DRAFT - Total Maximum Daily Load for Total Phosphorus and Dissolved Oxygen for Upper and Lower Melville Ponds and the Melville Ponds Tributary, Portsmouth, Rhode Island

STATE OF RHODE ISLAND
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
Office of Water Resources
235 Promenade St.
Providence, RI 02908

1 Table of Contents

List of Tables

List of Figures

Executive Summary

Section 303(d) of the Clean Water Act (CWA) requires states to determine on a biennial basis whether waterbodies are impaired (not meeting designated uses and/or water quality criteria). One of the underlying goals of the CWA is to restore all impaired waters so they meet applicable water quality standards. One of the key tools to meet this goal is the development of a total maximum daily load (TMDL). A TMDL is the amount of a pollutant a water can receive and still meet water quality standards.

A TMDL analysis was conducted for Upper and Lower Melville Ponds and the Melville Pond Tributary in Portsmouth, Rhode Island. These three waterbodies are on the Section 303(d) List of impaired waters for impairment of the Aquatic Life use due to total phosphorus (TP) and low dissolved oxygen. Reductions in phosphorus loadings are expected to result in reductions in phytoplankton/cyanobacterial biomass, which is expected to improve the dissolved oxygen conditions in the deeper areas of these waterbodies.

The TMDL analysis included: 1) an estimation of existing and allowable total phosphorus loads to each waterbody, 2) an evaluation of sources of phosphorus to the impaired waterbodies, and 3) allocation of the annual total phosphorus load capacity to point and nonpoint sources within the watershed. The TMDL also includes both required and recommended actions to reduce phosphorus loads to each waterbody.

The existing phosphorus loads to each reservoir were estimated using available water quality data, application of nutrient load/lake response models, and land use-based watershed modeling. The existing phosphorus load to the Melville Pond Tributary was estimated using a simple mass loading calculation. Land use modeling and extensive field reconnaissance were used to identify the most significant sources of phosphorus in the watershed. Stormwater runoff from urban areas in the watershed account for a majority of the external loading of phosphorus to the waterbodies in this study. As such, most of the annual total phosphorus load capacity is allocated to point sources as a wasteload allocation.

Continued and additional monitoring is recommended to document the in-waterbody responses, trends, and compliance with water quality criteria and thresholds following implementation of total phosphorus reduction measures. The process of implementing load reduction activities and monitoring in a step-wise fashion is called phased implementation and is the recommended approach for implementing this TMDL.

1 Introduction

The Federal Clean Water Act (CWA) provides regulations for the protection of the Nation's waters within the United States. As part of the CWA, states must establish water quality standards (WQS) for waters within their borders. WQS designate the use(s) of the waterbody (*e.g.,* recreation or protection of aquatic life), establish water quality criteria to protect the waterbody, and adopt requirements to protect and maintain designated uses. Additionally, states are required to evaluate all available water quality-related data and information and develop a list of waters that do not meet established WQS. These waters are 'impaired' and are placed on what is termed a 303(d) List.

States are required to submit their 303(d) list for EPA approval every two years. For each water on the list, the state identifies the pollutant causing the impairment, when known. In addition, the state assigns a priority for development of Total Maximum Daily Loads (TMDL) based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors (40 C.F.R. §130.7(b)(4)).

A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet water quality standards for that pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant. Pollutant sources are characterized as either point sources that receive a wasteload allocation (WLA) or nonpoint sources that receive a load allocation (LA).

For purposes of assigning WLAs, point sources include all sources subject to regulation under Rhode Island's Pollutant Discharge Elimination System (RIPDES) program, e.g., wastewater treatment facilities and some stormwater discharges. For purposes of assigning LAs, nonpoint sources include all remaining sources of the pollutant as well as natural background sources. TMDLs must also account for seasonal variations in water quality and include a margin of safety (MOS) to account for uncertainties in the technical analysis.

Melville Ponds were originally included on the 2010 303(d) list for impairment of the aquatic life use due to elevated levels of total phosphorus. Based on additional data collection activities in 2021 and 2023, two additional impairments were added to the state's 2024 303(d) List and are addressed in this TMDL: 1) Dissolved oxygen as an impairment to both reservoirs and 2) Total phosphorus as an impairment to the Melville Ponds tributary. The purpose of these TMDLs is to establish total phosphorus loading targets that are expected to achieve state water quality criteria and numeric criteria for total phosphorus and dissolved oxygen. Water quality that meets these objectives is expected to protect designated uses.

1.1 TMDL Study Area

Upper and Lower Melville Ponds[1] and Melville Ponds Tributary are situated in the Town of Portsmouth, located on Aquidneck Island, Rhode Island. The Melville Ponds Tributary begins at the outflow of Upper Melville Pond and then flows into Lower Melville Pond before discharging

[1] Upper Melville Ponds is also known locally as Thurston Gray Pond in honor of a long-time volunteer monitor

over a spillway into the East Passage of Narragansett Bay. The TMDL study area (Figure 2.1) comprises the combined watersheds of all three waterbodies. Table 1.1 provides waterbody name, size, and waterbody assessment unit ID.

Table 1.1. Assessment unit summaries applicable for this TMDL.

Waterbody Name	Waterbody ID	Surface Area or Length
Melville Ponds (Upper Melville Pond)	RI0007029L-01	9.85 acres
Melville Ponds (Lower Melville Pond)	RI0007029L-01	5.41 acres
Melville Ponds Tributary	RI0007029R-04	0.4596 miles

1.2 Water Quality Impairments

The water quality impairments addressed in this TMDL include total phosphorus and dissolved oxygen. **Total phosphorus** is directly related to the documented water quality impairments, including excess phytoplankton and macrophyte growth, low dissolved oxygen, and recurring and prolonged cyanobacteria blooms. **Dissolved oxygen** was added as an impairment to both Upper and Lower Melville Pond on the 2024 303(d) List and will be addressed by this TMDL. Table 1.2, excerpted from Rhode Island's 2024 Impaired Waters Report[2], details the use description, use attainment status, and cause/impairments.

Table 1.2. Use description, use attainment status, and cause/impairment for Melville Ponds and Melville Ponds Tributary (2024 Impaired Waters List Report).

Melville Ponds — RI0007029L-01 — 13.59 Acres — CLASS A
Melville Ponds. Portsmouth

Use Description	Use Attainment Status	Cause/Impairment	TMDL Schedule	TMDL Approval	Comment
Fish and Wildlife habitat	Not Supporting	DISSOLVED OXYGEN	2025	None	
	Not Supporting	PHOSPHORUS, TOTAL	2025	None	

Melville Ponds Trib — RI0007029R-04 — 0.46 Miles — CLASS A
Melville Ponds Tributary. Portsmouth

Use Description	Use Attainment Status	Cause/Impairment	TMDL Schedule	TMDL Approval	Comment
Fish and Wildlife habitat	Not Supporting	PHOSPHORUS, TOTAL	2025	None	

1.3 Priority Ranking

The 303(d) List identifies impaired waterbodies and a scheduled time frame for development of TMDLs. As such, it is used to help prioritize the State's water quality monitoring and restoration planning activities. Scheduling is not necessarily representative of the severity of water quality impacts, but rather reflects the priority given for TMDL development with consideration to

[2] 2024 Rhode Island Impaired Waters Report https://dem.ri.gov/sites/g/files/xkgbur861/files/2024-10/ridem-impaired-waters-report-24.pdf

shellfishing waters, drinking water supplies, other areas identified by the public as high priority areas, and data availability.

1.4 Applicable Water Quality Standards

A water quality standard defines the water quality goals of a surface waterbody, or portion thereof, by designating the use or uses of the water and by setting criteria necessary to protect those designated uses. Water quality standards are intended to protect public health, safety, and welfare, enhance the quality of water and serve the purposes of the federal Clean Water Act. The most recent amendment of the State's Water Quality Regulations
https://rules.sos.ri.gov/regulations/part/250-150-05-1
was completed in 2023 and is the basis for setting water quality targets in this TMDL.

1.4.1 Water Use Classification and Designated Uses

Surface waters of the state are categorized according to the water use classifications of § 1.9(B)of Rhode Island's Water Quality Regulations (https://rules.sos.ri.gov/regulations/part/250-150-05-1) and based on public health, recreation, propagation and protection of fish and wildlife, and economic and social benefit. Each class is identified by the most sensitive, and therefore governing, water uses to be protected. Surface waters may be suitable for other beneficial uses but are regulated to protect and enhance the designated uses. Water quality classifications represent the water quality **goals** for the waterbody, not the present conditions. Both Upper and Lower Melville Ponds and the Melville Ponds Tributary are **Class A waters** with the following designated uses:

Class A Designated Uses - These waters are designated for primary and secondary contact recreational activities and for fish and wildlife habitat. They shall be suitable for compatible industrial processes and cooling, hydropower, aquacultural uses, navigation, and irrigation and other agricultural uses. These waters shall have excellent aesthetic value.

1.4.2 Numeric and Narrative Water Quality Criteria

Existing numeric and narrative criteria for **total phosphorus** are provided in § 1.10 of Rhode Island Department of Environmental Management's (RIDEM) Water Quality Regulations (https://rules.sos.ri.gov/regulations/part/250-150-05-1) and are excerpted below.

Average Total phosphorus shall not exceed 0.025 mg/l in any lake, pond, kettlehole or reservoir, and average Total P in tributaries at the point where they enter such bodies of water shall not cause exceedance of this phosphorus criteria, except as naturally occurs, unless the Director determines, on a site-specific basis, that a different value for phosphorus is necessary to prevent cultural eutrophication.

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. New discharges of wastes containing phosphates will not be permitted into or immediately upstream of lakes or ponds. Phosphates shall be removed from existing discharges to the extent that such removal is or may become technically and reasonably feasible.

Existing numeric and narrative criteria for **dissolved oxygen** for warm water fish habitat are provided in § 1.10 of RIDEM's Water Quality Regulations (https://rules.sos.ri.gov/regulations/part/250-150-05-1) and are excerpted below. Melville Ponds are designated in § 1.25 of RIDEM's Water Quality Regulations as Undesignated Fisheries, which defaults to Warm Water Fisheries criteria.

Warm Water Fish Habitat - Dissolved oxygen content of not less than 60% saturation, based on a daily average, and an instantaneous minimum dissolved oxygen concentration of at least 5.0 mg/l, except as naturally occurs. The 7-day mean water column dissolved oxygen concentration shall not be less than 6 mg/l.

1.4.3 Numeric Water Quality Targets applicable for this TMDL

The numeric total phosphorus TMDL target concentration for Upper Melville Pond is equivalent to the state's 25 ug/l total phosphorus criteria. The numeric total phosphorus target concentration for the Melville Pond Tributary and the Lower Melville Pond is 20 ug/l. The allowable loads for both reservoirs and Melville Pond Tributary are calculated using these numeric criteria. These targets are meant to be assessed as seasonal means (April-Oct). The basis for setting a lower total phosphorus target for Lower Melville Pond is described in Section 5.3.

Numeric nutrient criteria for phosphorus in streams and rivers has not been adopted into Rhode Island regulations. The applicable adopted narrative nutrient criterion specifies that nutrient levels should not impair any usage, or cause undesirable aquatic species associated with cultural eutrophication, nor cause exceedance of the 25ug/l criterion in a downstream lake, pond, or reservoir. The 1986 EPA Quality Criteria for Water (https://19january2021snapshot.epa.gov/sites/static/files/2018-10/documents/quality-criteria-water-1986.pdf) states that 'to prevent the development of biological nuisances and to control accelerated or cultural eutrophication, total phosphates as phosphorus (TP) should not exceed 50 ug/l in any stream at the point where it enters any lake or reservoir'.

The 20ug/l target set for Melville Ponds Tributary, due to its connection to the downstream Lower Melville Pond, is well below this 50 ug/l total phosphorus target. Therefore, it is expected that the 20ug/l total phosphorus target for Melville Ponds Tributary is protective of the flowing waters of the tributary itself.

The TMDL must also ensure that the water quality criteria for dissolved oxygen are met. Reducing phosphorus is the most effective way to reduce algal abundance, because the growth of algae in freshwater environments is typically constrained by the availability of phosphorus. With algal abundance under control, dissolved oxygen violations of criteria will be reduced. Consequently, dissolved oxygen TMDL targets are not set explicitly in this TMDL. The warm water dissolved oxygen criteria will be met by achieving the ambient phosphorus concentrations presented above.

1.4.4 Anti-degradation Policy

The State Antidegradation Regulations (https://rules.sos.ri.gov/regulations/part/250-150-05-1) are based on the federal Antidegradation Policy requirements, Antidegradation Policy and Implementation Methods (40 C.F.R. § 131.12) and have as their objective the maintenance and protection of various levels of surface water quality and uses. Antidegradation applies 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 RIPDES permits.

2 Background

2.1 Watershed and Waterbody Characterization

Both reservoirs and the Melville Pond Tributary are located entirely in the Town of Portsmouth, Rhode Island and share a combined watershed of approximately 198 hectares (489 acres) (Figure 2.1). The direct watershed to Upper Melville Pond is approximately 99 hectares (245 acres) with inflow consisting primarily of groundwater discharge and a stormwater outfall discharging to a fairly defined channel within a small wetland area adjacent to the pond. This channel meanders approximately 250 meters (820 feet) through the wetland area prior to entering the pond.

Upper Melville Pond discharges via a grated weir structure to Pond 2, which makes up the 'headwaters' of Melville Ponds Tributary. This stream flows approximately 0.75 km (0.47 mi) through a forested wetland, including six other small impoundments (named by the US Navy as Ponds 3-8), with poorly draining soils due to the elevated water table. The stream then flows through a section of rock outcrop prior to discharging to Lower Melville Pond. The watershed of Lower Melville Pond is approximately 198 hectares (489 ac) in size and includes inflow from Melville Ponds tributary, groundwater discharge, several stormwater outfalls, and numerous overland flow sites.

Existing land use in the combined Melville Ponds watershed is comprised primarily of developed land (58%) and forest/brushland (25%), with small areas of wetlands (9%), and agriculture (5%). Figure 2.2 presents a more detailed breakout of land use type and location within the watershed. Percent impervious cover in the watershed is approximately 21%. Municipal Separate Storm Sewer System (MS4) regulated entities include Rhode Island Department of Transportation (RIDOT), Town of Portsmouth, and Naval Station Newport (NAVSTA Newport). MS4-regulated outfalls are depicted on Figure 2.3. NAVSTA Newport maintains sewer infrastructure within the Melville Ponds watershed that includes pump stations, force and gravity service mains, and manholes.

Although the combined watershed is small, there are a variety of recreational amenities that make it a popular location on Aquidneck Island, particularly with respect to freshwater recreational resources. The Melville Park Recreation Area is located within the watershed and receives heavy use from the public. The 153-acre tract is devoted to passive recreation and consists of all nine ponds (previously described), hardwood and pine forests, substantial wetland areas, and various hiking trails. The Melville Park Committee was established by the Portsmouth Town Council in 2008 to supervise the Melville Park Recreation Area. The committee actively engages with both the public and relative agencies and volunteer monitoring group (RIDEM, NAVSTA Newport, Town of Portsmouth, University of Rhode Island Watershed Watch) and expresses concern and interest in addressing the water quality issues currently impacting the ponds.

A popular dog park and the Newport RV Park are also located within the watershed. The RV Park has over 70 RV and tent sites and is sited adjacent to the trail system within the Melville Park Recreation Area. Upper Melville Pond has a wooden fishing dock along the southern shoreline and a small floating dock on the northern side used for launching canoes and kayaks. Lower Melville Pond has numerous fishing access sites off established hiking trails. Both ponds are stocked with trout and are popular for recreational fishing.

Land use has changed significantly since the reservoirs and their associated sedimentation basins were built by the Navy (Figures 2.4 and 2.5). In 1952, approximately 60% of the watershed consisted of agricultural land uses, which was the impetus for constructing the seven smaller ponds. Conversion of agricultural land use to residential and commercial land uses began in the mid to late 1980's and by 2020 only 6% of the watershed consisted of agricultural land uses.

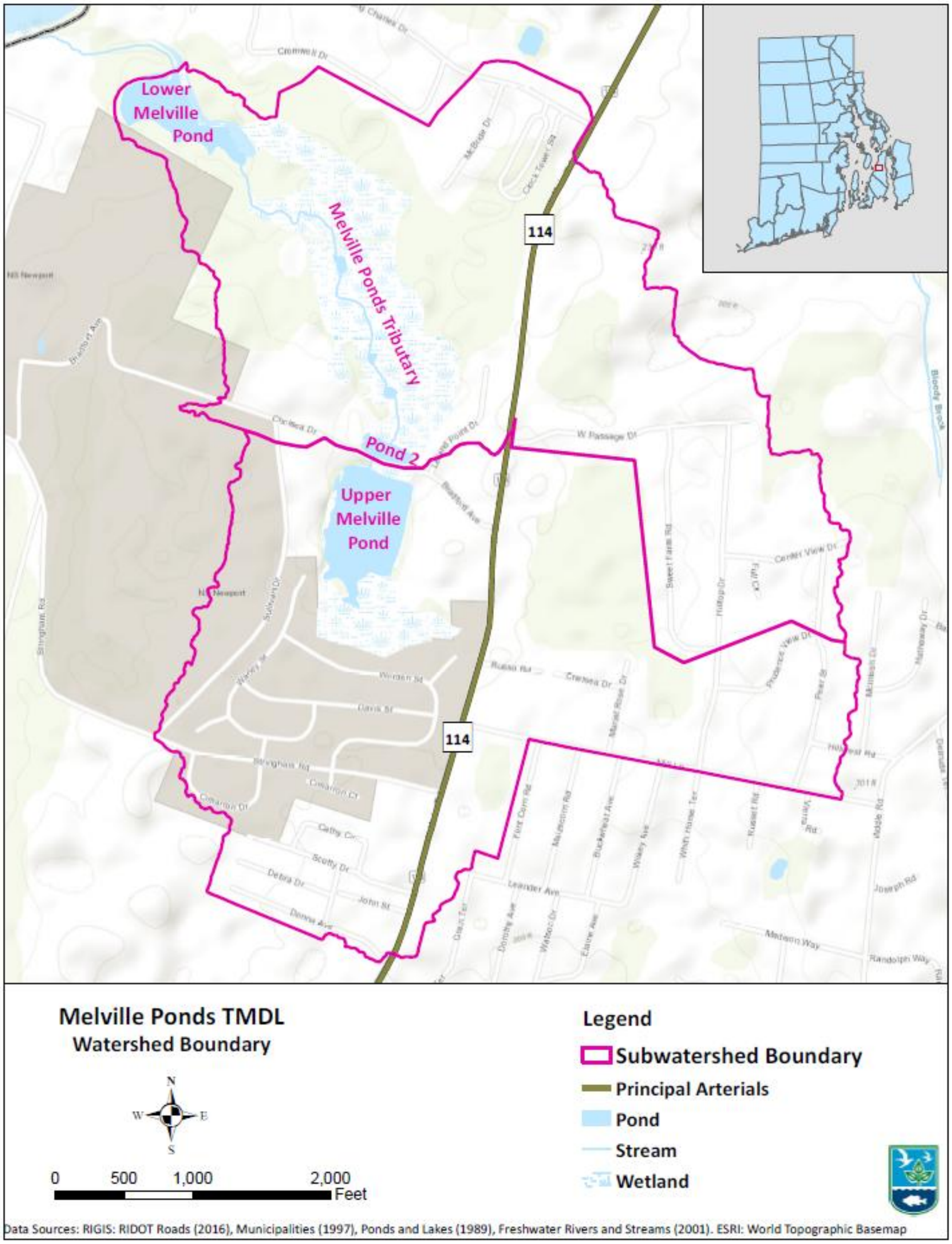

Figure 2.1 Locus and watershed map of Melville Ponds and Tributary.

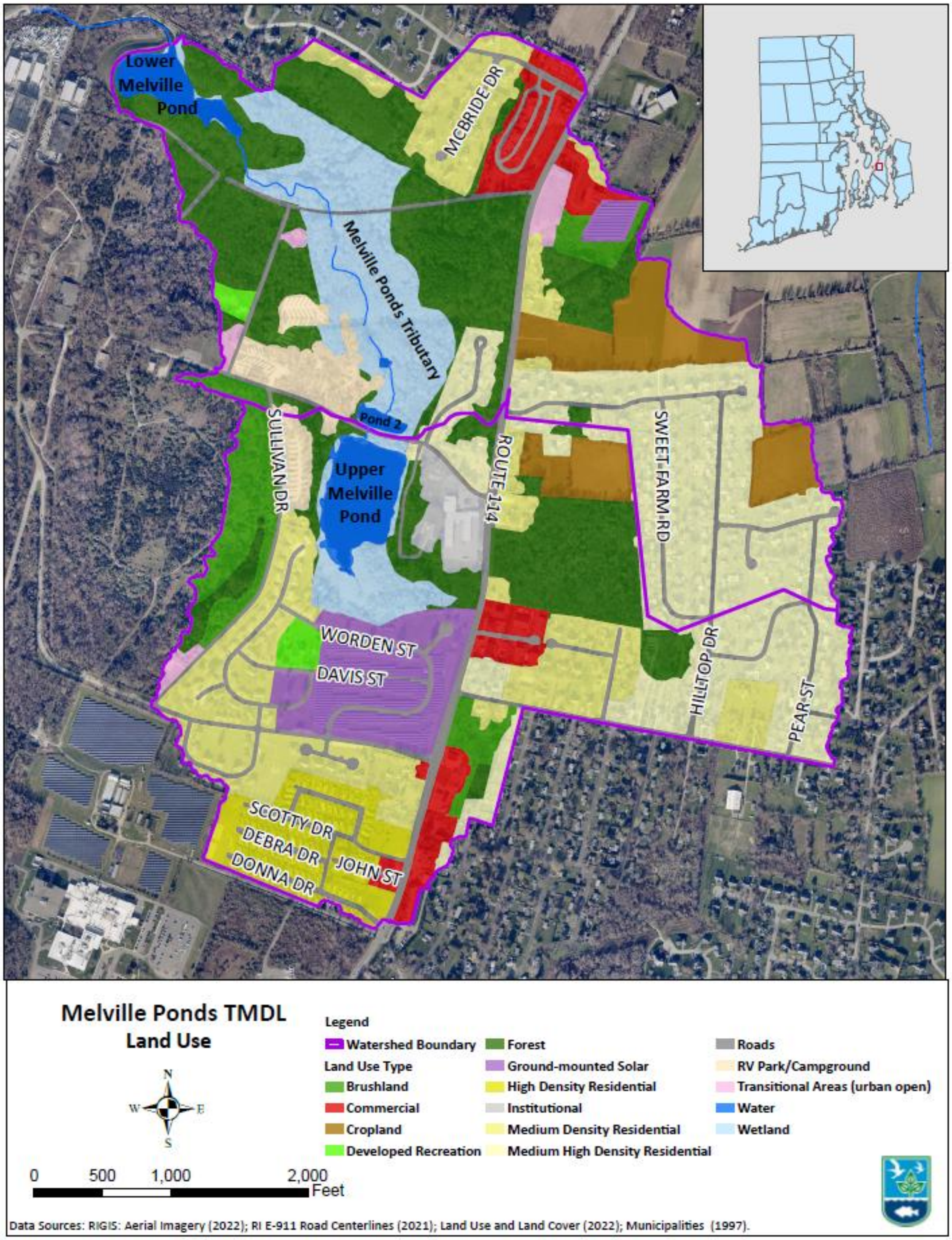

Figure 2.2. General land use in the Melville Ponds watershed.

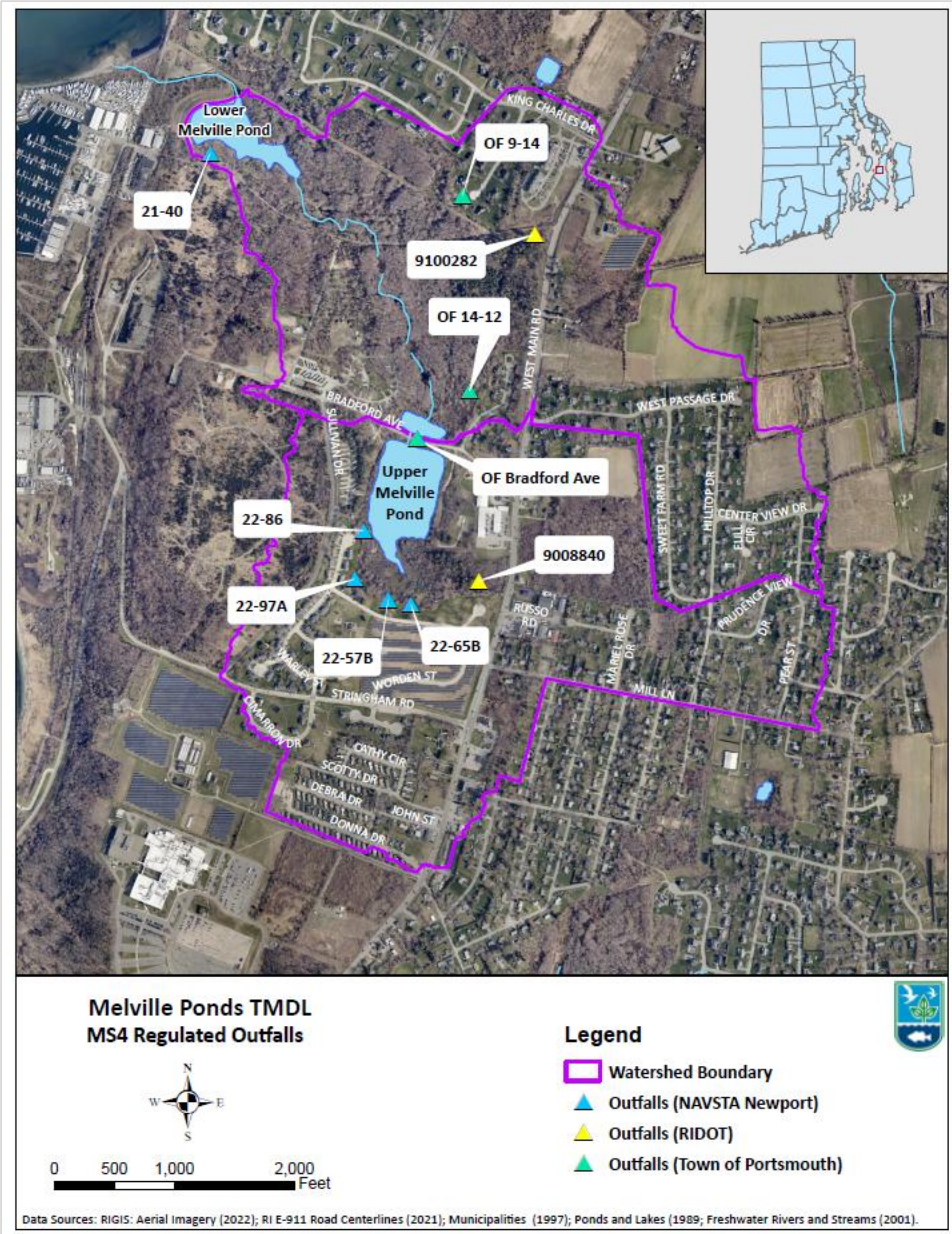

Figure 2.3. MS4 regulated outfalls in the Melville Ponds watershed.

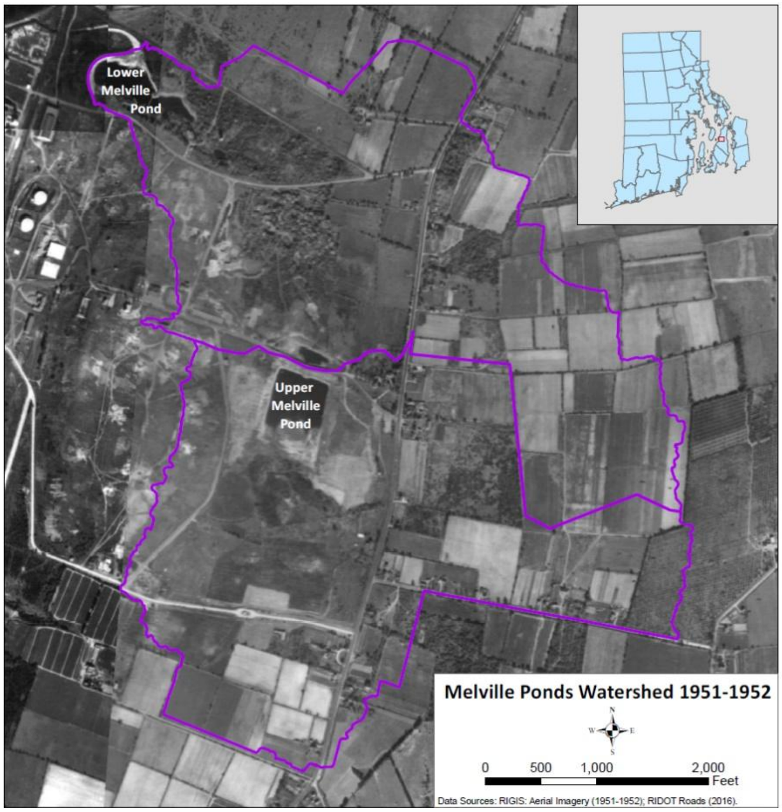

Figure 2.4. Aerial Photograph of Melville Ponds watershed in 1950's.

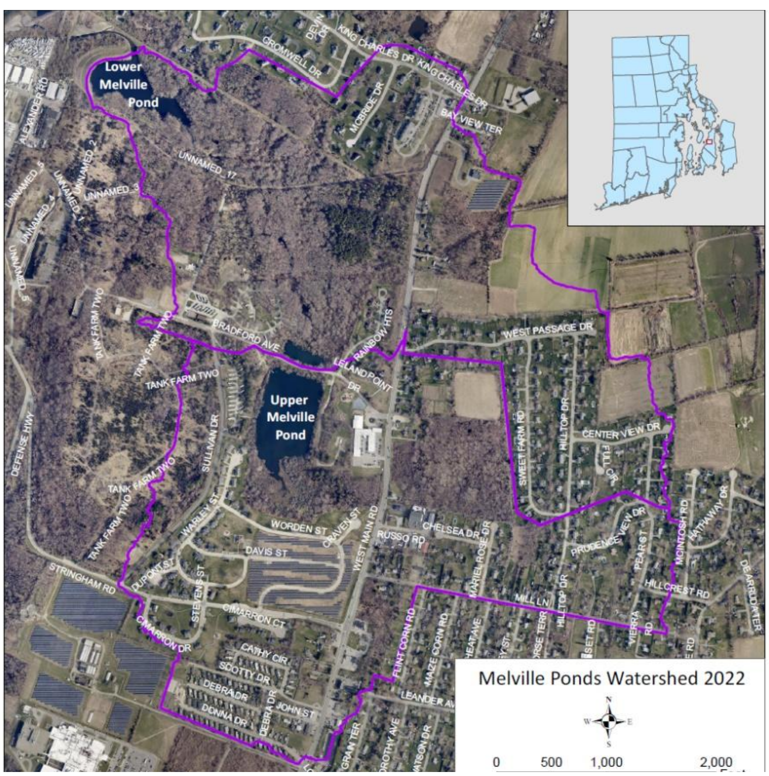

Figure 2.5. Aerial photograph of Melville Ponds watershed in 2022.

2.2 Reservoir and Tributary Characteristics

Upper and Lower Melville Ponds were built by the US Navy between 1942 and 1950 to be used as both drinking water and fire suppression supplies. Seven (7) smaller ponds (aka Ponds 2-8) were also built between the two reservoirs to act as sedimentation basins. Ownership of the ponds and associated infrastructure was transferred to the Town of Portsmouth in the 1970's. Currently, Upper Melville, Pond 2 (located off the north side of Bradford Ave), and Lower Melville are open-water ponds. The remaining 6 ponds have minimal open water remaining and now resemble and function as wetlands. The original infrastructure including dams and inlet, outlet, intake structures have not been maintained and are in poor and/or non-working condition.

According to historic plans, Upper Melville Pond and Pond 2 are hydraulically connected via a structure underneath Bradford Avenue. Schematic drawings of the historic connections (as they were to be designed) were provided to RIDEM by NAVSTA Newport. According to a site plan from 1944, Upper Melville Pond and Pond 2 are connected via two 36" culverts which are enclosed in a grated weir structure on the south side of Bradford Avenue. Staff from RIDEM attempted to locate the outlet pipes at the bottom of the grated weir structure to verify flow from Upper Melville Pond to Pond 2. The structure is currently in poor condition. The ladder is broken and any flow control mechanism that may have existed at one time is no longer present. Numerous large rocks are present at the bottom of the structure which prevented RIDEM staff from locating the pipes.

Both RIDEM staff and the Town of Portsmouth Department of Public Works attempted to confirm the connection between Upper Melville Pond and Pond 2 via dye study. No confirmation could be made, and it is unclear if the pipes are blocked, clogged, or collapsed. Members of the Town of Portsmouth Department of Public Works and the Melville Parks Committee have stated that on occasion when water levels get too high in Upper Melville Pond, debris needs to be cleared out from the outlet structure and the water level then subsequently drops. Pond 2 was visited in January 2024 by RIDEM staff. The pond was covered in ice extending about 15 feet from the shoreline, except for an open area of water near where the outlet of the two 36" pipes is expected to be based on the site plans. The drop in water level after clearing the outlet structure of debris and the lack of ice near the outlet imply that water is still moving from Upper Melville Pond to Pond 2.

Plans provided by the Navy also show that the original design of the system allowed water from Upper Melville Pond to be moved to the Melville Pond tributary through a concrete gate house located off the shoreline of the northwest corner of the pond and just off a floating dock. The gatehouse is approximately eight foot square and approximately 17 feet deep and has an 18" hand wheel that was designed to allow water from the pond to be diverted to the Melville Pond tributary near the outlet of Pond 3 via a 12" concrete/cast iron pipe. Staff from the Navy have stated that this wheel is no longer functional, and it is not known if the valve is open, closed, or partially open. RIDEM staff conducted a dye study but were unable to confirm flow from the 12" pipe to the tributary.

Bathymetric surveys were conducted in Upper and Lower Melville Pond by RIDEM in 2021. Extensive macrophyte coverage, dominated by wavy waternymph (*Najas flexilis*) in Upper Pond limited data collection and resulted in a dearth of depth datapoints which affected bathymetric map resolution. Bathymetric maps of each reservoir are provided in Figures 2.6 and 2.7. Select morphometric and other physical characteristics of Upper and Lower Melville Pond and the Melville Pond tributary are presented in Table 2.1.

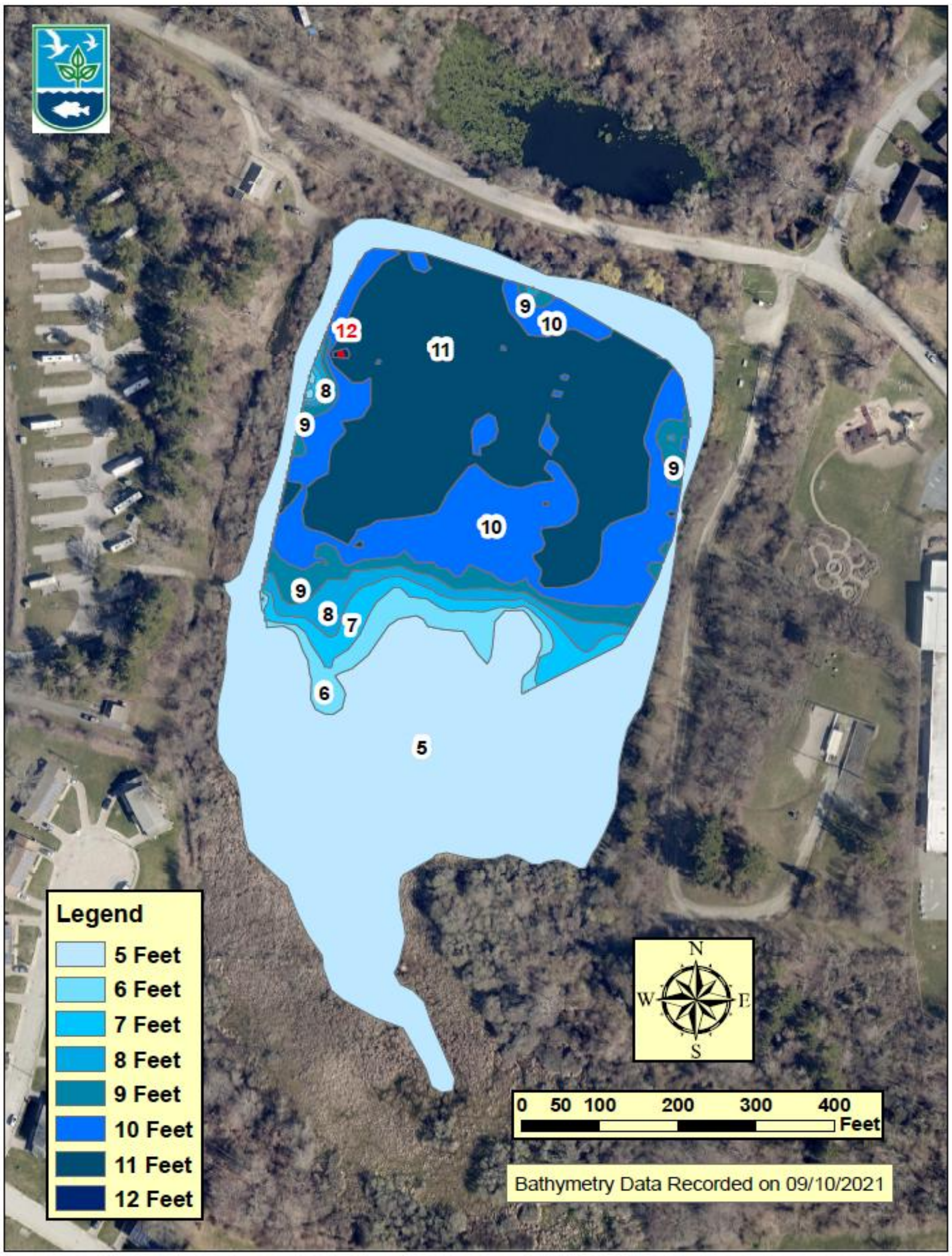

Figure 2.6 Bathymetric map of Upper Melville Pond.

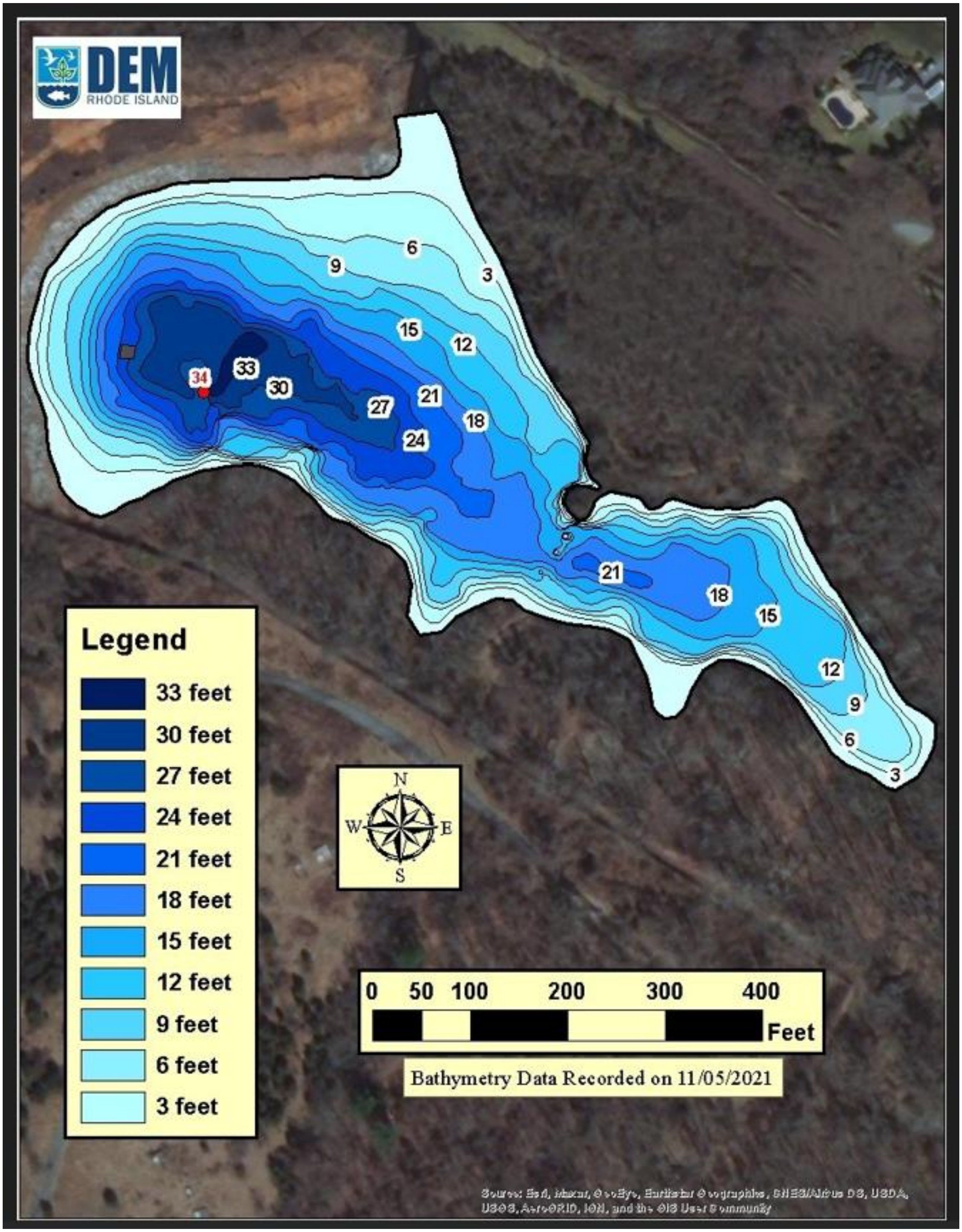

Figure 2.7. Bathymetric map of Lower Melville Pond.

Table 2.1. Morphometric characteristics of Upper and Lower Melville Pond and Melville Pond Tributary.

Parameter	Upper Melville Pond	Lower Melville Pond	Melville Pond Tributary
Surface Area (m^2)	39,862	21,893	
Mean Depth (m)	2.3	4.1	
Max Depth (m)	3.7	10.1	
Est. Volume (m^3)	92,338	92,289	
Est. Flushing Rate (yr^{-1})	3.4	11.5	
Length (km)			0.74

Vertical profiling of dissolved oxygen and temperature was conducted on a bi-weekly basis from May through October 2021 at the deepest point in both Upper and Lower Melville Pond https://dem.ri.gov/environmental-protection-bureau/water-resources/research-monitoring/restoration-studies-tmdl-documents. Vertical temperature profile plots for Upper and Lower Melville Ponds are presented in Figures 2.8 and 2.9 respectively.

Upper Melville Pond showed intermittent periods of weak stratification with water column mixing occurring after moderate wind events. During most of the summer, temperature profiles showed a clear epilimnion[3] with a thermocline[4] extending to the bottom. The extensive macrophyte coverage that exists in Upper Melville Pond during the growing season may alter the thermal dynamics/structure of the pond by inhibiting wind mixing.

As expected, thermal stratification in Lower Melville Pond was more pronounced and longer lasting. The reservoir (the deeper eastern lobe) exhibited stratification with a clear epilimnion, thermocline, and hypolimnion[5] beginning in mid-May and lasting through early October. By mid-October the thermocline began to decay and in early November the water column was fully mixed, which is typical of temperate dimictic[6] lakes.

[3] Epilimnion is the warmer water overlying the thermocline (temperature change point) of the lake water column during stratification

[4] A steep temperature gradient in a body of water marked by warmer temperature in the upper layer called the epilimnion and colder layer below called the hypolimnion

[5] The hypolimnion is the colder layer below the thermocline

[6] Meaning the waterbody has two period of full water column mixing (typically spring and fall)

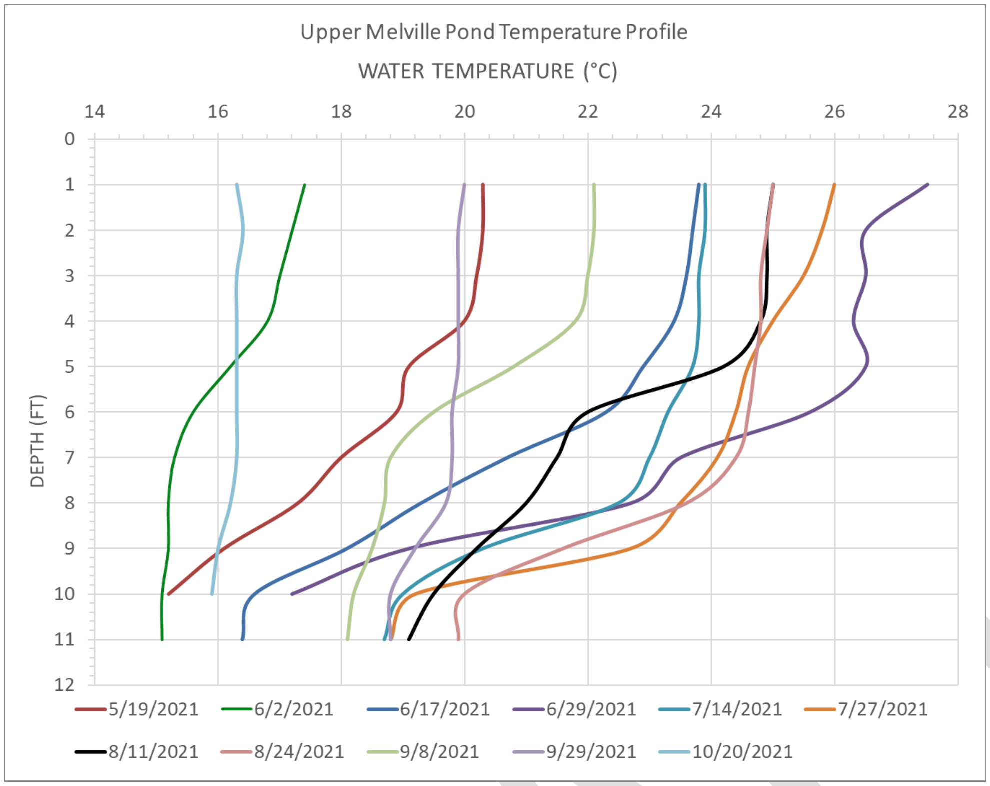

Figure 2.8. Upper Melville Pond temperature profile (2021).

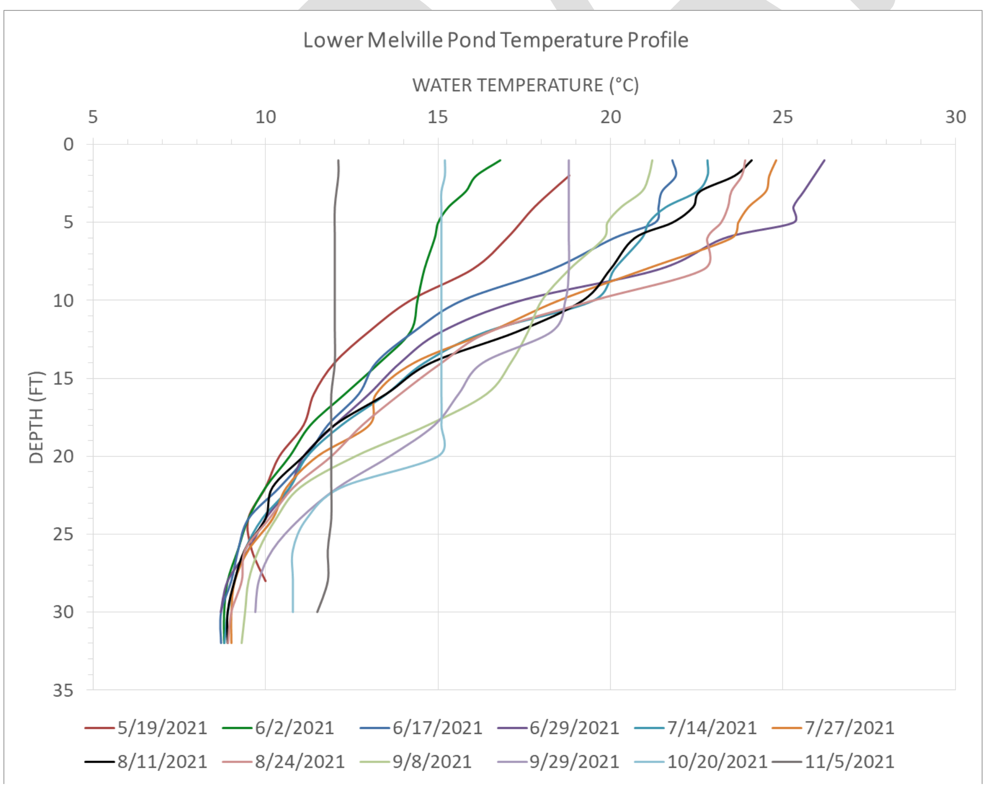

Figure 2.9. Lower Melville Pond temperature profile (2021).

3 Current Water Quality Conditions

Existing water quality data for Upper and Lower Melville Ponds and the Melville Pond tributary originate from two sources: the University of Rhode Island Watershed Watch Program volunteer monitoring and RIDEM Office of Water Resources (OWR). The University of Rhode Island (URI) Watershed Watch (URIWW) Program is headed by the Department of Natural Resource Sciences at URI and is an institutional collaborative between RIDEM, URI, and local sponsors.

Water quality analysis performed by URI Watershed Watch primarily provides information on nutrient enrichment, bacterial contamination, and lake acidification. The following parameters are monitored: water clarity (Secchi depth transparency), algal density (chlorophyll-a), dissolved oxygen, water temperature, alkalinity and pH, nutrients, and bacteria (enterococci in freshwaters and fecal coliform in marine waters). Volunteers with URIWW have been collecting data on Upper Melville Pond since 1997. The URIWW station in Upper Melville Pond is located at the deepest point in the reservoir, which is shown in Figure 3.1.

RIDEM OWR conducted bi-weekly water quality sampling and other data collection activities in Upper and Lower Melville Pond in May through October 2021 (See EPA-approved QAPP)(Figure 3.1). These data collection activities were meant to support TMDL development and included obtaining routine water quality samples and physical data. Data were collected from both ponds during bi-weekly surveys from May through October 2021. Water samples were collected from the surface (epilimnion) and, if stratified, from the hypolimnion. Under stratified conditions, samples analyzed for total phosphorus were collected from two depths[7] at the sample station: 1) epilimnion (surface) using a 2-meter vertically integrated sampler and 2) hypolimnion (depth) using a Van Dorn sampler.

All samples were analyzed for total phosphorus (TP), orthophosphate (PO_4), nitrite and nitrate nitrogen (NO_2 and NO_3-N), total Kjeldahl nitrogen (TKN), ammonia (NH_3), and chlorophyll-a. Water clarity was measured using a Secchi disc. To determine the physical state of the reservoir (i.e., stratification and de-stratification events), temperature, dissolved oxygen, and specific conductance was measured at specific increments from the surface to the bottom at the deepest location.

In 2023, RIDEM collected water samples from two locations (Figure 3.1) in the Melville Ponds Tributary (See Sampling Plan). Between June and September nine (9) samples were collected in the headwater and outlet of the stream. Samples were analyzed for total phosphorus and ortho-phosphorus. The purpose of the sampling was to characterize phosphorus dynamics in the stream-particularly the attenuation of phosphorus through the wetland system separating Upper and Lower Melville Pond.

[7] Upper Melville Pond did not exhibit typical epilimnion, thermocline, and hypolimnion set-up. Therefore, the term 'surface' and 'depth' are used instead of epilimnion and hypolimnion.

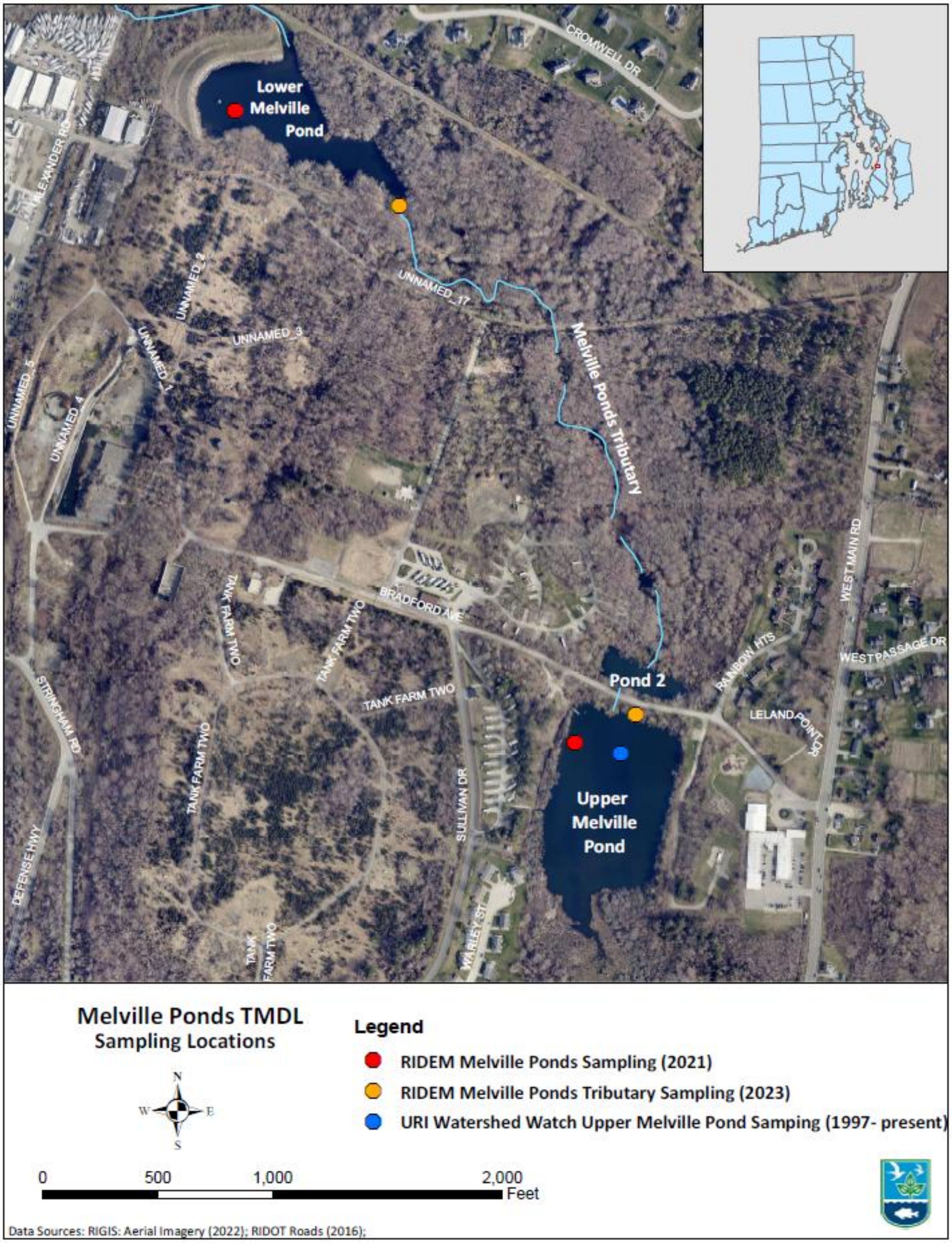

Figure 3.1. Water quality sampling information in Melville Ponds watershed.

3.1 Upper Melville Pond (WBID RI0007029L-01)

The URIWW period of record dataset for Upper Melville Pond is substantial and includes 23 years of seasonally collected total phosphorus data and 21 years of chlorophyll-a data. All URIWW samples were collected from the surface (or epilimnion) of the reservoir. The number of total phosphorus samples per year ranges from 3-5 while the number of chlorophyll-a samples per year ranges from 6-14. RIDEM collected additional water quality and physical data in Upper Melville Pond in 2021.

3.1.1 Total Phosphorus

Although seasonal mean epilimnetic total phosphorus concentrations in Upper Melville Pond show significant variation over the period of record (Figure 3.2), they consistently exceed the numeric water quality standard of 25 ug/l. A trend analysis was not completed, but there are no discernable trends in visual analysis of the period of record dataset. The year-to-year variation likely is due to seasonal variation in precipitation and concomitant levels of phosphorus loading and/or other factors including manipulation of the pond's outlet structure or aquatic plant or macroalgae growth and decay.

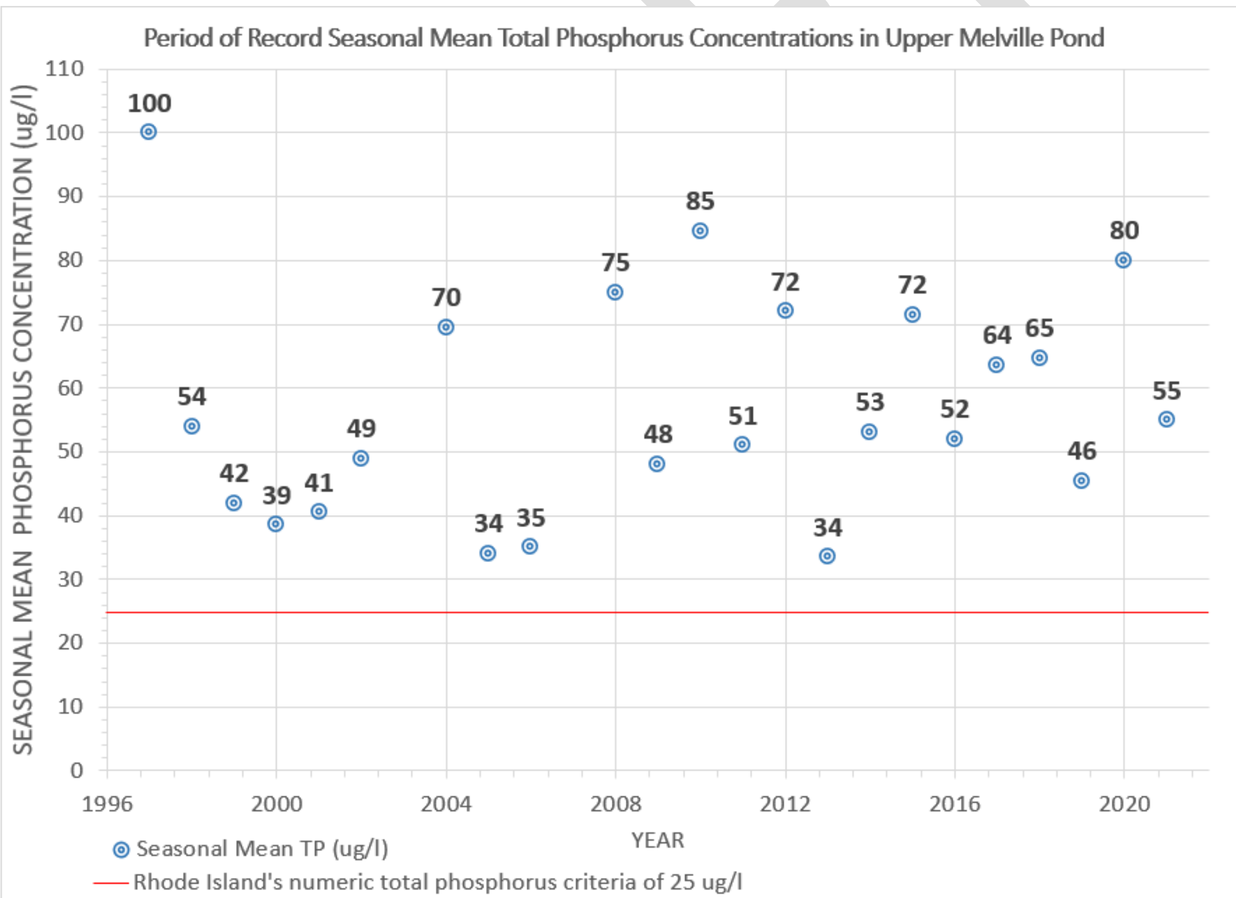

Figure 3.2. Period of record seasonal mean TP concentrations in Upper Melville Pond.

Figure 3.3 shows the total phosphorus concentrations in the upper and lower portions of the water column. As stated earlier, Upper Melville Pond did not fully stratify during 2021, however there were periods of weak stratification where the epilimnion transitioned to a thermocline that continued to the bottom of the reservoir. Between 6/29 and 9/29 of 2021 there were notable differences in surface and bottom total phosphorus concentrations suggesting that phosphorus may be accumulating in the bottom portion of the water column as phosphorus is being released from anoxic sediments. In the days prior to the 8/11/21 sampling date, a significant precipitation and wind event occurred, likely resulting in a fully mixed water column. The water column appeared to begin mixing after 8/24/2021 and between 9/29 and 10/20 became fully mixed.

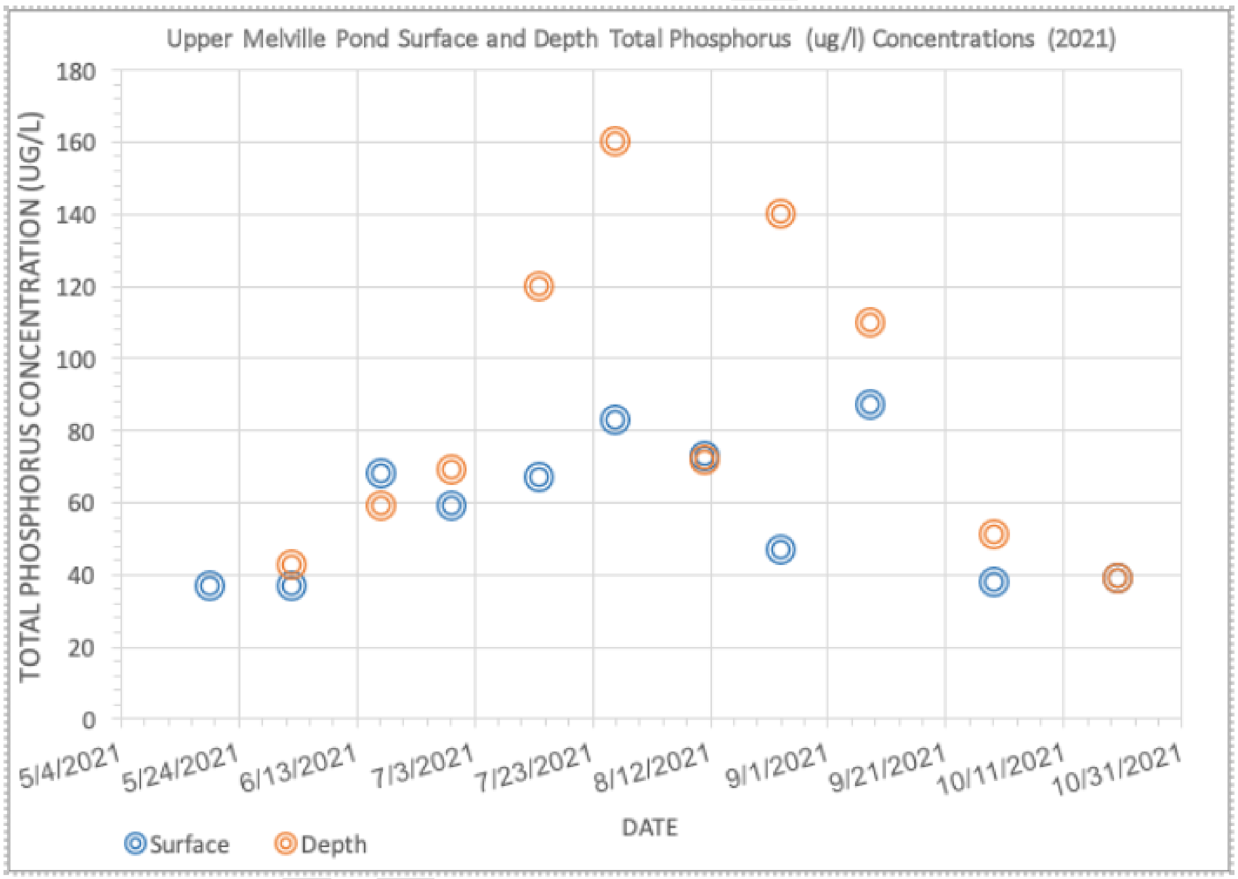

Figure 3.3. Surface and depth TP concentrations in Upper Melville Pond (2021).

3.1.2 Chlorophyll-a

Chlorophyll-a is the green photosynthetic pigment found in nearly all plants, algae, phytoplankton, and cyanobacteria. Chlorophyll-a is measured and reported as the number of micrograms per one liter (µg /l) of water. Water column chlorophyll-a concentration is correlated to phytoplankton biomass and is often used as a surrogate for phytoplankton abundance.

RIDEM does not have a numeric criterion for chlorophyll-a however, chlorophyll-a levels exceeding 10 ug/l are generally recognized as characteristic of eutrophic (or over-enriched with nutrients) waterbodies. In general, phytoplankton/cyanobacteria blooms indicate that nutrients are being supplied in excess. In peer-reviewed studies, Downing et al. (2001) analyzed the risk of waterbodies with phytoplankton populations dominated by cyanobacteria. Their study concluded that chlorophyll-a levels above 10 µg/l exponentially increased the likelihood of cyanobacteria dominance in the phytoplankton community.

Figure 3.4 displays the period of record (21-yrs) chlorophyll-a concentrations in Upper Melville Pond. Seasonal mean values range from less than 10 ug/l to over 40 ug/l with a notable upward visual trend in seasonal mean value for the period of record.

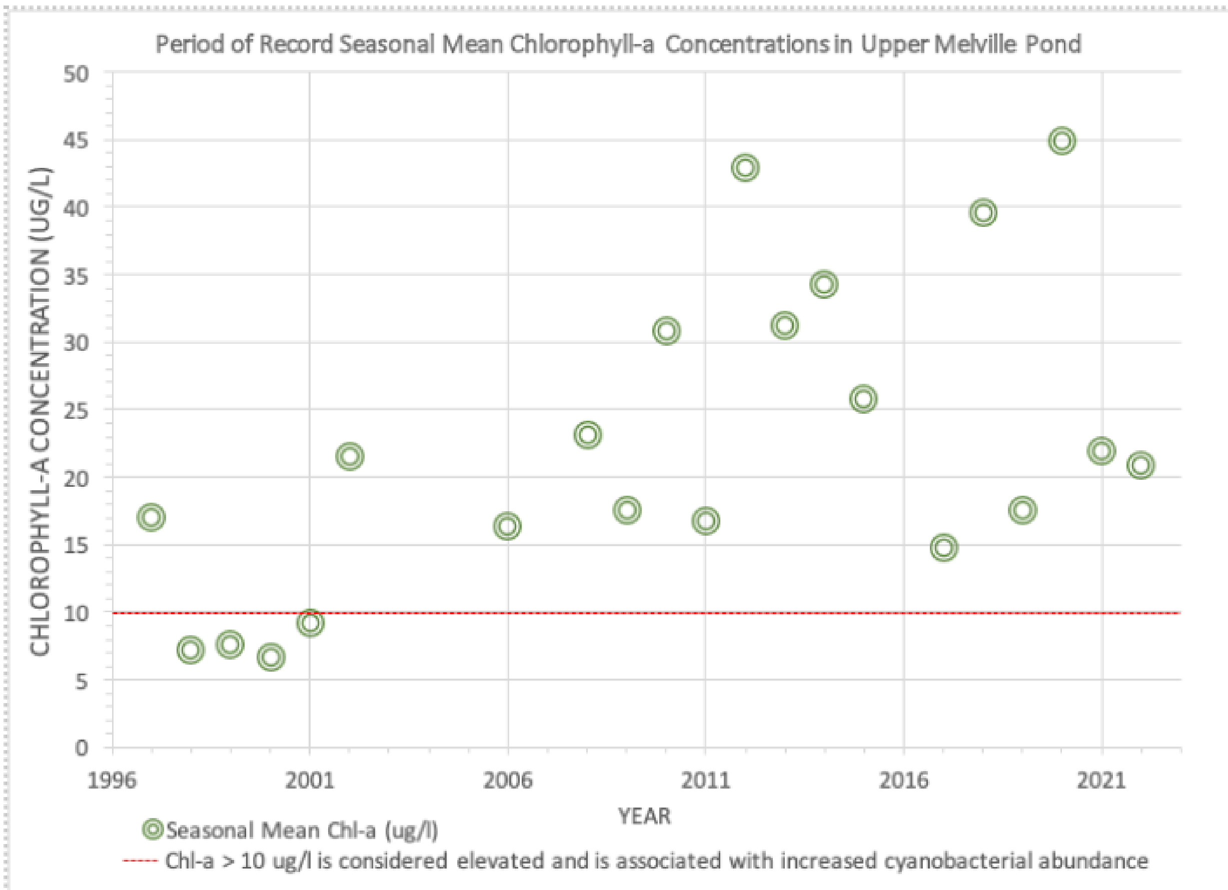

Figure 3.4. Period of record seasonal mean chlorophyll-a concentrations in Upper Melville Pond.

3.1.3 Dissolved Oxygen

Dissolved oxygen profiles generated from bi-weekly vertical sampling of Upper Melville Pond are presented in Figure 3.5. Dissolved oxygen values exhibited a consistent decline from a maximum surface value. The warm water dissolved oxygen criteria instantaneous minimum of 5.0 mg/l, shown as a red line in Figure 3.5, was routinely exceeded in the bottom portion of the water column, regardless of thermal structure, including above 2.0m in depth. As a result of these data, dissolved oxygen was added as an impairment to Upper Melville Pond on the state's 2024 303(d) List of Impaired waters.

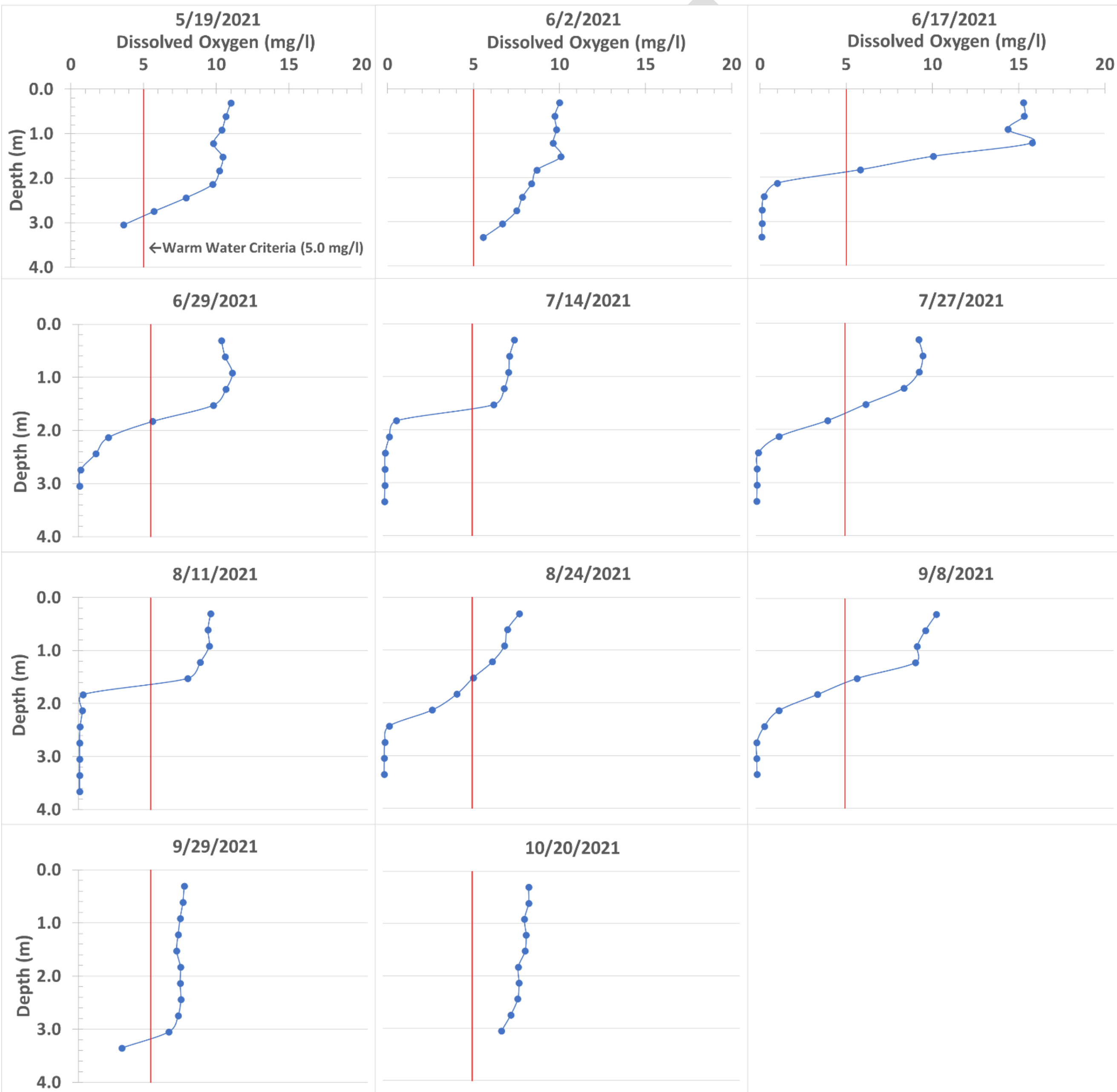

Figure 3.5. Upper Melville Pond dissolved oxygen profiles (2021).

3.2 Melville Pond Tributary (WB ID RI0007029R-04)

In 2023, RIDEM collected water samples from the headwaters and outlet of Melville Pond tributary. Samples were obtained on a bi-weekly basis from June through September and were analyzed for total phosphorus and orthophosphate. As stated previously, the main objective of the sampling was to characterize total phosphorus concentrations in the stream and evaluate phosphorus attenuation or gain between Upper and Lower Melville Ponds. The total phosphorus average percent loss (by concentration) between the headwater and outlet site was 46%. Figure 3.6 displays these data.

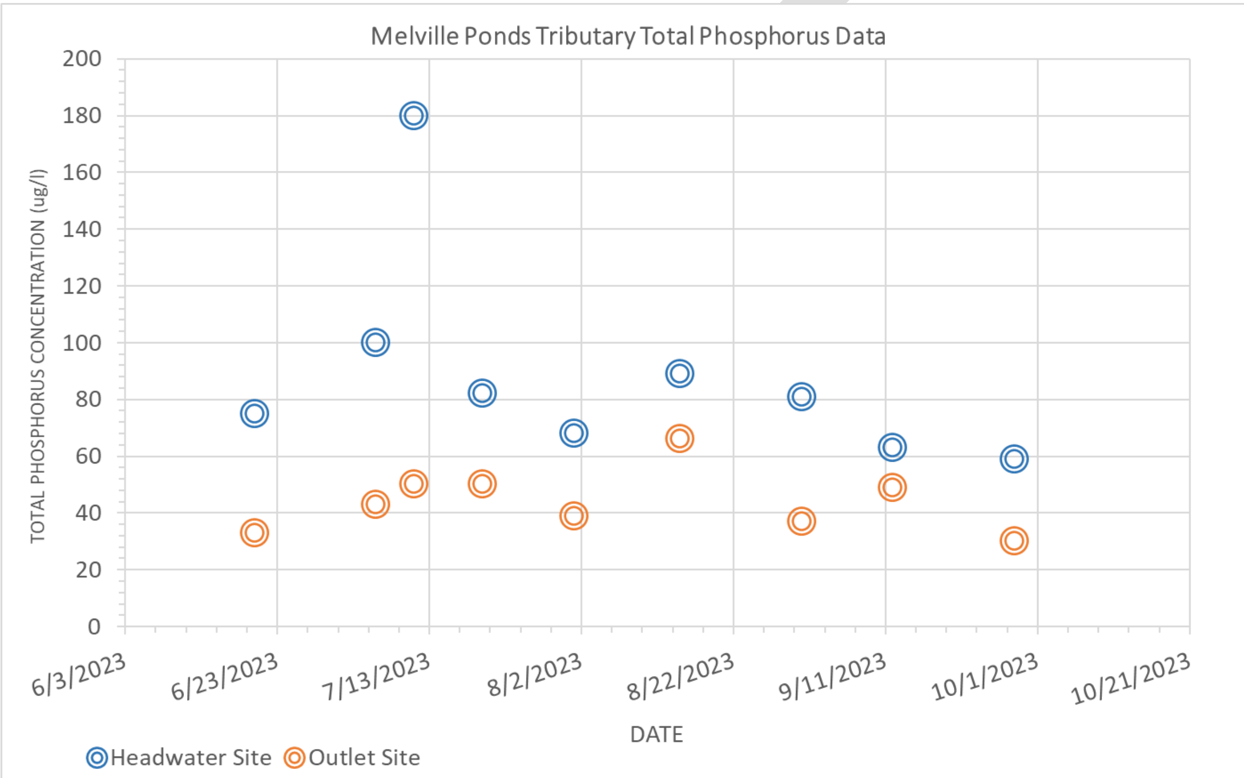

Figure 3.6. Total phosphorus concentrations in the Melville Ponds Tributary (2023).

3.3 Lower Melville Pond (WB ID RI0007029L-01)

Water chemistry and physical data in Lower Melville Pond were collected for the period May through October 2021 and at the station noted in Figure 3.1. The reservoir was thermally stratified during a majority of the monitoring period and samples were collected from the surface (epilimnion) and the hypolimnion. All samples were analyzed for total phosphorus (TP), orthophosphate (PO4), nitrite and nitrate nitrogen (NO_2 and NO_3-N), total Kjeldahl nitrogen (TKN), ammonia (NH_3), and chlorophyll-a. Temperature, dissolved oxygen, and specific conductance were measured at specific increments from the surface to the bottom at sampling location corresponding to the deepest location of the lake (Figure 3.1).

3.3.1 Total Phosphorus

Epilimnetic and hypolimnetic total phosphorus concentrations in Lower Melville Pond are displayed in Figure 3.7. The mean epilimnetic total phosphorus concentration of 45 ug/l is well above the numeric criteria of 25 ug/l. Hypolimnetic total phosphorus concentrations were elevated relative to epilimnetic concentrations, particularly from early July through the end of October. This suggests that phosphorus is being released from anoxic sediments (Section 3.2.3) into the overlying water column.

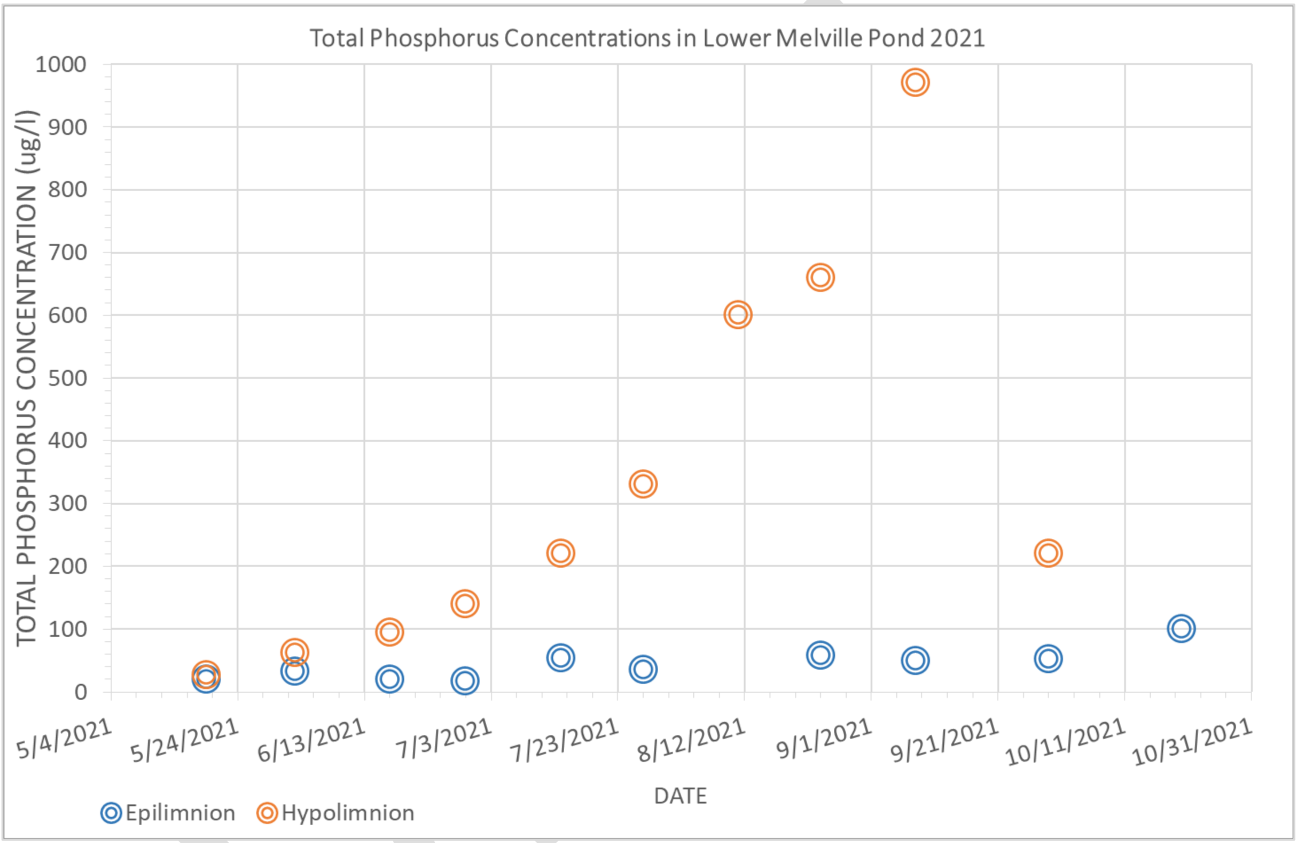

Figure 3.7. Total phosphorus concentrations in Lower Melville Pond (2021).

3.3.2 Chlorophyll-a

The significance of obtaining chlorophyll-a measurements in freshwater was explained in Section 3.1.2. Figure 3.8 displays the limited chlorophyll-a data obtained in Lower Melville Pond in 2021. Aside from the 07/14/2021 sampling date, chlorophyll-a concentrations were fairly low through mid-July. The chlorophyll-a concentration of 72 ug/l on 07/14/2021 corresponds with a sample collected on the same day (by RIDEM's Freshwater Harmful Algal Bloom program) that had a total cyanobacteria cell count of > 421,000 cells/ml. Between 07/14/2021 and 07/23/2021 chlorophyll-a concentrations decreased to ~ 8 ug/l and from there began to show an upward trend with another notable spike of (56.4 mg/l) in mid-August.

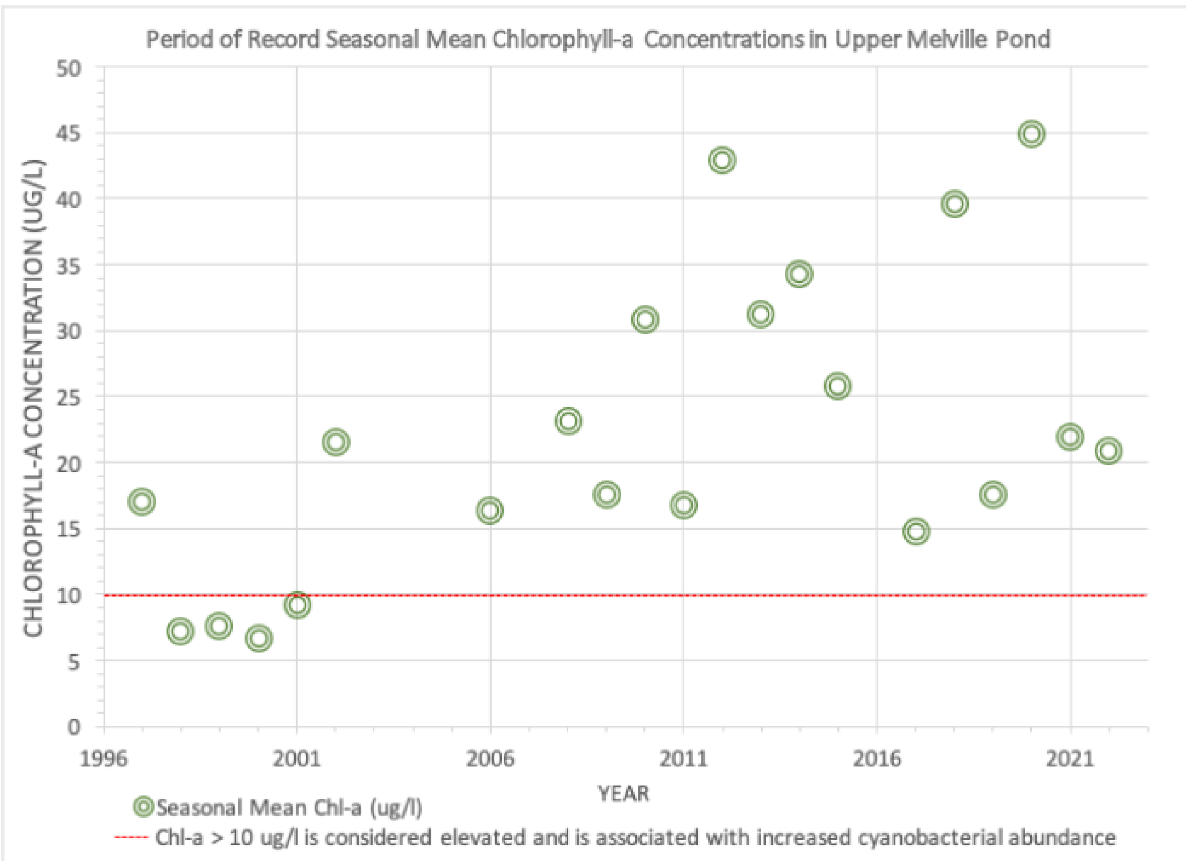

Figure 3.8. Chlorophyll-a concentrations in Lower Melville Pond (2021).

3.3.3 Dissolved Oxygen

Dissolved oxygen profiles generated from bi-weekly vertical sampling of Lower Melville Pond are presented in Figure 3.9. The profiles document thermal stratification as early as mid-May and continuing through the end of September. Water column mixing begins around the end of September with the water column becoming fully mixed by early November. The warm water dissolved oxygen criteria instantaneous minimum of 5.0 mg/l, shown in the red line in Figure 3.9, was exceeded in the upper 3.0 meters of the water column in later surveys. As a result of these data, dissolved oxygen was added as an impairment to Lower Melville Pond on the states' 2024 303(d) List.

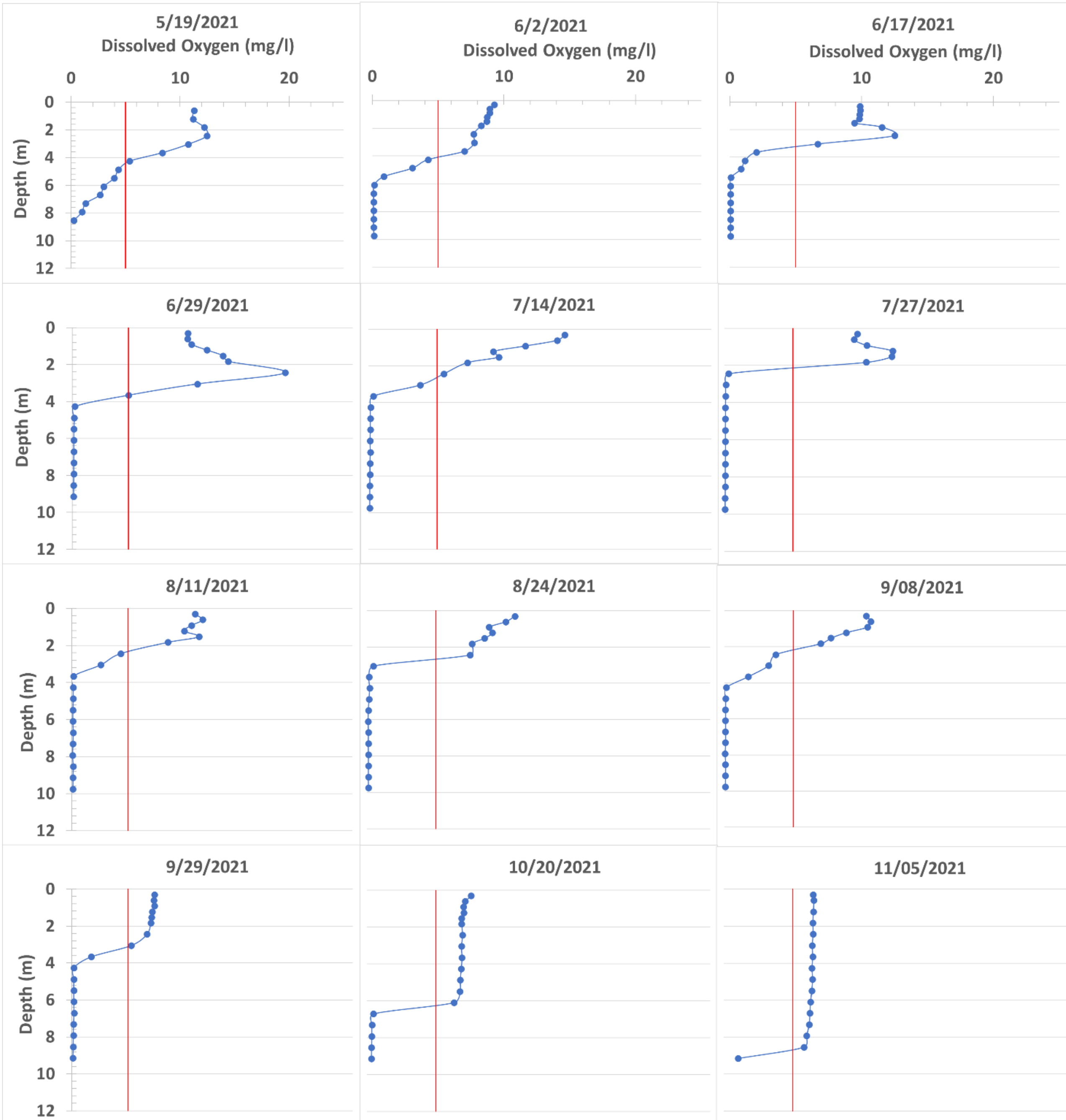

Figure 3.9. Lower Melville Pond dissolved oxygen profiles (2021).

3.3.4 Cyanobacteria Blooms in Upper and Lower Melville Pond

Cyanobacteria, also known as blue-green algae, are a group of bacteria that perform photosynthesis using the chlorophyll in their cells. Cyanobacteria may occur as single cells, thread-like filaments, or as colonies of various sizes and shapes composed of groups of many filaments or cells. They are naturally occurring in most freshwater aquatic ecosystems. Frequently occurring genera documented in lotic (ponds, lakes, reservoirs, etc.) waterbodies in Rhode Island include *Anabaena, Aphanizomenon, Microcystis, and Planktothrix*.

Both Upper and Lower Melville Ponds experience frequent and long-duration cyanobacteria blooms, which have resulted in recreational/health advisories for significant periods of time. RIDEM has been aware of cyanobacteria blooms in both waterbodies since 2012; however, it is possible that blooms occurred prior to 2012. A total of 37 samples have been collected in both waterbodies between 2012-2024. Approximately twenty-three (23) samples were collected from Upper Melville Pond and fourteen (14) samples were collected from Lower Melville Pond. Samples were analyzed for various cyanotoxins as well as cyanobacteria identification and enumeration (i.e. cell counts). Advisories are issued when any of the following three guidelines are met:

- Evidence of a visible cyanobacteria scum or mat or lake/pond-wide cyanobacteria bloom.
- Cyanobacteria cell count exceeding 70,000 cells/ml.
- Toxin (Microcystin-LR) level of lysed cells meeting or exceeding 4 ppb (µg/l).

Cyanobacteria blooms in Upper Melville Pond tend to be dominated by several genera of cyanobacteria, including *Anabaena, Aphanizomenon, Microcystis,* and *Woronichinia*. The cyanotoxin microcystin was detected in approximately half of samples collected from Upper Melville Pond. Anatoxin was detected in three of 23 samples. No other toxins[8] were detected in submitted samples. Cyanobacteria blooms in Lower Melville Pond were also dominated by *Anabaena, Aphanizomenon, Microcystis,* and *Woronichinia.*

Blooms in Lower Melville Pond tended to be confirmed later in the season than Upper Melville Pond. The cyanotoxin microcystin was detected in approximately 25% of water samples and anatoxin was detected from a single sample. Between 2020 and 2024, Lower Melville Pond has had a health/recreational advisory due to freshwater cyanobacteria blooms for an average of 121 days (primarily during the recreational season). In Upper Melville Pond, between 2012 and 2024, a health/recreational advisory was in place for an average of 140 days. RIDEM Fish and Wildlife normally stock both waterbodies with trout and occasionally salmon; however, when an advisory is in place, stocking is cancelled.

[8] Toxin samples are analyzed for total microcystins, cylindrospermopsin, anatoxin, and nodularin. Other cyanotoxins (e.g. saxitoxin) are not included in the toxin analysis

4 Sources of Phosphorus

4.1 Overview

The most significant source of phosphorus to Upper and Lower Melville Ponds and the Melville Pond Tributary is stormwater runoff from urban areas. Other sources may include decomposition of macroalgae and subsequent release of phosphorus into the water column, internal cycling of phosphorus from reservoir sediments, and fecal-derived nutrients from waterfowl and wildlife. An additional source of phosphorus may have been a compromised sewer line resulting in a potentially long-duration sanitary sewer overflow (SSO) within the Melville Pond watershed. This source was mitigated in 2023. Further details on the mitigation are in Section 4.4.

Sections 4.2 through 4.6 present more detail on the specific sources of phosphorus identified by RIDEM staff during the course of this TMDL study. Estimates of phosphorus loadings from various land uses in the reservoir watersheds are presented in Section 5.0. Phosphorus sources were characterized on an annual scale (lbs TP/yr). Long-term (annual) phosphorus loads are typically more critical to overall lake water quality than phosphorus loads during short-time period (e.g. day/storm event).

4.2 Developed Land Runoff

Stormwater runoff is generated from rain and snowmelt that flows over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground. Stormwater pollution is one of the leading sources of water quality degradation in Rhode Island, and urban runoff and other stormwater discharges are a significant cause of impairment to the state's waterbodies (https://dem.ri.gov/sites/g/files/xkgbur861/files/2024-10/npsmanplan.pdf). Water quality impacts are numerous, and common pollutants found in stormwater runoff include sediments, nutrients, pathogens, and toxic pollutants. Nutrients, primarily phosphorus, are of particular concern to ponds, lakes, and reservoirs and are a major source of degradation in many of Rhode Island's waters because they promote nuisance phytoplankton (including cyanobacteria) growth in freshwater bodies in the state (RIDEM/CRMC 2015).

Stormwater runoff is conveyed to the Melville Ponds or the Melville Ponds tributary either via overland runoff or piped drainage systems. The reason for the distinction is that most piped drainage systems are regulated as municipal separate storm sewer systems (MS4's) under RIDEM's Stormwater Program. The three (3) MS4s regulated within the Melville Ponds watershed are the Rhode Island Department of Transportation (RIDOT), the Town of Portsmouth, and Naval Station (NAVSTA) Newport (Figure 2.4). RIDEM-identified outfalls, by owner, are described further in Sections 4.2.1-4.2.4. Outfalls that are greater than 24" in diameter or have been identified as having a flow path connected to the waterbody are identified as priority outfalls, which require further investigation under the regulated entity's 2003 Phase II MS4 permit.

4.2.1 Town of Portsmouth

The Town of Portsmouth owns three (3) outfalls that discharge to the Lower Melville Ponds watershed. Outfalls OF 14-12 and OF 9-14 discharge to the Melville Pond Tributary, which eventually discharges to Lower Melville Pond. RIDEM also identified a paved swale that conveys stormwater from Bradford Avenue directly into Pond 2 that has not previously been identified as a stormwater outfall by the Town of Portsmouth. This paved swale is considered a point source discharge that is regulated under the MS4 permit.

An additional outfall, OF 14-11, was mapped by the Town but was not located in the field and is likely misidentified. The location description of OF 14-11 provided by the Town suggests that OF 14-11 is in fact RIDOT outfall 9008840.

Table 4.1 provides additional information about the three priority outfalls owned by the Town of Portsmouth in the watershed and Figure 2.3 shows the locations of the three field-identified outfalls.

Table 4.1. Town of Portsmouth outfalls.

Priority Outfall	Outfall ID	Location	Direct Discharge to	Diameter (inches)	Receiving Waterbody
Yes	OF 14-12	In the wetland area on the west side of Leland Point Drive, approximately 500 feet west northwest of the intersection of West Passage Drive and Route 114.	Wetland upstream of Lower Melville Pond	30	Melville Pond Tributary
Yes	OF 9-14	At the south end of McBride Drive, off of the southwest corner of the cul-de-sac.	Wetland upstream of Lower Melville Pond	30	Melville Pond Tributary
Yes	OF Bradford Ave	On the north side of Bradford Avenue between Upper Melville Pond and Pond 2.	Pond 2	N/A	Melville Pond Tributary

4.2.2 NAVSTA Newport

NAVSTA Newport reports that there are (5) outfalls within the Melville Ponds watershed, four (4) reported in the Upper Melville Pond watershed and one (1) within the Lower Melville Pond watershed. Only outfall (21-40) was located in the field by RIDEM staff. The remaining four (4) outfalls could not be located due to fencing and heavy vegetative growth. Table 4.2 provides information about the NAVSTA-Newport owned outfalls in the watershed and Figure 2.3 shows the reported locations of the outfalls.

Table 4.2. NAVSTA Newport outfalls.

Priority Outfall	Outfall ID	Location	Direct Discharge to	Diameter (inches)	Receiving Waterbody
Yes	22-97A	Behind the fence adjacent to Worden Street (based on mapping, not field-verified).	*Upper Melville Pond	24	*Upper Melville Pond
Yes	22-86	Behind the fence adjacent to Warley Street (based on mapping, not field-verified).	*Upper Melville Pond	12	*Upper Melville Pond
Yes	22-57B	Behind the fence adjacent to Worden Street (based on mapping, not field-verified).	*Upper Melville Pond	21	*Upper Melville Pond
Yes	22-65B	Behind the fence adjacent to Worden Street (based on mapping, not field-verified).	*Upper Melville Pond	21	*Upper Melville Pond
No[1]	21-40	On the south side of Lower Melville Pond, at the wooden bridge on the Access Road/trail "Unnamed 17" that runs along the south shore of Lower Melville.	Wooded Area	42	Lower Melville Pond

*Assumed but not confirmed

[1] Although Outfall 21-40 has a diameter greater than 24”, it is not considered a priority outfall because it drains a mostly pervious area, discharges to a wooded area upstream of Lower Melville Pond, and was not observed to be flowing by RIDEM during multiple wet weather field visits.

4.2.3 RIDOT

RIDOT owns two (2) outfalls that discharge to the Upper and Lower Melville Ponds watershed. Outfall 9008840 discharges to the wetland area upstream of Upper Melville Pond. Outfall 9100282 discharges to the wetland area upstream of Lower Melville Pond. Both outfalls were located in the field by RIDEM staff and were observed to have a direct surface water connection to the ponds during observed rain events. Table 4.3 provides information about the two RIDOT-owned priority outfalls in the watershed and Figure 2.3 shows the locations of the two outfalls.

Table 4.3. RIDOT outfalls.

Priority Outfall	Outfall ID	Location	Direct Discharge to	Diameter (inches)	Receiving Waterbody
Yes	9008840	On the west side of Route 114, in the wooded area south of Melville Elementary School, approximately 350 feet northwest of the intersection of Russo Road and Route 114.	Wetland upstream of Upper Melville Pond	30	Upper Melville Pond
Yes	9100282	On the west side of Route 114, in the wooded area approximately 185 feet southwest of the intersection of the access road south of Clock Tower Square and Route 114.	Wetland upstream of Lower Melville Pond	36	Lower Melville Pond

4.2.4 Privately-owned parcels and roads

There are three identified privately-owned neighborhoods in the Melville ponds watershed (Leland Point Drive, Clocktower Square, and the Springfield Group Melville neighborhood). These areas and associated identified stormwater structures are shown below in Figure 4.1.

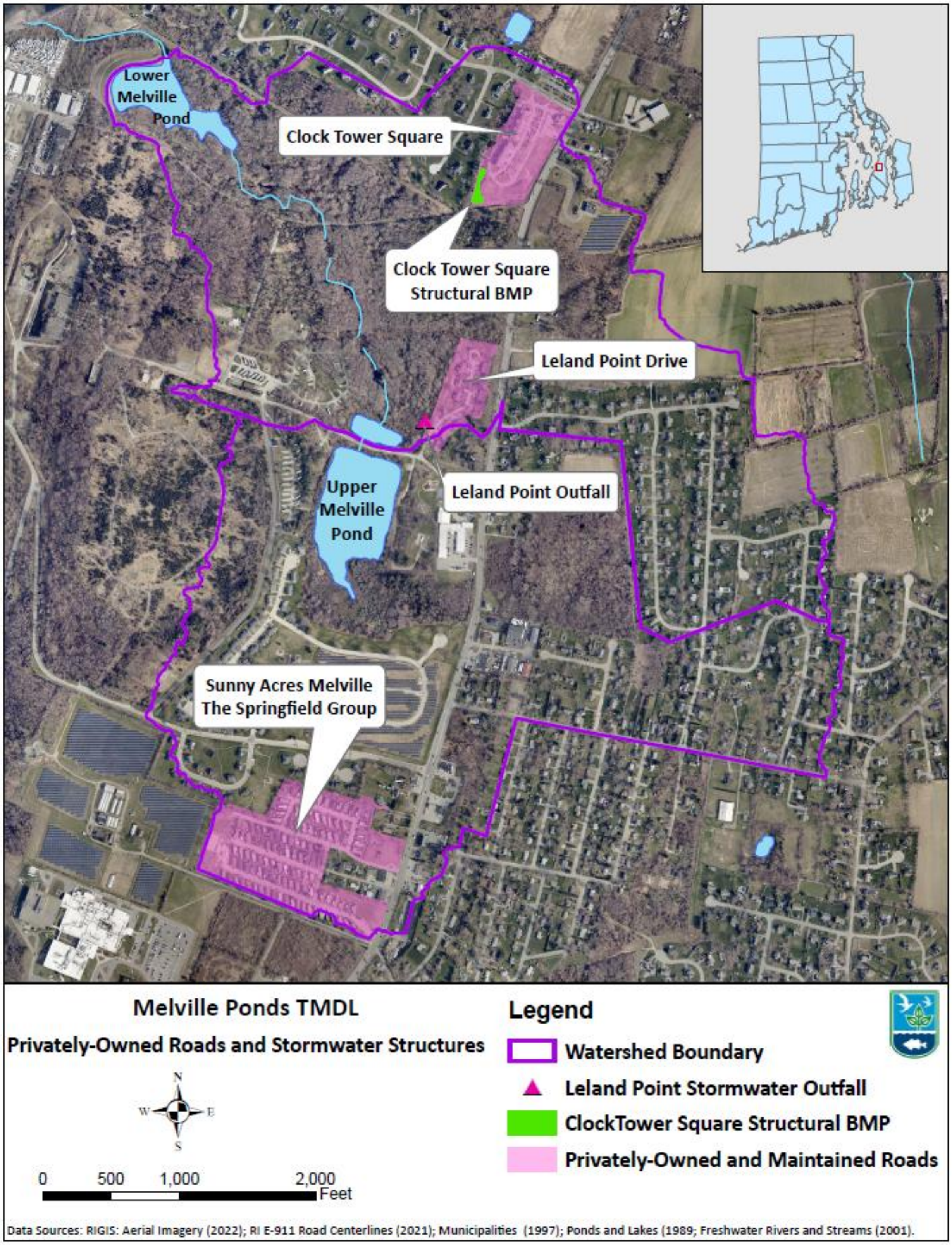

Figure 4.1. Privately-owned parcels in the Melville Ponds watershed.

4.2.5 Overland Flow Sites

Figure 4.2 shows five locations where RIDEM staff noted that sediment-laden flow from the nearby trails, roads and parking areas was entering Upper and Lower Melville Ponds during rain events. Sediment can be a significant source of phosphorus to waterbodies. These areas (Locations 1-5) are described below.

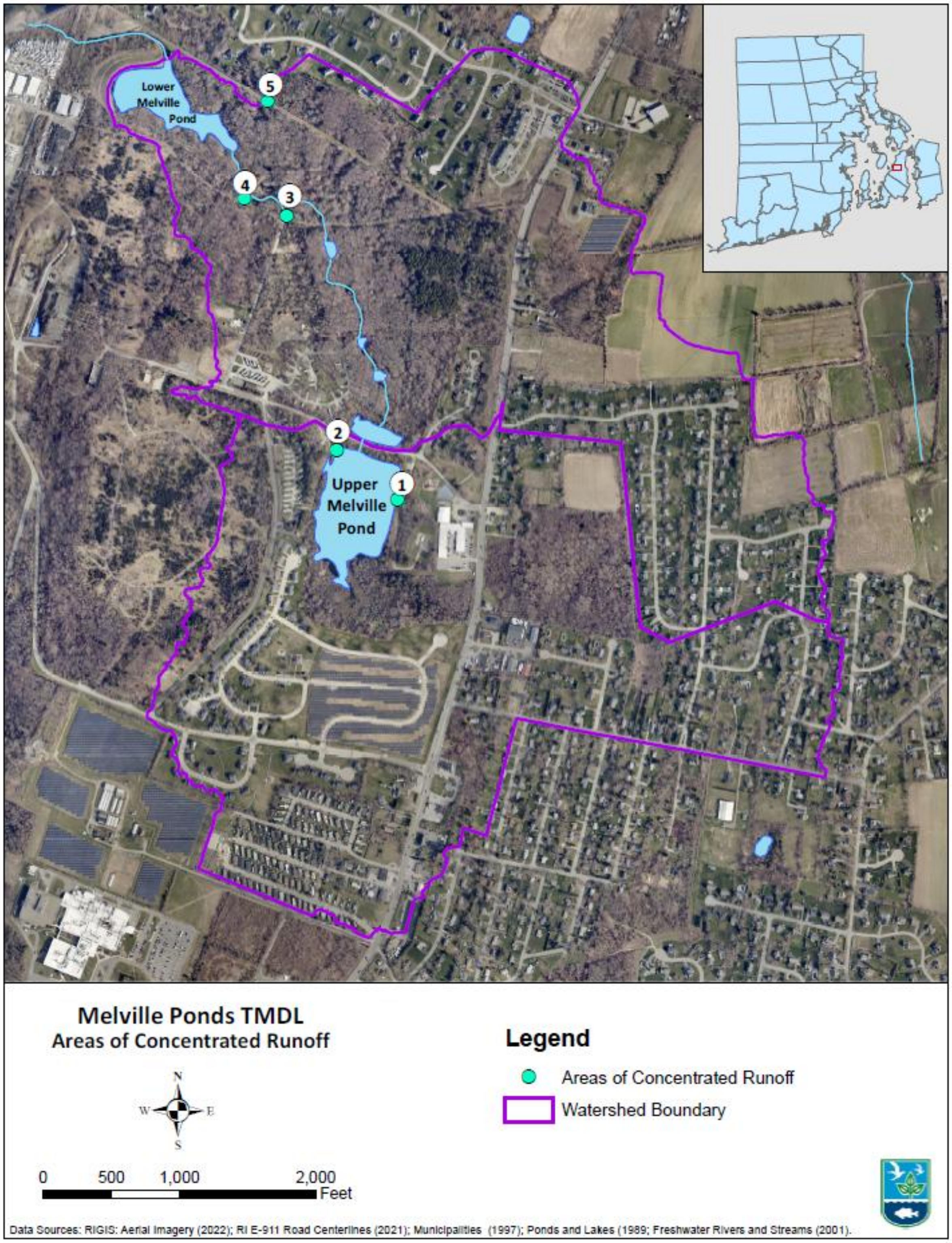

Figure 4.2. Areas of concentrated runoff impacting the Melville Ponds watershed.

Location 1: The access road off of Bradford Ave that runs along the eastern shoreline of Upper Melville Ponds. Runoff from the gravel access road flows into Upper Melville Pond via a concentrated flow path, formed by erosive flow.

Figure 4.3. Location 1: Runoff from gravel access road. Photo 10/14/2022.

Location 2: Gravel parking area on the northwest corner of Upper Melville Pond. The gravel parking area slopes towards Upper Melville Pond, resulting in erosive flow during rain events.

Figure 4.4. Location 2: Runoff from gravel parking area. Photo 12/07/2022.

Location 3: Downstream of the gravel parking area off of Smith Road where wood chips and other debris are stored (former site of Portsmouth Melville Dump). Runoff appears to flow from the gravel parking area off of Smith Road and enter the wetland area immediately north of the parking area. Runoff leaves the wetland area and flows under the access road via a culvert, then ultimately flows into the stream that discharges into Lower Melville Pond.

Figure 4.5. Location 3: Runoff from gravel parking area off of Smith Road. Photo 03/14/2023.

Location 4: Access Road/walking trail to Lower Melville Pond off Smith Road. Stormwater from Smith Road and the access road/walking trail to Lower Melville Pond enters the stream that flows to Lower Melville Pond.

Figure 4.6. Location 4: Runoff from access road/walking path to Lower Melville. Photo 03/14/2023.

Location 5: Mott Farm Road (gravel road running parallel to Cromwell Drive on the north side of Lower Melville Pond). There is a drainage ditch/swale on the north side of the road that conveys the overflow from the Clock Tower Square structural BMP. The drainage swale also periodically intercepts flow from the wetlands between Mott Farm Road and Cromwell Drive. The flow is conveyed under Mott Farm Road via a culvert and this flow eventually flows to Lower Melville Pond. There is substantial erosion at the inlet and the outlet of the culvert.

Figure 4.7. Location 5: Looking upstream at drainage swale from culvert inlet. Photo 03/28/2023.

4.3 Internal Phosphorus Load Estimates from Reservoir Sediments

There was some evidence of phosphorus release in Upper Melville Pond, however, because of the confounding influence of macrophyte decay the calculated load estimate was considered not reliable. There was clear evidence of phosphorus buildup in the hypolimnion in Lower Melville Pond however destratification and water column mixing did not occur until early November, when phytoplankton/cyanobacteria populations are in decline and increased flows likely move water out of the system (over the spillway). Internal loads are not accounted for or allocated in these TMDLs due to the large amount of uncertainty in load estimates, which would introduce uncertainty into the external load analysis, and ultimately because the internal loading is the direct result of historical external loading. Therefore, the load estimates forming the basis of the TMDLs and the focus of this TMDL's implementation section is the control of identified external sources of phosphorus discharged to these lakes.

However, it must be understood that even if external loading is significantly reduced, improvement in water quality may be delayed, possibly for decades, because of continued internal loading from historical external loading. Given that there is evidence of some internal release of phosphorus occurring in both reservoirs, consideration and further study should be given to in-reservoir management techniques to control internal cycling. Methods to control internal cycling of phosphorus from sediments are discussed in the Implementation Section of this TMDL.

4.4 Bradford Avenue Sewer Line (NAVSTA Newport)

During RIDEM's identification of sources of phosphorus to Melville Ponds, it was noted that the sewer line along Bradford Avenue in Portsmouth is in very close proximity to both Upper Melville Pond and Pond 2, located on the north side of the road (Figure 4.6). As stated earlier, sewer infrastructure is owned and operated by NAVSTA Newport. At numerous times during 2020-2021, RIDEM staff noted a strong musty odor that appeared to be coming from Pond 2. In addition, the color of the water in this impoundment has been observed to have an unusual reddish brown tint during summer periods.

Due to the age of the sewer line in this area, the condition of the pavement on Bradford Avenue (significant buckling and cracking overlying this section of sewer line), and its proximity to surface waters, RIDEM determined that this section of sewer may be a potential source of pollutants, including phosphorus. This determination was supported by published findings from the Aquidneck Island Infrastructure Assessment report (May 2021) which contained assessments of stormwater, pavement condition, water infrastructure, and sewer infrastructure owned by the Navy.

As part of the evaluation of the Navy's wastewater collection system, assessments were performed by the Pare Corporation on portions of gravity collection systems, manholes, pump-stations, and pipe walls. The 2021 Report discusses the results of CCTV inspections of the sewer system, and it was noted that there was significant (> 30%) sagging observed along certain portions of the sewer line (Figure 4. 6- between MH 75-1 and MH 75-2).

The sag in certain sections was significant enough to obstruct the use of the CCTV camera. It was also noted that multiple areas had blockages preventing CCTV cameras from passing, including two other areas along Bradford Avenue.

Figure 4.8. Section of sewer line sag and ultimate radial breakage and SSO.

Based on the above information and field observations, RIDEM required the Navy to perform further investigation of the sewer line along Bradford Avenue (letter dated Nov 28th, 2022), including, but not limited, to dye testing and/or smoke testing, to verify the integrity of its collection system. The purpose of the investigation was to determine the extent to which exfiltration of sewage from the sewer line is or may be reaching surface waters (either Upper Melville Pond or Pond 2), since any discharges of this type would be a prohibited Sanitary Sewer Overflow (SSO). RIDEM required that this work be done within 90-days from the letter.

RIDEM received notice that the Navy conducted dye testing on January 12, 2023. Based on this testing they determined that no SSO flowed to surface waters. The Navy informed RIDEM that they planned to jet rod the lines of concern on January 18th, 2023 to clear any blockages, and, after jet rodding, the line would be scoped to verify that blockages were cleared. The Navy jet rodded the lines and saw nothing out of the ordinary, however upon scoping the line the Navy informed RIDEM that a radial break in the line was discovered in the area of initial concern (between MH 75-1 and MH 75-2) along with a sanitary sewer overflow. RIDEM was notified on February 23, 2023 that an SSO was occurring with an estimated bypass volume of 440 gallons per day (GPD). An emergency repair was conducted, and the work was completed on March 3rd, 2023, effectively ending the SSO.

The Navy's notification to RIDEM stated that no waterbodies were impacted by the bypass. Since the radial break and resulting bypass occurred underground, no surface water impacts were observed to Upper Melville Pond, Pond 2 or any of the downgradient waterbodies, including Lower Melville Pond. Although no direct surface water impacts were observed, it is possible that Upper Melville Pond and/or Pond 2 were impacted by the subsurface bypass due to their proximity to the radial break.

The SSO report provided to RIDEM by the Navy stated that the SSO bypass began on February 23, 2023. This is the date that the radial break was discovered by the Navy; however, it is reasonable to assume that the radial break was present and the resulting bypass was occurring for an undetermined period of time prior to discovery on February 23, 2023. The SSO report notes that the radial break caused sagging of the line, which was also documented in the 2021 report, further suggesting that the SSO was occurring for an undetermined period of time dating back to at least 2021.

The Navy estimated that 440 gallons per day (GPD) were discharging into the ground as a result of the bypass, assuming that the bypass volume was 10% of daily flow through the pipe. Without further information including the exact bypass volume, the exact time period during which the bypass occurred, the flow path of the overflow volume, and the expected attenuation prior to contact with a surface water, it is difficult to estimate an accurate phosphorus load that was associated with this SSO. It is however reasonable to assume that the SSO was a source of phosphorus to Upper Melville Pond or Pond 2 given their proximity to the radial break and the duration the SSO is thought to have occurred.

Due to the uncertainty of obtaining an accurate estimate of phosphorus loading and the fact that the discharge has been eliminated, this source is not included in the TMDL calculations. In addition, if a load estimate was included, it would have received a wasteload allocation of zero (0), because it was an illegal discharge.

4.5 Other Potential Sources

As stated in Section 4.1 other sources of phosphorus may include decomposition of macrophytes and subsequent release of phosphorus into the water column and fecal-derived nutrients from waterfowl, and natural background sources. Derivation of useful estimates of annual phosphorus loads from these sources to Upper or Lower Melville Ponds is not possible given the lack of site-specific information needed; however, a brief overview of these potential sources is given below.

Extensive Macrophyte Growth

RIDEM has documented Guadalupe waternymph (*Najas guadalupensis*) as widespread in Upper Melville Pond. This aquatic plant prefers stagnant or slow-moving waters and is more tolerant of turbidity and eutrophic conditions (Wentz and Stuckey 1971). During the growing season, coverage of Upper Melville Pond by this macroalgae was estimated by RIDEM staff to be 70-90% and it is widely considered by both local residents and the Melville Park Committee to be at nuisance levels. The Town of Portsmouth has applied to RIDEM for herbicide treatments of various nuisance phytoplankton and aquatic plants algae since early 2000’s. Decaying macrophytes are a well-known source of nutrients to waterbodies (Nichols and Keeney 1973, Carpenter 1980), but release rates and estimates of total loading of phosphorus to the water column are difficult to quantify. In addition, the rates of release of macrophyte-derived nutrients depend on water temperatures, the nutrient makeup of the particular macrophyte species, and numerous other factors.

Waterfowl Populations in Melville Ponds Watershed

Fecal-derived nutrients have the potential to enrich surface water and thus contribute to the process of eutrophication. There have been a significant number of papers published examining how nutrients from both migratory and resident bird populations can affect water quality and speed the process of cultural eutrophication (Manny et al, 1994; Moore et al. 1998; Purcell, 1999; Portnoy, 1990; Kitchel et al., 1999, and Bland et al., 1996). Even in small numbers, larger waterfowl like geese are likely a significant source of phosphorus to waterbodies. However, studies have shown that the impact of fecal-derived nutrient loadings to waterbodies from birds varies with bird species, bird population density, feeding habits, dilution capacity of the waterbody, and time of year.

It is difficult to accurately estimate goose populations on either pond. Geese have not been observed by RIDEM staff on Upper Melville Pond. RIDEM have noted Canada Geese congregating along the northern shoreline of Lower Melville Pond on several occasions during winter field visits. Numbers reported on those days of observation ranged from 40-60 individuals, however these were single-day reports and as such may not be reflective of longer-term population size on the pond. It is worth noting that RIDEM staff have never observed fecal material along the dam buffer.

Natural Background Sources

There are many 'natural' sources of phosphorus in aquatic systems. Natural sources include native waterfowl and wildlife waste, atmospheric deposition, tributary inputs of organic material, and biological decomposition. These sources are difficult to evaluate and quantify.

The Simple Method was used to evaluate watershed-derived natural background loads of phosphorus to each reservoir. The total natural background phosphorus load was calculated as the sum of loads from atmospheric sources and forest/wetland land use categories. All atmospheric loading estimates are based on literature-derived annual loading rates. Natural background phosphorus loads (expressed as a percentage of the total load) ranged from 2% in Upper Melville Pond to 5% in Lower Melville Pond.

5 TMDL Analysis

A TMDL identifies the pollutant loading that a waterbody can assimilate per unit of time without violating water quality standards (40 C.F.R. 130.2). The TMDL is often defined as the sum of loads allocated to point sources (i.e. waste load allocation, WLA), loads allocated to nonpoint sources, including natural background sources (i.e. load allocation, LA), and a margin of safety (MOS). The loadings are required to be expressed as mass per time, toxicity, or other appropriate measures (https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-130/section-130.2).

For lentic (non-flowing) waterbodies, TMDLs are often expressed in terms of allowable annual loadings of phosphorus, because the growth of phytoplankton responds to changes in annual rather than daily loadings of nutrients. Both Upper and Lower Melville Pond and the Melville Pond Tributary TMDLs are expressed as annual loads. These annual loading targets should be used to guide implementation efforts since the annual load of total phosphorus as a TMDL target is more easily aligned with the design of BMPs used to implement both nonpoint source and stormwater controls. A daily load can be obtained by dividing the annual load by 365 but is not presented in this document to avoid having two different values presented for implementation purposes, which occur on an annual basis as described earlier.

5.1 Margin of Safety (MOS)

The MOS is a required component of the TMDL that addresses uncertainties in the technical analysis and loading estimates. The MOS may be incorporated into the TMDL implicitly using conservative assumptions to develop the allocations or explicitly by allocating a portion of the TMDL as the MOS. For Upper and Lower Melville Ponds, ten (10) percent of the load capacity is allocated as an explicit MOS. A 10% explicit MOS will also apply to the Melville Pond tributary.

5.2 Critical Conditions and Seasonal Variation

Critical conditions for the reservoirs generally occur from May through October, when the occurrence of cyanobacteria blooms, low dissolved oxygen, and nuisance aquatic plant growth are usually greatest. This is also the time period that coincides with increased recreational uses such as fishing (and trout stocking) and boating. Since these TMDLs are based on information collected during the most environmentally sensitive period (i.e., the growing season) and were developed to be protective of this critical time period, they will also be protective of water quality during all other seasons.

5.3 Numeric Total Phosphorus Target Concentrations

RIDEM has set 25 ug/l as the numeric total phosphorus target concentration for Upper Melville Pond. The 25 ug/l concentration target is consistent with the State's water quality criteria for total phosphorus. A concentration target of 20 ug/l was set for lower Melville Pond, which has a maximum depth greater than 5 meters. The lower target of 20 ug/l is meant to address dissolved oxygen impairments and is consistent with EPA approved TMDLs developed by RIDEM in waterbodies with maximum depths greater than 5 meters (https://dem.ri.gov/sites/g/files/xkgbur861/files/programs/benviron/water/quality/rest/pdfs/mashpaug.pdf)

A 20 ug/l total phosphorus target concentration was also set for the Melville Pond Tributary. This target is applicable at the point of inflow to Lower Melville Pond and is meant to be protective of the 20 ug/l total phosphorus target for Lower Melville Pond.

The primary goal of this TMDL is to address the eutrophication-related water quality impairments in Upper and Lower Melville Ponds associated with excess phosphorus loadings. These include frequent and long-duration cyanobacteria blooms and low dissolved oxygen concentrations. Reducing phosphorus concentrations is generally considered the most effective way to reduce cyanobacterial biomass in freshwater systems.

With phytoplankton abundance under control, the variability in dissolved oxygen levels (high daytime values, low nighttime values, and depressed oxygen levels following bloom crashes)[9] is expected to be reduced. Therefore, dissolved oxygen and algae/phytoplankton TMDL targets are not set explicitly by the TMDL. The Department believes that these impairments will be addressed by reducing water column phosphorus concentrations to appropriate levels.

5.4 Technical Approach Overview

The technical approach for developing these TMDLs utilizes a combination of empirical lake phosphorus response model applications and an export coefficient-based phosphorus load estimation procedure. Empirical modeling was used to derive estimates of existing and allowable total phosphorus loads to each reservoir. These models utilize a combination of physical and chemical data/information from each waterbody to evaluate the relationship between average in-waterbody phosphorus concentration and annual phosphorus loading from the watershed.

The Simple Method (Scheuler 1987) provides a secondary estimate of annual phosphorus loads generated from various land uses within the Melville Ponds sub-watersheds. This spreadsheet-based technique requires a modest amount of information including sub-watershed drainage area, impervious cover, stormwater runoff phosphorus concentrations (from various land use categories), and annual precipitation. Results from this land use modeling were used to apportion the allowable annual phosphorus load to each waterbody into wasteload and load allocations.

5.5 Primary Estimates of Annual Total Phosphorus Loads – Empirical Models

Various empirical models have been developed to predict in-lake total phosphorus concentration from data on annual phosphorus loadings, hydraulic flushing rates, and lake morphometry (Vollenweider (1975), Dillon and Rigler (1974), Kirchner and Dillon (1975), Chapra, (1975), Jones and Bachmann (1976), Reckhow (1977 and 1979), Canfield and Bachmann (1981), and Walker (2001). These models are based on statistical relationships between mass

[9] While continuous data was not collected verifying the variability of DO in Lower Melville Pond, it is well documented that oxygen supersaturation can occur under high phytoplankton abundance.

loading of phosphorus and average total phosphorus concentrations in the epilimnion. The models typically take into consideration the waterbody's hydraulic loading rate and a factor to account for settling and storage of phosphorus in the lake sediments. Many of these empirical models have been used by states and tribes to develop phosphorus TMDLs in lentic waterbodies.

Three (3) empirical lake models relating external phosphorus loads to in-lake total phosphorus concentrations were used to back-calculate the existing total phosphorus loads to each reservoir. The three empirical lake models presented in Table 5.1 have been used by RIDEM to develop total phosphorus TMDLs for 22 waterbody (lake, pond, reservoir) segments in Rhode Island. These models require a modest amount of physical and chemical information specific to each waterbody including 1) mean epilimnetic total phosphorus concentration, 2) annual reservoir outflow, 3) reservoir volume, surface area, and depth, 4) phosphorus settling rate, 5) reservoir flushing rate, and 6) hydraulic loading rate. Model reference and TMDL applications are shown in Table 5.1.

Table 5.1. Lake and reservoir TMDLs developed by RIDEM utilizing empirical lake loading models.

Empirical Model	Reference/Source	TMDL Application(s)[1]
Walker 2001	Quantifying Uncertainty in Phosphorus TMDLs for Lakes, New England Interstate Water Pollution Control Commission (NEIWPCC). http://wwwalker.net/pdf/lake_tmdl_www_march_2001.pdf	Yawgoo and Barber Pond TMDLs
Canfield, D.E. and Bachmann, R.W. 1981	Prediction of total phosphorus concentrations, chlorophyll a, and secchi depths in natural and artificial lakes. Canadian Journal of Fisheries and Aquatic Sciences. 38(4): 414-423. https://iwinst.org/wp-content/uploads/2021/04/CanfieldJr.D.E.andR_.W.Bachmanss.1981.Predictionof-1.pdf	9 Newport Water Supply Reservoir TMDLs
Reckhow, K.H 1979	Uncertainty applied to Vollenweider's phosphorus criterion. J. Water Poll. Cont. Fed. 51:2123-2128. https://www.jstor.org/stable/25040686	Belville Ponds TMDL Scott Pond TMDL 9 Eutrophic Ponds TMDLs

[1] https://dem.ri.gov/environmental-protection-bureau/water-resources/research-monitoring/restoration-studies-tmdl-documents

The mean of the three model results was used as a best estimate of the existing annual total phosphorus load to each reservoir. The models were also used to back-calculate the allowable annual total phosphorus load to each reservoir given either the 25 ug/l target (for Upper Melville Pond) or 20 ug/l target (for Lower Melville Pond). Results are presented in Table 5.2. **Appendix A** provides additional detail on model variables used, sources of data, and final calculations.

Table 5.2. Existing and allowable total phosphorus loads to Upper and Lower Melville Pond.

UPPER MELVILLE POND		
Method	Existing Load Estimate (lbs/yr)	Allowable Load Estimate (lbs/yr)
Walker (2001)	55	27
Canfield and Bachmann (1981)	75	29
Reckhow (1979)	97	46
Mean	**76**	**34**
LOWER MELVILLE POND		
Method	Existing Load Estimate (lbs/yr)	Allowable Load Estimate (lbs/yr)
Walker (2001)	141	61
Canfield and Bachmann (1981)	152	58
Reckhow (1979)	157	70
Mean	**150**	**63**

5.6 Secondary Estimates of Total Phosphorus Loads – Land Use Model

5.6.1 Application of Simple Method

The allocation of the allowable load to each reservoir relies on the results obtained from estimates of annual phosphorus loads using the Simple Method (Scheuler 1987). The Simple Method is a land use export coefficient-based load estimation procedure that calculates stormwater runoff pollutant loads using land use cover, annual rainfall, runoff coefficients based on percent impervious cover, and total phosphorus event mean concentrations for various land use types.

Use of the Simple Method involves separation of various land uses into specific categories (i.e. residential (high, medium, and low-density), commercial, industrial, and roadway), as well as other land uses such as forest, wetland, and agriculture, and calculation of annual total phosphorus loads for each type of land use. Land use categories were re-compartmentalized into one of three primary land use categories: urban, non-point and natural background. For the purposes of this TMDL, the land use types in the "urban" category are those that are considered to discharge to the MS4 systems.

Urban sources comprise land uses (commercial, all residential, industrial, roadways, etc.) that are considered to drain directly to point sources (i.e. pipe, ditch, swale, etc.) that are currently regulated via an MS4 permit. Natural background sources comprise phosphorus loads generated from forested lands, wetlands, brushlands, and atmospheric deposition. Non-point sources include phosphorus loads generated from transitional areas, developed recreation, agriculture, etc. These categories represent the three 'phosphorus source categories' that will receive a wasteload or load allocation. A report describing the various data sources, land use classifications, GIS analysis, and other information used in the application of the Simple Method to both reservoirs is available on the RIDEM TMDL website[10].

[10] https://dem.ri.gov/sites/g/files/xkgbur861/files/2025-08/Application%20of%20the%20Simple%20Method%20to%20Melville%20Ponds%20TMDL.pdf

Table 5.3. Compartmentalized land use categories in the Melville Ponds Watersheds.

Land Use Classification	TMDL Allocation Category	TMDL Allocation
Forest	Natural Background	Load Allocation
Wetland		
Brushland		
Ground Mounted Solar Energy Systems	Non-point Sources	Load Allocation
Developed Recreation		
Transitional Areas (Urban open)		
Cropland (row crop)		
Commercial	Urban land uses contributing to MS4	Wasteload Allocation
Roads (all)		
High Density Residential (< 1/8 lots)		
Medium High Density Residential (1/4 – 1/8 acre lots)		
Medium Density Residential (1 – 1/4 acre lots)		
Institutional (schools, hospitals, churches, etc.)		
RV Park/Campground		

5.7 Simple Method Results and Final Estimates of Annual Load to Melville Ponds

Table 5.4 summarizes the Simple method estimates of annual phosphorus loads (by TMDL Category) to Upper and Lower Melville Pond. These estimated annual loads were adjusted/attenuated based on their percent contribution of the total load, to the empirical model results. Phosphorus loads 'generated' in the watershed are expected to be attenuated to varying degrees prior to actual delivery to a waterbody.

Phosphorus attenuation in a watershed occurs via physical, chemical and biological processes, often within wetlands or existing stormwater treatment units. Physical processes include sedimentation. Chemical processes include sorption onto various materials such as aluminum and iron oxides. Biological processes include uptake by wetland vegetation and bacteria. A substantial amount of attenuation occurs between Upper and Lower Melville Ponds in the seven smaller impounded wetlands along the Melville Tributary (Section 5.11).

Attenuation rates were adjusted such that the sum of the TMDL category load equaled the empirical model result. In the Upper Melville Pond watershed, the attenuation rate was 67% ((230 lbs-76 lbs)/230 lbs)) X 100. For Lower Melville Pond, the average annual phosphorus load predicted by the empirical models was greater than the annual load predicted by the Simple Method. This does not mean that attenuation of phosphorus is not occurring within the sub-catchment but rather that the additional loading can be attributed to internal cycling of phosphorus from reservoir sediments. The annual loads in the last column of Table 5.4. are believed to be the best estimates available.

Table 5.4. Final annual TP load estimates for Upper and Lower Melville Pond.

UPPER MELVILLE POND				
TMDL Category	***Simple Method Estimated Load (lbs/yr)***	***Percent of Total Predicted Load***	***Empirical Model Predicted TP load (lbs/yr)***	***Estimated TP load to Upper Melville Pond (lbs/yr)***
Regulated Point Sources	219	95	76	72
Non-point Sources	7	3		2
Natural Background	4	2		2
LOWER MELVILLE POND				
TMDL Category	***Simple Method Estimated Load (lbs/yr)***	***Percent of Total Predicted Load***	***Empirical Model Predicted TP load (lbs/yr)***	***Estimated TP Load to Lower Melville Pond (lbs/yr)***
Regulated Point Sources	128	90	150	135
Non-point Sources	7	5		7
Natural Background	8	6		8

5.8 Loading Capacity and Allocation of the Allowable Loads to Melville Ponds

The annual load capacity is defined in 40 C.F.R. § 130.2(f) as, "The greatest amount of loading that a water can receive without violating water quality standards." The loading capacity is to be protective even during critical conditions, such as summertime conditions for TP loading to nutrient enriched lakes. The allowable total phosphorus loads, or TMDL, for Upper and Lower Melville Pond can be expressed as follows:

$$TMDL = \sum WLA + \sum LA + MOS$$

The allocations for each TMDL are expressed as annual loads since annual loads better align with the design and implementation of watershed and lake management strategies. The annual total phosphorus load capacity for Upper Melville Pond is 34 lbs per year and the load capacity for Lower Melville Pond is 63 lbs per year. This total was distributed as LA, WLA, and a MOS using the following approach:

- A single WLA accounts for urban land use that are considered to drain directly to point sources (i.e. pipe, ditch, swale, etc.);

- A single LA accounts for all other areas. Some flow paths as noted in Section 4.2.5 have not been assigned/included in a separate WLA given that they occur in other areas included in the LA.;

- The MOS is set to 10% of the load capacity and is inclusive of the inability to predict internal cycling of phosphorus from reservoir sediments (see below);

- Internal loads are not accounted for or allocated in these TMDLs. The focus of this TMDL's implementation section is the control of identified external sources of phosphorus discharged to these waterbodies. However, it must be understood that even if external loading is significantly reduced, improvement in water quality may be delayed, possibly for decades, because of continued internal loading. Methods to control internal cycling of phosphorus from sediments are discussed in the Implementation Section of this TMDL.

Table 5.6 presents the WLAs and LAs for Upper and Lower Melville Ponds.

Table 5.5. Upper and Lower Melville Ponds phosphorus load allocation - TMDLs.

UPPER MELVILLE POND			
TMDL Category	***Existing Load (lbs TP/yr)***	***TMDL (lbs TP/yr)***	***Percent Reduction***
WLA	72	28	61%
LA	2	1	61%
Natural Background	2	1	0
MOS		3	na
TOTAL	**76**	**34**	
LOWER MELVILLE POND			
TMDL Category	***Existing Load (lbs TP/yr)***	***TMDL (lbs TP/yr)***	***Percent Reduction***
WLA	135	46	66%
LA	7	3	66%
Natural Background	8	8	0
MOS		6	na
TOTAL	**150**	**63**	

5.9 Estimates of Existing and Allowable Total Phosphorus Loads to Melville Pond Tributary

The existing annual phosphorus load to the Melville Pond tributary was estimated using: 1) multi-year total phosphorus concentration data from two datasets, 2) a phosphorus attenuation factor, and 3) a mean annual flow estimate (For 1 and 2 see Appendix B). Nine (9) water samples were collected at both the inlet and outlet of the Melville Pond tributary (Figure 3.1) on a bi-weekly basis between June and September 2023. The purpose of this sampling was to evaluate the levels of phosphorus in the inflow to Lower Melville Pond and to determine the total phosphorus attenuation between the headwaters and the inlet to Lower Melville Pond.

The mean total phosphorus concentration at the headwater and inlet sites was 89 ug/l and 44 ug/l, respectively. For each sampling event, the percent attenuation ranged from 22-72% and the mean of the individual (n=9) percent attenuation statistics between the two sites was calculated to be 46%. This percent total phosphorus attenuation factor was applied to the 2021 dataset (n=11) collected at the inlet and the resulting values were added to the 2021 dataset. The mean of the combined dataset of total phosphorus concentrations (n=20) was **37 ug/l**.

Mean daily flow for the Melville Pond tributary was estimated using the regression equation for Q50 developed by Bent et al. (2014).

$$1.4791(DRNAREA)^{1.05}(STRDENED)^{-0.39} \text{ where:}$$

DRNAREA = Drainage area, in square miles

STRDENED = Stream density, in miles per square mile

Bent et al. (2014) developed regression equations to estimate several streamflow statistics in Rhode Island streams, which are also used in the Rhode Island USGS StreamStats application. The regression equations were developed using data from 41 long-term and 19 short-term

stream gages in and near Rhode Island. The estimated Q50 (mean daily flow) was **1.19 cfs** for Melville Ponds Tributary.
The following equation (Thomann and Mueller 1977) was used to estimate the annual phosphorus load from the Melville Pond Tributary at the point of discharge to Lower Melville Pond:

$$L = f\ c\ d$$

Where: L = Load (lbs/day)
f = conversion factor = 5.39
c = concentration of pollutant (mg/l) = 0.037
d = discharge = 1.19 cfs

Solving for L results in an annual phosphorus load estimate of **87 lbs/year**. Substituting a total phosphorus target concentration of 20 ug/l into the above equation results in a load capacity or allowable annual load of **47 lbs/year**.

5.9.1 Allocation of the Allowable Total Phosphorus Load to Melville Pond Tributary

The approach for allocating the allowable total phosphorus load of 47 lbs/year to the Melville Pond Tributary is the same as described above for the reservoirs. The Simple Method was applied to the direct catchment of the tributary and resulted in an annual total phosphorus load estimate of 114 lbs/yr. Approximately 101 lbs/yr was generated from point sources within the catchment, 7 lbs/yr from non-point sources, and 6 lbs/yr from natural background sources. Table 5.7 Summarizes the load allocations for the Melville Pond tributary. It should be noted that sources of phosphorus are similar in Lower Melville Pond and the Melville Ponds Tributary, since the tributary watershed is entirely contained within the Lower Melville Ponds watershed.

The larger reduction (61%) applicable to Lower Melville Pond should be used with respect to phosphorus reduction in the tributary since the tributary watershed is entirely contained within the Lower Melville Ponds watershed. It is therefore expected that implementation of the Lower Melville Ponds TMDL will result in achievement of the Melville Ponds Tributary TMDL as well.

Table 5.6. Melville Pond Tributary load allocation.

Melville Pond Tributary			
TMDL Category	***Existing Load (lbs TP/yr)***	***TMDL (lbs TP/yr)***	***Percent Reduction***
WLA	77	35	54%
LA	5	2	54%
Natural Background	5	5	0
MOS		5	na
TOTAL	**87**	**47**	

5.10 Reasonable Assurance

When a TMDL is developed for waters impaired by point sources only, the issuance of a National Pollutant Discharge Elimination System (NPDES/RIPDES) or state issued permit provides the reasonable assurance that the wasteload allocation contained in the TMDL will be achieved, because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with 'the assumptions and requirements of any available wasteload allocation' in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA assumes that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions for a TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards.

The waterbody segments addressed in this TMDL are impaired primarily by point sources (Table 5.5 and 5.6). Reductions in phosphorus loadings from regulated point sources are required to meet the water quality targets set in the TMDL. Section 5.0 of this TMDL describes how WLAs from regulated point sources (MS4s) were determined. As described in Section 4.2.5 and Section 6.1.1.1.2 of the Implementation Plan of this TMDL, RIDEM has identified several areas of nonpoint source pollution to Upper and Lower Melville Pond and the Melville Pond tributary.

Control of nonpoint sources of phosphorus loadings is also considered important to water quality improvements in the reservoirs. The primary mechanism for implementing control actions is through the RIDEM Nonpoint Source Grant Program which is made possible by federal Clean Water Act Section 319 funds. Section 319 Grants are available for projects to protect and restore water quality through reducing and managing nonpoint source pollution and for projects restoring aquatic habitat. ***Projects must be consistent with the goals and actions in the USEPA approved RI Nonpoint Source Management Program Plan***. A draft Nonpoint Source Management Program Plan for Aquidneck Island where Melville Ponds and Tributary are located is being developed by RIDEM with an anticipated completion date of 2025.

5.11 Strengths and Weaknesses in TMDL Approach

Strengths:

• RIDEM's general approach to developing lake total phosphorus TMDLs is similar to those utilized by other states and includes widely used and well accepted methodologies.

• The TMDLs are based on data collected in the reservoirs and tributary.

• The empirical models applied to the reservoirs have been documented in the scientific literature to be applicable/appropriate to artificial lakes (reservoirs).

• Significant resources were spent on field investigations to confirm both point and non-point sources of phosphorus in the watershed. Multiple outfalls were discovered by RIDEM staff that were not previously identified from MS4 mapping.

Weaknesses:

• Inherent uncertainty of TP load estimates using the Simple Method or other land use-based phosphorus load prediction methodologies.

• Results from any land-use based phosphorus load prediction methodologies may under-predict nutrient loads from various land uses given site-specific variability in attenuation/retention factors.

• Lack of robust estimates of average annual load to each waterbody from macrophyte decay l and internal release of phosphorus from reservoir sediments.

6 TMDL Implementation

6.1 Stormwater Management

Reductions in total phosphorus loading to both reservoirs and the Melville Pond Tributary is critical to achieving water quality improvements. Stormwater management throughout the watershed is an essential component of the overall loading reductions. Implementation methods for reducing phosphorus in stormwater include continued implementation of the Phase II RIPDES MS4 General Permit (Phase II Permit), permittee-specific requirements of the Melville Ponds TMDL, and recommendations for control of non-regulated stormwater sources.

6.1.1 Phase II RIPDES MS4 General Permit (Phase II Permit)

Stormwater runoff is most often carried to waterways by publicly owned drainage networks. Historically, these networks were designed to carry stormwater away from developed land as quickly as possible to prevent flooding with little to no treatment of pollutants. In 1999, the USEPA finalized its Stormwater Phase II rule, which required the operators of MS4s to obtain permits and to implement a stormwater management program to control polluted discharges.

The RIDEM RIPDES Program administers the Phase II program in Rhode Island using a General Permit that was established in 2003. Rhode Island municipalities, the Rhode Island Department of Transportation (RIDOT), and Federal, State, and Quasi-State agencies serving more 1000 people per day are regulated under the Phase II program. The Town of Portsmouth, Naval Station (NAVSTA) Newport, and RIDOT are regulated under the Phase II permit within the Melville Ponds watershed.

The 2003[11] Phase II General MS4 Permit requires permittees to develop a stormwater management program that is based on six minimum control measures. Operators must develop Stormwater Management Program Plans (SWMPPs) that detail how their programs comply with the Phase II Permit. SWMPPS also include requirements for stormwater that discharges to impaired waters.

The six minimum control measures (MCM) are listed below.

- **Public Education and Outreach:** Informs the public about the impacts of stormwater on surface water bodies and provides information on ways to reduce impacts.
- **Public Involvement/Participation**: Ensures that the SWMPP and Annual Reports are publicly available and provides opportunities for public involvement in the MS4 program.
- **Illicit Discharge Detection and Elimination (IDDE):** A program to identify and eliminate non-stormwater discharges within the MS4 system.
- **Construction Site Stormwater Runoff Control:** Focuses on soil erosion and sediment control during construction for sites disturbing 1 or more acres.

[11] The permit expired in 2008 and has been administratively continued until a new permit is issued. Regulated entities must comply with their current permit.

- **Post Construction Stormwater Runoff Control**: Ensures that LID (low impact development), appropriate structural stormwater BMPs and a long-term maintenance plan are included in the design of new development and redevelopment sites disturbing 1 or more acres.
- **Pollution Prevention and Good Housekeeping in Municipal Operations**: Focuses on reducing stormwater runoff and pollution from permittee-owned properties through structural and non-structural BMP implementation.

General Stormwater Best Practices and Recommendations
The following section describes best practices for stormwater management that permittees can take to reduce stormwater pollution within the watershed.

LID Site Planning
Low Impact Development (LID) is both a site planning process and an application of small-scale management practices that minimizes stormwater runoff, disperses runoff across multiple locations, and utilizes a more naturalized system approach to runoff management. Some examples of LID include the following:

- Protecting open space, natural drainage areas, riparian buffers, wetlands and streams on development sites.
- Minimizing soil compaction and soil loss during development.
- Reducing manicured turf lawns and the use of lawn fertilizers by including areas such as pollinator gardens in design.
- Minimizing impervious surfaces by reducing street, driveway and sidewalk widths, reducing the size of cul-de-sacs, and using permeable surfaces when possible.
- Infiltrating or treating stormwater as close as possible to the point it enters the ground.
- Breaking up or disconnecting the flow of stormwater over impervious surfaces via rain gardens, vegetated swales, permeable pavers, infiltration trenches, etc.

RIDEM encourages the use of LID and considers it to be the industry standard. The regulatory requirements of the Rhode Island Stormwater Design and Installations Manual (RI Stormwater Manual) (RIDEM, 2015) were adopted into regulation in 2018 (RIDEM, 2018). Developers are required to consider and evaluate the use of LID for all permitted new development and redevelopment projects.

LID Resources:
LID Fact Sheet (URI et al., 2019)
LID Site Planning and Design Techniques: A Municipal Self Assessment (URI et al., 2019)
Rhode Island Low Impact Design Site Guidance and Planning Manual (RIDEM and CRMC, 2011).
The Rhode Island Stormwater Management, Design and Installation Rules (RIDEM, 2018).
The Rhode Island Stormwater Design and Installation Standards Manual (RIDEM and CRMC, 2015).

Structural and non-structural BMPs
RIDEM recommends that a combination of structural and non-structural BMPs be used to manage stormwater runoff in the Melville Ponds watershed. Structural and non-structural BMPs are often used together. Effective pollutant management is best achieved from a management systems approach, as opposed to an approach that focuses on individual practices. Some individual practices may not be very effective alone, but in combination with others, may be more successful in preventing water pollution.

Structural BMPs
Structural Best Management Practices (BMPs) (also referred to as Stormwater Treatment Units (STUs)) are engineered constructed systems that are designed to provide water quality and/or water quantity control benefits. Structural BMPs are used to address both existing watershed impairments and the impacts of new development.

The Rhode Island Stormwater Manual provides extensive guidance on the different types of structural BMPs, design and installation considerations, pollutant removal estimations for each type of BMP, and long-term maintenance requirements. Table 1, excerpted from the RI Stormwater Manual, provides an overview of common structural BMPs.

Group	Practice	Description
Wet Vegetated Treatment Systems (WVTS)	Shallow WVTS	A surface wet stormwater basin that provides water quality treatment primarily in a shallow vegetated permanent pool.
	Gravel WVTS	A wet stormwater basin that provides water quality treatment primarily in a wet gravel bed with emergent vegetation.
Infiltration	Infiltration Trenches/Chambers/ Dry Wells	An infiltration practice that stores the water quality volume in the void spaces of a trench or open chamber filled with or embedded in clean gravel before it is infiltrated into underlying soils.[1]
	Infiltration Basin	An infiltration practice that stores the water quality volume in a shallow surface depression before it is infiltrated into the underlying soils.[1]
	Permeable Paving	A practice that stores the water quality volume in the void spaces of a clean sand or gravel base before it is infiltrated into the underlying soils.[1]
Filtering Practices	Sand Filter	A filtering practice that treats stormwater by settling out larger particles in a sediment chamber, and then by filtering stormwater through a surface or underground sand matrix.
	Organic Filter	A filtering practice that uses an organic medium such as compost in the filter, or incorporates organic material in addition to sand (e.g., peat/sand mixture).
	Bioretention	A shallow depression that treats stormwater as it flows through a soil matrix, and is returned to the storm drain system, or infiltrated into underlying soils or substratum.
Green Roofs	Extensive	Rooftop vegetated with low, drought-tolerant plant species and a shallow planting media designed for performance. Not typically designed for public access.
	Intensive	Rooftop vegetated with trees and shrubs with a deeper planting soil and walkways, typically designed for both performance and public access.
Open Channels	Dry Swale	An open vegetated channel or depression explicitly designed to detain and promote filtration of stormwater runoff into an underlying fabricated soil matrix.
	Wet Swale	An open vegetated channel or depression designed to retain water or intercept groundwater for water quality treatment.

[1] The bottom of infiltration practices must be in the natural soil profile, i.e., shall not be located in bedrock. Where a TMDL or CRMC goal requires maximum treatment of runoff, the bottom of infiltration practices shall be within the uppermost soil horizons (A or B) or another BMP would be required.

Figure 6.1. Table 5-1 from the Rhode Island Stormwater Manual. List of BMPs acceptable for water quality.

Non-structural BMPs
Non-structural BMPs are a broad group of practices designed to prevent pollution through maintenance and management measures. They are typically related to the improvement of operational techniques or the performance of necessary stewardship tasks that are of an ongoing nature. Nonstructural measures are effective at controlling pollution generation at the source, thereby reducing the need for costly "end-of-pipe" treatment by structural BMPs. Examples of non-structural BMPs include the following:

- Targeted public education about pet waste pick up, yard maintenance practices, stormwater management, etc.
- More frequent and/or targeted street sweeping and catch basin cleaning.
- Roadside erosion and ditch maintenance.
- Specifications regarding how and when to apply fertilizers and pesticides.
- Reducing runoff at the source via rain barrels and rain gardens.

Structural and non-structural BMP Resources:
Rhode Island Stormwater Solutions Website (RIDEM, 2024)
Rhode Island Soil Erosion and Sediment Control Handbook (RI State Conservation Committee, 2016).
The Rhode Island Stormwater Management, Design, and Installation Rules (RIDEM, 2018).
The Rhode Island Stormwater Design and Installation Standards Manual (RIDEM and CRMC, 2015).

6.1.1.1 Required SWMPP Amendments
If an EPA-approved TMDL indicates that discharges from an MS4 require non-structural or structural storm water controls then, within one hundred and eighty (180) days of notice by RIDEM, Part IV.D of the 2003 Phase II Permit requires permittees to address TMDL provisions in their SWMPP. This TMDL has determined that discharges from the Town of Portsmouth MS4 and NAVSTA Newport MS4 contain the pollutant of concern (total phosphorus) and that nonstructural and structural controls are needed to meet the provisions of this TMDL. Under the 2003 Phase II Permit in effect at time of this TMDL, the Town of Portsmouth and NAVSTA Newport are therefore required to amend their SWMPPs to meet the provisions of this TMDL. The SWMPP amendments shall be addressed in a separate document referred to as a **TMDL Implementation Plan (TMDL IP).** In accordance with the 2003 Phase II Permit, the TMDL IP must be submitted within **one hundred and eighty (180) days** of the date of written notice from RIDEM that the TMDL has been approved by EPA.

The TMDL IP must specifically address the requirements included in Part IV.D of the 2003 Phase II Permit. The permittees should refer to this section of the Phase II Permit to review the requirements that are applicable to all TMDL IPs. Provisions that are specific to the Melville Ponds TMDL that must be addressed in the TMDL IP are listed in the following sections.

RIDOT entered a consent decree with EPA in 2015 to ensure RIDOT's compliance with the 2003 Phase II Permit. RIDOT previously completed a Stormwater Control Plan (SCP) and a Feasibility Study for the Melville Ponds watershed. In accordance with the consent decree (Section VI.B.18.f), within two (2) years of EPA approval of this TMDL, RIDOT is required to update the pertinent portions of the Melville Ponds SCP to meet the provisions of this TMDL and submit the updates to EPA for review and approval. RIDOT may submit these updates as a supplement to the SCP, in which case it is not required to complete a TMDL IP in addition to the SCP update.

6.1.1.1.1 Provisions specific to the Melville Ponds TMDL

The following sections detail permittee-specifics of the Melville Ponds TMDL. RIDOT, NAVSTA Newport, and the Town of Portsmouth must coordinate to confirm outfall ownership and system interconnections. It is common for state-owned and municipal-owned storm drains to interconnect. Operators must comply with Phase II Permit requirements if they contribute stormwater to priority outfalls via system interconnections, even if they do not own the outfall. In order for stormwater implementation to be successful, cooperation between MS4 operators is necessary when developing the TMDL IPs, implementing the six minimum control measures, and conducting feasibility analyses to determine suitable locations for the construction of structural BMPs. It can be difficult to find funding and suitable space within the watershed for the installation of structural BMPs. Coordination among the MS4 permittees may reduce these difficulties.

6.1.1.1.2 Town of Portsmouth

Refer to Table 4.1 and Figure 2.3 for information about the two priority outfalls in the watershed owned by the Town of Portsmouth.

Within one hundred and eighty (180) days of notification by RIDEM, under the current 2003 Phase II Permit, the Town of Portsmouth must complete a TMDL IP and address the following **in addition to** the general requirements listed in Part IV.D of the MS4 Permit:

- The TMDL IP must address all parts of the watershed that discharge to Upper and Lower Melville Ponds and the Melville Ponds Tributary.
- RIDEM has determined that the six minimum control measures alone are insufficient to restore water quality and that additional structural stormwater controls or measures are necessary to meet the WLA for Upper and Lower Melville Ponds. The Town of Portsmouth must assess the feasibility of installation of structural BMPs within the catchment areas of the two outfalls and the catchment areas of any interconnections with the RIDOT system, through the Scope of Work (SOW) described in Part IV.D(4) of the MS4 Permit.
- The Town of Portsmouth's stormwater drainage system interconnects with RIDOT's drainage system in multiple locations. Town-owned roads that are either suspected or confirmed to interconnect with the drainage system of the RIDOT-owned outfall 9008840 include John Street, Mill Lane, Russo Road, Chelsea Drive, Mariel Rose Drive,

the southern portion of Hilltop Drive, Prudence View Drive and Pear Street. The Town of Portsmouth must coordinate with RIDOT to identify all interconnections and delineate the interconnecting catchments to outfall 9008840.

- Substantial sediment and trash deposits were found downstream of RIDOT outfall 9008840 during field investigations by RIDEM. As stated above, the Town of Portsmouth's stormwater system interconnects with the RIDOT stormwater system that discharges to RIDOT outfall 9008840. The Town must conduct a catchment area investigation for the stormwater system(s) that interconnect with the RIDOT systems draining to outfall 9008840 which shall include the following:
  - Inspection and cleaning of catch basins within the catchment(s). Any catch basin that is found to be > 50% full of sediment should be noted and a schedule for cleaning shall be developed such that the catch basin is never more than 50% full.
  - Evaluate the catchment(s) for excess sources of sediment from land use, construction, areas of bare earth, interconnected systems or other sources.
  - Implement corrective actions to address any source(s) of sediment and/or trash within the catchment(s).
  - Evaluate the catchment(s) for the feasibility of installation of structural BMPs that will reduce excess sediment and trash deposits to the system.
  - Provide results of the catchment investigation in the TMDL IP.
- The Town must make the following updates to their outfall mapping:
  - Update the location of OF 14-12. The outfall is mapped as being on the east side of Leland Point Drive, but was confirmed by RIDEM to be located on the west side of Leland Point Drive at approximately 41.5852°N, -71.2708°W.
  - Verify the ownership of OF 14-11. Based on review of drainage plans at the Town of Portsmouth Department of Public Works, RIDEM suspects that OF 14-11 is misidentified as a town-owned outfall. Based on the description of the location of OF 14-11, it is likely that OF 14-11 is in fact RIDOT-owned outfall 9008840.
- Provide the inspection schedule and the most recent maintenance records for the Melville elementary infiltration basin (rain garden).
- All catch basins shall be inspected at least twice per year, once between November 15 and December 15 (after leaf fall), and once during the month of April (after snow melt) and at other times as necessary, and cleaned of sediment and debris to prevent the discharge of pollutants from structures or outfalls. The Town must remove accumulated materials from catch basins (i.e. catch basin cleaning) twice per year, once between November 15 and December 15 (after leaf fall) and once during the months of April (after snow melt) such that a minimum sump storage capacity of 50% is maintained

throughout the year. Ensure that grates and covers are clear of debris. Provide an inspection summary with the MS4 annual report.

- Increase street sweeping to at least twice per year for all curbed roadways, once between November 15 and December 15 (after leaf fall) and once during the month of April (after snow melt) and at other times as may be necessary. Sweeping shall be performed with the use of mechanical or vacuum sweepers. Provide an inspection summary with the MS4 annual report.

- RIDEM identified a paved waterway on Bradford Avenue that is functioning as an outfall. The paved waterway discharges stormwater into Pond 2 (Figure 1). The Town shall include this paved swale in the MS4 program and evaluate options for installation of structural controls within the outfall's catchment.

- Include an evaluation of the effectiveness of the six minimum control measures in the TMDL IP in addressing the following:
    - Public education/Public involvement:
        - New outreach methods such as social media or the town website to distribute educational materials.
        - Distributing messages at appropriate times during the year. For example, a message about proper disposal of leaf litter and yard waste should be distributed in the spring and the fall including the following topics:
            - For residential audience:
              • Proper disposal of pet and yard waste.
              • Reducing/eliminating use of fertilizer on lawns.
              • Infiltrating and reducing stormwater discharges to the MS4 from private property by utilizing rain gardens, rain barrels and porous driveway materials on private property.
            - For commercial audience:
              • Proper waste disposal and dumpster management.
              • Reducing/eliminating use of fertilizer on properties.
              • Eliminating use of detergents and chemical cleaners on driveways or parking areas.
            - For developer audience:
              • Encouraging use of LID and infiltrating structural BMPs where possible.
              • Proper sediment and soil erosion control during construction.

- Illicit Discharge Detection and Elimination:
    - OF 14-12 was observed to be flowing during dry weather. The Town must conduct an IDDE investigation for this outfall in accordance with Part IV.B.3.b.5.vii of the Phase II Permit.

- Good Housekeeping/Pollution Prevention:
    - Evaluate options for reducing erosion in the areas described in section 4.2.5 with the goal of redirecting flow to areas that would promote infiltration and filtration prior to discharge to the water bodies. Section IV.B.6.b.1.iv of the Phase II Permit requires the MS4 operator to include procedures to minimize the erosion of road shoulders and roadside ditches by requiring stabilization of these areas. Recommended methods for stabilization include rip rap, or gravel, to reduce the velocity of the stormwater runoff, or planting of grass, shrubs or trees.
    - Incorporate infiltrating BMPs into any new construction on permittee-owned properties when feasible.
    - Evaluate permittee-owned properties in the watershed for opportunities to incorporate infiltrating and/or phosphorus-reducing structural BMPs via retrofitting. Provide a list of municipally owned properties and structural BMPs in the watershed and evaluate opportunities for future retrofitting.
    - Eliminate or reduce fertilizer application on permittee-owned properties.

Figure 6.2. Stormwater runoff on Bradford Avenue discharging into Pond 2 via paved swale. Photo 10/14/2022.

6.1.1.1.3 NAVSTA Newport

Refer to Table 4.2 and Figure 2.3 for information about the priority outfalls in the watershed owned by NAVSTA Newport.

Within one hundred and eighty (180) days of notification by RIDEM, under the current 2003 Phase II Permit, NAVSTA Newport must complete a TMDL IP and address the following in addition to the general requirements listed in Part IV.D of the MS4 Permit.

- The TMDL IP must address all parts of the watershed that discharge to Upper and Lower Melville Ponds and the Melville Ponds Tributary.
- RIDEM has determined that the six minimum control measures alone are insufficient to restore water quality and that additional structural stormwater controls or measures are necessary to meet the WLA for Upper and Lower Melville Ponds. NAVSTA Newport must assess the feasibility of installation of structural and non-structural BMPs within the catchment area of the priority outfalls, through the Scope of Work (SOW) described in Part IV.D of the MS4 Permit.
- NAVSTA Newport must confirm the location of the four (4) outfalls that RIDEM was unable to field verify (22-97A, 22-57B, 22-65B, 22-86) and provide the following information:
    - Photographs of the outfalls.
    - Assessment of the condition of the outfalls.
    - Material and diameter of the outfalls.
    - Presence/absence of flow.
    - Latitude/longitude coordinates of the outfalls.
    - Degree of hydraulic connectivity to Upper Melville Pond (direct or indirect connection).
    - Estimated distance of outfall from the pond.
- If any of the four outfalls identified above are found to be flowing during dry weather, conduct an IDDE investigation for the four outfalls (22-97A, 22-57B, 22-65B, 22-86) in accordance with Part IV.B.3.b.5.vii of the MS4 Permit.
- NAVSTA Newport shall update the locations of the outfalls in their GIS mapping if necessary and submit the updated mapping to RIDEM as part of the TMDL IP.
- NAVSTA Newport GIS mapping indicates that there are two Stormceptor 4800 devices installed within the stormwater drainage system of Outfall 22-97A and Outfall 22-57B. NAVSTA Newport must provide the maintenance schedule and most recent maintenance record of these two devices as part of the TMDL IP.
- All catch basins shall be inspected at least twice per year, once between November 15 and December 15 (after leaf fall), and once during the month of April (after snow melt) and at other times as necessary, and cleaned of sediment and debris to prevent the

discharge of pollutants from structures or outfalls. NAVSTA Newport must remove accumulated materials from catch basins (i.e. catch basin cleaning) twice per year, once between November 15 and December 15 (after leaf fall) and once during the months of April (after snow melt) such that a minimum sump storage capacity of 50% is maintained throughout the year. Ensure that grates and covers are clear of debris. Provide an inspection summary with the MS4 annual report.

- Increase street sweeping to at least twice per year for all curbed roadways, once between November 15 and December 15 (after leaf fall) and once during the month of April (after snow melt) and at other times as may be necessary. Sweeping shall be performed with the use of mechanical or vacuum sweepers. Provide an inspection summary with the MS4 annual report.
- Include an evaluation of the effectiveness of the six minimum control measures in the TMDL IP in addressing the following:
    - Public education/Public involvement:
        - New outreach methods to distribute educational materials to residential properties, including email.
        - Distributing messages at appropriate times during the year. For example, a message about proper disposal of leaf litter and yard waste should be distributed in the spring and the fall including the following topics:
            - For residential audience:
              • Proper disposal of pet and yard waste.
              • Reducing use of fertilizer and pesticides on lawns.
              • Infiltrating and reducing stormwater in the yard using rain gardens, rain barrels and porous driveway materials.
            - For developer audience:
              • Encouraging use of LID and infiltrating structural BMPs where possible.
              • Proper sediment and soil erosion control during construction.
    - Good Housekeeping/Pollution Prevention:
        - Incorporate infiltrating BMPs into any new construction on permittee-owned properties when feasible.
        - Evaluate permittee-owned properties in the watershed for opportunities to incorporate infiltrating and/or phosphorus-reducing structural BMPs via retrofitting. Provide a list of NAVTSA Newport-owned properties and structural BMPs in the watershed and evaluate opportunities for future retrofitting.
        - Eliminate or reduce fertilizer application on permittee-owned properties.

6.1.1.1.4 RIDOT

Refer to Table 4.3 and Figure 2.3 for information about the two priority outfalls in the watershed that are owned by RIDOT.

RIDOT must address the following in the SCP update:

- Provide the estimated phosphorus load reduction for each proposed STU, following the methodology in Appendix 3 of the Consent Decree. If the total load reduction associated with the previously proposed STUs does not meet the required percent reduction, RIDOT must evaluate the feasibility of additional structural BMPs or enhanced non-structural BMPs within the catchments of the two outfalls and any interconnected stormwater drainage networks.
- Provide an update on the potential structural Stormwater Treatment Units (STUs) previously identified in the SCP, including the following:
  - Updated status (complete, in progress, infeasible, etc.).
  - Reason(s) for infeasibility (if applicable).
  - Estimated phosphorus removal for each STU.
  - Updated schedule including interim design milestones and proposed construction start and completion dates.
  - Update the RIDOT Stormwater Map Viewer to indicate the current status of all proposed structural STUs.
- Substantial sediment and trash deposits were found downstream of outfall 9008840 during field investigations by RIDEM. RIDOT shall conduct a catchment area investigation for this outfall which shall include the following:
  - Inspection and cleaning of catch basins within the catchment. Any catch basin that is found to be > 50% full of sediment shallbe noted and a schedule for cleaning shall be developed such that the catch basin is never more than 50% full.
  - Evaluate the catchment for excess sources of sediment from land use, construction, areas of bare earth, interconnected systems or other sources.
  - Implement corrective actions to address any source(s) of sediment within the RIDOT catchment that are not already addressed by planned STUs.
  - Evaluate whether the STUs that were previously proposed for this catchment will adequately address the excess sediment and trash deposits in light of the findings of the catchment investigation. If necessary, propose additional STUs and/or enhanced non-structural BMPs to adequately address the excess sediment and trash deposits.
  - Coordinate with the Town of Portsmouth to investigate interconnected systems.

- Provide results of the catchment investigation in the updated SCP.

- The stormwater drainage systems of several town-owned roads and private roads interconnect with RIDOT's drainage system. The roads that are either suspected or confirmed to interconnect with the drainage system of the RIDOT-owned outfall 9008840 include Donna Drive, John Street, Scotty Drive, Mill Lane, Russo Road, Chelsea Drive, Mariel Rose Drive, the southern portion of Hilltop Drive, Prudence View Drive and Pear Street. RIDOT must work with the Town of Portsmouth and the private neighborhoods to identify all interconnections and delineate the interconnecting catchments to outfall 9008840 and to evaluate these catchments for the feasibility of structural STUs.

- The watershed boundary for Melville Ponds was modified based on field investigations and review of drainage plans at the Town of Portsmouth Department of Public Works. These modifications are detailed in the "Application of the Simple Method to Upper and Lower Melville Ponds" Memo. RIDOT must update the watershed boundary and all relevant portions of the SCP based on the new watershed boundary.

- According to the IDDE Screening Results Notification Report for Melville Ponds (Fuss & O'Neill, 2020), outfall 9100282 could not be located in the field and was initially incorrectly identified as an outgoing interconnection. Outfall 9100282 was located by RIDOT and RIDEM during the development of this TMDL and is confirmed to discharge to the wetland upstream of Lower Melville Pond. RIDOT must update the SCP as necessary to indicate Outfall 9100282 is not an outgoing interconnection.

- All catch basins shall be inspected at least twice per year, once between November 15 and December 15 (after leaf fall), and once during the month of April (after snow melt) and at other times as necessary, and cleaned of sediment and debris to prevent the discharge of pollutants from structures or outfalls. The Town must remove accumulated materials from catch basins (i.e. catch basin cleaning) twice per year, once between November 15 and December 15 (after leaf fall) and once during the months of April (after snow melt) such that a minimum sump storage capacity of 50% is maintained throughout the year. Ensure that grates and covers are clear of debris. Provide an inspection summary with the MS4 annual report.

- Increase street sweeping to at least twice per year for all curbed roadways, once between November 15 and December 15 (after leaf fall) and once during the month of April (after snow melt) and at other times as may be necessary. Sweeping shall be performed with the use of mechanical or vacuum sweepers. Provide an inspection summary with the MS4 annual report.

6.1.2 Additional Stormwater Management Implementation Recommendations and Resources

Privately-owned roads and stormwater structures

RIDEM recommends the following stormwater management practices for the privately-owned roads and stormwater structures described in Section 4.2.4:

- **Clocktower Square:** Perform the necessary maintenance on the stormwater retention/detention basin in accordance with the Operation and Maintenance Plan approved for the BMP under RIPDES Permit RIR101119, as required by Minimum Standard 11: Stormwater Management System Operation and Maintenance of the RI Stormwater Manual. RIDEM noted during field visits that it does not appear that regular maintenance has been performed on this BMP and therefore the BMP is likely not functioning as intended/designed.
- **Leland Point Drive:** The stormwater outfall for Leland Point Drive was noted to be more than 75% blocked. The outfall should be cleaned out and the catch basins on Leland Point Drive should be inspected and cleaned out as well if necessary.
- **Springfield Group Melville neighborhood:** Evaluate opportunities for structural and non-structural BMPs throughout the neighborhood. RIDEM recommends increasing street sweeping to at least twice per year for all curbed roadways, once between November 15 and December 15 (after leaf fall) and once during the month of April (after snow melt) and at other times as may be necessary. RIDEM recommends that sweeping be performed with the use of mechanical or vacuum sweepers.

Recommendations for Residents

There are many steps that residents can take to reduce the total phosphorus in stormwater runoff. These options include the following:

- Avoid blowing or raking leaves or grass clippings into the street where they may be washed into catch basins or outfalls. Instead, mulch or compost the leaves or bring yard waste to the Town transfer station.
- Reduce the potential for sediment transport via erosion by vegetating areas of bare soil on residential properties.
- Reduce/eliminate the amount of fertilizer used on lawns. Many lawns are over fertilized and lawn chemicals get washed into storm drains during rain events. Follow the following tips:
    - Mow high and leave grass clippings on the lawn to improve the health of the lawn naturally and reduce the need for fertilizer.
    - Do not fertilize before a rain event.

    - Use slow-release fertilizer.
    - Avoid step-programs offered by lawn care companies. Reduce fertilizing to once a year in September and increase from there as needed.
- Always pick up and dispose of pet waste in the trash, whether it's on the sidewalk or on the lawn. Just like lawn chemicals, pet waste can be washed into storm drains during rain events and can be a source of phosphorus as well as bacteria to waterbodies.
- Conserving water will reduce the amount of stormwater and associated pollutant load leaving the property. Conserve water with the following tips:
    - Reduce the frequency of lawn watering and water the lawn at appropriate times. Established lawns need only 1 inch of water (including rain) a week. Avoid watering if rain is in the forecast and water early in the morning or in the evening, not the middle of the day.
    - Invest in a rain barrel to collect rain water for watering lawns or gardens.
    - Install a rain garden to infiltrate stormwater in the yard.

The following resources provide more information on how residents can improve stormwater quality and reduce stormwater runoff:

https://dem.ri.gov/environmental-protection-bureau/water-resources/outreach-education/ri-stormwater-solutions-water-21

https://dem.ri.gov/ri-stormwater-solutions/stormwater-managers/educational-materials/by-pollutant/phosphorus.php

6.2 Control of Internal Loading of Phosphorus

There are four primary techniques to reduce internal loading of phosphorus in waterbodies: dredging, aeration/oxygenation of the hypolimnion, complete circulation/destratification of the entire lake, and the application of alum (or other phosphorus-binding agents). All techniques will require permitting from relevant authorities, such as RIDEM.

Dredging is the most effective method but is extremely costly (~50 times alum) and may encounter regulatory prohibitions (Welch, 2005), particularly with the contaminated sediments documented in both reservoirs. Hypolimnetic aeration/oxygenation treats anoxic phosphorus release only and depends on iron availability to bind phosphorus and iron may not be inactivated itself in highly polluted sediments. Complete circulation/destratification has the same effect on sediment phosphorus as hypolimnetic aeration, but with a greater risk of increasing phosphorus availability in the epilimnion by removing the thermocline barrier.

Also, shallow lakes are generally already aerated through other mechanisms, such as wind action. Aeration techniques also have no lasting effect and once the source of air is shut off the internal loading will return. Alum treatment has proven to be effective in both stratified anoxic and unstratified oxic lakes. While first year costs for alum and full aeration/oxygenation are similar (~$1,000-$3,000/hectare), alum cost is only one-tenth as much when spread over ten years. As with application of any chemical, the use of alum must be carefully evaluated and controlled to minimize the risk of potential negative chemical and biological impacts. Additionally, any regulatory permitting must be attained prior to use.

For Lower Melville Pond with likely more significant internal cycling of phosphorus, RIDEM recommends that a professional consultant with experience in the control of phosphorus release from pond sediments be hired to specifically address this source. The consultant should confirm the significance of internal cycling as a source of phosphorus to the pond, and secondly, evaluate the most effective and feasible BMPs to control phosphorus release from the sediment. Lastly, many BMPs used to control the release of internal phosphorus may have undesirable effects on the waterbody if not properly conducted and therefore the consultant should also be retained to oversee implementation of the selected BMPs.

7 Public Participation

On November 7th, 2023, RIDEM held an informational meeting to discuss nutrient-related water quality issues in the Melville Ponds watershed. The meeting was held at the Portsmouth Town Hall and was attended by approximately 10 individuals from the public, Melville Parks Committee staff, and Town of Portsmouth staff. The meeting was a combination of in-person and virtual and provided an opportunity for DEM to discuss efforts to evaluate and improve water quality in both reservoirs and to obtain input from stakeholders. DEM staff gave a presentation with the following agenda:

- The Clean Water Act and TMDLs
- TMDL Basics
- Waterbody and Watershed Characteristics
- Water Quality Impairments
- Water Quality Conditions
- Proposed Approach for Developing TMDLs
- Sources of Phosphorus
- Next Steps in the Process
- Questions? Feedback?

A final public meeting is scheduled for October 7th 2025, which will open a public comment period to provide input on the draft TMDL before final submission to EPA for approval.

8 Follow Up Monitoring

This is a phased TMDL and, as such, additional monitoring is required to ensure that water quality objectives are met as remedial actions are accomplished. Monitoring of Upper Melville Pond has been historically conducted by URI Watershed Watch (URIWW) volunteers. RIDEM encourages URIWW volunteers to continue monitoring Upper Melville Pond and also encourages the Town of Portsmouth Melville Parks Committee to secure funding to initiate monitoring in Lower Melville Pond.

9 References

Bland, J.K. 1996. A Gaggle of Geese … or maybe a Glut. Lakeline, North American Lake Management Society: 16(1): 10-11.

Canfield, D.E. and Bachmann, R.W. 1981. Prediction of total phosphorus concentrations, chlorophyll a, and secchi depths in natural and artificial lakes. Canadian Journal of Fisheries and Aquatic Sciences. 38(4): 414-423.

Carpenter, S.R. 1980. Enrichment of Lake Wingra, Wisconsin, by submersed macrophyte decay. Ecology. Volume 61, Issue 5. Pp 1145-1155.

Chapra, S. C., 1997, Surface Water-Quality Modeling. New York: McGraw-Hill. 844 p.

Dillon, P.J. and F.H. Rigler. 1974. The phosphorus-chlorophyll relationship in lakes. Limnology and Oceanography. September 1974, V. 19(5).

Jones, J.R. and Bachmann, R.W. 1976. Prediction of phosphorus and chlorophyll levels in lakes. Journal Water Pollution Control Federation. Vol. 48. No. 9. Annual Conference Issue.

Kitchell, J.F., D.E. Schindler, B.R. Herwig, D.M. Post, M.H. Olson, and M. Oldham. 1999. Nutrient cycling at the landscape scale: the role of diel foraging migrations by geese at the Bosque del Apache National Wildlife Refuge, New Mexico. Limnology and Oceanography 44 (3- 2): 828-836.

Kirchner, W.B., Dillon, P.J. 1975. An empirical method of estimating the retention of phosphorus in lakes. Water Resources Research. February 1975.

Manny, B.A., Johnson, W.C., and Wetzel, R.G. 1994. Nutrient Additions by Waterfowl to Lakes and Reservoirs: Predicting their Effects on Productivity and Water Quality. Hydrobiologia. 279- 280 (1): 121-132.

Moore, M.V., P. Zakova, K.A. Shaeffer, R.P. Burton. 1998. Potential Effects of Canada Geese and Climate Change on Phosphorus Inputs to Suburban Lakes of the Northeastern U.S.A. Lake and Reservoir Management 14 (1) 52-59.

Nichols, D.S., Keeney, D.R. Nitrogen and phosphorus release from decaying water milfoil. *Hydrobiologia* 42, 509–525 (1973). https://doi.org/10.1007/BF00047023

Portnoy, J. W. 1990. Gull Contributions of Phosphorus and Nitrogen to a Cape Cod Kettle Pond. Hydrobiologia. 202 (1-2): 61–69.

Purcell. S.L. 1999. The Significance of Waterfowl Feces as a Source of Nutrients to Algae in a Prairie Wetland. Master's Thesis. Department of Botany. University of Manitoba. Winnipeg, Manitoba.

Reckhow, K.H., 1979. Uncertainty analysis applied to Vollenweider's phosphorus loading criterion. J. Water Pollution Control Federation 51(8):2123-2128.

Schueler, T. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices*. MWCOG. Washington, D.C.

Vollenweider, R.A. Input-output models. Schweiz. Z. Hydrologie 37, 53–84 (1975). Walker, W.W. 1985 Statistical bases for mean chlorophyll-a criteria. Pg. 57-62. In: Lakes and Reservoir Management-Practical Applications, Proc. 4th Annual Conference, North American Lake Management Society, McAfee, NJ. 390pp.

Walker, W.W. 1985 Statistical bases for mean chlorophyll-a criteria. Pg. 57-62. In: Lakes and Reservoir Management-Practical Applications, Proc. 4th Annual Conference, North American Lake Management Society, McAfee, NJ. 390pp.

Walker (2001). Quantifying Uncertainty in Phosphorus TMDL's for Lakes. Prepared for: New England Interstate Water Pollution Control Commission and U.S. EPA R1. March 8 2001. 22pp.

Wentz, W. and Stuckey, R. 1971. The Changing Distribution of the Genus Najas in Ohio. The Ohio Journal of Science. V71n5 (September 1971). 292-302.

Appendix A: Calculation of Existing Total Phosphorus Loads to Upper Melville Pond and Lower Melville Pond

Application of empirical lake loading models to evaluate existing and allowable loads to Upper and Lower Melville Ponds (note TP variable is only parameter changed when calculating allowable P load)

Models Used:

A. Walker (2001)

B. Canfield, D.E. and Bachmann, R.W. (1981)

C. Reckhow, K.H., (1979).

UPPER MELVILLE POND

Table A. 1. Upper Melville Pond empirical equation variables and results.

Empirical Equation	Equation	Predicted TP Load (kg/yr)	Predicted TP Load (lbs/yr)
Walker 2001	L =TP*(Q+(U*A))	25	55
Canfield and Bachmann 1981	L = TP*(z(s+p))	34	75
Reckhow 1979	L = TP*(11.6+1.2q_s)	44	97
Average		**34**	**76**

UPPER MELVILLE POND

Variable	Description	Value	Units	Equation/Source
L	Phosphorus Load to Lake	Use eqn. to 'solve for'	kg/yr	
TP	Mean epilimnetic Total Phosphorus Concentration	52.0	ug/L	10-yr dataset (2014-2023). Ten-years of URIWW data. A single year of RIDEM data
Q	Annual Lake Outflow	0.31	Million m^3/yr	Assumed equal to inflow Q = (DA*R+(A(P-E)))/1,000,000
A	Surface Area of Pond	0.040	km^2	GIS analysis
U	Settling Rate	4.26	m/yr	U = (z*Q/A)$^{0.5}$
z	Average Depth of Pond	2.3	m	RIDEM Bathymetric Data
s	Phosphorus Sedimentation Coefficient	Calculate	yr^{-1}	s = 0.114(L/z)$^{0.589}$
p	Waterbody Flushing Rate	3.4	yr^{-1}	p=Q/V
V	Waterbody Volume	92,338	m^3	V=z*A (Use of RIDEM Bathymetric Data)
q_s	Areal Water Load	7.9	m	Q/A

Table A. 2. Upper Melville Pond total phosphorus data.

Collection Date	TP (ug/l)	Collection Date	TP (ug/l)	Collection Date	TP (ug/l)
5/15/14	25	5/2/18	29	06/29/21	59
6/20/14	56	7/12/18	83	07/14/21	67
7/17/14	59	10/17/18	82	07/27/21	83
8/14/14	57	5/8/19	51	08/11/21	73
9/10/14	58	7/18/19	50	08/24/21	47
10/16/14	35	10/15/19	41	09/08/21	87
5/7/15	13	6/10/20	44	09/29/21	38
7/16/15	62	7/8/20	71	10/20/21	39
10/15/15	81	10/21/20	89	5/1/2022	15
5/12/16	23	5/6/21	31	10/1/2022	41
7/20/16	66	7/8/21	37	6/14/2023	43
10/19/16	67	10/14/21	24	7/12/2023	50
5/11/17	26	05/19/21	37	10/18/2023	63
7/13/17	69	06/02/21	37		
10/12/17	58	06/17/21	68	**Average**	**52**

Walker Equation

$$P = L / (Q + U A) \qquad (7)$$

P = lake P concentration (ppb)
L = average external phosphorus load (kg/yr)
Q = average annual lake outflow (million cubic meters/yr)
A = lake surface area (km^2)
U = phosphorus settling velocity (m/yr)

The literature and experience with other regional lakes generally provide initial estimates of settling rate (U ~ 10 m/yr). Depending upon regional experience, other empirical models are sometimes used to provide initial estimates of settling rate as a function of depth and water load (e.g., $U = (Z Q / A)^{0.5}$, Vollenweider, 1976).

These estimates can be refined by calibrating the model to lake-specific data. For a given lake, the terms Q, U, and A are fixed, so that the equation can be solved for the external load corresponding to a given lake concentration:

$$L = P (Q + U A) = K P \qquad (8)$$

$$K = (Q + U A) \qquad (9)$$

For some retention models (e.g., Canfield & Bachman, 1982), the sedimentation rate is load-dependent, so that lake P concentration is not a linear function of load. These cases require numerical solution of the equation for the load corresponding to a given lake P concentration.

P = see Table A.2.
Q = annual hydraulic loading (outflow) = annual runoff volume + (net precip * surface area of pond)
Annual runoff volume calculated using Simple Method (292,688 cubic meters) + (precip-evap)(43.93 inches - 23 inches) * 39,862 square meters

Q = 313,879 cubic meters = 0.31 million cubic meters
A = surface area of pond = 39,862 square meters = 0.039862 = 0.040 square km
U = ((z*(Q/A))^0.5
  z = 2.3 meters
  Q = 0.31 million cubic meters
  A = 0.040 square km
U = 4.256

Canfield and Bachmann Equation
The Canfield and Bachmann model was developed and tested using data from 704 natural and artificial lakes, including 626 lakes in the U.S. EPA National Eutrophication Survey. Of these 704 lakes, 433 were artificial lakes. The Canfield and Bachmann (1981) model is essentially an expression of the Vollenweider equation (1975) with a modified sedimentation coefficient for artificial lakes and is expressed as follows:

$$TP = (L/1000) / 0.305 X Z (0.114 (L/Z)0.589 +1/T$$

Where:
TP = mean total phosphorus concentration (volume-weighted) for each reservoir in mg/l
L = loading rate in mg/m2 (converted to kg/yr or lbs/yr)
Z = mean depth of reservoir in meters
T = waterbody flushing rate

TP = see Table A.2.
Z = 2.3 meters
T = hydraulic flushing rate (Q) in cubic meters per year (313,879)/reservoir volume in cubic meters (92,338)
T = $3.4 yr^{-1}$

Reckhow Equation

The current annual mean phosphorus load was based on the average TP concentration and areal water loading (see below equation) using the Reckhow model (1979). The Reckhow model was developed from a database of lakes within a north temperate setting, thereby making it applicable for waterbodies within southern New England. The Reckhow model expresses phosphorus concentration (TP in mg/l) as a function of phosphorus loading (L, in g/m^2-yr), areal water loading (q_s, in m/yr), and apparent phosphorus settling velocity (v_s, in m/yr) in the form:

$$TP = L/(v_s + q_s)$$

Using a least squares regression, it was found that the apparent settling velocity could be fit using a weak function of q_s. This resulted in the fitted model:

$$TP = L/(11.6 + 1.2q_s)$$

Where:
L = Existing Load; and
q_s = Areal Water Load.

The estimation of Areal Water Load (q_s) was calculated in the following manner:

$$q_s = Q/Ao$$

Where:
Q = Inflow Water Volume; and
A_o = Lake Surface Area.

$$Q = (A_d \times r) + (A_o \times Pr)$$

Where:
q_s = Areal water loading (m/yr);
Q = Inflow water volume (m^3/yr);
A_d = Watershed area (m^2);
A_o = Waterbody surface area (m^2);
r = total annual unit runoff (m/yr); and
P_r = mean annual net precipitation (m/yr).

The back-calculation (calculating annual load by substituting mean TP concentration) is calculated using the following equation: $L = P(11.6 +1.2(q_s)$
P = see Table A.2
q_s = areal water load (hydraulic loading in cubic meters/waterbody area in meters) = 7.9 meters

LOWER MELVILLE POND

Table A. 3. Lower Melville Pond empirical equation variables.

Empirical Equation	Equation	Predicted TP Load (kg/yr)	Predicted TP Load (lbs/yr)
Walker 2001	$L = TP*(Q+(U*A))$	32	71
Canfield and Bachmann 1981	$L = TP*(z(s+p))$	38	84
Reckhow 1979	$L = TP*(11.6+1.2q_s)$	39	85
Average		**36**	**80**

LOWER MELVILLE POND

Variable	Description	Value	Units	Equation
L	Phosphorus Load to Lake	Use eqn. to 'solve for'	kg/yr	
TP	Mean epilimnetic Total Phosphorus Concentration	45	ug/L	A single year (2021) of RIDEM data. May-Oct bi-weekly
Q	Annual Lake Outflow	1.06	Million m^3/yr	Assumed equal to inflow $Q = (DA*R+(A(P-E)))/1{,}000{,}000$
A	Surface Area of Pond	0.022	km^2	GIS analysis
U	Settling Rate	14.42	m/yr	$U = (z*Q/A)^{0.5}$
z	Average Depth of Pond	4.1	m	RIDEM Bathymetric Data
s	Phosphorus Sedimentation Coefficient	Calculated based on load	yr^{-1}	$s = 0.114(L/z)^{0.589}$
p	Waterbody Flushing Rate	11.5	yr^{-1}	$p=Q/V$
V	Waterbody Volume	92,289	m^3	$V=z*A$ (RIDEM Bathymetric Data)
q_s	Areal Water Load	51.0	m	Q/A

Table A. 4. Lower Melville Pond total phosphorus data.

Collection Date	TP (ug/l)
5/19/2021	20
6/2/2021	32
6/17/2021	20
6/29/2021	17
7/14/2021	54
7/27/2021	35
8/11/2021	53
8/24/2021	58
9/8/2021	50
9/29/2021	52
10/20/2021	100
Average	**45**

Walker Equation

See Upper Melville Pond above for description

P= see Table A.4

Q= annual hydraulic loading (outflow)= USGS streamstat estimate (1.19 cfs) + direct watershed inputs (not including tributary) (based on Simple Method) = 0.04659 cfs + direct precipitation to Lower Melville Pond (0.0130 cfs) = 1.2496 cfs = **1.12 million cubic meters/yr**

A = surface area of the pond = 0.022 square km

U = U = ((z*(Q/A))^0.5
Z= 4.1 meters
Q = 1.12 million cubic meters
A= 0.022 square km
U = 14.42

Canfield and Bachmann Equation
See Upper Melville Pond above for description

TP= (L/1000) / 0.305 X Z (0.114 (L/Z)0.589 +1/T

Where:
TP = mean total phosphorus concentration (volume-weighted) for each reservoir in mg/l
L = loading rate in mg/m2
Z = mean depth of reservoir in meters
T = hydraulic flushing rate

TP = see Table A.4.
Z = 4.1 meters
T = hydraulic flushing rate = hydraulic loading (1,062,340 m^3/yr) / lower melville volume (92,289 m^3)
T = 11.5yr^{-1}

Reckhow Equation
See Upper Melville Pond above for description

The back-calculation (calculating annual load by substituting mean TP concentration) is calculated using the following equation: L = P(11.6 +1.2(q_s)
P = see Table A.4
q_s = areal water load (hydraulic loading in cubic meters/waterbody area in meters) = 7.9 meters

NOTE: The estimate of allowable load to Upper Melville Pond utilizes a 25 ug/l TP target concentration for all equations. The estimate of allowable load to Lower Melville Pond utilizes a 20 ug/l TP target concentration for all equations.

Appendix B: Total Phosphorus Data used for estimate of existing load to Melville Pond Tributary

Table B.1. Total phosphorus data from Melville Pond Tributary headwater and outlet. See Figure 3.1.

Sample Collection Date	Tributary headwater site TP (ug/l)	Tributary outlet site TP (ug/l)	Loss in ug/l	Expressed as a percent concentration loss
6/20/2023	75	33	42	56
7/6/2023	100	43	57	57
7/11/2023	180	50	130	72
7/20/2023	82	50	32	39
8/1/2023	68	39	29	43
8/15/2023	89	66	23	26
8/31/2023	81	37	44	54
9/12/2023	63	49	14	22
9/28/2023	59	30	29	49
Average Percent Loss				**46**

Table B.2. Upper Melville Pond outlet (tributary headwater site) TP concentration data with 46% attenuation applied. See Figure 3.1.

Sample Collection Date	TP concentration in ug/l Tributary headwater site (i.e. Upper Melville Pond outlet)	TP concentration with 46% attenuation applied (expected TP concentration in Melville Pond tributary at its point of inflow to Lower Melville Pond) in ug/l
05/19/21	37	20
06/02/21	37	20
06/17/21	68	37
06/29/21	59	32
07/14/21	67	36
07/27/21	83	45
08/11/21	73	39
08/24/21	47	25
09/08/21	87	47
09/29/21	38	21
10/20/21	39	21

The total phosphorus concentrations in the last column of Tables B.1 and B.2 were averaged and the resulting value of 37 ug/l was used as a best estimate of the average annual P concentration at the outlet of the Melville Pond tributary. It should be noted that the sample size (n=20) contains both dry and wet weather influenced values.