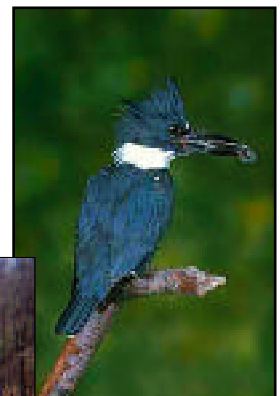
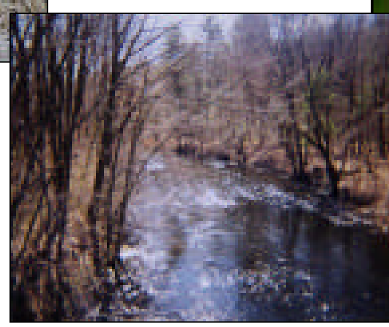
The French–Quinebaug Watershed Plan

A Preliminary Watershed Management Plan





conducted by
The Department of Landscape Architecture and Regional Planning
University of Massachusetts, Amherst

for
Commonwealth of Massachusetts Executive Office of Environmental Affairs
French–Quinebaug Watershed Basin Team

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Foreword

This report is the result of one-year team work to draw an initial frame for the French-Quinebaug Watershed Management Plan. The collaboration of University of Massachusetts-Landscape Architecture and Regional Planning Department and Executive of Environmental Affairs-French_Quinebaug Watershed Team created a opportunity to start the effort for protecting, enhancing both natural and cultural resources and managing the watershed in a comprehensive way. This highly collaborative work began in September 1998 to implement the idea of watershed approach stemmed from ***Clean Water Action Plan of 1998.*** The goal was (is) to enhance the coordination between the stakeholders, public and non-profit agencies and individuals in order to identify key issues, such as protecting hydrological resources, protecting biodiversity and historic resources while revealing the opportunities for residential and economic development, in the French-Quinebaug Watershed area.

The initial framework was drawn by the Watershed Team Members with regular monthly meetings throughout the year. Time to time these meetings extended to include other views and expertise during the process. These meetings and collaborations revealed the strengths, weakness and, at the same time, the opportunities for the watershed. Extension of Quinebaug-Shetucket Rivers Valley National Heritage Corridor from Connecticut to Massachusetts State is the most important opportunity exposed in this process. This expansion not only protects the cultural resources in the corridor but also preserves sensitive hydrological and biological resources to maintain and enhance the quality of life in the watershed while supports economic development.

The most important work during this process done by Landscape Architecture Graduate Students including the draft of this report, presentation of the work to the community and stakeholders several times.

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Introduction and Executive Summary

This study supports recent initiatives on the part of the Massachusetts Executive Office of Environmental Affairs and the Quinebaug-Shetucket Rivers Valley National Heritage Corridor to include the communities of Brimfield, Charlton, Dudley, E. Brookfield, Holland, Oxford, Soutbridge, Sturbridge and Webster of the French-Quinebaug watershed as part of the latter's designation as an environmental and cultural treasure. Together the two watersheds comprise the "Last Green Valley" in the megalopolis that stretches from Washington D.C. to Boston. The region offers residents and visitors a unique view into the American experience. As glaciers shaped the earth thousands of years ago, they left geologic and hydrologic patterns that have come to characterize the bucolic hill country of the French-Quinebaug, with its abundance of streams and its fertile lowlands and hilltops. Rich cultural and historical heritage adds to its special character. Mill towns and farmland make up the cultural landscape allowing both residents and visitors an opportunity to explore New England's agrarian and industrial past. Moreover, the watershed offers a look into the future, as high tech industries seek attractive places for their corporate campuses. For them, available land and unused mill buildings are powerful attractions and economic opportunities.

Perpetuation of these assets in the French-Quinebaug necessitates attention to existing and potential concerns, including water quality, open space preservation, wildlife habitats, and urban sprawl. At present, the watershed benefits from many natural and cultural amenities. To ensure a continuance in this quality of life and to encourage future prosperity, environmental and historic measures need to be taken by regional residents and planners. A first step is obtaining National Heritage status. For the Massachusetts portion of the watershed would provide a big boast to that effort.

The goals of this study are twofold: to identify key natural and cultural factors that together have created the region, and to illuminate environmental and cultural action and opportunities for all residents and visitors. This document is organized chronologically by the national and cultural forces that have shaped the watershed: geological, hydrological, biological, and cultural. Available data are both quantitative and qualitative, as studio members delved into the literature, applied ecological concepts, constructed charts, made maps, conducted surveys, compiled demographics, and explored the area on several trips.

The French-Quinebaug Watershed is part of the Thames River Basin and located in the Massachusetts and Connecticut States. Total watershed area is 1,474 sq. mile (251 sq. miles in MA). In the watershed there are two rivers; French and Quinebaug that are both tributaries of the Thames River that join in the Connecticut portion of the watershed. The length of the French River is 20.6 miles (14.4 in MA), the length of the Quinebaug is 65 miles (18.7 miles in MA). This study considers the Massachusetts of the watershed. Included in the watershed area are total or portions of the 13 towns of E. Brookfield, Wales, Monson, Holland, Warren, Brookfield, Sturbridge, Soutbridge, Spencer, Charlton, Douglas, Dudley, Webster, Oxford, Auburn, Leiscester.
This study contains examined key issues in the French-Quinebaug Watershed divided as hydrology, biodiversity and culture/history and synthesis of these three issues' findings in order to disclose possible development scenarios, recommend key action steps, and reveal the opportunities for the watershed. Overall, this study will create

consciousness within the watershed community to manage, maintain, protect and develop the area in every aspect.

The first section, hydrology, related issues are examined, such as geology, general soils water bodies, drainage patterns, environmental issues in the watershed. Surface and ground water quality—point, nonpoint pollution, dam safety—and water quantity—increase in the amount of impervious surface, and decrease in the amount of water flow—emerged as the major concerns in the watershed. Some of recommendations toward to enhance and protect hydrology of the French-Quinebaug are:

- Institute Best Management Practices (BMPs) throughout the watershed
- Minimize impervious surfaces where applicable
- Implement water quality monitoring for priority streams, rivers, lakes, ponds and reservoirs
- Monitor permitted point source discharges
- Regularly test groundwater quality surrounding solid waste facilities
- Assess and inspect underground storage tanks for leaks
- Inspect dams for contaminated sediments and structural integrity
- Remove or repair dams where necessary
- Give priority to urban and other area with large impervious surfaces, sand and gravel deposits, industrial land uses, point discharge areas, waterfront residential areas utilizing septic systems

Biodiversity of the French Quinebaug Watershed explored as the second component of the study. In this section, first, importance of biodiversity explained, and a method is developed by re-classifying of GAP vegetation data and considering of rare and endangered species in order to reveal the crucial issues for biodiversity in the French-Quinebaug Watershed. The study pinpoints that protection of large areas is important as well establishing/protecting the linkages between them. In addition, the protection of biodiversity does not exclude development in the area. Inventory / analysis of existing wildlife, and habitat mapping disclose the significant protection and priority protection areas for biodiversity, and build the recommendations for the watershed, such as:

- Study ‘priority protection’ areas more closely to determine actual species populations and movement barriers
- Examine open space acquisition options for ‘priority protection’ areas
- Ensure proper management of open space lands currently covering ‘priority protection’ areas
- Promote biodiversity in your backyard

Culture/History segment of the report narrates cultural resources and issues in the French-Quinebaug area historically and currently. Five sub-sections reveals the key issues related: a broad summary of the regional history, demographic profiles of the watershed communities, the identification of historical, cultural and recreational resources in the watershed, and lastly, the results of the community survey followed by the recommendations. This section of the report emphasizes protection of cultural and historic resources—such as trails—that also enhance hydrology and biodiversity conditions while providing new opportunities for the watershed community to improve the quality of life. The recommendations include:

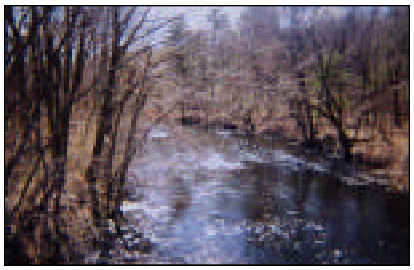
- Extend the Quinebaug-Shetucket Rivers Valley National Heritage Corridor from Connecticut to Massachusetts
- Develop tourism
- Develop sections of the Grand Trunk, Soutbridge Spur and other rail trails for recreational purposes
- Develop river awareness and other educational programs
- Encourage adaptive reuse

The conclusion of this report, presented in the last section, was developed with a complete synthesis of hydrology, biodiversity and culture/history sections' work. The synthesis presents two possible scenarios to illustrate the future of the French-Quinebaug Watershed. These scenarios aim to alert the community for worst-case situation, and provide an alternative option with a spatial concept to consider for the future development of the watershed. Along the scenarios, recommendations and key action steps are also provided, including:

- Support the application for inclusion in the Quinebaug-Shetucket Rivers Valley National Heritage Corridor by completing inventory of historic and cultural resources; designating historic districts; surveying historic buildings for potential reuse and restoration; coordinating efforts among the towns
- Create watershed awareness by developing communication network among the towns; defining a vision for the region; sharing responsibility among the three sub-basins of the watershed; inventing stream teams
- Protect hydrological resources by monitoring water quality, reducing point source pollution; enhancing buffers; taking an opportunistic approach to biodiversity planning; inventing stream teams
- Plan for biodiversity and open space protection by implementing open space plans; connecting patches important for biodiversity, avoiding suburban sprawl; and expanding protected open spaces for biodiversity
- Maintain visual and sensory qualities by developing model zoning ordinances; developing historic design guidelines; promoting agricultural restrictions and conservation restrictions; performing viewshed analyses; avoiding suburban sprawl
- Expand economic activity by performing economic development study; expanding Sturbridge Village; reusing Mill Architecture; attracting corporate retreat facilities
- Develop tourism by developing a tourist concept; promoting activities; designating scenic routes; promoting reuse of Mill Architecture; developing/expanding trail based recreation opportunities
- Consider implementation of Best Management Practices throughout the watershed and employ an adaptive management approach to improve ongoing management practices.

The French-Quinebaug Watershed in conclusion, possesses many opportunities with its diverse cultural and natural resources. Protecting these precious resources will assist to maintain and enhance the condition in the watershed.

1—Hydrology



1.1 Introduction to Hydrology

The hydrology of the French-Quinebaug Watershed is a function of several factors. These include the geology, natural resources, land use, and environmental threats within the watershed, in addition to hydrologic features of the watershed.

Within this analysis three questions are posed:
- What are the unique and scenic features of the French-Quinebaug?
- What are the threats to water quality and quantity?
- How can water quality and supply be protected and preserved?

An examination of the geology begins to reveal the complexity of this watershed.

1.2 Geology

Geology is a crucial element of a watershed in order to understand physical character of the area, and to reveal important hydrologic issues drawn by geology. The French-Quinebaug watershed is a geologically heterogeneous landscape. Several geologic components combine to form the current landscape. These components include bedrock and structural geology, surficial geology, and general soils. The resulting landscape contains both opportunities for land cultivation and development, as well as limitations to these. French-Quinebaug Watershed geology will be examined here in three sections that covers geological components.

1.2.1 Geologic History

The geologic history of the French-Quinebaug consists of a complex series of events, which began millions of years ago. Approximately 600 million years ago the mass of land we now know as North America was south of the equator and submerged by the Iapetus Ocean. Some 170 million years later, the Taconic Orogeny resulted from a collision with the Gondwana continent. This collision resulted in the uplifting of North America above water.

Millions of years of erosion and changing sea levels caused North America to once again become submerged by water until 400 million years ago. At this time the Acadian Orogeny occurred resulting from yet another collision of the North American and Gondwana continents. The resultant formation is known as the Pangea Supercontinent. This event resulted in the creation of the New England Appalachian Mountains approximately 350 million years ago. The once marine sedimentary rock of New England was metamorphosed from the collision stress. This resulted in the formation of folded gniesses, schists, and slate. Examples of folding can be observed at the bedrock outcrops in Wells State Park in Southbridge. Melting of selected metamorphic rocks resulted in granite igneous formations throughout New England.

Tensile stresses within the continent caused rifting, or splitting of the continent. Several rifts were formed; the largest of which now underlies the Atlantic Ocean. The Atlantic resulted from ocean water filling this rift, which continued to spread in width for millions of years. Around the same time a second rift formed parallel with the Atlantic. This is known as the Eastern Border Fault. This rift stretched from what is now New Haven, CT to Keene, NH. Although this rift failed to separate completely and form a new ocean, it resulted in what is now the Connecticut River Valley. If this rift had separated completely, eastern New England and the French-Quinebaug would have been a separate continent between North America and Europe. The area around the Eastern

Border Fault, including the French-Quinebaug, remained seismically active as earthquakes from the fault tilted sedimentary layers east 25 degrees.

Millions of years of erosion of this landscape resulted in a flat peneplain approximately 65 million years ago. Subsequent uplifting of this plain by 1000 feet caused erosion of the flat landscape. Glaciation 20,000 years ago resulted in the deposition of glacial till and outwash. Lake Hitchcock was formed in the Connecticut River Valley as melting glacial water was trapped in the valley by the glacier's margin. The glacier's margin retreated past the French-Quinebaug approximately 14,000 years ago and Lake Hitchcock drained approximately 12,500 years ago. This glaciation rounded and smoothed mountains and ridges of the French-Quinebaug. Hills were buried in till consisting of silt, fine sands, cobbles and boulders. Rounded hills of till known as drumlins were formed, and valleys were filled with glacial outwash sand and gravels.

The current landscape reflects this most recent geological event. Till is found covering the bedrock of the Upper Quinebaug uplands, glacial drumlins are found in the lower Quinebaug, and sand gravel deposits are found in the French River Valley.

1.2.2 Bedrock and Structural Geology

The bedrock and structural geology of the watershed is complex. Structurally, the French-Quinebaug Watershed belongs to the central upland of Massachusetts known as the Worcester County Plateau. The watershed contains highly folded and metamorphosed rock of both sedimentary and igneous origin. These rocks date from Precambrian (570+ million years ago) to Carboniferous (320 mya). The highly altered nature of the rocks suggests repeated folding and faulting. Broad bands of Carboniferous granite and highly folded schists are found in the watershed. Highly schistose beds are overlain by Silurian (408 mya) schists, crystalline limestone, and Devonian strata (360 mya). These strata are invaded by intrusions of igneous rocks such as granite of Carboniferous age (320 mya).

The French-Quinebaug is dominated by three structural regions (Figure 1.1) The Oakham Anticline is an intensely folded region found in the Upper Quinebaug. The Gardner Anticline is found in the Lower Quinebaug and Upper French. The Nashoba Block is found in the Lower French.

The bedrock and structural geology of the French – Quinebaug watershed has a minimal impact on land uses, as much of the bedrock is covered by glacial deposits and soils. Faults within the bedrock are inactive and pose no threat to public safety. The most common limitation posed by the bedrock units is in areas of shallow bedrock and bedrock outcroppings where construction and farming are complicated by shallow soils and hard bedrock. One of the primary threats to water quality in the watershed may be related to a unit of bedrock found in the French River basin. This area of the basin contains wells that have been contaminated by arsenic. It is possible that this contamination is caused by a mineral within the bedrock unit. This mineral, arsenopyrite, is the most common mineral containing arsenic. It is sparingly found in contact metamorphic deposits and in crystalline limestones.

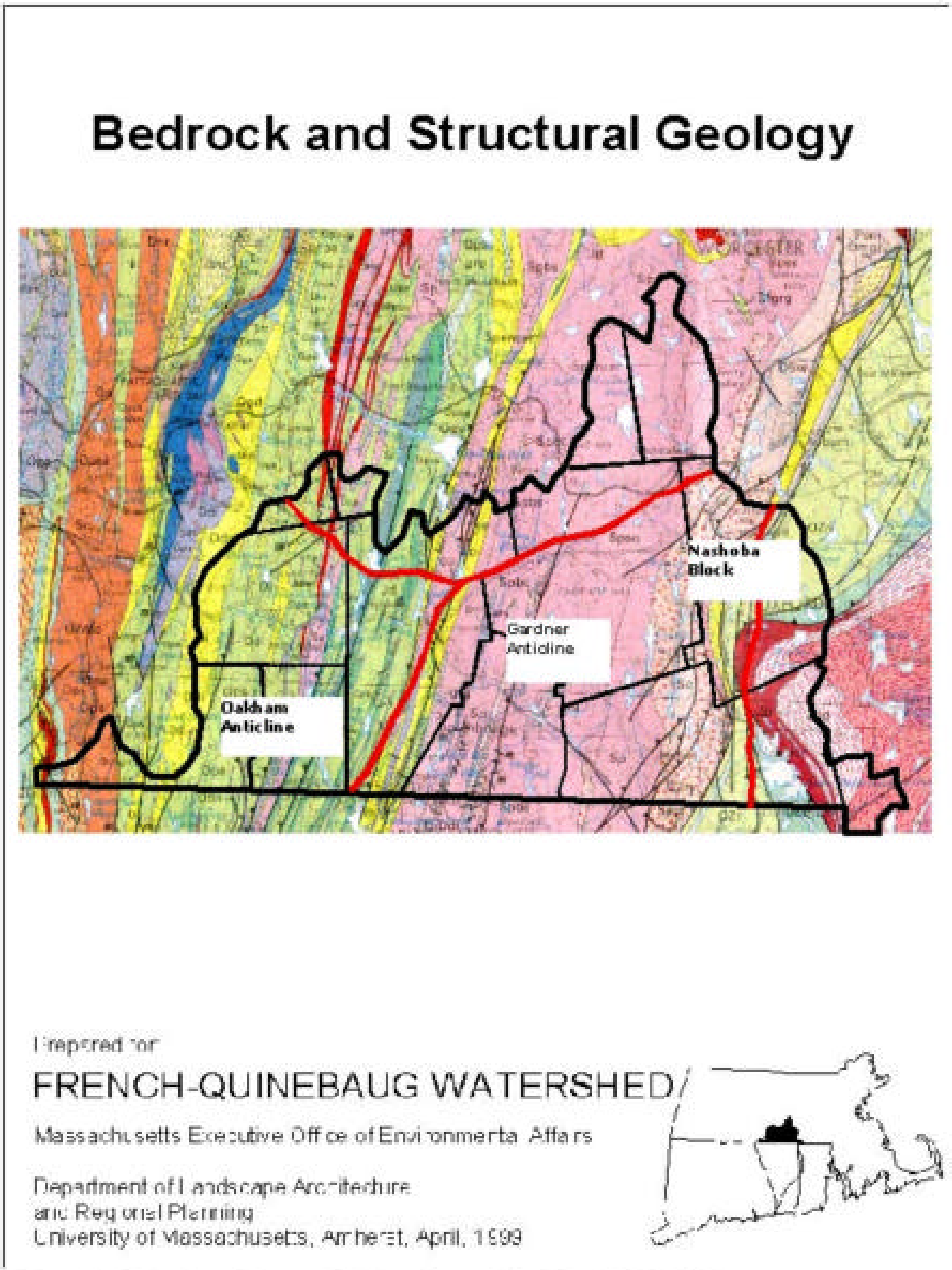


Figure 1.1. Bedrock and Stuctural Geology. Source: E-an Zen, USGS, 1983)

1.2.3 Surficial Geology

The surficial geology of the French-Quinebaug is a resultant of glaciation 14,000-20,000 years ago and fluvial processes since that time. Glacial till is found throughout the watershed and consists of unstratified or unsorted clays, silts, sands, gravel, cobbles, and boulders moved or deposited by glacial ice (Figure 1.2). The till of the French-Quinebaug is primarily sandy or loamy and has variable amounts of gravel, cobbles, and boulders. Sand and gravel deposits of the French-Quinebaug are primarily glacial outwash deposits. The most recent deposits in the watershed are represented by floodplain alluvium. This consists of gravel, sand, silt, and clay that has been reworked and deposited by rivers and streams within the watershed.

The distribution of sediment within the watershed is significant since sand and gravel areas have an important function and floodplain alluvium has limited potential for development. Sand and Gravel deposits are found in the floodplains and valleys within the watershed. Extensive deposits are found in the towns of Sturbridge and Oxford. These deposits function as valuable sources of groundwater (as a source for drinking water) and construction materials. Most gravel pits from the watershed are located within these deposits, but, gravel poits can cause serious environmental and estethic degradation e.g. by strypping the land of topsoil and mature vegetation and destroing habitat.

While sand and gravel deposit represents a resource, other sedimentary deposits pose limitations. Floodplain alluvium found in the watershed imposes a constraint, as these fine-grained deposits are generally unsuitable for septic systems and have limited suitability for infrastructure.

1.2.4 General Soils

The major factor in the formation of soils in the French-Quinebaug Watershed includes the parent material of the soil, climate, topography, time, and living organisms. Of these, the most significant factor in soil development is the parent material. The parent material of the French-Quinebaug soils originates from surficial geologic units including glacial till, glacial outwash and alluvial deposits as well as thick deposits of decomposed organic matter found in wet areas. Most of the soils found within the French-Quinebaug are of the same age, with the exception of soils found in recent floodplain deposits.

The soils found within the French-Quinebaug Watershed have a direct impact on land use, as they, interact with and are directly affected by land uses. Generally speaking, soils in the French-Quinebaug maybe suitable for agriculture, development, agriculture and development or neither.

The primary restriction of the soils in the watershed is their poor suitability for septic systems (Figure 1.3). This is attributed to one of two soil characteristics. A small amount of soils such as the Freetown-Swansea-Saco are poorly drained and have a high water table. These soils are therefore unsuitable for septic systems as they are too wet and come in direct contact with the water table. Many of these soils are also found along water bodies and therefore contribute to the degradation of water quality within those waters. A larger amount of soils are such as the Merrimac-Hinckley-Windsor, are excessively drained, and therefore do not provide any filtering capacity for septic effluent.

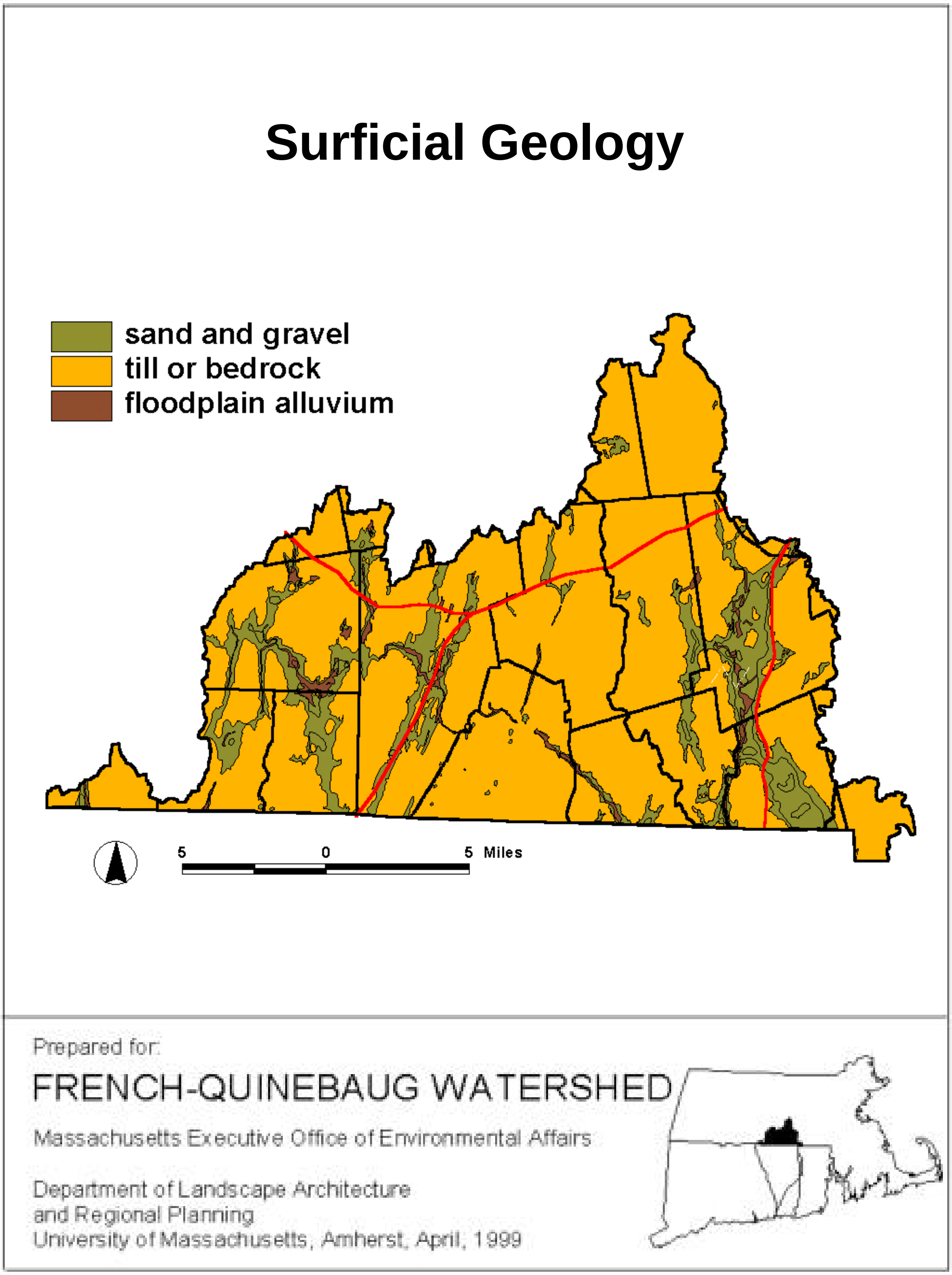


Figure 1.2: Surficial Geology Source Data: MassGIS

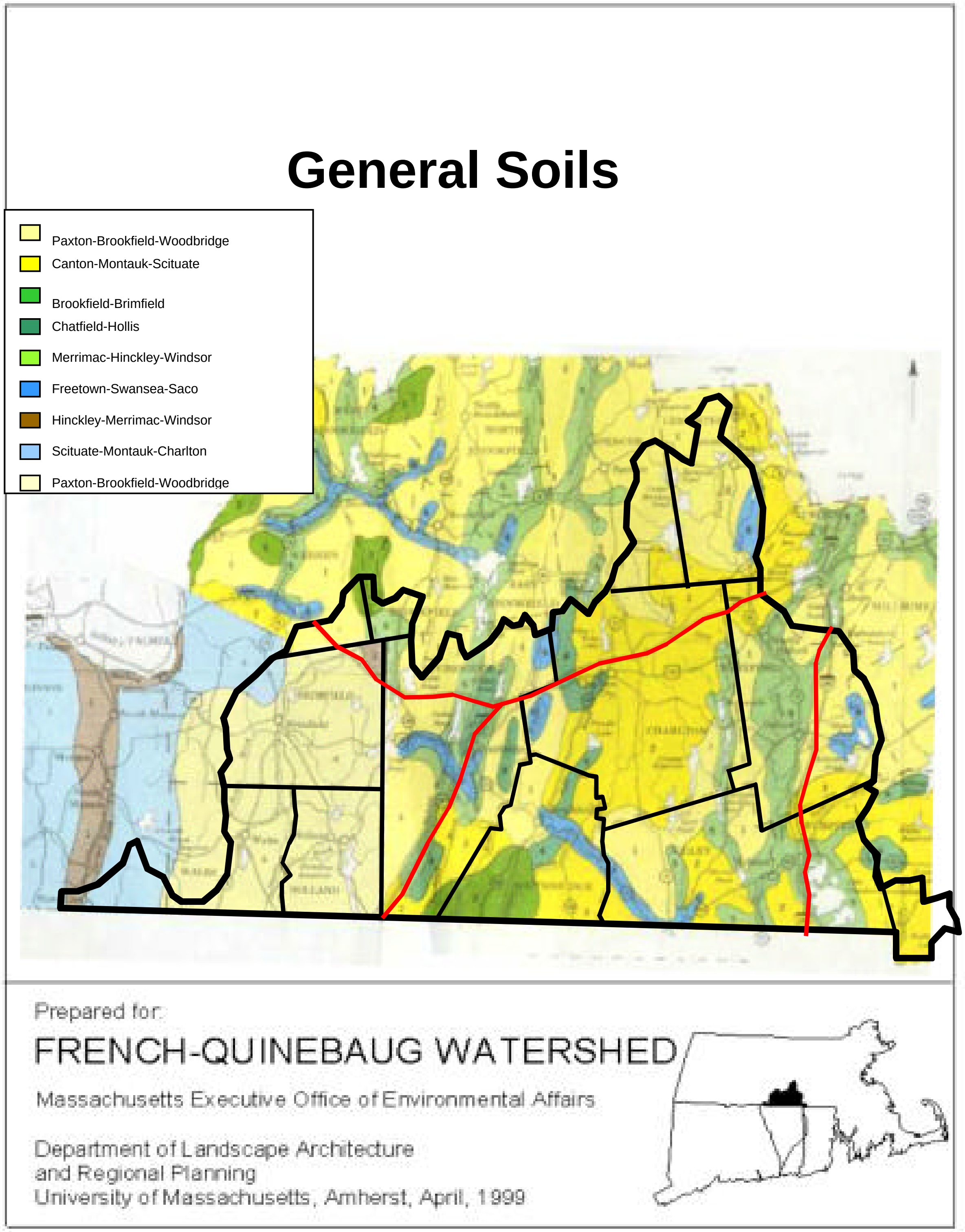


Figure 1.3: General Soils. Source: USDA NRCS

[1] "General Soils" Map is primarily for useful for regional analysis. Towns should also review detailed soils survey maps/reports for guiding local zoning and other by laws (this information is available from the Wocester Conservation District, 52 Boyden Road, Holden, MA, 01520)

1.3 Hydrology

Hydrology of the French-Quinebaug Watershed is examined in three sections; water bodies, drainage pattern and river profiles that provide basis information for the watershed. This information will provide general knowledge for the hydrology of the French-Quinebaug and, at the same time, draw a clear understanding for "how hydrologic features/components affected and connected with each other" and "why a holistic/regional approach is important for watershed management plans."

As it mentioned in Section1.2., geologic character affects the hydrological system in the area; French-Quinebaug Watershed is a typical post-glacial hydrologic system. Several flow patterns are present in addition to abundant wetlands, ponds, streams, rivers, and lakes. High stream gradients in both the French and Quinebaug rivers served as a source of power to mills and other industrial developments along the rivers. Several mill ponds remain on segments of the French and Quinebaug Rivers.

1.3.1 Water Bodies

The watershed in the study area consists of both the French and Quinebaug River Basins (Figure 1.5). The Quinebaug can be further divided into the Upper and Lower Quinebaug based upon drainage patterns. In addition to the French and Quinebaug Rivers, a variety of water bodies are found within the watershed including several streams, ponds, lakes, impoundments and reservoirs. This includes Lake Chaubunagungamaug (Webster Lake), which is the largest natural lake in Massachusetts. Other large water bodies include the U.S. Army Corps of Engineers' East Brimfield Reservoir in Brimfield, Sturbridge, and the Hamilton Reservoir in Holland. A number of lakes and ponds, most notably in the upper French watershed were established or enlarged by dams in the early nineteenth century to help provide a reasonable source of water for power generation and other manufacturing needs of downstreem mills.

Figure 1.4 Typical Stream in French-Quinebaug Watershed

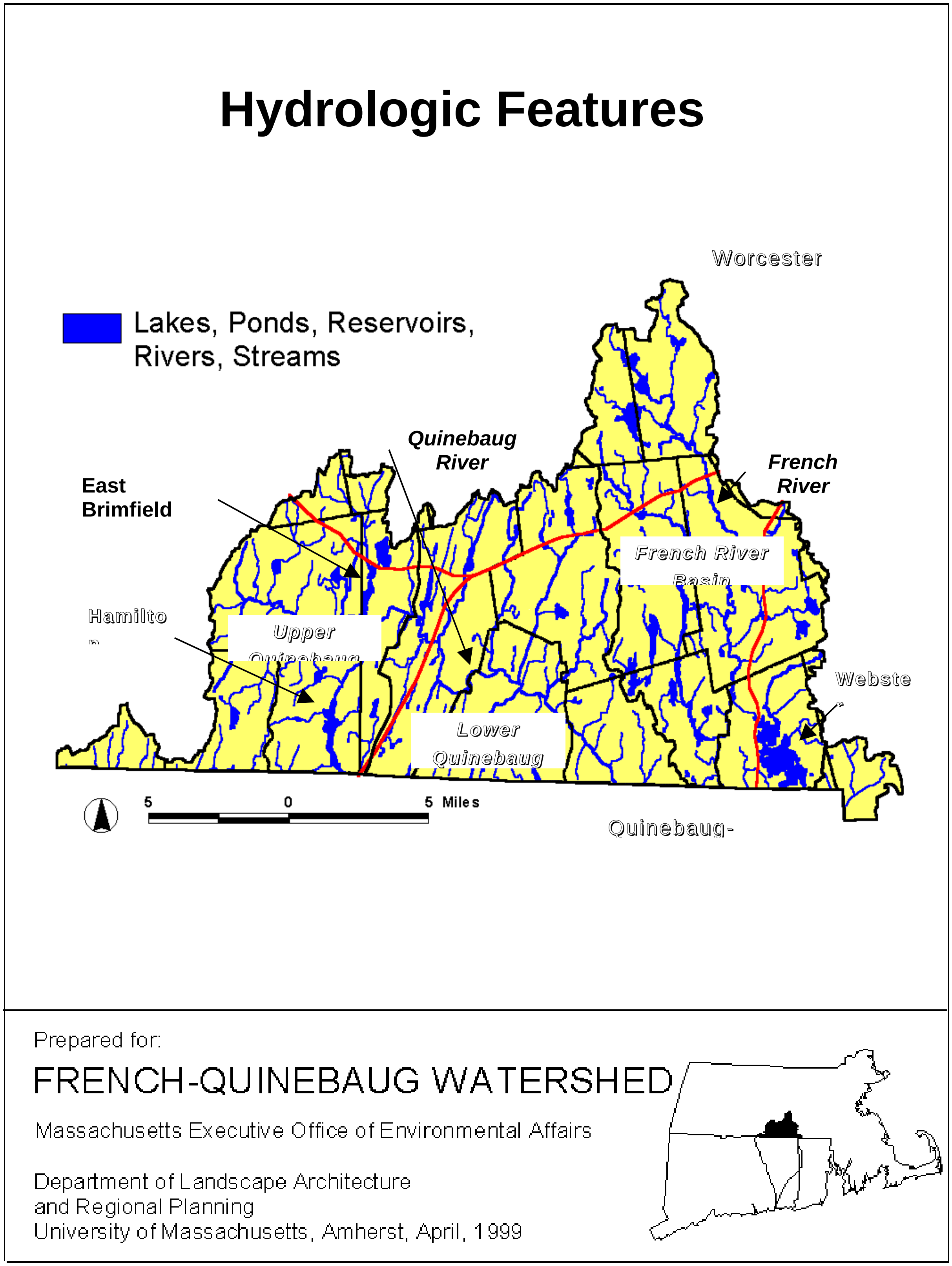


Figure 1.5 Hydrologic Features; Source Data: MassGIS

1.3.2 Drainage Pattern

The hydrology of the French-Quinebaug is characterized by three separate flow patterns found in the upper Quinebaug, lower Quinebaug, and French River watersheds (Figure 1.5). These patterns include a contorted drainage pattern in the upper Quinebaug (Figure 1.6). This drainage pattern typically occurs over coarsely layered metamorphic rocks. Igneous intrusions and differential lithologies have caused this chaotic drainage pattern. The parallel pattern of the lower Quinebaug is typical of areas of elongate landforms (Figure 1.7). These landforms include glacial drumlins that constrict and direct the drainage pattern. The French River watershed displays a dendritic pattern of drainage (Figure 1.8), is found in uniformly resistant crystalline rocks with a gentle regional slope.

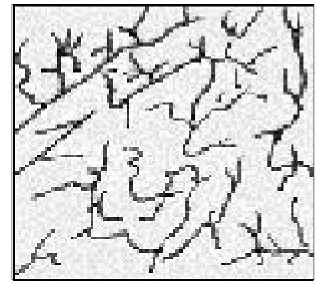


Figure 1.6 Contorted Drainage Upper Quinebaug

These patterns are significant in that they respond to the bedrock, structural, and surficial geology. The drainage patterns also affect the water quality and quantity within the watershed. Meandering patterns found in a contorted drainage allow deposition of sediment loading from storm runoff. Parallel and dendritic patterns, depending upon the relief of the river, represent a higher energy system with more turbid waters. When these patterns are analyzed with the relief of each river, conclusions can be made regarding the type of flow found within each region.

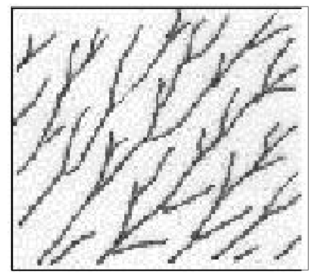


Figure 1.7 Parallel Drainage Lower Quinebaug

1.3.3 River Profiles

An examination of the river profiles reveals differential gradients in both the Upper and Lower French and Quinebaug Rivers. The Quinebaug River experiences a change in elevation of 200 feet in just three miles from the Westville Dam to its confluence with Cady Brook (Figure1.9). This portion of the river travels primarily through Southbridge. The river slows down considerably once leaving Southbridge, responding to the moderately sloping, rolling topography of Dudley.

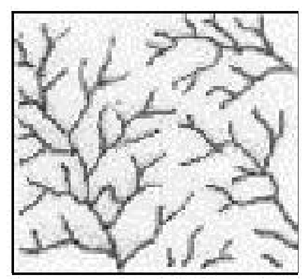


Figure 1..8 Dendritic Drainage French River Basin

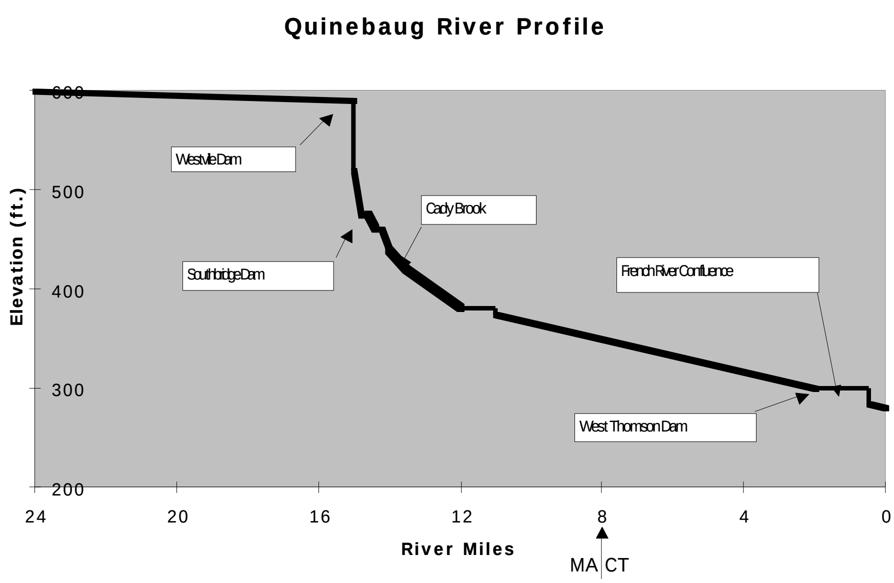


Figure 1.9 Quinebaug River Profile

The French River possesses a profile similar to that of the Quinebaug River. A steep gradient is present in the Upper French between Dutton Pond and Clara Barton Pond (Figure 1.10). This represents a change in gradient of 300 feet over eight miles. The river then slows down as it drops only 100 feet over an additional 12 miles through Oxford and between Webster and Dudley to the Connecticut border.

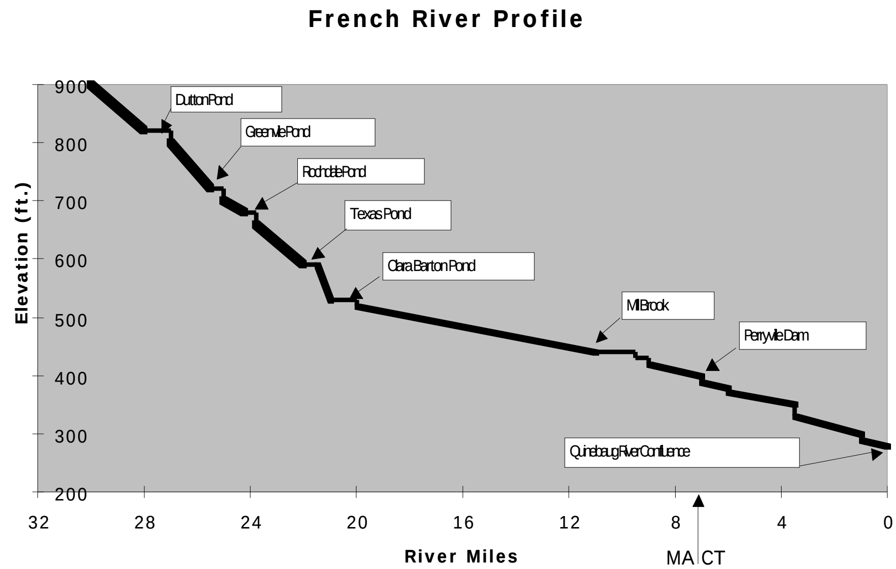


Figure 1.10 French River Profile

Different than today's tendency, drainage patterns were basis for historic land use. When we look at the historic land use pattern, drainage patterns and the river profiles indicate that there was a preferred land use along segments of each river. The high relief segment of the Quinebaug River corresponds to the parallel drainage, therefore providing a high energy system and ideal conditions for grist mills and the associated industries. These conditions are also found in the upper portion of the French River where sufficient relief and a well formed dendritic drainage pattern provides a relatively high energy system for mills. Lower energy portions of both the French and Quinebaug are found close to the Connecticut border in Dudley and Webster. This less than ideal scenario for mills and a gently rolling topography provided ideal conditions for agriculture in this portion of the watershed.

1.4 Environmental Issues in the French-Quinebaug

1.4.1 Hydrologic Cycle

The hydrologic cycle is one of the most important natural processes for the survival of the human species and the ecosystem as a whole. From the moment water reaches the earth in the form of precipitation, its path has a direct relation to how it appears in our drinking water sources, rivers and ocean. Pollution, both natural and anthropogenic, can appear in drinking water, endangering all ecological communities.

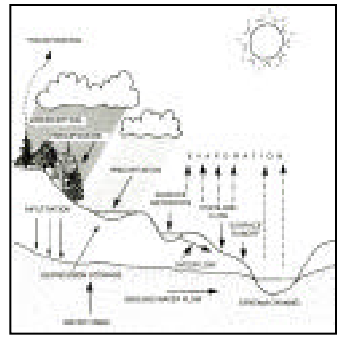


Figure 1.11
Hydrologic cycle on the land

There are five main processes that make up the hydrologic cycle:

1. **evaporation**: the sun heats the earth's surface waters until water particles vaporize into the atmosphere

2. **transpiration:** water and moisture within the tissue of plants are heated by the sun until they are released through the leaves of the plant into the atmosphere

3. **condensation**: air currents carry evaporated water through the earth's atmosphere until they begin to cool and form small droplets of moisture

4. **precipitation:** concentrated droplets join other droplets until they become too heavy to be carried by air and fall to the earth as fog, rain, snow, etcetera.

5. **runoff:** water infiltrates through the soil, but as the soil pore spaces become filled, the excess water trickles over saturated surfaces.

6. **infiltration:** water that infiltrates througgh the soil.

1.4.2 Environmental Impacts of Development

In the natural hydrologic cycle, water travels slowly through the various environmental compartments. On the soil surface, suspended particles and sediments settle out effectively filtering the water. Human development of the land, however, alters the hydrologic cycle and can have profound implications for water quality and available quantity. And the contaminants that appear in the water are directly influenced by the land use near the water body.

1.4.3 Impervious Surfaces

Perhaps the most influential factor of human development on a watershed today is an increase in the amount of impervious surfaces. Impervious surfaces, such as parking lots, rooftops, sidewalks, roads, and patios, create less areas where water can infiltrate into the soil and recharge groundwater.

In urban areas, stormwater runoff contains concentrated pollutants which eventually empty into the nearest natural water bodies. "Runoff from lands modified by human activities can harm surface water resources in two ways: by changing natural hydrologic patterns; and by elevating pollutant concentrations and loadings. Storm water runoff may contain or mobilize high levels of contaminants, such as sediment, suspended solids, nutrients, heavy metals, pathogens, toxins, oxygen- demanding substances, and floatables (Figure 1.12) (EPA, 1998).

Impervious surfaces create a number of environmental consequences which effect the hydrologic cycle in the following ways:

- Rainwater is prevented from moving into the soil, there by lessening groundwater recharge and ***reducing base stream flows.*** This is a particular concern in the French and Quinebaug Rivers, which already experience seasonal periods of low flow.

- Because it cannot infiltrate into the soil, more rainwater runs off, and moves more quickly, causing ***increased flooding, destabilized natural channels,*** and associated ***reduction of habitat*** and other stream values. Flooding and channel destabilization may require construction to channelize the stream, with further loss of natural stream uses.

- Rapidly moving water mobilizes soil particles of increasing size, causing erosion in non-impervious areas, and resulting in increased turbidity and sediment load to the receiving water body. The turbidity prevents sunlight form reaching photosynthesizing organisms, the settled soil particles alter the benthic habitat and ultimately the benthic communities.

- As runoff moves over impervious areas, it collects and concentrates nonpoint source pollutants- from cars, roadways, rooftops, etc.- ***degrading water quality*.**

- Impervious surfaces retain and reflect heat, causing increases in ambient air and water temperatures. Increased water temperature ***negatively impacts aquatic life.*** And oxygen content decrease in nearby streams because of the increase the in the amount of water.

Increase in the impervious surfaces serious consequences as indicated above. These consequences do not happen individually, they generally happen together, and the outcome occurs in a connected way. For example, if the amount of water is too much to be infiltrated into the soil during a storm, water runoff goes directly to streams or to the sewer systems. It bypasses the recharge of ground water, and infiltration steps that have result in decrease in the ground water amount and base stream flow. Additionally, this quick runoff causes erosion, flooding, and accordingly reduction of habitat. Besides these impacts, runoff carries non-point source pollution, and heated water degrades water quality. Increase in impervious surface is a serious concern especially in urbanizing watersheds that can create problems over the long term, and have costly solutions. Thus, each community or town needs to carefully review land use project proposals to avoid this problem in the future.

1.4.4 Pollutants

Pollutants appearing in our waters come from many sources. Excess nutrients, from of agricultural and commercial fertilizers may eventually reach the nearest surface water body, or the local aquifer. Industrial pollutants are discharged directly into the air or into water sources. Everyday activities, such as driving a car, fertilizing lawns and disposing of household waste in a septic system can also contribute to pollution. The following is a partial list of some of the pollutants produced from various activities.

The sources of pollutants are generally classified as point or nonpoint. ***Point sources*** can be identified as the "pipe" where the pollution is being discharged (e.g. smoke stack, sewer outfall). Nonpoint sources refer to pollution that is not coming from one specific place (e.g. stormwater runoff, acid rain). For example, a wastewater treatment facility located on a river may be both a point and a nonpoint source of pollutants. Runoff from impervious surfaces at the facility, if not properly managed, may contain nonpoint pollutants, while the sewage effluent itself constitutes a point source.

In the past 25 years there has been much progress made in regulating pollution from industrial ***point sources***. However, ***nonpoint sources***, containing concentrations of pollutants from various dispersed sources (ie.g. parking lots, storm drains), are responsible for up to 80% of the pollution in the waters of the United States (Bay Area Stormwater Management Agencies Association, 1997, p.3) Water quality in highly developed areas, which normally contain a large amount of impervious surfaces, is degraded when excessive runoff increases the amount of direct sediment, nutrient and toxic inputs flowing into a water system.

Use	**Some Contaminants of Concern**
Lawn Care	SOC/IOC, Atrazine, 2 and 4-D, methoxychlor, glyphoxychlor, dicamba, carbaryl, arsenic, mercury, diazinon
Combined Sewer Outfalls	Nitrate, nitrite, TCE, benzenexylene, arsenic, barium,cadmium, chromium, cyanide, selenium, silver, mercury, lead, acenaphthylene, acenaphthylene, chrysene, flouranthene, 2-methylnaphthalene, pryene
Industrial Parks	VOC/SOC/IOC/PCBs, pentachlorophenol, hexachlorophenol, benzene, carbon tetrachloride, asbestos, arsenic, barium, cadmium, chromium, mercury, selenium, antimony, aluminum, nitrate, zinc, silver, pyrene, phenol, hexachloroethane, fluorene, acetone, lead, thallium, nickel, cyanide, beryllium
Composting Facilities	MIC/IOC, nitrate, nitrite
Fishing/Boating	VOC/MIC, benzene, toluene, xylene, ethylbenzene, beryllium, hexachloroethane, MEK, MIBK, methylene chloride
Landfills and Dumps	VOC/SOC/IOC, styrene, nitrate, sulfate, arsenic, barium, cadmium, chromium, cyanide, lead, mercury, selenium, silver, TCE, hexachloroethane, carbon tetrachloride, chlorobenzene, benzene, PCBs, methylene chloride

Figure 1.13 DRAFT Land Use/ Associated Contaminants Matrix, Massachusetts Department of Environmental Protection. Source Water February 1999

In recent years, Best Management Practices (BMP's) have evolved to address many of the problems associated with nonpoint source pollution. These are innovative design and management practices aimed at reducing pollutants and/or speed and volume of runoff (See section 1.9.1).

1.4.5 Development in the French-Quinebaug Watershed

As a result of its proximity to urban areas such as Worcester, Springfield, Hartford and Boston, the French-Quinebaug Watershed area is a likely location for residential and industrial development. Development, if not properly balanced with the need to protect the watershed, could have detrimental effects on communities and natural resources (Figure 1.14). Uncontrolled development has led to urban sprawl in communities throughout New England and along the Atlantic Seaboard. Without implementation of controls at the local level, urban sprawl will continue to encroach on the French-Quinebaug Watershed. Especially the increasing amount of lawns in residential areas consist a threat to hydrology of the watershed, since they are mostly impervious and act similar to driveways, parking lots. In developing areas considering hydrological impacts, such as no more than 15% impervious surface will reduce the negative impacts on hydrology.

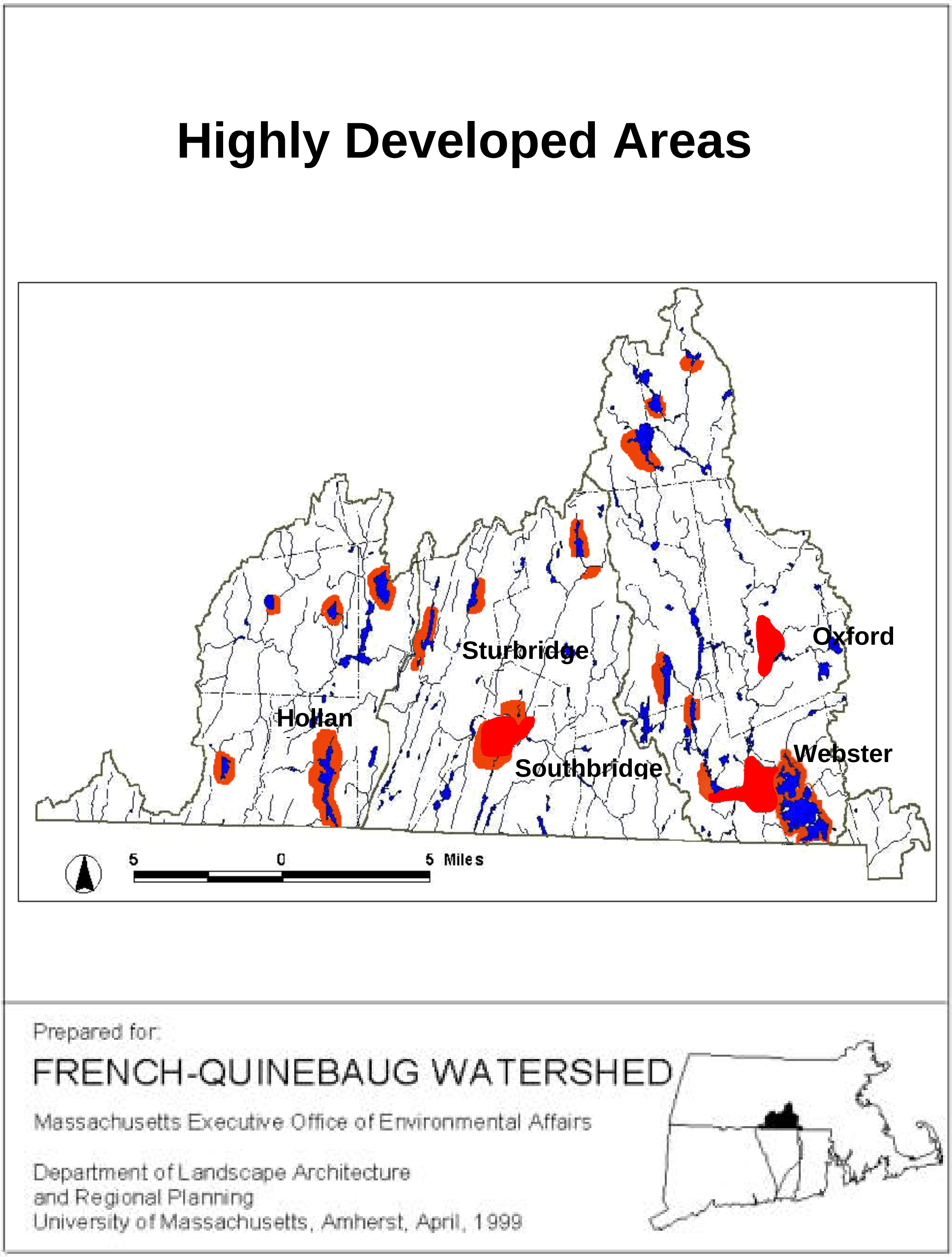


Figure 1.14 Highly Developed Areas. Source Data: USGS Topographic Maps

1.5 Water Quality in the French-Quinebaug Watershed

As noted in the following section, 1.5.1, water quality has been an issue starting with the 1800s. This issue is still an important part of the French-Quinebaug Watershed's hydrology that all towns need pay attention to. In this section water quality examined by looking the history of water quality in the watershed, by explaining the water quality threats in the area today, and by outlining water quantity related issues. Considering water quality issues can enhance several issues, such as protecting biodiversity and water resources and allow creating new economic resources, like tourism. Besides, this information is also useful to alert communities for possible problems related with water quality that will be very costly to solve in the long term.

1.5.1 History of Water Quality in the Area

The streams, rivers, ponds and lakes in the French-Quinebaug watershed have had, literally, a colorful past. From the first mills in the 1800s, (e.g. the Slater Mill in Webster) water quality in the area has been impeded by industrial and associated activities – from the mills, the populated areas surrounding them, and the subsequent networks of transportation. This development and usage of the rivers, combined with local geology and topography, has had a dramatic impact on water resources of this area. Past and present threats to these resources will be addressed in this section.

As discussed in the geological history of this watershed, the gradient of the French and Quinebaug Rivers served as a source of hydroelectric power to the mills in the 1800s (Figures 1.9, 1.10). Some of the well-known mills in the area from that time included the Charlton Woolen Company, Anglo Fabrics, West Dudley Paper Company, Cranston Print Works, Webster Lens Company, American Optical, and Stevens Linen Company. Many of these factories were still functioning into the mid1970s. Until very recent times, the industries were notorious for discharging untreated manufacturing process water directly into the rivers and impoundments. In a 1940 study the river was described as "often discolored with industrial wastes (7,752,000 gallons per day)" (WPA, 1940). That particular report noted the "markedly reddish color of the river below Southbridge" attributed to the "rouge" used as an abrasive in grinding lenses. Later reports range from milky white below the West Dudley Paper Company in 1974, to "tea-colored", to "blue–green" from prolific algal blooms. The French River in 1974 was documented below Mill Brook (the outlet of Webster Lake) to have the "general appearance of pea soup, although the color may vary from blue to green to rouge" (DWPC, 1974).

Color was not the only contaminant that the mills were contributing to the water. There is a legacy of pollution in the urban areas that can be attributed to both the industries listed above, and insufficient wastewater treatment. Discharges created sludge and sedimentation, particularly in slower moving waterbodies like ponds and impoundments behind dams. Nutrient and coliform levels were exceptionally high, with some presence of raw sewerage in local waterways, causing a great oxygen demand in the water. In 1974, the impoundment behind the Perryville Dam on the French River, at approximately 100 yards upstream of the Connecticut border, was known to have a "sludge deposit [that] had accumulated on the bottom, pieces of which occasionally came loose and floated to the top...[at which time] coliform bacteria counts skyrocketed up to the million level count" (DWPC 1974).

Wastewater discharges have contributed to degraded water quality in the area from historical times to present. Insufficiently treated effluent contributes nutrients, coliform, bacteria, solids and excess chlorides from the treatment process. Water bodies in areas downstream of these plants exhibit reduced water quality - for example, Texas Pond on the French River, below the Oxford-Rochdale WWTP; and the entire Quinebaug River between the Southbridge WWTP and West Thompson Lake in Connecticut. According to the 1989 Water Quality Report on the Lower Quinebaug, "up through 1986, Southbridge WWTP was a major contributor to high nutrients and organic loads in the Quinebaug River which ultimately caused dissolved oxygen sags and extensive algae growth in West Thompson Lake" (DWPC, 1990).

Webster's wastewater treatment plant underwent an upgrade in 1985, when the Webster and Dudley treatment facilities were combined and a sludge handling facility was added, but this did not adequately address the need for phosphorus removal. The majority of problems associated with wastewater treatment plants today are caused by high phosphorus loading. The Southbridge WWTP alone contributes 88% of phosphorus loading and 71% of ammonia-nitrate loading to the Quinebaug River to this point (DWPC 1990). As of the 1989 report, none of the plants had added phosphorus removal processing.

Many of the mills responsible for historically high levels of pollution in the rivers closed in the late 1970s, and those that remain operate under tougher NPDES (wastewater discharge permit) regulations, resulting in a measurable improvement in surface water quality. However, some problems with wastewater treatment plants remain, which are compounded by hard to manage non-point source pollution. As illustrated earlier, urban run-off generated by development constitutes a major threat to water quality, particularly in the Sturbridge and Southbridge areas on the Quinebaug, and the Webster and Dudley areas on the French (Figure 1.15).

1.5.2 Threats to Present Water Quality Conditions

Today, overall water quality in the French – Quinebaug Watershed is currently rated Class B ("Fishable and swimmable"), with 80% to 100% of waterbodies meeting All Designated Uses (U.S.EPA, 1999). The U.S.EPA ranks this watershed a 3 on a scale 1 to 5, with Less Serious Problems-Low Vulnerability to aquatic resources (USEPA, 1999). Almost all areas are acceptable for primary recreational uses, like swimming, and secondary recreational uses, like boating. There is debate, however, as to the safety of fish consumption for this area. The EPA has sited that all fish in the area are safe, while the Massachusetts Dept. of Public Health has identified at least one area, the East Brimfield Reservoir with Holland Pond in which fish tissue concentrations of mercury where high enough to necessitate a fish consumption advisory.

Even with the vast improvements made, some of the same problems remain. Water quality testing conducted in 1994 indicates areas that continue to exceed Class B maximum concentrations of coliform. Eutrophication, the nutrient enrichment process whereby lakes and ponds age, has been identified in several waterbodies. This involves elevated levels of phosphorus and nutrients, which leads to algal blooms, and excessive plant growth, sags in dissolved oxygen concentration, temperature increases, and an anoxic benthic habitat. Some eutrophied water bodies include Cedar Pond, West Thompson Lake, and Dutton Pond. Greenville and Rochdale Ponds have also been identified as threatened. Impoundments and ponds are at higher risk because they "are in the open sun and have slower velocities, creating an ideal growing environment for the proliferation of algae" (DWPC, 1988). The rivers, however, remain oxygenated because of the aeration that occurs in normal flow. The steep gradient of both rivers therefore, in addition to providing waterpower in the area, also provides aeration.

Other contributors to pollution and subsequent eutrophication include septic leachate in residential areas in the upper Quinebaug; the nutrient-enriched songitims favor the growth of invasive species of plants, particularlyMyrioplyllum sp.(water milfoil). Dense beds of aquatic macrophytes (plants) as well as algal blooms, result in wide fluctuations in dissolved oxygen; oxygen sags threaten the resident aquatic populations. In addition, sedimentation from soil erosion and unmaintained roads, has been identified by the Holland Conservation Commission.

1.5.3 Water Quantity and Low-Flow

Ironically, the French – Quinebaug watershed has problems due to both high- and low-flow. Excessive rainfall creates higher amounts of urban run-off, notedly in the areas of Sturbridge and Southbridge. There is evidence that this run-off contributes to high coliform levels instream in the Quinebaug River, including the Connecticut portion of the river. Conversely, this watershed is also characterized by low-flow, which is heightened during peak summer months. Low-flow can be associated with several issues, including lack of recharge to the ground water supply due to excessive run-off because of impervious surfaces, and excessive withdrawals from water supplies, but in essence creates a reliance on a regular level of precipitation.

Low-flow exaggerates existing water quality problems through a decrease in available dilution, and therefore an increase in pollutant increasing concentrations in water bodies. One particularly serious low-flow period was recorded in 1974; however, certain water bodies in this watershed have notably serious low-flow problems every year, for example, Cohassee and Hatchet Brooks; and there are concerns now particularly for the lower Quinebaug, with respect to the construction of the Millenium Power Plant in Charleton.

U.S. Generating Co. is constructing a natural gas-fired power facility in Charleton, the Millenium Plant. This plant employs a wet-cooling system in its process that will result in the evaporation of 2 million gallons perday (MGD). Water will be acquired from several sources–predominately from the Southbridge Wastewater Treatment Plant, but also from direct withdrawals from the Quinebaug River (Earth Tech, 1996).

The construction of this power plant has been controversial for many reasons, including concerns from its neighbors regarding noise, the impact of the rural character of the area by the massive construction, safety, and impact to wildlife in the area. In order to not to disturb the sensitive character of the landscape in the area, attention was paid for protection or reconstruction of the wetlands. In addition, conservation land was set aside on the site for the town of Charleton; and accommodations were made for displaced wildlife on the site, particularly by the addition of constructed vernal pools. Because of the nature of the re-grading of the hill on-site, while unsightly, Cady Brook has not been impacted.

However, several agencies in the state are particularly concerned about the impact of the large direct and indirect water withdrawals on the Quinebaug River, and the watershed in general. The plant may not make the maximum withdrawals on a daily basis – they will not be on-line continuously every day of the year, but, in fact, operate in conjunction with other plants in the area. However conditions occurring more and more frequently in this any uptake may exacerbate the problems already created by low-flow area.

Water quantity and low-flow is not a problem that affects just one area without affecting the surrounded. Because of the connected nature of the landscape, one activity in one town can cause other problems in another town or in other towns, or even in another state. The natural boundaries, such as watershed, do not consider political boundaries. Thus, collective effort between and within the towns in a watershed is necessary, as Watershed Initiative suggests. Since water quantity and low flow can cause costly tribulations, communities need to be aware of the consequences of the issues that can also change quality of life in the area .

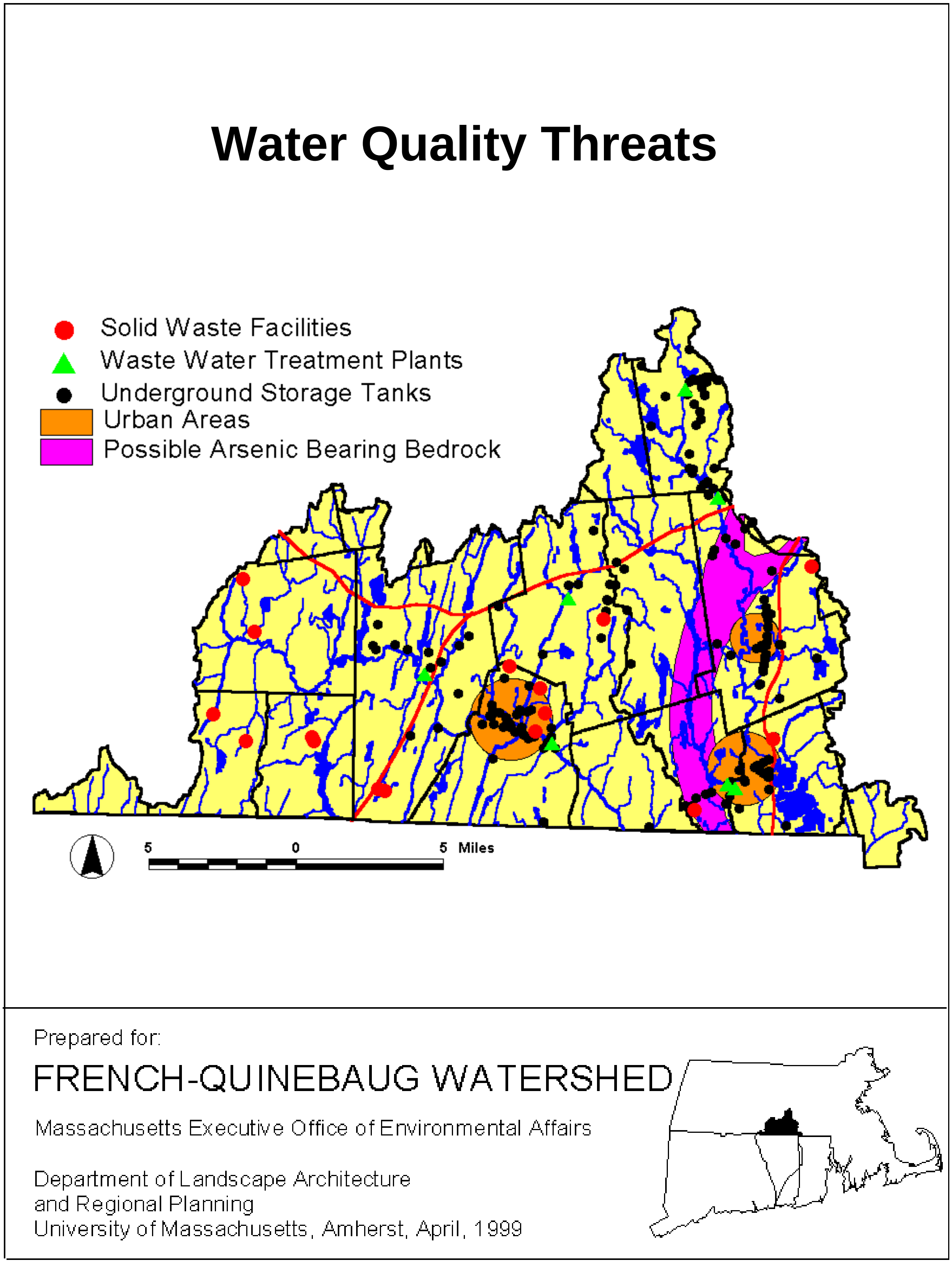


Figure 1.15 Water Quality Threats. Source Data: MassGIS

1.6 Dam Safety

Dam safety is an issue surrounding the structural integrity of dams within the French-Quinebaug, as well as typical presence of contaminated sediments impounded by these dams. There are over 210 dams in the French-Quinebaug Watershed in Massachusetts and Connecticut including four in Massachusetts, which belong to the Army Corps of Engineers (Figure 1.16) Their dams are well maintained and have over four thousand acres of water bodies and surrounding undeveloped acreage that are available for passive and developed recreational activities. These dams were constructed for provide flood control, and development is prohibited in the flood control zones. Conditions of the remaining dams are unknown, and the land generated from them is owned by cities, towns, and private owners.

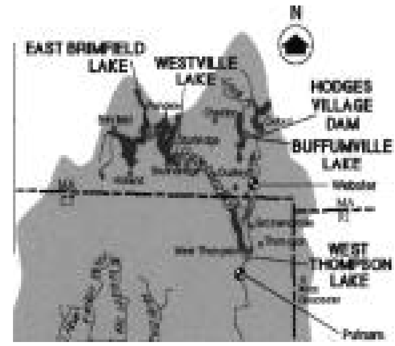


Figure 1.16 A.C.E. Dams

Structurally unstable dams represent flooding concerns, as well as threats to water quality due to the sediments that have become trapped behind many of these. Sediments within the Perryville Impoundment in Webster are contaminated with heavy metals that have accumulated during the life of the dam (Figure 1.17). Many of the dams have literally entombed sediments from industrial activity over one hundred years ago. Failure of these dams would release these sediments and severely degrade downstream water quality.

Dam safety is based on the potential for damage that may occur in the event of dam failure. The D.E.M. Dam Safety Division is the agency responsible for inspecting and maintaining records on all the dams in Massachusetts. This is done on a town-by-town basis, listing all dams per town and providing a more detailed report for each dam. Example: The town of Dudley has 41 dams, ranging from a hazard level of 1 to 3. The reports include the name of the dam, owner of the dam, date of last inspection, ID number, and hazard level. On the individual dam report, it lists in addition to all of the above, the physical condition of the dam, what repairs are needed as well as the estimated repair costs. Figure 1.18 shows how safety is evaluated for the report.

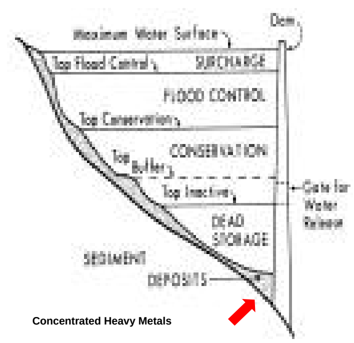


Figure 1.17 Contaminated Sediments

	Type Result	End Results
Level 1	High Hazard	Catastrophic loss of life
Level 2	Significant Hazard	Large property loss
Level 3	Low Hazard	Minimal property loss

Figure 1.18 Dam Safety Classification. Source: DEM, Dam Safety Division

The following is the basis of the hazard levels and their significance to dam safety***.***

> ***Hazards from human activity must also be considered when analyzing the risks posed by dams. By convention, classification of potential dam failure risk is based on the severity of potential impact, not on the structural safety of the dam. Thus, dams that may be of sound construction are labeled "high hazard" if failure could result in catastrophic loss of life—in other words, if people have settled in the potential inundation zone. The "high hazard" designation does not necessarily imply structural weakness or an unsafe dam. Lower classifications include "significant hazards" dams for which failure is estimated to result in large property loss, and "low hazard" dams for which failure is estimated to result in minimal property loss. Risk may well increase through time because few government entities have found the means to limit settlement below dams*** (U.S. Army Corps of Engineers, 1982b).

There are over 210 dams in the French and Quinebaug watershed, ranging from level 1 to 3. The problem at this point, is the accuracy of the data. Some of these dams were last inspected in the 1970's and 1980's, and the hazard potential classification is most likely in need of change. With the onward progression of development in the watershed area, the likelihood of increasing residential development below these dams has occurred. The recommendations to limit development to areas outside of hazard zones is not always feasible, and will have to be determined by individual towns or the watershed as a whole.

> ***The dam is man's principal means for controlling or influencing his water resource environment. Whether for supply, quality control, flood control, power, irrigation, flat-water recreation, or navigation. It can augment water downstream or prevent flow. It can turn a pristine stream into a chain of lakes. It can both flush a stream and prevent its flushing*** (Kaynor, 1979).

These words were written in 1979 and still indicate some of the concerns for today, especially regarding with interagency management of dams. Yet, since the dam building era is gone by, public policy is also changing. Dams are being removed and are increasingly difficult to build and maintain due to changes in economic uses of impoundments and changes in environmental regulations. Even though dams are not principal means for today's water resource management, they are still a consideration since they are affecting the water quality and quantity in many ways. In the French-Quinebaug Watershed, the old dams need attention from the towns they placed in; thus, towns should look closely at what dams they have and how to maintain what they want to keep.

Establishment of a watershed authority that would function as a liaison between different government offices would minimize the ambiguity concerning the management of dams within the watershed. The creation of hazard zones around dams would also assist in reducing damage should dam failure occur. Some of the dams in the French-Quinebaug/Shetucket area have not been inspected since the 70's. New inspections and assessment of hazard levels will be necessary to ensure dam safety.

1.7 Existing Watershed Protection

While threats exist within the watershed, several forms of state-level protection are in effect in the French-Quinebaug Watershed in Massachusetts. These include the Rivers Protection Act, Title V Regulations, Groundwater Protection Zones, the Massachusetts Drinking Water Regulations Surface Water Supply Protection Zones and Flood Zones. These represent the most relevant forms of water quality protection. Additional federal, state, and local environmental regulations, not described here, protect water quality within the watershed in a variety of ways (Figure 1.19)

1.7.1 Rivers Protection Act

This act is an amendment to the earlier Wetlands Protection Act. The new act regulates development along rivers, streams, lakes, ponds as well as wetlands. Riverfront resource areas protection zones measure 200 feet wide in rural areas and 25 feet wide in urban areas. Wetland buffer zones are 100 feet wide. While the land use within these protection zones is restricted, development is not prohibited.

1.7.2 Title 5

Title 5 regulates the siting of septic systems. It provides buffers around water bodies and requires soil percolation testing for septic system approval. This regulation is relevant to much of the French-Quinebaug Watershed, which primarily uses septic systems to treat and manage sewage. While Title V requires that soils be adequately drained, it does not prevent siting septic systems in soils that are excessively drained with limited filtration capacity.

The role of local officials in resource protection is very important, namely the Board of Health which implements Title 5 and manages solid waste, addresses odors, nuisances, private wells, water quality at beaches and generally in the community. The Board of Health is the permitting authority regarding on site sewage disposal systems for most applicants.

1.7.3 Zone II

A Zone II is that area of an aquifer that contributes water to a drinking water well under the most severe pumping and recharge conditions that can be realistically anticipated. Land uses surrounding a groundwater-based drinking water pumping station are regulated so as to protect the "cone of depression" surrounding the pumping station. Areas that have not been delineated are proteced by a fixed buffer zone around the existing well, the Interim Wellhead Protection Area (Figure 1.19).

1.7.4 Surface Water Supply Protection Zones

These protection zones are specified within the Massachusetts Drinking Water Regulations. They include Zones A, B, and C, which protect the land area surrounding Class A surface drinking water sources. Zone A protects the area within 400 feet of the source and 200 feet of any tributary to that source. Zone B protects an area within one-half mile of a surface drinking water source (Figure 1.19).

1.7.5 Flood Zones

These areas are regulated by the Federal Emergency Management Act, and include Flood Zone A. Large tracts of land within Flood Zone A are regulated to provide flooding easement for the four Army Corps of Engineers projects within the Masscahusetts portion of the watershed. These areas indirectly protect water quality by restricting development with the floodplain (Figure 1.19).

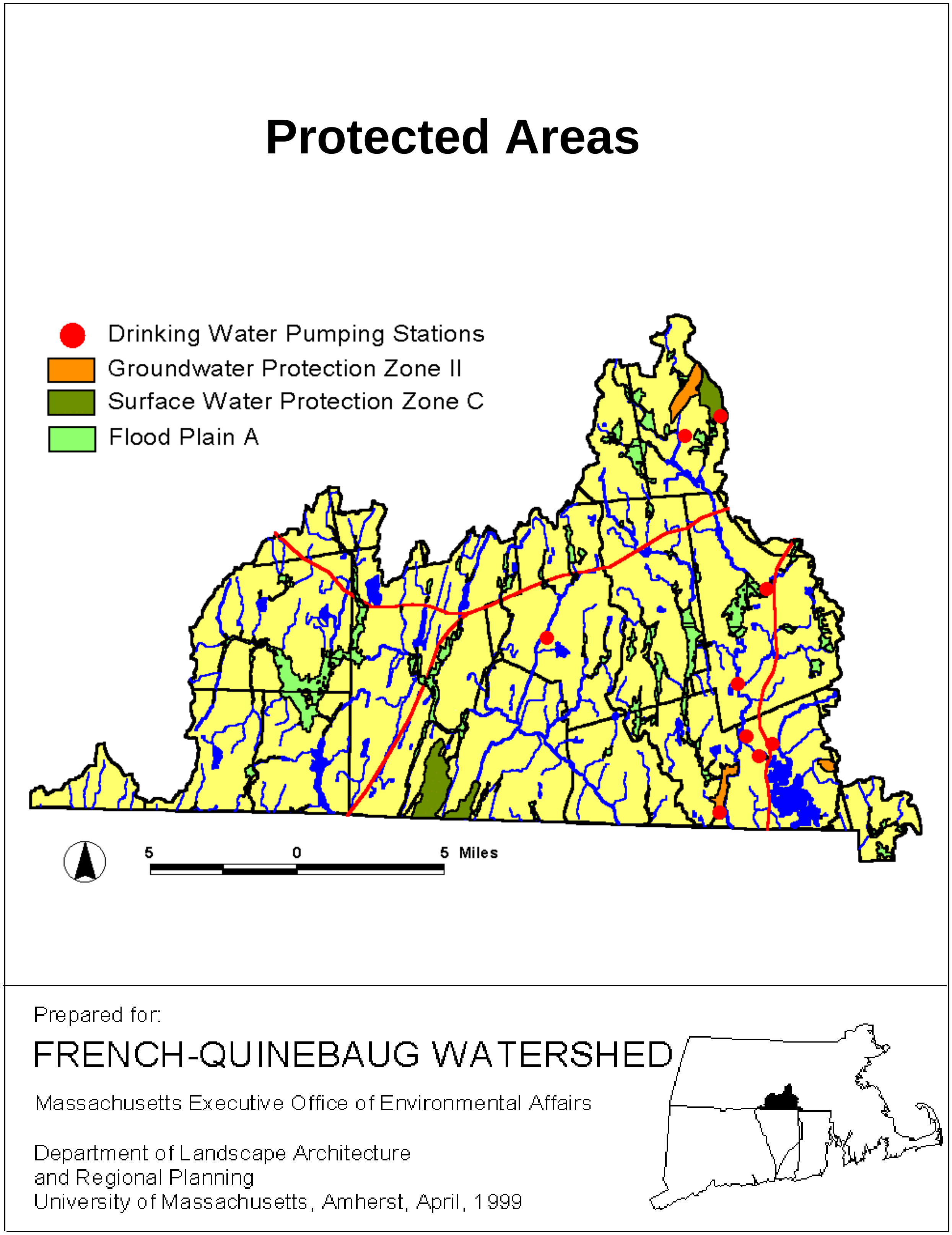


Figure 1.19 Protected Areas. Source Data:MassGIS

1.8 Best Management Practices (BMPs)

Best Management Practices can be defined as standard, innovative techniques designed for effectively and economically reducing sources of pollution, particularly non point source pollution.In a watershed management plan, these techniques are utilized around rivers, streams, and ponds to protect water resources with methods such as designing vegetative swales to collect run-off, restoring riparian vegetation, and constructing wetlands.

As mentioned previously, nonpoint sources are a significant source of contamination in the French – Quinebaug watershed. For example, large parking lots along the river in areas like Southbridge and Webster contribute excessive amounts of pollution via surface water run-off. Because these areas are nonpervious, water collects contaminants as it travels, eventually discharging into storm drains. There are several ways to manage nonpoint source pollution and to recharge the aquifer.

Numerous design features may be incorporated into development plans. First, the runoff process must be changed. For example, collection areas for infiltration may be created, such as wetlands to receive stormwater flows. The most important management tools to be considered are porous pavement and the removal of impervious surfaces that no longer serve a useful function. These are design features that should be considered prior to development.

To control sedimentation, erosion controls must be implemented, such as limited development on steep slopes and other areas with a high potential for erosion. Construction of sedimentation filters and traps would allow sediment to settle out of stormwater before deposition in a water body. Other important BMPs include re-vegetation, seeding and mulching. The creation of buffers between roadways and rivers would provide zones that collect sediment while slowing the flow of water (Figure 1.21). Stormwater would then have the time to infiltrate the soil and recharge the aquifer, thus limiting sediment entering the stream. Parking lot designs should include specialized retention areas added to handle storm-water runoff.

Throughout the French-Quinebaug Watershed there are many possibilities to implement best management practices. In order to have the most possible benefit from the design solution determining the objective(s) will be helpful to choose appropriate practice. Outlining the objectives and their uses is the first step to determine the appropriate BMPs. Figure 1.20 is a sample for the combination of objectives and needs-uses of BMPs. Implementers need to be aware of what they want to achieve while selecting practices. A partial list of best management practices will be given at the end of this section related to the goals (Figure 1.33).

Objectives	Needs and Uses
Enhance existing conditions	Aquatic habitat
Create wetlands to enhance water quality	Wetlands
Provide the capacity and outlet for existing storm sewers	Drainage
Provide active and passive recreation opportunities in diverse open and vegetated sites	Recreation/ Aesthetics
Provide a valley storage and flow capacity for the regional event	Flood protection
Prevent environmental and safety hazards	Safety

Figure 1.20 Sample of objectives for best management practices. Natural Channel Systems, An Approach to Management and Design, Canadian Ministry of Natural Resources

Figure 1.21 Stormwater Management. Source: Greening the Toronto Port, Waterfront Regeneration Trust

1.8.1 Site Specific Best Management Practices

Best Management Practices can be used for many purposes. Before introducing a partial list of best management practices, indication of possible uses for specific sites will give more concrete information.

- Utilize grey water for reuse or filter for recharge of ground water.
- In coordination with local plans and local official, use alternative septic systems that treat wastewater on site to a higher degree than the standard systems. Check all systems for leakage routinely.
- Replace aging septic systems around high water table areas like ponds and lakes with alternative systems as the old systems are replaced. Require new building projects to install alternative systems.
- Encourage the use of best stormwater management practices in areas with large amounts of storm-water runoff, such as Southbridge and Sturbridge should be encouraged to implement storm-water management practices. Construction of wetland retention areas to receive storm-water will further, reduce pollutants entering rivers.
- Consider alternative designs during the construction process of parking lots and roads. Require retention and filtration basins to be included in the design.
- Require a corridor buffer for storm-water runoff along roadways that are within 200 feet of waterways.
- Provide riparian corridors along waterways. Repair any damage from erosion along river and streams. Create a larger vegetated buffer area of 300 feet or better where necessary. Prohibit development in these sensitive areas.

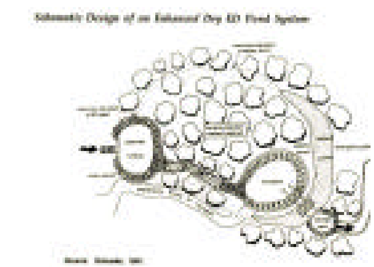


Figure 1.22 Extended Detention Pond. Source: Schueler et al, 1992

A partial list of site-specific Best Management Practices and their brief explanations are presented below. French –Quinebaug Watershed has heterogeneous built and natural landscapes. As mentioned before, in order to select appropriate best management practice(s), first, the goals need to be clarified; needs will determine the practices. Besides objectives the type of landscape-urban, suburban and rural- will give a direction in choosing process. In the following section first brief definition will be given for most used best management practices, than, in a matrix, possible uses, benefits to several issues, their application to urban, suburban and rural areas, and cost will be introduced. It should be acknowledged that this list does not cover all practices, it samples the most used ones by their characters, and provides a frame to evaluate the best management practices to use in specific sites.

Extended Detention Ponds: Extended Detention (ED) ponds temporarily detain a portion of stormwater runoff up to twenty-four hours after a storm using a fixed orifice. Such extended detention allows urban pollutants to settle out. The ED ponds are normally “dry” between storm events and do not have any permanent standing water (Figure 1.22) (Schueler et al, 1992, p.7).

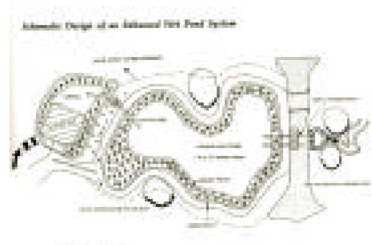


Figure 1.23 Wet Ponds. Source: Schueler et al, 1992

Wet Ponds: Conventional Wet Ponds have a permanent pool of water for treating incoming stormwater runoff. The enhanced wet pond designs, a forebay is installed to trap incoming sediments where they can easily removed; a fringe wetland is also established around the perimeter of the pond (Figure 1.23) (Schueler et al, 1992, p.15).

Stormwater Wetlands: These wetlands are shallow pools that create growing conditions suitable for the growth of mash plants. These stormwater wetlands are designed to maximize pollutant removal through wetland uptake, retention and settling (Figure 1.24). Stormwater wetlands are constructed systems and typically are not located within delineated natural wetlands. In addition, stormwater wetlands differ from artificial wetlands created to comply with mitigation requirement in that they do not replicate all the ecological consideration of natural wetlands (Schueler et al, 1992, p.23).

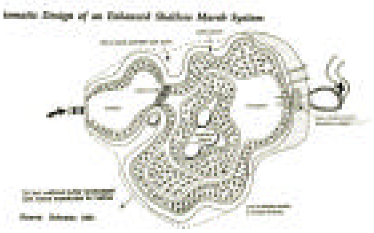


Figure 1.24 Stormwater Wetlands. Schueler et al, 1992

Multiple Pond Systems: This a collective term for a cluster of pond designs that incorporate redundant runoff treatment techniques within a single pond of series of ponds (Figure1.25). These pond designs employ a combination of two or more of the following: extended detention, permanent pool, shallow wetlands, or infiltration. Examples of a multiple pond system include the wet ED pond, ED wetlands, infiltration ponds and pond-marsh system (Schueler et al, 1992, p.31).

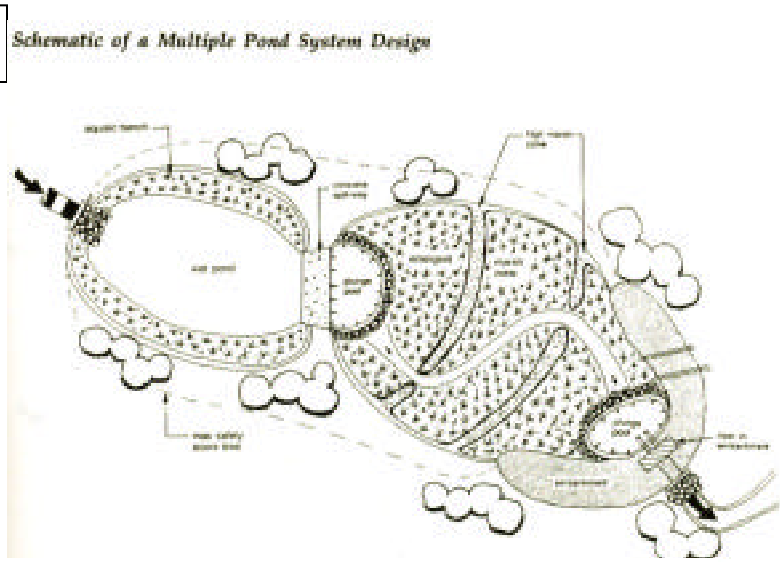


Figure 1.25 Multiple Pond System. Schueler et al, 1992

Infiltration Trenches: There are conventional and enhanced infiltration trenches. A conventional infiltration trench is a shallow, excavated trench that has been bad filled with stone to create an underground reservoir (Figure 1.26). Stormwater runoff diverted into the trench gradually infiltrates from the bottom of the trench in to the subsoil and eventually in to the water table. Enhanced infiltration trenches have extensive pretreatment systems to remove sediment and oil. They require on-site geotechnical investigations to determine appropriate design and location (Schueler et al, 1992, p.39).

Infiltration Basins: These basins are impoundment's where incoming stormwater runoff is stored until it gradually infiltrates through the soil of the basin floor (Figure 1.27) (Schueler et al, 1992, p.49).

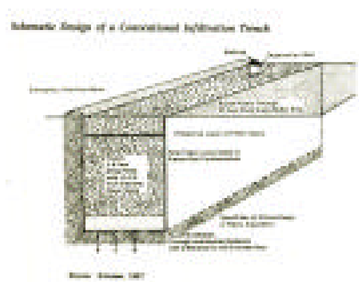


Figure 1.26 Infiltration Trenches. . Source: Schueler et al, 1992

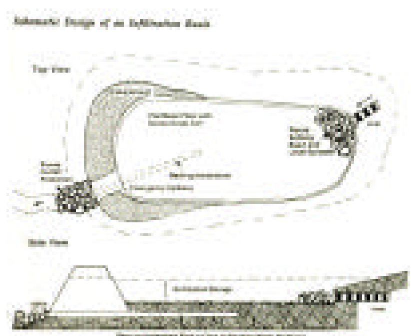


Figure 1.27 Infiltration Basin. Schueler et al, 1992

Porous Pavement: Porous Pavement is an alternative to conventional pavement whereby runoff is diverted through a porous asphalt layer and into an underground stone reservoir (Figure 1.28). The stored runoff then gradually infiltrates in to the subsoil (Schueler et al, 1992, p.55)..

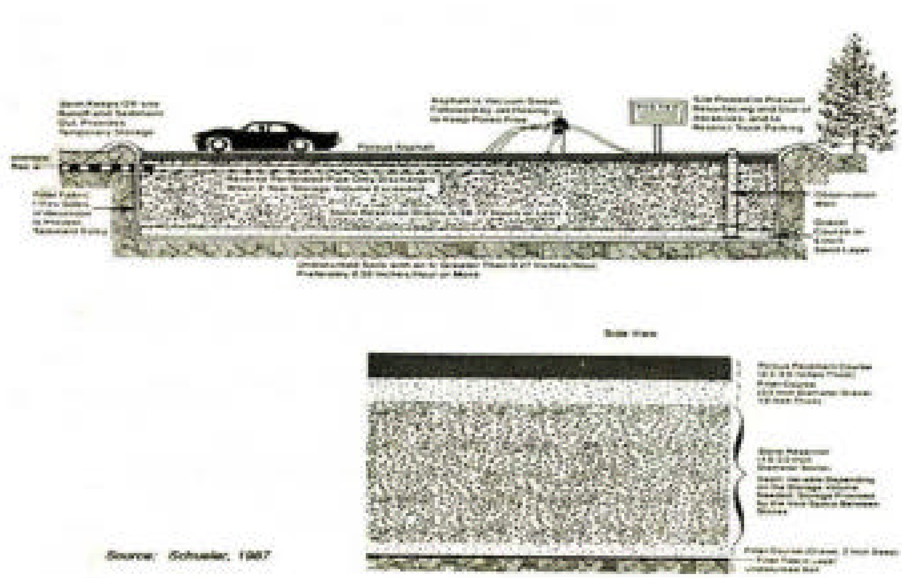


Figure 1.28 Porous Pavement. Source: Schueler et al, 1992

Sand Filters: Sand filters are a relatively new technique for treating stormwater, whereby the first flush of runoff is diverted into a self-contained bed of sand (Figure 1.29). The runoff is then strained through the sand, collected in underground pipes and returned back to the stream or channel (Schueler et al, 1992, p. 63)

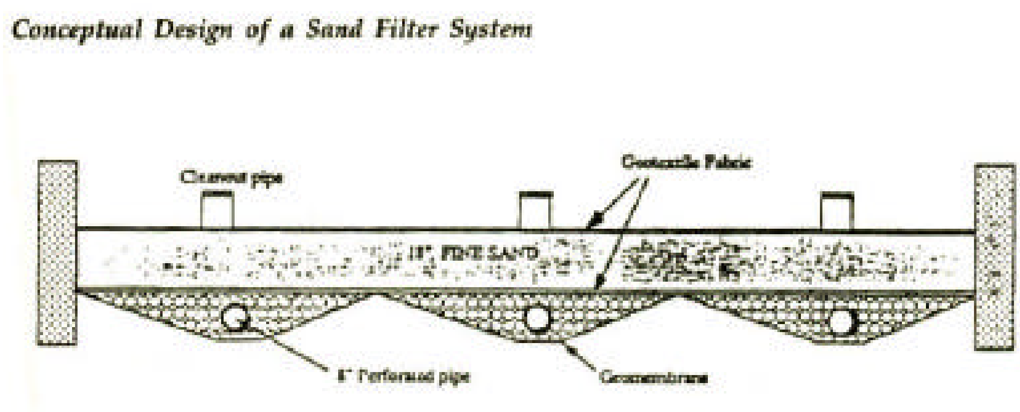


Figure 1.29 Sand Filter. Source: Schueler et al, 1992

Grassed Swales: These are earthen conveyance systems in which pollutants are removed from urban stormwater by filtration through grass and infiltration through soil (Figure 1.30) (Schueler et al, 1992, p. 71)

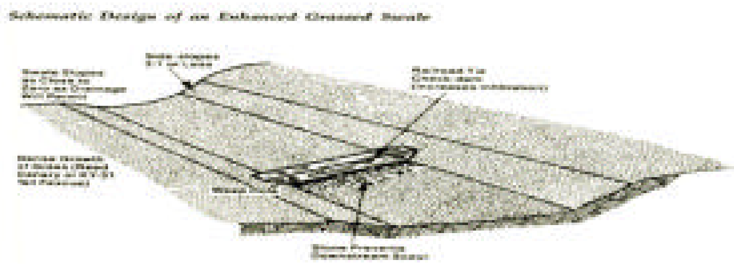


Figure 1.30 Grassed Swale. . Source: Schueler et al, 1992

Filter Strips: Filter strips are vegetated sections of land designed to accept runoff a soverland sheet flow from upstream development (Figure 1.31). They may adopt any natural vegetated form, form grassy meadow to small forest. The dense vegetative cover facilitates pollutant removal. Filter strips cannot treat high velocity flows, therefore, they have generally been recommended for use in agriculture and low density development. Filter Strips differ form natural buffers in that strips are not “natural” rather, they are designed and constructed specifically for the purpose of pollutant removal. A filter strip can also be an enhanced natural buffer, however, whereby the removal capability of the natural buffer is improved through engineering and maintenance activities such as land grading or the installation of a level spreader (Schueler et al, 1992, p. 79).

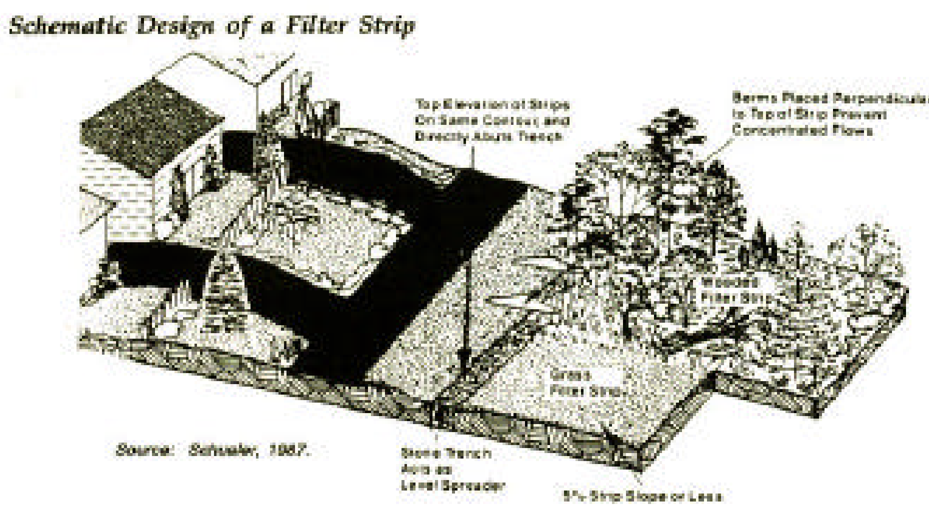


Figure 1.31 Filter Strip. Source: Schueler et al, 1992

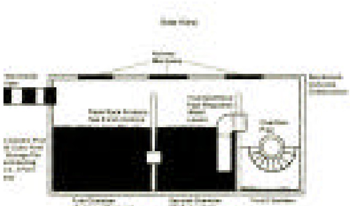


Figure 1.32 Water Quality Inlets. Source: Schueler et al, 1992

Water Quality Inlets / Oil Grit Separations: A water quality inlet is three-stage underground retention system designed to remove heavy particules and absorbed hydrocarbons from stormwater runoff. Also known as an oil’grit separator (Figure 1.32), (Schueler et al, 1992, p.87).

BMP Options/ Application Purpose	Stormwater runoff	Flood Protection	Erosion	Recreation /Aesthetics	Fish & Wildlife Protection	Non-Point Source Pollution Prevention	Urban	Suburban	Rural	Cost
Extended Detention Ponds	●	◐	●	○	◐	●	●	●	◐	Low
Wet Pond	●	◐	◐	◐	●	◐	●	●	◐	Moderate
Stormwater Wetlands	●	◐	◐	○	◐	●	●	●	◐	Moderate
Multiple Pond Systems	●	◐	◐	◐	●	●	●	●	●	High
Infiltration Trenches	●	◐	◐	○	○	◐	●	●	○	Moderate
Infiltration Basins	●	◐	◐	◐	◐	◐	●	●	●	Low
Porous Pavement	●	○	○	◐	○	●	●	●	○	Low
Sand Filters	●	○	○	○	○	●	●	●	○	Moderate
Grassed Swales	●	◐	○	○	◐	◐	●	●	○	Moderate
Filter Strips	●	●	●	●	●	◐	◐	●	●	Low
Water Quality Inlets	●	○	○	○	○	◐	●	◐	○	High

Figure 1.33 BMP Options and Application Purpose

1.9 Recommendations

In addition to the Best Management Practices previously discussed, there are several other methods to protect and preserve the hydrology of the French-Quinebaug Watershed. Outlined here are measures to protect both surface and groundwater quality in rural and urban areas, including an approach to ensure dam safety.

Surface Water Quality

- Institute Best Management Practices throughout the watershed.
- Implement water quality monitoring for priority streams, rivers, lakes, ponds. and reservoirs within the watershed.
- Remove manmade debris regularly from surface water bodies
- Minimize impervious surfaces where practicable.
- Where necessary, pave dirt road to prevent erosion and sedimentation.
- Monitor permitted point source discharges for compliance.
- Incorporate advanced treatment in wastewater treatment plant upgrades to protect water quality of the French and Quinebaug Rivers.
- Minimize or eliminate CSO outfalls, and separate sewerage and storm water where necessary.

Ground Water Quality

- Assess and inspect underground storage tanks for leaks.
- Regularly test groundwater quality surrounding solid waste facilities.
- Enforce Mass Title 5 regulations for on-site septic systems.

- Consider expansion of sewer systems in the highly developed areas of the watershed, being mindful of potential adverse impacts to stream flow due to reduced groundwater recharge.
- Encourage home testing of private drinking water wells, and test specifically for arsenic contamination within estimated arsenic rich bedrock area.

- Restrict industrial land uses on sand and gravel deposits, pass or strengthen local bylaws to require restoration and re-vegetation of mined areas.

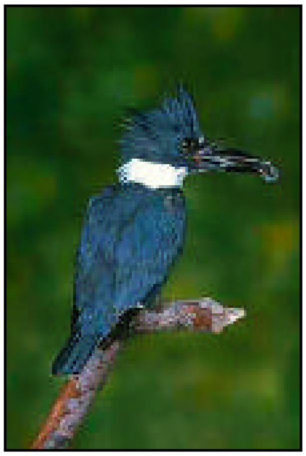
Dam Safety

- Inspect dams for contaminated sediments and structural integrity, and
- Remove or repair dams with priority given to:
  1. the most structurally compromised dams,
  2. higher level hazard dams, and
  3. dams with highly contaminated sediments

Priority Areas

- Urban and other areas with large amounts of impervious surfaces
- Sand and gravel deposits
- Industrial land uses
- Areas surrounding solid waste facilities
- Point discharge areas of industrial and municipal waste
- Waterfront residential areas utilizing individual septic systems

2—Biodiversity



2.1 Introduction to Biodiversity

Examining biodiversity of the French-Quinebaug Watershed will be helpful to pinpoint the sensitive and important issues for the ecological balance of the landscape. First, there will be a discussion of why we considered biodiversity in the watershed. Then, we will explain the method that is used in the assessment of biodiversity, followed by the information about the basic landscape ecological principles. Recommendations will give specific guidelines the possible uses this piece in the overall watershed management plan. . These recommendations serve as a starting point for the region to consider for biodiversity along the physical and economical development of the area.

2.1.2 What Is Biodiversity and Why it is Biodiversity Important?

Simply stated, "biodiversity is the variety of life forms, especially number of species, but including number of ecosystem types and genetic variation within species" (Forman, 1995, p. 38); and their richness-evenness ranging from the cellular level to the ecosystem as a whole. There is no distinction between exotic and native species, or endangered and common species, because biodiversity encompasses all living things.

Prioritizing biological diversity, as a management objective, remains the most proactive way to keep a wide realm of species intact and thriving as well as to eliminate the potential for creating more endangered and threatened species. Instead of altering the land to prioritize mainly economic, recreational and development needs, we need to look closely at the biological diversity present and what these species need for habitat. Only then can we creatively and strategically create patches of habitat, link corridors between patches and generally ensure that adequate habitat is protected. It is possible and desirable to achieve for compatibility between development and biodiversity planning.

In order to accurately assess the biodiversity of any region, the assemblage of native plants and animals known to occur in the region must be identified. Their rarity and conservation status must also be determined, as well as the number of location of species that are endangered, threatened or of special concern.

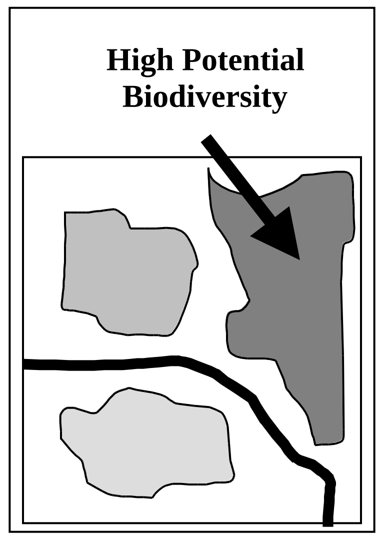


Figure 2.1 High Potential Biodiversity Diagram: Identifying patches of land with forest cover which supports the most number of species.

The term **endangered** means any species of plant or animal in danger of extinction throughout all of a significant portion of its range, and species of plants and animals in danger of extirpation as documented by biological research and inventory.

The term **threatened** means any species of plant or animal likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, and any species declining or rare as determined by biological research and inventory and likely to become endangered in the foreseeable future.

Special concern means any species of plant or animal which has been documented by biological research and inventory to have suffered a decline that could threaten the species if allowed to continue unchecked, or that occurs in such small numbers or with such a restricted distribution or specialized habitat requirements that it could easily become threatened within Massachusetts. Once these species have been determined, they can be placed in an assessment scheme to prioritize land that should be considered for conservation.

It is important to note that biodiversity protection based on an endangered species is a costly, reactive, and inefficient approach. The U.S. Fish & Wildlife service is currently promoting a different approach -- to find those "hot spots" of biodiversity that maintain, or likely maintain, healthy populations of species ***before*** they become extinct threatened or endangered. This program is known as GAP analysis. GAP data essentially identifies over 200 vegetative cover and non-cover types within the watershed and maps them for further interpretation.

2.2 Method

The best available data to calculate biodiversity in the watershed, GAP data, indicates forest cover type. That data was used to determine which patches of forest could support the most number of wildlife species. Figure 2.1 shows three patches of land, each shaded differently depending upon how many species that patch supports. The darkest patches are identified as having the highest potential biodiversity.

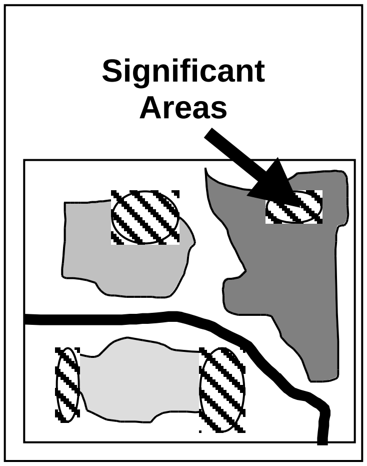


Figure 2.2 Signficant Areas Diagram: Identifying patches of land with both high potential biodiversity and rare species.

After determining areas of high potential biodiversity, as analyzed in the GAP data, we can then tweak the study by overlaying areas of rare species, thus meshing the old technique with the new. Figure 2.2 builds on Figure 2.1 by adding areas of known rare species habitats, as indicated by striped ovals. Any areas that are determined as biologically diverse by GAP data and overlap areas of endangered and threatened species are flagged as biodiversity "hotspots," as Figure 2.2 indicates with the arrow. It is these areas that must be treated with care in development and conservation. We recommend a 300 meter (~100 feet) buffer around these areas to provide a zone for the wildlife to prosper. It is suggested that development be limited in this area and that Environmental Impact Assessments determine that wildlife and wildlife habitats will not be significantly affected by any proposed development within such areas.

Any areas of Open Space -that areas of land or water essentially unimproved and set aside, dedicated, designated or reserved for public or private use or enjoyment (NJ Development Plan, 1999)- which already exist, such as Brimfield State Forest and Agricultural Preservation Restrictions, are then mapped and observed in conjunction with the biodiversity 'hotspots'. Any areas between the two that are not reserved for conservation need to be linked with vegetative corridors or stepping stones. This helps facilitate wildlife passage from one patch of land to another. (See figures 2.8-2.11).

2.3 Inventory and Analysis of Existing Wildlife

In planning for biodiversity, it is essential to have a knowledge of the existing wildlife populations in an area. The 1990 French River Greenway Plan (Horsley, Whitten, and Hegemenn Inc.) included a comprehensive list of dozens of wildlife species which are likely to reside in the Massachusetts portion of French-Quinebaug Watershed. This list was augmented by discussions with representatives of the Massachusetts Audubon Society and a local environmental consultant, Mr. Glen Krovowski. The final list includes over fifty wildlife species, representing a diverse group of mammals, birds, reptiles, and amphibians (see Figure 2.3). Common mammals in the watershed include the red fox, meadow vole, and eastern cottontail rabbit. Birds use the watershed for both regular habitat and for breeding, including the osprey, wild turkey, and kingfisher. The watershed's rich wetlands and riverways provide valuable habitat for scores of reptiles and amphibians, such as the Eastern American Toad, Northern brown snake, and Eastern box turtle.

In addition to examining common vertebrate species, rare and endangered species were inventoried and their habitats were analyzed. The Massachusetts Division of Fisheries, Wildlife and Environmental Law Enforcement monitors endangered species through the Natural Heritage & Endangered Species Program (NHESP). According to NHESP, 35 rare vertebrate, invertebrate, and plant species classified as rare, endangered or special concern inhabit the watershed (see Appendices B & C). There are eight species classified by the NHESP as ‘endangered’, ten considered as ‘threatened’, and 17 listed as ‘special concern’

The wood turtle and spotted turtle are of ‘special concern’ and each appear in over a dozen of the watersheds' communities. Other amphibians seen in many parts of the watershed, yet under NHESP observation, are the blue-spotted, four-toed, and marbled salamanders.

The American bittern is classified by NHESP as endangered, yet has been recorded in Briemfield, Brookfield, East Brookfield, Spencer, and West Brookfield. Two other endangered birds, the pied-billed grebe and the golden-winged warbler have been reported in the Brookfields.

Mammal, Bird, Reptile, Amphibian and Fish Species in French-Quinebaug Watershed

Mammals	**Birds**	**Reptiles and Amphibians**
Red Fox	Blue-Winged Teal	Marbled Salamander
Star-nosed Mole	Wood Duck	Jefferson Salamander
Red-backed Vole	Black Duck	Blue-Spotted Salamander
Meadow Vole	Mallard Duck	Spotted Salamander
Eastern Cottontail Rabbit	Osprey	Northern Dusky Salamander
	Northern Harrier	Northern Two-Lined Salamander
Fish	Wild Turkey	Red-Spotted Newt
Yellow Bullhead	Ruffed Grouse	Eastern American Toad
Brown Bullhead	Woodcock	Fowler's Toad
Large Mouth Bass	Great Horned Owl	Spring Peeper
Small Mouth Bass	Barred Owl	Gray Tree Frog
Yellow Perch	Red-Headed Woodpecker	Bull Frog
White Perch	Black-Backed Woodpecker	Green Frog
Yellow Horn Prout	Pileated Woodpecker	Leopard Frog
White-Bellied Horn Prout	Yellow-Bellied Sapsucker	Snapping Turtle
Redfin Shinner	Kingfisher	Box Turtle
Common Shinner	Phoebe	Painted Turtle
Pumpkinseed	Warblers	Northern Water Snake
White Sucker	Flycatcher	Northern Brown Snake
Carp		Northern Redbelly Snake
Northern Pike		Eastern Garter Snake
Chain Pickerel		
Black Crappie		
River Dace		
American Eel		
Bluegill		
Native Brown Trout		
Northern Blacknose Dace		

Figure 2.3 Mammal, Bird, Reptile, Amphibian and Fish Species. Source*: *Horsley, Whitten, and Hegemenn Inc*., *1990

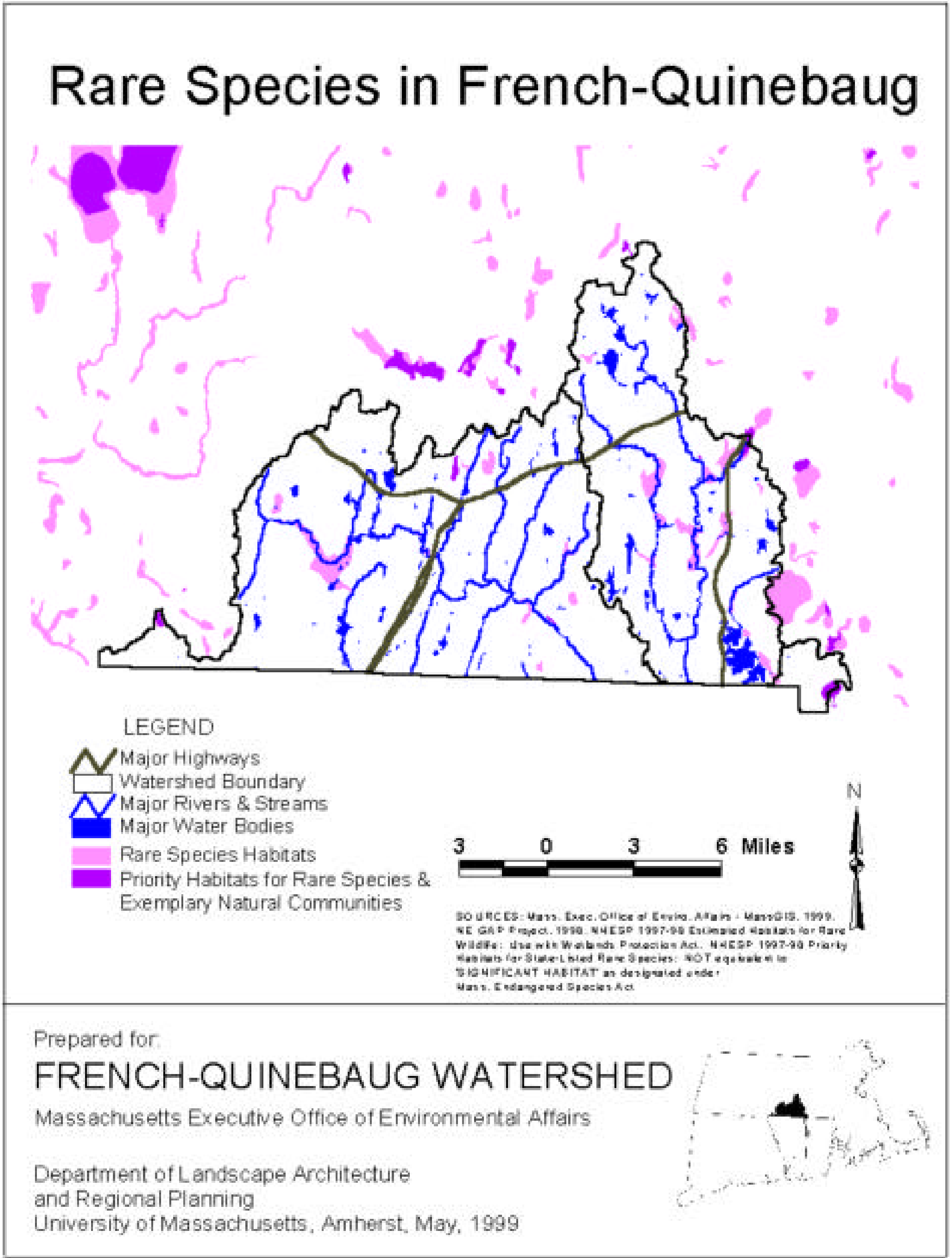


Figure 2.4 Composite Map of High Potential Biodiversity and Rare Species Habitats

Appendix C indicates the cities and towns where these rare and endangered species reside. NHESP also provided spatial data indicating the estimated habitats of rare species throughout the watershed and the locations of priority habitats (Figure 2.4). Priority habitat areas are areas which have important natural communities and rare species habitats. However, due to security concerns, NHESP does not disseminate the exact locations of specific species.

As Figure 2.4 indicates, there are only a few areas in the watershed where rare species have habitat, but there are a number of areas designated as priority habitats known by NHESP. Much of the rare and priority habitats are concentrated in the French River Watershed and just outside the borders of the Quinebaug Watershed. Figure 2.4 shows the Quabbin Reservoir to the northwest, habitat to numerous rare and endangered species. The Quabbin and other regional habitats for rare and endangered species must be considered in planning for biodiversity within the French-Quinebaug Watershed.

NHESP provides a wealth of detailed information on rare and endangered species. Appendix D includes a sample description of an endangered species, golden-winged warbler.

2.4 Habitat Mapping

To adequately address the level and distribution of biodiversity in the watershed, it is of great importance to know where wildlife breed winter. However, there are no data available that pinpoints the locations of all wildlife habitats. Therefore, a method was utilized to predict the probable habitats of wildlife. There are extensive spatial data indicating the locations of vegetation throughout the watershed. Using the vegetative data, areas were classified based upon how well they can potentially support wildlife. Areas which can support the most species were classified as having the greatest potential biodiversity. This method was adopted from the research of Dr. Richard DeGraaf and Prof. Jack Ahern. A flow chart is provided to illustrate the habitat mapping approach (Figure 2.5).

Spatial data provided by the University of Massachusetts GAP Analysis Project shows the land cover for the French-Quinebaug watershed. This spatial data consists of over 200 classes of land cover, from forest to urban. Professor Richard Degraaf of the University of Massachusetts has studied wildlife species habitats in Massachusetts and his results were published in the book ***Forest Wildlife of Massachusetts*** (DeGraaf and David, 1987). The book lists all species known to live in Massachusetts and notes the habitat in which those species breed or live during winter. In order to map the probable location of French-Quinebaug wildlife, there was a need to aggregate the GAP data into Degraaf's ten habitat categories. This aggregation was begun by the 1998 Landscape Planning Studio at UMass while working on a similar study in the Mill River Watershed. (Appendix E).

Once all of the land cover data was classified into one of the ten DeGraaf habitat-categories, the next step was to determine how many species each habitat-category can support. For each species expected to inhabit the watershed, their breeding and wintering habitats were compiled (Figure 2.6). Habitat-categories were totaled and ranked. The Oak/Maple/Birch Co-dominant category supported the most species: 47. The non-forest cover habitat-category supported the least species: 17 (Figure 2.7).

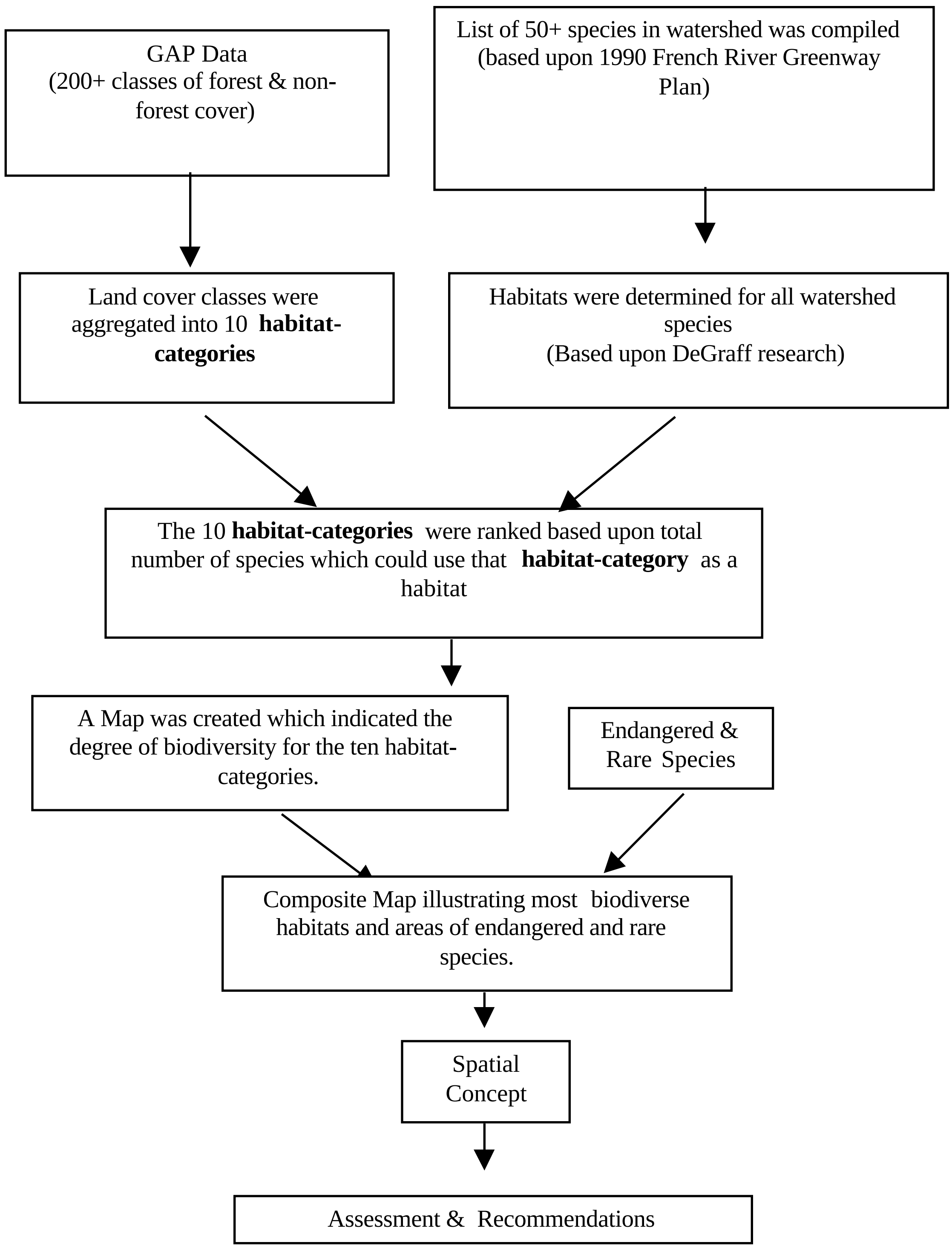


Figure 2.5- Habitat Mapping Flow Chart

Species	Northern Hardwood Dominant	Oak/Maple/ Birch Co-dominant	Red Maple Dominant	Oak Dominant	Birch Dominant	Maple/Oak /Conifer Co-dominant	Palustrine Wetlands	Conifer Dominant	Nonforest Cover	Fresh-water
Blue-Spotted Salamander (Breeding)							1		1	1
Blue-Spotted Salamander (Winter)	1	1	1							
Totals	35	46	44	33	29	39	36	28	17	28

Figure 2.6: Habitat category Supportive Capability

The results of this analysis were mapped to indicate potential biodiversity in the watershed (Figure 2.8). As the map indicates, there is a great amount of habitat in the watershed which supports high potential biodiversity. However, Oak/Maple/Birch Co-dominant, Red Maple Dominant, and Maple/Oak/Conifer Co-dominant support the most number of species. These habitat categories are spread throughout the watershed and provide rich habitats for a diverse range of species. Therefore, the top three habitat-categories, together, were identified as having high potential biodiversity.

Studying endangered species is essentially a reactive approach to landscape planning. In response to a serious problem, planners take drastic steps to save threatened species. On the other hand, the potential biodiversity mapping approach is proactive, planning for ways to protect areas which have high ecosystem value, before the species decline to an endangered level.

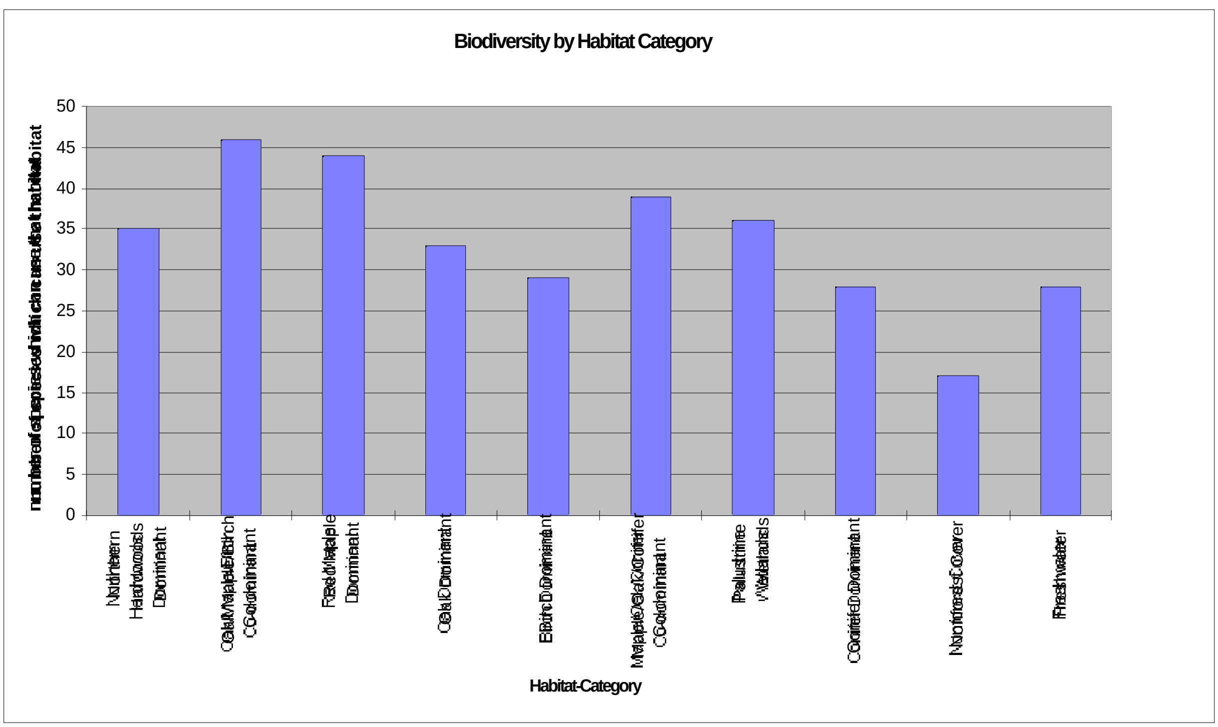


Figure 2.7: Potential Biodiversity by Habitat-Category

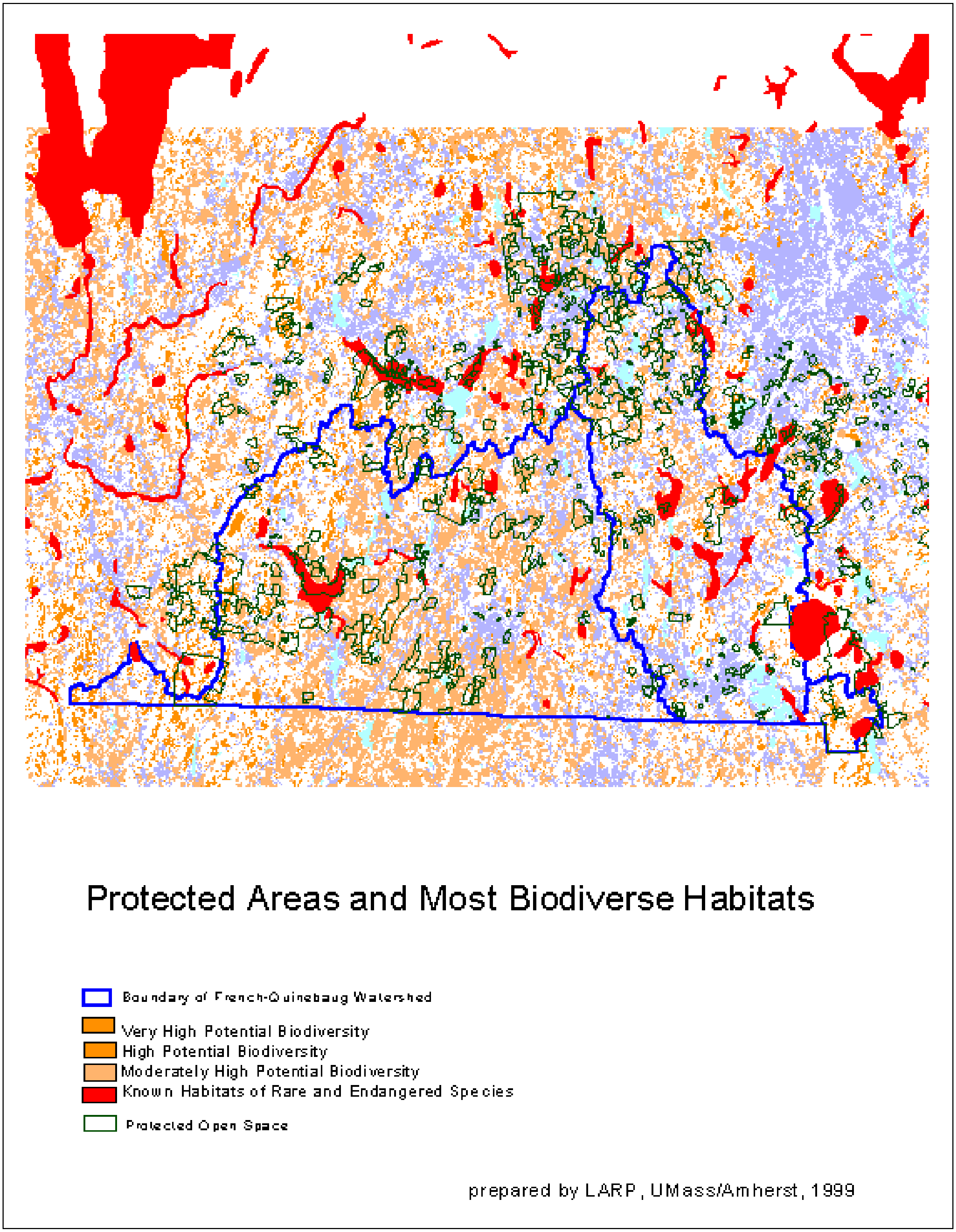


Figure 2.8 Protected Areas and Most Biodiversity Habitats. Data Source: MassGIS

But faced with endangered or threatened species, the watershed must also consider them in planning for biodiversity. The Massachusetts Division of Fisheries, Wildlife, and Environmental Law Enforcement monitors habitats of rare species through the Natural Heritage & Endangered Species Program (NHESP). NHESP has conducted extensive fieldwork and has mapped the habitats of many of these species. The NHESP datalayers also includes habitat areas for important natural communities, based upon their significance for biodiversity. By overlaying the NHESP datalayer along with areas of potentially high biodiversity, a more comprehensive picture of biodiversity develops (Figure 2.4).

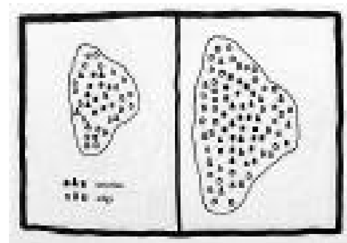


Figure 2.9 Large patch size is beneficial for wildlife (Source: Dramstad, 1996)

The next phase in the research posed the question: if communities in the French-Quinebaug Watershed could set aside lands for protection, which lands would get the maximum benefit for the smallest area? This was determined by identifying areas in the watershed, which were both habitats for rare species and had potentially high biodiversity (due to their vegetative cover) (Figure 2.11) This analysis yielded 147 acres of land concentrated in more than twenty nodes of varying size, throughout the watershed. Because the potentially high biodiversity analysis is not spatially exact and because wildlife often need buffer zones, a 300 meter buffer was added to the overlap areas. Together, the buffer and the overlap areas constitute 'significant areas'.

The final stage of the habitat mapping consists of a closer examination of the priority protection areas, as related to nearby urbanization, currently protected open space, and connectivity.

Figure 2.11 illustrates the areas of significant biodiversity within the watershed, by overlaying protected open space, some of these significant areas are shown as protected. However, other areas are among unprotected lands. Significant areas outside protected open space parcels should be designated as Priority Protection Areas (Figure 2.12).

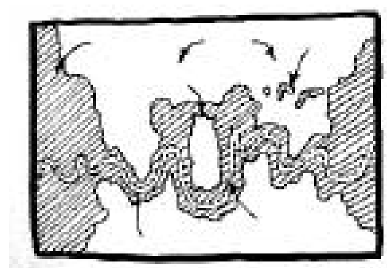


Figure 2.10 Connectivity along riparian corridors (Source: Dramstad, 1996).

Protected open space includes permanently protected lands in the watershed, including state forests, conservation easements, and lands in the Agricultural Preservation Restriction program. Not all of these protected open spaces are managed for the purposes of promoting biodiversity, however, at a minimum, they are not subject to immediate development (a serious threat to biodiversity).

To further provide meaning to the Significant Areas Map (Figure 2.11), an urbanization datalayer was overlayed. This data layer indicates where development and roads cut across the watershed. Significant areas which are dissected by major urbanization should be identified as Priority Protection Areas in need of further examination (Figure 2.12).

Employing the principles of landscape ecology, further recommendations will be made as to which other 'significant areas' should be designated for priority protection.

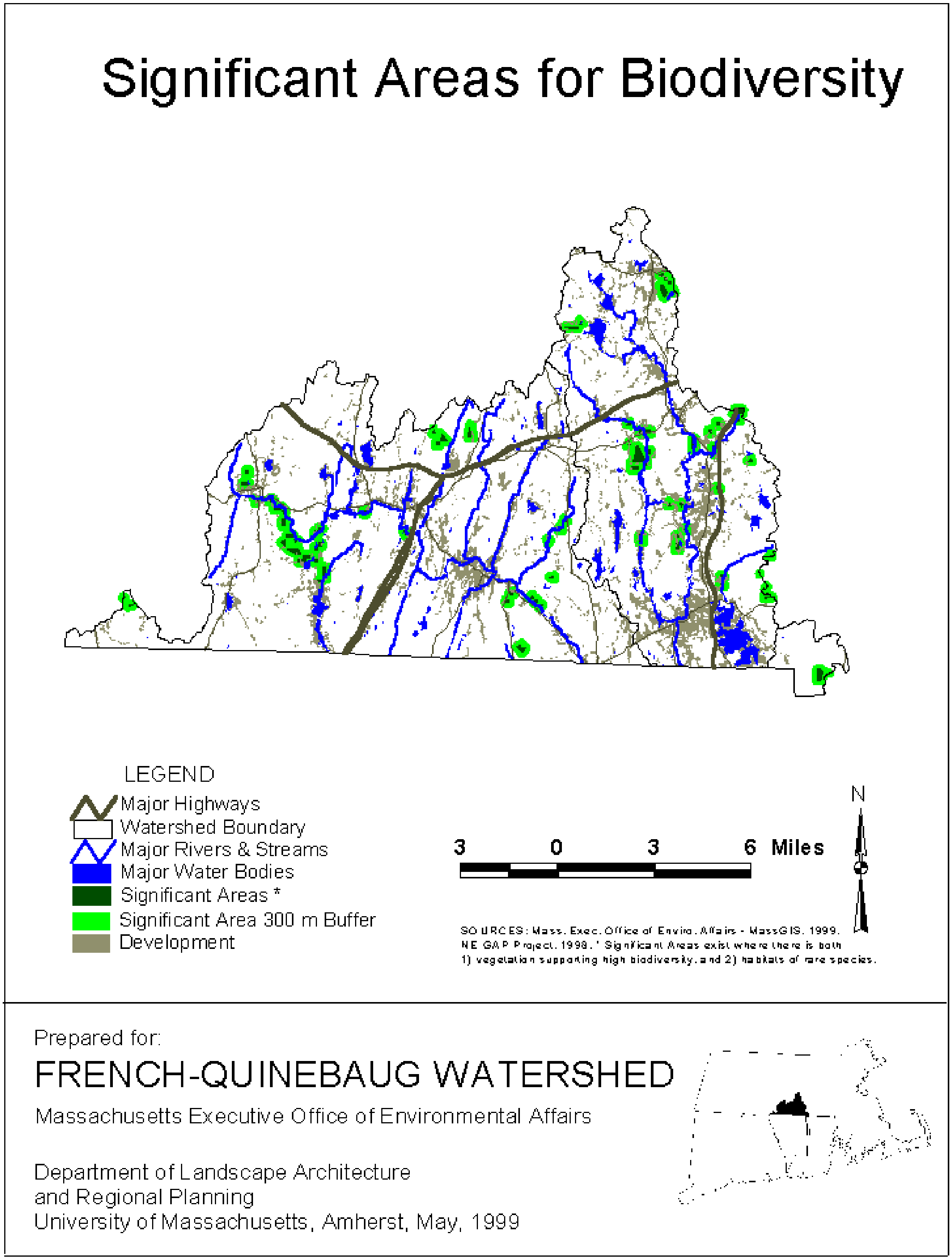


Figure 2.11 Significant Areas for Biodiversity. Source Data: MassGIS

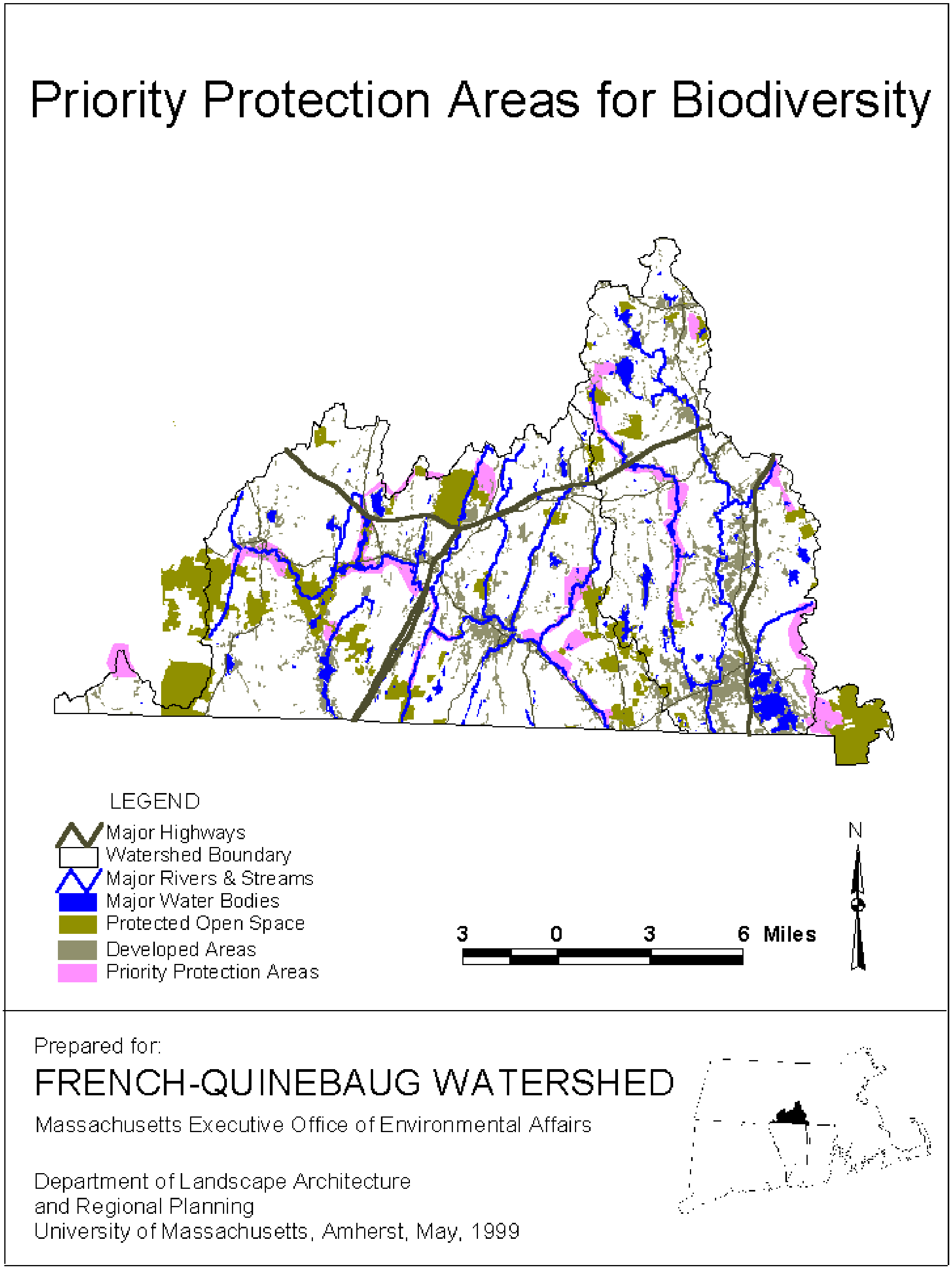


Figure 2.12 Priority Protected Areas for Biodiversity. Source Data: MassGIS

2.5 Landscape Ecology Principles

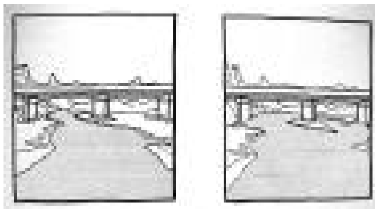


Figure 2.13 Culvert beneath interstate allowing land and water species to travel (Source: Dramstad, 1996)

Richard T.T. Forman (1995) has summarized several principles of landscape ecology that should be revered when planning on a regional or local level. Essentially, the structural pattern of a landscape or region is composed entirely of three types of elements: patches, corridors and matrices.

Patches are areas of vegetative cover that are either large or small, round or elongated, smooth or convoluted, few or numerous, dispersed or clustered and so forth. Generally speaking, larger patches are favored over smaller ones because

Many times, species are large land-roving types that need more land, whereas other interior species are more sensitive to the exterior happenings of the patch.

Corridors link patches, and are either narrow or wide, straight or curvy, continuous or disconnected, and so on.

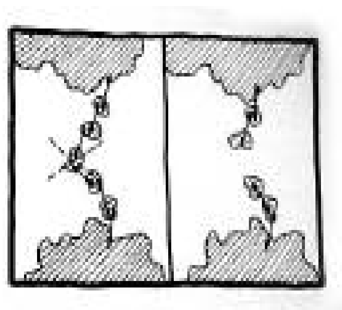


Figure 2.14 Stepping stones connect patches (Source: Dramstad, 1996)

Finally, pulling back from the region and looking at the landscape on a larger scale, the matrix is the pattern formed on the land, and can either be single or subdivided, variegated or nearly homogenous, continuous or perforated, and so on. These spatial patterns strongly control movement, flows and changes of wildlife species.

Note in Figure 2.9 the large patch of vegetation that allows larger species which require vast land areas, to thrive and roam. Additionally, these large patches create larger interior areas, protecting the interior species that might be sensitive to pressures immediately outside of the patch. Looking at Figure 2.10, we see the value of connectivity along riparian corridors, which is the path most wildlife prefer to take in their movement pattern. Figure 2.13 shows a highway over pass which allows passage for land and water traveling wildlife underneath highways. On the right, we see the appropriate path that provides both water and land movement under the bridge. In figure 2.14 we see the importance of 'stepping stones' to provide connectivity between patches of vegetation. Figure 2.15 shows what happens when a stepping stone is eliminated; wildlife can no longer move from patch to patch of vegetation.

2.6 Recommendations

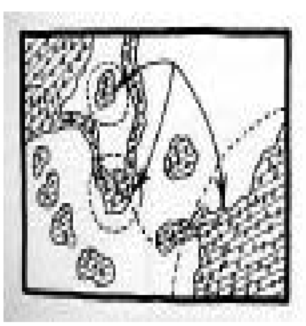


Figure 2.15h Elimination of stepping stones makes it impossible for wildlife to travel from patch to patch (Source:

This study has inventoried, analyzed, and assessed biodiversity in the French-Quinebaug Watershed. The final step in this preliminary plan is to build upon the findings of the research and to make final recommendations. The following are four general recommendations which the study team is making to help promote biodiversity in the region. These recommendations serve as a starting point for the region to plan for biodiversity and the environmental health of the watershed as a whole.

Study 'priority protection' areas more closely to determine actual species populations and movement barriers.

This study was the first step in identifying areas likely to have value for conserving biodiversity in the French-Quinebaug. However, further research is necessary prior to land acquisition efforts. The areas flagged as 'priority protection' areas must be more closely examined to determine actual species populations present (Figure 2.12). These areas should also be further studied to assess barriers to species movement, such as roadways or fences. Once this more detailed level of examination has occurred, the following recommendations can be fully implemented.

Examine open space acquisition options for "priority protection" areas.

This study has identified those areas in the watershed where there is the highest potential for biodiversity and where those areas coincide with habitats for rare and endangered species (Figure 2.11). These overlapping areas were further refined based upon proximity to riparian corridors, fragmentation due to urbanization, and existing protected lands. The result are a dozen areas identified as 'priority protection' areas where options should be explored for acquisition (Figure 2.12). To promote biodiversity, these priority protection areas should not be developed and should be set aside as open space. According ***to Our Irreplaceable Heritage***, "land acquisition is perhaps the most effective", tool for conserving biodiversity (Barbour, 1998. p.75). This can be achieved through a number of options.

1) Outright land purchase by municipality or state.
2) Purchase or donation of land with a land trust.
3) Acquisition of development rights by municipality or state (in combination with a transfer of those rights to a more suitable location).
4) Private participation in the Agricultural Preservation Restriction (APR) program.
5) Private participation in the Chapter 61 property tax abatement programs.

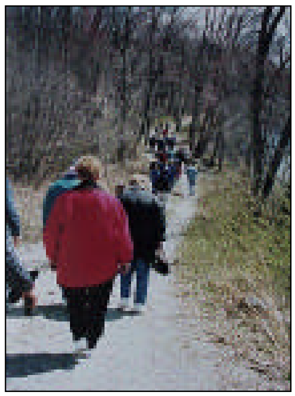
Ensure proper management of open space lands currently covering "priority protection" areas.

Although lands may be undeveloped, those lands are not necessarily managed for biodiversity. All open space lands in the watershed should be examined and the degree to which biodiversity is promoted should be assessed. In addition, the current management of lands identified as "priority protection" areas should be determined. If those lands can not be acquired or preserved in perpetuity, then owners should be encouraged to employ management practices which promote biodiversity.

Promoting biodiversity in your backyard

Even though much of the previous discussion to preserve biodiversity in the watershed has been at the large-scale level, much can be done to help at the private ownership level. Planting trees and shrubbery in yards helps wildlife make safe movement across the landscape. In particular, trees produce a canopy habitat for birds. Also, by not using pesticides and fertilizers on your property, the groundwater and the rivers in the watershed will receive fewer pollutants. Wildlife, as well as humans, needs fresh water and uncontaminated fish to eat in order to survive. Lastly, consider conservation easements on large tracts of land so that development will be limited on these important wildlife habitats and corridors.

3—Culture / History



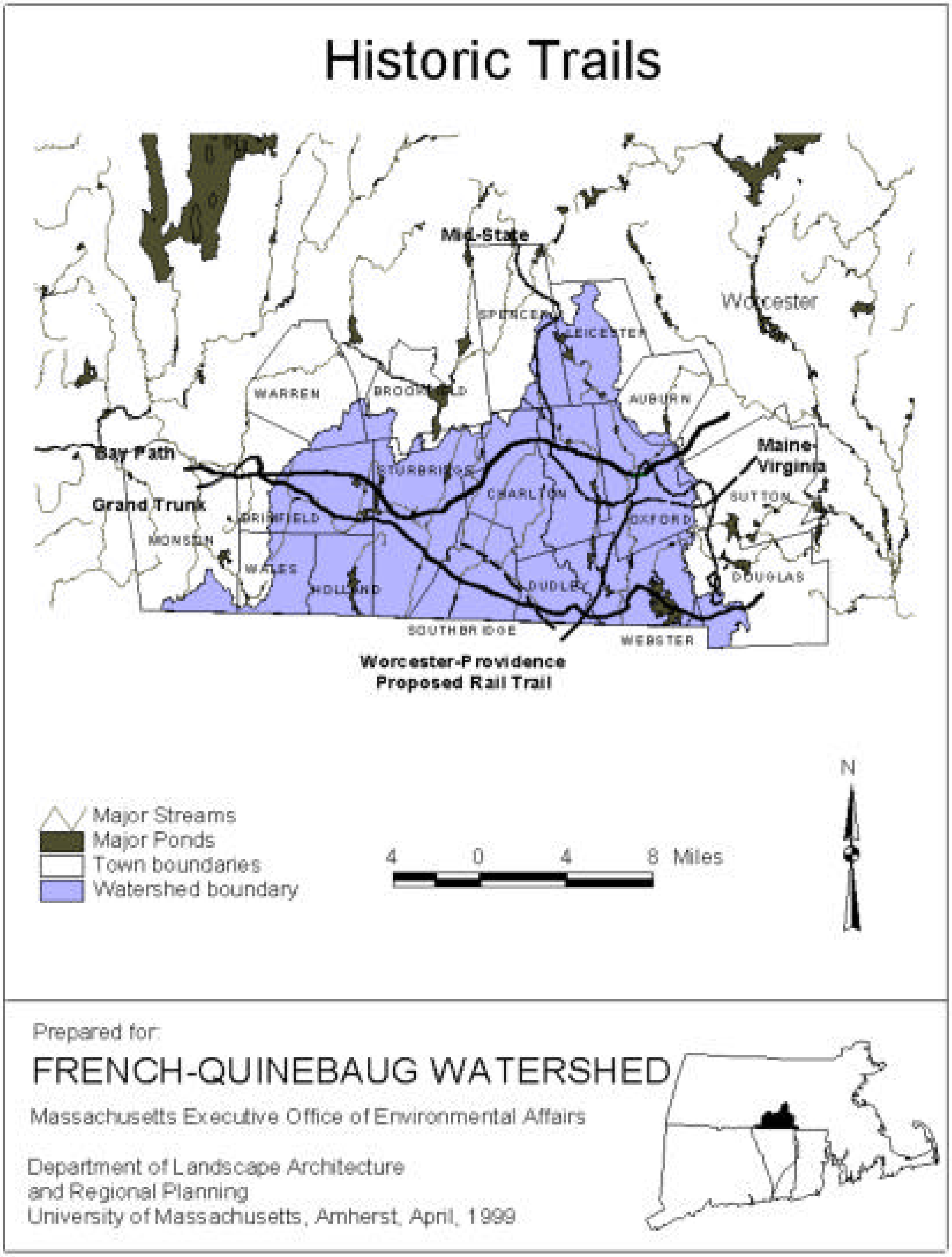
3 Cultural Resources and Issues

A vital component of comprehensive watershed planning is an understanding of the cultural resources and issues of the people who live in the area, both historically and currently. This human story of the French-Quinebaug watershed will be presented here in five sections. Section 1: a broad overview of regional history; section 2: demographic profiles of individuals, for example population, income, and education levels, and ethnicity; section 3: the identification of historical, cultural and recreational resources in the watershed; section 4: the results of the community survey conducted to obtain community input; and section 5: recommendations based upon all of the data collected and analyzed.

3.1 Cultural History in the French-Quinebaug

This brief history illuminates the dynamic between human activity and the landscape in the French-Quinebaug watershed from the earliest settlements to the present day. The landscape has shaped the culture of the inhabitants, beginning with the Native Americans and continuing through subsequent settlers, developing in them a strong sense of determination. Throughout all periods of human habitation, the waterways have played a vital role in how people have lived their lives. As indicated in Figure 3.1, box and lumber mill were located along the Quinebaug River for power generation. The waterways formed one of the many layers of transportation pathways that have crisscrossed the region throughout its history. Other networks include Native American pathways, which subsequently were transformed into early American roads and turnpikes. Railroads and streetcars followed stagecoach routes, and in the 20th century a network of highways crossed the region. This idea of networks, then, is an important theme in the history of the area, one which helps to us to understand where the region has been, as well as where it can go in the future.

Figure 3.1. Lumber Mill and Box Shop on the Quinebaug River. Source: 'A New England Town In Early Photography'


Historic Trails
Mid-State
Worcester
SPENCER
LEICESTER
WARREN
BROOKFIELD
AUBURN
Bay Path
Maine-Virginia
STURBRIDGE
CHARLTON
Grand Trunk
BRIMFIELD
SUTTON
OXFORD
MONSON
WALES
HOLLAND
DUDLEY
DOUGLAS
SOUTHBRIDGE
WEBSTER
Worcester-Providence
Proposed Rail Trail
Major Streams
Major Ponds
Town boundaries
Watershed boundary
4 0 4 8 Miles
N
Prepared for:
FRENCH-QUINEBAUG WATERSHED
Massachusetts Executive Office of Environmental Affairs
Department of Landscape Architecture
and Regional Planning
University of Massachusetts, Amherst, April, 1999

3.1.1 Native American Settlement

The human footprint on the French-Quinebaug dates to the prehistoric era, approximately 20,000 years ago, when the indigenous Algonquin people that included the Nipmuck, Pequot, and Mohegan tribes inhabited its forested uplands and river basins. Settlement patterns suggest that regional groups created important transportation routes through forests and along waterways in places where the natural features of the landscape presented opportunities. Examples include the "Bay Path," illustrated in Figure 3.2, parts of which still exist today and the "Great Trail," which stretched from New York to Boston. Their existence testifies to the historical importance placed upon transportation and communication networks. Area water bodies, another type of network, served as corridors for canoe travel for movement between seasonal camps. These transportation routes tended to follow the natural features of the land, making movement as easy as possible. As for waterways, historian Charles H. W. Foster argues, "...river and streams, rather than provide fixed boundaries as they do today, were reserved as general travel routes through territories" (1998, p 4). Archeological assessments have documented the presence of prehistoric sites around rivers, lakes and streams (Bell,1990).

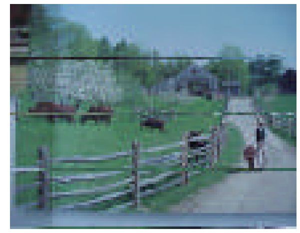


Figure 3.3: Agricultural Landscape

During the Late Woodland Period (A.D. 1200), the Algonquin Indian culture was based on agriculture, fishing, and hunting. Landscape structure was altered significantly by these practices, clearing the way, literally, for the early settlers. One agricultural practice was the use of wild fire to clear land for cultivation. Successful cultivation of maize, beans, squashes, and medicinal plants also required an understanding of local natural factors and assets. Human adaptation to the local environment revealed itself in the Algonquins' material culture. Their pottery, jewelry, utensils, and tools show an awareness of clay soils and local stone as natural features that they could manipulate and mine. Local people today still speak of the Tantiusques mine (also referred inaccurately as "leadmine") from which the Native Americans would extract graphite for facial adornment.

The Native American presence in the French-Quinebaug underwent crucial pressure to be assimilated into Puritan culture. Increasingly, as colonists ventured inland, the Native American population suffered from introduced diseases and assimilation pressures. Those areas in which tribes chose to convert became know as "Christian Towns." By the mid-1600s the growing impact of these cultural developments and clashes had reached an impasse. Former attempts to coexist disintegrated with the onset of King Philip's War in 1676.

Over the decades following King Philip's War, the relationship between the people and the land in the French-Quinebaug changed from a model of ecological coexistence to one of agricultural and industrial exploitation of its natural resources. Native American activity placed nominal demands on the watershed, yet their presence left a legacy of networks from which subsequent groups would benefit.

3.1.2 Early Settlement in the French- Quinebaug Watershed

European settlement in the watershed grew from a desire to utilize the rich natural resources of the inland, including agricultural land, abundant water sources, and rich woodlands.

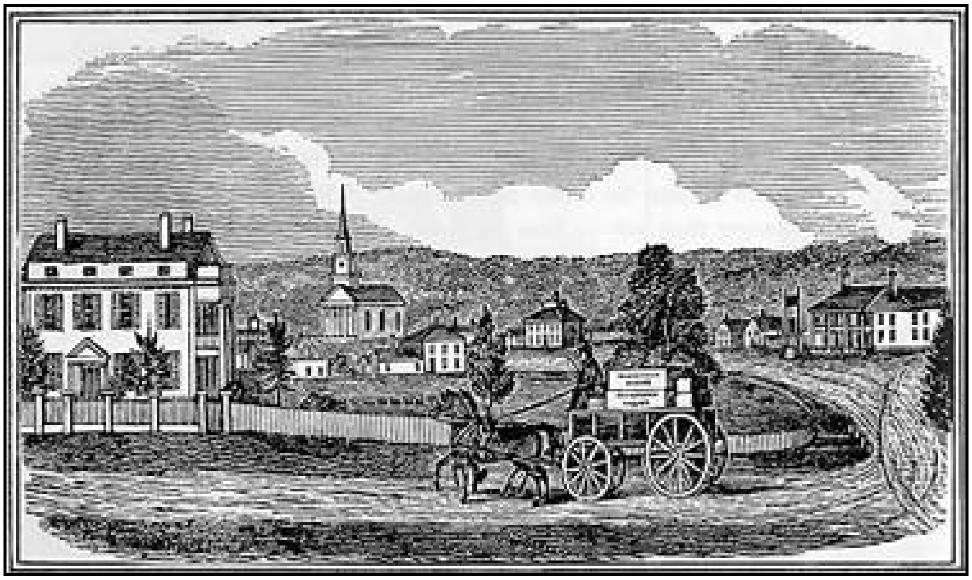


Figure 3.4: Woodcut of Brimfield, 1830's, by John Warner Barber

In the early 17th century trouble was brewing in England. Many in the upper classes feared economic insecurity as the peasants were losing their common land in the Inclosure Movement, a series of Parliamentary Acts which resulted in land ownership being transferred from the peasants to the wealthy. At this time, a segment of the society was discontent with the Church of England, namely the Puritans. As a result, some headed to America in hopes of serving God by purifying the church. It became their focus to establish a community that would fulfill God's will.

In the French-Quinebaug, the earliest settlers migrated from the Boston area, when Eastern Massachusetts could no longer provide the land necessary for the settlers to fulfill their obligation to the English Crown. The organizing force in this society was religion. Life and settlement revolved around town meetings during which early hardships, both political and economic, helped to mold character. The town hall stood as the nucleus around which these newcomers organized every aspect of society. Another settlement factor was close proximity to river and streams, both for irrigation and waterpower for grist and saw mills, which became the economic base of these early towns. Figures 3.3 and 3.4 illustrate the kind of communities early Europeans in this area created.

In the late 17th century and early 18th century the settlers' search for economic vitality stimulated industrial ingenuity. Agricultural endeavors tended towards local market consumption due to transportation limitations. As such, they were more isolated from the commercial activities of the larger urban centers, such as Boston, Providence, and Hartford. Farms were the center of family life and a base for other entrepreneurial ventures, as seen in the development of the home-based or cottage industry economy. Many individuals chose to readapt to the limitations placed on farming by diversifying their artisan and mechanical skills to other kinds of industrious activity. This prototype industrialization, evident in presence of 18th century mills, facilitated further industrial growth.

The primary factor in the area's industrialization was the favorable gradient of the region's rivers and streams. This gradient propelled the water with a force sufficient for powering mills, and in places that did not have this natural, dams were built. Ambitious individuals harnessed the waterpower for industrial manufacturing, producing the items listed in Figure 3.6. The lure to develop industry inland in regions such as the French-

Quinebaug was bolstered by the decline in maritime supremacy induced by the Embargo of 1807 and the War of 1812.

The arrival of Samuel Slater, an English immigrant, deserves mention because of his success in introducing water-powered spinning to his new country and its subsequent impact on the factory system in the early 1800s. Close proximity to powerful rivers, cheap labor, and accessible routes-all of which existed, or could, in this region became the catalysts to prosperity. The adoption of an industrial economy began with textile manufacturing, which dominated Massachusetts' economy until the 20th century. By 1850 more than half of the textile factories in the state were located in rural townships of less than five thousand, such as Dudley, Oxford, and Webster.

The demographic impact of the factory system led to a significant growth in the townships, as the factories came to depend on immigrant labor. When the local population could no longer supply the labor demand, eager industrialists searched abroad. In addition to adults, children, native and immigrant, constituted a large proportion of the work force. The Irish Potato famine in the first half of the 19th century

Figure 3.5: Immigrant labor force living in a work camp. Source: 'A New England Town in Early Photographs'

helped supply the work force to meet an ever-increasing demand for labor in the mills and on the rail lines. Webster saw groups of Irishmen come to work on the Norwich and Worcester Railroad. These men stayed only as long as work was available. The next influx consisted of French-Canadian farmers, who succumbed to the lure of mill managers looking for a new labor force. Quebec's poor soil and limited industry drove hundreds of families southward in a hope to better their lives in the emergent mill towns. After the Civil War, the demand for workers increased as American-Optical, Hamilton Woolen, and other major mills stepped up production. Other ethnic groups followed the Irish and the French-Canadians to the region, including Albanians, Greeks, Romanians, Poles, and Italians. Some of these immigrants lived in boarding houses, work camps, and tenements, illustrated in Figures 3.5 and 3.7.

Industrial activities in the French-Quinebaug Area included the production of:

- cotton goods
- woolen goods
- boots
- shoes
- leather
- palm-leaf hats
- straw bonnets
- chairs
- cabinetware
- trunks
- wagons
- sleighs
- plows
- axes
- scythes
- wire
- harnesses
- iron ore
- iron castings
- pocket rifles
- bits
- augers
- satinet factories
- card manufacturing

Agricultural products included:

- butter
- cheese
- beef cattle.

Granite quarries and graphite mines were also found.

Figure 3.6: Industrial Products Source: Massachusetts Towns

Figure 3.7: Construction of a work camp. Source: 'A New England Town in Early Photographs'

These new groups began to establish their own small communities by building churches and forming clubs within the towns. These groups changed the cultural dynamic of the French-Quinebaug by establishing permanency and creating communities rich in ethnic diversity.

Throughout the 1800s, the demographic changes coupled with the rise of industrial activity necessitated better transportation routes, such as canalways, trolley lines and railroads. Construction of these transportation modes and routes, including a Worcester to Springfield Trolley and the Worcester to Norwich railroad, required cheap labor, which the industrialists continued to find in the waves of immigrants flooding the country. Italians, for example, were the primary forces behind the building of the never completed Grand Trunk Railroad, depicted in Figures 3.8 and 3.9.

These industrial developments rapidly taxed the watershed. The construction of transportation routes disrupted natural features and decreased water quality. As the population grew, greater demands were placed on the water supply and on other natural resources, such as timber. Forests were stripped of timber necessary for housing, shops, rails, and fuel. Ever-increasing demands were being placed upon the environment.

By the end of the century, the prosperity ushered to the French-Quinebaug by industrialization began to lag because of the railroad expansion to the far-reaches of the country and because of the emergent power of the labor unions in the area. These developments placed the region in direct competition with the Western and the Southern states, which possessed superior soils, cheaper goods, and non-unionized labor.

Figure 3.8. Devastation to the Landscape Wrought by Construction of the Grand Trunk. Source: 'A New England Town In Early Photographs'

Figure 3.9: Supervisor instructing workers during construction of the Grand Trunk Railroad, Source: 'A New England Town in Early Photographs'

3.1.3 The French-Quinebaug in the 20th Century

Mills continued to hum along the French and Quinebaug rivers until the early 1920's when cheaper, non-union labor costs in the South and overseas slowly drew the mills out of the region. An agonizing economic decline slowed activity in many towns. Jobs left the area but the population continued to grow. One reason is the existence of bedroom communities within the watershed, from which its residents commuted to cities and towns outside the area for work including Worcester and Springfield. The most likely bedroom communities existed closest to Worcester, namely Leicester and Auburn. Commuters from these towns slightly outnumbered the people leaving the more heavily industrialized towns, such as Webster, Oxford, and Dudley. These bedroom communities faired better economically than the others in the watershed, with the exception of Sturbridge where tourism remained strong. The others experienced an economic decline that hampered development until W.W.II. The post-war period saw the area regain some of its former momentum as high tech industries searched for sites proximal to important research and development centers such as Boston. These technology-based industries attracted highly skilled workers. Area initiatives to boost the economy resulted in a variety of efforts. For instance, American Optical, shown in Figure 3.10, has led the country in fiber optics for generations. To ensure the longevity of their business they adapted to and incorporated state-of-the-art technology. Furthermore, they refitted their site in Southbridge to encourage non-manufacturing enterprises to set up business,

Figure 3.10: American Optical in Southbridge – offering new economic hope to the area

such as Department of Defense. The Department of Defense is setting up a financial training facility here. Other economic activity points to a continuance of the home-based economy present in this area since Colonial times, as seen in the array of arts, crafts, antiques, and produce available in the area. In the watershed agriculture has a substantial agricultural heritage, and farming and agriculture still viable of ways of living in the French-Quinebaug watershed area as we see in Dudley Another economic activity seen in the area is tourism. The primary tourist attraction is Old Sturbridge Village. People flock to the 19th century working museum because of its charm and its educational value. As a result, local shops benefit from the patronage. Tourism is viewed as a potential "clean industry" which can help the economy grow without doing too much damage to the way of life currently enjoyed here. Business is facilitated by highway networks which cross the region from north to south and east to west, including I-80, I-84 and I-395. Once again, the network of transportation pathways that have played a crucial role in the regional history will continue to shape its future.

3.2 Demographics

3.2.1 Population

Several sets of demographic data were analyzed for the watershed to gain an understanding of the people who have lived here historically and currently. Figure 3.11 is an historical graph of the watershed's population from 1800 to the year 2000. It shows a steady increase in population over the past 200 years, with a slightly accelerated growth rate from about 1940 on, which is probably a function of the automobile and modern infrastructure of the region – the last transportation network layer to cross the region.

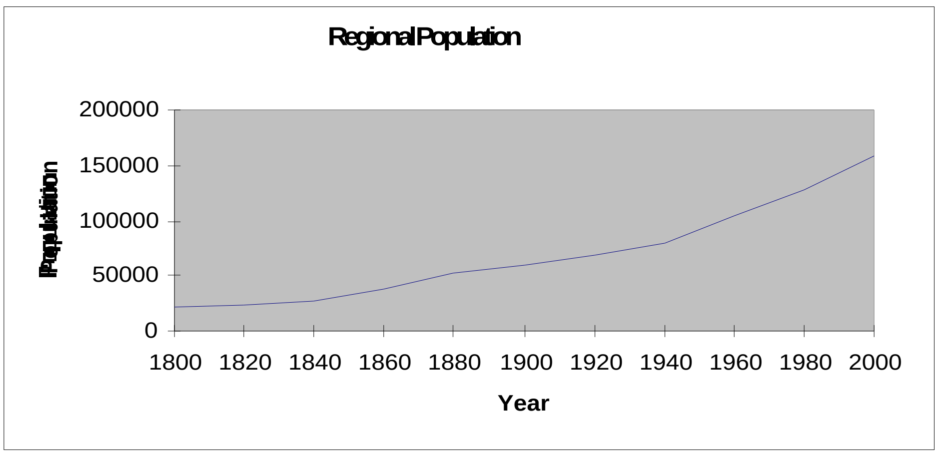


Figure 3.11: Historical population graph, 1800-2000. Source: 'Historical Atlas of Massachusetts'

During the 1950's and 60's the building of the interstate highway system opened up this area to people who wanted to live here but continue to work elsewhere, in particular Worcester and Springfield.

Figure 3.12 is a population distribution map for 1990 based on data from MassGIS, indicating that the highest population concentration in the watershed is in the central to eastern portion, with a lesser concentration of population in the western portion. Interestingly the highest population concentrations occur where the French and Quinebaug rivers primarily flow, and where the Massachusetts Turnpike (I-90) intersects north-south highways like I-84. The towns of Southbridge, Webster, and Auburn have the largest populations, while the towns of Holland, Wales, Brookfield and Brimfield have the smallest. We can see a shift in the cultural landscape from the west to the east, from a more rural quality to a more suburban or even urban one. Population concentration in the northeast corner of the watershed is a function of its proximity to Worcester, a city that employs many of the people who live in this area. Figure 3.13 is a projected population distribution for 2010 again based on data from MassGIS, showing a continuation of the current trend in population growth for the watershed. Population increases are anticipated to occur in many towns, but again will occur primarily in the places where it is already concentrated, to the central and eastern portions of the watershed. The highway corridor stretching from Worcester to Providence will also exacerbate the population growth in these areas. Good planning now can direct this anticipated growth to areas most able to manage it and can help to reduce the occurrence of suburban sprawl, which consumes land, water supplies and other important resources. Planning now will also help to preserve open space and significant historical and cultural resources. It is important to note that the population numbers presented here are somewhat higher than in actuality because the census information used includes population for whole towns, not just the portions of each town that fall within the watershed. Several of the towns on the edges of the watershed are only partially located within the French-Quinebaug. In some cases, the watershed encompasses less than 20% of towns located along the boundaries.

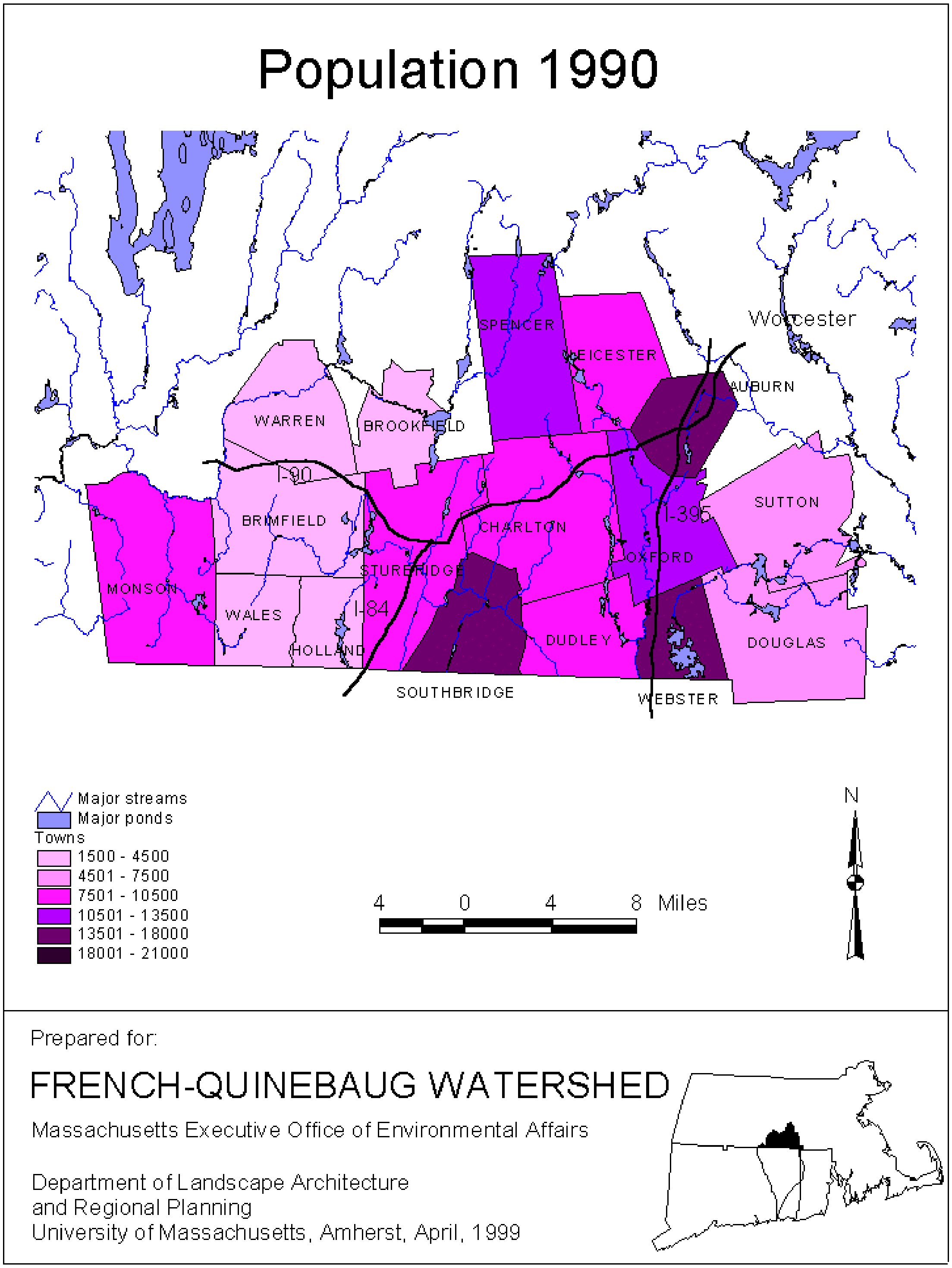


Figure. 3.12 Population 1990 Distribution Map, Source: MassGIS

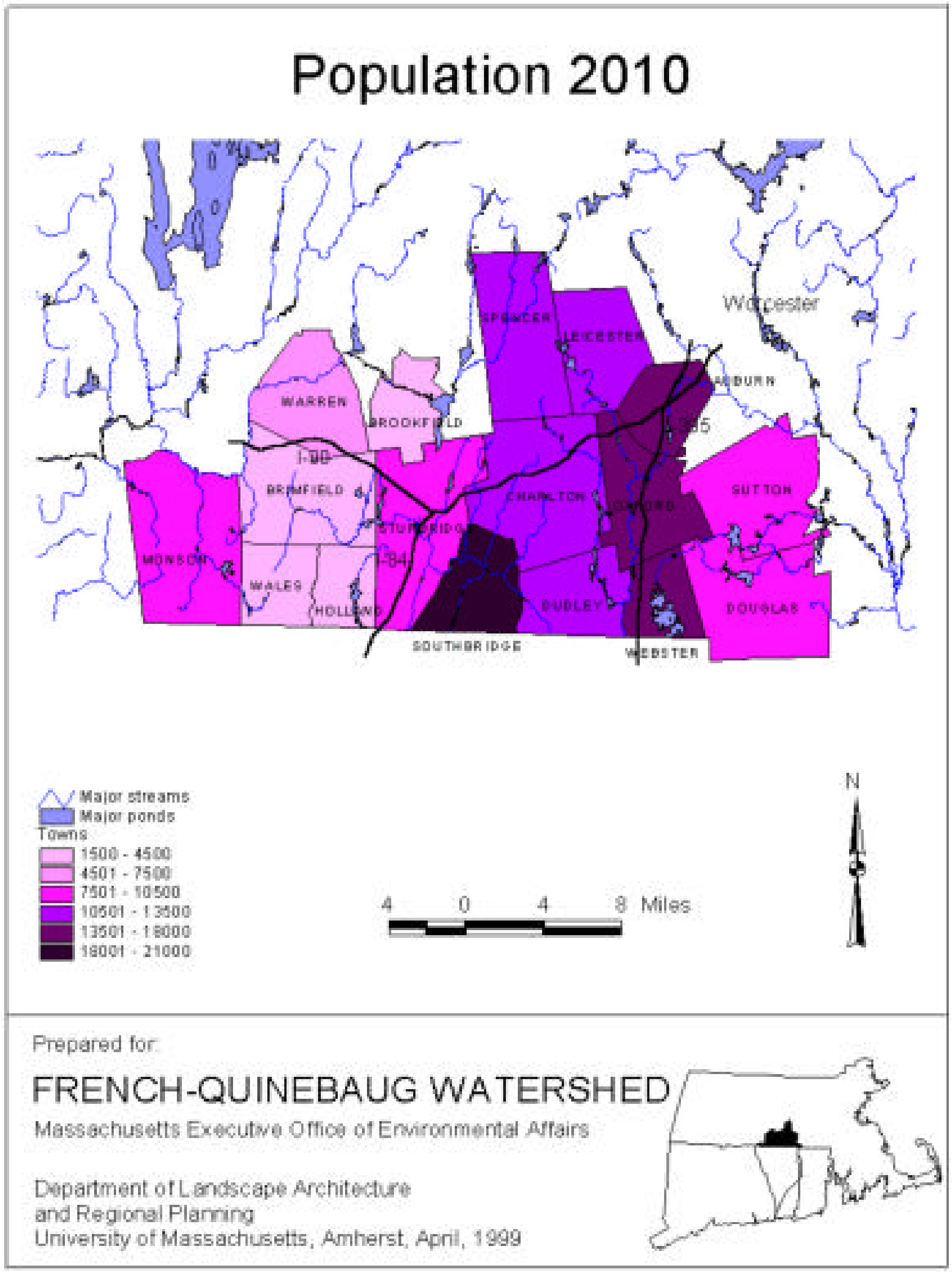


Figure. 3.13 Population Projection for 2010, Source: MassGIS

3.2.2 Income

Figure 3.14 illustrates average income level by town from U.S. census data, and it shows moderate variability among the towns, ranging from a yearly average of about $28,000 to $30,000 in Southbridge and Webster into the $42,000 to $48,000 range for Sturbridge, Sutton and Charlton. It is interesting to note that the towns with the lower average incomes are ones which had lacked economic recovery that followed the decline of the mills. They also have many old mill buildings and worker housing which could be adaptively reused, presenting an opportunity to improve their economies. Sturbridge is a fine example of such a town, which has adaptively reused many of its old mill buildings, and the medium income of this town is relatively high. The state median is $36,952, which places approximately half of the watershed's towns at slightly above average and half slightly below.

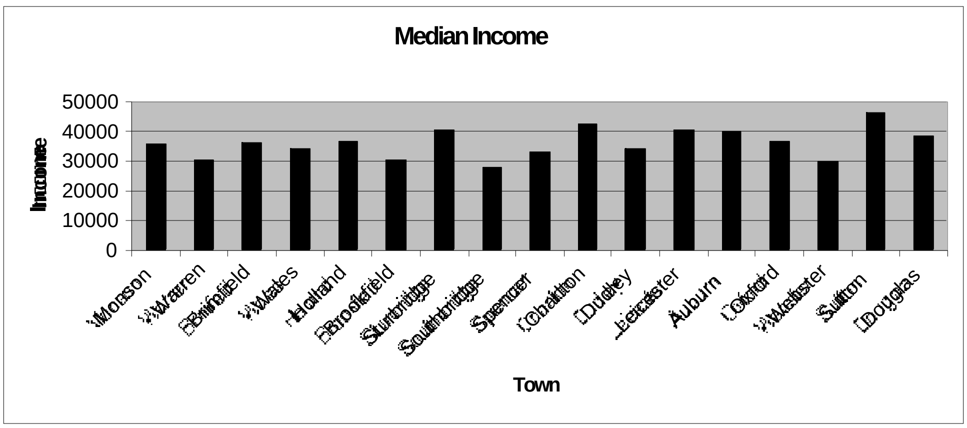


Figure 3.14 Median Income graph by town. Source: MassGIS

3.2.3 Education

Education levels by town from U.S. census data, again indicating a moderate range among the towns (Figure 3.15). About 65 to 85% of people have completed high school or higher, while 5 to 25%have earned a bachelor's degrees or higher. Not surprisingly these numbers tend to be positively correlated with income levels, and so towns with more education have a greater income.

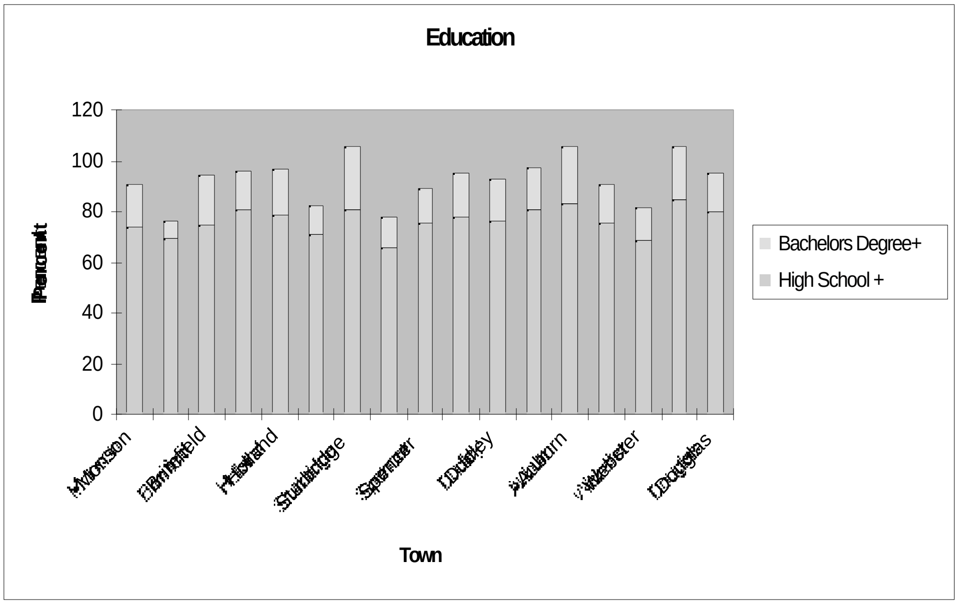


Figure 3.15: Education level by tow. Source: MassGIS

3.2.4 Ethnicity

Figure 3.16 illustrates racial ethnicity by town from U.S. census data, indicating that about 97% of the watershed's population are Caucasian. Figure 15 shows a breakdown of non-white population, which shows that Southbridge is the one town which shows considerable ethnic diversity, with about 15% of its population non-white, primarily Hispanic. Figure 17 illustrates that while Hispanic populations account for most of the watershed's non-white population, Asian, Black and American Indian populations are also prevalent.

It is important to note that the people of the watershed are far more ethnically diverse than these numbers might indicate. Under the label "Caucasian" fall many of the immigrant groups who came to the area historically and currently, including Irish, French-Canadian, Romanians, and Poles. The region can be understood as one that has attracted immigrant groups throughout its history, creating diversity that has contributed to the cultural landscape.

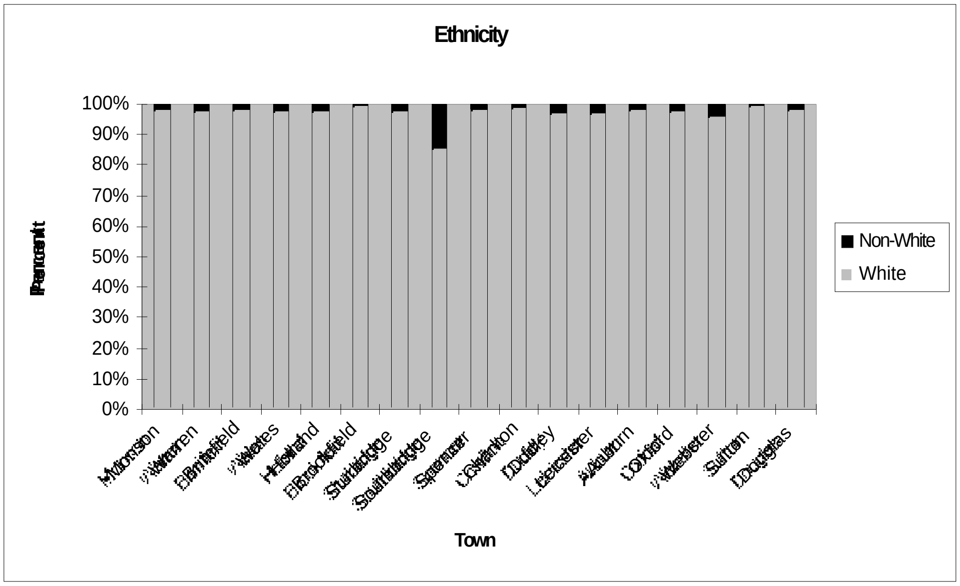


Figure 3.16: Racial ethnicity by town, Source: MassGIS

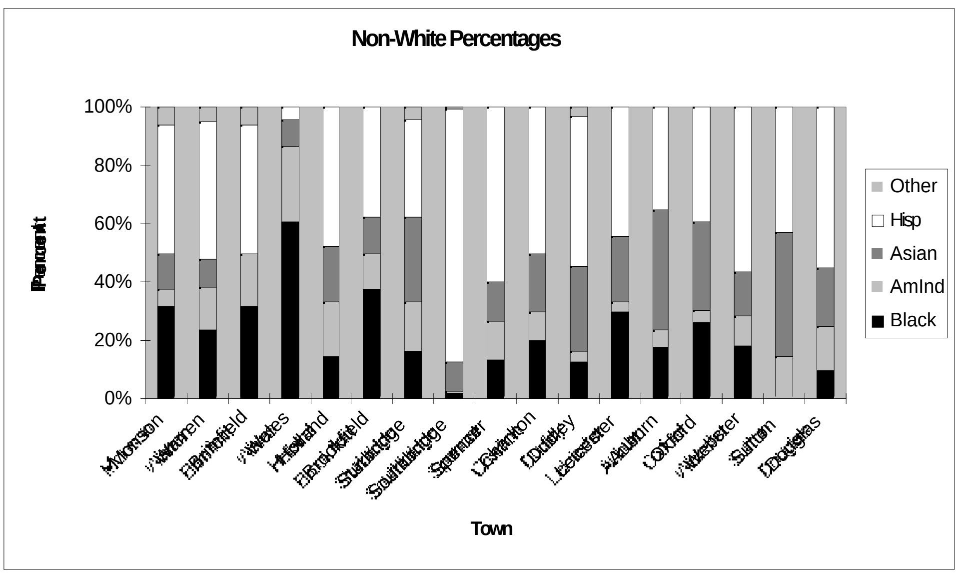


Figure 3.17: Non-white ethnicity by town, Source: MassGIS

3.3 Historic And Recreational Resources

In order to understand the historic resources in the watershed, we mapped and charted the State Register of Listed Historic Places. Appendix F is a chart of the State Register listed properties in the watershed, including their name, type of property, and date and reason of significance. The numbers correspond to those on Figure 3.18, a map of the distribution of Register-listed properties throughout the watershed; this information was obtained from the Massachusetts Historical Commission and local town historians. This map illustrates the unusual and noteworthy abundance of historic sites in the area, making this watershed a unique cultural and historical resource. Altogether there are 117 register listings for the watershed, including:

15 National Register Historic Districts (11 in Southbridge)
89 National Register Individual Properties (72 in Southbridge)
1 National Register Multiple Resource Area (town of Southbridge)
7 National Register Determinations of Eligibility
4 Preservation Restrictions
3 Local Historic Districts

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117 historic listings in total

The sites tend to be located in town centers, which in turn tend to be located along rivers. Southbridge has an enormous concentration of historic properties (84 listings), making it an extremely unique historical resource. In fact, the entire town is designated as a Multiple Resource Area on the State Register, again indicating its uniqueness as a cultural and historical resource. It is important to note that listings on the State Register are primarily honorific, and offer very minimal protection. For example, if state monies were funding a project, which affected a Register-listed property, a review process would be triggered, but this does not guarantee the protection of the site. The four properties with preservation restrictions (See Appendix F) have easements, which legally protect them, and so they have a much higher degree of protection than the other Register listed properties.

The unusual concentration of historic sites in the watershed supports the application of this area to join the Quinebaug-Shetucket Rivers Valley National Heritage Corridor. Clearly this is an area with a unique and important history, indicated by the abundance of historical structures that survive to tell this story. The funding and technical assistance that would result from Heritage Corridor status would help the region to preserve and further develop this vitally important cultural heritage.

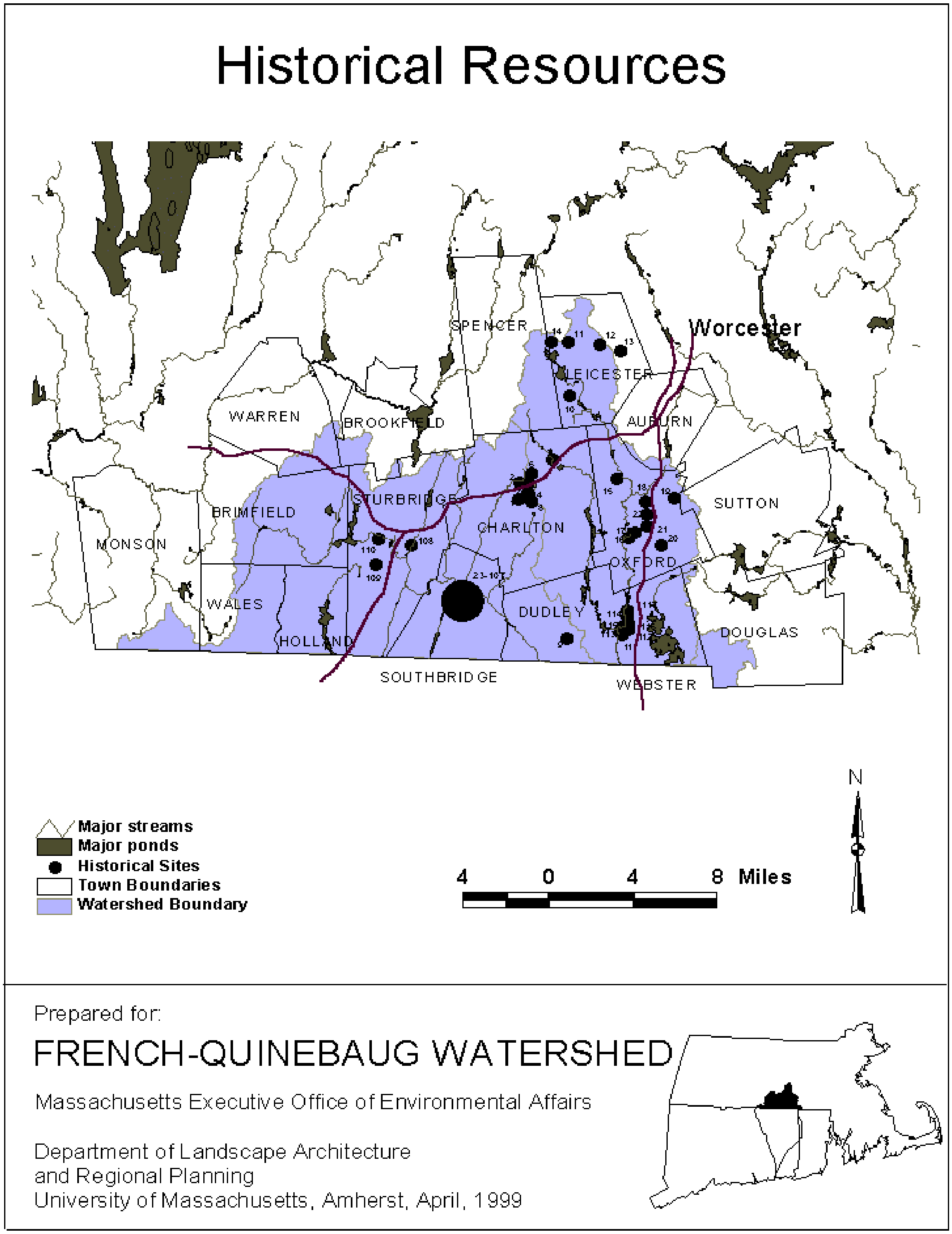


Figure. 3.18 Historical Resources Map, Source: State Register of Historic Places

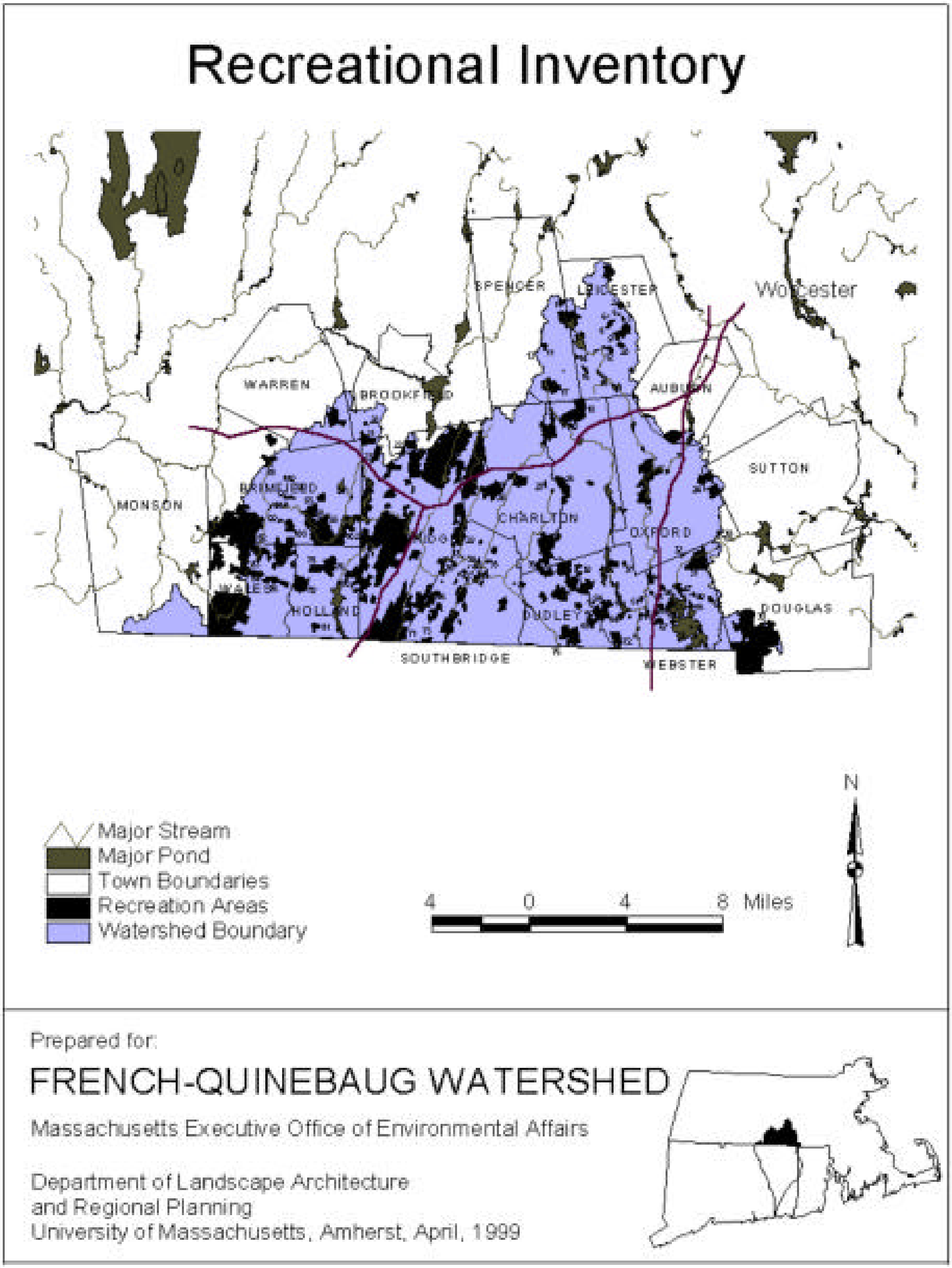


Figure. 3.19 Recreational Inventory, Source: MassGIS

Figure 3.19 shows the distribution of publicly accessible recreational sites in the watershed, and the numbers here correspond to the Recreational Inventory chart located in Appendix G. The map includes areas for camping, canoeing and hiking, as well as resources such as state forests, lakes, rivers, and streams. Yet, in this data-layer, which comes from MassGIS, also includes the parcels protected under the State's Agricultureal Preservation Restriction Program those are not open to public recreation. These areas also shown the recreational site map since these parcels are included in "open space" datalayer by MassGIS. There is a large number of recreational sites in the watershed, and they are fairly evenly distributed with a slightly higher concentration in the western portion. In addition to providing humans with recreational opportunities, these sites also offer important areas for wildlife habitat, as described in Section 2.

Figure. 3.20 Active recreation in the French-Quinebaug

3.4: Community Survey

Because community input is a vital part of comprehensive watershed planning, we conducted a survey to obtain community input on many different subjects, including three key areas: 1. What are the most important cultural, historical and recreational resources in the watershed; 2. What kind of future development do residents want; and 3. What resources or places need to be protected and preserved?

The survey consisted of several questions about these issues (see Appendix I). We conducted two versions of the survey, the first one more extensive and aimed at planners and town representatives. This was distributed to those attending the kickoff workshop at Old Sturbridge Village in late March. The second survey was shorter, aimed at the general public, and was conducted by random phone calls. We conducted nearly 80 surveys, which included about 50 from the community and about 30 from the planners and town representatives.

Regarding key historical, cultural and recreational resources, people consistently identified Old Sturbridge Village, the town of Sturbridge, the Brimfield antiques festival, and the Quinebaug River as key resources. Other areas identified as favorite historic and recreational places varied according to town. No one other resource emerged as a major watershed-wide attraction, probably because there are so many resources here.

Figure 3.21 Clara Barton House Museum

Regarding development, tourism was most often identified as the preferred form of future development for the watershed. Regarding resources to be protected and preserved, people identified water quality, historic areas like mills along the Quinebaug and the Clara Barton homestead (shown in Figure 3.21), agricultural areas like those in Dudley, local businesses, and rural character like that in the western towns of the watershed. It was interesting to note that most of the people expressing concern for water quality were the town representatives, not the community, who tended to identify economic concerns more frequently. Also of interest was the fact that only two respondents mentioned the newly constructed Millennium Power Plant. Both respondents felt that this was a negative addition to the watershed, and indicated interest in holding out for “better, cleaner businesses” in the future.

3.5 Recommendations

Based on the community input obtained from the surveys and the cultural resource research and analysis, an assessment of key historical, cultural and recreational resources in the watershed and ways to link them was prepared. This is shown in Figure 3.22 as a Recommendations map. Once again the idea of a network of pathways emerged as an important way to understand the area and to give it a sense of identity. The existing and proposed trails, like Bay path and Grand Trunk, will construct the bone of this network. Since Sturbridge, Brimfield and the Quinebaug River identified as important historic sites in the surveys, we included these sites as the attraction points that protects the cultural history of the watershed.

The map illustrates that these points are more or less connected by the old Grand Trunk rail line, shown on Figure 3.22 as the southern-most east-west trail on the map and passing through the towns of Sturbridge, Southbridge, and Webster. It is a valuable historical resource and a great way to connect many of the towns in the watershed. Other historic trails such as the Southbridge Spur (shown on Figure 3.22 as the short line connecting the town of Southbridge with the Connecticut border) pass through the other towns in the watershed, providing important regional links. While the physical impact of some of these railroads upon the landscape had been devastating historically, now their rights of ways can help to connect the region and to provide it with a sense of identity.

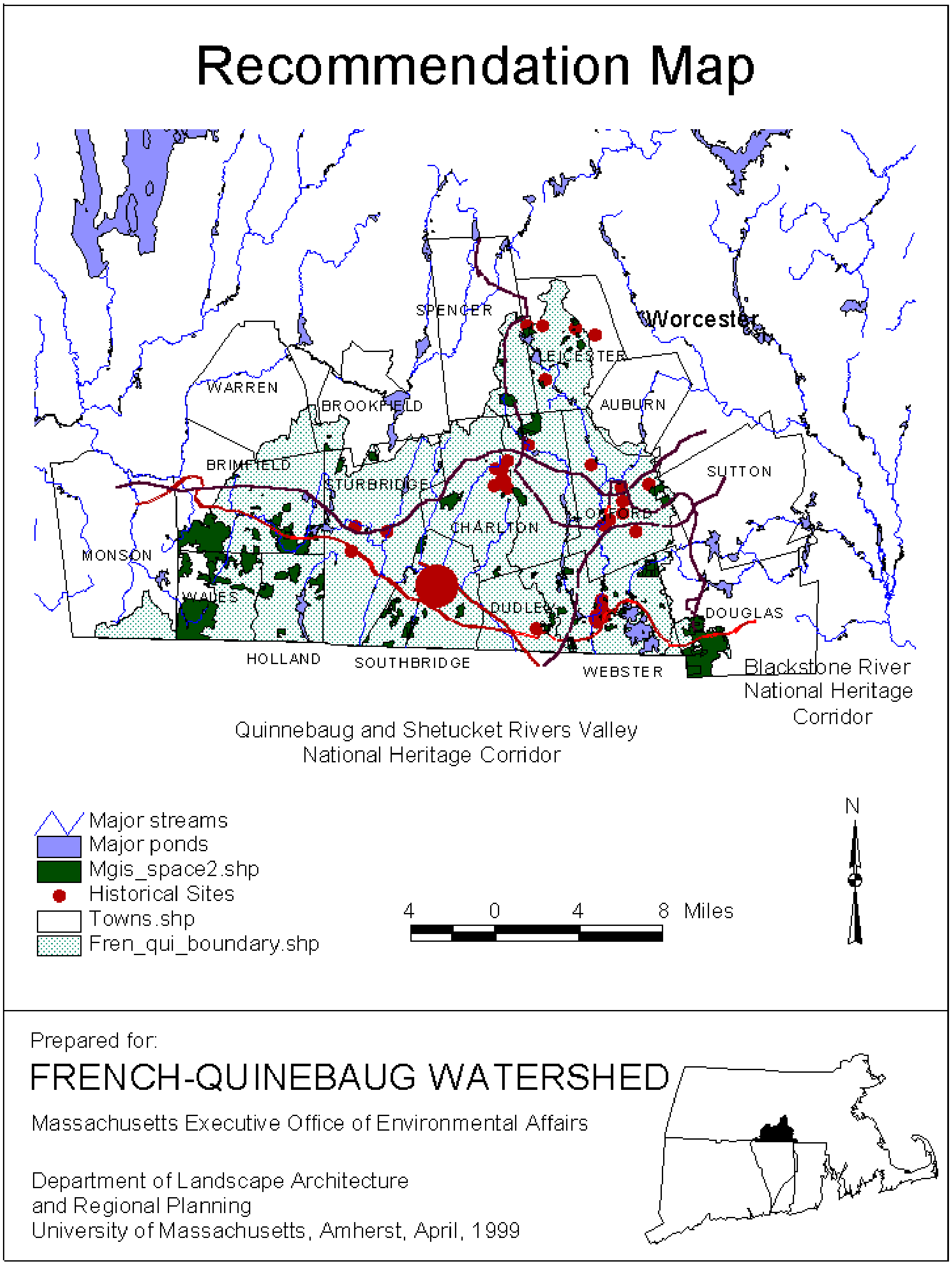


Figure 3.22 Recommendation Map. Source Data: MassGIS

In addition to this recommendation map, five specific recommendations emerged out of the community input from the surveys.

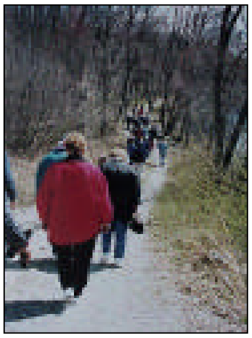


Figure. 3.23 Present day users of the Grand Trunk

Extend the Quinebaug-Shetucket Rivers Valley National Heritage Corridor from Connecticut into Massachusetts

The Quinebaug-Shetucket and the French-Quinebaug watersheds are part of the Thames Watershed. The goals of the Heritage Corridor are similar to community input from the surveys. Extension of the Heritage Corridor into the French-Quinebaug watershed is an opportunity for the people of this area to obtain federal funding and technical assistance for the following projects and recommendations.

Develop tourism

Tourism was identified by residents as the most desirable future form of development for the watershed. It represents a way for the economy to expand while still preserving open space and rural character, and it doesn't require expenditure on costly infrastructure like schools, water and sewer lines. Old Sturbridge Village and a newly developing tourism center in Webster-Dudley-Oxford are resources which already exist in the watershed and which can serve as models and sources of information for the future expansion of tourism.

Figure 3.24 Hamilton Woolen Co.

Develop sections of the Grand Trunk, Southbridge Spur, and other rail trails for recreational purposes

The Grand Trunk Railroad is an incredibly unique historical resource, of interest to railroading enthusiasts as the last great railroad project in the Northeast as well as to those captivated by the connection to the developer of the Grand Trunk, who lost his life on the Titanic. Sections of it as well as other defunct railroads such as the Southbridge Spur could be converted into a trail (see Figure 3.23), which would possess great historic, recreational, and environmental interest. The railroads pass through varied landscapes, ranging from towns to forests to fields. Not only would they link key historical, cultural, and recreational resources like Brimfield, Sturbridge, and Southbridge, but they would also physically link the towns, helping to increase the sense of regional identify as the French-Quinebaug watershed.

Develop river awareness and other educational programs

As mentioned earlier, it was surprising that so few members of the community identified water quality or other water related issues as a concern. There is an opportunity here for education. Educational programming could help to increase stewardship for the watershed by increasing people's knowledge of key resources, and would help to improve water quality.

Encourage adaptive reuse

Adaptive reuse is the creative adaptation of older, existing buildings into economically viable contemporary uses, illustrated in Figures 3.24 and 3.25. Within the watershed there are many old mills and other buildings with historic value and character which could be reused for new enterprises such as businesses. Adaptive reuse would help to preserve the heritage and historic character of the region while also preserving open space, both important issues identified by many people on the surveys. Businesses that reuse historic properties according to federal guidelines may be eligible to receive a federal tax credit. There is a good example of adaptive reuse at the American Optical campus in Southbridge. Formerly the home of an optical manufacturing company, in addition to its ongoing optical manufacturing and research activities, the campus now includes leased space to several different companies

3.6 Conclusion

The French-Quinebaug is an area rich in regional cultural history and recreational resources, an area with much to offer. In order to achieve the kinds of goals identified in the survey, namely to increase tourism and other forms of economic expansion while still protecting open space and historic character, the region must come together and act now to plan effectively for the future.

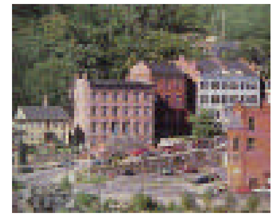


Figure.3.25 Historic Mills

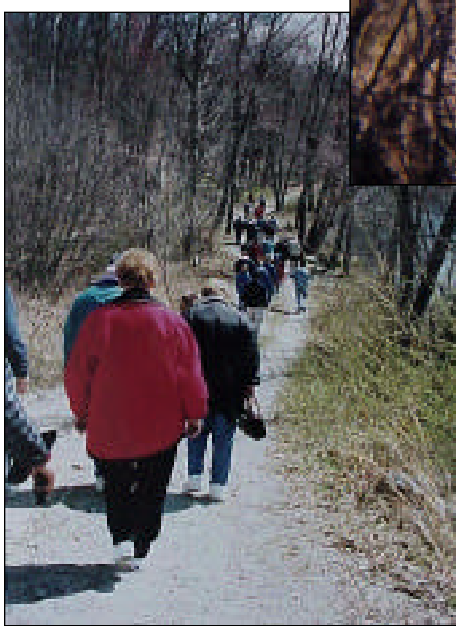
"Except for their political orientation toward Boston instead of Hartford, the Massachusetts towns in the Quinebaug watershed bear a strong resemblance to their Connecticut counterparts. They share the same settlement patterns, both Native American and Euro-American. Some towns now in northern Connecticut were settled and organized as part of Massachusetts before the colonial border was adjusted.

More significantly, we see in the Massachusetts towns the same complex relationship between "hill towns and mill towns" that was identified as the defining characteristic of the Connecticut part of the region. In both states this fundamental dichotomy is visible, often within the same town. Many of the same entrepreneurs, notably Samuel Slater, operated in both states. These mills also contributed to the remarkable ethnic diversity that is characteristic of the entire region.

Finally, within their respective states, these Quinebaug towns face the same challenges today. Collectively, the thirty-five towns form an island of relative quiet surrounded by the expanding megalopolis. The development pressures that are building around the edges of the region threaten the integrity of the distinctive historical landscapes recognized as significant by the Quinebaug and Shetucket Rivers Valley National Heritage Corridor." (Lowenthal, 1999)

We hope that the recommendations offered here, as well as the more substantial recommendations developed in the next chapter, can help the people of the French-Quinebaug to achieve the multiple objectives of cultural, economic, and environmental well-being.

4—Synthesis



4 Scenarios

The final chapter of the French-Quinebaug watershed study was developed with a complete synthesis of the three preceding studies, their findings and recommendations. The initial stages of the synthesis were characterized by a vast compilation of data, followed by an assessment of the hydrology, biodiversity and culture. A holistic approach was adopted when dealing with the many issues to be addressed in the French-Quinebaug watershed. This final section of the study can help to serve as a basis for future planning within the watershed by presenting a possible future scenario and a spatial concept for managed growth. The scenario and the spatial concept are not meant to be plans ready for implementation; rather they envision alternative futures for the watershed based on different management objectives in the near future. By no means are the two scenarios presented the only options for the watershed; there exist a multitude of possible futures. The two scenarios developed by this studio are intended to help the decision-makers of the watershed understand that different planning and management practices applied to the area result in alternative future environments. Each of the potential scenarios presents a separate set of consequences for the physical, biological and cultural environments.

This chapter develops and presents a “Build-Out Scenario” and a spatial concept for a managed growth scenario for the French and Quinebaug watershed. The scenario and the spatial concept are not meant to be plans ready for implementation; rather they envision alternative futures for the watershed based on different management objectives in the near future. By no means are the two scenarios presented the only two options for the watershed to develop; there exist multiple possible futures. The two scenarios worked out by this studio are intended to help the watershed communities understand that different planning and management practices applied in the area cause alternative future environments. Each scenario has consequences on the physical, biological, and cultural environment. They are created to help informed decision making on future development in the watershed communities.

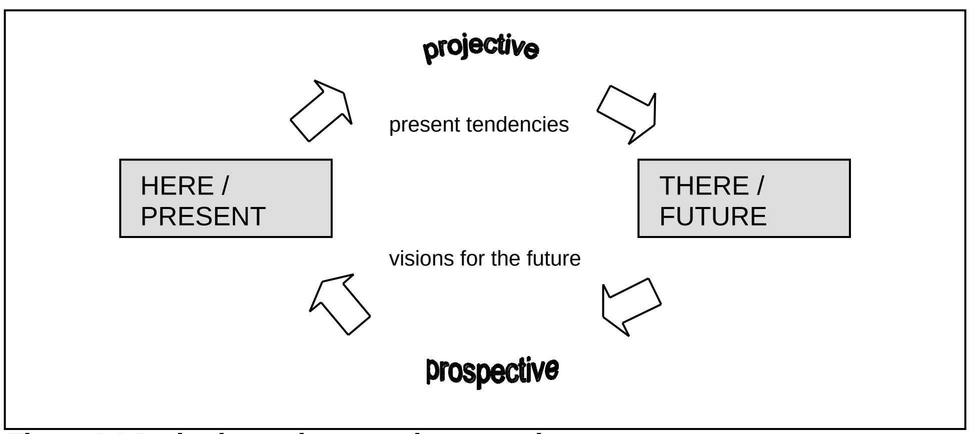


Figure 4.1 Projective and prospective scenarios

The build-out scenario and the spatial concept for a managed growth scenario are fundamentally different in character. The “Build-out Scenario” illustrates a future based on current laws and land use regulations and their allowance for development – it is ***projective*** and extends current trends into the future (see Figure 4.1). The spatial concept of the “Managed Growth Scenario” is a next step in the process of watershed planning for the French and Quinebaug. In contrast the managed growth scenario takes a ***prospective*** approach. It employs a vision for the watershed and tries to foresee management practices necessary to realize the vision (Schoonenboom, 1995). The spatial concept for the managed growth future uses the information and recommendations for the watershed's hydrological, biodiversity and cultural / historic resources as presented in the previous chapters of this report.

4.1 The Planning Process

Early preparation for this stage of the French-Quinebaug Watershed study began with research on a series of case studies. Many books and articles such as; "Tomorrow by Design: Regional Design Process for Sustainability" by Phil Lewis, "Possible Futures for the Muddy Creek Watershed", by the University of Oregon and several other text helped to provide a greater understanding of large scale planning techniques. This literature review also aided in providing an example of successful studies of a similar nature, as well as contributing additional synthesis strategies to an existing knowledge base. Upon this examination of the literature, we determined that two possible alternatives would assist the study best in evaluating the potential future of the watershed. In order to paint an accurate picture and to reach our goal of two possible futures, a process referred to as "NULA" was adopted.

The NULA process (**N**et **U**sable **L**and **A**vailable) identifies those areas within the watershed boundary that are available, or potentially available, for future development. The remaining areas of the watershed are either already developed, protected by current legislation and/or determined to be unsuitable for development (e.g. 100 year flood plains). Determining the watershed's net usable land available will provide a foundation for the creation of a "Build Out" scenario and the spatial concept for a "Managed Growth" scenario.

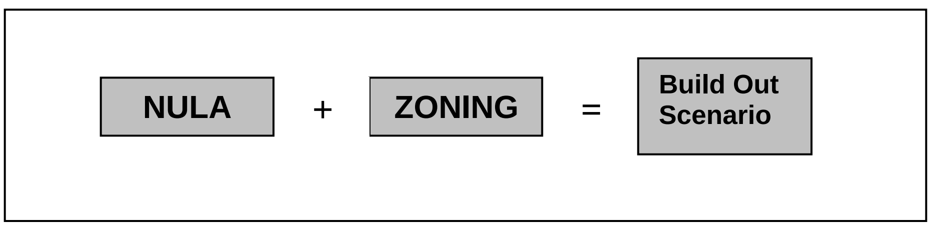


Figure 4.2 Build-Out Scenario flow diagram

Once the NULA is established, it is applied to the current zoning ordinances within the watershed's 18 towns and aids in creating the "Build Out" scenario (Figure 4.2). This scenario reflects what could hypothetically occur if the watershed is left to fully develop under current land use regulations. This assumes that no zoning changes will be made or that any additional lands will be preserved or protected. This scenario does not represent an actual prediction, but rather presents a theoretical maximum level of development in the French and Quinebaug watersheds (Ahern, 1998). Nonetheless, the "Build-Out" is useful because it establishes an explicit maximum reference value for future development and land use change.

Once the "Build Out" scenario was completed and its statistics were tabulated, steps were taken to create a spatial concept to provide a foundation for the development of an alternative future for the watershed. The ensuing steps required that serious consideration be given to current land use conditions, existing landscape patterns and management decisions that affect the watershed. This was initiated by compiling and assessing the findings and recommendations of the hydrology, biodiversity and cultural studies. Upon early integration of their discoveries and recommendations specific patterns that are unique to the French-Quinebaug watershed were identified. These patterns and special qualities were combined to begin formation of a spatially integrated watershed framework. This spatial concept will become the basis for the second of the two scenarios; the Managed Growth Scenario (Figure 4.3).

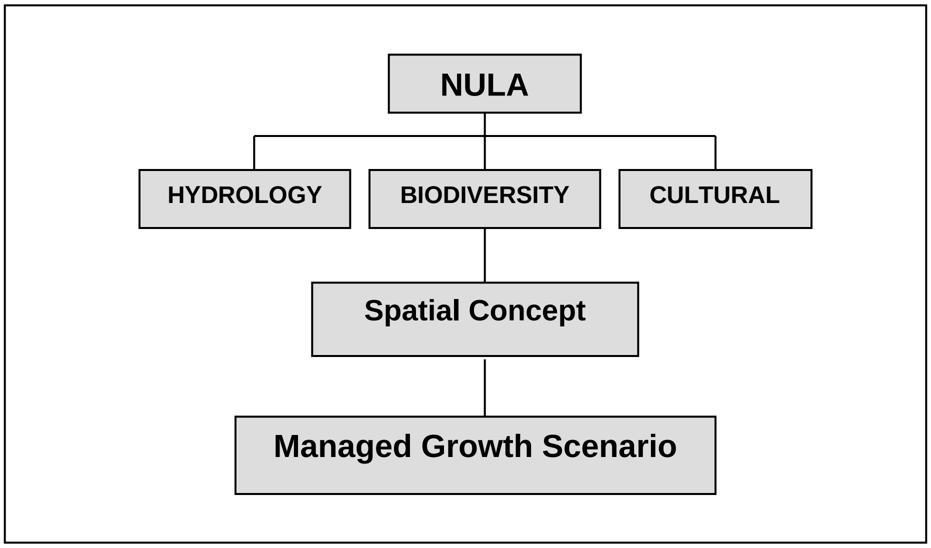


Figure 4.3 Managed Growth flow diagram

The managed growth scenario is based on the premise that preservation and development can occur simultaneously and still result in a sound watershed development strategy. The protection and enhancement of specific natural and cultural resources, combined with managed growth practices can contribute to an increased quality of life for the residents of the watershed. These major factors were the overlying theme in the creation of a spatial concept for the French-Quinebaug watershed. This concept attempts to highlight strategic areas within the watershed that should be further researched for preservation, development, recreational and tourist opportunities, among many others. To accompany this spatial concept for the Managed Growth Scenario, a series of recommendations and key action steps were established.

This spatial concept and its recommendations can aid in the future decision-making processes within the watershed approach. As opposed to the "build out" scenario, this concept suggests opportunities within the watershed that could greatly enhance its overall environmental health and character, while also providing ample opportunities for development. An integrated framework such as this represents an asset to those seeking to identify areas where future attention and focus should be generated. The goal of looking at the watershed holistically can begin with this managed growth concept and the overall watershed plan.

4.2 Net Usable Land Available

As stated earlier, a necessary step in the development of growth scenarios is identifying the total amount of land that is available for development in the planning area, i.e. the French and Quinebaug watershed. The Net Usable Land Available (NULA) is the land that can most easily be altered by man since it is available for development under current regulation and land ownership and policies. Determining the NULA is an eliminative process in which areas of land commonly agreed upon as unsuitable for development are subtracted from the total land belonging to the watershed (Figure 4.4). The NULA process establishes a directive base line of agreement that in general is acceptable for all stakeholders in the local communities. In addition to providing the basic statistics, the NULA presents the spatial distribution of the land identified as unsuitable for development.

A simplified land use map of the watershed developed from 1985 Mass GIS land use data serves as the base/background map for the NULA process (Figure 4.7).

We have identified four different categories of land commonly regarded as unsuitable for future development.

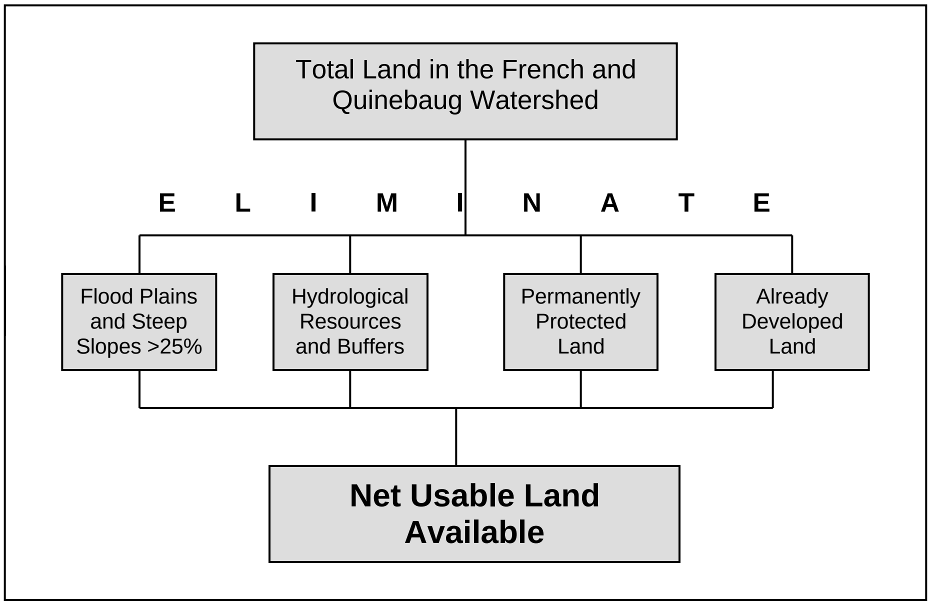


Figure 4.4 Net Usable Land Area Process

First, areas within floodplains or steep slopes are considered as unsuitable for development due to higher economic expenses for development and dangers to individuals or society. The hazardous areas include land within the 100-year flood plain and steep slopes (>25%). The black colored patches in Figure 4.8 represent these areas.

Second, hydrological resources and buffers around these as prescribed by State Legislation (Massachusetts River Protection Act, Massachusetts Wetland Protection Act) are excluded from the NULA. Rivers are buffered by 200 feet; wetlands are buffered by 100 feet. These areas can be seen in Figure 4.9.

Third, land that is permanently protected, i.e. State and Municipal Parks is deemed unavailable for future development and illustrated in Figure 4.10. Finally, areas already developed as residential, commercial, or industrial land are removed from the NULA. Please see Figure 4.11.

Figure 4.11 indicates the total land deemed unsuitable for development. Overall approximately 55% of the total land area in the French-Quinebaug Watershed is considered to be potentially available for development (Figure 4.7). The statistics are summarized in the following table (Figure 4.5). As there are overlaps between thematic areas, the total sum is larger than the actual area of land not available for development. For instance, some areas that are designated buffers for hydrological resources are at the same time located within the 100-year flood plain.

	Unsuitable Area (acres)	Percentage of Total Land
Flood Plains/ Steep Slopes	18,978.0	12.0%
Hydrological Resources	21,508.4	13.6%
Protected Open Space	13,917.2	8.8%
Already Developed Land	17,254.9	11.0%
Total Area Unsuitable for Future Development	70,389.3	45%

Figure 4.5 Land not suitable for future development

The remaining land is considered potentially available for future development: that means that within the 158,150 acres existing in the watershed 87,760.72 acres are developable in the future.

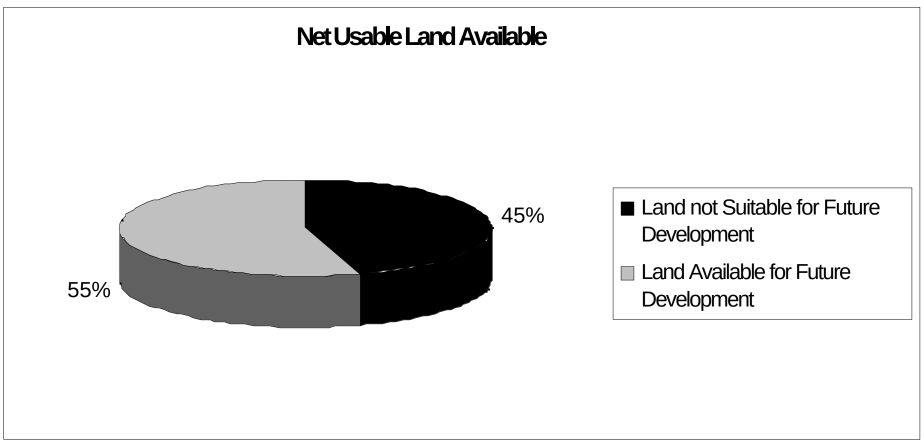


Figure 4.6 Net Usable Land Available

The NULA serves as a basis to create the Build-out Scenario and is subject for application of other discretionary factors in the process of creating the "Managed Growth" scenario.

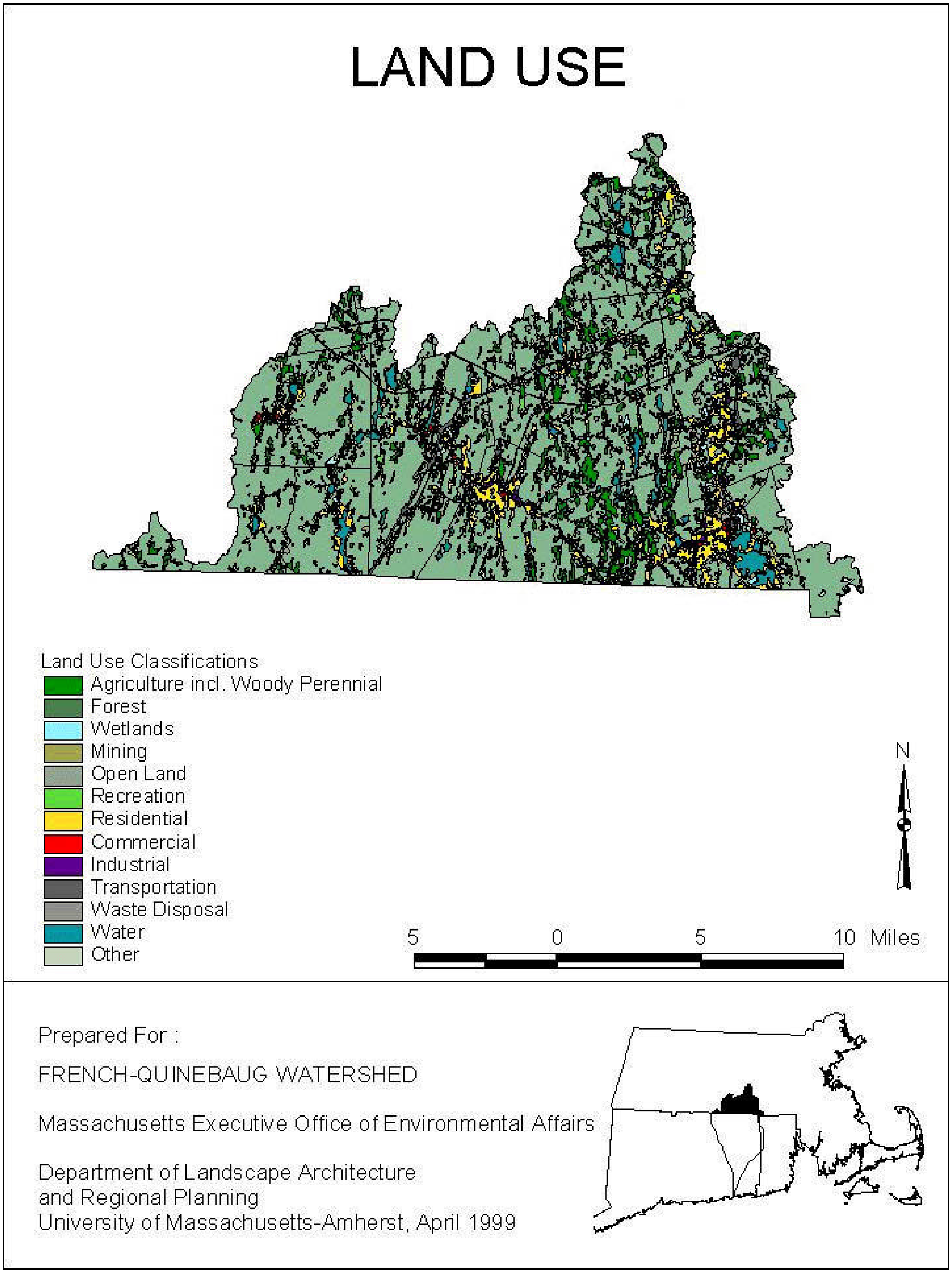


Figure 4.7 Land Use Map. Source Data: MassGIS (1985 Land Use Data)

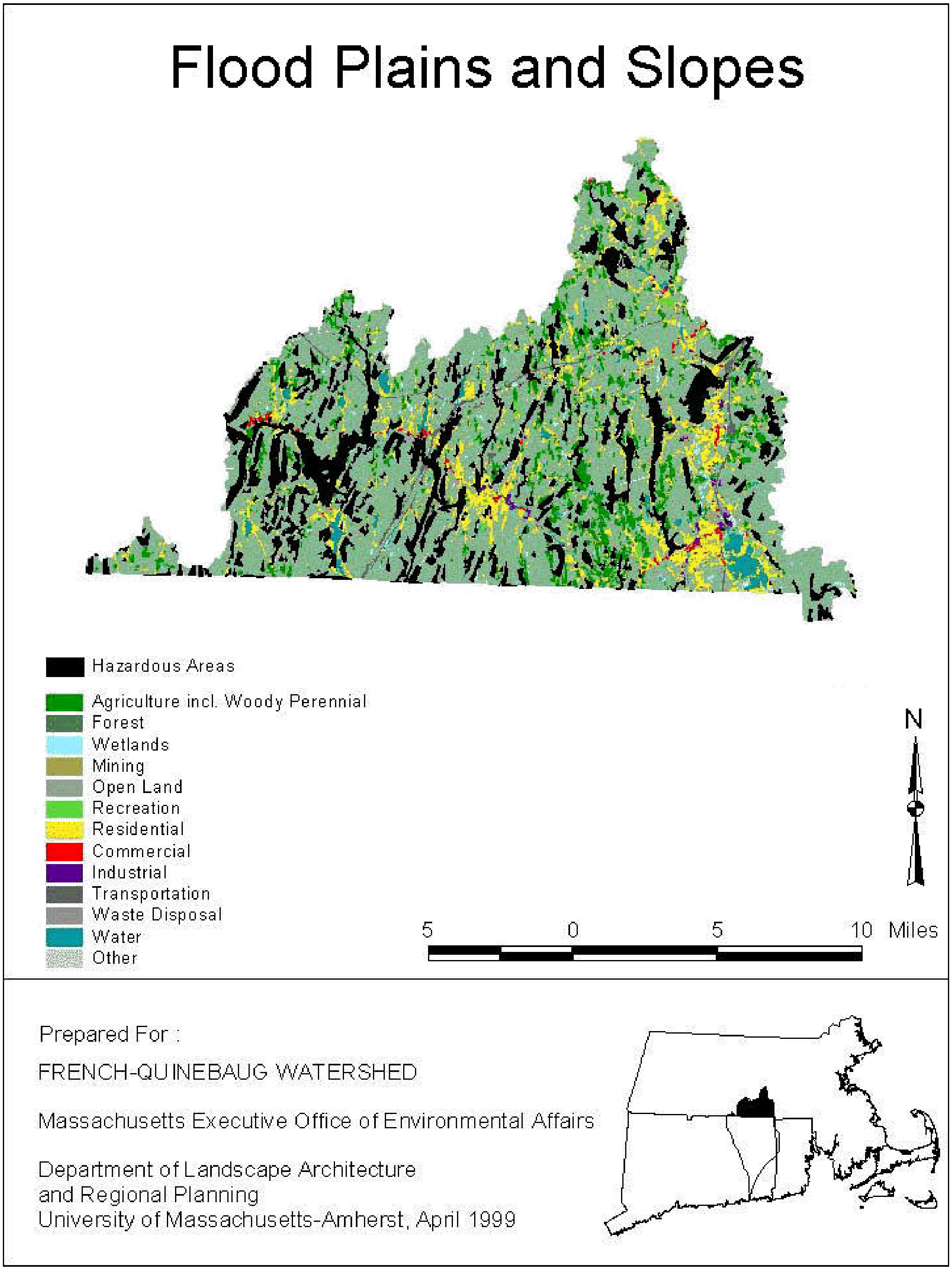


Figure 4.8 Flood Plains and Steep Slopes Unsuitable for future Development. Source Data: MassGIS (1985 Land Use Data)

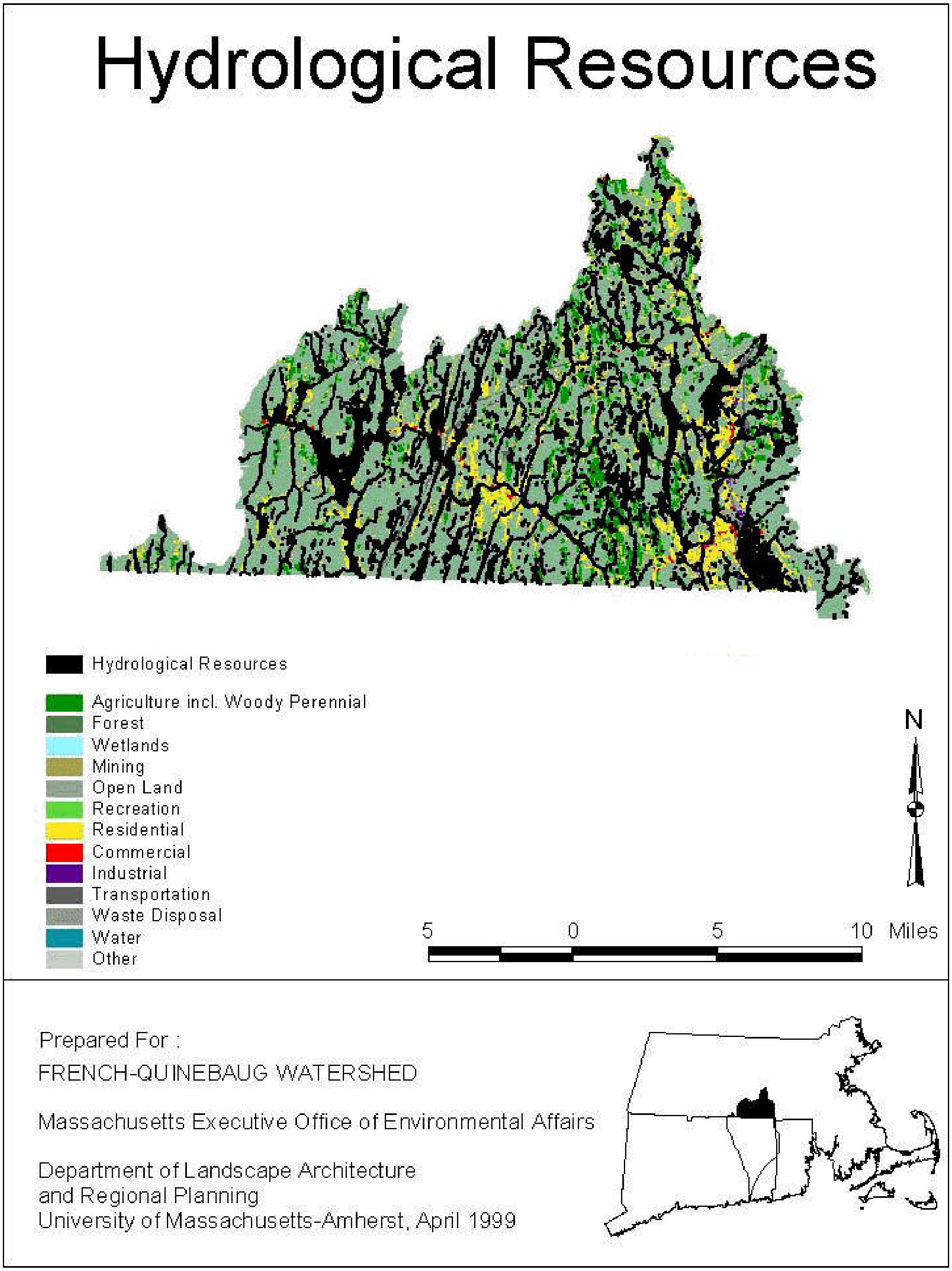


Figure 4.9 Rivers, Ponds and their Buffers Unsuitable for Future Development. Source Data: MassGIS (1985 Land Use Data)

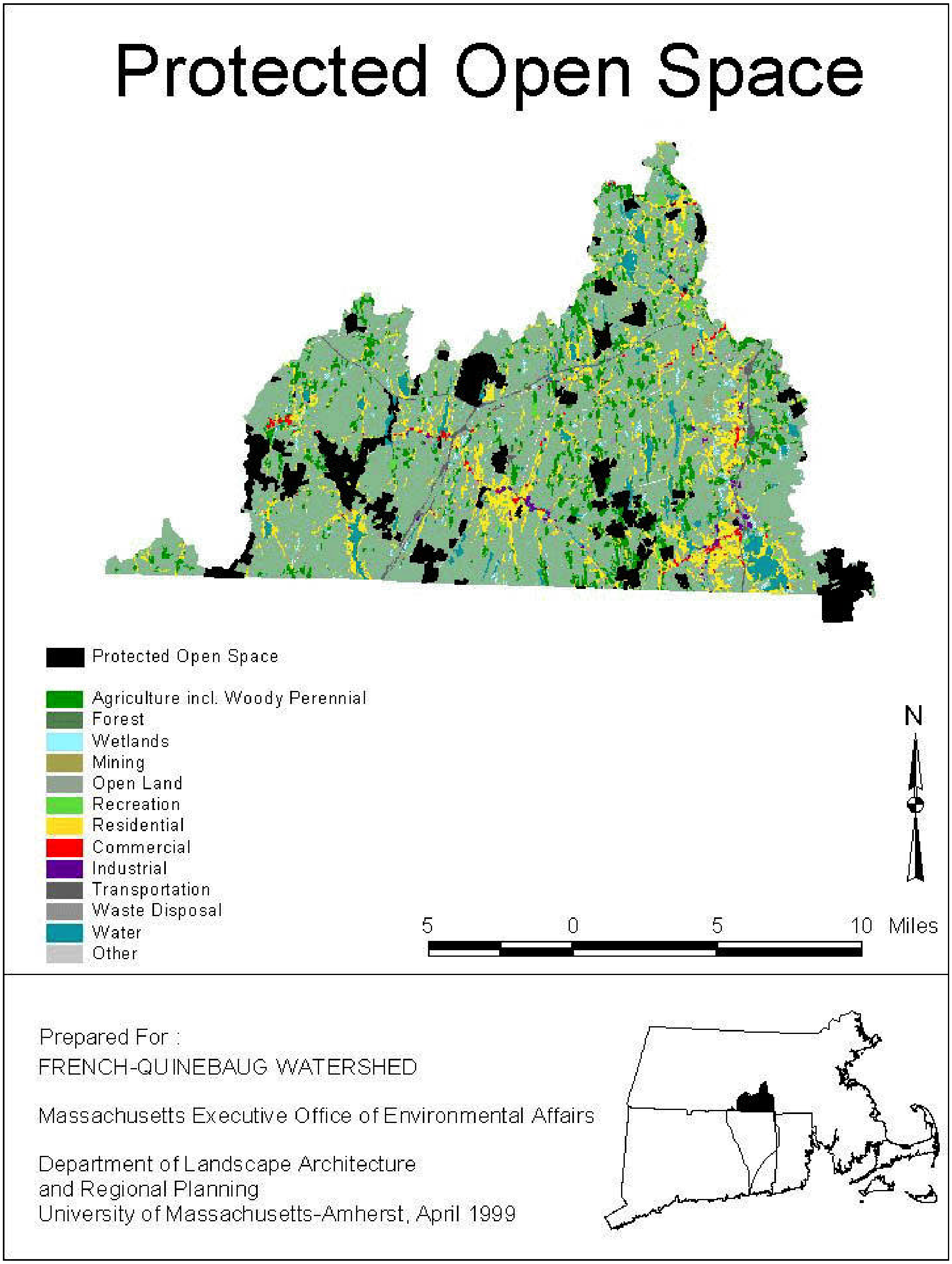


Figure 4.10 Permanenltly Protected Open Space Unsuitable for Future development.
Source Data: MassGIS (1985 Land Use Data)

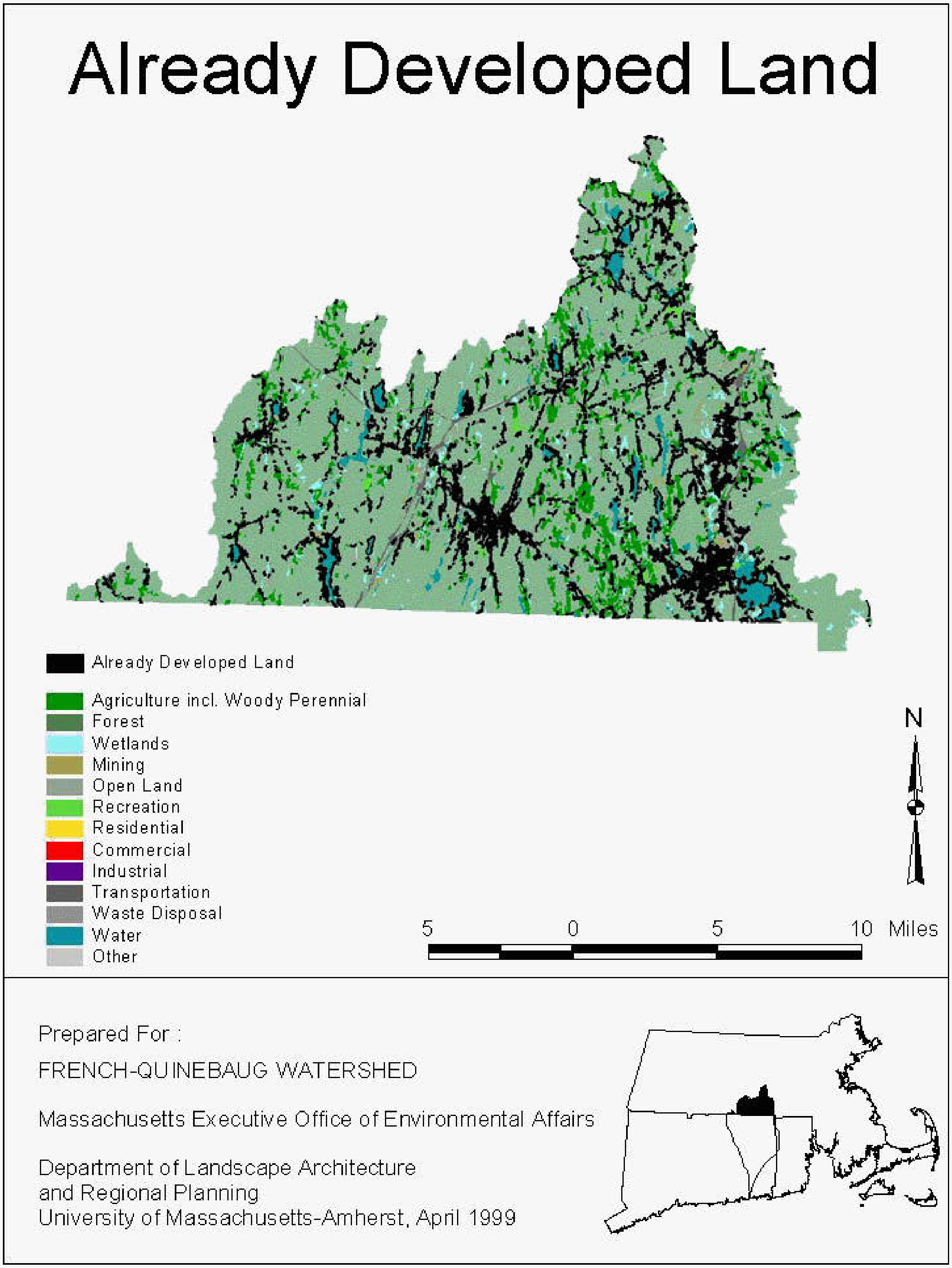


Figure 4.11 Already Developed Land. Source Data: MassGIS (1985 Land Use Data)

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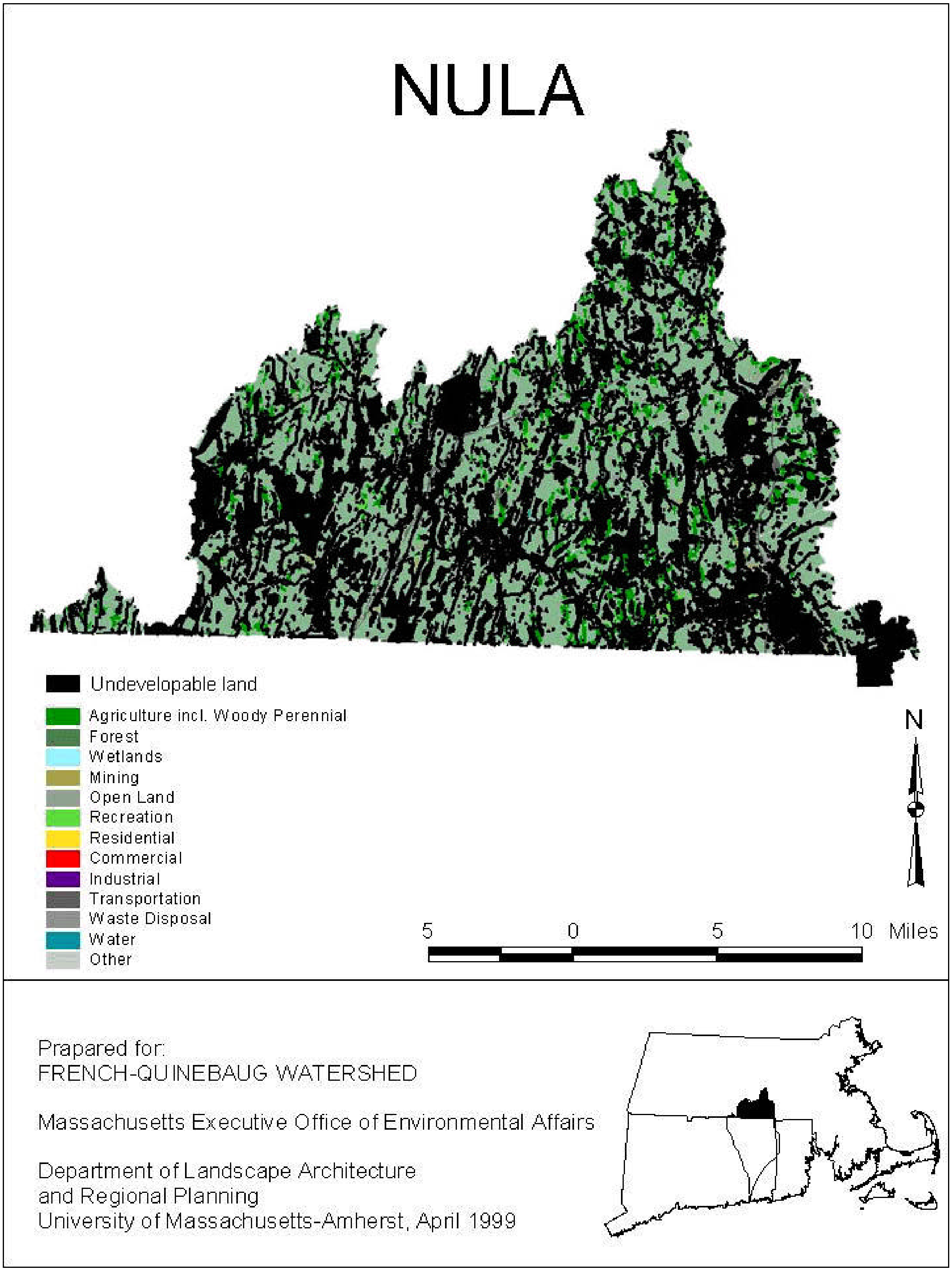

Figure 4.12: Net Usable Land Available Map. Source Data: MassGIS (1985 Land Use Data)

4.3 Build Out Scenario

Once the net usable land available (NULA) has been determined, it is possible to generate possible future population and land use scenarios. Knowing what has and is being done with the land helps in generating estimates of what may become of the land. The Build-Out Model used in this report is a projection of present uses and population onto the land still available. In this development scenario, it is assumed that all the land still available will be fully developed at the same density as exists today. This model attempts to use as few variables as possible, including density, present population, land already developed, and land still available. The purpose of this exercise is to establish a maximum development scenario against which other more balanced development scenarios can be measured. The result of the build out scenario should be considered as an extreme condition for a possible future development. It need to be also considered that the previous development might not be repeated for the future since there was no zoning controls for much of the watershed's development. Even though our scenario will depend on the previous development and density to show the extreme possible condition, these limitations should be acknowledged. Additionally, it needs to be noted that although there is a GIS coverage for zoning for most of the French Quinebaug Watershed towns, present zoning and density controls are not deliberated for the scenario since it was not feasible to do a detailed analysis without having all the towns in the area.

This Build-Out is a scenario in which the future population of the watershed is projected by multiplying the present population by the ratio of the net usable land available divided by the land already developed. For example, if a town has already developed 10,000 acres and still has 40,000 acres available, then the future population could increase by four times the present population assuming the present density. Because, if a town has ten acres and ten people, fifty acres at the same density will have fifty people. Thus, if the present population is 100,000, the future population will be 500,000 (present population of 100,000 plus an increase of 400,000). This is not a prediction. It is simply a projection of what the watershed could look like if all of the land still available for development is developed **at the present density** of population and uses.

Step 1. $\frac{\text{Net Usable Land Available}}{\text{Already Developed}}$ = Multiple of Increase

Step 2. (Present Population x Multiple of Increase) + Present Population = Future Population

In the case of the French-Quinebaug Watershed, 17,255 acres have already been developed. The NULA determined that there are still 87,760 acres of usable land available for development (This NULA did not consider soils, though poor soils are likely, in part, to coincide with the factors considered in the NULA). 87,760 acres of available land divided by 17,255 acres of developed land equals 5.08. Since the present population of the watershed is approximately 114,900, if future development proceeds at the same density and pattern as exists today, then the remaining land will accommodate 5.08 times the present population in addition to the present population. 114,900 persons multiplied by 5.08 equals 583,692 persons. Thus, the future population of the watershed would be 698,592 if the remaining usable land were developed at the same density as today.

Step 1. $\frac{87,760}{17,255}$ = 5.08 (Multiple of increase)

Step 2. (114,900 x 5.08) + 114,900 = 698,592 (Future population)

In figure 4.6 the Net Usable Land Available is everything that is not black. The NULA determined that, at least 55% of the land in the watershed is still potentially available (Figure 4.6). The NULA also determined that there is almost five times as much land still available as has been developed so far. Thus the land still available in the watershed can accommodate almost five times the existing population and development if future development follows present trends. The yellow land in Figure 4.13 below is zoned residential. In the Build-Out scenario it would all be completely covered in residential development. Likewise, the red areas would all be filled with commercial development and the purple with industrial development.

Population increase, population pressure, and development patterns can and will vary. Continued decentralization coupled with the major highways that crisscross the watershed could lead to rapid growth. To what degree this growth is controlled or guided will influence how much and how fast this area will grow in population and infrastructure. In the 1980's the population of the watershed increased 15.56% in substantially different patterns than previous development. In the 21st century that rate of growth could increase. The Massachusetts Audubon Society (Steel, 1999) estimates that 44 acres of open land is lost every day in Massachusetts, mainly to residential development.

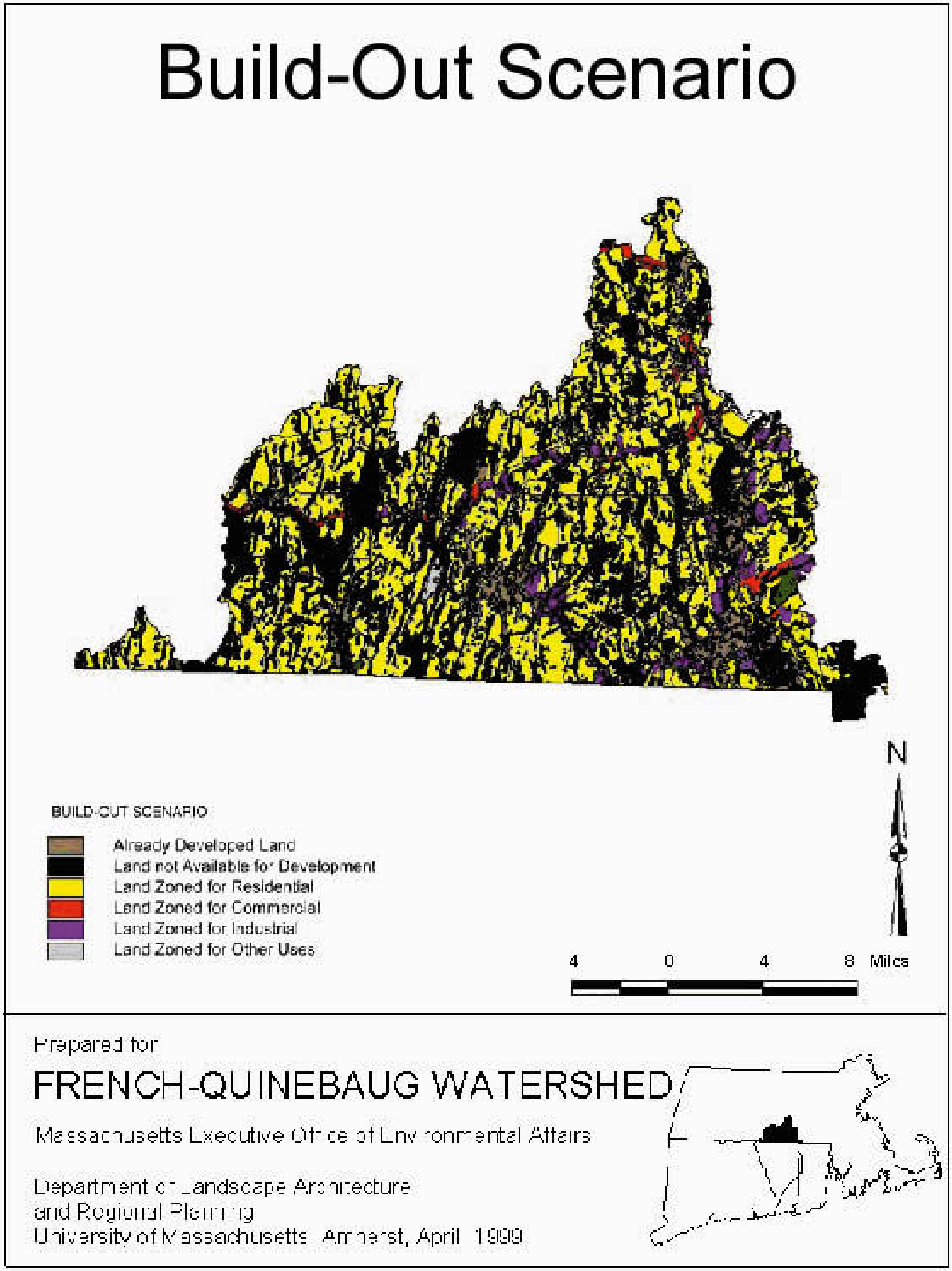

Figure 4.13 Build-Out Scenario. Source Data: MassGIS, Pioneer Valley Planning Commission, Cent. Mass. Planning Commission (1985 Land Use Data)

The nighttime satellite image in Figure 4.14 represents the amount of development in the United States through the light, associate with developed areas. Suddenly the numbers of the Build-Out scenario do not seem so extreme when you keep in mind that almost all of the development in the United States as reflected below has been built in this century.

Figure 4.14: Night Sky Satellite Image. Source: National Oceanic and Atmospheric Administration, September 19, 1992

Taking an even closer look at the French-Quinebaug Watershed area in this satellite image creates an even more impressive image of the potential development pressures. Figure 4.14 is a close-up of Figure 4.15 of the Boston to Washington megalopolis. The areas awash in light begin in Washington D.C, in the lower left corner, then heading diagonally to the upper right corner to Philadelphia, and New York City and Long Island are easily discernible. The “arm” reaching up from Long Island Sound is the development along the Connecticut River Valley including Hartford and the Springfield and Holyoke area at the top, forming a “fist”. The Boston Metropolitan area is easily seen, as is Cape Cod. What is relevant about this image is that the French-Quinebaug and the Quinebaug-Shetucket watersheds are some of the last few remaining dark spots in the night sky in central New England, i.e., undeveloped areas. If the impending development pressures are left unchecked then these last bits of relatively rural country could become just another bright spot in Megalopolis.

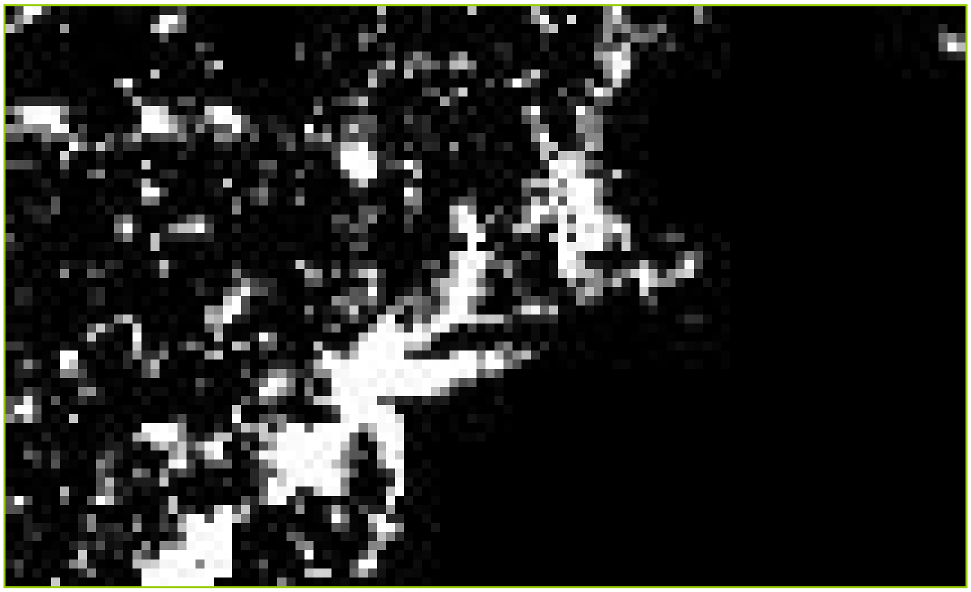

Figure 4.15: Northeast Night Sky Satellite Image. Source: National Oceanic and Atmospheric Administration, September 19, 1992

However, depending upon the pattern of development, the number of people who live here could have vastly different impacts on the land. If the communities in the watershed chose to encourage development to occur in clusters that preserve open space, re-use old sites and buildings (brownfields), and encourage urban infill development, then a much larger population could inhabit the watershed without occupying every available acre. A managed growth alternative, that aims to accommodate development while protecting rural character, habitat, and the environment in general, is discussed later.

4.4 Concept for a "Managed Growth" Scenario

4.4.1 Principles

The "managed growth" scenario is currently in the process of being developed and will be completed at a future date. Currently, the spatial concept has been created and this is the basis upon which the "managed growth" scenario will be developed (see Figure 4.3).

The purpose of future scenarios is to articulate and to visualize the spatial consequences of planning goals or assumptions and the steps necessary to realize them (Schoonenboom, 1995). The synthesis group will develop a "managed growth" scenario in order to provide an alternative future to the "build out" scenario. When considered together, the two scenarios will provide a reference base for stakeholders to consider when making future decisions that affect the French-Quinebaug watershed.

Prior to conception of the spatial concept, each of the hydrology, biodiversity and cultural studies were consulted (see Figure 4.3). It is this concept that will result in the alternative scenario. The total integration of these findings led to a discovery of a number of characteristics that are unique to the French-Quinebaug watershed. The major similarity found among the studies was that numerous cultural, historical, hydrological and biological assets are concentrated along the rivers and streams. The location of these multiple resources occurring within close proximity throughout the French-Quinebaug provides the basis for a unified watershed approach.

In addition, numerous other factors were considered such as cultural survey results, unique points of interest, historic sites, wildlife habitats and wildlife movement corridors. Incorporation of these factors and many others led to the establishment of a set of principles on which the watershed framework is based.

These principles for managed growth are:

- Accommodate for future growth.
  - ❑ Focus future development in existing urban areas to aid in the prevention of suburban sprawl.
  - ❑ Identify areas of unique importance to be preserved.
  - ❑ Preserve the watershed's existing rural character.
- Plan for water quality and biodiversity.
  - ❑ Obtain areas for protection of threatened and endangered species habitat not located within already protected open space.
  - ❑ Increase opportunities for water awareness.
  - ❑ Protect areas with high levels of potential biodiversity.
- Protect and enhance existing cultural resources.
  - ❑ Prioritize historic buildings and districts
  - ❑ Prioritize recreational opportunities
- Create linkages between resources.
  - ❑ Use trails to connect areas of high cultural and biological value.
  - ❑ Utilize existing features to connect areas of the watershed (ie. existing parks and waterways).
  - ❑ Designate ecological corridors to link and integrate important wildlife habitats.

4.4.2 Spatial Concept: Preferred Development Pattern

The spatial concept offered here is an alternative way to prepare for development rather than simply allowing full build-out to occur (as allowed by current zoning). In addition to comparing the NULA with existing zoning, the spatial concept encompasses hydrological, biodiversity, and cultural data (described earlier in sections 1-3). This spatial concept suggests that there are certain areas that should be targeted for development and that there are areas that should be targeted for increased land protection efforts. Furthermore, it is suggested that the watershed communities pursue a program of closer cooperation and linkage.

Within the French-Quinebaug Wateshed, areas that would benefit from increased protection, as well as those areas for development, have been identified in the NULA process described previously. For example, the southwest section of the watershed is an area that is, in general, well suited to protection. It is where the most species biodiversity and the least human habitation exists (See Section 2 – Biodiversity). It is an important link between "the Last Green Valley" of the Quinebaug and Shetucket Rivers Valley National Heritage Corridor and the "accidental wilderness" of the Quabbin Reservoir. This "Last Green Valley", so named because of its predominantly rural character in the middle of the eastern megalopolis, reaches across the political border into Massachusetts. One of the primary goals of this study is to explore this connection between the French-Quinebaug Watershed and the Quinebaug-Shetucket Rivers Valley National Heritage Corridor.

On the other hand, development is inevitable and necessary to maintain a viable economy. This spatial concept suggests that traditional downtown centers and the intersections of major roadways are areas that should be the focus of development activities and therefore should be the focus for incentives, programs and guidelines. Promoting in-fill development, adaptive re-use, and cluster zoning are a few ways that development can proceed without claiming all of the available land. Historic design guidelines, conservation restrictions, and agricultural preservation restrictions are a few tools in the long term planning process to preserve character. For example, in the gateway area to Old Sturbridge Village it would be advisable to try to extend the historical ambience beyond the village gates.

There are several opportunities to promote closer cooperation and linkage within and around the watershed. The first, is to become a part of the Quinebaug-Shetucket Rivers Valley National Heritage Corridor. This would not only bring federal money into the watershed, it would help spread watershed awareness and attract tourism.

Stepping Stones - Corridors

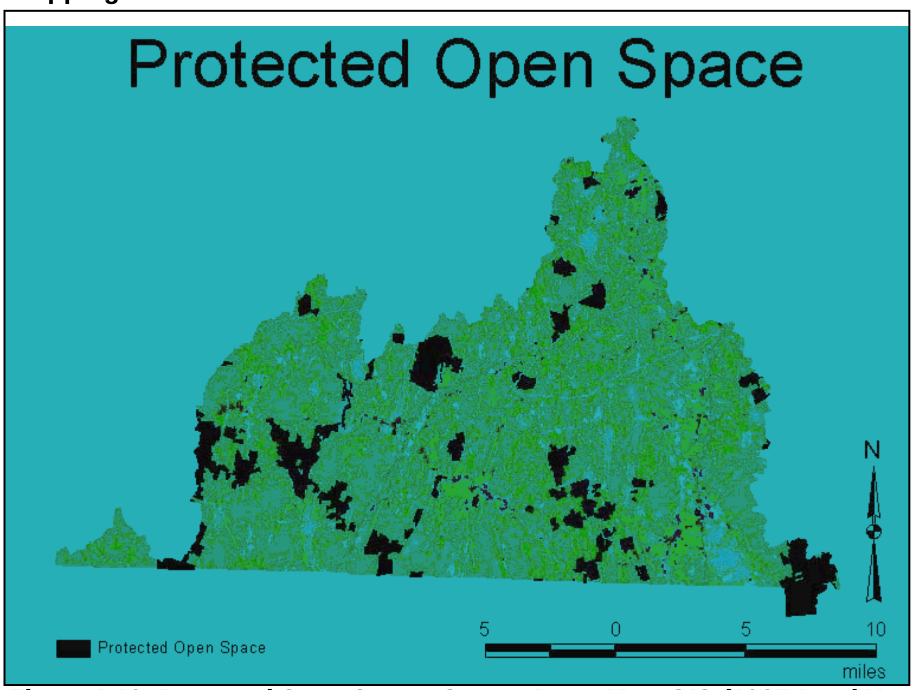

Figure 4.16: Protected Open Space**. **Source Data: MassGIS (1985 Land Use Data)

There are several viable multi-use trail opportunities in the watershed. This includes connecting stepping stones between already protected open spaces, existing trails, and defunct rail corridors. These connections could be greenways as well as trails in that they could help wildlife to move across the landscape. "Stepping stones" between the larger patches of open space can be discerned in Figure 4.16. Connecting these stepping stones to create corridors between the protected areas should be carefully considered because of the potential to link together a regional trail network. These potential linear connections between the protected areas, evident in Figure 4.17, need to be investigated further to see if they are as "connectable" on the ground as they appear on this map.

Connecting these stepping stones is only one of several greenway planning options available to the watershed. The archeological remains of a long uncompleted railroad line, the Southern New England (A.K.A. the Grand Trunk), that traverses the French-Quinebaug watershed presents an opportunity to link several communities with a multi-purpose trail. Field research, aerial photo imagery, Geographic Information System maps, and interviews indicate that certain sections could be developed in conjunction with other corridor opportunities to create a greenway network connecting the watershed within and with neighboring regions. This path network represents a key link in a statewide and interstate network because it connects with the Rhode Island trail network, Connecticut trails, and the Mid-State Trail, which connects to a vast network of trails in New Hampshire.

This particular former rail line is different from traditional rails-to-trails efforts in that the right-of-way was sold many years ago and much of the line has been developed, included in flood control projects or partly reclaimed by nature. Several sections throughout its length are still being used as a path. Presently one can walk from downtown Southbridge to Sturbridge largely along this old railroad grade. There are also sections in Palmer, Brimfield, Dudley, and Webster that are still used. Re-using the entire Grand Trunk railroad bed is not an option as there has been development on some sections and dilapidation on others. However, by weaving the Grand Trunk, The Bay Path and the stepping stones noted above, it should be possible to establish a multi-season, multi-use trail system that unites the watershed.

This network represents not only hiking and biking trails, but a trip through New England history. The old Bay Path Indian trail traverses the watershed from west to east, winding into Old Sturbridge Village and into Colonial times. Further south the remnants of the Grand Trunk, “the Last Great Train War in New England”, leads into Southbridge, an industrial town that has yet to fall prey to sprawl. Beyond Southbridge, the trail leads to the rolling hills and farm fields around Nichols College and Dudley, and then into Webster, where some of the earliest mills of the American Industrial Revolution surround the old Slater mansion along the French River. The major obstacles to converting this into a multi-purpose trail are acquiring easements along several sections and assuring abutters of the benefit of such a system to the overall health of region.

In the diagram shown in Figure 4.17, some of the nodes, patches, and corridors are portrayed in order to highlight the development, protection, and connections in the watershed, as well as to improve economy and quality of life of its populations. Small green circles indicate the linking of these “stepping stones” between protected areas.

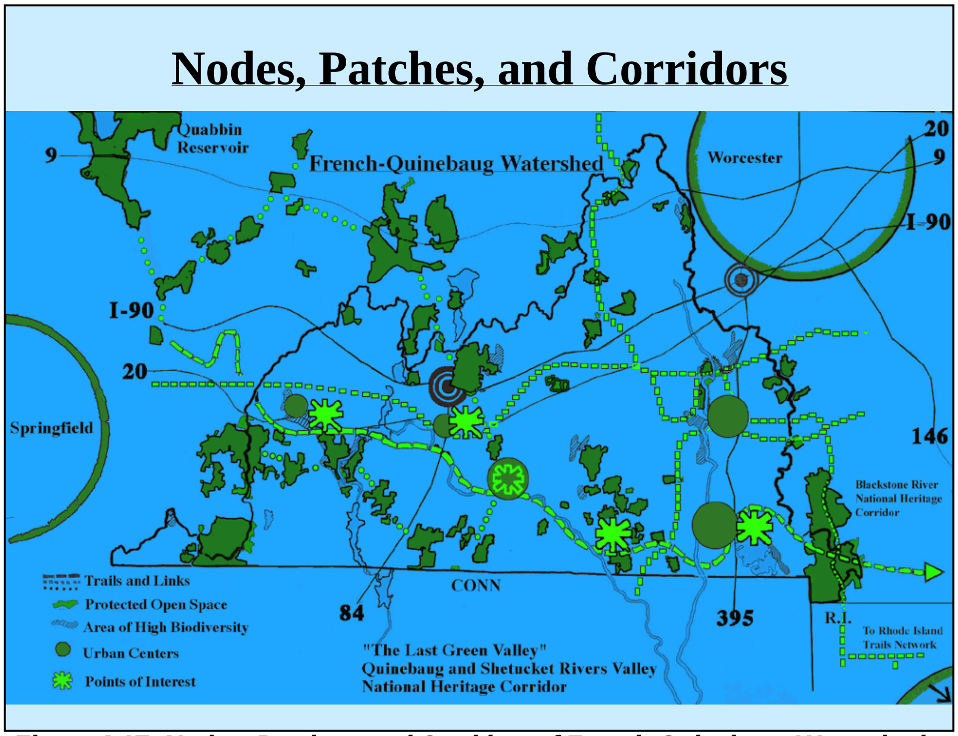

Figure 4.17: Nodes, Patches, and Corridors of French-Quinebaug Watershed

The Grand Trunk, Bay Path, and Mid-State Trails are indicated with the green rectangles. This conceptual rendition suggests the potential of weaving parts of each of these trials into a regional network.

Red circles indicate the intersections of major highways. The intersection of Interstates 90 and 84 occurs in Sturbridge. The intersection of Interstate 90 and 395 occurs just outside the watershed. These two points have tremendous attraction for development, first commercial and then residential. Intense development near the Rts 90 and 395 junction is ongoing; similar development near the Rts 90/84 junction is almost inevitable. It is important that the communities within the watershed are aware of this and prepare guidelines for how and where this development occurs.

In Figure 4.18 some of the key connections to be made are indicated. A large arrow connecting the “Last Green Valley” of the Quinebaug-Shetucket Heritage Corridor and the Quabbin Reservoir area, through the French-Quinebaug watershed, indicates a particularly important connection to make. Other arrows connect to the Blackstone River Valley National Heritage Corridor, and thick black lines indicate areas of possible connections. That is, there are areas, particularly river corridors, which host several different types of attractions in a common area. The rivers historically represented the transportation and power resource and thus much of the historical points of interest are located along them. Also, the riparian corridors are home to many species and natural attractions.

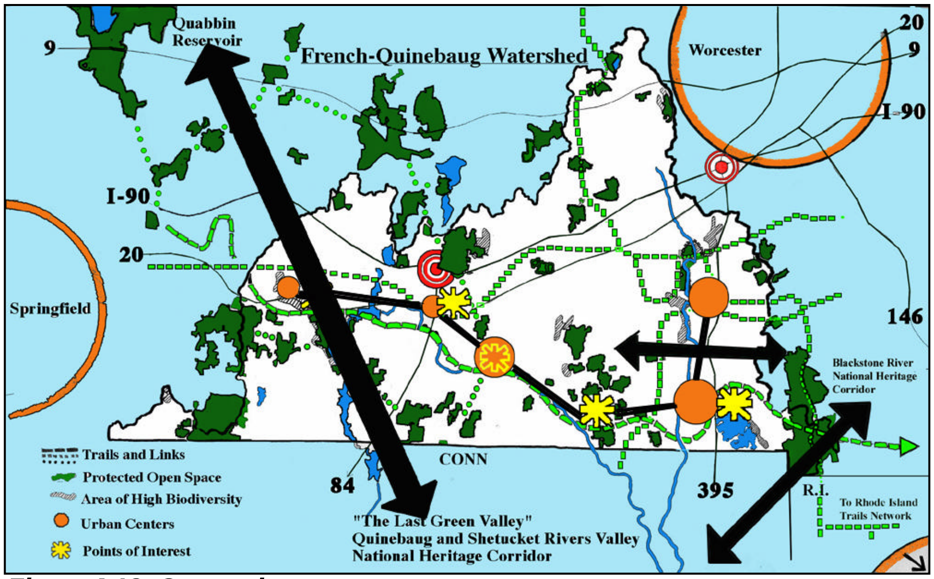

Figure 4.18: Connections

There are certain areas that would provide the most benefit as the result of increased land protection efforts. The sector south and west of Southbridge and Sturbridge is an area of high biodiversity and low human habitation. Also, Agricultural Preservation Restrictions would provide a reasonabel level of protection in the farmlands between Southbridge and Oxford-Webster. As this study proceeds and information is investigated at a smaller scale, more detailed recommendations regarding where exactly land protection and development should occur will be made. Overlaying the NULA over the hydrological, biodiversity, and cultural resource maps at the watershed scale only allows general suggestions. There are certainly areas throughout the watershed that would furnish valuable open space.

Development, on the other hand, would result in the least impact if conducted in already developed areas, especially in down town centers, and in close proximity to the major roadway intersections. Furthermore, it is important that the watershed communities exert some form of control over the type of development that occurs. This spatial concept recommends considering in-fill development, adaptive re-use, cluster zoning, historic design guidelines, and an assortment of incentives and restrictions in order to help guide growth in the French-Quinebaug watershed. Furthermore, it is suggested that the watershed communities pursue a program of closer cooperation and linkage

4.5 Recommendations and Key Action Steps

To reach the goals indicated in the spatial concept (see section 4.4) and the previous sections on hydrology, biodiversity, and cultural resources of the report, key action steps and recommendations for each of the major goals were established. This section intends to focus on future efforts relating to the activities of the French and Quinebaug Watershed Basin Team and activities in regard to future zoning and development in the 18 towns belonging to the French and Quinebaug watershed. The key action steps identified are from the points of view of the contributors of this study areas that warrant further exploration are shown in Figure 19.

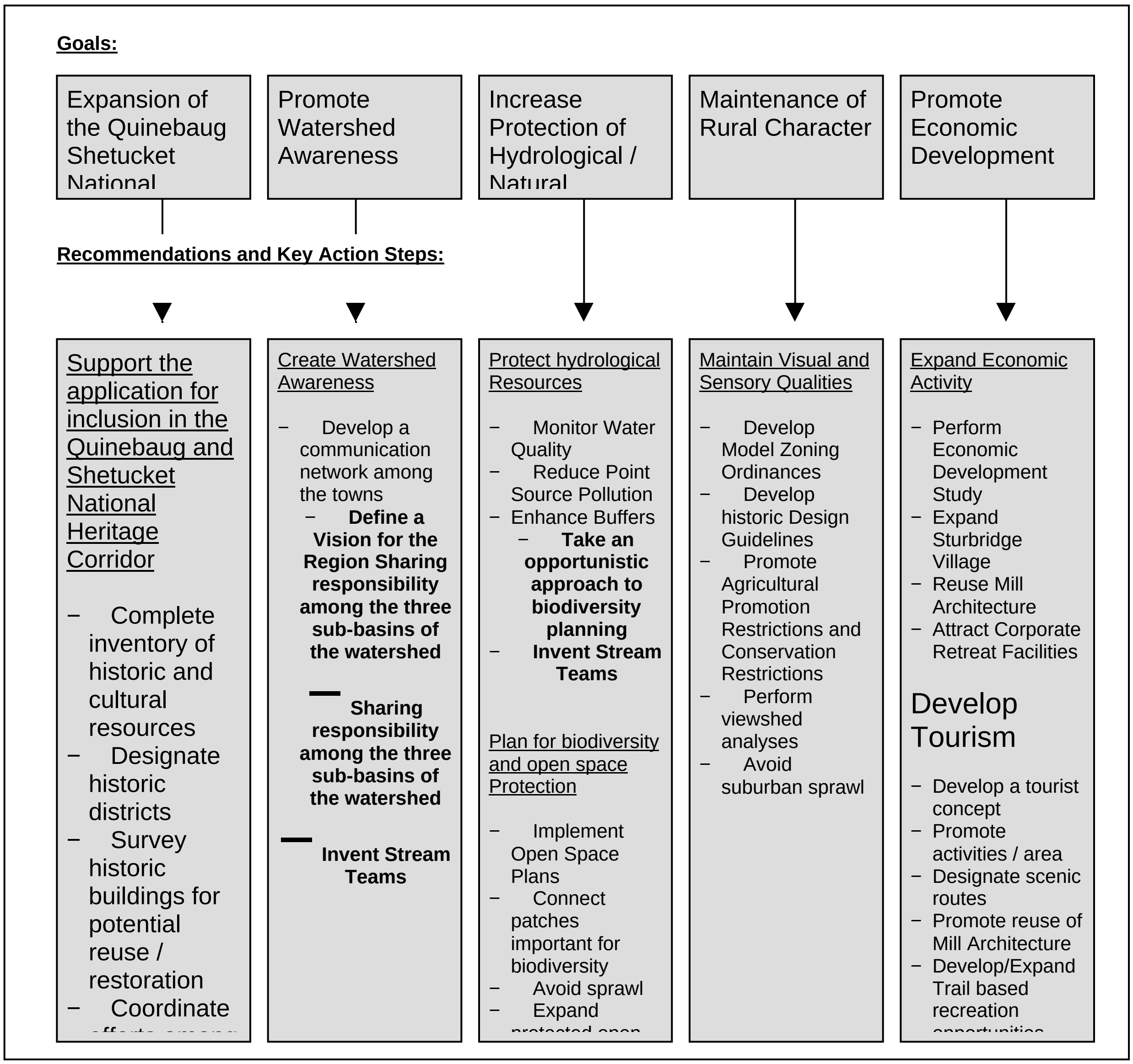

Figure 4.19: Goals, Recommendations, and Key Action Steps for the French and Quinebaug Watershed

1. Support the application for inclusion in the Quinebaug and Shetucket Rivers Valley National Heritage Corridor.

The Quinebaug and Shetucket Rivers Valley National Heritage Corridor currently is limited to the state of Connecticut. The adjacent areas of Connecticut and Massachusetts are "related by shared natural, cultural, historic, and scenic resources" (Quinebaug and Shetucket Rivers Valley National Heritage Corridor Reauthorization Act of 1999).
Inclusion into the National Heritage Corridor - if approved by Congress - would bring along various benefits to the Mass. Portion of the French and Quinebaug watershed:

1) Technical Assistance and funding for regional planning efforts;
2) Funding available for promotion of the cultural history of the area;
3) Funding for specific projects; and
4) Promotion of the watershed as a region

From an ecological perspective, the inclusion of the French and Quinebaug Watershed in Massachusetts into the Quinebaug and Shetucket Rivers Valley National Heritage Corridor is valuable, as the Massachusetts French and Quinebaug watershed flow into the Quinebaug and Shetucket watershed in Connecticut and form a larger hydrological and ecological entity.

The following Key Action Steps could result in documents supporting the inclusion in the Quinebaug and Shetucket Rivers Valley National Heritage Corridor:

- Complete an inventory of historic and cultural resources.
- Designate historic districts.
- Survey historic buildings for potential reuse / restoration.
- Coordinate efforts among the towns through town representatives.
- Need support letters from local officials, businessman, and other "movers and shakers" in the community.

2. Create Consciousness for the Watershed as an Entity.

Traditionally, in New England, the towns have great autonomy for local planning. However, along with the evolution of the discipline of environmental planning and a stronger concern for environmental quality as part of our quality of life, some planners call for a regional approach. The regional scale is meant to emphasize shared responsibilities among towns reflecting their strengths and weaknesses to optimize their pattern of future development. Rather than establishing a region as a jurisdictive and administrative unit by a random agglomeration of towns, landscape ecologists and landscape planners find ecological regions defined by boundaries of natural elements to be the most appropriate and relevant in respect to planning for sustainable environments (Forman & Godron 1986). Watersheds are commonly accepted to be the most appropriate ecological unit to be defined as a region. According to Brooks, the watershed as a hydrologic unit can often be "used as a physical-biological unit and a socio-economic-political unit for the planning and management of natural resources" (Brooks et al., 1991).

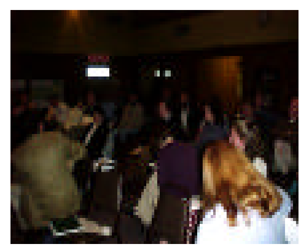


Figure 4.20: Stakeholders and Decision-Makers in the Watershed

- Although watershed planning has now been practiced elsewhere in Massachusetts for a few decades, the French and Quinebaug watersheds are new to this procedure and still the population lacks consciousness of belonging to a watershed. Some significant guides for the watershed approach are:
- Local people solve local problems. Local citizens and groups inform assessment and problem solving. Governments provide assistance where possible.
- Watersheds work as partnerships. Stakeholders and government agencies work together cooperatively and seeking consensus (Figure 4.19).

- Limited resources within the watershed form the basis for identifying the priority issues.

Develop a communication network among the towns

To promote the concept of the watershed, new administrative mechanisms that cross the boundaries of the eighteen involved towns can be useful. As part of the watershed planning process the French Quinebaug EOEA Watershed team has been established to direct expert knowledge from different fields in a cooperative manner, this environmental team includes local stakeholders, as well as members from various State Departments, such as the Department of Environmental Management (DEM) and the Department of Environmental Protection (DEP). In the same manner, policy makers and planner of the communities within the watershed should form a "watershed authority", watershed community council or similar to balance the interests of the individual communities with the interests of the entire watershed. The task of the new Watershed Team would be mainly to bring together boards, organizations, and citizens to perform their roles in partnership with each other as a shared responsibility. It will facilitate cooperative decision-making in the watershed and is ***not*** a controlling administration, in charge of planning and management decisions. Watershed Community Councils consisting of stakeholders, local stream teams, the EOEA team, and so forth represent the natural forum to prioritize watershed wide issues, lay out plans of action, and oversee the implementation of these plans.

Refine a Vision for the Region

The French and Quinebaug watershed, overall, is an area in which forests represent the predominant land use along with water, and low density residential housing. Together, they make up the rural character of the area. It was expressed during an introductory workshop of our planning exercise and in the surveys conducted, in general, that local citizens are concerned about strip development along the roads (particularly Route 20) and urban sprawl. Strip development and sprawl diminish the rural character of the region, the visual distinctiveness of the watershed, and the sensory quality. As these qualities are almost impossible to restore: once they are gone, a conservative planning approach (Ahern 1998) needs to be taken to preserve the watershed's rural character (Lynch 1976).

Along with the desire to maintain the rural countryside, the survey revealed that the population of the watershed is mainly interested in growth through tourism development rather than commercial or industrial expansion. Making use of the rich historic and cultural resources and promoting them with recreational possibilities provide an opportunity to increase the attraction of the area for tourists. Further recommendations to enhance the possibilities for historic experiences and recreational opportunities will be revealed in the spatial concept for the alternative future scenario (section 4.4.2) and in the key action steps spelled out later in this chapter.

These strengths and desires for future development and character should be discussed throughout the watershed, and the Basin Team and the proposed Watershed Authority can lead the discussion. A universal slogan to increase regional identification and enhance unity in respect to the future character and development of the watershed should be identified.

Establish Stream Teams

Stream Teams have, in other parts of Massachusetts, played a significant role in shaping watershed consciousness among the people in the watersheds (Himlan 1999). Stream Teams are composed of citizens volunteers involved in actions around the streams or aquifers in which they live. Stream teams bring together stakeholders as a cohesive entity and set priorities for the sub-watershed. Stream teams also take action. For example, they may: organize clean ups of the rivers and streams and their adjacent land parcels; invent educational, guided tours on areas of interest, e.g. flora and fauna of the river ways or water quality; or organize a river or canoeing festival. They also could be trained to collect and analyze water samples from two rivers. Having citizens conduct water quality testing promotes local stewardship of the rivers. Citizen monitors can help fill in the gaps where the State does not sample, yet, citizens water-monitoring effort should be conducted as and on-going concerns rather than one-shot deal. Through these actions, an awareness of and concern for the hydrological resources can evolve, and might incorporate the concept of the stream system in the thinking of the French and Quinebaug watershed.

Sharing responsibility among the three sub-basins of the watershed
According to the geology and the population statistics of the French and Quinebaug Watershed, the area can be subdivided into three sub-basins: the Western Quinebaug, the Central Quinebaug, and the French sub-basin. On a more detailed level than generally taken in this study, the three sub-basins face different problems and threats (such as development pressure) and have different strengths. Ideally, watershed association helps the communities in the watershed to understand what their strengths and weaknesses are, and together develop an approach of sharing responsibilities in terms of providing new areas for housing, commercial and industrial development; tourist targets; recreational opportunities; and biodiversity protection.

Within the watershed, the French sub-basin is subject to the highest development pressure due to its proximity to Worcester. Also in this area are smaller and more threatened patches of land which are important to preserve in order to maintain biodiversity. For this portion of the watershed will be to wisely link and protect natural resources while allowing for development.

The Central Quinebaug is the historic center of the watershed and would benefit by promoting this asset. The hub of Sturbridge and Southbridge is important both for visitors and economic development in the region. A careful approach to historic preservation and development of Southbridge's downtown area will be the most important issue to address in this portion of the region.

The Western Quinebaug is home to many large patches, represents numerous hydrological and biodiversity resources. Further, the population density in this portion of the planning area is very low; the residential settlement pattern is similar within most small communities. The area allows for the development of recreational assets, such as canoeing and other forms of water-related activities. The patches of ecological significance could be linked through multi-purpose greenways allowing for species habitat and migration as well as recreational possibilities as describes in Section 4.4.

Create an Educational Video, and Provide Information for Grant and Funding Opportunities
Through a video made available at the town halls, libraries, and local stores, the public can be made aware of the issues, resources, and opportunities within their watershed. A video filmed from a airplane of a canoe, and has a voice-over talk draws the watershed's history, significant landmarks, as well as outline the current stewardship effort can be an effective tool to support watershed protection efforts (CMRPC's suggestion). Besides the educational video, announcing grant and funding opportunities supports activities in the watershed will provide more and well informed watershed community. These announcements need to cover extensive range of opportunities from educational activities (see Appendix J) to water quality improvements.

3. Protect the Hydrological / Natural Resources

The ecological health of the French-Quinebaug watershed depends on the health of its hydrological resources: the rivers and their tributaries, the lakes and ponds, and the wetlands (Figure 4.21). Most of the areas important for biodiversity in the watershed are located directly adjacent to the water bodies and wetlands (Figure 2.10). Wooded buffers and stabilized shorelines are important resources for protecting sensitive habitats and for improving water quality.

Monitor Water Quality

Water quality is an important of identify the health of the hydrological system. The current efforts to monitor water quality should be extended to provide for identification of the key trends in water quality over time. Monitoring data may be used in a model to predict changes in the hydrological conditions of the area depending on different variables, for instance changes or pollutants in land uses. The results would be valuable for landscape planning and management in the French and Quinebaug watershed. The decision-makers could better understand the effects of their decisions to implement and consider the problems and threads in terms of water quality in a better way.

As data collection is labor and cost-intensive, we recommend cooperation with the academic institutions within and near the watershed. While students supervised by experts can assemble water quality data relatively inexpensively, they can at the same time be involved in an ongoing planning process and gain valuable experience. There is an opportunity for cooperation with Nichols College in the watershed area (in Dudley), and with the University of Massachusetts at Amherst, which is located nearby.

Reduce Non-Point Source Pollution

Many of the waterbodies in the French-Quinebaug Watershed are impacted by failing residential septic systems. This non-point source pollution results in the cultural eutrophication associated with excessive nutrient loads. These lakes, ponds, and impoundments (and, to a lesser degree, rivers and streams) are characterized by nuisance population of algae and/or aquatic macrophytes (plants). Recommendations concerning non-point source pollution are found in chapter 1.28.

Enhance Buffers

According to the Massachusetts River Protection Act, buffers of 200 feet around streams and ponds should be protected. However, it is possible for local conservation commissions to allow some development along rivers provided it complies with performance standards, intended to minimize impacts to the ecological, pollution-absorption and other functions of riparian areas. For wetlands, the Massachusetts Wetland Protection Act provides some protection to wetland resource areas and 100 foot buffer zones adjacent to those rivers. As vegetated buffers help to preserve water quality, the Wetlands and Rivers Act should be enforced in the watershed to protect the health of the hydrological system. It would be useful to develop guidelines for the administration of the Rivers Protection Act that should be made accessible to all towns in the watershed to support their decision-making, in respect to future development. Building permits should be given only when all relevant BMPs are considered in the proposed project. A handbook promoting these BMPs would provide useful information for watershed residents and business alike.

Develop and implement Open Space Plans

Open Space plans, when integrated within the master planning of each town, represent a great opportunity to guide development in these communities. Through open space plans and comprehensive master plans, urban sprawl can be minimized, and strategies for reuse or infill development can be promoted. Especially for the communities with a high development pressure, the design and implementation of open space plans can benefit the quality of life in the near future. Thus, we highly recommend the consideration of these documents supported by an external planner or a town greenway committee. Implemented open space plans allow, in addition, for application of certain grants and funds. Open Space and Recreation Plans must follow the guidelines of the Massachusetts Executive Office of Environmental Affairs – Division of Conservation Services (EOEA) to become eligible for state funding.

Connect patches important for biodiversity

To maintain a healthy biodiversity in the watershed, it is essential to identify the areas of potentially valuable habitat, as well as areas in which endangered or threatened species exist. To sustain habitats it is important that connectivity and a certain size of habitat is supported, and protected from fragmentation. Areas identified as important for biodiversity should be preserved and connected by greenways, corridors, or patches (see chapter 2.5). The work to date needs continuation and ground checks to verify the presence of species in the identified potential habitats.

Figure 4.22: Brimfield

4. Maintain the Rural Character

A major asset of the French and Quinebaug watershed is its rural character which is particularly unique as the watershed is surrounded by urban centers, i.e.,. Worcester, Providence, Springfield and Hartford. Development pressure, especially from the east, can lead to uncontrolled future construction activities that adversely impact the watershed visual quality and rural appearance. Several key action steps should be taken to carefully protect these scenic resources:

- Develop the application of Model Zoning by-laws in the towns. Cooperate and learn from each other within the watershed.
- Promote the adoption of Agricultural Preservation Restrictions and Conservation Restrictions.
- Perform a viewshed analysis for the entire area to assess and prioritize the areas most critical for maintaining the existing visual appearance.
- Conduct a survey roads that may be designated as Scenic Roads.
- Protect and preserve the watershed's remaining farmland.

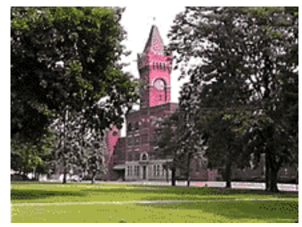

Figure 4.23: American Optical

5. Encourage Economic Development

Although the watershed is a rural environment, economic development is desired and should be encouraged. To plan economic development according to the strengths and weaknesses of the region and to support a desired future for the people of the watershed, the economic sectors in which to invest must be determined carefully. For example, the Brimfield antiques industry was identified as a unique and valuable economic resource of the French-Quinebaug Watershed (Figure 4.22). The survey revealed that the population of the French and Quinebaug watershed is interested in the development of tourism over industrial or commercial expansion. An economic development / feasibility study would provide valuable information, and serve as a guidance document for this form of economic development. Considering the natural and cultural landscape, we see an opportunity in establishing more corporate retreat facilities such as American Optical in Southbridge (Figure 4.23), especially if historic architecture can be reused. There are opportunities to expand the tourism sector in making use of already existing facilities and various landscape features in the watershed. The following key action steps should be taken into consideration:

- Develop a tourist concept focusing on historic assets, trail based tourism using the tremendous existing resources (Grand Trunk, Providence-Worcester Rail Line, and the existing trail network), water activities, and the expansion of Old Sturbridge Village (Figure 4.24)

- Promote the area and activities as a tourist destination. A website is a valuable marketing tool for accommodations, restaurants, activities, and special events.
- Designate scenic routes (i.e. Route 31 and Route 20).
- Reuse mill structures for tourist activities.
- Promote economic viability of local farms through roadside stands "pick your own" operations, and community-supported agriculture.

Preserve and Reuse the Mills

Figure 4.24: Old Sturbridge Village

The old mills and mill housing have a special role in the watershed. As they relate to the specific architecture and economic history of the region, they are tremendous cultural assets. Preservation and adaptive reuse of these structures serve several of the goals determined for the watershed: expansion of the National Heritage Corridor, creation of watershed awareness, maintenance of the local character, and economic development.

In the French and Quinebaug Watershed industrial mills have long played an important economic role. The mills along the waterways have produced energy for a variety of economic uses, provided manufactured goods used throughout the world, and attracted great numbers of immigrants to the area (Section 3.1). Today most of the mills remain unused architectural leftovers throughout the watershed. The mill architecture, though, is providing the watershed with uniqueness and cache and distinguishes it from other areas. In conjunction with the desire for tourism development, these buildings represent a great opportunity for adaptive reuse. Some of these uses (in terms of tourism) are cafes and restaurants, museums, art and antique galleries, bed & breakfasts, and hotels. Also, the old mill buildings can take on new uses not related to the tourism sector, such as commercial industrial centers, office spaces, residences and artists and craftsmen.

The former mill housing units are currently rented out for inexpensive leases and regarded as undesirable housing. Along with that, the investments to preserve the architecture are small and the traditional houses of the mill workers, over time, have suffered from decay. Yet, the mill houses reflect the history of the region and are in many points designed in accordance with current principles in planning. The higher density and the shared open spaces are, nowadays considered to enhance security and enrich the quality of life.

Preserving traditional mill architecture helps to enrich the cultural-historic identity, specialty and uniqueness of the French and Quinebaug Watershed.

Adaptive Management

In order to judge the impacts of future planning, management practices, and implementation in the watershed, evaluation and monitoring must be an ongoing process. If results of various management alternatives are continuously evaluated, this feedback can shape future planning and provide for shifts in goals and methods in case the actions taken do not lead to the results desired. In such a complex system as the watershed, there is always uncertainty included when implementing management practices (Peck, 1998) due to incomplete and imperfect knowledge of ecosystem components and their interactions. To be aware of these uncertainties offers the opportunity for conscious control of predefined variables, such as water quality, biodiversity, amount of impervious surfaces, etc. The evaluation of designated benchmarks allows experiences gained in earlier stages of the watershed management process to be applied in the future. Also, the goals for the watershed can be appraised continuously as new information, developments, or a changed perspective of the people develops.

It is very important to point that this five concepts are related and mutually reinforce eatch other. It was proven that it is very important to "Create Consciousness for the Watershed as an Entity", so that people can improve and " Protect the Hydrological /

Natural Resources" and "Maintain the Rural Character" both addressed as important by the communities. Consequently the good quality of life coping with a tourism, optical industries and other activities will "Encourage Economic Development" of the watershed. The importance of supporting "the application for inclusion in the Quinebaug and Shetucket Rivers Valley National Heritage Corridor" will not only emphasize the previous objectives but also will allow to improve an important and vast area subject to urban pressures and growing development.

Appendices

Appendix A

General Soil Descriptions (from USDA NRCS Soil Reports)

The general soil map units found in the general soils map (fig.1.3), show broad areas that have distinctive patterns of soils, relief, and drainage. These units consist of one or more major soils, but may include other minor soils. While the soils within any one map unit may vary in slope, depth, and drainage, the map is useful for comparing the suitability of large areas for general land uses. These soil units include:

- Paxton-Woodbridge-Ridgebury: Nearly level to steep, very deep, well drained to poorly drained soils on glaciated uplands. This unit is found extensively throughout the French-Quinebaug on upland hills and ridges. These soils were formed from glacial till derived from schist, gneiss, and granite. This unit is suitable for agriculture. Slope, wetness, frost action, slow permeability and depth to bedrock in minor soil units are the major limitations to non-agricultural land uses.
- Canton-Montauk-Scituate: Nearly level to steep, very deep, well-drained soils on glaciated uplands. This unit is found extensively throughout the watershed on upland hills and rolling flats, and covers most of the town of Charlton. This soil unit is suitable for agriculture and non-agricultural uses, although Canton soils are limited as sites for septic systems due to poor filtering capacity.
- Brookfield-Brimfield: Gently sloping to steep, very deep and shallow, well drained and somewhat excessively drained soils on glaciated uplands. This unit consists of soils on upland hills and ridges that have rock exposures throughout the unit. This unit is found in isolated areas of the watershed including Southbridge and Brookfield. This unit is generally poorly suited for agriculture. Slope, stones, and shallow bedrock are the primary limitations to agricultural and non-agricultural uses.
- Chatfield-Hollis: Gently sloping to steep, moderately deep and shallow, well drained and somewhat excessively drained soils on glaciated uplands. These soils were formed in glacial till and are found in limited areas of the watershed including Sturbridge and Charlton. Soils are found on hills and ridges with bedrock outcrops throughout. Shallow and exposed bedrock cause this soil unit to be poorly suited for agricultural and non-agricultural land uses.
- Merrimac-Hinckley-Windsor: Nearly level to steep, very deep, excessively drained and somewhat excessively drained soils on outwash plains. This map unit consists of soils on broad flat plains and in rolling steep areas throughout the watershed. These soils formed in the sands and gravels of glacial outwash and are therefore found coinciding with sand and gravel deposits. This soil unit is suitable for both agriculture and development. Limitations for agriculture include slope, low content of nutrients, and lack of moisture. Limitations to development are caused by high permeability, and therefore a poor filtering capacity of the soils for septic systems.
- Freetown-Swansea-Saco: Nearly level, very deep, very poorly drained soils on uplands, outwash plains, and floodplains. This map unit consists of soils on broad flats that are found in old glacial lakes or small ponds adjacent to streams. This soil unit formed in organic deposits and floodplain alluvium and is found throughout the watershed. While this unit is suitable for agriculture, flooding, and a high water table within these soils limits non-agricultural land uses.
- Paxton-Brookfield-Woodbridge: Very deep, gently sloping to steep, well drained and moderately well drained soils formed in loamy glacial till on uplands. This unit is found on low hills and ridges throughout Brimfield, Holland, and Wales. This unit is poorly suited for agriculture due to a high amount of stones on the surface. Upland areas are generally well suited for development although most soils within this unit have a restricted permeability and do not readily absorb effluent from septic systems.

- Scituate-Montauk-Charlton: Very deep, nearly level to very steep, well-drained and moderately well drained soils formed in loamy and sandy glacial till. This unit consists of hill and ridges found in a limited portion of the watershed in Monson. This unit is poorly suited for agriculture due to large amounts of stones on the surface. Upland areas are generally well suited for development.
- Hinckley-Merrimack-Windsor: Very deep, nearly level to steep, excessively drained, and somewhat excessively drained soils formed in sandy and gravelly outwash, on glacial outwash plains and terraces. This unit is found in a limited portion of the watershed in Monson. This unit is suitable for agricultural use and development, although high permeability and low filtering capacity of the soils restrict suitability for septic systems.

APPENDIX B

Rare & Endangered
Species in the French-Quinebaug Watershed (by Species)

This list includes all state-listed rare species populations known to have occurred within the last twenty-five years and reported to the Natural Heritage & Endangered Species Program. This report may exclude occurrence records of species particularly vulnerable to collection or killing. It was generated from NHESP's database on 5/5/97.

Natural Heritage & Endangered Species Program
MA Division of Fisheries & Wildlife
Route 135, Westborough, MA 01581
ftp://ftp.heritage.tnc.org/pub/nhp/us/ma/towna-e.htm

E=Endangered, T=Threatened, SC=Special Concern

Scientific Name	Common Name	Taxonomic Group	Status	Town
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	BRIMFIELD
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	BROOKFIELD
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	EAST BROOKFIELD
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	SPENCER
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	WEST BROOKFIELD
CORALLORRHIZA ODONTORHIZA	AUTUMN CORALROOT	Vascular Plant	SC	STURBRIDGE
EMYDOIDEA BLANDINGII	BLANDING'S TURTLE	Reptile	T	SPENCER
AMBYSTOMA LATERALE	BLUE-SPOTTED SALAMANDER	Amphibian	SC	BROOKFIELD
AMBYSTOMA LATERALE	BLUE-SPOTTED SALAMANDER	Amphibian	SC	EAST BROOKFIELD
AMBYSTOMA LATERALE	BLUE-SPOTTED SALAMANDER	Amphibian	SC	SPENCER
RANUNCULUS PENSYLVANICUS	BRISTLY BUTTERCUP	Vascular Plant	T	AUBURN
ADLUMIA FUNGOSA	CLIMBING FUMITORY	Vascular Plant	T	STURBRIDGE
ANAX LONGIPES	COMET DARNER	Odonate	SC	MONSON
ACCIPITER COOPERII	COOPER'S HAWK	Bird	SC	CHARLTON
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	AUBURN
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	DOUGLAS
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	MONSON
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	SPENCER
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	SUTTON
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	WEBSTER
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	WEST BROOKFIELD
HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	Amphibian	SC	EAST BROOKFIELD
HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	Amphibian	SC	SOUTHBRIDGE
HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	Amphibian	SC	WALES
ORONTIUM AQUATICUM	GOLDEN CLUB	Vascular Plant	T	MONSON
VERMIVORA CHRYSOPTERA	GOLDEN-WINGED WARBLER	Bird	E	BROOKFIELD
VERMIVORA CHRYSOPTERA	GOLDEN-WINGED WARBLER	Bird	E	WEST BROOKFIELD
AMMODRAMUS SAVANNARUM	GRASSHOPPER SPARROW	Bird	T	LEICESTER
RHODODENDRON MAXIMUM	GREAT LAUREL	Vascular Plant	T	AUBURN
MITOURA HESSELI	HESSEL'S HAIRSTREAK	Lepidoptera	SC	AUBURN
MITOURA HESSELI	HESSEL'S HAIRSTREAK	Lepidoptera	SC	DOUGLAS
RALLUS ELEGANS	KING RAIL	Bird	T	EAST BROOKFIELD
IXOBRYCHUS EXILIS	LEAST BITTERN	Bird	E	BROOKFIELD
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	DUDLEY
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	CHARLTON
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	DOUGLAS
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	OXFORD
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	SUTTON
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	WALES
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	WEBSTER
SOMATOCHLORA LINEARIS	MOCHA EMERALD	Odonate	SC	MONSON
CRANGONYX ABERRANS	MYSTIC VALLEY AMPHIPOD	Crustacean	SC	DOUGLAS
FIXSENIA FAVONIUS ONTARIO	NORTHERN HAIRSTREAK	Lepidoptera	SC	DOUGLAS
PODILYMBUS PODICEPS	PIED-BILLED GREBE	Bird	E	BROOKFIELD
PODILYMBUS PODICEPS	PIED-BILLED GREBE	Bird	E	EAST BROOKFIELD
CLEMATIS OCCIDENTALIS	PURPLE CLEMATIS	Vascular Plant	SC	BROOKFIELD
CLEMATIS OCCIDENTALIS	PURPLE CLEMATIS	Vascular Plant	SC	STURBRIDGE

SCLEROLEPIS UNIFLORA	SCLEROLEPIS	Vascular Plant	E	DOUGLAS
CISTOTHORUS PLATENSIS	SEDGE WREN	Bird	E	BROOKFIELD
SPHENOPHOLIS NITIDA	SHINING WEDGEGRASS	Vascular Plant	T	SOUTHBRIDGE
ERIOPHORUM GRACILE	SLENDER COTTONGRASS	Vascular Plant	T	DOUGLAS
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	AUBURN
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	BRIMFIELD
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	BROOKFIELD
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	DOUGLAS
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	ST BROOKFIELD
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	HOLLAND
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	LEICESTER
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	MILLBURY
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	MONSON
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	OXFORD
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	SPENCER
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	STURBRIDGE
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	SUTTON
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	WALES
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	WEBSTER
DESMODIUM HUMIFUSUM	SPREADING TICK-TREFOIL	Vascular Plant	E	OXFORD
AESHNA MUTATA	SPRING BLUE DARNER	Odonate	E	MONSON
GYRINOPHILUS PORPHYRITICUS	SPRING SALAMANDER	Amphibian	SC	DOUGLAS
STROPHITUS UNDULATUS	SQUAWFOOT	Mussel	SC	HOLLAND
ALASMIDONTA UNDULATA	TRIANGLE FLOATER	Mussel	SC	BRIMFIELD
ALASMIDONTA UNDULATA	TRIANGLE FLOATER	Mussel	SC	HOLLAND
ALASMIDONTA UNDULATA	TRIANGLE FLOATER	Mussel	SC	STURBRIDGE
SOREX PALUSTRIS	WATER SHREW	Mammal	SC	MONSON
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	AUBURN
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	BRIMFIELD
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	CHARLTON
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	DOUGLAS
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	ST BROOKFIELD
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	LEICESTER
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	MONSON
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	OXFORD
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	SOUTHBRIDGE
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	STURBRIDGE
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	SUTTON
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	WALES
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	WARREN
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	WEBSTER

APPENDIX C

Rare & Endangered
Species in the French-Quinebaug Watershed (by Species)

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Scientific Name	Common Name	Taxonomic Group	Status	Town
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CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	AUBURN
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	AUBURN
MITOURA HESSELI	HESSEL'S HAIRSTREAK	Lepidoptera	SC	AUBURN
RANUNCULUS PENSYLVANICUS	BRISTLY BUTTERCUP	Vascular Plant	T	AUBURN
RHODODENDRON MAXIMUM	GREAT LAUREL	Vascular Plant	T	AUBURN
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	AUBURN
ALASMIDONTA UNDULATA	TRIANGLE FLOATER	Mussel	SC	BRIMFIELD
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	BRIMFIELD
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	BRIMFIELD
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	BRIMFIELD
AMBYSTOMA LATERALE	BLUE-SPOTTED SALAMANDER	Amphibian	SC	BROOKFIELD
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	BROOKFIELD
CISTOTHORUS PLATENSIS	SEDGE WREN	Bird	E	BROOKFIELD
CLEMATIS OCCIDENTALIS	PURPLE CLEMATIS	Vascular Plant	SC	BROOKFIELD
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	BROOKFIELD
IXOBRYCHUS EXILIS	LEAST BITTERN	Bird	E	BROOKFIELD
PODILYMBUS PODICEPS	PIED-BILLED GREBE	Bird	E	BROOKFIELD
VERMIVORA CHRYSOPTERA	GOLDEN-WINGED WARBLER	Bird	E	BROOKFIELD
ACCIPITER COOPERII	COOPER'S HAWK	Bird	SC	CHARLTON
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	CHARLTON
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	CHARLTON
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	DOUGLAS
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	DOUGLAS
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	DOUGLAS
CRANGONYX ABERRANS	MYSTIC VALLEY AMPHIPOD	Crustacean	SC	DOUGLAS
ERIOPHORUM GRACILE	SLENDER COTTONGRASS	Vascular Plant	T	DOUGLAS
FIXSENIA FAVONIUS ONTARIO	NORTHERN HAIRSTREAK	Lepidoptera	SC	DOUGLAS
GYRINOPHILUS PORPHYRITICUS	SPRING SALAMANDER	Amphibian	SC	DOUGLAS
MITOURA HESSELI	HESSEL'S HAIRSTREAK	Lepidoptera	SC	DOUGLAS
SCLEROLEPIS UNIFLORA	SCLEROLEPIS	Vascular Plant	E	DOUGLAS
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	DOUGLAS
AMBYSTOMA LATERALE	BLUE-SPOTTED SALAMANDER	Amphibian	SC	EAST BROOKFIELD
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	EAST BROOKFIELD

CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	EAST BROOKFIELD
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	EAST BROOKFIELD
HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	Amphibian	SC	EAST BROOKFIELD
PODILYMBUS PODICEPS	PIED-BILLED GREBE	Bird	E	EAST BROOKFIELD
RALLUS ELEGANS	KING RAIL	Bird	T	EAST BROOKFIELD
ALASMIDONTA UNDULATA	TRIANGLE FLOATER	Mussel	SC	HOLLAND
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	HOLLAND
STROPHITUS UNDULATUS	SQUAWFOOT	Mussel	SC	HOLLAND
AMMODRAMUS SAVANNARUM	GRASSHOPPER SPARROW	Bird	T	LEICESTER
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	LEICESTER
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	LEICESTER
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	MILLBURY
AESHNA MUTATA	SPRING BLUE DARNER	Odonate	E	MONSON
ANAX LONGIPES	COMET DARNER	Odonate	SC	MONSON
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	MONSON
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	MONSON
ORONTIUM AQUATICUM	GOLDEN CLUB	Vascular Plant	T	MONSON
SOMATOCHLORA LINEARIS	MOCHA EMERALD	Odonate	SC	MONSON
SOREX PALUSTRIS	WATER SHREW	Mammal	SC	MONSON
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	MONSON
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	OXFORD
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	OXFORD
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	OXFORD
DESMODIUM HUMIFUSUM	SPREADING TICK-TREFOIL	Vascular Plant	E	OXFORD
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	SOUTHBRIDGE
HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	Amphibian	SC	SOUTHBRIDGE
SPHENOPHOLIS NITIDA	SHINING WEDGEGRASS	Vascular Plant	T	SOUTHBRIDGE
AMBYSTOMA LATERALE	BLUE-SPOTTED SALAMANDER	Amphibian	SC	SPENCER
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	SPENCER
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	SPENCER
EMYDOIDEA BLANDINGII	BLANDING'S TURTLE	Reptile	T	SPENCER
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	SPENCER
ADLUMIA FUNGOSA	CLIMBING FUMITORY	Vascular Plant	T	STURBRIDGE
ALASMIDONTA UNDULATA	TRIANGLE FLOATER	Mussel	SC	STURBRIDGE
CLEMATIS OCCIDENTALIS	PURPLE CLEMATIS	Vascular Plant	SC	STURBRIDGE
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	STURBRIDGE
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	STURBRIDGE
CORALLORRHIZA ODONTORHIZA	AUTUMN CORALROOT	Vascular Plant	SC	STURBRIDGE
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	SUTTON
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	SUTTON
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	SUTTON
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	SUTTON
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	WALES
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	WALES
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	WALES
HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	Amphibian	SC	WALES
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	WARREN
AMBYSTOMA OPACUM	MARBLED SALAMANDER	Amphibian	T	WEBSTER
CLEMMYS GUTTATA	SPOTTED TURTLE	Reptile	SC	WEBSTER
CLEMMYS INSCULPTA	WOOD TURTLE	Reptile	SC	WEBSTER
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	WEBSTER
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	Bird	E	WEST BROOKFIELD
TERRAPENE CAROLINA	EASTERN BOX TURTLE	Reptile	SC	WEST BROOKFIELD
VERMIVORA CHRYSOPTERA	GOLDEN-WINGED WARBLER	Bird	E	WEST BROOKFIELD

Appendix D:

NATURAL HERITAGE &
ENDANGERED SPECIES PROGRAM

Natural Heritage & Endangered Species Program
MA Division of Fisheries & Wildlife
Route 135
Westborough, MA 01581-3337

MASSACHUSETTS RARE AND ENDANGERED WILDLIFE

Golden-winged Warbler
(Vermivora chrysoptera)

DESCRIPTION: The Golden-winged Warbler is a beautiful bird, about 11cm (4.5 in.) in length, with a distinctive combination of colors and patterns. The male has a dull white underside and a gray back, with bright yellow patches on the crown (forehead) and upper wing surfaces, and a black throat and bill. A black "mask" extends across eyes, with patches of white above and below the mask. The female Golden-winged Warbler is similar in appearance, but the colors are considerable duller. Male Golden-wings Warblers sing most persistently in the morning early in the nesting season. Golden-wings make use of two types of songs. One of the songs is characterized by a high-pitched buzzy phrase followed by 1 to 6 shorter buzzy phrases, and is used to attract mates. The other song consists of 3 to 5 low buzzy phrases ending with a higher buzzy phrase, and is used to defend the bird's territory against other males.

SIMILAR SPECIES: The Blue-winged Warbler is a very close relative of the Golden-winged Warbler, but its body is predominantly yellow instead of gray and white. These two species of warblers often mate and produce hybrids, one of which is known as Brewster's Warbler. It is very similar in appearance to the Golden-winged Warbler, but has a yellow patch on its chest and lacks black throat color; its mask is also less conspicuous. The other hybrid, known as Lawrence's Warbler, has a yellowish head and underside, black throat and mask, and two white wingbars.

HABITAT IN MASSACHUSETTS: Golden-winged Warblers prefer woodland edges bordering early successional clearings (such as abandoned farmland and powerline areas), heavily overgrown with patches of grass, weeds, bushes, shrubs, and small trees. Common species of vegetation found in these habitats are grapevine (Vitis sp.), goldenrod (Solidago sp.), and birch (Betula sp.).

RANGE: The summer range of the Golden-winged Warbler extends from southern New Hampshire west to Minnesota and south to Iowa and New Jersey (and in the Appalachians to northern Georgia). During the early of the century, the Golden-winged Warbler's summer range expanded northward and eastward but it disappeared from the southern extent of its range. The winter range of the Golden-winged Warbler's extends from southern Mexico to Venezuela and Colombia.

BEHAVIOUR/ ECOLOGY: Golden-winged Warbler's usually arrive in New England in early May, the females arriving a day or two later than the males. The males immediately set up territories (which range in size from 1 to 5 acres) and sing in order to defend their territory and attract females. Males often return to the same site year after year. After pairing takes place, the females build bulky nests on or near the ground. The nest is constructed out of grasses, leaves, vine tendrils, and other fine materials, and is supported by bushes; or very frequently, by goldenrod stems. From mid-May to mid-June, three to seven creamy white eggs with brown speckles are laid, one egg per day. The eggs are incubated by the female for 10 to 11 days. Both parents feed and care for the nestlings. Although the chicks are able to leave the nest after ten days, the parents continue care for them until several weeks afterward. The chicks acquire their winter plumage about a month after birth, and reach maturity in one year. Golden-winged Warblers begin their southward migration in late August or early September. Golden-winged Warblers feed on larvae, small bugs, spiders, ants, beetles, and caterpillars (including Gypsy Moth caterpillars). The Golden-winged Warbler's feeding behavior resembles that of chickadees: it hops from twig to twig, sometimes hanging upside down, while peering about around the branches for insects. The life span of the Golden-winged Warbler's is about 2 to 5 years.

POPULATION STATUS: The Golden-winged Warbler is listed as an Endangered species in Massachusetts due to its rapidly decreasing population; in fact; there is no longer a viable population anywere in Massachusetts. In the 19th century, Golden-winged Warblers were rarely seen in New England. In the early 1900's, the population of Golden-winged Warbler in New England increased as many farmlands were abandoned. From then unitl 1940, Golden-winged Warbler were locally uncommon to common in Massachusetts, and Blue-winged Wrablers were not present. Since 1940, Blue-winged Wrablers increased steadly in numbers throughout the state, and have become common in many areas. At the same time, the number of Golden-winged Warblers has steadily declined to the point where they are now rare throughout Massachusetts, and completely absent over most areas. It appears that the Blue-winged Warblers may have been swamping the gene pool of the Golden-winged Warblers by interbriding with them. The courtship calls and displays of each species are very similar. As a result, Golden-winged Warblers often mate with Blue-winged Warblers, creating hybrids instead of true Golden-wings. However, Blue-winged Warblers also seem to be declining after reaching a zenith in the early 1980's.
Cowbird parasitism and loss or impairment of wintering habitat may also be part of the problem, but no one really understands exactly what happened to the Golden-wing; it is possible that the situation could reverse itself someday. The amount of suitable habitat for the Golden-wing does not seem to be a limiting factor; there is plenty of habitat available, but no birds to occupy it; many of the sites where Golden-winged Warblers have been seen since 1978 now appear to be abandoned. The only Golden-wings currently observed in Massachusetts are stray males which establish a territory in suitable habitat, advertise (usually widouth success, since there are no Golden-wing females arround) and depart southward in autumn. The male, if still alive, will return to the exact same territory the following spring and try again. After the male dies (in 2 to 3 years), the habitat again is vacant. The likelihood of another male turning up in the same place is extremely small; usually the next pioneering male will pick somewhere else, and the discouraging cycle will repeat itself. Lately, so few Golden-wings turn up in Massachusetts that one can no longer expect to see them anywhere widouth a lot of luck.

Appendix E:

		DEGRAAF AND RUDIS CLASSIFICATION											
		Poplar, Aspen, or Willow	White Birch	Northern Hardwoods			Red Maple		Northern Red Oak			White Pine-Hardwoods	
GAP VEGETATION MAJOR TYPES				Sugar Maple	Beech-Birch-Maple	Black Cherry	Red Maple, Swamp Hardwoods	Gray Birch-Red Maple	Northern Red Oak	Oak Hardwoods	Mixed Oak	Eastern White Pine, Northern Red Oak, with Red Maple as chief associate	Eastern White Pine, Northern Red Oak, or Black Oak predominant
A Northern Hardwoods (Sugar Maple Dominant)	1. Sugar Maple dominant (beech, ash, and/or birch)			■		■							
	2. Up to 20% white pine			■		■							
	6 Up to 20% Red Oak			■		■							
	7. Red Oak mixture with up to 20% white pine			■		■							
B Red Maple Dominant	4 Maple Dominant Deciduous						■		■				
C Oak Dominant	8 Red Oak Dominant Oak Mixture								■				
	12. Oak Dominant with up to 20% N Hardwood (cis. Red Maple mixture with Birch)								■				
	16. Oak Dominant with up to 20% Red Maple (cis. Birch)								■				
	17. Oak Dominant with up to 20% Birch (cis N. Hardwood and/or Red Maple)								■				
	20. Oak Dominant with up to 20% Birch and White Pine								■				

Appendix F:

Historical Resources Inventory

Source: the State Register of Historic Places
This chart corresponds to Figure 18, the distribution map. Numbers on that map correspond to the numbers in this chart.

Key: NRDIS = National Register Historic District
LHD = Local Historic District
NRIND = National Register Individual Property
MRMRA = National Register Multiple Resource Area
PR = Preservation Restriction
NRDOE = National Register Determination of Eligibility

	NAME OF	LOCATION	DATE	OPEN TO PUBLIC	HISTORICAL SIGNIFICANCE	REGISTE LISTING
1	Charlton Center Historic District	Main St. district, Charlton	NA	Y	19th + early 20th c. buildings and sites, includes home of Dr. William T.G.Morton, who first demonstrated use of ether as anathesia. (note: except Dr. Morton House, most of the others are private homes)	NRDIS
2	Northside Historic District Central	Stafford & Northside Sts., Charlton	1877	Y	Includes Rider Tavern, many examples of 19th c. architecture.	LHD
3	Northside Historic District East	Smith Rd & Stafford St., Charlton	NA	Y	Early 19th c., contains many Federal and Greek Revival buildings. Cady Brook Section home to numerous mill sites. (note: Many are private homes)	LHD
4	Northside Historic District South	Northside Rd, Charlton	NA	Y	Also contains many Federal and Greek Revival buildings (note: Many are private homes)	LHD
5	Northside School	Northside Rd., Charlton	(1848)	?	Also contains many Federal and Greek Revival buildings	LHD NRDIS PR
6	Northside Village Historic District	Stafford St, Charlton	NA	Y	Exhibits rural character of 19thc.	NRDIS
7	Rider Tavern	255 Stafford St., Charlton	Built 1797-1799	by appoint-ment	hosted Marquis de Layfayette, in 1824, served as inn and tavern for many years	NRIND LHD NRDIS
8	John Spurr House	Main St., Charlton	1798	?	Federal-style home of John Spurr the youngest member of the Boston Tea Pot rivate lawofficer)	NRIND NRDIS
9	Black Tavern	Dudley Center Rd., Dudley	1804	N, but can be rented for occasions	Oldest tavern in town	NRIND
10	Copeland Library	11 River St., Leicester	1884	N	Originally a fire house, classic Stick Style with unusual trim and bell tower	PR
11	Milestone	Rt. 9, Leicester	1767	Y	?	NRIND
12	Milestone	Main St., Leicester	1767	Y	?	NRIND
13	Milestone	Rt. 9 at Collier Corner,	1767	Y	?	NRIND
14	Shaw Site	Leicester/Spencer	?	N	state-sanctioned archeological study, named after Joseph Shaw who operated a gristmill in area	NRDOE

15	Clara Barton Homestead	Clara Barton Rd., Oxford	?	Y	Birthplace of Clara Barton, founder of the Red Cross	NRIND
16	15 Charlton Street	Oxford	?	?	?	NRDOE
17	7 Charlton Street	Oxford	?	?	?	NRDOE
18	Capt. Abijah Davis House	243 Main St., Oxford	?	?	?	NRDOE
19	William Hudson House	Hudson Rd., Oxford	?	?	?	NRIND
20	Hugenot Fort	Fort Hill Rd., Oxford	?	?	?	NRIND PR
21	Allen L. Joslin House	345 Main St., Oxford	?	?	Home of Dr. Joslin, of diabetes research fame	NRDOE
22	Benjamin Paine House	259 Main St., Oxford	?	?	?	NRDOE
23	Academie Brochu	29 Pine St , Southbridge	1899	N	Classic Revival, Parish School	NRIND NRMRA
24	Alden-Delahanty Block	858 Main St., Southbridge	1878-88	Y	High Victorian Gothic	NRIND NRMRA
25	William E. Alden Jr. House	428 Hamilton St. Southbridge	1882-87	N	Queen Anne	NRIND NRMRA
26	Cyrus Ammidown – Elbridge G. Harding Farmhouse	83 Lebanon Hill Road, Southbridge	Pre-1776	N	New England Style	NRIND NRMRA
27	Ashland Mill Tenement	141-145 Ashland Ave, Southbridge	1831-55	N	Federal Housing for Cotton Spinning Mill Workers	NRIND NRMRA
28	Bacon-Morse Historic District	N. Woodstock & Tipton Rock Rd., Southbridge	1750's -present	Y	Farm Houses in a rural setting	NRDIS NRMRA
29	Beechwood	495 Main St., Southbridge	1868	N	Stick-Main and South St. Upper Class House	NRIND NRMRA
30	34 Benefit Street	Southbridge	1870-78	N	Greek Revival, Worker House near A/O	NRIND NRMRA
31	Alexis Boyer House	306 Hamilton St., Southbridge	1888	N	Queen Anne, Ethnic French Area	NRIND NRMRA
32	Central Baptist Church	256 Main St., Southbridge	1866	Y	?	NRDIS PR
33	Central Mills Historic District	North and Central Sts., Southbridge	?	Y	?	NRDIS NRMRA
34	Centre Village Historic District	Main St., Southbridge	1830-Present	Y	100+ yr. Old brick commercial buildings. Appears today as it did 100 yrs. ago	NRDIS
35	Capt. John Chamberlain – Gilbert Bourdeau House	718 Main St., Southbridge	1855-70	N	Italianate	NRIND NRMRA
36	Chapin Block	208-222 Crane St., Southbridge	1888	N	Only shingle style comm. Block in Southbridge	NRIND NRMRA
37	Alpha Morse Cheney House	61 Chestnut St., Southbridge	1855	Y	Victorian Stick style, built by Alphacheny Org. Largest stockholders in A/o	NRIND NRMRA
38	J. M. Cheney Rental House	32 Edwards St., Southbridge	1878-98	N	Victorian Vernacular. JM Cheney was treasurer for Litchfield Shuttle Corp.	NRIND NRMRA

39	Lemuel-Glover Clarke Farmhouse	201 South St., Southbridge	1830-55	N	Greek Revival, Lg. Farm house,	NRIND NRMRA
40	Cliff Cottage	787 Mill St., Southbridge	1830-55	N	Most unique 19th c. building in Southbridge	NRIND NRMRA
41	E. Merritt Cole House	386 Main St., Southbridge	early 1800s	N	Cole was an original stockholder in A/O	NRIND NRMRA
42	Comins - Wall House	42 Hamilton St., Southbridge	1850	N	Greek Revival, Middle Class Workers House	NRIND NRMRA
43	Congregational Church	61 Elm St., Southbridge	1885	Y	Victorian Gothic	NRIND NRMRA
44	91 Coombs Street	Southbridge	1905	N	Queen Anne Vernacular, 3 Decker A/O worker housing	NRIND NRMRA
45	59-63 Crystal St.	Southbridge	1899-1904	N	Represents larger houses, built near A/o at turn of cent.	NRIND NRMRA
46	Edwin B. Cummings House	52 Marcy St., Southbridge	1870-78	N	Italianate/ Greek Revival	NRIND NRMRA
47	Dani & Soldani Cabinet Maker Factory	484 Worcester St., Southbridge	1914	N	Early 20th c. brick factory. First Italian manufactory to est. itself in town	NRIND NRMRA
48	3 Dean Street	Southbridge	1878-89	N	Good example of a small workers' cottage near A/O	NRIND NRMRA
49	Dennison District #2 Schoolhouse	Dennison Ln, Southbridge	1848	N	Ex. Of rural school house	NRIND NRMRA
50	Sylvester Dresser House	29 Summer St., Southbridge	1870	N	Victorian Gothic, Prominent townsperson	NRIND NRMRA
51	Dunbar-Vinton House	Hook and Hamilton Sts., Southbridge	1800-28	N	Federal, Unique early 19th c. home, ?school	NRIND NRMRA
52	Henry E. Durfee Farmhouse	281 Eastford St., Southbridge	1849	N	Greek Revival farm house, which retains its rural character	NRIND NRMRA
53	Elm Street Farmhouse	24 Elm St., Southbridge	?	?	?	NRIND NRMRA
54	Evangelical Free Church	Hamilton St., Southbridge	1869	Y	Transitional Romanesque Revival/ Victorian Gothic	NRIND NRMRA
55	James Gleason Cottage	31 Sayles St, Southbridge	1830-55	N	Transitional Greek Revival/ Gothic	NRIND NRMRA
56	Globe Village Fire House	West and Main Sts., Southbridge	1894	N	Colonial Revival influences	NRIND NRMRA
57	Glover Street Historic District	Glover, High and Poplar Sts., Southbridge	?	Y	?	NRDIS NRMRA
58	Hamilton Mill - West Street Factory Housing	45 West St., Southbridge	1831-55	N	Row of factory housing for Hamilton Woolen workers. Greek Revival	NRIND NRMRA
59	Hamilton Mill Brick House	16 High St., Southbridge	1830-55	N	Greek Revival	NRIND NRMRA
60	Hamilton Millwright - Agent's House	757-761 Main St., Southbridge	ca 1840	N	Built by Ham. Woolen Mill for John Edwards Bacon who helped to build the then largest mill in country.	NRIND NRMRA

61	Hamilton Woolen Co. Historic District	Along Mill St., Millbury	1849-1925	Y	Old factory buildings	NRDIS NRMRA
62	Theodore Harrington House	77 Hamilton St., Southbridge	ca1850	N	Greek Revival. Early house on street	NRIND NRMRA
63	Dr. Samuel Cyrus Hartwell House	79 Elm St., Southbridge	1870-78	Y	Queen Anne, State Senator in 1881	NRIND NRMRA
64	George H. Hartwell House	105 Hamilton St., Southbridge	1855-70	N	Italianate. Early house on street	NRIND NRMRA
65	High – School Streets Historic District	Southbridge	1840's-60	Y	Mostly Greek Revival. Lots sold by Hamilton Woolen Co.	NRDIS NRMRA
66	William Hodgson Two-Family House	103-105 Sayles St., Southbridge	1855-70	N	Greek Revival	NRIND NRMRA
67	Samuel Judson - Libya Merritt Litchfield House	313 South St., Southbridge	1830-37	N	Federal/Greek Revival	NRIND NRMRA
68	A. Kinney House	42 Edwards House, Southbridge	1855-70	N	Italianate	NRIND NRMRA
69	Joseph LaCroix - Ira Mosher House	56 Everett St., Southbridge	1904-07	N	Colonial Revival	NRIND NRMRA
70	Napoleon LaRochelle Two-Family House	30 Pine St., Southbridge	1878-94	N	Queen Anne	NRIND NRMRA
71	52 Main Street	Southbridge	1904-25	N	Classic 3-decker Queen Anne & French Canadian Influences	NRIND NRMRA
72	64 Main Street	Southbridge	1898-1904	N	Queen Anne Vernacular. Built by George Wells, A/O Pres.	NRIND NRMRA
73	70-72 Main Street	Southbridge	1898-1904	N	Colonial Revival. Built by George Wells	NRIND NRMRA
74	Maple St. Historic District	Maple St., Southbridge	?	Y	?	NRDIS NRMRA
75	Rinda Marcy House	64 South St., Southbridge	1878-98	N	Queen Anne	NRIND NRMRA
76	William McKinstry Farmhouse	361 Pleasant St., Southbridge	1780	N	New England Colonial Farm house	NRIND NRMRA
77	William McKinstry Jr. House	915 West Main St., Southbridge	1810-20	N	Federal w/ monitor roof. Documented in 1822	NRIND NRMRA
78	H. Morse House	230 South St., Southbridge	1830-55	N	Greek Revival	NRIND NRMRA
79	New York, New Haven and Hartford Passenger Depot	Depot St., Southbridge	1910	Y	New Haven Spanish	NRIND NRMRA
80	Notre Dame Roman Catholic Church	Main and Marcy Sts., Southbridge	1912	Y	Fr. Renaissance/ Monumental Church built by Fr.-Can. immigrants?	NRIND NRMRA
81	James Jacob Oakes House	14 South St., Southbridge	1855-70	N	Italianate-2nd Empire	NRIND NRMRA
82	E.M. Phillips House	35 Dresser St., Southbridge	1870-75	N	Italianate	NRIND NRMRA
83	Simon Plimpton farmhouse	561 South St., Southbridge	1819	N	Federal/ Large rural farm house	NRIND NRMRA
84	Stephen Richard House	239-241 Elm St., Southbridge	1850-78	N	5 bay vernacular. 1st Franco-Amer. Voter and industrialist in Southbridge.	NRIND NRMRA

85	25-27 River Street	Southbridge	1904-25	N	Triple decker Colonial Revival	NRIND NRMRA
86	29-31 River Street	Southbridge	1904-25	N	Triple decker Colonial Revival	NRIND NRMRA
87	Sacred Heart Church Historic District	Charlton St., Southbridge	?	Y	?	NRDIS NRMRA
88	Saint George's Greek Orthodox Church	55 North St., Southbridge	1932	Y	Byzantine	NRIND NRMRA
89	Saint Peter's Roman Catholic Church	Hamilton and Pine Sts., Southbridge	1853	N	Greek Revival, 1st Catholic Church in town	NRIND NRMRA
90	Luther Smith - Lucius Lyon Farmhouse	400 North Woodstock Rd., Southbridge	1831-55	N	Greek Revival farm house,	NRIND NRMRA
91	Southbridge Multiple Resource Area	10 districts & 71 ind. Prop. within the town, Southbridge	?	Y	?	NRMRA
92	Southbridge Town Hall	41 Elm St., Southbridge	1888	Y	Romanesque Rev. Housed both hall and high school	NRIND PR
93	Lorenzo R. Stone House	218 South St., Southbridge	1831-55	N	Greek Revival House	NRIND NRMRA
94	George Sumner House	32 Paige Hill Rd., Southbridge	1812-30	N	Federal. Sumner key early experimenter in mechanized textile man.	NRIND NRMRA
95	Eugene Tapin House	215 Lebanon Hill Rd., Southbridge	1929	N	Colonial Tudor Revival	NRIND NRMRA
96	Bella Tiffany - Manning Leonard House	25 Elm St., Southbridge	ca. 1832	N	Greek Revival. Bella-state rep. Leonard-prominent businessman	NRIND NRMRA
97	Twinehurst American Optical Company Neighborhood	Twinehurst Pl., Southbridge	?	Y	?	NRDIS NRMRA
98	Upper Chapin Street Historic District	Chapin St. & Forest Ave., Southbridge	?	Y	?	NRDIS NRMRA
99	Dea. Joshua Vinton - C.R. Boardman Farmhouse	93 Torrey Road, Southbridge	1760-1825	N	Federal	NRIND NRMRA
100	John M. Vinton - E.T. Torrey House	5 Torrey Rd., Southbridge	1841	N	Greek Revival	NRIND NRMRA
101	18 Walnut Street	Southbridge	1878-98	N	Shingle style	NRIND NRMRA
102	George Burnham and Ruth D.Wells House	Durfee Rd., Southbridge	1932	N	International style	NRIND NRMRA
103	Hiram C. Wells Double House	28-30 Dresser St., Southbridge	1888-94	N	Queen Anne / Revival	NRIND NRMRA
104	John M. Wells House	491 Eastford Rd., Southbridge	1927	N	Fr. Chateau. Largest house in town since 1st decade of 20thc.	NRIND NRMRA
105	Albert H. Wheeler House	219 South St., Southbridge	1887-96	N	Victorian. Wheeler was a successful businessman and Civil War veteran	NRIND NRMRA
106	Windsor Court Historic District	Windsor Ct. and North St., Southbridge	?	Y	?	NRDIS NRMRA

107	38-42 Worcester Street	Southbridge	1878-98	N	Early 3 decker in 'flats' section of town	NRIND NRMRA
108	Sturbridge Common Historic District	Main St. district, Sturbridge	?	Y	?	NRDIS
109	Tantiusques Reservation Site	Sturbridge	?	Y	Old graphite mine, trails on the property	NRIND
110	Oliver Wight House	Main St., Sturbridge	?	?	?	NRIND
111	District Five Schoolhouse	School St., Webster	?	?	?	NRIND
112	Eddy Block	119-131 Main St., Webster	?	?	?	NRIND
113	Main Street Historic District	Main St, Webster	?	Y	?	NRDIS NRDOE
114	Rock Castle School	Prospect St., Webster	?	?	?	NRIND
115	Shumway Block	112-116 Main St., Webster	?	Y	?	NRIND
116	Spaulding Block	141-143 Main St., Webster	?	Y	?	NRIND
117	Thompson School	Prospect St., Webster	?	?	?	NRIND

Appendix G

Recreational Resources Inventory

Source: MassGIS
This chart corresponds to Figure 3.19, the distribution map. Numbers on that map correspond to the numbers in this chart.

Public Access Types:
- Y: Yes; open to public
- 1: Public
- 4: Private, public welcome

Level of Protection:
- P: In Perpetuity
- T: Temporary (Chapter 61, 61A, 61B, some CRs)
- L: Limited (by something other than time)
- N: None
- X: Unknown

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RECREATIONAL INVENTORY					
	Site Name	**Town**	**Public Access**	**Level of Protection**	**Acres**
1	Elkleberry Land	Spencer	4	T	3.264
2	Primary School	Leicester	1	L	2.004
3	Leicester High School	Leicester	1	L	1.977
4	Burncoat Park/Town Park	Leicester/Spencer	1	P	9.493
5	Town Common	Leicester	1	P	0.338
6	Rawson Brook Cemetery	Leicester	1	P	0.11
7	J.E. Russell Park	Leicester	1	L	1.155
8	Pine Grove Cemetery	Leicester	1	P	4.429
9	Hillcrest Country Club	Leicester	4	T	9.073
10	Green Mountain Club	Leicester	1	T	0.626
11		Spencer	Y	P	3.167
12	Memorial School	Leicester	1	L	2.999
13	Spencer State Forest	Spencer	Y	P	0.255
14	Camp Wind	Leicester	4	L	0.838
15	Camp Wind	Leicester	4	L	2.899
16	Greenville Baptist Cemetery	Leicester	4	P	0.313
17	Four Cimmneys WMA	Spencer	1	P	21.856
18	Bennett Meadows WMA	Charlton/Spencer	1,X	P,T	31.123
19	Charlton Country Camping	Charlton	4	X	11.772
20	Brookfield Rod & Gun Club	Brookfield	4	T	0.894
21	Tantasqua Regional High School	Brookfield	Y	X	4.782
22	Hamilton Forest Area	Brookfield	1	P	6.456
23	Glen Echo Lake Access Area	Sturbridge	1	P	9.77
24	Merrill Pond WMA	Sutton/Oxford	Y	P	39.936

25	Bay Path Vocational School	Charlton	Y	X	17.721
26	Heritage Country Club	Charlton	4	X	29.077
27	Charlton Memorial Athletic Field	Charlton	Y	X	1.378
28	Prindle Pond		Y	X	0.227
29	McKinistry Brook WMA	Southbridge	Y	P	14.778
30	Douglas State Forest	Oxford	Y	P	216.32
31	200 Sportsmen Club	Webster	4	N	36.209
32	Town Forest Wood Lot	Webster	Y	N	1.046
33	Pleasant Street School	Southbridge	1	N	0.125
34	Henry Street Field	Southbridge	1	L	1.508
35	Applewood Camp Ground	Charlton	4	T	5.976
36	Southbridge Playground	Southbridge	1	X	2.89
37	Mass Audobon Society Land	Dudley	4	P	8.699
38	Charlton Street School	Southbridge	1	N	0.771
39	Gore pond	Dudley	1	P	1.739
40	Marcy Street School	Southbridge	1	N	0.291
41		Dudley	1	P	0.882
42		Southbridge	1	L	1
43	Oak Ridge Avenue Cemetery	Southbridge	1	P,X	3.915
44	Bigelow Rd Water Pumping Sta.	Webster	Y	X	1.562
45	Water Department Land	Southbridge	1	N	50.633
46	Mount Zion Cemetery	Webster	Y	P	2.358
47	Webster Fish and Game Land	Webster	4	X	3.229
48	Slater Street playground	Webster	Y	X	1.407
49	Resevoir	Webster	Y	X	0.7
50	Slater Memorial		Y	P	0.037
51	Dudley Intermediate School	Dudley	1	N	1.445
52	KOA Campground	Webster	4	N	2.554
53	Memorial Beach	Webster	Y	X	2.582
54	Corbin Cemetery	Dudley	1	P	0.624
55	Indian Ranch Campground	Webster	Y	N	2.739
56	Shephard Hill High School	Dudley	1	N	8.255
57	Pumping Station	Webster	Y	X	3.64
58	Park Avenue School	Webster	Y	X	3.27
59	Webster-Dudley Country Club	Dudley	1	n	6.473
60	Tank		Y	X	0.591
61	Main Street Common		Y	X	0.44
62	May Street Playground		Y	X	0.214
63	Webster Little League	Webster	4	X	0.499
64	Town Beach	Dudley	1	N	2.754
65	School Street School Lot		Y	N	0.095
66	Dudley Elementary School	Dudley	1	N	0.405
67	Bartlett High School	Webster	Y	X	4.842
68	Nichols College	Dudley	1	N	6.594
69	George Street Playground		Y	X	0.246
70	Berthol Field		Y	N	0.468
71	Breakneck Brook WMA	Southbridge	Y	P	2.724
72	Avalock Acres	Dudley	1	P	8.523

73	Goodell	Southbridge	Y	P	4.557
74	Webster Lake Boat Ramp	Webster	Y	P	0.107
75	Stevens Park	Dudley	1	P	0.111
76	Holland Pond	Holland			19.712
77	Town Beach				0.132
78	Springfield Girls Club	Holland			10.91
79	Palmer Beagle Club	Holland			20.946
80	Leadmine WMA	Holland			23.151
81	Holland Rod & Gun Club	Holland			5.502
82	Brimfield State Forest	Wales/Brimfield			287.686
83	Wales WMA	Wales			18.446
84	Wales Elementary School	Wales			11.6
85	Oak Haven Campground	Wales			12.383
86	Norcross Wildlife Sanctuary	Wales			177.465
87	Quaboag River Conservation Area	Brimfield			0.313
88	Brown 'Abijah Lot' Cons. Area	Brimfield			2.379
89	John W. Brown Conservation Area	Brimfield			0.376
90	Lake Sherman Conservation Area	Brimfield			0.068
91	Little Alum Pond Access Area	Brimfield			0.097
92	Hitchcock Acad. & Comm. Center	Brimfield			1.524
93	Town Common				0.481
94	Center Elementary School	Brimfield			1.313
95	Boys Club	Brimfield			18.116
96	Village Green Campground	Brimfield			4.063
97	East Brimfield Resevoir	Brimfield			99.581
98	Village Green Campground	Brimfield			3.527
99	DeGregorio Conservation Area	Brimfield			0.724
100	Sleepy Hollow Youth Barn Prop.	Brimfield			9.604
101	Florek Land	Brimfield			5.388
102	Quinebaug Cove	Brimfield			3.994
			Total Acres:		**1378.24**

Appendix H

Status of Town Plans

This chart indicates which towns have master plans and open space plans. Towns that do are eligible to receive certain types of funding, an incentive for all towns to develop such plans.

Town	Master Plan	Open Space Plan	Comments	Eligibility
Monson	Growth Management Plan---1989 Strategic Plan vol. 1, 2--------1985	Yes	April, 2004	Eligible for funds
Warren	No	No	No plan	Ineligible
Brimfield	No	No	Expired 1/95	Ineligible
Wales	No	No	No plan	Ineligible
Holland	No	Yes	September, 2003	Eligible for funds
Brookfield	No	No	No plan	Ineligible
Sturbridge	Yes-----1988	No	Draft 6/97	Ineligible
Southbridge	Yes-----1963	No	Draft 6/97	Ineligible
Spencer	No	No	Draft 6/98	Ineligible
Charlton	In Progress	Yes	December, 2001	Eligible for funds
Dudley	In Progress	No	Expired 3/93, Draft 6/94	Ineligible
Leicester	In Progress	No	Expired 6/93	Ineligible
Auburn	Yes-----1987	No	Expired 4/93	Ineligible
Oxford	Land Use Development Plan---1985	No	Expired 9/92	Ineligible
Webster	Yes-----1989	Yes	July, 2002	Eligible for funds
Sutton	Yes-----1992	No	Expired 1996	Ineligible
Douglas	Yes-----1998	Yes	January, 2000	Eligible for funds

Source: Department of Conservation Services

APPENDIX I

SURVEYS

Two different versions of the surveys were conducted.
Version 1 was more extensive, aimed at planners and town representatives
Version 2 was shorter, aimed at the general public

Version 1

Plan for the French-Quinebaug Watershed
Questions for Community Input

French-Quinebaug Watershed contains 18 towns in Central Massachusetts. French-Quinebaug Watershed Management Plan aims to identify the key issues and key participants in the watershed both for indicate water/environment related issues and some opportunities for the communities future development. This plan is developed with collaborative work with French Quinebaug Watershed Team and UMASS-Landscape Architecture and Regional Planning Department-Landscape Architecture Studio. Your input is important for the development of the plan, please consider visionary thinking since the plan is looking at a 20-year time-frame.

1. What town do you live in?_______________________for how many years?_________
What town do you work in?______________________for how many years?_________

2. Assuming that growth is going to take place in the next 25 years, what type of development would you like to **encourage?** For example: residential, commercial, tourism, industrial, agricultural)
a. in your town?__________________________b. in the watershed?______________________

3. What kind of development would you like to **discourage?**
a. in your town?____________________b. in the watershed?______________________

4. What are economic development and community growth concerns are important in your community?

5. What **specific natural resources** are most important to protect—those whose alteration would be a significant loss your community? (List specific locations if you know)
Land____
Water____
Air____
Wildlife____
Scenic quality____
Other____

6. What community resources are most important to protect? (List **specific** locations)
Historic areas____
Local Business / industry____
Farms / orchards____
Recreational areas____
Cultural resource____
Residential neighborhoods____
Other____

7. Are there any natural and/or community resources that have been lost over the years that you would like to see returned, if it were possible?

8. Which of the following uses do you envision for your community in the year 2010? Specifically, what and where would you like to see it sited?

Tourism destination(s)?____________________
Recreational site(s)?____________________
Local industrial center(s)?____________________
Regional industrial center(s)?____________________
Local commercial center(s)?____________________
Regional commercial center(s)?____________________
Local waste processing or disposal site(s)____________________
Regional waste processing or disposal site(s)____________________
Regional transportation hub?____________________
Residential development?____________________
Other____________________

9. What are your favorite places for:

Swimming __________ Hiking __________
Walking __________Canoeing __________
Fishing __________Scenic__________
Hunting __________ Shopping __________

10. Where do you take out of town guests?

11. Do you use the French/Quinebaug rivers for recreation?

-If yes, where____________________
-If no, why do not you use these waterways __________

12. Do you think the water in the French-Quinebaug is suitable for:

Drinking yes____no_____
Swimming yes____no_____
Fishing yes____no_____

14. Should riverfront land be conserved for recreation uses, such as trails and canoe launches and fishing access?

Yes__________ No__________
If yes;
-Who should acquire this land?
Town____State__Federal__Non-profit Gorups...Other(Specify)...
-Who should pay for acquiring land, and improving recreational facilities?
Town____State__Federal__Non-profit Groups...Other(Specify)...

15. Who should improve the rivers' water quality? Do you think Cleaning up the French-Quinebaug should be a public works priority.

Agree________ Disagree__________ Don't know__________

16. In your opinion, what are the most significant pollution sources affecting the French-Quinebaug water?

Land development____________
Industry_____________________
Cars_________________________
Lawn Chemicals______________
Geese + farm animals_________
Street sediment______________
Storm Water Drains____
Dogs_________________________
Other (specify)_______________

17. How old are you_____

18. What is your profession __________________?

Version 2

1. What town do you live in? How long have you lived there?
   What town do you work in? How long have you worked there?

2. How would you describe the town you live in?

3. How would you compare it to the towns around you?

4. Do you feel there are any threats to your community in terms of develoment, industry, tourism, population growth, etc.?

5. What kind of land use development do you think is important?
What places would you like to see protected?

6. Where do you take out of town guests?

7. What are some of your favorite places within your area, and what do you do there? (ie swim, fish, shop , ski, etc.)

8. What do you like or dislike about your downtown?

9. Do you think the French-Quinebaug is suitable for . . .
drinking? swimming? fishing?

10. Would you be interested in contributing further to the protection and management of the watershed? If yes, what is the best way to contact you?

11. Would you like to receive news of the watershed planning in the French-Quinebaug? If so, please give your name and address.

APPENDIX J

A Partial Listing of Grant and Loan Opportunities				
August 17, 1999				
Acronyms:				
MU - Municipalities	**SG** - State Government/Agency	**FMA** -Flood Mitigation Assistance		
IA - Interstate Agency	**WO** - Watershed Organizations/Associations	**MEMA** - Massachusetts Emergency Management Agency		**NOTE:** ***The information given below pertains***
RPA - Regional Planning	**MWI** - Massachusetts Watershed Initiative	**TG**-Tribal Government		***to the 1999 fiscal year unless otherwise***
Agency	**PFG** - Planning for Growth			***specified. Programs may not be funded for***
LG - Local Government	**NPO** - Non-Profit Organization	**Color Codes by Subject:**		***Fiscal Year 2000. Furthermore, programs***
PL - Private Landowner	**PO** - Private Organizations	(A) Stream, Lake, Pond Protection/Enhancement		***may be modified from year to year. Please***
CD - Conservation District	**WQM** - Citizen Water Quality Monitoring Groups	(B) Education and Research		***call the appropriate contact for more***
E - Educational Institution	**L&P** - Lake and/or Pond Associations	(C) Recreation and Forestry		***information about a specific program.***
		(D) Pollution Remediation and Prevention		
		(E) Drinking Water, Waste Water, Solid Waste Facility /Capacity		

Agency Grant Opportunities -	*Eligibility*	*RFR Date*	*Submittal Date*	*Award Date*	*Available Funds*	*Contact*
Through the Executive Office of Environmental						
Affairs (EOEA):						
Communities Connected by Water Program Two sections: Planning for Growth - sustainable economic growth ; Mass. Watershed Initiative- funds resource protection projects	**MWI/PFG** (joint)	February	December 15th 1999 through May 1st 1999	June	MWI <=$150k, PFG <=$100k	John Clarkeson (617) 727-9800 x248
Watershed Stewardship Program (Replaces the Capacity Building Program) (for restoration, research, environmental improvement, recreation)	**RPA, WO, NPO, E, MU, CD**		Through October 21, 1999		(6)Capacity <= $50k, (3)Comprehensive <= $120k	John Clarkeson (617) 727-9800 x248
Planning For Growth Program	**RPA, MU, LG**	February	April	June	up to $100,000	Kurt Gaertner (617) 727-9800 x273
(B)Outdoor Classroom Program	**E, Public Schools, MU**	June	Monthly Through March of 2000		up to $2,500	John Clarkeson (617) 727-9800 x248
Volunteer Monitoring Grants	**WO, WQM, NPO, Public E**	July 16th	August 24th	After Sept.15th	Up to $5,000 for volunteer monitoring, up to $2,000 for supplies	John Clarkeson (617) 727-9800 x248
(A) Five-Star Restoration Program (building diverse local partnerships for community-based wetland and riparian area restoration)	Partnership of any 5 **PO's** , and **Public O's** : Youth Orgs, MU, etc.		February 1st	mid-March	$5,000-$20,000	EPA Wetlands Info. Hotline:1-800-832-7828 ***see website below***

Planning For Growth Program	**RPA, MU, LG**	February	April	June	up to $100,000	Kurt Gaertner (617) 727-9800 x273
(B)Outdoor Classroom Program	**E, Public Schools, MU**	June	Monthly Through March of 2000		up to $2,500	John Clarkeson (617) 727-9800 x248
Volunteer Monitoring Grants	**WO, WQM, NPO, Public E**	July 16th	August 24th	After Sept.15th	Up to $5,000 for volunteer monitoring, up to $2,000 for supplies	John Clarkeson (617) 727-9800 x248
(A) Five-Star Restoration Program (building diverse local partnerships for community-based wetland and riparian area restoration)	Partnership of any 5 **PO's** , and **Public O's**: Youth Orgs, MU, etc.		February 1st	mid-March	$5,000-$20,000	EPA Wetlands Info. Hotline:1-800-832-7828 ***see website below***
Agency Grant Opportunities -	***Eligibility***	***RFR Date***	***Submittal Time***	***Award Date***	***Available Funds***	***Contact***
Through DCS:						
Self-Help Program	**MU**	Spring	Early Summer	TBD	$500k Maximum	Jennifer Soper (617) 727-1552 x292
Urban Self-Help Program	**MU**	Spring	Early Summer	TBD	$500k Maximum	Joan Robes (617) 727-1552 x544
Through the Department of Environmental						
Management (DEM): (B) (see also www.state.ma.us/dem/grants.htm **)**						

Agency Grant Opportunities -	*Eligibility*	*RFR Date*	*Submittal Time*	*Award Date*	*Available Funds*	*Contact*
Through DCS:						
Self-Help Program	**MU**	Spring	Early Summer	TBD	$500k Maximum	Jennifer Soper (617) 727-1552 x292
Urban Self-Help Program	**MU**	Spring	Early Summer	TBD	$500k Maximum	Joan Robes (617) 727-1552 x544
Through the Department of Environmental						
Management (DEM): (A) (see also www.state.ma.us/dem/grants.htm **)**						
(A) Lake and Pond Grant Program (Protection, preservation, enhancement of public ponds and lakes.)	**MU, WO, L&P**	November	December	*Call for Info*	$10,000 Maximum, 50/50 cost share	Steve Asen (617) 727-3267 x524
(A) Rivers and Harbors Grant Program (for design and construction on waterways, lakes, great ponds-includes cleanup)	**MU**	Grants Awarded on Case-by-Case Basis. Applications Accepted Anytime.			Up to $300,000, 25% local match for for dredging, 50% for other projects	Kevin Maguire, Director, DEM Office of Waterways at Hingham: (781) 740-1600 x100
(C) National Recreational Trails Act Grant Program	**MU,SG,IA,NPO,PO**	May	July	October	$2,000 - $20,000	Peter Brandenburg (617) 727-3180 x655
(C) Greenways and Trails Demonstration Grants Program	**MU, RPA, NPO**	Fall	Early Winter	Late Winter	$1,000-$5,000 (up to $10,000 for multi-town projects)	Jennifer Howard (413) 586-8706

Hazard Mitigation Grant Project (HMGP) (Post-Disaster)	**MU, SG, RPA, CD, TG, NPO, Housing Auth.**		November 13th		Contingent upon approval of funds, $750,000-$1.5 million state-wide	Patrick Young (508) 820-1445
Historic Landscape Preservation Grant Project	**MU**		June 1st, 4:00 P.M.		up to $50,000 per year per project, 30%-48% cash match required	Katy Lacy (617) 727-3180
(C) Urban Forestry Planning and Education Grants	**MU, NPO**		May 7th	July 1st	<$10,000 over 2 yrs, reimb.	Urban Forestry (617) 727-3180 x905
(C) Forest Stewardship Program Small Grants	**MU, SG, PO, NPO**		April 2nd		$500-$2,500	Steve Anderson (617) 727-3180
(C) Heritage Tree Care Grant Program	**MU**	***Call for more information***				Edith Makra (617) 626-1466
(C) Mass ReLeaf Fund (Fosters public-private-non-profit partnerships for planting and care of public trees.)	**MU**	April 12th	Contingent upon Availability of Funds		$5,000 Maximum	Edith Makra (617) 626-1466
Agency Grant Opportunities -	***Eligibility***	***RFR Date***	***Submittal Time***	***Award Date***	***Available Funds***	***Contact***
Through the Department of Environmental						
Protection (DEP):						

Protection (DEP):						
(D) Community Septic Management Program	**MU**	**"Expression of Interest" Required, Call for Info**			Optional Plans $100k, or $220k	Contact DEP Central regional Office: (508) 792-7650
(D) Municipal Recycling Grant Program	**MU**	July	September	TBD	No restrictions (previous $44-$121k)	Brooke Nash (617) 292-5984
(A) 604b Water Quality Management Planning Grant Program (www.state.ma.us/dep/brp/mf/files/granfs.htm)	**RPA,LG,CD, MU**	October	Late November/ Early December	January	$30,000 - $60,000	Gary Gonyea (617) 556-1152
(E) 319 Nonpoint Source Grant Program (www.state.ma.us/dep/brp/mf/files/granfs.htm)	**Any/All Org.**	March	May	TBD	$20,000 - $200,000	Beth McCann (617) 292-5901
(A) 104(b)(3) Wetlands and (E) Water Quality Grant Program (www.state.ma.us/dep/brp/mf/files/granfs.htm)	**NPO, WO, RPA**	January	March	TBD	TBD	Gary Gonyea (617) 556-1152
Agency Grant Opportunities -	***Eligibility***	***RFR Date***	***Submittal Time***	***Award Date***	***Available Funds***	***Contact***
(E) Research and Demonstration Grant Program (For Water Pollution Control) (www.state.ma.us/dep/brp/mf/files/granfs.htm)	**Any/All Org.**	**Unsolicited Proposals Accepted Anytime**			TBD	Steven McCurdy (617) 292-5779

Technical Assistance/Land Management Grants (Haz. Waste Disposal/Site Cleanups, water conservation, installation of BMP's etc.)	**RPA,CD,PO, NPO,E,SG,WO**	available at website	August 20, 12 noon	October 1st	$45,000 Maximum	Kathy Romero (617)292-5727 or DEP website: www.state.ma. us/dep
(D) Clean Water State (E) Revolving Loan Fund Program	**MU/**Wastewat er District		October 15th	after June 30th	$150-$200 million total available	Steven McCurdy (617) 292-5779 or Paul Anderson (508) 792-7692 (DEP Central Region)
(D) Community Septic Management (Loan) Program	**MU**	Call for Information			<$200,000 per MU	Joanne Kasper-Dunne (508) 767-2763 x3763 (DEP Central Region)
(D) Drinking Water State Revolving Loan Fund Program	**MU**	May	October 15th	See website/call for information	up to $400 million total available	Call Steven McCurdy (617) 292-5779 (DEP Boston) or Paul Anderson (508) 792-7692 (DEP Central)
Agency Grant Opportunities -	***Eligibility***	***RFR Date***	***Submittal Time***	***Award Date***	***Available Funds***	***Contact***
Through the Department of Fisheries and Wildlife and						

Agency Grant Opportunities -	*Eligibility*	*RFR Date*	*Submittal Time*	*Award Date*	*Available Funds*	*Contact*
Through the Department of Fisheries and Wildlife and						
Environmental Law Enforcement (DFWELE):						
(A) Urban Rivers Small Grants	**MU, NPO**	——Call for New Schedule Information——			$3,000 - $8,000	Patricia Sheppard (617) 626-1541
Clean Vessel Act Grants	**MU, Marinas**	——Call for New Schedule Information——			up to $50,000	Buell Hollister (617) 626-1524
(A) Riverways Small Grants Program (To further watershed, river, and stream protection.)	**MU, NPO** (prefers projs. that foster inter-org co-op.)		January 4th	January	$1,000-$5,000 per project- reimbursement for services basis; $50,000 total avail.	Maria Van Dusen (617) 727-1614 x360 Maria.Van.Dusen@state.ma.us

Threatened and Endangered Species Program	**All, except PL**	February 8th	March 10th	May 28th	$100,000 available	Robbin.Peach@ state.ma.us
Regional Planning Support Program (Supports Inplementation of regional plans with an environmental focus.)	**All, except PL**	February 8th	Apr.1, Aug.1, or Dec.1	May, Sept., Jan.	$100,000 available	Robbin.Peach@ state.ma.us
Agency Grant Opportunities -	***Eligibility***	***RFR Date***	***Submittal Time***	***Award Date***	***Available Funds***	***Contact***
Environmental Fellowship Program (One individual chosen annually-for acquisition of new skills, invigoration of leadership.)	Avail. To individuals through cooperating, tax-exempt institutions.	May 1st	June 15th	September 30th	One $40,000 grant for one individual, 1:1 match required	Robbin.Peach@ state.ma.us
General Grants Program (Supports general environmental projects with focus on water and related land resources.)	**All, except PL**	May 1st	June 15th	September 30th	$200,000 available	Robbin.Peach@ state.ma.us
(A) Water Quality Monitoring Program (Coastal areas and waterways.)	**All, except PL**	May 1st	June 15th	September 30th	$50,000 available	Robbin.Peach@ state.ma.us

Agency Grant Opportunities -	***Eligibility***	***RFR Date***	***Submittal Time***	***Award Date***	***Available Funds***	***Contact***
Environmental Fellowship Program (One individual chosen annually-for acquisition of new skills, invigoration of leadership.)	Avail. To individuals through cooperating, tax-exempt institutions.	May 1st	June 15th	September 30th	One $40,000 grant for one individual, 1:1 match required	Robbin.Peach@state.ma.us
General Grants Program (Supports general environmental projects with focus on water and related land resources.)	**All, except PL**	May 1st	June 15th	September 30th	$200,000 available	Robbin.Peach@state.ma.us
(A) Water Quality Monitoring Program (Coastal areas and waterways.)	**All, except PL**	May 1st	June 15th	September 30th	$50,000 available	Robbin.Peach@state.ma.us
Directed Grants (Trust reviews letters of intent that do not fit into its other programs.)	**All, except PL**	Guidelines available May 1st	April 1st, August 1st, or December 1st	May 28th, September 30th, or January 31st		Robbin.Peach@state.ma.us
Through The U.S. Geological Survey (USGS):						
(B) Water Resources Research Act	**E** (Research)	See website	April 8th	See website	<$250,000 per project 100% Match Required	ianrwww.unl.edu/ianr/waterctr/wchome.htm

Agency Grant Opportunities -	*Eligibility*	*RFR Date*	*Submittal Time*	*Award Date*	*Available Funds*	*Contact*
Through the Environmental Protection Agency (EPA):						
(E) Brownfields Economic Redevelopment Initiative (Facilitates brownfields cleanup and funds environmental job training.)	**SG, MU, LG**		March 1, 1999	June 1999	10 Pilot Projects Selected, each receives up to $200,000 over 2 years	EPA Region 1 Brownfields Coordinator John Podgurski (617) 918-1209
Sustainable Development Challenge Grants (For addressing serious envir. Problems through sustainable devel. strategies.)	**SG, NPO, LG**		September 29, 1999	June 2000	9.4 Million Available,20% Match Required, 2 award ranges a) $30,000-$100,000 b) $100,001-$250,000	Dr. Lynn Desautels (202) 260-6812 desautels.lynn @epa.gov
Livable Communities Grant Program (To help communities develop tools for growth management/sustain able growth.)	**MU, regions, SG, TG, NPO**		August 23,1999	Fall 1999	$5,000-$50,000, Minimum 20% match required, $300,000 Total Available Funds	Rosemary Monahan (617) 918-1087
(A) Wetlands Protection Development Grants Program (Increases a community's ability to protect its wetland resources.)	**SG, MU,**		Call hotline for more information.		$15 million total available funds, 25% Match Required	Call your EPA Region 1 Wetland Coordinator or EPA Wetland Hotline 1-800-832-7828

Agency Grant Opportunities -	*Eligibility*	*RFR Date*	*Submittal Time*	*Award Date*	*Available Funds*	*Contact*
(D) Hardship Grants Program for Rural Communities (wastewater treatment)	**Rural Communities population<3,000**		Call for more information or see website: www.epa.gov/owmitnet/smallc.htm		Grants or Technical Assistance	Stephanie vonFeck (202) 260-2268
(A) Funds for Source Water Protection (State Scale) (for local ground/source water protection in small, rural, or ec. disadv. communities in priority watersheds)	**SG, MU, NPO,TG**	Call for Info.	June 6th	Call for Info.	>$10,000 per project	Mary Jo Feuerbach (617) 918-1578
Funds for Source Water Protection (Multi-State/Region	**SG, MU, NPO,TG**	Call for Info.	June 6th	Call for Info.	$50,000-$100,000 per project	Evyonne Harris (202) 260-1399
Through The Army Corps of Engineers (COE):						
Planning Assistance to States Program (PAS)	**SG, RPA, WO**	—— Call for New Schedule Information———			50% Match Required	Mike Gildesgame (617) 727-3180 x1371
Flood Plain Management Services (FPMS)	**MU,SG,RPA, WO**	—— Call for New Schedule Information———			$50,000 - $100,000	Mike Gildesgame (617) 727-3180 x1371
Through the Dept. of Housing and Urban Development (HUD):						

Agency Grant Opportunities -	*Eligibility*	*RFR Date*	*Submittal Time*	*Award Date*	*Available Funds*	*Contact*
(D) Community Development Block Grant Program (Will fund wastewater, drinking water, economic development-related projects.)	**Villages** , small towns, cities pop. less than 50,000	*Must apply through state housing agency or local government agency that carries out development activities for low to moderate-income people- eligibility varies by state.*				Call clearinghouse for more information: 1-800-998-9999
Through the U.S. Department of Agriculture-Rural Utilities Service:						
(D) Rural Utilities Service Water and Waste Disposal Program (For drinking water, wastewater, solid waste systems.)	**MU, Co-ops, NPO, TG, Assoc.** in rural town, pop. <10,000.					Applications in rural development offices in state, county, district governments: SF-424 form.

Informative Websites and Related Links:						
www.state.ma.us/dep						
www.epa.gov						
www.epa.gov/reinvent/notebook						
www.epa.gov/OWOW/watershed/wacademy/fund.html						
www.epa.gov/owow/wetlands/restore/5star/announce.html						
www.epa.gov/region1/eco/grants				(Index of grants administered by EPA New England)		
www.epa.gov/owmitnet/eparev.htm						
www.epa.gov/region01/grants/index.html (index of grants administered by EPA New England)						
www.epa.gov/owmitnet (EPA's Office of Water's Office of Wasterwater Management homepage)						
www.epa.gov/swerosps/bf/mmatters.htm (Brownfields project funding sources.)						
www.epa.gov/ecocommunity (Community based environmental protection.)						
www.epa.gov/brownfields (General information about brownfields, including grants.)						
www.magnet.state.ma.us/czm/cprgp.htm						
www.estd.wvu.edu /nsfc_homepage.html (National Small Flows Clearinghouse- provides information about innovative, low-cost wastewater treatment for small communities with populations under 10,000. A "small-flows" system (septic, sewage treatment, etc.)						
www.agmconnect.org/maenvtr1.html						
www.home.eznet.net/~rgs						
www.powerbar/com/whoweare/dirt						
www.envsc.org						
www.ombwatch.org/ombw/npt/						
www.usda.gov/rus/water						

Miscellaneous/ Nonprofits:						
~Directory of Funding Sources for Grassroots River and Watershed Conservation Groups is available for $35 from River Network: (800) 423-6747 or rivernet@igc.apc.org						
~NPT Pilot Grant projects: for Grant Guidelines and 1998 recipients list send a blank e-mail message to nptgrants@lyris.ombw						
~REI Seed Grant Program: contact Chad Smith (202) 547-6900						
Table prepared by Jennifer Claster based on work done by:						
George Zoto, EOEA South Coastal Watershed Team Leader						
and **Ryan McGorty, EOEA Intern**						

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