SQUIBNOCKET POND

Individual System Assessment

Photo Credit: Ollie Becker, June 2021

Prepared by:

Martha's Vineyard Commission

RJS Development Solutions

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Funding Provided by:

MassDEP

Acknowledgments:

The Martha's Vineyard Commission would like to acknowledge all the contributors to this detailed watershed assessment.

- *Squibnocket Pond Working Group Members*
- *School for Marine Science and Technology*
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- *The Wampanoag Tribe of Gay Head (Aquinnah)*
- *The Martha's Vineyard Shellfish Group*
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- *Chris Murphy for his tireless dedication and contributions as the Chairman of the Up-Island Watershed Management Committee*

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RELEASE NOTES

Release of Squibnocket Pond – Individual System Assessment Report

The Martha's Vineyard Commission, in partnership with MassDEP, Town Officials and the Up-Island Management Plan Squibnocket Pond Working Group, is developing a framework for up-island watershed management. The primary goal of this effort is to develop and implement water quality mitigation strategies that apply to *all* up-island Great Ponds. Initial attention will be paid to: Squibnocket Pond, James Pond, Menemsha Pond, Chilmark Pond, and Tisbury Great Pond. The report you are receiving today, the Squibnocket Pond Individual System Assessment, represents completion of the first of four "acts" that will help us achieve our primary goal, which is to clean our up-island ponds.

This Individual Assessment Report, "Act I", articulates environmental conditions found in Squibnocket Pond and represents a multi-disciplinary approach to understanding many of the factors that contribute to impaired water quality in the Pond. Based on numerous studies completed in the past, as well 2021 data and analysis, this report describes the: Watershed, Physical Features, Water Quality, Biological Conditions, Socioeconomic Conditions and Land Conservation.

Although we hope you find the information presented in this report to be comprehensive and informative, it is important to note that ***the purpose of this assessment report is to inform strategic opportunities for restoring and protecting Squibnocket Pond water quality and surrounding habitats.***

With the completion of Act I, we will move on to the remaining acts. Act II will identify and describe a variety of technologies and biological approaches to mitigating impaired waters and habitats. This will include researching the strengths and weaknesses of each option and quantifying the level of contaminant mitigation expected from technology when applied to specific circumstances.

Act III will focus directly on assessing technologies in terms of potential for mitigating contaminants in Squibnocket Pond. This phase will focus on analyzing the technologies that are most likely to reduce existing impaired conditions. This will include quantification of potential contaminant reduction impact relative to specific characteristics/situations found in the Pond.

Up-Island Watershed Management (208 Report)

"Acts"

- **Act I – Individual System Assessment (see links below)**
- **Act II – Water quality mitigation technology and options**
- **Act III – Quantification of most appropriate technology for each unique challenge**
- **Act IV – Implementation strategies**

Act IV, the final act, will result in a management plan (208 Report) that will direct how we clean our up-island ponds. Based on information gathered in Acts I-III the management plan will define implementation steps that effectively and efficiently reduce

excess nutrients in Squibnocket Pond. Each technology improvement and its process will be articulated alongside a cost/benefit analysis of each option. Additionally, potential funding sources and other requirements, such as permitting, will be illustrated.

In conclusion, please find the links to Act I: The Squibnocket Pond Individual System Assessment and Annex below. This report was developed by MVC staff, an independent contractor from RJS Development Solutions, and the environmental consulting firm Horsley Witten. The draft was extensively peer reviewed by a variety of experts prior to release.

We look forward to sharing the Acts II-IV with you. If you have questions or comments, please direct them to: **Rachel Sorrentino** or **Sheri Caseau**

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Up-Island Watershed Management Plan (208 Report) Important Links:

Squibnocket Pond Individual System Assessment Report – prepared for the Up-Island 208 Watershed Management Plan: https://indd.adobe.com/view/769da4fb-e7c1-4740-80dc-84f49f2666d9

Squibnocket Pond Individual System Assessment Appendix Document: https://indd.adobe.com/view/df0fa7aa-e743-4ae2-b5f4-fab14665acec

MVC Virtual Pond Tour –Squibnocket Pond: https://storymaps.arcgis.com/stories/65fd695b21514cada08b923281ca7cad

MVC Ponds of the Vineyard Web Page: https://storymaps.arcgis.com/stories/30dc099fffe749178b33b977c1606a8e

Photo documentation of Squibnocket Pond (Ollie Becker): https://www.dropbox.com/sh/qpcuailsdz2pbga/AADbNBVUbafhjtJTMLSm4BAja/SQUIBNOCKET%20POND%20062321?dl=0&subfolder_nav_tracking=1

Note: all report figures and tables can be found in the appendix to this document. The appendix can also be found online at: https://indd.adobe.com/view/df0fa7aa-e743-4ae2-b5f4-fab14665acec

OVERVIEW

Squibnocket Pond is a brackish, coastal pond formed by a barrier beach on the southern coastline of Martha's Vineyard. The approximately 1,700-acre watershed[1] is located in the towns of Chilmark and Aquinnah. Squibnocket watershed areas are also under the jurisdiction of the Wampanoag Tribe of Gay Head (Aquinnah). The pond is part of the broader Menemsha-Squibnocket Pond Embayment System. The Squibnocket Pond system itself includes three sub-watersheds: Black Brook, Squibnocket Main Basin, and Squibnocket East[2], [3]. (Figure 1).

The Squibnocket Pond Watershed has areas of socioeconomic and biological value, including areas of cultural importance to the Wampanoag Tribe and critical habitat for species of conservation concern. Despite the watershed having large areas of forest and conservation land, the pond suffers from nutrient related impairments due to a combination of atmospheric deposits, watershed inputs, and limited tidal exchange.

Many of the physical, water quality, biological, and socioeconomic features of this watershed are described extensively in previous studies, including the 2017 Massachusetts Estuaries Project (MEP) Report for the Menemsha-Squibnocket Pond Embayment System and Martha's Vineyard Commission (MVC) State of the Pond Reports. The present existing conditions assessment report consolidates key watershed information from these data sources, input from local experts, and updated information from publicly available sources (e.g., MassGIS, US Census, and town records). This report is organized into four parts to describe: physical pond and watershed features, water quality, biological resources, and socioeconomic conditions.

Report Highlights:

- **Observed water quality issues in Squibnocket Pond can be attributed to physical characteristics as well as watershed nitrogen inputs.**
- **Squibnocket Pond currently has moderately impaired water quality. Water quality measures remain relatively constant for many of the sample stations. The sample site "SQB3" has the highest levels of nitrogen, highest total pigment, and lowest dissolved oxygen.**
- **Water quality analysis indicates impairment associated watershed nitrogen loading that is likely to negatively affect critical benthic communities.**
- **Despite large areas of forest, conserved land and relatively limited existing infrastructure, factors like population growth and continuing development pressures may further exacerbate water quality declines if appropriate nitrogen management efforts are not implemented.**
- **Relatively dense residential development with onsite disposal wastewater systems in the Black Brook and Squibnocket East sub-watersheds present areas of particular concern. Replacement of any low performance OSDS with enhanced nitrogen removal systems would be beneficial.**

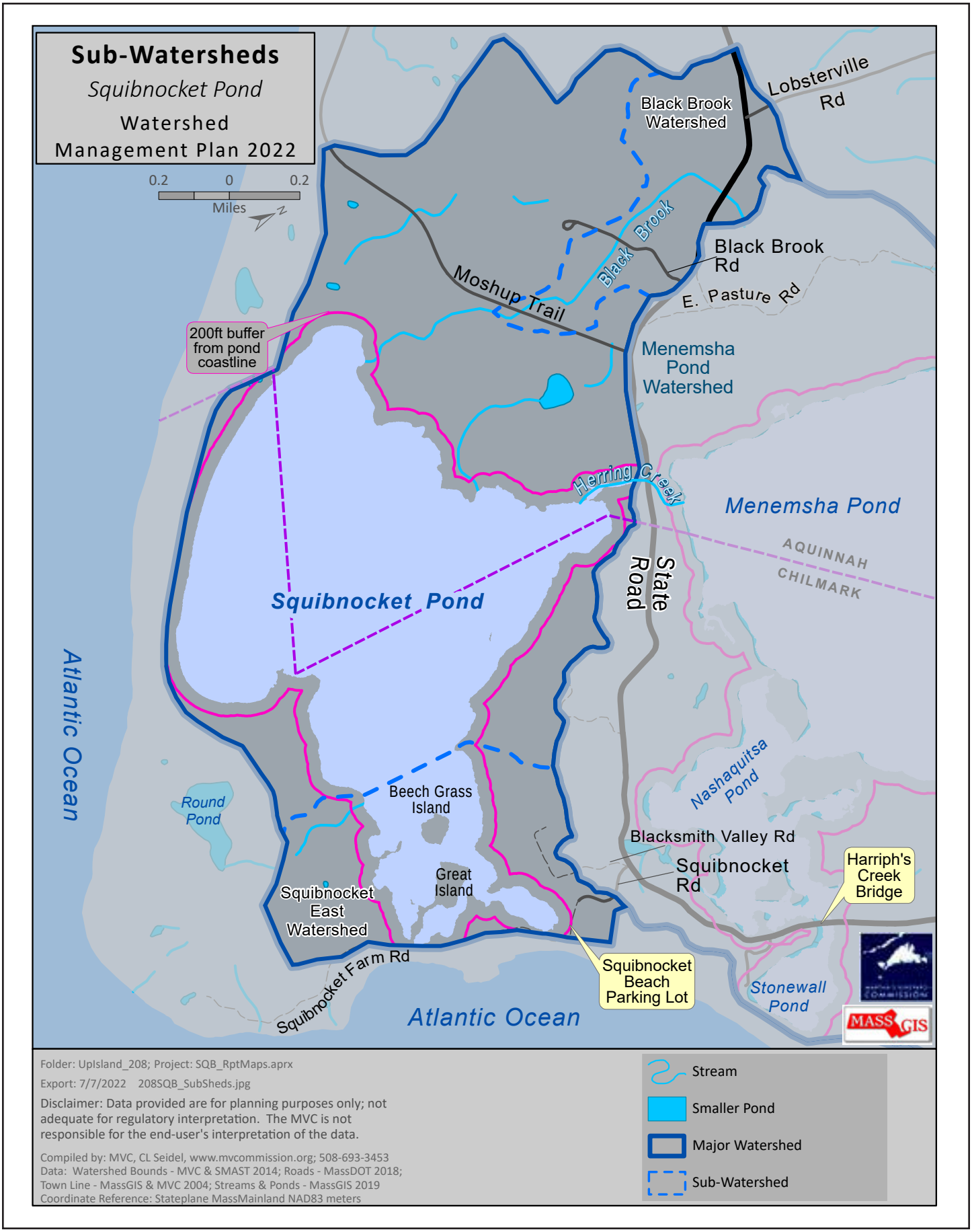

Figure 1. Watershed and Sub-watershed Boundaries for Squibnocket Pond (Martha's Vineyard Commission, 2021)

The Pond

The Squibnocket Pond Main Basin is formed by a barrier beach on its southwestern shore that separates the pond from the Atlantic Ocean[4]. The pond's surface area is approximately 600 acres, with over 500 acres of the area in the Main Basin[5].

According to the MEP, the pond's mean depth is 8.9 feet with zero tidal range[6]. The MEP survey of the pond's bathymetry indicated a maximum depth of 21 feet with the deepest parts in the southwest corner of the Squibnocket Pond Main Basin. Squibnocket East is much shallower with a depth of 0 to 6 feet (Figure 2). The total volume of Squibnocket Pond is estimated to be 263,881,477 cubic feet[7]. The dynamics of the barrier beach separating the pond from the Atlantic Ocean and coastal processes influence the ecological and biogeochemical structure of the pond.

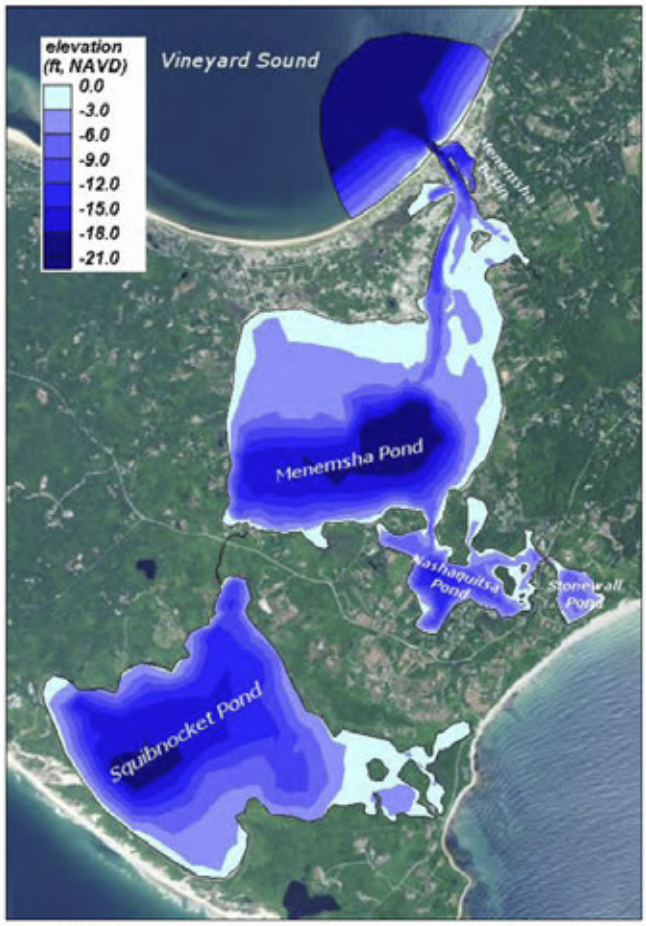

Figure V-3. Bathymetry data interpolated to the finite element mesh used with the RMA-2 hydrodynamic model. Contours represent the bottom elevation relative to mean low water (NAVD). The primary data source used to develop the grid mesh is the November 2015 survey of the main basins of system, supplemented by the 2013 USACE survey of Menemsha Creek, and NOAA GEODAS data used for the offshore area in Vineyard Sound.

Figure 2. Menemsha and Squibnocket Pond System Bathymetry Map (MEP 2017)

The Watershed

The contributing watershed to Squibnocket Pond was delineated by the MEP and MVC based on hydrology, geology, and topography[8], [9]. Figure 1 is a map that indicates the watershed and sub-watersheds boundaries. Squibnocket Pond watershed is divided into three sub-watersheds, the area of each is found below in Table 1.

Squibnocket Pond is hydrologically connected to Menemsha Pond via Herring Creek which connects the two basins using a culvert under State Road. While Squibnocket is closed to the Atlantic Ocean by its barrier beach, Menemsha Pond, which neighbors Squibnocket Pond remains open to the ocean via an armored inlet. The MEP included both Squibnocket and Menemsha Pond in one report, with the estuarine system analyses partitioned between Squibnocket Pond and Menemsha Ponds.

The Squibnocket Pond Watershed area includes popular areas for recreation, land development and land that is of critical cultural importance to the Wampanoag Tribe[10].

Land Cover

Land cover (also known as landscape patterns and conditions) within the watershed is a key component determining estuarine water quality. Undeveloped, forested lands and wetlands provide habitat and water quality benefits. Cultivated lands and impervious cover often contribute polluted runoff to receiving waters and alter natural hydrologic patterns (e.g., less recharge and evapotranspiration and more surface runoff). Information based on MVC's land cover data categories (as of 2016) is presented in the following paragraphs for all areas surrounding the pond[11] (Figure 3).

Impacts associated with land cover type must be carefully considered and conclusions drawn must reflect how various land cover types are managed. For example, depending on location and intensity of usage, even a few active agricultural acres can lead to adverse water quality impacts. However, not all agricultural land cover negatively influences the watershed. Agricultural land cover may, depending on the management practices employed by farmers, introduce fewer

Sub-watershed Name	Watershed Land Area (acres)	Land Area (% of watershed)
Black Brook	175	10.2%
Squibnocket East	269	15.6%
Squibnocket Pond	1,275	74.8%
Total Watershed	**1,719**	**100%**

Table 1. Squibnocket Pond Sub-watershed Area (acres)

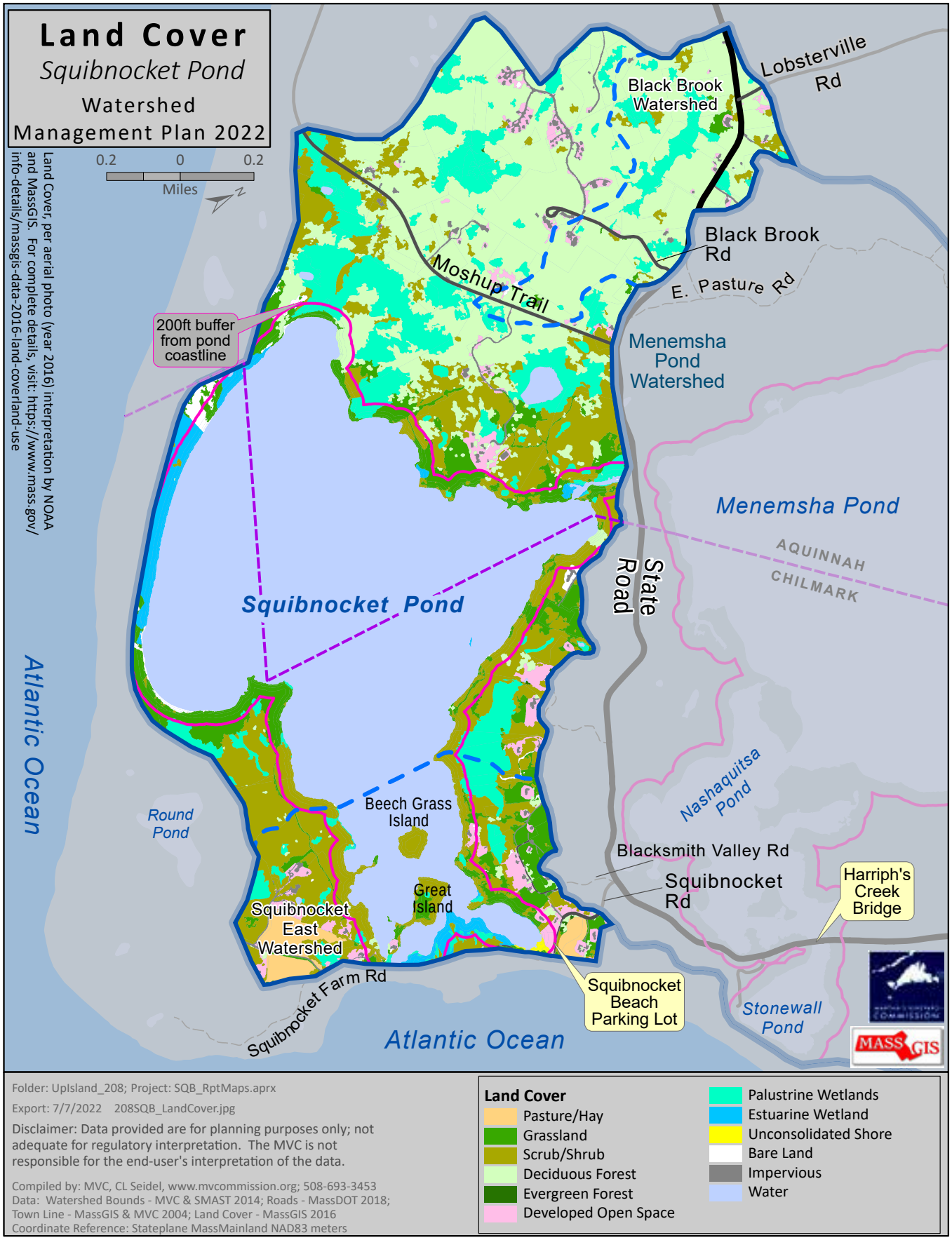

Figure 3. Squibnocket Pond Land Cover Types

nutrients than one would find if the land were subject to onsite residential or commercial wastewater systems.

The largest cover type in the Squibnocket watershed system is surface water at 37%, reflecting the large size of Squibnocket Pond relative to the watershed. The next largest land cover types are deciduous forest (23%), scrub/shrub (15%), palustrine wetland (11%), and grassland (7%). All other land cover types occupy 2% or less of the watershed. These values indicate that the Squibnocket Pond Watershed is mostly vegetated, and the pond edges are generally undeveloped (Figure 4).

Two of the more impactful land cover types—pasture/hay and impervious cover—make up <3% of the watershed combined. Pasture/hay, when fertilized or actively grazed by livestock, can negatively influence water quality in the watershed. Pollution from stormwater run-off that falls on impervious surfaces, is also known to negatively influence water quality in surrounding areas. Finally, cultivated area is often associated with negative water quality indicators. However, cultivated land cover type does not exist in the Squibnocket watershed.

The presence of pasture/hay land cover (1% of the watershed) can be

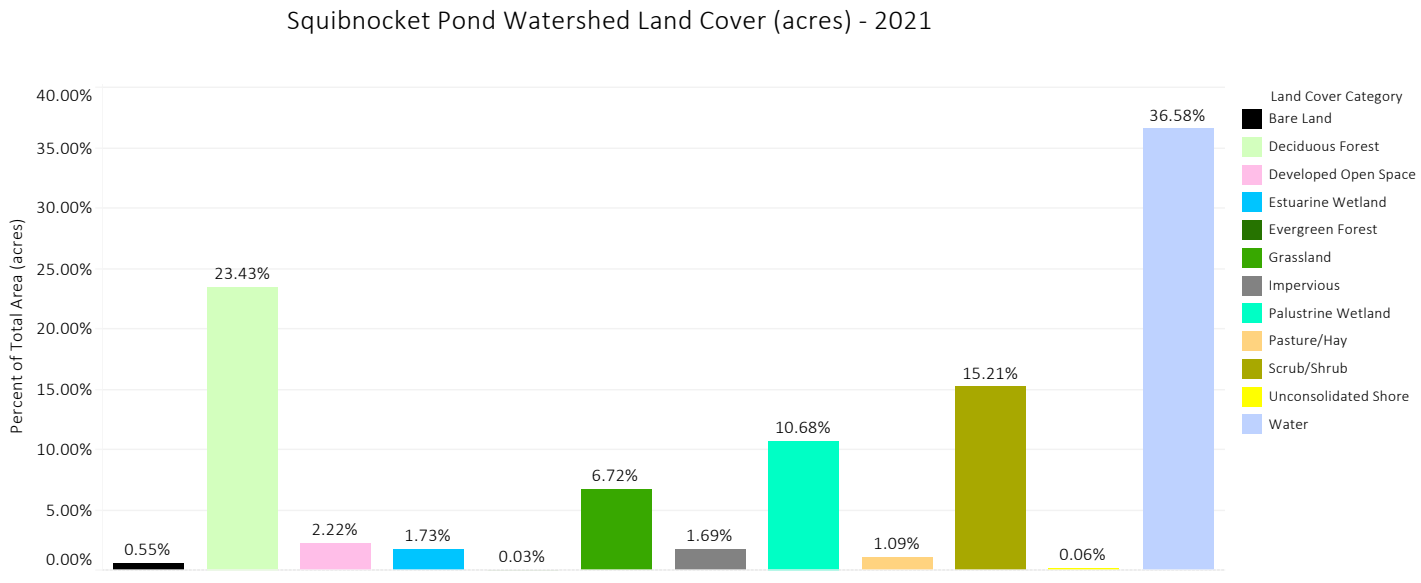

Figure 4. Squibnocket Pond Land Cover Area (acres)

indicative of animal grazing areas that may contribute pollutants to the watershed (e.g., nitrogen and/or bacteria from animal wastes). Further, legacy nutrients from historical agricultural uses can continue to contribute to water quality issues for decades due to the travel time it takes for pollutants in groundwater to be carried through the watershed. Historic land use information prior to 1971 is not available at this time; however, there was likely extensive agriculture in the Squibnocket Pond watershed, which included pasture, and perhaps cultivated, acreage[12].

Impervious land cover in the Squibnocket watershed represents 1.7% of the total land cover. Studies have shown that waterbodies can begin to experience adverse water quality impacts when impervious cover levels reach as little as 5% to 10%[13] of the watershed area. Additional management practices for impervious surfaces should be considered as development and/or additional impervious cover levels increase.

When considering land cover at the sub-watershed level, impervious cover represents less than 4% in each of the three sub-watersheds. Pasture/hay land cover is concentrated in Squibnocket East representing 7% of sub-watershed land cover. There is no pasture/hay land cover present in Black Brook sub-watershed and negligible (<0.1%) in the Squibnocket Pond Main Basin sub-watershed. Given overarching nutrient concerns, Squibnocket East could be a focus area for pasture/hay management strategies, especially in locations with limited riparian buffers between agricultural land uses and waterbodies.

Squibnocket Pond: Ollie Becker, June 2021

Geology and Soils

The contributing watersheds of the wider Menemsha-Squibnocket Pond System are located entirely on the island's western moraine. As a result, the watershed is generally located on moraine deposits, but the eastern portion of the watershed may have areas of sandy outwash and moraine mix[14].

The Natural Resources Conservation Service (2020) classifies predominant soils as Nantucket-Plymouth complex, Freetown, and Swansea mucks, Eastchop loamy sand, and Whitman Variant silt loam[15]. The majority of these soils are classified in Hydrologic Soil Groups A, A/D, B, and B/D (with the exception of the Nantucket-Plymouth complex, and Freetown and Swansea mucks). HSG A and B are generally suitable for infiltration (Figure 5). In other words, these soil types are likely to absorb more rainfall than others. Although the characteristics of these soils may reduce stormwater runoff by filtering stormwater (and wastewater), the attributes of these soil types can also increase the potential for pollutants to leach into groundwater.

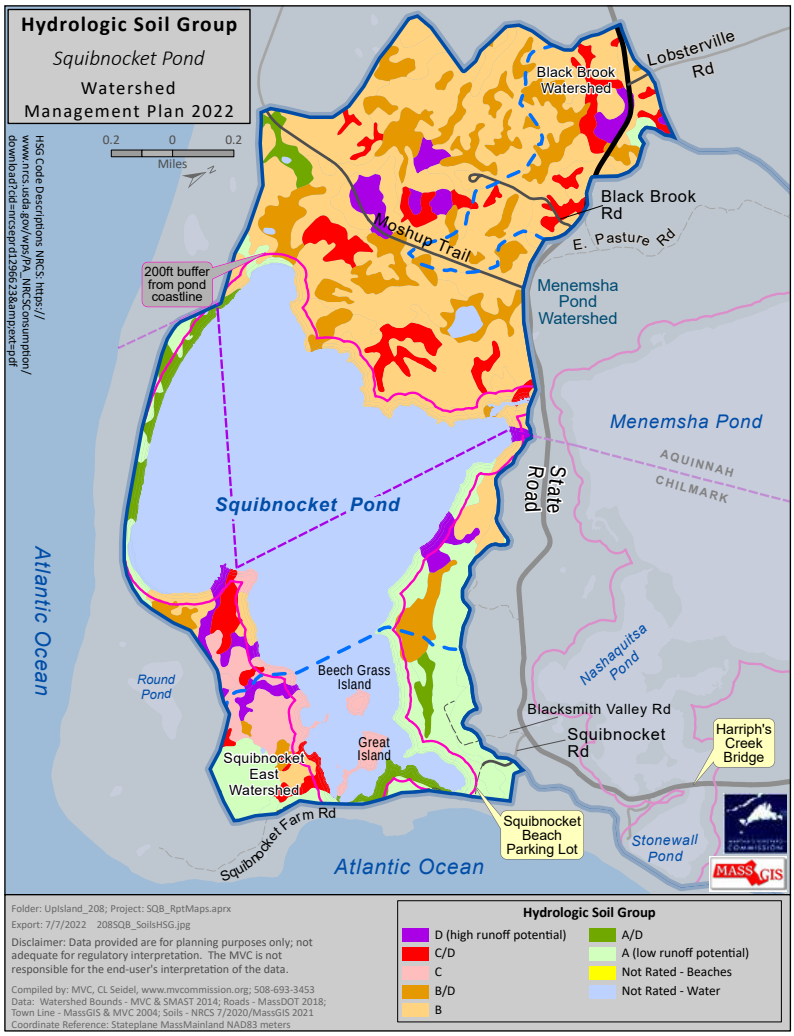

Figure 5. Squibnocket Pond Hydrologic Soil Groups

Figure 6 contains a map of all soil leaching potential in the Squibnocket watershed. Approximately one third of the watershed soils are categorized with a high potential for nitrate-nitrogen leaching (Figure 7), 15% of soil has moderate and 14% has low nitrogen-leaching potential[16]. The remaining 36% of area is categorized as "unrated" soil.

Based on sub-watershed level data (Figure 8), Black Brook sub-watershed has particularly high nitrate-nitrogen leaching potential, with 64% of the sub-watershed containing soils in that category. Soluble nitrate is highly mobile and easily moves through the soil profile, especially after heavy rainfall or with increased irrigation. These conditions demonstrate Squibnocket Pond's susceptibility to nitrogen pollution and the associated importance of effective designs for onsite wastewater systems and fertilizer management, especially in the Black Brook sub-watershed.

The combination of the soil properties (e.g., nitrogen leaching potential) and shallow groundwater tables can increase cove susceptibility to poor water quality. The average depth to groundwater in the area is estimated by the NRCS to be approximately 2.0 ft below the surface. However, these estimates are not available for all the Squibnocket Pond watershed (or western moraine) and should be used for general planning purposes only[17]. More accurate groundwater elevation data could be found via monitoring wells, onsite soil evaluations, and from local studies and records, if available. Depth to groundwater is important when considering stormwater and onsite wastewater management systems, as there are strict requirements regarding the distance separating groundwater and wastewater management systems.

Despite the watershed having large areas of forest and conservation land, Squibnocket Pond suffers from nutrient related impairments due to a combination of atmospheric deposits and watershed inputs.

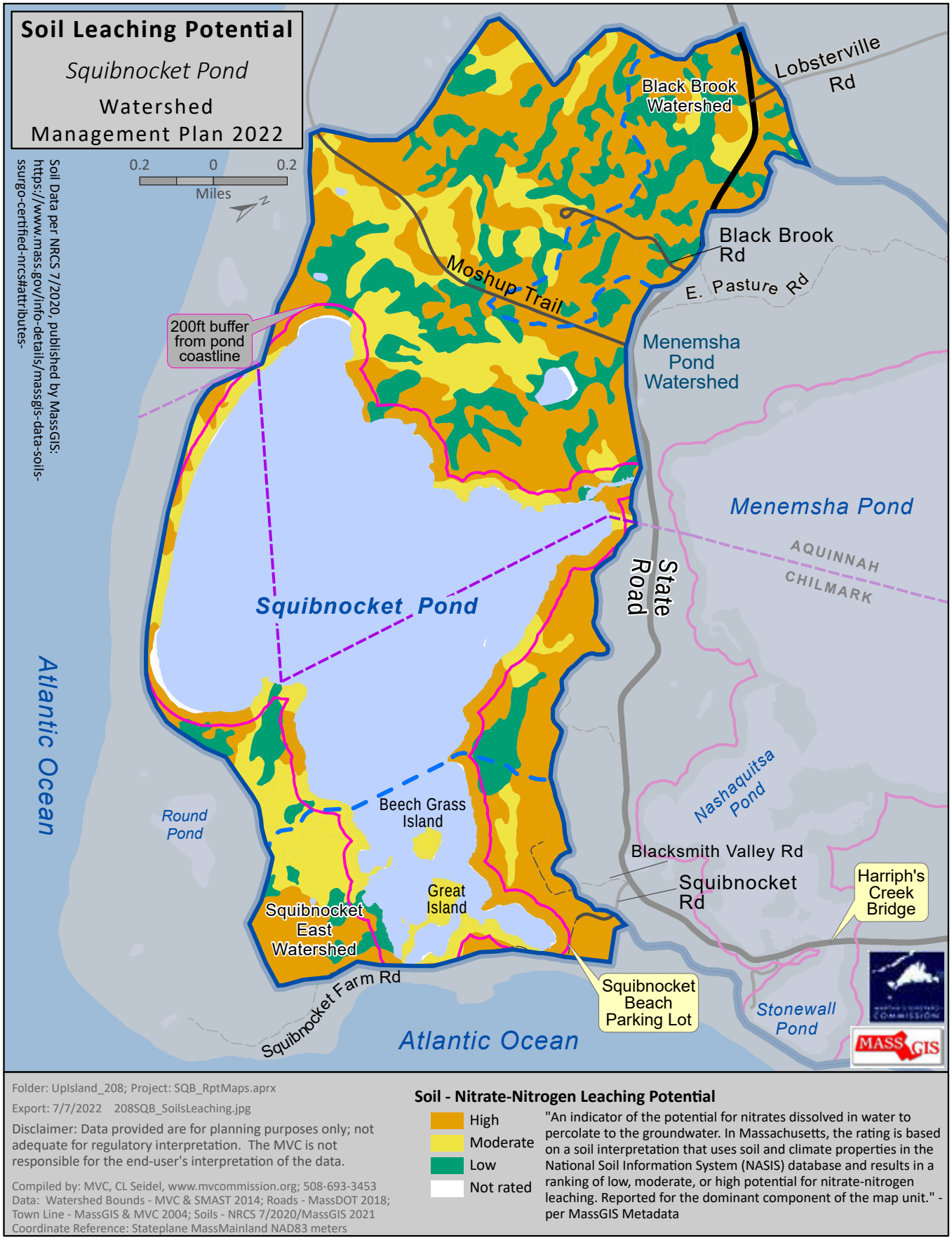

Figure 6. Squibnocket Pond Soil Leaching Potential

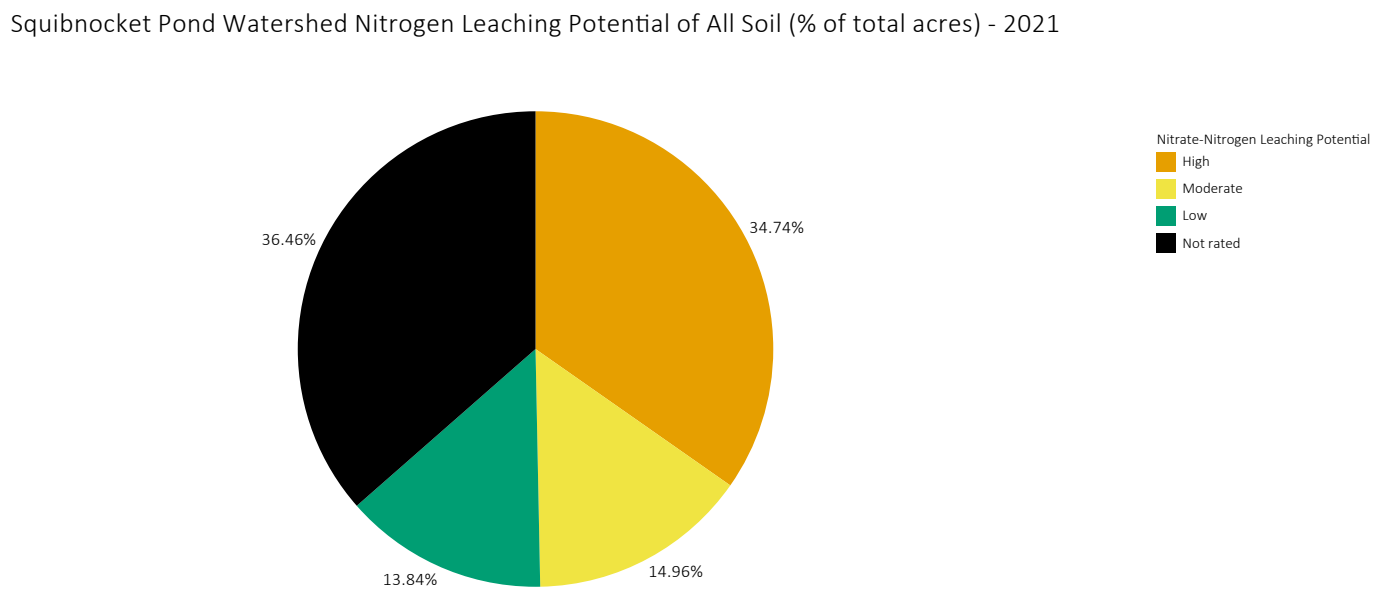

Figure 7. Squibnocket Watershed Nitrogen Leaching Potential

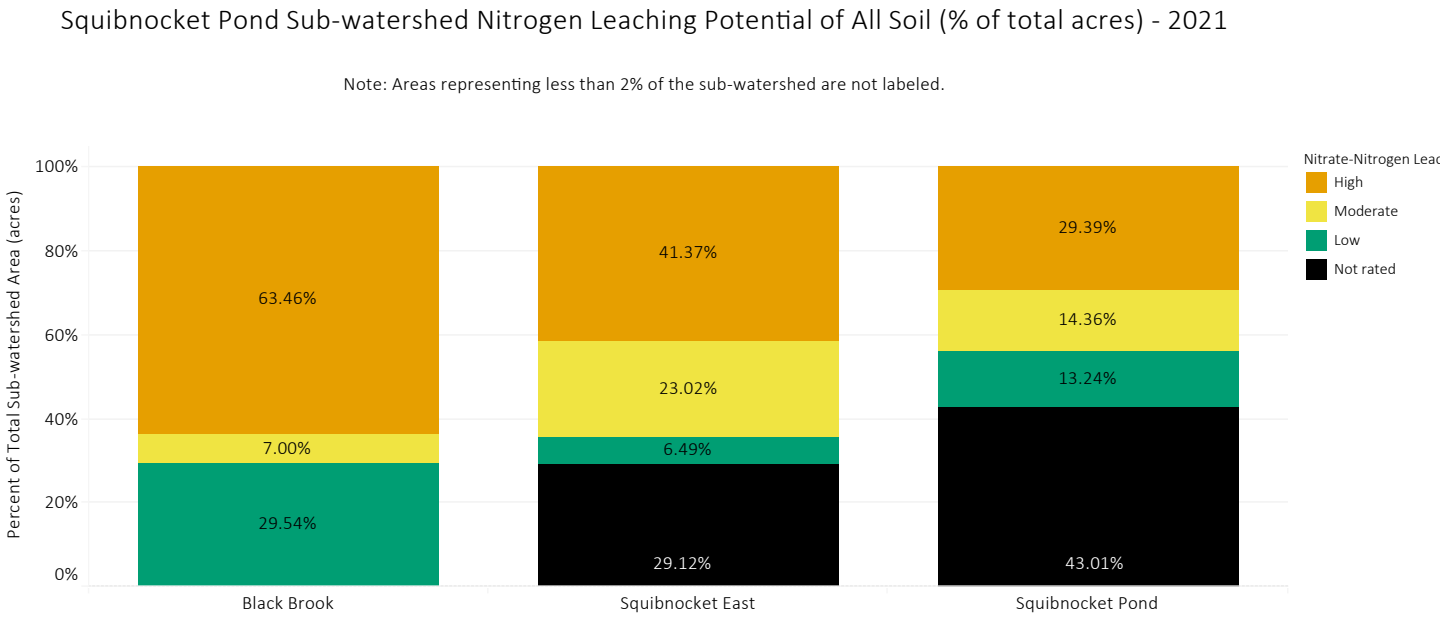

Figure 8. Squibnocket Nitrogen Leaching Potential by Sub-watershed

Flows and Residence Time

Freshwater enters the pond via precipitation, stream flows from Black Brook, and groundwater inflow. Black Brook is predominately a groundwater fed stream. Groundwater inputs to Squibnocket Pond are estimated to total 312,169 ft^3/day; contributions from each sub-watershed are summarized in Table 2[18].

Saltwater infiltrates the pond through wave action washovers at the barrier beach during storm events and limited exchange with Menemsha Pond via Herring Creek.

Historical records indicate that like many other coastal ponds on Martha's Vineyard, Squibnocket Pond has been subject to natural breaches and overwash events that increased salinity and provided habitat for valued species of finfish and shellfish, especially oysters. Records indicate that the present connection between Squibnocket Pond and Menemsha Pond was human made circa 1810, today this connection is referred to as Herring Creek. Natural beach breaches are not common in Squibnocket pond, therefore, flows into and out of the pond are largely dependent on the Herring Creek connection.

System residence time is the average time required for one unit of water (e.g., one water drop) to migrate from a point within the embayment to the entrance of the system (ocean). Local residence time is the average time needed for a water drop to migrate from inside a sub-basin of the pond to the outlet and then to the main basin. A lower residence time typically corresponds to better water quality.

It is estimated that the entire Squibnocket Pond system has an average residence time of 323 days or nearly 11 months (this is the time it takes Squibnocket Pond to flush with Vineyard Sound), while the local residence time is 152 days, or roughly five months[19]. The long residence time is a result of the poor tidal exchange described earlier. Although the sensitivity of the pond to nitrogen is associated with minimal tidal exchange, decreased travel time of groundwater also contributes to Squibnocket Pond's susceptibility to nutrient pollution[20].

Sub-watershed Name	Daily Input (ft^3/day)
Black Brook	50.001
Squibnocket East	54,547
Squibnocket Main	207,621
Total	**312,169**

Table 2. Squibnocket Pond Sub-watershed Groundwater Input

It is important to note that although system and local residence times are common measures of how much time it takes for one unit of water to circulate in the estuary system, it can take up to three times longer for 90% of all water within the entire system to circulate.

The hydrodynamic characteristics of the Squibnocket Pond watershed, including limited tidal exchange/flushing, soil conditions and groundwater travel time contribute to Squibnocket Pond susceptibility to nutrient pollution.

Summary

Squibnocket Pond is particularly sensitive to nitrogen enrichment because the barrier beach prevents regular tidal exchanges between the pond and the Atlantic Ocean,[21] and there is limited flushing or exchange with Menemsha Pond. While much of the watershed's land cover is vegetated, there are some areas of impervious cover, development, and small-scale agriculture – including historic agriculture - land cover that also contribute to compromised water quality.

Herring Creek, Squibnocket Pond: Ollie Becker, June 2021

WATER QUALITY

Previous studies considered Squibnocket Pond a complex system due to changing tidal patterns and the substantial freshwater component in its water column[22]. This pond is currently classified as an impaired waterbody for nitrogen and shows stress at some sites for dissolved oxygen, total pigment, and impaired habitat for benthic animals. Wastewater has been identified as the largest controllable nitrogen source entering Squibnocket Pond.

Relevant regulatory water quality standards and impairment thresholds are summarized in Table 3. These standards reflect the Massachusetts Surface Water Quality Standards (314 CMR 4.00), which designate uses and water quality criteria to support those uses, per the federal Clean Water Act[23] and the Massachusetts Integrated List of Waters[24].

Water quality samples are collected during the critical summer period by the MVC in Squibnocket at two locations in the pond's main basin: SQB1 and SQB3 (Figure 9).

Water Quality Parameters	Regulatory Standards	MEP Status (2017)*	MVC Average (2017-2021)	Standard Sources
Total Nitrogen	0.50 mg/L	Impaired (0.76 mg/L)	Exceeds Standard (0.76 mg/L)	2017 Massachusetts Estuary Project, TMDL
Temperature	<85°F/29.4°C (At one time) <80°F/26.7°C (Max daily mean)	Status Not Reported	Meets Standard Requirements (77°F / 25°C)	Massachusetts Surface Water Quality Standards (314 CMR 4.00)
Dissolved Oxygen	6.0 mg/L	SQB3 was below impairment threshold, reaching levels as low as 3mg/L. SQB1 meets standard requirements.	Meets Threshold Requirements (7.0mg/L)	Massachusetts Surface Water Quality Standards (314 CMR 4.00)
Total Pigment Gradient	10.0 µg/L	Meets Threshold Requirements** (7.3 µg/L)	SQB3 exceeds requirements (11.1 µg/L) SQB1 meets requirements (8.9 µg/L)	2020 Martha's Vineyard Water Quality Technical Report

*** Values in this column represent an average for data collected from all sampling sites from 1995-2007 and 2011, unless otherwise indicated.**

**** MEP pigment data was based on chlorophyll-a only. The Total Pigment Gradient data referenced for "MVC Average (2017-2021)" is based on Total Pigment.**

Table 3. Squibnocket Pond Water Quality Standards and Thresholds

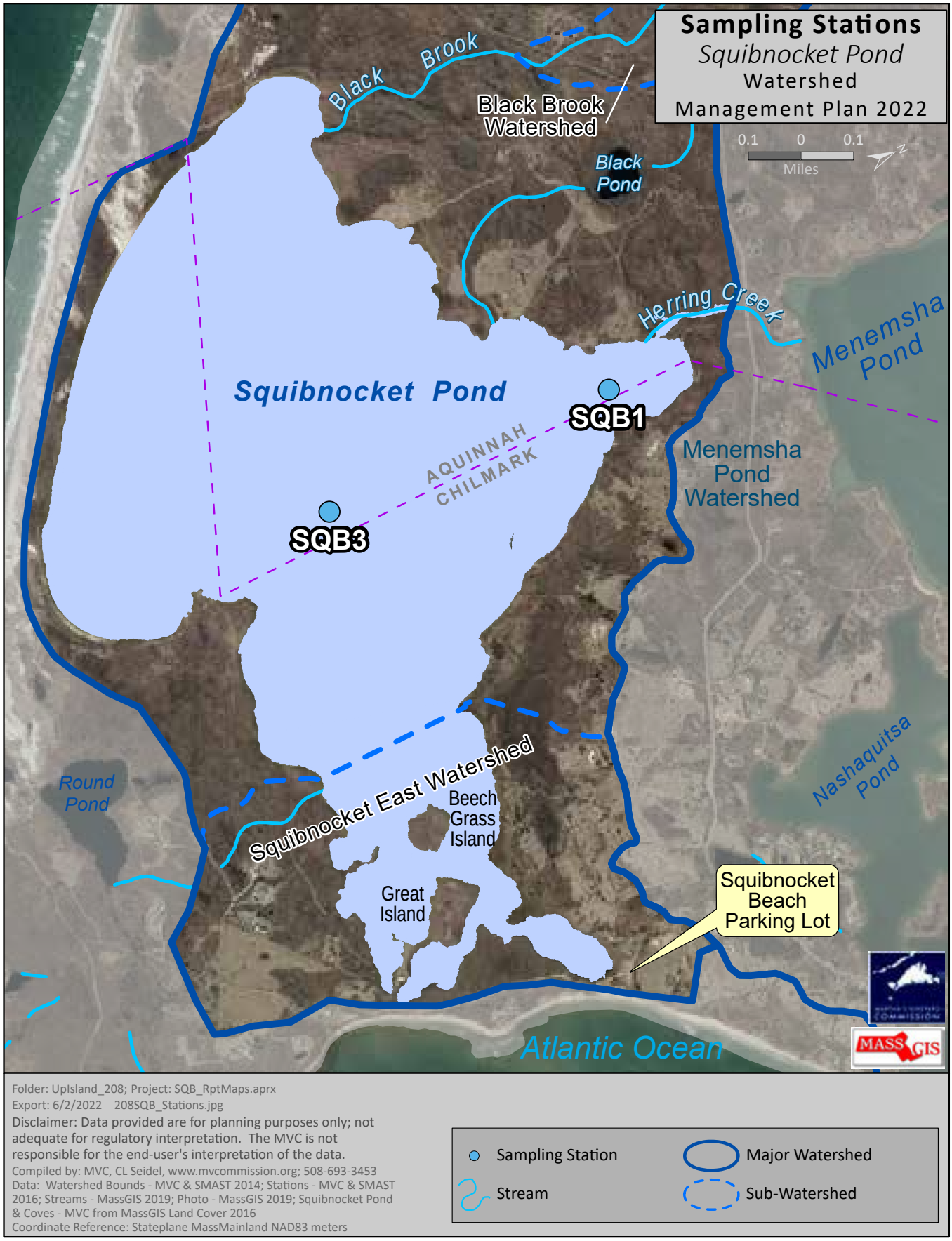

Figure 9. Squibnocket Pond Water Quality Sampling Stations (2017-2021)

The Wampanoag Tribe of Gay Head (Aquinnah) Tribe collects and analyzes water quality data at additional sites on a weekly basis as part of the Tribe's water quality monitoring program. The Tribe follows a rigorous protocol for collecting, analyzing, and reporting on a wide range of watershed health topics at the Wampanoag Environmental Laboratory. Tribal data is reported to the U.S. Environmental Protection Agency and can be found on the EPA's ATTAINS data portal (https://www.epa.gov/waterdata/attains) or within the EPA's "How's My Waterway" data tool (https://mywaterway.epa.gov/community/02535/monitoring)[25].

The MVC uses a variety of state and nationally adopted biological and chemical water quality indicators to monitor and assess ecosystem health, habitat suitability, and potential sources of stress including the following: salinity, conductivity, temperature, nitrogen, dissolved oxygen, chlorophyll-a, total pigment, and water clarity. Phosphorous sampling is not conducted because it was not found to be the limiting nutrient in Squibnocket Pond, or other similar estuaries in Massachusetts. Chemical analyses are performed at the Coastal Systems Analytical Facility at SMAST-UMass Dartmouth following procedures consistent with the MEP, which are part of numerous monitoring QAPPs approved by MassDEP and USEPA.

It is important to note that the MVC, and the community as a whole, benefit from a strong partnership with the Tribe, one in which data, analysis and expertise are shared regularly.

Water Quality Testing: Martha's Vineyard Commission

Salinity

Salinity is an important physical characteristic of a waterbody and can indicate habitat quality for aquatic organisms, as well as indicate the extent of tidal influence. As seen in Figure 10, average salinity is consistent at both sampling sites over the past five years[26], which is expected for ponds like Squibnocket, that have limited tidal influence. If significant changes in salinity are detected, dramatic impacts on the ecosystem may occur. Accordingly, changes in salinity have important habitat implications for future managements strategies.

Temperature

Water temperature exerts a strong influence on biological activity and dissolved oxygen levels; there is lower dissolved oxygen solubility at higher temperatures. As required by 314 CMR 4.00, temperature must not exceed 85˚ F (29.4˚ C) nor a maximum daily mean of 80˚ F (26.7˚ C). As seen in Figure 11, average water temperature at both sites have been below 80 ˚F since 2017.

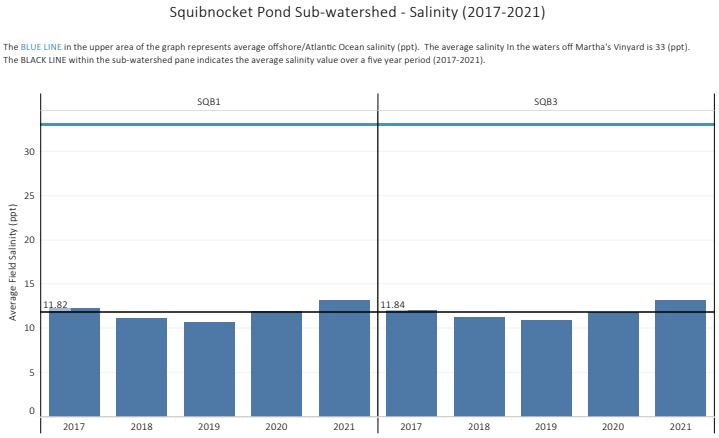

Figure 10. Squibnocket Pond Salinity Data (2017-2021)

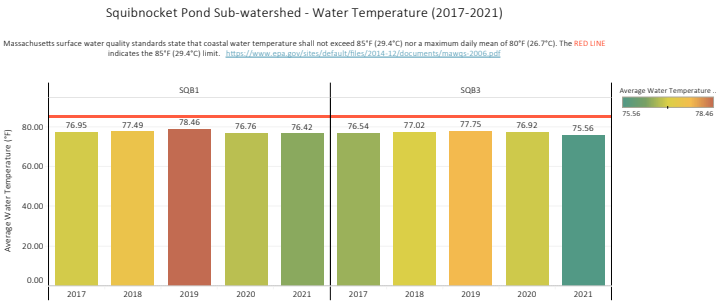

Figure 11. Squibnocket Pond Temperature Data (2017-2021)

Nitrogen

Nitrogen is typically the nutrient limiting algal growth in shallow temperate estuaries and therefore is often targeted for management strategies. While extremely low levels of nitrogen would negatively affect organisms in brackish water (by limiting potential for growth), nitrogen in excess can be harmful to estuarine water and habitat quality. Excess nitrogen and resulting eutrophication of our estuaries and coastal waters world-wide causes fish kills, loss of seagrass, including eelgrass, as well as benthic animal communities, and significant habitat declines.

Squibnocket Pond had poor water quality indicators in 2001, which the MVC determined was attributed primarily to natural eutrophication[27]. Based on the information contained in earlier studies, it is assumed that wastewater is the largest controllable source of nitrogen in the Squibnocket Pond Watershed. Per previous studies, other potential sources of nitrogen include landfill leachate, fertilizers, run-off from impervious surfaces, and direct atmospheric deposition. Table 4 summarizes the nitrogen load to Squibnocket Pond estimated from each source[28].

Source	Nitrogen Load (kg/year)
Wastewater	758
Landfill	8
Turf Fertilizers	68
Impervious Cover	140
Water Surface (atmospheric deposits)	3,308
Natural Surfaces	223
Buildout*	1,253
* Buildout loads include: wastewater disposal, fertilizer, and impervious surface additions from developable properties. .	

Table 4. Squibnocket Pond Nitrogen Load Model Inputs (Howes, et. al, 2017)

Data from 1995-2007 and 2011 analyses showed that total nitrogen (N) concentrations in the basin of Squibnocket Pond estuarine system were between 0.76 and 0.79 mg/L[29]. The 2017 MEP study established a nitrogen concentration of 0.50 mg/L as the threshold at which Squibnocket Pond could support healthy benthic animal communities in the basin[30].

Table 6 compares average total nitrogen concentrations from the 2017 MEP study with the MVC five year average and 2021 data. The 2017-2021 data shows little concentration change in the five years since the MEP analysis was completed. There was a slight decrease in nitrogen concentrations at SQB1 and a slight increase at SQB3.

However, although nitrogen concentrations varied between 2017-2021, the observed nitrogen concentrations in 2021 were higher than the five-year average (Figure 12). Moreover, both sampling locations have consistently remained impaired for nitrogen since the 2017 MEP study was completed.

Load reductions can potentially be achieved through a variety of strategies: better management of watershed nitrogen sources (wastewater, stormwater, fertilizers), increasing the natural attenuation of nitrogen within the freshwater systems, and/or modifying the tidal exchange[31].

See Table 5 for watershed loads and targets, as well as the percent change required to reach the threshold loads outlined in the MEP (in kg/year).

Sub-embayment	Present Load (kg/year)	Threshold Load (kg/year)	Threshold % Change
Black Brook	204.4	204.4	0%
Squibnocket East	273.8	273.8	0%
Squibnocket West	741.0	580.4	-22%
*Comparison of sub-embayment watershed **total watershed loads** (including septic, runoff, and fertilizer) used for modeling of present and threshold loading scenarios of the Squibnocket system. These loads do not include direct atmospheric deposition (onto the sub-embayment surface), or benthic flux loading terms.			
** Information published in Table VIII-3 (Page 175) of the Menemsha-Squibnocket Pond Embayment System Massachusetts Estuaries Project Report (2017).			

Table 5. Squibnocket Pond TOTAL Nitrogen Load Reductions Required to Achieve Nitrogen Threshold (TMDL)

Sub-embayment	Sampling Station	MEP Observed Total Nitrogen Concentration (2017) (mg/L)	2017-2021 Average Total Nitrogen Concentration (mg/L)	2021 Observed Total Nitrogen Concentration (mg/L)	Threshold Total Nitrogen Concentration (mg/L)
Squibnocket Basin - North	SQB1	0.76	0.73	0.82	0.50
Squibnocket Basin - South	SQB3	0.77	0.79	0.83	0.50

Table 6. Squibnocket Pond Total Nitrogen Data Comparison

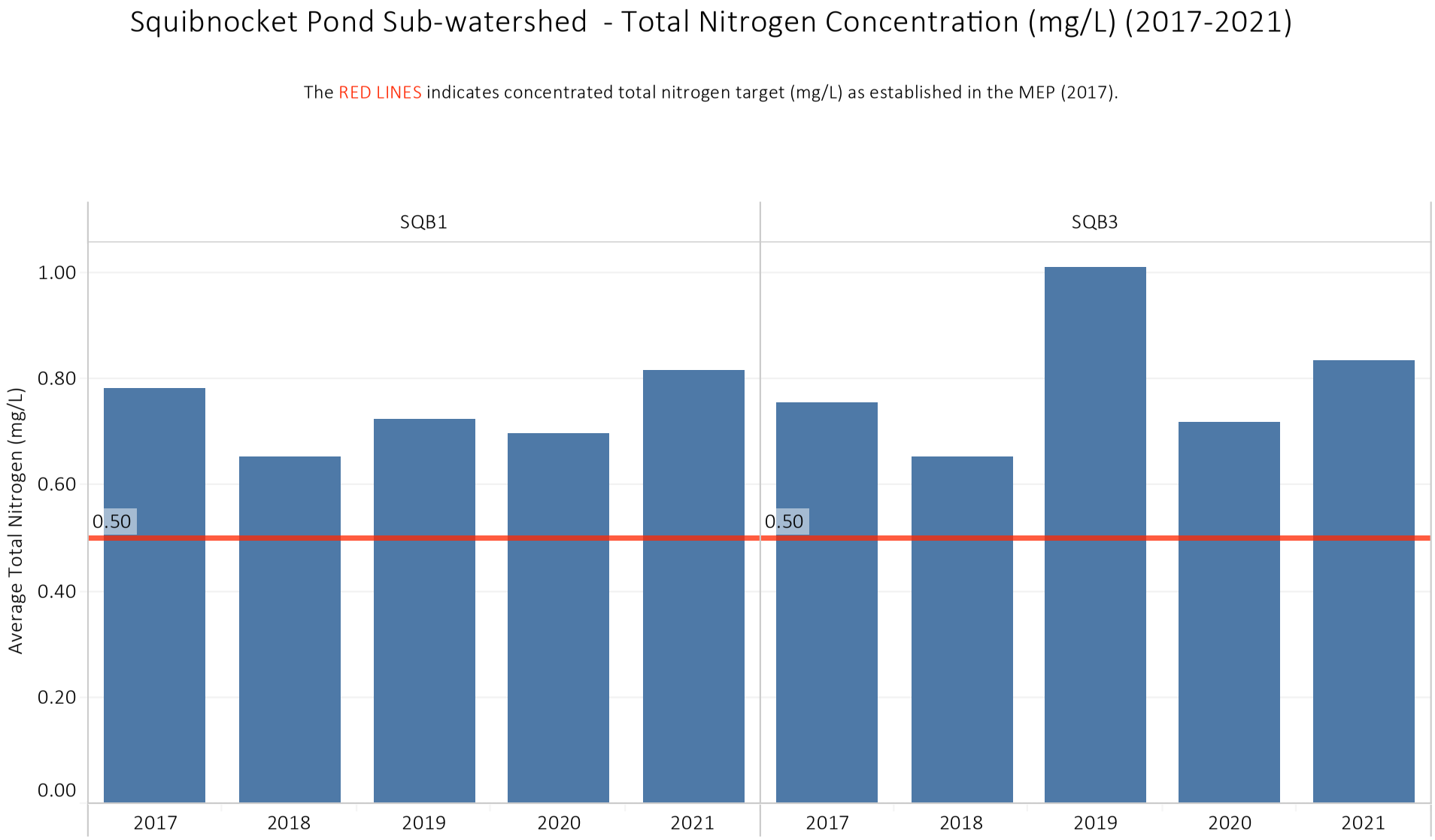

Figure 12. Squibnocket Pond Total Nitrogen by Sub-watershed (2017-2021)

Dissolved Oxygen

Dissolved Oxygen (DO) levels are a good indicator of water quality conditions that can affect plant and animal habitat. Low DO concentrations may indicate excessive nutrient (eutrophic) conditions. The DO threshold of 6 mg/L represents the amount of DO required for most organisms to thrive. The values indicated below represent DO as it is measured during the daytime, at the bottom of the pond, where the least mobile, and therefore most vulnerable species live.

All DO levels at SQB1 remain above the standard for all but two samples from 2017-2021. Over the course of five years (2017-2021) DO at SQB3 measurements were generally above 6 mg/L, however, there were occasional observations below standard in 2017, 2019 and 2021. It is important to note that DO levels can widely fluctuate with photosynthesis and respiration of plants throughout the day and night. The quality of the habitat is determined in large part by the time periods in which water quality is at its worst, even if that is for a short period of time. DO is likely to fall at night, therefore one could expect low quality habitat conditions in areas where the DO stays close to the threshold during the day[32] (Figure 13).

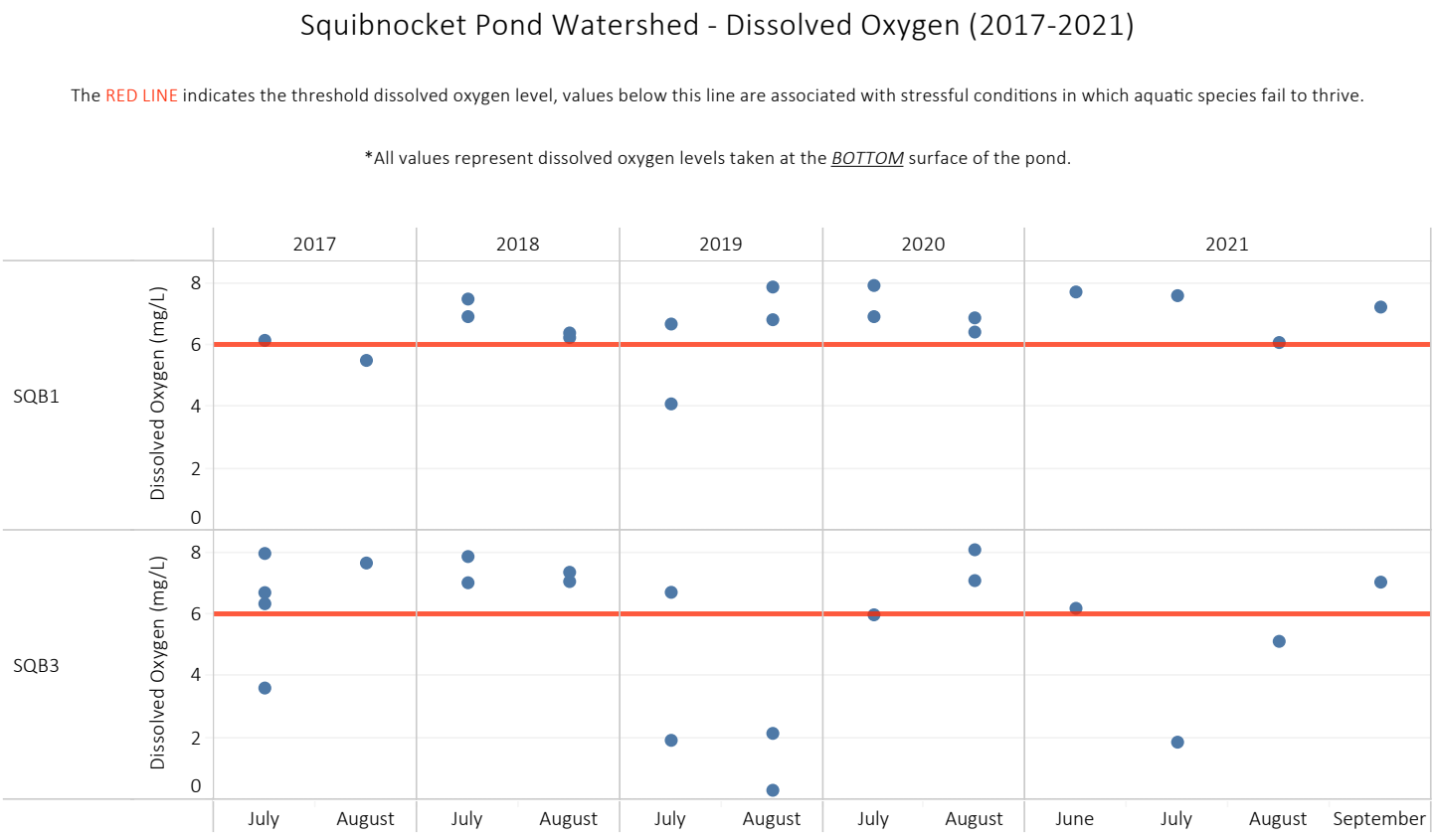

Figure 13. Squibnocket Pond Dissolved Oxygen by Sub-watershed (2017-2021)

Chlorophyll-a and Total Pigment

Chlorophyll-a is a water quality indicator used to classify the trophic condition of a waterbody and is reflective of the amount of algae (in this case phytoplankton) present. Chlorophyll-a is the major chlorophyll in green plants and algae and therefore is naturally present in aquatic systems. Excess algae, which is often expressed as elevated Chlorophyll-a values, can be harmful to ecosystems as it indicates high organic matter quantities that could result in low oxygen levels during algae aging and decay processes. Chlorophyll-a concentrations are higher at SQB3 than SQB1 due to the closeness of SQB1 to the tidal exchange from Menemsha Pond (Figure 14).

Total pigment is a combined measure of Chlorophyll-a and Pheophytin-a that indicates the amount of microscopic living and expiring plant matter in the water. While this is not a direct measure of phytoplankton, total pigment is a commonly used indicator for assessing biological and habitat health.

The MVC has been analyzing Squibnocket water samples for total pigment since 2017. Samples show substantial fluctuation in total pigment concentrations over the last five years. Furthermore, the extent to which the observed values show conditions in the entire pond is unclear because the frequency of sampling may allow the impact of blooms to be only partially captured before they have settled.

Data from 2021 clearly indicated a large bloom as there were extremely elevated levels at both SQB1 and SQB3 (Figure 15). 2021 samples show total pigment concentrations above the impairment threshold of 10.0 µg/L at both sampling locations[33]. High pigment concentrations combined with high total nitrogen levels in the pond may indicate eutrophication, especially at SQB3.

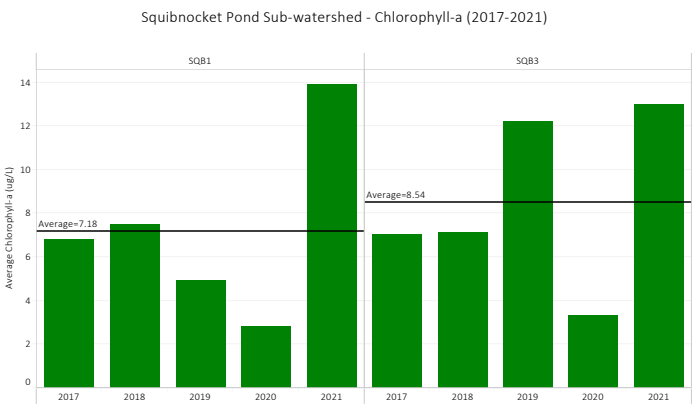

Figure 14. Squibnocket Pond Chlorophyll-a (2017-2021)

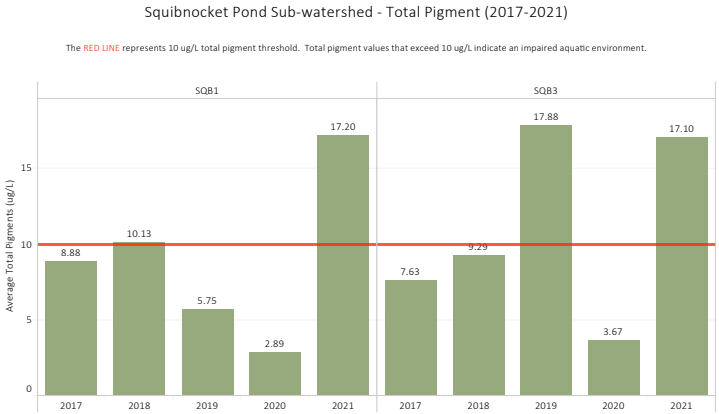

Figure 15. Squibnocket Pond Total Pigment (2017-2021)

Cyanobacteria

In 2021, the MVC began an island-wide cyanobacteria monitoring project. In the first year of the study, MVC focused on establishing a baseline of cyanobacterial presence and abundance in Island ponds. Cyanobacteria, can cause toxic algae blooms, which at certain concentrations, can be dangerous to human and animal health.

Bloom-forming cyanobacteria tend to be found grouped together as large colonies and filaments, while picocyanobacteria tend to be found as single cells and sometimes small colonies. Both types of these cyanobacteria (bloom-forming and pico) are known to produce cyanotoxins.

Squibnocket Pond was sampled every two weeks in collaboration with the Wampanoag Environmental Lab from June through September at the SQB1 and SQB3 sample sites. Bloom-forming cyanobacteria (those responsible for visible surface accumulations) were found at SQB3 in July 2021. As a result of positive Cyanobacterial identification, the local Board of Health closed the area to public access until human and animal health concerns associated with the toxic cyanobacteria bloom were no longer present.

In 2022, MVC will continue to monitor and research the bloom-forming cyanobacteria, picocyanobacterial populations and associated toxin levels in Squibnocket Pond. MVC will also work with its partners to analyze eDNA samples of the bacteria in order to identify the cyanobacteria at the species level.

Cyanobacteria Samples: Sheri Caseau, Martha's Vineyard Commission, 2021

Squibnocket Pond East, June 2021 - No Cyanobacteria Bloom: Ollie Becker, June 2021

Squibnocket Pond East, July 2021 - Cyanobacteria Bloom Present: Ollie Becker, July 28 2021

Summary

Since the 2017 MEP Report, Squibnocket Pond continues to demonstrate moderate levels of water and habitat quality impairment due to elevated nitrogen levels. Temperature and salinity are stable and generally show a consistent pattern. DO at SQB1 consistently meets standard requirements but does not reflect the main portion of the pond basin. Nitrogen and pigment increased in 2021 for both locations. When comparing the two sample sites, SQB3 is of more concern, and may better reflect conditions in the main areas of Squibnocket Pond. Water quality data at SQB3, where there is limited water exchange with Menemsha Pond, shows the highest levels of nitrogen, highest total pigment, and lowest DO levels.

The MVC does not test water quality at the far eastern end of Squibnocket pond. Future management plans would benefit from incorporating sample data from this area.

As noted elsewhere, load reductions could be achieved through a variety of strategies: better management of watershed nitrogen sources (wastewater, stormwater, and fertilizer use), increasing the natural attenuation of nitrogen within the freshwater systems, and/or modifying tidal exchange[34].

Squibnocket East Islands: Ollie Becker, June 2021

BIOLOGICAL CONDITIONS

Pond and Upland Habitat

Squibnocket Pond and the surrounding watershed include critical areas for rare and other species of conservation concern. There are areas designated by The MassWildlife's Natural Heritage & Endangered Species Program as Natural Communities, Priority Habitats of Rare Species, Estimated Habitats of Rare Wildlife and State Protected Rare Species[35] (Figure 16).

The state's areas of biodiversity and their habitats are mapped under the BioMap2 (2010) project. Both Core Habitat (Figure 17) and Critical Natural Landscape (Figure 18) exist in the Squibnocket watershed. Core Habitats include Aquatic Core, Priority Natural Communities, Wetlands, and Species of Conservation Concern[36]. Critical Natural Landscapes include Tern Foraging, Coastal Adaptation, Upland Buffer of Aquatic Core, Upland Area of Wetland Core, and Landscape Blocks[37]. There are approximately three endangered species, five threatened species, and 11 special concern species listed in the Squibnocket Pond Watershed in the Core 36 area[38]. The Core 36 area has two imperiled natural communities (Estuarine Subtidal: Coastal Salt Pond, Maritime Dune Community) and one vulnerable community (Maritime Beach Strand Community)[39].

Herring Creek, Squibnocket Pond: Ollie Becker, June 2021

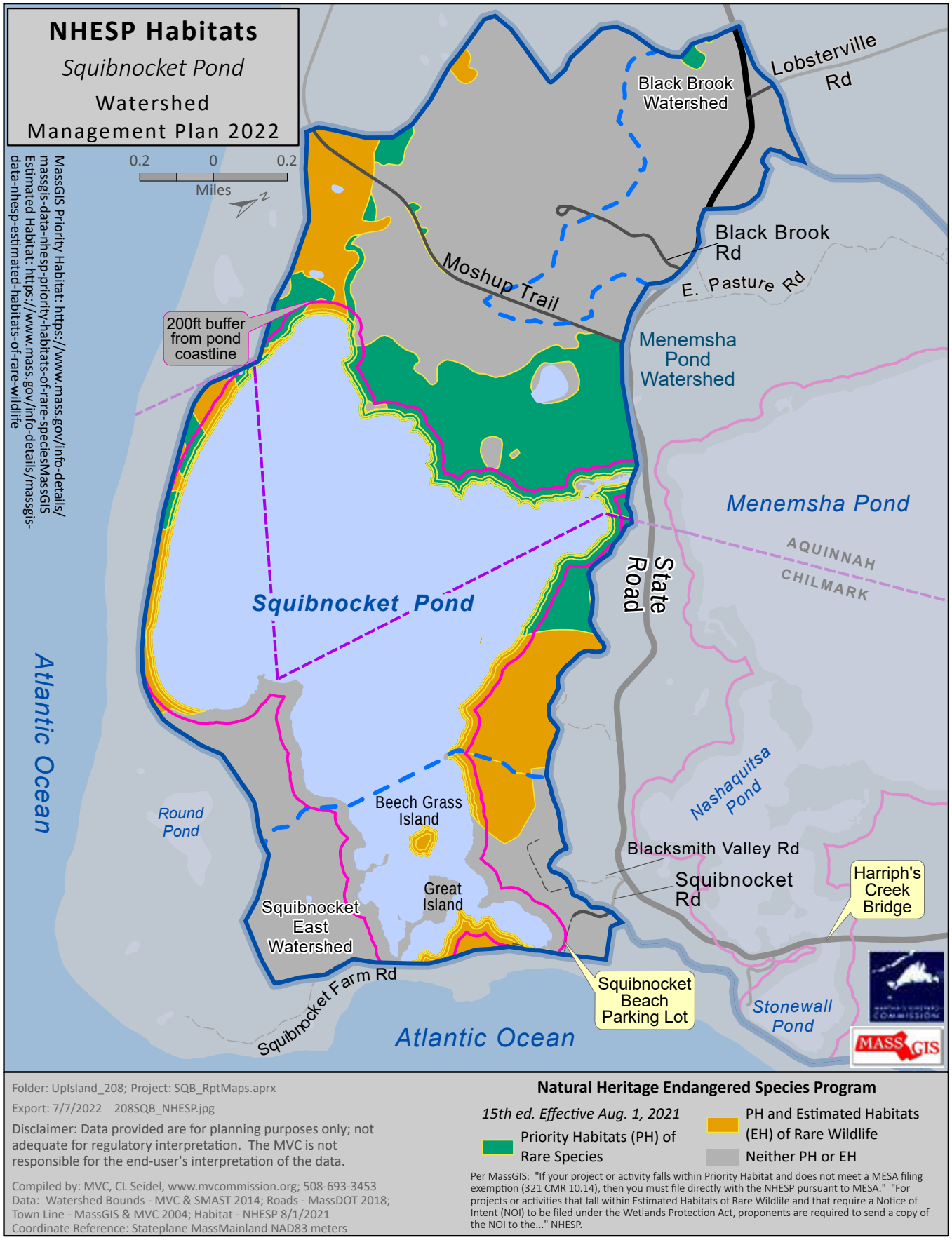

Figure 16. Natural Heritage & Endangered Species Program Map

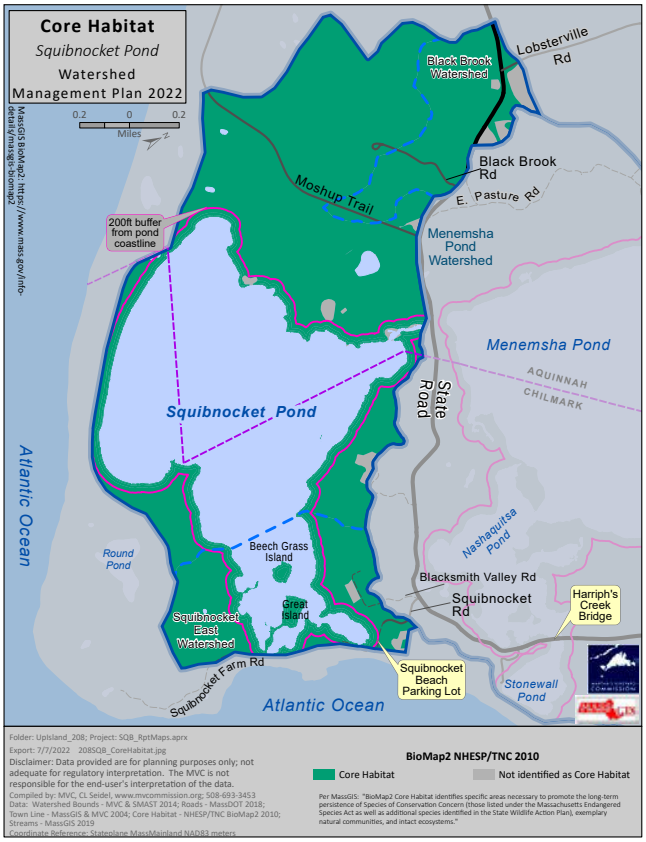

Figure 17. BioMap2 Core Habitat and Critical Natural Landscapes (Note Core IDs correspond with elements list)

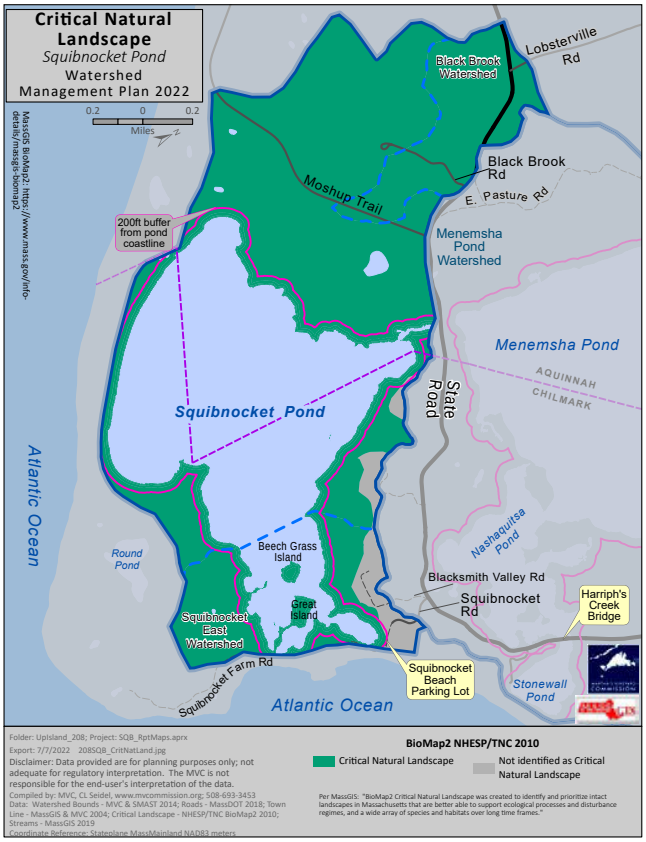

Figure 18. Critical Natural Landscape Map

Many of these habitats are in conservation areas, and, although there are conservation areas in the Squibnocket Pond Watershed, there are unrealized conservation opportunities that may provide permanent protection for key habitat areas. Wetlands also provide valuable habitat benefits to a variety of wildlife species (Figure 19).

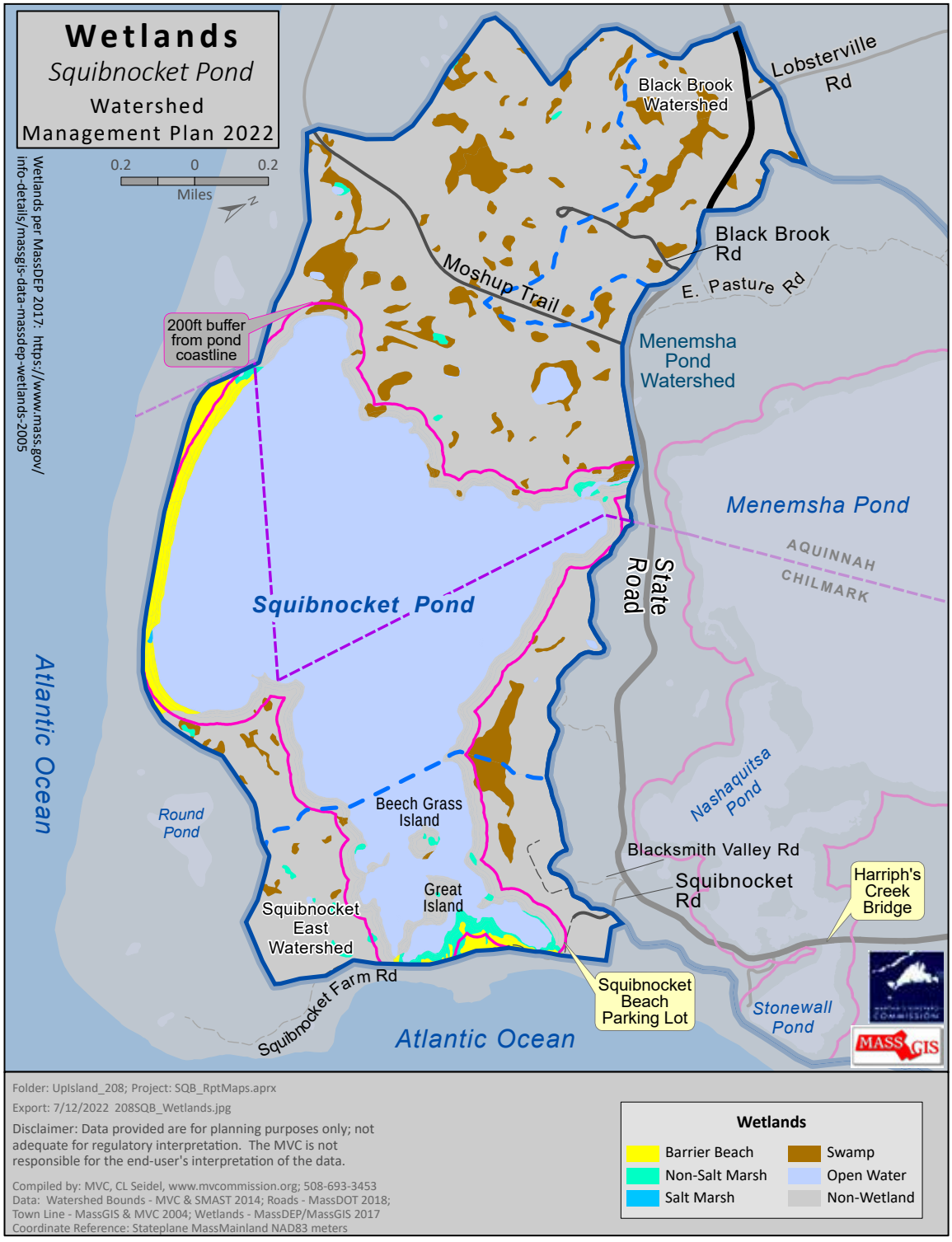

Figure 19. Squibnocket Pond Watershed Wetlands Map

Almost half of the Squibnocket Pond Watershed is characterized as conserved land, including 494 acres of conserved open space for which there is some level of legal protection. Therefore, habitats for species of concern in the Squibnocket Watershed are relatively well protected, but there are likely additional conservation opportunities.

The Squibnocket Pond is a valuable resource for the Wampanoag Tribe of Gay Head (Aquinnah). Stewardship of habitats is of critical importance to the Wampanoag Tribe. Aquatic resources within the Tribal lands are key components that directly benefit and meet the needs of the Tribe. Members of the Wampanoag Tribe rely on the Pond for cultural, subsistence activities and commercial fishing in the pond. As such, the Tribe dedicates resources to maintain the Pond's healthy habitat for fish and shellfish communities . Additional details on this topic are in the Socioeconomic section of this report.

Benthic infauna and epifauna surveys

Benthic infauna are organisms that live within the bottom sediments. The presence (or absence) of some types of benthic animals can reflect habitat quality, as well as conditions for other pond residents. The MEP study analyzed sediment samples at 11 locations in Squibnocket Pond to characterize the benthic community[40]. Since eelgrass habitat does not exist in the pond, conditions for benthic animals are indicators of ecosystem health in Squibnocket Pond.

Excessive nitrogen in the pond can be indicated by low diversity of benthic animal communities[41]. The number of benthic species and counts of individuals in each species shows the general diversity and evenness of the benthic infauna community, this is combined with the observed species assemblages to classify benthic habitat health.

Samples analyzed in the MEP study found that although there were a moderate to high number of individuals, there were fewer species in Squibnocket Pond when compared to higher quality habitat areas[42]. The community diversity and evenness indicators were measured to be low, suggesting poor habitat quality.

There are also certain benthic animals who can thrive in poor water quality conditions; their presence can be used to evaluate habitat health. Capitellids and Tubificids are examples of animals that thrive in nutrient and organic matter rich habitats. Capitellids and Tubificids are considered stress indicator species.

Squibnocket Pond samples showed low numbers of Capitellids and Tubificids. However, surveys found that Streblospio and Leptocheirus dominated the benthic communities,

both are species that have adapted to live in organically enriched habitat conditions implying that the Pond is a nitrogen enriched environment[43]. Furthermore, the MEP's dissolved oxygen analysis showed a variation of oxygen levels indicative of significant organic matter enrichment, in all areas except the northern portion of the Pond[44].

Thriving shellfish communities are another biological resource that can indicate habitat health. The Massachusetts Division of Marine Fisheries (DMF) has approved most of Squibnocket Pond for shellfish propagation and harvest, with the exception of the eastern areas of the pond[45]. DMF considers the pond suitable to grow American oysters[46]. More information about shellfishing activities is discussed below in the Socioeconomic section.

Finfish surveys

Squibnocket Pond provides habitat for white perch and important spawning areas for striped bass, alewife, and Atlantic blueback herring[47]. The creek between Menemsha and Squibnocket Ponds serves as a fish passage for breeding within Squibnocket Pond[48]. DMF has also observed anadromous fish within the Menemsha-Squibnocket Pond embayment system[49]. Fish and shellfish are important resources to the Wampanoag Tribe, and the Tribe actively manages and monitors the herring run (see Socioeconomic section).

Squibnocket Pond: Ollie Becker, June 2021

Eelgrass mapping

The MEP study concluded that the pond likely never supported eelgrass habitat based on low salinity, high nitrogen levels, low water clarity, and the structure of the basin[50]. Also, according to the MassDEP Eelgrass Viewer, eelgrass beds have never been mapped in Squibnocket Pond[51].

Phytoplankton survey

There are no documented phytoplankton surveys of Squibnocket Pond. However, other indicator parameters have been used to evaluate phytoplankton biomass. As described previously, several water quality indicators can be used to assess biological and habitat health. For example, chlorophyll-a is a proxy indicator measure for phytoplankton biomass[52]; and total pigment measurements can indicate the amount of live and expired plant matter within a body of water.

Summary

Squibnocket Pond and its upland watershed provide critical habitat for species of conservation concern. With the lack of eelgrass and the conclusion that the pond likely never supported eelgrass habitat, benthic infauna has been (and will continue to be) used as indicators of the overall ecological health of the pond[53]. The pond has shown patterns of benthic infauna communities consistent with nitrogen enrichment.

Squibnocket Pond: Ollie Becker, June 2021

SOCIOECONOMIC CONDITIONS

As described previously, the Squibnocket Pond Watershed spans the Town of Chilmark and Town of Aquinnah, and watershed areas are under jurisdiction of the Wampanoag Tribe of Gay Head (Aquinnah), including much of the Black Brook and the Squibnocket Pond Main Basin sub-watersheds. Tribal members trace their presence in the area to over 10,000 years ago and the Squibnocket Pond Watershed provides important cultural and subsistence resources for the Tribe. The area is well known for its shellfish and finfish resources. Pond management includes coordination between the Wampanoag, towns, MVC, and other state and federal regulators[54].

Town	Year-round Population 1950	Year-round Population 2020	Total Population % Increase 1950 - 2020	Peak In-season Population 2020
Aquinnah	88	439	399%	1,889
Chilmark	183	1,212	562%	6,530

Table 7. Squibnocket Pond Watershed Population

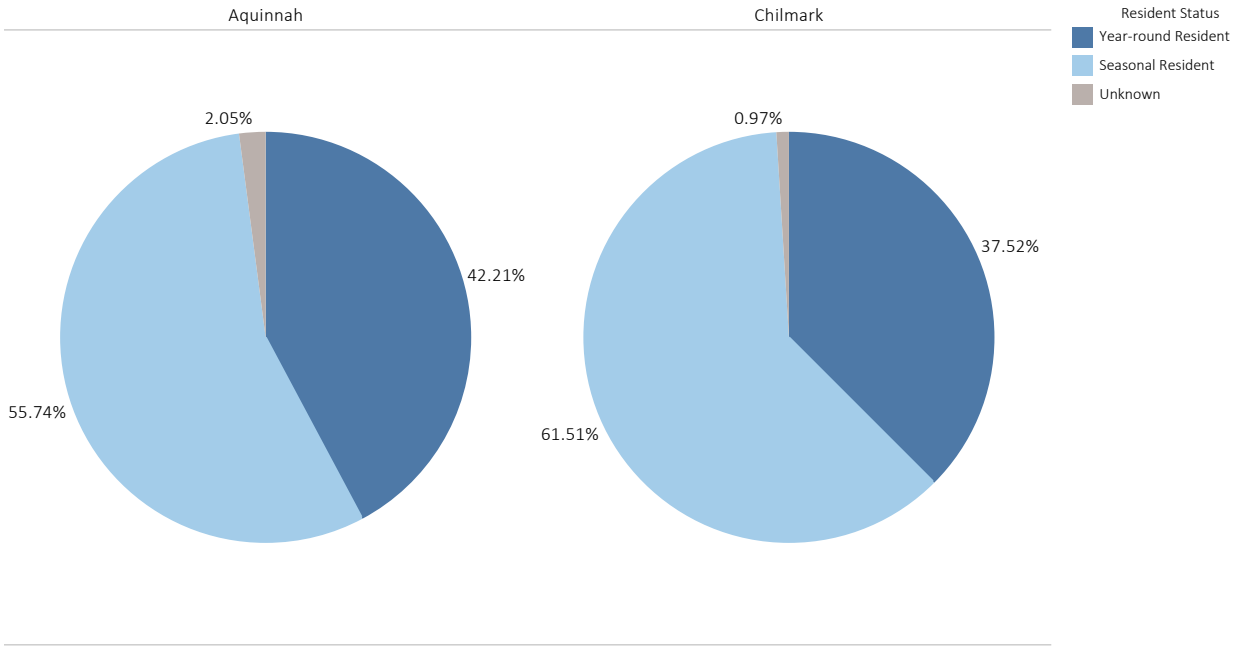

Figure 20. Housing and Residency Status (2021)

Population and housing

Both towns in the Squibnocket Pond watershed have experienced large population increases since the 1950s (Table 7). Data reported here is not limited to populations within the Squibnocket watershed alone, instead, this information reflects *town-wide* population statistics. Aquinnah's estimated year-round population increased from 88 people in 1950 to 439 people in 2020. Chilmark's estimated year-round population increased from 183 people in 1950 to 1,212 people in 2020. Due to a large seasonal population, Aquinnah and Chilmark populations increase by approximately 1,500 and 5,000 residents, respectively, each summer according to 2020 US Census data [55].

As is true for many other communities with seasonal populations, it is estimated that 56% of the parcels in Aquinnah and 62% of the parcels in Chilmark are seasonal homes (Figure 20)[56].

Increased population, both year-round and seasonal, contributes to water quality stressors, along with the associated nutrient inputs from onsite wastewater systems and changes in land use from previously undeveloped land.

Land use and development

As noted above, "Land Cover" refers to physical features and landscaping patterns/characteristics that exist in a particular area. For example, Land Cover can refer to the type of vegetation that exists in the watershed area (forests, pastures, wetlands etc.). "Land Use" refers to how the land is managed or used. Following this example, forested areas tend not to have large residential or commercial structures, agriculture land references pasture that feed animals, and wetlands, like forests, are unlikely to be used for residential or commercial purposes.

In this section of the report, we limit our discussion to "Land Use". Changes in land use can cause water quality declines in associated aquatic systems. For example, increased residential areas, impervious surfaces, and cultivated agriculture can contribute to higher nitrogen loading from watersheds to receiving waters.

While historic land use classifications differ from those used in 2021, changes in land use patterns can be seen when comparing 1971, 1985 and 1999 land use maps that are based on aerial photos. For example, in the Squibnocket Pond Watershed, conversion of forest and open space to residential land use areas is evident (Figure 21).

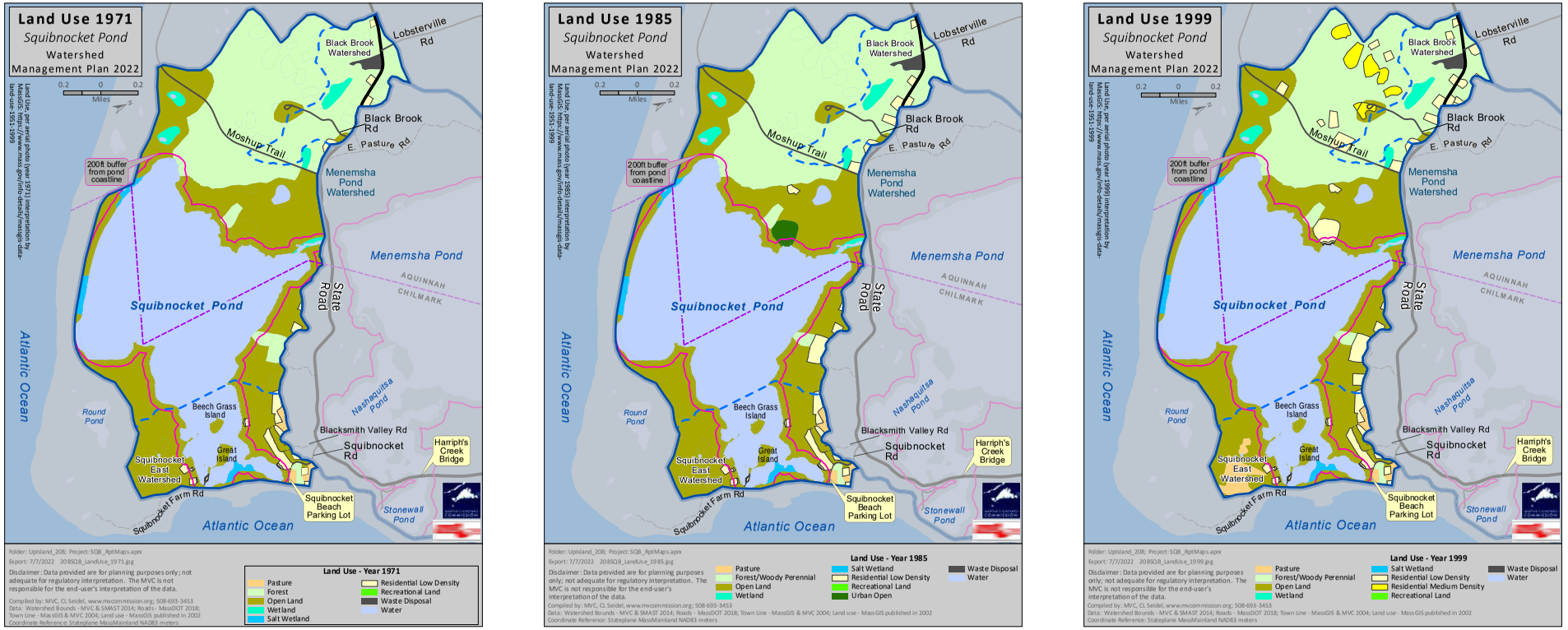

Figure 21. Land Use Map Comparison - 1971, 1985, 1999

The decrease in open space and forest has been roughly proportional to the increases in residential land use. In addition, there were increases in pasture areas between 1985 and 1999, it is unclear if this change in land use reflects new agricultural uses that could present additional water quality stressors[57].

The MVC tracks development over time using year-built data from the towns' assessing records. Figure 22 highlights the growth in the number of buildings since the 1700s.

Increased building development shifts the focus of onsite wastewater systems from merely disposal to how efficiently these systems process nitrogen.

According to MVC data, approximately two thirds (65%) of existing building development has occurred since 1980. A large portion of that development occurred since 1990, although peak structural development happened in the 1980s[58]. These values demonstrate that much of the development in the Squibnocket Pond watershed is relatively recent.

Current (2021) land use data for the Squibnocket Pond Watershed is shown in Figures 23 and 24. Residential and public service both continue to account for one third of the watershed, while undeveloped land remains approximately one fourth of the watershed[59, 60, 61].

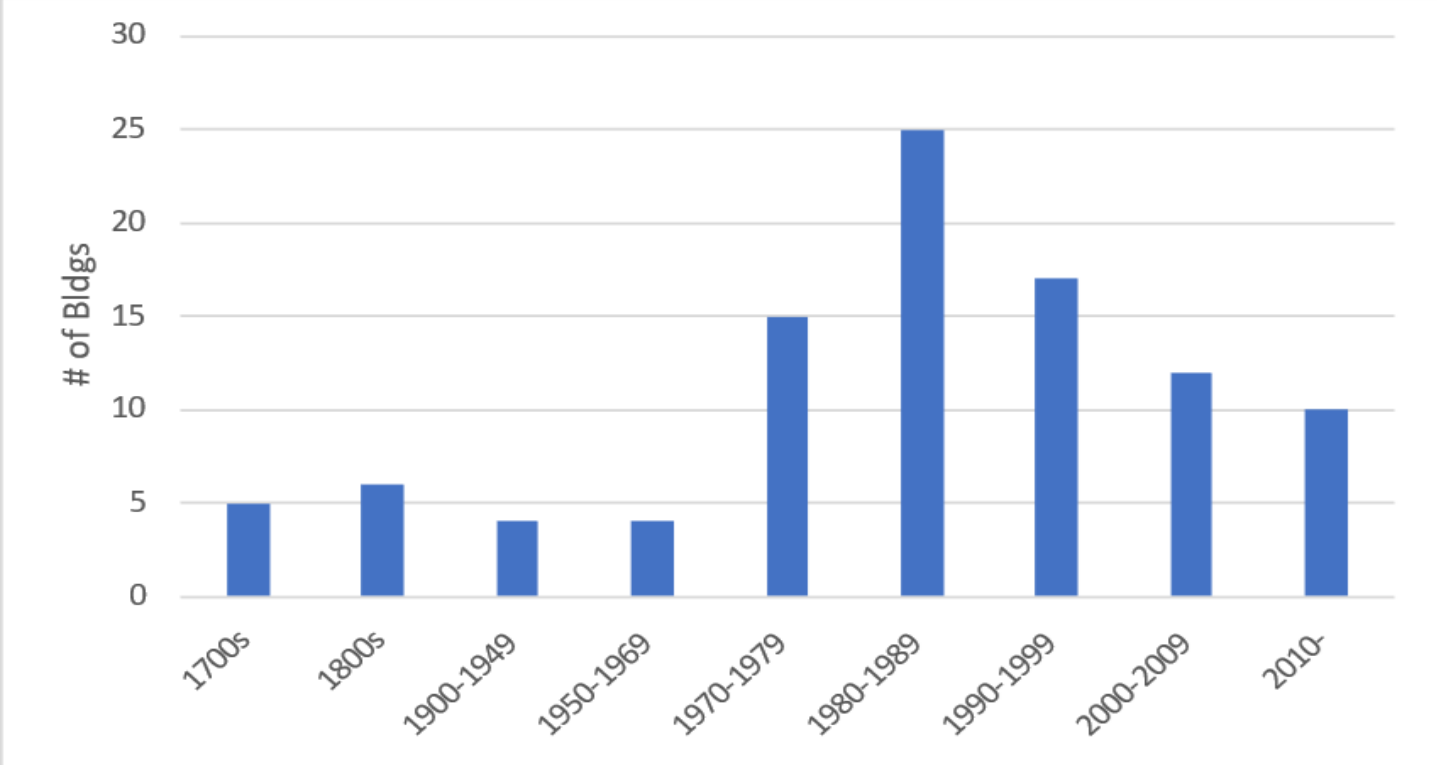

Figure 22. Construction Year of Oldest Building on a Given Parcel In Squibnocket Pond Watershed

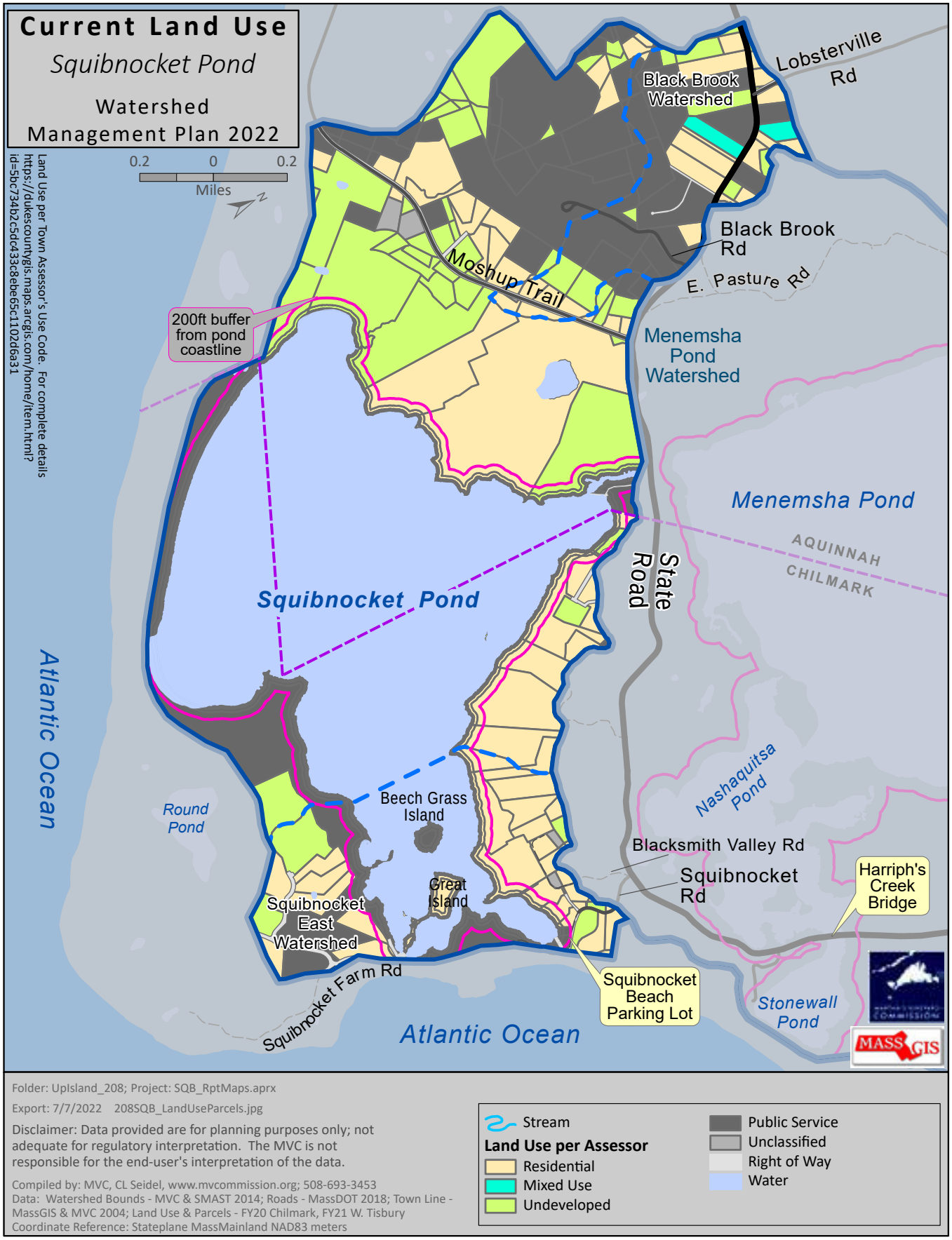

Figure 23. Squibnocket Pond Watershed Land Use Map (2021)

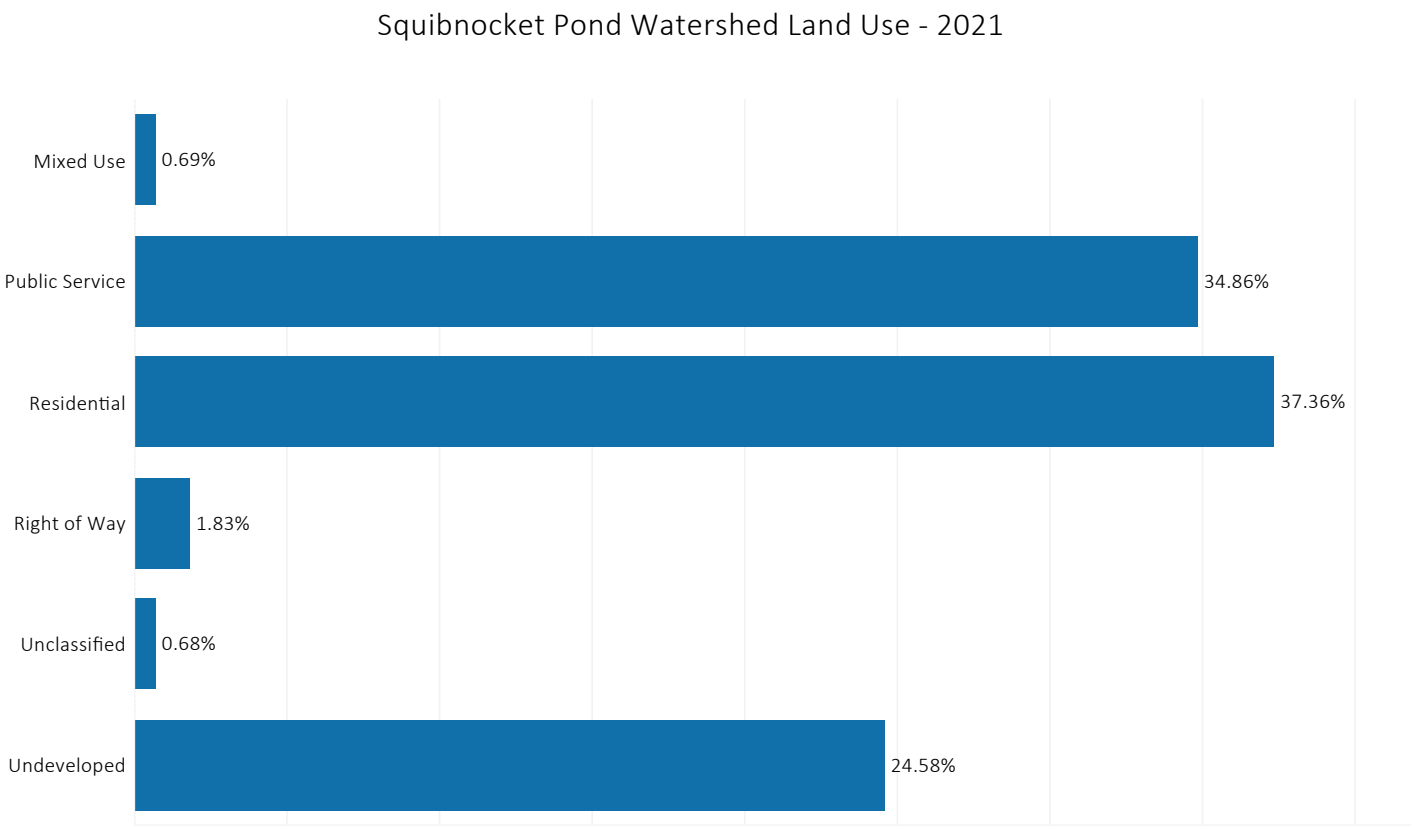

Figure 24. Land Use in Squibnocket Pond Watershed (2021)

Based on the use code assigned by the town assessor, there have been few watershed land use changes since 2017. Less undeveloped land, increased public service and right of way area, and residential land uses are the most prominent changes since the MEP study was completed. When considering the watershed as a whole, undeveloped land area decreased by 17%. Residential land area increased by 2% and Public Service Land area increased by 2%.

At the sub-watershed level, undeveloped land has decreased in all sub-watersheds, with the largest decreases found in Black Brook (-7%) and Squibnocket East (-9%) sub-watersheds. Residential land use has increased in Squibnocket East (8%), which may account for the decrease in undeveloped land in that sub-watershed. Notably, Black Brook and Squibnocket Main saw decreases in residential land use of 3% and 2% respectively. These values may be indicative of ongoing development pressures and land use changes could contribute to the water quality challenges presented earlier (Figure 25).

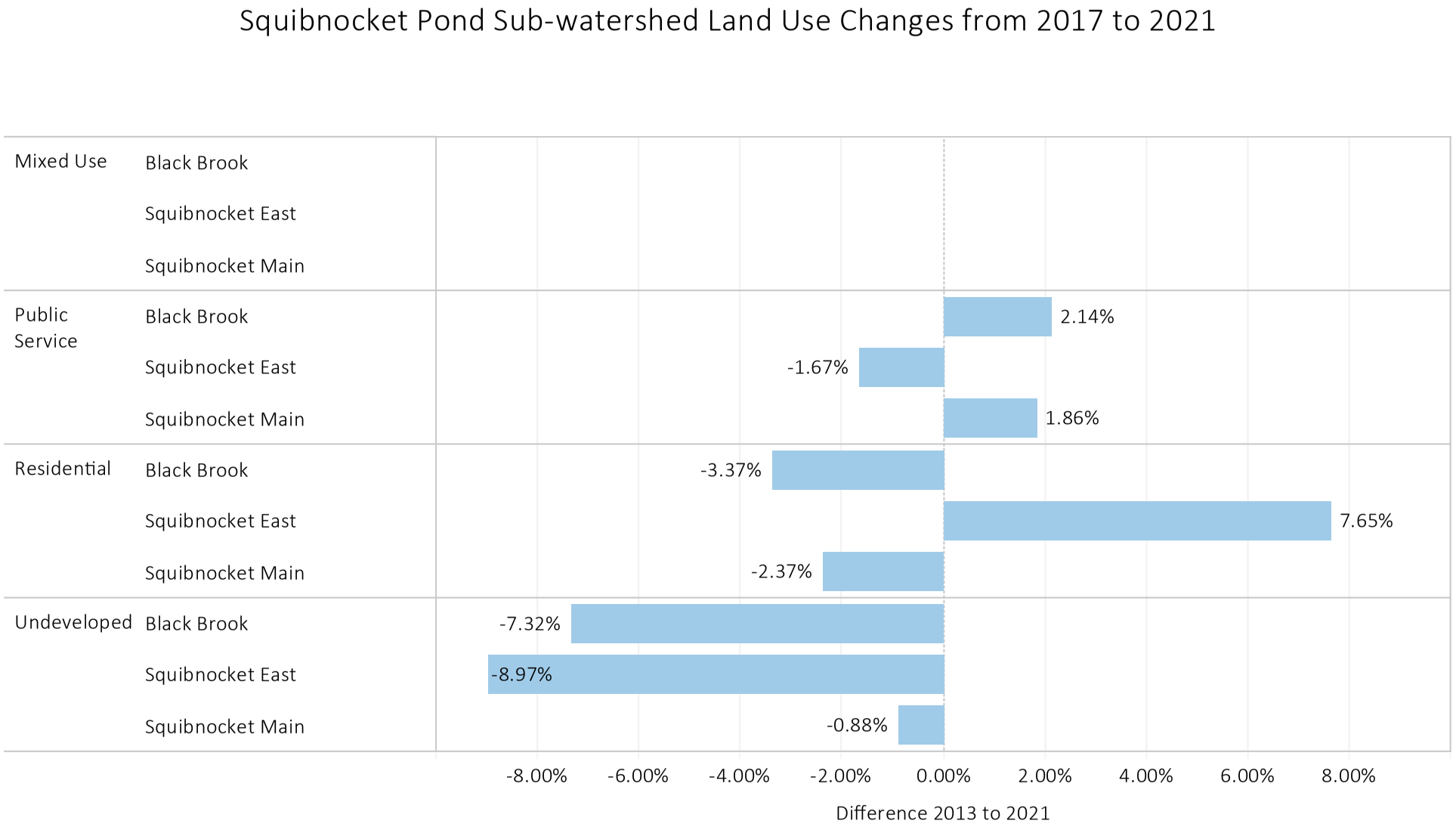

Figure 25. Squibnocket Pond Land Use Changes from 2015 to 2021

Current land use information for each sub-watershed is shown in Figure 26. There are relatively consistent land use patterns, with key distinctions in some sub-watersheds. For example, in Black Brook, public service and right of way are the largest type of land uses. Together, these cover roughly half the Black Brook sub-watershed. In the other two sub-watersheds, Squibnocket East and Squibnocket Main Basin, residential land use accounts for the largest area of usage.

The continued increase in development with additional onsite wastewater systems and loss of forest and open space supports the contention that management actions are needed to prevent increased impairment to Squibnocket Pond.

Unlike surrounding up-island areas, there are no documented agricultural land uses in the Squibnocket Pond watershed. The 2017 MEP report indicated a lack of "noticeable agricultural fields" in the Squibnocket Pond watershed[62]. However, based on the land cover and livestock data in neighboring areas, there are likely small-scale, non-commercial agricultural land uses supporting animal grazing.

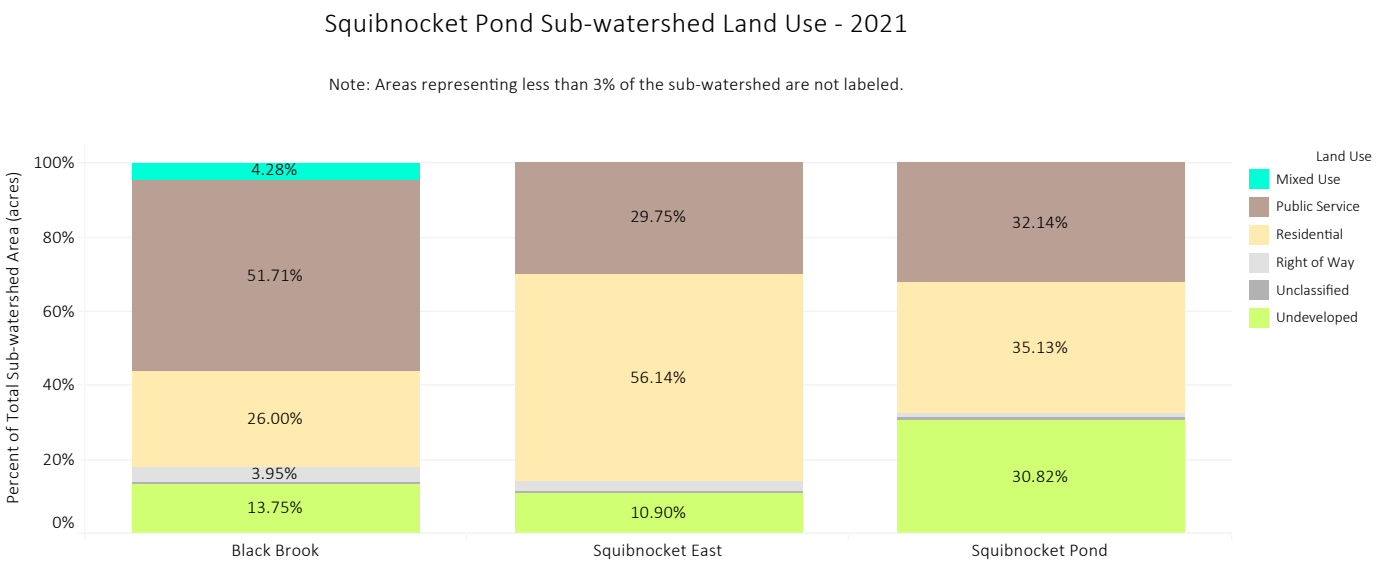

Figure 26. Squibnocket Pond Land Use Categories by Sub-watershed

Wastewater Management Systems

There is no centralized wastewater treatment facility in the watershed or decentralized package plants in the towns of Aquinnah or Chilmark[63]. The Aquinnah Tribal Housing Authority operates a wastewater treatment facility on Tribal land. Onsite disposal wastewater systems (OSDS) are a likely source of nitrogen loading to Squibnocket Pond. It is estimated that there are 25 non-Title V systems built before 1978, 36 Title V septic systems built after 1978, and one innovative alternative system in the watershed[64]. These systems are divided evenly across the sub-watersheds, with 17 OSDS in the Black Brook sub-watershed, 21 in Squibnocket East, and 24 in Squibnocket Pond main. The majority of the non-Title V systems (14 out of 25) are in the Squibnocket East sub-watershed. Given the size (see Table 1) of the sub-watersheds, residential development and OSDS systems are at a higher density in the smaller Black Brook and Squibnocket East sub-watersheds, than the larger Main Basin sub-watershed (see below).

Approximately 95% of all wastewater treatment systems are located greater than 200 feet from the pond. Development within 100 feet of the pond edge is closely monitored and regulated to ensure development does not occur immediately adjacent to the pond. There are three on-site wastewater systems located within 200 feet of the pond's edge, all of which are in the Squibnocket East sub-watershed and two of which are non-Title V systems[65] (Figure 27).

Squibnocket Pond: Ollie Becker, June 2021

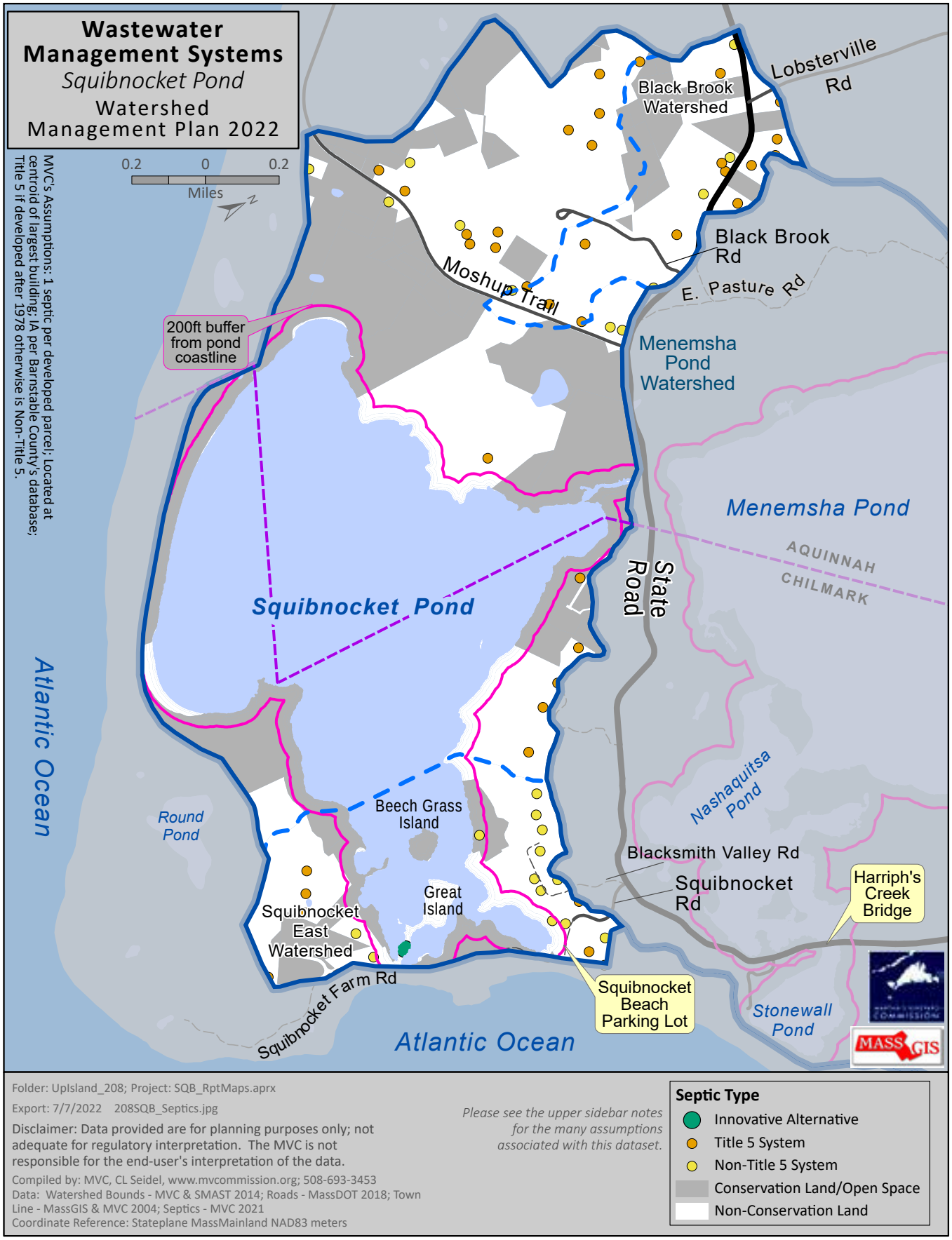

Figure 27. Wastewater Management Systems in Squibnocket Pond Map

Given the nitrogen load reduction targets, opportunities to improve wastewater management exist in the Squibnocket East sub-watershed with its large number of non-Title V systems. While OSDS closest to the pond edge may present the greatest opportunities for immediate impact, given the nitrogen leaching potential of watershed soils, replacement of any low performance OSDS with enhanced nitrogen removal systems would be beneficial.

Septic loads documented in the MEP (kg/year), as well as the target thresholds are noted in Table 8.

Sub-embayment	Present Load (kg/year)	Threshold Load (kg/year)	Threshold % Change
Black Brook	117.5	120.5	3%
Squibnocket East	182.5	182.5	0%
Squibnocket West	456.3	295.7	-35%
System Total	**756.2**	**598.6**	**-21%**

*Comparison of sub-embayment watershed **septic** loads (attenuated) used for modeling of present and threshold loading scenarios of the Squibnocket System. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux, runoff, or fertilizer loading terms.

** Information published in Table VIII-2 (Page 174) of the Squibnocket Pond Embayment System Massachusetts Estuaries Project Report (2017).

Table 8. Squibnocket Pond Total SEPTIC Nitrogen Load Reductions Required to Achieve Nitrogen Threshold (TMDL)

Stormwater Management

There is no formal inventory of public or private stormwater infrastructure in the watershed at this time; this makes an evaluation of the effectiveness of stormwater management difficult.

Neither Aquinnah nor Chilmark are considered "urbanized areas" under the 2010 U.S. Census, so neither town is covered under the Massachusetts Municipal Separate Storm Sewer System (MS4) permit. However, both towns are subject to the Massachusetts Stormwater Standards. The Town of Chilmark cleans and maintains the infrastructure on Chilmark town roads annually. The Massachusetts Department of Transportation (MassDOT) conducts similar maintenance on State Road, which is under MassDOT authority, and portions of which are in the Squibnocket Pond watershed[66].

The Wampanoag Tribe has developed and implemented non-point source best practices management, maintenance, and monitoring plans for the pond. These management plans highlight that Squibnocket Pond is particularly susceptible to nitrogen pollution and other non-point source pollution issues, especially due to its lack of tidal exchange[67].

Limited areas of impervious cover in the watershed lead to the conclusion that wastewater systems negatively impact water quality more than stormwater in the Squibnocket Pond Watershed. However, as indicated in the Wampanoag Tribe's non-point source pollution management plans, there are water quality concerns in Up-Island watersheds related to stormwater and non-point source runoff, including those from "urban areas and roadways, OSDS, construction activities, shoreline and riparian area modifications, marinas and boating, and aquaculture"[68]. An additional assessment of existing stormwater management and retrofit potential will be needed to target specific stormwater related improvements.

Older onsite disposal systems may present the greatest opportunities for immediate impact, especially the large number in Squibnocket East sub-watershed.

Buildout

Approximately 16% of the watershed is available for development, with another 13% considered potentially available for development [69]. As seen in the Development Status Map (Figure 28), just under half (49%) of the entire watershed area is currently conserved. A complete breakdown of watershed and sub-watershed land development status is shown in Figures 29 and 30.

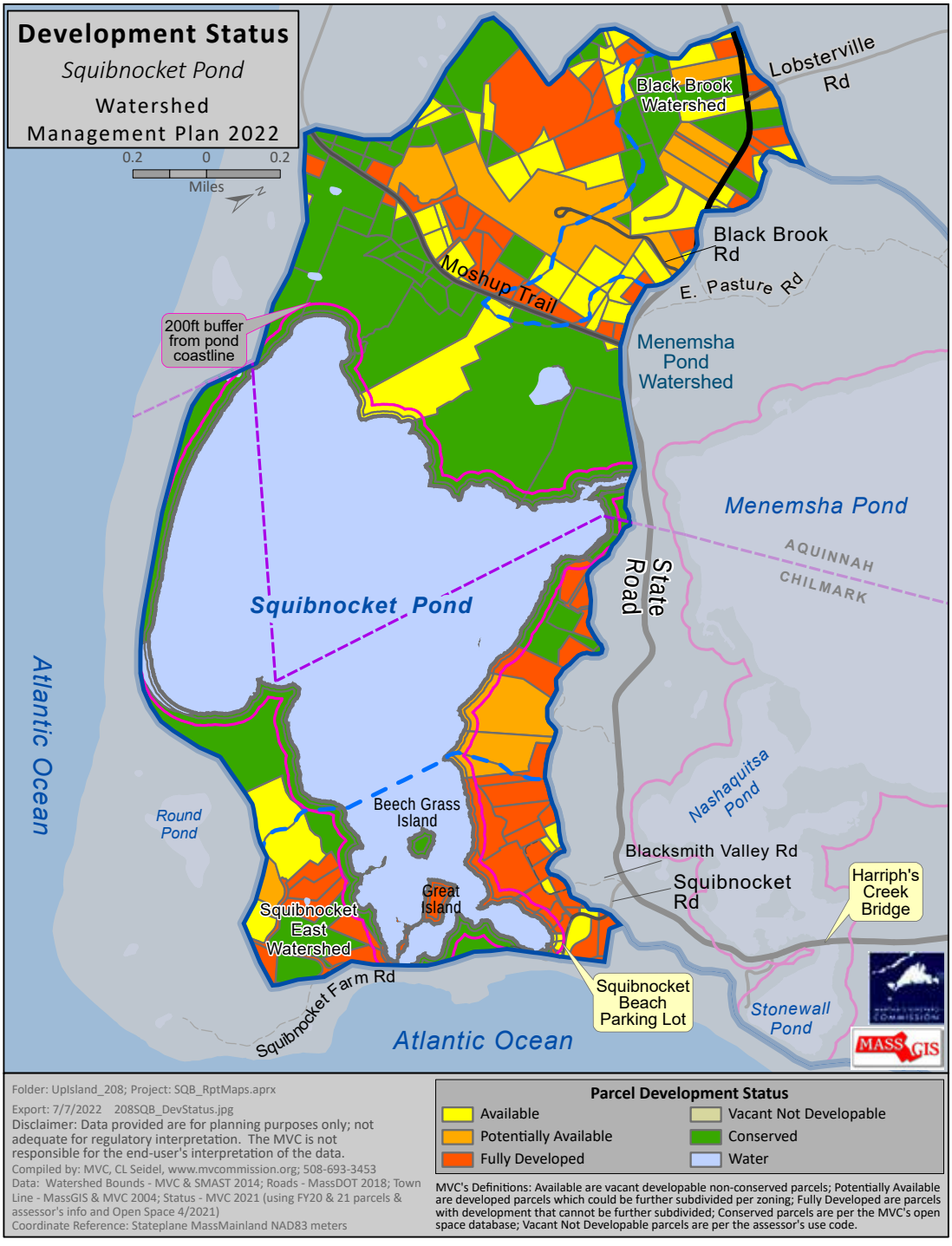

Figure 28. Squibnocket Pond Development Status Map

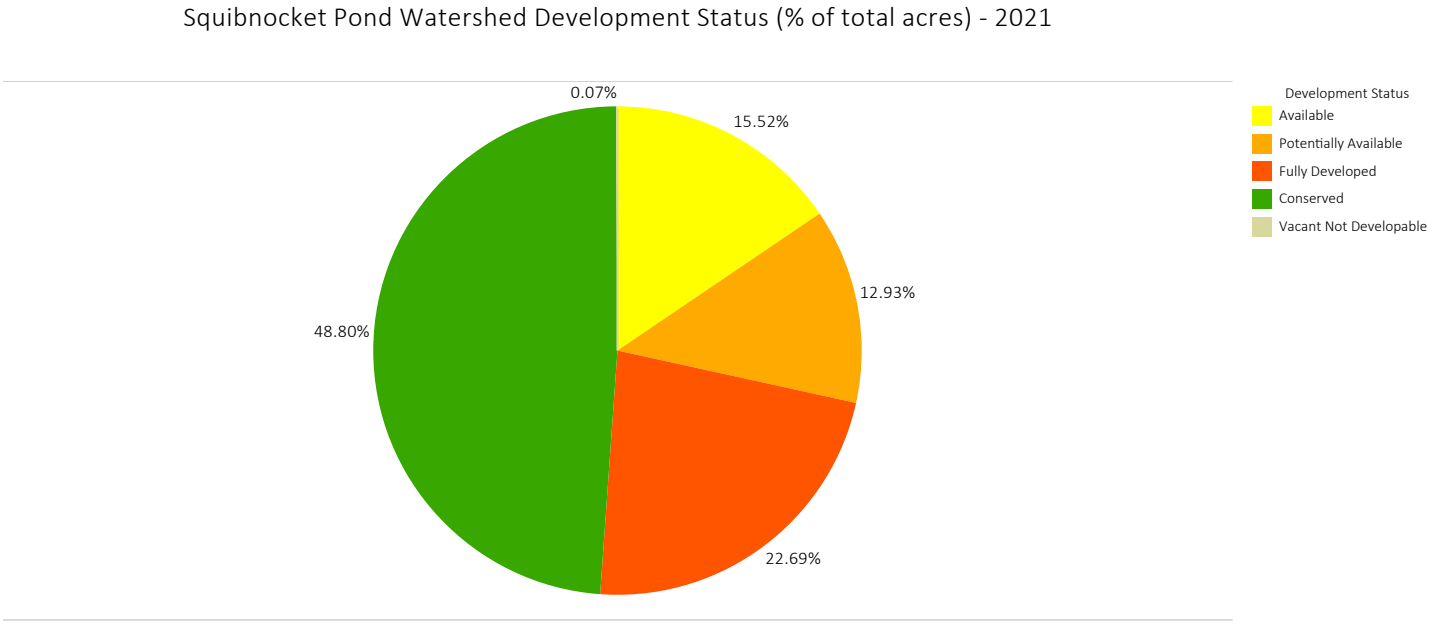

Figure 29. Squibnocket Pond Watershed Development Status/Land Availability

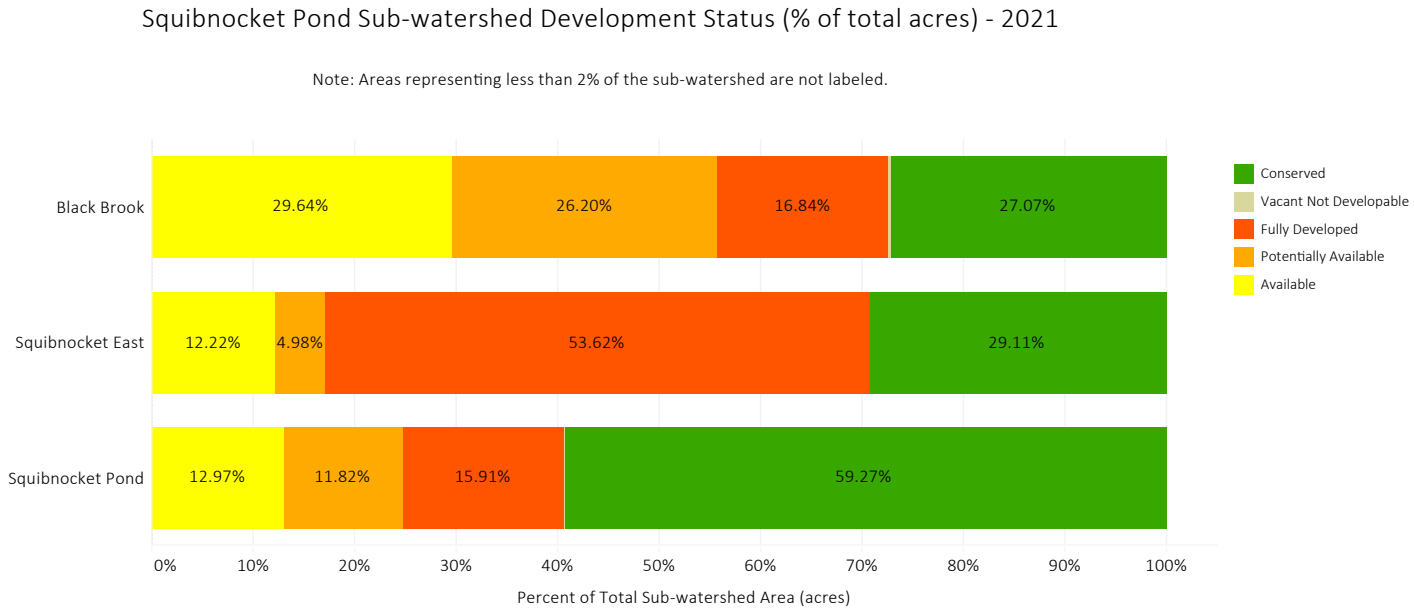

Figure 30. Development Status/Land Availability for Squibnocket Pond Sub-watersheds

At the sub-watershed level, these numbers vary. In particular, more than half (59%) of the Squibnocket Pond Main Basin sub-watershed is conserved, but less than 30% of the Squibnocket East and Black Brook sub-watersheds are conserved (29% and 27% respectively). Similarly, while more than half (53%) of Squibnocket East sub-watershed is developed, less than 20% of Black Brook and Squibnocket Pond Main Basin sub-watersheds are developed (16% and 17% respectively). In the Black Brook sub-watershed, over half of the sub-watershed is either available or potentially available for development.

Such development opportunities and associated development pressures have the potential to present further water quality issues in those sub-watersheds. In addition, high levels of conserved land in the Squibnocket Pond Main Basin provide water quality protection benefits. Increasing land conservation in Black Brook and Squibnocket East sub-watersheds could be a management option to help minimize future impacts.

According to current regulatory guidelines (e.g., zoning), the maximum number of structures allowable within the Squibnocket watershed is 252[70]. Of these, 124 (49%) have been built

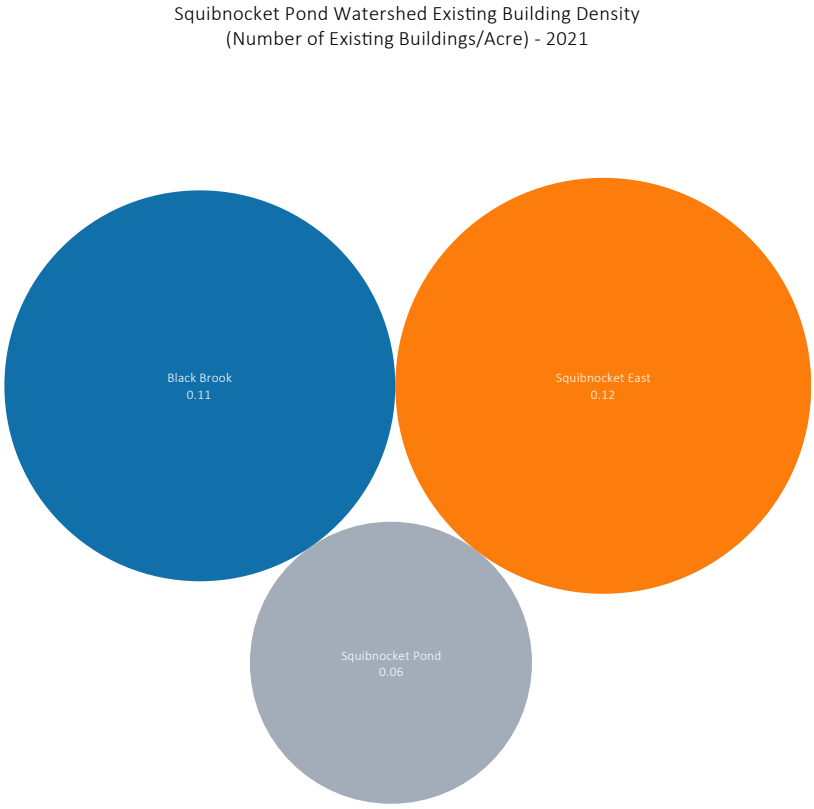

Figure 31. Existing Building Density (# Existing Buildings/Acres)

and another 128 could be built in the future. In both Black Brook and Squibnocket Pond Main Basin sub-watersheds, less than half of the projected potential buildings are currently built. The 26 structures that exist within the Squibnocket Pond Reserve area will not be developed in the future[71]. However, in other areas, potential development pressure could impact future water quality in the watershed.

The average building density for the entire Squibnocket watershed is 0.07 buildings for each acre of land. As shown in Figure 31, structure density within each sub-watershed varies, ranging from 0.06 in Squibnocket Pond Main Basin to 0.11 in Black Brook and 0.12 in Squibnocket Pond East. These densities further highlight the water quality pressures from denser residential development in Black Brook and Squibnocket Pond East sub-watersheds.

All development within the watershed, regardless of proximity to water surface areas, directly impacts water quality in the pond. Development closer to the pond edge has short term impacts, while development on parcels farther away from the pond edge will impact water well into the future as nitrogen makes its way to the pond. One way to illustrate the impact of development proximity as it relates to water quality in the pond is to consider the rate at which groundwater is transported through the watershed and into the pond. A general rule of thumb is that groundwater (and pollutants/nutrients in groundwater) travel approximately four hundred feet per year. Therefore, nutrients in the groundwater of a house built four hundred feet from the pond edge would take one year to reach the pond. The groundwater/nutrient load from a home that was built 2000 feet from the pond edge would begin to enter the pond and impact water quality five years from the date it was built.

Currently there are three structures within 200 feet of the shore of the pond, with an additional six that could be built in the future. A summary of existing and potential structures, along with their proximity to the pond according to sub-watershed is found in Figure 32.

Other Uses

No golf courses or active commercial cranberry bogs were present in the watershed as of 2017. Neither the towns of Aquinnah nor Chilmark have active landfills in the watershed. The unlined landfill managed by the town of Aquinnah in the past was located within the Squibnocket watershed, however, this landfill was capped in 2017[72].

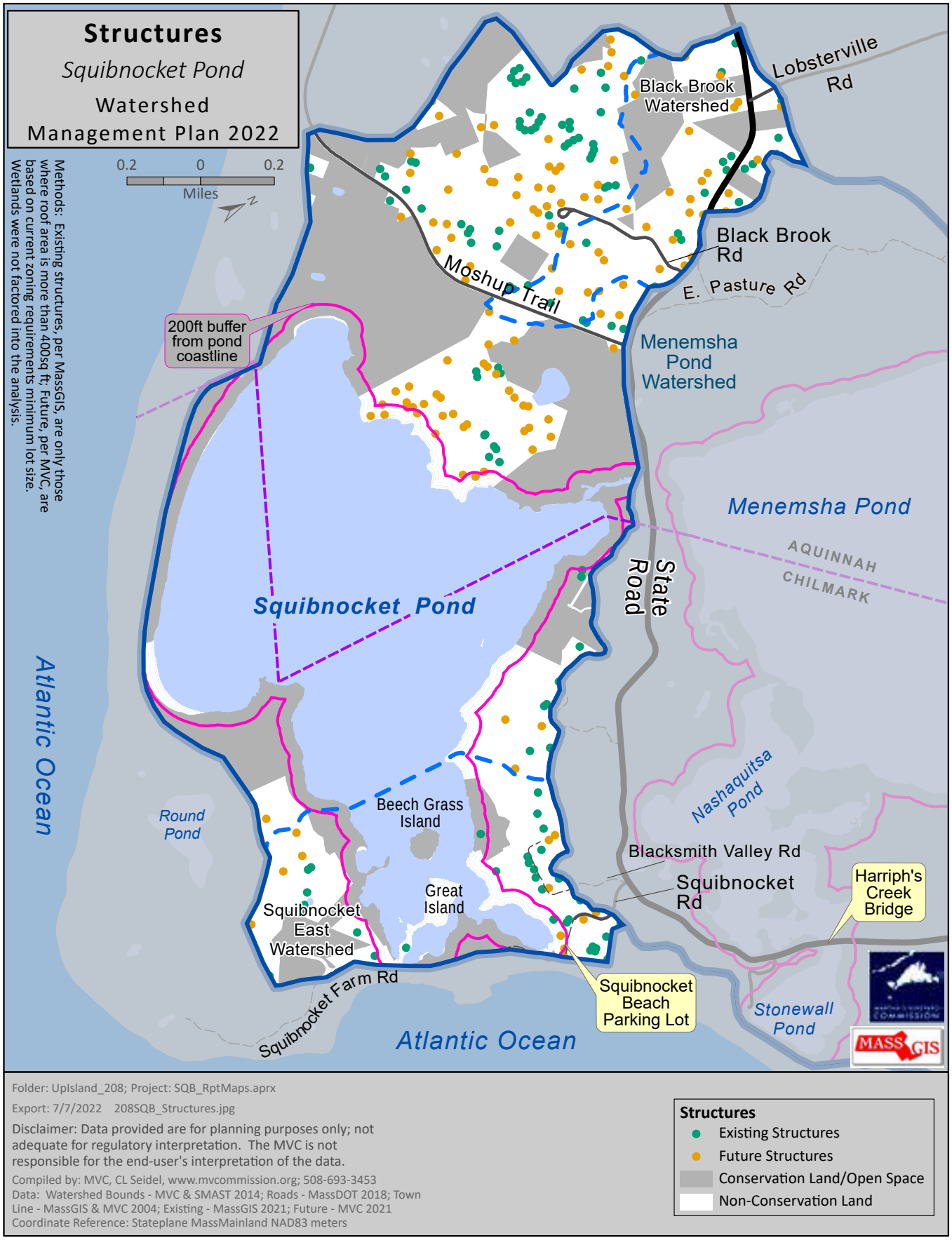

Figure 32. Existing and Potential Structures in Squibnocket Pond Watershed

Livestock

As indicated by the land cover and land use data, there is minimal agricultural land use in the Squibnocket Pond watershed. According to Chilmark surveys, there are currently 15 sheep present in the watershed and no other livestock[73] (Table 9). Livestock are most likely concentrated in the Squibnocket East sub-watershed, in which 7% of the land cover area is pasture/hay. While the small number of animals present in the watershed is not considered a source of water quality impact, there may be opportunities for improved operational management strategies.

	Cattle	Equines	Pigs	Sheep	Goats	Poultry	Total
2017 MEP Survey	0	0	0	0	0	0	0
2021 Town Survey	0	0	0	15	0	0	15
Percent Change	0%	0%	0%	100%	0%	0%	0%
Nitrogen Load Change (kg/year)	**0**	**0**	**0**	**43.8**	**0**	**0**	**0**

Table 9. Animal Count (2017 &2021) for the Squibnocket Pond Watershed

Squibnocket Pond, Great Island on the Right, Squibnocket Beach in Upper Left Corner
Ollie Becker, June 2021

Land Conservation

Land conservation areas protect water quality by lowering future nitrogen loading and by holding and filtering water and associated pollutants before they reach downstream waterbodies. In general, predominantly forested watersheds with limited developed or cultivated land alterations tend to have better water quality due to very low nutrient output from these areas when compared to developed land. Protecting additional acres of undeveloped land can be an effective management strategy to prevent further degradation of water quality. A map of all conserved open space is found in Figure 33.

Approximately 494 acres (29%) of the Squibnocket Pond Watershed open space is conserved with a clearly defined legal restriction protecting the land. Levels of protection (e.g., in perpetuity, limited/temporary, or unknown) can include agricultural, conservation, or easement restrictions (Figure 34).

Almost all conserved open space in the Squibnocket Pond Watershed is preserved in perpetuity (94%, 466 acres) and excluded from future development through legal restrictions[74]. These conservation areas include Toad Rock Preserve and trails off of Towhee Lane that are managed by the Martha's Vineyard Land Bank Commission and Sheriff's Meadow Foundation. These two organizations also own additional conservation land around the pond that is not publicly accessible[75]. In addition, in 2020 the two organizations collaborated on an agreement and transaction to conserve an additional 334 acres for the future Squibnocket Pond Reservation, which includes diverse habitat areas, trails, and a kayak landing[76]. The Town of Chilmark manages Squibnocket Beach, south of the pond[77]. From a watershed management perspective, conservation of undeveloped land or developable areas could represent an opportunity to "lock in" benefits associated with conservation land, especially in Core Habitat areas.

Approximately 16% of the watershed is available for development, with another 13% considered potentially available for development…. In the Black Brook sub-watershed, over half of the sub-watershed is either available or potentially available for development."

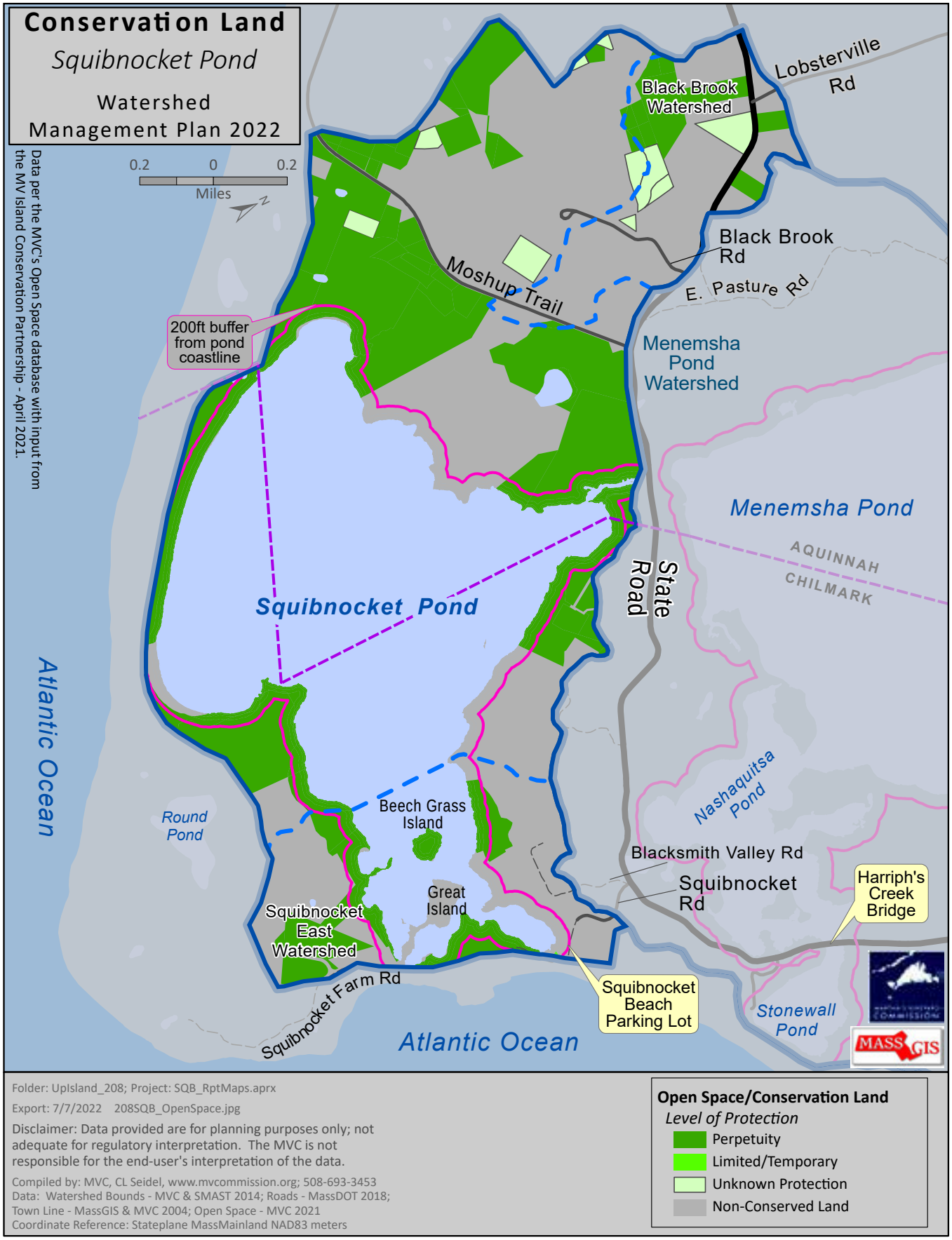

Figure 33. Squibnocket Pond Watershed Conservation Land Map

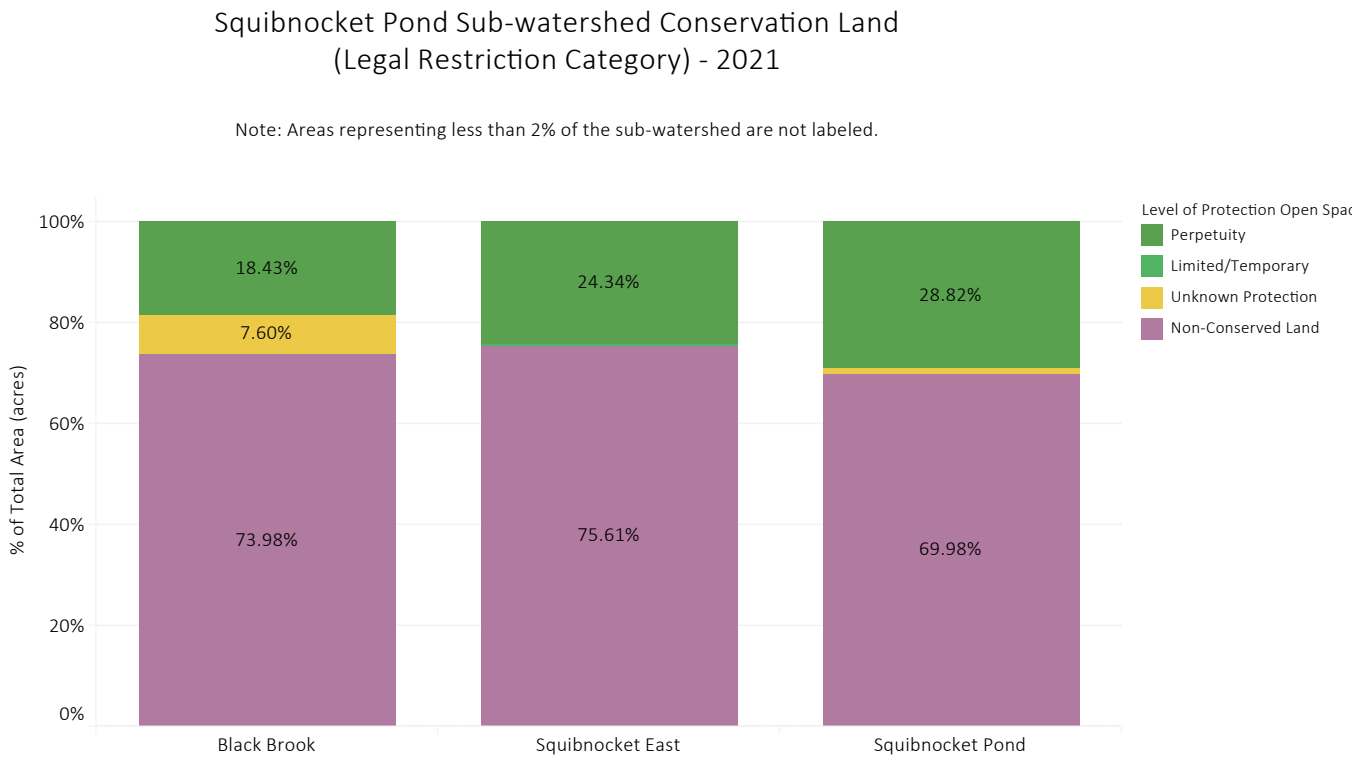

Figure 34. Legal Restrictions for Conservation Land in Squibnocket Watershed

Pond Uses

Squibnocket Pond and surrounding areas are a valuable recreational, cultural, and economic resource, especially for members of the Wampanoag Tribe. Maintaining water quality is crucial for these uses. Pond uses include recreational boating, swimming, fin fishing, and shell fishing. There are no mooring areas or marinas in the pond, however, a public kayak launch, in addition to an existing public launch area, is proposed for the aforementioned Squibnocket Pond Reservation. There are also a limited number of private docks and boat access points.

Shellfish Management Initiatives

As described earlier, areas of Squibnocket Pond are suitable for eastern (i.e., American) oysters, ribbed mussels, and bay scallops. According to the Massachusetts Division of Marine Fisheries (DMF), shell fishing is approved in Squibnocket Pond main basin, but prohibited in Squibnocket East due to bacteria most likely from wildlife[78] (Figure 35). Shell fishing is also prohibited in small areas of Squibnocket Pond south of Hillman Point on the southern end of the pond and where the Black Brook and Black Pond tributaries enter the pond on the northern end of the

area. As documented in a bay scallop management plan by the Wampanoag Tribe, the broader Menemsha Pond system includes important areas for shellfish harvesting, especially the bay scallop. However, within the Squibnocket Pond basin, shellfish may not thrive to the extent that they are available for larger scale harvesting.[79]

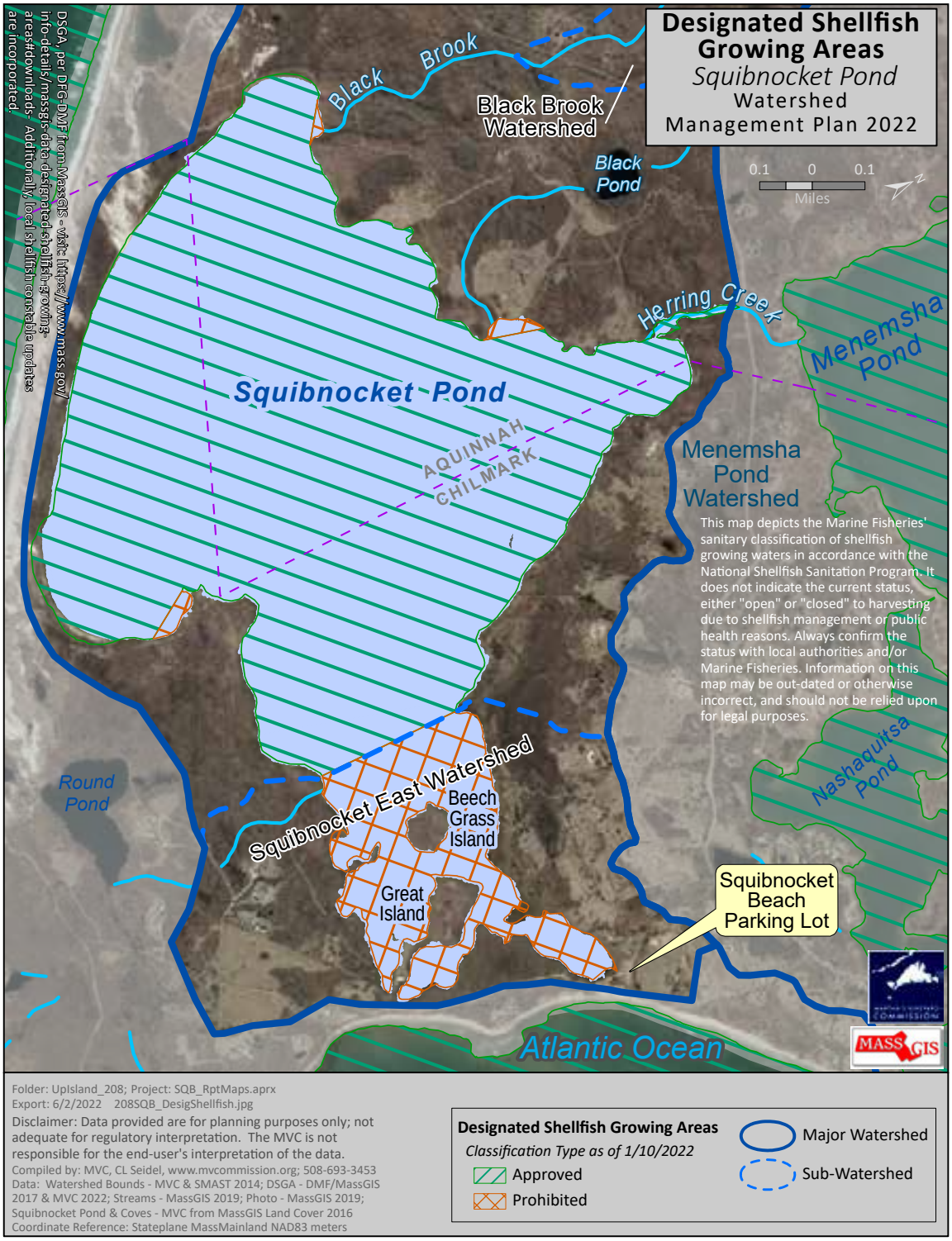

Figure 35. Squibnocket Pond Designated Shellfish Harvest Area

Local Regulations

Areas of the Squibnocket Pond watershed (and broader Menemsha-Squibnocket Pond Embayment) fall under the jurisdiction of the Towns of Aquinnah, Chilmark and the Wampanoag Tribe. Efforts to coordinate and collaborate across jurisdictions on environmental protection are common, especially as related to water quality and shellfish initiatives[80].

Aquinnah and Chilmark have Conservation Commissions that implement the MA Wetlands Protection Act, Planning Boards that oversee development under their jurisdictions, Boards of Health that regulate wastewater systems, and other relevant town bodies that influence pond management and water quality. Conservation Commission authority includes wetland resource areas and associated buffer zones, as defined by the Wetlands Protection Act and the town's bylaws and regulations. These regulations shape the form, density, and location of development, with implications for water quality.

Almost all of the watershed in Aquinnah is zoned as Rural Residential, with a small area between Squibnocket Pond and Menemsha Pond zoned as Marine Commercial. Both of these zoning districts have minimum lot sizes of two acres, with Rural Residential zone's only permitted use for detached single family residences, and "Marine Commercial" zones only permitted use for boat servicing, storage, and repair (no residential)[81]. Aquinnah also has a number of overlay and special districts that overlap with the Squibnocket Pond watershed:

- Coastal District Overlay includes restrictions for development within 100 and 200 feet of wetlands, waterbodies, beaches, dunes, and bluff crests.
- Coastal Areas zoning restricts certain development within 500 feet of the mean high-water mark of the ocean or major pond.
- Flood Plain Zone restricts development in flood-prone areas.
- The Moshup Trail Cultural and Historic District of Critical Planning Concern includes design standards.
- The Island Roads District – Major Roads District limits development immediately around certain roads.

In addition, Aquinnah's zoning includes various protections for special places, historic and archaeological sites[82].

The Squibnocket Pond watershed areas in Chilmark are all zoned as Agricultural-Residential District VI, which has one-family dwelling, farm, barn, or silo, riding stable, or nursery uses permitted on minimum lot sizes of three acres[83]. Chilmark also has a Coastal District Special Overlay District in its Zoning Bylaw that includes areas around Squibnocket Pond and prohibits most development in the "Shore Zone"[84]; development

is restricted in the "Inland Zone"[85], [86]. There is a special Squibnocket Pond District, with additional review, restrictions, and protections for the pond in four zones surrounding the pond, with stricter provisions as one moves closer to the pond shoreline. A Pond Advisory Committee provides additional oversight[87]. These regulations are intended to protect the areas immediately adjacent to the pond and reduce direct surface discharges to pondwaters. Of note, Aquinnah does not have a special district for the pond, but MVC and the MEP have recommended one[88].

Above all, Aquinnah and Chilmark's zoning is generally intended to limit development density and maintain the rural character of the area.

Fertilizer can be a source of nitrogen to Squibnocket waterbodies, so by controlling fertilizer use, both towns contribute to the protection Squibnocket Pond. The Chilmark Board of Health[89] regulates fertilizer use. Language for this regulation is found in "The Content and Application of Fertilizer for Turf on Martha's Vineyard" policies. This policy articulates best practices and standards related to timing, concentration, location, and processes for fertilizer application to lawns and other turf areas (playing fields, public areas, etc.).

Summary

Squibnocket Pond's socioeconomic conditions reflect a watershed that has large areas of vegetated land, including large areas of conservation land. The pond is also an important cultural, subsistence, and recreational resource. However, existing infrastructure (e.g., decentralized wastewater treatment), population growth and development pressures have the potential to amplify water quality issues.

Efforts to coordinate and collaborate across jurisdictions on environmental protection are common, especially as related to water quality and shellfish initiatives

ENDNOTES

1 Data provided by the Martha's Vineyard Commission, March, 2022.

2 Martha's Vineyard Commission, (2022). Squibnocket Pond. Accessed March 4, 2022 from https://www.mvcommission.org/squibnocket-pond.

3 Howes B.L., E.M. Eichner, R.I. Samimy, H.E. Ruthven, D.R. Schlezinger, J. S. Ramsey, (2017). Linked Watershed-Embayment Model to Determine the Critical Nitrogen Loading Threshold for the Menemsha-Squibnocket Pond Embayment System, Chilmark/Aquinnah, Massachusetts. SMAST/DEP Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

4 Howes et al., (2017).

5 Data provided by the Martha's Vineyard Commission, March 2022.

6 Howes et al., (2017).

7 Howes et al., (2017).

8 Martha's Vineyard Commission, (2015). Major Watersheds of Martha's Vineyard Map. Accessed March 4, 2022 from https://www.mvcommission.org/document/major-watersheds-marthas-vineyard-map.

9 These boundaries derive from various data sources, including those from MVC, SMAST modeling, and MEP, variation in calculated watershed size.

10 Howes et al., (2017).

11 These categories are provided for areas delineated within 200 feet of the pond edge and beyond 200 feet from the pond edge.

12 Data provided by the Martha's Vineyard Commission March 2022.

13 NOAA, (2021). How to Use Land Cover Data as a Water Quality Indicator. Accessed December 27, 2021 from https://coast.noaa.gov/howto/water-quality.html.

14 Howes et al., (2017).

15 Soil type interpretations are developed by soil scientists within the state of Massachusetts to provide information specific to the state of Massachusetts. "Not Rated" is a group of soil types that didn't fit the criteria to be assigned to a different rating category. In the up-island area, the 'not rated' category appears to be soil types of water and beaches. MVC, July 2022.

16 Data provided by Martha's Vineyard Commission, March 2022.

17 Howes et al., (2017).

18 Howes et al., (2017).

19 Howes et al., (2017).

20 Howes et al., (2017).

21 Howes et al., (2017).

22 Howes et. al, (2017)

23 https://www.mass.gov/regulations/314-CMR-4-the-massachusetts-surface-water-quality-standards

24 https://www.mass.gov/lists/integrated-lists-of-waters-related-reports

25 Wampanoag Tribe of Gay Head (Aquinnah) USEPA 319 Non-point Source Pollution Assessment Report, (2019). Martha's Vineyard Commission, personal communication, 2022.

26 UMass Dartmouth's School for Marine Science & Technology (SMAST), (2017-2021). Data provided by the Martha's Vineyard Commission 2021. Subsequent data summaries compiled by Horsley Witten Group 2021.

27 Howes et. al, (2017).

28 Howes et al., (2017).

29 Howes et. al, (2017).

30 Howes et. al, (2017).

31 Howes et. al, (2017).

32 Martha's Vineyard Commission, (2020). Squibnocket Pond 2020. M.V.C. Sampling Summary. Accessed December 2021 from https://www.mvcommission.org/sites/default/files/docs/squibnocket-202_55349401%20%281%29.pdf.

33 UMass Dartmouth's School for Marine Science & Technology (SMAST), (2017-2021). Data provided by the Martha's Vineyard Commission 2021. Subsequent data summaries compiled by Horsley Witten Group 2021.

34 Howes et. al, (2017).

35 Massachusetts Natural Heritage and Endangered Species Program (NHESP) (https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html) and Howes et al., (2017).

36 http://maps.massgis.state.ma.us/dfg/biomap2.htm. For definitions of these categories, visit the BioMap2 website.

37 http://maps.massgis.state.ma.us/dfg/biomap2.htm. For definitions of these categories, visit the BioMap2 website.

38 https://www.mass.gov/service-details/biomap2-town-reports. See Aquinnah and Chilmark reports.

39 https://www.mass.gov/service-details/biomap2-town-reports. See Aquinnah and Chilmark reports.

40 Howes et al., (2017).

41 DEP (2019).

42 Howes et al., (2017).

43 Howes et al., (2017).

44 Howes et al., (2017).

45 MassMapper, see Shellfish Growing Areas layer: https://maps.massgis.digital.mass.gov/MassMapper/

MassMapper.html.

46 MassMapper, see Shellfish Suitability Areas layer: https://maps.massgis.digital.mass.gov/MassMapper/MassMapper.html.

47 Normandeau Associates, Inc. (2019).

48 Andrews et al., (2017).

49 Howes et al., (2017).

50 Howes et al., (2017).

51 The MassDEP Eelgrass Viewer shows mapping project years from 1995, 2001, 2006/2007, 2010-2013, 2015-2017, and 2019-2022. The viewer is available here: https://mass-eoeea.maps.arcgis.com/apps/webappviewer/index.html?id=07f8d48c714f4f81bec49864ecf252da.

52 Howes et al., (2015).

53 Howes et al., (2017).

54 Wampanoag Tribe of Gay Head (Aquinnah), (2019). USEPA 319 Non-point Source Pollution Assessment Report.

55 U.S. Census Bureau (2019). American Community Survey (ACS) Five-Year Estimates 2015-2019 and U.S. Census Bureau (2020). 2020 Census. Data provided by the Martha's Vineyard Commission 2022.

56 U.S. Census Bureau (2019) and U.S. Census Bureau (2020). Data provided by the Martha's Vineyard Commission 2022.

57 Data provided by the Martha's Vineyard Commission, March 2022. Additional analysis conducted by Horsley Witten Group.

58 Town of Chilmark, (2020), Assessors Databases and MassGIS, (2020), Structures. Data provided by the Martha's Vineyard Commission March 2022.

59 Howes et al., (2017).

60 Town of Aquinnah (2019), Town of Chilmark (2020). Assessors Databases. Data provided by the Martha's Vineyard Commission March 2022.

61 The "Public Service" area is land that is exempt from taxes according to the assigned Assessor's Use Code. MVC, July 2022.

62 Howes et al., (2017).

63 Howes et al., (2017).

64 The septic numbers represent an approximate count of parcels containing a septic system. It is assumed only one septic per parcel. It is assumed that Non-title V septics are parcels that were initially developed prior to 1978; parcels initially developed in 1978 or later are assumed to have a Title V septic. Parcels with Innovative Alternative systems were identified & geolocated based on info provided by the Barnstable County Innovative/Alternative Septic System Tracking Program. The IA data only included info for Active IA systems in Chilmark & West Tisbury as of June 2nd, 2021. The location of non-IA septic systems is approximated and is simply the centroid of the structure with the greatest roof square footage on that particular parcel (data per MassGIS Structure polygons). The initial year built is based on the Assessor's year built data per their detailed building info export. If a parcel didn't have building info in that table, then the MVC consulted the town's Assess Table in their parcel geodatabase or the town's AxisGIS website. For parcels with multiple buildings, the earliest year built was used to classify Non-Title V vs Title V septic. Therefore, if the parcel's initial building was developed in 1965 but a second structure was built in 2000, then the type of septic assigned to that parcel is Non-Title V (since the Title V regulations went into effect in 1978). Finding developed parcels vs vacant parcels was identified by analyzing the MassGIS Structures data along with the Assessor's use code and assessed building value for the parcel. MVC, July 2022.

65 Town of Aquinnah, (2019) and Town of Chilmark, (2020), Assessors Databases and MassGIS, (2020), Structures, with support from Barnstable County. Data provided by the Martha's Vineyard Commission January 2022.

66 Andrews M and E Finn, Wampanoag Tribe of Gay Head (Aquinnah), (2017). Cooperative Resource Management Plan for the Bay Scallop Argopecten irradians in the Menemsha Pond Complex.

67 Andrews and Finn, (2017).

68 Andrews and Finn, (2017).

69 Town of Aquinnah, (2021) and Town of Chilmark, (2020), Assessors Databases and MassGIS, (2020), Structures. Data provided by the Martha's Vineyard Commission March 2022.

70 The future building analysis, performed in the Spring of 2021 by the MVC, incorporated the most currently available parcel boundary, structure, zoning data, and open space/Conservation land available. These data will not reflect the reality of the current moment as there is always a delay between obtaining data, processing, and then dissemination. The future buildout only considers minimum lot size per town zoning. For example, if a nine acre parcel in a three acre minimum zoning area has one existing structure, then the model will determine that 2 future buildings could be developed on this parcel. The analysis does not restrict building on wetlands nor does it incorporate Town Board of Health regulations or special housing association or deed restrictions. The model did restrict future development on land that is protected as conservation land (as of April 2021). This methodology results a maximum future buildout. MVC, July 2022.

71 Email correspondence with Adam Moore, Executive Director of the Sheriff's Meadow Foundation, July 8, 2022.

72 Howes et al., (2017).

73 Martha's Vineyard Commission, (2022). Farm Animal Reports. Data provided by the Martha's Vineyard Commission January 2022.

74 MVC & MV Island Conservation Partnership, (2021). Data provided by the Martha's Vineyard Commission 2022.

75 Martha's Vineyard Land Bank Commission, (2022). Accessed March 8, 2022 from http://www.mvlandbank.com/58toad_rock.shtml and http://www.mvlandbank.com/newfullmap2020.shtml ; Sheriffs Meadow Foundation, (2022). Accessed March 8, 2022 from https://sheriffsmeadow.org/lands/.

76 Sheriffs Meadow Foundation, (2022). Accessed March 8, 2022 from https://sheriffsmeadow.org/squibnocket-pond-reservation/ and https://sheriffsmeadow.org/news-updates/squibnocket-pond-reservation/ .

77 Town of Chilmark, (2022). Accessed March 8, 2022 from https://www.chilmarkma.gov/beach-committee/pages/beach-information

78 Howes et al., (2017).

79 Andrews and Finn, (2107).

80 Andrews and Finn, (2017).

81 Martha's Vineyard Commission, (2007). Aquinnah, MA Zoning. Accessed March 8, 2022 from https://www.mvcommission.org/sites/default/files/docs/aqu_zn_current.pdf. https://dukescountygis.maps.arcgis.com/apps/instant/interactivelegend/index.html?appid=efe97a77a8324945a61f3d8c74d95efb

82 Town of Aquinnah, (2019). Aquinnah Zoning By-Law (Complete Version). Accessed March 8, 2022 from https://www.aquinnah-ma.gov/sites/g/files/vyhlif261/f/uploads/aq_zoning_by-lawsupdated_5-14-19-abridged_11_0.pdf and Town of Aquinnah, (2015). Overlay Zoning of Aquinnah, MA. Accessed March 8, 2022 from https://www.aquinnah-ma.gov/sites/g/files/vyhlif261/f/uploads/overlay_zoning_map_-_aquinnah.pdf.

83 Martha's Vineyard Commission, (2015). Chilmark, MA Zoning. Accessed March 1, 2022 from https://www.mvcommission.org/sites/default/files/docs/chi_zn_current.pdf and Martha's Vineyard Commission (2022). Up-Island Watershed Land Use. Accessed March 1, 2022 from https://www.arcgis.com/apps/mapviewer/index.html?webmap=ab3dcefe9ebe40cbb7902d1de39dcb59.

84 "Shore Zone" includes area "from mean low water to one hundred (100) feet inland of the inland edge of any beach or marsh grasses, and one hundred (100) feet inland of the crest of any bluff exceeding a height of fifteen (15) feet."

85 "Inland Zone" refers to the area other than the Shoe Zone and "below the ten (10) foot elevation above mean sea level, or within five hundred (500) feet of mean high water of a coastal water body exceeding ten (10) acres in size, or the ocean; all of Noman's Island; all land within one hundred (100) feet of streams and wetlands draining into the Coastal Great Ponds"

86 Town of Chilmark, MA, (2019). Town of Chilmark Zoning Bylaws 2019. Accessed March 1, 2022 from https://www.chilmarkma.gov/sites/g/files/vyhlif2951/f/uploads/chilmark_zoning_bylaws_article_11.pdf.

87 Town of Chilmark, (2019).

88 Howes et al., (2017).

89 Town of Chilmark, (2019). Town of Chilmark Board of Health Regulations. Accessed December 27, 2021 from https://www.chilmarkma.gov/sites/g/files/vyhlif2951/f/uploads/boh_regulations_dec_2019.pdf.