MASSACHUSETTS
watershed·based plans

DRAFT FOR PUBLIC REVIEW

WATERSHED-BASED PLAN

Keyup Brook
Within the Towns of Erving and Northfield, MA

November 2023

Prepared By:

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Prepared For:

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

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Executive Summary

Introduction

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present the information in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans. This WBP was developed by the Franklin Regional Council of Governments (FRCOG) with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP).

This WBP was prepared for the Keyup Brook watershed, which is in the towns of Northfield and Erving. Keyup Brook is approximately 5 miles long and has a watershed area of 4,545 acres. Its headwaters are the Great Swamp in predominantly forested Northfield State Forest. The brook flows alongside roads and through developed areas for about 1.25 miles before its confluence with the Millers River. In its final half mile, the brook channel is highly modified and flows through the middle of the moderately developed village of Erving Center.

Impairments and Pollution Sources

Keyup Brook is a Category 5 water on the 2018/2020 Massachusetts Integrated List of Waters 303(d) list due to bacteria and PCBs in fish tissue. Although no source tracking sampling was done to determine the source of the bacteria loading detected in water samples collected in 2005, one potential source may have been a failed septic system located on Gulf Road at the headwaters to Jacks Brook. This situation was remedied in 2006 according to the Chair of the Northfield Board of Health.[1] Agriculture is almost nonexistent in the watershed and sewer is not thought to be an important source of bacteria loading from residential areas due to recent work on the sewer collection. If bacteria concentrations are still elevated in Keyup Brook, the likely sources would be old septic systems on Gulf Road in Northfield (<10), forest areas, and areas with beaver activity, and residential/commercial areas with outdoor pets.

Anecdotal and field investigation evidence suggests that the Keyup Brook experiences high volumes of sediment loading due to both ongoing channel erosion and infrequent but severe channel erosion events. Hydromodification of the lower watershed is a suspected cause of erosion and sediment loading in the lower watershed. The channel has been constricted by development, forcing a large volume of water from the upland to pass through a narrow channel. During intense storm events in which the brook level rises and flow increases, this constriction creates more stream and sediment power and erosive force in the brook, which can scour the channel and banks and dislodge sediment. To reduce the volume of water reaching the lower watershed, management measures may have to be implemented throughout the watershed. PCBs in fish tissue are not addressed in this WBP.

The brook is an FY 2022 319 priority watershed with a 2022 319 RPI score of 58.5.

Goals, Management Measures, and Funding

Water quality goals for this WBP are focused on reducing bacteria and sediment loading to Keyup Brook. This WBP includes an adaptive sequence to establish and track specific water quality goals. An interim goal has been

[1] Email communication with David Balk, Northfield Board of Health Chair, September 1, 2023.

established to reduce bacteria loading by 24% from the highest geomean recorded in 2005 in the next five years. The 24% bacteria reduction goal corresponds with the target set in the draft *Massachusetts Statewide TMDL for Pathogen-Impaired Inland Freshwater Rivers*. A second interim goal has been established to reduce sediment loading by 12.5 tons in the next five years.

It is expected that goals will be accomplished primarily through a) a comprehensive study of the hydrologic/hydraulic/geomorphic characteristics of the watershed, b) installation of structural best management practices (BMPs) to capture runoff and reduce pollutant loading, c) implementation of non-structural BMPs (e.g., road and BMP management, zoning), and c) watershed education and outreach. Structural BMPs installation will be preceded by engineering studies to determine the location for and types of priority BMPs.

It is expected that funding for management measures will be obtained from a variety of sources including grant funding, Town funds, volunteer efforts, and other sources.

Public Education and Outreach

Public education and outreach will be aimed at educating Erving Town staff, students, residents, and business owners, and Northfield Town staff and Jacks Brook watershed residents about the health of the Keyup Brook watershed, including the potential sources of nonpoint source pollution (contaminants released in a wide area rather than from one single source, such as a pipe) and fluvial geomorphic impairments (disturbance to stream channel shape, water flow, and sediment movement in a stream channel). Education and outreach will help to promote a comprehensive approach to ongoing stormwater management, including road BMPs and residential BMPs.

These public education and outreach goals can be achieved by engaging Erving and Northfield Town staff, watershed residents, and businesses within the watershed by incorporating watershed planning into other of Town planning arenas, such as transportation infrastructure planning, as well as by appropriate educational materials and online resources, informational signage and tours at BMP locations, and a variety of other means. It is expected that these programs will be evaluated by tracking attendance events and other tools applicable to the type of outreach performed.

Implementation Schedule and Evaluation Criteria

The WBP outlines milestones for applying for grants, further assessment, outreach and education, monitoring, BMP development and implementation, and operation and maintenance plans.

This WBP recommends that the Massachusetts Water Quality Monitoring program conduct water quality testing in Keyup Brook. It also recommends that the Millers River Watershed Council expand its water quality monitoring program to Keyup Brook under a DEP-approved QAPP. Indirect evaluation metrics are also included, such as the number of BMPs installed, hours/miles of road management, and BMP management. The long-term goal of this WBP is to delist Keyup Brook from the Massachusetts Integrated List of Waters 303(d) list, as well as to greatly reduce the amount of stormwater and mobilized sediment entering the brook.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to identify past and current water quality conditions and known and likely causes and sources of nonpoint source pollution in your watershed. It will also help interested parties to recognize data gaps, prioritize the NPS problems, identify appropriate best management practices and watershed-based strategies for addressing the problems, and develop proposals to fund the work using 319 nonpoint source competitive grant funds or similar programs. The goal of WBPs and projects aimed at reducing nonpoint source pollution is to restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA's) recommended format for "nine-element" watershed plans, as described below.

All states are required to develop WBPs, but not all states have taken the same approach. Most states develop WBPs only for selected watersheds. MassDEP's approach has been to develop a tool to support statewide development of WBPs so **that good projects in all areas of the state may be eligible for federal watershed implementation grant funds** under Section 319 of the Clean Water Act.

EPA guidelines promote the use of Section 319 funding for developing and implementing WBPs. WBPs are required for all projects implemented with Section 319 funds and are recommended for all watershed projects, whether they are designed to protect unimpaired waters, restore impaired waters, or both.

This WBP includes nine elements (a through i) in accordance with EPA Guidelines:

a) An **identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this WBP and to achieve any other watershed goals identified in the WBP, as discussed in item (b) immediately below.

b) An **estimate of the load reductions** expected for the management measures described under paragraph (c) below, recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time.

c) A **description of the nonpoint source (NPS) management measures** needed to achieve the load reductions estimated under paragraph (b) above as well as to achieve other watershed goals identified in this WBP and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d) An **estimate of the amounts of technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, United States Department of Agriculture's (USDA's) Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant federal, state, local, and private funds that may be available to assist in implementing this plan.

e) An **information/education component** that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f) A **schedule for implementing the NPS management measures** identified in this plan that is reasonably expeditious.

g) A description of **interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

h) A set of **criteria to determine if loading reductions are being achieved** over time and substantial progress is being made toward attaining water quality standards and, if not, the criteria for determining whether this WBP needs to be revised or, if a NPS total maximum daily load (TMDL) has been established, whether the TMDL needs to be revised.

i) A **monitoring component** to evaluate the effectiveness of the implementation efforts over time measured against the criteria established under item (h) immediately above.

General Watershed Information

This WBP was prepared for waterbodies located within the Keyup Brook watershed in Northfield and Erving, which is a 2020 604b priority watershed with a Recovery Potential Index score of 58.5. [2] These waterbodies include Keyup Brook (MA35-16) and its tributary, Jacks Brook (MA35-31). The entire watershed measures 4,545 acres.

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID):	Jacks Brook (MA35-31); Keyup Brook (MA35-16)
Major Basin:	Millers River
Watershed Area (within MA):	4,545 (ac)

[2] The Recovery Potential Screening Tool was developed by the U.S. EPA Office of Water to support prioritization planning for watershed restoration and protection Massachusetts. Recovery potential is the likelihood of an impaired water to attain a desired condition given its ecological capacity, exposure to stressors, and the social context affecting restoration efforts. Scoring higher on the index suggests a waterbody can recover quickly from the impairment.

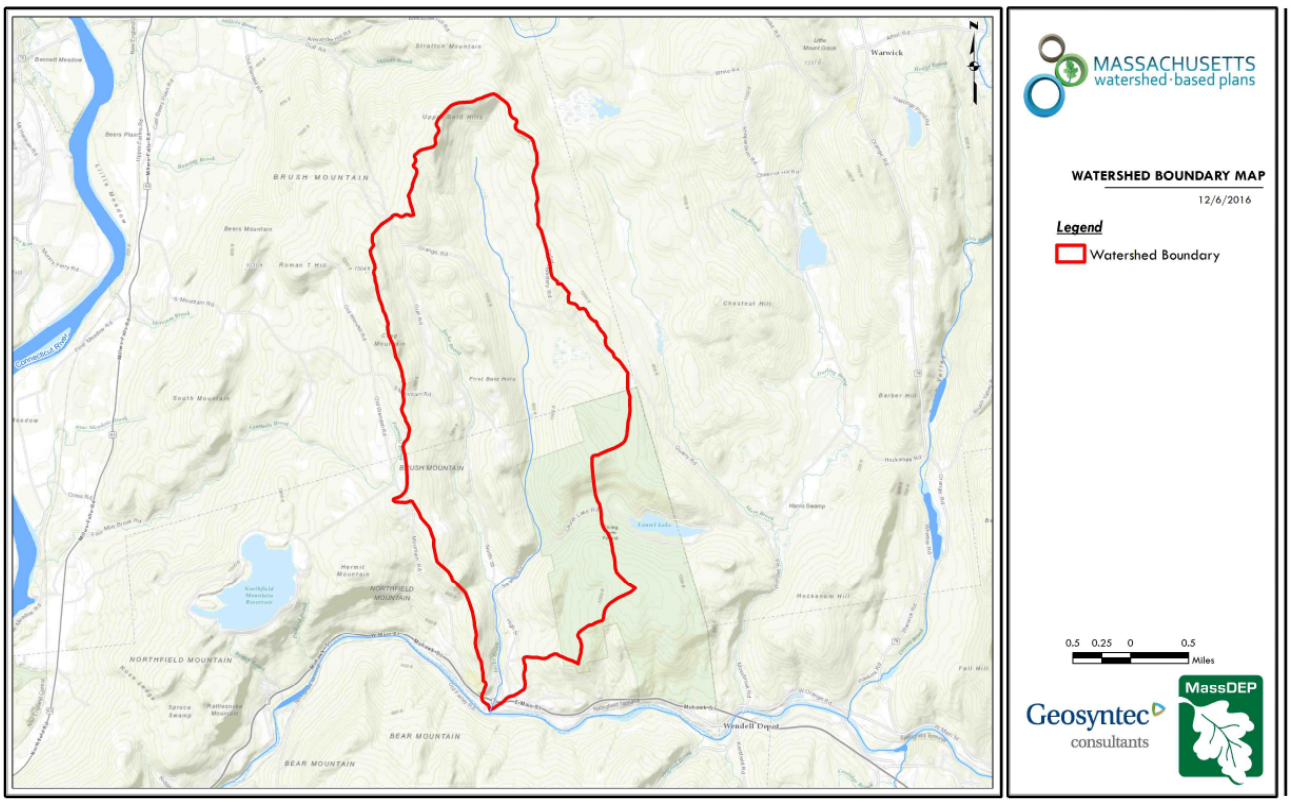

Figure 1: Watershed Boundary Map (MassGIS, 2007; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Ctrl + Click on the map to view a full-sized image in your web browser

Keyup Brook originates in the Great Swamp in the Northfield State Forest and flows south (Figure 1). It is met by Damon Brook in the Erving State Forest. Jacks Brook flows south parallel to North Street/Gulf Road, meeting Keyup Brook just north of the Swamp Road bridge, near the intersection with North Street in Erving. The last half mile of Keyup Brook flows through a straight, armored, and narrow modified channel through the moderately populated village of Erving Center. The brook discharges into the Millers River after flowing along the eastern edge of Riverside Park. Keyup Brook itself is about five miles long.

Figure 2 shows how Keyup and Jacks Brooks flow through relatively narrow valleys surrounded by high-elevation hills. Jacks Brook flows south between the Bald Hills and Brush Mountain, where there is a nearly 600-foot elevation difference between the brook and the Brush Mountain ridge. The wider valley that characterizes the upper watershed of Keyup Brook in the Northfield State Forest narrows between the Bald Hills and other hills in the northeast corner of Erving, flowing through a highly constricted valley along Swamp Road before it meets Jacks Brook.

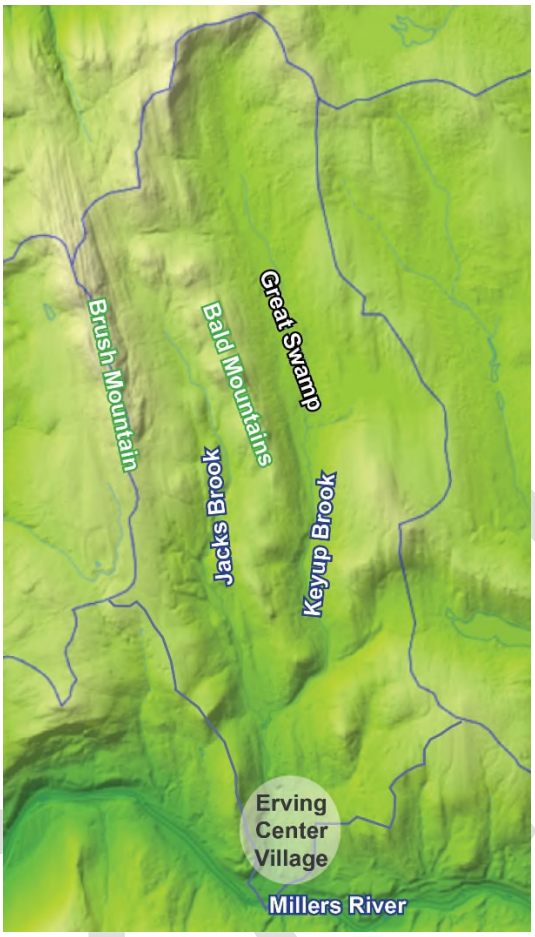

Figure 2: Major topographical features in the Keyup Brook Watershed

The watershed is over 90% forested. The upper watershed is heavily forested and very sparsely populated. There have been two forestry projects in the watershed in the last several years. There is no agricultural activity in the watershed beyond backyard animals, if any.

Around 3,650 acres (80% of the watershed) is permanently protected as Northfield and Erving State Forests or as municipal open space (see Figure A-3). Jacks Brook and Keyup Brook and the adjoining wetlands are Coldwater Fisheries Resources and are BioMap2 Aquatic Core Habitat. The wetland forming the headwaters of Damon Brook is recognized as a BioMap2 Core Habitat wetland. Fish surveys in the 1990s and 2000s identified brook trout, brown trout, blacknose dace, longnose dace, white sucker, and pumpkinseed in the Keyup Brook.[3] There are no NHESP-recognized Priority Habitats or Natural Communities in the watershed.

The catchment area for Keyup Brook is 0 to 3% impacted by groundwater withdrawal, suggesting that low flow resulting from groundwater withdrawal is not driving high pollutant concentrations where they are occurring.

[3] MassDEP 2004

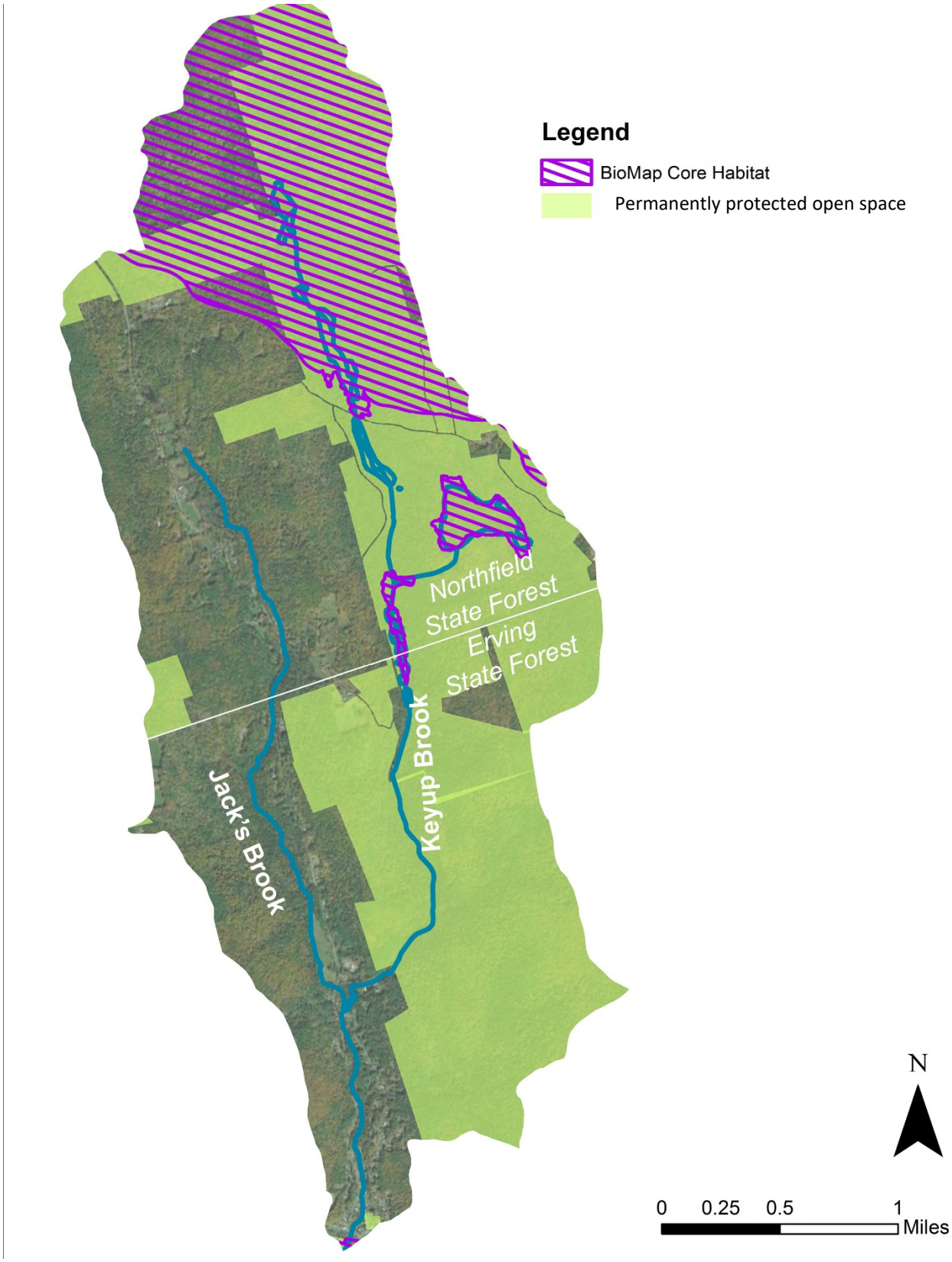

Figure A-3: Watershed Protected Open Space and BioMap areas (MassGIS 2023a; MassGIS 2023b)

Description of the Problem

The watershed is listed as impaired for *Escherichia coli* (*E. coli*) based on data collection from 2005. Additionally, sediment mobilization resulting from moderate and severe bank erosion is impacting both Keyup Brook and the Millers River.

The origin of the *E. coli* impairment is unknown. The watershed is predominantly forested. With the exception of a few residences, all buildings in the Erving portion of the watershed are on a sewer system not known to have any issues. There are no known septic issues at residences in the Northfield portion of the watershed, which are all on Jacks Brook. Wild animals and dog waste are possible sources of the bacteria.

Keyup Brook has limited access to its floodplain along parts of its reach due to channel incision. Steep topography and thin soil cover likely contribute to large amounts of runoff to the brook. Steep topography and roads constrain the stream channel in parts of the upper watershed, contributing to a concentrated flow in the brook channel during high precipitation and snowmelt events. In the middle and lower watershed, a mix of topography, roads, retaining walls, and other bank-armoring materials composed of fieldstone, rock, riprap, cement, and other materials confine the channel. Where the channel has been hardened, the brook is incised and bank heights are often too high to allow the brook access to its floodplain.

There is one dam and a number of weirs on Keyup Brook. The privately owned Pete's Pond Dam (a.k.a. Krusiewick Pond Dam) is located off Swamp Road near the intersection with High Street. The pond was historically deeper than it is today and was once stocked with fish and used as an ice pond. Sedimentation of the pond has made the pond very shallow, indicating that the dam and wetland vegetation are holding back a large amount of sediment. During heavy rains, water regularly overflows the pond, circumventing the dam structure entirely. The dam is considered a flood hazard risk by the Town.

Localized inundation flooding and fluvial erosion frequently occur along Keyup Brook (see Figure 4). According to the Erving Hazard Mitigation Plan, inundation flooding has been a problem where the brook intersects Laurel Lake Road and where it runs into the Millers River, the latter of which may be related to the accumulation of debris in the brook under bridges. In the last 20 years, heavy spring runoff has also flooded the area of Hanson Court and flash flooding has washed out parts of North Street.[4] In 2000, state biologists noted a large area of fluvial erosion next to a house along Swamp Road on the brook's southern bank while fish sampling (WM13KEYa). The sedimentation created by the erosion was said to be seriously compromising fish habitat integrity.[5] In December of 2019, a wintertime flood sent large sheets of ice from Pete's Pond down Keyup Brook where they settled on some residential properties. On July 18, 2021, Erving Center experienced a 6-inch rainfall that brought Keyup and Jacks Brooks to flood stage, causing extensive bank erosion and damage to infrastructure (Figures 4a through d). Fluvial erosion during this event caused structural damage to both the Swamp Road and Church Street bridges. At a ninety-degree turn in the river a short distance upstream of the Swamp Road bridge, mass streambank failure along North Street came within three feet of the sewer pipe located under the road. The Swamp Road bridge was entirely removed and the Town is currently studying replacement feasibility and waiting on answers about grant funding. The upstream embankment has been re-

[4] Town of Erving 2020
[5] MassDEP 2004, 142

stabilized with riprap (Figures 4e and f). The storm caused additional fluvial erosion along the steep rocky embankments and retaining walls that channelize Keyup Brook as it flows through Erving Center parallel to North Street. The foundations of a number of occupied and unoccupied houses in this section are within feet of the eroding bank and retaining walls. The foundation of a house on Hanson Court collapsed inward. The Church Street bridge is slated to be replaced and reopened to two-way traffic in 2025

Flooding and fluvial geomorphic instabilities can increase sediment loading and transport rates in waterways, which contributes to turbidity, suspended solids, and physical substrate habitat degradation. Figures 4a through 4f of bank instability and active erosion along Keyup Brook demonstrate ongoing fluvial geomorphic instabilities, which represent serious risk to public infrastructure and private property and threats to water quality.

Figure 4a: Bank and wall erosion adjacent to Hanson Court, facing east

Figure 4b: Bank erosion downstream side of Route 2 bridge, east bank

Figure 4c: Bank and wall erosion downstream side of Route 2 bridge, W bank

Figure 4d: Bank erosion in lower left corner at Church Street residence, facing north; note the hole in the lawn behind the retaining wall

Figure 4e: Swamp Road bridge removed after structural damage, west bank

Figure 4f: Riprap placed along North Street after extensive damage to road shoulder, in which bank erosion came within three feet of a sewer main; the former Swamp Road bridge abutments are in the photo background

Figure 4: Erosion along the Keyup Brook

Community Concerns

Individuals in the watershed are concerned about the incidence and future risk of erosion and sedimentation in the watershed. Residents living in the Keyup Brook watershed are concerned about the threats to water quality and habitat caused by excessive sediment transport and sedimentation. Residents whose properties border Keyup Brook both within and outside the Erving Center village are worried about the response of Keyup Brook to heavy rain events and the damage scouring and erosion has done to transportation infrastructure and structural channel walls in the village. There is concern that future flood events could damage not only roads and houses, but also the historical Pearl B. Care Engine House building and the Route 2 bridge.

Some residents are disappointed that Pete's Pond continues fill with sediment and display wetland characteristics, as they would like it to continue to be available for recreation purposes. There are also questions about the ecological and flood hazard impacts of the pond's transition to wetland.

Town staff would like to see watershed residents build their understanding of the causes of the brook's instability, how unmanaged stormwater contributes to bacteria, nutrient, and sediment pollution, and the types of solutions that are going to be most effective for protecting water quality and infrastructure in the long term, as heavy precipitation events become more frequent with climate change.

Summary of Completed and Ongoing Work

The FRCOG has completed a drainage structure and bridge assessment for the Town of Erving, which included stormwater drains (a.k.a catch basins), drainage and stream-crossing culverts, and summaries of the MassDOT bridge reports. Each point is mapped and rated for condition.[6]

A 100,000-gallon fire suppression water storage tank under the field at Riverfront Park is supplied by an inlet pipe in Keyup Brook. Although not designed for this purpose, the tank may serve to settle out a small amount of sediment and debris, as the Town has had to clean the tank since its installation.

The Town installed a playground in Riverfront Park that transitions into a stormwater management treatment train that discharges to the Millers River. Though not technically in the Keyup Brook watershed, the area has treated the floodwaters coming from Keyup Brook during major storm events (e.g. the July 2021 flood) in addition to treating runoff from the Park's fields and parking lot. It also demonstrates the Town's interest in protecting its waterways through stormwater management.

The Town cleans its catch basins on a rotating schedule and facilitates street sweeping once a year in spring. Plowed snow is rarely removed. Some sand and road salt is stored within the watershed in a shed behind the First Station. Most of the town's road material is stored at the Highway Department's facilities outside of the watershed.

Erving is an MVP Community eligible for funding that can leverage 319 and 604(b)-funded work.

[6] FRCOG 2019 ArcOnline Erving Culvert and Bridge Assessment

Watershed Based Plan Development

Project Partners and Stakeholder Input

This WBP was developed by the Franklin Regional Council of Governments (FRCOG) with input from and in collaboration with the Town of Erving and MassDEP. This WBP was developed using funds from the Section 319 program to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool. The FRCOG was the recipient of Section 319 funding in Fiscal Year 2020 to serve as the Regional Nonpoint Source Coordinator for Franklin County for the purpose of developing competitive s.319 Nonpoint Source Pollution grant proposals.

Assistance was given by the following plan development group:

- Town of Erving:
  - Mariah Kurtz, *Town Planner*
  - Bryan Smith, *Town Administrator*
  - Peter Sanders, *Water and Wastewater Superintendent*
  - *Erving Conservation Commission*
  - *Erving Board of Health*
  - *Erving Recreation Commission*
- Connecticut River Conservancy:
  - Andrea Donlon, *River Steward (through 2022)*
- Millers River Watershed Council:
  - Ivan Ussach, *Director*
- MassDEP:
  - Padmini Das, *Nonpoint Source Pollution Section Chief*
  - Malcolm Harper, *319 Grant Program Manager*
  - Judith Rondeau, *Nonpoint Source Watershed Specialist and Outreach Coordinator*
  - Meghan Selby, *604b Grant Program Manager*
  - Matthew Reardon, *TMDL Program Manager*

This WBP was developed as part of an iterative process. An initial conversation was held with Erving Town Planner Mariah Kurtz to establish some of the goals of the plan. FRCOG staff then collected and reviewed existing data on the watershed to develop a preliminary WBP. In November 2021, FRCOG staff completed a walking and driving tour of the watershed with the Town Planner and wrote up observations in the *FRCOG Nonpoint Source Field Assessment of the Keyup Brook Watershed*. In January 2022, FRCOG staff met with multiple Town staff to discuss the FRCOG's field observations and discuss opportunities for locating BMPs. In August 2022, MassDEP staff reviewed a draft of the plan and FRCOG staff incorporated feedback. In September 2022, FRCOG staff completed a second field walk with Erving Town Planner Mariah Kurtz. In August 2023, FRCOG staff presented the plan to the Erving Conservation Commission, Erving Board of Health, and Erving Recreation Commission. A completed first draft of the plan was shared with the Town in August 2023. Outreach to watershed residents consisted of a presentation and field walk in October, and a public review period that ran from November 1st to December 1st. Revisions were completed in December to reflect Town and community feedback. A final plan was submitted to MassDEP in December 2023.

While the FRCOG worked with the aforementioned groups and individuals on the drafting of the plan, the FRCOG reached out to a broad range of interested parties during the public review period, including Erving residents, DCR, and the Town of Northfield . The Town will want to continue broader outreach and input into the plan and implementation in the future to ensure the support of public and private landowners.

Water Quality Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's WBP Tool and supplemented by data from additional studies and a watershed field investigation, including:

- FRCOG (Franklin Regional Council of Governments). *Nonpoint Source Field Assessment of Keyup Brook*. November 9, 2021 and September 15, 2022. Accompanied by Town Planner Mariah Kurtz.

  This assessment was created to support the Keyup Brook WBP and is included in Appendix A

- MassDEP (Massachusetts Department of Environmental Protection). Underground Storage Tank Facility Search database. Last accessed 1/4/2021. https://ma-ust.windsorcloud.com/ust/facility/search?1

- MassDEP (Massachusetts Department of Environmental Protection). 2004. *Millers River Watershed 2000 Water Quality Assessment Report*. Report Number 35-AC-1. CN089.0. MassDEP, Massachusetts Division of Watershed Management, Watershed Planning Program, Worcester, MA. https://www.mass.gov/doc/millers-river-watershed-water-quality-assessment-report-2000-s-1/download

- MassDEP (Massachusetts Department of Environmental Protection). 2012. Technical Memorandum: Millers River Watershed 2005 DWM Water Quality Monitoring Data. TM 35-10. MassDEP, Massachusetts Division of Watershed Management, Watershed Planning Program, Worcester, MA. https://www.mass.gov/doc/technical-memorandum-cn-2222-millers-river-watershed-2005-dwm-water-quality-monitoring-data/download

- MassDEP (Massachusetts Department of Environmental Protection). 2020. *Water Quality laboratory data, 2005-2020*. https://www.mass.gov/guides/water-quality-monitoring-program-data. Last accessed 1/4/2022.

- MRPC (Montachusett Regional Planning Commission) and FRCOG (Franklin Regional Council of Governments). 2002. *Assessment of Non-Point Source Pollution for the Millers River Watershed in Massachusetts*. Nonpoint Source Project Number 2000-03/604. Prepared for the Massachusetts Department of Environmental Protection and US Environmental Protection Agency, Region 1.

Element A: Identify Causes of Impairment & Pollution Sources

Element A: Identify the causes and sources or groups of similar sources that need to be controlled to achieve the necessary pollutant load reductions estimated in the watershed based plan (WBP).

Water Quality Impairments

Waterways or bodies with weakened water quality are considered impaired. In the context of water quality regulation, impaired waters are those listed by MassDEP under Section 303(d) of the Clean Water Act as impaired by a pollutant, such as a pathogen or nutrient, or by other kinds of alterations, such as temperature or low flow. Known water quality impairments, as documented in the Massachusetts Department of Environmental Protection (MassDEP) 2022 Draft Massachusetts Integrated List of Waters,[7] are listed in Table A- . Impairment categories from the Integrated List are as follows in Table A-2:

Table A-1: 2022 MA Integrated List of Waters Categories

Integrated List Category	Description
1	Unimpaired and not threatened for all designated uses.
2	Unimpaired for some uses and not assessed for others.
3	Insufficient information to make assessments for any uses.
4	Impaired or threatened for one or more uses, but not requiring calculation of a Total Maximum Daily Load (TMDL), including: 4a: TMDL is completed 4b: Impairment controlled by alternative pollution control requirements 4c: Impairment not caused by a pollutant - TMDL not required
5	Impaired or threatened for one or more uses and requiring preparation of a TMDL.

Table A-2: Water Quality Impairments (MassDEP 2022)

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA35-16	Keyup Brook	5	Fish Consumption	PCBs In Fish Tissue	Contaminated Sediments
MA35-16	Keyup Brook	5	Fish Consumption	PCBs In Fish Tissue	Releases from Waste Sites or Dumps

[7] MassDEP 2022

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA35-16	**Keyup Brook**	**5**	Primary Contact Recreation	Escherichia Coli (*E. coli*)	Source Unknown
MA35-31	**Jacks Brook**	**5**	Fish Consumption	PCBs In Fish Tissue	Contaminated Sediments
MA35-31	**Jacks Brook**	**5**	Fish Consumption	PCBs In Fish Tissue	Releases from Waste Sites or Dumps

Water Quality Goals

A water quality goal is a quantitative or qualitative target pollution level in a water body. Water quality goals may be established for a variety of purposes, including the following:

a.) For **water bodies with known impairments**, a Total Maximum Daily Load (TMDL) is established by MassDEP and the United States Environmental Protection Agency (USEPA) as the maximum amount of the target pollutant that the waterbody can receive and still safely meet water quality standards. If the waterbody has a TMDL for total phosphorus (TP) or total nitrogen (TN), or total suspended solids (TSS), that information is provided below and included as a water quality goal.

b.) For **water bodies without a TMDL for total phosphorus** (TP), a default water quality goal for TP is based on target concentrations established in the Quality Criteria for Water (USEPA, 1986) (also known as the "Gold Book"). The Gold Book states that TP should not exceed 50 µg/L in any stream at the point where it enters any lake or reservoir, nor 25 µg/L within a lake or reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 µg/L as the TP target for all streams at their downstream discharge point, regardless of which type of water body the stream discharges to.

c.) Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013) prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. Keyup Brook watershed is a Class 'B' waterbody (see Table A-4). The water quality goal for fecal coliform bacteria is based on the Massachusetts Surface Water Quality Standards.

Table A-3: Surface Water Quality Classification by Assessment Unit

Assessment Unit ID	Waterbody	Class
MA35-16	Keyup Brook	B
MA35-31	Jacks Brook	B

d.) **Other water quality goals set by the community** (e.g., protection of high-quality waters, in-lake phosphorus concentration goal to reduce recurrence of cyanobacteria blooms, etc.).

Table A-4: Water Quality Goals

Pollutant	Goal	Source
Bacteria	**Class B Standards** For non-bathing waters: For *E. coli*, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml (typically based on min. 5 samples) and no single sample shall exceed 235 colonies/100 ml.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)
Total Suspended Solids	**Class B Standard** These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair anyuse assigned to this Class, that would cause aesthetically objectionable conditions, or that would impair the benthic biota, or degrade the chemical composition of the bottom.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)

Note: *There may be more than one water quality goal for bacteria due to different Massachusetts Surface Water Quality Standards Classes for different Assessment Units within the watershed.*

MassDEP Water Quality Assessment Report

A Water Quality Assessment Report is a detailed report on the condition of a watershed that assesses watershed conditions, perceived problems, and provides recommendations for each MassDEP-defined stream segment of a watershed. The section below summarizes the findings of the Millers River Watershed 2000 Water Quality Assessment Report that relate to water quality and water quality impairments. Select excerpts from this document relating to the water quality in the watershed are included below (note: relevant information is included directly from these documents for informational purposes and has not been modified).

Millers River Watershed 2000 Water Quality Assessment Report (MA35-16 - Keyup Brook)

AQUATIC LIFE

Habitat and Flow

A total of three stream reaches in Keyup Brook were surveyed by DWM biologists as part of the MA DEP biocriteria development project in September 1996 and/or September 2000 (Appendix A, Table 13). The most upstream reach sampled was downstream from the intersection of Swamp Road with Laurel Lake Road in Erving (station WM13KEY). In September 2000 the brook was approximately 4m wide with riffle/run and pool habitats approximately 0.1 and 0.25 m deep, respectively. There was some slight erosion noted on the one bank. Habitat quality during this survey appeared to be most limited by the amount of water (brook was shallow and the channel was not full). The next downstream reach was sampled on 19 September 2000. This reach was located upstream from the confluence with Jacks Brook and downstream from the first Laurel Lake Road crossing in Erving (station WM13KEYa). Here the reach was comprised of pool, riffle, and run habitat of a moderate gradient. A large area of erosion, however, was noted upstream of the sampling reach next to the driveway of a house and barn on the streams southern bank. This erosion was seriously compromising habitat integrity (sedimentation) of the reach surveyed (MA DEP 2000b). The most downstream reach sampled was located downstream from the Jacks Brook confluence in Erving (station WM11KEY) on 11 September 1996.

Biology

As part of the MA DEP biocriteria development project benthic macroinvertebrate samples were collected by DWM biologists from two reaches of Keyup Brook; downstream from the intersection of Swamp Road with Laurel Lake Road in Erving (station

WM13KEY) on 11 September 1996 and on 11 September 2000 and the second reach downstream from the confluence with Jacks Brook in Erving (station WM11KEY) on 11 September 1996 (Appendix A, Table 13). No RBP III analyses have been conducted on these data.

Fish population sampling was also conducted by DWM in these two reaches in Keyup Brook on 26 September 1996. The fish population sample in Keyup Brook (station WM13KEY) was comprised entirely of native brook trout while the downstream reach (WM11KEY) was comprised, in order of abundance, of blacknose dace (Rhinichthys atratulus), longnose dace (Rhinichthys cataractae), Salmo trutta (brown trout), white sucker (Catostomus commersoni) and an individual brook trout (Salvelinus fontinalis) (Appendix A, Table 13). On 19 September 2000 fish population sampling was conducted in the brook upstream from the confluence with Jacks Brook and downstream from the first Laurel Lake Road crossing in Erving (station WM13KEYa) by MA DEP DWM biologists. Blacknose dace (Rhinichthys atratulus) dominated the fish sample, while brook trout (Salvelinus fontinalis), brown trout (Salmo trutta) and white sucker (Catostomus commersoni) were also present (Appendix A, Table 13). All fish collected were fluvial specialists or fluvial dependant species. MA DFWELE also conducted fish population sampling in Keyup Brook in the vicinity of the intersection of Swamp Road with Laurel Lake Road in Erving (DWM station WM13KEY) using backpack shocking on 30 August 30 2000. A total of 76 fish represented by 4 species were collected. Fish species present, in order of abundance, included: brook trout (Salvelinus fontinalis), pumpkinseed (Lepomis gibbosus), white sucker (Catostomus commersoni) and blacknose dace (Rhinichthys atratulus). The dominant species was brook trout (n = 71). The presence of multiple age classes of brook and brown trout is indicative of excellent water and habitat quality.

Chemistry - water
In-situ measurements (DO, %saturation, pH, temperature, conductivity, and turbidity) of Keyup Brook downstream from the intersection of Swamp Road with Laurel Lake Road in Erving (station WM13KEY) were made on 26/27 September 1996 (Appendix A, table 8). Although not representative of worse-case (pre-dawn) conditions DO and oxygen saturation in the brook was good. The pH of the brook was extremely low at the upstream sampling station (4.6 and 4.9 SU) and was higher (6.0 SU) in the sampling reach downstream from the confluence with Jacks Brook in Erving (station WM11KEY).

The Aquatic Life Use is assessed as support for Keyup Brook based primarily on the fish population information. The presence of multiple age classes of brook and brown trout (including young of the year) is indicative of excellent habitat and water quality. All fish collected are examples of fluvial specialists or fluvial dependant species, which suggests that the flow regime has not been compromised at this location. However, this use is identified with an Alert Status because of the erosion problem noted upstream from the confluence with Jacks Brook and downstream from the first Laurel Lake Road crossing in Erving and because of the extremely low pH levels.

FISH CONSUMPTION
Although no fish toxics monitoring has been conducted in Keyup Brook all tributaries to the Millers River are included in the current Millers River Fish Consumption Advisory (MA DPH 2002a). Until site-specific data are generated the Fish Consumption Use is assessed as impaired (mercury and PCBs). The current source of PCBs in river water is contaminated sediments in the Otter and Millers Rivers. The original source of sediment contamination is believed to be located near the former Baldwinville Products Mill (property currently owned by American Tissue Mills, Inc.) and the Templeton WWTP and probably is related to historic discharge from the former Baldwinville Products Mill to the Otter River.

PRIMARY CONTACT AND SECONDARY CONTACT RECREATION AND AESTHETICS
No objectionable deposits, oils, odors, trash or debris were noted by DWM biologists in their sampling downstream from Laurel Lake Road in Erving on Keyup Brook in September 1996 and September 2000 (Appendix A, Table 13 and Appendix G).

Although too limited data are available to assess the Recreational Uses for Keyup Brook the Aesthetics Use is assessed as support based on observations made by DWM biologists.

The drainage area of this segment is approximately 7.1 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Forest 93%
Residential 3%
Agriculture 2%

The impervious area for the sub-basins within the Keyup Brook subwatershed is all less than 10%, therefore, it is classified as sensitive, predicting a low threat to water quality from impervious surface water runoff (Stoltzfus 2001).

MA DFWELE has proposed that Keyup Brook and its tributary, Jacks Brook, be reclassified in the SWQS as a cold water fishery (MassWildlife 2001).

NONPOINT SOURCES OF POLLUTION (POTENTIAL) [8]
The following potential sources of nonpoint pollution in this segment of the Millers River were identified in the MRPC (Montachusett Regional Planning Commission) and FRCOG (Franklin Regional Council of Governments) 2002 *Assessment of Non-Point Source Pollution for the Millers River Watershed in Massachusetts:*

Sand & Gravel Operations
A sand and gravel operation is located in the southern portion of this subwatershed.

Unpaved Roads
An unpaved road runs along a good portion of the length of Keyup Brook.

Report Recommendations:
Water Quality Classification
• Keyup Brook and Jacks Brook should be reclassified in the next revision of the SWQS as a cold-water fishery.

Water Quality Monitoring
• The low pH in Keyup Brook is probably naturally occurring but is also potentially impacted by or exacerbated by atmospheric deposition. This needs further investigation and documentation.
• Continue to periodically conduct biological monitoring (e.g., benthic macroinvertebrate and fish population) in Keyup Brook to assess the Aquatic Life Use.
• Continue to periodically conduct habitat quality evaluations in Keyup Brook to evaluate any potential impacts from erosion resulting in instream habitat quality degradation, determine the need to develop and implement an instream habitat restoration/improvement project, and to better assess the Aquatic Life Use.
• Monitor bacteria levels to assess the status of the Primary and Secondary Contact Recreation uses.

Nonpoint Sources of Pollution
• Long-term stabilization of the southern stream bank (upstream from the confluence with Jacks Brook and downstream from the first Laurel Lake Road crossing in Erving) in the vicinity of the house and barn is essential to maintaining the habitat quality within this and downstream reaches. This area constitutes a high risk for significant additional erosion and subsequent sedimentation. It was also noted that the riparian zone on the southern side of the stream was stabilized with tires and cement slabs at locations adjacent to the house and barn respectively. These stabilization efforts appeared to be a number of years old and relatively effective in preventing erosion.
• Investigate and confirm the presence of the sand and gravel operation in this subwatershed. Evaluate this site to ensure that it is being operated and maintained properly and that any water quality is protected. Best management practices should be followed for controlling stormwater pollutants, restricting erosion and dust, limiting the extent of excavation, and containing spills. The applicability of these sites for jurisdiction under MA DEP's WMA and NPDES permit programs should also be determined. A project was proposed by EOEA's Millers River Watershed Team to perform a comprehensive identification and assessment of all sand and gravel areas in the watershed to determine their location, ownership, status and history. Also proposed in this project was an education program for municipal boards to provide municipal officials with a good understanding of gravel operations and how to regulate them effectively. An evaluation of sand and gravel operation bylaws and regulations with recommendations on how to strengthen them was also included. Funding to work with communities on this project should be sought (e.g., 604b Water Quality Assessment).
• The unpaved roads that are in close proximity to watercourses should be field checked to verify their location and an evaluation should be performed to determine if there are any impacts from these roads on adjacent watercourses that may affect water quality. Best management practices, as described in Unpaved Roads BMP Manual (Berkshire Regional Planning Commission 2001), should then be implemented as appropriate.

Fish Consumption
• Despite the MA DPH recommendation that fishes taken from the tributaries of the Millers River should not be eaten or

[8] Neither of the two potential nonpoint sources of pollution listed in this 2000 WQA report here are ongoing concerns. The sand and gravel operation on Flagg Hill Road is no longer operating and there are no other known sand and gravel operations. As of the first field visit in 2021, the majority of the road miles along Keyup Brook were paved.

consumption should be limited body burdens of PCB and mercury in the edible portions of fish from Keyup Brook should be further investigated. Determination of natural or man-made barriers to migration in tributaries of the Millers River, including Keyup Brook, would assist in the identification of stream reaches where the potential for PCB contaminated fishes is greatest.

Land Protection

• The impervious area for the sub-basins within the Keyup Brook subwatershed is all less than 10%, therefore, it is classified as sensitive, predicting a low threat to water quality from impervious surface water runoff (Stoltzfus 2001). In order to preserve this subwatershed and prevent degradation of water quality, it is recommended that land use planning techniques be applied to direct development (smart growth), preserve sensitive areas, and maintain or reduce the impervious cover. The Towns of Erving and Northfield should review the information generated through the buildout analysis performed by EOEA that created a profile of how each community would look at full buildout according to its current zoning (EOEA 2000-2001). Additionally, a review of the Western Millers River Watershed Growth Management Plan (RGMPC and FRCOG 2002) and the Assessment of Non-Point Source Pollution (MRPC and FRCOG 2002) reports should be undertaken and appropriate recommendations should be implemented. It is recommended that both the communities of Erving and Northfield continue to work with the Franklin Regional Council of Governments on land use planning issues.

• It is recommended that the Towns of Erving and Northfield participate in the ongoing Millers River Watershed Regional Open Space Plan, which was initiated by the Mass. Watershed Initiative/Millers River Watershed Team and is being conducted by McGregor and Associates. Through this project Erving and Northfield can work cooperatively with other watershed communities to determine regional open space priorities and environmental goals including the protection of water quality.

Water Quality Data

Table A-5: 2005 MassDEP DWM Millers River Watershed Data for Keyup Brook[9]

KEY01 location: Church Street, Erving

Timeframe: May – September, 2005

2005 MassDEP DWM Millers River Watershed water quality data										
Unique ID	Station ID	Date	Time	OWMID	Duplicate	Analyte	Units	Result	Censor	Qualifier*
W1344	KEY01	5/11/2005	1055	35-1108		Ammonia-N	mg/L	<0.02	no	--
W1344	KEY01	6/14/2005	1040	35-1196		Ammonia-N	mg/L	<0.02	no	--
W1344	KEY01	7/13/2005	1010	35-1445		Ammonia-N	mg/L	<0.02	no	--
W1344	KEY01	8/9/2005	1020	35-1505		Ammonia-N	mg/L	<0.02	no	--
W1344	KEY01	9/14/2005	955	35-1665		Ammonia-N	mg/L	<0.02	no	--
W1344	KEY01	5/11/2005	1055	35-1108		Total Nitrogen	mg/L	##	yes	h
W1344	KEY01	6/14/2005	1040	35-1196		Total Nitrogen	mg/L	0.29	no	--
W1344	KEY01	7/13/2005	1010	35-1445		Total Nitrogen	mg/L	0.19	no	--
W1344	KEY01	8/9/2005	1020	35-1505		Total Nitrogen	mg/L	0.33	no	--
W1344	KEY01	9/14/2005	955	35-1665		Total Nitrogen	mg/L	0.28	no	--
W1344	KEY01	5/11/2005	1055	35-1108		Total Phosphorus	mg/L	<0.005	no	--
W1344	KEY01	6/14/2005	1040	35-1196		Total Phosphorus	mg/L	0.017	no	--
W1344	KEY01	7/13/2005	1010	35-1445		Total Phosphorus	mg/L	0.013	no	--
W1344	KEY01	8/9/2005	1020	35-1505		Total Phosphorus	mg/L	0.017	no	--
W1344	KEY01	9/14/2005	955	35-1665		Total Phosphorus	mg/L	0.016	no	--
W1344	KEY01	5/11/2005	1055	35-1108		*E. coli*	CFU/100 mL	100	no	e
W1344	KEY01	6/14/2005	1040	35-1196		*E. coli*	CFU/100 mL	170	no	--
W1344	KEY01	7/13/2005	1010	35-1445		*E. coli*	CFU/100 mL	270	no	--
W1344	KEY01	8/9/2005	1020	35-1505		*E. coli*	CFU/100 mL	64	no	--
W1344	KEY01	9/14/2005	955	35-1665		*E. coli*	CFU/100 mL	190	no	e
W1344	KEY01	5/11/2005	1055	35-1108		Fecal Coliforms	CFU/100 mL	84	no	e
W1344	KEY01	6/14/2005	1040	35-1196		Fecal Coliforms	CFU/100 mL	190	no	--
W1344	KEY01	7/13/2005	1010	35-1445		Fecal Coliforms	CFU/100 mL	360	no	--
W1344	KEY01	8/9/2005	1020	35-1505		Fecal Coliforms	CFU/100 mL	71	no	--
W1344	KEY01	9/14/2005	955	35-1665		Fecal Coliforms	CFU/100 mL	97	no	e
W1344	KEY01	5/11/2005	1055	35-1108		Turbidity	NTU	0.9	no	b
W1344	KEY01	6/14/2005	1040	35-1196		Turbidity	NTU	1.1	no	--
W1344	KEY01	7/13/2005	1010	35-1445		Turbidity	NTU	0.6	no	--
W1344	KEY01	8/9/2005	1020	35-1505		Turbidity	NTU	1.1	no	--
W1344	KEY01	9/14/2005	955	35-1665		Turbidity	NTU	0.6	no	--
W1344	KEY01	5/11/2005	1055	35-1108		Apparent color	PCU	20	no	--
W1344	KEY01	6/14/2005	1040	35-1196		Apparent color	PCU	65	no	--
W1344	KEY01	7/13/2005	1010	35-1445		Apparent color	PCU	50	no	--
W1344	KEY01	8/9/2005	1020	35-1505		Apparent color	PCU	55	no	--
W1344	KEY01	9/14/2005	955	35-1665		Apparent color	PCU	48	no	--
W1344	KEY01	5/11/2005	1055	35-1108		True Color	PCU	20	no	--
W1344	KEY01	6/14/2005	1040	35-1196		True Color	PCU	55	no	--
W1344	KEY01	7/13/2005	1010	35-1445		True Color	PCU	42	no	--
W1344	KEY01	8/9/2005	1020	35-1505		True Color	PCU	50	no	--
W1344	KEY01	9/14/2005	955	35-1665		True Color	PCU	43	no	--
W1344	KEY01	5/11/2005	1055	35-1108		Alkalinity	mg/L	<2	no	b
W1344	KEY01	6/14/2005	1040	35-1196		Alkalinity	mg/L	4	no	--
W1344	KEY01	7/13/2005	1010	35-1445		Alkalinity	mg/L	3	no	--

[9] MassDEP 2012

. 2005 MassDEP DWM Millers River Watershed water quality data

Unique ID	Station ID	Date	Time	OWMID	Duplicate	Analyte	Units	Result	Censor	Qualifier*
W1344	KEY01	8/9/2005	1020	35-1505		Alkalinity	mg/L	5	no	--
W1344	KEY01	9/14/2005	955	35-1665		Alkalinity	mg/L	8	no	--

*see Appendix 1 for a complete list of data qualifiers

2005 MassDEP DWM Millers River Watershed attended multi-probe data

Unique ID	Station ID	OWMID	Date	Time	Sample Depth (m)	Temperature (deg. C)	Temperature Qualifiers	pH (SU)	pH Qualifiers	Specific Conductivity (uS/cm)	Specific Conductivity Qualifiers	Total Dissolved Solids (mg/l)	Total Dissolved Solids Qualifiers	Dissolved Oxygen (mg/l)	Dissolved Oxygen Qualifiers	Saturation (%)	Saturation Qualifiers
W1344	KEY01	35-1109	5/11/05	10:59	0.4	11.4	--	6.8	--	33	--	21	--	10.9	--	102	--
W1344	KEY01	35-1270	6/10/05	10:45	0.4	17.4	--	6.3	--	31	--	20	--	##	i	##	i
W1344	KEY01	35-1271	6/13/05	9:41	0.2	18.8	--	6.7	--	34	--	22	--	8.4	i	92	i
W1344	KEY01	35-1174	6/14/05	10:44	0.2	19.6	--	6.5	--	38	--	25	--	9.1	--	99	--
W1344	KEY01	35-1351	7/11/05	10:26	0.2	17.9	--	6.2	--	27	--	18	--	9.1	--	97	--
W1344	KEY01	35-1423	7/13/05	10:12	0.1	17.8	--	6.6	--	32	--	20	--	9.7	--	102	--
W1344	KEY01	35-1610	8/5/05	10:46	**	20.0	--	6.8	--	30	--	20	--	8.1	i	90	i
W1344	KEY01	35-1611	8/8/05	10:12	0.1	19.0	--	6.6	--	39	--	25	--	8.4	i	92	i
W1344	KEY01	35-1533	8/9/05	10:28	0.2	20.1	--	6.9	--	41	--	27	--	9.1	--	100	--
W1344	KEY01	35-1233	9/9/2005	**	--	**	--	**	--	**	--	**	--	**	--	**	--
W1344	KEY01	35-1234	9/12/05	11:37	**	14.6	--	6.9	--	47	--	30	--	9.6	--	95	--
W1344	KEY01	35-1703	9/14/05	9:59	0.5	17.7	--	7.0	u	49	--	32	--	9.3	--	97	--

. 2005 MassDEP DWM Millers River Watershed unattended probe data

Deploy Information				Temperature					Dissolved Oxygen										
Station ID	Unique ID	Start Date	Deployment Duration (Hours)	Average (deg. C)	Maximum (deg. C)	Mean of the Daily Maximum (deg. C)	Amount of Time > 20 deg. C (Hours)	Percentage of Time > 20 deg. C	Average (mg/L)	Minimum (mg/L)	Amount of Time < 3.0 mg/L (Hours)	Percentage of Time < 3.0 mg/L	Amount of Time < 5.0 mg/L (Hours)	Percentage of Time < 5.0 mg/L	Amount of Time < 6.0 mg/L (Hours)	Percentage of Time < 6.0 mg/L	Average Saturation (%)	Minimum Saturation (%)	Maximum Saturation (%)
KEY01	W1344	06/10/05	70.5	19.6	21.9	21.4	25.5	36%	8.5	8.0	0.0	0.0%	0.0	0%	0.0	0%	94	92	98
KEY01	W1344	07/08/05	71.5	16.5	18.9	17.8	0.0	0%	9.2	8.7	0.0	0.0%	0.0	0%	0.0	0%	95	94	96
KEY01	W1344	08/05/05	71.0	19.9	21.7	20.9	36.3	51%	8.6	8.2	0.0	0.0%	0.0	0%	0.0	0%	95	94	98
KEY01	W1344	09/09/05	72.0	14.8	18.5	16.1	0.0	0%	8.5	6.9	0.0	0.0%	0.0	0%	0.0	0%	85	73	97

Table A-6: 2019 MassDEP Water Quality laboratory data for Keyup Brook[10]

Location: 500 feet upstream/North of Laurel Lake Road, Erving
Time frame: June – August, 2019

Station ID	Unique ID	Start Date	Ammonia (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	True Color (PCU)	Turbidity (NTU)
KEY01	W2895	6/11/2019	<0.04	<4.0	<0.04	.19	.011	45	.6
KEY01	W2895	7/16/2019	<0.04	<4.0	<0.14	.30	.016	48	<0.5
KEY01	W2895	8/13/2019	<0.04	<4.0	<0.10	.29	.012	45	<0.5

The geometric mean of *E. coli* over all 2005 samples was 141 CFU/100 mL, in exceedance of the 126 CFU/100 mL standard limit. Temperature stayed below or well below the limit of 20°C averaged over a 7-day period. PH readings stayed generally with in the 6.5 to 8.3 standard range. Dissolved oxygen remained above the standard minimum of 5.0 mg/L.

Turbidity measurements over two separate datasets show a max turbidity of 1.1 NTU.

Data Gaps

The most recent available data for *E. coli* dates from 2005. Source assessment monitoring has never been conducted for this pollutant, so no target area can be identified for *E. coli* BMPs. Given the limited amount of development in the watershed and the highly rated condition of Erving Center's municipal sewer system,[11] it is plausible that *E. coli* is no longer a significant source of pollutant loading or that a high percentage of the loading is coming from the presence of wildlife. The Massachusetts Water Quality Monitoring program may want to consider Keyup Brook a priority area for conducting water quality testing so as to resolve this question. It is also recommended that the Millers River Watershed Council expand their water quality monitoring program to the Keyup Brook to test for *E. coli*. Any future water quality testing could also be designed to determine whether the *E. coli* is from a human or animal source, and to identify hotspots such as higher bacteria levels nearer to where beavers are active.

There is no TSS data for Keyup Brook to aid in assessing the impacts of sediment mobilization and sedimentation from fluvial erosion in the brook. Fluvial erosion may generally be measured by two means: on-site erosion measurement and system level measurement. On-site measurement monitors the erosion at the level of soil

[10] MassDEP 2020
[11] As described in Pollution Sources below, the Erving Center municipal sewer system, which serves almost all residences in the Erving portion of the watershed, was slip-lined in 2009 and has no known infiltration or sanitary sewer overflow issues as of the 2020 Inflow and Infiltration Report.

processes at one or multiple erosion plots. System level measurement monitors erosion at the watershed level via measurements of total suspended load sediment or bed load sediment.

Alongside sediment and erosion measures, assessment of the Keyup Brook watershed could also highly benefit from the collection of data on stream processes and physical habitat structure. The State of Vermont has incorporated standards for aquatic habitat in Class A and B waters that consider stream flow and processes.[12] For rivers and streams, the criteria is defined as "Changes to flow characteristics, physical habitat structure, and stream processes [with] limited to minor differences from the natural condition and consistent with the full support of very high quality aquatic habitat." "Stream processes" are the hydrologic, bed-load sediment, and large woody debris regimes of a particular stream reach and the term is used to describe the erosion, deposition, sorting, and distribution of instream materials by the power of flowing water. Stream processes naturally work toward an equilibrium condition, a condition in which water flow, sediment, and woody debris are transported in a watershed in such a matter that the stream maintains its dimension, pattern, and profile without unnaturally aggrading or degrading the channel bed elevation (at the scale of a stream reach). When stream processes deviate from equilibrium condition and result in aggradation or degradation, aquatic habitat is compromised. Although there are no equivalent standards in Massachusetts, the protection and restoration of the physical integrity of Massachusetts waterways—in both impaired and healthy watersheds—has to support practices consistent with healthy fluvial processes. The protection and restoration of natural stream processes can serve as an important planning framework for identifying projects that address the dual goals of healthy water quality and healthy fluvial geomorphic functions (with the important climate change co-benefit of flood resilience) in the Keyup Brook WBP.

Land Use and Impervious Cover Information

Land use information and impervious cover is presented in the tables and figures below. Land use source data is from 2005 and was obtained from MassGIS (2009b).

Watershed Land Uses

Table A-7: Watershed Land Uses

Land Use	Area (acres)	% of Watershed
Agriculture	82.69	1.8
Commercial	9.62	0.2
Forest	4,285.31	94.3
High Density Residential	0	0
Highway	0.92	0
Industrial	4.69	0.1
Low Density Residential	94.44	2.1

[12] Vermont Agency of Natural Resources 2017: https://dec.vermont.gov/sites/dec/files/documents/wsmd_water_quality_standards_2016.pdf

Land Use	Area (acres)	% of Watershed
Medium Density Residential	29.16	0.6
Open Land	36.79	0.8
Water	1.43	0

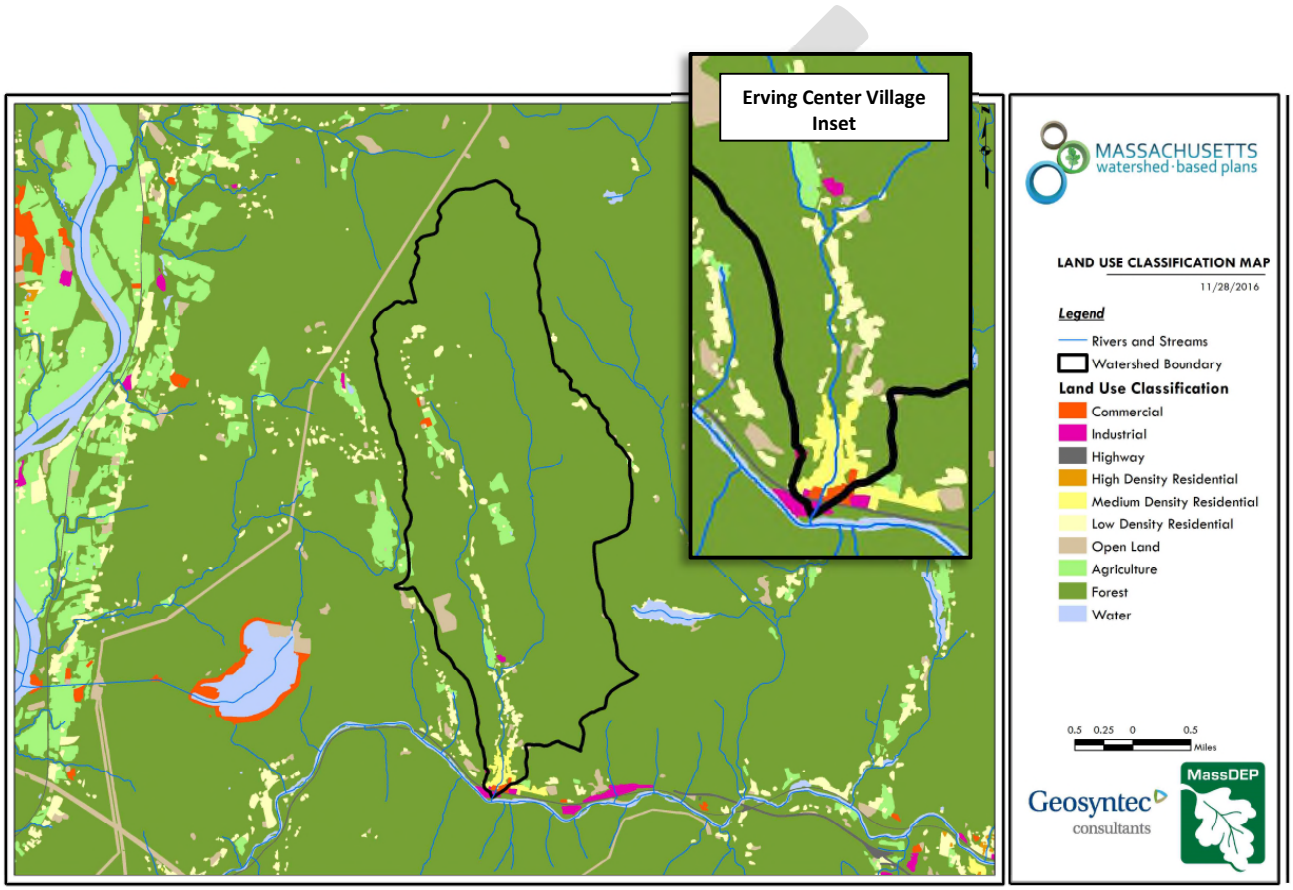

Figure A-1: Watershed Land Use Map (MassGIS, 2007; MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Ctrl + Click on the map to view a full-sized image in your web browser.

Watershed Impervious Cover

There is a strong link between impervious land cover and stream water quality. Impervious cover includes land surfaces that prevent the infiltration of water into the ground, such as paved roads and parking lots, roofs, basketball courts, etc.

Impervious areas that are directly connected (DCIA) to receiving waters (via storm sewers, gutters, or other impervious drainage pathways) produce higher runoff volumes and transport stormwater pollutants with

greater efficiency than disconnected impervious cover areas which are surrounded by vegetated, pervious land. Runoff volumes from disconnected impervious cover areas are reduced as stormwater infiltrates when it flows across adjacent pervious surfaces.

An estimate of DCIA for the watershed was calculated based on the Sutherland equations. The Sutherland equations estimate the proportion of impervious to pervious surface based on land use classifications for a given area.[13] USEPA provides guidance (USEPA, 2010) on the use of the Sutherland equations to predict relative levels of connection and disconnection based on the type of stormwater infrastructure within the total impervious area (TIA) of a watershed. Within each subwatershed, the total area of each land use was summed and used to calculate the percent TIA.

Table A-8: TIA and DCIA Values for the Watershed

	Estimated TIA (%)	Estimated DCIA (%)
Watershed	1.9	1.4

The relationship between TIA and water quality can generally be categorized as shown in Table A-XX:

Table A-9: Relationship between Total Impervious Area (TIA) and water quality[14]

% Watershed Impervious Cover	Stream Water Quality
0-10%	Typically high quality, and typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects.
11-25%	These streams show clear signs of degradation. Elevated storm flows begin to alter stream geometry, with evident erosion and channel widening. Streams banks become unstable, and physical stream habitat is degraded. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.
26-60%	These streams typically no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Biological quality is typically poor, dominated by pollution tolerant insects and fish. Water quality is consistently rated as fair to poor, and water recreation is often no longer possible due to the presence of high bacteria levels.
>60%	These streams are typical of “urban drainage”, with most ecological functions greatly impaired or absent, and the stream channel primarily functioning as a conveyance for stormwater flows.

[13] Sutherland 1995
[14] Schueler et al. 2009

While the TIA and DIA are important analyses, they do not properly account for the significant variation in the density of impervious surface within the watershed. The TIA and DIA are both very low in the upper watershed, where there are few roads and roadside residences, as well as in higher elevation portions of the lower watershed, contributing to good stream water quality. However, the last mile of Erving Center is significantly more developed and areas along the brook may have TIA and DIA rates over 10%.

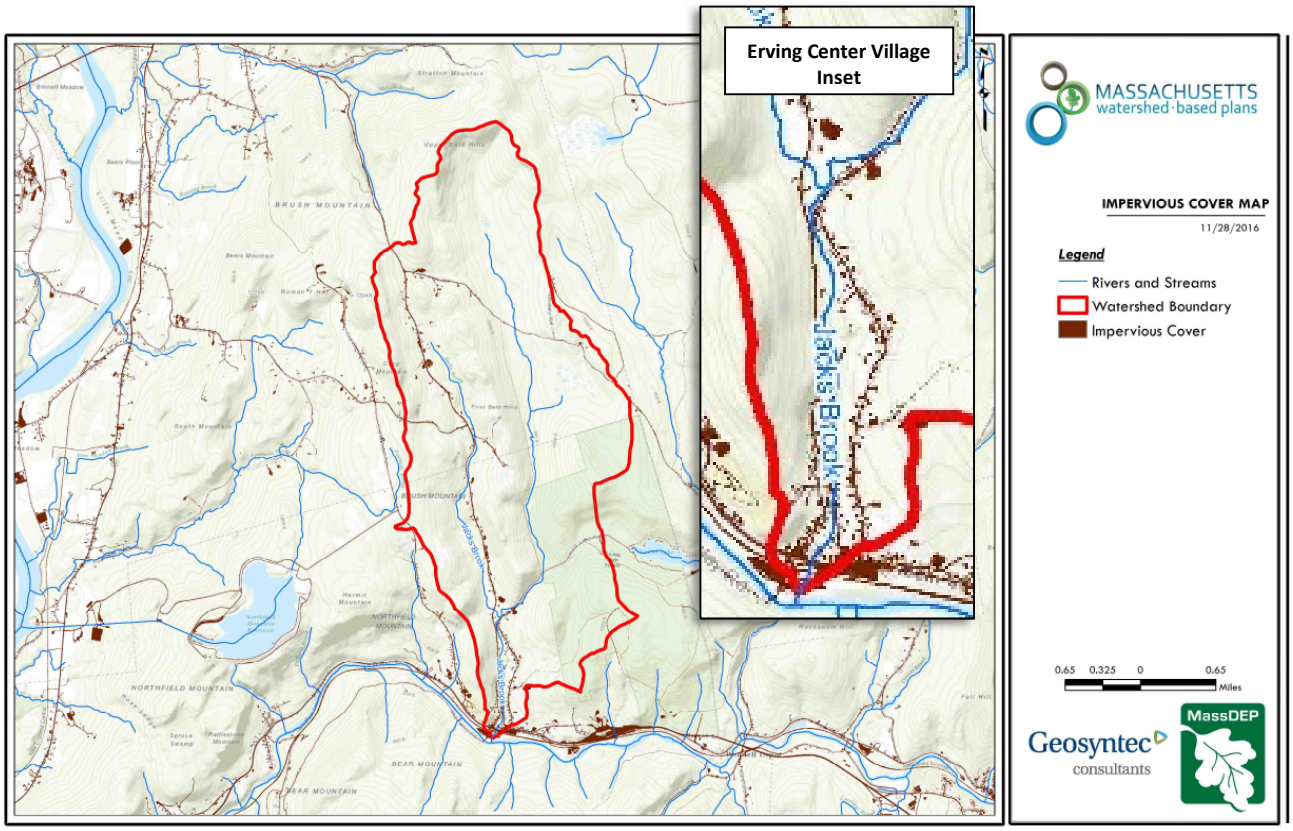

Figure A-2: Watershed Impervious Surface Map (MassGIS, 2007; MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Ctrl + Click on the map to view a full-sized image in your web browser

Pollution Sources

The majority of the Keyup Brook watershed is undeveloped forest, but 1.5 miles of the brook passes through residential areas with the last half mile being the moderately developed village area of Erving Center, where the exposure to contaminated stormwater runoff is greater and hydromodification has increased fluvial erosion.

Agriculture

To the best of the Town's knowledge, there is no livestock or manure spreading in the watershed. There are some open fields, most of which appear to be mowed for hay.

Forest and Forestry

The developed portions of the watershed described here represents a very small percentage of the watershed. Forested areas can contribute bacteria, sediment, and to a minimal degree, nutrient loading to the brook as well and the pollutant loading model Table A-11 estimates that forested land use around 90% of the total sediment loading to Keyup Brook. There have been two private forestry projects in the watershed in the last few years, located on Flagg Hill Road and Murdock Hill Road, and DCR does practice active forest management in Northfield and Erving State Forests, but this is not a heavily forested watershed.

Groundwater Withdrawal

The MassDEP Sustainable Water Management Initiative Interactive (SWMI) Map ranks HUC-12 watershed subbasins to show levels of impact on stream flow from groundwater withdrawal, based on percent of August median flow represented by August groundwater withdrawals. In the Keyup Brook watershed, groundwater is withdrawn for private wells and a four non-community public water supplies. When groundwater withdrawal significantly impacts streamflow rates, pollutants appear more concentrated than under normal flow conditions. Based on data last updated in 2013, the catchment area for Keyup Brook is listed as 0 to 3% impacted. This demonstrates that the Keyup Brook generally maintains the level of flow expected for a watershed its size, and suggests that low flow resulting from groundwater withdrawal is not driving high pollutant concentrations where they are occurring.

Hydromodification

The Keyup Brook stream channel has been straightened, channelized, and armored in multiple areas in this lower section of the watershed. Historical heavy channel management facilitated residential, commercial, and civic development alongside the brook, some of which is within the 100-foot buffer zone and the 200-foot Riverfront Area. Channel management and armoring to protect development in Keyup Brook's floodplain has likely caused an increase in the rate of erosion of the channel banks, as evidenced in part by the massive channel adjustment and erosion event in July 2021, and is very likely contributing high loading of suspended and embedded sediment in the stream. Although there is no data on TSS in the watershed, on-site soil erosion process were documented in the FRCOG's 2021 field visit (see the Description of the Problem section and Figure 4).

Mining

There was historically a gravel pit in the watershed off Flagg Hill Road approximately 500 feet from Keyup Brook. The site is now used as a log landing. According to the Erving Town Planner, there are no known issues with runoff at the site.

Roads

Paved roads are the dominant road type in the watershed; only Orange Road and the decommissioned Great Swamp Road, both in the upper watershed, are unpaved. No evidence of roadside erosion was found in fieldwork aside from the erosion along North Street in the vicinity of the Swamp Road bridge (see Description of Problem and Figures 4e and 4f).

Road Drainage Infrastructure

Failing culverts and full catch basins are potential sources of nonpoint source pollution because stormwater can end up subverting these drainage structures instead of being conveyed by them, potentially resulting in erosion and sedimentation during high flows. The FRCOG conducted a culvert assessment for the Town of Erving in 2019, finding approximately 10 drainage structures in critical condition and 13 in poor condition within the Erving section of the watershed.[15] Replacements and repairs of culverts and catch basins are opportunities to implement BMPs, such as converting a traditional catch basin to a deep sump catch basin, for example. Critically failing drainage structures, as identified in 2019, are listed in Table A-10. Some of this information may now be out of date if the Town has since replaced or repaired the structures.

Table A-10: Drainage Structures in Critical Condition within the Keyup Brook Watershed in Erving

Location	Structure type	Culvert number	Description
Church Street	Drop Inlet[16]	112	Completely blocked
High Street	Drop Inlet	16i	Completely blocked; can't find outlet
High Street	Round culvert	14o	Submerged
High Street	Drop Inlet	14i	75% blocked
High Street	Round culvert	13o	Completely blocked
North Street	Round culvert	66o	Submerged, 25% blocked; pipe broken due to rust
North Street	Round culvert	63o	Submerged, 50% blocked
North Street	Drop inlet	60	Completely blocked
North Street	Round culvert	57o	Completely blocked
North Street	Round culvert	51o	Completely blocked

Sewer and Septic

All residential homes in Erving Center within 1,000 feet of the two brooks are on municipal sewer. The 2020 Inflow and Infiltration Report for Erving Center's municipal sewer system notes that the system continues to have inflow issues (surface water that enters the wastewater system from drains and downspouts), but no known infiltration issues (groundwater that enters the wastewater system from holes and other failures in sewer pipes) or sanitary sewer overflows. The system was slip-lined in 2009. The absence of infiltration issues indicates that exfiltration, the seeping of sewage from sewer pipes to groundwater, is not a likely source of bacteria in the brook. Inflow could be causing unnecessary work for or strain on the water treatment system, in which case disconnecting downspouts and drains would be a beneficial practice.

An old sewer pipe, installed in 1998, ran through the Keyup Brook in the Riverside Park area until it was removed in 2021. The pipe was located farther downstream than the DEP's sampling sites.

In Northfield, there are around a dozen houses within 500 feet of Jacks Brook that are served by septic systems. According to the Northfield Board of Health, two of these systems have been replaced in the last fifteen years and one passed Title 5 inspection in 2017.[17] One of the two replaced systems was discovered in 2005 to have a failed with a very bad system leak and is located near the wetlands in the headwaters of Jacks Brook. This could

[15] FRCOG 2019 ArcOnline Erving Culvert and Bridge Assessment
[16] A drop inlet is a type of catch basin.
[17] Email correspondence with David Balk, Northampton Board of Health Chair, September 1, 2023.

have been the source of the high e.Coli concentrations in 2005. The remaining seven or so systems are old, dating back to the 1980s or with no information on file.

Stormwater Runoff from Development

Stormwater runoff can transport bacteria, sediment, and nutrients to water resources from all land surfaces, but the concentrations from pollutants increase dramatically in developed areas where there is a greater presence of impervious surface. Erving Center, in the lower watershed, contains residential, commercial, and civic development and a large portion of the impervious surface (DCIA) in the watershed. These types of development and associated roads can carry bacteria and nutrients from pet waste, nutrients from lawn fertilizers and road salt/sand, and sediment from landscaping or construction projects and road sand, among other pollutants.

The FRCOG's 2021 field assessment documented approximately thirteen residences, two commercial businesses, and one publicly owned building with less than a 30-foot buffer between the brook and either lawn, driveway, or a building. The parking lots for Flis Market and Erving Station contribute the largest areas of impervious surface within close proximity to the brook, but Route 2, the municipal parking lot on Route 2, the Erving Congregational Church, Riverfront Park, and the Erving Fire Department parking lots also contribute a large portion of the impervious surface in the watershed. It was noted that at least one of the residences along Keyup Brook had pets in the yard. These areas all represent opportunities for stormwater, landscaping, and pet waste management BMPs.

Most stormwater drains to catch basins that are located intermittently along roads. These structures offer an opportunity for pre-treatment and/or infiltration of stormwater instead of collection and conveyance of stormwater directly to the brook. Upgrading or replacing these structures with deep sump catch basins, leaching catch basins, infiltration trenches, or sediment traps/settling basins at outfalls could be an important part of a BMP strategy for reducing sediment and other pollutant loading to the brook and reducing the volume of water draining through town via the brook.

Private Stream Crossings

Some residents along the brook have developed vehicle stream crossings. The stream banks at the crossings looked stable at the time of the September 2022 fieldwalk.

Toxic Sites

The site at 8 East Main Street is a former gas station, automobile dealership, and automotive repair shop. An underground fuel storage tank was removed from the property in the 1970s.[18] In 2015, lead was detected at 0.0302 mg/L in a groundwater sample collected from a monitoring well installed at a separate location on the property, qualifying it as a reportable release.[19] The source of the lead was attributed to historical fill and the site is now closed with no Activity or Use Limitation (AUL). The Erving Paper Mill, on the Millers River upstream of the mouth of Keyup Brook, is a DEP regulated site and outside of the Keyup Brook watershed.

[18] MassDEP Underground Storage Tank Facility Search database, accessed 8/25/2022
[19] EEA Waste Site & Reportable Releases Data Portal, accessed 8/25/2022

Wildlife and Pets

According to Town officials, there is frequently beaver activity in the wetland at the base of Swamp Road, as well as nearby on Jacks Brook where it passes under North Street.

Analysis of Land Use as a Source of Impairment

Table 11 shows a complete list of suspected sources of NPS pollution.

Table A-11: Suspected sources of NPS pollution in the Keyup Brook Watershed

Pollutant	Source	Location
E. coli	Septic/sewer	• No known issues
	Agriculture	• None known
	Wildlife	• Beaver activity on Jacks Brook at North Street
	Dog waste	• Along High Street and Church Street
	Groundwater withdrawal	• No known impact on base flow
Sediment	Hydromodification of the stream channel	• Throughout watershed, focused especially from the Pete's Pond Dam to the intersection with Crescent Street
	Streambank erosion	• Behind houses along Swamp Road on the brook's southern bank (banks have tires and railroad embedded in them for stabilization) • Along North Street where Keyup Brook meets North Street • Eastern bank of the brook, along rear of Church Street residences • In stone wall stream embankments on both sides of the brook north and south of the Route 2 bridge (i.e. Hanson Court, Flis Market parking lot, Pearl B. Care historic firehouse building, and the Erving Station property).
	Road and drainage infrastructure erosion	• Bridge on Swamp Road at 39 Swamp Road • Swamp Road bridge at intersection of Swamp Road and North Street • Church Street Bridge • Municipal lot and staircase at the southwest corner of Route 2 and Arch Street (hillside leading to Arch Street)
	Sedimentation	• On Arch Street below the railroad bridge • In parking area on west side of Keyup Brook off of Crescent Street
	Mining	• None known
	Forest and forestry	• None known above baseline loading; no known issues with forest cutting projects
	Construction	• Exposed soil at construction site in Riverside Park along Keyup Brook in 2021; slope stabilized with coir coil and vegetation in 2022
Nutrients (nitrogen and phosphorus)	Agriculture	• None known
	Sewer and septic	• No known issues
	Stormwater runoff from development	• Roads and lawns alongside the brooks in Erving and Northfield • Large areas of impervious surface in Erving Center village

Stormwater runoff throughout the watershed is a potential source of nonpoint source pollution. The critical damage inflicted by the heavy rainstorms during the summer of 2021 demonstrates that high volumes of uncontrolled stormwater negatively impact not only water quality, but stream geomorphology and public and private infrastructure. To reduce the peak flow volumes and dissipate energy in the brook during heavy precipitation events, nonpoint source pollution BMPs can focus on slowing and spreading the flow of surface waters (surface runoff and stream flow) in the upper watershed coupled with capturing and slowing surface runoff and improving the drainage of roads in the middle and lower watershed. In the following section, loads for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) have been estimated. The model may underestimate TSS loading, as it does not take into consideration the topography, hydromodification, and the compounding impacts of fluvial erosion.

Pollutant Loading

A Geographic Information Systems (GIS) was used for the pollutant loading analysis for TP, TN, and TSS. MassGIS 2005 land use data (MassGIS, 2009b) was intersected with impervious cover data[20] and United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soils data[21] to create a combined land use/land cover grid. The grid was used to sum the total area of each unique land use/land cover type.

Directly connected impervious area was estimated using the Sutherland equation. Any reduction in impervious area due to disconnection—the area difference between total impervious area (TIA) and DCIA—was assigned to the pervious D soil category for that land use to simulate that some infiltration will likely occur after runoff from disconnected impervious surfaces passes over pervious surfaces.

Pollutant loading for key nonpoint source pollutants in the watershed was estimated by multiplying each land use/cover type area by its pollutant load export rate (PLER) as follows:

$$L_n = A_n * P_n$$

Where L_n = Loading of land use/cover type n (lb/yr);
A_n = area of land use/cover type n (acres);
P_n = pollutant load export rate of land use/cover type n (lb/acre/yr)

The PLERs are an estimate of the annual total pollutant load exported via stormwater from a given unit area of a particular land cover type. The PLER values for TN, TP and TSS were obtained from USEPA (see values provided in Appendix A).[22] Table A-12 lists estimated pollutant loads for the primary nonpoint source (NPS) pollutants total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS) in the watershed.

[20] MassGIS 2009a
[21] USDA NRCS and MassGIS 2012
[22] USEPA 2020; UNHSC 2018, Tetra Tech 2015

Table A-12: Estimated Pollutant Loading for Key Nonpoint Source Pollutants in Keyup Brook

Land Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
Forest	546	2,672	93.37
Low Density Residential	31	301	4.24
Agriculture	41	251	2.86
Medium Density Residential	13	101	1.47
Open Land	7	94	1.59
Commercial	10	88	1.10
Industrial	5	42	0.53
Highway	1	7	0.43
High Density Residential	0	0	0.00
TOTAL	**655**	**3,555**	**105.58**

[1]These estimates do not consider loads from point sources or septic systems.

Estimated *E. coli* Loading: Simple Method

Fecal coliform is more difficult to characterize than other pollutants. Data are extremely variable, even during repeated sampling at a single location. Because of this variability, it is difficult to establish different concentrations for each land use.

Using the Simple Method and the residential roads concentration value from the National Median Concentration for Chemical Constituents in Stormwater for *E. coli*,[23] *E. coli* loading in Keyup Brook is estimated to be 444 CFU/year. This method uses one of the higher concentration rates for urbanized areas (residential roads). Vegetated urban areas and forest will likely have lower bacteria concentrations than represented here, and landscaping areas, pasture, and hayfield with manure application will likely have dramatically higher concentrations.

The Simple Method for urban stormwater bacterial load calculation:

$$L = 1.03 * 10^{-3} * R * C * A$$

Where: L = Annual load (Billion Colonies)
R = Annual runoff (inches)
C = Bacteria concentration (#/100 ml)

[23] Schueler 1999

A = Area (acres)

$1.03 * 10^{-3}$ = Unit conversion factor

Element B: Determine Pollutant Load Reductions Needed to Achieve Water Quality Goals

Element B of your WBP should:

Determine the pollutant load reductions needed to achieve the water quality goals established in Element A. The water quality goals should incorporate Total Maximum Daily Load (TMDL) goals, when applicable. For impaired water bodies, a TMDL establishes pollutant loading limits as needed to attain water quality standards.

Estimated Pollutant Loads

Estimated pollutant loads for TP (655 lbs/year), TN (3555 lbs/year), and TSS (105.58 lbs/year) were previously presented in Table A-12 of this WBP. Bacteria loading estimates vary widely depending on the modeling method. The measured geomean concentration of *E. coli* was measured at 141 CFU/100mL in 2005 at the Church Street bridge.[24]

Water Quality Goals

Pollutant load reduction goals for WBPs can be based on water quality criteria, surface water standards, existing monitoring data, existing TMDL criteria, or other data. Water quality goals for this WBP are focused on reducing bacteria and TSS loading to Keyup Brook. To meet the standard established in the forthcoming MassDEP *TMDL for Pathogen-Impaired Inland Freshwater Rivers*, bacteria load must be reduced 24% below the highest *E. coli* geomean recorded in 2005 (166 CFU/100 mL). A sediment load reduction goal was calculated using the pre-development land cover (100% forested watershed) load as a target. TSS load reduction is expected to aid with bacteria and nutrient load reduction. A description of criteria for each water quality goal is described by Table B-1.

Table B-1: Pollutant Load Reductions Needed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Bacteria	*MSWQS for bacteria are concentration standards (e.g., colonies of fecal coliform bacteria per 100 ml), which are difficult to predict based on estimated annual loading.*	**Class B Standards** • Other Waters and Non-bathing Season at Bathing Beaches: For *E. coli*, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml	*Concentration based:* 24% reduction in the highest *E. coli* geomean recorded in 2005

[24] MassDEP 2012

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
	Estimated loading: 18 CFU/100mL. The data on which the 303(d) listing is based presents a geometric mean of 141 CFU/100 mL.	(typically based on min. 5 samples) and no single sample shall exceed 235 colonies/100 ml. For enterococci, geometric mean of samples from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	
Total Suspended Solids	106 ton/yr	**Class B Standards** These waters shall be free from floating, suspended and settleable solids in concentrations and combinations that would impair any use assigned to this Class [B], that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom. Estimated pre-development loading rate is 93.5 tons/year.	12.5 tons (long-term goal)

TMDL Pollutant Load Criteria

A draft *TMDL for Pathogen-Impaired Inland Freshwater Rivers* has been prepared by MassDEP. According to the Appendix pages for Keyup Brook, the draft TMDL criteria for Keyup Brook is a 24% reduction of the highest *E. coli* geomean in 2005 (166 CFU/100 mL), which would result in a bacteria count of 125 CFU/mL.[25]

[25] Provided to the FRCOG by Matthew Reardon, MassDEP, on April 7, 2022. The surface water quality standard (SWQS) was applied to the rolling geomean for all sample days in the given year within a 90-day window from the first sample event. The statistical threshold value criterion was applied to the single sample results because less than 10 samples were collected within the calendar year at the site. The highest maximum 90-day rolling geomean of the sites was used to calculate the percent load reduction required to meet SWQS.

Element C: Describe management measures that will be implemented to achieve water quality goals

Element C: A description of the nonpoint source management measures needed to achieve the pollutant load reductions presented in Element B, and a description of the critical areas where those measures will be needed to implement this plan.

The following section outlines a general plan for increasing awareness of and capacity for watershed management that reduces NPS pollution and builds flood resilience, followed by general site characteristics and management measure proposals for the Keyup Brook watershed. For purposes of characterizing watershed conditions and the types of management measures needed, the watershed is described as three watershed sections: upper, middle, and lower, broken up by development density (Figures C-1 and C-2). Proposed BMPs focus on slowing and spreading the flow of surface waters (surface runoff and stream flow) in the upper watershed and on capturing and slowing surface runoff and improving the drainage of roads in the middle and lower watershed. Recommendations fall into the categories of watershed management/capacity building, structural BMPs, and nonstructural BMPs. *Structural BMPs* are designed to remove pollutants from stormwater runoff or reduce the volume of stormwater runoff. *Nonstructural BMPs* are focused on pollutant reduction, management of pollutants, and preservation of natural features. Further studies and non-structural BMPs will be essential to solving water quality challenges in this watershed.

Watershed Management/Capacity Building

To achieve the goals of reducing *E. coli* and TSS loading in the Keyup Brook watershed, a broad collaboration of watershed residents and representatives from Town committees in Erving and Northfield will need to be brought together to develop a long-term vision for how to manage Keyup Brook and contributing stormwater. Building awareness will help Town staff, Boards, and Committees more consistently incorporate watershed planning and flood resilience into other of Town planning arenas, such as transportation infrastructure planning recreation planning, or zoning and permitting. It would also benefit the Towns to develop a clear, ongoing approach to educating the watershed community about the current and future issues the watershed faces and about the importance of improving watershed management. Town and FRCOG staff began this process in the public outreach process for this plan in the summer and fall of 2023, prior to its submittal to the DEP. Future engagement should build on this work.

Sampling in the watershed is necessary to establish a baseline for the presence of pollution and to track any changes in water quality that may be occurring as a result of implemented water quality management practices. The most cost-effective means to conduct water sampling is to identify and train a team of volunteers to conduct this sampling, overseen by the watershed stakeholder group. The Millers River Watershed Council could

either consider expanding its monitoring program to cover Keyup Brook or be a resource for training a Keyup Brook sampling team.

Structural BMPs

In order to properly design and prioritize structural measures, it is recommended to first fund a hydrologic and hydraulic (H&H) study and a fluvial geomorphic (FGM) study of the watershed and then hire an engineer to determine locations, type, and sizing of BMPs. BMPs can be designed for future storm sizes. In 2020 the MassDEP Stormwater Advisory Committee presented recommendations for updating the MassDEP Wetlands Regulations and Stormwater Handbook that included replacing the use of the Rainfall Frequency Atlas (TP40) with NOAA Atlas 14, which uses updated NOAA rainfall data, and calculating stormwater estimates based on 90% of the upper bound of the 90th percentile confidence interval (a method referred to as NOAA14+).[26] Using this updated data will help plan for the larger storms associated with climate change and will help ensure BMPs are designed to be climate resilient. Some communities are practicing NOAA14++ as a method by basing stormwater estimates on the upper bound of the 90th percentile confidence interval. Using the Athol, MA weather station, NOAA14+ estimates the following rainfall amounts for 24-hour storms:

100-year interval/24-hour storm:	8.72 inches
10-year interval/24-hour storm:	4.94 inches
2-year interval/24-hour storm:	3.19 inches

[26] MassDEP Stormwater Advisory Committee 2020

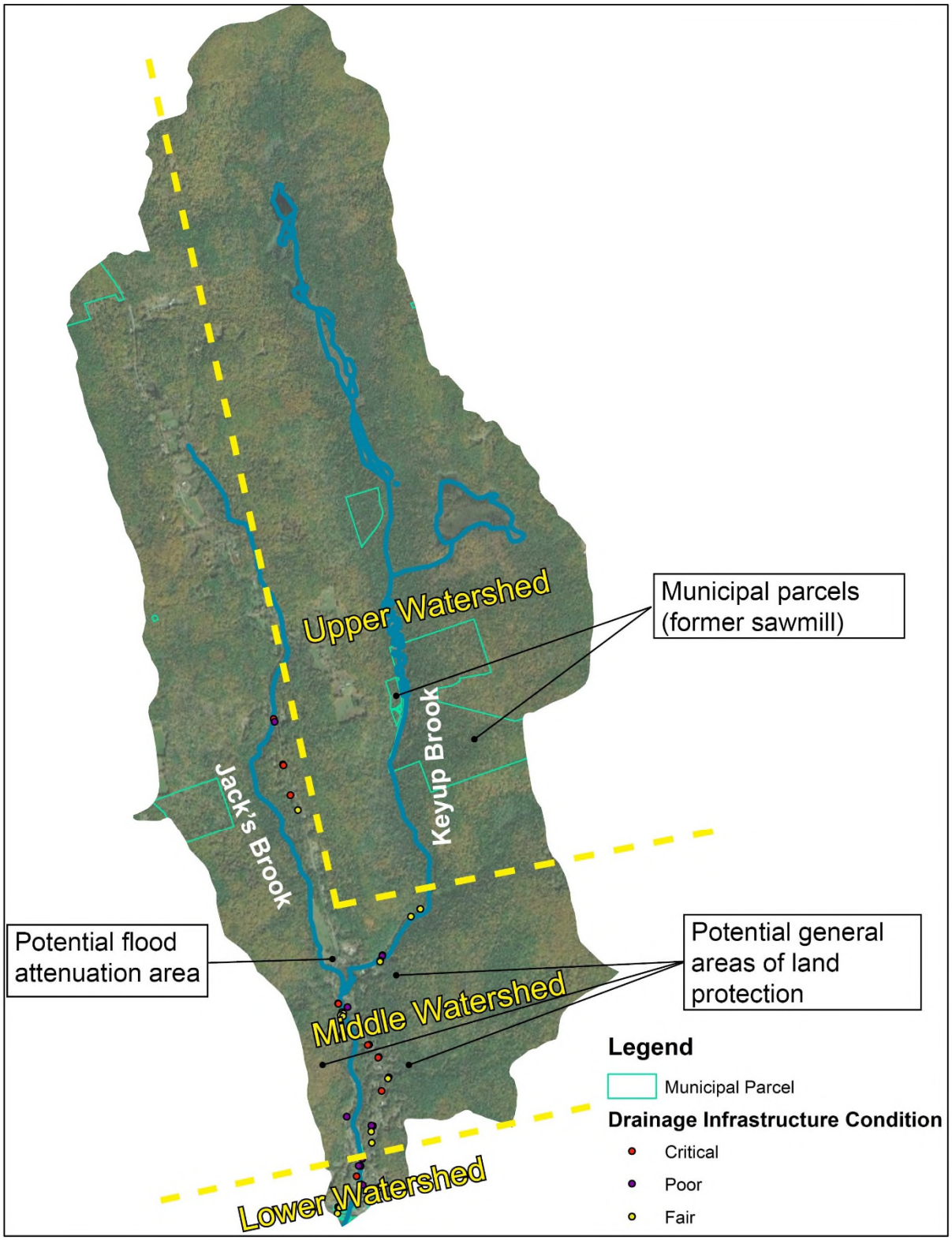

Figure C-1: Keyup Brook Watershed Sections and Upper and Middle Watershed Proposed BMP Locations

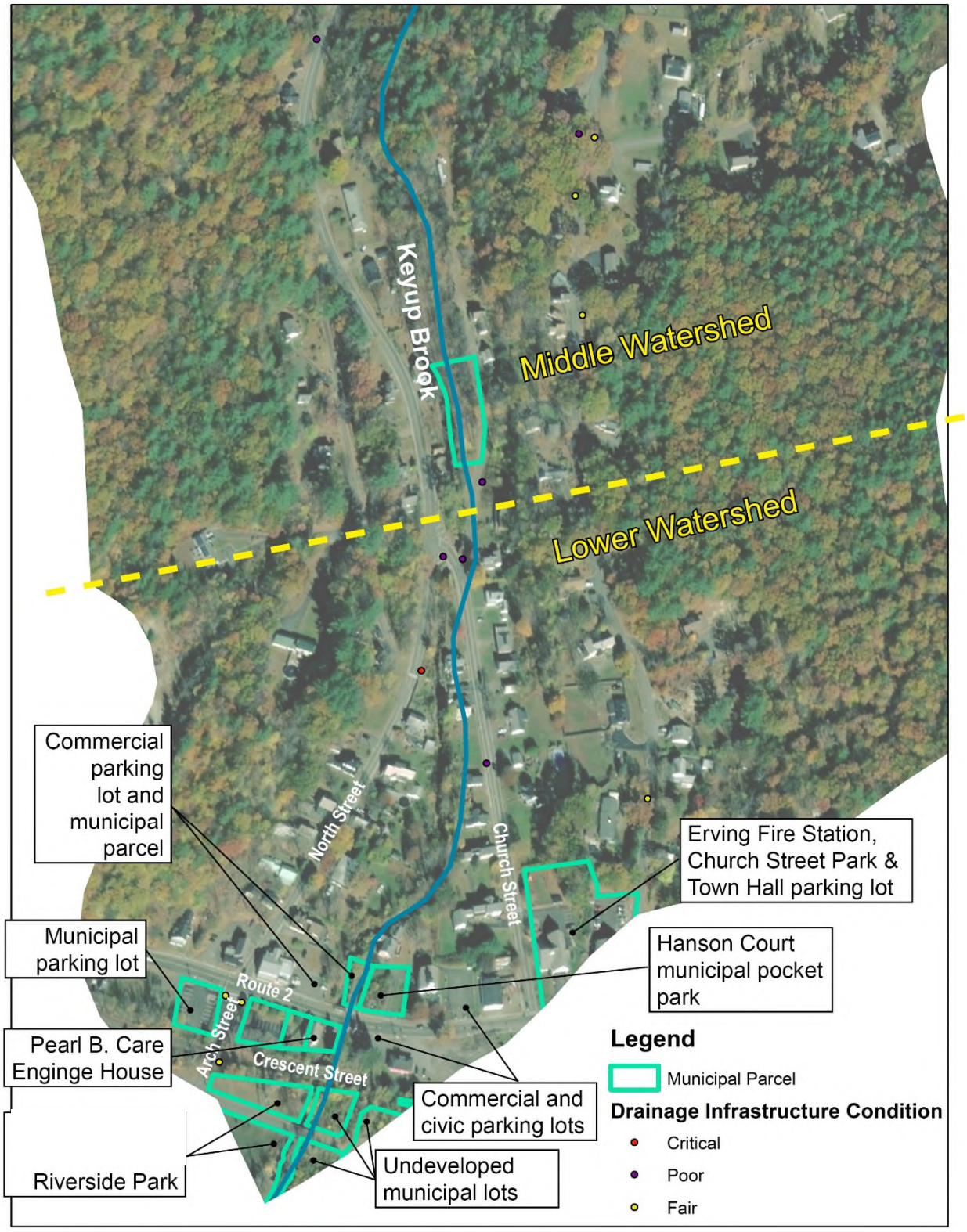

Figure C-2: Lower Watershed Proposed BMP Locations

Upper watershed

There is very little development in the forested upper watershed, which constitutes over half of the watershed land area. Because this section of the watershed drains such a large volume of water, any opportunity to infiltrate (soak up) surface runoff and reduce high flows in the Keyup Brook here will help reduce downstream sediment loading and erosion impacts. H&H and FGM studies of the Keyup Brook watershed could identify structural stormwater management projects such as floodplain reconnection, boulder clusters, and wood loading to increase flood attenuation, reduce sediment transport, and improve stream habitat of the upper watershed while reduce bacteria, sediment, and nutrient loading to downstream sections of the brook. The Town of Erving owns land on both sides of Keyup Brook totaling around 200 acres approximately 1 mile upstream from the Laurel Lake Road bridge that could be considered as a potential location(s) for flow and sediment abatement projects. Of these 200 municipal acres, the west-side parcel is the site of a historic sawmill and has vehicle access from North Road/Gulf Road via Murdock Hill Road.

Middle watershed

The middle section of the watershed—along Gulf Road/North Street and from the northern terminus of Swamp Road south to the Church Street bridge—is characterized by low-density development but is experiencing significant erosion in places. Because much of the riparian land along Jacks Brook and Keyup Brook is still undeveloped in this section, this part of the watershed may present some of the best opportunities for larger BMPs such as flood attenuation areas reduce the volume and intensity of stream flow or detention/retention areas that slow and infiltrate surface runoff.

In a few places, paved roads that run parallel and in close proximity to Jacks and Keyup Brooks are also opportunities to install roadside BMPs, such as vegetated ditches, properly designed turnouts, check dams, or deep sump catch basins that capture and filter road runoff. Management measures in the middle watershed can also include continued maintenance of stormwater drainage and road-stream crossings, such as the cleaning of catch basins and clearing of culverts. Measuring the amount of sediment removed by these cleaning practices can help estimate the amount of sediment loading in the watershed and indicate any improvements created by BMPs installation. The FRCOG's culvert assessment for the Town of Erving catalogues structures that were in poor or critical condition in the summer of 2019.[27]

The Swamp Road bridge destroyed by the 2021 July rains and the stretch of highly eroded bank along North Street are located in the middle watershed, just downstream of the convergence of Jacks and Keyup Brooks and the Pete's Pond Dam. There may be value in focusing on reducing stream power and capturing sediment upstream of this vulnerable section to reduce the intensity of future damage. The Town consulted with the Massachusetts Department of Ecological Restoration about the feasibility of restoring some of the floodplain at the 90-degree turn in Keyup Brook at North Street, but it is thought that this area has only nominal flood storage capacity.[28] A fluvial geomorphic study could identify other opportunities for floodplain restoration between the Swamp Road bridge and the Church Street bridge (see Nonstructural BMPs).

[27] FRCOG 2019. *Town of Erving Culvert and Bridge Assessment*

[28] According to the Town of Erving Assistant Town Planner

There are few municipally owned parcels in the middle watershed. The Town owns a 1,742 square-foot parcel adjacent to 65 High Street through which a small perennial stream flows before passing under High Street via a culvert. This parcel is not considered a viable site for a BMP because it is small and regulated by the Wetlands Protection Act. One municipal property on the east bank of Keyup Brook just north of the Church Street bridge is too steeply sloped for floodplain restoration or BMPs and doesn't appear to be a significant source of surface flow according to the watershed flow accumulation GIS analysis conducted for this project (Appendix C). The Town will likely have to work with private landowners to identify and secure any additional locations for BMPs in the middle section of the watershed. The FRCOG and Town did identify and discuss a few large, privately owned open space parcels adjacent to Jacks and Keyup Brooks that may have potential for floodplain restoration or storage of surface water. Further discussion with these private landowners is needed.

A beaver management plan could be helpful for areas of frequent beaver activity that pose a hazard to Town roads at Pete's Pond and Jacks Brook at North Street.

Lower watershed

In the lower watershed—from the Church Street bridge to Keyup Brook's confluence with the Millers River—the Keyup Brook is channelized through a moderately developed residential and commercial neighborhood. Solutions in this section could focus on dispersed municipal, roadway, and residential stormwater BMPs, including maintenance of existing stormwater BMPs. Floodplain restoration near Riverside Park could also be beneficial.

An effort to manage and update catch basins to better trap sediment and infiltrate water is one of the biggest and most straightforward set of opportunities the Town has to manage stormwater. Erving may already have installed deep sump catch basins, which unlike traditional catch basins, are designed to trap sediment deep in the catch basin at a lower level than the outflow pipe so that the water that leaves the basin has mostly had sediment filtered out. At a minimum, the Town can be regularly cleaning the sediment out of these catch basins to ensure they do not allow sediment to flow out. While deep sump catch basins are better than traditional catch basins at pre-treatment of stormwater, leaching catch basins (offline—not tied to the stormwater system) and 'Arlington' infiltration trenches (online—tied to the stormwater system) also allow water to leach into the ground, reducing the overall volume of stormwater and pollutant loading to the brook. Retrofitting stormwater outfalls with sediment traps and settling basins are also a good option for removing sediment before it enters the brook.

There are somewhat limited options for structural BMP installations on Town-owned land in the lower watershed. In the area around Church Street, the Town Hall building is outside of the watershed but the parking lot is within. The 0.5-acre Erving Fire Station is over 70 percent impervious, so any renovations to the site could incorporate stormwater BMPs. The adjacent 0.2-acre Church Street Park could be a good location for stormwater BMPs, and stormwater from the Fire Station, road, and the Town Hall parking lot could be directed to that location for treatment and infiltration. If a set of BMPs could be designed at this site that could effectively capture a large volume of water, the Town might consider prioritizing the property for stormwater capture and moving the existing play structures to Riverside Park.

There are two municipally owned parcels on Keyup Brook on the east side of the brook/north side of Route 2. The larger of these two properties (0.2 acres) contains a pocket park memorializing the old Town Hall. There is erosion of the embankment along the western edge of these properties where they meet the brook. A private driveway called Hanson Court, which the Town is legally obligated to maintain, encircles the pocket park. Two residences are accessed by Hanson Court north of the municipal properties.

The Town owns four parcels along the south side of Route 2 that include the Pearl B. Care Engine House building, a dirt parking lot, and a Park-and-Ride parking lot. The Pearl B. Care Engine House is located close to the brook's eroding stone-constructed bank. There may be a small amount of space to redirect stormwater coming from Route 2 and off the Route 2 bridge to a stormwater bridge to help slow the erosion of the stone embankment. Because there is erosion along the edge of the paved Park and Ride lot that is sending sediment down Arch Street, the Town may consider more BMPs for the parking lot and staircase area.

There is currently evidence that runoff is transporting sediment from the parking lots on Arch Street under the Arch Street overpass. Immediately below (south of) the underpass, on the east side of Arch Street and north side of Crescent Street, there is a strip of land that is part of the Riverside Park parcel but that is empty and unused except for an unused water tower. This parcel stretches from Arch Street to Keyup Brook, and may be an appropriate place to intercept water coming down Arch Street from Route 2 and the municipal parking lots. The Erving Recreation Commission expressed a desire to have the water tower removed and the parcel put to use.

Below the railroad bridge, although Riverside Park already effectively acts as a floodplain, there is potential for floodplain restoration BMPs in the undeveloped buffer on both sides of Keyup Brook and in the undeveloped municipal lot on the east side of the brook (on Crescent Street). At the very least, any further development in this area must keep flood risk and flood resilience central to its design.

The most viable locations for stormwater BMPs on public property appears to be the Church Street Park and the Riverside Park parcel with the water tower. The anticipated future renovation of adjacent public properties could include stormwater conveyance features that direct surface runoff to these areas (e.g., when the Town Hall is renovated, stormwater could be redirected to BMPs in the Church Street Park rather than to storm drains (catch basins).

General recommendations for structural BMPs on public roads and properties in the lower watershed include:

- Installation of deep sump catch basins, off-line leaching basins, infiltration trenches attached to catch basins, and sediment traps and settling basins at outfalls.
- Stormwater BMPs that capture and infiltrate as much of a municipal property's stormwater as possible
- Downspout disconnection
- Reduction of impervious surface

Watershed Wide

Businesses and residences throughout the watershed are also an important opportunity to improve stormwater management. Residential/commercial BMPs involve lawn and water management efforts. Lawn management includes removing pet waste, reducing fertilizer application, and even reducing lawn (which tends to be about 40% impervious and not efficient for infiltrating water). Water management can start with disconnecting

downspouts. Downspouts that outlet directly to catch basins or driveways put clean water into the stormwater system and into the brook, increasing the volume of water in the brook during a storm. Directing downspouts to lawn, vegetated areas, or rain barrels or cisterns allows that water to be used or infiltrated into the groundwater and recharge aquifers. Water management techniques aim to slow, treat, and infiltrate water into the landscape using BMPs such as infiltration trenches (e.g., French drains), bioswales, waterbars, bioretention areas, and rain gardens. Residences and businesses along the brook have the additional opportunity to create or expand their brook-side riparian buffers—planting or naturalizing areas along the water that slow and infiltrate surface runoff.

It is the Town's responsibility to monitor construction sites to ensure that contractors are in compliance with their stormwater pollution prevention plans (SWPPP) and making sure those erosion and sediment controls are working properly. Construction can leave exposed soil and uncovered materials vulnerable to quickly being washed away into waterways if not properly controlled. Erosion control is the practice of keeping dirt and sediment in place. Sediment control is the practice of capturing sediment that has broken free before it leaves the site.

Nonstructural BMPs

Studies

- An important approach to reducing the mobilization of sediment is to better understand and address the various sources of sediment in the Keyup Brook watershed. Conduct a comprehensive fluvial geomorphic (FGM) study to identify causes of channel instability and erosion, sedimentation, and habitat degradation. Within the study, assess road-stream crossings, expanding the database of information on whether these structures are properly sized and designed for their location in the stream. The study could identify Nature-Based Solutions projects for the upland watershed area to slow and spread the surface runoff and trap sediment, protect and restore water quality, enhance habitat, and provide flood resiliency benefits. A delineated river corridor can also be a product of the study. With a delineated river corridor, which includes the active river channel and the adjacent area where the river is expected to move over time through natural bank erosion and channel migration, the Town can develop management strategies for the river corridor, such as including a zoning overlay district, improving riparian buffers.

- Conduct an H&H study to estimate peak flow, floodwater elevations, flow velocities, and flow paths in the Keyup Brook watershed under current conditions and projected future conditions due to climate change. The results of the modeling would inform the sizing and type of stormwater BMPs proposed for the watershed. Completed together, an H&H and FGM study can project the response of the brook to future storms and the appropriate land conservation and water quality BMPs from which conceptual designs can be developed.

Land Protection

- Prioritize land protection of large undeveloped parcels in the middle watershed and along Keyup Brook, as development in this area could dramatically increase the volume of water reaching the brook and increase flood impacts.

Zoning and Regulations

- Consider developing a comprehensive set of stormwater bylaws and site review procedures to ensure that any new development or redevelopment captures, treats, and infiltrates water on site so as not to increase the volume of surface runoff reaching the brook. Adding low-impact development (LID) features to the subdivision regulations is another approach to reducing the impacts of surface runoff from development.

- Consider zoning changes to protect a buffer along Keyup Brook from further development (such as river corridor overlay zoning).

Road Management

- Continue street sweeping, catch basing cleaning, appropriate snow removal, and reduced salt and sand application. Replace problem culverts before they fail. Evaluate these road management BMPs to see if potential improvements can be implemented to achieve higher pollutant load reductions, such as increased frequency or improved technology.

Element D: Identify Technical and Financial Assistance Needed to Implement Plan

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

The WBP template includes Table D-1, which presents the funding needed to implement some of the management measures presented in this watershed plan. The table includes costs for structural and non-structural BMPs, operation and maintenance activities, information/education measures, and monitoring/evaluation activities. Cost estimates for funding needed to implement the management measures have been estimated based on similar projects that FRCOG is familiar with, but these costs could likely increase as time passes. This table will be updated to include further detail once the described studies are completed. When the Town of Erving or Northfield is listed as the Relevant Authority, this would include the Highway Department, Select Board, Conservation Commission, Board of Health, and Recreation Commission as appropriate. DCR is listed as a Relevant Authority when the suggested management member would apply to DCR-owned land.

Table D-1: Summary of Funding Needed to Implement the Watershed Plan.

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
Grant Application						
Grant Applications	Not applicable	Not applicable	Towns of Erving and Northfield, DCR	Grant assistance	N/A	Application for a 604b grant for an H&H, FGM, and BMP engineering study. Application for s.319 grant for BMP design and implementation.
Structural and Non-Structural BMPs (from Element C)						
Watershed Hydraulic & Hydrologic (H&H) Study	Not applicable	Not applicable	Towns of Erving and Northfield, DCR	Engineering consultant	$30,000	Studies could be combined into single study for cost savings.

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
Watershed Fluvial Geomorphic Assessment Study	Not applicable	Not applicable	Towns of Erving and Northfield, DCR	Fluvial geomorphic engineering consultant	$35,000 - $50,000	Studies could be combined into single study for cost savings.
Engineering study of potential stormwater BMPs	Not applicable	Not applicable	Towns of Erving and Northfield, DCR	Engineering consultant	To be determined	Studies could be combined into single study for cost savings.
Installation of new structural stormwater BMPs	To be determined	To be determined	Towns of Erving and Northfield	Engineering consultant, Contractor	To be determined	Stormwater BMPs and costs for design and installation will be determined by future studies.
Beaver Management Plan	To be determined	To be determined	Towns of Erving and Northfield	Engineering consultants	To be determined	
Erving and Northfield Highway Department best practices: street sweeping, catch basin cleaning, reduced salt application.	Potentially, if equipment is needed	To be determined	Towns of Erving and Northfield	Engineering consultant	To be determined	An engineering consultant could develop an O&M plan for Town roads.
Information/Education (see Element E)						
Signage	$3,000 – $10,000	Not applicable	Town of Erving	Consultant, FRCOG	$3,000 – $5,000	
Project updates (website and social media posts)	Not applicable	To be determined	Town of Erving	None	Not applicable	
Educational materials and/or presentation for residents	$1,500	To be determined	Town of Erving	Consultant, FRCOG	$1,500	
Public education site visits to demonstration projects	Not applicable	To be determined	Town of Erving	Consultant, FRCOG	To be determined	
Monitoring and Evaluation (see Element H/I)						
Sampling QAPP	Not applicable	Not applicable	Town of Erving, Millers River Watershed Council	$5,000	$5,000	Estimated cost; will vary widely depending on level of detail
Annual water quality sampling	Not applicable	Not applicable	Town of Erving, Millers River	$5,000	$5,000	Extent of sampling program TBD, this is placeholder estimate

Management Measures	Capital Costs	Operation & Maintenance Costs	Relevant Authorities	Technical Assistance Needed	Funding Needed	Notes
			Watershed Council			
BMP monitoring	Not applicable unless specific equipment was needed as recommended in the O&M Plan	To be determined. Estimates of annual costs would be provided in the O&M Plan.	Town of Erving, land owners and volunteers	Training of volunteers might be needed. Town staff might need training on BMPs for stormwater and road maintenance	$2,500 for annual training and printing of outreach materials	Funding for the O&M Plan implementation could come from the Town's Chapter 90 Program funding
				Total Funding Needed	**To be determined**	

Potential Funding Sources:

- 604b Water Quality Management Planning Grant Program
- Section 319 Nonpoint Source Competitive Grant Program
- Municipal Vulnerability Preparedness (MVP) Action Grant Program
- Long Island Sound Futures Fund (LISFF) through the National Fish and Wildlife Foundation (NFWF)
- Town Ch. 90 funds
- Town Capital Funds
- Town Wetland Funds (i.e., filing fees to enforce Massachusetts Wetlands Protection Act)
- Massachusetts Environmental Trust
- FEMA Hazard Mitigation Grant
- Volunteer time for public outreach and monitoring

Element E: Public Information and Education

Element E: Information and Education (I/E) component of the watershed plan used to:

1. Enhance public understanding of the project; and
2. Encourage early and continued public participation in selecting, designing, and implementing the NPS management measures that will be implemented.

Step 1: Goals and Objectives

The goals and objectives for the watershed information and education program.

1. Educate Town of Erving and Northfield staff and watershed residents about the health of the Keyup Brook watershed, including the potential sources of nonpoint source pollution and geomorphic impairments.
2. Promote the need for additional study of the watershed, including a hydrologic/hydraulic/fluvial geomorphic assessment.
3. Promote a comprehensive approach to ongoing stormwater management, including road BMPs and residential BMPs.

Step 2: Target Audience

Target audiences that need to be reached to meet the goals and objectives identified above.

1. All watershed residents
2. Town of Erving and Northfield staff, especially the Highway Department
3. Businesses within the watershed

Step 3: Outreach Products and Distribution

The outreach product(s) and distribution form(s) that will be used for each.

1. Provide general information about nonpoint source pollution, sources, and mitigation in Franklin County via the Healthy and Resilient Rivers online ArcGIS StoryMap.
2. Post this WBP and project information on the Town of Erving and Northfield websites and publicize via social media sites.
3. Work with Town staff to integrate water quality and flood resilience thinking into all Town planning and management.

4. Work with the Selectboard to develop educational outreach that provides context for all water-related issues and suggests structural and nonstructural stormwater BMPs watershed landowners.
5. Publicize the results of the BMP development, results, and monitoring data.
6. Create signage at select completed BMPs
7. Conduct tours of installed BMPs, open to the public.
8. When completed, obtain the FRCOG's Dirt Roads Toolkit for the Town of Erving and Northfield Highway Departments to inform good dirt road maintenance and stormwater management. Attend FRCOG workshop to train Highway Departments on dirt road management BMPs and the use of the Dirt Roads Toolkit.

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

1. Track the number of educational materials distributed in hardcopy or by email.
2. Attach a counter to websites and other social media to evaluate visits and download of materials.
3. Track the number of BMPs installed.
4. Track the hours and miles of road management and the number of BMPs maintained.
5. Track the number of informational signs installed.
6. Track the number of site visits/presentations conducted and attendees.

Additional outreach products will be determined if future management measures and activities are planned for implementation in the watershed. This section of the WBP will be updated when the plan is re-evaluated in 2027 in accordance with Element F&G.

Elements F & G: Implementation Schedule and Measurable Milestones

Element F: Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

Element G: A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

Table FG-1 provides a preliminary schedule for implementation of recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated at least once every three (3) years, or as needed, based on ongoing monitoring results and other ongoing efforts.

Table FG-1: Implementation Schedule and Interim Measurable Milestones

Category	Action	Estimated Cost	Year(s)
Monitoring /Evaluation	Work with the Millers River Watershed Council to write a Quality Assurance Project Plan (QAPP) for sampling Keyup Brook (or expand the existing QAPP if permitted	$2,000	2024
	Recruit and train volunteers for the Millers River Watershed Council monitoring program.	$2,500	2024
	Perform annual water quality sampling and BMP monitoring per Element H&I monitoring guidance.	$10,000	TBD
	Distribute water quality and BMP monitoring results through annual report card.	TBD	Annual
Grant Application	Apply for a 604b grant for H&H, FGM, and BMP study.	Staff time	2023/2024
Nonstructural BMPs	Watershed hydraulic and hydrologic (H&H) engineering study	$30,000	2024
	Watershed fluvial geomorphology study (FGM)	$35,000	2024
	Engineering study of potential stormwater BMPs	TBD	2024
	Beaver management plan	TBD	2025-6
	Ongoing Erving and Northfield road maintenance BMPs	TBD	2024 and ongoing
Structural BMPs	Obtain funding for and implement 3 to 9 BMPs (average 1 to 3 BMPs per year)	TBD	2026 – 2028
Public Education and Outreach *(See Element E)*	Provide information via Healthy and Climate Resilient Rivers ArcGIS StoryMap	N/A	2024
	Post WBP to Town website	N/A	2024
	Educational materials and/or presentations	$1,500	2024 and ongoing
	Project updates and monitoring data (website posts)	N/A	Annual
	Signage	$3,000	On-going
	Site visits	$750	Annual
	Road management best practices training to private and public road maintenance staff	TBD	2024 – 2026
Adaptive Management and Plan Updates	Charge a working group comprised of stakeholders and other interested parties to implement recommendations and track progress. Meet at least twice per year.	Volunteer	2024 and ongoing

Category	Action	Estimated Cost	Year(s)
	Re-evaluate Watershed-Based Plan at least once every three (3) years and adjust goals and plan, as needed, based on monitoring results and other observations and experiences.	TBD	Every 3 years from beginning of WBP implementation
	Delist Keyup Brook from the 303(d) list.	--	As soon as possible

Elements H & I: Progress Evaluation Criteria and Monitoring

Element H: A set of criteria used to determine (1) if loading reductions are being achieved over time and (2) if progress is being made toward attaining water quality goals. Element H asks "**how will you know if you are making progress towards water quality goals?**" The criteria established to track progress can be direct measurements (e.g., E. coli bacteria concentrations) or indirect indicators of load reduction (e.g., number of beach closings related to bacteria).

Element I: A monitoring component to evaluate the effectiveness of implementation efforts over time, as measured against the Element H criteria. Element I asks "**how, when, and where will you conduct monitoring?**"

The water quality target concentration(s) are presented under Element A of this plan. To achieve these target concentrations, the annual loading must be reduced to the amount described in Element B. Element C of this plan describes the various management measures that will be implemented to achieve this targeted load reduction. The evaluation criteria and monitoring program described below will be used to measure the effectiveness of the proposed management measures (described in Element C) in improving the water quality of Keyup Brook.

Direct Measurements

Direct measurements are generally expected to be performed as described below. Prior to implementing a direct measurement program, an abbreviated quality assurance project plan (QAPP) and/or Standard Operating Procedures (SOPs) will be established to flesh out details of the program and establish best practices for sample collection and analysis. Water quality monitoring may be performed through the volunteer-run Millers River Watershed Council to save on costs; however, it is noted that some funding would be required if new volunteers had to be trained and organized.

Brook Sampling

Establish regular sampling of priority pollutants bacteria and total suspended solids in Keyup Brook; potentially include analysis of other common NPS pollutants, such as total phosphorus and total nitrogen. Additional parameters such as temperature, conductivity, biochemical oxygen demand, salinity, dissolved oxygen, pH, and chlorine could provide additional data for consideration. Monitoring locations will be selected to build upon existing water quality data. It is recommended that, at a minimum, samples be taken at the previous testing location upstream of the intersection of Swamp Road and Laurel Lake Road and at the Church Street bridge. It is also recommended that samples be taken May through November during notable storm events with a goal to capture up to four events per year. Total suspended solids and discharge measurements can later be converted to estimates of loading and will aid in better characterizing base loading to Keyup Brook. Additional monitoring

locations may be selected based on accessibility and representativeness and shall be appropriate to quantify water quality improvements in the watershed.[29]

BMP, TSS, and Flow Monitoring

As feasible and dependent on available funding and Town staff capacity, the effectiveness of existing and proposed structural BMPs will be evaluated by routine inspection during and after storm events to measure amounts of sediment collected (i.e., sediment traps, catch basins, etc.). As feasible and dependent on funding for laboratory testing and availability of volunteers, TSS and discharge will also be periodically measured at the mouth of Keyup Brook during notable storm events with a goal to capture up to four events per year. TSS and discharge measurements can later be converted to estimates of annual loading.

Indirect Indicators of Load Reduction

Nonstructural BMPs:

Potential load reductions from nonstructural BMPs (i.e., street sweeping and catch basin cleaning) can be estimated from indirect indicators, such as the miles of streets swept or the number of catch basins cleaned. As indicated by Element C, it is recommended that sediment removal from these ongoing actives be estimated. Next, it is recommended that ongoing road maintenance activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency or improved technology.

Project-Specific Indicators

Number of BMPs Installed and Pollutant Reduction Estimates:

Anticipated pollutant load reductions from existing (i.e., under construction), ongoing, and future BMPs will be tracked as BMPs are installed. These exact indicators may be determined by the BMP engineering study described in Element C.

Geomorphic Indicators:

Project-specific indicators of projects focused on bank stability and reduction of TSS loading could include the number of projects installed, estimates of sediment load reductions, estimate of flow velocity reductions, number of linear feet of bank stabilized, and number of acres of floodplain reconnected.

TMDL Criteria

Keyup Brook (MA34-27) will be included in the forthcoming *Massachusetts Statewide TMDL for Pathogen-Impaired Inland Freshwater Rivers* currently in draft stage.

Adaptive Management

As discussed by Element B, the baseline monitoring program could be used to establish a long-term (i.e., 10 year) bacteria load reduction goal (or other parameter(s) depending on results). Long-term goals will be re-evaluated at least once every three (3) years and adaptively adjusted based on additional monitoring results and other indirect indicators. If monitoring results and indirect indicators do not show improvement to the pollutant

[29] Additional guidance is provided at: https://www.epa.gov/sites/production/files/2015-06/documents/stream.pdf and https://www.mass.gov/guides/water-quality-monitoring-for-volunteers#2

concentrations measured within the watershed, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

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Appendices

Appendix A – FRCOG Field Assessments

November 9 2021 FRCOG visit with Town Planner to Keyup Brook Watershed

Waypoint	Parcel_ID	Address	Public/ private	Stream buffer width and character	Additional Observations
1	6-4-18	Church Street	private	no veg, hardened with rock	Lots of damage from 7/18/21 storm; embankment failing within 20' of house; sinkholes behind retaining walls; driveway within 25' of brook
2	6-4-21	Church Street	private	house ranging from 2 - 10' from brook, rocky and vegetated embankment	Lots of damage from 7/18/21 storm, house within 3' of embankment at one corner; rocks being moved along embankment; house across the brook has a multigenerational very hard rock and cement retaining wall that is holding up better
4	6-4-24	Church Street	private	house on cement embankment	Private residence close with one corner directly aligned with embankment; saw less damage in 7/18/21 storm
3	6-4-22	Church Street	public	mown to 4' retaining wall	Town-owned property, have considered it as floodplain storage but may be difficult to engineer due to ledge close to surface
5		Highland Ave	public	3' buffer between road at all three corners; northeast corner appears gardened -- perennials and lawn scraps	bridge
6a	6-2-37. 6-2-36	Highland Ave	private	west side of brook is rock wall embankment; east side has forested riparian buffer with small sections where brook can access floodplain	
6b	6-2-37. 6-2-32	Highland Ave	private	building on cement embankment west side; east side has full forested floodplain	brook here on east side is wider, shallower, and the embankments much shorter--generally healthy looking
7	6-4-32	North Street	private	storage of equipment and materials within 50' of brook	same house as is across brook in waypoint #2 photos
8	6-4-13. 6-4-22	Route 2 and Hanson Court	public	30' partially vegetated buffer on west side; 10' mown buffer on east side then impervious road	town owns property on both sides and Crescent Road; no purpose for road other than to serve condemned house (parcel #6-4-16); LOTS of erosion and deposition here, still material lodged
9	6-4-82. 6-4-84	Crescent Street	public	from culvert: mostly vegetated on all sides except southwest corner is vegetated for 30', then mown field	2 box culverts, 2 railroad bridges between this culvert and Route 2; on southwest corner there is a intake for a 200 gallon storage tank (for use for fire safety) under the field/floodplain, overflow outlet is downstream a little ways--also meant to help with brook flooding

10	6-4-85. 6-4-84	Crescent Street	public	newly constructed road with loose dirt and fill w/in 10 feet of brook on both sides of brook; 10' of riprap on east side	project cleared out old buildings along Crescent Street and replaced an asbestos sewer pipe running through the brook with a pipe running under the brook; lots of exposed soil, gravel, and an opened 1-ton sandbag on the west side of the brook within feet of the brook; property on east side is the park, property on west side is not yet planned for-- maybe dog park, maybe river walk; base road construction present
11	6-10-1	Arch Street	public	N/A	playground design employs multiple stormwater BMPs and diverts any sheetflow from park (or Keyup Brook) into Millers
12	6-4-54	Route 2	public/priva	mown to 3-4' retaining wall	Pearl B Care historic firehouse building; bridge over Route 2 no replacement planned during Route 2 redo; note manhole near Pearl Care building
13		Swamp Road	public/priva	from missing bridge, 20 - 50' wooded buffer to road	bridge out after 7/18/21 storm washed out abutments and bridge started to sag; there was a small 12' half pipe draining surface runoff from road into brook
14	3-0-26	Swamp Road	public/priva	from bridge/culvert: northeast corner close to road w wooded buffer, northwest corner wooded, southeast and southwest corners 15' wooded buffer to yard,	pinched at the culvert, water over Swamp Road on the southwest corner
15	3-0-24	North Road	private	partially vegetated, with 20' length mown to brook	
16		North Road	public	10' wide buffer of new riprap along sharp outside turn of brook	50' of sever erosion, guardrail loss, very close to asphalt, within 3' of sewer pipe; there is a secondary channel in a nice little wooded floodplain area on the inside corner of this bend where water overflows; specialist from DEP told the Town after the 7/18/21 storm that deepening the channel would not necessarily mitigate flooding of main channel, as most of that space is already being used for flood storage; evidence that this is a recurring issue (all according to Mariah Kurtz)
17	63-A-1. 63-B-1	Orange Road	private	N/A	at very top of the watershed; house in a hollow that drains to the swamp; evidence of a number of animals in the past based on faencing and shelter buildings but not currently a suspected source
18	49-B-3.7	Orange Road	private	active drainage to Keyup Brook in ditch along roadside	water eroding both sides of road; Town has done some road work
19	49-B-2.4	Orange Road	private	tributary to Keyup Brook in ditch along roadside	8 houses total along Orange Road in Northfield (waypoints 17 - 19), evidence of erosion along driveways and in ditches

September 15, 2022

Field survey with Town Planner Mariah Kurtz & FRCOG staff

Municipal parcel on High Street: This is an impoundment to a perennial or intermittent stream. It is mostly forested. Someone mows a path on south side of impoundment to back side of adjacent property.

Swamp Road: Some minor erosion around in middle of Swamp Road bridge (not the bridge at the intersection of Swamp Road and North Street)

1st house from bridge: eroding banks; tires and wood placed in the bank

2nd house: a ford?

3rd house: a narrowing of the streambed with rocks; no buffer for a period; wide ford

Jacks Brook and adjacent field: Brooks seems to be untouched; buffer about the width of one mature tree canopy

Flis Market: Appx. 300 sq ft parking area, eastern edge of which is about 25 feet from brook. Lawn and shrubs buffer the parking area from the brook.

Municipal parking lots: Parking lots on both sides of Arch Street are draining into the low point of Arch Street under the railroad bridge and leaving sediment there. This sediment does not appear to be draining to the brook. However, the erosion along the parking lot and down the sides of the stairs on the west side parking lot is somewhat severe.

Riverside Park: No erosion noted at the recent construction site where the old sewer pipe was removed

Old Pearl Firehouse: Damage is more extensive than previously noted along the banks next to the old Pearl B. Care firehouse.

Mouth of Keyup Brook: No sign of sediment deposition

Appendix B – Pollutant Load Export Rates (PLERs)

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
AGRICULTURE, HSG A	0.45	7.14	2.59
AGRICULTURE, HSG B	0.45	29.4	2.59
AGRICULTURE, HSG C	0.45	59.8	2.59
AGRICULTURE, HSG D	0.45	91.0	2.59
AGRICULTURE, IMPERVIOUS	1.52	650	11.3
COMMERCIAL, HSG A	0.03	7.14	0.27
COMMERCIAL, HSG B	0.12	29.4	1.16
COMMERCIAL, HSG C	0.21	59.8	2.41
COMMERCIAL, HSG D	0.37	91.0	3.66
COMMERCIAL, IMPERVIOUS	1.78	377	15.1
FOREST, HSG A	0.12	7.14	0.54
FOREST, HSG B	0.12	29.4	0.54
FOREST, HSG C	0.12	59.8	0.54
FOREST, HSG D	0.12	91.0	0.54
FOREST, HSG IMPERVIOUS	1.52	650	11.3
HIGH DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
HIGH DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
HIGH DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
HIGH DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
HIGH DENSITY RESIDENTIAL, IMPERVIOUS	2.32	439	14.1
HIGHWAY, HSG A	0.03	7.14	0.27
HIGHWAY, HSG B	0.12	29.4	1.16
HIGHWAY, HSG C	0.21	59.8	2.41
HIGHWAY, HSG D	0.37	91.0	3.66
HIGHWAY, IMPERVIOUS	1.34	1,480	10.2
INDUSTRIAL, HSG A	0.03	7.14	0.27
INDUSTRIAL, HSG B	0.12	29.4	1.16
INDUSTRIAL, HSG C	0.21	59.8	2.41
INDUSTRIAL, HSG D	0.37	91.0	3.66

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
INDUSTRIAL, IMPERVIOUS	1.78	377	15.1
LOW DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
LOW DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
LOW DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
LOW DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
LOW DENSITY RESIDENTIAL, IMPERVIOUS	1.52	439	14.1
MEDIUM DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
MEDIUM DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
MEDIUM DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
MEDIUM DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
MEDIUM DENSITY RESIDENTIAL, IMPERVIOUS	1.96	439	14.1
OPEN LAND, HSG A	0.12	7.14	0.27
OPEN LAND, HSG B	0.12	29.4	1.16
OPEN LAND, HSG C	0.12	59.8	2.41
OPEN LAND, HSG D	0.12	91.0	3.66
OPEN LAND, IMPERVIOUS	1.52	650	11.3
[1]HSG = Hydrologic Soil Group			