

**Upper Patuxent River  
Watershed Restoration Action Strategy  
for  
Anne Arundel and Prince George's Counties, Maryland**

**Anne Arundel County Volume**

**Final Report  
February 2004**



Prince George's County  
Department of Environmental Resources  
Largo, Maryland



**ANNE  
ARUNDEL  
COUNTY**

M A R Y L A N D  
Anne Arundel County

Office of Environmental & Cultural Resources  
Annapolis, Maryland

**Upper Patuxent River  
Watershed Restoration Action Strategy  
for  
Anne Arundel and Prince George's Counties, Maryland**

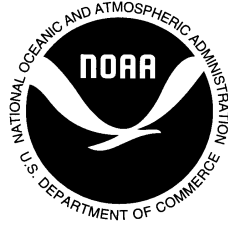
**Anne Arundel County Volume**

**Final Report  
February 2004**

Prepared by  
Anne Arundel County, Office of Environmental & Cultural Resources

**In Cooperation with**  
Office of Planning and Zoning, Geographic Information Systems  
Department of Public Works, Bureau of Engineering  
Department of Recreation and Parks  
Anne Arundel Soil Conservation District  
Prince George's County, Department of Environmental Resources

**Prepared for**  
Maryland Department of Natural Resources, Chesapeake and Coastal Watershed Service,  
Coastal Zone Management Division



Financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration (NOAA). The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA or any of its sub-agencies.



A publication of the Maryland Coastal Zone Management Program, Department of Natural Resources, pursuant to NOAA Award No. NA17OZ1124.

## ABSTRACT

The Upper Patuxent Watershed encompasses 56,399 acres (88 square miles) and lies entirely within Maryland's Coastal Plain. Within the study area, 40% (22,244 acres) of the watershed is located within Anne Arundel County and 57% (32,410 acres) within Prince George's County (Figure 1). The remaining 3% of this watershed (1,745 acres) lies within Howard and Montgomery Counties and is outside of the study area for this WRAS.

In the conduct of this WRAS, Anne Arundel and Prince George's Counties worked closely with State staff to collect existing information and develop a watershed characterization, and to field assess current stream habitat conditions, fish and aquatic invertebrate communities, and baseflow nutrient concentrations and loading rates. Additionally, the WRAS Partners (Anne Arundel and Prince George's Counties, and Maryland DNR) undertook public participation activities to ascertain the perceived issues and assets associated with the Upper Patuxent River watershed. The urban land within this watershed was also reviewed and assessed for the potential to retrofit or implement environmentally sensitive, low impact, development techniques that will address and reduce nonpoint source pollution from site runoff. From the existing information and current assessments, the WRAS Partners developed the Basin Condition Score, a methodology to prioritize subwatersheds for restoration and/or protection activities based on differences in ecological conditions (e.g., water quality, habitat conditions, land uses).

Based upon the work described above, a total of 63 restoration projects were identified in the Upper Patuxent River Watershed in Anne Arundel County. Excess stream erosion was the most frequently observed problem, followed by fish barriers and trash dumps. Habitat restoration project needs were observed in all subwatersheds assessed except for a subwatershed contained on the Patuxent Research Refuge.

Overall, stream macroinvertebrate conditions in the Upper Patuxent River watershed were rated as poor with nearly 75% of sampling sites receiving a rating of poor or very poor. Samples were typically dominated by pollution-tolerant species and had a dearth of sensitive organisms typically associated with unimpacted systems. Baseflow nutrient loading and concentrations in the Upper Patuxent River watershed were generally very low. Only four subwatersheds had stations with nitrate/nitrite concentrations above the 1mg/L threshold established as the limit for unimpaired streams. Only one station had nitrate/nitrite loading in the moderate range. For orthophosphate concentrations, levels were excessive only in Stocketts Run and elevated in a handful of other small subwatersheds.

Based upon the outcome of the WRAS, Anne Arundel and Prince George's Counties will continue to work to implement habitat restoration projects, low impact development techniques, and foster public stewardship of the Upper Patuxent River.

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## I. INTRODUCTION

In 1998, Maryland developed the Clean Water Action Plan (Clean Water Action Plan Technical Workgroup, 1998) to identify and restore watersheds not meeting clean water and other natural resource goals, and to sustain healthy conditions in those watersheds that currently meet these goals. Development of this Plan involved conducting a unified watershed assessment, prioritization for restoration or protection, and developing strategies for restoration or protection. The initial unified watershed assessment classified the Maryland 8-digit watersheds into the following categories:

- Category 1 – Watersheds not meeting clean water and other natural resource goals and needing restoration;
- Category 2 – Watersheds currently meeting goals that need preventive actions to sustain water quality and aquatic resources;
- Category 3 – Pristine or sensitive watersheds that need an extra level of protection; and
- Category 4 – Insufficient data.

Because of this effort, the Upper Patuxent River Watershed (Maryland 8-digit watershed 02131104) was classified as a Category 1 watershed in need of restoration.

The next step in the Clean Water Action Plan (CWAP) process was to assign restoration priorities to each watershed. Watersheds that failed to meet at least half of their goals (i.e., half of the evaluation indicators had values failing to meet Category 1 benchmarks) were considered Category 1 Priority Watersheds in need of restoration action in the near term (e.g., within 2 years of CWAP publication). The Upper Patuxent River Watershed received a Category I Priority for restoration.

The final component in the CWAP is the development of Watershed Restoration Action Strategies (WRAS) for watersheds in need of restoration or protection. A WRAS is a comprehensive restoration strategy that addresses all aspects of watershed condition and water quality. The WRAS is led by the local government, in partnership with the State, and encourages public participation in the strategy development and implementation. In 2002, Anne Arundel and Prince George's County entered into a cooperative agreement with Maryland Department of Natural Resources, to develop a bi-county WRAS for the portion of the Upper Patuxent River watershed located within these two counties. The cooperative agreement provided the Counties with an avenue to apply for and receive grant monies to assist in watershed assessment and planning, receive technical assistance from Maryland Department of Natural Resources (DNR), and develop the watershed restoration action strategy.

The Upper Patuxent Watershed encompasses 56,399 acres (88 square miles) and lies entirely within the Maryland's Coastal Plain. Within the study area, 40% (22,244 acres) of the watershed is located within Anne Arundel County and 57% (32,410 acres) within Prince George's County (Figure 1). The remaining 3% of this watershed (1,745 acres) lies within Howard and Montgomery Counties and is outside of the study area for this WRAS.

The overarching goal of the Upper Patuxent River WRAS is to minimize water quality impacts to the river and its' tributaries from land use changes. To accomplish this goal, action items

were developed based on a review of historic and current natural resources and water quality conditions, as well as through watershed stakeholder input.

In the conduct of this WRAS, Anne Arundel and Prince George's Counties worked closely with State staff to collect existing information and develop a watershed characterization, and to field assess current watershed and water quality conditions. Additionally, the WRAS Partners (Anne Arundel and Prince George's Counties, and Maryland DNR) undertook public participation activities to ascertain the perceived issues and assets associated with the Upper Patuxent River watershed. The urban land within this watershed was also reviewed and assessed for the potential to retrofit or implement environmentally sensitive, low impact, development techniques that will address and reduce nonpoint source pollution from site runoff. From the existing information and current assessments, the WRAS Partners developed a methodology to prioritize subwatersheds for restoration and/or protection activities based on differences in ecological conditions (e.g., water quality, habitat conditions, land uses). Restoration and protection action strategies were then developed to address and improve those ecological conditions, and to achieve the overall WRAS goal.

The overall results of the Upper Patuxent WRAS include:

- Prioritized listing of subwatersheds in need of restoration or protection,
- Prioritized listing of associated subwatershed projects that will address those restoration and protection needs,
- Potential programmatic changes to protect and preserve the Upper Patuxent River watershed.

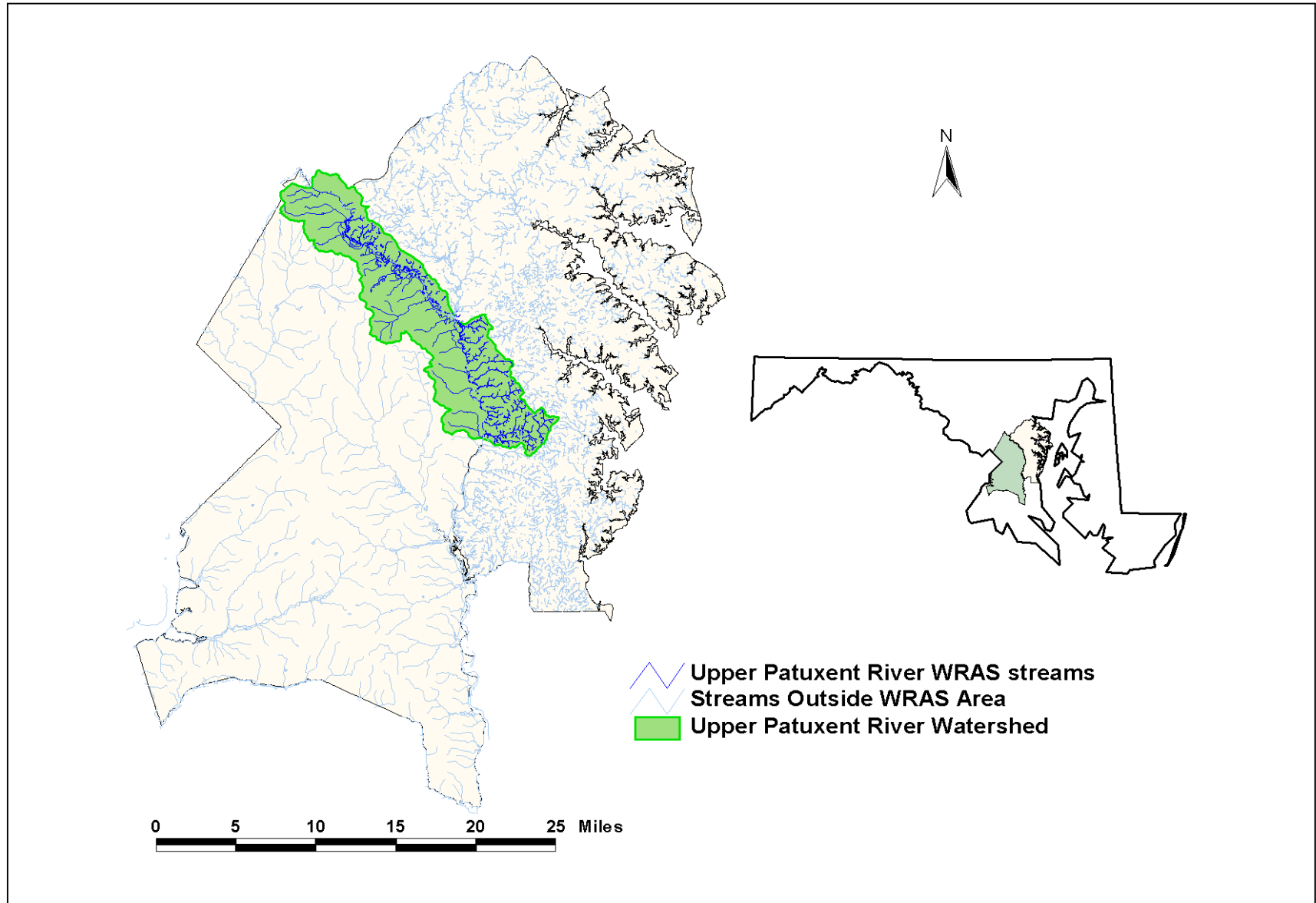


Figure 1. Location of the Upper Patuxent River watershed.

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**II. METHODS**

The WRAS Partners employed several methods to assess the ecological condition of the Upper Patuxent River watershed and to determine appropriate action strategies. Descriptions of each component of this study, and the methodology employed, are noted in the following text.

**WATERSHED CHARACTERIZATION**

The first step in developing the Upper Patuxent River WRAS was to compile and review the existing information relative to this watershed, and develop a watershed characterization based on this information. Existing data and information pertaining to water quality, land use, living resources and their habitats were identified by the WRAS Partners, and compiled and analyzed by DNR staff with input from Anne Arundel County and Prince George’s County staff. Information collected included numerous GIS coverages and associated databases, as well as hard copy data and reports. The information and data were summarized and presented in a succinct format such that the reviewer can readily identify information and issues, as well as sources for additional information. Information contained within the Upper Patuxent River Watershed Characterization is documented in Table 1. Finally, the characterization provides information on additional resources and how they can be used in the development of the WRAS (Maryland DNR, 2002a). The Upper Patuxent River Watershed Characterization was completed in December 2002 and can be found on DNR’s web site at [www.dnr.state.md.us/watersheds/surf/proj/wras.html](http://www.dnr.state.md.us/watersheds/surf/proj/wras.html).

**Table 1. Upper Patuxent River Watershed Characterization Report Contents**

<b>Water Quality</b>
River Basin Context of Local Water Quality Issues
Water Quality Standards and Designated Uses
303(d) Listing – Water Quality Limitations
Total Maximum Daily Loads
Monitored Water Quality – Status and Trends
Fish Tissue Monitoring Data
Pollution Sources – Point and Nonpoint Sources
<b>Land Use</b>
Landscape Indicators
Land Use in the Watershed
Sand and Gravel Mining
2020 Land Use and Land Cover Projections
Zoning
Impervious Surface Coverage
Sewer and Water Service
Smart Growth and Protected Lands
Green Infrastructure
Forested Natural Resource Areas at the Watershed Scale
Anne Arundel County Greenways Master Plan
Soils
Wetlands

**Table 1. Upper Patuxent River Watershed Characterization Report Contents**

<b>Living Resources and Habitat</b>
Living Resource Indicators
Current Biological Monitoring
Historic Biological Monitoring
Recreational and Migratory Fisheries
Sensitive Species
The Patuxent Research Refuge and Wildlife Research Center
<b>Restoration Targeting Tools</b>
2002 Stream Corridor Assessment
Stream Buffer Restoration
Low Impact Development Techniques
Wetland Restoration
Achieving Measurable Water Quality Improvement
Focusing Land Conservation Activities
<b>Potential Benchmarks for WRAS Goal Setting</b>
Coastal Zone Management
Chesapeake 2000 Agreement
Goals from the <i>Clean Water Action Plan</i>
Wetland, Stream and Forest Habitat Goals for Maryland's Tributary Strategies
Water Quality Improvement Act of 1998
Total Maximum Daily Loads
<b>Related Projects</b>
Hydrologic Studies for the City of Laurel
Laurel Lakes Watershed Assessment
The Patuxent River Commission
The Patuxent River Watershed Atlas of Resource and Watershed Management Priorities
Environmental Citizens Groups
Stream Monitoring Programs

**CURRENT CONDITIONS ASSESSMENT**

In addition to developing a watershed characterization based on previously collected data and information, this WRAS also includes a current conditions assessment of the Upper Patuxent River Watershed. The various assessment techniques are discussed below.

**Stream Corridor Assessment**

The Stream Corridor Assessment is one of the technological tools provided to the Counties, by Maryland DNR, to help assess the present environmental condition of the stream network. The Stream Corridor Assessment (SCA) provides a rapid overview of the tributary stream network, provides basic information about those streams, and identifies where potential environmental problems occur. Through this effort, 100 miles of perennial stream were field assessed within the 88 square mile watershed, approximately 50 miles within each County. Because of the size of this watershed and the associated number of stream miles, a subset of perennial streams were

chosen for assessment. Those streams targeted for the SCA are contained within drainage basins that exhibit land uses representative of the overall land uses within the watershed.

Members of the Maryland Conservation Corps (MCC), who had completed an intensive training program designed and instructed by Maryland DNR staff, conducted the Upper Patuxent River Watershed SCA. Through the intensive training, the MCC teams learned to assess the general condition of in-stream and riparian habitats, and to identify and assess severity and correctability for the following environmental problems:

- Channel alterations
- Exposed pipes
- Fish migration barriers
- Construction in or near the stream
- Unusual conditions observed (e.g., odors, scum, excessive algae, water color/clarity, red flock, sewage discharge, oil)
- Stream bank erosion sites
- Pipe outfalls
- Inadequate Stream Buffers
- Trash dumping sites

The Anne Arundel County Upper Patuxent River SCA surveys were conducted between late spring and early summer 2002. The Upper Patuxent River watershed was divided into a northern portion and a southern portion. The northern portion extends south from Maryland Route 198 to the confluence of the Patuxent and Little Patuxent Rivers while the southern portion extends south from the confluence to just below Maryland Route 214. Nine subwatersheds were identified for this assessment, two located in the northern portion of the Upper Patuxent River watershed, and seven in the southern portion. Most of the assessment was concentrated in southern subwatersheds because most of the northern portion subwatersheds are under control of the Patuxent Research Refuge and have very similar land uses. Figures 2 and 3 show the subwatersheds chosen for the SCA survey in Anne Arundel County. Table 2 summarizes basic information about each basin. See Pellicano and Yetman (2002), which can be downloaded from the Maryland DNR web site at [www.dnr.state.md.us/watersheds/surf/proj/wras.html](http://www.dnr.state.md.us/watersheds/surf/proj/wras.html), for complete results.

MCC teams physically walked along the targeted perennial streams, documenting the location, severity, and potential correctability of observed environmental problems. Prior to initiating this survey, Anne Arundel County staff sent information letters to all persons owning land adjacent to the targeted stream reaches. These letters also requested property owner permission to access the stream adjacent to the property, and provided a phone number and e-mail address to contact if the landowner did not want the crews to survey the stream on their property. Additionally, survey crews were instructed to not cross fence lines or enter any areas marked as “No Trespassing” unless specific permission to access the property had been granted by the landowner.

In preparation for the field component of the SCA, the survey manager identified representative sites along each stream reach where survey crews were instructed to record specific information regarding in-stream habitat conditions, wetted width of the stream, thalweg depth, and bottom type. These “representative sites” were denoted on the field maps used by the survey crews.

In the physical conduct of the SCA, field survey crews walked each mile of identified stream, documented any observed problems, and recorded required in-stream information for the “representative sites.” Documentation of observed problems also included determining the



severity of the problem, the ease of correcting that problem, and the accessibility of the problem site. A unique identification number was assigned to each problem observed and to each reference site identified along each surveyed stream reach. Each identifier was correlated to a location on the field map.

Photographs of the problem areas and the reference sites were taken to document field conditions from both the upstream and downstream views. MCC crews completed field data sheets for each environmental problem observed, as identified above, as well as for the representative sites along the stream reach. The results of the SCA survey efforts were submitted to Maryland DNR staff

**Table 2. Anne Arundel County Subwatersheds Assessed for the Upper Patuxent River WRAS**

<b>Subwatershed</b>	<b>Survey Team</b>	<b>Length Of Stream Surveyed (Miles)</b>	<b>Drainage Area (Acres)</b>
UPN1 (Unnamed Tributary to the Patuxent River)	DNR	1.77	358
UPN7 (Unnamed Tributary to the Patuxent River)	DNR	0.88	221
UPS1 (Cox Branch)	DNR	6.64	988
UPS3 (Unnamed Tributary to the Patuxent River)	DNR	4.00	725
USP4 (Unnamed Tributary to the Patuxent River)	DNR	5.57	1,266
UPS6 (Unnamed Tributary to the Patuxent River)	DNR	2.53	600
UPS9 (Stocketts Run)	DNR	23.9	4,108
UPS10 (Unnamed Tributary to the Patuxent River)	DNR	1.96	314
UPS11 (Unnamed Tributary to the Patuxent River)	DNR	0.97	129
<b>Total Surveyed</b>		<b>48.22</b>	<b>8,709</b>

who compiled the information into a database format, labeled and organized all photographs by site, and incorporated all data and photographs into a readily usable GIS format.

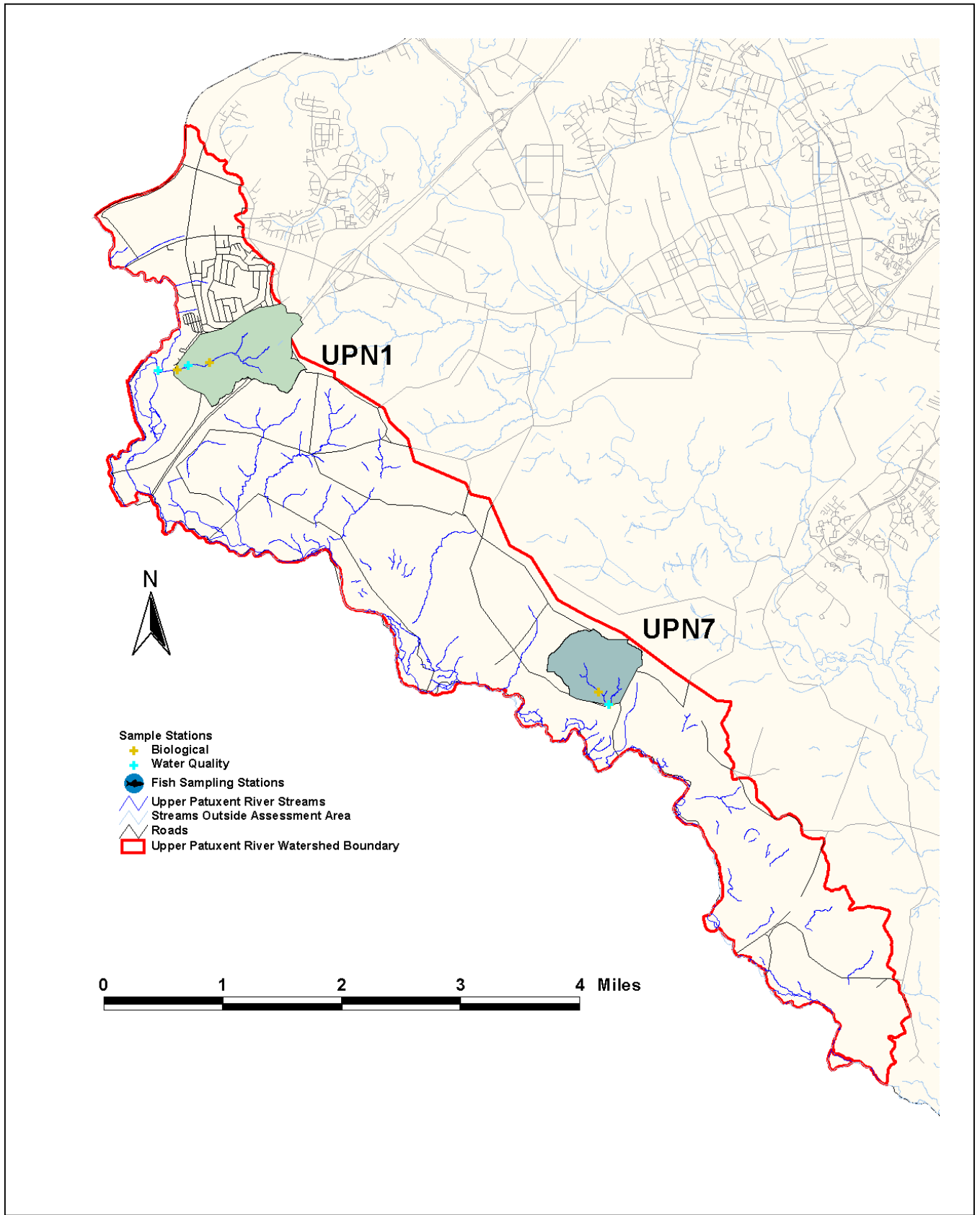
Complete information on the SCA methodology, including descriptive information for each problem type, and definitions for levels of severity, correctability, and accessibility, can be found

in “Stream Corridor Assessment Survey – Survey Protocols (Yetman, 2001). This document is available on-line, at the Maryland DNR web site, at <http://www.dnr.state.md.us/streams/pubs/other.html>.

Prince George’s County also divided the stream corridor assessment areas into two watershed areas, the Upper and Lower Watershed. The Upper Watershed consists of eight subwatersheds and the Lower has 10 subwatersheds. To increase the number of stream miles assessed, Prince George’s County performed additional stream corridor surveys. The County surveyed an additional 25.3 miles in Upper Watershed and Maryland DNR completed 57 stream miles. The watersheds surveyed, survey team, length of stream miles and drainage area of each watershed are identified in Table 3. The location of each Prince George’s County subwatershed is shown in Figures 4 and Figure 5.

**Table 3. Prince George’s County Stream Corridor Assessments**

<b>Subwatershed</b>	<b>Survey Team</b>	<b>Length of Stream Surveyed (miles)</b>	<b>Drainage Area (acres)</b>
<b>Upper Watershed</b>			
Bear Branch	PGC	6.8	1,562
Walker Branch	PGC	5.5	1,282
Crows Branch	PGC	4.3	1,100
Tributary 5	PGC	3.5	1,115
Tributary 6	PGC	2.3	1,084
Tributary 8	PGC	1.0	402
Patuxent Wildlife Refuge	PGC	1.2	474
Tributary 7	PGC	0.7	347
<b>Total Surveyed by PG</b>		<b>25.3</b>	<b>7,366</b>
<b>Lower Watershed</b>			
Horsepen Branch	DNR	19.4	4,332
Mill Branch	DNR	9.4	2,270
Green Branch	DNR	6.5	1,218
Honey Branch	DNR	2.5	1,083
Mount Nebo Branch	DNR	4.2	1,186
Tributary 3	DNR	4.5	1,640
Marsh Branch	DNR	4.3	1,053
Tributary 4	DNR	2.7	572
Tributary 1	DNR	2.5	746
Tributary 2	DNR	1.0	420
<b>Total Surveyed by DNR</b>		<b>57.0</b>	<b>14,520</b>
<b>Grand Total</b>		<b>82.3</b>	<b>21,886</b>



**Figure 2. Distribution of sampled subwatersheds in the northern portion of the Upper Patuxent River Watershed, Anne Arundel County.**

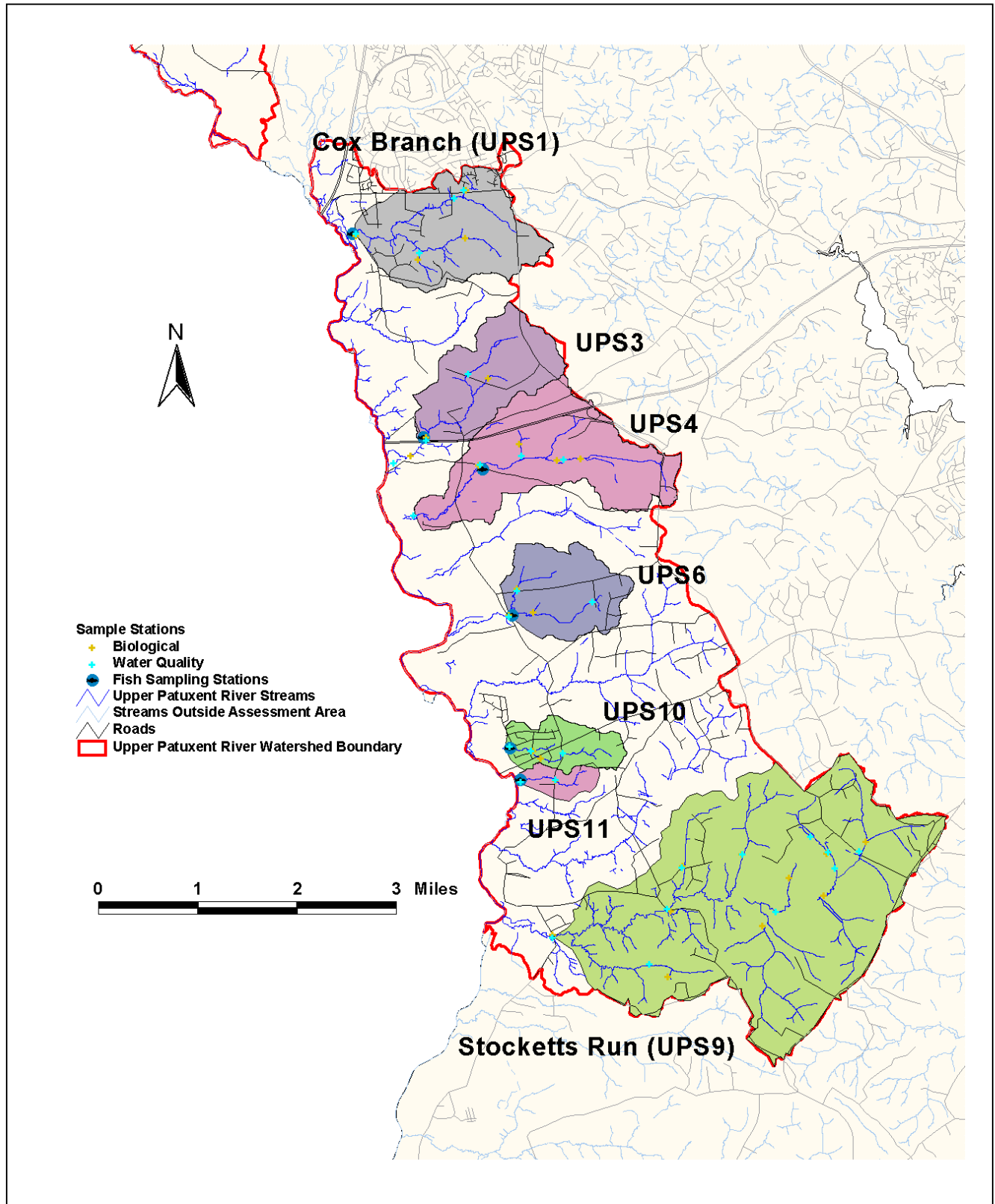


Figure 3. Distribution of sampled subwatersheds in the southern portion of the Upper Patuxent River Watershed, Anne Arundel County.

## Synoptic Surveys

The ability of a stream to support a diversity of aquatic life depends on the quality and availability of habitat as well as the physical and chemical characteristics of its water quality. While the habitat features of a stream can be easily observed, measurements of water quality require field sampling and usually some laboratory analyses of the samples. Results of a sampling program can also be highly variable and difficult to interpret, particularly if only a wet weather sampling program is undertaken.

Staff from Maryland DNR, in support of the Upper Patuxent WRAS, conducted synoptic surveys for water quality and biological community (benthic macroinvertebrate and fish) assessment in the spring and summer sampling periods. Maryland DNR synoptic survey sampling locations are denoted on Figures 2 and 3 in Anne Arundel County and in Figures 4 and 5 in Prince George's County. Complete details can be found in Maryland DNR (2002b), which can be downloaded from the DNR web site at [www.dnr.state.md.us/watersheds/surf/proj/wras.html](http://www.dnr.state.md.us/watersheds/surf/proj/wras.html).

### Water Quality Sampling

Synoptic water quality sampling, performed by Maryland DNR, occurred in the spring of 2002. Baseflow grab samples were collected at 31 sites in Anne Arundel County and 25 sites in Prince George's County. Samples were collected mid-stream, just below the water surface, and filtered on-site using Gelman GF/C 45 $\mu$  pore size filters. *In situ* water quality data and stream discharge measurements were taken at the time of sample collection. *In situ* parameters (i.e., water temperature, dissolved oxygen, pH, and conductivity) were measured using a Hydrolab Surveyor II.

The filtered water samples were stored on ice and frozen on the day of collection. Filtered samples were analyzed for dissolved inorganic nitrogen (NO<sub>3</sub>, NO<sub>2</sub>) and dissolved inorganic phosphorus (PO<sub>4</sub>) at the University of Maryland's Chesapeake Biological Laboratory. All analyses were conducted in accordance with U.S. EPA protocols.

Nutrient yields per unit area were calculated using watershed areas determined from digitized watershed maps. Where sampling sites were nested within a subwatershed, the mapped concentration for the downstream site was shown only for the area between that site and the next site upstream. Yield calculations for the downstream site, however, were based on the entire area upstream of that site, but were mapped showing just the area between sites. Therefore, the reported yields for the downstream sites illustrate the cumulative impact from all upstream activities.

Within Prince George's County, supplemental water quality monitoring was performed during the summer months. A cost effective initial water characterization was conducted during dry summer conditions when baseflow is at its lowest and water temperatures at a maximum. This is often a critical period for the survival of aquatic life. Water quality during this period can serve as a useful starting point for watershed restoration efforts and for the comparison of the water quality of different watersheds. Unless water is of sufficient quality during summer baseflow, restoration efforts to improve habitat or to reduce impacts on water quality will not be successful. The lower variability of baseflow water quality also allows differences in the water quality between watersheds to be more clearly observed.

The five watersheds selected in Prince George’s County for supplemental water quality characterization have a total drainage area of 8,409 acres and represent 26% of the total Upper Patuxent watershed area (Table 4; Figures 4 and 5 for station locations). They include a range of land uses and watershed sizes. The range in watershed size and land use is also intended to support a comparative analysis of more urbanized watersheds versus a reference forested site. Monthly sampling was completed from June to September for a total of three samples per site. Water quality parameters measured included temperature, pH, nutrients (Total Nitrogen, Total Phosphorus), trace metals (lead, zinc and copper) and Biochemical Oxygen Demand (BOD5). Discharge measurements were taken in conjunction with water sampling to determine baseflow loading estimates of the monitored parameters. The summer baseflow sampling effort augmented the spring baseflow sampling program completed by Maryland DNR in April of 2002.

**Table 4. Five Subwatersheds Selected for Supplemental Baseflow Characterization**

<b>Stream</b>	<b>Sampling Location</b>	<b>Drainage Area</b>	<b>Land Uses</b>
Mount Nebo	4-H Club Access Road south of Queen Anne Road	1114 Acres	Forested (50%) Low-density residential (20%) Agriculture (20%) Transportation (10%)
Horsepen Branch	At intersection with MD 197	3900 acres	Medium Density Residential (65%) Forested (25%) Golf Courses (5%) Commercial (5%)
Green Branch	Adjacent to Ballpark Road	531 Acres	Medium Density Residential (45%) Commercial (30%) Transportation (15%) Forested (10%)
Unnamed Tributary Draining to Blue Gill Pond (Reference Site)	Adjacent to exit road for the Patuxent Wildlife Refuge or alternatively adjacent to Loblolly Pine Drive	350 Acres	Forested (95%) Transportation (5%)
Crows Branch downstream of Confluence with Bear Branch	Adjacent to Bowie Road	2514 Acres	Commercial (15%) Medium Density Residential (50%) High Density Residential (10%) Forested (15%) Other (10%)



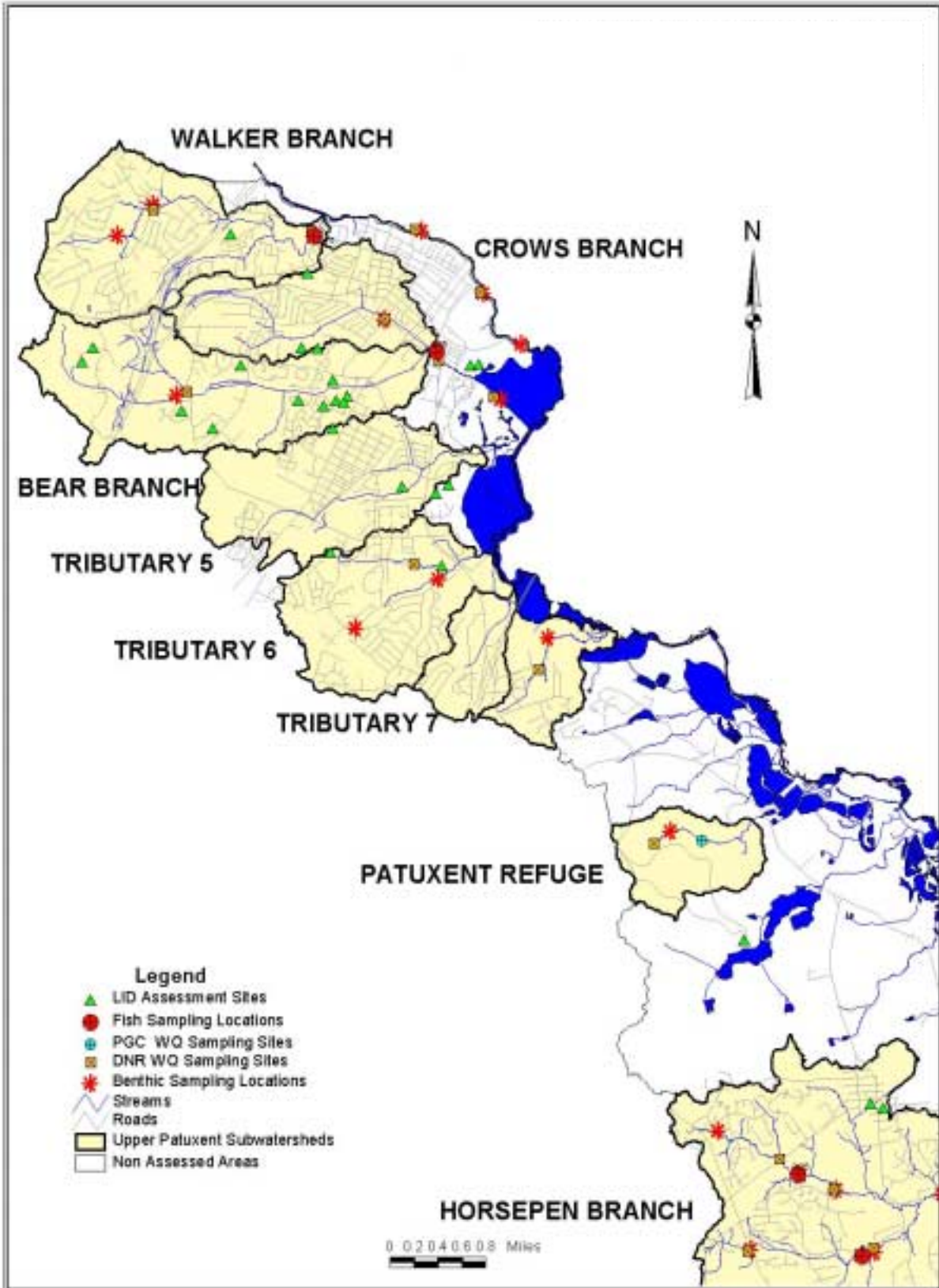


Figure 4. WRAS subwatersheds in the northern portion of the Upper Patuxent River Watershed, Prince George's County.

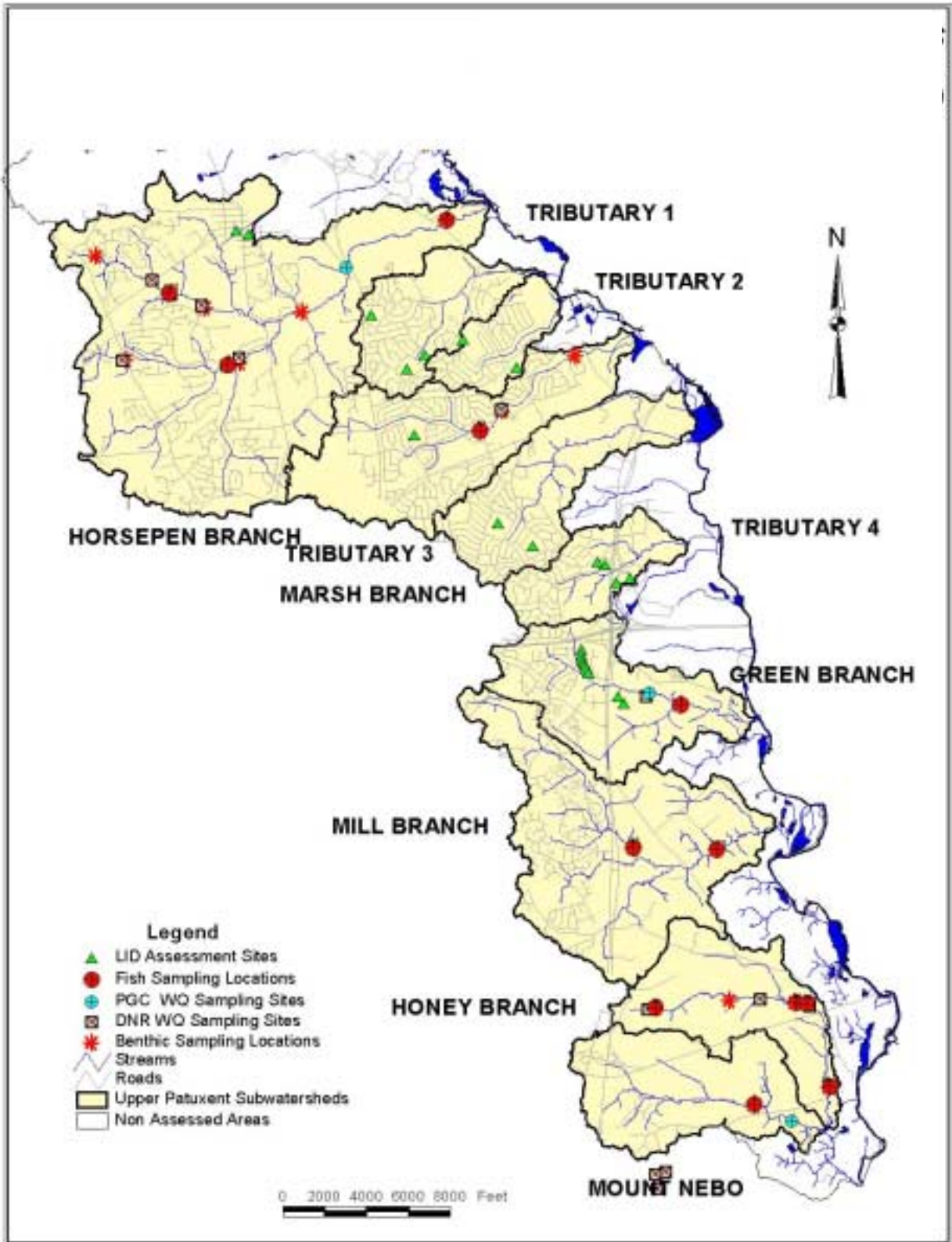


Figure 5. WRAS subwatersheds in the southern portion of the Upper Patuxent River Watershed, Prince George's County.



### Benthic Macroinvertebrate Sampling

Aquatic benthic macroinvertebrates were collected during the spring indexing period, concurrent with the synoptic water quality sampling. Samples were collected at nine sites in Anne Arundel County and six sites in Prince George's County. These sites were also sampled for water quality.

Macroinvertebrates were collected over a 20m<sup>2</sup> area of best available habitat using a 500- $\mu$  mesh size, 0.3m wide D-frame net. The best available habitats were defined as gravel riffles, snags, submerged vegetation, and root mats. Habitats were sampled in proportion to their occurrence at the designed sampling area. Samples were composited in a sieve bucket, fine sediments washed out, and large debris rinsed and discarded in the field. The remaining sample was transferred to a storage container, preserved with 70% ethanol, and returned to the laboratory for processing. In the laboratory, a 100-organism subsample was randomly collected from the field sample using a gridded tray. Organisms were identified to genus, recorded on a bench sheet, and archived for future reference. From these data, a macroinvertebrate index of biotic integrity (IBI) was calculated to facilitate ranking of site quality.

### Macroinvertebrate Habitat Assessment

In-stream and riparian habitat quality was assessed at the nine macroinvertebrate sampling sites in Anne Arundel County and the six sites in Prince George's County. This assessment, modified from Plafkin et al. (1998) to focus on the macroinvertebrate habitat, rates the in-stream structure, channel and lower bank morphology, and the upper bank and riparian area using a series of metrics. The metrics are weighted to provide more scoring potential to the parameters most directly influencing the macroinvertebrate community.

The primary habitat metrics rate the in-stream habitat quality and quantity available for use by the macroinvertebrate community. These metrics include the amount and type of woody debris, prevalence of undercut banks, the degree of embeddedness in riffles, pool depth, water velocity, and flow. These metrics are also given the most weight because of their direct importance to the health and diversity of the in-stream macroinvertebrate community. Secondary metrics assess channel morphology, rating the quality of the lower bank and structure of the stream channel. These metrics include relative measures of riffle extent, channel sinuosity, and extent of channel alterations caused by high flow events. These metrics receive less weight than the primary metrics because of their less direct impact on the in-stream macroinvertebrate communities. The tertiary metrics rate the quality of the upper bank and adjacent riparian areas. These metrics include scoring of the type and amount of bank vegetation, amount and frequency of bank erosion, and land use in the riparian area. These characteristics of the watershed are given the least weight because they are less important to the in-stream macroinvertebrate community.

### Fish Community Assessment

In the summer of 2002, fish were collected at six sites in Anne Arundel County and four sites in Prince George's County using backpack electroshocking gear. This sampling occurred in the summer to coincide with the MBSS index period for fish sampling. Block nets were placed at each end of a 75-meter reach of stream to preclude the fish from escaping. Two passes through this 75-meter reach were made with the backpack electroshockers. Fish were collected, weighed, enumerated, and identified to species. These data were then used to determine fish community taxa richness and biomass estimates.

### Supplemental Biological and Physical Stream Assessment

Anne Arundel County supplemented the synoptic data collection provided through Maryland DNR. Through this work effort, additional indicators of stream integrity were sampled or measured at 24 additional targeted sites, in nine subwatersheds, within the Anne Arundel portion of the Upper Patuxent River Watershed (see Figures 2 and 3 and the subwatershed maps in Section III for details on all station locations). Indicators assessed included additional benthic macroinvertebrate data, physical habitat quality, sediment particle size distribution, and channel area.

Supplemental benthic macroinvertebrate sampling and the macroinvertebrate habitat assessments used the same methods as described above (see Synoptic Surveys). The supplemental macroinvertebrate and habitat data were combined with those collected by Maryland DNR during the same indexing period to derive biological condition scores (IBIs) for a total of 33 sites in Anne Arundel County.

Additional physical stream assessment information collected included substrate particle size distribution and stream channel cross sectional area. Substrate particle size distribution was determined using a modified Wolman Pebble Count method. This method consisted of measuring 100 particles in ten transects, per assessment reach, distributed proportionally to reach features. For example, if an assessment reach consisted of 50% riffles and 50% pools, then 5 transects would be in riffles and five in pools. Stream cross sectional area was measured at a representative riffle as near the center of the assessment reach as possible. At this location, metal rebar monuments were installed on each side of the channel to provide a permanent location for subsequent future measurements and a topographic survey of the area between the two monuments was performed.

Complete information regarding the methods employed, the data collected, and conclusions and recommendations resulting from this effort are found in “*Anne Arundel County, Biological Assessment of the Upper Patuxent River Watershed*” (Pavlik and Stribling, 2003).

Prince George’s County also supplemented the biological data collection efforts provided through the Synoptic Survey. Prince George’s County sampled 31 sites for benthic macroinvertebrates and 14 sites for fish over three years in their 5-year rotating basin stream-monitoring program (Figures 4 and 5 for all biological sampling stations). Five streams were sampled during the year 2000, nine in 2001, and 20 in 2002. Approximately 65% of the sites sampled were on first order tributaries, and all were in small watersheds draining directly to the Patuxent River mainstem. Through this monitoring and assessment program, the county gathered information on the benthic and fish Indices of Biological Integrity (B-IBI and F-IBI), physical habitat quality, sediment particle size distribution, stream channel cross-sectional area, selected field chemistry, and land use/land cover distributions. Biological and physical habitat methods used were comparable to those used by the MBSS, and all fieldwork was performed during the same index period (March – April). All of these data, and a description of the methods and sites were provided in the WRAS report, the “*Upper Patuxent River Watershed Restoration Action Strategy (WRAS) Biological Assessment. Spring 2002, Prince George’s County, Maryland*” (Prince George’s County, 2003).

## **BASIN CONDITION SCORE**

WRAS Partners realized, early in the WRAS process, that an acceptable and scientifically sound methodology was needed whereby restoration and protection decisions could be made given the quantity of information collected. Therefore, the WRAS Partners initiated development of an assessment methodology to assist in the review and assimilation of data, and to provide a means to prioritize subwatersheds for restoration and/or protection actions.

The Basin Condition Score (BCS) is comprised of a series of indicators that score various characteristics of each subwatershed. Individual indicators are organized into groups that include water quality conditions, living resources conditions, habitat conditions, landscape conditions, and hydrologic conditions. Table 5 lists the indicator groups and their associated indicators. Details about how each indicator is scored can be found in the complete method description, which is contained in Appendix A. The data used to score the indicators comes from the SCA (Pellicano and Yetman, 2002), the synoptic survey data (Maryland DNR, 2002b), supplemental biological and habitat assessment data (Pavlik and Stribling, 2003), GIS data developed by Maryland DNR (Maryland DNR, 2002a), and the partner Counties. Once each indicator is scored, watershed conditions are determined using the ranges described in Table 6.

Some indicators within indicator groups are believed to better characterize critical ecological processes. Consequently, selected indicators are weighted to emphasize their importance over others when evaluating subwatershed health. Each indicator within a group is either unweighted or given a weighting factor of two or three. The decision about which indicators to weight is based on scientific literature and the best professional judgment of the authors. An indicator is unweighted if it has a lesser influence on ecological processes in a subwatershed of interest, or if lesser quality data had to be used to derive its score. Data quality decisions were made in consultation with GIS professionals and through discussions with the data collection participants (e.g., SCA survey manager).

## **RESTORATION PROJECT RANKING**

One of the products of the SCA Methodology application is a list of potential restoration sites associated with the problem identification process. As described in Yetman (2001), each observed problem is scored for severity, correctability, and accessibility. Table 7 provides brief definitions of how each category is scored in the SCA.

The SCA project rating data were used to rank projects within each subwatershed in the following manner. First, only projects with a severity rating of moderate or high were considered in the ranking process. Then, the scores for each category were summed and the projects with the lowest scores were judged the highest priority projects for implementation. The rationale for this approach is that projects that were judged highly severe but were also judged relatively easy to access and easily correctable would be the easiest to implement and have the largest “bang for the buck” in improving the subwatershed of interest. Projects that were somewhat more difficult to access and/or were judged more difficult to correct got lower scores using this approach. Prioritized project lists were generated for each subwatershed and are presented in the individual subwatershed narratives in Section III.

**Table 5. Individual Indicators Used to Develop the BCS**

<b>Indicator Group</b>	<b>Individual Indicator</b>
Water Quality Conditions	Baseflow Nitrate/Nitrite Concentration Departure
	Baseflow Orthophosphate Concentration Departure
Living Resource Conditions	Aquatic Insect Community Condition
	Anadromous Fish Utilization
	Presence/Absence of Sensitive Species Protection Areas
	Stream Fish Community Condition
Habitat Conditions	Channel Erosion
	Pipe Outfalls
	Buffer Conditions
	Fish Barriers
	Overall Habitat Rating
	Channel Alterations
Landscape Conditions	Current % Imperviousness
	Road Crossings
	Forest polygon edge/area
	Full Build Out Increase in Impervious Cover
	% of Subwatershed in Proposed Greenway
	% of Subwatershed Land Area with Permanent Protection
% of Subwatershed Land Area in Agricultural Land Use	
Hydrologic Conditions	Flooding Potential
	Stream Baseflow Condition

**Table 6. Scoring Ranges for BCS Methodology**

<b>Indicator Group</b>	<b>Subwatershed Quality Rating</b>			
	<b>Good</b>	<b>Fair</b>	<b>Poor</b>	<b>Very Poor</b>
Water Quality Conditions	<5	5-11	12-17	>17
Living Resource Conditions	<18	18-38	39-65	>65
Habitat Conditions	<38	38-83	84-128	>128
Landscape Conditions	<33	33-72	73-111	>111
Hydrologic Conditions	<8	8-17	18-26	>26
<b>Overall BCS</b>	<b>&lt;101</b>	<b>101-220</b>	<b>221-345</b>	<b>&gt;345</b>

**Table 7. Problem Evaluation Categories Scored During the SCA**

Category	Condition Rating Description (Assigned Point Value)		
	Low	Moderate	High
Severity	Problems generally are low intensity or only occur over a short distance of stream channel. Problems judged not significant. <b>(5)</b>	Problem somewhat widespread, assessment crews have observed worse during assessment. <b>(3)</b>	Problems generally widespread with large impact on system health. Magnitude and/or extent of problem relatively great. <b>(1)</b>
Correctability	Easy to correct. Typically, low intensity problems that might be solved with volunteer labor or little engineering analysis. <b>(1)</b>	More difficult to correct. Might require significant volunteer labor, or a small piece of construction equipment to correct. <b>(3)</b>	Most difficult. Impacts extensive and likely require professional expertise to diagnose and determine corrective actions. Large, expensive, construction projects typical. <b>(5)</b>
Accessibility	Easy to access. Near road crossings or on public property. <b>(1)</b>	Project might be accessible by foot but not easily by vehicle. <b>(3)</b>	Project difficult to access by foot and by vehicle. <b>(5)</b>

**LOW IMPACT DEVELOPMENT RETROFIT ASSESSMENT**

As summarized in the Characterization document, the Upper Patuxent River Watershed failed several watershed indicators associated with land development and stormwater management described in watershed’s the Clean Water Action Plan. These indicators are: percent impervious surface, population density and soil erodibility. Three other failing indicators are associated with aquatic living resources (Non-tidal Benthic Index of Biotic Integrity, Non-tidal Instream Habitat Index and Imperiled Aquatic Species Indicator).

Conventional land development techniques can dramatically alter natural hydrologic functions. Such site development techniques quickly remove stormwater from developed lands using roofs, gutters, downspouts, driveways, curb and gutter, roads, pipes, drainage swales, and other efficient drainage systems that convey runoff to end-of-pipe collection systems (stormwater management ponds). Resulting changes in hydrologic function include increased stormwater runoff, which amplifies the volume, frequency and rate of discharge; increased impervious surface, decreased infiltration and groundwater recharge; decreased time of concentration; decreased runoff travel times; and increased hydraulic connection. Natural features including vegetation are removed and/or dramatically altered. These changes adversely affect the ecosystems that were present before development.

Conventional stormwater management systems such as ponds have been shown to reduce pollutant runoff to some degree but have not been effective in protecting the habitat structure or hydrology of streams. Fish and macroinvertebrate studies have shown that SWM ponds alone are not enough to protect physical habitat structure (cover, substrate, sedimentation) or hydrology (baseflow, thermal fluxes or flashiness). Therefore, the implication is that SWM ponds are limited in their ability to protect streams and cannot reproduce predevelopment hydrological functions.

In both Prince George's and Anne Arundel Counties, there are developed areas with little or no stormwater management (SWM) or older SWM technology that is inadequate to protect the ecological structure of aquatic systems. Both Counties believe that a more holistic and site specific SWM approach is needed, particularly, for urban retrofit. In contrast to conventional stormwater management, Low Impact Development's main goal is to provide maximum protection of the ecological integrity of the receiving waters by maintaining the watershed's hydrologic regime. This goal is met by creatively designing hydrologic functions into the site design with the intent of replicating the predevelopment hydrology. This provides a significant positive impact on stream stability, habitat structure, baseflows, and water quality.

Low Impact Development (LID) is a comprehensive technology-based approach to manage urban stormwater. Stormwater is managed in small, cost-effective landscape features located on each lot (as compared to conveying it to an end of pipe control such as SWM pond). Source control employing reduced impervious surfaces, functional grading, open channel sections, disconnection and reduction of drainage areas and flowpaths, and bioretention/filtration landscape features maintain hydrologic functions (infiltration, groundwater recharge, frequency and volume of discharges).

Multifunctional site design is a key component to LID. LID controls reduce runoff by integrating stormwater controls throughout the site in many small, discrete units. These controls are located on-lot at the source of impacts. Using this type of design, environmental features are preserved and incorporated into the development. Examples of LID controls are bioretention (rain gardens), rain barrels, rooftop storage, green roofs and amended soils. Forming micro drainage areas and disconnecting drainage paths are in sharp contrast to the efficient drainage systems practiced in conventional land development.

In addition to developing a catalog of information relative to the natural resources health of the Upper Patuxent River Watershed, an assessment of urban lands was conducted. The purpose of this assessment was twofold. First, an attempt was made to identify areas appropriate for stormwater management retrofits such that the levels of control required by each County's stormwater management regulations could be met. Second, evaluations were conducted to determine if lands ripe for development/redevelopment could be managed with environmentally sensitive and low impact development (LID) site design techniques.

### **Site Selection**

Selection of viable retrofit and LID implementation sites was needed to facilitate the management of restoration efforts and to support the targeting of limited assessment resources. For the Prince George's County efforts, the initial step in the site selection process was the subdivision of the State's Upper Patuxent River Watershed into subwatersheds based on drainage

area and land use criteria. The subdivision of the Upper Patuxent River watershed resulted in 17 subwatersheds ranging in size from 350 to 4330 acres, with an average subwatershed size of 1250 acres. The subdivided subwatersheds had relatively homogenous land uses. The location of the 17 subwatersheds within the Prince George's County portion of the Upper Patuxent River Watershed is denoted in Figures 4 and 5.

In Prince George's County, BCS results, stream condition information, and biological and water quality assessment information were used to identify individual parcels for evaluation as potential retrofit sites. It was expected that focusing on a single parcel would increase the homogeneity of features recorded on the site evaluation forms. Homogeneous features on a parcel were needed to facilitate the ranking of sites. The parcels had various levels of urban and suburban land uses. Some parcels had storm water management (SWM) within or downstream of their watersheds. The parcels had various ownership types and opportunity criteria.

In Anne Arundel County, candidate areas of developed land were initially identified through use of GIS land use data and aerial photography. From this initial assessment, approximately 30 potential evaluation sites scattered throughout the subwatersheds of interest were identified for further field investigation. Most of these sites were residential areas. Preliminary investigations (windshield surveys) were then performed at six of the sites. During this time, it was determined that most of these residential sites did not require retrofitting. Most were large lot (1-3 acre) residential with many LID-type practices in place (e.g., large buffers, open section roadways, disconnected downspouts). Consequently, a decision was made to focus on an identified commercial site in the Crofton area of the watershed. As shown in Figure 6, the targeted site is a compact industrial park, allowing for the potential implementation of a variety of LID techniques for use as a demonstration site. Additionally, the site was developed under older County stormwater regulations using conventional facilities. This site is partially contained within one of the most impacted Anne Arundel County subwatersheds assessed through the SCA (Cox Branch, UPS1). The balance of the site drains directly into the Patuxent River.

### **Site Evaluation Procedures for LID Feasibility Determinations**

Concurrent with the site selection process, both Counties cooperatively developed a methodology for evaluating the feasibility of retrofitting LID to residential and commercial/industrial areas. As part of this process, an assessment of available data and required data was conducted, in-office assessments and site characterizations using GIS data were performed, and extensive field work was done at the focus areas to collect site-specific data to determine the most feasible types of LID best management practices for installation. The assessment of the data requirements and availability was needed to develop the evaluation procedure with the objective to rank the sites as to their potential for LID implementation and / or storm water management (SWM) retrofits. Data needs include mapping, impervious area, storm drain system layout, utilities, topography, parcel ownership, land use, and existing storm water management. Available information included the County's GIS and soils information. The parcel evaluation procedure included the development of data collection forms. The data collection forms, which were used in both office assessments and field assessments, were structured to facilitate collection of information and to rank the sites in a consistent manner. Three forms were developed to facilitate collection of data and subsequent analysis. Examples of the forms and a complete description of the assessment methods used in both Counties can be found in Appendix B.

## **PUBLIC PARTICIPATION**

Anne Arundel and Prince George's Counties cooperatively developed a strategy to provide for public participation in the development of the Upper Patuxent WRAS. The goals were to maximize public participation, provide a mechanism for stakeholders to be involved in the development of the WRAS and to have a major participatory element in the implementation phase. Components of the strategy included:

- Identification of Potential Stakeholders
- Development of Stakeholder Database(s)
- Formation of Committee Structure
- Stakeholder Kickoff Meeting
- Steering Committee Meetings
- Provide Opportunity for Public Comment and Participation in the Development of the Upper Patuxent WRAS
- Develop Public Outreach And Participation Strategy For The Implementation Phase Of The Upper Patuxent WRAS

### **Stakeholder Identification**

A list of potential stakeholder groups was developed for the WRAS process. Stakeholders included government agencies, municipalities, planning committees, community organizations, watershed and environmental groups, citizen activists, businesses and landowners. Prior to initiating the Stream Corridor Assessments, property owners adjacent to targeted streams were identified. Over 1200 property owners in Prince George's County and over 400 in Anne Arundel County were identified and contacted by mail. A copy of the contact letters can be found in Appendix C. The purpose of this contact was to (1) introduce the property owners to the watershed study goals and activities, (2), introduce the property owners to the field activities associated with the study, and (3) request permission to access property for in-stream and streamside habitat assessment and monitoring. Approximately, 33% of those contacted in Prince George's County and 28 % from Anne Arundel County responded to the letter. The vast majority of respondents were positive about the study; many requested further information, described problems that the County will address (see discussion under Development of Stakeholder Database), or expressed a desire to accompany field crews during the field surveys.



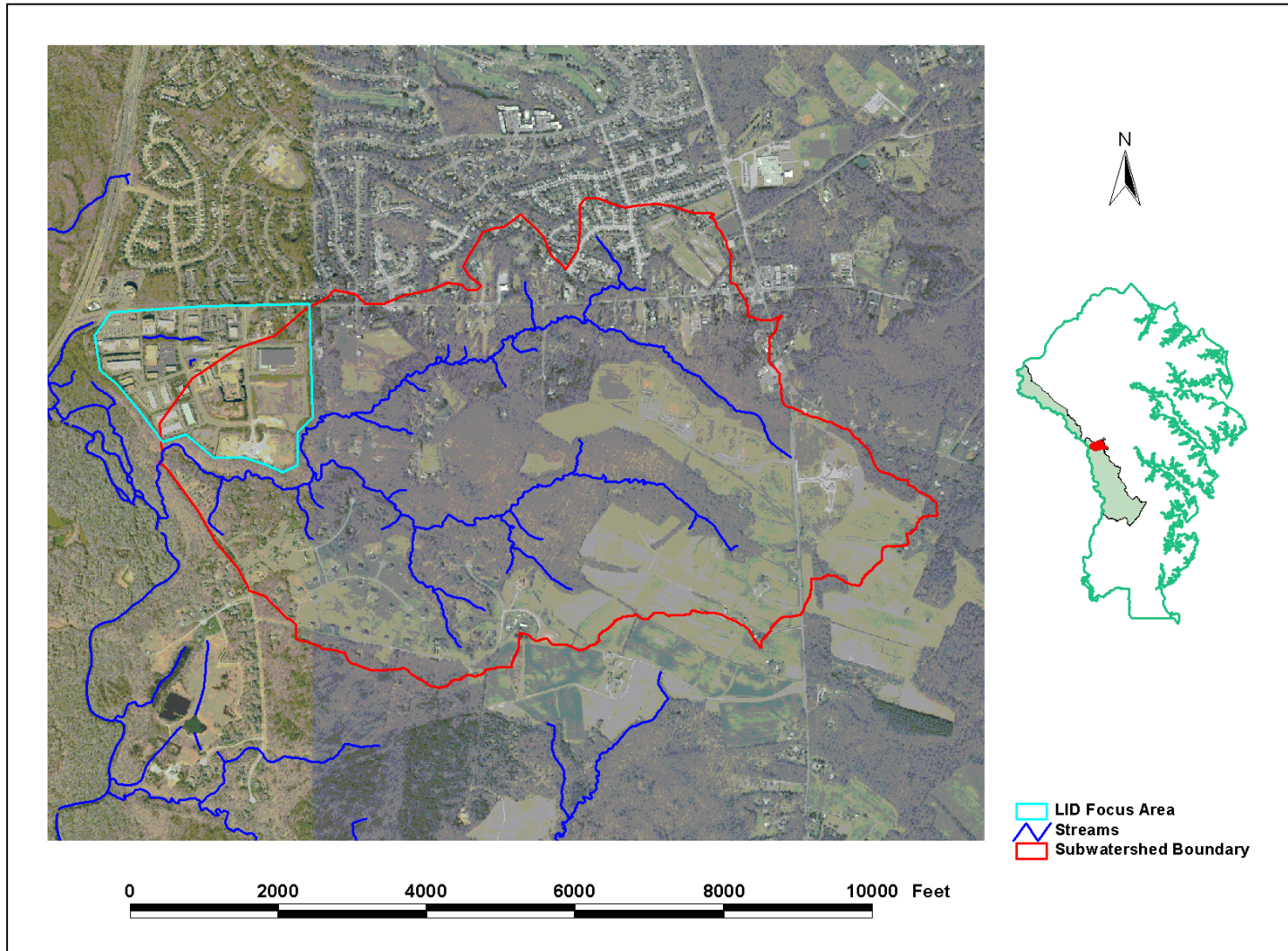


Figure 6. Map of the LID focus area located in the Cox Branch subwatershed (UPS1) in Anne Arundel County.

## **Development of Stakeholder Database(s)**

Prince George's County developed databases for the major commercial and industrial businesses, community organizations and individual citizen activists in the County's portion of the Upper Patuxent Watershed. The County is also developing a database of the results from the permission letter campaign. All of the databases will be incorporated into a GIS planning tool. These databases are designed for multiple uses that include:

- Identification and targeting of stakeholders for future watershed projects and studies;
- Development of an Upper Patuxent watershed organization;
- Identification of future restoration and retrofit sites;
- Stakeholder notification of watershed events, workshops and training opportunities; and
- Recruitment of volunteers for restoration and retrofit projects.

## **Formation of WRAS Committee Structure**

The committee structure consisted of a workgroup, steering committee and watershed stakeholder oversight organization. The workgroup was responsible for the planning and development of WRAS activities, public meetings, documents, and strategies. The group members included Anne Arundel and Prince George's Counties and Maryland DNR staff, and monthly strategy sessions were held. The Steering Committee's charge was to help direct the development of the watershed plan by providing input and recommendations to the workgroup. This input would meet the needs of the watershed stakeholders. Committee members were volunteers solicited from the Stakeholder Kickoff meeting and throughout the public participation phase. Comprised mainly of individuals who attended the Stakeholder Kickoff meeting, the Stakeholder Oversight Organization consisted of many interested stakeholders in the Upper Patuxent Watershed. The relationship and structure of the committees, as well as committee participants, is shown in Figure 7.

## **Stakeholder Kickoff Meeting**

Major watershed stakeholders were identified by the WRAS Partners and invited to a briefing held in September 2002. The purpose of this meeting was to introduce stakeholders to the Upper Patuxent WRAS. Of those invited, over 20 stakeholders attended the briefing. Those stakeholders represented major landowners (e.g., Department of the Interior's Patuxent Wildlife Refuge), local government agencies, NRCS, Soil Conservation Districts, civic associations, citizen watershed organizations, and Maryland Tributary Strategy Teams (i.e., Patuxent River Commission). Briefing presentations included an introduction to the WRAS process, the goals of the Upper Patuxent WRAS, and a description of the work effort involved. Stakeholders were also asked to identify their watershed concerns and any opportunities they saw for enhancing, restoring, and protecting the Upper Patuxent River watershed. Stakeholders also participated in a discussion of their long-term vision for the watershed. Lastly, volunteers were solicited to serve on the Upper Patuxent WRAS Steering Committee. Stakeholders were provided with handout packages that contained an agenda, slide show summaries, contacts lists for the project, maps, and educational materials

**Steering Committee Meetings**

The Steering Committee was comprised of representatives from the U.S. Department of the Interior (Patuxent Wildlife Refuge), the Patuxent River Greenways Committee, Anne Arundel County Small Area Planning committee representatives, citizen watershed organizations, City of Bowie, Maryland-National Capital Park and Planning Commission, Soil Conservation Districts, and County government agencies. The Steering Committee met four times between December 2002 and May 2003, to discuss the WRAS progress, and provided constructive feedback on WRAS activities. Table 8 indicates the meeting dates and subjects for the WRAS Steering Committee.

**Table 8. Upper Patuxent WRAS Steering Committee Meetings**

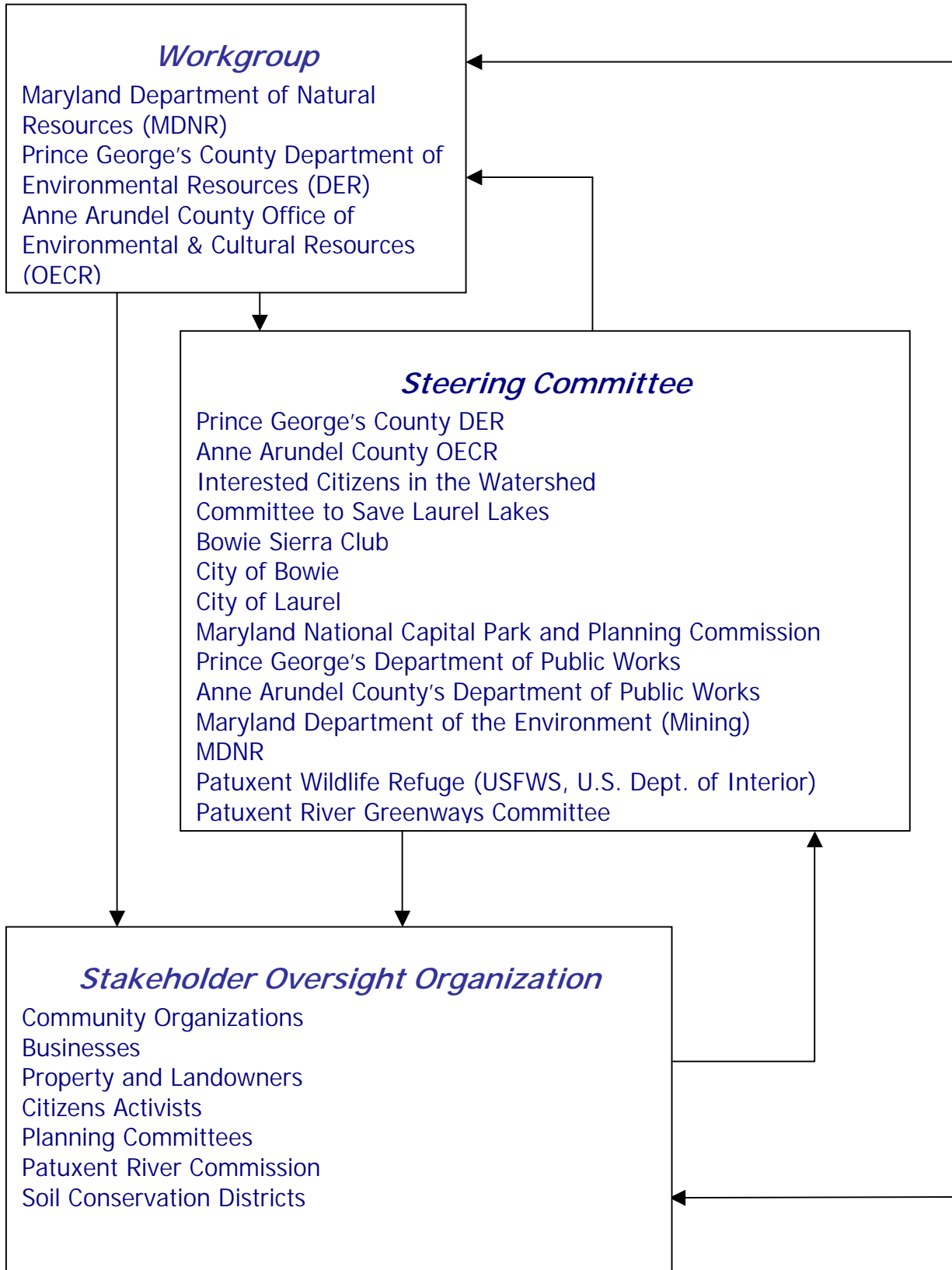
Meeting	Topics
December 2002	Overview of WRAS Program Upper Patuxent River Watershed Characterization Synoptic Survey Results
January 2003	Stream Corridor Assessment Survey Results– Upper Patuxent River Present and discuss draft outline for WRAS report
February 2003	Cancelled due to inclement weather
March 2003	Potential restoration activities LID activities Stormwater Management Retrofits Grant opportunities to support these activities Finalize WRAS report outline
April 2003	Decentralized Demonstration Project Grant Opportunities to implement WRAS recommendations

**Provide Opportunity for Public Comment and Participation in Upper Patuxent WRAS Development**

In addition to the Steering Committee and Stakeholder meetings, Prince George’s County solicited participation and input with the Committee to Save Laurel Lakes (CSLL), the Bowie Sierra Club, and the Cities of Bowie and Laurel at formal meetings and informal gatherings. Concerns, project ideas, and comments are incorporated into this final strategy.

**Develop Public Outreach and Participation Strategy for the Implementation Phase of the Upper Patuxent WRAS**

Public outreach and participation is key to the success of the Upper Patuxent WRAS. Both Anne Arundel and Prince George’s Counties have agreed that the main element in this strategy is to develop an Upper Patuxent Watershed Association. Other key elements are to provide watershed wide workshops on Low Impact Development geared for both professionals and the public. For a more detailed discussion on this strategy, see Section IV. Implementation.



**Figure 7. Schematic of public participation process in the Upper Patuxent River WRAS.**

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### III. RESULTS AND RECOMMENDATIONS

In this section, ecological conditions within the Anne Arundel County portion of the Upper Patuxent River watershed are discussed. First, a general overview of watershed conditions is presented. Summaries of the SCA results, the synoptic surveys, and the BCS outcomes are provided. Second, detailed discussions of each of the nine assessed subwatersheds are presented. These discussions include physical descriptions of each subwatershed, land use and land cover conditions, ecological conditions as evaluated by the BCS, and a list of prioritized restoration projects. Maps showing the location of the sample stations and the location of restoration projects are also included.

#### OVERALL WATERSHED CONDITIONS

##### Stream Corridor Assessment

As described in Section II, a total of nine subwatersheds were assessed in Anne Arundel County as part of this WRAS. Approximately 50 miles of stream were assessed as part of the Stream Corridor Assessment performed by the Maryland Department of Natural Resources, and 154 problems were identified (Pellicano and Yetman, 2002). As discussed in Yetman (2001), observed problems are ranked by three factors: severity, correctability, and access. For the purposes of this WRAS, only problems rated moderate or greater in severity are considered for further work. In a handful of cases, severity ratings were upgraded based on an inspection of the photographs taken and data collected during the assessment, or if problems appeared to be related to each other. For example, in UPS11, three headcutting areas occurred within approximately 600 feet of each other. Each, in isolation, was considered to rank low in severity. However, it is likely that all of these areas of geomorphic instability are influencing each other and are representative of a problem impacting the entire stream reach. Consequently, each was upgraded in severity and considered as a unified project for future action.

As shown in Tables 9 and 10, erosion was the dominant problem observed in the Upper Patuxent River, comprising 41% of all observed problems rated moderately severe or greater. All subwatersheds in this assessment showed some degree of erosion. A total of 26 individual severe projects were observed. Pellicano and Yetman (2002) reported a total of 38 sites.

The actual cause of these high rates of erosion cannot be determined from this assessment. However, it is well documented that land use conversions have adverse impacts on stream channel stability and other attributes of stream systems. Development in many of the assessed subwatersheds is too recent, from a stream stability standpoint, to have had significant impacts. Therefore, it is possible that historic agricultural activities have contributed to the observed erosion. Such a link has been demonstrated in impacts to biological communities (Harding et al., 1998).

**Table 9. Problems Observed in Anne Arundel County Subwatersheds**

<b>SCA Problem Category</b>	<b>Total in each Problem Category</b>	<b>Total Problems (%)</b>
Channel Alteration	2	3
Construction	2	3
Erosion	26	41
Exposed Pipe	1	2
Fish Barrier	12	19
Pipe Outfall	5	8
Trash Dumping	9	14
Unusual Condition	6	10
<b>Total Problems</b>	<b>63</b>	<b>100</b>

Fish barriers were also a significant problem in the Upper Patuxent River watershed, occurring in 8 of 9 subwatersheds, and accounted for 19% of total severe problems observed. A total of 16 miles (32%) of stream reaches were considered partially or completely closed to fish migration because of observed blockages. Fish movement is likely severely or completely impaired in UPS6 and UPS10 because of fish barriers located at the downstream end of these subwatersheds.

Significant trash dumping was also observed in 4 of 9 subwatersheds, comprising 14% of total severe problems observed. However, the majority of dumps occurred in UPS1 and UPS11, with 44% and 33% of total dumps occurring in these subwatersheds, respectively. Many of these sites were judged as suitable for volunteer clean-up efforts.

**Basin Condition Score Results**

As described in Section II, the condition of each assessed subwatershed was evaluated using the Basin Condition Score (BCS) method (see Appendix A for complete methodology). Results are summarized in Table 10 and in Figure 8. As illustrated in Figure 8, the BCS was able to provide discrimination among subwatersheds. Overall, conditions were judged fair in 67% (6 of 9) of the subwatersheds assessed. One of these subwatersheds UPN7 was one point from placement into the good category. At 101, it had the lowest overall BCS (best ecological condition) of any subwatershed. This subwatershed was completely contained within the U.S. Fish and Wildlife Service’s Patuxent Research Refuge. The other five subwatersheds had scores ranging from 126 in UPS3 to 216 in UPS10.

A total of three subwatersheds—Cox Branch (UPS1), UPS4, and UPS6—ranked in poor condition. Cox Branch had the worst BCS score at 274. UPS4 and UPS6 earned scores of 231 and 237, respectively. These subwatersheds had degraded habitat and living resource conditions. In addition, UPS6 had poor water quality ratings while landscape conditions were rated poor in Cox Branch (UPS1). Restoration activities in these subwatersheds should focus on habitat enhancement and land preservation activities that improve landscape conditions and enhance living resources. Specific recommendations are made for each subwatershed in the subwatershed discussions.



**Table 10. Number of Problems Judged Moderately Severe or Greater within each Assessed Subwatershed by Category**

Stream	Channel Alteration	In/Near Construction	Erosion	Exposed Pipe	Fish Barrier	Pipe Outfall	Trash Dumping	Unusual Condition	Subwatershed Total
UPN1			2		1	1	1	1	6
UPS1	1	1	5	1	2	1	4	2	17
UPS3			2						2
UPS4	1		3		2	1	1		8
UPS6			3		2			1	6
UPS9			5		1	1		1	8
UPS10		1	2		3	1		1	8
UPS11			4		1		3		8
<b>Grand Totals</b>	<b>2</b>	<b>2</b>	<b>26</b>	<b>1</b>	<b>12</b>	<b>5</b>	<b>9</b>	<b>6</b>	<b>63</b>

**Table 11. Summary of BCS results for each assessed subwatershed**

Subwatershed	Metric Groups					Total BCS	BCS Rank*
	Water Quality	Living Resources	Habitat	Landscape	Hydrology		
UPN1	5	71	57	70	9	212	5
UPN7	2	44	33	13	9	101	1
UPS1	11	71	102	78	12	274	9
UPS3	5	33	42	40	6	126	2
UPS4	8	51	96	68	8	231	7
UPS6	14	51	99	67	6	237	8
UPS9	17	44	29	47	15	152	3
UPS10	14	42	84	61	15	216	6
UPS11	8	51	75	49	9	192	4

Metric group scores and overall BCS results are color coded as follows: **Good**, **Fair**, **Poor**, **Very Poor**.

\*The lower the rank, the better the overall ecological condition.



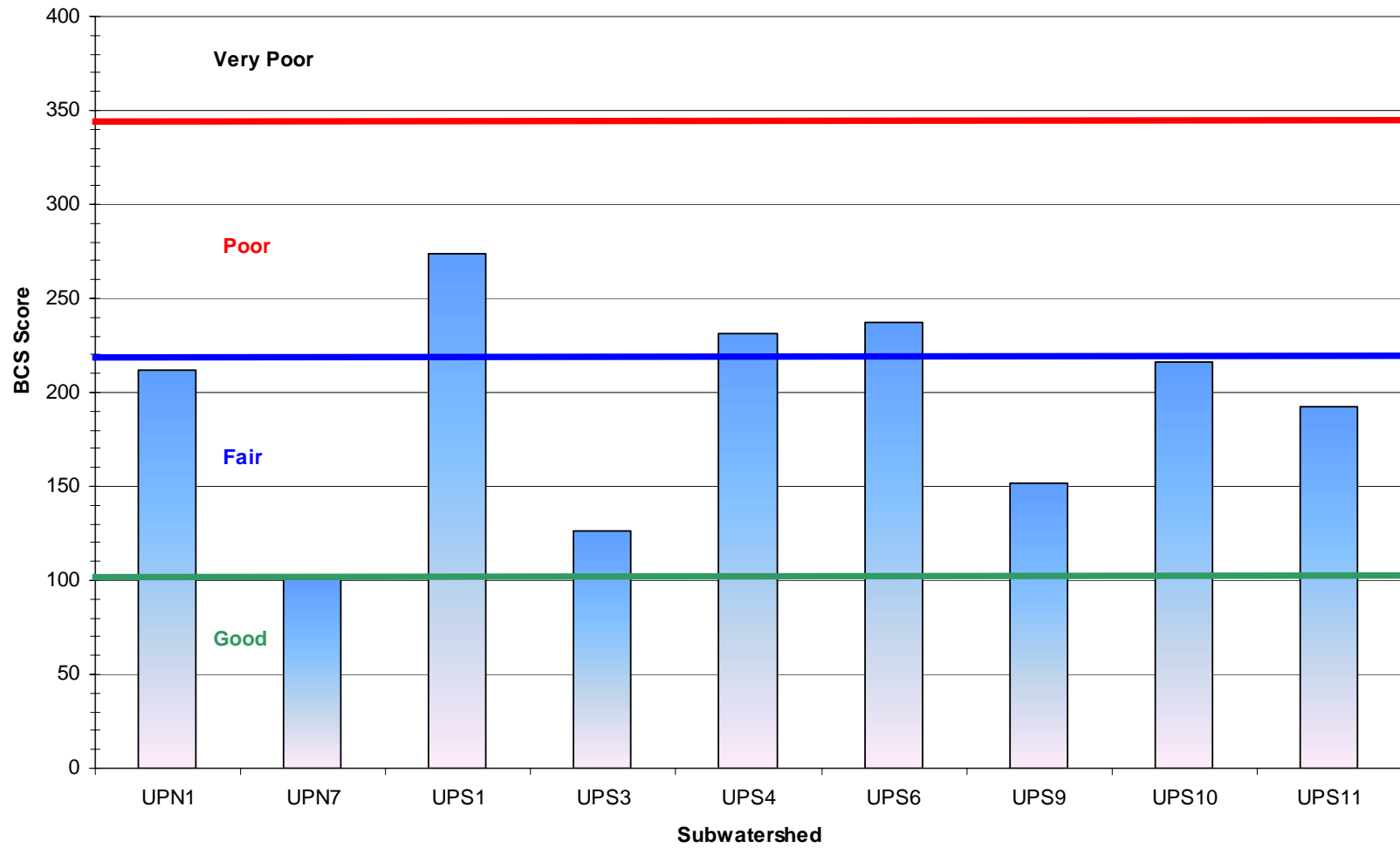


Figure 8. Summary of BCS results by subwatershed.

## Synoptic Survey Results

The assessment of water quality and biological conditions were based on sampling done in all subwatersheds, as described in Section II. Detailed descriptions and analysis are presented in DNR (2002b) and Pavlik and Stribling (2003). A summary of the results is discussed below.

### Water Quality Assessment

As described in DNR (2002b), baseflow nutrient loading and concentrations in the Upper Patuxent River watershed were generally very low. Only four subwatersheds—UPS1, UPS6, UPS9 and USP10—had stations with nitrate/nitrite concentrations above the 1mg/L threshold established as the limit for unimpaired streams. Only one station in UPS9 had nitrate/nitrite loading in the moderate range. For orthophosphate concentrations, levels were excessive only in Stocketts Run and elevated in a handful of other small subwatersheds.

The reason for these elevated values is not clear. Many of the subwatersheds in the southern portion of the assessment area have mixed amounts of agricultural and residential lands. The residential development in this part of the County is serviced exclusively by septic systems. The elevated levels of nutrients, especially nitrate/nitrite, could be the result of septic system effluent contributions to stream baseflow as it moves through the soil during the filtration process. It is also possible that repeated, long-term application of fertilizers to agricultural lands has elevated nutrient concentrations in shallow groundwater, which are then slowly released as stream baseflow. For orthophosphate, inputs from septic systems are thought to be limited (Novotny and Olem, 1994). Rainfall several days before sampling occurred was suspected of influencing orthophosphate concentrations (DNR, 2002b). In subwatersheds where elevated nutrient levels were observed (UPS1, UPS6, UPS9 and UPS10), additional water quality investigations may be necessary to determine if potential problems exist.

### Biological Community Assessment

As described in Section II, stream macroinvertebrates were sampled in all the assessed subwatersheds. Limited fish sampling was performed at six sites covering six of nine subwatersheds.

Overall, stream macroinvertebrate conditions in the Upper Patuxent River watershed were rated as poor with nearly 75% of sampling sites receiving a rating of poor or very poor. Samples were typically dominated by pollution-tolerant species and had a dearth of the sensitive organism typically associated with unimpacted systems. For example, 71% of sites sampled had 3 or less taxa from the orders Ephemeroptera, Plecoptera, and Trichoptera. Individuals from these groups are typically found in relatively unimpacted systems, which generally have 12 or more different taxa present.

The fish community observed in the six assessed subwatersheds was uniformly very poor. Species diversity was very low, with USP3 and UPS4 having four species, USP10 having three species, UPS1 with two species, and UPS6 and UPS11 with one species. All species observed were considered pollution tolerant.

Physical habitat in the watershed was characterized as partially supporting. Only one station (UPS6-001) was rated as supporting while 48% were rated partially supporting and 48% were rated as non-supporting. High levels of sediment, poor flow conditions, poor bank stability, and

low amounts of available in-stream habitat and streambank vegetation were the primary habitat impairments observed during the assessment.

These assessments were performed in March and April of 2002 when severe drought conditions were present. It is possible that these drought conditions temporarily impacted aquatic insect and fish communities, resulting in the poor assessment results. Additionally, numerous fish blockages were observed during the SCA work. It is likely that blockages are preventing the free migration of fishes between and within subwatersheds. Specific problems identified in each subwatershed are more thoroughly addressed in the following section.

**SUBWATERSHED CONDITIONS**

Within the Anne Arundel County portion of the Upper Patuxent River Watershed, subwatershed conditions were evaluated using the Basin Condition Score (BCS) methodology described in Section II (Methods). The complete BCS results for each metric can be found in Appendix D. For each subwatershed assessed, a discussion of land use and land cover, natural resource features, and watershed conditions based on the BCS results are presented below. In addition, a table summarizing the prioritized ranking of potential restoration and management opportunities identified in the SCA work is also included. There are eight basic project types identified in the SCA work (Yetman, 2001). These are summarized in Table 12.

**Table 12. Categories of Projects Observed during the SCA**

<b>Project Type</b>	<b>Abbreviation</b>	<b>Notes</b>
Trash Dump	TD	Any type of large trash concentration
Erosion Site	ES	Areas of stream bank or bottom erosion
Fish Barrier	FB	Any natural or manmade blockage that impedes fish movement
Channel Alteration	CA	Any type of channel straightening or other type of traditional river management alteration
Inadequate Buffer	IB	Buffer considered impacted if <50 feet wide from edge of stream
Pipe Outfall	PO	A direct discharge from a pipe into the stream
Unusual Conditions	UC	Any out of the ordinary condition not described in the other categories
Exposed Pipe	EP	An exposed length of pipe in the stream channel that could be damaged during high flows
In/near Stream Construction	IC	Any type of construction adjacent to or within the stream

Subwatershed maps are also incorporated into this discussion to denote the location of the subwatershed within the Upper Patuxent River Watershed, and the location of potential restoration and management opportunities within that subwatershed.

**UPN1—Unnamed Tributary to the Patuxent River**

This subwatershed is the northern most subwatershed assessed in Anne Arundel County during the WRAS. It is located east of Laurel and is intersected by Maryland Route 198 and the Baltimore-Washington Parkway. As illustrated in Figure 9, one water chemistry and two biological monitoring stations were established in the subwatershed for this project.

**Land Use.** Land use in this subwatershed is comprised of high density residential, including small lot (~8 units per acre) and apartment and town home development. A large fraction of the southern portion of the subwatershed is part of the Patuxent Research Refuge. A summary of land use is shown in Table 13.

**Table 13. Land Use Summary for UPN1**

Land Use	Acres	% of Area
Open Space	190.0	53.1
Single Family Residential	101.8	28.5
Multifamily Residential	0.3	0.1
Utility/Roadway Right-of-Way	40.0	11.2
Schools	23.7	6.6
Vacant Land	2.1	0.6
<b>Total Area</b>	<b>357.9</b>	<b>100.0</b>

Current total subwatershed imperviousness is estimated at 20% and concentrated in the northern and western portions of the subwatershed. The large amount of open space found within this subwatershed is comprised of Patuxent Research Refuge, which virtually assures that at least 53% of

this subwatershed will remain undeveloped for the foreseeable future.

**Natural Resources.** Approximately 53% of this subwatershed is under control of the U.S. Fish and Wildlife Service as part of the Patuxent Research Refuge. This area is nearly 100% forested with both deciduous and coniferous forest and likely provides high quality habitat to a variety of species. Approximately 6 acres of palustrine forested and scrub shrub wetland were mapped in this watershed by the National Wetlands Inventory. Approximately 1.4 miles of stream channel exist in this subwatershed.

**Watershed Conditions.** The BCS results for UPN1 are summarized below:

**Table 14. BCS summary for UPN1**

Metric Group	Metric Group Score	Condition Rating
Water Quality Conditions	5	Fair
Living Resource Conditions	71	Very Poor
Habitat Conditions	57	Fair
Landscape Conditions	70	Fair
Hydrologic Conditions	9	Fair
<b>Overall BCS</b>	<b>212</b>	<b>Fair</b>

Overall, conditions in this subwatershed were judged to be fair. Moderate amounts of watershed erosion were observed during the SCA work. Approximately 30% of stream reaches in this subwatershed were judged to be experiencing moderate or greater amounts of erosion. Stream insect populations were judged to be very poor overall, while habitat conditions were judged to be partially supporting, indicating that a water quality problem is a primary limiter of stream health in this subwatershed. High levels of sedimentation associated with the unstable reaches

described above could explain the depressed biological conditions. However, untreated stormwater runoff from the Baltimore-Washington Parkway and from the older developed areas located in the northern and western portions of the subwatershed could also be impacting biological conditions. Fish were not sampled because the stream was dry during the sample period. Buffer conditions were generally rated as fair, with approximately 9% of total stream reaches observed with moderate or greater levels of buffer impairment as defined by SCA criteria.

**Watershed Improvement Activities.** Based on conditions and land use characteristics in this subwatershed the following general recommendations are made:

- Provide additional stormwater management in unmanaged areas;
- Reduce overall sediment load by repairing unstable stream banks;
- Remove or correct fish passage impediments; and
- Schedule stream clean-ups.

As illustrated in Figure 10, the following specific projects are recommended for subwatershed UPN1:

**Table 15. Description and Ranking of Restoration Projects in UPN1**

SCA Site Number	Project Type	Project Description	Subwatershed Priority Ranking	Notes
UPB07405 UPB07406	FB/ UC	Shallow culvert under Brock Bridge Road and undercut area of Brock Bridge Road	1	These two projects should be executed concurrently.
UPC06401	ES	Severe headcut and erosion along tributary to UPN1 that drains residential development	2	A capital project under design by the County
UPC06402	PO	Pipe outfall at top of UPC06401	3	Addressed in above described County project
UPB07401	TD	Extensive trash dump	4	Located at downstream end of subwatershed
UPC07402	ES	Severe headcut and erosion in tributary	5	Located on Refuge property.



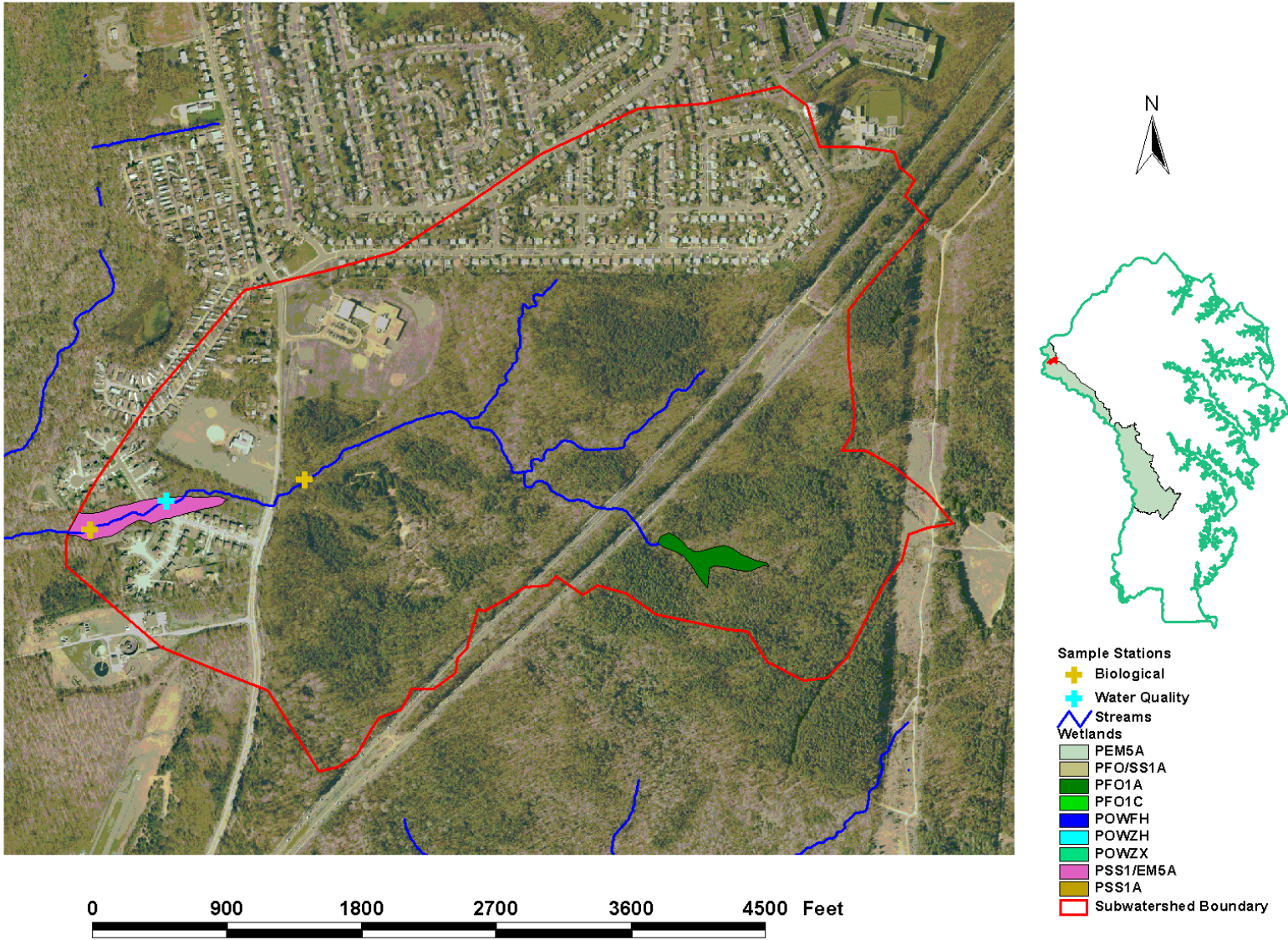


Figure 9. Overview of UPN1.





Figure 10. Location of potential restoration projects in UPN1.