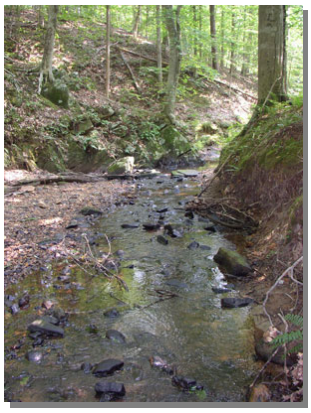
2 Monitoring and Sampling Methods

The fundamental principle of ecology is that everything is interrelated within an ecosystem. This principle is especially important when determining the health of a stream because the composition of the biological communities, chemistry of the water, and characteristics of the surrounding environment must all be considered. Bioassessments (evaluating biological communities to indicate overall ecosystem health) are used in concert with abiotic assessments such as habitat quality, water chemistry and contributing watershed characterizations, to reveal the overall picture of water quality and watershed health. Fairfax County's monitoring methodologies are modifications of the Environmental Protection Agency's Rapid Bioassessment Protocols (RBP) (Barbour et al. 1999). These monitoring methods and site selection criteria are fully detailed in Stormwater Planning Division's Standard Operating Procedures Manual for the Biological Stream Monitoring Program. This can be found online at:



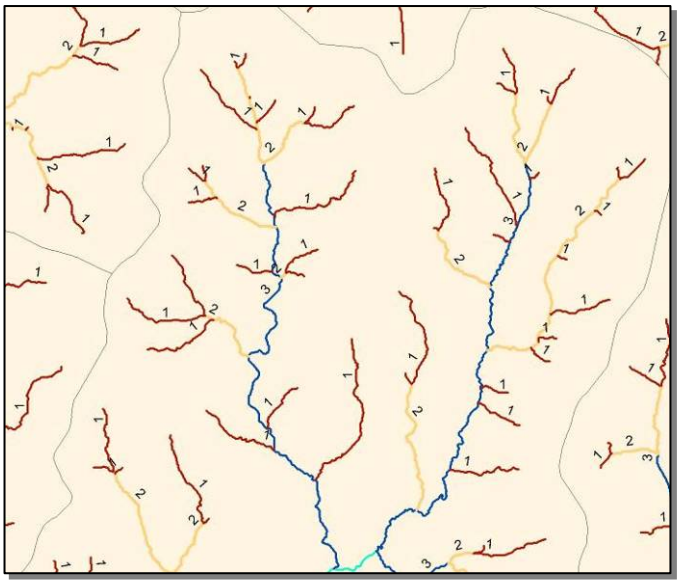
A typical piedmont stream

http://www.fairfaxcounty.gov/dpwes/stormwater/streams/assessment.htm

2.1 Site Selection

Fairfax County's monitoring sites are randomly selected using a probability-based stratification model, otherwise known as a stratified random approach, which employs two primary steps. First, streams are grouped into like classes called "strata" so that similar environments are directly compared. Secondly, sampling sites are randomly selected within each of these strata. This commonly-used approach, which also is employed by VDEQ, eliminates any site selection bias and is an accurate and cost-effective way to derive statistically defensible determinations of stream conditions on a countywide scale.

A "sampling frame" is the set of all potential sampling locations and is created using a synthetic stream layer derived from the county's Digital Elevation Model (DEM) using Geographic Information Systems (GIS). This highly accurate layer is used to stratify all streams into segments of varying lengths based on their Strahler stream order (Strahler, 1952). Stream orders range from the numerous small first order headwaters tributaries to the larger fifth order



Example of an ordered stream network in Fairfax County.

channels such as the main stem of Difficult Run. Streams with drainage areas less than 50 acres are assumed not to sustain perennial streamflow and thus are not included in the sample frame.

A two-stage site selection technique is used. Within each stratum (group of all streams of the same order), a stream segment is first selected at random. Next, a 100-meter sampling location is randomly selected within this segment, then field checked to ensure access and minimum site requirements are met. Sample reaches are allocated in a proportional manner according to the total stream length in each stratum (Table 1). In 2005, forty site locations from five strata were selected for the annual sampling campaign. A map depicting the locations of the 40 randomly-selected sites is shown in Figure 3.

Table 1: Distribution of 40 sample sites across 5 strata.

Stream Order	Total Length (miles)	Percentage of Total (%)	Number of Sampling Locations in the County
1	526.5	52.9	20
2	221.8	22.3	9
3	144.1	14.5	6
4	85.4	8.6	4
5	17.0	1.7	1

Pohick Creek – 4th Order Stream.

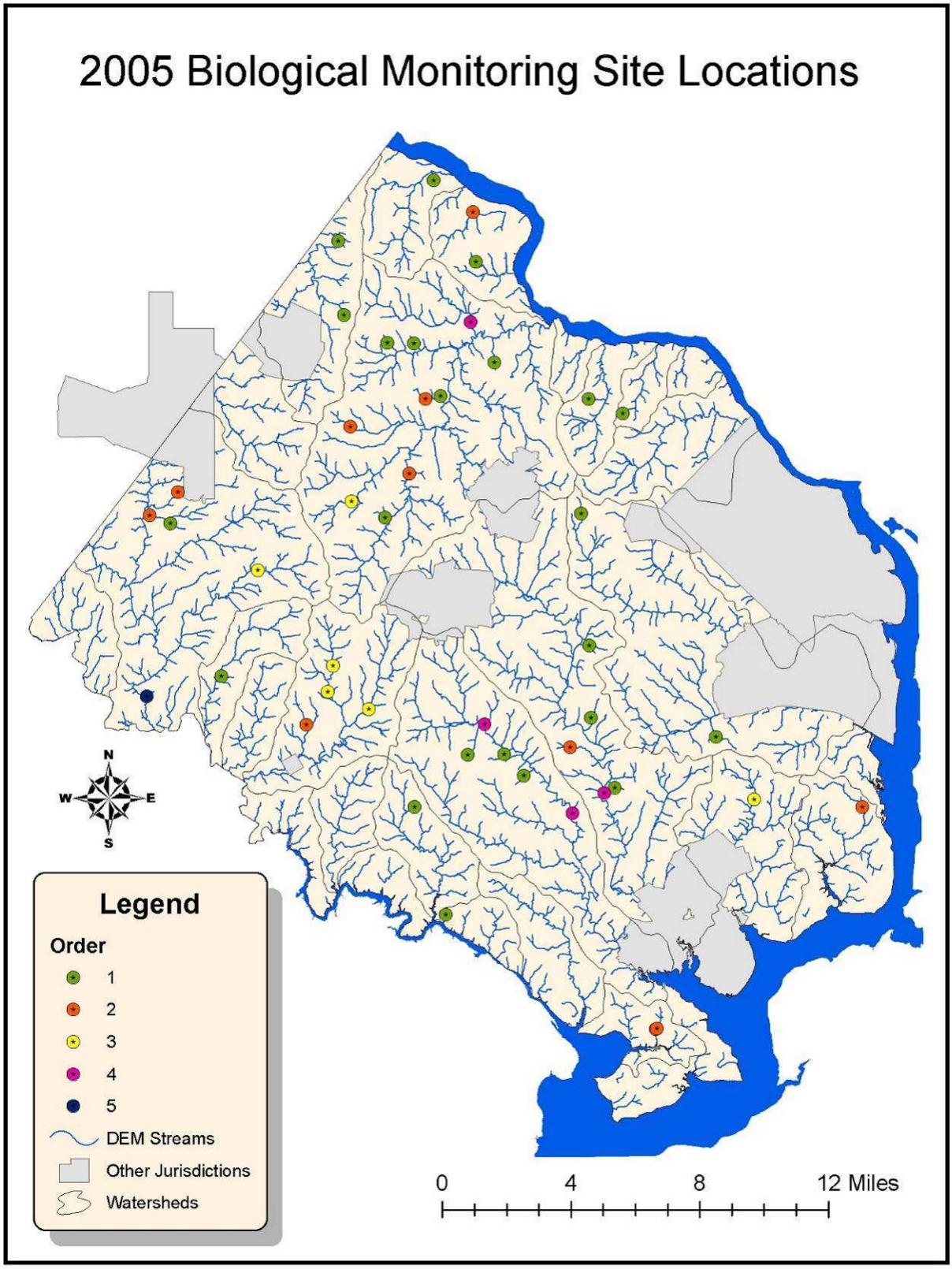


Figure 3: Locations of randomly-selected monitoring sites (biological and bacteriological) for 2005 sample year.

2.2 Bacteria and Water Chemistry

Escherichia coli (*E. coli*) is a type of bacteria commonly used as a water quality indicator because it is found in the intestines and waste of warm blooded animals. Alone, this bacterium in surface waters is generally not harmful to humans, and may exhibit broad natural variability in abundance. However, it may indicate the possible presence of pathogenic (disease-causing) bacteria and viruses. The level of *E. coli* in streams is used by localities to determine if primary recreational contact, such as swimming, fishing and boating, is safe in local and state waterways.

Collecting water samples

To determine the concentration of *E. coli* in streams and to continually screen for possible sewage contaminations, bacteria sampling is conducted at the randomly-selected biological monitoring locations throughout the county. Grab samples of stream water are collected twice each season, starting in the spring. Water chemistry parameters also are measured including nitrate and total phosphorous concentrations, pH, specific conductance, dissolved oxygen along with water temperature. The sampling program was initiated in 1969 by the Fairfax County Health Department (then known as the Department of Health's Division of Environmental Health) to monitor the water quality of the streams in the county. The Stormwater Planning Division assumed the program 2003 in an effort to consolidate stream sampling efforts.

E. coli, nitrate and total phosphorous samples are processed at the Fairfax County Health Department Laboratory, using the Colilert® Quanti Tray/2000 by Idexx and Skalar San++ Analyzer, respectively. The remaining chemical parameters are recorded in the field using a hand-held YSI meter.

2.3 Benthic Macroinvertebrates

Benthic macroinvertebrates are aquatic organisms found living on the bottom of the streambed (benthic), are visible without the use of a microscope (macro), and do not have a backbone (invertebrate). Benthic macroinvertebrates include aquatic snails, water mites, worms, leeches, crustaceans, and insects. In fact, the majority of them are aquatic insects or the larval forms of many common terrestrial insects such as black flies, mayflies, dragonflies, crane flies, stoneflies, beetles, waterbugs, and others.

A stonefly larvae

Benthic macroinvertebrates are diverse organisms with varying tolerances for toxic, nutrient, and sediment pollution, making them well suited as indicators for determining stream health and water quality. The benthic macroinvertebrates also play a critical role in the aquatic food web, by forming the core diet of many stream fishes and amphibians, as well as playing an essential role in many stream functions and processes. As

such, they are excellent indicators of the health and integrity of the stream ecosystem and can help reveal specific stressors on the system (if present).

Benthic samples are collected every spring, between mid-March and mid-April, using the "20-jab" multi-habitat sampling technique. This method involves taking 20 separate "jabs" or collections from different habitat types, such as: undercut banks, aquatic vegetation, riffles and snags. Preserved samples are taken to a county laboratory where the macroinvertebrates are separated from vegetative and inorganic debris and identified to the genus taxonomic level with the aid of microscopes.

Collecting a benthic sample using the 20-Jab method

A multi-metric index is used to categorize the condition of the benthic community. This index employs the numerical combination of several individual metrics based on the tolerance, community composition, habit type, and trophic (feeding) structure of the sample. Each metric is scored and then combined into the overall index score called the Index of Biotic Integrity (IBI). Separate indices are used for the Piedmont samples and Coastal Plain samples, as the benthic communities found in each region are markedly different. The Coastal Plain index consists of five separate metrics, while the Piedmont index is composed of ten metrics. The ultimate ratings compare sites to a reference or “least disturbed” condition which then allows them to be categorized as “excellent,” “good,” “fair,” “poor” and “very poor”. Details on the index can be found in the Fairfax County Stream Protection Strategy Baseline Study Appendix or the current Standard Operating Procedures manual (see section 6).

2.4 Fish Community

A balanced and diverse fish community is indicative of good stream health.

Collecting a fish sample using the electro-fisher (upper right)

Fish are very sensitive to both natural and human-induced changes within a given stream system and its surrounding watershed.

A backpack electro-fisher unit is used to send electricity into the water, stunning the fish momentarily, allowing for easy collection with a net. Once collected, the fish are identified to the species taxonomic level, counted to track their respective populations within each sampled reach, then released. Any unusual appearance or anomalies on the fish, such as fin and eye deformations, hemorrhages, parasites and/or tumors also are recorded. The fish are then released back into the water.

A multi-metric index called the Fish Index of Biotic Integrity (F-IBI) is used to categorize the condition of the fish community for each site. This index employs the numerical combination

of several individual metrics based on the tolerance, trophic (feeding) structure, or diversity of the sample. Each metric is scored and then combined into the overall index score. Separate indices are used for the Piedmont samples and Coastal Plain samples, as the fish communities found in each region are markedly different. The Coastal Plain index consists of five separate metrics, while the Piedmont index is composed of 10 metrics. The ultimate ratings compare sites to a reference or "least disturbed" condition which then allows them to be categorized as "excellent", "good", "fair," "poor" and "very poor." Details on the index can be found in the 2005 Annual Report on Fairfax County's Streams and in the Standard Operating Procedures manual (see references section).

2.5 Volunteer Monitoring

Two volunteer stream monitoring programs are coordinated independently by the Audubon Naturalist Society (ANS) and Northern Virginia Soil and Water Conservation District (NVSWCD). Volunteers monitor targeted stream sites for habitat quality, water chemistry and benthic macroinvertebrate community composition, usually once each season.

Volunteer monitors inspecting a kick-net seine sample

Benthic macroinvertebrate samples are collected using kick-net sampling techniques, in riffle and pool habitats. Samples are processed in the field and benthic macroinvertebrates are identified to the order (NVSWCD) and family (ANS) taxonomic levels.

Turbidity and nitrate/nitrite water quality parameters are measured at the time of the sample. The physical condition of the stream is also visually assessed for substrate composition, embeddedness, turbidity, bank cover, canopy cover and other features.

Volunteer data is being used to supplement county collected data in evaluating general trends and identifying areas in need of more monitoring. In working together with volunteer monitoring organizations, such as ANS and NVSWCD, the county effectively doubles the number of sites it monitors in a given year. Although these taxonomic identifications are not as high resolution as the county's, they greatly augment the stream monitoring efforts of the county. Volunteer data is collected and evaluated using the modified Virginia Save Our Streams (VASOS) protocols (see references) and rated "acceptable" or "unacceptable." The rating of acceptable corresponds well with the county's "excellent" and "good" ratings, while the "unacceptable" generally corresponds to the county's ratings of "fair," "poor" and "very poor".

2.6 Project Specific Monitoring

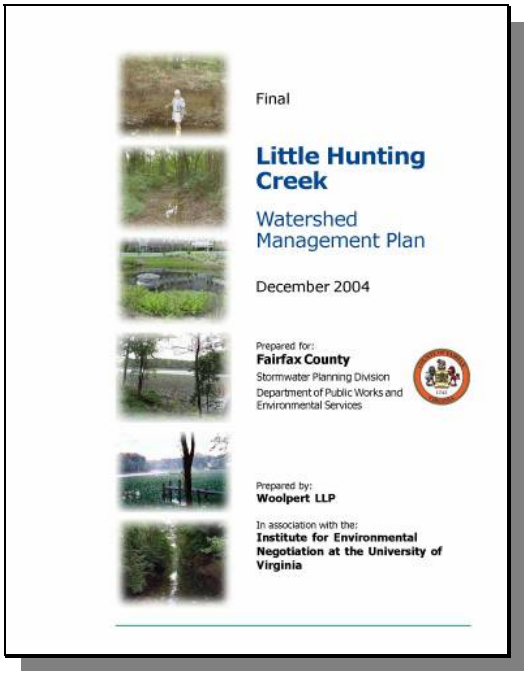
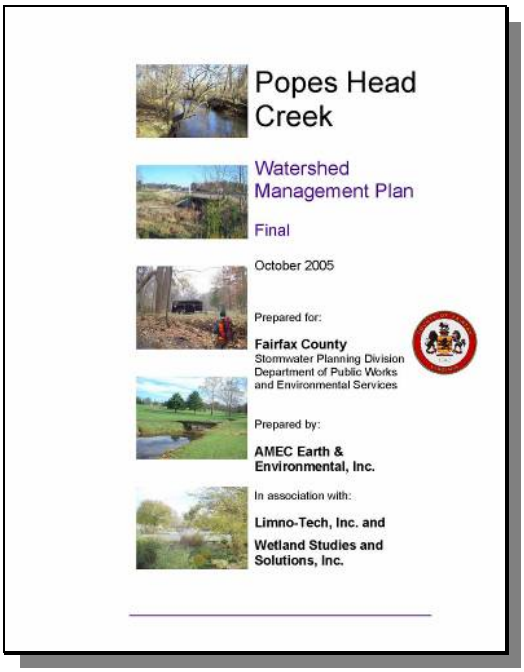
Currently the Stormwater Planning Division is completing stream restoration designs for Poplar Springs Court (Burke), Runnymeade subdivision (Franconia), and Bridle Path Lane (McLean). Last year, benthic macroinvertebrate samples were taken at each of these sites in Pohick Creek, Cameron Run, and Scotts Run, respectively. All three of

the sites were rated as “very poor”, because the samples collected did not even yield the minimum number of organisms required to conduct the analysis. Samples will continue to be taken after restoration activities are completed in order to evaluate the effectiveness of the projects and to assess how quickly biological communities recover.

The Kingstowne stream restoration project was a joint effort completed by Fairfax County, Northern Virginia Soil and Water Conservation District, Natural Resource Conservation Service, Citizens Alliance to Save Huntley, and Friends of Huntley Meadows Park. Construction was completed on the project in 1999. Since that time, volunteers have taken macroinvertebrate samples in the restored section. In a sample taken one year after the completion of construction, one midge larvae and one worm were found. This gave the reach a score of “unacceptable.” Three samples were taken in 2005 and more organisms were found, including crayfish, mayflies, dragonflies, damselflies and caddisflies. In January 2006, the restored reach was again sampled by volunteers and it scored “acceptable” for the first time. It is anticipated that projects increasingly will be monitored before and after construction to evaluate the effectiveness of the project, in hopes that other stream restoration projects will yield results similar to the Kingstowne stream. It should be noted that this positive response in the aquatic community took 7 years, which is not an atypical response time.

Kingstowne stream before restoration

Kingstowne stream after restoration

Project sites that are being evaluated for sampling in 2006 include: Hope Park Road floodplain/stream restoration and Mount Vernon National Park stream restoration, in the Popes Head Creek and Little Hunting Creek watersheds, respectively. These projects were identified in their respective watershed management plans. More restoration opportunities will be identified as watershed management plans are completed for the remaining watersheds in Fairfax County. It is envisioned that as more restoration efforts are undertaken, the habitat and, ultimately, the biological communities of these localized

stream segments may be afforded the ability to rebound from their impacted states. Annual Biological monitoring at selected project sites will continue to be used to document changes.