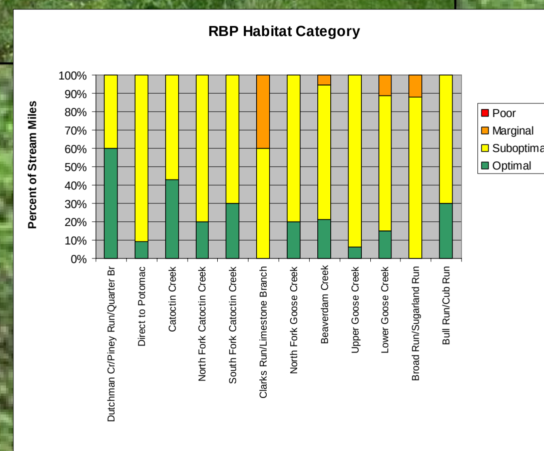
LOUDOUN COUNTY STREAM ASSESSMENT: RESULTS REPORT



Prepared for

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September 25, 2009

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1. INTRODUCTION

During 2009, Loudoun County has conducted a stream assessment to characterize the condition of aquatic resources throughout the County's watersheds. Field investigations and analysis focused on benthic macroinvertebrate monitoring and stream habitat assessment. The County will use results of the stream assessment in support of future watershed management decisions, particularly for the planning of restoration and environmental protection measures, and to plan future monitoring efforts. This document presents results of the stream assessment, including benthic and habitat assessments. Results of stream perenniality investigations, also conducted in 2009, are being provided separately and are summarized here.

Loudoun County identified a need for stream assessment data to support its watershed management efforts. Although there have been a number of previous sampling efforts in the County, there has not previously been any consistent, countywide picture of stream conditions. A review of previous stream biological and habitat data (Roth et al. 2009a) collected in Loudoun County confirmed the need for consistent countywide data to better characterize stream conditions. Two recent efforts, the Strategy for Watershed Management Solutions (Loudoun County 2006) and the Comprehensive Watershed Management Plan (CH2MHill 2008), recommended biological monitoring, particularly the use of probability-based sampling, to provide a statistically valid characterization of watershed conditions, as well as targeted monitoring to evaluate trends.

The purpose of the Loudoun County Stream Assessment conducted in 2009 was to:

- assess stream conditions, using benthic and habitat rapid assessment methods, and
- develop field-based information on stream perenniality, to refine existing information on extent and location of perennial streams.

Specific objectives of the Stream Assessment included:

- employ a probability-based benthic survey to provide an assessment of stream conditions throughout the County's watersheds (at 177 sites),
- target additional benthic sampling to provide additional information at sites already established by Virginia Department of Environmental Quality (DEQ, 23 sites),
- assess stream habitat in conjunction with all benthic sampling (same 200 sites),
- assess habitat conditions at additional sites to develop a more comprehensive picture of stream conditions throughout the County (300 sites), and
- develop field-based information on stream perenniality to support further planning/ management needs.

This report documents findings of the benthic and habitat assessments we conducted in Loudoun County during 2009. The purpose of this report is to present countywide and watershed-specific analyses of the assessment data collected. Chapter 2 provides an overview of the study design, monitoring methods, and ecological indicators employed. Chapter 3 presents results of probability-based sampling, including stream condition estimates on a countywide and watershed-specific basis. Chapter 4 provides a summary of results from targeted monitoring. Chapter 5 presents results of habitat assessments, including the additional habitat monitoring conducted throughout Loudoun County. Chapter 6 provides a brief summary of problem identification data, and Chapter 7 includes a summary of the stream perenniality study. Chapter 8 includes conclusions of the 2009 Loudoun County Stream Assessment. References are in Chapter 9. Digital files including field datasheets as scanned files, digital photographs, individual site data summaries, and a project geodatabase accompany this report.

2. STUDY DESIGN AND METHODS

The Loudoun County Stream Assessment included biological assessment using benthic macroinvertebrates and stream habitat assessment. The study was designed to support estimation of conditions both countywide and within specific watersheds by applying stream assessment methods of Virginia Department of Environmental Quality (DEQ) and the U.S. Environmental Protection Agency (EPA). The benthic assessment employed two types of strategies, probabilistic monitoring and targeted monitoring, to sample a total of 200 sites. Habitat assessments were conducted at all of the 200 benthic monitoring sites, plus at an additional 300 sites throughout the County. The sampling design and methods are described below, and further details are provided in the project's Strategic Plan and Protocols (Roth et al. 2009b) and Quality Assurance Project Plan (QAPP, Roth and Morgan 2009).

2.1 STUDY DESIGN

Loudoun County is undertaking this project to assess the condition of streams throughout the County. A comprehensive assessment of county streams can only be obtained by sampling representative stream segments using a probability-based (random sampling) design. The probability-based study design enables calculation of unbiased estimates such as mean values, or percentage of stream miles exceeding particular threshold values, with quantifiable confidence. Questions to be answered by the probability-based survey include, for example, the following:

- What is the percentage of stream miles in the County that are in excellent, good, or stressed biological condition, according to the Virginia DEQ's Stream Condition Index (VSCI) for benthic macroinvertebrates?
- What is the percentage of stream miles in excellent, good, or stressed biological condition by watershed?
- What are the mean benthic VSCI scores, by watershed?
- What percentage of stream miles exhibit degraded habitat condition, countywide and by watershed?
- What is the average habitat condition, by watershed?

Similar questions are able to be answered for other parameters assessed, such as specific habitat characteristics (e.g., bank stability, embeddedness, sediment deposition) that are part of EPA's Rapid Bioassessment Protocols (RBP).

In addition, other sampling strategies were designed as components of the Loudoun County Stream Assessment. Targeted sampling was employed to evaluate conditions at sites previously sampled by DEQ. Also, a large set of sites (300 additional sites) were investigated to assess habitat condition using RBP habitat methods, to provide a broader characterization of stream conditions throughout Loudoun County.

2.1.1 Benthic and Habitat Sampling – Probability-based Survey

For the probability-based survey, benthic and habitat assessments took place at 177 stream sites throughout Loudoun County watersheds, at locations selected by stratified random sampling. The probability-based sampling design supports overall assessment of the population of streams throughout the County and by watershed. Stream sampling sites were selected randomly using a probabilistic approach so that statistical inferences about the health of streams countywide can be made with known confidence. All streams designated as perennial in the National Hydrography Dataset (NHD) Medium Resolution stream network (USGS 2000) were included in the survey sample frame, with the exception of reservoirs and two unwadeable portions of the largest streams, which were excluded from the sample frame.

To allocate sites for sampling, the stream network was stratified into 12 primary sampling units (PSUs), each a Loudoun County watershed or, in the case of small watersheds, combinations of two or more watersheds (Figure 2-1). PSUs were allocated a minimum of 10 sites per watershed. The PSUs with larger numbers of stream miles received more than 10 sites in proportion to their number of stream miles, for a total of 177 sites (Table 2-1).

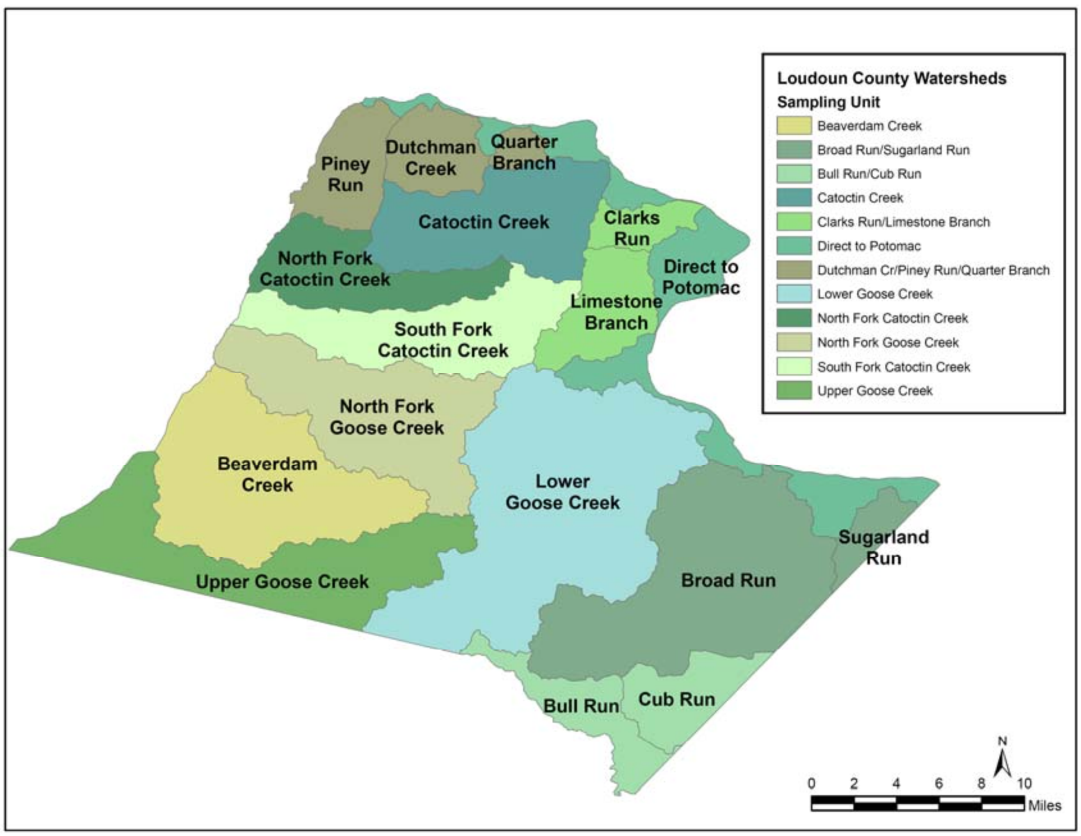

Figure 2-1. Loudoun County watersheds grouped into 12 Primary Sampling Units for the probability-based survey.

Table 2-1. Watershed area, stream mile breakdown, and site allocation for 12 Primary Sampling Units (PSUs) identified for the Loudoun County probability-based stream sampling. Stream miles were derived from the final sampling frame for probability-based sampling, based on the NHD Medium Resolution (1:100,000) stream network.				
Primary Sampling Unit (PSU)	**Area (Acres)**	**Length of Perennial Stream (Miles)**	**Length of Perennial Stream (% of County Total)**	**Number of Sites**
Bull Run/Cub Run	18,315.1	14.2	3.3	10
Dutchman Cr/Piney Run/Quarter Branch	19,634.1	27.8	6.5	10
Clarks Run/Limestone Branch	14,775.5	18.8	4.4	10
Beaverdam Creek	34,229.1	49.3	11.5	19
Broad Run/Sugarland Run	47,039.6	63.3	14.7	25
Catoctin Creek	23,135.3	37.4	8.7	14
Direct to Potomac	23,661.8	23.0	5.3	11
Lower Goose Creek	57,076.1	73.1	17.0	27
North Fork Catoctin Creek	14,931.9	16.6	3.9	10
North Fork Goose Creek	28,414.0	38.5	9.0	15
South Fork Catoctin Creek	21,143.7	26.8	6.2	10
Upper Goose Creek	31,220.2	40.9	9.5	16
Total	333,576.4	429.7	100.0	177

It was anticipated that some of the sites selected from the probabilistic analysis would not be assessed owing to site access constraints, landowner denial of permission to enter a property, or field conditions. When a site was found to be unsampleable, a replacement site in the same watershed was substituted. The actual number of sites sampled per PSU is indicated in Table 2-1. Actual site locations sampled for the probability-based survey are shown in Figure 2-2.

2.1.2 Benthic and Habitat Sampling – Targeted Sites

In addition to the probability-based survey, benthic macroinvertebrate and habitat assessments were conducted at 23 known, targeted sites. These sites had been previously sampled by Virginia DEQ, through its probability-based monitoring or targeted sampling programs. The targeted sampling sites are shown in Figure 2-3 and Table 2-2.

2.1.3 Habitat Sampling – Additional Sites

Data from the 200 benthic and habitat assessment sites described in Sections 2.1.1 and 2.1.2 will provide area-wide estimates and can also be used to develop predictive relationships between stream habitat and biological condition. In addition, we conducted habitat assessments at an additional 300 sites, which provide extensive information on other streams throughout Loudoun County (Figure 2-4).

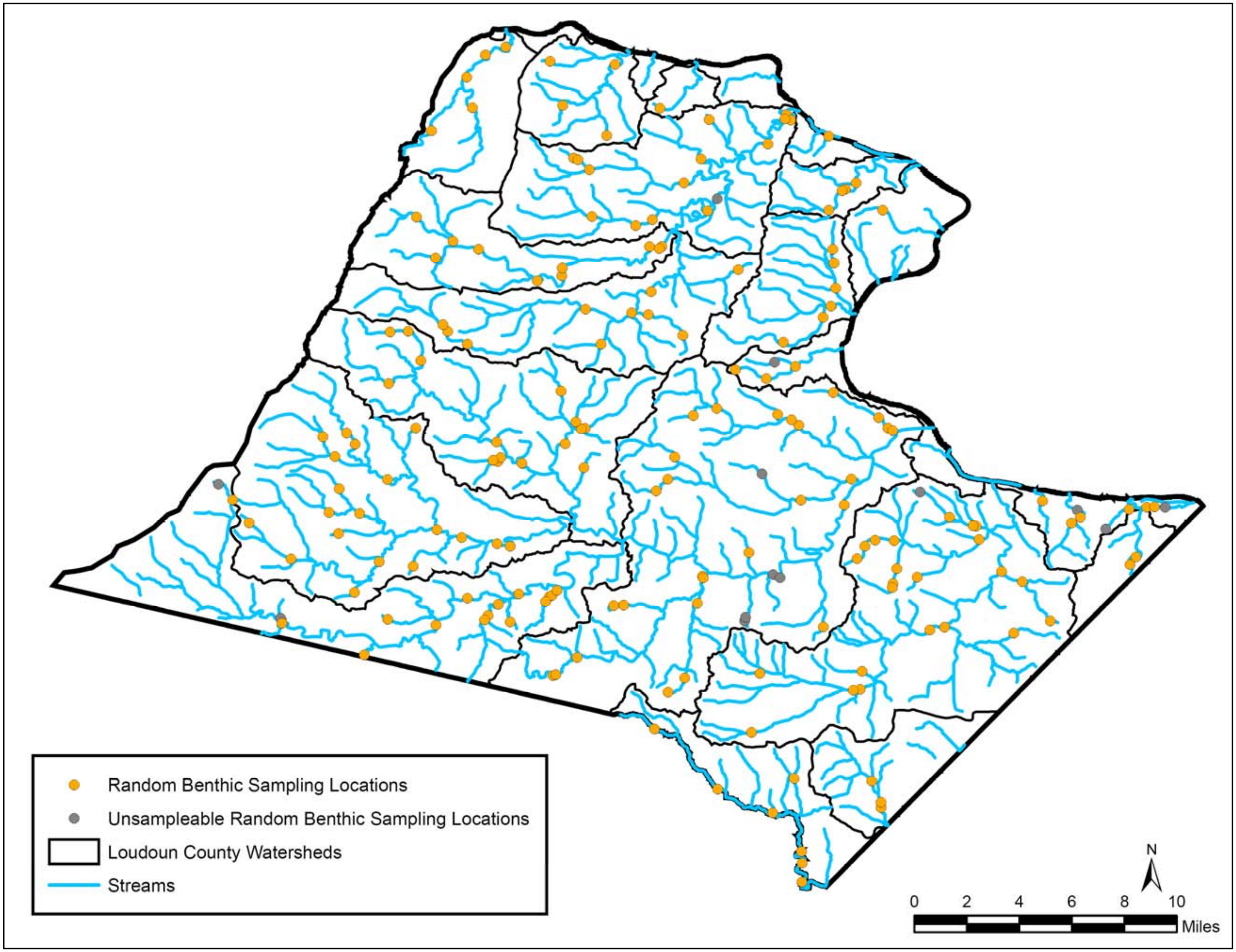

Figure 2-2. Locations of the 177 sites sampled in the probability-based survey of benthic and habitat conditions, Loudoun County Stream Assessment, 2009. Also shown are potential site locations where lack of access or unsuitable site conditions precluded sampling.

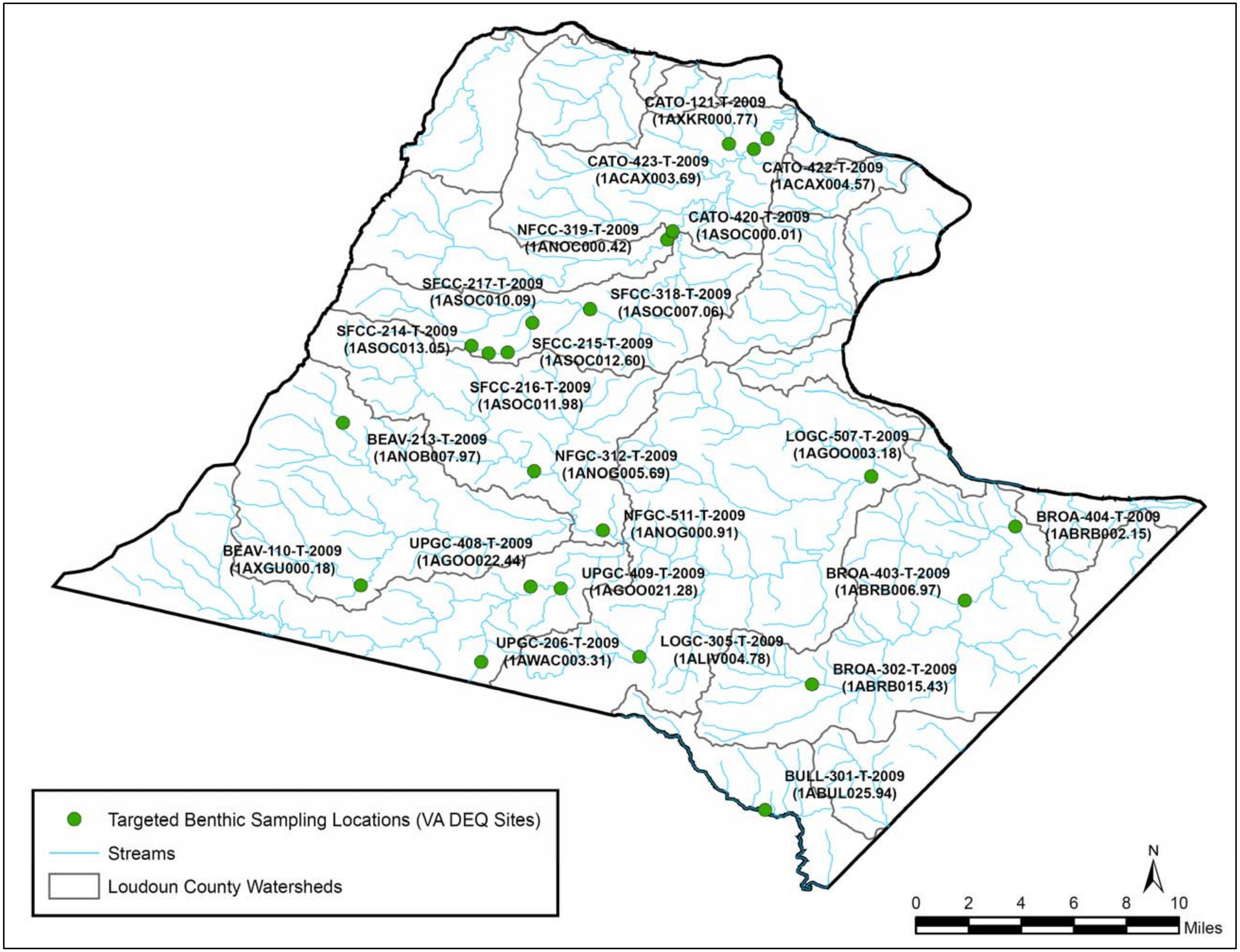

Figure 2-3. Targeted sites for stream benthic and habitat assessment, sampled in the Loudoun County Stream Assessment, 2009. These 23 sites had been previously sampled by Virginia DEQ benthic monitoring programs (DEQ Station ID listed in parentheses).

Table 2-2. Virginia DEQ sites, of which 23 were chosen as targeted monitoring stations for the 2009 Loudoun County Stream Assessment

Virginia DEQ Station ID	Latitude	Longitude	Stream Name	Site Name	Land Use	DEQ's Survey Reason	2009 Loudoun County Stream Assessment Station ID
1ABRB002.15	39.0467	-77.4328	Broad Run	Broad Run at Route 7	Urban/Residential	Citizen Request	BROA-404-T-2009
1ABRB006.97	39.0058	-77.4606	Broad Run	Broad Run Upstream from Waxpool Run	Urban	TMDL	BROA-403-T-2009
1ABRB015.43	38.9596	-77.5443	Broad Run	Broad Run Upstream from Route 621	Urban	TMDL	BROA-302-T-2009
1ABUL025.94	38.8894	-77.5706	Bull Run	Bull Run at Route 705	Agriculture	TMDL	BULL-301-T-2009
1ACAX003.69	39.2606	-77.5692	Catoctin Creek	Catoctin Creek downstream from Route 663	Agriculture	2008 Probabilistic Site – VAW05547-190	CATO-423-T-2009
1ACAX004.57	39.255	-77.5767	Catoctin Creek	Catoctin Creek at Route 663	Forest	This station is used as one of the reference sites.	CATO-422-T-2009
1AGOO002.38	39.0856	-77.5114	Goose Creek	Goose Creek at Route 7	Cropland	This station is an EPA Core Monitor Station.	
1AGOO003.18	39.0743	-77.5121	Goose Creek	Goose Creek Above Route 7	Rural	TMDL Study	LOGC-507-T-2009
1AGOO021.28	39.0126	-77.6831	Goose Creek	Goose Creek Downstream from Route 734	Pasture/Hay	Probabilistic site – VAW05547-126	UPGC-409-T-2009
1AGOO022.44	39.0136	-77.6997	Goose Creek	Goose Creek at Route 734	Forest	Prospective ecoregional reference	UPGC-408-T-2009
1ALIV004.78	38.975	-77.6397	Little River	Little River at Route 50	Suburban	Expand coverage in the suburban Potomac River watershed	LOGC-305-T-2009
1ANOB007.97	39.1039	-77.8031	North Fork Beaverdam Creek	North Fork Beaverdam Creek at Route 831	Rural/Forest	Prospective ecoregional reference	BEAV-213-T-2009
1ANOC000.42	39.205	-77.6244	North Fork Catoctin Creek	North Fork Catoctin Creek at Route 681	Agriculture	Citizen Request	NFCC-319-T-2009
1ANOG000.91	39.0446	-77.6598	North Fork Goose Creek	North Fork Goose Creek Upstream from Route 733	Forest	Probabilistic Site – VAEQ99-455	NFGC-511-T-2009
1ANOG005.69	39.0772	-77.6978	North Fork Goose Creek	North Fork Goose Creek at Route 722	Rural, Agriculture	Nutrient Criteria Pilot Program	NFGC-312-T-2009
1ASOC000.01	39.2098	-77.6214	South Fork Catoctin Creek	South Fork Catoctin Creek above Confluence with North Fork	Agriculture/Rural	Citizen Request	CATO-420-T-2009
1ASOC007.06	39.1666	-77.667	South Fork Catoctin Creek	South Fork Catoctin Creek at Route 738	Agriculture/Rural	TMDL	SFCC-318-T-2009
1ASOC010.09	39.1591	-77.6987	South Fork Catoctin Creek	South Fork Catoctin Creek at Route 711	Agriculture/Rural	TMDL	SFCC-217-T-2009
1ASOC011.98	39.1428	-77.7122	South Fork Catoctin Creek	South Fork Catoctin Creek Downstream of Route 611	Rural	Assess impacts on water quality from Town of Purcellville	SFCC-216-T-2009
1ASOC012.60	39.1422	-77.7228	South Fork Catoctin Creek	South Fork Catoctin Creek Above Route 690	Rural	Assess impacts on water quality from Town of Purcellville	SFCC-215-T-2009

Table 2-2. (Continued)

Virginia DEQ Station ID	Latitude	Longitude	Stream Name	Site Name	Land Use	DEQ's Survey Reason	2009 Loudoun County Stream Assessment Station ID
1ASOC013.05	39.1464	-77.7322	South Fork Catoctin Creek	South Fork Catoctin Creek Above Route 7 Bypass		Selected for reference condition study	SFCC-214-T-2009
1AWAC003.31	38.9721	-77.7268	Wancopin Creek	Wancopin Creek Downstream of Route 50	Rural/Residential	Probabilistic Station	UPGC-206-T-2009
1AXGU000.18	39.0143	-77.7932	Tributary to Beaverdam Creek	Unnamed Tributary to Beaverdam Creek Downstream from Route 790	Agricultural	2006 Probabilistic Site - VAW05547-062	BEAV-110-T-2009
1AXKR000.77	39.2578	-77.5905	Tributary to Catoctin Creek	Unnamed Tributary to Catoctin Creek Downstream from Route 663	Forest/ Agriculture	Probabilistic Site, VAEQ99-615	CATO-121-T-2009

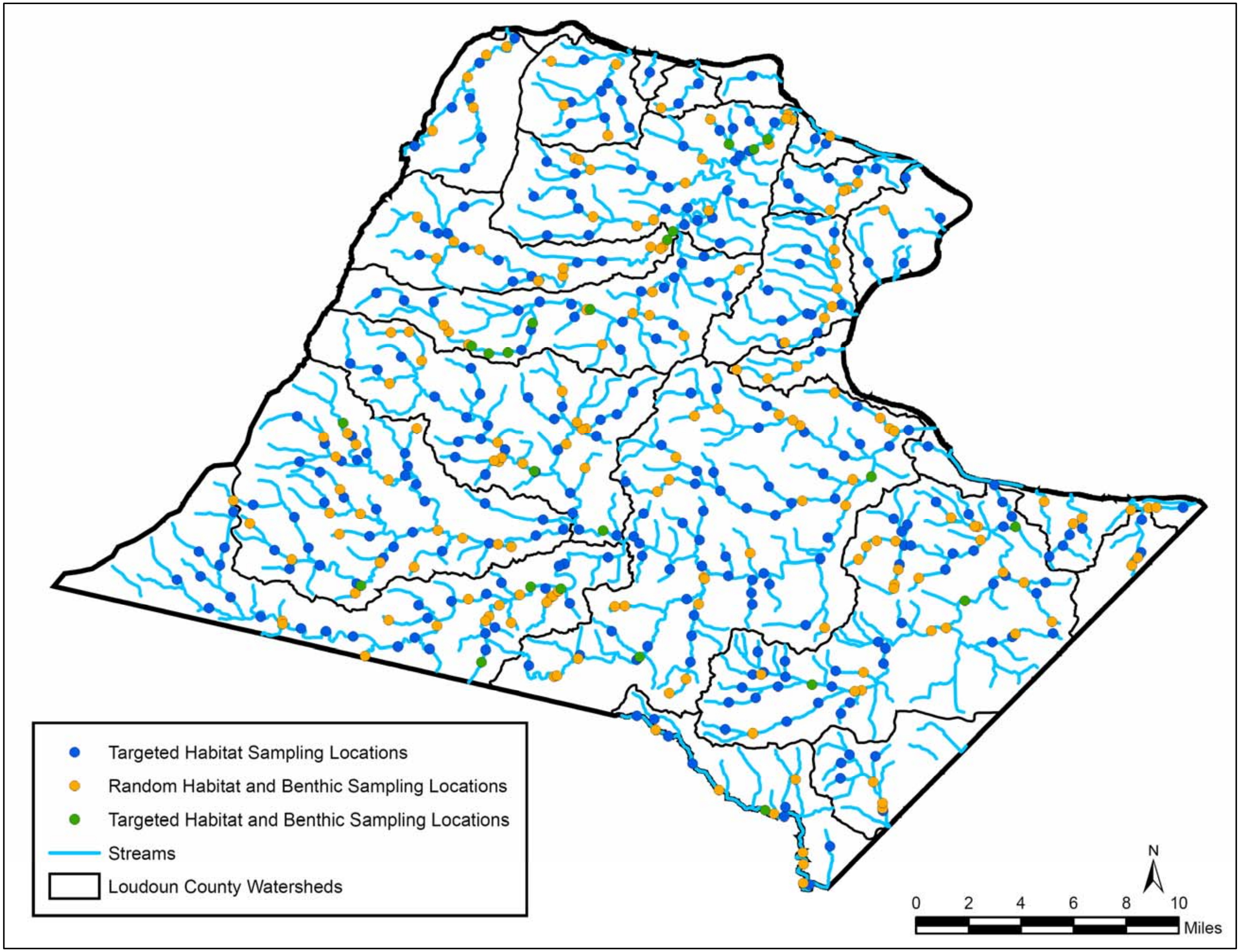

Figure 2-4. Locations of habitat assessment sites sampled by the Loudoun County Stream Assessment, 2009. Habitat assessments were conducted at the 200 benthic macroinvertebrate sampling sites, plus 300 additional sites sampled for habitat only.

Sites were allocated along the stream network with the intent of providing good overall coverage of stream areas and filling in gaps in the coverage, beyond that provided by the probability-based sampling. Site locations were distributed along the NHD-Medium Resolution stream network, between confluences, providing coverage of reaches to the extent possible. No exclusions of larger streams were made prior to habitat sampling, but reservoirs were excluded. Sites were hand placed using Geographic Information Systems (GIS), but in some cases the site locations were adjusted slightly upstream or downstream in the field if the original location was unsampleable. If no suitable site could be found along the same reach, a replacement location was substituted.

In all, approximately 240 of the 300 sites (80%) were allocated to sampling of streams designated as perennial by NHD. These 240 sites were placed over approximately 430 miles of perennial streams, or approximately one 100-meter sampling reach every two miles. Approximately 20% of the 300 habitat assessment sites (60 sites) were allocated to streams labeled as intermittent on the NHD-Medium Resolution network. This subset of sites was intended to evaluate the utility of habitat assessment protocols in these smaller, headwater streams.

2.1.4 Landowner Permission

Before beginning the assessment survey, all property owners whose property included candidate stream sampling points or access paths (properties that needed to be crossed to access the stream sites) were notified by letter or by direct contacts by Field Teams. If a landowner denied permission for sampling, or if a site was otherwise found to be unsampleable, a replacement site was substituted. For random sites, the next site in the pick order in the same watershed where field crews could obtain permission was chosen. For the non-random habitat sites, an alternate location in the same watershed where field crews could obtain permission was chosen.

2.2 FIELD AND LABORATORY METHODS

Benthic macroinvertebrate samples were collected in accordance with Virginia DEQ procedures (DEQ 2008). At each sample site, benthic macroinvertebrates were sampled using a D-net to collect organisms, following the single habitat (cobble) or multihabitat protocol. Samples from individual net kicks or jabs were composited into a single macroinvertebrate sample per site, which were preserved in ethanol for subsequent laboratory subsampling and identification. Samples were collected in the field within the spring index period of March – May 2009. No periods of extreme rainfall (i.e., exceeding three inches within a 48-hour period) were encountered.

Laboratory processing of benthic samples followed Virginia DEQ (2008) Standard Operating Procedures (SOPs) for subsampling/sorting, taxonomic identification, and enumeration. The benthic macroinvertebrate samples were sorted into subsamples of 110 organisms

+/- 10% and identified to the family taxonomic level or as specified in the SOP. Laboratory sorting and identification of benthic samples was completed during March – July 2009.

Stream habitat assessments were conducted in accordance with DEQ's protocols, as detailed in Virginia DEQ (2008), which are based on EPA's Rapid Bioassessment Protocol (Barbour et al. 1999). The RBP Habitat Assessment procedure is a well-established method for evaluating the structure and function of the physical habitat in a stream and its surrounding riparian area. Since biological potential is limited by the quality of the stream's physical habitat, an assessment of physical habitat is an important component of any biological stream survey. The RBP protocol consists of ten parameters appropriate for the evaluation of stream habitat (Table 2-3). The habitat assessment process involves rating each of the parameters on a 0 – 20 scale within four categories:

- Poor: 0-5
- Marginal: 6-10
- Suboptimal: 11-15
- Optimal: 16-20

Scores increase as habitat quality increases. To ensure consistency in the evaluation procedure, descriptions of the physical parameters and relative criteria are included on the rating form. Two or more digital photographs of each site were taken to record observed conditions. A suite of basic water quality parameters (pH, conductivity, temperature, and dissolved oxygen) were measured at each site using a multiparameter sonde (YSI or equivalent). In addition, particular problems such as a lack of adequate riparian buffer were noted on data sheets adopted from the Stream Corridor Assessment (SCA) protocol (Yetman 2001). Habitat assessments took place during March – July 2009.

Table 2-3. Parameters assessed in the US EPA's Rapid Bioassessment Protocol (RBP) Habitat Assessment procedure for high-gradient streams

Parameter	Rating Scale
1. Epifaunal Substrate/Available Cover	0 to 20
2. Embeddedness	0 to 20
3. Velocity/Depth Regime	0 to 20
4. Sediment Deposition	0 to 20
5. Channel Flow Status	0 to 20
6. Channel Alteration	0 to 20
7. Frequency of Riffles (or bends)	0 to 20
8. Bank Stability (each bank is scored separately)	0 to 10 left bank, 0 to 10 right bank
9. Vegetative Protection (each bank is scored separately)	0 to 10 left bank, 0 to 10 right bank
10. Riparian Vegetative Zone Width (each bank is scored separately)	0 to 10 left bank, 0 to 10 right bank

2.3 CALCULATING BENTHIC AND HABITAT INDICATORS

DEQ's Virginia Stream Condition Index (VSCI), a rapid bioassessment method using a specific sampling method and biological indicator appropriate to Virginia streams, was employed for analysis of benthic macroinvertebrate monitoring data. The VSCI represents a regional application of EPA's multimetric bioassessment approach. Virginia DEQ developed and validated the VSCI, a reference-based, multimetric indicator, specifically for non-coastal streams in Virginia (Tetra Tech 2003, DEQ 2006). Calculation of the VSCI score is based on eight standard metrics representing attributes of the benthic community (Table 2-4).

Table 2-4. Virginia Stream Condition Index (VSCI) metrics, definitions, and scoring.

Metric	Definition	Response to Increased Perturbation	Score
1. Total Taxa	Measures total number of taxa observed.	Decrease	(a)
2. EPT Taxa	Measures total number of pollution sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) observed.	Decrease	(a)
3. % Ephemeroptera	Measures % Ephemeroptera taxa present in sample.	Decrease	(a)
4. % Plecoptera + Trichoptera less Hydropsychidae	Measures % Plecoptera + Trichoptera, subtracting pollution tolerant Hydropsychidae.	Decrease	(a)
5. % Scrapers	Measures % scraper functional feeding group present in sample.	Decrease	(a)
6. % Chironomidae	Measures % pollution tolerant Chironomidae present in sample.	Increase	(b)
7. % Top 2 Dominant Taxa	Measures % dominance of the 2 most abundant taxa.	Increase	(b)
8. HBI (family)	Hilsenhoff Biotic Index (HBI).	Increase	(b)

(a) Score is the total possible score * the (metric value / by the standard best value X95).
(b) Score is the total possible score * the (total possible score - the metric value/the total possible score - the standard best value X5).

Scoring procedures compare each monitored site to a reference condition and are used to rate a monitored site in one of four categories: excellent, good, stress, and severe stress (DEQ 2008). Ratings were assigned using the following scale developed by DEQ, out of a maximum possible score of 100:

- Excellent: ≥ 73
- Good: 60 - 72
- Stress: 43-59
- Severe Stress: ≤ 42

An Ecological Data Application System (EDAS) program provided by Virginia DEQ (J. Hill, pers. comm.) was used to calculate VSCI scores. As per DEQ's approach, if a site's VSCI score fell between two categories, best professional judgment was used to assign the appropriate Assessment Category for that site (for example, a score of 42.5 falls between the Severe Stress and Stress categories).

Using the 10 parameters from the RBP Habitat Assessment procedure, individual metric scores were added together to provide an overall total habitat score at each site, with 200 points the maximum possible score at any site. Based on their total scores, sites were then assigned an Assessment Category, as follows:

- Optimal: 160 to 200
- Sub-optimal: 107 to < 160
- Marginal: 54 to < 107
- Poor: 0 to < 54

3. RESULTS OF PROBABILITY-BASED SURVEY

This chapter highlights results of the probability-based survey, including benthic assessments and habitat evaluations performed at 177 randomly selected stream sites throughout Loudoun County watersheds during spring 2009. Detailed tables of results, including mean and percent stream mile estimates with standard errors, are included in Appendix A.

3.1 BIOLOGICAL ASSESSMENT

Using DEQ's methods, VSCI scores were calculated for benthic samples collected at 177 randomly selected stream sites throughout Loudoun County watersheds (Figure 3-1). Individual site scores (Figure 3-2) ranged from 13.1 (Severe Stress) to 82.2 (Excellent).

Because of the probabilistic design of the survey, area-wide assessments of stream condition can be made. Mean VSCI scores were calculated for each of 12 PSUs in the County, i.e., the watersheds or watershed groupings identified in Table 2-1. Mean VSCI scores ranged from a low of 29.4 (Severe Stress) in the Broad Run/Sugarland Run PSU to a high of 58.6 (Stress) in the South Fork Catoctin Creek PSU (Figures 3-3 and 3-4).

In addition, the extent of stream length in the County (or within each PSU) that rate as Excellent, Good, Stress, or Severe Stress can be estimated with known confidence and expressed as a percent or number of stream miles. The percent of stream miles in the entire County in each category of interest can be estimated by weighting the individual PSU results by the number of stream miles in each PSU (Table 2-1).

For Loudoun County as a whole, an estimated 42.5% of the stream miles were rated as Severe Stress based on the macroinvertebrate bioassessment (Figure 3-5). Just under 4% of the stream miles in the County classified as Excellent, while 18% were Good and 35.7% were in the Stress category.

Percent stream mile estimates for VSCI by PSU are shown in Figure 3-6 and mapped in Figure 3-7. In all but one PSU, some stream miles were classified as Severe Stress based on poor benthic communities found in the streams. The Dutchman Creek/Piney Run/Quarter Branch and South Fork Catoctin Creek PSUs had the fewest stream miles classified as Severe Stress (10% in each). The Broad Run/Sugarland Run PSU had the greatest amount of stream miles classified as Severe Stress (92%). Half of the PSUs had some stream miles classified as Excellent based on good benthic communities found in streams. In Beaverdam Creek, South Fork Catoctin Creek, Bull Run/Cub Run, and Clarks Run/Limestone Branch PSUs, 10% of the stream miles classified as Excellent, while Upper Goose Creek and Lower Goose Creek also had some Excellent streams (6% and almost 4%, respectively). All PSUs had some stream miles classified as Good, except for Broad Run/Sugarland Run where all stream miles fell in the Stress (8%) or Severe Stress (92%) Assessment Categories.

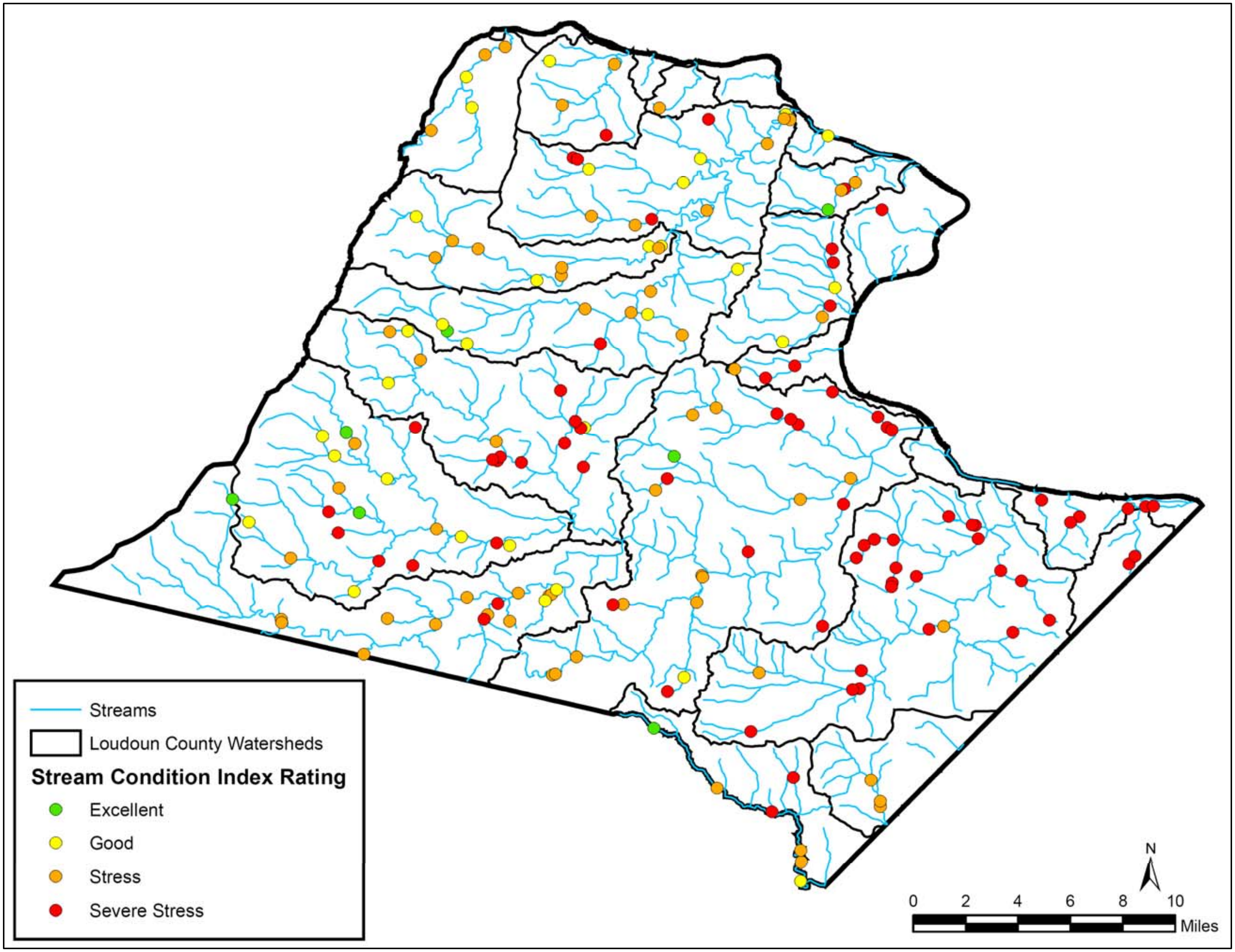

Figure 3-1. VSCI results for 177 probability-based monitoring sites in Loudoun County, 2009.

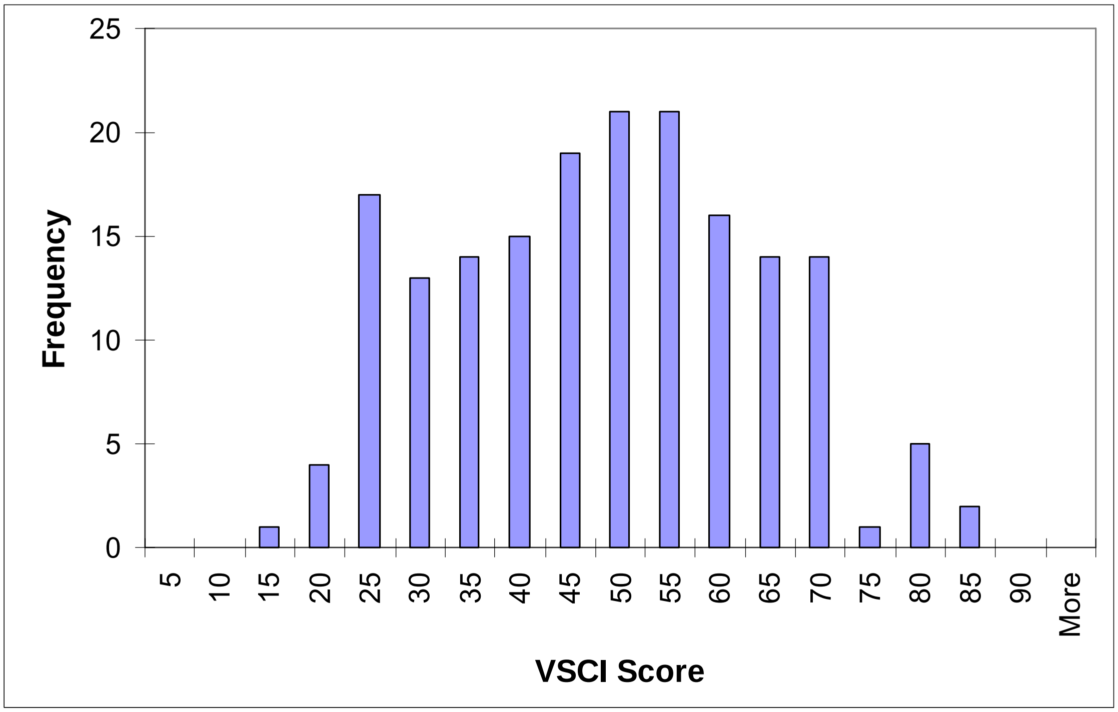

Figure 3-2. Histogram of VSCI scores for 177 probability-based monitoring sites in Loudoun County, 2009.

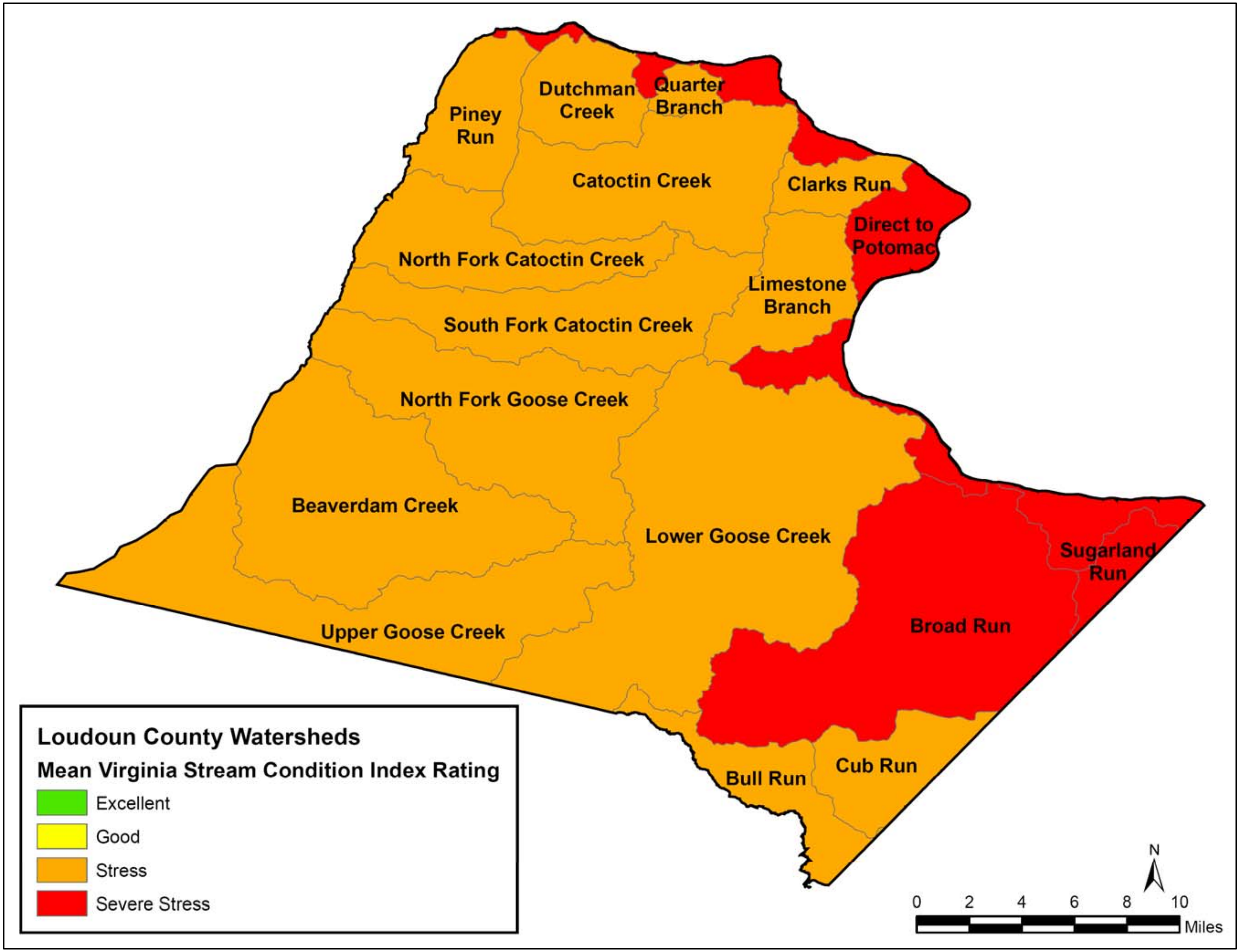

Figure 3-3. Mean VSCI scores by PSU, Loudoun County, 2009.

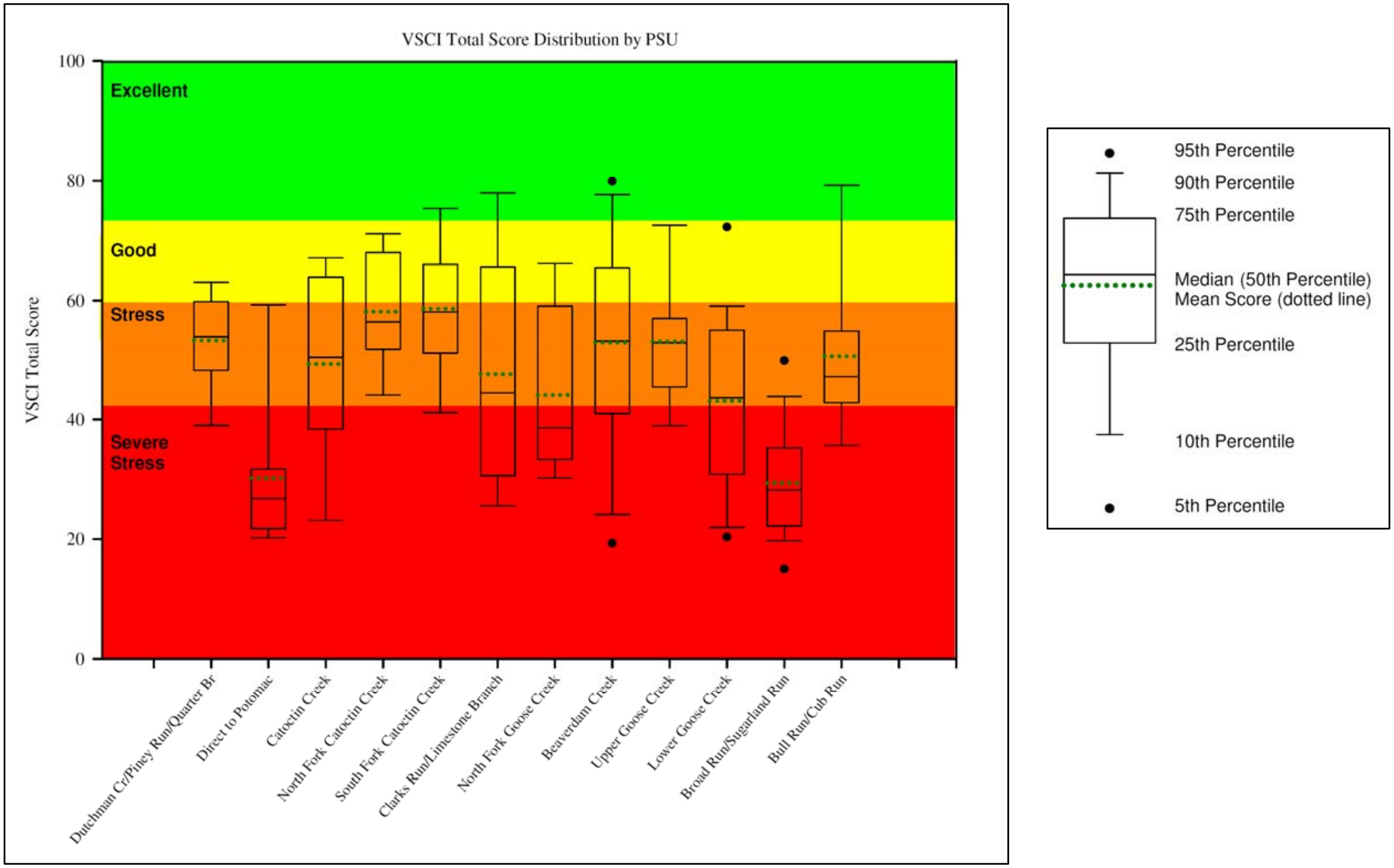

Figure 3-4. Distribution of VSCI scores by PSU. A graphical explanation of the various components of a box and whisker plot as used here and in additional graphs in this report is also presented.

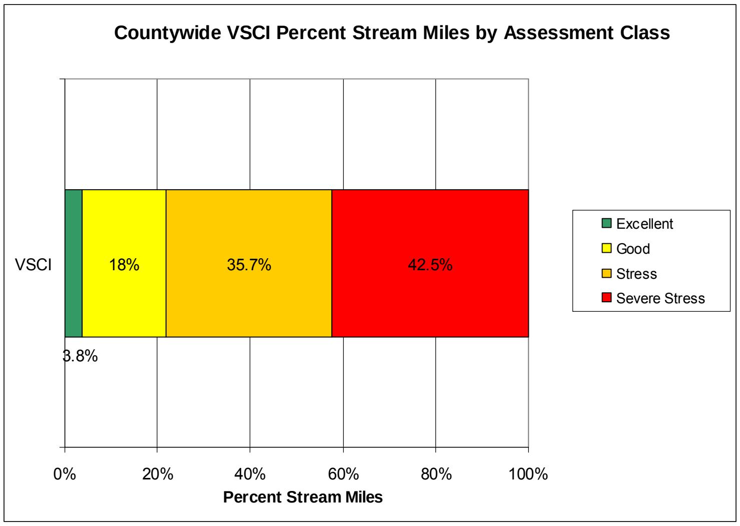

Figure 3-5. Percent of stream miles in Loudoun County that are rated as Excellent, Good, Stress, or Severe Stress based on results of probability-based benthic macroinvertebrate monitoring throughout Loudoun County watersheds.

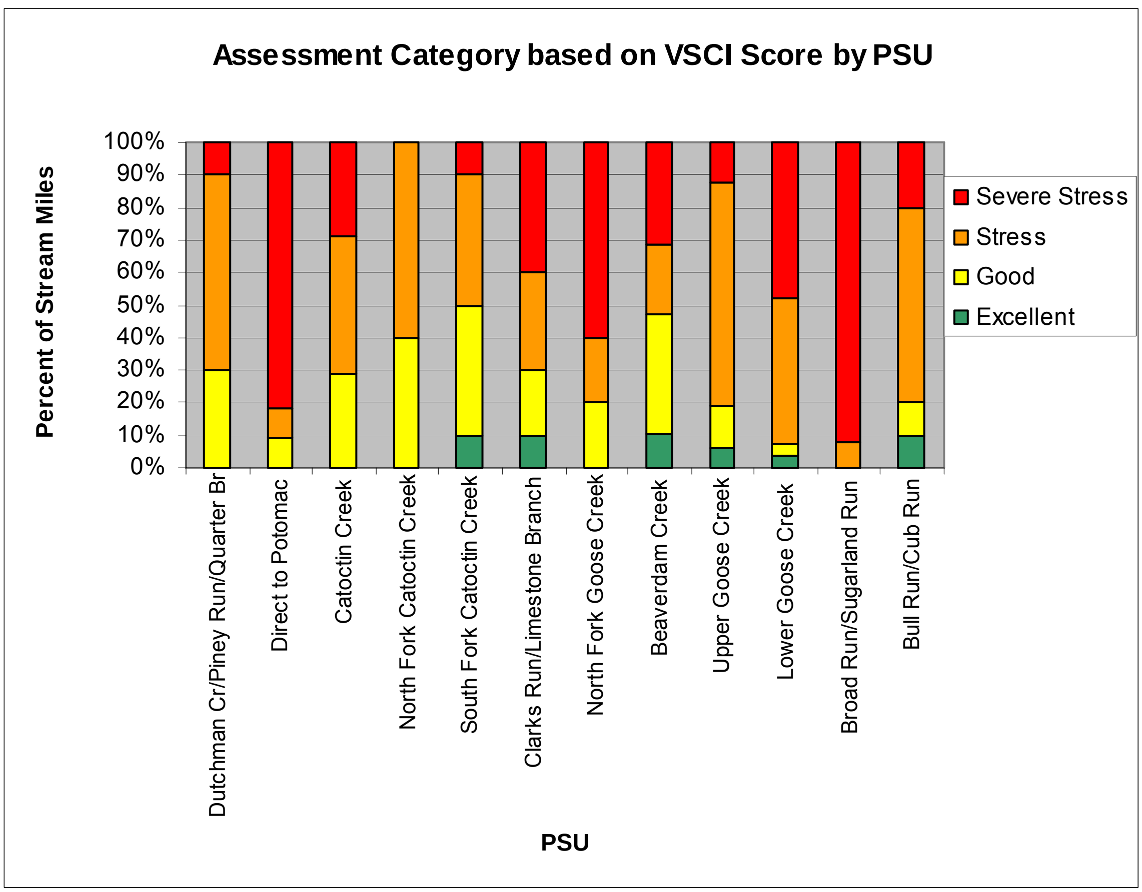

Figure 3-6. Percent of Stream Miles in each PSU in Loudoun County rated as Excellent, Good, Stress, or Severe Stress based on benthic macroinvertebrate VSCI scores.

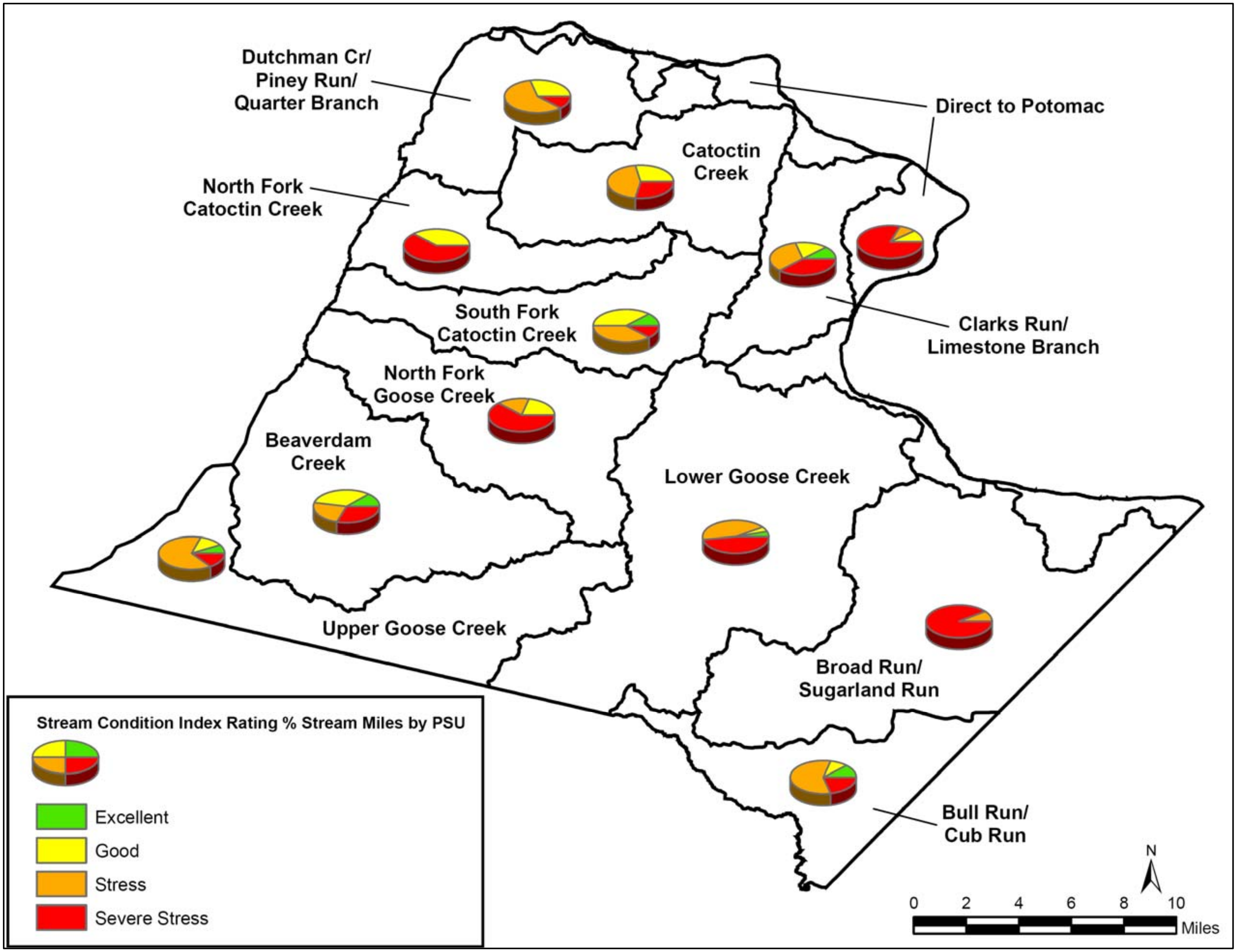

Figure 3-7. Geographic distribution of percent of stream miles by PSU in Loudoun County rated as Excellent, Good, Stress, or Severe Stress based on VSCI scores.

3.2 HABITAT

3.2.1 Overall Habitat Conditions

The RBP Habitat Assessment procedure was used to evaluate stream physical habitat at 177 randomly selected stream sites throughout Loudoun County watersheds (Figure 3-8). Across these sites, RBP Habitat Assessment scores ranged from 61 (Poor) to 176 (Optimal). Mean RBP habitat scores calculated for each PSU ranged from a low of 111.9 (Suboptimal) in the Clarks Run/Limestone Branch PSU to a high of 155.5 (Suboptimal) in the Dutchman Creek/Piney Run/Quarter Branch PSU; all PSU means were Suboptimal (Figures 3-9 and 3-10). In general, the Catoctin Creek watersheds (Catoctin, North Fork, and South Fork) and Bull Run/Cub Run had slightly higher mean scores than other PSUs, indicating generally better habitat conditions in the western portion of the County.

In estimates of stream condition for Loudoun County as a whole, 74.9% of the stream miles classified as Suboptimal based on the physical habitat assessment (Figure 3-11). Nineteen percent of the stream miles in the County classified as Optimal, while 5.1 % were Marginal. No streams in the County rated as Poor based on physical habitat.

The extent of stream in various habitat condition was also evaluated by PSU. With the exception of the Clarks Run/Limestone Branch and Broad Run/Sugarland Run PSUs, every PSU had some stream miles that rated as Optimal for overall habitat (Figures 3-12 and 3-13). The greatest percentage of Optimal stream miles were in the northern-most PSU, Dutchman Creek/Piney Run/Quarter Branch (60% of stream miles). Suboptimal habitat conditions were the dominant category in all other PSUs. Marginal habitat conditions were greatest in Clarks Run/Limestone Branch (40% of stream miles), and were also present in the Broad Run/ Sugarland Run (12% of stream miles), Lower Goose Creek (11.1% of stream miles), and Beaverdam Creek (5.3% of stream miles) PSUs. No PSU had streams that rated Poor in their overall assessment of habitat.

3.2.2 Individual Habitat Parameters

In addition to the overall RBP habitat scores, results for individual habitat metrics were examined. Even though many of the overall habitat scores were in the Suboptimal range, results for individual parameters may indicate particular aspects of habitat condition that are in far better (Optimal) or more degraded (Marginal to Poor) condition. Example results for several key parameters are described in this section. Each was rated on a 0 to 20 scale, from Poor to Optimal as described in Section 2.2. Similar to the analyses for VSCI and the overall RBP Habitat Assessment scores, the survey's probabilistic design provides area-wide estimates of means and percent stream miles, both countywide and by PSU.

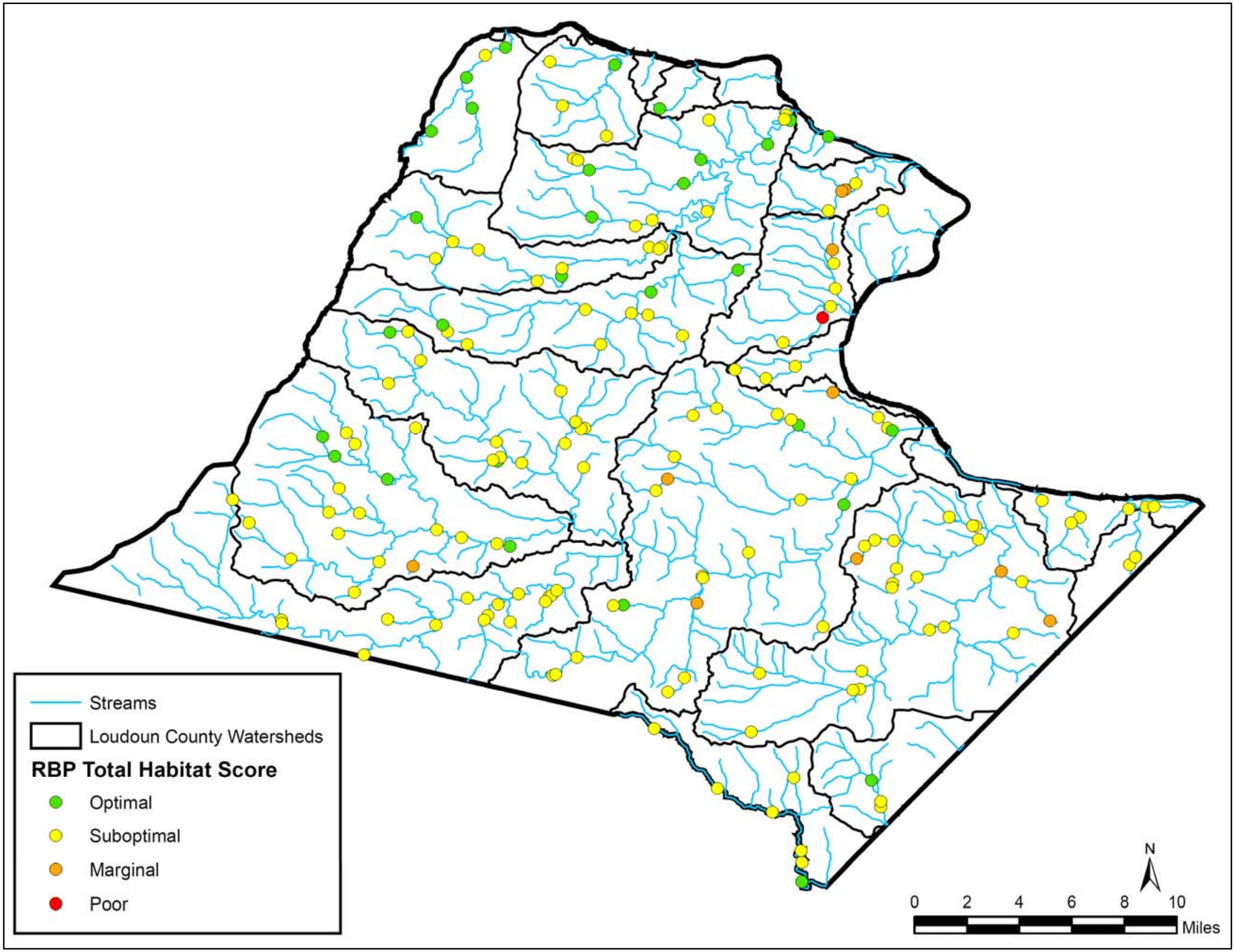

Figure 3-8. RBP Habitat Assessment results for 177 probability-based monitoring sites in Loudoun County, 2009.

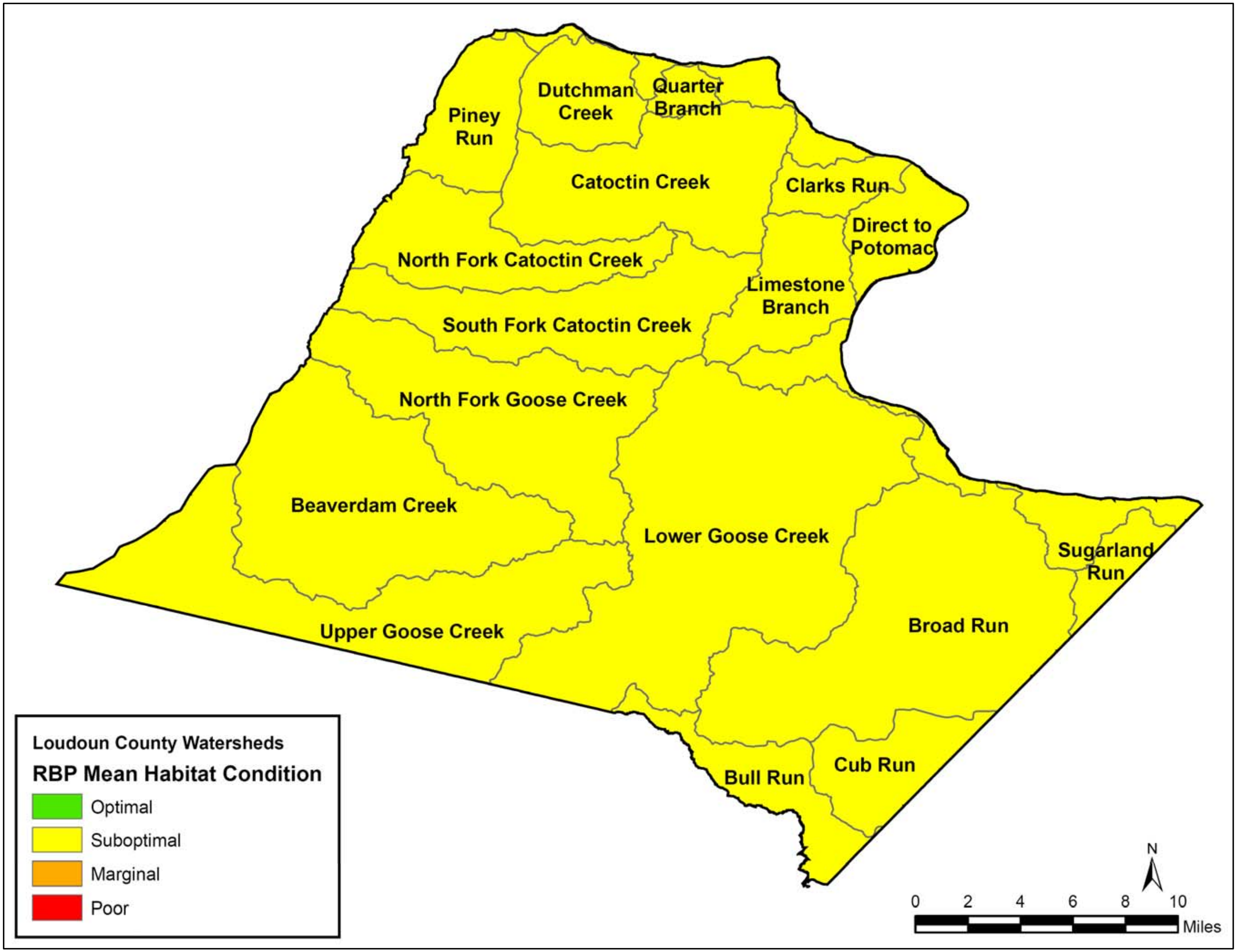

Figure 3-9. Mean RBP Habitat Assessment scores by PSU, Loudoun County, 2009.

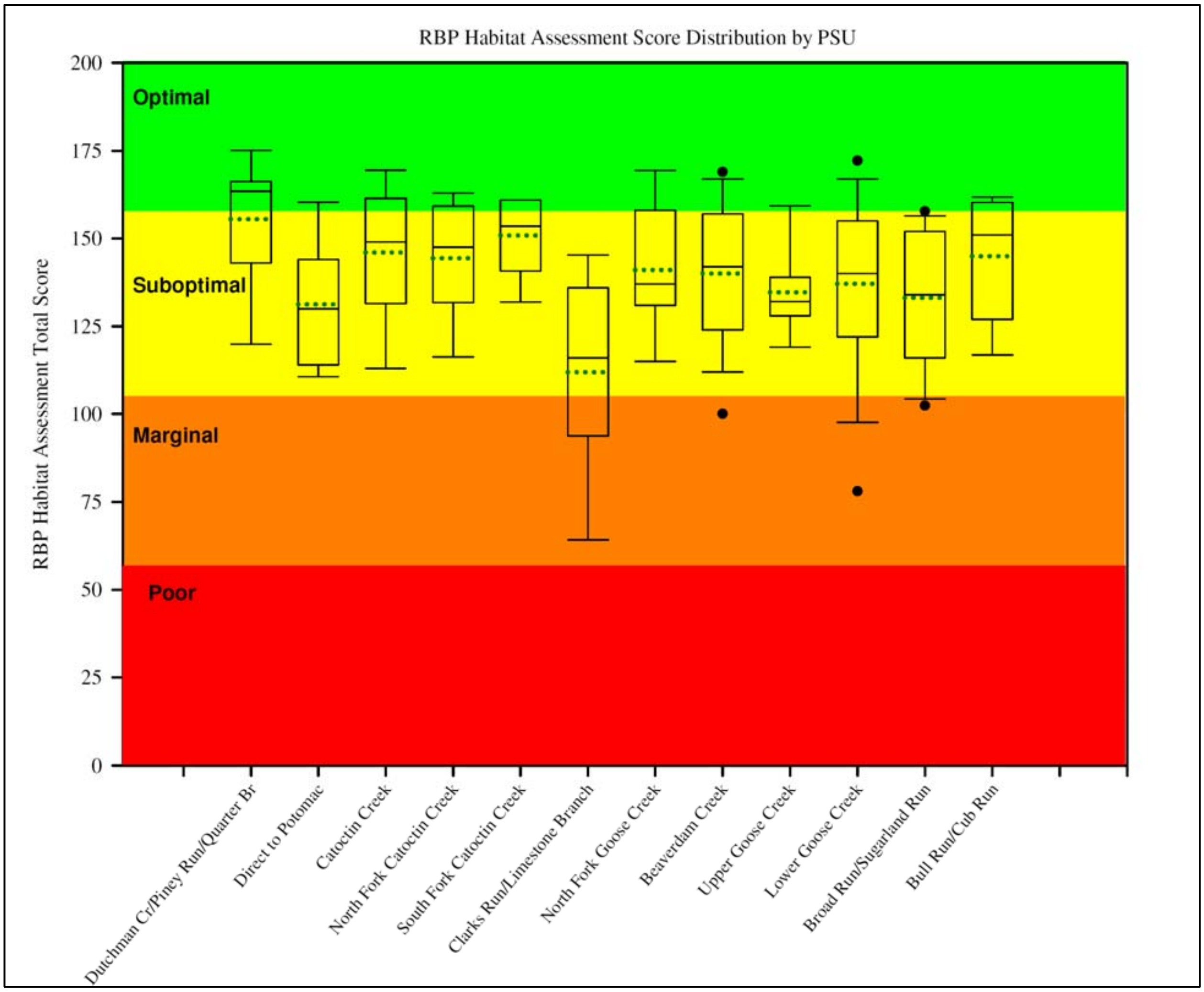

Figure 3-10. Distribution of RBP Habitat Assessment scores by PSU. See Figure 3-4 for a graphical explanation of the various components of a box and whisker plot.

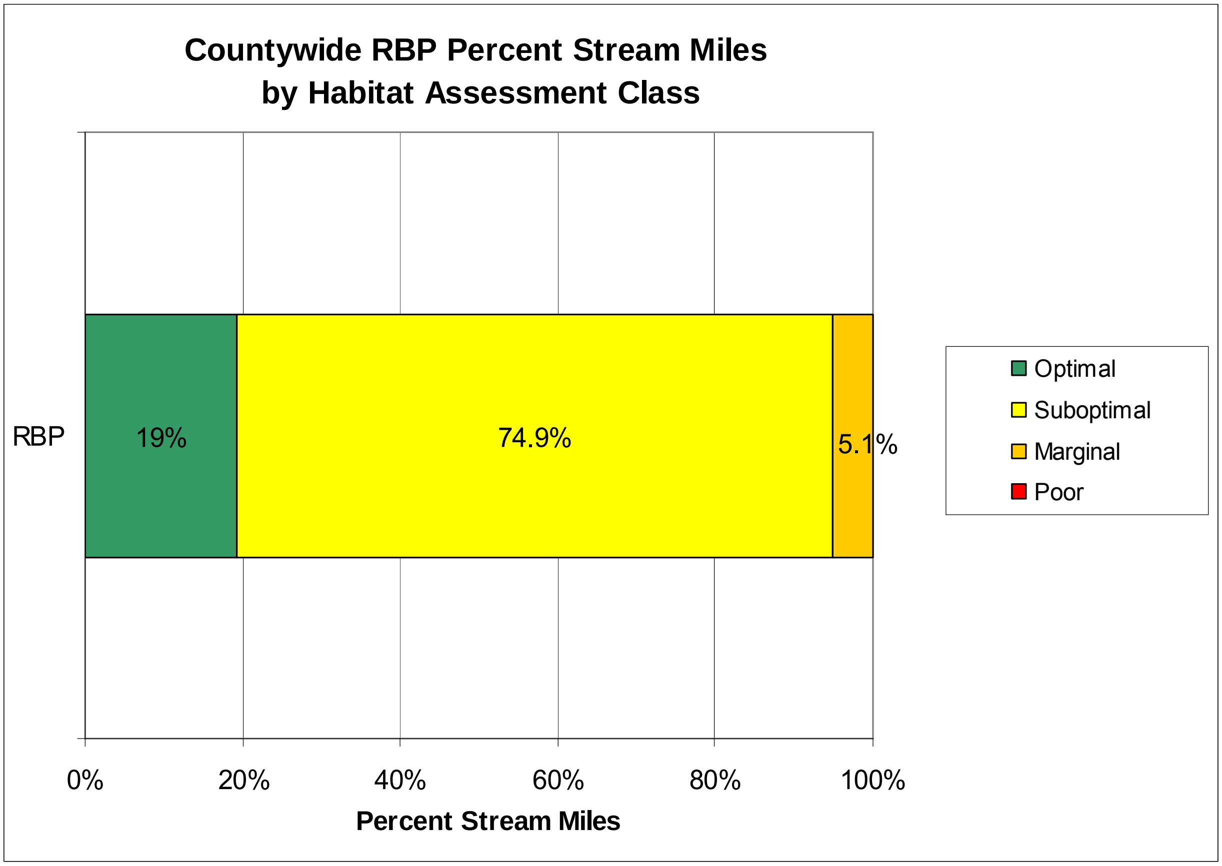

Figure 3-11. Percent of stream miles in Loudoun County rated as Optimal, Suboptimal, Marginal, and Poor based on results of RBP Habitat Assessments for the probability-based survey conducted throughout Loudoun County watersheds in 2009.

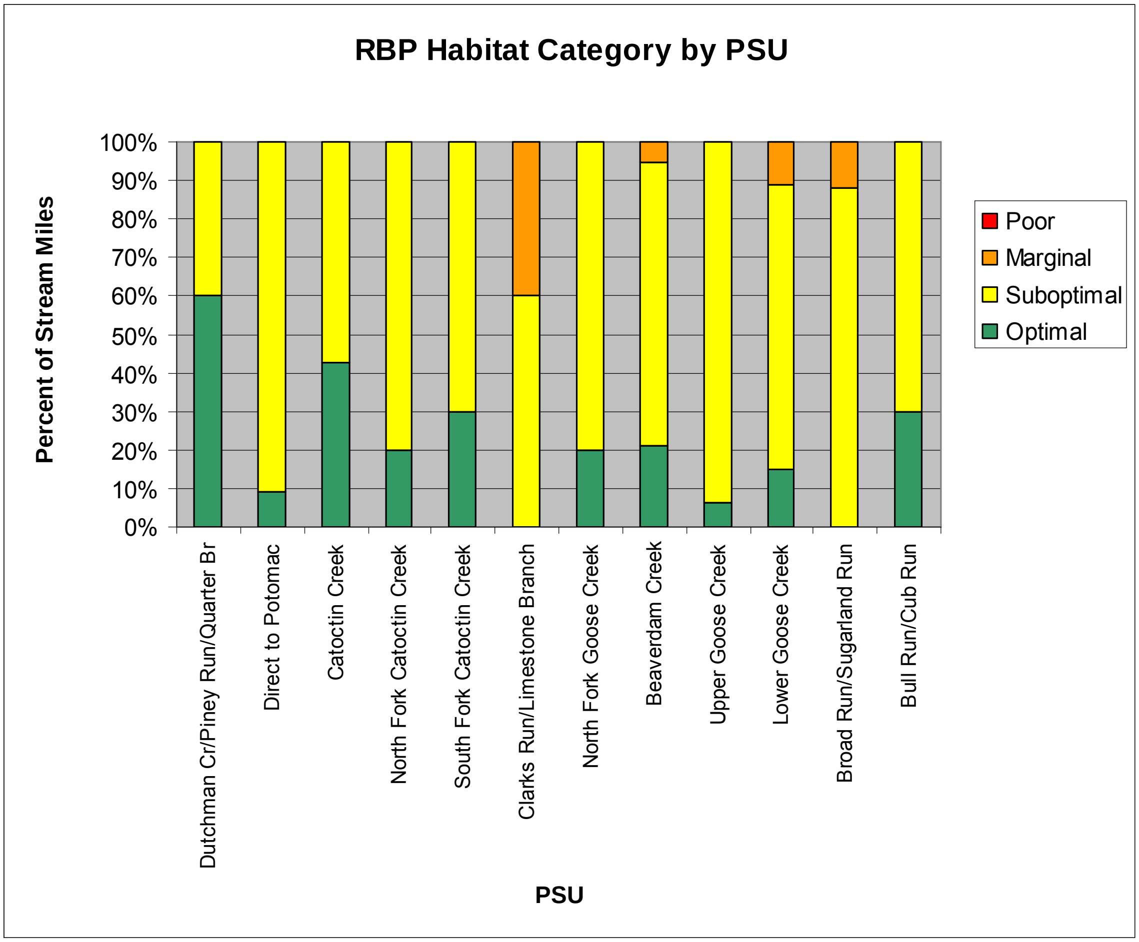

Figure 3-12. Percent of stream miles in each PSU in Loudoun County that rated as Optimal, Suboptimal, Marginal, and Poor based on total RBP Habitat Assessment scores.

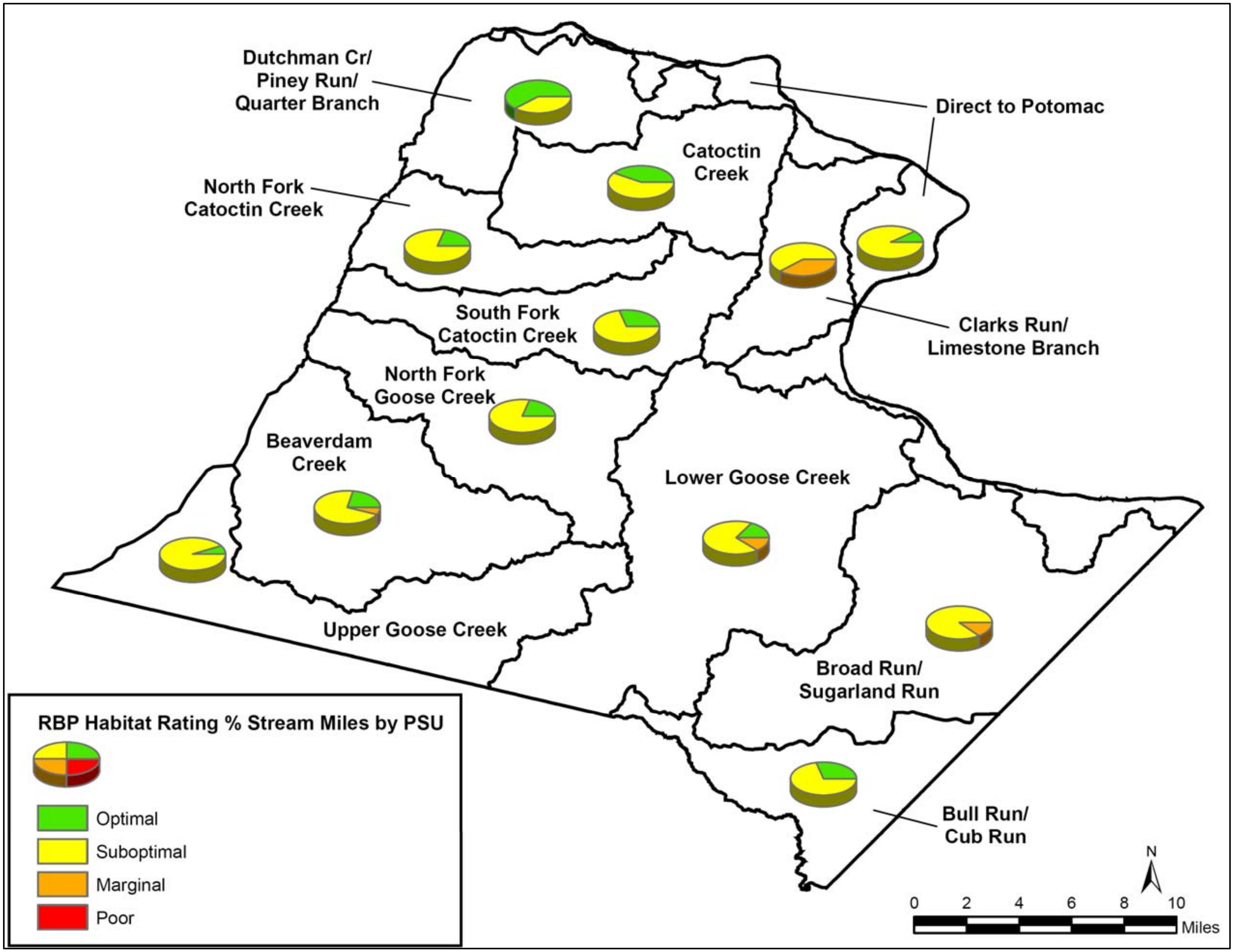

Figure 3-13. Geographic distribution of percent of stream miles by PSU in Loudoun County rated as Optimal, Suboptimal, Marginal, and Poor based on RPB Habitat scores.

3.2.2.1 Epifaunal Substrate/Available Cover

The Epifaunal Substrate/Available Cover metric of the EPA's RBP Habitat Assessment categorizes how much habitat there is for benthic macroinvertebrates and fish in the streams. Benthic macroinvertebrates require hard substrates such as rocks, snags, or woody debris to attach themselves to and to feed. The greater the amount and the variety of these structures (epifaunal substrate), the greater the number and the diversity of benthic macroinvertebrates in the stream. Similarly, fish require structures in the stream where they can hide, feed, and lay eggs. Submerged structures, including fallen trees, branches, or logs, large rocks, or undercut banks can all serve as available cover for fish.

In the Loudoun County Stream Assessment, the majority of the streams (88%) had Optimal or Suboptimal epifaunal substrate and available cover (Figure 3-14). The Clarks Run/ Limestone Branch PSU clearly exhibited the worst epifaunal substrate and available cover of all areas in the County (Figure 3-15). Sixty percent of the stream miles in Clarks Run/ Limestone Branch were rated Marginal or Poor for Epifaunal Substrate/Available Cover, and no stream miles are rated in the Excellent category. Only three other PSUs had stream miles with Poor epifaunal substrate and available cover: Direct to Potomac, Catoctin Creek, and Lower Goose Creek PSUs with 18%, 7%, and less than 4% of stream miles, respectively. This metric can be affected by agricultural runoff, as well as increased urbanization, both of which are likely occurring in these watersheds. The North Fork Catoctin Creek, South Fork Catoctin Creek, and Dutchman Creek/Piney Run/Quarter Branch PSUs had some of the best epifaunal substrate and available cover in the County, with no stream miles in the Marginal or Poor categories. In North Fork Catoctin Creek, 80% of the stream miles rated Optimal for Epifaunal Substrate/Available Cover, with the remaining 20% rated as Suboptimal. South Fork Catoctin Creek had 70% of stream miles rated as Optimal, and the Dutchman Creek/Piney Run/Quarter Branch PSU had 60% of stream miles rated as Optimal. These three PSUs make up the northwestern part of the County where development pressures are minimal.

3.2.2.2 Embeddedness

The Embeddedness metric of EPA's RBP Habitat Assessment procedure characterizes the extent to which rocks, gravel, cobble, and/or boulders in riffles are covered or sunken into the silt, sand, or mud of the stream bottom. The more embedded a stream is, the fewer sites there are for organisms to attach, feed, and hide.

Overall, the majority (73%) of streams in Loudoun County had Optimal or Suboptimal embeddedness conditions, and only 3.3% had Poor embeddedness (Figure 3-16). The Direct to Potomac PSU had the highest percentage of stream miles with Poor embeddedness (27%; Figure 3-17). Beaverdam Creek, Broad Run/Sugarland Run and Lower Goose Creek PSUs also had some streams with Poor embeddedness (5.3%, 4%, and 3.7%, respectively). Embeddedness was best in the Dutchman Creek/Piney Run/Quarter Branch PSU, where 90% of the stream miles were rated either Optimal (50%) or Suboptimal (40%) and in South Fork Catoctin where all stream miles were rated either Optimal (30%) or Suboptimal (70%).

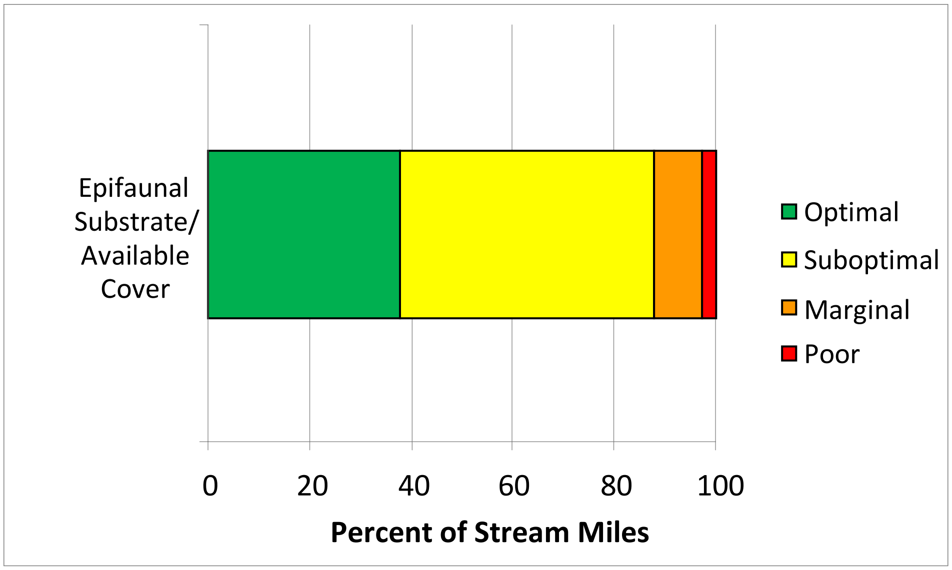

Figure 3-14. Percent of stream miles in Loudoun County that rated as Optimal, Suboptimal, Marginal, and Poor based on Epifaunal Substrate/Available Cover scores.

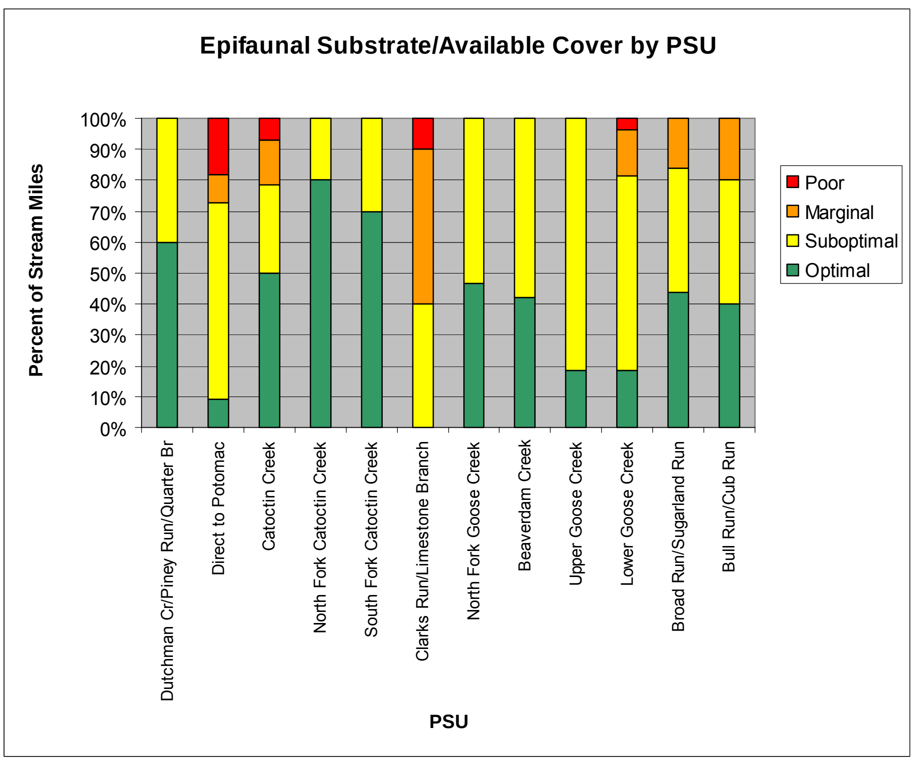

Figure 3-15. Percent of stream miles in each PSU in Loudoun County that rated as Optimal, Suboptimal, Marginal, and Poor based on Epifaunal Substrate/Available Cover scores assessed at stream sites in each PSU.

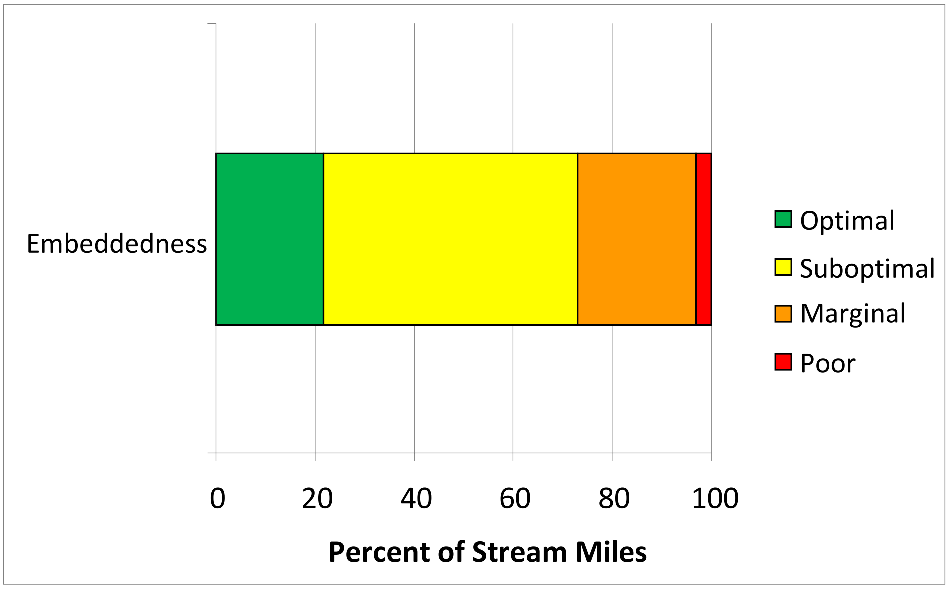

Figure 3-16. Percent of stream miles in Loudoun County that rated as Optimal, Suboptimal, Marginal, and Poor based on Embeddedness scores.

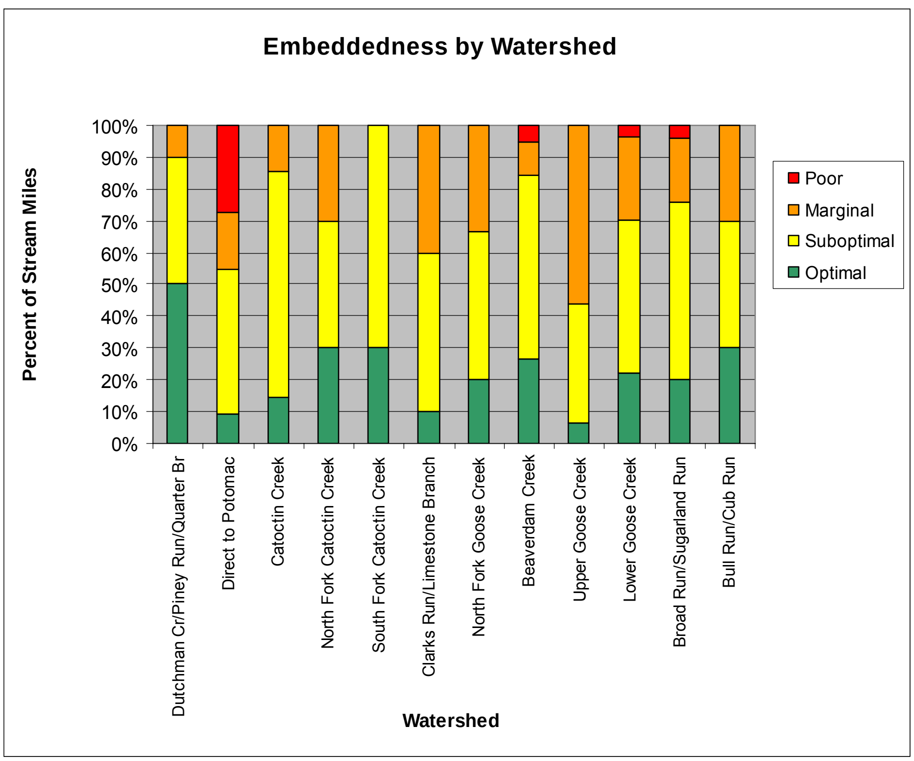

Figure 3-17. Percent of stream miles in each PSU in Loudoun County that rated as Optimal, Suboptimal, Marginal, and Poor based on Embeddedness scores assessed at stream sites in each PSU.

3.2.2.3 Sediment Deposition

Sediment can enter a stream from erosion in the watershed and erosion of stream banks. High levels of sediment deposition create an unstable and continuously changing environment that is unsuitable for many organisms. Sediment deposition may create islands in the middle of channels, may enlarge point bars or side bars, and may result in the filling in of pools.

Overall, as seen with the previous habitat metrics, the majority of streams in Loudoun County had Optimal (23.7%) or Suboptimal (54%) sediment deposition (Figure 3-18). Sediment Deposition mostly rated Optimal and Suboptimal in each of the PSUs (Figure 3-19). There were a minimal amount of stream miles that rated Poor for Sediment Deposition in the Direct to Potomac (9%), Upper Goose Creek (6.3%), Beaverdam Creek (5.3%) and Lower Goose Creek (3.7%) PSUs. However, Direct to Potomac also had the highest percentage of stream miles rated as Optimal (45%), evidence of the variability that exists in this PSU. In Clarks Run/Limestone Branch, no stream miles rated in the Optimal category, and the majority of the PSU (60%) had Marginal ratings for Sediment Deposition.

3.2.2.4 Bank Stability

The Bank Stability metric evaluates whether the stream banks are eroded, or have the potential for erosion. Steep banks are more likely to collapse and suffer from erosion than are gently sloping banks, and are therefore considered to be unstable. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil. In the RBP Habitat Assessment, each bank is evaluated separately on a 0 to 10 scale and the total score (right and left) is used for this parameter.

Overall, Bank Stability was more of a problem in Loudoun County streams than some of the previously analyzed habitat parameters. While the majority of stream miles in Loudoun County had good bank stability (28% are rated Optimal, and 35.5% are rated Suboptimal), a larger percentage of stream miles fell in the Marginal and Poor categories (26.6% and 9.9%, respectively; Figure 3-20). Bank stability was highly variable throughout the PSUs in Loudoun County (Figure 3-21). The Dutchman Creek/Piney Run/Quarter Branch PSU had the greatest percent of stream miles that were rated Optimal (60%), only 10% were Marginal, and none were rated Poor. Conditions were similar in South Fork Catoctin Creek PSU, with 10% of the stream miles rated as Poor and the remaining 90% of the stream miles either Optimal (40%) or Suboptimal (50%). In both Upper Goose Creek and North Fork Goose Creek PSUs, the majority of stream miles had Marginal or Poor bank stability. Similar to the results for Sediment Deposition (Figure 3-19), the Direct to Potomac PSU had highly variable bank stability conditions, with 45% of stream miles rated as Optimal but 36% rated as Poor.

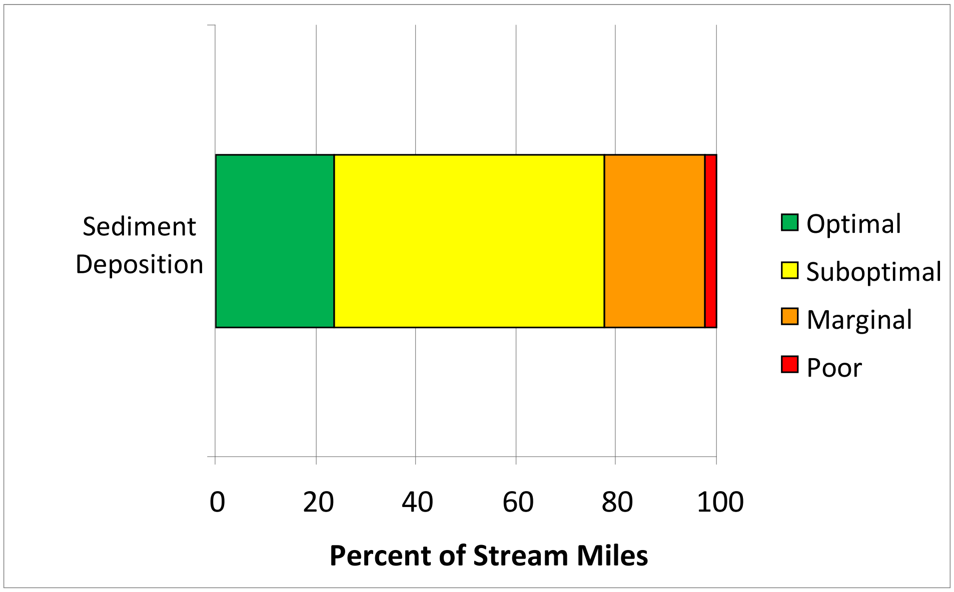

Figure 3-18. Percent of stream miles in Loudoun County with Optimal, Suboptimal, Marginal, and Poor Sediment Deposition scores.

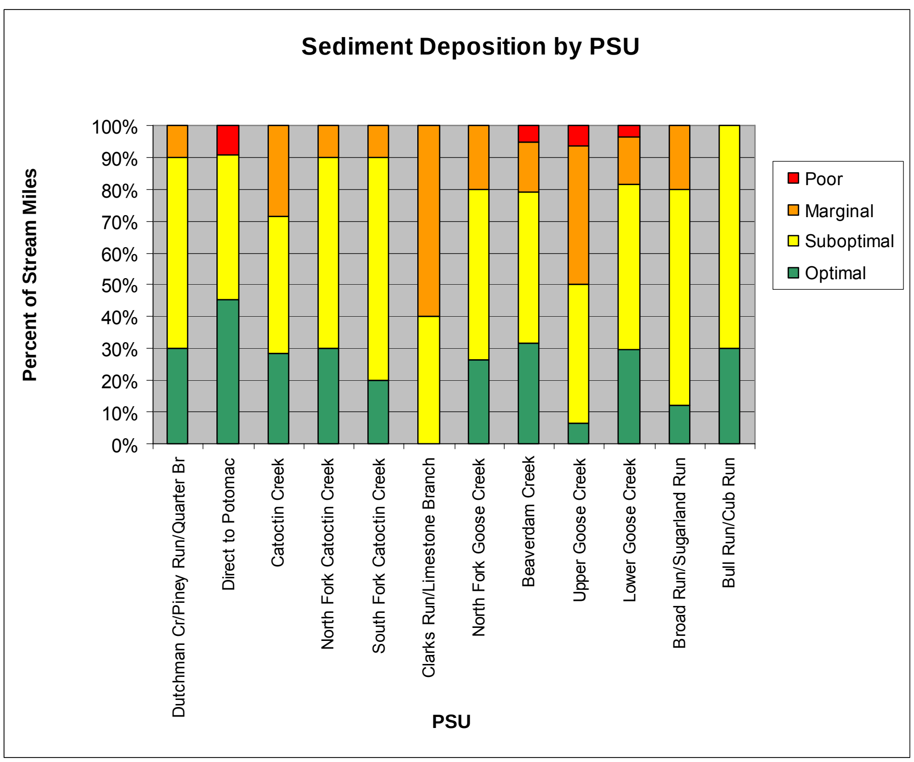

Figure 3-19. Percent of stream miles in each PSU in Loudoun County that rated as Optimal, Suboptimal, Marginal, and Poor based on Sediment Deposition scores assessed at stream sites in each PSU.

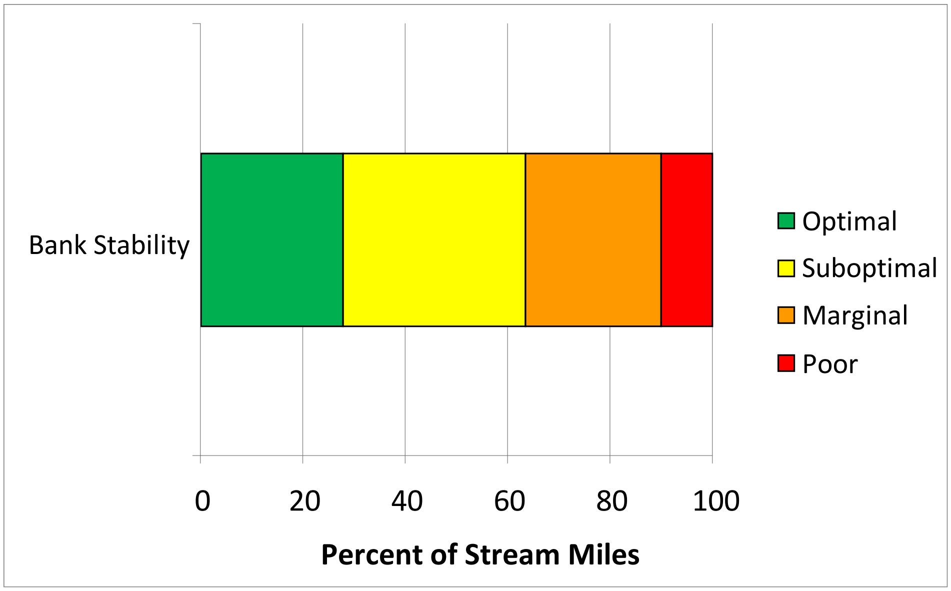

Figure 3-20. Percent of Loudoun County stream miles that rated as Optimal, Suboptimal, Marginal, and Poor for Bank Stability.

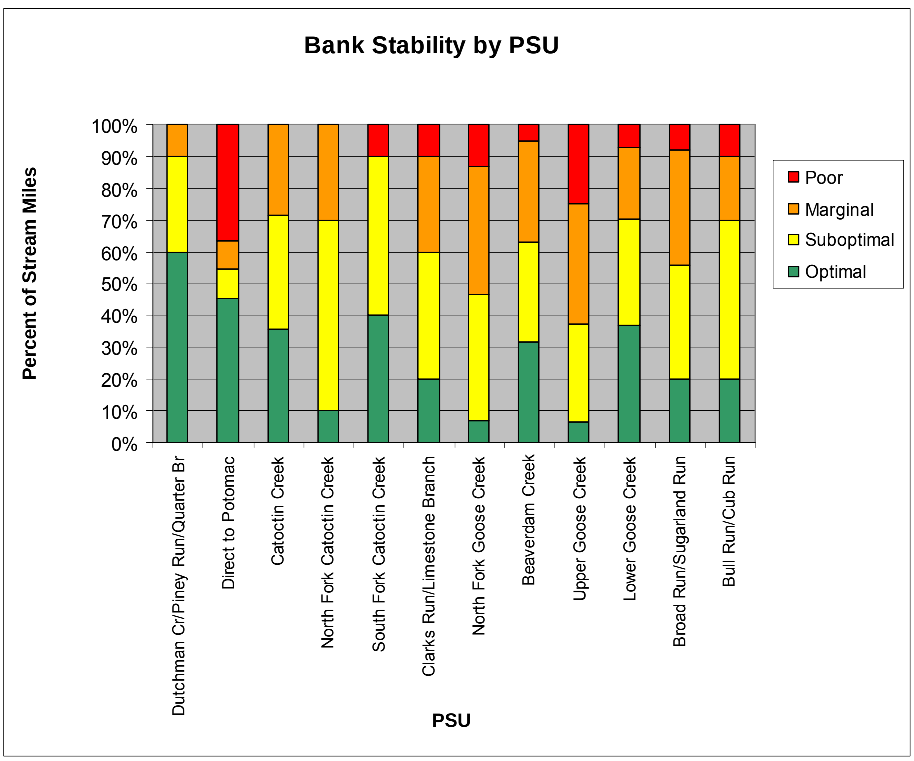

Figure 3-21. Percent of stream miles in each PSU in Loudoun County that are rated as Optimal, Suboptimal, Marginal, and Poor based on Bank Stability scores assessed at stream sites in each PSU.

3.2.2.5 Riparian Vegetative Zone Width

The Riparian Vegetative Zone metric evaluates the width of natural vegetation from the edge of the streambank out through the riparian zone. This vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input into the stream. A relatively undisturbed riparian zone supports a robust stream system; narrow riparian zones occur when roads, parking lots, fields, lawns, bare soil, rocks, or buildings are near the stream bank.

Countywide, more stream miles rated Poor for Riparian Vegetative Zone Width than for any other habitat metric examined (11.6%) (Figure 3-22). However, the majority of stream miles in Loudoun County had Optimal (49.5%) or Suboptimal (28.7%) riparian widths. The Dutchman Creek/Piney Run/Quarter Branch PSU had the best riparian widths in the County, with 80% of the stream miles in this PSU receiving an Optimal rating and 20% receiving a Suboptimal rating (Figure 3-23). Clarks Run/Limestone Branch, on the other hand, had half of its stream miles rated in the Marginal or Poor categories (30% and 40%, respectively), and only 20% rated as Optimal. PSUs in the northern part of the County (Dutchman Creek/Piney Run/Quarter Branch, Direct to Potomac, Catoctin Creek, and North Fork Catoctin Creek) had the greatest percentages of stream miles with Riparian Vegetation Zone Widths rated as Optimal (80%, 73%, 64%, and 60%, respectively). Riparian widths were not as good in Clarks Run/Limestone Branch, as half of the stream miles rated Poor (20%) or Marginal (30%).

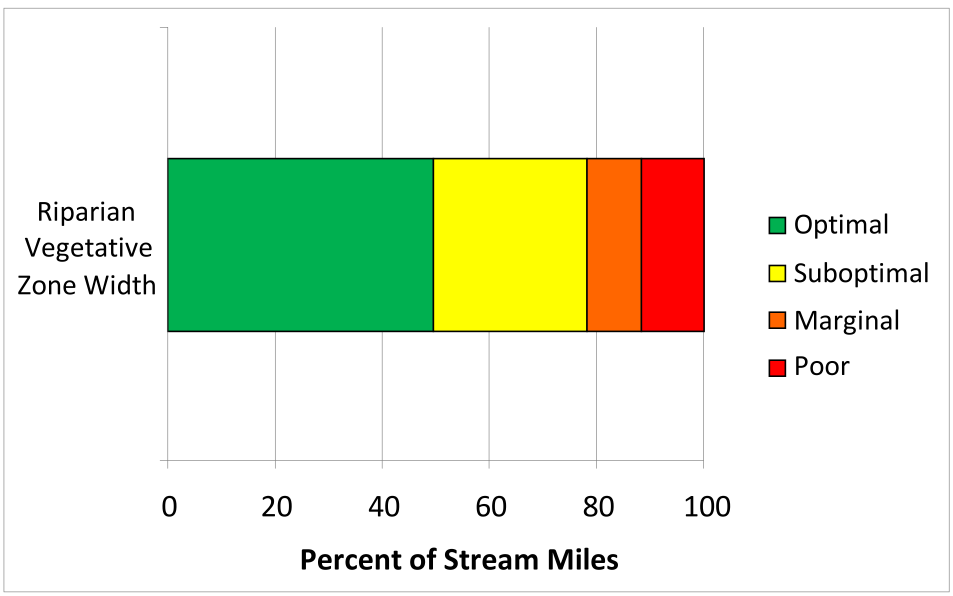

Figure 3-22. Percent of stream miles in Loudoun County with Optimal, Suboptimal, Marginal, and Poor Riparian Vegetative Zone Width scores.

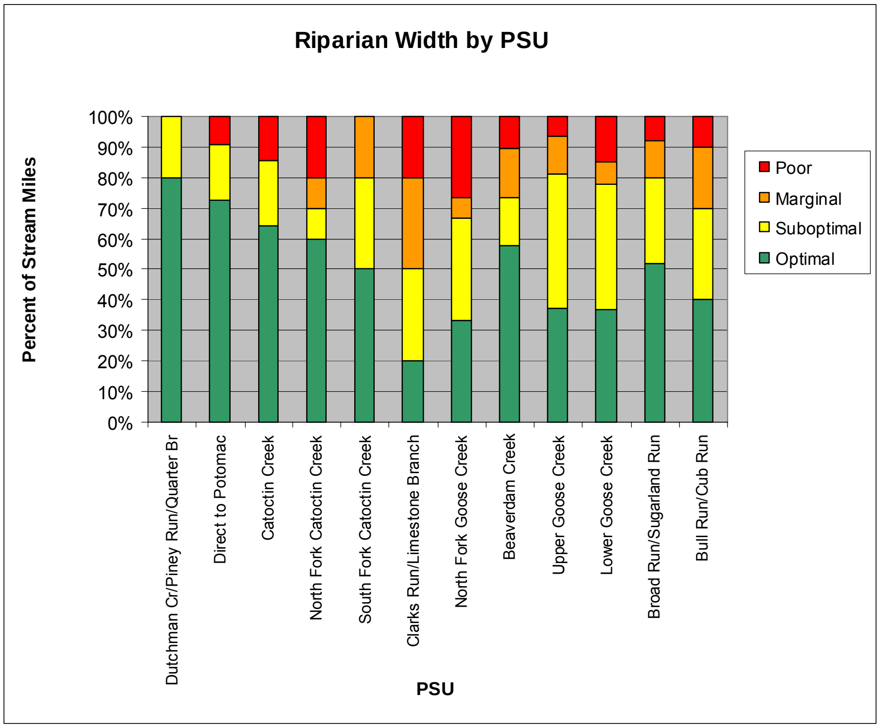

Figure 3-23. Percent of stream miles in each PSU in Loudoun County that are rated as Optimal, Suboptimal, Marginal, and Poor based on Riparian Vegetative Zone Width scores assessed at stream sites in each PSU.

3.3 WATER CHEMISTRY

At each of the 177 probability-based sampling sites, one-time *in situ* measurements of water quality were taken prior to field crews entering the stream. Measurements included temperature (in degrees Celsius), conductivity (in mS/cm), dissolved oxygen (DO; in mg/L), and pH (in pH units). Mean values for each parameter were calculated for each PSU and for the County as a whole (Appendix A; Figures 3-24, 3-26, 3-28, and 3-30). For each water quality parameter, categories were developed (based on state water quality parameters when applicable, see 9 VAC 25-260-50, Numerical criteria for dissolved oxygen, pH, and maximum temperature). Categories allowed for classification of stream miles by PSU in each category for each parameter (Appendix A).

3.3.1 Temperature

Water temperature has both direct and indirect effects on nearly all aspects of stream ecology. The amount of oxygen that can be dissolved in water is related to stream temperature, as colder water can hold more oxygen than warm water. Certain species of aquatic fish and macroinvertebrates have high oxygen demands, and therefore are reliant on streams with colder temperatures for habitat. Among the 177 probability-based stream sites in the Loudoun County

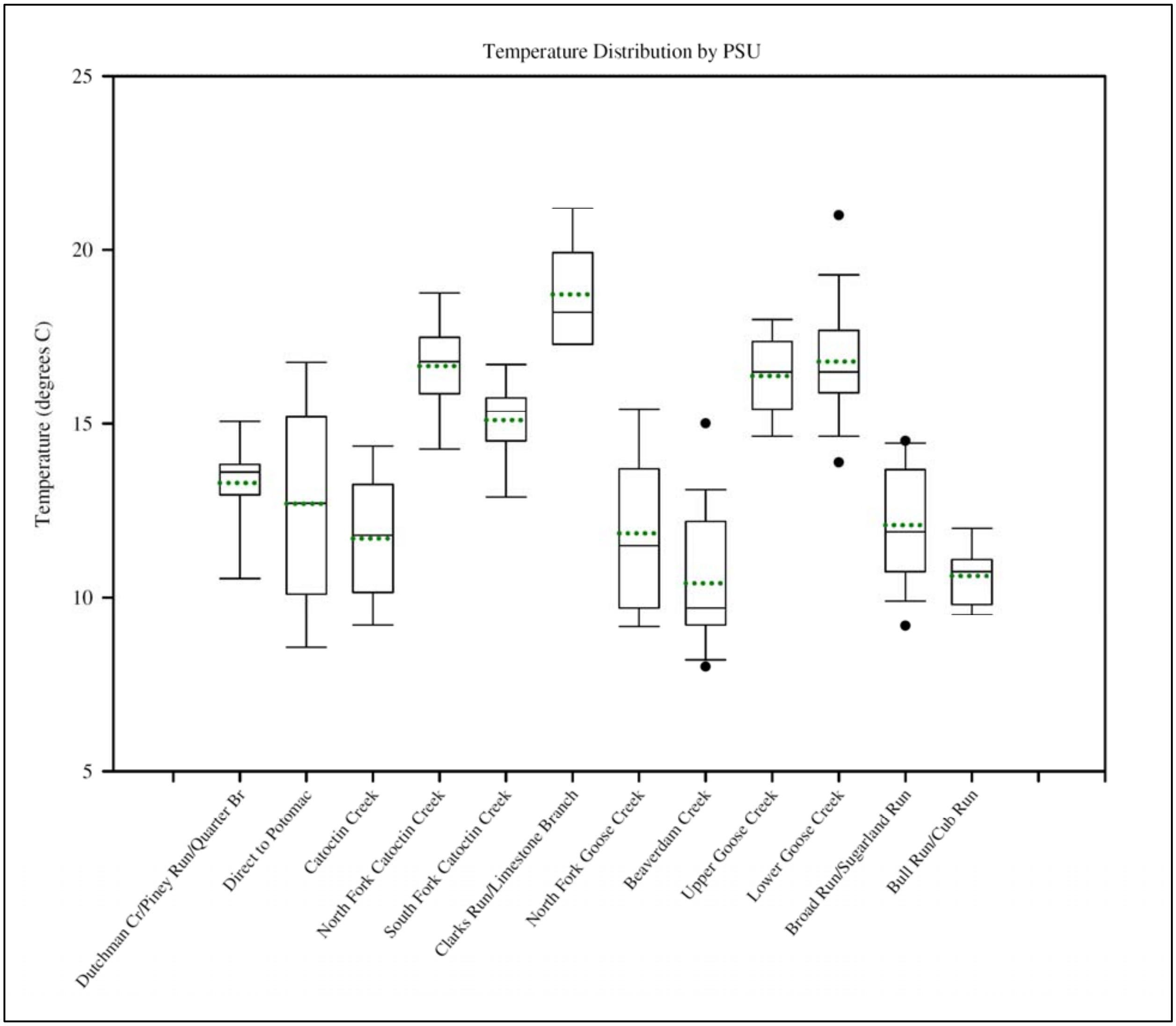

Figure 3-24. Distribution of *in situ* water temperature readings by PSU, Loudoun County Stream Assessment, 2009. See Figure 3-4 for a graphical explanation of the various components of a box and whisker plot.

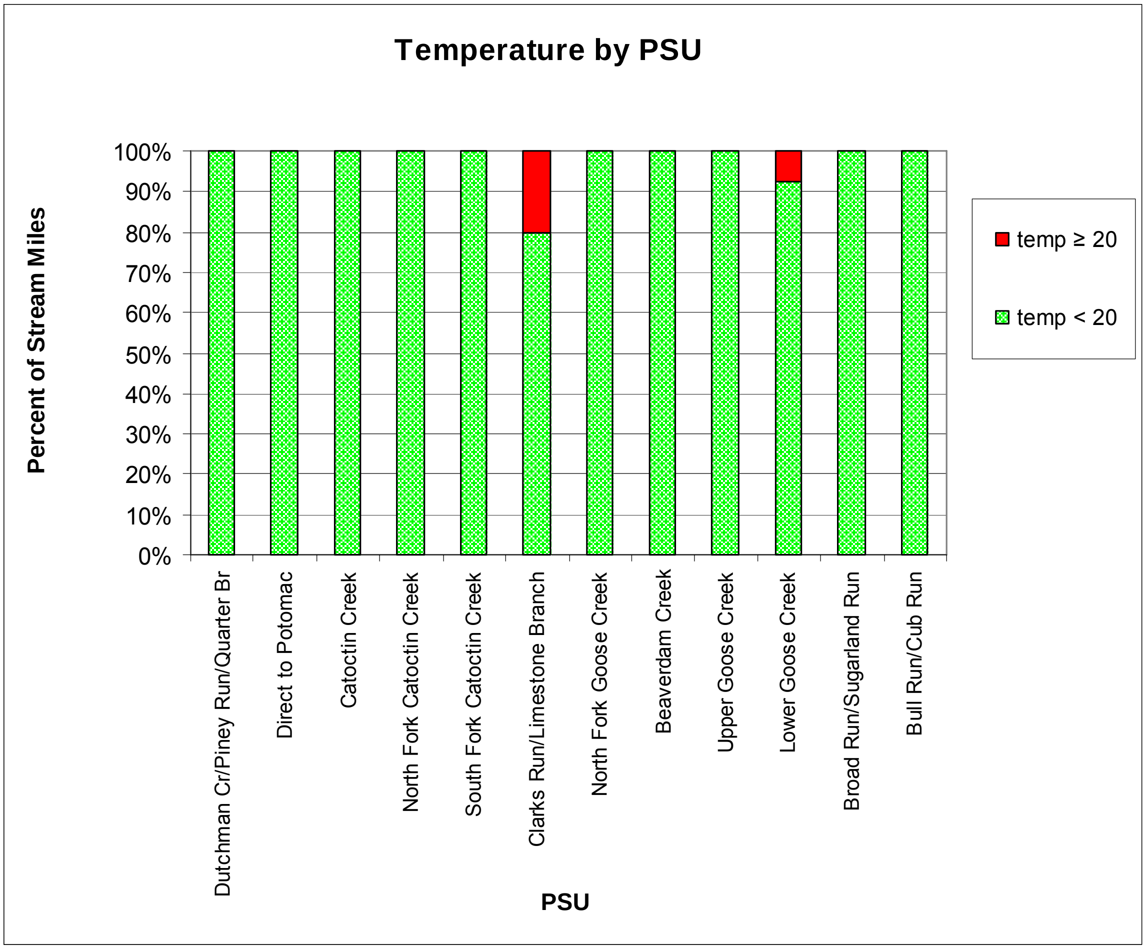

Figure 3-25. Percent of stream miles in each PSU in Loudoun County where *in situ* stream temperature readings were either greater than or equal to 20 degrees Celsius or less than 20 degrees Celsius.

Stream Assessment, temperature readings ranged from 8.0 to 21.4 degrees Celsius. By PSU, the *in situ* mean stream temperature varied from a low of 10.4 degrees Celsius in the Beaverdam Creek PSU to a high of 18.7 degrees Celsius in the Clarks Run/Limestone Branch PSU (Figure 3-24). Stream temperature can vary based on a suite of environmental parameters including recent precipitation and ambient air temperature, making it important to recognize that these measurements are only representative of moment-in-time conditions at each sampling site. Seasonal differences across the sampling period of March – May, as well as time of day, should be considered in interpreting these observations. Stream temperature is also influenced by shading, as greater riparian cover provides greater shading of the stream. Interestingly, the Clarks Run/Limestone Branch PSU exhibited the greatest mean stream temperature (Figure 3-24) and the fewest stream miles with Optimal riparian width (Figure 3-23).

Based on the Virginia water quality standards for trout streams, we classified temperature into two categories: sites with temperature less than 20 degrees Celsius and sites with temperature greater than or equal to 20 degrees Celsius. In every PSU except the Clarks Run/ Limestone Branch and the Lower Goose Creek PSUs, 100% of the stream miles had temperatures less than 20 degrees (Figure 3-25).

3.3.2 Conductivity

Conductivity is a measurement of the ability of water to conduct an electrical current. A stream's conductivity is directly proportional to the concentrations and types of positively and negatively charged ions present. Sources of ions are both naturally occurring and anthropogenic in origin, and include soil, bedrock, human and animal waste, fertilizers, pesticides, herbicides, and road salt. Among the 177 probability-based sites sampled in the Loudoun County Stream Assessment, conductivity readings ranged from 0.044 to 0.808 mS/cm. High conductivity readings of 0.803 and 0.808 mS/cm were found in the Broad Run PSU and could be indicative of failing septic tanks, sewage spills, and/or agricultural runoff containing phosphates and nitrates. Mean *in situ* conductivity values ranged from a low of 0.108 mS/cm in the Dutchman Creek/ Piney Run/Quarter Branch PSU to a high of 0.435 mS/cm in the Broad Run/Sugarland Run PSU (Figure 3-26). Conductivity values were highest in the three eastern-most PSUs (Broad Run/ Sugarland Run, Direct to Potomac, and Bull Run/Cub Run), areas of the County where extensive urbanization has occurred, including development associated with Dulles International Airport in the southeastern part of the county.

Conductivity was classified into one of two categories: sites with conductivity greater than or equal to 0.600 mS/cm and sites with conductivities less than 0.600 mS/cm. The PSUs with some stream miles with high conductivity (Bull Run/Cub Run, Broad Run/Sugarland Run, and Direct to Potomac PSUs) could have some compromised water quality as a result of urbanization, while most of the stream miles in the County had conductivity values in the normal range (Figure 3-27).

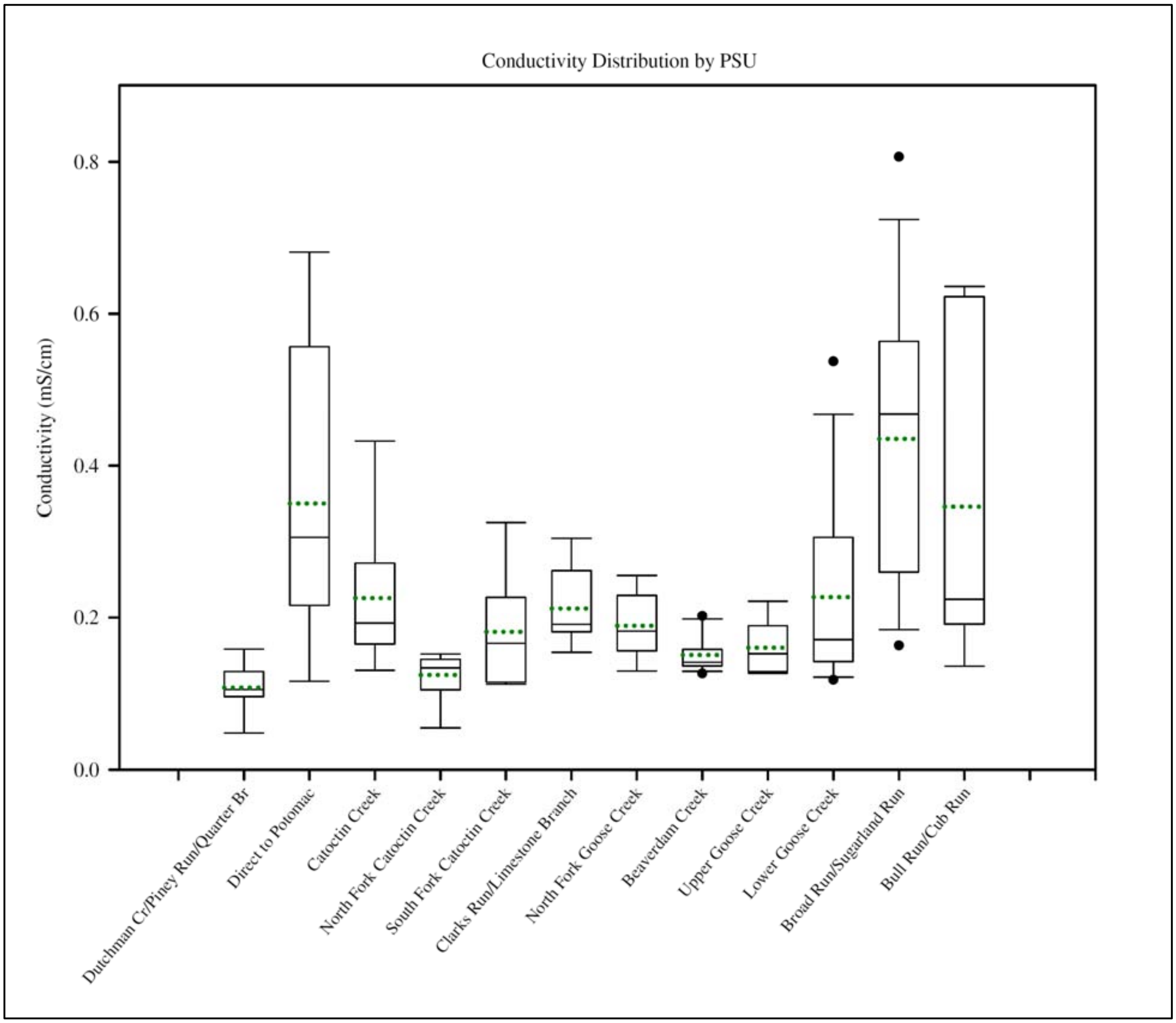

Figure 3-26. Distribution of *in situ* conductivity levels by PSU, Loudoun County Stream Assessment, 2009. See Figure 3-4 for a graphical explanation of the various components of a box and whisker plot.

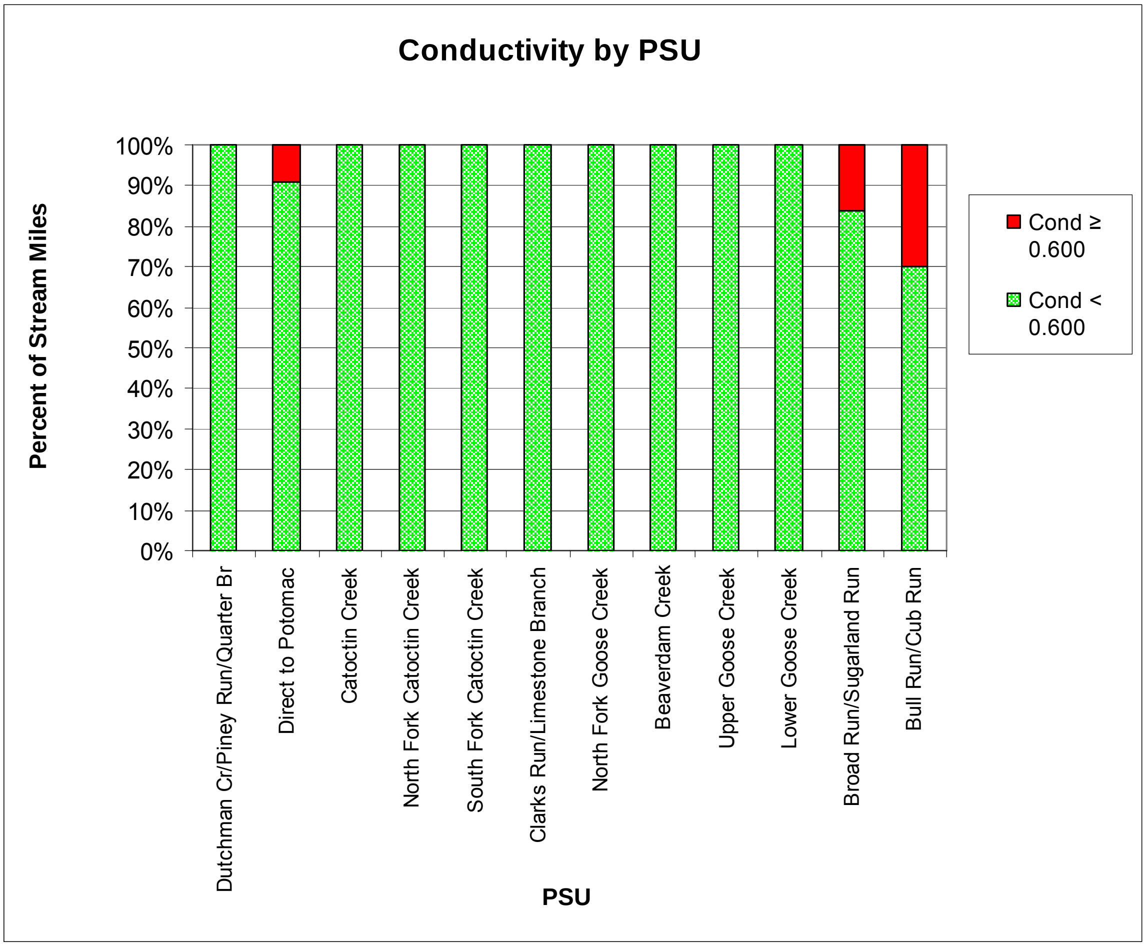

Figure 3-27. Percent of stream miles in each PSU in Loudoun County where *in situ* stream conductivity readings were either greater than or equal to 0.600 mS/cm or less than 0.600 mS/cm.

3.3.3 Dissolved Oxygen

Dissolved oxygen is critical for aquatic life. Some species of aquatic benthic macroinvertebrates and fish have high oxygen demands and rely on colder streams with high levels of dissolved oxygen for habitat. Other species can tolerate degraded conditions where dissolved oxygen levels are minimal. Dissolved oxygen concentrations increase wherever the water flow becomes turbulent, such as in a riffle areas, and decrease wherever the water flow is slow or still, such as backwater or stagnant areas. The amount of dissolved oxygen in a stream is partially related to the temperature of the water. Among the 177 probability-based sites in the Loudoun County Stream Assessment, no sites had dissolved oxygen values lower than the state water quality standard minimum value of 4.0 mg/l or minimum daily average of 5.0 mg/l (9 VAC 25 260-50.) By PSU, in situ mean dissolved oxygen values ranged from a low of 9.0 mg/l in Upper Goose Creek to a high of 12.1 mg/l in the Catoctin Creek PSU (Figure 3-28). Similar to stream temperature values discussed in section 3.3.1, it is important to recognize that these in situ dissolved oxygen values are only representative of moment-in-time conditions at each sampling site.

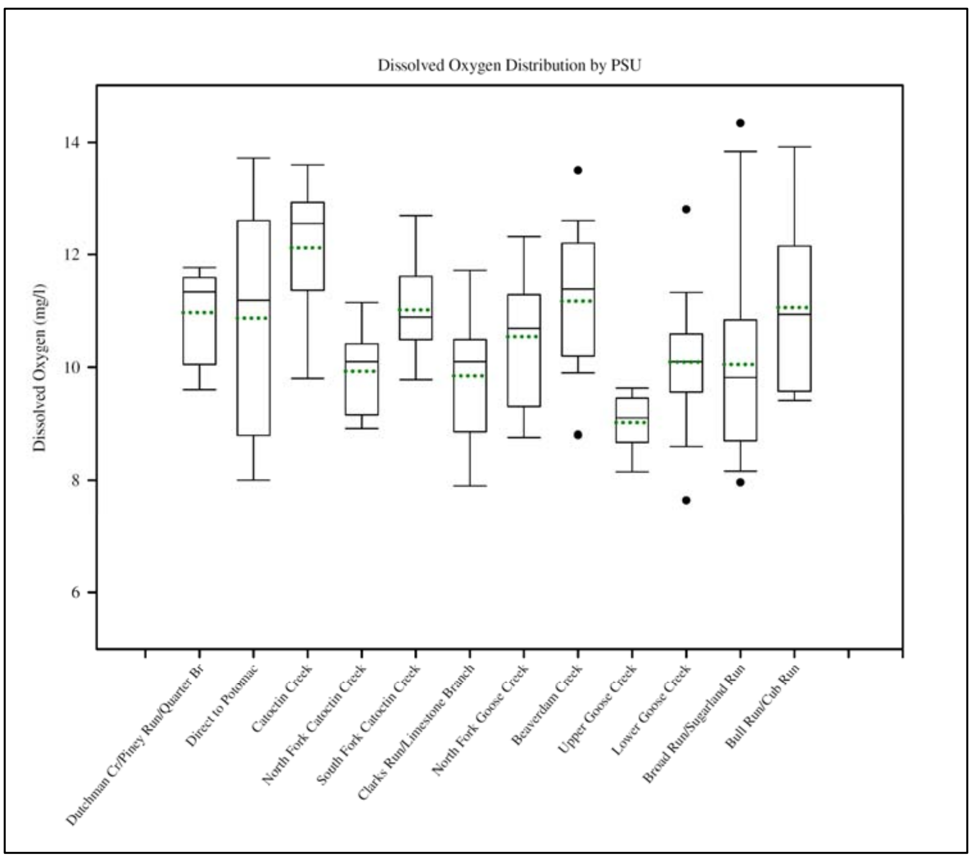

Figure 3-28. Distribution of *in situ* dissolved oxygen levels by PSU, Loudoun County Stream Assessment, 2009. See Figure 3-4 for a graphical explanation of the various components of a box and whisker plot.

Based on the Virginia water quality standards for the Piedmont zone, sites were classified into two categories, including those with dissolved oxygen values less than 4 mg/l and those with dissolved oxygen values greater than or equal to 4.0 mg/l. All stream miles in the County exhibited good water quality with respect to dissolved oxygen, with no sites falling below the minimum water quality standard of 4.0 mg/l (Figure 3-29).

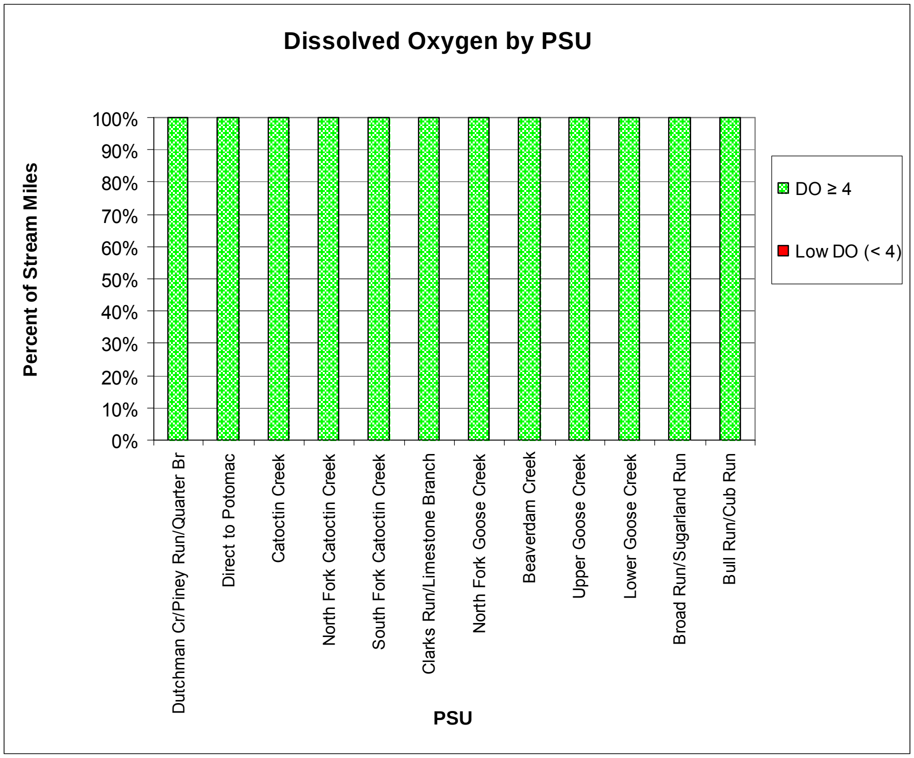

Figure 3-29. Percent of stream miles in each PSU in Loudoun County where *in situ* stream dissolved oxygen readings were either greater than or equal to 4.0 mg/l or less than 4.0 mg/l.

3.3.4 pH

The pH of water determines the solubility and biological availability of chemical constituents such as nutrients and heavy metals. The pH scale ranges from 0 to 14, with a pH of 7 considered neutral. Substances with pH less than 7 are acidic, while substances with pH greater than 7 are basic. Geology of the watershed and the original source of the water determine the initial pH of stream water, and seasonal and daily variations in photosynthesis cause natural changes of pH levels in a stream. Changes in pH can also be caused by discharges of municipal or industrial effluents. In the 177 probability-based sites in the Loudoun County Stream Assessment, *in situ* mean pH ranged from a low of 7.34 in the Upper Goose Creek PSU to a high of 8.32 in the Beaverdam Creek PSU (Figure 3-30). Virginia state water quality standards for non swamp waters state that pH levels should not be below 6.0 nor above 9.0, which were met at all but 4 of the 177 probability-based sampling sites.

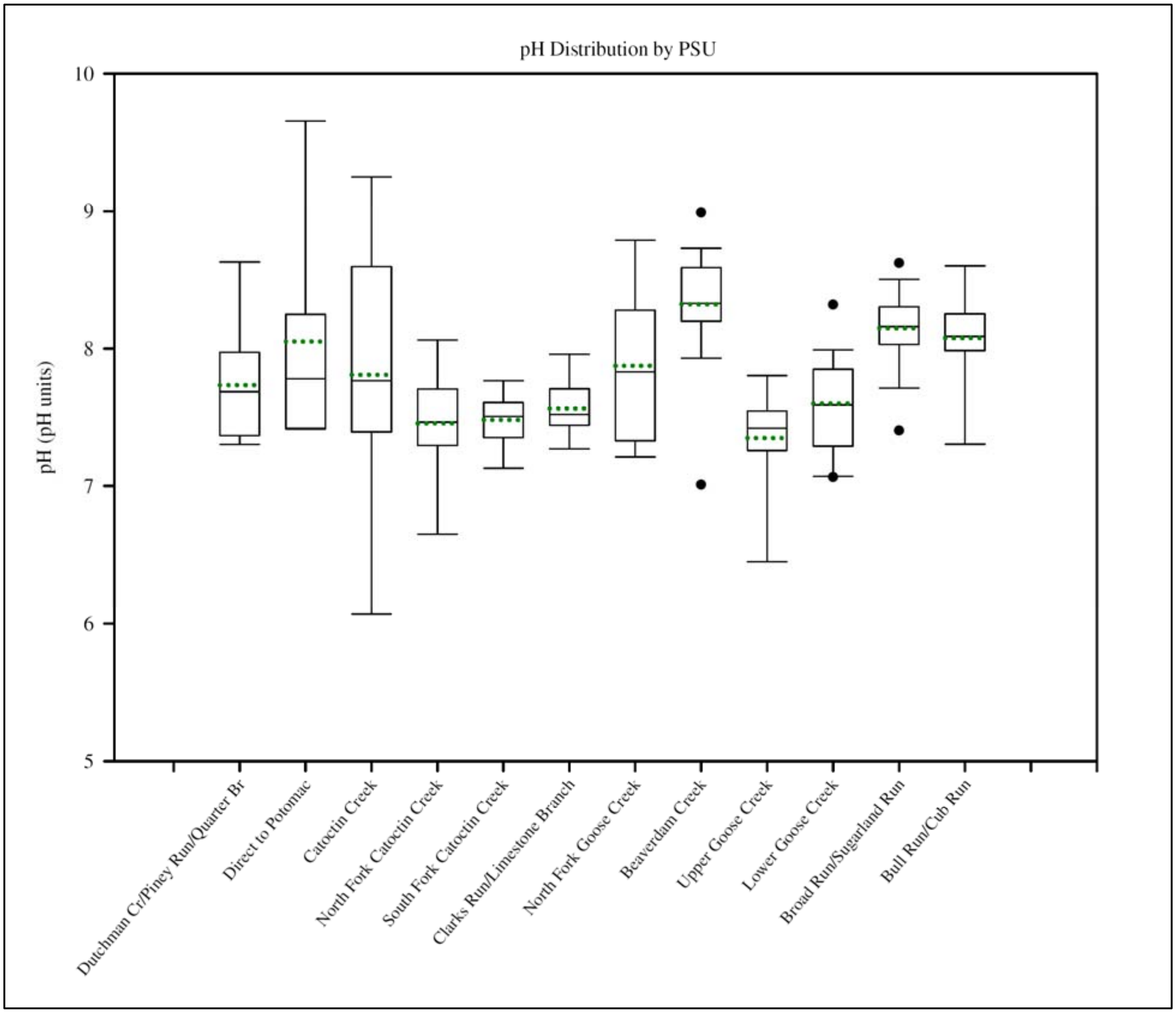

Figure 3-30. Distribution of *in situ* pH levels by PSU, Loudoun County Stream Assessment, 2009. See Figure 3-4 for a graphical explanation of the various components of a box and whisker plot.

Based on the Virginia state water quality standards for non swamp waters, pH levels should not be below 6.0 nor above 9.0. Sampling sites were classified into one of three categories, based on their *in situ* pH, including sites that were below the water quality standards, sites that fell within the water quality standards, and sites that exceeded the water quality standards. Most of the stream miles in the County fell within the water quality standards for pH, with the exception of 21.4% of the stream miles in the Catoctin Creek PSU and 9.1% of the stream miles in the Direct to Potomac PSU, where pH values exceeded the water quality standards (Figure 3-31).

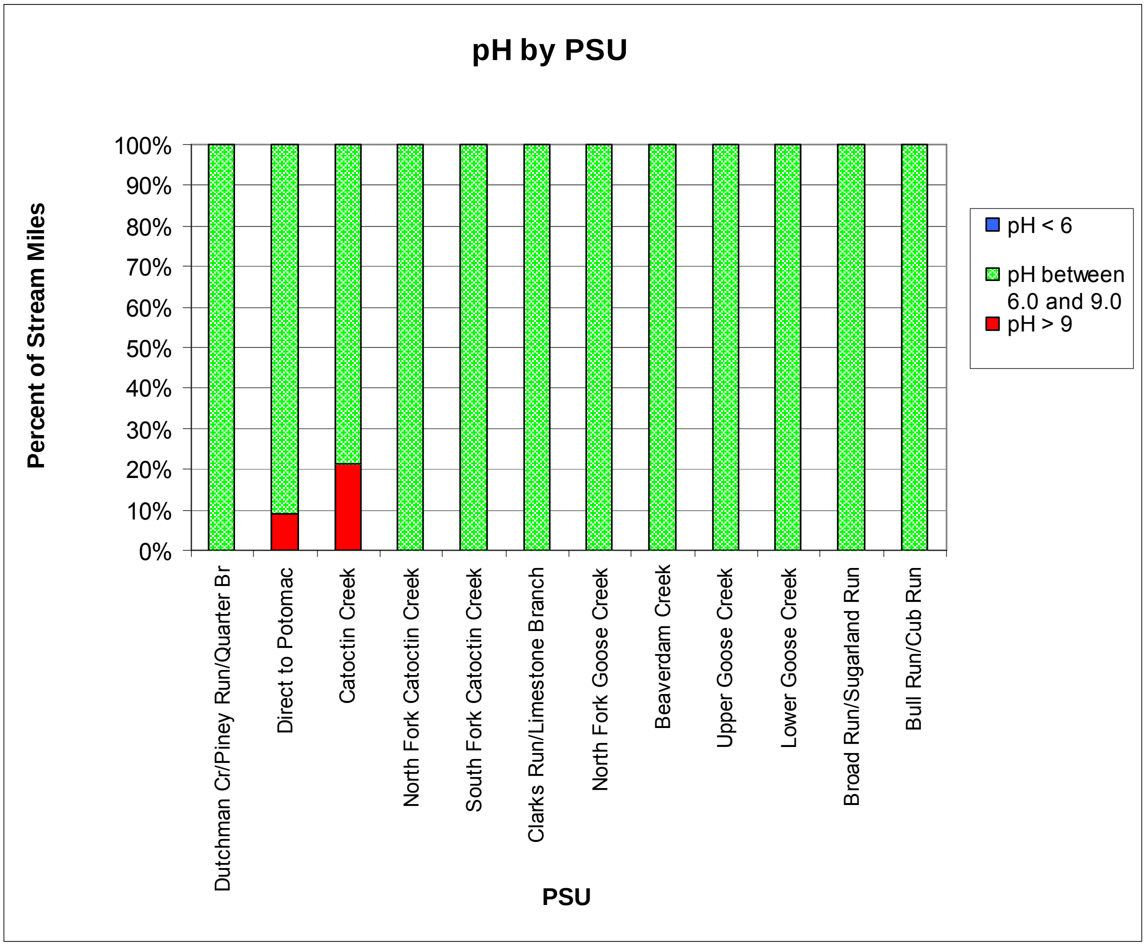

Figure 3-31. Percent of stream miles in each PSU in Loudoun County where *in situ* stream pH readings were within, below, or above the state water quality standards for non swamp streams.

4. RESULTS OF TARGETED SITE SAMPLING

4.1 BIOLOGICAL ASSESSMENT

This chapter highlights results of the targeted site sampling, including benthic assessments and habitat evaluations performed at 23 stream sites throughout Loudoun County watersheds during spring 2009. These 23 stream sites were locations previously sampled by Virginia DEQ. DEQ previously sampled 24 locations in Loudoun County (Table 2-2). A DEQ error in one site's coordinates had placed it outside of the County, and therefore that site was not included in Versar's sampling plan. Key results are listed in Table 4-1. Complete data are provided in the project geodatabase.

Table 4-1. VSCI and RBP Habitat Assessment scores for targeted sites in the 2009 Loudoun County Stream Assessment

2009 Loudoun County Stream Assessment Station ID	Virginia DEQ Station ID	VSCI Score	VSCI Assessment Category	RBP Habitat Assessment Score	RBP Habitat Assessment Category
BEAV-110-T-2009	1AXGU000.18	63.4	Good	151	Suboptimal
BEAV-213-T-2009	1ANOB007.97	64.7	Good	149	Suboptimal
BROA-302-T-2009	1ABRB015.43	46.5	Stress	135	Suboptimal
BROA-403-T-2009	1ABRB006.97	22.2	Severe Stress	141	Suboptimal
BROA-404-T-2009	1ABRB002.15	40.7	Severe Stress	160	Optimal
BULL-301-T-2009	1ABUL025.94	44.8	Stress	169	Optimal
CATO-121-T-2009	1AXKR000.77	76.2	Excellent	161	Optimal
CATO-420-T-2009	1ASOC000.01	26.7	Severe Stress	157	Suboptimal
CATO-422-T-2009	1ACAX004.57	40.8	Severe Stress	106	Marginal
CATO-423-T-2009	1ACAX003.69	56.3	Stress	147	Suboptimal
LOGC-305-T-2009	1ALIV004.78	53.5	Stress	131	Suboptimal
LOGC-507-T-2009	1AGOO003.18	45.9	Stress	150	Suboptimal
NFCC-319-T-2009	1ANOC000.42	42.7	Stress	143	Suboptimal
NFGC-312-T-2009	1ANOG005.69	29.6	Severe Stress	140	Suboptimal
NFGC-511-T-2009	1ANOG000.91	26.1	Severe Stress	159	Suboptimal
SFCC-214-T-2009	1ASOC013.05	64.3	Good	143	Suboptimal
SFCC-215-T-2009	1ASOC012.60	57.3	Stress	162	Optimal
SFCC-216-T-2009	1ASOC011.98	19.4	Severe Stress	146	Suboptimal
SFCC-217-T-2009	1ASOC010.09	52.0	Stress	162	Optimal
SFCC-318-T-2009	1ASOC007.06	54.8	Stress	141	Suboptimal
UPGC-206-T-2009	1AWAC003.31	34.2	Severe Stress	115	Suboptimal
UPGC-408-T-2009	1AGOO022.44	57.4	Stress	146	Suboptimal
UPGC-409-T-2009	1AGOO021.28	28.3	Severe Stress	103	Marginal

VSCI scores were calculated for benthic samples collected at each of the 23 targeted sampling locations (Figure 4-1 and Table 4-1). All but four sites were rated as Stress or Severe Stress. Only one site, CATO-121-T-2009, obtained a rating of Excellent. The scores at most sites were consistent with those from previous years' spring sampling efforts by DEQ. Previous DEQ data showed that scores at any given site were sometimes variable (changing by one or two rating categories) depending on whether sites were sampled in the spring or fall season. Five sites (NFGC-511-T-2009, UPGC-409-T-2009, LOGC-507-T-2009, CATO-420-T-2009, and CATO-422-T-2009) showed a decline in stream condition compared to previous years. Comparison to future DEQ data will help determine if this is simply due to annual variation or due to some change in stream quality.

4.2 HABITAT ASSESSMENT

4.2.1 Overall Habitat Conditions

The RBP Habitat Assessment procedure was used to evaluate stream physical habitat at the 23 targeted sampling locations in Loudoun County (Figure 4-2 and Table 4-1). The overall habitat scores show that habitat conditions at most of the sites sampled were good, with all but 2 sites classified as either Optimal or Suboptimal for habitat condition. No site had conditions that were rated as Poor. Similar to the VSCI scores, data from this survey were generally consistent with data collected during previous DEQ sampling at these locations. This indicates that habitat conditions at the targeted sampling locations were stable, with only some minor variation due to normal seasonal and annual fluctuation.

4.2.2 Individual Habitat Parameters

Habitat condition is the result of a combination of many factors, each of which is rated separately during an RBP Habitat Assessment. As would be expected from the high overall habitat scores, the scores for most of the individual parameters were in the Suboptimal and Optimal categories. However, individual sites had low scores for particular metrics, allowing for subtle differentiation between site conditions, even for sites in the same overall Assessment Category. These individual parameter scores may help to explain why the VSCI scores indicated that the biota were stressed while overall RBP habitat scores indicated that the streams were in good physical condition. Below are the results for a few of the individual habitat parameters.

4.2.2.1 Epifaunal Substrate/Available Cover

The Epifaunal Substrate/Available Cover parameter allows us to analyze if one of the most basic needs of instream fauna are being met, i.e., physical shelter. Epifaunal substrate influences how abundant various taxa may become, as they compete for both a physical space to

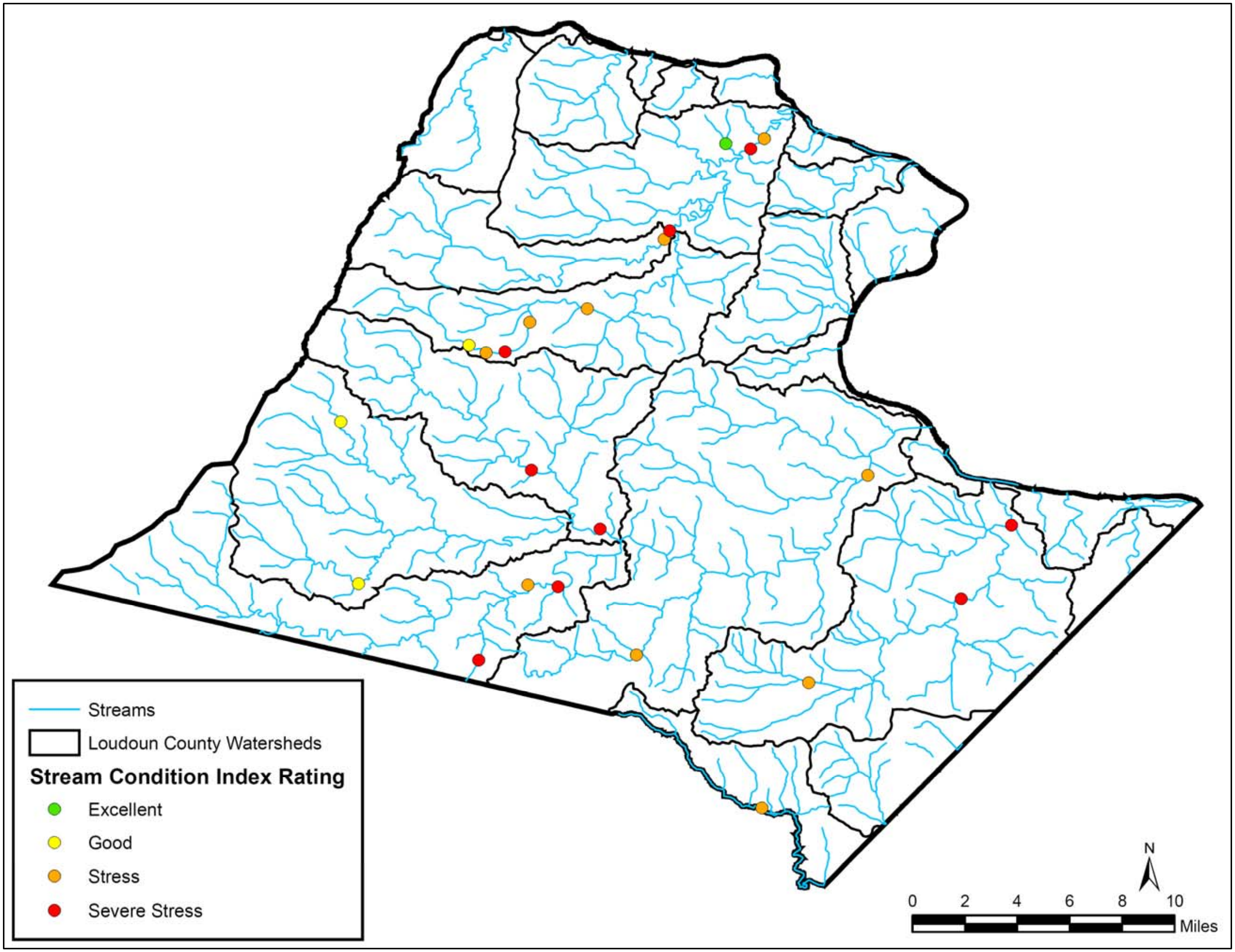

Figure 4-1. Macroinvertebrate VSCI results for 23 targeted sampling sites, previously sampled by VA DEQ, in Loudoun County, 2009.

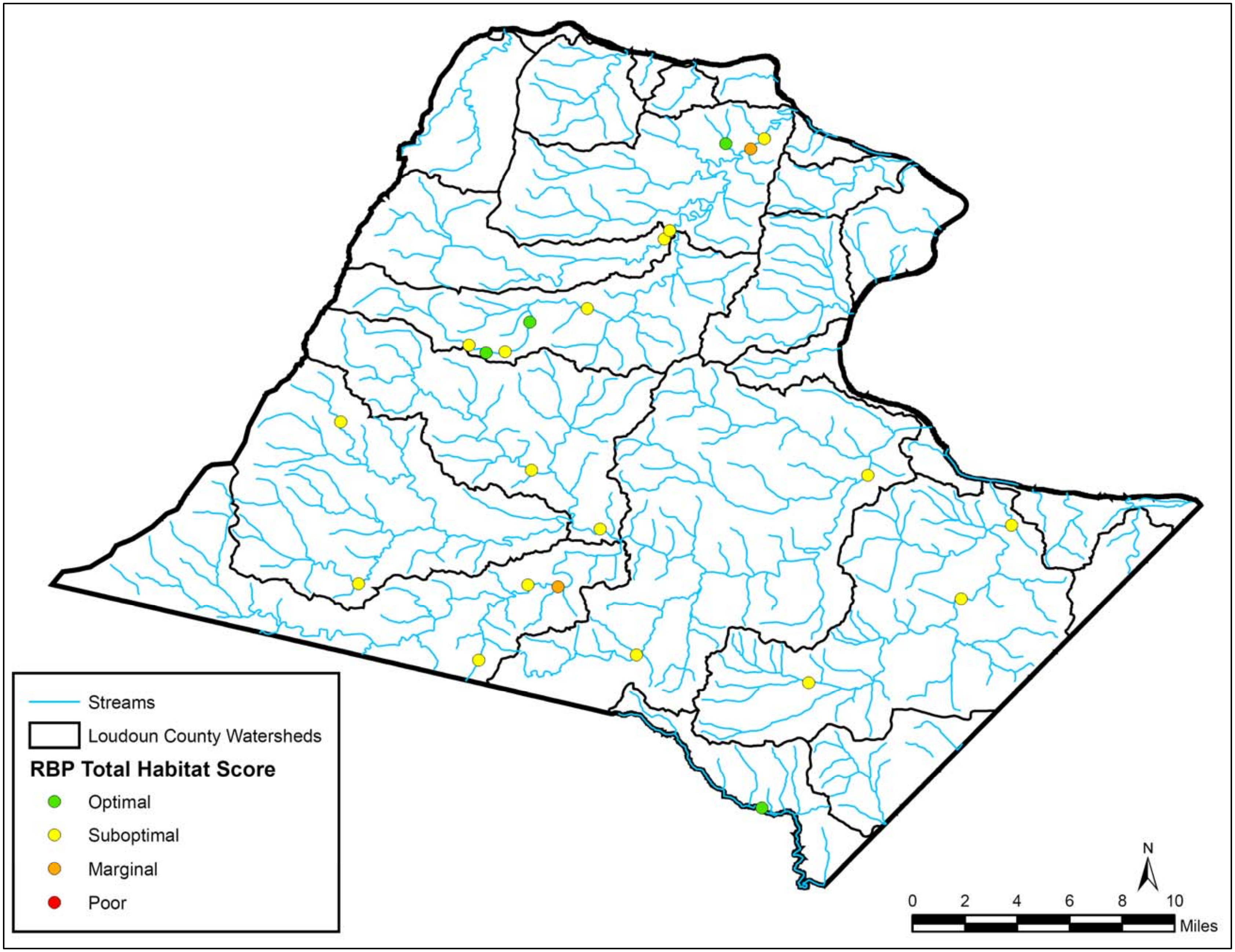

Figure 4-2. RBP Habitat Assessment results for 23 targeted sampling sites, previously sampled by VA DEQ, in Loudoun County, 2009.

live and safe shelter from predators. A wide variety of plentiful habitat types is best, incorporating different elements such as cobble riffles, large woody debris, active instream rootwads, and aquatic plants. The four sites with the lowest scores for this metric (BROA-403-T-3009, BROA-404-T-3009, CATO-422-T-2009, and UPGC-409-T-2009), all in the Marginal range, were all sites in the Severe Stress category according to the VSCI. Improving conditions at these sites would likely involve addressing the lack of good, sufficient cover for benthic macroinvertebrates. All other sites rated in the Optimal or Suboptimal categories for this metric.

4.2.2.2 Embeddedness

The Embeddedness parameter evaluates how much of the substrate present at a site is actually available to the fish and benthic macroinvertebrates in a stream. Excess sediment settled around cobble and gravel can choke stream organisms and fill in the spaces they would otherwise be able to occupy and use for shelter and defense. The five sites with scores for this metric in the Marginal or Poor Assessment Categories were rated by the VSCI as indicating either Stress or Severe Stress. UPGC-206-T-2009 is a good example of how a site with good substrate present, as evidenced by an Epifaunal Substrate score of 15, may still have biota under Severe Stress, when that substrate is not fully functioning and available, as indicated by this site's Embeddedness score of 6 (Marginal).

4.2.2.3 Bank Stability

The Bank Stability parameter evaluation can indicate many things about a stream, including whether there is a large supply of sediment available to the stream, if the stream is subject to high, flashy stormflows, and whether there is sufficient vegetation along the stream's banks to keep it stable. Bank Stability was rated as being either Marginal or Poor, along one or both banks, at 11 of the targeted sampling locations. The sites that the VSCI rated as Excellent or Good generally had Bank Stability ratings of Optimal or Suboptimal.

4.2.2.4 Riparian Vegetative Zone Width

The riparian zone is a very important component of stream health. A well-forested riparian zone may provide food for biota through allocthonous inputs, filter nutrients and pollutants from runoff, provide bank stabilization, and provide shade that prevents elevated water temperatures. Fourteen of the targeted sampling locations had riparian buffer, along one or both banks, that rated as Marginal or Poor. The sites that the VSCI rated as Good or Excellent generally had Riparian Vegetative Zone Width ratings of Optimal or Suboptimal. Streams with good biota typically feature healthy riparian vegetated buffers.

4.3 WATER QUALITY

In-situ water quality was measured at each site, including temperature, conductivity, dissolved oxygen and pH. Dissolved oxygen is a major limiting factor for aquatic life. DO levels at all sites were above the commonly accepted standard of 5 mg/l, the lowest level that most aquatic organisms can withstand. Temperature and conductivity were within the expected ranges at all sites. pH was good at most sites, though three sites had a pH value of 8.00 or above. These sites were BROA-403-T-2009, BULL-301-T-2009, and BEAV-110-T-2009. Future sampling would be useful to determine if these were anomalous levels or if there are surrounding landscape conditions leading to long-term elevated pH levels at these sites.

5. RESULTS OF COUNTYWIDE HABITAT ASSESSMENT

This chapter highlights results of the stream habitat assessment conducted as part of the 2009 Loudoun County Stream Assessment. This consisted of habitat evaluations performed at the 177 randomly-selected benthic sampling locations, and 23 targeted benthic sampling locations (as reported in Sections 3.2 and 4.2, respectively), along with an additional 300 locations (Figure 5-1) distributed to provide countywide coverage of the entire stream network. The one area excluded from the survey was the southeastern portion of the Broad Run watershed, where access to streams was prohibited due to their location on Washington Dulles International Airport property.

5.1 OVERALL HABITAT CONDITIONS

Among all 500 sites, overall RBP Habitat Assessment scores ranged from 61 (Marginal) to 176 (Optimal) out of a possible total 200 points. Although site quality ranged from Marginal to Optimal, by far, the majority of sites (400) fell in the Suboptimal category. The remaining 100 sites were almost evenly divided between the Marginal and Optimal categories. There were no sites that rated in the Poor category.

Figure 5-2 shows some patterns of overall habitat condition by watershed. In North Fork Catoctin, South Fork Catoctin, and the western portion of Upper Goose Creek, all sites sampled were Optimal to Suboptimal. Nearly all sites in Dutchman Creek/Piney Run/Quarter Branch were also Optimal to Suboptimal (with the exception of one Piney Run site), as were most sites in Bull Run/Cub Run (with the exception of two sites in Bull Run). Optimal, Suboptimal, and Marginal conditions were found on both mainstem streams and their tributaries, in streams ranging from 1st order headwaters to larger 5th order stretches navigable by canoe. Marginal conditions were noted in both agricultural and urban areas.

5.2 INDIVIDUAL HABITAT PARAMETERS

Habitat condition is the result of a combination of many factors, each of which is rated individually during an RBP Habitat Assessment. As would be expected from the high overall RBP Habitat Assessment scores, the scores for most of the individual parameters were in the Suboptimal and Optimal Assessment Categories. However, individual sites had low scores for particular parameters, allowing for subtle differentiation between site conditions, even for sites in the same overall Assessment Category. These individual parameter scores help characterize habitat quality. For example, a site may lack good habitat structure for biota, as shown by a low Epifaunal Substrate/Available Cover score, or a site might benefit from additional riparian vegetation, as shown by a low Riparian Vegetative Zone Width score. Below are the results for a few of the individual habitat parameters.

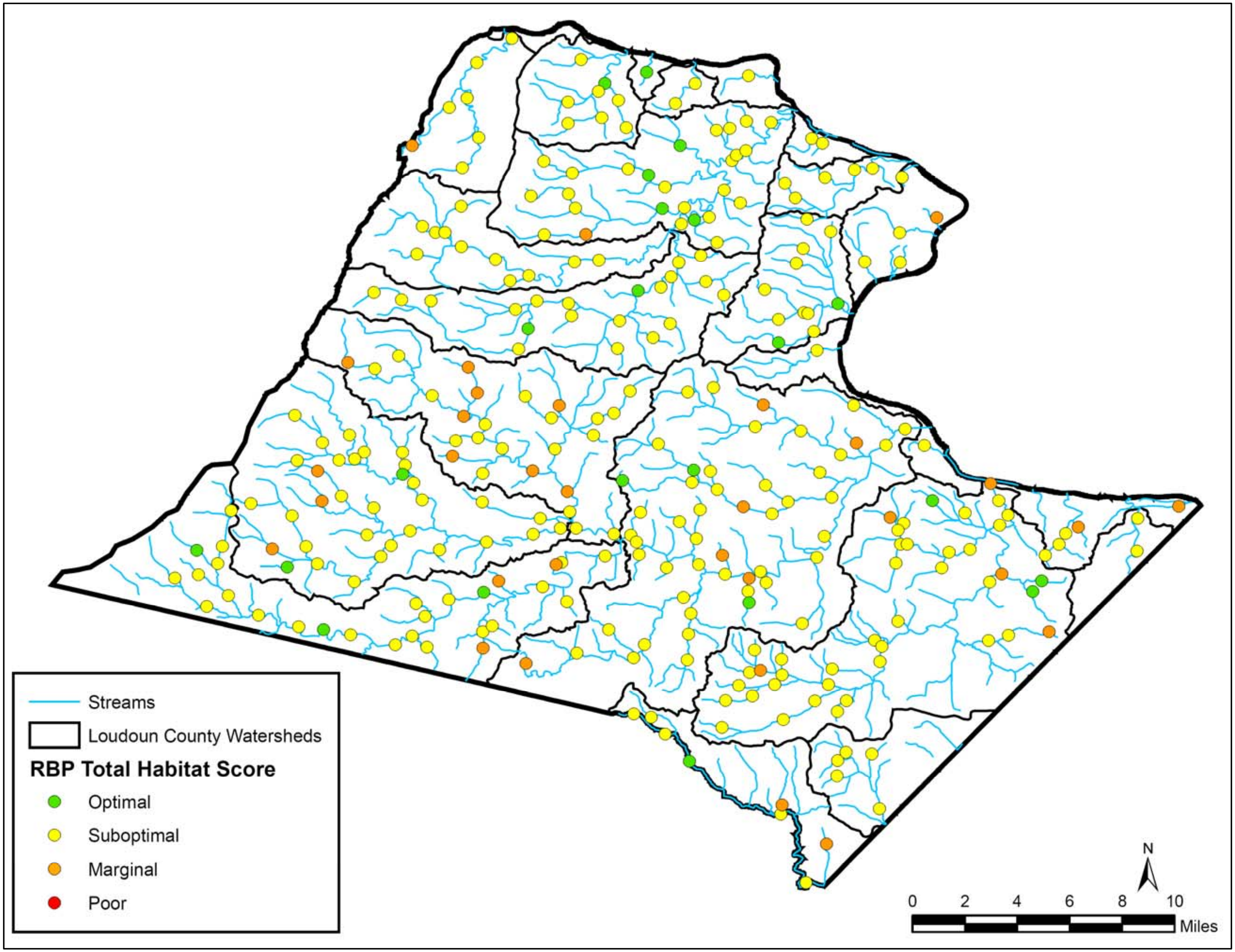

Figure 5-1. RBP Habitat Assessment results for the 300 non-random habitat sites in Loudoun County, 2009.

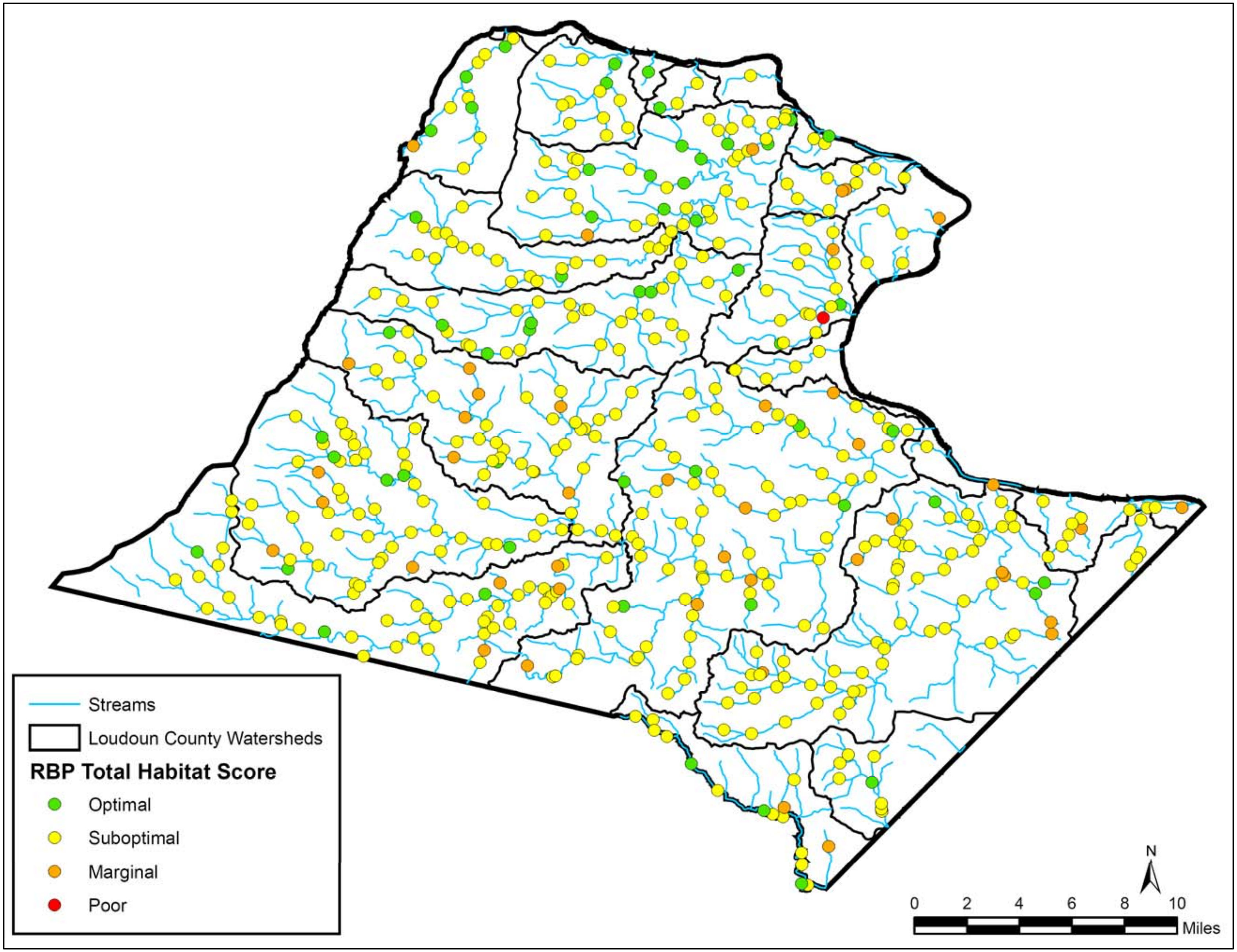

Figure 5-2. RBP Habitat Assessment results for all 500 sites sampled in Loudoun County, 2009.

5.2.1 Epifaunal Substrate/Available Cover

Less than 1/5 of the sites sampled fell into the Marginal or Poor categories for Epifaunal Substrate/Available Cover (Figure 5-3). There was a heavy cluster of sites in the Optimal category in the Catoctin watershed. Otherwise, Epifaunal Substrate/Available Cover quality varied throughout the County, similar to the pattern seen in the overall RBP Habitat Assessment scores.

5.2.2 Embeddedness

The watersheds in the northern portion of Loudoun County showed low embeddedness, with a large number of sites scoring in the Optimal to Suboptimal range (Figure 5-4). The central and southern portions of the County exhibit a more varied set of conditions, ranging from Optimal to Marginal, with a few scattered sites scoring in the Poor category.

5.2.3 Bank Stability

Marginal to Poor Bank Stability was widespread (Figure 5-5). Almost half of the sites sampled (226) had at least one bank rated as being in Marginal or Poor condition. Similar to the previous habitat parameters discussed, sites in the northern watersheds, particularly Catoctin, had a higher number of sites in the Optimal and Suboptimal categories, while the rest of the County exhibited a mixed array of conditions, with little clustering.

5.2.4 Riparian Vegetative Zone Width

Approximately 150 sites had Riparian Vegetative Zone Widths rated Marginal or Poor, 135 were rated Suboptimal, and 217 were rated in the Optimal category (Figure 5-6). These numbers show that there was a fairly large proportion of sites throughout the County with a vegetated corridor. However, as is evident from the map, these well-forested stretches were frequently interspersed with lesser quality riparian buffers. Fragmented forest along streams allows for gaps in the protection that a riparian buffer provides. Runoff not intercepted by a forested riparian buffer is more likely to reach a stream before infiltrating into the ground, allowing for flashy flows, increased water temperatures that can be stressful to biota, and the entry of nutrients and pollutants into the waterway.

5.3 WATER QUALITY

In-situ water quality was measured at each of the 500 sites, including temperature, conductivity, DO, and pH. DO levels at all but two sites were found to be above the commonly accepted standard of 5 mg/l, the lowest level that most aquatic organisms can withstand. For

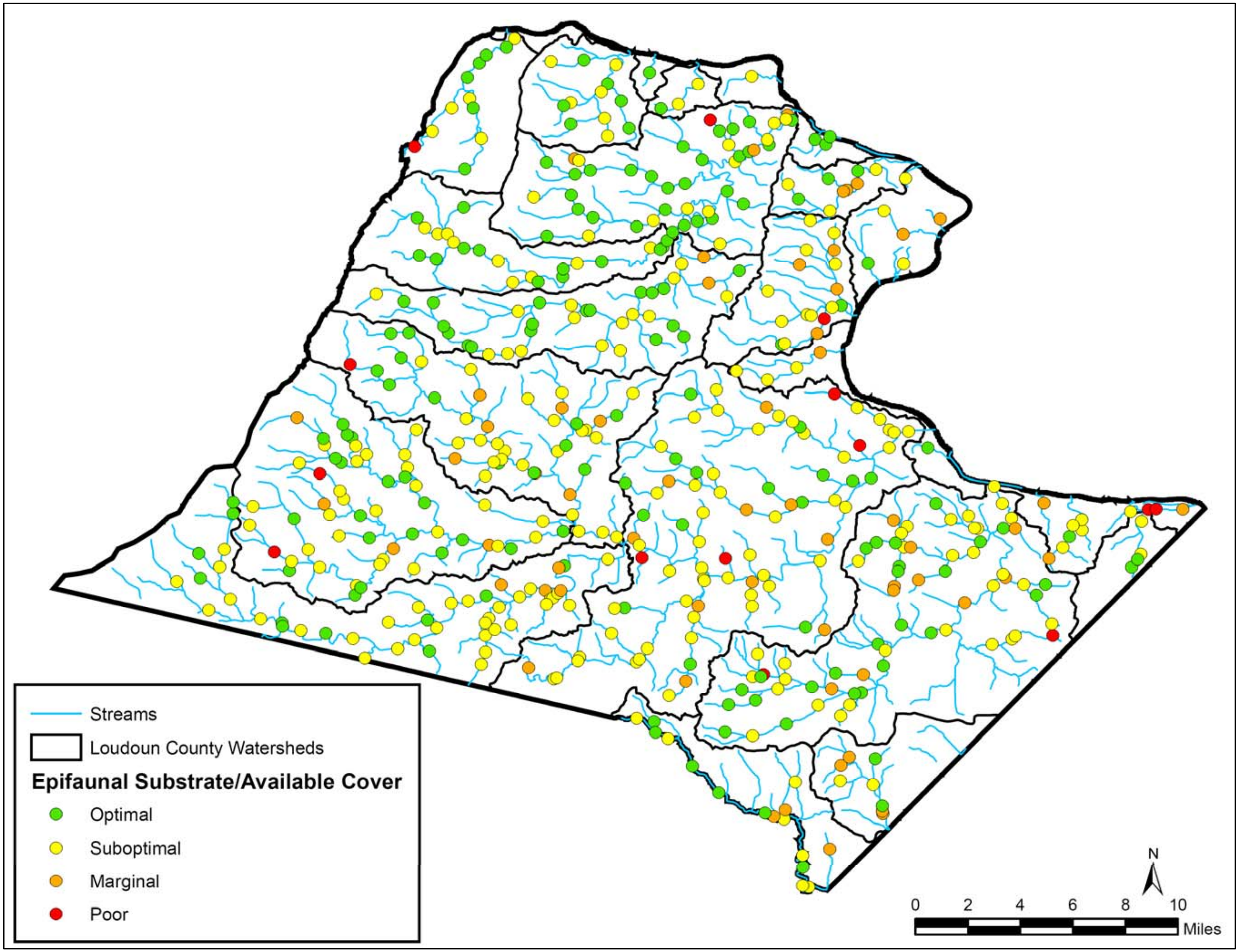

Figure 5-3. Epifaunal Substrate/Available Cover ratings for all 500 sites sampled in Loudoun County, 2009.

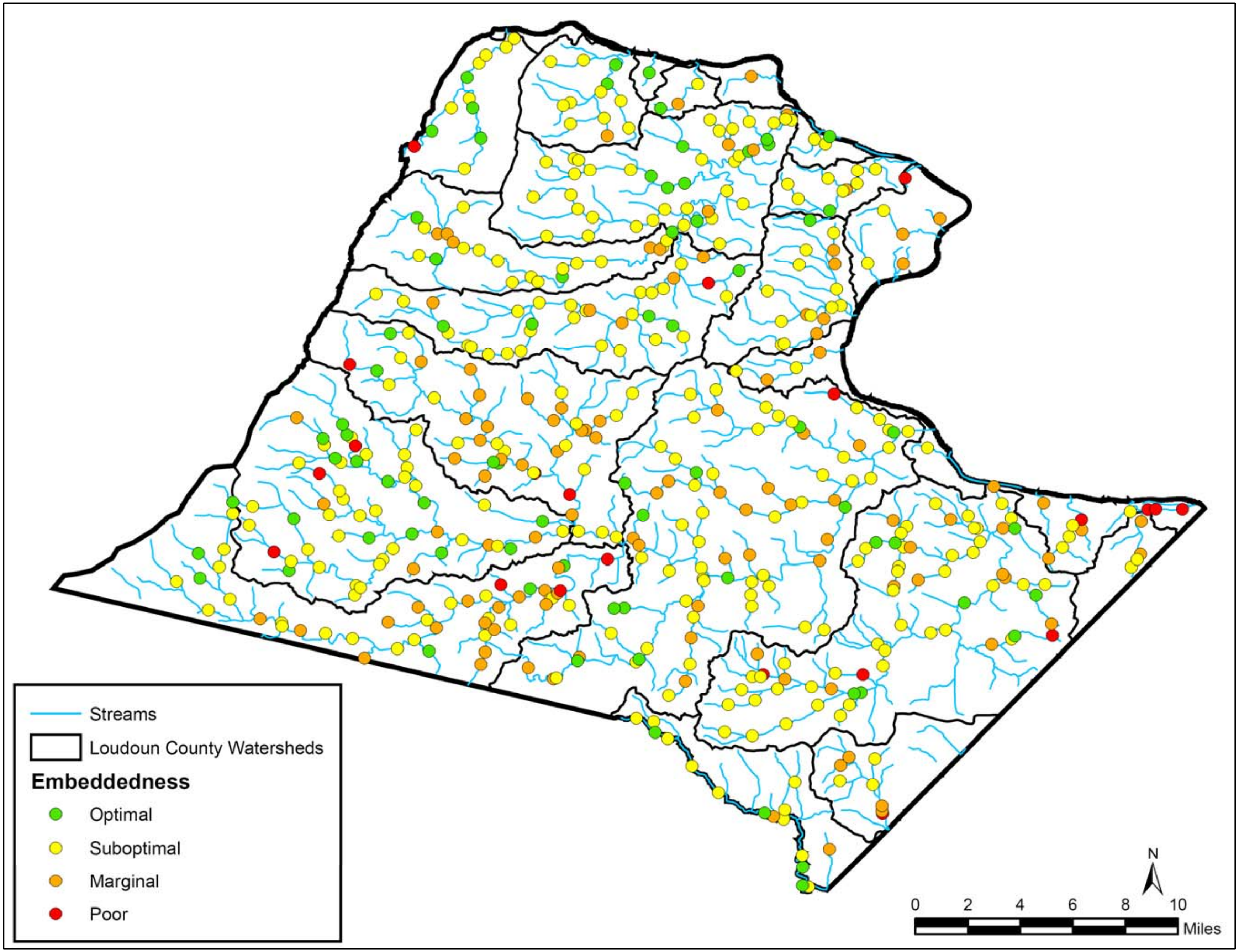

Figure 5-4. Embeddedness ratings for all 500 sites sampled in Loudoun County, 2009.

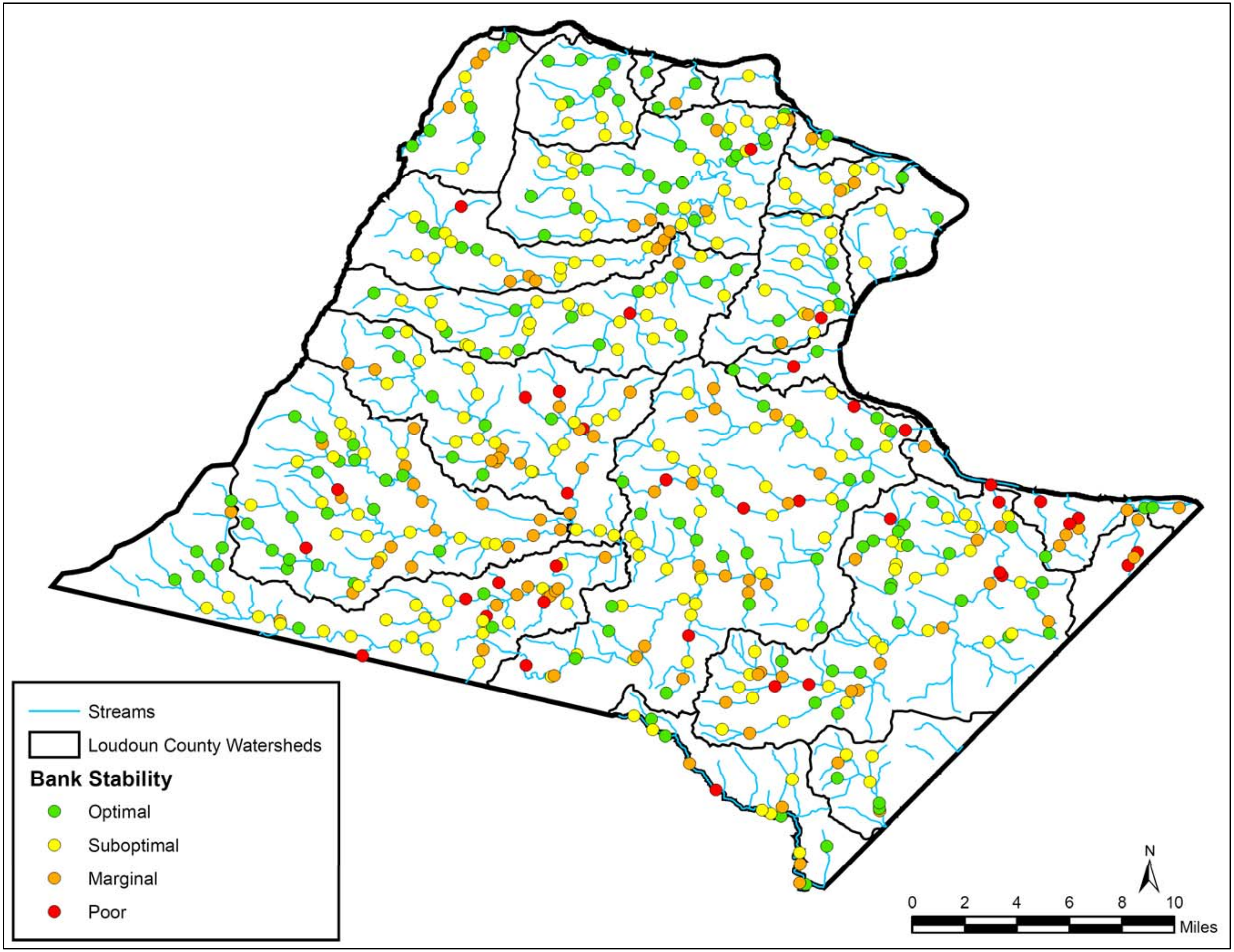

Figure 5-5. Bank Stability ratings for all 500 sites sampled in Loudoun County, 2009.

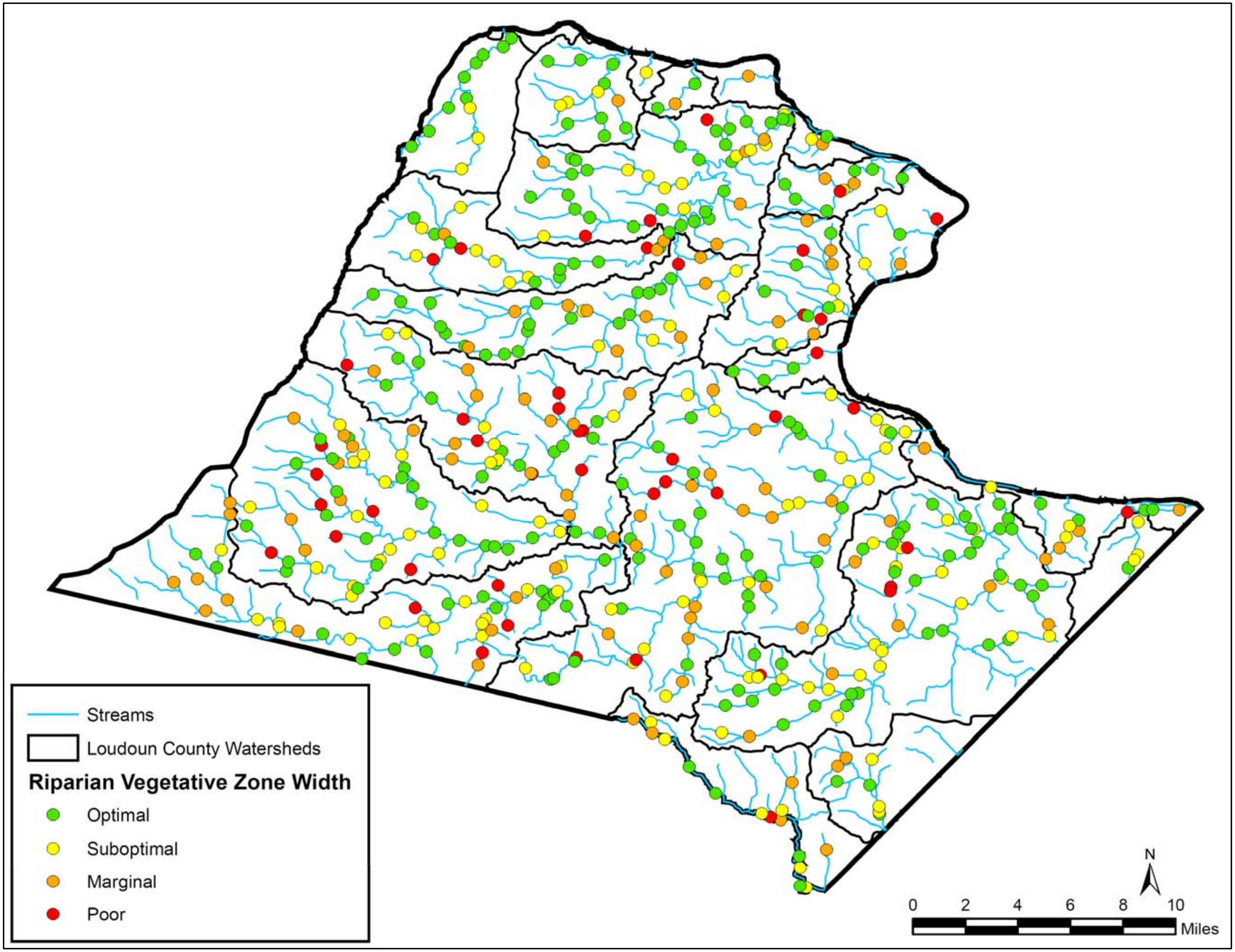

Figure 5-6. Riparian Vegetative Zone Width ratings for all 500 sites sampled in Loudoun County, 2009.

these two sites, comments recorded by field crews indicated that the water was barely flowing and there was standing water in some areas. Physical aeration due to water flowing over coarse substrate is an important means of introducing oxygen into the water. The low DO in these streams is most likely from the low flow conditions, and not the result of any underlying issue. Temperature and conductivity were within the expected ranges at all sites. At most sites, pH was good, although 72 sites had a pH value of 8.0 or greater. Elevated pH values at these sites were likely a result of the region's geology and the limestone present in the area. Only two sites had low pH (less than or equal to 6.0).

6. PROBLEM SITES

During each of the habitat assessments performed in the Loudoun County Stream Assessment, field staff surveyed the stream site to identify any environmental problems that could be readily observed along the stream corridor. Using datasheets adopted from the Stream Corridor Assessment protocol (Yetman 2001), problem sites were noted and photographed whenever encountered. Problems in the following nine categories were recorded:

1) **Channelization:** refers to the once common practice of dredging, straightening and/or widening stream channels in an attempt to reduce flooding or to lower the ground water table. This was done using a number of different approaches, including: widening the stream channel so it would hold more water, building berms along the edges to the stream to hold the flood flow in the channel, straightening the stream to increase the slope of the water to move it faster through an area and/or reducing the roughness of the stream channel by constructing a smooth channel out of concrete.

2) **Erosion:** the detachment of material from the bed or sides of the stream channel. Too much erosion destabilizes stream banks, destroying in-stream habitat and causing significant sediment pollution problems downstream.

3) **Inadequate Buffer:** occurs when there is little to no forested area surrounding the stream corridor. Forested buffers help shade the stream, provide bank stability, and remove nutrients, sediment and pollutants from runoff.

4) **Fish Barriers:** anything in the stream that significantly interferes with the upstream movement of fish.

5) **Exposed Pipe:** any pipes that are either in the stream or along the stream's immediate banks that could be damaged by a high flow event.

6) **Pipe Outfall:** include any pipes or small manmade channels that discharge into the stream through the stream corridor.

7) **Trash Dumping Site:** include places where large amounts of trash have been dumped inside the stream corridor or places where trash tends to accumulate.

8) **Near or Instream Construction:** major disturbances or construction activity in the stream corridor or its surrounding area at the time of the survey.

9) **Unusual Condition:** includes anything out of the ordinary, including unusual odor, scum, excessive algae, water color/clarity, red flock, oil on surface, etc.

For each problem encountered, the site condition was evaluated for its severity, correctability, and ease of access.

Problem sites were noted by field crews at 170 sites surveyed in the Loudoun County Stream Assessment (34% of all sites surveyed) (Appendix B, Table B-1). Problem sites were identified in each of the 12 PSUs (Table 6-1). In all, 249 problems were identified; some sites had multiple problems. Inadequate Buffer and Erosion were the most frequently encountered problems, noted at 93 and 85 sites, respectively (18.6% and 17% of all sites surveyed). Channelization occurred at 23 sites (4.6% of all sites). Lower Goose Creek had the most problems identified (53), including 20 sites with erosion problems and 19 with inadequate buffer. The Dutchman Creek/Piney Run/Quarter Branch PSU had the fewest problems identified (3), including one site that had significant erosion and two sites with inadequate buffer. The lack of problems in this PSU is consistent with results obtained in the RBP habitat survey, as this PSU had the highest mean RBP habitat score (155.5, Suboptimal) of all PSUs in Loudoun County.

For exact details on the problems identified, scanned field sheets are included in digital format as a supplement to this report. Individual sites with problems are listed in Appendix B, Table B-1.

Table 6-1. Counts, by PSU, of problems as identified through surveying 500 stream sites, Loudoun County Stream Assessment, 2009. Countywide totals are also given.

PSU	Channel -ization	Erosion	Inadequate Buffer	Fish Barrier	Exposed Pipe	Pipe Outfall	Trash Dumping	Near or Instream Construction	Unusual Condition	Total
Dutchman Creek/Piney Run/Quarter Branch	0	1	2	0	0	0	0	0	0	3
Direct to Potomac	3	6	7	2	1	1	3	1	1	25
Catoctin Creek	1	2	3	0	2	0	0	0	0	8
North Fork Catoctin Creek	1	3	5	0	0	0	0	0	0	9
South Fork Catoctin Creek	2	5	7	1	0	0	0	0	1	16
Clarks Run/Limestone Branch	1	5	5	0	0	0	0	0	0	11
North Fork Goose Creek	1	13	15	2	0	0	1	0	4	36
Beaverdam Creek	0	4	9	0	0	0	0	0	0	13
Upper Goose Creek	1	16	8	1	2	0	0	1	1	30
Lower Goose Creek	5	20	19	1	0	4	0	2	2	53
Broad Run/Sugarland Run	5	9	8	4	0	1	1	0	5	33
Bull Run/Cub Run	3	1	5	0	0	2	0	0	1	12
Countywide	23	85	93	11	5	8	5	4	15	249

7. FIELD DETERMINATIONS OF STREAM PERENNIALITY

Field investigations were conducted to provide field-truthed determinations of stream perenniality at selected sites throughout Loudoun County. To accomplish this goal, the team utilized the methods developed by the North Carolina Division of Water Quality, as adapted by Fairfax County, Virginia (Fairfax County Department of Public Works and Environmental Services 2003).

7.1 OVERVIEW OF METHOD

Proposed site locations were initially determined by Loudoun County utilizing a GIS desktop analysis that identified reach breaks based upon United States Geologic Survey mapping (National Hydrography Dataset High Resolution, NHD-HD), which identified perennial versus intermittent flow. Further desktop review of proposed sampling points was conducted to make some adjustments to these initial locations based upon drainage area, stream order, land use, and previous experience with identifying stream perenniality for Fairfax County.

Upon arrival at a targeted site, field crews walked the stream to determine an approximate point of perenniality. Once at the approximate point, field crews utilized the methodology established in the Fairfax County Protocol to evaluate the following:

- Presence or absence of flowing water
- Presence of high groundwater table or springs and seeps
- Leaf litter in the streambed
- Drift lines
- Sediment on debris or plants
- Riffle-pool sequence
- Stream substrate sorting
- Presence of natural levees
- Sinuosity
- Active/relic floodplain
- Braided channel
- Recent alluvial deposits
- Bankfull bench presence
- Continuous bed and bank
- Stream order
- Streambed soils (e.g., chroma)
- Vegetation (rooted aquatic plants, periphyton, iron oxiding bacteria, wetland plants)
- Benthic macroinvertebrates (bivalves, EPT)
- Vertebrates (fish, amphibians)

Each of the above metrics were recorded on a field data sheet and assigned a score to provide an overall score to a given reach to determine perenniality. Field data sheets were compiled for areas both upstream and downstream of the approximated point of perenniality and combined with best professional judgment to determine whether the chosen point was indeed perennial. Once the point of perenniality was chosen, the field crew marked the sites on the field map, took site photographs, and recorded the location of the point of perenniality in the GPS unit.

7.2 LOGISTICS AND PROPERTY ACCESS

Prior to each day's field work, Biohabitats field staff reviewed field maps along with the most up to date version of landowner permission responses provided by Loudoun County staff. Permissions were reviewed to determine if landowners had requested contact, either via email or telephone, prior to sampling. Local stream gauges and precipitation gauges were evaluated to determine if prior rainfall events would hinder field sampling efforts. United States Geological Survey (USGS) gauges were accessed via the internet at www.va.water.usgs.gov/Loudoun/data.htm and field work was conducted only if there was less than 1.0" of rain within the previous 24 hours as determined by two Loudoun County rain gauges. The gauge closest to the anticipated sampling sites was used to make the determination. Due to the numerous precipitation events throughout early spring, there were some instances when rainfall slightly exceeded the 1.0" of rainfall. In these cases the crew would perform a cursory site investigation to see if actual field conditions prohibited sampling (e.g., the stream was too turbid to identify the necessary metrics, or benthic macroinvertebrate drift was probable). Due to the abundance of rainfall during the assessment efforts, if the 1.0" threshold was not reached when field work had begun, but rain was occurring or was anticipated, office staff monitored the USGS gauges and reported to field staff when the nearest gauge had reached one inch and field conditions were deemed unsampleable, and field efforts were ceased.

Loudoun County was responsible for obtaining permission from landowners for access to targeted perenniality determination sites. Prior to field activities, the county submitted permission letters to 556 landowners for 280 targeted perenniality sites. Of the 566 landowners contacted by mail, 284 replied to the County's request for access, of which 172 agreed to allow field crews on the targeted properties. In practice, however, additional properties required access, given that the actual points of perenniality were, in many cases, determined to be substantially upstream of the initial candidate sites. Field staff requested permissions by directly contacting landowners in the field. At sites where landowners denied permission to access properties, sampling was not conducted. Access to target points on Dulles Airport property was not considered possible and not attempted due to security considerations. In all, determinations of stream perenniality were completed at 155 sites.

7.3 APPLICATION OF THE ASSESSMENT METHODOLOGY

Initially, reaches were accessed at the target point, then followed upstream (choosing the reach of greatest flow if the reach split) until a point of perenniality was determined. This was later determined to be too time consuming and ultimately reaches were accessed from their highest point (furthest mapped intermittent line) and walked downstream or upstream until the point of perenniality was determined. When selecting a target stream that had multiple branches above the target point, the reach chosen was that which extended furthest from the target point.

Field sheets were typically filled out for two reaches per site: an upstream non-perennial reach and a downstream perennial reach. The point between these two reaches was determined to be the point of perenniality. The following conventions were followed in particular situations:

- If a reach was followed upstream to its source and was found to be perennial up until the point it emanated from the surface (i.e., a springhead or springhouse), that point was considered the point of perenniality, and no non-perennial reach data was taken but the source was noted on the perennial data sheet.

- If a reach was followed downstream from its upstream end and was found to be non-perennial until it met a mapped blue line tributary which had previously been determined to be perennial, the point of confluence with the blue line would be considered as the point of perenniality and hence no data sheet would be filled out for a perennial reach.

- If the point of perenniality was determined to be in a different county, then a perennial reach data sheet was used and a GPS point located at the county line but no ephemeral reach data was pursued or taken in adjacent counties.

For each site investigated, when a point of perenniality was found, a note of the actual location was made on the field map. If the site was not perennial or did not exist, notes were clearly made.

To further clarify datasheets and to ensure that the correct number of data sheets were being completed at each site, Biohabitats revised the nomenclature on the data sheets only to reflect if the reach being assessed was perennial or nonperennial. Perennial reaches were noted with a P designation while non-perennial reaches utilized an N designation. For example, the perennial data sheet for Beaver Creek site 917 would be titled BEAV-917-P-2009 while the nonperennial data sheet would be labeled BEAV-917-N-2009. The title of the data point within the personal geodatabase, which reflects the point of perenniality, is identified by the predetermined designation of BEAV-917-P-2009.

Attempts were made to download the GPS every night, and at the very minimum, the data were copied from the unit to the project folder once the field crew returned to the office. Photographs were renamed as soon as possible by the field staff that collected the information to ensure accuracy and reliability. Photos were renumbered to coincide with the associated target location and the number designated to the photograph via the camera itself. For example, if the photograph number on the camera was 547 and the location was LOGC-909-P-2009, the photograph was renamed LOGC-909-P-2009-547.

7.4 QUALITY ASSURANCE/QUALITY CONTROL

Throughout field assessment efforts, field crews were rotated to ensure that field protocols were adhered to and that biases were not developed. Throughout the field assessment, questions were encouraged and if a team had any questions or differences in opinion about parameters within the methodology, other qualified staff were contacted for clarification. Prior to concluding perenniality determinations along each tributary, field crews reviewed each data sheet to ensure its completeness and to ensure that the perenniality score was tabulated correctly. Once back in the office, field map notes were transcribed to a clean copy of the map. The point of perenniality was located on the map and a label was placed on the map denoting the date and initials of the field crew members. Data sheets were cross checked with field maps to ensure the correct number of data sheets correlated with each map. Once the data sheets and maps were evaluated, the photographs for each site were correlated to verify that the proper number of photographs were associated with each site and were labeled properly.

7.5 RESULTS AND DISCUSSION

The field-determined points of perenniality were identified on maps and compiled into a project geodatabase, which was provided to Loudoun County Building and Development, along with electronic versions of annotated maps, field data sheets, and digital photographs.

In general, the Fairfax County protocol worked very well in evaluating perenniality in Loudoun County streams, and only in a few instances was a stream determined to be perennial when the score fell below the 25 point threshold. In these cases, the presence of specific macroinvertebrates with multiyear larval stages was the overriding factor in classifying the stream as perennial. Some of the crew members who had prior experience with similar protocols were initially skeptical of the methodology, but were quickly persuaded by its accuracy and consistency.

Overall, the majority of points were located above their targeted locations, which had been roughly based on perennial stream locations in the NHD High Resolution data. There did not appear to be any general watershed trends or land cover trends, other than the fact that many of the points of perenniality in highly urbanized areas were at pipe outfalls. Further GIS analysis may yield trends that may be applied to future field efforts or local planning and zoning.

Although a few selected perenniality points were found to be within a reasonably short distance from the anticipated point, the majority of the points of perenniality were significantly upstream, up to a mile or more, from the targeted point. The points of perenniality typically were located along the mapped historic soil drain line. This information would lead us to believe that there are far more actual perenniality points (and greater perennial stream length) than originally anticipated prior to field investigations.

8. DISCUSSION

The 2009 Loudoun County Stream Assessment provided extensive information on the biological and physical conditions present in the County's wadeable streams. In this section, we examine the findings of the stream assessment, including both probability-based and targeted components, to interpret those results and contribute to a better understanding of the current status of Loudoun County streams.

8.1 BENTHIC MACROINVERTEBRATES

Overall, VSCI results indicated that benthic macroinvertebrates have been degraded to a great degree and extent in many of the County's watersheds. Countywide, an estimated 42.5% of stream miles were rated as Severe Stress and another 35.7% as Stress according to the VSCI. Only 18% of stream miles classified as Good and less than 4% as Excellent, the two categories representing sites comparable to reference conditions.

Degraded biological conditions were particularly noteworthy in the eastern and southeastern parts of the County. For example, the Broad Run/Sugarland Run and Direct to Potomac PSUs each had mean VSCI scores and more than 80% of stream miles in the Severe Stress category. In contrast, highest scores were generally found in western Loudoun County, suggesting areas worthy of preservation and protection to maintain this high quality ecological condition.

In general, benthic scores were somewhat lower than one might have expected, based on a review of previous of biological monitoring data (Roth et al. 2009a). In fact, this was the most extensive, probability-based survey ever conducted in Loudoun County, meaning that site selection was unbiased and representative of conditions present in the County. Consultation with DEQ found that lower VSCI scores are often observed in spring compared with fall sampling. DEQ has noted that scores for the same site may fluctuate 20 to 30 points, with scores typically lower in spring (J. Hill, pers. comm.). DEQ does not employ a separate scoring system by season, despite these observed differences in VSCI scores.

Of the eight metrics that make up the VSCI, the metrics for Percent Ephemeroptera (mayflies), Percent Plecoptera and Trichoptera (stoneflies and caddisflies, subtracting pollution tolerant Hydropsychid caddisflies), and Percent Scrapers appeared to have the greatest influence on the resulting low benthic scores. Each of these three metrics exhibited a predominance of low scores, while the other metrics had a more normal distribution of values.

It is also important to consider the reference standard with which Loudoun County stream sites are being compared. The VSCI relies on a reference condition that was established using data from streams throughout non-coastal Virginia (TetraTech 2003). In developing the VSCI, the original reference data set included just 7 sites in the Northern Piedmont (the ecoregion encompassing Loudoun County) and 4 sites in the Piedmont out of an initial 62 sites, with the remaining sites from less populated areas of Virginia: Blue Ridge, Ridge and Valley, and Central Appalachians. The authors noted that "while the reference criteria do not define pristine sites, nor even a minimally disturbed condition, they do represent the least disturbed condition readily available in the state." In metric testing, some scores tended to be slightly lower for the Piedmont regions. However, the lack of sufficient data to define reference condition precluded development of a separate VSCI for Northern Piedmont or Piedmont. Given the extent and long history of urban and agricultural land uses in Northern Virginia, it may be difficult to find many stream sites in Loudoun County that are comparable to the reference condition.

In the Loudoun County Stream Assessment, VSCI scores for 23 targeted sites, sampled at locations previously monitored by DEQ, spanned a range from Excellent (1 site) to Good (3), Stress (10), and Severe Stress (9). Scores at most sites were consistent with those from previous years' spring sampling efforts by DEQ. Five sites showed a decline in stream condition compared to previous years.

During Spring 2009, DEQ conducted benthic macroinvertebrate monitoring at nine targeted sites also sampled in the Loudoun County Stream Assessment. DEQ sampled one site twice (DEQ's site IAGOO022.44, Loudoun County Stream Assessment site UPGC-408-T-2009), obtaining similar results in each replicate. A comparison of the VSCI scores calculated from DEQ samples with those calculated from samples in this study shows considerable agreement in results (Table 8-1 and Figure 8-1). At four of the sites, both studies rated the sites within the same Assessment Categories. When the ratings differed, they were off by only one Assessment Category (for instance, one study's rating was Stress while the other study's rating was Severe Stress). Neither study consistently rated sites higher or lower than the other study, and difference in results can be attributed to environmental variability in complex stream ecosystems.

Table 8-1. Comparison of VSCI scores and Assessment Categories at sites sampled by DEQ and by the Loudoun County Stream Assessment, Spring 2009.

Virginia DEQ Station ID	2009 Loudoun County Stream Assessment Station ID	Virginia DEQ VSCI Score	Virginia DEQ VSCI Assessment Category	2009 Loudoun County Stream Assessment VSCI Score	2009 Loudoun County Stream Assessment VSCI Assessment Category
1ABRB015.43	BROA-302-T-2009	33.2	Severe Stress	46.5	Stress
1ABRB006.97	BROA-403-T-2009	32.1	Severe Stress	22.2	Severe Stress
1ABRB002.15	BROA-404-T-2009	22.2	Severe Stress	40.7	Severe Stress
1ASOC000.01	CATO-420-T-2009	48.9	Stress	26.7	Severe Stress
1ANOC000.42	NFCC-319-T-2009	55.8	Stress	42.7	Stress
1ASOC013.05	SFCC-214-T-2009	55.0	Stress	64.3	Good
1ASOC010.09	SFCC-217-T-2009	48.3	Stress	52.0	Stress
1ASOC007.06	SFCC-318-T-2009	33.2	Severe Stress	54.8	Stress
1AGOO022.44	UPGC-408-T-2009	63.0	Good	57.4	Stress
1AGOO022.44*	UPGC-408-T-2009	72.7	Good	57.4	Stress

* indicates a duplicate sample taken by DEQ at this site.

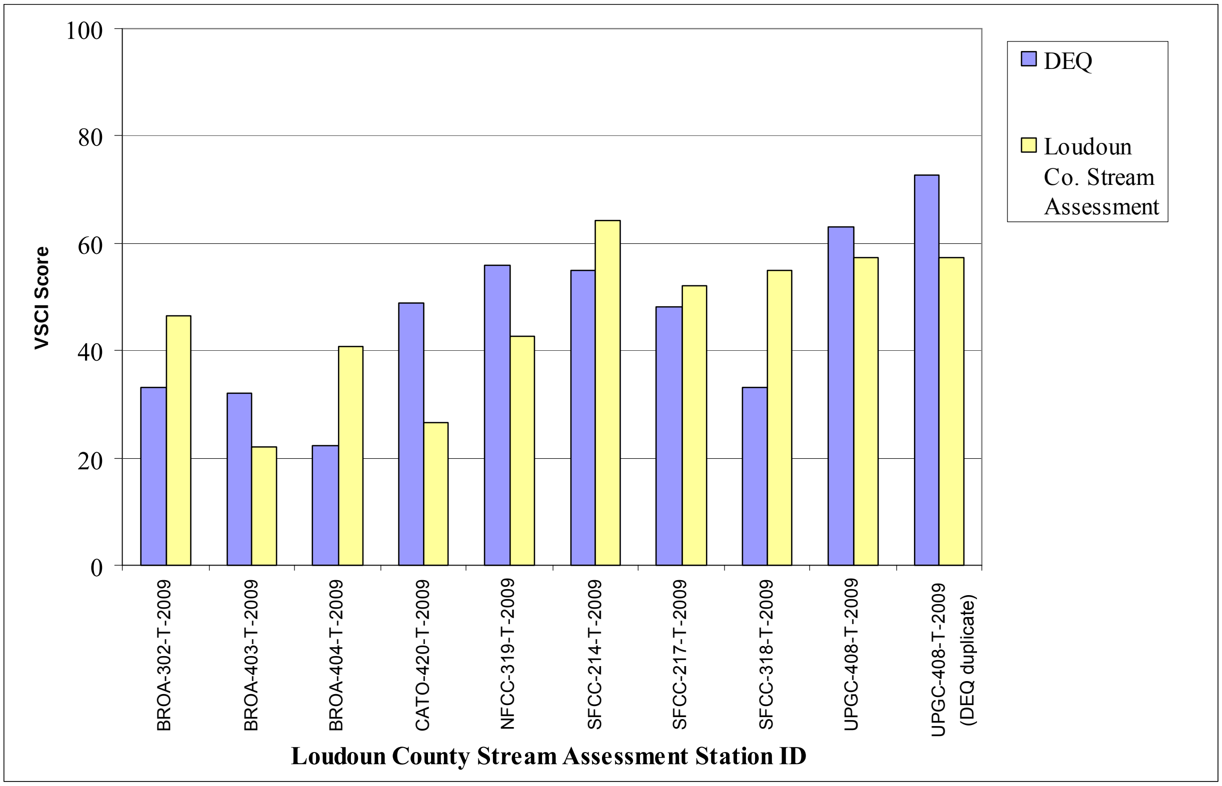

Figure 8-1. Comparison of VSCI scores at nine sites sampled by DEQ and by the Loudoun County Stream Assessment, Spring 2009. One site was sampled twice by DEQ and both sets of results are presented.

The additional 177 probability-based sites sampled in the Loudoun County Stream Assessment provide geographic coverage to fill in data gaps between established DEQ site locations and allow for area-wide assessment of condition. For example, in addition to the three targeted sites in Broad Run rated as Stress to Severe Stress, all 23 of the random site locations in Broad Run were also rated as Stress to Severe Stress. This provides context for the three targeted sites and suggests that degraded biological conditions are widespread in this watershed. In fact, an estimated 92% of stream miles in the Broad Run/Sugarland Run PSU were classified as Severe Stress and the remainder as Stress.

8.2 HABITAT ASSESSMENT

In the probability-based survey, habitat conditions, assessed using EPA and DEQ's RBP method, were on average in the Suboptimal range, the second best of four category ratings both countywide and in all watersheds. Nearly 75% of stream miles in Loudoun County classified as Suboptimal based on the physical habitat assessment. Nineteen percent of the stream miles classified as Optimal, while about 5% were Marginal. No streams in the County rated as Poor based on physical habitat. Optimal habitat was most common in Dutchman Creek/Piney Run/ Quarter Branch. Habitat Assessment scores for the 23 targeted sites were primarily Suboptimal (17 sites), with a few Optimal (4) and Marginal (2).

Generally, favorable conditions were recorded for key habitat parameters, with the majority of streams having Optimal to Suboptimal ratings for Epifaunal Substrate/Available Cover (88% of stream miles), Riparian Vegetative Zone Width (78%), Embeddedness (73%), and Sediment Deposition (78%). Problems with Bank Stability were more common, with only 53% of stream miles rated Optimal to Suboptimal. As expected, individual parameters exhibited more variation both within and among PSUs than did the overall RBP habitat scores.

When all habitat assessment data were combined (500 sites countywide), the majority of sites (400) fell in the Suboptimal Assessment Category, with the remaining divided between the Marginal and Optimal categories, and no sites rated as Poor. Some watersheds had all or nearly all sites rated as Optimal to Suboptimal. Marginal conditions were noted in both agricultural and urban areas. Habitat conditions can vary substantially with local conditions, and in fact, we noted instances of widely varying habitat quality among sites along the same stream.

Some significant opportunities to improve habitat conditions may be found throughout Loudoun County. Most notably, nearly half of the streams surveyed had at least one bank in marginal or poor condition, suggesting that altered flow regime (flashiness) is a potential problem. When lands are cleared for urban and agricultural uses, natural streamflow patterns can be disrupted, resulting in more frequent high flow events that scour streambanks and can alter channel morphology. Embeddedness was noted fairly extensively, particularly in the central and eastern portions of the county. While many streams were well-buffered by riparian vegetation, opportunities exist for improvement of riparian vegetation in both rural and urban areas.

Many streams have not yet been overly impacted by surrounding land uses and development, and are good candidates for conservation and protection. The predominance of streams rated as Suboptimal suggests that, although few streams may be considered pristine, there are many areas in Loudoun County with fairly good habitat quality. This is not unexpected, but given the long history of agricultural uses and recent expanding urbanization in Loudoun County it is encouraging that good opportunities exist for preservation and improvement of stream habitat. The fact that no sites rated as Poor indicates that Loudoun County streams have not yet destabilized to the point of severe degradation commonly observed in more heavily developed areas of the Washington Metropolitan region.

8.3 WATER CHEMISTRY

Water chemistry data, for the most part, did not indicate significant stressors to streams systems. The low DO levels observed at only a few sites were associated with low flow. In a few cases, high pH values were observed. Interestingly, there were a few sites with high conductivity, generally found in more urban areas, which may be indicative of pollutant inputs.

These single-point-in-time measures only provide limited information on the parameters measured and provide no data to evaluate nutrient loads or other potential water chemistry problems.

8.4 RELATIONSHIPS BETWEEN BENTHIC AND HABITAT CONDITIONS

Based on the hypothesis that healthy benthic communities occupy stream sites with healthy habitat characteristics, we explored the relationships between VSCI scores and various individual habitat parameters from the RBP Habitat Assessment. We examined regression relationships between VSCI and Epifaunal Substrate/Available Cover, Embeddedness, Sediment Deposition, Bank Stability, and Riparian Vegetative Zone Width scores, as well as overall RBP Habitat Assessment scores. Regression relationships were significant between VSCI score and Epifaunal Substrate ($p < 0.0001$) and Embeddedness ($p < 0.0001$), despite low regression coefficients ($r^2 = 0.13$, and $r^2=0.08$, respectively). There was a significant relationship between VSCI and the overall RBP Habitat Assessment score, but again with a low regression coefficient ($p < 0.0001$, $r^2 = 0.11$).

8.5 PROBLEM SITES

Observations of nine specific problem types were recorded at 170 sites (34% of all sites surveyed). Inadequate Buffer and Erosion were encountered most frequently, noted at 93 and 85 sites, respectively. Channelization occurred at 23 sites. Lower Goose Creek had the most problems identified, while Dutchman Creek/Piney Run/Quarter Branch PSU had the fewest problems identified. Data collected on these specific problem types may be useful in future watershed management efforts of Loudoun County.

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APPENDIX A

MEANS AND PERCENT

STREAM MILE ESTIMATES

Table A-1. Mean RBP Habitat Assessment total score, with Standard Deviation and Standard Error for 12 PSUs in Loudoun County, VA			
PSU	**Mean**	**Standard Deviation**	**Standard Error**
Dutchman Creek/Piney Run/Quarter Branch	155.5	17.39	5.50
Direct to Potomac	131.3	16.98	5.12
Catoctin Creek	146.1	19.85	5.30
North Fork Catoctin Creek	144.4	16.91	5.35
South Fork Catoctin Creek	150.9	10.30	3.26
Clarks Run/Limestone Branch	111.9	25.74	8.14
North Fork Goose Creek	141.0	17.93	4.63
Beaverdam Creek	140.0	20.41	4.68
Upper Goose Creek	134.7	11.88	2.97
Lower Goose Creek	137.1	24.95	4.80
Broad Run/Sugarland Run	133.1	16.98	3.73
Bull Run/Cub Run	145.0	17.11	5.41

Table A-2. Mean Virginia Stream Condition Index (VSCI) score with Standard Deviation and Standard Error for 12 PSUs in Loudoun County, VA			
PSU	**Mean**	**Standard Deviation**	**Standard Error**
Dutchman Creek/Piney Run/Quarter Branch	53.34	7.69	2.43
Direct to Potomac	30.28	12.88	3.88
Catoctin Creek	49.32	14.64	3.91
North Fork Catoctin Creek	58.15	9.31	2.95
South Fork Catoctin Creek	58.62	10.63	3.36
Clarks Run/Limestone Branch	47.61	18.00	5.69
North Fork Goose Creek	44.14	12.99	3.35
Beaverdam Creek	52.98	16.84	3.86
Upper Goose Creek	53.15	12.00	3.00
Lower Goose Creek	43.12	14.28	2.79
Broad Run/Sugarland Run	29.45	9.31	1.87
Bull Run/Cub Run	50.60	12.76	4.03

Table A-3. Percent Stream Miles and Standard Error (SE) by Assessment Category for five selected RBP Habitat Assessment metrics and total RBP Habitat Assessment Score for 12 PSUs in Loudoun County, VA and Countywide. (na= not applicable)

	Optimal	SE	Suboptimal	SE	Marginal	SE	Poor	SE
Dutchman Creek/Piney Run/Quarter Branch								
Epifaunal Substrate/ Available Cover	60.0%	0.16	40.0%	0.16	0.0%	n/a	0.0%	na
Embeddedness	50.0%	0.17	40.0%	0.16	10.0%	0.10	0.0%	na
Sediment Deposition	30.0%	0.15	60.0%	0.16	10.0%	0.10	0.0%	na
Bank Stability (both banks combined)	60.0%	0.16	30.0%	0.15	10.0%	0.1	0.0%	na
Riparian Vegetative Zone Width (both banks combined)	80.0%	0.13	20.0%	0.13	0.0%	na	0.0%	na
Total Score	60.0%	0.16	40.0%	0.16	0.0%	na	0.0%	na
Direct to Potomac								
Epifaunal Substrate/ Available Cover	9.1%	0.09	63.6%	0.15	9.1%	0.09	18.2%	0.12
Embeddedness	9.1%	0.09	45.5%	0.16	18.2%	0.12	27.3%	0.14
Sediment Deposition	45.5%	0.16	45.5%	0.16	0.0%	na	9.1%	0.09
Bank Stability (both banks combined)	45.5%	0.16	9.1%	0.09	9.1%	0.09	36.4%	0.15
Riparian Vegetative Zone Width (both banks combined)	72.7%	0.14	18.2%	0.12	0%	na	9.1%	0.09
Total Score	9.1%	0.09	0.9%	0.09	0.0%	na	0.0%	na
Catoctin Creek								
Epifaunal Substrate/ Available Cover	50.0%	0.14	28.6%	0.13	14.3%	0.10	7.1%	0.07
Embeddedness	14.3%	0.10	71.4%	0.13	14.3%	0.10	0.0%	na
Sediment Deposition	28.6%	0.13	42.9%	0.14	28.6%	0.13	0.0%	na
Bank Stability (both banks combined)	35.7%	0.13	35.7%	0.13	28.6%	0.13	0.0%	na
Riparian Vegetative Zone Width (both banks combined)	64.3%	0.13	21.4%	0.11	0.0%	na	14.3%	0.10
Total Score	42.9%	0.14	57.1%	0.14	0.0%	na	0.0%	na
North Fork Catoctin Creek								
Epifaunal Substrate/ Available Cover	80.0%	0.13	20.0%	0.13	0.0%	na	0.0%	na
Embeddedness	30.0%	0.15	40.0%	0.16	30.0%	0.15	0.0%	na
Sediment Deposition	30.0%	0.15	60.0%	0.16	10.0%	0.10	0.0%	na
Bank Stability (both banks combined)	10.0%	0.10	60.0%	0.16	30.0%	0.15	0.0%	na
Riparian Vegetative Zone Width (both banks combined)	60.0%	0.16	10.0%	0.10	10.0%	0.10	20.0%	0.13
Total Score	20.0%	0.13	80.0%	0.13	0.0%	na	0.0%	na

Table A-3. (Continued)	Optimal	SE	Suboptimal	SE	Marginal	SE	Poor	SE
South Fork Catoctin Creek								
Epifaunal Substrate/ Available Cover	70.0%	0.15	30.0%	0.15	0.0%	na	0.0%	na
Embeddedness	30.0%	0.15	70.0%	0.15	0.0%	na	0.0%	na
Sediment Deposition	20.0%	0.13	70.0%	0.15	10.0%	0.10	0.0%	na
Bank Stability (both banks combined)	40.0%	0.16	50.0%	0.17	0.0%	na	10.0%	0.10
Riparian Vegetative Zone Width (both banks combined)	50.0%	0.17	30.0%	0.15	20.0%	0.13	0.0%	na
Total Score	30%	0.15	70%	0.15	0.0%	na	0.0%	na
Clarks Run/Limestone Branch								
Epifaunal Substrate/ Available Cover	0.0%	na	40.0%	0.16	50.0%	0.17	10.0%	0.10
Embeddedness	10.0%	0.10	50.0%	0.17	40.0%	0.10	0.0%	na
Sediment Deposition	0.0%	na	40.0%	0.16	60.0%	0.16	0.0%	na
Bank Stability (both banks combined)	20.0%	0.13	40.0%	0.16	30.0%	0.15	10.0%	0.10
Riparian Vegetative Zone Width (both banks combined)	20.0%	0.13	30.0%	0.15	30.0%	0.15	20.0%	0.13
Total Score	0.0%	na	60.0%	0.1633	40.0%	0.16	0.0%	na
North Fork Goose Creek								
Epifaunal Substrate/ Available Cover	46.7%	0.13	53.3%	0.13	0.0%	na	0.0%	na
Embeddedness	20.0%	0.11	46.7%	0.13	33.3%	0.13	0.0%	na
Sediment Deposition	26.7%	0.12	53.3%	0.13	20.0%	0.11	0.0%	na
Bank Stability (both banks combined)	6.7%	0.07	40.0%	0.13	40.0%	0.13	13.3%	0.09
Riparian Vegetative Zone Width (both banks combined)	33.3%	0.13	33.3%	0.13	6.7%	0.07	26.7%	0.12
Total Score	20.0%	0.11	80.0%	0.11	0.0%	na	0.0%	na
Beaverdam Creek								
Epifaunal Substrate/ Available Cover	42.1%	0.12	57.9%	0.12	0.0%	na	0.0%	na
Embeddedness	26.3%	0.10	57.9%	0.12	10.5%	0.07	5.3%	0.05
Sediment Deposition	31.6%	0.11	47.4%	0.12	15.8%	0.09	5.3%	0.05
Bank Stability (both banks combined)	31.6%	0.11	31.6%	0.11	31.6%	0.11	5.3%	0.05
Riparian Vegetative Zone Width (both banks combined)	57.9%	0.12	15.8%	0.09	15.8%	0.09	10.5%	0.07
Total Score	21.1%	0.10	73.7%	0.10	5.3%	0.05	0%	na

Table A-3. (Continued)								
	Optimal	**SE**	**Suboptimal**	**SE**	**Marginal**	**SE**	**Poor**	**SE**
Upper Goose Creek								
Epifaunal Substrate/ Available Cover	18.8%	0.10	81.3%	0.10	0.0%	na	0.0%	na
Embeddedness	6.3%	0.06	37.5%	0.13	56.3%	0.13	0.0%	na
Sediment Deposition	6.3%	0.06	43.8%	0.13	43.8%	0.13	6.3%	0.06
Bank Stability (both banks combined)	6.3%	0.06	31.3%	0.12	37.5%	0.13	25%	0.11
Riparian Vegetative Zone Width (both banks combined)	37.5%	0.13	43.8%	0.13	12.5%	0.09	6.3%	0.06
Total Score	6.3%	0.06	93.8%	0.06	0.0%	na	0.0%	na
Lower Goose Creek								
Epifaunal Substrate/ Available Cover	18.5%	0.08	63.0%	0.09	14.8%	0.07	3.7%	0.04
Embeddedness	22.2%	0.08	48.1%	0.10	25.9%	0.08	3.7%	0.04
Sediment Deposition	29.6%	0.09	51.9%	0.10	14.8%	0.07	3.7%	0.04
Bank Stability (both banks combined)	37.0%	0.09	33.3%	0.09	22.2%	0.08	7.4%	0.05
Riparian Vegetative Zone Width (both banks combined)	37.0%	0.09	40.7%	0.10	7.4%	0.05	14.8%	0.07
Total Score	14.8%	0.07	74.1%	0.09	11.1%	0.06	0.0%	na
Broad Run/ Sugarland Run								
Epifaunal Substrate/ Available Cover	44.0%	0.10	40.0%	0.10	16.0%	0.07	0.0%	na
Embeddedness	20.0%	0.08	56.0%	0.10	20.0%	0.08	4.0%	0.04
Sediment Deposition	12.0%	0.07	68.0%	0.10	20.0%	0.08	0.0%	na
Bank Stability (both banks combined)	20.0%	0.08	36.0%	0.10	36.0%	0.10	8.0%	0.06
Riparian Vegetative Zone Width (both banks combined)	52.0%	0.10	28.0%	0.09	12.0%	0.07	8.0%	0.06
Total Score	0.0%	na	88.0%	0.07	12.0%	0.07	0.0%	na
Bull Run/Cub Run								
Epifaunal Substrate/ Available Cover	40.0%	0.16	40.0%	0.16	20.0%	0.13	0.0%	na
Embeddedness	30.0%	0.15	40.0%	0.16	30.0%	0.15	0.0%	na
Sediment Deposition	30.0%	0.15	70.0%	0.15	0.0%	na	0.0%	na
Bank Stability (both banks combined)	20.0%	0.13	50.0%	0.17	20.0%	0.13	10.0%	0.10
Riparian Vegetative Zone Width (both banks combined)	40.0%	0.16	30.0%	0.15	20.0%	0.13	10.0%	0.10
Total Score	30.0%	0.15	70.0%	0.15	0.0%	na	0.0%	na

Table A-3. (Continued)								
	Optimal	**SE**	**Suboptimal**	**SE**	**Marginal**	**SE**	**Poor**	**SE**
Countywide								
Epifaunal Substrate/ Available Cover	37.9%	0.04	50.0%	0.04	9.5%	0.02	2.7%	0.01
Embeddedness	21.6%	0.03	51.5%	0.04	23.7%	0.03	3.3%	0.01
Sediment Deposition	23.7%	0.03	54.0%	0.04	20.0%	0.03	2.3%	0.01
Bank Stability (both banks combined)	27.9%	0.03	35.5%	0.04	26.6%	0.03	9.9%	0.02
Riparian Vegetative Zone Width (both banks combined)	49.5%	0.04	28.7%	0.03	10.2%	0.02	11.6%	0.02
Total Score	19.0%	0.03	74.9%	0.03	5.1%	0.01	0.0%	na

Table A-4. Percent Stream Miles and Standard Error by Assessment Category for overall Virginia Stream Condition Index (VSCI) score for 12 PSUs in Loudoun County, VA and Countywide.

PSU	Excellent	Standard Error	Good	Standard Error	Stress	Standard Error	Severe Stress	Standard Error
Dutchman Creek/Piney Run/Quarter Branch	0.0%	na	30%	0.15	60%	0.16	10%	0.10
Direct to Potomac	0.0%	na	9.1%	0.09	9.1%	0.09	81.8%	0.12
Catoctin Creek	0.0%	na	28.6%	0.13	42.9%	0.14	28.6%	0.13
North Fork Catoctin Creek	0.0%	na	40.0%	0.16	60.0%	0.16	0.0%	n.a.
South Fork Catoctin Creek	10.0%	0.10	40.0%	0.16	40.0%	0.16	10.0%	0.10
Clarks Run/Limestone Branch	10.0%	0.10	20.0%	0.13	30.0%	0.15	40.0%	0.16
North Fork Goose Creek	0.0%	na	20.0%	0.11	20.0%	0.11	60.0%	0.13
Beaverdam Creek	10.5%	0.07	36.8%	0.11	21.1%	0.10	31.6%	0.11
Upper Goose Creek	6.3%	0.06	12.5%	0.09	68.8%	0.12	12.5%	0.09
Lower Goose Creek	3.7%	0.04	3.7%	0.04	44.4%	0.10	48.1%	0.10
Broad Run/Sugarland Run	0.0%	na	0.0%	na	8.0%	0.06	92.0%	0.06
Bull Run/Cub Run	10.0%	0.10	10.0%	0.10	60.0%	0.16	20.0%	0.13
Countywide	3.8%	0.01	18.0%	0.03	35.7%	0.03	42.5%	0.03

Table A-5. Mean, Standard Deviation, and Standard Error *in situ* water quality parameters by PSU, Loudoun County Stream Assessment, 2009. Countywide results are also presented.

PSU	Temperature			Conductivity			Dissolved Oxygen			pH		
	Mean (degrees)	Standard Deviation	Standard Error	Mean (mS/cm)	Standard Deviation	Standard Error	Mean (mg/L)	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error
Dutchman Cr/ Piney Run/ Quarter Branch	13.3	1.29	0.41	0.108	0.03	0.010	11.0	0.85	0.27	7.73	0.43	0.14
Direct to Potomac	12.7	2.99	0.90	0.350	0.19	0.057	10.9	1.99	0.60	8.05	0.73	0.22
Catoctin Creek	11.7	1.85	0.49	0.226	0.10	0.026	12.1	1.31	0.35	7.81	1.00	0.27
North Fork Catoctin Creek	16.7	1.29	0.41	0.124	0.03	0.010	9.9	0.77	0.24	7.46	0.43	0.14
South Fork Catoctin Creek	15.1	1.15	0.36	0.181	0.08	0.025	11.0	0.86	0.27	7.48	0.20	0.06
Clarks Run/ Limestone Branch	18.7	1.46	0.46	0.211	0.05	0.016	9.8	1.24	0.39	7.56	0.21	0.07
North Fork Goose Creek	11.9	2.29	0.59	0.189	0.05	0.012	10.6	1.27	0.33	7.88	0.55	0.14
Beaverdam Creek	10.4	1.90	0.44	0.150	0.03	0.005	11.2	1.17	0.27	8.32	0.41	0.09
Upper Goose Creek	16.4	1.18	0.30	0.160	0.04	0.010	9.0	0.51	0.13	7.35	0.40	0.10
Lower Goose Creek	16.8	1.71	0.33	0.227	0.13	0.025	10.1	1.16	0.22	7.60	0.34	0.07
Broad Run/Sugarland Run	12.1	1.60	0.32	0.435	0.19	0.038	10.1	1.78	0.36	8.15	0.29	0.06
Bull Run/Cub Run	10.6	0.81	0.26	0.346	0.21	0.065	11.1	1.57	0.50	8.08	0.36	0.11
Countywide	13.8	1.73	0.13	0.234	0.12	0.009	10.5	1.33	0.10	7.8	0.53	0.04

Table A-6. Percent of Stream Miles and Standard Error by temperature category by PSU, Loudoun County Stream Assessment, 2009. Countywide results are also presented.				
PSU	**Temp < 20 °C**	**Standard Error**	**Temp ≥ 20 °C**	**Standard Error**
Dutchman Cr/ Piney Run/ Quarter Branch	100.0%	na	0.0%	na
Direct to Potomac	100.0%	na	0.0%	na
Catoctin Creek	100.0%	na	0.0%	na
North Fork Catoctin Creek	100.0%	na	0.0%	na
South Fork Catoctin Creek	100.0%	na	0.0%	na
Clarks Run/ Limestone Branch	80.0%	0.13	20.0%	0.13
North Fork Goose Creek	100.0%	na	0.0%	na
Beaverdam Creek	100.0%	na	0.0%	na
Upper Goose Creek	100.0%	na	0.0%	na
Lower Goose Creek	92.6%	0.05	7.4%	0.05
Broad Run/ Sugarland Run	100.0%	na	0.0%	na
Bull Run/Cub Run	100.0%	na	0.0%	na
Countywide	97.9%	0.01	2.1%	0.01

Table A-7. Percent of Stream Miles and Standard Error by conductivity category by PSU Loudoun County Stream Assessment, 2009. Countywide results are also presented.				
PSU	**Conductivity < 0.600 mS/cm**	**Standard Error**	**Conductivity ≥ 0.600 mS/cm**	**Standard Error**
Dutchman Cr/ Piney Run/ Quarter Branch	100.0%	na	0.0%	na
Direct to Potomac	90.9%	0.09	9.1%	0.09
Catoctin Creek	100.0%	na	0.0%	na
North Fork Catoctin Creek	100.0.0%	na	0.0%	na
South Fork Catoctin Creek	100.0%	na	0.0%	na
Clarks Run/ Limestone Branch	100.0%	na	0.0%	na
North Fork Goose Creek	100.0%	na	0.0%	na
Beaverdam Creek	100.0%	na	0.0%	na
Upper Goose Creek	100.0%	na	0.0%	na
Lower Goose Creek	100.0%	na	0.0%	na
Broad Run/ Sugarland Run	84.0%	0.07	16.0%	0.07
Bull Run/Cub Run	70.0%	0.15	30.0%	0.15
Countywide	96.2%	0.01	3.8%	0.01

Table A-8. Percent of Stream Miles and Standard Error by dissolved oxygen category by PSU, Loudoun County Stream Assessment, 2009. Countywide results are also presented.

PSU	Dissolved Oxygen < 4 mg/l	Standard Error	Dissolved Oxygen ≥ 4 mg/l	Standard Error
Dutchman Cr/ Piney Run/ Quarter Branch	0.0%	na	100.0%	na
Direct to Potomac	0.0%	na	100.0%	na
Catoctin Creek	0.0%	na	100.0%	na
North Fork Catoctin Creek	0.0%	na	100.0%	na
South Fork Catoctin Creek	0.0%	na	100.0%	na
Clarks Run/ Limestone Branch	0.0%	na	100.0%	na
North Fork Goose Creek	0.0%	na	100.0%	na
Beaverdam Creek	0.0%	na	100.0%	na
Upper Goose Creek	0.0%	na	100.0%	na
Lower Goose Creek	0.0%	na	100.0%	na
Broad Run/ Sugarland Run	0.0%	na	100.0%	na
Bull Run/Cub Run	0.0%	na	100.0%	na
Countywide	0.0%	na	100.0%	na

Table A-9. Percent of Stream Miles and Standard Error by pH category by PSU, Loudoun County Stream Assessment, 2009. Countywide results are also presented.

PSU	pH > 9	Standard Error	pH between 6.0 and 9.0	Standard Error	pH < 6	Standard Error
Dutchman Cr/ Piney Run/ Quarter Branch	0.0%	na	100.0%	na	0.0%	na
Direct to Potomac	9.1%	0.09	90.9%	0.09	0.0%	na
Catoctin Creek	21.4%	0.11	78.6%	0.11	0.0%	na
North Fork Catoctin Creek	0.0%	na	100.0%	na	0.0%	na
South Fork Catoctin Creek	0.0%	na	100.0%	na	0.0%	na
Clarks Run/ Limestone Branch	0.0%	na	100.0%	na	0.0%	na
North Fork Goose Creek	0.0%	na	100.0%	na	0.0%	na
Beaverdam Creek	0.0%	na	100.0%	na	0.0%	na
Upper Goose Creek	0.0%	na	100.0%	na	0.0%	na
Lower Goose Creek	0.0%	na	100.0%	na	0.0%	na
Broad Run/ Sugarland Run	0.0%	na	100.0%	na	0.0%	na
Bull Run/Cub Run	0.0%	na	100.0%	na	0.0%	na
Countywide	2.4%	0.01	97.6%	0.01	0.0%	na

APPENDIX B

OBSERVED

PROBLEM SITES

Table B-1. Problems identified at sites surveyed in the Loudoun County Stream Assessment, 2009

Station ID	Date	Channelization	Erosion	Inadequate Buffer	Fish Barrier	Exposed Pipe	Pipe Outfall	Trash Dumping	Near or Instream Construction	Unusual Condition
BEAV-111-R-2009	4/14/2009			X						
BEAV-112-H-2009	6/15/2009			X						
BEAV-113-H-2009	6/15/2009			X						
BEAV-116-H-2009	6/8/2009			X						
BEAV-116-R-2009	4/13/2009			X						
BEAV-117-H-2009	6/24/2009			X						
BEAV-118-H-2009	6/8/2009		X							
BEAV-215-R-2009	4/8/2009			X						
BEAV-220-R-2009	4/13/2009			X						
BEAV-226-H-2009	6/9/2009			X						
BEAV-227-H-2009	6/24/2009		X							
BEAV-305-H-2009	6/25/2009		X							
BEAV-310-H-2009	6/25/2009		X							
BROA-105-H-2009	6/1/2009				X					
BROA-115-H-2009	6/2/2009						X			
BROA-121-H-2009	6/2/2009	X								
BROA-121-R-2009	4/2/2009			X	X					
BROA-123-H-2009	6/8/2009									X
BROA-126-R-2009	4/2/2009				X					
BROA-136-H-2009	7/16/2009	X								
BROA-140-R-2009	4/7/2009			X						
BROA-142-R-2009	4/7/2009			X	X					
BROA-207-R-2009	4/2/2009	X	X	X						
BROA-209-H-2009	7/14/2009		X	X						
BROA-210-H-2009	7/14/2009		X							
BROA-239-H-2009	6/8/2009		X							
BROA-242-H-2009	7/14/2009									X
BROA-302-T-2009	5/28/2009		X	X						
BROA-334-R-2009	4/7/2009			X						X

Table B-1. (Continued)

Station ID	Date	Channelization	Erosion	Inadequate Buffer	Fish Barrier	Exposed Pipe	Pipe Outfall	Trash Dumping	Near or Instream Construction	Unusual Condition
BROA-403-T-2009	3/31/2009	X						X		
BULL-104-R-2009	4/7/2009			X						
BULL-105-H-2009	7/13/2009			X						
BULL-106-R-2009	4/1/2009			X						
BULL-108-H-2009	7/23/2009	X		X			X			
BULL-109-R-2009	4/2/2009	X								
BULL-301-R-2009	4/2/2009		X							X
CATO-105-R-2009	4/10/2009					X				
CATO-118-R-2009	4/16/2009	X								
CATO-123-H-2009	6/26/2009			X						
CATO-208-H-2009	6/9/2009			X						
CATO-210-R-2009	4/10/2009			X						
CATO-216-R-2009	4/16/2009					X				
CATO-224-H-2009	6/9/2009		X							
CATO-226-H-2009	7/24/2009		X							
CLAR-201-R-2009	4/9/2009		X							
CLAR-203-R-2009	4/9/2009			X						
CUBR-105-H-2009	6/11/2009	X					X			
CUBR-206-H-2009	6/26/2009			X						
DTPO-102-R-2009	4/10/2009	X		X	X					
DTPO-105-R-2009	4/9/2009	X								
DTPO-109-H-2009	6/11/2009					X				
DTPO-110-H-2009	7/24/2009		X	X						
DTPO-110-R-2009	4/10/2009		X							
DTPO-112-H-2009	6/26/2009	X	X					X	X	
DTPO-113-H-2009	6/25/2009			X						
DTPO-114-H-2009	6/26/2009		X		X					
DTPO-201-R-2009	4/8/2009		X	X				X		
DTPO-203-R-2009	4/8/2009			X				X		X

Table B-1. (Continued)

Station ID	Date	Channelization	Erosion	Inadequate Buffer	Fish Barrier	Exposed Pipe	Pipe Outfall	Trash Dumping	Near or Instream Construction	Unusual Condition
DTPO-205-H-2009	6/11/2009						X			
DTPO-206-H-2009	7/24/2009			X						
DTPO-215-H-2009	6/26/2009		X	X						
DUTC-105-H-2009	6/10/2009			X						
LIME-102-R-2009	4/10/2009	X	X	X						
LIME-103-H-2009	6/29/2009		X	X						
LIME-104-H-2009	6/10/2009			X						
LIME-206-H-2009	7/14/2009		X	X						
LIME-208-H-2009	6/29/2009		X							
LOGC-101-R-2009	4/14/2009		X	X						
LOGC-102-H-2009	6/10/2009		X	X						
LOGC-103-H-2009	6/2/2009	X		X			X			
LOGC-108-H-2009	6/4/2009	X		X					X	X
LOGC-111-H-2009	6/2/2009		X							
LOGC-115-H-2009	6/30/2009			X						
LOGC-121-H-2009	7/23/2009		X							
LOGC-135-H-2009	6/30/2009	X		X			X			
LOGC-136-R-2009	5/21/2009	X	X	X	X					
LOGC-137-R-2009	5/14/2009		X	X			X			
LOGC-140-H-2009	6/30/2009		X	X						
LOGC-142-R-2009	5/14/2009		X							
LOGC-143-R-2009	4/16/2009			X						
LOGC-148-H-2009	6/3/2009		X							
LOGC-104-H-2009	7/10/2009			X						
LOGC-209-H-2009	6/4/2009								X	
LOGC-213-H-2009	7/24/2009									X
LOGC-215-R-2009	4/14/2009			X						
LOGC-217-H-2009	6/4/2009		X	X						
LOGC-219-H-2009	6/17/2009		X	X						

Table B-1. (Continued)

Station ID	Date	Channelization	Erosion	Inadequate Buffer	Fish Barrier	Exposed Pipe	Pipe Outfall	Trash Dumping	Near or Instream Construction	Unusual Condition
LOGC-229-R-2009	5/6/2009	X								
LOGC-236-H-2009	6/30/2009		X	X						
LOGC-238-R-2009	5/26/2009		X							
LOGC-247-H-2009	6/3/2009		X							
LOGC-260-R-2009	5/14/2009		X	X						
LOGC-305-T-2009	4/7/2009			X			X			
LOGC-337-H-2009	6/3/2009		X							
LOGC-145-H-2009	6/3/2009		X	X						
LOGC-525-H-2009	7/15/2009			X						
LOGC-530-H-2009	7/15/2009		X							
LOGC-532-H-2009	6/9/2009		X							
LOGC-539-H-2009	7/15/2009		X							
NFCC-101-H-2009	6/12/2009		X							
NFCC-107-H-2009	6/12/2009		X							
NFCC-208-H-2009	6/12/2009			X						
NFCC-109-R-2009	5/12/2009			X						
NFCC-305-H-2009	6/29/2009	X		X						
NFCC-316-R-2009	5/12/2009			X						
NFCC-320-R-2009	5/12/2009		X	X						
NFGC-105-R-2009	4/13/2009									X
NFGC-109-R-2009	4/15/2009									X
NFGC-113-H-2009	7/8/2009			X						
NFGC-115-H-2009	5/28/2009			X						
NFGC-117-H-2009	5/27/2009	X	X	X						
NFGC-117-R-2009	5/5/2009			X						
NFGC-118-H-2009	5/27/2009		X	X						
NFGC-119-R-2009	5/5/2009				X			X		X
NFGC-120-H-2009	7/8/2009									
NFGC-134-H-2009	7/2/2009			X	X					X

Table B-1. (Continued)

Station ID	Date	Channelization	Erosion	Inadequate Buffer	Fish Barrier	Exposed Pipe	Pipe Outfall	Trash Dumping	Near or Instream Construction	Unusual Condition
NFGC-137-H-2009	5/27/2009		X							
NFGC-213-R-2009	4/15/2009			X						
NFGC-218-R-2009	5/5/2009		X	X						
NFGC-219-H-2009	7/2/2009		X	X						
NFGC-220-R-2009	5/5/2009		X							
NFGC-327-H-2009	5/28/2009		X							
NFGC-328-H-2009	5/28/2009		X	X						
NFGC-329-H-2009	7/10/2009		X	X						
NFGC-331-H-2009	5/28/2009		X	X						
NFGC-336-H-2009	7/7/2009		X	X						
NFGC-430-H-2009	7/10/2009		X	X						
NFGC-433-H-2009	5/28/2009		X	X						
PINE-107-H-2009	6/10/2009			X						
QUTR-102-H-2009	7/6/2009		X							
SFCC-101-R-2009	5/8/2009	X								
SFCC-102-H-2009	7/14/2009		X	X						
SFCC-107-H-2009	7/9/2009				X					
SFCC-114-R-2009	5/8/2009	X								
SFCC-115-H-2009	5/27/2009			X						
SFCC-116-H-2009	5/26/2009			X						
SFCC-203-H-2009	7/6/2009									X
SFCC-213-R-2009	5/11/2009			X						
SFCC-214-T-2009	5/26/2009		X	X						
SFCC-301-H-2009	7/8/2009			X						
SFCC-308-H-2009	7/6/2009		X	X						
SFCC-310-R-2009	5/11/2009		X							
SFCC-311-H-2009	7/24/2009		X							
SUGA-201-H-2009	6/17/2009		X							X
SUGA-201-R-2009	4/8/2009	X	X	X						

Table B-1. (Continued)

Station ID	Date	Channelization	Erosion	Inadequate Buffer	Fish Barrier	Exposed Pipe	Pipe Outfall	Trash Dumping	Near or Instream Construction	Unusual Condition
SUGA-202-H-2009	6/12/2009		X							
SUGA-202-R-2009	4/8/2009		X							X
UPGC-101-H-2009	5/28/2009		X							
UPGC-101-R-2009	5/7/2009			X						
UPGC-104-R-2009	5/7/2009			X						
UPGC-108-H-2009	6/3/2009		X							
UPGC-110-R-2009	5/6/2009		X							
UPGC-114-H-2009	7/23/2009			X						
UPGC-115-R-2009	5/7/2009		X	X						
UPGC-119-R-2009	5/6/2009		X							
UPGC-120-R-2009	5/11/2009		X							
UPGC-123-R-2009	5/21/2009				X					
UPGC-125-R-2009	5/7/2009		X							
UPGC-136-R-2009	5/21/2009		X							
UPGC-206-T-2009	3/31/2009	X		X		X			X	
UPGC-207-R-2009	5/13/2009		X							
UPGC-217-R-2009	5/13/2009		X							
UPGC-221-R-2009	5/13/2009		X							
UPGC-227-H-2009	7/7/2009		X	X						
UPGC-302-R-2009	5/11/2009		X							
UPGC-405-R-2009	5/11/2009		X							
UPGC-409-R-2009	5/13/2009		X							
UPGC-409-T-2009	3/30/2009					X				
UPGC-414-R-2009	5/11/2009			X						X
UPGC-416-H-2009	7/14/2009		X	X						