Section 2
Watershed Overview

2.1 Introduction

The Cub Run and Bull Run watersheds receive stormwater runoff from portions of western Fairfax County and eastern Loudoun County. The watersheds are a major tributary to the nia), the Potomac River estuaries and the Chesapeake Bay. Figure 2-1 shows the general location of the watersheds in southwestern Fairfax County and their relationship to the Occoquan Reservoir and Potomac River Estuary. The Cub Run watershed comprises 63 square miles (10 percent) of the 595 square-mile drainage area to the Occoquan Reservoir.

Cub Run is a major tributary to Bull Run, which forms the Fairfax County/Prince William County border. Bull Run and its tributaries also drain large areas outside the study area in Loudoun, Prince William and Fauquier counties.

The Cub Run and Bull Run watersheds include portions of Fairfax County that have developed rapidly over the past 25 years. As a result, a large portion of the Cub Run watershed is approaching build-out conditions. Future development will mostly occur in the western portions of the watershed, including low-, medium- and high-density residential, low-intensity commercial, and industrial land uses.

The wide range of stream quality conditions in the Cub Run and Bull Run watersheds largely reflect the variations in the intensity of land development. The existing stormwater management programs, land use and preserved open space are significant factors affecting stream conditions in the watershed:

- Because of its recent development and stormwater management history, the Cub Run and Bull Run watersheds have some of the most proactive and protective stormwater management controls in the region. The watershed includes more than 400 stormwater ponds. This history of stormwater controls is provided in Section 2.5.

- A large area of the southern portions of the watershed is zoned for low-density (one house per five acres) development in an area referred to as the Residential-Conservation District. See Section 2.6.1 for a description of the 1982 rezoning that created the Residential-Conservation (R-C) District implemented to protect water quality in the Occoquan Reservoir. This area may include institutional uses approved through the special permit or special exception process.

- Parkland and other preserved open space make up about 11 square miles or 23 percent of the total watershed area within Fairfax County.

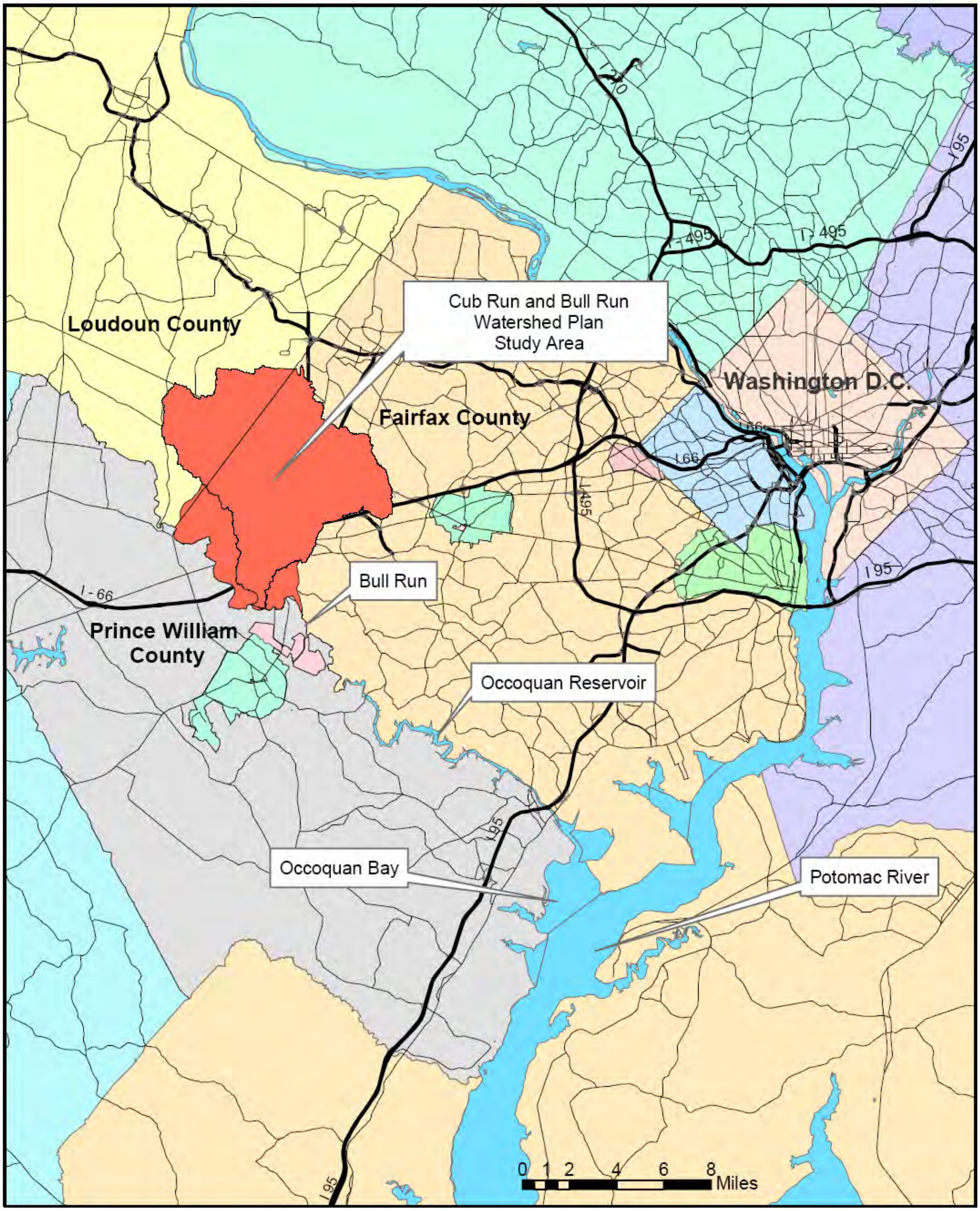


Figure 2-1
General Location of the Cub Run and
Bull Run Watershed Plan Study Area

The following sections provide an overview of the watershed and description of its existing conditions based on a review of previous studies, data and reports.

2.2 Description of Watershed

The Cub Run and Bull Run watersheds included in the watershed plan are shown on Figure 2-2 and include the following areas:

1. **Cub Run Watershed** - Areas in Fairfax County and Loudoun County that drain to Cub Run. Cub Run receives runoff from 39 square miles of western Fairfax County and 14 square miles of eastern Loudoun County. The total Cub Run watershed area is approximately 53 square miles. The watershed includes seven square miles within Dulles International Airport, which straddles the county line.

2. **Bull Run Watershed** - Areas of Fairfax and Loudoun counties that drain directly to Bull Run west of Little Rocky Run and east of the Fairfax County/Loudoun County border. This includes 8.4 square miles of Fairfax County and 1.3 square miles of Loudoun County (total area is 9.7 square miles).

The project study area equals 63 square miles, one of the largest watersheds in Fairfax County.

Fifteen square miles of the Cub Run study area lies within Loudoun County. The watershed plan will consider the impacts of existing development and future growth in Loudoun County on the downstream Fairfax County stream segments. The watershed plan may recommend watershed management solutions, but not specific projects, within Loudoun County. The Cub Run watershed plan will promote dialog concerning common natural resources between Fairfax County and Loudoun County and allow the jurisdictions to collaborate in the protection and restoration of the Cub Run watershed and Occoquan Reservoir water supply.

The following two sections discuss the streams and general drainage patterns within the Cub Run and Bull Run watersheds.

2.2.1 Cub Run Watershed

The Cub Run watershed includes the following named tributaries or watersheds:

- Big Rocky Run
- Cain Branch
- Dead Run
- Elklick Run
- Flatlick Branch
- Frog Branch – Tributary to Flatlick Branch
- Oxlick Branch – Tributary to Flatlick Branch
- Round Lick Branch

Figure 2-2
Major Subwatersheds in
the Cub Run and Bull Run Watersheds

- Sand Branch
- Schneider Branch

These named subwatersheds are shown on Figure 2-2. The following briefly describes each subwatershed's drainage features. Section 3 of this report provides details on the land use, stormwater controls and stream conditions within each subwatershed.

Upper Cub Run

The Cub Run main stem and its farthest upstream tributaries, Dead Run and Sand Branch, begin in a topographically flat wetland complex on the lightly developed property surrounding Dulles International Airport. After crossing the Dulles property line into Fairfax County, Cub Run flows for a short distance before flows are increased by the addition of Cain Branch and Schneider Branch from the east. These watersheds include runoff from the recently developed commercial areas along Route 50 west of the Route 28 interchange, Dulles International Airport and the residential/commercial area development surrounding Chantilly.

Cub Run continues south to its confluence with two tributaries - Flatlick Branch and Elklick Branch - that have different land use characteristics.

Flatlick Branch

Flowing from the east, Flatlick Branch and its two major tributaries, Frog Branch and Oxlick Branch, run through the suburban developed areas around Chantilly, business districts along the Route 50 corridor, and newly developed Westfields commercial areas. Development in the upstream portions of the Flatlick Branch subwatershed has approached build-out conditions and raised the percent impervious of the major subwatershed close to 20 percent.

Elklick Branch

The Elklick Run subwatershed lies west of Cub Run and extends into eastern Loudoun County. The Fairfax County portions of the Elklick Run watershed lie within the large-lot R-C District of the Occoquan Reservoir watershed that limits potential development density to one house per five acres and includes large areas of Fairfax County parkland. The Fairfax County portions of the Elklick Run subwatershed are and will remain lightly developed.

The Loudoun County portion of the subwatershed include the South Riding community and large undeveloped areas. Future development will include residential, commercial, office and industrial land use.

Round Lick Branch

Two miles downstream from the Elklick Run/Cub Run confluence, Round Lick branch flows into Cub Run from the northeast. This tributary includes residential communities near Sully Station and a large area within the Ellanor C. Lawrence Park.

Big Rocky Run

Cub Run receives a final major input from Big Rocky Run, a large subwatershed that has it headwaters near Fair Oaks Mall and Fairfax Government Center. Big Rocky Run flows southwest through the developed suburban areas of Fair Lakes and Centreville, including the residential areas between Route 50 and Route 29, and portions of Centreville west of Route 28.

Lower Cub Run

After the confluence with Big Rocky Run, the Cub Run main stem runs parallel to, and then crosses under, I-66. For the remainder of its course, Cub Run meanders south through the forested Bull Run Regional Park before joining Bull Run on its way to the Occoquan Reservoir, Potomac River and Chesapeake Bay.

2.2.2 Bull Run Watershed

The watershed also includes areas in Fairfax County that drain directly to Bull Run. The main stem of Bull Run, which forms the boundary between Fairfax County and Prince William County, is not explicitly included in the watershed plan since it falls within two jurisdictions, and it is most affected by watershed conditions upstream from Fairfax County, including Loudoun, Prince William and Fauquier counties.

Bull Run West

Bull Run Regional Park and the Fairfax National Golf Course make up much of the watershed that drains directly to Bull Run west of Cub Run (Bull Run West). This watershed also includes a large active quarry (Luck Stone) and several unnamed tributaries. This area lies entirely within the R-C District and includes large areas of largely undeveloped privately owned land.

Bull Run East

Bull Run tributaries between Little Rocky Run and Cub Run (Bull Run East) north of Compton Road include areas of dense residential development in Centreville. Areas south of Compton Road are in the R-C District and are lightly developed. Much of this land is within the Bull Run Regional Park. The Upper Occoquan Sewage Authority (UOSA) advanced wastewater treatment plant is also within this portion of the study area. See Section 2.6.1 for additional information regarding the UOSA treatment plant.

2.3 Historical Development

The Cub Run watershed includes portions of Fairfax County that have grown rapidly over the past 25 years. The Report of the New Millennium Occoquan Watershed Task Force documents that "the population of Centreville alone has doubled from 26,585 in 1990 to 48,661 in 2000" and "Over 48 percent of homes in Centreville have been built since 1990, while over 85 percent have been built since 1980."

A recent study from Virginia Tech (2003) documents the following population growth in the combined Fairfax and Loudoun county portions of the Cub Run watershed between 1980 and 2000:

- 1980 – 20,360
- 1990 – 58,036
- 2000 – 98,119

Virginia Tech's report also documents that the impervious area fraction in the Cub Run watershed has also increased along with the population increase:

- 1980 – 6.7%
- 1985 – 9.3%
- 1990 – 13.1%
- 1995 – 15.8%
- 2000 – 17.8%

Impervious area is the percent of the land area covered by roads, sidewalks, buildings, parking lots, driveways and sidewalks that prevents the infiltration of rainfall into the soil and increases the peak flow and volume of runoff. Impervious area is therefore a very good measure of the intensity of development and its potential impact on the streams.

Areas of significant development include:

- Chantilly
- Westfields
- Sully Station
- Centreville
- Fair Lakes
- South Riding (Loudoun County)

Several major roads and highways pass through the Cub Run watershed:

- Interstate 66 - east of West Ox Road

- Route 50 – Lee Jackson Memorial Highway passes through the watershed from southeast to northwest. The eastern border of the watershed is near the intersection of Route 50 and West Ox Road (609). The watershed's western boarder is at Route 50 and Gum Springs Road in Loudoun County.

- Route 29 – Lee Highway west of the vicinity of the Route 28 intersection

- Route 28 – Sully Road from Dulles International Airport south to Bull Run

- Route 7100 - Fairfax County Parkway from near Route 29 north to Franklin Farm Road.

Figure 2-3 shows the location of these areas and major roads.

2.4 Future Development

Future growth will be guided by the land use plans adopted by Fairfax and Loudoun counties and planned expansion projects for Dulles International Airport. The following sections provide an overview of the planned future development within these areas. Section 3 of this report provides detailed information on the existing and future land use for the major subwatersheds.

The proposed projects, listed in sections 6 and 7, were prepared anticipating build-out conditions in the Cub Run and Bull Run watersheds based on the 2001 Fairfax County Comprehensive Land Use Plan. By assuming the area is built-out, the plan addresses the projected quantity and quality of stormwater runoff from all future development.

Several highway improvement projects that have potential impacts on the watershed are summarized in Section 2.4.4.

2.4.1 Fairfax County

The following bullets provide an overview of the development that may occur in the Fairfax County portions of the Cub Run and Bull Run watersheds based on the Fairfax County Comprehensive Land Use Plan:

- Areas in the watershed east of Walney Road and Centreville Road have relatively little growth potential. Future development will occur where the few remaining vacant developable parcels are developed. Parcels where the existing land use density is significantly less than the density allowed by the land use plan will be redeveloped or infill will occur. This development results in relatively small increases in impervious area.

- Large areas in the R-C District in the southern and western portions of Fairfax County can be developed at a density of no more than one residence per five acres. The planned density is not expected to change since Fairfax County is committed to protecting the Occoquan watershed, and the five-acre zoning has been upheld by three court cases since the mid-1980s.

- Areas in Fairfax County west of Walney/Centreville Road, north of Braddock Road, and east of Pleasant Valley Road include vacant and undeveloped parcels that have planned land use of mixed industrial, office and commercial areas. Much of this development is ongoing.

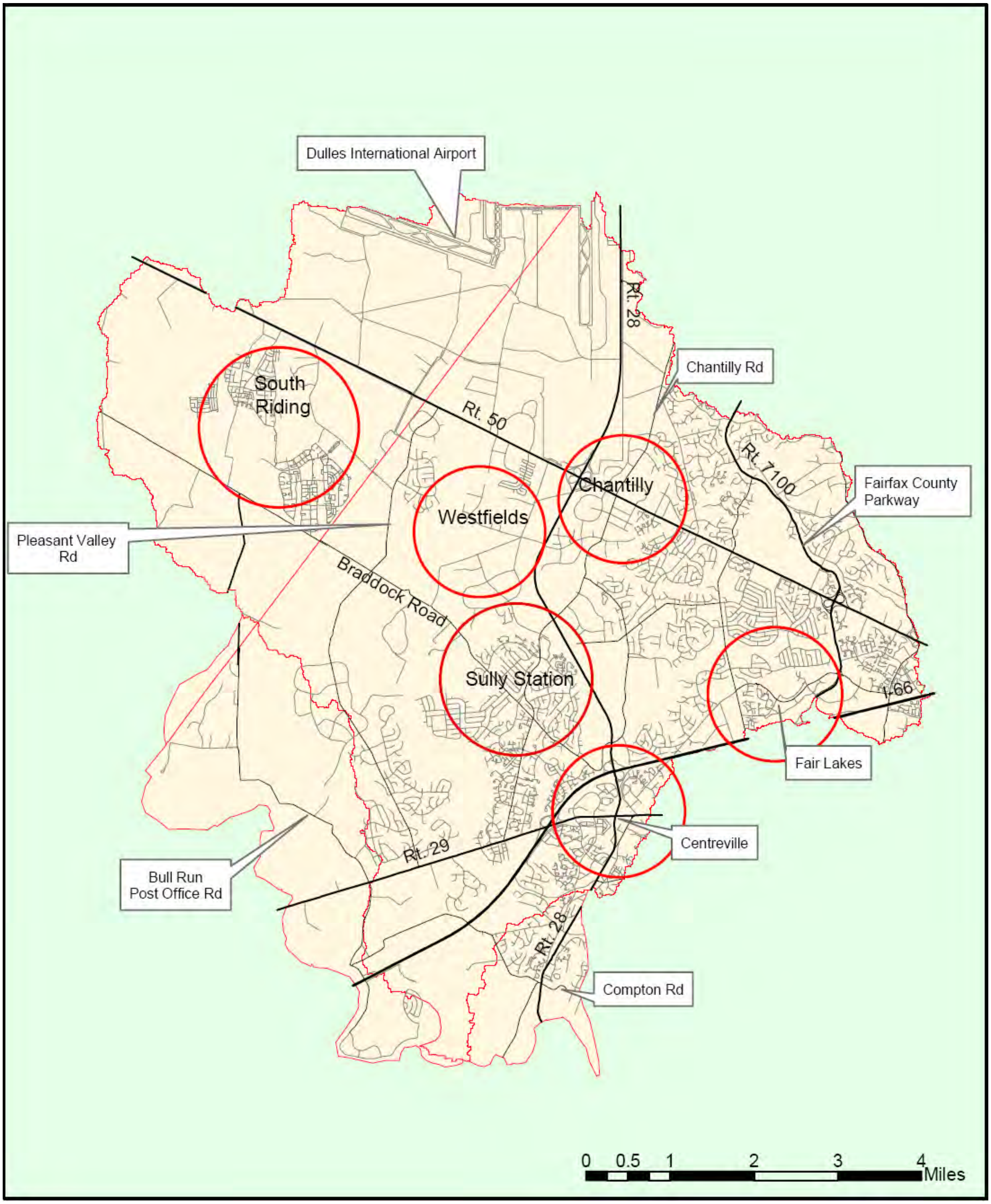


Figure 2-3
Location of Major Developed Areas
Within the Cub Run and Bull Run
Watershed

2.4.2 Loudoun County

The Loudoun County General Plan determines development in Loudoun County. As defined by the plan, the highest density will occur north of Braddock Road. This includes low-, medium- and high-density residential, low-intensity commercial, and industrial land uses with densities similar to Fairfax County areas of the watershed.

The project team met several times with the Loudoun County Department of Planning to identify and verify the planned land use in the Loudoun County portions of the watershed at a level of detail appropriate for this watershed plan.

The Loudoun County General Plan identifies three policy areas within the Cub Run and Bull Run watersheds. These areas and their planned land use are described below. Figure 2-4 presents the general locations of these Policy Areas and associated land use, using the corresponding land use designations from the Fairfax County watershed plans.

Route 50 Corridor Business Area

Areas in Loudoun County generally adjacent to and north of Route 50 have planned commercial, business, retail and industrial land uses. Industrial areas are planned for north of Route 50 near Dulles International Airport. Areas south of and adjacent to Route 50 are planned for business and commercial land uses. Planned development along this highway will be similar to the existing and new development along the adjacent Fairfax County portions of Route 50.

Suburban Policy Area

Areas between Braddock Road and Route 50 are in the Suburban Policy Area and include a mix of residential development densities. Approved development plans for these areas were used to identify the future land use. This area will have a mix of low-, medium- and high-density residential development similar to that in Fairfax County's Big Rocky Run and upper Flatlick branch subwatersheds.

Transition Policy Area

Areas in Loudoun County south of Braddock Road are designated by the Loudoun County General Plan as the Lower Foley and Lower Bull Run Transition Policy areas. The Transition Policy areas provide a transition between the Suburban and Rural Policy Areas.

The Lower Foley Transition Policy area includes portions of the Elklick Run subwatershed south of Braddock Road. The plan allows for a blend of residential development, including countryside villages on central utilities at residential densities up to two dwelling units per acre. Development in a clustered pattern at one unit per three acres or one unit per acre is appropriate. Density transfers from the Lower Bull Run Transition Policy area would allow countryside villages at densities of up to three units per acre.

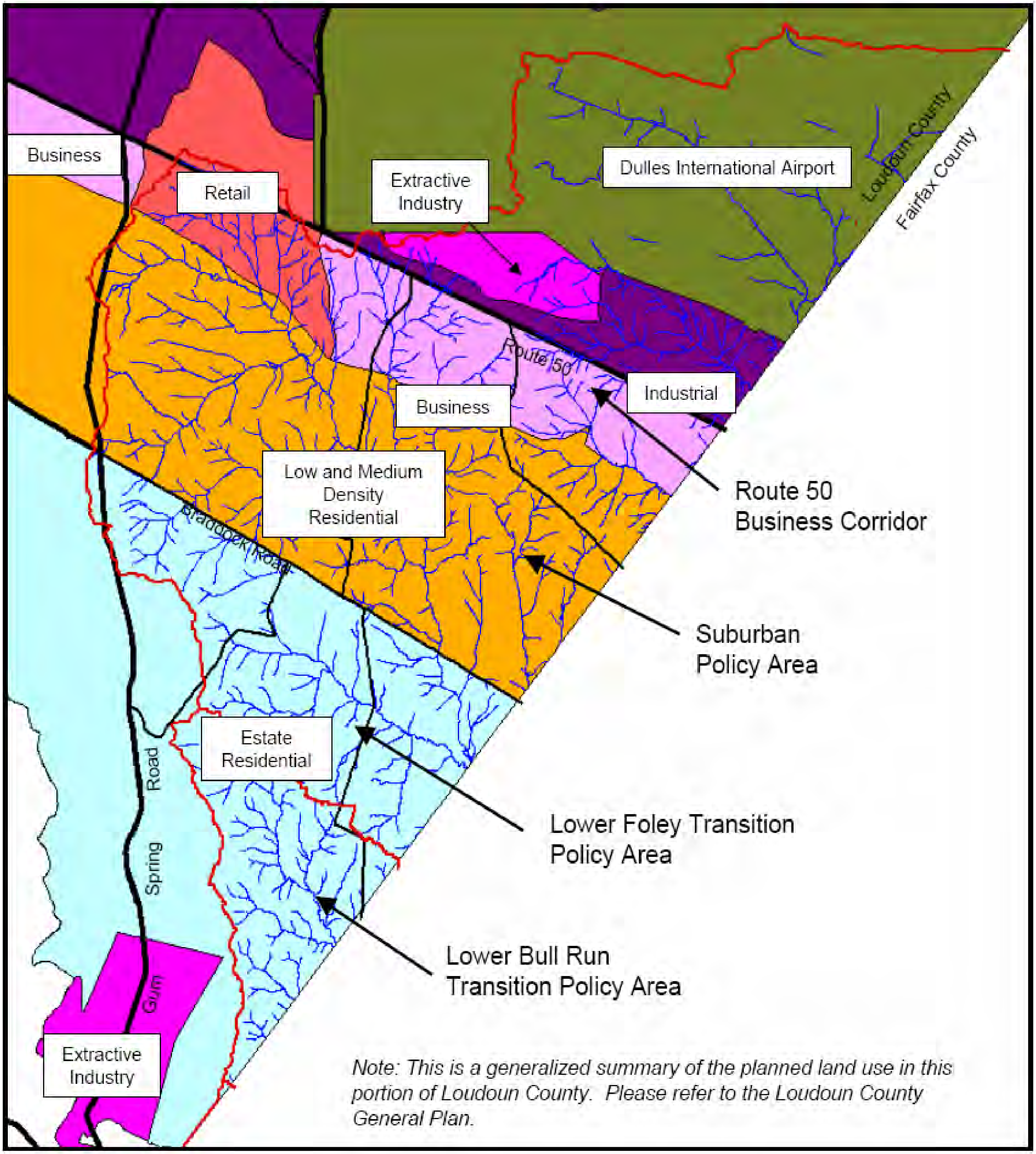


Figure 2-4
Planned Land Use and Planning Policy Areas in the Loudoun County Portions of the Watershed

The modeling of this area assumed an average density of one house per two acres having an impervious area of 13 percent based on the Loudoun County General Plan. Judging from the approved and pending development plans submitted after the modeling was completed, the modeled density is probably less than the density that will occur. The density will be greater than the five-acre minimum lot size allowed in the adjacent Fairfax County R-C District and will affect conditions in the Fairfax County streams downstream from this development.

2.4.3 Dulles International Airport

Dulles International Airport controls a large area (4,500 acres) in the headwaters of Cub Run. This airport property includes Sand Branch and Dead Run along with unnamed tributaries.

Much of the airport property is and will remain undeveloped to provide required safety buffers near the runways. Runways, taxiways, ramps, parking, terminals, hangers and other support facilities contribute significantly to the impervious area within the airport boundaries. Some of these facilities were constructed in the early 1970s and do not have stormwater peak shaving or water quality controls.

The airport has a long-range (25-year) plan to construct new facilities (Figure 2-5). The planned facilities include a new north-south runway and associated taxiways, a new east-west runway and associated taxiways and new terminal facilities. These improvements will significantly increase the total impervious area in the upper Cub Run watershed. Construction will directly disturb streams and wetlands within the airport property.

A final Environmental Impact Statement (FEIS) and record of decision for these improvements was published in 2005. Build Alternative 3 was selected as the preferred alternative. During FAA's review process it became clear that two alternatives met the purpose and need for the project. However, build Alternative 3 (Figure 2-5) has the fewest overall environmental impacts. According to the FEIS, impacts include approximately 286.1 acres of wetland impacts, 39 acres of 100-year floodplain impacts, 124,045 linear feet (23.5 miles) of stream impacts and 3,485.6 acres of biotic community impacts.

To compensate for the unavoidable wetland and stream losses, the Metropolitan Washington Airports Authority (MWAA) has proposed to purchase credits from wetland and stream mitigation banks. A mitigation bank is a wetland or stream area that has been restored, created, enhanced, or (in exceptional circumstances) preserved, and set aside to compensate for future impacts of development on wetlands and streams.

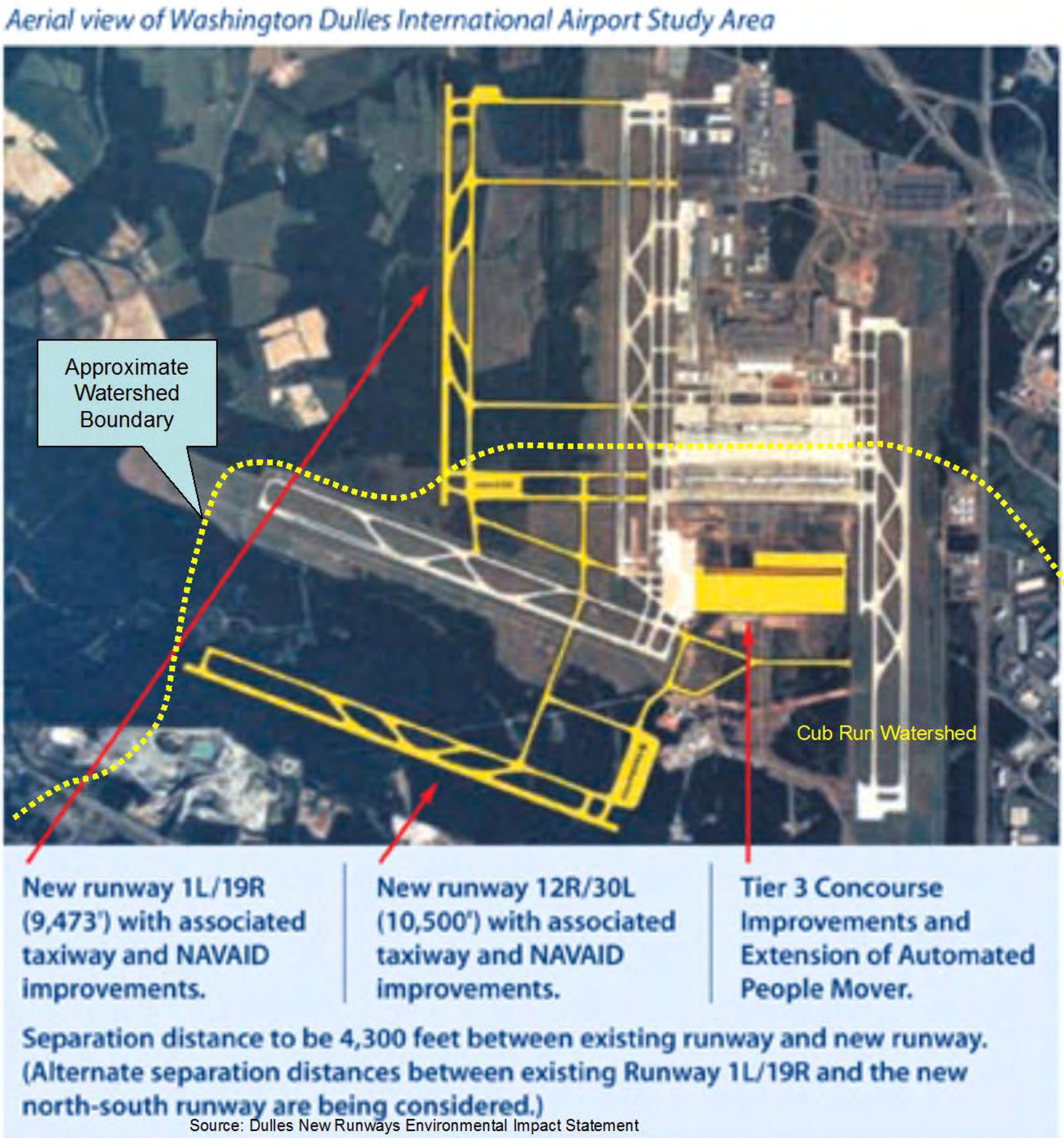


Figure 2-5
Planned Improvements at Dulles International Airport

As a federal agency, the Federal Aviation Administration (FAA) is not strictly required to provide the stormwater controls required by Fairfax and Loudoun counties. The stormwater management plan for the new improvements includes stormwater detention and water quality controls. Fairfax County and Loudoun County are working closely with the FAA and the MWAA to ensure improvements include stormwater controls that provide a level of protection similar to that required by the counties.

Based on discussions with the MWAA, development will include innovative stormwater controls that will mitigate the impacts near the source. The initial project phases will not affect the Cub Run streams. This will provide an opportunity to evaluate the efficacy of these stormwater controls. Also, the current plans for the Cub Run portion of the airport includes a large dry pond that will provide controls for areas that currently have no stormwater facilities.

The FEIS documents that the 100-year floodplain elevations will not increase more than one foot. A one foot increase would affect residential properties, with the most significant impacts in the Pleasant Valley neighborhood. In an August 30, 2005 letter to the U.S. Army Corps of Engineers, the MWAA has made a commitment to provide "stormwater retention that will prevent an increase in peak flows for the 1-, 2-, 10- and 100-year storms off-airport." These facilities ensure no downstream increase in the 100-year flood elevation.

In addition to the above improvements, other areas of the Dulles International Airport property may be developed. For example, the Smithsonian National Air and Space Museum Udvar-Hazy Center is on airport property. Evaluations for this study assume areas south of the museum may be developed at a density comparable to Low Intensity Commercial. There are no documented plans to develop this area; however, nothing precludes development. Given the need for airport support services, including parking and car rental, such development may occur in this area. This assumption includes the potential impacts of this development on the Cub Run watershed.

2.4.4 Highway Construction Projects

Several highway construction projects are planned within the Cub Run and Bull Run watersheds. Construction of highways and stream crossings will have direct impacts on the streams and stream valleys along the highway routes. Increased impervious area and resulting increase in runoff will affect local streams.

Tri-County Parkway

Several potential routes for the proposed Tri-County Parkway affect the Cub Run and Bull Run watersheds. At the request of Fairfax, Loudoun and Prince William counties, the Virginia Department of Transportation (VDOT) and the Federal Highway Administration (FHWA) initiated this study to evaluate a new north/south transportation link in Northern Virginia to connect the City of Manassas with I-66 and the Loudoun County Parkway in the Dulles area. The Tri-County Parkway is contained in the Northern Virginia 2020 Transportation Plan and in the comprehensive plans for Fairfax, Loudoun and Prince William counties.

A Draft Environmental Impact Study (DEIS) was completed for this highway project in the fall of 2005. The following two build alternatives affect the Cub Run and Bull Run watersheds:

The Comprehensive Plan Build Alternative

The Comprehensive Plan build alternative closely follows the routes in the Fairfax and Loudoun County Comprehensive Land Use Plans consisting of segments F', F, and E on Figure 2-6. The southern extent of the Loudoun County Parkway is Braddock Road (Route 620). The proposed route starts at the Loudoun County Parkway at Braddock Road and passes through the eastern portion of the Bull Run Regional Park. This alignment ends at the VA 234 and VA 28 interchange south of the City of Manassas.

This route has the greatest length within the Cub Run and Bull Run watersheds, affecting primarily the Bull Run West and Lower Cub Run subwatersheds. The proposed route places the highway on or very near the Cub Run stream though Bull Run Regional Park.

According to the DEIS, this alternative will:

- Affect 43,000 linear feet of streams
- Affect 49 acres of wetlands
- Affect 440 acres of forest land
- Affect 278.8 acres of 100-year floodplain
- Result in the channelization of portions of the Cub Run main stem
- Disrupt functions of the large Bull Run and Cub Run floodplain near the confluence of those two streams
- Affect significant areas of public and private open space in the R-C zoning district along Bull Run Post Office Road
- Affect Elklick Run in Loudoun County which drains into Fairfax County

The West Four Build Alternative

The West Four build alternative consists of Segments F', G, and C on Figure 2-6. The route starts at the southern terminus of the Loudoun County Parkway at Braddock Road (Route 620) and proceeds southwest, ending at the 234/I-66 interchange near the western boundary of the Manassas National Battlefield Park.

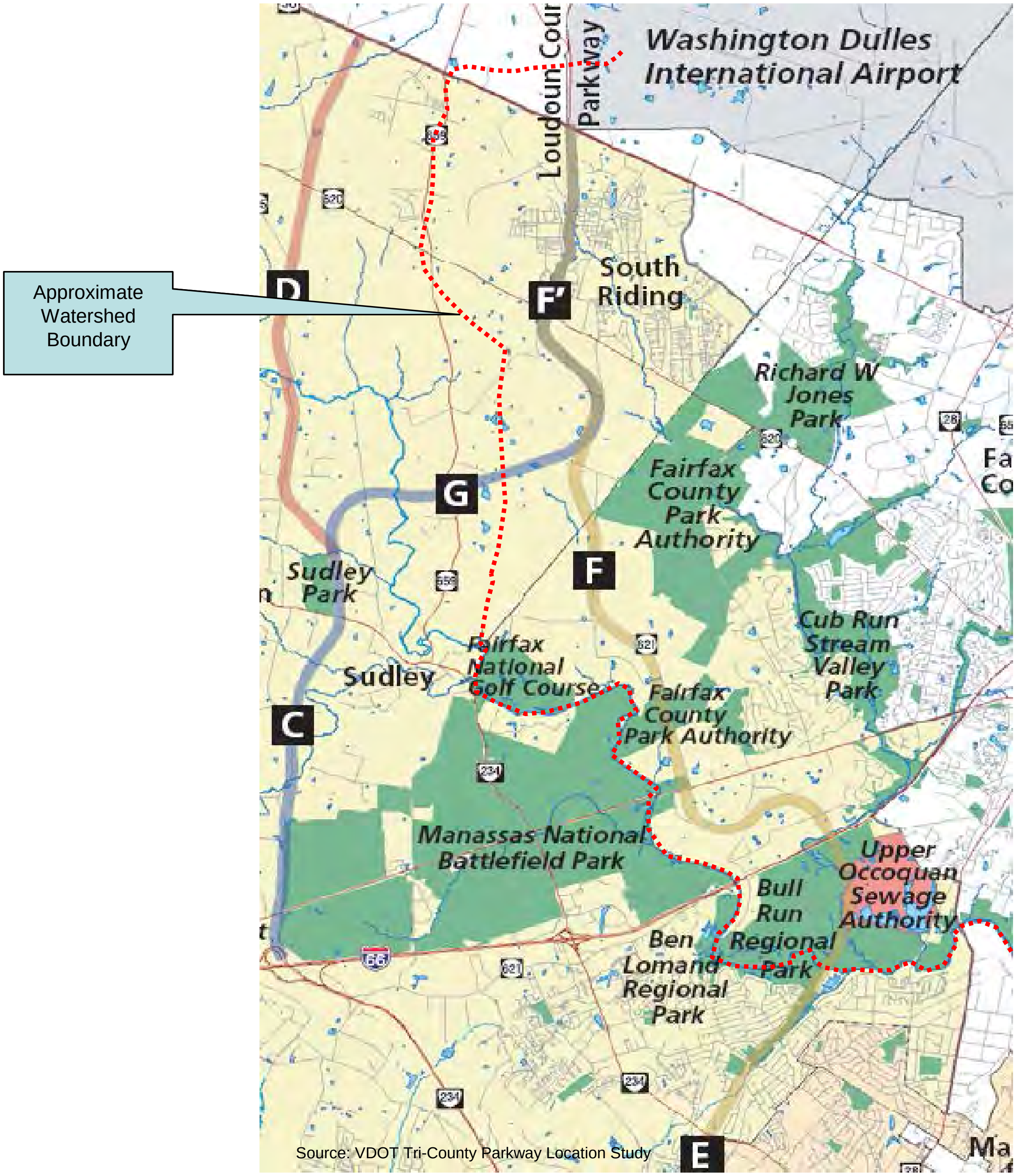


Figure 2-6
Candidate Build Alternatives for the
Tri-County Parkway

This route has a shorter length within the Cub Run and Bull Run watersheds. The route will affect the headwaters of Elklick Run and Cub Run but not the major streams directly.

Selected Alternative

Findings from the DEIS, input from the public hearings and local governments and comments on the DEIS were presented to the Commonwealth Transportation Board (CTB) during its September 2005 meeting. On November 17, 2005, the CTB approved the West Two Alternative for the Tri-County Parkway which lies outside the Cub Run and Bull Run watersheds. It is composed of segments D and C on Figure 2-6, west of the Manassas National Battlefield. The alignment starts at US 50, John S. Mosby Highway, and extends southerly, ending at the 234/I-66 interchange, near the western boundary of the Manassas National Battlefield Park. The alignment is 10.5 miles long.

Manassas National Battlefield Park Bypass

The proposed Manassas National Battlefield Park Bypass will affect the Bull Run West subwatershed. The Federal Manassas National Battlefield Park Amendments Act required that the Federal Highway Administration conduct a study regarding the relocation of routes 29 and 234 within the Manassas National Battlefield Park with the goal of closing these highways within the park boundaries. The study identified five potential routes. A Draft Environmental Impact Statement (DEIS) was published in March 2005, and the public comment period closed in June 2005. The final DEIS has not yet been published.

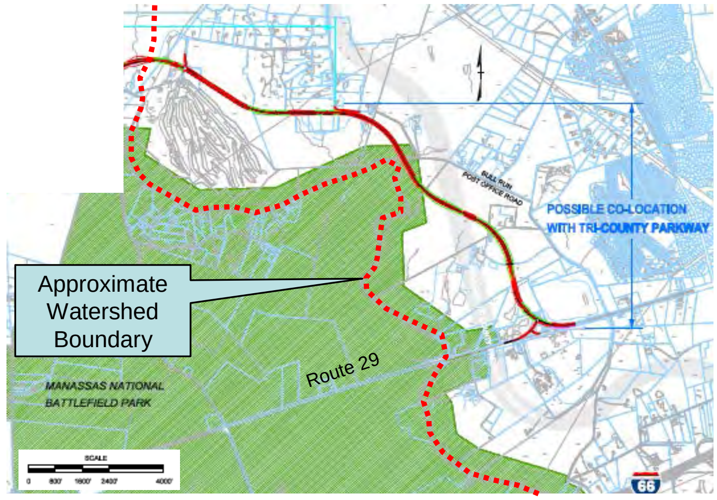
All five build alternatives affect the western portions of the Bull Run West subwatershed near Bull Run. The portions of these routes within the Cub Run watershed are shown on Figure 2-7. This figure includes modifications to alternative D based on input from the public.

The northern alternatives, A, B, C and D, start at Route 29 between Bull Run and Pleasant Valley Road. Alternatives A and B are further north; B and C are closer to Bull Run. Alternative D is identified as the preferred alternative in the DEIS. Alternatives A, B, C and D affect significant public and private open space in the R-C District along Bull Run Post Office Road. Build alternatives C and the preferred alignment D would have one bridge crossing of Bull Run, and affect large areas of bottomland hardwood forest and floodplain as well as parkland and other open space.

The southerly alternative G starts at Route 28 and Bull Run Post Office Road, and proceeds south to parallel Route 66. This alternative has fewer impacts on the Bull Run West watershed than the northerly alternatives but still includes one crossing of Bull Run that will affect private and public lands, and wetlands within the 100-year floodplain.

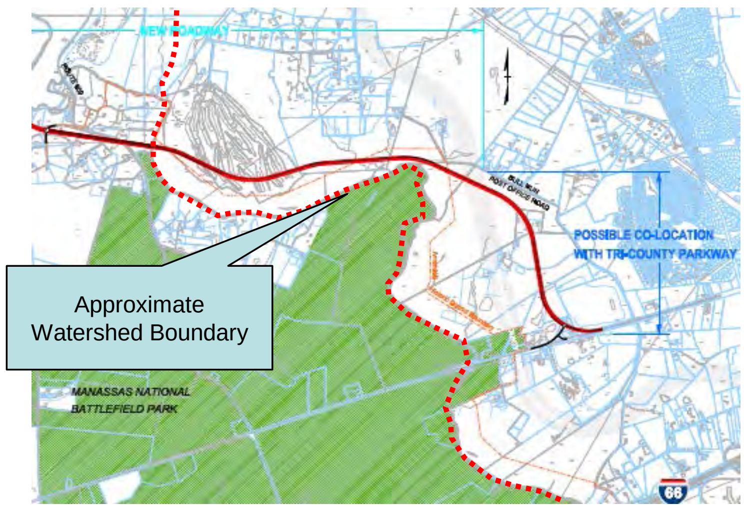
Candidate Build

Alternatives A and B



Candidate Build

Alternatives C and D



Candidate Build
Alternatives G

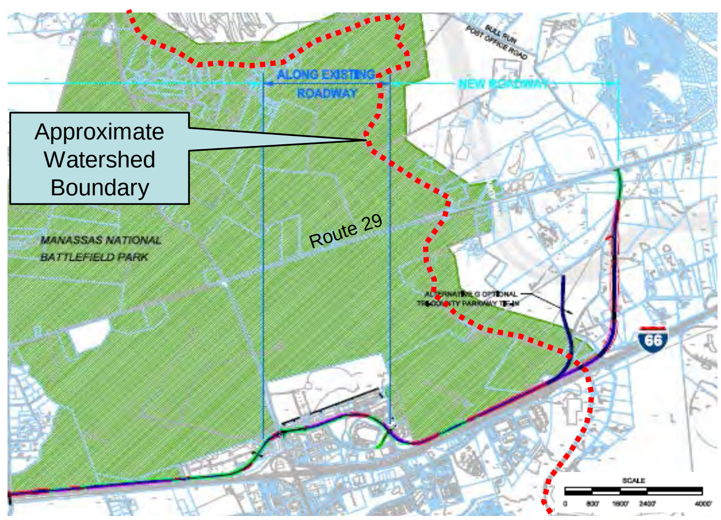


Figure 2-7
Manassas National Battlefield
Park Bypass Build Alternatives

Other Highway Improvement Projects

The Fairfax County Comprehensive Plan includes the following highway projects within the Cub Run and Bull Run watersheds:

- Widening of Pleasant Valley Road to four lanes.
- Widening of Walney Road to four lanes between Poplar Tree Road and Route 50. The only remaining two-lane segment is where Walney Road crosses Flatlick Branch and will eliminate frequent roadway flooding.
- Extending Poplar Tree Road as a four-lane road between Walney Road and Stonecroft Boulevard. This improvement has been completed as Westfields Boulevard.
- Constructing various Route 28 interchange improvements (Route 50, Westfields Boulevard) within the watershed. These improvements have been completed or are under construction. The planned construction of an interchange at Willard Road will affect the watershed.
- Widening of Braddock Road and Old Lee Road. The transportation plan widens Braddock Road to four lanes from the Loudoun County line to a location east of Pleasant Valley Road, and constructs a new four-lane road (referred to as the Old Lee Road extension) from this location to Old Lee Road. Old Lee Road would also be widened to four lanes from the extension to a location near Willard Road and Lee Road. Under the planned widening, Braddock Road would remain two lanes east of the Old Lee Road extension. This project would improve the Braddock Road and Old Lee Road bridge crossings of Cub Run, eliminating frequent roadway flooding at these two locations.

  The widening of Pleasant Valley Road, widening of Braddock Road, and construction of the Old Lee Road extension will affect open space, public parks (primarily the Sully Woodlands Fairfax County Park Authority Park) and streams in the watershed.

2.5 Stormwater Management History

The following presents the history of stormwater management requirements in the watershed and their impact on Cub Run and Bull Run. Because of past stormwater management efforts, Cub Run watershed ranks high among other watersheds in the county for having the greatest number and density of stormwater controls serving its existing development.

2.5.1 Cub and Bull Run Watershed Drainage Plan: March 1979

The 1979 Fairfax County Master Plan for Flood Control and Drainage for the Cub Run and Bull Run watersheds documents stormwater management problems from the late 1970s and predicts future stormwater problems resulting from the development of the watersheds. At the time of this study, the watersheds were categorized as predominantly rural, with farmland, recreational space and vacant tracts accounting for more than 50 percent of the land area. The report documents five major residential centers: 1) Greenbriar and Brookfield subdivisions along Stringfellow Road south of Route 50, 2) the unincorporated Centreville area, 3) Country Club Manor near Sully Station, 4) Meadows of Chantilly Mobile Home Community south of Route 50 west of Route 28 and 5) London Town at the intersection of Route 29 and Stone Road. Commercial and industrial development was limited. Figures in the 1979 report document residential development constructed before 1980.

The report accurately recognized that the study area would grow rapidly between 1990 and 2000. To mediate anticipated stormwater flooding and erosion problems, and enable watershed drainage-ways to carry stormwater safely with minimal disruption, 46 projects with a cost of $2.9 million (1979 dollars) were recommended. The projects primarily included road crossing improvements, riprap installation or gabion streambank protection, and relocation of houses susceptible to flooding.

As was the standard at that time, the improvements focused on providing drainage and preventing flooding. Although the possibility of negative environmental impacts from watershed development is briefly mentioned, the plan does not include projects for storing increased stormwater runoff or improving water quality.

2.5.2 Peak-Shaving Stormwater Controls

Since 1972, the county has required new development to include stormwater facilities (primarily detention ponds) that control the peak runoff for all areas in the county. The early requirement was for the control of the 10-year peak flow. A requirement for control of the 2-year flow was introduced in 1979. The Fairfax County Public Facilities Manual requires that the peak flows produced by the 2- and 10-year storm events are not increased by the new development. Since most of the construction has occurred since 1972, much of the development in the watershed has peak shaving controls.

Peak shaving stores flows in a stormwater pond and releases it at a rate equal to the predevelopment flow rate.

2.5.3 Neighborhoods without Stormwater Controls

Several medium-density residential areas (0.25-acre lots) were developed before peak-shaving controls were required. These areas, their approximate drainage area and their subwatersheds are listed below:

- Greenbriar and Birch Pond (614 acres): Middle Big Rocky Run – Frog Branch
- Brookfield (326 acres): Frog Branch and Flatlick Branch
- Country Club Manor (353 acres): Lower Round Lick and directly to Cub Run main stem (includes Chalet Woods)
- Pleasant Valley (193 acres): Directly to Cub Run main stem

Pleasant Valley was built before water quality controls were required but should have peak flow controls based on the date of the development (approximately 1980). This area was likely granted a detention waiver at the time of development, since it is along the major floodplain of the Cub Run main stem. A pond at this location could delay peak flows from the development sufficiently such that it coincides with flows from upstream areas producing a higher peak flow and greater potential for flooding in Cub Run.

These uncontrolled medium-density residential areas are highlighted on Figure 2-8. The total area is 1,486 acres or about six percent of the total drainage area of Cub Run in Fairfax County (39 square miles).

2.5.4 Regional Stormwater Ponds

In 1989, the county developed a plan that identified the location of regional stormwater ponds in its then developing portions (Cub Run, Difficult Run, Little Rocky Run, Horsepen Creek and Sugarland Run). The goal of the Regional Stormwater Management Plan was to reduce the number of structural stormwater management controls (wet ponds and dry ponds) with larger regional stormwater facilities. The fewer number of regional ponds would be easier and less costly to maintain. Drainage areas for regional ponds range from 100 to 300 acres. Onsite structural stormwater management controls for individual developments have drainage areas typically less than 20 acres. A single regional pond could eliminate the need for as many as 10 to 20 onsite ponds.

The 1989 stormwater management plan recommended 31 regional pond sites in the Cub Run watershed. Seventeen ponds (60 percent) have been constructed, leaving 14 in various planning stages. Several regional ponds were moved from the original proposed locations, and some were constructed with reduced storage volume. An additional regional pond near Fair Lakes has also been constructed.

The locations of the existing and proposed regional ponds are shown on Figure 2-9.

Combined, the existing regional stormwater ponds cover 4.6 square miles or 12 percent of the Cub Run watershed in Fairfax County and approximately 20 percent of the developed acreage. These regional ponds provide both peak flow and water quality control for the upstream watershed.

In some cases development within the areas upstream from unconstructed regional ponds may have been granted a detention waiver by the county. The requirement for constructing peak flow controls was waived with the understanding that the regional pond would be constructed in the future to provide the required peak flow control. Water quality control requirements were not waived in the Occoquan Reservoir watershed which includes Cub Run and Bull Run. Temporary ponds were sometimes constructed with the understanding that the property on which the facility is located could be developed if the regional pond is constructed.

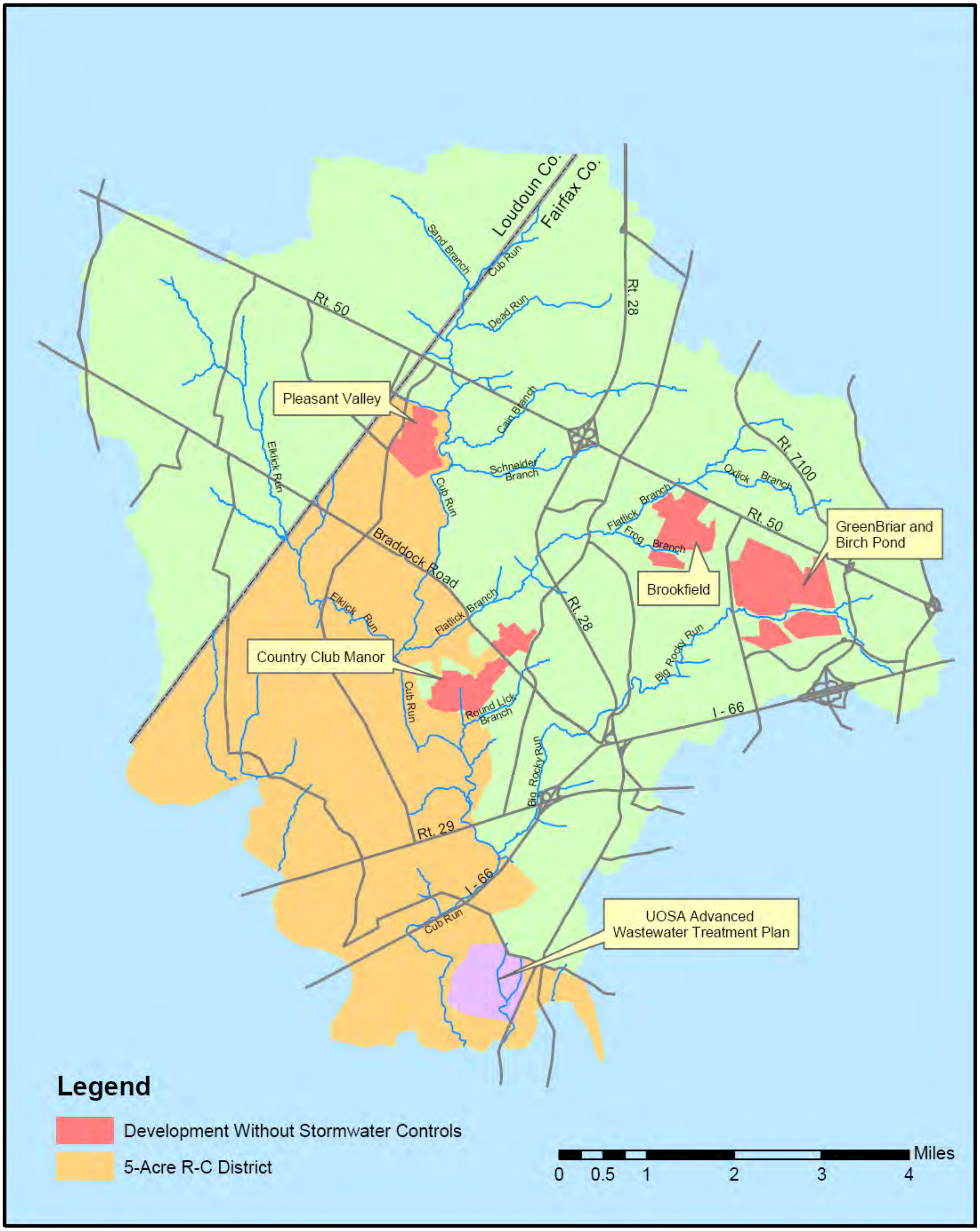


Figure 2-8
Neighborhoods Without Stormwater Controls and the Upper Occoquan Sewage Authority Advanced Wastewater Treatment Plant

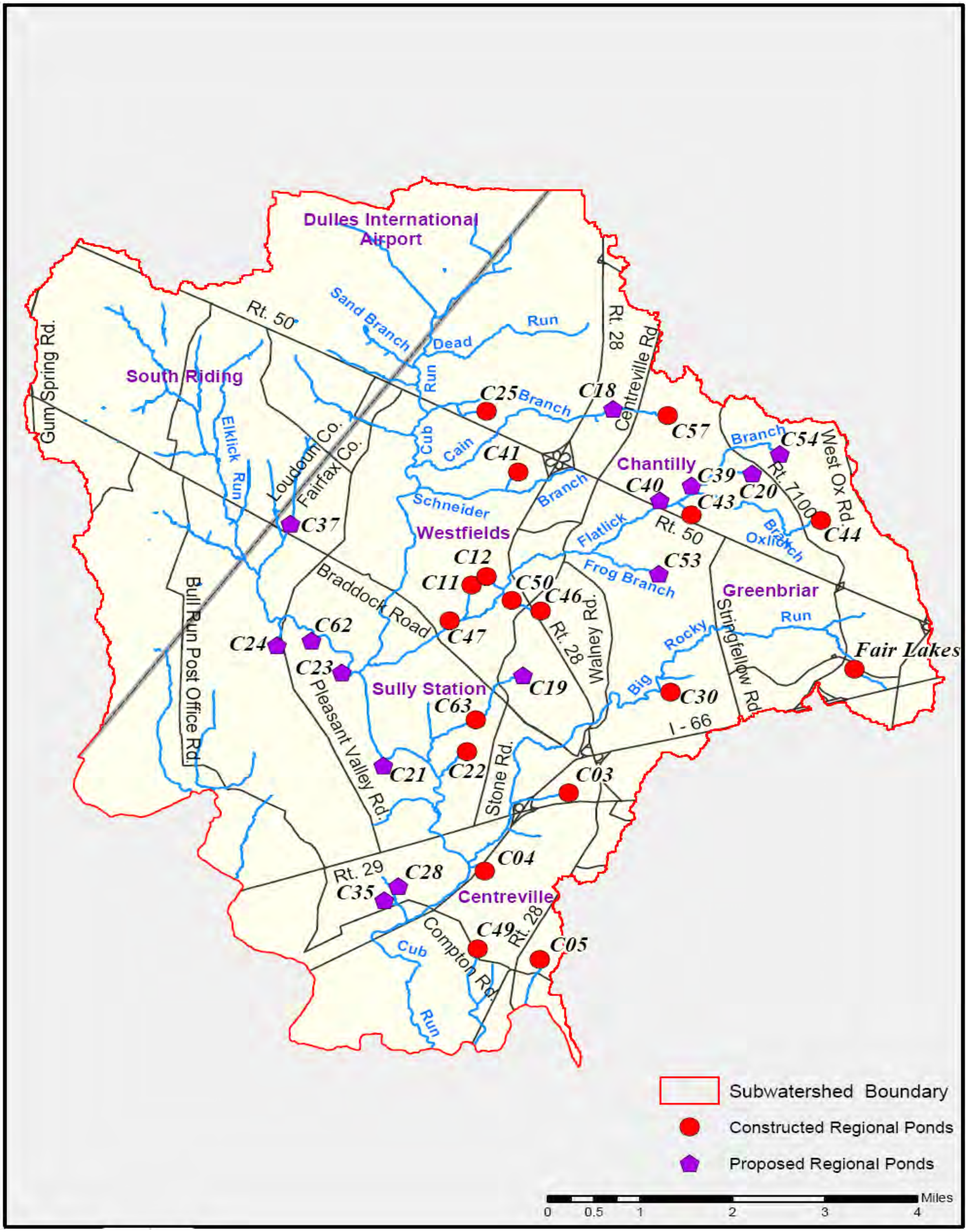


Figure 2-9
Existing and Proposed
Fairfax County Regional Ponds

Detention waivers do not have a major impact on the stormwater controls in the Cub Run and Bull Run watersheds. All proposed regional pond sites have upstream stormwater ponds.

The Fairfax County regional pond program has not been fully implemented, primarily due to opposition from the residents who lived near the proposed pond sites. Section 6.2 further discusses the regional ponds that have not been constructed and identifies those recommended for construction as part of the Cub Run and Bull Run Watershed Management Plan. These evaluations consider the need for the proposed regional ponds and evaluate stormwater alternatives to supplant or reduce the size of the ponds.

The following sections summarize several reports and studies that relate to the Fairfax County regional stormwater pond program.

2.5.4.1 Regional Stormwater Management Plan: January 1989

The goal of this study was to enhance the efficiency and cost-effectiveness of stormwater management in Fairfax County by strategically locating larger regional detention facilities in lieu of numerous smaller onsite detention dry or wet ponds for development projects.

This study identified a regional detention facility network for the then rapidly developing sections of Fairfax County that provided water quality, erosion and flood control benefits. The plan identified the locations, provided a conceptual design, and documented the flood and streambank erosion-control benefits provided by the regional ponds.

For the Cub Run watershed, the plan also identified regional pond sites that provide sufficient storage volumes to accommodate wet detention water quality storage to meet Occoquan Reservoir Water Supply Protection Overlay District (WSPOD) nutrient reduction requirements.

The 1989 regional stormwater management plan identified the location of 31 regional detention regional ponds (21 wet and 10 extended dry) within the Cub Run watershed. The study included 12 existing regional ponds.

For the entire Occoquan Reservoir watershed in Fairfax County (100.8 square miles), the recommended regional facilities were projected to reduce future total phosphorus annual loadings by 11 percent and total nitrogen annual loadings by seven percent.

2.5.4.2 The Role of Regional Ponds in Fairfax County's Watershed Management: March 2003

The Regional Pond Subcommittee's main objective was to develop a unified position on the use of regional ponds as well as alternative stormwater controls. The report presents findings concerning regional ponds related to the following:

- Ecology
- Economics
- Local, State, and Federal Permits, Regulations and Policies
- Hydrology and Design
- Land Use and Watershed Management
- Parks and Recreation
- Health and Safety
- Aesthetics
- Construction Planning and Phasing
- Public Participation, Outreach and Support
- Stormwater Management in Other Jurisdictions

The report also summarizes the findings of the 1989 report on the safety and liability task force for stormwater management.

As a result of these findings, the Regional Pond Subcommittee formulated an ideal stormwater management program.

The subcommittee's unified position on regional ponds and other watershed management tools is that regional ponds should not be considered the preferred stormwater management alternative. Rather, regional ponds should be considered one of many tools available for stormwater management.

The following highlight the key points contained in the 61 recommendations for improving the Fairfax County stormwater management program:

- Revise the current county policy regarding regional ponds to reflect the subcommittee's unified position on regional ponds.

- Develop recommendations for stormwater management practices as part of the watershed planning process. Until that time, use a proposed interim decision matrix to determine whether regional ponds are appropriate. A pilot project should be initiated to validate the interim decision matrix.

- Develop a second matrix in preparing watershed management plans. This matrix should provide options when considering and evaluating stormwater management alternatives.

- Evaluate the impacts on stormwater management systems carefully when making land use decisions.

The subcommittee recommends the following:

- Require temporary onsite facilities in watersheds where regional facilities are planned, until regional ponds or equivalent stormwater practices are implemented.

- Establish conditions on stormwater management (detention) and BMP (water quality) waivers to ensure that measures are provided to offset, to the greatest extent practicable, the impacts of the waivers being granted. Waivers dealing with stormwater controls and floodplain management should only be granted in concurrence with watershed management plans.

- Use alternatives to regional ponds where consistent with the watershed management plans. When regional ponds are warranted, techniques should be used to reduce the impacts of the pond.

- Allocate adequate resources to accomplish these recommendations.

2.5.4.3 Forested Wetlands Committee Report: April 1993

The Forested Wetlands Committee report to the Fairfax County Board of Supervisors on "Methods to Protect Wetlands during Implementation of Regional Stormwater Ponds" was prepared in April 1993. This report identifies methods that minimize forested wetland disturbance produced by regional stormwater management ponds. The committee also reviewed the Code of Virginia stormwater utility enabling legislation for its potential application in Fairfax County.

Committee recommendations include the following:

1. Institute a wetlands protection policy for regional ponds

2. Encourage innovative and state-of-the-art regional pond designs

3. Improve regional pond maintenance and efficiency

4. Develop policies that address unprotected areas of the regional system. This recommendation targets stream segments and wetlands located upstream of the planned and constructed regional ponds. The recommendation also identifies the need to protect stream segments before building the regional pond.

5. Provide recommendations for constructing wet versus dry regional ponds

6. Re-examine the county regional pond program periodically

7. Consider placing regional ponds outside the major floodplain

2.5.5 Pro Rata Share Master Plan for Flood Control and Drainage Projects

The Department of Public Works and Environmental Services maintains a Fairfax County Master Plan for Flood Control and Drainage Pro-Rata Share Projects. These projects form the basis for pro-rata charges for new development in the watershed. When a new development is constructed, the developer pays into a fund for implementing stormwater improvements within the watershed. The payment amount is computed, or pro-rated, based on the impervious area created by the development.

These projects were derived from multiple sources, including a 1978 report completed by Parsons, Brinckerhoff, Quade & Douglass, the Regional Pond Plan completed in 1988, citizen drainage complaints, maintenance problems and local drainage studies. The county maintains a database of drainage projects identified from these sources.

The Master Plan includes 66 pro-rata projects in the Bull Run and Cub Run watersheds. Reviewing the number and types of projects included in the Master Plan is useful since they reflect an appraisal of watershed conditions that need to be evaluated and addressed in the Cub Run watershed plan. These projects are also evaluated for inclusion in the watershed plan. The status of these projects are documented in Section 6-10.

The Bull Run watershed includes five stream-crossing improvement projects along Bull Run Post Office Road and Sudley Road. No other projects are located in the Bull Run watershed.

The projects within the Cub Run watershed are summarized in the following sections.

2.5.5.1 Cub Run Watershed Road Crossing Improvement Projects

Six projects identify the need to replace the culvert or bridge, and/or raise the road elevation at locations where roads cross streams. Streams frequently overtop the roadway during rain storms at these locations:

- CU401 - Compton Road upstream from UOSA advanced wastewater treatment facility (65-3)
- CU411 – Compton Road at small tributary to Cub Run (64-3)
- CU421 - Heron Drive at small tributary to Big Rocky Run (54-2)
- CU451 – Dorforth Drive at small tributary to Big Rocky Run (45-4)
- CU481 – Birch Drive at small tributary to Flatlick Branch (34-4)
- Lees Corner Road at Flatlick Branch (34-2)

The tax map on which the crossing is located is indicated in parentheses.

2.5.5.2 Cub Run Watershed Regional Stormwater Ponds

The Pro-Rata Share Project Master Plan includes 32 regional stormwater ponds within the Cub Run watershed. This includes the 31 sites recommended in the 1989 Regional Stormwater Management Plan as well as one additional site in Fair Lakes. The status of the regional ponds is summarized below:

Number of Ponds	Status	Regional Pond Sites
8	Constructed as recommended in the 1989 Regional Stormwater Management Plan	C04, C11, C12, C25, C30, C41, C46, C47
10	Constructed at reduced size or volume from the recommendations in the 1989 Regional Stormwater Management Plan. Some aspect of the design was less than fully "regional" as defined in the 1989 Management Plan (e.g. detention storage may not be provided for the entire drainage area or the detention requirements may not have been based on undeveloped conditions).	Fair Lakes, C03, C05, C22, C43, C44, C49, C50, C57, C63
14	Unconstructed Regional Ponds	C18, C19, C20, C21, C23, C24, C28, C35, C37, C39, C40, C53, C54, C62

Figure 2-9 provides the approximate location of the constructed and not-yet-constructed regional stormwater ponds. The status of these regional ponds in the Cub Run watershed plan are presented in Section 6.2.

2.5.5.3 Cub Run Watershed Stream Restoration and Stabilization Projects

The Pro-Rata Share Project Master Plan includes 23 stream restoration and stabilization projects. These projects suggest locations were stream erosion is a primary concern.

For the most part, these projects are scattered throughout the Cub Run watershed. However, they include much of the Flatlick Branch and Frog Branch stream segments upstream from Route 28. Stream restoration projects are also identified in the lower reaches of Cub Run within Bull Run Regional Park.

None of the identified stream restoration projects were constructed. These projects were considered in developing stream restoration reaches as described in Section 6.5.

2.5.6 Other Stormwater Management Initiatives

The following provides an overview of other reports and studies related to Fairfax County stormwater management initiatives.

2.5.6.1 Infill and Residential Development Study: July 2000

The Fairfax County Departments of Planning and Zoning, Transportation, and Public Works and Environmental Services were charged by the Board of Supervisors and the Planning Commission with evaluating issues and recommending improvements for managing residential infill development. The subsequent "Infill and Residential Development Study" report was published in July 2000.

The term "infill development" includes the following residential development activities:

- Demolishing an existing home on a lot and building a larger home
- Subdividing a single lot into two or more building lots
- Developing one or more new residences on an undeveloped or underutilized site within an existing, established neighborhood
- Developing a relatively large subdivision surrounded by other subdivisions
- Redeveloping an existing subdivision

The issues most frequently cited as problems with infill development regarding its impacts on the immediate environs include:

- Compatibility of the new development with the existing neighborhood/area, including lot size, house size, house orientation, setbacks, topography, etc.
- Additional traffic congestion and cut-through traffic
- Loss of trees, tree preservation and loss of open space
- Storm drainage and erosion control
- Public outreach

The "Infill and Residential Development Study" makes recommendations that address the above issues.

Thirteen recommendations address improvements to construction-related sediment and erosion control programs. Ten recommendations concern improvements to implementation, inspection and monitoring of the sedimentation and erosion control program, and mitigation of downstream impacts during construction. These twenty-three recommendations have little impact on the Cub Run and Bull Run Watershed Management Plan.

The following three recommendations may affect the overall master planning effort in the Cub Run and Bull Run watersheds and elsewhere in the county.

SW11 – Recommendation SW11 recognized that water quality controls or best management practices (BMPs) are important for maintaining good ecological health of streams in Fairfax County. To enhance the current practices and address issues critical to improving the health of the environment, several recommendations were made that include:

- Providing additional guidance on BMP selection and enhanced design standards in the Public Facilities Manual
- Establishing a county-wide monitoring program to assess BMP performance
- Allowing BMP credit for contributions to a "land trust fund"
- Facilitating the implementation of bioretention/ biofiltration facilities ("rain gardens"), underground sand filters in residential areas, and manufactured or ultra-urban BMP systems in Fairfax as acceptable privately maintained BMPs
- Linking enhanced design features for extended detention and retention pond BMPs to increase pollutant removal efficiencies
- Encouraging the retrofitting of existing detention-only ponds to enhance water pollution treatment

SW12 - Recommendation SW12 discusses how the Public Facility Manual should be improved so the county's adequate-outfall policy is consistent with new state requirements and does more to address the outfall concerns as full urbanization is approached. The adequate-outfall policy ensures streams that receive the flow from new development or infill development have sufficient capacity and will not erode or flood. An amendment to the Public Facilities Manual adopted in February 2006 strengthens the adequate outfall requirements.

SW13 - Recommendation SW13 discusses changes to the zoning application process to ensure that residential zoning development plan applications adequately address the land area disturbance and land area requirement (footprint) for onsite stormwater management facilities. A zoning ordinance amendment adopted in March 2004 includes revisions that address recommendation SW13.

2.5.6.2 Stormwater Needs Assessment Project Recommendations

In 2003, the Department of Public Works and Environmental Services participated in a strategic planning forum to refocus the stormwater management efforts to better address the increasing expectations of county residents, state and federal regulators. This strategic planning effort identified:

1. Level of service for stormwater management should be based on a clear understanding of public needs.
2. Selected level of service must be supported by an adequate and stable source of funding.

To fully implement these major requirements into county stormwater management practice, the current county level of stormwater service was compared to the overall public need. Based on this comparison, it was recommended that the Fairfax County Department of Public Works and Environmental Services develop a comprehensive stormwater program that enhances levels of service in program management, planning, infrastructure maintenance, enforcement of performance standards, capital construction and regulatory controls.

This planning effort found that enhancing the current level of stormwater management services would initially increase total program costs from a budget of $11.7 million in fiscal year 2004 to $28 million in fiscal year 2006. As the level of service increases further during the five-year moderate growth-planning period, the projected budget would increase from $28 million in fiscal year 2006 to $52 million in fiscal year 2010. The recommended funding source for this significant increase in county level of service and overall program costs is the creation of the stormwater management user-fee along with secondary funding methods such as Pro-Rata Share, federal and state grants, and special direct fees.

Before the stormwater utility user-fee can be enacted and the level of stormwater management is increased significantly, a citizen-based advisory committee was appointed by the Board of Supervisors to review county recommendations. After seven months of discussion and review, the committee members developed the following recommendations:

1. The committee unanimously supports a long-term dedicated source of funding for the stormwater management program.

2. The committee embraces the County Executive's FY 2006 budget with a dedication of one cent on the tax rate for stormwater in addition to the current level of funding.

3. Most of the committee supports implementation of the utility fee, effective in FY 2007, to address the level of service outlined in the projected program.

2.5.7 Loudoun County Stormwater Controls

The Loudoun County Facilities Standards Manual requires that post-development peak flows from the 1- and 10-year storms should not exceed the predevelopment peak flows. Loudoun County also requires water quality BMP controls such that the annual post-development stormwater pollution load should not exceed the pre-development load. The Loudoun County standards encourage nonstructural BMP measures such as those identified in the Virginia Stormwater Management Handbook to meet these requirements. As a result of these requirements, the major development in the Cub Run watershed, South Riding, includes 10 wet ponds that serve virtually all of the developed area. Future development will have similar stormwater controls.

2.5.8 Summary of Stormwater Controls

The Cub Run watershed has one of the highest density and degree of coverage of stormwater management controls of any watershed in Fairfax County. Most of the development occurred after stormwater regulations requiring both peak shaving and water quality controls were enacted. GIS layers of the stormwater facilities

(STORMNET) include 415 wet and dry ponds in the Fairfax County portions of the watershed.

Furthermore, much of the higher-density residential development in Loudoun County (South Riding) has occurred recently and is covered by current county stormwater requirements. These areas have wet ponds that comply with Loudoun County stormwater requirements.

Only a few isolated developed residential areas do not have stormwater controls. This is in stark contrast to watersheds in eastern Fairfax County where large areas of residential development lack stormwater controls.

Most areas in the watershed provide the stormwater controls required by the Fairfax County Public Facilities Manual. These controls typically consist of wet or dry ponds.

It should be noted that the Gate Post Estates neighborhood has innovative stormwater design that incorporates elements of both low-impact development and traditional stormwater controls. This neighborhood is south of Route 29 and west of the Cub Run main stem. The streets in this neighborhood are narrower than those in the traditional Fairfax County neighborhoods. Furthermore, sidewalks are on only one side of the street. Combined, these design features reduce the impervious area.

The streets have drainage swales instead of the traditional curb and gutter designs in traditional neighborhoods. This design slows the flow velocity, reduces peak runoff flows and allows infiltration into the soils before the runoff reaches the streams. It also improves the quality of the runoff.

Gate Post Estates shows that alternative low-impact stormwater controls can be used with few, if any, drainage problems, are aesthetically pleasing and should serve as examples for designs that can be effectively implemented in new residential and commercial development.

As described further below, the Cub Run watershed streams are better than would be expected for an area with this development density. The stormwater controls described above are at least partially responsible for the current stream conditions.

2.6 Watershed Protection and Open Space Preservation Initiatives

The following sections provide information about Occoquan Reservoir watershed protection, the Chesapeake Bay Preservation Ordinance and open space preservation initiatives that affect the past, existing and future conditions in the Cub Run and Bull Run watersheds.

2.6.1 Occoquan Reservoir Watershed Protection Initiatives

The Occoquan Reservoir, owned and operated by Fairfax Water, is a major drinking water source for northern Virginia, including Fairfax County.

In the late 1960s, the reservoir's water quality was degrading, primarily due to the nutrients being discharged from point and nonpoint sources of pollution. The reservoir was experiencing periodic extensive algal blooms, resulting in serious water quality problems including taste and odor in finished drinking water, water treatment concerns, low dissolved oxygen levels and fish kills.

Several important initiatives to protect the Occoquan Reservoir water quality have significant effects on the Cub Run and Bull Run streams, development in the watersheds and stormwater controls.

2.6.1.1 Upper Occoquan Sewage Authority

In 1971, the State Water Control Board enacted the "Occoquan Policy" that regulates wastewater treatment and sanitary sewer facility design within the Occoquan Reservoir watershed. The Upper Occoquan Sewage Authority (UOSA) was created to construct, manage and operate the facilities required to meet these requirements. The UOSA advanced wastewater treatment plant (AWTP) was placed in service in 1978 and replaced 11 less efficient wastewater treatment plants in the Occoquan watershed. The UOSA water reclamation facility is in the southeastern Cub Run and Bull Run watershed.

The UOSA AWTP is one of the most technologically advanced in the United States and provides very high quality treated wastewater discharge. This AWTP resulted in significant water quality improvements in Cub Run, Bull Run and the Occoquan water supply reservoir. Treated effluent discharges to a large lake within the Bull Run East subwatershed where it is subsequently discharged to Bull Run.

Five wastewater plants located in Cub Run were taken out of service after completion of the UOSA facilities:

- Upper Cub Run - Cub Run immediately south of Cain Branch
- Middle Cub Run – Cub Run upstream from Lee Highway
- Flatlick – Flatlick Branch upstream from Sully Road
- Greenbriar – Big Rocky Run at Stringfellow Road
- Big Rocky Run – Big Rocky Run downstream from Lee Highway

These wastewater treatment plants used old wastewater treatment technologies. The elimination of these wastewater treatment plants produced significant water quality improvements in the Cub Run streams and Occoquan Reservoir.

2.6.1.2 Residential-Conservation District Rezoning

The second management program implemented in the Cub Run watershed was the reduction in the planned residential density for several thousand acres in western Fairfax County from 0.25- to 1.0-acre lot sizes to five-acre lot sizes and related rezoning within an area identified as the R-C District. This rezoning affects 18.3 square miles or about 37.5 percent of the combined Cub Run and Bull Run watershed in Fairfax County, and nearly 100 percent of the Bull Run watershed. This area is shown on Figure 2-8. The Occoquan zoning actions were adopted and became effective in 1982.

The rezoning maintains the maximum development density and impervious land cover at a level that approximates natural undeveloped runoff volumes, peak flow rates and runoff water quality. Various studies have shown that streams with an impervious area of less than 10 percent show little impact from development. Sampling by Fairfax County as part of the Stream Protection Strategy Baseline Study (January 2001) confirms that the streams in the R-C District have higher habitat quality than most of Fairfax County's streams. The higher habitat quality is due to the low imperviousness levels and resulting reduced impacts from stormwater runoff.

The R-C District may include institutional uses with greater impervious cover approved through special permit or special exception.

The following areas in the R-C District were developed at a higher density where the development existed or was planned at the time of rezoning:

- Gate Post Estates. This neighborhood includes innovative low-impact development stormwater controls (narrow streets, drainage swales and sidewalks on only one side of the street) in combination with conventional dry ponds.
- Virginia Run and other development along southern portions of Pleasant Valley Road
- Pleasant Valley

R-C District areas outside the neighborhoods identified above are generally not served by public sanitary sewer and water supply systems. These areas rely on private wells and septic systems.

Additional parcels smaller than five acres that existed at the time of the rezoning were also allowed to remain.

A related rezoning action in 1982 allowed for increased densities in portions of the watershed near Dulles International Airport to include office, commercial and industrial land uses to promote employment.

2.6.1.3 Water Supply Protection Overlay District

As part of the 1982 zoning actions, a Watershed Supply Protection Overlay District (WSPOD) was created to protect the Occoquan Reservoir water supply. The WSPOD includes all areas in Fairfax County that drain to the reservoir. The WSPOD formalized a requirement established in 1980 for stormwater controls that reduce nonpoint nutrient runoff for areas within the WSPOD but outside the R-C District. Specifically, stormwater controls were required to reduce post-development phosphorus loadings by 50 percent.

Other than the neighborhoods where development was previously planned at the time of the 1982 rezoning, water quality controls were not required for development within the R-C District. Stormwater controls are generally required for institutional uses in the R-C district that have been approved through special permit or special exception.

Cub Run developments constructed after 1980 have structural stormwater controls for water quality management. Since much of the Cub Run watershed was developed after this time, most of the developed portions of the watershed have both peak flow and water quality controls. Since relatively little development occurred in the watershed between 1972 and 1980, few areas have peak-shaving controls with no water quality controls.

The primary structural stormwater BMP controls in the Cub Run watershed are wet ponds, extended detention dry ponds and modified wet ponds that include extended detention. Wet ponds have a permanent pool that removes nutrients through settling and uptake by plants. Extended detention dry ponds are dry between storm events but store runoff when it rains and slowly release it at a controlled rate, providing nutrient removal through settling. Some ponds are hybrids of wet and extended detention.

Water quality controls in the county outside the WSPOD require a 40 percent phosphorus load reduction. The Chesapeake Bay Preservation Ordinance that required these water quality controls was enacted in 1993 - 13 years after water quality BMP controls were adopted for the Occoquan watershed, which includes the Cub Run and Bull Run watersheds, and 11 years after the adoption of the WSPOD.

The following sections provide an overview of previous reports concerning protection of the Occoquan Reservoir water supply.

2.6.1.4 Fulfilling the Promise: The Occoquan Watershed in the New Millennium: January 2003

In 2002, Fairfax County marked the 20th anniversary of the landmark decision to rezone nearly 41,000 acres in the Occoquan watershed to protect the county's water supply. As part of the 20th anniversary celebration, the Fairfax County Board of Supervisors established a New Millennium Occoquan Watershed Task Force to assess issues facing the Fairfax County portion of the Occoquan Watershed, examine gaps in programs, define the roles of volunteer organizations and provide a vision for the future management of the watershed. The Task Force was also directed to develop management options for consideration at the county level, as well as options as part of a regional watershed planning effort.

The challenge facing the county and region is how to manage the reservoir and the watershed, recognizing its primary benefit as a reliable source of safe, clean drinking water, and its importance as an integrated ecological and hydrological system with multiple uses.

The Task Force Report (January 2003) describes historical and existing conditions in the reservoir. This report can be obtained from the Fairfax County website (www.FairfaxCounty.gov) by searching for the report title.

The UOSA water reclamation facility and elimination of other, less efficient wastewater treatment plants significantly improved the reservoir's water quality.

The Fairfax County 1982 rezoning of several thousand acres to a minimum lot size of five acres and regional implementation of stormwater BMP requirements have helped to maintain the reservoir's water quality despite significant growth and development in the watershed. According to the Occoquan Watershed Monitoring Laboratory, Occoquan Reservoir water quality has remained stable or has slightly improved since 1978 when the UOSA water reclamation facility went on-line. During the same time, the population in the watershed (including the counties of Fairfax, Prince William, Loudoun and Fauquier, and the cities of Manassas and Manassas Park) has nearly tripled.

According to the Fairfax County Stream Protection Strategy Baseline Study (described in Section 2.7.1.2), many of the county's healthiest streams are in the rezoned portion of the Occoquan watershed. The large-lot development and open space minimized impervious surface cover and maximized tree canopy thereby protecting the streams. These results support the assumption that the low development density in the R-C District effectively protects the local streams without additional stormwater controls.

The task force endorses existing programs and policies aimed at maintaining water quality in the Occoquan Reservoir. The task force's report presents 29 detailed recommendations. Key recommendations that affect the Cub Run and Bull Run Watershed Management Plan include:

- Strive to reduce nutrient and sediment contributions to the reservoir beyond those being achieved through existing policies and ordinances
- Maintain the integrity of the R-C District rezoning
- Continue regular stream assessments through Stream Protection Strategy staff and continued partnership with volunteer stream monitors
- Develop and implement the Stormwater Planning Division's watershed management planning process
- Study and adopt new stormwater management designs
- Encourage the use of effective LID techniques
- Continue to press for tree conservation and preservation-enabling legislation
- Establish tree canopy goals for the Occoquan watershed and determine appropriate implementation measures for attaining those goals

- Encourage the revegetation of riparian stream buffers with native vegetation
- Implement the findings of the Infill and Residential Development Study (described in Section 2.5.6.1)
- Fully fund watershed management planning as well as the implementation of adopted plan measures. As part of the planning process:
  - Investigate the effectiveness of existing stream valley protection mechanisms
  - Identify additional regulatory and/or non-regulatory measures that may be needed to protect stream valleys adequately
  - Identify additional performance requirements that may be appropriate to ensure that by-right development in the R-C District will not adversely affect stream quality
- Investigate an "Onsite Sewage Disposal System Management Authority" that would perform routine maintenance and monitor all onsite sewage treatment systems within the watershed. Onsite disposal systems refer to septic systems and other sewage disposal systems that serve single residences or group of residences not served by publicly operated sanitary sewer systems.

Many of these recommendations are addressed by the actions in this watershed plan.

2.6.1.5 Northern Virginia Regional Commission's Occoquan Reservoir Watershed Program and Watershed Model

The Northern Virginia Regional Commission (NVRC) maintains the Occoquan program and watershed model. The purpose of NVRC's Occoquan Reservoir Watershed Nonpoint Pollution Management Program is to help localities maintain water quality in the Occoquan Reservoir through control of nonpoint pollutant loadings. NVRC maintains the Occoquan Reservoir Watershed Computer Model. During the early 1980s, this model was the basis for rezoning the Fairfax County portion of the watershed to protect the Occoquan Reservoir drinking water supply from pollution from urban development. Every five years, NVRC assesses changes in land uses in the watershed to update the model and to help localities determine whether additional land management is needed.

2.6.1.6 Fairfax Water Source Water Assessment Program

Under the Safe Drinking Water Act, states are required to develop comprehensive Source Water Assessment programs that identify the critical watersheds that supply public drinking water, provide an inventory of contaminants in the watershed and assess the susceptibility of the water supply to contamination. The Source Water Assessment Report is available through the Fairfax Water website at www.FairfaxWater.ORG.

For the Occoquan Reservoir water supply, the source water assessment area is defined as those areas of Fairfax and Prince William counties directly tributary to the Occoquan Reservoir. This includes only those areas downstream of Lake Jackson and the free-flowing portion of Bull Run. The Cub Run and Bull Run watersheds are not included in the designated Occoquan Reservoir source water assessment area.

The assessment area is further broken down into Zone 1, defined as the 5-mile radius upstream of the intake at Occoquan Dam, and Zone 2, which includes the remaining area. The Occoquan source water assessment area is 64 square miles, with 25 square miles in Zone 1 and 39 square miles in Zone 2.

The Source Water Assessment inventories the land use, identifies potential users of hazardous materials and documents sources of water contamination that have occurred over the past five years. Source water susceptibility assessments for Fairfax Water raw water supplies were conducted by the Virginia Department of Health. Based on state criteria, the Potomac River and the Occoquan Reservoir water supplies are highly susceptible to contamination. This determination is consistent with the state's findings for other surface water supply sources (rivers, lakes, streams) throughout Virginia.

2.6.2 Chesapeake Bay Preservation Ordinance

Revisions to the Fairfax County Chesapeake Bay Preservation Ordinance (CBPO) were adopted on November 18, 2003. This ordinance identifies Resource Protection Areas (RPA) that protect water quality and habitat by filtering stormwater runoff, reducing the volume of stormwater runoff, preventing erosion and performing other biological and ecological functions.

Resource Protection Areas include: 1) tidal wetlands, 2) tidal shores, 3) water bodies with perennial flow, 4) nontidal wetlands connected by surface flow and contiguous to a tidal wetland or water body with perennial flow and 5) buffer areas that includes all land within a major floodplain or within 100 feet of a feature identified in 1 through 4.

With few exceptions, the CBPO regulations limit new development or disturbance within the RPA. However, structures and disturbance in the RPA that existed at the time the ordinance was adopted are allowed to remain.

The RPAs are a powerful tool that protect the stream valleys from future development and redevelopment.

Figure 2-10 shows the approximate extent of the RPA in the Cub Run watershed based on recent Fairfax County mapping studies. This map shows the general extent of the RPA within the watershed. The extent of the RPA is constantly being revised. Please refer to recent official maps for an accurate and current depiction.

The RPA covers six square miles or 13 percent of the Fairfax County portions of the Cub Run and Bull Run watersheds.

Figure 2-10
Chesapeake Bay Preservation
Ordinance Resource Protection Area

2.6.3 Parkland and Other Open Space

Parkland and other open spaces cover about 11 square miles or 23 percent of the total watershed area in Fairfax County. Approximately 27 of the 70 miles of stream (39 percent) included in this study (streams in Fairfax County with drainage area greater than 100 to 300 acres) are contained within stream valley parks. These parks and other open spaces are shown on Figure 2-11. Combined, these areas protect large areas of the watershed from future development and provide major watershed protection benefits. Protection of these areas is the main reason flooding is not an issue in the Cub Run watershed (Section 2.7.6).

Much of this area is undeveloped woodlands that serve a variety of watershed protection benefits:

- Reduces development density and impervious cover
- Protects environmentally sensitive areas
- Reduces peak flows
- Improves water quality
- Maintains stream valley buffers, which protect water quality and habitat by filtering stormwater runoff
- Filters runoff from developed areas
- Provides wildlife habitat
- Protects wetlands

2.6.3.1 Fairfax County Park Authority (FCPA) Parkland

More than 4,000 acres of parkland exists within the Cub Run and Bull Run watershed plan study area. Parcels of land have been acquired since the 1970s to protect floodplains and other open space for water quality, wildlife and recreational benefits. Several established Fairfax County Park Authority (FCPA) parks lie within the watershed, collectively known as Sully Woodlands and include:

- Ellanor C. Lawrence Park
- Cub Run Stream Valley Park
- Rocky Run Stream Valley Park
- Frog Branch Stream Valley Park
- Poplar Tree Park
- Sully Park

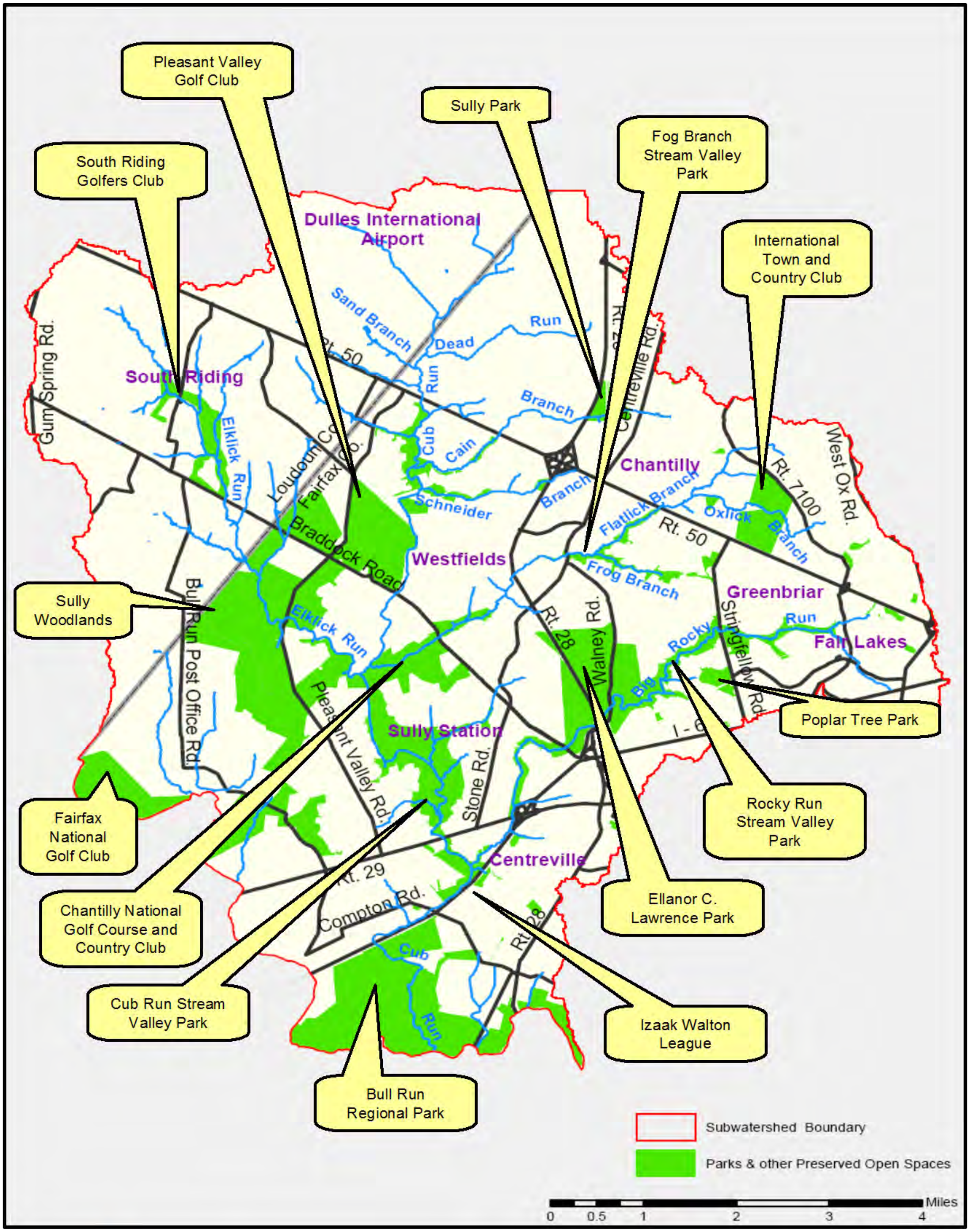


Figure 2-11
Parks and Other Reserved Open Space in the Cub Run and Bull Run Watersheds

FCPA is developing a Sully Woodlands Regional Master Plan to guide park acquisition, development and use for all FCPA parkland within the Cub Run and Bull Run watersheds. Much of this land is undeveloped woodland. The park master plan is being coordinated with this watershed plan.

One guiding principle for the Sully Woodlands Master Plan is to provide open space and natural resource protection. The plan will set aside large portions of this area focusing on environmentally or culturally sensitive areas as undeveloped open space parkland. However, active recreational opportunities are also a priority of FCPA and will be implemented in the park where appropriate. This development will be implemented to minimize watershed impacts.

2.6.3.2 Northern Virginia Regional Park Authority (NVRPA) Parkland

The Northern Virginia Regional Park Authority Bull Run Regional Park contains a large drainage area in the southern portion of the watershed. This park was acquired in the 1950s specifically to protect the Occoquan watershed and reservoir and lies largely within the Cub Run and Bull Run flood plain. Combined with the Cub Run Stream Valley Park, Bull Run Regional Park preserves some of the largest areas of contiguous floodplains and non-tidal wetlands in Fairfax County.

2.6.3.3 Other Preserved Undeveloped Areas

The watershed contains other preserved privately and publicly owned open and undeveloped areas, including:

- Areas preserved by the Izaak Walton League
- Pleasant Valley Golfers Club at Richard Jones park
- Chantilly National Golf Course and Country Club
- International Town and Country Club
- Fairfax National Golf Club
- Undeveloped “buffer areas” within Dulles International Airport

In addition to these parks and golf courses, homeowner associations and multi-family residential development (condominiums, apartments, town houses) includes large areas of largely undeveloped common areas. Much of these areas are located within stream valleys where development is not allowed due their location within the 100-year floodplain and RPA. This privately owned protected space also provides a valuable resource for watershed management.

2.7 Overall Watershed Conditions Based on Previous Studies and Reports

The following sections describe previous reports and other studies that provide background information on the ecological conditions, water quality, geology, soils, physical stream conditions, impaired waters and flooding.

2.7.1 Ecological Conditions

2.7.1.1 Cub and Bull Environmental Baseline: August 1977

This report was compiled as part of the 1997 Master Plan for Flood Control and Drainage and documented the development and environmental conditions in the watershed. The main objectives were to establish an environmental baseline for the Bull and Cub watersheds, to assess future changes to watershed quality, to develop an environmental framework for the master plan and to reduce environmental effects of future development.

The prevailing conclusion of this baseline report was that due to lack of development in the watershed at the time most of the habitat was in excellent condition and shows little sign of human impact.

Over the 26 years since this report was prepared, the amount of development in this portion of Fairfax County has increased significantly. Therefore, the habitat conditions described in the report may serve as watershed habitat quality goals for the current watershed plan.

2.7.1.2 Stream Protection Strategy Baseline Study: January 2001

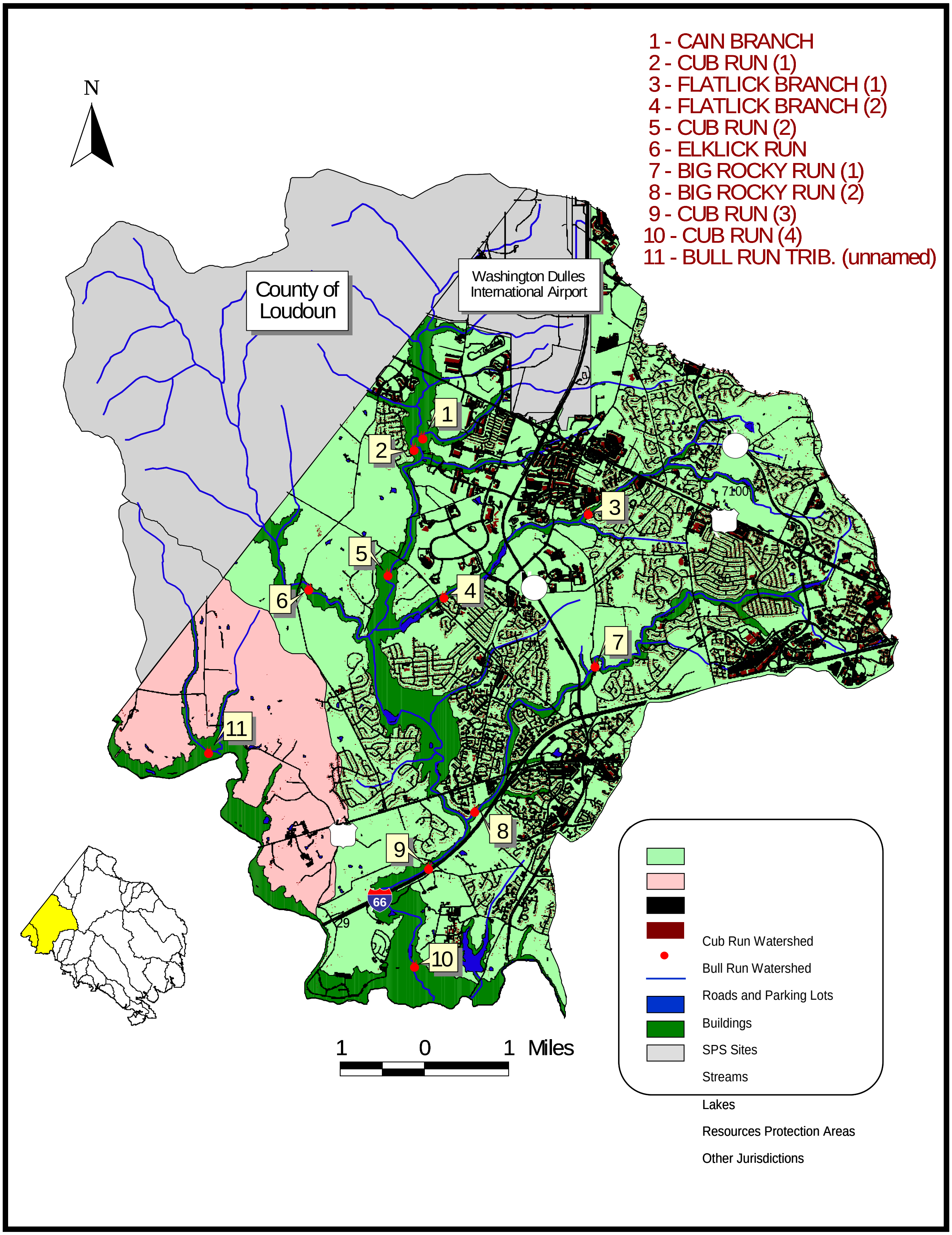
The Countywide Stream Protection Strategy (SPS) Program periodically samples major streams and tributaries throughout the county to assess stream, water and habitat quality.

The SPS assessments include biological indicators of the ecological health in the streams that include aquatic insects (benthic macroinvertebrates) and fish, fecal coliform bacteria, selected chemical parameters and habitat assessment of several physical characteristics. The SPS Program aims to better understand the degree of stream degradation, formulate measures to reverse negative trends, identify and prioritize areas with the greatest needs, and recommend targeted stream preservation and restoration.

The Stream Protection Strategy Baseline Study provided a 1999 “snapshot” of watershed conditions throughout Fairfax County to supply the necessary background information to implement county-wide watershed management plans.

The report also provides a historical perspective on the evolution of stormwater management in the county, describes the effects of urbanization on the stream environment and describes the importance of biological monitoring in assessing the stream conditions.

Ten locations were sampled in the Upper Bull Run watershed group, which includes Cub Run and Bull Run. These sampling locations are shown on Figure 2-12. This figure also presents the land cover in the watershed.


1 - CAIN BRANCH
2 - CUB RUN (1)
3 - FLATLICK BRANCH (1)
4 - FLATLICK BRANCH (2)
5 - CUB RUN (2)
6 - ELKLICK RUN
7 - BIG ROCKY RUN (1)
8 - BIG ROCKY RUN (2)
9 - CUB RUN (3)
10 - CUB RUN (4)
11 - BULL RUN TRIB. (unnamed)
N
County of Loudoun
Washington Dulles International Airport
1
2
3
4
5
6
7
8
9
10
11
7100
66
29
1 0 1 Miles
Cub Run Watershed
Bull Run Watershed
Roads and Parking Lots
Buildings
SPS Sites
Streams
Lakes
Resources Protection Areas
Other Jurisdictions

The study also considers sampling performed under the Northern Virginia Soil and Water Conservation District (NVSWCD) Volunteer Stream Monitoring Program and sampling by volunteers for the Audubon Naturalist Society (ANS) Water Quality Monitoring Program. These monitoring locations are shown on Figure 2-13.

Based on this sampling, the Cub Run and Bull Run watersheds exhibit a range of stream quality conditions that reflect the variations in the intensity of land development. The fish richness in the two watersheds was relatively high compared to other watersheds in the county. The most notable exception was Elklick Run, which scored in the lowest category.

Many of the benthic macroinvertebrate samples collected were ranked as fair within Cub Run, indicating stream degradation. Conversely, the Bull Run monitoring site was ranked in the highest category, with almost 30 percent of the community composed of intolerant organisms. These organisms are unable to tolerate water quality and environmental changes generally associated with a degraded water body.

Throughout both the Cub Run and Bull Run watersheds, sampling demonstrated an overall trend toward fair habitat quality, with many sites showing the impact of substantial sediment deposition. An exception of note was Big Rocky Run, which received the highest ranking for overall quality of instream and riparian habitat. This high rating may result from the protection provided by Ellanor C. Lawrence Park. Geologic conditions also support the habitat in this stream.

Although some subwatersheds within the Cub Run watershed have been significantly degraded, Cub Run also possesses many systems of high quality, including some within areas with high levels of imperviousness. The report conjectures that portions of the watershed may be approaching levels of development at the threshold for impairment for a healthy stream habitat capable of supporting a wide range in native organisms. As discussed in Section 2.7.3, the soils and geology affect the stream health.

The Stream Protection Strategy Baseline Report identifies three watershed management categories based on the overall stream ranking and projected development. Figure 2-14 shows the stream watershed management categories for the Cub Run and Bull Run watersheds.

The areas with the highest overall stream quality in the headwaters of Bull Run, Cub Run, and Big Rocky Run are included in the Watershed Protection management category. In these areas of high watershed quality, the main management strategy is to identify and protect the conditions responsible for producing these high-quality stream environments.

Slightly impaired areas, including Elklick Run and Cain Branch, are assigned to the Watershed Restoration Level I management category. Management strategies in this portion of the watershed are to identify and remedy the causes of stream degradation.

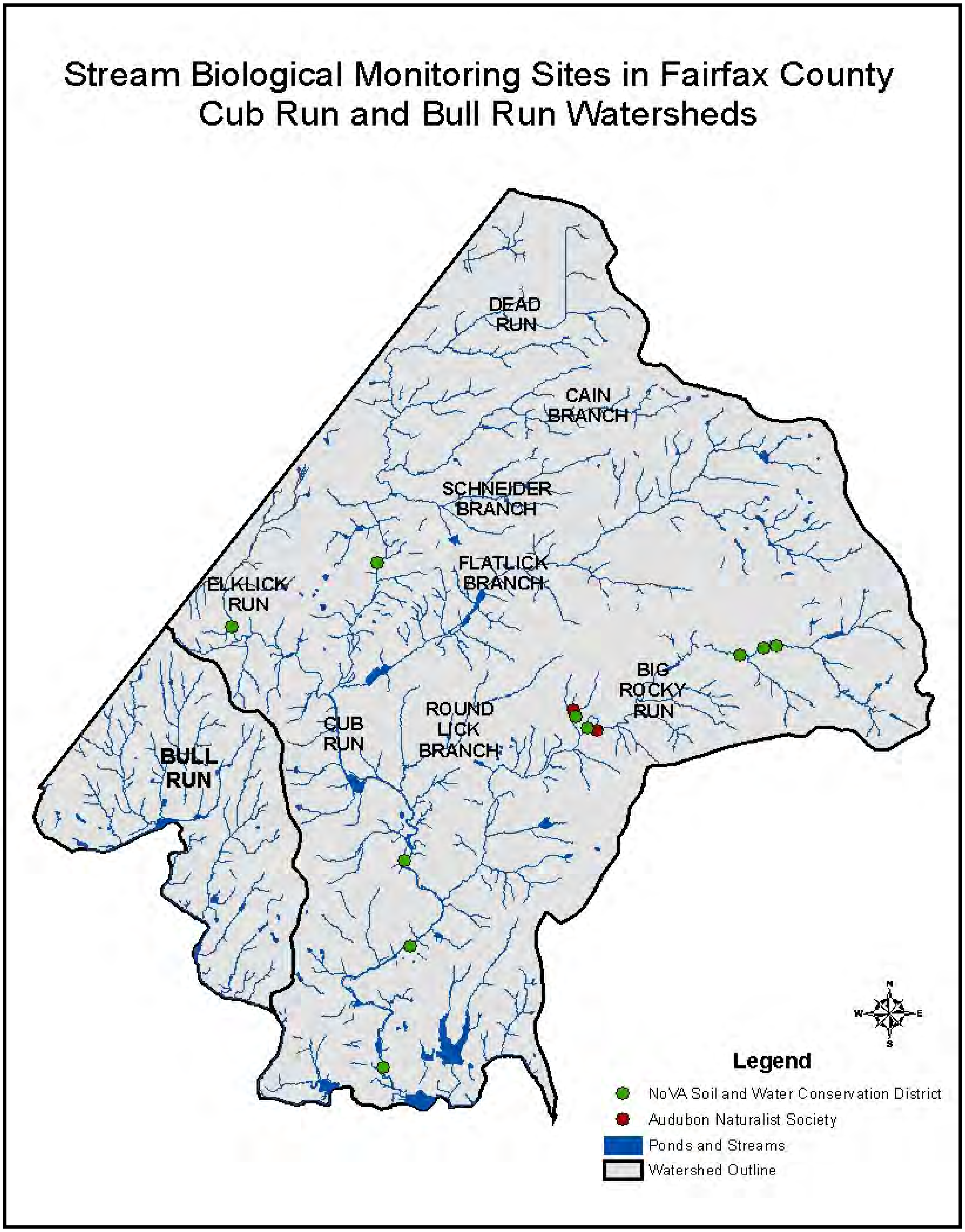


Figure 2-13
Volunteer Monitoring Sites in the
Cub Run and Bull Run Watersheds

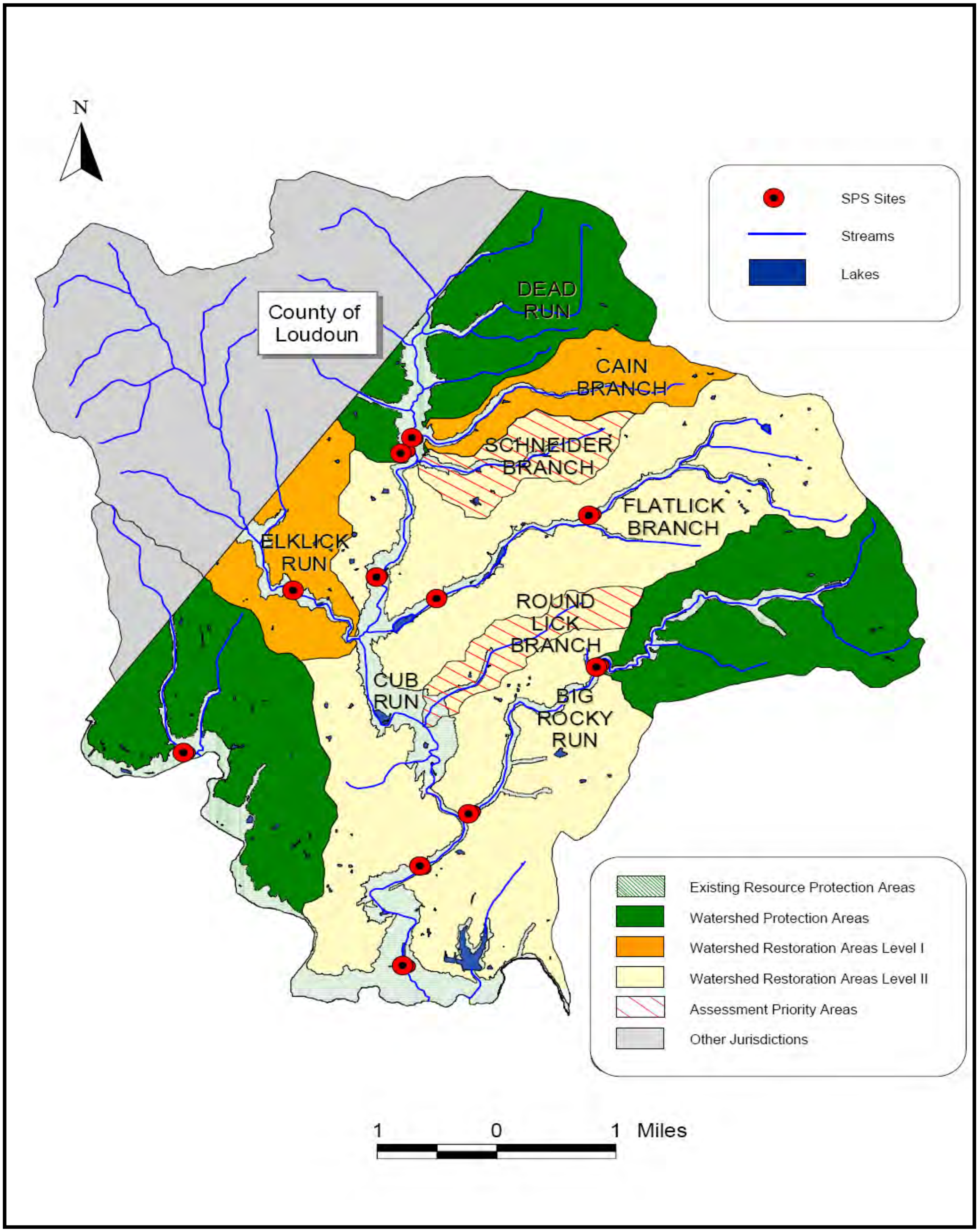


Figure 2-14
SPS Watershed Management Categories
in the Cub Run and Bull Run Watersheds

Sufficient data were not available to accurately classify Schneider Branch and Round Lick Branch stream segments for the SPS Baseline Study. These streams were subsequently surveyed in 2001 and categorized as Watershed Restoration Level II.

The remainder of the Cub Run watershed, including Schneider Branch, Flatlick Branch, Round Lick Branch and Cub Run South of Schneider Branch, falls within the Watershed Restoration Area Level II management category. As a result of this impaired designation, these areas need to be managed to prevent further watershed degradation. This management category's primary goal is to prevent further degradation and to improve water quality to comply with Chesapeake Bay initiatives, Total Maximum Daily Load regulations and other water quality standards.

The study establishes the framework for long-term stream quality assessments.

2.7.2 Water Quality

The following reports and summaries of sampling data provide information on the water quality in the Cub Run and Bull Run streams.

2.7.2.1 Water Quality Standards

All state waters, including wetlands, are designated for the following uses: recreation, e.g., swimming and boating; propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and production of edible and marketable natural resources, e.g., fish and shellfish.

To support this use, the Virginia Department of Environmental Quality (DEQ) provides standards for dissolved oxygen, pH, temperature and coliform bacteria for nontidal waters in the coastal plain and piedmont zones:

- Minimum Dissolved Oxygen: 4.0 mg/L
- Daily Average Dissolved Oxygen: 5.0 mg/L
- pH: 6.0 to 9.0
- Maximum Temperature: 32 ^{o}C (89.6 F)

The state does not provide an aquatic life standard for nitrate, but the public water supply standard is 10 mg/L.

Similarly, the state does not provide an aquatic life standard for phosphorus. However, 0.2 mg/l is used as a screening value to determine if a free flowing stream is impaired, and 0.05 mg/l is used to determine if a lake is impaired.

DEQ has established coliform bacteria criteria for all surface waters, except shellfish waters, as follows: "...the fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 milliliter (ml) of water for two or more samples over a 30-day period, or a fecal coliform bacteria level of 1,000 per 100 ml at any time."

DEQ also establishes acute and chronic toxicity limits for various parameters. "Acute toxicity" means an adverse effect that usually occurs shortly after exposure to a pollutant. "Chronic toxicity" means an adverse effect that is irreversible or progressive, or occurs because the rate of injury is greater than the rate of repair during prolonged exposure to a pollutant. This includes low-level, long-term effects such as reduction in growth or reproduction.

Toxicity criteria for cadmium, copper, lead and zinc are a somewhat complex function of hardness with toxicity increasing with decreasing hardness. The acute and chronic toxicity concentrations at a total hardness of 100 mg/l as CaCO3 (an approximate values for Cub Run streams) are as follows:

	Acute	**Chronic**
Cadmium	**3.9 ug/l**	**1.1 ug/l**
Copper	**13 ug/l**	**9.0 ug/l**
Lead	**120 ug/l**	**14 ug/l**
Zinc	**120 ug/l**	**120 ug/l**

2.7.2.2 Nutrients

Phosphorus and nitrogen - nutrients that support plant and algae growth - can produce algal blooms in reservoirs, lakes, estuaries and embayments. Because of the short residence times, these nutrients generally have little effect on conditions in streams and lakes within the Cub Run watershed. The nutrients (primarily phosphorus) that run off Cub Run and Bull Run watersheds affect water quality in the downstream Occoquan Reservoir with secondary impacts on the Potomac River estuaries and the Chesapeake Bay. Nutrients are the primary cause of water quality impairment, including algal blooms and “dead zones” with depleted oxygen concentrations in the Chesapeake Bay and its tributaries. It should be noted that the Occoquan Reservoir reduces the impact of Cub Run watershed nutrient loads on the Chesapeake Bay.

2.7.2.3 Sediment

Streams within the Cub Run and Bull Run watersheds carry high sediment loads during storm events. Increased sediment in streams has several detrimental effects. The sediment reduces the conveyance capacity of some stream segments, resulting in more frequent bank overflows. This condition is most pronounced in the lower reaches of Cub Run within Bull Run Regional Park. Sedimentation affects the storage capacity in lakes and stormwater ponds throughout the watershed. Many of these ponds will require dredging to preserve and restore their function. Sedimentation from Cub Run watershed also slowly fills the Occoquan Reservoir, reducing the storage capacity required to meet water needs during droughts. Finally, sediment deposition in the streams affects the stream habitat.

Stream sediment in urban watersheds comes primarily from two sources:

- Runoff from construction sites and other areas of disturbed land: Even with county and state erosion control requirements, construction can be a major contributor of sediment loading to the local streams while construction is ongoing. Sediment loading from construction sites can be very high, and properly designed sediment control practices typically achieve sediment removal efficiencies of 70 to 80 percent as documented in the Virginia Erosion and Sediment Control Handbook. Therefore, even properly designed and maintained construction sites contribute to stream sediment.

- Erosion of streambeds and banks: As streams deepen and widen in response to increased flows, the eroded soil is carried as sediment to downstream segments.

Instream or stream-bank erosion is likely to be the largest contributor of sediment to the Cub Run streams, particularly the main stem of Cub Run and downstream segments of major tributaries. Over the long term, natural equilibrium processes will eventually cause the streams to reach a stable cross-section, and the scouring of sediment loads will decline. Alternatively, stream restoration and stabilization projects can be used to reduce stream channel erosion and downstream sediment loads.

2.7.2.4 Accotink Creek Fecal Coliform Source Tracking

As described in the following sections, coliform bacteria concentrations frequently exceed water quality standards. The U.S. Geological Survey (USGS) is undertaking a statewide bacteria source tracking study to identify the origin of fecal coliform in Virginia streams.

The Accotink Creek watershed (upstream of Lake Accotink and downstream from Woodburn Road) in Fairfax County is one of three Virginia watersheds in the study. Along with other jurisdictions, Fairfax County has entered into a joint grant-match funding agreement with the USGS to fund portions of the cost for the study. The study commenced in April 1999 and is ongoing. Preliminary results from the bacteria-source tracking indicate that coliform bacteria in the streams can be traced to various human and animal sources as presented in Figure 2-15.

The objectives of this study include:

1. Demonstrating a multiple-tracer approach for tracking the sources of human fecal coliform bacteria observed in Accotink Creek

2. Identifying the distribution and sources of the human coliform bacteria within the Accotink Creek watershed by evaluating contributions from storm drains, stream tributaries and regions of diffuse subsurface flow into the creek

The study will be used when implementing the Total Maximum Daily Load for the impaired section of Accotink Creek.

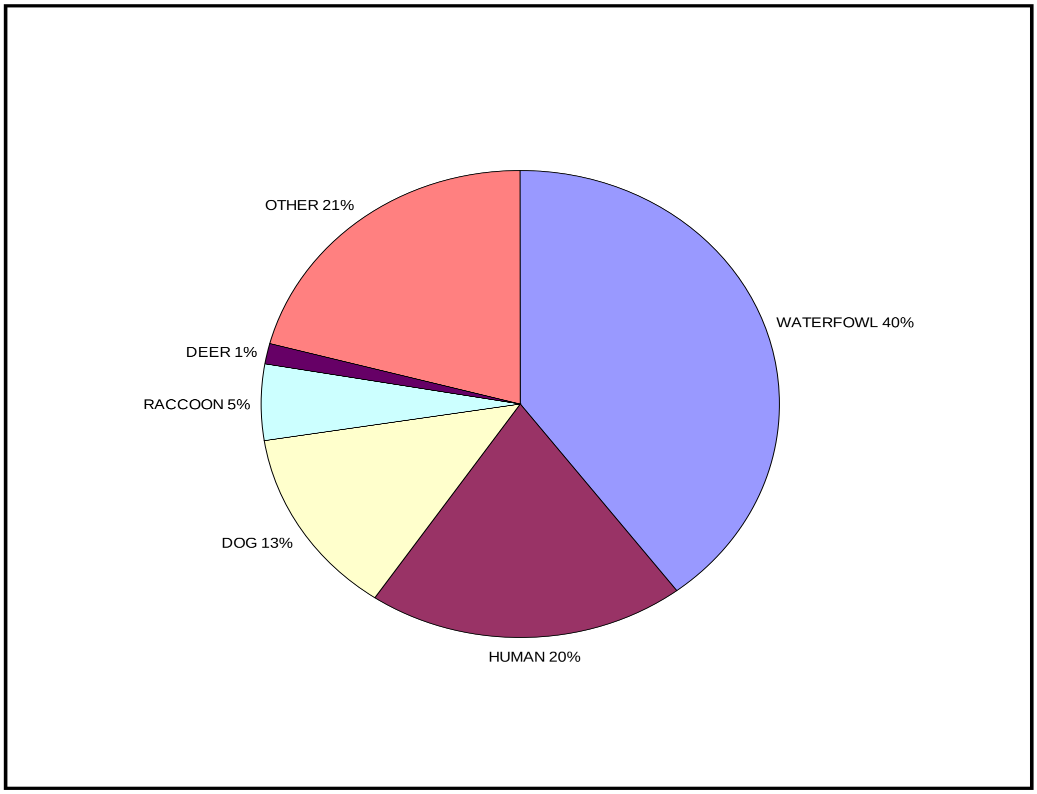


Figure 2-15
Summary of Coliform Distribution For Accotink Creek

2.7.2.5 Fairfax County Health Department Annual Stream Water Quality Data and Reports (2001 and 2002)

Fairfax County monitors stream water quality at 84 sampling locations within the county. The following parameters are monitored:

- Coliform bacteria
- Dissolved oxygen
- Nitrate nitrogen
- pH
- Total phosphorus
- Temperature
- Selected heavy metals

Data are available for 1986 through 2002. Summary reports are available for 1997 through 2003. The following presents the general findings regarding sampling performed in the Cub Run and Bull Run watersheds based on the 2001 and 2002 reports.

Water quality parameters are collected and measured at six locations in the Cub Run watershed and one location in the Bull Run watershed:

Station	Stream	Location
29-02	Big Rocky Run	Braddock Road
29-03	Cub Run	Braddock Road
29-04	Cub Run	Compton Road
29-05	Flatlick Branch	Lee Jackson Memorial Highway (Route 50)
29-06	Flatlick Branch	Braddock Road
29-08	Cub Run	Braddock Road
30-01	Bull Run	Lee Highway (Route 29). This sample is from Bull Run and includes the effects of areas upstream from Fairfax County

Summaries in the 2002 data summary report are presented in the following sections. This report can be obtained from the Fairfax County website (www.FairfaxCounty.gov) by searching for the report title ("Annual Stream Water Quality Report").

Fecal coliform bacteria, while not necessarily harmful in themselves, are found in the intestinal tracts of warm-blooded animals, including humans, and therefore can indicate fecal contamination and the possible presence of pathogenic organisms. The Commonwealth of Virginia Department of Environmental Quality (DEQ) has established a criteria for all surface waters, except shellfish waters, as follows: "...the fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a 30-day period, or a fecal coliform bacteria level of 1,000 per 100 ml at any time." In the following discussions, the geometric mean for the sampling period is compared to the 200 per 100 ml DEQ criteria. Also, the number of samples greater than 200 are indicated. This does not necessarily mean that the fecal coliform limit is exceeded due to the 30-day criterion. However, if the geometric mean is significantly greater than 200 or a large number of samples are greater than 200, it is possible the water quality exceeded this criterion during the sampling program.

Table 2-1 presents the number of fecal coliform samples within the identified ranges at the monitoring locations for the 2002 calendar year. This summary shows that the fecal coliform concentrations regularly exceed the 200 colonies/100 ml mean and 1,000 colonies/100 ml maximum state criteria.

Table 2-2 presents geometric means of the fecal coliform concentrations at each sampling location for calendar years 1997 through 2002. The averages for 2002 are between 379 and 747 colonies per 100 ml. The geometric means for all stations for all years exceeds 200 per 100 ml. The annual variations are affected by rainfall and sampling dates, and likely do not reflect coliform concentration trends.

Table 2-1
Summary of 2002 Coliform Data

Station	Number of Samples		
	<200 / 100 ml	**200 – 1,000 / 100 ml**	**>1,000 / 100 ml ***
Cub Run			
29-02	3	10	2
29-03	5	7	4
29-04	4	10	2
29-05	6	5	5
29-06	3	12	2
29-08	3	6	5
Total Cub Run	24	50	49
Bull Run			
30-01	2	6	8

** Individual samples with concentrations greater than 1,000 per 100 ml exceed the state criteria.*

Table 2-2
Summary of Geometric Mean of Coliform Data 1997 – 2002

Station	Coliform Geometric Mean (#/100 ml) for Calendar Year *					
	1997	**1998**	**1999**	**2000**	**2001**	**2002**
29-02	754	511	421	348	660	478
29-03	760	626	646	528	679	379
29-04	662	484	458	349	695	439
29-05	840	981	670	372	699	455
29-06	641	577	692	374	628	440
29-08	527	500	446	390	679	568
30-01	527	419	698	339	676	747

** All sites exceed the 200 per 100 ml mean coliform bacteria state criteria, suggesting the criteria may possibly be exceeded*

The coliform concentrations in the Cub Run watershed are similar to those found in many of the county's other watersheds and elsewhere with similar development densities.

Table 2-3 presents average annual concentrations for various sampled water quality parameters for 2002.

The station on Cub Run at Braddock Road (29-03) has one sample where the dissolved oxygen was less that 4 mg/l. This suggests that on occasions the dissolved oxygen concentrations reach low levels that may affect the health of the streams.

The station on Flatlick Branch at Route 50 (29-05) has nitrate concentrations that are 50 percent greater than the other stations in the watershed. This trend of high nitrate concentrations is not reflected at downstream station 29-06 but is consistent for both 2001 and 2002. The nitrate concentrations are significantly less than the 10 mg/l drinking water standard.

The total phosphorus concentrations are consistently less than 0.2 mg/l concentration used as a screening value for impaired free flowing stream but may exceed 0.05 mg/l used to determine if a lake is potentially impaired.

Table 2-3
Summary of Water Quality Data for Calendar Year 2002

Station	Average of Samples for Calendar Year 2002			
	Dissolved Oxygen (mg/l) *	**Nitrate Nitrogen (mg/l)**	**pH**	**Total Phosphorus (mg/l) ****
29-02	8.5	0.6	7.5	0.1
29-03	8.7	0.8	7.6	0.1
29-04	9.2	0.8	7.8	0.1
29-05	8.6	1.2	6.9	0.1
29-06	8.1	0.8	7.4	0.1
29-08	8.9	0.8	7.6	0.1
30-01	8.9	0.9	7.5	0.1

** Station 29-03 had one of the 16 samples where the dissolved oxygen concentration was less than 4.0 mg/l. Dissolved oxygen concentration samples for all other stations were greater than 4.0 mg/l.*
*** - Detection limit of procedure used to analyze water samples for total phosphorus is 0.1 mg/l All samples are below this detection limit.*

Sampling data for heavy metals fall within acceptable ranges.

Other than the cases identified above, none of these water quality sampling data show exceptionally high or low values that would identify conditions upstream from the monitoring stations that cause degraded water quality.

2.7.2.6 Final Report: Quantifying NPS Pollutant Discharges from an Urbanizing Headwater Basin

This section summarizes the report titled "Final Report: Quantifying Nonpoint Source (NPS) Pollutant Discharges from an Urbanizing Headwater Basin" (Dougherty, September 2003). This study was completed at Virginia Tech under the grant from the Virginia Water Resource Research Center.

This report summarizes long-term discharge and water quality data for four headwater subwatersheds in the Occoquan Reservoir watershed. Three of the subwatersheds - Cedar Run, Upper Bull Run and Upper Broad Run - are predominantly forest and mixed agriculture. The fourth watershed, Cub Run, is rapidly urbanizing, with 50 percent of the watershed classified as urban. The basins do not have any point discharges from wastewater treatment plants or other facilities. Therefore, the observed concentrations result entirely from nonpoint sources.

The four watersheds have different land use characteristics. The following documents the percent of the watershed area covered by forest, agricultural land and urban development:

Watershed	Forest	Agriculture	Urban
Cub Run	47%	16%	37%
Cedar Run	47%	48%	5%
Upper Bull Run	49%	37%	14%
Upper Broad Run	48%	48%	4%

Cedar Run and Upper Broad Run have similar land use. Upper Bull Run has somewhat more urban land use. Cub Run has the greatest area of urban land use.

Table 2-4 summarizes land use and land cover estimates for the Cub Run watershed from available mapping from 1990 though 2000.

Over this period non-urban open land decreased from 79 percent of the watershed area to 49.3 percent. Townhouse and medium-density residential land uses increased the most during this period.

Table 2-4
Cub Run Watershed Land Use Summaries
Percent of Total Watershed Area

Land Use Category	1980	1985	1990	1995	2000
1 - Forest and Idle Land	52.0%	46.1%	45.6%	48.7%	45.0%
2 - Mixed Minimum Till and Pasture	22.0%	17.4%	12.7%	3.1%	1.8%
3 - Mixed Convention Till and Livestock	5.0%	4.1%	3.1%	2.7%	2.5%
4 - Disturbed Land and Roads	5.2%	2.2%	4.2%	2.8%	1.3%
5 - Industrial, Commercial, and Institutional	7.2%	11.4%	12.3%	16.0%	18.2%
6 - Townhouse and Medium Density Residential	5.9%	15.3%	18.5%	21.1%	24.8%
7 - Low Density Residential and Golf Courses	2.7%	3.5%	3.6%	5.5%	6.4%
8 - Urban Subtotal	21%	32.4%	38.5%	45.4%	50.7%
9 - Non-Urban Subtotal	79%	67.6%	61.5%	54.6%	49.3%

Includes Loudoun County portions of Cub Run watershed but does not include Bull Run portions of the project study area.

The report documents the total population in the Cub Run watershed for the years 1980, 1990 and 2000, as shown below. The population increase is between 7,500 and 8,000 persons per year. The population in 2000 was nearly five times the population in 1980. The total watershed 2000 population density was about 1,900 persons per square mile or 2.9 persons per acre:

- 1980 20,360
- 1990 58,036
- 2000 98,119

The report also documents impervious area increases over this period. Impervious land cover refers to the surface area of rooftops, streets, parking lots, driveways and sidewalks. Impervious area increases the total runoff and peak runoff from the land surface, and reduces infiltration into the soil and groundwater. Impervious area is a direct measure of the development in the watershed. Impervious cover for the Cub Run watershed is estimated below:

- 1980 6.7%
- 1985 9.3%
- 1990 13.1%
- 1995 15.8%
- 2000 17.8%

Impervious area has increased linearly over this period. Over the last 20 years the total impervious area of the Cub Run watershed has increased from 6 percent in 1980 to 18 percent by 2000, while the three other undeveloped watersheds have remained at a constant two percent impervious area.

Table 2-5 documents the mean annual discharge from the four subwatersheds during both storm and non-storm events. The highest runoff values in inches are shown in bold. Cub Run has the highest storm flow and total flow when expressed in inches of runoff over the watershed.

Table 2-5
Mean Annual Storm and Non-Storm Discharge - 1979-2002

	Cub Run Watershed (49 sq. mi.)	**Cedar Run Watershed (154 sq. mi.)**	**Upper Bull Run Watershed (26 sq. mi.)**	**Upper Broad Run Watershed (50 sq. mi.)**
Non-storm flow	27.0 cfs 7.48 inches	84.2 cfs 7.44 inches	13.9 cfs 7.28 inches	33.6 cfs **9.02 inches**
Storm flow	27.3 cfs **7.56 inches**	67.7 cfs 5.98 inches	11.9 cfs 6.26 inches	16.8 cfs 4.53 inches
Total flow	54.3 cfs **15.04 inches**	151.9 cfs 13.42 inches	25.8 cfs 13.54 inches	50.4 cfs 13.54 inches

Discharge means calculated using 21 years of data (1979, 1980, 1982 excluded)

The flow data suggests that the increased imperious cover has caused the mean annual discharge of the Cub Run watershed to be greater than undeveloped watersheds of comparable size. The impervious area has also increased storm runoff and reduced groundwater infiltration. As a result, the mean annual flow volume during storm events is greater than the base flow that occurs between events.

Tables 2-6 and 2-7 document mean annual pollutant concentrations and loads for the four subwatersheds studied. The study analyzed about 24 years of rainfall, flow and water quality data collected by the Occoquan Reservoir Monitoring Laboratory (OWML). The study focused on measurements of total suspended solids (TSS), dissolved and particulate nitrogen, and phosphorus.

Table 2-6 presents concentrations for non-storm and storm flows. The highest concentrations for the four watersheds are in bold. Of all the parameters, Cub Run has the highest concentrations for storm flow TSS only. The values in the other basins may be affected by the agricultural land uses in these watersheds.

Table 2-6
Mean Annual Storm and Non-Storm Pollutant Concentrations, 1979-2002

	Cub Run (49 sq. mi.)	**Cedar Run (154 sq. mi.)**	**Upper Bull Run (26 sq. mi.)**	**Upper Broad Run (50 sq. mi.)**
Non-Storm Flow				
TSS (mg/l)	5.48	4.27	4.05	**8.13**
Particulate P (mg/l)	0.013	0.012	0.010	**0.020**
Dissolved P* (mg/l)	0.032	**0.043**	0.019	0.021
Particulate N (mg/l)	0.076	0.077	0.074	**0.091**
Dissolved N** (mg/l)	0.982	**1.02**	0.616	0.811
Storm Flow				
TSS (mg/l)	**195**	108	163	113
Particulate P (mg/l)	0.197	0.167	0.203	**0.205**
Dissolved P* (mg/l)	0.057	**0.102**	0.061	0.051
Particulate N (mg/l)	0.727	0.629	**0.822**	0.623
Dissolved N** (mg/l)	1.16	1.58	1.16	**1.22**

Calculated using 21 years of data (1979, 1980, 1982 excluded)
**Directly measured as total soluble phosphorus*
*** Indirectly measured as the sum of Kjeldahl nitrogen and oxidized nitrogen*

The storm flow pollutant and sediment loads are generally proportional to total subwatershed drainage area. The only exception is the Cub Run watershed where storm flow TSS and nutrient loads were significantly higher than the similarly sized but lightly developed Upper Broad Run watershed. During non-storm events (dry periods), the opposite was true with Upper Broad Run producing significantly higher TSS than Cub Run.

According to this report, one explanation for these results is the “first flush effect” of impervious surface. As the amount of impervious surface increases in a watershed, pollutant and sediment loads are more easily washed away during storm events, resulting in higher storm event and overall pollutant loads. With higher sediment and nutrient loads leaving the watershed during storm events, less sediment and fewer pollutants leave the watershed during dry periods.

Table 2-7 presents total annual loads in tons per year and pounds per acre per year. These load estimates combine the runoff concentrations and volumes. The watersheds with the largest pollutant load per acre have bold text. Cub Run has the highest TSS, total phosphorus and total nitrogen annual loading rates per acre and the second highest rates for the other parameters.

Table 2-7
Mean Total Annual Pollutant Loads 1979-2002

	Cub Run (49 sq. mi.)	**Cedar Run (154 sq. mi.)**	**Upper Bull Run (26 sq. mi.)**	**Upper Broad Run (50 sq. mi.)**
Total flow				
TSS Tons Pounds per acre	7,031 **448.0**	10,069 204.8	3,022 365.0	3,384 209.0
Particulate P Tons Pounds per acre	6.3 0.40	13.7 0.28	3.5 **0.43**	5.9 0.37
Dissolved P* Tons Pounds per acre	2.5 0.16	11.0 **0.22**	1.0 0.13	1.8 0.11
Total P Tons Pounds per acre	8.8 **0.56**	24.7 0.50	4.6 0.55	7.7 0.48
Particulate N Tons Pounds per acre	21.6 1.37	47.9 0.97	13.8 **1.67**	17.0 1.05
Dissolved N** Tons Pounds per acre	62.0 3.95	198.7 **4.04**	24.3 2.94	51.3 3.17
Total N Tons Pounds per acre	83.6 **5.33**	246.6 5.01	38.1 4.61	68.3 4.22

Calculated using 21 years of data (1979, 1980, 1982 excluded)
Includes combined storm and non-storm loads
**Directly measured as total soluble phosphorus*
*** Indirectly measured as the sum of Kjeldahl nitrogen and oxidized nitrogen*

The report discussion includes the following observations:

- Cub Run exhibits higher unit runoff rates compared to the other basins.
- The increased discharge is mainly from stormwater runoff.
- Discharges were most responsive to increased rainfall and urbanization during winter and spring.
- Nonpoint source loading rates (mass per unit area) from the Cub Run basin exceed the other basins for total suspended solids, phosphorus and nitrogen. The years

that these loadings from the Cub Run watershed became the highest compared to the other three basins are summarized below:

- Total Suspended Solids – 1983
- Total Phosphorus – 1986
- Total Nitrogen – 1990

Presumably, these higher annual loading rates are caused by the urban development that has occurred within the Cub Run watershed.

2.7.2.7 OWML Monitoring Station Water Quality Data

Virginia Tech's Occoquan Watershed Monitoring Laboratory (OWML) maintains a flow and water quality station (ST50) located on Cub Run at the Compton Road bridge. The station measures the flows and water quality from 49 square miles of the Cub Run watershed. Data from this station were used in the analyses in the report described in Section 2.9.2.5 that summarizes the flows and nutrient concentrations for storm and non-storm events.

Data from this monitoring station were reviewed to provide the following summaries of water quality as listed in Table 2-8. These summaries are computed from 13 years of flow data from January 1990 through December 2003

OWML monitors base flow, or dry weather flow, water quality conditions approximately once a week. The dataset includes 523 samples. However, all parameters were not measured for all samples. Table 2-8 presents average, median, maximum and minimum concentrations for all sampled parameters. The reported maximum and minimum are the values exceeded two percent and 98 percent of the time to exclude extreme outliers and erroneous values.

OWML also takes composite samples during storm events. Table 2-9 presents flow weighted average concentrations, and the maximum and minimum concentrations for all sampled parameters. The reported maximum and minimum are the values exceeded two percent and 98 percent of the time to exclude extreme outliers and erroneous values. The dataset includes 318 sampled storm events. However, all parameters are not measured for all samples.

Table 2-8
Summary of Base Flow Samples for OWML Station ST50
Located on Cub Run at Compton Road

Parameter	Average	Median	Maximum	Minimum
Dissolved Oxygen (mg/L)*	9.8	9.3	14.8	5
pH	7.5	7.5	8.1	7.0
Temperature (Degrees C)	16.3	17.5	27	0
Conductivity at 25 deg C	334	315	704	190
Total Alkalinity (mg/l as CaCO3)	85.3	85.7	129.6	45.9
Total Hardness (mg/l as CaCO3)	126.1	125	210	71.9
Orthophosphate Phosphorus (mg/l as P)	0.02	0.02	0.06	0.01
Total Soluble Phosphorus (mg/l as P)	0.04	0.03	0.08	0.01
Total Phosphorus (mg/l as N)	0.05	0.04	0.12	0.01
Ammonia Nitrogen (mg/l as P)	0.04	0.03	0.17	0.01
Soluble Kjeldahl Nitrogen (mg/l)	0.37	0.35	0.77	0.14
Total Kjeldahl Nitrogen (mg/l)	0.42	0.38	0.95	0.16
Oxidized Nitrogen (mg/l as N)	0.66	0.59	1.66	0.04
Chemical Oxygen Demand (mg/l)	12.72	11.95	22.6	7.3
Turbidity (NTU)	10.1	6.8	36.3	1.9
Total Suspended Solids (mg/l)	5.8	3.6	28	1.2
Soluble Calcium (mg/l)	31.9	31.0	56.2	19.5
Extractable Copper (ug/l)	4.6	3.3	15.3	2.1
Soluble Copper (ug/l)	4.3	2.9	12	2.0
Soluble Potassium (mg/l)	4.0	3.6	9.9	2.8
Soluble Magnesium (mg/l)	10.3	10.2	16.7	5.8
Soluble Sodium (mg/l)	30.4	24.2	85.2	14.9
Extractable Lead (ug/l) 7 samples	12.9	7.7	47.1	3.0
Extractable Zinc (ug/l)	25.6	19.5	77.5	14.5
Soluble Zinc (ug/l) 7 samples	21.7	20	33.9	15.1

** 95 percent of the dissolved oxygen values are greater than 6.8 mg/l*
Computed from samples for 1990 through 2003
To exclude outliers and potentially erroneous values, maximum is value exceeded 2% of the time and minimum is value exceeded 98% of the time.

Table 2-9
Summary of Wet Weather Flow Samples for OWML Station ST50
Located on Cub Run at Compton Road

Parameter	Average	Maximum	Minimum
Temperature (Degrees C)	6.6	18.6	3.3
Conductivity at 25 deg C	203.5	661	99.8
Total Hardness (mg/l as CaCO3)	58.1	165.6	34.9
Orthophosphate Phosphorus (mg/l as P)	0.04	0.11	0.01
Total Soluble Phosphorus (mg/l as P)	0.06	0.11	0.02
Total Phosphorus (mg/l as P)	0.24	0.57	0.06
Ammonia Nitrogen (mg/l as N)	0.05	0.48	0.01
Soluble Kjeldahl Nitrogen (mg/l)	0.57	1.15	0.37
Total Kjeldahl Nitrogen (mg/l)	1.24	3.02	0.6
Oxidized Nitrogen (mg/l as N)	0.57	1.48	0.17
COD (mg/l)	30.5	61.2	16.5
Turbidity (NTU)	154.4	330	28.7
Total Suspended Solids (mg/l)	210	557	29.3
Soluble Calcium (mg/l)	14.3	29.9	5.6
Extractable Copper (ug/l)	25.7	124.1	8.2
Soluble Copper (ug/l)	11.1	26.5	3.5
Soluble Potassium (mg/l)	3.5	5.5	2.5
Soluble Magnesium (mg/l)	4.4	9.1	2.1
Soluble Sodium (mg/l)	19.3	69.4	5.7
Extractable Lead (ug/l)	7.0	12.5	3.3
Soluble Lead (ug/l) 2 Samples	3.6	4.1	3.1
Extractable Zinc (ug/l)	74.1	254	34.0
Soluble Zinc (ug/l)	31.3	79.8	14.0

Computed from samples for 1990 through 2003
To exclude outliers and potentially erroneous values, maximum is value exceeded 2% of the time and minimum is value exceeded 98% of the time.

2.7.2.8 Virginia DEQ Water Quality Data

The Commonwealth of Virginia DEQ samples water quality at 12 locations within the Cub Run watershed:

- Cub Run at Compton Road – 28 Samples
- Cub Run at Route 29 – 103 Samples
- Cub Run at Old Lee Road – 13 Samples
- Cub Run at Route 50 - Two Samples
- Elklick Run at Pleasant Valley Road – 17 Samples
- Flatlick Branch Downstream From Braddock Road - Two Samples
- Flatlick Branch at Braddock Road - Three Samples
- Flatlick Branch at Route 28 – One Sample
- Flatlick Branch at Walney Road – One Sample
- Flatlick Branch at Lees Corner Road – One Sample
- Big Rocky Run at Route 29 – 43 Samples - All Data Prior to 1980
- Big Rocky Run Stringfellow Road – Three Samples

The available water quality data for the four stations that have more than three visits and samples from 1990 to 2005 are summarized in Tables 2-10 through 2-13. Most of the stations have data starting in 2000 with roughly three visits per year. Some stations have data from the 1990s that were included in the summaries. Data prior to 1990 were not included since they do no represent current conditions.

All the parameters fall within expected ranges. Other than fecal coliform, none of the measured parameters exceed state criteria. The geometric means are less than the state criteria of 200 colonies per 100 ml at all stations except Cub Run at Route 29. The Elklick Run at Pleasant Valley Road station has the lowest average coliform bacteria concentrations. No significant differences are observed between the average values for the phosphorus concentrations between these four stations. Total nitrogen concentrations (computed by summing nitrite, nitrate, and total Kjeldahl nitrogen) for the stations at Old Lee Road are lower (0.87 mg/l) compared to the other three stations (1.1 – 1.3 mg/l).

Table 2-10
Summary of Water Quality Data for
Virginia Department of Environmental Quality Station
Located on Cub Run at Compton Road (1ACUB002.61)

Parameter	Average	Maximum	Minimum	Number of Observations
Turbidity (FTU)	5.9	17.9	2.9	9
Specific Conductance (UMHOS/CM @ 25C)	469	1074	252	11
Total Nitrogen (mg/l as N)	1.3	1.8	0.73	13
Ammonia Nitrogen (mg/l as N)	< 0.04	0.09	< 0.04	18
Nitrite Nitrogen (mg/l as N)	0.02	0.08	< 0.01	11
Nitrate Nitrogen (mg/l as N)	0.74	2.11	0.04	11
Total Kjeldahl Nitrogen (mg/l as N)	0.5	0.8	0.3	11
Total Dissolved Nitrogen (mg/l as N)	1.140	1.456	0.659	7
Particulate Nitrogen (mg/l as N)	0.043	0.086	< 0.01	7
Total Phosphorus (mg/l as P)	0.05	0.09	0.02	25
Orthophosphate Phosphorus (mg/l as P)	0.03	0.06	< 0.02	18
Total Dissolved Phosphorus (mg/l as P)	0.032	0.054	0.007	7
Particulate Phosphorus (mg/l as P)	0.015	0.0244	0.008	7
Total Hardness (mg/l as CaCO3)	125.5	195	81.6	11
Fecal Coliform (Number per 100 ml) *	148.9	> 2,000	< 25	27
Enterococci (Number per 100 ml) *	142.2	> 800	10	0
TSS (mg/l)	252.8	425	170	11

** - Geometric mean is reported for the average for bacteria.*

Table 2-11
Summary of Water Quality Data for
Virginia Department of Environmental Quality Station
Located on Cub Run at Route 29 (1ACUB003.74)

Parameter	Average	Maximum	Minimum	Number of Observations
Turbidity (FTU)	13.1	77	2.4	32
Specific Conductance (UMHOS/CM @ 25C)	361	1893	74.9	47
Ammonia Nitrogen (mg/l as N)	< 0.04	0.13	< 0.04	46
Nitrite Nitrogen (mg/l as N)	0.02	0.05	< 0.01	46
Nitrate Nitrogen (mg/l as N)	0.52	1.65	< 0.04	46
Total Kjeldahl Nitrogen (mg/l as N)	0.6	1.2	0.3	46
Total Phosphorus (mg/l as P)	0.05	0.1	0.02	46
Orthophosphate Phosphorus (mg/l as P)	0.03	0.12	< 0.02	39
Total Hardness (mg/l as CaCO3)	108.6	200	18.6	44
Fecal Coliform (Number per 100 ml) *	243.3	2100	< 100	41
TSS (mg/l)	209.4	464	49	47
5-Day BOD (mg/l)	< 2	18	< 2	47
COD (mg/l)	16.4	26	9	33
pH	7.2	8.16	5.8	47

** - Geometric mean is reported for the average for bacteria.*

Table 2-12
Summary of Water Quality Data for
Virginia Department of Environmental Quality Station
Located on Cub Run at Old Lee Road (1ACUB008.60)

Parameter	**Average**	**Maximum**	**Minimum**	**Number of Observations**
Turbidity (FTU)	6.0	21.1	1.05	9
Specific Conductance (UMHOS/CM @ 25C)	387	732	1.9	12
Ammonia Nitrogen (mg/l as N)	< 0.04	0.81	< 0.04	14
Nitrite Nitrogen (mg/l as N)	0.02	0.14	< 0.01	14
Nitrate Nitrogen (mg/l as N)	0.35	1.37	< 0.04	14
Total Kjeldahl Nitrogen (mg/l as N)	0.5	2.6	0.1	14
Total Phosphorus (mg/l as P)	0.04	0.13	< 0.01	14
Orthophosphate Phosphorus (mg/l as P)	0.03	0.06	< 0.02	12
Total Hardness (mg/l as CaCO3)	117.3	211	5	12
Fecal Coliform (Number per 100 ml) *	192.3	> 8000	< 100	12
TSS (mg/l)	239.9	408	5	14

* - *Geometric mean is reported for the average for bacteria.*

Table 2-13
Summary of Water Quality Data for
Virginia Department of Environmental Quality Station
Located on Elklick Run at Pleasant Valley Road (1AELC001.39)

Parameter	Average	Maximum	Minimum	Number of Observations
Turbidity (FTU)	8.8	25.8	1.1	9
Specific Conductance (UMHOS/CM @ 25C)	425	771	2.31	12
Total Nitrogen (mg/l as N)	1.8	2.44	1.43	5
Ammonia Nitrogen (mg/l as N)	< 0.04	0.12	< 0.04	17
Nitrite Nitrogen (mg/l as N)	0.02	0.04	< 0.01	12
Nitrate Nitrogen (mg/l as N)	0.68	2.15	0.04	12
Total Kjeldahl Nitrogen (mg/l as N)	0.5	0.9	0.1	12
Total Phosphorus (mg/l as P)	0.04	0.08	0.01	17
Orthophosphate Phosphorus (mg/l as P)	0.02	0.05	< 0.02	12
Total Hardness (mg/l as CaCO3)	186.5	305	83.4	12
Fecal Coliform (Number per 100 ml) *	109.9	> 2000	< 25	14
E. Coli (Number per 100 ml) *	228.0	> 2000	< 25	5
TSS (mg/l)	282.3	505	5	12

* - *Geometric mean is reported for the average for bacteria.*

2.7.3 Soils and Geology

The underlying geology and soil conditions affect the health of the streams and their susceptibility to erosion.

2.7.3.1 Generalized Geology

Fairfax County is within three geologic provinces:

- The eastern part (east of I-95) is underlain by unconsolidated sediments of the Coastal Plain Province.
- The central part is underlain by crystalline metamorphic and igneous rocks of the Piedmont Province.
- The western part is underlain by sedimentary and crystalline rocks of the Triassic Basin Province, which is a subprovince of the Piedmont Upland.

The Cub Run watershed is mostly in the Triassic Basin Province. The tip of the watershed near Fair Oaks area east of the Fairfax County Parkway (Route 7100) and south of Route 50 is in the Piedmont Province.

The location of these provinces is shown in Figure 2-16. Portions of the watershed in Loudoun County are also in the Triassic Basin Province.

The two provinces that occur within the Cub Run and Bull Run watersheds are further described below.

Piedmont Province

The Piedmont Province occupies approximately 56 percent of Fairfax County. It is in the central portion of the county, west of the Coastal Plain. The province is underlain by metamorphic rocks, predominantly schist, granite, gneiss and greenstone. A well-dissected, dendritic drainage pattern occurs throughout the province. The hilltops are typically wide and rolling, except in places along the lower tributaries of large streams where V-shaped valleys with steep slopes and narrow ridge tops occur.

Triassic Basin Province

The Triassic Basin Province occurs in western Fairfax County. Most of the Cub Run and Bull Run watersheds is in this province. The geology consists largely of red sedimentary rocks, including sandstone, siltstone, shale and conglomerate.

A horseshoe-shaped intrusion of igneous diabase, diorite and syenite rocks occurs near Centreville (Figure 2-16). Igneous intrusion refers to volcanic rock that intruded into the surrounding sedimentary rock now exposed at or near the land surface.

Within the Triassic Basin Province the drainage is somewhat dendritic but not as well developed as in the Piedmont Upland. The hilltops are wide and gently rolling, with long gently sloping side slopes and nearly level areas. In Cub Run, areas near Dulles

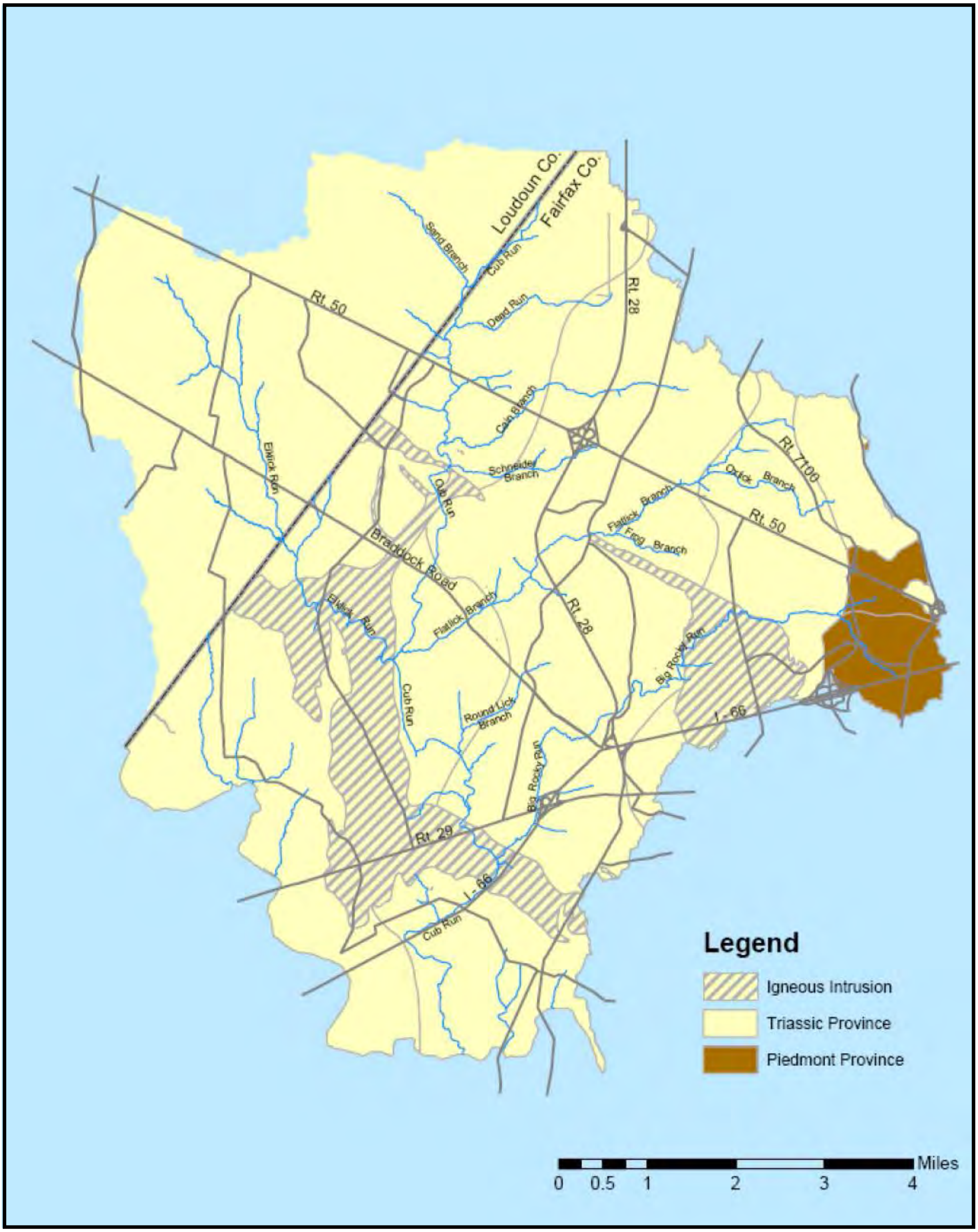


Figure 2-16
Generalized Geology of the
Cub Run and Bull Run Watersheds

International Airport are flat with shallow stream valleys. The topography becomes steeper towards the south.

2.7.3.2 Soils

Soils are formed from the weathering of the underlying bedrock. The soil's physical and engineering properties are largely determined by the rock from which they are derived. Areas underlain by shale are silty to clayey soils. Soils underlain by sandstones are silty and loamy soils. Soils over the igneous bedrock have a plastic clay layer. Soils in the Piedmont Province tend to be better drained.

Soils in the watershed have low infiltration rates for the most part. The soils are classified into hydrologic soil groups based on their infiltration characteristics. The groups range from A to D, with A having the highest infiltration rates and D having the lowest. Soil group A produces less runoff rates than D soils. Stormwater management facilities (e.g., biofiltration for low-impact development) that rely on infiltration will not work well in areas with D soils.

Figure 2-17 shows the hydrologic soil group classifications for the soils in the watershed. The distribution of hydrologic soil groups is as follows:

- Soils in the upland areas of Piedmont Province of the watershed tend to have B soils with moderately high infiltration rates.
- The soils between the Piedmont Province and the Cub Run main stem channel have a mix of B and C soils. The fraction of C soils increases from east to west across this portion of the watershed.
- Soils over the igneous intrusion have D soils. More than half of this area is within the R-C District (5-acre residential lots).
- Soils in much of Loudoun County are D soils.
- The breakdown of hydrologic soil groups for the entire study area is as follows:

  A – 0%
  B – 16%
  C – 50%
  D – 34%

2.7.3.3 Impact of Geology and Soils on Stream Conditions

The underlying geology and soil properties influence the condition of the streams in the watershed.

Big Rocky Run's name is appropriate. Upstream from Route 28, much of the streambed contains rocks of various sizes. The bedrock exposed in this watershed is red sandstone of the Triassic Basin Province. Similar conditions can be seen in Frog Branch and the Bull Run East subwatershed streams.

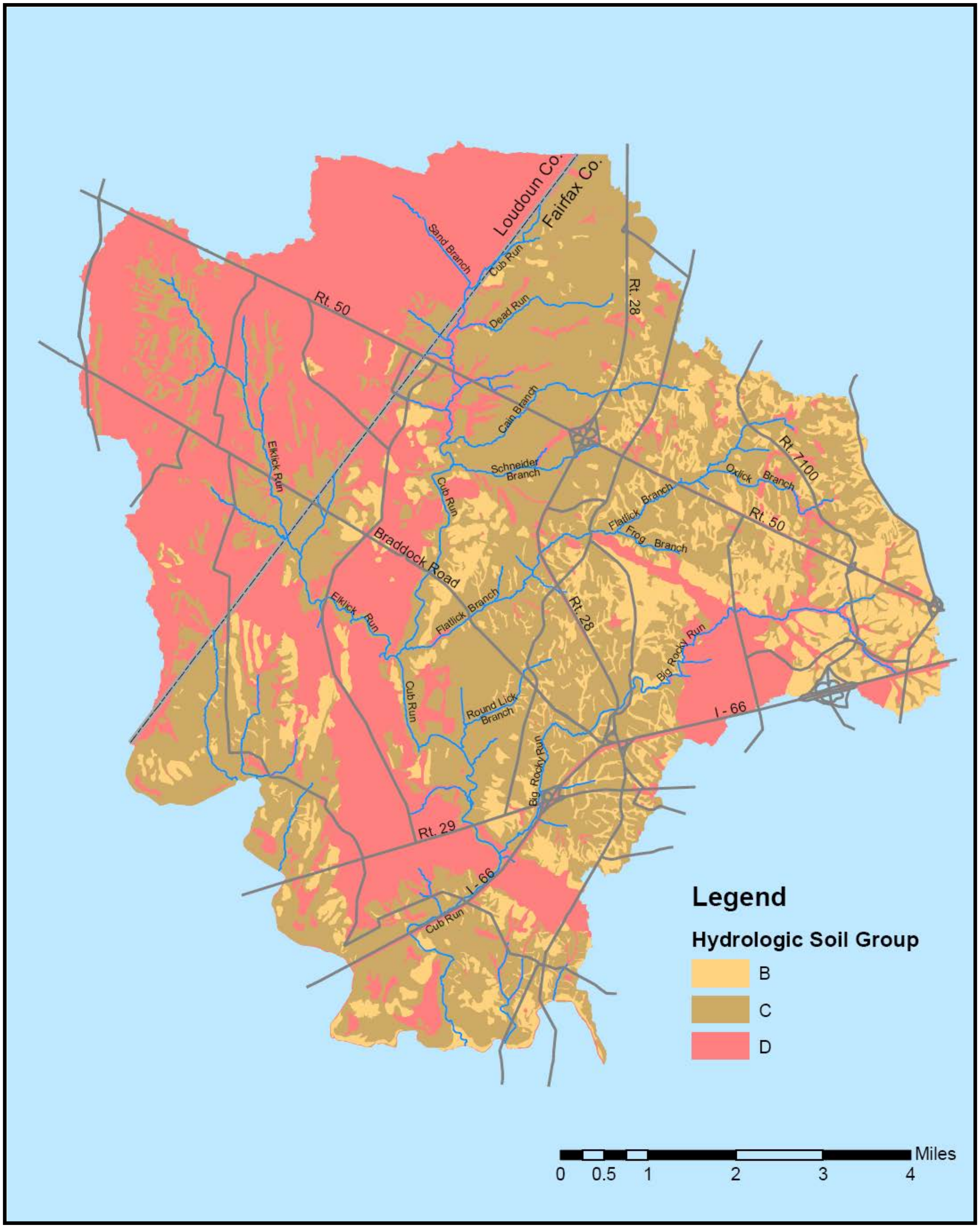


Figure 2-17
Hydrologic Soil Groups in the
Cub Run and Bull Run Watersheds

The rocky strata provides habitat for fish and benthic organisms, and make Big Rocky Run, Frog Branch and streams in the Bull Run East subwatershed less susceptible to streambed and streambank erosion.

The impact of the watershed geology can also be seen in the main stem of Cub Run downstream from Route 29 to just below the Big Rocky Run confluence. This stream segment is within an igneous intrusion area. The steeper gradient of the stream results from the bedrock being less erodable. The streambed consists of rocks and boulders that provide habitat and make the streambank and bed less susceptible to erosion from urban stormwater flows. Furthermore, the higher bed slope prevents sedimentation. These conditions combine to provide good stream habitat.

Most of the remaining streams are in areas of the Triassic Basin Province underlain by shale. The shale weathers easily and therefore provides little resistance to streambed and streambank erosion. The fine clayey soils that form the streambanks are highly erodable and make it difficult to control sediment from construction sites. These soils create the vertical streambanks found in many of the streams north of Route 29.

2.7.4 Physical Stream Condition

2.7.4.1 Stream Physical Assessment Study: February 2004

Fairfax County completed a county-wide Stream Physical Assessment Study in 2003. The results are in "Fairfax County Stream Physical Assessment Report," published in February 2004. Please refer to the Stream Physical Assessment report for details on how the studies were performed and the county-wide results.

The study focused on streams with drainage areas greater than 50 acres. Field crews documented conditions of approximately 800 miles of stream. This includes 105 miles of the Cub and Bull Run watersheds. A GIS tool and database contain the data and photos that document the stream conditions. The Stream Physical Assessment Study assesses the physical stream habitat, incorporating several measures of stream conditions that affect habitat, including vegetated buffer, streambank stability, channel alteration, embeddedness, epifaunal substrate and instream cover. The Stream Physical Assessment Study also provides an inventory of the following conditions:

- Stream channel condition and habitat characteristics
- Stream reaches with deficient buffers
- Streambank erosion
- Head cuts
- Pipes
- Ditches
- Obstructions
- Road and other stream crossings
- Dump sites
- Utility line exposure

Section 3 summarizes stream assessment results for the major subwatersheds in Cub Run and Bull Run. These data were also used to identify stream restoration, buffer restoration and dump-site-removal structural projects, as described in Section 6.

The Physical Assessment Study documents the Channel Evolutionary Model (CEM) stage of the streams. This model classifies the streams into one of five categories based on the stream characteristics. The CEM recognizes that streams go through stages as they react to changes in stream flows produced by urbanization. First, the streambed down-cuts and then the stream widens as the banks erode. If the flow remains constant (e.g., no further development occurs in the watershed), the streams will stabilize to a new streambed and floodplain configuration. The CEM stages are shown in Figure 2-18 and are described below:

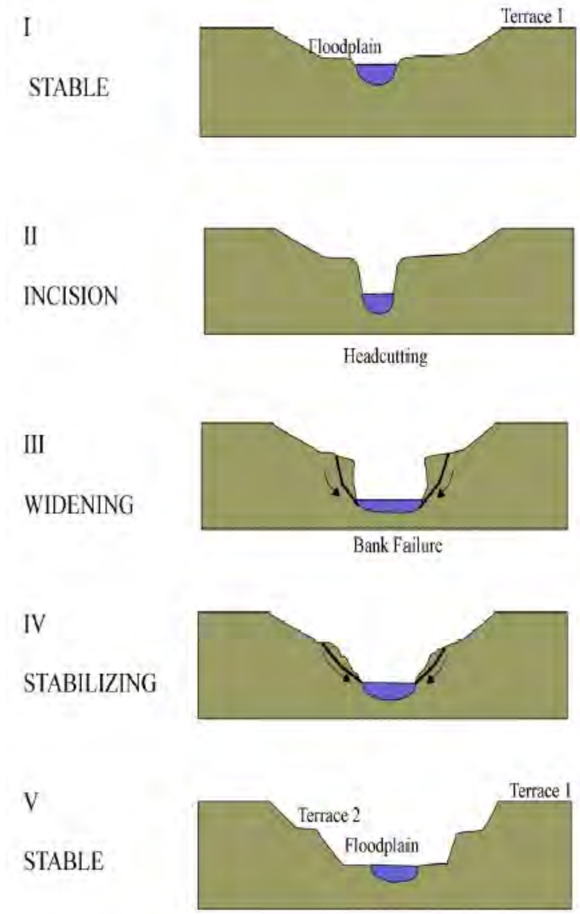


Figure 2-18
Incised Channel Evolutionary Model:
Progression from Natural Stream (I) Channel
from Highly Eroded Stream Channel (V)

- I – STABLE: This represents a stable stream condition such as one that might exist in a natural area without any development.

- II – INCISION: The typical first response of a stream to urban development is downward erosion of the streambed, producing a deepening of the channel. The stream is disconnected from its floodplain. This condition suggests that the stream is unstable for present flow conditions and ongoing stream erosion will affect habitat quality. A stream in this condition may exhibit "head cuts" when the downstream channel has incised while the upstream segment has not. This results in a waterfall in the stream. If unimpeded by roots, rock, or manmade obstacles, the head cut will migrate upstream as erosion continues.

- III – WIDENING: The streambanks may fall or slough into the stream as further erosion occurs and the channel banks become unstable. The eroded bank material increases the sediment load carried by the stream. Habitat quality is degraded and adjacent infrastructure is threatened. Trees may fall into the stream, potentially producing snags and stream obstructions.

- IV – STABILIZING: If flow conditions remain constant and do not increase further, the stream will eventually reach a stable configuration where the banks are stable and a stable sediment erosion/deposition regime has been reached.
- V – STABLE: The stable stream will exhibit a floodplain and terraces from the historic floodplains. Habitat quality typically improves once the channel reaches this stable condition.

Figure 2-19 provides the CEM stage for the Cub Run and Bull Run streams. These CEM stages are discussed in detail in Section 3.

2.7.5 303(d) Impaired Waters and TMDLs

Section 303(d) of the Federal Clean Water Act requires each state to submit a Total Maximum Daily Load (TMDL) Priority List to the EPA. The 303(d) Report on Impaired Waters in Virginia lists streams and other water bodies that do not meet water quality standards for their designated use. The Virginia DEQ samples streams and lists those that do not meet the designated water quality criteria.

Most impaired waters require the development of TMDL for the parameter causing the impairment. TMDL studies identify the cause of the impairment and estimates maximum loadings that will allow the impaired water body to meet the standards. According to the Clean Water Act, all TMDL studies must be completed by 2011.

Various streams in Fairfax County are on this list primarily because the criteria for fecal coliform concentrations for contact recreational use are exceeded. The listed streams include Mills Creek, Accotink Creek, Popes Head Creek, Sugarland Run, Difficult Run, Tripps Run, Pimmit Run, Four Mile Run and Holmes Run.

None of the streams in the Cub Run watershed are listed as impaired. Bull Run downstream from the confluence with Cub Run is listed for exceeding fecal coliform criteria for recreational use, moderate impairment of stream benthic communities and excessive PCB concentrations in fish tissue.

2.7.6 Flooding

2.7.6.1 Road Flooding Memorandum: August 1998

This August 28, 1998 memorandum identifies procedures that county police officers will use to warn motorists of flooding and, when necessary, to close roads. The memorandum lists 27 sites in Fairfax County with flip-down advisory signs that must

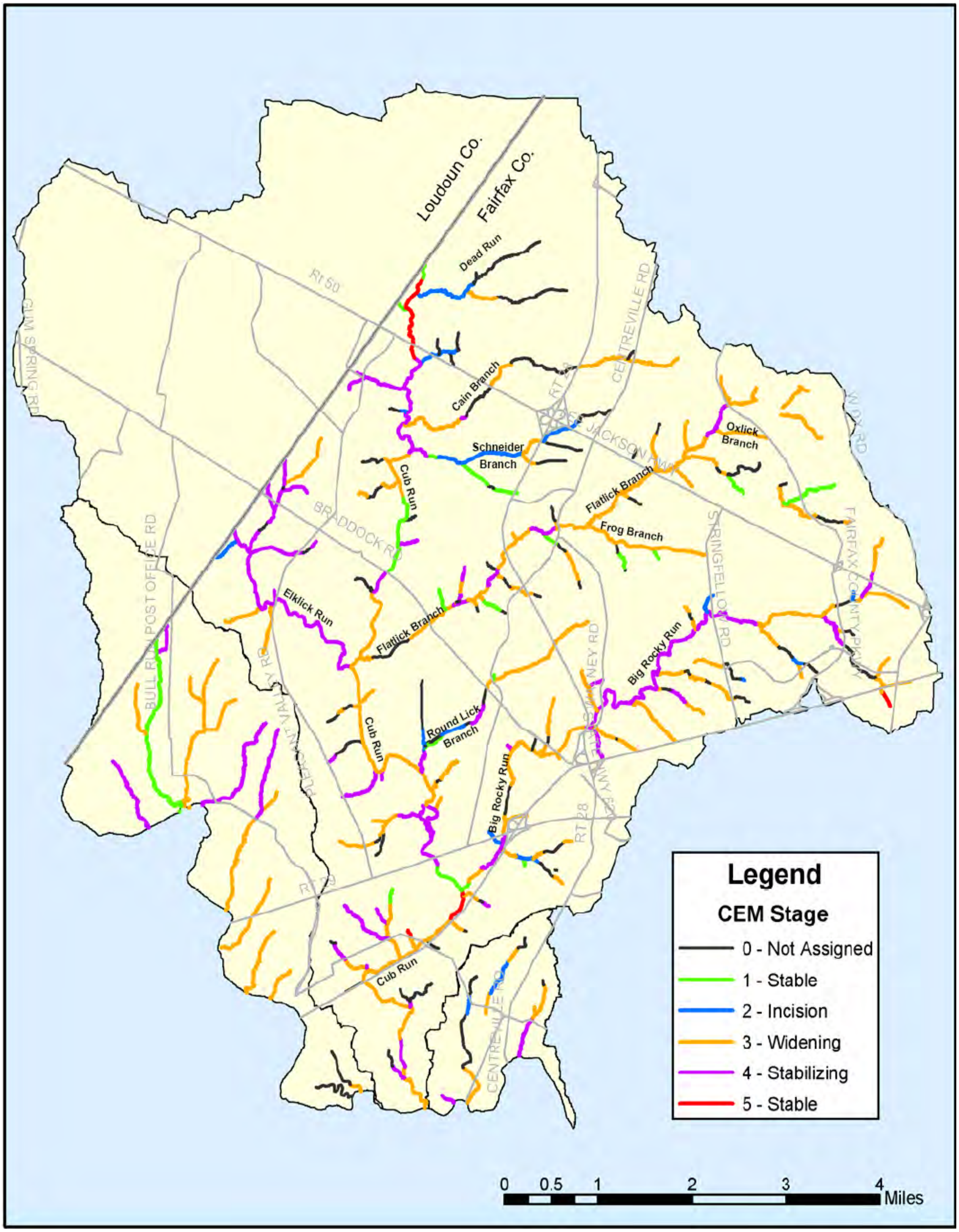


Figure 2-19
Stream Channel Evolutionary Model
Stages in the Cub Run and Bull Run Watersheds

be manually opened to provide warnings to motorists. The memorandum includes the following stream crossings in the Cub Run and Bull Run watersheds:

- Walney Road between intersection of Willard Road and Westfields Blvd. This road crosses Flatlick Branch.

- Old Lee Road between the intersections of Braddock Road and Stonecroft Boulevard. This road runs parallel to and crosses Cub Run.

These and other road crossings that experience frequent flooding are identified in the watershed plan in section 6.9.

2.7.6.2 Review of DPWES Maintenance Database

The DPWES Maintenance and Stormwater Management Division citizen complaint database includes 29,600 complaint records logged throughout the county from January 1984 through November 2003. The database includes detailed information on the complaint and the actions taken.

The following summarize complaints where flooding issues were identified within the Cub Run watershed:

- Thirty-six involved yard flooding
- One involved roadway flooding
- Nine involved house flooding

Careful review of these complaints found none that could be related to flooding caused by major streams. Instead, the flooding was caused by problems in the local property drainage or the minor storm drainage systems.

2.7.6.3 100-Year Floodplain

Using the Fairfax County GIS building layer and 100-year flood layer, 40 structures are within the Bull Run and Cub Run 100-year floodplain.

After careful review of these results, only two unoccupied buildings were determined to be within the 100-year floodplain where possible flooding is a concern.

The remaining structures include:

- Various buildings within Bull Run Regional Park. Nearly all of this park is included in the 100-year floodplain produced by Bull Run.

- Various small sheds and other out buildings

- UOSA wastewater pump stations and power substations

- A few buildings that have subsequently been removed

Much of the floodplain lies within stream valley parks or otherwise protected as open space. The complaint records, evaluation of buildings in the 100-year floodplain and comments received from the public indicate that structure flooding is not a major issue in the Cub Run and Bull Run watersheds.

2.8 Watershed Modeling

Computer models were developed to simulate the following:

- Runoff from the land surface
- Flows, velocities and depths of flows in the stream channels
- Capacity of bridges and culverts where roadways cross the streams and the potential for flooding at these locations
- Water quality concentrations and total annual loads

The models were developed to simulate existing and future conditions. The models also can simulate the benefits of existing stormwater controls and future stormwater controls required for new development based on the stormwater management requirements of Fairfax and Loudoun counties. Finally, the models were used to describe the benefits from stormwater control improvements recommended in the watershed plan.

The U.S. Environmental Protection Agency Storm Water Management Model RUNOFF and TRANSPORT computer models were used to compute runoff flows and water quality from the land surface and to route these flows through the stream network. The U.S. Army Corps of Engineers' HECRAS model was used to perform detailed simulations of the stream and road-crossing hydraulics. The models and the model setup are described in a separate Model Development and Application Technical Memorandum (CDM, 2006).

In summary, the watershed was divided into 284 subbasins that range from 13 to 613 acres and average 142 acres in size. Parameters such as the slope, soil characteristics, impervious cover and others describe the runoff from the land surface. Land use data are used to describe runoff water quality.

Results of simulations to characterize existing and future conditions for various subwatersheds, including a summary of the overall watershed characteristics, are summarized in Section 3 and described in detail in Appendix B for the following four scenarios:

Existing land use without stormwater controls. This condition assumes that on-site and regional dry and wet ponds were not constructed. These results are presented to demonstrate the benefits from these existing stormwater controls.

Existing land use with existing stormwater controls. This represents existing watershed conditions.

Future land use with existing stormwater controls. This scenario assumes new ponds and other stormwater controls required by Fairfax County and Loudoun County are not constructed. These results are presented to demonstrate the benefits from new stormwater controls to be constructed as additional development occurs.

Future build-out land use with existing and future stormwater controls required for new development by Loudoun County and Fairfax County. This scenario does not include the benefits provided by the watershed plan recommendations.

Results documenting the benefits of various structural controls recommended by the watershed plan are included in Section 6 and 7, and documented in Appendix B. Table 2-14 summarizes the average annual pollutant removal efficiency of various stormwater water quality control best management practices (BMPs) used to evaluate future water quality with stormwater controls. These values are derived from various sources and represent values typically used to model these BMPs.

Total flows presented in the summary tables in section 3 represent the total peak simulated flow at the outlet of the subwatershed. Average velocities represent the length-weighted average of the peak velocities in all modeled stream segments.

Average annual loads (tons per year) and loads per acre (lbs/acre/year) are presented for the following parameters:

- Total Phosphorus
- Dissolved Phosphorus
- Total Nitrogen
- Total Kjeldahl Nitrogen
- Nitrate Nitrogen
- BOD5
- Zinc
- Lead
- Copper
- Cadmium

These are computed for a five-year simulation from 1996 through 2001 using local rainfall.

Table 2-14
Summary of Average Pollutant Removal Efficiencies for
Stormwater Water Quality BMPs

Type of Water Quality BMP	**Removal Efficiency**			
	Wet Detention Basin	**Extended Dry Detention Basin**	**Extended Dry Detention Basin with Wetlands Bottom**	**Bioretention LID**
Total Phosphorus	50%	40%	50%	50%
Dissolved Phosphorus	50%	0%	30%	20%
Total Nitrogen	30%	30%	55%	45%
Dissolved Nitrogen	25%	0%	30%	20%
BOD-5	30%	30%	30%	30%
Total Suspended Solids	80%	80%	80%	80%
Lead	80%	80%	80%	80%
Copper	50%	50%	50%	80%
Zinc	50%	50%	50%	80%
Cadmium	50%	50%	50%	80%