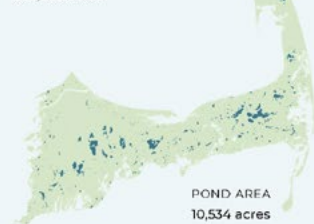
A RESOURCE OF THE CAPE COD FRESHWATER INITIATIVE



Water quality is critical to the vitality of the region's pond ecosystems and coastal embayments. Yet pollutants found in stormwater runoff, and in groundwater by which ponds are recharged, threaten the region's freshwater quality. Understanding the broad issues that impact Cape Cod's freshwater ponds, characteristics of the region's ponds, and actions at the local level all help set a baseline for understanding and action.

Cape Cod

LAND AREA
263,985 acres



POND AREA
10,534 acres

4% of total regional area is comprised of freshwater ponds and lakes

Top 5 Largest Ponds

POND	AREA
1. Long Pond (Brewster)	742.9 acres
2. Mashpee-Wakeby Pond	735.9 acres
3. Wequaquet Lake	673.1 acres
4. Johns Pond	336.7 acres
5. Upper Mill Pond	260.1 acres

Top 5 Deepest Ponds

POND	DEPTH
1. Cliff Pond	88 ft.
2. Ashumet Pond	84 ft.
3. Flax Pond	75 ft.
4. Long Pond (Brewster)	70 ft.
5. Higgins Pond	66 ft.

890
PONDS

166
10+ Acre Ponds

395
Named Ponds

12 ACRES
Average Pond Size

24 FEET
Average Pond Depth

27
Fish Stocked Ponds

107
Ponds Adjacent to Cranberry Bogs

22
Ponds that Cross Town Boundaries

96
Ponds with Public Access

122
State Listed Great Ponds

14%
Impervious Surfaces in Pond 300ft Buffer

63
Ponds with Coastal Plain Pondshores

388
Ponds with Rare Species Habitat

Pond Monitoring

Of the region's 890 ponds, only 61 have three consecutive years of recent monitoring data and only 24% of all the ponds have available monitoring data. The data record for this monitoring spans 20 years with an average of 1 sampling event every other year at each monitored pond.

218

Ponds Monitored

61

Ponds with 3 Consecutive Years of Recent Data (2016-2021)

Water Quality Impairments

A lack of consistent and available monitoring data for all ponds means that we may be underestimating threats to waterbody health.

25

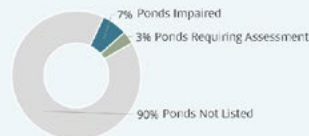
Harmful Algal Bloom Advisories Since 2017 (DPH Reported)

88

Ponds listed on MassDEP's Draft 2022 Integrated List of Waters

25

Freshwater Bathing Beaches with Sampling Failures for Fecal Coliform in 2022



Barnstable County Ponds Profile

A RESOURCE OF THE CAPE COD FRESHWATER INITIATIVE

Pond Watersheds

The land area that contributes to freshwater ponds and lakes is referred to as a pond watershed. Relatively few pond watersheds have been delineated across the Cape. Land area within pond watersheds is much larger than the water bodies themselves. On Cape Cod, 17% of the region's total land area is within a delineated pond watershed.

167
Pond Watersheds Delineated

43,762
Acres of Pond Watershed Area

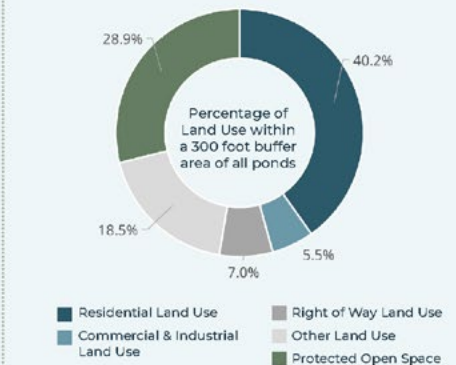
31
Pond Watersheds that Cross Town Boundaries

Freshwater Ponds
Pond Watershed Area



Land Use in Pond Buffer Area

Understanding the way that land is used around our freshwater ponds contributes to a better understanding of potential pond impacts, stressors, and viable strategies to protect or restore pond health. 17,681 acres (or 7%) of the region's total land area is within 300 feet of a freshwater pond.



Documented Town Reports and Actions

16

Town Specific Freshwater Reports

41

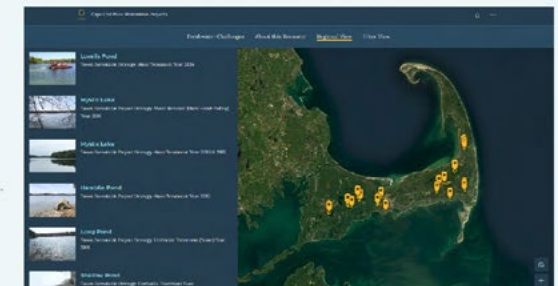
Pond Specific Freshwater Reports

Local Pond Organizations

Independent groups, organizing around a single or multiple ponds, voluntarily conduct educational and advocacy efforts and collect water quality monitoring data, which is not always available or sufficient for regional analysis.

40

Local Pond Organizations



Pond Strategies Implemented

Updates and additional projects will be added as information becomes available. Review project details at: ccom.link/pond-restoration-projects

61

Pond Strategies Implemented

Compiled using best available data; subject to change. Learn more about the region's freshwater resources at: capecodcommission.org/freshwater

Pond Profiles, available for all 15 towns and the county, provide a snapshot of regional and town-by-town pond information. Information includes freshwater pond characteristics, monitoring efforts, water quality impairments, surrounding land use and watershed details, along with related town actions and strategies, and existing local pond organizations. Explore: capecodcommission.org/our-work/cape-cod-ponds-profiles/

ANALYSIS OF PHYSICAL CHARACTERISTICS

To better understand whether physical characteristics of ponds and their watersheds contribute to changes in water quality, the Commission conducted a series of Geographic Information System (GIS) analyses of Cape Cod ponds.¹⁷ These analyses included an assessment of potential internal and external drivers of water quality degradation. Pond characteristics, such as depth, acreage, location within a watershed, as well as surrounding watershed characteristics, such as size, amount and proximity of development, and adjacency to golf courses, can be either stressors or benefits to a pond. While this analysis did not identify any clear correlations between pond and watershed characteristics and water quality, it did reinforce the observation that each pond is unique and will require individual analysis to understand the causes of water quality and habitat decline.



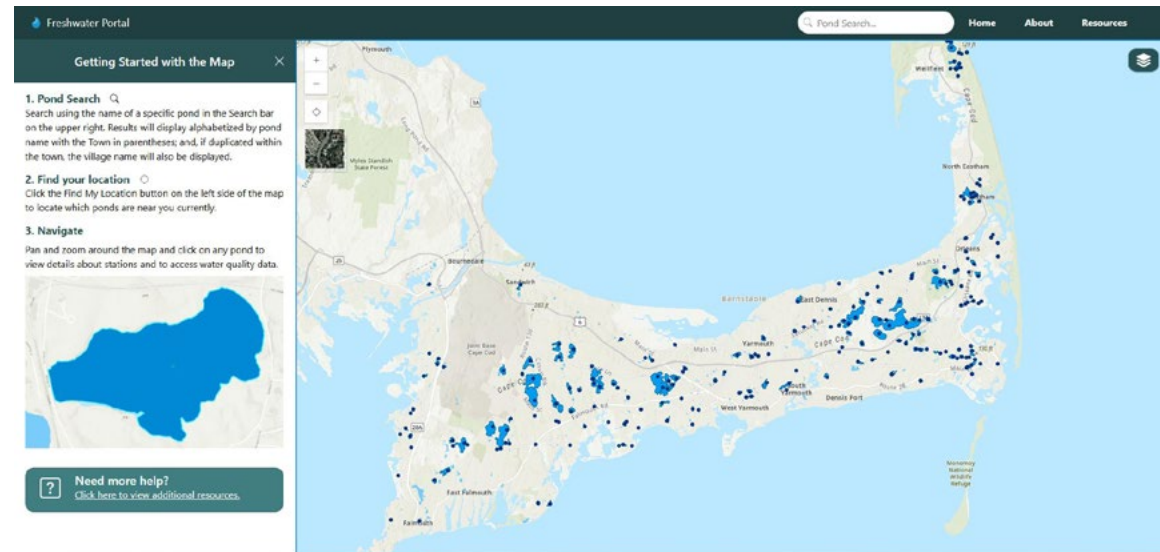
The map above indicates the top 30 most stressed ponds (named ponds) from the Analysis of Physical Characteristics.

¹⁷ <https://capecodcommission.org/our-work/pond-characteristics>

WATER QUALITY MONITORING AND ANALYSIS

In order to enable a more complete understanding of changes in pond health through sufficient water quality monitoring and consistent data collection, the Commission, in partnership with APCC, launched the [Cape Cod Regional Pond Monitoring Program](#). The Program monitors 50 representative ponds across Cape Cod to provide insight into regional freshwater pond water quality and how it is influenced by factors including pond size, surrounding land use, land cover, and watershed characteristics.

To ensure these data, along with historic monitoring data, are analyzed and available to inform decision-making, the Commission, in partnership with the Woods Hole Oceanographic Institution (WHOI) and the Timmons Group, developed the [Cape Cod Water Quality Data Portal](#), a map-based tool that allows users to explore freshwater and marine water quality data aggregated from local and regional partners. It depicts high-level temporal trends in water quality parameters at various spatial scales ranging from individual monitoring stations to



The new freshwater portal allows users to view available monitoring data. Explore the data at: waterquality.capecodcommission.org/

whole coastal embayments or ponds. Trend analyses are updated as new data are added to the database.

Since monitoring all 890 freshwater ponds in the region is infeasible, the Commission also worked with partners to investigate new strategies for understanding changes in pond characteristics and health, including the use of remote sensing. This work involves correlating observations from satellite imagery with measured water quality data

to develop a model of water quality for Cape Cod ponds and lakes. More information on efforts to utilize remote sensing to better understand changes in ponds and lakes is available at: <https://capecodcommission.org/our-work/remote-sensing>.

Expanded Data Collection and Analysis

Ongoing and consistent freshwater data collection.

Development and implementation of the Regional Pond Monitoring Program was a critical step toward generating consistent data from ponds. The program builds on years of varied water quality monitoring across Cape Cod; now, with the new and historic data collected and made available through the Water Quality Data Portal, users may explore changing water quality conditions in Cape Cod ponds over time.

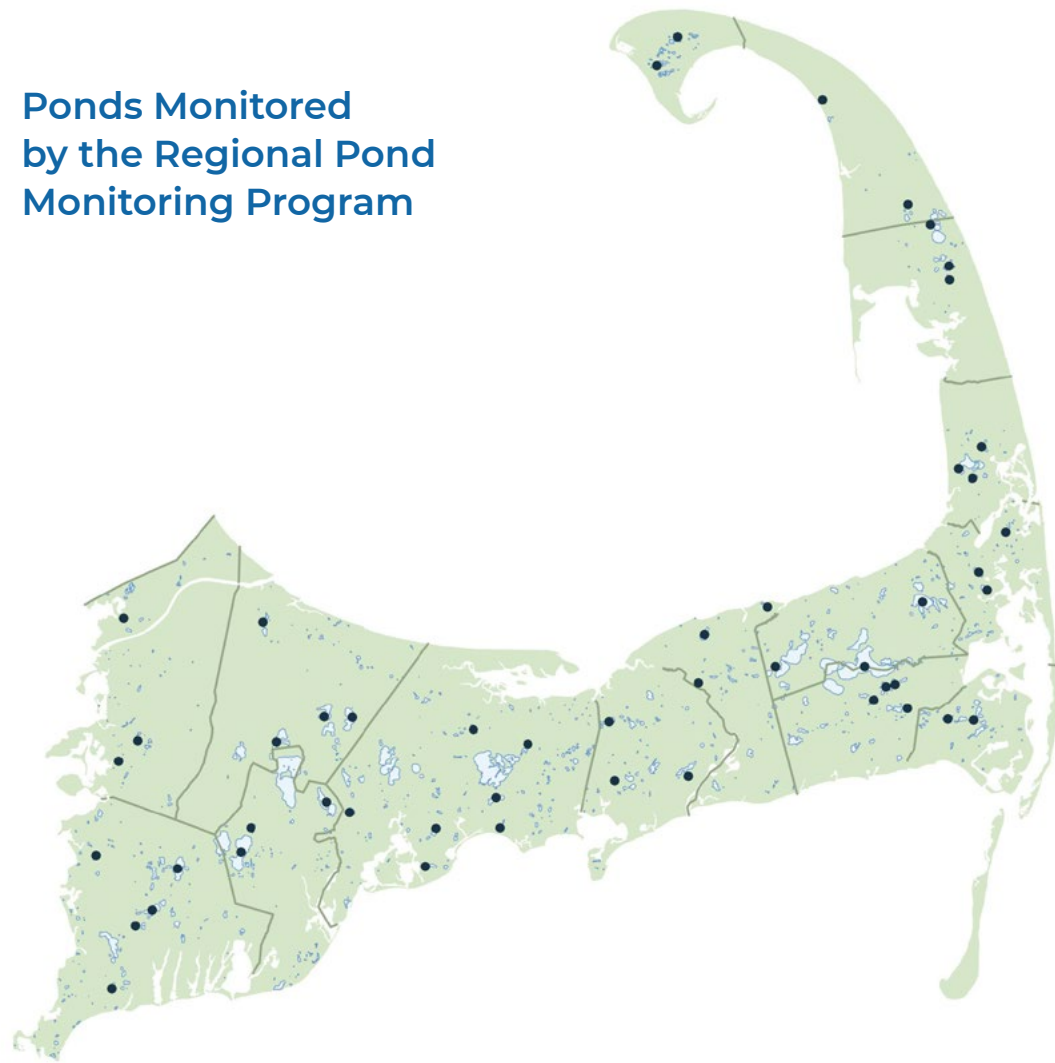


Regional Pond Monitoring Program

The historic data record indicated that more comprehensive data collection is necessary to understand whether ponds are getting warmer and what might be driving that behavior; whether cyanobacteria blooms are increasing and why; and the degree to which internal phosphorus loads are responsible for observed changes in algal and plant growth throughout the region's ponds. Over time, the focus of monitoring has also generally shifted from baseline monitoring to tracking changes in water quality, measuring the effectiveness of restoration projects, and complementing larger watershed management programs. The [Regional Pond Monitoring Program](#) monitors a consistent set of ponds throughout Cape Cod on a more frequent basis than previous efforts.

The Program, operated by APCC with sample analysis conducted by the Center for Coastal Studies, monitors ponds across Cape Cod to provide insight into regional freshwater pond water quality and how it is influenced by factors including pond size, surrounding land use, land cover,

Ponds Monitored by the Regional Pond Monitoring Program



The Regional Monitoring Program monitors 50 representative ponds throughout the region.

and watershed characteristics. The ponds selected to be monitored are representative of the wide variety of physical and landscape characteristics amongst Cape Cod ponds, and are monitored monthly from March through November. The Program was designed to complement existing monitoring efforts and provide baseline data regarding how different types of ponds respond to changing regional environmental conditions throughout the monitoring season and from year to year. Selection of ponds was coordinated with municipal and other monitoring programs to prevent duplicating efforts and maximize data coverage across the region.

Monitoring began in April 2023 and in its first two seasons the Program completed over 700 pond sampling events and added more than 100,000 data points to the region's freshwater data record. While a longer record of data is necessary to understand specific changes in individual ponds, data collection has enabled a better understanding of the impacts of climate change on Cape Cod's

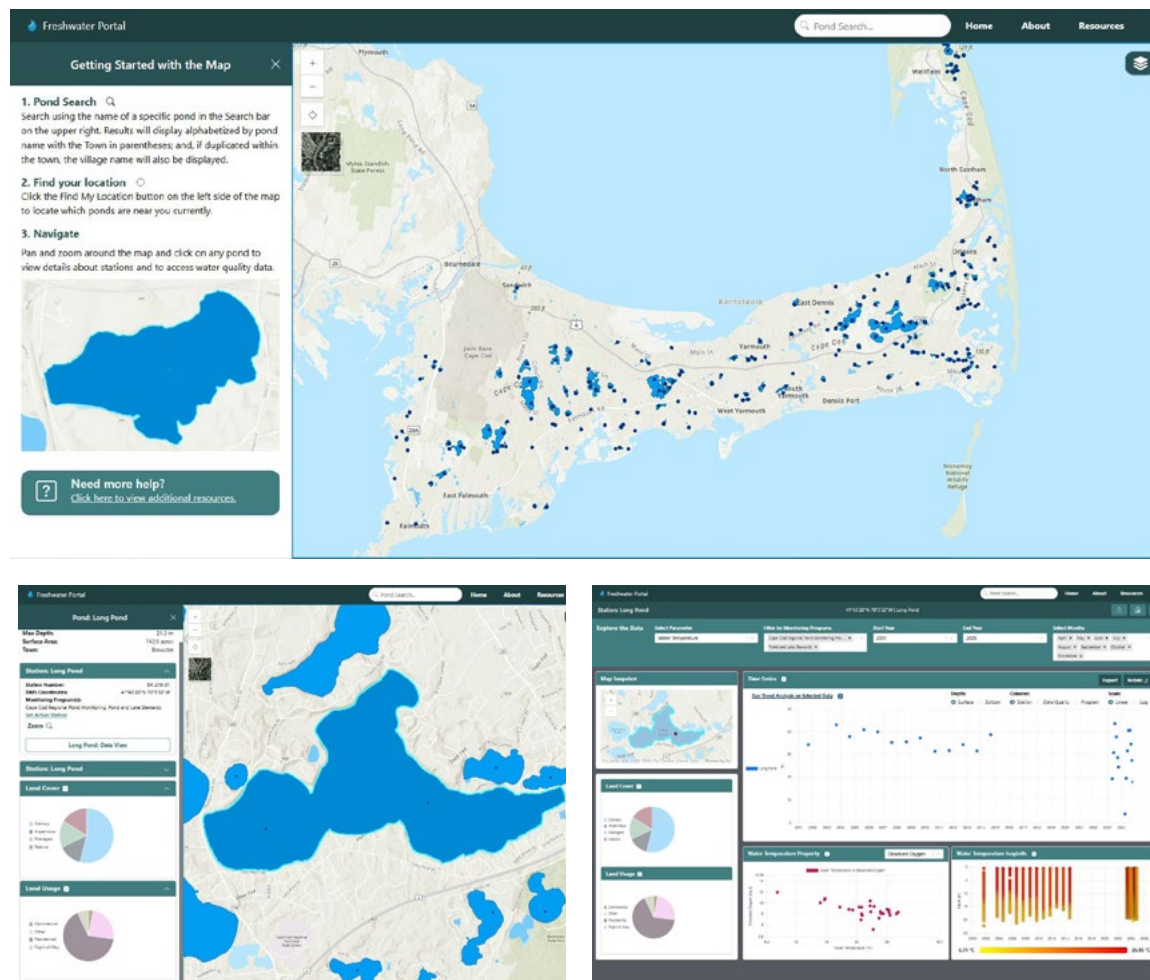
ponds, which is affecting the timeframe and duration of pond stratification, and, in turn, dissolved oxygen and habitat conditions.

Cape Cod Water Quality Data Portal

To ensure that water quality monitoring data and associated trend analyses are available to support decision-making, Commission staff developed the Regional Water Quality Database to bring historic and current monitoring data together in one location in conjunction with tools for analysis of trends over time. The [Cape Cod Water Quality Data Portal](https://waterquality.capecodcommission.org/) is a map-based tool that allows users to explore freshwater and marine water quality data aggregated from local and regional partners. The portal depicts high-level temporal trends in water quality parameters at various spatial scales ranging from individual monitoring stations to whole embayments in the marine portal, and provides multiple data views for pond monitoring stations in the freshwater

portal. This application adds to a suite of tools available to equip town staff and stakeholders with the best available data for addressing water quality at the local and regional scales.

Development of the data portal was conducted in collaboration with the Woods Hole Oceanographic Institution (WHOI), and the developer, Timmons Group. Researchers with expertise in managing and analyzing large scale data sets worked with Commission staff to conduct analyses and develop algorithms to support display of data and trends in the portal. Commission staff also convened an end user group to provide input and refine the data portal, with a particular focus on the data and analysis necessary to inform local decision-making and meet the needs of the broader community. Development of the portal leveraged the existing data framework to provide both freshwater and marine water quality data at <https://waterquality.capecodcommission.org/>.



The Cape Cod Water Quality Data Portal includes the new freshwater module that allows users to view, plot, and download available freshwater monitoring data and trend analyses. Explore the data at: waterquality.capecodcommission.org/

ABOUT THE WATER QUALITY DATA PORTAL END USER GROUP

Commission staff worked with project partners and a web developer to create a web-based interface for the Water Quality Data Portal, to enable improved access to pond monitoring data and provide on-demand trend analyses to better assist communities in their efforts to understand and address pond water quality concerns. The Commission convened a group of end users, including representatives from government agencies, research and nonprofit organizations, pond groups, and others, to provide insight and feedback into the development of this tool. This end user group met several times between spring and fall 2024.

Meeting topics included an overview of the project, examples of data views, and discussion of areas of interest for data analyses. End users were asked for feedback on their goals or objectives when working with freshwater pond data, questions the data could help to answer, whether one pond or multiple pond views were preferred, how to navigate to and view the data, which data parameters to include, and what the end user wants to get out of the application.

Remote Sensing

Recognizing that it is physically and financially impractical to monitor all ponds on Cape Cod, new strategies for understanding changes in pond characteristics region-wide are being investigated.

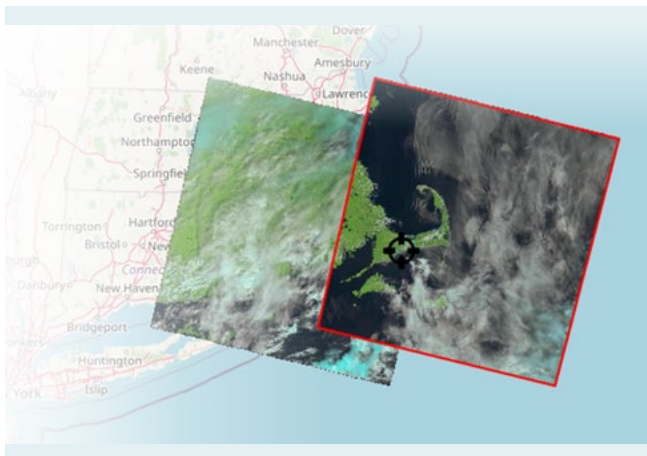
The Commission worked with NOAA to develop a framework for assessing water clarity for Cape Cod ponds using satellite reflectance data. The study combined existing field-measured Secchi disk depth data, field-measured maximum pond depths, and satellite reflectance data to derive satellite-estimated Secchi disk depths for 193 Cape Cod ponds. Using satellite imagery from the joint National Aeronautics and Space

Administration (NASA) and United States Geological Survey (USGS) Landsat Program, water clarity estimates were generated for ponds in the study as far back as 1984, allowing for a nearly 40-year time series to be analyzed (1984 – 2022). Full details of the study are published in the [Journal of Environmental Management](#).¹⁸

The study revealed that satellite remote sensing data is well suited to regularly monitor water clarity within many Cape Cod ponds. About half of Cape Cod's ponds meet the spatial requirement to be monitored by satellite imagery; however, only about 60% of those ponds have maximum pond depth data to support the analysis. Long-term trends generally suggest improving water

clarity in 81% of analyzed ponds since 1984, but recent short-term changes indicate that as many as half of the ponds analyzed showed deteriorating water clarity from 2021 to 2022. The overall complexity of Cape Cod's 890 ponds, along with seasonal changes in precipitation and groundwater flow, can lead to significant variability in water quality parameters from year-to-year. Continued data collection to support the analysis of long-term trends will be important to better understand overall regional trends in pond water quality. This initial study identified the need for future efforts to focus on increasing the number of ponds included in the analysis and identifying environmental drivers of change in water clarity.

In a separate remote sensing project funded by the Southeast New England Program (SNEP), the Cape Cod Commission is working with project partners at the University of Minnesota, University of Rhode Island Watershed Watch, and APCC to expand beyond water clarity data by collecting and



LEVERAGING TECHNOLOGY TO BETTER UNDERSTAND PONDS

A subset of ponds were assessed using existing satellite imagery and water clarity data. The analysis generated indicators of pond health both for individual ponds and across the region, providing insights over time without requiring physical monitoring.

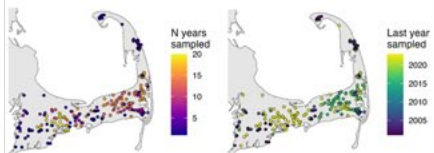
18 Coffey, M. M.; Nezhin, N.P.; Bartlett, N.; Pasakarnis, T.; Lewis, T.N.; DiGiacomo, P.M. *Satellite imagery as a management tool for monitoring water clarity across freshwater ponds on Cape Cod, Massachusetts*, Journal of Environmental Management, Volume 355, March 2024. <https://www.sciencedirect.com/science/article/pii/S0301479724003207>

Development of Automated Remote Sensing Methods for Water Quality Mapping

TO BETTER UNDERSTAND CHANGING CONDITIONS IN CAPE COD AND RHODE ISLAND LAKES AND PONDS

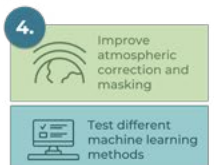
Introduction

Cape Cod has 890 ponds that are integral to the region's water resources and economic vitality. Healthy ponds provide valuable ecosystem services. Assessing pond health is important for our communities, however, physically monitoring all ponds is not attainable. On Cape Cod there are historical and current efforts to monitor approximately 230 ponds, but many of these monitoring efforts occur once a year providing a snapshot of the pond water quality. Additionally, the methodology of the monitoring is inconsistent from year to year and from pond to pond. Similar gaps in lake monitoring exist throughout the SNEP region.



Monitoring has been going on for 20+ years on Cape Cod, but many ponds have not been monitored for more than five years (left map). Some ponds have been monitored in the past five years (right map), while most haven't been monitored for 10 years or more.

Methods and Process



Prepare images with automated processes



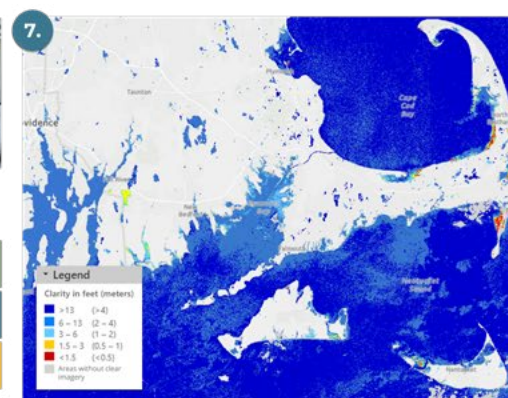
Measure and compile water quality data for Cape Cod and Rhode Island from 2017-2026



Process satellite imagery



Apply water quality models to satellite images using field validation data



Generate remotely sensed water quality data throughout the SNEP Region, available via an online interactive map. Similar to the figure above, which is showing water clarity derived from satellite imagery.

Overview

Project partners are aggregating existing and historical water quality data (water clarity, chlorophyll-a, and colored dissolved organic matter (CDOM)) from Cape Cod and Rhode Island, as well as supplemental data for the SNEP region that is available through the National Water Quality Portal. Monitoring efforts will continue through the project lifespan (2026). Utilizing an automated pipeline built in a high-performance computing environment, satellite data products will be generated to analyze and predict pond water quality. Secchi disk depth, chlorophyll-a, and CDOM measurements will be used to calibrate satellite imagery to the region.



536 MONITORING LOCATIONS USED TO CALIBRATE SATELLITE ANALYSIS
Rhode Island Watershed Watch will contribute data from 176 locations; for Cape Cod the Pond and Lake Stewards and Cape Cod Regional Monitoring Program monitor a combined 230 ponds; APCC's Cyanobacteria Program monitors 130 ponds.

Goals



Establish a predictive relationship between satellite observations and water clarity and chlorophyll.



Generate monthly estimates of water clarity, chlorophyll-a, CDOM.



Explore indicators that support cyanobacteria growth to assess predictive capabilities.



Make results available publicly through an interactive web viewer.

PROJECT PARTNERS
Funding provided by USFWS through a Southeastern New England Program cooperative agreement.



Reference
Olinson, L. D. Porter, 2023. Advanced Water Quality Monitoring of Optically Variable Lake Systems Using Landsat 8 OLI and Sentinel 2 MSI Imagery in an Automated High-Performance Computing Environment. UNM Water Council.

EXPANDING THE REMOTE SENSING PROJECT

Remote sensing project poster presented by Commission staff at the Southeast New England Program (SNEP) 2024 Symposium in Bristol, RI. Full poster available at: epa.gov/system/files/documents/2024-07/2024-snep-symposium-poster_nye-lewis.pdf

analyzing field data to correlate observations from satellite imagery with measured water quality data.¹⁹

University of Minnesota modelers are working with the Commission to create a model for estimating lake and pond water quality and clarity in the SNEP region using satellite imagery. APCC has coordinated the collection of field data on Cape Cod with the schedule of passing satellites to support development of the model; APCC staff are also providing guidance on analysis and data products. University of Rhode Island Watershed Watch is sharing data from their ongoing monitoring of over 60 lakes and ponds throughout Rhode Island and Southeastern Massachusetts to improve model development.

The three-year project began in October 2023 and will conclude in 2026. Project outcomes are anticipated to include a dataset and model of water quality in lakes and ponds that can be used to inform management of freshwater ecosystems in and around the coastal southern New England region.

More information on efforts to utilize remote sensing to better understand changes in ponds and lakes is available at: <https://capecodcommission.org/our-work/remote-sensing>.

Value of Continued and Expanded Data Collection

Having incorporated historical data into the Regional Water Quality Database, the foundation and momentum have been established to continue to collect and incorporate new data as they are received from monitoring groups, towns, PALS, and the Regional Pond Monitoring Program. As pond data sets grow over time, the ability to detect long-term trends and observe responses to environmental changes and/or management actions will continue to improve.

Information from the Regional Pond Monitoring Program has highlighted the importance of data collection that enables the region to track changes in pond

conditions from spring into the fall. The ability to identify when, and for how long, stratification sets in, quantify the relative contributions of internal and external phosphorus loading, and characterize how nutrient availability relates to algal growth at different times of year is critical for informing management decisions. All of these conditions are important for understanding the dynamics of individual ponds. After the first year of monitoring, the sampling season was expanded for the second year to include March and November for certain ponds where stratification had set in prior to the April sampling event, or in cases where fall turnover, the breakdown of the stratified layers, had not occurred in October.

Targeted monitoring of additional ponds and parameters would provide an enhanced ability to observe regional trends. Adding a parameter, increasing monitoring frequency, or identifying specific ponds based on pond characteristics for targeted analysis could all be beneficial for different purposes. For example, to better define changes in the onset and duration of stratification, weekly monitoring of dissolved oxygen and

19 *Remote Sensing and Water Clarity*, Cape Cod Commission. <https://capecodcommission.org/our-work/remote-sensing>

temperature from mid-April through late May and from mid-September through October could provide valuable insights.

There are clear opportunities to build upon, improve, and focus the current monitoring efforts across the region. Regional partners must work together to optimize monitoring and management by first defining the specific questions to be addressed and

then designing the monitoring and analysis efforts to answer those questions. Funding constraints will necessarily focus and limit the scope of monitoring, and partners will need to periodically reassess both the questions being asked and approaches employed to obtain valid data for long-term management of water quality.

Data collected will inform local and regional planning initiatives, the selection of strategies and approaches for managing specific pond challenges, and evaluation of the effectiveness of projects implemented. It is the foundation for adaptive management and must be prioritized to ensure long-term and successful implementation of the Freshwater Strategy and local water quality plans.



Strategies

Identifying tools to address pond health.

Strategies for supporting local and regional freshwater plans and projects are necessary to support broader environmental and economic goals and objectives. The potential solutions to address pond water quality are numerous.



Throughout the Freshwater Initiative, Commission staff conducted research on local pond plans and implementation projects, as well as strategies employed elsewhere. This included review of projects from other parts of the country with similar freshwater challenges and water resources priorities, and considerable review of the scientific literature associated with freshwater ponds and lakes, such as articles in [LakeLine](#), a publication of the North American Lake Management Society, and other limnological journals. Sources of information also included the Commission's [Technologies Matrix](#) and [Freshwater Pond Restoration Projects Viewer](#), Massachusetts' [Practical Guide to Lake Management](#), and New York's [Diet for a Small Lake](#).

PRACTICAL GUIDE TO LAKE MANAGEMENT IN MASSACHUSETTS

The Massachusetts Department of Conservation and Recreation (DCR) is in the process of updating the Practical Guide, which, when completed, will be another important resource for pond managers. DCR staff and their consultant on the Practical Guide participated on the technical advisory group, helping to align the strategies database with the anticipated update of the Practical Guide.



POND RESTORATION PROJECTS VIEWER

The interface displays a map of Cape Cod with various management approaches and a detailed view of Mystic Lake Barnstable. The management approaches listed are:

- All Management Approaches
- Freshwater/Pond Area Regulation
- Vegetation Management
- Nutrient Management
- Sediment (Watershed) Management
- Algae Management

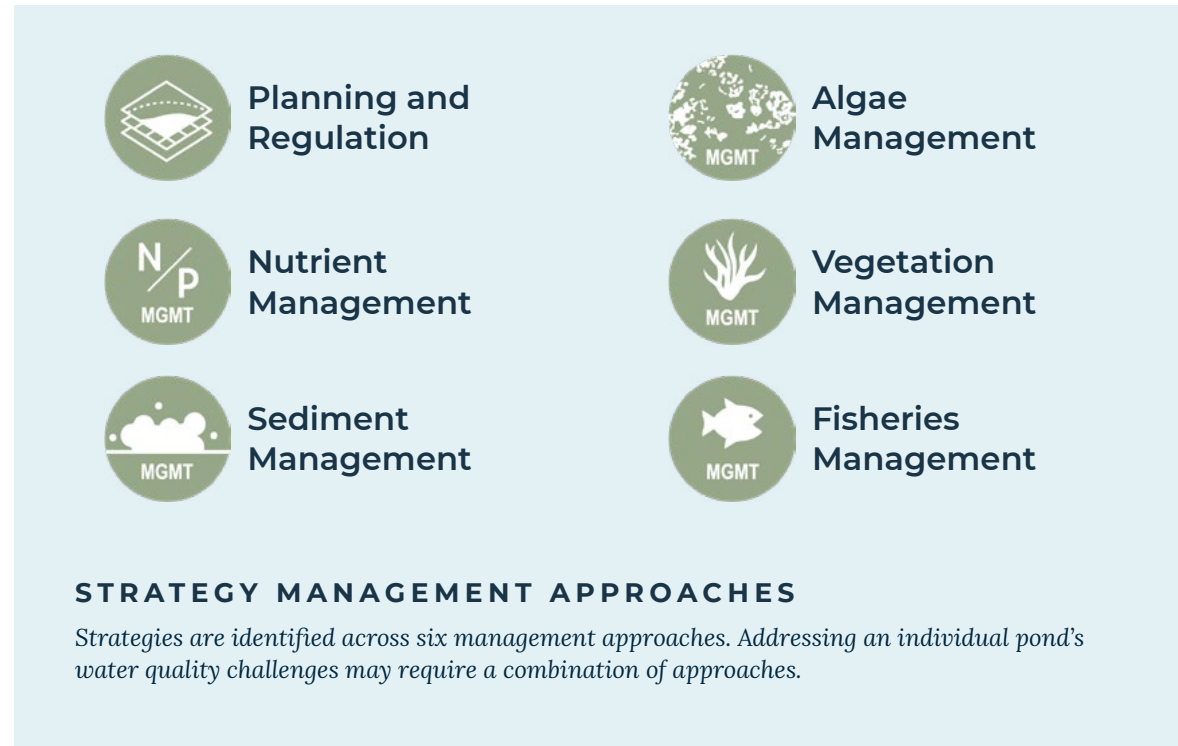
The detailed view for Mystic Lake Barnstable includes the following information:

Management Approach	Nutrient Management (Inactivation)
Project Strategy	Alum Treatment
Problem Addressing	Algae blooms and decreased water clarity from elevated phosphorous levels (from internal loading), mussel die off
Results	Following treatment, water clarity increased. While chlorophyll data was limited, chlorophyll levels in deep waters generally declined. Phosphorus values at the top of the water column remained high while levels at the bottom were low following treatment. The treatment addressed high levels in the bottom of the pond but did little to reduce levels in the upper strata of the pond.

POND RESTORATION PROJECTS VIEWER

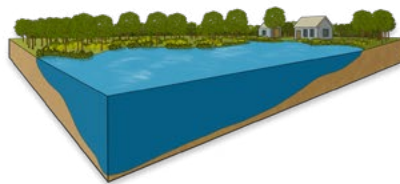
Pond management strategies are being implemented across Cape Cod to improve water quality and overall pond health. In many cases, these strategies are recommendations included in a pond assessment report and/or are part of watershed management planning. The Pond Restoration Projects Viewer identifies pond-specific challenges, strategies, and results to inform further action on Cape Cod ponds. Projects can be filtered by management approach, or the user can navigate to a specific town or pond.

In reviewing these local plans, journal articles, and pond management project documents, Commission staff identified numerous strategies that could be effective in addressing freshwater challenges and protecting those resources not yet exhibiting degradation. Information collected formed the basis for a pond-specific strategies database that includes a range of technologies, regulatory and voluntary options, and management approaches for protecting and restoring pond water quality. While some approaches have been implemented for decades, providing lessons from their application, other strategies are new and still being researched by scientists across the country.



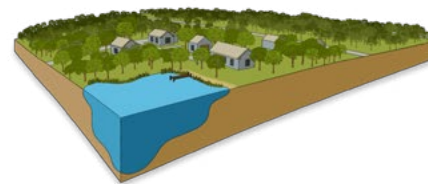
SCALE OF APPROACHES

Strategies included in the database are identified by scale of approach, along with other factors.



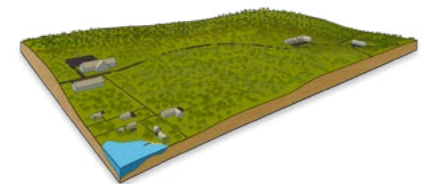
IN POND

Sediment, nutrient, algae, and vegetation management approaches



POND SHORE

Vegetated buffers, fertilizer management, stormwater management, septic setbacks, I/A septic systems



WATERSHED

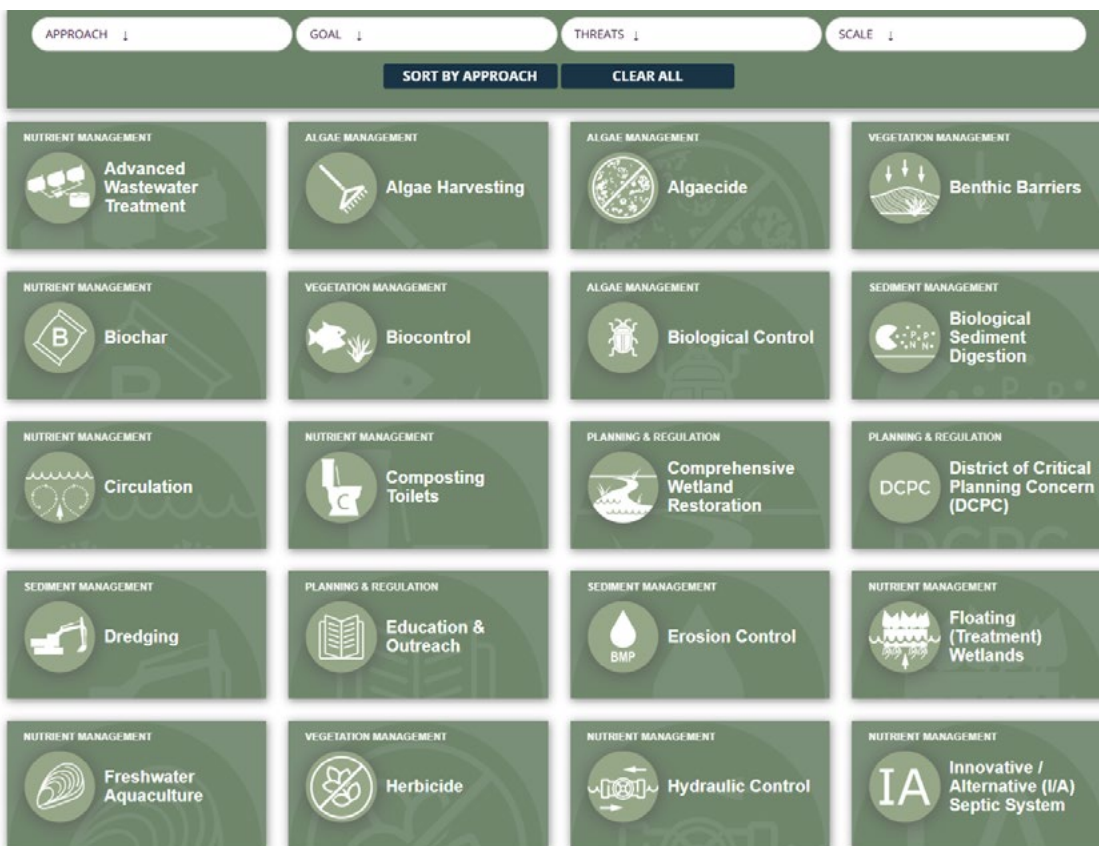
Comprehensive watershed planning, land use regulations, land protection, advanced wastewater treatment

Over 35 strategies were identified. The strategies range in scale from approaches applicable in-pond, those appropriate along the pond shore, and those that could be applied watershed-wide. They also vary in the types of pond management challenges they address. Some focus on pond-related planning and regulations and highlight opportunities to protect land around ponds and reform zoning and permitting to be more protective of ponds. Others offer ways to manage specific threats to ponds, such as nutrients and sediments, through various traditional and innovative wastewater and stormwater management techniques. Still others explore ways to manage vegetation and algae through mechanical, chemical and biological methods.

Strategy fact sheets provide an overview of each strategy, as well as information on the threat(s) addressed, implementation examples, permitting and siting requirements, and scale of implementation, among other details. Strategy fact sheets are available at: capecodcommission.org/our-work/pond-strategies.

An individualized approach is needed as every pond has different characteristics, whether historical use and treatment, hydrologic factors, size, or exposure to

weather elements. Understanding pond characteristics and the current health of a pond are important when choosing the most effective pond improvement strategy.



FRESHWATER STRATEGIES VIEWER | The strategies viewer allows users to filter and sort freshwater strategy options by management approach, goal, threats addressed, and scale of approach. It provides a brief overview along with the more detailed fact sheet for download. Explore at: capecodcommission.org/our-work/pond-strategies.

Recommendations

Key recommendations for protecting and improving freshwater resources.

While there are dozens of different strategies municipalities, pond organizations, and others can employ to ensure healthier and better protected ponds, certain actions surfaced as necessary and impactful approaches for the region. The following key recommendations have the potential to improve the region's understanding of ponds and lakes, support improved freshwater habitats and water quality, and enable local and regional action.



Key Recommendations

Necessary and impactful approaches to advance freshwater priorities throughout the region



Maintain and expand funding for the Regional Pond Monitoring Program



Develop a regional funding program for town projects



Improve access to state and federal grant funds



Prioritize ponds for action



Promote best practices and universally beneficial strategies



Integrate freshwater ponds into municipal water resource planning



Utilize pond buffer guidance



Develop model wetland bylaws and orders of conditions



Streamline wetland permitting to facilitate restoration of pond shore buffers



Expand regional monitoring and laboratory capacity



Enhance understanding of groundwater interactions and address data gaps



Improve consistent communication and outreach for varied pond users



Foster appreciation and respect for Cape Cod's ponds



RECOMMENDATION

Maintain and expand funding for the Regional Pond Monitoring Program

The Cape Cod Regional Pond Monitoring Program is generating highly valuable data to inform decision-making at the local and regional scale and provide an understanding of changing conditions in the region's ponds. Two years into the program, APCC has staffed and successfully mobilized volunteers to collect data on a monthly basis, March through November, at 50 ponds across the region.

The Monitoring Program has demonstrated the importance of water quality monitoring for the region's ponds. In January 2025, the Cape and Islands Water Protection Fund Management Board authorized funding to continue the Regional Pond Monitoring Program, consistent with the legislation establishing the Fund, which allows for up to 10% of annual revenues to be used for monitoring activities. The cash flow model developed to support administration of the Fund indicates that the Fund should have the capacity to support coastal and freshwater monitoring into the future, including the potential for expansion of the existing programs. Going forward, towns should reinforce the value of continued freshwater monitoring by incorporating appropriate language into water resource planning documents or local comprehensive plans.

RESOURCES

- [Regional Pond Monitoring Program](#)
- [Water Quality Data Portal](#)

RECOMMENDATION



Develop a regional funding program for town projects

Limited municipal staff capacity makes identifying grant opportunities and preparing proposals to move necessary pond and lake management projects forward challenging. With pond water quality challenges on the rise and increasing public interest in addressing the health of freshwater resources, considerable funds are needed to evaluate the cause of the problems, develop plans to address them, and implement solutions. A dedicated regional funding program could facilitate access to, and distribution of, funds to municipal projects across the Cape. Legislators, advocacy groups, and appropriate regional entities should explore the potential for developing a regional grant program for town pond management projects. Potential funding sources include the Massachusetts State Revolving Fund, MassDEP's 319 Grant Program, future Environmental Bond Bills, or modifications to the Community Preservation Act.

RESOURCES

- [Regional Pond Monitoring Program](#)
- [Water Quality Data Portal](#)
- [Town Pond Profiles](#)
- [Strategies Database and Fact Sheets](#)



RECOMMENDATION



Improve access to state and federal grant funds

Existing, long-term funding programs, such as MassDEP's 604b and 319 grants, have well established funding streams for non-point source pollution management, but Cape communities have made limited use of these resources to date. Lengthy grant applications and requirements may deter some municipal staff from pursuing these funds for worthy and eligible projects. MassDEP is encouraging establishment of regional coordinators to assist communities in developing projects and drafting proposals that align with federal and state water quality programs and enhance access to these funds. The Cape Cod Commission should explore the opportunities, requirements, limitations, and benefits of establishing a regional coordinator position to help take advantage of MassDEP administered grants. A regional coordinator could help towns access other state and federal grants that support and promote water quality improvement projects. Should a regional coordinator position not be the most effective approach for Cape Cod, municipalities, with the support of the Cape

Cod Commission and other regional entities, should consider collaborative approaches for pursuing state and federal grant programs.

The linkage between Cape Cod's environment and economy should be leveraged as towns consider implementation projects; grants that support economic development and/or are consistent with the Cape Cod Comprehensive Economic Development Strategy will expand the universe of potential funding resources. Additionally, many state and federal funding programs support land acquisition to protect source waters and water supplies, as well as habitat. Land prioritization projects, such as The Compact of Cape Cod Conservation Trust's Priority Ponds Project, should be updated and may serve to help build the case for grant applications. Similarly, the APCC's Ecosystem Restoration Program Inventory of potential and in-process projects may also help prioritize projects for funding. Regional entities should maintain lists of current grant programs to highlight opportunities.

RESOURCES:

- [Phosphorus Hotspots Map](#)
- [Pond Atlas Viewer](#)
- [The Compact of Cape Cod Conservation Trust's Priority Ponds Project](#)
- [MassDEP Guidance on 604b and 319 grants](#)
- [Model Pond Prioritization Framework](#)





RECOMMENDATION

Prioritize ponds for action

With hundreds of ponds across Cape Cod and limited funds and staffing, towns must be strategic in selecting ponds for management actions. As more is known about concerning changes in pond water quality, demand for interventions and action on ponds will require communities to prioritize ponds given limited resources. Employing a prioritization framework may help town staff prioritize ponds for action, present rationales for those choices to the public, and support funding requests before town meeting, town council, and/or in grant proposals. Stakeholder interest in tracking indicators of pond health, such as the number of public health advisories or beach closures, could also serve as criteria for a prioritization framework. Towns may also prioritize ponds for the purpose of piloting novel strategies.

RESOURCES

- [Model Pond Prioritization Framework](#)
- Town Pond Reports/Action Plans
- [Pond Atlas Viewer](#)
- [Water Quality Data Portal](#)
- [Strategies Database and Fact Sheets](#)



RECOMMENDATION

Promote best practices and universally beneficial strategies

Certain “universally beneficial” strategies can be implemented to improve water quality, even in instances where limited data or information is available. Reducing the use of fertilizers and pesticides throughout the watershed, but particularly within the buffers to ponds, will bring co-benefits such as improved habitat, aesthetics, and community character. Stormwater management systems or stormwater control measures (SCMs) can be incorporated into related planning and construction activities within pond shore buffers and watersheds. Many towns on Cape Cod are responsible for managing stormwater from public property and roadways through the Massachusetts Small Municipal Separate Storm Sewer System (MS4) permit program. Town responsibilities under this program may include identifying locations for SCM installation, mapping and

managing existing stormwater infrastructure, and public education and outreach. When ponds are listed on the State’s Integrated Waters List, there are specific requirements under the MS4 permit, however many more opportunities likely exist around ponds, particularly where ponds have not been studied sufficiently to determine whether listing is necessary. More information on specific SCM designs can be found in the 208 Technologies Matrix. The Commission has also identified stormwater runoff hot spots along pond shores that can be referenced to identify potential project opportunities (Phosphorus Hotspots Map). Utilizing nature-based solutions wherever possible will bring co-benefits and should be prioritized. Reducing lawns and highly managed landscapes within pond buffers, taking steps to reduce or manage erosion, and restoring

RESOURCES

- [Phosphorus Hotspots Map](#)
- [Strategies Database and Fact Sheets](#)
- [208 Technologies Matrix](#)
- [Pond Atlas Viewer](#)
- [Pond Buffer Guidance](#)

these areas with native plantings will have great benefits in improving water quality and wildlife habitat. Towns and others can help promote these best practices through their development regulations and guidelines.

RECOMMENDATION



Integrate freshwater ponds into municipal water resource planning

Towns regularly prepare and revise plans to address municipal needs. To the extent these plans do not currently incorporate consideration of freshwater resources, towns should ensure a vision of pond protection is included in local comprehensive plans and open space plans, and that they are incorporated into future updates of plans intended to address management of coastal waters, tidal rivers, estuaries, and drinking water supplies. Towns should consider freshwater planning in source water (water drawn from groundwater or surface waters for public water supply consumption) protection plans, comprehensive wastewater management plans and targeted watershed management plans. The Commission should consider incorporating pond water quality into guidance documents or models for

these various plans, including the 208 Plan consistency criteria. Any future updates to the 208 Plan should reflect the findings and recommendations of the Cape Cod Freshwater Strategy.

Through these planning efforts or other municipal initiatives there are opportunities to recognize and promote the co-benefits (or unanticipated benefits) of certain actions on improving pond water quality. Efforts including modernizing septic system records to track age, location, and maintenance activity; improved homeowner education and understanding about septic system maintenance and management; stormwater management; reduced fertilizer use; and sewerage may have significant positive impacts on ponds beyond their primary purpose.

RESOURCES

- [Regional Pond Monitoring Program](#)
- [Phosphorus Hotspots Map](#)
- [Water Quality Data Portal](#)
- [Pond Atlas Viewer](#)

RECOMMENDATION

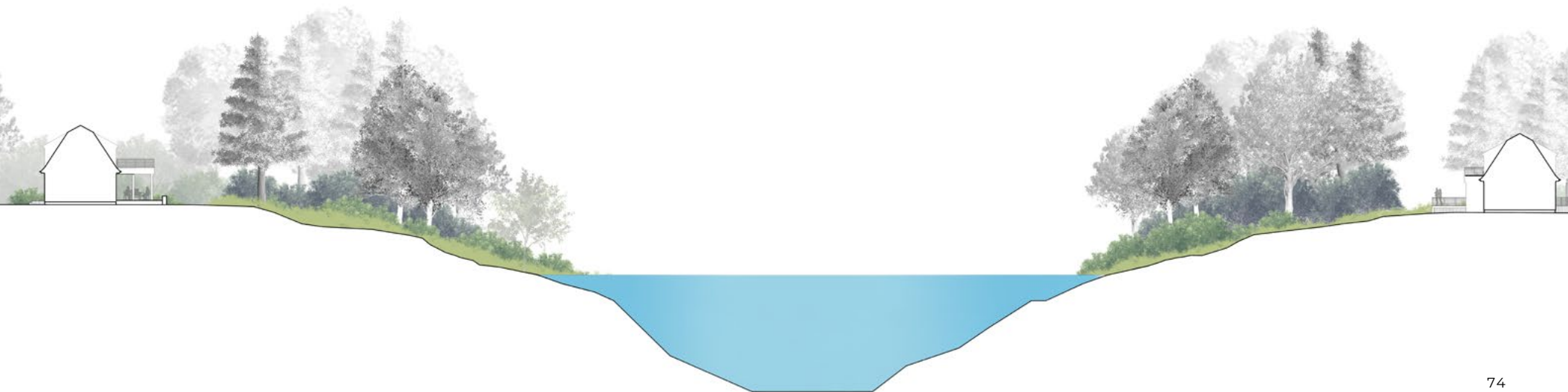


Utilize pond buffer guidance

Vegetated buffers between developed areas and freshwater ponds are essential to maintaining and improving pond water quality and aquatic and pond shore ecosystems. Towns, pond organizations, and private property owners should maintain and enhance vegetated buffers to ponds, which can promote community acceptance of restored and naturalized pond buffers by example. Towns should consider incorporating the buffer guidance into their regulatory procedures, and pond groups could find ways to promote use of the guidance within their networks and influence. The Cape Cod Freshwater Pond Buffer Guidance includes local examples of pond shore best practices, planting plans for Cape Cod's pond shore landscapes, a list of native plants appropriate for the Cape Cod freshwater pond shore environment, and a directory of local sources of native plants. Pond buffers maintained or restored with native vegetation help support natural plant and wildlife communities and improve pond ecosystem health.

RESOURCES

- [Strategies Database and Fact Sheets](#)
- [Pond Buffer Guidance](#)
- [Pond Atlas Viewer](#)
- [Phosphorus Hotspots Map](#)



RECOMMENDATION

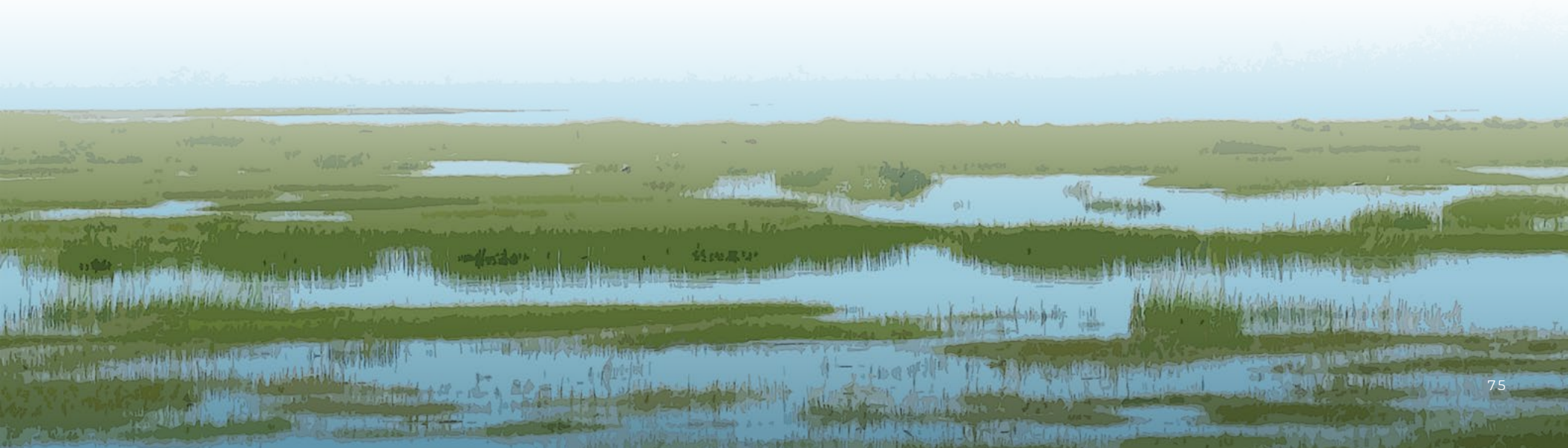


Develop model wetland bylaws and orders of conditions

Development pressures around ponds can result in significant changes to pond buffers and natural communities, if not managed. Municipal plans, such as local comprehensive plans and open space and recreation plans, should establish a vision for protected and restored natural pond buffers that serve to filter water and provide habitat. Clear regulatory language detailing what is allowed, and not allowed, is needed to help manage development impacts and ensure pond buffers are protected and restored. The Cape Cod Commission should review existing municipal bylaws and regulations governing pond shore activities, identify best practices, and develop a coordinated set of model wetlands bylaws, regulations, and orders of conditions for different pond shore activities. Examining a framework for fines that could be applied consistently across the region would also assist in sending a clear message about expectations for protecting the pond shore environment. Town conservation and natural resources staff, as well as MassDEP representatives, conservation commissions, boards of health, and planning board members should contribute to and inform the development of these materials.

RESOURCES

- [Legal Guidance](#)
- [Pond Buffer Guidance](#)
- [Strategies Database and Fact Sheets](#)



RECOMMENDATION



Streamline wetland permitting to facilitate restoration of pond shore buffers

Pond shore property owners with traditional landscaping may be discouraged from making meaningful improvements to revegetate their pond shore buffers due to perceived or actual permitting requirements. Towns should consider whether changes are needed to help streamline the permitting process, such as reducing filing requirements, time frames, or costs, in order to create incentives for pond shore restoration at the residential scale. The Cape Cod Commission should work with MassDEP and town conservation staff to examine the feasibility and drawbacks of using a general permit to allow for administrative approval of restoration projects that propose the use of native plant species, meet design parameters, or are small in scale.

RESOURCES

- [Pond Buffer Guidance](#)



RECOMMENDATION



Expand regional monitoring and laboratory capacity

Expansion of monitoring efforts necessitates additional laboratory capacity to assist with analysis or to reduce travel times to deliver monitoring samples. As opportunities and capacity are realized to expand the Regional Pond Monitoring Program, priorities must be established. Additionally, regional staff should explore the feasibility of monitoring unstressed ponds as controls and establishing a small number of ponds as sentinel ponds. Sentinel pond monitoring would entail expanded monitoring of a few ponds selected to represent the range of ponds across Cape Cod. As funding is available, expanded monitoring of all ponds could include collecting data on physical attributes (water temperature, water level, local weather) and biology (macroinvertebrates, zooplankton, phytoplankton, fish, and macrophytes), as well as water chemistry (including emerging contaminants), to form a fuller picture of the Cape's freshwater ponds.

RESOURCES

- [Regional Pond Monitoring Program](#)
- [Pond Atlas Viewer](#)
- [Water Quality Data Portal](#)



RECOMMENDATION



Enhance understanding of groundwater interactions and address data gaps

Understanding the interactions between surface water and groundwater, the flow of nutrients and contaminants, and the impact of fluctuations in water levels from drought and sea level rise will greatly enhance understanding of the dynamics within the regional hydrologic system. Regional and municipal partners should pursue funding to support the development of a sophisticated groundwater model to illustrate changes in weather and water withdrawals and to assist in understanding the implications of land use activities.

As noted, historic and new sources of data have been identified, gathered, and compiled to assemble a more complete picture of ponds; however, many gaps remain. Regional and local actors should continue to coordinate to fill the gaps in existing data to promote better understanding of pond dynamics and facilitate identification of

appropriate strategies. Some of the priority data gaps include:

- Maximum pond depths
- Pond volumes
- Pond water residence times
- Pond watershed delineations
- Sediment assessments
- Biological monitoring data (vegetation, plankton, and invertebrates)

Additionally, capturing pond bathymetry and phosphorus concentrations in groundwater would enable better understanding of pond ecosystems. Tracking when and why ponds are closed to water access could also inform prioritizing ponds and identification of appropriate strategies.

Town staff have indicated that additional sampling equipment (e.g., dataloggers) is needed to support expanded monitoring.

RESOURCES:

- [Regional Pond Monitoring Program](#)
- [Ponds Network](#)
- [Pond Atlas Viewer](#)

Funding for shared equipment should be explored. As data, pond reports, and other resources are developed and identified, they should be incorporated into publicly accessible databases, portals, websites, and other resources.

RECOMMENDATION



Improve consistent communication and outreach for varied pond users

Stakeholders consistently emphasized the need for ongoing education about ponds, pond ecology, and water quality challenges for pond shore property owners, pond users, residents, and visitors to Cape Cod. A communications toolkit has been developed to educate pond users about the natural variation in Cape Cod's pond functions and appearance, how human in-water and landside activities impact pond health, connections to the region's economy, and best practices for preserving ponds.

The communications toolkit should help municipal staff, pond groups, and advocates employ consistent messaging, themes, and other content. The toolkit serves as a guide for delivering effective messaging on signs at pond shores and through varied print and online media. It also identifies means to engage different types of pond users, encourage them to modify their activities around ponds, and support pond management activities.

Regular gatherings for interested individuals, such as the Cape Cod Pond Network quarterly meetings or observation of pond and lake month, and utilizing resources within the toolkit, may improve communication, understanding, and enthusiasm for taking action to support pond health. Other targeted outreach could include engaging neighbors to ponds to get involved with protecting "their pond." Pond groups, the town, and others may help motivate the community to become good stewards of shared freshwater resources through community engagement, reward systems, highlighting "a pond of the week," or celebrating stories of individuals' voluntary efforts to make changes to their properties or shared beaches. The Orleans Pond Coalition's "pond pledge" is an example of a program to motivate and create a community around good pond shore practices: <https://www.orleanspondcoalition.org/the-h2orleans-pond-pledge/>.

RESOURCES

- [Pond Atlas](#)
- [Strategies Database and Fact Sheets](#)
- [MA Practical Guide to Pond and Lake Management](#)
- [Communications Toolkit](#)
- [Ponds Network](#)



RECOMMENDATION



Foster appreciation and respect for Cape Cod's ponds

Individuals with very different interests and experiences share a stake in the health of Cape Cod's freshwater ponds. As a destination region that hosts national and international visitors, a coordinated and consistent campaign is needed to highlight the importance and fragility of Cape Cod's natural environment, including its ponds. Currently, Cape Cod branding highlights the beauty of the region's beaches and historic villages as reasons to visit, invest, and live here. Expanding this messaging to highlight the fragility of the Cape Cod environment is necessary and could help inform residents and the visiting public of the value of ponds and how to enjoy them responsibly. Local, regional, and state governments, non-profit organizations, and the region's chambers of commerce should collaborate to develop and spread positive messaging about the value of healthy freshwater ecosystems.

RESOURCES

- [Pond Atlas](#)
- [Strategies Database and Fact Sheets](#)
- [Communications Toolkit](#)
- [Ponds Network](#)





Taking Action

Cape Cod's ponds and lakes require action.

Cape Cod's ponds and lakes are in jeopardy. The Freshwater Initiative provided the opportunity for a dedicated planning process to better understand the challenges ponds face and identify potential solutions. This Strategy equips local and regional stakeholders with the data, information, and resources necessary to take action.

Through the Freshwater Initiative, individuals and organizations, municipalities and businesses, and state and federal agency staff offered their experiences, perspectives, and expertise and confirmed their commitment to protecting and halting the decline of these ‘character-defining’ resources. Going forward, all members of the Cape Cod community will need to work together to effect meaningful change. The many passionate pond people in the region must continue to advocate for pond health. Individuals, towns, agencies and organizations must partner to elevate pond protection efforts and garner broad community support to reduce and eliminate pollutant inputs to ponds, protect pond buffers and watersheds, and secure funding to plan for and implement pond restoration strategies.

The recommendations presented above highlight key steps needed to improve pond protection and advance restoration strategies. The following identifies how members of the community can and should be engaged in action moving forward.

Partners in Pond Protection

The region must continue to prioritize protection and restoration of water resources and advance proactive planning and implementation of strategies to support freshwater ponds. The Cape Cod Commission and municipalities, as well as existing and new pond organizations, stakeholders, and advocates must work together to advance regional recommendations and prompt both positive change and lasting protection of these critical ecosystems.

Cape Cod municipalities, the Cape Cod Commission, and other government partners can support pond action through many of their established roles. Partnerships between towns, between towns and the Commission, and between government and other entities will support successful outcomes. Local, regional, state and other governmental entities must collaborate to ensure that freshwater ponds are included in local and regional plans, such as water resources management plans, local comprehensive plans, and open space and recreation plans.

Municipalities should consider and adopt tools, such as zoning changes, bylaws and regulations, to protect freshwater ponds.

Given limited funding resources, the region must be opportunistic in identifying, dedicating, and pursuing funds to advance freshwater goals. Municipalities should identify and dedicate resources, such as Community Preservation Act and other local funds, to protect pond buffers and advance pond restoration projects. The Cape Cod legislative delegation should work with stakeholders to incorporate programs and funding for freshwater preservation and restoration projects into the next environmental bond bill and other legislation.

Many dedicated and engaged individuals and entities are positioned to expand actions that promote pond stewardship. As many small ponds are privately owned, private landowners have an important role as advocates and protectors of their ponds. Private property owners around larger ponds are also key players in modeling good land use practices, advocating for pond and buffer protection and restoration, and engaging in the collection and dissemination of accurate

data and information regarding pond health. Dozens of pond associations, frequently made up of property owners adjacent or proximate to ponds, are active on Cape Cod. Some groups, such as the Brewster and Orleans Ponds Coalitions have been around for decades, educating the community about how to protect ponds; others are newly formed. There are also new alliances of established pond groups working to coordinate their efforts within a municipality. These entities are well positioned to help other pond associations become established, contributing to the broader network of individuals and organizations dedicated to fostering healthy freshwater resources.

Many land trusts on Cape Cod include freshwater ponds in their portfolios or have identified parcels around ponds as priorities for acquisition. Acquiring these parcels will have a long-term impact on pond protection and stewardship, as land trusts can play an important role in collecting and sharing data and information, as well as planning for and managing projects that advance pond restoration.

Key Commission Actions

The recommendations identified in this strategy will require engagement and action of many public and private entities, organizations, and community members. The Cape Cod Commission can provide support and serve as a convener in advancing many of the recommendations, but comprehensive implementation will depend on a range of actors. There are several key actions the Commission commits to advancing in the near-term.

COMMUNICATING THE STRATEGY

Commission staff will disseminate the Freshwater Strategy to stakeholders throughout the region. Staff will ensure the strategy is easily accessible, provide presentations to interested organizations and entities, and provide supporting materials and data.

IDENTIFY OPPORTUNITIES TO EXPAND MONITORING

Building on the successful implementation of the Regional Pond Monitoring Program, Commission staff will identify and prioritize opportunities to expand monitoring and address data gaps. Staff will continue to work with the Cape Cod and Islands Water Protection Fund Management Board to prioritize funding for continued monitoring and consider expanding data collection.

MAINTAIN AND EXPAND DATA ACCESS

Commission staff will maintain the water quality database and portal to ensure access to the most up-to-date data and trend analyses. Staff will also engage town staff and other stakeholders to identify additional analyses and functionality that would aid local decision-making and consider expanding the data portal, as opportunities arise.

SUPPORT TOWNS IN ACCESSING STATE AND FEDERAL GRANT FUNDS

Commission staff will explore the opportunities, requirements, limitations, and benefits of establishing a regional coordinator position to help take advantage of MassDEP administered grants. Should a regional coordinator position not be the most effective approach for Cape Cod, Commission staff will evaluate other collaborative approaches for pursuing state and federal grant programs.

DEVELOP MODEL WETLAND BYLAWS AND ORDERS OF CONDITIONS

Commission staff will review existing municipal bylaws and regulations governing pond shore activities and identify best practices. Staff will pursue resources to develop a coordinated set of model wetlands bylaws, regulations, and orders of conditions for different pond shore activities.

Measuring Success

As the region advances recommendations outlined in this strategy, as well as local planning and project implementation, continuing to track trends in water quality is needed to measure progress. There are several metrics the Cape Cod Commission will track to understand how the strategy recommendations are influencing pond health:

- Local funds dedicated to pond protection and restoration projects
- State and federal funds obtained for pond protection and restoration projects
- Use and application of pond buffer guidance by local conservation commissions and staff
- Amendments to relevant municipal bylaws and regulations
- Data sets provided for integration into the regional water quality database

The [town and county pond profiles](#) provide information on pond characteristics, as well as monitoring, water quality impairments,

and land use on pond buffer areas. These profiles will be updated periodically to understand changes at the local and regional scales, incorporate recent town actions and initiatives, and ensure the best available data and information is represented.

Trends for the following data points will help to understand the impact of implementation of recommendations at the local and regional scale, though substantive changes in any of these data points may not be seen in the short-term:

- Changes in land cover and land use within pond buffers
- Number of cyanobacteria advisories issued annually
- Total phosphorus in monitored ponds
- Total nitrogen in monitored ponds
- Chlorophyll a concentrations in monitored ponds
- Dissolved oxygen in monitored ponds

The Freshwater Initiative has highlighted support for elevating and prioritizing pond health. Shifting public understanding and attitudes to promote more positive interactions with the environment is critical. Broad engagement of residents and visitors to the region, through consistent messaging about the value of ponds and the need to take active steps to protect them, will help instill awareness and build support. This Cape Cod Freshwater Strategy identifies multiple actions, strategies, tools, and resources that should help the region advance a better future for Cape Cod's ponds.



The Cape Cod Freshwater Strategy

PONDS AND LAKES



CAPE COD
COMMISSION

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