NWQI Assessment Report for the Sakonnet River Watershed, Rhode Island

NRCS Rhode Island
RHODE ISLAND

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I. Background and Purpose of the Assessment

This section provides an overview of the National Water Quality Initiative (NWQI) assessment area, identifies the primary water quality resource concerns, and outlines the associated water quality objectives. It also summarizes how the problems can be addressed through Natural Resources Conservation Service (NRCS) technical and financial assistance.

General Overview of Assessment Area

This NWQI assessment focuses on the Sakonnet River watershed in southeastern Rhode Island. The drainage area covers one 12-digit hydrologic unit code (HUC) watershed (12-digit HUC ID: 010900040910). The watershed drains approximately 56 square miles and lies within the broader Narraganset Bay Basin (NRCS 2014). The Sakonnet River is a tidal strait located in the middle of the watershed, which flows for 14 miles between Mount Hope Bay and Rhode Island Sound (New England Water Science Center 2019). The western coastline of the watershed drains eastern portions of Aquidneck Island.

The southern coast of Rhode island, which encompasses the Sakonnet River watershed, supports several coastal lagoons with shallow water that are separated from the open ocean by a natural barrier, creating a protected environment that hosts an assortment of wildlife and recreational activities such as boating, swimming, paddling, tubing, kite surfing, fishing, and birding (Carin 2021). Additionally, the Sakonnet River tidal strait is an important shellfishing area that contributes to the state's $7 million shellfishing industry and supports the economy through tourism and commerce (RIDEM 2013).

The Sakonnet River watershed also contains important water supply sources for the Newport Water System (Newport Water), which supports retail service in Newport, Middletown, and small sections of Portsmouth (RIDEM 2018a). Newport Water draws its raw water supply from a system of nine surface reservoirs, four of which are located in the watershed, including Gardiner Pond, Paradise Pond, Nonquit Pond, and Watson Reservoir. The reservoirs and their associated watersheds are located in Newport, Middletown, Portsmouth, Tiverton, and Little Compton (RIDEM 2018a).

The watershed land area is approximately 40% forested. Agricultural land makes up a little over 20% of the area and is located mainly southeastern and southwestern areas of the watershed. Production is mainly focused on forage (e.g., other hay/non-alfalfa), corn, and pasture. Developed land makes up about 23% of the land area.

Water Quality Degradation Resource Concerns and Impairments

Excessive levels of nutrients and pathogens are the main water quality concerns for several waterbodies in the Sakonnet River watershed. The four water supply reservoirs within the watershed, Nelson Paradise Pond, Gardiner Pond, Nonquit Pond, and Watson Reservoir, are currently listed as impaired due to total organic carbon (TOC) and total phosphorus (TP) exceedances. TP impairments are also reported for Maidford River, Paradise Brook, Borden Brook, Quaket Creek, and tributaries to Nonquit Pond and Watson Reservoir (RIDEM 2022).

In addition, Maidford River is listed for numerous other impairments (lead, turbidity, and a failed benthic macroinvertebrate bioassessment). Shellfishing is also currently prohibited in some parts of the

Sakonnet River tidal straits. Total Maximum Daily Loads (TMDLs) have been developed to address nutrient and pathogen impairments for waterbodies in the watershed (RIDEM 2022).

Constituents of Concern

Water quality concerns are primarily caused by excessive TOC and phosphorus in surface waters, as well as pathogens, such as fecal coliform (FC) and enterococci. Nelson Paradise Pond (RI0007035L-02), Gardiner Pond (RI0007035L-01), Nonquit Pond (RI0007035L-08), and Watson Reservoir (RI0007035L-07) (Newport Water Supply Reservoirs) are impaired due to excessive concentrations of TOC and TP.

Opportunities and Objectives for Meeting Water Quality Goals

The NWQI assessment provided an opportunity for NRCS and partners to take a focused look at water quality concerns within the Sakonnet River watershed. The Agricultural Conservation Planning Framework (ACPF) was applied to identify critical source areas (runoff risk) in agricultural fields and determine priority areas for structural best management practices (BMPs). Existing and potential future water quality loads in the watersheds were estimated using the Spreadsheet Tool for Estimating Pollutant Loads (STEPL). Load reductions were modeled using established conservation practice efficiencies. The efficiencies of combined practices were calculated using STEPL's BMP Calculator. Although STEPL does not model bacteria, it is assumed that conservations practices simulated for nutrient and sediment load reductions would also likely help to reduce bacteria loads from agricultural sources in each drainage area.

The ultimate goal is to meet designated criteria. Class AA designations apply to four Newport Water Supply Reservoirs: Nonquit Pond, Watson Reservoir, Gardiner Pond, and Nelson (Paradise) Pond. To meet this goal, NRCS' focus will be to increase the participation rate and the level of conservation to address water quality concerns within the watershed.

Within the first phase of this effort (2023–2028) NRCS expect to increase participation by 15%. Acreage with conservation treatment (or the level of conservation treatment) is expected to increase by 10%, while the number of conservation practices applied is expected to increase by 15% during the first phase of this effort. Each year of the first phase will include a programmatic review of the data to allow for adjustments for outreach and treatments.

Assessment of NRCS' Ability to Help Partners Reach Watershed Goals

Eastern District Field Office NRCS staff have the capacity and resources to provide effective and timely technical assistance to landowners and operators within the NWQI watersheds. The NRCS staff include the following: District Conservationist, two Soil Conservationists, and access to a Civil Engineer and Civil Engineering Technician. In addition, the field office staff can request assistance from state office technical specialists. Technical assistance will include outreach, conservation planning, design, layout, construction check of practices, and practice evaluation.

The Eastern District Soil and Water (SWCD) staff will assist with outreach and promotion of NWQI efforts in addition to providing Environmental Quality Incentives Program (EQIP) support through agreements with NRCS.

II. Watershed Characterization

This section provides an overview of the Sakonnet River watershed and identifies associated water resource concerns. The background information is useful context for water quality assessment and watershed planning.

Location of Watershed within the Drainage Network

The Sakonnet River watershed (HUC-12 ID: 010900040910), in Newport County, Rhode Island, is the focus of this NWQI assessment. The Sakonnet River is a tidal embayment that flows approximately 11 miles between Mount Hope Bay and Rhode Island Sound (New England Water Science Center 2019). The watershed drains approximately 56 square miles and lies within the broader Narragansett Bay system along the northeast coastline of Aquidneck Island and the Town of Portsmouth, Rhode Island (NRCS 2014; RIDEM 2005). It covers a large proportion of Newport County and includes the towns of Middletown, Portsmouth, and Tiverton. Figure 1 displays the location of the watershed within the State of Rhode Island. Marine waters enter from Rhode Island Sound and freshwater enters through several stream inflows and direct groundwater discharge.

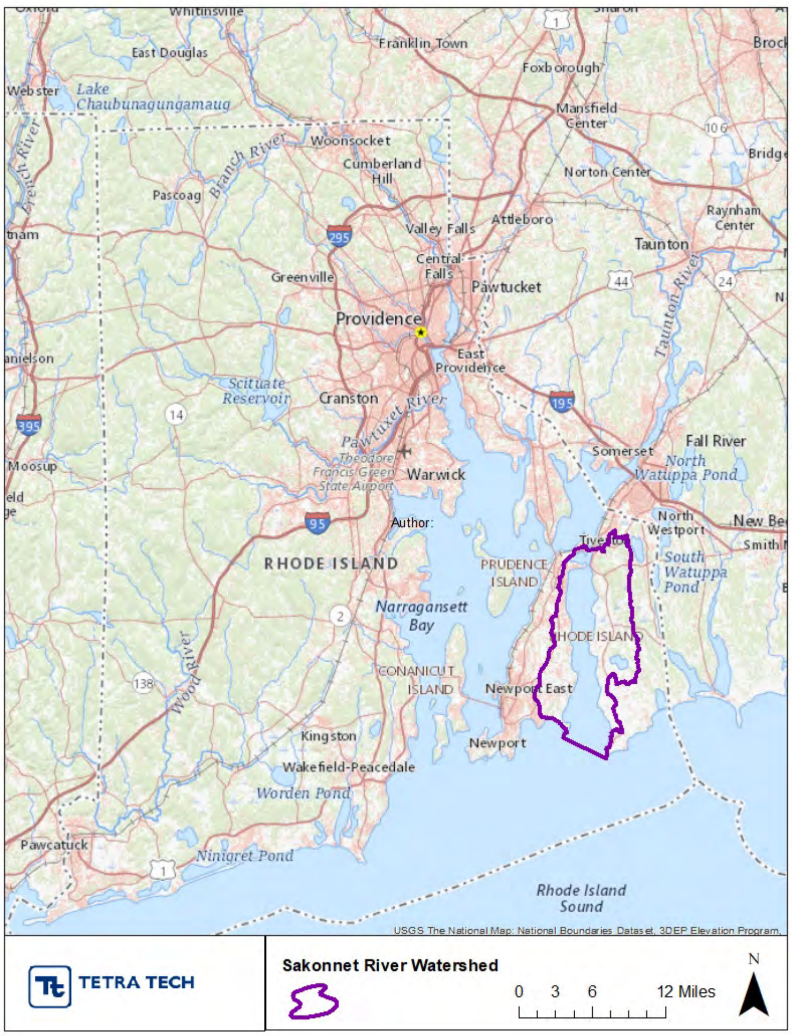

Figure 1. Location of the Sakonnet River watershed within the state of Rhode Island.

Landscape Characteristics

A description of landscape characteristics in terms of both major land resource areas (MLRAs) and ecoregions can help inform watershed management.

Major Land Resource Area

MLRAs are geographic areas characterized by similar soils, climate, water resources, and land uses (NRCS 2006). Rhode Island forms part of MLRA 144A New England and Eastern New York Upland, Southern Part, which covers areas of Connecticut, Rhode Island, and Massachusetts, and makes up about 6% of the total MLRA area (Figure 2). The full area covers about 18,590 square miles, and consists of two sections, an eastern and western part, with the Sakonnet River watershed area located within the eastern part (NRCS 2006). The MLRA 144A is characterized primarily by forested areas, numerous wetlands, small areas of cropland and pasture, and abundant cranberry bogs. The forested areas include oak-hickory and oak-pine, which have coastal influences and are used for wood products, hunting, and other kinds of recreation. Agriculture in the area is dominated by dairy, nursery, and greenhouse stock. Forage crops for dairy cattle, truck crops, small fruits, and apples are grown on some farms, mainly near the larger towns and cities (Griffith et al. 2009).

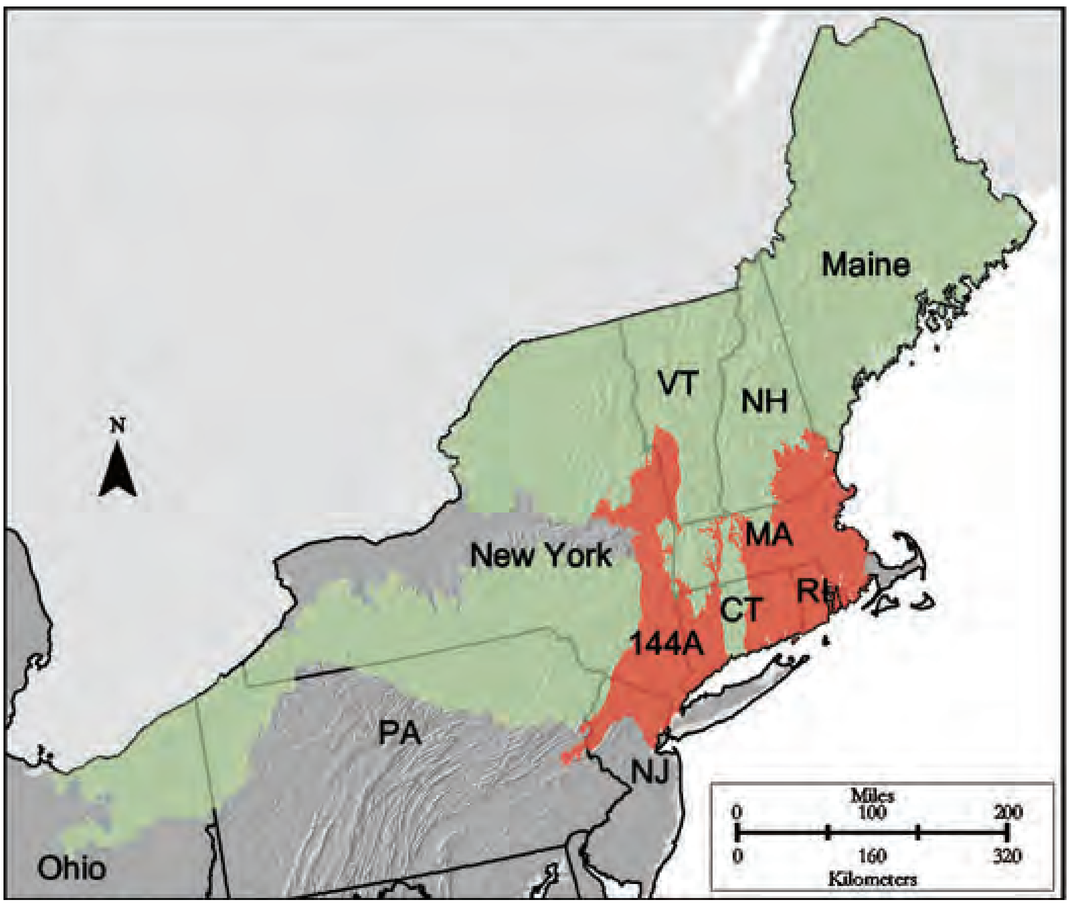

Figure 2. Location of MLRA 144A, with orange shading showing the extent of the MLRA. Green shading indicates North Lakes States Land Resource Region (NRCS 2006).

Ecoregion

Ecoregions are based on abiotic and biotic factors such as climate, geology, vegetation, wildlife, and hydrology. The mapping of ecoregions is therefore beneficial in the management of ecosystems. The Sakonnet River watershed falls within the Narragansett/Bristol Lowland (level IV) and the Northeastern Coastal Zone Ecoregion (level III) (Griffith et al. 2009). A map of the level IV ecoregions found within the state of Rhode Island, together with the Sakonnet River watershed location, is shown in Figure 3.

The Narragansett/Bristol Lowland, where the Sakonnet River watershed is located, is a region in eastern Rhode Island and a portion of Massachusetts east of Rhode Island. The region includes the Narragansett Basin, the Narragansett Bay, and the archipelago in the bay. It extends farther inland east and northeast from the bay. The western and northern boundaries of the ecoregion are tied closely to geology and topography, while the southeastern boundary with Cape Cod coincides more with changes in vegetation and soils. The area is mostly composed of flat to gently rolling irregular plains with most elevations under 200 feet. The vegetation is varied, with some of the oak-hickory and oak-pine forests having coastal influences, and land cover is mostly mixed forest with numerous wetlands and small areas of cropland and pasture (Griffith et al. 2009).

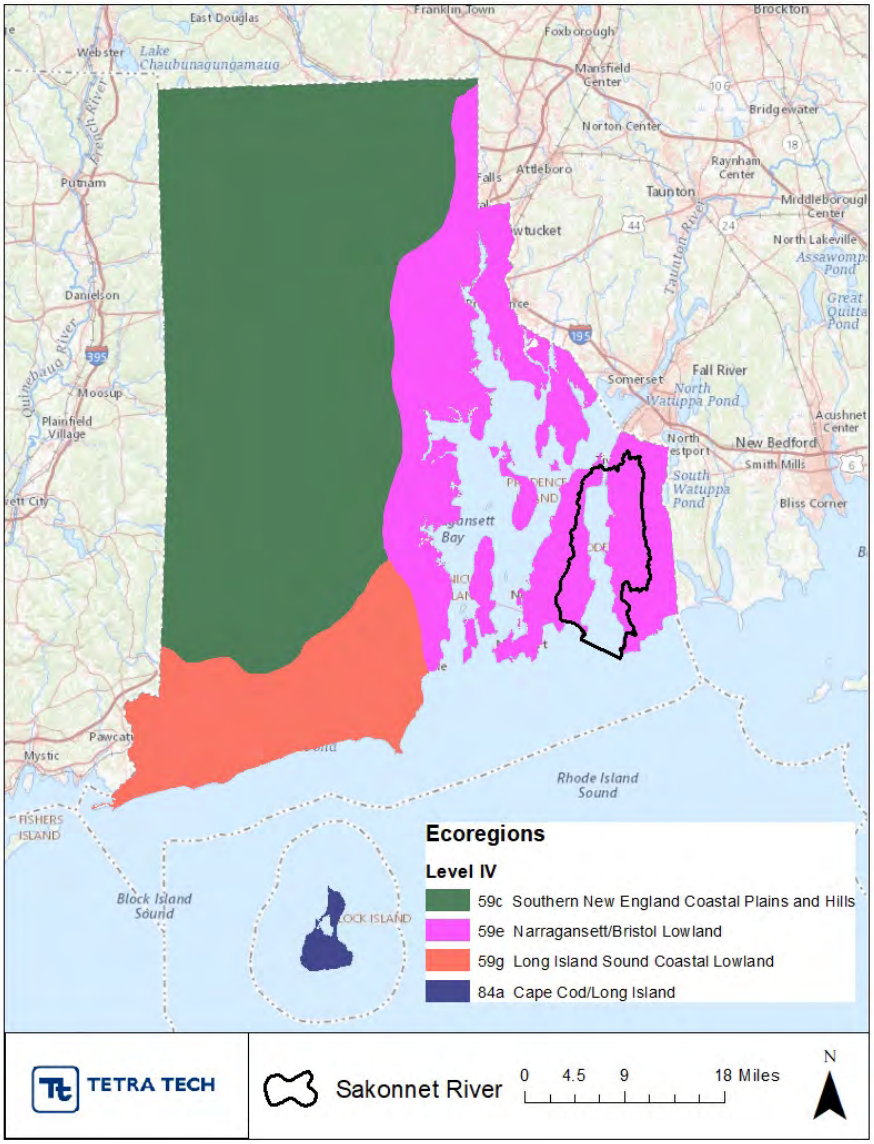

Figure 3. Level IV Ecoregions of Rhode Island.

Regional Climate Overview

The climate in the region is considered humid continental with hot summers and year-round precipitation (Köppen climate classification Dfa). Precipitation near the coasts is slightly lower in the summer and slightly higher in spring and fall in inland areas. Additionally, rainfall occurs as high-intensity, convective thunderstorms during the summer. During the winter, most of the precipitation occurs as moderate-intensity storms (northeasters) that produce large amounts of rain or snow (Griffith et al. 2009; NRCS 2006).

Long-term average annual temperature for Newport County, Rhode Island ranges from about 46 °F to 54 °F (Figure 4). Temperatures in the region vary widely on an annual basis, with the coldest month being January (average minimum temperature of ~21 °F and average maximum temperature of ~38 °F) and the warmest month generally being July (average minimum temperature of ~66 °F and average maximum temperature of ~76 °F). The average annual temperature has increased 0.3 °F per decade over the past 100 years. The annual frost-free period for this region averages 190 days and ranges between 145 and 240 days (Griffith et al. 2009). Long-term average annual precipitation ranges from 26 to 61 inches for Newport County, Rhode Island. Annual precipitation has increased 0.59 inches per decade since 1900 (Figure 5).

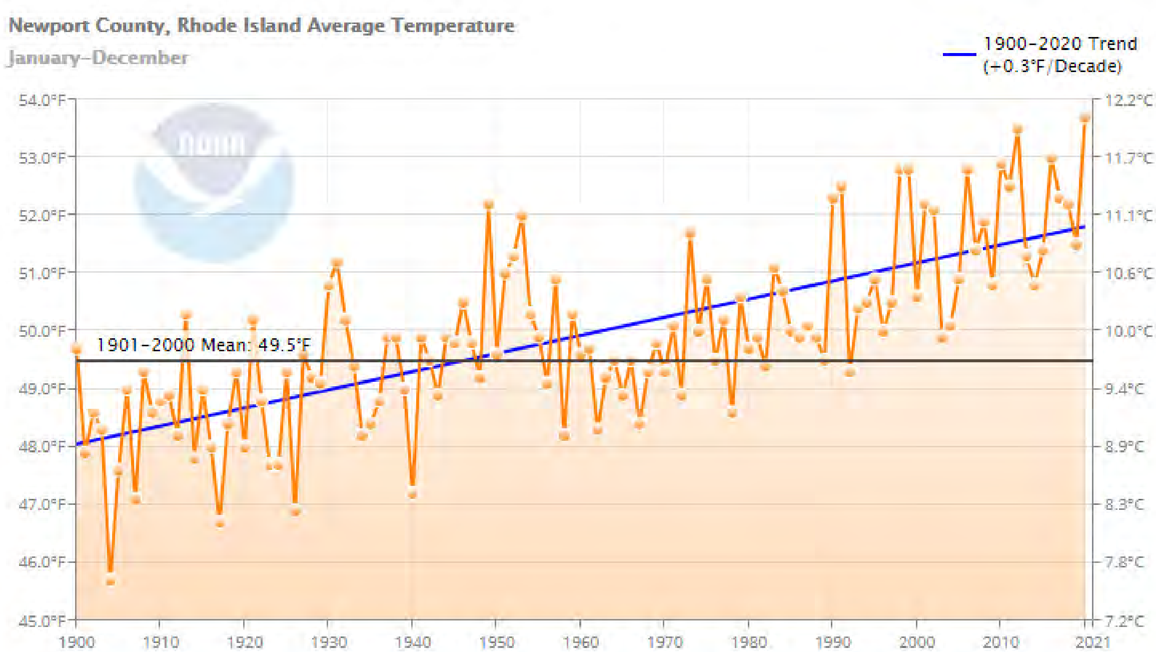

Figure 4. Average annual temperature in Newport County, Rhode Island, 1900–2020 (NOAA 2020).

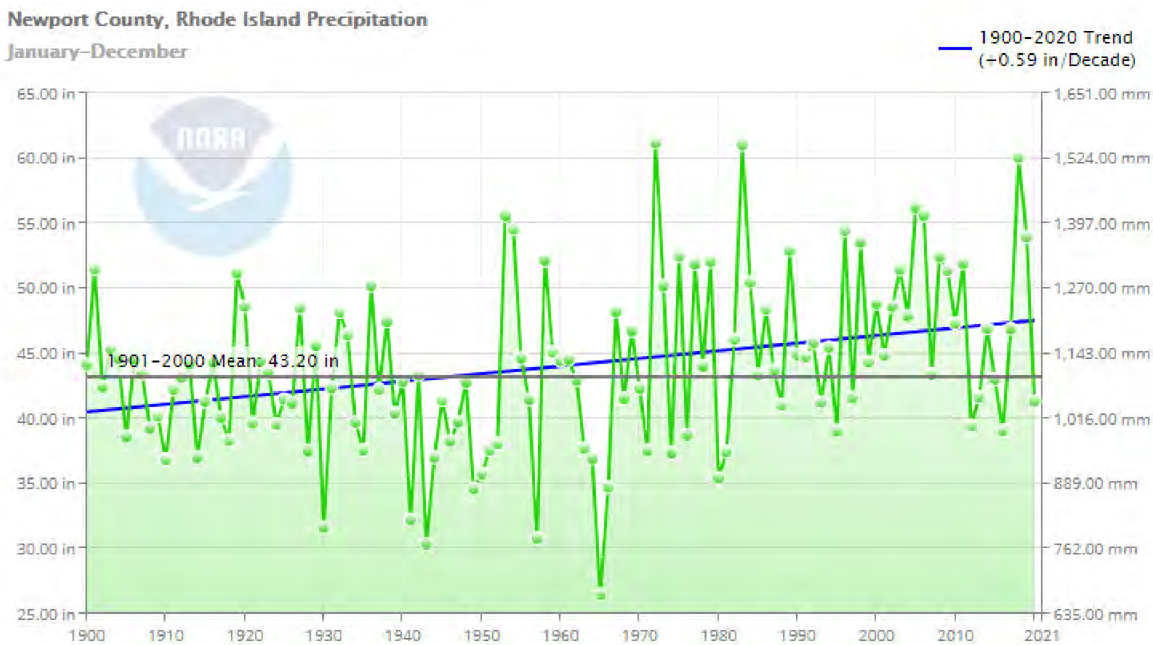

Figure 5. Average annual precipitation in Newport County, Rhode Island, 1900–2020 (NOAA 2020).

Topography

The topography for the ecoregion consists of flat to gently rolling irregular plains with low elevations (typically under 200 feet). Within the watershed, elevation ranges from about 0 feet (areas adjacent to Sakonnet River tidal straits) to 322.2 feet at the highest elevation (the headwaters of streams). Figure 6 shows the elevation changes throughout the Sakonnet River watershed.

The watershed is relatively flat with an average slope of 2.3% (0%–46.6%). About 17% of pastureland is estimated to be on slopes > 3%, while 2% is indicated to be on slopes > 9%. Similarly, for cropland, 5% is estimated to be on slopes > 3%, with ~1% on slopes > 9% (see EnviroAtlas for more information).

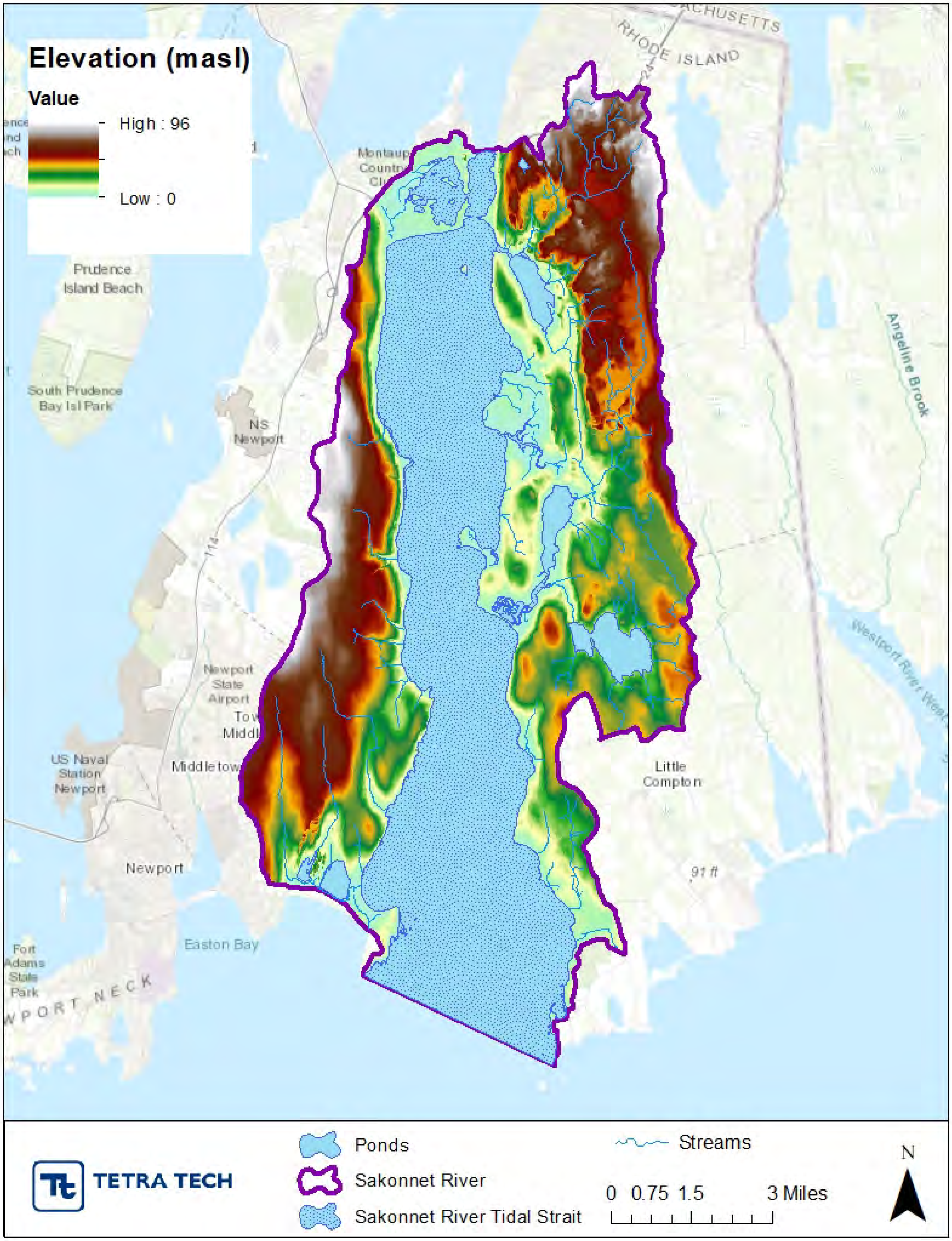

Figure 6. Elevation levels (meters above sea level [masl]) within the Sakonnet River watershed (note: 0–96 masl = 0 to 322.2 feet above sea level).

Geology, Geomorphology, and Soils

Geology and Geomorphology

Although bedrock outcrops are not common here, there is an extensive covering of glacial till in the area, which consists almost entirely of till plains and drumlins dissected by narrow valleys with a thin mantle of till. The southernmost boundary of MLRA 144a marks the farthest southward extent of glaciation on the eastern seaboard. The river valleys and coastal plains are filled with glacial lake sediments, marine sediments, and glacial outwash (NRCS 2006).

The bedrock in the MLRA area consists primarily of igneous and metamorphic rocks of early Paleozoic age (NRCS 2006). The different rock types that underlay the watershed are shown in Figure 7. Arenite and granite are the main bedrock types in the watershed.

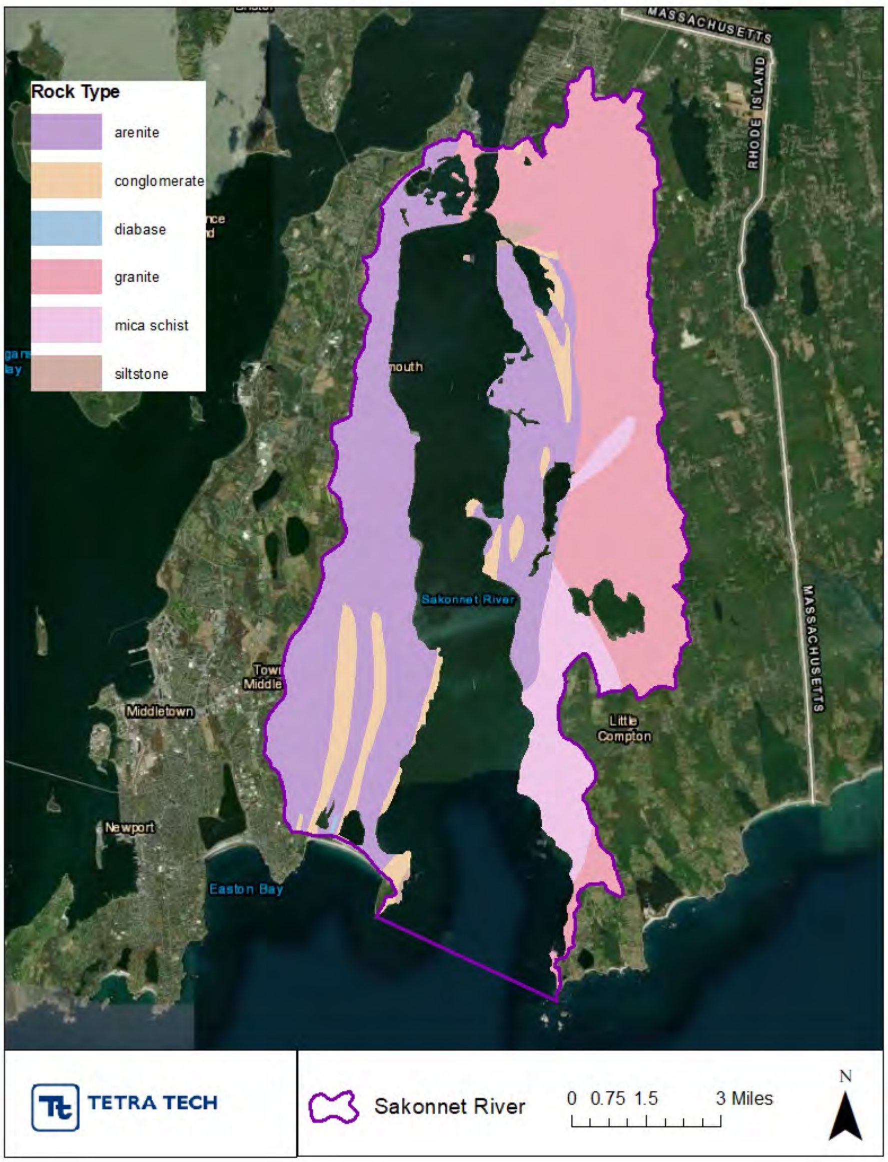

Figure 7. Location of different rock types that underlay the Sakonnet River watershed.

Soils

Information about soil types and characteristics is important when planning management practices in a watershed. The dominant soil orders in the MLRA are Entisols, Histosols, and Inceptisols (NRCS 2006), and the dominant soils in the ecoregion where the watershed is located are coarse-loamy and sandy, well-drained, mesic Inceptisols and Entisols or poorly drained Inceptisols formed in glacial till areas (Griffith et al. 2009).

United States Department of Agriculture (USDA) NRCS has mapped the soils in the area and classified them on the basis of slope and type. The main soil types in the watershed are Newport, Pittstown, Stissing, and Canton and Charlton. Numerous other minor soil types are also present within the assessment area (NRCS 2019). A summary of the main soil types is given in Table 1 (NRCS 2019).

Table 1. Summary of main soil types in the Sakonnet River watershed (NRCS 2019)

Soil Name	Soil Profile	Parent Material
Newport	Silt loam, very stony silt loam, extremely stony silt, urban land complex	Loamy lodgment till derived from metamorphic and sedimentary rock
Pittstown	Silt loam, very stony silt loam	Loamy lodgment till derived from metamorphic and sedimentary rock
Stissing	Silt loam, very stony silt loam	Loamy lodgment till derived from metamorphic and sedimentary rock
Canton and Charlton	Fine sandy loams	Coarse-loamy over sandy melt-out till derived from gneiss, granite, and/or schist

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value the more susceptible the soil is to sheet and rill erosion by water. Within the Sakonnet watershed, K ranges from 0.02 to 0.43. Areas with K values between 0.3 and 0.43 make up 29% of the watershed area.

Hydrologic soil groups (HSGs) are groups of soils that have similar runoff potential under similar storm and cover conditions. Figure 8 shows the spatial extent of HSGs in the Sakonnet River watershed, while Table 2 summarizes the breakdown of HSGs. Group C (slow infiltration) covers the largest amount of the watershed area, followed by group D (very slow infiltration) (NRCS 2019). Areas covered by dual HSGs (B/D and C/D) are also present in the watershed.

Table 2. Area and coverage of each hydrologic soil group in the Sakonnet River watershed (NRCS 2019)

Hydrologic Soil Group Type	Coverage (%)[a]
A - High Infiltration	4
A/D - High/Very Slow Infiltration	3
B - Moderate Infiltration	10
B/D - Medium/Very Slow Infiltration	4
C - Slow Infiltration	59
C/D - Medium/Very Slow Infiltration	<1
D - Very Slow Infiltration	21
Total	100

Note:

[a] Numbers were rounded to the nearest whole number

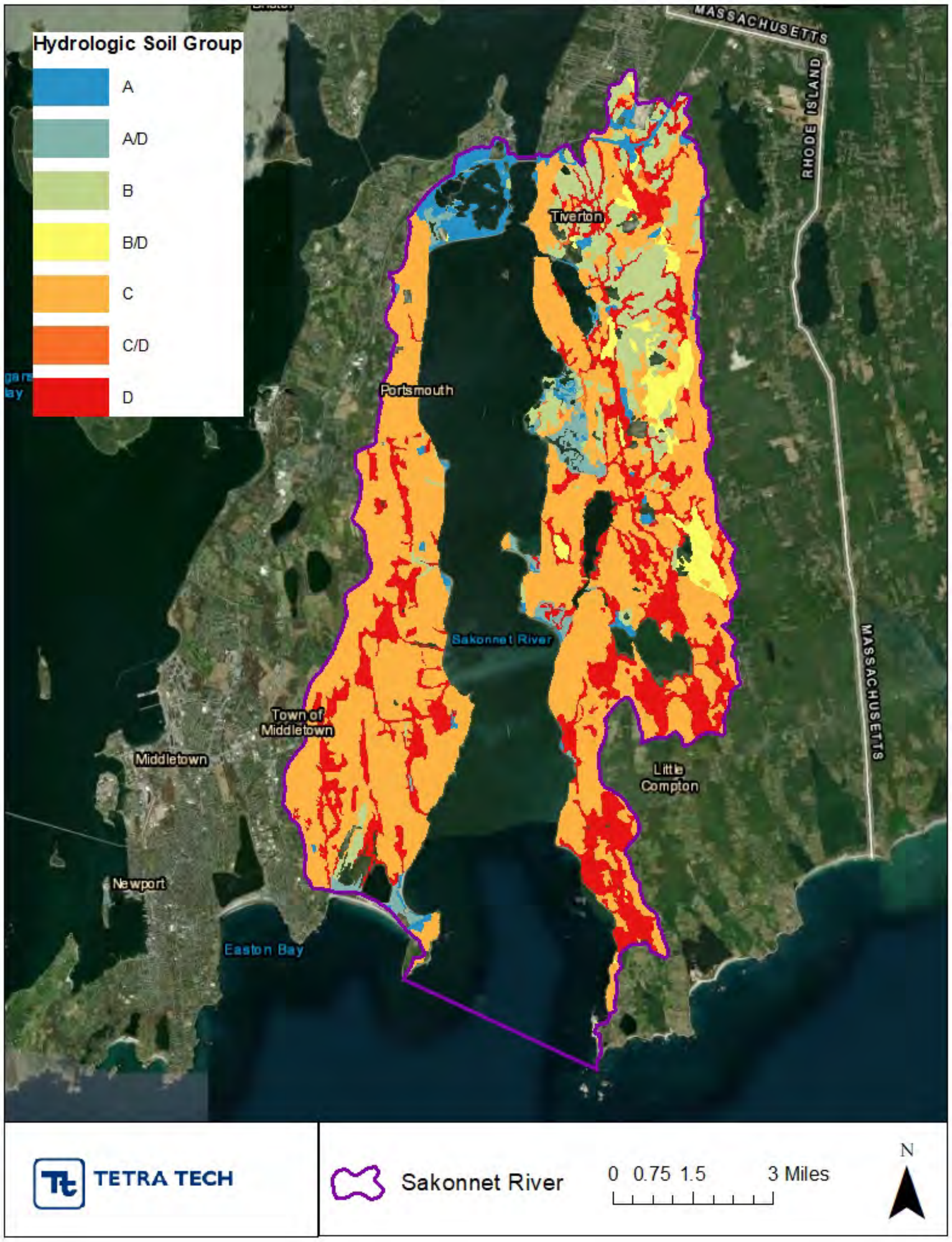

Figure 8. Map of hydrologic soil groups in the Sakonnet River watershed.

The majority of the watershed is considered to be “well drained” based on SSURGO drainage classifications. Drainage classes represent the moisture condition of the soil and how frequently the soil is saturated or not throughout the year. The locations of various soil drainage classes within the watershed are shown in Figure 9.

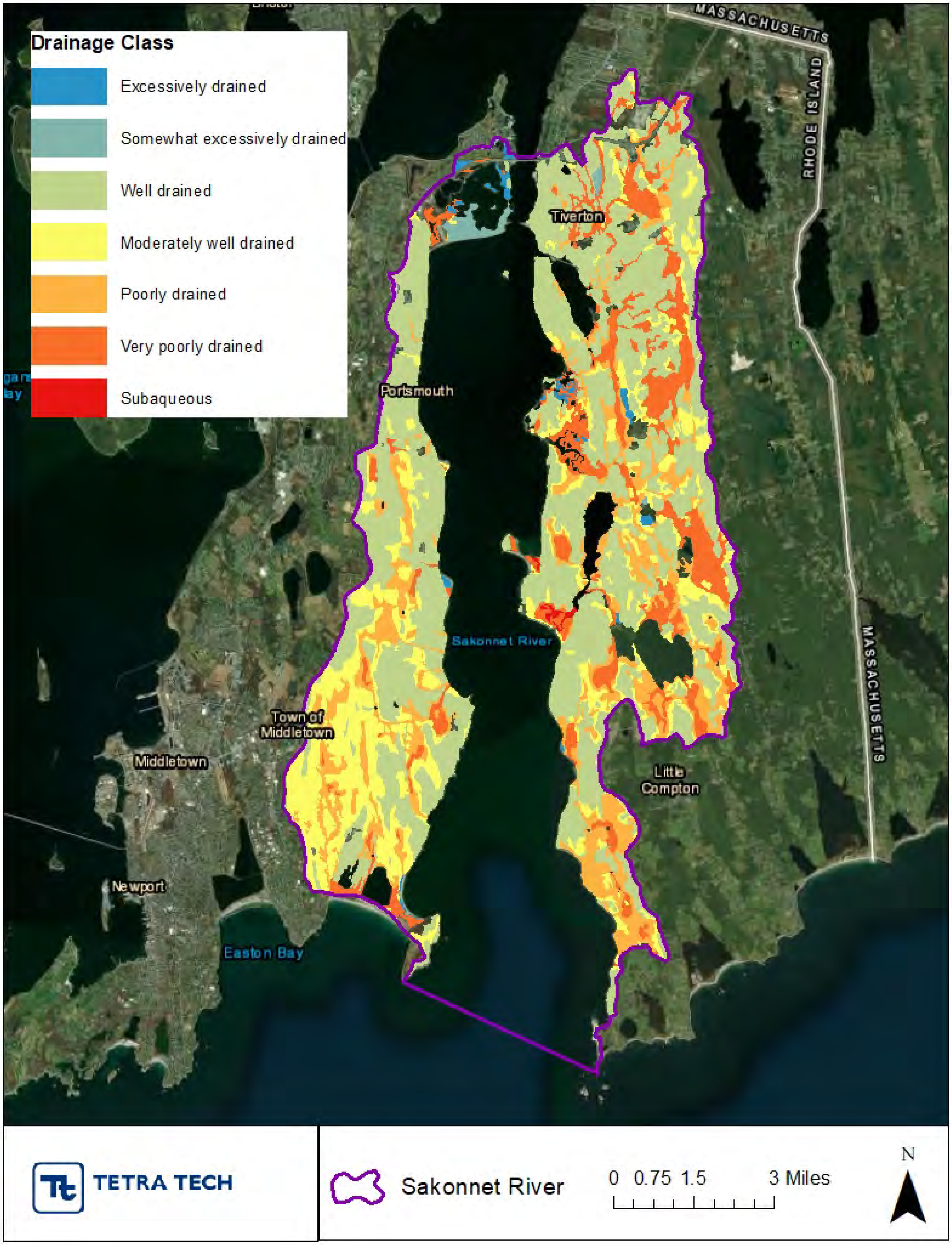

Figure 9. Spatial distribution of soil drainage classes within the Sakonnet River watershed.

Figure 10 shows the locations of various farmland soil classes within the study area. The map identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. Areas classified as “prime farmland” represent 26% of the watershed. The majority of the study area is considered “not prime farmland” (~63%). Farmland considered to be of statewide importance (~11%) is distributed throughout the watershed (see SSURGO for more information on farmland classes).

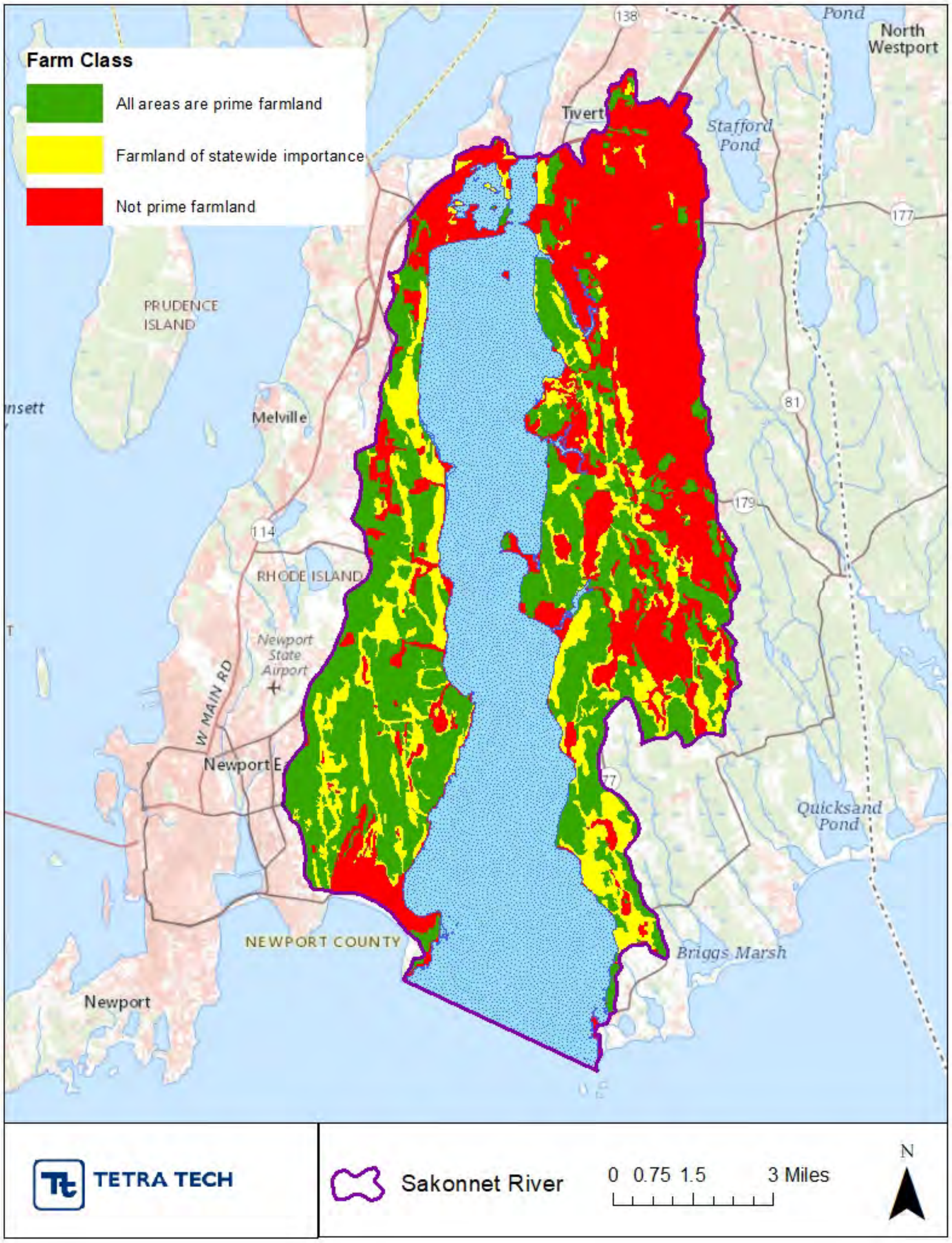

Figure 10. Location of various farmland classes within the Sakonnet River watershed.

Drainage Network

The stream network and locations of impoundments within the Sakonnet River watershed are displayed in Figure 11. The watershed consists of a complex network of tributaries, wetlands, and smaller ponds with associated rivers and brooks, all of which drain to the the Sakonnet River tidal strait. Sin and Flesh Brook, Borden Brook, Patchet Brook, Maidford River, and Paradise Brook are the main streams in the drainage area. The stream network consists of approximately 26 stream miles and 11 miles of the Sakonnet River tidal strait. Streams are mainly first and second order (NHDPlus Version 2). It is estimated that approximately 4 out of 26 stream miles in the Sakonnet watershed are in agricultural areas.

Several reservoirs and ponds are also in the watershed including The Cove, Nannaquaket Pond, Cedar Swamp, Nonquit Pond, Harold E Watson Reservoir, Gardiner Pond, and Nelson Pond. Nonquit Pond, Gardiner Pond, Harold E Watson Reservoir and Nelson Pond act as drinking water supply reservoirs for the the city of Newport (RIDEM 2021b). The characteristics of these reservoirs are given in Table 3. The system serves approximately 14,700 retail customers across Aquidneck Island (Newport, Middletown, and a small section of Portsmouth) and sells water to the Portsmouth Water and Fire District (PWFD) and Naval Station Newport (10 connections) on a wholesale basis (RIDEM 2021).

Table 3. Physical Characteristics of the Newport Water Supply Reservoirs within the Sakonnet River watershed

Reservoir	Surface Area (m^2)[a]	Mean Depth (m)[1]	Drainage Area (km^2)	Reservoir Function Designation	Main Tributaries
Nonquit Pond	808,940	2.65	17.96	Storage	Borden Brook Quaker Brook Various unnamed
Watson Reservoir	1,506,595	4.41	9.29	Storage	Various ephemeral (unnamed)
Gardiner Pond	403,863	3.99	0.59	Storage	Maidford River
Nelson (Paradise) Pond	125,853	3.02	2.22	Storage	Maidford River Paradise Brook

Note:
[a] At full capacity

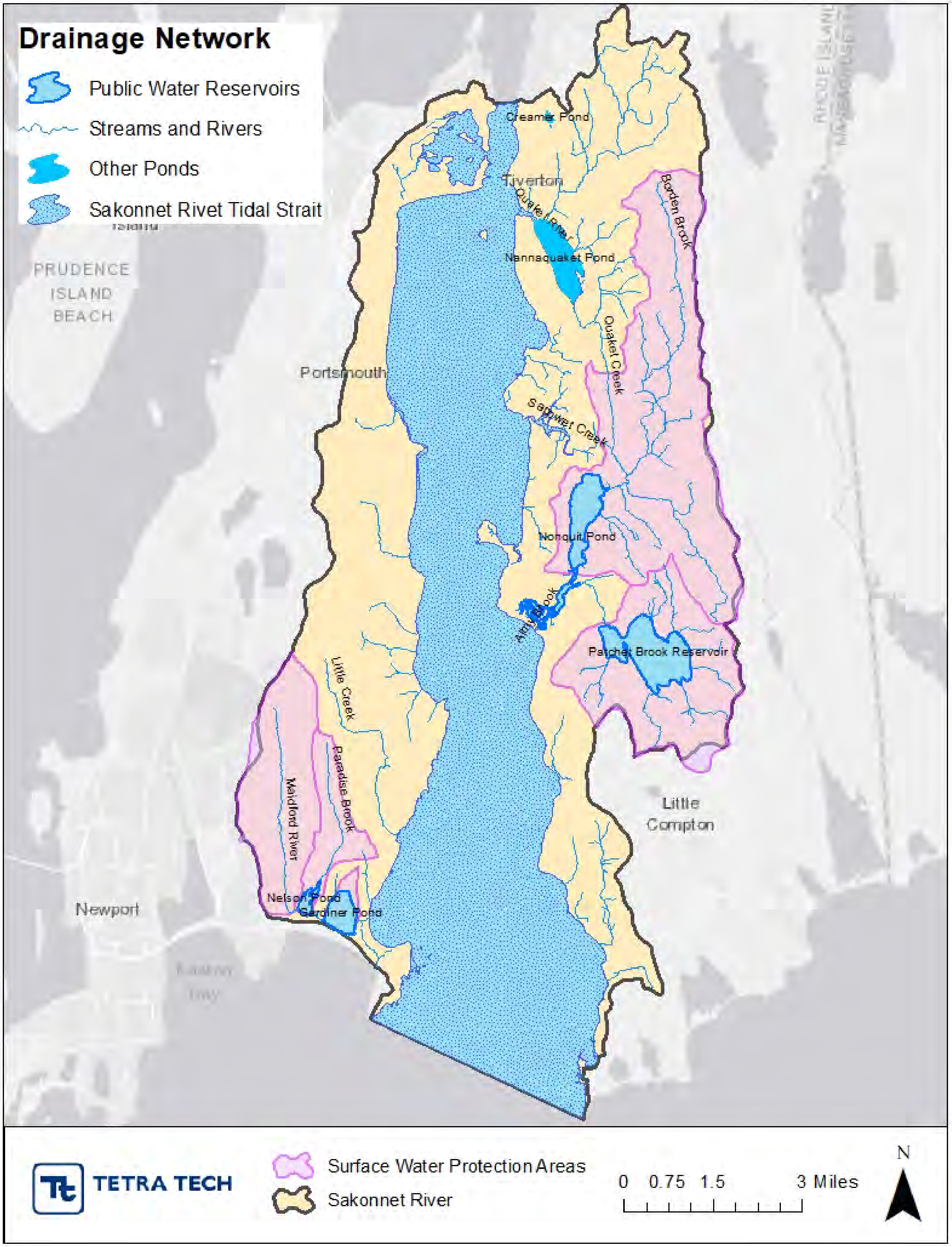

Figure 11. Rivers, streams, and other waterbodies within the Sakonnet River watershed. Note: Patchet Brook Reservoir is also known as Watson Reservoir.

The Sakonnet River watershed contains some wetland areas (about 12% of the watershed). Wetland areas are mainly composed of freshwater forested/shrub wetlands and estuarine/marine wetlands with some areas of freshwater emergent wetlands present (USFWS 2018). The locations of wetland areas with the watershed extent are displayed in Figure 12.

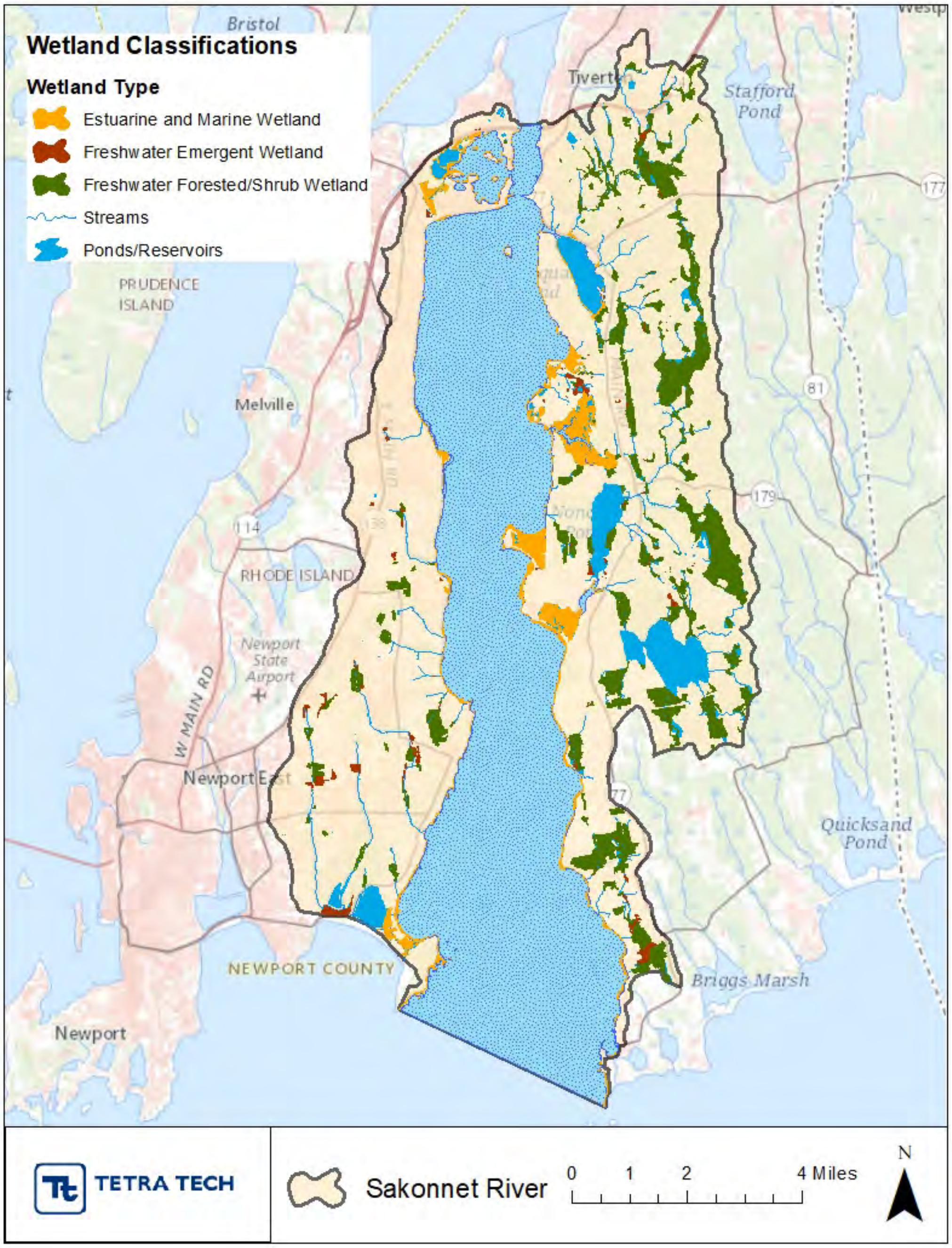

Figure 12. Locations of wetland within the drainage areas (USFWS 2018).

Land Cover and Land Use

The spatial distribution of different land use classes within the Sakonnet River is displayed in Figure 13. Southern parts of the watershed are mainly agriculture, with large areas of hay/pasture and some cropland. Eastern and northeastern portions are dominated by forest and wetlands. The northwestern area of the watershed is mainly urban.

Land cover types within the watershed were determined using the [USDA NASS 2020 Cropland Data Layer](#) (CDL). Table 4 provides a breakdown of various CDL classes within the Sakonnet River watershed. Agricultural land accounts for approximately 22% of the watershed area and includes other hay/non alfalfa (17.8%), corn (2.7%), and numerous other crops (~1%) (USDA NASS 2021). Forested land (> 40% of the overall area) covers the majority of the Sakonnet River watershed. Developed land (~23%) also makes up a large proportion of the area (see Table 4). The spatial distribution of the main crop types within the watershed is provided in Figure 14.

Table 4. Area and coverage of land use types in the Sakonnet River watershed (USDA NASS 2021)

Land Use Type	Acreage (Acres)	Coverage (%)
Other Hay/Non-Alfalfa	4,163.5	17.8%
Deciduous Forest	4,062.7	17.4%
Woody Wetlands	3,160.7	13.5%
Mixed Forest	2,153.2	9.2%
Developed/Low Intensity	1,990	8.5%
Developed/Medium Intensity	1,996.7	8.6%
[1]Open Water	1,445.8	6.2%
Developed/Open Space	1,226.5	5.3%
Herbaceous Wetlands	845.8	3.6%
Corn	628.9	2.7%
Other Crops	614.1	2.6%
Barren	420.3	1.8%
Developed/High Intensity	256.9	1.1%
Grass/Pasture	244.9	1.1%
Evergreen Forest	93.4	0.4%
Shrubland	31.6	0.1%
Total	23,335	100%

Note:

[1] Does not include marine waters from Sakonnet River tidal straits.

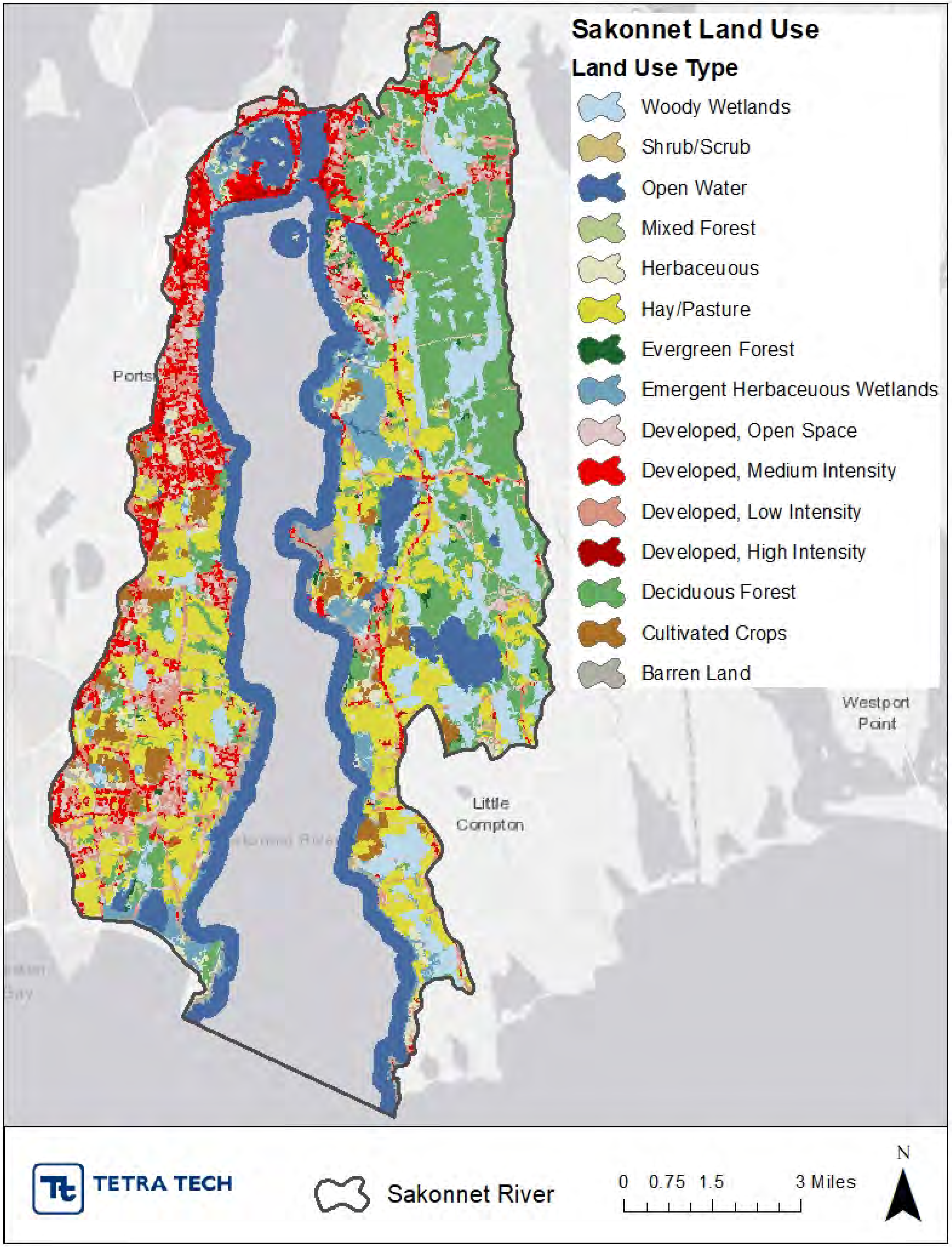

Figure 13. Spatial distribution of land use within the Sakonnet River watershed (Dewitz 2019).

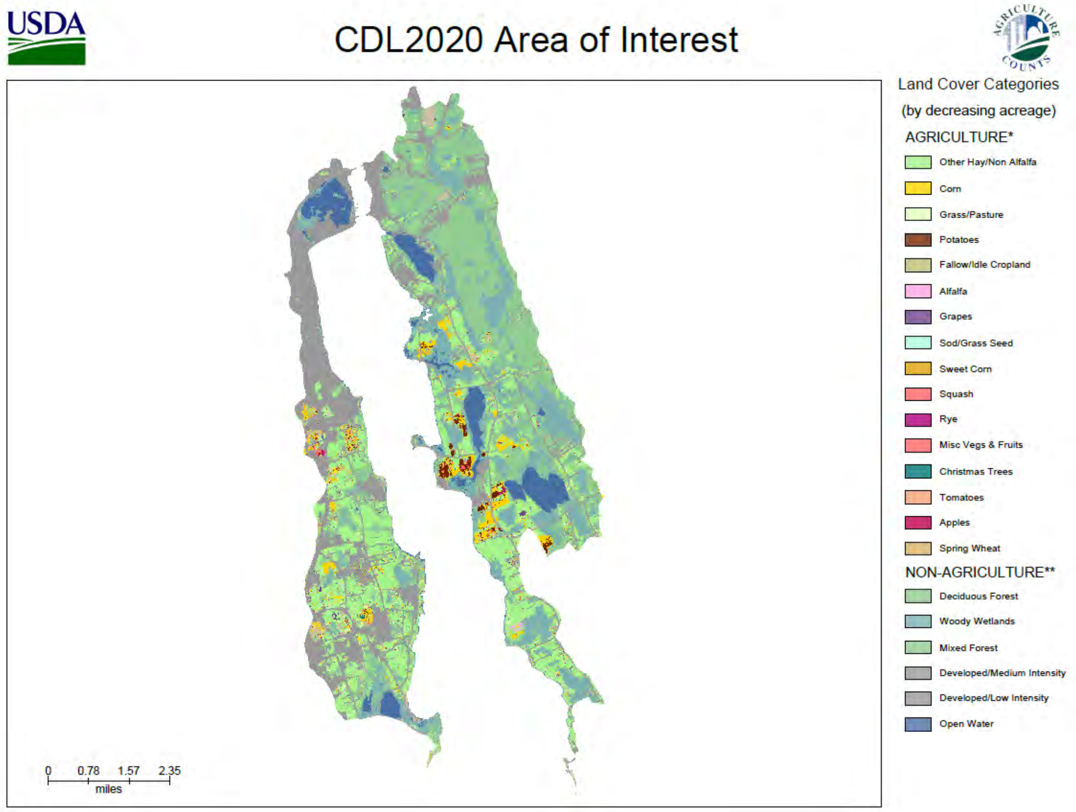

*Figure 14. Land use distribution across the assessment area (USDA NASS 2021). * Denotes the top 16 agricultural categories; ** Denotes the top 6 non-agriculture categories.*

Socioeconomic Conditions

The Sakonnet watershed spans Newport County, Rhode Island and includes the towns of Middletown, Portsmouth, and Tiverton. County subdivisions and populated places are shown in Figure 15. A summary of population data for these locations can be found in Table 5. Based on the 2010 U.S. Census, the population of Newport County is approximately 82,082. The population is expected to remain similar in upcoming years. The median income in Newport County was $79,454 and 94% of the population attained a high school education or higher and 48% of the population attained a bachelor's degree or higher. The main industries in Newport County, Rhode Island are health care and social assistance, educational services, and retail trade (Deloitte and Datawheel 2018; U.S. Census Bureau 2018).

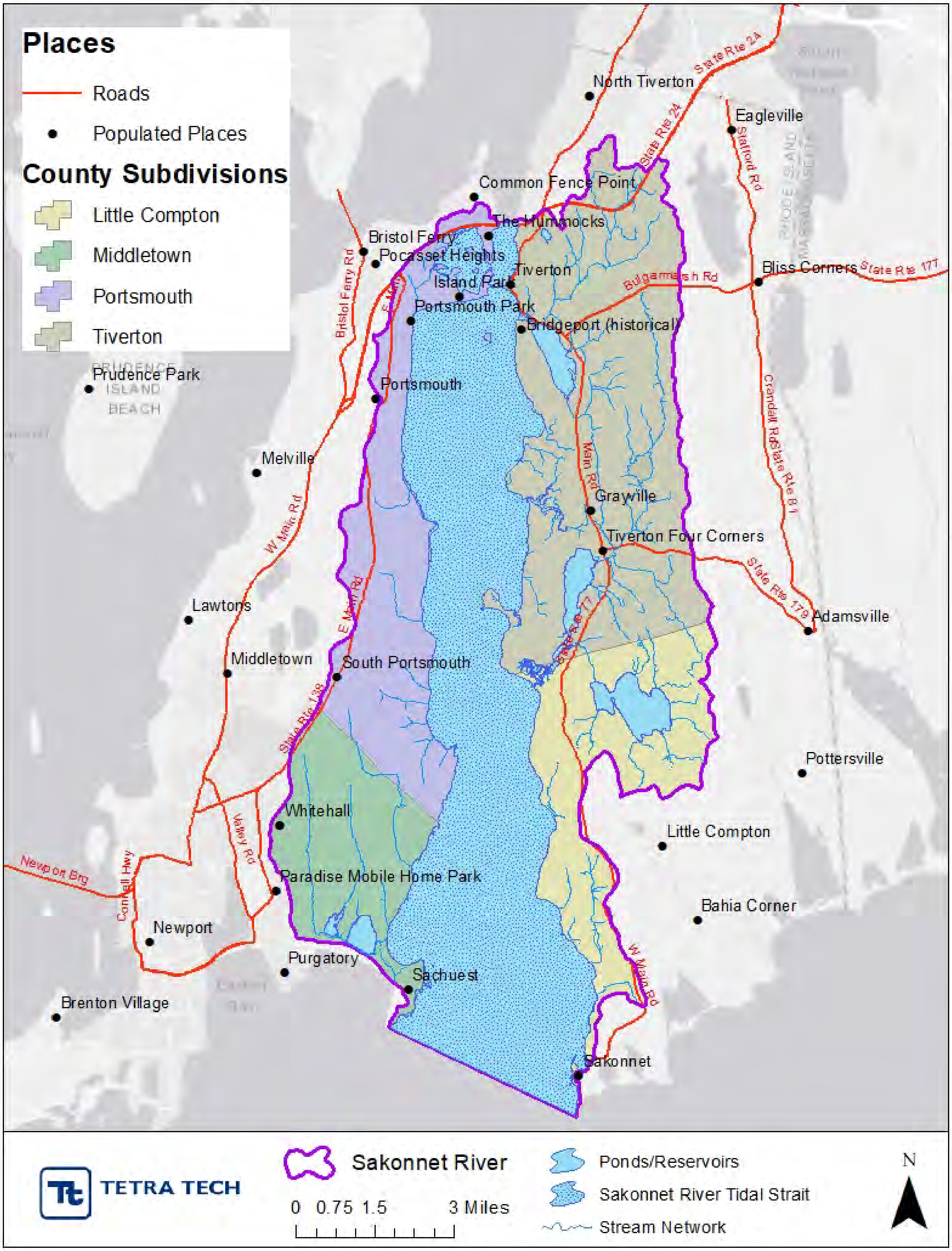

Figure 15. Town boundaries and populated places within the Sakonnet River watershed (U.S. Census Bureau 2018).

Table 5. Population data for the Sakonnet River watershed jurisdictions from the U.S. 2018 Census

	Rhode Island	Newport County	Middletown Town	Portsmouth Town	Tiverton Town
Total Population	1,059,361	82,082	15,888	17,226	15,662
Total Households	470,168	42,779	NA	NA	NA
Median Household Income	$67,167	$79,454	$73,609	$100,453	$75,295
Education Attainment- High School Graduate or Higher	89%	94%	94%	95%	92%
Education Attainment- Bachelor's Degree or Higher	34%	48%	46%	52%	33%

The 2017 USDA Agriculture Census indicates that there are 196 farms in Newport County that operate over approximately 9,713 acres. The average size of farm within the county is 50 acres, with the majority of farms ranging from 10–49 acres in size (USDA NASS 2017).

The total market value of products sold from these farms was $19,280,000 in 2017, with an average of $98,365 of market value of products sold per farm. Crops make up the majority of share of sales at 63% and livestock and poultry products account for the remaining 37% of sales. Newport County agricultural sales account for 33% of sales for the state of Rhode Island (USDA NASS 2017).

Out of the crops produced, forage occupies the most acreage, followed by vegetables, nursey stock crops, potatoes, and then corn for silage or greenchop. The highest sales come from vegetable and nursery products. Out of the livestock raised, cattle and calves occupy the most acreage and milk from cows had the highest sales out of livestock products sold (USDA NASS 2017).

III. Hydrologic and Water Quality Characterization

This section describes the hydrology and water quality conditions within the Sakonnet River watershed. The objective is to demonstrate the transport mechanisms for pollutants of concern, and the spatial and temporal characteristics of transport. A summary of available data and resources compiled for the watershed is also provided.

Available Data and Resources

TMDLs and Management Plans/Report

Table 6 summarizes available plans and reports, including TMDL reports and watershed planning reports, within the Sakonnet River watershed. A draft TMDL was completed in 2021 to address TP and TOC impairments for the City of Newport Drinking Water Reservoirs. Four of those of nine reservoirs (Nonquit Pond, Watson Reservoir, Gardiner Pond, and Paradise Pond) are located in the Sakonnet River watershed.

A statewide TMDL was completed for bacteria impaired waters in 2011 and was updated in 2014. As part of the process, Rhode Island Department of Environmental Management (RIDEM) also created summary reports for bacteria impaired water body segments across the state and included separate summaries for Maidford River (Segments 2A and 2B) and Paradise Brook within the watershed.

Other relevant reports include a watershed plan for the Aquidneck Island (covers the western coastal area of the Sakonnet River watershed) and reports that address the Newport Water System's nine source reservoirs, water quality monitoring data collected from those reservoirs, and development of target phosphorus and chlorophyll-*a* concentrations within those reservoirs.

Data and Other Resources

Table 7 provides a summary of available data and other resources in the watershed.

Hydrological Data: Limited flow data are available for streams and rivers in the watershed. There are no United States Geological Survey (USGS) sites that monitor streamflow in the watershed. However, some limited flow measurements for sites on the Maidford River and Paradise Brook were recorded during recent water quality sampling (December 2014 to January 2016) associated with NWQI sampling (RIDEM 2017).

Water Quality Monitoring Data: Recent water quality data are available from RIDEM for select streams and reservoirs within the watershed. NWQI water quality studies for Nonquit Pond Tributaries (between November 2016 and October 2017) and Maidford River and Paradise Brook (between December 2014 and January 2016) provide information about current conditions in some streams. Recent water quality monitoring by USGS (2018–2019) is also available for the Sakonnet River tidal straits (Sorenson 2021).

Other Data: Climate data were collected from the National Oceanic and Atmospheric Administration (NOAA) Tiverton, Rhode Island, climate station located within the watershed.

Reports

Table 6. Compilation of available reports used to characterize hydrology and water quality conditions in the watershed

Title	Year Published	Author(s)	Type of Resource	Description
Rhode Island Statewide Total Maximum Daily Load (TMDL) for Bacteria Impaired Waters	2011	RIDEM	TMDL Report	This statewide TMDL provides a framework to address bacterial pollution by establishing the allowable bacterial contributions for Rhode Island's surface waters, providing documentation of impairment, and specifying the pollutant reductions needed to meet water quality standards.
Maidford River Segment 2A	2011	RIDEM	TMDL Report	Water body summary TMDL report from the Rhode Island Statewide Bacteria TMDL.
Maidford River Segment 2B	2011	RIDEM	TMDL Report	Water body summary TMDL report from the Rhode Island Statewide Bacteria TMDL.
Paradise Brook	2011	RIDEM	TMDL Report	Water body summary TMDL report from the Rhode Island Statewide Bacteria TMDL.
Total Maximum Daily Loads for Phosphorus for the City of Newport Drinking Water Reservoirs	2021	RIDEM	TMDL Report	Provides TMDL plans to address total phosphorus and total organic carbon impairments for four drinking water reservoirs within the watershed (Nonquit Pond, Watson Reservoir, Gardiner Pond, and Paradise Pond) as well as three other drinking water reservoirs not located within the watershed.
Aquidneck Island Watershed Plan	2021	RIDEM	Watershed Plan	Provides watershed planning framework for the Aquidneck Island watershed within the Sakonnet River watershed. The document includes an assessment of impaired freshwaters and proposed goals for the area's future watershed plan.
Source Water Protection Initiative for Newport Water Supply Reservoirs	2015	RIDEM	Report	Report documents the efforts to restore the quality of the Newport Water System's nine source reservoirs.
Surface Water Monitoring in the Newport Water Supply Reservoirs 2015	2017	RIDEM	Data Report	The report summarizes the analytical chemistry results of water quality monitoring data collected biweekly from early May through mid-October 2015 from the nine Newport Water Division drinking water supply reservoirs.

Title	Year Published	Author(s)	Type of Resource	Description
Development of Numeric Phosphorus and Chlorophyll-a Targets for the Newport Water Supply Reservoirs	2018	RIDEM	Report	The report establishes target phosphorus and chlorophyll-a concentrations for the nine water supply source reservoirs that ensure that algal growth and total organic carbon concentrations are reduced to a level that supports drinking water and aquatic life uses.

Data

Table 7. Compilation of available data used to characterize hydrology and water quality conditions in the watershed

Title	Year(s) of Data Included	Description	Available Data Parameters	Monitoring Frequency
NWQI Water Quality Study and Pollutant Source Identification for Nonquit Pond	2016–2017	As a part of the NWQI, instream monitoring at numerous locations along the tributaries (Borden Brook, Quaket Creek and others unnamed) to Nonquit Pond on 6 occasions between November 2016 and October 2017.	Water Quality: nutrients, sediment, bacteria	Occasional
NWQI Water Quality Study and Pollutant Source Identification for Maidford River and Paradise Brook	2014–2016	As part of the NWQI, monitoring took place on 6 occasions between December 2014 and January 2016 at sites on Maidford River and Paradise Brook.	Streamflow; Water Quality: nutrients, sediment, bacteria	Occasional
Contrasting behavior of nitrate and phosphate flux from high flow events on small agricultural and urban watersheds	2014–2017	University of Rhode Island project collected real-time water quality data (in-situ sensors) between October 2014 through March 2017 on Maidford River.	Water Quality: nutrients	Occasional
Base-flow index grid for the conterminous United States	2014	This 1-kilometer raster (grid) dataset for the conterminous United States was created by interpolating base-flow index (BFI) values estimated at USGS stream gages. Base flow is the component of streamflow that can be attributed to groundwater discharge into streams.	Baseflow indices	N/A

Title	Year(s) of Data Included	Description	Available Data Parameters	Monitoring Frequency
Water Balance (estimated)	1960–1990	The Model My watershed model simulates 30 years of daily water fluxes using the Generalized watershed Loading Function Enhanced (GWLF-E) model that was developed for the MapShed desktop modeling application.	Average monthly water fluxes: stream flow, surface runoff, subsurface flow, evapotranspiration, precipitation	Daily
Tiverton, RI climate station data	1981–2010	Climate data collected from the Tiverton, RI climate station, located within the watershed.	Average precipitation, average minimum temperature, average mean temperature, average maximum temperature	Daily
Water-Quality Conditions in the Sakonnet River, Rhode Island, 2018-2019	2018–2019	USGS New England Water Science Center and U.S. Environmental Protection Agency (EPA) Region 1 conducted water-quality monitoring in the Sakonnnet River during 2018-2019.	Water quality: physical, chemical, nutrients	Continuous

Runoff and Streamflow Hydrology

Overview

Runoff and streamflow vary naturally in response to changes in the rate and timing of water inputs to a watershed (e.g., precipitation), water outputs from a watershed (e.g., evapotranspiration [ET]), and changes in watershed storage (e.g., groundwater, snow, ice). Other factors like soils, land use, and human activity also impact runoff and hydrology. Runoff and streamflow are the principal drivers of changes in water quality. The soils, geology, and hydrology of the watershed indicate that infiltration, upland recharge, and local discharge of shallow subsurface flow are important in the maintenance of stream baseflow. This section summarizes the climate and hydrologic regime in the assessment area using available data and modeling tools.

Methods Used in the Analysis

Available estimated and modeled hydrological data were used to characterize hydrology when measured data were not available:

- NOAA National Weather Climate data from Tiverton, Rhode Island station was used to assess climate conditions within the watershed.
- The *Model My Watershed* application was applied to simulate the precipitation-runoff budget and runoff for the watershed.
- The ACPF was used to assess runoff risk for agricultural fields in the watershed.
- USGS estimations were used to assess the baseflow contributions and calculate a variety of other flow metrics for the location.
- The USGS StreamStats tool was used to estimate low flow and peak flow statistics.

Climate Data

The NOAA climate station at Tiverton, RI, located in the northeast of the watershed (Network ID:GHCND:USC00377581; latitude/longitude: -41.6268°, -71.2093°; elevation: 90 ft) provides data on long-term climate for the Sakonnet River watershed. Table 8 shows various temperature and precipitation metrics for the 1981–2010 climate period at the station (data from NOAA's Data Tools: 1981-2010 Normals). The mean monthly temperature for the month of January was 30 °F, and for July was 73.3 °F. Monthly air temperatures range from about 22.1 °F to 37.8 °F (average minimum to average maximum) in January to 64.3 °F to 82.3 °F (average minimum to average maximum) in July (see Table 8).

The average annual precipitation for this period was 48.5 inches. Average monthly precipitation ranges from 2.8–5.7 inches (Table 8). Precipitation is generally evenly distributed throughout the year, with precipitation slightly higher in the spring and fall in inland areas, and slightly lower in the summer near coastal areas (NRCS 2006). Most precipitation during the winter occurs as moderate-intensity storms, or northeasters, that produce large amounts of rain or snow (NRCS 2006).

Table 8. Average temperature and precipitation measurements from Tiverton, RI climate station, 1981–2010

Month	Average Precipitation (inches)	Average Minimum Temperature (°F)	Average Mean Temperature	Average Maximum Temperature (°F)
January	3.85	22.1	30.0	37.8
February	3.77	24.1	32.6	41.0
March	5.68	30.5	39.5	48.5
April	4.82	38.8	48.6	58.3
May	3.64	48.5	58.3	68.1
June	3.88	58.1	67.3	76.5
July	2.79	64.3	73.3	82.3
August	3.80	63.6	72.9	82.1
September	3.73	56.2	65.2	74.3
October	3.93	46.4	54.8	63.2
November	4.33	37.1	44.6	52.2
December	4.32	28.3	35.1	42.0
Summary	48.54 (total)	43.2 (mean)	51.9 (mean)	60.5 (mean)

Precipitation-Runoff Budget

The water balance for the watershed was generated using the Model My Watershed application (average monthly flux for 30 years of daily water balance) and shows how much of the annual average precipitation that falls on the watershed leaves as streamflow and evapotranspiration. It also indicates the proportion of streamflow provided by surface runoff and subsurface flow. Table 9 summarizes the estimated average annual and average monthly water flux. Of the approximately 44 inches of average annual precipitation falling on the watershed, ~24 inches (55%) leaves as streamflow (7 inches surface runoff, 16.8 inches groundwater discharge), and ~20 inches (45%) leaves as evapotranspiration. Highest streamflow volumes occur during spring.

Table 9. Average monthly water fluxes (units in inches) from 30-years of daily water balance (simulated by Model My Watershed) for the watershed

Month	Stream Flow (in.)	Surface Runoff (in.)	Subsurface Flow (in.)	Evapotranspiration (in.)	Precipitation (in.)
January	**3.3**	1.1	2.2	**0.2**	**3.7**
February	**3.3**	1.1	2.2	**0.2**	**3.6**
March	**3.8**	1.1	2.7	**0.7**	**3.9**
April	**2.8**	0.3	2.5	**1.6**	**3.9**
May	**1.8**	0.2	1.6	**2.9**	**3.5**
June	**1.1**	0.2	0.9	**3.8**	**3.2**
July	**0.4**	0.1	0.3	**3.3**	**3.0**
August	**0.4**	0.3	0.1	**2.8**	**3.4**
September	**0.4**	0.3	0.1	**2.1**	**3.3**
October	**1.1**	0.5	0.6	**1.3**	**3.5**
November	**2.1**	0.8	1.3	**0.7**	**4.3**
December	**3.3**	1.0	2.3	**0.3**	**4.2**
Annual	**23.8**	7.0	16.7	**19.8**	**43.6**

Note:
A database of national-scale daily weather data was previously compiled by EPA for use in water balance simulations. These data were used to estimate daily weather data (i.e., precipitation and temperature; compiled for the time period 1960-1990) for use in driving runoff calculations.

Baseflow contributes a large proportion of streamflow in the watershed and sustains flow during dry weather. USGS has conducted baseflow modeling in the region that relates annual precipitation and recharge rates to streamflow. Analysis for the Sakonnet River watershed showed baseflow index rates of approximately 55%–63%. As a reference, modeling suggests that baseflow indices range from about 51% (northwestern parts of the state) to approximately 71% (southwest part of the state) in Rhode Island.

Runoff and Streamflow Hydrology

No long-term USGS stream gages are currently maintained within the Sakonnet River watershed. Streamflow and runoff were thus assessed based on estimates from available report information, Model My Watershed, and the USGS Streamstats Tools. Runoff was estimated for hypothetical 1-inch and 2-inch storm events over 24 hours using Model My Watershed. The results are displayed in Table 10. For a 2-inch storm event, 49 percent of the precipitation forms runoff and approximately 43 percent infiltrates into the soils.

Table 10. Runoff generated by hypothetical 24-hour storm events in the Sakonnet River watershed (simulated by SLAMM and TR-55 algorithms in Model My Watershed)

Storm Event Precipitation Fate	Water Depth (in.)		Water Volume (ft^3)	
	1-inch Storm Event	2-inch Storm Event	1-inch Storm Event	2-inch Storm Event
Runoff	0.40	0.97	51,359,026	126,526,757
Evapotranspiration	0.17	0.17	21,387,019	21,387,019
Infiltration	0.44	0.86	57,173,870	111,926,053

Streamflow was measured during NWQI water quality monitoring on the Maidford River and Paradise Brook between the December 2014 and January 2016. Table 11 displays measured discharges during wet and dry weather at one downstream site on Maidford River (Newport Water Intake) and one downstream site on Paradise Brook (Downstream of Equestrian Facility). Approximately 1.5–2.2 inches of rain fell during each of the three wet-weather monitoring events. Observations for Maidford River suggest that flow during dry weather is driven by groundwater contributions. However, flow increases dramatically during precipitation events, relative to flow levels during dry weather. Similar observations were reported in Paradise Brook (RIDEM 2017).

Table 11. Summary of flow measurements during NWQI sample between December 2014 and January 2016 (N = 6)

Water body	Site	Dry Weather Discharge (cfs)	Wet Weather Discharge (cfs)
Maidford River	Newport Water Intake	1.95–2.64	24.85–98.42*
Paradise Brook	Downstream of Equestrian Facility	0.39–0.82	5.06–22.61*

*Flow estimated by regressing flows against drainage areas associated with each site.

The USGS StreamStats tool also provides some low streamflow and peak streamflow statistics for streams in the Sakonnet River watershed. Information for Little Creek is based on a partial flow record, while all other stream data are based on flow estimations from the StreamStats tool. A summary of information for various streams is provided in Table 12.

Table 12. Streamflow statistics for streams within the Sakonnet River watershed based on the USGS StreamStats tool

Stream Name	7-day, 10-year Flow (cfs)	20-percent Annual Exceedance Probability Flood (cfs)
Maidford River	0.049	342
Borden Brook	0.0405	115
Paradise Brook	0.000651	740
Sin Flesh Brook	0.0182	171
Little Creek	0.009	1.27

Water Quality Conditions

Overview

This section reviews applicable standards, details current impairments, and assesses available water quality monitoring data for the watershed. Available water quality data indicate that a number of streams exceed recreational water quality standards due to excessive levels of bacteria—some of these streams have had TMDLs developed (FB Environmental Associates, Inc. 2011). Pathogens associated with bacteria can present a risk of human exposure through recreational water quality and drinking water. Impairments caused by TP are also evident in the four drinking water reservoirs and the streams that discharge to them.

Applicable Water Quality Standards

Water quality standards are the basis for Rhode Island's water quality management program. Water quality standards define the goals for a water body by designating its uses, setting criteria to protect those uses, and establishing provisions to maintain and protect water quality from pollutants. The standards are composed of three parts: designated uses, water quality criteria, and antidegradation. Each of these components is briefly discussed below.

Surface Water Classes and Designated Uses

As described in Rhode Island's water quality standards (RIDEM 2020), all surface waters in the state are assigned to one of four freshwater classes (A, AA, B, B1) or one of three saltwater classes (SA, SB, SB1), described in Table 13. Freshwaters in the Sakonnet River watershed have been assigned to all four of the freshwater classes (AA, A, B, and B1), as shown in Figure 16. Saltwater in the Sakonnet River (estuarine tidal strait) have been assigned to two of the three saltwater classes (SA and SB).

Table 13. Designated uses for surface waters in the Sakonnet Watershed (source: RIDEM 2020)

Classification	Designated Uses
Class AA	• Source of public drinking water supply (PDWS) or tributaries within PDWS watershed • Primary and secondary contact recreational activities • Fish and wildlife habitat • Shall have excellent aesthetic value
Class A	• Primary and secondary contact recreational activities • Fish and wildlife habitat • Suitable for compatible industrial processes (e.g., cooling, hydropower, agriculture) • Shall have excellent aesthetic value
Class B	• Fish and wildlife habitat • Primary and secondary contact recreational activities. • Suitable for compatible industrial processes (e.g., cooling, hydropower, agriculture) • Shall have good aesthetic value
Class B1	• Primary and secondary contact recreational activities • Fish and wildlife habitat • Suitable for compatible industrial processes (e.g., cooling, hydropower, agriculture) • Shall have good aesthetic value • Primary contact recreational activities may be impacted due to pathogens from approved wastewater discharges; however, all Class B criteria must be met
Class SA	• Shellfish harvesting for direct human consumption • Primary and secondary contact recreational activities • Fish and wildlife habitat • Suitable for aquacultural uses, navigation, and industrial cooling • Shall have good aesthetic value
Class SB	• Primary and secondary contact recreational activities • Shellfish harvesting for controlled relay and depuration • Fish and wildlife habitat • Suitable for aquacultural uses (other than shellfish for direct human consumption), navigation, and industrial cooling • Shall have good aesthetic value

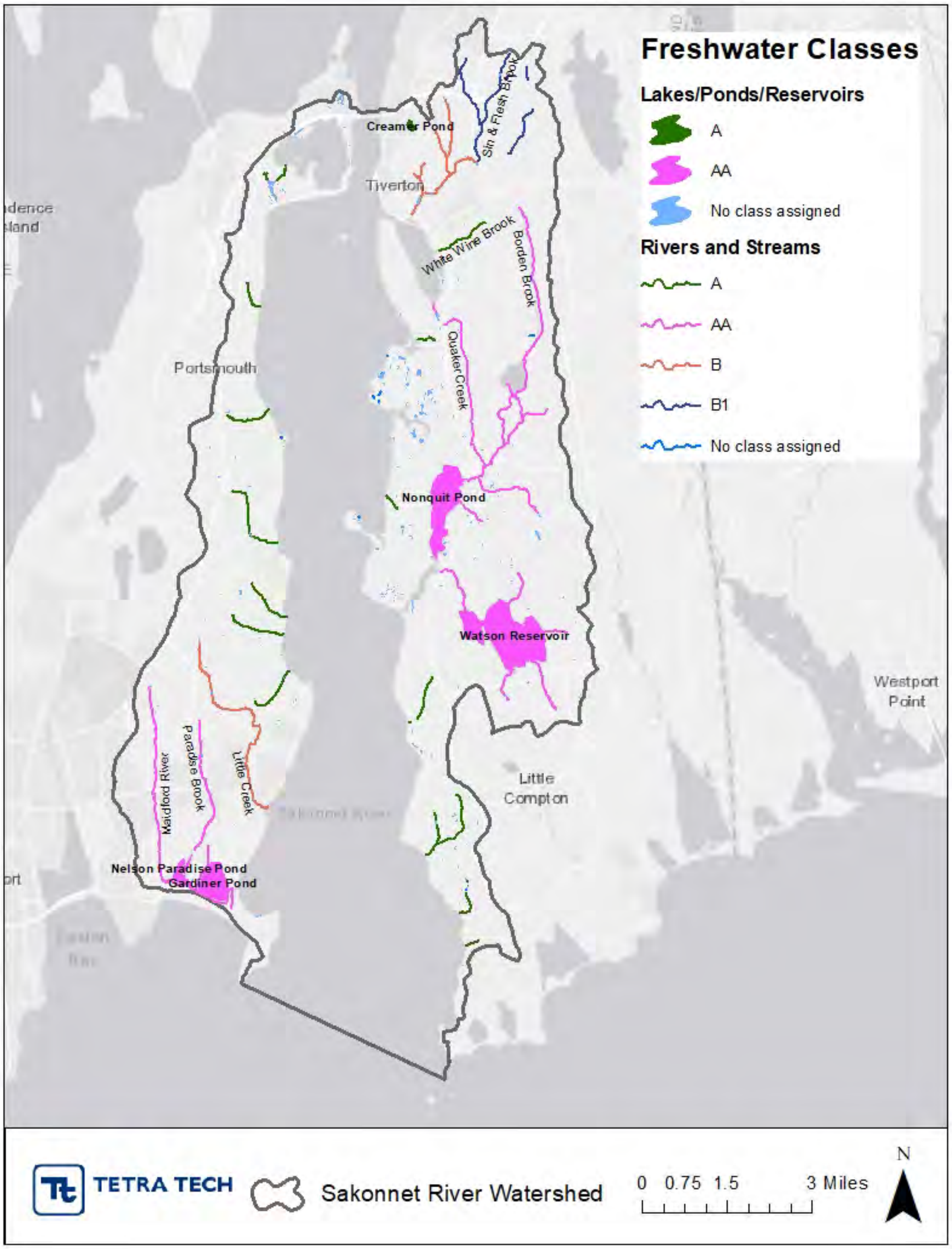

Figure 16. Freshwater classifications for the Sakonnet River watershed.

Water classes are in turn defined by the designated uses. Designated uses are the desirable uses that surface waters should support such as swimming (i.e., primary contact recreation) and fishing (i.e., aquatic life). Table 14 summarizes the designated uses and associated water classes that are applicable to the Sakonnet River watershed. All uses are outlined in Rhode Island's state surface water quality regulations (RIDEM 2020). Reservoirs (and associated tributaries) contributing to the Newport drinking water supply are assigned to class AA. Other freshwaters in the watershed are assigned to classes A, B, and B1 and therefore should support fish and wildlife habitat and primary and secondary contact recreational activities. Saltwater in the Sakonnet River (classes SA and SB) should support fish and wildlife habitat, primary and secondary contact recreational activities, and shellfish harvesting for direct human consumption or controlled relay and depuration.

Table 14. Designated uses and applicable surface water classes for surface waters in the Sakonnet River watershed (RIDEM 2020)

Designated Use	Description	Applicable Surface Water Class
Public drinking water supply	The water body can supply safe drinking water with conventional treatment.	AA
Primary contact recreation	Swimming, water skiing, surfing, and similar water contact activities where a high degree of bodily contact with the water, immersion, and ingestion are likely.	AA, A, B, B1, B; SA, SB
Secondary contact recreation	Boating, canoeing, fishing, kayaking, or other recreational activities in which there is minimal contact by the human body with the water and the probability of immersion and/or ingestion of the water is minimal.	AA, A, B, B1, B; SA, SB
Fish and wildlife habitat	Waters suitable for the protection, maintenance, and propagation of a viable community of aquatic life and wildlife.	AA, A, B, B1, B; SA, SB
Shellfish harvesting for direct human consumption	The water body supports a population of shellfish and is free from pathogens that could pose a human health risk to consumers	SA
Shellfish harvesting for controlled relay and depuration	Waters are suitable for the transplant of shellfish to Class SA waters for ambient depuration and controlled harvest.	SB
No specific analogous use, but implicit in “fish and wildlife habitat”	The water body supports fish free from contamination that could pose a human health risk to consumers.	AA, A, B, B1, B; SA, SB

Relevant Water Quality Criteria (Nutrients, Sediment, Bacteria)

The second major component of Rhode Island’s water quality standards is the criteria intended to protect the designated uses of all surface waters. Criteria can be expressed in either numeric or narrative form. A water body that meets the criteria for its assigned classification is considered to meet its intended use.

A summary of applicable water quality standards found for key water quality parameters in the Sakonnet Watershed assessment area are given in Table 15. More details can be found in Rhode Island’s Water Quality Regulations (RIDEM 2020) and in Rhode Island’s *2022 Consolidated Assessment and Listing Methodology (CALM) for Section 305(B) and 303(D) Integrated Water Quality Monitoring and Assessment Reporting* (RIDEM 2021a).

The regulations do not contain numeric criteria for nutrients and sediment in rivers or estuarine waters. However, numeric water quality criterion for TP have been adopted in lakes and tributaries at the point they enter lakes. TP may be listed as the suspected cause of impairment in freshwater rivers with persistent eutrophication and/or low dissolved oxygen. Similarly, total nitrogen (TN) may be listed as the suspected cause of impairment in saltwater’s (RIDEM 2021a). Rhode Island’s regulations also contain narrative nutrient criteria for nutrient concentrations associated with cultural eutrophication (anthropogenic sources of nutrients) that cause undesirable or nuisance aquatic vegetation or render waters unsuitable for the designated uses (RIDEM 2020).

For bacteria, Rhode Island primarily uses enterococci to determine risk associated with primary and secondary contact recreation activities in freshwater. Sections 1.10(D)(1) and 1.10(E)(1) of the Water Quality Regulations (RIDEM 2020) identify two types of recreational uses:

1. Primary Contact Recreation defined as "those water-related recreational activities that involve significant ingestion risks and includes, but is not limited to, swimming, diving, surfing, and water skiing."
2. Secondary Contact Recreation defined as "those water-related recreational activities where the probability of water ingestion is minimal and includes, but is not limited to, boating and fishing."

The water quality standards have maintained FC criteria for use in evaluating swimming use when adequate enterococci data are not available. In some freshwaters where *E. coli* data are available, the EPA criteria for this indicator is used to evaluate exceedances (RIDEM 2020).

Table 15. Applicable water quality standards in the NWQI assessment area (Source: RIDEM 2020)

Water Quality Parameter	Water Quality Criteria	Comment
Total Phosphorus	**Numeric:** Average TP < 0.025 mg/L in any lake, pond, kettle hole or reservoir, and tributaries at the point where they enter such bodies of water **Narrative:** None in such concentration that would impair any usages specifically assigned to said Class, or cause undesirable or nuisance aquatic species associated with cultural eutrophication, nor cause exceedance of the criterion above in a downstream lake, pond, or reservoir.	Exception if as naturally occurs
Total Nitrogen	**Narrative:** None in such concentration that would impair any usages specifically assigned to said Class, or cause undesirable or nuisance aquatic species associated with cultural eutrophication, nor cause exceedance of the criterion above in a downstream lake, pond, or reservoir.	EPA Guidance for Northeastern Coastal Zone: 610 µg/L
Total Suspended Solids	No EPA or RIDEM criteria	EPA guidance 25,000 µg/L for protection of juvenile fish, larvae, and eggs.
Turbidity	**Narrative:** None in such concentrations that would impair any usages specifically assigned to this class. Turbidity not to exceed 5 NTU over background.	-
Bacteria – Fecal Coliform	**Primary Contact Recreation**: • Geometric mean < 200 most probable number (MPN)/100 mL • No more than 10% of the total samples taken > 400 MPN/100 mL	Applied only when adequate enterococci data are not available
Bacteria – Enterococci	**Primary Contact Recreation:** • Non-Designated Bathing Beach Waters Geometric Mean Density: 54 colonies/100 mL	Only applies May through October

Water Quality Parameter	Water Quality Criteria	Comment
Dissolved Oxygen	**Cold Water Fish Habitat**: • Daily average ≥ 75% saturation • Instantaneous minimum 5 mg/L	Exception if naturally occurs
	Cold water fish spawning areas; early life stages not directly exposed to the water column: • 7 day mean ≥ 9.5 mg/L not directly exposed • Instantaneous minimum ≥ 8 mg/L	October 1 to May 14
	Cold water fish spawning areas; early life stages exposed to the water column: • 7 day mean ≥ 6.5 mg/L not directly exposed • Instantaneous minimum ≥ 5.0 mg/L	October 1 to May 14
	Warm Water Fish Habitat: • Daily average ≥ 60% saturation • Instantaneous minimum ≥ 5.0 mg/L, except as naturally occurs • 7 day mean ≥ 6 mg/L	Exception if naturally occurs
pH	6.5–9.0 pH units or as naturally occurs	-
Dissolved Organic Carbon	No known in-stream criteria or guidance	-
Iron	1000 µg/L	-

Antidegradation

The third component of water quality standards is antidegradation, which is a provision designed to preserve and protect the existing beneficial uses and to minimize degradation of the state's surface waters (Part 250-RICR-150-05-1.20 of RIDEM 2020). Antidegradation applies to "to all projects or activities subject to these regulations which will likely lower water quality or affect existing or designated water uses, including but not limited to all Water Quality Certification reviews and any new or modified [Rhode Island Discharge Elimination System (RIPDES)] permits." The antidegradation regulations consist of four tiers of water quality protection:

- Tier 1: Protection of Existing Uses
- Tier 2: Protection of Water Quality in High Quality Waters
- Tier 2½: Protection of Water Quality for Special Resource Protection Waters (SRPWs)
- Tier 3: Protection of Water Quality for Outstanding National Resource Waters (ONRWs)

Impairments

The recent State of Rhode Island 2022 Integrated Water Quality Monitoring and Assessment Report summarizes impaired water bodies within the watershed and lists the causes of impairments (RIDEM 2022). Table 16 lists impaired waterbodies and Figure 17 shows the location of impaired assessment units within the watershed.

Nelson Paradise Pond, Gardiner Pond, Nonquit Pond, and Watson Reservoir are currently listed as impaired due to TOC and TP exceedances. TP impairments are also reported for Maidford River, Paradise Brook, Borden Brook, Quaket Creek, and tributaries to Nonquit Pond and Watson Reservoir (RIDEM 2022).

Maidford River is also impaired due to lead, turbidity, and a low score benthic macroinvertebrate bioassessment. Maidford River and Paradise Brook have approved TMDLs for FC (FB Environmental Associates, Inc. 2011). Enterococci impairments are currently evident in Little Creek, Sin & Flesh Brook, Borden Brook, Quaket Creek, Pachet Brook (enterococci and FC), and tributaries to Nonquit Pond and Watson Reservoir (see Table 16 for the associated water body IDs).

Shellfishing is currently prohibited for some estuarine parts of the Sakonnet River. FC TMDLs have been approved for some of these impaired areas (FB Environmental Associates, Inc. 2011).

Table 16. Impaired freshwaters within the Sakonnet River watershed

Water body ID (WBID)	**Water body Name**	**Impairment (Category)**
RI0007035R-02A	Maidford River	FC (4A); lead (5); turbidity (5); benthic macroinvertebrates bioassessments (5); TP (5)
RI0007035R-02B	Maidford River	FC (4A)
RI0007035R-03	Paradise Brook	FC (4A); turbidity (5); TP (5)
RI0010031R-02	Little Creek	*Enterococcus* (5)
RI0010031R-05B	Sin & Flesh Brook	*Enterococcus* (5)
RI0010031R-01	Borden Brook	TP(5); *Enterococcus* (5)
RI0010031R-04	Quaket Creek	*Enterococcus* (5); TP (5); iron (5)
RI0010031R-20	Tributary to Nonquit Pond	TP(5); *Enterococcus* (5)
RI0010031R-03	Pachet Brook	FC (5); *Enterococcus* (5)
RI0010031R-21	Tributaries to Watson Reservoir	TP (5)
Reservoirs		
RI0007035L-02	Nelson Paradise Pond	Flow regime modification (4C); TOC (5); TP (5)
RI0007035L-01	Gardiner Pond	Flow regime modification (4C); TOC (5); TP(5)
RI0007035L-08	Nonquit Pond	TOC (5); TP (5)
RI0007035L-07	Watson Reservoir	TOC (5); TP (5)

Notes:
4A - Impaired water body with approved TMDL
4C - No TMDL required. Impairment is not a pollutant
5 - Impaired water body requiring a TMDL

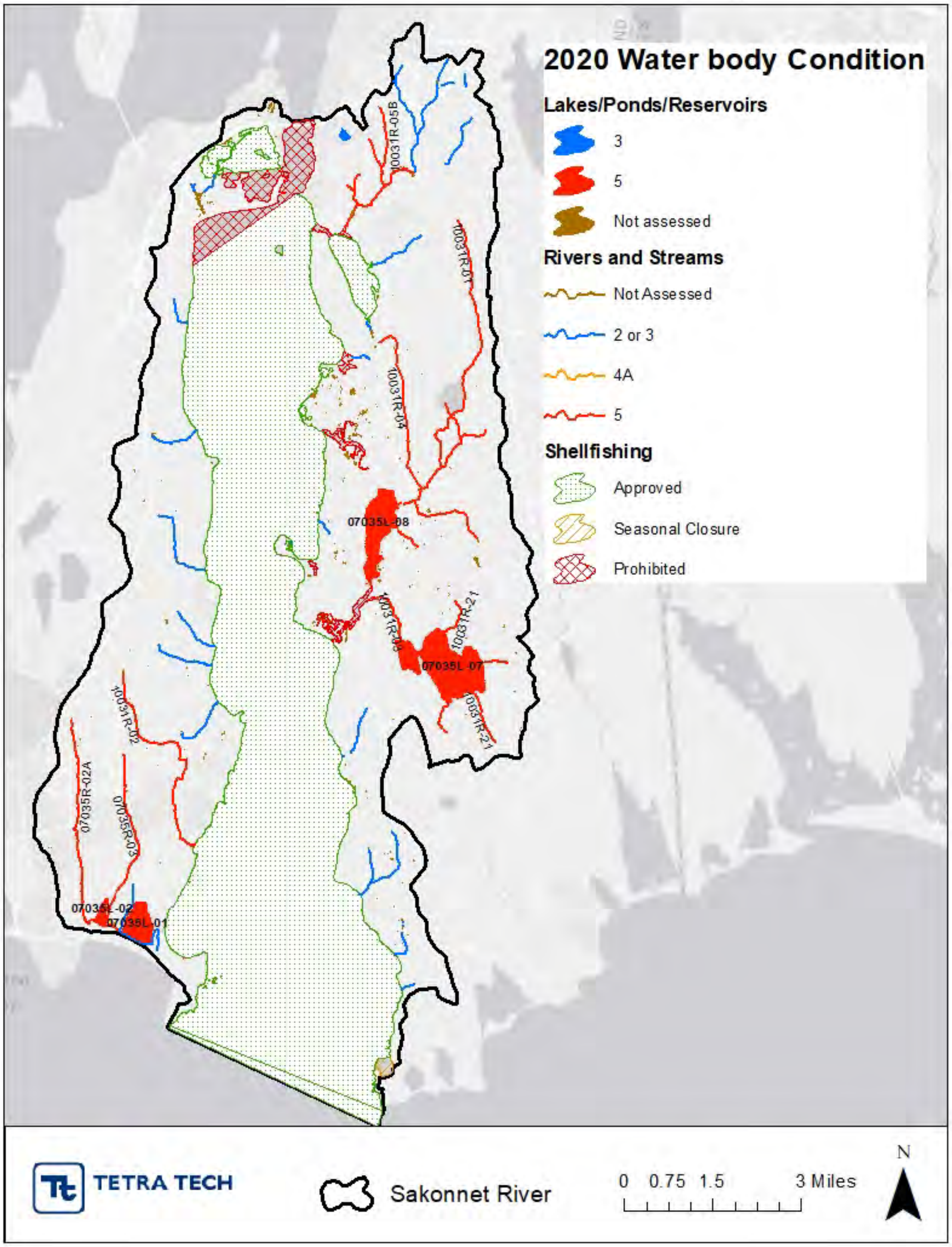

Figure 17. Impaired water bodies in the Sakonnet River watershed. Category 5: impaired or threatened, require a TMDL. Category 4A: impaired or threatened, TMDL has been completed; Category 3: insufficient or no data/information to make an assessment decision; Category 2: attain some of the designated uses, insufficient or no data/information available to determine if remaining uses are attained.

Water Quality Monitoring Data

Available Data and Site Locations

Water quality monitoring data are available for a number water bodies within the Sakonnet River watershed. As part of the NWQI, monitoring took place on six occasions between December 2014 and January 2016 at sites on the Maidford River and Paradise Brook (RIDEM 2017). Additionally, a University of Rhode Island project collected real-time water quality data (in-situ sensors) between October 2014 and March 2017 on the Maidford River (Frazar et al. 2019). Bacteria monitoring has also been conducted at locations in the Maidford River and Paradise Brook since the mid-2000s. Monitoring as part of NWQI was conducted on six occasions at numerous locations along the tributaries to Nonquit Pond (Borden Brook, Quaket Creek, and others unnamed) between November 2016 and October 2017 (RIDEM 2018b).

A selection of data from NWQI and RIDEM monitoring is used to characterize current water quality conditions in streams and reservoirs within the watershed. More information on the locations of the water quality monitoring sites used to assess current conditions in the watershed can be found in associated NWQI Water Quality Study and Pollutant Source Identification reports for Nonquit Pond Tributaries and Maidford River and Paradise Brook. Pertinent data are summarized in the following sections.

Rivers and Streams

Total Phosphorus: Observed TP concentrations (dry and wet weather sampling) for selected sites on the Maidford River and Paradise Brook between December 2014 and January 2016 are displayed in Figure 18. TP concentrations ranged from 18 to 4,700 µg/L at sites on Maidford River and 42 to 2,800 µg/L at sites on Paradise Brook (Figure 18). Median TP concentrations at all sites on Maidford River and Paradise Brook exceeded the state water quality standards (tributaries to lake/pond/reservoir: 25 µg/L) and EPA level III ecoregion guidance (reference condition for level III ecoregion 59 streams: 24 µg/L).

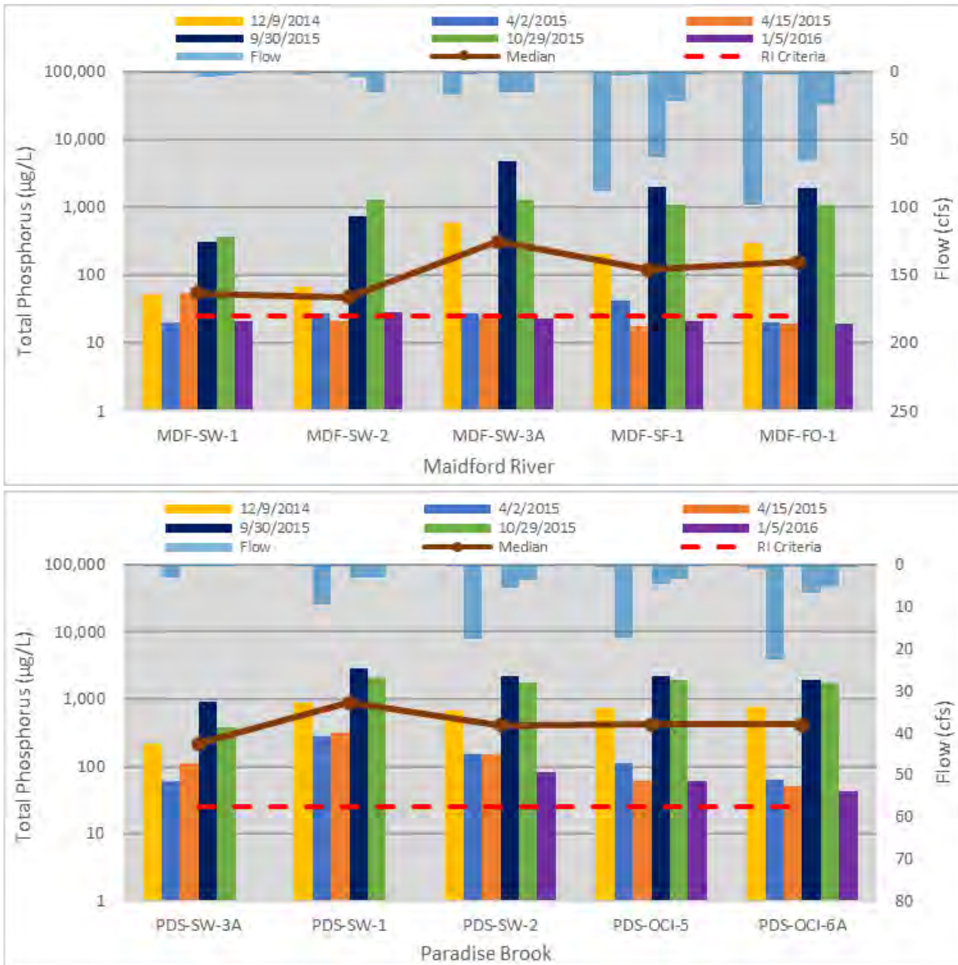

Figure 18. Observed total phosphorus concentrations at selected sites on the Maidford River (top) and Paradise Brook (bottom) between December 2014 and January 2016.

Observed TP concentrations (dry and wet weather sampling) for selected sites on Borden Brook, Quaket Creek, and an unnamed tributary to Nonquit Pond between November 2016 and October 2017 are displayed in Figure 19. TP concentrations ranged from 10 to 170 µg/L at sites on Borden Brook, 10 to 290 µg/L at sites on Quaket Creek, and 10 to 820 µg/L at two sites on the unnamed tributary (Figure 19). Median TP concentrations at all sites on Quaket Creek and the unnamed tributary exceeded the state water quality and EPA level III ecoregion guidance. Median TP concentrations at two downstream sites on Borden Creek (Bt and B3, after the confluence of Quaket Creek) exceeded the state water quality standard.

Observed ranges and medians for dissolved P in the Maidford River, Paradise Brook, Borden Brook, Quaket Creek, and the unnamed tributary are provided in Table 17.

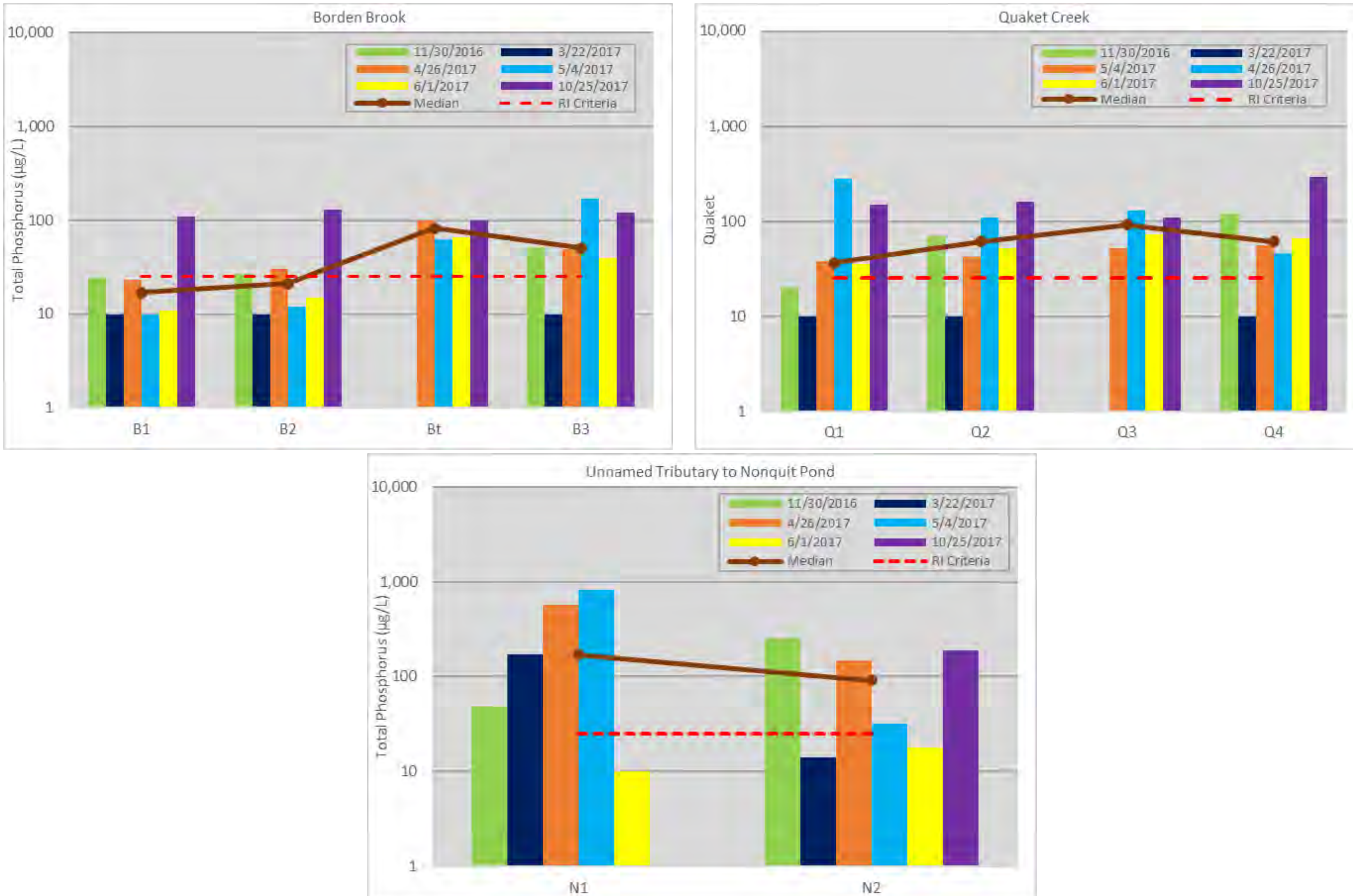

Figure 19. Observed total phosphorus concentrations at selected sites on Borden Brook (top left), Quaket Creek (top right) and an unnamed tributary to Nonquit Pond (bottom) between November 2016 and October 2017. The limit of detection for TP samples was 10 µg/L.

Total Nitrogen: Observed TN concentrations (dry and wet weather sampling) for sites on the Maidford River and Paradise Brook between December 2014 and January 2016 are displayed in Figure 20. TN concentrations ranged from 830 to 4,290 µg/L at sites on the Maidford River and 1,450 to 6,790 µg/L at sites on Paradise Brook. Median TN concentrations at all sites on the Maidford River and Paradise Brook exceeded EPA level III ecoregion guidance for TN of 610 µg/L (reference condition for level III ecoregion 59 streams).

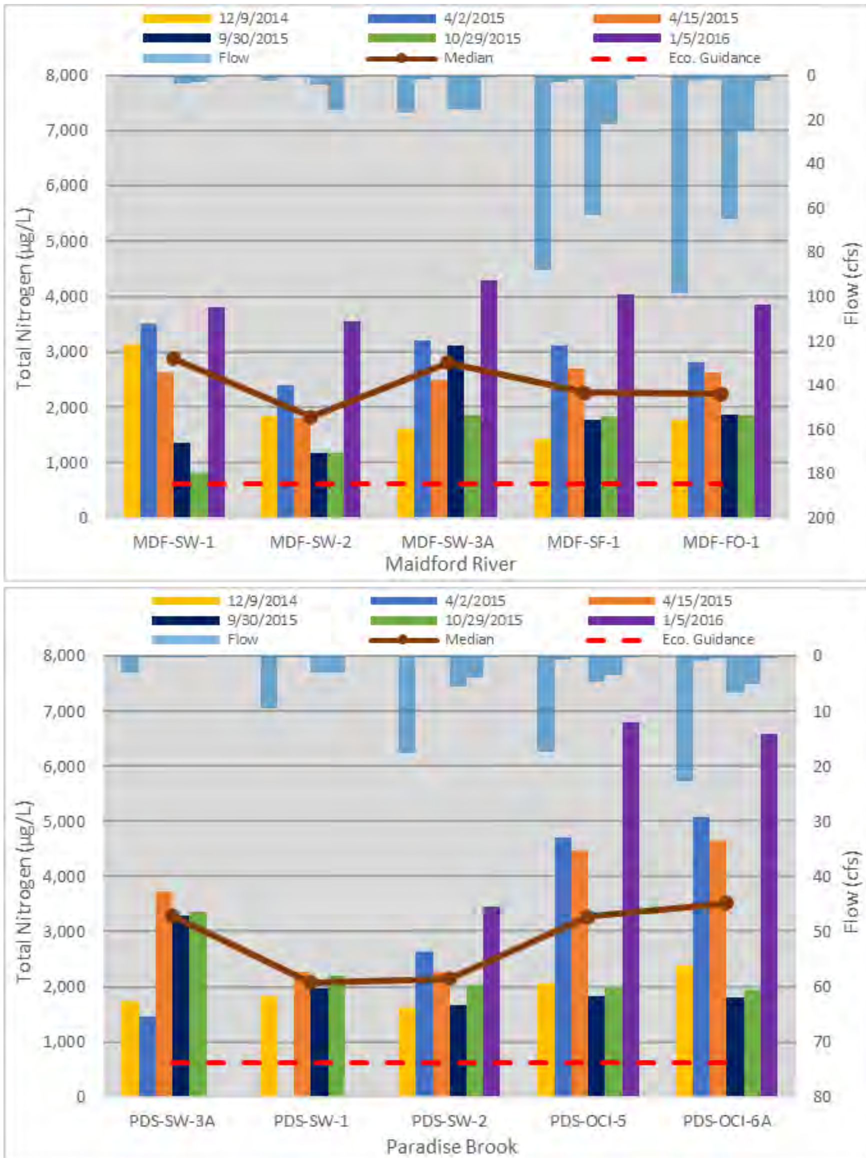

Figure 20. Observed total nitrogen concentrations at selected sites on the Maidford River (top) and Paradise Brook (bottom) between December 2014 and January 2016.

Observed TN concentrations (dry and wet weather sampling) for sites on Borden Brook, Quaket Creek, and an unnamed tributary to Nonquit Pond between November 2016 and October 2017 are displayed in Figure 21. TN concentrations ranged from 360 to 1,520 µg/L at sites on Borden Brook, 286 to 5,950 µg/L at sites on Quaket Creek, and 625 to 2,530 µg/L on the unnamed tributary (Figure 21). Median TN concentrations at all sites on Quaket Creek and the unnamed tributary exceeded the state water quality and EPA level III ecoregion guidance. Three sites on Borden Brook (B1, Bt and B3) exceeded the EPA ecoregion guidance for median TN values.

Observed ranges and median concentrations for ammonia, total Kjeldahl nitrogen (TKN), nitrate, and organic nitrogen in Maidford River, Paradise Brook, Borden Brook, Quaket Creek, and the unnamed tributary are provided in Table 17.

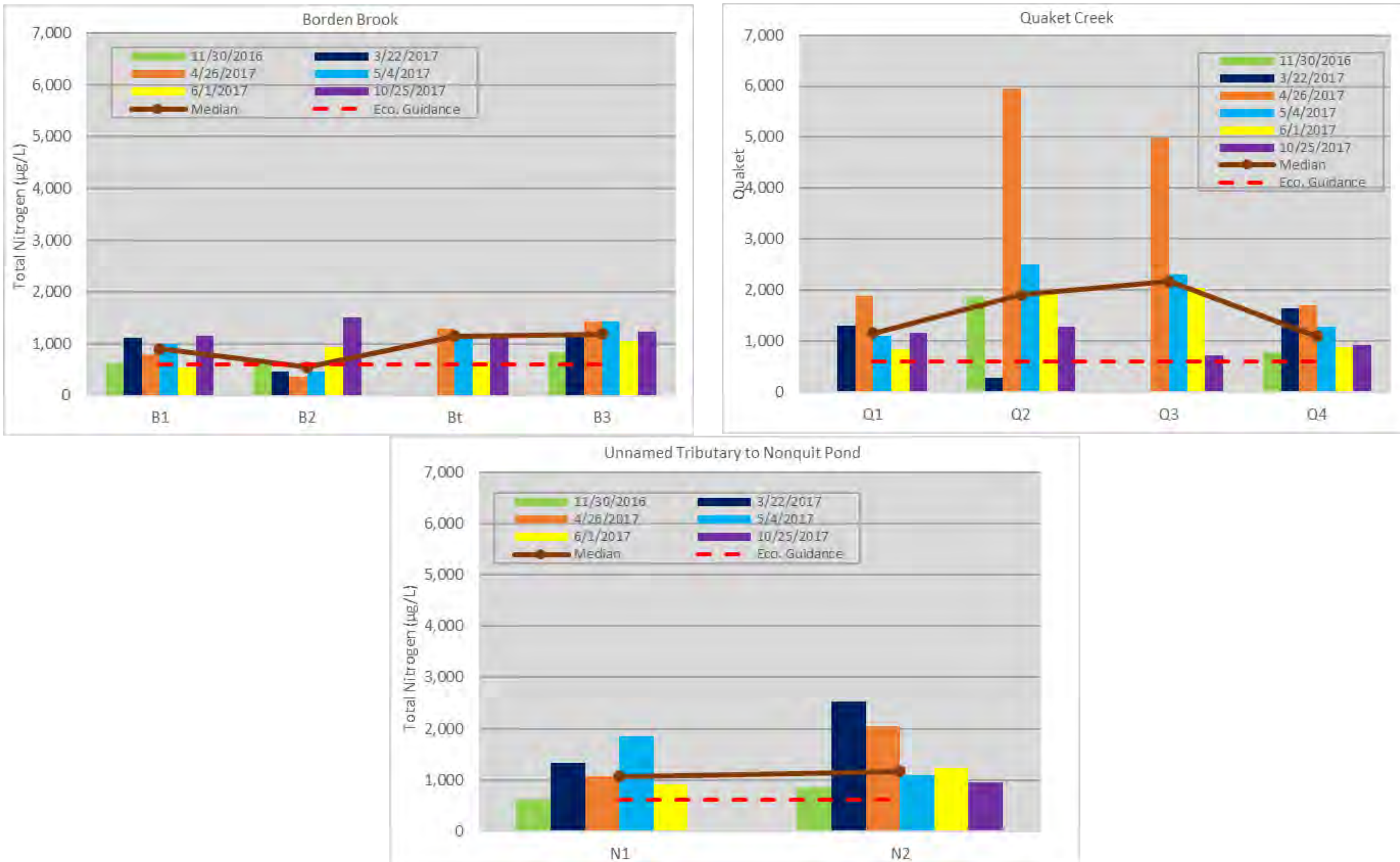

Figure 21. Observed total nitrogen concentrations at selected sites on Borden Brook (top left), Quaket Creek (top right) and an unnamed tributary to Nonquit Pond (bottom) between November 2016 and October 2017.

Total Suspended Solids: Observed total suspended solids (TSS) concentrations (dry and wet weather sampling) for sites on the Maidford River and Paradise Brook between December 2014 and January 2016 are displayed in Figure 22. TSS concentrations ranged from 1,000 to 450,000 µg/L at sites on Maidford River and 200 to 210,000 µg/L at sites on Paradise Brook. Median TSS concentrations at all sites on Maidford River were below the EPA guidance for protection of juvenile fish, larvae, and eggs (25,000 µg/l). Median TSS concentrations at two sites on Paradise Brook (PDS-SW1 and PDS-OCI-6A) exceeded the EPA guidance value.

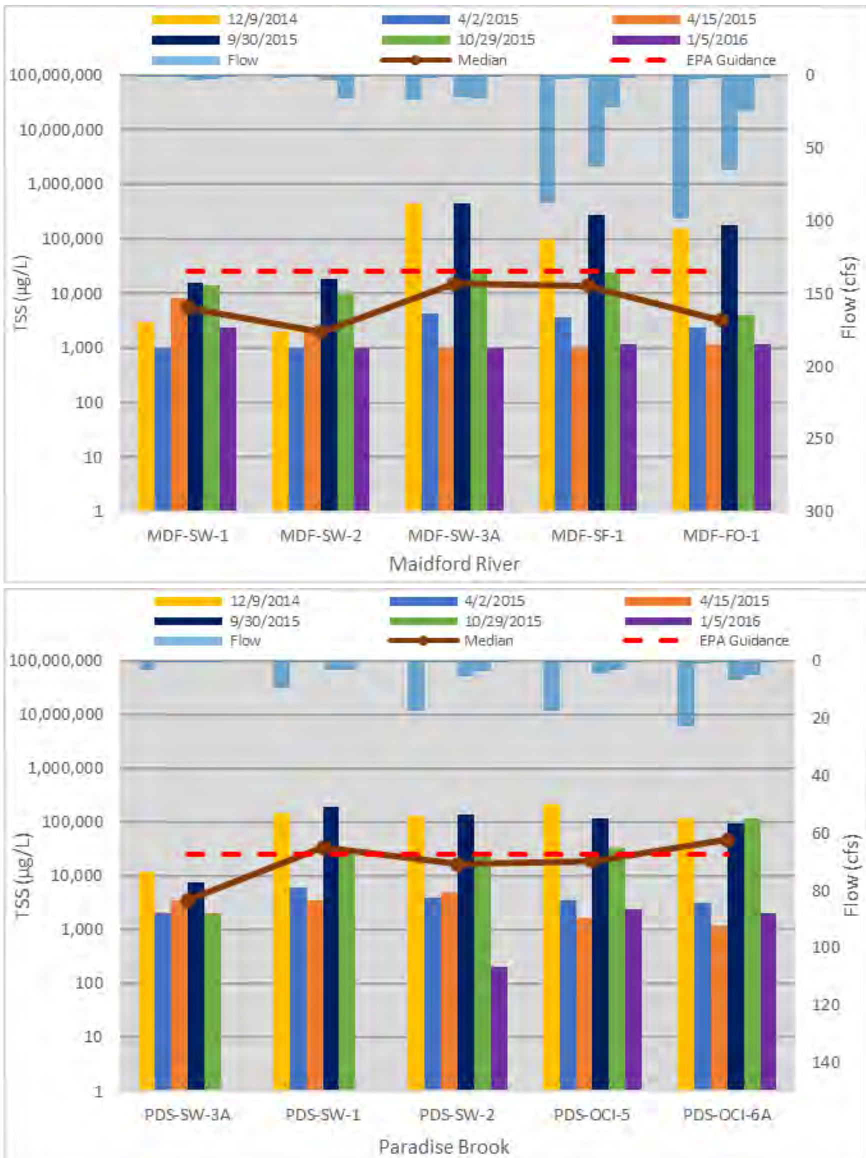

Figure 22. Observed total suspended solids concentrations at selected sites on Maidford River (top) and Paradise Brook (bottom) between December 2014 and January 2016. The limit of detection for TSS samples in Maidford River was 1,000 µg/l.

Observed TSS concentrations (dry and wet weather sampling) for sites on Borden Brook, Quaket Creek, and an unnamed tributary to Nonquit Pond between November 2016 and October 2017 are displayed in Figure 23. TSS concentrations ranged from 1,000 to 12,000 µg/L at sites on Borden Brook, 1,600 to 16,000 µg/L at sites on Quaket Creek, and 1,000 to 30,000 µg/L on the unnamed tributary (Figure 23). Median TSS concentrations at all sites on Quaket Creek, Borden Brook, and the unnamed tributary were below the EPA guidance value.

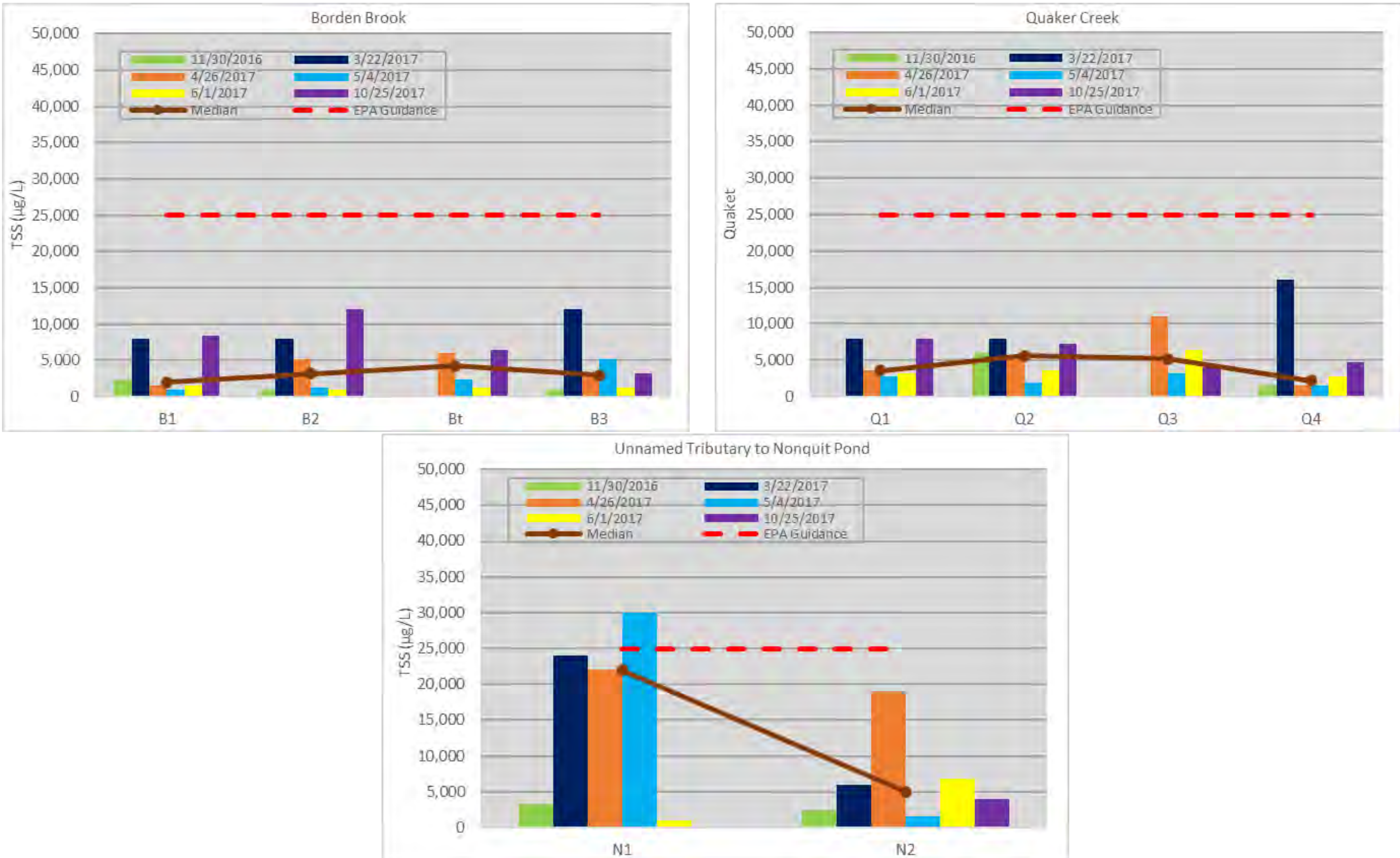

Figure 23. Observed total suspended solids concentrations at selected sites on Borden Brook (top left), Quaket Creek (top right) and an unnamed tributary to Nonquit Pond (bottom) between November 2016 and October 2017. The limit of detection for TSS samples was 1,000 µg/l.

Bacteria: Observed FC concentrations (dry and wet weather sampling) for sites on the Maidford River and Paradise Brook between December 2014 and January 2016 are displayed in Figure 24. FC concentrations ranged from 2 to 16,400 colony forming units (CFU)/100 mL at sites on Maidford River and from 2 to 190,000 CFU/100 mL at sites on Paradise Brook. The geometric mean concentration at all sites on Paradise Brook was above the state geometric mean standard for primary contact recreation (200 CFU/100 mL). Geometric mean concentrations at three downstream sites on the Maidford River (MDF-SW-3A, MDF-SF-1, and MDF-FO-1) were also above the state geometric mean standard for primary recreation.

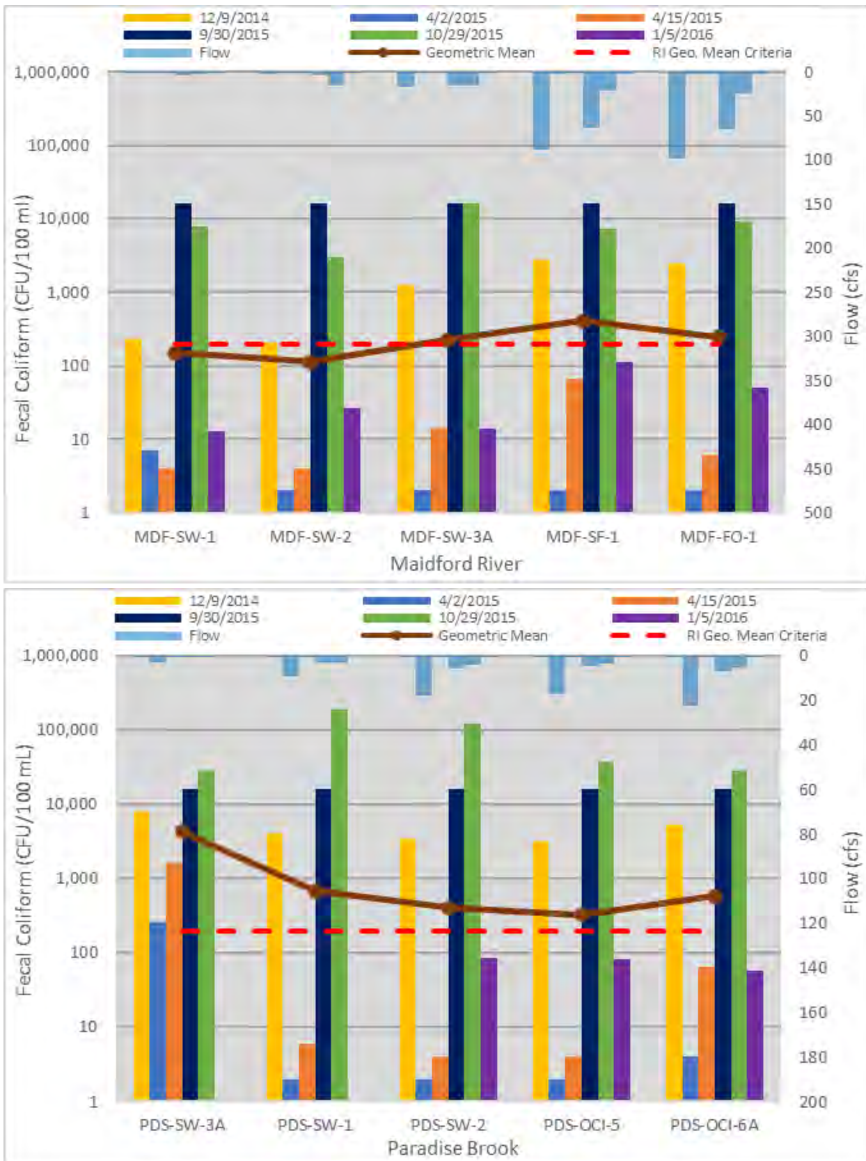

Figure 24. Observed fecal coliform concentrations at selected sites on the Maidford River (top) and Paradise Brook (bottom) between December 2014 and January 2016. The limits of detection for FC samples were 2 CFU/100 ml and 16,000 CFU/100 mL.

Observed enterococci concentrations (dry and wet weather sampling) for sites on Borden Brook, Quaket Creek, and an unnamed tributary to Nonquit Pond between March 2017 and October 2017 are displayed in Figure 25. Enterococci concentrations ranged from 2 to 14,100 most probably number (MPN)/100 mL at sites on Borden Brook, 10 to 7,700 MPN/100 mL at sites on Quaket Creek, and from 10 to 15,500 MPN/100 mL on the unnamed tributary. The geometric mean concentration at all sites on Quaket Creek and the unnamed tributary were above the state geometric mean standard for primary contact recreation in non-designated bathing beach waters (54 colonies/100 mL). Geometric mean concentrations at three sites on Borden Brook (B2, Bt, and B3) were also above the state geometric mean standard.

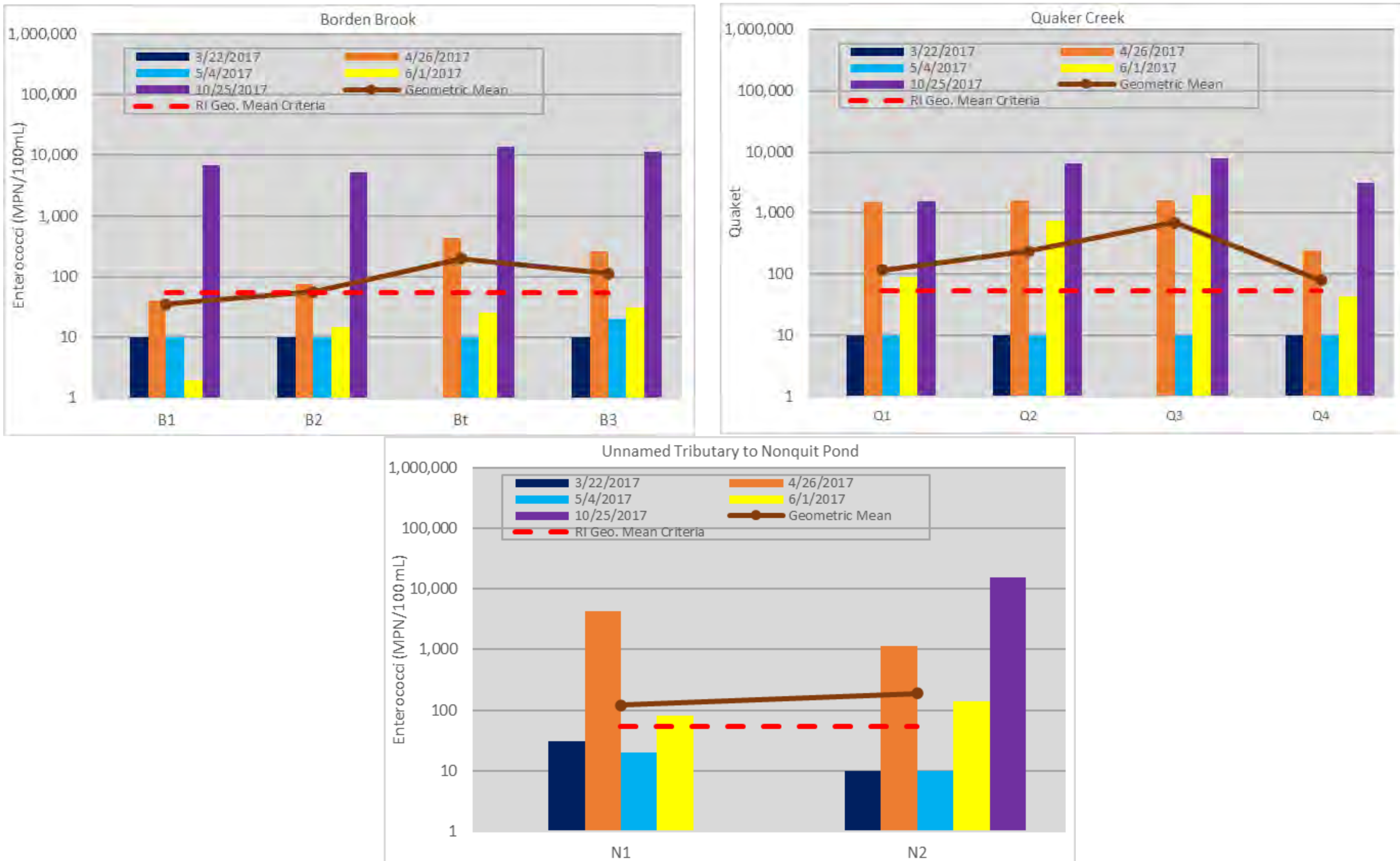

Figure 25. Observed enterococci concentrations at selected sites on Borden Brook (top left), Quaket Creek (top right), and an unnamed tributary to Nonquit Pond (bottom) between March 2017 and October 2017. The limit of detection for enterococci samples was 10 MPN/100 mL.

Other Water Quality Parameters: a summary of water quality monitoring results for other parameters on the Maidford River, Paradise Brook, Borden Brook, Quaket Creek, and the unnamed tributary are shown in Table 17. The median DO concentration for Quaket Creek was below the RIDEM instantaneous minimum threshold (5 µg/L). For Paradise Brook and the unnamed tributary, median turbidity measurements were also above the state standard.

Median TKN values for the Maidford River, Paradise Brook, Borden Brook, Quaket Creek, and the unnamed tributary were above the Level III ecoregion (Eastern Coastal Plain) guidance of 300 µg/L. Median nitrate values for the Maidford River and Paradise Brook were also above the Level III ecoregion (Eastern Coastal Plain) guidance of 310 µg/L.

Table 17. Summary of monitoring results for other water quality parameters in the Maidford River, Paradise Brook, Borden Brook, Quaket Creek, and an unnamed tributary to Nonquit Pond

Parameter	Maidford River		Paradise Brook		Borden Brook		Quaket Creek		Unnamed Tributary		Thresholds
	Range	Median	Range	Median	Range	Median	Range	Median	Range	Median	
Temperature (°C)	ND	ND	ND	ND	3.9–17.2	12.1	2.5–17.2	12.2	10.1–17.5	13.2	RIDEM: 28.33 °C
Dissolved Oxygen (mg/L)	ND	ND	ND	ND	5.6–15	9.5	0.1–8.9	**4.8**	7.3–10.4	8.6	RIDEM: Instantaneous min ≥ 5 µg/L
Specific Conductance (µs/cm)	ND	ND	ND	ND	69–193	107	184–2,406	328	70–177	93	NHDES Guidance: 835 µs/cm
pH	ND	ND	ND	ND	5.5–9.6	7.85	6.3–10	8.7	5.6–8	7.3	RIDEM: 6.5–9.0
Turbidity (NTU)	0.2–550	3.2	0.59–240	**8.55**	0.2–4.1	0.9	0.3–12	2.3	0.2–10	**5.3**	RIDEM: 5 NTU
Dissolved Organic Carbon (µg/L)	ND	ND	ND	ND	10,600–28,500	18,650	1,340–34,200	14,300	7,820–27,700	17,100	N/A
Ammonia (µg/L)	100–400	100	100–200	100	100–137	100	100–100	100	100–461	100	RIDEM: Toxicity varies with pH. At pH of 9.0, ammonia is toxic to salmonids at 885 µg/L. At pH of 6.5, ammonia is toxic to salmonids at 32,600 µg/L.
TKN (µg/L)	100–2,100	**600**	400–2,200	**1,250**	300–1,390	**985**	600–4,500	**1,200**	600–1,920	**940**	Level III ecoregion guidance: 300 µg/L
Nitrate (µg/L)	230–5,990	**1,990**	70–6,190	**820**	50–320	50	50–1,450	300	50–1,230	60	Level III ecoregion guidance: 310 µg/L
Organic Nitrogen (µg/L)	ND	ND	ND	ND	250–1,340	935	0–3,010	1,000	324–1,661	890	N/A
Dissolved Phosphorus (µg/L)	ND	ND	ND	ND	10–140	26	10–190	33	10–730	130	N/A

Bolded red font for median values indicates that the concentration was above the threshold (provided in the last column).

Ponds and Reservoirs

The aquatic life use impairment for TP in Nonquit Pond, Watson Reservoir, Gardiner Pond, and Paradise Pond (2014 303(d) list) originated from an analysis of 2011 and 2012 datasets collected by the Newport Water Department (RIDEM 2021b). These data are displayed in Table 18.

The impairment listings were confirmed with additional data collected by RIDEM in 2015. Table 19 provides a summary of trophic state related parameters, as well as the Trophic State Index (TSI) calculations in Nonquit Pond, Watson Reservoir, Gardiner Pond, and Paradise Pond from the 2015 dataset (RIDEM 2021b). The trophic status of each reservoir was calculated according to Carlson (1977).

Table 18. Mean epilimnetic total phosphorus concentrations of reservoirs in the Sakonnet River watershed

Reservoir	2011 Mean TP (mg/L)[a]	2012 Mean TP (mg/L)[a]	2015 Mean TP (mg/L)[a]
Nonquit Pond	**0.038**	**0.100**	**0.041**
Watson Reservoir	0.022	**0.058**	0.022[b]
Gardiner Pond	**0.026**	**0.032**	**0.043**
Paradise Pond	**0.058**	**0.078**	**0.080**

Notes:
Bold fond indicates exceedance of aquatic life criterion value (0.025 mg/L).
[a] N =12; RIDEM samples only. Values presented are epilimnetic mean values.
[b] Includes dataset collected in 2015 by contractors to the Newport Water Department.

Table 19. Calculated Trophic Indices from 2015 sampling of reservoirs in the Sakonnet River watershed. Epilimnetic means for each parameter are generally based on 12 samples

Reservoir	TP (µg/L)	TN (µg/L)	Chl-a (µg/L)	Secchi (meters)	Calculated Carlson Trophic State Index			Trophic State[a]
					TSI (TP)	TSI (Chl-a)	TSI (Secchi)	
Nonquit	41.3	594.9	16.2	1.0	57.8	57.9	60.0	Eutrophic
Watson	17.2	597.9	14.4	1.47	45.2	56.8	54.5	Eutrophic
Gardiner	43.1	1209.7	36.7	1.15	58.4	65.9	58.0	Eutrophic
Paradise	79.6	1191.5	37.3	0.86	67.3	66.1	62.2	Eutrophic

Note:
[a] TSI values of 50 – 70 = eutrophic

Sakonnet River (Tidal Strait)

This NWQI assessment focuses predominantly on freshwaters which drain to the Sakonnet River tidal straits. Here, however, brief context about current water quality conditions in the Sakonnet River tidal straits is provided.

Some areas of the tidal straits are already permanently closed to shellfishing due to elevated bacteria concentrations. Low dissolved oxygen conditions are also of particular concern for aquatic habitat and the overall ecological health of the system. To address concerns about the lack of data on water quality conditions in the Sakonnet River, the USGS New England Water Science Center, in cooperation with EPA Region 1 and RIDEM, conducted water quality monitoring in the Sakonnet River during 2018–2019. Data were collected from April 28 to November 11, 2018 and from June 19 to November 26, 2019. More information about these monitoring efforts can be found at the following links:

- USGS: Characterization of Water Quality in the Sakonnet River, Rhode Island, 2018-19
- USGS: Physical and Chemical Data to Characterize Water-Quality Conditions in the Sakonnet River, Rhode Island, 2018-2019

IV. Resource Analysis and Source Assessment

The resource analysis includes a source assessment, comparisons between existing and potential conditions, and the types/extent of conservation practices needed to assist in meeting the water quality goals. Ultimately these results will help establish what land uses are producing the most pollution and what practices would be the most useful in reducing nutrient and sediment loads within the watershed. Although bacteria loads are not explicitly considered in the analysis, it is expected that results would help target the main sources and lead to concurrent reductions.

Causes and Sources of the Resource Problem

Nutrients, bacteria, and sediment are the main surface water resource stressors in the Sakonnet River watershed. Four drinking water reservoirs (Paradise Pond, Gardiner Pond, Nonquit Pond, and Watson Reservoir) are currently listed as impaired due to TOC and TP exceedances. TP impairments are also reported for Maidford River, Paradise Brook, Borden Brook, Quaket Creek and tributaries to Nonquit Pond and Watson Reservoir. Additionally, bacteria impairments are evident for many of these streams (see Table 16).

Information from the watershed characterization, hydrologic characterization, and water quality characterization suggests that areas of agricultural land are likely to be key contributors of pollutant loading to water bodies in the watershed. Impaired water bodies in the Sakonnet watershed are adjacent to areas of agricultural land.

Assessment Tools

Existing and potential future water quality loads were estimated using STEPL. STEPL uses simple algorithms to calculate nutrient and sediment loads from different land uses and load reductions from implementation of conservation practices (Tetra Tech, Inc. 2018). Annual nutrient loading was calculated based on the annual runoff volume and established land use specific pollutant concentrations. The annual sediment load from sheet and rill erosion was calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. Accuracy is primarily limited by the wide variability in pollutant runoff concentrations across watersheds since these concentrations are used to calculate annual pollutant loadings.

Load reductions for the watersheds were modeled with STEPL using established conservation practice efficiencies provided in STEPL version 4.4b. The efficiencies of combined practices were calculated using STEPL's BMP Calculator. Although STEPL does not model bacteria, it is assumed that simulated nutrient and sediment load reductions would also likely help to reduce bacteria loads from agricultural sources in each drainage area.

The ACPF was applied to identify critical source areas (runoff risk) in agricultural fields and determine priority areas for structural BMPs. ACPF identifies locations where specific landscape attributes are favorable for implementing certain conservation practices and includes methods to help prioritize these locations according to their susceptibility to runoff and erosion. It was developed by the USDA's Agricultural Research Service in partnership with the USDA NRCS to support agricultural watershed management using high-resolution elevation data and uses an ArcGIS toolbox to identify site-specific opportunities for installing conservation practices across small watersheds. It is used in conjunction with local knowledge of water and soil resource concerns, landscape features, and producer conservation preferences. Together, these provide a better understanding of the options available in developing a watershed conservation plan.

Analysis and Assessment of Watershed Conditions

STEPL Model Inputs

Models were developed for the Sakonnet watershed following methods and input requirements outlined in the STEPL user's guide. Model inputs include drainage area, soil hydrologic group, land use, animal numbers, and estimates for septic systems. Land use was derived from the 2020 USDA Cropland Data Layer (USDA NASS 2021). Animal numbers were extracted from the STEPL Input Data Server and adjusted based on input from local NRCS staff. Manure application frequency was estimated by local NRCS staff and weighted proportionally according to acreage and frequency. Cropland irrigation amounts were determined based on input from local NRCS staff. Septic system information was derived from the data inputs used in the Watershed Treatment Model (WTM) developed for Newport's drinking water supply reservoirs[1]. The overall number of septic systems and average population per system were based on a weighted average of the population served by septic system type and number of septic systems in each of the reservoir drainage areas. Septic failure rates were also obtained from the WTM inputs.

USLE parameters were modified to reflect local soil erodibility (K factor) and slopes (LS factor). Soil nutrient concentrations were applied at the default values for the region.

Confined animal feeding operation (CAFO) acres were derived based on information from local NRCS staff. Each CAFO was assumed to have 800 square feet of impacted area, with 75% imperviousness. The number of feedlots was provided by local NRCS staff and 2% were reported as zero discharge facilities.

The number of gullies and their dimensions were estimated by NRCS staff based on local knowledge and assumed an average gully dimension across the watershed. The current level of BMP treatment in the Sakonnet watershed was also estimated by NRCS field staff using available data and best professional judgement. Details on currently implemented practices are outlined in upcoming sections.

Current Conditions

The watershed is evaluated as priority subwatersheds (individual reservoir drainage areas which are subject to a phosphorus TMDL) and non-priority subwatersheds (the remaining area of the Sakonnet watershed). Average annual pollutant loads, yields, and concentrations simulated by STEPL under current conditions in each drainage area are summarized in Table 20. Table 21 summarizes pollutant loads from various sources within the Sakonnet River watershed.

Within the non-priority areas of the Sakonnet watershed, urban is the dominant source of nonpoint source pollution. However, cropland and pasture/hay are also key contributors to nonpoint source pollution within the non-priority areas. Feedlots and gullies are much smaller nutrient sources.

[1] RIDEM, Office of Water Resources. 2018. *Application of the Watershed Treatment Model to the City of Newport's Drinking Water Supply Reservoirs – Summary Report*.

Pollutant loads from various sources within priority subwatersheds are summarized in Table 22 to Table 26. In the Gardiner Pond, Nonquit Pond, and Watson Pond subwatersheds, nutrients are primarily from cropland. Urban areas contribute most significantly to Maidford River nutrient loads. Nutrient sources in the Paradise Pond subwatershed are relatively evenly split between urban, cropland, and pastureland. Sediment load sources are generally proportional to the nutrient load sources by land use; however, in the Nonquit Pond subwatershed gullies are the largest source of sediment. Overall, the source assessments suggest that cropland and pasture/hay are the key land uses with potentially reducible pollutant sources in each subwatershed drainage area.

Table 20. STEPL results for existing pollutant loads, yields, and concentrations in the Sakonnet Watershed

Drainage Area	Runoff (ac-ft)	Runoff Yield (ac-ft/ac)	% Rainfall as runoff	Annual Load			Annual Yield			Mean Concentration (mg/L)		
				TN (lb/yr)	TP (lb/yr)	Sed (t/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)	Sed (t/ac/yr)	TN	TP	Sed
*Remainder of Sakonnet watershed	9,460.5	0.97	30%	65,442	11,579	1,397	6.68	1.18	0.14	2.53	0.45	106.15
Gardiner Pond	32.5	0.63	20%	246	69	17.6	4.786	1.339	0.343	2.79	0.78	400.42
Maidford River	1,347.2	0.94	30%	9,893	1,676	291.3	6.885	1.166	0.203	2.69	0.46	158.83
Nonquit Pond	2,332.8	0.56	18%	12,114	2,476	339.4	2.893	0.591	0.081	1.90	0.39	106.38
Paradise Pond	389.3	0.77	24%	2,862	540	90.9	5.654	1.067	0.179	2.70	0.51	170.97
Watson Reservoir	1,199.2	0.63	20%	7,386	1,558	251.8	3.877	0.818	0.132	2.26	0.48	154.10

Notes:

TN = total nitrogen; TP = total phosphorus; Sed = sediment; ac-ft = acre-feet; ac-ft/ac = acre-feet per acre; lb/yr = pounds per year; t/yr = tons per year; lb/ac/yr = pounds per acre per year; t/ac/yr = tons per acre per year; mg/L = milligrams per liter

*All areas of the watershed that are not part of Gardiner Pond, Maidford River, Nonquit Pond, Paradise Pond and Watson Reservoir drainage areas.

Table 21. Summary of current source contributions within non-priority subwatersheds of the Sakonnet watershed

Sources	TN Load (lb/yr)	TN Load %	TP Load (lb/yr)	TP Load %	Sediment Load (t/yr)	Sediment Load %
Urban[a,b]	32,790	50%	5,062	44%	753	54%
Cropland	11,835	18%	2,807	24%	321	23%
Pasture/Hay	12,158	19%	1,479	13%	232	17%
Forest	438	1%	215	2%	11	1%
Feedlots	3,747	6%	252	2%	0	0%
Septic	4,244	6%	1,662	14%	0	0%
Gullies	230	0%	101	1%	79	6%
Total[c]	***65,442***	***100%***	***11,579***	***100%***	***1,397***	***100%***

Notes:

[a] Urban loads are presented for information only and may represent an overestimate, as no existing BMPs or other load reduction measures have been applied to the existing conditions for this land use.

[b] Urban sources include both residential and commercial sources.

[c.] Any differences in the totals are a result of rounding.

Table 22. Summary of current source contributions for the Gardiner Pond subwatershed drainage area

Sources	TN Load (lb/yr)	TN Load %	TP Load (lb/yr)	TP Load %	Sediment Load (t/yr)	Sediment Load %
Urban[a,b]	30.5	12%	4.7	7%	0.7	4%
Cropland	103.8	42%	30.7	45%	7.1	41%
Pasture/Hay	60.6	25%	11.6	17%	3.2	18%
Forest	12.8	5%	6.1	9%	0.9	5%
Feedlots	0.0	0%	0.0	0%	0.0	0%
Septic	21.3	9%	8.3	12%	0.0	0%
Gullies	16.4	7%	7.2	11%	5.7	32%
Total[c]	***245.5***	***100%***	***68.7***	***100%***	***17.6***	***100%***

Notes:

[a] Urban loads are presented for information only and may represent an overestimate, as no existing BMPs or other load reduction measures have been applied to the existing conditions for this land use.

[b] Urban sources include both residential and commercial sources.

[c.] Any differences in the totals are a result of rounding.

Table 23. Summary of current source contributions for the Maidford River subwatershed drainage area

Sources	TN Load		TP Load		Sediment Load	
	(lb/yr)	%	(lb/yr)	%	(t/yr)	%
Urban[a,b]	4335.2	44%	669.2	40%	99.6	34%
Cropland	1908.6	19%	482.4	29%	73.1	25%
Pasture/Hay	2375.9	24%	330.9	20%	65.6	23%
Forest	56.0	1%	27.3	2%	2.1	1%
Feedlots	981.3	10%	66.0	4%	0.0	0%
Septic	88.5	1%	34.7	2%	0.0	0%
Gullies	148.0	1%	65.1	4%	51.0	18%
Total[c]	**9893.4**	***100%***	**1675.6**	***100%***	**291.3**	***100%***

Notes:

[a] Urban loads are presented for information only and may represent an overestimate, as no existing BMPs or other load reduction measures have been applied to the existing conditions for this land use.
[b] Urban sources include both residential and commercial sources.
[c.] Any differences in the totals are a result of rounding.

Table 24. Summary of current source contributions for Nonquit Pond subwatershed drainage area

Sources	TN Load		TP Load		Sediment Load	
	(lb/yr)	%	(lb/yr)	%	(t/yr)	%
Urban[a,b]	1807.3	15%	279.0	11%	41.5	12%
Cropland	4573.5	38%	902.3	36%	71.9	21%
Pasture/Hay	2094.0	17%	270.4	11%	47.6	14%
Forest	1015.8	8%	497.1	20%	31.0	9%
Feedlots	1605.8	13%	108.1	4%	0.0	0%
Septic	590.6	5%	231.3	9%	0.0	0%
Gullies	427.5	4%	188.1	8%	147.4	43%
Total[c]	**12114.4**	***100%***	**2476.3**	***100%***	**339.4**	***100%***

Notes:

[a] Urban loads are presented for information only and may represent an overestimate, as no existing BMPs or other load reduction measures have been applied to the existing conditions for this land use.
[b] Urban sources include both residential and commercial sources.
[c.] Any differences in the totals are a result of rounding.

Table 25. Summary of current source contributions for the Paradise Pond subwatershed drainage area

Sources	TN Load		TP Load		Sediment Load	
	(lb/yr)	**%**	**(lb/yr)**	**%**	**(t/yr)**	**%**
Urban[a,b]	889.1	31%	137.2	25%	20.4	22%
Cropland	564.1	20%	147.7	27%	25.3	28%
Pasture/Hay	782.4	27%	117.3	22%	25.6	28%
Forest	60.4	2%	29.3	5%	2.6	3%
Feedlots	356.8	12%	24.0	4%	0.0	0%
Septic	160.3	6%	62.8	12%	0.0	0%
Gullies	49.3	2%	21.7	4%	17.0	19%
Total[c]	**2862.4**	***100%***	**540.0**	***100%***	**90.9**	***100%***

Notes:

[a] Urban loads are presented for information only and may represent an overestimate, as no existing BMPs or other load reduction measures have been applied to the existing conditions for this land use.
[b] Urban sources include both residential and commercial sources.
[c.] Any differences in the totals are a result of rounding.

Table 26. Summary of current source contributions for the Watson Reservoir subwatershed drainage area

Sources	TN Load		TP Load		Sediment Load	
	(lb/yr)	**%**	**(lb/yr)**	**%**	**(t/yr)**	**%**
Urban[a,b]	995.9	13%	153.7	10%	22.9	9%
Cropland	3106.6	42%	777.8	50%	113.6	45%
Pasture/Hay	1845.8	25%	252.0	16%	48.5	19%
Forest	369.9	5%	180.4	12%	13.0	5%
Feedlots	713.7	10%	48.0	3%	0.0	0%
Septic	198.3	3%	77.7	5%	0.0	0%
Gullies	156.2	2%	68.7	4%	53.9	21%
Total[c]	**7386.4**	***100%***	**1558.4**	***100%***	**251.8**	***100%***

Notes:

[a] Urban loads are presented for information only and may represent an overestimate, as no existing BMPs or other load reduction measures have been applied to the existing conditions for this land use.
[b] Urban sources include both residential and commercial sources.
[c.] Any differences in the totals are a result of rounding.

Potential Conditions

Load Reduction Analysis

As reported previously, the current level of BMP treatment in the Sakonnet watershed was estimated by NRCS field staff using available data and best professional judgement. Thirty-two percent of cropland and 30 percent of pastureland currently have some existing level of treatment in place (current conditions). In addition, 90 percent of feedlots have some existing level of treatment in place and another 2 percent are zero discharge facilities. The pollutant loads associated with current conditions were initially estimated using STEPL (see previous tables) and used as a baseline to assess the potential reductions associated with further implementation of BMPs across each watershed.

As part of the TP TMDL for Newport Drinking Water Reservoirs, load reductions for nonpoint sources of pollution were developed for Paradise Pond, Gardiner Pond, Nonquit Pond, and Watson Reservoir that will achieve water quality targets. The TMDL sets allowable loads for phosphorus, and the associated agricultural land use reductions for Paradise Pond, Gardiner Pond, Nonquit Pond, and Watson Reservoir are displayed in Table 27. More details on the TP TMDL can be found here.

Table 27. Phosphorus reductions derived for Paradise Pond, Gardiner Pond, Maidford River, Nonquit Pond, and Watson Reservoir in the Newport Drinking Water Reservoirs TMDL

Sakonnet Watershed Reservoir Name	TP Reduction Required from Agricultural Sources
Nonquit Pond	85%
Watson Reservoir	25%
Gardiner Pond	65%
Paradise Pond	84%
Maidford River	84%

As no TMDL exists for the full Sakonnet River HUC-12 drainage area, the TP TMDL reduction percentage for Watson Reservoir (25%) was used as a target for the non-priority subwatersheds. The priority subwatersheds (Paradise Pond, Gardiner Pond, Maidford River, Nonquit Pond, and Watson Reservoir) were each included in the 25% reduction scenario, with additional phases of reductions to achieve higher reduction targets associated with the TMDL. A load reduction analysis was subsequently conducted using the STEPL model that applied incremental increases in BMP implementation from current conditions to try to meet the implementations scenarios:

- Phase 1: approximate 25% reduction in TP from agricultural sources across the entire Sakonnet watershed (non-priority subwatersheds and priority subwatersheds).
- Phase 2: approximate 65% reduction in TP from agricultural sources in applicable priority subwatersheds (Gardiner Pond, Paradise Pond, Maidford River, and Nonquit Pond).
- Phase 3: approximate 85% reduction in TP from agricultural sources in applicable priority subwatersheds (Paradise Pond, Maidford River, and Nonquit Pond).

The analysis provides information about the extent of practices that could be deployed on agricultural land to achieve the TP TMDL targets and get the most water quality benefit across the Sakonnet River watershed. The associated load reductions provide a suite of targets that could be achieved through phased implementation. Given the significant existing levels of agricultural practice implementation throughout the watershed, implementation levels necessary to meet the 65% and 85% reduction targets were considered to be hypothetical, and likely unachievable in a real-world scenario. Moreover, the 85% reduction could not be mathematically achieved with the available implementation practices. However, the 25% implementation scenario provides an implementable roadmap to reducing nutrients throughout the watershed. A summary of the scenarios modeled and the associated BMPs is given in Table 28.

Table 28. Summary of implementation scenarios and load reductions simulated in the Sakonnet River watershed

Implementation Scenario	Level of Implementation (% of Land Treated)			
	***Current**	**Phase 1**	**Phase 2**	**Phase 3**
Cropland				
Buffer - Forest (100ft wide)	5%	5%	-	-
Buffer - Grass (35ft wide)	10%	10%	-	-
Conservation Tillage1, Cover Crop 2, Nutrient Management 1, Forest Buffer	1%	1%	-	-
Conservation Tillage1, Cover Crop 2, Nutrient Management 1, Grass Buffer	5%	7%	-	-
Conservation Tillage1, Cover Crop 2, Nutrient Management 1	5%	10%	-	-
Conservation Tillage1, Nutrient Management 1, Forest Buffer	1%	1%	-	-
Conservation Tillage1, Nutrient Management 1, Grass Buffer	5%	7%	-	-
Conservation Tillage1, Nutrient Management 1	5%	10%	-	-
Cover Crop2, Nutrient Management 1, Forest Buffer	1%	1%	-	-
Cover Crop2, Nutrient Management 1, Grass Buffer	5%	5%	-	-
Cover Crop2, Nutrient Management 1	5%	7%	-	-
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2, Forest Buffer	-		20%	100%
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2, Grass Buffer	-		21%	-
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2	-	5%	45%	-
Conservation Tillage 1	5%	2%	-	-
Conservation Tillage 2	2%	5%	-	-
Contour Farming	1%	1%	1%	-
Controlled Drainage	2%	2%	2%	-
Cover Crop 2	5%	-	-	-
Land Retirement	-	-	4%	-
Nutrient Management 1	5%	-	-	-
Total	**68%**	**79%**	**93%**	**100%**
Pasture/Hay				
30m Buffer with Optimal Grazing	2%	2%	5%	
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection, Forest Buffer	2%	2%	5%	-
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection, Grass Buffer	2%	5%	15%	100%

Implementation Scenario	Level of Implementation (% of Land Treated)			
	*Current	Phase 1	Phase 2	Phase 3
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection	1%	5%	-	-
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Forest Buffer	5%	5%	10%	-
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Grass Buffer	5%	8%	15%	-
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting	1%	3%	-	-
Prescribed Grazing, Pasture and Hayland Planting, Forest Buffer	5%	10%	-	-
Prescribed Grazing, Pasture and Hayland Planting, Grass Buffer	5%	10%	15%	-
Prescribed Grazing, Pasture and Hayland Planting	2%	3%	-	-
Forest Buffer (minimum 35 feet wide)	5%	-	-	-
Grass Buffer (minimum 35 feet wide)	10%	12%	25%	-
Grazing Land Management (rotational grazing with fenced areas)	5%	5%	-	-
Heavy Use Area Protection	2%	2%	-	-
Litter Storage and Management	2%	2%	-	-
Livestock Exclusion Fencing	2%	2%	-	-
Pasture and Hayland Planting (Forage Planting)	5%	-	-	-
Prescribed Grazing	5%	-	-	-
Streambank Stabilization and Fencing	2%	2%	10%	-
Winter Feeding Facility	2%	5%	-	-
Total	**70%**	**83%**	**100%**	**100%**
Gully Restoration	**0%**	**100%**	**100%**	**100%**
Manure Storage Areas				
Diversion	5%	5%	5%	0%
Filter strip	30%	30%	30%	35%
Runoff Management System	30%	30%	30%	20%
Waste Management System	10%	15%	25%	35%
Waste Storage Facility	15%	10%	0%	0%
Zero Discharge	2%	2%	2%	2%
Total	**92%**	**92%**	**92%**	**92%**

Notes:
*Current: existing BMP implementation estimated by NRCS
Conservation tillage 1 – conservation tillage 30-59% residue
Cover crop 2 – group A traditional normal planting time
Nutrient Management 1 – determined rate
Nutrient Management 2 – determined rate plus additional considerations

Results

Load reductions associated with different management scenarios modeled in each watershed are given in Tables 29, 30, and 31. The analysis suggests that further adoption of management practices can significantly reduce nutrient and sediment loads within the Sakonnet Watershed; however, a high level of implementation will be needed. The scenarios assume that those agricultural operations that currently implement one or two conservation practices will adopt additional practices to achieve further reductions, and those operations currently without conservation practices will adopt several new practices as well. Grass and forest buffers, coupled with other practices on crop and pastureland are indicated to be integral to achieving phosphorus reduction targets.

Table 29. Summary of management scenarios and phosphorus load reductions simulated in the Sakonnet Watershed

	Non-Priority Subwatersheds	Watson Reservoir	Gardiner Pond	Nonquit Pond	Paradise Pond	Maidford River
Existing Condition						
TP Load (lbs) Total	4,640	1,147	50	1,469	311	944
Phase 1 (25%)						
TP Load (lbs) Total	3,453	826	34	982	227	686
Total Load Reductions	25%	28%	32%	33%	27%	27%
Reductions by Source						
Cropland	27%	26%	23%	28%	25%	26%
Pastureland	22%	22%	22%	22%	22%	22%
Feedlots	6%	6%	-	6%	6%	6%
Gully	90%	90%	90%	90%	90%	90%
Phase 2 (65%)						
TP Load (lbs) Total			14	432	108	316
Total Load Reductions			71%	71%	65%	67%
Reductions by Source						
Cropland			71%	76%	73%	74%
Pastureland			60%	62%	61%	61%
Feedlots			-	17%	17%	17%
Gully			90%	90%	90%	90%
Phase 3 (85%)						
TP Load (lbs) Total				238	59	167
Total Load Reductions				84%	81%	82%
Reductions by Source						
Cropland				91%	89%	90%
Pastureland				81%	81%	81%
Feedlots				23%	23%	23%
Gully				90%	90%	90%

Table 30. Summary of management scenarios and nitrogen load reductions simulated in the Sakonnet Watershed

	Non-Priority Subwatersheds	Watson Reservoir	Gardiner Pond	Nonquit Pond	Paradise Pond	Maidford River
Existing Condition						
TN Load (lbs) Total	27,970	5,822	181	8,701	1,753	5,414
Phase 1 (25%)						
TN Load (lbs) Total	21,989	4,540	130	6,764	1,384	1,909
Total Load Reductions	21%	22%	28%	22%	21%	65%
Reductions by Source						
Cropland	21%	21%	20%	21%	21%	21%
Pastureland	27%	26%	25%	27%	26%	26%
Feedlots	1%	1%	-	1%	1%	1%
Gully	90%	90%	90%	90%	90%	90%
Phase 2 (65%)						
TN Load (lbs) Total			60	4,041	799	2,398
Total Load Reductions			67%	54%	54%	56%
Reductions by Source						
Cropland			62%	59%	61%	61%
Pastureland			69%	72%	71%	72%
Feedlots			-	3%	3%	3%
Gully			90%	90%	90%	90%
Phase 3 (85%)						
TN Load (lbs) Total				2,735	525	1,535
Total Load Reductions				69%	70%	72%
Reductions by Source						
Cropland				77%	79%	79%
Pastureland				91%	90%	90%
Feedlots				10%	10%	10%
Gully				90%	90%	90%

Table 31. Summary of management scenarios and sediment load reductions simulated in the Sakonnet Watershed

	Non-Priority Subwatersheds	Watson Reservoir	Gardiner Pond	Nonquit Pond	Paradise Pond	Maidford River
Existing Condition						
Sediment Load (lbs) Total	1,266,045	433,193	32,053	533,684	135,717	379,320
Phase 1 (25%)						
Sediment Load (lbs) Total	915,118	275,657	18,046	223,674	85,655	234,791
Total Load Reductions	28%	36%	44%	58%	37%	38%
Reductions by Source						
Cropland	17%	17%	17%	17%	17%	17%
Pastureland	21%	21%	21%	21%	21%	21%
Feedlots			-	-	-	-
Gully	90%	90%	90%	90%	90%	90%
Phase 2 (65%)						
Sediment Load (lbs) Total			8,641	118,185	42,250	115,264
Total Load Reductions			73%	78%	69%	70%
Reductions by Source						
Cropland			67%	67%	67%	67%
Pastureland			57%	57%	57%	57%
Feedlots			-	-	-	-
Gully			90%	90%	90%	90%
Phase 3 (85%)						
Sediment Load (lbs) Total				54,250	20,429	55,526
Total Load Reductions				90%	85%	85%
Reductions by Source						
Cropland				96%	86%	88%
Pastureland				80%	80%	80%
Feedlots				-	-	-
Gully				90%	90%	90%

Conservation Practice Effectiveness

Beyond the standard individual crop and pastureland conservation practices, several combinations of practices were assumed to occur throughout the watershed for the existing conditions scenario, as well as for the future pollutant reduction phases of implementation. These practices have pollutant removal efficiencies that are higher than the individual practices. Table 32 shows the modeled reduction efficiencies (percent) associated with combinations of conservation practices in the Sakonnet River watershed. This information can be useful to help identify the most effective combination of conservation practices or conservation practice in reducing pollutant loads. Full details on efficiencies associated with individual practices can be found in Appendix A.

For cropland, simulations for the combination of “cover crops, nutrient management, conservation tillage, and forest buffers (100 ft),” was most effective at reducing nutrient and sediment loads. Substituting a grass buffer or removing the buffer component, still yielded very high phosphorus removal efficiencies. For pasture/hay, the combination of “alternative water supply, prescribed grazing, pasture and hayland planting heavy use protection area, and a grass buffer” was the most effective management option, followed closely by “alternative water supply, prescribed grazing, pasture and hayland planting and a grass buffer.”

Most of the feedlot areas were already significantly treated by nutrient reducing practices, so while the practices are very efficient there was limited scope for additional reductions. Gully treatment was assumed to address all gullies that appear annually at a 90% efficiency. Gullies are caused by erosive forces triggered by a number of factors, including excess rainfall, poor infiltration, concentrated runoff from upslope or excessive erosion within wheel tracks and furrows. Gully prevention strategies vary based on the cause of erosion, but generally focus on vegetation as mitigation. Measures could include cover crops, contouring, no-till, strip cropping, maintaining residue cover, and grassed waterways.

Table 32. Summary of conservation practices efficiencies in the Sakonnet River watershed

Conservation Practices	**TN Efficiency**	**TP Efficiency**	**TSS Efficiency**
Cropland			
Conservation Tillage1, Cover Crop 2, Nutrient Management 1, Forest Buffer	70%	82%	78%
Conservation Tillage1, Cover Crop 2, Nutrient Management 1, Grass Buffer	62%	81%	75%
Conservation Tillage1, Cover Crop 2, Nutrient Management 1	42%	67%	46%
Conservation Tillage1, Nutrient Management 1, Forest Buffer	63%	81%	75%
Conservation Tillage1, Nutrient Management 1, Grass Buffer	52%	80%	72%
Conservation Tillage1, Nutrient Management 1	28%	65%	40%
Cover Crop2, Nutrient Management 1, Forest Buffer	65%	73%	63%
Cover Crop2, Nutrient Management 1, Grass Buffer	55%	71%	58%
Cover Crop2, Nutrient Management 1	32%	49%	10%
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2, Forest Buffer	76%	93%	91%
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2, Grass Buffer	70%	93%	90%
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2	55%	87%	79%
Pastureland			
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection, Forest Buffer	81%	72%	83%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection, Grass Buffer	96%	89%	87%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection	66%	53%	64%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Forest Buffer	77%	65%	75%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Grass Buffer	95%	86%	81%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting	58%	42%	46%
Prescribed Grazing, Pasture and Hayland Planting, Forest Buffer	73%	61%	69%
Prescribed Grazing, Pasture and Hayland Planting, Grass Buffer	94%	85%	77%
Prescribed Grazing, Pasture and Hayland Planting	52%	34%	33%

Summary of Vulnerable Acres

To target areas with the most pollution potential, a map of runoff risk was developed using ACPF to help field staff isolate areas of concern and prioritize projects. Four vulnerability classes were used to rank the agricultural risk based on runoff potential. Risk classification includes A (very high risk), B (high), C (moderate), and D (low) designations (Porter et al. 2018). Figure 26 shows the process applied in ACPF assigned run off risk classifications to fields.

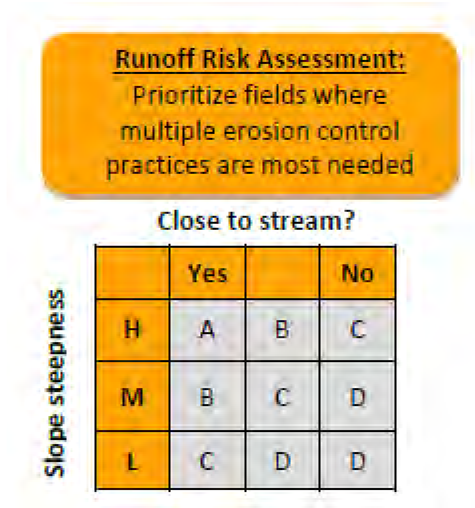

Figure 26. Runoff risk assessment matrix applied in the ACPF.

Fields with "very high" or "high" runoff risk represent the most critical areas for pollution potential from agricultural land and should be prioritized for planning. Land areas indicated to have a "moderate" runoff risk are also key as a pollution source. "Low" risk fields are considered a lesser priority for treatment. A "low" classification does not mean that a runoff-control conservation practice would not benefit a given field, but rather indicates that other fields have a greater potential to deliver sediment and nutrients to the streams via surface runoff (Porter et al. 2018).

Figure 27 shows the spatial distribution of vulnerable fields in the watersheds and helps to locate agricultural land areas where conservation measures could be focused in order to meet water quality goals. The breakdown of other run off risk classifications by area is provided in Table 33.

It should be noted that agricultural land areas only make up a proportion of each drainage area. Forest land also makes up a considerable proportion of some subwatersheds (e.g., Nonquit Pond and Watson Reservoir), and is also eligible for treatment within the NWQI program; however, pollutant loadings from agricultural sources are considered to be key controllable contributing factors.

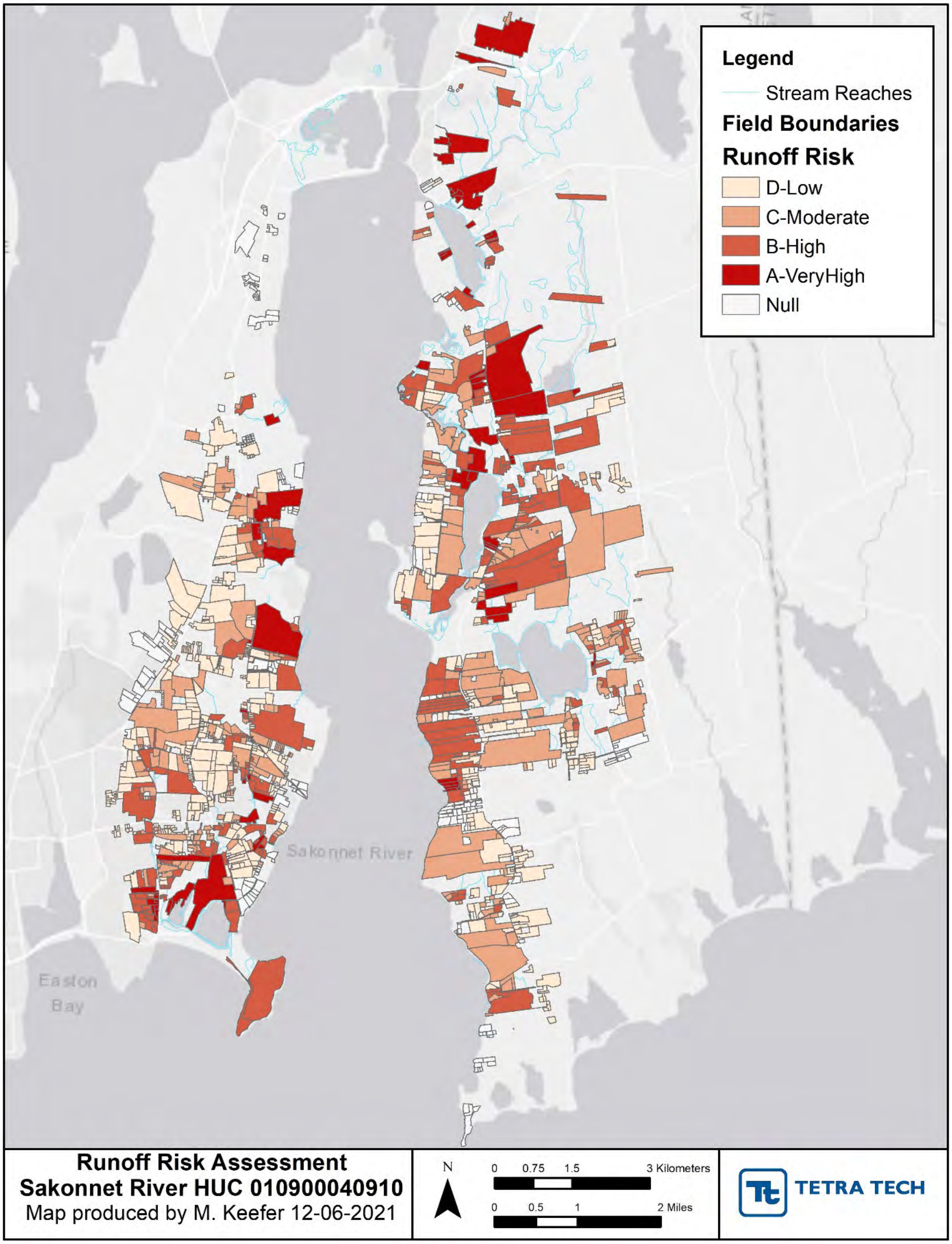

Figure 27. Spatial distribution of run off risk classifications for fields within the Sakonnet River watershed.

Table 33. Summary of runoff risk acres for fields within the Sakonnet River watershed

Run Off Risk	Area (acres)	Number of Fields
Very High	1,500	73
High	2,783	209
Moderate	3,307	302
Low	2,746	543
Null	812	238

Analysis of Treatment and Opportunities

Current Level of Treatment in the Watershed

Rhode Island is not a traditional agricultural state. Since it is not a traditional agricultural state, it is challenging to follow normal characterization of the watershed, which uses conventional methods of inventory such as land use or land cover to characterize how the land is utilized. Still, it is the best data available and should be used as a guideline for characterization. Rhode Island's farms are small and diverse and often contribute to the acres of land outside of the lands that are characterized as agricultural. Because of this, acres contributing to agriculture may seem over-reported when in fact they are being more accurately accounted for and reported. It is this reasoning in which NRCS in Rhode Island seeks to reach those individuals by utilizing conventional land cover data but also looking beyond the normal land cover acres to account for "backyard farms" which are a big impact in Rhode Island.

In 2012, NRCS in Rhode Island teamed up with the State of Rhode Island – Department of Environmental Management and with the Rhode Island Association of Conservation Districts to develop a statewide agricultural inventory. This inventory provided NRCS and RIDEM a glimpse into "backyard farming" and provided some much-needed information on conservation needs across the state. As a result of this information and good outreach, Rhode Island's conservation acres have gone beyond normal land cover acres.

The Sakonnet River watershed is a great example. Since 2012, the Sakonnet River watershed has applied 828 conservation practices across 4,352 planning land unit (PLU) acres of land. A PLU is the equivalent of a field that has similar management. Of those practices, 323 were "Core" conservation practices as identified by the NWQI. NWQI "Core" conservation practices are conservation practices that have the most benefit for addressing water quality issues. The 323 "Core" conservation practices were applied on 3,474 PLU acres across the Sakonnet River watershed. During the last 10 years, "Core" conservation practices have accounted for 80% of the total applied conservation practices PLU acreage. NWQI "supporting" conservation practices are conservation practices that are applied in support of the "Core" conservation practices. Over the last 10 years, there have been 275 "Supporting" conservation practices applied across 1,980 PLU acres. Core and supporting conservation practice are shown in Table 34.

Table 34. Number of core and supporting conservation practices applied (2012–2022)

Conservation Practice	Core (number)	Supporting (number)	Grand Total
Cover Crop	83		83
Prescribed Grazing	80		80
Conservation Crop Rotation	49		49
Fence		43	43
Brush Management		38	38
Lined Waterway or Outlet		29	29
Nutrient Management	29		29
Mulching		26	26
Pasture and Hay Planting		20	20
Access Road		20	20
Critical Area Planting	16		16
Conservation Cover	13		13
Herbaceous Weed Treatment		12	12
Underground Outlet		10	10
Structure for Water Control		10	10
Water Well		10	10
Livestock Pipeline		10	10
Irrigation Water Management	10		10
Watering Facility		9	9
Grassed Waterway	9		9
Forest Stand Improvement	9		9
Tree/Shrub Establishment	8		8
Roof Runoff Structure		8	8
Diversion		7	7
Irrigation System, Micro irrigation		7	7
Pest Management Conservation System		6	6
Sediment Basin		5	5
Access Control	5		5
Heavy Use Area Protection	5		5
Trails and Walkways	3		3
Grade Stabilization Structure	3		3
Restoration of Rare or Declining Natural Communities		1	1
Hedgerow Planting		1	1
Field Border	1		1
Windbreak/Shelterbelt Renovation		1	1
Irrigation Pipeline		1	1
Stream Crossing		1	1
Grand Total	**323**	**275**	**598**

Analysis of Producers Available in the Watershed to Participate in the Initiative and Their Likely Willingness to Participate

Farm Service Agency (FSA) data indicates 271 distinct tracts within the Sakonnet River watershed. NRCS Data indicates that there are 96 distinct tracts that have utilized NRCS programs over the last ten years and implemented 828 conservation practices. Of those tracts, 15 distinct tracts have applied 323 “Core” conservation practices.

One goal will be to increase participation from the 271 distinct tracts for water quality purposes. Some producers may be ineligible to participate but the local field office will offer technical assistance to encourage treatment in critical source areas. Eligible producers throughout the watershed will be able to apply for programs to receive financial assistance for implementing conservation practices to promote water quality. As part of NRCS’ financial assistance programs, applicants go through a process which ranks the applicants’ assessment and planned practices to prioritize assistance in areas that are the most vulnerable with practices that do the most to address the resource concern. To promote areas that are most vulnerable, additional ranking points will be given to producers located in areas that are rated very high, high, or moderate within high priority critical source areas. Ranking points will be greatest for locations rated very high and lowest for locations rated moderate or low.

NRCS data indicates that while there is a considerable willingness for producers to participate in NRCS programs within the Sakonnet River watershed, there are varying levels of conservation throughout the watershed. Another goal will be to increase the level of conservation by promoting pollutant reduction conservation practices in a systematic approach in which a suite of conservation practices will be applied together to achieve the desired level of pollutant load reduction. To promote pollutant reduction conservation practices, additional ranking points will be given to producers willing to increase their level of conservation based on load reduction conservation practices.

When an applicant receives extra points for high priority critical source areas and/or increasing their level of conservation based on load reduction conservation practices, the applicant will have a higher overall score and therefore have a better opportunity to receive funding. This ranking process is critical, especially when there is a limited amount of funding. By providing extra points, funding is able to go to areas where it will provide the most benefit.

NRCS in Rhode Island will continue using an Outreach Agreement with the Districts in support of providing outreach to the Sakonnet River watershed. Outreach events will be tracked to provide information such as: type of event, number of participants attending. NRCS will monitor the participation in terms of number of contracts and number of practices to adjust the number of outreach events that occur each year.

Assessment of Balancing Critical Area Treatment with Participation to Achieve the Most Effective Prioritization of Implementation

To effectively prioritize implementation of conservation practices, the ACPF Runoff Risk Assessment was used to provide “Critical Areas of Treatment” as shown in the Summary of Vulnerable Acres section, above. These “Critical Areas of Treatment” will receive additional ranking points. Projects in these Critical Areas will receive increasing points for projects that are within “Moderate”, “High” and “Very High” areas. Additional ranking points will also be provided to participants that increase the level of conservation by implementing load reduction conservation practices as a bundle to achieve a better level of load reduction. These practices are outlined in the “Planning for sub-watershed with a load reduction established by a TMDL” section, below. Providing additional points for these criteria will allow participants the highest opportunity for NRCS program funding. Additionally, participants will have opportunities for selection within the EQIP fund pool as well as the NWQI fund pool.

Set of Preferred Practices, Locations, Responsible Parties, Costs, and Timelines

NRCS in Rhode Island will seek to provide assistance in the Sakonnet River watershed utilizing multiple approaches to planning. This is needed due to the different levels of load reductions that are outlined for the watershed. NRCS in Rhode Island will continue to work within the NWQI conservation practice concepts for "Avoiding, Controlling and Trapping" nutrients to benefit water quality while also increasing the level of conservation by promoting load reduction conservation practices as a systematic approach in which a suite of conservation practices will be applied together to achieve the desired level of load reduction.

Table 35 identifies the preferred conservation practices based on the modeled efficiencies for nutrient load reductions. These conservation practices have been identified as having the most benefit for reducing nutrient loading and will serve as the preferred conservation practices for the watershed.

Table 35. List of "preferred" conservation practices

Conservation Practices	Code	Avoiding	Controlling	Trapping
Access Control	472	X		
Composting Facility	317	X		
Conservation Cover	327	X		
Cover Crop	340	X		
Critical Area Planting	342		X	X
Diversion	362		X	
Fence	382	X		
Field Border	386		X	
Filter Strip	393			X
Grassed Waterway	412		X	
Heavy Use Area Protection	561	X		
Lined Waterway Outlet	468		X	
Livestock Pipeline	516	X		
Nutrient Management	590	X		
Pasture and Hay Planting	512	X		
Prescribed Grazing	528	X		
Residue and Tillage Management, Mulch Till	345		X	
Residue and Tillage Management, No Till/Strip Till/Direct Seed	329		X	
Residue and Tillage Management, Ridge Till	346		X	
Residue Management, Seasonal	344		X	
Riparian Forest Buffer	391			X
Riparian Herbaceous Cover	390			X
Roofs and Covers	367	X		
Roof Runoff Structure	558	X		
Streambank and Shoreline Protection	580	X		
Tree/Shrub Establishment	612	X		
Waste Storage Facility	313	X		
Watering Facility	614	X		

Planning within a Sub-watershed with a Load Reduction Established by a TMDL

NRCS data indicates that there are varying levels of conservation throughout the watershed. While it is commendable to achieve conservation across 4,352 PLU acres, we need to encourage planning to adopt higher levels of load reductions. In some local watersheds, higher levels of load reductions are identified by the TMDL (see Figure 28 and Table 36 below). In the watersheds listed in the table below, conservation planning will be promoted to achieve the listed load reduction utilizing conservation practices identified in Table 32. In cases where the landowner cannot or does not want to adopt higher levels of load reductions, conservation practices may be used from the NWQI Conservation Practice list for Core and Supporting conservation practices to achieve water quality benefits.

Figure 28. Map of Paradise Pond, Gardiner Pond, Nonquit Pond, and Watson Reservoir with the associated TP reductions required from agricultural sources shown in Table 36. Note: colors for reservoir reductions represent associated drainage areas from Table 36.

Table 36. Phosphorus reductions derived for Paradise Pond, Gardiner Pond, Nonquit Pond and Watson Reservoir in the Newport Drinking Water Reservoirs TMDL

Sakonnet Watershed Reservoir Name	TP reduction required from Agricultural Sources
Nonquit Pond	85%
Watson Reservoir	25%
Gardiner Pond	65%
Paradise Pond	84%
	84%

For the rest of the watershed, one goal will be to increase the level of conservation by promoting load reduction conservation practices across the whole Sakonnet River watershed to 25% or greater.

Costs and Timeline

Cropland

It is estimated that over the next ten years NRCS can increase the level of participation for conservation on 2,173 acres of cropland (see Table 37). It is also estimated that over the next ten years NRCS can increase the level of conservation on 1,810 acres of cropland. Using a systems approach to achieve a higher level of conservation can be accomplished focusing on the conservation practices which are commonly used in Rhode Island and provide benefit for water quality. Other conservation practices may be used from the NWQI Conservation Practice list for Core and Supporting conservation practices.

Table 37. Conservation investment information for cropland

CONSERVATION INVESTMENT INFORMATION			
	FUTURE	USDA INVESTMENT	
CONSERVATION SYSTEMS BY TREATMENT LEVELS	New Treatment Units	Installation Cost 75%	Total Present Value Cost
System Acres Treated	**2,173.3**		
Conservation Cover (ac.) 327	543	$57,347	$68,817
Cover Crop (ac.) 340	1,087	$42,901	$51,482
Mulching (ac.) 484	543	$278,374	$334,049
Nutrient Management (ac.) 590	1,087	$14,808	$17,770
Residue and Tillage Management, Mulch Till (ac.) 345	1,087	$15,844	$19,012
Riparian Forest Buffer (ac.) 391	217	$346,144	$415,373
Riparian Herbaceous Cover (ac.) 390	217	$141,262	$169,514
	Subtotal	**$896,681**	**$1,076,017**
Treated Level Increased Acres	**1,809.8**		
Conservation Cover (ac.) 327	239	$25,233	$30,279
Cover Crop (ac.) 340	931	$36,739	$44,087
Mulching (ac.) 484	963	$493,381	$592,057
Nutrient Management (ac.) 590	931	$12,681	$15,218
Residue and Tillage Management, Mulch Till (ac.) 345	931	$13,568	$16,281
Riparian Forest Buffer (ac.) 391	367	$584,668	$701,602
Riparian Herbaceous Cover (ac.) 390	367	$238,604	$286,325
	Subtotal	**$1,404,874**	**$1,685,849**
TOTAL ACRES TREATED / ESTIMATED TREATMENT COSTS	**3,983.1**	**$2,301,555**	**$2,761,866**

Pasture

It is estimated that over the next ten years NRCS can increase the level of participation for conservation on 1,225 acres of pastureland (see Table 38). It is also estimated that over the next ten years NRCS can increase the level of conservation on 1,020 acres of pastureland. Using a systems approach to achieve a higher level of conservation can be accomplished focusing on the conservation practices which are commonly used in Rhode Island and provide benefit for water quality. Other conservation practices may be used from the NWQI Conservation Practice list for Core and Supporting conservation practices.

Table 38. Conservation investment information for pasture

CONSERVATION INVESTMENT INFORMATION			
	FUTURE	USDA INVESTMENT	
CONSERVATION SYSTEMS BY TREATMENT LEVELS	New Treatment Units	Installation Cost 75%	Total Present Value Cost
System Acres Treated	**1,225.4**		
Conservation Cover (ac.) 327	306	$32,334	$38,801
Fence (ft.) 382	73,524	$213,955	$256,746
Pasture & Hayland Planting (ac.) 512	306	$69,069	$82,883
Pipeline (ft.) 516	30,635	$81,106	$97,327
Prescribed Grazing (ac.) 528	613	$38,747	$46,497
Riparian Forest Buffer (ac.) 391	123	$195,169	$234,202
Riparian Herbaceous Cover (ac.) 390	123	$79,649	$95,578
Watering Facility (no.) 614	0	$0	$0
	Subtotal	**$710,029**	**$852,034**
Treated Level Increased Acres	**1,020.4**		
Conservation Cover (ac.) 327	900	$95,005	$114,005
Diversion (ft.) 362	15,306	$76,455	$91,746
Fence (ft.) 382	93,576	$272,306	$326,767
Heavy Use Area Protection (ac.) 561	10	$25	$30
Pasture & Hayland Planting (ac.) 512	390	$87,906	$105,487
Pipeline (ft.) 516	13,479	$35,687	$42,824
Prescribed Grazing (ac.) 528	678	$42,861	$51,434
Riparian Forest Buffer (ac.) 391	207	$329,657	$395,589
Riparian Herbaceous Cover (ac.) 390	207	$134,534	$161,440
Roof Runoff Structure (no.) 558	102	$1,087	$1,304
Streambank & Shoreline Protection (ft.) 580	5,102	$72,208	$86,649
Waste Storage Facility (no.) 313	244,902	$1,260,020	$1,512,023
Watering Facility (no.) 614	102	$52,990	$63,588
	Subtotal	**$2,460,740**	**$2,952,888**
TOTAL ACRES TREATED / ESTIMATED TREATMENT COSTS	**2,245.8**	**$3,170,769**	**$3,804,922**

V. Summary and Recommendations

This section summarizes water quality resource concerns, the water quality objectives and the extent that the problem can be addressed through NRCS technical and financial assistance.

Description of Water Quality Impairments

The most recent *State of Rhode Island 2022 Impaired Waters Report* indicates that Nelson Paradise Pond (RI0007035L-02), Gardiner Pond (RI0007035L-01), Nonquit Pond (RI0007035L-08), and Watson Reservoir (RI0007035L-07) are impaired due to excessive concentrations of TOC and TP. Additionally, tributaries that discharge to all four reservoirs (Maidford River: RI0007035R-02A and RI0007035R-02B; Paradise Brook: RI0007035R-03; Borden Brook: RI0010031R-01; Quaket Brook: RI0010031R-04; Tributary to Nonquit Pond: RI0010031R-20; Tributaries to Watson Reservoir: RI0010031R-21) are also impaired because of TP exceedances. TMDLs have been developed for all four reservoirs.

Maidford River (RI0007035R-02A and RI0007035R-02B), Paradise Brook (RI0007035R-03), Little Creek (RI0010031R-02), Sin & Flesh Brook (RI0010031R-05B), Borden Brook (RI0010031R-01), Quaket Creek (RI0010031R-04), Pachet Brook (RI0010031R-03) and a tributary to Nonquit Pond (RI0010031R-20) are impaired due to high levels of bacteria (*Enterococcus* and/or FC). Shellfishing is also currently prohibited for some estuarine parts of the Sakonnet River tidal straits because of high levels of bacteria. TMDLs have been developed and approved for many of the streams listed and the Sakonnet River tidal straits. Part of Maidford River (RI0007035R-02A) also has impairments related to turbidity, lead, and benthic macroinvertebrates bioassessments.

Description of Water Quality Reduction Goals

The main goal is to meet TMDL reduction targets for TP (see Table 39) in the four drinking water reservoirs and also meet designated criteria for surface water classes across the Sakonnet River watershed. According to the state's water quality standards (RIDEM 2020), waterbodies in the Sakonnet River watershed have been assigned to Class AA, to Class A, Class B, Class B1, Class SA, and Class SB (see Figure 16 for details).

- Class AA waters: are designated as a source of public drinking water supply or tributary to that supply. They are also habitat for fish and wildlife and primary/secondary contact recreation and should have excellent aesthetic value.
- Class A waters: are designated as a habitat for fish and wildlife, and for primary and secondary contact recreation. They should have excellent aesthetic value.
- Class B: are designated as a habitat for fish and wildlife, and for primary and secondary contact recreation. They should have good aesthetic value.
- Class B1: are designated as a habitat for fish and wildlife, and for primary and secondary contact recreation. They should have good aesthetic value. Primary contact recreational activities may be impacted due to pathogens from approved wastewater discharges. However, all Class B criteria must be met.
- Class SA waters: are designated as a source of shellfish harvesting for direct human consumption. They are also habitat for fish and wildlife and primary/secondary contact recreation and should have good aesthetic value.

- Class SA waters: are designated as a source of shellfish harvesting for controlled relay and depuration. They are also habitat for fish and wildlife and primary/secondary contact recreation and should have good aesthetic value.

Table 39. Goals for sub-watersheds and the rest of the Sakonnet watershed

Sakonnet Watershed Reservoir Name	TP Reduction Required from Agricultural Sources
Nonquit Pond	85%
Watson Reservoir	25%
Gardiner Pond	65%
Paradise Pond	84%
Rest of the Sakonnet watershed	25%

The NWQI is focused on agricultural sources of nonpoint sources of pollution. The key objective is therefore to reduce nutrient, sediment, and bacterial loadings from agricultural sources and meet criteria that ensure waters are suitable for drinking water supply (drinking water supply reservoirs), aquatic habitat, wildlife, and recreation. Conservation practices for agricultural operations should reduce the potential of both nutrient, sediment and bacterial laden runoff from reaching waterbodies. For the period of 2023–2033, goals will be focused on increasing participation and increasing level of conservation for water quality. Water quality monitoring will continue to be done by RIDEM.

Establish Interim Metrics to Track Progress

The NRCS based metrics for tracking progress would utilize:

1. Integrated Data for Enterprise Analysis (IDEA) which provides reports for internal analysis of National Planning and Agreements Database (NPAD).
2. Protracts which provides contracting information.

Metrics will include the number of clients, acres treated, and practices planned and installed. The percent of nutrient load reduction based on modeled efficiencies for conservation practices will also be tracked throughout the watershed as well as the sub-watersheds affected by a TMDL. Annual review of these metrics will allow progress to be analyzed and discussed to better determine if goals for implementation and effectiveness are on track.

Locations of Critical Source Areas or Vulnerable Acres Needing Treatment

Fields with “very high” or “high” runoff risk represent the most critical areas for pollution potential from agricultural land and should be prioritized for planning. Land areas indicated to have a “moderate” runoff risk are also a key as a pollution source. “Low” risk fields are considered a lesser priority for treatment. A “low” classification does not mean that a runoff-control conservation practice would not benefit a given field, but rather indicates that other fields have a greater potential to deliver sediment and nutrients to the streams via surface runoff (Porter et al. 2018). Locations of these Critical Source Areas are shown in Figure 27, with a summary of runoff risk acres for fields within the Sakonnet River watershed detailed in Table 33.

Description and Evaluation of Planned Practice Scenarios and Alternatives that Meet Water Quality Objectives, Including Estimation of Treatment Costs

To increase the level of conservation, NRCS in Rhode Island will promote conservation systems to improve nutrient reducing efficiencies. Conservation systems that will be included are listed in Table 32. Conservation practices included on the NWQI list of core and supporting conservation practices will also be utilized as needed.

Documentation of NEPA Concerns

The National Environmental Policy Act of 1964 requires all federal agencies to conduct an environmental review of all federal actions. This requirement also applies to area wide or watershed planning activities. As part of these plans the responsible federal agency is required to evaluate the individual and cumulative effects of the actions being proposed. Any project that has significant environmental impacts must be evaluated with an Environmental Assessment (EA) or Environmental Impact Statement (EIS) unless the activities are eligible under a categorical exclusion or are covered by an existing EA or EIS.

NRCS utilizes a planning process that incorporates an evaluation of potential environmental impacts using an Environmental Evaluation checklist. NRCS also has categorical exemptions for a number of different activities that include many of our conservation practices. These categorical exemptions include conservation practices that reduce soil erosion, involve the planting of vegetation and/or restore areas to natural ecological systems.

As mentioned above, as part of the planning process, each planned practice will be evaluated individually and combination with other planned practices to ensure it meets the criteria of the categorical exclusions and any existing EAs. Any significant negative practice impacts, either individually or cumulatively, will first try to be avoided, then minimized and/or mitigated to the extent possible or eliminated from the individual farm plan if necessary.

Outreach Strategy & Plan

NRCS in Rhode Island has a Public Affairs Specialist on staff and utilizes partnership agreements with the Soil and Water Districts of Rhode Island to provide assistance with outreach. This partnership allows NRCS to increase outreach efforts, as well as reach more of the public than it would on our own. The SWCDs coordinate outreach events with NRCS staffing to place the right people in the right place at the right time. This model has demonstrated benefits and value in our efforts to reach the public with our programs over the years.

The overall objective of community outreach in the Sakonnet River watershed is to develop an atmosphere that promotes the understanding and desire for sustained, long-term protection and improvement of the aquatic resources in the watershed. Specific goals of education efforts in the watershed include the following:

- Increase public awareness of the value of clean water.
- Increase public awareness of agricultural runoff and encourage behaviors that will help reduce levels of nutrients and sediment in the watershed, better understand watershed dynamics, and foster stewardship opportunities.
- Increase public awareness of how BMPs can help improve water quality and habitat restoration.

- Increase public awareness of the long term environmental and economic advantages of protecting and improving water quality and habitat in the Sakonnet River watershed.

Table 40 outlines objectives, indicators, and an implementation schedule identified to meet the education and outreach goals defined above.

Table 40. Outlined objectives, indicators, and implementation schedule identified in order to meet education and outreach goals

Education Objective	Indicator	Schedule
Outreach Events: Outreach events will be scheduled and advertised to provide information to the public on clean water, agricultural runoff, the effect of BMPs and where to find help.	A field day will be held for landowners and interested public to provide information on clean water, agricultural runoff, the effect of BMPs and where to find help to promote public interest. The number of attendees will be documented.	Once a year or on request throughout the life of the project.
Field Days: A field day will be held to showcase some of the BMPs installed under NWQI. This will allow the landowners and the interested public to view some of the practices that are being installed to benefit water quality in the watershed.	Attendance at this field day will be documented and reported.	Field day in the watershed will take place around months 20 and 30 of the project.
Educational Literature: Brochures and fact sheet will be developed to inform landowners/operators about water quality and ways they can protect and improve the water quality in their watershed. The fact sheet contains information about the watershed and the numbers and types of BMPs installed.	Brochures and fact sheets will be distributed. These brochures and fact sheets will be handed out at the field days and outreach meetings and will also be available at the district offices.	Throughout the life of the project

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Appendix A – Conservation Practice Efficiencies

Conservation Practices	TN Efficiency	TP Efficiency	TSS Efficiency
Cropland			
Combination Practices			
Conservation Tillage1, Cover Crop 2, Nutrient Management 1, Forest Buffer	70%	82%	78%
Conservation Tillage1, Cover Crop 2, Nutrient Management 1, Grass Buffer	62%	81%	75%
Conservation Tillage1, Cover Crop 2, Nutrient Management 1	42%	67%	46%
Conservation Tillage1, Nutrient Management 1, Forest Buffer	63%	81%	75%
Conservation Tillage1, Nutrient Management 1, Grass Buffer	52%	80%	72%
Conservation Tillage1, Nutrient Management 1	28%	65%	40%
Cover Crop2, Nutrient Management 1, Forest Buffer	65%	73%	63%
Cover Crop2, Nutrient Management 1, Grass Buffer	55%	71%	58%
Cover Crop2, Nutrient Management 1	32%	49%	10%
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2, Forest Buffer	76%	93%	91%
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2, Grass Buffer	70%	93%	90%
Conservation Tillage 2, Cover Crop 2, Nutrient Management 2	55%	87%	79%
Individual Practices			
Bioreactor	45%	ND	ND
Buffer - Forest (100ft wide)	48%	47%	59%
Buffer - Grass (35ft wide)	34%	44%	53%
Combined BMPs-Calculated	0%	0%	0%
Conservation Tillage 1 (30-59% Residue)	15%	36%	40%
Conservation Tillage 2 (equal or more than 60% Residue)	25%	69%	77%
Contour Farming	28%	40%	34%
Controlled Drainage	39%	35%	ND
Cover Crop 1 (Group A Commodity) (High Till only for Sediment)	1%	ND	ND
Cover Crop 2 (Group A Traditional Normal Planting Time) (High Till only for TP and Sediment)	20%	7%	10%
Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	20%	15%	20%
Land Retirement	90%	81%	95%
Nutrient Management 1 (Determined Rate)	15%	45%	ND
Nutrient Management 2 (Determined Rate Plus Additional Considerations)	25%	56%	ND
Streambank Stabilization and Fencing	75%	75%	75%
Terrace	25%	31%	40%
Two-Stage Ditch	12%	28%	ND

Conservation Practices	TN Efficiency	TP Efficiency	TSS Efficiency
Pastureland			
Combination Practices			
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection, Forest Buffer	81%	72%	83%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection, Grass Buffer	96%	89%	87%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Heavy Use Area Protection	66%	53%	64%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Forest Buffer	77%	65%	75%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting, Grass Buffer	95%	86%	81%
Prescribed Grazing, Alternative Water Supply, Pasture and Hayland Planting	58%	42%	46%
Prescribed Grazing, Pasture and Hayland Planting, Forest Buffer	73%	61%	69%
Prescribed Grazing, Pasture and Hayland Planting, Grass Buffer	94%	85%	77%
Prescribed Grazing, Pasture and Hayland Planting	52%	34%	33%
Individual Practices			
30m Buffer with Optimal Grazing	36%	65%	ND
Alternative Water Supply	13%	12%	19%
Combined BMPs-Calculated	0%	0%	0%
Critical Area Planting	18%	20%	42%
Forest Buffer (minimum 35 feet wide)	45%	40%	53%
Grass Buffer (minimum 35 feet wide)	87%	77%	65%
Grazing Land Management (rotational grazing with fenced areas)	43%	26%	ND
Heavy Use Area Protection	18%	19%	33%
Litter Storage and Management	14%	14%	0%
Livestock Exclusion Fencing	20%	30%	62%
Multiple Practices	25%	21%	22%
Pasture and Hayland Planting (also called Forage Planting)	18%	15%	ND
Prescribed Grazing	41%	23%	33%
Streambank Protection w/o Fencing	15%	22%	58%
Streambank Stabilization and Fencing	75%	75%	75%
Use Exclusion	39%	4%	59%
Winter Feeding Facility	35%	40%	40%
Feedlots			
Diversion	45%	70%	ND
Filter strip	ND	85%	ND
Runoff Mgmt System	ND	83%	ND

Conservation Practices	TN Efficiency	TP Efficiency	TSS Efficiency
Solids Separation Basin	35%	31%	ND
Solids Separation Basin w/Infilt Bed	ND	80%	ND
Terrace	55%	85%	ND
Waste Mgmt System	80%	90%	ND
Waste Storage Facility	65%	60%	ND