dcr
Massachusetts

Watershed Protection Plan FY24-FY28

Four seasons across the watershed system:
Quabbin Reservoir – winter; Ware River – fall;
Wachusett Reservoir – summer;
Sudbury and Foss Reservoirs – spring.

June 2023

Massachusetts Department of Conservation and Recreation
Division of Water Supply Protection
Office of Watershed Protection

Abstract
The Department of Conservation and Recreation, Division of Water Supply Protection, Office of Watershed Management manages and protects the drinking water supply watersheds that provide water for approximately 3.1 million Massachusetts residents. This Watershed System is comprised of three active water supply watersheds, the Quabbin Reservoir, Ware River, and Wachusett Reservoir, and an emergency supply comprised of the Sudbury and Foss Reservoirs. Watershed Protection Plans were initially developed for the active supply watersheds in 1991, with updates in 1998 and 2003 for the Wachusett Reservoir and 2000 for Quabbin Reservoir and Ware River. The Sudbury and Foss Reservoirs had a plan prepared in 1997. The *2008 Watershed Protection Plan* updated and unified all of these documents. The *2013 Watershed Protection Plan* update and *Watershed Protection Plan FY19-FY23* maintained the comprehensive, unified approach to this critical document.

The *Watershed Protection Plan FY24-FY28* continues DCR's successful efforts of managing the source of an unfiltered water supply. This plan update provides a structured methodology to assess changes in watershed threats, develops programs to address the threats, and prioritizes staff assignments so they are congruent with current watershed management issues. The plan concludes with a five-year implementation strategy that summarizes objectives for the Division of Water Supply Protection to achieve from Fiscal Years 2024 to 2028.

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Department of Conservation and Recreation Watershed Protection Plan FY24-FY28

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Acronyms

ACOE	US Army Corps of Engineers
ADA	Americans with Disability Act
AIS	Aquatic Invasive Species
ALB	Asian Longhorned Beetle
AST	Aboveground Storage Tank
ATV	All-terrain Vehicle
BLA	Quabbin Reservoir Boat Launch Area
BMP	Best Management Practice
CFI	Continuous Forestry Inventory
cfu	Colony Forming Units
CMR	Code of Massachusetts Regulation
CVA	Chicopee Valley Aqueduct
DAR	MA Dept of Agricultural Resources
DCR	MA Dept of Conservation and Recreation
DFW	MA Dept of Fish and Wildlife
DWSP	DCR's Division of Water Supply Protection
EOEEA	MA Executive Office of Energy and Environmental Affairs
EPA	US Environmental Protection Agency
MEP	MA Environmental Police
EQ	DWSP Environmental Quality Section
EQA	Environmental Quality Assessment
FCPA	MA Forest Cutting Practices Act
FoQ	Friends of Quabbin
FY	Fiscal Year (July-June)
GIS	Geographic Information Systems
ICS	Incident Command System
LAP	Land Acquisition Panel
LMP	DWSP 2017 Land Management Plan
MassDEP	MA Dept of Environmental Protection
MassDOT	MA Department of Transportation
MassGIS	Commonwealth's Office of Geographic Information
MCP	Mass Contingency Plan
mgd	Million gallons per day
MGL	MA General Law
MS4	Municipal Separate Storm Sewer Systems
MSP	MA State Police
MWRA	MA Water Resources Authority
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
OAG	MA Office of the Attorney General
ORV	Off-road Vehicle
PILOT	Payments in Lieu of Taxes
PPCP	Pharmaceutical and Personal Care Products
QVC	Les and Terry Campbell Quabbin Visitor Center
Res Ops	Reservoir Operations Group
ROW	Right of Way
SOP	Standard Operating Procedure
STAC	Science and Technical Advisory Committee
SWPPP	Stormwater Pollution Prevention Plan
SWTR	Federal Surface Water Treatment Rule
USDA	US Department of Agriculture
USGS	United States Geological Survey
UST	Underground Storage Tank
UV	Ultraviolet Light
WPR	Watershed Preservation Restriction
WQSWAT	Water Quality Sampling and Analysis Team
WsPA	Watershed Protection Act

1 Introduction

The Massachusetts Department of Conservation and Recreation (DCR), Division of Water Supply Protection, Office of Watershed Management (DWSP) manages and protects the drinking water supply watersheds that provide water for approximately 3.1 million Massachusetts residents. DWSP provides the Massachusetts Water Resources Authority (MWRA) source water for treatment and distribution to 53 communities in the Commonwealth (Figure 1-1). The DCR/MWRA water supply system is one of the few unfiltered drinking water supplies in the country (see Section 3-1).

1.1 DWSP Mission

The legislatively mandated mission of DWSP is defined in MGL c. 92 A1/2½, §2:

> *[DWSP] shall construct, maintain and operate a system of watersheds, reservoirs, water rights and rights in sources of water supply, shall supply thereby a sufficient supply of pure water to the Massachusetts Water Resources Authority, and shall utilize and conserve said water and other natural resources to protect, preserve and enhance the environment of the Commonwealth and to assure the availability of pure water for future generations.*

Building on this mission, DWSP's charge has adopted these major goals:

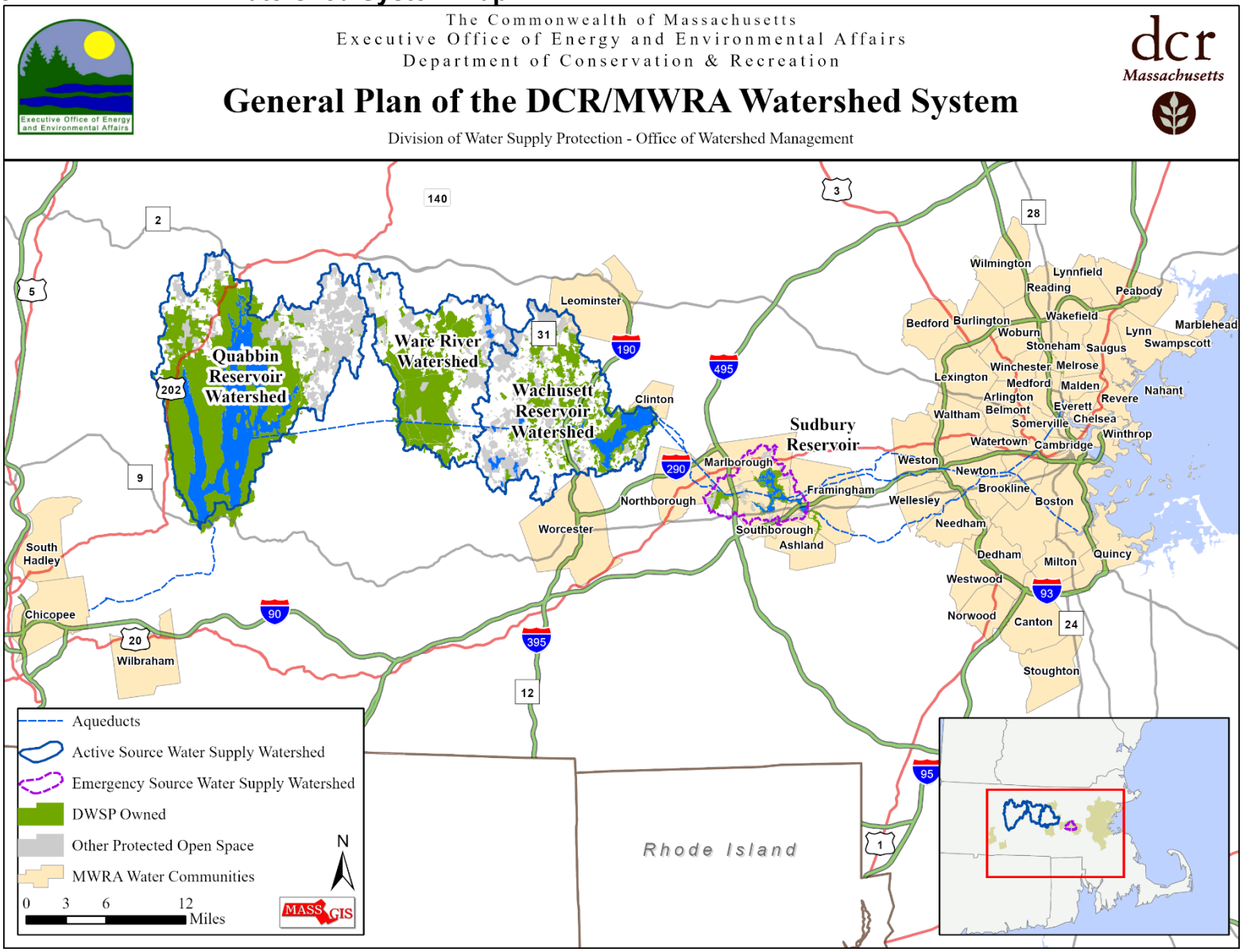
- To maintain and operate the source facilities (including dams) safely and efficiently.
- To preserve and improve water quality of the supply sources, through regulation, direct action, and cooperation, as needed to protect public health and to meet state and federal water quality standards.
- To fulfill the watershed protection and management requirements associated with drinking water regulations.
- To involve watershed towns, residents, and the public in appropriate ways in the conduct of DWSP's watershed management functions.

In addition, DWSP has defined water quality goals for the system:

- Prevent waterborne disease.
- Maintain high-quality source water.
- Meet the source water coliform and turbidity criteria.
- Reduce/control nutrient inputs to the reservoirs.
- Reduce risk of a chemical or hazardous material spill.
- Control general pollutant transport into the reservoirs.

Together, this mission and DWSP goals provide the basis for all of DWSP's activities.

Figure 1-1: DCR/MWRA Watershed System Map



DWSP is one division within the Department of Conservation and Recreation. DCR is the state's largest land owner, with over 450,000 acres of land and water under its control. DCR encompasses an expansive range of natural and cultural resources – not only the watershed system's land and reservoirs but also roadways, bridges, ponds, dams, waterways, and regulatory control over private forestry in the Commonwealth; it is perhaps best recognized, however, as the manager of the State Park system.

All of DWSP's functions are first and foremost related to its legislative mandate to provide "a sufficient supply of pure water to the Massachusetts Water Resources Authority" and "to assure the availability of pure water for future generations."

DCR has recently engaged in an agency-wide Strategic Readiness Initiative, an evaluation and planning process to ensure it is prepared for the dynamic future ahead. This initiative has DCR looking toward the future, recognizing it must adapt to meet the challenges of the changing world. The agency will play a critical role in adapting to, and mitigating, the impacts of climate change while continuing to provide an array of opportunities that support the collective physical, mental, social, and economic health of residents and visitors.

One result from the DCR Strategic Readiness Initiative is a set of Core Principals that accompany the agency's mission statement.

DCR Mission:

To protect, promote, and enhance, our common wealth of natural, cultural, and recreational resources, for the well-being of all.

Core Principles:

1. Provide access to a diversity of outdoor recreational experiences and unique landscapes that is equitable, inclusive, and welcoming.
2. Conserve lands, water, and forests by integrating science, research, and technical expertise into the management of our natural resources.
3. Advance climate change mitigation and adaptation efforts by implementing sustainable practices and advancing resiliency across our infrastructure, assets, and resources.
4. Support healthy communities by providing places for people to connect with nature and each other.
5. Inspire generations of stewards by recognizing and honoring our legacy through partnerships, public engagement, and education.

DWSP's mission and goals are reflected in these agency-wide principles. It is imperative to note, however, that DWSP's role as the manager of the unfiltered source waters and surrounding watersheds for over 3 million people's drinking water is very different than the recreation focus of the DCR State Park system. All of DWSP's functions are first and foremost related to its legislative mandate to provide "a sufficient supply of pure water to the Massachusetts Water Resources Authority" and "to assure the availability of pure water for future generations."

1.2 Watershed Protection Planning Process

DWSP's important mission – to utilize and conserve water and other natural resources to protect, preserve and enhance the environment of the Commonwealth and to assure the availability of pure water for future generations – requires a thoughtful and deliberative approach to develop programs that can achieve the very broad goal . Watershed Protection Plans are an important tool used by DWSP to implement programs that enable staff to carry out this mission. The purpose of this report is to update the *FY19-FY23 Watershed Protection Plan*. It summarizes a year-long assessment process conducted by DWSP staff and updates watershed control programs in order to continue effectively protecting the drinking water supply.

The watershed protection planning process and implementation of plan recommendations has been on-going since DCR's first Watershed Protection Plans were completed in 1991. Since that time, significant accomplishments have been made to greatly increase protection of the water supply, including:

- Acquisition of approximately 28,000 additional acres of land since 1985.
- Passage of the Watershed Protection Act's comprehensive land use regulations.
- Implementation of successful bird harassment programs at both Quabbin and Wachusett Reservoirs.
- Construction of sewers (with transport to a treatment plant outside the watershed) in areas no longer suitable for on-site wastewater disposal.
- Implementation of monitoring and control programs for invasive species.
- Redesign of roadway drainage to remove stormwater and eliminate risk from transportation releases.

Priorities for watershed control programs change as water quality threats are contained and new issues emerge. The process used to develop Watershed Protection Plans provides a structured methodology to assess changes in watershed threats, develop programs to address the threats, and review staff assignments to ensure that staff priorities align with current watershed issues. Table 1-1 provides a summary of the more significant changes and proposals made in this update from the previous plan.

Table 1-1: Significant Changes Made in Watershed Protection Plan Update FY24-FY28

Section	Change
3.2.1	Add Climate Change as separate topic
3.2.2	Update information regarding PFAS
3.2.3	Discuss impacts from Covid-19 pandemic
3.2.4	Update information regarding chloride
4	Consolidate presentation of issues under Programs; no longer have separate chapters for each watershed.
4.15	Add discussion of Payments in Lieu of Taxes Program
4.15	Change Emergency Response to Emergency Spill Response
4.16, Appendix	Add GIS Program to Control Programs

The *FY24-FY28 Watershed Protection Plan Update* is organized into five chapters. After this Introduction, Chapter 2 describes the watershed system. Chapter 3 analyzes potential sources of pollution. Chapter 4 presents the goals of DWSP's watershed control programs and the manner in which these control programs are implemented across the watershed system. The Organization and Management of DWSP, including a five-year Implementation Plan, are discussed in Chapter 5. This document integrates information from an array of detailed plans, reports, and other publications. Most of the referenced materials are available on the DWSP website.

Three views of the watershed system: East Branch of the Ware River (previous page); Quabbin Reservoir looking north (above); Wachusett Reservoir looking south towards the Cosgrove Intake (below).

2 The Watershed System

The first step in developing a watershed protection program is to delineate the watershed and assess major characteristics of the watershed, including stream hydrology, reservoir characteristics, land use, water quality, soil characteristics, and population trends. This information has been collected and updated by DWSP staff since the preparation of the first watershed protection plans. A brief summary is presented in this section.

2.1 Reservoir System

The source of water for the DCR/MWRA Water Supply System comes from three separate watersheds: Quabbin Reservoir, Ware River, and Wachusett Reservoir. The system also has an emergency water supply source, the Sudbury and Foss Reservoirs. The watershed system, shown in Figure 1-1, is large and well protected. Table 2-1 presents a summary of acreage information for the system.

Table 2-1: DCR/DWSP Watershed System Acreage

System	Watershed	Land Area (acres)	Reservoir Area (acres)	Total Watershed Area (acres)
Active	Quabbin Reservoir	95,364	24,582	119,946
Active	Ware River	61,671	0	61,671
Active	Wachusett Reservoir	70,876	4,033	74,909
Emergency	Sudbury Reservoir and Foss Reservoir	16,298	1,486	17,784

DWSP, 2023. Data changed from previous years due to improved cartography.

The system was built over two centuries from east to west, as engineers and planners expanded the system to meet demands of the growing metropolitan Boston area. This chapter and the remainder of the plan describe the system's components from west to east, which chronologically follows from the newest to the oldest portions of the system.

2.1.1 Quabbin Reservoir

Quabbin Reservoir is located in the valley of the Swift River, a tributary to the Connecticut River, in central Massachusetts. The reservoir was created in 1939 when the Swift River was impounded by the newly constructed Winsor Dam. Quabbin Reservoir has a watershed area of 95,466 acres (excluding the reservoir surface area). At full capacity, when its elevation is 530 feet above sea level, the reservoir covers an area of approximately 24,469 acres. The reservoir has 39 square miles of surface area and is 18 miles long. It has 118 miles of shoreline and holds 412 billion gallons when filled to capacity. The mean depth of the reservoir is 45 feet and the maximum depth is 141 feet. The Quabbin Reservoir is an oligotrophic drinking water reservoir, very clear and rich in oxygen with low nutrient levels so it does not readily support substantial algal or plant growth. It functions as both a terminal supply reservoir for the Chicopee Valley Aqueduct system in central Massachusetts and as a storage reservoir for the Quabbin Aqueduct system serving metropolitan Boston to the east.

2.1.2 Ware River

The Ware River watershed encompasses 61,737 acres in the Central Uplands of north central Massachusetts, east of Quabbin Reservoir. The Ware River watershed essentially functions as a tributary to Quabbin Reservoir via the Quabbin Aqueduct and a diversion structure along the Ware River in Barre. There is no permanent reservoir located in the Ware River Watershed.

2.1.3 Wachusett Reservoir

The Wachusett Reservoir watershed is located in central Massachusetts east of the Ware River. The reservoir, completed in 1906, was created by constructing a dam across the South Branch of the Nashua River. The reservoir surface area is 4,122 acres and the watershed consists of 74,800 acres. The reservoir has 6.5 square miles of surface area and holds 65 billion gallons when filled to capacity. The mean depth of the reservoir is 49 feet and the maximum depth is 122 feet. The normal operation range is between 387 and 392 feet above sea level; the overflow elevation is 395 feet above sea level. Like Quabbin, Wachusett is an oligotrophic reservoir. Quabbin water is transferred to the Wachusett Reservoir through the Quabbin Aqueduct.

2.1.4 Sudbury and Foss Reservoirs

The seven reservoirs that originally comprised the Sudbury Reservoir System were constructed over several decades in the late nineteenth century, with the largest component, the Sudbury Reservoir, completed in 1896. Over the course of the twentieth century, five reservoirs – Hopkinton, Whitehall, Ashland, Brackett, and Stearns – have been removed from the watershed system due to a combination of limited yield, poor water quality, contamination, and superior supplies from the west. The Foss and Sudbury Reservoirs, which are hydrologically separated from these other reservoirs, while removed from the active water supply system in the 1960s, remain as an emergency source supply. The watershed surrounding the Sudbury and Foss is much more developed than any other part of the system. The reservoir is classified as meso-eutrophic, with more nutrients available for plant and algal growth compared to the active reservoirs. The water is suitable for drinking water in emergency situations; Sudbury Reservoir and Foss Reservoir were most recently put into service very briefly in 2010.

2.2 Land Cover and Land Use

Land cover and land use within the watersheds varies. Quabbin Reservoir watershed is sparsely populated and has a small percentage of developed land. The watersheds become more populated and developed as one travels from west to east in the system. The relative proportion of protected lands also decreases from west to east. Overall, however, the active system is characterized by large tracts of undeveloped land with low population densities in the developed portions of the watersheds (Figures 2-1 to 2-4).

Land use and land cover data are an important tool for developing watershed protection strategies. Detailed analyses have been conducted for previous watershed protection plans. The *2013 Watershed Protection Plan Update* utilized a 2009 digital dataset of land use from the Commonwealth's Office of Geographic Information (MassGIS) using semi-automated methods and digital ortho-imagery captured in April 2005. The *DCR Watershed Protection Plan FY19-FY23* aggregated the thirty-three land use codes classification scheme into seven major categories for ease of analysis. Wachusett staff had also updated that watershed's land cover data in 2016 through visual interpretation and field visits. A Land Cover Update Model was then created in ArcGIS Model Builder which updated the land cover based on a one-meter cell size. While this work provided more accurate depiction of land use in the Wachusett Reservoir watershed, there were no significant changes in 2018 from the figures reported in the 2013 plan.

The revised Land Use figures demonstrate that a small portion of the watershed system consists of impervious surfaces.

This iteration of the Watershed Protection Plan utilizes the MassGIS 2016 Land Cover/Land Use data, which was developed collaboratively by MassGIS and the federal National Oceanic and Atmospheric Administration's Office of Coastal Management, released in 2019 to the public. This dataset consists of two components – land cover class and parcel use code – which can be used independently or together. For example, a user can display areas of impervious surface (land cover), or commercial parcels (land use). When used together, it is possible to display and quantify the portions of commercial parcels which are covered by impervious surfaces, or to show portions of residential parcels which are used as developed open space (e.g., yards).

DWSP took advantage of these possible combinations to fine tune the queries used to determine each land cover or land use category. These analyses changed a few of the previous land use categories, providing a differentiation between non-impervious and impervious surfaces. This perspective is especially noticeable when comparing residential or commercial/industrial percentages between this plan and earlier versions. For example, it was previously only possible to select an entire parcel as a residential or commercial/industrial parcel, even if only a small portion of the parcel was impervious (e.g., house, parking area, building, etc.). The new MassGIS dataset made it possible to select and measure the specific areas on a parcel where impervious use was detected (e.g., structures, decks, pools, parking areas, etc.).

Figure 2-1: Quabbin Reservoir Watershed Land Cover and Land Use

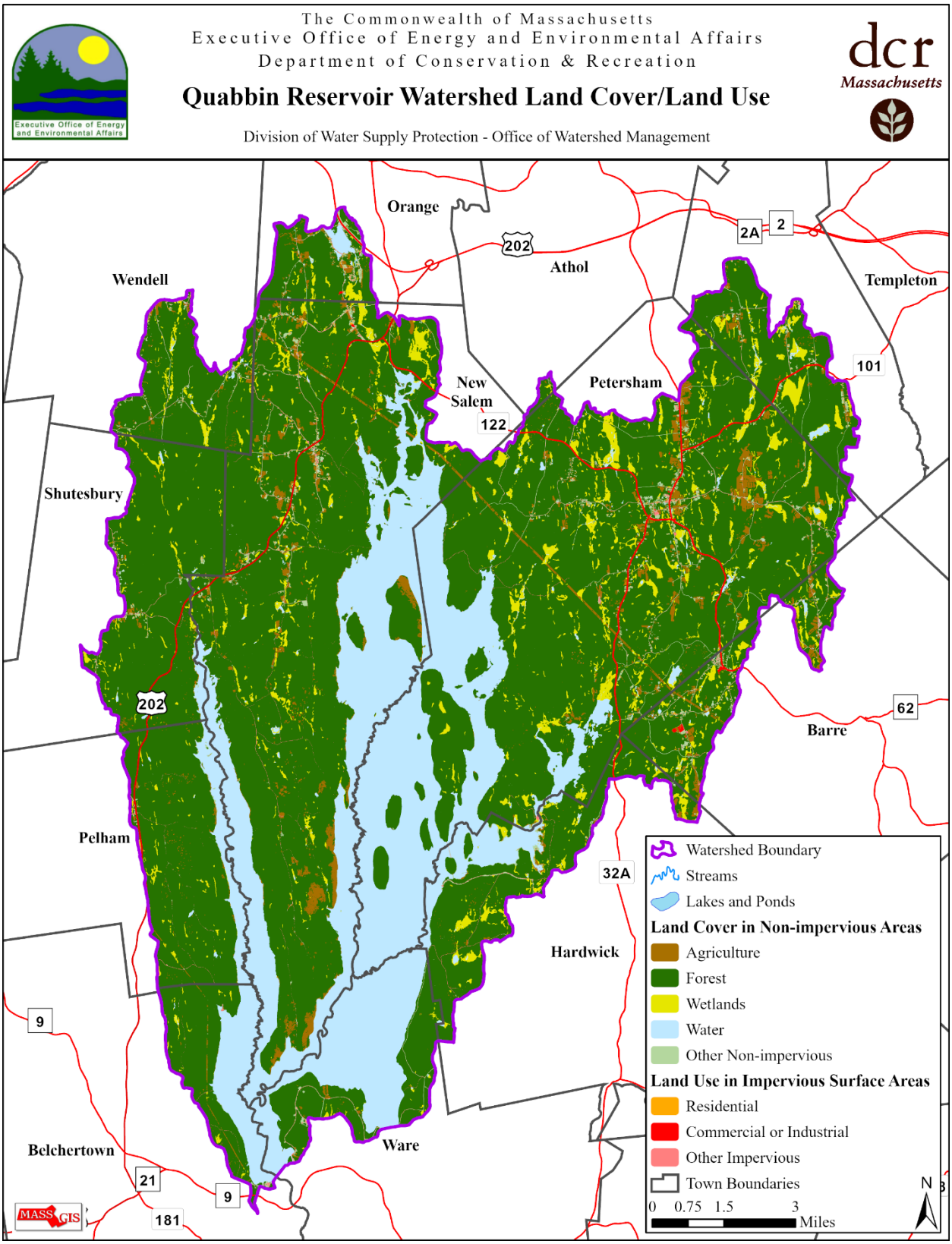


Figure 2-2: Ware River Watershed Land Cover and Land Use

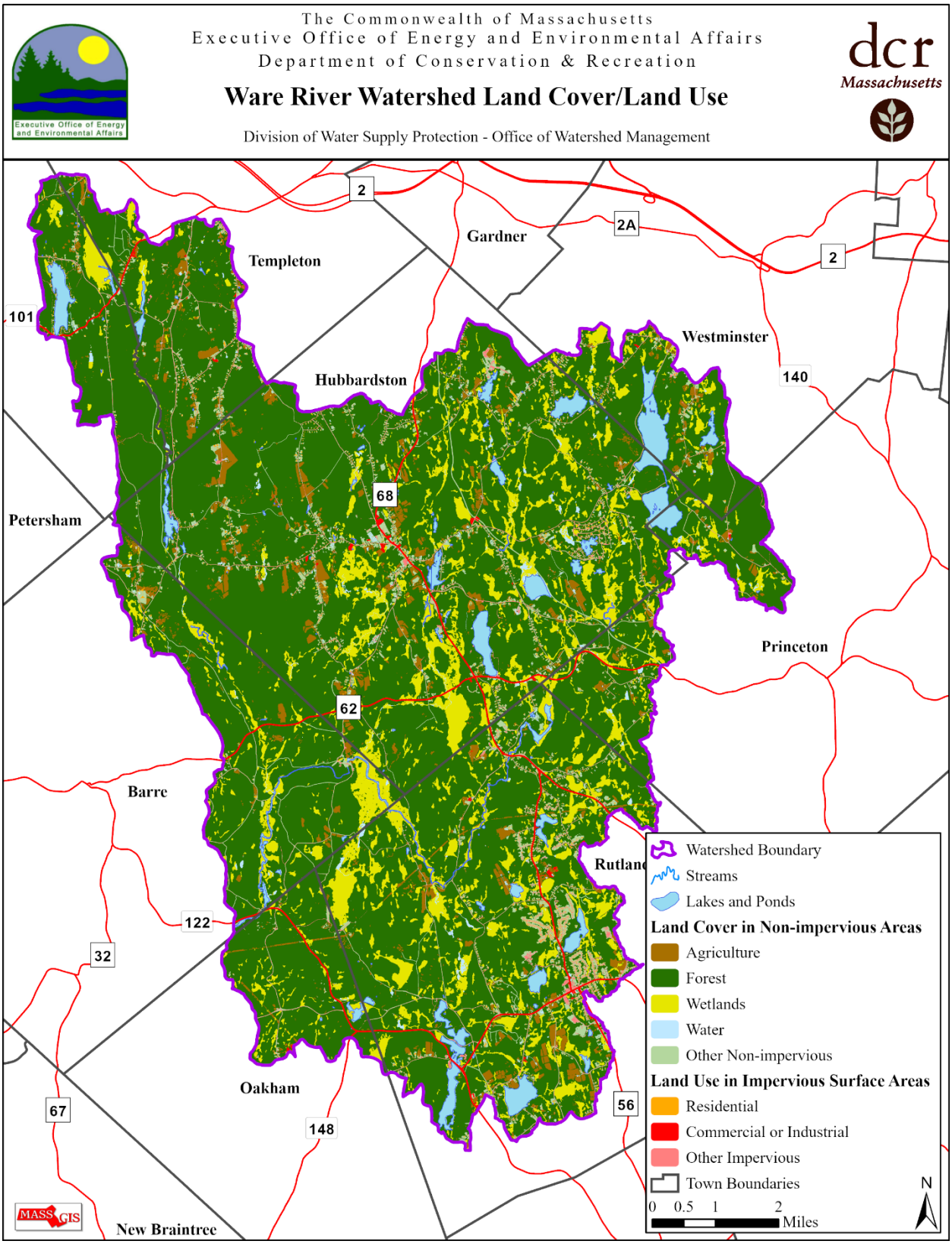


Figure 2-3: Wachusett Reservoir Watershed Land Cover and Land Use

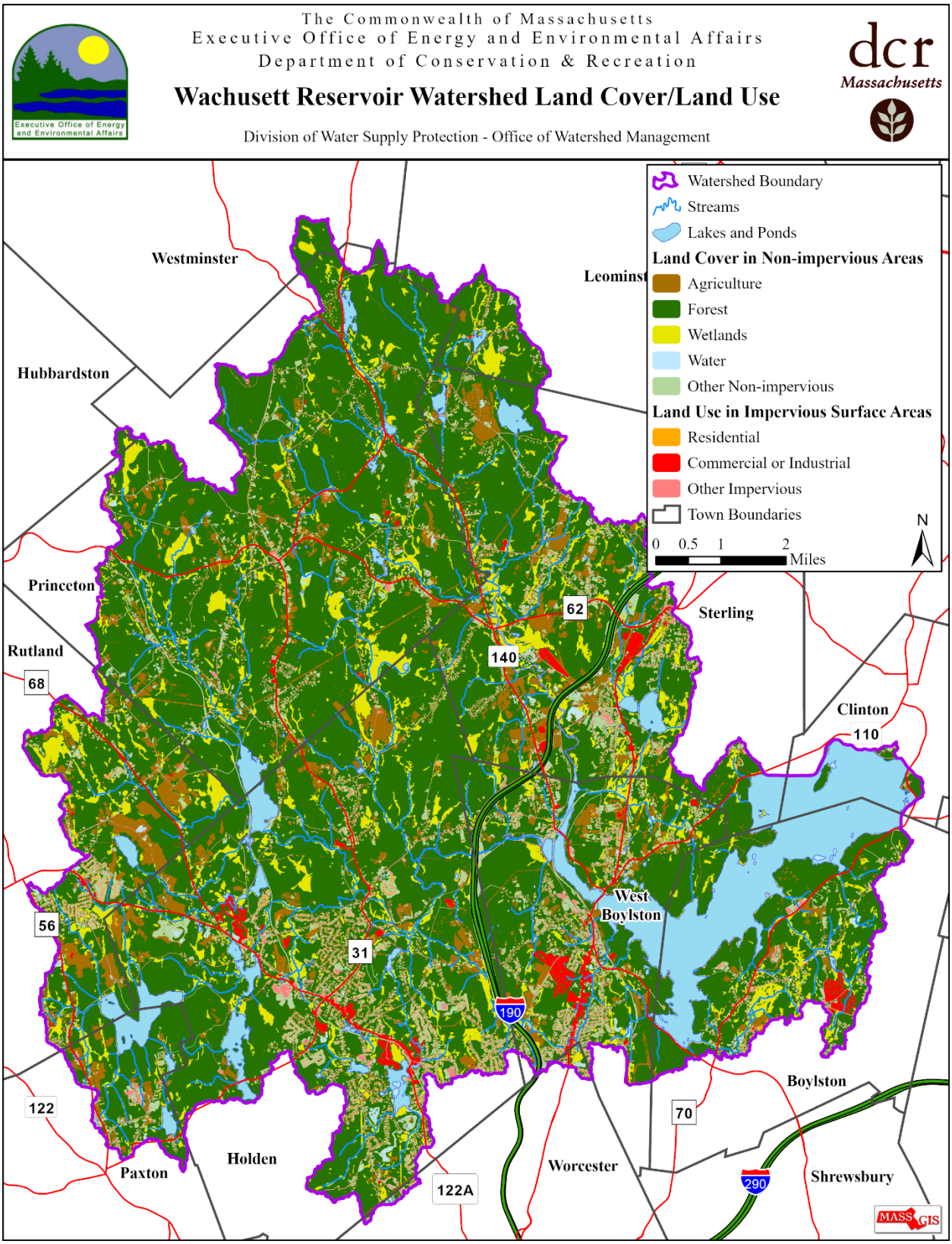
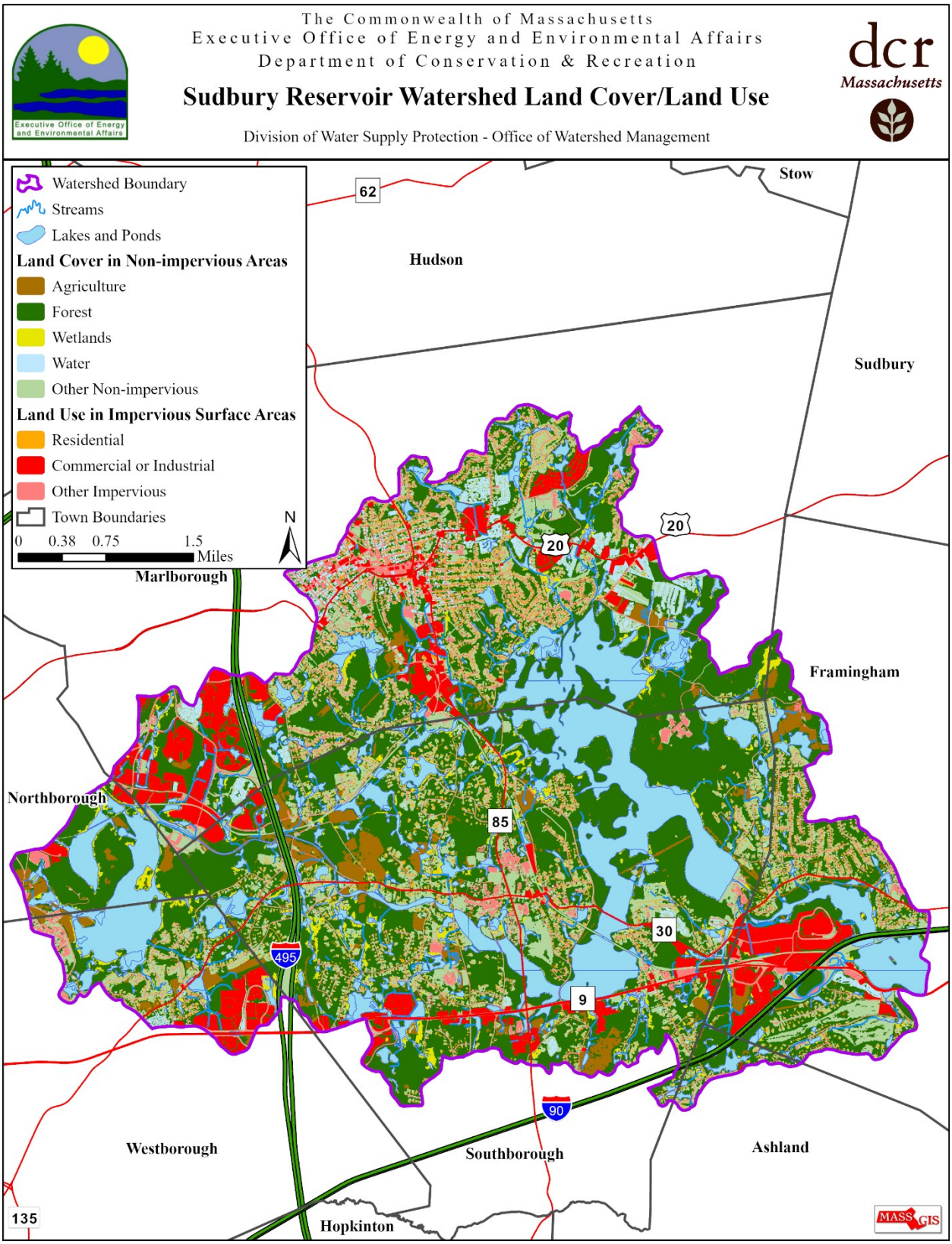


Figure 2-4: Sudbury Reservoir Watershed Land Cover and Land Use



The revised Land Use figures (Table 2-2) demonstrate that a small portion of the watershed system consists of impervious surfaces. Residential percentages have subsequently decreased across all watersheds, most noticeably in the densely populated Sudbury Reservoir Watershed. The residential use was calculated at 30.5 percent in the last plan; the recent data calculated the area to 5.94 percent of the watershed. The "missing" portion has been accounted for as "developed open space" (e.g., yards, playgrounds, etc.) under the "Non-impervious, Other" category. A detailed description of the queries used to determine each land cover/land use categories' percentage can be found in Appendix A.

DWSP identified a limitation to the automated machine learning techniques used to develop the MassGIS 2016 Land Cover/Land Use data. Some areas of active forestry, shoreline, and utility rights-of-way were mis-classified as one of three land cover codes used to identify agricultural land cover: cultivated land, pasture/hay, or grassland. While these areas may appear as "agriculture" on the maps, there is no active crop/fruit farming or livestock on any DWSP lands. DWSP does maintain some land as fields for habitat and cultural purposes: approximately 200 acres each in the Quabbin Reservoir and Ware River watersheds, and approximately 350 acres in the Wachusett Reservoir watershed. See Appendix A for additional information

Table 2-2: Summary of Land Cover/Land Use in the DCR/DWSP Watershed System
Figures shown are percentage of watershed, excluding the reservoirs.

		Non-Impervious					Impervious		
System	Watershed	Forest	Wetland	Agri-culture	Open Water	Other	Residential	Commercial/ Industrial	Other
Active	Quabbin	87.62	4.99	3.42	1.25	1.82	0.24	0.01	1.33
Active	Ware	74.77	11.61	3.81	3.22	3.19	0.87	0.06	2.47
Active	Wachusett	66.91	10.06	6.63	2.29	7.20	2.15	0.45	4.19
Emergency	Sudbury and Foss	45.09	13.07	4.09	0.17	17.31	5.94	5.56	8.78

Source: DCR and MassGIS. MassGIS data published in 2019. Open Water excludes reservoir area. Please refer to Appendix A for details on how these values were calculated.
Due to classification limitations, several areas of land on DWSP property consisting of harvested forestry areas and shoreline were identified as agriculture. Total mis-classified: Quabbin – 1.0 percent; Ware – 0.3 percent; Wachusett – 0.7 percent; Sudbury and Foss – 0.5 percent.
Forest, Wetland, Agriculture, Open Water, and Other are classified as non-impervious; Residential, Commercial/Industrial, and Other are classified as Impervious.

2.3 Land Protection

The Watershed System is well protected.

The Watershed System is well protected, as shown in Table 2-3. DWSP has an extensive Land Protection Program which has spent $139 million provided by Commonwealth and MWRA funding since 1985 to acquire 26,431 acres in both fee and Watershed Preservation Restriction as described in Chapters 3.2.1 and 3.2.2. This total acreage also includes the beneficiary of many gift sales/donations as well as federally funded Forest Legacy projects. Detailed accomplishments within each watershed are presented in Chapters

4.1-4.2. Small scale maps displaying DWSP and other protected lands are displayed in the respective watershed's program sections (Figures 4-1 – 4-4).

Table 2-3: Summary of Protected Lands in the DWSP Watershed System

System	Watershed	DWSP Fee	DWSP WPR	Other Protected	Total Protected	Land Area	Off-Water-shed Fee	Off-Water-shed WPR	Reser-voir
Active	Quabbin Reservoir	54,280	4,804	14,451	73,535	95,364	4,374	26	24,582
Active	Ware River	23,803	1,404	7,874	33,081	61,671	549	0	N/A
Active	Wachusett Reservoir	17,698	2,716	12,263	32,847	70,876	712	23	4,033
Active	**Total**	**95,781**	**8,924**	**34,588**	**139,464**	**227,911**	**5,635**	**49**	**28,615**
Emergency	Sudbury and Foss Reservoirs	2,367	0	1,810	4,177	16,298	408	0	1,486

Source: DWSP and MassGIS; all figures in acres. As of June 2022. Fee – land owned in fee simple by Commonwealth of MA managed by DWSP; WPR – Watershed Preservation Restrictions, similar to Conservation Restrictions, are land restrictions on private property in DWSP's Watershed System; Other Protected – land owned in fee simple by other MA state agencies, municipalities, or non-profit organizations for conservation purposes listed as permanently or limited protected open space by MassGIS; Off-Watershed – land owned in fee or held under a WPR managed by DWSP that is outside the boundary of the respective watershed.

Table 2-3 continued: Ownership as Percent of Watershed Land Area

System	Watershed	DWSP Controlled	Other Protected	Total Protected	DWSP Controlled Including Reservoirs
Active	Quabbin Reservoir	62.0	15.2	77.1	69.8
Active	Ware River	40.9	12.8	53.6	40.9
Active	Wachusett Reservoir	29.0	17.3	46.3	32.9
Active	**Total**	**46.0**	**15.2**	**61.2**	52.0
Emergency	Sudbury and Foss Reservoirs	14.5	11.1	25.6	21.7

Data from MassGIS and DCR Records. As of June 2022. Land area excludes the reservoir surface.

2.3.1 Quabbin Reservoir

The Quabbin Reservoir watershed is the least developed in the system. In addition, Quabbin was the beneficiary of the most aggressive land acquisition program at the time of its construction. Approximately 77 percent of the Quabbin Reservoir Watershed is protected lands with 62 percent of the Quabbin Reservoir Watershed Land Area directly controlled by DWSP. Other state agencies, non-governmental organizations, and watershed communities own the remaining protected lands. Eighty-eight percent of the land in the Quabbin watershed is forested, making it the dominant land use. Wetlands are the second most present land cover at 5 percent of the watershed. The percent of impervious cover in the watershed as a whole is a remarkable less than two percent.

2.3.2 Ware River

In the Ware River watershed, 54 percent of the land is classified as protected open space. Of this total, DWSP controls 25,486 acres, or 41 percent of the watershed. DWSP owns approximately 23,803 acres in fee, with an additional 1,404 acres controlled through Watershed Preservation Restrictions. Other government agencies, local governments, and non-government organizations own the remainder of protected open space. The Ware River watershed is still largely undeveloped and forested (75 percent), with wetland, cropland and pasture comprise the majority of remaining uses. Ownership patterns have changed in recent years for private lands, with average parcel size declining as larger parcels are subdivided for residential development or through the estate probate process as large landowners die and their land is passed on to multiple descendants. The Ware River watershed is approximately 3 percent impervious.

2.3.3 Wachusett Reservoir

Land use in the Wachusett Reservoir watershed remains dominated by undeveloped forest, open water, and wetlands, as over 79 percent of the watershed are in these categories. ; Residential development is relatively common, with updated assessment methodology indicating that approximately 2 percent of the watershed is currently residential impervious area. Agricultural has diminished over the years to around 6 percent of the watershed area. Commercial and industrial land uses are very uncommon and tend to be located in distinct areas such as in town centers or along major roadways. In total, 46 percent of the land is classified as protected open space. This is a much greater percentage of protected land than when the first watershed protection plans were written due to DWSP's aggressive land acquisition program and work with other land protection groups. DWSP now controls just over 20,000 acres in the Wachusett Reservoir watershed, or 29 percent of the land area. It is estimated that 6.8 percent of land in the Wachusett Reservoir watershed is impervious .

2.3.4 Sudbury and Foss Reservoirs

The Sudbury watershed, located just twenty miles from metropolitan Boston, is much more developed than active parts of the system. A major highway crosses Foss Reservoir, and several industrial/commercial developments exist in the watershed. Nevertheless, approximately 45 percent of the watershed is forested. A quarter of the watershed is protected, with DWSP lands comprising over half of this amount. Approximately 20 percent of the Sudbury Reservoir watershed land area is impervious.

2.4 Population

Despite [population] growth…DWSP's watershed management activities have maintained excellent source water quality in this water supply.

Twelve municipalities are wholly or partially located in the Quabbin Reservoir's watershed: Athol, Barre, Belchertown, Hardwick, New Salem, Orange, Pelham, Petersham, Phillipston, Shutesbury, Ware, and Wendell. Portions of Barre and Phillipston are also in the Ware River Watershed. Additional communities located in the Ware River Watershed are Hubbardston, Oakham, Rutland, Princeton, Templeton, and Westminster. Portions of Princeton and Rutland also lie in the Wachusett watershed, along with most or all of

Boylston, Holden, Paxton, Sterling, and West Boylston. Framingham, Marlborough, Northborough, Southborough, and Westborough comprise the Sudbury watershed.

Table 2-4 shows the populations according to the 2020 US Census. The data illustrates the increase in population as one travels from Quabbin watershed eastward. It also demonstrates that there are several towns in the Wachusett and Ware watersheds, such as Rutland, and Holden that continue to see growth as a suburban housing option for both Worcester and Boston. Projections of future growth will integrate impacts from Covid-19 work dynamics, as the ability to work remotely has provided people the mobility to work farther away from urban centers.

Despite this growth – which is shown for entire towns and not necessarily just within the watershed system – DWSP's watershed management activities have maintained excellent source water quality in this water supply. Acquisition of land, in either fee or as a Watershed Preservation Restriction, and the subsequent control of significant portions of the watershed system provides critical protection. Implementation of the Watershed Protection Act and support of other environmental regulations, along with continual monitoring within the watersheds, has minimized impacts from construction and renovation. Ongoing support of wastewater and stormwater controls keeps major pollutants out of the water supply. DWSP will continue its successful efforts to work with all appropriate state, federal, local, regional, and non-profit agencies as well as the residents of the watershed system to "provide clean water for future generations." Section 4 explains the entire suite of DWSP control programs in detail.

The 2020 Census data can also be illustrated to show how density increases from west to east, with the most populated areas in the active water supply system surrounding Wachusett Reservoir (Figure 2-5).

Figure 2-5. Population Density by Census Block Group

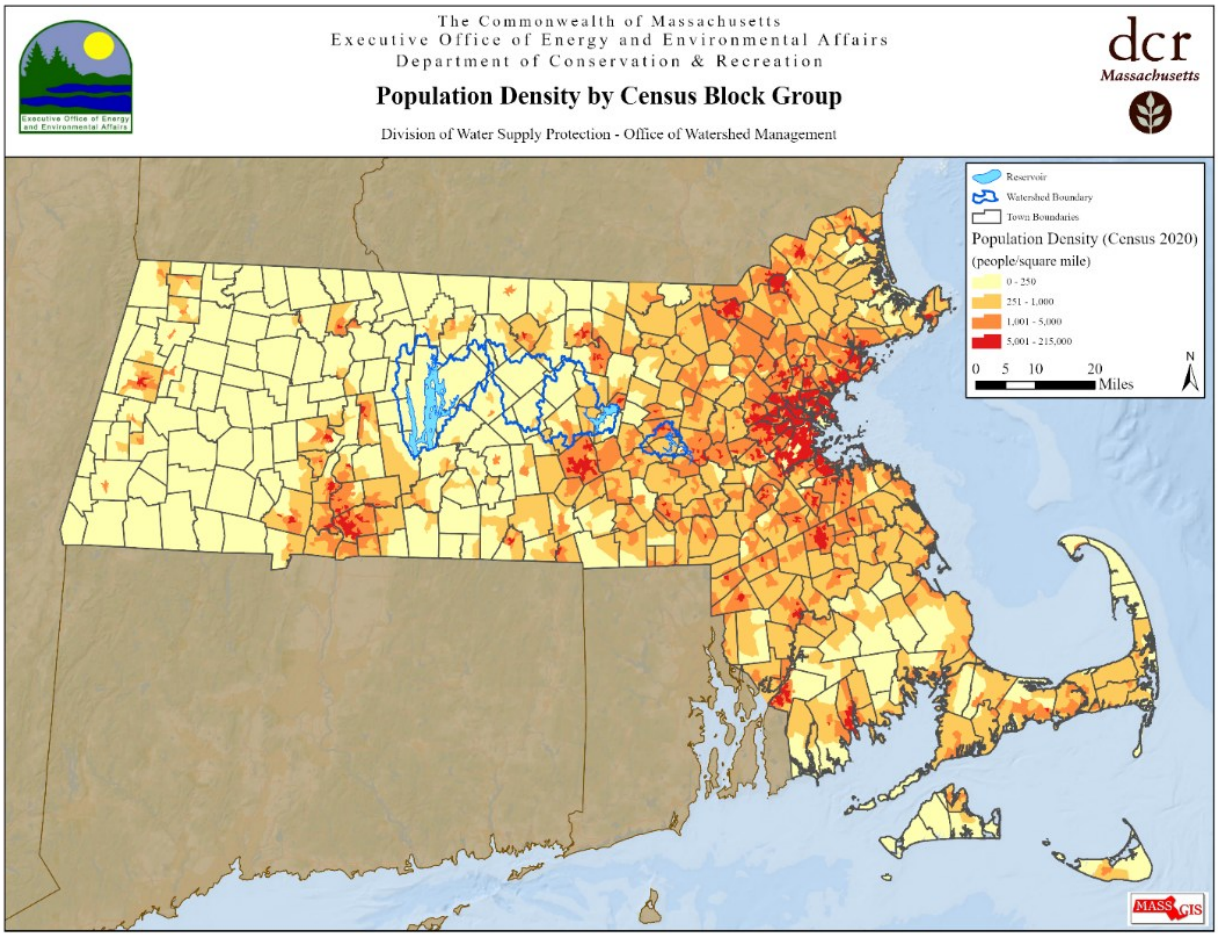


Table 2-4: Watershed Town Populations 2010 and 2020

Town	2010 Population	2020 Population	Change	Percent Change
Athol	11,584	11,945	361	3.1
Barre	5,398	5,530	132	2.4
Belchertown	14,649	15,350	701	4.8
Boylston	4,355	4,849	494	11.3
Framingham	68,318	72,362	4,044	5.9
Hardwick	2,990	2,667	-323	-10.8
Holden	17,346	19,905	2,559	14.8
Hubbardston	4,382	4,328	-54	-1.2
Marlborough	38,499	41,793	3,294	8.6
New Salem	990	983	-7	-0.7
Northborough	14,155	15,741	1,586	11.2
Oakham	1,902	1,851	-51	-2.7
Orange	7,839	7,569	-270	-3.4
Paxton	4,806	5,004	198	4.1
Pelham	1,321	1,280	-41	-3.1
Petersham	1,234	1,194	-40	-3.2
Phillipston	1,682	1,726	44	2.6
Princeton	3,413	3,495	82	2.4
Rutland	7,973	9,049	1,076	13.5
Shutesbury	1,771	1,717	-54	-3.0
Southborough	9,767	10,450	683	7.0
Sterling	7,808	7,985	177	2.3
Templeton	8,013	8,149	136	1.7
Ware	9,872	10,066	194	2.0
Wendell	848	924	76	9.0
West Boylston	7,669	7,877	208	2.7
Westborough	18,272	21,567	3,295	18.0
Westminster	7,277	8,213	936	12.9

Source: UMass Donahue Institute.
Note: These figures are for entire municipality. Most towns are not fully within a given watershed. Several towns are split between two watersheds; they are placed in this table based on majority of area in a given watershed and/or administrative practice of DWSP.

2.5 Water Quality

DWSP conducts extensive water quality monitoring of the surface waters in the water supply watersheds. Routine water quality monitoring provides data that are used to assess current water quality conditions. Routine monitoring also allows staff to establish ranges of values for parameters considered normal or typical. Review of the routine data results allows screening for excursions from normal ranges, alerting staff to potential contamination events. Data collected in routine sampling over several years are used to assess watershed trends. Shorter term studies may be conducted to evaluate specific issues. Although it is often difficult to measure and/or link discrete water quality impacts to specific management actions, DWSP's goal is to base all management decisions on potential water quality impacts.

The DCR/MWRA water supply system consistently meets all regulatory standards established by the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (MassDEP).

In addition to all the tributary and reservoir sampling, source water quality at the intakes is monitored for compliance with drinking water regulations (310 CMR 22.00). DWSP works closely with MWRA to comply with regulatory requirements for source water. MWRA conducts hundreds of thousands of additional tests on samples collected from the Carroll Water Treatment Plant, the Brutsch Water Treatment Facility, and throughout the system to ensure compliance with standards for the distribution system. MWRA's comprehensive testing is summarized in their Annual Consumer Confidence Report. All MWRA water test results can be found on the MWRA water testing website. The DCR/MWRA water supply system consistently meets all regulatory standards established by the U.S. Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (MassDEP).

2.5.1 Watershed and Reservoir Monitoring

Quabbin Reservoir/Ware River

Since 2005, the water quality monitoring program has included up to 14 sampling stations in the Quabbin Reservoir watershed and up to 10 sampling stations in the Ware River watershed. As of 2017, 24 surface water monitoring stations are routinely monitored, including all major tributary inflows to Quabbin Reservoir, some minor tributaries flowing to the Quabbin Reservoir or Ware River, and selected locations within the Quabbin Reservoir. Of the 24 monitoring stations, 11 stations are located within the Quabbin Reservoir watershed, and 10 tributary stations are in the Ware River watershed to characterize this supplemental source water supply. Each watershed is divided into sanitary districts, and water quality of each watershed is monitored with "core" sites and "Environmental Quality Assessment" (EQA) sites. Core sites are long-term monitoring stations, while EQA sites support ongoing evaluations of threats to water quality by sanitary district. The remaining three sampling stations are located within the reservoir and are monitored monthly during the months of April through December, weather-permitting, with samples collected from several depths at each location.

Each tributary station is sampled biweekly, with sampling runs alternating between the Quabbin Reservoir watershed and the Ware River watershed. Samples are collected by hand early in the work week (typically Tuesday) regardless of weather conditions. Tributary stream temperature, dissolved oxygen, pH, and specific conductance levels are determined in the field using a Eureka multiprobe meter. Samples from core sites are collected biweekly for turbidity, bacteria, and calcium analyses, while samples for nutrient analysis are collected quarterly. UV_{254} absorbance samples from core sites are analyzed quarterly in the Quabbin watershed and biweekly in the Ware River watershed. Samples from EQA Sites are collected biweekly for alkalinity, turbidity, bacteria, nutrients, calcium, and UV_{254}. Bacteria include total coliform bacteria and *Escherichia coli* (*E. coli*) bacteria, which are analyzed at the MWRA Quabbin laboratory. Nutrients include nitrate, total Kjeldahl nitrogen, and total phosphorus. Calcium monitoring was begun in 2010 in response to the potential threat of zebra mussels in the reservoir. Calcium is a key indicator for the viability of this invasive species; levels remain well below the threshold for zebra mussel colonization.

Wachusett Reservoir

An extensive monitoring system remains in place for tributary and reservoir sampling in the Wachusett watershed. Sampling plans are evaluated and modified annually. Environmental Quality (EQ) staff collect routine water quality samples from 18 stations on 17 tributaries and from Shaft 1. There are four reservoir nutrient and phytoplankton sampling stations. In addition, seven groundwater wells are also monitored for depth and water quality.

Tributary monitoring stations are visited two or three times per month, as long as there is adequate flow. Field parameters (temperature, specific conductance, pH, dissolved oxygen) are measured in-situ during all monitoring visits. Samples are collected for bacteria and turbidity twice per month. Bacteria samples are analyzed at the MWRA Southborough Laboratory and turbidity is measured in the field with a portable turbidimeter or at the DWSP Wachusett Laboratory. Nutrient, alkalinity, UV_{254}, chloride and TSS samples are collected monthly from the ten primary tributary stations and Shaft 1 (when the Quabbin transfer is on), and analyzed at the MWRA Deer Island lab. Additional tributary locations are monitored as needed to support special studies or potential enforcement actions.

Reservoir nutrient sampling is conducted in May at the onset of stratification, July in the middle of the stratification, near the end of the stratification period in October, and following turnover in early December. These samples are collected at three routine locations: Basin North (BN3417), Basin South (BS3412), and Thomas Basin (TB3427) and analyzed at the MWRA Deer Island Laboratory. Routine monitoring for phytoplankton occurs at either Basin North or Cosgrove Intake and follows a seasonal schedule with samples collected every other week from October through April and at least once per week from May through September. EQ Aquatic Biology staff perform all phytoplankton analyses. Bacterial transect samples (*E. coli*) are collected routinely (at least monthly) during ice-free conditions at 23 fixed surface locations on the reservoir. Reservoir bacteria samples are analyzed at the MWRA Southborough Laboratory.

Sudbury and Foss Reservoirs
There is currently no regular water sampling by DWSP in the Sudbury watershed; MWRA does perform annual water quality sampling and analysis as part of its Emergency Reservoirs Water Quality program. Nutrient data from numerous previous monitoring efforts of Sudbury Reservoir (going back as far as 2002) consistently show elevated levels of nutrients as one would expect for this urbanized water body. In addition to loading of phosphorus, nitrogen, and bacteria from the developed watershed, the data indicate that there are two additional major factors influencing water quality in this system: 1) the development of hypolimnetic anoxia that recurs each summer (leading to "internal" loading of nutrients); and 2) the periodic transfer of colder and higher quality water from Wachusett through the open channel into Sudbury. DWSP has documented that the rare transfer from Wachusett in September can destabilize the thermal stratification structure in Sudbury and hasten the occurrence of turnover thereby interrupting the influence of hypolimnetic anoxia.

2.5.2 Monitoring for Compliance with Federal and State Drinking Water Standards

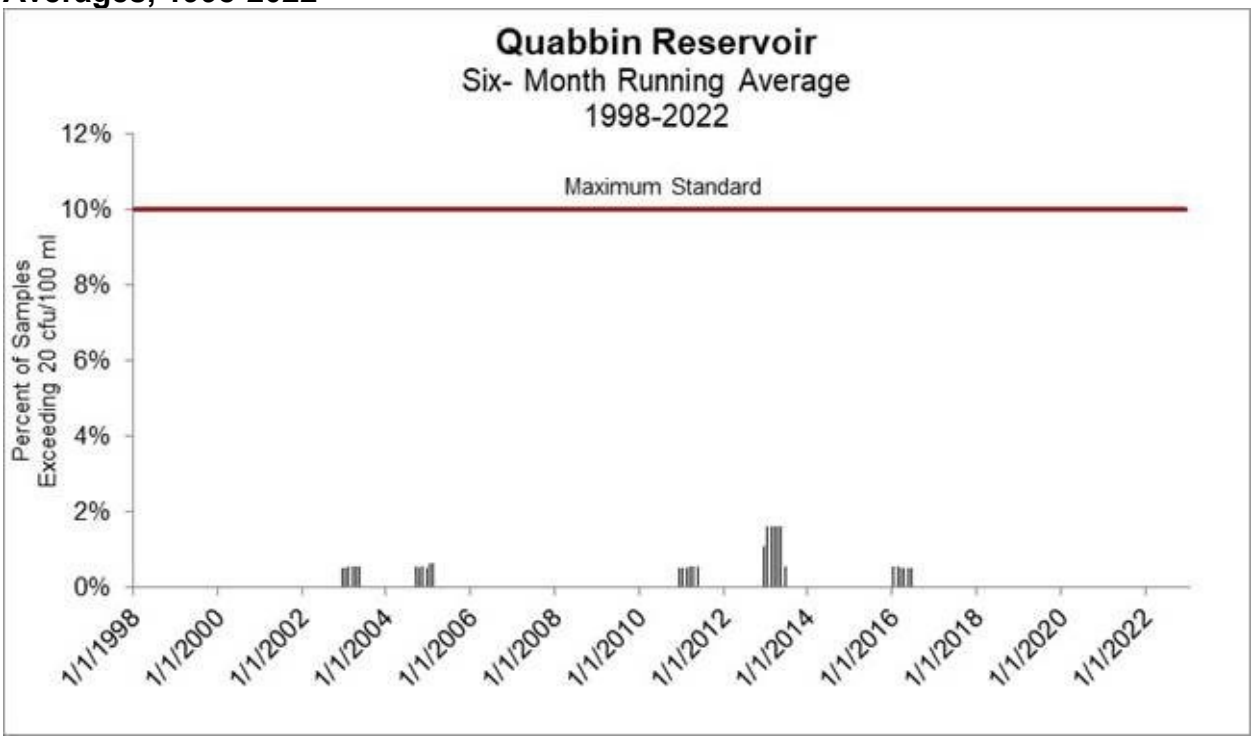
The [federal fecal coliform] standard has never been exceeded at Quabbin Reservoir and the last time for Wachusett Reservoir was in the spring of 1999.

The Federal Surface Water Treatment Rule (SWTR) requires that fecal coliform concentrations of raw water just prior to disinfection for an unfiltered surface water supply be no greater than 20 colonies per 100 ml in ninety percent of the samples in any six-month period. Fecal coliform testing at the Wachusett Cosgrove Intake and the Winsor Intake began in 1991. The Winsor Intake transmits water to the Winsor Power Station, the Swift River and the McLaughlin Fish Hatchery; water leaving the Winsor Power Station goes into Chicopee Valley Aqueduct (CVA).

The initial testing in 1991 showed that Wachusett exceeded this standard at certain times of the year. Quabbin was able to meet the standard but also showed seasonal increases in fecal coliform concentrations. Staff investigations revealed that the source of the bacteria was seasonal bird populations. The development and implementation of bird harassment activities resulted in a dramatic drop in both roosting gull populations and fecal coliform concentrations.

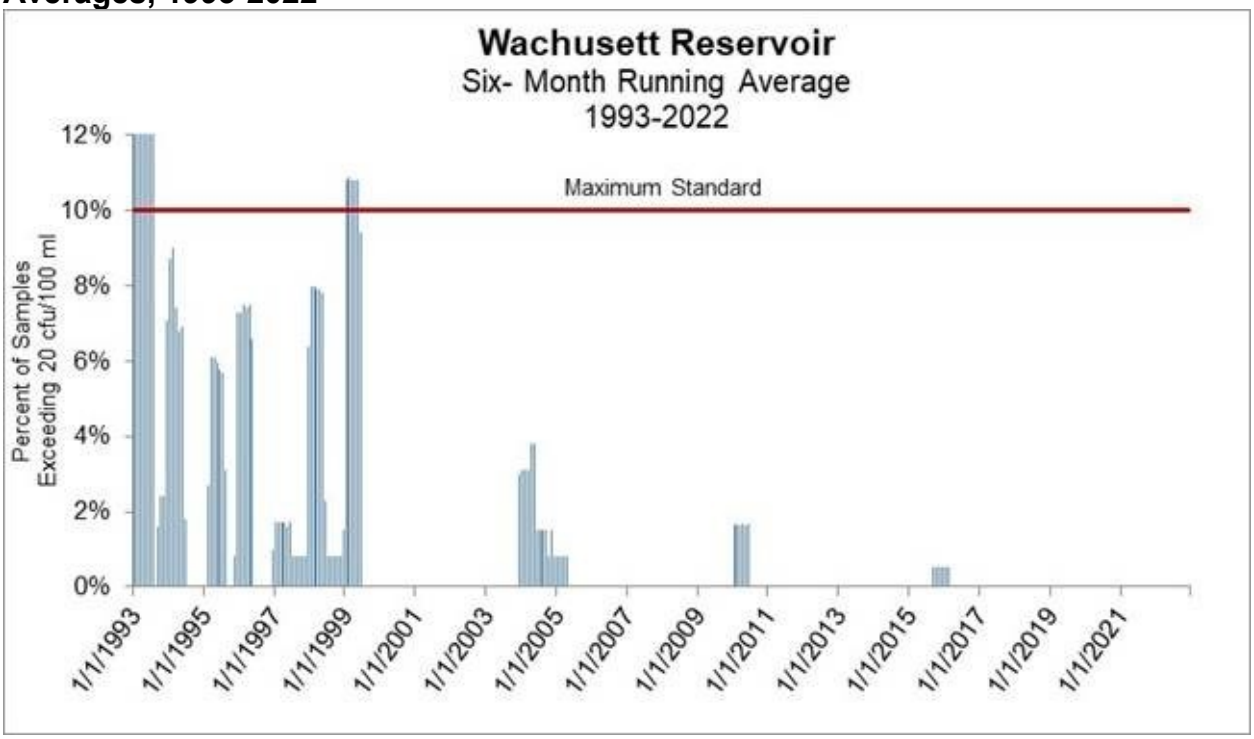
The standard has never been exceeded at Quabbin Reservoir (Figure 2-6) and the last time for Wachusett Reservoir was in the spring of 1999 (Figure 2-7). A sample above 20 cfu/100 ml is an unusual occurrence that is usually due to extreme weather conditions which may also prevent active gull harassment by DWSP crews.

Figure 2-6: Quabbin Reservoir Fecal Coliform Bacteria Concentration Six Month Averages, 1998-2022



Source: MWRA, 2023

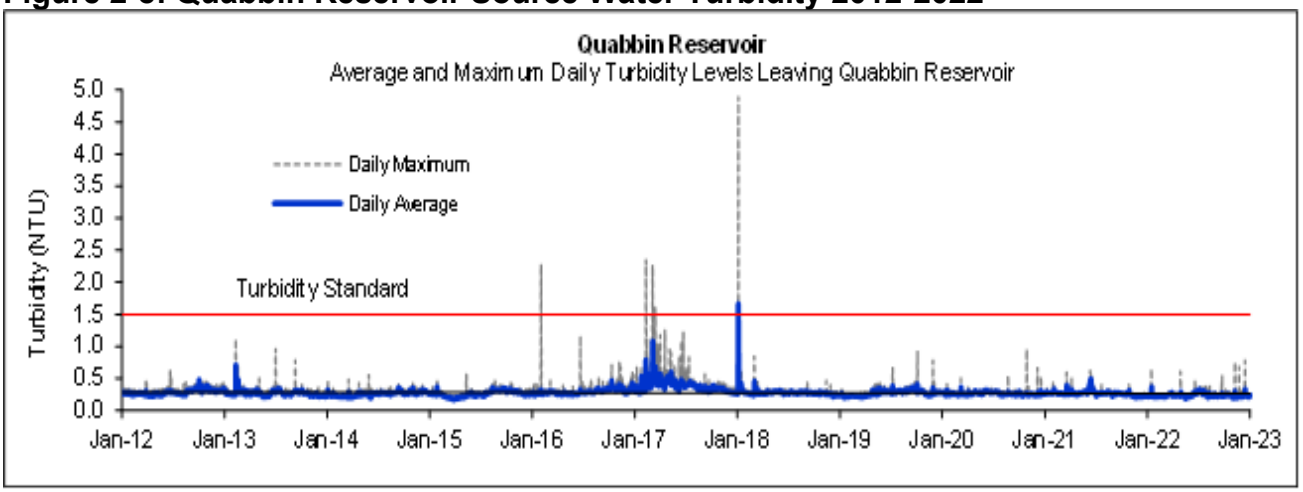
Figure 2-7: Wachusett Reservoir Fecal Coliform Bacteria Concentration Six Month Averages, 1993-2022



Source: MWRA

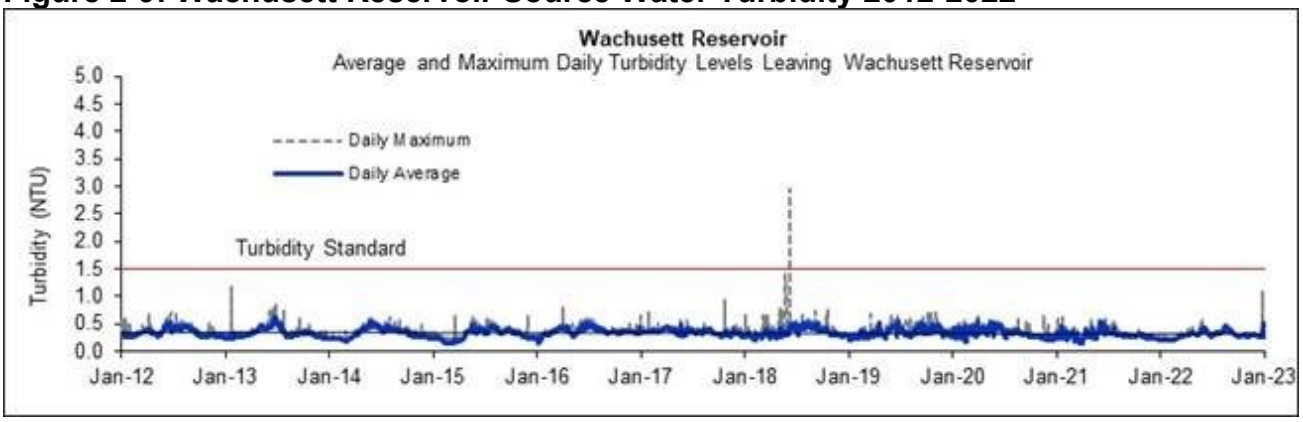
There are two standards for turbidity: all water must be below five NTU (Nephelometric Turbidity Units), and water only can be above one NTU if it does not interfere with effective disinfection. Figure 2-8 depicts daily maximum and average turbidity levels for 2008-2017 at Quabbin Reservoir, where turbidity levels averaged well below 0.5 NTU. Turbidity levels of one or above are reported to MassDEP immediately, while monitoring and operational adjustments are continued to ensure treatment effectiveness. Large turbidity spikes are infrequent and short-term; they can be attributed to severe weather events or operational impacts. None of the turbidity spikes interfered with disinfection and no violations of drinking water standards occurred. Wachusett reservoir turbidity, measured at the Carroll Treatment Plant, generally is below 0.5 NTU. Turbidity values for 2012 through 2022 are shown in Figure 2-9.

Figure 2-8: Quabbin Reservoir Source Water Turbidity 2012-2022



Source: MWRA, 2023

Figure 2-9: Wachusett Reservoir Source Water Turbidity 2012-2022



Source: MWRA, 2023

2.6 Hydrology

2.6.1 Quabbin Reservoir

Quabbin Reservoir was created by damming portions of the Swift River (Figure 2-10). There are four discharge locations from the reservoir: the release through the Winsor Intake to the Swift River, the discharge through the Chicopee Valley Aqueduct (CVA) to provide water to three western MA communities, the discharge through the Quabbin Aqueduct to Wachusett Reservoir and, ultimately, the communities in metropolitan Boston and MetroWest areas, and, if needed, the Quabbin Spillway. Quabbin reservoir is fed by streams in its watershed as well as transfers from the Ware River. The Quabbin spillway discharges to the Swift River.

2.6.2 Ware River

Waters from the Ware River can be diverted to the system (Figure 2-11). Water is collected at Ware River Intake and transported to Quabbin Reservoir via the Quabbin Aqueduct. Although water could also be diverted from Ware River to Wachusett Reservoir, it is DWSP and MWRA operating policy, stated in a MWRA Standard Operating Procedure (SOP), to divert only to Quabbin.

2.6.3 Wachusett Reservoir

More than fifty percent of annual inflow into Wachusett Reservoir is from the Quabbin Reservoir; an additional thirty percent is provided by the Stillwater and Quinapoxet Rivers (Figure 2-12). Quabbin transfers, Quinapoxet River and Stillwater River all enter the reservoir through the Thomas Basin and pass through a constriction under the Route 12 Bridge. Water in the Wachusett Reservoir is assumed to have an approximate six-month residence time, although during stratified conditions cold water transfers from the Quabbin Reservoir can pass through the reservoir in as little as three weeks. This phenomenon is called the Quabbin interflow and has been extensively studied by DWSP and MWRA staff. The Wachusett spillway discharges to the Nashua River.

2.6.4 Sudbury and Foss Reservoirs

The major hydrologic inputs to the Sudbury and Foss reservoirs are the natural watershed drainage and the flow from the Wachusett Aqueduct and Open Channel (Figure 2-13). Water flows from the Sudbury to the Foss. Overflow from the Foss will enter into the Stearns Reservoir and eventually flow into the Sudbury River.

DWSP and MWRA cooperate with U.S. Geological Survey to maintain continuous, real time recording gages at a total of ten sites. Data from the sites are used to monitor hydrologic inputs and mandated releases. A summary of information about the gages is presented in Table 2-5. Continuous, real-time data for each station are available at the USGS web site,

Table 2-5: USGS Stream Gages

Station Number	Location	Utilization	Parameters
01170500	Connecticut River at Montague City	Required for decisions on releases from Quabbin to the Swift River	Stage-Discharge
01174500	East Branch Swift River near Hardwick	Streamflow monitoring	Stage-only
01174565	West Branch Swift River near Shutesbury	Streamflow monitoring	Stage-Discharge
01175500	Swift River at West Ware	Monitors Quabbin Reservoir release to Swift River and downstream conditions	Stage-Discharge
01173000	Ware River at Intake Works near Barre	Required for decisions on Ware River Transfer	Stage-Discharge, Temperature
01095220	Stillwater River at Sterling MA	Streamflow monitoring	Index-Velocity, Temperature, Conductivity, Precipitation
01095375	Quinapoxet River near Holden, MA	Streamflow monitoring	Stage-Discharge, Temperature, Conductivity, Precipitation
01095434	Gates Brook near West Boylston	Streamflow monitoring	Stage-Discharge, Temperature, Conductivity
01095503	Nashua River at Water Street at Clinton	Monitors Wachusett Reservoir release to Nashua River and downstream conditions	Stage-Discharge, Temperature
01098530	Sudbury River at Saxonville, MA	Monitors Sudbury Reservoir release to Sudbury River	Stage-Discharge

Figure 2-10: Quabbin Reservoir Watershed Hydrography

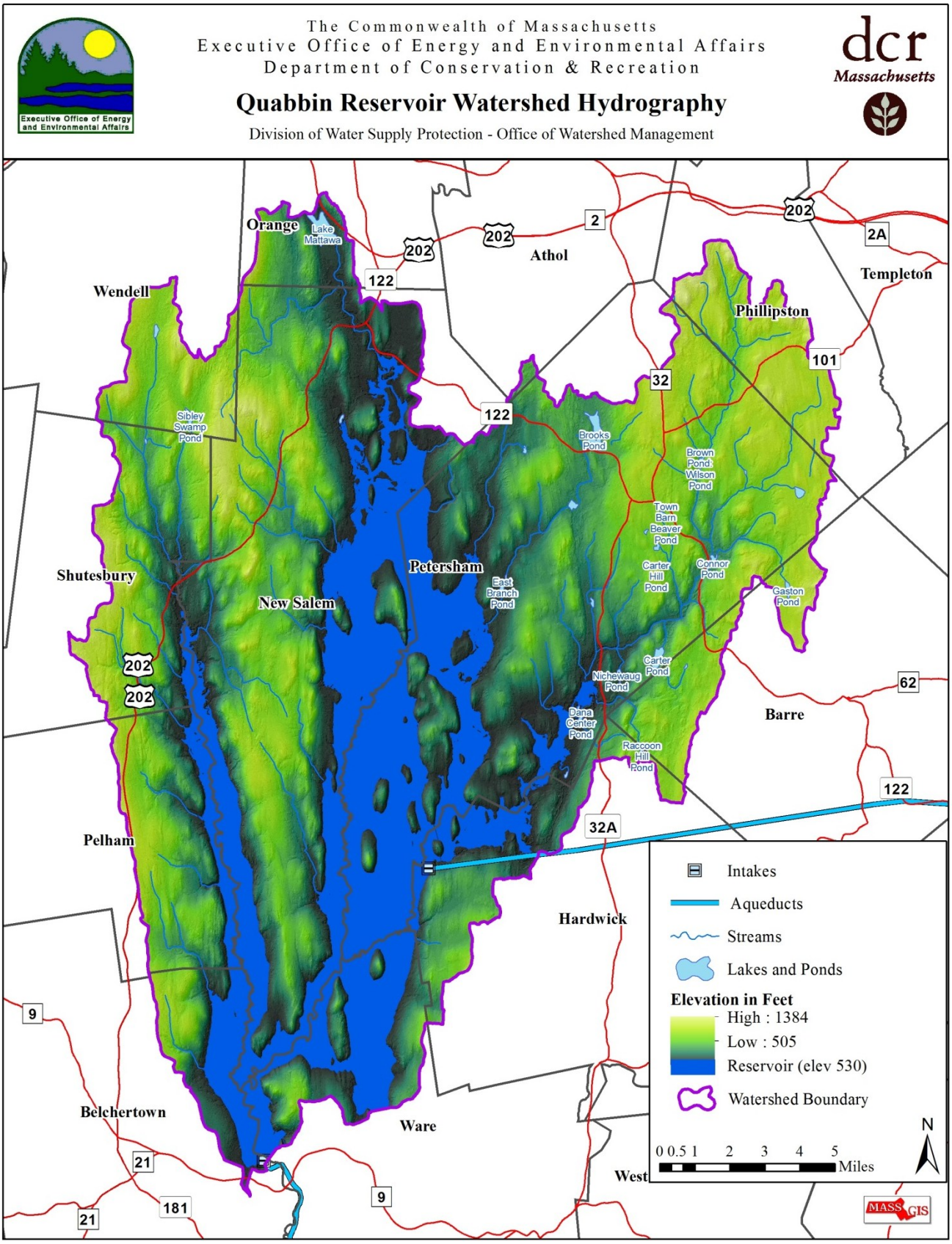


Figure 2-11: Ware River Watershed Hydrography

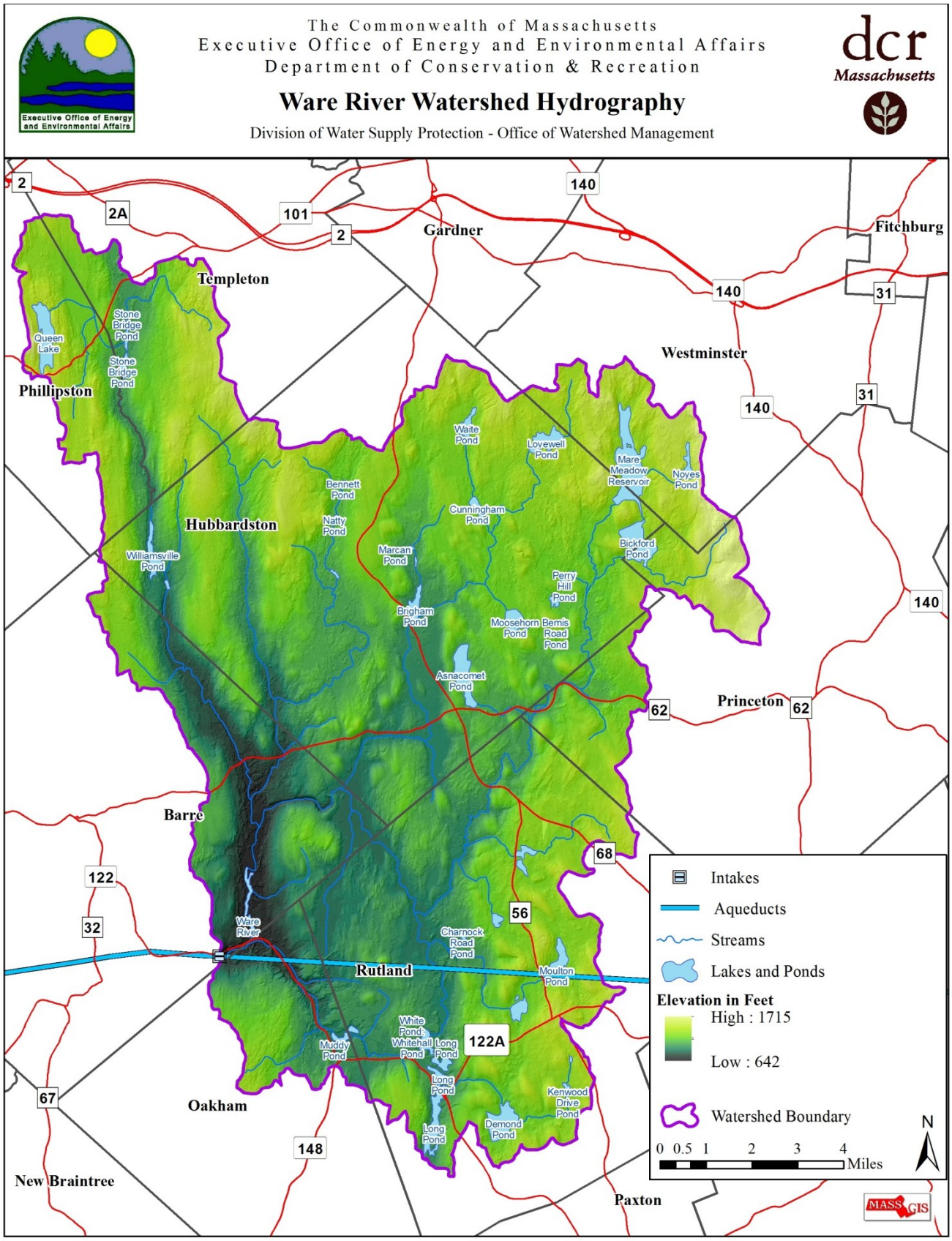


Figure 2-12: Wachusett Reservoir Watershed Hydrography

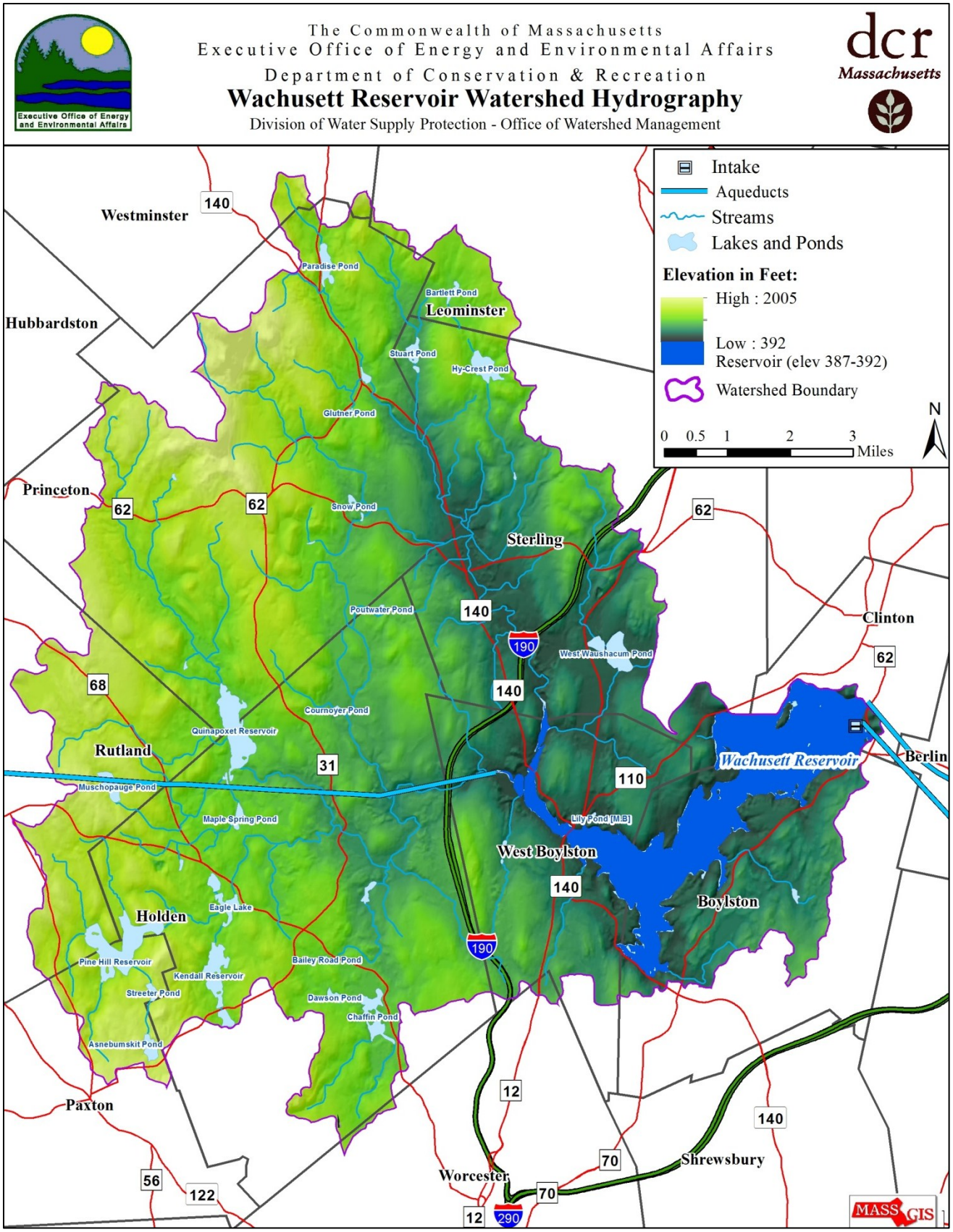
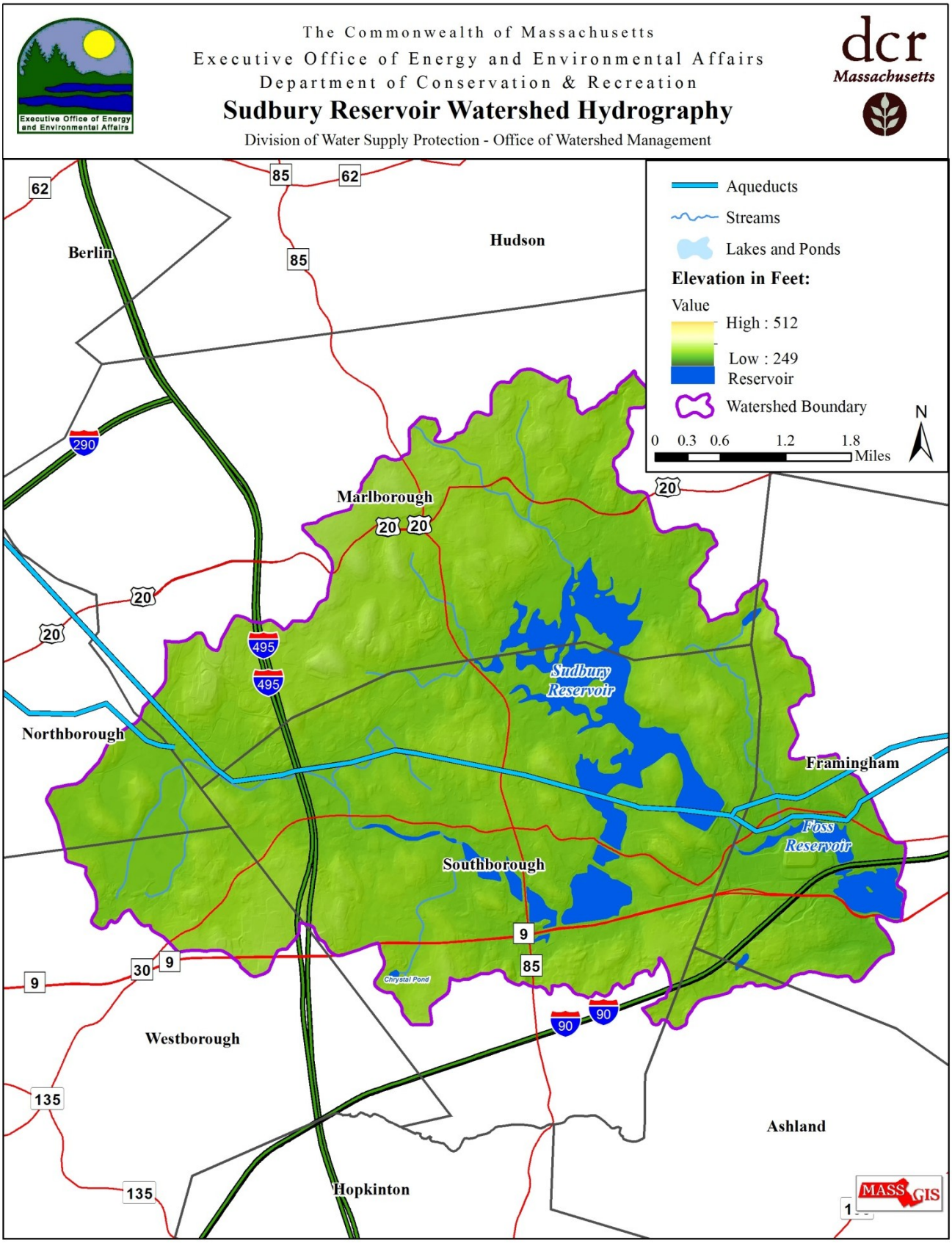


Figure 2-13: Sudbury Reservoir Watershed Hydrography



2.7 System Operation and Safe Yield

DWSP partners with the MWRA to deliver water to a total of 3.1 million people and 5,500 industrial users in 53 communities. There are two distribution systems supplied by the DWSP system. The Chicopee Valley Aqueduct is fed by the Quabbin Reservoir and supplies three communities in western Massachusetts. Quabbin water is also transferred east, through the Quabbin Aqueduct to Wachusett Reservoir, where it enters the Cosgrove Intake to travel to communities in the east. MWRA completed a new pump station at the terminus of the Wachusett Aqueduct to provide redundancy for water transport to the treatment plant via the intake at the Wachusett Dam and Wachusett Aqueduct. MWRA provides ozonation and Ultraviolet light (UV) for primary disinfection, chloramination for residual disinfection, corrosion control, and fluoridation at the John J. Carroll Water Treatment Plant in Marlborough prior to delivery to municipalities in the greater Boston and MetroWest regions. MWRA provides UV and chlorination for disinfection at the William A. Brutsch Treatment Facility serving the three Chicopee valley Aqueduct communities south of Quabbin. The long-term average yields from each source are summarized in Table 2-6.

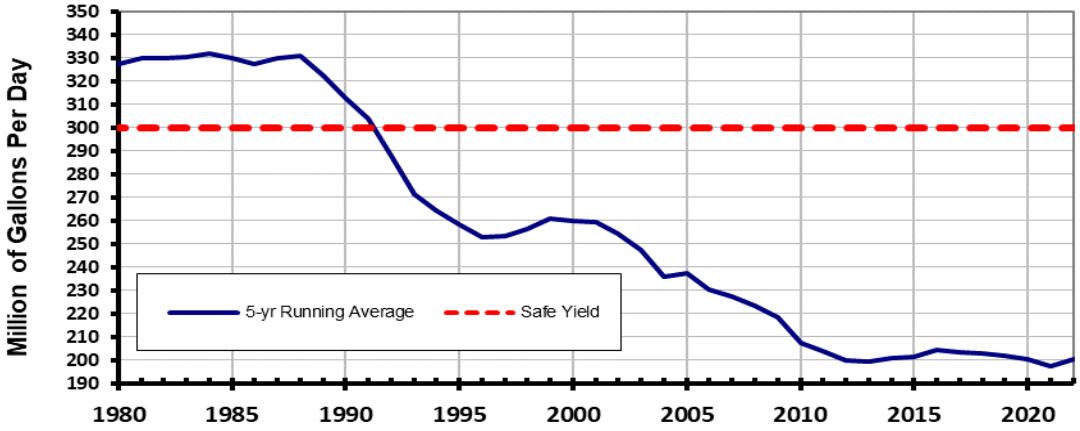
Table 2-6: Long-Term Average Yields from Supply Sources

System	Source	Watershed Land Area (sq. mi.)	Watershed Yield (mgd)
Active	Quabbin Reservoir	149	195
Active	Ware River	97	47
Active	Wachusett Reservoir	111	127
Active	Total	401	369
Emergency	Sudbury Reservoir	21	18*
Emergency	Foss Reservoir	5	

Source: DWSP and MWRA. * Off-line emergency reservoir; requires a boil order if used. Watershed Yield is for Sudbury and Foss Reservoirs combined.

Due to the large storage volumes, 300 million gallons per day (mgd) can safely be supplied constantly by this system (referred to as the “safe yield”), even with release requirements and operational constraints and during a drought as severe as the 1960s multi-year drought. Withdrawals for water supply peaked in 1980 at 340 mgd, but have come down substantially due to MWRA’s demand management programs (Figure 2-14).

Figure 2-14: DCR/MWRA Water Supply System Water Use, 1980-2022



The average system withdrawal from 2018 to 2022 was 200.4 mgd, with a low of 194.66 in 2021 and a high of 211.62 mgd in 2022. The high figure was due to a drought and several communities temporarily using additional water while responding to PFAS contamination (see Section 3.2.2) in their local sources. Monthly water use data is available on the MWRA's website.

It is worth noting that since MWRA was created, MWRA has added demand from eight additional communities and the McLaughlin Fish Hatchery, as well as the added demand from the substantial growth in population and employment within the original service area. The five-year average demand would have been almost nine mgd lower, at 191.4 mgd, without these added communities and hatchery demands. This further demonstrates the substantial improvements in water use efficiency within the MWRA service area, which have improved system reliability and allowed MWRA to provide service to additional communities in need of that reliable supply.

In 2022, the MWRA Advisory Board and MWRA Board of Directors, recognizing the opportunity to relieve environmental stress of some river basins and the substantial burden that PFAS contamination was placing on some communities near the MWRA service area, voted to temporarily waive the entrance fee for new communities joining the MWRA system. The policy change included a 20 mgd limit of the total amount of new use and a five-year time window.

The objective [of DWSP and MWRA operating policies] is to optimize delivery of high-quality drinking water while ensuring adequate volume in storage to respond to fluctuations in precipitation and demand, meeting downstream minimum flow release requirements, and preventing violations of minimum pool reservoir stage limitations.

DWSP and MWRA staff coordinate to make systems operations decisions. Operating policies for the water supply system cover several topics, including watershed yield, public safety, and the generation of hydropower. The objective is to optimize delivery of high-quality drinking water while ensuring adequate volume in storage to respond to fluctuations in precipitation and demand, meeting downstream minimum flow

release requirements, and preventing violations of minimum pool reservoir stage limitations.
Two interagency groups have been established to facilitate this work: the Reservoir Operations Group (Res Ops) and the Water Quality Sampling and Analysis Team (WQSAT). Examples of the issues dealt with by these groups include establishing a normal range of reservoir elevations for Wachusett Reservoir, decision-making for initiating Quabbin transfers, developing reservoir treatment thresholds for taste and odor organisms, coordinating security and emergency-response capabilities, developing watershed water quality sampling programs, managing flood control, and planning for major infrastructure improvements. Reservoir operations coordination also includes the Army Corps of Engineers (ACOE), MA Fish & Wildlife (DFW), and MassDEP.

2.7.1 Emergency System

The Sudbury and Foss Reservoirs remain the only emergency drinking water source reservoirs for over 2 million residents of Eastern Massachusetts. There are three conditions under which these reservoirs would be used as an emergency source for the greater Boston and MetroWest area:

1. Wachusett Reservoir is declared non-potable.
2. The inability to convey water from the Wachusett Reservoir to the MWRA system.
3. Extended, extreme drought.

The combined resources of Sudbury and Foss Reservoirs could provide an estimated long-term safe yield of 18.0 mgd and could provide a rate of 200 mgd for a maximum of 30 days before virtual depletion of these sources. Water quality will be an issue should any of the emergency scenarios occur. In the event of a serious drought, low water levels in Sudbury would be anticipated to result in higher temperatures, greater algae blooms, and taste and odor problems. Water from Sudbury and Foss Reservoirs was last used in May 2010 when a coupling on a 10-foot diameter pipe in Weston failed, and the Chestnut Hill Emergency Pump Station was needed to meet peak demands; a boil order was required by MassDEP.

The potential for the Sudbury system to be utilized has decreased since the completion of the Hultman Aqueduct overhaul and completion of the valve chambers that connect the aqueduct to the newer MetroWest Tunnel. MWRA now has the ability to divert water from the tunnel to the Aqueduct should circumstances warrant. Wachusett Reservoir water flows to the Carroll Water Treatment Plant primarily via the Cosgrove Tunnel. The likelihood of aqueduct failure and vulnerability from Wachusett Reservoir contamination have been reduced because the upgraded Wachusett Aqueduct and new Aqueduct pump station can also deliver water for treatment and distribution.

2.7.2 Drought Management

The amount of water a system can supply can be enhanced if a drought management plan is used to curtail demand during extended dry conditions. MWRA has a MassDEP-approved Drought Management Plan that was developed in 1989. The objective of the

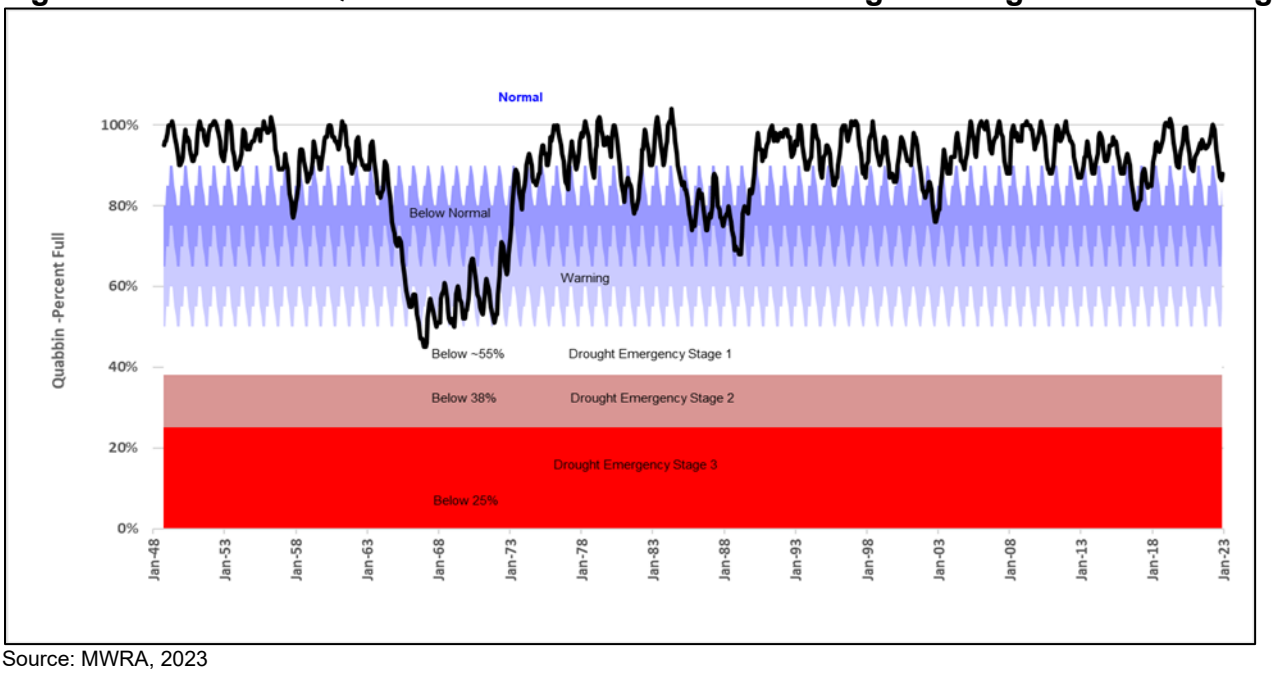
plan is to conserve water through implementing demand reduction measures. Due to the size of Quabbin and Wachusett Reservoirs, their volume drops slowly during a drought and then refills slowly after a drought. The Drought Management Plan is designed to ramp up slowly and would be expected to remain in effect after other systems have recovered. MWRA is a member of the state Drought Management Task Force, which is supported by staff from the Office of Water Resources within the Division of Water Supply Protection.

Drought response actions are triggered by seasonal levels of Quabbin Reservoir – the saw tooth pattern in Figure 2-15 shows Quabbin Reservoir levels in relation to the Drought Management Plan Operating Ranges.

Table 2-7 describes the stages of the Drought Management Plan, giving triggering levels, reduction targets and the broad actions that need to be taken to achieve those targets. Given the expected gradual response of the DCR/MWRA system to drought, it is anticipated that response actions would be fine-tuned as the system moved toward Drought Warning. At current low demand levels, the DCR/MWRA System would be able to withstand the drought of record without triggering restrictions.

Internal MWRA modeling has shown that the Drought Management Plan may increase Safe Yield (the amount of water that can reliably be supplied on a continuous basis during a critical drought) by 8 to 10 mgd. If ever necessary, DWSP will work closely with MWRA in implementing the Drought Management Plan. MWRA anticipates reviewing and updating the Drought Management Plan by the spring of 2025 in response to recent changes in the Water Management Act regulations.

Figure 2-15: Historic Quabbin Reservoir Levels and Drought Management Plan Stages



Source: MWRA, 2023

Quabbin Shaft 12 Intake at three different drought stages (from top left):
10/13/1966 – elevation 496 feet;
9/5/2016 – elevation 521 feet;
9/20/2022 – elevation 524.57 feet.

Table 2-7: Drought Management Plan Stages

Stage	Trigger Range (Quabbin percent Full)	Average Trigger Range (Quabbin percent Full)	Target Water Use Reduction	Response Measures
Normal Operation	80-100	90	0	
Below Normal	65-90	78	Previous year's system use	Advise Drought Management Task Force, local officials and media. Distribute materials. Repair leaks. Rehabilitate meters.
Drought Warning	50-75	63	5 percent	Identify drought coordinator. Restrict outdoor and municipal use. Request voluntary cuts from large and visible users (car washes, restaurants, etc.). Activate Water Bank. Enforcement: fines.
Drought Emergency Stage 1	38-60	49	10 percent	Ban non-essential outdoor, municipal water use. Request more larger user cutbacks. Distribute new materials. Continue coordination of local actions. Consider rate structure changes.
Drought Emergency Stage 2	25-38	32	15 percent	Increase meter reading frequency. Establish mandatory rationing and enforcement. Distribute informational materials and feedback on savings. Modify rate structures. Moratorium on new connections.
Drought Emergency Stage 3	Below 25	Below 25	30 percent	Revise rationing for 30 percent reduction. Continue distribution of materials and organization of local response. Implement emergency sources or interconnections.

Source: MWRA

2.8 Regulatory Oversight

DWSP relies on its own specific watershed protection regulations (313 CMR 11.00) as well as a wide array of federal and state regulations to promote private land owners' responsibility for environmental and public health protection (Table 2-8). DWSP works with the appropriate local, state, and/or federal government agencies to enforce these laws.

DWSP utilizes federal, state and local regulations in cooperation with the corresponding authorities to require actions by responsible parties when conditions that pollute watershed resources are found.

The Watershed Protection Act (see Chapter 4.8) provides DWSP regulatory oversight on critical buffer areas around water resources in the Quabbin Reservoir, Ware River, and Wachusett Reservoir watersheds. Public access (see Chapter 4.5) and general water quality protection rules are set forth in Section 11.09 of these DWSP regulations, which states that no person shall engage in any activity which could degrade the quality of the Waters of the Watershed System. This latter part of the regulation is very broad and, therefore, difficult to use as a basis for enforcement when pollution is documented. DWSP, however, also utilizes federal, state and local regulations in cooperation with the corresponding authorities to require actions by responsible parties when conditions that pollute watershed resources are found.

DWSP staff has worked with the US EPA, the Massachusetts DEP, and local boards and commissions to correct situations where pollution has entered watershed tributaries. Results have included both environmental remediation and fines.

Table 2-8: Environmental Regulations Employed in Watershed Protection Activities

Regulation	Authority	Issue	Relevance
313 CMR 11.01-08	DWSP	Watershed Protection	Provisions of the Watershed Protection Act; establishes protective buffers around resource areas.
313 CMR 11.09	DWSP	Watershed Protection	Prohibits any action which could degrade the Waters of the Watershed System or interfere with their use as a source of water supply.
310 CMR 15.00 "Title 5"	DEP *Administered locally by board of health*	Subsurface Sewage Disposal	Regulates siting, design, and inspection of on-site systems.
310 CMR 10.00	DEP *Administered locally by conservation commission*	Wetlands	Restricts alteration and/or filling of wetlands; requires review of all projects within 100 feet of wetlands or within floodplains.
310 CMR 13.00	DEP *Administered locally by conservation commission*	Rivers Protection Act	Establishes protected wetland resource area – riverfront.
310 CMR 22.00	DEP	MA Drinking Water Regulations	State-wide regulations for all drinking water supplies.
40 CFR Parts 9, 122, 123 and 124	EPA *Administered by DEP*	Stormwater Phase II	Replaces/augments DEP Stormwater Management Policy; part of NPDES program.
310 CMR 40.0000 "21E"	DEP	Hazardous Waste Site Cleanup (Mass Contingency Plan)	Establishes a process for prioritization, investigation, and cleanup of hazardous materials releases.
310 CMR 40.0000	DEP	Underground Storage Tanks	Regulates design and construction of new or replacement tanks.
527 CMR 4.00 & 9.00	DFS, local fire department	Underground Storage Tanks	Regulates removal, installation and maintenance of USTs.
304 CMR 11.00	DCR Bureau of Forestry	Forest Cutting Practices Act	Regulates how forests are managed.
M.G.L. c. 21G	DEP	Water Management Act	Regulates the quantity of water withdrawn from both surface water supplies (MWRA responsibility).
301 CMR 11.00 "MEPA"	EEA	Massachusetts Environmental Policy Act	Requires comprehensive environmental assessment and public review of major projects.
333 CMR 11.00	DAR	Pesticide Regulations	Restricts type and location of pesticides; requires filing of 5-year Vegetative Management Plans and annual Yearly Operating Plans.

3 Watershed Protection Assessment

DWSP and MWRA use a multi-barrier approach to protect the water supply system. The multi-barrier approach is defined as an integrated system of procedures, processes, and tools that collectively prevent or reduce the contamination of drinking water from source to tap in order to reduce risks to public health. The multi-barrier approach relies on integrated programs that prevent contamination of drinking water at all points in the system, from source to tap. Source protection is guided by the DWSP watershed protection program. Water treatment is provided at the John J. Carroll Water Treatment Plant at Walnut Hill in Marlborough and the William A. Brutsch Water Treatment Facility in Ware. Distribution pipeline maintenance and improvement program ensures that high-quality is maintained to the tap.

As an unfiltered water supply, the DCR/MWRA system must comply with federal drinking water regulations. The Surface Water Treatment Rule (SWTR, June 1989) essentially requires filtration of all surface water supplies, but allows filtration waivers if specific criteria are met. One of the criteria required for unfiltered public water systems is an effective watershed control program that can preserve high quality source water through control of pollutants in the watershed.

DWSP and its predecessor agencies have historically understood the importance of watershed protection. Watershed protection programs were initially described and managed through a variety of programs and documents, including Sanitary Surveys and Land Management Plans. Development of comprehensive Watershed Protection Plans began in 1990 in response to requirements of the SWTR. The history of these plans is described Section 3.1; the organization of the plan has evolved over time, but the general approach remains similar and is described in this chapter.

The *FY24-FY28 Watershed Protection Plan* provides a systematic approach to evaluate potential water quality threats and to develop and implement programs that eliminate or minimize these threats. Priorities for watershed control programs change as water quality threats are contained and new issues emerge. The process used to develop Watershed Protection Plans provides a structured methodology to assess changes in watershed threats, develop programs to address the threats, and review staff assignments to ensure that staff priorities align with current watershed issues. This *FY24-FY28 Watershed Protection Plan* outlines major goals and programs for Fiscal Year 2024 through 2028 (July 1, 2023, through June 30, 2028).

The FY24-FY28 Watershed Protection Plan provides a systematic approach to evaluate potential water quality threats and to develop and implement programs that eliminate or minimize these threats.

3.1 History

The Boston area drinking water supply, like the city itself, has a long history. Cisterns were originally used in the 17th century. The need for water, which came from

increasingly further distances, grew with Boston's population. The 18th century tapping of Jamaica Pond, using log pipes with three-to-four-inch internal diameters over a distance of about five miles, was one of the first instances in the country of a community reaching out to another town for drinking water. During the 19th century, drinking water came mostly from Lake Cochituate in Natick; some communities were also served by the Mystic Lakes. Officials determined that these sources of supply would prove inadequate, so in 1878 a system of seven reservoirs was constructed to supplement the Cochituate system by holding back the Sudbury River.

The dawn of the 20th century saw limited yield, urbanization of the watersheds, and unsatisfactory water quality, which led to an 1895 study by the state health board that recommended the development of a reservoir along the South Branch of the Nashua River. The Wachusett Reservoir was the world's largest constructed reservoir when it was completed in 1908, however in a just a few decades it too was insufficient for the growing needs of eastern Massachusetts.

Ultimately, the Quabbin Reservoir was created in the 1930s, using the Winsor dam to impound the Swift River and flood an area formerly occupied by the four Western Massachusetts towns of Dana, Enfield, Prescott, and Greenwich. At the same time, the Ware River was also identified as a drinking water source; diversions of water from the river are conveyed into the Quabbin Reservoir through the Quabbin tunnel from October through June when flows in the river are sufficient and water is needed.

The development of the DCR/MWRA watershed system has been shaped by feats of engineering and multiple laws. The quantity of water available from these three watersheds, combined with water conservation measures implemented over the past twenty years, is a sufficient quantity for the foreseeable future (see Section 2). The following sub-sections provide a description of the most recent legal requirements and planning efforts that have had a role in the management of this renowned drinking water supply.

3.1.1 Creation of the MWRA

The DCR/MWRA water system was established by Chapter 372 of the Acts of 1984. The Act reassigned, as of June 30, 1985, various responsibilities of the former Metropolitan District Commission (MDC) Water Division to the MWRA and the MDC Division of Watershed Management (now the DCR/DWSP; see Section 3.1.8). A

Memorandum of Understanding (MOU) was developed between the two agencies on April 9, 1986, that documented the responsibilities between the agencies concerning "the division of personnel, property, and responsibilities for maintenance, operations, policy making and long-range planning pursuant to Chapter 372 of the Acts of 1984." The MOU was updated in April 2004 after DCR's creation (see Section 5.2).

3.1.2 SDWAA and SWTR

The DCR/MWRA system is regulated as a Public Water Supply by the U.S. Environmental Protection Agency (EPA). EPA has delegated enforcement of the drinking water regulations to the Massachusetts Department of Environmental Protection (MassDEP). The 1986 Amendments to the 1974 Safe Drinking Water Act (SDWAA) and the 1989 Surface Water Treatment Rule (SWTR) established major changes in drinking water regulations.

The impact of these changes to this system was evaluated in a MWRA project, summarized in the report *Safe Drinking Water Act Impact Study prepared for Massachusetts Water Resources Authority by CH2M Hill and Peer Consultants, March 8, 1989*. This study assessed existing conditions in the [DCR]/MWRA system, identified areas of noncompliance, and recommended actions necessary to come into compliance with the SDWAA. With respect to the watershed, the 1989 study found that:

> The [DCR] and MWRA currently do not have a watershed control program that meets the site-specific conditions of the SWTR. To be in compliance with the site-specific conditions, and, thus, avoid filtration, the following conditions would have to be met.
>
> A. There must be a disinfection system that meets the criteria for Giardia cyst inactivation and residual maintenance.
>   a. A program must be developed in which the activities in the watershed are monitored and controlled by complete ownership of the land and/or by written agreements with landowners.
> B. A program must be implemented in which all activities that could affect source water quality are identified and controlled.
> C. Onsite sanitary surveys must be performed annually on the watersheds.
> D. It must be shown that the system in its current configuration has not had an identified waterborne disease outbreak, as determined by State and local health officials.
> E. The distribution system must meet the long-term MCL of the Total Coliform Rule.
> F. The water system must be in continuous compliance with the requirements for trihalomethanes.

Staff began work on developing a watershed program to address these needs.

3.1.3 MassDEP Guidance for Development of a Watershed Protection Plan

In 1989, MassDEP issued guidance for development of watershed protection programs in the publication DEP DWS Policy 89-09 *DEP Guidance on the Preparation of a Watershed Resource Protection Plan (WRPP)*. This policy described the minimum components for a Watershed Resource Protection Plan (WRPP):

> It is DEP/DWS policy to accept for review a report describing a Watershed Resource Protection Plan which includes at a minimum, the information described below:
>
> A. Watershed Description
> B. Identification of Watershed Characteristics and Activities Detrimental to Water Quality
> C. Control of Detrimental Activities
> D. Monitoring
> E. Agreements and Land Ownership
> F. Management and Operations.

3.1.4 The 1991 Watershed Protection Plans

[DCR] and MWRA worked to develop Watershed Protection Plans in accordance with the MassDEP guidance and to be used to guide the watershed protection program. Two separate plans were developed: *Watershed Protection Plan Quabbin Reservoir and Ware River Watersheds 1991* and the *Watershed Protection Plan Wachusett Reservoir Watershed 1991*. A separate plan was required for the Quabbin/Ware system because it provides water for communities served by the Chicopee Valley Aqueduct (CVA). The Quabbin Plan was submitted to MassDEP for review; MassDEP approved the plan and granted a waiver from the filtration requirements of the SDWA for the CVA in 1991.

The Wachusett Reservoir plan was not submitted when completed due to concerns about meeting the source water quality requirements for filtration waiver. [DCR] and MWRA did recognize the importance of watershed protection in all systems, filtered and unfiltered, and committed to implementing a strong watershed protection program at Wachusett although the plan was not formally submitted to the regulatory agencies. Significant resources were added in order to carry out recommendations contained in the Wachusett and Quabbin plans.

3.1.5 Wachusett Reservoir Filtration Waiver

In 1993, MWRA requested a more flexible approach to SDWA compliance for Wachusett Reservoir, believing that filtration might not be necessary to meet the requirements of the Surface Water Treatment Rule. This decision was made, in part, due to the successful implementation of many programs developed in the 1991 Plan, as these controls produced dramatic improvements in source water quality. On June 11, 1993, [DCR] and MWRA entered into an administrative consent order with MassDEP

which set forth a compliance schedule for meeting the requirements of the SWTR for Wachusett Reservoir. The consent order permitted a dual track approach: [DCR] and MWRA would pursue aggressive watershed protection in order to obtain a filtration waiver; at the same time, MWRA would continue to do design work for filtration should the watershed protection measures fail to secure a Filtration Avoidance Determination. The Wachusett Watershed Protection Plan was submitted to MassDEP in 1993 with an updated implementation plan, and formally approved by MassDEP in 1994.

In October 1998, [DCR] and MWRA requested a redetermination from MassDEP to grant the system a waiver from filtration requirements. Since passage of the SWTR, the two agencies had accomplished major improvements in the watershed protection program as well as in water treatment and in the distribution system. Watershed Protection accomplishments included an aggressive land acquisition program to increase the holdings of protected lands, passage and implementation of the Watershed Protection Act which established land use controls in sensitive watershed areas, successful wildlife management program which improved source water quality, and commitment to sewer areas of the Wachusett Reservoir watershed that were not suitable for on-site wastewater disposal. This work was completed following the 1991 Watershed Protection Plans. In November 1998, MassDEP granted MDC/MWRA a waiver from the requirements of filtration. A subsequent federal court ruling confirmed this decision to provide a filtration waiver.

3.1.6 Watershed Protection Plan Updates 1998-2000

An updated watershed protection plan for Wachusett Reservoir watershed, *Watershed Protection Plan Update for Metropolitan Boston Water System Wachusett Reservoir*, was developed as part of the filtration waiver process.

MassDEP had developed a *Program to Measure Success of Watershed Protection Efforts Conducted by Public Surface Water Supplies to Obtain, and Maintain, a Waiver from Filtration Requirements* ("Measures of Success," 1996). The Measures of Success identified programmatic milestones organized into ten categories:

1. Watershed Control
2. Public Access/Recreation
3. Wildlife Management
4. Infrastructure Improvements
5. In-lake Problems
6. Sampling
7. System Operation/Maintenance
8. Staffing
9. Emergency Planning/Response
10. Education/Multi-town coordination.

The 1998 Wachusett plan include a section that demonstrated compliance with all of MassDEP's programmatic milestones. The Updated Wachusett Watershed Protection Plan was submitted to MassDEP in December 1998, and approved by MassDEP in February 1999.

The Quabbin/Ware River 1991 plan was developed with an eight-year implementation schedule. Therefore, the Quabbin/Ware plan was updated in 2000. Similar to the 1998 Wachusett plan, the Quabbin/Ware plan included a section that demonstrated compliance with all of MassDEP's "Measures of Success" programmatic milestones. The Quabbin/Ware plan update was submitted to MassDEP in December 2000 and was approved by MassDEP in 2001.

3.1.7 Source Water Assessment Program

The Federal Safe Drinking Water Act Amendments requires every state to examine existing and potential threats to the quality of all its public water supply sources and to develop a Source Water Assessment Program (SWAP). In 2002, MassDEP conducted a SWAP process for all public ground and surface water sources in Massachusetts, including one for the MWRA Quabbin Reservoir, Ware River, and Wachusett Reservoir. The SWAP noted that the [DCR]/MWRA system met MassDEP's annual review of "Measures of Success" for implementation of Watershed Protection Plans and disinfection treatment processes. The SWAP further noted that [DCR] implemented MassDEP-approved Watershed Protection Plans to protect source waters since 1991. The [DCR] and MWRA plans were more representative of the true nature of the watersheds than the SWAP, which was developed by a uniform, statewide process based on information available for every source in the state.

3.1.8 DCR and Subsequent Watershed Protection Plan Updates

In July of 2003, the MDC was combined with the Massachusetts Department of Environmental Management. A new agency, the Department of Conservation and Recreation was created. The responsibilities of the MDC/DWM were transferred to the DCR Division of Water Supply Protection.

In December 2003, a second update to the Wachusett Reservoir Watershed Protection Plan was completed. The *2003 Watershed Protection Plan Update for the Wachusett Reservoir Watershed* was submitted to MassDEP and approved by MassDEP in 2004. The 2003 plan included an updated "Measures of Success." The 2003 plan also addressed the issues raised in the SWAP.

The 2008 Watershed Protection Plan Update consolidated the Wachusett and Quabbin plans into one document, and integrated an update to the 1997 Sudbury Watershed Protection Plan as well.
The 2013 DWSP Watershed Protection Plan update and the FY19-FY23 Watershed Protection Plan, like all previous Watershed Protection Plans, were approved by MassDEP's Drinking Water Program and follow their guidance for developing an unfiltered water supply system's watershed protection plan.

Implementation of the Watershed Protection Program is reviewed annually by MassDEP, as part of their annual inspection of the entire DCR/MWRA system. Two inspections are conducted, one for the Quabbin Reservoir and Ware River watersheds, and the other on the Wachusett Reservoir watershed. MassDEP has granted continued

approval to DWSP and MWRA for both these watershed protection programs (see Section 3.3).

3.1.9 Emergency System – Sudbury

Sudbury Reservoir is classified an Emergency Water Supply Source by the MassDEP. There is no current plan to re-activate the reservoir as a permanent active source.

There is no regulatory guidance regarding watershed protection for Emergency Water Supply Sources. Federal and State Drinking Water Regulations pertaining to Emergency Water Supply Sources mainly deal with issues that arise when there is need to bring an emergency source on line (e.g., issuance of boil water orders).

The Sudbury system is a valuable resource and DWSP conducts several management programs in the watershed. The level of protection, however, provided through DWSP programs are less stringent than for the active water supply watersheds. Though not required by federal and state drinking water regulations, a Watershed Protection Plan was prepared for the Sudbury Reservoir and Foss Reservoir in June 1997 and has been part of the Watershed Protection Plan since 2008.

3.2 Critical Issues

3.2.1 Climate Change

According to the 2018 Massachusetts Integrated State Hazard Mitigation and Climate Adaptation Plan (SHMCAP), climate change is *a change in the state of the climate that can be identified by statistical changes of its properties that persist for an extended period, whether due to natural variability or as a result of human activity*.

Climate change was recognized as a potential source of pollution, as described in Section 3.3, in previous iterations of the Watershed Protection Plan. Understanding of the impacts and responses to climate change have advanced rapidly over the past five years. DWSP, DCR, Executive Office of Energy and Environmental Affairs (EOEEA), the Governor, and Legislature have all taken steps to address this topic. Through the process of reviewing information for this plan, DWSP has decided that the issue of climate change is too large and comprehensive to consider it as a single source of pollution, rather it is integral to every facet of pollution sources and their assessment. Therefore, it has been removed from the list of potential pollution sources. The topic will be addressed as needed in the description of each pollutant source and DWSP's management programs.

DCR and DWSP's Approach to Climate Change

One of DCR's core principles is to advance climate change mitigation and adaptation efforts by implementing sustainable practices and advancing resiliency across its infrastructure assets and resources. To facilitate these efforts, DCR's Office of Climate Resilience provides support and expertise to staff across all of DCR, ensuring climate change considerations are incorporated into agency initiatives, planning processes, and projects. The Office of Climate Resilience works on existing efforts to support the mitigation of greenhouse gas emissions as well as compliance with state Executive Order 594, issued on April 22, 2021. This agency-wide group focuses on building resilience across DCR's buildings, roads, dams, beaches, forests, and all other facets of its properties in order to adapt to the impacts from climate change, including flooding, sea level rise, and changes in historic temperature ranges. The Office of Climate Resilience also serves as the primary liaison to EOEEA regarding the State Hazard Mitigation and Climate Adaptation Plan (SHMCAP) and the Clean Energy and Climate Plan for 2050. DWSP, in coordination with DCR's Office of Climate Resilience, works to identify, plan for, and respond to impacts from climate change through identifying DWSP's climate vulnerability and engaging in adaptation and mitigation strategies. The following terms relating to climate change are defined as follows:

One of DCR's core principles is to advance climate change mitigation and adaptation efforts by implementing sustainable practices and advancing resiliency across its infrastructure assets and resources.

Vulnerability

The degree to which a system is susceptible to adverse effects of climate change, including climate variability and extremes.

Adaptation

An action that seeks to reduce vulnerability and risk to an anticipated climate impact. This may include such things as flood barriers, living shorelines, elevated buildings, and increased tree canopy.

Mitigation

An action that makes the impacts of climate change less severe by preventing or reducing the emission of greenhouse gases into the atmosphere. This may include such things as reducing operational reliance upon burning fossil fuels and protecting and conserving land, coastal systems and forests.

DWSP's strategy to dealing with climate change incorporates a variety of adaptation and mitigation actions, which are discussed in more detail throughout the plan. Additionally, specific efforts to mitigate greenhouse gas emissions, such as reducing DWSP's operational impacts through the decrease or elimination of fossil fuels, electrification of heating systems and vehicles, and the installation and expansion of renewable energy and its associated policies are developed by DCR's Net Zero Task Force which works on the implementation of initiatives to meet State Executive Order 594.

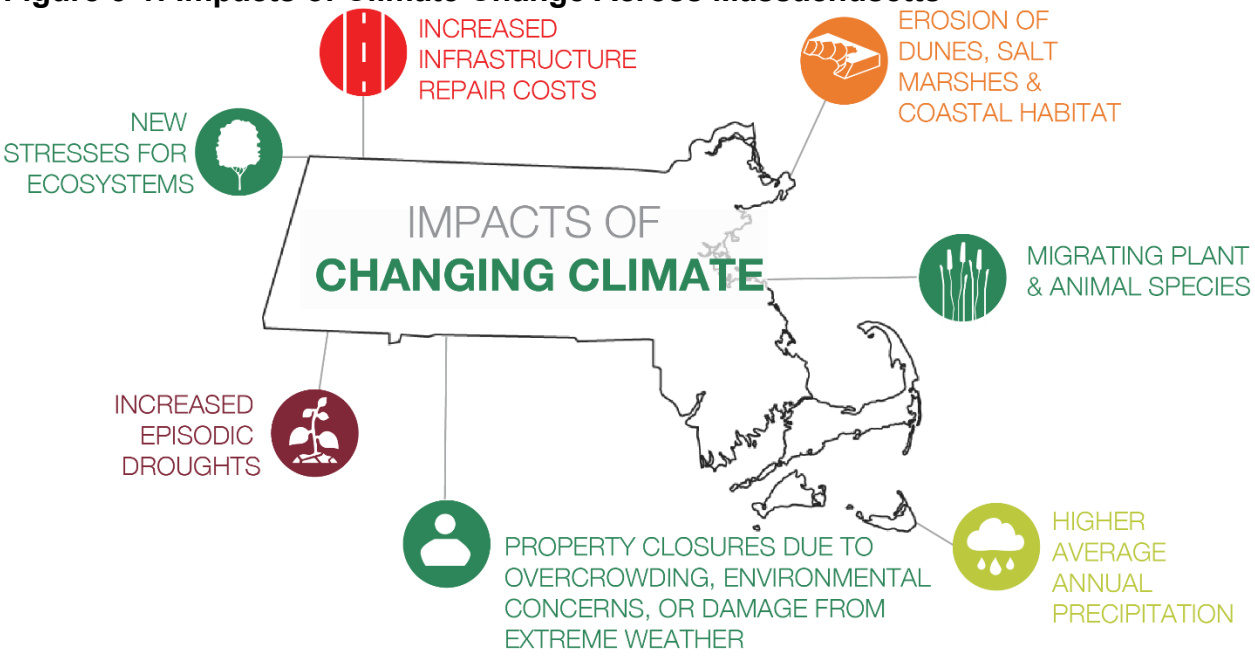
Watershed Scale Impacts of Climate Change

Specific impacts of climate change will be addressed as needed in the description of each pollutant source and DWSP's management programs throughout the Watershed Protection Plan. Massachusetts-wide climate projections and watershed-scale impacts are summarized here.

Climate projections for Massachusetts predict rising air and water temperatures and changes in the timing, intensity, and duration of precipitation, with lengthy dry periods and infrequent but very heavy episodes of rainfall (2022 Massachusetts Climate Change Assessment). This will result in direct and indirect impacts from climate change, as well as short-term and long-term effects on the quality and quantity of water available in the DWSP's watersheds (Figure 3-1). Impacts can include:

- Higher water temperatures reduce dissolved oxygen levels in water, adversely impacting aquatic life.
- Increased frequency and intensity of rainfall may cause flooding, erosion, and sedimentation problems, with changes in stormwater runoff carrying a variety of pollutants into streams and wetlands.
- The combination of decreased oxygen, increased stormwater runoff, and increased temperatures can result in harmful algal blooms across DWSP watersheds.
- Changing patterns and quantities of precipitation can lead to drought, less dilution of pollutants, impacts to aquatic organisms, and changes to the timing and amounts of water storage in the reservoirs.
- Variations in temperature and precipitation also can lead to new stresses on existing ecosystems and changes in plant and animal populations, altering forest composition and creating opportunities for new invasive species arriving or problematic resident species becoming more dominant.
- Damage to infrastructure resulting in increased maintenance and repair costs.

Figure 3-1: Impacts of Climate Change Across Massachusetts



DCR Vulnerability Assessment

To address the effects of climate change, the previous Watershed Protection Plan recommended that DWSP initiate a comprehensive vulnerability assessment. In 2021, DCR completed the first agency-wide Climate Change Vulnerability Assessment. The model was based on a similar process used by the National Park Service (NPS) Climate Change Vulnerably Assessment and the exposure analysis was based on the Climate Resilient Design Standards Tool, developed by EOEEA.

The climate vulnerability assessment is a tool to help DCR identify properties with the greatest exposure and sensitivity, as well as factoring in the site's adaptive capacity based on their natural resources and infrastructure assets. This assessment used a spatial data-driven process and developed a standardized climate change vulnerability assessment methodology to be used across all properties, allowing for a flexible model that can incorporate updates, additions, and refinements in the future.

This assessment included all land that DCR owns or manages, which were grouped into 528 sites for evaluation, and used the latest climate science data available for the Commonwealth of Massachusetts. Sites were grouped based on management facilities with DWSP watersheds split into four sites (Table 3-1). The assessment considered the exposure, sensitivity, and adaptive capacity of each DCR property based on the Department's mission, with the final product being vulnerability scores for each climate parameter and a composite vulnerability score across climate parameters for the 2030 and 2070 planning horizons. Vulnerability, defined as the degree to which a system is susceptible to adverse effects of climate change, including climate variability and extremes, is a function of exposure, sensitivity, and adaptive capacity. For the purpose of this assessment, those terms are defined as:

Exposure: Whether an area that will experience a specific hazard. Hazards included in the analysis were coastal, urban, and riverine flooding, extreme heat, and wildfire.

Sensitivity: Whether the site has assets or functionality that will be damaged or disrupted from exposure to a hazard (e.g., an asset in the floodplain with critical systems located below the future projected flood elevation is considered highly sensitive to flooding).

Adaptive Capacity: The ability of assets to accommodate or recover from the impacts of climate change.

Table 3-1: DCR Vulnerability Scores for Watershed Sites

SITE NAME	*Overall Vulnerability Score 2030*	*Overall Vulnerability Score 2070*
Quabbin Reservoir Watershed	Moderate	Moderate
Sudbury Reservoir Watershed	Reduced	Reduced
Wachusett Reservoir Watershed	Moderate	Moderate
Ware River Watershed	Moderate	Moderate

DWSP recognizes that ongoing and future impacts from, and vulnerability to, climate change may vary between and within the four watersheds, requiring scaled and targeted analysis to reflect these variances. The DCR-wide vulnerability assessment combined all lands within each watershed for analysis, limiting the ability to parse through nuanced differences between subbasins and management sites within watersheds. The vulnerability assessment was also limited by the exclusion of scoring for specific assets, such as individual dams or other major infrastructure.

A DWSP-specific comprehensive vulnerability assessment will be initiated in coordination with DCR's Office of Climate Resilience. This process will help prioritize capital planning decisions and designs, investigate opportunities for resilience and climate adaptation, and identify hazards and constraints at the sub-watershed level. The DWSP Vulnerability Assessment will consider sub-watershed scale sites and update data utilized in sensitivity and adaptive capacity measurements to match DWSP's specific mission and management goals.

Climate Change Issues in the Watershed Protection Plan

DWSP, as a public water supplier, has an obligation to maintain safe and consistent water quality and quantity for the MWRA's users. DWSP must prepare for and react to all of the issues raised by the threat of climate change and its associated impacts to meet this mission. DWSP has engaged in division-wide planning efforts, developed policies, initiated new programs, and collected data to address current and projected climate change impacts. While covered in more detail throughout the different plan sections, the following are highlighted selections of these activities.

- Active land acquisition permanently protects forested landscapes within the watershed and helps to sequester carbon and prevent carbon emissions that come with land being developed. *(See Land Acquisition 4.1)*
- DWSP's vast network of lands are sustainably managed as structurally and compositionally diverse forests making these lands more resilient to impacts of climate change, such as severe weather events, temperature and precipitation changes, outbreaks of disease, and invasive plant and pest infestations. (*See Land Management 4.3)*
- Dam inspections continue with a focus on high and significant hazard dams to identify and prioritize deficiencies that would be vulnerable to climate change impacts. (*See Infrastructure Management 4.7)*
- Replacement culverts and other infrastructure are sized appropriately to address likely changes in water flow due to ongoing climate change. *(See Infrastructure Management 4.7)*
- Annual water quality reports are being analyzed for the potential use of the historical record to support analyses of long-term trends and effects of climate change. (*See Water Quality and Hydraulic Monitoring 4.11)*
- DWSP has worked closely with the MassDOT to design and construct stormwater BMPs in key locations, such as on state highways around Wachusett Reservoir, to prepare for the stormwater runoff and associated pollutant loads associated with predicted changes in precipitation patterns (*See Stormwater Management 4.15)*
- Methodologies for inventorying and tracking at-risk infrastructure throughout the watersheds have been developed, including a comprehensive road infrastructure inventory. (*See GIS 4.17)*
- DWSP is collaborating with other agencies, including MassDOT to implement a Road Salt Reduction program by sharing knowledge and information about road salt use in the watershed with the ultimate goal of reducing salt loading on both DWSP and municipal properties in preparation from more frequent and intense storms resulting from a changing climate. (*See Chlorides 3.2.4)*

These actions have already begun to address the critical threat of climate change and DWSP will continue to work from this base to expand DWSP's efforts. Coordination will continue with DCR's Office of Climate Resilience on climate related planning and project implementation, including the initiation of a DWSP specific comprehensive vulnerability assessment that incorporates the impact on important natural resources. DWSP will strive to utilize consistent climate change data and projections across its programs, including data collected internally as well as statewide level data, in order to identify current impacts and assess projected impacts. Staff will continue to monitor and evaluate climate change research and scientific literature, data, and recommendations.

3.2.2 PFAS

Per- and Polyfluoroalkyl substances (PFAS) are an anthropogenic threat to the DCR/MWRA water supply system not identified in previous versions of the Watershed Protection Plan.

PFAS consists of a group of more than 5,000 synthetic chemicals in use since the 1940s, widely used for their water and oil repellent properties (in products such as Teflon and Scotchgard) that remain persistent in the environment. Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are subsets of PFAS that have been most widely studied at this point in time. PFAS are called "forever chemicals" because the carbon-flourine bonds which make up this group of chemicals are very strong and difficult to break down.

According to the Environmental Protection Agency:

- Because of their widespread use and their persistence in the environment, many PFAS are found in the blood of people and animals all over the world and are present at low levels in a variety of food products and in the environment.
- PFAS are found in water, air, fish, and soil at locations across the nation and the globe.
- Scientific studies have shown that exposure to some PFAS in the environment may be linked to harmful health effects in humans and animals.
- There are thousands of PFAS chemicals, and they are found in many different consumer, commercial, and industrial products. This makes it challenging to study and assess the potential human health and environmental risks.

Both PFOA and PFOS have been phased out starting in 2006 but have been replaced in recent years. In chemical and product manufacturing, GenX chemicals are considered a replacement for PFOA, and perfluorobutane sulfonate (PFBS) is considered a replacement for PFOS.

Since PFAS are used in many applications, there are several ways they can enter into the environment including consumer products, drinking water, and some firefighting foams (aqueous firefighting foam (AFFF)) where it is used to suppress hydrocarbon fuel fires. Detailed information including AFFF fate and transport, mechanisms of release to the environment and best management practices can be found online on the Interstate Technology and Regulatory Council (ITRC) website.

There have been recent reports that artificial turf was found to contain PFAS in both the backing material and in the blades themselves, in compost where wastewater sludge has been used in the process, and in ski waxes. These potential sources of PFAS introduction, in addition to large historical past fires, are a specific concern for watershed management and should be considered during building development and recreational use policies.

Based on human studies in populations exposed to PFOA and PFOS and new scientific information on these chemicals health effects, the Environmental Protection Agency

issued an interim drinking water health advisory in June 2022 which updates an advisory issued in 2016 of a combined 70 parts per trillion (ppt). The current Interim updated health advisory for PFOA is 0.004 parts per trillion (ppt) and the interim updated health advisory for PFOS is 0.02 ppt. Final health advisories for GenX chemicals and PFBS are 10 ppt and 2,000 ppt. Interim health advisories will be in place until EPA's PFAS National Primary Drinking Water Regulation is in effect. In 2020, MassDEP published the PFAS public drinking water standard or Massachusetts Maximum Contaminant Level (MMCL) of 20 parts per trillion (ppt) for the sum of the concentrations of six specific PFAS. MassDEP is working to review the new EPA Interim Health Advisories and will determine next steps based upon that review.

MWRA has tested for the six regulated PFAS as well as a dozen other PFAS compounds, using extremely sensitive testing methods…No more than trace amounts, too low to be quantified, were detected…Quabbin and Wachusett Reservoirs are well protected source reservoirs with no identified potential sources of PFAS.

Starting in 2019, MWRA has tested for the six regulated PFAS as well as a dozen other PFAS compounds, using extremely sensitive testing methods. MWRA began quarterly testing as required by the MassDEP regulation in January 2021. No more than trace amounts, too low to be quantified, were detected during the first two quarterly sampling rounds. The sum of the six regulated PFAS compounds was zero, below the new MassDEP standard of 20 parts per trillion. MassDEP issued a sampling waiver for the remaining two quarters of 2021 based on these results and the fact that the Quabbin and Wachusett Reservoirs are well protected source reservoirs with no identified potential sources of PFAS. MWRA sampled twice during 2021 and sampled again in 2023 during the next 3-year compliance period as required by MassDEP. MWRA will also be conducting sampling for 29 PFAS compounds as part of EPA's Unregulated Contaminants Monitoring Rule (UCMR5) during 2023- 2025. Initial 2023 results indicate that none of the 25 compounds were detected. MWRA data indicates that it would also easily meet the proposed federal drinking water proposed by EPA in March 2023

In March 2023, EPA released draft National Primary Drinking Water Regulations for six PFAS compounds (Table 3-2). Based on current and historic sampling results, the DWSP/MWRA water supply will easily meet these standards. DWSP and MWRA staff will carefully review the proposed regulations during comment and potential implementation periods.

Table 3-2: Proposed EPA PFAS Standards and Current Test Results

Compound	Current MassDEP Standard	Proposed EPA Standard	MWRA Result[1]	Meets Standard
PFOA	Combined 20 ppt	4 ppt	Trace	YES
PFOS	Combined 20 ppt	4 ppt	Trace	YES
PFNA	Combined 20 ppt	10 ppt*	Non-Detect	YES
PFHxS	Combined 20 ppt	9 ppt*	Non-Detect	YES
PFHpA	Combined 20 ppt	No EPA standard	Trace	YES
PFDA	Combined 20 ppt	No EPA standard	Non-Detect	YES
PFBS	No state standard	2,000 ppt*	Trace	YES
HFPO-DA	No state standard	10 ppt*	Non-Detect	YES

[1] Based on most recent testing for MassDEP regulations. These results would all be classified as zero or non-detectable under the proposed federal standard

* These four compounds to be regulated as a combined Hazard Index based on Health Based Water Concentration ratios

Trace = present, but at concentrations too low to be reliably quantitated with current analytical technology.

Source: MWRA; accessed 5/8/2023.

3.2.3 Covid-19 Pandemic

Covid-19 (coronavirus disease 2019) is a disease caused by the SARS-CoV-2 virus and was discovered in Wuhan, China in December 2019. It is very contagious and quickly spread around the world. The pandemic caused by Covid-19 reached the United States in March 2020, causing havoc to all societal functions.

A pandemic was not identified as a potential pollution source or management issue in the previous plan. DWSP adjusted to the parameters of the pandemic with staff fully covering all program responsibilities, either remotely or in person. The immediate and short-term responses to the pandemic are shifting to long-term, programmatic changes to some aspects of watershed management.

One significant issue is an increase in public access. DWSP saw a dramatic jump in the early months of the pandemic when DWSP lands were used by many who had never previously explored the region. The pandemic-induced switch to remote work has caused a change in rural and suburban demographics, as more people can now work from home, and that home does not necessarily need to be close to their city-based employment. Population is shifting in the region and the real estate market is making it more expensive to purchase property for watershed protection.

3.2.4 Chlorides

Sodium Chloride is the main component of road salt applied to roads, parking lots and driveways as part of snow and ice maintenance to allow for safer travel on public and private paved surfaces during and after winter storm events. DWSP has documented a long-term increasing trend of the concentration of Sodium Chloride (NaCl) in surface water in the Wachusett watershed and reservoir.

Increased levels of chloride in surface water and groundwater are a concern as negative impacts can occur for aquatic life such as fish and benthic macroinvertebrates.

Excessive chlorides in groundwater can dominate summer baseflows in tributaries during summer low flow periods. Changes in the specific conductance of reservoir water can alter algae and plankton patterns in the reservoir itself. Finally, increased levels of salts can change the water chemistry of finished water, possibly resulting in leaching of metals from supply infrastructure.

Although mentioned in previous protection plans, the breadth and scope of salt impacts have come into focus over the past five years. As a result, DWSP has developed a multi-pronged approach with the goal of reducing salt applications in the watershed with the following components.

…the breadth and scope of salt impacts have come into focus over the past five years. As a result, DWSP has developed a multi-pronged approach with the goal of reducing salt applications in the watershed…+

Education, Training and Outreach

DWSP and MWRA have collaborated with the UMass Baystate roads program to offer no cost winter snow and ice operations training to watershed town DPW employees in 2019, 2021 and 2022. DCR and MWRA employees have attended the training as well.

In 2021, DWSP produced an informational video about the importance of road salt reduction that is published on YouTube and posted on the DWSP website. Collaboration with MassDOT District 3 has resulted in the exchange of information and equipment that has greatly benefited the DWSP winter program. Presentations on chlorides have been given to the MWRA trust board, WSCAC, MassDOT, MassDOT contractors, and others.

Improve Data Collection Capability

DWSP has expanded the water quality monitoring program on several fronts to learn more about patterns of chloride in the watershed. Groundwater monitoring was started in 2019 and currently includes monthly monitoring at eight wells. Results have revealed concerning levels of chlorides at some locations and provided initial information about patterns and sources of chloride in the watershed.

Real time continuous monitoring mayfly stations have been installed on several tributaries without USGS gages that will all for daily chloride loading estimates to be calculated. See section 4.10.3 for more details on the results and descriptions of these initiatives.

In addition to recording the use of salt in winter operations, DWSP has also sought out and documented information on the amount of salt used by the towns and MassDOT, as well as estimates of salt used on parking lots.

Model Impact of Reducing Inputs
DWSP works with UMass under a research Inter-agency Service Agreement (ISA) that allows for the inclusion and study of complex and novel water quality topics such as the fate of salt within the watershed. The publication of "Long-term analysis or road salt loading and transport in a rural drinking water watershed" by Sjoper et al. in 2021 provided a road map that revealed measurable water quality improvements will only be realized with a sustained long-term decrease in the amount of salt applied. UMass has begun work on modelling the potential impact of hypothetical reductions in salt applications to guide where to concentrate future salt reduction efforts.

A second outcome of the UMass research was the identification of the linear relationship between the percentage of paved surface and surface water conductivity (chloride). As paved surfaces reach of 4 percent of a watershed, there is a very high probability that the EPA chronic threshold for Chloride (230 mg/L) for aquatic life criteria will be exceeded and there could be water supply distribution/delivery impacts. This work has now been incorporated into the DWSP land acquisition program when prioritizing purchases.

Upgrade DCR Practices
DWSP has taken many steps to upgrade internal snow and ice operations. After participating in the Baystate Roads snow and ice training, pre-treating with solid salt was adopted. Although not feasible for every storm, this resulted in an immediate reduction in the total amount of salt used and underlined the importance of pre-treatments.

The key to salt reductions lies in utilizing a liquid salt brine solution as a pretreatment. Brine serves as an anti-icing agent to prevent snow and ice from binding to the road surface, allowing for easier removal, fewer applications, and faster return to a clean paved surface. DWSP has purchased a salt brine generator, walk along sidewalks brine sprayers, and a truck-based brine sprayer in anticipation of incorporating brine pre-treatment in the winter of 2022-2023. Reductions of up to 35 percent less salt applied per winter have been realized by programs moving from solid salt to the adoption of salt brine.

Provide a Salt Reduction Grant Program to Assist Wachusett Watershed Communities
The Salt Reduction Grant program was first established by DWSP in FY21. This 50/50 matching grant program makes funds of up to $20,000 available for seven towns in the Wachusett watershed in order to facilitate the purchase of new equipment that assists with the purchase of new technologies and equipment that reduce the use of salt. More than $119,000 has been dispersed via 9 grants awarded to date, including more than $36,000 in FY23. Successful grant awards across fiscal years FY21, FY22 and FY23 have been applied towards two new salt storage facilities, flexible plow blades that remove snow and ice more effectively from uneven surfaces (which ultimately requires less salt to maintain the roadway), roadway temperature sensors in plow vehicles, and a portion of costs for a new salt brine generator.

3.3 Review of MassDEP Annual Inspections

An annual inspection is a requirement of the Massachusetts Drinking Water Regulations, 310 CMR 22.20A, for systems with a filtration waiver. The Watershed Protection/Control Program and the disinfection process are interrelated protective barriers to contamination that, when implemented cooperatively, assure a high degree of water quality control. MassDEP evaluates the implementation and effectiveness of this "multi-barrier approach" to source protection through its watershed inspection process.

MassDEP performs two inspections on the DWSP/MWRA water supply system (PWS ID 6000000): one on the Quabbin Reservoir and Ware River watersheds, and the other on the Wachusett Reservoir watershed. The former is done by MassDEP's Western Regional Office; the water treatment portion of the inspection focuses on the William A. Brutsch Water Treatment Facility (WABWTF) in the Town of Ware, which delivers water via the Chicopee Valley Aqueduct (CVA) to Chicopee Water Department, South Hadley Fire District No. 1, and Wilbraham Water Department. Staff from MassDEP's Boston Office inspect the Wachusett Reservoir watershed and intake, while Northeast Regional Office staff annually inspect the John J. Carroll Water Treatment Facility in Marlborough and the associated aqueducts used by MWRA to provide drinking water to communities in the greater Boston area. Staff from the U.S. Environmental Protection Agency's New England office also usually attend the inspections.

Inspection of the watershed and review of drinking water treatment processes include an evaluation of specific criteria to measure the system's ability to produce safe drinking water. These inspections are performed on both DWSP and MWRA facilities. Inspection elements included the following (responsible agency in parenthesis):

A. Review of the effectiveness of the Watershed Protection/Control Program Plan (DWSP).
B. Review of the physical condition of the source intakes and how well they are protected (DWSP/MWRA).
C. Review of the appropriateness of the system's disinfection equipment and maintenance program in order to ensure a high operating reliability (MWRA).
D. Inspection of the disinfection equipment and review for appropriateness and physical deterioration (MWRA).
E. Review of management/operating procedures (DWSP/MWRA).
F. Review of data records that included source water total and fecal coliform bacteria data and turbidity levels with the objective of ensuring that all required tests were conducted and recorded (DWSP/MWRA).
G. Review of bacteriological data for the occurrence of coliform in the distribution system in order to ensure that the disinfection process is effectively applied (MWRA).
H. Review of disinfection byproduct data from the distribution system (MWRA).
I. Identification of any improvements that are needed in the equipment, system maintenance, system operation, or data collection processes (DWSP/MWRA).
J. Review of the status of any Safe Drinking Water Act compliance issues previously identified (DWSP/MWRA).
K. Confirmation that the system is using a laboratory certified by MassDEP for the required analytical methods (DWSP/MWRA).

Source Water Quality Conditions
One of the most critical factors assessed by MassDEP are source water quality conditions. The Field Operations Department of MWRA submits monthly water quality reports to MassDEP, consisting of daily fecal coliform bacteria and turbidity results. This data represents how well DWSP is managing the unfiltered watershed for these two key parameters. MWRA uses its own laboratories, which have been certified by MassDEP for the required analytical methods.

Throughout the past five years, both the Quabbin Reservoir and Wachusett Reservoir have demonstrated that the requirements for fecal coliform bacteria at 310 CMR 22.20A(2)(a)1 of less than 20 cfu/100 ml in at least 90 percent of the representative source waters tests has been consistently met (see Section 4.10). Similarly, turbidity values were below 1 nephelometric turbidity unit (NTU) during the monitoring periods, meeting the requirements of 310 CMR 22.20A(2)(a)2 and 22.20A(2)(a)3.

Watershed Protection/Control Program
As previously mentioned, the Watershed Protection/Control Program and the disinfection process are interrelated protective barriers to contamination that, when implemented cooperatively, assure a high degree of water quality control. MassDEP's inspections, which are comprised of staff presentations along with field visits to sites across the watershed, focus on several elements; most are consistent each year, though specific topics are often selected by MassDEP that are reviewed in-depth. These inspection elements have included:

- *Sources and Watersheds*
- *Security and Public Access Management*
- *Wildlife*
- *Forestry Management*
- *Invasive Species*
- *Water Infrastructure*
- *Environmental Quality Assessments*
- *Water Quality Monitoring*
- *Education*
- *Emergency Response*
- *Watershed Protection Act*
- *Maintenance and Improvements*

Follow up from the site inspections includes required submittals of reports and responses to MassDEP's identified corrective actions. DWSP typically provides annual reports on the following: land acquisition; Watershed Ranger interactions; Natural Resource activities regarding deer, beavers, and loons; bird harassment; water quality and tributary monitoring; Environmental Quality Assessments; Watershed Protection Act implementation; forestry; invasive species; watershed security; and watershed and infrastructure maintenance. There are often explanations of issues that needed clarification or more details, such as swimming and wading violations, in which DWSP demonstrates control of the watershed. Over the past five years, MassDEP has asked DWSP and MWRA to address several specific items (Table 3-3).

Table 3-3: MassDEP Inspection Issues

Issue	DWSP Response
Obey Lawful Directions and Swimming violations	Rangers continuously monitor the watershed system. DWSP utilizes 313 CMR 11.09(2)(a)(23) for vehicles in Quabbin Park after posted closing time. Information provided on details of each swimming violation.
Ware River Horse Trails	Reviewed request for designation of "T6" trail for horses. Confirmed past use and that most of trail is dry, rocky, and hilly, and thus suitable for horseback riding. DWSP utilized a Student Conservation Association crew to re-route the one section of trail that was going through a wetland.
Pelham Timber Harvest Issues	A situation arose at a timber harvest location due to damage reported on the forwarder/skid roads, in which rutting facilitated sediment transport. DWSP downstream inspections found minimal sediments and the bridges, water bars, hay bales, and corduroy worked to minimize impacts on the intermittent streams. DWSP performed mitigation on the property. DWSP improved communication with loggers to prevent this type of damage, revised how often foresters inspect projects, and increased performance bond requirements for future projects.
BLA Boat Fuel Storage	Redesigned fuel storage at Boat Launch Areas. Now consists of above ground, explosion proof storage cabinets set in a 66 gallon/5,000 lb. spill basin for secondary containment. In the cabinet, fuel is stored in five-gallon safety cans with spill proof nozzles. Storage cabinets are located closer to the attendants and further away from the existing underground vaults and resource areas.
Unauthorized Trails in the Ware River Watershed	Trails are routinely monitored and assessed by DWSP; in many cases, unauthorized trails are blocked by rocks, brush, or trees. DWSP monitors and replaces signs as needed. DWSP established a permanent Watershed Ranger presence in the Ware River, with three full-time staff stationed in Oakham. DWSP is working with user groups as part of the Ware Public Access Management Plan update. MassDEP emphasized that any increases in public access that DCR allows as part of existing public access plans should not lead to a lesser level of watershed protection. Increased activities shall be sufficiently managed and monitored to prevent adverse impacts to water quality. DWSP developed method for monitoring trails using GIS.
Water Quality Database	DWSP has implemented the Watershed system data Visualization Environment (WAVE), a portal to visualize and review data developed in collaboration between the Wachusett and Quabbin Environmental Quality staff.
New Salem Facility	The DWSP field office in New Salem, which provided space for foresters, watershed maintenance, and natural resources staff, burned down in a large fire in April 2018. Staff are currently using a modular trailer on site. During debris removal, testing was done and a small amount of contaminated soil was discovered and removed; at the same time an underground storage tank was also removed. DWSP continues to work with DCR and MWRA to determine best way to rebuild a permanent structure on the site.

Issue	DWSP Response
Aquatic Invasive Species	Details provided on monitoring, prevention, and removal efforts. Descriptions include annual surveys, Quabbin Boat Seal program, boater self-monitoring, fragment barriers, reporting processes, and amount of AIS removed.
Quabbin Road Management Plan	This plan is implemented through regular maintenance activities and meetings of a road working group comprised of Civil Engineer, Forestry, Maintenance, and Management staff.
Wachusett Bluff/Shoreline Erosion	Monitoring of bluff erosion is ongoing. Recommendations to minimize bluff erosion have been incorporated into regular forest management activities as appropriate.
Health of Watershed Trees	Spongy moths (*Lymantria dispar*) had been the greatest recent threat to the health of the forest in the watershed as the population of was increasing over several years. The reemergence of the *Entomophaga maimaiga* fungus in 2019 and the subsequent crash in the spongy moth population has reduced expectations of wide-spread defoliation and minimized large-scale mortality of forest on DWSP property. DWSP will continue to monitor and perform salvage operations where necessary.
Asian Long-Horned Beetle	Forestry staff works with DCR ALB staff who continue to survey regulated areas within the watershed. DCR ALB coordinates the removal of infested trees once a thorough inspection of all host trees in the area is completed. To date, infested trees showed only old evidence of egg sites and emergence holes. No new beetles have been found since 2019.
Staffing Levels	DWSP is working with DCR and EOEEA to fill empty permanent slots. Successfully covering required tasks while waiting to hire new staff.
Stormwater Management	Work continues with MassDOT to remove the two remaining direct discharges to Wachusett Reservoir along Route 110 in Sterling. Worked with EPA to enforce NPDES General Permit for Discharges from Construction Activities, resulting in a $10,500 penalty on a site in Holden. DWSP maintains BMPs on its property to ensure that they work as designed.
Reservoir Intake Maintenance	Masonry wall leakage into the Winsor Intake at Quabbin is being addressed by MWRA through a construction contract that began in 2023.

DWSP and MWRA staff work closely with MassDEP to coordinate these annual inspections and subsequent delivery of requested information and documentation. MassDEP reviews this information to determine if the drinking water supply meets all conditions as specified in 310 CMR 22.20A(2) to maintain a waiver from filtration requirements. ***MassDEP has concluded every year that DWSP's Watershed Protection Control Program is effective in minimizing and preventing microbiological contamination of these source water supplies. Combined with MWRA's treatment and distribution of the drinking water, MassDEP has found that the DWSP/MWRA system continuously meets the criteria for avoiding filtration.***

3.4 Pollution Sources and Assessment

DWSP staff identify activities or conditions that could potentially degrade water quality and develop strategies to control these threats on a daily basis. The process undertaken in developing the *2018 DWSP Watershed Protection Plan Update* provided a long-term and systematic approach to evaluating threats and developing comprehensive, integrated programs to deal with the threats. The original threat assessment for watershed protection plan development was conducted in 1991, following guidelines developed by MassDEP. Assessments were repeated in 1998, 2003, 2008, and 2013 for Wachusett Reservoir and 2000, 2008, and 2013 for Quabbin Reservoir and Ware River. The process was reviewed and updated with each plan to better assess potential sources of contamination in the watersheds.

The basic assessment approach consists of three steps:

1. Compile a list of potential land uses that could degrade water quality. Identify pollutants or contaminants of concern that are associated with each activity. This pollutant list is not intended as a comprehensive inventory of water quality threats from activities or uses; rather it is developed as a tool to assist in conducting the evaluation.
2. Conduct a watershed-wide review to update the status of the activities identified as potential cause of concern in Step 1.
3. Conduct a screening level review to evaluate the threats. This is a qualitative evaluation that incorporates relevant water quality data collected since the last assessment and staff input of field observations made during the same period. Assign a ranking of Low, Medium or High.

It is very important to note that this is a tool used by DWSP and other watershed managers as part of a comprehensive planning process to develop control programs and prioritize efforts. It is a difficult process where staff strive to be vigilant for potential threats but not unnecessarily alarm users or regulators about conditions in the watershed.

DWSP staff, as in past Watershed Protection Plan iterations, have made the evaluation under a hypothetical scenario where the existing DWSP control programs do not exist. Because DWSP has an extensive watershed protection program in place, the rankings should not be interpreted as the actual risk to the DWSP system.

The source categories developed for use in this assessment are summarized in Table 3-4. As with the pollutant categories, this list was developed as a screening tool and is not intended as a definitive catalog. It was developed with the intention of encompassing all potential pollution sources in order to develop a comprehensive protection program.

Table 3-4: Potential Contaminant Source Categories

Source	Concern
Wildlife	Threat to water quality from wildlife populations. *Examples: the direct threat of pollution from avian and aquatic mammal waste; indirect threats to water quality such as over browsing by herbivores and impacts from beaver activity.*
Public Access/ Recreation	Threat to water quality from public access on publicly owned properties. *Examples: erosion from human activities; waste from humans or animals; trash disposal and dumping.*
Timber Harvesting/ Forestry	Threat to water quality from timber harvesting activities. *Examples: harvesting within wetlands and riparian zones; road and landing construction and use; stream crossings; mechanical preparation for tree planting; spills from power equipment.*
Wastewater	Threat to water quality from wastewater treated in on-site systems or transported via sewers to (off-watershed) wastewater treatment plants. *Examples: leachate from failing or improperly sited on-site septic systems; release of untreated sewage from a sewer or pump station; gull feeding at treatment plants and then roosting on reservoirs.*
Roadways, Railways and Rights-of-Way	Threat to water quality from roads and railways. *Examples: pollutants transported by stormwater runoff; releases of fuel or transported products caused by accidents; maintenance practices such as herbicide treatment of ROWs; potential contaminant impacts from de-icing or fire suppressant material.*
Agriculture	Threat to water quality from growing and harvesting crops and keeping livestock. *Examples: horse stables; waterfowl feeding at agricultural sites and then roosting on reservoirs; spreading of fertilizer, compost and wood ash.*
Construction	Threat to water quality from construction activities on a site. *Examples: earth moving with inadequate erosion and sediment controls; releases from construction equipment; introduction of invasive species through use of inappropriate erosion controls.*
Commercial, Industrial, and Governmental Sites	Threat to water quality from activities on sites in commercial, industrial, or governmental use. *Examples: runoff due to increased impervious surfaces; release of materials stored and used on site; kennels; gravel mining; construction of solar farms.*
Residential Sites	Threat to water quality from practices associated with land in residential use. *Examples: nutrient and pesticides from lawn care products; pet waste; pharmaceuticals and personal care products (PPCPs) from on-site wastewater disposal systems; use of non-native species in landscaping or aquaria.*
Future Growth	Threat to water quality from development of land that is currently undeveloped. *Examples: potential contaminants related to property development, which could be residential, agricultural, commercial, or industrial*.
Security Threats	Threat to water quality from malicious attempts to contaminate water.

DWSP created five categories of pollutants that are most likely to be associated with these potential threats and share common properties for the purpose of this screening. These categories are based on conventional definitions which have been adapted to

meet DWSP's efforts to assess potential sources and develop protection programs. The five water quality pollutants categories are: Pathogens, Nutrients, Turbidity, Anthropogenic Compounds, and Invasive Species. This discussion has been developed as a tool to help conduct the threat assessment.

Pathogens

Pathogens are biological agents that can cause illness or disease. Indicator organisms, such as fecal coliform and total fecal coliform, are commonly examined, as specific pathogens are difficult and expensive to test for in water. Such tests "indicate" possibility of presence of pathogenic compounds. Pathogens include cyanobacteria, photosynthetic bacteria that share similar characteristics of algae and can multiply quickly in response to conditions that are favorable for their growth. Harmful algal blooms composed of cyanobacteria have the potential to produce toxins that can be harmful to the environment, animals, and public health. Prevention of pathogen contamination is a high priority for water suppliers. Extensive watershed and reservoir testing using indicator organisms is conducted by DWSP and MWRA (Table 3-5).

Table 3-5: Bacteria Testing Summary

Sample Location	Agency	Test	Standard
Intake to Carroll Treatment Plant and Chicopee Valley Aqueduct	MWRA	Fecal Coliform	*Federal Surface Water Treatment Rule (SWTR):* Fecal coliform concentrations at a reservoir intake of an unfiltered system shall not exceed 20 colonies per 100 ml in 90 percent of the samples in any six-month period.
Reservoir	DCR	Fecal Coliform	*Massachusetts Water Quality Standards (314 CMR 4.00):* Water supply intakes in unfiltered public water supplies requires either fecal coliform shall not exceed 20 fecal coliform organisms per 100 ml in all samples taken in any six month period, or total coliform shall not exceed 100 organisms per 100 ml in 90 percent of the samples taken in any six month period. If both fecal coliform and total coliform are measured, then only the fecal coliform criterion must be met.
Stream	DCR	*E. Coli*	*Massachusetts Water Quality Standards (314 CMR 4.05c):* The geometric mean of all *E. coli* samples taken within the most recent six months shall not exceed 126 colonies per 100 ml, typically based on a minimum of five samples, and no single sample shall exceed 235 colonies per 100 ml.

Nutrients

In discussions of water quality, DWSP uses the term nutrients as a category of chemical compounds that promote aquatic plant growth, primarily certain forms of phosphorus and nitrogen. Elevated levels of nutrients and the subsequent increase in aquatic plant growth can be deleterious to aquatic life and can impact drinking water quality. DWSP uses Total Phosphorus, Ammonia-nitrogen and Nitrate-nitrogen to evaluate the nutrient levels in the watershed streams and reservoirs. DWSP collects nutrient samples from the reservoir and its tributaries.

Turbidity

Turbidity is a measure of the clarity of water. Material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. Turbidity samples are collected from watershed streams as part of routine sampling and in special studies to evaluate specific issues, such as monitoring the effectiveness of erosion controls at a construction site. Samples collected for turbidity are analyzed by DWSP staff using a turbidity meter.

Anthropogenic Compounds

There are many non-natural chemicals that pose potential threat to the drinking water supply. These compounds are often defined relative to the environmental laws that regulate the compounds. These materials are grouped in a category called Anthropogenic Compounds for the purpose of this assessment. The category includes hazardous materials, pesticides, Per- and Polyfluoroalkyl substances (PFAS), and Pharmaceuticals and Personal Care Products (PPCPs) as pollutants. These pollutants can find their way into the water supply from human activities via accidents or by deliberate discharges, directly or indirectly, to ground and surface waters. DWSP does not routinely monitor for any anthropogenic compounds in the reservoirs; MWRA has not found any of these items in the regular analyses they perform on the finished water.

Invasive Species

The US Department of Agriculture defines invasive species as a species that is: 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). For water quality and distribution considerations, DWSP is primarily concerned with Aquatic Invasive Species (AIS). DWSP monitors extensively for AIS; MWRA has funded extensive AIS control efforts in the watershed system since 2002 in addition to reservoir-wide surveys to detect new invasives. Terrestrial invasives may not categorically threaten the short-term protection of a drinking water supply, but they can monopolize species composition, interfere with native tree regeneration, and simplify the structural complexity of the watershed cover. Their impact can conflict with watershed objectives for a diverse, resistant, and resilient forest cover.

The potential sources of water quality contaminants most likely to be associated with the activities identified are presented in Table 3-6.

DWSP staff conducted a review of each watershed to assess the potential threat from the pollution sources described above. The assessment process provided important information that was used to update the watershed control programs. The following is a brief summary of the detailed description developed for each watershed along with the ranking of the potential threat to water quality in each watershed. This assessment is summarized in Table 3-7 at the end of this Section.

Table 3-6: Potential Sources of Water Quality Contaminants

Source	Pathogens	Nutrients	Turbidity	Anthropogenic Compounds	Invasive Species
Wildlife	Yes	Yes	Yes		Yes
Public Access/Recreation-	Yes	Yes	Yes	Yes	Yes
Timber Harvesting			Yes	Yes	Yes
Roadways/Railways/Utilities			Yes	Yes	Yes
Agriculture	Yes	Yes	Yes	Yes	Yes
Construction			Yes	Yes	Yes
Commercial, Industrial, and Governmental Sites	Yes	Yes	Yes	Yes	Yes
Residential Sites	Yes	Yes	Yes	Yes	Yes
Wastewater	Yes	Yes		Yes	
Future Growth	Yes	Yes	Yes	Yes	Yes
Security Threats	Yes			Yes	

3.4.1 Wildlife

Wildlife populations can directly threaten water quality through bacterial contamination from bird and mammal feces, unstable beaver dams, and indirectly through herbivore over-browsing that impacts forest regeneration. Water quality issues most likely to be created or spread by wildlife are pathogens, nutrients, turbidity and sedimentation, and invasive species. Burrowing mammals are a threat to infrastructure and are also considered in the threat assessment.

Predicted warming temperatures might also impact migratory behavior of wildlife, with greater numbers of waterfowl remaining in the area for an extended period of time. Higher temperatures could delay or prevent reservoir ice cover, allowing direct access by gulls, geese, and ducks throughout the winter and increasing the possibility of contamination by nutrients and pathogens.

Quabbin Reservoir

The types of wildlife most closely monitored at Quabbin are: 1) ring-billed gulls, herring gulls, great black-back gulls, Canada geese, and other waterfowl; 2) beaver and muskrat; and 3) white-tailed deer and moose. The threat from wildlife within the Quabbin Reservoir watershed is assessed through a wide range of monitoring activities and protection procedures to document their presence, type, and activity. General and systematic monitoring is conducted on a daily basis in the water quality monitoring program, on a weekly basis in the CVA Shoreline Weekly Survey (looking for nuisance animals), on a biweekly basis in the watershed monitoring program, and a monthly basis in the reservoir monitoring program. Targeted monitoring and protection activities are conducted through

the Gull Harassment Program, the Canada Goose Population Control Program, Pathogen Control Zone Program, and the White-tailed Deer Management Program.

FY24-FY28 Watershed Program System-wide Assessment of Importance for Planning: High.

Ware River

Data on the wildlife resources and their impacts in the Ware River Watershed come from surveys (e.g., monitoring of moose sign, aquatic invasive surveys of ponds and rivers), staff reports (e.g., about beaver-plugged road culverts), observations made during Environmental Quality Assessments, and via water quality sampling results. Additional data comes from the New England Research Institute for Moose and Forest Dynamics at UMass Amherst and from the Division of Fisheries & Wildlife. Deer hunting has historically been allowed throughout the Ware River watershed, which has limited the impact from browsing that is seen in Quabbin and Wachusett watersheds.

When water sampling data indicate elevated bacteria counts, staff conduct field investigations to determine the source. The elevated results are frequently attributed to beavers and their habitat; mitigation is performed as necessary.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

Wachusett Reservoir

Wachusett Reservoir, similar to Quabbin, provides a daytime loafing area and nighttime roosting site for a large number of gulls, geese, ducks, and cormorants. Numbers generally begin to increase in late summer and early fall and reach a maximum of up to a few thousand gulls during the winter months when other water bodies freeze. Nesting populations of resident geese utilize the reservoir shoreline and islands. Pathogens and nutrients from avian feces are a significant threat to water quality.

Beaver can cause localized damage to roads, culverts, and trees, and catastrophic beaver dam failure can lead to downstream flooding and elevated concentrations of nutrients, bacteria, and sediment. Burrowing by beaver, muskrat, and other mammals has the potential to damage dikes or dams.

Watershed management dictates that an actively growing, diverse, multi-age forest should be managed for regulating stream flow, maintaining water quality and preventing erosion. Expanding deer populations pose a threat to the forest within areas of the Wachusett Reservoir watershed. The White-tailed Deer Management Program at Wachusett Reservoir and around the Wachusett Reservoir watershed help address the impacts of overabundant deer on tree regeneration and growth.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: High.

Sudbury Reservoir
As a mostly urban/suburban watershed, the wildlife issues present in the Sudbury Reservoir system are not as varied as those in the Quabbin Reservoir, Ware River, or Wachusett Reservoir watersheds. As an emergency water supply, there is less need to manage for water quality impacts from wildlife on the reservoir.

The most serious threat to water quality that is actively managed by DWSP is the resident Canada goose population on the Sudbury Reservoir. Data collected by DWSP Natural Resources staff indicates that the Sudbury and Foss Reservoirs are used by roosting gulls on a regular, but intermittent basis. Control of burrowing animals is important in the Sudbury Reservoir system. Deer hunting is permitted on DWSP-owned lands around the Sudbury Reservoir to help address issues associated with overabundant deer impacts on tree regeneration and growth.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

3.4.2 Public Access/Recreation

Public access is the human presence and activities on DWSP owned lands and waters. The potential threat to water quality from public access and recreation comes both from allowed (e.g., hiking) and prohibited (e.g., swimming, dumping) activities. Pollutants most likely to be introduced to water resources due to public access and recreation are pathogens, nutrients, turbidity, and invasive species.

Quabbin Reservoir
Recreation, both passive and active, by the general public is the most common public access activity on Quabbin lands and waters. Presently the most popular land-based activities at Quabbin include driving for sight-seeing, walking and bicycling (on designated routes), and bird watching. Water-based activities are boat fishing through one of the three Boat Launch Areas and shore fishing from several locations around the reservoir. Unauthorized activities on both DWSP lands and waters are considered a potential threat to water quality.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Ware River
Public access and recreational activities are allowed on designated portions of DWSP's Ware River watershed lands, but are most popular in the areas closest to Route 122. Information on public access and recreation comes largely from staff observations, public interactions, and Watershed Rangers. Recreation is an activity of particular

concern in the Ware River watershed due to: an increase in uncontrolled and/or unauthorized vehicular access or use; the expansion of snowmobiling, mountain biking, and horseback riding; and the extension of a rail trail.

Substantial staff time is now spent dealing with recreational issues, including impact control, working with user groups, and resolving user conflicts. Unrestricted public access can result in dumping and vandalism problems on the watershed. Access to the more remote portions of the watershed is obtained when gates are open for legitimate DWSP activities. Partying, vandalism, and dumping has been an issue in recent years. Off-road vehicle (ORV) usage is occurring illegally in the watershed, resulting in soil erosion, direct water pollution from vehicles driving through streams, littering, and passage into areas not readily accessible to the public. All these impacts are potentially problematic.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Wachusett Reservoir

The *Wachusett Reservoir Watershed 2011 Public Access Plan Update* describes the current status of recreational activities on DWSP lands in the Wachusett Reservoir watershed. The most popular activities on DWSP lands include walking and fishing from shore. Many other activities, including trapping, boating, biking, and horseback riding are not allowed, or allowed in limited areas.

Enforcement of DWSP public access regulations and assessment of impacts from public access on DWSP land is done primarily by the Watershed Rangers. Watershed Rangers interact with the public to prevent or reduce inappropriate recreational uses.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Sudbury Reservoir

The Sudbury Reservoir land holdings are a popular area for the surrounding watershed communities, which are much more highly populated than any other part of the system. Wachusett/Sudbury Ranger staff regularly patrol to enforce DWSP public access requirements. Illegal swimming chronically occurs at certain spots around the two reservoirs, in particular the train trestle crossing the Foss Reservoir. Boating violations mostly occur from the launching of small craft at nearby roadways or adjacent private lands. Shoreline fishing is currently allowed along most of the Sudbury Reservoir shoreline, with a fishing season that runs from the first Saturday in April until November 30 each year, provided no ice is present.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

3.4.3 Timber Harvesting

The maintenance and diversification of forest cover is an excellent strategy for supporting watershed protection efforts. Timber harvesting in Massachusetts is a highly regulated activity controlled by the MA Forest Cutting Practices Act (FCPA; MGL Chapter 132, §§ 40-46 and 304 CMR 11.00). Harvesting on DWSP lands is also conducted under additional layers of water quality protection that are outlined in the comprehensive *2017 Land Management Plan*. Risks to water quality may arise from a variety of harvesting-related activities including road and landing construction and use; crossing streams and wetlands; harvesting in wetlands and riparian zones; mechanical site preparation; and spills of hazardous materials from equipment. The pollutants most likely introduced to the watershed through timber harvesting are organic and mineral sediments, which can affect turbidity, and anthropogenic compounds. However, due to the extensive regulation and oversight of timber harvesting on both DWSP and private lands, this activity is rated as a low potential risk to water quality in all four watersheds.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

3.4.4 Highways/Railways/ROW

The threats to water quality from roads, railways, and Rights-of-Way (ROWs) include pollutants transported by stormwater runoff, releases of fuel or transported products caused by accidents, and maintenance practices such as herbicide treatment of ROWs or sand and salt application for ice and snow treatment. The construction of new roadways or improvements to existing ones can lead to problems with erosion and sedimentation unless adequate management practices are utilized. The pollutants of concern related to Highways/Railways/ROW are turbidity, anthropogenic compounds, and invasive species.

Long term increases in specific conductance in watershed tributaries and in the reservoirs suggest that salt applied during winter storms remains present in groundwater and surface water throughout the year. Best management practices may slow the movement of road salt runoff but do not prevent salt from eventually reaching the reservoir. DWSP will examine all potential causes of the specific conductance increase and will propose specific remedial action if it is needed.

Quabbin Reservoir
In the Quabbin Reservoir watershed there are many locations where roads and streams intersect, and it is likely that a piped drainage outfall or paved chute empties directly into a tributary. Maintenance of these roads is the responsibility of Massachusetts Department of Transportation Highway Division (MassDOT), local communities, or DWSP; DWSP maintains over 200 miles of roads on its property. There are no functioning railways located in the Quabbin Reservoir Watershed. Annual reviews of ROW maintenance plans are conducted for the three electrical utilities in the Quabbin Reservoir Watershed.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Ware River
The issues of concern related to roadways, railways, and other ROWs in the Ware River mainly relate to fuel or other hazardous material spills and the application of pesticides to control vegetation growth along those corridors. Despite the fact that the Ware River watershed is situated in a relatively rural part of Massachusetts, there are still a number of transportation and transmission corridors that pass through the watershed. These include six numbered state highways, many town roads, one active railway, and several electrical transmission lines. GIS data indicates that there are approximately 272 miles of roadways in the watershed, seven miles of active railroad lines, 12 miles of above-ground utility transmission lines and another 12 miles of underground cable line. These land uses represent linear access points into the heart of the watershed, many of which cross or run adjacent to streams, rivers, wetlands and other water bodies, that may also involve activities that are potentially harmful to water quality (e.g., vegetation control operations).
DWSP lands in the Ware River watershed have historically been much more open to vehicle access than its counterpart in either the Quabbin Reservoir or Wachusett Reservoir watersheds. This poses a particular challenge in regard to controlling illegal dumping, vandalism, and other access-related issues. Some town roads in the Ware River Watershed are dirt with country drainage, often draining directly to resource areas. Stormwater impacts along existing public ways, especially those adjacent to steep slopes, can be exacerbated under current statewide subdivision control laws which allow “Approval Not Required” house lots (MGL c. 41, §§81L and P), as there are no requirements for improved drainage with this common form of development.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Wachusett Reservoir
There are nearly 500 miles of primary and secondary roadways, including Interstate 190, and almost thirty miles of railroad tracks in the Wachusett Reservoir watershed. The transportation of hazardous materials has a high potential risk to water quality due to the proximity of a number of roadways and railroads to the reservoir. While the construction of Best Management Practices (BMPs) and reconfiguration of drainage

pathways has removed almost all direct discharges to the reservoir and consequently reduced the risk from an accidental release, the risk remains high due to train traffic; recent changes in railroad management, however, has improved operations, facilities, and communication. Local fire departments have been provided training and access to emergency response materials by DWSP to help prevent any hazardous materials spilled from reaching the reservoir.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: High.

Sudbury Reservoir

There are over 265 miles of roads throughout the Sudbury and Foss basin. Two of Massachusetts's major thoroughfares bisect the watershed: the Massachusetts Turnpike, running east/west, and Interstate 495, running north/south. There are also four heavily traveled state numbered routes that pre-date the modern highways: Rte. 9, Rte. 20, and Rte. 30 running east/west, and Rte. 85, running north/south. Approximately 9 miles of rail line operated by CSX runs in an east/west direction across the watershed. The rail line and the Turnpike both travel across the southerly section of the Foss Reservoir. Rte. 9 runs along the southern border of the two reservoirs, and Rte. 85 crosses the Sudbury Reservoir at its western arm near its connection with the Open Channel.

DWSP depends on the local public works departments, MassDOT, and CSX to safely operate their respective road or rail line. The most significant risk from this myriad of transportation corridors is an accidental spill of hazardous materials. DWSP utilizes an Emergency Spill Management Plan and protocol developed in association with MWRA and local responders. These procedures were utilized successfully in 2004 to contain a spill of diesel fuel from a school bus parking yard that drained directly to Foss Reservoir.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: High.

3.4.5 Agriculture

Threats to water quality from agriculture are related both to the keeping of livestock and to the cultivation and harvest of crops. This category also includes hobby farms, backyard horses, and kennels. Pollutants of concern from agriculture are pathogens, nutrients, turbidity, and anthropogenic compounds. The percentage of land in agricultural use is very low in all watersheds, and most of the agricultural operations are small. DCR and MassDEP regulations (see Section 3.2.11) provide setbacks and buffers that further protect water resources.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

3.4.6 Construction

Threats from construction activities include earth moving with inadequate erosion and sediment controls, releases from construction equipment, and invasive species growth in disturbed areas. The pollutants of concern are turbidity, anthropogenic compounds, and invasive species. Construction is a threat to water quality from activities such as land clearing and earth moving for the creation of new driveways, access routes, drainage basins, septic systems, and building lots. These activities can be the source of nutrients and sedimentation. In addition, unprotected work sites during construction activities, coupled with inadequate erosion and sedimentation controls, can also yield turbidity and nutrients into nearby water bodies.

Quabbin Reservoir

Over seventy percent of the watershed is protected open space, where new construction is not allowed. Areas where construction is possible have significant protection from zoning. Construction activity is principally residential.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

Ware River
A few towns in the Ware River watershed have experienced rapid growth over several years, at times overwhelming the ability of local boards to monitor and control construction activity. Parts of the Ware River watershed are in what is known as the "Sprawl Frontier" of Boston and Worcester, an exurban area likely to continue growing.

A significant portion of the new construction in the watershed is occurring on hillsides that are less stable and thus more prone to erosion and sedimentation during the construction phase. In some cases the hillsides developed or slated for development lie directly above water resource areas with little or no intervening level uplands to mitigate the effects of construction-induced runoff.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Wachusett Reservoir
Construction is still active in the watershed. Identification of construction activities is accomplished through regular communication with local boards and commissions, review of Watershed Protection Act applications, Massachusetts Environmental Policy Act filings, and sites regulated through EPA Municipal Separate Storm Sewer Systems (MS4) and Construction General Permits.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Sudbury Reservoir
The Sudbury Reservoir watershed is in a very active area for construction and redevelopment of currently developed sites. In addition, DWSP land holdings are small and development has occurred in close proximity to the reservoirs.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

3.4.7 Commercial/Industrial/Governmental Sites

Threats to water quality from activities on commercial, industrial, or governmental sites include increased runoff from large amounts of impervious surfaces commonly associated with these uses, and the potential release of materials stored and used on-site. Discharges to the ground via shallow injection wells or infiltration devices can lead to groundwater contamination and long-term water quality problems. Pollutants of concern most likely to be generated from commercial, industrial, and governmental sites are anthropogenic compounds.

Quabbin Reservoir

Facilities evaluated in this category at Quabbin Reservoir include automotive repair shops, a junk yard, community Department of Public Works garages, DWSP facilities, a sawmill, and gravel pits. There are a very limited number of these sites, and they are generally well regulated by MassDEP and local officials.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Ware River

Most commercial and industrial establishments in the Ware River watershed are small retail establishments, primarily located in the towns of Hubbardston and Rutland. There are a variety of governmental offices and other facilities in the watershed, including schools, town halls, libraries, fire stations, DWSP facilities, and town garages. In addition, there is a MassDOT maintenance facility located on the shore of Long Pond in Rutland that could be of concern if a spill should occur onsite. Numerous gravel pits are scattered throughout the watershed, evidence of the glacial history of the area.

There are no active solid waste facilities in the Ware River watershed at the present time. There is one active landfill just off the watershed downstream of the Shaft 8 Intake. Recent EQA assessments identified an old, overgrown landfill in Templeton that was not properly closed.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Wachusett Reservoir
There are many businesses and industries within the Wachusett Reservoir watershed, mostly concentrated in a few areas of Holden and West Boylston, especially along Routes 12 and 122A. Governmental sites such as state and municipal office complexes, schools, highway department facilities, DWSP facilities, and public safety buildings are scattered throughout watershed communities.

Staff made a concerted effort to gather information on any location that uses, stores, or generates hazardous materials, closed landfills, and on all spills and releases of hazardous materials. Information including hazardous waste generator status was added to more than 200 files.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Sudbury Reservoir
There are several nodes of commercial and industrial activities in the Sudbury and Foss Reservoirs watershed, mostly clustered around the major transportation arteries of the Mass Turnpike, I-495, and Route 9. While many of these sites are in the western edge of the watershed, the Framingham Technology Park is situated adjacent to Foss Reservoir. Commercial activity also spreads along the length of Route 9 as it borders the two reservoirs, and there is a strip of commercial sites along Route 85 to the northwest of Sudbury Reservoir.

According to a 2010 study completed by the MetroWest Regional Collaborative and the Metropolitan Area Planning Council, it is noted that the Route 9 corridor along Southborough, Framingham, Natick and Wellesley has the potential to expand commercial space by 88 percent under current zoning by-laws. In addition, traffic would also be expected to grow by 40 percent with this development. While towns are pushing to increase this economic development, “smart growth” design would decrease commercial space, according to the Collaborative.

There are three closed or inactive solid waste facilities in the Sudbury Reservoir basin. Spills or releases of hazardous materials of certain concentrations are reportable to MassDEP under the Mass Contingency Plan (MCP). DWSP monitors submitted reports of cleanup efforts and relays concerns to MassDEP as conditions warrant for these sites.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

3.4.8 Residential Sites

The threats to water quality from practices associated with residential use include nutrients and pesticides from lawn care products, unmanaged pet waste, disposal of pharmaceuticals, personal care products and household hazardous materials, and use of non-native species in landscaping or aquaria. The major pollutants of concern for residential sites are pathogens, nutrients, anthropogenic compounds and invasive species.

Quabbin Reservoir
Residential use is quite limited in the Quabbin Reservoir watershed at less than two percent of total land use. Although there can be some impact from residential sites, they are considered a low potential threat to water quality at Quabbin Reservoir.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

Ware River
There are no indications of significant issues related to residential sites in the Ware River watershed except for occasional septic system failures or other localized problems. Some residential sites have had releases of oil from heating oil storage tanks. Encroachments, however, are a concern as homeowners sometimes "extend" their property onto adjacent state land. Encroachment onto DWSP lands is a long-standing issue with impacts throughout the watershed. Encroachment can range from mild – cutting of foot paths or trails – to severe – storing of excavators, digging, vehicles abandoned on DWSP property. Another concern related to residential development is the conversion of summer cottages to year-round residences; there is the potential for water quality impacts, at least localized, since this often occurs along lake shores.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Wachusett Reservoir
Population in the Wachusett Reservoir watershed has increased by about ten percent in the past fifteen years, with a majority of the growth taking place in Rutland and Holden, two communities with sewered portions of town. An increase in population means increased residential use and a subsequent increase in potential problems. Household pets, especially dogs, have been identified as a possible major source of pathogens in the Wachusett Reservoir watershed. Lawn care and large household gardens are a potential source of nutrients, pesticides, and herbicides, and in extreme cases can result in erosion and sedimentation problems. Control of insect or rodent pests in and around residential development can lead to contamination of groundwater and surface

water. Household use of hazardous materials leads to an increased risk of accidents or inappropriate disposal.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Sudbury Reservoir
Almost one third of the Sudbury Reservoir watershed is in residential development, with over 140,000 residents in the five towns encompassing this watershed. Stormwater runoff from residential sites poses a risk to the water supply. Dumping into storm drains, pet waste, improper disposal and storage of hazardous materials, automobile fluid leaks, fertilizer and pesticide use makes its way into the reservoir via storm drains and tributaries during rain events.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

3.4.9 Wastewater

Human wastewater may be treated with on-site systems or connected to a sewer for treatment at a municipal wastewater treatment plant. Properly functioning on-site treatment systems should not cause contamination of either groundwater or surface waters. Recent studies have indicated that some chemical compounds, including Pharmaceuticals and Personal Care Products (PPCPs), may not be removed in septic systems. Municipal sewerage systems in the watershed system transport sewage out of the watershed. Municipal sewers can cause water quality problems from events such as breaks in sewer lines and sewer pump failures. The primary pollutant of concern in this category is pathogens. In addition, human wastewater can contain nutrients and anthropogenic compounds.

Quabbin Reservoir
There are no sewered areas in the Quabbin Reservoir watershed. All homes and facilities are served by on-site wastewater disposal. Wastewater is considered a low potential threat to water quality given the overall low population density in the watershed and the current state-wide and watershed specific regulations in place for installation, repair, and conversion of septic systems.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

Ware River

Most towns in the Ware River watershed rely on on-site septic systems. Current Title 5 regulations, technological advances in septic system design and installation, and increasing oversight by local boards of health have improved over the past several years. As failed systems are identified, they are repaired or replaced with better-functioning systems. On small lots where space limitations prevent conventional systems (e.g., around lakes or ponds), failed systems or cesspools are commonly replaced by tight tanks, an improvement over pre-existing conditions.

Sewer lines exist in only two relatively small parts of the Ware River watershed – in and around the center of Rutland and in a small portion of Templeton. In both cases, the wastewater collected in these systems is transported off-watershed.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Wachusett Reservoir

A majority of homes, businesses, and industries in the Wachusett Reservoir watershed utilize on-site wastewater disposal. On-site systems are monitored by DWSP staff to ensure that wastewater disposal issues do not become a water quality problem by investigating any reports of failing septic systems. Routine water quality monitoring of tributaries is used to detect any dramatic increases in fecal coliform concentrations that may be linked to problems with septic systems.

Major investments in constructing and maintaining sewers in key locations of the watershed have been made by DWSP, MWRA, predecessor agencies, and local municipalities, including the original 1930s era Rutland-Holden trunk line, the 1980s Rutland-Holden relief line, and the more recent $83 million expansion in West Boylston and Holden. Many homes in the Wachusett Reservoir watershed are now connected to these municipal sewer systems, which treat and discharge effluent off-watershed. All properties with available sewer connections in West Boylston were required to connect by July 2007, and most have done so, with more than seventy percent of the town now connected to the municipal sewer system. Individual homes and businesses in Holden are not required to connect to the sewer, but more than fifty-five percent in Holden are now connected.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

Sudbury Reservoir

The majority of the Sudbury Reservoir watershed is sewered. The town of Framingham is serviced by the MWRA sewer system. The city of Marlborough and the town of Westborough have their own municipally operated sewer service, while the town of Northborough is partially sewered using Marlborough's facilities. Portions of

Westborough and Northborough still utilize septic systems. The Town of Southborough relies solely on septic systems, with no plans to add sewers. The 2009 Town of Southborough Open Space Plan notes: “A vote to install sewers has always been rejected because of concerns over the increase in development density that sewers historically bring.” None of the municipal wastewater treatment plant discharges are within the Sudbury Reservoir watershed.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

3.4.10 Future Growth

Changes in land use without careful planning can have long-term impacts on hydrology and water quality, as unregulated growth and development can introduce a variety of pollutants into tributaries and the reservoir. Potential contaminants are closely related to zoning and include pathogens, nutrients, turbidity, anthropogenic compounds, and invasive species.

Quabbin Reservoir

Land ownership analyses and Watershed Protection Act maps are the primary tools used to assess future growth in the Quabbin Reservoir watershed. Watershed town zoning maps and master plans can also help assess potential growth impact on individual towns. At the state level, Executive Office of Energy and Environmental Affairs (EOEEA) conducted a build-out analysis for all towns. Permanent land protection has increased in the watershed over the past decade; however growth is also increasing all around the perimeter of the watershed. Staff are observing growth as remote parcels are developed according to local zoning bylaws, which often specify a density of a new dwelling on every one or two acres. Ongoing and potential future growth has increased as development continues to push west. Despite the presence of Quabbin Reservoir, DWSP and other protected lands, and the general rural nature of the watershed, there will continually be pressure for future growth in the watershed as land prices remain relatively low compared to the developed portions of the state.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Ware River
Future growth in the Ware River watershed can be affected by a variety of factors, including statewide and local decisions related to zoning and land use practices, economic conditions, and open space protection programs. EOEEA build out data suggests that almost 23,000 acres in the Ware River watershed are potentially available for future growth. While much of this land is located in the upper reaches of the watershed, significant acreages of developable land are also available in relatively close proximity to the major tributaries. Portions of the watershed with easy access to Route 2 in Templeton and Phillipston are likely to experience significant growth in the future. The eastern portions of the watershed are within what has been described as the "Sprawl Frontier" of Boston and Worcester. Growth in Rutland (25.5 percent) over the last census period was more than twice as rapid as any other watershed community and four times the rate overall in Worcester County; the town continued to grow an additional 7.6 percent since 2010. Exurban growth will likely continue apace, especially in those areas with significant amounts of developable privately-owned lands, barring significant economic disruption or increases in gasoline prices.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Wachusett Reservoir
Population in the Wachusett Reservoir watershed continues to increase, placing additional pressure on undeveloped lands. Total population of the six primary watershed communities increased 8 percent between 2010 and 2022. Not all communities are experiencing an equal amount of pressure since the 2010 census, with small increases in Sterling, West Boylston, Princeton and Paxton, a moderate increase Boylston (though much of the town is not withing the watershed), and the most significant gains in Holden (see Table 2-4).

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Medium.

Sudbury Reservoir
The Sudbury Reservoir watershed is part of the MetroWest region, a focal point for growth in the greater Boston region. Its location and transportation infrastructure provide access to employment, services, and other amenities. There is little land available, however, for new development, so future growth will be more likely to result in redevelopment of properties already in residential, commercial, or industrial use.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

3.4.11 Security Threats

The probability of intentional contamination of a drinking water supply is relatively low, but the issue is taken seriously by all water utilities. Watershed Security Programs provide surveillance of the watershed and protect the water supply system from intentional malicious actions. DWSP, working with MWRA, have made many improvements to strengthen security measures that protect the watershed system.

FY24-FY28 Watershed Protection Program Assessment of Importance for Planning: Low.

3.4.12 System-wide Assessment of Potential Threats

A summary of the relative potential water quality threats from land uses and activities, to be used for watershed protection program planning is presented in Table 3-7.

A reminder that these evaluations are made under a hypothetical scenario where the existing DWSP control programs do not exist. Because DWSP has an extensive watershed protection program in place, the rankings should not be interpreted as the actual risk to the DWSP system.

Table 3-7: DWSP Watershed System-wide Assessment of Potential Contaminant Sources for Watershed Protection Program Planning FY24-FY28

Source	Quabbin (Active)	Ware (Active)	Wachusett (Active)	Sudbury (Emergency)
Wildlife	High	Low	High	Medium
Public Access/ Recreation	Medium	Medium	Medium	Medium
Timber Harvesting	Low	Low	Low	Low
Highways/ Railways/ROW	Medium	Medium	High	High
Agriculture	Low	Low	Low	Low
Construction	Low	Medium	Medium	Medium
Commercial/ Industrial/ Government Sites	Medium	Medium	Medium	Medium
Residential Sites	Low	Medium	Medium	Medium
Wastewater	Low	Low	Low	Low
Future Growth	Medium	Medium	Medium	Low
Security Threats	Low	Low	Low	Low

Each reservoir has a method to release excess water when above capacity. The Quabbin Spillway (above) and Wachusett Spillway (right) sends water, respectively, to the Swift River and Nashua River. The Sudbury Reservoir (below)was designed to spill over the face of the dam into the Sudbury River.

4 Watershed Protection Control Programs

The DCR DWSP Watershed Protection Program provides a drinking water source of exceptionally high quality. DWSP is committed to the goal of maintaining and enhancing this level of quality for future generations. In order to achieve this goal, DWSP has organized its efforts into programs that control water quality threats identified in ongoing assessments. This concept is used to manage staff, set priorities, and establish budgets. The programs are elastic, with the ability to shift in response to organizational changes as well as emerging issues as they are identified by DWSP.

The DCR DWSP Watershed Protection Program provides a drinking water source of exceptionally high quality. DWSP is committed to the goal of maintaining and enhancing this level of quality for future generations.

DWSP protection efforts are organized into sixteen programs in this iteration of the Watershed Protection Plan. In comparison, the *2019-2023 Watershed Protection Plan* organized the protection program in fifteen programs. This plan includes all the protection program components from previous plans, reorganized to better reflect current internal organizational structure.

The overall goal of the control programs is to develop proactive strategies to prevent water quality problems wherever possible and to respond to detected problems quickly to limit their potential impact. The sixteen programs and their goals are shown in Table 4-1.

The Sudbury system is an emergency supply, and so the protection program conducted by DWSP is less aggressive than the program in the active supply watersheds. As shown in Table 4-1, a subset of the sixteen control programs is utilized in the Sudbury to provide an appropriate level of watershed protection.

Implementation of the DWSP Watershed Protection Plan is an iterative and ongoing process. It builds on an extensive body of work conducted by DWSP staff.

Implementation of the DWSP Watershed Protection Plan is an iterative and ongoing process. It builds on an extensive body of work conducted by DWSP staff. Table 4-2 summarizes the relation between DWSP's Control Programs and the potential pollutant sources for which they are most effective. The purpose of this table is to illustrate that DWSP has developed multiple, overlapping control programs to protect from potential contamination threats and provide effective water supply protection.

The following sections provide a description of each program as it relates to the entire watershed system. Subsequent sub-sections describe how these control programs are developed and implemented, respectively, for Quabbin Watershed, Ware River Watershed, Wachusett Watershed, and Sudbury Watershed.

Table 4-1: DWSP Watershed Protection Control Programs

DWSP Programs	Goal	Quabbin, Ware, Wachusett	Sudbury
Land Acquisition	Purchase critical lands by fee and Watershed Preservation Restriction (WPR) using money allocated for land acquisition in MWRA's capital budget as well as other funding sources and gifts.	Yes	
Watershed Preservation Restriction Monitoring	Maintain control of watershed lands through stewardship of Watershed Preservation Restrictions.	Yes	
Land Management	Maintain a vigorously growing, multi-aged, multi-species forest using forest management programs developed by DWSP staff. Manage all lands to minimize potential water quality impacts.	Yes	Yes
Wildlife Management	Protect the water supply and infrastructure from adverse impacts caused directly or indirectly by wildlife. Protect common, rare, and significant wildlife species and their habitats.	Yes	Yes
Public Access Management	Manage public access to DWSP lands and waters to protect water quality in compliance with Watershed Protection regulations (313 CMR 11.00) and all other applicable laws (including 310 CMR 22.00) through policies established in Public Access Management Plans.	Yes	Yes
Watershed Security	Maintain and improve watershed security programs and provide surveillance of critical watershed facilities to protect the watershed system from potential threats.	Yes	Yes
Infrastructure Maintenance	Maintain the integrity of all High Hazard class dams under joint DWSP/MWRA control, maintain and improve DWSP facilities and equipment, and maintain internal roadways to allow them to sufficiently support their use for the water supply protection program.	Yes	Yes
Watershed Protection Act	Enhance protection of the water supply through implementation of the Watershed Protection Act, which regulates land use in critical areas of the watersheds.	Yes	
Education and Outreach	Provide educational opportunities and materials to inform the public about watershed protection and drinking water issues.	Yes	Yes
Water Quality and Hydrologic Monitoring	Conduct tributary and reservoir sampling. Identify short-term water quality problems and maintain the historical record for long-term trend analyses. Use data analyses and assessments in management decisions.	Yes	Yes

DWSP Programs	Goal	Quabbin, Ware, Wachusett	Sudbury
Watershed Monitoring and Assessment	Use Environmental Quality Assessments, site inspections, local board meetings, and information from Watershed Rangers and other DWSP staff to identify and address potential water quality threats and possible violations of state or federal regulations.	Yes	Yes
Aquatic Invasive Species Management	Prevent introduction and spread of Aquatic Invasive Species through monitoring, public education, exclusion, and decontamination measures at potential entry points. Implement active management when appropriate.	Yes	Yes
Wastewater Management	Monitor on-site wastewater disposal systems and operation of Rutland-Holden sewer to ensure proper treatment of wastewater.	Yes	
Stormwater Management	Reduce water quality problems caused by uncontrolled stormwater.	Yes	
Emergency Response	Maintain and improve short- and long-term emergency response capabilities to protect the water supply.	Yes	Yes
GIS	Leverage GIS technology to support and enhance all DWSP programs.	Yes	Yes

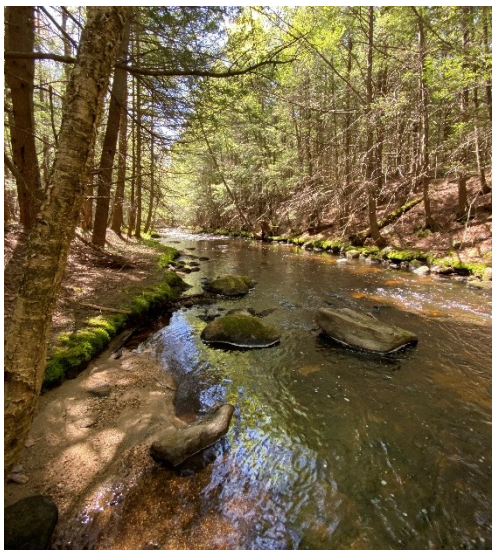
Table 4-2: Potential Contaminant Sources and Watershed Control Programs

Potential Contaminant Sources	Land Acquisition	Watershed Preservation Restriction Monitoring	Land Management	Wildlife Management	Public Access Management	Watershed Security	Infrastructure	Watershed Protection Act	Education and Outreach	Water Quality/Hydrologic Monitoring	Watershed Monitoring and Assessment	Aquatic Invasive Species	Wastewater Management	Stormwater Management	Emergency Response	GIS
Wildlife			**Yes**	**Yes**			**Yes**			**Yes**	**Yes**	**Yes**				**Yes**
Public Access/ Recreation			**Yes**	**Yes**	**Yes**	**Yes**	**Yes**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**		**Yes**	**Yes**
Timber Harvesting			**Yes**					**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Wastewater	**Yes**	**Yes**						**Yes**		**Yes**	**Yes**		**Yes**		**Yes**	**Yes**
Roadways, Railways and Rights-of-Way					**Yes**			**Yes**		**Yes**	**Yes**	**Yes**	**Yes**		**Yes**	**Yes**
Agriculture	**Yes**	**Yes**						**Yes**	**Yes**	**Yes**	**Yes**		**Yes**	**Yes**		**Yes**
Construction	**Yes**	**Yes**						**Yes**		**Yes**	**Yes**		**Yes**	**Yes**		**Yes**
Commercial, Industrial, and Governmental Sites	**Yes**	**Yes**						**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**		**Yes**
Residential Sites	**Yes**	**Yes**						**Yes**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**		**Yes**
Future Growth	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**			**Yes**		**Yes**	**Yes**	**Yes**	**Yes**	**Yes**		**Yes**
Security Threats	**Yes**				**Yes**	**Yes**	**Yes**			**Yes**	**Yes**				**Yes**	**Yes**

4.1 Land Acquisition

Goal

Purchase critical lands by fee and Watershed Preservation Restriction (WPR) using money allocated for land acquisition in MWRA's capital budget as well as other funding sources and gifts.



Land procurement permanently protects watershed land from development and allows DWSP to maintain the ideal water quality protection landscapes by restoring and/or maintaining a stable vegetative cover. The Land Acquisition Program purchases critical lands in fee or by Watershed Preservation Restriction (WPR, see 4.2). The purchase or control of additional forested, relatively undisturbed properties provides permanent protection to watershed lands, proactively reduces threats to water quality that would result from additional urbanization, helps mitigate the growing impacts of climate change, and increases the adaptive capacity of DWSP's existing holdings. Benefits to the source water supply system include preventing urbanization-related water quality degradation from threats such as bacteria, pathogens, nutrients, sediments, heavy metals, other pollutants associated with waste management, and increased and more rapid storm water discharge caused by expanding impervious surface area.

Land acquired in fee joins DWSP's vast network of lands which are sustainably managed as structurally and compositionally diverse forests. This has the added benefit of making these lands more resilient to impacts of climate change, such as severe weather events, temperature and precipitation changes, outbreaks of disease, and invasive plant and pest infestations. Land protected using WPRs remain privately owned and managed but are subject to restrictions that prevent the land from being developed and forests from being converted to other land uses. Permanently protecting these forested landscapes helps to sequester carbon and prevent carbon emissions that come with land being developed.

The Land Acquisition Program uses money allocated in the MWRA's capital budget for the purchase of lands in fee or by WPR. DWSP also utilizes other funding sources whenever possible, such as state and federal grant programs and partner contributions, and encourages landowners

to take advantage of tax benefit programs that allow them to make gift or bargain sales to the state. Acquisition of WPRs rather than fee interest is preferred due to lower costs to the program.

The Land Acquisition Panel (LAP) was formed by DWSP to help determine the most appropriate and efficacious way to prioritize land procurement options. The LAP, which includes DCR and MWRA staff, developed a land acquisition model for the Wachusett, Quabbin and Ware River watersheds that incorporates various geographic, hydrologic, and regulatory parameters to develop weighted criteria to identify critical parcels. The model has been a part of LAP's land acquisition prioritization process in the Wachusett watershed for over 25 years, and the Quabbin and Ware River watersheds since 2019. DWSP continues to review the model to determine how it may need to be modified so it can be best utilized.

Taking a holistic approach to procurement evaluation not only allows for prioritization of critical water resources, but also healthy, robust ecosystems that enhance the resilience and adaptive capacity of the watersheds in the face of climate change impacts.

In addition to utilizing the land acquisition model, the LAP also considers climate resiliency, biodiversity and habitat value, connectivity with other protected lands, boundary consolidation, and management or access enhancement, such as in-holdings, to assess and prioritize acquisition options. Taking a holistic approach to procurement evaluation not only allows for prioritization of critical water resources, but also healthy, robust ecosystems that enhance the resilience and adaptive capacity of the watersheds in the face of climate change impacts.

Since 1985, DWSP has acquired over 27,820 acres in both fee (18,730 acres) and WPR (9,090 acres). Of the total acquired acreage, $144.4 million of ratepayer money has been spent on over 23,905 acres, and $3.7 million in federal funds purchased 2,569 acres. DWSP aims to obtain the best value for the Commonwealth when purchasing land by encouraging landowners to take advantage of tax programs through making bargain sales or donating the entire cost of their property. Approximately 1,350-acres have been acquired since 1985 through no cost or gift transactions.

All recommendations from the previous *Watershed Protection Plan (FY19-FY23)* have been addressed. As land became available, Land Acquisition Panel meetings were held to review proposals and highly ranked parcels were acquired. Staff made a concerted effort to leverage funding by protecting lands with WPRs and acquiring land through gifts or through cooperative efforts with land trusts. However, commercial and residential development continues in the watershed system. All future efforts to acquire land will be focused on highly rated remaining undeveloped areas. Due diligence and negotiations continue on additional properties in the watershed. Numerous smaller holdings within the watershed system will continue to be offered as changes in ownership and market conditions motivate people to sell undeveloped tracts. The MWRA has agreed to continue to financially support land acquisition efforts, committing $5 million dollars in Capital funds for FY24 through FY28.

4.1.1 Quabbin Reservoir

The watershed has been divided into three land acquisition priority sectors: primary is the West Branch of the Swift River and Hop Brook, secondary is the Middle Branch of the Swift River along with Fever Brook, and tertiary is the East Branch of the Swift River.

Accomplishments

- Spent approximately $2.19 million on land acquisition in the Quabbin Reservoir watershed from FY18 to FY22, procuring over 1,095 acres of which 166 acres were in fee and 929 in WPR (Table 4-3).
- Of the total acquired acreage, $1.6 million of ratepayer money was spent on over 744 acres, $593,000 of federal funds purchased 267 acres, and 84 acres were acquired through no cost or gift transactions.
- Watershed Preservation Restrictions made up most parcels acquired (14) in the past five years but three new properties were fee acquisitions.
- The acreages and percentages of DWSP-protected land in the watershed over time are summarized in Table 4-3 and Table 4-3. As indicated, the percentage of DWSP-protected land in the watershed has increased from 54.3 percent in 1985 to 62.0 percent at the FY22.

Table 4-3: DWSP Purchases within the Quabbin Watershed, FY18-FY22

Year	Number of Properties	Fee Acres	WPR Acres	Total Acres	Cost*
FY18	9	48.4	416.3	464.7	$454,000
FY19	2	0	208	208	$250,000
FY20	3	117.8	135.6	253.4	$605,000
FY21	0	0	0	0	$0
FY22	2	0	169.8	169.8	$292,000
TOTAL	**16**	**166.2**	**929.6**	**1095.8**	**$1,601,000**

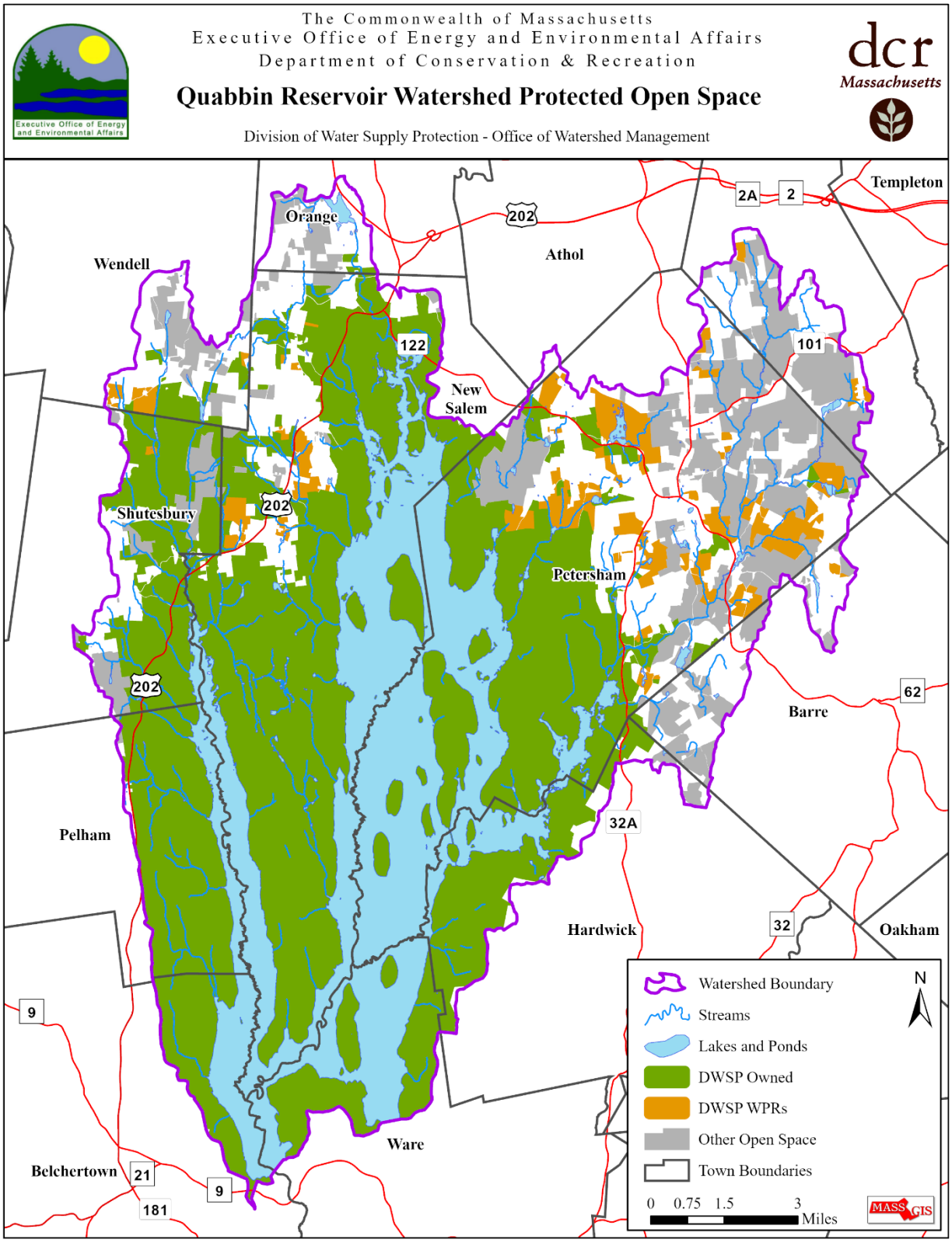
Source: DWSP.
* Cost represents funding by MWRA. Does not include $593,000 in federal funds or gifts.

Table 4-4: DWSP Protected Land with the Quabbin Reservoir Watershed 1985-2022

1985 Acres	1985 Percent of Watershed	2008 Acres	2008 Percent of Watershed	2013 Acres	2013 Percent of Watershed	2022 Acres	2022 Percent of Watershed
51,792	54.3	54,050	56.6	55,355	58.0	59,084	62.0

Source: MassGIS, 2022. Acreage includes WPRs. Acreage differentials from previous years due to increased accuracy of MassGIS data.

Figure 4-1: Quabbin Reservoir Watershed Protected Open Space



4.1.2 Ware River

DWSP currently controls 25,207 acres in the Ware River watershed, or 41 percent of the land area. This acreage includes the most critical property closest to the Shaft 8 intake building on the Ware River, providing protection to the most vulnerable land within the watershed.

DWSP maintains a long-term perspective on the water needs of the Commonwealth. Land will continue to be procured within the Ware River watershed while the acquisition costs are a value to the Commonwealth and MWRA. Acquisitions will be primarily driven by water quality considerations, such as proximity to tributaries and intakes, that represent key parcels for acquisition as the water resources from the Ware River water will continue to be utilized, as legislatively allowed, within the DCR/MWRA water supply system.

These Ware River watershed land acquisition model divides the region into two land acquisition priority sectors: primary is the Burnshirt River, Canesto River and Natty Pond Brook, and secondary is the West Branch, East Branch, and Pommagusset Mill/Parker Brooks.

Accomplishments

- Acquired over 456 acres in the Ware River watershed from FY18-FY22, of which 68 acres were in fee and 387 acres in Watershed Preservation Restrictions (Table 4-5).
- Most of this property, 397 acres, was purchased through the federal Forest Legacy Program's "Q2W" Project utilizing $922,500 in federal funds. The remaining acquired properties were gifted to DWSP.
- Watershed Preservation Restrictions made up five parcels acquired in the past five years, while three new properties were fee acquisitions.

Table 4-5: DWSP Purchases within the Ware River Watershed, FY18-FY22

Year	Number of Properties	Fee Acres	WPR Acres	Total Acres	Cost*
FY18	3	0	321.5	321.5	$0
FY19	3	60	25.8	85.8	$0
FY20	0	0	0	0	$0
FY21	0	0	0	0	$0
FY22	2	8.7	40.1	48.8	$0
TOTAL	**8**	**68.7**	**387.4**	**456.1**	**$0**

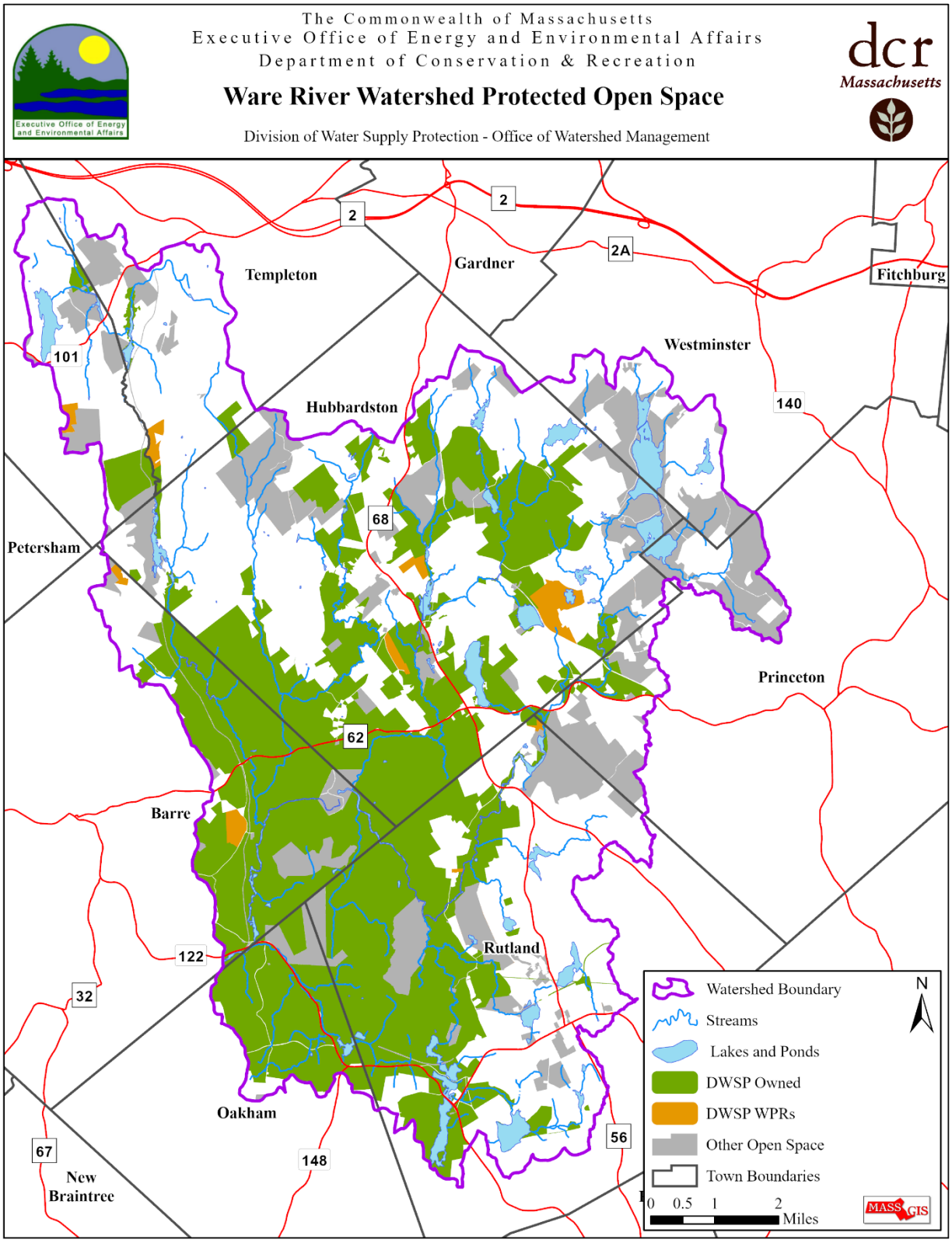
Source: DWSP.
* Cost represents funding by MWRA. Does not include $922,500 in federal funds or gifts.

Table 4-6: DWSP Protected Land within the Ware River Watershed, 1985-2022

1985 Acres	1985 Percent of Watershed	2008 Acres	2008 Percent of Watershed	2013 Acres	2013 Percent of Watershed	2022 Acres	2022 Percent of Watershed
19,300	31.3%	24,137	39.1%	24,232	39.3%	25,207	40.9%

Source: MassGIS. Acres includes WPRs. Acreage differentials from previous years due to increased accuracy of MassGIS data.

Figure 4-2: Ware River Watershed Protected Open Space



4.1.3 Wachusett Reservoir

DWSP continues to concentrate efforts toward acquiring land in the Wachusett Reservoir watershed due to the lower percentage of the watershed that is under DWSP ownership and the continued increase in property values compared to the Ware River and Quabbin. Land protection priorities in the Wachusett Reservoir watershed are primarily driven by water quality considerations, such as proximity to tributaries and intakes, which are reflected in the Wachusett Reservoir watershed land acquisition model. The watershed has been divided into three land acquisition priority sectors: primary is the Reservoir Basin, secondary is the Central Basin, and tertiary is the Worcester Basin.

Accomplishments

- Spent approximately $5.3 million of ratepayer funds on land acquisition in the Wachusett Reservoir watershed from FY18 to FY22, procuring over 695 acres of which 606 acres were in fee and 89 acres in Watershed Preservation Restrictions (Table 4-7).
- Utilized other funding sources to offset the costs of acquisition. Federal Forest Legacy funds totaling $285,000 were used towards the purchase of 99 acres of the acquired area, and another 81 acres were obtained through no cost or gift transactions.
- Acquired eighteen parcels in the past five years as fee acquisitions and five new properties as WPRs.

Table 4-7: DWSP Purchases within the Wachusett Watershed, FY18-FY22

Year	Number of Properties	Fee Acres	WPR Acres	Total Acres	Cost*
FY18	7	238.9	31.9	270.8	$1,910,000
FY19	8	93.7	43.7	137.4	$1,706,000
FY20	4	73.2	0	73.2	$622,000
FY21	2	37.1	0	37.1	$517,500
FY22	2	162.9	13.8	176.7	$568,000
TOTAL	**23**	**605.8**	**89.4**	**695.2**	**$5,323,500**

Source: DWSP. *Cost represents funding by MWRA. Does not include an additional $345,000 in federal funds or gifts.

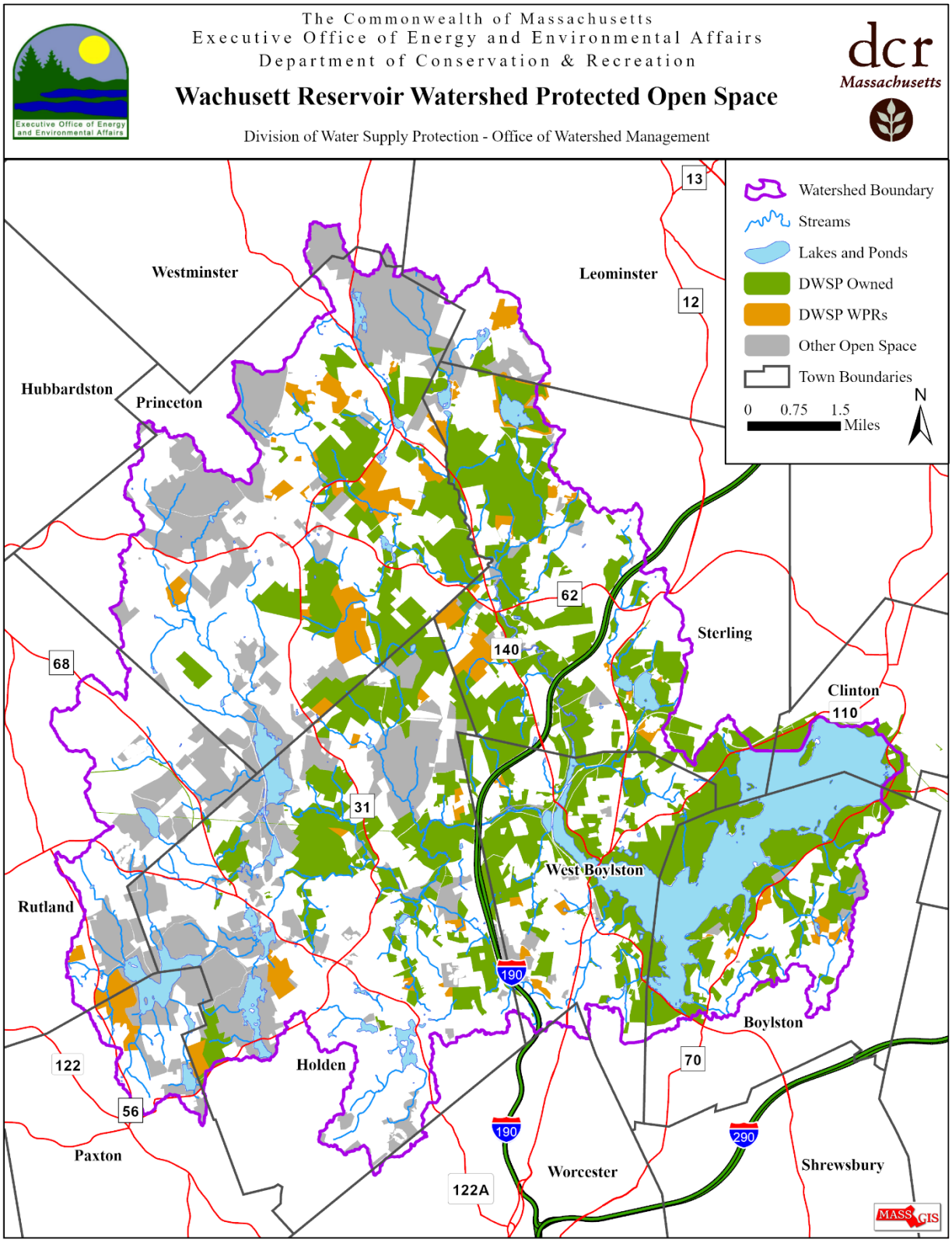
More than $120 million has been spent since 1985 on watershed land acquisition in the Wachusett Reservoir watershed. The MWRA's 1993 Consent Order with the MassDEP required DWSP to acquire or control 25 percent of the Wachusett Reservoir watershed in order to avoid filtration. The DWSP achieved that goal through a combination of aggressive land acquisition and a "care and control agreement" with State Parks and the DFW that incorporated their lands located in the watershed. As indicated in Table 4-8, the percentage of DWSP-protected land in the watershed has increased from 7.9 percent in 1985 to 29.0 percent at the FY22. In addition to the acreage under control of DWSP, there are approximately 12,200 acres (17.2 percent) of other protected open space in the Wachusett watershed.

Table 4-8: DWSP Controlled Land within the Wachusett Reservoir Watershed, 1985-2022

1985 Acres	1985 Percent of Watershed	2008 Acres	2008 Percent of Watershed	2013 Acres	2013 Percent of Watershed	2022 Acres	2022 Percent of Watershed
5,608	7.9%	18,888	26.8%	20,084	28.4%	20,584	29.0%

Source: MassGIS. Acreage differentials from previous years due to increased accuracy of MassGIS data.

Figure 4-3: Wachusett Reservoir Watershed Protected Open Space



4.1.4 Sudbury Reservoir

The Sudbury and Foss Reservoirs are an emergency source supply for the MWRA. DWSP and the MWRA focus the limited resources available for land procurement in the active water supply watersheds of Quabbin Reservoir, Ware River, and Wachusett Reservoir, so there is no land acquisition occurring in the Sudbury Reservoir watershed. DWSP continues to manage the area acquired during the development of this water supply in the late 19th century (Table 4-9 and Figure 4-4).

Table 4-9: DWSP Protected Lands in the Sudbury and Foss Reservoirs Watershed

DWSP Fee (acres)	DWSP WPR (acres)	Other Protected (acres)	Total Protected (acres)	Land Area (acres)	Protected as percent of Land Area
2,367	0	1,810	4,177	16,298	25.6

4.1.5 Payments in Lieu of Taxes

The Watershed Management Payment in Lieu of Taxes (PILOT) program is the method that compensates the 29 communities that contain the land owned by the agency for water supply purposes. (Figure 4-5). The Watershed Management PILOT program is mandated by MGL Chapter 59, Section 5G. This legislation updated old payment laws MGL Chapter 59 Sections D, E, & F, which were written in the 1940s, and did not value lands in all communities currently entitled to payments. The current PILOT law was first ratified in 1984 for the Quabbin Reservoir and Ware River watersheds. The law was amended in 1987 to include communities in the Wachusett and Sudbury Reservoir watershed.

The Watershed Management PILOT amount is determined by multiplying the Department of Revenue (DOR) valuation of DWSP land by the local commercial tax rate. The process used by DOR for valuing State Owned Land (SOL – which includes DCR Watershed Management) under MGL c. 58 changed in FY19 due to the Mass Municipal Modernization Act, Chapter 218, Section 108 of the Acts of 2016. Under the new process, DOR determined a base year SOL valuation for each community as of January 1, 2017. This base year valuation used DOR guidelines on segmenting lands into prime lots (the requisite frontage and area needed to build a single-family home in each community), rear acreage, and unbuildable acreage, as well as discount adjustments for the total number of prime lots and total acreage. After a hearing and appeal process, base year SOL valuations were finalized.

Going forward under this process, the base year valuations are now adjusted every two years by a percentage equal to the change in a city or town's equalized cash value (EQV). Valuations are also updated annually to include the value of any acquisitions and/or dispositions in a community. Calculations for acquired lands (or dispositions) will be made using the cost per acre average for each town, adjusted by the EQV.

Figure 4-4: Sudbury Reservoir Watershed Protected Open Space

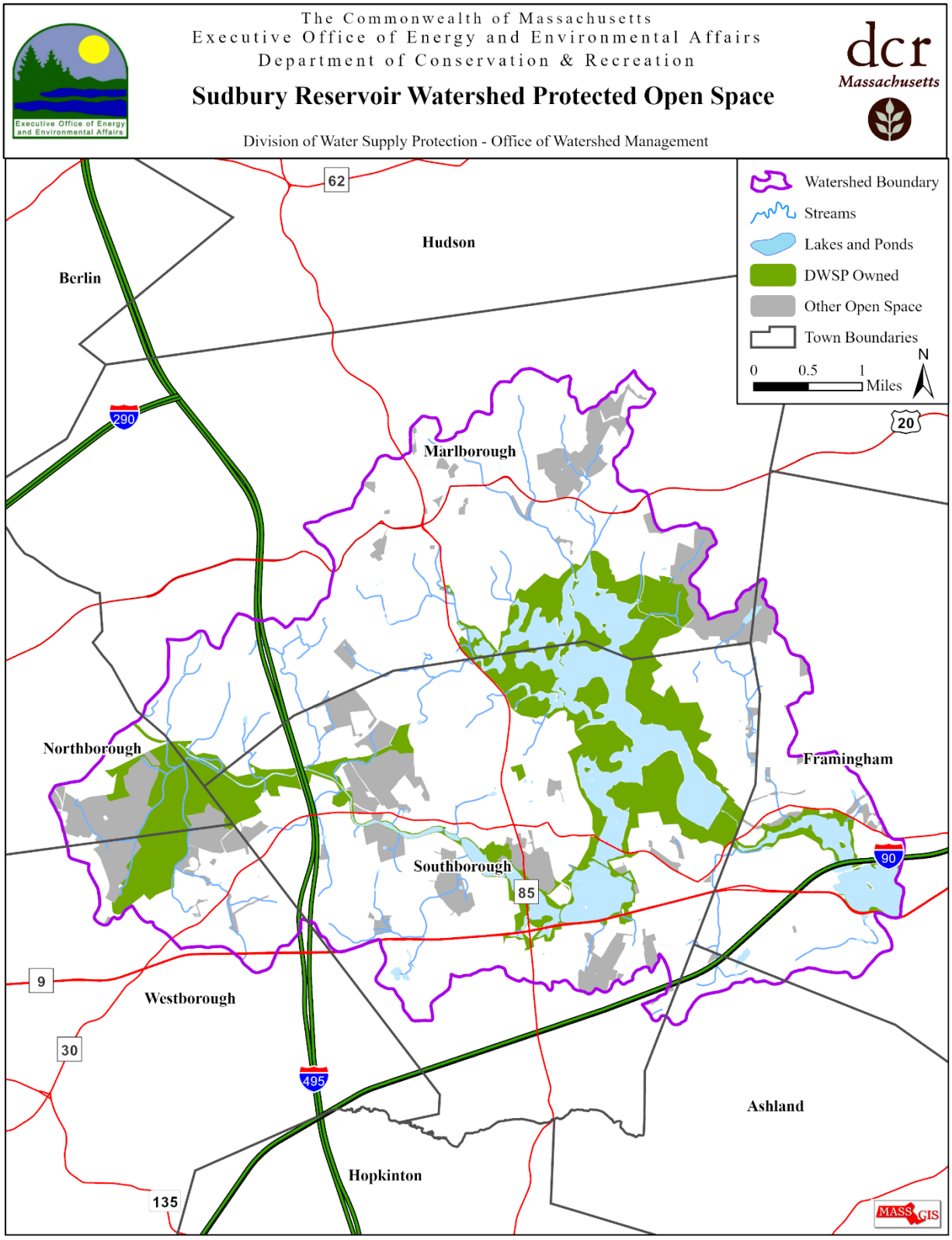
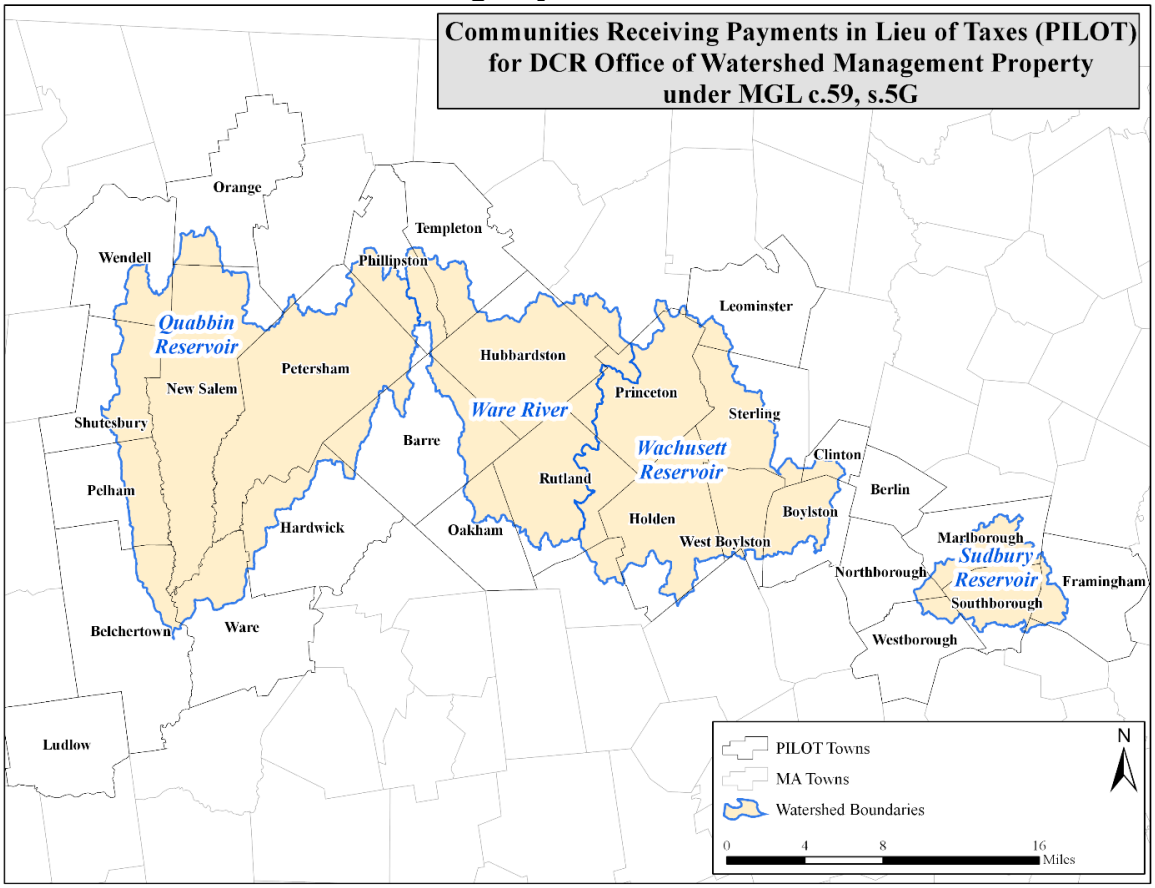


Figure 4-5: Communities Receiving Payments in Lieu of Taxes



Many towns also receive compensation for other State Owned Lands that are not used for water supply protection. The Watershed PILOT program differs from this program in several ways:

- **MWRA ratepayers pay the bill.** Funds for the Watershed Management PILOT payments come from MWRA rate payers who use the reservoir waters; the MWRA provides funding to DCR to make PILOT payments to the watershed towns. Unlike the reimbursement program for other state-owned lands, which are disbursed through the State's Local Aid program ("Cherry Sheets") and is based on legislative allocation, the Watershed Management program is paid in full directly to each community. The DCR payment does not appear on the Cherry Sheet.
- **DCR PILOT utilizes the local commercial tax rate.** Watershed Management PILOT is required to utilize each community's commercial tax rate in calculating the PILOT obligation.
- **The payment can never be less than the previous year.** MGL c. 59, s. 5G states that Watershed Management PILOT can never be less than the previous year's payment. This "hold harmless" clause provides the watershed communities the security of level funding even if a drop in valuation or tax rate

combines to lower the calculated PILOT. Over the past five years, the annual hold harmless total has averaged $2 million.

- **There is a separate payment for annexed lands in the Quabbin Watershed.** Four towns were lost due to the creation of the Quabbin Reservoir: Dana, Enfield, Greenwich, and Prescott. The area from the four towns was added (or annexed) to six towns that surround the reservoir: Belchertown, Hardwick, New Salem, Pelham, Petersham, and Ware. The Watershed PILOT legislation requires a second payment to be made for these annexed lands. The 27,345 acres are valued separately by the Department of Revenue and classified as "Annexed Lands" within PILOT calculations. Approximately $660,000 is paid annually for Annexed Lands, which is about a quarter of the PILOT made to the Quabbin communities and around eight percent of the total annual PILOT.

Since the [Watershed Payment in Lieu of Taxes] legislation's enactment, more than $191 million has been paid to watershed communities that contain water supply lands

Approximately $42 million has been distributed in PILOT since FY2019 (Table 4-10). Since the legislation's enactment, more than $191 million has been paid to watershed communities that contain water supply lands (Figure 4-6). There is a wide variation in the per-acre PILOT payment from community to community due to varying real estate prices, which are a key factor in determining land valuation and local tax rates (Figure 4-7).

Figure 4-6: PILOT Payments by Year, 1985-2023

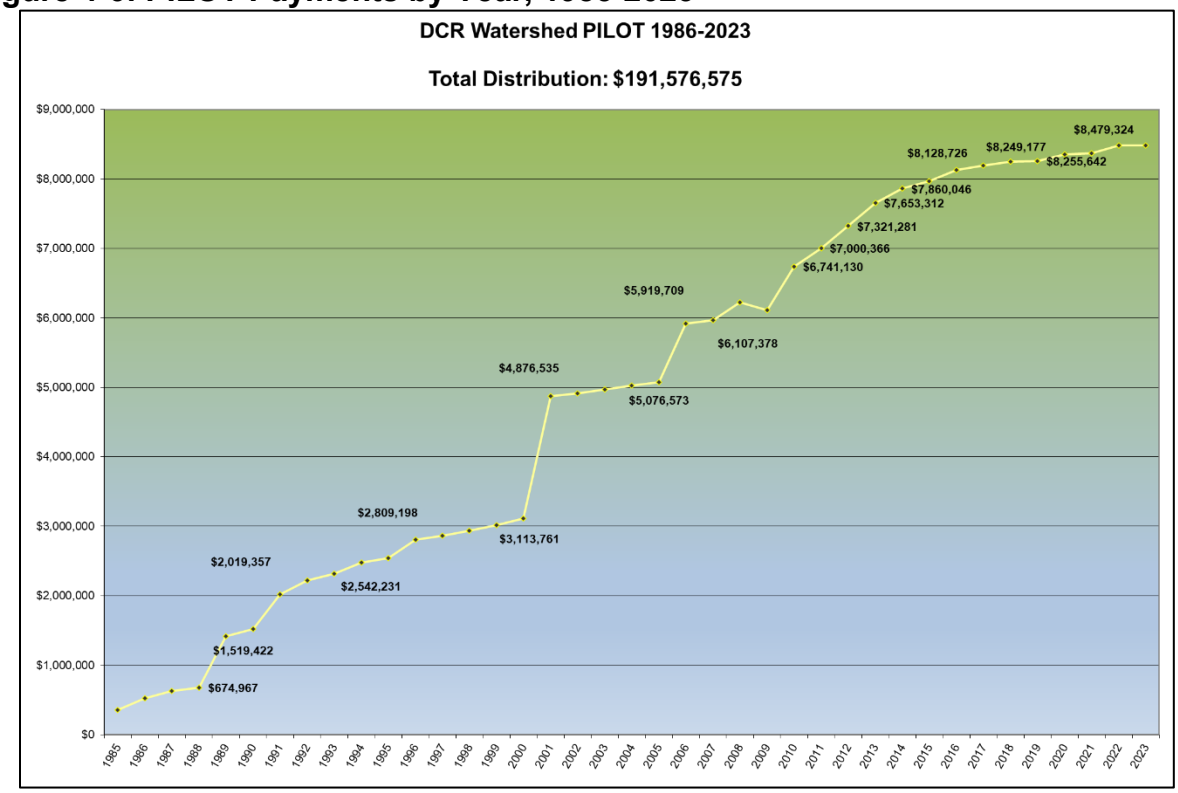
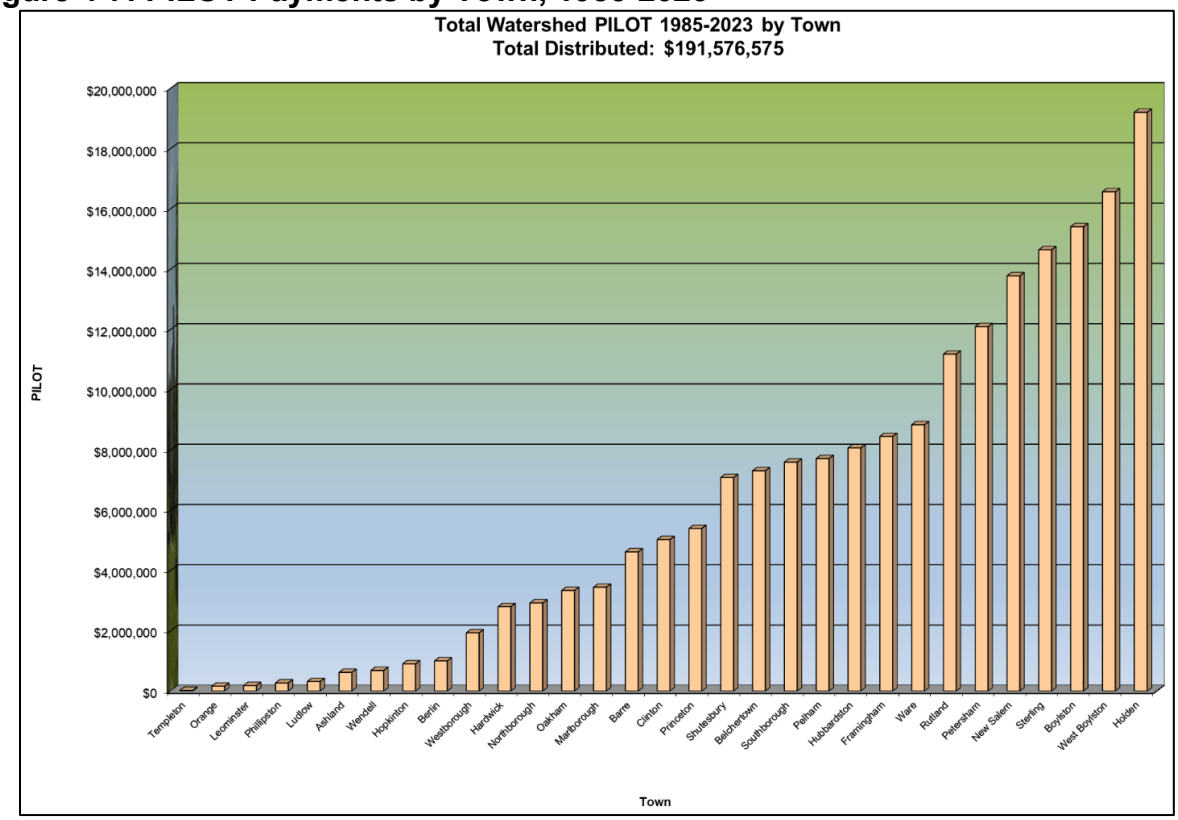


Figure 4-7: PILOT Payments by Town, 1985-2023



DWSP worked closely with DOR's Division of Local Services (DLS) to make Watershed PILOT data available on the DOR's website in a fashion similar to other community monetary distributions; this portal became available in FY23. Additional details about the PILOT program are also available on the DWSP website.

Table 4-10: DCR Watershed Payment in Lieu of Taxes to Watershed Towns FY19-FY23

Community	Total PILOT FY19-FY23	Total Harm Holdless FY19-FY23	Percent of PILOT from Hold Harmless
Barre	$930,845	$344,075	37
Belchertown	$1,285,370	$139,848	11
Belchertown – Annexed Lands	$253,125	$100,533	40
Berlin	$284,328	$12,147	4
Boylston	$2,987,677	$287,897	10
Clinton	$1,029,745	$139,087	14
Framingham	$1,309,655	$424,563	32
Hardwick	$612,707	$18,724	3
Hardwick – Annexed Lands	$4,705	$1,692	36
Holden	$4,598,080	$1,461,075	32
Hubbardston	$1,797,617	$26,355	1
Leominster	$43,440	$27,274	63
Ludlow	$52,620	$29,248	56
Marlborough	$564,010	$298,135	53
New Salem	$2,602,355	$961,955	37
New Salem – Annexed Lands	$1,008,020	$444,313	44
Northborough	$517,335	$59,629	12
Oakham	$735,340	$59,041	8
Orange	$55,524	$1,280	2
Pelham	$1,690,430	$477,453	28
Pelham - Annexed Lands	$190,485	$103,237	54
Petersham	$1,483,610	$622,665	42
Petersham – Annexed Lands	$1,016,530	$586,793	58
Phillipston	$59,565	$47,729	80
Princeton	$1,438,233	$29,624	2
Rutland	$2,629,300	$668,168	25
Shutesbury	$1,496,960	$661,624	44
Southborough	$1,532,551	$40,993	3
Sterling	$4,057,698	$67,314	2
Templeton	$5,410	$943	17
Ware	$966,305	$266,070	28
Ware - Annexed Lands	$837,905	$366,319	44
Wendell	$160,497	$0	0
West Boylston	$3,417,910	$1,370,522	40
Westborough	$281,664	$5,698	2
TOTAL	**$41,937,544**	**$10,152,028**	**24**

Source: DCR DWSP, 2023 and MA Department of Revenue.
Note: PILOT can never be less than the previous year's payment. Hold Harmless is the difference between the minimum PILOT due calculated by multiplying the DOR valuation by the community's commercial tax rate and the previous year's PILOT.

4.1.6 Five Year Objectives

- Purchase lands in fee or through a Watershed Preservation Restriction (WPR).
- Prioritize acquisitions through land sensitivity models and other relevant criteria such as climate resiliency, biodiversity and ecosystem health, connectivity with other protected lands, boundary consolidation, and management or access enhancement.
- Present information about proposed parcels to the Land Acquisition Panel (LAP) and MWRA Executive Board for review and approval.
- Review existing Land Acquisition models and modify as necessary.
- Partner with other state agencies, federal agencies, municipalities, and land trusts/conservation organizations to advance mutual land protection goals and increase conservation capacity.
- Leverage state and federal grants, partner contributions, and gifts and bargain sales, whenever possible and appropriate.
- Complete a DWSP Watershed focused vulnerability assessment to identify vulnerable areas that could benefit from land acquisition.
- Create a DWSP Land Procurement Plan for the next 10 years.

4.2 Watershed Preservation Restriction Monitoring

A Watershed Preservation Restriction (WPR) is a legal agreement between DWSP and a private landowner where the landowner sells or donates the development rights of their property to DWSP while keeping ownership of the land. The WPR remains in effect in perpetuity and carries forward even if the landowner sells the property.

In recent years there has been a strong preference for acquisition of WPRs rather than acquiring land in fee. Lands protected through WPRs are less costly than outright acquisitions and do not involve annual payments in lieu of taxes (PILOT) to watershed towns, as the private landowner continues to pay local real estate taxes. Because WPRs are still privately owned, DWSP has ongoing stewardship obligations to make sure that the landowner is abiding by a list of restrictions, including prohibitions on construction, dumping, mining, and certain agricultural practices. Important objectives of the Watershed Preservation Restriction Monitoring Program are documentation of baseline conditions on all WPR properties, routine monitoring to check compliance with restrictions, resolution of any violations, and maintenance of good working relationships with landowners.

Goal

Maintain control of watershed lands through stewardship of Watershed Preservation Restrictions.

DWSP's first WPRs were purchased during the 1990s, and several WPRs have been purchased each year. There are 152 WPRs covering 9,020 acres.

DWSP continues to acquire new WPRs. As the number of WPRs increases, accomplishing basic stewardship goals with existing resources becomes more difficult and could lead to an increased risk for violations. In FY19, DWSP started utilizing eight other DWSP staff members to assist the WPR Coordinator with WPR monitoring and implemented the use of iPads and ArcGIS online apps to streamline the monitoring and reporting process. These additional resources are helping keep the program on track to meet the goal of one visit every two years. DWSP is also piloting the use of remote monitoring. If proven effective and efficient, remote monitoring will be incorporated into DWSP's

monitoring protocol and reduce the need for more staff as the WPR portfolio grows. Use of an existing statewide database could prove to be beneficial to tracking WPR information; additional staff resources are necessary to help with uploading and managing this DWSP data.

4.2.1 Quabbin Reservoir

There are currently 65 WPRs in the Quabbin Reservoir watershed, covering 4,964 acres. Since FY18, 13 WPRs covering 926 acres have been protected in the Quabbin Watershed. Baseline Documentation Reports were completed for all new acquisitions. High-priority WPR properties were monitored on an annual basis. Other WPRs were generally monitored every two years. DWSP staff worked with landowners to ensure compliance on all WPRs within the watershed. Meetings were held with successor landowners as soon as possible after property transfers to review the WPR terms and answer questions. Several new resources were created and shared with WPR landowners, including a WPR Landowner Handbook, a WPR webpage, and an electronic newsletter.

Because WPRs are still privately owned, DWSP has ongoing stewardship obligations to make sure that the landowner is abiding by a list of restrictions, including prohibitions on construction, dumping, mining, and certain agricultural practices.

4.2.2 Ware River

There are currently 19 WPRs, covering 1,358 acres in the Ware River watershed. Since FY18, DWSP purchased or had donated five watershed preservation restrictions on 388 acres within the Ware River watershed. Baseline Documentation Reports were completed for all new acquisitions. High-priority WPRs properties were monitored on an annual basis. Other WPRs were generally monitored every two years. DWSP staff worked with landowners to ensure compliance on all watershed preservation restrictions within the watershed. Meetings were held with successor landowners as soon as possible after property transfers to review the WPR terms and answer questions. Several new resources were created and shared with WPR landowners including, a WPR Landowner Handbook, a WPR webpage, and an electronic newsletter.

4.2.3 Wachusett Reservoir

Important objectives of the Watershed Preservation Restriction Monitoring Program are documentation of baseline conditions on all WPR properties, routine monitoring to check compliance with restrictions, resolution of any violations, and maintenance of good working relationships with landowners.

There are currently 68 WPRs in the Wachusett Reservoir Watershed, covering 2,964 acres. Since FY18, five WPRs covering 89 acres have been protected in the Wachusett Reservoir watershed. Baseline Documentation Reports were completed for all new acquisitions. High-priority WPR properties were monitored on an annual basis; other WPRs were generally monitored every two years. DWSP staff worked with landowners to ensure compliance on all watershed preservation restrictions within the watershed. Meetings were held with successor landowners as soon as possible after property transfers to review the WPR terms and answer questions. Several new resources were created and shared with WPR landowners including, a WPR Landowner Handbook, a WPR webpage, and an electronic newsletter.

4.2.4 Sudbury Reservoir

There are no Watershed Preservation Restrictions in the Sudbury Reservoir watershed.

4.2.5 Five Year Objectives

- Complete baseline documentation reports prior to WPR acquisition.
- Monitor each WPR every two years; monitor high-priority ones annually.
- Maintain strategy to meet WPR monitoring goal.
- Maintain good working relationships with landowners and resolve WPR violations.
- Maintain records and distribute information as necessary.
- Collaborate with other divisions of DCR, EOEEA, and other statewide conservation programs.

4.3 Land Management

The Land Management program incorporates principles from the current scientific knowledge of watershed and natural resource management to develop and implement policies, goals, and methods for managing DWSP lands. The primary goal of the program is to continue to create and maintain a vigorously growing, multi-aged, multi-species forest using forest management programs developed by DWSP staff. Forest cover provides the best protection for drinking water quality. Maintaining a vigorously growing multi-aged, multi-species forest will provide the best resistance to and resilience following a variety of known and unknown threats. Designated non-forested lands are managed in a manner to minimize potential water quality impacts.

Goal

Maintain a watershed protection forest by managing for a vigorous, multi-aged, species-diverse forest, that provides resistance and resilience to a variety of potential environmental stressors while protecting water quality in perpetuity through sound, sustainable, watershed forest management techniques.

The Land Management program takes guidance from the *DWSP 2017 Land Management Plan* (LMP), which replaces earlier watershed-specific plans and addresses how DWSP cares for and manages Forested Lands, Non-Forested Lands, Wildlife, and Cultural Resources. Specific details of land management activities can be found in the *DWSP 2017 Land Management Plan* and are not reproduced in this document. During the upcoming five-year interim DWSP will review the LMP internally and with outside direction as needed. Any adaptive course corrections determined to be necessary to continue to meet land management goals will be implemented.

EEA's "Forests as Climate Solutions" initiative, launched in June 2023, will accelerate progress toward the state's land conservation goals of protecting 30 percent of the Commonwealth in 2030 and 40 percent in 2050. This program will expand existing state programs, invest in forest conservation, enhance a network of forest reserves, and develop forest management guidelines based on the latest climate science. DWSP will work with this team, bringing its expertise in managing the watershed forest to help develop climate-oriented forestry practices for state lands that increase carbon storage and resilience to climate change.

4.3.1 Forest Management Planning and Implementation

Silvicultural operations (timber harvesting) on DWSP lands are carefully planned and monitored. New forestry projects are proposed annually by DWSP foresters, reviewed by DWSP staff for consistency with goals and practices identified in the LMP, and presented online and at public meetings for comment. Approved projects are then prepared for harvest in compliance with their proposal intent, with any modifications resulting from the internal and public review process, with all applicable regulatory requirements, and with any additional LMP requirements, BMPs, and other considerations.

Water Quality Monitoring and Forest Management

DWSP monitors water quality in the context of forest management activities. Short-term monitoring focuses on sedimentation and turbidity measurements at a selection of temporary forestry stream crossings at each watershed, to assure that BMP implementation is achieving desired water quality standards. An analysis of data collected over more than ten years indicates that DWSP's stream crossing BMPs are tremendously successful in preventing sedimentation and changes to stream turbidity, showing no significant impact above expected background levels. As a result, EQ staff will sample only as needed to address specific issues.

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Long-term monitoring consists of two paired-watershed studies at Quabbin and Wachusett (both treatment and control watersheds at each region), with measurements of water yield and stream chemistry being collected and analyzed to determine watershed-level effects from applied forest management activities. Treatment harvesting has occurred at the Quabbin study and stream monitoring for detection of impacts is ongoing. The treatment harvest at Wachusett is anticipated during the upcoming WPP period.

4.3.2 Forest Inventory and Forest Health Monitoring

DWSP implements a long-term Continuous Forest Inventory (CFI) across all its properties, collecting information on tree volume and growth, harvesting and mortality, species diversity, and forest disturbances. This project has been in place since the early 1960s at Quabbin and Ware River and was expanded to include Wachusett and Sudbury in 2021. Collection methods have been standardized for all DWSP lands and a full analysis of the complete historical dataset is ongoing. An outgrowth of this project will include updating and standardizing forest cover type mapping for all Division lands using land cover classifications developed as part of the updated CFI protocol standards.

Damaging insects and disease-causing organisms are a normal part of the forest ecosystem, but the presence of non-native organisms without natural predators and parasites can be a serious threat. Forest insect populations are influenced by temperature and other environmental conditions, and so future changes in climate can

be expected to affect forest insect outbreaks. In some cases, larger and more frequent insect outbreaks may occur, but in other cases recurring outbreaks may be disrupted. Shifts in temperatures that directly influence insects, as well as reduced host tree resistance caused by changes in precipitation can contribute to forest insect population growth. DWSP's approach to prevention of infestation as well as managing the effects and outcomes if present varies by species and is described in detail in the LMP. Staff routinely spot signs of potential problems related to insects and/or diseases including spongy moth, red pine scale, hemlock woolly adelgid, Emerald ash borer, Spotted Lanternfly, Southern Pine Beetle, and Asian Long-horned Beetle. Staff regularly interact and share information with DCR Forest Health officials and other researchers.

4.3.3 Climate Change Monitoring and Forest Resiliency Data

There is a long history of data collection on DWSP watersheds that includes measurements of physical, chemical, and biological parameters as part of the water quality and forest health monitoring programs. Much of this data could be utilized in detecting and documenting the indicators of climate change.

Many of the forest management resiliency actions suggested by climate change experts are already regularly implemented by DWSP.

Many of the forest management resiliency actions suggested by climate change experts are already regularly implemented by DWSP. For example, simply maintaining and promoting a diverse mix of coniferous and deciduous tree species may minimize changes in water yield as precipitation patterns and hydrology respond to increasing surface air temperatures. However, it is understood that climate change will lead to continued alterations in storm frequency and intensity, and these impacts are likely to additionally impact access by causing forest road erosion and may require the installation of larger culverts to accommodate increases in streamflow volume as a result. Table 4-11 gives an overview of forest resiliency strategies currently being implemented by DWSP.

Table 4-11: DWSP Current Climate Change Forest Resiliency Strategies

Forest Resiliency Strategies	Implementation
A. Sustain fundamental ecological functions	1. Reduce impacts to soils and nutrient cycling. 2. Maintain or restore riparian areas. 3. Reduce competition for moisture, nutrients, and light. 4. Promote carbon sequestration or storage in soils and forest biomass. 5. Avoid stream crossings or use appropriate BMPs when crossings are necessary to reduce impact. 6. Protect and buffer wetlands and vernal pools using recommendations outlined in the LMP and established BMPs to minimize disturbance.

Forest Resiliency Strategies	Implementation
B. Reduce the impact of biological stressors and environmental conditions.	1. Maintain or improve the ability of forests to resist pests and pathogens. 2. Prevent the introduction and establishment of invasive plant species and remove existing invasive species. 3. Address herbivory impact on the regeneration of desired species. 4. Enhance conditions of internal roads, repair and/or upgrade culverts.
C. Reduce the risk and long-term impacts of severe disturbances	1. Alter forest structure or composition to reduce risk or severity of wildfire. 2. Establish fuel breaks to slow the spread of catastrophic fire. 3. Alter forest structure (age classes) to reduce severity or extent of potential damage. 4. Design forest management that mimics a natural disturbance. 5. Promote restoration after a disturbance. 6. Salvage dead or damaged trees.
D. Maintain/create refugia and enhance species and habitat diversity	1. Prioritize and maintain Natural Communities as defined by the NHESP. 2. Promote and maintain at-risk species habitat. 3. Maintain or restore diversity of native species. 4. Retain biological legacies at the species or stand level. 5. Manage for a suite of stand age classes to increase temporal and structural diversity. 6. Manage or restore DWSP defined Focus Areas for specific types of rare habitat.
E. Increase ecosystem redundancy across the landscape.	1. Manage similar stand types over a range of sites and conditions. 2. Manage the forest at the landscape/watershed-level
F. Promote landscape connectivity	1. Reduce forest or stand fragmentation. 2. Maintain and create forest/habitat corridors through management or stand retention.
G. Maintain and enhance genetic diversity.	1. If necessary, use plantings and other native stock from across their native range to establish regeneration. 2. Favor existing genotypes that are better adapted to future conditions.
H. Facilitate community adjustments through species transitions	1. Favor or restore native species that are expected to be adapted to future conditions. 2. Establish or encourage new mixes of native species. 3. Guide changes in species composition at early stages of stand development. 4. Protect future-adapted seedlings and saplings. 5. Target species for harvest that are predicted to be distinctly maladapted to future conditions. 6. Manage for species and genotypes with wide moisture and temperature tolerances.

4.3.4 Terrestrial Invasive Plant Species

Damaging insects and disease-causing organisms are a normal part of the forest ecosystem, but the presence of non-native organisms without natural predators and parasites can be a serious threat to forest health. Terrestrial invasive plant species were discussed in DWSP's *Terrestrial Invasive Plant Management Strategy* (TIMPS, 2011) as well as in the 2017 LMP.

Terrestrial exotic plants may not in themselves threaten the short-term protection of a drinking water supply watershed, but their persistence and potentially invasive nature can monopolize species composition, simplify structural complexity, and damage existing resources. These effects conflict with watershed objectives for a diverse and resilient forest cover to protect water quality. Some invasive plant problems on DWSP properties are the result of former land uses, or of deliberate plantings of species that addressed specific concerns but later exhibited invasive behavior. Other invasive species populations have spread onto DWSP lands from landscaping equipment or construction work, such as roadsides or backyards.

Terrestrial exotic plants may not in themselves threaten the short-term protection of a drinking water supply watershed, but their persistence and potentially invasive nature can monopolize species composition, simplify structural complexity, and damage existing resources

As described in the TIMPS and LMP, a number of invasive plant species widespread in the region are also established on DWSP properties, with several newly introduced species actively spreading. Preventing the introduction and controlling established invasive species is important to maintain favorable conditions for water quality through the ecosystem services provided by a resilient watershed forest.

Within the guidelines of the TIPMS, DWSP has been implementing a variety of small-scale control efforts focused on:

- Grassland and barrens habitat restoration projects.
- Protection of known rare plant species populations.
- Controlling new populations of recently introduced invasive species such as stiltgrass and mile-a-minute vine while they are still possible to be contained.
- Heavy equipment inspections prior to use in forest harvesting activities.

To build upon these efforts, DWSP will develop and implement a watershed-wide terrestrial invasive plant management plan over the next five years. This plan will set goals for invasive and interfering plant survey, mapping, and prioritize control across all DWSP properties. DWSP will describe the use of integrated vegetation management (i.e., mechanical, chemical, biological, and cultural control methods) for the control of terrestrial invasive and interfering plants and in a variety of settings including forests, and describe plans to monitor and evaluate the results of these control efforts for their effectiveness and cost.

4.3.5 The Use of Prescribed Fire

Significant progress has been made to develop a prescribed fire program for silvicultural objectives and to support habitat restoration on DWSP lands. Incorporating prescribed fire as an additional management tool will assist with resiliency goals by diversifying the vegetation communities and species across the watersheds. Fire-adapted plants are often deep-rooted, drought tolerant species that recover quickly after disturbance. They contribute to water filtration, and soil stabilization. Due to lack of fire across the landscape over the last century, these species have declined and been replaced by more generalist, less drought tolerant species. With climate change projections yielding more extreme cycles of drought, incorporating this species diversity is vital. Climate change has facilitated the movement of pathogens and pests affecting forest health, also highlighting the need for diversity of communities and species.

4.3.6 Ecosystem Health through Land Management

A healthy watershed, one that is intact in its physical, chemical, and biological components and their interrelationships, is rich in biodiversity such that it is resilient to withstand change and stressors are essential for long-term water quality. As one of the largest landowners in central Massachusetts, DWSP has an obligation to be good stewards of the land that supports our forest filter. In concert with the Division of Fisheries and Wildlife and the Natural Heritage Program, the DWSP promotes a healthy ecosystem through an active habitat management program for rare natural communities and state-listed wildlife.

The Land Management program has continued to implement the *DWSP 2017 Land Management Plan* to meet the goal of maintaining a diverse and resilient watershed protection forest. The LMP will continue to guide DWSP land management activities in the FY24-FY28 period.

As one of the largest landowners in central Massachusetts, DWSP has an obligation to be good stewards of the land that supports our forest filter.

4.3.7 Quabbin Reservoir

Accomplishments

- Focused regeneration monitoring during the last five years on sampling in areas harvested 15 years earlier.
- Established agenda to work with forest biometricians over the next few years to further refine regeneration data collection methods.
- Included the collection of regeneration data in 2018, 2021, and 2022 forest monitoring.

    - Analysis of the data shows that tree regeneration develops following forest management operations at Quabbin in quantities sufficient to assure the continuation of forest cover.
    - Hardwood tree diversity, however, is still lower than desirable due to a number of factors, likely including the slow recovery from many decades of intense herbivore pressure.
    - Additional discussion of tree regeneration and the influence of current and historical deer density can be found in the Wildlife Management Section of the LMP (4.4.2).
- Remeasured 363 Continuous Forest Inventory (CFI) plots as part of a regular 10-year cycle collaborative effort with UMass following the 2020 growing season.
- Continued to develop remote sensing assessments of spongy moth damage from the CFI dataset that show the Quabbin Reservoir watershed lands are growing more wood volume than is being harvested or lost to mortality.
- Collected baseline data as part of a long-term paired-watershed forestry and water quality monitoring research effort at both Quabbin and Wachusett watersheds.
    - The treatment phase of this study at Quabbin occurred in 2019 with a harvest on the East Branch of Underhill Brook subwatershed.
    - Continued to collect stream data on this stream and the control subwatershed (Middle Branch of Dickey Brook) to follow through on project goals, with a final report expected within the next five years.
- Proposed and reviewed annually new forestry lots and made available for public comment prior to timber marking and sale.
- DWSP foresters issued 43 permits to harvest forest products on 1,404 acres from FY19 to FY23.
- DWSP foresters supervised 48 timber harvest operations, some of which were sold prior to FY19 on 1,407 acres from FY19 to FY23.
- Focused invasive plant control efforts at Quabbin during the last five years on identification and containment of newly found and expanding stiltgrass infestations and sporadic small-scale mechanical treatments of some well-established species by forestry staff.
- Began to identify locations to use prescribed fire as part of silvicultural operations.
    - Advocated for prescribed fire in the promotion and retention of oak, and oak-hickory stands. Prescribed fire is a well-documented tool that assists with the recruitment and maintenance of these species. Oaks tend to be slower growing and shade intolerant. Prescribed fire assists by removing the more competitive and more aggressive species that may outgrow and shade them.
    - Initiated use fire to maintain fields and continued use on restoration areas and woodlands. Benefits of using fire over mechanical treatments include reducing accumulated thatch and litter, allowing for better seed to ground contact, which in turn increases species diversity and native warm season grass recruitment. Fire can also decrease undesirable encroaching woody vegetation and invasives.

    - Started development of a burn plan for the Gay's Hill barrens as part of a pitch pine/oak barrens habitat enhancement project at the north end of Quabbin Reservoir near Blackington Swamp.
    - Developed a burn plan for the Prescott Peninsula fields;13.7 acres of fields were burned in the fall of 2022 as part of a maintenance regime.
- Inspected and maintained 32.6 miles of property boundary line during the past five years. The entire perimeter of DWSP land in the Quabbin Reservoir watershed, excluding the reservoir, is nearly 1,714 miles. Some properties are bounded by roads, railroad frontage, and shorelines; there are sections of boundary that cross swamps and marshes that are considered too difficult to maintain. It is DWSP's goal to utilize a 10-year interval to service the entire area that requires full maintenance.
- Located and investigated six encroachments during the past five years. Although DWSP properties are clearly marked, private landowners sometimes encroach on these properties for their own use.
    - After an initial field investigation, a letter was sent to each property owner; in most cases the encroachment was easily rectified.
    - In instances where the landowner was reluctant to comply, assistance was requested from DCR General Counsel's Office as well as state or local police.
- Continued to contribute to a large monitoring program funded by the National Science Foundation; the National Ecological Observatory Network (NEON) is a continental-scale research platform for discovering and understanding the impacts of climate change, land-use change, and invasive species on ecology. The NEON network is comprised of sites centered in 20 eco-climatic domains representing distinct regions of vegetation, landforms, climate, and ecosystem performance. Both Northeast core sites for this program are located within the Quabbin Reservoir watershed. The aquatic core site is located on DWSP land along Hop Brook in New Salem, and the core terrestrial site is located in Harvard Forest in Petersham.

4.3.8 Ware River

Accomplishments

- Issued timber sale permits for harvests on 15 lots covering 242.1 acres throughout the Ware River watershed from FY19 to FY23, following the standard DWSP forest management proposal review process.
- Completed 16 permitted harvests, some of which were sold earlier, covering 257 acres, from FY19 to FY23.
- Forest monitoring included the collection of regeneration data in 2018, 2021, and 2022.
- Remeasured, 112 Continuous Forest Inventory (CFI) plots following the 2019 growing season as part of the regular 10-year cycle. Monitored terrestrial invasive species as part of CFI plots.
- Initiated research projects looking at controlling herbivory and releasing white oak saplings in collaboration with the Connecticut Agricultural Experiment Station. Included in this research was the construction of a slashwall. The goal

of this project is to use existing material on site to create a natural fence around the harvest to prevent herbivory by deer and moose; results are ongoing.

- Focused invasive plant control efforts at Ware River on multiple habitat restoration projects including the Barre Heath, Oak Hill Wildlife Management Area, and the Twin Hill and Riis Hill field reclamation sites.
- Identified and actively restoring globally rare inland barrens habitats in cooperation with the Massachusetts Natural Heritage and Endangered Species Program, including three locations of inland heathlands.
  - Fire, which will ultimately be the tool used to manage these rare areas, is reintroduced to the habitats after the initial timber harvest to release the understory heathland vegetation.
  - A burn plan is in development for the Pine Plains barrens and Water Supply fields in Rutland. The Pine Plains barrens is a globally rare fire-dependent inland heathland restoration. Many of the fields in the Ware River Watershed have formerly been hayed by lease but are no longer leased and managed internally by DWSP staff.
  - A burn plan for the Barre Heathland restoration has been developed and implemented in April of 2021 over approximately half the current restoration area. This is part of the restoration of a globally rare inland heathland, in which fire will be used to restore and maintain.
- Inspected and maintained 13.1 miles of property boundary line during the past five years. The entire perimeter of DWSP land in the Ware River Reservoir watershed is nearly 176.2 miles. Some properties are bounded by roads, railroad frontage, and shorelines; there are sections of boundary that cross swamps and marshes that are considered too difficult to maintain. It is DWSP's goal to utilize a 10-year interval to service the entire area that requires full maintenance.
- Located and investigated 21 encroachments during the past five years.
  - After an initial field investigation, a letter was sent to each property owner and DWSP met with the property owner on site to discuss the encroachment; in many cases the encroachment was easily rectified.
  - In instances where the landowner was unwilling to comply, assistance was requested from DCR Office of General Counsel.

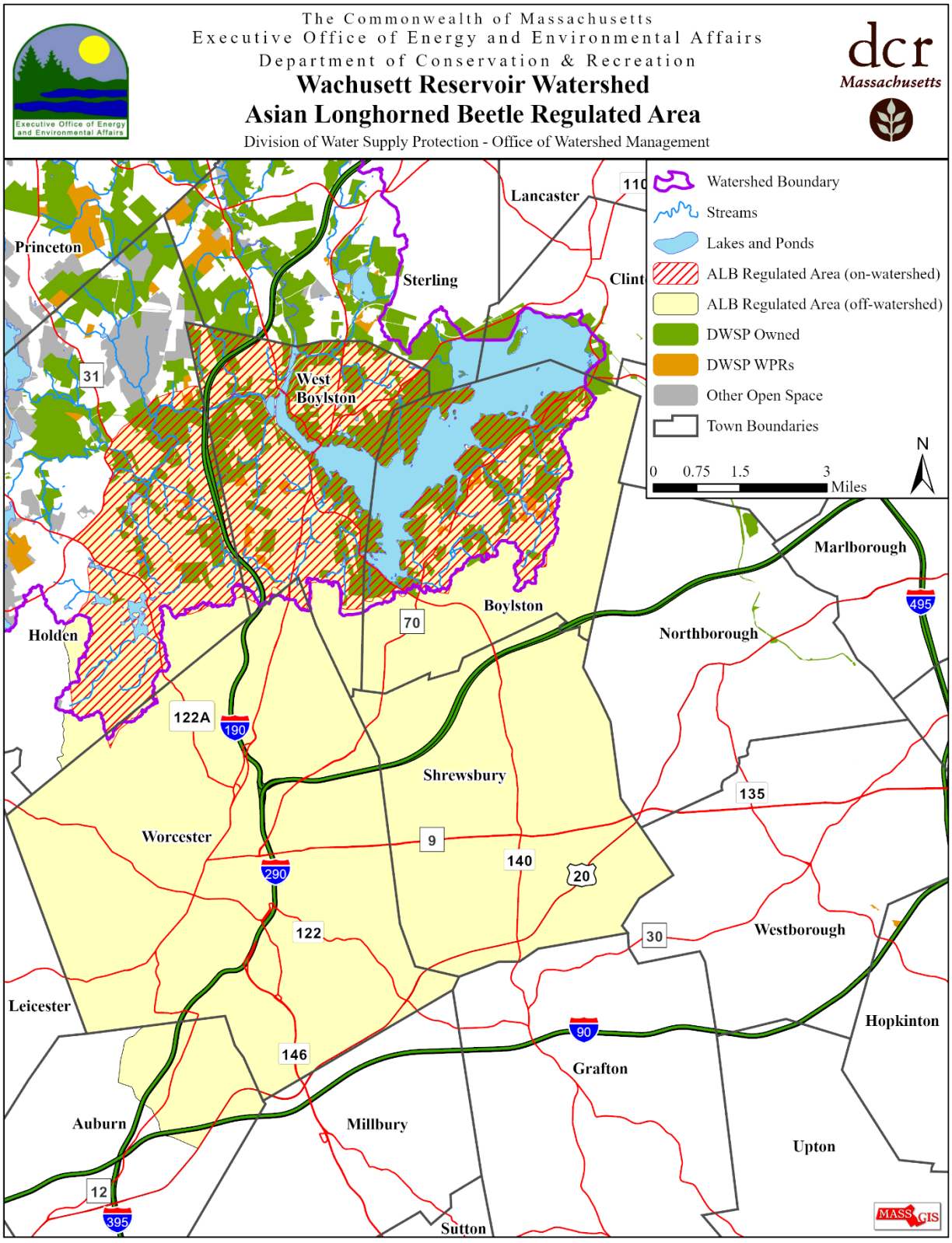
4.3.9 Wachusett Reservoir

Accomplishments

- Prepared and put out for sale 29 timber sales on a combined 1,565 acres.
- Completed 23 sales on a combined 1,164 acres. An additional six lots were completed on a combined 288 acres that were sold prior to 7/1/2018.
- Created 286 acres of young forest as a result of management, helping meet the forest management program goal of being creating a greater diversity of age classes within the forest.
- Developed criteria to decide which DWSP-owned property will be maintained as hay fields through the agricultural permitting system.
  - Created a management plan for every field that has been chosen for continued agricultural use, which includes a map of all required buffers,

specifications for allowable fertilizers and soil testing, and restrictions on timing or number of cuts allowed and the type and frequency of reseeding.
    - Maximized wildlife value on some leased fields with additional restrictions when deemed necessary in order to conserve grassland nesting birds and other wildlife.
- Established and measured for the first time on DWSP lands at Wachusett Reservoir 111 Continuous Forest Inventory (CFI) plots. Data collection occurred following the 2021 growing season.
- Collected baseline data as part of a long-term paired-watershed forestry and water quality monitoring research effort at both Quabbin and Wachusett watersheds.
- Inspected and maintained 76 miles of property boundary line during the past five years. The entire perimeter of DWSP land in the Wachusett Reservoir watershed, excluding the reservoir, is nearly 359 miles. Some properties are bounded by roads, railroad frontage, and shorelines; there are sections of boundary that cross swamps and marshes that are considered too difficult to maintain. Approximately 256 miles of boundary line require full maintenance. It is DWSP's goal to utilize a 10-year interval to service the entire area that requires full maintenance.
- Located and investigated 51 encroachments during the past five years.
    - After an initial field investigation, a letter was sent to each property owner and DWSP met with the property owner on site to discuss the encroachment; in many cases the encroachment was easily rectified.
    - In instances where the landowner was unwilling to comply, assistance was requested from DCR Office of General Counsel.
- Continued to follow and support Asian long-horned beetle eradication efforts. Figure 4-8 shows DWSP property that remains under quarantine.
    - The detection of Asian long-horned beetle (ALB) in Worcester in 2008 resulted in a lengthy and expensive control effort. ALB is one of the most destructive invasive insects in the United States, infesting a wide variety of hardwoods found in the watershed forests.
    - The Massachusetts Cooperative Asian Long-horned Beetle Eradication Project is a coordinated effort by federal, state, and local agencies with the goal of preventing the spread of ALB to other areas of New England. The ALB Eradication Project established quarantine areas and protocols for surveying and eliminating host trees.
    - Asian long-horned beetle host tree removal operations were conducted on 132 acres at nine locations on DWSP properties in the Wachusett Reservoir watershed during the early stages of the control efforts.
    - No sign of any Asian long-horned beetle was found in 2022, the first time this has happened since the eradication program began in 2008.
    - No infested trees have been found in the Wachusett watershed since early 2019 and no beetles have been caught since 2015 in the 300 traps that are put out annually.

Figure 4-8: Wachusett Reservoir Watershed ALB Regulated Area



- The ALB program is nearing the end of the second complete survey of the regulated area as of 2023. It is expected that a third complete survey of the

regulated area will take place, and this is expected to take five years to complete.

- Continued to monitor invasive plant species currently found on DWSP properties in the Wachusett Reservoir watershed, which include Mile-a-minute vine, Japanese stiltgrass, Japanese knotweed, Canada thistle, Norway maple, Asiatic bittersweet, glossy buckthorn, honeysuckle, autumn olive, and multiflora rose.
- Controlled multiple species of invasive plants as part of an ongoing grassland restoration project in West Boylston during the past five years.

4.3.10 Sudbury Reservoir

Accomplishments

- Prepared, put out for sale, and completed one timber sale on 19 acres. Further management of the forest around the Sudbury Reservoir and Foss Reservoir has been put on hold pending efforts to control the deer herd.
- Assessed impact of white-tailed deer on Sudbury Reservoir watershed forests and initiated mitigation efforts.
  - Conducted annual/periodic deer pellet surveys in 2018 to determine density of white-tailed deer on Sudbury Reservoir DWSP lands in order to determine baseline deer density ranges prior to implementation of deer population control through licensed hunting.
  - Estimated the deer density to be well over the 20 deer/mi^2 threshold that the scientific literature recommends for forest health and regeneration.
  - Initiated deer hunting on DWSP lands at Sudbury Reservoir in 2019.
  - Estimated that up to 200 deer have been taken from water supply lands at the Sudbury since the deer management program began.
  - Concluded from spring 20200 pellet counts that the deer density stands at approximately 16.5 deer/mi^2.
- Continued ongoing inventory and assessment of terrestrial invasive species.
  - Invasive plant species of note on DWSP properties in the Sudbury Reservoir watershed include garlic mustard, Asiatic bittersweet, honeysuckle, winged euonymus, tree-of-heaven, and amur corktree.
  - No control efforts have been undertaken during the last five years.
  - Invasive plant populations will be prioritized for control and management.
- Established and measured 12 CFI plots for the first time on DWSP lands at Sudbury Reservoir. Data collection occurred following the 2021 growing season.
- Continued efforts to work with EPA, MassDEP, DCR Parks, towns, and other interested parties on ways to best manage and/or transfer the remaining DWSP property in the South Sudbury basin surrounding Stearns and Brackett Reservoirs (Framingham Reservoirs 1 and 2). While DWSP still controls some property and is responsible for the two associated dams, the area is not considered part of this Watershed Protection Plan.
- Blazed and tagged 14 miles of the 24 miles of maintainable property boundary line in the North Sudbury basin.
- Identified and rectified encroachments.
  - Recognized ongoing problem in the Sudbury watershed due in part to limited ownership, unclear boundaries, and a lack of monitoring and enforcement.

- Watershed Rangers managed both minor (e.g., mowing onto commonwealth property) and significant (e.g., re-grading, landscaping, or placing structures directly adjacent to the reservoirs) incidents.

4.3.11 Five Year Objectives

- Continue to implement the *DWSP 2017 Land Management Plan*, including adaptive changes resulting from the five-year review. Initiate ten-year update.
- Continue long-term monitoring (water yield and quality) to research and verify the effectiveness of existing statewide and DWSP-specific forestry Best Management Practices (BMPs) and DWSP harvest regulation strategies in protecting the surface water supply.
- Use ongoing CFI analysis to inform land management decision making/policies.
- Continue forestry operations and follow all documented management techniques including operational oversight of active timber harvesting.
  Protect and restore watershed forest resiliency through an updated integrated vegetation management plan for controlling invasive and undesirable terrestrial plants that impact forested lands under the care and control of DWSP..
- Assess forest health in the watershed system by monitoring regeneration and other indicators of forest health, especially in areas of timber harvest operations.
- Continue regular periodic boundary line maintenance and posting. Assess and monitor status of encroachments onto DWSP property and take follow-up actions to resolve encroachments.
- Coordinate monitoring and analysis efforts with National Ecological Observatory Network (NEON) regarding climate change.
- Implement strategies to identify and mitigate potential impacts of climate change on land management in the DWSP water supply system.
- Implement Forest Stand Adjustments on watershed forests to provide more diverse, resilient forests and improved wildlife habitat, tree vigor, carbon storage and stand diversity.
- Research and monitor, including long-term water quality sampling, to verify the effectiveness of existing statewide and DWSP-specific forestry Best Management Practices (BMPs) in protecting the water supply.
- Support cooperative efforts to monitor and control invasive pests that could impact watershed forest health such as Asian long-horned beetle.
- Manage hayfields and other open areas.
- Reinitiate forestry operations after documenting evidence of significant reductions of the current high deer population and improved understory vegetation response, and follow all documented management techniques including oversight of active timber harvesting in Sudbury Watershed. *(Sudbury)*
- Transfer DWSP lands at Stearns and Brackett Reservoirs (Framingham 1 and 2) to State Parks or other interested entity. *(Sudbury)*

4.4 Wildlife Management

The primary focus of the Wildlife Management program on the watersheds is to protect the water supply from potential adverse impacts caused directly or indirectly by wildlife while also protecting wildlife diversity and habitats. Mitigating the negative impacts of roosting birds, aquatic wildlife, and burrowing animals on the water supply is a critical component of management. In addition, broad scale, active wildlife management, especially to manage the deer populations, is conducted as part of this plan for the protection of the drinking water supply.

The watershed system supports an abundance of wildlife, and many species are monitored by DWSP personnel, other agencies, and researchers. DWSP is required by state and federal law to protect rare, uncommon, threatened, or endangered species. In general, DWSP works to protect important wildlife and their habitats while minimizing or eliminating adverse wildlife impacts on other watershed resources. Where applicable, active management to enhance wildlife habitat may occur.

While management to protect the water supply is a major component of wildlife management, DWSP property is also inhabited by many state and federally listed, threatened or endangered species. Watershed activities avoid adversely impacting these species or their habitats, primarily through inventory and survey work to locate rare species and habitats, proper coordination with MassWildlife's Natural Heritage and Endangered Species Program, and proper precautions using management guidelines and Conservation Management Practices (CMPs) to support rare species and certain habitats. DWSP recognizes the regional importance of maintaining some of its lands as open grassland, shrubland, or other non-forest land. A variety of plant and animal species are dependent on non-forested land.

Goal

Protect the water supply and infrastructure from adverse impacts caused directly or indirectly by wildlife. Protect common, rare, and significant wildlife species and their habitats through stewardship.

The Wildlife Management Program takes guidance from the LMP. This section summarizes several key topics; specific details of all wildlife management actions can be found in the LMP.

4.4.1 Bird Harassment Programs

The Watershed Bird Harassment Program operates year-round, but the active harassment phase usually takes place between mid-October and mid-April, with a break in the winter if ice prevents the birds from roosting. Although some birds are present at the reservoir all day, most leave the roost shortly after sunrise, spend the day feeding elsewhere, and return to the reservoir to spend the night. During the active harassment phase, both Quabbin and Wachusett maintain a "Bird Free Zone" patrolled by shore, and when necessary or weather permitting by boat crews, utilizing pyrotechnics and herding techniques to move the gulls and other waterfowl outside of the sensitive water supply protection area (Figures 4-9, 4-10). Documentation of bird numbers and movement is important, and weekly counts of roosting birds are done just before dark by DWSP staff.

A majority of the birds present year-round at the Wachusett Reservoir are gulls, but there are also hundreds of resident and migratory geese and ducks. Harassment efforts directed at gulls are generally effective against these other birds. In addition, there is a seasonal population of cormorants present during the summer and fall that perch on containment booms and on the MWRA monitoring buoys in the reservoir. Although these birds are few in number relative to the other species, they usually do not respond to harassment efforts. Mute swans, a non-native invasive species, are present but numbers are low and are being monitored.

In addition to active harassment, several passive techniques have been used, such as placing netting to exclude birds from critical areas, adding wire to fencing to discourage perching on specific structures, and manipulating habitat to discourage bird use. DWSP continues to work with other state agencies to reduce gull numbers at solid waste landfills.

To aid efforts to disperse and move gulls from the reservoir, long-term control has focused on reducing food resources. A long-term monitoring and management program continues in an effort to identify and control alternative food sources, provide information on breeding sites and seasonal movement, and maintain control of locations, such as landfills and wastewater treatment plants, where work has been done to remove sources of food.

The primary goal of the Watershed Bird Harassment Program is to ensure long-term, continued compliance with source water fecal coliform criteria through a safe and effective program.

4.4.2 Canada Goose Population Control

Canada geese can expel *Giardia* cysts into the environment and be carriers of *Cryptosporidium spp*. The Watershed Canada Goose Population Control Program includes locating active nesting areas in selected areas of the Reservoir's shoreline, particularly on islands. After nests are discovered, the eggs are marked and treated to prevent hatching. Geese are attracted to short, manicured lawns. Wherever possible, grass will be allowed to grow to 2 ft or more. Geese need space to take off and feel uncomfortable in areas where they cannot see predators. In addition, efforts are made to prevent geese from accessing any administrative lawns, the dikes and the spillways. Efforts will continue to focus on eliminating resident geese from breeding and excluding birds from food resources. Barrier fencing is constructed, coyote decoys deployed, and active harassment implemented to discourage geese access onto lawns and Reservoirs.

4.4.3 Pathogen Control Zone Program

The Pathogen Control Zone program is designed to control the occurrence of *Giardia* spp. And *Cryptosporidium* spp. in the reservoirs by preventing populations of aquatic mammals, specifically beaver and muskrat, near intake structures. The program is conducted in a delineated zone (Figure 4-9, 4-10) where regular monitoring for selected aquatic mammals occurs. When these species are identified in this area, efforts are made to remove the populations with priority on populations closest to the intake. In addition, fecal samples from most removed animals are tested for the presence of *Giardia* and *Cryptosporidium*. When water sampling data has elevated bacteria counts, EQ staff conduct field investigations to determine the source. The elevated results have frequently been attributed to beavers and their habitat; mitigation is performed as necessary.

4.4.4 White-tailed Deer Impact Management Program

Overabundant white-tailed deer populations pose a significant threat to forest regeneration and future health of forests to protect water quality. When deer populations are protected for many years and sustained at high densities, forest structure may be altered completely, resulting in park-like stands with grass or ferns dominating the understory. Situations like this were documented on the Quabbin Reservation prior to the implementation of the Deer Management Program.

The goal of Watershed Deer management Programs is to reduce and maintain the deer population at levels that allow for diverse tree species regeneration and forest understory structure resulting in the development of a healthy, resilient, and diverse forest that can adequately and continuously protect water quality. This is accomplished by an annual, dynamic deer hunt within all of the Watersheds. The Deer Management Program seeks to achieve deer densities that can be maintained with a regular hunting season. Deer density estimates are evaluated using harvest data and pellet-group counts (DeCalesta 2013).

4.4.5 Problem Animal Response

This program addresses various wildlife problems that arise throughout the watershed and are not covered by other programs, such as burrowing animals (woodchucks, moles, and voles) causing damage to the integrity of earthen dams, dikes, and other watershed structures. Beaver problems outside the Pathogen Control zone are addressed as necessary. Lethal methods are used to remove these problem animals under the direction of the DWSP Wildlife Biologist.

4.4.6 Rare and Declining Species Habitat Maintenance

DWSP works to avoid adversely impacting rare wildlife species or their habitats. The Division recognizes that protection of the water supply must always take top priority but when rare species or habitats are detected or are known in an area, the Natural Resources Section works with wildlife and habitat specialists from Mass Wildlife and the Natural Heritage and Endangered Species Program to mitigate potential impacts and follow BMP's. DWSP may also manage habitats in certain areas for the benefit of wildlife species that are rare or of special.

DWSP recognizes the regional importance of maintaining some of its lands as open grassland, shrubland, or other non-forest land. A variety of plant and animal species are dependent on non-forested land. The *2017 Land Management Plan* includes the designation of several Focus Areas in which DWSP seeks to develop and maintain acreage of young forest habitat and oak-pine barrens habitat. Since 2018, several of the Focus Areas have been managed, including the restart of the DWSP Prescribed Fire Program.

Loons are a state-listed species in Massachusetts that are hyper-sensitive to environmental stressors, pollution and toxicity. DWSP monitors these populations on the Quabbin and Wachusett Reservoirs as a bio-indicator of water quality and ecosystem health.

4.4.7 Quabbin Reservoir

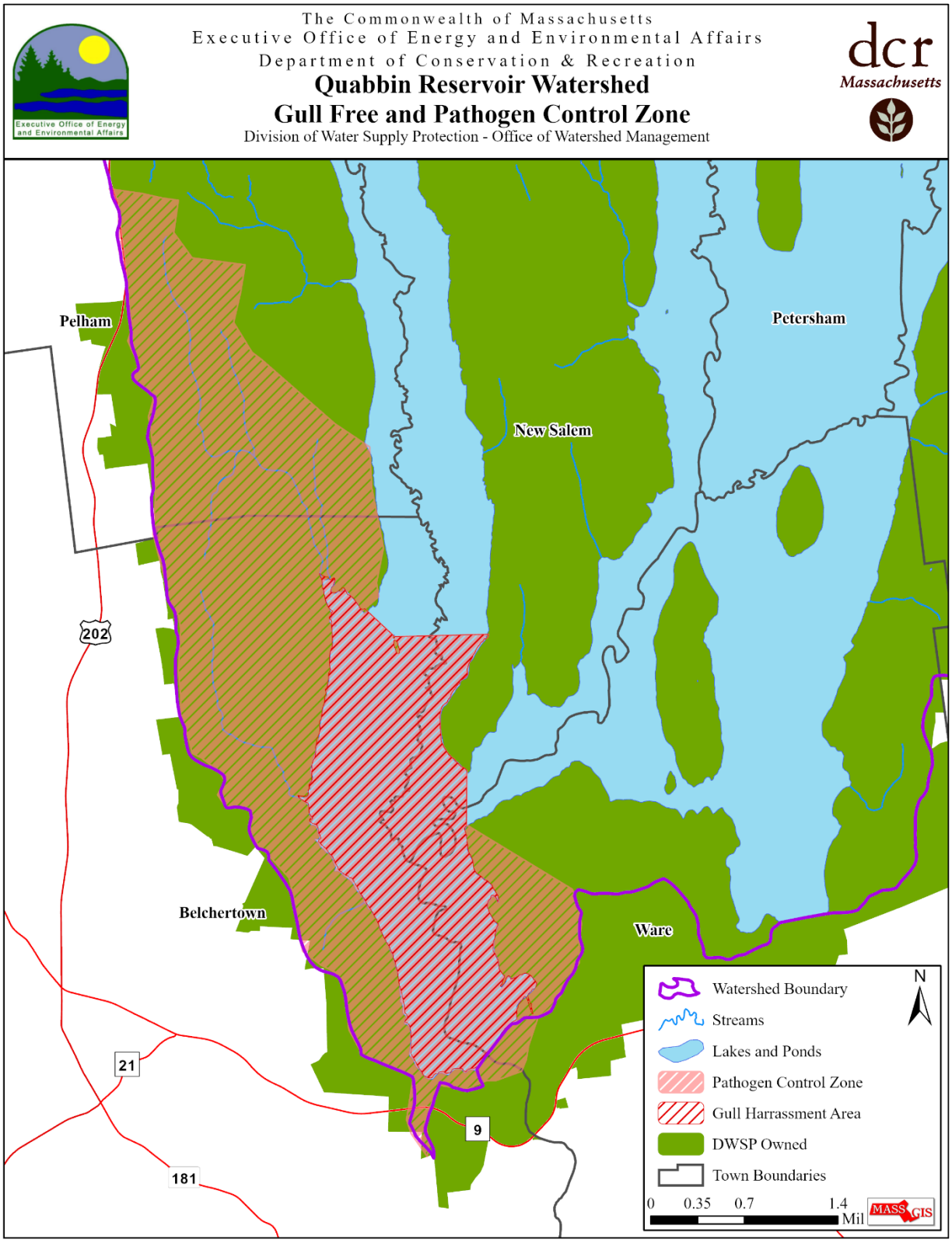
Accomplishments

- Results from daily bacteriological testing of water entering the Winsor Dam Intake indicate fecal coliform levels consistently remained well below the SWTR source water quality standard since the inception of the control program.
- Reduced fecal coliform levels caused by birds through harassment, coupled with food source reduction efforts, which have been an important component in maintaining Quabbin Reservoir's filtration waiver by. Produced weekly summary reports on the program during the active phase and annual reports were

completed after the active phase. Harassment safety protocols were improved for program staff.

- Contracted with MassDOT Aeronautics Program beginning in 2020 to use drones to identify and count roosting gulls at Quabbin Reservoir. Weekly counts counted at Quabbin Reservoir have provided accurate and detailed information on the location and size of roosting gulls. This information is used to inform the Bird Harassment Programs.
- Limited potential food sources for gulls in the vicinity of the watershed.
  - Monitored landfills, wastewater treatment plants, parking lots and agricultural fields on an ongoing basis.
  - Followed up with facility managers, parking lot owners, and private landowners if gull problem areas were observed to install signage and to control food sources at these locations.
  - Equipped open tanks at wastewater treatment plans being utilized by gulls with wire to deter gulls from landing.
- Managed impacts from Canada geese.
  - Allowed administrative lawns and short, attractive grass on the dikes and spillways to grow to discourage Canada goose feeding.
  - Performed goose harassment as needed around Winsor Basin.
  - Installed and maintained goose fencing in critical locations.
  - Surveyed reservoir islands and nearby ponds; eggs were treated to prevent hatching.
  - Implemented new harassment techniques were, including the installation of coyote goose-repellent decoys.
- Conducted regular surveys of the Quabbin pathogen control zone and removed beavers attempting to build dams and lodges within this zone (Figure 4-9).
- Most aquatic mammals removed from pathogen control zone were analyzed, as well as fecal samples from gulls and geese, when possible, for the presence of *Giardia* and *Cryptosporidium*.
- Implemented Quabbin Deer Hunt.
  - Identified that Quabbin deer populations have decreased substantially since the initial hunts in 1991; data indicates that regeneration goals are being met.
  - Conducted the annual Quabbin Controlled Deer hunt for the past five years on Quabbin Reservation lands.
  - Launched a pilot deer management program in 2019 to modify the traditional controlled two-day hunts. People were allowed to hunt the whole two-week shotgun season in the Pelham Zone. Due to the success of this program, this style hunt was subsequently applied to two additional zones (Hardwick and New Salem). Between 458 and 688 hunters participated in a Quabbin hunt each year and harvested over 135 deer.
  - Published an Annual Deer Management Report.

Figure 4-9: Quabbin Reservoir Watershed Pathogen Control Zone



- Responded to a variable number of beaver-related flooding issues in several locations on DWSP lands in the Quabbin Reservoir watershed each year. Routine surveys were conducted of Winsor Dam and Goodnough Dike; when necessary, burrows were treated at each location.
- Maintained open lands through mowing using tractor-mounted deck mowers and a skid steer with a drum grinder attachment to mow larger woody growth.
- Updated the Quabbin Park Mowing Plan to reduce the amount of maintained lawn and introduce more wildlife and pollinator friendly habitat. This also reduced the amount of lawn that needs to be maintained.
- Continued loon blood, feather, and egg testing which showed that the birds are below toxic levels for heavy metals such as mercury.
- Placed up to twelve floating nest platforms/rafts in selected locations annually to provide safe breeding locations for State-listed Common loons. These rafts are unaffected by changing Reservoir levels.

4.4.8 Ware River

Wildlife management in the Ware River watershed primarily consists of research, dealing with problem animals, and collaborating with hunters. Research is conducted by DWSP staff and other agencies on gulls, deer, moose, and bats. Problem animals, typically beaver that block road culverts, are dealt with on a case-by-case basis. Accommodations for hunters (of whitetail deer and game birds) are made by controlling gate access during applicable seasons. Additionally, seasonal trout stocking occurs on the Ware River. Water quality threats from wildlife is considered a low risk in the watershed, so less emphasis is placed on monitoring and managing wildlife that can impact water quality.

Accomplishments

- Evaluated beaver flooding problems and implemented appropriate control measures as needed.
- Conducted annual deer and moose sign surveys.
- Published initial results from a moose exclosure study conducted by researchers partly on DWSP land; the study is ongoing.
- Identified and located vernal pools, which were assessed for obligate species and verified.

4.4.9 Wachusett Reservoir

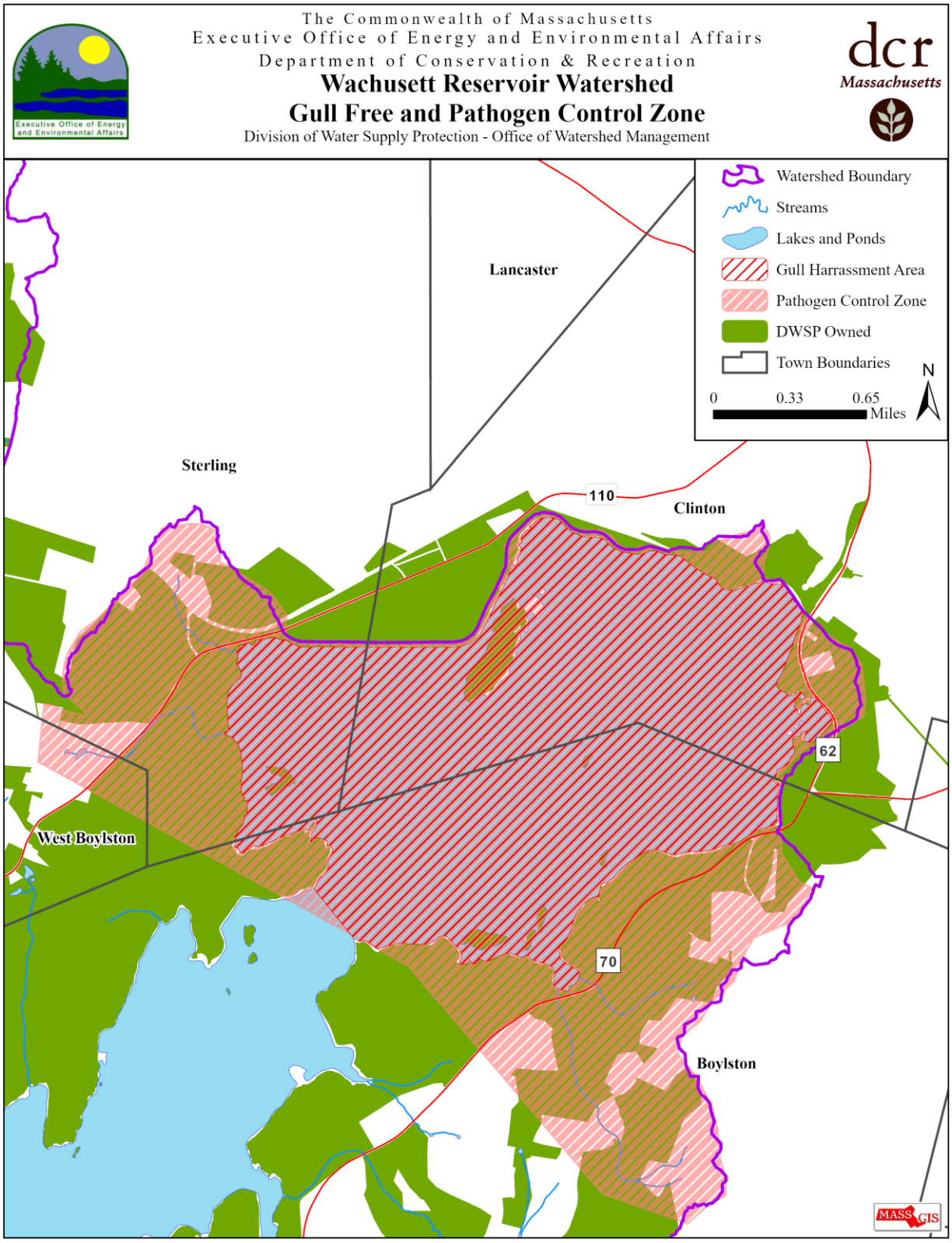
Accomplishments

- Successfully implemented the Bird Harassment Program during the past five years, with periodic daytime monitoring of the reservoir usually starting in mid-August and evening observations and harassment implemented in mid-September. Boats, pyrotechnics, and lasers were used effectively to move birds away from the intake and maintain bacteria concentrations below the regulatory threshold. The program was conducted continuously through March in most years unless ice cover halted operations.

- Documented all activities and results of these actions in weekly reports that are distributed regularly to appropriate individuals. The source water standard for fecal coliform was met throughout the year.
- Coordinated active gull harassment efforts between area landfills near the Wachusett Reservoir (which have been identified as a food source for gulls that roost on the reservoir) and USDA that resulted in a substantial reduction in gull use.
- Natural Resources staff continued efforts to reduce overall gull population by monitoring other regional feeding areas and installing exclusion wires when problems were identified.
- Contracted with MassDOT to use drones to periodically identify and count roosting gulls at the Wachusett Reservoir. This information confirmed shoreline count accuracy and provided detailed information on the size of the gull roost. This size and location of the gull roost is used to inform the Bird Harassment Program.
- Reduced the local goose population through an intense population reduction program.
  - Located Canada goose nests on the reservoir annually and treated the eggs in each nest to prevent hatching.
  - Saw continued decline in the number of goslings and resident adult geese has declined since the effort was initiated, whose goal is the gradual long-term reduction in the resident adult goose population.
  - Observed an overall reduction in the number of nests (-69.4 percent) found and total eggs treated (-68.4 percent) since the first years of the program (1996-2000). The goose management program has prevented 221 eggs from hatching at the Wachusett Reservoir in the last five years.
- Monitored and controlled populations of beaver and muskrat in the Pathogen Control Zone near the intake to prevent occurrence of *Giardia* spp. And *Cryptosporidium* spp. In the Wachusett Reservoir (Figure 4-10). While most of the reservoir's shoreline provides marginal to poor beaver habitat, there are areas with sufficient resources to support beaver. Any populations at the north end of the reservoir are removed and fecal samples from all removed animals are tested for the presence of *Giardia* and *Cryptosporidium* Individuals in other areas are removed as needed. Data collected to date indicate a very low level of infection.
- Opened two zones to deer hunting to address overabundant deer populations on the east side of I-190 in the Wachusett Reservoir watershed.
  - Opened The Wachusett Reservoir Zone, or the areas immediately inside the interior Reservoir gates, were for the month of December only under a controlled hunt framework. Additional Wachusett-specific antlerless permits were available for this hunt.
  - The hunt has evolved since 2018 and is now open to permitted hunters for all deer seasons, and additional antlerless permits are still available to help reduce the deer population.
  - Opened other DWSP lands outside of the Reservoir Zone on the east side of I-190 to hunting for all game species, including deer, following MassWildlife and DWSP rules and regulations.

- Monitored deer populations using a pellet count survey method, harvest data and browse surveys. Results from these studies and from regeneration surveys directed the management programs launched in the Wachusett Reservoir watershed. Wachusett deer populations have decreased substantially since the launch of the program.
- Completed routine surveys of all dams and dikes to look for damage caused by burrowing mammals. Burrows were treated and filled annually.
- Continued long-term wildlife monitoring at forestry sites during the past five years as well as ongoing studies on common loons.
- Incorporated more grassland bird and acoustic bat monitoring into annual surveys.
- Maintained ongoing cooperative research with DFW on eagles, lake trout, and American kestrels.
- Continued testing loon blood, feather and egg samples which showed that the Wachusett Reservoir is below toxic levels for heavy metals such as mercury. Placed up to seven floating nest platforms/rafts in selected locations annually to provide safe breeding locations for State-listed Common loons. These rafts are unaffected by changing Reservoir levels.

Figure 4-10: Wachusett Reservoir Gull Free Zone and Pathogen Control Zone



4.4.10 Sudbury Reservoir

As an emergency backup water supply, there is no active bird harassment program or Pathogen Control Zone as described at Quabbin and Wachusett Reservoirs.

Data collected by DWSP Natural Resources Staff indicate that the reservoirs within the Sudbury System are used by roosting gulls on a regular, but intermittent, basis. In the event that this system had to go online as an emergency supply, particularly during the fall or winter months, it may be necessary to assess the extent of the roosting and/or initiate a harassment program if conditions warranted.

Accomplishments

- Targeted wildlife management activities in the Sudbury Reservoir watershed on the resident Canada goose population.
  - Continued a population reduction program that was initiated in 2007, which has helped limit the growth of the resident population.
  - Surveyed all reservoir islands, some shoreline sites, and the area around the MWRA facilities each spring to locate nesting Canada geese; eggs in nests were oiled to prevent hatching.
  - Completed shoreline surveys each summer to document goslings and assess the success of oiling.
- Measured deer density surveys using the pellet count method, signs of deer browse, and forest regeneration monitoring, which indicated that the Sudbury Reservoir watershed forests have an overabundant deer population.
- Initiated a deer management program on Sudbury Reservoir watershed lands in 2019 to address overabundant deer population concerns and reduce impacts to forest regeneration.
  - Hunters were provided access for deer hunting only, following DFW and DWSP rules and regulations.
  - An unlimited number of hunters could apply for access annually.
  - Added, the Sudbury Reservoir Watershed lands access permit was to the 5-year access permit (used on Wachusett Watershed lands) in 2022; all legal game could be hunted in both watersheds using this permit.
  - Found that he deer population continues to be reduced to more sustainable levels.

4.4.11 Five Year Objectives

- Continue year-round bird observations and harassment efforts on the Quabbin and Wachusett Reservoirs.
- Control the resident Canada goose population on the Quabbin, Wachusett, and Sudbury Reservoirs.
- Continue to monitor gull populations within the watershed and take steps to reduce the attractiveness of human derived food sources. Monitor, assess, and control aquatic and burrowing mammals that threaten water quality or infrastructure.

- Monitor deer and moose populations and their impact on forest dynamics through pellet counts, browsing surveys, and/or exclosure studies.
- Administer the White-tailed Deer Management Program in the watershed system, including the application, permit, biological data collection, and other components of the program. Adapt and adjust management methods as appropriate in collaboration with MassWildlife.
- Develop a deer management program for Quabbin Park.
- Test fecal samples for the presence of *Giardia* and *Cryptosporidium*.
- Monitor and manage known populations of and habitat for rare and declining species as an indicator of ecosystem health; Complete a watershed-wide vulnerability assessment to identify potential impacts of climate change on wildlife in the water supply watersheds.

Above: DWSP Natural Resource staff placing a floating loon raft in place.
Below: A loon using the raft for a nest (photo courtesy of Bruce DeGraaf).

4.5 Public Access Management

Human activity on or near water supply source waters can introduce disease-causing agents to the water supply and cause increases in nutrients, turbidity, and invasive species. Federal and state drinking water regulations require that public access on drinking water supply lands must be managed to minimize the risk of waterborne disease and to control other impacts such as erosion and sedimentation. The reservoirs and associated lands are valuable environmental resources of the Commonwealth that are open space attractions to watershed residents and the general public alike. Public access has historically been allowed on portions of DWSP's water supply lands, and DWSP believes that controlled public access can continue to be allowed without creating significant risk to the watershed system.

Goal

Manage public access to DWSP lands and waters to protect water quality in compliance with Watershed Protection regulations (313 CMR 11.00) and all other applicable laws (including 310 CMR 22.00) through policies established in Public Access Management Plans.

The Public Access Management program guides and controls public access and use of DWSP lands in order to protect water quality, safety, and security. A Public Access Management Plan is in place for each watershed. Public access includes the ability to enter and use land for recreational activities, legal restrictions or prohibitions related to access or specific land or water-based recreational activities, sign placement, mapping, user education, and inter-governmental coordination and public safety. Public access is controlled by regulations (313 CMR 11.09) and public access policies.

Watershed Ranger staff has the primary responsibility for monitoring and enforcing appropriate public access, with the police as the official enforcement entity if needed. Watershed Rangers spend most of their time utilizing visitor contacts to explain watershed protection efforts and public access controls (Table 4-12). Enforcement through education and outreach is a priority.

Watershed Rangers were given additional support for rules enforcement in September 2015 with the ability to issue non-criminal citations and also parking tickets starting in May 2016. Watershed Rangers issued non-criminal citations under 313

CMR 11.09 (Watershed Protection); 302 CMR 18.00 (Aquatic Nuisance Control Plan); 313 CMR 5.00 (Parking and Penalties); and MGL 92A ½ §8 (Watershed Management Enforcement). In 2021, however, changes in state law and a subsequent legal review removed the ability of Watershed Rangers to write citations, as it was determined that MGL Chapter 132A/7A does not apply to MA DCR Rangers, as they are not appointed as Deputy Environmental Police Officers. Currently, there are no DCR Rangers who are deputized and therefore the Rangers can no longer issue non-criminal citations. Watershed Rangers will continue to employ education and enforcement methods and for all serious offenses utilize MSP, MEP, local Police Departments, and federal agencies (e.g., FAA, FBI, CIA). There is also a requirement under 310 CMR 22.20B(7) to report all enforcement actions to MassDEP.

Federal and state drinking water regulations require that public access on drinking water supply lands must be managed to minimize the risk of waterborne disease and to control other impacts such as erosion and sedimentation.

Signs, kiosks, and other printed information provide guidance on allowed activities and locations where specific recreational uses can be enjoyed.

Table 4-12: Visitor Contacts within the DWSP Watershed System, FY2013-2017

Year	Quabbin/Ware Number of Visitor Contacts	Quabbin/Ware Number of Violations	Wachusett/Sudbury Number of Visitor Contacts	Wachusett/Sudbury Number of Violations
FY18	33,988	389	16,394	683
FY19	25,986	480	18,797	493
FY20	28,831	635	25,142	1,211
FY21	46,599	1,877	26,295	1,785
FY22	38,269	1,086	13,841	641

Source: DWSP Wachusett Watershed Rangers

4.5.1 Quabbin Reservoir

The 2018 *Public Access Management Plan Update: Quabbin Reservoir Watershed System* describes DWSP's Public Access Management Program in detail; please refer to the plan for current policies and associated maps.

Stakeholders have been involved in public access policy review and modification since the first Public Access Plan was developed for Quabbin in 1988. The general public (local residents, land abutters, visitors, and environmental organizations) have been generally supportive of DWSP's policies to protect the public water supply while allowing controlled access. Public access management has become a high priority in DWSP's watershed protection efforts, especially following the events of September 11, 2001.

The interest in legal recreational public access is changing, as measured by the number of people visiting and frequency in which they visit DWSP lands and waters. This trend of increased intensity of use is best quantified by Watershed Ranger encounters and

the number and size of Interpretive Services visitor programs. This increased intensity, for the most part, has been concentrated within Quabbin Park; approximately half of Quabbin Park is outside of the Reservoir's watershed. Informal public access to DWSP lands and waters is increasing as residential development continues in the watershed. Use of the Boat Launch Areas (BLAs; see below) has fluctuated over time; there are currently fewer people fishing than historical numbers.

Visitor Education regarding access rules is formally conducted by Interpretative Services and informally by the Watershed Rangers and BLA staff. The Les and Terry Campbell Quabbin Visitor Center (QVC), located in Quabbin Park, remains busiest on weekends and some holidays.

Access Rules and Regulations – Monitoring and Compliance
While monitoring public access activities on DWSP lands and waters, Watershed Rangers use a variety of enforcement methods, but rely primarily on education.

The Watershed Rangers also work with other law enforcement agencies, such as the Massachusetts State Police (MSP) and Massachusetts Environmental Police (MEP), to enforce access rules and regulations. The rangers are in regular contact with these agencies; they communicate with them and other enforcement agencies when situations occur that require law enforcement personnel. In addition, the MEP provide rules enforcement for complementary state-wide environmental regulations. Watershed Rangers are in radio contact with both the MEP and MSP, share weekly activity reports with the MSP, and regularly meet with both groups. These relationships are critical to the enforcement of DWSP regulations.

Access Permit Issuance, Monitoring, and Enforcement
Access permits are issued by DWSP to individuals or groups requesting unique access to watershed property in the Quabbin Reservoir watershed. There are three main categories of access permits issued by DWSP: research, timber harvesting operations, and visitor/educational needs, which are administered by Administration, Forestry, and Interpretive Services, respectively. All three types of permits are monitored by the Watershed Ranger staff and MSP. Enforcement of permit conditions is conducted by the section issuing the permit in coordination with the findings of the Watershed Ranger staff or MSP/MEP if necessary. These permits allow monitoring, tracking, and evaluation of public access activities on DWSP's lands and waters.

Scientific Research Proposal Review and Permitting
DWSP has supported a wide variety of scientific research on the watershed by providing access to its properties, directed management activities, and/or limited direct funding. Research proposals are reviewed by the Regional Director with guidance from DWSP senior staff. Research proposals are reviewed against specific criteria related to supporting or improving watershed protection activities. If granted, researchers receive conditional permits that expire annually. Researchers are required to notify the Watershed Rangers prior to accessing research areas. Research findings, databases, and publications are shared with DWSP, and researchers are required to submit an annual report before they are eligible to renew their permit. This program is tracked in a

database to provide security and to help avoid user conflicts with other research, forestry activities, and other land use activities managed by DWSP.

Public Access Information
DWSP recognizes the role of public education in the protection of public drinking water supplies and associated resources. DWSP staff disseminates information about access policies and recreation on Quabbin Reservoir watershed lands and waters. Educational programs are operated at the QVC, where staff, exhibits, and materials help visitors interpret the DWSP/MWRA water system, the history of the reservoirs, and the natural and cultural features of the watershed. Interpretive Services staff further educates the public through the DCR website with videos, brochures, and other online displays. DWSP also offers outreach programs to groups in watershed and water user communities. By raising the public's awareness and appreciation for these precious resources, DWSP is helping to fulfill its mandate to "protect, conserve and enhance the resources of the Commonwealth and to assure the availability of pure water for future generations."

Signage
The first informational signs were created and installed around the Quabbin Reservoir watershed in the 1940s to help control access to certain lands and waters. Today, DWSP staff use various types of equipment to make, repair, or re-word signs in-house. DWSP staff can quickly produce professional signs to communicate a message, such as describing a specific activity, demarcating land ownership, emphasizing rules, and providing directions. Signage types range from single-use, historical signs to special event signage. Updated, accurate, and legible signage is an invaluable, yet ever-changing, watershed protection tool. DWSP acquired new digital sign making equipment to produce educational, security, and special event signage for both Regions.

Boat Launch Areas (BLAs)
DWSP operates three BLAs which provide limited access to the Quabbin Reservoir in a manner that protects water quality and controls impacts of motorized boats. Motor boat fishing at Quabbin Reservoir is a legacy of political decisions made during the 1950s that were implemented against the recommendations of Quabbin Reservoir's managers. The main responsibilities of BLA staff are to prevent human contact with the water, monitor equipment use near and on the water, and prevent the introduction of aquatic invasive species.

The BLA facilities operate off-the-grid using solar power for communication and wood heat. The BLA boat seal program, as well as the method of payment, have been modernized. The combination of cell phone

boosters, i-pads, and credit card readers have transformed the formerly all paper record and cash transaction systems to a more secure, accurate, and time saving electronic boat seal tracking process and credit card only payment program.

Public education and rules enforcement is performed by staff at the BLAs, Watershed Rangers, MEP, and MSP. Private motorboats used for fishing are inspected for invasive species and tagged by DWSP staff with a seal prior to being put in the water. Public restrooms are provided at the launch areas and, for day-long boat users, at mapped locations on shore in more remote areas. Boat motor size is limited by the Watershed Protection regulations (313 CMR 11.00); times and locations of access are also limited by DWSP policies.

Quabbin Park and Quabbin Park Cemetery
DWSP produced policy, operations, and maintenance plans for Quabbin Park and Quabbin Park Cemetery. The focus of these plans is on protocols for routine and special maintenance work. Specific guidance is provided on vegetation management as well as culvert and guardrail maintenance.

Special Event Oversight
DWSP watershed lands, specifically the Quabbin Park, are popular sites that are frequently requested for many small private and public events. DWSP staff work to control access, protect vulnerable areas, prevent conflicts, and protect public safety in order to balance the desire for these events with the goal of drinking water supply protection. These events generally require access permits issued by the Interpretative Services staff, which are subsequently monitored by the Watershed Rangers.

Field Education
Watershed Rangers are DWSP's "good will ambassadors," not only showing a positive presence but also speaking on behalf of DWSP about watershed stewardship and drinking water supply protection to visitors. Through their positive interaction with visitors, the Watershed Rangers protect these open spaces and encourage all people to do the same by obeying all watershed rules and regulations.

Through their positive interaction with visitors, the Watershed Rangers protect these open spaces and encourage all people to do the same by obeying all watershed rules and regulations.

Accomplishments

- Updated and modernized Quabbin Research permitting process. All communication is done electronically, a current active researcher database is maintained and can be accessed electronically in the field, parking passes were made mandatory for all researchers, and new and renewed permits are submitted through an online portal.
- Initiated use of iPads to track boat seals at the Quabbin BLAs.
- Developed a real-time dashboard to summarize the number of private and rental boats on the water.

- Switched all boating purchases to electronica transactions (season passes and in-person sales) using an iPad; no cash sales are now allowed.
- Completed a Quabbin Park Cemetery Operations plan.
- The access permit process was streamlined and modernized; all permit requests are submitted through an online portal and permits are generated and distributed electronically; MSP and Rangers are notified electronically of approved permits.
- An interactive Quabbin Access Map was created by DWSP GIS Unit with the assistance of the IS staff and went live in Spring of 2020.
- Watershed Rangers, IS Staff and DWSP Sign Shop coordinated an overhaul of the Quabbin Park Trail System and signage in 2020 and 2021.
- A new Quabbin Park Trail map was produced and distributed both online and via the QVC by DWSP GIS and IS Staff
- A new online hunting map was launched.
- Provided timely updates of the DCR Watershed web page to for accurate information about changes to public access.
- DWSP responded to increased demand from public users due to the Covid-19 pandemic.
- Watershed Rangers reported 120,000 visitor contacts in the Quabbin Watershed, which resulted in 1,737 documented violations from January 2018 through September 2022.
- Quabbin Watershed Rangers average a total of 25,855 visitor contacts and 342 violations per year. During the Covid Pandemic rangers documented 34,267 visitor contacts and 627 violations in a year.
- Quabbin Watershed Advisory Committee meetings were regularly attended by DWSP staff to address issues and inform the committee and the public about DWSP activities.

4.5.2 Ware River

The Ware River Watershed has offered relatively open access to the public and provided outdoor recreational opportunities to multiple user groups, including horse riders, snowmobilers, bike riders, hunters and fishermen, and dog walkers. Public access and recreation on the watershed are presently governed by the 2010 *Ware River Watershed Public Access Management Plan Update.*

The 2010 plan outlines a number of policies, guidelines, and restrictions for recreational activities and other public access on the watershed reservation. It strives for a balance between appropriate recreational activities and the need to protect water quality and the natural, cultural, and historical values of the watershed lands. DWSP began to update the 2010 Public Access Plan in 2018. The pandemic slowed the progress of the updated plan. A final plan is anticipated in 2023. Please refer to the plan for current policies and associated maps.

Access Rules and Regulations – Monitoring and Compliance

The addition of three dedicated Watershed Ranger staff has enabled regular patrols in the Ware River watershed every day of the week, with seasonal changes and special

focus on problem locations. Bicycles, ATVs, kayaks, and a boat are also now available to the rangers to provide different vantage points and better access to remote areas. Watershed Rangers have focused on areas with frequent and recurring issues, such as Long Pond, the Rutland Prison Camp Ruins, and the boat launch at Comet Pond. That has led to a better compliance from the general public in regard to DWSP rules and regulations. The previous effort of mapping and closing unauthorized trails, staff meetings with user groups, and increased Watershed Ranger patrols have resulted in a significant reduction in new unauthorized trail building and in usage of existing unauthorized trails.

Access Permit Issuance, Monitoring, and Enforcement
Access permits are issued to individuals and groups for special events where twenty-five or more attendees are anticipated. Typical examples include group horseback rides and organized running or biking events. Watershed Rangers review the proposed itinerary and route for the event and provide assistance and oversight at the event if needed.

Public Access Information
DWSP has continued its effort in the last five years to educate the public about what types of recreation are allowed in the watershed and where those activities are allowed. Information regarding rules and regulations on public access is available online, through the QVC, and is displayed on kiosks and signs throughout the watershed. Watershed Rangers and other DWSP staff use visitor contacts to educate users about the watershed and the rules and restrictions that govern recreation. IS staff provide online content to the DCR website to further educate the public in the form of videos, brochures, and online displays and offer outreach programs to groups in watershed and water user communities. DWSP has developed and will continue to develop online access and hunting/fishing maps.

Public Access Management Plan Update (2018-present)
The process of updating the Ware River Watershed Public Access Management Plan began in 2018 and was scheduled to be completed in 2020. DWSP committed to a very public process for the update because of past controversy surrounding the limited restrictions on public access. DWSP developed *10-point Management Principles* and *Public Engagement Plan* for these public meetings. DWSP held several facilitated public meetings to discuss the update and to look for input in the Fall of 2018 and through 2019. DWSP staff also had more focused meetings with representatives of different user groups to discuss issues and look for opportunities to enhance user group experiences while better protecting water quality. DWSP conducted a *Stakeholder Issue Survey* in 2019 and identified major themes regarding public access use/types of recreation/conflicts/problem areas) DWSP worked on the draft Public Access Management Plan and made decisions on key issues based on staff knowledge, available science, and public input.

DWSP scheduled facilitated public meetings in late 2019 and early 2020 to present some decisions on key issues. The public meetings were cancelled in March of 2020 when the Covid-19 pandemic started. The Public Access Management Plan update

process was put on hold while DCR and DWSP adjusted to the pandemic and worked to mitigate the impacts of it on staff and the public. The plan should be completed in 2023.

Covid 19 Pandemic Response
There was a large increase in visitors to DCR properties across the state as the pandemic made outdoor activities more attractive. Ware River Watershed Rangers average a total of 5,174 visitor contacts and 392 violations per year. During the Covid Pandemic rangers documented 12,332 visitor contacts and 1,250 violations in a year.

Accomplishments

- DWSP has added three full time Watershed Ranger positions in the Ware River Watershed.
- DWSP responded to increased demand from public users due to the Covid-19 pandemic.
- DWSP signed a new MOU with Mass Fish and Wildlife refining language regarding the Wildlife Management Areas (WMA's) within Ware River Watershed and improved signage and mapping of those areas.
- A new online hunting map was launched.
- Monitored Mass Central Rail Trail maintenance activities.
- Provided timely updates of the DCR Watershed web page to for accurate information about changes to public access.
- Informational kiosks and websites were updated regularly with new and current public information.
- Watershed Rangers, IS Staff and DWSP Sign Shop coordinated an overhaul of the signage in the watershed in 2021.
- Ware River Watershed Advisory Committee meetings were regularly attended by DWSP staff to address issues and inform the committee and the public about DWSP activities.
- Finalized Public Access Management Plan update.
- DWSP met with DCR Parks to coordinate the management of several areas managed for Public Access: Ware River Rail Trail, Comet Pond Swimming Beach; Rutland State Park/Whitehall Pond/Swimming Area; Long Pond Parking area; and Comet Pond Public Access boat launch parking area.
- A dedicated phone number for the Ware River Watershed Rangers has been added. This number allows members of the public to contact the Rangers directly with questions or concerns in the Ware River.
- Watershed Rangers reported 30,413 visitor contacts in the Ware River Watershed, which resulted in 2,722 documented violations from January 2018 through September 2022.

4.5.3 Wachusett Reservoir

The use of watershed lands for recreation can conflict with the primary mission of water supply protection and requires careful control of these activities to limit the risk of

negative impacts. Specific practices and procedures that address recreational issues and help identify unauthorized activities, reduce future instances of encroachment or trespass, and propose solutions for problems are addressed in the *Wachusett Reservoir Watershed 2011 Public Access Plan Update*. Please refer to the plan for current policies and associated maps; the plan provides detailed descriptions of a wide range of public access issues and includes a number of tasks proposed to improve water supply protection efforts. Additional information on public access can be found within the 2017 Land Management Plan.

The Wachusett Reservoir Public Access Plan went through an update that was completed in June 2023. The update process began with an online survey to collect input from the public. A Remote Public listening session was held in October 2022 to provide an overview of the process and allow for the public to submit initial comments regarding the plan. An in-person meeting was held in April 2023 to present a draft plan and take additional comments; the draft plan was posted on the DWSP website and further public comments could be submitted through the DCR web portal until the end of May 2023. The plan was finalized in June 2023 with implementation beginning as of July 2023 (Fiscal Year 2024).

Public access is controlled by regulations (313 CMR 11.09) and public access plans and policies. Watershed Ranger staff have the primary responsibility for monitoring and enforcing appropriate public access. State, local, and Environmental police serve as additional enforcement entity if needed or for egregious violations. Rangers spend most of their time utilizing visitor contacts to explain watershed protection efforts and public access controls. Enforcement through education and outreach is a priority and has been highly successful. Signs, kiosks, and printed materials provide guidance on allowed activities and places where specific recreational uses are allowed.

Public access on non-DWSP property has the potential to impact tributary water quality and eventually the reservoir. Staff now assesses permitted uses in state forests and parks, Division of Fisheries and Wildlife properties, Massachusetts Audubon Sanctuaries, private land trusts, and other protected open space to determine if there are any significant threats to water quality.

Accomplishments

- Implemented the comprehensive *Wachusett Public Access Plan Update 2011*.
- Completed *Wachusett Public Access Plan Update 2023* for implementation beginning in FY24.
- The Watershed Ranger staff patrolled the Wachusett watershed seven days a week, providing education about rules and encouraging good stewardship habits.
- Continued coordination with the MSP and the MEP.
- Reduced number of illegal swimmers and waders.
- Continued to encounter and initiate enforcement against use of ATVs on DWSP property.
- Maintained and updated information placed on key kiosk and bulletin board locations around the watershed. Topics on water quality, DWSP operations and public access issues are updated at least on a quarterly basis.

- Distributed brochures were at a range of events, including the West Boylston Fall Festival, Nashua Riverfest, New England Public Works Expo, Clinton Old Home Day, Holden Public Safety Day, Springdale Mill Day, Massachusetts Municipal Association Annual Conference, Johnny Appleseed Festival, Wachusett Dam Opening (Spring and Fall each year), Tower Hill Botanic Garden, Mass Envirothon, Princeton Arts Festival, and at the Main Entrance of John Augustus Hall.
- Implemented on-going fishing line recycling program. Asked fisherman to discard old and unusable fishing line in specially made canisters located at several heavily used fishing areas. In addition to protecting wildlife, this line is kept out of landfills by recycling into other products.
- Educated anglers on Aquatic Invasive Species (AIS), using Watershed Ranger contacts, notices at local bait and tackle shops, advisories posted on DWSP bulletin boards and kiosks, and through contacts with watershed sportsmen's clubs.
- Made efforts to counter the continual pressure to utilize DWSP land for dog walking, even though dogs are prohibited on DWSP land. Conducted significant outreach to educate watershed residents and watershed visitors on the dangers of pet waste.
  - Distributed nearly 18,000 brochures on pet waste.
  - Placed information on bulletin boards and kiosks.
  - Mailed letters to neighborhoods where dog waste is the suspected cause of higher bacteria levels in tributaries.
  - Worked with local school and scout troops.
  - Produced an award-winning animated public service announcement.
- Offered popular and well-attended educational/interpretive programs.
- Integrated improvements to public access and universal access as part of the proposed Quinapoxet Dam Removal project in West Boylston. If completed, the project area would replace and upgrade the existing older universal access trail and fishing platform. New signage explaining the history of the dam site and the ecological importance of the dam removal are also planned.

4.5.4 Sudbury Reservoir

DWSP policies regarding public access in the Sudbury system are detailed in the *20022 Sudbury and Foss Reservoirs Watershed Public Access Plan Update*, which was updated and finalized in 2022. Please refer to the plan for current policies and associated maps. A key component to the plan is the designation of resource management districts and corresponding public access rules. Many activities are not allowed in the Sudbury and Foss Reservoir watersheds due to the limited resources available to protect both the public and DWSP property. There are ongoing enforcement issues surrounding illegal uses, such as chronic swimming at the railroad trestle crossing the Foss Reservoir. This issue remains a challenging one for Rangers with limited enforcement capabilities; joint operations with CSX Railroad Police were held to attempt to stop this illegal activity. A fishing season has been added to Foss Reservoir.

More extensive ranger patrols of Sudbury Watershed have occurred during the past five years and, as expected, more violations have been observed. A slight uptick in transient sites is occurring and has the potential to become a more frequent issue due to rising housing costs. Many canoes, kayaks and jon type boats have been removed from the woods along the shoreline. Through the use of boat patrols, the Watershed Rangers also discovered a few party spots along the shoreline and islands.

Problem access areas are noted through ranger patrols. Gates, barriers and signs are repaired and placed as conditions warrant.

Aquatic Invasive Species pose a threat when using fishing gear that has been submerged in an infested lake, pond, or stream area. Therefore, while fishing is allowed from the shoreline at many areas around the Sudbury Reservoir, it is important that users be vigilant about cleaning any fishing equipment. DWSP encourages that any visible mud, plants, fish or animals be removed before transporting equipment and any fishing equipment that comes into contact with the water be thoroughly cleaned and dried before using at the Sudbury Reservoir or any of its tributaries.

Bacterial contamination and nutrient contribution from dog waste continues to be a threat to water quality due to the amount of residential neighborhoods abutting the tributaries and reservoir as well as illegal dog walking on DWSP lands.

The Sudbury Reservoir watershed includes many open space and recreation fields not owned by DWSP. Callahan State Park allows for a variety of public recreation, including dog walking. Lands are also owned by the Sudbury Valley Trustees, Boy Scouts of America, municipal departments and private schools, offering vast areas of open space for use.

Numerous sports fields are located along tributaries to the reservoir, where chemical use, in addition to human activity, poses a risk to the water supply. These fields offer wide open spaces for Canada geese and are often an area for dog walkers, providing a pathway for bacteria and pathogens to get into the water supply.

The 9/11 Memorial Field and associated parking area is located in close proximity to the Sudbury Reservoir in Southborough. It is a 15-acre site that is leased by the Town of Southborough from DWSP and has been in existence since 2002. A 15-year lease was signed in 2017, and replacement of the artificial turf and drainage improvements began in February 2018. Potential impacts to water quality exist at this location, but an opportunity for outreach and education also is present.

Impacts such as an increase in litter, biking and illegal dog walking could become a potential problem in this watershed due to the creation of trails and more extensive use of existing trails. A portion of the Bay Circuit Trail, a 184-mile permanent recreation trail and corridor that travels through 34 communities, is located within the watershed. Maps and information made available to the public for the Bay Circuit Trail list the area as a drinking water supply and instruct users to follow posted rules and regulations. Portions

of the trail that were previously on streets without sidewalks have been re-routed through the woods adjacent to the Fayville Dam.

The Boroughs Trail Loop, created by the Sudbury Valley Trustees and representatives from the towns of Marlborough, Southborough, Westborough and Northborough, is a 33-mile regional trail that was opened in 2018 to connect the existing trail networks of the four towns. To date, the completed portion of the trail encompasses 24 miles, of which over ten miles are located on DWSP lands through agreements with DWSP and MWRA. Additional finances were obtained for the development of the 1.9-mile Peninsula Trail, which will connect the existing Boroughs Loop Trail and the recently completed Aqueduct trail.

An agreement with MWRA and the Southborough Trails Committee has allowed the creation of a new section of the Boroughs Loop Trail, partly parallel to the Open Channel. Dogs and bicycles are not allowed on any portion of the trail on DWSP property. Other new trail sections include the Panther Trail, Bay Circuit Trail Connector, completed in 2020, and the Aqueduct Trail, which splits off from the Bay Circuit Trail and Burrows Loop Trail completed in 2022. The Sudbury Reservoir Trail is also located adjacent to the southwest portion of the reservoir.

DWSP continues to get reports of illegal boating on the reservoir throughout the summer. The Rangers and MEP Officer assigned to this area have tried to curb this activity.

Accomplishments

- Watershed Rangers routinely patrolled and educated visitors within the watershed.
- Worked with local and state law enforcement to curb activities such as trespassing, illegal hunting and trapping as outlined in the 2022 Sudbury and Foss Reservoirs Public Access Plan Update.
- Conducted regular night operations starting Memorial Day weekend and continuing through Labor Day weekend; a ranger will stay on late and patrol on Friday, Saturday and occasional Sunday nights.
- Curbed illegal partying and night time access on DCR property.
- Responded to and assisted at a fairly large wildfire during the summer of 2022 in an inaccessible, remote area of the watershed in Marlborough. According to the Marlborough Fire Department Facebook page, the fire was likely caused due to an unattended or poorly extinguished campfire.

4.5.5 Five Year Objectives

- Implement, and when necessary review and update, each watershed's Public Access Management Plan.
- Maintain working relationships with MSP, MEP, and local police.
- Monitor DWSP lands and water to ensure compliance with rules and regulations designed to protect the water supply and protect the public.
- Implement existing protocol for maintaining gates and other structural controls.
- Continue and expand public education and outreach activities related to watershed management and water supply protection within the watershed system communities and on DWSP lands.
- Expand use of electronic media to disseminate information.
- Continue to improve signage and maps; update to reflect allowed uses and MEMA emergency information.
- Maintain GIS trails data layer.
- Keep four-sided informational kiosks up to date and investigate the feasibility of replacing with professional NPS style signage.
- Improve online mapping of recreational opportunities.
- Reconstruct and improve, where appropriate, universal access sites.
- Investigate alternatives to issuing citations; focus enforcement on education.
- Update, as needed, the Quabbin Park and Quabbin Park Cemetery Policy and Operations and Maintenance Plans. *(Quabbin)*
- Operate the shoreline fishing programs on the reservoirs and boat fishing program on Quabbin Reservoir in a manner that minimizes threats to water quality.
- Implement the Quabbin Boat Seal program. *(Quabbin)*
- Maintain a productive working relationship with Wachusett Greenways, who manage the Mass Central Rail Trail on DWSP lands through the Wachusett and Ware River watersheds.

4.6 Watershed Security

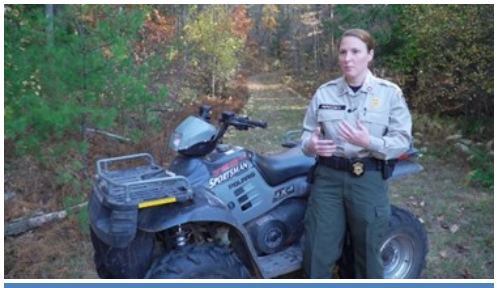
Watershed Security is a vital function in an unfiltered public water supply system. The terrorist attacks of September 11, 2001, forced all public water suppliers to re-focus their attention on the security of the water supply. DWSP and MWRA consider security of the water system to be of the highest importance. Security of the water system is comprehensive – source to tap – but is also flexible enough to adjust to a range of potential threat conditions. The probability of intentional contamination of a drinking water supply is relatively low, but it is possible to contaminate a portion of a drinking water system and cause adverse public health consequences or decrease public confidence in the water supply. DWSP's policies are periodically reviewed in order to achieve the goal of providing a safe and secure water supply system.

Watershed security programs include those measures taken watershed-wide, directly around the reservoirs, and at specific facilities and structures. The need to protect public works infrastructure from criminal/terrorist activity requires strong and ever evolving preventative methods. Measures taken run the gamut from surveillance to physical barriers. Watershed Rangers provide a visible presence and subsequent deterrent while physical structures are constantly evaluated for susceptibility.

Goal

Maintain and improve watershed security programs and provide surveillance of critical watershed facilities to protect the watershed system from potential threats.

The primary responsibility of the Watershed Rangers is to protect drinking water resources by conducting regularly-scheduled patrols and surveillance of DWSP-owned lands and waters. Patrols are focused on both popular recreational access locations and security areas around the watershed system. Patrols are conducted by motor vehicle, boat, bicycle, snowmobile, foot, and all-terrain vehicles. Watershed Rangers provide security for DWSP facilities and other designated buildings and regularly monitor potential trouble spots on the watersheds. Special use and group permits may be checked by Watershed Rangers to ensure that permittees are in compliance. Watershed Rangers keep daily logs of their



patrolling activities. In addition, Watershed Rangers are trained as emergency first responders, maintain radio communication with local and state police, have undertaken ice rescue training, and have Incident Command System certifications.

Physical barriers are used where needed throughout the watershed to prevent unauthorized access to sensitive areas. Locked metal gates and wooden barways are located throughout the watershed to limit vehicular access. In addition, concrete barriers, metal security fencing, and boulders/felled trees are used to limit access to certain areas. These structures are regularly installed, monitored, and replaced when necessary.

DWSP and MWRA consider security of the water system to be of the highest importance. Security of the water system is comprehensive – source to tap – but is also flexible enough to adjust to a range of potential threat conditions.

Rapid advancements in technology have contributed to improved communication within DWSP and from outside of DWSP. DWSP staff regularly receive inquiries via email, often accompanied with photos, from the visiting public regarding questions or concerns. This mode of communication can be responded to quickly, greatly enhancing watershed security. DWSP will explore additional technology opportunities to enhance security through improved communication. In addition, DWSP and MWRA will continue to explore options to monitor areas remotely to further improve watershed system security.

A Vulnerability Assessment was required by the federal *Public Health Security and Bioterrorism Preparedness and Response Act of 2002* – Title IV, Section 401, which amended the Safe Drinking Water Act. In this amendment, each community water system serving a population of greater than 3,300 persons is required to conduct an assessment of the vulnerability of its system to a terrorist attack or other intentional acts intended to substantially disrupt the ability of the system to provide a safe and reliable supply of drinking water. Section 2013 of the 2018 America's Water Infrastructure Improvements Act (AWIA) also required evaluations of the vulnerability and resilience of key water facilities, and the development of appropriate response plans to mitigate any identified vulnerabilities. MWRA completed all the required evaluations and certified completion to EPA by the 2020 deadlines. DWSP and MWRA are implementing the recommendations of these assessments; due to the sensitive nature of this matter, however, specific details will not be included in this report.

4.6.1 Quabbin Reservoir

Accomplishments

- Watershed Rangers completed daily security patrols checks of locks, signage, gates, and access barriers.
- Watershed Rangers now carry iPads, GPS, and/or Smartphones and have real-time access to a Quabbin boater portal (including emergency contacts and information on current boat traffic) and a boat decontamination calendar.

- Watershed Rangers overhauled their record keeping procedures and moved from a paper process to a digital e-logs. The Captain and Lieutenant have access to daily field logs of rangers on duty, can print reports from these logs, and report incidents and CMR violations on a map. Supervisors have the ability to manage citations, including overdue citations, open citations, parking tickets, and closed citations.
- Watershed Rangers can also access Smartsheet information from the field, including permits and work orders.
- A Massachusetts State Police Marine Unit took over responsibility for patrolling Quabbin Reservoir during the fishing season. The unit patrols seven days per week.
- Watershed Rangers conducted daily patrols of gates/barways, dam, dike, CVA, and Shaft 8.
- Maintenance and repairs to the gates/barways were performed as needed.
- Watershed Rangers also deploy up to six motion-activated cameras throughout the watershed to better monitor remote locations. Photos are systematically collected, reviewed, and inventoried.
- Ban letters were developed with DCR Legal and issued to 12 individuals.
- Security camera monitoring available to MSP, Watershed Rangers, and MWRA (24-7 in Chelsea facility).

4.6.2 Ware River

The components of the Drinking Water Supply System that are considered most vulnerable in the Ware River watershed are under the control of MWRA, who provide the majority of the security to those facilities.

Three Watershed Rangers are now dedicated to the Ware River watershed full-time. Watershed Rangers have offices, vehicles, and all other necessary equipment at the Oakham Field Office.. The US Army Corps of Engineers (ACOE) also has a Ranger Section stationed at Barre Falls Dam that provides additional security to the land they control within the watershed.

Security checks of MWRA and ACOE facilities are made under agreements with those agencies. Watershed Security is also enhanced by a cooperative relationship with MSP, MEP, local police and MWRA.

Physical barriers, such as security fencing/no access signage, locked gates and barways, serve to protect certain areas of the watershed. Surveillance of problem areas, such as illegal dumping sites and illegal trails (i.e., single track bike/horse/hiking) was enhanced with the use of portable game cameras. Opportunities exist to utilize new technologies (e.g., surveillance cameras, smart tags, dedicated email for reporting suspicious activities) as part of the security program.

Accomplishments

- Three full time Watershed Ranger positions have been added and dedicated to Ware River Watershed.
- DWSP facilities, gates, and barriers are checked daily by Watershed Rangers.
- A bridge was installed on Brigham Rd to allow for quicker response by DWSP staff.
- The locks on all gates have been changed and keys have been distributed to necessary staff and outside agency personnel. A new digital system for tracking and processing key assignments has been successfully implemented.
- DWSP staff has participated in security trainings.
- A safety assessment of some of the structures at the Rutland Prison Camp Ruins was contracted out and completed by an engineering firm. DWSP has presented the results to the Rutland Historic Commission and is working to build consensus on how to reduce hazards at the site.
- New exclusion barriers (fencing and security gates) have been installed around dumping and problem areas.
- DWSP staff met with local police departments and distributed maps and information about DWSP management lands and waters in the Ware River Watershed and discussed ongoing issues.
- Two ATVs and a boat were dedicated to Ware River Watershed to help with Watershed Ranger Patrols.
- The access permit process was streamlined and modernized; all permit requests for access to DWSP lands behind locked gates are submitted through an online portal and permits are generated and distributed electronically. Watershed Rangers are notified electronically of approved permits. DWSP regularly monitor these access permits and activities.
- Watershed Rangers now carry iPads, GPS, and/or Smartphones and have real-time access to a Quabbin boater portal (including emergency contacts and information on current boat traffic) and a boat decontamination calendar.
- Watershed Rangers overhauled their record keeping procedures and moved from a paper process to a digital e-logs. The Captain and Lieutenants have access to daily field logs of rangers on duty, can print reports from these logs, and report incidents and CMR violations on a map. Supervisors have the ability to manage citations, including overdue citations, open citations, parking tickets, and closed citations.
- Watershed Rangers can access Smartsheet information from the field, including permits and work orders.
- Watershed Rangers participated in collaborative patrols with MEP, and coordinated with state and local law enforcement as necessary.
- DWSP is currently in the process of adding fencing at the former Wain-Roy property to address security and trespass issues.
- Vandalism has been documented and reported to state and local law enforcement officials, particularly hate speech graffiti and domestic terrorist postings.

4.6.3 Wachusett Reservoir

One aspect of watershed security in the Wachusett Reservoir watershed that has remained a constant concern for water quality by both intentional and unintentional means is the rail lines that traverse through the watershed and over the reservoir. MOUs have existed with the railroad owners for many years. Railroad ownership transferred to CSX in 2022.

Since that time, railroad crossing restoration has occurred at three crossings: Prescott Street, Temple Street, and Shrewsbury Street. CSX and MWRA agreed to several conditions after the acquisition, to improve the safety and security of the rail operations on tracks within the watershed:

- Upgrading and maintaining tracks from FRA Class 1 to Class 3.
- Installation of guard rails at reservoir crossings
- Limiting track speeds to 25 miles per hour.
- No parking or idling within the watershed.
- Installing railcar monitoring equipment for dragging equipment and hot wheel bearings.
- Providing information on hazardous materials being transported.
- Providing notice of derailments, spills or releases.
- Continuing ongoing communication with the railroad.

Accomplishments

- Rangers attended and stayed current on all Medical, Search and Rescue, and other on the job-related training such as OSHA 10, Spill Response, Boating/ATV safety. Staff attended additional training as provided by the Massachusetts State Police (MSP) and regularly coordinate with the MSP and the Massachusetts Environmental Police.
- Ranger patrols were conducted during all hours in response to violation trends. Trespassing and vandalism at critical infrastructure increased during the COVID-19 pandemic as did general visitor use of our properties.
- Cameras previously installed on top of the Clinton Dam were upgraded by the MWRA.
- A new camera was installed adjacent to Thomas Street in West Boylston to monitor the rail line crossing the Thomas Basin for emergency response purposes.
- New signage was installed in DCR/DWSP owned parking lots because of COVID-19. They are now posted “No Parking After Dark.” Vehicles found in violation were ticketed.
- Security gates throughout the watershed were refreshed with paint and locks were evaluated and replaced if necessary.
- Gave numbers to the Wachusett Aqueduct gates.
- Direct access to the reservoir is a clear threat to water quality. Fencing prohibiting access to the water along the shoreline of the North Dike is being replaced as financial means allows. Over 3,300 feet to date have been replaced.

- Installation of a new Fire Alarm system was completed for John Augustus Hall in 2021. Building security has been improved with upgrades to the security system (cameras) and updated software provided by American Alarm.
- Driveway and building perimeter lighting was upgraded at John Augustus Hall in 2018.

4.6.4 Sudbury Reservoir

The largest security concern in the Sudbury watershed is the amount of roadway and the railroad lines that abut or cross the reservoir. There are also many technological, chemical and biomedical companies in the watershed. The *Combined DCR & MWRA Inter-Agency Emergency Spill Response/Prevention Plan for the Wachusett and Sudbury Watersheds* provides guidance for releases of hazardous materials. MWRA had a consultant prepare the Sudbury and Foss Dams Emergency Action Plan in February of 2018.

Watershed Rangers regularly patrol the area. Local, State, and MEP are also responsible for monitoring the watershed.

Accomplishments

- Watershed Rangers regularly patrolled the area providing “24/7/365” monitoring of the reservoir and critical infrastructure along with the Massachusetts State Police via their watershed patrol from the Millbury Barracks.
- A Watershed Gate Inventory feature layer was created in ArcGIS Online and is managed by the Watershed Rangers and Watershed Maintenance personnel. There are two versions of this data layer, one is an internal version with robust attribute information, the other is a public-facing layer which is used in agency public-facing maps/apps dealing with public access.
- Security gates throughout the watershed were inventoried and numbered, refreshed with paint and locks were evaluated and replaced if necessary. Additional gates were installed where fire roads have been targeted to be brought back into service.
- A new ranger patrol boat was purchased for the Sudbury system to assist in more frequent ranger patrols and emergency response.
- Three vacant buildings at Salem End Road were boarded up and secured. Two other vacant, constantly vandalized buildings were razed.

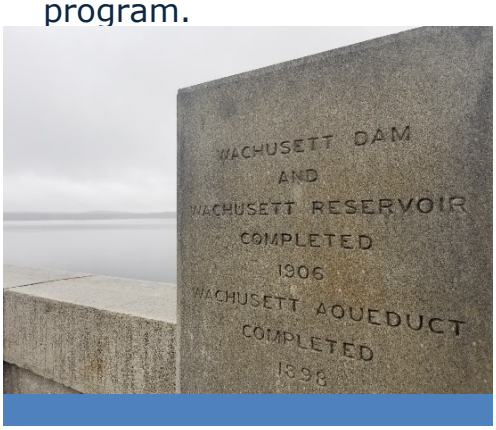
4.6.5 Five Year Objectives

- Continue Watershed Ranger patrols on all DWSP properties, with particular focus on high security sites and known problem areas.
- Coordinate with MWRA in order to maintain comprehensive system-wide approach on all security issues.
- Work with local, state and federal responders and ensure they receive current agency emergency contact information on a regular basis.
- Remain up to date with any guidance materials available from EPA, American Water Works Association, and Department of Homeland Security.
- Improve physical access control structures, as necessary, and implement a maintenance program.
- Investigate any incidences of vandalism and equipment theft.
- Investigate alternatives to issuing civil citations for infractions of DCR regulations.

4.7 Infrastructure Management

Goal

Maintain the integrity of all high hazard dams under DWSP control, maintain and improve DWSP facilities and equipment, and maintain internal roadways to allow them to sufficiently support their use for the water supply protection program.



The Infrastructure Maintenance program provides resources to preserve the integrity of dams, provide upkeep and improvements to facilities, and construct and repair the roads, culverts and bridges which are under DWSP control. These activities are conducted by professional engineering staff, contractors overseen by engineering staff, and skilled mechanics, equipment operators, tradesmen, and laborers.

Buildings owned by DWSP must comply with the Americans with Disabilities Act (ADA) Accessibility for Buildings Guidelines and will also incorporate recommendations for energy efficiency and clean energy. DWSP strives to make infrastructure decisions that conserve energy and reduce greenhouse gases without compromising public safety and can be accomplished within budgetary restrictions. DWSP maintained fire roads and improvement projects on DWSP property are monitored by EQ staff and follow or exceed all applicable state, federal and municipal regulations during the work phase.

4.7.1 Quabbin Reservoir

Program components include: reservoir operations, dams and dike maintenance, facilities management, BLAs, Quabbin Park, Quabbin Park Cemetery, internal DWSP roads and culvert maintenance, bridge inspections, surveying and drafting, construction planning and supervision, fleet procurement and maintenance, and snow removal. Opportunities to improve energy efficiency and sustainability are sought and implemented where possible.

Dam and Dike

The Quabbin Reservoir is impounded by two large, earthen structures: Winsor Dam and Goodnough Dike. These two major, high hazard dams and their ancillary structures are inspected and maintained jointly by MWRA and DWSP. DWSP works with MWRA to optimize the delivery of high-quality water for drinking water supply while ensuring adequate

volume in storage to respond to fluctuations in precipitation and demand, meet downstream minimum flow release requirements, and prevent violation of minimum pool reservoir stage limitations. In addition, hydroelectricity is generated by the downward flow of water from the Quabbin Reservoir to the Wachusett Reservoir. Another notable dam that is co-managed by DCR and MWRA is the Quabbin Spillway Dam – totaling 400-linear feet in length; when surcharged the structure passes water downstream to the Swift River.

DWSP also owns and maintains 15 small dams located throughout the Quabbin Reservoir and Ware River watersheds. These dams are regularly maintained, inspected, and monitored by DWSP staff in accordance with Massachusetts Dam Safety Regulations.

Facilities Management
DWSP Quabbin/Ware Region manages and maintains 26 separate facilities ranging in size from small photovoltaic power sheds to the 40,000-square-foot Administration building. Ancillary structures and utilities associated with these facilities include water supply systems, septic systems, IT equipment, fueling islands, and heating systems that include the 60 horsepower, wood-fired boiler system that heats the Administration building. Ongoing maintenance and repairs to these facilities provides compliance with public health, safety, and environmental standards, while opportunities are realized to improve energy efficiency, universal access, and the long-term sustainability of each facility.

Internal DWSP Roadways/Culverts/Bridges
DWSP manages and maintains a network of more than 300 miles of roads in the Quabbin/Ware Region. The majority of these roads are unpaved and susceptible to road washouts. The stream crossings of many of these roads are spanned with simple culvert pipe or box structures. However, a smaller number of bridge crossings exist that service woods roads, timber harvesting traffic, and recreational trails throughout the watersheds. The amount of staff time and resources devoted to repair and upkeep of the roads within the Region is not insignificant.

The Infrastructure Maintenance program provides resources to preserve the integrity of dams, provide upkeep and improvements to facilities, and construct and repair the roads, culverts and bridges which are under DWSP control.

In addition, DWSP is responsible for the primary care and control of five major bridge spans, including the Spillway Bridge Crossing at Winsor Dam and Horseshoe Dam bridge crossing at BLA 3.

Gravel Pits
DWSP owns approximately 20 acres of gravel pits. Gravel resources are primarily used for repair and upkeep of roads within the Region. Certain watershed towns, Petersham and New Salem, extract material from gravel pits on DWSP property (MGL, Ch. 240, Sect. 4, Acts of 1938) . There are also privately owned gravel pits in the watersheds.

Construction Planning and Supervision
DWSP staff provides a wide array of construction support services ranging from project planning, contract writing, survey, design, permitting, and construction oversight. In-house projects have included boat ramp replacements, septic systems design and installation, and design and construction of stormwater treatment BMPs. In addition to serving as design and construction engineer on a number of in-house projects, Civil Engineering staff also work closely with private contractors on the development of facility improvement plans and on oversight of construction.

Snow and Ice Management
Snow removal work is performed to meet the following goals: 1) provide 24/7 access to the Administration Building/MWRA lab, MSP, and stockroom facility; 2) clear work areas for employee access prior to and during business hours; 3) make Quabbin Park and Cemetery accessible to the public within a reasonable amount of time after a storm has ended; 4) plow roads throughout the watershed based on priority access and ongoing activities; and 5) reduce the use of road salt on paved surfaces and sand/salt on internal gravel roads.

Spillway Watch
As the reservoir rises and increased pressure is exerted on the infrastructure, DWSP staff conduct inspections and coordinate with MWRA and the local emergency managers and downstream landowners to convey updates on reservoir levels, spillway discharges and total flow. The inspection frequency, timing and reporting protocols are triggered based on reservoir elevation, spill volume, flow rate and response to significant precipitation events. The Reservoir has pooled enough to spill periodically every year since 2018.

Accomplishments
- A Facility Master Plan for the Quabbin South Campus complex was completed.
- A new hydro-seeder was acquired, and DWSP worked with private contractors to initiate a nutrient enrichment and turf restoration project on the dam slopes.
- CE staff developed the ArcGIS Road Infrastructure Management Experience (RIME) which organizes and tracks maintenance and repair work on the internal road network.
- A Roads Working Group was established, and the Road Management Plan was completed.
- The photovoltaic system at BLA 1 was replaced.
- Improvements were made on the Quabbin Tower including new beacon lights, ventilation fans, hazardous material abatement, and interior/exterior cleaning.
- Gate 40 culvert was replaced with a new pre-cast concrete culvert.
- A Gravel Best Management Practices document was completed as well as individual management plans for each new pit; NHESP permits were acquired for pits in certain locations.
- Required permitting and individual gravel management plans were completed for each DWSP pit.
- A new water supply was established for the Quabbin Administration building.

- Progress was made on the design of the new Quabbin Maintenance Garage
- DWSP worked with architects to develop new site plans for the New Salem location; plans were shared with MWRA.
- Significant effort was invested in Quabbin Dam and Dike monitoring and maintenance, including monthly inspections and reporting.
- The Snow and Ice Management Program was improved to reduce the use of road salt on paved surfaces and sand/salt on gravel surfaces maintained by DWSP.
- DWSP staff have implemented a pre- treat brine application system to reduce salt usage on paved surfaces and also calibrated equipment used in sand/salt applications, which are regularly monitored.
- Extensive Quabbin Park Cemetery upgrades were completed: irrigation, historical restoration, and hazardous tree removal.
- Updated Spillway Watch protocols and conducted appropriate inspections, coordinating with local emergency managers and downstream landowners.

4.7.2 Ware River

Dams

DWSP engineers must complete periodic Phase 1 Dam Safety Inspections on Demond Pond in Rutland, Asnacomet Pond in Hubbardston, and Brigham Pond in Hubbardston in order to comply with state law. There are also 13 smaller dams on DWSP property within the watershed. In addition, DWSP owns the trail, bridges, and tunnels associated with the MassCentral Rail Trail, although the non-profit organization Wachusett Greenways is partly responsible for maintenance of these structures.

Boat Ramps

Boat access at Long Pond boat ramp and Asnacomet (Comet) Pond boat ramp, although formally under control by the Office of Boating and Fishing, is seasonally managed by DWSP staff. DWSP plows the parking lot at Comet Pond boat ramp in the winter, and installs jersey barriers over the winter to prevent vehicles from driving onto the pond's ice. DWSP has resumed care and control of the parking lot at Long Pond (formerly managed by DCR State Parks).

Internal DWSP Roadways/Culverts/Bridges

DWSP road maintenance is on-going throughout the year to protect water quality and insure DWSP staff access. Over 125 miles of gravel roads and rights of way are monitored, maintained and repaired through the year in the Ware River watershed. DWSP ensures that staff are properly trained, equipment is regularly inspected and serviced, and appropriate materials are used in this program.

DWSP maintained fire roads and improvement projects on DWSP property are monitored by EQ staff and follow or exceed all applicable state, federal and municipal regulations during the work phase.

Accomplishments

- The Office of Boating and Fishing recently installed a new boat ramp on Long Pond. DCR/DWSP is in the planning stages of downsizing the footprint of the parking lot at Long Pond ramp area.
- Gravel Management Plans were developed for two sites. The plans went through the permitting and approval process. Both gravel pits are now operational and will supply gravel for road and infrastructure projects for the foreseeable future.
- Completed Dam Safety inspection for Brigham Dam.
- A portable bridge was installed over the West Branch of the Ware River on Brigham Rd. in Hubbardston which greatly increases access to that part of the watershed to staff and for land management activities.
- Updated and maintained equipment available to the maintenance staff.
- An internal "Green Committee" has focused on replacing light fixtures and recycling.
- Efforts led by the Civil Engineering Section staff resulted in the development of the Road Infrastructure Management Experience (RIME), an ArcGIS based platform tool designed to manage, track and aide in the maintenance and management of the more than 1,000 structures that support the Quabbin/Ware River Road network.
- Approximately 25 percent of all structures have been re-inspected, inventoried and records updated to reflect status and condition.
- A Working Group was established between Management, Watershed Maintenance, Forestry, and Civil Engineering staff to help guide management and coordination of road improvement efforts. The group completed an update in 2020 of the Quabbin and Ware River Road Management Plan.
- Implemented various Covid mitigation efforts for staff and visitors.

DWSP strives to make infrastructure decisions that conserve energy and reduce greenhouse gases without compromising public safety and can be accomplished within budgetary restrictions.

4.7.3 Wachusett Reservoir

Accomplishments

- Inspected and maintained a number of large and small dams, miles of improved and unimproved roads, and facilities ranging from administrative offices to maintenance garages and storage sheds throughout the watershed.
  - A Phase II inspection of Unionville Pond Dam was completed in 2017.
  - Monthly inspections of the Wachusett Dam and dikes continued during the past five years, along with normal maintenance activities.
  - Liming of the dikes has raised soil pH to desired levels for vegetation cover.
  - Semi-annual inspections and maintenance were conducted on several smaller dams within the watershed.

    - A geotechnical evaluation of River Road, the access road to the Wachusett Lower Gate House in Clinton, was completed. A small area of the slope slid into the pond in 2018; MWRA then had an additional study conducted and a stabilization design was developed.
    - Approximately 900 feet of the Lancaster Mill Pond bank along River Road was stabilized in 2021 and the road was rebuilt.
    - Quinapoxet Dam removal design plans were developed in conjunction with MWRA and DER.
    - CE and EQ staff evaluated a small dam in Princeton for possible removal, but it was determined to be not economically feasible nor an imminent threat.
- DWSP forest roads were inspected regularly and a number of areas needing maintenance and improvements were addressed.
- CE and EQ staff worked together to develop a forest roads inspection and review protocol, and combined efforts to ensure proper design and environmental review.
- A recent focus on the upgrade and maintenance of facilities has resulted in many improvements.
    - Construction was completed on a new Clinton Maintenance Headquarters building in 2019.
    - New boilers were installed in John Augustus Hall in 2018 and a completely new fire alarm system was installed in 2021.
    - The West Boylston Maintenance Yard barn had its roof replaced in 2022.
    - Lead paint abatement was conducted on the Stillwater farmhouse siding in 2021 and stabilization work and a temporary roof patch was installed on the Stillwater Farm barn in 2022.
    - Abatement work was conducted at the Hulick Riding Arena in Sterling and Grove St. garage in Clinton.
    - The Walker parcel buildings in Princeton were demolished along with the Radio Shack in Clinton.
    - A parking lot and rain garden were constructed at Gate 28.
    - DCR has secured Provisional Priority Project Status with DER for the removal of Edwards Pond Dam and the restoration of Malden Brook.

4.7.4 Sudbury Reservoir

The main infrastructure elements in the Sudbury and Foss Reservoirs watersheds are the reservoirs' respective dams, spillways, gatehouses, and associated dikes. There are also emergency pipelines that connect Foss Reservoir Gatehouse to Stearns Reservoir Gatehouse and the Sudbury Aqueduct. DWSP also maintains responsibility for dam infrastructure maintenance on Stearns (Framingham No. 1) and Brackett (Framingham No. 2) Reservoirs, even though these two reservoirs are no longer an emergency source supply for the water supply system. DWSP and MWRA work cooperatively to ensure that the biannual dam safety inspections required under 302 CMR 10.00 are completed and results reported to the DCR Office of Dam Safety. DWSP's Civil Engineers perform routine monthly inspections.

Accomplishments

- The Sudbury and Foss Reservoir Dams Emergency Action Plans were developed for MWRA in 2018.
- The Stearns and Brackett Reservoirs Stewardship Plan was completed in 2021.
- The abatement of asbestos in the Bullard House in Framingham was conducted and the roof was replaced in 2022.
- Phase 1 inspections were conducted of Stearns and Brackett Reservoirs' dams in 2022.
- DWSP designed and Lakes and Ponds constructed a boat ramp at Stearns Reservoir.

4.7.5 Five Year Objectives

- Maintain and rehabilitate DWSP facilities, infrastructure and roads (as outlined in Regional Road Management Plans), taking into consideration changes needed to assess climate change.
- Maintain DWSP fuel storage facilities in proper working order and in compliance with all applicable codes and regulations. Investigate feasibility of upgrading or converting underground storage tanks to above ground structures.
- Investigate alternative means for controlling invasive plants and vegetation impacting the dam slopes and implement recommended actions.
- Continue to reduce energy use through energy efficiency practices.
- Explore and provide new opportunities for solar power, installation of electric vehicle charging stations, solar canopies, and other "green" energy alternatives to support DCR facilities and operations.
- Acquire EV/BEV vehicles and equipment.
- Upgrade DCR radio communication equipment.
- Expand Snow and Ice Management techniques to include new technology on DWSP maintained paved areas.
- Continue and expand work with watershed town DPWs to reduce the use of road salt.
- Monitor reservoir elevation, spillway discharges and conduct inspections according to the Spillway Watch protocols.
- Maintain existing gravel locations and continue to research, assess, and permit new locations.
- Complete a watershed-wide vulnerability assessment to identify potential impacts of climate change on infrastructure in the water supply.

4.8 Watershed Protection Act

The Watershed Protection Act (WsPA, also known as the "Cohen Bill") is a 1992 state law (Chapter 36 of the Acts of 1992; MGL Chapter 92A½ §§1, 5) implemented by DWSP that restricts certain land uses in the Quabbin Reservoir, Ware River, and Wachusett Reservoir watersheds. There are two types of WsPA protective buffers: the "Primary Protection Zone" – the area within 400 feet of the reservoirs and 200 feet of tributaries and surface waters – where alteration is prohibited; the "Secondary Protection Zone" – the area between 200 and 400 feet of tributaries and surface waters, on land within flood plains, over some aquifers, and within bordering vegetated wetlands – where certain activities are not allowed, including storage, disposal or use of toxic, hazardous, and certain other materials, alteration of bordering vegetated wetlands, and dense development. Landowners proposing certain construction or other land use activities within established buffer zones along the regulated tributaries or surface waters of the watershed must comply with such restrictions and may apply to DWSP for either a determination of non-jurisdiction, exemption, or compliance, or for a variance that allows them to proceed with their plans (possibly with certain restrictions).

Goal

Enhance protection of the water supply through implementation of the Watershed Protection Act, which regulates land use in critical areas of the watershed.

Over twelve percent of the three active source watersheds receive some level of protection through the WsPA. The WsPA regulations, 313 CMR 11.01-11.08, however do not prevent all development, as there are a number of exemptions and legacy provisions that reduce the breadth of the law. In these instances, the regulations are still able to promote improved site designs, helping to control potentially harmful water quality impacts, particularly within 200 feet of tributaries and surface waters.

Much of the easily developable land in the watershed system, particularly in the Wachusett Reservoir and Ware River watersheds, has been utilized and there is pressure to develop marginal land with increased risks from both short-term site development impacts and long-term land use alteration. One potential difficulty in administering the WsPA is that neither the Act itself, nor the corresponding regulations, require landowners to contact DWSP prior to conducting regulated

Over twelve percent of the three active source watersheds receive some level of protection through the WsPA…DWSP depends upon having good relationships with town boards, building inspectors, realtors, consulting engineers, surveyors, septic system designers, and others to inform landowners about the law and their obligations.

activities on their land. As a result, DWSP depends upon having good relationships with town boards, building inspectors, realtors, consulting engineers, surveyors, septic system designers, and others to inform landowners about the law and their obligations. WsPA regulations promote both water quality and community land use protection that is accepted by landowners, realtors, developers, and town officials. Development is monitored by DWSP staff through attendance of meetings of municipal boards and committees and review of legal advertisements and other information in local newspapers. Landowners impacted by the WsPA are notified of requirements and staff works closely with them to develop projects that comply with WsPA regulations.

The WsPA has been effectively implemented, maintaining both inter- and intra-agency coordination for the past five years. Staff were able to quickly negotiate the needs of working remotely due Covid 19 restrictions, as they were able to continue to meet with applicants and their representatives, review applications, and issue decisions within time frames as required by the regulations. During the pandemic, staff successfully held virtual public hearings to discuss water quality issues for Variance applications. Staff held construction kick-off meetings, inspected active projects to ensure compliance with conditions and visited sites where work had been completed to check for problems. Building permits and property transfers for watershed communities were reviewed monthly to identify additional properties affected by the WsPA, and owners were notified of regulatory jurisdiction.

An updated ArcGIS Online database was created in 2021/2022 for the management of the Watershed Protection Act (WsPA) files; this is a major improvement to the historic database. These files include applications submitted to DWSP for review under the WsPA and violations of the WsPA. WsPA files dating back to 1992 were uploaded from the respective regions' Access databases into the new WsPA database. The WsPA database enables DWSP staff to use an ArcGIS Online program to track the permitting status of projects from the application phase through the construction phase and provides the ability to monitor projects on an ongoing basis. Users can upload information while doing field work using FieldMaps 123 to upload photos, notes, etc. directly into the database. Various decision and summary reports can be generated saving staff time. All related WsPA documents such as applications, decisions, plans, reports, etc. can be viewed by clicking a link to the associated SharePoint folder. The new WsPA database will be a great resource for DWSP staff in the administration of the WsPA (Refer to Appendix B for a more detailed description of the WsPA database).

A significant hindrance to both staff and the public identified during the initial phases of the Covid restrictions is the legal requirement under 313 CMR 11.02(2) that all WsPA applications must be submitted by mail or in person. DWSP was able to work through this hurdle while staff were working remotely, however it brought into focus that most information could be provided electronically. Staff will work with DCR Office of General

Counsel on updating the regulations to allow for an option to submit WsPA applications through the DCR website.

Staff from across DWSP who implement the WsPA meet regularly as part of the internal Watershed Protection Act Working Group (WsPAWG) to discuss pertinent, confusing, or controversial issues and to resolve problems related to implementation of the regulations. Staff visit Town Halls in watershed communities to distribute brochures and applications and inquiries are made to determine if additional WsPA maps are needed. Maps are usually available in five offices – Town Clerk, Board of Health, Conservation Commission, Planning Board, and Building Inspector. Visiting each community also gives DWSP staff the ability to answer questions and to find out if there has been any staff turnover. A "Watershed Protection Act Viewer" tool has been developed as a resource for towns, landowners, and developers. It is publicly available on the DCR website.

There has been both inter- and intra-agency coordination on regulations that often intersect with the WsPA, including the Wetland Protection Act, Title 5 (septic systems) , and both state and federal stormwater programs. Staff also utilize the Massachusetts Environmental Policy Act to identify, review, and comment on projects in the watershed.

Education and outreach are important for landowners and town officials in order to promote common areas of concern about the effects of development on water quality and ways to mitigate these impacts. DWSP provides technical assistance, as required under the Act's regulations (Chapter 36 of the Acts of 1992, Section 15) to watershed communities by working cooperatively, upon request by local boards, on projects of mutual concern including development of local regulations. Staff support local implementation of state environmental regulations through training, project review, and professional services, such as GIS mapping, environmental engineering, and planning.

4.8.1 Quabbin Reservoir

The Watershed Protection Act (WsPA) regulations, 313 CMR 11.00, applies to the following towns in the Quabbin Reservoir watershed: Athol, Barre, Belchertown, Hardwick, New Salem, Orange, Pelham, Petersham, Phillipston, Shutesbury, Ware, and Wendell (Figure 4-11).

Accomplishments

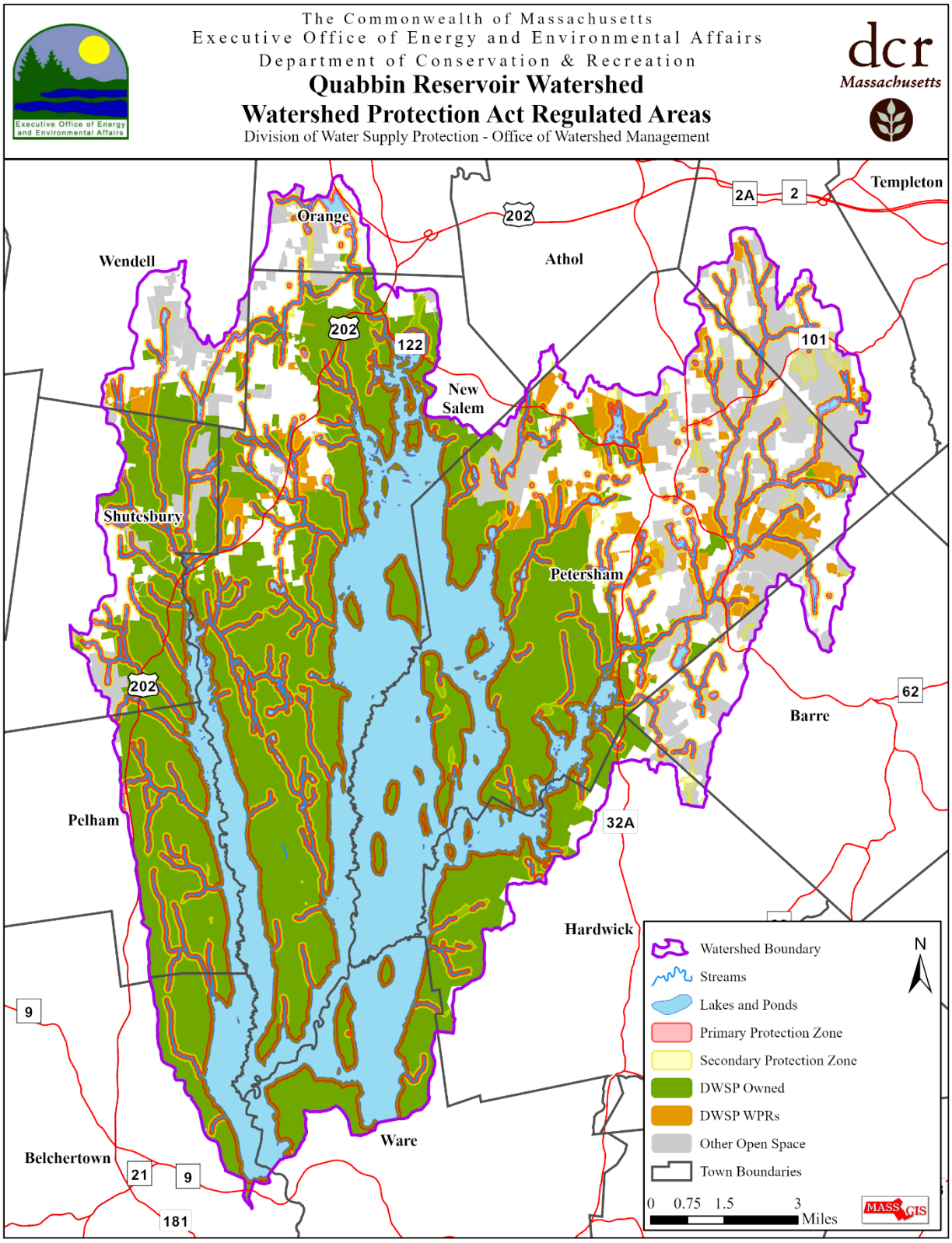
- DWSP staff handled 42 WsPA cases during the past five years in the Quabbin Reservoir watershed (Table 4-13).

Table 4-13: Quabbin Reservoir Watershed – Watershed Protection Act Decisions

Year	Advisory Opinions	Determinations	Variances	Denials
FY18	9	0	0	0
FY19	8	2	0	0
FY20	8	1	0	0
FY21	6	3	0	0
FY22	7	6	0	2
Total	38	12	0	2

Source: DWSP Quabbin/Ware Environmental Planning

Figure 4-11: Quabbin Reservoir Watershed Watershed Protection Act Regulated Areas



4.8.2 Ware River

The WsPA regulations, 313 CMR 11.00, apply to the following towns in the Ware River watershed: Barre, Hubbardston, Oakham, Phillipston, Princeton, Rutland, Templeton, and Westminster (Figure 4-12).

Accomplishments

- Staff worked on 147 WsPA cases in the Ware River watershed between FY 2018 and FY 2022 (Table 4-14).

Table 4-14: Ware River Watershed – Watershed Protection Act Decisions

Year	Advisory Opinions	Determinations	Variances	Denials
FY18	14	9	3	3
FY19	12	4	1	0
FY20	14	7	4	3
FY21	23	10	4	3
FY22	13	10	7	3
Total	76	40	19	12

Source: DWSP Quabbin/Ware Environmental Planning

4.8.3 Wachusett Reservoir

WsPA regulations (313 CMR 11.01-11.08) apply to regulated areas in Boylston, Clinton, Holden, Leominster, Paxton, Princeton, Rutland, Sterling, West Boylston, and Worcester (Figure 4-13).

Accomplishments

- There was a total of 251 applications filed under the WsPA during the past five years, including 76 Request for Advisory Rulings, 157 Applications for Watershed Determination of Applicability, and 18 Application for Variances filings (Table 4-15).
- There were also 22 proposals that were denied because the desired activity was prohibited within the area identified in the proposal.
- In addition, there were several applications that were filed but never completed. These incomplete applications were reviewed, and letters sent to the owner or applicant informing them of the information needed to complete the filing but the requested information was never submitted.

Table 4-15: Wachusett Reservoir Watershed – Watershed Protection Act Decisions

Year	Advisory Opinions	Determinations	Variances	Denials
FY18	8	49	4	9
FY19	16	33	2	4
FY20	14	34	7	7
FY21	20	16	3	1
FY22	18	25	2	1
Total	76	157	18	22

Source: DWSP Wachusett Environmental Planning

Figure 4-12: Ware River Watershed Watershed Protection Act Regulated Areas

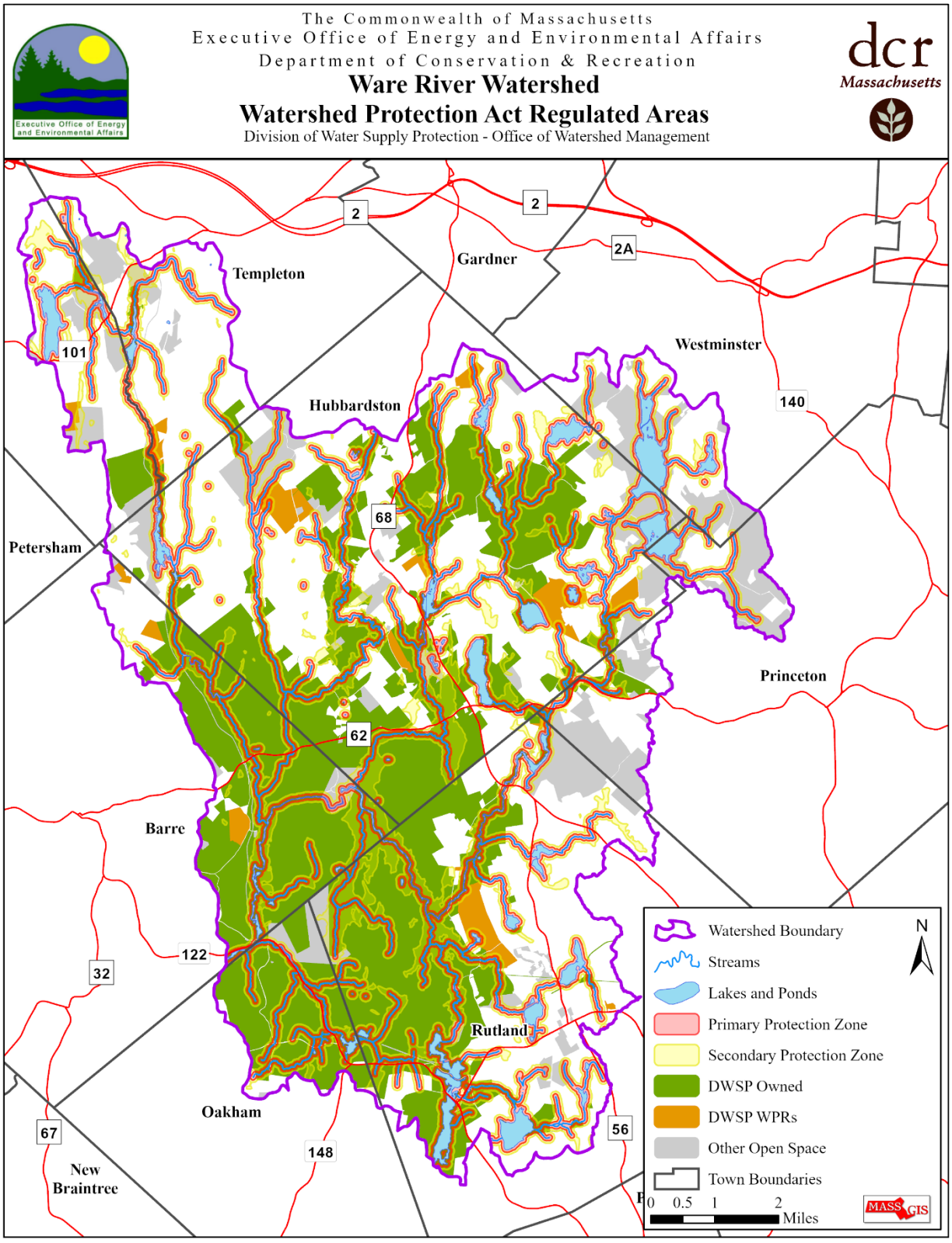
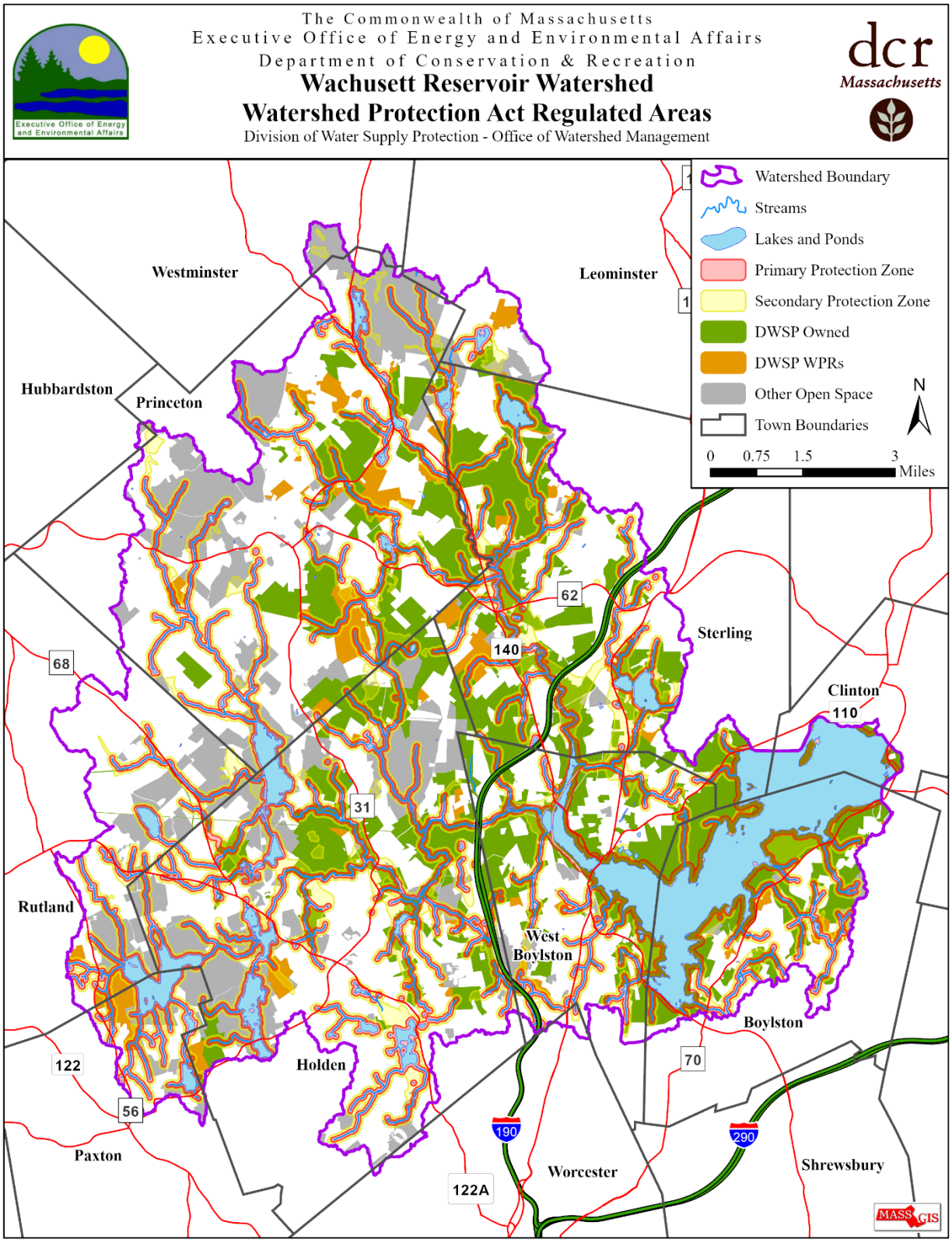


Figure 4-13: Wachusett Reservoir Watershed Watershed Protection Act Regulated Areas



4.8.4 Sudbury Reservoir

The Watershed Protection Act's regulations do not encompass the Sudbury Reservoir watershed.

4.8.5 Five Year Objectives

- Implement the Watershed Protection Act and regulations.
- Review WsPA applications for compliance with WsPA Regulations, MEPA applicability, and other environmental regulations.
- Coordinate with DWSP staff (e.g., EQ, Engineering) to ensure that WsPA projects comply with other environmental regulations, including NPDES construction general permit and MassDEP's Stormwater Management Standards.
- Continue using and maintaining the WsPA database to provide an efficient process to monitor projects throughout each watershed.
- Inspect properties of previous filings for compliance with decisions and conditions.
- Maintain good relations with building inspectors and other town permitting staff and boards to enhance the notification of potentially affected parties of WsPA requirements.
- Provide professional support to watershed communities on land use planning or other associated topics related to DWSP mission.
- Review, as possible, building permits and sales; notify new property owners of their need to file.
- Mail watershed packets, as possible, with outreach materials to new homeowners within the watershed found through property transfer lists.
- Review and update Watershed Protection regulations; amend to allow electronic submittal of WsPA applications.

4.9 Education and Outreach

The Education and Outreach program provides public education for students, local residents, and visitors on the importance of watershed protection. Educational programs are an effective way to protect watershed resources over the long term by instilling a better understanding and appreciation of stewardship of natural resources. Many water suppliers incorporate interpretive services into their watershed protection programs to enhance their measure of water quality and resource protection. An educated user population is one of the best ways to protect water quality in a drinking water supply watershed.

Goal

Provide educational opportunities and materials to inform the public about watershed protection and drinking water issues.

Interpretive services, education, and outreach are delivered through school programs, interpretive programs on DWSP properties (primarily at the QVC in Belchertown and the Stillwater Farm Interpretive Site in Sterling), watershed community programs, and through Watershed Ranger interactions that inform the public about watershed protection and drinking water issues. Non-personal outreach includes signage, brochures, publications, DCR DWSP website, and digital media.

Covid-19 made a significant impact to how Interpretive Services staff interact with the public. A full schedule of public programs and multiple school visits were slated for the spring of 2020; all programs were canceled. At-home activity guides were quickly developed in their place and posted on the DWSP website. Reconnecting to Watershed schools has taken some effort since remote learning was in place; virtual field trips and teacher resources were developed and made available via the internet. The process of re-establishing in person programming began in July 2021. New connections with the public and educators have been made utilizing the skills developed during the pandemic, in particular educational videos and other virtual resources. While programming has rebounded, DWSP continues to re-introduce itself with the public as a destination to visit and learn more about reservoir history and management.

4.9.1 Quabbin Reservoir

The Education and Outreach program is primarily based at the QVC in Belchertown, MA, and includes education programs, teacher workshops, and general information about DWSP resources. Three full-time and one seasonal Interpretative Services staff members are available to assist with visitor information and services. In addition, an automated telephone system provides 24-hour access to current information on fishing, hunting, programs, rules and regulations, and public access. Current information and updates are also available on the DCR website.

Visitor Center

The Les and Terry Campbell Quabbin Visitor Center (QVC) is located on the first floor of the DWSP Quabbin Administration Building in Belchertown and is generally open six days a week from 8:30 am. To 4:30 p.m. The Center is closed for Thanksgiving, Christmas and New Year's Day. The Center features exhibits, brochures, books, and videos about Quabbin and Ware River Watershed management and history. Maps, books, trail guides and related materials are available for purchase from the Friends of Quabbin (FoQ) at the QVC. Vital records for the disincorporated towns of Dana, Enfield, Greenwich, and Prescott are available for genealogical research.

The QVC was formally re-named the Les and Terry Campbell Quabbin Visitor Center by Chapter 325 of the Acts of 2022. Les Campbell, a sanitary engineer at Quabbin Reservoir, founded the QVC in 1984 and his wife Terry was the first volunteer to staff the center. The couple also helped form the Friends of Quabbin and Les was a renowned photographer, particularly of the watershed.

Visitor Education

Groups visiting Quabbin Reservoir can stop at the QVC for an introduction to the Quabbin Reservoir and Ware River Watershed by DWSP staff, including a history of both areas, a summary of reservoir construction, an overview of the DWSP/MWRA water system, DWSP watershed management activities, and information about wildlife and other natural resources. More extensive programs on the history and natural resources of the region are also available. The QVC also offers an ongoing series of guest speakers on a variety of topics ranging from wildlife and local history to art and photography. Group size is limited, and program reservations must be made well in advance of the anticipated date. A variety of self-guided educational opportunities exist for groups visiting Quabbin Park and Reservation, including over 100 miles of trails and roads open for hiking and limited biking. Interpretive staff are available to consult with teachers planning Quabbin Reservoir or water-related programs in their school, or for those interested in a group visit to the reservoir. Interpretive staff also maintain up-to-date information kiosks at selected sites in the Quabbin Reservoir and Ware River watersheds.

Educational programs are an effective way to protect watershed resources over the long term by instilling a better understanding and appreciation of stewardship of natural resources. An educated user population is one of the best ways to protect water quality in a drinking water supply watershed.

School Programs/Community Based Education
Educational programs are offered for school groups at the QVC on a variety of topics, from Quabbin and Ware River watershed history to the bald eagle restoration program, as well as many topics related to watershed protection. Group programs are offered on a first come, first serve basis. Classroom programs and field trips are also offered to schools and groups. Priority is given to schools and groups in the watershed area and to communities which receive water from the metropolitan water supply system. Topics include water quality, water awareness, watersheds, natural history, and Quabbin area history. Quabbin Interpretive staff occasionally offer teacher workshops on Water Quality Testing, Watersheds, Project WET, Project WILD, Project Learning Tree, Quabbin History, and other topics. Interpretive staff also have a long history of involvement with the Massachusetts Envirothon.

Visitor Permitting
Interpretive Services staff currently works as the liaison for review of and issuance of group and special permits. Staff provide educational programs to groups interested in visiting parts of the watershed within the constraints of the rules and regulations.

Records Research and Management
Upon dissolution of the Swift River Valley towns for construction of the Quabbin Reservoir, the Quabbin Superintendent (now Regional Director) became Town Clerk for Dana, Greenwich, Prescott, and Enfield. Each Superintendent/Regional Director has held this office and has been responsible for maintaining and managing the Vital Records of previous inhabitants of the valley towns. Copies of these records are stored at the Quabbin Administration Building and are available to the public for research purposes. Similarly, the original survey "Taking Sheets," photographs, and records of each property purchased by the Commonwealth prior to the actual reservoir construction are archived in the Quabbin Engineering Office. Interpretive Services staff frequently draw upon in-house collections of artifacts, as well as the extensive records of reservoir construction and the early management of the watershed lands, for educational outreach purposes.

Over the past three years, the Real Estate Photos for both the Quabbin and Ware River Projects were added to the Digital Commonwealth website, providing access to these resources to a much wider audience than ever before. The photographs related to the removal of the cemeteries and construction of the Quabbin Park Cemetery were also added to the Digital Commonwealth archive. This enormous project was completed through the joint efforts of the DCR Archives and MWRA Library staff.

Quabbin Park Cemetery
Information about the cemetery, its history, the layout of lots, and the process of accessing Vital Records and burials at the Quabbin Park Cemetery is disseminated through the QVC in person, by phone, or by electronic and written correspondences. Since 2020, the cemetery records have been available through the DCR website in a searchable database created by the Watershed GIS Section. In addition, an informational sign for visitors is posted at near the entrance of the cemetery.

Outreach and Public Relations

Future efforts of Interpretive Services staff will focus on visitor outreach and education related to the role of the Quabbin Reservoir as a public drinking water supply resource. In person and remote programs will continue to be the central piece of visitor outreach, along with a staffed QVC. Interpretive Services staff will also aim to provide more online educational content in the form of videos and self-guided materials for visitors. A social media presence could provide opportunities to educate the public about the complexities of water supply protection. Ongoing coordination with other DWSP staff will provide the public with a deeper understanding of the many facets of water supply protection and watershed management.

Accomplishments

- The QVC had approximately 82,000 visitors over the past five years. IS Staff offered 293 public and school programs to 13,570 students and visitors and responded to over 21,000 phone calls.
- During the pandemic, Quabbin /Ware River Region Interpretive staff continued to respond to visitor inquires via phone and email despite the closure of the QVC building. New ways were incorporated to accomplish outreach, including pivoting to online resource sharing.
- In May 2021, the QVC was reopened for a four-day week schedule and operated that way for the duration of the year. Quabbin IS staff have worked to rebuild both public and educational programming that was affected by the COVID pandemic.
- Public programming has expanded to include regular public hikes and tours in Quabbin Park and Reservation. This has included additional coordination with staff from Forestry, Natural Resources, and Environmental Quality to expand the public's understanding of the issues surrounding forest management, aquatic invasive prevention and wildlife management on watershed lands.
- Educational programming has expanded to include remote programs, in-school presentations, and guided programs in Quabbin Park and Reservation.
- A new and updated orientation film for the QVC provides an excellent overview of the history and management of the Quabbin Reservoir for visitors.
- The Quabbin Park trail system was completely overhauled with assistance from the Watershed Rangers, Sign Shop, and GIS staff. The overhaul included new trail markers and a visitor friendly map.
- Quabbin hosted the 2022 MA Envirothon with 24 participating schools. Lexington High School won the state championship and also won the National Envirothon.
- IS partnered with GIS staff to develop online resources, including an interactive access map for Quabbin Reservation, an interactive AcrGIS StoryMap for Quabbin Park Cemetery, a virtual Memorial Day ceremony in 2020, guided "trip tips" for various trails, and video field trips.
- Since 2022, the QVC operated 6 days/week throughout the year providing general information to thousands of visitors.
- IS staff provided community education with visits to libraries, historical societies, and community groups such as the Grange.

- After several years of work with the DCR Archivist, the Digital Commonwealth Project and the Boston Public Library Digital Services uploaded over 2,700 images in the Swift River Real Estate Series to the Digital Commonwealth website.

4.9.2 Ware River

Interpretive Services for the Ware River watershed are mainly provided by Interpretive Services staff based at the QVC. The QVC also handles public relations and group access permitting and maintains a library of Ware related records. Ware River field staff, located in the Oakham field office, occasionally, and as time allows, handle inquiries. The addition of dedicated Ware River Watershed Ranger staff in 2019 allowed the Watershed Rangers to take on the role of providing informal education and interpretation to the public regarding the history and management of the Ware River. .

The addition of dedicated Ware River Watershed Ranger staff in 2019 allowed the Watershed Rangers to take on the role of providing informal education and interpretation to the public regarding the history and management of the Ware River.

Accomplishments

- Informational kiosks in the watershed were updated annually.
- The dedicated Ware River Watershed Ranger staff provided informal education and interpretation for visitors to the area on a regular basis.
- Quabbin and Ware River IS staff provided both in person and remote interpretive programs focusing on the history of the Ware River villages and the management of the Ware River Watershed.
- Work began on the initial Ware River Interpretive Plan. Quabbin/Ware River Region IS staff coordinated with Natural Resources, Forestry, and Watershed Ranger staff to identify topics and management areas that are most misunderstood by the public.

4.9.3 Wachusett Reservoir

The DWSP Wachusett Reservoir has an established program of public education with local schools and provides outreach to the watershed community through public programs on DWSP properties and watershed interpretive sites, kiosks, and through Ranger interactions.

The Wachusett Reservoir Interpretive Services Plan has formalized the public programs offered throughout the watershed and is updated regularly as a flexible document without specific time-sensitive tasks. The Interpretive Plan has been updated with Statements of Significance and overall themes focusing on programming related to the DWSP mission.

The Education and Outreach section of the Interpretive Plan examines the role of education and outreach in managing the Wachusett Reservoir Watershed. It also describes the goals, themes, and components of the education and outreach program

and offers recommendations for future activities. The plan has been updated with templates for virtual field trips to align state curriculum and Next Generation Science Standards related to DWSP's mission.

Accomplishments

- Rangers and Interpretive Staff conducted more than 170 separate programs with 5,200 attendees during the past five years. In-person programming was suspended from March 2020-July 2021.
- Staff hosted annual openings of the Clinton Dam walkway and were able to interact with the more than 13,200 people who attended. The opening of the dam walkway was canceled for May 2020, October 2020, and May 2021.
- Interpretive and Ranger staff paritcipated in DCR agency-wide initiatives: School Vacation Programs, Self Guided Trip-tips, Storywalks, Girl Scout Weekend, First Day Hike, Park Serve Day, and Earth Day activities.
- Teacher workshops were held, and education specialists provided programs for fourth to eighth grade, high school, and college students. New lesson plans and hands-on labs were developed and conducted for classrooms of fifth, sixth, and eighth graders in watershed schools.
- Environmental Quality section staff supported the Mass Envirothon:
  - Attended Steering Committee meetings.
  - Presented workshops on water quality, bioassessment, groundwater, and stormwater pollution for over 1,600 students and coaches
  - Updated the water curriculum and administered the water test at the Envirothon competition.
  - Transitioned all workshops to a virtual format during the pandemic and assisted with the development of a remote competition.
  - Assisted with the competition returning to an in person event, which was held at Quabbin Reservoir in May 2022.

- Interpretive and informational kiosk wayside panels, installed and made available online, were developed for an overall updated and standardized look. Kiosk posters were revised with links and QR codes to DWSP website for additional information and corresponding video on the YouTube playlist. Information kiosks and the bulletin boards at the John Augustus Hall field headquarters in West Boylston were updated regularly.
- Interpretive staff reviewed, revised and distributed informational brochures. Staff developed and updated printed materials. These were made available in digital format for the DWSP website on public access issues, stormwater management, water quality, aquatic invasive species control and road salt reduction. More than 8,000 brochures have been distributed over the past five years.
- Video tours and curriculum kits were created and distributed to support classrooms during pandemic closure. Watershed videos, online activity guides, and STEM activities were sent to schools and shared with educators in the watershed.
- Produced outreach videos for the public, which were then made avilable on the DWSP website and dedicated YouTube playlist.
- Mailedletters to residents where dog waste was a noticeable problem.
- Participated in West Boylston and Clinton High School *School to Career Internship Program.*
- Presentated three training sessions on stormwater pollution prevention for DCR labor staff and supervisors.

4.9.4 Sudbury Reservoir

Watershed Rangers, besides patrolling DWSP property, are also able to educate visitors on DWSP rules and regulations, the DCR/MWRA water supply system, and DWSP efforts to manage the watershed. The publications and education material developed and distributed by DWSP's Interpretive Service staff at the Quabbin/Ware River Region Visitor Center, Stillwater Farm, and Wachusett Environmental Quality is shared with the Sudbury Reservoir watershed communities. In particular, brochures on various stormwater topics have been shared with town departments, boards, and commissions, as needed, in the Sudbury Reservoir watershed.

Grant funding for trail work awarded to the cities and towns surrounding the Sudbury Reservoir to develop the Boroughs Loop/Aqueduct Trail provides an opportunity for placing educational and interpretive signage on watershed protection and water quality topics in areas that have not been previously accessible.

Assistance and programming within watershed school classrooms will continue as staff and resources allow.

Accomplishments

- Routine "in the field" education has been ongoing by the Watershed Rangers. Several formal interpretive programs were presented:
  - "Sudbury Saunter" – a hike along the shores of the Sudbury Reservoir to explore old roads, stone walls, cellar holes and former home sites.

    - History Hike gave participants an opportunity to check out the new Peninsula Trail and learn about the history of the building of the Sudbury Reservoir and the Fayville Dam.
- Hosted several Geocaching “cache in-trash out” events. These programs draw large crowds that gathers and removes a vast amount of trash.
- Brochures on the dangers of pet waste were provided to the town of Southborough Board of Health for use in problem neighborhoods where dog waste bags were being disposed in the storm drain system.
- A Sudbury Reservoir fact sheet has been developed.
- Environmental Quality staff participated with a year-long project at Fay School in Southborough about water quality in the Sudbury Reservoir by teaching about sources of pollution in the Fay School’s drainage area.
- Environmental Quality staff assisted the Southborough Trails Group with messaging about dog waste for their week-long dog waste campaign and new signage to be placed along the Boroughs Loop Trails sections not located on DWSP property.

4.9.5 Five Year Objectives

- Offer public engagement opportunities at DWSP facilites, in particular the Les and Terry Campbell Quabbin Visitor Center and Stillwater Farm.
- Review, update, initiate, and implement, watershed specific Interpretive Services Plans which reflect the current objectives in watershed management and climate change mitigation.
- Conduct, record, and evaluate public education programs with a focus on water supply, water quality, Aquatic Invasive Species, and climate change.
- Partner with other DWSP sections to provide public education and support materials for all DWSP projects.
- Utilize the DWSP website and DCR social meda to provide information and resources for the public. Post teaching resources, school program, and field trip menus. Research, create, and circulate electronic media for interpretation.
- Continue to develop different methods of outreach to watershed residents and communities. Consider presenting evening programs for the public several times a year.
- Re-establish and maintain teacher workshops, focusing on topics related to water supply and watershed management.
- Continue to support Mass Envirothon. Participate in additional programs with other environmental groups.
- Maintain and/or intiate informational kiosks and signage. Coordinate with Watershed Rangers and other staff on content.
- Provide information on less understood elements of the water supply system, such as the Ware River watershed and the Sudbury and Foss Reservoirs.
- Provide programs that reduce threats from public access (e.g., Earth Day cleanups, fishing line collections, etc.).
- Support stormwater education efforts in watershed towns.

4.10 Water Quality and Hydrologic Monitoring

The Water Quality and Hydrologic Monitoring program conducts routine tributary and reservoir sampling to identify short-term water quality problems and maintain the historical record for long-term trend analysis, with annual adjustments to the sampling plan to adapt to changing conditions. It is a comprehensive program used for several purposes:

- Screen for potential pollutants.
- Measure the effectiveness of watershed management programs.
- Understand the responses of the reservoirs to a variety of physical, chemical, and biological inputs.
- Assess the ecological health of the reservoirs and the watershed system.

Goal

Conduct tributary and reservoir sampling. Identify short-term water quality problems and maintain the historical record for long-term trend analyses. Use data analyses and assessments to inform management decisions.

Environmental Quality staff develops and implements water quality monitoring programs. Hydrologic data are collected to support water quality work and reservoir operations. Stormwater sampling is conducted to assess potential stormwater contaminant inputs. In some cases, water quality impacts may not be apparent due to limitations in methodology or due to extended time periods for impacts to become discernible. DWSP continually reviews its sampling programs to meet changing priorities and public health concerns, as well as to incorporate newly developed analytical methods and updated regulatory requirements. DWSP plans to develop more integrated assessments of water quality across the entire system and develop and use mathematical models when possible, to assist water quality elements of watershed management issues.

Water quality data provide information on a variety of physical, chemical, and biological parameters. Water quantity (flow) data are necessary to develop and compare watershed loadings and have become increasingly important as the use of predictive modeling becomes more common.

Data are used to identify potential water quality problems and ensure protection of the water supply sources.

The Water Quality Sampling Program is designed to characterize and monitor water quality in the different subbasins of each watershed, often in conjunction with Environmental Quality Assessments (see Section 4.11). Sampling results are summarized in annual water quality reports and are incorporated into EQA reports. Water quality parameters are added to the suite of DWSP's analyses as needed; for example, sodium and chloride were incorporated into monitoring programs to determine potential impacts of road salt runoff to surface water quality. Additional water sampling is performed in response to elevated bacteria levels at sample sites or as needed to investigate potential causes or factors.

All monitoring programs are developed and executed in coordination with MWRA. To further this cooperation, DWSP and MWRA staff holds quarterly or as needed Water Quality Sampling and Analysis Team (WQSAT) meetings; MassDEP also annually inspects DWSP. DWSP monitoring is presently used entirely for watershed protection planning and implementation purposes. For example, *E. coli* or coliform data are used to track pollution sources in tributaries as well as gull locations on the reservoirs; other parameters, such as specific conductance, are currently being analyzed for potential pollutants, such as road salt. All system monitoring for compliance with federal drinking water regulations is done by MWRA and not discussed in this report.

There is a long history of data collection by DWSP on its watersheds, which makes DWSP uniquely positioned to detect and document indicators of climate change. These include physical, chemical, and biological parameter measurements made as part of the water quality monitoring program as well as forest health data.

More powerful and frequent storm events that cause changes in the patterns and amount of rainfall can degrade water quality through stormwater runoff. DWSP has worked with the MassDOT in the design and construction of stormwater BMPs for stormwater runoff and pollutant loading associated with changes in precipitation patterns. During the review process of stormwater management plans for projects in the watershed, as well as DWSP culvert replacement and other internal road improvement projects, DWSP takes into consideration climate change impacts in determining culvert size and other stormwater structures.

DWSP continually reviews its sampling programs to meet changing priorities and public health concerns, as well as to incorporate newly developed analytical methods and updated regulatory requirements.

Warming temperatures can provide conditions for harmful algal blooms to form in water, which can be toxic to aquatic life and humans. Cyanobacteria blooms in summer months, and recently even in the fall as well, have been documented. Increases in fertilizer applications coupled with stronger intensity storm events and increased runoff can result in negative impacts to water quality. As part of DWSP's Interpretive Services Programs, whenever Cyanobacteria or algae advisory notices are posted, additional

information about the causes of the blooms will also be included, such as: increased nutrients from fertilizer, pet waste, faulty septic systems, and how the introduction of these pollution sources into our natural systems can be exacerbated by climate change.

4.10.1 Quabbin Reservoir

Water Quality Monitoring

Winsor Intake Area Monitoring

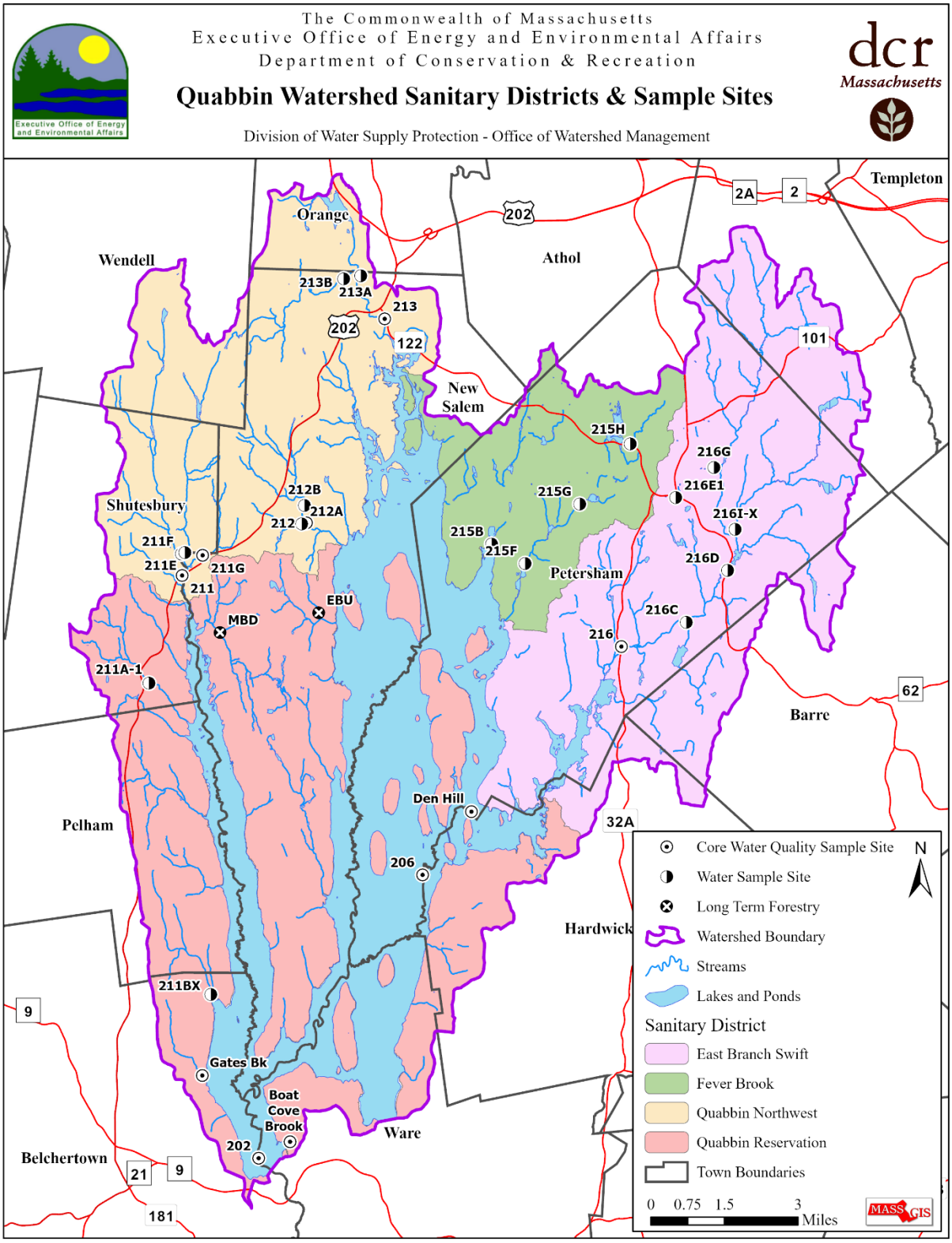
DWSP conducts daily site and data monitoring and weekly inspections by foot, vehicle, or boat to identify potential anthropogenic or natural contamination. Follow-up assessments are conducted as needed. Staff regularly monitor wildlife activity in the area surrounding the Winsor Intake, which provides water to the Chicopee Valley Aqueduct (CVA). Daily and monthly sampling and analysis from the intake is conducted by MWRA laboratory staff. These samples are analyzed to measure fecal coliform, *Giardia* and *Cryptosporidium*, and total coliform; levels found to exceed certain thresholds trigger DWSP staff notification for additional investigation. Daily monitoring by MWRA include fecal coliform, total coliform, and *E. coli*; turbidity, ultraviolet absorbance at wavelength 254 nm (UV_{254}); and pH, alkalinity, and specific conductance.

Reservoir Monitoring

DWSP staff routinely collect water quality samples at three established sample sites on Quabbin Reservoir, except during periods of adverse weather and ice conditions in the winter and spring (Figure 4-14). Samples are collected at select depths for various analyses. Water quality parameters measured include phytoplankton and zooplankton, bacteria, ammonia, nitrate, total Kjeldahl nitrogen (TKN), total phosphorus, silica, ultraviolet absorbance at wavelength 254 nm (UV_{254}), total organic carbon, chloride, sodium, and calcium. Monitoring frequencies for these parameters ranges from semimonthly to quarterly. Water column profiles of temperature, dissolved oxygen, pH, conductivity, chlorophyll-a, and phycocyanin are collected at each site.

A real-time water quality monitoring buoy was deployed in Quabbin Reservoir in late 2020. Profiles of the water column are automatically performed on six-hour intervals for a range of parameters (e.g., water temperature, pH, dissolved oxygen, chlorophyll, phycocyanin, and specific conductance). Results are used by DWSP to augment routine profiles and phytoplankton sampling programs. The high frequency profile data also allows for identification and visualization of diurnal patterns and both short and long-term effects of environmental forces such as cooling temperatures during turnover and seiche effects due to wind events. The buoy is typically operational from mid-spring to late fall each year.

Figure 4-14: Quabbin Reservoir Watershed Water Quality Sanitary Districts and Sample Sites



Tributary Monitoring

Surface water in the Quabbin Reservoir watershed is routinely monitored, including major tributaries to the reservoir. Sampling locations include seven core sites as well as a number of sites which rotate among subwatersheds on an annual basis (EQA sites). The number and locations of sample sites varies annually, depending on assessment and monitoring needs (Figure 4-14). Tributary samples are collected biweekly. Samples are analyzed for: *E. coli* bacteria, total coliform, turbidity, calcium, sodium, chloride, select nutrients, alkalinity, UV_{254}, total organic carbon, pH, temperature, dissolved oxygen, and specific conductance. These data are analyzed and reported annually and summarized approximately every ten years.

Forestry Water Quality Monitoring – Short- and Long-term

Water quality samples are regularly collected for short-term monitoring at active timber harvest lots and at long-term monitoring sites to assess potential water quality impacts of harvests. Sampling for short-term monitoring is performed during dry and wet weather, and samples are collected upstream and downstream of the harvest lot and some stream crossings. Sampling is initiated prior to any disturbance, in order to establish baseline conditions, and continues until after the timber harvest has been completed. Samples collected for short-term forestry monitoring are analyzed for turbidity.

A paired watershed study was established in 2014 to evaluate the potential impacts of forest management on water quality in the Quabbin Reservoir watershed. Samples are collected from two tributaries monthly and analyzed for a range of constituents (nutrients, total suspended solids, UV_{254}, total and dissolved organic carbon). Additional samples are collected during select meteorological events (e.g., precipitation and snowmelt) to characterize controls on nutrient and sediment loading from either tributary. One location serves as a control site. The remaining location was harvested in the upstream reaches of the watershed. Sampling spans a baseline period prior to timber harvesting and continues following timber harvesting. Data are used to quantify potential impacts to the relationship between the two locations following timber harvests. The results of this study will be summarized in a project report following completion of the post-harvest monitoring period.

Hydrological Monitoring

Meteorological Monitoring

DWSP performs meteorological monitoring in collaboration with MWRA to better measure and understand hydrological resources in the watershed. Daily precipitation has been measured at the Belchertown monitoring station since 1930. DWSP staff access meteorological data at additional weather stations across the Quabbin Reservoir watershed via the National Oceanic and Atmospheric Administration (NOAA) National Climate Data Center (NCDC) Climate Data Online (CDO) portal. These data are used for a number of applications, including regulatory reporting, assessment of pollutant loads, and informing water transfer protocols between Quabbin and Wachusett Reservoirs.

USGS Stream Gages

DWSP and MWRA cooperate with U.S. Geological Survey (USGS), Water Resources Division, to maintain continuous, real-time stream gages at two sites in the Quabbin Reservoir watershed: on the East Branch Swift River in Hardwick and the West Branch Swift River in Shutesbury (Table 2-5). Real time data are available from these stations at the USGS website. The National Ecological Observatory Network (NEON) maintains a stream gage at Hop brook. DWSP staff measure water level in Core tributaries via a network of pressure transducers and routinely monitoring streamflow. Rating curves are in development for the remaining Core tributaries, with the exception of Boat Cove Brook, in the Quabbin Reservoir watershed.

Accomplishments

- Routinely collected water quality samples from Quabbin Reservoir and its tributaries and collected *in situ* measurements using water quality meters.
- Water quality data were reported annually in the Annual Water Quality Report, and every five years for each sanitary district in each respective EQA Report. Quabbin/Ware Region EQ Section instituted collaboration with Wachusett/Sudbury Region EQ Section to streamline and standardize Annual Water Quality Reports from both Regions.
- Deployed and supported seasonal maintenance of a continuous water quality monitoring buoy at Site 202 since FY21 at the southern end of Quabbin Reservoir in cooperation with MWRA.
- Conducted turbidity monitoring on stream crossings within the watershed to quantify potential impacts to surface water quality resulting from active timber harvest operations. Sites were inspected and samples were collected before, during, and after each timber harvest.
- Monitored water quality and quantity at long-term forestry sites, including during storm events during each season to assess nutrient and sediment loads during these events.
- Executed the first DCR Quabbin Hydrologic Monitoring Program. Staff gages were established at four Core tributaries and two long-term forestry study sites in the Quabbin Reservoir watershed. Streamflow is routinely measured at a variety of flow conditions to develop site-specific stage-discharge rating curves. Deployed HOBOs on schedule with data collection procedures for collection and processing to inform the annual Water Quality Report.
- Maintained a database of historical water quality and hydrologic monitoring information and collaborated with the Wachusett Region and UMass to improve data management practices.
- Improved response to data requests using new database applications developed in-house.
- Collaborated with UMass to develop an interactive application that reviews and interprets data from multiple sources.

- Collaborated with the National Ecological Observation Network (NEON) conducting environmental monitoring on DWSP water supply lands.
- Upgraded field water quality monitoring equipment to EXO2 Sondes; equipment now standardized between Regions and between DWSP and MWRA.
- Prepared response for DEP regarding 2019 *Chrysosphaerella* aggregation.

4.10.2 Ware River

The Water Quality Sampling Program is designed to characterize and monitor water quality in the different subbasins of the Ware River watershed, usually in conjunction with EQAs (see Section 4.11). Sampling results are summarized in an annual water quality report and are incorporated into EQA reports. Water quality parameters are added to the suite of analyses as needed, such as sodium and chloride, which were incorporated into monitoring programs beginning in 2019 to determine potential impacts of road salt runoff to surface water quality within the Ware River watershed. Additional water sampling is performed in response to elevated bacteria levels at sample sites or during enforcement activities.

Water Quality Monitoring

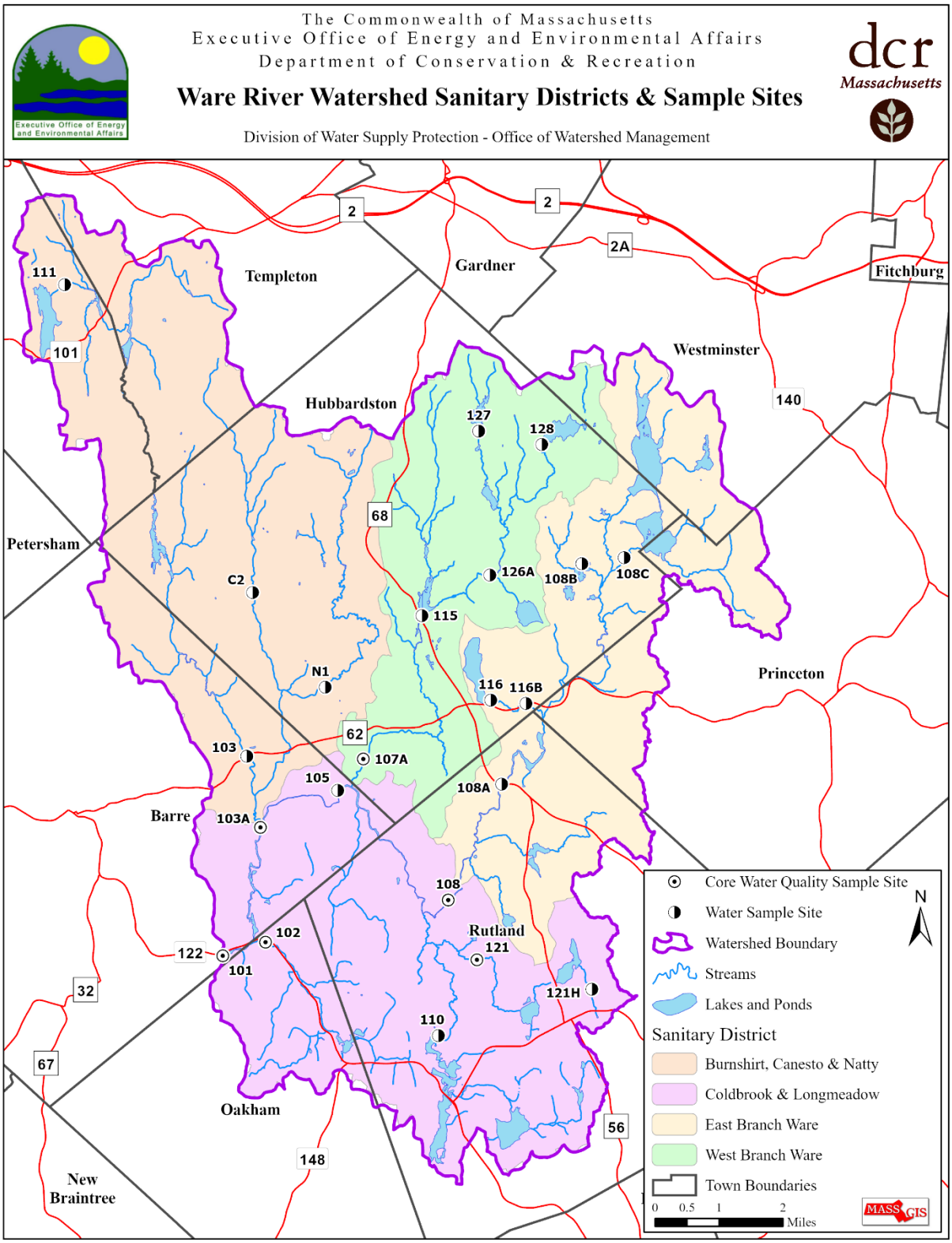
Tributary Monitoring

Surface water monitoring sites are monitored biweekly in the Ware River watershed. The number and locations of sample sites varies annually, depending on assessment and monitoring needs (Figure 4-15). Some sites are sampled every year and provide long-term data. Tributary samples are analyzed for the following parameters: *E. coli* bacteria, total coliform, turbidity, calcium, sodium, chloride, select nutrients, alkalinity, UV_{254}, pH, temperature, dissolved oxygen, and specific conductance. These data are analyzed and reported annually and summarized approximately every ten years.

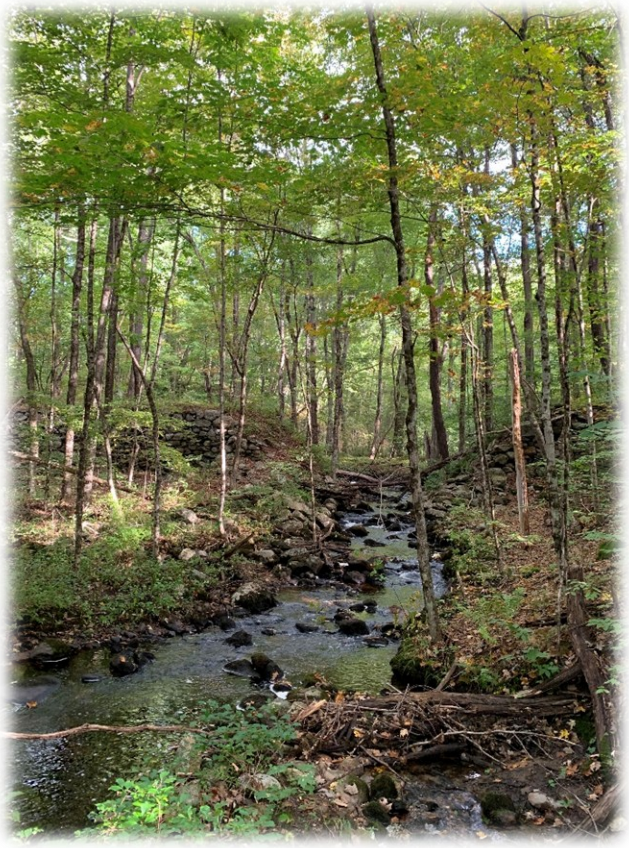
Shaft 8 – Quabbin Aqueduct Intake

Samples are collected biweekly from Shaft 8 (Figure 4-15, Site 101) as part of routine tributary monitoring. This is a long-term, historical monitoring site.

Figure 4-15: Ware River Watershed Water Quality Sanitary Districts and Sample Sites



Forestry Water Quality Monitoring – Short-term



Water quality samples are regularly collected for short-term monitoring at active timber harvest lots to assess potential water quality impacts of harvests. Sampling for short-term monitoring is performed during dry and wet weather, and samples are collected upstream and downstream of the harvest lot and some stream crossings. Sampling is initiated prior to any disturbance in order to establish baseline conditions, and continues until after the timber harvest has been completed. Samples collected for short-term forestry monitoring are analyzed for turbidity.

Hydrological Monitoring

Meteorological Monitoring

DWSP staff access daily precipitation and temperature data at weather stations across the Ware River watershed via the National Oceanic and Atmospheric Administration (NOAA) National Climate Data Center (NCDC) Climate Data Online (CDO) portal. These data are used to supplement hydrologic and water quality datasets and aid in interpretation of long-term and emerging patterns in water quality and associated streamflow.

USGS Stream Gages

The ACOE at Barre Falls Dam maintains stream gages below the dam and at Barre Plains. The USGS maintains a stream gage (number 01172500) on the Ware River downstream of Shaft 8. In addition, MWRA has gages in the Shaft 8 intake building. DWSP is planning on installing additional gages to monitor and assess water quantity in the watershed.

Accomplishments

- Routinely collected water quality samples from tributaries and collect *in situ* measurements of additional parameters via multiparameter water quality meters. Bacteriological and chemical analyses performed by MWRA at the Quabbin or Deer Island laboratories. Interacted regularly with the MWRA lab to assure efficient operations.
- Reported water quality data in the Annual Water Quality Report, and every five years for each sanitary district in each respective EQA Report.
- Maintained a database of historical water quality and hydrologic monitoring results. A robust regional analysis of trends in water quality may require decades of water quality and hydrometeorological data, spanning several stations.

- Collaborated with personnel from Wachusett Reservoir and UMass Amherst Environmental Engineering to improve data management practices.
- Collaborated with graduate students and faculty from the UMass Amherst Department of Civil and Environmental Engineering to develop an interactive application that facilitates review and interpretation of data from multiple sources. Efforts to maintain and improve data management of water quality and hydrometeorological data across DWSP remain ongoing.
- Conducted various activities related to Ware River diversions, including surveys of the intake area prior to diversions.
- Monitored turbidity on stream crossings within the watershed to quantify potential impacts to surface water quality resulting from timber harvest operations. Sites were inspected and samples were collected before, during, and after each timber harvest.
- Monitored subdivision proposals for water quality impacts; comments submitted to local and state entities involved in their approval.
- Monitored Mass Central Rail Trail maintenance activities, reroute project, and bridge repairs.

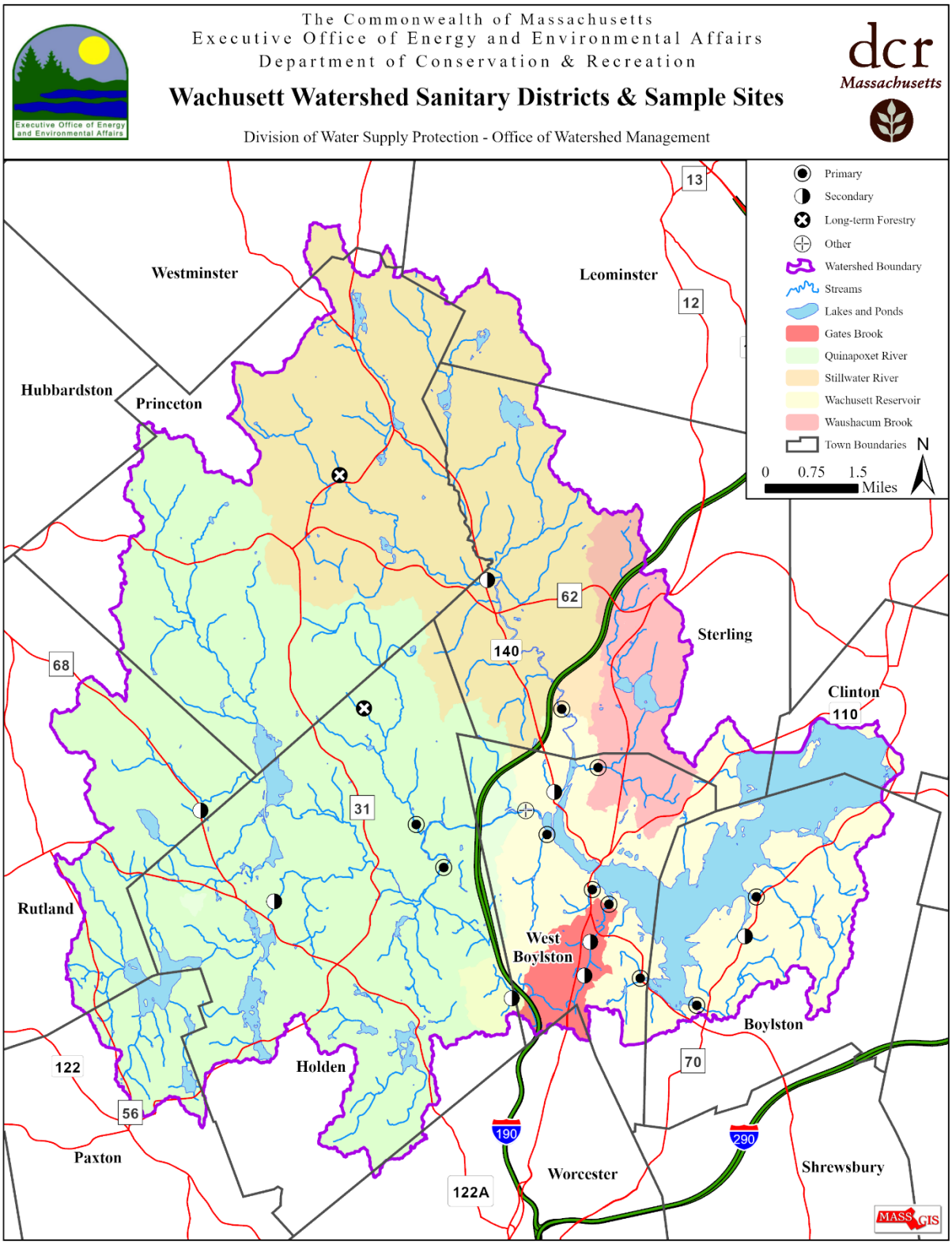
4.10.3 Wachusett Reservoir

Accomplishments

- Environmental Quality staff collected routine water quality samples from 18 stations (17 tributaries) in fiscal years 2017 – 2023 (Figure 4-16).
- Utilized data collected from MWRA buoy on Wachusett Reservoir.
- Nutrients and total suspended solids samples were collected monthly from ten primary tributary locations.
  - In response to the rising trend in specific conductance in Wachusett Watershed waters, monthly chloride sampling was initiated at the primary tributaries in January 2018.
  - Alkalinity sampling was added to the monthly nutrient sampling project in September 2020 due to a rising trend observed in Wachusett Reservoir.
  - Bacteria and turbidity samples were collected twice per month at the 18 routine water quality monitoring stations, which includes the ten primary tributary locations. Field parameters (temperature, dissolved oxygen, specific conductance, pH) were collected using a YSI handheld meter at all routine monitoring visits.
  - At the primary sampling locations, stream depth was recorded and discharge was calculated using rating curves developed by DCR staff or USGS. Annual Water Quality Reports were completed each year and posted on the DCR website.
- Continuous monitoring (at 10 – 15-minute increments) continued at the ten primary tributaries.
  - USGS provided continuous monitoring of stage/discharge, temperature and specific conductance at Gates Brook and the Stillwater and Quinapoxet Rivers, while DCR monitored stage/discharge, and temperature at the other seven primary monitoring locations using HOBO dataloggers.

Figure 4-16: Wachusett Reservoir Watershed Water Quality Sanitary Districts and

Sample Sites



    - Installed a new continuous water quality monitoring station (Mayfly) in 2018 at Waushacum Brook to measure stage/discharge, temperature, and specific conductance using a Hydros21 sensor and Mayfly datalogger.
    - Installed Mayfly stations in 2021 at five other primary tributaries: French, Malagasco, Muddy, Malden, and West Boylston Brooks.
    - The use of HOBO dataloggers will eventually be phased out as their batteries are depleted and after the new Mayfly stations have been thoroughly assessed for data accuracy and year-round reliability.
- Investigated a persistent bacterial load in 2018 in Gates Brook watershed.
    - Bacteria samples were taken at multiple locations along Gates Brook over many months and the location of the bacteria source was identified.
    - Water samples were sent to Source Molecular for DNA analysis and the only positive fecal marker was for birds.
    - Subsequent field investigations documented large numbers of roosting birds in a wetland area adjacent to Prospect Street in West Boylston.
    - Elevated bacteria concentration in the upper reaches of Gates Brook are still common, however there is sufficient distance between the bacterial source and the Wachusett Reservoir for bacteria to get trapped in wetlands or degrade such that viable bacteria loads to the reservoir are not a water quality threat.
- Groundwater level, snow pack, and precipitation were monitored regularly. During FY19 – FY23 59 individual stream discharge measurements were made to verify or update stage-discharge relationships.
- In order to explore groundwater quality and aquifer levels throughout the Wachusett Reservoir watershed, groundwater monitoring was expanded in 2019 to include six former USGS wells and an abandoned groundwater remediation monitoring well.
    - This new program started with the collection of specific conductance, temperature, and water level.
    - In July 2019, chloride sample collection was added to the groundwater monitoring program.
    - Chloride samples were sent to the MWRA lab in Deer Island as part of a new project code “WATWEL.”
    - Purchased a flow cell in 2022, which facilitated the measurement of all routine field parameters (specific conductance, pH, dissolved oxygen, and temperature) from monitoring wells using YSI ProPlus/ProQuatro meters.
- Collected, additional groundwater samples between August 2019 and May 2022 during routine well monitoring to be analyzed for stable isotopes, deuterium (2H) and oxygen-18 (18O). These data will allow DWSP to observe the influence of rain, which contains fewer heavy isotopes, in the samples collected from wells in the watershed. This monitoring effort is anticipated to lead to a better understanding of groundwater recharge and aquifer dynamics.
- Migrated the water quality database in 2021 from MS Access to SQL Server, which is a more robust and secure database management system.
    - All data management tools were updated to integrate with the new SQL Server database.

    - SQL Server enabled staff to continue to manage data effectively while working from home during the COVID-19 pandemic and during post-pandemic hybrid work, which would not have been possible using MS Access.
- Wrote new 14 individual Standard Operating Procedures (SOPs) for all major water quality and hydrological monitoring elements/projects.
    - Detailed documentation of these projects ensures that procedures are transparent and provides a valuable reference for new staff, managers, or future staff who may need to understand how monitoring was carried out in prior years.
    - SOPs are reviewed annually, and updates are noted in the change log at the beginning of each SOP.
- A draft of the first Quality Assurance Project Plan (QAPP) for Wachusett Reservoir watershed water quality and hydrologic monitoring programs was written and is scheduled to go into effect in FY24.
    - This plan describes how EQ staff will evaluate its water quality and hydrologic monitoring programs and determine if SOPs and sampling plans were followed, if equipment calibration and maintenance schedules were adhered to, and detail how and when data issues will be flagged and recorded.
    - It is intended that this document will be reviewed periodically and updated as needed to ensure that data generated through water quality monitoring efforts are accurate and reliable.
- Developed new solute loading models to estimate nutrient loads (total nitrogen, total phosphorus, total organic carbon) in primary tributaries.
    - Staff utilized two R packages developed by USGS, (Loadflex and WRTDS) to build and run several types of loading models simultaneously.
    - This modeling framework, which is entirely script based, offers increased transparency, provides better documentation of how input data were derived and how outputs were calculated, and is easier to update annually.
- Developed several special monitoring initiatives in response to the concern over the increasing trend of specific conductance/chloride observed in the Wachusett Reservoir watershed.
    - Designed to gather more information about the spatial extent and variability of chlorides in Wachusett Watershed surface waters.
    - A short-term conductivity monitoring initiative began in April 2021. The goal of this monitoring effort, referred to as a “conductivity blitz,” was to collect specific conductance measurements at as many surface water locations across the watershed as possible. Measurements were taken in streams, wetlands, and ponds, avoiding storm runoff so that measurements reflected baseflow water chemistry, providing insight into groundwater ion concentrations which would otherwise require additional well sampling.
- Expanded groundwater monitoring (WATWEL) in May 2021 to include several other parameters that will be analyzed in relation to chloride levels in order to discern various sources of chlorides that have become dissolved in groundwater, such as halite (road salt), fertilizers, septic systems, alternative deicers or water-rock interactions.

    - This expansion of groundwater monitoring was a short-term effort that was incorporated into the WATWEL project.
    - The project was concluded in April 2022 after 12 samples were collected at each monitoring well.
    - A full analysis of the data is pending, and the results will be presented in the 2022 Annual Water Quality Report.
- Developed several field data input tools using ArcGIS Online and Survey123. See the GIS Section (4.16) for additional details about these applications.
    - Applications were created for field data input for snow pack surveys, stage and turbidity measurements, HOBO and Mayfly downloads, short-term forestry monitoring, and the conductivity blitz.
    - These applications allow for field data to be recorded in digital format, increased data completeness and accuracy, and facilitated automated workflows for data processing and import to the water quality database.
- Developed TribTools data management application in 2019.
    - This application replaced much of the functionality of Aquarius software, which proved costly, inflexible, and cumbersome to use and maintain.
    - TribTools provides custom tools to create and maintain stage-discharge rating curves, process and import HOBO data, and more recently, process, import, and correct Mayfly station data.
- Maintained an interagency service agreement (ISA) with the UMass, Amherst, Department of Civil/Environment Engineering throughout the implementation period of the current Watershed Protection Plan. Studies conducted under this agreement have facilitated a better understanding of reservoir and watershed processes. UMass has also been available as a resource to advise DWSP staff on issues that arise.
- Concluded a two-year project in 2018 in collaboration with graduate student Nick Zinck. This project developed two custom applications that greatly advanced DWSP data management and data analysis capabilities.
    - The Water data Visualization Environment (WAVE) application is a DWSP-wide data portal that allows users to explore water quality and hydrologic data, calculate statistics, and quickly generate graphics and tabular data summaries.
    - The Water data Importer Tool (WIT) is a second application that facilitates data processing and import to DWSP databases.
    - Both of these tools are integral to data management workflows and have been continuously updated and enhanced.
- UMass graduate student Josh Soper and advisors published a paper in the Journal of Hydrology presenting research on salt loading in Wachusett Watershed.
    - Study computed a chloride mass balance for years 2000-2019 and discussed the spatio-temporal aspects of salt loading to the tributaries and export from the Reservoir.
    - This research quantified the association between paved surfaces and chloride loads, finding a strong positive correlation between the two.
- UMass maintained a two-dimensional water quality model of Wachusett Reservoir (CEQUAL-W2).

    - The model is updated annually and a catalogue of models that begins in 1998 spans a variety of hydrologic inputs (wet years, dry years, different transfer regimes).
    - Development of the model has identified problems with hydrologic data collection which have since been corrected, provided better understanding of reservoir processes and allows for a more accurate assessment of the impact of watershed inputs to the reservoir.
- Dr. Lilian Jeznach, a former UMass student and current Assistant Professor of Engineering at Roger Williams University, has continued work on the CEQUAL-W2 model with a focus on developing the model's algae and chlorophyll *a* forecasting capabilities. This work is ongoing and will continue during the next phase of the UMass ISA.
- Collected macroinvertebrate samples biennially from selected tributaries to supplement routine water quality sampling.
    - Biotic communities integrate the effects of short-term environmental stresses and reflect impacts of intermittent or low-level pollution events potentially missed by routine sampling programs.
    - A biomonitoring program compares biotic communities at different stream sites and then uses a variety of metrics to calculate the degree of site impairment.
    - DWSP can use aquatic macroinvertebrates to determine the degree of site impairment because they are easy and inexpensive to collect, relatively easy to identify, abundant in most streams, and indicative of localized conditions as a result of their sessile nature.
    - Samples were collected from twenty-two locations during the past five years and identification and assessment are ongoing.
- Completed plankton monitoring at multiple depths weekly, or more frequently, in the Wachusett Reservoir.
    - Recorded temperature, specific conductance, dissolved oxygen concentration, percent oxygen saturation, chlorophyll *a*, and hydrogen ion activity (pH) profiles weekly.
    - Collected nutrient samples four times per year during critical stratification periods at three depths from three locations.
    - Collected bacterial transect samples from 23 surface stations on the reservoir monthly or more frequently throughout the year.
- Included cyanobacteria in routine reservoir plankton monitoring.
    - Cyanobacteria are photosynthetic bacteria that share similar characteristics of algae and can multiply quickly in response to favorable conditions. These organisms have the potential to produce toxins that can be harmful to the environment, animals, and public health.
    - DWSP Aquatic Biologists assisted MWRA with collection of samples for cyanotoxin analysis as part of EPA's Fourth Unregulated Contaminant Monitoring Rule (UCMR 4) since 2016.
    - Water quality connected to cyanobacteria, to date, have not been recorded at the intake.
    - DWSP recorded several ephemeral and one longer-lasting cyanobacteria events in Wachusett Reservoir.

    - Increased monitoring surrounding these events in accordance with annual sampling plans. Details can be found in annual water quality reports.
- Published the results of the 2017 Angler Creel Survey in 2019.
    - The Angler Creel Survey has been conducted every five years since 2012.
    - Comparison of the 2017 results to earlier creel surveys conducted periodically since 1979 show that the species most frequently caught by anglers continue to change, and that this may reflect changes in the fish community composition.
    - EQ staff and Watershed Rangers initiated the angler creel survey in the spring of 2022 and results will be published in a future report.
    - Fish are an important component of the reservoir ecosystem, and knowledge of fish population dynamics in the reservoir is important to understanding the Wachusett Reservoir food web and its impacts upon drinking water quality.
- Collaborated with DFW biologists to capture spawning lake trout.
    - Annual lake trout tagging program initiated in 2014.
    - Spawning lake trout captured each fall since 2017 as part of this ongoing program.
    - A total of 902 lake trout have been tagged, measured, weighed, and released back into the reservoir since the start of the program.
- Continued the long-term monitoring study to assess the potential impact of forestry on water quality with routine monthly sampling and quarterly storm sampling.
    - Continued to gather data from a control subbasin and an active subbasin for a ten-year period before, during, and following completion of timber harvesting operation.
    - The study includes monthly dry weather discrete grab sampling and quarterly storm event monitoring using automatic samplers.
    - Parameters monitored are flow, pH, temperature, dissolved oxygen, turbidity, total suspended solids, total organic carbon, ammonia, nitrate, nitrite, and total phosphorus.
    - Lack of reliable streamflow data between 2013 and 2017 prevented a statistically robust hydrological comparison between the two subbasins.
    - A weir was constructed at the Holden monitoring site in 2019 and one was constructed in 2020 at the Princeton monitoring site.
    - Storm sampling was put on hold in 2019, as a sufficient number of storm samples had been collected.
    - All necessary pre-harvest data has been collected at both study locations and the experimental lot (Princeton) was put out to bid and sold in 2021.
    - It is expected that timber harvesting will commence at the Princeton site in FY23 and storm sampling will resume after the harvest is complete.

4.10.4 Sudbury Reservoir

The Sudbury and Foss Reservoirs, as emergency source water supplies, are not subject to the same level of thorough examination as the Quabbin and Wachusett Reservoirs, the active drinking water sources in the DCR/MWRA water supply system. MWRA has a program of water quality monitoring for all of its reserve water supplies,

both source (Sudbury and Foss) and distribution (Chestnut Hill, Fells, Norumbega, Spot Pond, and Weston) reservoirs which continues the historical record of water quality status of these water bodies.

Maintaining a baseline for water quality in Sudbury Reservoir tributaries is no longer conducted as routine sampling. Additional site-specific sampling or focused on water quality investigations can be conducted as needed. DWSP staff are aware of conditions that may produce harmful cyanobacteria algal blooms and report to MWRA on their presence if detected during routine investigations.

MWRA contractors, starting in 2018, collect water column profiles and samples from Sudbury Reservoir for analysis of nutrients and algae by MWRA labs. Recent results have shown anoxia developing at close to the bottom at deep locations which may be contributing to nutrient cycling within the reservoir.

Accomplishments

- Data collected from the tributary sampling in prior years has resulted in a baseline for water quality parameters.
- DWSP did not conduct water quality or hydrologic monitoring in Sudbury Watershed during FY18-FY23.
- Aquatic biology staff reviewed MWRA contracts and resulting reports focused on aquatic invasive species monitoring and annual water quality data collection.
- Staff periodically responded to requests for algae identification.

4.10.5 Five Year Objectives

- Assure that water entering the Winsor and Cosgrove Intakes meets MassDEP standards for microbial and physicochemical parameters.
- Conduct routine and non-routine tributary and reservoir sampling program to collect, interpret, and manage hydrometeorological and reservoir data. Identify potential water quality problems and maintain the historical record for long-term trend analysis. Make annual adjustments to the sampling plan to adapt to changing conditions and new water quality threats. Make necessary monitoring program changes to identify causal factors for significant trends.
- Maintain and expand use of a data management system. Develop and utilize database backed tools and applications to facilitate data management, review and analysis, writing reports, and modeling efforts. Use the system to assess for potential gaps in the sampling program as well as the potential use of the historical record to support analyses of long-term trends and effects of climate change.

- Develop and implement streamflow monitoring at selected watershed sites. Monitor hydrologic budget (streamflow, groundwater levels, precipitation data, snowpack) and continue to make necessary improvements. Evaluate permitting requirements, equipment needs, and staff hours for implementation and maintenance. Work with USGS to supplement in-house monitoring. Coordinate implementation with sampling plans and database.
- Maintain and calibrate field and lab equipment at recommended frequencies and procure new parts and equipment as needed to ensure data integrity. Review and update equipment inventory at least annually. Ensure vendor contracts are renewed prior to expiration.
- Collaborate with MWRA to deploy and maintain continuous water quality monitoring buoys.
- Finalize a Quality Assurance Project Plan document for quality assurance to ensure programs are adhering to best practices and operating efficiently. Follow protocols in QAPP and SOPs and make revisions as necessary. Document QA/QC metrics in Annual Water Quality Reports.
- Publish annual Water Quality reports.
- Continue implementation of long-term paired subbasins assessment of the impacts of forestry on water quality and quantity in the watershed system.
- Review previously collected storm sample data and determine if additional storm sampling should be conducted.
- Work with researchers to investigate climate change questions related to algae blooms in the watershed system.
- Investigate water quality trends of concern in collaboration with MWRA and/or UMass.
- Manage contract with UMass and review project scope annually. Improve water quality models and develop new research topics.
- Evaluate spatial heterogeneity of chloride contamination in surface waters and groundwaters at the watershed scale. Pursue identification of sources of chloride indicated by groundwater sampling. Target salt-application reduction initiatives to reduce potential future anthropogenic impacts in watersheds deemed most-impacted and/or highest risk to future degradation.
- Use water quality and hydrologic data to assess potential impacts of climate change on the water supply as part of a watershed-wide vulnerability assessment.
- Identify potential sources of PFAS contamination. Evaluate strategies for characterizing subwatershed vulnerability.
- Continue cooperative efforts with area colleges and universities to provide help with monitoring, assessment, and modeling efforts, which also offer training, education, and collaboration with a diversity of students.
- Consider utilizing “citizen science” approach for sampling when feasible for large sampling events.

4.11 Watershed Monitoring and Assessment

Goal

Use Environmental Quality Assessments, site inspections, local board meetings, and information from the public, Watershed Rangers and other DWSP staff to identify and address potential water quality threats and possible violations of federal, state and local environmental regulations.

DWSP utilizes site inspections, Environmental Quality Assessments (EQAs), local board meetings, and information from Watershed Rangers to identify possible violations of state and federal regulations and potential water quality threats. Threats may be identified by unusual water quality sampling results, field observations by DWSP staff, review of public records, or notification from watershed residents. Suspected threats are investigated, identified, and then corrective actions are pursued utilizing the legal support of all applicable environmental laws. DWSP works with the appropriate local, state, and federal government agencies to enforce these laws.

EQAs provide a systematic method to locate and control all sources of pollution in each active watershed. EQAs are comprehensive inventories and evaluations of threats to water quality, including DWSP facilities. These reports are conducted by EQ staff on a recurring basis within distinct geographic areas called sanitary districts that are based on watershed hydrology (Figures 4-18 through 4-20). The EQAs incorporate field inspections, water quality data analysis, and records review, including compliance with environmental regulations for wastewater, stormwater, agriculture, and hazardous materials and waste. The assessment and mitigation components of this program receive equal consideration during the EQA process. EQAs develop recommendations for actions to improve watershed protection and water quality that are incorporated into the annual Work Plans.

Federal, state, and local environmental regulations provide a significant level of protection for the watershed. Regulations may prohibit activities or establish limits or controls on activities. Regulations may also establish protection zones which complement those established in the Watershed Protection regulations (313 CMR 11.00). Notably section 22.20B of Massachusetts Drinking Water regulations (310 CMR 22.00) establishes protections zones for drinking water reservoir and their tributaries; Zones A, B, and C

are applicable to all MWRA source water supplies. Spills or releases of hazardous materials of certain concentrations are reportable to MassDEP under the Mass Contingency Plan (MCP). DWSP monitors submitted reports of cleanup efforts for large sites and relays concerns to MassDEP as conditions warrant for sites within the watershed system. DWSP works with the appropriate local, state, and federal government agencies to enforce these laws.

Environmental Quality Assessments (EQAs) provide a systematic method to locate and control all sources of pollution in each active watershed. EQAs are comprehensive inventories and evaluations of threats to water quality, including DWSP facilities.

Climate change for the Northeast is projected to result in shorter, more intense and more frequent rain events and severe storms which can potentially contribute more contaminants to surface waters. Research and data will be reviewed for guidance on potential impacts from stormwater pollution, erosion, and emergency preparedness. DWSP will complete a watershed-wide vulnerability assessment to identify potential impacts of climate change on the water supply.

4.11.1 Quabbin Reservoir

The Quabbin Reservoir watershed has been divided into four sanitary districts for assessment purposes: 1) Quabbin Northwest Sanitary District; 2) Fever Brook Sanitary District; 3) East Branch Swift River Sanitary District; and 4) Quabbin Reservation Sanitary District. Each sanitary district is further divided into sub-districts (Table 4-16). The water quality monitoring program, described in Section 4.10, includes monitoring of each sanitary district to provide water quality data supporting the EQAs. EQAs will be completed according to the schedule in Table 4-18.

Accomplishments

- Completed EQAs of each sanitary district of the Quabbin Reservoir watershed within the five-year Watershed Protection Plan schedule (Table 4-22).
- Implemented a new Division template for EQA reports starting in 2020 to allow for greater consistency across all DWSP watersheds.
- Reviewed and addressed mitigation recommendations following the completion of each EQA.
- Regularly monitored Utility Rights-of-Way activities (e.g., vegetation management, sideline trimming, hazard tree removal, and pole/line repairs); review and comments were made to Yearly Operational Plans.
- Continued to map farming activities for agricultural surveys in EQAs.

Table 4-16: Quabbin Reservoir Watershed Sanitary District and Sub-district Attributes

Sanitary District/ Sanitary Sub-district	Drainage Area (acres)	Percernt DWSP Land Ownership	USGS Stream (miles)
Quabbin Northwest Sanitary District			
West Swift River Sanitary Sub-district	9,010	48.7	24.8
Middle Swift River Sanitary Sub-district	7,880	41.7	14.3
Hop Brook Sanitary Sub-district	6,290	60.8	19.6
Fever Brook Sanitary District			
West Fever Brook Sanitary Sub-district	5,340	57.8	6.1
East Fever Brook Sanitary Sub-district	5,600	37.0	7.9
East Branch Swift River Sanitary District			
East Swift River Upper Sanitary Sub-district	6,590	<1	16.8
East Swift River Lower Sanitary Sub-district	8,260	20.1	21.5
Pottapaug Pond Sanitary Sub-district	7,340	76.6	7.2
East Petersham Sanitary Sub-district	7,170	1.2	13.2
Quabbin Reservation Sanitary District			
Winsor Dam Sanitary Sub-district	6,680	99.1	10.3
Shaft 12 (includes islands) Sanitary Sub-district	13,200	97.4	18.7
West Arm (Quabbin Reservoir) Sanitary Sub-district	12,600	90.3	36.3

Source: DWSP GIS, 2022

Table 4-17: Quabbin Reservoir Watershed Environmental Quality Assessment Schedule

Sanitary District	Years Completed	Next EQA
Quabbin Northwest Sanitary District	2000, 2006, 2007, 2013, 2017, 2022	2027
Fever Brook Sanitary District	2003, 2008, 2014, 2018	2023
East Branch Swift River Sanitary District	2003, 2008, 2012, 2016, 2021	2026
Quabbin Reservation Sanitary District	2003, 2005, 2007, 2011, 2015, 2020	2025

Source: DWSP EQ, 2023

4.11.2 Ware River

The Ware River watershed has been divided into four sanitary districts for assessment purposes: 1) Burnshirt, Canesto, and Natty Pond Sanitary District; 2) West Branch Ware Sanitary District; 3) East Branch Ware Sanitary District; and 4) Coldbrook and Longmeadow Sanitary District. Each sanitary district is further divided into subdistricts (Table 4-18). The water quality monitoring program, described in Section 4.10, includes monitoring of each sanitary district to provide water quality data supporting the EQAs. EQAs will be completed according to the schedule in Table 4-20.

Table 4-18: Ware River Watershed Sanitary District and Sub-district Attributes

Sanitary District/ Sanitary Sub-district	Drainage Area (acres)	Percent DWSP Land Ownership	USGS Stream (miles)
Burnshirt, Canesto, & Natty Pond Sanitary District			
Queen Sanitary Sub-district	454	0	1.12
Burnshirt Headwaters Sanitary Sub-district	4,470	3.5	42.45
Burnshirt Sanitary Sub-district	6,880	44.2	58.62
Canesto Sanitary Sub-district	4,620	27.8	43.34
Natty Pond Brook Sanitary Sub-district	3,510	37.7	37.76
West Branch Ware River Sanitary District			
West Branch Ware Headwaters Sanitary Sub-district	7,270	38.2	70.01
West Branch Ware Sanitary Sub-district	3,370	66.3	31.73
East Branch Ware River Sanitary District			
East Branch Ware Headwaters Sanitary Sub-district	4,030	0	23.08
East Branch Ware Sanitary Sub-district	7,100	20.4	67.71
Asnacomet Sanitary Sub-district	538	29.2	2.04
Pommogusset Sanitary Sub-district	2,390	10.1	17.95
Coldbrook & Longmeadow Sanitary District			
Demond Pond Sanitary Sub-district	1,430	15.6	10.70
Rutland State Park Sanitary Sub-district	2,010	57	15.14
Mill Brook Sanitary Sub-district	2,200	10.1	21.12
Barre Falls Sanitary Sub-district	4,850	82.7	48.15
Ware River Intake Sanitary Sub-district	6,530	88.5	62.06

Source: DWSP GIS, 2022

Table 4-19: Ware River Watershed Environmental Quality Assessment Schedule

Sanitary District	Completed Plans	Future Schedule
Burnshirt, Canesto, & Natty Pond	1992, 2010, 2014, 2018	2023
West Branch Ware River	2000, 2008, 2011, 2015, 2020	2024
East Branch Ware River	1994, 2012, 2016, 2021	2025
Coldbrook & Longmeadow	1992, 1994, 2009, 2013, 2017, 2022	2026

Source: DWSP EQ, 2023

Accomplishments

- Completed EQAs of each sanitary district of the Ware River watershed within the five-year Watershed Protection Plan schedule (Table 4-19), providing a focused assessment of each district.
- Implemented a new Division template for EQA reports starting in 2020, for greater consistency across all DWSP watersheds.

- Reviewed and addressed mitigation recommendations following the completion of each EQA.
- Monitored activities in utility Rights-of-Way to ensure compliance with regulations and DWSP policies.
- Monitored status of agricultural operations, above ground storage tanks, hazardous waste generators, spills, and hazardous materials through field inspections and records reviews.

4.11.3 Wachusett Reservoir

The Wachusett Reservoir watershed is subdivided into five Sanitary Districts (Table 4-20). EQAs are completed annually, focusing on one Sanitary District at a time and follow a five-year rotating schedule. An important component of each EQA is a thorough review for compliance with environmental regulations, including those addressing wastewater, stormwater, agriculture, and hazardous waste and materials. Both wastewater and stormwater are significant threats in the Wachusett Reservoir watershed and are addressed separately in Sections 4.13 and 4.14.

Table 4-20: Wachusett Reservoir Watershed Sanitary District and Sub-district Attributes

Sanitary District/Sanitary Subbasin	Drainage Area (acres)	Percent DWSP Land Ownership	USGS Stream (miles)
Stillwater River Sanitary District			
Babcock Brook	1,449	25.7	2.7
Ball Brook	444	50.2	1.4
East Branch Rocky Brook	149	51.7	0.5
East Wachusett (31)	2,211	14.2	5.5
East Wachusett (140)	1,024	33.7	2.6
East Wachusett (Bull)	835	26.0	1.9
Houghton Brook	471	67.5	1.6
Justice Brook	3,094	13.1	4.8
Keyes (Hobbs)	1,824	5.3	2.3
Keyes (Onion)	1,081	31.4	2.9
Keyes (Gleason)	76	30.3	0.4
Rocky Brook	1,282	60.1	3.6
Scanlon Brook	638	22.9	1.3
Stillwater (62)	2,380	55.6	8.8
Stillwater (Muddy Pond)	2,015	38.5	2.7
Wilder Brook	416	13.0	1.5
Quinapoxet River Sanitary District			
Asnebumskit (Mill Street)	661	24.4	2.8
Asnebumskit (Princeton Street)	1,391	0.3	3.9
Asnebumskit Pond	293	3.8	0.5
Chaffins	1,918	0.8	5.0
Chaffins (Malden)	673	11.6	1.2
Chaffins (Poor Farm)	566	0.0	0.9
Chaffins (Unionville)	499	19.2	1.2

Sanitary District/Sanitary Subbasin	Drainage Area (acres)	Percent DWSP Land Ownership	USGS Stream (miles)
Chaffins (Wachusett)	403	12.7	0.6
Cobb Brook	1,565	8.0	2.6
Cold Brook	666	21.5	1.4
East Branch South Wachusett Brook	972	0.0	2.1
Governor Brook	2,524	49.8	7.6
Hog Hill Brook	538	63.0	1.1
Jordan Farm	127	0.0	0.4
Kendall Reservoir	1,246	13.4	1.8
Maple Spring Pond	898	9.4	3.2
Muschopauge Brook	2,520	0.1	4.0
Muschopauge Pond	1,213	10.5	2.6
Pine Hill Reservoir	3,894	0.0	14.4
Quinapoxet (Canada Mills)	1,447	32.8	5.3
Quinapoxet (Circular Dam)	1,955	48.3	5.0
Quinapoxet Mill Street)	1,305	48.7	3.7
Quinapoxet Reservoir Direct	1,149	0.1	1.5
South Wachusett Brook	2,416	4.2	5.9
Streeter Pond	174	0.0	0.7
Swamp 15 Brook	712	25.6	3.4
Trap Rock Quarry	67	0.0	0.0
Trout Brook	1,144	4.6	2.4
Warren Tannery Brook	780	12.3	2.3
West Branch South Wachusett Brook	1,751	0.0	3.4
Wachusett Reservoir Sanitary District			
Beaman 2	17	0.0	0.0
Beaman 3	8	0.0	0.0
Beaman 3.5	149	29.5	0.0
Boylston Brook	133	1.5	0.4
Cook Brook (Wyoming)	111	0.0	0.3
French Brook	1,349	27.5	5.4
Hastings Cove	380	59.2	1.4
Malagasco Brook	559	32.9	3.5
Malden Brook	1,532	35.8	4.0
Middle Basin North (Davenport Point to Narrows)	706	94.9	1.2
Middle Basin South (Dover Point to Narrows)	727	66.4	1.4
Muddy Brook	476	30.3	1.6
North Basin (Dam to Narrows)	571	80.4	0.6
North Basin (Narrows to North Dike)	564	80.5	1.3
North Basin (North Dike to Spillway)	64	84.4	0.0
Oakdale	289	6.2	0.5
Oakdale Basin	107	85.0	0.0
Quinapoxet Basin	195	53.8	0.1

Sanitary District/Sanitary Subbasin	Drainage Area (acres)	Percent DWSP Land Ownership	USGS Stream (miles)
South Basin North (Route 140 Bridge to Davenport Point)	336	74.1	2.4
South Basin South (Route 140 Bridge to Dover Point)	1,180	65.3	0.6
Stillwater Basin	581	61.5	0.0
Thomas Basin East	288	60.1	0.0
Thomas Basin West	183	36.6	0.0
West Boylston Brook	227	3.5	1.0
Waushacum Brook Sanitary District			
Waushacum (Connelly)	1061	16.5	3.3
Waushacum (Fairbanks)	210	48.6	0.7
Waushacum (Filter beds)	294	3.4	0.3
Waushacum (Prescott St)	1377	30.6	3.2
Waushacum (WWPond)	991	48.6	2.2
Pandolf-Perkins Quarry	47	0.0	0.0
Gates Brook Sanitary District			
Gates Brook 1	147	36.1	0.7
Gates Brook 2	80	0.0	0.3
Gates Brook 3	100	5.0	0.8
Gates Brook 4	85	1.2	0.5
Gates Brook 6	221	0.5	0.5
Gates Brook 9	342	18.4	1.4
Scarlett Brook (down)	184	3.3	0.4
Scarlett Brook (up)	138	0.7	0.3

Source: DWSP EQ, 2023

Accomplishments

- Completed EQAs for the five-year Sanitary District cycle. Reports completed during the past five years and the schedule for future reports are shown in Table 4-21. Recommendations from all EQAs were incorporated into annual work plans.

Table 4-21: Wachusett Reservoir Watershed Environmental Quality Assessment Schedule

Sanitary District	Years Completed	Next EQA
Waushacum Brook	2017	2024
Stillwater River	2006, 2010, 2015, 2020	2025
Quinapoxet River	2004, 2009, 2014, 2021	2026
Reservoir	2003, 2008, 2013, 2022	2027
Gates Brook	2018, 2023	2028

Source: DWSP GIS, 2023

- Continued data gathering on agriculture, hazardous material use and storage, underground storage tanks, aboveground storage tanks, and accidental releases, which are all now part of the comprehensive EQ database described in Section 6.11 previously in this section.
  - Used field inspections and review of third-party databases to obtain all necessary information.
  - Provided educational materials and technical assistance to help reduce agricultural impacts to water quality.
- Worked with the EPA, MassDEP, and local boards and commissions to correct situations where pollutants have impacted tributaries.
  - Hundreds of sites have been inspected for a variety of possible water quality threats and corrective actions taken when necessary.
  - Results have included both environmental remediation and fines.
- Monitored and improved agricultural sites.
  - Efforts included site inspections, numerous letters mailed to farm owners on good housekeeping, best management practices, and cooperative efforts through conversation with farmers.
  - Sent over 100 letters during COVID pandemic to owners of agricultural operations and hobby farms reminding them of agricultural Best Management Practices in lieu of field inspections.
  - Inspected all agricultural sites on the 5-year rotating EQA cycle, although new sites are added, and existing site information is modified as needed, for the entire watershed.
  - Noted that of the original “dirty dozen” agricultural operations identified in the 1990s, there are only a few remaining active farms, with a couple under MDAR’s Agricultural Preservation Restriction program.
  - Observed a watershed-wide shift from actual agricultural operations to more hobby farms and more homes with chickens since the start of COVID.
  - Utilized social media, when available on the State’s computer network, as an invaluable tool for monitoring the larger agricultural sites on a regular basis.
- Continued to proactively investigate issues that could impact water quality in the watershed.
  - Facilitated monitoring and resolving water quality problems using the EQ database.
  - Documented all problems and subsequent resolution activities in site specific/owner specific files.
  - Established timelines for future monitoring and enforcement activities.
  - Developed a companion database guide, which is regularly updated. The database enables rapid searches by subbasin, town, street, landowner, issue, file status, etc. and includes the ability to add electronic plans and documents.
  - Tracked staff activity easily via a newly developed automated weekly report.
  - Created over 320 EQ tracking files in the past five years (Table 4-22) to follow staff’s daily field work in the watershed. Note: the number of new files created annually decreased dramatically in FY21 due to COVID restrictions, staff working remotely, lack of continued database access, and lack of IT support for the EQ database in Microsoft Access.

Table 4-22: Wachusett Reservoir Watershed – Newly Created Files

Year	Number of EQ Files Created
FY18	79
FY19	89
FY20	96
FY21	3
FY22	54

Source: DWSP Wachusett EQ, 2023

- Initiated migration of the EQ database to ArcGIS Online.
  - Provided an entirely new spatially integrated user interface for creating and updating files on water quality investigations and assessments in the Wachusett and Sudbury Watersheds.
  - Separated documentation of field visits, agricultural site activity, and Construction General Permit monitoring from the primary EQ database. These are now tracked in separate ArcGIS-based applications which can be integrated with the primary EQ database to simultaneously visualize all watershed monitoring files.
  - Initiated ability for staff to input and view information remotely without the need for a VPN connection, including in the field on iPads.
  - Started development of customized reports and dashboards to allow staff to search for data in various ways and allow managers to quickly view information on active issues.
- Continued implementation of the comprehensive Wachusett Watershed Hydrology Mapping Project, which is refining water resources and stormwater infrastructure data.
  - Collected data from field investigations using an ArcGIS Field Maps application with an iPad on an ArcGIS Online platform.
  - Processed data on a desktop PC using the ArcGIS Pro program.
  - Collected data from construction plans and geo-referenced when possible.
  - Facilitated data collection through a collaboration with watershed towns and participation in the Commonwealth EOEEA summer intern program. Two interns participated in the Summer of 2019 while one participated in 2022. COVID precautions prevented participation in the 2020 and 2021 seasons.
  - Located, verified, and mapped drainage structures, per project goals.
  - Identified connections within the stormwater network and mapped flow from storm drains to terminal outlets, including flow within stormwater BMPs.
  - Edited natural stream flow to correct errors and show flow direction.
  - Delineated wetlands when data was available.
  - Collected extensive attribute information for each structure or feature.

4.11.4 Sudbury Reservoir

Since Environmental Quality Assessments are not conducted in the Sudbury watershed, assessments are obtained through communication with local boards and commissions, state and federal regulatory authorities, and the regional planning agency, the Metropolitan Area Planning Council. DWSP supports enforcement of all local, state, and federal environmental regulations regarding wastewater management, stormwater management, agriculture, and hazardous materials and waste. Visual outdoor inspections of industrial and commercial sites will be conducted when staffing and time allows, and any issues that could impact water quality will be followed up through DWSP and/or local boards or commissions. Watershed Rangers, through regular patrols, inform EQ staff of situations that they feel requires investigation. DWSP will continue to follow through with reports made by Ranger staff.

Since Environmental Quality Assessments are not conducted in the Sudbury watershed, assessments are obtained through communication with local boards and commissions, state and federal regulatory authorities, and the regional planning agency.

There are two active railroads within this watershed. The freight line through the center of Southborough is used occasionally, and the MBTA Framingham/Worcester line which bisects the watershed operates both day and night. This line is shared with CSX (freight), Amtrak and MBTA commuter trains (both passenger). Releases and derailments could pose a serious threat to the water supply. Transflo CSX remains located in Westborough along the Southborough border. Hazardous materials are stored here to be transported by rail or truck to their Northeast destinations. Although this site is located off-watershed, it will be prudent to continue to monitor the transport of these materials within the watershed and any projected expansion or changes to the site.

There are several modes of commercial and industrial activities that are mostly clustered around the major transportation arteries of the Mass Turnpike/I-90, I-495, and Route 9. While many of these sites are in the western edge of the watershed, the Framingham Technology Park is situated adjacent to Foss Reservoir and the 9/90 Corporate Center is located on the southern end of the Sudbury Reservoir. Commercial activity also spreads along the length of Route 9 as it borders the two reservoirs, and there is a strip of commercial sites along Route 85 to the northwest of Sudbury Reservoir.

The Town of Southborough received a $45,000 Planning Assistance Grant from the Executive Office of Energy and Environmental Affairs in 2021 to identify viable wastewater solutions for sustainable economic development along Route 9, the town's primary commercial artery.

MassDOT has proposed several projects that fall within the watershed which are either in the design or construction phase. Two of them are major projects: the I-495/Route 9 interchange improvement project while the other is the I-495/I-90 interchange.

The I-495/Route 9 interchange improvement project moved beyond the study phase to its current design phase. This project involves the replacement of the I-495 north- and south-bound bridges and construction of a braided ramp system, including construction of four new ramp bridges. Route 9 improvements extend from the Computer Drive/Research Drive intersection to the Crystal Pond Road intersection. Improvements include widening Route 9 as required, adding an auxiliary lane on Route 9 west-bound between I-495 south-bound and Computer Drive, reconfiguration and reconstruction of the Route 9/Crystal Pond Road intersection, and limited improvements to intersections along Research Drive and Computer Drive. Other improvements include bicycle and pedestrian improvements as feasible.

The I-495/I-90 (MA Turnpike) interchange improvement project is currently underway as of the of 2022. Construction will occur in five phases as designs are reviewed and completed. Work began on the first phase in late 2022. Once complete, there will be four lanes in this area on Route 495 North and Southbound, and the existing loops will be removed. Although this work directly affects the Sudbury South Basin (which is no longer part of the drinking water supply system), design plans were reviewed and will continue to be reviewed throughout the project timeline by DWSP to ensure any storm water drainage does not impact the Sudbury North Basin – and thus the Sudbury and Foss Reservoirs.

Other road projects in the watershed include bridge replacement projects on Route I-90 and roadway resurfacing. A total of six bridge replacement projects encompassing both east- and west-bound lanes over Parkerville, Cordaville and Woodland Roads in Southborough and Flanders Road in Westborough were completed.

Since 2017, MassDOT has been improving road infrastructure along Route 9 in phases, throughout Westborough and Southborough. In 2018/2019, road resurfacing, and reconstruction of sidewalks took place from just east of Lyman Street in Westborough to just west of White Bagley/Breakneck Hill Road in Southborough. Work also included resurfacing the ramps at Computer/Research Drive and Route 85.

Solid waste facilities do not pose a threat to the Sudbury Reservoir. According to MassGIS and MassDEP, there are three closed or inactive solid waste facilities in the Sudbury basin. One is in Framingham, situated between Route 9 and the MA Turnpike. The other two are in Southborough: one is a capped and unlined municipal solid waste site that is now a town soccer field on Parkerville Road, and the other is Mt. Vickery Road dump adjacent to the southern edge of Sudbury Reservoir. Annual testing by the town is completed on the Parkerville Road site. DWSP will review any available MassDEP data or reports related to the landfills under the state's Solid Waste Regulations.

There is minimal water quality impact from crop and pasture lands in the Sudbury and Foss Reservoirs due to the limited amount of agricultural areas within the watershed. Only about 6 percent of the land use in the watershed is agriculture, with a trend towards smaller hobby farms and backyard animals.

Chestnut Hill Farm, subject to Conservation Restrictions held by the Town of Southborough and under the care and control of the Trustees of Reservations, is one of the largest sites at 170 acres. The property is bisected by the Hultman Aqueduct. The Trustees acquired acreage in 2018 to the west across Chestnut Hill Road, enabling a connection with the farm's existing trail system to other public tails. The farm raises livestock and vegetable crops and offers a community supported agriculture (CSA) program. The property is also crisscrossed with walking trails and offers several educational programs and a summer camp. No water quality impacts from activities at this location have been observed.

Accomplishments

- Investigated a report of a white substance discharging to the Foss reservoir from behind the Sanofi complex by DCR, MWRA and MassDEP. A definitive source was never identified; however it was likely paint dumped into a storm drain.
- Determined a report of trash ending up in Sudbury Reservoir came from a Fay School dumpster. Regional Director sent letters to Headmaster and the trash (school papers, lunch wrappers) removed by Rangers.
- Conducted several investigations in response to potential violations of the Wetlands Protection Act. The most significant was a large construction project at 84 Main Street, Southborough; DWSP worked with the project engineer and Town of Southborough conservation agent. Clearing of vegetation and installation of riprap adjacent to the Open Channel was deemed excessive and the owner responded by removing some of the riprap and replanting the stream bank. DWSP is monitoring ongoing construction.
- Provided input to watershed towns regarding Municipal Vulnerability Preparedness (MVP) programs.
    - Stormwater basin maintenance and salt reduction methods were highlighted for inclusion in the plans with grant funding a goal for eligible practices.
    - A GIS data layer of impervious surfaces was developed for Southborough, which received an MVP grant to gain a better understanding of how stormwater affects the town during storm events and how to manage negative impacts.

- Reviewed several plans for projects in watershed, with comments provided to project proponents, consultants and municipalities through the local and state permitting process.
  - Reviewed a proposal to construct a landscaping and winter salt storage facility at 200 Turnpike Road in Southborough. Cooperation with the project engineers resulted in substantial improvements to the project design, including stormwater controls, good housekeeping, and annual best management practices training. The project continues moving through the municipal permitting process.
  - Followed the proposal to construct the "Park Central" 200-unit residential housing project in Southborough. Objections to the project and subsequent appeals have delayed the project; however, as of February 2023, the project approval process continues.
  - Participated in the 2022 MEPA process for a master plan being developed for the Sanofi complex (formerly Genzyme) in the Framingham Industrial Park. Attended hearings and provided comments, in particular regarding snow and road salt management.

4.11.5 Five Year Objectives

- Conduct Environmental Quality Assessments (EQAs), including fieldwork and review of state and federal databases, as scheduled. Incorporate recommendations from EQAs into annual Work Plans. Present findings and proposed mitigation measures annually to DWSP staff. Use fieldwork, local contacts, and EQAs to identify potential violations, notify local boards and staff with enforcement authority, and work collaboratively to remediate water quality concerns.
- Coordinate with local, state and federal agencies, including Conservation Commissions, MassDEP, Mass Attorney General, U.S. EPA, to enforce all environmental regulations.
- Review project permitting at local, state, and federal levels of government.
- Monitor status of agricultural operations, above ground storage tanks, hazardous waste generators, spills, and hazardous materials use through field inspections and government databases records reviews.
- Monitor activities in utility Rights-of-Way (e.g., powerlines, highways, railways). Review and comment on Yearly Operating Plans (YOPs) and five-year Vegetation Management Plans (VMPs) as needed. Manage access, when needed, through DCR gates/internal roads and onto islands.
- Assess status of municipal facilities and practices, including DPW yards, closed landfills and road maintenance practices. Work with towns and MassDEP to resolve any water quality issues.
- Monitor for changes in use in industrial areas.
- Monitor climate change research, data, and recommendations to assess potential impacts of climate change to the water supply.
- Identify potential projects through EQA fieldwork that offer combined opportunities for water quality improvement, increased climate change resiliency,

and ecological enhancement. Provide technical assistance to towns interested in pursuing implementation, including potential grant funding, of identified projects.

- Continue to improve and maintain the newly developed EQ Database and other ArcGIS based tracking tools. Make updates and enhancements as needed to allow staff to record and access pertinent information. Develop new reports and dashboards, as needed, to facilitate timely investigations of watershed issues, writing of EQAs, and documenting staff effort.
    - Provide input to Municipal Vulnerability Preparedness programs watershed towns.

4.12 Aquatic Invasive Species Management

Potential impacts from the spread of Aquatic Invasive Species (AIS) vary according to the characteristics of the invading organism. Many AIS cause local extinctions of native species through competition or predation. This loss of biodiversity causes changes in the trophic structure of the community because of disruptions of food web connections, productivity, energy flow, and nutrient cycling. Invasive aquatic macrophytes aggressively displace native plants and grow so densely that littoral zone habitats become choked with vegetation. Water quality is impaired by excessive macrophyte growth because macrophytes function as nutrient pumps, extracting nutrients from the sediment with their roots and releasing them to the surrounding water.

The importance of AIS prevention and management is well documented in DWSP AIS Management Plan reports and elsewhere. Consequences of AIS introduction and spread specific to drinking water quality include increased potential for production of trihalomethane, changes in water color, turbidity, and phytoplankton growth.

Goal

Prevent introduction and spread of Aquatic Invasive Species through monitoring, public education, exclusion, and decontamination measures at potential entry points. Implement active management when appropriate.

Managing the watershed system to prevent the introduction of AIS requires a comprehensive strategy that integrates public education and outreach, exclusion and decontamination measures at boat ramps and other potential entry points, and an expanded monitoring program. Public education focuses particularly on recreational anglers and boaters, but also includes those involved in the sale of bait, aquarium fish, water gardens, and exotic pets. Routine monitoring also expands beyond the reservoir and the tributaries to include lakes and ponds in the watershed system.

Climate change is an important consideration when evaluating future aquatic invasive concerns, as it may generally increase the likelihood of invasion by new aquatic macrophyte species. Climate change holds the potential for longer growing seasons, which may allow for additional opportunities for introductions of invasive species (due to a longer period of activity by humans and other vectors) and increased growth rates in warmer temperatures.

Weather related ecosystem disturbances, such as more intense precipitation events or extended periods of drought, can disrupt native communities and provide opportunities for invasive species to populate an area.

4.12.1 Quabbin Reservoir

The Quabbin Reservoir has remained largely free of Aquatic Invasive Species (AIS). Potential modes of AIS introduction to the reservoir include wildlife (such as birds or mammals), wind distribution of seeds from nearby water bodies, fishing equipment, or boats (if not monitored). Over 30,000 anglers visit Quabbin each year, bringing a relatively large potential for introduction of AIS to the reservoir if not carefully controlled. The 2009 discovery of zebra mussels in Massachusetts led to the development and adoption of the Quabbin Boat Seal Program, the hiring of an Aquatic Biologist, and the prioritization of AIS controls as a major program.

Climate change is an important consideration when evaluating future aquatic invasive concerns, as it may generally increase the likelihood of invasion by new aquatic macrophyte species.

AIS management activities in the Quabbin Reservoir watershed include: reservoir monitoring; surveys of watershed ponds and rivers; and the identification, collection, and analysis of plants and zooplankton. Some water bodies are surveyed annually, and others are surveyed on a rotating annual schedule by subwatershed. Macrophyte surveys are conducted during the growing season and have been performed periodically since 1998 and on a regular basis since 2006. Floating fragment barriers are placed and maintained around the BLAs and at the regulating ponds prior to the spillways to the reservoir.

Aquatic Invasive Species – biweekly, monthly, and seasonally

Non-native aquatic invasive species within the reservoir are monitored and managed through several focused efforts. This effort characterizes macrophyte flora using visual observation and mapping techniques in areas with the greatest potential for introduction of AIS. In addition, AIS surveys of the reservoir have been performed by consulting firms on an annual basis since 2013, under a contract with MWRA. These surveys provide the most comprehensive data currently available on aquatic macrophytes in the Quabbin Reservoir.

DWSP conducts routine monitoring for invasive macrophytes throughout the watershed, focusing primarily on ponds and lakes with public boat ramps and public recreation. Priority is given to water bodies with ramps suitable for launching trailered boats. Monitoring of aquatic invasive macrophytes and invertebrates has been conducted since 2006.

The Quabbin Boat Seal program was established in 2009 due to the potential for aquatic invasive species to be introduced by private boats through the Boat Launch Areas. The program runs throughout the year and includes boat quarantines, boat decontamination (at a privately-run car wash), inspections, and sealing. Private boats

are inspected and must be sealed before launching on the reservoir; a comprehensive database tracks sealed boats. A kayak/canoe rental program operates at two BLAs to keep these types of private boats out of the regulating ponds that feed into the reservoir; kayaks and canoes are not permitted on the main body of the reservoir.

Accomplishments

- Surveyed Quabbin Reservoir annually for AIS.
- Conducted AIS assessments of watershed lakes and ponds.
- Conducted public outreach and education about AIS, including signage, brochures, and presentations.
- Educated fishermen about AIS and Asian jumping worms during Boat Decontamination and Cold Weather Quarantine.
- Continued to operate the Quabbin Boat Seal Program. Updated and standardized boater records; there are currently 2,410 unique boats in the Quabbin Boat Decontamination/ Boat Seal database. Through 2022, a total of 3,197 boat decontaminations have been conducted. Cold weather quarantine accounted for another 1,350 boats sealed since 2010. Approximately 108,400 boat seals have been processed at the BLAs since 2010.
- Completed Aquatic Invasive Species Assessment and Management Summary: 2010-2022, Quabbin Reservoir and Ware River Watershed

4.12.2 Ware River

AIS program activities within the Ware River watershed include surveys of ponds and rivers, and the identification, collection, and analysis of plants and zooplankton. Some water bodies are surveyed annually, while others are done in conjunction with EQAs.

Macrophyte surveys are done during the growing season and have been completed on a regular basis since 2010.

MWRA contracts with a consultant annually to survey for aquatic macrophytes in the Shaft 8 intake area and immediately upstream, with invasive macrophyte removal conducted by a separate MWRA contractor.

DWSP runs a self-certification program for boaters at Long Pond and Comet Pond. The Long Pond boat permit program serves as an educational and control program. Staff also conduct outreach and education through signage, newsletter articles, and talking with users at boat ramps in the watershed.

Accomplishments

- Monitored and collected samples from numerous water bodies in the watershed.
- Collected samples at Shaft 8 for AIS prior to diversions and during the annual Ware River drawdown.

4.12.3 Wachusett Reservoir

Concentrated [Diver Assisted Suction Harvesting (DASH)] efforts over the years have greatly reduced distribution and density of target species, with the documented return of native species.

Management of invasive aquatic vegetation in Wachusett Reservoir was initiated in 2002. Management initially focused on the upper reaches of the reservoir system but expanded in the following years to encompass well established AIS populations as well as pioneer infestations as they are detected. MWRA has continued to annually deploy Diver Assisted Suction Harvesting (DASH) contractors to address aquatic invasive plants. Concentrated efforts over the years have greatly reduced distribution and density of target species, with the documented return of native species.

Seven aquatic and emergent vegetation species have been documented in Wachusett Reservoir, including Eurasian Milfoil, Fanwort, and Variable Milfoil. Eleven non-native but ubiquitous fish species (i.e., Smallmouth Bass, Largemouth Bass, Yellow Bullhead, etc.) and two non-native invertebrates (Chinese Mystery Snail, Virile Crayfish) have also been documented. Five additional aquatic macrophyte species, including Hydrilla, Brittle naiad, and Curly-leaf pondweed have been documented in water bodies in close proximity to the reservoir.

Year to year harvesting totals, specific management strategies, and overall program results are presented in the annual Water Quality Report. The AIS management plans provide an overview of the AIS management program, outline responses, and assess threats from novel introductions. These plans are updated periodically (most recently in 2010 and 2016) and work is underway on the next update, which is expected to address AIS topics from a divisional perspective to include the entire watershed system.

Accomplishments

- Routinely managed Eurasian Milfoil, Variable Milfoil, and Fanwort via physical means (hand-harvesting and Diver Assisted Suction Harvesting (DASH)) throughout the reservoir.
- Added dense beds of Variable Milfoil in Quinapoxet Basin to the DASH management program in 2020.
- Identified three systems of watershed and off-watershed ponds and several off-watershed ponds that are close to the reservoir that harbor invasive species, including five not yet present in the reservoir.
  - Initiated, upon discovery, management to reduce the chance of these species spreading to the Reservoir.
  - Reduced density of all six target species
  - Eliminated target species in two cases – Brazilian Elodea in Clamshell Pond, Clinton and Eurasian Milfoil in Middle Lily Pond, West Boylston.
- Routinely inspected the reservoir and other water bodies in the watershed for invasive macrophytes. Priority given to water bodies with access suitable for boats or with other related risk factors. These efforts are supplemented by MWRA through periodic macrophyte surveys performed by independent contractors.

- Completed the every-five-year survey of the entire reservoir shoreline in 2021.
  - Recorded aquatic vegetation biovolume with boat-based sonar equipment and produced a biovolume map of the entire 37.5-mile reservoir shoreline.
  - Comparisons from survey to survey allowed biologists to document areas of potential new invasive species growth as well as changes in composition over time made through natural processes or management interventions.
  - Collected biovolume data annually in primary management areas (i.e., Stillwater Basin, Quinapoxet Basin, etc.) to document removal efforts and regeneration of native plant beds.
- Modernized the AIS plant harvesting program with the development of several ArcGIS online tools that collect and display data in near-real time. Plant removal and quality assurance contractors enter data in a standardized format using custom Survey123 applications. These data are then displayed in a AGOL Dashboard accessible by the contractors and project partners. These applications allow progress to be monitored, data tracked, and modifications to be made to activities as needed.
- Created and recorded a remote AIS training presentation for Ranger and Interpretive staff in 2020. This training is now available on-demand to new staff and can be updated as needed.

4.12.4 Sudbury Reservoir

Several aquatic invasive macrophytes are present in Sudbury Reservoir. Some, including Eurasian milfoil, are well established at high densities and/or have large distributions, rendering available management efforts ineffective. Others, including Water Chestnut, were identified early enough in their invasion that management was initiated and has been maintained. Water chestnut was first discovered by DWSP biologists in 2006 in the northern portions of the reservoir. This species reproduces via seed, making control possible if plants are removed on a yearly basis before producing seeds; Water chestnut management has been conducted successfully since 2007. MWRA has contracted with biological survey firms which conduct annual monitoring of the aquatic vegetation and water quality in Sudbury Reservoir. Separate MWRA contracts are in place to annually perform direct management of infestations.

Since 2015, MWRA performs winter drawdowns at Foss Reservoir to reduce the biovolume of invasive Eurasian milfoil. The water level is progressively lowered beginning November 1 to a depth of ten feet below normal, and remains lowered until a significant freezing event occurs.

Fanwort was first identified in Sudbury Reservoir by MWRA-contracted surveyors in 2017. Distribution was initially thought to be relatively isolated; however, additional surveys associated with control efforts determined the plant to be widespread in 2021. Management via Diver Assisted Suction Harvesting and fragment barrier placement took place in isolated areas until 2021.

Surveys conducted by MWRA contractors in 2021 identified fanwort in several areas and many contiguous acres of the reservoir. The size of the infestation rendered management with the currently available tools impractical, especially given the widespread distribution of other AIS already established in Sudbury Reservoir. To meet the goal of maintaining the reservoir as an emergency backup supply, and protecting downstream water resources, a control area was established in the basin closest to the Sudbury Dam. This area will be surveyed annually by divers and fanwort, Eurasian milfoil, and any other AIS determined to be a threat will be removed via physical methods.

Asian clam was discovered in 2022 in a southern Sudbury Reservoir basin; this was deemed inevitable given that this aquatic invasive mollusk is present throughout the region. MWRA's aquatic macrophyte consultant will assess the extent during the annual survey in the summer months.

The feasibility of managing new introductions or expansions of AIS within Sudbury Reservoir will continue to be assessed on a case-by-case basis in coordination with MWRA.

Accomplishments

- Conducted annual removal of Water Chestnut, which will continue for the foreseeable future. The total biomass of this species has been reduced by 99 percent according to recent MWRA contractor reports and management

strategies have evolved from mechanical harvesting to hand-harvesting in isolated areas.
- Implemented, with MWRA, an Aquatic Invasive Species Decontamination Protocol that includes both Wachusett and Sudbury Reservoirs. Required all MWRA, DWSP and contractor boats (and associated equipment) to be decontaminated in accordance with the protocol and inspected before being launched.
- Established a decontamination protocol with local fire departments who may deploy their boats on the reservoirs in an emergency or for training,
- Watershed Rangers continued to patrol the reservoir from land and by boat to limit unauthorized use, as the illegal use of privately owned canoes and small boats pose an ongoing AIS threat to the reserve water supply. Rangers also swept the reservoir shoreline once per year to remove any boats or canoes stored or hidden on DWSP property along the reservoir shoreline.

4.12.5 Five Year Objectives

- Implement current watershed-specific AIS Management Plans.
- Complete a DWSP-wide comprehensive AIS Management Plan that presents a framework for monitoring and making decisions regarding current and new AIS threats across the watershed system.
- Continue routine tributary and reservoir sampling to identify short-term and long-term threats from aquatic invasive species. Prioritize and conduct surveys of watershed/local waterways to inspect reservoirs, lakes, ponds, and tributaries for presence of aquatic invasive species.
- Protect infrastructure from harmful effects of invasive species.
- Perform aquatic vegetation surveys prior to AIS management projects. Provide results to MWRA and contractors to guide plant removal efforts. Monitor, advise, and assist contractors with plant removal operations as necessary, including boat decontamination inspections and data management through ArcGIS Online apps.
- Conduct surveys, gather information, and make recommendations for management actions on an individual basis if/when new infestations are found in accordance with current action plan(s).
- Inspect equipment and gear to be used in or on reservoirs.
- Monitor privately owned water bodies in the watershed system.
- Continue to educate Ranger and Interpretive staff on AIS and other water quality topics for incorporation into education programs.
- Update DWSP web pages and include information on current management practices, accomplishments, and educational resources.
- Update AIS signage found throughout the watershed.
- Accompany any cyanobacteria advisory signage with educational signage on excessive fertilizer use and faulty septic systems as potential contributors to algae blooms.
- Communicate with regional initiatives, such as SuAsCo Cooperative Invasive Species Management Area.

4.13 Wastewater Management

Improper disposal of wastewater is a serious threat to the water supply due to the potential for contamination by pathogens and nutrients, and any release of untreated wastewater must be considered of highest priority for action by DWSP staff. Staff monitor installation, repair, and maintenance of DWSP onsite wastewater disposal systems and work as needed with state and local regulators to ensure compliance with all applicable regulations – in particular 310 CMR 15.000 ("Title 5"), so that wastewater is handled safely throughout the watershed system.

DCR owns the Rutland Holden Sewer Trunk Line that carries municipal sewage from the towns of Rutland Holden and West Boylston to the city of Worcester and ultimately treatment at the Upper Blackstone Water Pollution Abatement facility. MWRA operates and maintains the Rutland-Holden Trunk and Trunk Relief sewers on DCR's behalf. The treated effluent is discharged outside the watershed system into the Blackstone River.

Goal

Monitor on-site wastewater disposal systems and operation of Rutland-Holden sewer to ensure proper treatment of waste.

4.13.1 Quabbin Reservoir

On-site septic systems and, to a lesser extent "tight tanks", are the methods of wastewater treatment or collection/disposal within the Quabbin Reservoir watershed; there are no wastewater treatment plants within the watershed. Septic systems throughout Massachusetts are regulated by Title 5 regulations. Massachusetts' Title 5 regulations, last modified in 1995, are now fully implemented by local Boards of Health across the watershed. Board of Health records vary considerably within Quabbin watershed towns, making it difficult for DWSP to easily monitor activities related to system installations, repairs, and replacements on private lands in the watershed that are outside of the areas regulated by the WsPA.

DWSP's Watershed Protection regulations provide an additional level of protection to review new system siting proposed within regulated areas with potential to help relocate the system out of these sensitive areas, as well as an avenue to review repairs/conversions. System

conversions from septic to tight tanks are common for lake houses on very small lots where a conventional system cannot be sited (e.g., Lake Mattawa). Installations of new septic systems, septic repairs, and septic conversions occur regularly within the watershed. DWSP facilities in the watershed are all serviced by septic systems, which are maintained by DWSP staff.

Accomplishments

- Upgraded a majority of DWSP systems beginning in 1998 as part of the Clean State Initiative.
- To date, 14 DWSP-Quabbin septic systems have been replaced; two systems have been abandoned/closed (Quabbin Park Cemetery and Antennae site); and one system has been converted from a septic system to tight tank (BLA 3).

4.13.2 Ware River

The majority of the Ware River watershed is served by on-site wastewater disposal systems. There are portions of Rutland within the Ware River watershed that are serviced by the Rutland/Holden trunk and relief line sewer system. Since July 1, 2018, the Town of Rutland has reported that there have been 75 new connections to the Town-owned sewer collection system that ultimately discharges into the trunk and relief sewer lines.

Improper disposal of wastewater is a serious threat to the water supply due to the potential for contamination by pathogens and nutrients, and any release of untreated wastewater must be considered of highest priority for action by DWSP staff.

Accomplishments

- Staff followed up on potential issues identified through field observations, notifications from towns, and/or EQA findings.
- DWSP encouraged replacement of cesspools with Title 5 compliant systems.
- DWSP and MWRA continued to cooperatively manage the Rutland-Holden Trunk sewer.
- The MWRA performed subsurface TV inspection of portions of the trunk and relief sewer lines. The Town of Rutland performed a subsurface inspection and inflow and infiltration (I/I) study of the trunk and relief sewer lines within the Town boundaries in the spring of 2020.
- Based upon the findings of the 2020 investigation, National Water Main performed manhole repairs, heavy cleaning and relining of approximately 6,800 LF of pipe within the Ware River Watershed that were identified during the investigation and I/I study.
- No permits for the Rutland/Holden trunk and relief sewers (connection, crossing, driveway, etc.) have been issued since the last Watershed Protection Plan update. There have been no sanitary sewer overflows during the past five years. DWSP also completed and submitted the required DEP sewage overflow notification information, including the development of a web page related to the sewer program.

4.13.3 Wachusett Reservoir

The Metropolitan District Water Supply Commission, a predecessor agency of DCR, was authorized in 1932 to construct, maintain and operate one or more sewer mains for watershed protection purposes; construction on the sewer main and local sewers in the Towns of Holden and Rutland began in 1938. Upon completion, the main trunk sewer and select spurs in Rutland off the trunk were retained by the Metropolitan District Commission (MDC – another DCR predecessor); the rest of the local sewers were turned over for ownership and operation to the towns. Ownership of the local sewers has remained with the towns as the sewer systems expanded, while DCR still has ownership and along with MWRA oversee the operation of the trunk and relief main sewers.

Some areas in West Boylston and Holden were identified in the early1990s as being too small for homeowners to install properly sized Title 5 septic systems. The MDC subsequently paid for the design and construction of expanded sewered areas in Holden and the installation of a new sewer collection system in West Boylston with a combination of state and MWRA funds. Upon completion of these construction phases, ownership, care, and control of these sewers was transferred to the respective towns.

Problems in many areas of the Wachusett Reservoir watershed have been reduced with completion of the new sewers in West Boylston and the expanded sewers in Holden.

Problems in many areas of the Wachusett Reservoir watershed have thus been reduced with completion of the new sewers in West Boylston and the expanded sewers in Holden. Connections to the sewer have improved tributary water quality and reduced the threat from wastewater. DWSP staff have improved mapping of water resources and shared information with MassDEP and local Boards of Health. Staff continues to provide technical support as requested and reviewed more than 200 septic system plans.

Accomplishments

- Continued to cooperatively manage the Rutland-Holden Trunk sewer with MWRA. Began to research better management options for all parties, which could possibly include establishing a regional sewer district.
- Helped facilitate subsurface inspections and repairs.
  - MWRA performed an internal CCTV inspection of portions of the trunk and relief sewer lines.
  - The Town of Rutland performed an internal inspection and inflow and infiltration (I/I) study of the trunk and relief sewer lines within the Town boundaries in the spring of 2020.
  - MWRA contractor Green Mountain Pipeline, Inc., performed manhole repairs, heavy cleaning and relining of key segments that were identified during the investigation and I/I study.
- Substantially completed the Base Bid and Alternate Bid No.1 (C-line pipes). A re-test inspection of the completed work remains and will be performed in Spring 2023. The inspection will include television inspection of the completed CIPP sections and topside manhole inspections for rehabilitated manholes.

- No connection permits, utility crossing permits, or driveway crossing permits have been issued since the last Watershed Protection Plan update. There have been no sanitary sewer overflows during the past five years.
- Completed and submitted the required DEP sewage notification information.
- Obtained information from the Town of Holden on the 28 sewer pump stations operated by the Holden Water and Sewer Division, including a list of operation and maintenance checks performed daily, weekly, and annually. All wet wells are vacuumed and cleaned twice per year and valves are disassembled and cleaned annually. Operation and maintenance manuals are located at each pump station.
- Obtained information from the Town of West Boylston on the 14 sewer pump stations operated by Weston and Sampson Services, including a list of operation and maintenance checks performed daily, weekly, and annually. Operation and maintenance manuals are located at each pump station.
- Performed a risk assessment on all pump stations located within the Wachusett Reservoir watershed. Staff considered size of the station, nearby streams, bodies of water or drainage structures, topography, visibility, and accessibility as part of this assessment,. This information was then reviewed with MWRA, and a list of spill response supplies was generated to be purchased, should DCR need to assist the Towns with response to any overflows or operational problems.
- Tracked connections to the municipal sewers and regularly entered the data in a spreadsheet and a GIS datalayer. An update to the GIS sewer line datalayer is underway and the final product will accurately depict all sewered areas.
- Continued to work with boards of health in watershed communities to provide technical assistance when requested on septic system repairs and new installations. Information gathered during system reviews is added to the new septic system database.

4.13.4 Sudbury Reservoir

There is no specific Wastewater Management program in the Sudbury Reservoir watershed. Wastewater issues are covered under the Watershed Monitoring and Surveillance program. If the Sudbury Reservoir watershed is determined to be re-evaluated as a priority, then increasing watershed staff will be necessary to accomplish a thorough, comprehensive Watershed Monitoring and Surveillance Program necessary to identify, assess, and resolve any issues in the watershed.

Threats to the reservoir persist from the Town of Southborough's reliance on septic systems. The town's Board of Health has been proactive in protecting the environment, adding addenda to the state Title 5 Code since the early 2000s. The town's new public safety complex on a portion of St. Mark's golf course was completed in 2019; it brings a fairly large subsurface sewage disposal unit in close proximity to the Sudbury Reservoir.

In January 2020, there was a sewer line break in Framingham resulting in a release of sewerage into the wetland system associated with Foss Reservoir; Environmental Quality staff responded to assess any water quality threat. This Sanitary Sewer Overflow was reported to the Framingham Department of Public Works and DEP was notified. The cause of the SSO was determined to be a force main 4-foot-long lateral crack. The DPW met with the Conservation Director and MWRA to inspect the site and placed additional lime to the affected area as directed by the Conservation Director and MWRA.

The Framingham DPW inspected the pipe both upstream and downstream of the break and found nothing of concern. Framingham DPW conducted site cleanup and restoration, including the removal of the sewage contaminated soil. As a result of this incident and the difficulty of the DPW finding lime at this time of year, it was decided that DWSP purchase and store lime in the DCR Response Shed to support response teams if there are future releases.

4.13.5 Five Year Objectives

- Review water quality data and other pertinent information to identify potential problem sites due to wastewater.
- Continue to implement and monitor WsPA regulatory requirements for septic system installations (new, repair, replacement).
- Work with local Boards of Health and MassDEP to enforce Title 5 compliance.
- Provide technical assistance, upon request and staff availability.
- Respond to sewage releases and assess water quality threats or impacts.
- Manage the Rutland-Holden trunk sewer and Rutland-Holden Relief trunk sewer.
- Design a study, once all known sewer and septic connections are mapped, to determine if populated areas that experienced significant conversion from septic to sewer have seen statistically significant reduction in nutrient loading.

4.14 Stormwater Management

Stormwater carries pollutants from many different sources to watershed tributaries and reservoirs. It is currently considered the most significant threat to water quality in the Wachusett Reservoir watershed. The DWSP Stormwater Management program develops and implements strategies to reduce pollutant loads from stormwater, such as quantifying stormwater inputs and assisting private individuals, businesses, and local municipalities in their efforts to reduce pollutant loading. DWSP has worked closely with the MassDOT to design and construct stormwater BMPs in key locations on state highways around Wachusett Reservoir.

4.14.1 Quabbin Reservoir

Stormwater management within the Quabbin Reservoir watershed is primarily focused on road drainage systems. The total impervious surface within the watershed is less than one percent. Historically, a hydraulically efficient storm drain system is one that collects and conveys stormwater from the road surface and surrounding area to the nearest receiving watercourse as efficiently and as quickly as possible, which is typically not the best approach for water quality protection. Road redevelopment projects occurring within the watershed present an opportunity to correct or make improvements to better safeguard receiving watercourses against the effects of stormwater pollution. These projects include work immediately adjacent to Quabbin Reservoir as well as road systems in the wider watershed.

Goal

Reduce water quality problems caused by untreated stormwater.

Other discharges of concern are flows to tributaries from the State roadways that surround the reservoir, primarily Routes 202, 122, 32A, and 9. Staff strive to work cooperatively with MassDOT and local officials on stormwater management design aspects and redevelopment improvements of highway and local road reconstruction projects. DWSP efforts begin with the review of project designs and continue through the construction phases of the project to completion. Although none of these drainage systems discharge directly to the reservoir, staff work to assure potential roadway stormwater impacts are limited.

A significant portion of the watershed roads are rural roads incorporating "country drainage" systems (i.e., no piped collection and conveyance of stormwater), and unpaved roads are common. DWSP is the largest owner of gravel roads within the watershed, with more than 250 miles under its direct care and control. DWSP's gravel roads provide access for water quality monitoring, water supply protection purposes, wildlife management, fire protection, forest management, and controlled visitor access. The system is maintained using best management practices to limit road washouts, ensure road reliability and safety, and to satisfy environmental standards.

Accomplishments

- Monitored the NPDES database for stormwater management projects.
- Reviewed MassDOT projects for stormwater improvements, such as the Glen Valley Road bridge in Petersham.

4.14.2 Ware River

Stormwater management within the Ware River watershed is primarily treatment systems at newer subdivisions and road drainage. A significant portion of roads in the Ware River watershed have country drainage. Dirt roads, both DWSP and town owned, are common in the watershed. Stormwater management of paved roads with culverts is handled cooperatively with other agencies, primarily MassDOT. Staff monitor and provide input on road projects, particularly those that involve stormwater discharge.

Accomplishments

- Reviewed MassDOT projects and provided input for stormwater improvements on Evergreen Road bridge in Hubbardston and Moulton Pond dam and bridge in Rutland.
- EQ monitored stormwater impacts from new subdivisions in Rutland and worked with EP staff on mitigation.

4.14.3 Wachusett Reservoir

Water quality sampling suggests that significant portions of annual pollutant loads to the reservoir are contributed during storm events. Contaminant concentrations can rise rapidly during first flush and tributary flow increases rapidly as well. DWSP works with the appropriate agencies and watershed communities to increase compliance with stormwater regulations, including Federal NPDES stormwater requirements and Massachusetts Stormwater Standards. DWSP designs and constructs stormwater BMPs on its properties to help control.

Water quality sampling suggests that significant portions of annual pollutant loads to the reservoir are contributed during storm events…DWSP works with the appropriate agencies and watershed communities to increase compliance with stormwater regulations…

DWSP completed a study in 2008 that created a comprehensive inventory of locations where stormwater runoff discharged directly to the reservoir. Direct discharges at the northern end of the reservoir were eliminated early in the program.

Accomplishments

- Completed construction to redesign the drainage at the Beaman Street Bridge and along Route 140 at South Bay in West Boylston. Assumed responsibility for the maintenance of all associated stormwater control structures.
- Started design work to eliminate the last remaining direct discharges to the Reservoir along Route 110 in Sterling; construction anticipated in 2024.
- Continued to improve GIS datalayers of all stormwater drainage structures, stormwater treatment BMPs, and flow pathways as part of the Wachusett Watershed Hydrology Mapping Project
- Regularly inspected all active construction sites with Construction General Permits (disturbances of more than one acre) in both wet and dry weather.
- Inspected and maintained, as needed, all DWSP stormwater treatment BMPs.
- Began a monitoring program to gather data on the efficiency and effectiveness of DWSP owned and managed BMPs. This information will help determine future rehabilitation work.
- Established an "on-call" contract with a maintenance contractor to perform drainage and BMP maintenance services including, but not limited to, vacuum truck services.
- Prepared design plans for the modification of the drainage structures at the BMP forebays at Gate 25 and WB10. These were initially designed to be impervious for the purposes of providing storage for spills, but has resulted in persistent standing water which has caused algae and nuisance wildlife issues. The new designs allow periodic drainage. Two out of the five forebays have been modified, and the remaining will be modified as funding allows.
- Constructed a spill containment basin at Gate 41 in 2018 to capture potential spills from the end of Park Street in Clinton.
- Constructed a new public parking area was in fall of 2020 at Gate 28; a rain garden was designed and installed at that location.
- Constructed a stormwater treatment unit and sedimentation basin as part of MWRA's River Street Clinton repair and stabilization project, completed in 2021.

4.14.4 Sudbury Reservoir

Education and outreach on stormwater pollution prevention, as a non-traditional Best Management Practice, is an important component of a successful stormwater management program. DWSP staff has developed a series of brochures on various stormwater topics which will be shared with town departments, boards and commissions as needed for use in the Sudbury Reservoir watershed.

A new public safety complex has been approved by voters of Southborough to be built on a portion of St. Mark's golf course, off of Cordaville Road and in close proximity to the reservoir.
Stormwater pollution problems will be addressed as needed.

Accomplishments

- Provided significant outreach to trails groups on dog waste pick up initiative and provided overview for signage.
- Reached out to Southborough Conservation Commission agent on stormwater issues by providing copies of all DWSP brochures which were mailed to new homeowners.
- Provided comments on stormwater issues through the MVP process.
- Conducted regular mowing on DWSP property; buffer areas around pertinent resources have been left in place to mitigate the impacts from stormwater runoff.

4.14.5 Five Year Objectives

- Provide input into state and local road reconstruction projects to influence stormwater management design aspects of projects. Work with MassDOT and local DPWs to improve infrastructure to control stormwater and with conservation commissions, MassDEP, and EPA for compliance with state and federal stormwater requirements.
- Integrate, maintain, and monitor structural storm water Best Management Practices (BMPs) needed and/or constructed on DWSP property.
- Inspect all construction sites greater than one acre to ensure compliance with Stormwater Pollution Prevention Plans (SWPPPs).
- Examine DWSP stormwater management as part of road management plans.
- Work with MassDOT to develop a cooperative arrangement that will allow for improved access and more frequent maintenance of stormwater treatment BMPs.
- Initiate plan to inventory, monitor, and assess performance of stormwater BMPs on privately-owned property.
- Coordinate with Planning Boards to ensure that all construction projects that have a stormwater management component are reviewed and that any new or changed stormwater infrastructure is added to DWSP GIS datalayers.
- Investigate installing rain gardens at key areas in the watershed system.
- Continue to raise awareness of stormwater as a pollutant in the watershed system, including techniques for reducing runoff and improving the quality of stormwater runoff. Provide stormwater programs, resources and/or support, as resources allow, to town departments, boards and commissions. Consider evening Interpretive programs on stormwater management topics.
- Complete a watershed-wide vulnerability assessment to identify potential impacts of climate change on stormwater impacts in the water supply.
- Design and conduct water quality monitoring studies to evaluate effectiveness of and optimize performance of direct discharge project structural BMPs.

Wachusett

- Work with MassDOT to complete drainage improvements to a section of Route 110 in Sterling, which is the last direct discharge to Wachusett Reservoir.
- Update map of stormwater conveyance structures and define stormwater subbasins.

- Review, summarize, and assist in the development, upon request, of bylaws to manage construction site runoff and post- construction runoff, and assist communities with mapping and impervious surfaces analyses.
- Provide regional training, as requested, on stormwater issues for town employees, DWSP staff, and others.
- Evaluate the potential for producing a prioritization model using the stormwater network delineation that takes into account land cover, proximity to tributaries, and other criteria to categorize watershed areas for relative stormwater treatment needs.

Above: Construction of Direct Discharge Elimination infrastructure in West Boylston adjacent to Thomas Basin. Below: Completed project looking towards Rt. 12 causeway and main body of Wachusett Reservoir. DWSP coordinated with MassDOT to design and fund this work.

4.15 Emergency Spill Response

Despite the best efforts to implement control over public access, maintenance, land management and other activities on watershed property, emergency situations – especially those involving spills of hazardous materials – could result in immediate threats to public drinking water supplies. Therefore, emergency response is a crucial part of watershed protection programs, especially where water supply reservoirs or watersheds are readily accessible to potential contamination sources, such as transportation corridors passing closely to the reservoir or tributaries.

DWSP maintains and improves emergency response capabilities to assist local emergency responders should a release occur. A prompt response that recognizes the importance of the tributaries and reservoirs can help minimize any impact to the water supply. DWSP staff, along with MWRA and consultants, provide expertise regarding the hydrologic characteristics of the reservoir and its tributaries, on-water spill control, and specialized equipment for reservoir response. Components of this program include Incident Command training, first responder training for on-water and terrestrial releases, the purchase of equipment, including MWRA-supplied boom and response trailers, staging of materials at key locations around the reservoirs, mathematical modeling of potential spill scenarios, and development of Standard Operating Procedures for emergency situations.

Goal

Maintain and improve short- and long-term emergency spill response capabilities to protect the water supply.

DWSP has developed and will implement a multi-year *Emergency Training and Exercise Plan*. This plan provides the framework for enhancing the preparedness capabilities identified by the previously conducted *Threat and Hazard Identification Risk Assessment*. This plan also includes the improvement components identified from previous emergency response exercises.

4.15.1 Quabbin Reservoir

Planning

DWSP developed a spill response SOP for Quabbin Reservoir and Ware River watersheds, which provides guidance related to spills of hazardous materials. It includes contact information for DWSP and MWRA staff, as well as local emergency management agencies, contact procedures, information on the DWSP radio system, and roles/responsibilities for staff and local emergency personnel. It also includes information on Incident Command procedures, maps, and other pertinent information that might be needed during emergency situations.

Emergency procedures have also been developed for loggers working on the watershed, including emergency contact cards that instruct loggers who to call in the event of a spill or other emergency situation.

Training

Annual training, in conjunction with MWRA, is provided to DWSP staff and local emergency officials on containment boom deployment and terrestrial spill response. The Watershed Rangers are key participants in these trainings and also receive additional emergency response training.

Annual training, in conjunction with MWRA, is provided to DWSP staff and local emergency officials on containment boom deployment and terrestrial spill response.

Equipment

Emergency response equipment is stored and maintained in several locations in the watershed. There are three spill response trailers: one holds boom supplies, another contains terrestrial spill response equipment and supplies, and the third stores supplies mainly pertaining to on-water spill situations. These trailers are sited in appropriate locations for quick access in the event of an emergency situation. A boom deployment shed is stocked and maintained on the bank of the West Branch Swift River (due to the proximity of Route 202). Additional boom supplies are stored in particularly sensitive locations around the reservoir where rapid deployment may be necessary. Spill response supplies are also positioned near active timber harvesting operations or ROW construction work when the site is located close to the reservoir, certain tributaries, or sensitive areas. Spill response equipment is periodically checked, tested, and maintained; new or replacement equipment is added on a regular basis.

Accomplishments

- Developed and distributed a Spill Response Standard Operation Procedures (SOP) to all staff. The SOP contains flow charts and information on how to respond to various spill situations on DWSP property.
- Maintained and inspected monthly three spill response trailers and replaced items when needed. MassDEP maintained a regional response trailer at the Quabbin Administration Building.
- Upgraded trailers as part of MWRA's Vehicle Maintenance Program, as new trailers are provided to replace older ones.
- Prepared spill response plans for every DWSP timber harvest.

- Constructed above ground fuel storage with secondary spill containment at each BLA near rental boat ramps.
- Built dedicated spill response vaults/sheds and equipped with materials at each Boat Launch Area near the public ramps.

4.15.2 Ware River

Responsibility for emergency spill response in the Ware River watershed is divided among several work units: Administrative and Technical Support staff are responsible for developing response plans and training; the Watershed Rangers are often the first responders in emergency situations and thus have additional training and response equipment; and staff from all other work units obtain spill response training.

Accomplishments

- Staff completed an array of spill response trainings: Basic Boom Deployment Operations, Terrestrial Spill Response Operations, River/Small Water Body Spill Response Operations, Night Emergency Response Operations, Fishing Area Specific Spill-Boom-Boat Operations, Trailer and Equipment Survey and Assessment, Shaft 8 River Spill Response Operations, Winter Emergency Response Operations Planning, OPA 90, Small Boat Operator Training, HAZWOPER Training, Dam Emergency Response Field Training, Marine Spill Supervisor Training, Cold Water Response Training, and Hazardous Waste Operations Training.
- Provided all Watershed Rangers with Incident Command System (ICS) training.
- Located and removed illegal dump sites on DWSP property.
- Developed spill response plans for all active timber harvest operations and shared with timber harvest contractors.
- Developed Spill Response Standard Operation Procedures (SOP) for Quabbin and Ware River Watershed.

4.15.3 Wachusett Reservoir

DWSP and the MWRA have deployed Emergency Response trailers in key areas throughout the watershed. Annual training has been conducted for DWSP staff and area responders in spill response, boom deployment, and Incident Command System. Nearly all staff has taken ICS 700 and ICS 100 classes, and several have taken ICS 200, ICS 300, and Oil Pollution Act of 1990 Qualified Individual Training.

DWSP continues to monitor any spills in the watershed and work with federal, state, and local officials to ensure successful remediation.

DWSP and MWRA regularly hold a variety of trainings and drills to acquaint the workforce with how to react to an ongoing emergency. For example, the fall 2015 simulated release was a large-scale exercise involving over two hundred individuals from several federal, state, local, and private agencies and organizations; smaller-scale exercises were held in 2022.

DWSP continues to monitor any spills in the watershed and work with federal, state, and local officials to ensure successful remediation. DWSP staff has participated in meetings and exercises as part of the South Wachusett Regional Emergency Planning Committee. DWSP also completed a Comprehensive Emergency Management Plan that details actions and procedures for incidents that occur on DWSP property or that have the potential to impact the water supply. An unannounced mock hazardous materials release drill was conducted in the woods near Justice Brook in 2017.

Accomplishments

- Participated in a multi-agency emergency response drill coordinated by MWRA in June of 2022.
  - This three-day exercise presented a novel spill scenario involving a hypothetical truck accident which resulted in the loss of containment of thermoelectric generators in the vicinity of storm drains near the Wachusett Reservoir.
  - This mock event played out the steps to take to address the physical containment, access, sampling, and coordination with other agencies.
- Upgraded anchor points around the reservoir for boom attachment.
- Upgraded trailers as part of MWRA's Vehicle Maintenance Program, as new trailers are provided to replace older ones.
- Built sheds at Gate 1 and the boat cove in Clinton to store new emergency response equipment.
- Provided ICS training to key staff, including all new personnel.

- Continued the working group with MWRA to look at potential impacts of a large hazardous material release from a train crossing the reservoir.
- Produced a Wachusett/Sudbury Comprehensive Emergency Management Plan in 2021 to provide the framework and guidance in the prevention, preparation, mitigation, response, and recovery of any type of incident within the Wachusett and Sudbury watersheds.
- Conducted a full-scale exercise in May 2022, simulating a railroad incident at Thomas Basin, with 83 people from various organizations.
- Developed mathematical model of the reservoir, in conjunction with UMass Amherst Department of Civil and Environmental Engineering, to evaluate spill scenarios. This information was used during the full-scale training exercise and provided a rapid assessment of possible concentrations and likely intake arrival time of contaminants.
- Conducted dam safety trainings to educate staff on dam safety awareness and response. Held a dam safety tabletop exercise, utilizing a failure of Unionville

Pond Dam as the scenario. Thirty personnel from various state, regional, local and private organizations that participated in the event.
- Held conversations with local fire chiefs about how much of each type of fire suppressant foams containing PFAS was kept locally; confirmation provided that all "legacy foams" have been removed from the watershed. Developed and distributed a brochure on fire suppressant foams to all watershed fire departments.
- Communicated with CSX Railroad, which has recently acquired the rail line that abuts Wachusett Reservoir (see Watershed Security, 4.6.3, for additional details). CSX has upgraded the rail line replacing all tracks and sections of ties within the watershed, installed guard rails at key reservoir crossings, installed emergency sensors to detect dragging equipment and hot wheel bearings, and are providing regular reports on the hazardous material transported across the watershed. DWSP will explore the potential of CSX as a funding resource for future training and emergency response exercises.

4.15.4 Sudbury Reservoir

While not the same high priority as the Quabbin and Wachusett Reservoirs, DWSP and MWRA must still be prepared for accidents near the Sudbury and Foss Reservoirs. Updated protocols for the Sudbury watershed are integrated into the 2017 *Combined DCR & MWRA Inter-Agency Emergency Spill Response/Prevention Plan for the Wachusett and Sudbury Watersheds*. The plan details actions and procedures for incidents that occur on DWSP property or that have the potential to impact the water supply or surrounding property. A critical component to any Emergency Response is communication, cooperation, and coordination with the local first responders as well as MassDEP.

Accomplishments

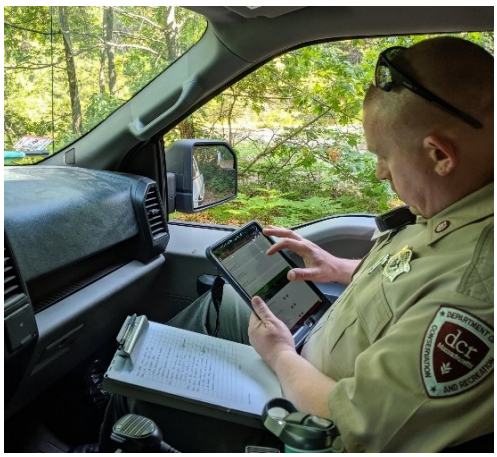
- Trained staff on reservoir boom deployment and terrestrial spill response.
- Conducted boom deployment training on Sudbury and Foss Reservoirs in 2019 with MWRA, Southborough, Marlborough, and Framingham Fire Departments.
- Updated the emergency response protocol using inter-agency protocols in the 2017 *Combined DCR & MWRA Inter-Agency Emergency Spill Response/Prevention Plan for the Wachusett and Sudbury Watersheds*.
- Conducted a Dam Safety Tabletop exercise at Framingham State University in 2017 with multiple agencies, including DCR, MassDEP, Framingham Fire Department, Framingham Police Department, Framingham Department of Public Works, Framingham State University, MWRA, and MSP. Based on After Action Report and Improvement Plan, Unified Command trainings were provided by MEMA to Framingham Fire Department, Police Department, and Department of Public Works; DCR; MassDEP; Framingham State University; and MWRA.
- Conducted a Threat and Hazard Identification Risk Assessment (THIRA) to determine the most likely threats or hazards that would most occur or would have a significant impact on the water supply, facilities, and operations of the Wachusett and Sudbury watersheds.

4.15.5 Five Year Objectives

- Implement the Emergency Spill SOP and update as necessary.
- Provide emergency response support services. Ensure that DWSP and town emergency responders are aware of emergency protocols put in place by DWSP and are provided emergency contact phone numbers on a regular basis and when changes occur.
- Provide Incident Command System (ICS) training to appropriate staff and emergency response training for new DWSP employees and refresher training for veteran staff.
- Coordinate with MWRA and local emergency officials to provide ICS, emergency response training, and annual tabletop or field exercises.
- Construct, repair, or upgrade additional structural controls to reduce the likelihood of transportation spills traveling along main tributaries and reaching the reservoirs.
- Evaluate, monitor, and oversee spills that threaten water quality or DWSP property and work with appropriate federal, state, and local agencies to contain and remediate. Follow submitted reports until remediation efforts have been completed under Mass Contingency Plan.
- Prepare a summary report of information related to containment structures associated with direct discharge abatement projects for use in case of an accidental spill.
- Produce spill response plans and spill notification cards for timber harvesting operations.
- Finalize and update, as needed, the Emergency Response Manuals for each watershed.
- Update, as needed, Emergency Action Plans for dams in the watershed system, utilizing current and future climate data.
- Coordinate efforts between Quabbin/Ware and Wachusett/Sudbury regions. Evaluate establishment of a division-wide position to coordinate emergency response equipment, supplies, planning, and training or other alternatives for effective coordination.

4.16 GIS

The Geographic Information Systems (GIS) program provides DWSP staff with the field and decision-making tools required to support all other watershed control programs. Over the past five years, DWSP's GIS program has evolved quickly to leverage new technologies available in the cloud, extending and enhancing the agency's capabilities beyond creating printable maps and conducting spatial analyses. Besides these traditional applications, GIS now provides the agency with an array of functions:



- Efficiently conduct field work.
- Realize savings in staff time by adopting modern workflows, such as streamlining or eliminating paper-based workflows.
- Visualize data in online dashboards that enhances decision-making.
- Generate information quickly and accurately for reports.
- Facilitate effective public/stakeholder engagement.
- Continue to conduct spatial analyses and create printable maps.

Goal

Utilize Geographic Information System technologies to enhance and support all watershed management activities.

The GIS program's primary goal is to provide expertise, training, tools, and support to all watershed control programs to ensure that DWSP staff can accomplish program goals. In addition, the GIS program also provides DWSP representation amongst EEA's other GIS coordinators, ensuring that DWSP benefits as much as possible from GIS-related spending and initiatives within the secretariat. Over the past five years, the DWSP GIS program has risen to be a leader of GIS use within EEA.

The following sub-sections describe how GIS programs work across the watershed system. Most applications are used in all four watersheds, or have the capacity to work in any program or location; there are also a few examples of watershed specific projects. Therefore, there are no summaries similar to previous sections that detail work in each watershed or a specific list of

accomplishments. Instead, please see the Appendix for detailed examples of projects the GIS program has facilitated, oversees on an ongoing basis, or completed in the past five years. Projects have been selected because they highlight a representative workflow or represent the accomplishment of an important goal. There are also many operational sections which are independently completing excellent GIS work; their work is not included here unless otherwise noted.

Return-on-Investment (ROI) studies have been performed on several projects (see Appendix). The ROIs highlight how GIS can provide significant savings in staff time on both simple and complicated efforts. Small-scale projects make up the majority of projects undertaken by the GIS program; adding these efforts together demonstrates the positive financial impact of these new GIS based workflows.

4.16.1 Field Data Collection

GIS-supported field data collection allows staff to collect robust spatial, quantitative, and qualitative data quickly and easily on iPads while in the field. Over the past five years, the majority of paper-based workflows have been converted into more streamlined and efficient computer-based processes that utilize a suite of mobile apps designed to facilitate data collection. (Table 4-23).

DWSP utilizes a suite of tools available through Esri's ArcGIS Online platform. These applications are crucial to the success of many programs' data collection efforts; many even work in areas of the watersheds where there is no cell coverage. Data collected in this way can then be used within other applications supported through ArcGIS Online or can be brought into desktop GIS to support mapping and analysis.

Table 4-23: GIS Field Data Applications

Application	Data Collection Format	Description
Field Maps	Map-centric	A map-based data collection experience, allowing users to view their location on a map in relation to reference data. Supports data collection and editing, locating assets and their information, inspection workflows, note-taking and annotation, and automatic location tracking. Allows for collection of spatial, quantitative, qualitative, and image data.
Survey123	Form-centric	A form-based data collection experience which allows users to enter information into a responsive form that supports conditional visibility, defaults, complex calculations, and more. Great for supporting complex data collection needs and for enforcing data quality standards. Allows for collection of spatial, quantitative, qualitative, and image data.
QuickCapture	Rapid	Designed as a "big button app" to facilitate rapid (at speed) data collection. Allows users to quickly record observations while moving (e.g., on a boat) at speed by selecting from pre-configured options that minimize data entry time. Allows for collection of spatial, quantitative, qualitative, and image data.

4.16.2 Dashboarding and Data Visualization for Decision-making

The ability to visualize data and interpret trends is crucial to ensuring data is used in decision-making processes. In the past, this could be accomplished by working with data in programs such as desktop GIS, Excel, or R. While those modes are still effective, there are now online Dashboards that can be created to convey complex spatial and attribute information on a single screen. Dashboards can integrate maps, charts, lists, and graphics to create a visually appealing, interactive, and intuitive way to interpret data. DWSP is using Dashboards to present data trends and detailed information to assist in both decision-making and reporting, and as a method for communicating complex data trends to the public and stakeholders.

The ability to visualize data and interpret trends is crucial to ensuring data is used in decision-making processes.

Dashboarding is currently used to support many internal programs workflows:

- Visualizing and reviewing information from the *Watershed Protection Act* database (see Section 4.8).
- Summarizing active *Construction General Permitting* inspection information (see Sections 4.8 and 4.11).
- Presenting information for quarterly reporting on requests made through the *Wachusett Region Work Order* system (see Section 5).
- Highlighting trends and hot spots of CMR violations or incidents recorded in the *Rangers Daily Log* (see Section 4.5).
- Displaying a series of *Road Infrastructure Management Experience* dashboards to present detailed information for planning and maintenance of internal road infrastructure (see Section 4.7).
- Provide statistics and data summaries on *Beaver Activity* for reporting purposes (see Section 4.4).
- Summarizing and presenting results of the *2022 Wachusett Creel Survey* to internal stakeholders (see Section 4.4).

Dashboards are also used to communicate complex or dynamic information to the public; some examples of public dashboards include:

- DCR/DWSP Regional Gull Survey
- Quabbin Bird Harassment Program
- Wachusett Reservoir Aquatic Invasive Species Removal
- Quabbin Reservoir Boat Launch Area Rental Availability.

4.16.3 Reporting

The GIS program has enabled DWSP staff to synthesize collected information into standardized reports with the click of a button – a critical step for translating data collection efforts into material that can be interpreted by both internal and external parties. Reports can include detailed information such as attribute data, map(s),

image(s), or summary statistics; templates can be as simple or complex as needed. Report templates are being successfully used by a variety of programs, including:

- Watershed Preservation Restriction Monitoring and Baseline Documentation Reports
- Watershed Protection Act Variance and Applicability Decisions
- Construction General Permitting Inspection Details and Summary Reporting
- Bird Harassment Program
- Ranger Quarterly CMR Violations.

4.16.4 Data Management

It is imperative to provide staff access to authoritative data for use in their daily mapping and analysis, ensuring that any decisions derived from geospatial data are made with confidence. There have been subtle shifts over the years in how DWSP accessed geospatial data; since the COVID-19 pandemic began, however, there has been a fundamental shift in the ways staff search for and access data. Prior to the pandemic, data resided in several on-premises servers, however DWSP switched to cloud data storage in the ArcGIS Online (AGOL) platform in mid-2021; this change to cloud data storage provides easy access to data from anywhere, whether working in the office, remotely, or in the field. ArcGIS Pro enables staff to:

It is imperative to provide staff access to authoritative data for use in their daily mapping and analysis, ensuring that any decisions derived from geospatial data are made with confidence.

- Easily integrate with AGOL, which includes authoritative data from multiple sources, including DWSP, EEA and MassGIS.
- Leverage data collected in the field.
- Use locally stored data.

The GIS program is committed to ensuring continued access to a robust data catalog that enables staff to complete GIS tasks as required by their programs. Targeted training and an easy-to-use Data Inventory allow for quickly locating the data required to complete projects. In addition, governance standards of the online environment ensure that data is properly shared, documented and attributed by creators. The GIS program works continuously to ensure that data meets these standards.

4.16.5 Workflow Automation

Automation allows workflows to take advantage of some type of automatic action based on a “trigger.” A trigger could be a scheduled task on Windows, a Survey123 form submission, or a modification of an existing data record. DWSP is taking advantage of automation by integrating the many programs now using ArcGIS Online with Microsoft Power Automate. Examples of how this software is used include:

- Sending email notifications when a new request is submitted with the *Wachusett Region Work Order Request* form.
- Reminding Planning staff about upcoming decision deadlines for filings in the *Watershed Protection Act Database*.
- Automatically creating new folders in designated SharePoint locations for the *Environmental Quality Database.*
- Sending various notifications for *Quabbin Park Cemetery* internments.
- Updating the file status of *Environmental Quality Database* files when new entries are added to an Update Log.

Workflow automation also involves scheduled operations which can power real-time dashboards, process data for cleanup or update operations, backup content, or export data for use in other applications. This type of automation powers the Quabbin Reservoir Boat Launch Area Dashboard as well as perform automatic daily, weekly and monthly backups of DWSP's ArcGIS Online content for disaster recovery.

4.16.6 Public/Stakeholder Engagement

The GIS Program facilitates public engagement through traditional printed maps, interactive online mapping applications, and online applications such as StoryMaps or Dashboards. Over the past five years, several robust, user-friendly programs have been posted on the DCR website, including:

- Watershed Protection Act Viewer provides anyone the ability to view their property in relation to WsPA regulatory buffers.
- *DWSP Deer Hunter Field Map Viewer* and other hunting-specific applications allows hunters in the watershed system to access information at home and in the field. *This app is undergoing revisions; current version can be found on the Quabbin Hunt website.*
- Interactive Quabbin Reservoir Access Map is a response to increased visitation of the Quabbin watershed during the first year of COVID-19.
- DCR/DWSP Regional Gull Survey shares information with partners and stakeholders through a dashboard
- Quabbin Park Cemetery facilitates an online experience for searching and exploring the cemetery.
- Engaging, informative stories are told through The Watersheds, Quabbin Park Cemetery, and Preserving Massachusetts Forest Land Through the Forest Legacy Program StoryMaps.

4.16.7 Spatial Analysis

Spatial analysis is key to answering questions about location-oriented problems and to understanding data in the context of geography. The GIS program provides DWSP staff with expertise and assistance, as needed, in completing spatial analysis projects, including:

- Revise and expand the Land Acquisition Program's Land Acquisition Model.
- Conduct an analysis of impervious surface and paved area percentages by watershed subbasin.
- Model Lake Trout habitat suitability in the Wachusett Reservoir.
- Assist in siting the best location for a new section of rail trail.

GIS staff will continue to help colleagues answer location-based questions and identify new ways to utilize spatial analysis to examine complex topics.

4.16.8 Cartography

This traditional function of the GIS program remains an important part of the way in which DWSP communicates geographic information with staff, stakeholders, and the public. Although the necessity of printed maps has diminished with the onset and adoption of online mapping applications, the GIS Program is able to use improved desktop GIS technology to provide high-quality, printable maps.

4.16.9 Training and Education

DWSP has GIS users of all skill levels within operational sections, ranging from Natural Resources to Rangers, and Environmental Quality to Watershed Maintenance. Providing training and continuing education opportunities is key to ensuring that DWSP staff feel empowered to use the available GIS technology. Training varies from project or workflow-specific, to more advanced desktop GIS training, to encouraging staff to take free trainings or workshops available through Esri (the GIS software vendor used by the Commonwealth). Empowering staff to feel comfortable using GIS-powered tools ensures that adoption of new workflows and technology is embraced by all DWSP programs.

4.16.10 Five Year Objectives:

- Provide GIS support to staff, including training, data curation and management, licensing, project development and management, analyses, and cartography.
- Ensure GIS staff receive and pursue training to keep skills relevant.
- Continue to curate and manage data catalog for GIS users ensuring data is up-to-date and relevant.
- Maintain existing workflows and tools so staff can continue to conduct business as usual.
- Design new and update existing tools and applications to constantly take advantage of new technology offered in the ArcGIS Online platform.
- Provide staff with recommendations on how to best leverage new and emerging technologies to ensure that DWSP staff and programs remain current.
- Continue to collaborate with other EEA GIS Coordinators to ensure that EEA's investment in GIS is leveraged to the fullest extent possible, ensuring that all secretariat GIS programs benefit from continued future investment.

5 Implementation

5.1 Organization and Management

DCR's Division of Water Supply Protection, Office of Watershed Management (DWSP) implements the watershed management program developed and described in this report. The organizational structure of the Office of Watershed Management is shown in Table 5-1.

Table 5-1: DCR/DWSP Office of Watershed Management Organization

Section		
Division	**Wachusett/Sudbury**	**Quabbin/Ware**
Management: Division Director Budget Director Natural Resources Director	***Management:*** Regional Director Deputy Regional Director	***Management:*** Regional Director Deputy Regional Director
Budget and Administrative Support	Administrative and Technical Support	Administrative and Technical Support
Program Coordination and Technical Support – GIS	GIS	GIS
Natural Resources	Forestry	Forestry
Program Coordination and Technical Support – Environmental Planning	Environmental Planning	Environmental Planning
	Environmental Quality	Environmental Quality
	Civil Engineering	Civil Engineering
	Watershed Rangers	Watershed Rangers
	Interpretive Services	Interpretive Services
	Watershed Maintenance	Watershed Maintenance

DWSP has a complement of staff located across the watersheds and in the Boston headquarters of DCR that implement this plan and the annual Work Plans. This includes both full-time staff and seasonal staff. A review of full-time staff (FTE) was performed in 2018 to determine the staffing levels and positions needed to meet the responsibilities for watershed protection and land management. That exercise determined the optimum number of FTEs to be 150. That number was recently raised to 151 by the conversion of a year-round seasonal Ranger position into a full-time staff position. DWSP management will continue to review and refine the staffing needs and will work to make certain positions are filled as they become vacant. Staffing details are available in each annual Work Plan.

5.2 MWRA Memorandum of Understanding and the Water Supply Protection Trust

A Memorandum of Understanding (MOU) was signed in 2004 between the DCR and the MWRA that coordinates the implementation of the respective agencies responsibilities in regard to the "protection, construction, operation, maintenance and improvement of water supply resources, facilities, and infrastructure within the [Metropolitan Boston

water supply] watershed and waterworks system." Section 7.0 of this MOU details the development of an annual Work Plan for the Office of Watershed Management.

The legislature further enhanced the ability of the Office of Watershed Management to maintain the drinking water supply by establishing a Water Supply Protection Trust, created by Chapter 149 of the Acts of 2004, §27, and written into the general laws at MGL c. 10, §75. The Trust provides a more efficient mechanism for MWRA's funding of the Office of Watershed Management. The Trust has also allowed the Office of Watershed Management to manage its budget more efficiently.

The Water Supply Protection Trust has a five-person board of trustees responsible for approving the Office of Watershed Management's annual Work Plan and budget each spring for the following fiscal year beginning in July. The members of the board of trustees are:

1. The Secretary of the Executive Office of Energy and Environmental Affairs
2. The Executive Director of the MWRA
3. A representative jointly selected by the North Worcester County Quabbin Anglers Association, Inc. and the Quabbin Fishermen's Association, Inc.
4. A representative from the Swift River Valley Historical Society
5. The Chairman of the MWRA Advisory Board.

The Water Supply Protection Trust works diligently to ensure that the Office of Watershed Management has sufficient funding to staff and implement the *Watershed Protection Plan Update FY24-FY28*.

5.3 Work Plan and Annual Budget

DWSP prepares an annual Work Plan that meets all of the requirements set forth by the MOU and achieves the watershed protection goals and objectives developed in this report. The annual Work Plans include a detailed description of tasks for the two operational sections – Quabbin/Ware and Wachusett/Sudbury. The Work Plan's tasks are developed and organized by the programs described in this report.

DWSP prepares an annual Work Plan that ...achieves the watershed protection goals and objectives developed in this report. The Work Plan's tasks are developed and organized by the programs described in this report.

The Quabbin/Ware and the Wachusett/Sudbury Five Year Program Objectives are presented, respectively, in Table 5-2 and Table 5-3. These tables will be the basis for developing annual Work Plans for Fiscal Years 2024 through 2028. Annual Work Plans and the associated budget process ensure that DWSP achieves the five-year objectives and overall system-wide goals of the watershed protection program. All objectives unless noted otherwise are ongoing throughout this five-year period.
Progress reports are submitted to MWRA to keep the agency informed on DWSP's progress towards achieving annual goals set out in the budget. Implementation also

requires ongoing evaluation of the effectiveness of the programs and modification to adapt to changing conditions or concerns.

The creation of the Water Supply Protection Trust and the reporting parameters established by the MOU has created an efficient and transparent mechanism for MWRA's funding of DWSP activities. The funding of major capital expenditures, Payments in Lieu of Taxes, and land acquisition are also the responsibility of MWRA.

5.3.1 Quabbin/Ware Operational Section Five Year Implementation Plan

Table 5-2: Quabbin/Ware Operational Section Five Year Implementation Table

Key to Abbreviations

Quabbin/Ware Staff: A=Administration; CE=Civil Engineers; EP=Environmental Planning; EQ=Environmental Quality; F=Forestry; GIS=Geographic Information Services; IS=Interpretive Services; RD=Regional Director, Assistant Regional Director; WM=Watershed Maintenance; WR=Watershed Rangers

Division Staff: AF=Administration and Finance; D=Division Director; GIS =Geographic Information Services; NR= Natural Resources; P=Planning

Number	Objective	Lead	Additional Staff
	A. Land Acquisition *Goal: Purchase critical lands by fee and Watershed Preservation Restriction (WPR) using money allocated for land acquisition in MWRA's capital budget as well as other funding sources and gifts.*		
1.	Continue to evaluate and set land acquisition priorities, update priority parcels layer, and reach out to landowners about important parcels in the watersheds.	NR	GIS
2.	Lead the Division of Water Supply Protection in the fee acquisition or protection of water resources via Watershed Preservation Restriction (WPR) on important tracts of land based upon their hydrological, ecological and ability to support climate resiliency within the Wachusett Reservoir watershed.	NR	GIS, P, A, AF
3.	Continue to develop and expand the Land Acquisition Model in order to incorporate advancements in GIS data, limit environmental stressors, and implement system-wide climate resiliency strategies.	NR	D, RD, EQ, F, GIS, P
4.	Collaborate with Land Trusts and other land protection groups to acquire lands through gifts and other means.	NR	
5.	Implement the Payments in Lieu of Taxes program.	P	AF
	B. Watershed Preservation Restriction Monitoring *Goal: Maintain control of watershed lands through stewardship of Watershed Preservation Restrictions.*		
1.	Complete baseline documentation reports prior to WPR acquisition.	NR	GIS
2.	Monitor each WPR every two years; monitor high-priority ones annually.	NR	EQ, EP, F
3.	Maintain good working relationships with landowners and resolve WPR violations.	NR	EP, F, EQ, P
4.	Maintain records and distribute information as necessary. Enhance field inspections by integrating use of ArcGIS online.	NR	GIS
5.	Collaborate with other divisions of DCR, EOEEA, and other statewide conservation programs.	NR	

Number	Objective	Lead	Additional Staff
.	**C. Land Management** *Goal: Maintain a vigorously growing, multi-aged, multi-species forest using forest management programs developed by DWSP staff. Manage all lands to minimize potential water quality impacts*		
1.	Continue to implement the 2017 Land Management Plan.	RD	F, NR, EQ
2.	Continue long-term monitoring (water yield and quality) to research and verify the effectiveness of existing statewide and DWSP-specific forestry Best Management Practices (BMPs) and DWSP harvest regulation strategies in protecting the surface water supply.	EQ	F, NR
3.	Continue forestry operations and follow all documented management techniques including oversight and water quality monitoring of active timber harvesting. Implement water quality monitoring according to the most current EQ protocols.	F	EQ
4.	Develop a Terrestrial Invasive Plant Management Plan and implement invasive plant control activities identified in the plan.	F	NR
5.	Assess forest health in Quabbin Reservoir and Ware River watersheds by monitoring regeneration and other indicators of forest health, especially in areas of timber harvesting operations.	F	NR
6.	Assess and monitor status of encroachments onto DWSP property in Quabbin and Ware River watersheds, and take follow-up actions to resolve encroachments.	F	CE, WR
7.	Coordinate monitoring and analysis efforts with National Ecological Observatory Network (NEON) regarding climate change.	RD	F
8.	Implement strategies from the planned DWSP system-wide Climate Vulnerability Assessment to identify and mitigate potential impacts of climate change on land management throughout the water supply system.	NR	F, EQ
	D. Wildlife Management *Goal: Protect the water supply and infrastructure from adverse impacts caused directly or indirectly by wildlife. Protect common, rare, and significant wildlife species and their habitats.*		
1.	Continue year-round bird observations and harassment efforts on the reservoir.	EQ	NR, CE, RD, WM
2.	Control the resident Canada goose population on the Quabbin Reservoir.	NR	EQ, WM, RD, CE
3.	Continue to monitor gull populations within the watershed and take steps to reduce the attractiveness of human derived food sources.	NR	
4.	Monitor, assess, and control aquatic and burrowing mammals that threaten water quality or infrastructure.	NR	WM, WR, EQ, F
5.	Monitor moose populations and their impact on forest dynamics through browsing surveys, annual moose sign surveys, and exclosure studies.	NR	F
6.	Administer the White-tailed Deer Management Program in the watershed system, including applications, permits, biological data collection, and other components of the program. Adapt and adjust management methods as appropriate in collaboration with MassWildlife.	NR	RD, IS, WM, P, WR

Number	Objective	Lead	Additional Staff
7.	Develop a deer management program for Quabbin Park.	RD	NR
8.	Test fecal samples for the presence of *Giardia* and *Cryptosporidium*.	NR	
9.	Manage habitat for rare species; monitor populations of select species.	NR	F, WM
10.	Monitor and assess impact of newly created young forest and barrens habitat on rare and declining species populations.	NR	
	E. Public Access Management *Goal: Manage public access to DWSP lands and waters to protect water quality in compliance with Watershed Protection regulations (313 CMR 11.00) and all other applicable laws (including 310 CMR 22.00) through policies established in Public Access Management Plans.*		
1.	Implement Quabbin Public Access Management Plan.	RD	EQ, WR, IS
2.	Evaluate, update, and implement Ware Public Access Management Plan.	RD	IS, WR, EQ, F, P
3.	Develop improved, uniform signage and maps; improve online mapping of recreational opportunities.	RD	IS, WR
4.	Maintain working relationships with State, Environmental, and local police.	RD	WR
5.	Monitor DWSP lands and water to ensure compliance with rules and regulations designed to protect the water supply and protect the public.	RD	WR, F, EQ
6.	Implement existing protocol for maintaining gates and other structural controls.	WR	WM
7.	Expand use of electronic media to disseminate information.	IS	WR
8.	Prepare and implement Quabbin Park Operations and Maintenance Plan.	RD	WR, WM, NR
9.	Operate the shoreline and boat fishing program in designated portions of Quabbin Reservoir in a manner that minimizes threats to water quality and accommodates visitors with accessibility needs. Implement the Quabbin Boat Seal program.	RD	WM, IS, EQ
	F. Watershed Security *Goal: Maintain and improve watershed security programs and provide surveillance of critical watershed facilities to protect the watershed system from potential threats .*		
1.	Coordinate with MWRA in order to maintain comprehensive system-wide approach on all security issues.	D	RD, WR
2.	Continue Watershed Ranger patrols on all DWSP properties, with particular focus on highly vulnerability sites.	WR	
3.	Work with local, state and federal responders and ensure they receive current agency emergency contact information on a regular basis.	WR	
4.	Remain up to date with any guidance materials available from EPA, American Water Works Association, and Department of Homeland Security.	CE	EQ
5.	Improve physical access control structures, as necessary, and implement a maintenance program.	WM	

Number	Objective	Lead	Additional Staff
G. Infrastructure Management *Goal: Maintain the integrity of all high hazard dams under DWSP control, maintain and improve DWSP facilities and equipment, and maintain internal roadways to allow them to sufficiently support their use for the water supply protection program.*			
1.	Monitor and maintain large dams, reservoir elevation, spillways, and dikes. Periodically update Emergency Action Plans utilizing current and projected climate data.	CE	
2.	Maintain and rehabilitate DWSP facilities and roads. Investigate road alignment and stream crossing improvements when possible for purposes of emergency response and land management needs.	CE	WM, EQ
3.	Redevelop and improve the condition of roads and stream crossings to allow for greater access to the New Boston Road corridor in the Quabbin Reservoir Northwest Region, including the installation or repair of three new bridges.	CE	WM, EQ
4.	Evaluate need for reservoir maintenance in vicinity of hangar ramp and Winsor intake.	RD	CE, EQ
5.	Work with MWRA on renovation of Quabbin Administration Building, including drinking water system.	RD	CE
6.	Complete construction of maintenance building on Blue Meadow Road.	RD	CE, WM
7.	Assess infrastructure needs and explore alternative mechanisms for funding to make needed repairs to small dams and bridges.	CE	
8.	Evaluate the feasibility of removing or repairing unsafe small dams.	CE	RD, NR, EQ
9.	Maintain DWSP fuel storage facilities in proper working order and in compliance with all applicable codes and regulations. Investigate feasibility of upgrading or converting underground storage tanks to above ground structures.	CE	
10.	Upgrade photovoltaic facilities at BLA 2 and 3. Upgrade BLA 3 road access.	CE	
11.	Finalize structural study of Quabbin Tower and use that information to improve masonry conditions to eliminate water infiltration.	CE	
12.	Reduce energy use through energy efficiency practices.	RD	CE
13.	Evaluate gravel resources in Quabbin and Ware watersheds. Follow gravel management procedures as outlined in the Land Management Plan and develop a plan for future DWSP gravel needs.	EQ	CE, WM
14.	Develop Ware River Watershed Road Plan.	RD	CE, EQ, WM
15.	Rehabilitate Long Pond parking lot to reduce size of impervious area.	CE	RD
16.	Finalize MOU with Wachusett Greenways regarding management of Mass Central Rail Trail.	RD	

Number	Objective	Lead	Additional Staff
	H. Watershed Protection Act *Goal: Enhance protection of the water supply through implementation of the Watershed Protection Act, which regulates land use in critical areas of the watersheds.*		
1.	Implement the Watershed Protection Act and regulations.	EP	RD, P
2.	Maintain good relations with building inspectors and other town permitting staff and boards to enhance the notification of potentially affected parties of WsPA requirements.	EP	EQ
3.	Provide professional support on land use planning or other associated topics related to DWSP mission to watershed communities.	EP	
4.	Review WsPA applications for stormwater applicability, including NPDES construction general permit, MA Stormwater Performance Standards, and/or town stormwater bylaws. Coordinate with other DWSP staff to ensure that WsPA projects comply with other environmental regulations.	EP	EQ
	I. Education and Outreach *Goal: Provide educational opportunities and materials to inform the public about watershed protection and drinking water issues.*		
1.	Implement and amend, as needed, the Quabbin Interpretive Services Plan.	IS	WR
2.	Maintain and/or initiate information sites, such as kiosks, and programs in watersheds. Expand interpretive signage opportunities to enhance public understanding of the water supply system.	IS	EQ, ATS, WR
3.	Operate Quabbin Visitor Center.	IS	
4.	Conduct and monitor established program of public education. Expand educational outreach efforts on aquatic invasive species and climate change.	IS	EQ
5.	Participate in environmental programs with other environmental groups, including environmental education teacher training and Mass Envirothon.	IS	
6.	Research and implement electronic media to enhance interpretation programs for visitors and communicate with watershed residents.	IS	NR, P
7.	Complete the Interpretive Services Plan for the Ware River watershed.	IS	
8.	Promote outreach to user groups in the Ware River watershed.	RD	IS, WR
9.	Utilize the DWSP website to provide information and resources for the public.	P	IS, EQ, WR, F, NR, RD
	J. Water Quality and Hydrologic Monitoring *Goal: Conduct tributary and reservoir sampling. Identify short-term water quality problems and maintain the historical record for long-term trend analyses. Use data analyses and assessments in management decisions.*		
1.	Conduct routine tributary and reservoir sampling program to identify potential water quality problems and maintain the historical record for long-term trend analysis, with annual adjustments to the sampling plan to adapt to changing conditions.	EQ	

Number	Objective	Lead	Additional Staff
2.	Improve water quality data management using program to compile data from water quality sampling, weather, reservoir, and stream flow monitoring, plankton, etc. Meet periodically with Wachusett staff on app use and improvement.	EQ	CE, F, NR
3.	Assure that water entering the Winsor Intake meets MassDEP standards for microbial and physicochemical parameters.	EQ	
4.	Conduct short- and long-term water quality monitoring program of timber harvest sites to assess for potential impacts to water quality.	EQ	NR
5.	Develop and implement streamflow monitoring at selected watershed sites. Evaluate permitting requirements, equipment needs, and staff hours for implementation and maintenance. Coordinate implementation with sampling plans and new database.	EQ	
6.	Engage researchers to investigate climate change questions related to algae blooms and invasive species in the Quabbin Reservoir.	RD	
7.	Conduct targeted sampling at sites with potential for water quality impacts in the Ware River watershed.	EQ	
8.	Collect, interpret, and manage meteorological and reservoir data. Coordinate data sharing. Investigate and implement wind monitoring to help determine wind impacts to changes in water quality parameters, such as turbidity and fecal coliform levels.	CE	EQ
9.	Utilize long-term water quality data to investigate increases in turbidity at Winsor Intake.	EQ	
10.	Finalize and implement a *Cryptosporidium* and *Giardia* Action Plan with MWRA to establish guidelines for inter-agency notifications and coordination.	EQ	
11.	Work with MWRA to install continuous water quality monitoring buoy at Quabbin Reservoir.	EQ	RD
12.	Use water quality and hydrologic data to assess potential impacts of climate change on the water supply as part of a watershed-wide vulnerability assessment.	D	All
	K. Watershed Monitoring and Assessment *Goal: Use Environmental Quality Assessments, site inspections, local board meetings, and information from Watershed Rangers and other DWSP staff to identify and address potential water quality threats and possible violations of state or federal regulations.*		
1.	Conduct Environmental Quality Assessments (EQAs) as scheduled. Incorporate recommendations from EQAs into annual Work Plans. Present findings and proposed mitigation measures annually to DWSP staff.	EQ	CE
2.	Use fieldwork, local contacts, and EQAs to find violations of environmental regulations.	EQ	WR
3.	Coordinate with other agencies, such as MassDEP and Attorney General, to enforce all environmental regulations.	EQ	EP, P
4.	Monitor status of agricultural operations, above ground storage tanks, hazardous waste generators, spills, and hazardous materials use through field inspections and records reviews.	EQ	

Number	Objective	Lead	Additional Staff
5.	Monitor activities in utility Rights-of-Way (e.g., powerlines, highways).	EQ	P
6.	Establish a Division-wide PFAS working group	EQ	RD, D
7.	Monitor climate change research, data, and recommendations.	EQ	
8.	Use watershed monitoring information to help assess potential impacts of climate change on the water supply as part of a watershed-wide vulnerability assessment.	D	All
	L. Aquatic Invasive Species Management *Goal: Prevent introduction and spread of Aquatic Invasive Species through monitoring, public education, exclusion, and decontamination measures at potential entry points. Implement active management when appropriate.*		
1.	Implement and update, as needed, the 2010 Aquatic Invasive Species Management Plan.	EQ	
2.	Operate the Quabbin Boat Seal Program, and evaluate ways to streamline program.	EQ	WM, WR, IS
3.	Survey, monitor, and prevent the spread of aquatic invasive macrophytes in the Quabbin Reservoir and throughout water bodies in the Quabbin and Ware River watersheds.	EQ	
4.	Monitor condition of fragment barriers at the Quabbin Reservoir regulating ponds and Shaft 8, replacing or adjusting as needed.	EQ	
5.	Conduct pre-diversion surveys of AIS at Shaft 8 to help prevent spread of AIS. Monitor condition of fragment barriers, replacing or adjusting as needed.	EQ	RD, CE
6.	Inspect equipment and gear to be used in or on Quabbin Reservoir. Notify other agencies and/or consultants of decontamination requirements.	EQ	RD, CE
7.	Control populations of AIS, when possible and necessary, in Quabbin Reservoir and surrounding water bodies.	EQ	RD, CE
	M. Wastewater Management *Goal: Monitor on-site wastewater disposal systems and operation of Rutland-Holden sewer to ensure proper treatment of waste.*		
1.	Review water quality data and other pertinent information to identify potential problem sites.	EQ	
2.	Monitor and enforce the provisions of Title 5, working with local Boards of Health and MassDEP.	EP	
3.	Provide technical assistance, upon request, to towns regarding onsite wastewater management issues.	EQ	CE
4.	Identify larger on-site systems with inspection requirements under MassDEP regulations in the Ware River watershed.	EQ	

Number	Objective	Lead	Additional Staff
	N. Stormwater Management *Goal: Reduce water quality problems caused by uncontrolled stormwater.*		
1.	Provide input into state and local road reconstruction projects to influence storm water management design aspects of projects.	EQ	
2.	Integrate, maintain, and monitor structural storm water Best Management Practices (BMPs) needed and/or constructed on DWSP property.	CE	EQ
3.	Inspect all construction sites greater than one acre to ensure compliance with Stormwater Pollution Prevention Plans (SWPPPs).	EQ	
4.	Examine DWSP stormwater management as part of Ware River Watershed Road Plan.	CE	EQ
5.	Initiate plan to inventory, monitor, and assess performance of stormwater BMPs on privately-owned property.	EQ	CE
	O. Emergency Spill Response *Goal: Maintain and improve short- and long-term emergency response capabilities to protect the water supply.*		
1.	Provide emergency response support services; maintain response supplies and up-to-date contact lists.	RD	WR, WM, EQ
2.	Provide Incident Command System (ICS) training to appropriate staff.	CE	
3.	Coordinate with MWRA and local emergency officials to provide ICS, emergency response training, and annual tabletop or field exercises.	RD	WR, EQ
4.	Construct additional structural controls to reduce likelihood of spills reaching the Quabbin Reservoir.	CE	
5.	Repair and/or upgrade the boom deployment shed inside Gate 16.	CE	
6.	Explore the possibility of establishing an additional shed on Prescott peninsula.	CE	
7.	Evaluate, monitor, and oversee spills that threaten water quality or DWSP property and work with appropriate federal, state, and local agencies to contain and remediate.	EQ	
8.	Review, finalize, and implement the Emergency Response Manual for the Quabbin and Ware River watersheds.	RD	EQ, WR, WM, CE
9.	Produce spill response plans and spill notification cards for timber harvesting operations, and continue to offer spill response training for timber harvesters working on the Quabbin and Ware River watersheds.	F	EQ
	P. Geographic Information Systems *Goal: Utilize Geographic Information System technologies to enhance and support all watershed management activities.*		
1.	Provide GIS support to staff in the following areas: training and technical support, data curation and management, project development and management, analyses, cartography and licensing. GIS	GIS	

Number	Objective	Lead	Additional Staff
2.	Coordinate with Management, Watershed Rangers and Division Director in development of a DWSP-wide public access map which distills current public access regulations via an interactive web mapping application.	GIS	D, RD, IS, P, WR
3.	Coordinate with Natural Resources, Rangers, Aquatic Biology and Management on the development of a DWSP-wide 'Sportsman Map' that brings together current information on areas open to hunting and fishing into a user-friendly web and mobile experience.	GIS	NR, EQ, WR, D, RD
4.	Coordinate with Planning staff and Management on development of methodology for accepting public submissions for Watershed Protection Act filings. Leverage out-of-the-box tools and integrate with the new cloud-based WsPA database.	GIS	EP, P, RD, D
5.	Coordinate with Environmental Quality staff on the development of a new, cloud-based EQ database. Provide a series of data management tools, dashboards, and reporting methods to meet staff needs.	GIS	EQ
6.	Collaborate with other EEA GIS Coordinators to ensure the Division continues to benefit from EEA investment in GIS technology.	GIS	

5.3.2 Wachusett/Sudbury Operational Section Five Year Implementation Plan

Table 5-3: Wachusett/Sudbury Operational Section Five Year Implementation Table

Key to Abbreviations

Wachusett/Sudbury Staff: A=Administration; CE=Civil Engineers; EP=Environmental Planning; EQ=Environmental Quality; F=Forestry; GIS=Geographic Information Services; IS=Interpretive Services; RD=Regional Director, Assistant Regional Director; WM=Watershed Maintenance; WR=Watershed Rangers

Division Staff: AF=Administration and Finance; D=Division Director; GIS =Geographic Information Services; NR= Natural Resources; P=Planning

Number	Objective	Lead	Additional Staff
	A. Land Acquisition *Goal: Purchase critical lands by fee and Watershed Preservation Restriction (WPR) using money allocated for land acquisition in MWRA's capital budget as well as other funding sources and gifts.*		
1.	Continue to evaluate and set land acquisition priorities, update priority parcels layer, and reach out to landowners about important parcels in the watersheds.	NR	GIS
2.	Lead the Division of Water Supply Protection in the fee acquisition or protection of water resources via Watershed Preservation Restriction (WPR) on important tracts of land based upon their hydrological, ecological and ability to support climate resiliency within the Wachusett Reservoir watershed.	NR	GIS, P, A, AF
3.	Continue to develop and expand the Land Acquisition Model in order to incorporate advancements in GIS data, limit environmental stressors, and implement system-wide climate resiliency strategies.	NR	D, RD, EQ, F, GIS, P
4.	Collaborate with Land Trusts and other land protection groups to acquire lands through gifts and other means.	NR	
5.	Implement the Payments in Lieu of Taxes program.	P	AF
	B. Watershed Preservation Restriction Monitoring *Goal: Maintain control of watershed lands through stewardship of Watershed Preservation Restrictions.*		
1.	Complete baseline documentation reports prior to WPR acquisition.	NR	GIS
2.	Monitor each WPR every two years; monitor high-priority ones annually.	NR	EQ, EP, F
3.	Maintain good working relationships with landowners and resolve WPR violations.	NR	EP, F, EQ
4.	Maintain records and distribute information as necessary. Enhance field inspections by integrating use of ArcGIS online.	NR	GIS

5.	Collaborate with other divisions of DCR, EOEEA, and other statewide conservation programs.	NR	
	C. Land Management *Goal: Maintain a vigorously growing, multi-aged, multi-species forest using forest management programs developed by DWSP staff. Manage all lands to minimize potential water quality impacts.*		
1.	Continue to implement the 2017 Land Management Plan.	RD	F, NR, EQ
2.	Continue long-term monitoring (water yield and quality) to research and verify the effectiveness of existing statewide and DWSP-specific forestry Best Management Practices (BMPs) and DWSP harvest regulation strategies in protecting the surface water supply.	EQ	F, NR
3.	Continue forestry operations and follow all documented management techniques, including operational oversight of active timber harvesting. Implement water quality monitoring according to the most current EQ protocols	F	EQ
4.	Develop a Terrestrial Invasive Plant Management Plan and implement invasive plant control activities identified in the plan.	F	NR
5.	Assess forest health in Wachusett Reservoir and Sudbury Reservoir watersheds by monitoring regeneration and other indicators of forest health, especially in areas of timber harvesting operations.	F	NR
6.	Support cooperative efforts to monitor and control Asian Longhorned Beetle.	F	
7.	Continue regular periodic boundary line maintenance and posting. Assess and monitor all encroachment activities and work with Watershed Rangers to resolve all conflicts in Wachusett and Sudbury watersheds.	F	WR
8.	Manage hayfields and other open areas.	F	EQ
9.	Use ongoing CFI analysis to inform land management decision making and policies.	F	NR
10.	Continue forestry operations that are feasible in the presence of a high deer population and follow all documented management techniques including oversight of active timber harvesting in Sudbury Watershed.	F	
11.	Monitor for beech leaf disease and tree conditions.	F	
12.	Transfer DWSP lands at Reservoir No. 1 and 2 to State Parks or other interested entities.	D	RD, P, CE
13.	Implement strategies from the planned DWSP system-wide Climate Vulnerability Assessment to identify and mitigate potential impacts of climate change on land management throughout the water supply system.	NR	F, EQ

	D. Wildlife Management *Goal: Protect the water supply and infrastructure from adverse impacts caused directly or indirectly by wildlife. Protect common, rare, and significant wildlife species and their habitats.*		
1.	Continue year-round bird observations and harassment efforts on the reservoir.	EQ	NR, CE, RD, WM
2.	Control the resident Canada goose population on the Wachusett and Sudbury Reservoirs.	NR	CE, RD, WM
3.	Continue to monitor gull populations within the watershed and take steps to reduce the attractiveness of human derived food sources.	NR	
4.	Monitor, assess, and control aquatic and burrowing mammals that threaten water quality or infrastructure.	NR	
5.	Monitor deer and moose populations and their impact on forest dynamics in the Wachusett and Sudbury Watersheds through pellet counts, browsing surveys, and/or exclosure studies.	NR	F
6.	Administer the White-tailed Deer Management Program in the watershed system, including applications, permits, biological data collection, and other components of the program. Adapt and adjust management methods as appropriate in collaboration with MassWildlife.	NR	RD
7.	Complete a watershed-wide vulnerability assessment to identify potential impacts of climate change on wildlife in the water supply.	NR	
8.	Test fecal samples for presence of *Giardia* and *Cryptosporidium*.	NR	
9.	Manage habitat for rare species; monitor populations of select species.	NR	F, WM
10.	Monitor and assess impact of newly created young forest and barrens habitat on rare and declining species populations.	NR	
	E. Public Access Management *Goal: Manage public access to DWSP lands and waters to protect water quality in compliance with Watershed Protection regulations (313 CMR 11.00) and all other applicable laws (including 310 CMR 22.00) through policies established in Public Access Management Plans.*		
1.	Implement Watershed Public Access Management Plans for Wachusett Reservoir and Sudbury Reservoir watersheds.	RD	WR, EQ
2.	Provide periodic review of public access policies with updates, as needed.	RD	WR, EQ
3.	Reconstruct and improve, where appropriate, universal access sites.	RD	CE, EQ, WR
4.	Maintain working relationships with State, Environmental, and local police.	WR	
5.	Monitor DWSP lands and water to ensure compliance with rules and regulations designed to protect the water supply and protect the public.	WR	

6.	Maintain gates and other structural controls using existing protocol.	WR	WM
7.	Continue to develop improved, uniform signage and maps.	RD	WR, WM
8.	Expand use of electronic media to disseminate information.	WR	
9.	Develop an online Interactive Wachusett Public Access application/map.	GIS	WR
10.	Replace existing signage with updated regulatory signage.	WR	
11.	Construct safety related items in Sudbury Watersheds, including parking areas and DWSP boat storage.	CE	RD, WR
	F. Watershed Security *Goal: Maintain and improve watershed security programs and provide surveillance of critical watershed facilities to protect the watershed system from potential threats .*		
1.	Coordinate with MWRA in order to maintain comprehensive system-wide approach on all security issues.	D	RD, WR
2.	Continue Watershed Ranger patrols on all DWSP properties, with particular focus on highly vulnerable sites.	WR	
3.	Assess options for securing access areas, including boat cove adjacent to Route 70.	WR	CE, RD
4.	Work with local, state and federal responders and ensure they receive current agency emergency contact information on a regular basis.	WR	
5.	Remain up to date with any guidance materials available from EPA, American Water Works Association, and Department of Homeland Security.	CE	EQ
6.	Improve physical access control structures, as necessary, and implement a maintenance program.	WM	
7.	Assess feasibility of upgrading existing camera systems.	RD	ARD,WR
7.	Update signage with proper MEMA dispatch emergency phone number.	WR	
	G. Infrastructure Management *Goal: Maintain the integrity of all high hazard dams under DWSP control, maintain and improve DWSP facilities and equipment, and maintain internal roadways to allow them to sufficiently support their use for the water supply protection program.*		
1.	Monitor and maintain large dams, reservoir elevation, spillways, and dikes. Periodically update Emergency Action Plans utilizing current and projected climate data.	CE	
2.	Conduct annual inspection of roads and develop annual plan for repairs of Wachusett internal roads. Investigate road alignment and stream crossing improvements, when possible, for purposes of emergency response and land management needs.	CE	

3.	Assess infrastructure and oversee repairs, maintenance, and renovation projects at DWSP facilities. Explore alternative mechanisms for funding to make needed repairs to small dams and bridges. Wachusett projects include: Assessment of Ranger Station and Stillwater Farm house; ADA-compliant walkway to Wachusett Dam promenade; explore upgrade to Clinton boat ramp to accomadate lower reservoir operating elevations. Sudbury projects include: boat ramps at East Main St., Acre Bridge Rd., Foss Reservoir; ensure secure access to Foss Reservoir gatehouse.	CE	
4.	Maintain existing BMPs to manage stormwater and assess need for additional control measures.	CE	EQ
5.	Reduce energy use through simple energy efficiency practices.	CE	All
6.	Maintain fire roads for water supply operations as necessary in Sudbury Watershed.	CE	WM
7.	Pursue funding for improvements to Stearns and Brackett Reservoirs, as identified in the Phase I & II Reports.	CE	
8.	Size replacement culverts and other infrastructure to address likely changes in flow due to ongoing climate change.	CE	EQ
9.	Demolish abandoned buildings and structures, restoring areas to natural state.	CE	EQ, WM
10.	Work with MWRA and DER in the removal of Quinapoxet Dam and Edwards Pond Dam.	CE	EQ
11.	Implement turf management plan on North and South Dikes.	CE	WM
	H. Watershed Protection Act *Goal: Enhance protection of the water supply through implementation of the Watershed Protection Act, which regulates land use in critical areas of the watersheds.*		
1.	Implement the Watershed Protection Act and regulations.	EP	RD, P
2.	Review building permits and sales and notify property owners of their need to file.	EP	
3.	Inspect previous filings for compliance with decisions and conditions.	EP	
4.	Provide professional support on land use planning or other associated topics related to DWSP mission to watershed communities.	EP	P
5.	Maintain good relations with building inspectors and other town permitting staff and boards to enhance the notification of potentially affected parties of WsPA requirements.	EP	EQ
6.	Review WsPA applications for stormwater applicability, including NPDES construction general permit, MA Stormwater Performance Standards, and/or town stormwater bylaws. Coordinate with other DWSP staff to ensure that WsPA projects comply with other environmental regulations.	EP	EQ

	I. Education and Outreach *Goal: Provide educational opportunities and materials to inform the public about watershed protection and drinking water issues.*		
1.	Review, implement, and amend as needed, the Wachusett Interpretive Services Plan.	IS	WR, EQ
2.	Conduct, record, and evaluate public education programs with a focus on water supply, water quality, Aquatic Invasive Species, and climate change.	IS	WR, EQ
3.	Conduct programs at Stillwater Farm interpretive site.	IS	WR
4.	Conduct environmental education teacher training and support Mass Envirothon.	IS	EQ
5.	Participate in environmental programs with other environmental groups.	IS	
6.	Research and implement electronic media to enhance interpretation programs and communicate with watershed residents.	IS	NR, P
7.	Develop a Wachusett Reservoir Watershed guide that includes maps, history, rules, and other pertinent information regarding water quality.	IS	
8.	Support stormwater education efforts in Wachusett Reservoir watershed towns that must meet federal Small Municipal Separate Storm Sewer Systems (MS4) requirements.	EQ	
9.	Provide programs that reduce threats from public access (e.g., Earth Day cleanups, fishing line collections, etc.)	WR	
10.	Educate the public of the importance of Sudbury and Foss Reservoirs as a reserve drinking water supply and natural resource through informal education as staff availability allows.	IS	EQ
11.	Maintain and/or initiate information sites, such as kiosks, and programs in watersheds. Expand interpretive signage opportunities to enhance public understanding of the water supply system.	IS	
12.	Utilize the DWSP website to provide information and resources for the public.	P	IS, EQ, WR, F, NR, RD
	J. Water Quality and Hydrologic Monitoring *Goal: Conduct tributary and reservoir sampling. Identify short-term water quality problems and maintain the historical record for long-term trend analyses. Use data analyses and assessments in management decisions.*		
1.	Conduct routine and non-routine reservoir, groundwater, and tributary sampling. Compile data and interpret in annual report. Make necessary monitoring changes to identify causal factors for significant trends.	EQ	
2.	Monitor hydrologic budget (groundwater, stream flow, precipitation data, snow pack) and continue to make necessary improvements. Maintain Joint-Funding Agreement with USGS to supplement in-house monitoring.	EQ	
3.	Expand stormwater sampling program to quantify stormwater loading.	EQ	

4.	Manage new contract with UMass and annually review project scope. Improve water quality models and develop new research topics.	EQ	
5.	Develop and maintain tools and applications to facilitate field data collection, data management, review and analysis, writing reports, and modeling efforts.	EQ	
6.	Publish a pair of thirty-year Water Quality Summary reports that include assessment of possible correlation of a range of factors with tributary and reservoir water quality. Include an assessment of possible impacts of climate change on water quality and hydrology.	EQ	
7.	Implement long-term paired subbasins assessment of the impacts of forestry on water quality and quantity in the Wachusett watershed.	EQ	
8.	Increase understanding of reservoir dynamics by collecting profiles in South Basin, Andrews Harbor, etc. in late summer or early fall when the interflow is well established. Investigate interaction between plankton and interflow water quality with Roger Williams University.	EQ	
9.	Investigate potential and actual water quality problems, including water sampling, in Sudbury watershed as needed and as staff time allows.	EQ	
10.	Continue monitoring of fish populations in the reservoir and watershed to expand knowledge of the reservoir food web and impacts on drinking water quality.	EQ	
11.	Finalize and implement a *Cryptosporidium* and *Giardia* Action Plan with MWRA to establish guidelines for inter-agency notifications and coordination.	EQ	
12.	Use water quality and hydrologic data to assess potential impacts of climate change on the water supply as part of a watershed-wide vulnerability assessment.	D	All
	K. Watershed Monitoring and Assessment *Goal: Use Environmental Quality Assessments, site inspections, local board meetings, and information from Watershed Rangers and other DWSP staff to identify and address potential water quality threats and possible violations of state or federal regulations.*		
1.	Use field inspections and review of state and federal databases to identify sources of pollution and develop mitigation measures for one Environmental Quality Assessment (EQA) per year. Develop and implement EQA recommendations and include recommendations as specific tasks in annual workplans. Present findings and proposed mitigation measures annually to DWSP staff..	EQ	
2.	Use fieldwork, local contacts, and EQAs to find violations of environmental regulations.	EQ	
3.	Coordinate with other agencies, such as MassDEP and Attorney General, to enforce all environmental regulations.	EQ	
4.	Improve tracking of local road projects and local updates to stormwater infrastructure. Add new information to appropriate GIS datalayer.	EQ	
5.	Update information on agricultural operations, hazardous waste generators, spills, USTs, and hazardous materials use through field inspections and record review	EQ	

6.	Assess status of municipal facilities and practices, including DPW yards, closed landfills and road maintenance practices. Work with towns and MassDEP to resolve any water quality issues.	EQ	
7.	Continue efforts to complete the Wachusett Watershed Hydrology Mapping Project for all five sub-watersheds.	EQ	GIS
8.	Establish a Division-wide PFAS working group	EQ	RD, D
9.	Monitor climate change research, data, and recommendations.	EQ	
10.	Use watershed monitoring information to help assess potential impacts of climate change on the water supply as part of a watershed-wide vulnerability assessment.	D	All
	L. Aquatic Invasive Species *Goal: Prevent introduction and spread of Aquatic Invasive Species through monitoring, public education, exclusion, and decontamination measures at potential entry points. Implement active management when appropriate.*		
1.	Inspect reservoirs, lakes, ponds and tributaries for presence of AIS. Make recommendations for management actions if/when new infestations are found. Monitor, when possible, privately owned water bodies in the watershed system.	EQ	
2.	Perform aquatic vegetation survey work prior to Thomas, Oakdale, and cove vegetation management. Provide report to MWRA and contractors to guide plant removal efforts. Monitor, advise, and assist contractors with any necessary removal operations.	EQ	
3.	Conduct aquatic vegetation surveys prior to and after aquatic treatments planned for the Lily Ponds and South Meadow Pond complex and Clamshell Pond.	EQ	
4.	Use appropriate methods to prevent the spread of pioneering stands of *Phragmites* along the Wachusett Reservoir shoreline.	EQ	
5.	Enforce the decontamination procedures for all watercraft entering the reservoirs by inspecting each vessel and collecting completed decontamination certification forms. Notify other agencies and/or consultants of decontamination requirements.	EQ	
6.	Protect infrastructure from harmful effects of *Water Chestnut* and other invasive species in the Sudbury watershed.	EQ	
7.	Continue established program of public education on AIS. Educate fishermen on the harmful effects of AIS and encourage proper fishing equipment cleaning. Assess feasibility of adding educational signage at popular fishing areas and town owned fields adjacent to the reservoir.	IS	WR, EQ
8.	Develop and implement study to determine if water quality is the primary vector for AIS distribution in the reservoir coves and basins	EQ	
9.	Assess the feasibility of continued fanwort removal in the Sudbury Reservoir.	EQ	

10.	Communicate with SuAsCo Cooperative Invasive Species Management Area and keep informed of their activities and outreach.	EQ	
	M. Wastewater Management *Goal: Monitor on-site wastewater disposal systems and operation of Rutland-Holden sewer to ensure proper treatment of waste.*		
1.	Monitor and enforce provisions of Title 5, using water quality data and working with Boards of Health and MassDEP. Provide technical assistance, upon request.	EQ	
2.	Track new connections to sewer lines and maintain database and GIS data layer.	EQ	GIS
3.	Compile data on all onsite septic systems and enter into database.	EQ	
4.	Manage with MWRA, the Rutland-Holden trunk sewer and Rutland-Holden Relief trunk sewer.	CE	
5.	Pursue long-term alternatives for DCR sewer management with Worcester and DCR sewer communities	RD	
	N. Stormwater Management *Goal: Reduce water quality problems caused by uncontrolled stormwater.*		
1.	Locate, assess, and require maintenance of public and private stormwater BMPs and BMPs on DWSP property.	EQ	
2.	Work with MassDOT and local DPWs to improve infrastructure to control stormwater and with conservations commissions, MassDEP, and EPA for compliance with state and federal stormwater requirements.	EQ	
3.	Assume responsibility from MassDOT for maintenance of 17 stormwater basins and nine stormwater treatment units (SWTUs) established by drainage improvements around Wachusett Reservoir. Train DWSP staff to maintain the basins; determine frequency of maintenance; contract services for a vacuum truck; assess maintenance needs for lined forebays that provide storage for spills; modify specific forebays to allow periodic draining that can prevent algae and nuisance wildlife.	CE	WM, EQ
4.	Support cooperative efforts with federal, state, and local authorities to implement the six minimum control measures that operators of regulated small MS4s must incorporate into stormwater management programs.	EQ	
5.	Assess the feasibility of removing pavement at the off-line Worcester Pump Station site and/or regrade the area so runoff does not directly enter the reservoir.	EQ	
6.	Work with town officials to implement program of public education and outreach related to stormwater and the MS4 permit where applicable.	EQ	
7.	Update map of stormwater conveyance structures and define stormwater subbasins.	EQ	
8.	Inspect all construction sites greater than one acre to ensure compliance with Stormwater Pollution Prevention Plans (SWPPPs).	EQ	

9.	Review, summarize, and assist in the development of bylaws to manage construction site runoff and post- construction runoff if requested, and assist communities with mapping and impervious surfaces analysis	EQ	
10.	Provide regional training on stormwater issues for town employees, DWSP staff, and others.	EQ	
11.	Design and conduct water quality monitoring studies to evaluate effectiveness of and optimize performance of direct discharge project structural BMPs.	EQ	
12.	Design a prioritization model using stormwater network and storm sewer delineations that considers land cover, proximity to tributaries, and other criteria to categorize watershed areas for relative stormwater treatment needs.	EQ	GIS
13.	Coordinate with Planning Boards to ensure that all construction projects that have a stormwater management component are reviewed and that any new or changed stormwater infrastructure is added to DWSP GIS data layers.	EQ	EP
14.	Raise awareness of stormwater as a pollutant in the Sudbury watershed, including techniques for reducing runoff and improving the quality of stormwater runoff, as an effort to create a behavior change among watershed residents that will protect natural resources. Provide stormwater programs, resources and/or support as resources allow to town departments, boards and commissions in the Sudbury watershed.	EQ	WR, IS
	O. Emergency Spill Response *Goal: Maintain and improve short- and long-term emergency response capabilities to protect the water supply.*		
1.	Provide emergency response support services; maintain response supplies and up-to-date contact lists.	CE	
2.	Provide Incident Command System training to appropriate staff.	CE	
3.	Coordinate with MWRA and local officials to provide emergency response training and annual tabletop or field exercises.	CE	RD
4.	Construct additional structural controls to reduce likelihood of spills reaching the reservoir.	CE	EQ
5.	Monitor sites of releases or spills that occur near a resource area and follow submitted reports until remediation efforts have been completed under Mass Contingency Plan.	EQ	
6.	Implement Multi-year Training and Exercise Plan.	CE	
7.	Ensure that DWSP and town emergency responders are aware of emergency protocols put in place by DWSP and are provided emergency contact phone numbers on a regular basis and when changes occur.	CE	
8.	Provide emergency response training for new DWSP employees and refresher training for veteran staff.	CE	
9.	Conduct emergency response training events with the local first responders.	CE	

10.	Provide infrastructure support in Sudbury watershed, including a boom trailer and covered boat storage.	CE	
11.	Update, as needed Comprehensive Emergency Management Plan for Wachusett and Sudbury Reservoirs.	CE	
12.	Produce spill response plans and spill notification cards for timber harvesting operations.	F	EQ
13.	Prepare a summary report of information related to containment structures associated with direct discharge abatement projects for use in case of an accidental spill.	EQ	CE
	P. Geographic Information Systems Goal: Utilize Geographic Information System technologies to enhance and support all watershed management activities.		
1.	Provide GIS support to staff in the following areas: training and technical support, data curation and management, project development and management, analyses, cartography and licensing.	GIS	
2.	Coordinate with Management, Watershed Rangers and Division Director in development of a DWSP-wide public access map which distills current public access regulations via an interactive web mapping application.	GIS	D, RD, IS, P, WR
3.	Coordinate with Natural Resources, Rangers, Aquatic Biology and Management on the development of a DWSP-wide 'Sportsman Map' that brings together current information on areas open to hunting and fishing into a user-friendly web and mobile experience.	GIS	NR, EQ, WR, D, RD
4.	Coordinate with Planning staff and Management on development of methodology for accepting public submissions for Watershed Protection Act filings. Leverage out-of-the-box tools and integrate with the new cloud-based WsPA database.	GIS	EP, P, RD, D
5.	Coordinate with Environmental Quality staff on the development of a new, cloud-based EQ database. Provide a series of data management tools, dashboards, and reporting methods to meet staff needs.	GIS	EQ
6.	Collaborate with other EEA GIS Coordinators to ensure the Division continues to benefit from EEA investment in GIS technology.	GIS	

6 References

6.1 DCR Division of Water Supply Protection Publications, Reference Reports, and Other Documentation

6.1.1 Legal References

Session Laws

- Chapter 262, Acts of 1932. Rutland-Holden Trunk Sewer Legislation
- Chapters 460 and 501, Acts of 1938. Rutland-Holden Trunk Sewer Legislation
- Chapters 286 & 287, Acts of 1939. Rutland-Holden Trunk Sewer Legislation
- Chapter 737 of the Acts of 1972. Kelly-Whetmore Act
- Chapter 372 of the Acts of 1984. MWRA Enabling Act
- Chapter 36 of the Acts of 1992. Watershed Protection Act
- Chapter 15, Acts of 1996, § 2420-7961. Holden and West Boylston Sewer Construction/Expansion
- Chapter 26 of the Acts of 2003, § 290. Creation of Department of Conservation and Recreation
- Chapter 149 of the Acts of 2004, s. 27. Creation of Water Supply Protection Trust

Massachusetts General Laws

- MGL c. 10, § 73 . Water Supply Protection Trust General Law.
- MGL c. 92A½. DCR Watershed Management General Laws.

Code of Massachusetts Regulations

- 313 CMR 11.00. Watershed Protection regulations.
- Other Environmental Regulations

Other Legal Documents

- DCR/MWRA Memorandum of Understanding
- Executive Order No. 484: Leading by Example – Clean Energy and Efficient Buildings

6.1.2 Documentation by Program

Unless otherwise noted, all publications by Department of Conservation and Recreation, Division of Water Supply Protection.

Watershed Preservation Restrictions (WPR):

- WPR Working Group worksheets
  - Baseline Documentation Procedure
  - Monitoring Procedure
  - Landowner Relations Procedure

    - Enforcement Procedure
    - Reserved Rights Procedure
- Baseline Documentation Reports
- Annual Monitoring Reports

Land Management

- Continuous Forestry Inventory (CFI) Data
- *From Here Forward: Proposed Changes to the Department of Conservation and Recreation Division of Water Supply Protection's Watershed Forest Management Program* (2013)
- *Land Management Plan* (2017-2027)
  Previous Land Management Plans
    - *Quabbin Land Management Plan* (2007 – 2017)
    - *Sudbury Land Management Plan* (2004 – 2013)
    - *Wachusett Land Management Plan* (2001 – 2010)
    - *Ware Land Management Plan* (2003-2013)
- *Terrestrial Invasive Plant Species Management Strategy* (2011)
- *Science and Technical Advisory Committee (STAC) Report* (2012)

Wildlife Management

- Annual Aquatic Wildlife Pathogen Control Zone report
- Annual Canada Goose Population Control Program Report
- Annual Common Loon Summary report
- Long-term Wildlife Resource Monitoring Program Report (2005)
- Quabbin Gull Harassment Program Reports (2010-2013)
- *Regional Movements, Feeding Behavior, and Roosting Patterns of Ring-billed, Herring, and Great Black-back Gulls Utilizing Wachusett and Quabbin Reservoirs, Massachusetts* (2007)
- Ring-billed, Herring, and Great Black-back Gull Study: 2008-2010 Report and Proposed Management Recommendations (2010)
- Ring-billed, Herring, and Great Black-back Gull Study: Progress Report (2008, 2009)
- White-tailed Deer Control Program Report (2010)

Public Access Management

- *Quabbin Public Access Management Plan Evaluation* (2011)
- *Quabbin Public Access Management Plan Update* (2018)
- *Quabbin Public Access Management Plan Update* (2006)
- *Sudbury and Foss Reservoirs Public Access Plan Update* (2022)
- *Sudbury and Foss Reservoirs Public Access Plan Update* (2010)
- *Wachusett Public Access Plan Update* (2011)
- *Ware River Watershed Public Access Management Plan Evaluation* (2011)
- *Ware River Watershed Public Access Management Plan Update* (2010)

Watershed Security

- Hydraulic and Hydrology Study of Winsor Dam (2012)
- MWRA Vulnerability Assessment (2003)

Infrastructure

- Building Inspection Reports
- Dam and Facility Inspection Reports
- MWRA Emergency Action Plan for the Wachusett Reservoir Dam (2011)
- MWRA Vulnerability Assessment (2003)
- Quabbin Park Plan (2013)

Watershed Protection Act

- Guidance Document for Making Applications under the Watershed Protection Act
- Watershed Protection Act Brochures
  - Horses and the Watershed Protection Act
  - Landscaping and the Watershed Protection Act
  - Watershed Protection Act Fact Sheet

Interpretive Services

- *Downstream* newsletter (biannual, 2008-2017)
- *Quabbin Reservoir Interpretive Plan* (1988)
- *Stillwater Farm Operational Plan* (2008)
- *Wachusett Reservoir Interpretive Plan* (2009)

Water Quality and Quantity Monitoring

- *Aquatic Invasive Species Assessment and Management Plan* (2010)
- Field Guide to the Aquatic Macrophytes of the MWRA Reservoir System (ESS Group, Inc., 2011)
- MDC Water Quality Data, 1990-1999 (2000)
- *Nutrient and Plankton Dynamics in Quabbin Reservoir* (2000)
- *Nutrient and Plankton Dynamics in Wachusett Reservoir, 1998–2002* (2002)
- Quabbin Reservoir and Ware River Watersheds Ten Year Water Quality Data Review 2000-2009 (2011)
- Quabbin Reservoir Watershed and Ware River Watershed Annual Water Quality Reports (2006-2017)
- Quabbin Reservoir/Ware River Aquatic Macrophyte Assessment (2006, 2009, 2013)
- USGS stream gages.
- Wachusett Reservoir and Watershed Annual Water Quality Reports (1988–2017)
- Wachusett Tributaries Ten Year Water Quality Summaries (1988–1997, 1998–2007)

Aquatic Invasive Species Management

- Aquatic Macrophytes of the MWRA Reservoir System (ESS, 2013, 2011, and 2009)

- *Aquatic Invasive Species Assessment and Management Plan* (2010)
- Zebra Mussel Tank Bioassays (Quabbin Reservoir and Laurel Lake MA);Subcontract: Sandra Nierzwicki-Bauer, Darrin Fresh Water Institute, Rensselaer Polytechnic Institute, Bolton Landing, NY. FINAL REPORT- July 16, 2010

Environmental Quality Assessments (EQA)

- Burnshirt, Canesto, and Natty Pond Sanitary District (1992, 2010, 2014, 2018)
- Coldbrook and Longmeadow Sanitary District (1992, 1994, 2009, 2013, 2017, 2022)
- East Branch Ware River Sanitary District (1994, 2003, 2008, 2012, 2016, 2021)
- Fever Brook Sanitary District (2003, 2008, 2014, 2018)
- Gates Brook Sanitary District (2018, 2023)
- Quabbin Northwest Sanitary District (2000, 2006, 2007, 2013, 2017, 2022)
- Quabbin Reservation Sanitary District (2003, 2005, 2007, 2011, 2015, 2020)
- Quinapoxet District Sanitary District (2004, 2009, 2014, 2021)
- Reservoir District Sanitary District (2003, 2008, 2013, 2022)
- Stillwater District Sanitary District (2006, 2010, 2015, 2020)
- Thomas Basin Sanitary District (2008, 2013)
- West Branch Ware River Sanitary District (2000, 2008, 2011, 2015, 2020)
- Waushacum Brook Sanitary District (2017)
- Worcester District Sanitary District (2010, 2016)

Wastewater Management

- DWSP monthly Sewer Flow Reports to Communities and Upper Blackstone Water Pollution Control Facility

Stormwater Management

- Massachusetts Interstate, Merrimack and South Coastal Small MS4 General Permit (2010 Draft)
- Massachusetts Stormwater Handbook (MassDEP, 2008)
- Quabbin Reservation: Culvert Mapping Project (2008)
- Stormwater Report for Hangar Storm Drain Improvement Project, DCR Administrative Complex – Quabbin Reservoir (2012).
- Wachusett Reservoir Direct Discharge Phase II Study (CEI, 2012)
- Wachusett Reservoir Direct Discharge Report (2008)
- Wachusett Stormwater Management BMP database
- Wachusett Stormwater Study (Camp Dresser McKee, 1999)

Emergency Spill Response

- *Emergency Response Handbook – Quabbin/Ware Region* (2010)
- Quabbin/Ware Spill Response Standard Operation Procedures (2023)
- *Using CE-Qual-W2 to Model a Contaminant Spill into the Wachusett Reservoir* (Lillian M. Clark (UMass), 2013)
- *Wachusett Reservoir and Watershed Emergency Spill Response and Prevention Plan* (2008)
- *Wachusett/Sudbury Comprehensive Emergency Management Plan* (2012)

Implementation

- *Division of Water Supply Protection, Office of Watershed Management Annual Work Plan* (2005-2023)
- *Division of Water Supply Protection, Office of Watershed Management Annual Work Plan Final Report* (2005-2022)
- *Quabbin Reservoir and Ware River Watershed Protection Plan* (1991, 2000, 2008)
- *Sudbury Reservoir Watershed Protection Plan* (1997, 2008)
- *Wachusett Reservoir Watershed Protection Plan* (1991, 1998, 2003, 2008)

6.2 Outside Documentation

American Water Works Association, *G300-14 Source Water Protection*, Denver, CO 2014.

American Water Works Association, *G300-22 Source Water Protection*, Denver, CO 2022.

American Water Works Association, *Operational Guide to AWWA Standard G300, Source Water Protection, Second Edition*, Denver, CO 2016

American Water Works Association, *M50 Water Resources Planning, Third Edition*, Denver, CO 2017.

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Appendix A: Land Use Calculations

The MassGIS 2016 Land Cover/Land Use data was used to summarize the land cover/land use data for each watershed shown in Table 2-2. This data was developed collaboratively by MassGIS and NOAA's Office of Coastal Management in 2016 and released in 2019 to the public. This dataset consists of two components – land cover class and parcel use code – which can be used independently or together. For example, a user can display areas of impervious surface (land cover), or commercial parcels (land use). When used together, it is possible to display and quantify the portions of commercial parcels which are covered by impervious surfaces, or to show portions of residential parcels which are used as developed open space (e.g., yards).

The land cover portion of the dataset was created in raster format by NOAA's Coastal Change Analysis Program (C-CAP). The 2016 data was initially developed as 1-meter raster dataset. The land use portion of the dataset was derived from the Property Type Classification Code associated with each parcel in Massachusetts per the MassGIS Property Tax Parcels layer (a polygon dataset). The "use codes" are defined by the Massachusetts Department of Revenue Division of Local Services, although there are also some custom codes used by municipalities. The final, combined, dataset brings together the land use and land cover data. Land Cover data was converted to polygon features and then the Identity tool was used to geometrically combine the land cover polygons with the parcel polygons. The resulting data available from MassGIS is a polygon dataset. For a more in-depth explanation of this data, please visit the MassGIS website.

The following attribute queries were used to calculate land cover and land use values for Table 2-2. In the descriptions below, '*Land Cover Codes*' refers to attribute field COVERCODE and, '*Land Use Codes*' refers to attribute field USEGENCODE within the MassGIS 2016 Land Cover/Land Use data.

Forest Codes:

- Select by Land Cover Codes – 9 (deciduous), 10 (evergreen), 12 (scrub/shrub)
    - *SQL query: COVERCODE = 9 Or COVERCODE = 10 Or COVERCODE = 12*
- Once initial selection made, remove Land Use Codes 55 (ROW) and 88 (water) from selection
    - *SQL query: USEGENCODE = 55 Or USEGENCODE = 88*

Wetland Codes:

- Select by Land Cover Codes – 13 (palustrine forested wetland), 14 (palustrine scrub/shrub wetland), 15 (palustrine emergent wetland), 22 (palustrine aquatic bed)
    - *SQL query: COVERCODE = 13 Or COVERCODE = 14 Or COVERCODE = 15 Or COVERCODE = 22*
- Once initial selection made, remove Land Use Code 88 (water) from selection
    - *SQL query: USEGENCODE = 88*

Agriculture Codes:

- Select by Land Cover Codes – 6 (cultivated land), 7 (pasture/hay), 8 (grassland)
    - *SQL query: COVERCODE = 6 Or COVERCODE = 7 Or COVERCODE = 8*
- Once initial selection made, remove Land Use Code 88 (water) from selection
    - *SQL query: USEGENCODE = 88*

Note: Some areas of active forestry, shoreline, and utility rights of way were mis-classified as one of three land cover codes. While these areas may appear as "agriculture" on the maps and in calculations, there is no active crop/fruit farming or livestock on any DWSP lands. DWSP does maintain some land as fields for habitat and cultural purposes: approximately 200 acres each in the Quabbin Reservoir and Ware River watersheds, and approximately 350 acres in the Wachusett Reservoir watershed. The following table has adjustments to percent of watershed area due to this misclassification.

Watershed	Total Acres Agriculture on DWSP Lands	Acres of Managed Fields on DWSP Lands	Total Acres Mis-classified as Agriculture	Watershed Land Area	Percent of Watershed Mis-classified as Agriculture
Quabbin Reservoir	1,143	200	943	95,364	1.0
Ware River	398	200	198	61,671	0.3
Wachusett Reservoir	878	348	530	70,876	0.7
Sudbury Reservoir	74	0	74	16,298	0.5

Open Water Codes:

- Select by Land Cover Code = 21 (open water) OR Land Use Code = 88 (water)
    - *SQL query: COVERCODE = 21 Or USEGENCODE = 88*

'Other' Non-Impervious Codes:

- Select by Land Cover Codes – 5 (developed open space), 19 (unconsolidated shore), 20 (bare land)
    - *SQL query: COVERCODE = 5 Or COVERCODE = 19 Or COVERCODE = 20*

Residential Codes:

- Select by Land Cover Code = 2 (impervious) AND Land Use Codes – 10 (mixed use, primarily residential), 11 (single family), 12 (multi-family), 13 (other residential)
    - *SQL query: COVERCODE = 2 And (USEGENCODE = 10 Or USEGENCODE = 11 Or USEGENCODE = 12 Or USEGENCODE = 13)*

Commercial/Industrial Codes:

- Select by Land Cover Code = 2 (impervious) AND Land Use Codes – 3 (commercial), 4 (industrial), 30 (mixed used, primarily commercial)

    - *SQL query: COVERCODE = 2 And (USEGENCODE = 3 Or USEGENCODE = 4 Or USEGENCODE = 30)*

'Other' Impervious Codes:

- Select by Land Cover Code = 2
    - *SQL query: COVERCODE = 2*
- *Remove* the following Land Use Codes from selection – 3 (commercial), 4 (industrial), 10 (mixed use, primarily residential), 11 (single family), 12 (multi-family), 13 (other residential), 30 (mixed used, primarily commercial), 88 (water)
    - *SQL query: USEGENCODE = 3 Or USEGENCODE = 4 Or USEGENCODE = 10 Or USEGENCODE = 11 Or USEGENCODE = 12 Or USEGENCODE = 13 Or USEGENCODE = 30 Or USEGENCODE = 88*
- *Add* the following to the selection – Land Use Code = 55 AND Land Cover Code – 9 (deciduous), 10 (evergreen), 12 (scrub/shrub)
    - *SQL query: USEGENCODE = 55 And (COVERCODE = 9 Or COVERCODE = 10 Or COVERCODE = 12)*

Appendix B: GIS Program Workflow Examples

This appendix contains detailed examples of projects the GIS program has facilitated, oversees on an ongoing basis, or completed in the past five years. Projects have been selected because they highlight a representative workflow or represent the accomplishment of an important goal. Most examples are system-wide applications, but there are several that are unique to a specific watershed. There are also many operational sections which are independently completing excellent GIS work; their work is not included here unless otherwise noted.

Interactive Access Map

Software used - Basic Viewer, ArcGIS Pro, Field Maps, Web AppBuilder.

A collaborative effort with Interpretive Services and Management developed an interactive public access map for the Quabbin Watershed. The primary goal was to clearly define allowed areas of public access and what activities can occur in those locations. The map highlights access gates and clearly spells out access rules/regulations, displays DWSP roads and trails where public access is allowed, defines allowed uses (e.g., bicycle, hiking, cross country skiing, etc.), display fishing areas (including Boat Launch Areas and shoreline fishing access), and clearly defined prohibited areas and activities. Points of interest around the watershed are highlighted to demonstrate locations interest, such as landmarks, parking areas, the QVC, and cemetery. Input from other sections was critical in ensuring that displayed information was correct; Watershed Rangers manage the Gate Inventory layer, while Interpretive Services, Forestry and Engineering staff were key players in ensuring the trail and road inventory was accurate.

This interactive map became an important way to communicate access information to the public with the onset of COVID in March 2020. A splash screen appears each time the map is visited, allowing DWSP to provide the public with up-to-date information about important closures, notices, etc. Over 35,000 users have visited this app to find information about trails use in the Quabbin (Figure A-1). A unified public access app for all four watersheds is planned to replace the Quabbin specific version.

As part of this project, it was necessary to create a system-wide Trail & Road Inventory for use in internal and external online applications. See *Trail Inventory and Unauthorized Trail Monitoring* for additional details on this portion of the project.

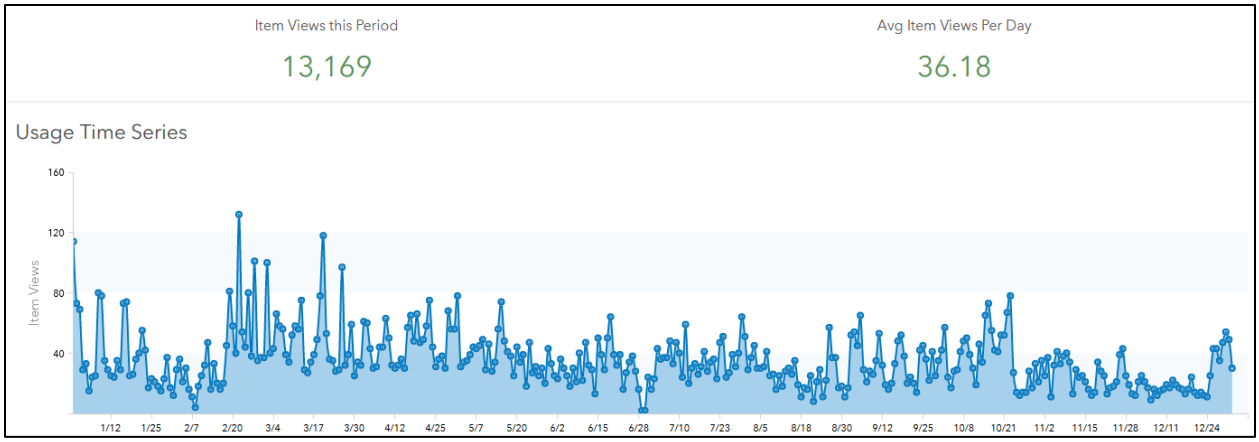

Figure A-1: Usage of the Quabbin Public Access Map for 2021.

Trail Inventory and Unauthorized Trail Monitoring

The Quabbin Public Access Viewer was the inspiration to create an improved Trail & Road Inventory for use in internal and external online applications. An upgraded, more detailed data schema was developed to apply to DWSP data through a collaboration with DCRS; this set-up leaves open the opportunity for future intra-agency collaboration on a statewide trail application. Creating a series of layers in ArcGIS Online allowed staff to edit the data easily in a variety of ways, including ArcGIS Pro and Field Maps. Edits appear in real-time in the public version of this layer. Custom coding created a detailed and informative pop-up window that clearly defines what is and is not allowed on any trail or road on DWSP property. This detailed data is now available for all DWSP watersheds.

Software used - ArcGIS Pro, Field Maps and Web AppBuilder.

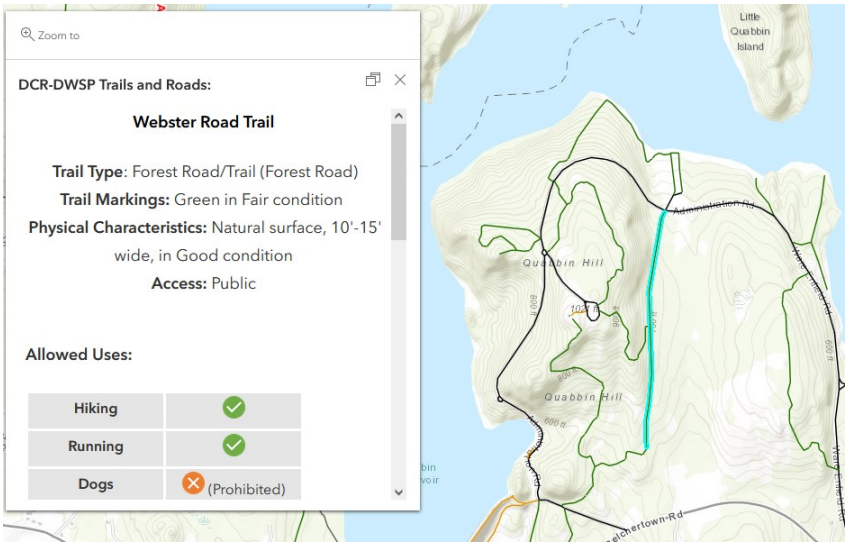

Figure A-2: Example of pop-up for Webster Road Trail in Quabbin Park. Allowed uses are clearly defined using icons.

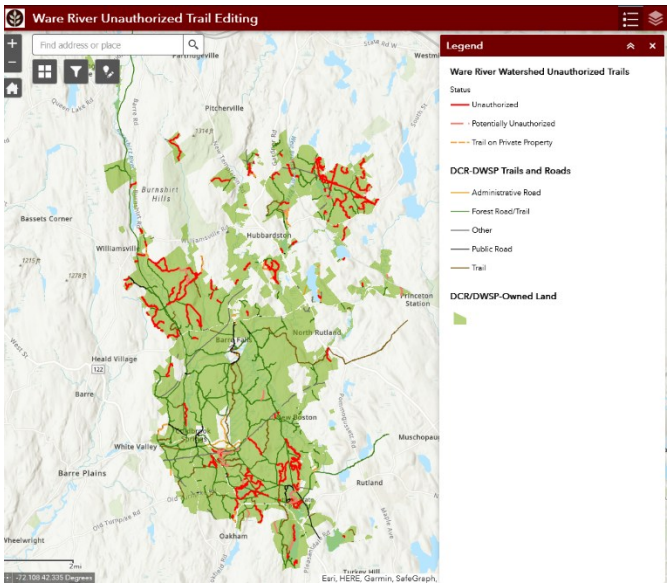

Figure A-3: Locations of unauthorized trails within the Ware River Watershed. Ranger staff can use iPads and Field Maps to collect and update information while in the field. All information can be viewed in the office via a web application.

It was important within the Ware River to facilitate the monitoring of unauthorized uses of both legal and illegal trails throughout the watershed. Watershed Ranger and Forestry staff track these uses through a series of attribute fields which are specifically designed to deal with unauthorized trails. In addition, it is possible to keep track of "re-visits" to unauthorized trails to keep a log of status changes over time. Collecting this data assures MassDEP that DWSP is meeting its obligations to monitor and manage public access and unauthorized used within the Ware River watershed. This information is only visible to internal staff and is not available to the public.

Hunting Access and Controlled Hunts

The Natural Resources section wanted to communicate clear and concise hunt information while also allowing hunters to see and explore where they can hunt. This goal was accomplished through the use of online viewers, providing the public with a system-wide hunting application, and two controlled hunt applications for Quabbin and Wachusett. These apps can be used in a web browser on any computer or mobile device; instructions are provided to hunters which also allows them to take advantage of Field Maps to see where they are on a map while scouting potential hunting locations. These initial programs are expected to migrate into a more modern-looking, unified "*Sportsman experience*," which will combine the various applications together into one place and also include fishing opportunities.

Software used - Basic Viewer, ArcGIS Pro and Field Maps.

Creation of these applications was led by Natural Resources staff, but also required the assistance of various sections to ensure that data was correctly presented. Ranger staff curate and maintain the Parking and Access layers, while GIS staff maintains the Huntable Land and Setbacks layers. Reference data, such as stonewalls, is provided by Foresters, while public authoritative data from MassGIS is also leveraged when possible. Natural Resources staff provide oversight to ensure that the correct information is included and shared with the public.

Beaver Activity Monitoring

Software used - Field Maps, Survey123 and Dashboards.

The Beaver Activity Monitoring workflow is representative of field data collection processes established by DWSP. Natural Resources staff can now use field data collection apps to monitor beaver activity, record trapping and removal locations, and record trapped/removed beaver biological information throughout the watershed system. Integrating Field Maps and Survey123 provides both a map-centric view (Field Maps) and form-centric data entry of (Survey123). This set-up enables information to be passed from the Trapping & Removal Sites layer in Field Maps to the Beaver Biological Data form, ensuring that data records are properly and effortlessly connected.

A Dashboard provides a map and summaries – as tables, indicators, and charts – which can be used within annual reports. The Dashboard is configured to display all collected information but can be filtered by date ranges, providing the flexibility to generate custom summaries going back to fall 2017. Staff can also quickly and easily export data summarized within tables and charts to CSV files for further analysis or reporting.

Information gathered using these field data collection tools can also easily be accessed in desktop GIS for editing or additional analysis. For example, beaver data can be used to visualize trends in active beaver sites over time, which could help identify "hot spots" that would be candidates for mitigation efforts.

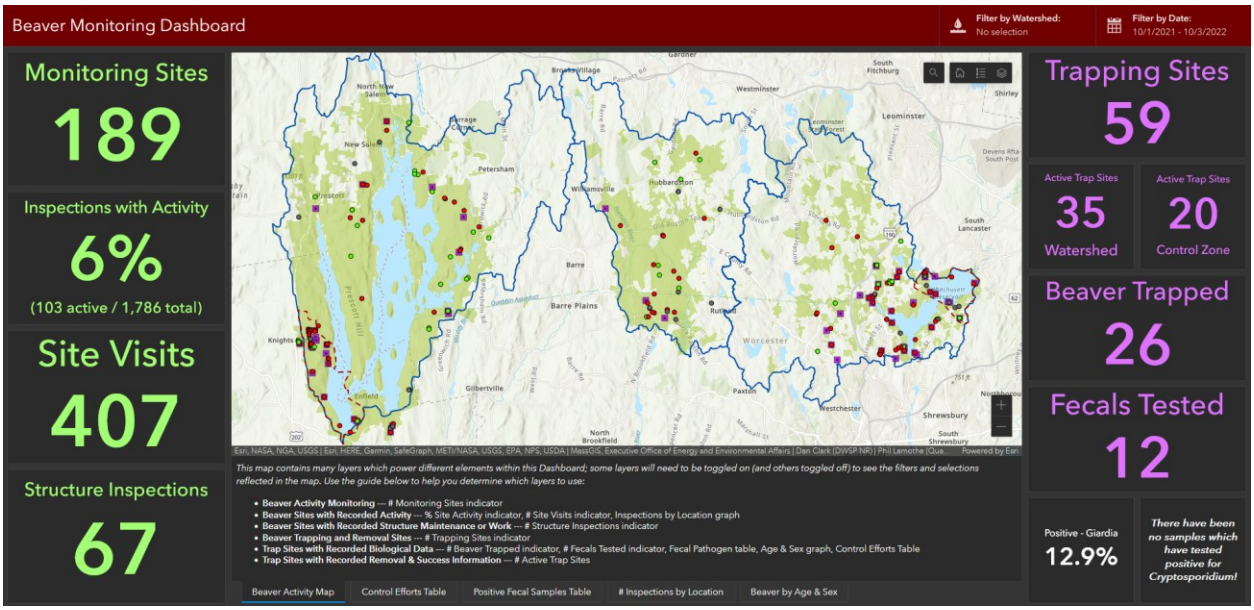

Figure A-4: This Dashboard provides NR staff with a quick operational picture of beaver activity throughout the watersheds. Using this, NR staff can easily generate reports, and to summarized statistics from their collected data.

Watershed Protection Act Database Migration

The goal of this project was to provide Environmental Planning staff with a unified Watershed Protection Act (WsPA) database that can be easily managed using tools available through ArcGIS Online. The key objective was to migrate regional non-spatial WsPA databases into a unified, functional, spatial database that provides Planning staff with new tools for data management, data exploration, and reporting.

Software used - ArcGIS Pro, Field Maps, Survey123, Dashboards, StoryMap Collections, Experience Builder, SharePoint and Power Automate.

Data quality controls – utilizing domains, constraints, calculations, and custom code – ensure that no duplicate file numbers can be entered, that all address questions have a reverse geocode "search" capability, and related projects within a 0.5 mi radius can be easily located. A data entry form integrated with Experience Builder facilitates the capture of the filing parcel boundary and attribute information from authoritative MassGIS parcel data ensuring that the original filing boundary is maintained in DWSP records. Power Automate is used to automatically create a new folder in SharePoint for storage of project files when a new WsPA file is entered, as well as to send a series of automatic email reminders as a filing nears decision deadlines.

This workflow combines Survey123 with a Dashboard to provide staff an efficient interface for managing the database. The "Data Update" Dashboard offers various filters for searching the database and the ability to easily determine what information is missing from an incomplete file. This internal workflow also has a "read only" version to share with associated staff that do not regularly handle WsPA applications. The "Data Exploration" Dashboard provides all staff the ability to query the database for reporting purposes. Using Survey123 as the "front end" of this new database has DWSP well-prepared for the eventual change to electronic submittal of WsPA applications.

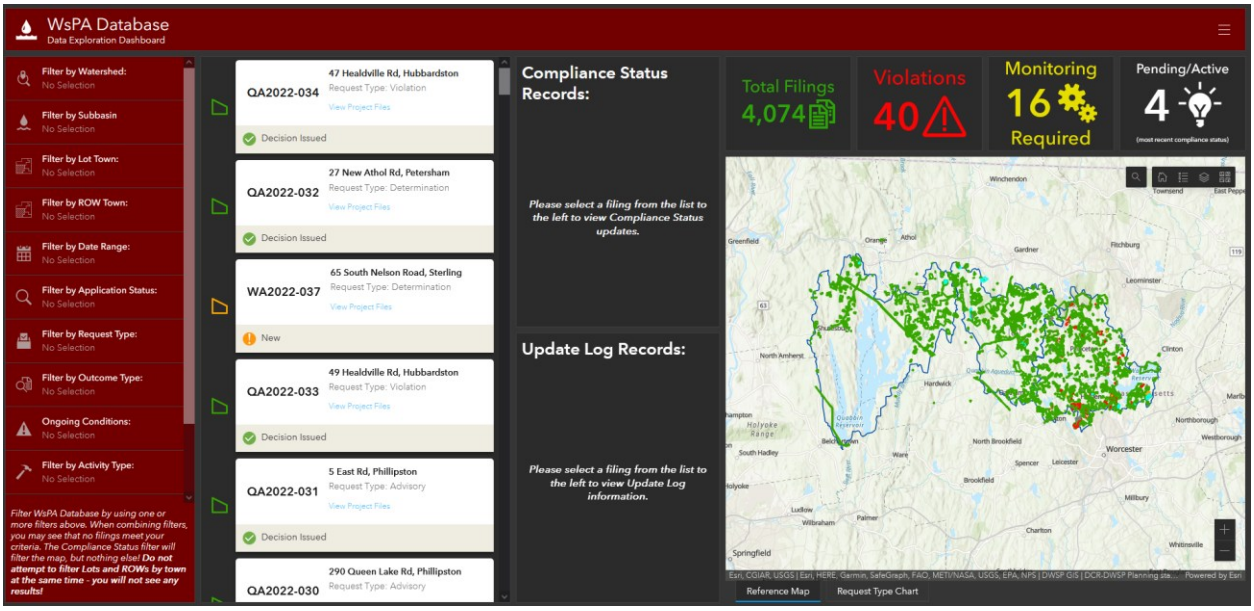

Figure A-5:WsPA Data Exploration Dashboard allows staff to use filters along left to answer questions about WsPA data for various purposes, including for EQA, quarterly and annual reports.

A Return on Investment (ROI) was written at the completion of this project; this highlights the significant savings in staff time from the Access data base and paper-based workflow (at 675 hours annually) to the ArcGIS Online-based workflow (at 150 hours annually). This savings in staff time is an additional bonus to the many other tangible benefits of this workflow migration mentioned above.

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)				
Hours to complete current workflow	9.0	*Time to complete the current work flow once.*	Current workflow cost	$315.00
Hourly wage rate*	35.00		Current annual cost	$23,625
Annual occurrence of workflow	75			
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhanced Workflow Costs				
Hours to complete workflow after enhancement	2.0	*Time to complete the enhanced work flow once.*	Enhanced workflow cost	$70.00
Hourly wage rate*	35.00		Enhanced annual cost	$5,250
Annual occurrence of workflow	75			
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhancement Production Costs and Savings				
Hours to complete enhancement	108.0		Enhancement cost	$3,780.00
Hourly wage rate*	35.00		Initial Annual Savings	$14,595
Annual maintenance costs of enhancement, if any	$0.00		Future Annual Savings	$18,375
Projected ROI				
			Initial Year ROI	120%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost			**Future Annual ROI**	203%

Figure A-6: A completed Return on Investment (ROI) study for this workflow migration clearly shows savings in staff time that were introduced once the new workflow was adopted.

Land Acquisition Panel StoryMap

The Land Acquisition Panel (LAP, Section 4.1) keeps up with the fast-paced real estate market, confidentially assessing potential acquisitions on an ongoing schedule. Historically LAP met in person

Software used - StoryMaps (ArcGIS Online).

and reviewed cases presented on printed maps. It was decided in mid-2020, as the COVID-19 pandemic forced staff to work remotely, to pivot the review of potential projects to a digital format. LAP now uses ArcGIS Online StoryMaps to review projects prior to every meeting.

Collaboration between the Land Acquisition Program Coordinator and the Wachusett Regional GIS Specialist results in an immersive experience where LAP members can review narrative, facts/figures, interactive maps, and images of proposed acquisitions. Each prospective property receives its own chapter within the StoryMap, which includes a parcel overview, WsPA information, relationship to other DWSP holdings, information on the parcel ranking on the Land Acquisition Model, and details on natural resources on or adjacent to the property.

The LAP StoryMap also allows for archival of projects, including those which are complete, projects which were not selected for potential acquisition by the panel, or projects that never came to fruition. This is useful as a record of parcels which have come in front of the panel and if a project becomes active once more.

Figure A-7: Mock-up of the Land Acquisition Panel StoryMap.

Watershed Preservation Restriction (WPR) Monitoring

Software used - ArcGIS Pro, Field Maps, Survey123, Web AppBuilder, Tracker and Python.

WPR monitoring (Section 4.2) occurs primarily on a bi-yearly basis, except for the annual requirement for parcels acquired through the federal Forest Legacy program. Limited staff availability and a complicated, time-consuming monitoring process had made DWSP behind on monitoring goals. While recruiting additional staff to assist with monitoring efforts, a new workflow was developed that combines field data collection tools (Field Maps and Survey123) and online tools (Web AppBuilder and Survey123 Reports) to streamline the monitoring and report-writing process. The Survey123 form guides staff through the monitoring process and ensure that data is collected consistently and efficiently.

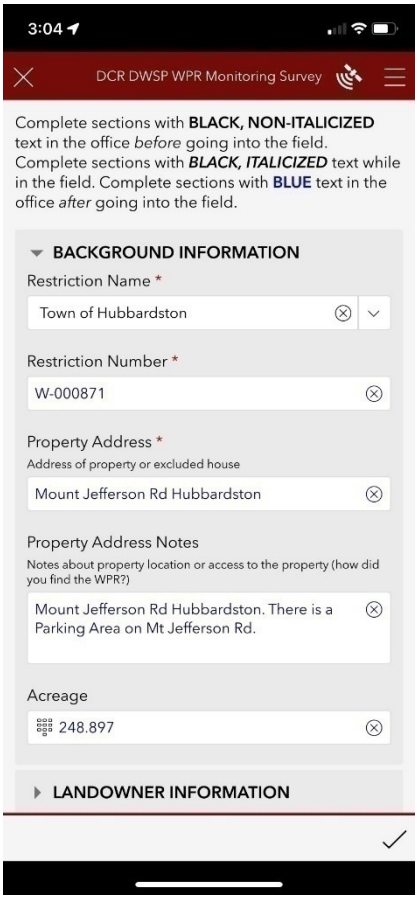

Figure A-8: By entering the restriction name at the top of the form, information about the WPR (blue text) is pulled into the form for monitors to review and update.

The survey form can be completed over time, allowing staff flexibility to enter information before, during, and after a monitoring visit. The monitoring process has been further streamlined by pulling information from past visits into the current form, allowing review and update as needed. This reduces the amount of time staff need to spend on data entry prior to the monitoring visit. Field Maps automatically tracks the monitor's location on the property; this is used within the report's monitoring map that shows the path traveled during a visit. The collected track also provides a historic record to refer to in subsequent years, ensuring that monitors visit different parts of the property on other visits.

A standardized monitoring report can be generated with the click of a button, and monitoring maps are developed using an online application, ensuring consistency regardless of the monitor. Collaboration with colleagues in DCRS ensured the same workflow and monitoring report template were adopted by the Conservation Restriction Monitoring program. All DCR monitoring efforts now result in the same type of report, showcasing agency unity.

This streamlined monitoring workflow is administered through a collaboration between the GIS and WPR programs. This workflow has helped DWSP meet its obligations to bi-annually monitor WPRs. These tools provide the WPR program the ability to quickly address any potential issues or violations of the WPR agreement which could negatively impact water quality.

Watershed Security – Gate Inventory

Software used - Field Maps, Survey123, Web AppBuilder and Attachment Viewer.

This project developed a comprehensive gate inventory of all DWSP owned/managed gates throughout the watershed system. The gate inventory is managed and updated on a regular basis by Ranger and Maintenance staff. The workflow was designed allow staff to easily find comprehensive information on gate type, lock details, signage present, and gate/lock conditions. Attribute fields track gate inspections and identify where work is needed to replace signage, locks, and repair gates. Two connected versions of the data are available through ArcGIS Online – an internal version which DWSP staff can edit and a non-editable public version for use in DWSP public access web applications.

Maintaining a gate inventory in this way ensures that public-facing applications contain up-to-date information on access gates. As soon as updates are made by staff to the inventory, the information becomes available to the public. Providing gate numbers and pictures of the gate helps visitors know their location while on DWSP properties. This layer is used within all public access applications, including the Quabbin Public Viewer and the various deer hunt maps.

Watershed Ranger Daily e-Log Program

Software used - Survey123, Dashboards, Python and Amazon WorkSpace.

The GIS Program worked with the Wachusett-Sudbury Rangers to transform their tedious and inefficient paper-based daily patrol log into a digital e-log. This process also created a series of useful reporting and management tools to further improve their understanding of where additional ranger presence was required in the watersheds. This workflow migration eliminated the requirement that hundreds of paper logs be manually entered into Excel to complete weekly and quarterly reports. This not only saves valuable staff time, but it also reduces data entry errors and/or the likelihood that a paper log may be accidentally lost. Using Survey123, Rangers now start one log at the beginning of a shift and add log entries throughout the day. A single log entry can contain one incident and up to three CMR violations (including the number of violations recorded); locations are collected for all incidents and CMR violations. This information is used to quickly generate quarterly reports; individual daily e-logs can also be exported to detailed reports for use in legal proceedings.

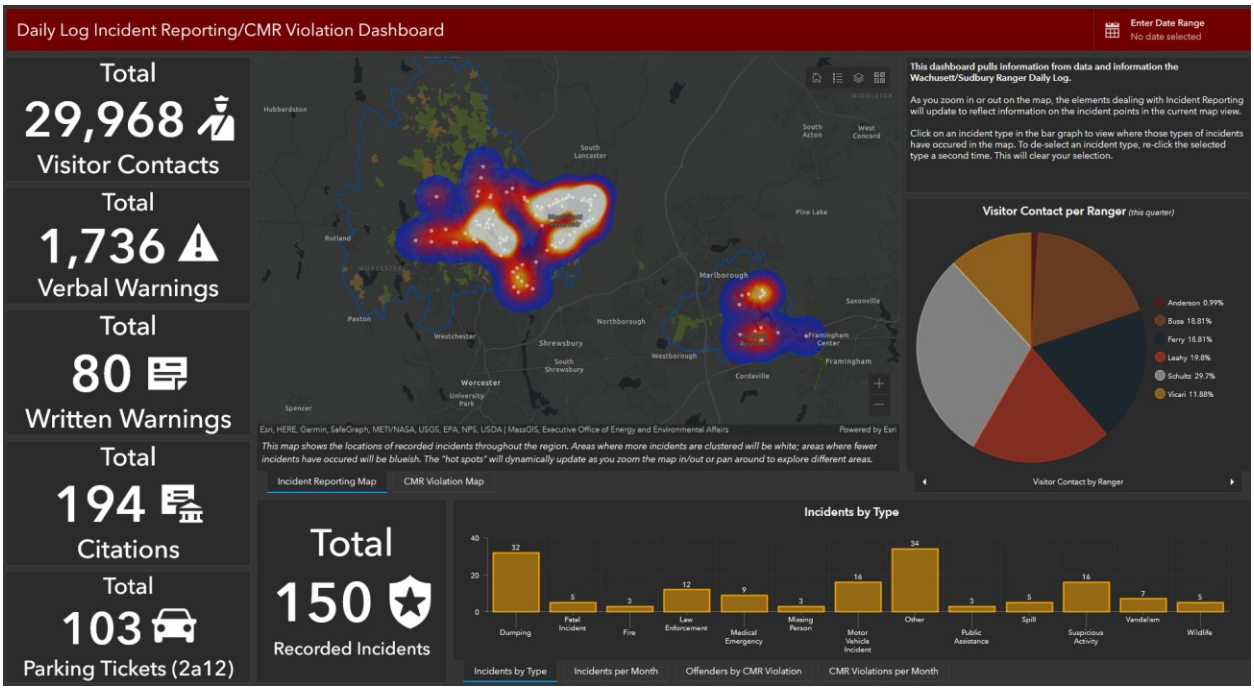

Figure A-9: This Dashboard summarizes all information collected via the e-log. All elements can be filtered by date (upper right corner) to provide users with statistics/details on what occurred within the selected date range.

An "Accountability" Dashboard allows Ranger management to review submitted logs over two weeks to ensure staff are properly completing their logs. An "Incident and CMR Reporting" Dashboard provides all Rangers and regional management with an operational picture of what and where is happening in the region. This presentation includes heat maps of both incident and CMR violation locations, charts, graphs, and indicators; all content can be filtered by user-specified date ranges. This Dashboard is useful for quickly completing weekly reports as well as allocating limited ranger resources. The goal of increasing Ranger efficiency is less violations and a subsequent increase in groundwater/tributary/reservoir water quality, benefiting DWSP and MWRA management, MWRA ratepayers, and the flora/fauna within each watershed.

A Return-on-Investment (ROI) study for this workflow migrations shows that the initial year savings was 97 percent, while future annual ROI will be 263 percent savings, demonstrating that these workflow modernization projects hugely beneficial to the agency. Comparing the paper-based workflow costs (under Current Workflow Costs) with the e-log workflow costs (under Enhanced Workflow Costs), shows significant savings in the amount of staff time required to complete both weekly and quarterly reporting requirements. Ranger staff can now better utilize their time to complete more important tasks. After the success of this project for the Wachusett-Sudbury Region, this same workflow transformation was implemented for the Quabbin-Ware River Region Rangers.

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)				
Hours to complete current workflow - ***quarterly reporting***	6.0		*Current workflow cost*	$198.00
Hourly wage rate*	33.00		*Current annual cost*	$792.00
Annual occurrence of workflow	4			
Hours to complete current workflow - ***weekly reporting***	8.0	*tally of time spent by Ranger captain & 2x lieutenants on weekly reporting*	*Current workflow cost*	$264.00
Hourly wage rate*	33.0		*Current annual cost*	$13,728.00
Annual occurrence of workflow	52		***Current TOTAL annual***	$14,520
Enhanced Workflow Costs				
Hours to complete workflow after enhancement - ***quarterly reporting***	0.25		*Enhanced workflow cost*	$8.25
Hourly wage rate*	33.00		*Enhanced annual cost*	$33.00
Annual occurrence of workflow	4			
Hours to complete workflow after enhancement - ***weekly reporting***	0.50		*Enhanced workflow cost*	$16.50
Hourly wage rate*	33.00		*Enhanced annual cost*	$858.00
Annual occurrence of workflow	52		***Enhanced TOTAL annual cost***	$891
Enhancement Production Costs and Savings				
Hours to complete enhancement	130.0		**Enhancement cost**	$4,290.00
Hourly wage rate*	33.00		**Initial Annual Savings**	$9,339
Annual maintenance costs of enhancement, if any	$0.00		**Future Annual Savings**	$13,629
Projected ROI				
			Initial Year ROI	97%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost			**Future Annual ROI**	263%

Figure A-10: Return on Investment (ROI) study for Watershed Ranger workflow transformation. This ROI study was only completed at the conclusion of the Wachusett-Sudbury Region workflow migration and does not include savings realized by implementing this same workflow within the Quabbin-Ware River Region.

Boat Seal Program

Software used: Survey123, Dashboards, Python, Amazon Workspace, Power Automate, and SharePoint.

This project modernized the Quabbin Boat Seal Program, moving it away from a paper-based methodology into a streamlined and time efficient mobile data collection system. There are two main components to this project: first there is the *Boat Seal Tag In/Out Survey and Dashboard* and second there is the *Boat Appointment and Decontamination Survey*. This new system utilizes Survey123 and Dashboards in conjunction with custom Python scripting to power the Boat Seal database to monitor compliance with the Boat Seal Program (maintained by Environmental Quality staff), and a real-time dashboard that can be utilized by Management, Boat Launch Area staff and Watershed Rangers to monitor reservoir usage and the number/names of boaters on the water at each Boat Launch Area (BLA).

A Survey123 form allows attendants at each BLA to enter a new survey response each time a boater enters or exits a BLA. Critical information such as Boater Name, Boat Registration Number, and Boat Seal Number are recorded. Methodology for reducing data entry errors were introduced, the most important being the implementation of a "Boater ID Card" system; this allows BLA attendants to simply scan a boater's card to automatically pull in the correct Name and Registration Number into the form. Each time a survey is submitted, data is sent to a cloud database within ArcGIS Online.

A series of Python scripts were created to download and process data collected by BLA attendants every 15 minutes. These scripts result in data that can be used in a real-time Dashboard. The Quabbin Reservoir Boat Launch Area Dashboard, used only by DWSP staff, is updated every 15 minutes during the April to October fishing season. This dashboard presents the total number of boats (private and rental) on the reservoir with breakdowns by area and includes boater names and registration numbers, providing enhanced public safety and emergency response capabilities. BLA supervisors use the data to determine priority for visiting BLAs throughout the day, while Ranger staff can determine allocation of resources. Two derivative products are also available: a public dashboard for rental boat availability, and an internal Emergency Contact Dashboard which Rangers can use in case of emergencies.

A *Reporting Tools Dashboard* was developed to provide statistics on boating throughout the season. This Dashboard can be filtered by BLA or can be used to show summaries of all collected information; it also is useful for quick information on reservoir usage (Figure x-x).

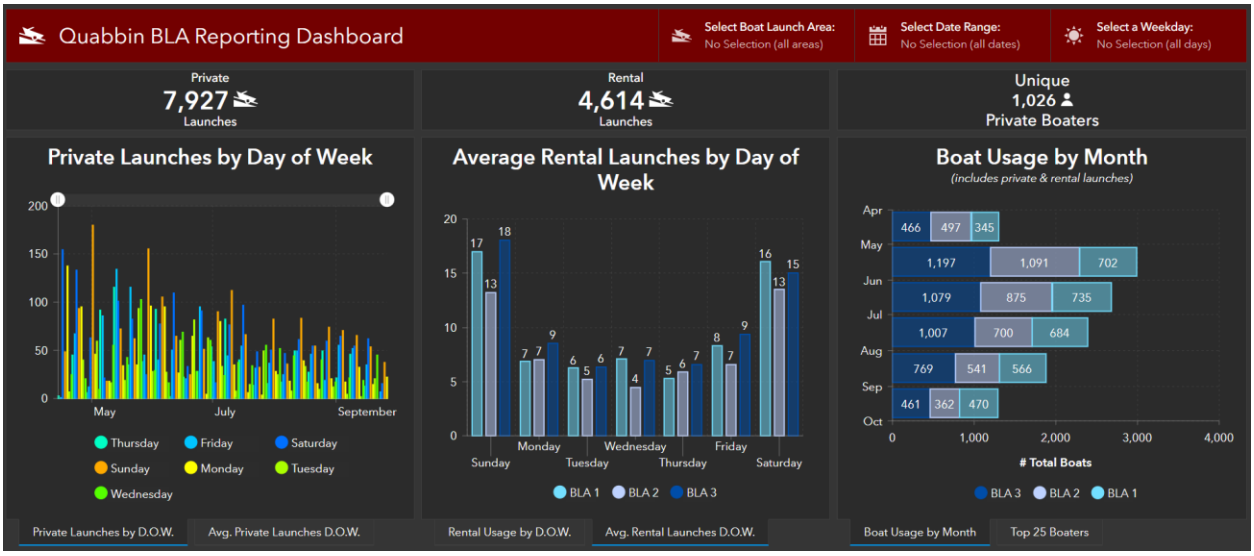

Figure A-11: Screen Capture of the Quabbin BLA Reporting Dashboard.

The *Boat Appointment and Decontamination Survey* allows DWSP staff to conduct boat decontamination inspections. This ensures the Boater Database is up to date with accurate boater information and ensures all required information from a decontamination appointment is efficiently and accurately captured. This workflow is an excellent example of collaboration between sections – Interpretive Services, Environmental Quality and Watershed Ranger staff all work together to collect information and conduct decontaminations.

Both components result in a standardized boater database which is updates three to four times per week, using semi-automated methods to check for data consistency and flag potential program violations. Boat seal and decontamination information were previously captured on paper forms and not entered until after the boating season was

over. This not only cost us massive amounts of staff time (approx. 768 hours), but it also prevented the potential enforcement of violations in a timely manner.

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)				
**These current workflow costs have been estimated for one season of the boater program using data from 2018.*				
Hours to complete current workflow *(appointments)*	11.3	*This value represents the actual number of times the workflow is completed multiplied by the time taken to complete the workflow once according to IS staff.*	*Current workflow cost*	$294.23
Hourly wage rate*	26.00			
Hours to complete current workflow *(decontamination)*	25.9	*This value represents the actual number of times the workflow is completed multiplied by the time taken to complete the workflow once according to EQ/Ranger staff.*	*Current workflow cost*	$517.33
Hourly wage rate*	20.00			
Hours to complete current workflow *(BLA)*	116.7	*This value represents an estimated number of times the workflow was completed in 2018 multiplied by the time taken to complete the workflow once according to BLA attendants.*	*Current workflow cost*	$2,450.00
Hourly wage rate*	21.00			
Hours to complete current workflow *(data entry)*	768.8	*This value based on reports of time spent on task by staff.*	*Current workflow cost*	$25,368.75
Hourly wage rate*	33.00		**Current annual cost**	$28,630
Annual occurrence of workflow	1			
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhanced Workflow Costs				
**These enhanced workflow costs have been estimated for one season of the boater program.*				
Hours to complete workflow after enhancement *(appointments)*	11.3	*This value represents the estimated number of times the workflow is completed multiplied by the time taken to complete the workflow once according to IS staff.*	*Enhanced workflow cost*	$294.23
Hourly wage rate*	26.00			
Hours to complete workflow after enhancement *(decontamination)*	16.2	*This value represents the estimated number of times the workflow is completed multiplied by the time taken to complete the workflow once according to EQ/Ranger staff.*	*Enhanced workflow cost*	$323.33
Hourly wage rate*	20.00			
Hours to complete workflow after enhancement *(BLA)*	141	*This value represents the number of times the workflow was completed in 2019 multiplied by the time taken to complete the workflow once.*	*Enhanced workflow cost*	$2,965.90
Hourly wage rate*	21.00		*One time equipment*	$2,587
Annual occurrence of workflow	1		**Enhanced annual cost**	$6,170.47
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhancement Production Costs and Savings				
Hours to complete enhancement	200.0	*This value represents the estimated number of hours spent on development; this adds up hours for GIS, EQ and EEA-IT time.*	**Enhancement cost**	$6,600.00
Hourly wage rate*	33.00		**Initial Annual Savings**	**$15,860**
Annual maintenance costs of enhancement***	$1,560.00	*The actual cost for three iPad data plans per year.*	**Future Annual Savings**	**$20,900**
Projected ROI				
			Initial Year ROI	**73%**
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost			**Future Annual ROI**	**164%**

Figure A-12: ROI study for the Quabbin Boat Seal Program.

Due to the importance of the BLA program and the extensive nature of this workflow update, a Return-on-Investment (ROI) analysis was performed to determine the savings that could be expected due to this workflow modernization (Figure A-11). The ROI showed that significant staff time was saved by eliminating manual data entry – time that can now be used to complete other, more important tasks. The ROI report also demonstrates how DWSP is seeing value from the investment EEA has made in all secretariat GIS programs.

Bird Harassment Program

This project modernized the Quabbin Bird Harassment Program (BHP), moving it away from a paper-based system and into a more streamlined and time efficient mobile data collection system. This updated workflow also enables real-time analysis, Dashboarding, and results in a Hub site that can serve as a centralized repository and access point for program information.

Software used - Survey123, Dashboards and Hub Sites.

Central to the development of this new workflow was the ability to create a standardized way to capture the nightly program's observation information and produce a daily report. The new workflow ensured a standard product and helped save staff time after completing their efforts to move birds away from critical areas on the reservoirs. A report template was developed in collaboration with EQ and CE staff that automatically generates a report at the end of each shift.

All the data is integrated in a Hub site which is available to DWSP or partner agencies, such as MWRA; various sections of the site are only visible if staff are logged into their AGOL account, while others are password protected for additional security and control of content. The Hub Site brings together disparate pieces of the BHP program into one place, making it easier for management and program participants to access important information and forms from one place. It is possible for users with proper credentials to access all BHP-related Survey123 forms, such as the BHP survey, the Quabbin Roost Count survey and the Reservoir Temperature/Bacteria Count surveys. The Hub site also includes a Dashboard of regional gull activity from the Natural Resources department, which helps provide a better overall picture of gull activity in Central Massachusetts. Staff are better able to make informed decisions with all this information together in one place.

An ROI study on the Bird Harassment Program's workflow showed future annual savings of over three-quarters of the current cost for data collection and distribution. (Figure A-12)

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)			
Hours to complete current workflow	1.2	Current workflow	$39.60
Hourly wage rate*	33.00	Current annual cost	$3,168
Annual occurrence of workflow	80		
Other workflow costs (consumables/travel exp., etc.)			
Enhanced Workflow Costs			
Hours to complete workflow after enhancement	0.5	Enhanced workflow	$16.50
Hourly wage rate*	33.00	Enhanced annual cost	$1,320
Annual occurrence of workflow	80		
Other workflow costs (consumables/travel exp., etc.)			
Enhancement Production Costs and Savings			
Hours to complete enhancement	30.0	Enhancement cost	$990.00
Hourly wage rate*	33.00	Initial Annual Savings	$858
Annual maintenance costs of enhancement, if any	$0.00	Future Annual Savings	$1,848
Projected ROI			
		Initial Year ROI	-6%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost		**Future Annual ROI**	80%

Figure A-13: ROI study for the Quabbin Bird Harassment Program.

Quabbin Park Cemetery

Software used - StoryMaps, Survey123, Dashboards, ArcGIS Pro, Experience Builder, Web AppBuilder, Field Maps, and Power Automate.

The Quabbin Park Cemetery, established between 1931 and 1932, was created as the final resting place for the remains from local cemeteries within the area of the proposed Quabbin Reservoir; ultimately there were 34 cemeteries with 7,613 graves removed. The majority of these graves, 6,601, were reinterred in Quabbin Park Cemetery, while the remainder were reinterred in surrounding town cemeteries by their respective families. DWSP manages the Quabbin Park Cemetery and maintains all associated historical records.

DWSP contracted GraVoc in early 2000 to develop a cemetery management system, which included digitizing over 12,200 index cards of burial and owner lot records. While this program was very helpful in updating new burials and owner lots, it was seldom used due to infrequent burials, there was no spatial component linking records to actual grave locations, no ability to view or enter information while in the cemetery, and there were annual software maintenance fees.

EEA has an Enterprise License Agreement with Esri to provide a suite of software services familiar to staff which includes the capability of linking tabular records to spatial features. DWSP decided to use this suite of software available through ArcGIS Online to rebuild the cemetery database. This update allows DWSP to utilize field data collection tools to manage records on interments, lot ownership and deeded lots. In addition, an online Cemetery database provides access to the public via online applications, allowing interested groups to query the database records to locate someone buried in the cemetery (a request made often by public advocates, such as the Friends of Quabbin and the Quabbin Watershed Advisory Council).

A suite of Survey123 forms, Dashboards and Power Automate notifications now allow Engineering, Maintenance and GIS staff to manage new and existing interments in the Cemetery database. A detailed workflow, data consistency checks within the Survey123 forms, and email notifications ensure that new interments are entered properly and are included within the authoritative Cemetery database. These tools also allow non-GIS users to enter, manage and interact with the Cemetery database through a web browser.

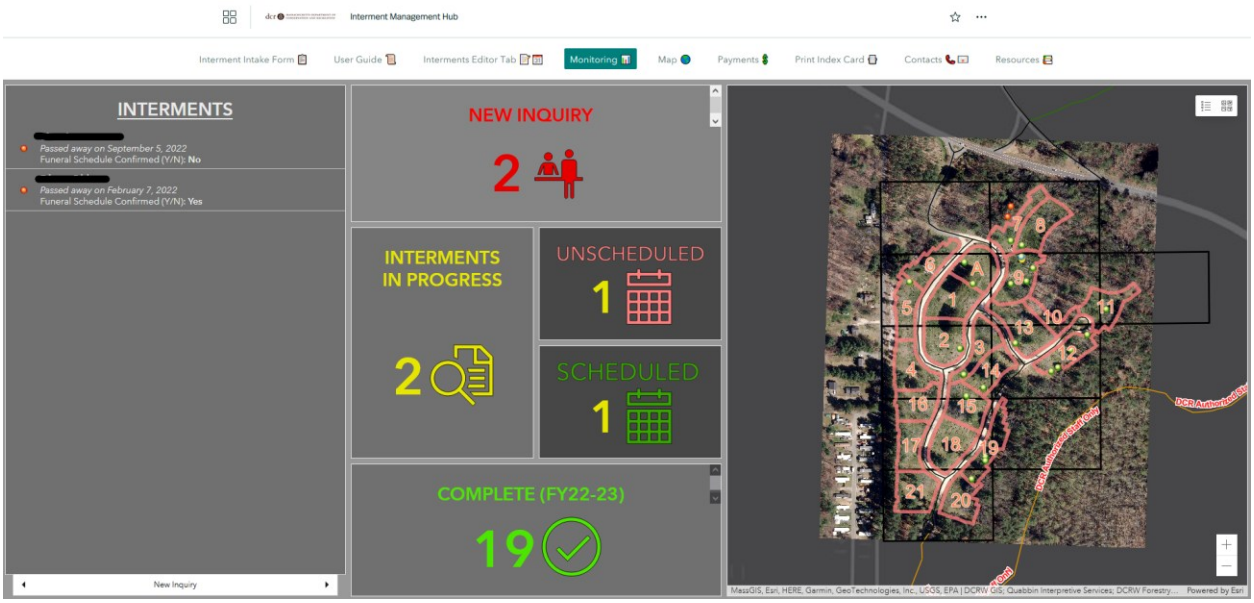

Figure A-14: The Monitoring dashboard from the internal Cemetery Interment Management Hub, which allows staff to review interments moving through the process from "new interment" to "completed interment."

A series of public-facing applications are also available which facilitate interaction and querying of the Cemetery database. Both map-centric (Web AppBuilder) and form-centric (Experience Builder) applications were configured to facilitate data searches. A new webpage was created to bring all these tools together into one location. Interpretive Services staff also collaborated with the GIS program to develop a Quabbin Park Cemetery Tour StoryMap. This immersive page provides a detailed tour of the cemetery that includes narrative, historic images, and an interactive map.

This project highlights how the GIS program can provide solutions to problems that are not necessarily GIS-specific. None of these cemetery related apps would have been possible without the work done to migrate the database into ArcGIS Online. Thinking creatively about how to utilize a range of software improved workflows, while also expanding access to information by stakeholders, partners, and the public.

Wachusett-Sudbury Employee Portal and Resources

Software used - Hub Site, Survey123, Dashboards, SharePoint, Power Automate and Power Apps.

The ArcGIS Online platform provides access to many tools that might not obviously fall under the GIS program's purview; however it is easy to create a website (using ArcGIS Hub) for a specific program, project, or purpose. Wachusett-Sudbury regional management collaborated with the GIS Program in late 2019 to develop an Employee Portal to replace the internal "DCR Intranet" that was used for sharing a variety of employee information. The timing was fortuitous, as the COVID-19 pandemic would make the Intranet largely inaccessible because it required a network connection (not available to most staff). The Employee Portal went live in January 2020

and provides all DWSP staff access to important tools, forms, and information through an internet connection. Credentials to either ArcGIS Online and/or a mass.gov account are required to access most of the information available on the Portal, ensuring that access is controlled and limited to only DWSP staff.

The Employee Portal integrates with other ArcGIS Online tools, including Survey123 Work Order Request, Time Off Request, and Boat Reservation forms; Work Order Status Dashboard; and various public-facing applications which are useful to staff. A series of password protected pages also provide staff with easy access to all their ArcGIS Online-based tools. Defining access to these pages through ArcGIS Online groups guarantees that the pages only become visible to logged-in users. The Employee Portal brings all these disparate elements together in one place, providing Wachusett-Sudbury staff with a useful home page.

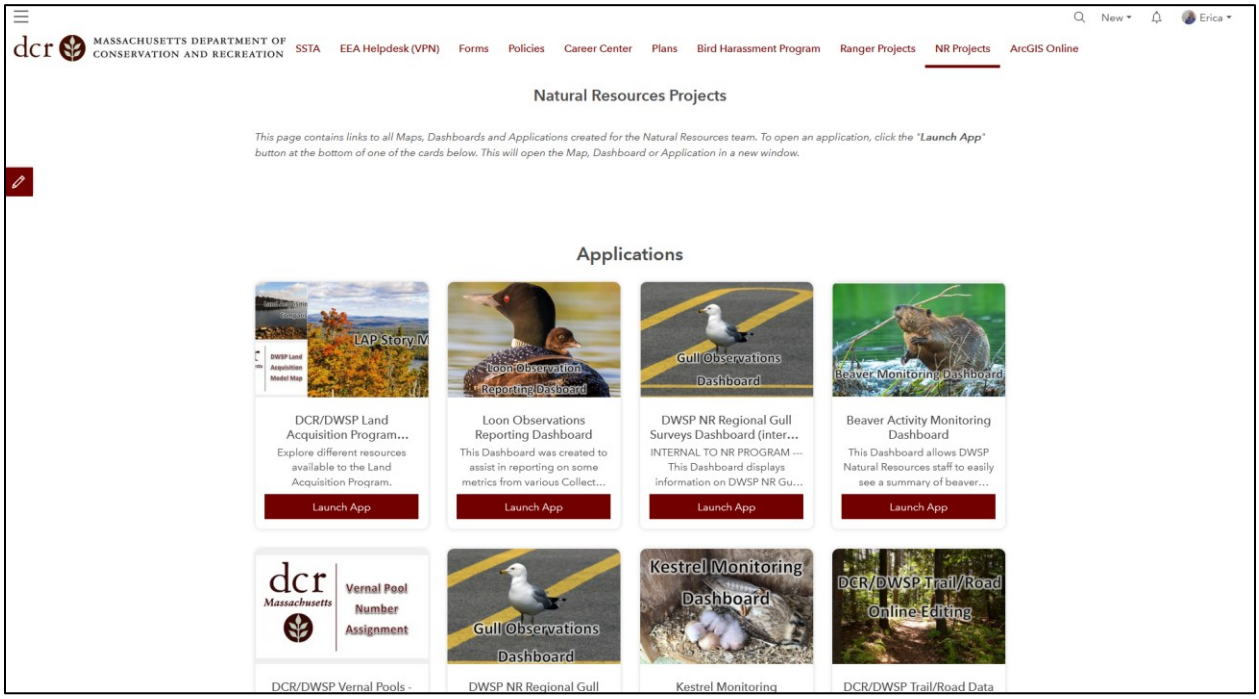

Figure A-15: Example of Natural Resources section project page; this and the 'Ranger Projects' pages are only accessible to subsets of users when they log in with their ArcGIS Online credentials.

Reservoir Surveys for Aquatic Invasive Species Monitoring

Software used - Field Maps and QuickCapture.

This project enables aquatic biologists to efficiently collect point locations or polygon areas, attributes and photos while conducting Aquatic Invasive Species reservoir surveys in a moving boat. QuickCapture was selected for this workflow, as this "big button" app is ideal for "at speed" data collection and requires few on-screen clicks for collecting basic attribute data and a photo. In addition, this same app can be used to simultaneously collect locations and information about native species encountered during the surveys. Field

Maps can be used to enter additional notes or information if required and for reference of previously collected data.

This project was the result of the GIS program helping Wachusett aquatic biology staff to realize their goal of quick and efficient data collection while conducting surveys in a moving boat. Due to the success of this data collection program, the Quabbin aquatic program also adopted this same workflow for conducting their reservoir surveys.

Figure A-16: The data collection screen of QuickCapture. Biologists adjust the density (top grey bar, currently set to 'Sparse') and then select a category and click a button to capture a point location or to start tracing a polygon area.

Lake Trout Modeling

Software used - ArcGIS Pro and Field Maps.

DWSP aquatic biologists complete lake trout surveys in the Wachusett Reservoir each October and November. Staff have a good idea of where to set nets during sampling based on their knowledge of the reservoir and lake trout spawning habits, but they realized it was possible there were additional desirable sampling locations that were being overlooked. A lake trout habitat suitability model was completed prior to 2017's sampling, using methodology developed by Bigelow & Hubert (2008), to better predict where spawning would likely occur. Suitability was modeled via an overlay analysis using five inputs in a Weighted Sum overlay.

Parameter	Weight
Fetch (*based on avg. direction past 5 season's wind directions*)	0.44
Slope (*between 3 and 25 percent*)	0.14
Depth (*areas ≤ 6.5m*)	0.28
Erosive Zone (*areas ≤ mud DBD 13.6297*)	0.07
Transition Zone (*1m buffer around erosive zone*)	0.07

Figure A-17: Model parameters and weights used to determine lake trout habitat suitability index. The result of this model was used to improve location selection for net sets.

The output of this model was a continuous raster layer for the entire reservoir and three polygon layers showing three classes of areas lake trout should find suitable for spawning. Biologists were better able to select locations for net sets during sampling with this analysis.

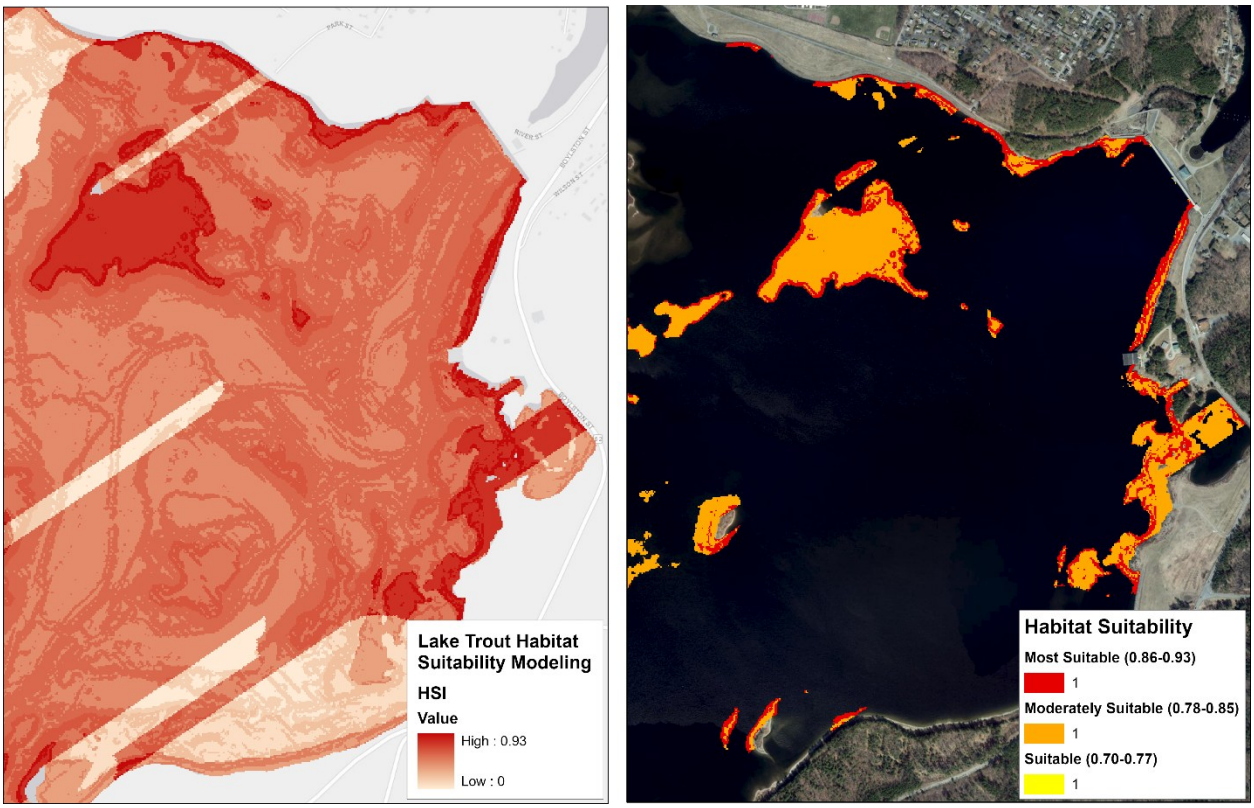

Figure A-18: Habitat suitability model (left) shows moderately and most suitable areas in darker red. By extracting values from habitat suitability model, areas of moderate suitability and most suitable areas are isolated (right).

The next step to streamline the data collection workflow occurred in 2019 by transitioning data collection from a combination of onboard sonar and paper forms to leverage Field Maps. This further enhanced the ability to plan net sets by providing the ability to view past net set locations while on the water. By collecting locations and catch data for each net, it was possible to standardize data collection efforts and to eliminate the need to transcribe data from paper forms. Field Maps also made it possible for all historic net set and catch data to be included in the new online database to ensure that all information was available during surveys.

A Return-on-Investment study was performed after the completion of this simple workflow migration. The ROI highlights how GIS can provide significant savings – almost 200 percent on an annual basis – on a relatively uncomplicated project. Small-scale projects such as this Lake Trout modeling make up the majority of projects undertaken by the GIS program; adding these efforts together demonstrates the positive financial impact of these new GIS based workflows.

Current Workflow Costs: (Enter values in left column (see wage notes below). Values in right column are calculated, no need to enter these values)				
Hours to complete current workflow	2.0	*This value represents the time taken to complete the original workflow one time.*	Current workflow cost	$66.00
Hourly wage rate*	33.00		Current annual cost	$462
Annual occurrence of workflow	7	*The number of times (nights) the LT survey is completed each year.*		
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhanced Workflow Costs				
Hours to complete workflow after enhancement	0.5	*This value represents the time taken to complete the workflow after the enhancement.*	Enhanced workflow cost	$16.50
Hourly wage rate*	33.00		Enhanced annual cost	$116
Annual occurrence of workflow	7			
Other workflow costs (consumables/travel exp., etc.)	$0.00			
Enhancement Production Costs and Savings				
Hours to complete enhancement	2.3	*Time taken to set up Collector map, including initial meeting (.5), schema development (.5), depolyment (.75) and revision time (.5).*	Enhancement cost	$75.90
Hourly wage rate*	33.00		Initial Annual Savings	$271
Annual maintenance costs of enhancement, if any	$0.00		Future Annual Savings	$347
Projected ROI				
			Initial Year ROI	102%
ROI=Savings minus Enhancement Cost divided by Enhancement Cost plus Enhanced Annual Cost			**Future Annual ROI**	181%

Figure A-19: ROI study for the Lake Trout workflow migration from a paper-based data collection workflow to leverage Field Maps.