PEMIGEWASSET WATERSHED RESOURCE CO-OCCURRENCE MAPPING AND ANALYSIS

Pemigewasset River, Plymouth, NH

FINAL REPORT
JUNE 2008

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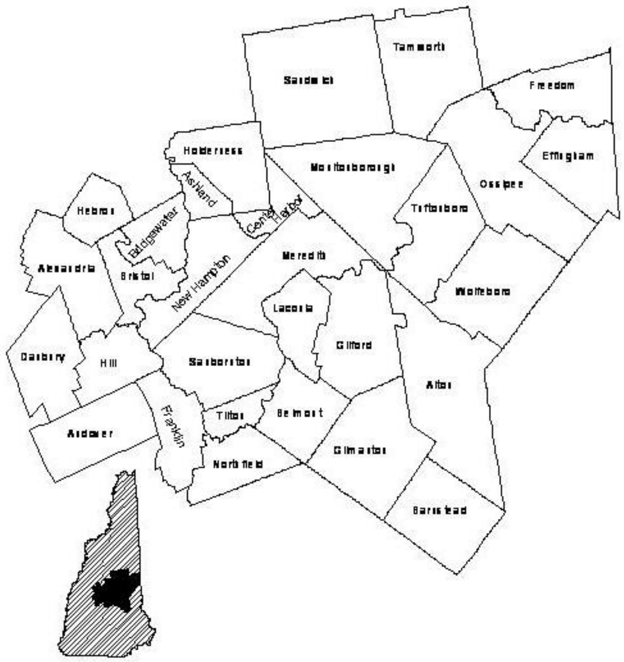

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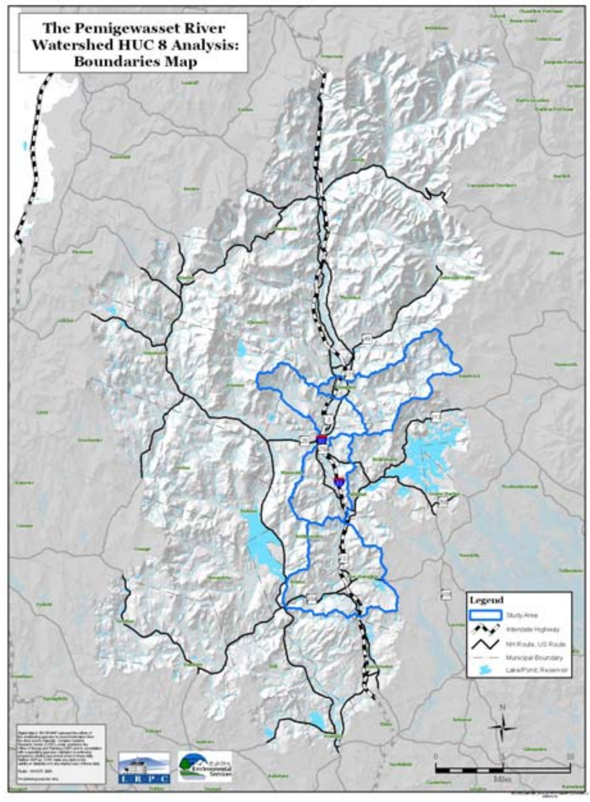
SUMMARY STATEMENT

New Hampshire is currently the fastest growing state in New England. From 1980 to 2006, the population grew by 43 percent – more than twice the regional average of 20 percent.[1] The growing population is putting pressure on the region's forests, rivers, and lakes as land is converted from its natural state to developed areas. Our natural resources are also facing threats from increasing recreational use, invasive species, and pollution.

Figure 1. Pemigewasset River Watershed and Study Area (outlined in blue)



Amidst these mounting land use pressures are several programs designed to address resource protection. New rules for the Comprehensive Shoreland Protection Act to increase protection for our irreplaceable shorelines will go into effect July 1, 2008. New Hampshire has also recently signed an agreement with the U.S. Army Corps of Engineers to enact the In-Lieu Fee Program. This program will allow developers impacting wetlands to pay a 'fee' to the state that will in turn be used to purchase and/or restore wetland and upland habitat within the watershed.

This report is designed to provide assistance to the Pemigewasset River Local Advisory Committee (PRLAC), municipalities, and other planning entities for identifying conservation planning opportunities in the Pemigewasset watershed, and in four identified subwatersheds, through the development of co-occurrence maps. The maps show where areas of high quality waters, wetlands, and uplands occur, but do not provide site specific information. The next phase of this project will provide more specific recommendations for one of the subwatersheds in the Study Area through the development of a Conservation Plan.

The four subwatersheds evaluated in this report encompass part of the Pemigewasset River corridor, where 1,000 feet on each side of the river fall within PRLAC's jurisdiction. We denote the four subwatersheds as the 'Study Area,' illustrated in Figure 1 (large version found as Map 1, page 17).

[1] *Development Trends Report*, LRPC, 2008

I. INTRODUCTION

WHY CONDUCT CO-OCCURRENCE MAPPING?

Co-occurrence mapping is created by layering a series of individual maps (i.e. datasets) on top of one another to create a graduated snapshot of the region. For the Pemigewasset watershed, water quality datasets were used to create a snapshot of current conditions. The end-product is a map that uses graduated colors to illustrate where the areas of highest quality waters, wetlands, and uplands are located within the watershed. This map can become the foundation for conservation planning efforts in the watershed.

PURPOSE

The purpose of this report is to provide a systematic, science-based approach to identify areas of high quality waters (surface and ground water), wetlands, and uplands for the larger Pemigewasset watershed and the Study Area. The co-occurrence results will enable PRLAC and the municipalities to make informed land use planning decisions to preserve or conserve these identified areas.

Conservation planning across political boundaries is often a challenge due to differing datasets, regulations, and policies. This is particularly true for the Pemigewasset as 36 municipalities from five different counties are partly or wholly within the watershed boundary, Figure I-1. This is further complicated as towns in the northern part of the watershed are supported by North Country Council, those in the west by the Upper Valley Lake Sunapee Region Planning Commission, and towns in the south are served by the Lakes Region Planning Commission.

Figure I-1. New Hampshire towns partly or wholly within the Pemigewasset watershed:

Alexandria	Franconia	Piermont
Andover	Franklin	Plymouth
Ashland	Grafton	Rumney
Benton	Groton	Sanbornton
Bethlehem	Hebron	Sandwich
Bridgewater	Hill	Springfield
Bristol	Holderness	Thornton
Campton	Lincoln	Unorganized Territory
Center Harbor	Moultonborough	Warren
Danbury	New Hampton	Waterville Valley
Dorchester	Orange	Wentworth
Ellsworth	Orford	Woodstock

The co-occurrence results will supply all municipalities within the Pemigewasset watershed with baseline data on which to make decisions. It also provides PRLAC an opportunity to recommend areas of preservation and/or restoration to the NH DES In-Lieu Fee Program. The project will benefit the entire watershed as the maps are used to identify and protect these resource areas.

Since the maps illustrate locations of high quality resources, they also highlight the areas where few high quality areas remain, due in part to development. This information can often be just as valuable as it gives stakeholders an opportunity to protect the remaining open space in these areas through land use planning.

DEFINITIONS

The following definitions may be useful when reading this report:

Catchment
A catchment is a part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.[2]

Watershed
A watershed is a geographic area in which all water drains to a given stream, lake, wetland, estuary, or ocean.[3] The greater Pemigewasset watershed is comprised of many sub-watersheds, which are, in turn, comprised of many catchments.

Hydrologic Unit Code (HUC)
The HUC is a hierarchical, numeric code that uniquely identifies hydrologic units. Hydrologic units are subdivisions of watersheds nested from largest to smallest areas and are used to organize hydrologic data. HUCs are constructed as follows:

- the first two digits identify the region,
- the first four digits identify subregions,
- the first six digits identify accounting units,
- the first eight digits identify cataloging units,
- the first ten digits identify watershed units,
- the full twelve digits identify subwatershed units.

The USGS developed the first eight-digit HUC for the United States, while the U.S. Department of Agriculture, Natural Resource Conservation Service (USDA-NRCS) within each state is developing the full twelve-digit HUC.[4]

[2] http://water.usgs.gov/wsc/glossary.html#TOC, website accessed June 6, 2008.
[3] http://www.des.state.nh.us/wmb/was/, website accessed June 6, 2008.
[4] http://www.mass.gov/mgis/nrcshuc.htm, website accessed June 6, 2008.

II. Watershed Overview

Significant Natural Resources

The Pemigewasset watershed drains approximately 1,000 square miles and flows through three counties: Grafton, Belknap, and Merrimack. The Pemigewasset River's headwaters are in Profile Lake in Franconia Notch State Park. Leaving the Notch, the river widens as it moves southerly along its approximately 70-mile route to its confluence in Franklin with the Winnipesaukee River, thereby forming the Merrimack River. The East Branch of the Pemigewasset River starts in the Pemigewasset Wilderness Area of the White Mountain National Forest.

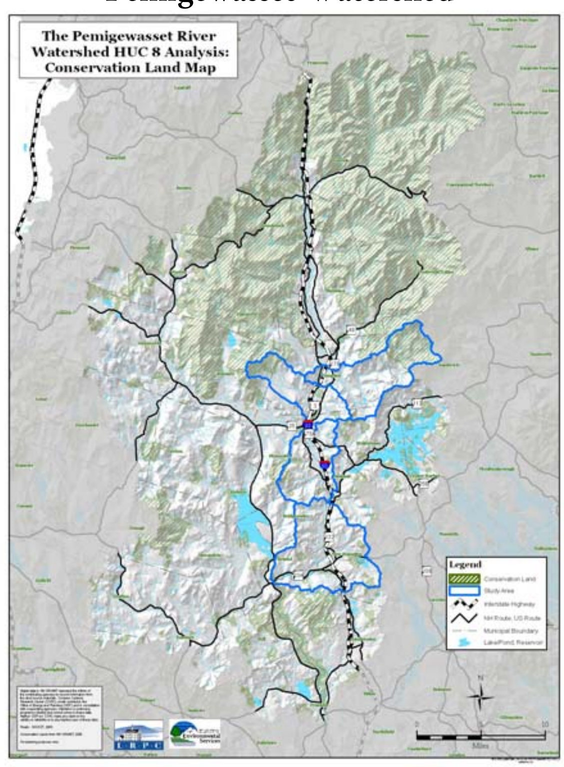
Sand and gravel deposits form a stratified-drift aquifer adjacent to the river through most of its length. Bedrock typically lies about 100 feet below the surface, although in some areas it may be as much as several hundred feet below. Wells in these aquifers provide municipal water for many communities along the river's length. These and adjoining aquifers also provide domestic water for innumerable household wells. Flow in the aquifers ultimately discharges underground into the river.[5]

Status of Land Conservation

The entire Pemigewasset watershed contains approximately 654,455 acres. The majority of the northern portion of the Pemigewasset watershed lies within the White Mountain National Forest (WMNF) boundary. The WMNF is nearly 800,000 acres, of which 217,176 acres are within the Pemigewasset watershed. When added to state, municipal, and private conservation lands, the land currently conserved in the entire Pemigewasset watershed totals 263,653 acres or 40 percent of the watershed, Figure II-1 (large version found as Map 2, page 19).

The Study Area contains 72,608 acres, of which 7,624 acres are WMNF land. Combined with other state, municipal, and private conservation lands, there are a total of 10,269 acres of land in conservation, or 14 percent of the total land in the Study Area.

Figure II-1. Conservation Lands in the Pemigewasset Watershed



[5] *Pemigewasset River Corridor Management Plan*, LRPC, 2001

III. Co-occurrence Analysis

General Approach

The goal was to identify areas of high quality waters, wetlands, and uplands in the Pemigewasset watershed and Study Area for the In-Lieu Fee Program and other municipal planning purposes. The LRPC used the following approach:

- Employ a science-based approach using existing, statewide data
- Incorporate documented natural resource features and predictive GIS modeling
- Analyze data at the HUC 8 scale for the Pemigewasset watershed
- Analyze data at the catchment scale for four subwatersheds (each is a HUC 12), i.e. the Study Area, within the Pemigewasset watershed:
    1. Beebe River
    2. Campton Tributaries
    3. Plymouth/Ashland Tributaries
    4. Bristol/New Hampton Tributaries
- Synthesize information to identify significant areas for conservation, restoration and/or preservation

Delineating the Resource Co-occurrence Areas

For the purpose of this report, the LRPC interpreted "significant resource features" to include those lands and waters most important for identifying living resources (flora and fauna) and water quality. Five categories of key features were identified (listed below) that best address living resources and water quality. These features are embedded in the datasets used in the co-occurrence analysis.

1. High quality stream watersheds
2. Large and high quality wetland systems
3. Riparian zones on freshwater rivers, streams, lakes and ponds
4. Unfragmented forest ecosystems
5. Exemplary natural communities and significant wildlife habitat

Composite maps were created that capture these key features for the Pemigewasset watershed and Study Area. (All of the maps mentioned in this report can be found in *Chapter V: Pemigewasset Watershed Co-occurrence Maps*, starting on page 17.) The Habitat Composite and Hydrology Composite maps were created for both the Pemigewasset watershed and Study Area, while the Revised Catchment Hydrology Composite was created only for the Study Area. This is explained further in the Steps 1-5 on the following pages.

The Supplementary Layers maps were also created for both the Pemigewasset watershed and Study Area. The Supplementary Layers maps were not included in the co-occurrence scoring (see below), as the datasets did not necessarily identify a high quality water, wetland, or upland. However, they were added to the final co-occurrence maps for planning purposes. Included in the Supplementary Layer maps are impaired waterbodies. A list of the impaired waterbodies within the Pemigewasset watershed was developed from the Draft 2008 NH DES 303(d) list, and is found in Appendix A.

Upon completion of the composite maps, the co-occurrence analysis for high quality waters was created for the Pemigewasset watershed and Study Area. The co-occurrence analysis identifies areas where several resource values coincide and overlap, thus signaling locations with multiple key features and potentially higher priority for protection. The following steps outline the process used to determine the areas of high quality waters for the co-occurrence analysis.

Step 1. Research and Develop Co-occurrence Analysis Methodology

Discussions with New Hampshire Department of Environmental Services and Department of Fish and Wildlife staff were conducted to determine the best approach for a science-based co-occurrence analysis, and continued throughout the modeling process. Several plans were used to shape the methodology, including, *The Land Conservation Plan for New Hampshire's Coastal Watersheds (2006)*, *Ammonoosuc Watershed Region Conservation Plan (2005)*, and *A Land Conservation Plan for the Ashuelot River Watershed (2006).*

Step 2. Assemble Datasets

Datasets used to create the model came from a variety of sources, listed below. Descriptions of the datasets are found in the attached appendices.

1. Wildlife Habitat (NH Wildlife Action Plan)
2. Water Quality
    a. Aquifer (NH DES)
    b. Flood Storage Lands (Natural Services Network)
3. Water Supply Lands (Natural Services Network)
4. HUC 12 Water Quality (NH Wildlife Action Plan – re-ranked for comparison within the watershed)

Step 3. Create Composite Maps for the Pemigewasset Watershed

Composite maps were created in order to better illustrate the steps involved in grouping the datasets. Each composite was created with several datasets from a number of sources. Figure III-1 illustrates how the composite maps were used to create the resource co-occurrence model. Each of the composite maps is in Chapter V, starting on page 17. The specific datasets used to create the composite maps for the Pemigewasset watershed are listed in Figure III-2.

Step 4. Refine Composite Maps for the Study Area

The composite maps developed for the Pemigewasset watershed were refined to provide the best available data at the subwatershed level. In order to provide more specific hydrologic detail for the Study Area, the LRPC used USGS SPARROW data. The USGS SPARROW data are based on the catchment scale, a larger scale than a subwatershed, and were used to develop the Revised Catchment Hydrology composite map. Additional information about USGS SPARROW data is found in Appendix C. Figure III-3 illustrates the datasets and scoring system used to create the Study Area co-occurrence analysis.

Figure III-1. Schematic of Resource Co-occurrence Analysis

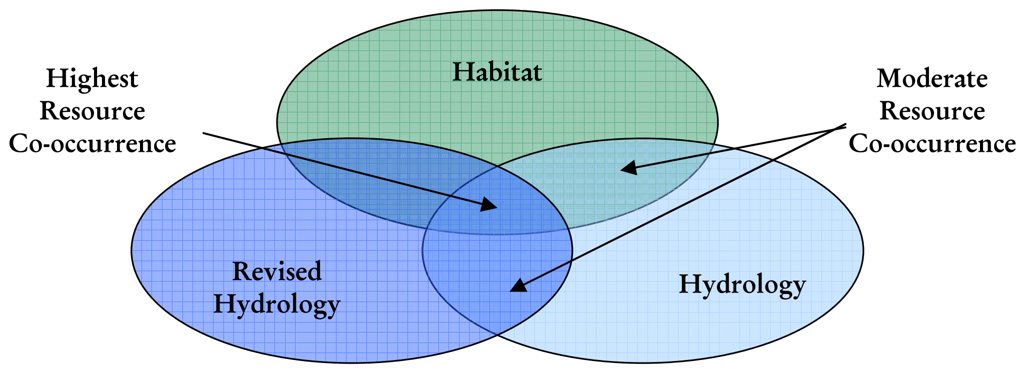


Figure III-2. Pemigewasset Watershed Co-occurrence Analysis Scoring System [1-9]

Composite	Data layer		Value
Habitat Composite			
	Wildlife Action Plan Habitat		
		Tier 1: Highest ranked habitat in NH	3
		Tier 2: Highest ranked habitat in biological region	2
		Tier 3: Supporting landscape	1
	Conservation Focus Areas		1
Hydrology Composite			
	Aquifer		1
	Flood Storage Land		1
		Wetlands	
		100-year floodplains	
	Water Supply Land		1
		Highly transmissive aquifers	
		Favorable gravel well sites	
	Water Quality		
		Tier 1: Top 15% in HUC 8 watershed	2
		Tier 2: Next 15% in HUC 8 watershed	1
Supplementary Layers			
	Impaired waterbodies (NH DES 303d list)		NA*
	Wellhead Protection Areas		NA
	Conservation Lands		NA

*NA = Not Applicable

Step 5. Conduct Co-occurrence

Areas of high quality waters, wetlands, and uplands are areas of highest co-occurrence in the Pemigewasset watershed and Study Area. A numerical value was assigned to each dataset in order to create a weighted analysis of different datasets.

A straight-forward, systematic scoring system was used to maximize transparency so the analysis can be reproduced by municipalities, PRLAC, NH DES, and others. Since the scoring system is very basic, it can also be modified and adapted based on local input and municipal requirements. The scoring system ranges from one to nine for the Pemigewasset watershed, with nine being the highest quality waters. The scoring system for the Study Area ranges from one to thirteen, with thirteen being the highest quality waters. The four-point difference in the scoring is due to the addition of the Revised Catchment Hydrology Composite map in the Study Area analysis. The numerical value assigned to each data layer for the Pemigewasset watershed analysis is shown in Figure III-2, and for the Study Area in Figure III-3.

This analysis is weighted most heavily towards water resources, specifically ground water resources. Five of the nine possible points in the scoring system are based on water resources, and three of those five are specific to ground water (aquifer boundaries, flood storage lands, and water supply lands). This is important for the Pemigewasset watershed because the vast majority of the population relies on small or individual ground water withdrawal wells due to rural development patterns. In order to better protect the Pemigewasset aquifer and drinking water resources the system is thus weighted heavily in favor of ground water. Appendix B illustrates the hydrologic cycle and how ground water contributes to the cycle.

Figure III-3. Study Area Co-occurrence Analysis Scoring System [1-13]

Composite	Data layer		Value
Habitat Composite			
	Wildlife Action Plan Habitat		
		Tier 1: Highest ranked habitat in NH	3
		Tier 2: Highest ranked habitat in biological region	2
		Tier 3: Supporting landscape	1
	Conservation Focus Areas		1
Hydrology Composite			
	Aquifer		1
	Flood Storage Land		1
		Wetlands	
		100-year floodplains	
	Water Supply Land		1
		Highly transmissive aquifers	
		Favorable gravel well sites	
	Water Quality		
		Tier 1: Top 15% in HUC 8 watershed	2
		Tier 2: Next 15% in HUC 8 watershed	1

Composite	Data layer		Value
Revised Catchment Hydrology Composite			
	Catchment Water Quality (SPARROW data)		
		Tier 1	4
		Tier 2	3
		Tier 3	2
		Tier 4	1
Supplementary Layers (for planning purposes)			
	Impaired waterbodies (NH DES 303d list)		NA*
	Wellhead Protection Areas		NA
	Conservation Lands		NA

*NA = Not Applicable

DATA LIMITATIONS

This report was developed using the best data and guidance available to LRPC. Based on the data described above, and in the appendices, the Pemigewasset watershed contains a wide range of significant ecological resources. While this analysis provides an understanding of the location and status of certain resources, the site specific distribution of these resources is incomplete. Therefore this analysis should be used in cooperation with other planning tools and local expertise.

Most of the data used in this project was developed on a statewide scale and is not site-specific. The NH Wildlife Action Plan and USGS SPARROW data are predictive, based on Land Use and other data sources. While SPARROW catchments are far smaller than even HUC 12 watersheds (there are 111 catchments within the Study Area), the data refinement is limited to the catchment.

The datasets and scoring system used in this analysis may be revised or adapted to better reflect the goals of the municipality or organization. Modifying the numerical values for each dataset will produce different results.

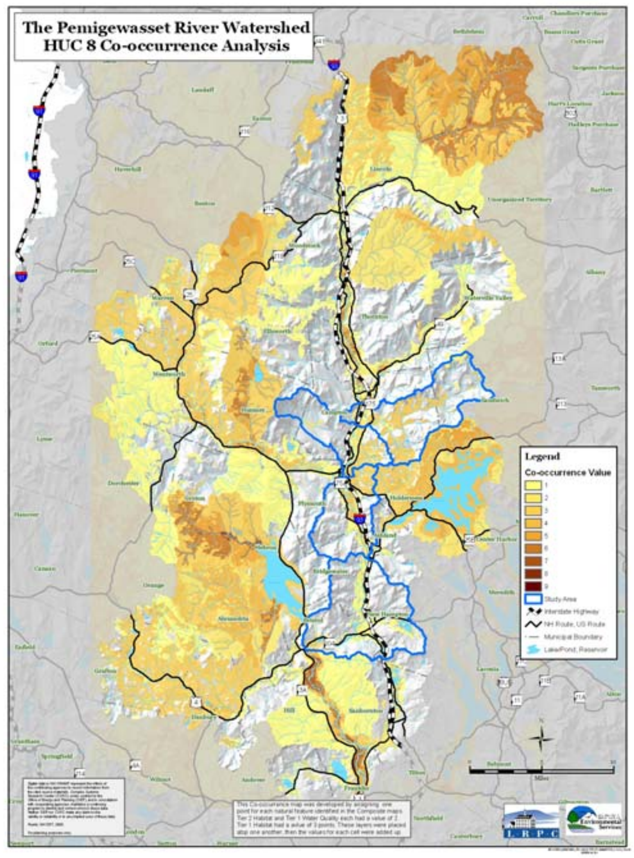
IV. CONSERVATION AND IMPLEMENTATION STRATEGIES

RESULTS

Pemigewasset Watershed

Areas of high quality waters, wetlands, and uplands are areas of highest co-occurrence. Final results show where these high quality areas are located within the Pemigewasset watershed and smaller Study Area. As one may expect, the majority of the highly ranked (darkly shaded) areas are within lesser developed regions of the Pemigewasset watershed, as shown in Figure IV-1 (larger version found as Map 5, page 25). Many of the upper reaches of streams or rivers in the watershed and designated conservation lands can be categorized as moderate to high quality. These include the headwaters of the East Branch Pemigewasset River, Baker River, Squam River, Smith River, and Cockermouth River.

Figure IV-1. Pemigewasset Watershed Resource Co-occurrence



However, there are a number of exceptions where the higher ranked areas are within areas under development pressure. Most notably, the lower reaches of the Pemigewasset River corridor, the confluence of the Baker River and Pemigewasset River, and around Newfound and Squam Lakes. Each of these areas is experiencing increasing development pressure as waterfronts and steeper slopes are built upon and the towns are built out.

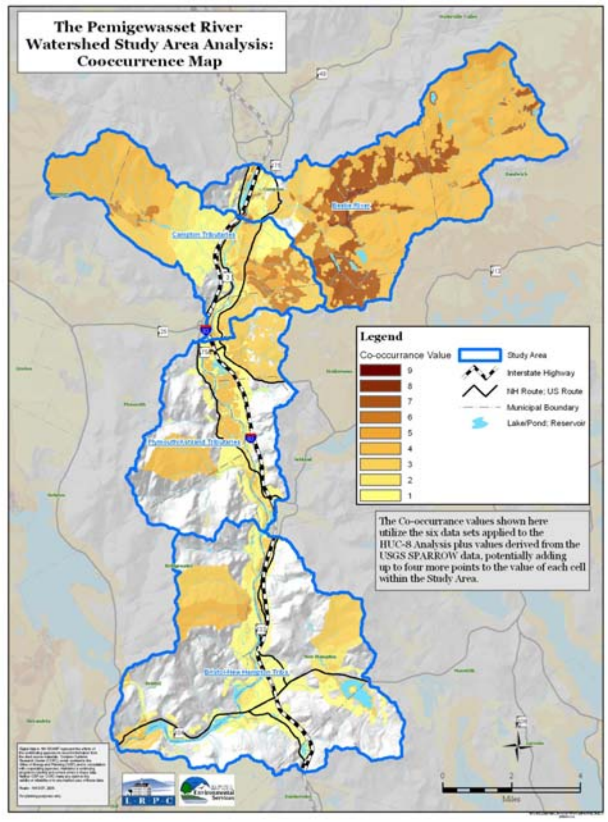
Study Area

When viewed as part of the greater Pemigewasset watershed, the Study Area has comparatively few areas ranked as high quality, as seen in Figure IV-1. However, the Revised Catchment Hydrology dataset provides greater detail when viewing the Study Area, as shown in Figure IV-2, (larger version found as Map 11, page 37). This larger scale and more detailed analysis better identifies areas of high quality in the Study Area. In general, the majority of high quality waters, wetlands, and uplands in the Study Area also correspond to areas with minimal development. The results from each of the four subwatersheds are given below.

Beebe River Subwatershed
This subwatershed has the greatest amount of significant habitat in the Study Area. The majority of the Beebe River subwatershed is of moderate or high quality waters. The highest quality waters correspond to the Beebe River corridor, Ryan Brook, and a few locations on the Pemigewasset River corridor. Interestingly, the areas of highest quality lie outside of the WMNF or other conservation lands. This illustrates that not all areas in conservation are necessarily of high water quality, and highlights the need for continued diligence when planning for conservation purposes.

Campton Tributaries Subwatershed
The areas of high quality in the Campton tributaries are within the catchments of Palmer Brook, Durbin Brook, and Livermore Falls. The Campton Bog and Bog Pond are also of high quality. The upper reaches of Bog Brook are of moderate quality. There are a few small pockets of high co-occurrence along the Pemigewasset River corridor throughout the subwatershed.

Figure IV-2. Study Area Resource Co-occurrence



Plymouth/Ashland Tributaries Subwatershed
The Pemigewasset River corridor and an unnamed tributary and pond in the northernmost section of the subwatershed have the highest quality waters. The catchment for Glove Hollow Brook is of moderate quality. The remainder of the subwatershed is of low resource co-occurrence.

Bristol/New Hampton Tributaries Subwatershed
This subwatershed has the fewest areas of moderate to high quality waters of the four in the Study Area. This may, in part, be due to a higher level of development. Areas of moderate quality do occur along the Pemigewasset River corridor in the northern section of the subwatershed, and surrounding Pemigewasset Lake and Ayers Island. This subwatershed also has very little land in conservation, making it more vulnerable to additional development.

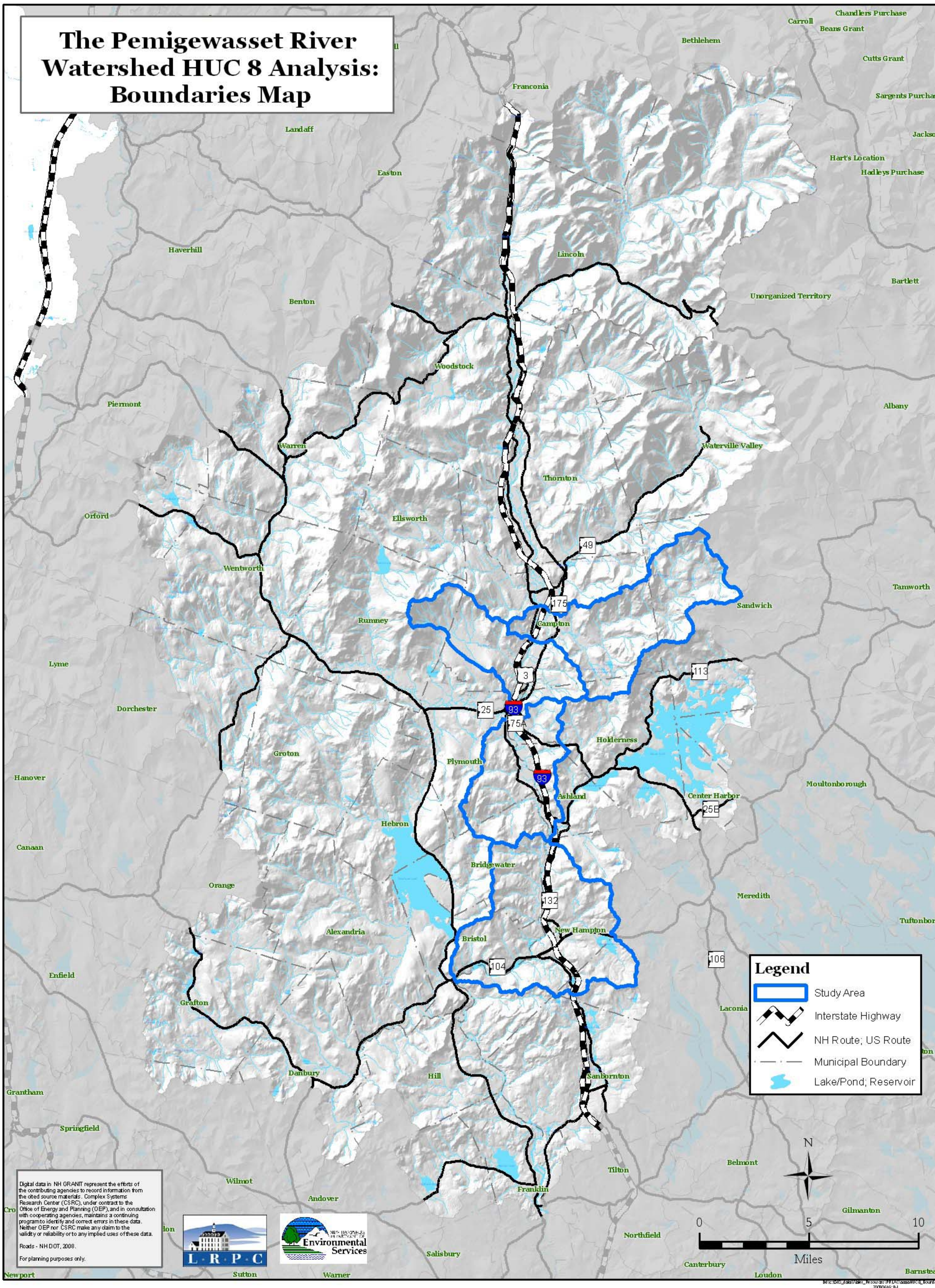
IN-LIEU FEE PROGRAM & CONSERVATION PLANNING RECOMMENDATIONS

Areas of high quality waters, wetlands, and uplands are areas of highest co-occurrence in the Pemigewasset watershed (darkest shades of brown on Figure IV-1 or Map 5, page 25) and Study Area (Figure IV-2 or Map 11, page 37). The following recommendations can assist PRLAC, municipalities, and other planning entities identify locations for preservation and/or restoration through the In-Lieu Fee Program.

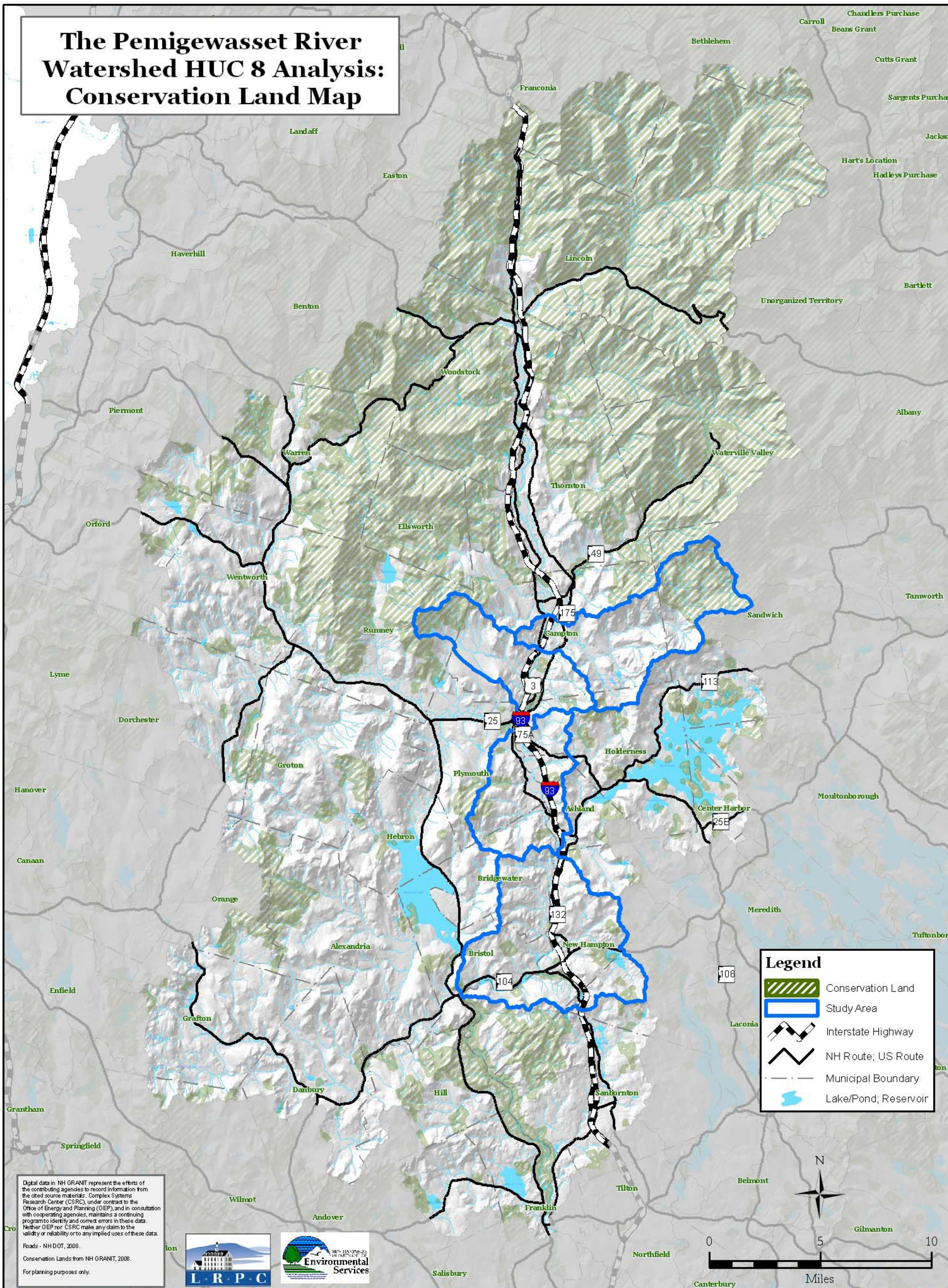
- Areas of high co-occurrence should be targeted for preservation and/or restoration through programmatic and land use planning.
- Areas of high co-occurrence outside of, but adjacent to, existing conservation lands should also be of high priority for conservation planning, particularly if these areas could potentially link designated conservation lands. This would improve connectivity, the prevalence of habitat corridors, and increased recreation opportunities.
- Conversely, areas that show low to moderate co-occurrence and face significant development pressure should also be under consideration for further protection.
- The datasets and scoring system used in this analysis may be revised or adapted to better reflect the goals of the municipality or organization. For example, if one wants to place greater weight on ground water protection, each transmissivity layer can be scored with a graduated point system, thereby placing the highest value on the area of highest transmissivity.

V. Pemigewasset Watershed Co-Occurrence Maps

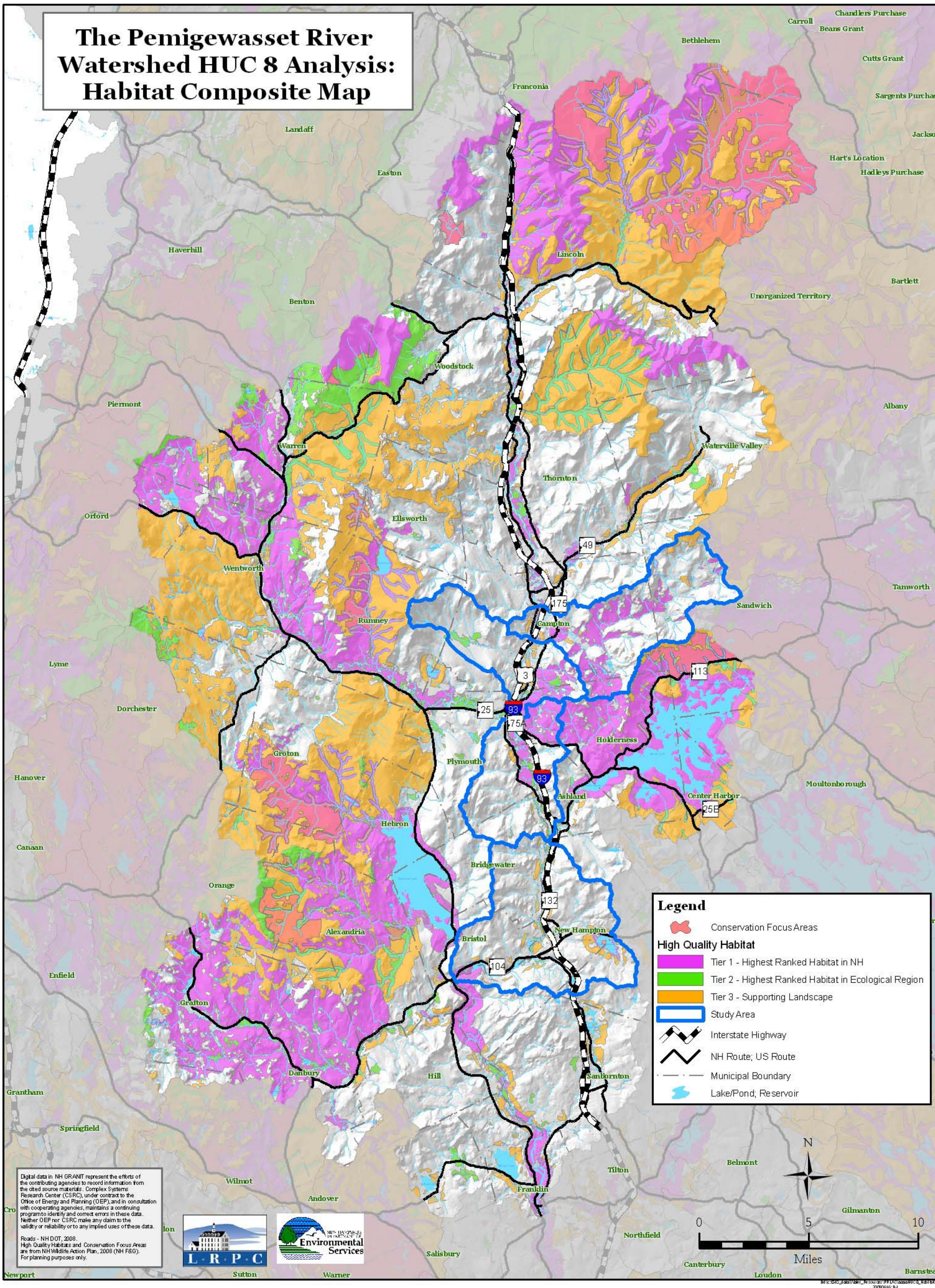
Map 1. Pemigewasset Watershed – Highlighting Study Area



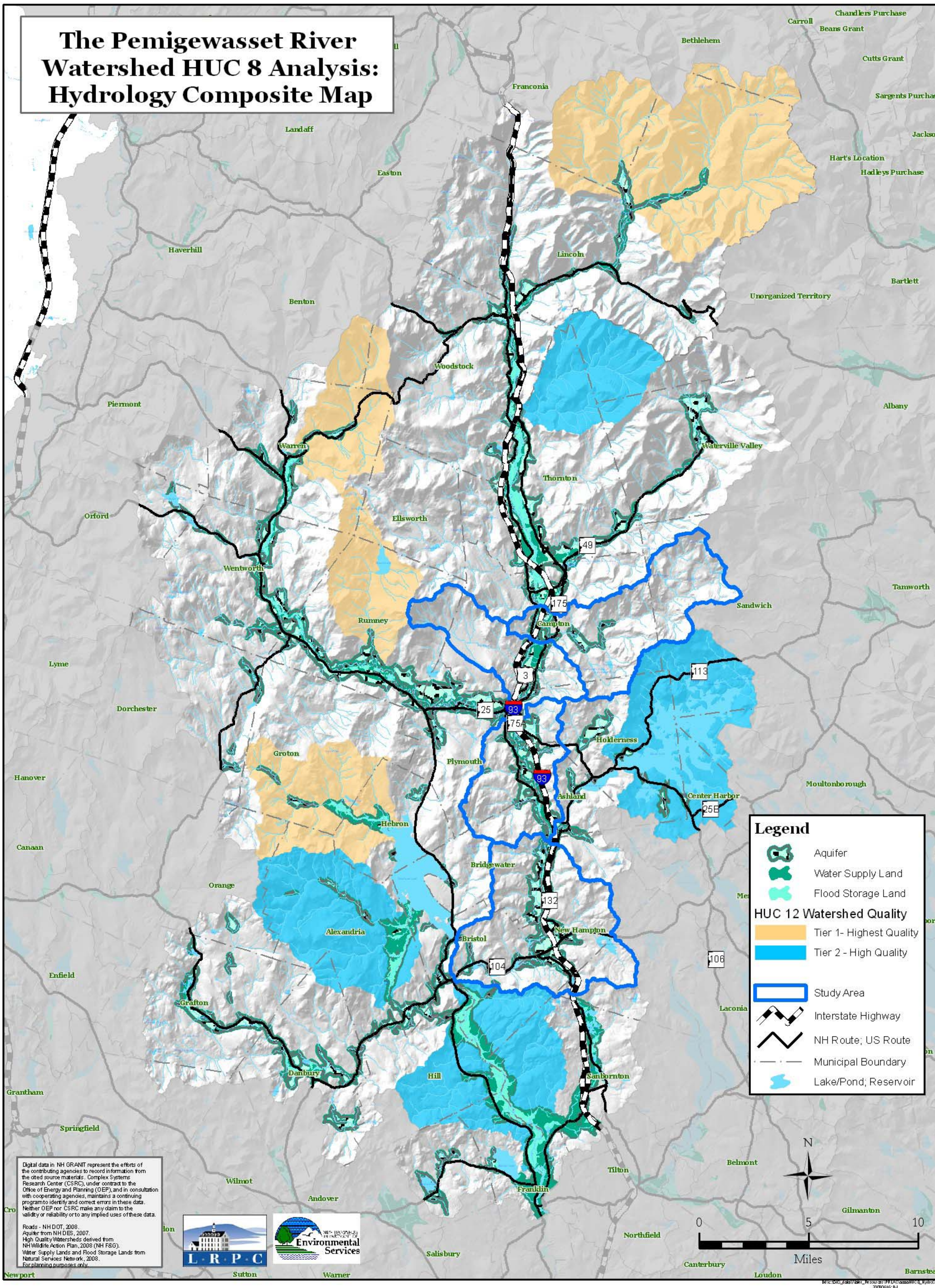
Map 2. Pemigewasset Watershed Analysis –Conservation Lands



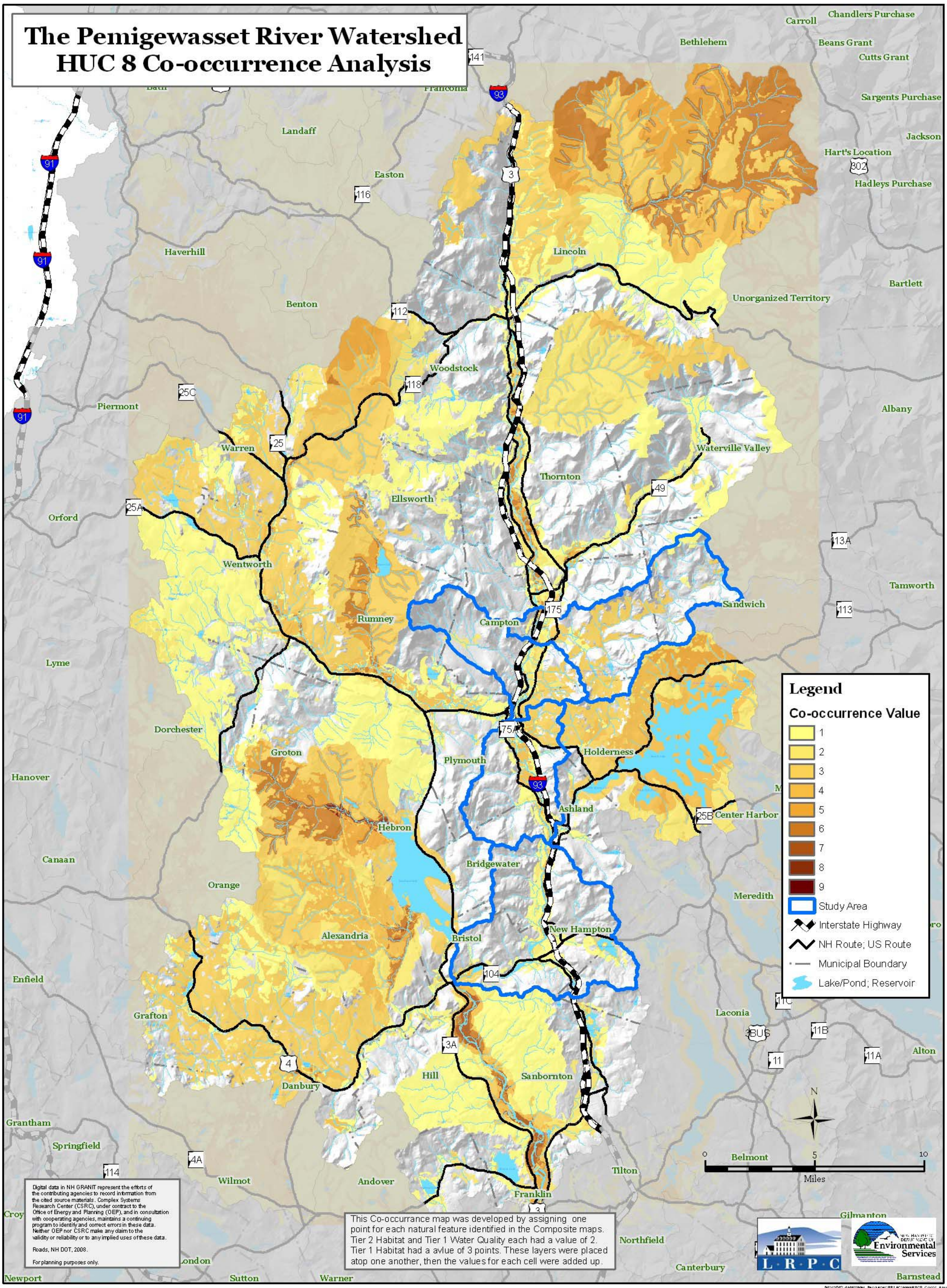
Map 3. Pemigewasset Watershed Analysis – Habitat Composite



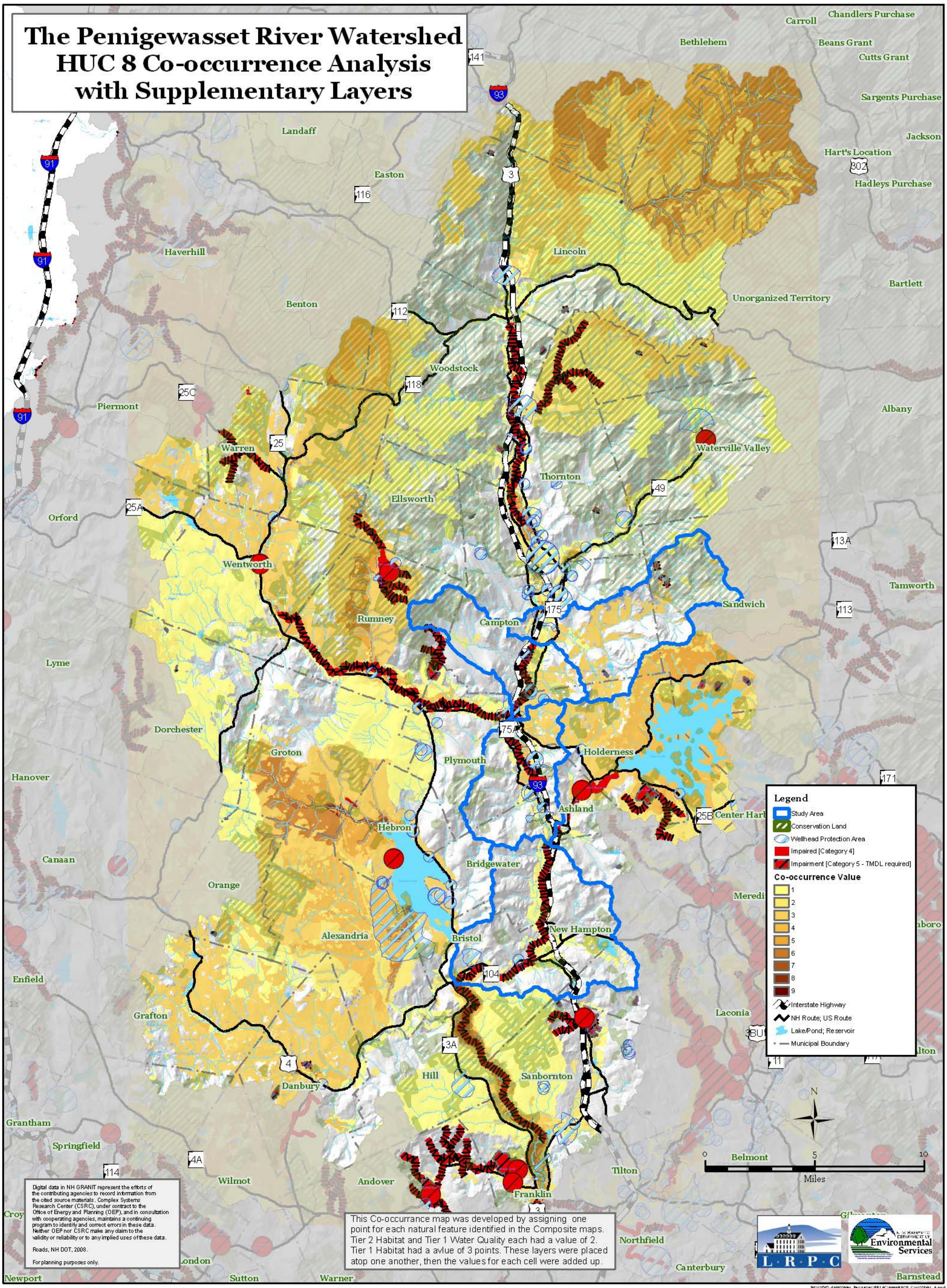
Map 4. Pemigewasset Watershed Analysis – Hydrology Composite



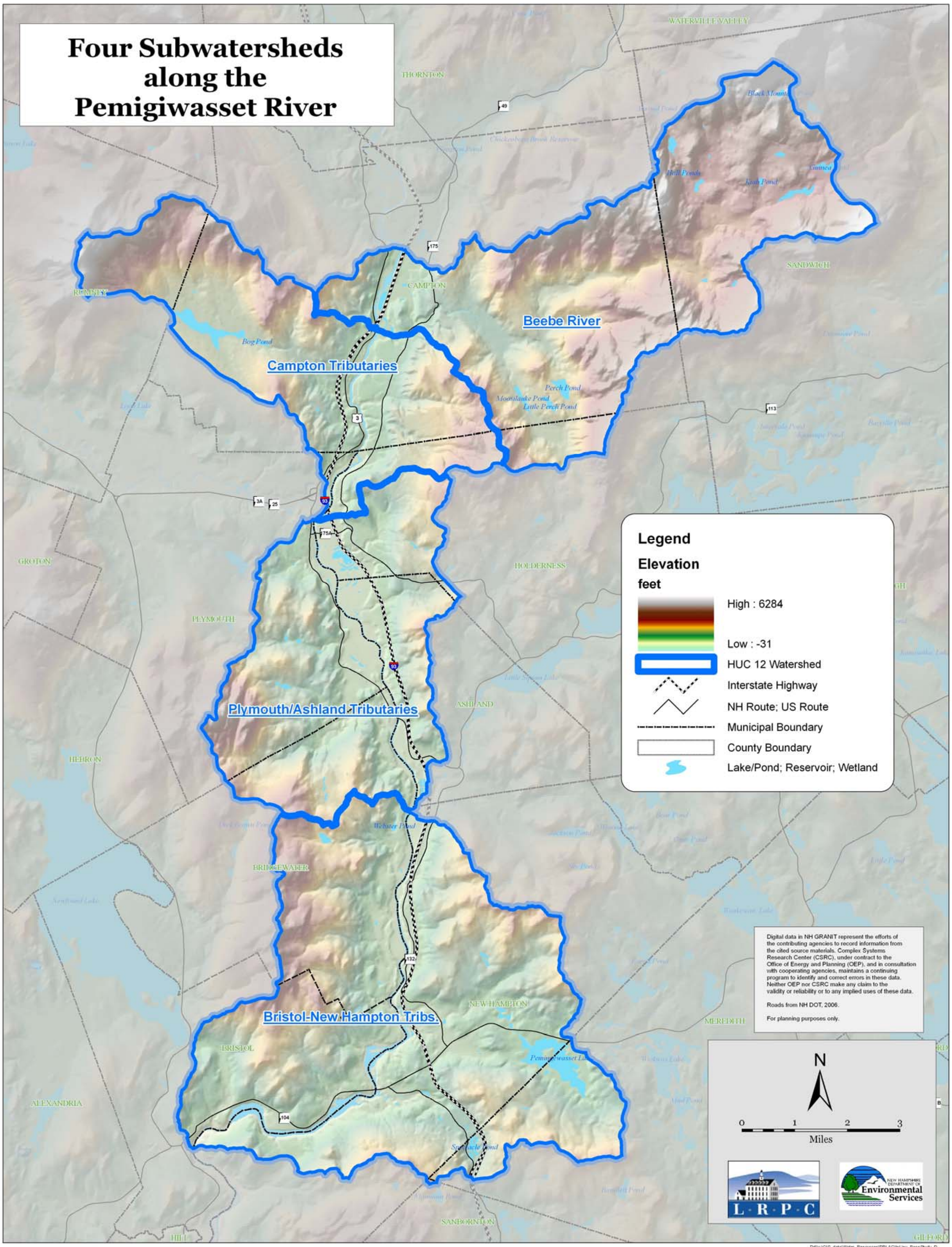
Map 5. Pemigewasset Watershed Analysis – Resource Co-occurrence



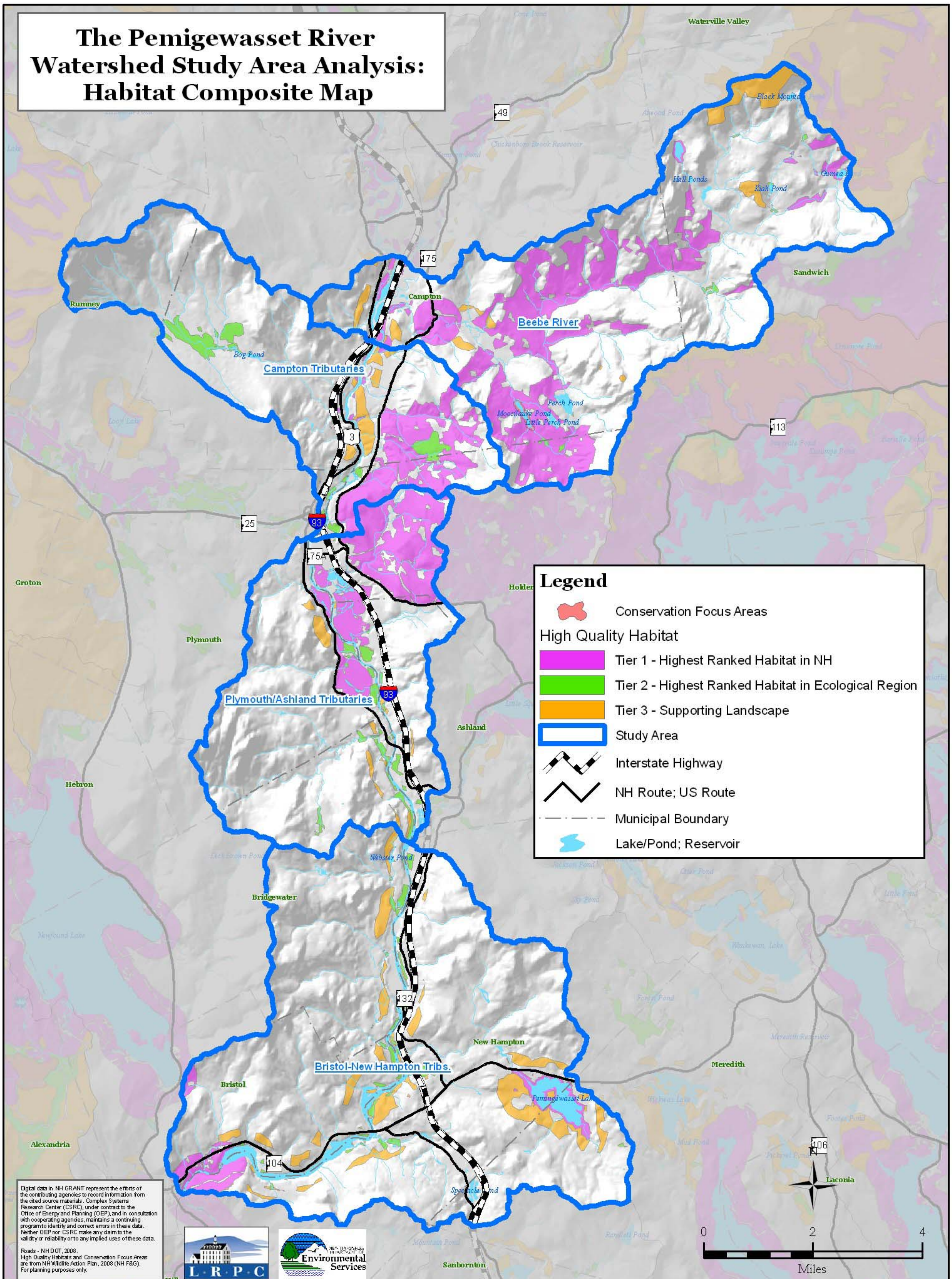
Map 6. Pemigewasset Watershed Analysis – Resource Co-occurrence & Supplementary Layers



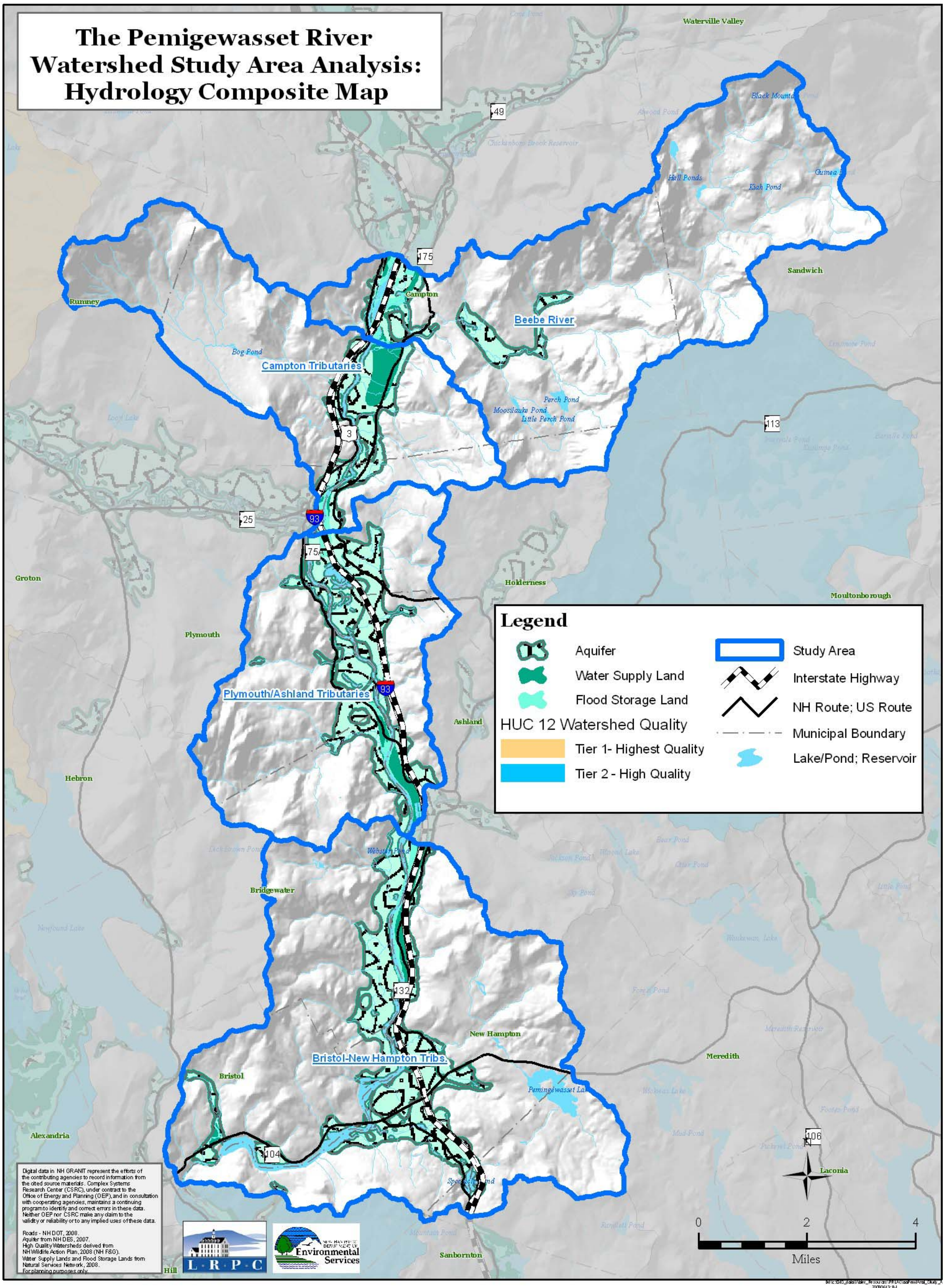
Map 7. Study Area



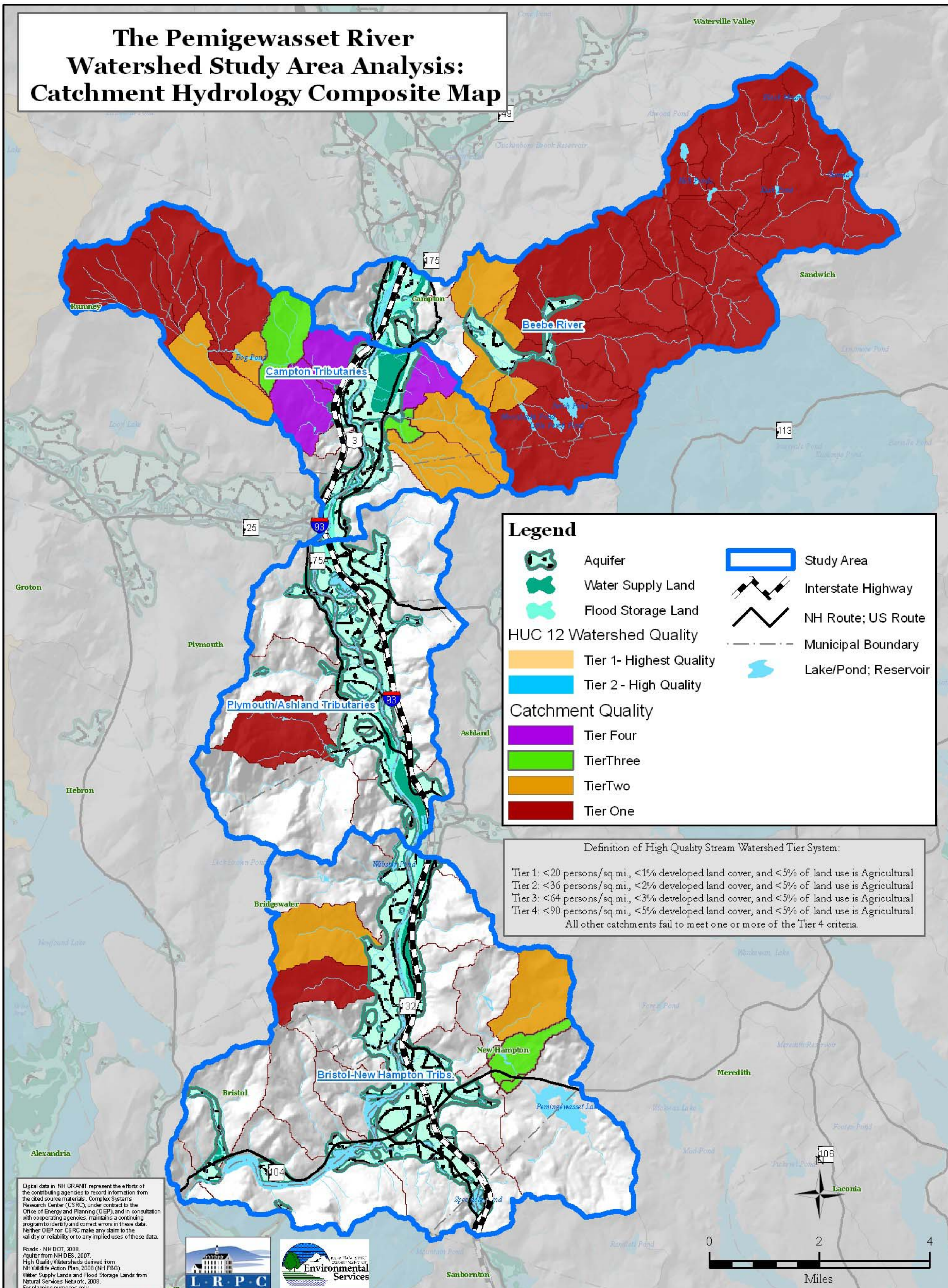
Map 8. Study Area Analysis – Habitat Composite



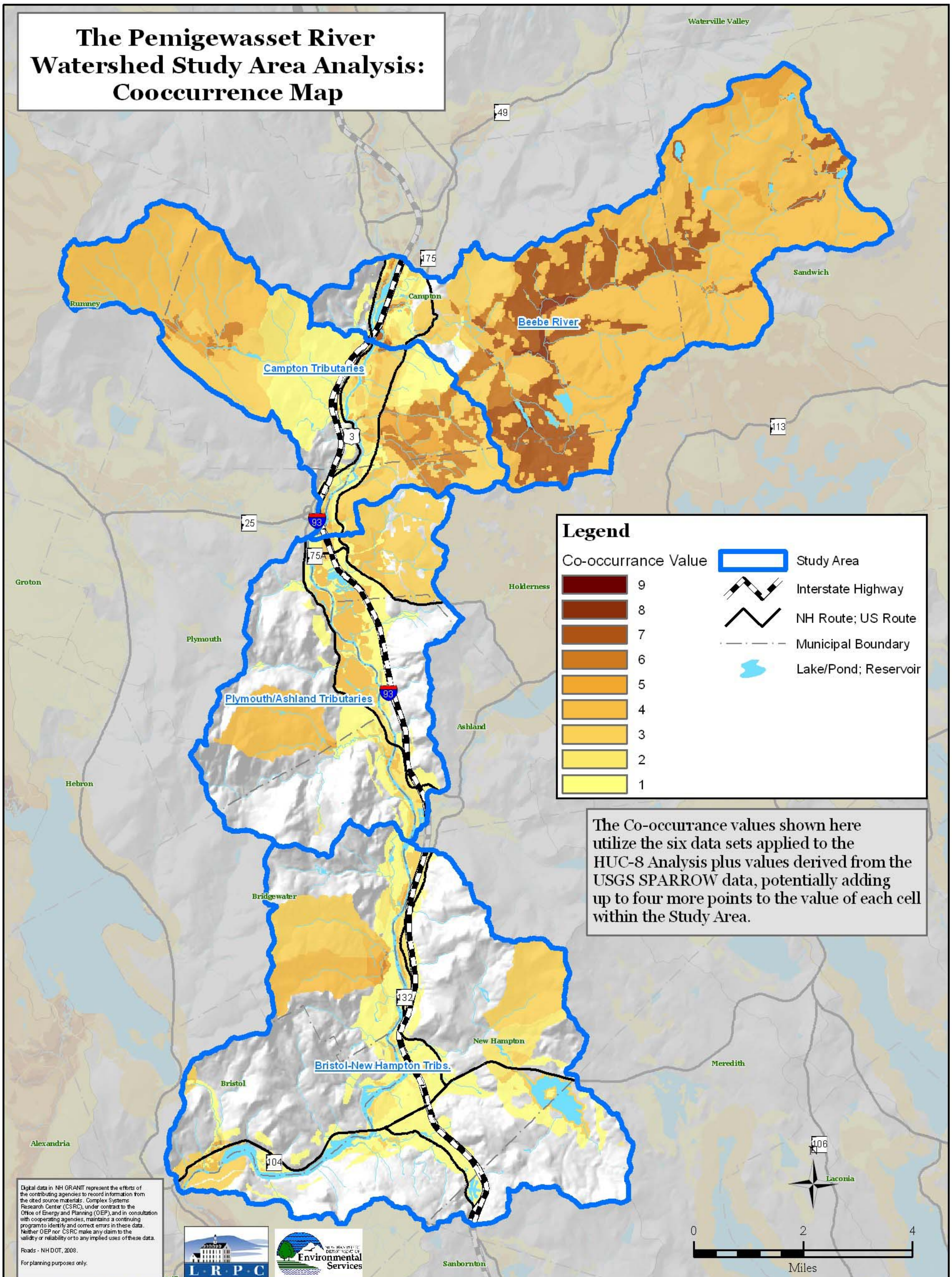
Map 9. Study Area Analysis – Hydrology Composite



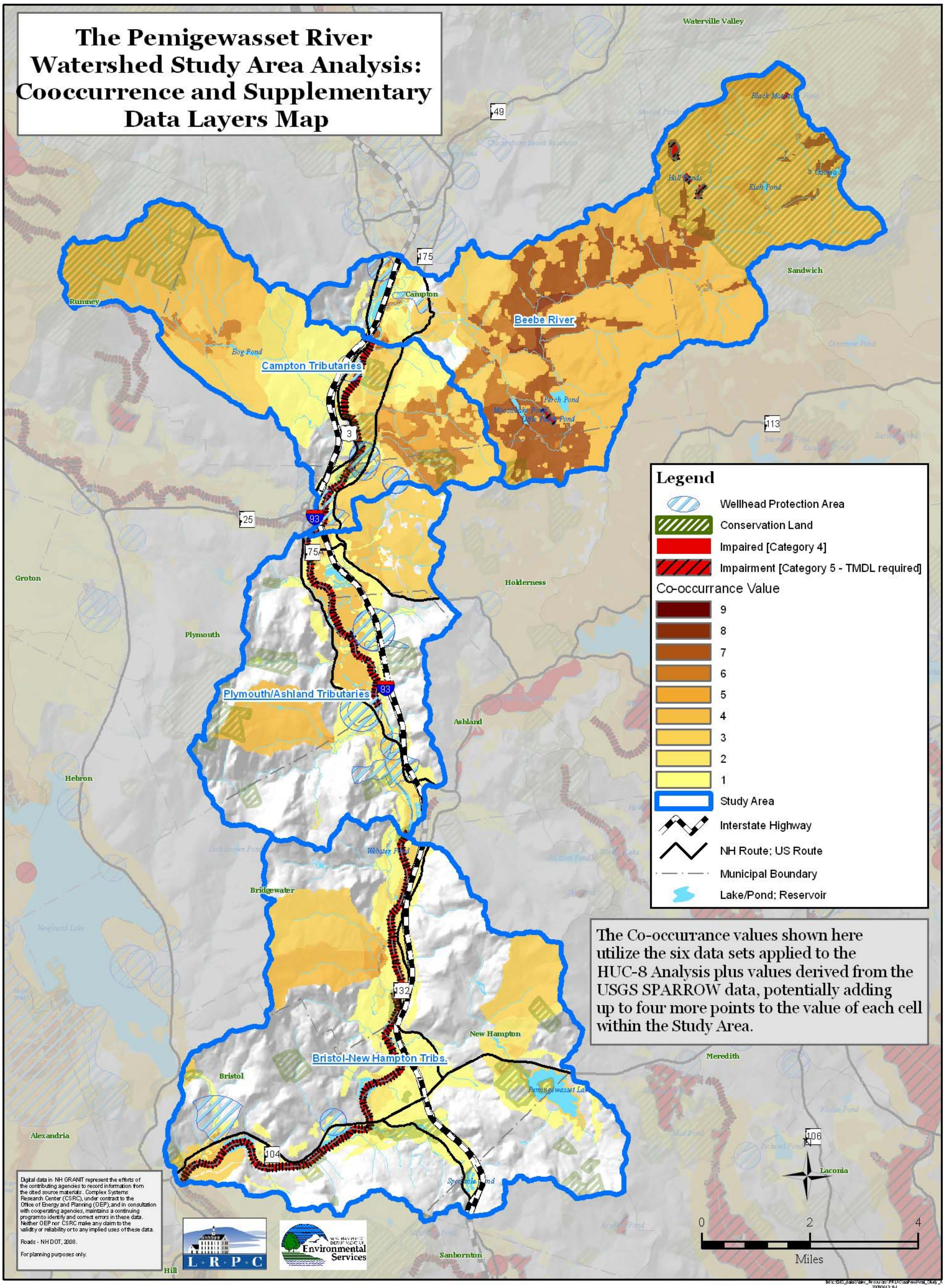
Map 10. Study Area Analysis – Revised Catchment Hydrology Composite



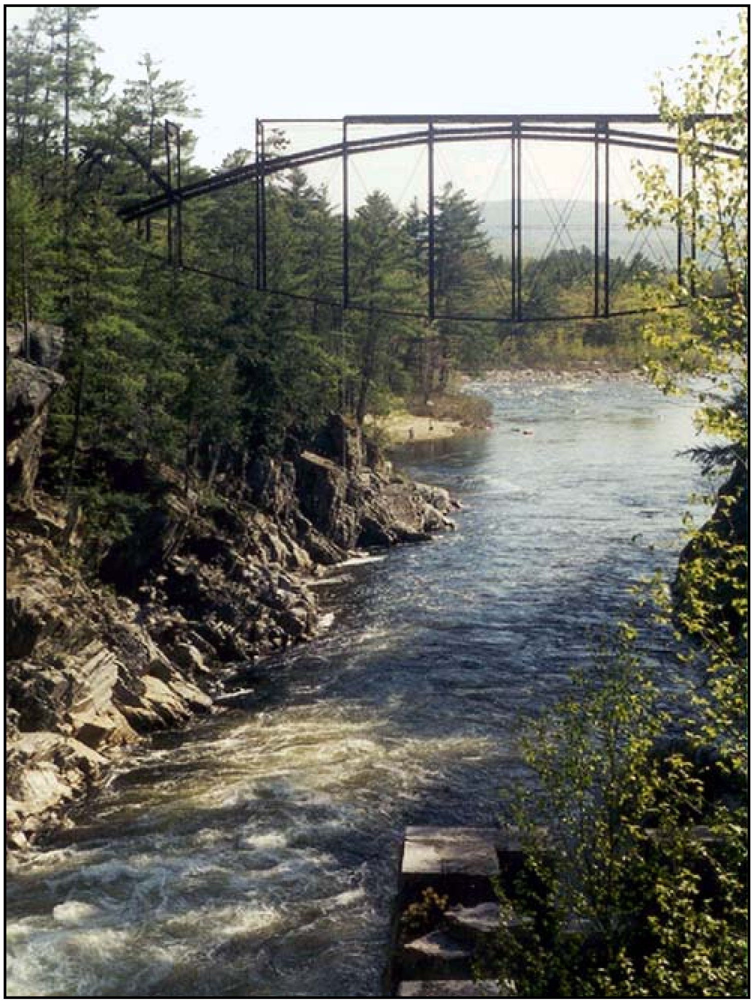
Map 11. Study Area Analysis – Co-occurrence Analysis



Map 12. Study Area Analysis – Resource Co-occurrence & Supplementary Layers



APPENDICES



Pumpkin Seed Bridge at Livermore Falls, Campton, NH

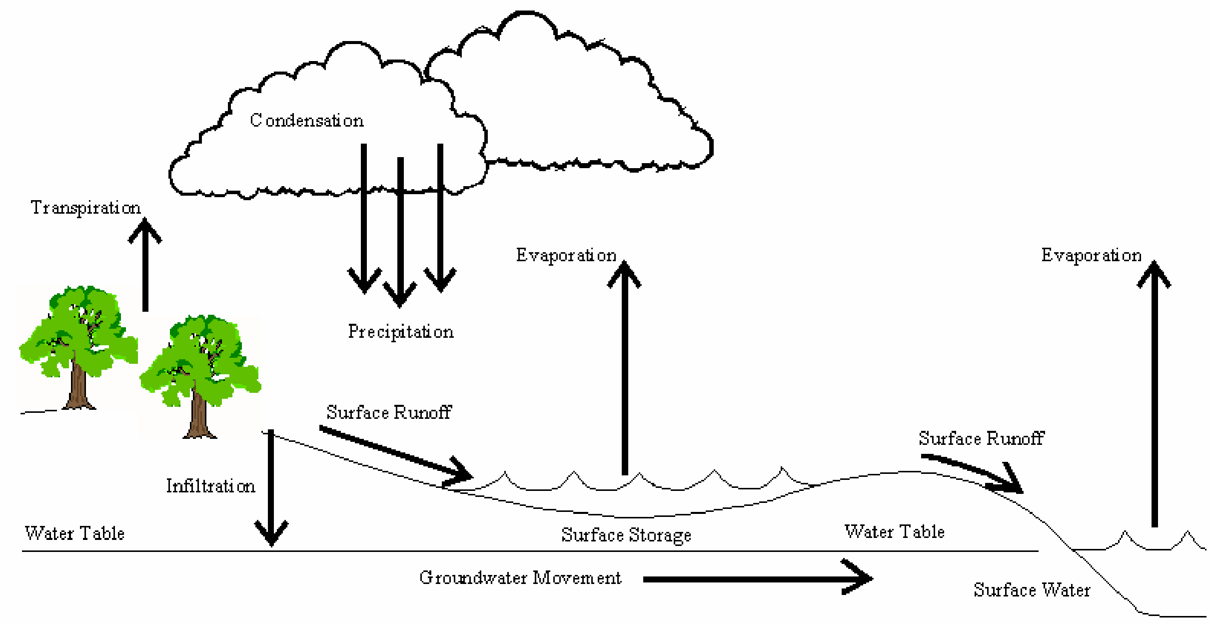
APPENDIX A: DRAFT 2008-303(d) LIST OF IMPAIRED WATERBODIES FOR THE PEMIGEWASSET WATERSHED

Assessment Unit ID	Assessment Unit Name	Water Size	Size Unit	Primary Town	Use Description	Impairment Name	DES Category	Threaten	Tmdl priority	Tmdl Schedule	Probable Source Name
NHIMP700010401-01-02	TOWN BEACH CORCORAN'S POND	1.38	ACRES	WATERVILLE VALLEY	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2013	Pollutants from Public Bathing Areas
NHIMP700010801-08	Pemigewasset River, IMP, W/CWF	500	ACRES	NEW HAMPTON	Aquatic Life	Dissolved oxygen saturation	5-M	N	LOW	2021	Impacts from Hydrostructure Flow Regulation/modification
NHIMP700010801-08	Pemigewasset River, IMP, W/CWF	500	ACRES	NEW HAMPTON	Aquatic Life	Dissolved oxygen saturation	5-M	N	LOW	2021	Municipal Point Source Discharges
NHIMP700010801-08	Pemigewasset River, IMP, W/CWF	500	ACRES	NEW HAMPTON	Aquatic Life	Dissolved oxygen saturation	5-M	N	LOW	2021	Source Unknown
NHIMP700010801-08	Pemigewasset River, IMP, W/CWF	500	ACRES	NEW HAMPTON	Aquatic Life	pH	5-P	N	LOW	2017	Source Unknown
NHIMP700010804-03	SUCKER BROOK-SUCKER BROOK I DAM	0.15	ACRES	ANDOVER	Aquatic Life	Dissolved oxygen saturation	5-P	N	LOW	2021	Source Unknown
NHIMP700010804-03	SUCKER BROOK-SUCKER BROOK I DAM	0.15	ACRES	ANDOVER	Aquatic Life	Oxygen, Dissolved	5-M	N	LOW	2021	Source Unknown
NHLAK700010306-01-02	CAMP HAPPY T RANCH BEACH	1.38	ACRES	RUMNEY	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2019	Source Unknown
NHLAK700010402-07	PERCH POND, CAMPTON, W/CWF	43.3	ACRES	CAMPTON	Aquatic Life	pH	5-P	N	LOW	2021	Source Unknown
NHLAK700010501-05	WHITE OAK POND, HOLDERNESS, WWF	291	ACRES	HOLDERNESS	Aquatic Life	Dissolved oxygen saturation	5-M	N	LOW	2019	Source Unknown
NHLAK700010502-01-02	LITTLE SQUAM LAKE-TOWN BEACH	0.752	ACRES	ASHLAND	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2017	Source Unknown
NHLAK700010603-02-02	TOWN BEACH #2 NEWFOUND LAKE	4.97	ACRES	BRISTOL	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2021	Source Unknown
NHLAK700010603-02-05	WELLINGTON STATE PARK NEWFOUND LAKE	6.061	ACRES	BRISTOL	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2021	Source Unknown
NHLAK700010603-02-13	CAMP WI-CO-SU-TA BEACH	1.38	ACRES	HEBRON	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2019	Source Unknown
NHLAK700010701-02-01	KILTON POND, GRAFTON, WWF	68	ACRES	GRAFTON	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHLAK700010701-02-02	KILTON POND-HUFF BEACH	0.315	ACRES	GRAFTON	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHLAK700010802-03-02	TOWN BEACH #2 HERMIT LAKE	1.28	ACRES	SANBORNTON	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2021	Source Unknown
NHLAK700010804-02-01	WEBSTER LAKE, FRANKLIN, W/CWF	583.45	ACRES	FRANKLIN	Primary Contact Recreation	*Cyanobacteria hepatotoxic microcystins*	5-M	N	LOW	2017	Source Unknown
NHLAK700010804-02-02	WEBSTER LAKE-GRIFFIN TOWN BEACH	1.28	ACRES	FRANKLIN	Primary Contact Recreation	*Cyanobacteria hepatotoxic microcystins*	5-M	N	LOW	2017	Source Unknown
NHLAK700010804-02-02	WEBSTER LAKE-GRIFFIN TOWN BEACH	1.28	ACRES	FRANKLIN	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2017	Source Unknown
NHLAK700010804-02-03	WEBSTER LAKE-LEGACE TOWN BEACH	1.28	ACRES	FRANKLIN	Primary Contact Recreation	*Cyanobacteria hepatotoxic microcystins*	5-M	N	LOW	2017	Source Unknown
NHLAK700010804-02-03	WEBSTER LAKE-LEGACE TOWN BEACH	1.28	ACRES	FRANKLIN	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2019	Source Unknown
NHLAK700030403-01	ADDER POND, ANDOVER, W/CWF	26	ACRES	ANDOVER	Primary Contact Recreation	Chlorophyll-A	5-M	N	LOW	2021	Source Unknown
NHRIV700010104-06	Loon Pond Brook	0.35	MILES	LINCOLN	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHRIV700010104-07	East Branch Pemigewasset River, PWS, WTF	7.68	MILES	LINCOLN	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHRIV700010203-01	Pemigewasset River, CWF	5.72	MILES	WOODSTOCK	Aquatic Life	Aluminum	5-M	N	LOW	2017	Source Unknown
NHRIV700010203-01	Pemigewasset River, CWF	5.72	MILES	WOODSTOCK	Aquatic Life	pH	5-M	N	LOW	2016	Source Unknown
NHRIV700010204-02	Eastman Brook, WTF	9.15	MILES	THORNTON	Aquatic Life	pH	5-M	N	LOW	2019	Source Unknown
NHRIV700010205-12	Pemigewasset River, CWF	7.18	MILES	THORNTON	Aquatic Life	pH	5-P	N	LOW	2017	Source Unknown
NHRIV700010206-05	West Branch Brook	9.14	MILES	CAMPTON	Aquatic Life	Aluminum	5-M	N	LOW	2021	Source Unknown
NHRIV700010302-06	Ore Hill Brook, CWF	5.25	MILES	WARREN	Aquatic Life	Aluminum	5-M	N	LOW	2016	Acid Mine Drainage
NHRIV700010302-06	Ore Hill Brook, CWF	5.25	MILES	WARREN	Aquatic Life	Copper	5-M	N	LOW	2016	Acid Mine Drainage
NHRIV700010302-06	Ore Hill Brook, CWF	5.25	MILES	WARREN	Aquatic Life	Lead	5-M	N	LOW	2016	Acid Mine Drainage
NHRIV700010302-06	Ore Hill Brook, CWF	5.25	MILES	WARREN	Aquatic Life	Zinc	5-M	N	LOW	2016	Acid Mine Drainage
NHRIV700010302-06	Ore Hill Brook, CWF	5.25	MILES	WARREN	Aquatic Life	pH	5-M	N	LOW	2016	Acid Mine Drainage
NHRIV700010303-09-01	Baker River, CWF	0.72	MILES	WENTWORTH	Primary Contact Recreation	*Escherichia coli*	5-M	N	LOW	2021	Source Unknown
NHRIV700010303-12	Baker River, CWF	1.66	MILES	WENTWORTH	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2021	Source Unknown

Assessment Unit ID	Assessment Unit Name	Water Size	Size Unit	Primary Town	Use Description	Impairment Name	DES Category	Threaten	Tmdl priority	Tmdl Schedule	Probable Source Name
NHRIV700010305-11	Baker River, CWF	7.23	MILES	RUMNEY	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2019	Source Unknown
NHRIV700010306-03	Sucker Brook	2.37	MILES	ELLSWORTH	Aquatic Life	pH	5-M	N	LOW	2016	Source Unknown
NHRIV700010306-04	Unnamed Brook to Stinson Lake	0.96	MILES	RUMNEY	Aquatic Life	pH	5-M	N	LOW	2016	Source Unknown
NHRIV700010306-05	Unnamed Brook to Stinson Lake	1.42	MILES	RUMNEY	Aquatic Life	pH	5-M	N	LOW	2016	Source Unknown
NHRIV700010306-06	Unnamed Brook to Stinson Lake, CWF	2.63	MILES	RUMNEY	Aquatic Life	pH	5-P	N	LOW	2016	Source Unknown
NHRIV700010307-05	Unnamed Brook to Loon Lake	4.29	MILES	RUMNEY	Aquatic Life	pH	5-M	N	LOW	2016	Source Unknown
NHRIV700010307-11	Baker River, CWF	9.87	MILES	PLYMOUTH	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2019	Source Unknown
NHRIV700010401-13	Mad River, WTF	8.79	MILES	THORNTON	Aquatic Life	pH	5-P	N	LOW	2021	Source Unknown
NHRIV700010403-03	Bog Brook	3.51	MILES	CAMPTON	Aquatic Life	Aluminum	5-M	N	LOW	2021	Source Unknown
NHRIV700010403-06	Pemigewasset River, WWF	4.31	MILES	CAMPTON	Aquatic Life	pH	5-P	N	LOW	2017	Source Unknown
NHRIV700010404-03	Clay Brook	8.83	MILES	BRIDGEWATER	Aquatic Life	PH	5-M	N	LOW	2021	Source Unknown
NHRIV700010404-06	Pemigewasset River, W/CWF	3.89	MILES	ASHLAND	Aquatic Life	pH	5-P	N	LOW	2017	Source Unknown
NHRIV700010501-12	Unnamed Brook to White Oak Pond	3.83	MILES	HOLDERNESS	Aquatic Life	pH	5-P	N	LOW	2016	Source Unknown
NHRIV700010501-13	UNNAMED BROOK - TO WHITE OAK POND	1.47	MILES	HOLDERNESS	Aquatic Life	pH	5-P	N	LOW	2019	Source Unknown
NHRIV700010502-08	SQUAM RIVER	0.44	MILES	ASHLAND	Aquatic Life	Benthic-Macroinvertebrate Bioassessments (Streams)	5-P	N	LOW	2017	Source Unknown
NHRIV700010502-08	SQUAM RIVER	0.44	MILES	ASHLAND	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHRIV700010602-05	FOWLER RIVER - UNNAMED BROOK, CWF	3.31	MILES	ALEXANDRIA	Aquatic Life	Aluminum	5-M	N	LOW	2021	Source Unknown
NHRIV700010602-05	FOWLER RIVER - UNNAMED BROOK, CWF	3.31	MILES	ALEXANDRIA	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHRIV700010602-09	Bog Brook, CWF	4.59	MILES	ALEXANDRIA	Aquatic Life	Aluminum	5-M	N	LOW	2021	Source Unknown
NHRIV700010602-09	Bog Brook, CWF	4.59	MILES	ALEXANDRIA	Aquatic Life	pH	5-P	N	LOW	2021	Source Unknown
NHRIV700010602-09	Bog Brook, CWF	4.59	MILES	ALEXANDRIA	Primary Contact Recreation	*Escherichia coli*	5-M	N	LOW	2021	Source Unknown
NHRIV700010603-01	Cilley Brook	8.46	MILES	HEBRON	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHRIV700010701-02	Smith River	1.32	MILES	GRAFTON	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHRIV700010702-22	Smith River, CWF	7.53	MILES	ALEXANDRIA	Aquatic Life	pH	5-P	N	LOW	2021	Source Unknown
NHRIV700010801-22	Pemigewasset River, W/CWF	5.39	MILES	NEW HAMPTON	Aquatic Life	pH	5-P	N	LOW	2017	Source Unknown
NHRIV700010801-23	Pemigewasset River, W/CWF	1.01	MILES	NEW HAMPTON	Aquatic Life	Dissolved oxygen saturation	5-M	N	LOW	2019	Source Unknown
NHRIV700010802-02	Hadley Brook	3.47	MILES	SANBORNTON	Aquatic Life	pH	5-M	N	LOW	2019	Source Unknown
NHRIV700010802-07	Salmon Brook, CWF	6.04	MILES	SANBORNTON	Aquatic Life	Aluminum	5-M	N	LOW	2021	Source Unknown
NHRIV700010802-07	Salmon Brook, CWF	6.04	MILES	SANBORNTON	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2021	Source Unknown
NHRIV700010803-07	Weeks Brook, CWF	8.22	MILES	SANBORNTON	Aquatic Life	Aluminum	5-M	N	LOW	2021	Source Unknown
NHRIV700010803-07	Weeks Brook, CWF	8.22	MILES	SANBORNTON	Primary Contact Recreation	*Escherichia coli*	5-M	N	LOW	2021	Source Unknown
NHRIV700010803-13	Pemigewasset River, W/CWF	10.15	MILES	NEW HAMPTON	Aquatic Life	pH	5-M	N	LOW	2017	Source Unknown
NHRIV700010804-03	TILTON BROOK	1.81	MILES	ANDOVER	Aquatic Life	pH	5-M	N	LOW	2019	Source Unknown
NHRIV700010804-04	UNNAMED BROOK - TO HIGHLAND LAKE	3.13	MILES	ANDOVER	Aquatic Life	pH	5-M	N	LOW	2019	Source Unknown
NHRIV700010804-05	SUCKER BROOK - UNNAMED BROOKS	6.53	MILES	ANDOVER	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2019	Source Unknown
NHRIV700010804-07	UNNAMED BROOK - TO SUCKER BROOK	3.8	MILES	ANDOVER	Aquatic Life	pH	5-M	N	LOW	2021	Source Unknown
NHRIV700010804-07	UNNAMED BROOK - TO SUCKER BROOK	3.8	MILES	ANDOVER	Primary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2019	Source Unknown
NHRIV700010804-07	UNNAMED BROOK - TO SUCKER BROOK	3.8	MILES	ANDOVER	Secondary Contact Recreation	*Escherichia coli*	5-P	N	LOW	2019	Source Unknown
NHRIV700010804-14	Pemigewasset River, W/CWF	0.91	MILES	FRANKLIN	Secondary Contact Recreation	*Escherichia coli*	5-M	N	LOW	2021	Source Unknown

APPENDIX B: THE HYDROLOGIC CYCLE

Figure B-1: The Hydrologic Cycle



A stratified drift aquifer stores water in the spaces between particles of sand and gravel (called stratified drift) left behind by glaciers. The 'soaking down to the water table' is called recharging the aquifer, bringing water down into the saturated zone where it than can yield water to wells or springs.

Groundwater is the water that flows underground eventually discharging out into rivers, streams and wetlands. Wetland functions include the storage of water, transformation of nutrients (purifying water), the growth of living organisms that need the protection of grasses and shallow water to mature, the diversity of wetland plants, and they are also temporary refuge to an extraordinary number of migrating birds.

Water stored in the aquifer is recharged, or replenished, when rain and snowmelt soak the ground again and move down through the soil to the saturated zone below the water table, rather than evaporating or running off in to surface waters. One of the most critical determinants of groundwater quality is the location of these recharge areas in relation to land use and potential contamination sources.

APPENDIX C: DATA DESCRIPTIONS

This report was developed to serve three functions: assist PRLAC in its education and outreach efforts, serve as the foundation for Part Two of this project – development of a Watershed Conservation Plan, and inform the state's In-Lieu Fee Committee on decisions regarding funding of projects in the Pemigewasset Watershed. Therefore, much thought was given to the choice of data and any analyzing that might occur. Utilizing data that has as much local detail as possible was desirable for the first two functions, but having data that could be applied throughout the entire HUC-8 watershed was a necessary requirement to ensure comparability for In-Lieu Fee decision-making. Incorporating the USGS SPARROW data serves the function of localizing some of the statewide data.

Likewise, the data processing needed to be fairly straightforward and applicable throughout this and other watersheds. The analyzing conducted for this project did customize some of the data at the watershed level. Further customization could be conducted by adjusting point values to give greater emphasis to certain features, dependent upon the desired goal. Care should be taken when conducting this type of customization to document such weighting, especially when making comparisons with other watersheds.

Listed below is an outline of the materials and processes used to develop the maps for this Natural Resources Co-occurrence Report:

I. Software
    A. ESRI ArcGIS 9.2– ArcMap
    B. ESRI Spatial Analyst Extension
II. Data Sets
    A. Base layers
        1. political boundaries (NH GRANIT)
        2. hydrology (NH GRANIT)
        3. watersheds (NH DES)
        4. roads (NH DOT)
        5. elevation – derived from Digital Elevation Models (NH GRANIT) using Spatial Analyst Extension
        6. hillshade – derived from Digital Elevation Models (NH GRANIT) using Spatial Analyst Extension.
    B. Habitat layers
        1. Highest ranked habitat - the condition of wildlife habitats was analyzed by ranking the biological, landscape, and human impact factors most affecting each habitat type, including rare plant and animal species, biodiversity, size of habitat and how close it is to other patches of that habitat, density of roads around the habitat, dams, recreational use, and pollution. - NH Wildlife Action Plan (NH F&G)

2. Conservation focus areas - those places that combine a number of high ranked habitats in one area - NH Wildlife Action Plan (NH F&G).

C. Hydrology layers
1. aquifer – boundaries of the aquifer (USGS at NH GRANIT)
2. flood storage lands – including 100-year floodplains as well as lacustrine, riverine, and palustrine wetlands (Natural Services Network)
3. water supply lands – high transmissivity aquifers and favorable gravel well sites (Natural Services Network)
4. HUC 12 water quality – huc12bio [provides aquatic habitat condition attributes by HUC 12 watershed] from the NH Wildlife Action Plan (NH F&G), adapted - see IIIA.

D. SPARROW data - **SPA**tially **R**eferenced **R**egressions **O**n **W**atershed
1. Attributes relate in-stream water-quality measurements to spatially referenced characteristics of watersheds, including contaminant sources and factors influencing terrestrial and stream transport (USGS).

E. Supplemental layers
1. conservation lands – Land held in conservation by either a public or private entity (NH GRANIT)
2. wellhead protection areas – area of protection surrounding community wells, exact dimensions depend on the size of the well and shape of the landscape (NH DES)
3. impaired water bodies – from hydrologic assessment units, whether waterbodies and stream segments are impaired by a chemical or organism and to what degree (NH DES).

III. Analysis

A. Re-ranking for watershed
1. After selecting all of the HUC-12 subwatersheds in the Pemigewasset watershed, they were ranked according to COND2, which is a composite score based on the biological, landscape, and human impact factors impacting waterbodies. The top 15% of these subwatersheds were assigned to Tier 1 and the next 15% were designated as Tier 2 in terms of water quality within the Pemigewasset watershed.

B. SPARROW data
1. The criteria used for determining High Quality Stream Watersheds in this report mirrors that of the *Coastal Watersheds Plan (2006).* Three attributes were used to establish the four tiers, population density, percent developed land, and percent of agricultural land use. For a catchment to qualify for any of the tiers, it had to have less than 5% agricultural land use.

Figure C-1. SPARROW Data Qualifications for a Catchment

Tier	Population Density	% developed land cover	% of land use is Agricultural
Tier 1	<20 persons/sq.mi.	<1%	<5%
Tier 2	<36 persons/sq.mi.	<2%	<5%
Tier 3	<64 persons/sq.mi.	<3%	<5%
Tier 4	<90 persons/sq.mi.	<5%	<5%

C. Convert to Raster
   1. To conduct co-occurrence mapping, all layers that were in shapefile/vector format needed to be converted to raster format. This was done using the ArcToolbox → Conversion Tools → To Raster → Feature to Raster. The WAP data is already in raster format, therefore cell size (100 ft.) and raster extent were all registered to the waptiers raster during vector to raster conversion.

D. Reclassify
   1. Each of these new rasters was then reclassified, assigning point values for the relevant attributes. This was done using Spatial Analyst Tools → Reclass → Reclassify. Again the waptiers raster was used as the reference for cell size and raster extent. In most situations, all values above "0" were assigned a value of "1"; "No data" was reclassified as "0".
   2. The point values of 0, 1, 2, 3 (waptiers) and 1, 2 (HUC-12 water quality) were assigned based on existing classifications.
   3. Each of the four SPARROW data rasters was reclassified with a value appropriate to the Tier ranking. (It should be noted that Tier 1 in the SPARROW data represents the highest quality catchment (example; Tier 1 = 4, NoData; Tier 4 = 1, NoData).

E. Weighted Sum/Final Score
   1. The values in each cell of the reclassified rasters were then added together using Spatial Analyst Tools → Overlay → Weighted Sum. Each raster had a weight of "1", thus all features have equal weight.
   2. For the Study Area the same steps were followed but the SPARROW data was added to the Weighted Sum operation.