SECTION 1

Introduction

Fairfax County has recently completed a number of studies and projects related to watershed protection and restoration. These include the Stream Protection Strategy (SPS) program, a wetlands assessment and monitoring program, a perennial streams mapping project, and the development of comprehensive management plans for the County's watersheds. The SPS program is an ongoing biological monitoring effort with the overall goal of identifying and assessing trends in stream conditions County-wide. The baseline SPS study, completed in January 2001, documented current conditions throughout the County's streams on the basis of biological indicators and provided a foundation for prioritizing and implementing sound watershed management strategies.

The Stream Assessment/Watershed Management Program is being implemented with the overall goal of providing a consistent basis for protecting and restoring the receiving water systems and other natural resources in the County. The data collected from the first phase of this project, a comprehensive assessment of stream physical conditions County-wide, will allow the County a better understanding of each watershed and its stream network. The data from the stream physical assessment will be integrated with the County's land use goals to anticipate and mitigate stormwater impacts.

1.1 Background

Fairfax County is located in the northeastern part of the state of Virginia, bordering the Potomac River. The County is bordered to the east by Arlington County, and the Cities of Falls Church and Alexandria. The Potomac River borders the County to the northeast and southeast. To the northwest and southwest, lie Loudoun and Prince William County, respectively. Within the borders of Fairfax County are three incorporated towns (Vienna, Herndon, and Clifton) and one city (Fairfax City). A map of the County and neighboring jurisdictions is shown in Figure 1-1.

Fairfax County was completely rural until World War II, with dairy farming being the most important single industry. Today it is highly urbanized and approaching ultimate build-out conditions, as envisioned in the County's Comprehensive Plan. The total land area of Fairfax County, including incorporated towns is 395 mi^2. It is the most populous jurisdiction in Virginia as well as the Washington D.C. metropolitan area. The current (2003) population is estimated to be 1,015,600 with 369,900 households. Most land in the county is devoted to residential, commercial, recreational, and open-land uses, with heavy industry essentially nonexistent.

There are two major physiographic provinces in the County, with the boundary between them generally approximated by Interstate 95. The Coastal Plain province lies to the east has relatively gentle topography and consists of unconsolidated strata deposited by ancient rivers and oceans. The Piedmont Upland province lies to the west, and consists of rolling hills underlain by metamorphic rocks. A sub-region of the Piedmont Upland province, the

Triassic Basin (also called the Piedmont Lowland) is located in the southwest corner of the county, and consists of areas of somewhat lower relief underlain by sedimentary rocks. The County has 30 designated watersheds (Figure 1-1). The southwestern part of the County drains into the Occoquan River. Except for two watersheds (Sugarland Run and Horsepen Creek) that drain into Loudoun County, the northern and southeastern parts of the county drain to the Potomac River.

During the early years of development in Fairfax County, the emphasis on storm water management was on conveyance and channelization. Major flood plains were delineated and flood control projects implemented. Starting in 1972, on-site detention control was required for all new development. In the early 1980's, water quality Best Management Practices (BMPs) were required for new development in the southern areas of the county draining to the Occoquan reservoir, a major source of drinking water for the County.[1] BMPs were required for new development throughout the county in 1993. The County generally encourages opportunities to retrofit existing older storm water devices that were designed for flood control.

In the late 1970s, master drainage plans were prepared for all watersheds in Fairfax County. This included the delineation of boundaries for 29 watersheds,[2] and the development of a masterplan for each watershed that consisted of an immediate action plan and a future plan. The immediate action plans described the physical improvements required to solve existing problems including flooding, erosion, sedimentation, and other environmental problems. These plans included various least-cost solutions to the problems identified. The future plans described improvements for problems that were predicted to occur through the year 2000. The cost of these improvements has been the basis for the pro-rata cost sharing system used by the County to allocate costs for watershed improvements to be borne by private developers. The County's Capital Improvement Program was also developed on the basis of these costs.

In 1989, the County adopted a Regional Stormwater Management Plan (RSMP), which proposed regional ponds in the most rapidly developing watersheds in the county. The adoption of this plan marked a shift in Fairfax County's approach to implementing stormwater management from onsite controls to regional controls. In general, facilities in the RSMP are designed to provide water quantity and quality control for areas of between 100 to 300 acres. Since the adoption of the RSMP, it has been the County's objective to implement regional stormwater management ponds wherever opportunities exist. In January, 2002, a multiagency committee recommended that regional ponds should not be considered the preferred alternative, but just one of many tools considered for stormwater management.[3]

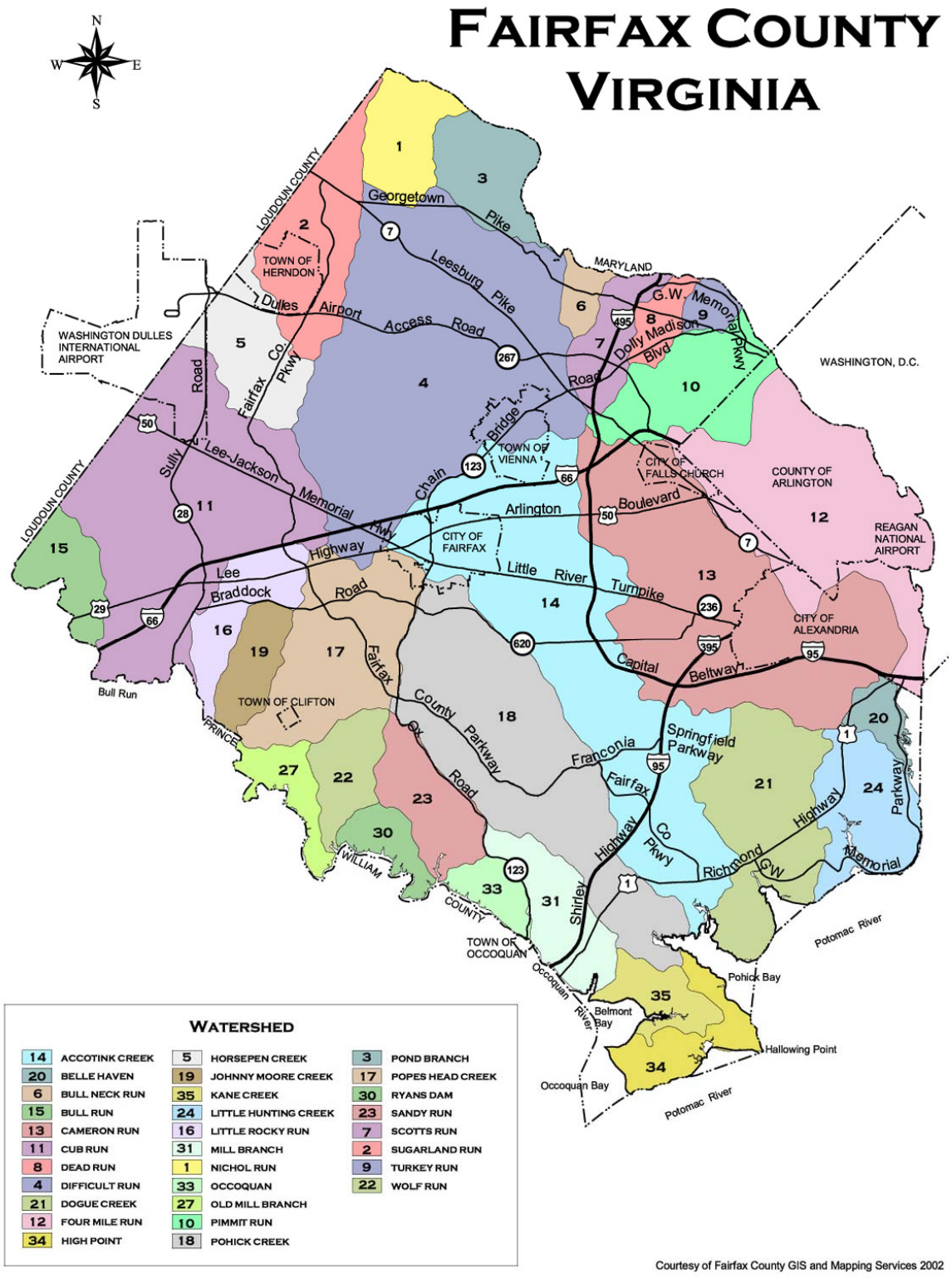
---

[1] In 1982, the Fairfax County Board of Supervisors decided to downzone 41,000 acres of the Occoquan Watershed in the County, and limit development to 5-acre lots. The decision was upheld in a landmark court decision in 1985. As part of the downzoning, the entirety of the Occoquan watershed in Fairfax County (excluding the Town of Clifton) was designated as the Water Supply Overlay District (WSPOD) where BMPs were required for all development.

[2] Excluding the Four Mile Run watershed.

[3] The committee's report on regional ponds as a watershed management tool can be downloaded at: http://www.fairfaxcounty .gov/dpwes/watersheds/ponds.htm.

FIGURE 1-1 Fairfax County Jurisdictional Boundaries and Designated Watersheds



Recently, Fairfax County has embarked upon a number of significant studies and projects related to watershed protection and restoration. These include the Stream Protection Strategy (SPS) program, a wetlands assessment program, a perennial streams mapping project, and the development of comprehensive management plans for the County's watersheds.

Fairfax County's Stream Protection Strategy (SPS) program is an ongoing biological monitoring effort with the overall goal of identifying and assessing trends in stream conditions countywide. The baseline SPS study, completed in January 2001, documented current conditions throughout the county's streams based on biological indicators, and provided a foundation for prioritizing and implementing sound watershed management strategies.

A three-year study to inventory existing wetland resources and characterize wetland response to degrees of urbanization was in initiated in August 2000 by the County in partnership with George Mason University. The study will also examine the function, usefulness, and sustainability of wetlands in stormwater management and provide critical information on wetland management in urban watersheds.

In September 2001, the County initiated a major effort to update its base stream map of all perennial and intermittent streams. In addition to the identification and mapping of perennial streams, this project inventoried physical and ecological conditions in headwater streams, and reevaluated the County's resource protection areas (RPAs) designated under the Chesapeake Bay Preservation Ordinance (CBPO), Chapter 118 of the Fairfax County Code. Updated RPA maps were adopted by the Fairfax County Board of Supervisors in November 2003.

In December 2001, the County embarked on a significant effort to develop watershed management plans for the 30 designated watersheds within the County over a proposed 5-7 year period. The overall goal for the development of watershed management plans is to provide a consistent basis for the evaluation and implementation of solutions for protecting and restoring the receiving water systems and other natural resources of the County. Under the first phase of this project, initiated in August 2002, an assessment of the physical condition of the County's estimated 800 stream miles was conducted. Habitat and geomorphic conditions were visually evaluated and scored. In addition, stormwater infrastructure such as road culverts and stormwater outfalls were inventoried and assessed. The data, including an extensive photo record, were integrated into a Geographic Information System (GIS) to allow watershed planners to visualize stream conditions and assist them in making sound management decisions for stream protection and restoration.

1.2 Purpose for a Stream Physical Assessment

The protocols presented in this document were followed to conduct the stream physical assessment. The purpose of the assessment was to collect information on and document the following:

- Habitat conditions (habitat assessment)
- Impacts on the stream from specific infrastructure and problem areas (infrastructure inventory)

- General stream characteristics
- Geomorphic classification of stream type

A baseline assessment was conducted on approximately 801 miles of streams throughout the county. The assessment results will be incorporated into the watershed planning process to determine appropriate management strategies. Although this project does not specifically address watershed management planning, its results will tie directly into the County's watershed planning process.

SECTION 2

Stream Assessment Methods

This section summarizes the methods used to perform the stream assessments. The stream assessments were performed in all County watersheds for a total of approximately 801 stream miles.

In addition to following the protocols, the stream assessments were conducted with input from County staff and watershed consultants in August and September 2002. The protocols were presented and field tested on August 12 and 14 and subsequently revised on the basis of further County input and field tests in early October 2002. County-wide stream assessments and stream feature inventories were then conducted between October 2002 and February 2003. Supplemental stream assessments for the Pimmit Run and Accotink Creek watersheds were completed in February 2005. Through the field assessments, baseline conditions of the stream habitats were established. These habitat conditions are a measure of stream integrity from which watershed conditions can be inferred.

2.1 Protocols

2.1.1 Habitat Assessment

The habitat assessment protocols and metrics presented here were used on several watershed management projects in ecoregions of the Piedmont and Coastal Plain provinces for documenting the stream physical conditions. The protocols used on these projects were adapted from existing sources, tested and documented in the scientific literature, and recommended by the U.S. Environmental Protection Agency (USEPA). Appendix A contains a discussion summarizing how "visually based" stream habitat assessment protocols were selected and adapted for the watershedwide management programs.

2.1.1.1 Habitat Assessment Metrics

An evaluation of habitat quality is critical to any assessment of ecological integrity. The habitat quality evaluation is accomplished by characterizing selected physical parameters that represent stream conditions. Metrics for the visual based approach depend on several conditions to accurately assess the quality of the physical habitat structure:

- The metrics selected to represent the various features of habitat structure need to be relevant and clearly defined
- The metrics must be sensitive to a continuum of conditions from the optimum to the poorest
- The judgement criteria for the attributes of each parameter should minimize subjectivity through quantitative measurements or specific categorical choices

Table 2-1 lists metrics cited in the literature and adopted by many states and environmental groups, including the USEPA, to conduct "visually based" stream and riparian zone

assessments for their biological and aquatic quality monitoring programs. Several of these metrics were tested and evaluated in the development of watershedwide assessment protocols for several municipalities in Virginia and the southeast. The table describes each metric and its relevance to instream aquatic integrity.

TABLE 2-1
Habitat Assessment Metrics
Fairfax County Stream Physical Assessment

Metric	Description	Comment
Epifaunal substrate/available cover	Includes the relative quantity and variety of natural structures in streams such as cobble, large rocks, fallen trees, logs and branches, feeding, or sites for spawning and nursery functions of aquatic macrofauna.	High- and low-gradient streams. Variability occurs when percent area coverage is misinterpreted.
Embeddedness	Extent to which rocks (gravel, cobbles, and boulders) are sunk into the silt, sand, or mud of the stream bottom.	High-gradient streams. It may also be useful to lift a few rocks in riffle areas and observe the extent of the dark area on their underside. Observations should be taken in the upstream and central portions of riffles (i.e., run).
Pool substrate characterization	Type and condition of bottom substrates found in pools. Firmer sediments and rooted aquatic plants support a wider variety of organisms than a pool substrate dominated by mud or bedrock and no plants.	Low-gradient streams. Requires visual inspection of pool substrate.
Velocity depth combinations	Patterns of velocity and depth combinations: • slow-deep • slow-shallow • fast-deep • fast-shallow	High-gradient streams. Guidelines are 0.5-m depth to separate shallow from deep and 0.3 m to separate fast from slow. Guidelines may not be sensitive enough to discriminate between large- and small-stream systems.
Pool variability	Rating of overall mixture of pool types according to size and depth. In rivers with low sinuosity (few bends) and monotonous pool characteristics, very little instream habitat variety exists to support a diverse community. The four basic types of pools: • large-shallow • large-deep • small-shallow • small-deep	Low-gradient streams. Any pool dimension (e.g., length, width) greater than half the cross-section of the stream is a large pool. Small pools have lengths and widths less than half the width of the stream. Pools with depths greater than 1.0 m are deep. Shallow pools are less than 1.0 m deep. Guidelines may not be sensitive enough to discriminate between large- and small-stream systems.
Sediment deposition	Amount of sediment that has accumulated and the changes that have occurred to the stream bottom as a result of deposition. Sediment deposition may cause the formation of islands, point bars (areas of increased deposition usually at the beginning of a meander that increase in size as the channel is diverted toward the outer bank) or shoals, or result in the filling of pools.	High- and low-gradient streams. Estimation of growth of point bars requires visual determination of their stability (e.g., presence of vegetation).

TABLE 2-1
Habitat Assessment Metrics
Fairfax County Stream Physical Assessment

Metric	Description	Comment
Channel flow status	The degree to which the channel is filled with water during normal-flow periods. Flow status changes as the channel enlarges. Useful for interpreting biological condition during abnormal- or lowered-flow conditions.	High- and low-gradient streams. This is a seasonal parameter. A decrease in water will wet smaller portions of the streambed, thus decreasing available habitat for aquatic organisms. Observers use the toe of slope and vegetation line on the lower bank as reference point to estimate channel flow status. Variability occurs if stream is a C type or a C type forming in an F channel.
Channel alteration	Measurement of large-scale alteration of instream habitat, which affects stream biotic integrity and causes scouring. Channel alteration is present when, among other possible changes, • artificial embankments, riprap, and other forms of artificial bank stabilization or structures are present • dredging has altered bank stability • dams and bridges are present • banks and channels have been disturbed by livestock or agricultural practices or hydrology	High- and-low gradient streams. Variability occurs when discriminating between natural conditions and induced by development or other human use.
Frequency of riffles	Measure of sequence of riffles and the heterogeneity occurring in a stream. A riffle/run (i.e., distanced between riffles divided by width of stream) ratio is use to as a measure of heterogeneity.	High-gradient streams. Observers must estimate distance between riffles. For high gradient streams were riffles are uncommon, a run/bend rations is used.
Channel sinuosity	Evaluates the meandering or sinuosity of the stream.	Low-gradient streams. Run/bend ratio may not necessarily provide an accurate measurement. Stream length divided by valley length requires map measurements.
Bank stability	Measures the existence of or the potential for detachment of soil from the upper and lower stream banks and its movement into the stream. 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. Reinforcement of banks via rocks, artificial or natural, provides stability.	High- and low-gradient streams. Observers must evaluate bank soil condition, slope, shape, root mat density, etc.

TABLE 2-1
Habitat Assessment Metrics
Fairfax County Stream Physical Assessment

Metric	Description	Comment
Bank vegetative protection	Measures the amount of the stream bank that is covered by vegetation. This parameter supplies information on the ability of the bank to resist erosion. Banks that have full, natural plant growth are better for fish and macroinvertebrates than those without vegetation protection and those shored up with concrete or riprap.	High- and low-gradient streams. Observers must consider the following when scoring vegetative protection: • Is the vegetation native and natural or planted and introduced? • Are the upper story, under story, and ground cover vegetation well balanced? • What is the standing crop biomass? • During which season is this assessment being conducted?
Vegetation buffer zone width	Measures the width and conditions of the vegetation or land use from the edge of the upper stream bank through, and in some cases beyond, the flood plain and riparian zone. The vegetative zone is a buffer to pollutants entering a stream from runoff and minimizes erosion.	High- and low-gradient streams. Observers must walk in the buffer area, paying close attention to the amount of natural vegetation present and how deep it extends from the bank and to disturbances that may effect the transport of pollutants through the zone. Vegetated buffer zone assessment involves documenting three conditions: • vegetation cover type • breaks • vegetated zone width
Canopy cover	Measures the amount of cover overhead that provides shading and cooling of the water.	High- and low-gradient streams. Assessment involves vegetation cover type and density of leaf material. Metric is sensitive to season and size of stream.
Aesthetics	Measures the perception of what constitutes desirable surface water and aquatic integrity.	High- and low-gradient streams. Highly subjective and does not necessarily relate to the ability of a stream to support aquatic life.
Riffle/run depth	Measures conditions for fish habitat and refuge.	High- and low-gradient streams. Established pool or riffle depths may not be sensitive to discriminate between large and small stream systems.

The habitat assessment metrics were evaluated for their sensitivity to accurately measure and document the conditions and represent the stream and riparian features (see Appendix A). Overall, the metrics evaluated responded to the expected field conditions and support watershed-management decisions. The selected metrics are listed in Table 2-2 for glide/pool (low gradient) and riffle/run (high gradient) streams. A detailed discussion of the metrics can be found in Appendix A.

The County decided to apply only the riffle/run set of metrics to the Piedmont and Triassic physiographic provinces and the glide/pool (low-gradient) metrics to the coastal plain physiographic province. The watersheds located within each physiographic province are listed in Table 2-3. As shown in the table several watersheds extend into two physiographic provinces.

TABLE 2-2
Selected Habitat Assessment Metrics
Fairfax County Stream Physical Assessment

Glide/Pool	Riffle/Run
Instream Habitat	
Bottom substrate/available cover	Instream cover
Pool substrate characterization	Epifaunal substrate
Pool variability	Embeddedness in run areas
Channel Morphology	
Channel/bank alteration	Channel/bank alteration
Channel sinuosity	Frequency of riffles
Sediment deposition	Sediment deposition
Channel flow status	Channel flow status
Riparian and Bank Structure	
Bank vegetative protection	Bank vegetative protection
Bank stability	Bank stability
Vegetation buffer zone width	Vegetation buffer zone width

The stream assessments were performed with forms and instructions developed during the protocol development phase and updated on the basis of feedback from the accuracy and precision evaluation, which is summarized below. The updates involved mostly moving fields on the forms and adding additional explanations about scoring criteria. The field forms are in Attachments to Appendix A.

The field teams were also provided with field notebooks that included the forms, instructions, maps, and pictures representing scoring criteria. The instructions also included a Health and Safety Plan and a Quality Assurance Project Plan (QAPP).[4]

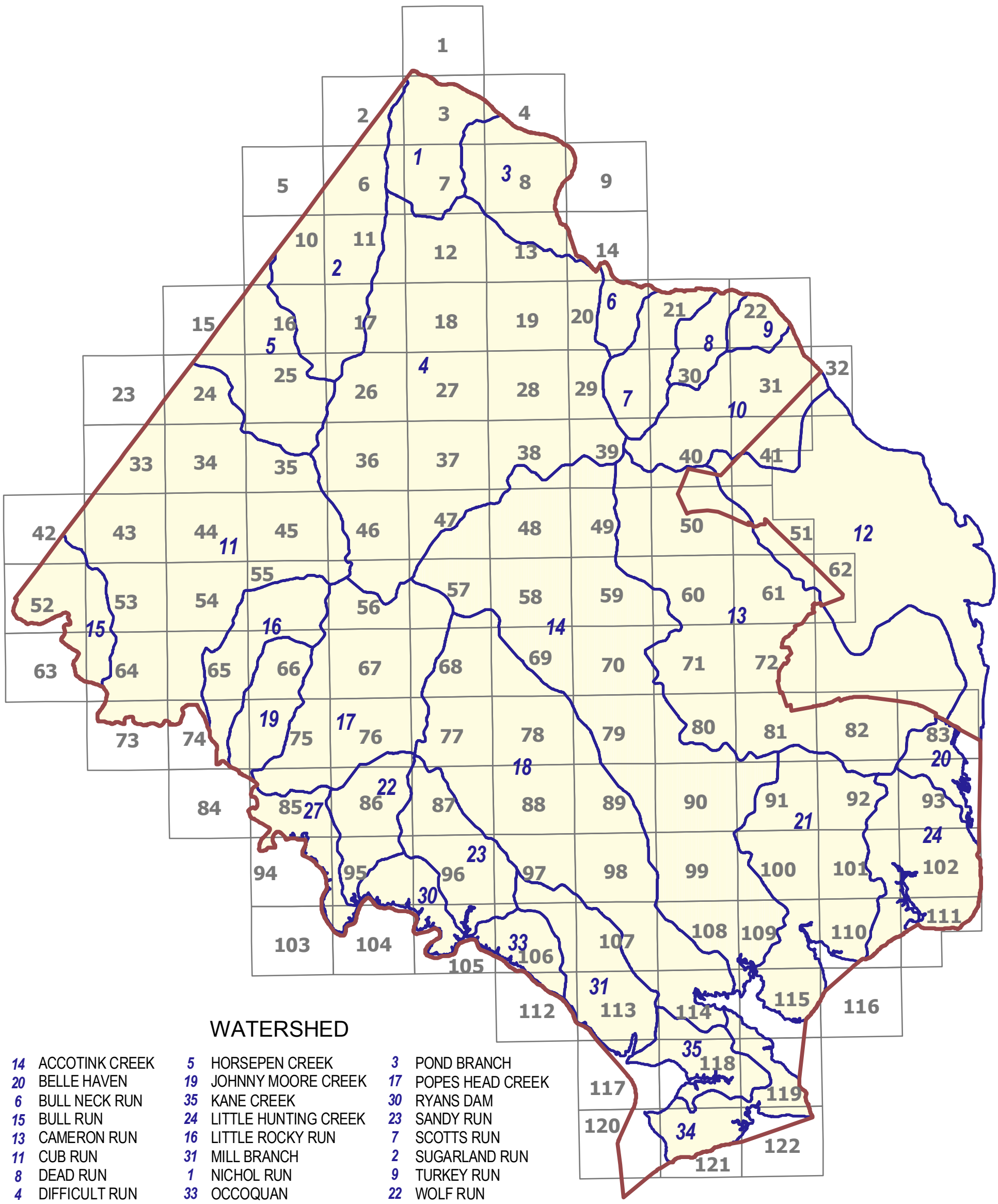
The protocol for stream assessments involved evaluating streams with contributory areas greater than 50 acres, as mapped by the County. Streams in the remainder of the watersheds were assessed for habitat and infrastructure. To assist in data collection, County-wide planimetric field maps were developed at a scale of 1 in. to 200 ft. Figure 2-1 shows the index to these maps as they overlay the county watersheds.

2.1.1.2 Watershed and Reach Naming Convention

The habitat and geomorphic assessment protocols call for each reach defined in the field having a unique name. To facilitate reach naming, watersheds and reaches were each assigned a two-letter abbreviation. For example,

- **Watershed code**—Two letters, e.g., "LH" for Little Hunting Creek watershed, "AC" for Accotink Creek watershed
- **Reach code**—Two letters, e.g., "BB" for Bear Branch, "PS" for Paul Spring Branch

[4] Available as a separate document.



Fairfax County Boundary

1 Fairfax County Map Index

Watersheds

Figure 2-1
Fairfax County Map Index
Fairfax County Stream Physical Assessment

N

0 3 6 9 Miles

CH2MHILL

The watershed and reach codes can be found in Appendix B.

TABLE 2-3
List of Watersheds in Each Physiographic Provinces
Fairfax County Stream Physical Assessment

Coastal Plain	Piedmont	Piedmont (Triasic)
Accotink Creek Watershed	Accotink Creek Watershed	Bull Run Watershed
Belle Haven Watershed	Bull Neck Run Watershed	Cub Run Watershed
Cameron Run Watershed	Cameron Run Watershed	Horsepen Creek Watershed
Dogue Creek Watershed	Cub Run Watershed	Little Rocky Run Watershed
Four Mile Run Watershed	Dead Run Watershed	Sugarland Run Watershed
High Point Watershed	Difficult Run Watershed	
Kane Creek Watershed	Four Mile Run Watershed	
Little Hunting Creek Watershed	Horsepen Creek Watershed	
Mill Branch Watershed	Johnny Moore Creek Watershed	
Pimmit Run Watershed	Little Rocky Run Watershed	
Pohick Creek Watershed	Mill Branch Watershed	
	Nichol Run Watershed	
	Old Mill Branch Watershed	
	Occoquan Watershed	
	Pimmit Run Watershed	
	Pohick Creek Watershed	
	Pond Branch Watershed	
	Popes Head Creek Watershed	
	Ryans Dam Watershed	
	Sandy Run Watershed	
	Scotts Run Watershed	
	Turkey Run Watershed	
	Sugarland Run Watershed	
	Wolf Run Watershed	

2.1.2 Infrastructure Inventory

2.1.2.1 Infrastructure Items

The infrastructure inventory identified and characterized the following items:

- Deficient buffer vegetation
- Ditches
- Dump sites
- Erosion areas
- Head cuts
- Obstructions
- Pipes

- Road and other stream crossings
- Utility lines

Each infrastructure item identified in the field was noted on the appropriate inventory form with data recorded as explained in Appendix A and then located on a map with the inventory code (see below) and photographed if appropriate. Visual estimates of lengths and measurements were noted.

Each inventory item was assigned an impact score according to the criteria listed on the bottom of each inventory form. The field forms are provided in Attachments to Appendix A.

2.1.2.2 Infrastructure Item Naming Conventions

Each inventory item is assigned a unique one-letter infrastructure code:

- Buffer, B
- Crossing, C
- Ditch, D
- Dump, M
- Erosion, E
- Head cut, H
- Obstruction, T
- Pipe, P
- Utility, U

2.1.3 Inventory List Example

The list item "ACBB02.D04" designates the Accotink Creek Watershed (AC), Bear Branch (BB), Reach no. 2 (02), Ditch no. 4 (D04); or, the fourth ditch in the second reach of Bear Branch.

2.1.4 Stream Characteristics

Each stream reach was characterized in the field on the basis of one or more of the following factors:

- **Stream restoration candidate—**including a qualitative assessment of the need and potential for restoration.
- **Stream assessment—**Identifies if the habitat assessment was conducted. Some sites were eliminated from assessment for the following reasons:
  - **Wetland—**The forms are not responsive to wetlands.
  - **No access—**Property owner will not allow access to his or her property.
  - **Dangerous conditions—**Safety is always first.
  - **Pond/lake—**The forms are not responsive to impounded water.
  - **No flow—**Flow must be present for the habitat assessment.
  - **Too deep—**The majority of the steam must be wadable.
- **Infrastructure assessment—**Identifies if the infrastructure inventory was conducted, with some sites being eliminated for similar reasons to those for habitat assessment.

Note that some reaches that were not assessed for habitat were assessed for infrastructure inventory items, where possible.

- **Water appearance**
- **Water odor**
- **Sediment odors**
- **Fish**—Identifies qualitatively the presence or absence of fish.
- **Aquatic plants**—Identifies qualitatively the presence or absence of aquatic plants.
- **Algae**—Identifies qualitatively the presence or absence of algae.

Each stream characteristic item identified in the field was noted on the appropriate inventory form with data recorded as explained in Appendix A. The field forms are provided in Attachments to Appendix A.

2.1.5 Channel Evolution Model (Geomorphic) Assessment

The channel evolution model (CEM)–based geomorphic assessment entailed identifying the evolutionary stage of the system to each assessment reach. The CEM is used to identify stream successional stages from an early stable system with one terrace through an unstable changing environment (e.g., widening and downcutting) to a stable system with two terraces. The percent of the assessment reach represented by each evolutionary stage was determined by visual observations of the channel cross-section as well as other morphological observations within the study area. The various visual indicators utilized are summarized in Figure 2-2.

In addition to assigning CEM channel type(s), cross-sectional measurements were taken at one or more representative points (depending on the number of CEM types assigned) over the assessment reach.

Field forms for performing the CEM-based assessment are provided in Attachments to Appendix A.

2.2 Training

In order to maintain uniformity across field teams, a training class was prepared. The training class consisted of presentations, samples, and a field demonstration. The 2-day training workshop included a half-day overview in the office during which the presentations and samples were shown. The overview addressed the goals of the program, assessment performance, impact and habitat scoring criteria, logging of data on forms, and questions from the teams.

The second half of the workshop was conducted in the field. The workshop attendees were divided into four groups. Each group included an experienced person who led the teams through the forms and maps. At the end of each reach the groups compared their scores and evaluated scoring differences.

Following this initial 2-day training period, it was decided that two additional days should be devoted to on-the-job training prior to conducting the accuracy and precision evaluation (see below). During this additional training, each two-person field team conducted stream assessments at a slower pace while accompanied by a third, more experienced, lead person.

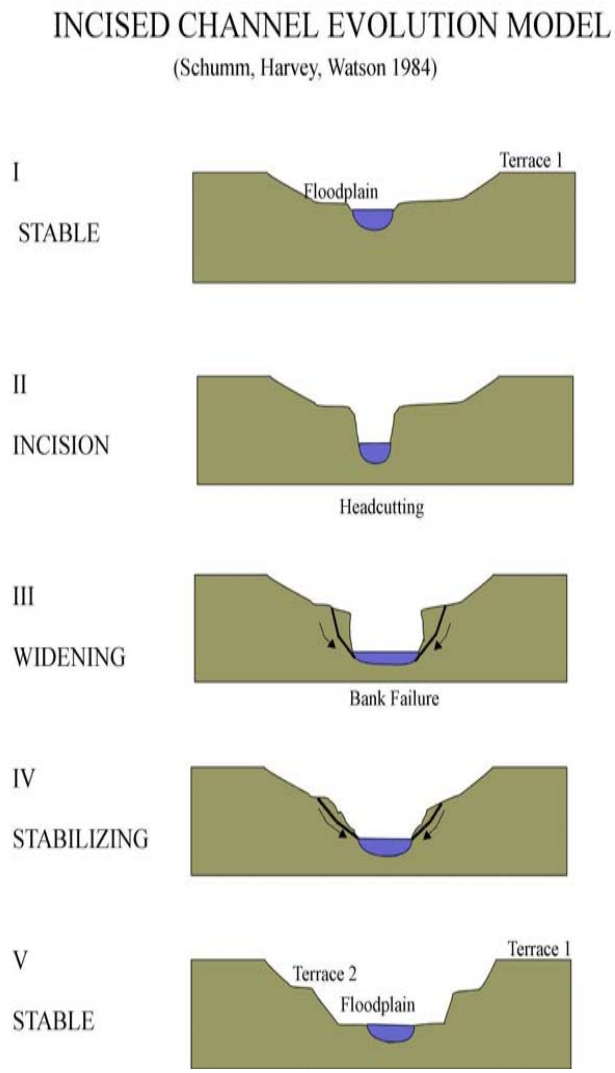
2.3 Accuracy and Precision Evaluation

Accuracy and precision were evaluated for stream physical assessment metrics according to the procedures documented in Appendix C. Seven two- or three-person teams participated in the assessment. The evaluations were conducted by having the teams assess two sites previously identified by the County and previously assessed as part of the County Stream Protection Strategy (SPS):

- Dogue Creek (DCDC01), a site located in the coastal plain physiographic region, in the Dogue Creek watershed
- Elk Horn Run (OCEH01), a site located in the Piedmont physiographic region, in the Occoquan watershed not far from the Occoquan River

Appendix C contains site location maps and upstream and downstream photographs from reaches identified by the field teams. Assessments for Elk Horn Run were not carried out consistently by the field teams because the lower segment was located in a wetland area. While dropping the site from the data analysis presented in this document was considered, it was determined that that the results provided important information about wetland-upland interface field conditions and therefore the analysis of the pertinent data collected was included.

FIGURE 2-2
Indicators for Assigning Channel Type in the Incised Channel Evolution Model
Fairfax County Stream Physical Assessment



Type I: Well-developed base flow and bankfull channel; consistent floodplain features easily identified; one terrace apparent above active floodplain; predictable channel morphology; floodplain covered by diverse vegetation; streambanks ≤ 45°.

Type II: Head cuts; exposed cultural features (along channel bottom); sediment deposits absent or sparse; exposed bedrock (parts of reach); streambank slopes > 45°.

Type III: Stream bank sloughing, sloughed material eroding; streambank slopes > 60° or vertical/undercut; erosion on inside of bends; accelerated bend migration; exposed cultural features (along channel banks); exposed bedrock (majority of reach).

Type IV: Streambank aggrading; sloughed material not eroded; sloughed material colonized by vegetation; base flow, bankfull and floodplain channel developing; predictable channel morphology developing; streambank slopes ≤ 45 °.

Type V: Well developed base flow and bankfull channel; consistent floodplain features easily identified; two terraces apparent above active floodplain; predictable channel morphology; streambanks ≤ 45°.

2.3.1 Precision Evaluation

Tables 2-4 and 2-5 present the standard deviation, mean, and coefficient of variation (COV) of the Dogue Creek and the Elk Horn Run sites for the individual habitat metrics and the total habitat scores. The statistics were calculated from the individual scores of each team member and the average score of each team.

TABLE 2-4
Standard Deviation, Mean, and Coefficient of Variation for Dogue Creek, by Individual Score, and by Average Team Score
Fairfax County Stream Physical Assessment

	Statistics on Individual Basis				Statistics on Team Basis			
Glide/Pool Metrics	**Standard Deviation**	**Mean**	**Coefficient of Variation (%)**	**Sample Size**	**Standard Deviation**	**Mean**	**Coefficient of Variation (%)**	**Sample Size**
Bottom substrate/ available cover	2.9	11.9	25	16	2.4	12.3	20	7
Pool substrate characterization	3.4	10.4	33	16	3.1	10.7	29	7
Pool variability	2.1	12.4	17	16	1.8	12.4	15	7
Channel/bank alteration	4.1	12.4	33	16	3.8	12.7	30	7
Sediment deposition	2.5	8.6	29	16	2.1	8.9	24	7
Channel sinuosity	4.6	6.8	68	16	4.8	7.2	66	7
Channel flow status—drought	2.8	9.1	31	16	2.8	9.2	31	7
Channel flow status—normal	2.7	12.6	21	16	2.4	12.7	19	7
Bank Vegetative Protection								
LB	1.5	3.3	47	16	1.3	3.4	38	7
RB	1.7	3.5	49	16	1.6	3.6	43	7
Bank Stability								
LB	1.8	3.9	47	16	0.7	9.1	38	7
RB	1.7	4.1	41	16	2.2	7.5	35	7
Vegetation Buffer Zone Width								
LB	0.9	9.1	10	16	23.1	118.3	8	7
RB	2.0	7.6	27	16	21.3	109.0	29	7
Total without drought channel flow status	22.2	106.5	21	16	21.27	109.0	20	7

TABLE 2-5
Standard Deviation, Mean and Coefficient of Variation for Elk Horn Run, by Individual Score, and by Average Team Score
Fairfax County Stream Physical Assessment

	Statistics on Individual Basis				Statistics on Team Basis			
Riffle/Run Metrics	**Standard Deviation**	**Mean**	**Coefficient of Variation (%)**	**Sample Size**	**Standard Deviation**	**Mean**	**Coefficient of Variation (%)**	**Sample Size**
Instream cover	3.0	10.5	29	11	2.4	10.4	23	5
Epifaunal substrate	4.1	4.6	89	11	4.3	5.0	85	5
Embeddedness	5.0	9.4	54	11	5.3	9.8	54	5
Channel/bank alteration	1.9	15.7	12	11	1.7	15.6	11	5
Sediment deposition	2.5	14.0	18	11	2.5	13.7	18	5
Frequency of riffles	3.1	5.4	59	11	2.8	5.7	49	5
Channel flow status—drought	1.6	1.4	119	11	1.7	1.5	115	5
Channel flow status—normal	5.6	10.6	53	11	5.4	9.9	54	5
Bank Vegetative Protection								
LB	1.3	7.5	17	11	1.3	7.4	17	5
RB	1.4	7.6	18	11	1.4	7.5	19	5
Bank Stability								
LB	1.0	7.8	13	11	0.5	7.7	7	5
RB	1.0	7.9	13	11	0.7	7.8	9	5
Vegetation Buffer Zone Width								
LB	1.6	6.1	26	11	1.2	5.9	21	5
RB	1.6	7.1	23	11	1.7	7.0	24	5
Total without drought channel flow status	7.3	114.4	6	11	5.8	113.5	5	5

No set goals were established for the precision evaluation; however, in discussions with County staff a reasonable target was suggested: that the COV for the overall habitat score should not exceed 15 percent, while the COV for any one metric should not exceed 25 percent. The results shown in Tables 2-4 and 2-5 indicate that, in general, these targets have not been met for the glide/pool system, but they were more frequently met for the

riffle/run system. However, the overall COV for the glide/pool system of 20 percent is not unreasonable, and the overall COV for the riffle/run system of 5 percent is excellent (the latter for fewer teams, because of the problems assessing the wetlands area at the riffle/run site).

The glide/pool metrics with the most inconsistent results, based on the COV, are as follows, in declining order:

- **Channel sinuosity**—The discrepancies with sinuosity are a result of map wheel measurements of GIS coverage and observations of internal channel meandering through point bars.
- **Bank vegetative protection**—Bank vegetative protection differences are a result of misidentification of the demarcation between actual bank vegetation (that vegetative cover that occurs between the bank toe of slope and the top of bank) and riparian vegetative cover.
- **Bank stability**—The condition of the Dogue Creek system was such that bank stability could be easily misinterpreted. The creek did not have any active erosion with slumping, however, it was scoured and had little vegetative stability.
- **Channel flow status**—Given the drought conditions occurring at the time of evaluation, normal channel flow status was variable. The internal meandering within a larger established streambed increased the variability of this measurement.
- **Pool substrate characterization**—Pool substrate was easily determined by the dominant bed material, however, determining the "quality" of the pool in relation to habitat for fish and aquatic macroinvertebrates varied depending on experience of the assessor(s).
- **Sediment deposition**—Determining sediment deposition is a subjective estimation of the amount of point bars and unstable sediment within a stream. The variability of this measurement increased because the drought conditions increased the amount of exposed sediments resulting in an overestimate of the point bar depositions.

The conflicting riffle-run metrics are a direct result of the wetland system of Elk Horn Run. Applying stream protocols to a system with braided and overgrown wetland channels can produce a wide range of differing results. The metrics with the most inconsistent results, based on the COV, are as follows, in declining order:

- Channel flow status—drought
- Epifaunal substrate
- Embeddedness
- Frequency of riffles
- Vegetation buffer zone width
- Instream cover

2.3.2 Accuracy Evaluation

Table 2-6 presents the total habitat assessment score and condition rating for the two sites and the seven teams. Figure 2-3 shows the spread in the total habitat scores. Additional

graphical analyses are contained in Appendix C illustrating the scatter in the raw data and the average data by team, for each of the individual habitat metrics.

Team 2 was assumed to be made up of the most experienced team. No County assessment information for these sites was provided. All the habitat assessment scores fell within one rating category of the Team 2 category for the Elk Horn Run site, and all but one total habitat assessment score (Team 3) fell within one rating category of the Team 2 category for the Dogue Creek site. Note that the Team 2 score was the only one to rate Dogue Creek as "Poor" (by just three points), while all others rated it fair or good.

TABLE 2-6
Total Habitat Assessment Score and Condition Rating for Elk Horn Run and Dogue Creek by Team
Fairfax County Stream Physical Assessment

	OCEH001		DCDC001	
Team	**Score**	**Condition**	**Score**	**Condition**
1	110	Fair	111	Fair
2	123	Good	78	Poor
3	DNA	DNA	146	Good
4	108	Fair	94	Fair
5	DNA	DNA	115	Fair
6	116	Fair	101	Fair
7	112	Fair	120	Fair

Preliminary condition rating categories are as follows (these were later revised—see Section 3):

0–40	Very poor
41–80	Poor
81–120	Fair
121–160	Good
161–200	Excellent

OCEH001 data for Team 2 are obtained by combining the two Elk Horn Reaches.

DNA = Did not assess.

2.3.3 Channel Evolution Model Evaluation

Table 2-7 presents the channel evolution model rating for each team and assessment site. The Dogue Creek data show good consistency, with five of seven teams rating the site a 3, and the other two rating it a 3.5 or 4.

FIGURE 2-3
Total Habitat Scores, by Team, by Site
Fairfax County Stream Physical Assessment

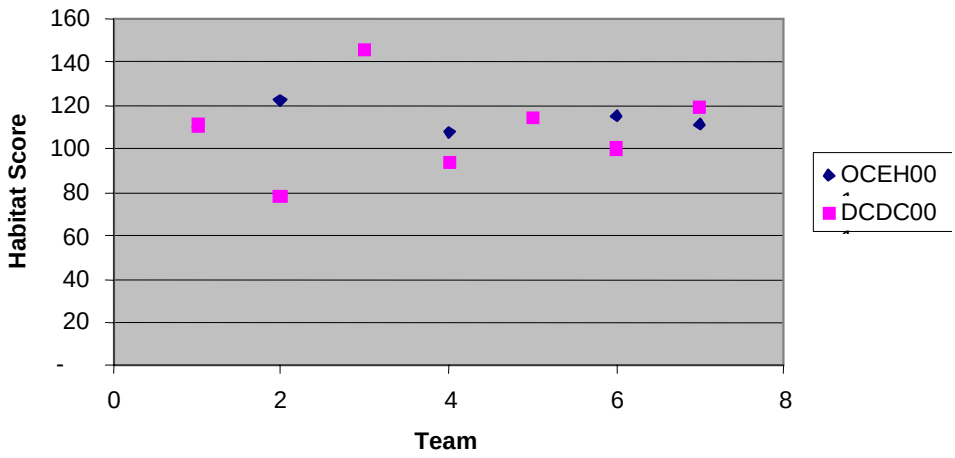


TABLE 2-7
Channel Evolution Model (CEM) Rating for Elk Horn Run and Dogue Creek by Team
Fairfax County Stream Physical Assessment

TEAM	OCEH001 (Points B to C)	OCEH002 (Points C to D)	DCDC001
	Wetland	Transitional Channel	Channel
1	4.5, sand	DNA	4, sand
2	1, sand	1.5, gravel	3, sand
3	DNA	DNA	3, sand
4	4.5, Sand	DNA	3.5, sand
5	DNA	DNA	3, sand
6	DNA	3.5, gravel	3, sand
7	DNA	2.5, sand	3, sand

DNA = Did not assess.

2.4 Field Activities

2.4.1 Data Collection

In order to assess the 802 miles of streams in a reasonable timeframe, seven field teams of two to three persons each were organized. The field activities were performed almost continuously from October through mid-February. The teams collected the necessary data

and logged it on field forms and maps. For areas that could not be evaluated due to the following conditions, the teams still collected as much visual information as possible:

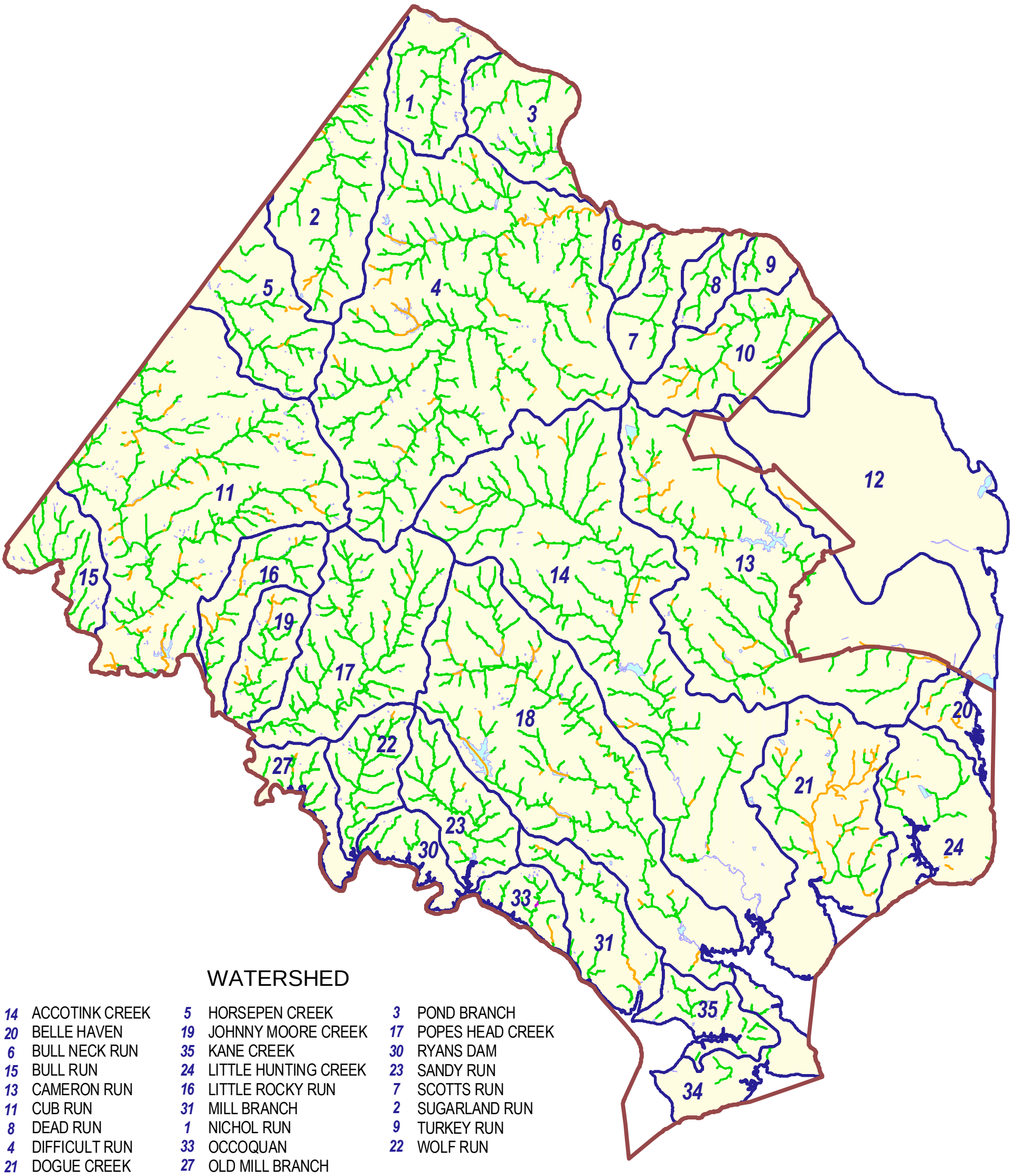
- Wetland with no defined channel
- Pond or a lake
- Flow was not present
- No access to the stream reach
- Conditions were too dangerous to walk the stream reach

In many instances when habitat assessments could not be performed, full or partial inventory assessments were still performed. The assessments resulted in 1851 reaches being assessed.

Figure 2-4 shows the stream reaches and their assessment status: habitat and inventory assessment, inventory assessment only, no assessment. Table 2-8 summarizes the miles of streams that were assessed County-wide and Table 2-9 summarizes this information by watershed. Approximately 88 percent of the streams had both habitat and inventory assessments performed. Another 10 percent had inventory assessments done. The remaining 2 percent were not assessed due to reasons mentioned above. Decisions to assess or not to assess a portion of the stream were made in the field based on information available at the sites.

TABLE 2-8
Summary of Habitat and Inventory Assessments Performed, County-Wide
Fairfax County Stream Physical Assessment

Assessment	No. of Reaches	Total Length (ft)	Total Length (miles)
Habitat and inventory assessment	1,526	3,784,958	716.8
Inventory assessment only—walked	311	436,096	82.6
Inventory assessment only—not walked	13	13,288	2.5
Subtotal—assessed	1,851	4,234,342	801.9
No assessment—walked	38	25,113	9.1
No assessment—not walked	31	47,892	4.8
Total	1,9197	4,307,347	815.8



WATERSHED

14	ACCOTINK CREEK	5	HORSEPEN CREEK	3	POND BRANCH
20	BELLE HAVEN	19	JOHNNY MOORE CREEK	17	POPES HEAD CREEK
6	BULL NECK RUN	35	KANE CREEK	30	RYANS DAM
15	BULL RUN	24	LITTLE HUNTING CREEK	23	SANDY RUN
13	CAMERON RUN	16	LITTLE ROCKY RUN	7	SCOTTS RUN
11	CUB RUN	31	MILL BRANCH	2	SUGARLAND RUN
8	DEAD RUN	1	NICHOL RUN	9	TURKEY RUN
4	DIFFICULT RUN	33	OCCOQUAN	22	WOLF RUN
21	DOGUE CREEK	27	OLD MILL BRANCH		
12	FOUR MILE RUN	10	PIMMIT RUN		
34	HIGH POINT	18	POHICK CREEK		

Fairfax County Boundary

Assessment Status

- Habitat and Inventory
- Habitat Only
- Inventory Only
- No Assessment
- Lakes and Ponds
- Watersheds

N

0 3 6 9 Miles

CH2MHILL

Figure 2-4
Stream Assessment Status
Fairfax County Stream Physical Assessment

TABLE 2-9
Summary of Habitat and Inventory Assessments Performed, by Watershed
Fairfax County Stream Physical Assessment

	Habitat and Inventory Assessment		Inventory Assessment Only		Total Assessed		Not Assessed*	
Watershed	**No. of Reaches**	**Miles**	**No. of Reaches**	**Miles**	**No. of Reaches**	**Miles**	**No. of Reaches**	**Miles**
Accotink Creek	147	85.5	36	6.1	183	91.6	3	0.8
Belle Haven	5	1.8	7	1.6	12	3.4	0	0.0
Bull Run	5	4.8	1	0.1	6	4.9	0	0.0
Bull Neck Run	14	13.1	0	0.0	14	13.1	0	0.0
Cameron Run	133	48.7	31	9.2	164	57.9	7	1.6
Cub Run	255	74.9	65	12.9	320	87.7	19	4.5
Dead Run	11	6.0	0	0.0	11	6.0	0	0.0
Difficult Run	267	129.7	52	14.2	319	143.9	10	1.4
Dogue Creek	39	16.6	41	15.5	80	32.0	0	0.0
Four Mile Run	2	0.8	1	1.0	3	1.8	0	0.0
High Point	6	3.0	0	0.0	6	3.0	1	0.2
Horsepen Creek	39	17.5	5	1.2	44	18.7	4	0.7
Johnny Moore Creek	26	11.3	8	2.0	34	13.3	3	0.2
Kane Creek	15	7.3	0	0.0	15	7.3	0	0.0
Little Hunting Creek	23	9.9	5	1.4	28	11.3	1	0.2
Little Rocky Run	22	13.2	9	2.8	31	16.0	2	0.1
Mill Branch	28	14.3	3	1.4	31	15.7	3	1.2
Nichol Run	24	13.7	0	0.0	24	13.7	3	0.4
Occoquan	13	6.0	1	0.5	14	6.6	0	0.0
Old Mill Branch	16	6.0	2	0.3	18	6.3	0	0.0
Pimmit Run	42	18.1	12	3.7	54	21.87	0	0.0
Pohick Creek	151	70.1	26	8.0	177	78.1	6	1.3
Pond Branch	29	17.0	1	0.2	30	17.3	5	0.9
Popes Head Creek	91	49.6	6	0.7	97	50.4	2	0.2
Ryans Dam	4	4.3	0	0.0	4	4.3	0	0.0
Sandy Run	35	20.4	2	0.2	37	20.6	0	0.0

TABLE 2-9
Summary of Habitat and Inventory Assessments Performed, by Watershed
Fairfax County Stream Physical Assessment

	Habitat and Inventory Assessment		Inventory Assessment Only		Total Assessed		Not Assessed*	
Watershed	**No. of Reaches**	**Miles**	**No. of Reaches**	**Miles**	**No. of Reaches**	**Miles**	**No. of Reaches**	**Miles**
Scotts Run	15	8.2	0	0.0	15	8.2	0	0.0
Sugarland Run	46	26.6	8	1.9	54	28.5	0	0.0
Turkey Run	5	2.8	0	0.0	5	2.8	0	0.0
Wolf Run	19	16.1	2	0.3	21	16.4	0	0.0
Total	1,527	717.1	324	85.1	1,851	802.3	69	13.9

*Note: Only includes reaches for which field teams identified the reach end points and identified reasons it could not be assessed, such as reach is piped or not accessible. Does not include stream miles that were not assessed for other reasons, such as having drainage area less than 50 acres.

Appendix D tabulates the reasons that were listed by the field teams for areas where habitat assessments were not conducted. The presence of wetlands and the presence of ponds or lakes each contributed about 20 percent of the stream lengths that were not assessed. The two other primary reasons for lack of habitat assessments were piped streams and streams channelized in concrete or ditches.

In addition to collecting data on forms and maps, the teams photographed the inventoried facilities per criteria listed on the forms and in the instructions. In instances where conditions were too dangerous or areas could not be accessed photographs may not have been taken. Overall, the teams took over 11,000 photographs.

TABLE 2-10
Summary of Inventory Points by Category
Fairfax County Stream Physical Assessment

Impact Score	Total
Deficient Buffers	2,566
Crossings	3,039
Ditches and Pipes	2,279
Erosion	550
Head Cut	122
Obstruction	7946
Utility	186

The inventory assessments yielded approximately 9,536 inventory points. Exhibits 3, 4, 5 and 6 (in map pockets) depict the inventory point locations for the entire County, as follows: Crossings (Exhibit 3), Buffer Deficiency (Exhibit 4), Pipes, Ditches, Dumps, and Utilities (Exhibit 5), and Erosion and Obstructions (Exhibit 6). Table 2-10 summarizes the number of inventory items collected in each category.

2.4.2 Quality Control

In order to ensure consistency between the different teams and quality of data, a number of quality control measures were enacted during the stream assessments. These quality control measures included:

- **Field Team Composition**—each field team was composed of two experienced field staff with a background in biology and/or engineering. During field assessments, habitat conditions and impact scores were compared and discussed to ensure an accurate assessment.
- **Field Team Coordination**—a field coordinator was assigned to manage staff and the field activities. This individual was responsible for field assignments and the review of field forms and maps that were completed by the field teams.
- **Daily Meetings**—each morning the teams met to discuss issues from the previous day and to answer questions from data reviews. The meetings also served as a means to provide updates or changes to the teams. If similar issues were noted in data received from several field teams, this was discussed during the meeting and summarized in writing for distribution.
- **Field Data Review**—the field teams turned in completed field forms, photo logs, and maps on a daily basis. This allowed for review of the data to verify that items entered on the field forms were entered correctly and had corresponding entries on the planimetric maps and photo logs.

These quality control processes performed during the field activities provided more consistent data for database entry and digitization into a Geographic Information System (GIS). [5] Separate quality control measures were undertaken for the data entry into the data management system, as follows.

2.4.2.1 Database

The data collected on the field forms were entered by a database entry clerk into the database. In order to ensure that the data was entered correctly these quality control measures were enacted:

- Training—The database entry clerk was briefed on the significance of each data field and the parameters that were expected for each field and was asked to flag any inconsistencies in the data to be entered.
- Data check—A comprehensive check on the data entered was performed by a second person.
- GIS link—The database was linked to the GIS to match information; mismatched information from the database and GIS was further investigated and resolved.

[5] User and system documentation for the Stream Assessment Data Management Tool is provided separately (CH2M HILL, 2003).

2.4.2.2 GIS

The data collected by the field team on the field maps was digitized. Quality control of the digitization was accomplished through similar procedures as those for the database entry as follows:

- Training—The GIS technician was briefed on the map coding parameters.
- Check—Each digitized map was checked by a second person to ensure that all marked features were entered correctly.
- GIS link—The digitized points were linked to the database to identify and resolve inconsistencies.