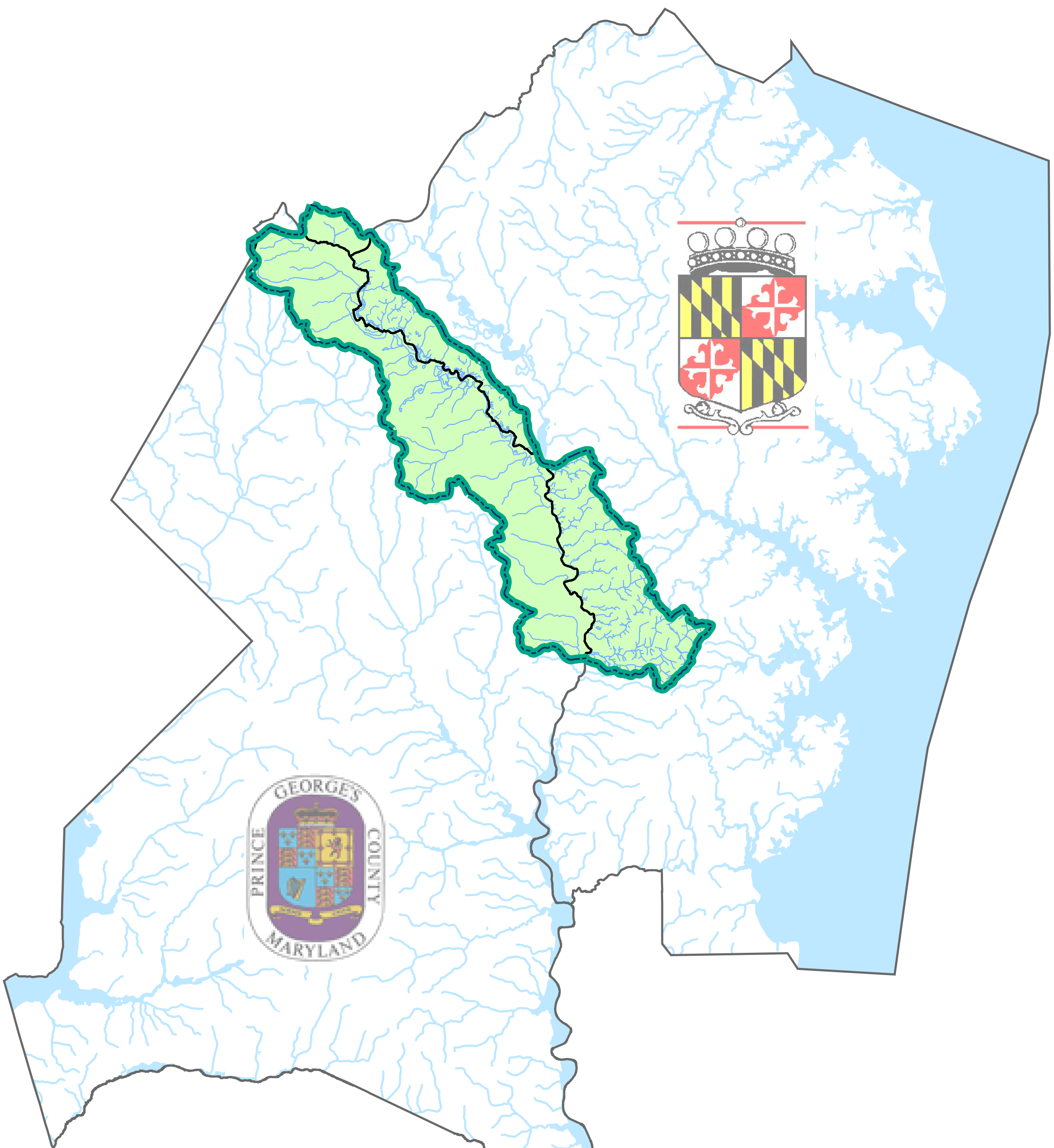
Upper Patuxent River Watershed Characterization

December 2002



Product of the Maryland
Department of Natural Resources
In partnership with Prince George's
and Anne Arundel Counties

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Watershed Characterization

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In support of Anne Arundel and Prince George's Counties'
Watershed Restoration Action Strategy
for the
Upper Patuxent River Watershed

Product of the
Maryland Department of Natural Resources
Chesapeake and Coastal Watershed Service
In partnership with
Anne Arundel and Prince George's Counties

Parris N. Glendening
Governor

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Lt. Governor

A message to Maryland's citizens

The Maryland Department of Natural Resources (DNR) seeks to preserve, protect and enhance the living resources of the state. Working in partnership with the citizens of Maryland, this worthwhile goal will become a reality. This publication provides information that will increase your understanding of how DNR strives to reach that goal through its many diverse programs.

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see www.state.md.us/watersheds/surf/proj/wras.html

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EXECUTIVE SUMMARY

For the Upper Patuxent River Watershed Characterization

Anne Arundel and Prince George's Counties, Maryland are receiving Federal grant funding and State technical assistance to prepare a Watershed Restoration Action Strategy (WRAS) for the Upper Patuxent River watershed. This Maryland 8-digit watershed (02131104) is ranked as a Priority Watershed in need of restoration by the 1998 Maryland Clean Water Action Plan. Anne Arundel and Prince George's Counties applied for grant funding and volunteered to develop a bi-county strategy in this watershed to improve water quality and in-stream habitat using Low Impact Development (LID) techniques and restoration projects.

The purpose of the Watershed Characterization is to assist Anne Arundel and Prince George's Counties in collecting information and identifying issues that may be used as the Counties generate the Watershed Restoration Action Strategy.

Water Quality

The Upper Patuxent River watershed is a Use-I water body with designated uses of water contact recreation and protection of aquatic life. Maryland's 1996 303(d) List for Water Quality Limited Segments reports that the waters of this watershed do not support all their designated uses. Causes for these limitations were attributed to excessive nutrients and sediments. These limitations were given a low priority rank for TMDL development. No new limitations were added in the 1998 303(d) list or in the draft 2002 303(d) list. The most recent 305(b) Water Quality Report (2000) shows no water quality impairment and no impairments to the aquatic community.

Land Use

The Upper Patuxent River watershed encompasses about 56,278 acres of land and water of which 96 % (54,533 acres) falls within Anne Arundel and Prince George's Counties. This portion of the watershed is referred to as the WRAS study area. The remaining 4 % of the watershed occurs within Howard County and Montgomery Counties and falls outside of the WRAS study area. About 57 % of the WRAS study area occurs within Prince George's County (32,313 acres) with the remaining 39 % located in Anne Arundel County (22,220 acres). The watershed is located in northeastern Prince George's County and western Anne Arundel County, with the Patuxent River mainstem serving as the geographic boundary between the two counties. Ninety-five percent of the land area is located within the Coastal Plain physiographic province with the remainder located within the Piedmont physiographic province.

Forested land occupies approximately 45 % of the WRAS study area. Forest land is distributed nearly equally between the two counties. Much of this forest land has been classified as Green Infrastructure or, in Anne Arundel County, as part of the county adopted Greenways Master Plan. A large forest block, found in the upper-mid portion of the watershed, is part of the Federally owned Patuxent Research Refuge. Other forested lands occur along the main stem of the Patuxent River and some of its tributaries in the southern portion of the watershed.

Developed land occurs most predominantly in Prince George's county and represents about 32 % of the WRAS study area. Urbanized regions are concentrated around the cities of

Bowie, Laurel and Maryland City. These areas will be evaluated for low impact development retrofits as part of the Watershed Restoration Action Strategy.

Agricultural land occupies 19 % of the WRAS study area and is concentrated in Anne Arundel county. Approximately 1,848 acres of agricultural land are protected through easements. All of these properties occur within Anne Arundel county.

Living Resources and Habitat

Assessments of benthos, fish and physical habitat were conducted by the Maryland Biological Stream Survey in 1997 at 5 sites. Fish communities were ranked from Very Poor to Good and benthic communities were ranked from Very Poor to Fair. Fish species found during the survey are very common in Maryland and most are tolerant of anthropogenic stressors related to nutrient and sediment pollution. Sites supporting low biological scores were associated with upland urbanization and inadequate riparian buffers.

Historically, the Upper Patuxent River basin supported reproducing populations of anadromous and estuarine fish species (shad, herring, white perch and yellow perch). Herring and shad can still be fished from the lower portion of the watershed near the Rt. 214 bridge.

Twelve (12) areas of sensitive species are identified in the Upper Patuxent River watershed. A large cluster of these areas occur within the Patuxent Research Refuge and others can be found within the southern portion of the Patuxent River's floodplain. Within these sensitive species areas, 155 acres of wetlands have been designated as Wetlands of Special State Concern and have additional regulatory requirements beyond the general permitting requirements that apply to wetlands.

Restoration Targeting Tools

During 2002, a stream corridor assessment was conducted to visually assess and characterize approximately 100 miles of stream within this watershed. Information provided through this assessment includes data relative to stream bank stability, riparian habitat, fish passage, pipe crossings, leaking pipes, trash accumulation and any other unusual problems. This information is available in a separate document and will be made available online (http://intranet/watersheds/surf/proj/wras.html) or can be accessed by contacting the counties.

In addition, other services provided by the Maryland Department of Natural Resources in 2002 include benthic macroinveterbrate community assessment, fish community assessment, synoptic water quality and flow data collection. This information is also available in a separate document and will be made available online (http://intranet/watersheds/surf/proj/wras.html) or can be accessed by contacting the counties.

Computerized mapping was used to demonstrate opportunities for targeting protection and restoration projects incuding restoration of stream buffers, riparian forest and wetlands. Collectively, this information and the computerized map analyses provided in the characterization will be used in assessing current condition, identifying areas in need of rehabilitation or protection, and are tools for developing the restoration strategy.

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INTRODUCTION

Background

In 1998, Maryland completed a Unified Watershed Assessment of all 134 of the state's watersheds in order to identify high priorities for restoration action based on impaired waters and high priorities for conservation action based on high or unique natural resource value. The assessment was conducted by the Maryland Department of Natural Resources (DNR) under the direction of the US Environmental Protection Agency's Clean Water Action Plan initiative with assistance from the Maryland Departments of Environment, Agriculture and Planning and the University of Maryland. It moved beyond consideration of water quality in the streams in the state, which had been assessed regularly since the early 1970's., to a larger consideration of living resources in the streams and the landscape conditions which could impact both water quality and living resources.[1,2]

As part of the State's response to the findings of the Unified Watershed Assessment, DNR is offering technical and financial assistance to local governments who are willing to work cooperatively to develop and implement Watershed Restoration Action Strategies (WRAS) addressing needs for restoration and conservation in priority watersheds. One of these is the Upper Patuxent River watershed in Prince George's and Anne Arundel Counties in which the Counties, DNR and other local cooperators, both public and private, are engaged in the strategy development program.

Location

The Upper Patuxent River watershed is located within the Patuxent River basin as shown in Map 1: Regional Context. The majority of the Upper Patuxent River watershed is within Anne Arundel and Prince George's Counties, Maryland. This area is the focus of the Watershed Restoration Action Strategy and this Watershed Characterization. Map 2: WRAS Project Area shows the county boundaries and highlights major roads, cities, streams and other features. About 39% of the watershed is in Anne Arundel County while Prince George's county supports 57% of the watershed. The remaining 4% of the watershed falls mostly within Howard county. As shown in Map 3 Streams and Watershed Management Units, the two Counties are on opposite sides of the Patuxent River. Therefore, their subwatersheds are hydrologically distinct. Each county has delineated subwatersheds that are referred to as Watershed Management units for the purposes of

Upper Patuxent River Watershed Acreage Summary

County	Land	Water	Total
Anne Arundel	22,212	8	22,220
Prince George's	32,008	305	32,313
Howard and Montgomery	1,745	0	1,745
Watershed Total	55,965	313	56,278

this report. The Bear Branch watershed, in the northernmost portion of the Prince George's County WRAS study area, has been a focus area due to its influence on flood management and water quality issues within the City of Laurel and the Laurel Lakes (see Related Projects section in this document).

Purpose of the Characterization

One of the earliest steps toward devising a Watershed Restoration Action Strategy is to characterize the watershed using immediately available information. This Watershed Characterization is intended to meet several objectives:

- ♦ Briefly summarize the most important or relevant information and issues
- ♦ Provide preliminary findings based on this information
- ♦ Identify sources for more information or analysis
- ♦ Suggest opportunities for additional characterization and restoration work.
- ♦ Provide a common base of information for local governments and interested citizens.

Additional Characterization Recommended

The Watershed Characterization is intended to be one starting point that can be updated as needed. It is part of a framework for a more thorough assessment involving an array of additional inputs:

- ♦ Self-investigation by the local entity
- ♦ Targeted technical assistance and assessment by partner agencies or contractors
- ♦ Input from local citizens
- ♦ Completion of a Stream Corridor Assessment, in which DNR personnel physically walk the streams and catalogue important issues.
- ♦ Completion of a synoptic water quality survey, i.e. a program of water sample analysis, that can be used to focus on local issues like nutrient hot spots, point source discharges or other selected issues. This is also part of the technical assistance offered by DNR.

Identifying Gaps in Information

It is important to identify gaps in available watershed knowledge and gauge the importance of these gaps. In assessing data gaps, we have found it helpful to review information in four categories:

- ♦ Habitat: physical structure, stream stability and biotic community (including riparian zones)
- ♦ Water Quantity: high water - storm flow & flooding; low water - baseflow problems from dams, water withdrawals, reduced infiltration
- ♦ Water Quality: water chemistry; toxics, nutrients, sediment, nuisance odors/scums, etc.
- ♦ Cumulative effects associated with habitat, water quantity and water quality.

Adaptive Management

Because restoration is an active evolving process, the Watershed Characterization and the resulting Watershed Restoration Action Strategy should be maintained as living documents within an active evolving restoration process. These documents will need to be updated periodically as new, more relevant information becomes available and as the watershed response is monitored and reassessed. The term, "adaptive management", underscores the idea that this Watershed Restoration Action Strategy is a dynamic work in progress. Strategies for restoration and conservation should address not only current and historic conditions, but should be developed to anticipate future conditions. As new information becomes available and responses from implemented strategies and changing watershed conditions are monitored and assessed, the Watershed Restoration Action Strategy should be revisited and reevaluated. Watershed management planning is a circular process that builds upon itself.

WATER QUALITY

Water quality is in many respects the driving condition in the health of Maryland's streams. Historically, the emphasis has been on chemical water quality. More recently, interest has focused on the biological conditions in streams and estuaries; active consideration of the physical parameters is even more recent. This developmental path is reflected in the ways in which streams have been monitored, the types of data gathered, and the regulatory approach taken.

River Basin Context of Local Water Quality Issues

The Upper Patuxent River watershed is located just above the midpoint of the Patuxent River Tributary Basin as shown in Map 1 Regional Context. As a result of this hydrologic location, water quality issues in the watershed are attributed both to local origins and upstream origins. The northern portion of the Upper Patuxent River watershed receives the combined stream flow from two in-line watersheds, Brighton Dam and Rocky Gorge. Stream flow from the Brighton Dam discharges into the Rocky Gorge Dam which then, in turn, discharges stream flow into the Upper Patuxent River watershed. This particular combination of reservoirs is unique in Maryland. The reservoir systems supply potable water through the Washington Suburban Sanitary Commission system to the Maryland suburban area of Washington, D.C.. These watersheds are included in the Patuxent Reservoir agreement to protect water quality. The dominant land use in these watersheds include crop, pasture and forest land intermingled with mostly low density residential properties. Recently conducted flood studies (see **Related Projects** section in this document), used zoning maps to assess future land use and concluded that the nature of the watershed would not drastically change. The dominant zoning class is rural residential. However, there are several pockets of denser development zoned. The two dams present in these upstream watersheds have significant effects on the water quality within the Upper Patuxent watershed by acting as sediment traps. Most of the suspended sediments in the waters of the WRAS watershed either originate from non point sources within the watershed or are delivered by the Little Patuxent and the Middle Patuxent watersheds. These watersheds drain into the southern portion of the Upper Patuxent River watershed. In addition to crop, pasture, forest and low density residential land, these watersheds also drain significant land areas supporting high density residential and commercial/industrial use. A watershed characterization and a Watershed Restoration Action Strategy have been completed for the Howard County portion of the Little Patuxent watershed, through the first round of WRAS watersheds, and can be accessed through the internet at http://www.dnr.state.md.us/watersheds/surf/proj/wras.html. Information on the other watersheds draining into the Upper Patuxent River watershed can be found on the Watershed Profiles section at http://mddnr.chesapeakebay.net/wsprofiles/surf/prof/prof.html of the DNR Surf Your Watershed internet site.

Upper Patuxent River flows are such that most nutrients are transported downstream to the Patuxent River estuary, rather than settling out in the upper reaches of the river. This results in manifestation of water quality problems in the lower reaches of the Patuxent River. For example, excessive algae growth in the Patuxent estuary during warm months is caused by high nutrient loads that arise from upstream nutrient sources, including the Upper Patuxent River. While this characterization does not focus on the larger Patuxent River Basin issues, it is important to realize that other State and Federal programs, and requirements driven by downstream issues, will affect Upper Patuxent River watershed programs such as the future development of a total maximum daily load (TMDL).

Water Quality Standards and Designated Uses

All streams and other waters of the State are assigned a "designated use" in regulation, COMAR 26.08.02.08 which is associated with a set of water quality criteria necessary to support that use. All waters in the Upper Patuxent River watershed are designated as Use I.

- ♦ Use I, Water Contact Recreation (swimming, boating and fishing) and Protection of Aquatic Life.

COMAR or The Maryland Department of the Environment should be contacted for official regulatory information.[3,5]

Water Quality Indicators - Setting Priority for Restoration and Protection

The Clean Water Action Plan's *1998 Unified Watershed Assessment* established priorities for watersheds in the State for restoration and protection. In the Plan, the Upper Patuxent River watershed was listed in as a **Category 1 Priority** watershed, which is a category for watersheds with the *highest* priority for restoration.

- ♦ **Category 1 Priority watersheds:** Watersheds needing restoration and failed to meet at least half of their water quality and natural resource goals.

As the basis for the prioritization, indicators of water quality, landscape and living resources were developed for all watersheds in Maryland. These indicators are presented in the following table which is accompanied by a detailed description of water quality indicators. Other approaches to assessing water quality have been in use for several years and are further described below. In general, they do not look comparatively at watersheds as the Unified Assessment did in an effort to set priorities. The Unified Assessment also considered a range of living resource and landscape indicators described later.

Unified Watershed Assessment Water Quality Indicators			
Water Quality Indicator	**Finding**	**Status***	**Bench Mark**
State 303(d) Impairment Number	**2**	**Fail**	A watershed automatically fails this benchmark if it is listed for 1 or more impairments on the 303(d)
Non-tidal Total Nitrogen Index	**7.0**	**Fail**	In comparison to 138 watersheds in Maryland, this watershed IS among the 25 % having the lowest relative Total Nitrogen Index
Non-tidal Total Phosphorus Index	**7.0**	**Pass**	In comparison to 138 watersheds in Maryland, this watershed IS NOT among the 25 % having the lowest relative Total Phosphorus Index
Modeled Total Nitrogen Load	**9.13**	**Pass**	In comparison to 138 watersheds in Maryland, this watershed IS NOT among the 25 % having the highest nitrogen loads.
Modeled Total Phosphorus Load	**0.52**	**Pass**	In comparison to 138 watersheds in Maryland, this watershed IS NOT among 25 % having the highest phosphorus loads.

NOTES: See Interpreting Water Quality Indicators for additional explanation for each indicator.

* Pass = Average watershed conditions measured by this indicator are better than the Statewide benchmark (unshaded).

* Fail = Average watershed conditions measured by this indicator are worse than the Statewide benchmark (shaded).

Interpreting Water Quality Indicators

State 303(d) Impairment Number. This number is used to characterize watersheds relative to regulatory requirements of the Federal Clean Water Act. It is based on numerous water quality-related factors that are tracked by the State of Maryland under these federal requirements.

Non-Tidal Total N Index. This index is a mean of monitored data (1994 - 1996) and scored according to a 10-level scale (1 - most degraded to 10 - best conditions). Watersheds whose score value is in the lower 25 percent of scores for the 138 watersheds receive a Category 1 rating for this indicator and receive a rank of "fail".

Non-Tidal Total P Index. A parallel approach was used for developing the phosphorus index.

Modeled TN Load. Nitrogen Load is a measure of how much of this important nutrient is reaching streams and other surface waters. For each type of land use in the watershed, on average, stormwater tends to carry or transport a characteristic amount of nitrogen from the land to nearby streams. Based on these averages, a computer model can be used to estimate how much nitrogen is likely to be reaching local streams. This method was applied Statewide to all the 138 watersheds in Maryland to allow comparison of "modeled total nitrogen load" among them. A rank of "pass" means that this watershed was among the 104 (75%) out of 138 total watersheds in Maryland that had the lower estimated total nitrogen load.

Modeled TP Load. It is a measure of how much of this important nutrient is reaching streams and other surface waters. The ranking for modeled TP Load was performed in parallel to the ranking for modeled TN Load above. (Note: details of the models differ.) The rank of "pass" means that this watershed was among the 104 (75%) out of 138 total watersheds in Maryland that had the lower estimated total phosphorus load.

Not Supporting Designated Use – 303(d) Listings

As required under Section 303(d) of the Federal Clean Water Act, Maryland tracks waterways that did not support their designated use in a prioritized list of "Water Quality Limited Basin Segments." The Upper Patuxent River watershed first appeared on the Maryland's 303(d) list in 1996 (the original list). Since 1996, the status and the impairing pollutants have not been changed.[4] The water quality limitations cited for the Upper Patuxent River watershed include:

- ***Nutrients****: This particular impairment, referred to as "nutrient star"reflects inclusion of the Upper Patuxent River watershed in the Chesapeake Bay Tributary Strategies. "Nutrient *" listings first appeared on the 1996 303(d) list and were modeled loadings based upon land-use trends. Waters with this designation may not have supporting water quality data. Nutrient sources resulting in this impairment include nonpoint and natural sources. Localized nutrients impairments may not exist.
- ***Suspended Sediment***: In the 1996 303(d) list, the Upper Patuxent River watershed is also listed for suspended sediment from nonpoint and natural sources.

Nutrients enter waterways from all types of land and from the atmosphere. The nutrients of primary concern are nitrogen and phosphorus. In general, an acre of forest land contributes smaller amounts of nutrients than a given area of other land uses. Residential land can be an important contributor of nutrients depending on fertilizer use, areal extent of lawn and the status of septic systems. Typically, farmers carefully control nutrient applications so the amount of nutrients entering waterways from crop land varies greatly depending on management techniques employed at a particular farm. The atmosphere can contribute various forms of nitrogen arising from the burning of fossil fuels in power plants and from automobile exhaust. Information on the variety and efficiency of best management practices (BMPs) commonly used to control nutrient loading to waterways can be found in Maryland's Tributary Strategies Technical Reference.[6]

Suspended sediment arises from stream bed and bank erosion and from land that is poorly vegetated or disturbed. Construction sites, crop land and bare ground are common contributors. The amount of sediment contributed varies greatly site to site depending upon management controls that are used. Without further assessment, no one particular source of suspended sediment can be identified within the Upper Patuxent Watershed. Information collected from the Stream Corridor Assessment will allow site specific identification of probable stream bed and bank suspended sediment sources.

The 303(d) list also reflects the priority rankings established by the Maryland Department of the Environment for those waterbodies listed as water quality limited. Priority ranking takes into account the severity of the pollution and the uses made of such water. This approach results in the establishment of a high, medium or low priority designation. The Upper Patuxent River watershed has been designated as a Low priority which means that the degree of impairment is fairly low and has less of an impact on designated uses than a waterbody prioritized as high. These priorities, in addition to other considerations, help the State set the schedule for work needed to conduct water quality assessments and Total Maximum Daily Load (TMDL) development.

Total Maximum Daily Loads

As of the recently drafted 2002 303(d) list, the Upper Patuxent River remains listed as impaired. The Maryland Department of the Environment (MDE) has responsibility under the Clean Water Act to take action on the waterbodies listed on the 303(d) list. An action can consist either of a TMDL (total maximum daily load) submitted to the US EPA or a submittal of a water quality analysis indicating the waterbody meets standards. A TMDL calculates the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. This maximum allowable loading must consider point and nonpoint sources while allowing for future growth and a margin of safety. As of 7/02/2002, a date has not been set to begin work on the Upper Patuxent River watershed TMDL calculation. More information on Maryland's TMDL program and current and future schedules for 303(d) listed waterbodies can be accessed through the MDE Internet site at http://www.mde.state.md.us/tmdl/index.html.

Comparative Water Quality Status and Trends - Chesapeake Bay Program

Water quality status and trends for the Upper Patuxent River watershed were characterized by the parameters that are listed below for two CORE (a long term monitoring program initiated in 1974) water quality monitoring stations located within the watershed (See Map 4: CORE Water Quality Monitoring Stations and Permitted Discharges). This assessment is part of a broader, tributary basin analysis designed to assist the Patuxent River Commission in its development of Tributary Strategies to reduce nitrogen and phosphorus loading to the Chesapeake Bay. Status and trend information is calculated from data collected as part of the DNR's Chesapeake Bay Water and Habitat Quality Monitoring Program. Water quality samples are collected once or twice a month. Status is a measure of current condition (most recent three years) at a station compared either to scientifically-based benchmark values or to a benchmark data set. Based on this comparison, the station is given a ranking of "GOOD," "FAIR," or "POOR." Trends are a measure of how the system has been changing over time, either improving or worsening. The magnitude of the trend is expressed as the percent change since the beginning of the study period. Trends are measured from 1985 to the most recent year of data, for most stations. More details on the methodology and information for other monitoring stations within the Patuxent River Tributary Basin can be accessed through the internet at http://www.dnr.state.md.us/bay/tribstrat/patuxent/pr_status_trends.html.

	Upstream Site Laurel (Below Rocky Gorge Dam) PXT0809		**Downstream Site US50 Bridge PXT0603 (TF1.0)**	
Parameter	**Status 1997 -99 data**	**Trend 1985 through 1999**	**Status 1997 -99 data**	**Trend 1985 through 1999**
Total Nitrogen	Good	No Trend	Fair	Improving (43%)
Total Phosphorus	Good	No Trend	Poor	Improving (41 %)
Total Suspended Solids	Fair	No Trend	Fair	Improving (21 %)

Both total nitrogen and phosphorus concentrations increase from the Rocky Gorge Dam to the midpoint of the watershed at the US50 monitoring station as a result of point and non-point source nutrient pollution from the northern portion of the Upper Patuxent River watershed Although mainstem water quality is decreased downstream, overall trends show that water quality, in relation to nitrogen, phosphorus and sediment, are improving at the US50 site.

More recent data (01/2000 - 02/2002) collected at the two CORE monitoring stations listed above continue to show trends of increasing nutrient and sediment pollution between Rocky Gorge and the US50 Bridge (table below). On average, at the US50 bridge site, Nitrite-Nitrate loads increase 1.6 times and Total Phosphorus loads increase 4 times over those levels observed upstream at the Rocky Gorge Dam station. Likewise, a 5 fold increase in Total Suspended Sediments is apparent between Rocky Gorge and the US50 bridge. It should be recognized that the upstream Rocky Gorge and Brighton Dams will reduce downstream export of sediment by trapping sediment within the reservoir basin. The sediment loads measured at the Route 50 bridge reflect the sediments picked up from within the Upper Patuxent and those which entered the watershed through erosional processes occurring in the Little Patuxent and Middle Patuxent River watersheds (which enter the Upper Patuxent upstream of the Route 50 bridge).

01/2000 - 02/2002	**Upstream Site Laurel (Below Rocky Gorge Dam) PXT0809**		**Downstream Site US50 Bridge TF1.0**	
Parameter	**Average** (S.E.)	**Min/Max**	**Average** (S.E.)	**Min/Max**
Nitrite-Nitrate* (mg/l)	0.89 (0.34)	0.33/1.45	1.43 (0.26)	0.93/2.05
Total Phosphorus (mg/l)	0.026 (0.008)	0.012/0.040	0.104 (0.063)	0.034/0.400
Total Suspended Solids (mg/l)	5 (3)	< 1/10	25 (46)	< 1/ 223

* Nitrite-Nitrate are common forms of inorganic nitrogen that are readily available for plant uptake. This parameter was used for comparison due to the absence of reported Total Nitrogen data for PXT0809 station
(S.E.) = Standard Error

Fish Tissue Monitoring Data

Metals in fish tissue were also monitored at the two CORE sites. Fish tissue from a variety of species collected between the years 1985 and 1997 were tested for silver, arsenic, cadmium, chromium, copper, mercury, nickel, lead and zinc. None of the samples in this watershed, nor in the entire Patuxent River Basin, exceeded the screening level for these metal pollutants.

Sources of Pollution

1. Point Sources

Discharges from discrete conveyances like pipes are called "point sources." Point sources may contribute pollution to surface water or to groundwater. For example, wastewater treatment plant discharges may contribute nutrients or microbes that consume oxygen (measured as Biological Oxygen Demand (BOD) and reduce oxygen available for aquatic life. Industrial point sources may contribute various forms of pollution. Some understanding of point source discharges in a watershed targeted for restoration is useful in helping to prioritize potential restoration projects.

According to the Maryland Department of the Environment (MDE) permit database as summarized in the following table, there are 22 permitted surface water discharges in the Upper Patuxent River Watershed. Many of these discharges are for stormwater associated with industrial activities and for both small-scale and major wastewater treatment plant discharges. Industrial stormwater discharges that are permitted can be considered point sources of pollution because of end-of-pipe conveyance and the possibility that industrial stormwater may transmit some regulated pollutants. The table below provides more detail on these point-source discharges and is accompanied by site location provided in Map 4: CORE Water Quality Monitoring Stations and Permitted Discharges. Characteristics of these permitted discharges (volume, temperature, pollutants, etc.) are tracked by MDE through the permit system. This information is accessible to the public and can be obtained from MDE through a written request. Refer to Appendix 1 for more detail on the types of activities regulated by the following permit categories.

POINT SOURCES: NPDES PERMITS and GROUNDWATER DISCHARGE PERMITS Upper Patuxent River Watershed			
Map #	**Facility Name**	**MDE Permit Category (NPDES Permit/ Type)**	**Additional Information**
1	Brandywine Enterprises, Inc. - Davidsonville	General Industrial (MDG493115/ WMA5)	Sand and Gravel Mine
2	Chaney Enterprises - Crofton Concrete Plant	General Industrial (WMA5)	Concrete plant
3	Federal Express - Crofton	Industrial Stormwater (WMA5SW)	Stormwater discharge from vehicle maintenance facility
4	Maryland City Water Reclamation Facility	Major Wastewater Treatment (MD0062596/ WMA2M)	**1990 BNR Upgrade to Activated Sludge**
5	Maryland City Water Reclamation Facility	Industrial Stormwater (WMA5SW)	Stormwater discharge from Sewage Treatment Plant
6	U.S.A.F. Transmitters Station	Wastewater Treatment (MD0025631/ WMA2)	Small-scale wastewater treatment facility
7	B & B Auto Salvage, LTD.	Industrial Stormwater (WMA5SW)	
8	Bowie Used Auto Parts	Industrial Stormwater (WMA5SW)	
9	Carroll Independent Fuel Company - Laurel	General Terminal (Oil) (MDG343976/WAS6T)	Stormwater or testwater from Oil Terminal
10	City of Bowie WWTP	Major Wastewater Treatment (MD0021628/ WMA2M)	**1991 BNR Upgrade to Oxidation Ditch**
11	Laurel Fuel Oil and Heating Co., Inc.	General Terminal (Oil) (MDG344261/WAS6T)	Stormwater or testwater from Oil Terminal
12	Mitchellville XTRA Mart	Groundwater (Oil) (WAS6R)	Groundwater remediation permit due to oil contamination
13	National Wildlife Visitor’s Center	Wastewater Treatment (MD0065358/ WMA2)	Small-scale wastewater treatment facility
14	Parkway WWTP	Major Wastewater Treatment (MD0021725/ WMA2M	**1992 BNR Upgrade to Activated Sludge**

15	Parkway WWTP	Industrial Stormwater (WMA5SW)	Stormwater discharge from Sewage Treatment Plant
16	Patuxent Wildlife Research Center	Wastewater Treatment (MD0025623/ WMA2)	Smale-scale wastewater treatment facility
17	Percontee, Inc.	Industrial Stormwater (WMA5SW)	
18	Roadway Express, Inc. - Laurel	Industrial Stormwater (WMA5SW)	Industrial stormwater discharge from truck terminal
19	SHA - Laurel Shop	Industrial Stormwater (WMA5SW)	Stormwater discharge from highway maintenance shop
20	The Bechdon Company, Inc.	Industrial Stormwater (WMA5SW)	
21	United Parcel Service - Burtonsville	Industrial Stormwater (WMA5SW)	Stormwater discharge from vehicle maintenance facility
22	United Parcel Service - Remote Shop	Industrial Stormwater (WMA5SW)	Stormwater discharge from vehicle maintenance facility

Of the point source discharges listed above, six (6) facilities are permitted for wastewater treatment plant discharges. Discharges of this type have been tracked by the Chesapeake Bay Program since 1985 in order to quantify nitrogen and phosphorus loading to the Bay and identify opportunities for significant point source reductions. Three of the facilities are major wastewater treatment plants and are considered to be significant point sources of nutrient pollution. In the early 1990s, these facilities upgraded to Biological Nutrient Removal (BNR) technologies which resulted in significant reductions in nutrient discharges to adjacent surface waters. The following table presents information on nitrogen and phosphorus discharges from these major facilities and three other minor wastewater treatment plants. The data are presented for discharges (expressed as loading rates and concentrations) observed in 1985 (or whenever the facility first became active) and discharges observed in 2000 (most recent, available data). Loading rates reflect how much nutrient is delivered to receiving waters on an annual basis while concentration reflects the "strength" of the discharges. Particularly noticeable in the three major wastewater treatment plants are the significant decreases in both loads and concentrations of nitrogen and phosphorus. These decreases can be attributed to the treatment plant BNR upgrades. This information is derived from the Chesapeake Bay Program's Point Source database which can be reviewed on a watershed basis.[7]

Nitrogen and Phosphorus Discharges Major and Minor Wastewater Treatment Facilities							
Name	**Date**	**N Load (lbs/yr)**	**N Conc. (mg/l)**	**P Load (lbs/yr)**	**P Conc. (mg/l)**	**Flow (MGD) ***	**Status**
Parkway	1985	253,211	18.00	40,870	2.91	4.62	Active
	2000	63,213	3.47	5,304	00.20	5.96	
City of Bowie	1985	95,119	15.71	31,185	5.15	1.99	Active
	2000	44,442	7.65	992	00.10	1.90	
Maryland City - old	1985	35,421	18.62	9,558	5.02	0.60	Inactive
	1990	26,754	12.37	4,513	2.09	0.70	
Maryland City - new (replaced old facility)	1991	11,254	5.56	421	00.20	0.60	Active
	2000	20,306	6.65	1,479	00.40	1.00	
Patuxent Wildlife Research Center	1985	955	34.44	235	7.24	0.03	Active
	2000	136	2.35	174	3.00	0.02	
National Wildlife Visitors Center	1999	429	18.00	75	3.17	0.01	Active
	2000	68	18.00	7	2.09	0.001	
USAF Transmitters Station	1985	91	9.99	51	5.65	0.003	Active
	1995	37	18.00	6	3.00	0.004	
(MGD)* = Million Gallons per day							

2. Non-point Sources

Nonpoint sources are also significant contributors of pollutants, particularly nutrients and sediment. These diffuse sources include rain water that runs off roofs, streets and parking lots (sometimes via storm drains) into nearby surface waters, as well as run-off from farm fields and, to a much lesser extent, forests. Also included in nonpoint source pollution is deposition from the atmosphere and contributions from ground water, where septic systems are a factor.

The only readily available estimate of non-point source loads for the Upper Patuxent watershed are based on results from the EPA Chesapeake Bay Program's Watershed Model which address nutrient loading at the scale of larger watersheds. Applying this computer model to the Upper Patuxent watershed provided these estimates:

Non-point Source Nitrogen Loading = 7.43 pounds/acre/year (lb/ac-yr)
Non-point Source Phosphorus Loading = 0.43 pounds/acre/year (lb/ac-yr)

These estimates take into account data from water quality monitoring and loading rate estimates based on land use. Listed below are land use types characterized with various non-point source loading rates. These estimates are specific to the Patuxent River basin. Estimates are based on Year 2000 scenarios which take into account both the land use activities and the type and extent of BMPs for the control of non-point source pollution. Hot spots, or areas that deserve further attention if non-point source pollution control is desired, can be identified by comparing the approximate non-point source loading rates presented in the table below with the generalized map of land use land cover in the watershed (Chapter 2: Land Use). Refer to Maryland's Tributary Strategies Technical Reference on the effectiveness of BMPs for control of nonpoint source nutrient pollution.[6]

Nonpoint Source Pollution Load Rates By Land Use
Chesapeake Bay Watershed Model, in lb/ac-yr
Year 2000 Scenario

Land Use	Nitrogen	Phosphorus	Sediment
Urban	16.38	1.17	0.33
Crop land	15.32	0.78	1.67
Pasture	4.01	0.63	0.47
Forest	1.27	0.02	0.00

LAND USE

Landscape Indicators

Water quality, particularly in streams and rivers, is affected by the characteristics of the riparian zone and the land use throughout the watershed. In an effort to gauge the affects of land use on water quality, and to allow comparison between watersheds, DNR has developed a series of Landscape Indicators. These indicators can be used to portray landscape conditions on a watershed scale that tend to support good water quality or that tend to degrade water quality.

The *Maryland Clean Water Action Plan* published in 1998 listed landscape indicators for the Upper Patuxent River watershed.[2] The following table summarizes these indicators, with the exception of the population density indicator, which is based on 2000 Census data not available when the *Unified Assessment* was done. Most indicator rankings (pass / fail) are relative measures that compare the Upper Patuxent River watershed with the other 137 watersheds of similar size that together cover the entire State of Maryland.

Landscape Indicator	Finding	Status*	Bench Mark
Impervious Surface (%)	15.6	Fail	Of 138 watersheds in Maryland, this one is among the 34 watersheds (25%) with the most impervious surface.
Population Density (persons/land acre)	1.93	Fail	Of 138 watersheds in Maryland, this one is among the 34 watersheds (25%) with the highest population density
Historic Wetland Loss (acres)	10,106	Pass	Of 138 watersheds in Maryland, this one is among the 104 watersheds (75%) with fewer historic losses.
Unbuffered Streams (%)	29	Pass	Of 138 watersheds in Maryland, this one is among the 104 watersheds (75%) having the greatest extent of streams without forest buffers.
Soil Erodibility Index	0.3	Fail	Of 138 watersheds in Maryland, this one is among the 34 watersheds (25%) with the highest potential soil erodibility.

NOTES: See Interpreting Landscape Indicators for additional explanation for each indicator.
*Pass = Average watershed conditions measured by this indicator are better than the Statewide benchmark (unshaded).
*Fail = Average watershed conditions measured by this indicator are worse than the Statewide benchmark (shaded).

Interpreting Landscape Indicators

Impervious Surface. Reduction of impervious area can be a valuable component of a successful Watershed Restoration Action Strategy (WRAS). Roads, parking areas, roofs and other human constructions are collectively called impervious surface. Impervious surface blocks the natural seepage of rain into the ground. Unlike many natural surfaces, impervious surface typically concentrates stormwater runoff, accelerates flow rates and directs stormwater to the nearest stream. Side-effects of impervious surfaces become increasingly significant as the percentage of impervious area increases. Examples include reduction of groundwater infiltration, soil and stream bank erosion, sedimentation, destabilization or loss of aquatic habitat, and "flashy" stream flows (reduced flow between storms and excessive flows associated with storms.)

Population Density. While population density may be beyond the scope of a WRAS, directing growth is a potential WRAS component. Humans are usually very successful in competing for use of land and water. As human population increases, effects of human activity tend to degrade, displace or eliminate natural habitat. Watersheds with higher populations, assuming other factors are equal, tend to exhibit greater impacts on waterways and habitat. However, growth can be directed in ways to reduce negative impacts.

Historic Wetland Loss. The historic wetland loss estimate is based on the assumption that the hydric soils were all, at one time, wetlands. Targeted restoration of historic wetland areas can be an effective WRAS component. In most of Maryland's watersheds, extensive wetland areas have been converted to other uses by draining and filling. This conversion unavoidably reduces or eliminates the natural functions that wetlands provide. These functions include habitat and nursery areas for many aquatic organisms, flood attenuation, and uptake and redistribution of nutrients, etc. In general, watersheds exhibiting greater wetland loss tend to also exhibit greater loss of the beneficial functions that wetlands provide. Strategic replacement of wetlands can significantly improve natural function in local watershed areas.

Unbuffered Streams. Corridors 100 feet wide (50 feet either side) along streams were combined with forest cover to develop this indicator. In most of Maryland, trees are key to healthy natural streams. They provide numerous essential habitat functions: shade to keep water temperatures down in warm months, leaf litter "food" for aquatic organisms, roots to stabilize stream banks, vegetative cover for wildlife, etc. In general, reduction or loss of riparian trees / stream buffers degrades stream habitat while replacement of trees / natural buffers enhances stream habitat. (For this indicator, intermittent streams were not considered.)

Soil Erodibility.

Sedimentation from eroding soils contributes to the lack of water clarity that plays a major role in the decline of Bay grasses. Other pollutants, including the nutrient phosphorus, may be bound up in the sediments and thus conveyed to surface waters, also. A finding of 0.30 means that the Upper Patuxent River watershed has "moderate" soil erodibility. This index considers the potential erodibility of soil as a result of soil type, slope steepness and the extent of crop land within 1000 feet of waterways. Watersheds with more highly erodible soils are naturally more susceptible to surface erosion, sedimentation, streambank erosion and other problems related to soil movement. These negative effects of soil erodibility on water quality can be minimized through careful management. A WRAS can reasonably promote a reduction in disturbance of erodible soils and/or effective soil conservation practices like planting stream buffers.NOTE: (Soil erodibility is a natural condition.). The soil erodibility indicator does not account for land management practices. The naturally erodible soils of the Upper Patuxent River watershed can be addressed by techniques called Best Management Practices (BMPs) to prevent soil loss that are typically in use on local farms. BMPs like no-till, reduced till, cover crops, field strips, and others significantly reduce erosion and sediment movement. More information on BMP options and efficiencies for sediment controls on farms can be accessed through the Maryland Department of Agriculture website.[8]

Land Use

The following table summarizes land use for the Upper Patuxent River Watershed study area using the Maryland Department of Planning 2000 land use data set. Land use is dominated by forested lands (44.7 %), developed lands (32.4 %), followed by a smaller representation of agricultural lands (18.7 %). Viewing these land uses as potential nonpoint sources of nutrients, agricultural lands are likely to dominate loading to local waterways in the southern portion of the watershed while urban land use will dominate the nonpoint sources of nutrient loads in the northern portion of the watershed. Most of the agricultural land is located within Anne Arundel county and is classified as cropland, which generally contributes higher nutrient loads compared to pasture or orchard land. The developed residential land which dominates the land area in Prince George's portion of the watershed is primarily medium and high density. Of the 44 % forest cover in the watershed, nearly equal parts are distributed within each county. A large block of forest occurs within the middle to upper portion of the watershed. These forest lands are part of the Federally owned Patuxent Wildlife Refuge. Other forested areas are aligned with the main stem of the Patuxent River and some of its tributaries in the southern portion of the watershed. Map 5: Generalized Land Use Land Cover shows the distribution of lands in the watershed. In reviewing this information, an error in land use classification was noticed in the Patuxent Research Refuge (see Map 5). The pocket of urban land identified in the refuge area should be reclassified to agriculture and other.

Land Use Upper Patuxent River Watershed Study Area				
Category	**Description**	**Prince George's Acres**	**Anne Arundel Acres**	**%**
Agriculture	Field, Pasture, Ag buildings	2,699	7,431	**18.7**
Forest	All woodlands and brush	12,970	11,270	**44.7**
Urban	All developed areas	14,636	2,947	**32.4**
Open Urban Land	Recreational urban lands (golf courses, parks), cemeteries and entrapped undeveloped land	1327	33	**2.5**
Other	Extractive and Bare Ground	376	531	**1.7**
Watershed Total (excluding open water)		**32,008**	**22,212**	

Sand and Gravel Mining

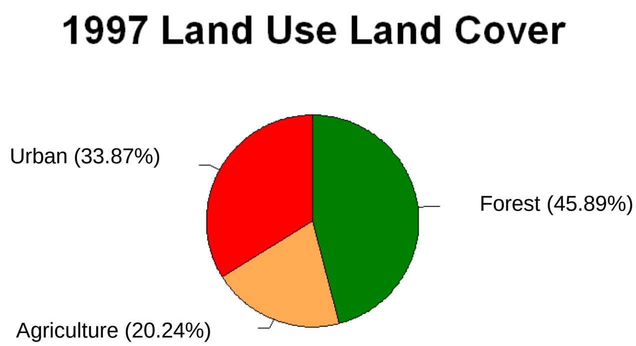
Map 5: Generalized Land Use Land Cover also shows the locations for permitted sand and gravel mining operations in Anne Arundel and Prince George's county. The permitted sites identified in Map 5 may be active or closed mining operations. Before 1977, sand and gravel mining operations did not require a permit and are not reflected in this map. Most of the sites in Anne Arundel county are located in the floodplain region which is underlain with extensive sand and gravel floodplain deposits. Several mining operations occur within the Bear Branch watershed that drains to the Laurel Lakes. Recent watershed and hydrologic studies (see **Related Projects** section in this document) showed that these operations are significant sources of sediment, especially of clay-sized particles that may be causing the Laurel Lakes to be consistently cloudy.

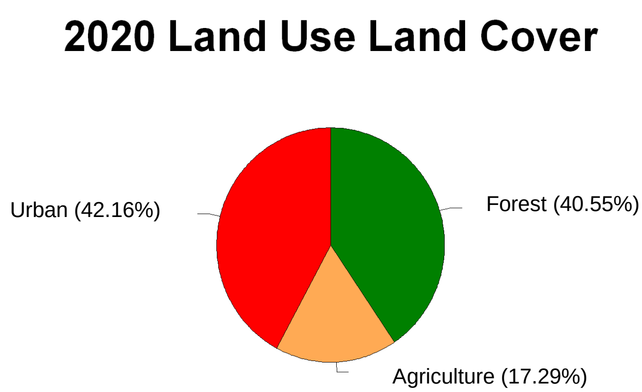
The Maryland Department of the Environment's Surface Mining Division has provided assistance in the identification of abandoned sand and gravel mining operations. These abandoned sites can be reclaimed and represent opportunities for wetland restoration projects or other rehabilitated uses.

2020 Land Use and Land Cover Projection

The Maryland Department of Planning's (MDP) projections for the year 2020 are presented using aggregations for urban, agricultural and forested land use land cover categories. The analysis was conducted on a watershed basis using the 1997 land use/land cover data as the baseline. The following charts demonstrate the shift in land use/land cover projected from 1997 to 2020 between the three generalized categories.

For the Upper Patuxent River Watershed, urban lands are projected to increase from about 34 % to about 42 % of the watershed. This projected shift to urbanized land use and land cover is at the expense of both agricultural and forested land use loss.





Zoning

The Annotated Code of Maryland, Article 25A, gives all counties the authority to plan and zone property. Zoning regulates how individual property can be used in terms of the bulk, density and type of land activities. The zoning code defines zoning classifications and permitted uses, and maps assign those zoning classifications to individual properties. Zoning is one of the more important tools a county has to determine where and what kind of growth will occur. In addition, zoning is used to designate where growth needs to be limited in order to preserve natural resource features or specific land uses, such as agriculture. Zoning districts and their requirements can differ widely among counties. The table below is an aggregation of the zoning codes from Anne Arundel and Prince George's county into fairly similar categories based on density thresholds and rural resource protection. Map 6: Generalized Zoning Codes presents generalized zoning classes that were created by merging similar zoning codes between Prince George's and Anne Arundel counties.

In the Upper Patuxent River watershed, Open Space and Residential Agricultural zoning limits development and strives towards preservation of agricultural uses. A significant portion of the southern end of the watershed and along the main stem of the Patuxent River have these zoning designations. Within Anne Arundel county, Residential Agricultural zoning will be more likely to preserve agricultural land uses than in Prince Georges county due to the lower density restrictions. The less restrictive Residential Agricultural zoning criteria in Prince George's county may produce development too dense to adequately protect rural resources. The northern portion of the watershed is primarily zoned for residential development and some commercial/industrial development. Most of the residential zoning districts, which are zoned for low density development, will produce residential communities with a minimum lots size of one (1) acre.

Generalized Zoning Classes Upper Patuxent Watershed			
General Zoning Class	**Description**	**Prince George's Acres**	**Anne Arundel Acres**
Commercial/Industrial	All zoning that addresses commercial or industrial use	1,779	620
Open Space	Promotes agricultural and natural resource land use and provides areas for low-intensity residential development	6,926	6,301
AA Residential Agricultural	Encourages the retention of agriculture as a primary land use and provides for large-lot residential uses (1 dwelling unit/20 acres)		14,296
PG Residential Agricultural	Encourages the retention of agriculture as a primary land use and provides for large-lot residential uses (1 dwelling unit/2 acres)	2,790	
Residential Low Density	Single-family/duplex dwelling units on lots at least ½ acre (~ 2 dwelling units/acre)	10,259	172
Residential Medium Density	Single-family/duplex and townhouse dwelling units on lots less than ½ acre but at least 1/8 acre (2 - 8 dwelling units/acre)	2,837	702
Residential High Density	Townhouses, garden apartments and high-rise apartments/condominiums (> 8 dwelling units/acre)	884	47
OUT	No Zoning		

Impervious Surface

Urbanization and the increase in impervious surfaces that accompanies development can significantly impact stream health. Increases in the extent of upstream impervious surface are strongly associated with a decrease in stream quality. As impervious surfaces increase, less water infiltrates the soil and more water enters stream systems through runoff or stormwater discharge. This introduces more non-point source pollution, higher temperatures, reduced baseflow and more erosive flood flow; all of which contributes to stream quality degradation. Through extensive biological monitoring, conducted by the Maryland Biological Stream Survey, the following thresholds for upstream impervious land cover impacts on stream quality were developed:[9]

Upstream Impervious Cover Thresholds	Impacts on Stream Quality
Above 25%	Only hardy, pollution-tolerant reptiles and amphibians can thrive, while more pollution-sensitive species are eliminated
Above 15%	Stream health is never rated good, based on a combined fish and benthic macroinvertebrate Index of Biotic Integrity
Above 2%	Negative impacts to stream health begin. For example, in cold-water habitats, pollution-sensitive brook trout are never found

Map 7: Percent Impervious Surface, reflects data developed by the University of Maryland's Regional Earth Sciences Application Center (RESAC)[10], and displays the amount of impervious surface cover expressed as a percentage throughout the Upper Patuxent River watershed. Overall, the average percent impervious cover for this watershed is 8.5 %. This value differs from the Percent Impervious Surface Cover landscape indicator (15.6%) that was developed for the *Unified Assessment* as a result of different assessment methods. The data presented in Map 7 was recently made available to DNR by the RESAC and is based on direct measurements of impervious surface through remote sensing imagery. This is a significant improvement over the methods used for the Unified Assessment which relied on approximations of impervious surface cover relative to land use class. As expected impervious surface cover is associated with developed portions of the watershed, principally Laurel, Bowie and portions of Maryland City and Crofton. Stream segments downstream from these highly impervious areas will likely exhibit more degraded conditions relative to those draining forested regions.

Another common way of evaluating this information is as a watershed indicator. The average percent impervious surface cover for each watershed management unit is presented on Map 8: Average Percent Impervious Surface by Watershed Management Unit. Watershed indicators are color coded according to the cover thresholds indicated in the table above. Although several of the Anne Arundel county watershed management units in the southern portion of the watershed have low impervious surface cover indicators below the 2 % threshold, these are dominated by agricultural land use. Stream quality will likely be negatively impacted by water quality issues associated with agricultural non-point pollution sources. In the northern Anne Arundel county portion of the watershed, watershed management units with an average impervious cover below the 2 % threshold are also associated with forested land cover and are likely to support higher quality stream segments. Watershed management units in the upper northern portion of Prince George's county that exhibit average percent impervious surface cover above 25% are associated with the industrial, commercial and residential development land uses associated with the city of Laurel and stream health is likely to reflect degraded conditions. In addition, the larger watershed management units in Prince George's county mask out localized hot spots of high impervious surface cover, particularly in the Bowie area. The streams that drain the Bowie area are impacted by a much higher degree of percent impervious cover than the watershed indicators would suggest. In general, this indicator can be helpful to highlight issue areas, but it should also be used in conjunction with other types of information, such as land use cover and on-site assessments, and at scales that are meaningful to the stream resources in question.

Sewer and Water Service

Land areas with existing sewer service, and areas slated for sewer service are displayed in Map 9: Water Management. The areas planned for sewer service in the future represent phase-ins for planned growth over time. The regions showing “No Plans for Service” generally cooccur with protected land holdings and with areas designated for Rural Legacy. The development that occurs in these areas will rely on septic systems for sewer services.

Smart Growth and Protected Lands

Map 10: Priority Funding Areas, Rural Legacy and Protected Lands provides a vision of where future development is desired, where it should be minimized and where it is restricted. Within Maryland's Smart Growth program, there are two targeting programs that should be considered as potential watershed restoration projects are considered. In Rural Legacy Areas, protection of rural land from future development through purchase of easements (or in fee simple) is promoted. One of the goals of this program is to make connections between areas that are already protected to form contiguous areas of undeveloped land. In general, the large blocks of agricultural land and open urban land fall within the Rural Legacy Areas and are eligible for additional protection using Rural Legacy funding. Map 10 shows several agricultural easements in place within the Rural Legacy area, indicating some progress has been made towards this overall objective. Priority Funding Areas (PFA) are regions that have been targeted for future development and are centered on the existing urbanized areas of Laurel, Maryland City and Bowie. The overall objective is to minimize sprawl development and concentrate growth in designated areas. PFAs are eligible for State funds that can be used to build on existing facilities as an incentive to concentrate growth.

As used in the context of watershed restoration, "protected land" includes any land with some form of long term limitation on conversion to urban / developed land use. This protection may be in various forms: public ownership for natural resource or recreational intent, private ownership where a third party acquired the development rights or otherwise acquired the right to limit use through the purchase of an easement, etc. The extent of "protection" varies greatly from one circumstance to the next. Therefore, for some protected land, it may be necessary to explore the details of land protection parcel by parcel through the local land records office to determine the true extent of protection. For purposes of watershed restoration, a knowledge of existing protected lands can provide a starting point in prioritizing potential restoration activities. In some cases, protected lands may provide opportunities for restoration projects because owners of these lands may value natural resource protection or enhancement goals.

There are 15,469 acres of protected land within the Upper Patuxent River watershed which represents about 28% of the entire watershed. Large blocks of Federally owned property occur in the mid to upper portion of the watershed and span its width. These properties includes the Patuxent Research Refuge (PRR), which allows public access, Fort Meade and the National Agricultural Research Center. All forested land within the PRR is protected. Three large tracts on the PRR are also registered with the American Forestry Association as Research Natural Areas (RNAs). Other publicly owned properties include approximately 560 acres of Wildlife and Natural Resource Management Areas owned by DNR and a variety of county owned property consisting of parks, trails and some institutional facilities. Notably, an extensive network of county owned properties line the Patuxent River, forming the Patuxent River Park system.

Private property protected through easements represent a subset of protected lands. Within the WRAS study area, approximately 1,848 acres of land are protected through agricultural easements, all of which fall within Anne Arundel County. Prior to 1990, the primary means of preserving agricultural lands, in Anne Arundel County, was through the State Agricultural Preservation Program. In response to concerns for preserving smaller acreages of agricultural lands, Anne Arundel County established its own Agricultural Land Preservation and Acquisition Program. This is a voluntary program in which a landowner may enlist into the program forming an Agricultural District, receive a property tax credit, and may later offer to sell a development rights easement across the established District to the County. The easement runs with the land in perpetuity. Since 1992, the County program has been the major funding source for easement purchases.

Green Infrastructure

DNR has mapped a network of ecologically important lands, comprised of hubs and linking corridors, using several of the GIS data layers used to develop other indicators. Hubs contain one or more of the following:

- ♦ areas containing sensitive plant or animal species;
- ♦ large blocks of contiguous interior forest (at least 250 contiguous acres, plous the 300 foot transition zone);
- ♦ wetland complexes with at least 250 acres of unmodified wetlands;
- ♦ streams or rivers with aquatic species of concern, rare coldwater or blackwater ecosystems, or important to anadromous fish, and their associated riparian forest and wetlands; and
- ♦ conservation areas already protected by public and private organizations.

This "Green Infrastructure" provides the bulk of the state's natural support system. Ecosystem services, such as cleaning the air, filtering and cooling water, storing and cycling nutrients, conserving and generating soils, pollinating crops and other plants, regulating climate, protecting areas against storm and flood damage, and maintaining hydrologic function.

An example of how important and beneficial these services are is apparent in the monitoring studies on stream health conducted by Patuxent Research Refuge (PRR) biologists (Holiday Obrecht, PRR, personal communication). The PPR's pristine forested wetlands along 4.5 miles of the Patuxent River and 3.5 miles of the Little Patuxent River provide a tremendous water quality benefit for the downstream watershed. These benefits have been well documented by macroinvertebrate studies showing pollution tolerant species at the headwater end of PRR's watershed and pollution intolerant species where both river exit PRR.

Protection of Green Infrastructure lands may be addressed through various existing programs including Rural Legacy, Program Open Space, conservation easements and others. The 2001 Maryland General Assembly approved $35 million for the Green Print program which is targeted primarily to protecting Green Infrastructure areas. This funding category is administered by Program Open Space.

Map 11: Green Infrastructure and other Forested Areas shows several significant local characteristics of Green Infrastructure and also highlights Green Infrastructure "gaps". These are areas within the hub and corridor system that are either developed, used for agricultural or urban lawn or exist as barren or transitional features (quarries, shrubland, etc). Restoration opportunities within the Green Infrastructure can be targeted to "fill-in" these gaps, particularly those on agricultural, urban lawn or barren/transitional areas. Other opportunities to support the regional Green Infrastructure could focus on expanding the extent of hub and corridor features. Green Infrastructure mapping has been extended beyond the watershed borders in Map 11 to illustrate this relationship between localized Green Infrastructure elements and the regional Green Infrastructure network.

- ♦ A large Green Infrastructure Hub exists within the upper middle portion of the WRAS watershed. Federal lands occupy most of the hub within the watershed and offer protection from future development. The Patuxent Research Refuge occurs within this hub.
- ♦ A connecting corridor runs down the Patuxent River, south of the hub. Many of these lands are protected, as well, through the two County park system.

Green Infrastructure Upper Patuxent River Watershed			
Category	**Description**	**Prince George's Acres**	**Anne Arundel Acres**
Hub	Large blocks of natural areas, primarily forests and wetlands.	7,504	7,652
Corridors	Natural area connections between hubs, primarily along riparian corridors.	893	383
Developed Gap	Developed region within the Green Infrastructure	339	147
Agricultural or Lawn Gap	Possible restoration opportunity within the Green Infrastructure	842	1040
Barren Gap	Possible restoration opportunity within the Green Infrastructure	80	518

Forested Natural Resource Areas at the Watershed Scale

The Green Infrastructure scenario described here, due to its Statewide or regional focus, may not identify forested natural resource areas that are locally significant. Patches of forest land occur within the watershed that do not meet the size requirement for the Green Infrastructure but are locally important for biodiversity, soil, air and water quality, quality of life and recreational uses. It is helpful to employ GIS information at the watershed scale to help identify natural areas of potential local significance. Map 11: Green Infrastructure and other Forested Areas identifies other areas that may have local natural resource importance that fall outside of the statewide Green Infrastructure. This GIS map (and similar scenarios) can be used to assist in prioritizing areas for further assessment and to help clarify local interests and needs for locally important natural resource areas.

- Several stream headwater areas have local watersheds dominated by forests. These areas may have relatively high quality stream habitat if other stresses, such as significant concentrated stormwater flows or intensive human activities are not present. Forested headwater streams represent areas worthy of a high degree of resource protection from development impacts. DNR's Surf Your Watershed profile for this watershed shows that 12% of headwater streams are in core forests (http://mddnr.chesapeakebay.net/wsprofiles/surf/prof/prof.html). Core forests are defined as forests greater than 300 feet from differing land cover or primary, secondary or county roads (roads large enough to break the canopy cover).
- Other stream segments, beyond those in headwater regions, have forested buffer zones and provide important ecological and environmental functions for improving stream habitat. Forested buffers adjacent to crop land are important for filtering the nutrients and sediments that would otherwise be deposited into streams.
- Outside of the Green Infrastructure, fragmented forest habitat characterizes the remaining forest land. Fragmentation tends to reduce habitat value for some wildlife, to limit species diversity, to reduce resilience to stresses like disease, etc. The negative effects of forest fragmentation could be reduced by targeting reforestation efforts to connect isolated forest patches at a localized scale.

Anne Arundel County Greenways Master Plan

The Anne Arundel County Greenways Master Plan will help the county decide where to focus its land preservation and protection efforts including land acquisitions. In the past, without a plan, these efforts have been somewhat random and have not led towards an integrated network of open spaces. The Greenways Master Plan has been adopted by the Anne Arundel County council and will be used to guide and prioritize the County's efforts.

Communities define greenways in different ways but, basically, greenways are corridors of open space that are protected for their ecological and/or recreation benefits. Some communities emphasize the ecological aspects of greenways, others focus on the recreational aspects, and some take a mixed approach.. The proposed greenways network (Map 12: Anne Arundel County Greenways Master Plan) is ecological, based on the needs of different animal species, but many greenways will have recreational use.

1. Relationship to the State's Green Infrastructure

There is considerable overlap between the county's Greenways Master Plan and the State's Green Infrastructure (compare with State Green Infrastructure inset on Map 12). The methods used to define the Greenways Master Plan are very similar to those used to develop State's Green Infrastructure. 'Hubs' at least 250 acres in size, and corridors at least 200 feet wide connecting the hubs were identified. The recommendations of the County's Small Area Plans and Maryland's Greenprint Program (Green Infrastructure) were also taken into account.

2. Progress towards protecting Anne Arundel County Greenways within the Upper Patuxent River Watershed

Map 12: Anne Arundel County Greenways Master Plan also shows the Greenways that are currently protected by public ownership or easement. Significant strides towards meeting the county's land preservation and protection objectives have been met. To date, the county has protected 74% of the Greenways Master Plan within the Upper Patuxent River Watershed.

Anne Arundel County Greenways Master Plan Acres Upper Patuxent River Watershed	
Proposed Greenways	10,114 acres
Protected Greenways	7,527 acres (74 %)

Soils

Soil conditions, like soil type and moisture conditions, greatly affect how land may be used and the potential for vegetation and habitat on the land. Soil conditions are one determining factor for water quality in streams and rivers. Local soil conditions vary greatly from site to site as published information in the Soil Survey for Anne Arundel and Prince George's Counties shows. This complicated information can be effectively summarized using generalizations about groups of soils with similar properties.

Map 13: Hydric and Erodible Soils depicts soils that are considered highly erodible and exhibit hydric properties. This map is a compilation of two soil data sets. The Prince George's County soils are represented by the Maryland Department of Planning's Natural Soils Groups. Anne Arundel County is in the process of digitizing and updating their county soil survey maps. The information presented here, for Anne Arundel County, is currently in draft form, but will be certified in the near future by a State Soil Scientist from the Natural Resources Conservation Service. As described earlier, erodible soils are classified on both slope and physical properties related to texture. Soils with finer particle sizes, such as clay or silt dominated textures, tend to be loosened more readily. These properties are exacerbated on steeper slopes and with land uses, such as agriculture, that loosen soil and expose soils to the erosive forces of wind and rain. Hydric soils exhibit chemical and physical properties that are associated with long periods of wetness, and, therefore, are indicative of either historic or current day wetlands. Both slope and wetness are conditions that may limit agricultural or development potential. Most of the hydric soils within the Upper Patuxent River watershed are concentrated along the riparian zone and flood plain. According to the data, erodible soils are widely distributed throughout Anne Arundel county and are more weakly represented in Prince George's county. It is possible that the extent of erodible soils may be more prevalent in Prince George's county than the map suggests. Soils and topography are unlikely to be radically different from each other from one side of the watershed to the other. Since Anne Arundel county soil maps have been certified and mapped at finer scales, the soils of Prince George's county are likely to be similar.

Soil characteristics can also be used as a basis for identifying potential areas for restoration projects or habitat protection. Erodible soils can be targeted for reforestation or sediment control practices to reduce potentially high soil losses and sediment loading into adjacent streams. Hydric soils that do not support wetlands and are currently undeveloped can be targeted for wetland restoration projects. Once areas of interest are targeted and land owner interest is verified, additional detailed soil assessment is an essential step in identifying viable restoration project sites.

Wetlands

1. Wetland Categories

The Eastern Coastal Plain Province likely has the highest diversity of emergent estuarine and palustrine wetland communities relative to other Maryland physiographic regions because both tidal and nontidal freshwater marshes occur here. Wetlands are most abundant in the Coastal Plain due to the low topographic relief and high groundwater table characteristic of the region. Most of the wetlands in the Upper Patuxent River Watershed are palustrine wetlands of various types.[11]

<u>Palustrine Wetlands:</u> Palustrine wetlands are represented by fresh water marshes and swamps, including tidal and nontidal wetlands. Palustrine wetlands are categorized by predominant vegetation. The following types of palustrine wetlands occur within the Upper Patuxent River Watershed.

1. *Palustrine Forested* wetlands are the most abundant and widely distributed palustrine wetland type on the Coastal Plain. Woody vegetation 20 feet or taller dominants these wetlands. These wetlands are found on floodplains along the freshwater tidal and nontidal portions of rivers and streams, in upland depressions, and in broad flat areas between otherwise distinct watersheds. Tidal freshwater swamps occur along coastal rivers in areas subject to tidal influence.

2. *Palustrine Scrub-shrub* swamps and bogs are not abundant on the Coastal Plain but are represented in the Upper Patuxent River watershed. Woody plants less than 20 feet characterize these wetlands. Although bogs are rare within Anne Arundel and Prince George’s County, “magnolia bogs” have been identified. It is unknown whether any of these rare bogs occur within this watershed.

3. *Palustrine Emergent* wetlands on the Coastal Plain are often called marshes and are characterized by a wide range of herbaceous vegetation, such as sedges, grasses, reeds and forbs.

4. *Palustrine Farmed* wetlands once supported native wetland vegetation but were drained and cleared for agricultural use.

<u>Other Wetlands:</u> Within the Upper Patuxent River watershed, aquatic bed and shoreline wetlands can be found in small number and are associated with stream, pond and lake features. Aquatic bed wetlands often support a variety of plants, including floating and submerged species.

2. Tracking Wetlands

Oversight of activities affecting wetlands involves several regulatory jurisdictions. The Maryland Deptartment of the Environment (MDE) is the lead agency for the State and cooperates with DNR, the Army Corps of Engineers and other Federal and local agencies. As part of its responsibility, MDE tracks State permitting and the net gain or loss of wetlands over time. As the Wetlands Regulatory Status table shows, changes tracked in the State regulatory program have been minor in the Upper Patuxent River watershed.

Tracking Nontidal Wetland Change
Upper Patuxent River Watershed
Permits Authorized = 7
Letters of Authorization Issued = 87

Wetland Class	Description	Acres
Permanent Impacts	acres altered under permit from MDE	-2.30
Permittee Mitigation	acres restored by permit holder as required by permit	3.87
Programmatic Gains	acres restored by MDE using fee in lieu funds	0
Other Gains	acres restored when not required by permit	0.05
Net Gain/Loss		1.62

Note: Regulatory tracking for authorized nontidal wetland losses began in 1991. Comprehensive tracking of voluntary wetland gains began in 1998. Tidal wetland changes are not shown.

3. Wetland Distribution

Wetlands in the Upper Patuxent River watershed tend to occur along waterways as shown in Map 14: Wetlands. In comparing the wetlands map to Map 5: Generalized Land Use Land Cover, it can be seen that much of the forested land in the watershed is found in association with wetlands or adjacent to them.

A comparison of the two maps shows that many of the nontidal wetland areas are depicted as forest on the land use map. This difference is simply the result of two differing views of the landscape. For example, wooded nontidal wetlands can be viewed as “wetlands” from a habitat / regulatory perspective and they can be viewed as “forest” from a land use perspective.

In the Upper Patuxent River watershed, differing perspectives on counting wetlands are significant for watershed management. From a land use perspective, 274 acres of wetlands are identified by the Maryland Department of Planning. From a habitat / regulatory perspective, there are approximately 4,605 acres of wetlands in the watershed. The acreages for various wetland types in the Upper Patuxent River watershed show that palustrine forested wetlands are the most common and are found predominantly along the floodplain of the Patuxent River.

In the context of the Watershed Restoration Action Strategy (WRAS), wetlands serve valuable water quality and habitat functions that may not be provided by other land uses. Therefore, protection and enhancement of existing wetlands, and restoration of past wetland areas, can be a valuable element in the WRAS. Nontidal Wetlands of Special State Concern are the best example of Maryland’s nontidal wetland habitats and are designated for special protection under the State’s nontidal wetland regulations. These wetlands have exceptional ecological and educational value. For any proposed project that requires a wetland permit, these selected wetlands have additional regulatory requirements beyond the permitting requirements that apply to wetlands generally. For a listing of designated sites see COMAR 26.23.06.01 at www.dsd.state.md.us (Also see the Wetland Restoration section within this characterization.) In the Upper Patuxent River watershed, large tracts of Wetlands of Special State Concern occur within and south of the Patuxent Wildlife Refuge.

Wetlands found within the Upper Patuxent River Watershed	
Wetland Type	**Acres**
Palustrine Forested	4,123
Palustrine Emergent	217
Palustrine Scrub-Shrub	200
Palustrine Farmed	45
Other Aquatic Beds or Shoreline Wetlands	20
Total Wetland Acreage	4,605
Total WSSC Acreage	155
Data source: National Wetlands Inventory and MD Department of Natural Resources	

LIVING RESOURCES AND HABITAT

Overview

Living resources, including all the animals, plants and other organisms that call the land and waters of the Upper Patuxent River watershed home, are being affected by human activity. The information summarized here suggests that some of the significant stresses on living resources in the watershed are manipulation of habitat, excessive movement of sediment and excessive availability of nutrients.

The living resource information summarized here should be considered a partial representation because numerous areas of potential interest or concern could not be included due to lack of information, time, etc. For example, information on many forms of aquatic life, woodland communities, terrestrial habitats, etc. should be considered as watershed restoration decisions are being made. Therefore, it is recommended that stakeholders in the watershed identify important living resource issues or priorities so that additional effort can be focused where it is most needed. New information should be added or referenced as it becomes available.

Living Resource Indicators

Aquatic organisms are sensitive, in varying degrees, to changes in water quality and aquatic habitat. This association offers two perspectives that are important for watershed restoration. First, improvements for living resources offer potential goals, objectives and opportunities to gauge progress in watershed restoration. Second, the status of selected species can be used as to gauge local conditions for water quality, habitat, etc. This second perspective is the basis for using living resources as an "indicator."

The *Maryland Clean Water Action Plan* published in 1998 listed the following living resource indicators for the Upper Patuxent River Watershed.[2] Compared to other watersheds in Maryland, the Upper Patuxent River watershed exhibits poor conditions for submerged aquatic vegetation and for bottom-dwelling organisms in nontidal streams.

Living Resource Indicator	Finding	Status*	Bench Mark
Non-Tidal Benthic Index of Biotic Integrity	5.05	Fail	Scale of 1 (worst) to 10 (best) Score less than 6 yields a rank of "fail"
Non-Tidal Fish Index of Biotic Integrity	6.83	Pass	Scale of 1 (worst) to 10 (best) Score less than 6 yields a rank of "fail"
Non-Tidal Instream Habitat Index	4.21	Fail	Scale of 1 (worst) to 10 (best). Of 138 watersheds in Maryland, this one is among the 34 watersheds (25%) with the lowest Instream Habitat Index.

NOTES: See Interpreting Living Resource Indicators for additional explanation for each indicator.
* Pass = Average watershed conditions measured by this indicator are better than the Statewide benchmark (unshaded).
* Fail = Average watershed conditions measured by this indicator are worse than the Statewide benchmark (shaded).

Interpreting Living Resource Indicators

General. Several of these indices rely on index rankings generated from a limited number of sampling sites which were then generalized to represent entire watersheds. Considering this limitation on field data, the forthcoming biological survey will be useful.

Non-Tidal Benthic Index of Biotic Integrity. This index allows comparison of streams based on the populations of bottom-dwelling "bugs" (benthic macroinvertebrate organisms) found in the stream. For coastal plain streams, this index employs seven measurements of these populations which is translated into a rank for each sampling site. An index less than 6 indicates that benthic organisms are significantly stressed by local conditions.

Non-Tidal Fish Index of Biotic Integrity. An index less than 6 indicates that improvements would be beneficial to fish populations. This index allows comparison of selected streams (first through third order nontidal streams) based on fish community health. In each sampling site where fish are surveyed, the makeup of the overall fish population is measured in nine distinct ways such as the number of native species, number of benthic fish species, percent of individuals that are "tolerant" species, etc. These nine scores are then integrated to generate an index ranking for the survey site. An index of 8 or greater indicates conditions favorable for fish.

Non-Tidal In-Stream Habitat Index. This index allows comparison of streams based fish and benthic habitat as measured by in-stream and riparian conditions. For each stream site that was assessed, visual field observations are used to score the site for substrate type, habitat features, bank conditions, riparian vegetation width, remoteness, aesthetic value, etc. These scores are then integrated to generate a single rank for each stream site.

Current Biological Monitoring

Maryland Biological Stream Survey

The DNR program, Maryland Biological Stream Survey, assesses in-stream aquatic communities and stream habitat conditions in the State's non-tidal, freshwater, "wadeable" (1st-3rd order) streams. The work includes assessments for fish and benthic macroinvertebrate ("stream bugs") communities and for physical habitat quality. Five (5) sites in the Upper Patuxent River watershed were assessed in 1997 during Round One of the Survey (1995-1997) and are summarized in the 1997 MBSS Indicators Table. Map 15: Biological Monitoring Sites shows the site location and the text box, Why Look at Benthos in Streams?, provides additional information regarding the use of benthic macroinvertebrates as biological indicators.

Scores for biological communities for the sites surveyed ranged from Very Poor to Good for fish communities and from Very Poor to Fair for benthic communities. Physical Habitat Indices for the sites ranged from Very Poor to Fair. The fish species identified during this survey period for all sites are presented in the 1997 MBSS Fish Species Table. Most of these species are very common in Maryland and most are tolerant of anthropogenic stressors related to nutrient and sediment pollution. A few fish species collected at Sites 3, 4 and 5 have been rated as intolerant. These species also depend on rocky stream bottoms for egg-laying habitat and are sensitive to siltation. Nearly all of the species, with the exception of fish in the sunfish family (bluegill, green sunfish, pumpkinseed), are native to the Chesapeake Bay drainage basin.

Scores for Sites 1 and 2, located in the northern portion of the watershed, were notably lower than the other three sites. There were only two fish species found at Sites 1 and 2 compared to other sites. By taking a closer look at the physical habitat and land use characteristics related to these sites (appendix 1 at the end of this chapter), it can be noted that upstream land use was more urbanized and that both sites exhibited either a very narrow forested riparian buffer (Site 1: 14 feet) or did not possess a naturally vegetated buffer zone (Site 2). In fact, the channel in Site 2 has been significantly altered and hardened with concrete.

Water quality measurements conducted in concert with the biological and physical assessments do not highlight any particular problems in the monitored variables (Appendix 2). Oxygen levels were well above the state water quality standard of 5 mg/l and Nitrate levels were not above the threshold of 1 mg/L. Nitrate levels above 1 mg/l may affect aquatic life. In addition, both temperature and pH were within acceptable ranges for State water quality criteria.

The Maryland Biological Stream Survey is now engaged in Round Two (2000-2004) of the survey. The Round Two survey has been redesigned to focus on Maryland's 8-digit watersheds as its primary sampling unit (PSU). Each PSU will have 10 or more sampling sites. The next round of sampling for the Upper Patuxent Watershed is scheduled for 2004.

1997 MBSS Indicators[12] Upper Patuxent Watershed							
Site #	**Stream Location**	**Fish IBI**		**Benthos IBI**		**Physical Habitat Index**	
		Score	**Condition**	**Score**	**Condition**	**Score**	**Condition**
1	**Patuxent River**	1.89	Very poor	1.86	Very Poor	41.19	Poor
2	**Walker Branch**			1.86	Very Poor	2.56	Very Poor
3	**Horsepen Branch**	3.5	Fair	2.71	Poor	63.36	Fair
4	**Honey Branch**	4.0	Good	2.43	Poor	61.55	Fair
5	**Stockett's Run**	3.0	Fair	2.71	Poor	63.87	Fair
Fish Index of Biotic Integrity Benthic Index of Biotic Integrity Physical Habitat Index		Ranges from 1.0 (worst) to 5.0 (best) Ranges from 1.0 (worst) to 5.0 (best) Ranges from 0 (worst) to 100 (best)					

1997 MBSS Fish Species[12]								
Site					Fish Species	Tolerance	Trophic Status	Interesting Facts
1	2	3	4	5				
		X	X	X	American Eel	NR	GE	A catadromous fish; adults live in freshwater and migrate to Sargasso Sea to spawn.
		X	X	X	Least Brook Lamprey	NR	FF	Larval stage may last more than 10 years; adults die shortly after spawning.
X	X	X	X	X	Blacknose Dace	T	OM	Tolerant of a wide range of environmental conditions and pollutants; 2nd most abundant fish in the state.
X	X				Creek Chub	T	GE	As with other minnows, has no teeth around the jaw but is capable of taking large prey items.
		X	X		Fallfish	I	GE	Male builds large gravel nest to protect eggs.
		X	X	X	Rosyside Dace	I	IV	Minnow sensitive to heavy siltation.
			X	X	Swallowtail Shiner	I	IV	Uses both minnow and sunfish nests for spawning.
		X	X	X	Tessellated Darter	T	IV	Male often cares for nests containing eggs that it did not fertilize.
		X	X	X	White Sucker	T	OM	Can reach 17 years of age with lengths over 23 inches.
		X	X		Eastern Mudminnow	T	IV	Buries itself in the mud during the day.
			X	X	Green Sunfish	T	GE	Intolerant of low pH but tolerant of many other types of stressors.
			X		Bluegill	T	IV	Abundant as a result of its tolerance to a variety of conditions.
		X	X		Pumpkinseed	T	IV	Tolerant of darkly-stained acidic waters; a regular visitor to brackish waters.

Tolerance (to anthropogenic stresses): T = Tolerant, I = Intolerant, NR = Not Rated
Trophic Status: GE = Generalist, FF = Filter Feeder, OM = Omnivore, IV = Invertivore

Historic Biological Monitoring

1. The Bowie Project

A biological and water quality study was conducted from 1994-1995 by the Maryland Department of Natural Resources which replicated an earlier and similar study conducted in 1978. The purpose of the original 1978 study was to evaluate the causes of highly acidic water in Millstream Branch. The Bowie Project sampling sites are located on Map 15: Biological Monitoring Sites. The macroinvertebrate samples from all four stations indicate that the communities are severely impacted. The major impact appears to be heavy storm water flows with resulting habitat destruction and alteration. Many samples had few, if any, representatives of the more pollution intolerant species.

In comparison with the 1978 data, the macroinvertebrate community at Millstream Branch indicated a modest recovery that is likely due to stream corridor habitat recovery through the reestablishment of a forest buffer. However, macroinvertebrate communities at the Horsepen Branch and Newsstop Branch stations show a different trend. The health of the macroinvertebrate communities declined between 1978 and 1995. The decline was attributed to recent development in this watershed which has produced damaging storm flows, sedimentation and contamination from road and parking lot surfaces.

2. CORE station benthic macroinvertebrate monitoring [13]

From 1976 to 1992, benthic macroinbertebrate communities have been studied by DNR at the two CORE monitoring stations located in the Upper Patuxent River watershed (see Map 15: Biological Monitoring Sites) for use as biological indicators of water quality status and trends.

PXT0603 station (Rt 50): Over the study period, biotic index values improved, reflecting the shift from pollution tolerant organisms to more pollution sensitive organisms. Improvements were attributed to major improvements and upgrades in the sewage treatment plants during the late 1980s to early 1990s.

PXT0809 station (below dam): This station is strongly influenced by the release of water from T.H. Duckett Reservoir. The reservoir has water quality problems due to increasing nutrient enrichment from agricultural and urban runoff. Even though diversity and biotic index values increased over time, the values still remained in the "Poor" range. Additionally, these increases were attributed to an increase in the percentage of a species (Hydropsychidae) known to dominate water systems with organic pollution impacts.

3. 1968 Biological Survey[14]

In 1967, a biological survey of the Upper and Middle Patuxent River and its tributaries was conducted by the Federal Water Pollution Control Administration. Thirty-five (35) stations located between the Maryland Route 97 near Roxbury Mills and the Maryland Route 4 Bridge near Wayson's corners were sampled. Many of the samples were located within the Upper Patuxent River watershed. This report documents habitat and benthic community characteristics that were prevalent over 30 years ago and can serve as a useful historical comparison to present day conditions. In general, most stations within the Upper Patuxent River watershed exhibited poor to fair biological and water quality conditions.

Why Look at Benthos in Streams?

Benthos are sometimes called "stream bugs" though that name overly simplifies the diverse membership of this group. Unimpaired natural streams may support a great diversity of species ranging from bacteria and algae to invertebrates like crayfish and insects to fish, reptiles and mammals. Benthic macroinvertebrates, collectively called benthos, are an important component of a stream's ecosystem. This group includes mayflies, caddisflies, crayfish, etc. that inhabit the stream bottom, its sediments and organic debris and live on plant life (macrophytes) within the stream.

The food web in streams relies significantly on benthos. Benthos are often the most abundant source of food for fish and other small animals. Many benthic macroinvertebrates live on decomposing leaves and other organic materials in the stream. By this activity, these organisms are significant processors of organic materials in the stream. Benthos often provide the primary means that nutrients from organic debris are transformed to other biologically usable forms. These nutrients become available again and are transported downstream where other organisms use them.

Benthos are a valuable tool for stream evaluation. This group of species has been extensively evaluated for use in water quality assessment, in evaluating biological conditions of streams and in gauging influences on streams by surrounding lands. Benthos serve as good indicators of water resource integrity because they are fairly sedentary in nature and their diversity offers numerous ways to interpret conditions. They have different sensitivities to changing conditions. They have a wide range of functions in the stream. They use different life cycle strategies for survival.

Recreational and Migratory Fisheries

1. Anadromous and Estuarine Finfish Spawning Locations

The Anadromous Fish Stream Survey, conducted in the Patuxent River basin from 1980 to 1983, was the first inventory of spawning locations and distribution for anadromous herring (alewife and blueback herring) and shad (American and hickory) populations, as well for the estuarine migratory white and yellow perch populations[15]. The survey results show that the Upper Patuxent River watershed did provide spawning habitat for these species nearly 20 years ago. No other comprehensive study of spawning habitat has been conducted since this time period. The locations and occurrence of spawning runs in this watershed does indicate the potential to restore, enhance and extend spawning habitat through a watershed restoration program.

The alosids (herring and shad) spend most of their life-cycle in ocean waters and migrate to freshwater zones to spawn. Herring populations migrate further upstream than do shad during spawning season. White and yellow perch are resident, estuarine fish that migrate to freshwater streams for spawning. Map 16: Alosid and Perch Spawning Locations show documented spawning areas for herring, shad and perch populations within the Upper Patuxent River watershed. These species, particularly herring and shad, were once some of the most valuable commercial and recreational fisheries in the Chesapeake Bay. Today, these fisheries are at extremely low levels of abundance compared to historic populations. The causes for these declines are attributed to disruption of spawning habitat through watershed development impacts, fish blockages and overharvesting.

Herring spawning areas were identified as far upstream as Horsepen Branch and were also found within the Little Patuxent River watershed, indicating successful passage through portions of the Upper Patuxent River watershed (Map 16). A single shad spawning area, near the bottom of the watershed, was identified near the Stockett's Run confluence. Only one other shad spawning site was identified within the entire Patuxent River Basin. Historically, the Patuxent River between the Queen Anne Bridge (Rt. 214) and Rt. 50 supported a hickory shad sport fishery. Shad typically spawn in tidal freshwater habitats. The head of tide is in the vicinity of the Queen Anne Bridge. Herring and shad can still be caught at this site with Drop (bow) nets fished from the shoreline and the bridge[15] (Don Cosden, DNR Fisheries Service, personal communication).

Both yellow perch and white perch spawn in the Upper Patuxent River watershed (Map 16). The survey documents a wider distribution of white perch spawning areas than those idenfied for white perch. White perch spawning occurs throughout the river length of the Upper Patuxent River watershed to just below the Rocky Gorge Dam.

2. Anadromous Fish Restoration

DNR Fisheries Service has been conducting a project to restore populations of American shad and hickory shad to the Patuxent River.[16,17] "Spawning populations began a drastic decline early in the 20th century and many river stocks were extirpated by the 1970s. Populations of both shad species are being replenished through hatchery introductions. To date, the program has stocked 9.5 million American shad and 42 million hickory shad in both the Patuxent and Choptank tributaries. As anadromous fish, the spawning and nursery habitats occur in upstream, freshwater portions of the river. After the first growing season, juveniles migrate to the ocean where they spend the next several years before returning as adults. DNR then samples for these adults as they enter the historic spawning areas of the rivers where they were stocked. This data will provide information on shad stock-recruitment dynamics in these tributaries. Return rates of adult spawners will determine what level of stocking is needed to produce a self-sustaining spawning population. The goal is to restore naturally reproducing populations of shad in these rivers." [16]. To date, the shad restoration effort is proving successful. In 1999, wild juvenile shad were collected during the spring survey, indicating that the adult hatchery fish are reproducing within the Patuxent tributary basin.

3. Fish Passage Blockages

Many fish species need to move from one stream segment to the next in order to maintain healthy, resilient populations. This is particularly true for anadromous fish species because they spawn and hatch from eggs in free flowing streams but live most of their lives in estuarine or ocean waters. Blockages in streams can inhibit or prevent many fish species from moving up stream to otherwise viable habitat. One action that can be undertaken to open up more available spawning and nursery habitat for both anadromous fish and migratory resident fish is the removal of fish passage blockages. Map 17: Fish Passage Blockages and Trout Stocking Locations shows the extent and type of potential blockages identified by DNR's Fish Passage Program. Of the 29 blockages identified, 15 are dam structures, 10 are pipeline crossings, and the remainder consist of blockages by box culverts and gabions.

The dam blockage in Horsepen Branch was removed in 1995, opening up 10 miles of stream habitat to fish migration. The work was completed through a partnership with the Southern Maryland Agricultural Association and the Maryland Department of Natural Resources. Fish passage beyond the Upper Patuxent River watershed is halted by the Rocky Gorge Dam. Two fish ladder projects have also been completed in the Patuxent Research Refuge (Holiday Obrecht, PRR, personal communication). These projects were completed in the Little Patuxent River watershed. One occurred on the Midway Branch tributary and another one was developed as part of the new dam constructed on Lake Allen. Although these projects did not occur within the WRAS watershed, they did open several miles of previously blocked drainage to anadromous fish breeding. These projects provide significant habitat benefit to the breeding anadromous fish populations within the entire Patuxent River basin, and thus, this WRAS watershed.

Fish blockages can be addressed by either installing a fish passage structure or by removing the blocakge. In many cases, blockage removal is desirable, particularly in cases where low dam structures are no longer needed. In general, removal of fish blockages is recommended if they would open a large stream segment containing high quality habitat with existing or potential return of significant fish populations. Removal of fish passage blockages should be prioritized to maximize the increase in appropriate habitat and can be integrated with stream corridor restoration projects. These locations will be updated for those streams assessed during the 2002 Stream Corridor Assessment (see Restoration Targeting Tools).

4. Recreational Fisheries

DNR Fisheries Service concentrates on recreational trout stocking at Laurel Lake and on a segment of the Patuxent River located immediately downstream of the H.T. Duckett Dam (See Map 17: Fish Passage Blockages and Trout Stocking Locations). DNR stocks catchable size trout into these "Put and Take" areas several times each Spring and once in the Fall. About 750 trout/year are put into Laurel Lake and the Patuxent River area is stocked with about 1500 trout/year. Anglers are allowed to fish with any legal bait, lure or fly and the limit is five trout/day in "Put and Take" areas and 2 trout/day elsewhere. A daily limit allows for a longer season to fish and spreads the resource among more anglers.

Fish surveys conducted from 1980 - 1983 (DNR Fisheries Service) also revealed the presence of a variety of warmwater fish species. Sampling stations located below the Rocky Gorge Dam (top of the watershed) and at the Queen Anne Bridge (bottom of the watershed) documented the species listed in the following table.

1985 Statewide Fisheries Survey Patuxent River		
American eel	Blacknose dace	Pumpkinseed
Redfin pickerel	Creek chub	Bluegill
Golden shiner	Fallfish	Black crappie
Spottail shiner	White sucker	Tesselated darter
Swallowtail shiner	White catfish	

Sensitive Species

Sensitive species are most widely known in the form of Federally-listed Endangered or Threatened animals such as the bald eagle. In addition to these charismatic rare animals, both US EPA and Maryland DNR work through their respective Federal and State programs to protect numerous endangered, threatened, or rare species of plants, animals and ecological communities of those species. A complete list of these species can be found on DNR's Wildlife and Heritage Service's website.[18]

For the purposes of watershed restoration, it is valuable to account for known locations of habitat for these species. These places are often indicators, and sometimes important constituents, of the network of natural areas or "green infrastructure" that are the foundation for many essential natural watershed processes. Protecting these species and/or promoting expansion of their habitats can be an effective foundation for a watershed restoration program.

1. Habitat Protection Categories

One way to characterize a watershed for sensitive species is to know habitat locations using several broad categories employed by DNR's Wildlife and Heritage Division. These categories are described in the text box Maryland's Sensitive Species Protection Categories. More details and guidance can be requested from Division staff.

Two of the three categories used to help protect sensitive species during review of applications for a State permit or approval or involve State funds are found in the Upper Patuxent River Watershed as shown in Map 18: Sensitive Species Habitat. For projects potentially affecting these areas, the State permit or approval will include recommendations and/or requirements to protect sensitive species and their habitat. In addition, many counties have incorporated safeguards for these areas into their permit review process.

These categories do not place requirements on any activities that do not require a permit/approval or do not involve State funds. However, there are State and Federal restrictions that address "takings" of protected species that apply more broadly. In addition, property owners are encouraged to seek advice on protecting the sensitive species / habitat within their ownership.

2. Rare Fish and Mussels

DNR recently initiated a project to rank watersheds across Maryland to aid in targeting conservation and restoration efforts to benefit known populations of rare fish and mussels. Higher ranking for a watershed suggests that restoration or conservation projects may have greater potential to protect aquatic species diversity. Projects could be used to protect, enhance or expand existing aquatic habitat. A ranking of neutral indicates that information is insufficient (rather than these species are absent or that the area is low priority.) Neutral areas upstream of higher ranked areas are potentially important because they affect rare fish and mussel populations located downstream. In neutral ranked areas, it is reasonable to rely on other available criteria for targeting watershed conservation and restoration projects. This ranking considers information from 1970 to 1997 only for rare species of fish or mussels being tracked in Maryland. Four possible ranks were used for this project: Very High, High, Moderately High and Neutral. Each rare species being tracked contributed to this ranking based on two criteria: 1) presence or absence, and 2) if present, weighting relative rarity on worldwide and Statewide scales. In comparison to the more than 1000 small (12-digit) watersheds identified by DNR in Maryland, all of the 12-digit sub-watersheds (DNR units) in the Upper Patuxent River Watershed ranked "neutral."

Maryland's Sensitive Species Protection Areas in the Upper Patuxent River Watershed

**Sensitive Species
Project Review Area
(SSPRA)**

At least 12 SSPRAs are identified in (completely or partially) the Upper Patuxent River watershed. Each SSPRA contains one or more sensitive species habitats. However, the entire SSPRA is not considered sensitive habitat. The SSPRA is an envelop identified for review purposes to help ensure that applications for permit or approval in or near sensitive areas receive adequate attention and safeguards for the sensitive species / habitat they contain. At least one SSPRA compasses each NHA and WSSC. Also see Map 18: Sensitive Species Habitat.

**Natural Heritage Area
(NHA)**

No NHAs are located in the Upper Patuxent River watershed. NHAs are rare ecological communities that encompass sensitive species habitat. They are designated in State regulation COMAR 08.03.08.10. For any proposed project that requires a State permit or approval that may affect an NHA, recommendations and/or requirements are placed in the permit or approval that are specifically aimed at protecting the NHA.

**Wetlands of
Special State Concern
(WSSC)**

Nearly 20 WSSCs, covering 155 acres, are designated in the Upper Patuxent River watershed. These wetlands are associated with one or more sensitive species habitats that are in or near the wetland. For any proposed project that requires a wetland permit, these selected wetlands have additional regulatory requirements beyond the permitting requirements that apply to wetlands generally. For a listing of designated sites see COMAR 26.23.06.01 at www.dsd.state.md.us

The Patuxent Research Refuge and Wildlife Research Center

Located in the upper portion of the watershed, the "Patuxent Research Refuge is one of over 500 refuges in the National Wildlife Refuge System administered by the U.S. Fish and Wildlife Service. Established in 1936 by executive order of President Franklin D. Roosevelt, the Patuxent Research Refuge is the Nation's only National Wildlife Refuge established to support wildlife research. With land surrounding the Patuxent and Little Patuxent Rivers between Washington, D.C. and Baltimore, MD, the Refuge has grown from the original 2,670 acres to its present size of 12,750 acres and encompasses land formerly managed by the Departments of Agriculture and Defense."

The U.S. Fish and Wildlife Service owns and manages this large land base. The refuge is at least 75% forested. Three large tracts have been registered as Research Natural Areas (RNAs) with the American Forestry Association. The forest cover and various wetland projects within the refuge provides tremendous water quality improvement benefits along its portion of the watershed (Holiday Obrecht, PRR, personal communication).

"Patuxent Research Refuge supports a wide diversity of wildlife in forest, meadow, and wetland habitats. The land is managed to maintain biological diversity for the protection and benefit of native and migratory species. During the fall and spring migrations, many waterfowl species stop to rest and feed. Over 200 species of birds occur on the Refuge. Increasing forest fragmentation in the area due to urban development has damaged many populations of neotropical migratory birds. The Refuge is one of the largest forested areas in the mid-Atlantic region and provides critical breeding habitat and an important nesting area for these species." (Excerpt from http://patuxent.fws.gov/)

The Patuxent Wildlife Research Center (PWRC) is located on the Patuxent Research Refuge. It is one of 17 centers operated by the U.S Geological Survey. PWRC's mission is ***"To excel in wildlife and natural resource science, providing the information needed to better manage the nation's biological resources"***. USGS Biological Research focuses on six large programmatic efforts called Program Elements: Contaminants, Ecosystems, Fisheries, Invasive Species, Status and Trends, and Wildlife. The Center is home to both the North American Breeding Bird Survey and Amphibian Monitoring Program. More detail on the research programs and staff at the Center and on the Biological Resources of the Reserve can be accessed online at http://www.pwrc.usgs.gov.

RESTORATION TARGETING TOOLS

2002 Stream Corridor Assessment

Using the Stream Corridor Assessment Methodology (SCAM) developed and applied by the DNR Watershed Restoration Division, valuable information can be compiled to assist in targeting restoration activities. In partnership with Prince George's and Anne Arundel Counties, DNR will complete a Stream Corridor Assessment in the Upper Patuxent River watershed before the end 2002. Trained teams from the Maryland Conservation Corps will walk along streams to identify and document potential problems and restoration opportunities such as the items listed below:

Stream Corridor Assessment Data Collection Categories	
Pipe Outfalls	Fish Blockages
Pond Sites	Exposed Pipe
Tree Blockages	Unusual Conditions
Inadequate Buffers	Trash Dumping
Erosion	In or Near Stream Construction

A stream corridor assessment report will be generated, including maps and photographs, to support targeting decisions for restoration projects. Draft data summaries are expected to be available in winter 2002. The results of the stream corridor assessment will provide a valuable foundation for development of the Watershed Restoration Action Strategy.

Stream Buffer Restoration

1. Benefits and General Recommendations

Natural vegetation in stream riparian zones act as stream buffers that can provide numerous valuable environmental benefits:

– Reducing surface runoff
– Preventing erosion and sediment movement
– Using nutrients for vegetative growth and moderating nutrient entry into the stream
– Moderating temperature, particularly reducing warm season water temperature
– Providing organic material (decomposing leaves) that are the foundation of natural food webs in stream systems
– Providing overhead and in-stream cover and habitat
– Promoting high quality aquatic habitat and diverse populations of aquatic species.

To realize these environmental benefits, DNR generally recommends that forested stream buffers be at least 100 feet wide on each side of the stream corridor and consist of woody species that would have naturally occurred on the restoration site. DNR is promoting this type of stream buffer for local jurisdictions and land owners who are willing to go beyond the minimum buffer standards required by local regulation or to meet funding criteria (35 feet for CREP funding). The DNR Watershed Restoration Division and other programs like CREP are available to assist land owners who volunteer to explore these opportunities.

2. Using GIS

Identifying the areas that need buffers planted and prioritizing them for restoration is often a time-consuming and expensive project. Fortunately, use of a computerized Geographic Information System (GIS) to manipulate remote sensing data can help save limited time and funds. To assist in this technical endeavor, DNR Watershed Management and Analysis Division has developed GIS-based tools to assist in the buffer restoration targeting process. With these tools, GIS maps and other information can be generated to help select stream segments for additional Stream Corridor Assessment, to identify geographic areas for community and land owner contact and for similar uses. Then, with an appropriate level of on-the-ground verification or "ground truthing," these GIS tools can provide an efficient first step toward stream buffer restoration.

Several scenarios are presented in the following sections to help consider potential areas for stream buffer restoration. These scenarios can be used alone or in combination as models for targeting potential restoration sites for field verification. These maps are intended to demonstrate a methodology that can be used to locate sites having a high probability of optimizing certain ecological benefits of stream buffers. The resolution of the data used to generate these maps is not sufficient for an accurate site assessment, but can be used to identify potential candidate sites for more detailed investigation.

3. Headwater Stream Buffers

Headwater streams are also called first order streams. These streams, unlike other streams (second order, etc.), intercept all of the surface runoff within the watersheds that they drain. In addition, for many watersheds, first order streams drain the majority of the land within the entire watershed. Therefore, stream buffers restored along headwater streams (first order) tend to have greater potential to intercept nutrients and sediments than stream buffers placed elsewhere. In targeting stream buffer restoration projects, giving higher priority to headwater streams is one approach to optimizing nutrient and sediment retention.

Restoring headwater stream buffers can also provide habitat benefits that can extend downstream of the project area. Forested headwater streams provide important organic material, like decomposing leaves, that "feed" the stream's food web. They also introduce woody debris which enhances in-stream physical habitat. The potential for riparian forest buffers to significantly influence stream temperature is greatest in headwater regions. These factors, in addition to positive water quality effects, are key to improving aquatic habitat.

4. Land Use and Stream Buffers

One factor that affects the ability of stream buffers to intercept nonpoint source pollutants is adjacent land use. Nutrient and sediment loads from different land uses can vary significantly (see Nonpoint Source Pollution Load Rates by Land Use Table in Water Quality section). By identifying land uses in riparian areas with inadequate stream buffers, like crop land adjacent to streams, the potential to reduce nutrient and sediment loads can be improved. To assist in finding areas with crop land adjacent to streams, the same land use data shown in Map 5: Generalized Land Use Land Cover can be filtered using GIS. The new scenario shown in Map 19: Land Use Scenario for Stream Buffer Restoration focuses on the land use within a 100 feet of a stream on either side. This view, supplemented with the land use pollution loading rates, suggests potential buffer restoration opportunities that could minimize nutrient and sediment loads. Utilizing this approach, buffer restoration should be targeted towards crop land to maximize nutrient and sediment load reductions.

5. Nutrient Uptake from Hydric Soils in Stream Buffers

In general, the nutrient nitrogen moves from the land into streams in surface water runoff and in groundwater. A significant percentage of nitrogen enters streams in groundwater. Stream buffers can be used to capture nitrogen moving in groundwater if buffer restoration projects have several key attributes:

– Plant with roots deep enough to intercept groundwater as it moves toward the stream
– Plants with high nitrogen uptake capability
– Targeting buffer restoration projects to maximize groundwater interception by buffer plants, and
– Buffers are not short-circuited by stormwater drainage or far filed tile draingage that results in direct discharge to streams.

Hydric soils in stream riparian areas can be used as one factor to help select stream buffer restoration sites. Siting buffer restoration on hydric soils would offer several benefits:

– Plant roots are more likely to be in contact with groundwater for longer periods of time
– Hydric soils tend to be marginal for many agricultural and urban land uses
– Natural vegetation in wet areas often offer greater potential for habitat.

Map 20: Hydric Soils Scenario for Stream Buffer Restoration identifies lands adjacent to streams that are composed hydric soil and also have insufficient stream buffers in the Upper Patuxent River watershed. An important next step in using this information is verification of field conditions. Care must be taken during field validation to evaluate any hydrologic modification of these soils, such as ditching or draining activities, which would serve to decrease potential benefits.

A refinement of the above scenario would be to target buffer restoration opportunities that occur on hydric soil and have an agricultural land use. Nutrient retention could be optimized by combining the higher potential nutrient uptake with land areas that have higher potential nutrient loading to streams.

6. Optimizing Water Quality Benefits by Combining Priorities

Strategic targeting of stream buffer restoration projects can take into account many different potential benefits. Several of these scenarios are presented independently in this section. However, site selection and project design generally incorporate numerous factors to optimize benefits from the project. For example, finding a site with a mix of attributes like those in the following list could result in the greatest control of nonpoint source pollution and enhancement to living resources:

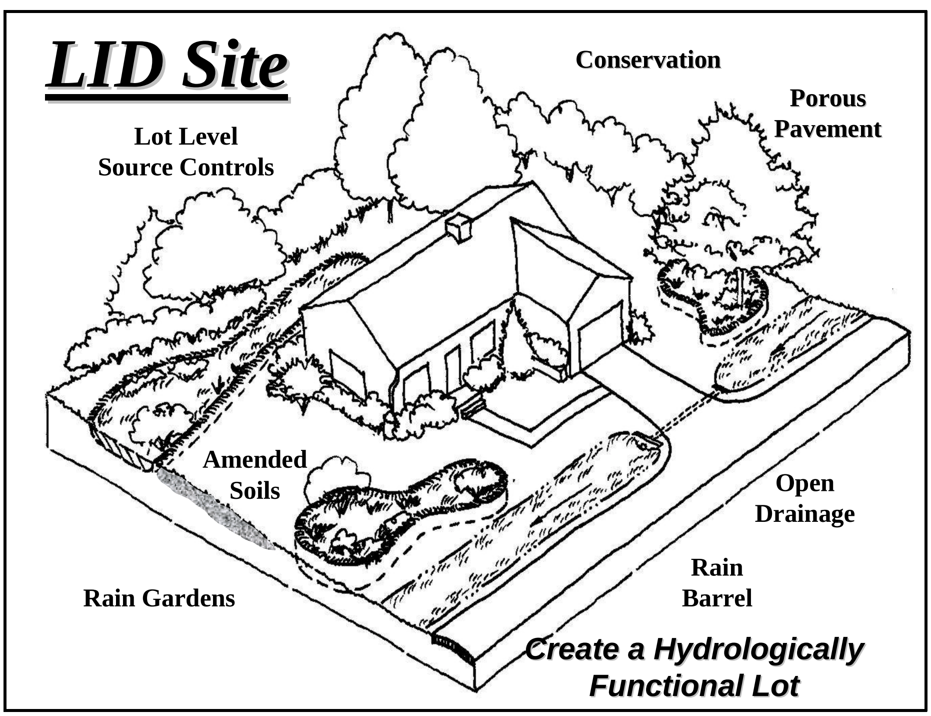
– land owner willingness / incentives
– marginal land use in the riparian zone
– headwater stream
– hydric soils
– selecting appropriate woody/grass species
– adjacent to existing wetlands / habitat

Low Impact Development Techniques

A restoration action strategy that will be employed in the Upper Patuxent River watershed will utilize Low Impact Development (LID) techniques. LID techniques emphasis proper site design techniques that protect the environment and water resources by minimizing the negative effects of impervious surfaces and enhancing the positive benefits of pervious surfaces. These techniques apply both to new development projects and can be used to retro-fit existing developed areas.

Prince George's county has pioneered these techniques in many of its new development areas and for urban retrofits. LID development uses every part of the landscape to maintain the natural runoff conditions. The figure below shows how the LID techniques can be incorporated into every part of the lot design. The roofs, pavement, road design, soils, and landscaping elements have been modified to store, detain, infiltrate or filter runoff.

Both commercial/industrial and high density residential will be evaluated for LID retrofits. The more intensely developed commercial and industrial areas, such as those found in Maryland City and the City of Bowie, will be among the first areas identified for urban retrofits through LID techniques. The information presented in Map 7: Percent Impervious Surface and Map 8: Average Percent Impervious Surface by Watershed Management Unit, in combination with data gathered from land use maps, chemical/biological surveys and the stream corridor assessment, can be used to assist in the identification of other investigation areas. Opportunities to address urban LID retrofit include redesigning hydrologic controls on roofs, buildings, down spouts, sidewalks, parking lots, open space and landscaped areas.



Wetland Restoration

Wetlands serve important environmental functions such as providing habitat and nursery areas for many organisms, facilitating nutrient uptake and recycling, providing erosion control. However, most watersheds in Maryland have significantly fewer wetland acres today than in the past. This loss due to draining, filling, etc. has led to habitat loss and negative water quality impacts in streams and in the Chesapeake Bay. Reversing this historic trend is an important goal of wetland restoration. One approach to identifying candidate wetland restoration sites involves identifying "historic" wetland areas based on the presence of hydric soils. This process can be accelerated by using GIS to overlay soils information with other data like land use. The GIS products can then assist in initiating the candidate site search process, targeting site investigations and helping to identify land owners. To promote wetland restoration, DNR's Watershed Management and Analysis Division has developed GIS capability for these purposes.

For the Upper Patuxent River watershed, GIS was used to map and prioritize areas of hydric soil for potential wetland restoration. One of many possible scenarios for finding potential wetland restoration sites is presented on the following map. Map 21: Wetland Restoration Opportunities. This map identifies wetland restoration opportunities as areas of hydric soil that currently do not support wetlands, forests or are developed. These are hydric soils on open land that have potential for restoration. These opportunities have been characterized into two subsets:

1. Restoration opportunities that are in close proximity (within 300 feet) of existing wetlands and streams. Wetland restoration in these highlighted areas may have greater opportunities for enhancing existing habitat and providing more water quality benefits to surface water.

2. Other restoration opportunities that fall outside of a 300 foot buffer.

The potential wetland restoration sites suggested in this scenario can be filtered further by using more accurate wetlands and soil information, considering landownership, etc. Additional steps would be beneficial in applying this information such as considering additional criteria like habitat enhancement opportunities, sensitive species protection, targeting specific streams or subwatersheds for intensive restoration, and using Conservation Reserve Enhancement Program (CREP) information.

Additional wetland restoration opportunities may be identified on non-agricultural lands. For example, residential properties, particularly low density areas, or industrial/commercial property may also provide viable project sites that do not appear in the scenarios presented above.

Targeting To Achieve Measurable Water Quality Improvement

Selecting restoration projects that are likely to produce measurable success is an important consideration in prioritizing projects for implementation. In the early stages of a watershed restoration program, measurable water quality improvement can be one of the strongest ways to demonstrate project success. In general, targeting restoration projects to one or a few selected tributaries or small watersheds will tend to offer the greatest probability of producing measurable water quality improvement.

Restoration and conservation activities in the Patuxent Research Refuge provides clear demonstration of these benefits (Holiday Obrecht, PPR, personal communication). Wetland systems have been constructed in numerous locations to improve water quality in wastewater and stormwater run-off. In addition, all forested lands on the PPR are protected, which amounts to about 75% of its landmass. Improvements in water quality are reflected in the shift from pollution tolerant to pollution intolerant stream macroinvertebrate communities from the headwater edge of the PPR to the discharging point. Practices such as these, if extended to other regions of the Upper Patuxent River watershed, can also be expected to provide measurable improvements to water quality.

If restoration projects are targeted to selected Upper Patuxent River tributaries, improvement in in-stream water quality may be measurable in terms of water quality parameters, benthic populations or other parameters. Water quality improvements achieved in the tributary will also inevitably contribute to improving the river mainstem. As a cautionary note, improvement in the mainstem of the river may not be measurable, particularly if the magnitude of the problem is large and attributable to many non-point pollution sources, both within the watershed and upstream.

Focusing Land Conservation Activities

Targeting tools can also be developed for focusing land conservation activities to address key ecological or working landscape objectives. In the scenario presented in Map 22: Conservation Scenario for GreenInfrastructure, Anne Arundel County Greenways and Other Forest Land, a subset of the GreenInfrastructure, Anne Arundel County Greenways and other forest land that are currently not under protection through public ownership or easement agreement have been identified. Protection mechanisms to conserve these lands can be focused to support the conservation of ecologically valuable lands that may be lost to land use conversion. Similar scenarios could be constructed to focus agricultural easement programs on agricultural lands currently without a conservation agreement.

POTENTIAL BENCHMARKS FOR WRAS GOAL SETTING

Several programs designed to manage water quality and/or living resources have existing or proposed goals that are relevant to setting goals for the Upper Patuxent River Watershed Restoration Action Strategy (WRAS). The goals from these other programs tend to overlap and run parallel to potential interests for developing WRAS goals. Therefore, to assist in WRAS development, selected goals from other programs are included here as points of reference. By aligning WRAS development with other programmatic efforts, the strategy will position itself more favorably for future funding.

Coastal Zone Management (NOAA)

– Watershed strategies are defined as comprehensive plans that will identify areas of concern, monitoring strategies, gaps in information, mitigation options, and restoration and protection opportunities.

– Projects funded under Coastal Zone Management must be in Maryland's Coastal Zone and must include a local program change as part of the effort. This could include incorporation into the County Comprehensive Plan, adoption of local implementing tools like zoning ordinances and environmental codes, modification of sensitive areas elements or alterations to Smart Growth Priority Funding Areas.

Chesapeake 2000 Agreement (EPA)

The Chesapeake 2000 Agreement (C2K) includes several significant commitments pertaining to local watershed management planning and implementation. The goal in the C2K Agreement that is directly related to the development of watershed management plans and action strategies is "By 2010, work with local governments, community watershed groups and watershed organizations to develop and implement locally supported watershed management plans in two-thirds of the Bay watershed covered by this Agreement. These plans would address the protection, conservation and restoration of stream corridors, riparian buffers and wetlands for the purposes of improving habitat and water quality, with the collateral benefits for optimizing flow and water supply."

Four common elements of watershed management planning were adopted by the Chesapeake Bay Program member jurisdictions to be applied Bay-wide. Those elements support the WRAS components. The four approved C2K Agreement watershed planning elements are as follows:

1. Does the plan "address the protection, conservation and restoration of stream corridors, riparian forest buffers and wetlands?" Each watershed management plan needs to be based on an assessment of natural resources within the watershed. At a minimum, the assessment will evaluate the condition of stream corridors, riparian buffers and wetlands within the watershed.

2. Does the plan reflect the goals and objectives of "improving habitat and water quality?" The plan should reflect the issues that the stakeholders feel are important, and, at a minimum, exhibit a benefit to habitat and water quality within the watershed.
   The goals should be based on priority issues identified by the watershed assessment.

3. Does the plan identify implementation mechanisms?
   Capacity to implement the plan will be demonstrated by identifying:
   - What are the specific management actions?
   - What are the resources necessary for implementation?
   - Who will implement the plan?
   - And when will the actions will be implemented?

   The implementation mechanisms should also incorporate a periodic re-evaluation to ensure the plan is "living" and flexible to the changes in the watershed.

4. Does the plan have demonstrated local support? Every effort should be made to demonstrate a diversity of local support. At a minimum, local governments, community groups and watershed organizations should be encouraged to participate in developing and implementing the watershed management plan.

Goals from the *Clean Water Action Plan* [2]:

– Clean Water Goals - Maryland watersheds should meet water quality standards, including numerical criteria as well as narrative standards and designated uses.

– Watersheds should achieve healthy conditions as indicated by natural resource indicators related to the condition of the water itself (e.g. water chemistry), aquatic living resources and physical habitat, as well as landscape factors (e.g. buffered streams and wetland restoration).

Wetland, Stream and Forest Habitat Goals for Maryland's Tributary Strategies:

– These are quantitative goals that have been allocated to, or are in the process of being developed for each of Maryland's ten major tributary basins. The WRAS study area provides a useful tool for quantifying and conducting habitat restoration and conservation activities that can be used to support these statewide goals.

– A key feature of the Habitat Goals initiative is the development of stream goals based on input from local agencies, organizations, and watershed management planning efforts.

Water Quality Improvement Act of 1998

- The most significant feature is requiring nutrient management plans for virtually all Maryland farms. The requirement is being phased in over a several year period.
- Nitrogen-based plan implementation will be required on all farms beginning December 31, 2001.
- Phosphorus-based plan implementation will be required on farms using chemical fertilizer beginning December 31, 2002 and on farms using manure or biosolids by July 1, 2005.
- Up to 87.5% cost share is available for development of nutrient management plans and up to $20 per ton cost share assistance with costs of manure transportation are available. Implementation of projects assisted by this funding has the potential to move nutrients to sites where they are needed.

Total Maximum Daily Loads (TMDLs)[5]

- Data derived from this characterization and the biological and chemical survey completed by DNR can be used as additional information in the TMDL process.
- Future action strategies can be used to assist planning and implementation necessary to reach TMDL limits, once a TMDL has been calculated.

RELATED PROJECTS

Overview

There are numerous projects and programs that have the potential to contribute to successful development and implementation of a Watershed Restoration Action Strategy (WRAS). The listing included here suggests opportunities for cooperation and coordination that can improve the likelihood of success for the WRAS. This listing is not all-inclusive. It is recommended that this list be augmented as new information becomes available and that follow-up should continue to promote the WRAS process with these and other projects and programs

Hydrologic Studies for the City of Laurel [19]

Two hydrologic studies have been performed for the City of Laurel for the purpose of flood management, watershed management and as planning tools relative to land use impacts.

- The **Crow Branch and Bear Branch Hydrologic Study** identified the 100-year floodplain and flooding issues for these tributaries of the Patuxent River. Hydrologic analyses were performed under existing watershed conditions for the 2-, 10-, and the 100-year storms. These results will be used to prepare a physical map revision of the Flood Insurance Rate Map (FIRM) for the City of Laurel. The study included simulating the Laurel Lakes facility, but only for flood events.
- The **Patuxent River Hydrologic Study** went from the headwaters to the river crossing of the Baltimore-Washington Parkway and included the Washington Surburban Sanitary Commission (WSSC) reservoirs at Brighton Dam and Rocky Gorge Dam. The drainage area analyzed was 150 mi^2. The hydrologic analysis was simulated for the existing watershed conditions and reflects the flooding potential of the City of Laurel at the time the study was completed. This information was used to update the hydrologic model for revising the August 19, 1985 Federal Emergency Management Agencies (FEMA) Flood insurance Study (FIS) for the City of Laurel.

Laurel Lakes Watershed Assessment [20]

A watershed assessment of the Laurel Lakes was performed by a Prince George’s County consultant. The report is currently being reviewed by the Concerned Citizens to Save the Laurel Lakes, an environmental citizens group referenced below. This group will provide feedback to the Programs and Planning Division of the Prince George’s County Department of Environmental Resources.

The Patuxent River Commission [21]

The Patuxent River Commission (a.k.a. Patuxent Tributary Team) is a thirty-four member body created by State legislation in 1980. Its membership represents a cross-section of the watershed's interest groups, including: businesses, developers, State and local governments, federal facilities, environmental, academic, agricultural, and waterman interests. The Commission serves as an interjurisdictional forum for Patuxent issues and develops and oversees implementation of the Patuxent River Policy Plan and the Patusent Tributary Strategy. Their vision is: *We, the Patuxent River Commission, envision a Patuxent River ecosystem as vital and productive in 2050 as it was in the 1950s. We therefore commit to be stewards and advocates for the Patuxent River and to lead and inspire actions to protect, enhance, and restore living resources and the natural, cultural, economic, and recreational values of the Patuxent River and its watershed.* More information on the Commission can be found on their internet site: http://www.mdp.state.md.us/info/patux.htm

The Patuxent River Watershed Atlas of Resource and Watershed Management Priorities [21]

This study is useful for considering how the Upper Patuxent River watershed fits into the broader context of the land use-related resources and issues of the Patuxent River Tributary Basin. As a whole, the Patuxent Tributary Basin is the largest tributary basin within Maryland (930 square miles) and has served as the proving ground for many of the Chesapeake Bay Program initiatives. The core of protected lands within the Upper Patuxent River watershed is one of the 4 key protected land areas identified within the entire Patuxent River basin. Managing growth in a way that protects rural resources was identified as an area of concern since the most abundant type of zoning in the basin is characterized as "Least Protective Rural Zoning". Such rural zoning districts allow densities between 1 and 10 acre lots per new household which tends to be too dense to adequately protect rural resources and too disbursed to form communities and efficient development patterns.

Environmental Citizens Groups

Two citizens groups are particularly active within the Upper Patuxent River watershed. Both of these groups have representatives on the Upper Patuxent River WRAS Steering Committee.

- Prince George's Group, Maryland Chapter, Sierra Club
  http://www.maryland.sierraclub.org/pg/
- Concerned Citizens to Save the Laurel Lakes (CCSLL)
  Contact Sharon Meigs, Senior Environmental Planner, Programs and Planning Division, Department of Environmental Resources, Prince George's County
  slmeigs@co.pg.md.us

Stream Monitoring Programs

Resources, training and programs exist for citizen volunteers who would like to be involved in stream monitoring projects within the Upper Patuxent River watershed.

- Prince George's County Stream Teams: Volunteer Program
  Contact Sharon Meigs, Senior Environmental Planner, Programs and Planning Division, Department of Environmental Resources, Prince George's County
  slmeigs@co.pg.md.us
- DNR Stream Waders
  Contact Dan Boward, Resource Assessment Service, Monitoring and Nontidal Assessment, DNR
  dboward@dnr.state.md.us

In addition, DNR's Maryland Biological Stream Survey (MBSS) will continue to assess the Upper Patuxent River watershed during each round of the survey. This watershed will be assessed for Round 2 of the survey in 2004. More information on the MBSS can be found at http://www.dnr.state.md.us/streams/mbss/index.html.

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APPENDICES

Appendix 1: Permit categories used for MDE Permitted Point Sources

- **Wastewater Treatment and Major Wastewater Treatment Permits (WMA2, WMA2M)**

  Municipal surface water discharge permits (Discharge of wastewater to surface waters):

  The municipal surface water discharge permit is a combined state and federal permit under the National Pollutant Discharge Elimination System (NPDES). This permit is issued for sewage treatment plants and some water treatment plants that discharge to State surface waters. The permit is designed to protect the quality of the body of water receiving the discharge.

  Anyone who discharges wastewater to surface waters needs a surface water discharge permit. Applicants include municipalities, counties, schools and commercial water and wastewater treatment plants, as well as treatment systems for private residences that discharge to surface waters.

- **Industrial Stormwater Permits (WMA5, WMA5SW)**

  Industrial Wastewater/Stormwater General Discharge Permits:

  The general permits for industrial wastewater discharge apply to categories of business activities which are generally very similar in their wastewater characteristics. General permits with standardized permit conditions have been established for:

  - Stormwater associated with industrial activities
  - Surface coal mines
  - Mineral mines, quarries, borrow pits, ready-mix concrete and asphalt plants
  - Seafood processors
  - Hydrostatic testing of tanks and pipelines
  - Marinas
  - Concentrated animal feeding operations

- **General Terminal (Oil) or Groundwater (Oil) Permits (WAS6T, WAS6R)**

  Oil Control Program General Wastewater Discharge Permits

  The general permits for wastewater discharges from oil related activities apply to categories of business activities which are generally very similar in their wastewater characteristics. General permits with standardized permit conditions have been established for:

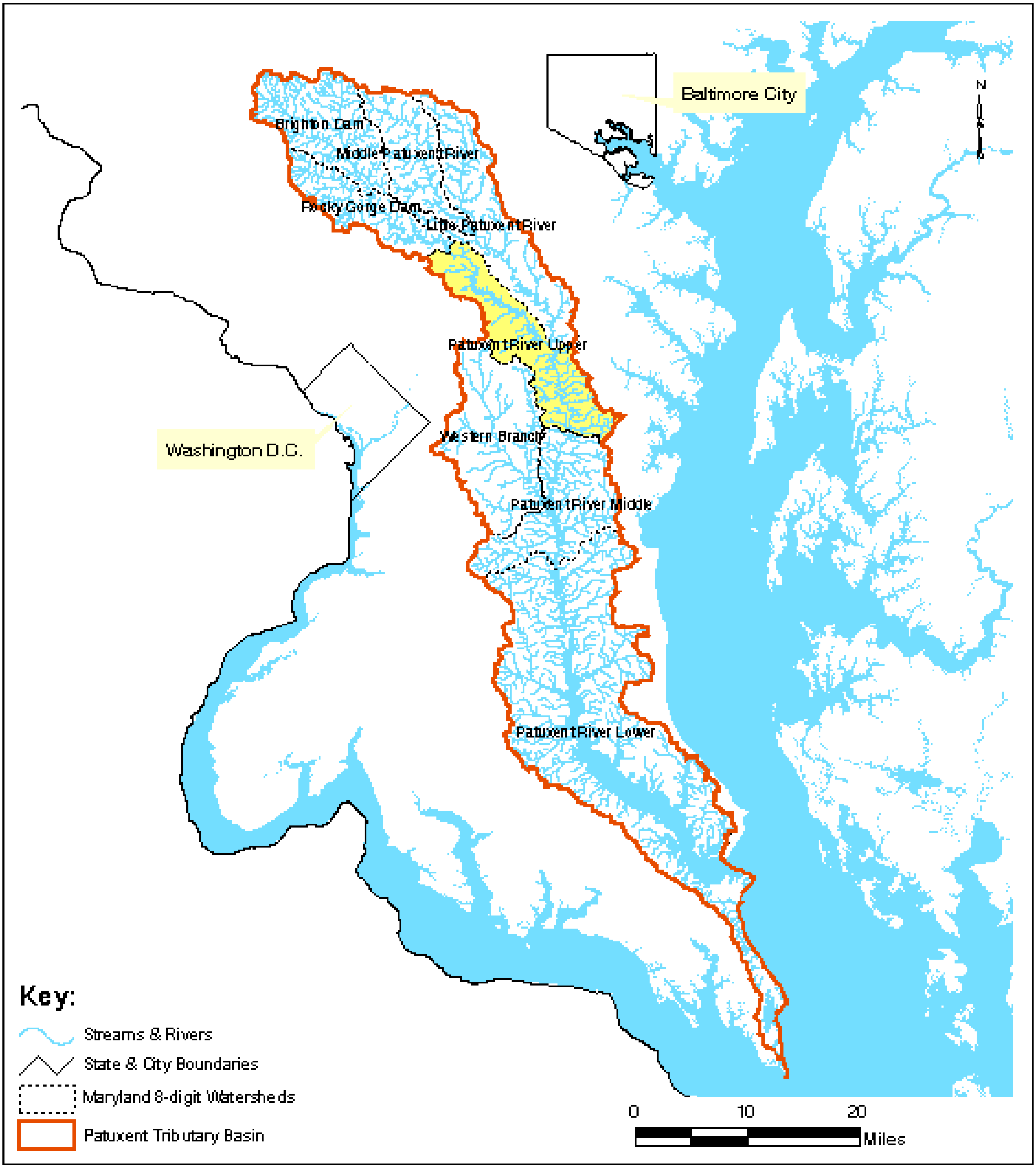
  - Storm water and hydrostatic test water from oil terminals for terminals without pipeline or marine facilities and less than 5 million gallons total storage capacity; and
  - Remediated groundwater from petroleum contaminated groundwater sources.

  The general permits are for ground or surface water discharges.

Appendix 2: 1997 MBSS Site Characteristics

Physical Habitat Metrics						**Scores range from 0 (poor) to 20 (good)**
Sites	**1**	**2**	**3**	**4**	**5**	
Instream Habitat	13.0	1.0	8.0	9.0	7.0	Perceived value of habitat to fish communities
Epifaunal Substrate	11.0	2.0	4.0	11.0	5.0	Habitat value for benthic invertebrates (hard stable substrates rate higher vs those with excessive fine sediments)
Velocity/Depth Diversity	7.0	2.0	14.0	9.0	13.0	Diversity of depth and velocity regimes
Pool Quality	8.0	2.0	14.0	11.0	12.0	Variety and complexity of pool habitats
Riffle Quality	6.0	0	11.0	9.0	11.0	Depth, complexity, and functional importance of riffle/run habitat
Channel Alteration	12.0	20.0	4.0	8.0	10.0	Changes in the shape of the stream channel (channelized, hardened streams rate lower vs those with natural meanders)
Bank Stability	4.0	19.0	3.0	9.0	6.0	Higher = Banks stabilized with vegetation or other material, minimal bank erosion present
Remoteness	1.0	0	8.0	11.0	14.0	Higher = more remote with less human disturbance
Aesthetic Quality	5.0	1.0	9.0	18.0	12.0	Visual appeal of the site
Landuse Characteristics of Upstream Watershed						
Sites	**1**	**2**	**3**	**4**	**5**	
Percent Urban	38.08	33.13	27.4	2.96	1.21	
Percent Agricultural	12.56	9.24	23.25	68.36	51.25	
Percent Forest	49.3	58.41	40.24	28.16	47.54	
Percent Wetlands	0	0	0.02	0.06	0.02	
Percent Barren	0	0	8.94	0	0	
Percent Water	0	0	0.09	0.21	0.21	
Riparian Width (ft)	14	0	50.0	50.0	50.0	
Buffer Type	FR		FR	FR	FR	FR = Forested
Water Quality Metrics						
Sites	**1**	**2**	**3**	**4**	**5**	
Dissolved Oxygen (ppm)	9	9	9	9	8	
pH	8	7	7	7	7	
Nitrate Nitrogen (mg/l)	1	1	1	1	1	
Temperature (C)	22	18	18	18	20	
Key to MBSS sampling site						
Site 1	HO-N-022-104-97					
Site 2	PG-N-007-127-97					
Site 3	PG-N-097-121-97					
Site 4	PG-N-274-128-97					
Site 5	AA-N-021-112-97					

Map 1: Regional Context



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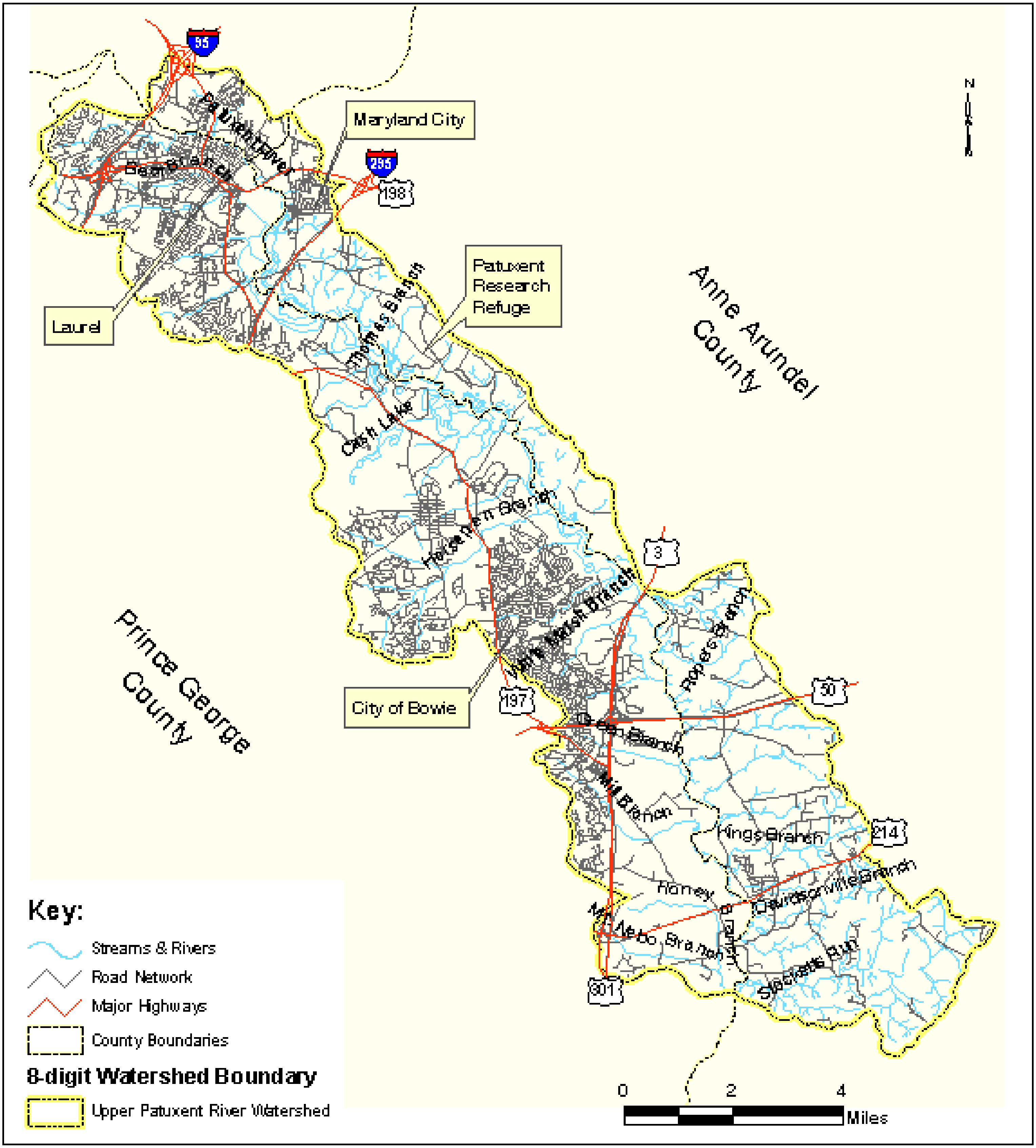
Map 2: WRAS Project Area



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Map 3: Streams & Watershed Management Units

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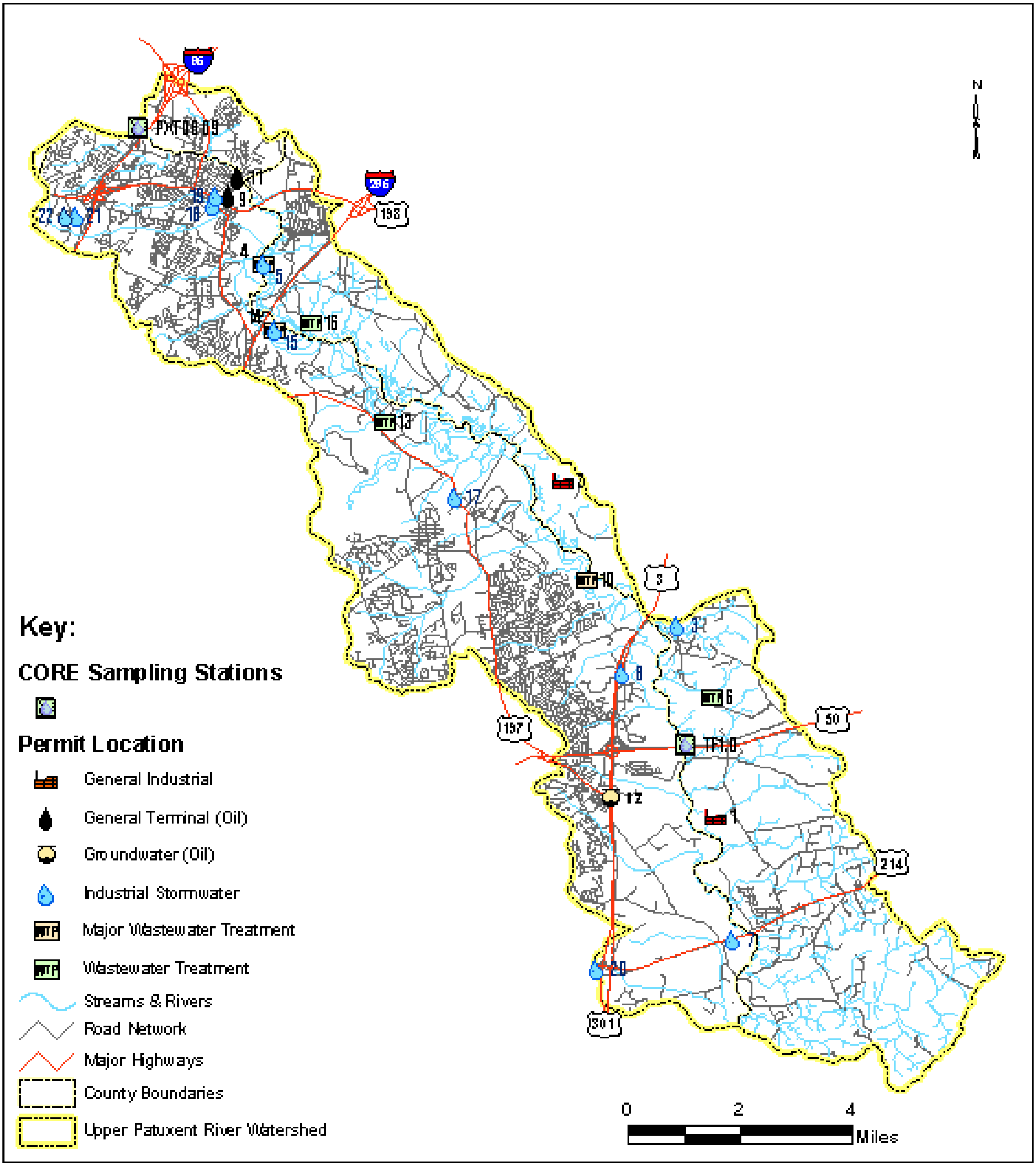
Map 4: CORE Water Quality Monitoring Stations and Permitted Discharges



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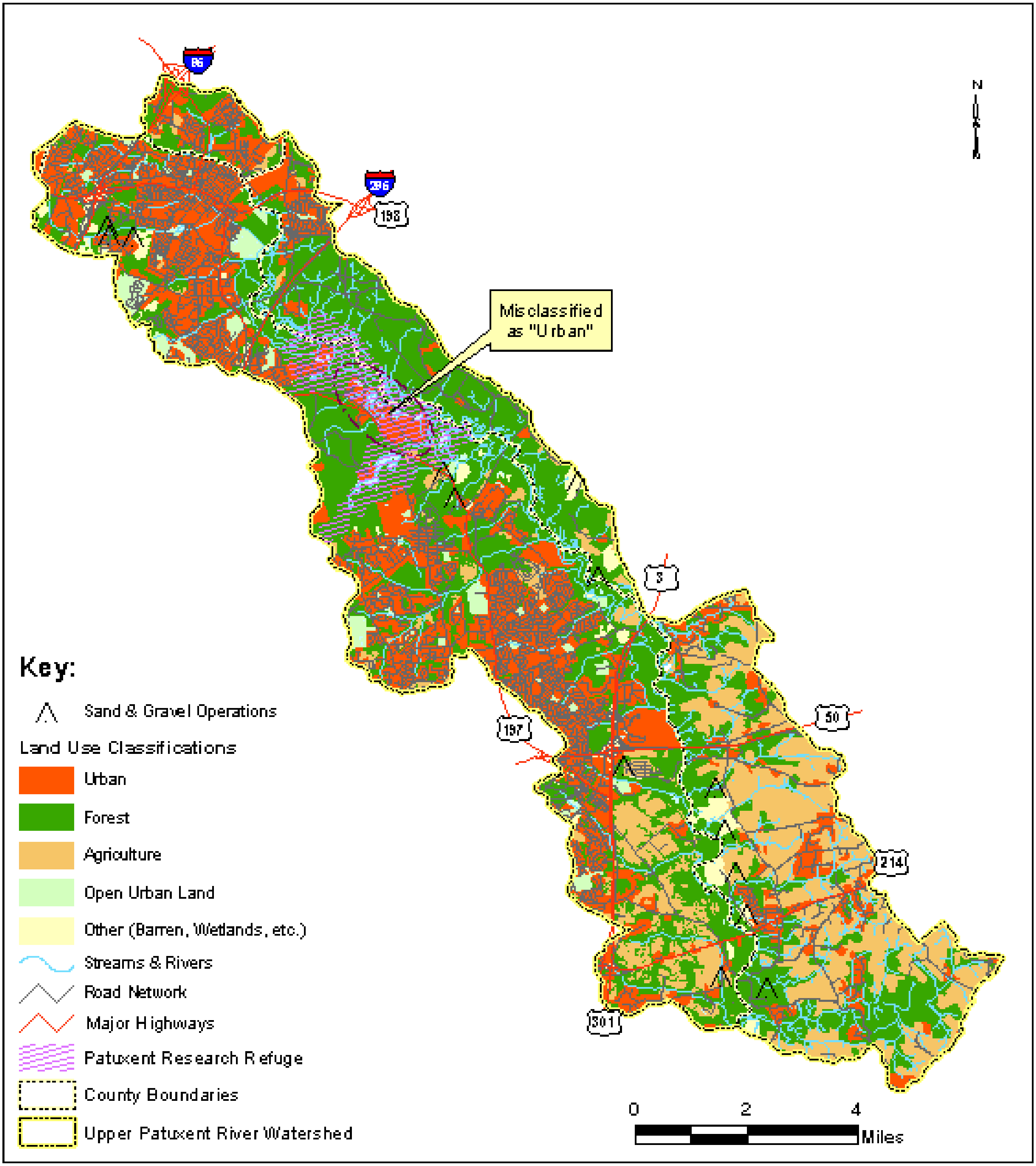
Map 5: Generalized Land Use Land Cover



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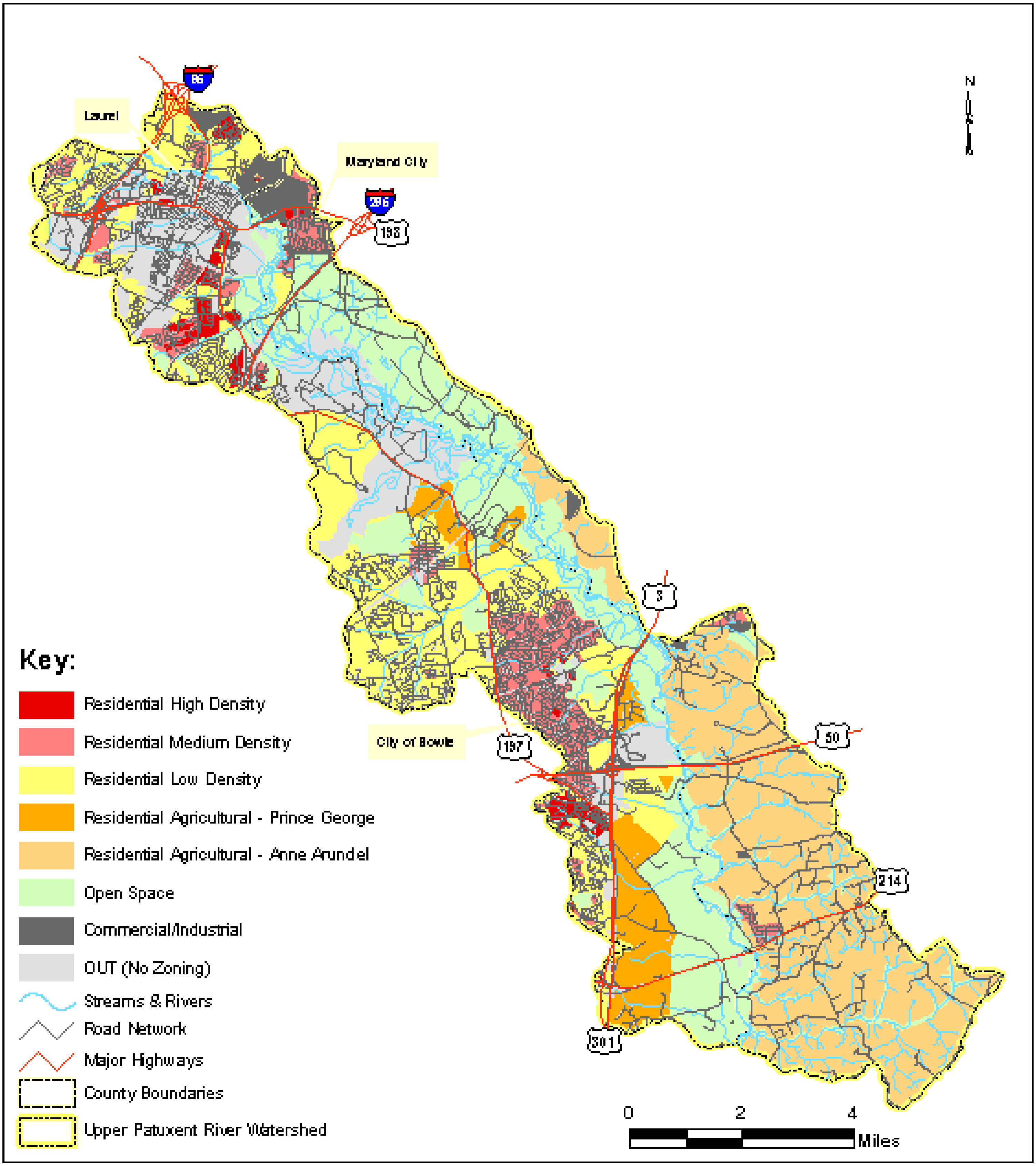
Map 6: Generalized Zoning Codes



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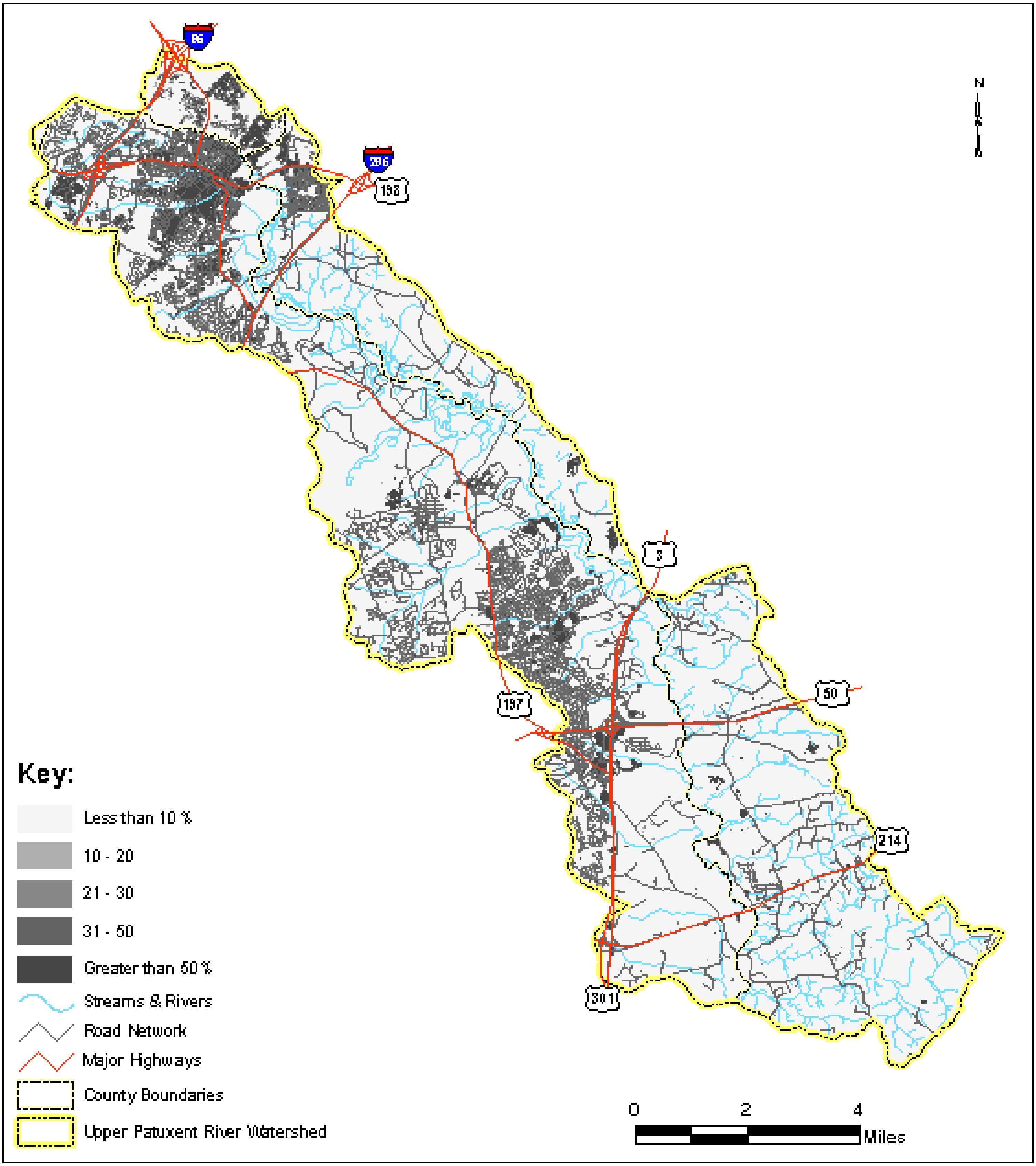
Map 7: Percent Impervious Surface



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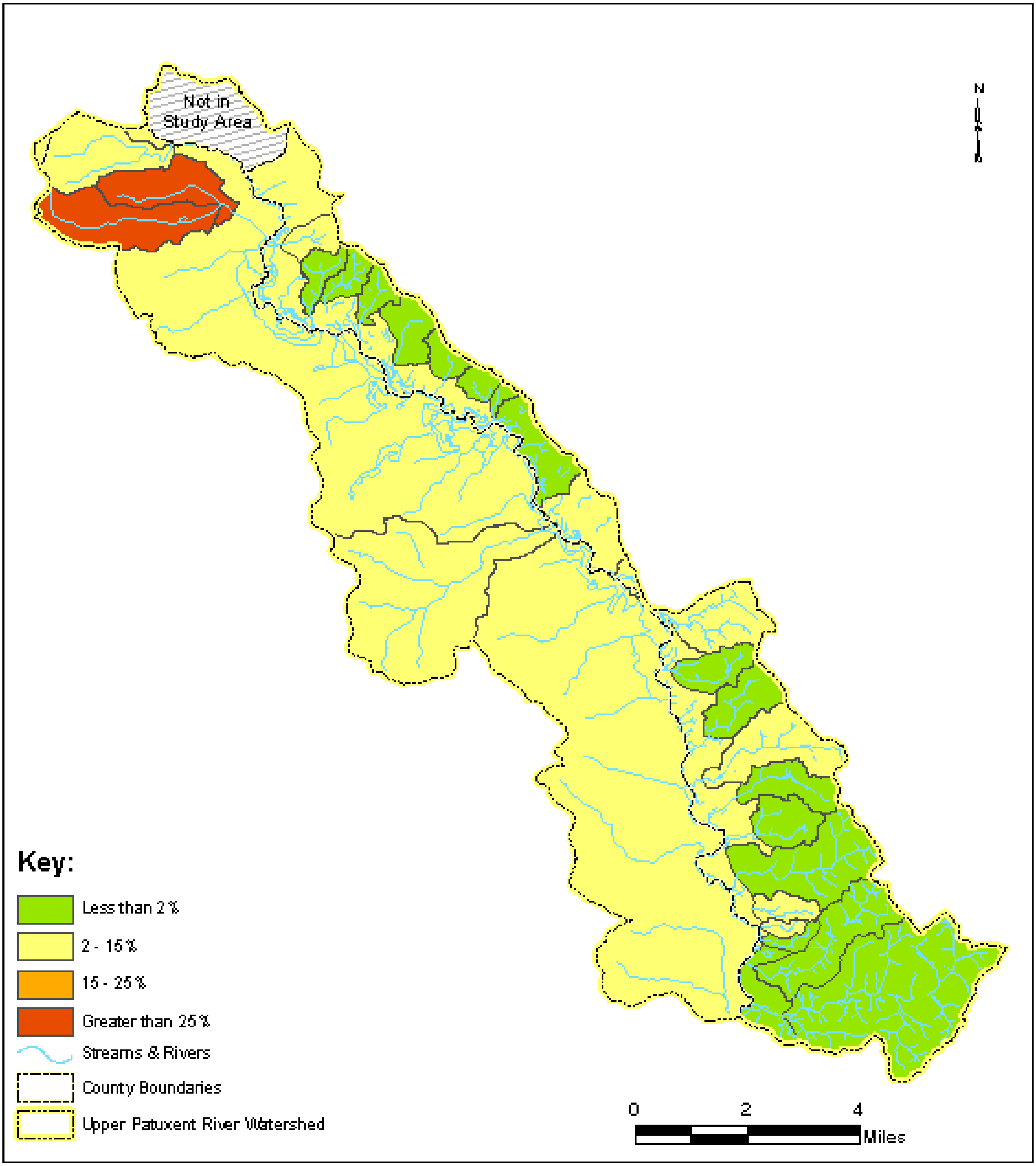
Map 8: Average Percent Impervious Surface by Watershed Management Unit



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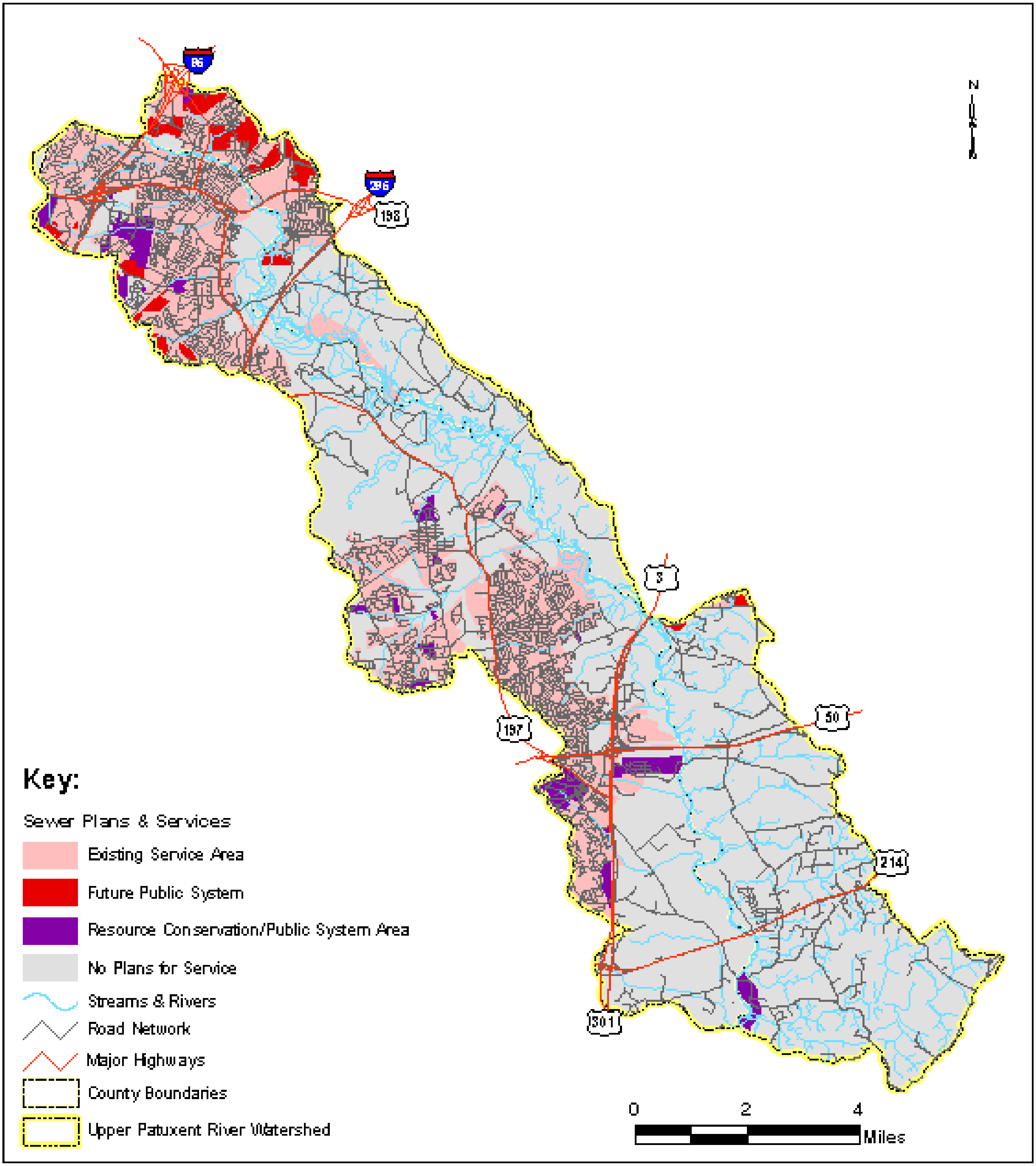
Map 9: Water Management



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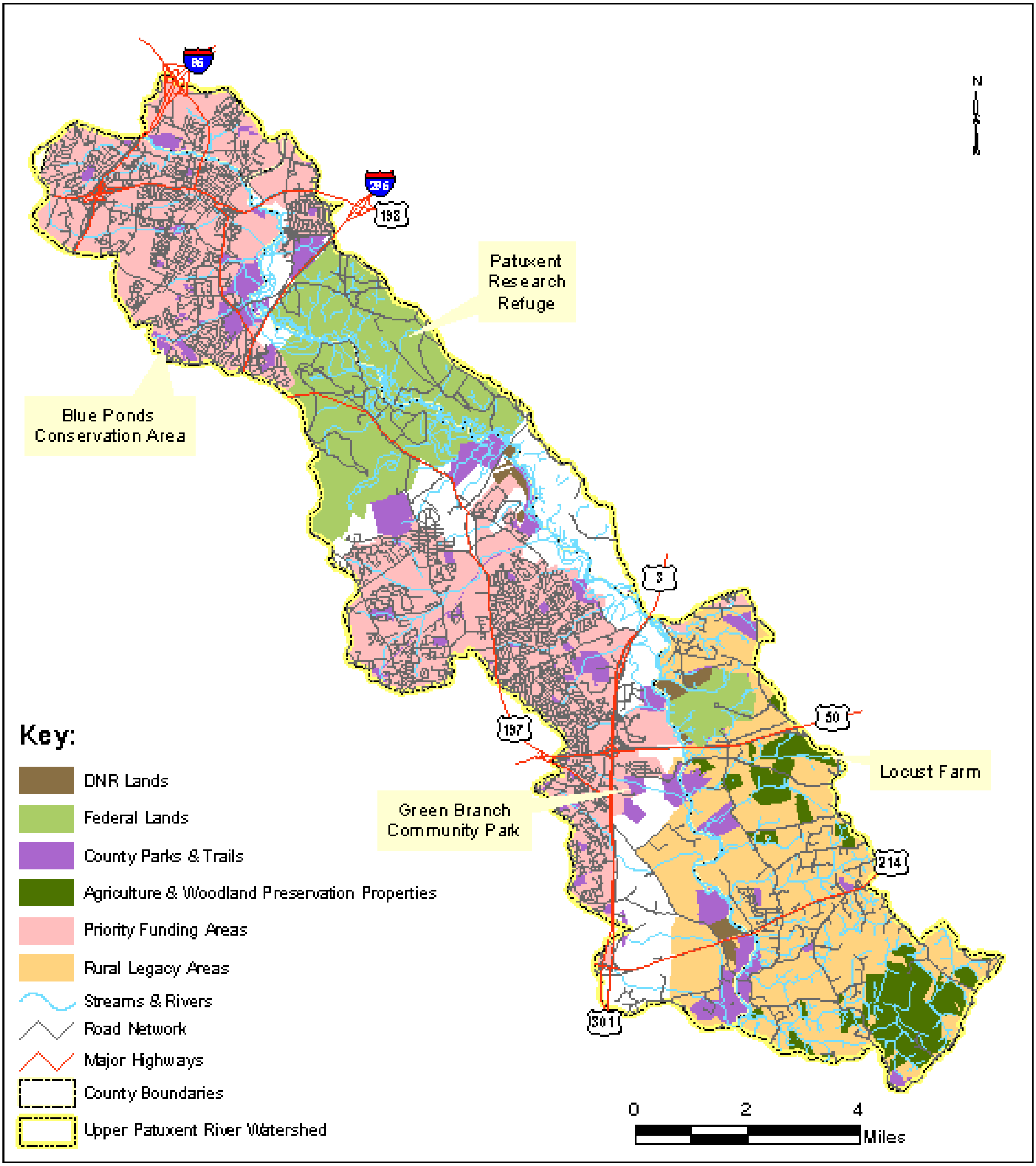
Map 10: Priority Funding Areas, Rural Legacy & Protected Lands



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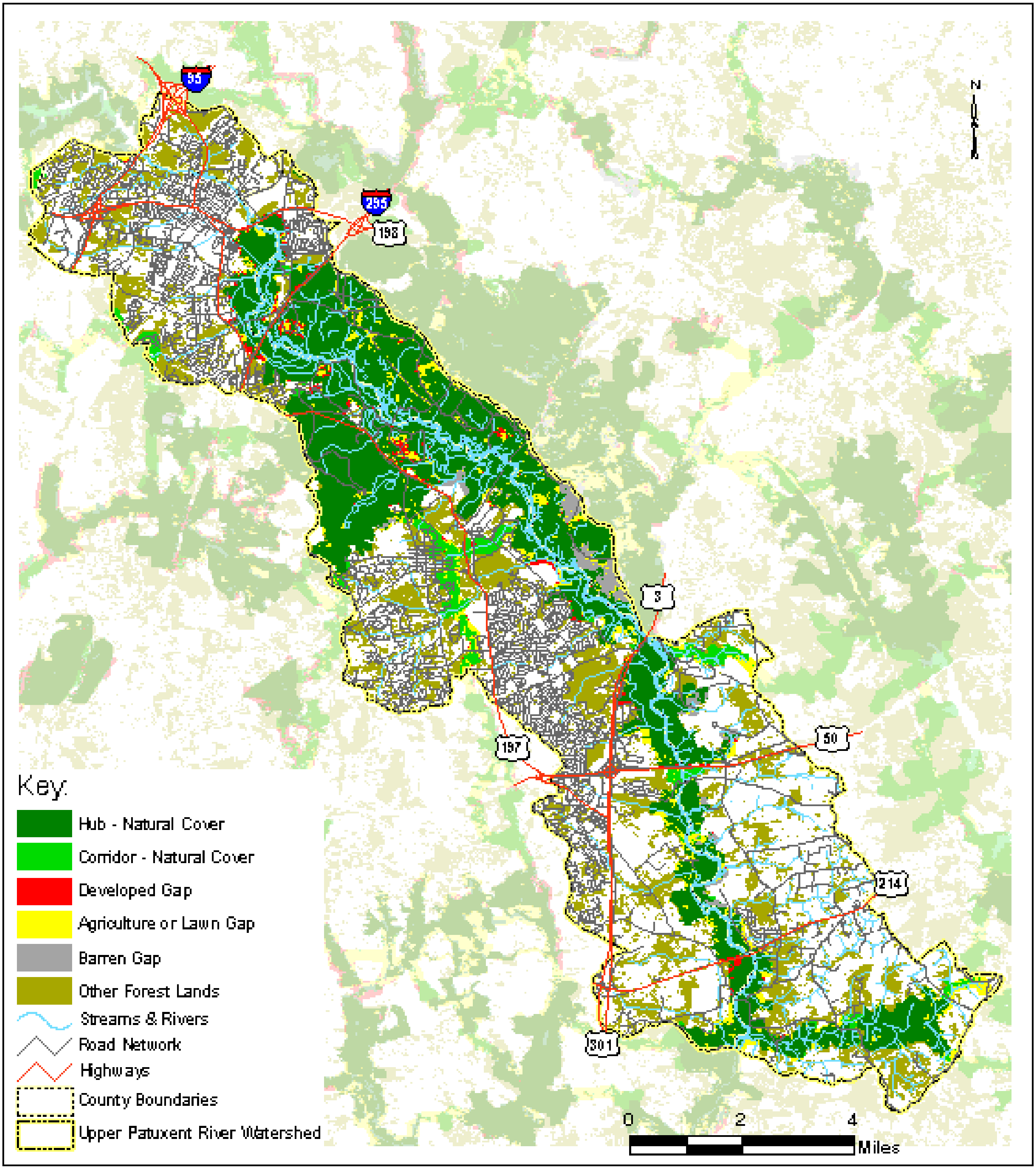
Map 11: Green Infrastructure and other Forested Areas



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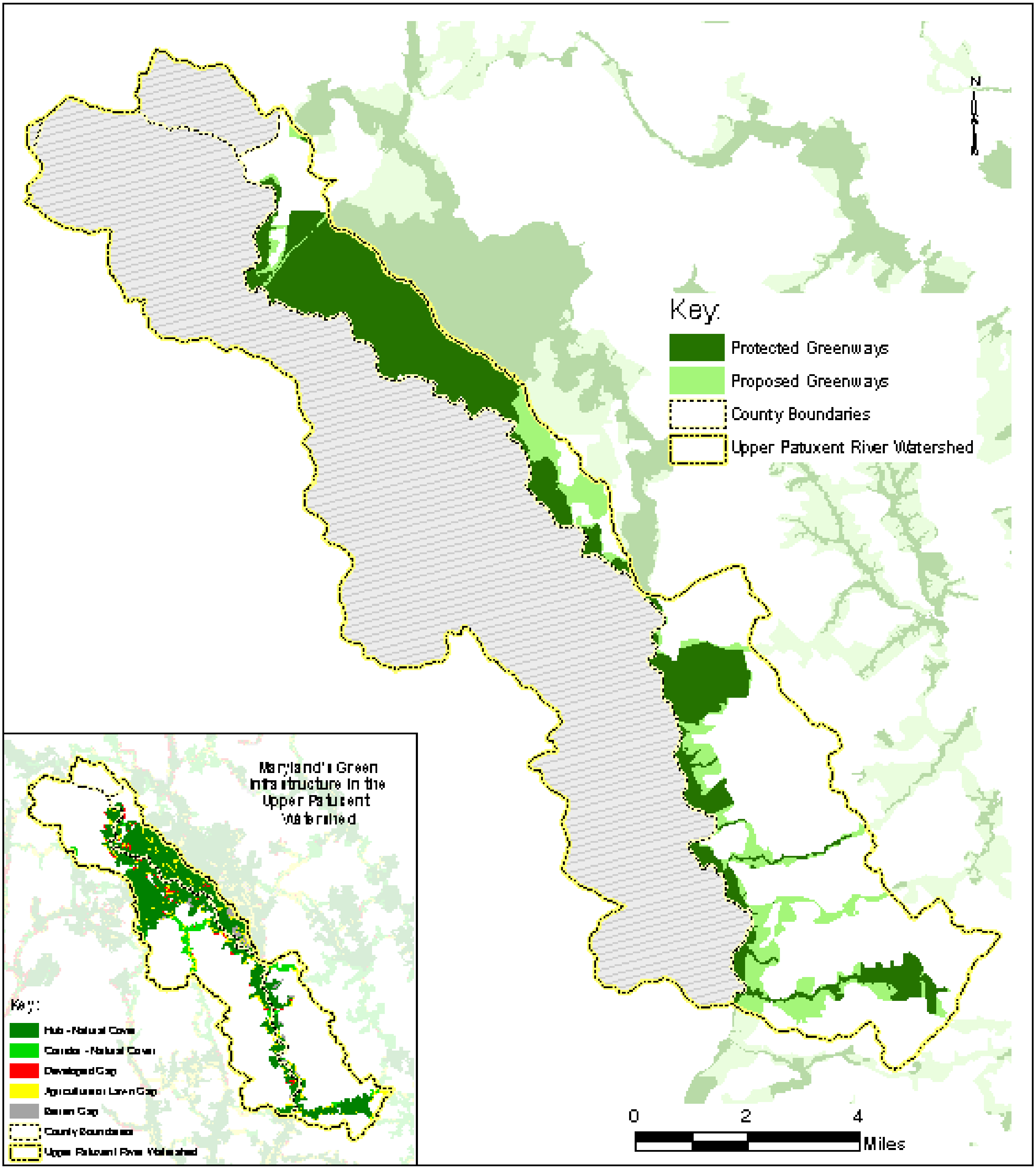
Map 12: Anne Arundel County Greenways Master Plan



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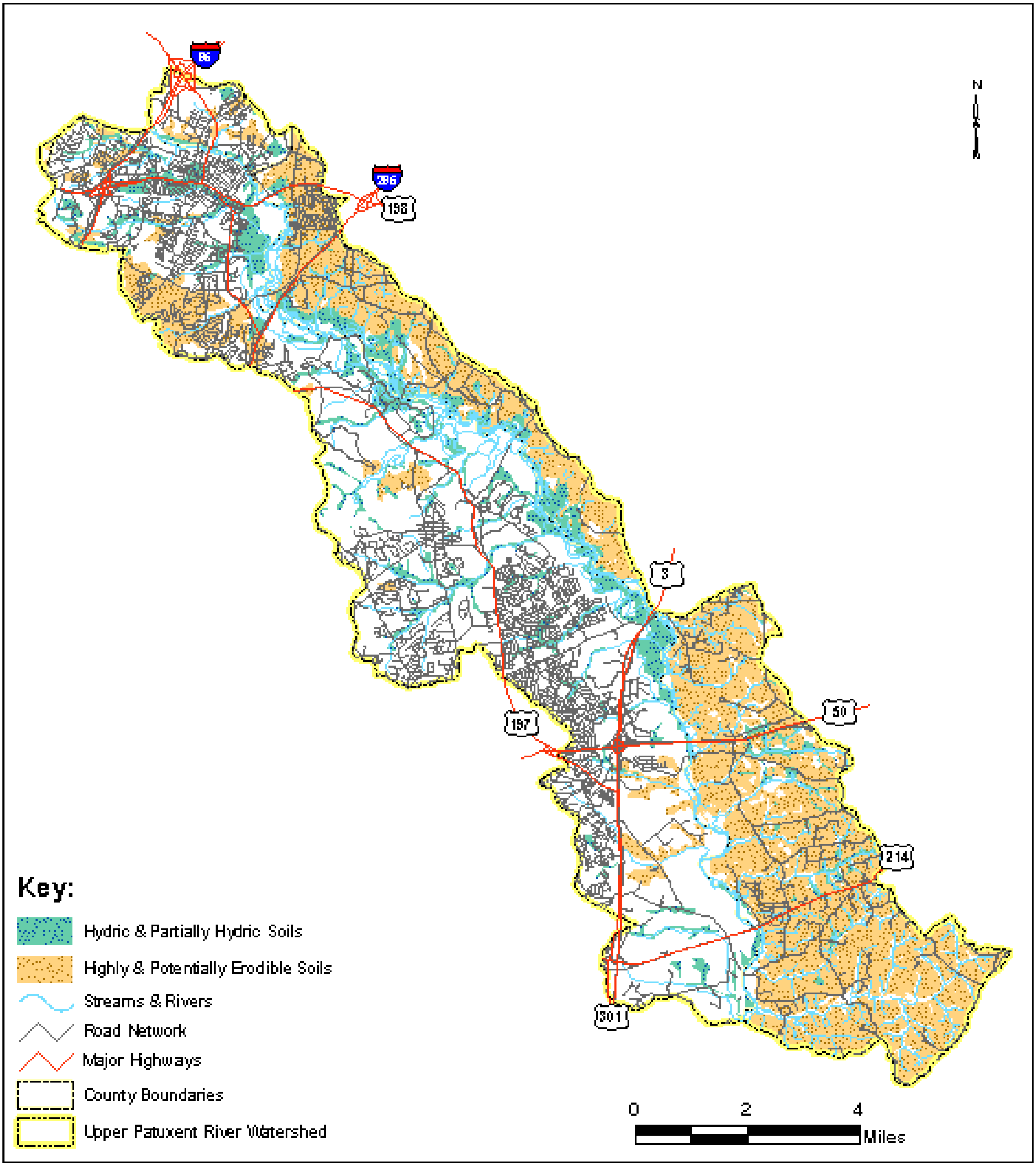
Map 13: Hydric and Erodible Soils



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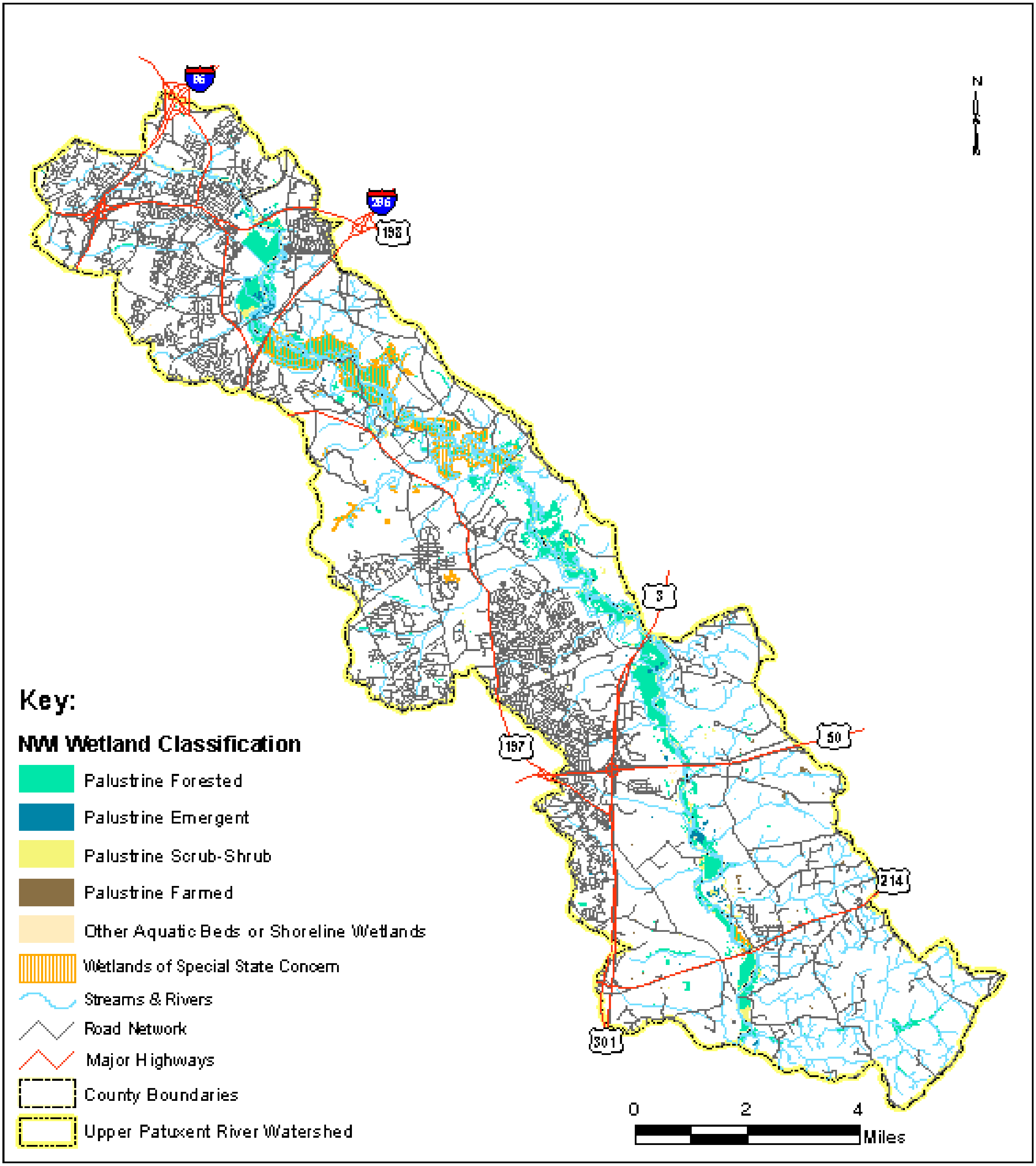
Map 14: Wetlands



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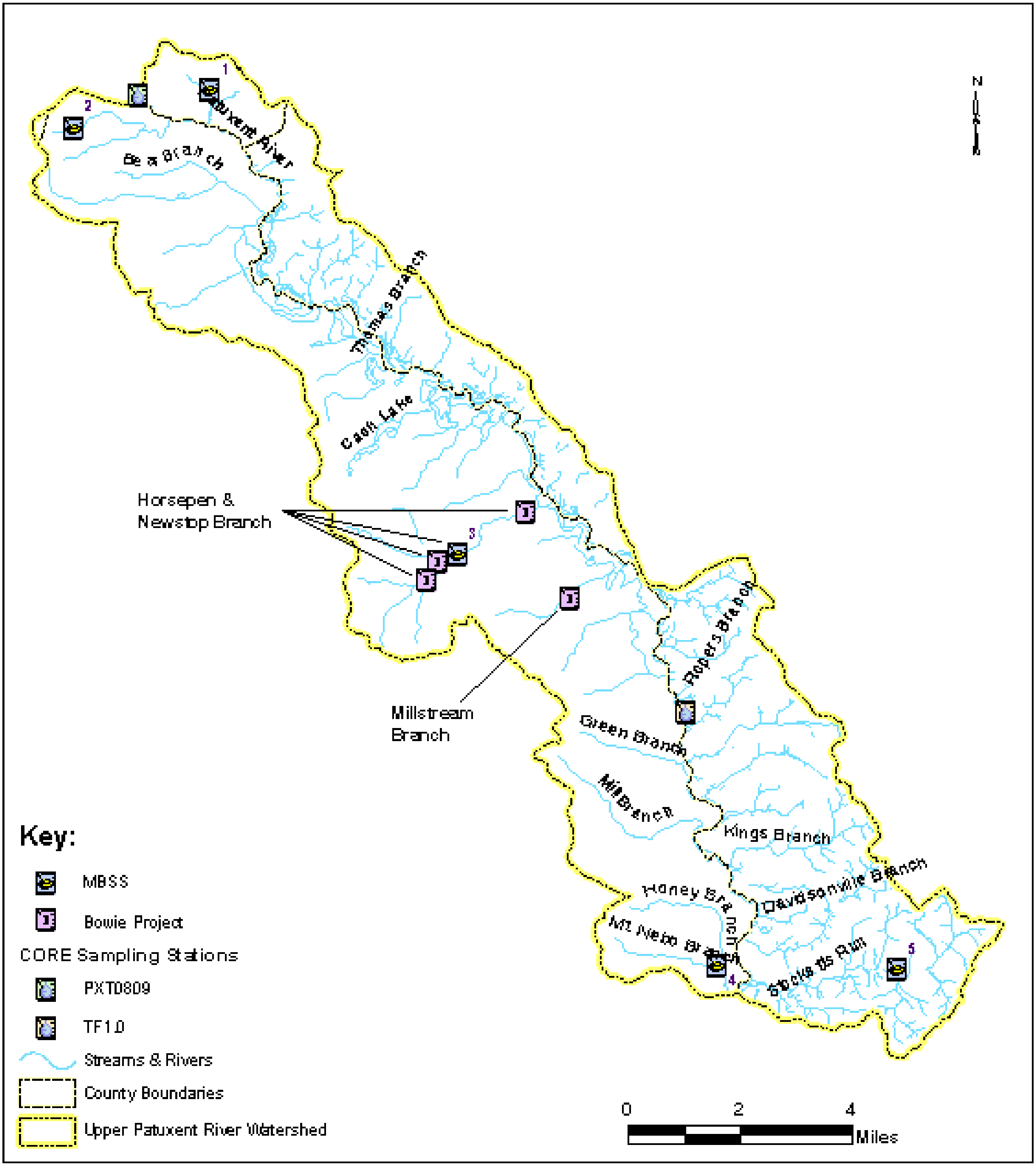
Map 15: Biological Monitoring Sites



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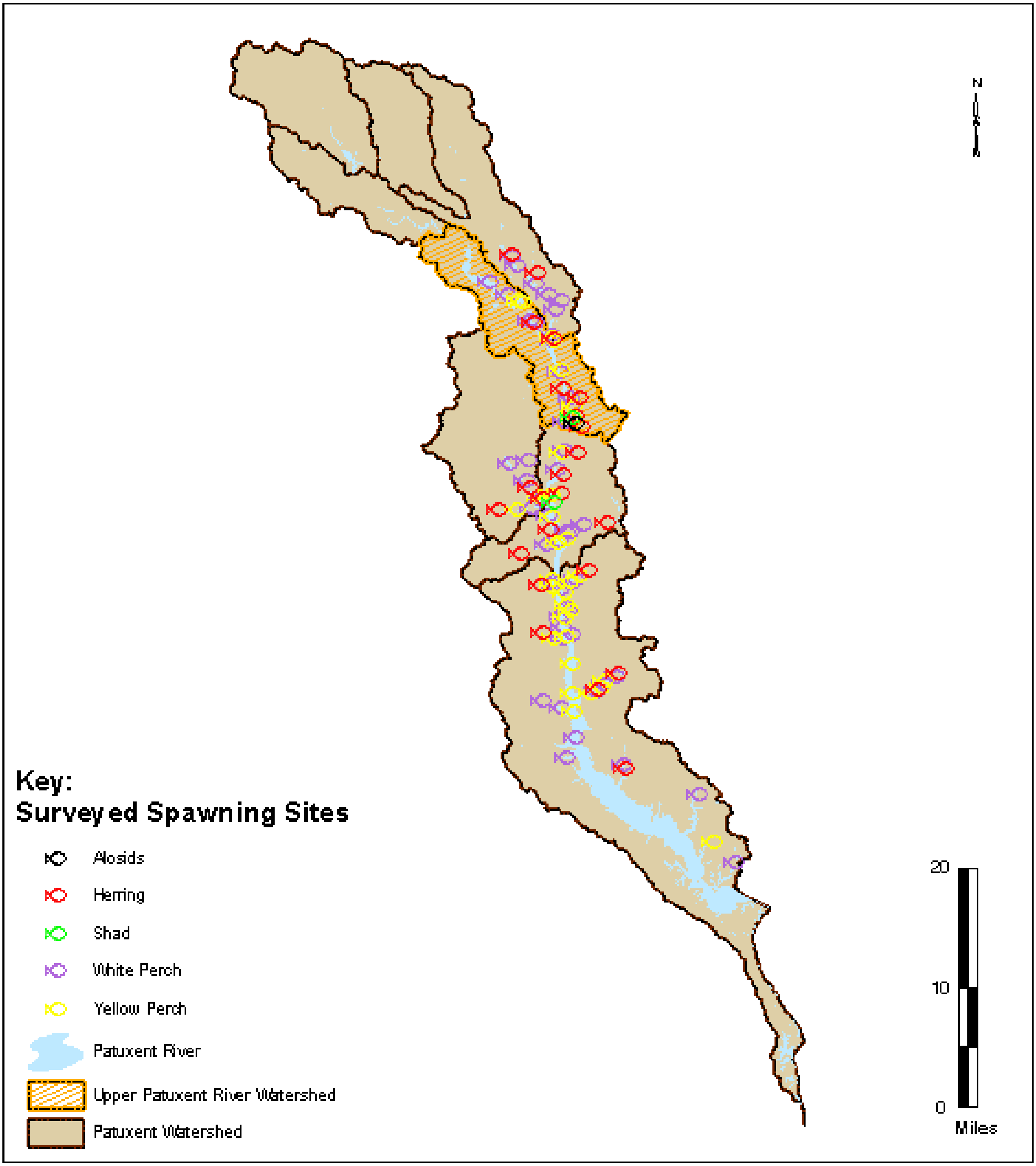
Map 16: Alosid and Perch Spawning Locations



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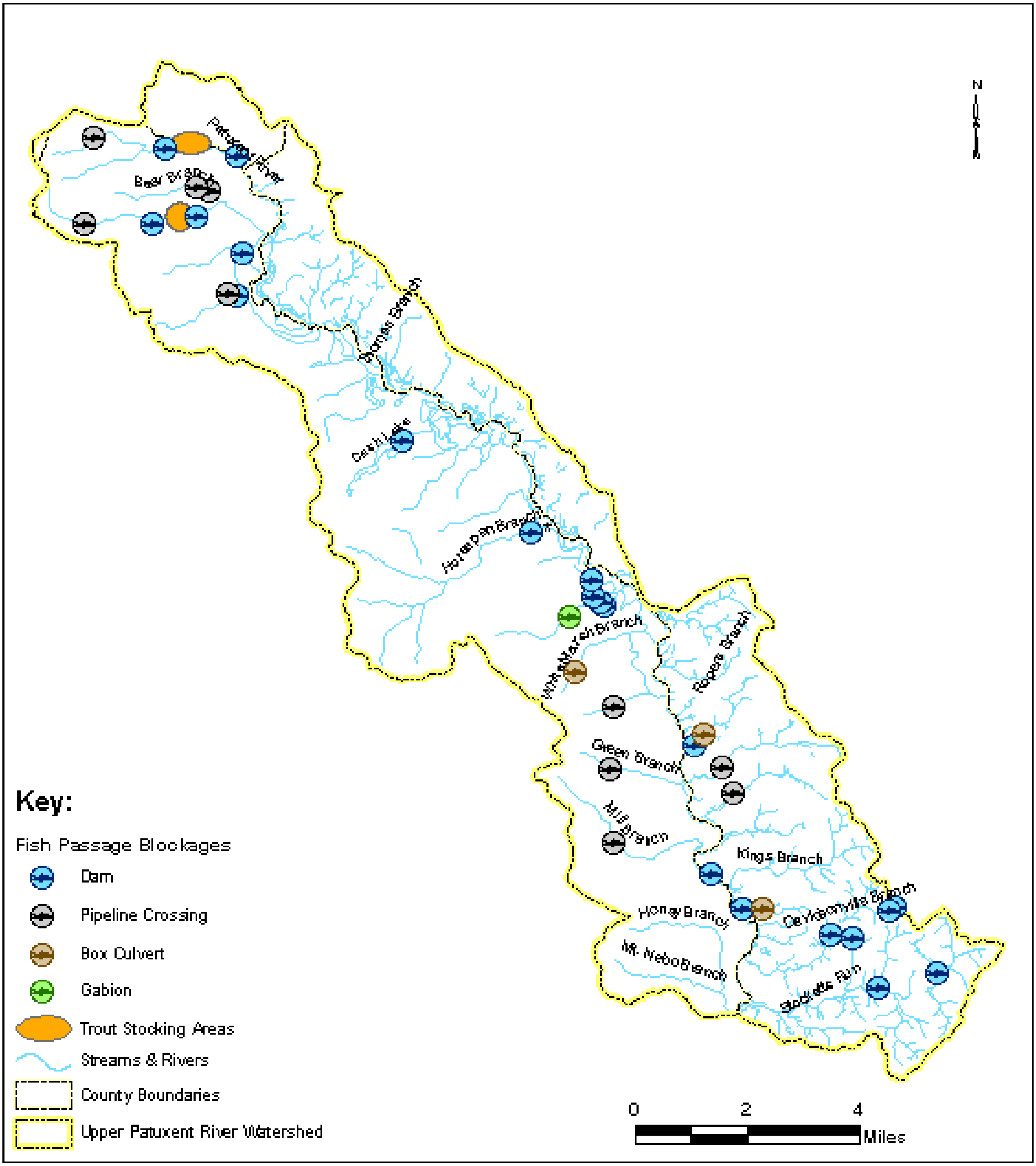
Map 17: Fish Passage Blockages and Trout Stocking Locations



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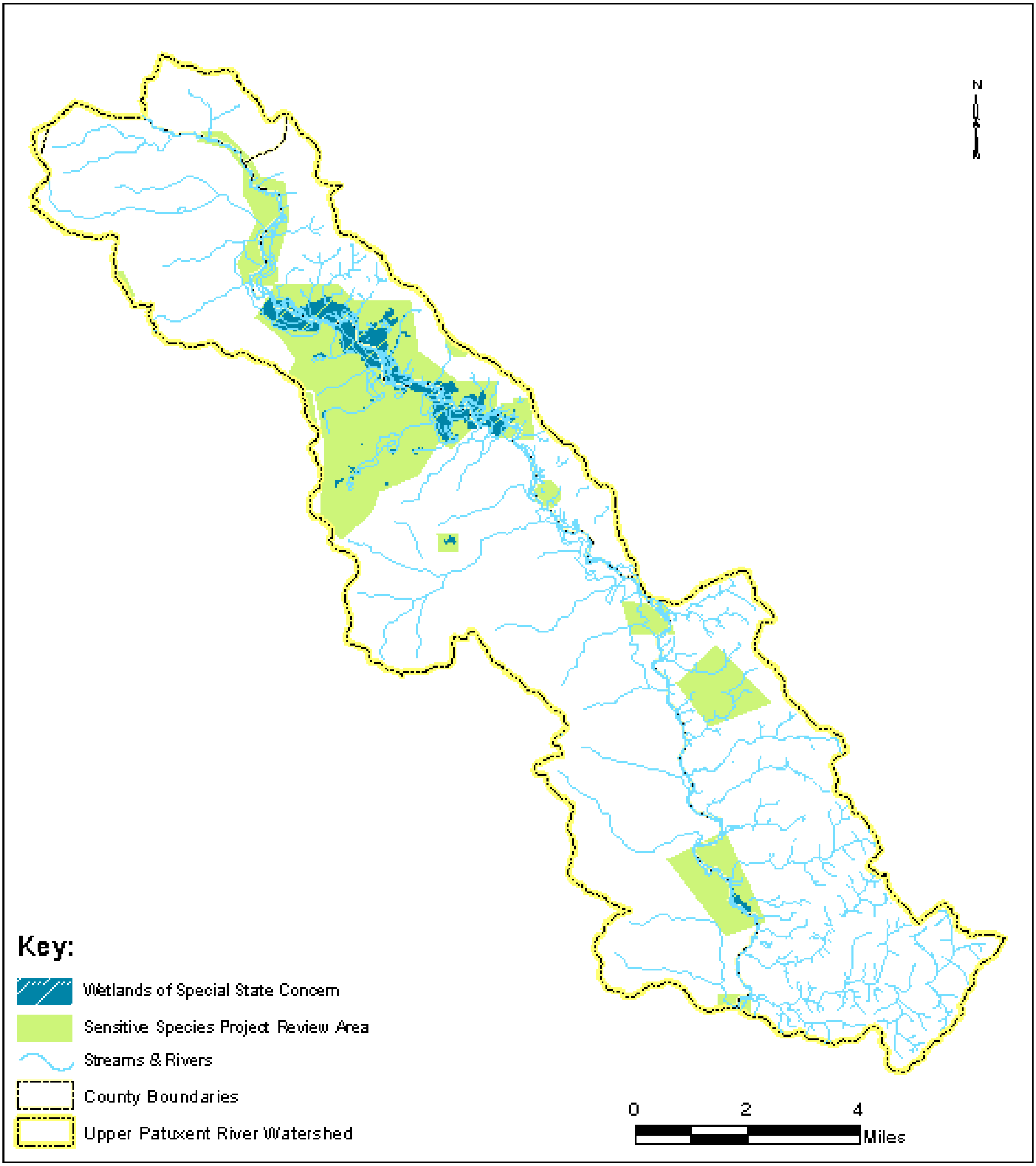
Map 18: Sensitive Species Habitat



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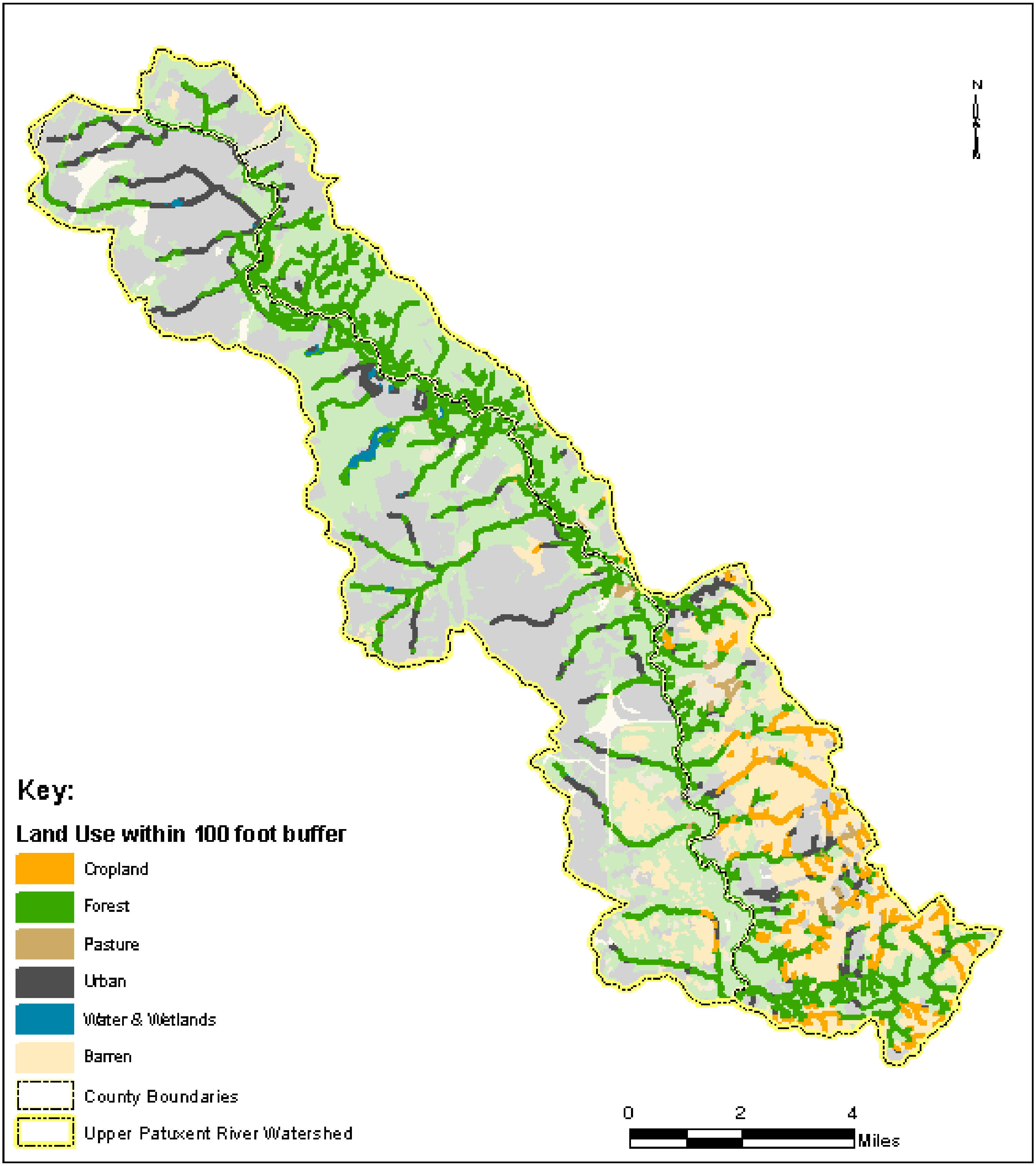
Map 19: Land Use Scenario for Stream Buffer Restoration



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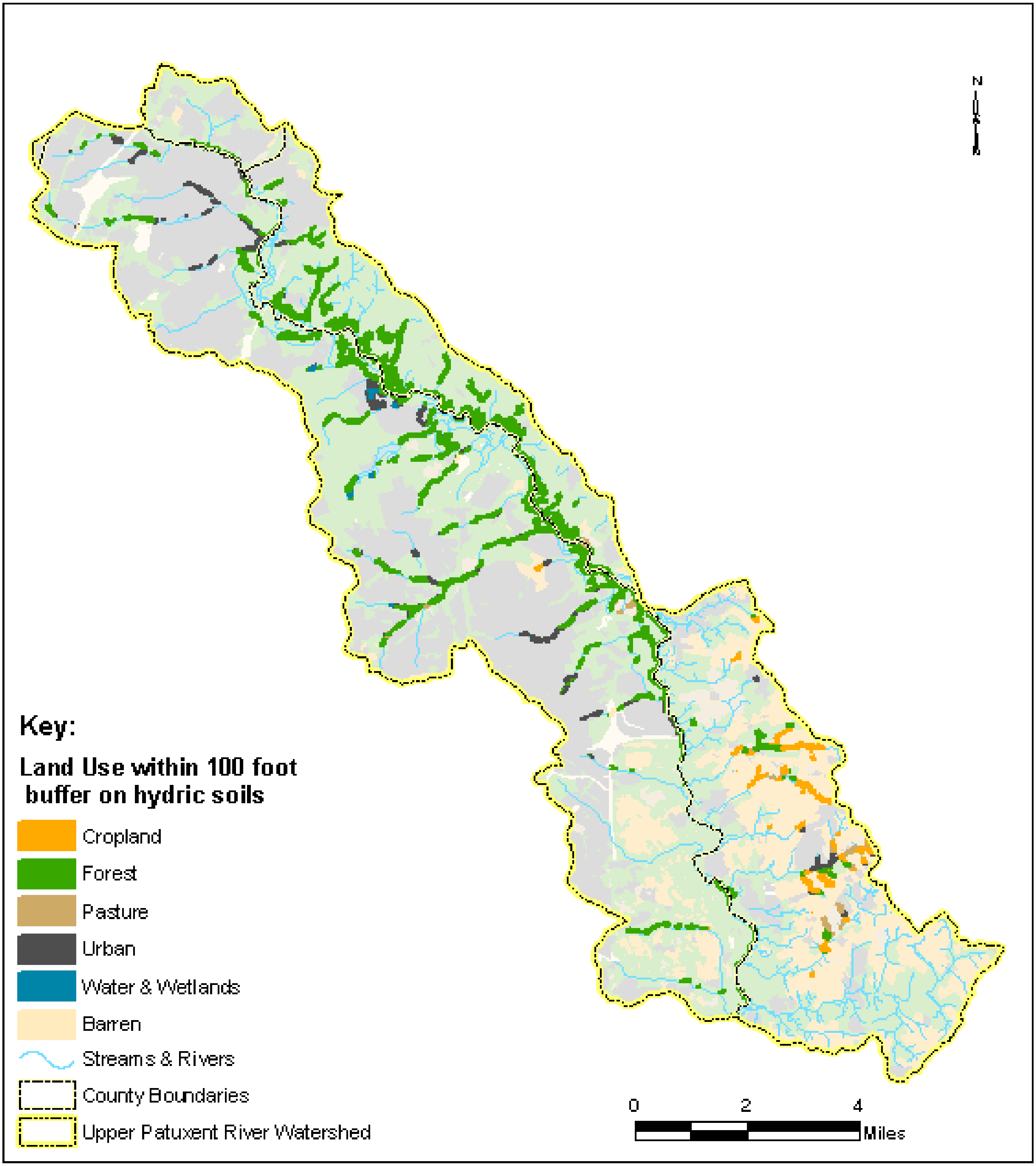
Map 20: Hydric Soils Scenario for Stream Buffer Restoration



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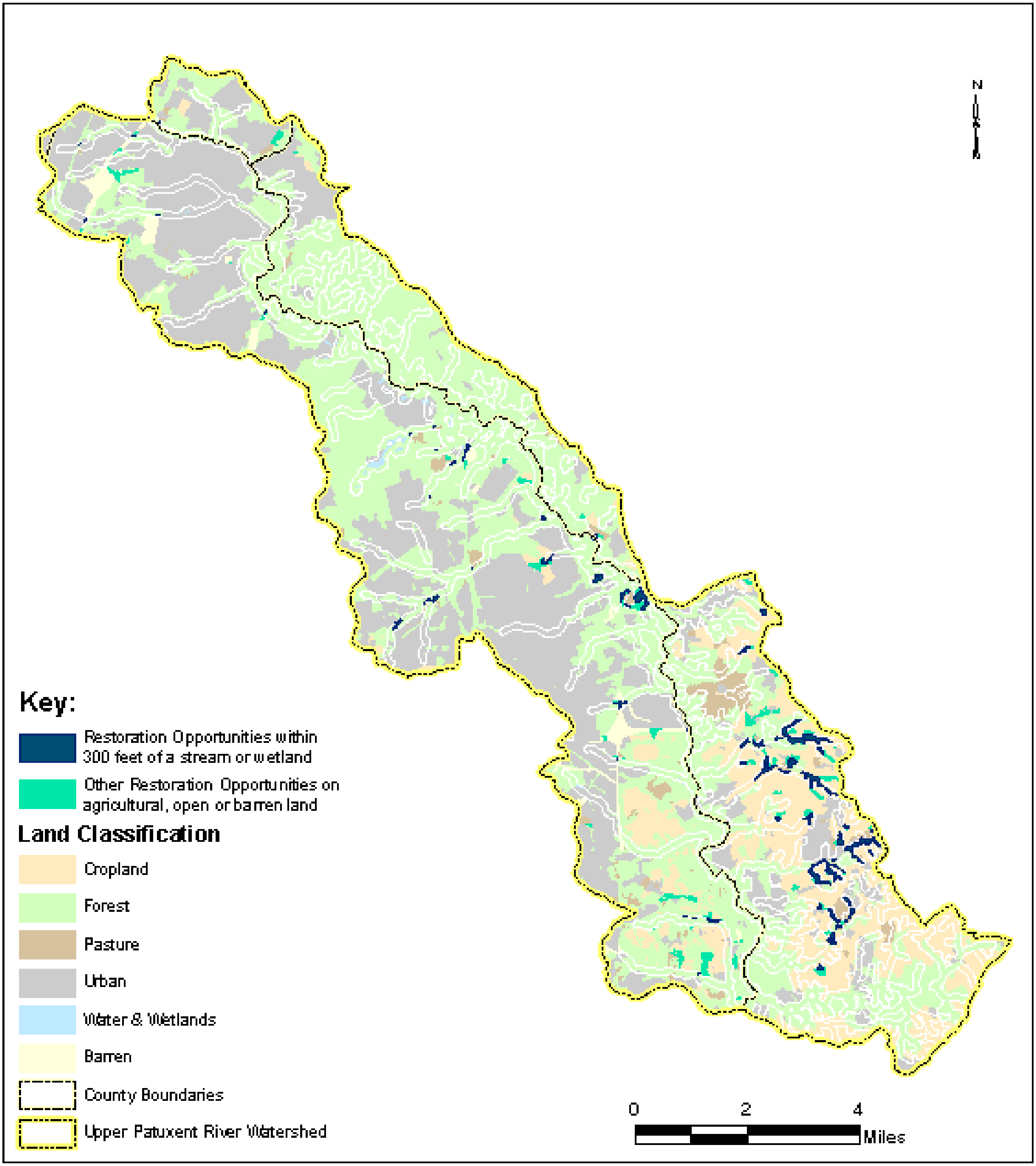
Map 21: Wetland Restoration Opportunites



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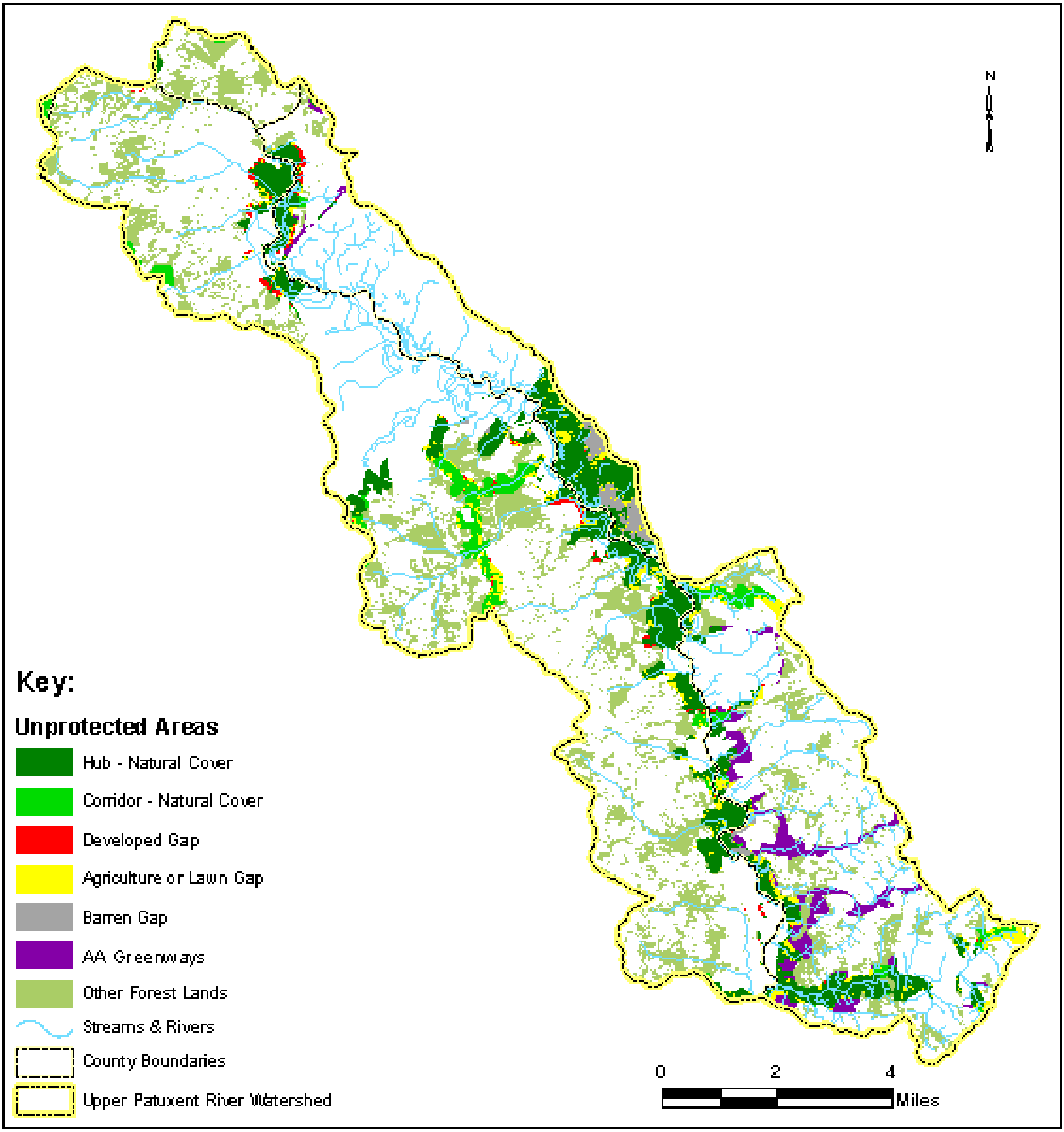
Map 22: Conservation Scenario for Green Infrastructure, Anne Arundel County Greenways & Other Forest Lands



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