Executive Office of Environmental Affairs

SHAWSHEEN RIVER

Watershed Assessment Report
2002-2007

EXECUTIVE OFFICE of
ENVIRONMENTAL AFFAIRS

The Commonwealth of Massachusetts

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Dear Friends of the Shawsheen River Watershed:

It is with great pleasure that I present you with the Year 3 Assessment Report for the Shawsheen River Watershed. The report outlines the main environmental issues that face the watershed and provides the most current status of the Shawsheen River. This report will help formulate the 5-Year Watershed Action Plan that will guide state and local environmental actions within the Shawsheen River Watershed. The plan will implement the goals of the Executive Office of Environmental Affairs which include: improving water quality; restoring natural flows to rivers; protecting and restoring biodiversity and habitats; improving public access and balanced resource use; improving local capacity; and promoting a shared responsibility for watershed protection and management.

The former Shawsheen River Watershed Team Leader developed this Assessment Report after extensive research and input by state and federal agencies, Regional Planning Agencies, watershed groups and organizations, and team members. The priority issues identified in the report include:

- Water Quality
- Water Quantity, Supply, and Flow
- Habitat
- Land Use, Open Space, and Impervious Surfaces Cover
- Public Advocacy and Attitudes Towards Watershed Resources Protection

I commend everyone that was involved with the Shawsheen River Watershed Assessment effort. Thank you for your dedication, perseverance, and commitment. The watershed approach is the best way for government and community partners to make significant progress in addressing the environmental challenges of the 21st Century. If you are not currently a participant, I strongly encourage you to become active in the Shawsheen River Watershed restoration and protection efforts.

Regards,

Ellen Roy Herzfelder

Ellen Roy Herzfelder

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THE SHAWSHEEN RIVER – GEOGRAPHIC DESCRIPTION

The Shawsheen River, a tributary to the Merrimack River, is located in northeastern Massachusetts where it is bordered by the Merrimack, Ipswich, Charles, and Concord Rivers as well as Boston Harbor. The Shawsheen watershed includes approximately 60 miles of named streams and encompasses a drainage area of 78 square miles. About 4.5% of the watershed is covered by wetland or open waters. The main stem of the Shawsheen River flows 25 miles from the headwaters in Hanscom Field in Bedford to its confluence with the Merrimack River in Lawrence. The mainstem channel depth ranges between one half and five feet. In Andover, the river is impounded by two dams, one at Ballardvale Village and the other at Stevens Street.

The watershed includes 20 lakes, ponds, or impoundments. Almost half of these water bodies are in Andover. Five are wholly or partly located in Tewksbury. The other lakes are located in Bedford, Billerica, Burlington, and Wilmington.

All or a portion of twelve cities and towns lie within the watershed. They are Andover, Bedford, Billerica, Burlington, Concord, Lawrence, Lexington, Lincoln, North Andover, Tewksbury, Wilmington and Woburn. Portions of Andover, Lawrence, and Lexington are the most urban in character, but almost all of these municipalities are densely populated.

The people who live in the basin place a significant demand on its water resources. Although Burlington maintains the only direct withdrawal of surface water from the Shawsheen River, Bedford, Burlington, and Tewksbury pump water from wells located near the river or its tributaries for at least a portion of their water supply. High population density has created a significant need for source wastewater management. Over one third of the watershed is residential with house lots between one quarter to one third of an acre. Many of these areas rely on individual on-site septic systems for sewage disposal. These septic systems are the principle source of discharges to groundwater or surface water in the basin.

The Shawsheen River meanders through relatively flat terrain in the coastal plain region of New England, just north of metropolitan Boston. Land use patterns within the watershed have been influenced by its proximity to Boston and by the establishment of the Hanscom Air Force Base in Bedford in 1942, at the headwaters of the Shawsheen. The watershed is predominantly suburban residential with over 50% of the land area developed. Impervious surfaces cover a substantial portion of the watershed, especially at the Air Force Base in the headwaters. Two large wetland areas occur in the middle section of the river located in Tewksbury. Other smaller wetlands are found throughout the watershed as well.

One special study in conjunction with the Hanscom Base property has been the "Headwaters Habitat TMDL Project," focusing on habitat degradation. Fluctuating flow conditions negatively impact habitats (i.e., the normal diversity and populations of aquatic species). When the Air Force Base was built in 1940's, the original course of the river running through the base property, (which was serpentine in character), was moved and reformed into a straight drainage channel on the east border of the property. This coupled with increased impervious cover of runways, roadways, and rooftops, created a flash flow situation during heavy rains. The project is developing a BMP (best management practices) implementation plan (e.g. detention basins), to help retard the rapid runoff situation.

This Assessment Report covers the four main areas of concern in the Shawsheen River Watershed: water quality; water quantity, supply, and flow; habitat; and land use planning and open space. It concludes with an overview of public attitudes and perception as they relate to the river.

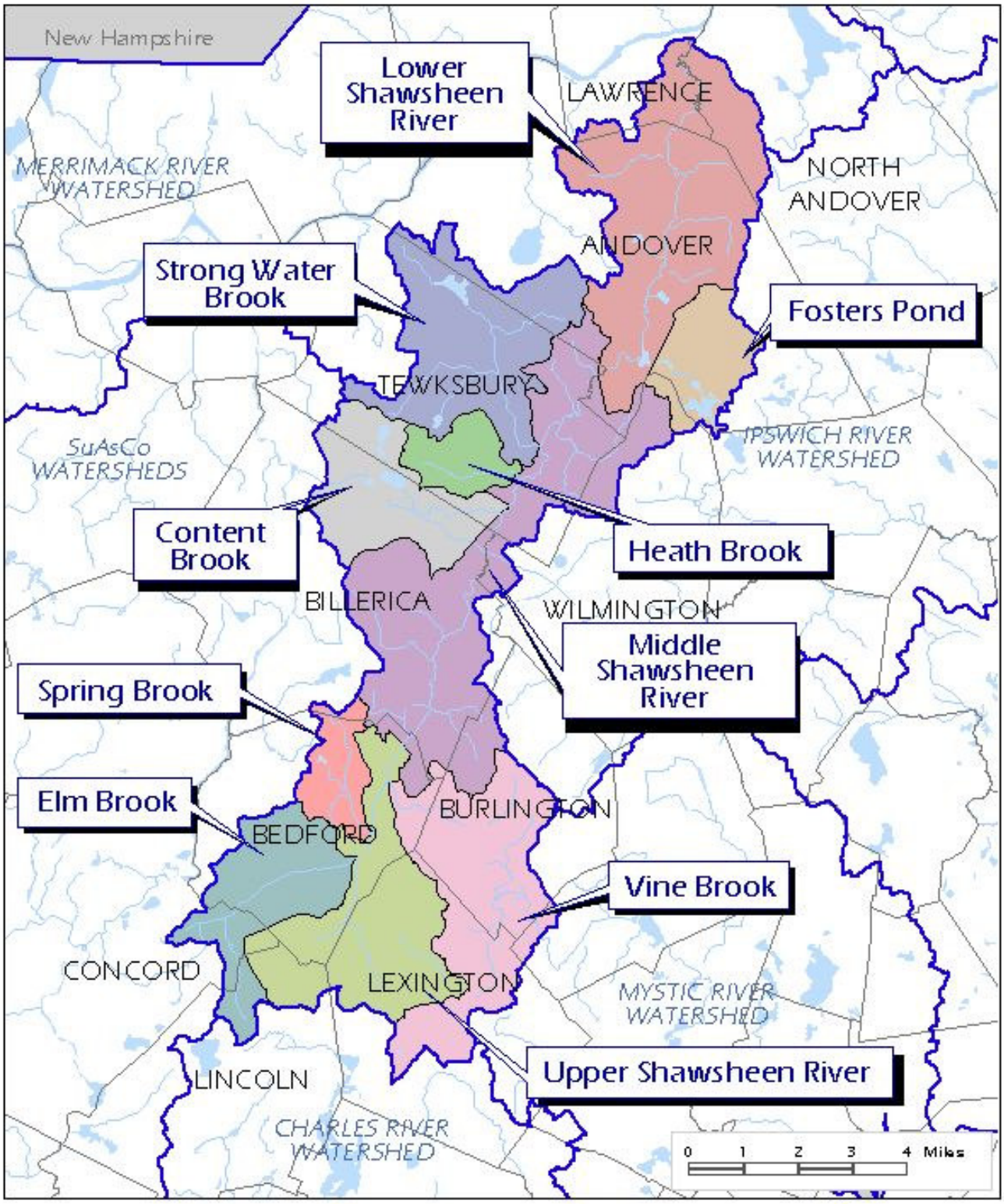


Figure 1: Shawsheen Watershed Sub-basins

WATER QUALITY

Water Quality Improvements in the Past 25 Years

*[1]Water quality has improved basin-wide since 1972. Fecal coliform has declined from an average of 600 colonies per 100 milliliters in 1968 to 340 in 2000. Particular improvements are noted in the mid-basin mainstream area in Billerica and Tewksbury. This five-mile stretch partially meets water quality standards for this pollutant. This means that the water body meets the standard most of the time; exceptions occur in wet weather.

Total phosphorus levels have decreased from an average of 0.16 parts per million 1968 to 0.05 in 1995. TKN nitrogen levels have decreased slightly from 0.78 parts per million in 1968 to 0.59 in 1995. Suspended solids have also improved from an average of 7.7 parts per million in 1995.[*2]

Almost all industrial discharges have been eliminated and there are no municipal wastewater treatment plant discharges in the basin. Because of plant closings and connections to municipal sewer systems that discharge to other basins, the number of industrial discharges and the volumes of pollutants have declined dramatically over the past 25 years. This may, to a large extent, account for the improvements in water quality.

Despite this improvement, some problems remain. Nitrate nitrogen and ammonia levels have remained the same since 1968. Recent stream team data collected over the past two years indicate that in at least five tributary areas that had not been monitored before, there are serious hot spots of fecal coliform violations as well as elevated levels of nutrients and suspended solids.

The causes of water pollution in the Shawsheen are nonpoint sources. Although the water quality of the Shawsheen River and its tributaries is considered good by many standards, a few pollutants from suspected nonpoint sources of pollution such as failing septic systems and stormwater runoff consistently prevent the main stem from meeting Class B (fishable/swimmable) criteria. Tributaries, including segments of Elm Brook, Vine Brook, and Rogers Brook, are also impaired.[*3]

Many of the lakes and ponds in the watershed have excessive plant density and are considered non-swimmable. Non-native plant species have been discovered around several ponds. Particularly noteworthy is the purple loosestrife that is pervasive throughout the wetland areas of the watershed.

Pathogens are the main cause of water quality problems. Nutrients, particularly inorganic nitrogen, also threaten to impair water quality. Low dissolved oxygen levels frequently cause violations of water quality standards. Turbidity and unknown toxicity are only an occasional source of water quality problems.[*4]

[*1] The Shawsheen/Merrimack River: A working report. The State of the Waters in Massachusetts. The 25th Anniversary of the Clean Waters Act. 1997.
[*2] IBID…..pg 2
[*3] IBID…..pg 2
[*4] IBID…..pg 2

Present Water Quality, By Sub-basin

The former Shawsheen Watershed team, through project support from the Executive Office of Environmental Affairs (EOEA), USAF Hanscom, Raytheon Corp., and other sponsors conducted a comprehensive stream team monitoring program consisting of over 120 monitoring stations during 1996-1998. Additionally, two ex-Massachusetts Watershed Initiative projects in 1999 and 2000 mapped and identified over 250 storm drain outfalls along the entire mainstem length of the Shawsheen River. Some water quality monitoring of a selection of these outfalls was done in 2000 and 2001.

The 1996-1998 stream team monitoring program revealed nearly two dozen fecal coliform hot spot problem locations scattered throughout the tributary areas of the watershed (counts over 600 col/100ml), and well over three dozen moderately elevated fecal coliform locations (counts 200 and 600 col/100ml). Hot spot problem locations involved the following tributaries: Kiln, Elm, Vine, Spring/Beaver, McKee/Webb/Jones, Content, Strongwater/Meadow, Sutton, Rogers, as well as Foster's Pond, Pump's Pond, and Hussey Pond. This list includes 90% of the named tributaries and 35% of the ponds in the watershed.[*5]

Geometric average for fecal coliform for all 1996-98 monitoring for all monitoring stations in each tributary includes the following: Kiln-360; Elm-415; Vine-580; Spring-921; Sutton-159; Meadow/Strong Water-655; Content/Heath-232; McKee/Webb/Jones-4097; Rogers-2223; Hussey Pond-342; Pomp's Pond-104; Fosters Pond-2,227.[*6] In almost all tributaries, the geometric averages are elevated due to at least one or more hot spot sampling locations (600 col/100 ml or more). Close to 24 of these sites have been identified, and reported to appropriate municipal and/or state DEP officials. At least a dozen of these pollution hot spot problems have either been resolved, or progress is underway to resolve them.

It should be noted that prior to the 1996-1998 Merrimack River Watershed Council (MRWC) stream team data in the tributaries, the only data gathered was DEP data 1968-1995, at the confluences of Elm, Vine, Strongwater, and Roger's Brooks with the mainstem of the Shawsheen River. Much of the remaining past DEP data (1968-1995) is in mainstem locations. The geometric average for fecal coliform in the 1990 and 1995 DEP water quality studies for all stations was 385, and in the 2000 studies it was 345. Comparison shows slight overall improvements in the mainstem bacteria counts over the past decade. Yet, all tributaries and most ponds (except Pomp's Pond) fail to meet Massachusetts Water Quality Standards for fecal coliform (200 col/100 ml or less). Also, much of the mainstem fails to meet the standards as well, except for approximately a 5-mile mainstem portion from Billerica through Tewksbury (which has seen slow improvement over the past decade).

Dissolved Oxygen (D.O.) levels, (the minimum standard is 5.0 mg/l or greater), have generally met standards from the DEP studies 1968-1995, although there has been a mainstem portion between North Bedford and Tewksbury which has had some problems in the past particularly during warm weather. This is probably due to natural wetland conditions. The MRWC stream team studies from 1996-1998, gave us the first look at D.O. levels in all the major tributaries, and indicated considerable problem areas. Averages for dissolved oxygen levels for all stations sampling from 1996-1998 were: Kiln-3.2; Elm-3.7; Vine-3.5; Sutton-0.2; Meadow/Strongwater-2.7; Content/Heath-2.8; McKee/Webb/Jones-3.1; Roger's-3.6; Hussey Pond-3.6; Pomp's Pond-3.1; Foster's Pond-2.7.[*7] All these averages indicate that water quality standards for D. O. are not met in any major tributary, or the three ponds where data was gathered. These MRWC studies clearly indicate far greater water quality problems in the tributary areas than in the mainstem for both fecal coliform bacteria and D.O. levels.

[*5] Merrimack River Watershed Council. Shawsheen River Watershed 1996-1998 Volunteer Monitoring Report. May 1999.
[*6] IBID
[*7] IBID

Turbidity, in the 1995 DEP water quality study, averaged 4.0 NTU over 13 mainstem (2 tributary confluence) stations. In the 1996-1998 MRWC stream team studies, turbidity averaged: Kiln - 5.0 (NTU's), Elm – 7.4; Vine – 4.5; Spring – 5.6; Sutton – 17.8; Meadow/Strong Water – 3; Content/Heath – 6.2; McKee/Webb/Jones – 3.0; Roger's – 3.0; Hussey Pond – 2.6; Pomp's Pond – 2.4; Foster's Pond – 2.1.[*8] This also indicates greater water quality problems in the tributaries than in the mainstem.

The principal parameter in the Shawsheen River generating the most discussion between the EPA and the State DEP regulators regarding water quality violations is bacteria (Fecal Coliform) counts. The former Shawsheen watershed team elicited project support from the National Wildlife Federation in 1997-98 to conduct a Bacteria TMDL (Total Maximum Daily Load) Study. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop TMDLs for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of their water resources.[*9]

High levels of fecal coliform bacteria have been recorded throughout the Shawsheen Watershed. Fecal coliform bacteria are used as indicators for pathogenic microorganisms that can cause gastrointestinal illness through ingestion or by entering through open skin. The entire length of the Shawsheen River appears in the "Final Massachusetts Section 303(d) list of waters – 1998" (MDEP, 1999), due to pathogen violations. In Massachusetts, use of the term "pathogens" on the 303(d) list directly corresponds to fecal coliform. Additionally, three tributaries to the Shawsheen River: Rogers Brook (from its headwaters to its confluence with the Shawsheen River), Vine Brook (from its headwaters to its confluence with the Shawsheen River), and Elm Brook (from its headwaters to its confluence with the Shawsheen River) are also listed for pathogen violations.[*10]

*Potential Dry Weather/Continuous Sources[*12]*

Based on a review of NPDES permitted point sources in the watershed, information on the areas of the watershed serviced by septic systems and a review of the Shawsheen River Watershed 1996-1998 Volunteer Monitoring Report, potential dry weather sources were identified. These sources which are all continuous, even during wet weather events, include:

- point sources
- sewer line breaks/leaks
- illicit disposal to storm drains
- poorly performing septic systems
- direct wildfowl

Dry weather sources of fecal coliform within the Shawsheen River Watershed are discussed below.

Point Sources

The greatest potential source of human fecal coliform from point sources is raw sewage. Ten NPDES permitted point sources are known to discharge in the Shawsheen River waters. Most of these are minor non-contact cooling water permits. Only one minor permit discharges treated wastewater into the watershed (in Bedford), and the permittee (Battle Road Condominiums, Inc.), is not regarded by the EPA

[*8] IBID
[*9] Limno-Tech, Inc., Ann Arbor, Michigan. "Proposed Bacteria TMDL for the Shawsheen River." July, 1999. 114.
[*10] IBID…..pg 4
[*12] IBID…..pg 17

or DEP as a prime contributor to overall watershed bacteria problems, or even in its immediate tributary discharge area on the southwest side of Hanscom Air Base/Bedford.

Sewer Line Breaks/Leaks
Raw sewage, although not usually discharged intentionally, can reach waterbodies through leaks in sanitary sewer systems, overflows from surcharged sanitary sewers (sanitary sewer overflows), illicit connections of sanitary sewers to storm sewer collection systems, or unidentified broken sanitary sewer lines. According to the Center for Watershed Protection (CWP, 1999), "in some communities, as many as 10 percent of all pipe outfalls have dry weather flow. Even if only a few of these flows contain sewage, they can produce very high bacteria concentrations because of low instream flow."[*13]

The Merrimack River Watershed Council volunteers have discovered sewer line breaks and leaks within three tributary subwatersheds to the Shawsheen River which appear on the 303(d) list i.e. Rogers Brook, Elm Brook and Vine Brook, as well as near several mainstem Shawsheen River sampling stations. Water quality monitoring 1996-1998, has identified well over a dozen total sewer line breaks/leaks on these tributaries and mainstem locations. In many instances fecal coliform counts were very high (>5,000 col/100 ml), and often residual bacteria effects were monitored for quite a distance downstream. In the cases of Elm Brook and Rogers Brook confluences with the Shawsheen mainstem, there were considerable loading impacts measured for ¼ to ½ mile downstream of the confluence point on the mainstem.

Illicit Disposal to Storm Drains
Illicit disposal of sewage to storm drains can have as large an impact as broken or leaking sewer pipes. The Merrimack River Watershed Council volunteers discovered that some businesses were improperly dumping sewage and were not hooked up to the sewer system near the Shawsheen River station in North Bedford.[*14] This is likely to be the cause of excessive fecal coliform concentrations at this station. Long after this TMDL project was completed, other volunteers found similar breaks into storm drain lines off Dunham Road in Billerica.

Poorly Performing Septic Systems
Onsite septic systems hold the potential to deliver bacteria to surface waters due to failure of the system to provide adequate treatment. The causes of septic system failure are numerous: inadequate soils, poor design, siting, testing or inspection, hydraulic overloading, tree growth in the drain field, old age, and failure to clean out. Poorly performing septics may contribute fecal coliform concentrations of 20,000 counts/100 ml.[*15]

No information is available on the specific locations of septic systems, septic tank densities or failure rates in the Shawsheen River Watershed. However, the Merrimack River Watershed Council surveyed each of the towns in the watershed to get an estimate of the percent of sewered versus non-sewered area of each town. This survey indicated that most of the Shawsheen River Watershed is serviced by sewer lines, with only portions of the Towns of Bedford, Andover, Billerica, and Tewksbury serviced by septic systems. Using 1990 census data for each of the towns to estimate the number of homes, and assuming a failure rate of 3%, the number of failing systems can be estimated for the portion of each town within the watershed (Table 1).

[*13] IBID….. pg 18-19
[*14] IBID….. pg 19
[*15] IBID….. pg 20

Table 1. Summary of % of each town serviced by sewer.[*16]

Town	% Sewered	#Single Unit Homes In Watershed[A]	# Septic Systems[B]	# Failing Systems[C]	Tributaries w/in Town Boundaries
Andover	90	3,963	396	12	Baker's Meadow, Content Brook, Roger'sBrook Hussey Pond
Bedford	94	2,511	151	5	Spring Brook, Elm Brook
Billerica	70	4,607	1,382	41	Content Brook, McKee, Web and Jones Brooks
Burlington	100				
Lawrence	100				
North Andover	100				
Tewksbury	45	5,629	3,096	93	Strongwater Brook, Sutton Brook, Content Brook, Heath Brook

[A] Number of single unit homes per 1990 U.S. Census.
[B] Number of homes on septic systems in the watershed, assuming one septic system per home.
[C] Number of homes with failing septic systems based on 3% national failure rate.

Almost the entire length of the Shawsheen River falls within the town boundaries of Bedford, Billerica, Tewksbury, and Andover. Therefore, septic systems are a potential source of bacteria, on much of the mainstem of the Shawsheen River, as well as the following tributaries: Baker's Meadow, Content Brook, Roger's Brook, Hussey Pond, Spring Brook, Elm Brook, McKee/Webb and Jones Brooks, Strongwater Brook, Sutton Brook and Heath Brook.

Direct Wildfowl
Animals that are not pets can be a potential source of fecal coliform, even in an urban environment. Geese, gulls, and ducks are speculated to be a major bacterial source in urban areas, particularly at lakes and stormwater ponds where large resident populations have become established. However, relatively little data is available to quantify whether geese and ducks are a major source of fecal coliform. Wildfowl are of particular concern in the following subwatersheds: Pinnacle Brook, Strong Water Brook, Foster's Pond, and Baker's Meadow due in part to the undeveloped land adjacent to some of these waterways. Of these tributaries, dry weather fecal coliform water quality violations were only observed at the mouth of Strongwater Brook.[*17] Much waterfowl contamination is believed to occur during and immediately following wet weather events.

[*16] IBID….. pg 21
[*17] IBID….. pg 21

Wet Weather Sources

Potential sources for wet weather violations of fecal coliform standards were identified from an analysis of land use patterns, a literature review, and a review of the Shawsheen River Watershed 1996-1998 Volunteer Monitoring Report. These sources include:

- Stormwater runoff carrying bacteria from:
  - Domestic animals
  - Livestock
  - Wildlife
- Pump station overflows

High stormwater runoff loads of bacteria are more likely to be caused by bacteria from domestic animals rather than from livestock and wildlife. This is based on an analysis of fecal coliform violations at stations of downstream of areas with higher concentrations of livestock and wildlife.[*18]

Stormwater Runoff

With over half of the watershed developed with either urban or residential land use, the potential for conversion of precipitation to significant amounts of stormwater runoff exists. Stormwater runoff may carry fecal coliform from pets, livestock, and wildlife to the Shawsheen River and its tributaries. Urban stormwater runoff appears to be a significant wet weather source of bacteria not only to the Shawsheen River, but also to its tributaries. In several tributary watersheds, including Vine Brook and Elm Brook, an apparent correlation has been noted between the highly developed lower sections with high bacteria levels, in addition to an apparent correlation between high turbidity and fecal coliform levels. In Elm Brook, runoff is suspected to contribute fecal coliform since most Bedford residents are on the town sewer system, although it should be remembered that a possible sewer leak was also noted in the midsection part of the Elm Brook subwatershed.[*19]

Domestic Animals

One source of bacteria in stormwater runoff in urban areas like the Shawsheen River Watershed, is the feces from household pets such as cats and dogs, which comprise a large potential source of bacteria (~23,000,000 #/gm (CWP, 1999)). A rule of thumb estimate for the number of dogs is ~1 dog per 10 people producing an estimated 0.5 pound of feces per dog per day. This translates to an estimated 10,700 dogs in the watershed producing 5,400 pounds of feces per day. Unless this waste is picked up and properly disposed, runoff flushes the bacteria from the parks and yards where pets are walked into nearby waterways.[*20]

Livestock

In rural areas, runoff from livestock areas may be a source of bacteria. Within the Shawsheen River Watershed, only 1% of the watershed area is classified as pasture land, and the tributary watersheds with the highest percentage of pasture land are Sutton Brook and Strong Water Brook, with 13% and 5% respectively. Sutton Brook only slightly violated water quality standards at its mouth during dry weather (geometric mean=289 in 1997) and did not violate standards during wet weather, indicating that stormwater runoff of livestock waste is not a significant problem in this watershed. In the Strong Water Brook Watershed, however, there are a few suspected sources for the fecal coliform levels observed at the confluence of Pinnacle Brook and Strong Water Brook. This may contribute to the 1996 wet weather violation of water quality standards at the mouth of Strong Water Brook. However, high fecal coliform

[*18] IBID….. pg 21
[*19] IBID….. pg 21-22
[*20] IBID….. pg 22

levels (geometric mean=374 in 1998) were also noted at this station during dry weather, leaving open the possibility of a dry weather source in the Strong Water Brook Watershed.[*21]

Wildlife

Rural wildlife can also contribute to stormwater loads of bacteria. Wildfowl are noted to be of particular concern in the following subwatersheds: Pinnacle Brook, Strong Water Brook, Foster's Pond, and Baker's Meadow due in part to the undeveloped land adjacent to some of these waterways. Of these tributaries, wet weather fecal coliform water quality violations were observed at the mouth of Strong Water Brook and Foster's Pond. These may be due to the runoff of bacteria from deposits left by wildlife, although their contribution is difficult to quantify.[*22]

Pump Station Overflows

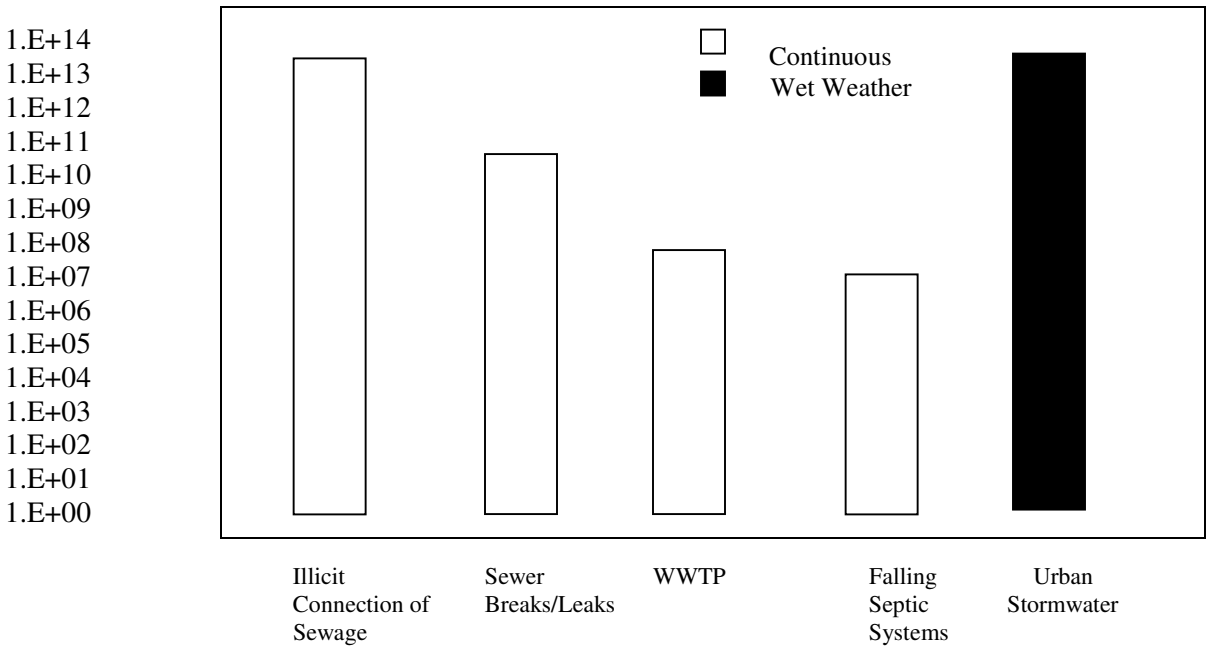
Although there are no known combined sewers in the watershed, there is a pumping station overflow noted on Terrace Hall Road, near Middlesex Turnpike, where the sewer overflows into Vine Brook (MRWC hot spot results, 1999). Pump station by-passes may contribute fecal coliform concentrations that are likely to be similar to those from combined sewer overflows.[*23] Fecal coliform bacteria concentrations from combined sewer overflows or pump station by-passes can be on the order of 10^4 to 10^7 counts/100 ml. While fecal coliform concentrations are expected to be very high in these overflows, the total fecal load delivered to Vine Brook depends upon the quantity of water that is discharged. Overflow situations occur on an average of once or twice per year during high rainfall/runoff situations, which surge the capacity of the existing trunk sewer lines.

[*21] IBID….. pg 22
[*22] IBID….. pg 23
[*23] IBID….. pg 23

MAGNITUDE OF LOADS

Dry and wet weather loads were estimated for each of the following sources, with the relative magnitudes of these sources shown in Figure 2.

Figure 2. Fecal Coliform Loads by Source[*24]



[*24] IBID….. pg 24

WATER QUANTITY, SUPPLY, and FLOW

The Shawsheen Watershed effort, through the former Team had water quantity and flow issues as one of its two top priorities since the inception of the former Watershed Initiative in late 1994, (the other top priority being bacteria pollution reduction). Three serious rain/flooding damage events have occurred during the past 13 years. This flooding has crystallized citizen interest in studying the situation and determining mitigating solutions to help reduce flooding potential in the future.

The former watershed team formulated and supported several projects, starting in 1999, to study the situation and make recommendations. The former team first identified that a flow analysis project on the watershed was necessary to address water-related issues such as water quality impairment, flooding, and low flow. Various former team partners joined together to make plans, and to obtain funds: Merrimack River Watershed Council (MRWC); Shawsheen River Watershed Association (SRWA); U.S. Air Force, Hanscom; Massport; Towns of Bedford, Wilmington, Tewksbury, and Andover. This need was reinforced by flood events in April of 1987, October of 1996, and June of 1998. Also, the Shawsheen River headwaters on the Hanscom property are listed under section 303(d) of the Federal Clean Water Act as impaired due to habitat alteration by hydro modification associated with alternating high storm water runoff and low base flow. Both high flow and low flow were studied together and addressed by analyzing impacts of land use/land cover changes over recent decades. The study was formulated to consist of:

- Water balance analysis – understanding long term hydrology of the watershed that will lead to solutions to the flow problems in the watershed:
  - Quantify the hydrological balance for all sub-watersheds, including surface runoff and base/flow; and
  - Assess land use impact on hydrological balance.

- Stream network modeling – define the short-term hydrology of the watershed:
  - Simulate surface runoff response to precipitation at desired locations within the Hanscom sub-basin and along the mainstem; and
  - Identify and recommend best management practices (BMP's) for improving low flow and flooding problems;

- (Longer-Term)
  - Find funding to assist communities in implementing the BMP's watershed-wide; and
  - Implement BMP's.

The Shawsheen River Basin is rich in history and natural resources, which has changed over time as the watershed has developed. According to MassGIS land use data (MassGIS, 1997), the impervious area in the Shawsheen Watershed is about 19% of the total area. The Hanscom sub-watershed is the highest (34%), and the Pomp's Pond/Baker's Meadow sub-watershed is the lowest (8%). Imperviousness (cover) defined as human constructed cover, e.g., roadways, parking lots, driveways, building rooftops, etc., blocks normal vertical drainage of rainwater through the soil to replenish groundwater levels. Table 1 summarizes relative values for land use in thirteen sub-watersheds that encompass the Shawsheen Basin.

Table 2. Surface area, major land cover, and percentage of imperviousness in the Shawsheen Basin and its Sub-basins[*25]

Sub-Watershed	Basin Area (mi^2)	Forest (Acres)	Residential (Acres)	Commercial/ Industrial (Acres)	Transport (Acres)	Imperviousness
Hanscom	2.03	257.8	212.7	19.1	378.2	34%
Kiln Brook	4.66	668.6	1268.7	239.3	237.6	28%
Elm Brook	5.84	1648.1	1086.3	239.3	237.6	13%
Spring/Beaver/Upper Shawsheen	5.33	1194.2	1129.5	460.5	67.4	17%
Vine Brook	9.94	1654.4	2663.7	1086.0	187.8	25%
McKee/Webb/Jones/Middle Shawsheen	8.86	1368.0	3144.8	461.1	9.0	17%
Heath/Content/Middle Shawsheen	9.34	1846.1	2790.1	446.8	146.8	16%
Strong/Meadow/Middle Shawsheen	10.1	2357.2	1872.6	643.4	167.7	13%
Sutton/Middle Shawsheen	4.82	1463.2	775.4	380.3	99.3	17%
Foster's Pond./Lower Shawsheen	4.65	1241.6	1088.7	187.5	8.2	10%
Pomp's Pond/Lower Shawsheen	3.46	659.7	1044.9	66.6	0.0	8%
Roger's Brook/ Lower Shawsheen	2.14	302.6	631.5	210.1	0.0	24%
Hussey Pond/Lower Shawsheen	6.99	1053.9	2163.6	408.6	189.5	29%
Shawsheen	**78.1**	**15715**	**19872**	**4889**	**1741**	**19%**

[*25] Merrimack River Watershed Council, Water Flow Analysis, Shawsheen River, Report #1 October 2000, pg 3.

Notably, the installation of the Hanscom Air Force Base (HAFB) in 1942 is one of the most striking changes to the nature of this watershed. Significant amount of pervious land has been converted to impervious land as a result of the construction of runways, office buildings, parking lots, roads, residences, etc. The natural channels and streams were replaced by concrete culverts and deepened and widened channels to accommodate the storm water runoff from increased impervious surfaces. Development and expansion of the Air Force Base brought satellite businesses and industries to the Shawsheen River Watershed. To support this growth, communities expanded infrastructure, including roads and highways, sanitary and storm sewers, and other public facilities. According to Laffin et al., 1998, approximately 25% of the watershed was developed by 1960. The percentage increased to approximately 50% by 1971, but has shown relatively little increase since 1971. The most striking increase in development occurred between 1951 and 1971. One can observe similar trends in population growth among communities adjacent to the base. Major growth near the HAFB and the surrounding communities greatly contributed to the water quality and flow problems in this watershed.[*26]

As a result of rapid development and excessive land use changes, there has been severe flooding in Shawsheen River communities during large storm events such as April of 1987, October of 1996, and June of 1998. Widespread basement/street/building flooding was common during these storm events. Although low flow, and water quality impairment are equally important issues as flooding, these issues are not as directly felt by the Shawsheen communities.[*27] One reason is that none of the communities, except the Town of Burlington, depend on the Shawsheen River flow potable drinking water supply.

One of the tasks of the flow analysis study was to appraise water supply from the river being used, versus wastewater being discharged to the river by community. Table 3 reveals that most water supplies come into the basin from outside, (except Burlington and 25% of Bedford, and most wastewater is discharged outside the basin (except in areas served by septic systems).

One should note that most of the recent water quality monitoring programs (namely DEP, and the MRWC) have occurred during the summer months when the river flows in its low capacity. Water quality is invariably affected by relative water quantity (flow). Reduction in flow often increases the pollution concentration in the remaining water column. Therefore, low flow results in increased impairment in water quality. There have been several periods in the past decade where river flows practically ceased in the mainstem and many of the tributaries such as in the summers of 1995, 1999, and 2001. It is clear that low flow is a serious issue in this watershed. Fixing the low flow problem may prove to be more difficult than fixing the flooding problems.[*29] However, it is important to fix the low flow problem before the watershed is permanently degraded. Therefore, the goals set at the outset of the quantity/flow study were to estimate the water budget, which provides a quantitative estimation of precipitation distribution falling on a watershed, versus where it goes, e.g., evapotranspiration, runoff, soil absorption to replenish groundwater and base flow. The subsequent modeling study and development will depend on this information.

[*26] IBID…..pg 4
[*27] IBID…..pg 5
[*29] IBID…..pg 6

TABLE 3: Summary of Municipal Drinking Water Supply and Wastewater Treatment in the Shawsheen River Watershed.[*28]

TOWNS	DRINKING WATER SUPPLY Source	Quantity	WASTEWATER TREATMENT Where	Quantity	RECORDS OF FLOOD/DROUGHT
Andover	Haggett's Pond-replenished by the Merrimack via Fish Brook Andover Well in Shawsheen River Valley	25 million gallons/day (peak flow: 8-10 million gallons/day)	Greater Lawrence Sanitary District (GLDS)		See FEMA
Bedford	75% from MWRA 25% from wells	1 million 4 gallons/day total 200-350 thousand gallons/ day from wells	MWRA Deer Island	1 million 6 gallons/day	Shawsheen overflowed 2-3 years ago
Billerica	Concord River	5 million gallons/day	Back into Concord River	3.1 million gallons/day	Pinehurst area floods around the Shawsheen, Concord also floods
Burlington	Mill Pond in Shawsheen Watershed. Vine Brook ground water well (not currently in use)	Daily average 3.7 million gallons/day 1.3 billion gallons/day	MWRA	4-16 million gallons/day	None
Concord	Five wells and one surface pond	4 million gallons/day from well 1 million gallons/day from pond	Concord River Waste Water Treatment Plant	1 million gallons/day	None
Lawrence	Merrimack River	6.1 million gallons/day	GLDS	15 million gallons/day Many towns use GLDS	
Lincoln	Flint's Pond-naturally recharged private wells. Underground backup well Town of Weston	Two million gallons/day from Weston. 1.1 million gallons/day from Flint's Pond Other figures unknown	Individual septic systems On-site treatment plant that discharges into Shawsheen for condo development in Lincoln	All-no figures	Flooding on Air Force Base where river is channeled. Large portion of Lincoln is wetland
North Andover	Lake Chochichewick Use Andover as emergency Basin	Average of 3.14 million gallons/day from lake	GLDS	1.55 billion gallons in 1997 Note: Increasing 1-1.5% every year	
Tewksbury	Merrimack River mostly in summary-30 million gallons from Andover purchased	2.67 million gallons/day 2.1 in low flow 4.4 in high flow	40-50% goes to Lowell Region Remainder is septic systems	1.2 million gallons/day to Lowell Region. 2.5 million gallons/day into septic systems.	None
Wilmington	9 groundwater wells	300-900 gallons/minute from wells. Note: water use increase every year	2 water treatment plants	1.5 million gallons/day goes to MWRA	During 50-year storm events, 20% of town is flooded
Woburn	Spot's Pond in Stoneham (MWRA) Wells in Horn Pond area		MWRA Deer Island		

[*28] Merrimack River Watershed Council (unpublished) paper, part of flow analysis, Shawsheen Project, 1999-2000.

Data collection for the water balance modeling was based upon climate data, stream flow data, land use/ land cover data, and soil data. Climate data was obtained from the Northeast Regional Climate Center, Cornell University, Ithaca, NY. This included daily rainfall, snowfall, maximum and minimum temperatures for Reading, Lowell, Lawrence, and Bedford for the years 1928, 1948, 1957, and 1960. Stream flow data was obtained from two continuous flow gauges: Wilmington, operating since 1964; and Hanscom Field, operating since 1995. The MassGIS Statewide 1:25,000 land use data layer was obtained from EOEA. This data layer has 37 land use classifications, e.g., agriculture, forest, open land, residential, commercial, industrial, transportation, etc. Aerial photo flyovers from 1938 and 1952 were obtained from the Natural Resource Conservation Service (NRCS), and the United States Department of Agriculture (USDA).

Land cover is the primary input parameter of the GWLF model (the model that was utilized in project). The types of land uses present in the watershed determine runoff and infiltration rates. The present water balance was estimated using the MassGIS land use data layer. The pre-development water balance, which reflects the natural condition of the watershed, was estimated by using the 1938 and 1952 aerial photo series.

Soil survey maps for Essex and Middlesex counties were collected from NRCS, based upon Soil Conservation Service Hydrological Soil Groups A, B, C, and D.

Water balance, or hydrologic budget, attempts to understand the role of water within the Shawsheen watershed and its subwatersheds. The hydrologic cycle is a constantly running system, consisting of solar energy (heat) causing evaporation and transpiration of moisture from the earth surface to the atmosphere; condensation and precipitation as the warm air rises and cools and when precipitation meets earth; and runoff from surface as well as seepage into the ground to the water table and eventual subsurface runoff (as baseflow) into the sides and bottom of rivers/lakes/ponds. Stream flow is derived from both surface runoff and subsurface runoff (baseflow).

The hydrologic budget of a watershed is a mathematical statement of its hydrologic cycle. This is expressed by equating the difference between inflow and outflow of watersheds/subwatersheds to the rate of change of storage within the basin for a specified time period.[*30] The Generalized Watershed Loading Function (GWLF) Model performs these estimations by representing the watershed system as a set of simplistic mathematical equations. The model is based on simple runoff, sediment, and groundwater relationships combined with empirical parameters.[*31] In this project, the GWLF was employed to estimate the water balance in each of 13 subwatersheds.

Present Water Balance (1990-1999) in the Shawsheen Watershed

The ten year (4/89 – 3/99) mean water balance for all subwatersheds in the Shawsheen River is summarized in Table 4. There is no major water withdrawal, except a diversion in the Middle Shawsheen River by the Town of Burlington, as well as no major discharges in the Shawsheen River and its tributaries.

[*30] IBID…..pg 10
[*31] IBID…..pg 10

Table 4.[*32] Ten-year (4/89-3/99) water balance results from application of GWLF v2.0 for the Shawsheen River watershed by sub-basin.

Sub-Watershed	Basin Area (mi^{-2})	Precipitation (inches)	Evapotranspiration (inches)	Baseflow (inches)	Surface Runoff (inches)	Stream Flow (inches)	% Base Flow
Hanscom	2.03	53.7	24.3	9.4	19.7	28.3	33
Kiln Brook	4.66	53.7	24.3	13.8	10.7	24.4	57
Elm Brook	5.84	53.7	24.3	15.0	9.0	24.0	63
Spring/Beaver/Upper Shawsheen	5.33	53.7	24.3	14.8	9.3	24.1	61
Vine Brook	9.94	54.0	24.3	17.6	11.7	29.4	60
McKee/Webb/Jones/Middle Shawsheen	8.86	54.4	24.2	15.3	9.5	19.6	62
Heath/Content/Middle Shawsheen	9.34	52.1	24.2	13.9	8.8	24.6	57
Strong/Meadow/Middle Shawsheen	10.1	48.8	24.1	11.7	8.4	20.1	58
Sutton/Middle Shawsheen	4.82	53.5	24.2	15.0	9.0	24.0	63
Foster's Pond/Lower Shawsheen	4.65	49.7	24.3	13.5	7.1	20.6	66
Pomp's Pond/Lower Shawsheen	3.46	47.1	24.3	11.9	6.7	18.7	64
Roger's Brook/Lower Shawsheen	2.14	47.1	24.3	9.3	10.2	19.5	48
Hussey Pond/Lower Shawsheen	6.99	47.1	24.3	9.5	10.0	19.5	49

The water balance elements are given in inches per year. The volume or quantity of each element can be estimated by multiplying its respective area. It is noted that the precipitation and evapotranspiration are almost uniform among all sub-watersheds. These two elements are primarily governed by large-scale events, such as regional and continental climate patterns. Local land use or land cover changes rarely affect the precipitation pattern of a watershed like the Shawsheen River.[*33] In the New England climate, the evapotranspiration is limited by solar energy available, because the precipitation is uniformly distributed throughout the year and the surface is sufficiently wet enough to evaporate water at its potential, except in July, August, and September (Hartmann, 1994). Therefore the predicated values are expected and reasonable.

[*32] IBID…..pg 13
[*33] IBID

The surface runoff and baseflow show significant variation among the sub-watersheds. Both surface runoff and baseflow supply water to the stream. Overall, more than half of the precipitation that falls on this watershed is available in the stream as stream flow. However, the distribution of stream flow among surface runoff and baseflow reveals that the baseflow in the Shawsheen River is significantly lacking.[*34] The values for the contribution of baseflow to stream flow are given in Table 4. The values range from a low of 33% in the Hanscom sub-watershed to a maximum of 66% in the Foster's Pond/Lower Shawsheen sub-watershed. The average condition for the entire watershed is 57%. In general, baseflow contribution is low (< 60% on average) throughout the watershed due to the significant urbanization in the watershed. Based on the soil and surficial geology, as well as the topography of this watershed, the results reveal that the Shawsheen River is significantly lacking in baseflow, which is needed to sustain stream quality during dry weather.

Furthermore, the water balance was simulated with the pre-development land use data. Since the climate data was not available for these periods, the ten-year balance was simulated with current data (4/89 – 3/99) and pre-development land use data. The comparison of baseflow between current balance and pre-development balance (Table 5) reveals that the development and related land use changes created this critical situation in baseflow reduction, which is indeed an important threat to the people who widely use the Shawsheen River for recreational activities during the summer.

Table 5.[*35] Baseflow estimated from MassGIS land use data (current) and aerial photos of 1938 and 1952 (pre-development).

Sub Watershed	Baseflow (current) %	Baseflow (pre-development) %
Hanscom	33.16	71.40
Kiln Brook	56.20	74.30
Elm Brook	62.58	76.10
Spring/U Shaw	61.45	74.80
Vine Brook	60.03	68.89
McKee/Webb	61.65	74.04
Heath/Content	56.76	68.71
Strong/Meadow	58.20	71.49
Sutton/M Shaw	62.48	65.62
Foster's Pond	65.45	71.04
Pomp's Pond	63.98	66.88
Roger's Brook	47.50	66.69
Hussey Pond	48.78	70.69

[*34] IBID…..pg 14
[*35] IBID…..pg 14

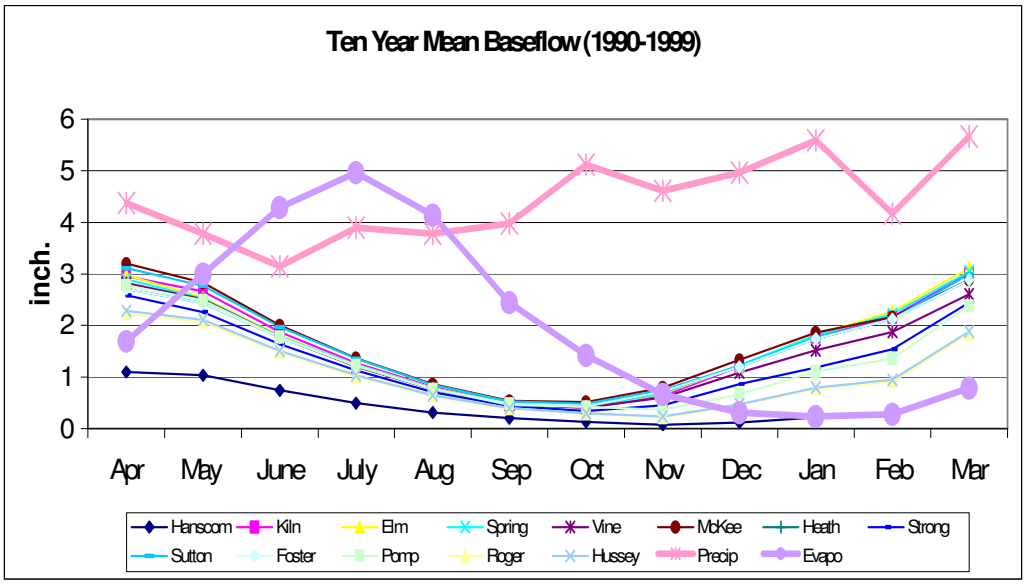


Figure 3.[*36] Ten year monthly mean baseflow for all 13 sub-watersheds of the Shawsheen River Watershed. The average precipitation (P) and evapotranspiration (ET) are also plotted for providing the seasonal pattern of hydrological elements in the Shawsheen.

Baseflow distribution throughout a year is plotted in Figure 3. Baseflow looks extremely low during August, September, October, and November. During the summer months, the baseflow naturally decreases due to intensive evapotranspiration. However, sub-watersheds with excessive development and impervious coverage show almost no baseflow during the summer months. If there is no rain during this period, there will be no water in the river. This was the case during the summer of 1999.[*37]

It is interesting to note that a clear relation exists between the percentage of baseflow (baseflow* 100/streamflow) and the percentage of imperviousness among the sub-watersheds in the Shawsheen River. As the percentage of imperviousness of a watershed increases, the percentage of baseflow contribution to the river linearly decreases. One can infer, in a relationship between the percentage of imperviousness and the percentage of surface runoff contribution that the surface runoff linearly increases as the imperviousness of a watershed increases. This kind of empirical relationship is an excellent tool for planning purposes, especially where there is a scarcity in resources to perform a detailed analysis to estimate baseflow.[*38]

[*36] IBID…..pg 15
[*37] IBID…..pg 15
[*38] IBID…..pg 15

HABITAT

During the 1995-2001 time period, 3 major studies were completed in the watershed to assess habitat health: (1) Shawsheen River Watershed 1997 Aquatic Habitat Assessment Project; (2) DFWELE 1998 Shawsheen River Fishery Survey; (3) Shawsheen River Watershed (EOEA) Massachusetts Wetlands Restoration Program Project.

The goal of the Shawsheen River Watershed Aquatic Habitat Assessment Project was improved habitat for the Shawsheen River and its tributaries. Based on research done on the quality of the Shawsheen River Watershed, many believe that the watershed is impaired due to past practices and destructive actions. These practices have reduced biological diversity. The purpose of this project was to determine why, how, and to what extent the watershed is impaired, and to find the most efficient remedies. The follow-up assessment was focused on different aspects of the stream ecosystem that were believed to be important to habitat quality, benthic macroinvertebrates, flow, and the fish community.

The project was divided into three main tasks. It began with an exploration of historical and currently available information sources on the Shawsheen River, including valuable information from people who are knowledgeable about the river and its past. Hanscom Air Force Base interns and stream team volunteers then gathered current field information throughout the summer and fall months. Habitat assessments and benthic macroinvertebrate surveys were performed. Although not all sections of the watershed were explored, enough surveys were completed to determine which areas are in need of restoration and which areas need further study. Results from the studies were then analyzed and combined into a plan for the river system with recommendations for habitat restoration by site location.

Results showed that none of the assessed areas scored as excellent habitats, i.e., comparable to the best situation to be expected within the ecoregion. Many were rated as poor, having severe habitat alterations. Benthic macroinvertebrate populations for the most part were lacking diversity and abundance, a sign that habitats are suffering. Volunteers have discovered the potential for a strong aquatic and riparian habitat in the Shawsheen River. However, it is clear that considerable efforts must be made in order to improve this habitat. Restoration is important, as is the prevention of further encroachment on the existing habitat.[*39]

Approach Taken[*40]

Shawsheen River aquatic habitats were surveyed by volunteers and interns according to procedures established by the Merrimack River Watershed Council and River Watch Network (RWN). Survey teams were trained by RWN to assure consistency of data collection. The number of river reaches surveyed was limited by the availability of interns and volunteers. The survey addressed the conditions of the mainstem Shawsheen River and some tributary locations.

Two types of habitat surveys were performed.

Habitat Assessment:

The purpose of the survey was to evaluate a 300' stretch of stream to determine the quality of its habitat for fish and other wildlife. Volunteers analyzed particular parameters including shelter for fish and attachment sites for macroinvertebrates, pool substrate characterization and variability, bank/channel alteration and condition, bank vegetation protection, sediment deposition, and channel flow.

[*39] Merrimack River Watershed Council. Shawsheen River Watershed 1997 Aquatic Habitat Assessment Report pg. 1.

[*40] IBID

Benthic Macroinvertebrate Assessment:
This survey determines habitat quality and serves as a depiction of the quality of the river over an extended period of time. Volunteers collected and identified benthic macroinverbrates, (aquatic organisms that spend at least part of their life cycles on the stream bottom), for a given stream area. Each type of macroinvertebrate has a different level of tolerance to pollution; therefore, the types and abundance of organisms that survive help determine stream condition. For example, mayflies and stoneflies both have a low tolerance to pollution, while scuds and worms have a high tolerance to pollution.

Results Summary[*41]

Upper Shawsheen River Watershed
Kiln/North Lexington Brooks
All of Kiln Brook's habitat assessments resulted in scores of fair or poor for many reasons. While Kiln Brook scored high in most locations for fish and macroinvertebrate shelter, other habitat characteristics were failing. Problems for Kiln Brook varied by location. Poor flow was a problem in one location, creating limitations for the abundance and variety of organisms living in that area. With the vast amount of impervious surface surrounding Kiln Brook, flows tend to fluctuate greatly with rain events. Quickly changing flow regimes also make it difficult for organisms to survive.

Lack of pool variability was a major factor in Kiln Brook's poor habitat conditions. Pool variability is the availability of each of the four size/depth combinations in the segment. Segments with all four size/depth or velocity/depth combinations are better able to provide and maintain a stable aquatic environment. Bank vegetation and the condition of the banks were insufficient in some areas as well. Bank vegetative protection is an indicator of the stability of the banks provided by the root systems of plants, a food source, and shading. In some locations, however, bank vegetative protection was 100%, providing optimum food and in-stream habitat conditions.

Another problem with the habitat of Kiln Brook is the straightening of the stream. In most of the locations surveyed, the stream is straight. A stream that has been channelized provides far fewer habitats for macroinvertebrates and other organisms than do natural streams. This problem continues downstream from Hanscom as well. Some areas are also faced with the problem of sediment deposition, which may result in unstable and continually changing aquatic habitat.

The most effective way to revive the habitat of Kiln Brook is to restore the stream's buffer zone. This would be most easily and efficiently done by restoring bank vegetation. A sufficient bank vegetative zone will help control flow from the base and airfields, decrease the amount of sediment being carried to the stream, and help control quickly changing flows by containing some of the runoff water that would normally flow directly into the stream. Improved vegetative protection will also help stabilize the banks, provide more food, and create a better canopy of shade over the stream.

Elm Brook
Habitat results varied for the surveyed sections of Elm Brook. Only one section was shown to provide a good habitat. One problem facing Elm Brook is its lack of shelter for fish and macroinvertebrates. Another major problem is the lack of pool variability in the muddy-bottom sections and stream velocity and depth in the rocky-bottom section. Without this variation of size/depth and velocity/depth combinations in the stream, fewer types of organisms can be supported by the habitat.

[*41] IBID…..pg 17-19

Another problem facing Elm Brook is the insufficient width of the riparian vegetative zone, i.e. the natural vegetation from the edge of the stream bank outward from the stream. This zone provides stream shading, retains nutrients and sediments, and provides a food source to the stream. The condition of the bank is also poor in some locations. Fluctuating flows and the straightening of the stream channel are other concerns for Elm Brook's habitat.

It appears as though Elm Brook's greatest problems could be remedied through the restoration of the riparian zone and stream banks, and the prevention of any further development near the edges of the stream. Further assessment would also be useful in determining what other solutions would be suitable for Elm Brook's particular problems.

Middle Shawsheen River Watershed [*42]

McKee/Webb/Jones Brook

The McKee/Webb/Jones Brook section supports the best habitat of all the surveys done in the Shawsheen River. Results showed that four out of the five sections surveyed had good habitat conditions. These results most likely stem from the quality of the stream banks, the steady flow of the stream, and the natural, unaltered channel. The healthy condition of the banks, the expanse of bank vegetative protection, and the wide riparian vegetative zone all contribute to the shading of the stream, provide a sediment and nutrient buffer, supply food to the habitat, and help sustain a high quality habitat. Natural streams, with their meandering channels, provide more habitats for macroinvertebrates than do streams that have been altered and channelized.

This section also has its share of problems. Shelter for fish and macroinvertebrates is lacking in some locations. Pool variability is a problem in a few areas. The lack of a varying habitat limits the diversity of organisms that can survive in the area.

Overall, the habitat in this area is in good condition and opportunities for making it better are readily available. Restoration of shelter habitat is recommended. Surveys of this habitat should be continued to monitor any changes that may occur. Benthic macroinvertebrate assessments should be performed as well. The physical properties of the habitat have been assessed and appear to be healthy; however, what organisms the habitat is actually supporting should be documented.

Heath/Content Brooks

One habitat survey was completed for this section, with results concluding that it is in fair condition. The major problems with the section are problems that have been common to other sections of the Shawsheen River Watershed. The stream has been channelized, therefore providing fewer habitats for macroinvertebrates and other organisms. The other major concern is the lack of pool variability. The majority of pools are small-shallow, limiting the abundance and richness of organisms that can survive there.

Bank vegetation, however, appears to be in good condition. Much wildlife was spotted during the shoreline surveys in this area. Unfortunately, one habitat survey cannot tell us enough about the habitat of the entire section. Therefore, we recommend that more surveys and benthic macroinvertebrate assessments be done.

[*42] IBID…..pg 20-21

Lower Shawsheen River Watershed [*43]

Roger's Brook

One habitat assessment survey was completed for this section, and according to the results, it is in fair condition. The problem is the lack of a wide riparian vegetative zone that would provide shading, contain nutrients and sediment, and serve as a food and cover source for the stream and wildlife. Channel flow status, the percent of existing channel that is filled with water, is rather poor for this section as well. Only about half of the channel was filled and the riffle substrates were mostly exposed at the time of the assessment. Areas of the stream that are periodically dry are not available as living and feeding areas for aquatic organisms. Therefore, the greater the area of streambed covered with water, the greater the variety and abundance of organisms. Other concerns include limited attachment sites for macroinvertebrates and areas of moderate sediment deposition.

According to the habitat assessors, the section appears to be relatively quiet and conducive to some wildlife. Shoreline survey results add that the area is partly undeveloped/unprotected land, with potential for a strong habitat. There is an abundance of wildlife, but also a number of parking lots that contribute runoff to the stream, with a possibility of sewage runoff.

Poor water quality from problems such as inefficient septic systems may also have an adverse impact on the habitat. While dissolved oxygen levels could support cold and warm water fisheries, bacteria levels consistently exceeded standards at each site. It has been recommended that the benthic macroinvertebrate population be assessed to determine what effects the bacteria levels have on the aquatic habitat. More habitat assessment should also be completed.

It has also been suggested that work be started on restoring the riparian vegetative zone to help control any runoff problems, particularly sewage runoff, and decrease sediment deposits. Stream teams and communities should strive to turn some of these undeveloped/unprotected areas into protected land and prevent any further development near the stream.

Hussey Pond/Lower Shawsheen

One assessment survey for this section indicated fair habitat condition. The section had a poor score for channel sinuosity; it has been channelized to some degree. The survey found no major problems in the section; however, there are some concerns. The pool substrate and the pool size/depth combinations lack variability, limiting the diversity of aquatic organisms that can live there. Channel flow is somewhat poor, with the water filling only about half of the streambed at the time of the assessment. Sediment deposits also affect part of the stream.

Habitat assessors, as well as shoreline surveyors, noted that the area supports an abundance of wildlife, particularly a wide variety of birds. Unfortunately, excess debris in and around the stream degrades the habitat.

More habitat assessments and benthic macroinvertebrate studies will be needed to determine if this segment is representative of the entire section. Educating people about the potential of the habitat, and the importance of preserving it, is one step toward dealing with the debris problem. Stream team members have already jumped on this task by hosting a public tour of the area and holding clean ups to take their own action against the problem.

[*43] IBID…..pg 21-23

Fish[*44]

There are three dams on the Shawsheen River mainstem, all located in Andover. They are the Ballardvale, Balmoral, and the Stevens Street Dams. A fourth, the Red Rock Dam is breached. These dams prevent anadromous fish, such as shad, alewife, Atlantic salmon, and migrating brook trout from moving upstream to spawn. There are no fish passage facilities on these dams. These dams change the river environment by impeding flows, raising water temperatures, and causing silt build up.
There was a report released in 1969 by the Massachusetts Division of Fisheries and Game titled "Delineation of Anadromous Fish Habitat and Obstructions to Fish Passage on Tributaries". It stated "With the exception of the Concord and Shawsheen Rivers, all other tributaries in Massachusetts have little to offer either species (referring to Atlantic Salmon and American Shad) in the form of nursery habitat and therefore the construction of fishways on those streams is unwarranted."

Undocumented reports suggest that the last salmon was caught in the Shawsheen in 1945 or 1947. Bill Estes of the Massachusetts Division of Fisheries & Wildlife (MDFW) believes that this date should be around 1850.

For well over fifty years, the MDFW has stocked Brown Trout, Brook Trout, and Rainbow Trout in varying numbers in the Shawsheen River. They are not self-supporting, and usually die by August if not caught. A few trout may linger into the fall if they find cold pockets in the river. Generally the water temperature gets to be lethal for trout by late summer. The optimal temperature for trout is between 55-65 degrees F.

The Shawsheen River supports a self-sustaining warm water fishery. On August 2, 1954, the DFW conducted a fishery inventory from several stations on the Shawsheen River using Rotenone poisoning. They found Chain Pickerel, Redfin Pickerel, White Suckers, Lake Chubsuckers, American Eel, Brown Bullheads, Pumpkinseeds, Golden Shiners, Small Mouth Bass, Bluegills, Yellowbelly Sunfish, Eastern Banded Sunfish, Tesselated Darter, and some hatchery-stocked trout.

Now the MDFW uses electro-shocking, which is not as accurate a sampling method because some fish escape. However, the fish are not killed with this method. On September 4, 1980, one station in Bedford documented Chain Pickerel, Common Shiner, Redfin Pickerel, and American Eel. Although 5,800 trout were stocked in April and May of 1980, it is interesting to note that not one was found in this sampling. Once again, on August 8, 1988, one station in Bedford produced Golden Shiners, Chain Pickerel, Redfin Pickerel, White Suckers, Pumpkinseed, and Fallfish. In April and May of 1988, 1,750 trout had been stocked but none were found in the samples. This suggests that the trout do not survive the summer.

In 1998 the MDFW conducted a fish survey along 9 stations of the Shawsheen River from the Route 4 Bridge in Bedford to South Lawrence. This is the sample and sampling station location summary.[*45]

FSI Sept. 9 Lawrence Upstream of Loring Street - Station-Length: 121 meters

56	American Eel	160-890 mm
8	Bluegill	71-147 mm
20	Redbreast Sunfish	72-129 mm
5	Lamprey	150-160 mm
2	Largemouth Bass	56 + 204 mm
1	Yellow Bullhead	185 mm

FS2 Sept. 9 South Lawrence Upstream of Route 114 - Station-Length: 130 meters

[*44] IBID…..pg 11-12
[*45] Massachusetts Division of Fisheries, Wildlife and Environmental Law Enforcement. Unpublished report on summer 1998 Shawsheen fisheries survey.

77	American Eel	80-450 mm
7	White Sucker	129-172 mm
4	Redfin Pickerel	100-145 mm
5	Fallfish	56-103 mm
5	Pumpkinseed Sunfish	71-107 mm
25	Bluegill	48-123 mm
10	Lamprey	80-180 mm
1	Atlantic Salmon (Smolt)	127 mm

FS3 Sept. 10 Andover Northeast of Route 28 Bridge - Station-Length: 150 meters

62	American Eel	100-400 mm
18	Redbreast Sunfish	60-144 mm
1	Largemouth Bass	63 mm
4	Chain Pickerel	172-217 mm
24	Bluegill	51-116 mm
4	Lamprey	150-160 mm

FS4 Sept. 10 Andover Reservation Road - Station-Length: 137 meters

101	American Eel	100-380 mm
23	Redbreast Sunfish	54-149 mm
19	Bluegill	65-173 mm
4	Redfin Pickerel	145-165 mm
1	Chain Pickerel	281 mm
1	White Sucker	205 mm
1	Fallfish	195 mm
1	Pumpkinseed Sunfish	65 mm

FS5 Oct. 1 Andover Downstream of Ballardvale Dam - Station-Length: 200 meters

134	American Eel	120-470 mm
16	Bluegill	67-166 mm
20	Pumpkinseed Sunfish	71- 85 mm
7	Largemouth Bass	71-185 mm
16	Fallfish	139-278 mm
6	Redbreast Sunfish	53-132 mm
4	Redfin Pickerel	162-226 mm
1	Brown Trout	365 mm

FS6 Sept. 11 Tewkbury Opposite Mohawk Drive - Station-Length: 147 meters

46	American Eel	110-570 mm
1	Yellow Bullhead	60 mm
9	Chain Pickerel	66-121 mm
3	Pumpkinseed Sunfish	54- 90 mm
16	Redfin Pickerel	122-154 mm
1	Fallfish	257 mm

FS7 Sept. 11 Billerica Downstream of Route 129 - Station Length: 144 meters

44	American Eel	110-450 mm
29	Redfin Pickerel	86-141 mm
3	Chain Pickerel	102-110 mm
30	Redbreast Sunfish	41-164 mm
1	Banded Sunfish	57 mm

1	Bluegill	71 mm
1	White Sucker	160 mm
2	Largemouth Bass	75 + 122 mm
3	Pumpkinseed Sunfish	75- 89 mm
1	Rainbow Trout	310 mm
1	Creek Chob	(Specimen Preserved) 123 mm
1	Longear Sunfish	(Specimen Preserved) 141 mm

FS8 Sept. 30 Bedford Downstream of Middlesex Turnpike - Station Length: 141 meters

7	Creek Chubsucker	91-132 mm
75	Redfin Pickerel	75-220 mm
3	Bluegill	77- 80 mm
4	Largemouth Bass	53- 86 mm
12	Pumpkinseed Sunfish	62- 94 mm
4	Chain Pickerel	80-100 mm
3	Redbreast Sunfish	102-127 mm
3	Longear Sunfish	119-140 mm
36	American Eel	110-540 mm
1	Rainbow Trout	280 mm
1	Brown Trout	330 mm

FS9 Sept. 24 Bedford Upstream of Route 4 Bridge - Station Length: 123 meters

2	White Sucker	72-154 mm
4	Chain Pickerel	65-132 mm
6	Banded Sunfish	71- 86 mm
21	Redfin Pickerel	70-222 mm
5	Unidentified Cyprinias	(Specimens Preserved) 32-38 mm
4	Pumpkinseed Sunfish	95-123 mm
1	Bluegill	125 mm
11	American Eel	170-400 mm

Wildlife[*46]

Thomas French of the MDFW stated that the Shawsheen Watershed generally has more species diversity of wildlife than it did fifty years ago, but that since there is less habitat, there are fewer animals. Fifty years ago there were no coyote, turkey, fisher, beaver, or otter. Since then fishes, coyote, and otter have returned.

These animals came back naturally, while the turkey and beaver were reintroduced to the area approximately twenty years ago. Since then the beaver population has dramatically increased, partially due to the new beaver trapping laws, which allow only live trappings. Also, the state requires a permit to break down a beaver dam. Furthermore, natural predators are no longer present in the watershed.

Beaver dams are causing flooding problems in the Shawsheen Watershed. There are currently at least five major beaver dams including one in Billerica, one in Andover, two in Lawrence, and one at Hanscom Air Force Base. The beaver dam at Hanscom field is causing severe drainage problems in the northwest section of the airfield.

[*46] Merrimack River Watershed Council. Shawsheen River Watershed 1997 Aquatic Habitat Assessment Report.

Other species that thrive in suburban areas have also greatly increased in the Shawsheen Watershed. There are raccoons, opossums, striped skunks, and eastern cottontail rabbits, and to a lesser degree, red foxes. The raccoon population had escalated to a high of 80 raccoon per square mile in suburban areas according to Mr. French. Since 1992, rabies has been reducing this population.

Over the past fifty years, while mammal species have increased, most bird species have decreased. However, waterfowl populations, such as mallards and resident Canada Geese are now common. In the past, the wood duck was practically disappearing in the watershed. Wood duck numbers, which have been very low, have increased due to nesting box programs, stricter hunting regulations, and habitat conditions, which benefit from beaver activity.

Amphibians and reptiles have definitely declined due to loss of habitat. They need wetlands and the surrounding area. Also, it is harder for them to repopulate themselves, since they cannot travel to a different area as easily as birds and mammals can.

Wetlands

Since colonial times, a wide range of human activities and extensive changes to the landscape hasve significantly affected the watershed of the Shawsheen River. The pre-industrial period saw extensive forest clearing to supply wood products, create grazing lands, and support agriculture. Wetlands were ditched, drained, and impounded for crop production, irrigation, and water supply. Although population density was relatively sparse, human land uses were intensive and widespread.

The industrial revolution brought different, more destructive, and more permanent changes as roads and rail lines criss-crossed the landscape, dams were built to harness power and supply water, and wetlands were filled in for residential, commercial, and industrial development. In just 40 years between 1950 and 1990, the watershed's human population has more than tripled. "Swamps" frequently served as local dumpsites, and all types of liquid wastes were piped directly into their bordering rivers and streams. The watershed has lost nearly one-quarter of its original wetland areas, and many of the remaining wetlands are fragmented by infrastructure and degraded by polluted runoff. [*47]

From a practical perspective, most of the lost wetlands in the Shawsheen Watershed cannot be restored because buildings, infrastructure, and other human development now occupy the land. However, there are many smaller areas of historically filled and degraded wetlands that still have the potential to be restored back to health because they have yet to be developed for permanent human uses.

Despite the apparent physical restoration potential at these sites, other practical considerations such as land ownership, high project costs, and contamination issues may impede the implementation of some projects. On the other hand, partnerships with private corporate donors, new government restoration initiatives, and the significant environmental benefits of these projects may emerge as driving forces to restore these sites. One thing is certain – the amount of local community initiative and support for wetlands restoration will play a major role in determining how many projects actually get done.

The EOEA Wetlands Restoration Program began in 1997 to embark on a four-part wetlands evaluation study of the Shawsheen River, which ultimately lead to a Final Wetland Restoration Plan. This Final Shawsheen River Watershed Wetlands Restoration Plan (Final Plan) presents the Shawsheen Watershed community with maps and summary descriptions of 63 potential wetland restoration sites. The Massachusetts Wetlands Restoration Program (MWRP) has determined that each of these sites likely contains historically damaged or destroyed wetlands that, if restored, could produce significant

[*47] IBID…..pg 4

environmental benefits. The Final Plan also lays out an action strategy that helps interested parties understand what it takes to restore a damaged or destroyed wetland back to health. The overall goal of the Final Plan is to help municipalities, state and federal agencies, and other organizations and individuals to identify, prioritize, and initiate wetland restoration projects.[*48]

The Final Plan is the last in a series of four documents that make up the overall wetlands restoration planning effort in the Shawsheen Watershed. The first document provided a technical analysis and inventory of wetlands and wetland impacts within the watershed.[*49] The technical analysis was followed by the Preliminary Report which inventoried impacted wetlands, summarized watershed problems, and proposed wetlands restoration goals for community review and input.[*50] The Draft Plan presented a final set of restoration goals based on community input as well as draft lists of prioritized potential restoration sites for further investigation and field work.[*51]

During the summer of 2001, MWRP staff and scientists from other restoration partners (the evaluation team) field-inspected a representative sample of priority sites from the Draft Plan to evaluate their restoration potential. Sites were selected from areas throughout the watershed and included the whole range of the National Wetlands Inventory (NWI) wetland and impact types.

During the field evaluations, the following questions were reviewed for each site:

- Are the wetland and impact types observed in the field the same as those identified in the Draft Plan and the NWI analysis?
- What has caused the damage to the wetland?
- What practical, physical actions might be performed to restore the wetland?
- What wetland functions would be improved by restoring this site/would restoration produce significant benefits relative to existing wetland conditions?
- What practical issues might inhibit restoration (e.g., permitting, cost, amount of new wetland disturbance required, or negative collateral effects such as flooding and mosquito problems)?
- Taking all factors into account, is this site a good candidate for a priority restoration project?[*52]

Findings and Conclusions

The evaluation team found that the majority of sites visited have limited to no practical restoration potential. Most sites did exhibit evidence of the impacts noted in the NWI analysis, but in the vast majority of cases, these impacts did not appear to be severely degrading the wetland and/or there were few if any practical, physical restoration actions that could be taken. The team concluded, therefore, that most of the sites identified by the NWI analysis and presented in the Draft MWRP Plan are not good candidates for priority wetland restoration projects.

Another key finding of the evaluation team was that the watershed contains numerous, smaller (0.5-3 acre) areas of severely impacted and formerly destroyed wetlands that have practical, physical restoration potential. The NWI analysis did not identify these sites for the simple reason that it focuses on existing wetlands, and because many are too small for detection using the NWI protocols. Restoration of these smaller sites in most cases would produce locally significant environmental benefits relative to their existing degraded or non-wetland conditions.[*54]

[*48] EOEA Massachusetts Wetlands Restoration Program. "Durey. Final Shawsheen River Watershed Wetlands Restoration Plan, May 2002." pg 1
[*49] R. Tiner etal., "Wetlands and Potential Wetland Restoration Sites for the Shawsheen Watershed" (April 2000).
[*50] H. Durey, "Shawsheen River Watershed Wetlands Restoration Plan: Preliminary Report (February 2001).
[*51] H. Durey, "Draft Shawsheen River Watershed Wetlands Restoration Plan" (June 2001).
[*52] IBID…..pg 5
[*53] IBID…..pg 6

The new group of 63 potential sites in this Final Plan likely represents no more than 200 acres of restoration opportunity, and only a fraction of the sites identified will likely be restored in the near term. The restoration of these sites will produce locally significant benefits (e.g., reduced flooding and improved habitat), but there simply are not enough to create the watershed-level improvements envisioned in the original planning process. Thus, the Final Plan does not prioritize sites for watershed-level improvements.[*54]

All potential restoration sites were given a priority ranking of low, medium, or high based on a review of GIS and site visit information. Priority rankings are subjective determinations made using the best professional judgment of MWRP staff, while asking this fundamental question: considering all known physical and practical factors, which sites appear to have the greatest restoration potential? The primary criteria for this determination are size, ownership, potential environmental benefits, and general "do-ability" (which for many sites includes known practical circumstances that may affect a restoration effort). The rankings are not definitive; rather, they are intended as a guide to help watershed communities prioritize potential projects.

Next Steps – Action Strategy
MWRP is committed to working with the Shawsheen Watershed community to complete as many good restoration projects as possible. One of their project managers/wetland scientists has been assigned to the watershed to pursue a select few, high priority sites and demonstration projects, and to work with people and groups that are interested in other sites identified in the Final Plan. A few projects have already gained some interest and momentum – with identification of project sponsors, application for grant funds, and consideration of feasibility studies. Their goal is to have several restoration projects underway within the next year.

The former EOEA Shawsheen River Watershed Team has played a significant role in supporting wetlands restoration. The former team formed a wetlands restoration workgroup to develop and carry out strategies that address the challenges of implementation, including raising funds, identifying project sponsors, nurturing public and political support, and developing public/private restoration partnerships with corporate donors.

[*54] IBID…..pg 6

LAND-USE, OPEN SPACE, IMPERVIOUS SURFACES COVER

Two major reports, resulting from projects, were produced between 1997-2001 to give the watershed a better understanding of the relationships between land use, open space, impervious surface cover, and resource quality: 1) Merrimack River Watershed Council and Northern Middlesex Council of Governments: "Minimizing Environmental Impacts of Building: A Subwatershed Approach in the Shawsheen;" and 2) Merrimack River Watershed Council: "The Shawsheen Watershed, A Land Use and Regulatory Review of Nonpoint Source Pollution Management."

The "Minimizing Environmental Impacts of Building: A Sub-Watershed Approach in the Shawsheen" report presents the results of a planning-level, environmental impact analysis that was conducted for three subwatersheds in the Shawsheen Watershed: Strong Water Brook, Content Brook, and Pinnacle Brook. The goal of the study was to evaluate potential impacts to water quality and quantity, based on expected future development, and to recommend BMPs (structural and non-structural) to minimize future impacts and maximize protection of watershed functions. Throughout the project, staff from the Merrimack River Watershed Council (MRWC) and the Northern Middlesex Council of Governments (NMCOG) met with town planners, engineers, DPW officials and conservation agents, and with local engineering firms from Tewksbury and Billerica to discuss recommendations and solicit feedback.

A watershed model Generalized Watershed Loading Functions (GWLF), was used to evaluate potential water-related environmental impacts that are expected with future development. The model estimated changes in streamflow, runoff, nutrient loading, and erosion that can be expected under buildout conditions as defined by the recent buildout analysis conducted by the Northern Middlesex Council of Governments (NMCOG). Model results showed the following trends.[*53]

- Future imperviousness is expected to range from 21% to 28%.
- All subwatersheds will experience a significant increase in runoff and decrease in baseflow under buildout conditions.
- Major land use changes will be from forested land nd open space, to residential, commercial and industrial.

Based on the current condition of the subwatersheds and results of watershed modeling, the project proposed that all future development meet the following watershed design objectives for stormwater BMPs particularly in Strong Water Brook, Content Brook, and Pinnacle Brook:[* 54]

- Reduce stormwater pollutant loads.
- Maintain groundwater recharge and quality.
- Protect stream channels.
- Prevent increased overbank flooding.
- Safely convey extreme floods.

The project then evaluates the current and future land uses in the Strong Water and Content Brook subwatersheds and makes subwatershed-specific recommendations for planning, design, and non-structural BMPs that will minimize the impacts of impervious surfaces. Utilizing the five watershed design objectives above, BMP's were selected based on a watershed approach. The following approaches and recommendations are presented in detail in the report and summarized as follows:[* 55]

- There are few large undeveloped parcels remaining in the Strong Water and Content Brook subwatersheds. Key parcels include the state hospital lands in Tewksbury and the Iron Horse Park superfund site. Key open spaces on the hospital site should be identified for protection, and

[*6654] IBID…..pg 2
[*6755] IBID…..pg 2

the Billerica Planning Board should consider promoting environmentally innovative redevelopment of the Iron Horse site.
- DEP Stormwater Standards should be incorporated into zoning and subdivision regulations.
- Performance Standards should be developed for minimum grading and clearing of lots, and establishing maximum impervious area thresholds.

The project then developed feedback from three working group meetings that were held with municipal officials and engineering firms from Tewksbury, Billerica, and Andover. Watershed modeling results and BMP recommendations were discussed and feedback was solicited from those responsible for implementing many of the recommendations. The following are several obstacles to implementing stormwater BMPs that were identified by participants:[*56]

- There continues to be a great need for education about the basics of stormwater and watershed hydrology. For example, the connection needs to be made between cutting down trees in your yard, and a flooded basement.
- Several planners suggested performance standards as the best way to facilitate watershed friendly development. Performance standards set a goal or target but do not mandate how the developer must meet the target.
- Sufficient maintenance of structural BMPs continues to be a big problem. Towns should maintain an electronic database on structural BMPs and should work with developers to institute a program that gives developers some or all responsibility for ensuring the BMPs in their developments are properly maintained.

Impervious Cover and Watershed Management

One of the most important overriding principles of this buildout study was that of impervious surfaces cover, and how that affects resource quality. Recent studies have demonstrated that the percentage of paved surfaces ("impervious cover") in a subwatershed is directly related to the hydrological, habitat, and water quality characteristics of the watershed stream. As little as 10 percent impervious cover in a subwatershed can have irreversible, damaging effects on stream quality and habitat. The Center for Watershed Protection in Maryland has developed a system to categorize subwatersheds according to their approximate percentage of impervious cover:

- 0 to 10 percent: Sensitive Streams
- 11 to 25 percent: Impacted Streams
- 26 percent and above: Non-supporting Streams

Sensitive Streams have very little development in their watersheds and are characterized by stable channels, good to excellent water quality, and good to excellent biodiversity. Impacted streams are more unstable, with only fair to good water quality and biodiversity. Much of the Shawsheen River is in the "impacted," 10 – 25% Impervious Sources Category. Non-supporting streams tend to be highly unstable and have fair to poor water quality and poor biodiversity. Depending on conditions, some impacted or non-supporting streams can be restored to higher levels of ecological function.[*57]

Impervious cover is made up of the rooftops of buildings and the many paved elements of our transportation system: roads, driveways, and parking lots. Suburban development over the last fifty years has increased the amount of transport related impervious surface relative to building-related imperviousness. Zoning typically regulates the size of buildings to a much greater degree than the size of other impervious surfaces. Impervious cover in medium-density, single-family neighborhoods can range from 20 percent to 50 percent, depending on how roads and parking are designed. Commercial areas

[*56] IBID…..pg 2
[*57] IBID…..pg 24

often have higher percentages because of large surface parking lots. Zoning usually requires the provision of a minimum number of parking spaces per housing unit or per 1000 s.f. of office space, but rarely sets a maximum. Therefore, one of the most important ways to improve the impact of development on water resources is to pay more attention to the design of parking areas. Billerica has already begun taking steps in this direction by requiring developers to demonstrate the need for their maximum parking plan before they are permitted to build out the parking lot.[*58]

Impervious Cover and Land Use in the Content Brook Subwatershed

[*59] The Content Brook Subwatershed is located predominately in North and East Billerica, with a small portion around Long Pond in southwest Tewksbury. The existing residential areas in both the Billerica and Tewksbury portions of the subwatershed are predominantly single family homes on lots of less than one acre. Quite a large portion of the source region of this watershed is comprised of a former town landfill site (Shaeffer), and a former large railway maintenance center and storage yard (Iron Horse Park). With the capping and revegetation of the landfills, part of the acreage will be returned to a somewhat less impervious state for stormwater runoff, but the landfill cap will bar significant infiltration. It seems unlikely therefore, that redevelopment of this site will reduce the impervious coverage percentage significantly.

Based on analysis of landuse data, the Merrimack River Watershed Council estimates the impervious cover percentage in the Content Brook Subwatershed at 23 percent. Potential buildout under current zoning could bring impervious cover to 28 percent. With a relatively high level of impervious cover and the impacts of the Iron Horse superfund site in the subwatershed, it puts Content Brook at the boundary between an "impacted" and a "non-supporting" stream. The stream's actual level of ecological function can only be elevated through fieldwork.

Infill development and redevelopment opportunities in the Content Brook Subwatershed should, however, emphasize best management practices and greenway creation. The Middlesex Canal passes through the superfund site and the Content Brook Subwatershed. The Canal Commission, the Northern Middlesex Council of Governments, the Town of Billerica, and MassHighway are collaborating in a long-term plan to create a Middlesex Canal historic park at the Concord River Mill Pond (which is just outside the Content Brook Subwatershed) and revive the canal as a recreational greenway.

Impervious Cover and Land Use in the Strong Water Brook Subwatershed

[*60] The Strong Water Brook Subwatershed is located entirely in the Town of Tewksbury. The northwest edge and the center of the subwatershed are relatively underdeveloped because of wetlands and the Tewksbury State Hospital grounds. Along the other edges of the subwatershed there is a mixture of residential, commercial, and industrial uses. The residential development includes neighborhoods of single-family homes on smaller lots south of Route 38 and predominately one-acre lots to the north, as well as multifamily developments. Round Pond, at the southern edge of the subwatershed, lacks a significant vegetative buffer and has residential development very close to the pond shores. The town owns the pond but there is no public access. Commercial development along Route 38 is strip retail and services, with typical conditions of extensive impervious cover in the form of parking lots. Industrial uses located in several different parts of the subwatershed also have more than 30 percent impervious cover.

[*58] IBID…..pg 30
[*59] IBID…..pg 24-25
[*60] IBID…..pg 26-27

Strong Water Brook originates in tributaries south of Route 38 where impervious cover is significant, particularly around and downstream of Round Pond. Portions of the Great Swamp also drain into the subwatershed. After it leaves the sprawl corridor of Route 38, Strong Water Brook travels through the extensive open space acreage of Tewksbury State Hospital, which includes wetlands, leased agricultural fields, and meadows. The estimated current impervious cover of the Strong Water Brook Subwatershed is 18 percent. Buildout based on current zoning would bring impervious cover to 21 percent. Because of the hospital lands and the extensive wetlands in the subwatershed, Strong Water Brook can probably be classified as an "impacted" stream, possibly amenable to some restoration of stream biodiversity. This classification, however, is based on the assumption that the hospital lands would continue to be used for agriculture.

Excluding any possible development of the hospital lands, most of the potentially developable parcels are infill parcels on the edges of the subwatershed in areas with at least 10 percent impervious surfaces. The town has zoned the state hospital open space parcels for farming in order to retain more control over potential development should the state sell the land to private owners. These private owners would then have to seek rezoning or a use variance if they wish to develop the property. However, municipal zoning does not affect state property.

Land Use and Regulatory Review of Nonpoint Source Pollution Management

The purpose of this project was to assess cumulative nonpoint source pollution threats to seven towns that comprise the majority of the land area of the watershed: Andover, North Andover, Bedford, Billerica, Burlington, Lexington, and Tewksbury. The intent of this is to document and evaluate the effectiveness of existing land use plans, by-laws and ordinances, regulations, policies, and practices in controlling nonpoint source pollution and protecting water resources in the Shawsheen River Watershed. This report contains an overview of the nonpoint source pollution management issues in the watershed, findings and recommendations applicable to the watershed, a discussion of the methods used to perform the evaluation, narratives focusing on each town, and a matrix providing a comparative checklist for the seven towns included in this review.

Some examples of watershed-wide themes and issues that were common with many of the communities include:[*61]

- Much of the Shawsheen River Watershed is sewered. Burlington has the most sewered area (98%); Tewksbury has the least sewered area (35%). Future development in the basin will be sewered wherever sewers are available. Some local officials report concern about future septic system malfunctions and failure, with some communities already aware of localized problems. The majority of towns in the basin with septic problems have septic system management plans in place.

- Four of the seven communities studied have recent community Master Plans, all of which are being implemented. The remaining communities in the watershed do not have Comprehensive or Master Plans.

- Five of the seven towns have a local wetlands by-law in place. Each by-law specifies resources worthy of protection in addition to the eight statutory interests protected under the Wetlands Protection Act. A sixth town, Andover, has completed preparation of a comprehensive local by-law and regulations, and adoption is pending.

[*61] IBID…..pg 3-4

- Stormwater drainage patterns in the Shawsheen Watershed have altered over the course of many decades, with far-reaching hydrologic impacts, including water quality degradation, increased frequency and severity of flooding, and decreased dry-weather flow. Many Shawsheen River communities have adopted good stormwater regulations, which will reduce the impacts of new development and help prevent the continued degradation of the watershed. Because the watershed is heavily developed, however, improvements to water quality are unlikely to occur without remediation of existing stormwater hotspots.

- Maintenance of all accepted town roads and their associated drainage infrastructure is the responsibility of the local Departments of Public Works (DPWs). It is clear, based on interviews conducted with local officials, that the DPWs need more resources (staff, training, equipment, and funding) to upgrade and maintain stormwater infrastructure. Catch basins in most towns are cleaned, on average, only once per year, a schedule that may not be sufficient to remove pollutants before they enter waterways. Most towns sweep their streets, on average, once per year but more frequent sweeping may also be beneficial.

- Many towns are requiring the installation of stormwater Best Management Practices (BMPs) in new development projects. Maintenance of these BMPs has become a challenge. Some towns are not accepting certain types of stormwater BMPs, thus requiring private owners to maintain them. In other cases, towns may accept the structures but lack the resources to maintain then adequately.

- While conservation commissions are now enforcing the DEP Stormwater Management Standards for projects that fall within wetland buffer zones, some towns have few stormwater requirements for projects outside of the commission's jurisdiction. Some communities (most notably, Andover, Lexington, Burlington, and North Andover) have adopted stormwater controls through subdivision and site plan review regulations, while others, as a practice only, have Planning Boards that are usually rigorous in their review of stormwater and erosion controls. None, however, have officially adopted the DEP Stormwater Management Standards outside of the conservation commission's jurisdiction, a practice that would establish a uniform level of stormwater management town-wide.

- Most of the Conservation Administrators/Agents cited difficulties with implementation of the Rivers Protection Act. Barriers to implementation stem mainly from the ambiguity of the Act's language. Conservation Administrators/Agents suggest that better state guidance and a consistent interpretation of the regulations by DEP employees would help to remove these barriers.

- Site planning and design standards can help minimize the environmental impacts from new developments by requiring that development fit the specific characteristics of the site, rather than a one-size-fits-all development design that does not respect site features. All of the towns require some level of site planning and design review intended to protect sensitive resources and minimize environmental degradation caused by development. Lexington regulations require that a landscape architect act as the lead party responsible for any site analysis and for the design of any development proposal. By identifying steep slopes, wetlands, and other sensitive natural features, the landscape architect can help ensure that good design principles will minimize environmental degradation and minimize stormwater generation, erosion, and sedimentation.

Each town was extensively interviewed, with appropriate documents gathered, reviewed and summarized in this report. Each town's report was sub-divided into the following subjects: town overview relative to watershed; planning regarding nonpoint pollution control; open space planning; zoning; local wetlands protection; stormwater management/erosion controls; infrastructure, and public works practices;

wastewater and septic management; pollution prevention programs; and references. The report covers details in each of these subjects for each of the seven towns.

The following is a synopsis of general findings and recommendations for open space planning for each of the seven towns. (The reader is referred to the full report for information on the other subjects described above).

Open Space Planning

Andover

*[62] In 1998, Andover updated its open space and recreation plan, building on the work of previous open space plans, prepared by the town approximately every five years since 1970. Protection of open space has long been a priority for Andover, and town officials have worked collaboratively with state agencies and nonprofit land trusts to preserve many key parcels, including substantial frontage along the Shawsheen River. Town-wide, approximately 21% of Andover's 32-square mile land area is protected open space and outdoor recreation land. Of this, about 10% is owned by the town. Most of the remainder is held by the former Department of Environmental Management (now Department of Conservation and Recreation [DCR]), The Trustees of Reservations, and the Andover Village Improvement Society (AVIS), a local land trust.

Protection of open space along the Shawsheen River is a major priority of the 1998 Open Space Plan, which states that "whenever and wherever possible, land along both sides of the Shawsheen River should be acquired or otherwise protected from development," especially when any change in use is contemplated. The open space plan also emphasizes the creation of a public greenway and trail network along the river, and Andover is working collaboratively with neighboring Lawrence and North Andover to accomplish this. A number of specific sites have been targeted for preservation, including Den Rock Park and parcels near Pole Hill in Ballardvale, the Lowell Junction area, and the industrially-zones flood plain west of Route 1-93 on the east bank of the river.

The open space plan also recommends a series of actions aimed at protecting and enhancing water quality. These include Town Meeting adoption of the recently drafted local wetlands by-law, strict enforcement of the town's earth movement (zoning) by-law, and education of property owners on the safe use of pesticides and herbicides (including alternatives to their use).

The 1998 Open Space Plan was created with substantial community participation and has the solid backing of multiple town boards and organizations. It places a premium on the threatened land and water resources of the Shawsheen River corridor and provides both a framework and specific strategies for protecting these resources.

Tewksbury

*[63] Tewksbury completed an update of its Open Space and Recreation Plan in the summer of 1998. The Shawsheen River is identified in the plan as "among the most under-used and under-protected places in the Town of Tewksbury…This river... is nearly inaccessible to the public for both boating and scenic viewing." In a public survey and in public meetings, community members saw the river as an important resource and advocated for preservation and improved public accessibility. One of the plan's priority goals, therefore, is to "explore and enact measures to restore and preserve the quality of the water and banks of the Shawsheen River."

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*[62] IBID…..pg 20-21

*[63] IBID…..pg 75-76

More generally, the plan recommends aggressive measures to protect the water supply, including enactment of an Aquifer Protection By-law, preservation of wellfields as open space, regulation of appropriate uses of wellfield land, and protection of aquifer recharge areas. The plan recommends strict enforcement of the local and state wetlands protection laws as an important aspect of aquifer recharge area protection.

Acquisition of open space has not been a high priority for Tewskbury's town administration. There are approximately 71 acres of open space along the Shawsheen River. Most of the conservation commission land in the town has been acquired through tax title and cluster developments. Tax title properties along the Shawsheen are transferred as a matter of policy to the conservation commission, resulting in many small parcels along the river. There are informal access trails to the river through private and corporate land and the Open Space Plan recommends acquisition, conservation restrictions, or access easements as a way to permit greater public use of these trails.

Another focus of open space concern is the potential for changes in use or disposition by the Commonwealth of the state hospital grounds, which lie within the Shawsheen Watershed. These grounds are "the most significant area of contiguous open space in the town," comprised of 778 acres, including 662 acres in open space. Of this acreage, 318 are active farmland and another 162 acres are prime farmland not currently cultivated. The remaining open space is composed mostly of wetlands along Strong Water Brook, a major tributary of the Shawsheen River. The state could potentially change the land use and build on the acres currently used for agriculture and passive open space without being subjected to town land use regulations. The state could also sell the land to a private owner. Since 1992 the town has zoned the hospital grounds for agricultural use as a way of ensuring municipal influence over changes in land use by a potential private owner, who would have to seek a zoning variance for non-agricultural uses.

North Andover

[*64] North Andover adopted its first comprehensive Open Space Plan in 1970. Since that date, the plan has been updated several times. The 1995 Open Space and Recreation Plan complements other important planning initiatives in the community, in particular, the Master Plan, the Balance Growth Plan, and the Lake Cochichewick Watershed Plan. It articulates a common theme: "…the need to balance the inevitable growth of the community with the desire to preserve those attributes which define the community's character and, in many ways, drive the community's growth and prosperity."

Developed through an extensive public participation and review process, the 1995 Open Space and Recreation Plan contains five broad goals aimed at preserving North Andover's open space and community character:

- Increased watershed land acquisition.
- Protection of hilltops.
- Enhanced access to the Merrimack River.
- Completion of linkages between existing open spaces.
- Protection of farmland and scenic landscapes.

To achieve these goals, the plan prescribes 17 general municipal actions ranging from natural resources protection to environmental education. Foremost among these are the "protection of water resources" (especially Lake Cochichewick, the town's sole drinking water supply) and the "expansion of existing conservation land." The lake is the town's top conservation priority because of rapid residential growth in the lake's watershed in recent decades and the consequent degradation of the lake's water quality. The

[*64] IBID…..pg 65-55

town's open space acquisition efforts are focused primarily on the Lake Cochichewick Watershed rather than other areas of the community.

Public open space preservation opportunities in the Shawsheen River corridor are extremely limited. The drainage area constitutes only two square miles (about 7%) of North Andover's total land area, and much of which is either already heavily developed or fragmented. To help ensure that the remaining open areas bordering the Shawsheen River remain a natural, vegetated greenway and are not impaired by further development encroachment or other harmful activities, the conservation commission has established a 100-foot non-disturbance buffer zone along the river. The conservation commission's plans for this area focus more on improving public access to and along the banks of the Shawsheen River (primarily through easements) than on purchasing properties – especially non-riverfront properties – in the watershed in general. North Andover is collaborating with neighboring Andover and Lawrence on an inter-municipal Shawsheen River Greenway and Trail Project funded through the Massachusetts Highway Department's ISTEA Enhancements Program.

Lexington

[*65] The town's Open Space Plan was revised in 1997 and is currently awaiting approval by the Division of Conservation Service of the Executive Office of Environmental Affairs. The plan specifically mentions the Shawsheen Watershed and the need for Lexington to protect the water supplies of surrounding towns. There is no coordination of planning or land acquisition with neighboring communities.

Sixty percent of the Town of Lexington drains into the Shawsheen Watershed. According to the conservation commission, not enough attention is given to the Shawsheen River in comparison to other rivers and streams in Lexington. Within the Shawsheen Watershed there are approximately 148 acres that are targeted for open space acquisition (plus various other parcels not on the critical list).

Implementation of the Open Space Plan has yet to begun. According to the conservation commission, this is unfortunate because there are a few parcels targeted for acquisition that are currently for sale or likely to go on the market in the near future. However, there are neither available resources, nor anyone charged with finding ways to creatively finance desirable acquisition – both of which may result in missed opportunities for open space preservation.

Burlington

[*66] The Town's Open Space Plan was updated in 1996 as part of the master planning process. There is no coordination of planning or land acquisition with neighboring communities. The Vine Brook corridor (the main tributary of the Shawsheen River located within Burlington) is heavily built out; therefore, there are very few remaining opportunities for acquisition along its banks, or anywhere within the Shawsheen Watershed itself. The town-owned wellfields are located within the Shawsheen Watershed and do provide a large tract of protected open space.

A 270-acre land-locked parcel south of Route 3, within the Shawsheen Watershed, is currently undeveloped open space. This parcel was taken by eminent domain for water supply protection and conservation purposes. Town Meeting recently defeated a conceptual proposal by the Board of Selectmen and the Landlocked Parcel Committee to pursue a golf course and recreation center on this site, clearly articulating a desire to keep this land as a "town forest" for future generations to enjoy. This property is not protected by conservation restriction nor is it under the direct management of the conservation commission, but there may be some protection if the purposes of the eminent domain taking were recorded in the deed or other legal documents.

[*65] IBID…..pg 55
[*66] IBID…..pg 45

Billerica

[*67] The Billerica Open Space and Recreation Plan was approved in 1997 and the town's open space committee is proceeding slowly with implementation. Although the Shawsheen River plays a role in the plan, Billerica residents consider the Concord River as more important because it is the town's source of drinking water. There is more existing open space along the Concord and less existing development, and there are more potential areas for open space acquisition.

Currently there are 10.6 acres of protected open space along the Shawsheen River and nearly 250 acres of semi-protected land comprised of town forest and parklands and the Shawsheen Regional Technical School lands. The rest of the watershed has scattered open space parcels that do not form a network. The watershed as a whole has approximately 184 acres of open space protected in perpetuity. Plan recommendations relating to the Shawsheen Watershed include preservation of the floodplain and acquisition of the wooded scenic bluff and adjacent wetlands near Shawsheen Regional Technical School, creation of a greenway along the river that would connect with protected land in Bedford, and more access to the river for fishing and boating. However, at present the Shawsheen River corridor is not a high priority for open space acquisition except if lands are available through tax title proceedings.

Bedford

The Town of Bedford Open Space and Recreation Plan was recently updated for the 1997 to 2002 period. It is one element of the Town's Comprehensive Plan. The conservation commission has already started to implement the plan. As with the comprehensive planning process, the town does not try to coordinate open space planning with neighboring communities. Although all of the goals of the plan directly affect the Shawsheen Watershed, it is not given specific attention in the plan.

Currently, there are 28.3 contiguous acres of protected land in the riverfront area. Unfortunately, most buildable (non-wetland) land along the banks is already developed. There is only one parcel of land on the banks of the Shawsheen River that is currently designated as land of Conservation Interest. There are seven parcels currently regulated under Chapter 61 that lie within the Shawsheen River Watershed. The town will consider these parcels for acquisition when and if they are put up for sale. Cluster and Planned Residential Districts (PRD) zoning provide the opportunity for open space preservation within Bedford.

[*67] IBID…..pg 38

PUBLIC ADVOCACY and ATTITUDES TOWARD WATERSHED RESOURCES PROTECTION

Organized Citizen Efforts

In 1971, the Shawsheen River Watershed Association (SRWA) was started in Andover. It had representatives from all of the Shawsheen River communities. Issues were discussed and committees formed. Sanitarian Joseph Barbagallo stated that he would tour all the communities regularly as the Shawsheen River Water Inspector. This SRWA continued at least until 1975. A report, compiled by Robert Hamilton of Billerica indicates, "from 1972-75 there seems little change in the environment of the river". He mentions that the watershed supports a large amount of wildlife such as mink, heron, songbirds, fox, muskrats, rabbits, pheasant, and woodcock. He also mentioned that wood duck nesting boxes were maintained by SRWA.

On April 25, 1988 in the Andover Town Hall, Maria Van Dusen of the Adopt-A-Stream Program (DFWELE) presented a program to area residents. At the meeting, it was recognized that it was important to try to work with upstream communities since what happened to the river upstream could greatly affect the water quality downstream. She proposed that an effort be made to form a new Shawsheen River Watershed Association with representatives from each of the seven communities in the watershed.

The Shawsheen Watershed Environmental Action Team (SWEAT) was founded in 1982 by Bob LeBoeuf. The purpose of the group is to raise awareness of the Shawsheen River and to protect the remaining open areas of the watershed. They have organized canoe races, river day celebrations, conducted a survey of landowners along the river in Tewksbury, and published the SWEAT Gazette. SWEAT has sponsored at least six major river cleanups each year since 1991. Bob Rauseo, president of SWEAT, stated that the group has pulled out more than 45 cubic yards of trash in a single day.

The river cleanups by SWEAT were done in conjunction with the Drivers Environmental Survey (DES). John Hicks-Courant reports that DES started in 1991 and officially ended in 1996. During the five years, the group provided support for SWEAT cleanups. There were between 3-6 members active in the Shawsheen River cleanups. He also stated that these members would continue to help SWEAT with the cleanups even though the DES group has disbanded.

Since the spring of 1996, the Merrimack River Watershed Council recruited and trained over one hundred volunteers organized in stream teams. These stream teams documented watershed conditions throughout the Shawsheen Watershed. This MRWC effort revitalized the Shawsheen River Watershed Association (SRWA), which is working to improve communication and interaction among watershed communities to restore the river, its tributaries, and the watershed.

Since 1996 a completely new Shawsheen River Watershed Association began to emerge, with its home base in Tewksbury. Many of the early members who joined in 1997 and started participating in monthly meetings, were active members in the already existing SWEAT Group. Andre Blouin was elected as the first president, and a board of directors was nominated and elected by the regular attendees of the monthly meetings. The primary impetus of the early re-formation of the SRWA was the flooding concerns during heavy rainfall periods in Billerica, Tewksbury, and Andover. But, quickly, other issues became a focus too, including: ongoing river trash cleanups, recreational outings (canoe trips); open space/trails protection; water quality problems; development/redevelopment issues; and habitat, including beaver problems.

The year 1999 saw the election of a new president, Bob Rauseo, and the formal development of an organizational charter and constitution, with a formal state of officers and board of directors, with terms of office, etc. Early in 2000 the organization received its formal 501C(3) tax filing status as a valid non-profit organization. During 1999 and 2000, the organization wrote, and was awarded, a grant from The Greater Lowell Foundation, to develop its membership through a survey sent out to over 700 citizens, and to expand its notoriety by offering a series of educational seminars held throughout the basin to increase citizen awareness about the resources of the watershed, and to instruct how these resources might better be protected.

It is a pleasure to report that the Shawsheen River Watershed Association has shown remarkable growth in membership and program offerings during 2001. There are presently close to 100 dues paying members. During 2001, SRWA sponsored a highly successful "Owls" demonstration show, with over 200 citizens participating. In addition to expanded river cleanup events, and SRWA sponsored canoe trips, the SRWA has become a more active and vocal advocate throughout the watershed on development issues, such as: Route 3 Expansion, and resultant wetlands mitigation recommendations; effects of Tewksbury Shopping Plaza expansion; effects of Power Mill, Andover development; Gradall Lane hazardous waste problems; Pomps Pond flow problems; and many other concerns. The SRWA has two new logos, and has a bi-monthly newsletter that reaches over 200 people in the watershed. Additionally, the SRWA had considerable input in developing initial ideas to help the watershed which were translated into the former Shawsheen team's development of three MWI projects which were approved for FY'02 funding: (1) Removal from the River, and Disposal of Tires; (2) Installing Shawsheen River Signs at 25 river road crossings; (3) Develop and publish a Shawsheen River Recreational activities/access map and guide.

Public Attitudes in the Shawsheen River Watershed

In late 1997 – early 1998, a project to assess public attitudes in the Shawsheen and Housatonic Watersheds was carried out by a consortium of organizations such as River Network, Merrimack River Watershed Council, Connecticut River Watershed Council, and The Housatonic Valley Association. Focus groups of randomly selected citizens were held from each watershed. Discussion centered on the following several themes i.e. Is the environment in the watershed getting better; what are the current and future chief environmental threats; what is the quality of the drinking water. For the Shawsheen Group, the following is a sampling of themes related through discussion.

Is the environment getting better

While people believe things are getting better when it comes to the environment in Massachusetts, they also think more needs to be done because of the mistakes that were made in the past. They think that in the past people made mistakes when it came to the environment, because they did not know any better. Now we know better, and it is up to us to correct those mistakes – especially as it relates to public health and drinking water quality.

Chief environmental threats

People think there has been just too much development where they live. They believe development has affected the quality of water. The decline of the river is another consequence of development – though this is not the most important result of development. Linking continued development to a further decline of the Shawsheen River is seen as a probable reality in the future. Traffic, increased housing density, and erosion in the quality of life are more readily apparent consequences of development to this group than is decline in the quality of the Shawsheen River.

Effect of development on environmental quality

Participants in the group had a clear perception of why development continues unchecked and what that means for the environment. To them, there is too much development because development is managed poorly by local government. It is managed poorly because of politics and the power relationship between regulators and developers. This leads to building everywhere, including on marginal lots, and to real environmental problems with water flow, level and runoff.

While people think development is out of control, and they do not want it encouraged, they also do not want to prohibit, ban, or stop it. Participants want development controlled, monitored, and managed responsibly. Part of the responsible management equation is the consideration and weighing of the environmental consequences (especially to water quality) of development. Participants believe: "We have to make choices about development, but that does not mean we have to choose between protecting natural resources and development. We can do both if choices are made responsibly with an understanding and weighing of how proposed developments will affect quality of life and environment". Today, the choices that are made about development are not (always) done responsibly.

Drinking water supply quality

Participants in the focus group were so concerned about the quality of their tap water that some had switched to drinking bottled water, others had purchased water filters, and others avoided using tap water when it smelled of chemicals. Clean water is perceived as one of the two most important environmental issues; an important finding for those interested in watershed protection. Given this, watershed protection should be positioned as a way to protect our water and keep it clean. The economic ramifications of watershed protection are also important to stress. We can protect watersheds now or pay a lot more to have our drinking water filtered later.

Public perception on the existence of the Shawsheen River

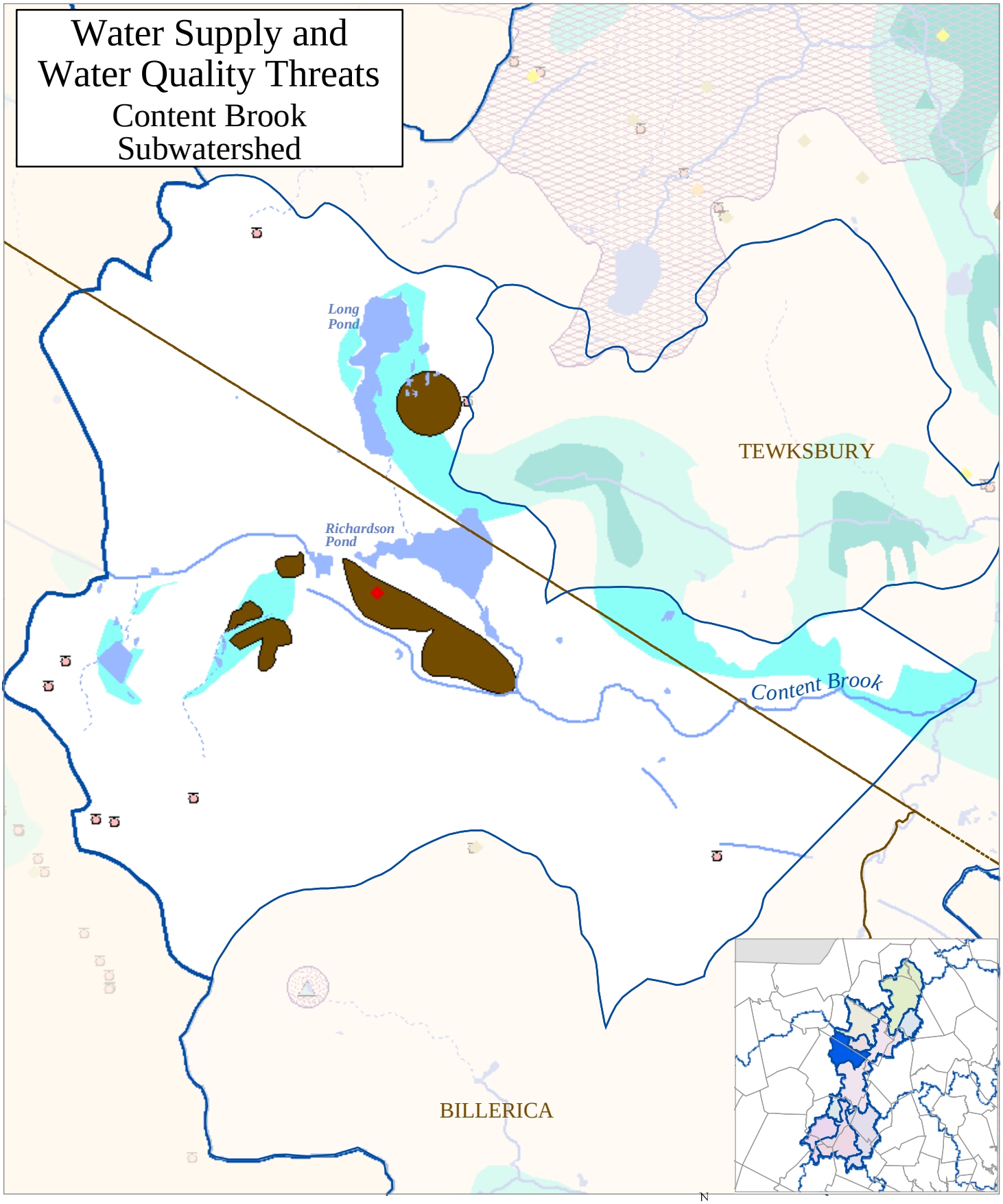
Initially for some participants in the group, it appeared that the Shawsheen River was so far degraded there was no compelling reason to spend a lot of time cleaning it up. The primary perception of the Shawsheen River was quite negative. When pushed, people did claim that the river is important to them, but their low level of knowledge about the river reveals quite a different picture. Their drinking water does not come from the Shawsheen River and the river is not perceived as important to their quality of life.

This special focus group survey and study of the Shawsheen waters, reveals some facts demonstrating important challenges in the future of educating the public about the value of the resources that are available in the watershed. The survey indicates that most people know little about, nor care about, the positive attributes dealing with resources of the watershed. Most people almost totally ignore the watershed as a resource in their lives. Most assume it is past quality and value now is very seriously degraded. There is also the strong perception that many still regard it as a public sewer, (witness the volumes of trash very visibly present on the sides and bottom of the river).

In view of these needs, the former Shawsheen team and the Shawsheen River Watershed Association proposed future education and training programs such as: installing Shawsheen River signs on roadway crossings of the river; educational forums of habitat diversity; riverways protection; canoe trips and river cleanups; public advertising to reduce littering; and professional training with town personnel and DPWs on stormwater BMP pollution control housekeeping practices.

APPENDIX 1 – WATERSHED MAPS

Water Supply and Water Quality Threats
Content Brook Subwatershed



Public Water Supply
- Community Ground Water
- Community Surface Water
- Transient Non-Community

Water Supply Protection Areas
- Interin wellhead protection areas
- ZONE IIs

21E Sites
- Tier 1A
- Tier 1B
- Tier 1C
- Tier 2
- Default Tier 1B
- Solid Waste Facilities
- Underground Storage Tanks

Aquifers
- > 300 gpm yield
- 100-300 gpm yield

Watershed boundary
- Major basin
- Tributary basin

N

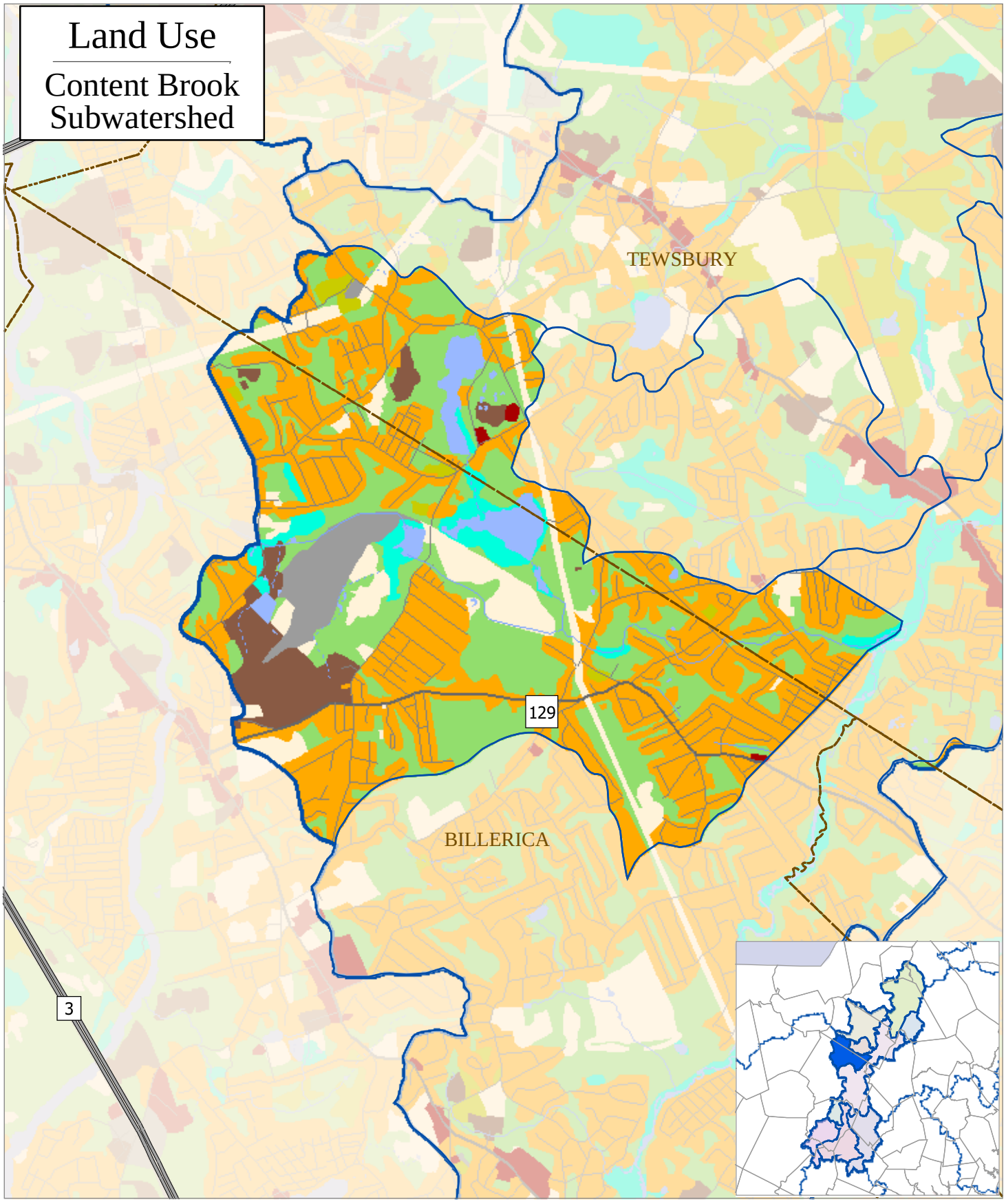
0 0.5 Miles
0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Content Brook Subwatershed



Land Use

- Agriculture
- Forest
- Wetland
- Open water
- Residential
- Industrial
- Commercial
- Transportation
- Open land

Watershed boundary
- Major basin
- Tributary basin

Note: Data derived from 1999 aerial photography.

N

0 0.5 1 Miles

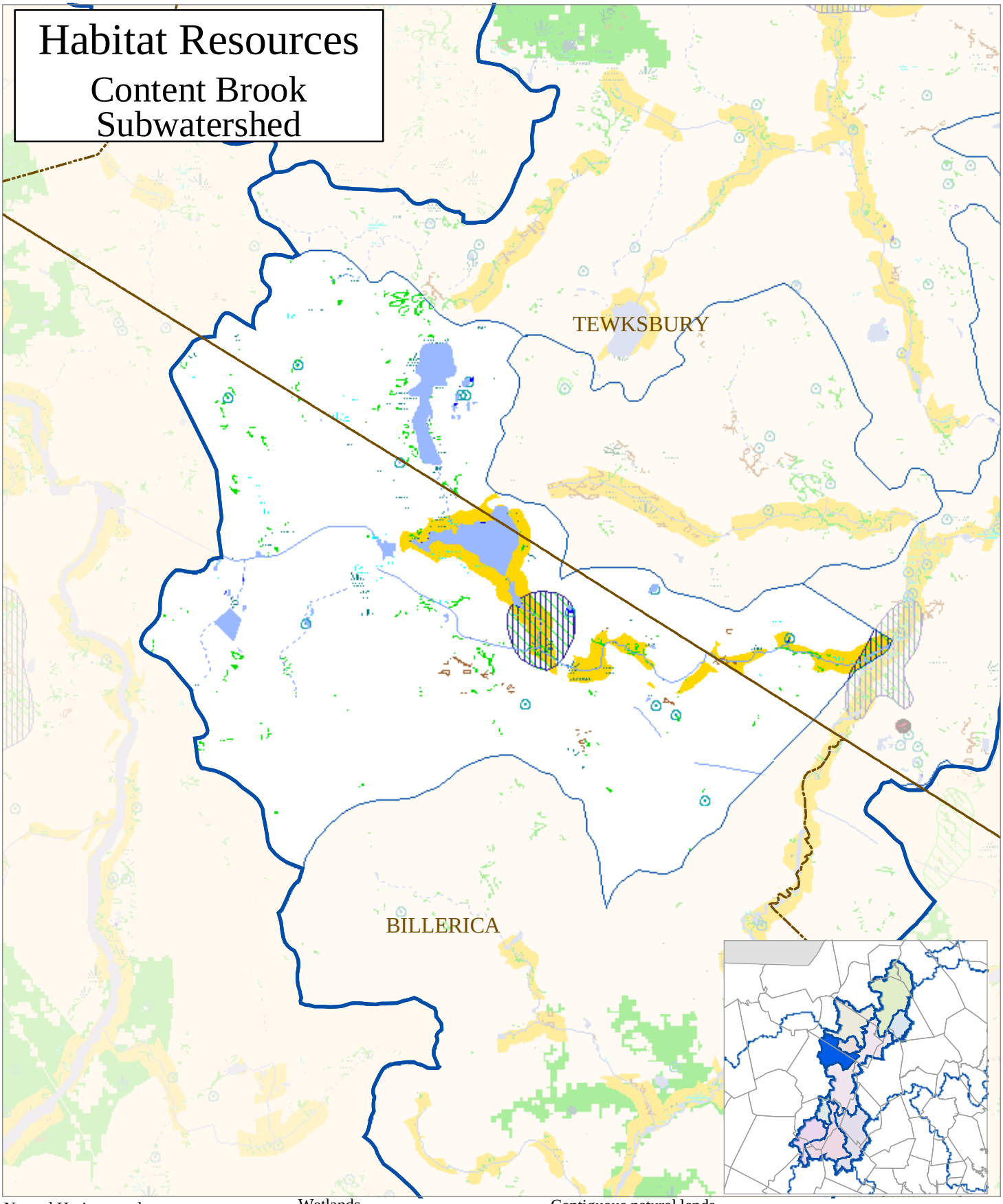
0 1 Kilometers

William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Content Brook Subwatershed



Natural Heritage and Endangered Species Program
- NHESP Certified Vernal Pools
- Potential Vernal Pools
- Estimated Habitats of Rare Wildlife
- Priority Habitat Sites
- 100 meter natural land riparian buffer

Wetlands
- BOG
- DEEP MARSH
- SHRUB SWAMP
- WOODED SWAMP CONIFEROUS
- WOODED SWAMP DECIDUOUS
- WOODED SWAMP MIXED TREES
- SHALLOW MARSH MEADOW OR FEN

Contiguous natural lands
- 250 - 499 acres
- 500 - 1999 acres
- > 2000 acres

Watershed boundary
- Major basin
- Tributary basin

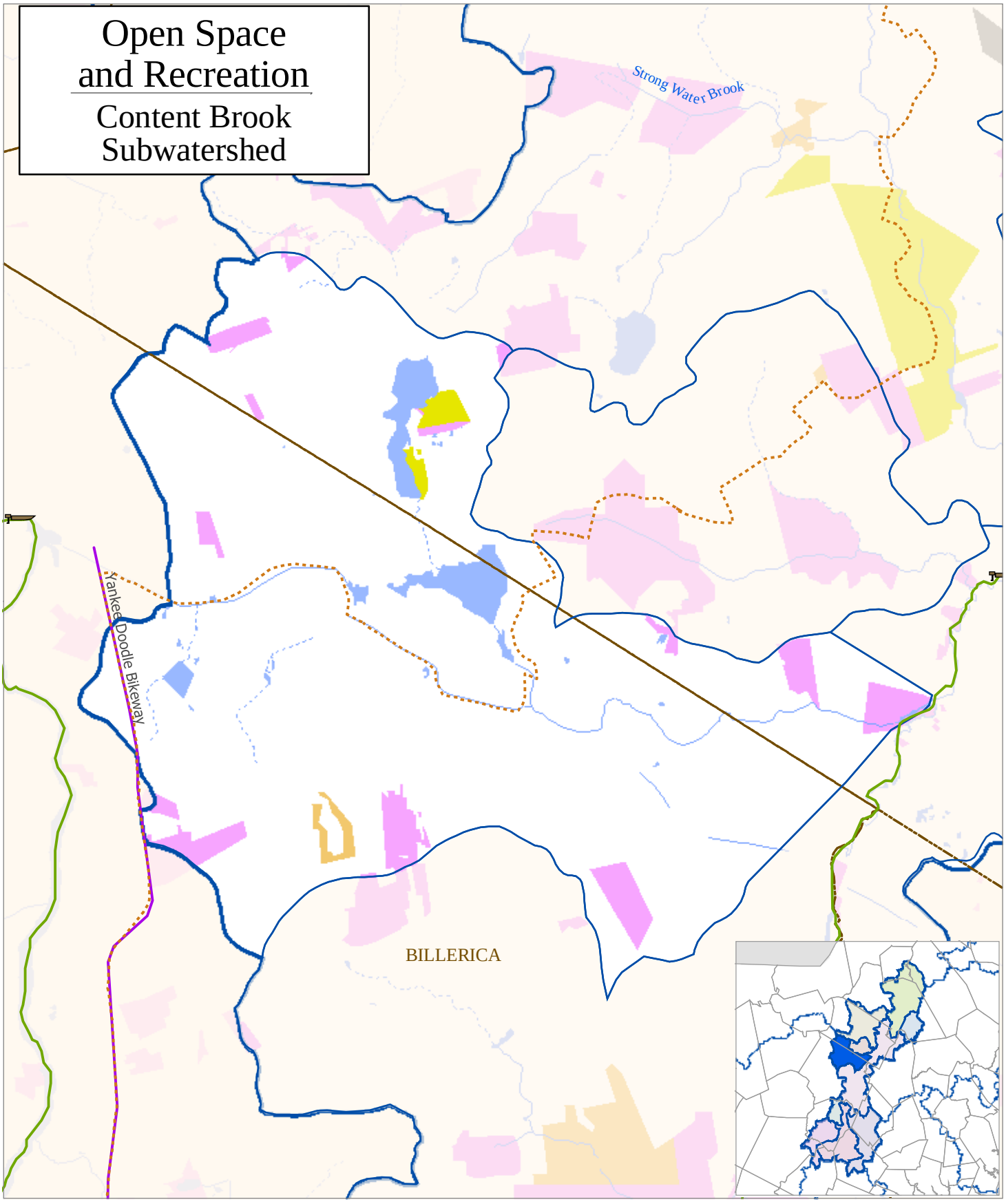
0 0.5 1 Miles
0 1 Kilometers

N

Feb 2003

Open Space and Recreation

Content Brook Subwatershed



Deed Restrictions

- Conservation Restriction
- Agricultural Preservation Restriction

Watershed boundary

- Major basin
- Tributary basin

Open Space by ownership

- DEM
- OTHER STATE
- NON-PROFIT ORGANIZATION
- MUNICIPAL
- FEDERAL
- PRIVATE, NOT CHAPTER 61
- UNKNOWN

- Existing Rail Trail
- Bay Circuit Trail

Bicycle Trails

- Existing
- Existing Unimproved
- On-Road Connection
- Considered

N

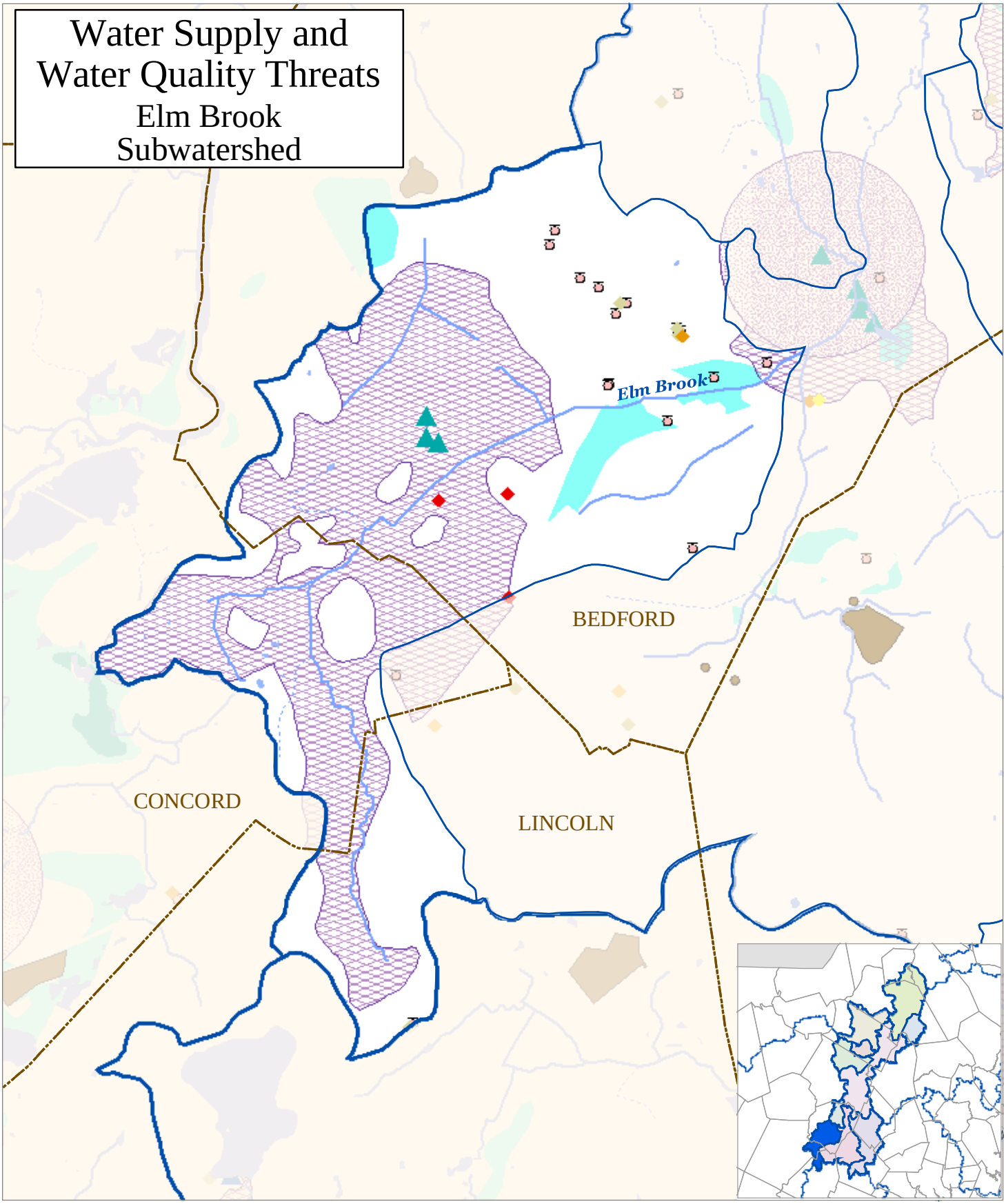
0 0.5 Miles

0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Water Supply and Water Quality Threats
Elm Brook Subwatershed



Public Water Supply
- Community Ground Water
- Community Surface Water
- Transient Non-Community

Water Supply Protection Areas
- Interin wellhead protection areas
- ZONE IIs

21E Sites
- Tier 1A
- Tier 1B
- Tier 1C
- Tier 2
- Default Tier 1B
- Solid Waste Facilities
- Underground Storage Tanks

Aquifers
- > 300 gpm yield
- 100-300 gpm yield

Watershed boundary
- Major basin
- Tributary basin

N

0 0.5 1 Miles

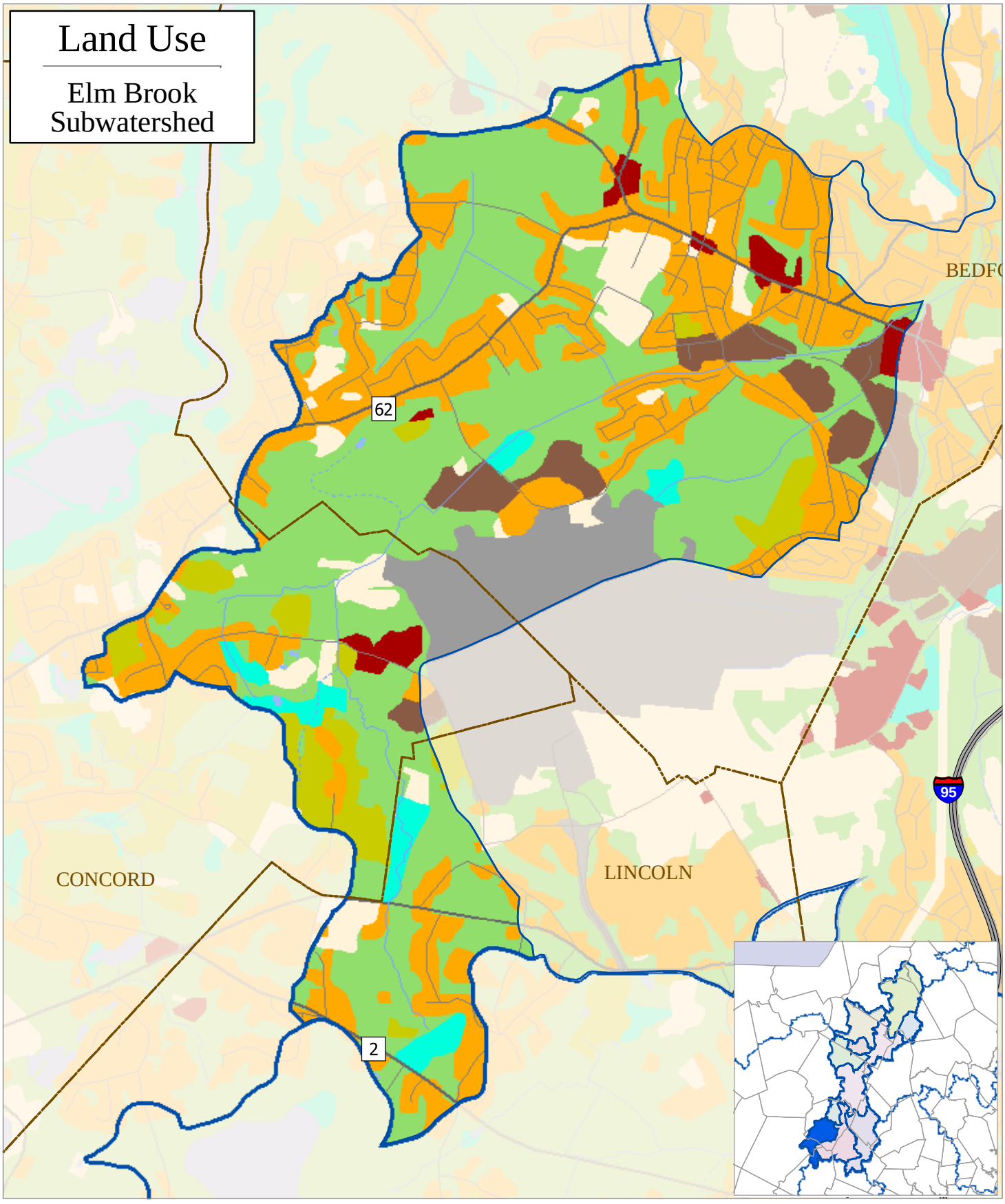
0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Elm Brook Subwatershed



Land Use

- Agriculture
- Forest
- Wetland
- Open water
- Residential
- Industrial
- Commercial
- Transportation
- Open land

Watershed boundary

- Major basin
- Tributary basin

Note: Data derived from 1999 aerial photography.

N

0 0.5 Miles

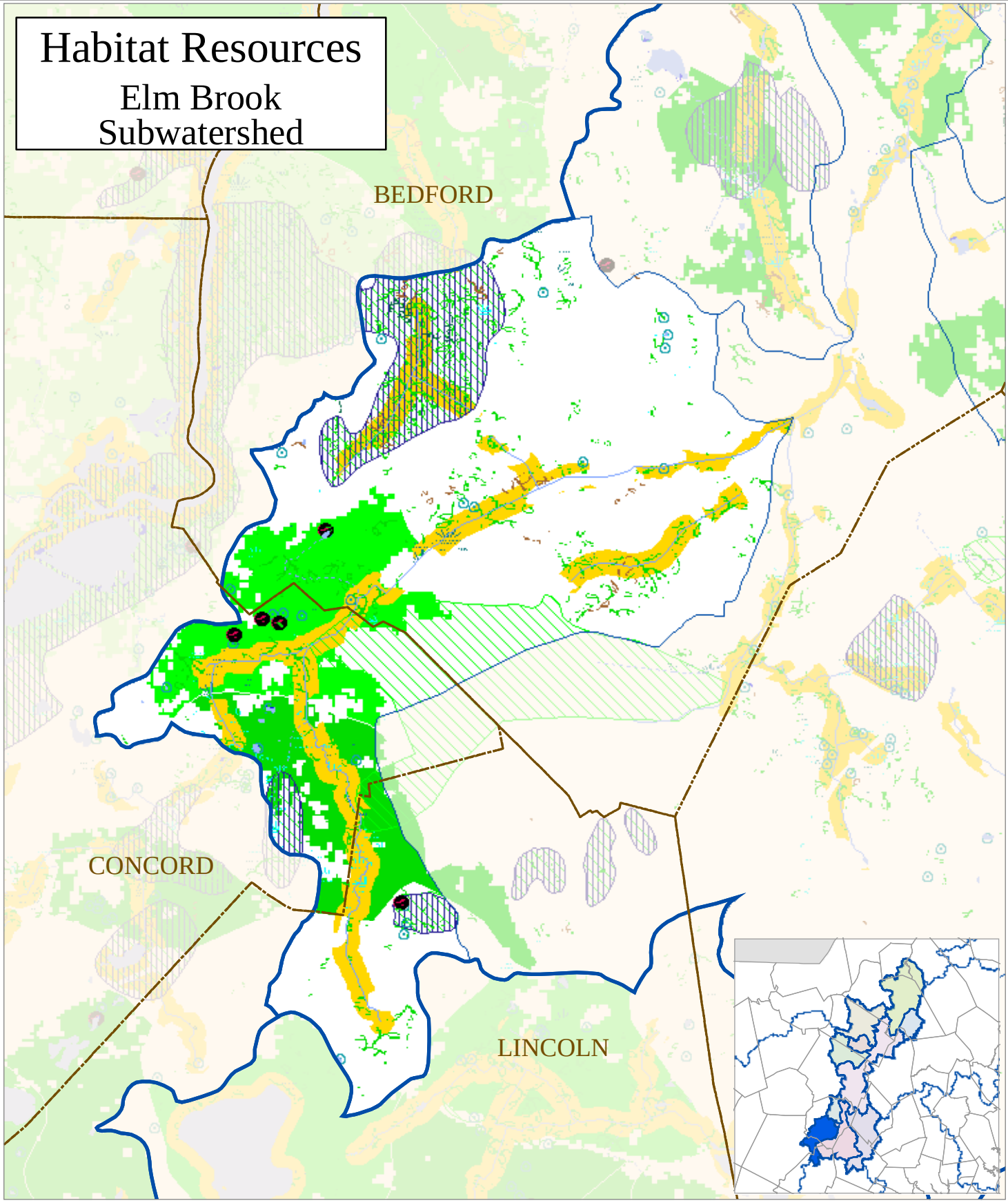
0 1 Kilometers

William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Elm Brook Subwatershed



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- WOODED SWAMP MIXED TREES
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Contiguous natural lands
- 250 - 499 acres
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Watershed boundary
- Major basin
- Tributary basin

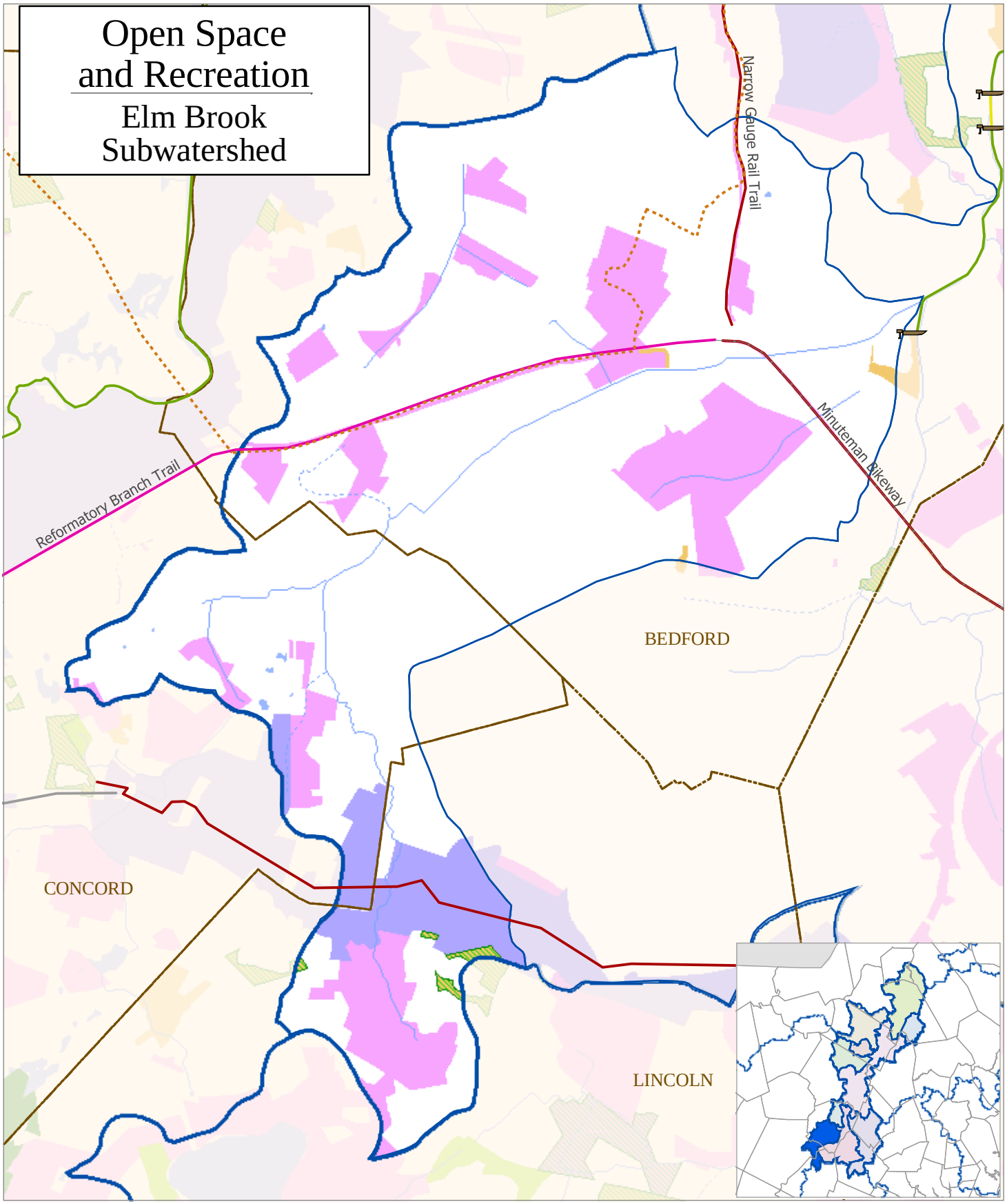
0 0.5 1 Miles
0 1 Kilometers

N

Feb 2003

Open Space and Recreation

Elm Brook Subwatershed



Deed Restrictions

- Conservation Restriction
- Agricultural Preservation Restriction

Watershed boundary

- Major basin
- Tributary basin

Open Space by ownership

- DEM
- OTHER STATE
- NON-PROFIT ORGANIZATION
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- FEDERAL
- PRIVATE, NOT CHAPTER 61
- UNKNOWN

- Existing Rail Trail
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Bicycle Trails

- Existing
- Existing Unimproved
- On-Road Connection
- Considered

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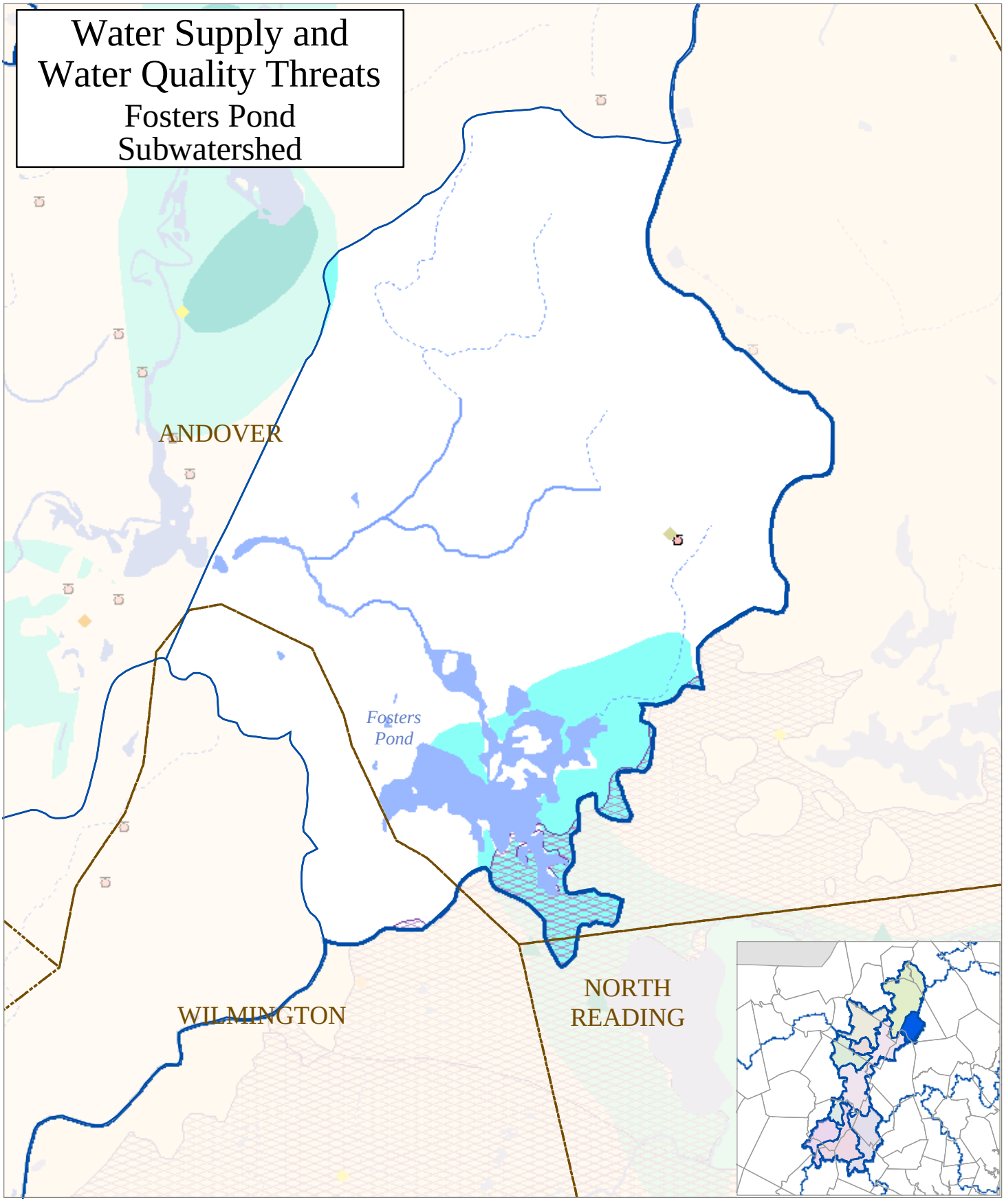
0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Water Supply and Water Quality Threats

Fosters Pond Subwatershed



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Underground Storage Tanks

Aquifers
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- 100-300 gpm yield

Watershed boundary
- Major basin
- Tributary basin

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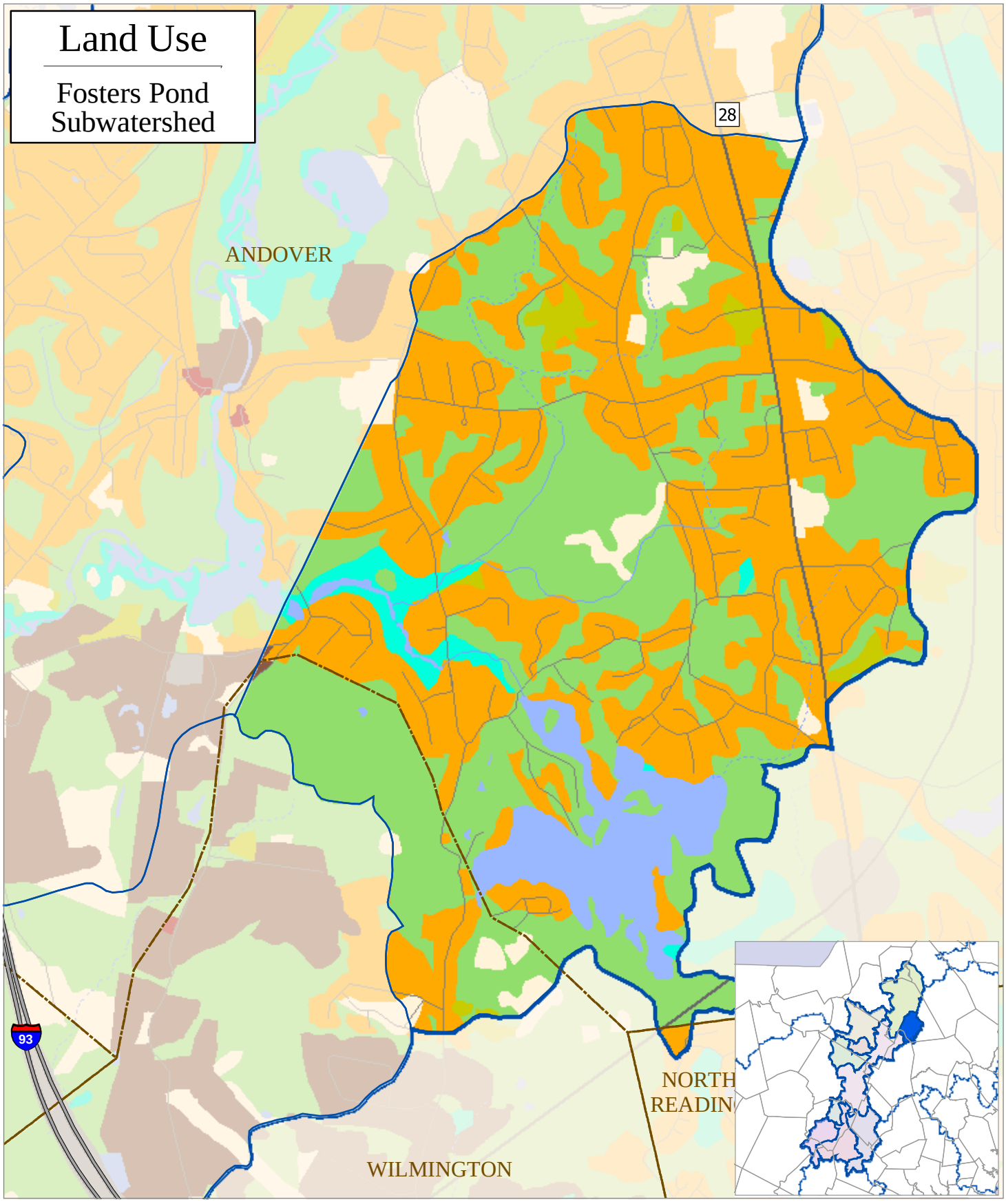
0 0.5 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Fosters Pond Subwatershed



Land Use

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- Forest
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- Industrial
- Commercial
- Transportation
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Watershed boundary

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- Tributary basin

Note: Data derived from 1999 aerial photography.

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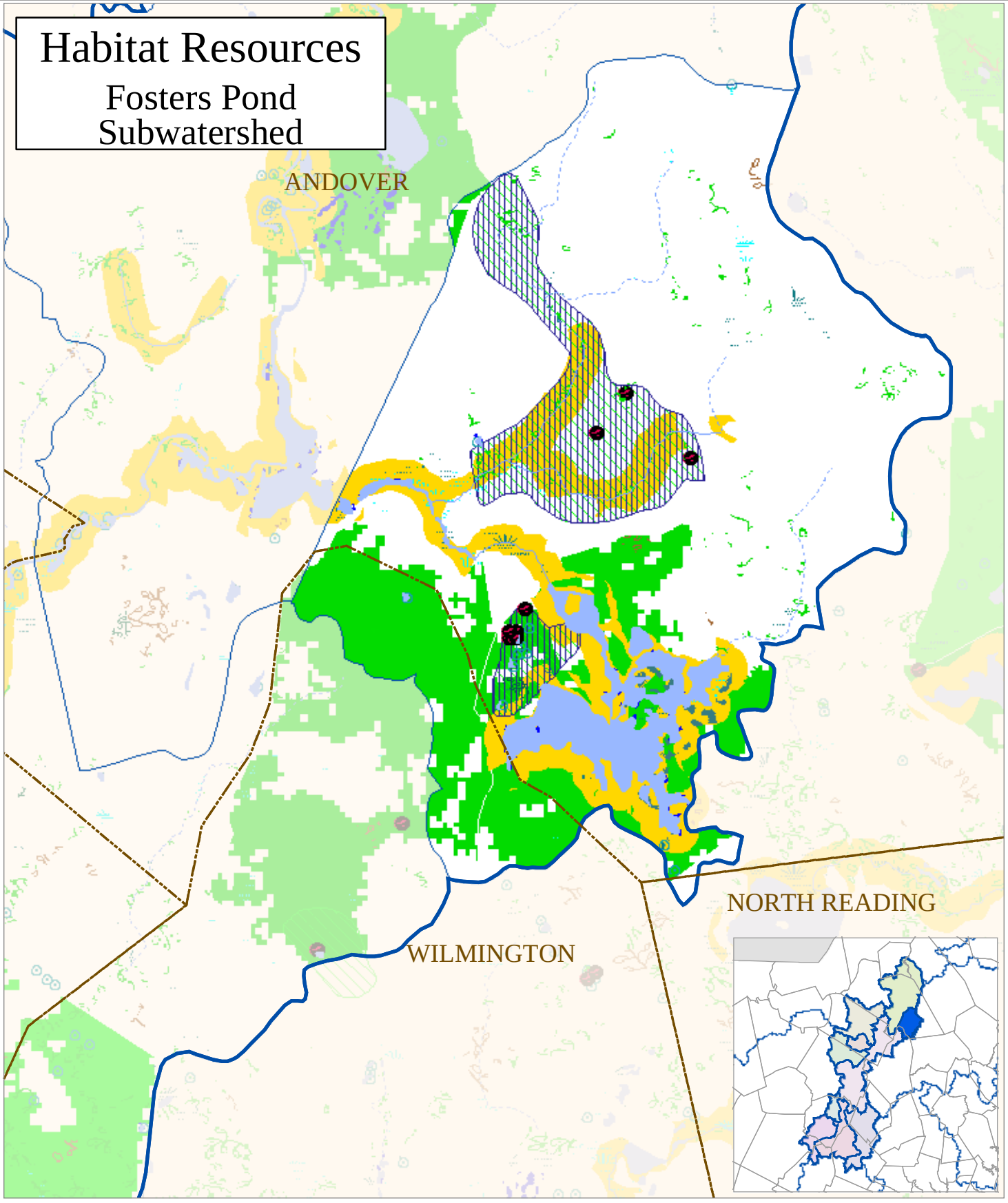
0 1 Kilometers

William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Fosters Pond Subwatershed



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- Major basin
- Tributary basin

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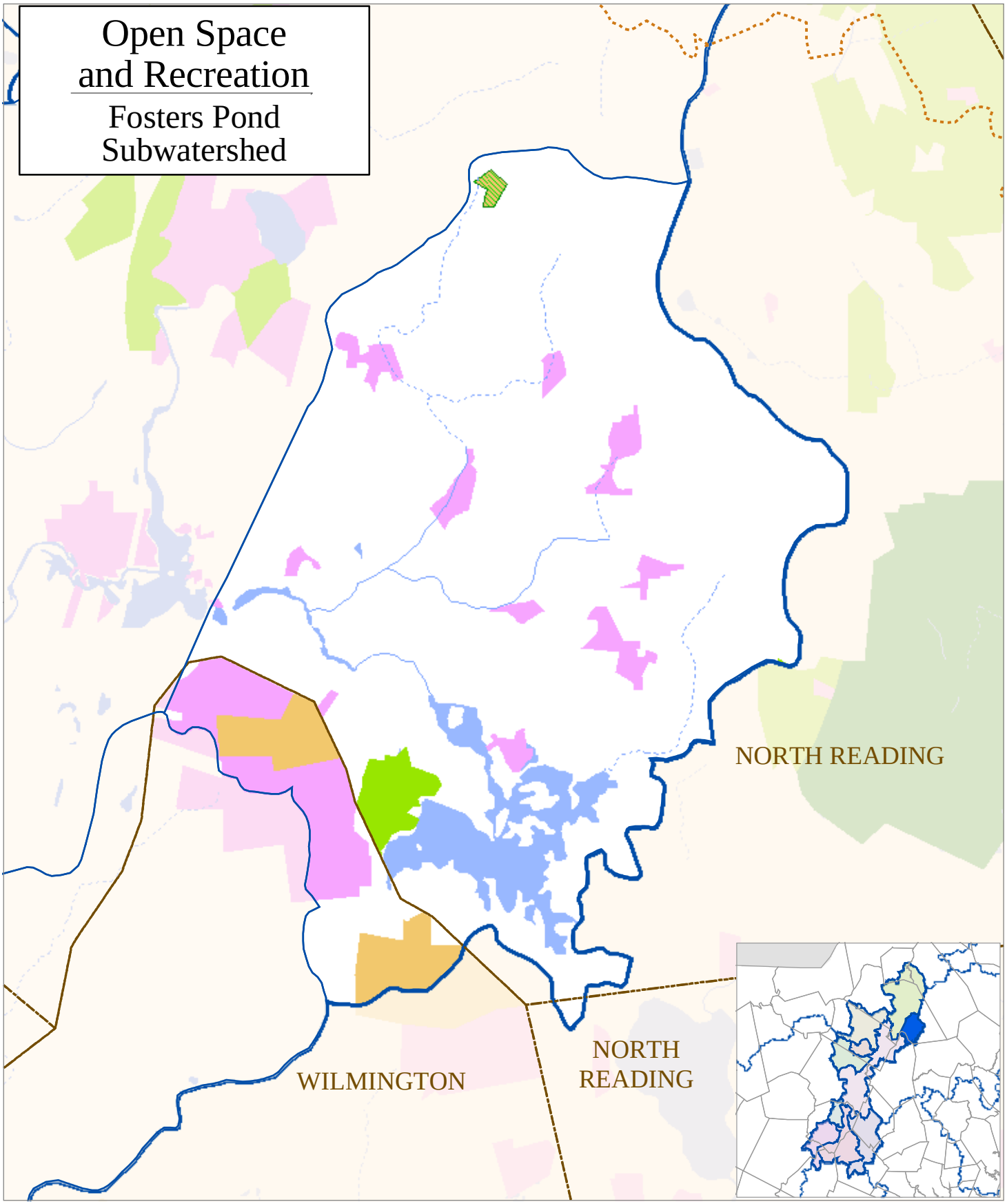
0 1 Kilometers

N

Feb 2003

Open Space and Recreation

Fosters Pond Subwatershed



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Watershed boundary

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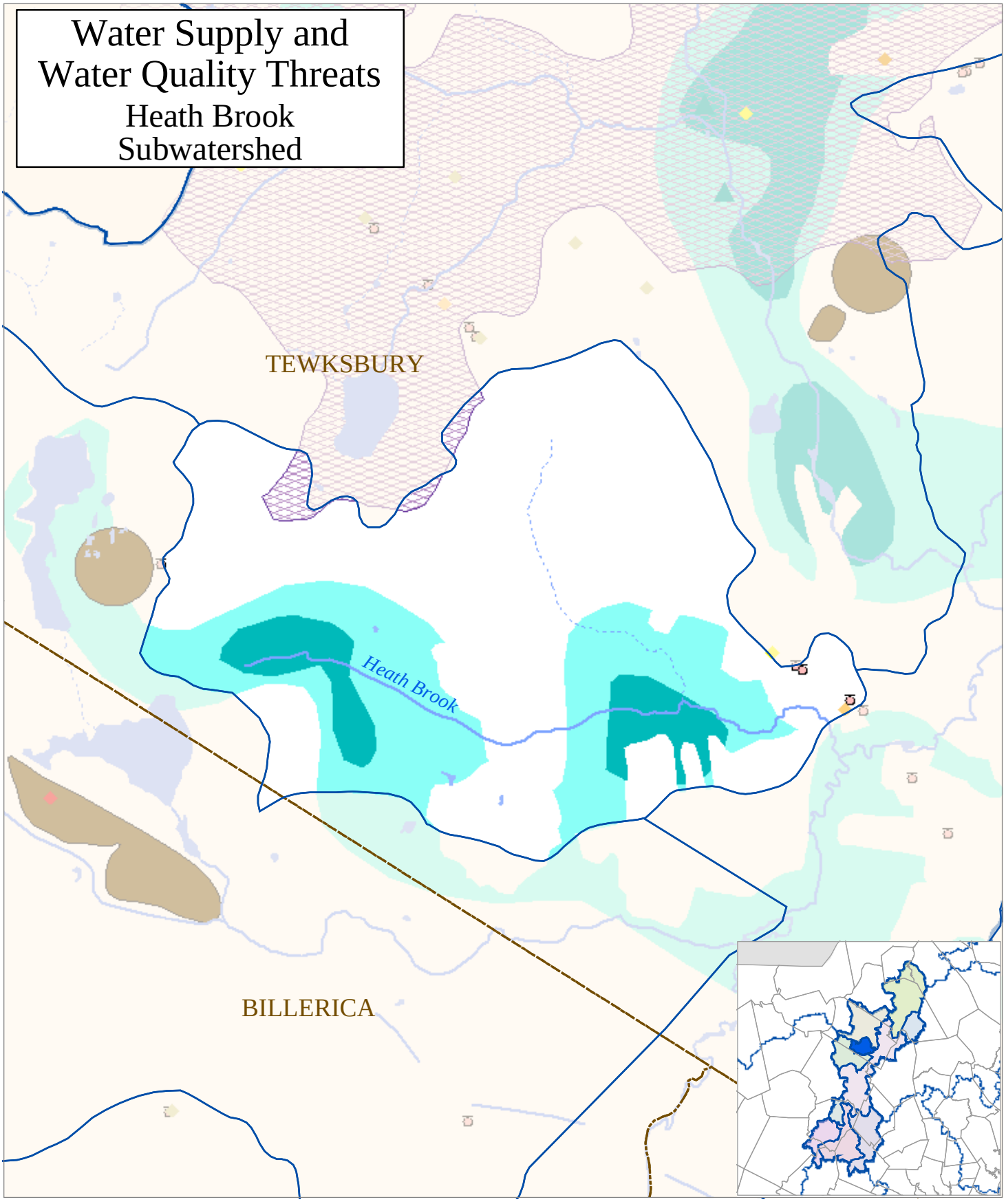
William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Water Supply and Water Quality Threats
Heath Brook Subwatershed



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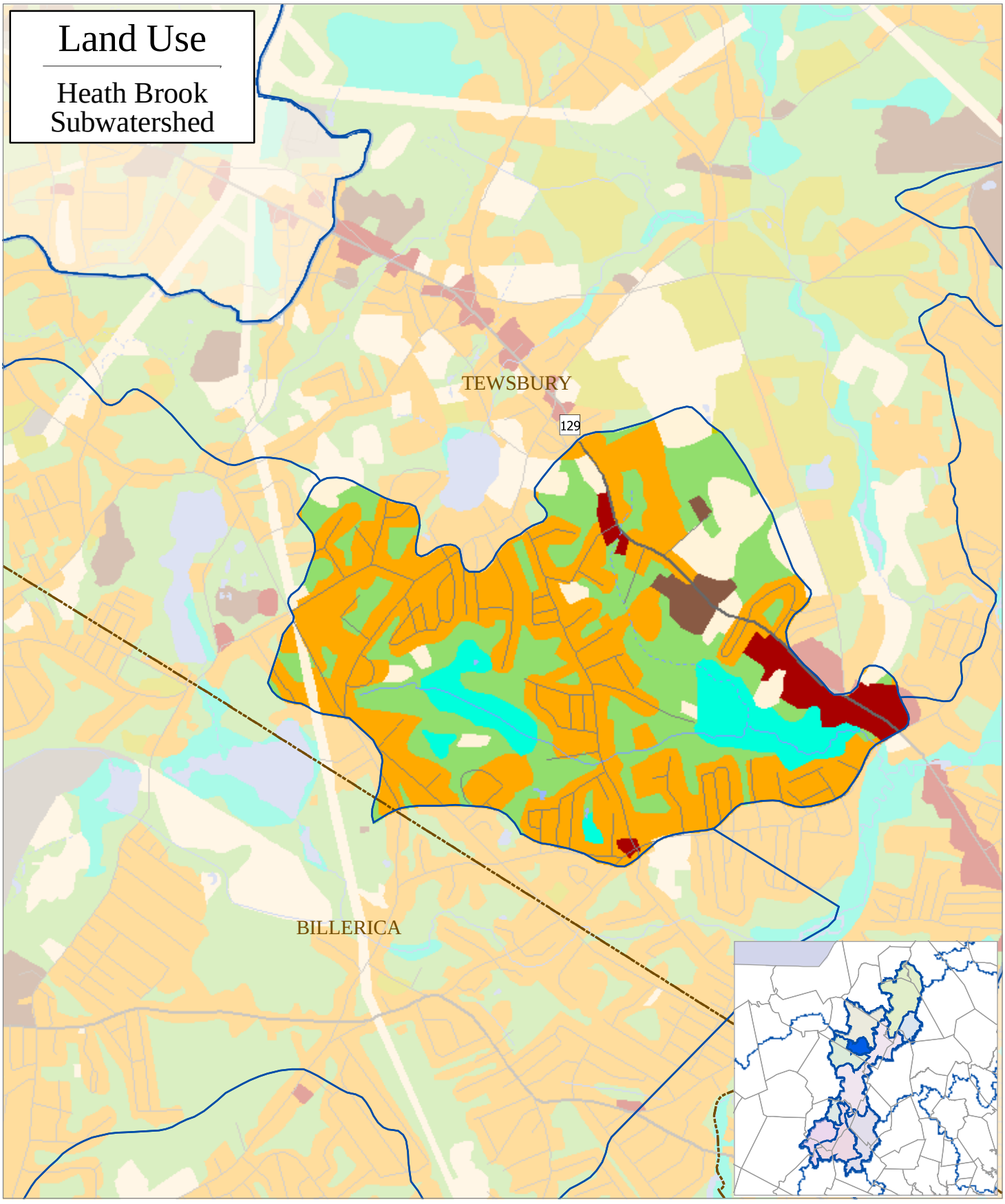
0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Heath Brook Subwatershed



Land Use

- Agriculture
- Forest
- Wetland
- Open water
- Residential
- Industrial
- Commercial
- Transportation
- Open land

Watershed boundary

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Note: Data derived from 1999 aerial photography.

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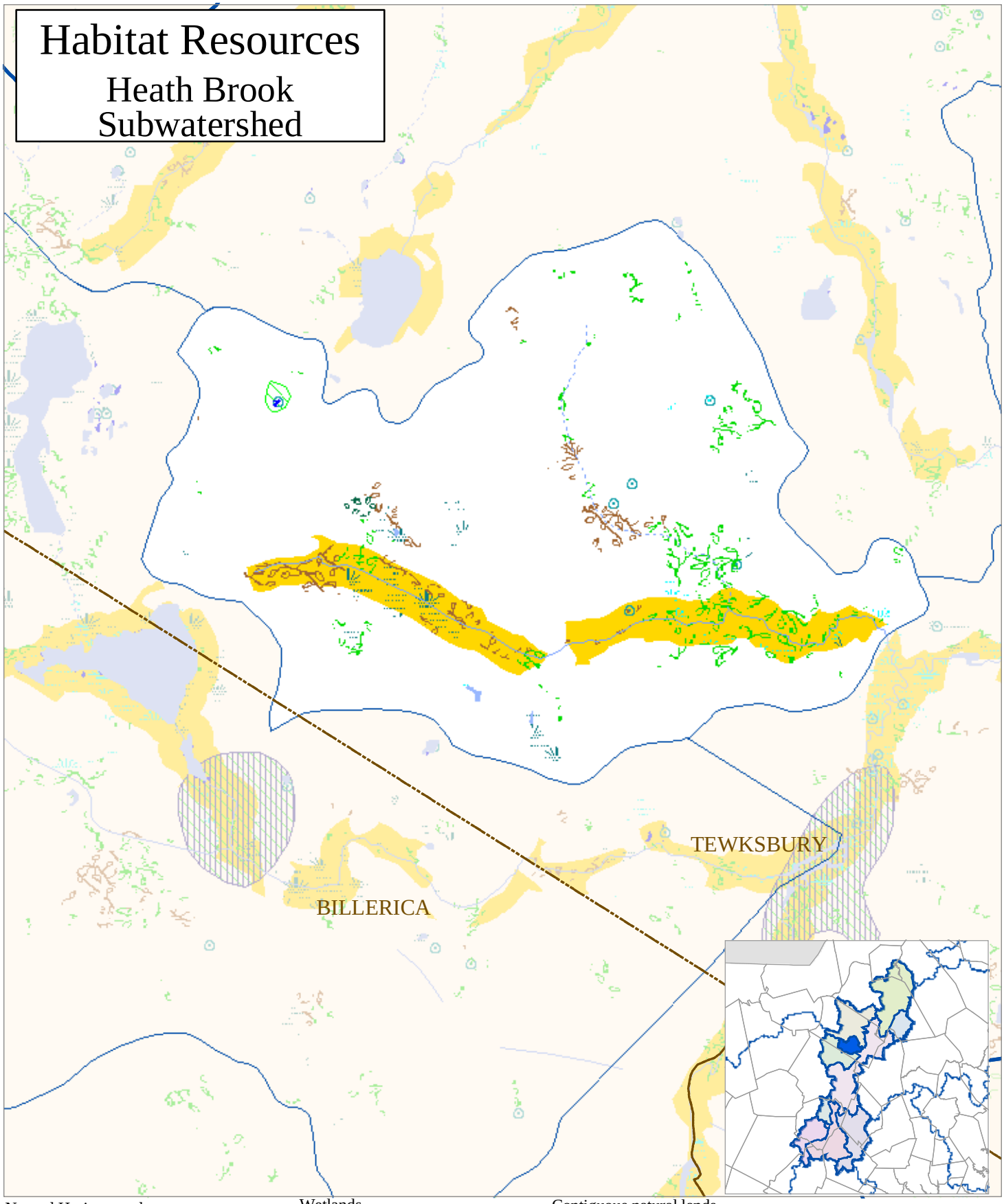
William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Heath Brook Subwatershed



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Watershed boundary
- Major basin
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0 0.5 Miles
0 1 Kilometers

N

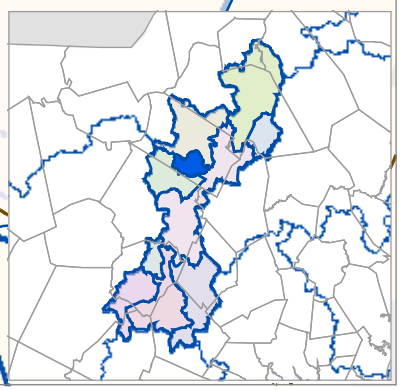
Feb 2003

Open Space and Recreation

Heath Brook Subwatershed

TEWSBURY

BILLERICA



Deed Restrictions

- Conservation Restriction
- Agricultural Preservation Restriction

Canoe Trips

- Trip Segment
- Portage (1 - 4)
- Canoe Access Points

Open Space by ownership

- DEM
- OTHER STATE
- NON-PROFIT ORGANIZATION
- MUNICIPAL
- FEDERAL
- PRIVATE, NOT CHAPTER 61
- UNKNOWN

- Existing Rail Trail
- Bay Circuit Trail

Bicycle Trails

- Existing
- Existing Unimproved
- On-Road Connection
- Considered

N

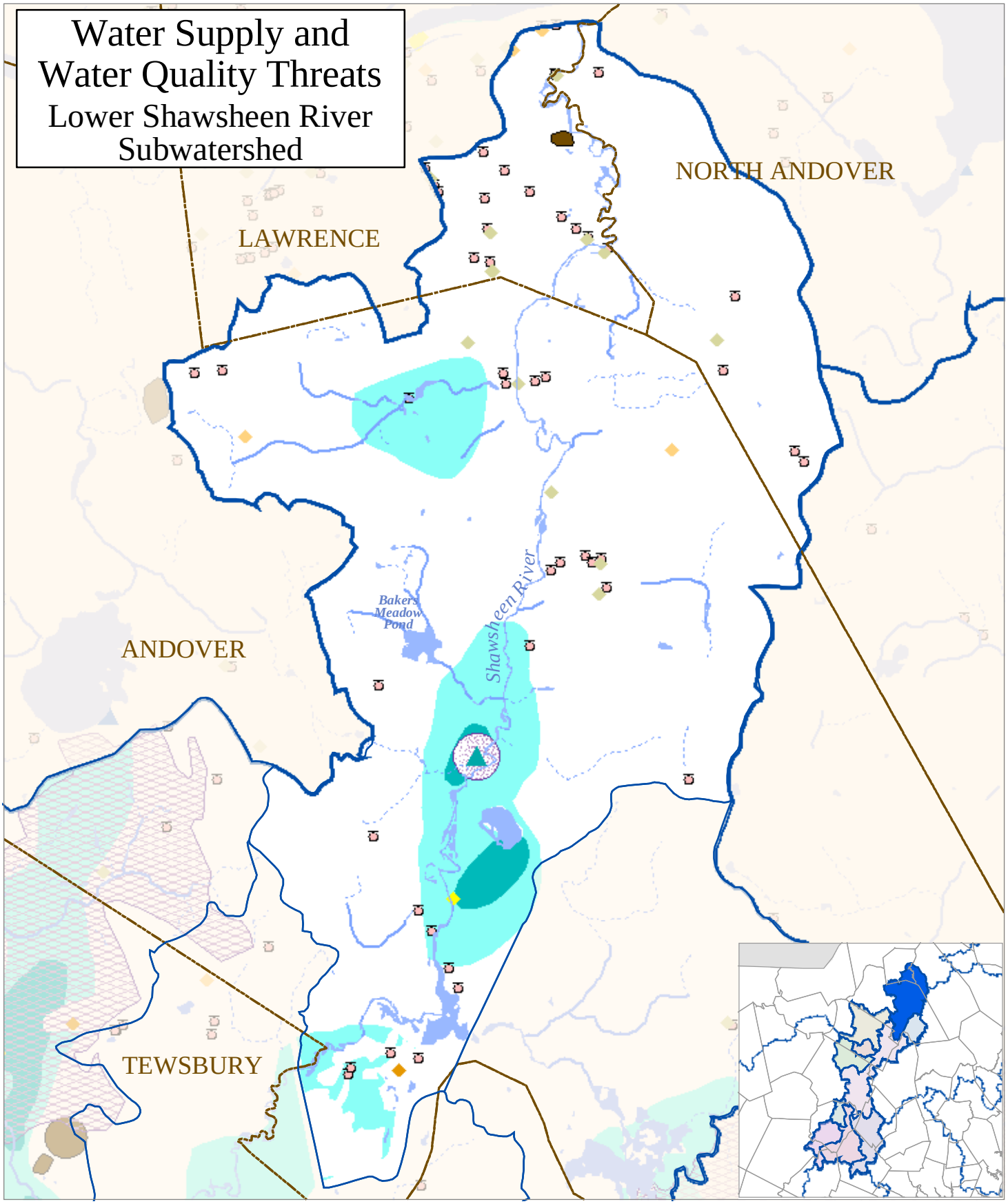
0 0.5 Miles

0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Water Supply and Water Quality Threats
Lower Shawsheen River Subwatershed



Public Water Supply
- Community Ground Water
- Community Surface Water
- Transient Non-Community

Water Supply Protection Areas
- Interin wellhead protection areas
- ZONE IIs

21E Sites
- Tier 1A
- Tier 1B
- Tier 1C
- Tier 2
- Default Tier 1B
- Solid Waste Facilities
- Underground Storage Tanks

Aquifers
- > 300 gpm yield
- 100-300 gpm yield

Watershed boundary
- Major basin
- Tributary basin

N

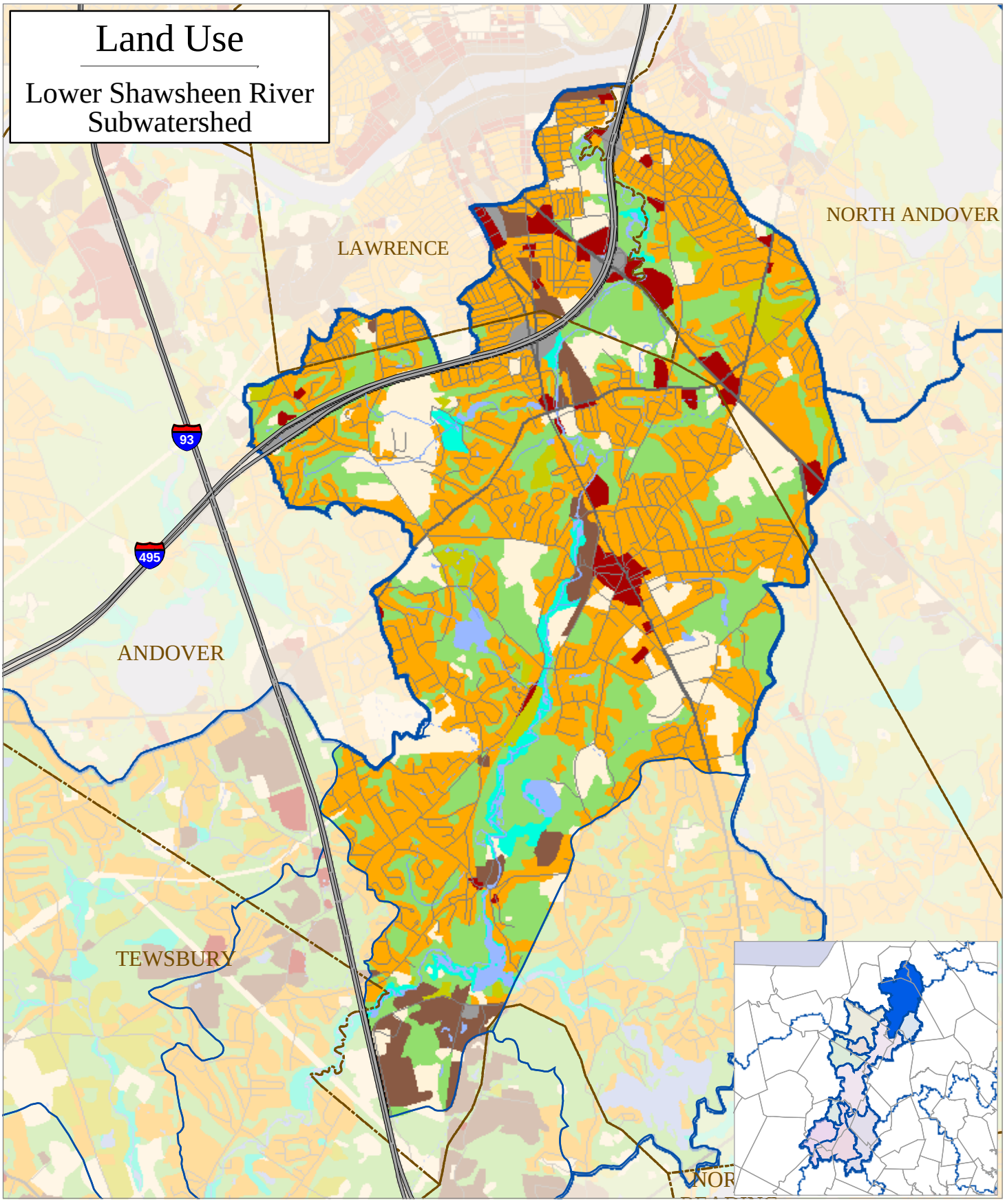
0 0.5 1 Miles
0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Lower Shawsheen River Subwatershed



Land Use

- Agriculture
- Forest
- Wetland
- Open water
- Residential
- Industrial
- Commercial
- Transportation
- Open land

Watershed boundary

- Major basin
- Tributary basin

Note: Data derived from 1999 aerial photography.

N

0 0.5 1 Miles

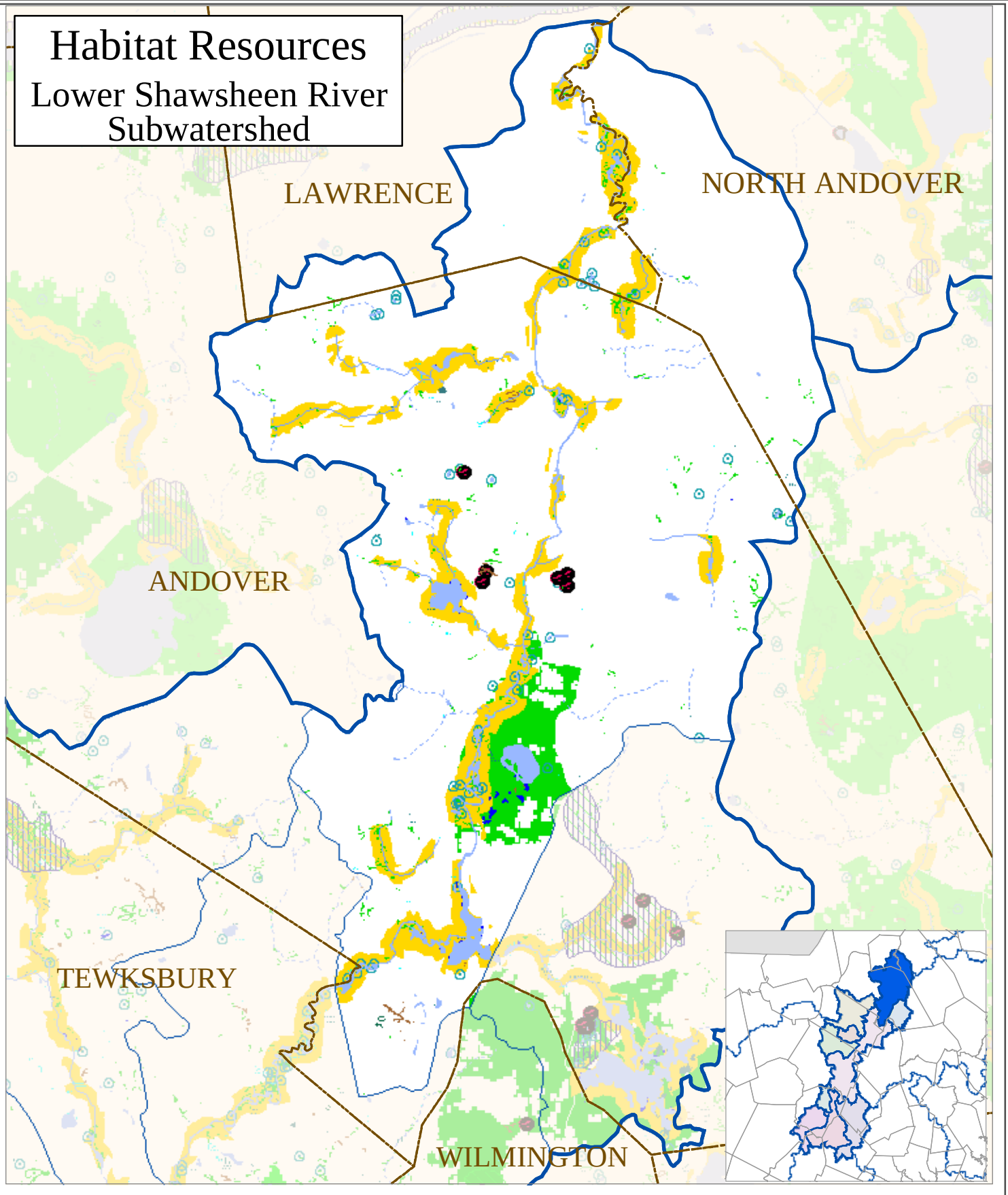
0 1 2 Kilometers

William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Lower Shawsheen River Subwatershed



Natural Heritage and Endangered Species Program
- NHESP Certified Vernal Pools
- Potential Vernal Pools
- Estimated Habitats of Rare Wildlife
- Priority Habitat Sites

100 meter natural land riparian buffer

Wetlands
- BOG
- DEEP MARSH
- SHRUB SWAMP
- WOODED SWAMP CONIFEROUS
- WOODED SWAMP DECIDUOUS
- WOODED SWAMP MIXED TREES
- SHALLOW MARSH MEADOW OR FEN

Contiguous natural lands
- 250 - 499 acres
- 500 - 1999 acres
- > 2000 acres

Watershed boundary
- Major basin
- Tributary basin

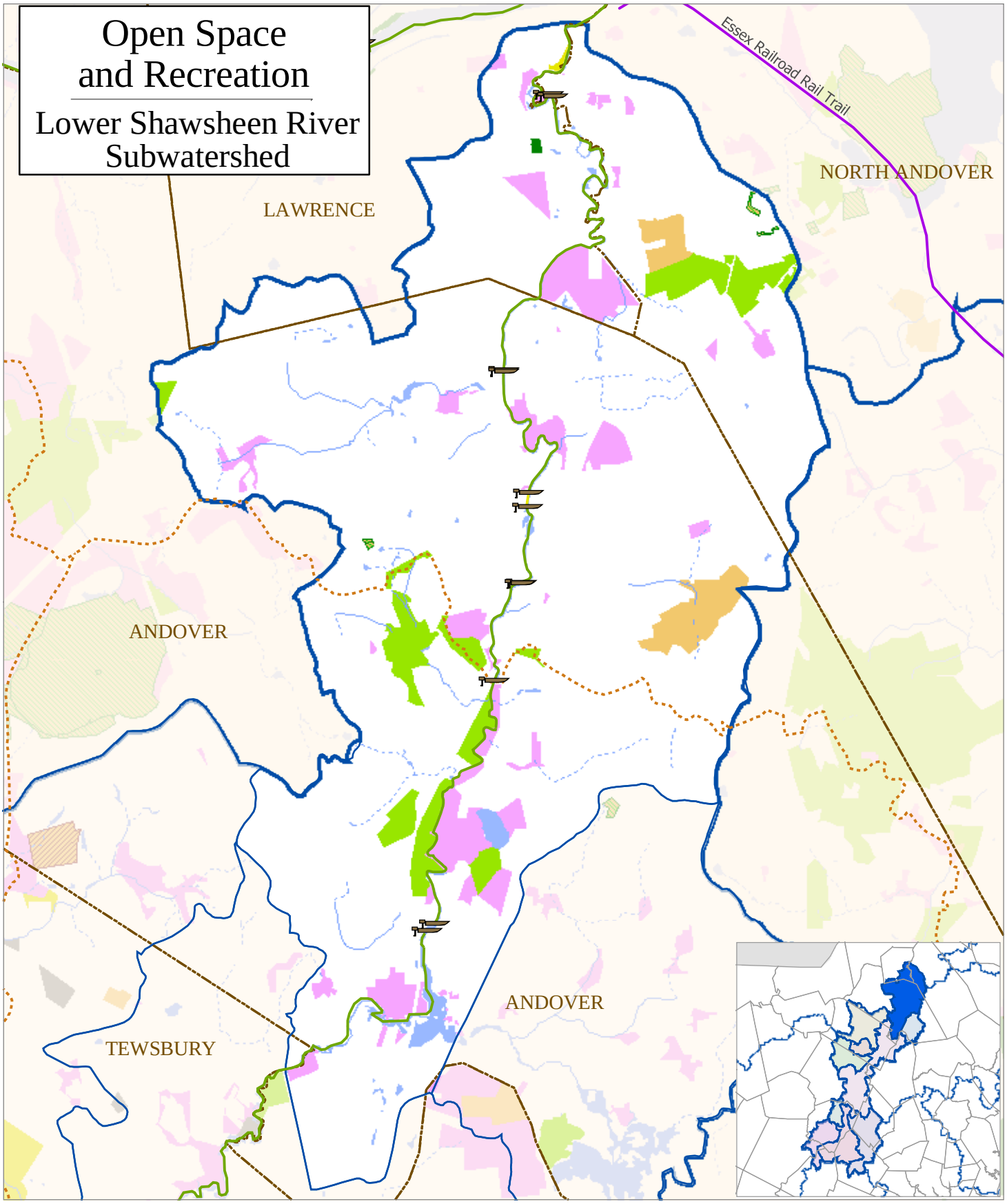
0 0.5 1 Miles
0 0.5 1 1.5 Kilometers

N

Feb 2003

Open Space and Recreation

Lower Shawsheen River Subwatershed



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Canoe Trips

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N

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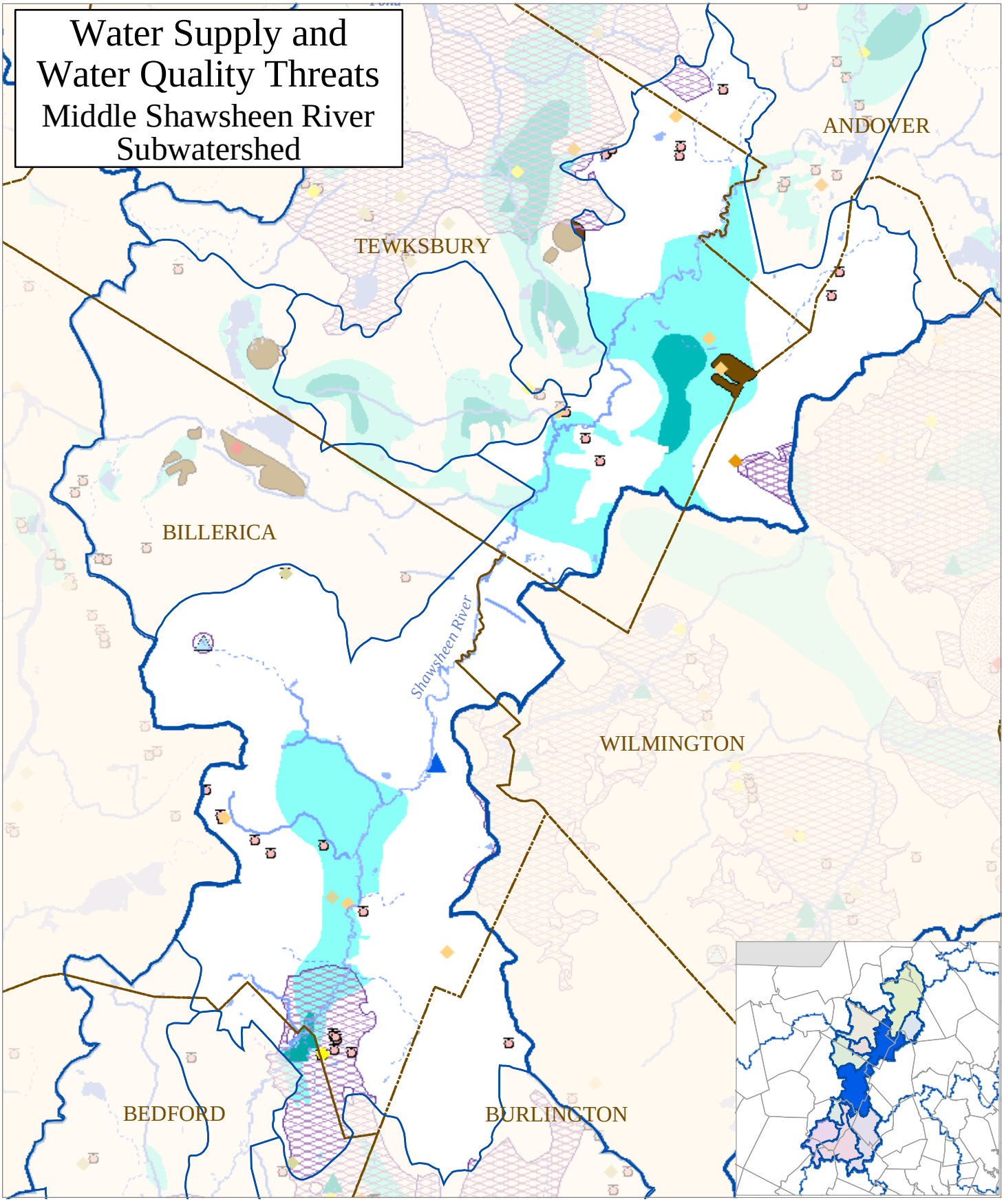
0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Water Supply and Water Quality Threats
Middle Shawsheen River Subwatershed



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Aquifers
- > 300 gpm yield
- 100-300 gpm yield

Watershed boundary
- Major basin
- Tributary basin

N

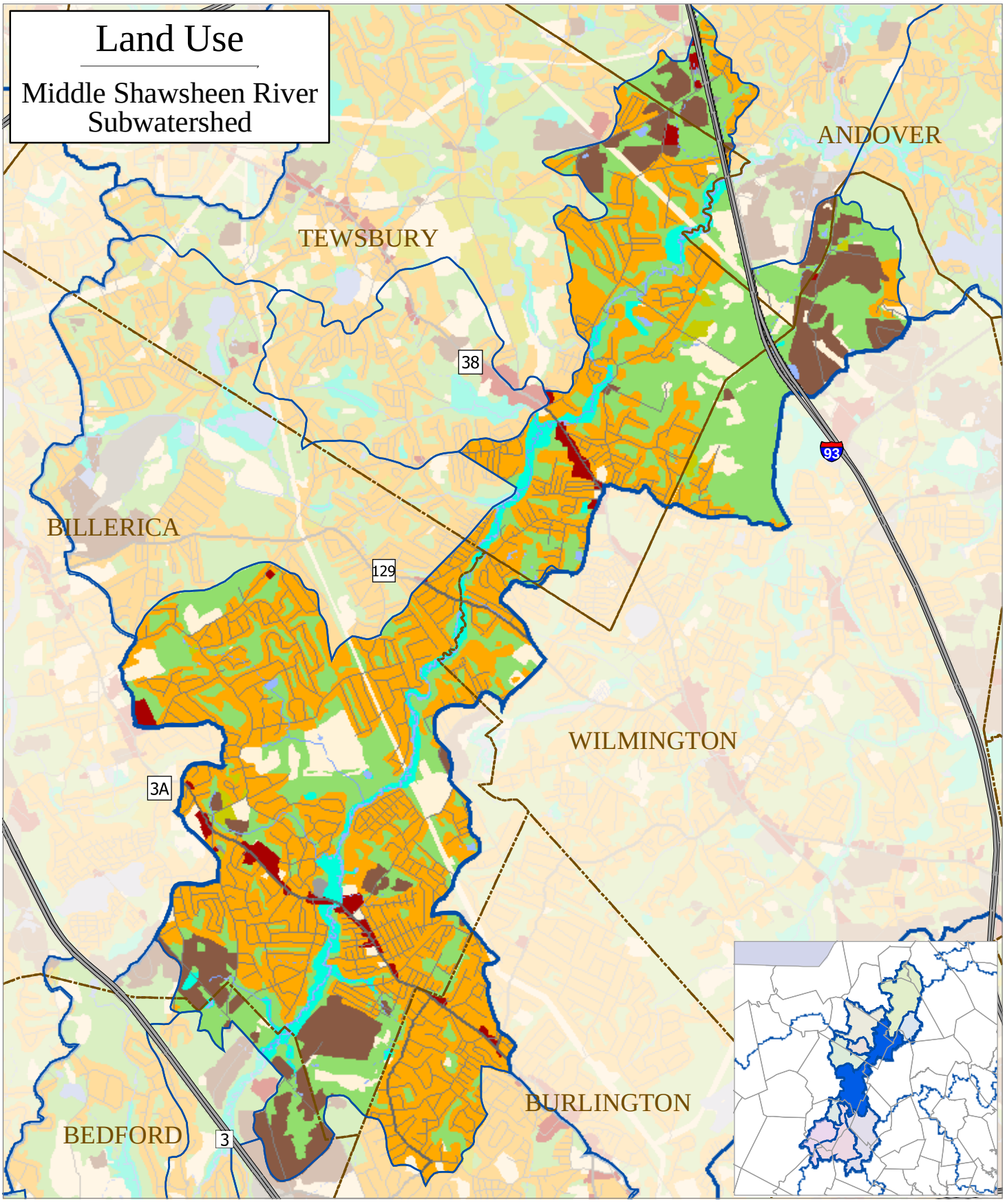
0 0.5 1 Miles
0 1 2 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Middle Shawsheen River Subwatershed



Land Use

- Agriculture
- Forest
- Wetland
- Open water
- Residential
- Industrial
- Commercial
- Transportation
- Open land

Watershed boundary

- Major basin
- Tributary basin

Note: Data derived from 1999 aerial photography.

N

0 0.5 1 1.5 Miles

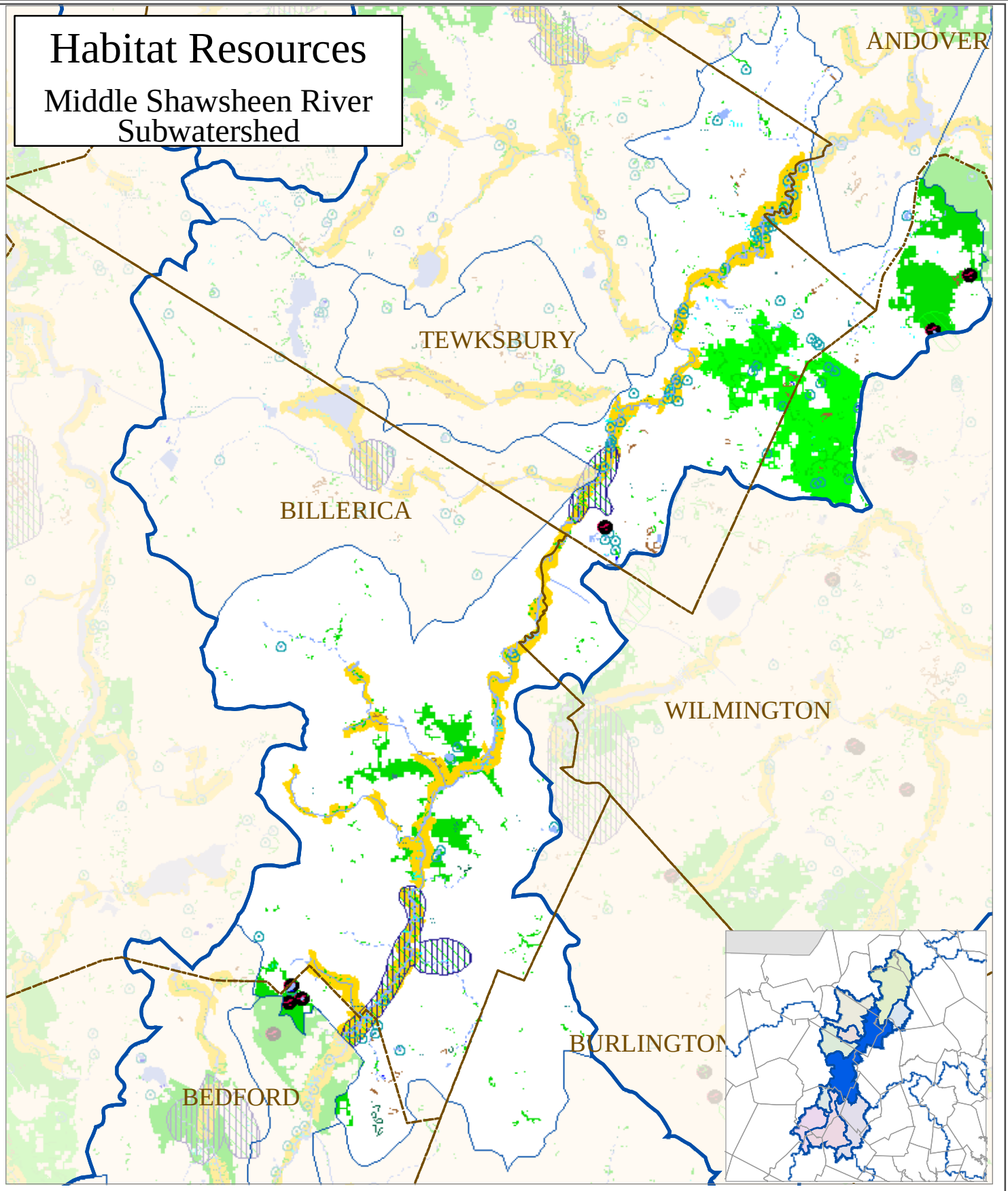
0 1 2 Kilometers

William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Middle Shawsheen River Subwatershed



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Watershed boundary
- Major basin
- Tributary basin

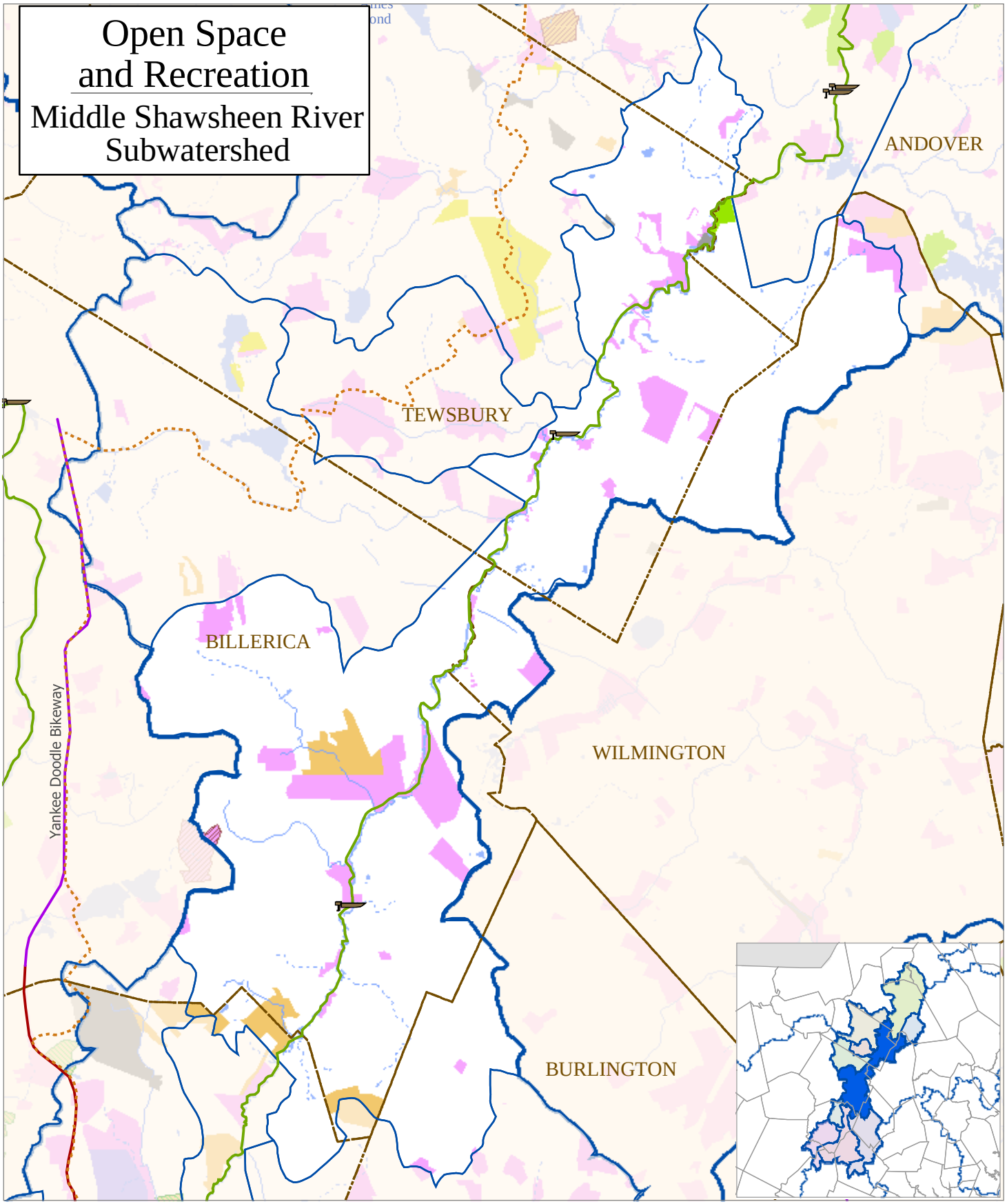
0 0.5 1 Miles
0 0.5 1 1.5 Kilometers

N

Feb 2003

Open Space and Recreation

Middle Shawsheen River Subwatershed



Deed Restrictions
- Conservation Restriction
- Agricultural Preservation Restriction

Canoe Trips
- Trip Segment
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N

0 0.5 1 1.5 Miles

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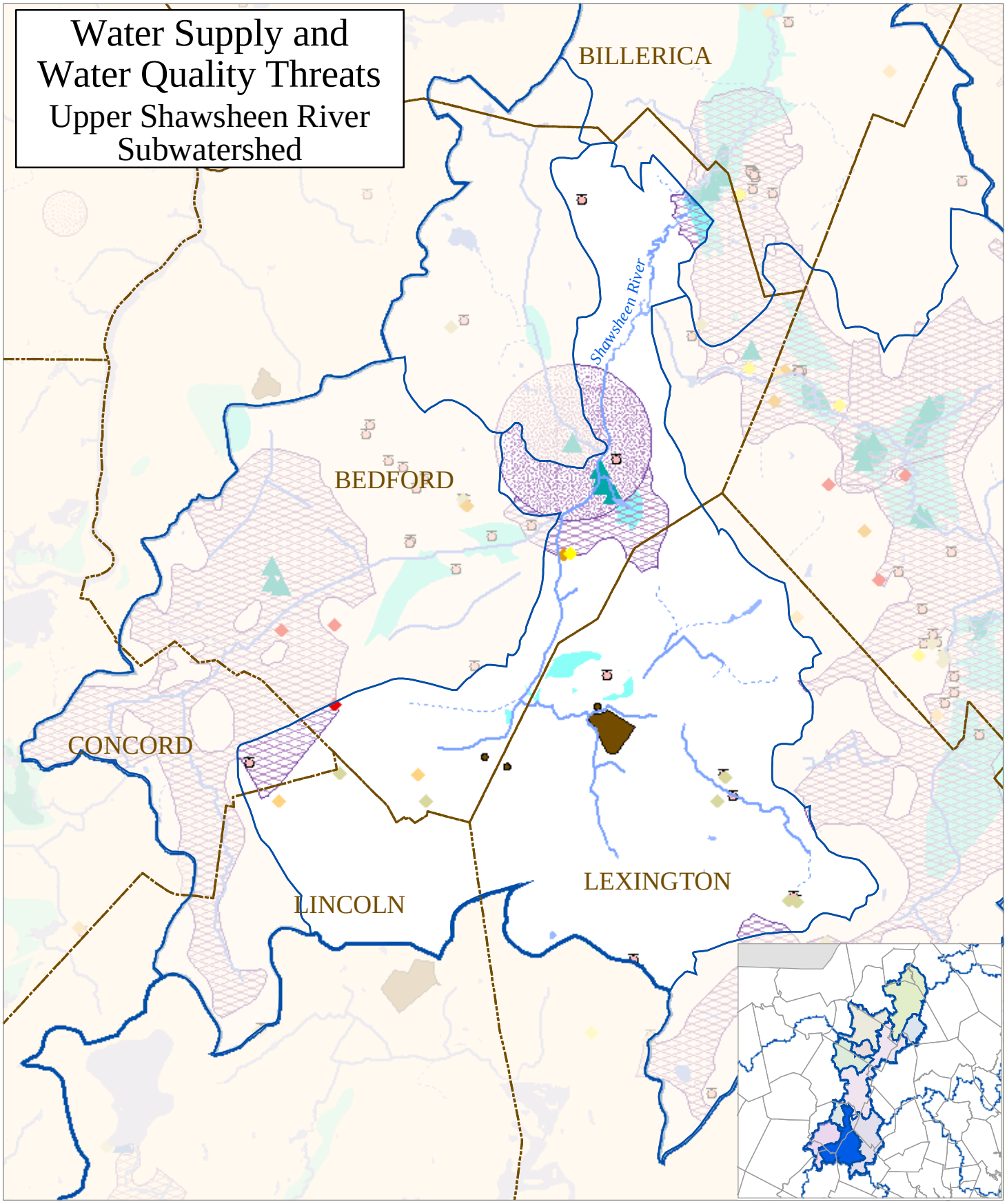
William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Water Supply and Water Quality Threats
Upper Shawsheen River Subwatershed



Public Water Supply
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Water Supply Protection Areas
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Watershed boundary
- Major basin
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N

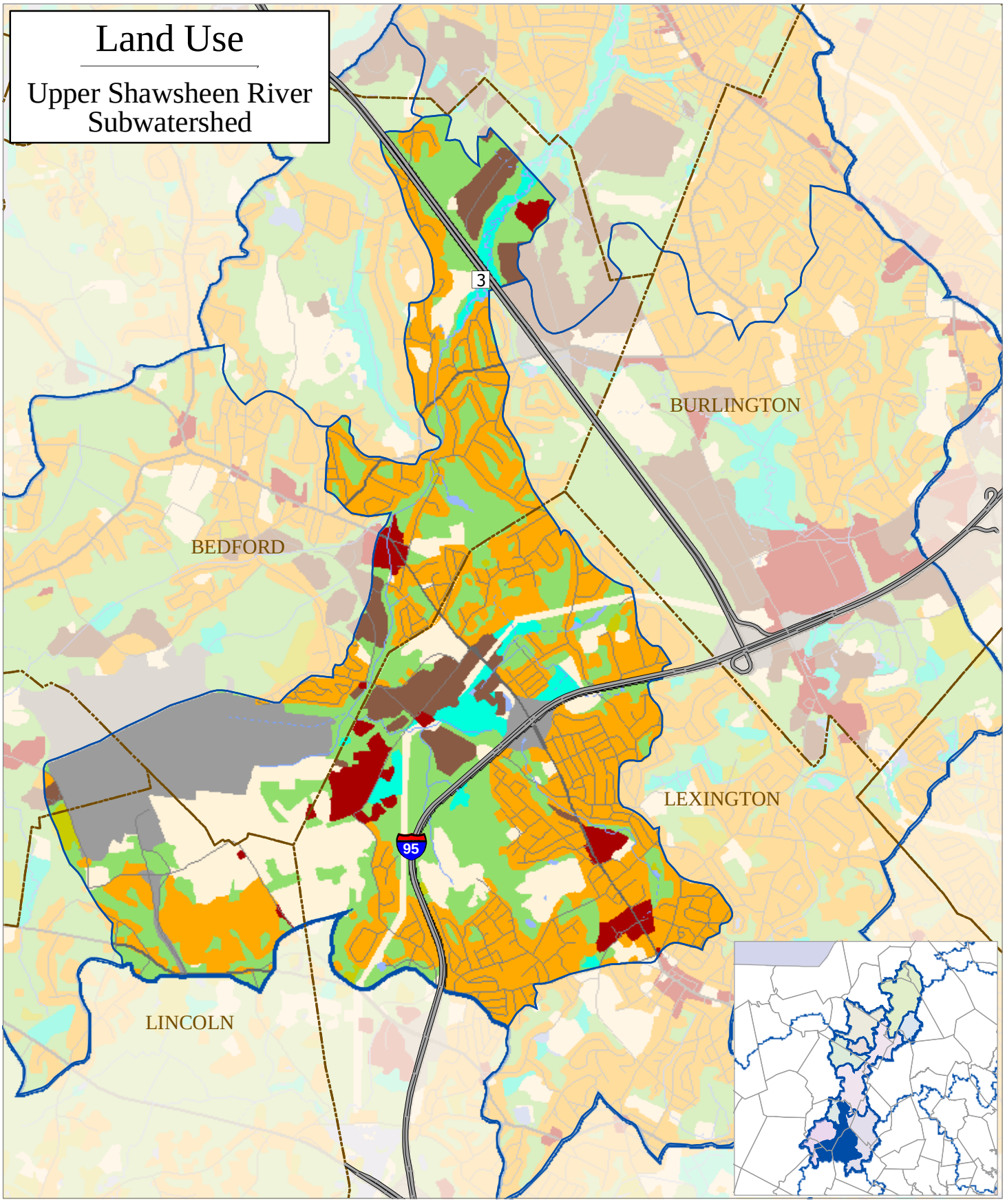
0 0.5 1 Miles
0 1 2 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Upper Shawsheen River Subwatershed



Land Use

- Agriculture
- Forest
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- Transportation
- Open land

Watershed boundary

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- Tributary basin

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N

0 0.5 1 Miles

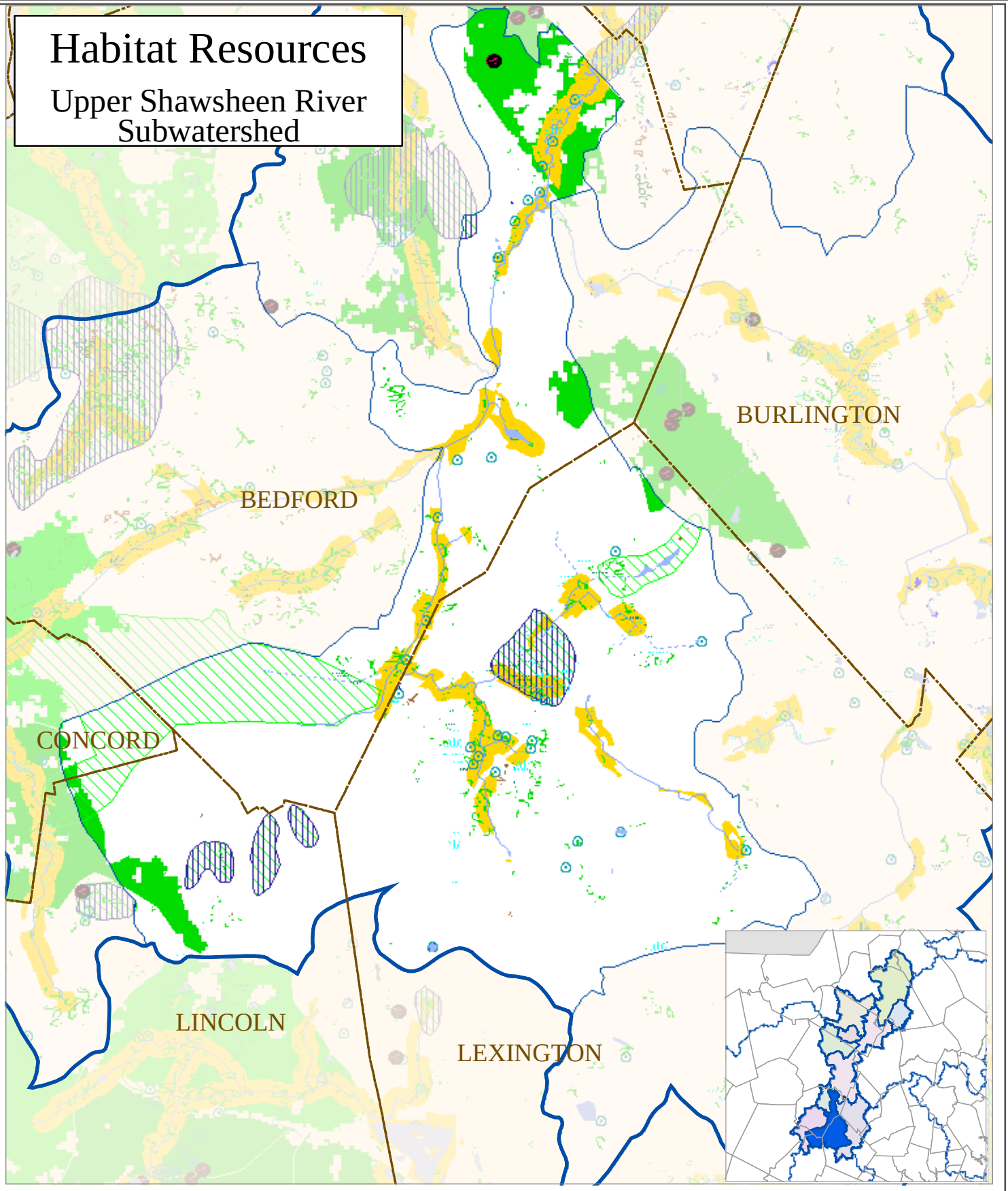
0 1 Kilometers

William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Upper Shawsheen River Subwatershed



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- Major basin
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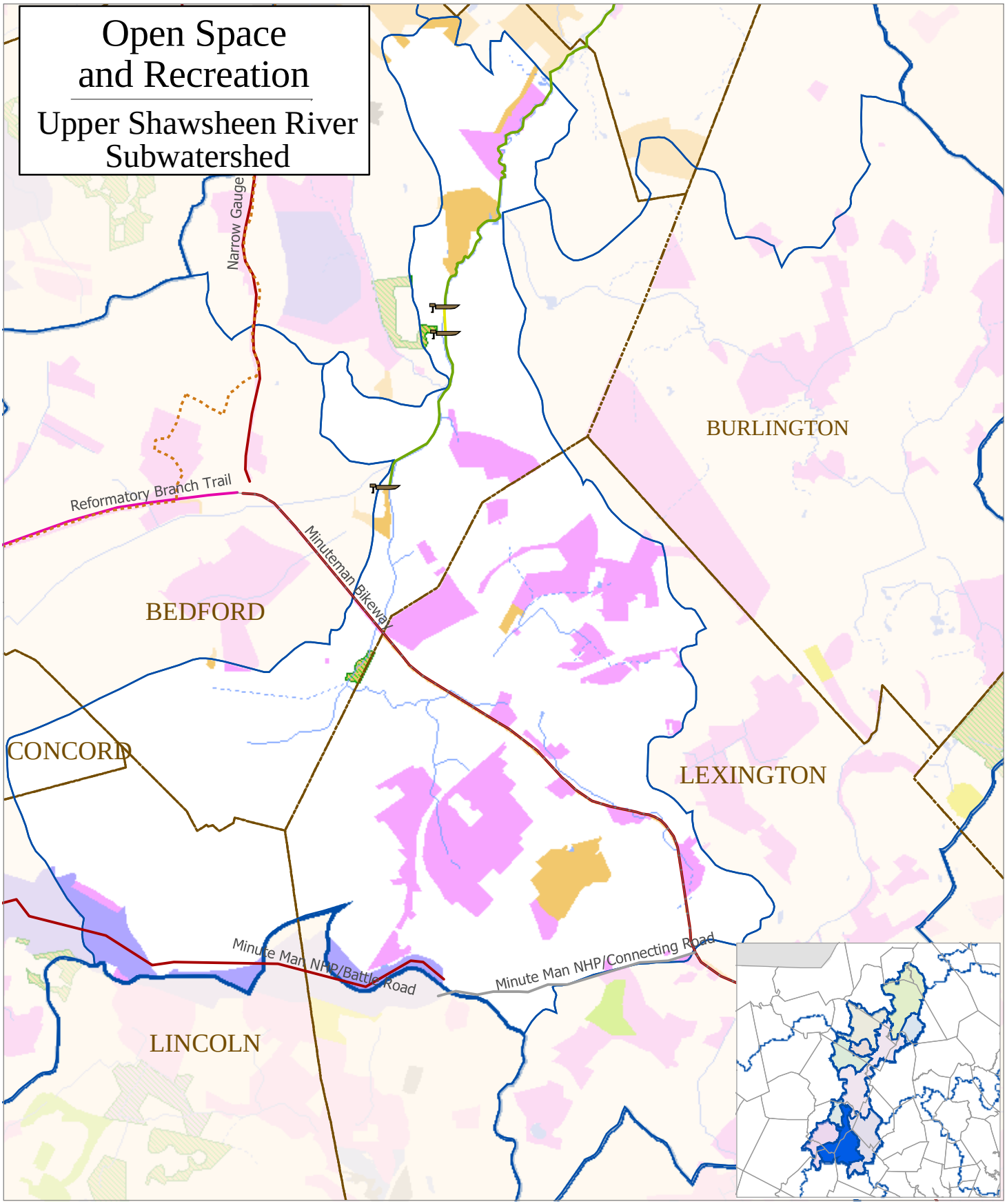
0 0.5 Miles
0 0.5 1 Kilometers

N

Feb 2003

Open Space and Recreation

Upper Shawsheen River Subwatershed



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N

0 0.5 1 Miles
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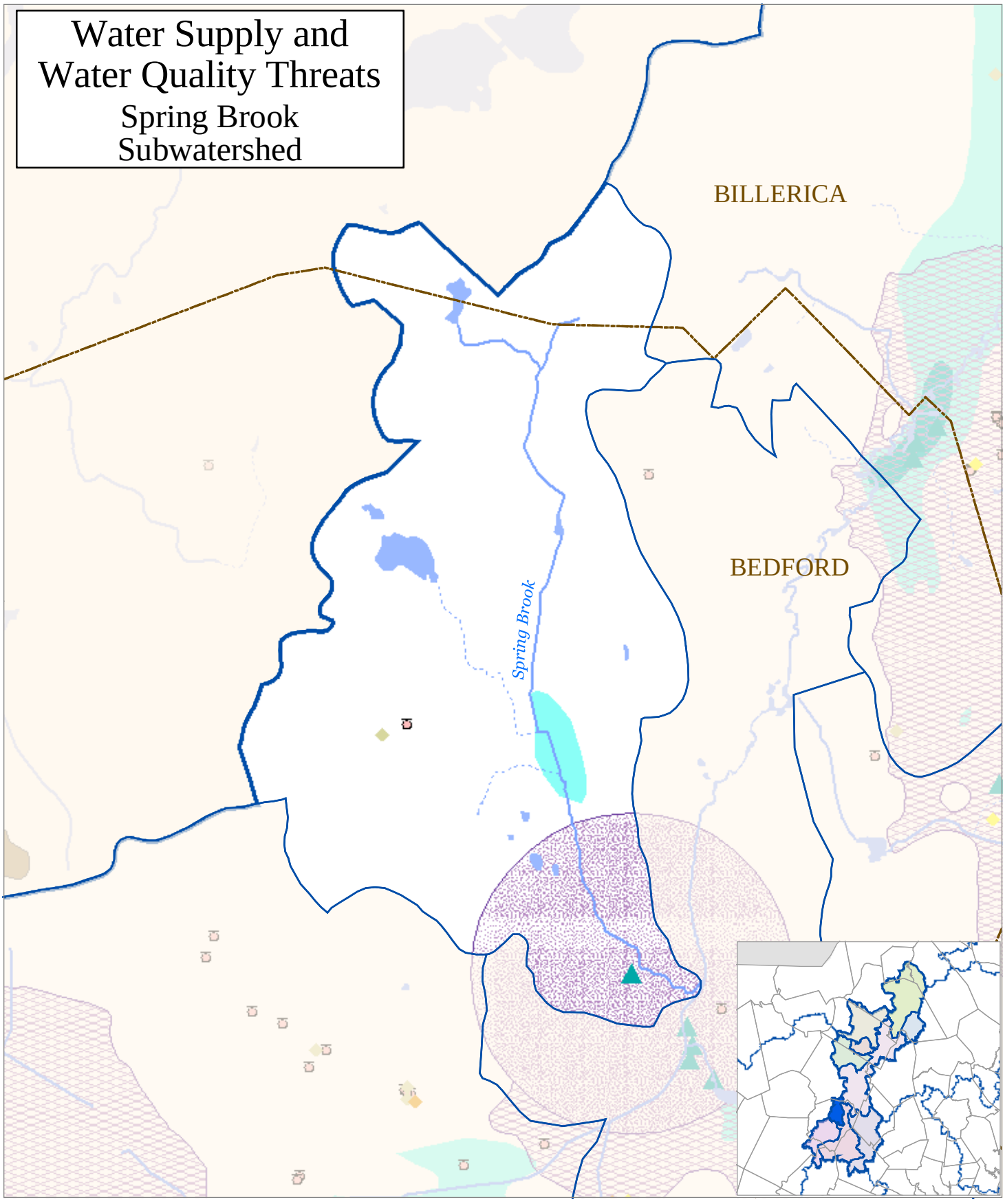
William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Water Supply and Water Quality Threats

Spring Brook Subwatershed



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0 0.5 Miles

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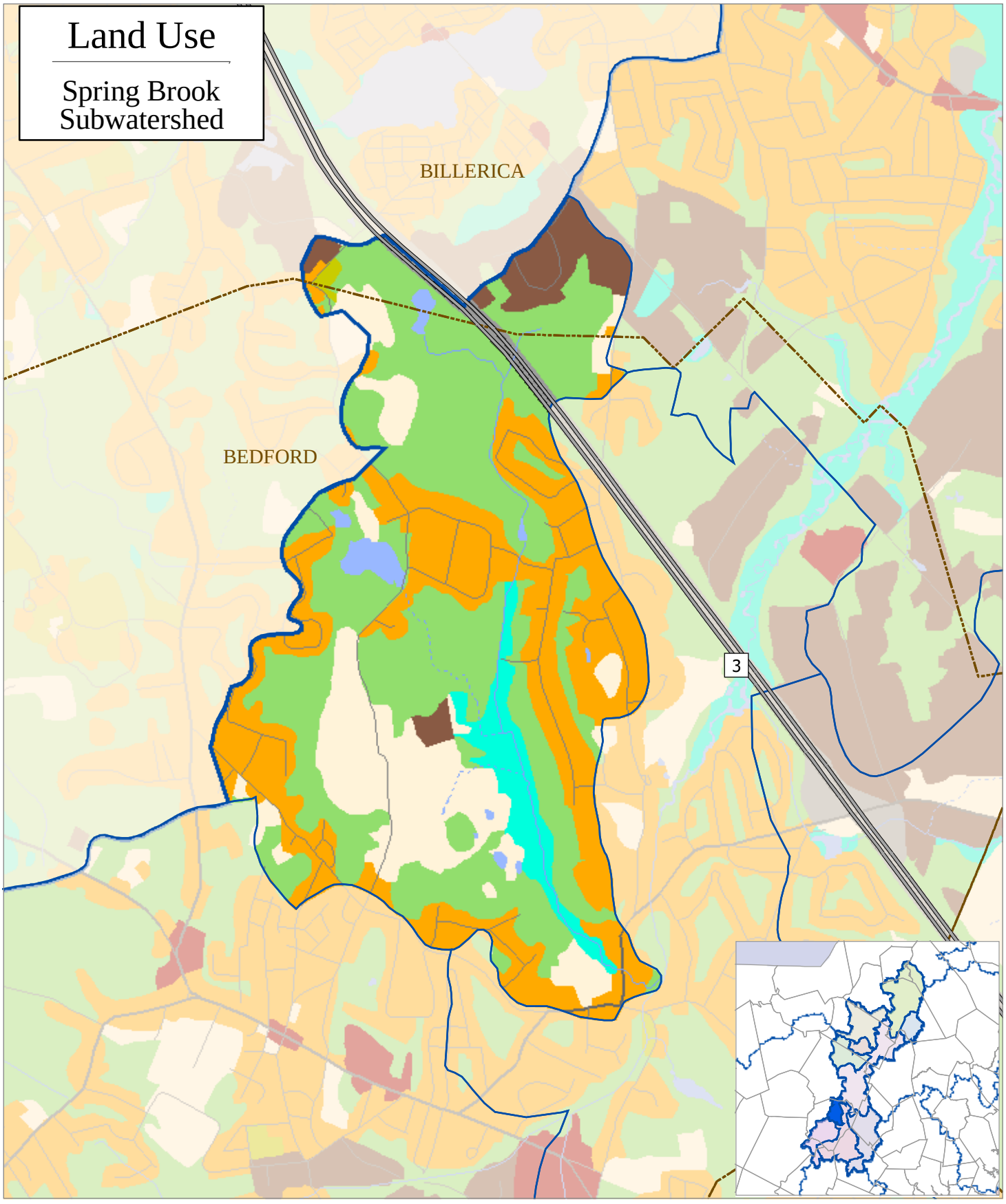
William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Spring Brook Subwatershed



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William Dunn,
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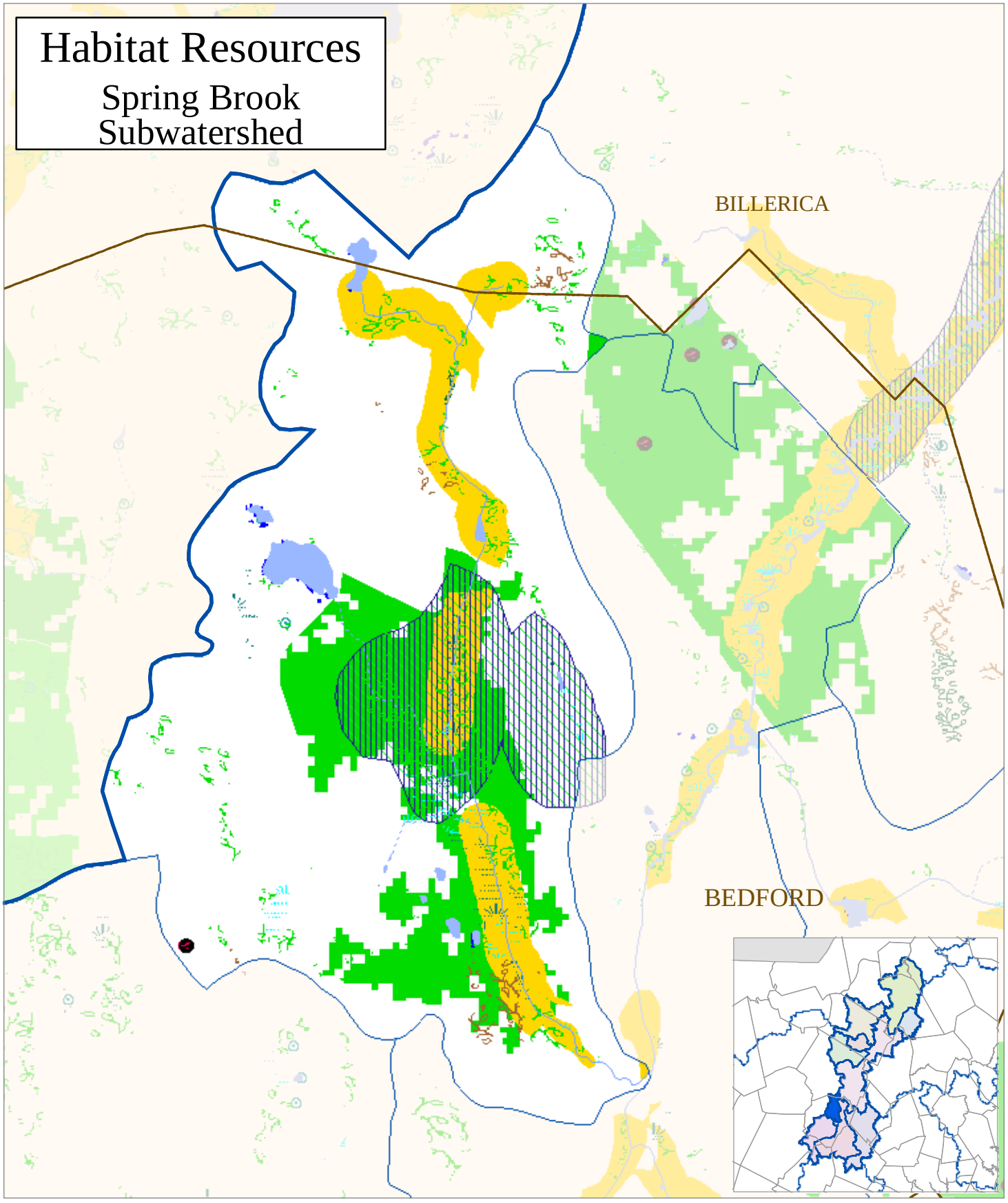
Team Leader

Feb 2003

Habitat Resources

Spring Brook Subwatershed



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0 0.5 Miles
0 0.5 Kilometers

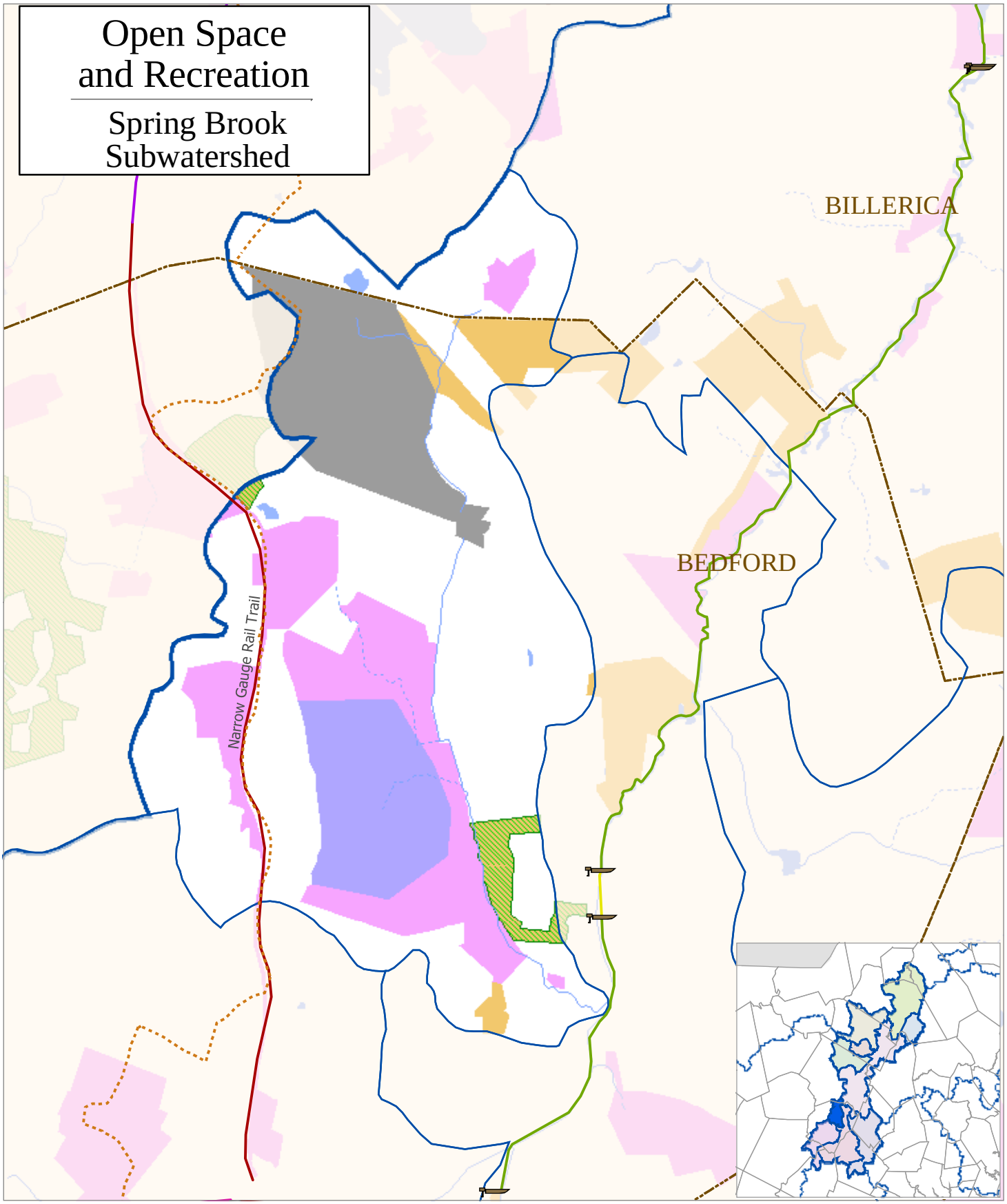
N

MASS GIS

Feb 2003

Open Space and Recreation

Spring Brook Subwatershed



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N

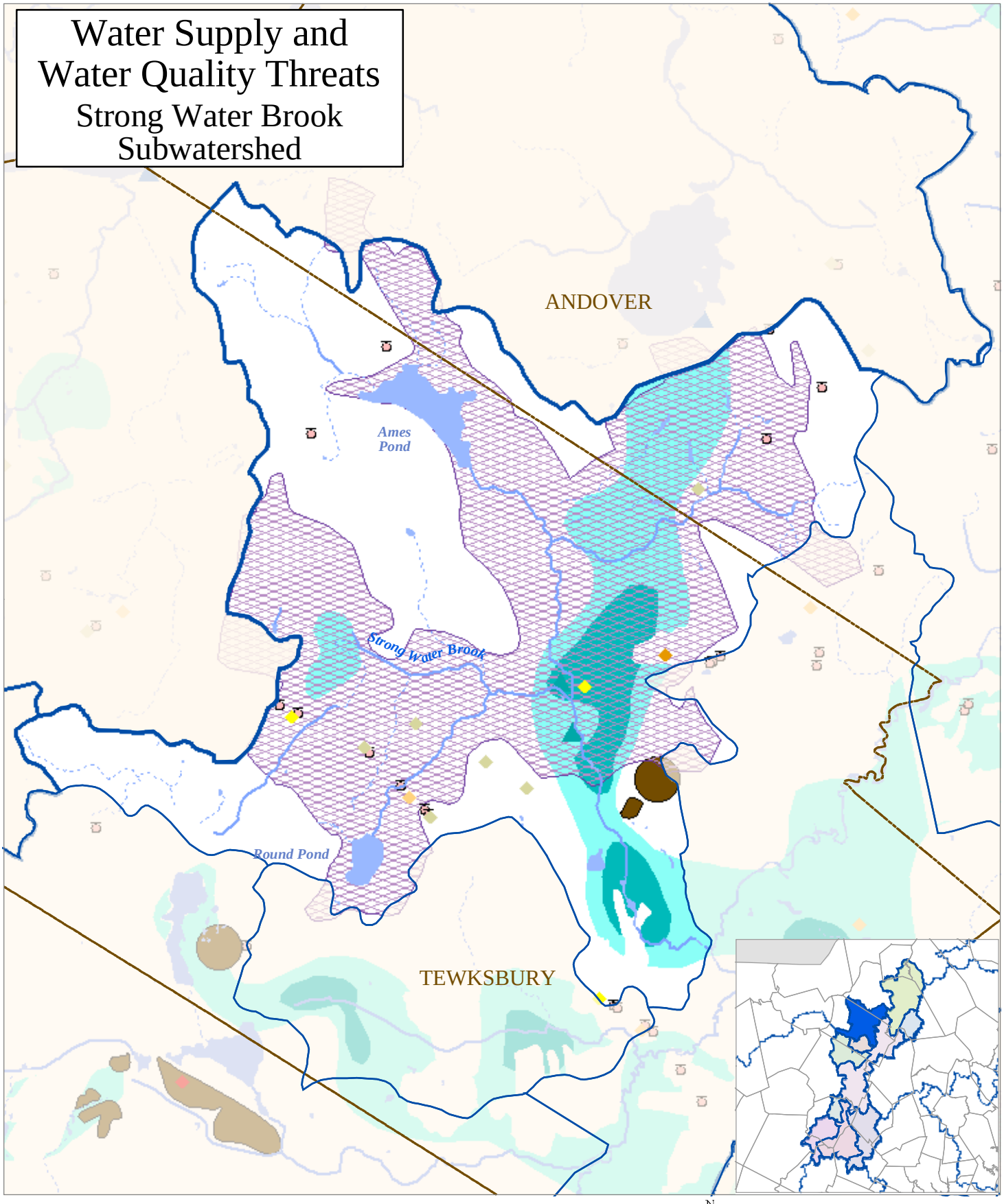
0 0.5 Miles

0 0.5 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Water Supply and Water Quality Threats
Strong Water Brook Subwatershed



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N

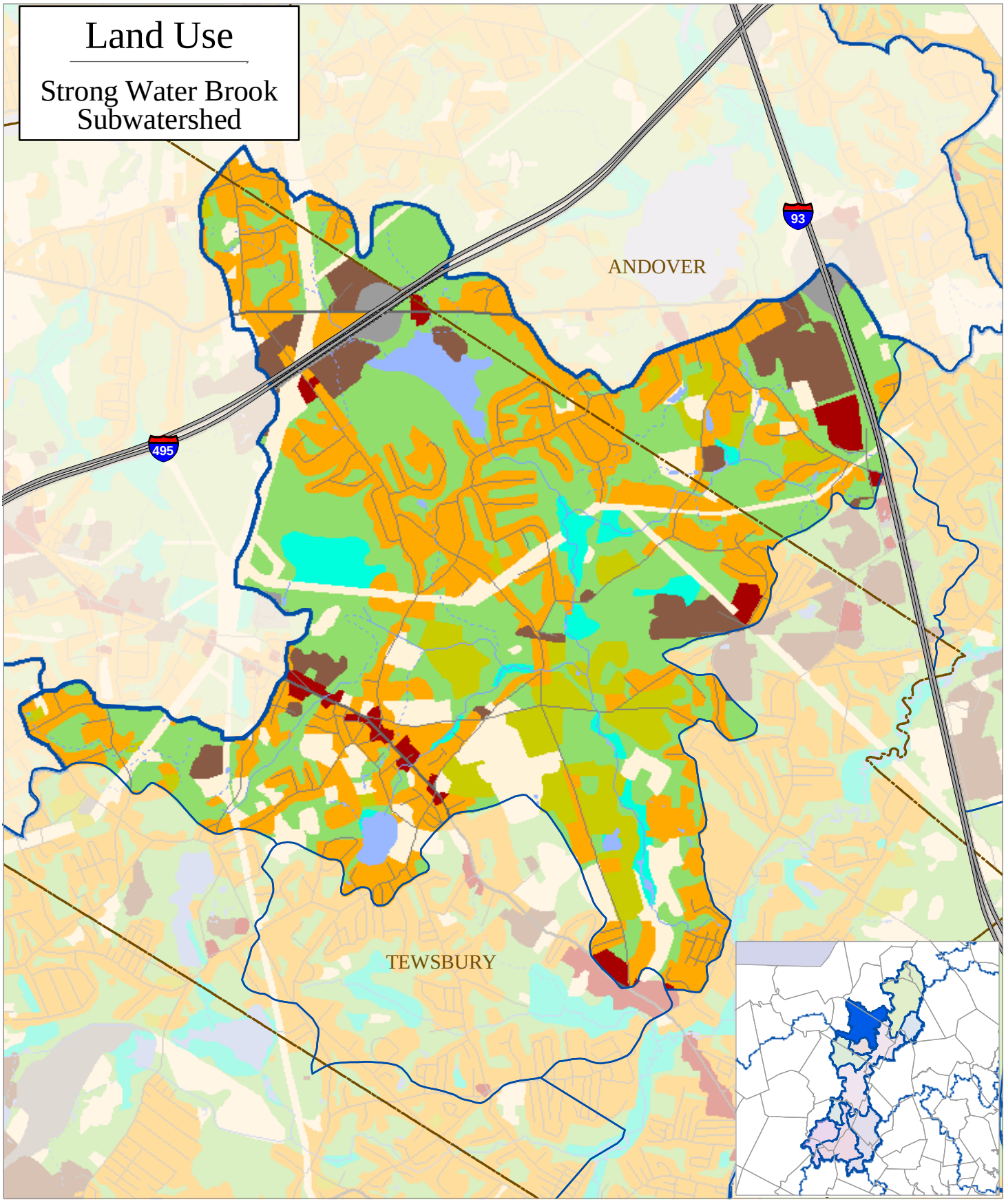
0 0.5 1 Miles
0 1 Kilometers

William Dunn,
Shawsheen River Watershed Team Leader

Feb 2003

Land Use

Strong Water Brook Subwatershed



Land Use

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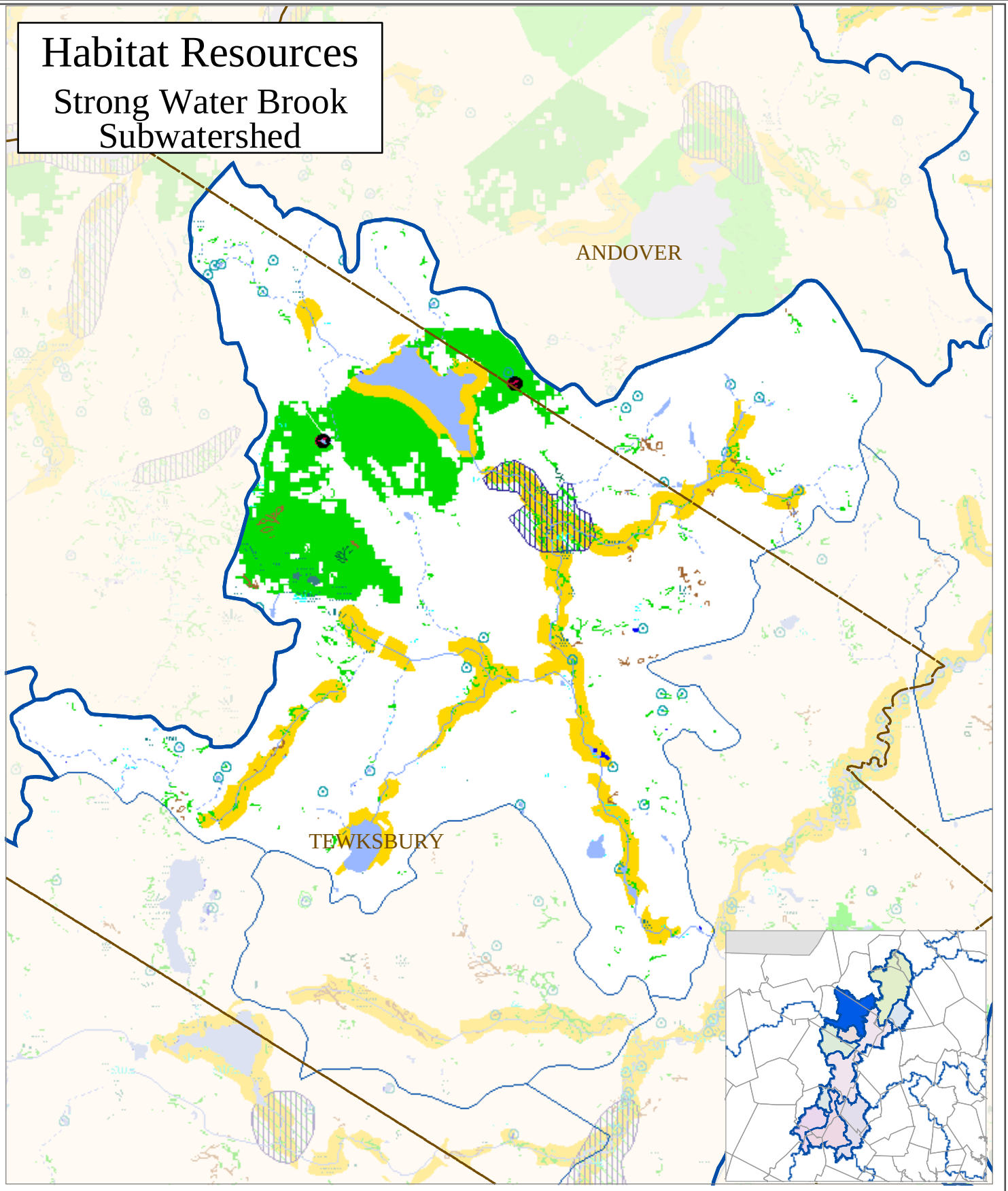
William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Strong Water Brook Subwatershed



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0 0.5 1 Miles
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N

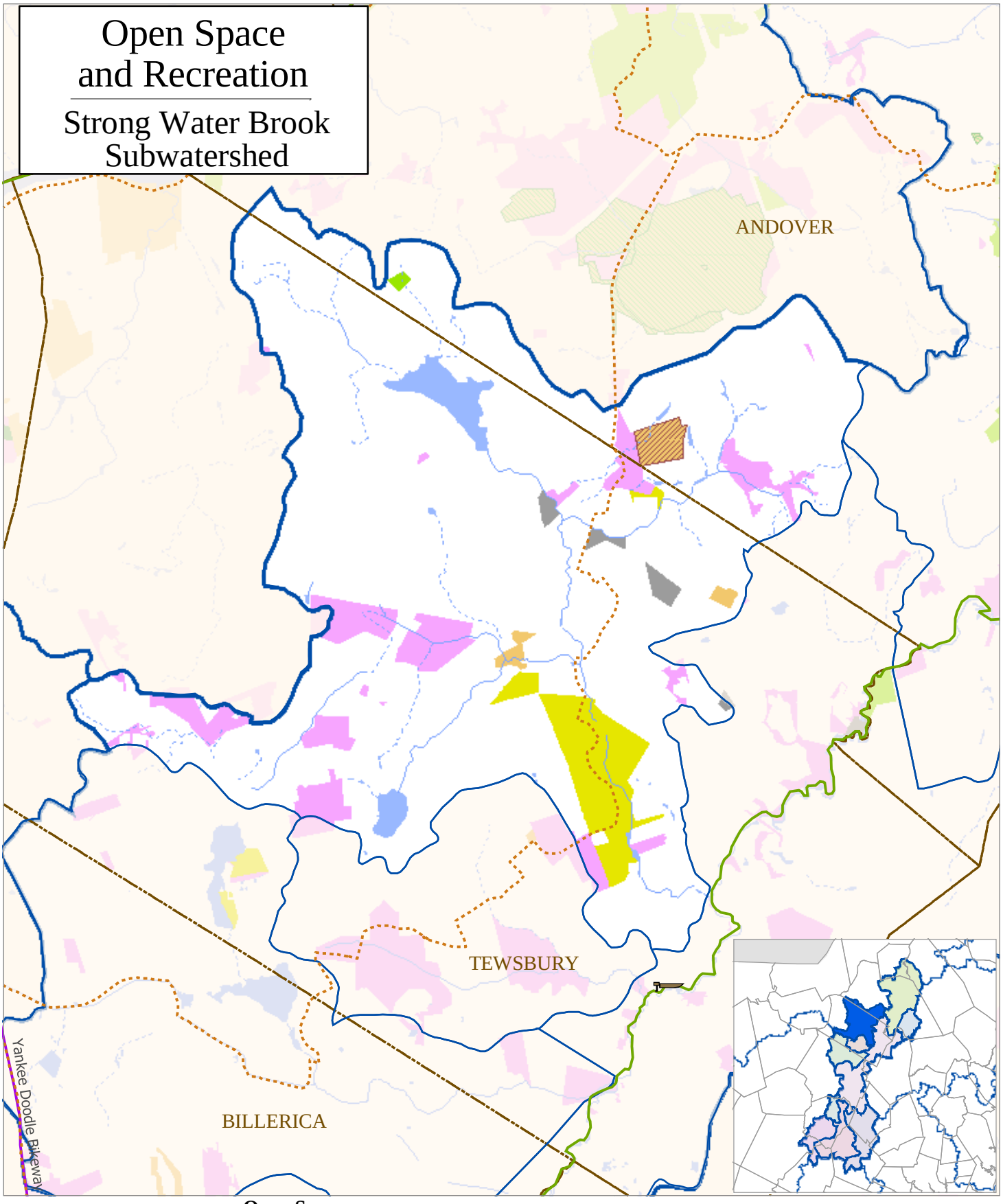
Communities Connected by Water
Massachusetts Watershed Initiative

MASS GIS

Feb 2003

Open Space and Recreation

Strong Water Brook Subwatershed



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William Dunn,
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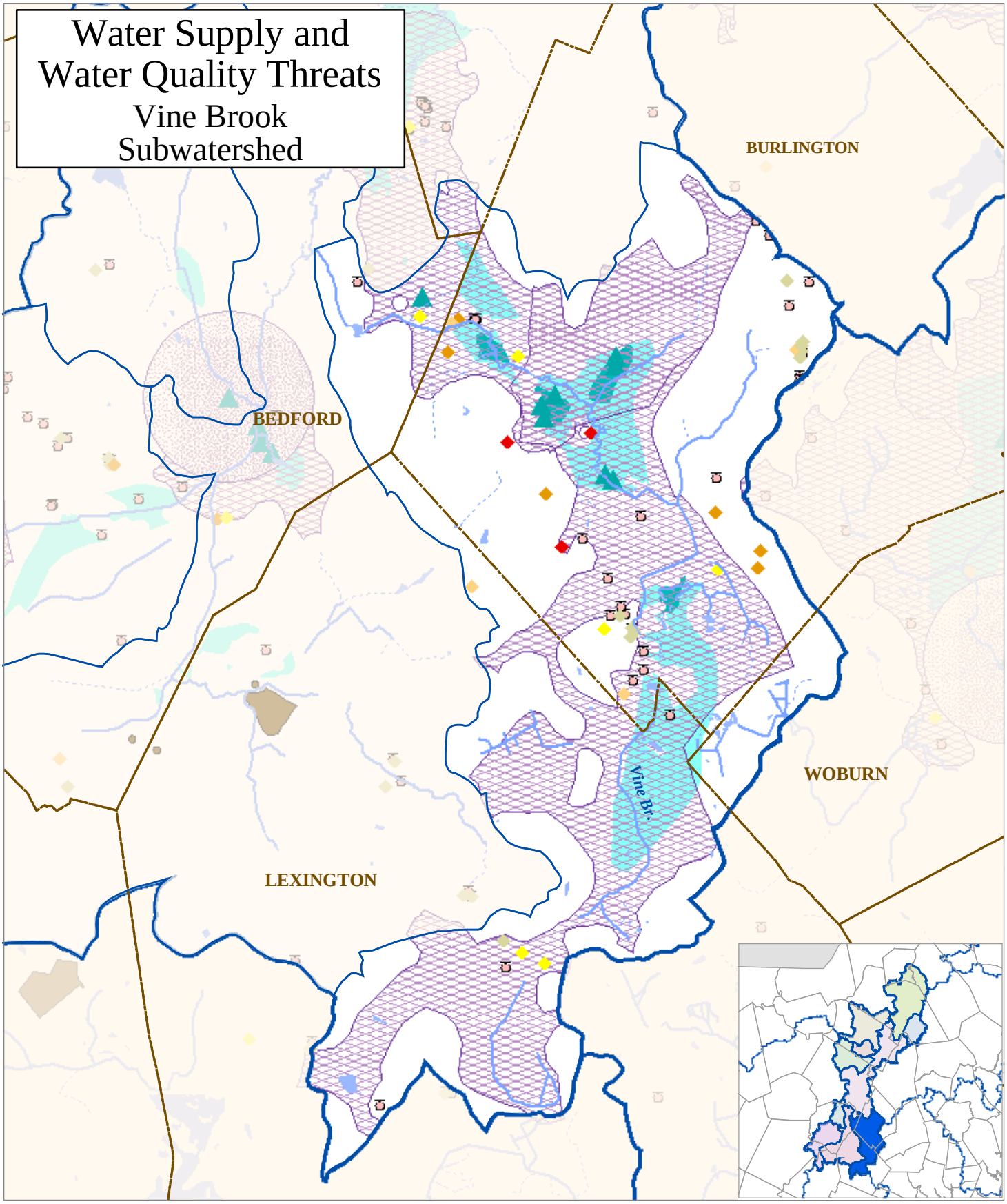
Feb 2003

Water Supply and Water Quality Threats
Vine Brook Subwatershed



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0 0.5 1 Miles

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William Dunn,
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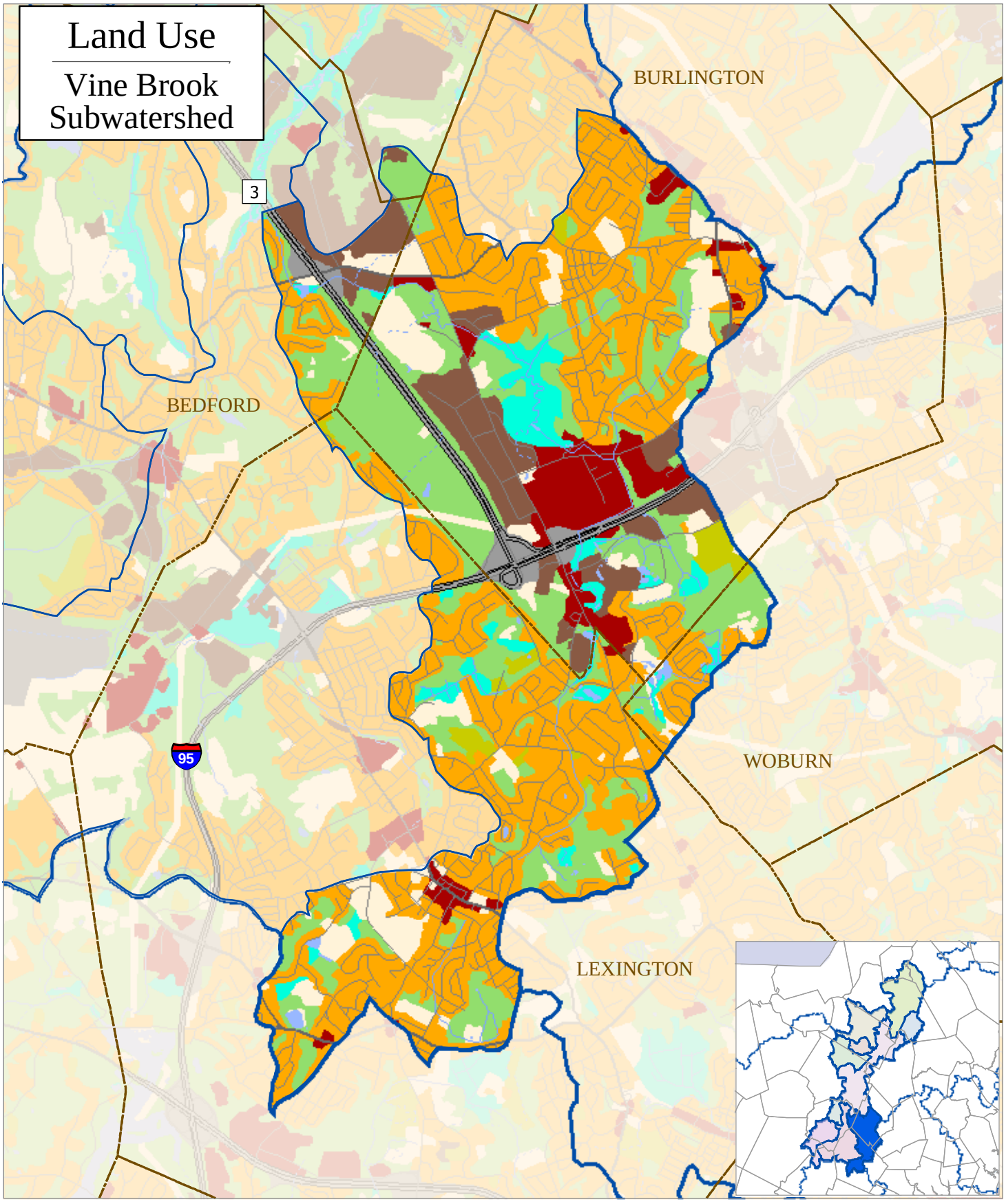
Feb 2003

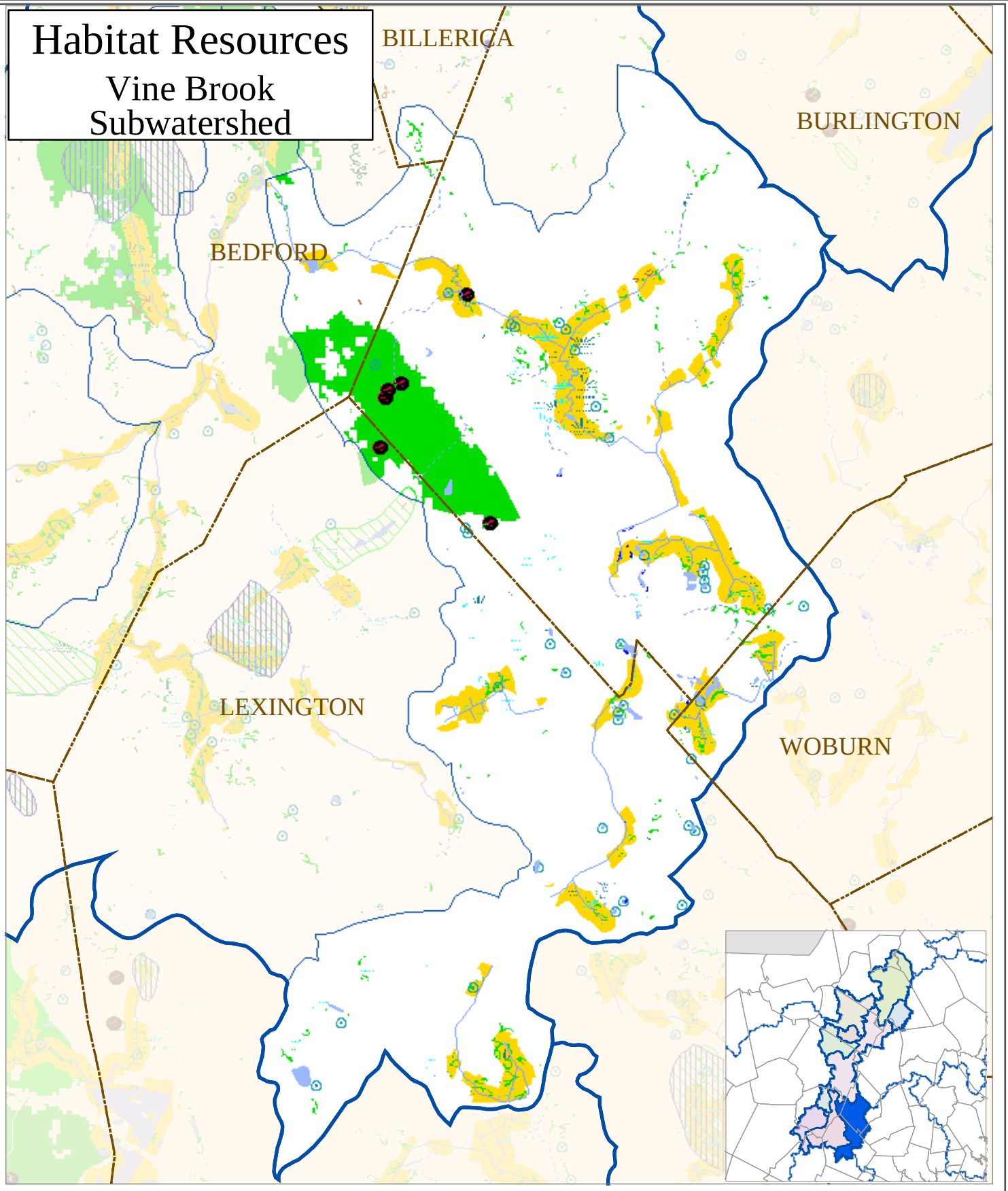


William Dunn,
Shawsheen River Watershed
Team Leader

Feb 2003

Habitat Resources

Vine Brook Subwatershed



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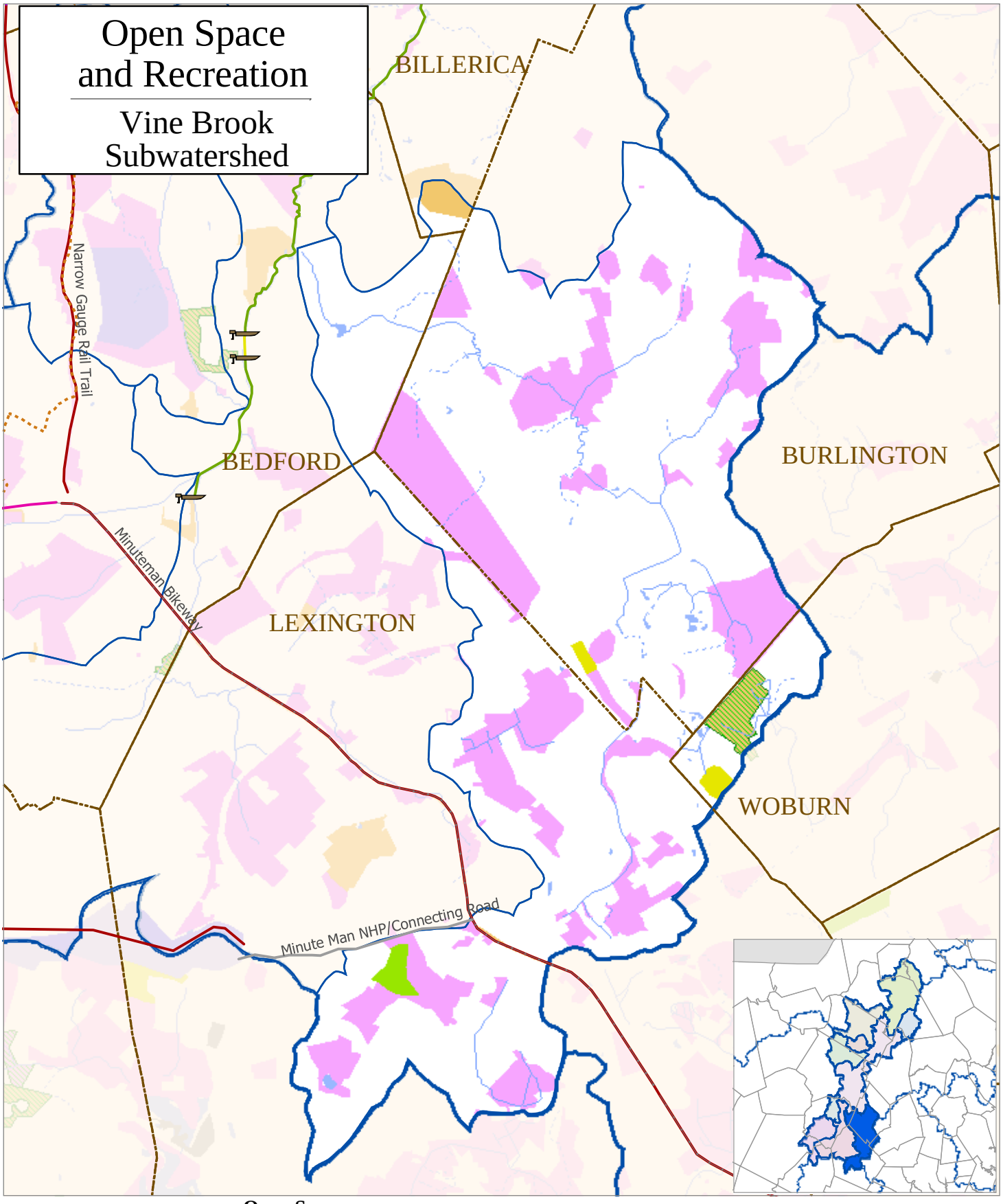
N

Feb 2003

Open Space and Recreation

Vine Brook Subwatershed



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William Dunn,
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Feb 2003

APPENDIX 2 – REFERENCES

Water Quality

- Shawsheen River Basin 1968 Water Quality Survey Data, DEP.
- Shawsheen River Basin 1974 Water Quality Survey Data, DEP.
- Shawsheen River 1989 Water Quality Survey Data and Analysis, DEP.
- Shawsheen River Basin 1975 Water Quality Analysis and Basin Plan, DEP.
- Shawsheen River 1997 Watershed Assessment Report (Draft). DEP/DWM.
- The Shawsheen/Merrimack River: A Working Report. The State of Waters in Massachusetts. The 25th Anniversary of the Clean Waters Act. 1997.
- Shawsheen River 1996-1998 Volunteer Monitoring Report. Merrimack River Watershed Council, May 1999.
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- 1996 Shawsheen Assessment Summary Report. The Shawsheen Watershed Team.
- "The Shawsheen River Watershed: What is it? Why is it in Trouble? How Can You Help?" brochure. Merrimack River Watershed Council, 1999.
- Shawsheen River Watershed Storm Drain Assessment, Towns of Bedford & Billerica, Massachusetts. Environmental Science Services, Inc., June 2002.
- Shawsheen River Watershed Solutions to Hotspot Pollution Problems. Unpublished Report. Merrimack River Watershed Council, July 2000.
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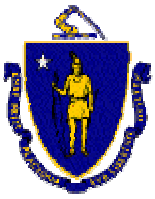

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