Appendix A: Watershed Workbook

The watershed workbook is a reader-friendly document that is designed to provide the residents and stakeholders of the Sugarland Run and Horsepen Creek watersheds with information about their watersheds. The watershed workbook describes the watershed study methodology and summarizes the County-wide goals and objectives. The watershed workbook characterizes the existing state of the watersheds and describes the various methods and tools used in the evaluation of all the watershed management areas within the Sugarland Run and Horsepen Creek watersheds. The watershed workbook is a draft document that contains the information and modeling results available at the time and has not been, and will not be, updated or finalized.

Appendix B: Technical Documents

i. Subwatershed Strategies

Technical Memo 3.2 describes how initial strategies were developed for Sugarland Run and Horsepen Creek watersheds. The memo discusses the characterization of subwatershed improvement, stream restoration, and regional pond alternative strategies. The memo also describes how based on these strategies priority subwatersheds were identified and potential candidate restoration projects were selected.

ii. Prioritization

Technical Memo 3.4/3.5 describes how potential candidate projects were evaluated and the final list of projects incorporated in the watershed management plan was selected. The memo describes how candidate projects were investigated in the field to evaluate the scope, feasibility, and benefits of each candidate project. The memo also discusses the procedure by which candidate structural projects were evaluated and ranked.

iii. Modeling description

Technical Memo 3.6 describes the selection of projects to be further evaluated with hydrologic and hydraulic models. The memo discusses this assessment of potential impacts and discusses if objectives were met by implementing the modeled projects. The memo summarizes the setup, calibration and results of the hydrologic and hydraulic modeling performed. Results from the final STEPL pollution model were also summarized in this memo.

Appendix C: Public Involvement

Summaries of the initial community workshop, the draft plan forum and each of the five Watershed Advisory Group (WAG) meetings that were held through the watershed management plan development process are included in Appendix C.

i. October 30, 2008
ii. December 10, 2008
iii. March 3, 2009
iv. June 3, 2009
v. March 9, 2010
vi. July 21, 2010
vii. August 3, 2010

Appendix A: Watershed Workbook

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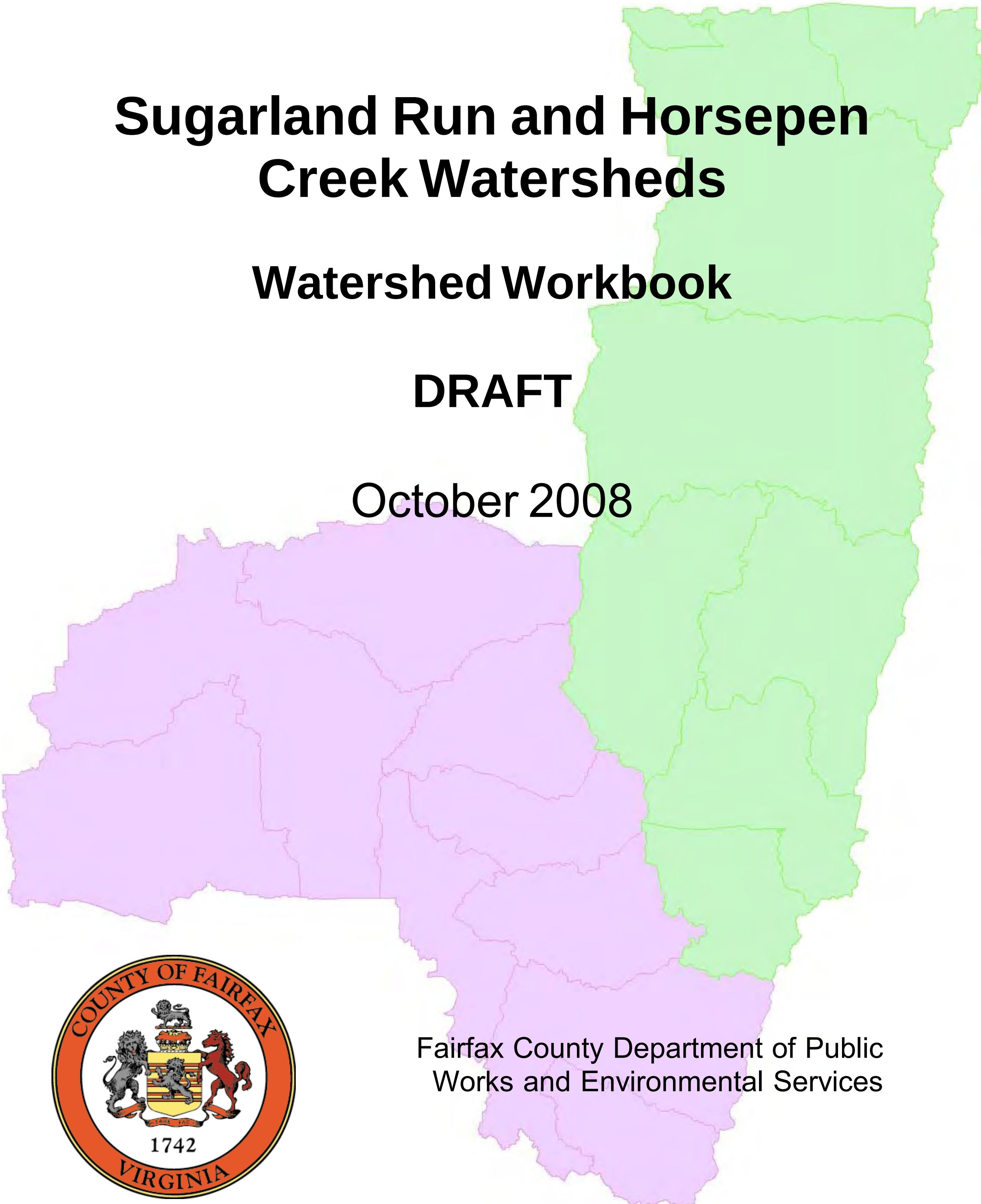
Sugarland Run and Horsepen Creek Watersheds

Watershed Workbook

DRAFT

October 2008



Fairfax County Department of Public Works and Environmental Services

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SUGARLAND RUN
AND
HORSEPEN CREEK
WATERSHED WORKBOOK

DRAFT

October 2008

Prepared for:

County of Fairfax
Watershed Planning and Assessment Branch
Department of Public Works and Environmental Services
Stormwater Planning Division
12000 Government Center Parkway, Suite 449
Fairfax, Virginia 22035-0052

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1.1 Introduction

1.2 Background, Goals and Objectives

Fairfax County is located in the Northeastern part of the Commonwealth of Virginia. Thirty watersheds comprise Fairfax County, including the Sugarland Run and Horsepen Creek watersheds, as shown in Figure 1.1. In order to comply with the Chesapeake Bay 2000 Agreement, the Fairfax County Department of Public Works and Environmental Services Stormwater Planning Division is in the process of developing and implementing watershed management plans for all 30 watersheds. The watershed management plans aim to evaluate the interactions between pollutant sources, watershed stressors, and conditions within streams and other waterbodies. The county will use the information from these plans to prioritize watershed restoration and protection projects.

The county has developed goals and objectives to be applied to all watersheds during the watershed management plan development process. The countywide goals and objectives will allow plan recommendations to be linked to the Countywide Watershed Assessment. The Countywide Watershed Assessment methodology will be used to measure and track future achievement of watershed management plan goals and objectives. According to the Fairfax County WMP Subwatershed Ranking Approach (Tetra Tech, 2008), the countywide watershed planning goals are to:

1. Improve and maintain watershed functions in Fairfax County, including water quality, habitat, and hydrology.

2. Protect human health, safety, and property by reducing stormwater impacts.

3. Involve stakeholders in the protection, maintenance and restoration of county watersheds.

The county has developed countywide objectives that are linked to the above goals, as presented in Table 1.1. This table also shows how each objective is linked to the three watershed planning goals.

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Figure 1.1
Fairfax County Watersheds

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Table 1.1 Fairfax County Watershed Planning Final Objectives

Objective		Linked to Goal(s)
CATEGORY 1. HYDROLOGY		
1A.	Minimize impacts of stormwater runoff on stream hydrology to promote stable stream morphology, protect habitat, and support biota.	1
1B.	Minimize flooding to protect property and human health and safety.	2
CATEGORY 2. HABITAT		
2A.	Provide for healthy habitat through protecting, restoring, and maintaining riparian buffers, wetlands, and instream habitat.	1
2B.	Improve and maintain diversity of native plants and animals in the county.	1
CATEGORY 3. STREAM WATER QUALITY		
3A.	Minimize impacts to stream water quality from pollutants in stormwater runoff.	1, 2
CATEGORY 4. DRINKING WATER QUALITY		
4A.	Minimize impacts to drinking water sources from pathogens, nutrients, and toxics in stormwater runoff.	2
4B.	Minimize impacts to drinking water storage capacity from sediment in stormwater runoff.	2
CATEGORY 5 STEWARDSHIP		
5A.	Encourage the public to participate in watershed stewardship.	3
5B.	Coordinate with regional jurisdictions on watershed management and restoration efforts such as Chesapeake Bay initiatives.	3
5C.	Improve watershed aesthetics in Fairfax County.	1, 3

Source: Fairfax County WMP Subwatershed Ranking Approach, Tetra Tech, 2008.

1.3 Watershed Workbook Organization

This watershed workbook is designed to provide the residents and stakeholders of the Sugarland Run and Horsepen Creek watersheds with information about their watersheds. This will help create a more informed public and encourage participation in the watershed planning and restoration process.

This watershed workbook contains the following information in each chapter.

Chapter 1 **Introduction** - Compilation of Overall Watershed Condition Data
Chapter 2 **Watershed Study Methodology** – Description of Methodologies Used
Chapter 3 **Sugarland Run Watershed Study** – Sugarland Run Preliminary Results
Chapter 4 **Horsepen Creek Watershed Study –** Horsepen Creek Preliminary Results
Chapter 5 **Glossary**

1.4 Watershed History and Condition

1.3.1 General Watershed Characteristics

The Sugarland Run and Horsepen Creek watersheds are located in the Northwestern portion of Fairfax County, as shown in Figure 1.2. Both watersheds are described in detail below.

Sugarland Run

Sugarland Run Watershed is made up of Sugarland Run, Offuts Branch, Folly Lick Branch, and Rosiers Branch. Sugarland Run flows north from its origin near Reston's Rosedown Avenue into Loudoun County, discharging to the Potomac River. Offuts Branch originates near Leesburg Pike (VA Route 7) and flows west to its confluence with Sugarland Run. Folly Lick Branch flows north from its headwaters in the town of Herndon to its confluence with Sugarland Run. Rosiers Branch is situated to the east of Sugarland Run and flows west to its confluence with Sugarland Run. About one-third of the watershed lies in Loudoun County. The portion of the Sugarland Run Watershed that lies within Fairfax County has a drainage area of approximately 15.3 square miles. There are approximately 48.6 miles of perennial streams in the entire watershed and 31.1 miles of perennial streams in Fairfax County.

Horsepen Creek

Horsepen Creek Watershed is comprised of Horsepen Run, Frying Pan Branch, Cedar Run, and Merrybrook Run. Horsepen Run flows northwest from its headwaters near Fox Mill Road towards its confluence with Broad Run in Loudoun County. Frying Pan Branch originates near Herndon's Fox Mill Road and flows west to its confluence with Horsepen Run. Cedar Run originates to the south of Horsepen Run and flows northwest to its confluence with Horsepen Run. Merrybrook Run originates to the north of Horsepen Run and flows northwest to its confluence with Horsepen Run in Loudoun County. A portion of the watershed lies in neighboring Loudoun County. The area of the Horsepen Creek Watershed that lies within Fairfax County has a drainage area of approximately 9.6 square miles. There are approximately 36.3 miles of perennial streams in the entire watershed and 19.4 miles of perennial streams in Fairfax County.

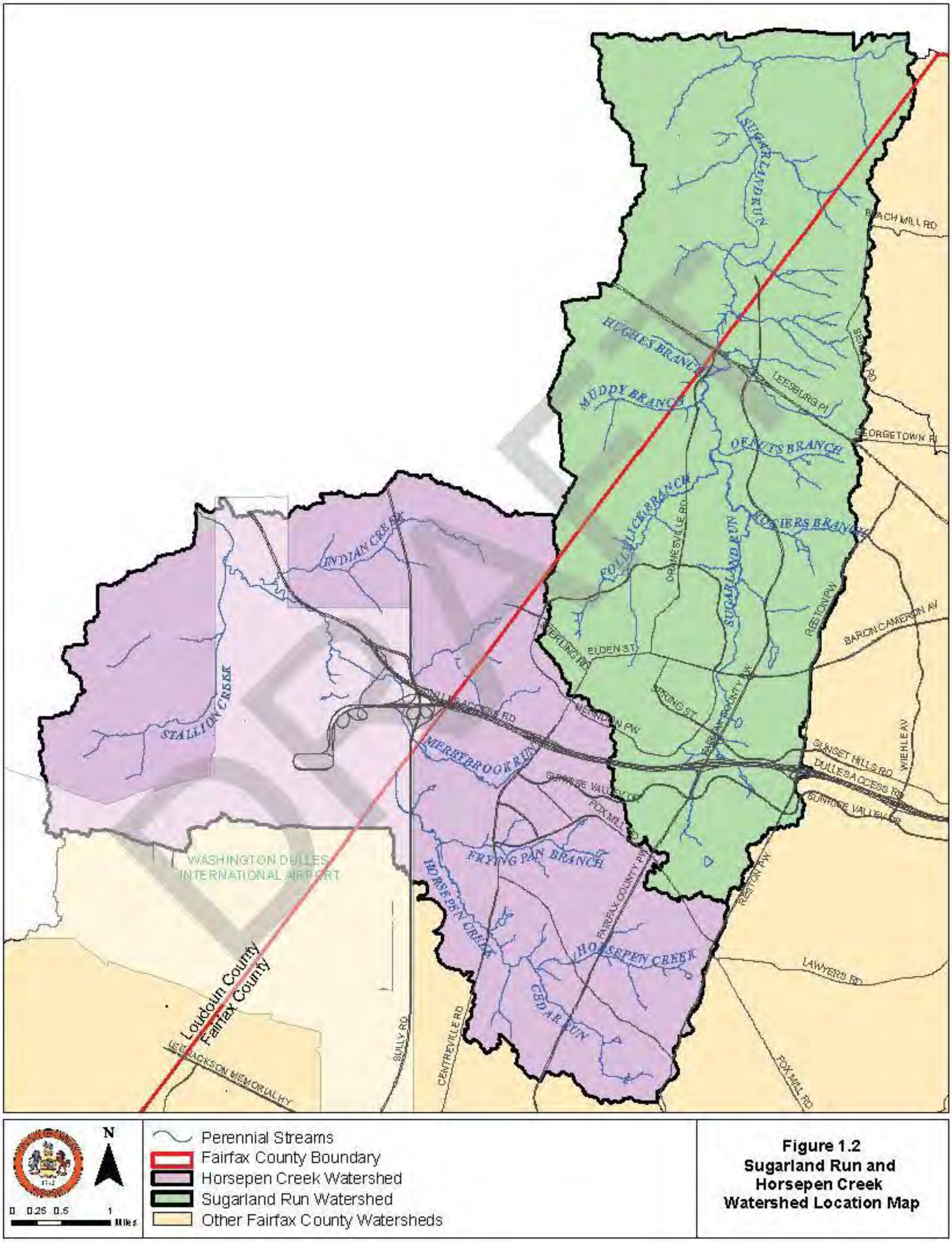

Figure 1.2
Sugarland Run and Horsepen Creek Watershed Location Map

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1.3.2 Watershed History and Population Growth

Watershed History

The Sugarland Run and Horsepen Creek watersheds have an interesting history. Early European rangers, who periodically scouted the area for Indians in the late 1600s to early 1700s, discovered sugar maple trees and named the nearby stream Sugarland Run. In 1709 Daniel McCarty obtained a large land grant on the west side of Sugarland Run. By 1720 he was using Sugarland Rolling Road, now Georgetown Pike, to roll hogsheads of tobacco to market. The town of Floris, once known as "Frying Pan," was situated between Horsepen Run and Frying Pan Branch. Leesburg Pike (Route 7) passes through the northern end of the Sugarland Run watershed. The road was originally known as Eastern Ridge Road, and can be traced back to 1699 when the Governor of Virginia sent a mission to the emperor of the Piscataway tribe on Conoy Island. (Parsons, Brinckerhoff, Quade, and Douglass, 1977).

The Town of Herndon lies almost entirely in the headwaters of the Sugarland Run Watershed with a small portion in the Horsepen Creek Watershed. The Town of Herndon was founded in 1879 and covers 4.25 square miles. The town was originally surrounded by dairy farms, which shipped their milk daily to Washington, D.C. for processing and distribution. The town was also a vacation haven for city dwellers, who traveled to the area by railroad. The vacationers soon began building spacious summer houses throughout Herndon, which led to population growth (Town of Herndon, 2008).

Population Growth

There was very little growth within the Sugarland Run and Horsepen Creek watersheds toward the end of the 19th century. A Bureau of Topographic Engineers map from 1862 shows cultivated fields in the Horsepen Creek and Sugarland Run watersheds and large forested areas in the Sugarland Run Watershed. In 1879, the Sugarland Run Watershed had a housing density of one house per 120 acres and was the fourth most densely occupied watershed in Northern Virginia. The Horsepen Creek Watershed had a density of one house per 256 acres which was somewhat below the average of one house per 204 acres for the whole region (Parsons, Brinckerhoff, Quade, and Douglas, 1977).

In 1900 Fairfax County was largely agricultural, with dairy farming being the most important single industry. The population was just over 12,000. Four decades later, the population was still under 50,000. Beginning in the early 1940s, the county's economy shifted from agriculture to largely commercial. After World War II many people moved into Fairfax County from Washington, D.C. During this time the population grew from roughly 50,000 to 500,000. In the 1970s the population of Fairfax grew to almost 900,000 residents, driven by technology-based businesses which were less dependent on urban centers than conventional industry, resulting in suburban expansion (Fairfax County, 2001). Today, Fairfax County is the most populous jurisdiction in Virginia as well as the Washington D.C. metropolitan area, with the 2005 population estimated at 1,047,500, with 387,700 households (Fairfax County, 2006a).

The population of the Town of Herndon has also been increasing dramatically in recent years, with a 34 percent increase from 16,139 in 1990 to 21,655 in 2000 (US Census Bureau 2000, n.d.). The Sugarland Run and Horsepen Creek watersheds also experienced a population increase of over 52 percent in the 1990s. Herndon (and the unincorporated area to the south of Herndon) is part of the Dulles Technology Corridor, and is home to the headquarters of such companies as AOL, Verizon Business, Network Solutions and Airbus North America. The majority of recent development has consisted of residential infill development to meet the housing demands of corporate growth.

Infill Development in Fairfax County

In July 2000, the Fairfax County Departments of Planning and Zoning, Transportation and Public Works, and Environmental Services prepared a report that evaluated issues and provided recommendations for improving the manner in which residential infill development occurs in the county, with the primary focus being the impacts of new residential development on the immediate surroundings (Fairfax County, 2006b). "Infill development" in Fairfax County refers to activities such as demolishing an existing home and building a larger home on the same lot; 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 that is surrounded by other recently developed subdivisions; or redeveloping an existing subdivision. The report included recommendations to address the compatibility of infill development with the existing neighborhood/area, traffic flow and cut-through traffic, tree preservation and the preservation of open space in the neighborhood, and stormwater management and erosion and sediment control.

1.3.3 Existing and Future Land Use

Fairfax County encompasses an area of approximately 395 square miles. The land use is primarily residential, with smaller areas of commercial, recreational, and open land uses. The county is largely developed, and is approaching maximum build-out conditions (Fairfax County, 2006a). According to the 1999 Demographic Reports Document, only 17.3 percent of the land area is considered underutilized residential, vacant residential or nonresidential land. (Fairfax County, 2001).

The Fairfax County Stormwater Planning Division has created standard land use categories to unify watershed management planning throughout the county. The categories are assigned a code for easy identification. The Fairfax County land use categories are presented in Table 1.2.

Table 1.2 Generalized Land Use Categories

Land Use	Code	Description
Open Space	OS	Open space, parkland, or vacant land
Estate Residential	ESR	Single-family detached greater than 2 acres per residence
Low Density Residential	LDR	Single-family detached 0.5-2 acres per residence
Medium Density Residential	MDR	Single-family detached less than 0.5 acres per residence and multifamily residential less than 8 dwelling units per acre
High Density Residential	HDR	All residential less than 0.125 acre per residence (8 or greater dwelling units per acre)
Low Intensity Commercial	LIC	Commercial uses including low rise and limited offices and neighborhood retail
High Intensity Commercial	HIC	Commercial uses including high density offices and highway retail
Industrial	IND	Industrial uses
Golf Course	GC	Golf courses, originally considered open space
Water	WATER	Perennial streams buffered 10’
Institutional	INT	School or institutions, originally considered LIC
Transportation	TRANS	Transportation, areas not represented by parcels

Source: County of Fairfax Department of Public Works, 2003

According to Technical Memorandum No. 3, prepared by County of Fairfax Department of Public Works (Fairfax County, 2003), the Horsepen Creek Watershed comprises 6,436 acres, of which 674 are vacant and 73 are underdeveloped. Approximately 11 percent of the watershed is not fully utilized. The Sugarland Run Watershed comprises 8,917 acres, 546 of which are vacant and 200 of which are underdeveloped. Approximately 8.4 percent of the watershed is not fully utilized. Figure 1.3 shows the existing and future land use by category in the Sugarland Run and Horsepen Creek watersheds.

The future land use conditions are defined by the planned land use and the zoned land use. If the planned and zoned land uses conflict, the classification with the greatest density will be used to evaluate future conditions. The results derived from these maps will be discussed in greater detail in future chapters.

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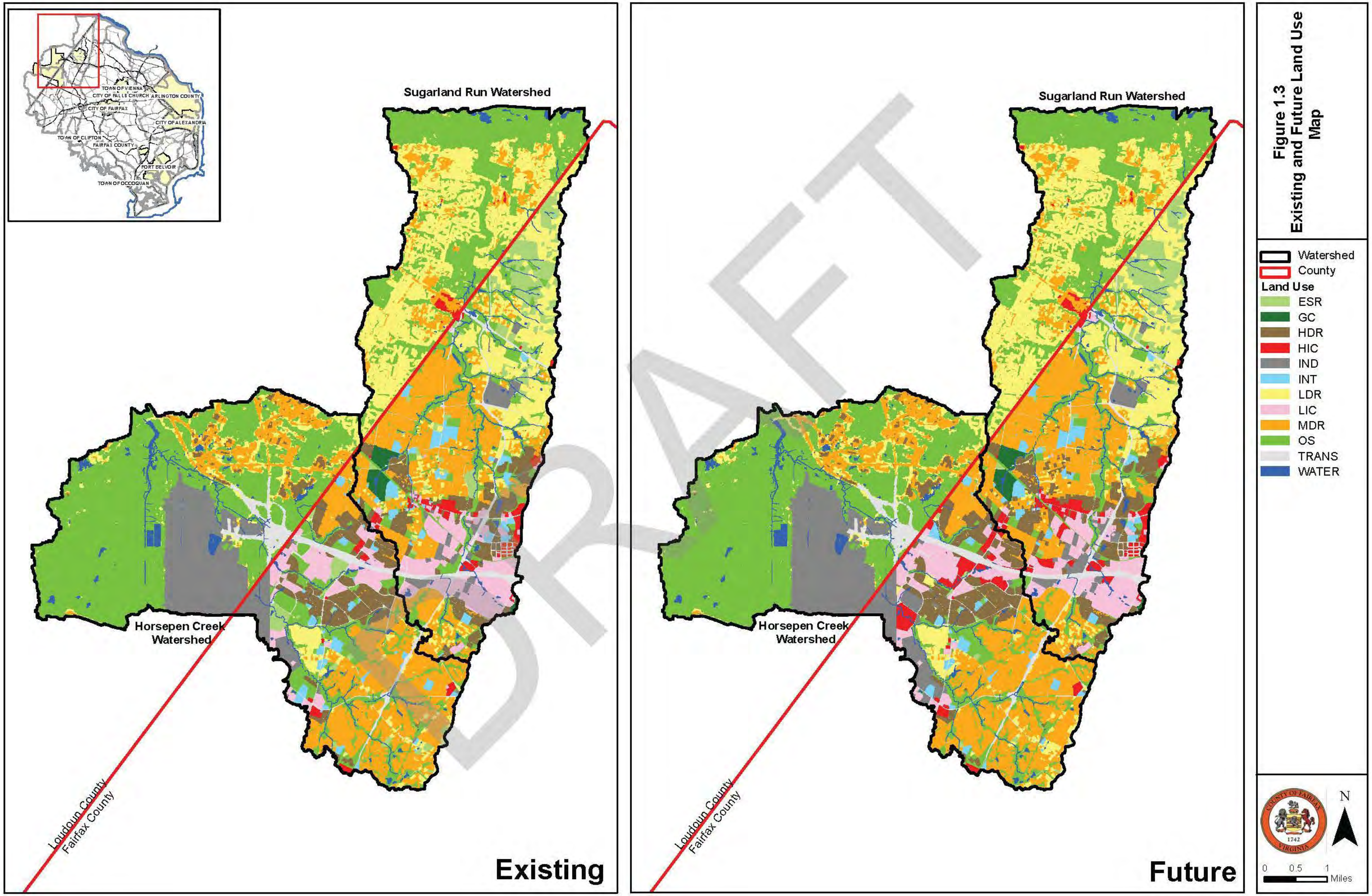

Figure 1.3 Existing and Future Land Use Map

1.3.4 Aquatic Environment

The overall quality of aquatic environments is dependent on many interconnecting factors. Major factors include water quality, stream habitat, and vegetative cover. Due to the changing relationship of these factors, the analysis of aquatic life, including benthic macroinvertebrates and fish populations, can better represent overall stream health.

Habitat Studies

An Environmental Baseline report was prepared by Parsons, Brinckerhoff, Quade, and Douglas in 1977 to assess changes within the Fairfax County watersheds, provide a general environmental framework for the development of the master plan for flood control, and aid in predicting the environmental effects of proposed improvements. According to the report, areas with upland hardwood forests, softwood forests, abandoned fields, floodplain forests, floodplain meadows, tidal fresh marshes, and hemlock cove forests (considered good to excellent wildlife habitats) were the most common throughout the Horsepen Creek and Sugarland Run watersheds, with particularly high terrestrial habitat quality. The exception was around the urbanized areas of Herndon and Reston. Due to the high habitat quality, animal population and diversity were high, with more wood turtles found in the area than anywhere else in the county. The aquatic field studies were less favorable. The test sites within the Horsepen Creek Watershed ranged from very good on the upper Horsepen Creek to good-fair on the lower Horsepen Creek. The Sugarland Run sites ranged from fair-poor on the lower Sugarland Run to poor-very poor on the upper Sugarland Run.

The Fairfax County Stream Protection Strategy program (Fairfax County, 2001) focused on recommendations for protection and restoration activities on a subwatershed basis, prioritization of areas for allocation of limited resources, establishment of a framework for long-term stream quality monitoring, and support for overall watershed management. Detailed biological and habitat data were collected in 2001 from five testing sites located within the Horsepen Creek and Sugarland Run watersheds. Based on the study, both Horsepen Creek and Sugarland Run watersheds were designated as Watershed Restoration Area Level II. The primary goal of the Watershed Restoration Level II areas was to prevent further degradation and implement measures to improve water quality to comply with Chesapeake Bay initiatives and other water quality initiatives and standards.

Although the 1976 data (Parsons, Brinckerhoff, Quade, and Douglas, 1977) and 2001 data (Fairfax County, 2001) cannot be directly compared due to differing methods of evaluation, it is evident that there is a general trend of decreasing quality within the Horsepen Creek Watershed. There appears to be no change in habitat quality in the Sugarland Run Watershed between 1976 and 2001. Horsepen Creek and Sugarland Run watersheds have very high percentages of impervious cover (20-46 percent), which has led to degraded stream conditions.

Stream Physical Assessment

Fairfax County conducted a stream physical assessment in 2005 to obtain baseline data for the County's streams (CH2MHill, 2005). The streams were evaluated based on habitat conditions, impacts to the stream from infrastructure and problem areas, general stream characteristics and geomorphic classification. The overall goal of the stream assessment program was to provide a consistent basis for protecting and restoring the receiving water systems and other natural resources in Fairfax County.

Approximately 17 miles of streams were assessed in the Horsepen Creek Watershed during the 2005 study. The habitat conditions for roughly 1.1 miles were classified as very poor, 3.5 miles were classified as poor, 6.1 miles were classified as fair, 6.1 miles were classified as good, and 1.3 miles were classified as excellent. The watershed received a length-weighted habitat score of 100, which represents overall fair habitat conditions. Approximately 26 miles of stream were assessed in the Sugarland Run Watershed. The habitat conditions for roughly 4.2 miles were classified as poor, 7.6 miles were classified as fair, and 13.9 miles were classified as good. Overall, the watershed was given a length-weighted habitat score of 111, or fair conditions.

Stream geomorphology was also investigated as part of the stream physical assessment in 2005 to obtain baseline data for the county's streams. Stream geomorphology is the study of forces of water as it travels through the landscape. These forces create channels, floodplains, terraces and drainage patterns. They can help explain erosion, sediment transportation and sediment deposition. Geomorphic channel classifications were based on the Channel Evolution Model (CEM) developed by Schumm et al. (1984). The CEM characterized the majority of the Horsepen Creek watershed to be in the evolutionary Stage 3, with the remainder in Stage 2. Evolutionary Stage 3 is characterized by streambank sloughing, eroded sloughed material, and bend erosion. Evolutionary Stage 2 is characterized by head cuts and deficient sediment deposits. The CEM established that 60 percent of the Sugarland Run watershed has Stage 3 channels, with the remainder in Stage 4. Evolutionary Stage 4 channels are characterized by streambank aggrading, vegetated sloughed material, and the development of base flow, bankfull, and floodplain channels.

An infrastructure inventory was conducted as part of the 2005 stream physical assessment to identify impacts on the stream from specific infrastructure and problem areas. The study identified and characterized deficient riparian buffers, ditches, dump sites, erosion areas, head cuts obstructions, road crossings and pipes. Within Horsepen Creek, 322 inventory hits were recorded, with the most significant problems being head cuts. Within Sugarland Run, 281 inventory hits were recorded, with the most significant problems including deficient riparian buffers, head cuts, a road crossing, a pipe, and an eroded area.

Impaired Waters

Section 305(b) of the U.S. Clean Water Act requires each state to submit a report on all information regarding its waters once every two years. Section 303(d) of the Clean Water Act requires a list of waters with impaired water quality for each state. Waters that are impaired due to human activities and pollutants require a total maximum daily load (TMDL) plan to restore their water quality. Once a TMDL is approved, a TMDL Implementation Plan is developed to restore impaired waters and maintain their improved water quality. The Virginia 2004 Integrated Water Quality Assessment Report (Virginia Department of Environmental Quality, 2004) provides information about the water quality conditions in Virginia from January 1, 1998 to December 31, 2002, and the Virginia 2006 Integrated Water Quality Assessment Report (Virginia Department of Environmental Quality, 2006) provides information about the water quality conditions in Virginia from January 1, 2000 to December 31, 2004.

The 2006 Integrated Report presents water quality assessment results for approximately 14,265 miles of free-flowing streams and rivers, or about 28.3 percent of Virginia's streams and rivers for which sufficient data were available. The leading cause of impairment of designated use was violation of the bacteria standards. Agricultural practices appear to be one of the primary sources contributing to bacteria standards violations. However, urban runoff, leaking sanitary sewers, failing septic tanks, domestic animals, and wildlife can be significant contributors. Figure 1.4 shows 303(d) impaired waters within the Sugarland Run and Horsepen Creek watersheds, based on the 2006 Integrated Report. A total of 5.75 miles of Sugarland Run is impaired beginning at the confluence with Folly Lick Branch at approximately river mile 5.75, and continuing downstream until the confluence with the Potomac River. Sugarland Run was first listed as impaired for fecal coliform in 2002 and for Escherichia coli bacteria (E. coli) in 2006, and therefore did not support the recreational use goal. It was added to the 303(d) list in 2002 and the TMDL development date is 2014.

Wetlands

Wetlands are vital to the watershed ecosystem because they filter pollutants and sediments from stormwater, reduce flooding, provide wildlife habitat and function as a nursery for aquatic life food chains. There are approximately 13,000 to 18,000 acres of wetlands in Fairfax County. Non-tidal wetlands comprise approximately 7,000 to 10,000 acres of Fairfax County. The Horsepen Creek Watershed contains 382 acres of non-tidal wetlands and the Sugarland Run Watershed contains 709 acres of non-tidal wetlands (U.S. Fish and Wildlife Service, 2008).

In the Sugarland Run Watershed, a majority of the wetlands are forested freshwater/shrub wetlands. These types of wetlands are dominant on the Sugarland Run Branch and Folly Lick Branch, especially in open space areas and within golf courses. Freshwater pond wetlands occur at the headwaters of all the streams in the Sugarland Run Watershed.

In the Horsepen Creek Watershed, a majority of the wetlands are freshwater ponds and freshwater emergent wetlands. These types of wetlands can be found on the Cedar Run Branch, Horsepen Run Branch and Frying Pan Branch. They are mainly located at the headwaters of each branch. Wetlands such as forested freshwater/shrub wetlands are located at the confluence and main stem sections.

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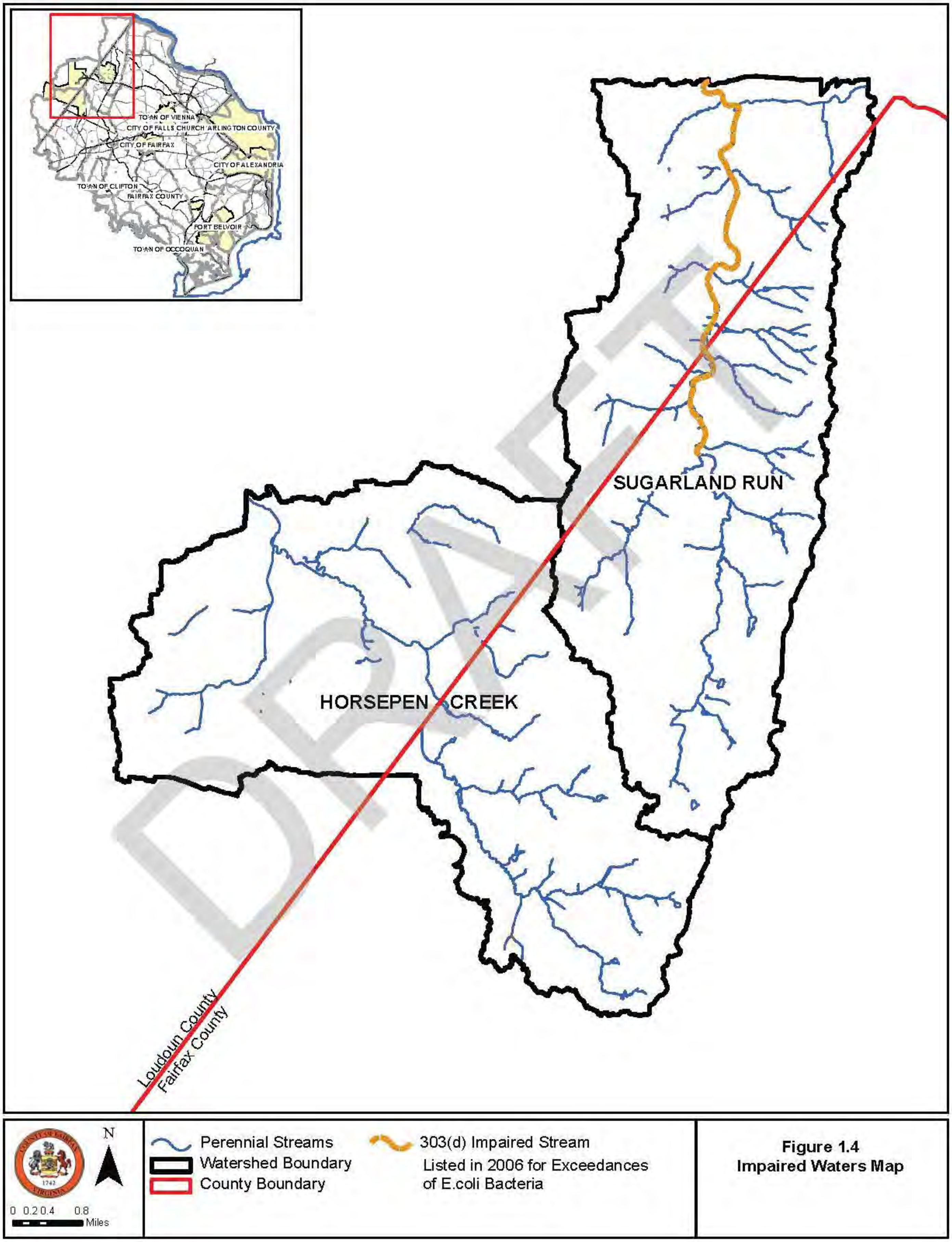

Figure 1.4
Impaired Waters Map

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1.3.5 Terrestrial Environment

<u>Forest Resources</u>
In the early 1600s, the Chesapeake Bay region was estimated to have 95 percent of its landmass covered by tree canopy. By the middle of the 19th century, historic evidence suggests that timber harvesting, agriculture, and fuel and military activities had reduced tree canopy levels to about 30 percent in Northern Virginia. With a sharp decrease in farming activities and an increase in land development in the early 1970s, Fairfax County's canopy cover rose to approximately 80 percent. Currently, the county's tree canopy cover is estimated at approximately 41 percent, or 104,000 acres of the county's 252,828 acres. The current tree canopy is comprised of 68 percent (70,720 acres) native forests, and 32 percent (33,280 acres) planted landscape trees, areas with early succession-stage tree communities, and areas dominated by invasive trees and non-native plant species. The present level of tree canopy corresponds closely to the 40 percent that is recommended by American Forests for communities east of the Mississippi River (Tree Action Plan Work Group, 2006).

The vision of the Fairfax County Tree Commission's Tree Action Plan is to leave the land, water, and air quality better than it was found. The recommended actions proposed within the plan are based on three framework goals: 1) To commit to preserving current tree assets by fostering health and regeneration of specimen trees and urban forest; 2) To enhance the legacy for future generations by increasing the quantity and quality of trees and wooded areas; and, 3) To more effectively integrate urban forestry in planning and policy making (Tree Action Plan Work Group, 2006).

<u>Terrestrial Flora and Fauna</u>
The Virginia Department of Conservation and Recreation's Natural Heritage Program (DCR-DNH) maintains a statewide inventory of plants, animals, natural communities, and other biological resources that are rare, threatened, endangered, or of special concern within the Commonwealth of Virginia. The database is updated annually as information becomes available to the department. In the Sugarland Run Watershed, rare, threatened and endangered species include the wood turtle (*Glyptemys insculpta*), purple milkweed (*Asclepias purpurascens*), and the white trout-lily (*Erythronium albidum*). In the Horsepen Creek Watershed, rare, threatened and endangered species include stiff goldenrod (*Oligoneuron rigidum* var. *rigidum*) (Virginia DCR-DNH, 2008).

1.3.6 Resource Protection Areas

Resource Protection Areas are vegetated riparian buffer areas that include land within a major floodplain and land within 100 feet of the water body in the floodplain. Resource Protection Areas in Sugarland Run and Horsepen Creek watersheds are shown in Figure 1.5. These buffer areas are important in the reduction of sediments and nutrients, as well as the other adverse effects of human activities. Under the county's old Chesapeake Bay Preservation Ordinance, if streams were not identified as perennial on the U.S. Geological Survey map, they did not warrant being in a Resource Protection Area (Fairfax County, Virginia, March 23, 2007).

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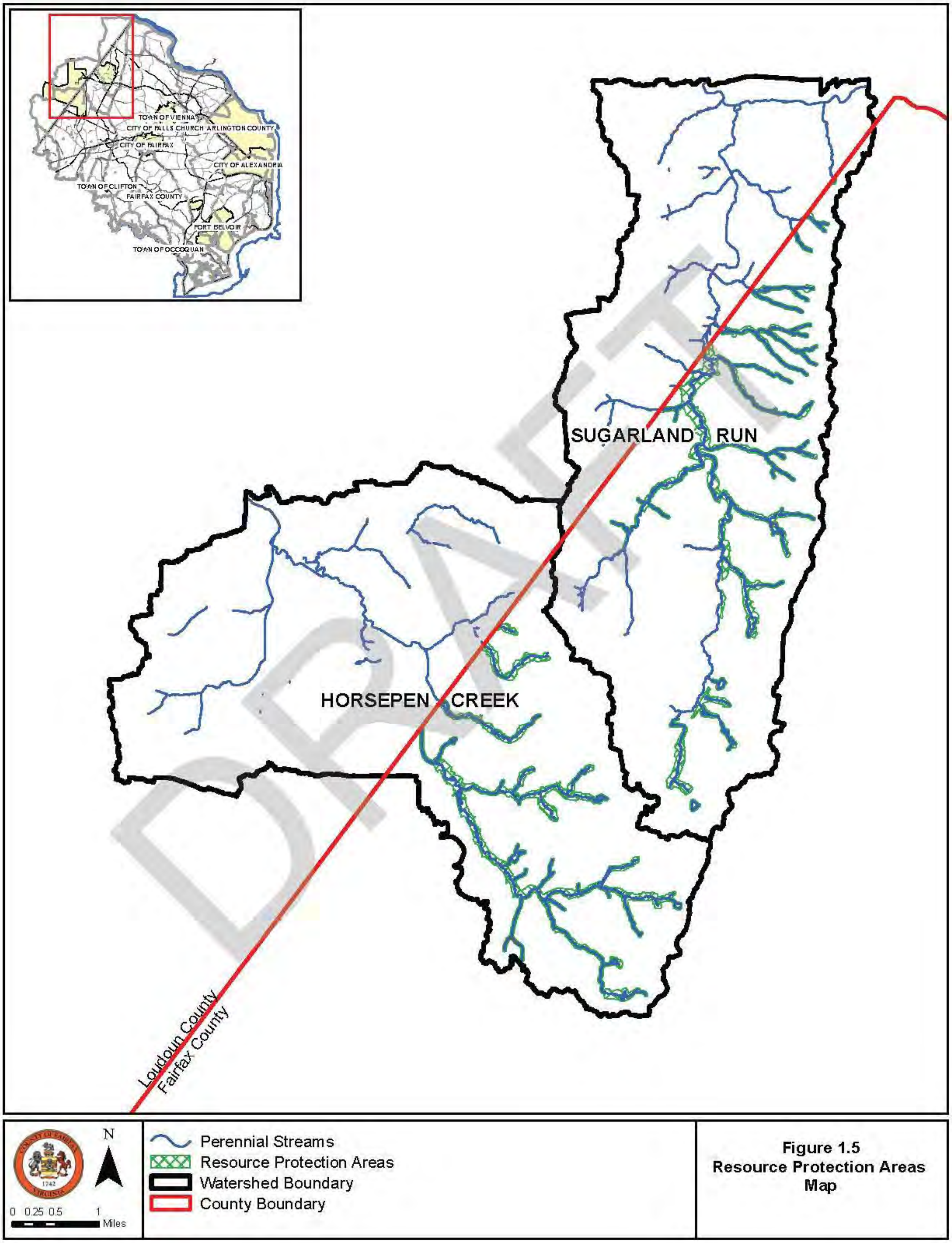

Figure 1.5
Resource Protection Areas Map

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The Perennial Stream Mapping Project was initiated to address concerns that all perennial streams were not being protected under the county's Chesapeake Bay Preservation Ordinance. At that time, the county's ordinance only listed perennial streams as those streams which were depicted as perennial on the U.S. Geological Survey topographical maps. To ensure compliance with the state's revised Chesapeake Bay Preservation Area Designation and Management Regulations, Fairfax County began the process of accurately mapping all streams in the county in 2002. By October 2003, the field work was completed and the new Resource Protection Area maps were generated (Fairfax County, Virginia, March 23, 2007).

1.3.7 Stormwater Management

Regional stormwater management prior to the late 1970s, had been achieved in Fairfax County through developer cooperation, rezoning proffers and joint county/developer projects. The Fairfax County Regional Stormwater Management Plan (Camp Dresser & McKee, Inc., 1989) was developed to identify the most appropriate locations for regional stormwater detention facilities. The recommended regional basin network for the plan was developed through a multi- step process with criteria that included land availability, topography and available storage. Once sited, the detention basins were modeled using hydrologic models to determine watershed-wide impacts.

The Fairfax County Drainage Master Plan (Fairfax County, January 2007) is a database of stormwater and drainage projects that are derived from the following sources: basin drainage plans by Parsons, Brinkerhoff, Quade and Douglas from the late 1970s, a Regional Pond Plan by Camp, Dresser, and McKee from 1989, citizen drainage complaints, recorded maintenance problems, and localized drainage studies. Within the Horsepen Creek Watershed, the database lists a total of 27 projects, 22 of which are listed as inactive (not an actively funded county project), one is listed as deleted because it was not a drainage project, two are listed as partially funded active county projects, and the remaining two are listed as fully funded county projects. Within the Sugarland Run Watershed, the database lists a total of 30 projects, 26 of which are listed as inactive, three are partially funded active county projects, and one is a completed basin project that is not fully a regional pond as constructed. A majority of the inactive projects are stream restorations and stormwater pipe and culvert work. The actively funded projects are all regional detention ponds

The Basin Plan (Parsons, Brinckerhoff, Quade, and Douglas, 1979) was created as a part of the overall stormwater management program for Fairfax County. The plan includes an analysis of stormwater problems throughout the watersheds and recommended solutions. The solutions were weighted according to cost, construction feasibility, and environmental and aesthetic considerations. The problems identified within the watersheds included sediment and debris accumulations, flooding of adjacent sewer lines, bank erosion, channelization, or the need for detention ponds. Thirty-two projects were recommended in the Horsepen Creek Watershed at a total cost of $3,032,000 and 29 projects were recommended in the Sugarland Run Watershed at a total cost of $2,938,000.

Fairfax County approved the use of stormwater detention ponds (Regional Ponds) in 1987. This idea of regional ponds was reviewed by the Fairfax County Board of Supervisors and was adopted in 1989 as the Regional Stormwater Management Plan (Fairfax County, 2003). The plan was to provide regional detention for rapidly developing areas of Fairfax County. The purpose was to promote safety and reduce the county's liability exposure for stormwater management facilities within residential areas. The implementation of 134 regional ponds was proposed as a preferred type of stormwater management. A Regional Pond Subcommittee was developed in 2002 to re-evaluate this type of stormwater management practice. This subcommittee compiled a comprehensive list of issues and organized them into categories. They then considered what would be an ideal stormwater program within the subject area. The subcommittee determined that although regional ponds are not the preferred stormwater management alternative, they should be considered one of many tools that can be used to manage stormwater in Fairfax County. (Fairfax County, 2003).

A Forested Wetland Committee was also developed to determine methods to minimize the disturbance of wetlands, primarily forested wetlands, during the implementation of regional stormwater management ponds. The following are the recommendations of the subcommittee regarding wetlands and regional stormwater management facilities.

1. A regional pond wetlands protection policy should be instituted which will examine all regional sites for wetland impacts and will locate stormwater facilities strategically to avoid wetland areas.
2. The design and construction of innovative and state-of-the-art Best Management Practices (BMPs) should be encouraged.
3. The maintenance and efficiency of BMPs should be a top priority.
4. Protection must be addressed for stream channels and associated riparian wetlands before the stormwater facilities are built.
5. Each site should be evaluated on a case-by-case basis to determine the appropriate BMP.
6. The Fairfax County BMP program should be re-evaluated every four years.
7. Regional ponds located in the Chesapeake Protection Areas should be moved outside the major floodplain.

The watershed management plan that is developed as a result of this project will be used by Fairfax County to select watershed management projects for future construction. These watershed management practices will be carefully selected to make the best use of county resources and at the same time provide the most benefit to the largest area of the county.

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2.1 Watershed Study Methodology

2.2 Watershed Management Areas and Subwatersheds

Fairfax County contains 30 watersheds, including the Horsepen Creek and Sugarland Run Watersheds. A watershed is the land area that drains into a stream. They are defined by the topography of the area and do not follow county, state or national boundaries. The size of a watershed can vary from a few acres for a small stream to many square miles for a large river. The watersheds within Fairfax County are part of the larger Potomac River basin. The Potomac River, in turn, is part of the even larger Chesapeake Bay Watershed, which drains 64,000 square miles and extends from New York through Pennsylvania, Delaware, West Virginia, Maryland, Virginia and the District of Columbia.

For management and planning purposes, watersheds are further broken down into watershed management areas (WMAs) and subwatersheds. A WMA is generally four square miles (2,560 acres) in size and is the contributing drainage area to a major tributary or a group of subwatersheds with similar characteristics. A subwatershed ranges in size from 100 to 300 acres. Due to their smaller size, WMAs and subwatersheds are easier to target for specific watershed management and restoration strategies. The WMAs in the Sugarland Run and Horsepen Creek watersheds are shown in Figure 2.1.

2.3 Existing and Future Land Use

One of the leading causes of stream degradation, including water quality impairments and habitat decline, is changes in land use. As shown in Figure 1.4 in Chapter 1, the Sugarland Run and Horsepen Creek watersheds are highly developed. Monitoring changes in land use will provide critical information to the overall health of the watersheds. For example, high density residential, commercial and industrial land uses generally produce higher stormwater runoff volumes and pollutant loads, whereas open space and estate residential land uses have a much lower impact on the health of the watershed.

For this study, the existing and future land use within the Sugarland Run and Horsepen Creek watersheds were analyzed to assist with the selection of areas for field reconnaissance. Open space land use data was compared to building footprint data provided by the county to determine areas of new construction. The areas thought to be newly constructed were field-verified to ensure accuracy. The land use GIS was updated to reflect changes found during the field reconnaissance. The land use GIS was also used to identify neighborhoods and other development areas for the Neighborhood Source Assessments (NSA), which are described further in Chapters 3 and 4. At least one representative neighborhood was chosen per WMA, based upon the land use within the area. The existing and future land use data will be further utilized to identify current and future management opportunities and project areas to better achieve the county's goals and objectives.

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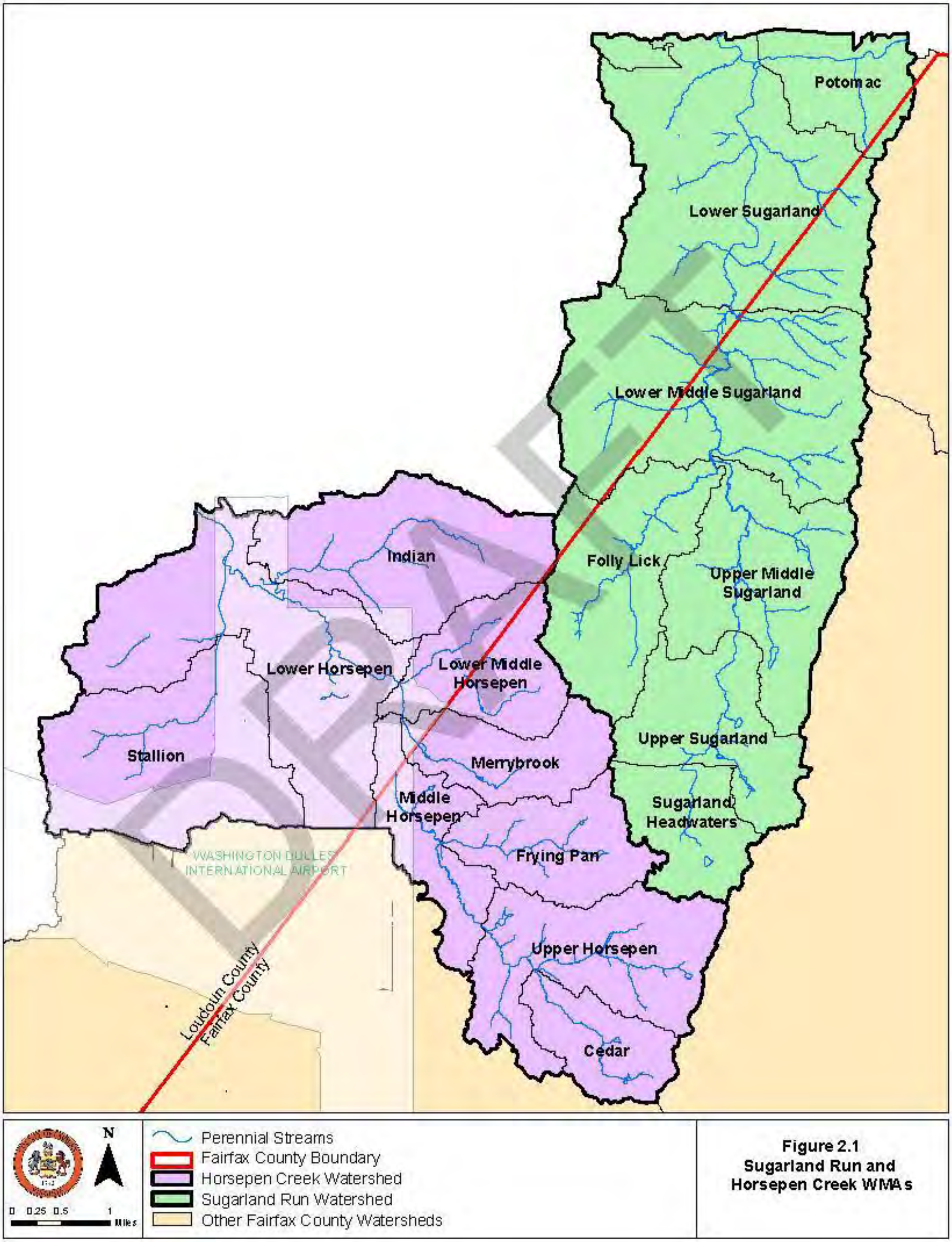

Figure 2.1
Sugarland Run and Horsepen Creek WMAs

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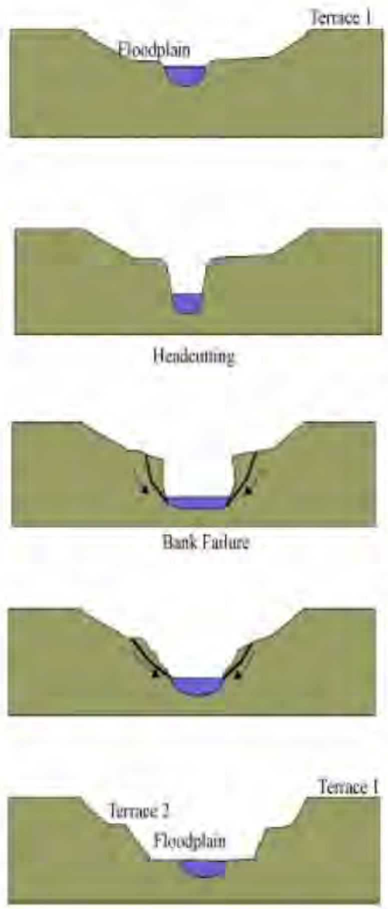
2.4 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was conducted to update and supplement existing Fairfax County GIS data so current field conditions were accurately represented. Once these data were acquired, spatial analysis was performed to characterize county watersheds as they currently exist using the county's GIS. The reconnaissance effort included the identification of pollution sources, current stormwater management practices and potential restoration opportunities across the various watersheds.

Fairfax County conducted a physical stream assessment in 2005 to obtain baseline data for the County's streams, as described in Chapter 1. A supplemental physical stream assessment was completed during the summer of 2008, in which approximately nine miles of stream within the Sugarland Run and Horsepen Creek watersheds were surveyed. The assessment included portions of Sugarland Run, Offuts Branch, Folly Lick Branch, Horsepen Creek and Merrybrook Run. The original physical stream assessment protocol was followed which included an infrastructure inventory, a habitat assessment, stream characterizations, and a Channel Evolution Model assessment. The infrastructure inventory identified and characterized the following:

- Ditches
- Dump sites
- Erosion areas
- Head cuts
- Obstructions
- Pipes
- Road and other stream crossings
- Utility lines

The habitat assessment and stream characterization served to document the stream physical conditions, while the Channel Evolution Model assessment evaluated the stability of the stream. The Channel Evolution Model can define the stages the stream channel geomorphology will take after a disturbance, and can be used to predict future conditions. Geomorphology is the process by which stream channels adjust to changes within the associated watershed. Stream geomorphology is a natural process that occurs slowly over time. The features of a stream channel are determined by the type of soil, the slope, and the flow experienced by the channel. Alterations to the watershed will lead to changes in the stream channel; the channel will rework itself to meet the new watershed conditions. Figure 2.2 shows the five stages of geomorphic condition in the Channel Evolution Model.



Type 1: Well-developed base flow and bankfull channel; consistent floodplain features easily identified; one terrace apparent above active floodplain; predictable channel morphology; floodplain covered by diverse vegetation; stream banks less than or equal to 45°

Type 2: Head cuts; exposed cultural features (along channel bottom); sediment deposits absent or sparse; exposed bedrock (parts of reach); stream bank slopes greater than 45°

Type 3: Stream bank sloughing, sloughed material eroding; stream bank slopes greater than 60° or vertical/undercut; erosion on inside of bends; accelerated bend migration; exposed cultural features (along channel banks); exposed bedrock (majority of reach)

Type 4: Stream bank aggrading; sloughed material not eroded; sloughed material colonized by vegetation; base flow, bankfull, and floodplain channel developing; predictable channel morphology developing; stream bank slopes less than or equal to 45°

Type 5: Well-developed base flow and bankfull channel; consistent floodplain features easily identified; two terraces apparent above active floodplain; predictable channel morphology; stream banks less than or equal to 45°

Figure 2.2 Channel Evolution Model Stages (Schumm, et al., 1984)

Along with habitat assessments, the stream reaches were placed in one of five stages of geomorphic condition in the Channel Evolution Model (CEM). Approximately 60 percent of the Sugarland Run Watershed was in Evolutionary Stage 3, with the remainder in Evolutionary Stage 4. Stage 3 is the widening stage and is characterized by streambank sloughing, erosion on insides of bends, accelerated bed migration, and exposed bedrock. Stage 4 is the stabilizing stage which is characterized by streambank aggrading, base flow, bankfull, and floodplain channel developing, and a predictable channel morphology developing. The majority of channels in the Horsepen Creek Watershed are in Evolutionary Stage 3, with the rest in Stage 2. Stage 2 is the incision stage which is characterized by head cuts, absent sediment deposits, and exposed bedrock (Fairfax County, 2001).

2.5 Watershed Characterization

Successful management of a watershed requires the assessment of the interactions between pollutant sources, watershed stressors, and conditions within streams and other waterbodies. The goal is to identify existing and potential problem areas and evaluate subwatershed restoration opportunities. This requires a direct evaluation of the existing stream conditions and stormwater infrastructure, streambank erosion, flooding, unique watershed conditions, water quality problems, and other factors relating to the ecosystem and stormwater drainage network.

The watershed characterization data obtained from previous studies and provided by the county were used to create maps to characterize the watersheds. Two types of maps were developed: stream condition maps and stormwater infrastructure maps. The stream condition maps display the overall health and stability of the streams within the watersheds and the stormwater infrastructure maps display the extent and type of stormwater management facilities within the watersheds. Chapters 3 and 4 provide more detailed information on a WMA scale.

2.6 Modeling

Storm events are classified by the amount of rainfall, in inches, that occurs over the duration of a storm. The amount of rainfall depends on how frequently the storm will statistically occur and how long the storm will last. Based on many years of rainfall data collected, storms of varying strength have been established based on the duration and probability of that event occurring within any given year. In general, smaller storms occur more frequently than larger storms of equal duration. Hence, a 2-year, 24-hour storm (having a 50% chance of happening in a given year) has less rainfall than a 10-year, 24-hour storm (having a 10% chance of happening in a given year). Stormwater runoff (which is related to the strength of the storm) is surplus rainfall that does not soak into the ground. This surplus rainfall flows (or 'runs off') from roof tops, parking lots and other impervious surfaces and is ultimately received by storm drainage systems, culverts and streams.

Modeling is a way to mathematically predict and spatially represent what will occur with a given rainfall event. There are two primary types of models that are used to achieve this goal; hydrologic and hydraulic:

- Hydrologic models take into account several factors: the particular rainfall event of interest, the physical nature of the land area where the rainfall occurs and how quickly the resulting stormwater runoff drains this given land area. Hydrologic models can describe both the quantity of stormwater runoff and the resulting pollution, such as nutrients (nitrogen and phosphorus) and sediment, that is transported by the runoff.

- Hydraulic models represent the effect the stormwater runoff from a particular rainfall event has on both man-made and natural systems. Hydraulic models can predict both the ability of man-made culverts/channels to convey stormwater runoff and the spatial extent of potential flooding.

Table 2.1 shows three storm events and the rationale for modeling.

Table 2.1 Rationale for Storm Event Modeling

Storm Event	Rationale for Modeling
2-year, 24-hour	Represents the amount of runoff that defines the shape of the receiving streams.
10-year, 24-hour	Used to determine which road culverts will have adequate capacity to convey this storm without overtopping the road.
100-year, 24-hour	Used to define the limits of flood inundation zones

For this study, the Storm Water Management Model (SWMM), a hydrologic model developed by the U. S. Environmental Protection Agency (EPA), was used to quantify stormwater runoff. SWMM is a dynamic rainfall-runoff simulation model that can simulate runoff quantity and quality for single rain event or long-term conditions in primarily urban areas. It was used in this project to estimate the quantity of stormwater runoff at specific pre-determined locations within the watershed and calculate the peak rate of those flows at these locations as well. Specifically, the runoff component of SWMM operates on a collection of treatment areas within subwatersheds on which rain falls and runoff is generated. The routing portion of SWMM transports this runoff through a conveyance system of pipes, channels and storage/treatment devices. SWMM tracks the quantity of runoff generated within each treatment area, and the flow rate and flow depth of water in each pipe and channel during a simulation period comprised of multiple time steps

The Spreadsheet Tool for Estimating Pollutant Loading (STEPL) developed by the U. S. EPA Office of Water is another hydrologic model used to estimate the quantity of pollution and sediment transported by stormwater runoff. The STEPL model employs simple algorithms to calculate nutrient and sediment loads from different land uses and the load reductions that would result from the implementation of various best management practices. The nutrient loading is calculated based on the runoff volume and the pollutant concentrations in the runoff water as influenced by factors such as the land use distribution and management practices. Sediment loads are calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. The sediment and pollutant load reductions that result from the implementation of BMPs are computed using known BMP efficiencies.

The hydraulic model used in this project is the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model developed by the United States Army Corps of Engineers (USACE) to manage rivers and harbors under their jurisdiction. The model is a one dimensional program that provides no direct modeling of the hydraulic effect of cross section shape changes, bends, and other two- and three-dimensional aspects of flow. Aside from this limitation, the model has found wide acceptance in simulating the hydraulics of water flow through natural and/or manmade channels and rivers. HEC-RAS is commonly used for modeling water flowing through a system of open channels with the objective of computing water surface profiles. The computed surface profiles are then used to predict and evaluate conveyance capability of culverts and bridges and determine the spatial extent of potential flooding dependent on the specific topography in the area of interest.

2.7 Subwatershed Ranking

The purpose of the subwatershed ranking is to provide a systematic means of compiling available water quality and natural resources information. Ranking subwatersheds based on watershed characterization and modeling results provides a tool for planners and managers to set priorities and to use as they consider which subwatersheds should undergo further study.

Three basic indicator categories are used to rank subwatershed conditions including watershed impact indicators, source indicators, and programmatic indicators. These indicator categories are described below.

Watershed impact composite scores are calculated by analyzing a variety of indicators including channel morphology, flooding hazards, aquatic/terrestrial habitat and water quality.

Source indicator composite scores were calculated by analyzing a variety of pollutant sources and environmental stressors, including urban land cover, channelized streams, industrial and stormwater outfalls, septic systems and water quality. They provide information on the source of watershed impacts and stressors.

Programmatic indicators describe the existence or benefits of stormwater management facilities and programs. There is no scoring associated with programmatic indicators; however, a data inventory will be compiled in order to help determine where stormwater management is needed most during candidate project identification.

The scores from these indicators are rolled up into composite scores which are used in the prioritization and subwatershed ranking process. In cases where a subwatershed did not have any reported data for a particular indicator, or data was only geographically available for a portion of the subwatershed (e.g., headwaters only), the metric value from another subwatershed with reported data ("reference subwatershed") was used. Several factors were considered when assigning surrogate metric values. These factors are listed in priority order below:

1. Land use and land cover distribution based on the Virginia Department of Forestry's 2005 Virginia Forest Cover Map
2. Location of reference subwatershed (within the same WMA was preferable)
3. Similar drainage area
4. Proximity of reference subwatershed
5. Similar stream order (e.g., headwater, major waterway stem, main stem outlet)
6. Hydrologic connectivity

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3.1 Sugarland Run Watershed

The Sugarland Run Watershed consists of seven watershed management areas (WMAs) as listed below:

1. Folly Lick
2. Headwaters
3. Lower Sugarland
4. Lower Middle Sugarland
5. Potomac
6. Upper Sugarland
7. Upper Middle Sugarland

WMAs in the Sugarland Run Watershed are shown in Figure 3.1. As shown in the figure, most of the Folly Lick WMA is located in Fairfax County, about half of the Lower Middle Sugarland WMA is located in Fairfax County, and only small portions of the Potomac WMA and the Lower Sugarland WMA are located within Fairfax County. Only areas within Fairfax County were evaluated as part of this study; however, information on stormwater structures and stream crossings near the county border was gathered and evaluated to determine how it would affect stormwater flows in Fairfax County. The following information is provided for each WMA in the subsequent sections of this chapter:

1. WMA Characteristics
2. Existing and Future Land Use Information
3. Field Reconnaissance and Stream Physical Assessment Information
4. WMA Characterization
5. STEPL Modeling
6. HEC-RAS Modeling
7. Subwatershed Ranking

Table 3.1 illustrates the total area of each WMA, the current impervious conditions and the extent and type of stormwater treatment within each WMA.

Table 3.1 Sugarland Run Watershed WMA Summaries

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Folly Lick	1813.7	547.3	30%	156.72	41.29	9.53	1606.15
Headwaters	929	315.13	34%	242.2	8.9	18.1	659.8
Lower Sugarland	3742.7	403.95	11%	135.8*	28*	6.4*	679.7*
Lower Middle Sugarland	3503.1	501.3	14%	391.7*	77.2*	866.5*	676.7*
Potomac	1053	42	4%	0*	43.7*	2.71*	23.9*
Upper Sugarland	1391	677.5	49%	294.7	85.73	18	992.57
Upper Middle Sugarland	1975.1	561.4	28%	125.8	63.9	172.9	1612.5
Watershed Totals	**14,408**	**3,048.6**	**21%**	**1346.92**	**348.72**	**1094.14**	**6251.32**

* Treatment only within Fairfax County

Figures for Chapter 3 are provided in the beginning of the chapter and are followed by a detailed discussion of each WMA in Sections 3.1 through Section 3.7. Section 3.8 includes a discussion of SWMM modeling results, including a SWMM Peak Flow Map for the 2-year storm event.

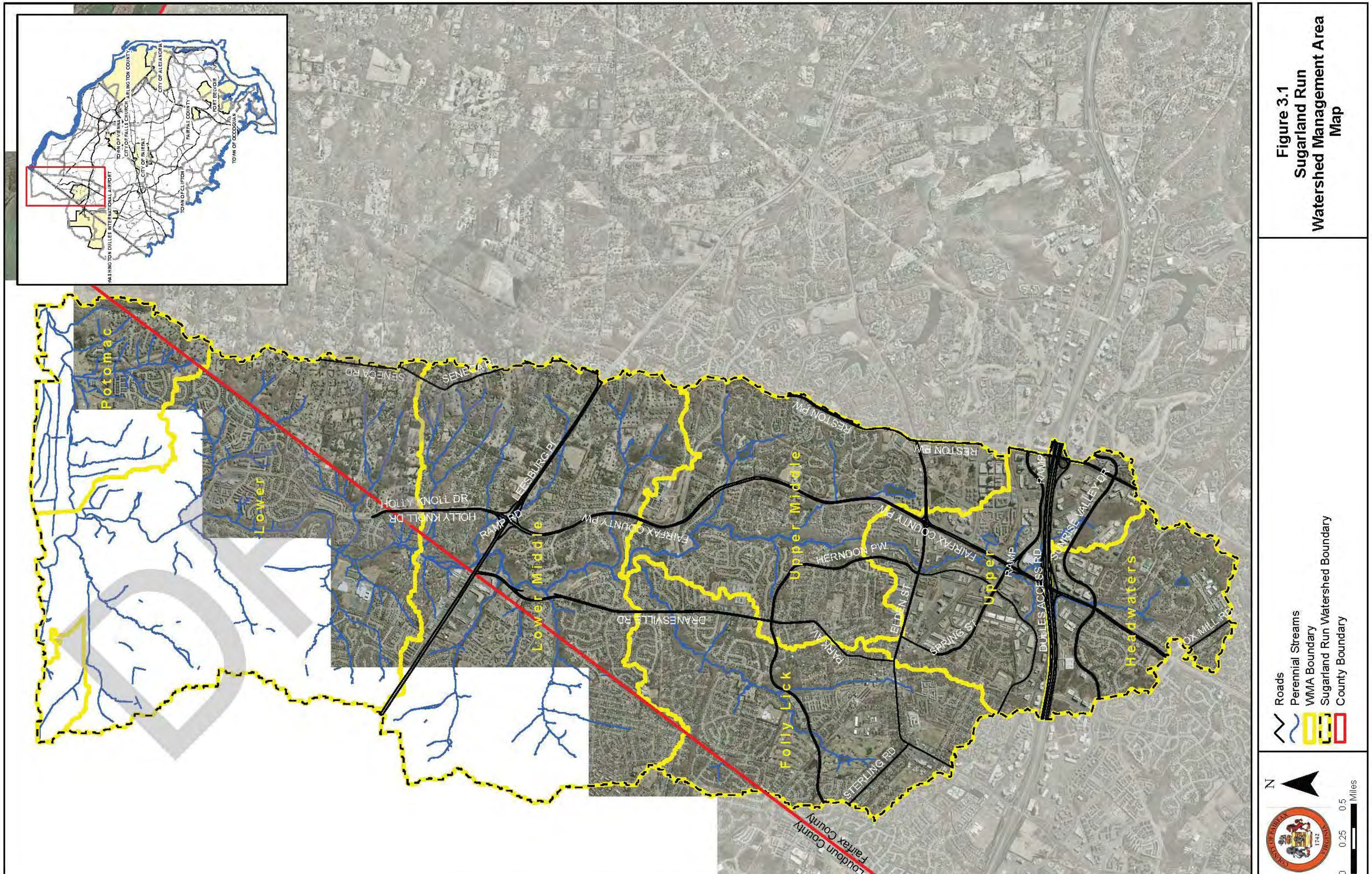
Figure 3.1
Sugarland Run
Watershed Management Area
Map
Roads
Perennial Streams
WMA Boundary
Sugarland Run Watershed Boundary
County Boundary
N
0
0.25
0.5
Miles
Potomac
Lower
Lower Middle
Upper Middle
Folly Lick
Upper
Headwaters
SENECA RD
LEESBURG PI
HOLLY KNOLL DR
RAMP RD
FAIRFAX COUNTY PW
DRANESVILLE RD
RESTON PW
HERNDON PW
ELDEN ST
SPRING ST
STERLING RD
DULLES ACCESS RD
SUNRISE VALLEY DR
FOX MILL RD
RAMP
Loudoun County
Fairfax County

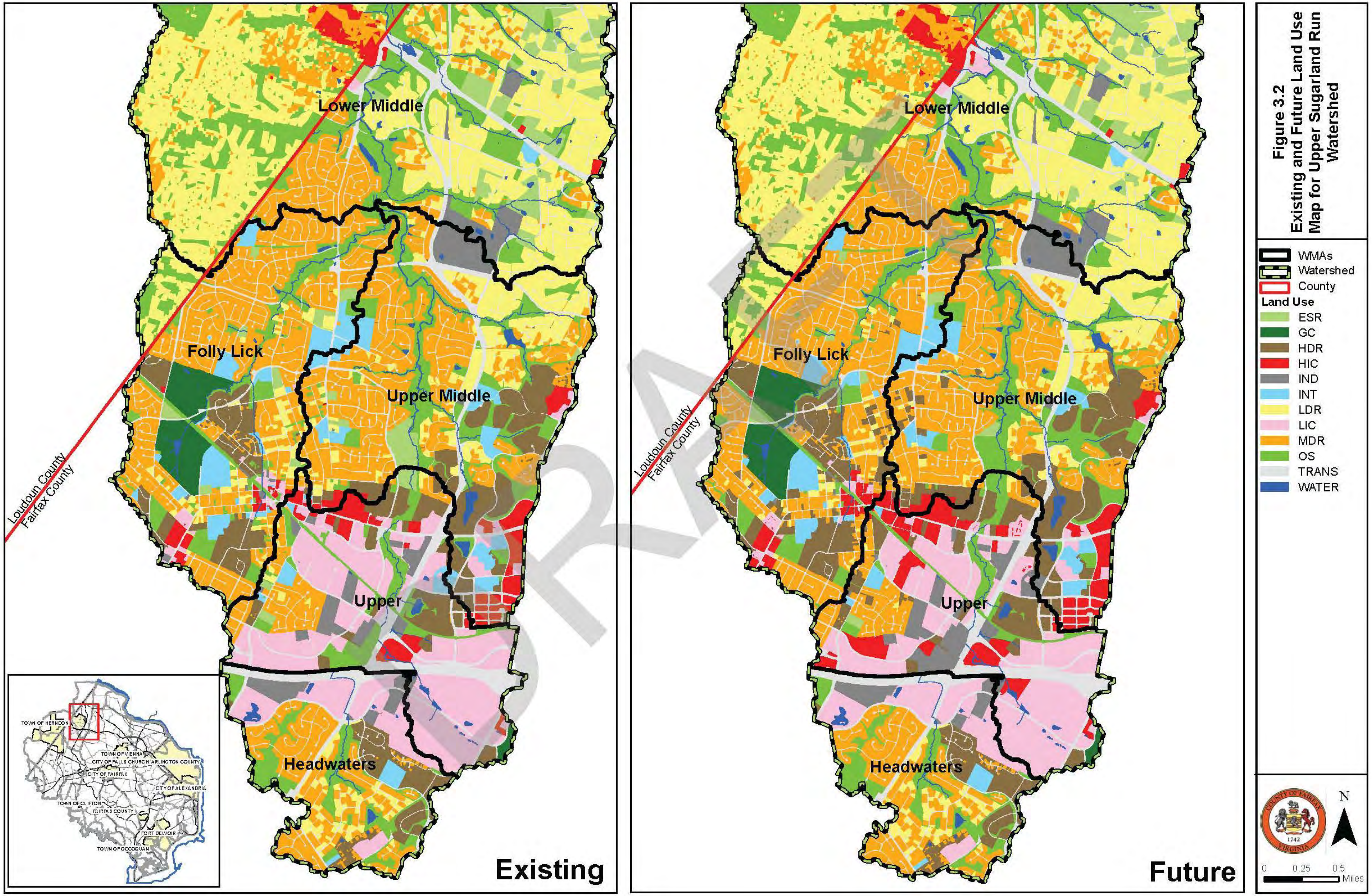

Figure 3.2
Existing and Future Land Use Map for Upper Sugarland Run Watershed

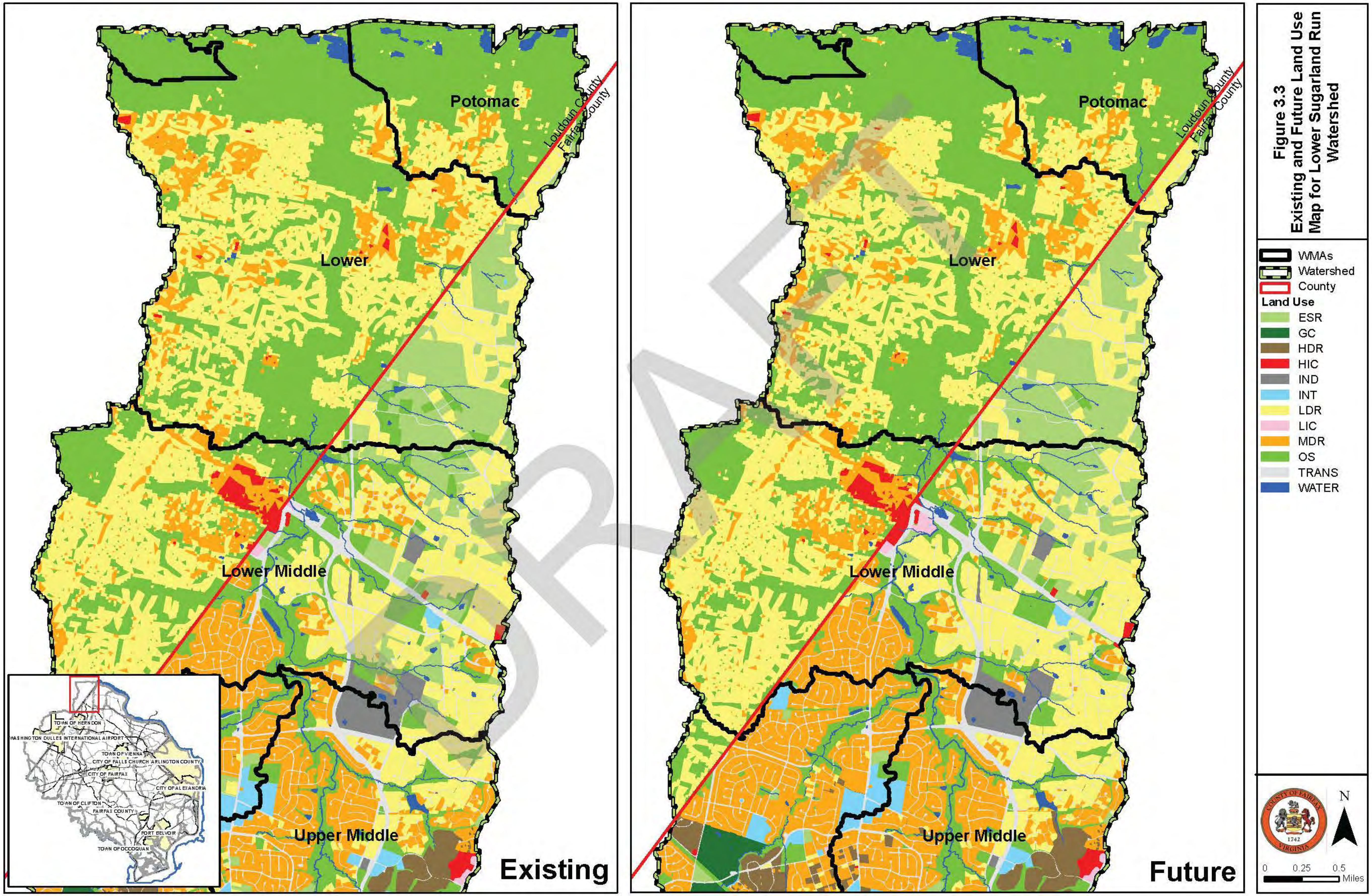

Figure 3.3 Existing and Future Land Use Map for Lower Sugarland Run Watershed

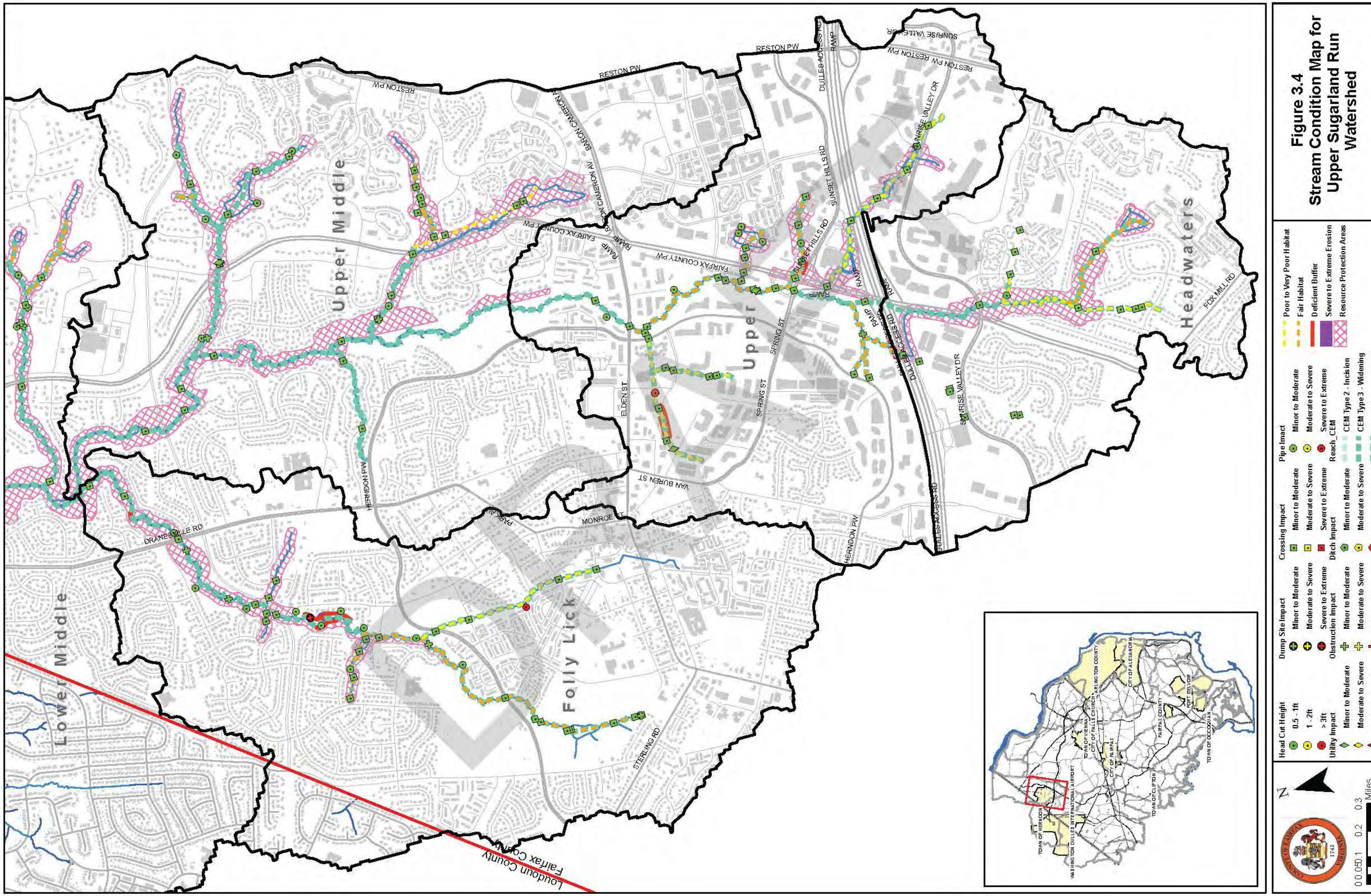
Figure 3.4
Stream Condition Map for
Upper Sugarland Run
Watershed
Poor to Very Poor Habitat
Fair Habitat
Deficient Buffer
Severe to Extreme Erosion
Resource Protection Areas
Pipe Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Reach_CEM
CEM Type 2 - Incision
CEM Type 3 - Widening
CEM Type 4 - Stabilizing
Crossing Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Ditch Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Dump Site Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Obstruction Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Head Cut Height
0.5 - 1ft
1 - 2ft
> 3ft
Utility Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
N
0 0.05 0.1 0.2 0.3
Miles
Upper Middle
Upper
Headwaters
Folly Lick
Lower Middle
RESTON PW
BARON CAMERON AV
FAIRFAX COUNTY PW
DULLES ACCESS RD
SUNSET HILLS RD
SUNRISE VALLEY DR
SPRING ST
ELDEN ST
VAN BUREN ST
HERNDON PW
MONROE ST
DRANESVILLE RD
STERLING RD
FOX MILL RD
RAMP
Loudoun County
Fairfax County

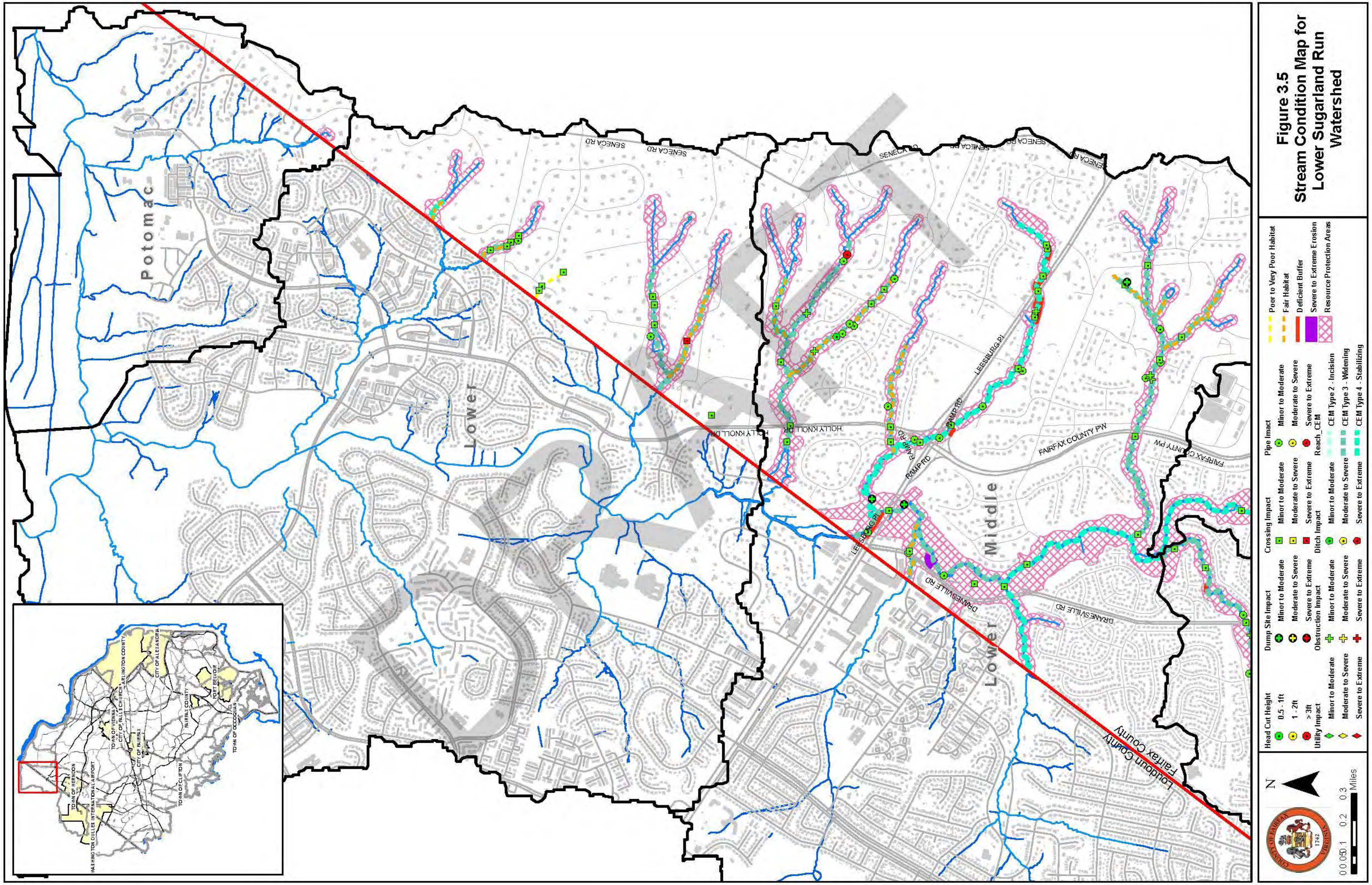
Figure 3.5
Stream Condition Map for
Lower Sugarland Run
Watershed
Poor to Very Poor Habitat
Fair Habitat
Deficient Buffer
Severe to Extreme Erosion
Resource Protection Areas
Pipe Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Reach CEM
CEM Type 2 - Incision
CEM Type 3 - Widening
CEM Type 4 - Stabilizing
Crossing Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Ditch Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Dump Site Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Obstruction Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Head Cut Height
0.5 - 1ft
1 - 2ft
> 3ft
Utility Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
N
0 0.05 0.1 0.2 0.3
Miles
Potomac
Lower
Middle
Lower
SENECA RD
HOLLY KNOLL DR
LEESBURG PI
RAMP RD
FAIRFAX COUNTY PW
DRANESVILLE RD
Fairfax County
Loudoun County
DRAFT

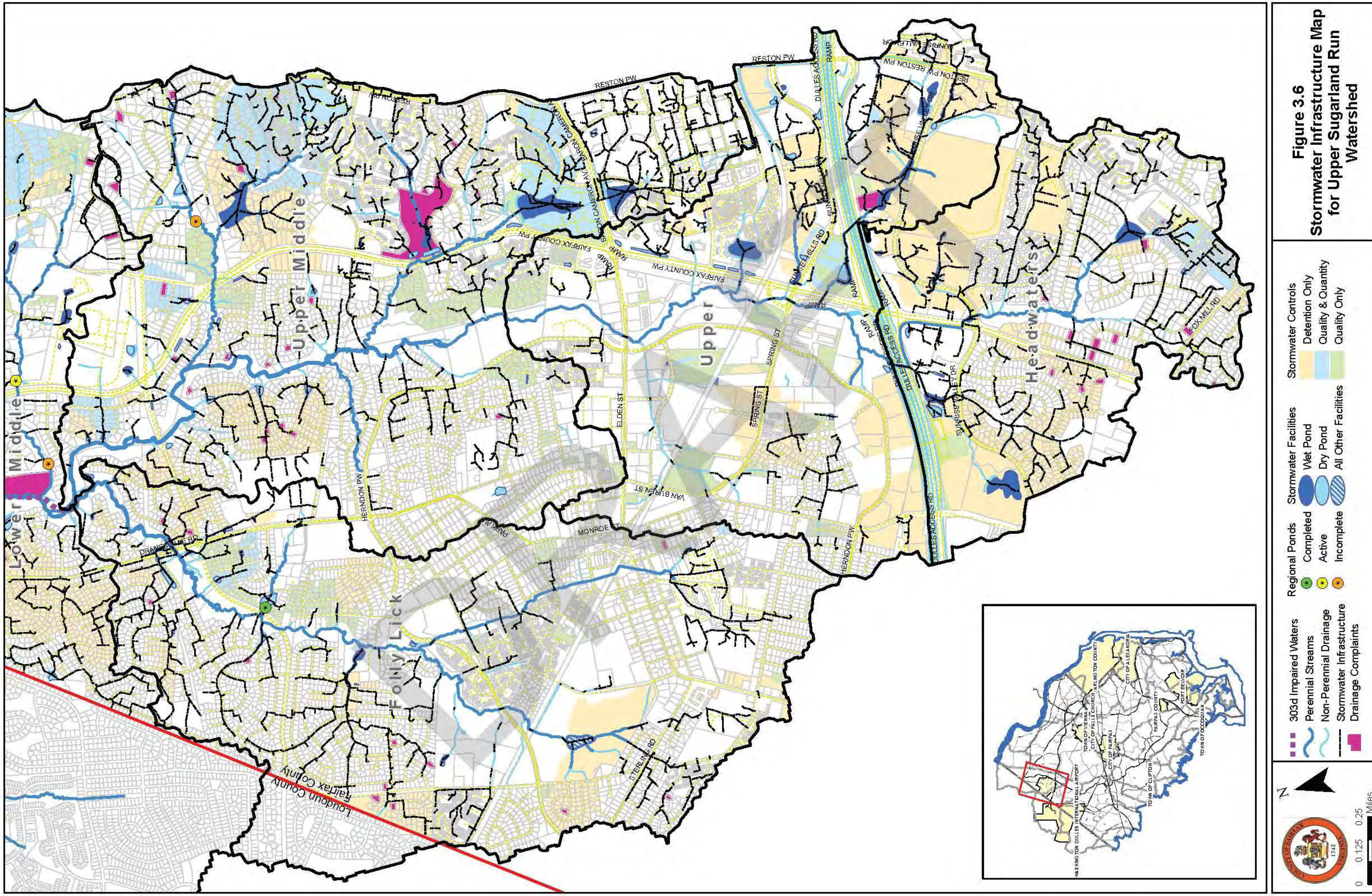
Figure 3.6
Stormwater Infrastructure Map for Upper Sugarland Run Watershed
303d Impaired Waters
Perennial Streams
Non-Perennial Drainage
Stormwater Infrastructure
Drainage Complaints
Regional Ponds
Completed
Active
Incomplete
Stormwater Facilities
Wet Pond
Dry Pond
All Other Facilities
Stormwater Controls
Detention Only
Quality & Quantity
Quality Only
N
0 0.125 0.25 Miles
Upper Middle
Lower Middle
Upper
Headwaters
Folly Lick
Fairfax County
Loudoun County
RESTON PW
FAIRFAX COUNTY PW
DULLES ACCESS RD
ELDEN ST
SPRING ST
HERNDON PW
VAN BUREN ST
MONROE ST
STERLING RD
SUNRISE VALLEY DR
FOX MILL RD
RAMP

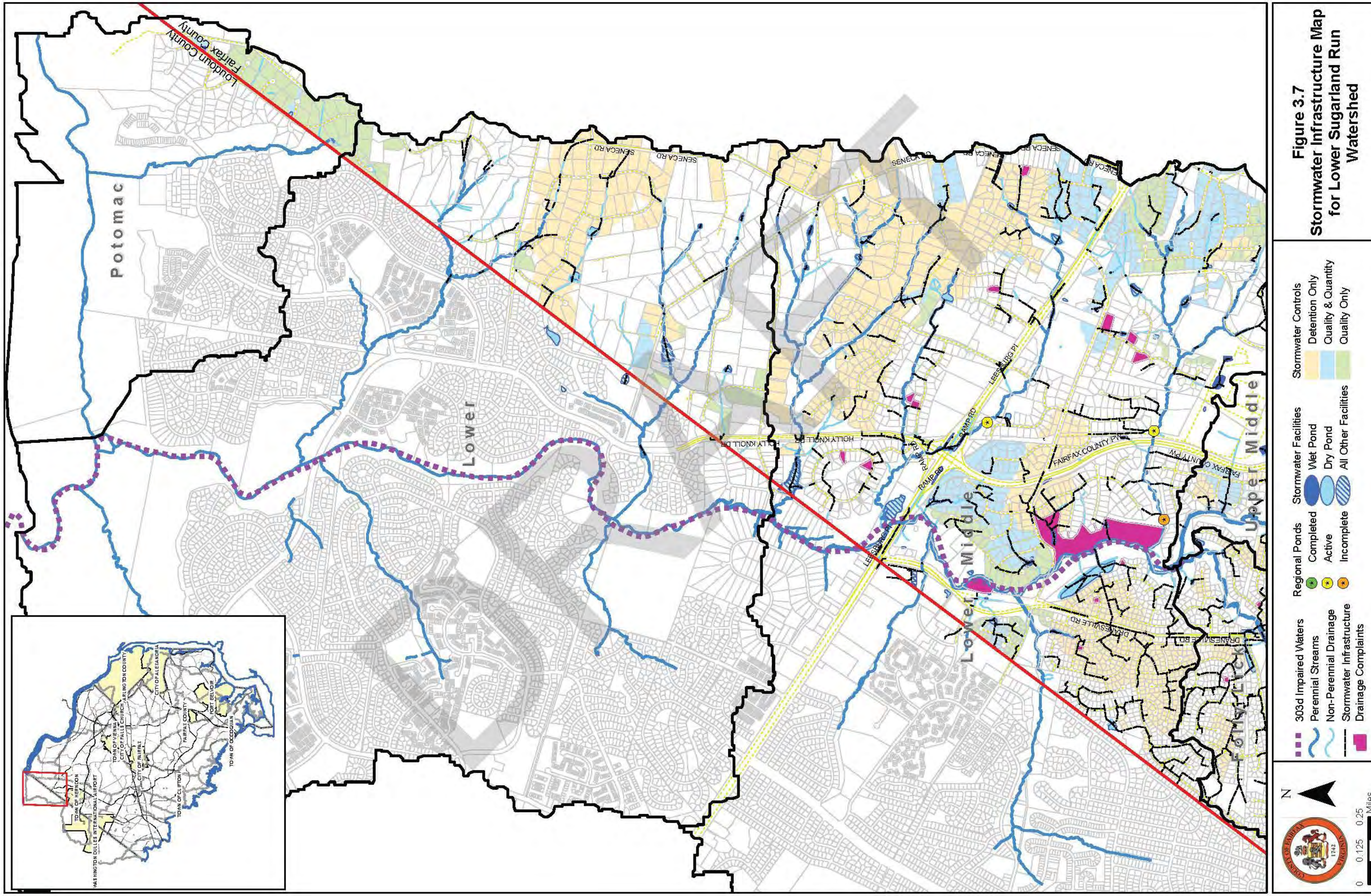

Figure 3.7
Stormwater Infrastructure Map for Lower Sugarland Run Watershed

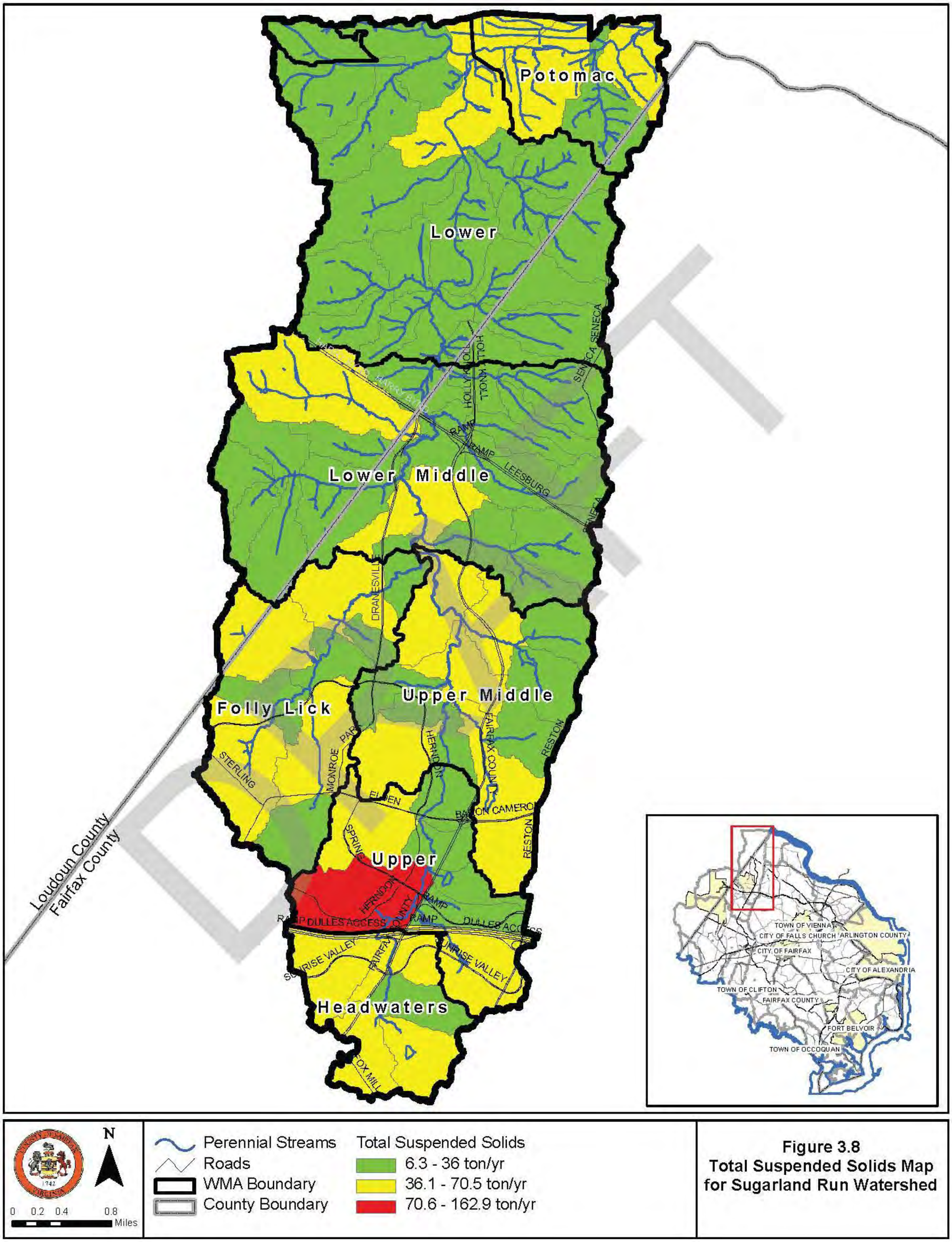

Figure 3.8
Total Suspended Solids Map for Sugarland Run Watershed

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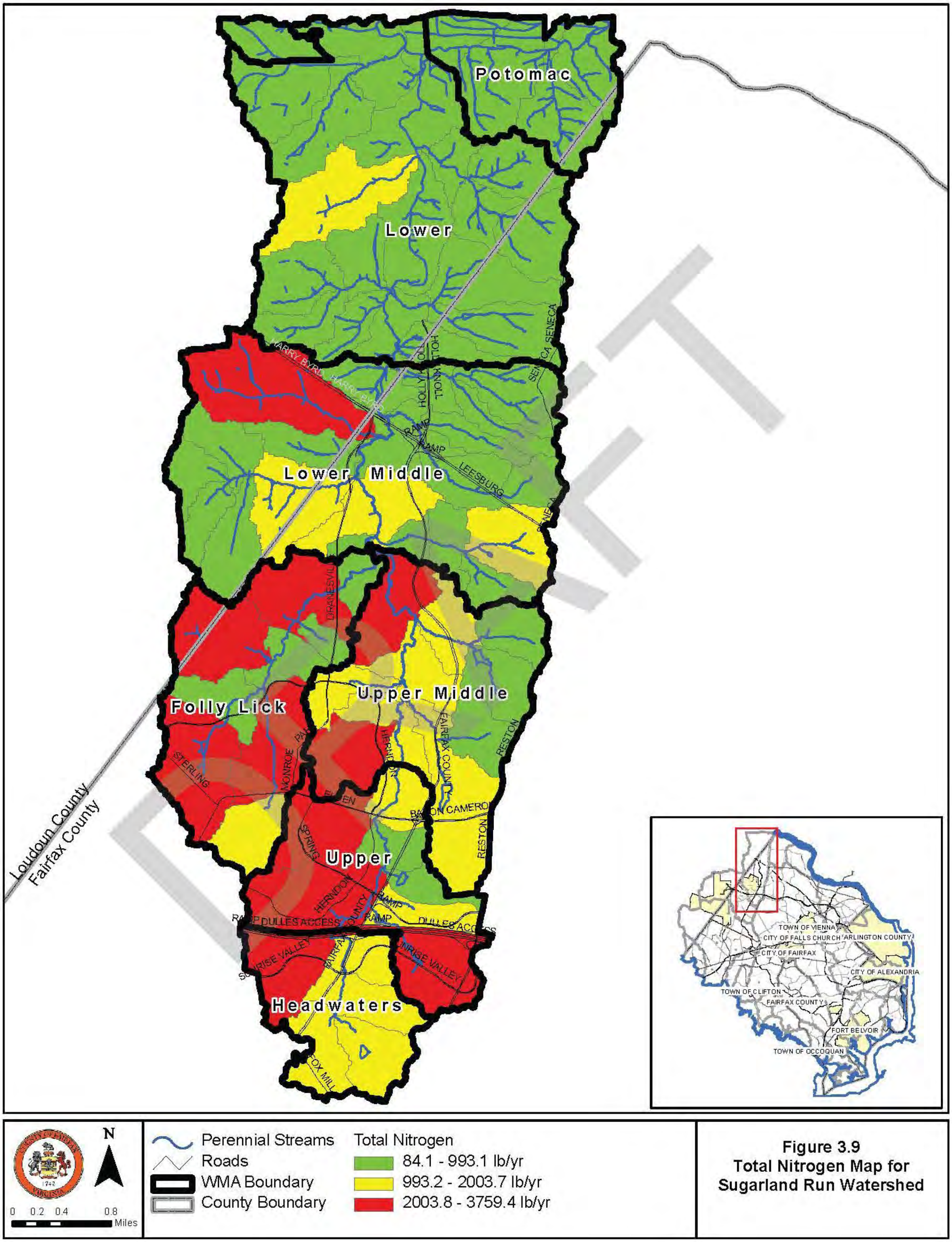

Figure 3.9
Total Nitrogen Map for Sugarland Run Watershed

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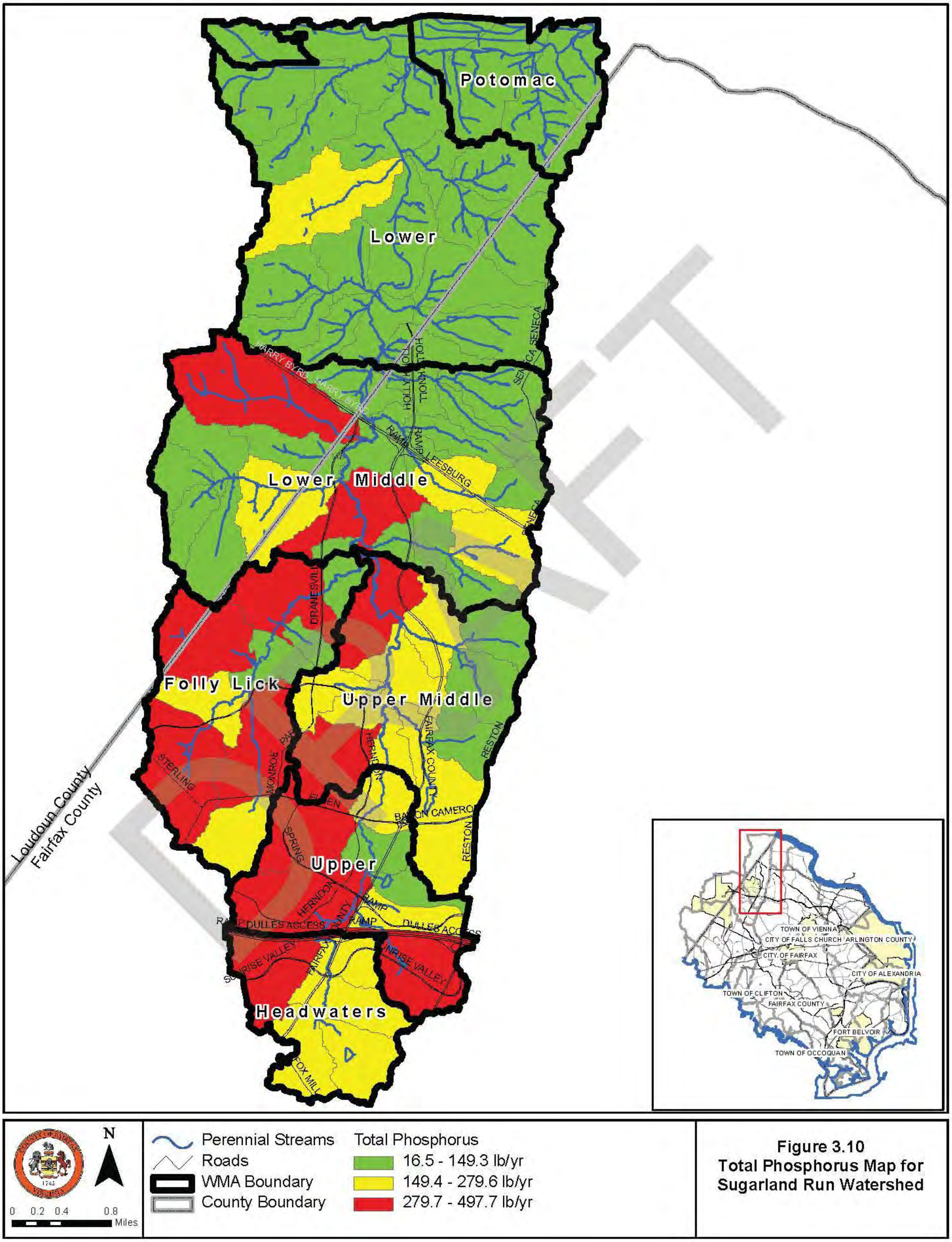

Figure 3.10
Total Phosphorus Map for Sugarland Run Watershed

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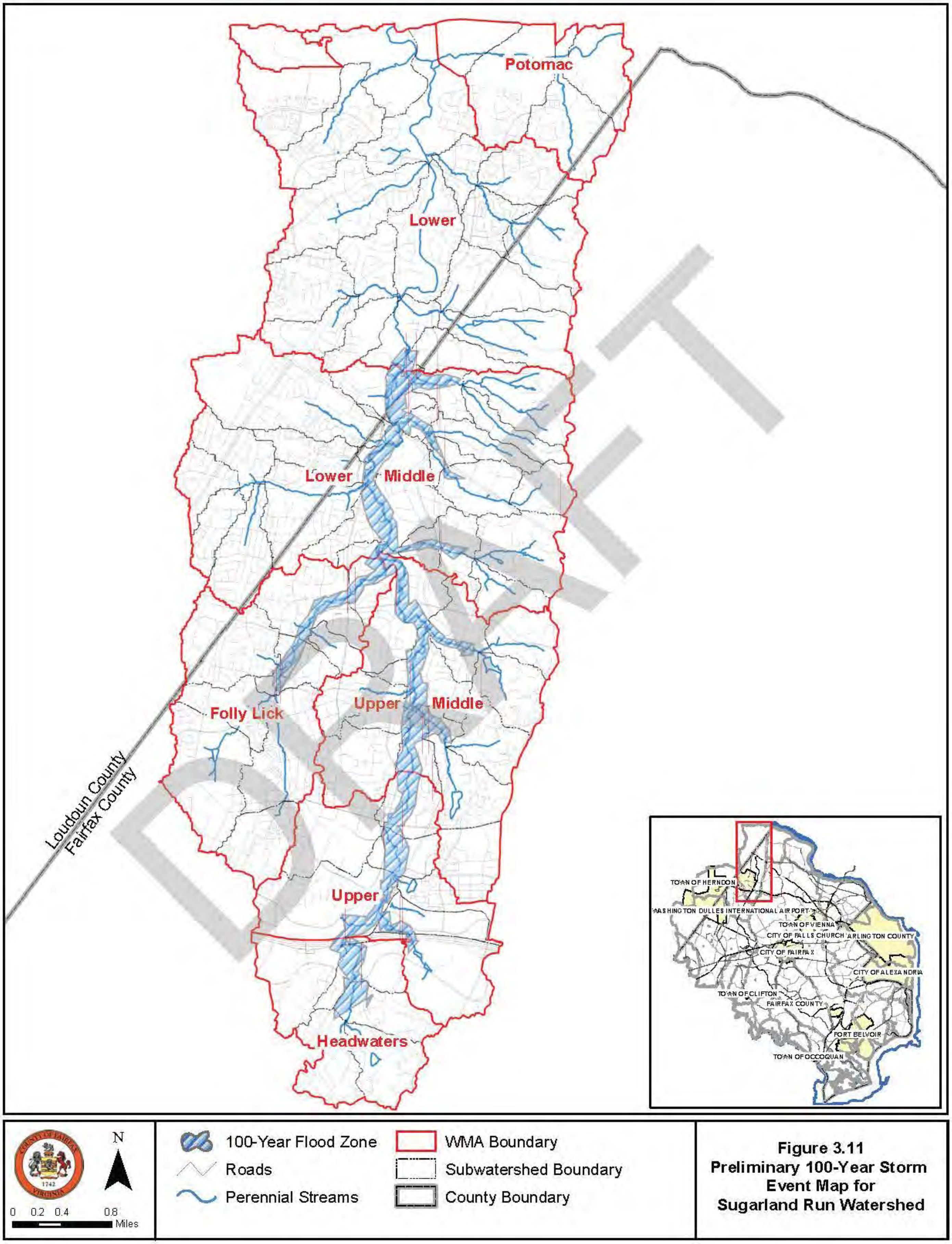

Figure 3.11
Preliminary 100-Year Storm Event Map for Sugarland Run Watershed

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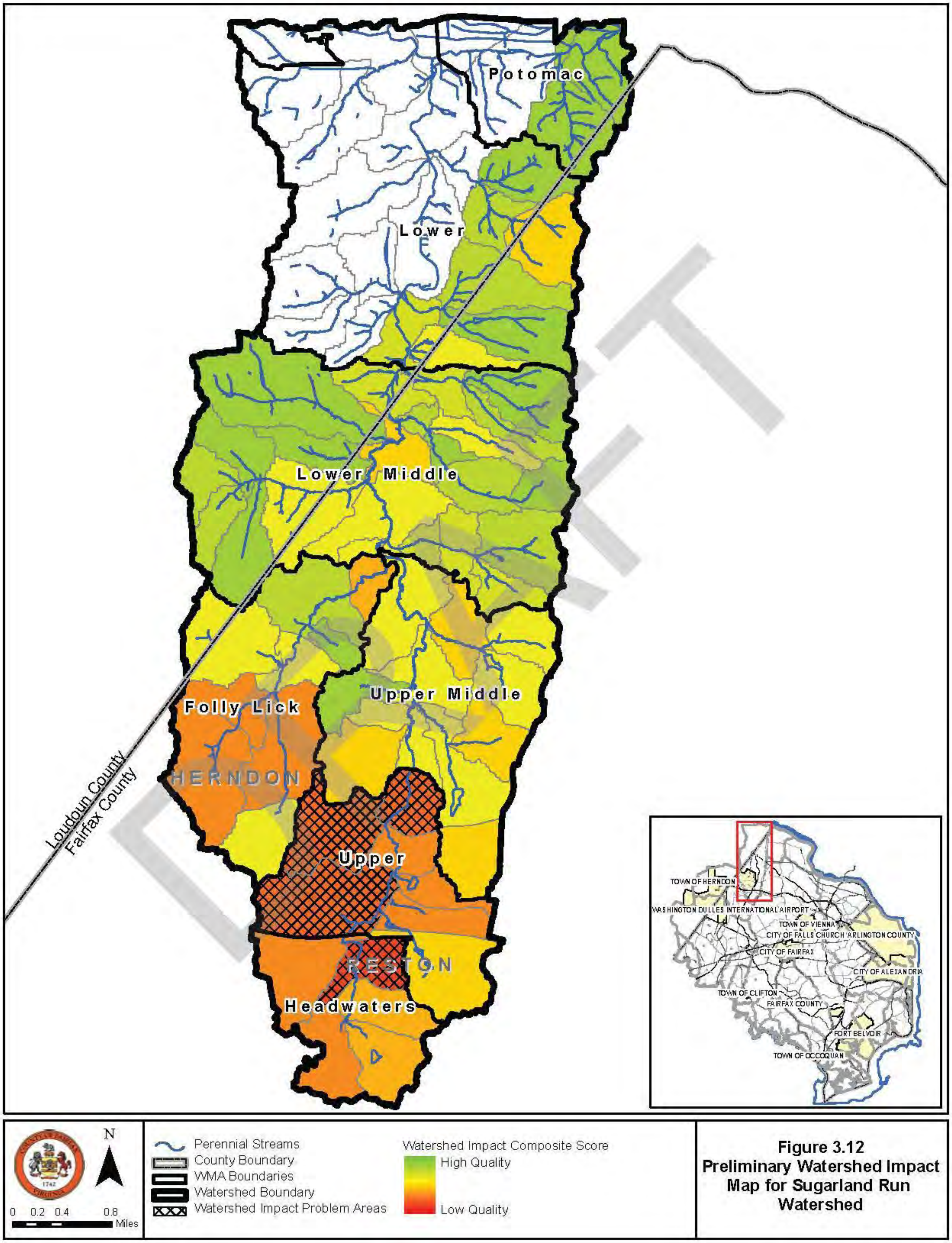

Figure 3.12
Preliminary Watershed Impact Map for Sugarland Run Watershed

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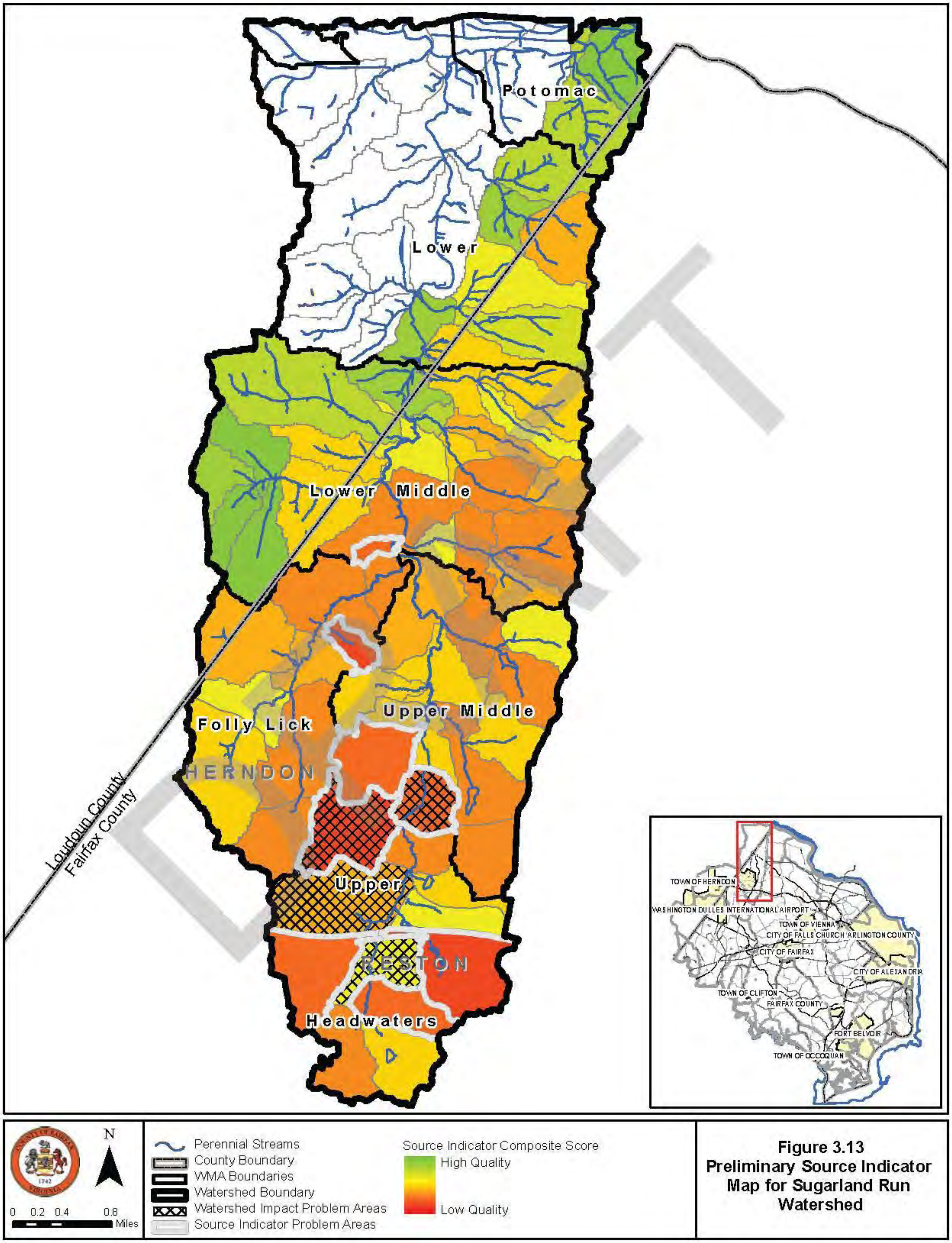

Figure 3.13
Preliminary Source Indicator Map for Sugarland Run Watershed

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3.1 Folly Lick WMA

3.1.1 Folly Lick WMA Characteristics

The Folly Lick WMA is located in the western portion of the Sugarland Run Watershed. The watershed comprises 1,813 acres (2.83 square miles). Approximately half of the watershed is contained within the Herndon Parkway and the other half of the watershed lies north of the parkway. Figure 3.1 shows the location of the Folly Lick WMA.

Approximately 5.3 miles of perennial streams are located within the Folly Lick WMA. The streams range from poor to fair condition in the Herndon section to good condition in the northern section. The streams flow northeast toward the confluence with Sugarland Run, and flow primarily through medium density residential and open space areas. The headwaters of the eastern portion of the WMA travel though a golf course while the streams in the eastern portion of the WMA travel through an industrial/commercial land use area.

3.1.2 Existing and Future Land Use

The southern half of the Sugarland Run Watershed is highly developed, including the Folly Lick WMA. Approximately 77 percent of the WMA is urbanized, primarily consisting of medium density residential (40 percent), open space (13 percent) and transportation networks (15 percent) land uses, as shown in Table 3.2. The open space is primarily clustered around the stream corridors.

Table 3.2 Existing and Future Land Use for Folly Lick WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	1.8	1.1
High Density Residential	9.1	11.3
Medium Density Residential	36.9	37.8
Low Density Residential	6.5	5.0
Industrial	0.4	0.2
Low Intensity Commercial	1.3	0.8
High Intensity Commercial	1.5	2.3
Institutional	6.8	6.7
Open Space	12.7	11.9
Golf Course	7.4	7.4
Transportation	15.0	15.0
Water	0.7	0.7
Total	100	100

Source: Fairfax County GIS, 2008

Table 3.2 and Figure 3.2 show expected changes in land use as the Folly Lick WMA continues to develop. A slight increase in high density residential and high intensity commercial land use, with a corresponding decrease in open space, low density residential and low intensity commercial areas within the Folly Lick WMA are projected.

3.1.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Folly Lick WMA to evaluate projects proposed by the county, identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Folly Lick WMA:

1. Evaluated drainage complaints.
2. Evaluated proposed projects by the county.
3. Evaluated existing stormwater facilities.
4. Evaluated on-site septic systems.
5. Conducted a neighborhood source assessment.
6. Conducted a hotspot investigation.
7. Conducted a stream physical assessment.

The results of each of the field reconnaissance surveys are briefly described below.

<u>Drainage Complaints</u>
One hundred and nineteen (119) drainage complaints have been documented within the Folly Lick WMA between 2001 and 2006. Of those, seven representative complaints were chosen for field investigation. The complaints included cave-ins and sinkholes around stormwater management facilities and on properties.

<u>Proposed County Project</u>
Based upon past evaluations and reports, multiple stormwater projects have been proposed within the Folly Lick WMA. Field investigations were used to determine whether the projects were still viable. The projects included stream restoration and stabilization projects on Folly Lick Branch, raising the road and installing culverts, construction of a regional pond and replacement of a storm sewer on Fantasia Drive.

<u>Existing Stormwater Facilities</u>
Nine stormwater management facilities were evaluated within the Folly Lick WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Three of the nine facilities were found to not provide stormwater management functions. The remaining facilities were functioning as designed and only a few presented some opportunity for retrofit.

<u>On-site Septic Systems</u>
Portions of the Sugarland Run watershed still use on-site septic systems. Properties using on-site systems were chosen for field reconnaissance if problems were noted in the area. Three on-site septic systems were visited in the Folly Lick WMA. Two of those sites showed no visible signs of problems and one site was an abandoned farm that was not accessible due to fenced properties around its perimeter.

Neighborhood Source Assessment (NSA)

Two representative neighborhoods were chosen for the NSA to help identify potential improvement projects throughout the Folly Lick WMA. The chosen neighborhoods consisted of single family detached houses on quarter-acre lots. Two stormwater management facilities were identified, including one wet pond and one dry pond. The NSA indicated that there is the potential for stormwater management facility retrofits as well as a need for better lawn and landscaping practices in the Folly Lick WMA.

Hot Spot Investigation (HSI)

Seven representative facilities with the potential to generate concentrated stormwater pollution were chosen within the Folly Lick WMA for the HSI. An investigation was conducted of each facility and the corresponding property to identify sources of pollution. Two schools were targeted for the HSI: one revealed a potential hotspot and the other did not. The Herndon Golf Course was also investigated, resulting in the detection of a potential hotspot. A review of the stormwater pollution plan is recommended along with an onsite visit for that facility. Three commercial categories and one apartment building were targeted as the final four facilities, all of which were classified as potential hot spots. This indicated the need for future education efforts and the need for review of the stormwater pollution prevention plan for each facility.

Stream Physical Assessment (SPA)

A supplemental stream physical assessment was conducted on 1.3 miles of stream within the Folly Lick WMA. This stream segment was chosen for re-assessment because two county stream restoration and stabilization projects were located in the stream segment, two additional projects were proposed, and it drains to a 303(d) impaired stream. The stream was found to be in good habitat condition. There were 11 bank erosion problems, five obstructions and four pipes/drainage ditch erosion problems.

3.1.4 Folly Lick WMA Characterization

Approximately 5.3 miles of streams were assessed within the Folly Lick WMA to determine the overall stream conditions in the WMA. As shown in Figure 3.4, the stream length assessed has good habitat conditions in the upper portion and fair to poor habitat conditions in the lower portions. Most of the streams in the Folly Lick WMA are protected by the resource protection areas as described in Chapter 1. The Folly Lick main stem was designated as protected in 1993. Mild to moderate erosion areas were identified during field reconnaissance. Most of the erosion occurred at road crossings, but some also occurred in riparian buffers, pipes and deficient buffer areas. A portion of the stream has been straightened and channelized through Herndon. This section has a severe headcut and moderate to severe buffer deficiency. At the confluence where the tributaries join, a few areas of moderate to severe erosion were also identified. The main stem of Folly Lick is in Channel Evolution Model Stage 3, which means it is an unstable channel that is experiencing significant bank erosion. The headwaters are in Channel Evolution Model Stage 4, which indicates the stream is attempting to stabilize by developing a bankful and floodplain channel.

As shown in Figure 3.6, the Folly Lick WMA contains a few stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network. These facilities are all dry ponds with the largest being approximately two acres and the remaining between one-third and one acre in size. One regional pond project is being considered for the area. Based on Table 3.3, stormwater runoff from only about 12 percent of the area in this WMA is treated. Stormwater runoff from approximately 88 percent of the area in this WMA is not treated by any means. Stormwater runoff from most of the area that does receive treatment is only treated for quantity and not water quality. Therefore, more stormwater management facilities are needed in the Folly Lick WMA. Drainage complaints made by residents consisted of cave-ins and sinkholes.

Table 3.3 Folly Lick WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Folly Lick	1813.69	547.30	30%	156.72	41.29	9.53	1606.15

3.1.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 3.8, 3.9 and 3.10 present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 3.4 below shows the total pollutant loading to the endpoint of Folly Lick WMA. According to the STEPL model results, the Folly Lick WMA contributes approximately 16 percent of the total suspended solids, 17 percent of the total nitrogen, and 17 percent of the total phosphorous annual loads to the Sugarland Watershed. Pollutant loadings normalized to the acres within the drainage area of Folly Lick WMA are presented in Table 3.5. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Folly Lick WMA as compared with unit area loads for the entire watershed.

Table 3.4 Summary of Pollutant Loadings for Folly Lick WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Folly Lick	343.9	13,535.44	2,073.57
WS Totals	**2,185.08**	**80,136.31**	**11,991.66**

Table 3.5 Summary of Pollutant Loadings Normalized by Drainage Area for Folly Lick WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	**Total Nitrogen (pounds/acre/year)**	**Total Phosphorus (pounds/acre/year)**
Folly Lick	0.190	7.466	1.144
WS Totals	**0.151**	**5.529**	**0.827**

3.1.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Folly Lick WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 3.11, a 100-year storm in the Folly Lick WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

One bridge and one culvert are located within the Folly Lick WMA. The bridge and culvert were modeled to determine if the 100-year storm exceeded their capacity to carry the flow. The modeling shows that the bridge does not carry the 100-year stormflow and will overtop, nor does it carry the 2- or 10-year stormflows. The culvert does not carry the 100-year stormflow and water will pond upstream of the culvert structure. The existence of the ponded water will extend the time period of maximum flow through the culvert. When the ponded water is fully drained, the flow elevation will begin to drop.

3.1.7 Folly Lick WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall conditions in the subwatersheds. Figure 3.12 illustrates the results obtained for the subwatershed ranking of watershed impacts; the lowest scoring subwatersheds were identified as potential problem areas. None of the subwatersheds within the Folly Lick WMA have been identified as a potential problem area. Based upon existing conditions, most of the northern portion of the WMA is in good condition, but traveling south toward the headwaters of Folly Lick Branch the conditions deteriorate.

The Folly Lick WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources, as shown in Figure 3.13. The lowest ranking subwatersheds were identified as additional potential problem areas. One of the subwatersheds within the Folly Lick WMA has been identified as a potential problem area. Most of the Folly Lick WMA shows high levels of stressors and pollutant sources.

3.2 Headwaters WMA

3.2.1 Headwaters WMA Characteristics

The Headwaters WMA is located in the southern portion of the Sugarland Run Watershed. The watershed is comprised of 929 acres (1.45 square miles) and is located south of the Dulles Access Road, as shown in Figure 3.1.

Approximately 1.4 miles of perennial streams exist within the Headwaters WMA, and a majority of these streams range from poor to fair condition. The streams flow north toward the confluence with the main stem of Sugarland Run. The streams travel primarily through medium density residential and open space areas. The northern portion of the stream travels though a low intensity commercial land use area.

3.2.2 Existing and Future Land Use

The southern half of the Sugarland Run Watershed is highly developed, and the Headwaters WMA falls within that portion. Approximately 86 percent of the Headwaters WMA is urbanized, primarily consisting of medium and high density residential (38 percent), commercial and industrial (21 percent), and transportation networks (19 percent) land uses, as shown in Table 3.6. The open space is primarily clustered around the stream corridors.

Table 3.6 Existing and Future Land Use for Headwaters WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
High Density Residential	11.7	11.7
Medium Density Residential	26.5	26.8
Low Density Residential	5.4	5.4
Industrial	5.0	5.0
Low Intensity Commercial	16.2	16.1
Institutional	1.7	1.7
Open Space	13.8	13.6
Transportation	18.5	18.5
Water	1.2	1.2
Total	100	100

Source: Fairfax County GIS, 2008

Table 3.6 and Figure 3.2 show expected changes in land use as the Headwaters WMA continues to develop. A slight increase in medium density residential areas and a slight decrease in open space areas are projected within the Headwaters WMA.

3.2.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Headwaters WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Headwaters WMA:

1. Evaluated drainage complaints.
2. Evaluated proposed projects by the county.
3. Evaluated existing stormwater facilities.
4. Conducted a neighborhood source assessment.
5. Conducted a hotspot investigation.

The results of each of the above evaluations are briefly described below.

Drainage Complaints

One hundred and three (103) drainage complaints have been documented within the Headwaters WMA between 2001 and 2006. Of those, four representative complaints were chosen for field investigation. The complaints included erosion and sediment buildup around stormwater management facilities. Field verifications showed no evidence of erosion or sediment at three locations and minor erosion at the stormwater management facility in one location.

Proposed County Project

Based upon past evaluations and reports, two stormwater projects have been proposed within the Headwaters WMA. Field investigations were used to determine whether these projects were still viable. The projects included a stream restoration and stabilization project on the Headwaters Branch and raising the road and installing a culvert at Fox Mill Road. The streambank stabilization project has been completed and the area was stabilized with rip-rap. The road raising project was not located.

Existing Stormwater Facilities

Twelve (12) stormwater management facilities were evaluated within the Headwaters WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Seven of the 12 facilities were wet ponds. They were functioning as designed and one of them presented some opportunity for retrofit. The remaining five facilities did not provide stormwater management functions or were not present at the location specified.

Neighborhood Source Assessment (NSA)

Three representative neighborhoods were chosen for NSAs to help identify potential improvement projects throughout the Headwaters WMA. The chosen neighborhoods consisted of one low intensity commercial classification and three single-family detached houses on quarter- half-acre lots. Three stormwater management facilities were identified as wet ponds on the commercial property. One single-family property contained a dry pond, one contained a wet pond and the third did not have a stormwater management facility. The NSA indicated the potential for a stormwater management facility retrofit at the dry pond location; all assessments showed a need for better lawn and landscaping practices.

Hot Spot Investigation (HSI)

Six representative facilities with the potential to generate concentrated stormwater pollution were chosen within the Headwaters WMA for the HSI. An investigation was conducted of the facilities and the corresponding properties identifying sources of pollution. All facilities were commercial classifications. One facility was confirmed as not a hotspot, but should be included in future education efforts. Four other facilities were potential hot spots and one was a confirmed hotspot. The confirmed hotspot was located off Sunrise Valley Road and should be followed up with an onsite visit. A review of the stormwater pollution plan is recommended for all of the sites along with future education efforts.

3.2.4 Headwaters WMA Characterization

Approximately 1.4 miles of stream were assessed within the Headwaters WMA to determine the overall stream conditions in the WMA. As shown in Figure 3.4, the stream length assessed had poor to fair habitat conditions. Most of the streams in the Headwaters WMA are protected by the resource protection areas as described in Chapter 1. The Headwaters main stem was designated as protected in 2003. Mild to moderate erosion areas were identified during field reconnaissance. Most of the erosion occurred at road crossings, but erosion also occurred in deficient buffer areas. One stream segment revealed a moderate to severe erosion level at a deficient buffer area. All of the Headwaters WMA is in Channel Evolution Model Stage 3, which indicates an unstable channel that is experiencing significant bank erosion.

As shown in Figure 3.6, the Headwaters WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network. The majority of these facilities are wet ponds. Table 3.7 indicates that stormwater runoff from approximately 29 percent of the area in this WMA is treated, and approximately 71 percent of the area in this WMA is not treated by any means. Stormwater runoff from most of the area that does receive treatment is only treated for quantity and not water quality. Therefore, more stormwater management facilities are needed in the Headwaters WMA. Drainage complaints made by residents consisted of erosion and sediment build-up around stormwater treatment facilities.

Table 3.7 Headwaters WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Headwaters	929.00	315.13	34%	242.2	8.9	18.1	659.8

3.2.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 3.8, 3.9 and 3.10 present the results of the STEPL model for total suspended solids, total nitrogen and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 3.8 below shows the total pollutant loading to the endpoint of Headwaters WMA. According to the STEPL model results, the Headwaters WMA contributes approximately nine percent of the total suspended solids, 10 percent of the total nitrogen, and 10 percent of the total phosphorous annual loads to Sugarland

Watershed. Pollutant loadings normalized to the acres within the drainage area of Headwaters WMA are presented in Table 3.9. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Headwaters WMA as compared with unit area loads for the entire watershed.

Table 3.8 Summary of Pollutant Loadings for Headwaters WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/yr)	**Total Nitrogen (pounds/yr)**	**Total Phosphorus (pounds/year)**
Headwaters	204.5	8,216.82	1,198.13
WS Totals	**2,185.08**	**80,136.31**	**11,991.66**

Table 3.9 Summary of Pollutant Loadings Normalized by Drainage Area for Headwaters WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/yr)	**Total Nitrogen (pounds/acre/yr)**	**Total Phosphorus (pounds/acre/yr)**
Headwaters	0.220	8.845	1.290
WS Totals	**0.151**	**5.529**	**0.827**

3.2.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Headwaters WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 3.11, a 100-year storm in the Headwaters WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

Two culverts are located within the Headwaters WMA. The culverts were modeled to determine if the 100-year storm exceeded their capacity to carry the flow. The modeling shows that both culverts do not carry the 100-year stormflow and will overtop. Water will pond upstream of the culvert structures. The existence of the ponded water will extend the time period of maximum flow through the culverts. When the ponded water is fully drained, the flow elevations will begin to drop.

3.2.7 Headwaters WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall conditions in the subwatersheds. Figure 3.12 illustrates the results obtained for the subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. One subwatershed within the Headwaters WMA has been identified as a potential problem area. Based upon existing conditions, all of the WMA is in very poor condition.

The WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 3.13. The lowest ranking subwatersheds were identified as additional potential problem areas. One additional problems area was identified within the Headwaters WMA. Most of the WMA shows high levels of stressors and pollutant sources.

3.3 Lower Sugarland WMA

3.3.1 Lower Sugarland WMA Characteristics

The Lower Sugarland WMA is located in the northern portion of the Sugarland Run Watershed. The watershed comprises 3,742 acres (5.85 square miles) and is located north of Leesburg Pike. It is intersected by the Loudoun County border, as shown in Figure 3.1. The portion within Fairfax County is less than one-third of the total Lower Sugarland WMA, comprising 691 acres square miles).

Approximately 13.8 miles of perennial streams exist within the Lower Sugarland WMA, which range from fair to good condition. The streams flow west into Loudoun County, traveling primarily through estate residential and open space areas.

3.3.2 Existing and Future Land Use

The southern half of the Sugarland Run Watershed is highly developed, while the northern half is far less developed. The Lower Sugarland WMA falls within the less developed half of the watershed. Approximately 60 percent of the Lower Sugarland WMA is urbanized, consisting of low density residential (38 percent), open space (40 percent) and medium density residential (11 percent), as shown in Table 3.10.

Table 3.10 Existing and Future Land Use for Lower Sugarland WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	9.9	11.1
Medium Density Residential	10.5	10.5
Low Density Residential	37.8	37.8
High Intensity Commercial	0.2	0.2
Open Space	39.5	38.3
Transportation	1.3	1.3
Water	0.8	0.8
Total	100	100

Source: Fairfax County GIS, 2008

Table 3.10 and Figure 3.3 show expected changes in land use as the Lower Sugarland WMA continues to develop. A very slight decrease in open space areas and an increase in estate residential areas within the Lower Sugarland WMA are projected.

3.3.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Lower Sugarland WMA to evaluate projects proposed by the county, to identify problem areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Lower Sugarland WMA:

1. Evaluated project proposed by the county.
2. Evaluated existing stormwater facilities.
3. Evaluated on-site septic systems.
4. Conducted a neighborhood source assessment.

The results of each of the above evaluations are briefly described below.

Proposed County Project

Based upon past evaluations and reports, one stormwater management project had been proposed within the Lower Sugarland WMA. Field investigations were used to determine whether the project was still viable. The project included raising the road and installing a new culvert. The field investigations concluded that the existing culvert is undersized, road flooding was evident, erosion was visible downstream of culvert and that the culvert does need to be replaced.

Existing Stormwater Facilities

Fourteen stormwater management facilities were evaluated within the Lower Sugarland WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Four of the 14 facilities were dry ponds and were functioning as designed, with no room for additional storage volume. The remaining 10 facilities were either not present at the location or were old farm ponds. A few of these facilities had beneficial forested buffers and wetland vegetation around the perimeters.

On-Site Septic Systems

Portions of the Sugarland Run watershed still use on-site septic systems. Properties using on-site systems were chosen for field reconnaissance if problems were noted in the area. One on-site septic area was visited in the Lower Sugarland WMA. The site could not be accessed due to a locked and gated fence but did not show any visible problems from the perimeter.

Neighborhood Source Assessment (NSA)

Four representative neighborhoods were chosen for the NSA to help identify potential improvement projects throughout the Lower Sugarland WMA. The chosen neighborhoods consisted of single-family detached houses ranging from one-half-acre lots to over one-acre lots. Three dry pond stormwater management facilities were identified in one NSA, three farm ponds were located in one NSA and the remaining two NSAs each contained one farm pond. Two of the assessments showed buffers were present but encroachment was evident. The NSA indicated a need for better lawn and landscaping practices.

3.3.4 Lower Sugarland WMA Characterization

Approximately 13.8 miles of streams were assessed within the Lower Sugarland WMA, within the Fairfax County boundary, to determine the overall stream conditions. Some portions of the Lower Sugarland WMA were not assessed, including the portions within Loudoun County. As can be seen from Figure 3.5, the stream lengths were mainly assessed as fair to good condition, with one tributary ranked as poor condition. Most of the streams in the Lower Sugarland WMA are protected by the resource protection areas as described in Chapter 1. The Lower Sugarland main stem was designated as protected in 2003. Mild to moderate erosion areas were identified during field reconnaissance. Most of the erosion occurred at road crossings and deficient buffer areas. One section had a moderate to severe erosion problem at a circular concrete crossing. Most of the Lower Sugarland WMA is in Channel Evolution Model Stage 3, which indicates an unstable channel that is experiencing significant bank erosion.

As shown in Figure 3.7, the Lower Sugarland WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network. The majority of these facilities are farm ponds. Table 3.11 indicates that stormwater runoff from approximately 20 percent of the area in this WMA is treated, and 80 percent of the area in this WMA is not treated by any means. Stormwater runoff from most of the area that does receive treatment is only treated for quantity and not water quality. Therefore, more stormwater management is needed within the developed portion of the Lower Sugarland WMA. Approximately 11 percent of the area in the Lower Sugarland WMA is impervious.

Table 3.11 Lower Sugarland WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Lower Sugarland	3,743	403.95	11%	135.8*	28.0*	6.4*	679.7*

* Treatment only within Fairfax County

3.3.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 3.8, 3.9 and 3.10. present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA.. Table 3.12 below shows the total pollutant loading to the endpoint of Lower Sugarland WMA. According to the STEPL model results, the Lower Sugarland WMA contributes approximately 16 percent of the total suspended solids, 13 percent of the total nitrogen, and 14 percent of the total phosphorous annual loads to Sugarland Watershed. Pollutant loadings normalized to the acres within the drainage area of Lower Sugarland WMA are presented in Table 3.13. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Lower Sugarland WMA as compared with unit area loads for the entire watershed.

Table 3.12 Summary of Pollutant Loadings for Lower Sugarland WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Lower Sugarland	340.7	10,864.18	1,684.90
WS Totals	**2,185.08**	**80,136.31**	**11,991.66**

Table 3.13 Summary of Pollutant Loadings Normalized by Drainage Area for Lower Sugarland WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Lower Sugarland	0.091	2.903	0.450
WS Totals	**0.151**	**5.529**	**0.827**

3.3.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Lower Sugarland WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 3.11, a 100-year storm in the Lower Sugarland WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope. There are no bridges or culverts on the modeled stream reaches in the Lower Sugarland WMA, so none were modeled.

3.3.7 Lower Sugarland WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 3.12 illustrates the results obtained for the subwatershed ranking of watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. Most of the Lower Sugarland WMA lies outside Fairfax County, and therefore those subwatersheds were not scored. No subwatersheds within the Lower Sugarland WMA have been identified as potential problem areas. Based upon existing conditions, all of the scored WMA is in good condition.

The WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 3.13. The lowest ranking subwatersheds were identified as additional potential problem areas. No additional problems areas were identified within the Lower Sugarland WMA. Most of the WMA indicates low levels of stressors and pollutant sources.

3.4 Lower Middle Sugarland WMA

3.4.1 Lower Middle Sugarland WMA Characteristics

The Lower Middle Sugarland WMA is located in the northern portion of the Sugarland Run Watershed. The watershed comprises 3,590 acres (5.61 square miles) and is located north of Wiehle Road. The WMA is intersected by the Loudoun County border as shown in Figure 3.1. The portion within Fairfax County is approximately half of the total Lower Middle WMA, comprising 2,012 acres (3.14 square miles).

Approximately 14.8 miles of perennial streams exist within the Lower Middle Sugarland WMA. These streams range from fair to good condition. The streams flow west into Loudoun County. The streams travel primarily through open space areas with medium density and low density residential areas on the perimeter.

3.4.2 Existing and Future Land Use

The southern half of Sugarland Run Watershed is highly developed, while the northern half is far less developed. The Lower Middle Sugarland WMA lies in the middle of the Sugarland Run Watershed, with both ends of the development spectrum represented. Approximately 75 percent of the Lower Middle Sugarland WMA is urbanized, consisting of low density residential (40 percent), open space (24 percent) and medium density residential (13 percent), as shown in Table 3.14.

Table 3.14 and Figure 3.3 show expected changes in land use as the Lower Middle Sugarland WMA continues to develop. A decrease in estate residential and open space areas and increase in low density residential and high intensity commercial areas within the Lower Middle Sugarland WMA are projected.

Table 3.14 Existing and Future Land Use for Lower Middle Sugarland WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	7.0	6.2
High Density Residential	.01	.01
Medium Density Residential	13.4	13.5
Low Density Residential	40.0	41.9
Low Intensity Commercial	0.1	0.3
High Intensity Commercial	1.5	1.7
Industrial	1.9	1.9
Institutional	0.2	0.2
Open Space	24.2	22.6
Transportation	8.2	8.2
Water	1.0	1.0
Total	100	100

Source: Fairfax County GIS, 2008

3.4.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Lower Middle Sugarland Watershed Management Area to evaluate projects proposed by the county, to identify problem areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Lower Middle Sugarland WMA:

1. Evaluated drainage complaints.
2. Evaluated projects proposed by the county.
3. Evaluated existing stormwater facilities.
4. Conducted a neighborhood source assessment.
5. Conducted a hotspot investigation.
6. Conducted a stream physical assessment

The results of each of the above evaluations are briefly described below.

Drainage Complaints

One hundred and two (102) drainage complaints have been documented within the Lower Middle Sugarland WMA between 2001 and 2006. Of those, three representative complaints were chosen for field investigation. The complaints included cave-ins and erosion around stormwater management facilities. No evidence was found in two of the locations and minor erosion was observed in one location.

Proposed County Projects

Based upon past evaluations and reports, multiple stormwater projects have been proposed within the Lower Middle Sugarland WMA. Field investigations were used to determine whether the projects were still needed. The projects included 11 stream restoration and stabilization projects. Four of those projects were not reviewed because of gated access restrictions. Seven of the projects showed evidence of moderate to severe erosion. Three regional pond projects were proposed in the Lower Middle Sugarland WMA. One pond was completed and the remaining two are not yet completed. Five projects were proposed to raise roads and install culverts. Two of those projects were completed and the remaining three were recommended to also be completed.

Existing Stormwater Facilities

Twenty-one (21) stormwater management facilities were evaluated within the Lower Middle Sugarland WMA to determine the need for repairs or the potential for retrofits to increase the benefit of the facilities. Four of the 21 stormwater facilities were dry ponds; three were functioning as designed and one was functioning as a wet pond due to a clogged structure. Ten of the stormwater facilities were in forested buffer areas; some had wetland vegetation and were functioning as farm or ornamental ponds. Three of the stormwater facilities were functioning as farm ponds but have the potential for retrofit. Two of the facilities were farm ponds that are in bad condition due to homeowner negligence. The remaining two locations did not contain a stormwater management facility.

Neighborhood Source Assessment (NSA)

Five representative neighborhoods were chosen for the NSA to help identify potential improvement projects throughout the Lower Middle Sugarland WMA. Three of the chosen neighborhoods consisted of single-family detached houses on on-half-acre to one-acre lots. All of the neighborhoods contained buffer areas with evidence of encroachment and either dry ponds or wet ponds for stormwater management. One neighborhood consisted of one-acre lots, and had two stormwater management facilities with the potential for additional volume. The remaining neighborhood consisted of one-quarter-acre lots with three dry ponds for stormwater management. The NSA indicated the potential for stormwater management facility retrofit as well as a need for better lawn and landscaping practices.

Hot Spot Investigation (HSI)

Three representative facilities with the potential to generate concentrated stormwater pollution were chosen within the Lower Middle Sugarland WMA to complete a HSI. An investigation was conducted of each facility and its corresponding property to identify sources of pollution. All three locations targeted for the HSI were commercial locations. One was not considered a hotspot and the other two were considered potential hotspots. This indicated the need for future education efforts and review of the stormwater pollution prevention plans for each facility.

Stream Physical Assessment (SPA)
A supplemental stream physical assessment was conducted on 2.5 miles of stream within the Lower Middle Sugarland WMA. The stream segment was chosen for re-assessment because several county stream restoration and stabilization projects were located on the stream, two additional projects were proposed and because the stream segment is listed as a 303(d) impaired stream. The stream was found to be in good to excellent habitat condition. The SPA identified 17 bank erosion problems, three obstructions and three pipes/drainage ditch erosion problems.

3.4.4 Lower Middle Sugarland WMA Characterization

Approximately 14.8 miles of streams were assessed within the Lower Middle Sugarland WMA to determine the overall stream conditions. As shown in Figure 3.5, the assessed stream segment had fair to good habitat conditions. Most of the streams in the Lower Middle WMA are protected by the resource protection areas as described in Chapter 1. The Lower Middle Sugarland main stem was designated as protected in 1993 and the other tributaries were added in 2003. Mild to moderate erosion areas were identified during field reconnaissance. Most of the erosion occurred at road crossings and in deficient buffer areas. Mild to moderate obstructions and dumps were also identified. Two sections had moderate to severe erosion problems at deficient buffer areas. Approximately half of the Lower Middle Sugarland WMA is in Channel Evolution Model Stage 3, which indicates an unstable channel that is experiencing significant bank erosion. The remaining portions are in Stage 4, which indicates that the stream is attempting to stabilize by developing a bankful and floodplain channel.

As shown in Figure 3.7, the Lower Middle Sugarland WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network. The majority of these facilities are farm ponds. Table 3.15 indicates that stormwater runoff from approximately 67 percent of the area in this WMA is treated, and approximately 33 percent of the area in this WMA is not treated by any means. Stormwater runoff from most of the area that does receive treatment is treated for quantity and water quality. Only about 14 percent of the watershed area is impervious. As development continues in Lower Middle Sugarland WMA, additional stormwater facilities should be installed. Since a significant portion of the watershed area in the Lower Middle Sugarland WMA is already treated with for quantity and water quality, the primary focus in this WMA should be to ensure that all of the existing stormwater treatment facilities are operated and maintained properly.

Table 3.15 Lower Middle Sugarland WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Lower Middle Sugarland	3,503	501.3	14%	391.7*	77.2*	866.5*	676.7*

* Treatment only within Fairfax County

3.4.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 3.8, 3.9 and 3.10 present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 3.16 below shows the total pollutant loading to the endpoint of Lower Middle Sugarland WMA. According to the STEPL model results, the Lower Middle Sugarland WMA contributes approximately 23 percent of the total suspended solids, 22 percent of the total nitrogen, and 23 percent of the total phosphorous annual loads to Sugarland Watershed. Pollutant loadings normalized to the acres within the drainage area of Lower Middle Sugarland WMA are presented in Table 3.17. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Lower Middle WMA as compared with unit area loads for the entire watershed.

Table 3.16 Summary of Pollutant Loadings for Lower Middle Sugarland WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Lower Middle Sugarland	503.0	17,873.39	2,738.69
WS Totals	**2,185.08**	**80,136.31**	**11,991.66**

Table 3.17 Summary of Pollutant Loadings Normalized by Drainage Area for Lower Middle Sugarland WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Lower Middle Sugarland	0.140	4.979	0.763
WS Totals	**0.151**	**5.529**	**0.827**

3.4.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Lower Middle Sugarland WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 3.11, a 100-year storm in the Lower Middle Sugarland WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

One bridge and three culverts are located within the Lower Middle Sugarland WMA. The bridge was modeled to determine if the 100-year storm exceeded its capacity to carry the flow. The modeling shows that the bridge does not carry the 100-year stormflow. One culvert does not carry the 100-year stormflow and water will pond upstream of the culvert structure. The existence of the ponded water will extend the time period of maximum flow through the culvert. When the ponded water is fully drained, the flow elevation will begin to drop. The two other culverts carry the 100-year stormflow.

3.4.7 Lower Middle Sugarland WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 3.12 illustrates the results obtained for the subwatershed ranking of watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. No subwatersheds within the Lower Middle WMA have been identified as potential problem areas. Based upon the evaluation, the majority of the WMA is in good condition. The exception was one subwatershed that scored fair.

The WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 3.13. The lowest ranking subwatersheds were identified as additional potential problem areas. One additional problem area was identified within the Lower Middle Sugarland WMA. The rest of the WMA were ranked as low to moderate levels of stressors and pollutant sources.

3.5 Potomac WMA

3.5.1 Potomac WMA Characteristics

The Potomac WMA is located at the northern tip of the Sugarland Run Watershed. The watershed comprises 1,053 acres (1.64 square miles) and is located at the border of Loudoun County, as shown in Figure 3.1. The portion of the WMA within Fairfax County only contains 70 acres (0.1 square miles); the rest is in Loudoun County.

Approximately 3.0 miles of perennial stream exist within the Potomac WMA in Fairfax County, which range from fair to good condition. The stream flows west into Loudoun County, traveling through an estate residential area.

3.5.2 Existing and Future Land Use

The Potomac WMA falls within the less developed area of the Sugarland Run Watershed. Approximately 26 percent of the WMA is urbanized, consisting of low density residential (17 percent) and open space (74 percent) land uses, as shown in Table 3.18.

Table 3.18 Existing and Future Land Use for Potomac WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	0.8	0.8
Medium Density Residential	4.3	4.3
Low Density Residential	17.1	17.1
Open Space	73.7	73.7
Transportation	0.8	0.8
Water	3.3	3.3
Total	100	100

Source: Fairfax County GIS, 2008

Table 3.18 and Figure 3.3 show that no changes are expected in land use as the Potomac WMA continues to develop.

3.5.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was conducted within the Potomac WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Potomac WMA:

1. Evaluated existing stormwater facilities.
2. Conducted a neighborhood source assessment.

The results of each of the above evaluations are briefly described below.

Existing Stormwater Facilities
Two stormwater management facilities were evaluated in the Potomac WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Both of the facilities were dry ponds and were functioning as designed.

Neighborhood Source Assessment (NSA)
One representative neighborhood was chosen for the NSA to help identify potential improvement projects throughout the Potomac WMA. The chosen neighborhood consisted of single-family detached houses on one-acre lots. Two stormwater management facilities were identified as dry ponds. The NSA indicated that buffers were present and encroachment was evident. Better lawn and landscaping practices are needed.

3.5.4 Potomac WMA Characterization

Approximately 3.0 miles of stream was assessed within the Fairfax County portion of the Potomac WMA to determine the overall stream conditions. Only about 7 percent of the Potomac WMA is located in Fairfax County; therefore, no stream information is available for the majority of the WMA.

As shown in Figure 3.7, the Potomac WMA contains two stormwater management facilities within the Fairfax County boundary that collect and treat stormwater runoff. The remaining stormwater treatment facilities outside of Fairfax County are not known. Table 3.19 indicates that stormwater runoff from approximately 66 percent of the area in this WMA is treated, and approximately 34 percent of the area in this WMA is not treated by any means. Stormwater runoff from most of the area that does receive treatment is treated for water quality and not quantity. Approximately 4 percent of the area in the Potomac WMA is impervious.

Table 3.19 Potomac WMA Summary (within Fairfax County)

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Potomac	1,053	42	4%	0*	43.7*	2.71*	23.9*

* Treatment only within Fairfax County

3.5.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 3.8, 3.9 and 3.10 present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 3.20 below shows the total pollutant loading to the endpoint of Potomac WMA. According to the STEPL model results, the Potomac WMA contributes approximately 8 percent of the total suspended solids, 3 percent of the total nitrogen, and 4 percent of the total phosphorous annual loads to Sugarland Watershed. Pollutant loadings normalized to the acres within the drainage area of Potomac WMA are presented in Table 3.21. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Potomac WMA as compared with unit area loads for the entire watershed.

Table 3.20 Summary of Pollutant Loadings for Potomac WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Potomac	167.5	2260.6	435.4
WS Totals	**2,185.08**	**80,136.31**	**11,991.66**

Table 3.21 Summary of Pollutant Loadings Normalized by Drainage Area for Potomac WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	**Total Nitrogen (pounds/acre/year)**	**Total Phosphorus (pounds/acre/year)**
Potomac	0.159	2.147	0.413
WS Totals	**0.151**	**5.529**	**0.827**

3.5.6 HEC-RAS Modeling

The Potomac WMA was not modeled using HEC-RAS since the majority of the WMA is located in Loudoun County.

3.5.7 Potomac WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 3.12 illustrates the results obtained for the subwatershed ranking of watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. Approximately half of the Potomac WMA was not scored because it is located within Loudoun County. No subwatersheds within the Potomac WMA have been identified as potential problem areas. Based upon existing conditions, the scored portion of the WMA is in good condition.

The WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 3.13. The lowest ranking subwatersheds were identified as additional potential problem areas. No additional problems areas were identified within the Potomac WMA. The WMA was ranked as having low levels of stressors and pollutant sources.

3.6 Upper Sugarland WMA

3.6.1 Upper Sugarland WMA Characteristics

The Upper Sugarland WMA is located in the southern portion of the Sugarland Run Watershed. The watershed comprises 1391 acres (2.71 square miles), and the WMA is located along the southern portion of Sugarland Run along the Dulles Access Road, as shown in Figure 3.1.

Approximately 3.5 miles of perennial streams exist within the Upper Sugarland WMA, which range from poor to good condition. The streams flow north through the watershed. The Upper Sugarland main stem travels primarily through estate residential land use, while the tributaries flow through low intensity commercial land use.

3.6.2 Existing and Future Land Use

The Upper Sugarland WMA lies within a highly developed area within the Sugarland Run Watershed. Approximately 82 percent of the Upper Sugarland WMA is urbanized, consisting of low intensity commercial (39.6 percent), transportation (18.1 percent), and high density residential (10 percent) land uses, as shown in Table 3.22.

Table 3.22 Existing and Future Land Use for Upper Sugarland WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	1.3	0.3
High Density Residential	10.0	11.9
Medium Density Residential	7.5	7.3
Low Density Residential	0.9	0.5
Low Intensity Commercial	39.6	34.5
High Intensity Commercial	5.3	10.6
Industrial	5.1	8.1
Institutional	1.5	0.8
Golf Course	0.7	0.7
Open Space	9.1	6.4
Transportation	18.1	18.1
Water	0.8	0.8
Total	100	100

Source: Fairfax County GIS, 2008

Table 3.22 and Figure 3.2 show expected changes in land use as the Upper Sugarland WMA continues to develop. A decrease in estate, medium and low residential, open space and institutional land use is projected. This correlates with an increase in high density residential, industrial and high intensity commercial areas within the Upper Sugarland WMA.

3.6.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Upper Sugarland WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Upper Sugarland WMA:

1. Evaluated drainage complaints.
2. Evaluated projects proposed by the county.
3. Evaluated existing stormwater facilities.
4. Conducted a neighborhood source assessment.
5. Conducted a hotspot investigation.
6. Conducted a stream physical assessment

The results of each of the above evaluations are briefly described in the following sections.

Drainage Complaints
Nineteen (19) drainage complaints have been documented within the Upper Sugarland WMA between 2001 and 2006. Of those, one representative complaint was chosen for field investigation. The complaint was regarding erosion, but no evidence of erosion was found at this location.

Proposed County Project
Based upon past evaluations and reports, three stormwater projects have been proposed by the county within the Upper Sugarland WMA. Field investigations were used to determine whether these projects were still needed. The projects included a stream restoration and stabilization project of the Upper Sugarland WMA, which was completed, and one storm drain replacement, which was also completed. The third project, which was to raise the road and install a culvert, was not found.

Existing Stormwater Facilities
Fifteen stormwater management facilities were evaluated within the Upper Sugarland WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Four of the 15 facilities were dry ponds and were found to be functioning as designed. One dry pond was functioning properly and could have additional volume added. Four facilities were wet ponds and contained wetland vegetation and some water quality protection features. Three facilities were not stormwater facilities but over-widened stream channels, with possible retrofit capabilities. The remaining two locations did not contain any stormwater management facilities.

Neighborhood Source Assessment (NSA)
Three representative neighborhoods were chosen for the NSA to help identify potential improvement projects throughout the Upper Sugarland WMA. One of the chosen neighborhoods consisted of single-family detached houses and two consisted of commercial properties. The single-family detached neighborhood consisted of lots on one-half-acre properties and did not provide any stormwater treatment facilities. One commercial NSA contained stormwater inlets that were clean and free of debris. The remaining commercial NSA contained three wet ponds and one dry pond. The potential for a pond retrofit exists at the dry pond location. The NSA indicated the potential for stormwater management facility retrofits as well as a need for better lawn and landscaping practices.

Hot Spot Investigation (HSI)
Sixteen representative facilities with the potential to produce concentrated stormwater pollution were chosen within the Upper Sugarland WMA to complete a HSI. An investigation was conducted of the facilities and the corresponding property to identify sources of pollution. Three locations were reviewed and were not identified as hotspots. Eight facilities were identified as potential hotspots and were recommended for follow-up visits and permit checking. Five facilities were confirmed hotspots and were recommended for follow-up site inspections.

Stream Physical Assessment (SPA)
A supplemental stream physical assessment was conducted on 0.05 miles of stream within the Upper Sugarland WMA. This segment was chosen for re-assessment because two possible

project locations, including a stream restoration and stabilization project and a road/culvert project, were located in the Upper Sugarland WMA. The stream was found to be in fair habitat condition.

3.6.4 Upper Sugarland WMA Characterization

Approximately 3.5 miles of streams were assessed within the Upper Sugarland WMA to determine the overall stream conditions. As shown in Figure 3.4, the main stream lengths assessed were in fair to good habitat condition, while the tributaries were in poor condition. Most of the streams in the Upper Sugarland WMA are protected by the resource protection areas as described in Chapter 1. The Upper Sugarland main stem was designated as protected in 2003. Mild to moderate erosion areas were identified during field reconnaissance. Most of the erosion occurred at road crossings, with some obstructions and deficient buffer areas. Most of the Upper Sugarland WMA is in Channel Evolution Model Stage 3, which indicates an unstable channel that is experiencing significant bank erosion. A few portions are in Stage 4, which indicates the stream is attempting to stabilize by developing a bankful and floodplain channel.

As shown in Figure 3.6, the Upper Sugarland WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network. These facilities are wet ponds and dry ponds. Table 3.23 indicates that even though many stormwater facilities are in place, much of the stormwater generated within the Upper Sugarland WMA is untreated. Eighty-two percent of the Upper Sugarland WMA within Fairfax County is developed and only 26 percent of that area treats stormwater. Therefore, more stormwater management is needed within the developed portion of the Upper Sugarland WMA.

Table 3.23 Upper Sugarland WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Upper Sugarland	1391.0	677.5	49%	294.7	85.73	18.0	992.57

3.6.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 3.8, 3.9 and 3.10 present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 3.24 below shows the total pollutant loading to the endpoint of Upper Sugarland WMA. According to the STEPL model results, the Upper Sugarland WMA contributes approximately 15 percent of the total suspended solids, 17 percent of the total nitrogen, and 15 percent of the total phosphorous annual loads to Sugarland Watershed. Pollutant loadings normalized to the acres within the drainage area of Upper Sugarland WMA are presented in Table 3.25. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Upper Sugarland WMA as compared with unit area loads for the entire watershed.

Table 3.24 Summary of Pollutant Loadings for Upper Sugarland WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Upper Sugarland	320.5	13,200.51	1,812.14
WS Totals	**2,185.08**	**80,136.31**	**11,991.66**

Table 3.25 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Upper Sugarland	0.230	9.490	1.303
WS Totals	**0.151**	**5.529**	**0.827**

3.6.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Upper Sugarland WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 3.11, a 100-year storm in the Upper Sugarland WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

Five culverts are located within the Upper Sugarland WMA. The culverts were modeled to determine if the 100-year storm exceeded their capacity to carry the flow. The modeling shows that the five culverts do not carry the 100-year stormflow. Three of these culverts will pond water upstream of the culvert structure. The existence of the ponded water will extend the time period of maximum flow through the culvert. When the ponded water is fully drained, the flow elevation will begin to drop. The other two culverts will overtop their structures.

3.6.7 Upper Sugarland WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 3.12 illustrates the results obtained for the subwatershed ranking of watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. Three subwatersheds within the Upper Sugarland WMA have been identified as potential problem areas. Based upon existing conditions, the condition of the entire WMA is moderate.

The WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 3.13. The lowest ranking subwatersheds were identified as additional potential problem areas. Three additional problem areas were identified within the Upper Sugarland WMA. The WMA was ranked as having moderate to high levels of stressors and pollutant sources.

3.7 Upper Middle Sugarland WMA

3.7.1 Upper Middle Sugarland WMA Characteristics

The Upper Middle Sugarland WMA is located in the middle of the Sugarland Run Watershed. The watershed comprises 1,975 acres (3.09 square miles) and is located along the eastern portion of Sugarland Run. The WMA lies partially within Herndon, along the Fairfax Parkway as shown in Figure 3.1.

Approximately 6.8 miles of perennial streams exist within the Upper Middle Sugarland WMA. Most of these streams are in good condition with only one small tributary in poor condition. The streams flow north and northwest through the watershed. The stream travels primarily through open space areas with medium density and low density residential land use areas on the perimeter.

3.7.2 Existing and Future Land Use

The Upper Middle Sugarland WMA is in a highly developed area within the Sugarland Run Watershed. Approximately 82 percent of the Upper Middle Sugarland WMA is urbanized, consisting of medium density residential (29 percent), open space (15 percent) and transportation (16 percent), as shown in Table 3.26.

Table 3.26 and Figure 3.2 show expected changes in land use as the Upper Middle Sugarland WMA continues to develop. A decrease in estate residential, low density residential and institutional land use is projected. An increase in the high density residential industrial areas within the Upper Middle Sugarland WMA is also projected.

Table 3.26 Existing and Future Land Use for Upper Middle Sugarland WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	2.0	0.4
High Density Residential	11.9	13.6
Medium Density Residential	28.6	28.8
Low Density Residential	12.5	11.8
Low Intensity Commercial	1.1	1.1
High Intensity Commercial	4.8	4.8
Industrial	2.8	3.0
Institutional	4.9	3.9
Open Space	14.5	15.6
Transportation	15.5	15.5
Water	1.5	1.5
Total	100	100

Source: Fairfax County GIS, 2008

3.7.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was conducted within the Upper Middle Sugarland WMA to evaluate projects proposed by the county, to identify problem areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Upper Middle Sugarland WMA:

1. Evaluated drainage complaints.
2. Evaluated projects proposed by the county.
3. Evaluated existing stormwater facilities.
4. Conducted a neighborhood source assessment.
5. Conducted a hotspot investigation.
6. Conducted a stream physical assessment.

The results of each of the above evaluations are briefly described below.

Drainage Complaints

One hundred and seventy (170) drainage complaints have been documented within the Upper Middle Sugarland WMA between 2001 and 2006. Of those, 11 representative complaints were chosen for field investigation. The complaints included erosion, flooding and undermining. Five of the complaints observed showed no signs of disturbance, four of the complaints showed erosion and undermining and two of the complaint areas have been repaired.

Proposed County Projects

Based upon past evaluations and reports, multiple stormwater projects have been proposed by the county within the Upper Middle Sugarland WMA. Field investigations were used to determine whether projects were still needed. The projects included stream restoration and stabilization projects of Upper Middle Branch and raising the road and installing culverts. One of the culvert installation projects was not accessible. The other two were not completed but are recommended to be completed. One stream restoration project was not completed and is also recommended to be completed.

Existing Stormwater Facilities

Fifteen stormwater management facilities were evaluated within the Upper Middle Sugarland WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Ten of the 15 facilities were dry ponds and were functioning as designed. One facility was a farm/ornamental pond with no water quality features and no room for additional volume. Two stormwater management facilities were wet ponds and in good functioning condition. The remaining two locations did not have a facility present; however, they presented possible retrofit opportunities.

Neighborhood Source Assessment (NSA)

Five representative neighborhoods were chosen for the NSA to help identify potential improvement projects throughout the Upper Middle Sugarland WMA. Four of the chosen neighborhoods consisted of single-family detached houses and the other consisted of a multi-family complex. Two stormwater management facilities identified were located on single-family quarter-acre lots with dry pond stormwater facilities. They both had pond retrofit potential. Another neighborhood with single family homes on one-half-acre lots included three dry ponds and a pond retrofit potential. One single-family neighborhood had a dry pond with adequate buffers and no encroachment was visible. The neighborhood assessment with the multi-family complex had no stormwater facilities present at the location, but storm sewers were present and free of debris. The NSA indicated the potential for stormwater management facility retrofit as well as better lawn and landscaping practices.

Hot Spot Investigation (HSI)

Seven representative facilities with the potential to generate concentrated stormwater pollution were chosen within the Upper Middle Sugarland WMA to complete a HSI. An investigation was conducted of the facilities and the corresponding property to identify sources of pollution. Two schools were targeted for the HSI; one had a potential hotspot and the other had no hotspots. Two commercial buildings were evaluated; one revealed a potential hotspot and the other was not considered a hotspot. A review of the stormwater pollution plan is recommended for the potential hotspot site along with an additional site visit and a check to see if an NPDES permit is recorded. The Fairfax County Public Library was also evaluated as a potential hotspot. An on-site inspection of the storm drain system and a review of the storm water pollution prevention plan is recommended for the library. The remaining two facilities were not evaluated due to access denial.

Stream Physical Assessment (SPA)

A supplemental stream physical assessment was conducted on 1.1 miles of stream within the Upper Middle Sugarland WMA. This stream segment was chosen for re-assessment because a possible project location was identified, a stream restoration and stabilization project was located in the WMA and it drains to a 303(d) impaired stream. The stream was found to be in good to excellent habitat condition. The investigation identified 11 bank erosion problems, four obstructions and five pipes/drainage ditch erosion problems.

3.7.4 Upper Middle Sugarland WMA Characterization

Approximately 6.8 miles of streams were assessed within the Upper Middle Sugarland WMA to determine the overall stream conditions. As shown in Figure 3.4, the stream length assessed had fair to good habitat conditions, with the exception of one tributary in poor condition. Most of the streams in the Upper Middle Sugarland WMA are protected by the resource protection areas as described in Chapter 1. The Upper Middle Sugarland main stem was designated as protected in 1993 with the addition of Rosiers Branch in 2003. Mild to moderate erosion areas were identified during field reconnaissance. Most of the erosion occurred at road crossings and in piped locations. Most of the Upper Middle Sugarland WMA is in Channel Evolution Model Stage 4, which indicates the stream is attempting to stabilize by developing a bankful and floodplain channel. Two smaller tributaries in the Upper Middle Sugarland WMA are in Channel Evolution Model Stage 3, which indicates an unstable channel that is experiencing significant bank erosion.

As shown in Figure 3.6, the Upper Middle Sugarland WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network. The majority of these facilities are dry ponds. Table 3.27 indicates that stormwater runoff from approximately 18 percent of the area in this WMA is treated, and approximately 82 percent of the area in this WMA is not treated by any means. Stormwater runoff from the areas that do receive treatment is treated for both quantity and water quality. Approximately 28 percent of the area in this WMA is impervious. More stormwater management facilities are needed in the Upper Middle Sugarland WMA.

Table 3.27 Upper Middle Sugarland WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Upper Middle Sugarland	1975.1	561.4	28%	125.8	63.9	172.9	1612.5

3.7.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 3.8, 3.9 and 3.10 present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 3.28 shows the total pollutant loading to the endpoint of Upper Middle Sugarland WMA. According to the STEPL model results, the Upper Middle Sugarland WMA contributes approximately 20 percent of the total suspended solids, 20 percent of the total nitrogen, and 20 percent of the total phosphorous annual loads to the Sugarland Run Watershed. Pollutant loadings normalized to the acres within the drainage area of Upper Middle Sugarland WMA are presented in Table 3.29. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Upper Middle Sugarland WMA as compared with unit area loads for the entire watershed.

Table 3.28 Summary of Pollutant Loadings for Upper Middle Sugarland WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Upper Middle Sugarland	435.4	16,079.07	2,403.64
WS Totals	**2,185.08**	**80,136.31**	**11,991.66**

Table 3.29 Summary of Pollutant Loadings Normalized by Drainage Area for Upper Middle Sugarland WMA

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Upper Middle Sugarland	0.220	8.137	1.216
WS Totals	**0.151**	**5.529**	**0.827**

3.7.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Upper Middle Sugarland WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 3.11, a 100-year storm in the Upper Middle Sugarland WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

One bridge and six culverts are located within the Upper Middle Sugarland WMA. The bridge and six culverts were modeled to determine if the 100-year storm exceeded their capacity to carry the flow. The modeling shows that the bridge and two culverts carry the 100-year stormflow. Two culverts do not carry the 100-year stormflow and water will pond upstream of the culvert structure. The existence of the ponded water will extend the time period of maximum flow through the culvert. When the ponded water is fully drained, the flow elevation will begin to drop. Two other culverts do not carry the 100-year stormflow and will overtop.

3.7.7 Upper Middle Sugarland WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 3.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. No potential problem areas were identified within the Upper Middle Sugarland WMA. Based upon existing conditions, the remainder of the WMA is in good condition.

The WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 3.13. The lowest ranking subwatersheds were identified as additional potential problem areas. One additional problem area was identified within the Upper Middle Sugarland WMA. The remainder of the WMA was ranked as having moderate levels of stressors and pollutant sources.

3.8 SWMM Modeling for Sugarland Run Watershed

The Stormwater Management Model (SWMM) was used to determine the peak rate (maximum volume of water per second) of stormwater flows in stream channels during a storm. The 2-year and 10-year storm flows were modeled; these are the storm flows that, on average, occur once every 2-years or 10-years. Figure 3.14 shows peak rates of flow for the 2-year storm across the watershed. As shown in Figure 3.14, within each WMA, peak flows tend to increase downstream as more drainage area has more stormwater runoff to the stream channel. In a similar manner, an upstream, contributing WMA augments the flow in a downstream, receiving WMA. Because stormwater runoff flow carries pollutants, pollutant loadings also increase downstream within a WMA and from one WMA to the next.

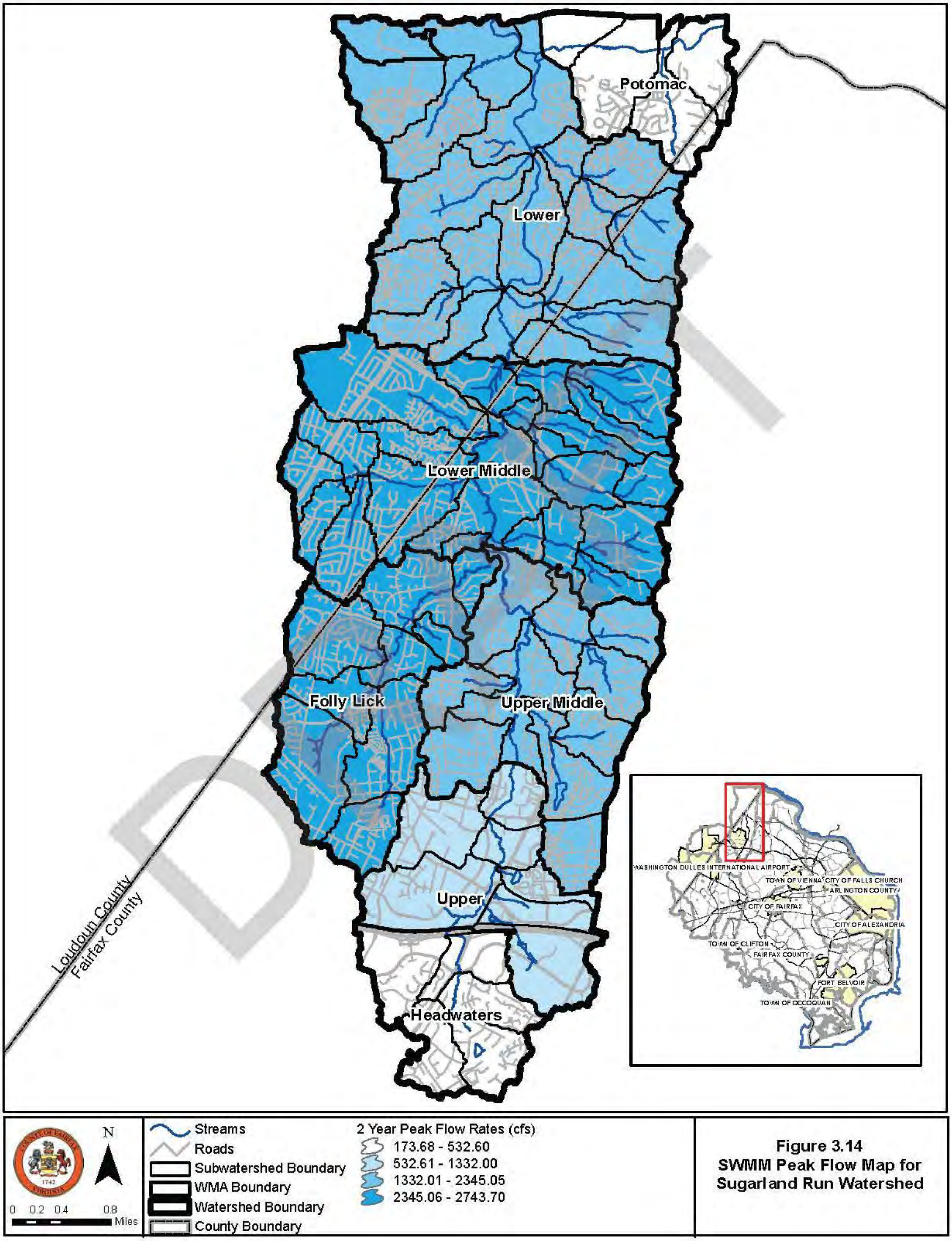

Figure 3.14
SWMM Peak Flow Map for Sugarland Run Watershed

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Table 3.30 shows peak flows for the 2-year and 10-year storms in the WMAs in the Sugarland watershed. The SWMM model shows that peak flows are generally increasing from the upstream, contributing WMAs to the downstream WMAs. The Lower and Lower Middle Sugarland WMA have the highest cumulative peak flows because they are the receiving WMAs for all the stormwater runoff in the watershed. Peak flows for the 10-year storm are approximately twice as large as the flows for the 2-year storm.

Table 3.30 Summary of SWMM and STEPL Results

		Stormwater Runoff Peak Flow Values		Pollutant Loadings		
WMA Name[1]	**Contributing WMA(s)[2]**	**2-yr storm (cubic ft/sec)**	**10-yr storm (cubic ft/sec)**	**Total Suspended Solids (tons/yr)**	**Total Nitrogen (pounds/yr)**	**Total Phosphorus (pounds/yr)**
Headwaters	Headwaters	532.6	1,034.82	204.53	8,216.82	1,198.13
Upper	Headwaters	1,332	2,631.39	524.98	21,417.33	3,010.27
Upper Middle	Upper, Upper Middle	2,331.66	4,596.55	960.33	37,496.40	5,413.91
Lower Middle	Upper Middle, Folly Lick, Lower Middle	2,743.7	5,246.56	1,807.20	68,905.23	10,226.16
Lower	Lower Middle, Potomac West, Lower	2,345.05	5,799.64	2,166.47	79,952.86	11,951.36
WS Totals		**2,345.05**	**5,799.64**	**2,166.47**	**79,952.86**	**11,951.36**
Potomac East	Potomac East	173.68	388.6	148.86	2,077.12	395.09
WS Totals		**173.68**	**388.6**	**148.86**	**2,077.12**	**395.09**

1. The "WMA Name" is the WMA for which there is a node that has the individual, cumulative peak flows (2 and 10 year) for the entire upstream drainage area. Example: The first WMA with such a node is the "Upper" WMA.
2. The "Contributing WMA(s)" are the upstream WMAs for which there is not a node that has the individual, cumulative peak flows (2 and 10 year) for the entire upstream drainage area. Example: The "Upper Middle" WMA includes all the stormwater draining from the Upper WMA and the Upper Middle WMA.

To determine which WMA has the greatest flows, the peak flows in Table 3.30 were recalculated based on WMA drainage area. Table 3.31 shows these flows normalized by WMA drainage area. Upper Sugarland WMA has the most stormwater runoff during the 2-year storm and Lower Sugarland WMA has the least. During the 10-year storm, the Sugarland Headwaters WMA has the most cumulative stormwater runoff per drainage area and the Lower Sugarland WMA the least. The eastern portion of the Potomac WMA drains directly into the Potomac River and the peak flow values resulting from this area were not considered to be contributions to the Sugarland Watershed.

The STEPL model was used to estimate the pollutant loadings for total suspended solids (sediments), total nitrogen, and total phosphorus for each WMA and the results are shown in Table 3.30. As stormwater flows accumulate downstream, so do the pollutant loadings carried by the flows. Pollutant loads pass from the upstream, contributing WMAs to downstream WMAs. The cumulative, downstream loadings may increase or decrease depending on the presence and magnitude of new sources and the relative increase in drainage area and associated flows. The Lower Sugarland WMA has the greatest cumulative pollutant loading and the Sugarland Headwaters WMA the least. The eastern portion of the Potomac WMA drains directly into the Potomac River and the pollutant loading resulting from this area do not contribute to the Sugarland Watershed stormflows.

Table 3.31 Summary of SWMM and STEPL Results Normalized by Drainage Area

			Stormwater Runoff Peak Flow Values		Pollutant Loadings		
WMA Name[1]	**Contributing WMA(s)[2]**	**Drainage Area (Acres)**	**2-yr storm (cubic ft/sec)**	**10-yr storm (cubic ft/sec)**	**Total Suspended Solids (tons/yr)**	**Total Nitrogen (pounds/yr)**	**Total Phosphorus (pounds/yr)**
Headwaters	Headwaters	929.00	0.573	1.114	0.220	8.845	1.290
Upper	Headwaters	2,320.00	0.574	1.134	0.226	9.232	1.298
Upper Middle	Upper, Upper Middle	4,296.00	0.543	1.070	0.224	8.728	1.260
Lower Middle	Upper Middle, Folly Lick, Lower Middle	9,699.00	0.283	0.541	0.186	7.104	1.054
Lower	Lower Middle, Potomac West, Lower	14,354.00	0.163	0.404	0.151	5.570	0.833
WS Totals		**14,354.00**	**0.163**	**0.404**	**0.151**	**5.570**	**0.833**
Potomac East	Potomac East	140.00	1.241	2.776	1.063	14.837	2.822
WS Totals		**140.00**	**1.241**	**2.776**	**1.063**	**14.837**	**2.822**

1. The "WMA Name" is the WMA for which there is a node that has the individual, cumulative peak flows (2 and 10 year) for the entire upstream drainage area. Example: The first WMA with such a node is the "Upper" WMA.
2. The "Contributing WMA(s)" are the upstream WMAs for which there is not a node that has the individual, cumulative peak flows (2 and 10 year) for the entire upstream drainage area. Example: The "Upper Middle" WMA includes all the stormwater draining from the Upper WMA and the Upper Middle WMA.

To determine if the pollutant loadings shown in Table 3.30 are increasing or decreasing with downstream flow, the loadings were recalculated based on WMA drainage area. Table 3.31 shows pollutant loadings normalized by the contributing drainage area. Pollutant loadings in the Sugarland Watershed decrease with downstream flow, indicating that the increase in flow is relatively greater than the increase in added pollutants. The one exception is the increase in pollutant loadings from the Headwaters WMA to the Upper WMA, which implies that the addition of flow is low relative to the addition of new pollutants in the Upper WMA.

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4.1 Horsepen Creek Watershed

The Horsepen Creek Watershed consists of nine watershed management areas (WMAa) as listed below:

1. Cedar Run
2. Frying Pan
3. Indian
4. Lower Horsepen
5. Lower Middle Horsepen
6. Merrybrook
7. Middle Horsepen
8. Stallion
9 Upper Horsepen

WMAs in the Horsepen Creek Watershed are shown in Figure 4.1. As shown in the figure, all of the Stallion WMA is located in Loudoun County and only very small portions of the Lower Horsepen WMA and the Indian WMA are located in Fairfax County. Most of the Merrybrook WMA, the Lower Middle Horsepen WMA and the Middle Horsepen WMA are located in Fairfax County with only small portions of these WMAs located in Loudoun County. Only areas within Fairfax County were evaluated as part of this study; however, information on stormwater structures and stream crossings near the county border was gathered and evaluated based on how it would affect stormwater flows in Fairfax County. The following information is provided for each WMA in the subsequent sections of this chapter:

1. WMA Characteristics
2. Existing and Future Land Use Information
3. Field Reconnaissance and Stream Physical Assessment Information
4. WMA Characterization
5. STEPL Modeling
6. HEC-RAS Modeling
7. Subwatershed Ranking

Table 4.1 illustrates the total area of each WMA, the current impervious conditions and the extent and type of stormwater treatment within each WMA.

Table 4.1 Horsepen Creek Watershed WMA Summaries

WMA Name	Total Area (acres)	Impervious Current Conditions (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Cedar Run	783	203.7	26%	103.6	20.8	0	658.6
Frying Pan	1,131	338.4	30%	207.2	83	116.4	724.4
Indian	2,067	325.0	16%	No Data for Loudoun County			
Lower	3,190	571	18%	No Data for Loudoun County			
Lower Middle Horsepen	1,186	379.7	32%	1.5*	41.9*	71.9*	1071*
Merrybrook	967	396.2	41%	68.4	0	115.1	783.5
Middle Horsepen	953	215.1	23%	102.2	18.7	9.2	822.9
Stallion	2,394	190.6	8%	No Data for Loudoun County			
Upper Horsepen	1,929	556.4	29%	373.3	56.9	188.4	1310.4
Watershed Totals	**14,600**	**3,176**	**22%**	**856.2**	**221.3**	**501**	**5370.8**

* Treatment only within Fairfax County

Figures for Chapter 4 are provided in the beginning of the chapter and are followed by a detailed discussion of each WMA in Sections 4.1 through Section 4.9. Section 4.10 includes a discussion of SWMM modeling results, including a SWMM Peak Flow Map for the 2-year and 10-year storm event.

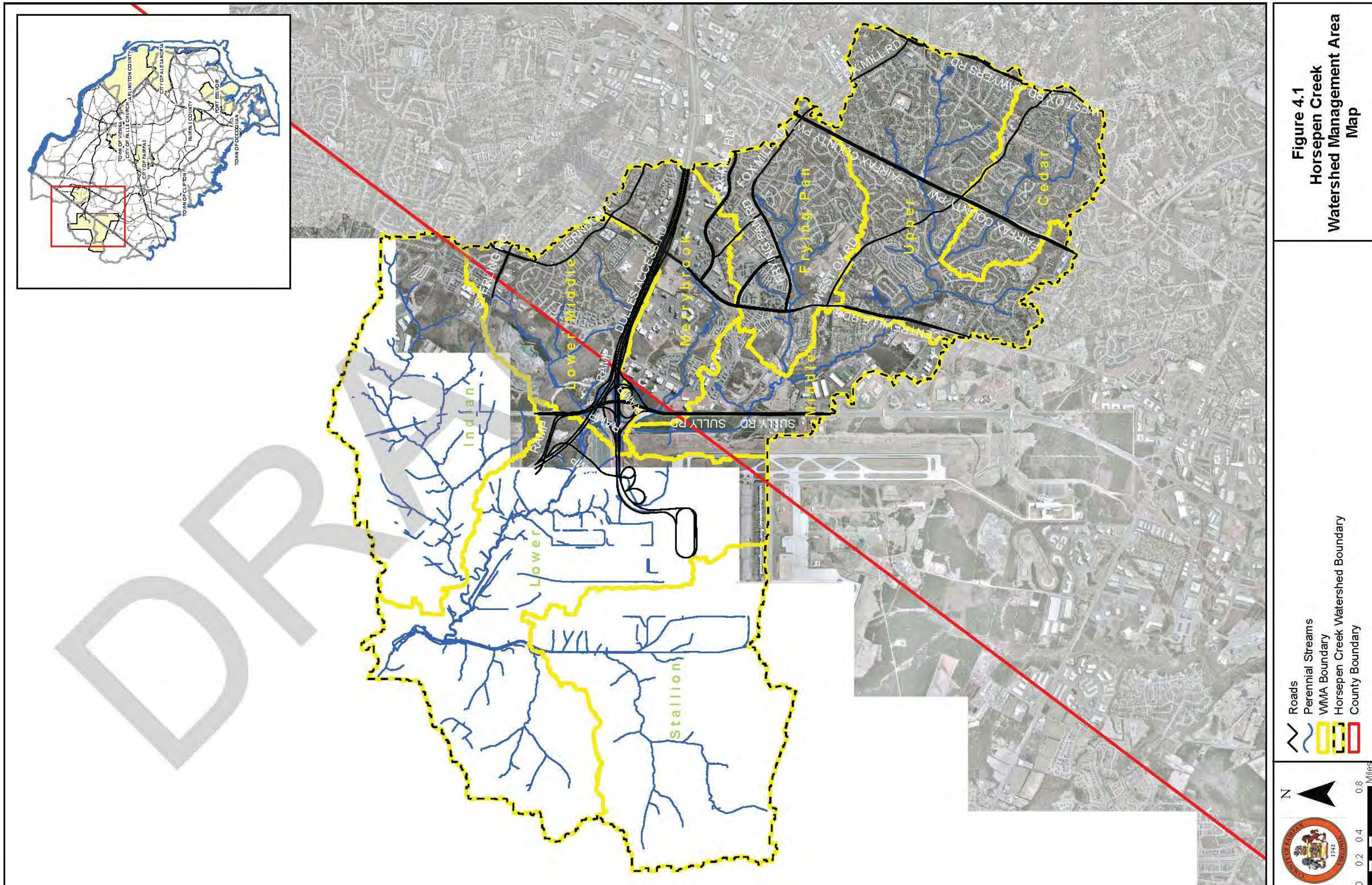
Figure 4.1
Horsepen Creek
Watershed Management Area
Map
Roads
Perennial Streams
WMA Boundary
Horsepen Creek Watershed Boundary
County Boundary
N
0 0.2 0.4 0.8
Miles
Indian
Lower
Stallion
Lower Middle
Merrybrook
Flying Pan
Middle
Upper
Cedar
SULLY RD
DULLES ACCESS RD
FAIRFAX COUNTY PW
WEST OX RD
FOX MILL RD
LAWYERS RD
RAMP

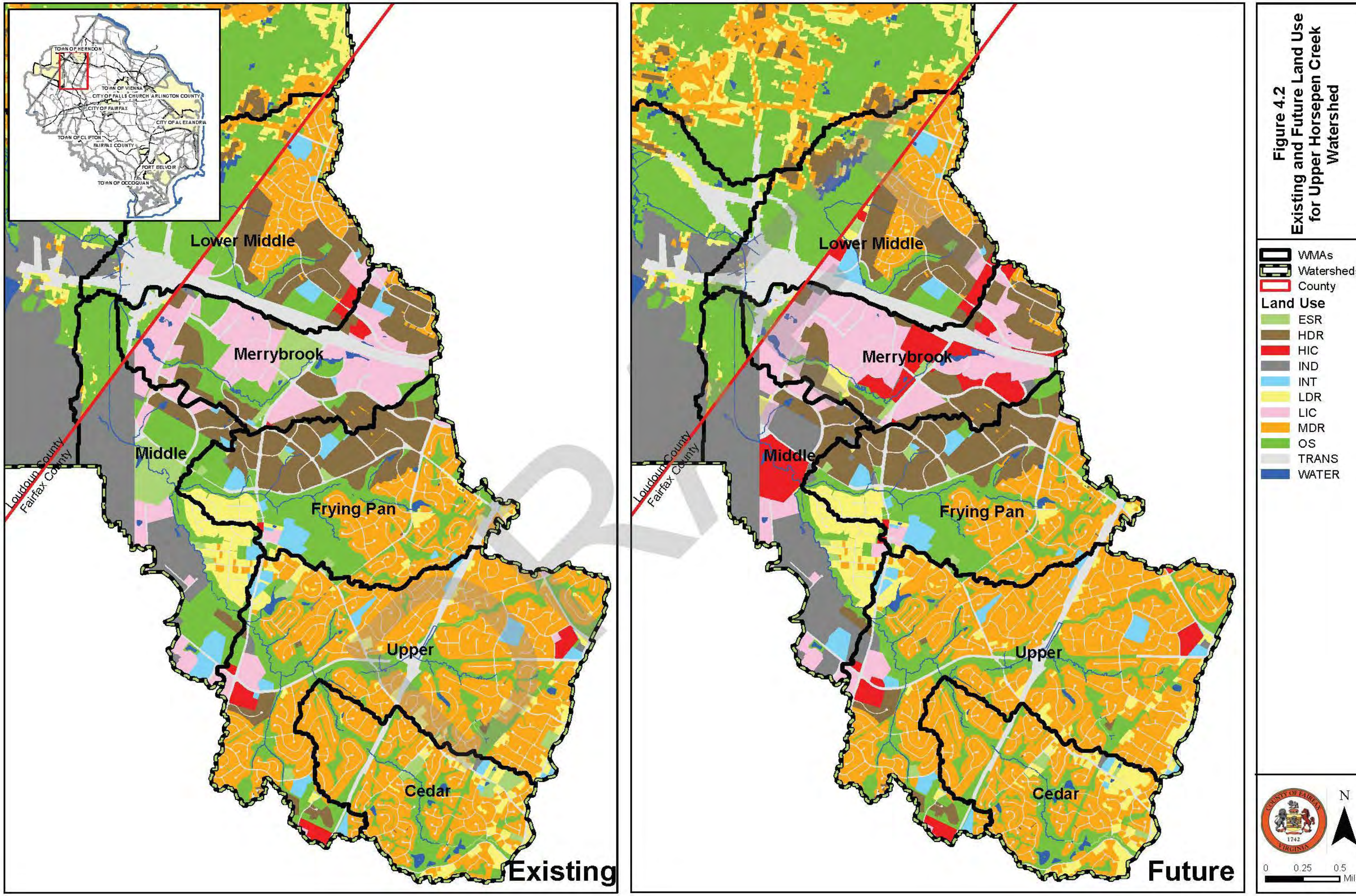

Figure 4.2 Existing and Future Land Use for Upper Horsepen Creek Watershed

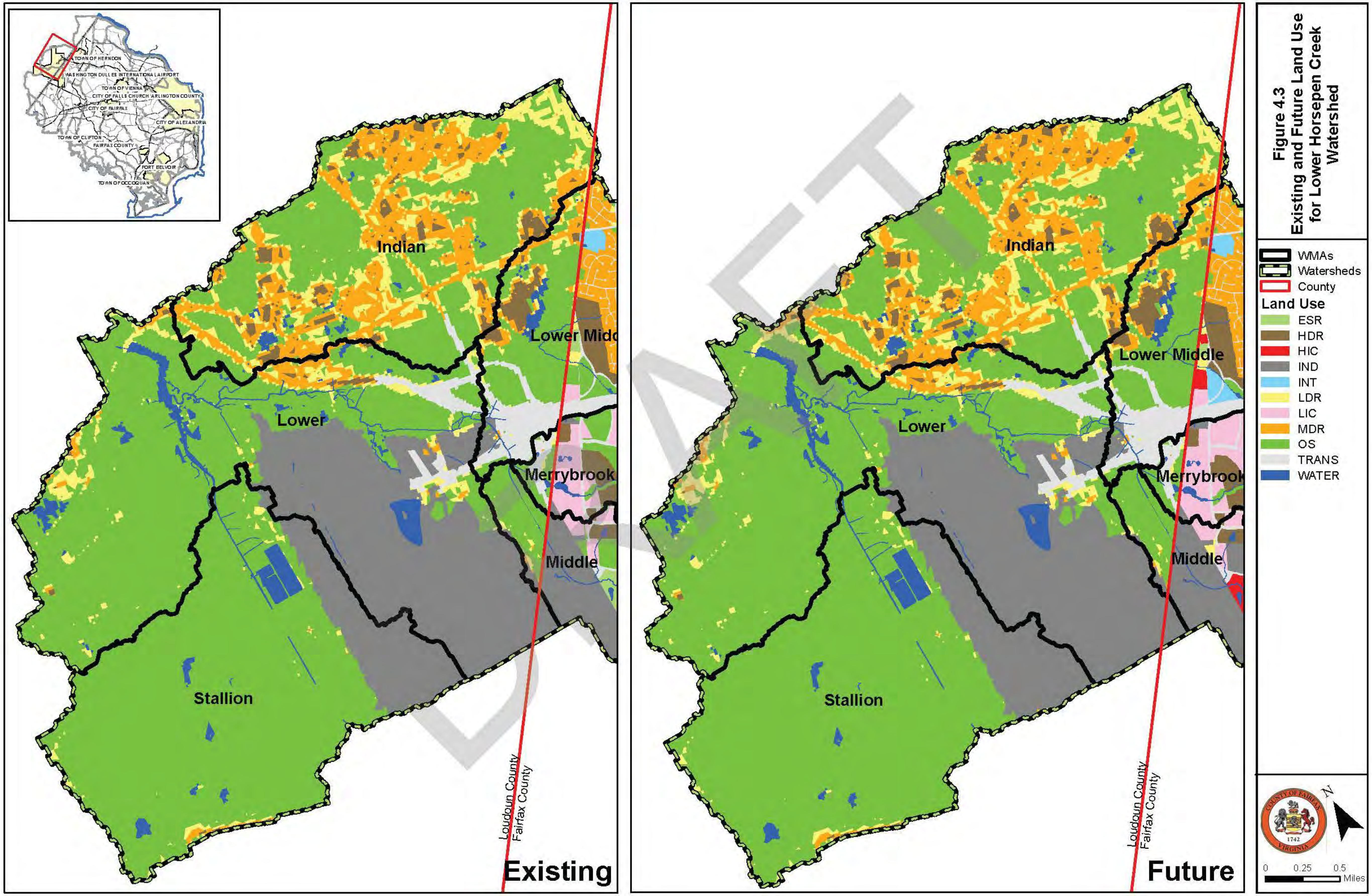

Figure 4.3
Existing and Future Land Use for Lower Horsepen Creek Watershed

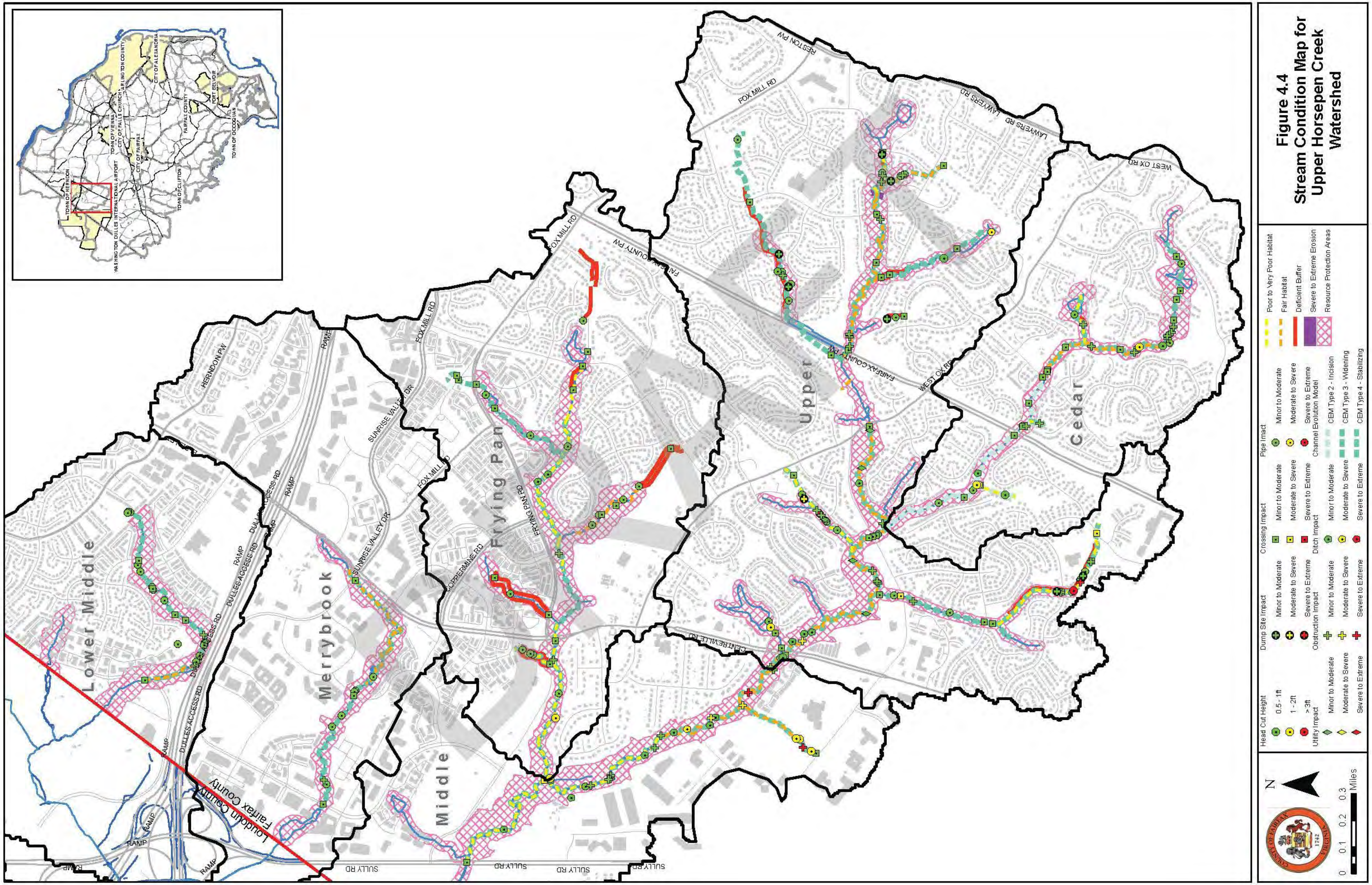

Figure 4.4
Stream Condition Map for
Upper Horsepen Creek
Watershed
Poor to Very Poor Habitat
Fair Habitat
Deficient Buffer
Severe to Extreme Erosion
Resource Protection Areas
Pipe Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Channel Evolution Model
CEM Type 2 - Incision
CEM Type 3 - Widening
CEM Type 4 - Stabilizing
Crossing Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Ditch Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Dump Site Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Obstruction Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
Head Cut Height
0.5 - 1ft
1 - 2ft
> 3ft
Utility Impact
Minor to Moderate
Moderate to Severe
Severe to Extreme
N
0 0.1 0.2 0.3 Miles
Lower Middle
Merrybrook
Frying Pan
Middle
Upper
Cedar
Fairfax County
Loudoun County
FOX MILL RD
RESTON PW
LAWYERS RD
WEST OX RD
FAIRFAX COUNTY PW
CENTREVILLE RD
SULLY RD
HERNDON PW
SUNRISE VALLEY DR
DULLES ACCESS RD
FRYING PAN RD
COPPERMINE RD
RAMP

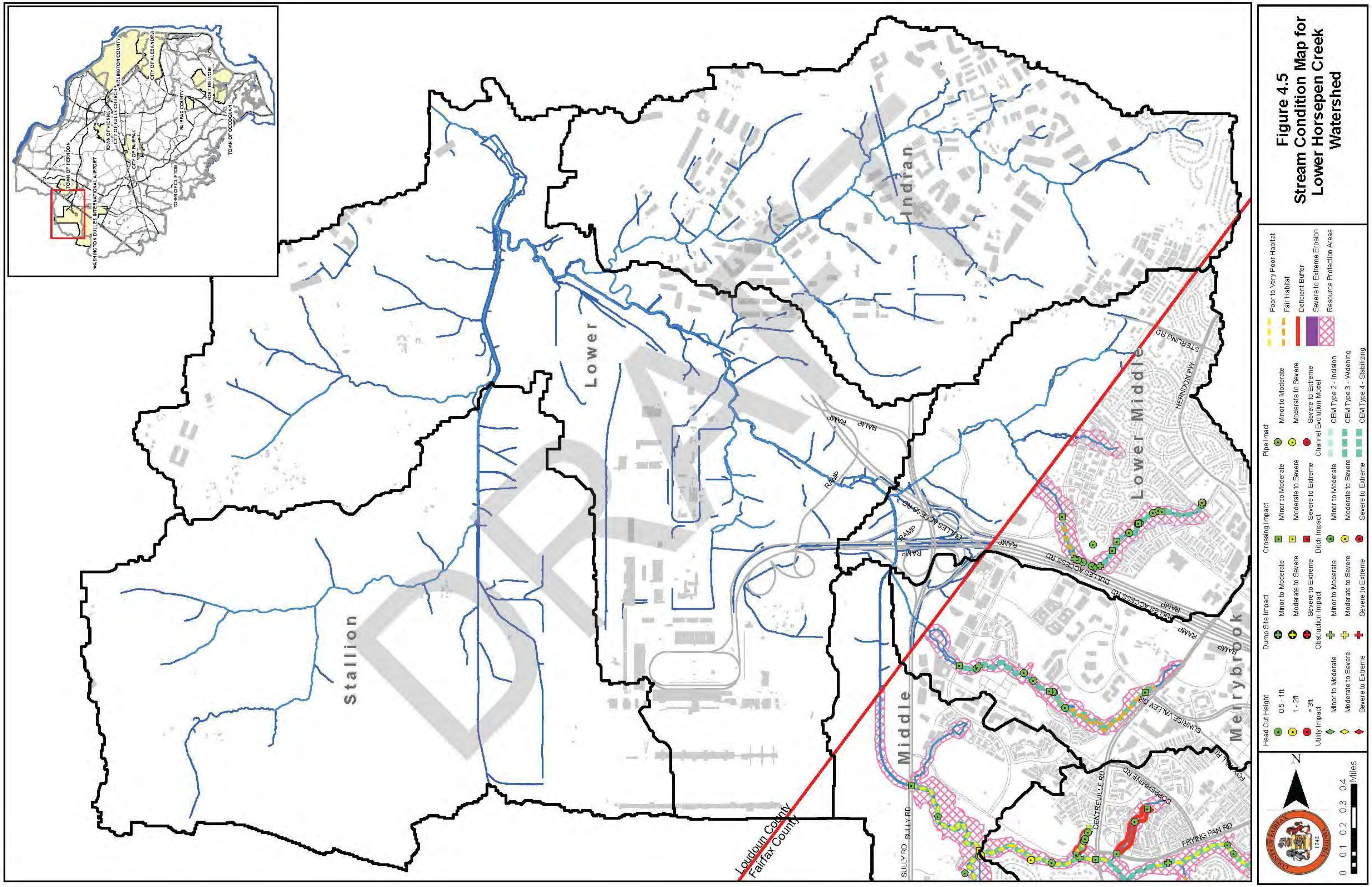

Figure 4.5
Stream Condition Map for Lower Horsepen Creek Watershed

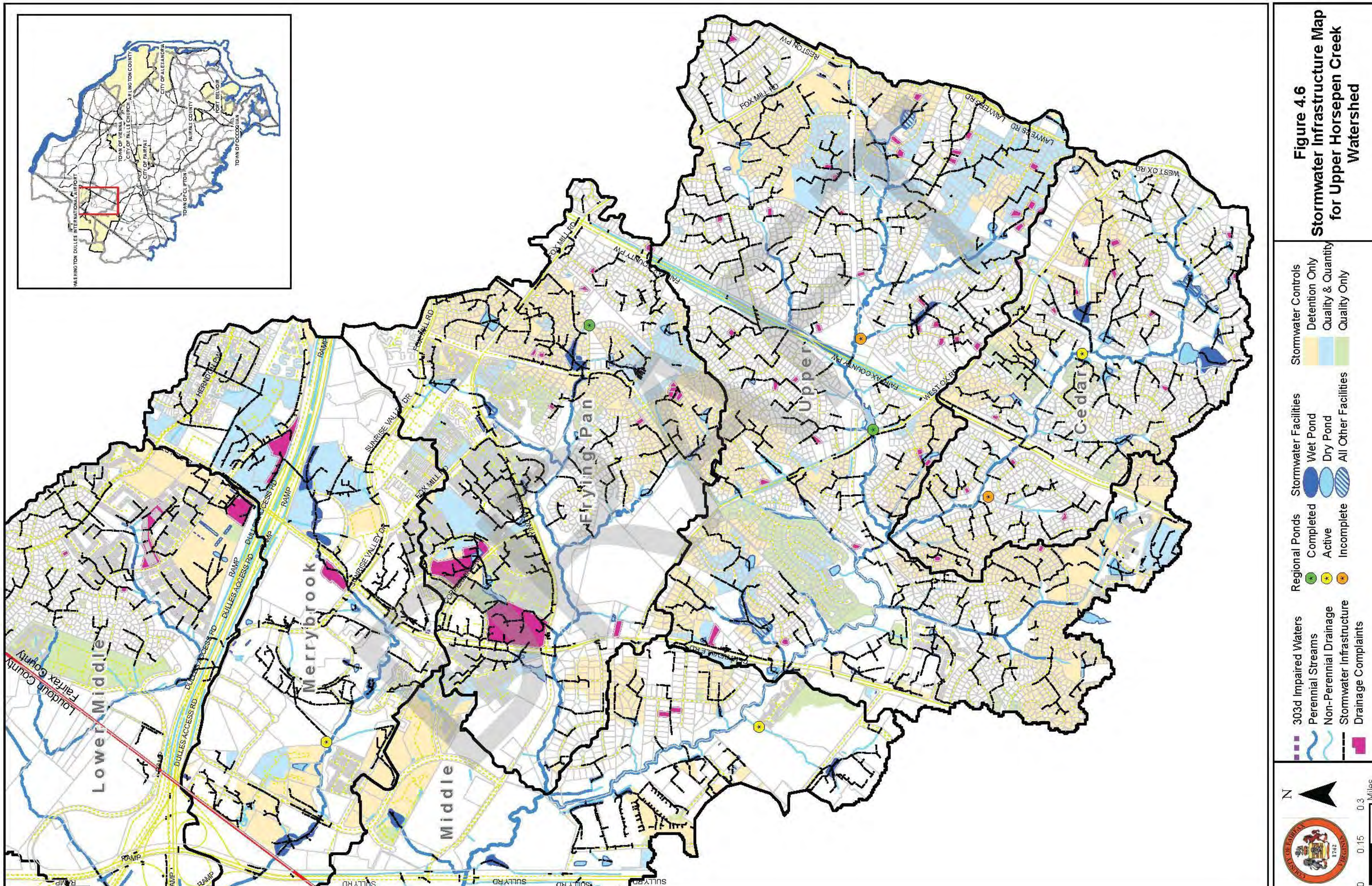
Figure 4.6
Stormwater Infrastructure Map
for Upper Horsepen Creek
Watershed
303d Impaired Waters
Perennial Streams
Non-Perennial Drainage
Stormwater Infrastructure
Drainage Complaints
Regional Ponds
Completed
Active
Incomplete
Stormwater Facilities
Wet Pond
Dry Pond
All Other Facilities
Stormwater Controls
Detention Only
Quality & Quantity
Quality Only
N
0
0.15
0.3
Miles
Upper
Cedar
Frying Pan
Merrybrook
Middle
Lower Middle
Loudoun County
Fairfax County
RESTON PW
FOX MILL RD
LAWYERS RD
WEST OX RD
FAIRFAX COUNTY PW
SUNRISE VALLEY DR
DULLES ACCESS RD
HERNDON PW
SULLY RD
RAMP

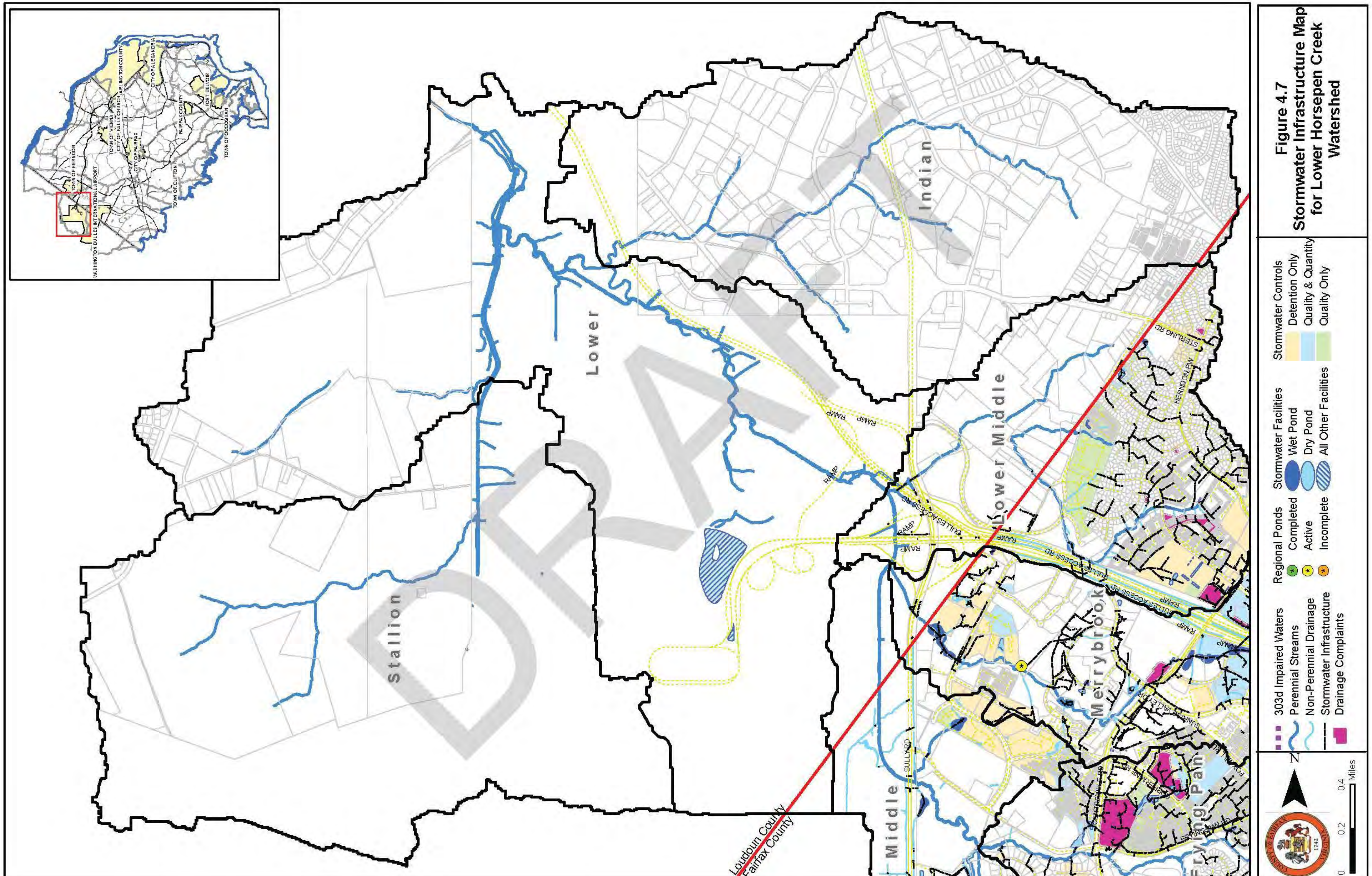
Figure 4.7
Stormwater Infrastructure Map for Lower Horsepen Creek Watershed
303d Impaired Waters
Perennial Streams
Non-Perennial Drainage
Stormwater Infrastructure
Drainage Complaints
Regional Ponds
Completed
Active
Incomplete
Stormwater Facilities
Wet Pond
Dry Pond
All Other Facilities
Stormwater Controls
Detention Only
Quality & Quantity
Quality Only
Miles
0
0.2
0.4
Indian
Lower
Stallion
Lower Middle
Merrybrook
Middle
Frying Pan
Loudoun County
Fairfax County
DRAFT

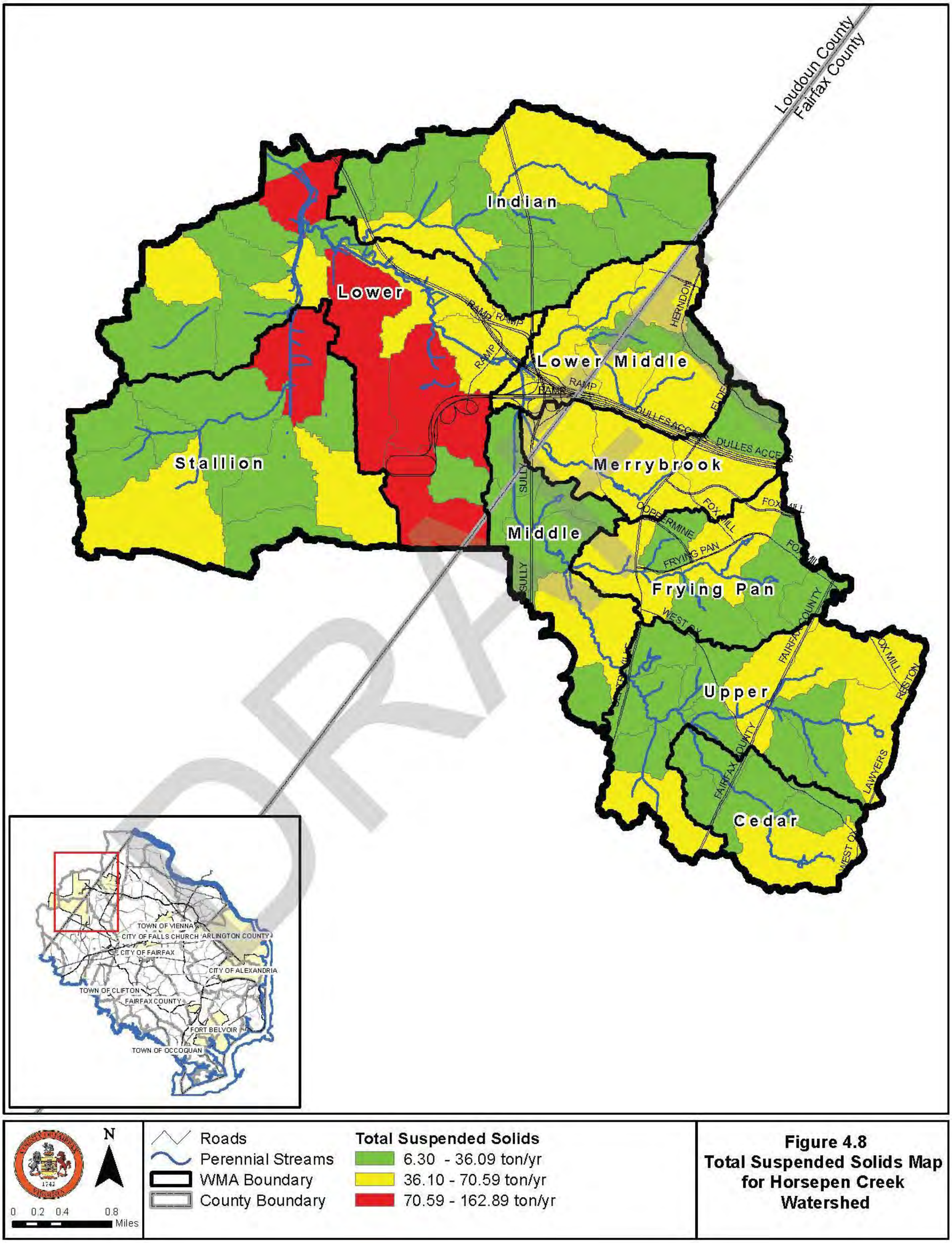

Figure 4.8
Total Suspended Solids Map for Horsepen Creek Watershed

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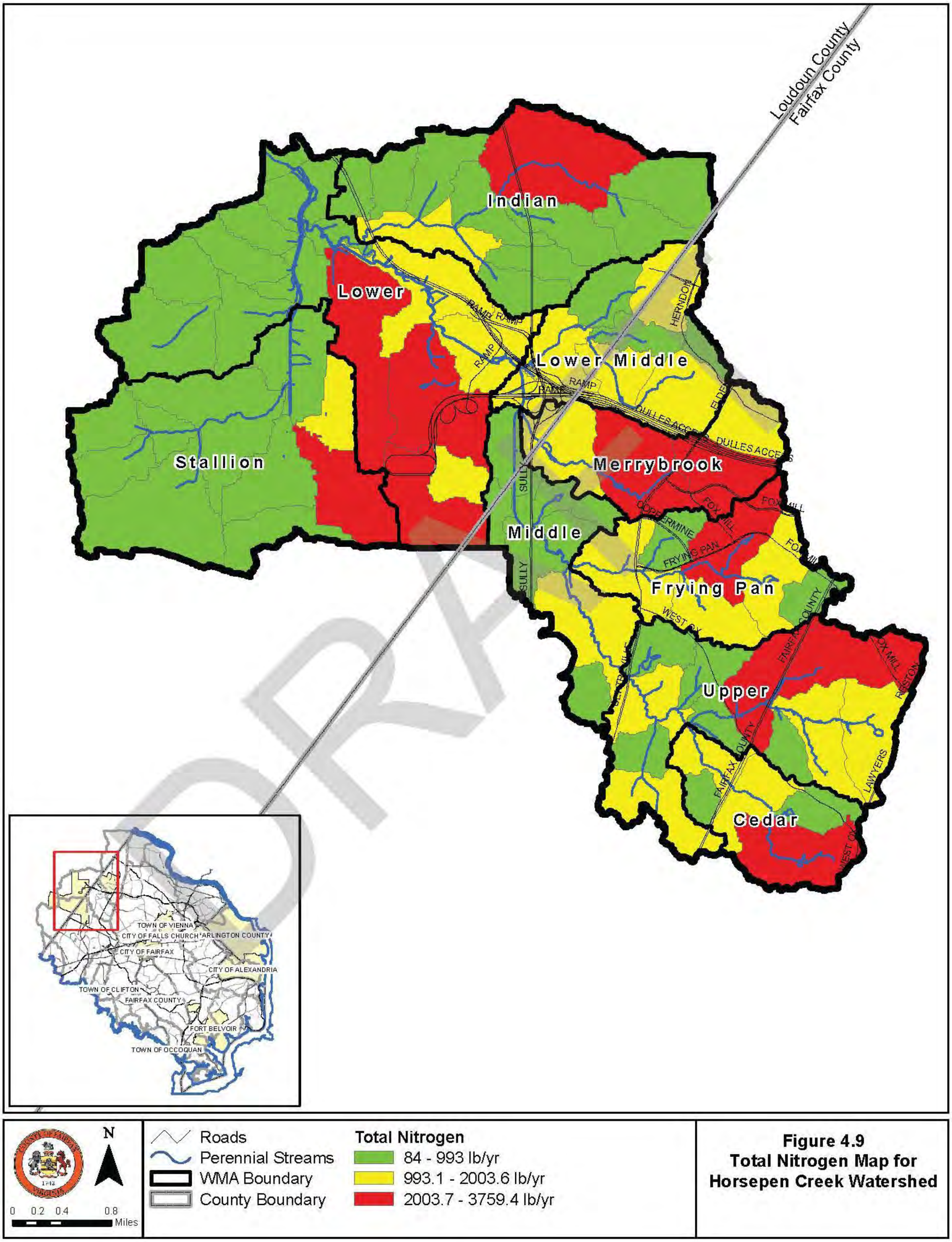

Figure 4.9
Total Nitrogen Map for Horsepen Creek Watershed

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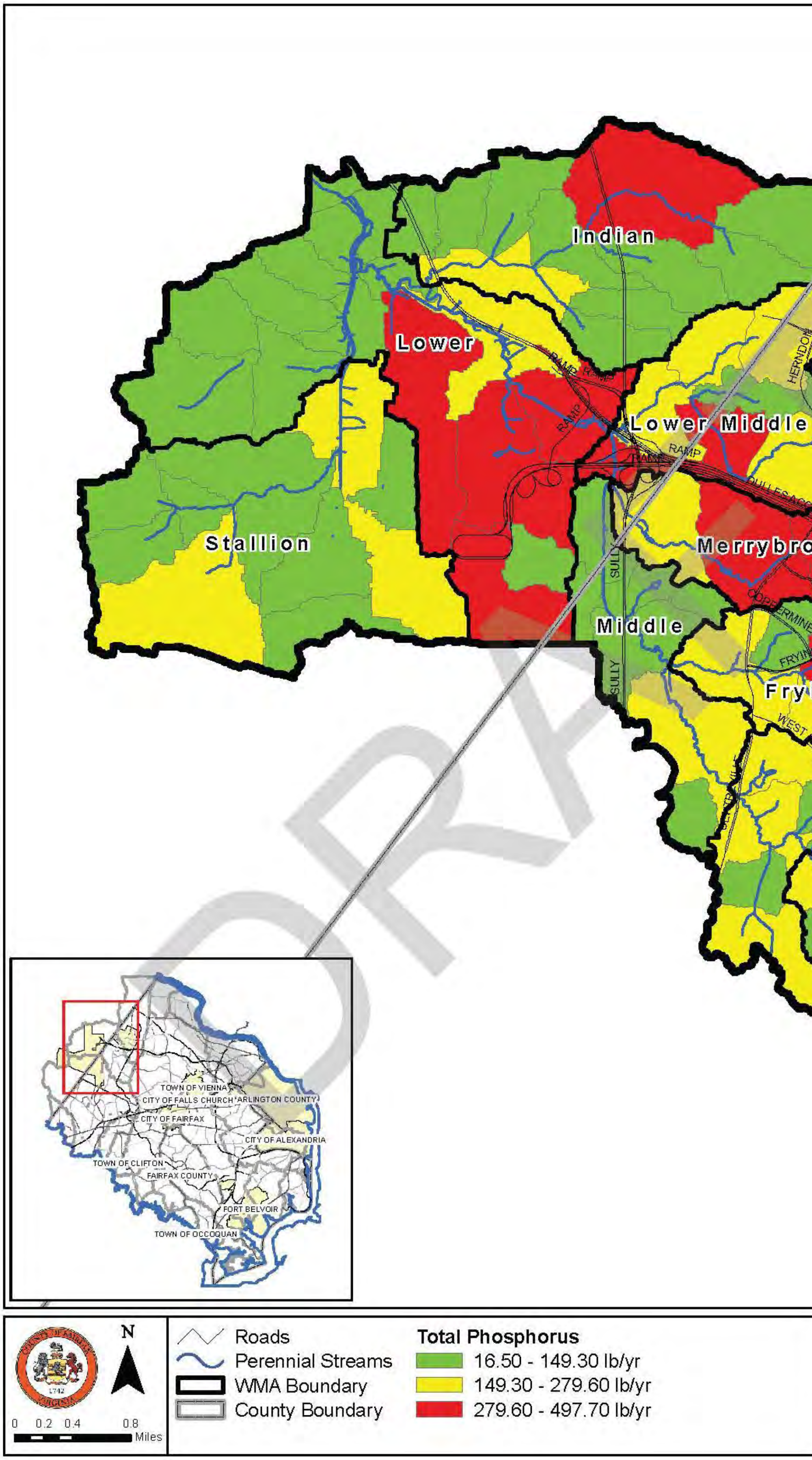

Figure 4.10
Total Phosphorus Map for Horsepen Creek Watershed

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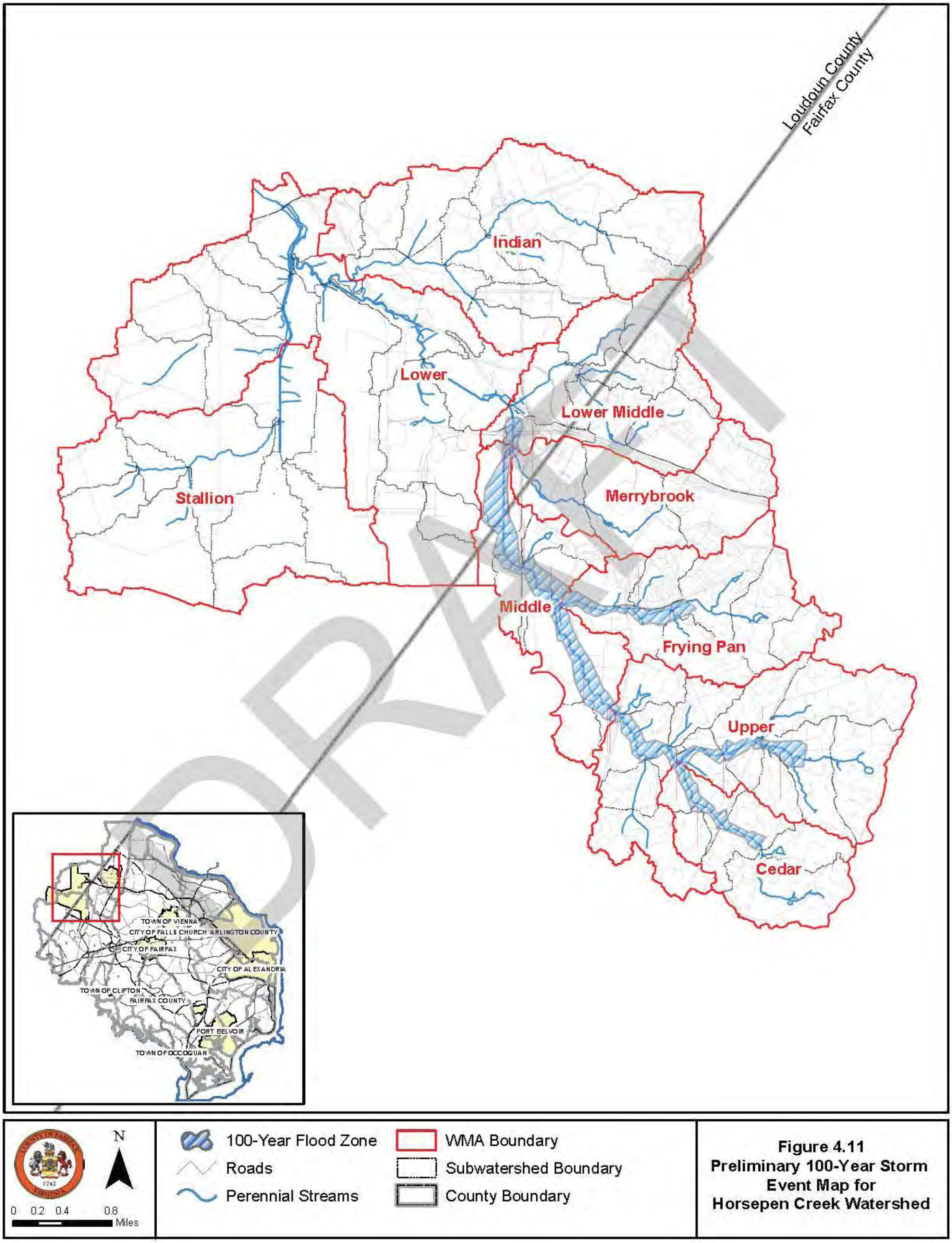

Figure 4.11
Preliminary 100-Year Storm Event Map for Horsepen Creek Watershed

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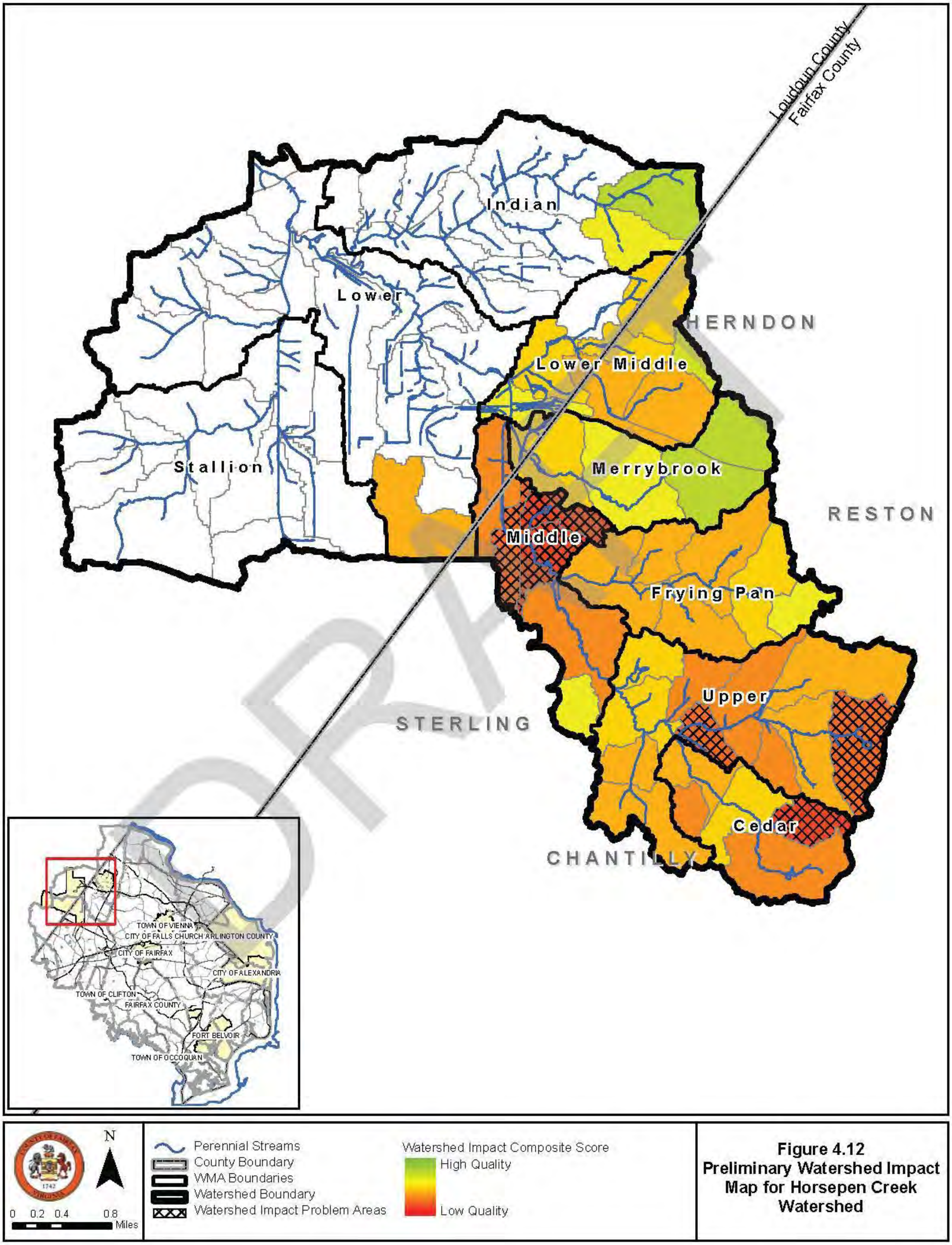

Figure 4.12
Preliminary Watershed Impact Map for Horsepen Creek Watershed

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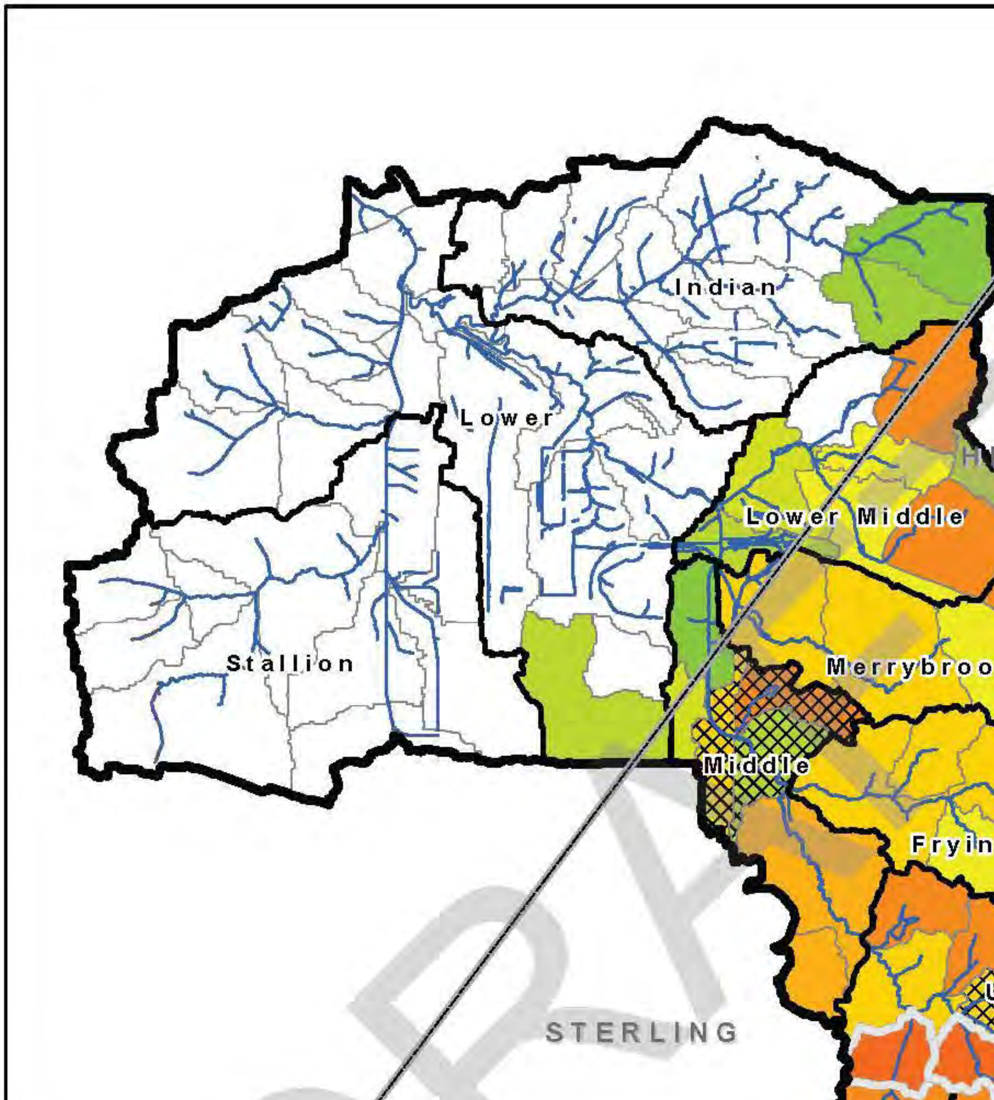

Figure 4.13
Preliminary Source Indicator Map for Horsepen Creek Watershed

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4.1 Cedar Run WMA

4.1.1 Cedar Run WMA Characteristics

The Cedar Run WMA is located in the southern tip of the Horsepen Creek Watershed. It is the smallest WMA in the watershed and comprises 783 acres (1.2 square miles). This WMA is almost entirely contained between the Fairfax County Parkway and West Ox Road. A small portion of the WMA extends west beyond the Fairfax County Parkway. See Figure 4.1 for the location of the Cedar Run WMA.

Approximately 2.4 miles of perennial streams are located within the Cedar Run WMA. Most of these streams are in good to fair condition. The streams flow in a northwest direction toward the confluence with Horsepen Creek and travel through primarily medium density residential and open space areas, including parkland along the lower portion of Cedar Run.

4.1.2 Existing and Future Land Use

The Horsepen Creek Watershed, including the Cedar Run WMA, is highly developed. Approximately 65 percent of the WMA is urbanized, consisting primarily of medium and high density residential (49 percent), transportation networks (15 percent) and industrial and institutional (1 percent) land uses, as shown in Table 4.2. Open space is primarily clustered around the stream corridors, and the downstream end of Cedar Run designated as parkland.

Table 4.2 Existing and Future Land Use in Cedar Run WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	3.3	1.2
High Density Residential	0.1	2.1
Medium Density Residential	48.9	48.9
Low Density Residential	7.5	8.1
High Intensity Commercial	0.0	0.0
Low Intensity Commercial	0.0	0.0
Industrial	0.3	0.3
Institutional	0.6	0.6
Open Space	22.4	21.8
Transportation	15.4	15.4
Water	1.4	1.4
Total	100	100

Source: Fairfax County GIS, 2008

Table 4.2 and Figure 4.2 show the expected change in land use as the Cedar Run WMA continues to develop. A slight decrease in open space and estate residential land use is projected with a corresponding increase in high and low density residential areas within the Cedar Run WMA.

4.1.3 Field Reconnaissance

Field reconnaissance was completed within the Cedar Run WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Cedar Run WMA:

1. Evaluated drainage complaints.
2. Evaluated projects proposed by the county.
3. Evaluated existing stormwater facilities.
4. Conducted a neighborhood source assessment.

The results of each of the field reconnaissance surveys are briefly described below:

Drainage Complaints
One hundred and twelve (112) drainage complaints have been documented within the Cedar Run WMA between 2001 and 2006. Of those, 14 representative complaints were chosen for field investigation. The complaints included erosion around stormwater management facilities, streambank erosion and yard flooding.

Proposed County Projects
Based upon past evaluations and reports, multiple stormwater projects have been proposed within the Cedar Run WMA. Field investigations were conducted to determine whether these projects were still viable. The projects included a stream restoration and stabilization project on Cedar Run, the construction of two regional ponds, and the replacement of a culvert under West Ox Road. Field investigations also verified the completion of a culvert replacement project under Ashburton Avenue.

Existing Stormwater Facilities
Ten stormwater management facilities were evaluated within the Cedar Run WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Two of the 10 facilities were found to inadequately provide stormwater management functions. The remaining facilities were functioning as designed, although most presented some opportunity for retrofit.

Neighborhood Source Assessment (NSA)
A representative neighborhood was chosen for a NSA to help identify potential improvement projects throughout the Cedar Run WMA. The chosen neighborhood consisted of single family detached houses on quarter-acre lots. Five stormwater management facilities were identified, including two farm ponds and three dry ponds. The NSA indicated the potential for stormwater management facility retrofit potential and a need for better lawn and landscaping practices.

4.1.4 Cedar Run WMA Characterization

Approximately 2.5 miles of streams were assessed within the Cedar Run WMA to determine the overall stream conditions in the WMA. As shown in Figure 4.4, the majority of stream length assessed has good habitat conditions, with the exception of two small tributaries which have poor habitat conditions. Most of the streams in the Cedar Run WMA are protected by resource protection areas, as described in Chapter 1. The main stem was designated as protected in 1993, whereas the headwaters were not added until 2003 and 2005. Several erosion areas, pipes, deficient riparian buffers, obstructions and stream crossings were identified during field reconnaissance, although the majority of the problems were considered minor to moderate. One area of deficient riparian buffer was considered severe to extreme, but that area has a very high restoration potential. The main stem of Cedar Run is in Channel Evolution Model Stage 2, which means the channel is experiencing bed erosion and becoming deeper. The headwaters are in Channel Evolution Model Stage 3, which indicates an unstable channel that is experiencing significant bank erosion.

As shown in Figure 4.6, the Cedar Run WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network, including dry ponds, wet ponds and farm ponds. Two regional pond projects are being considered for the area. Table 4.3 indicates that stormwater runoff from approximately 16 percent of the area in this WMA is treated, and approximately 84 percent of the area in this WMA is not treated by any means. Stormwater runoff from most of the areas that do receive treatment is treated for quantity only. Approximately 26 percent of the area in this WMA is impervious. Additional stormwater management facilities are needed in the Cedar Run WMA.

Table 4.3 Cedar Run WMA Summary

WMA Name	Total Area (acres)	Impervious Current Conditions (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Cedar Run	783	203.7	26%	103.6	20.8	0	658.6

4.1.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 4.8, 4.9, and 4.10. present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.4 below shows the total pollutant loading to the endpoint of Cedar Run WMA. According to the STEPL model results, the Cedar Run WMA contributes approximately 5 percent of the total suspended solids, 7 percent of the total nitrogen, and 7 percent of the total phosphorous annual loads to the Horsepen Watershed. Pollutant loadings normalized to the acres within the drainage area of Cedar Run WMA are presented in Table 4.5. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Cedar Run WMA as compared with unit area loads for the entire watershed.

Table 4.4 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Cedar Run	162.0	5,970.55	908.05
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.5 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Cedar Run	0.207	7.625	1.160
WS Totals	**0.205**	**6.069**	**0.894**

4.1.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Cedar Run WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 4.11, a 100-year storm in the Cedar Run WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

Two culverts are located within the Cedar Run WMA. The culverts were modeled to determine if the 100-year storm exceeded their capacity to carry the flow. The modeling shows that one culvert does not carry the 100-year stormflow and water will pond in the culvert and upstream of the culvert structure. The existence of the ponded water will extend the time period of maximum flow through the culvert. When the ponded water is fully drained, the flow elevation will begin to drop. The second culvert does carry the 100-year stormflow.

4.1.7 Cedar Run WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 4.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. One subwatershed within the Cedar Run WMA has been identified as a potential problem area. Based upon existing conditions, the condition of the remainder of the WMA is moderate.

The Cedar Run WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 4.13. The lowest ranking subwatersheds were identified as additional potential problem areas. Two of the five subwatersheds within the Cedar Run WMA have been identified as additional problem areas. The remainder of the Cedar Run WMA was ranked as having moderate levels of stressors and pollutant sources.

4.2 Frying Pan WMA

4.2.1 Frying Pan WMA Characteristics

The Frying Pan WMA is located in the central portion of the Horsepen Creek Watershed, and it is bordered on the east by the Sugarland Run Watershed. It is the fourth smallest WMA in the Horsepen Creek Watershed and consists of 1,131 acres (1.8 square miles). The WMA is almost entirely split in half by Frying Pan Road. It is traversed by Centreville Rd on the west and Sunrise Valley Drive on the north. See Figure 4.1 for the location of the Frying Pan WMA.

There are approximately 3.6 miles of perennial streams within the Frying Pan WMA. Most of these streams are in poor condition. The streams flow in a western direction toward the confluence with Horsepen Creek. The streams travel through a combination of low, medium and high density residential and open space areas. The majority of the open space is designated as parkland.

4.2.2 Existing and Future Land Use

Approximately 65 percent of the Frying Pan WMA is urbanized, consisting primarily of high density residential (24 percent), medium density residential (23 percent), institutional (4 percent), and transportation networks (14 percent) land uses, as shown in Table 4.6. The area of open space is significant and is primarily clustered around the stream corridors and the area between Frying Pan Road and West Ox Road, which is also designated as parkland.

Table 4.6 and Figure 4.2, show the expected change in land use as the Frying Pan WMA continues to develop. A slight decrease in low density residential, institutional and open space land use, with a corresponding increase in high and medium density residential, high and low intensity commercial and industrial areas is projected within the Frying Pan WMA.

Table 4.6 Existing and Future Land Use in Frying Pan WMA

Land Use Type	Existing	Future
	Percent (%)	Percent (%)
Estate Residential	1.0	1.0
High Density Residential	24.4	26.8
Medium Density Residential	22.7	23.2
Low Density Residential	5.6	5.5
High Intensity Commercial	0.1	0.2
Low Intensity Commercial	0.7	0.8
Industrial	0.0	0.6
Institutional	4.3	4.1
Open Space	26.0	22.8
Transportation	14.3	14.3
Water	0.7	0.7
Total	100	100

Source: Fairfax County GIS, 2008

4.2.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Frying Pan WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Cedar Run WMA:

1. Evaluated drainage complaints.
2. Reviewed on-site septic areas.
3. Documented new construction.
4. Evaluated projects proposed by the county.
5. Evaluated existing stormwater facilities.
6. Conducted neighborhood source assessments.
7. Conducted hot spot investigations.

The results of each of the field reconnaissance surveys are briefly described below.

<u>Drainage Complaints</u>
One hundred and eight (108) drainage complaints have been documented within the Frying Pan WMA between 2001 and 2003. Of those, two representative complaints were chosen for field investigation. The complaints included yard flooding and a stormwater infrastructure problem.

<u>On-Site Septic</u>
Portions of the Horsepen Creek watershed still use on-site septic systems. Properties using on-site systems were chosen for field reconnaissance if problems were noted in the area. One on-site septic area was visited, although no problems were noted.

New Construction
To document areas of growth or re-growth within the watershed, new construction areas were identified for field reconnaissance. Three new constructions areas were field verified including a new church and two apartment buildings.

Proposed County Projects
Based upon past evaluations and reports, multiple stormwater projects have been proposed within the Frying Pan WMA. Field investigations were conducted to determine whether these projects were still viable. Field investigations verified the completion of a culvert replacement project under Centreville Road, a road raising project along a portion of the Frying Pan Branch, a culvert replacement project under Monroe Street and the construction of the Sycamore Lakes regional pond.

Existing Stormwater Facilities
Seventeen (17) stormwater management facilities were evaluated within the Frying Pan WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Four of the 17 facilities were found to not exist, and one was found to not provide stormwater management functions. The remaining facilities were functioning as designed, although most presented some opportunity for retrofit.

Neighborhood Source Assessment (NSA)
Four representative neighborhoods were chosen for a NSA to help identify potential improvement projects throughout the Frying Pan WMA. Three of the chosen neighborhoods consisted of single-family detached houses on lot sizes ranging from less than a quarter-acre to a half-acre. The fourth was a multi-family townhouse complex. The neighborhood conditions, as well as the stormwater management facilities, were evaluated. The NSAs indicated the potential for stormwater management facility retrofit and a need for better lawn and landscaping practices.

Hot Spot Investigation (HSI)
A representative facility with the potential to generate concentrated stormwater pollution was chosen within the Frying Pan WMA for the HSI. An investigation was conducted of the facility and the corresponding property to identify sources of pollution. A school was targeted for the HSI within the Frying Pan WMA, which was identified as a potential hotspot. This indicated the need for future education efforts and the need for a review of the stormwater pollution prevention plan.

4.2.4 Frying Pan WMA Characterization

Approximately 4.4 miles of streams were assessed within the Frying Pan WMA to determine the overall stream conditions in the WMA. As shown in Figure 4.4, the majority of the main stem of the Frying Pan Branch has poor to very poor habitat conditions. One exception is a small section of stream near the intersection of Centreville Road and Frying Pan Road which has excellent habitat conditions. The tributaries have good to fair habitat conditions, with the exception of the small tributary downstream of Centreville Road which has poor to very poor habitat conditions. Most of the streams in the Frying Pan WMA are protected by the resource protection area, as described in Chapter 1. The main stem was designated as protected in 1993, whereas the headwaters were not added until 2003 and 2005. Several pipes, ditches, deficient riparian buffer areas, obstructions and stream crossings were identified during field reconnaissance, although the majority of the problems were considered minor to moderate. A few areas of deficient riparian buffer were considered moderate to severe; however, the restoration potential for these areas is considered low. The surveyed channels in this WMA are in Channel Evolution Model Stage 3. This indicates an unstable channel that is experiencing significant bank erosion.

As shown in Figure 4.6, the Frying Pan WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network. These facilities include dry ponds, wet ponds and farm ponds. A regional pond project has been constructed in the headwaters of the Frying Pan WMA, near Monroe Street. Table 4.7 indicates that stormwater runoff from approximately 36 percent of the area in this WMA is treated, and approximately 64 percent of the area in this WMA is not treated by any means. Stormwater runoff from the areas that do receive treatment is treated for both quantity and water quality. Approximately 30 percent of the area in this WMA is impervious. Additional stormwater management facilities are needed in the Frying Pan WMA to control and treat stormwater is this WMA.

Table 4.7 Frying Pan WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Frying Pan	1,131	338.4	30%	207.2	83	116.4	724.4

4.2.5 STEPL Modeling

The STEPL model was used to estimate nutrient loadings in each subwatershed as described in Section 2.5. Figures 4.8, 4.9, and 4.10 present the results of the STEPL model, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.8 shows the total pollutant loading to the endpoint of Frying Pan WMA. According to the STEPL model results, the Frying Pan WMA contributes approximately 7 percent of the total suspended solids, 10 percent of the total nitrogen, and 10 percent of the total phosphorous annual loads to the Sugarland Watershed. Pollutant loadings normalized to the acres within the drainage area of Frying Pan WMA are presented in Table 4.9. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Frying Pan WMA as compared with unit area loads for the entire watershed.

Table 4.8 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Frying Pan	208.6	8,484.30	1,246.75
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.9 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Frying Pan	0.184	7.502	1.102
WS Totals	**0.205**	**6.069**	**0.894**

4.2.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Frying Pan WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 4.11, a 100-year storm in the Frying Pan WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

One culvert is located within the Frying Pan WMA. This culvert was modeled to determine if the 100-year storm exceeded the capacity of the culvert to carry the flow. The modeling shows that the culvert does not carry the 100-year stormflow and water will pond upstream of the culvert structure. The existence of the ponded water will extend the time period of maximum flow through the culvert. When the ponded water is fully drained, the flow elevation will begin to drop.

4.2.7 Frying Pan WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 4.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. No subwatersheds within the Frying Pan WMA have been identified as a potential problem area. Based upon existing conditions, the remainder of the WMA is in fair to moderate condition.

The Frying Pan WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 4.13. The lowest ranking subwatersheds were identified as additional potential problem areas. One subwatershed within the Frying Pan WMA has been identified as additional problem areas. The remainder of the Frying Pan WMA was ranked as having moderate levels of stressors and pollutant sources.

4.3 Indian WMA

4.3.1 Indian WMA Characteristics

The Indian WMA is the northern border of the Horsepen Creek Watershed and is located almost entirely within Loudoun County. It is the third largest WMA in the Horsepen Creek Watershed and consists of 2,066 acres (3.2 square miles). Only 5.3 acres of the Indian WMA are located in Fairfax County. The WMA is bisected by Sully Road and is bordered on the west by the Dulles Greenway. See Figure 4.1 for the location of the Indian WMA.

There are approximately 4.5 miles of perennial streams within the Indian WMA. These streams flow in a western direction toward the confluence with Horsepen Creek. The streams flow through a combination of low and medium density residential and open space areas.

4.3.2 Existing and Future Land Use

The Indian WMA is partially urbanized, consisting of primarily open space (50 percent), medium density residential (24 percent) and low density residential (18 percent) land uses, as shown in Table 4.10. The open space land use is clustered throughout the Indian WMA.

Table 4.10 Existing and Future Land Use in Indian WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	0.0	0.0
High Density Residential	5.8	5.8
Medium Density Residential	24.5	24.5
Low Density Residential	18.2	18.2
High Intensity Commercial	0.0	0.0
Low Intensity Commercial	0.0	0.0
Industrial	0.0	0.0
Institutional	0.0	0.0
Open Space	50.0	50.0
Transportation	0.4	0.4
Water	1.1	1.1
Total	100	100

Source: Fairfax County GIS, 2008

Table 4.10 and Figure 4.3 show that no change in land use is expected within the Indian WMA.

4.3.3 Field Reconnaissance and Stream Physical Assessment

No field reconnaissance was completed for the Indian WMA since all but 5.3 acres of the total 2,066 acres of the WMA are located in Loudoun County.

4.3.4 Indian WMA Characterization

No stream condition information is available or has been collected for the Indian WMA since most of the WMA is located in Loudoun County. The current stormwater treatment types for the Indian WMA are unknown. No existing stormwater facilities are currently shown on the Stormwater Infrastructure Map for this area.

4.3.5 STEPL Modeling

Figures 4.8, 4.9 and 4.10 present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.11 shows the total pollutant loading to the endpoint of Indian WMA. According to the STEPL model results, the Indian WMA contributes approximately 10 percent of the total suspended solids, 11 percent of the total nitrogen, and 11 percent of the total phosphorous annual loads to the Sugarland Watershed. Pollutant loadings normalized to the acres within the drainage area of Indian WMA are presented in Table 4.12. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Indian WMA as compared with unit area loads for the entire watershed.

Table 4.11 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Indian	292.8	9,309.71	1,406.42
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.12 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/yr)	Total Nitrogen (pounds/acre/yr)	Total Phosphorus (pounds/acre/yr)
Indian	0.142	4.506	0.681
WS Totals	**0.205**	**6.069**	**0.894**

4.3.6 HEC-RAS Modeling

The Indian WMA was not modeled in HEC-RAS because most of the WMA is located in Loudoun County.

4.3.7 Indian WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 4.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. Only two subwatersheds within the Fairfax County portion of the Indian WMA were scored. No subwatersheds within the Indian WMA have been identified as potential problem areas. Based upon existing conditions, the remainder of the WMA is in fair condition.

The Indian WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 4.13. The lowest ranking subwatersheds were identified as additional potential problem areas. No additional subwatersheds within the Indian WMA have been identified as additional problem areas. The remainder of the Indian WMA was ranked as having low levels of stressors and pollutant sources.

4.4 Lower Horsepen WMA

4.4.1 Lower Horsepen WMA Characteristics

The Lower Horsepen WMA is located in the northwestern portion of the Horsepen Creek Watershed. The bottom right hand corner of the Lower Horsepen WMA is located in Fairfax County and the remaining portion of the WMA is located in Loudoun County. It is the largest WMA in the watershed and consists of 3,189 acres (5.0 square miles). The WMA is bordered to the north by the Dulles Greenway. Only 20.6 acres (less than 1 percent) of this WMA are located in Fairfax County. See Figure 4.1 for the location of the Lower Horsepen WMA.

There are approximately 7.0 miles of perennial streams within the Lower Horsepen WMA. These streams flow north and northwest toward the confluence with Horsepen Creek. The streams flow through primarily industrial and open space areas, including portions of the Dulles International Airport.

4.4.2 Existing and Future Land Use

Approximately 44 percent of the Lower Horsepen WMA is urbanized as shown in Table 4.3. The largest land use type in the WMA is open space which comprises over 52 percent of the area. The large industrial area (34.5 percent) in the WMA is primarily comprised of the Dulles International Airport.

Table 4.13 Existing and Future Land Use in Lower Horsepen WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	0.0	0.0
High Density Residential	0.5	0.5
Medium Density Residential	2.2	2.2
Low Density Residential	4.2	4.2
High Intensity Commercial	0.0	0.0
Low Intensity Commercial	0.0	0.0
Industrial	34.5	34.5
Institutional	0.0	0.0
Open Space	52.6	52.6
Transportation	2.3	2.3
Water	3.7	3.7
Total	100	100

Source: Fairfax County GIS, 2008

Table 4.13 and Figure 4.3 indicate that no change in land use is expected within the Lower Horsepen WMA.

4.4.3 Field Reconnaissance and Stream Physical Assessment

Only 20.6 acres of the total 3,189 acres in the Lower Horsepen WMA are located in Fairfax County; therefore, no field reconnaissance was conducted for this area.

4.4.4 Lower Horsepen WMA Characterization

Almost 100 percent of the Lower Horsepen WMA lies outside Fairfax County. Therefore, no stream condition information is available or has been collected for the Lower Horsepen WMA.

The current stormwater treatment types for the Lower Horsepen WMA are unknown, as most of the watershed is located in Loudoun County. Approximately 18 percent of this WMA is impervious, and no information is known about the stormwater treatment facilities in this WMA.

4.4.5 STEPL Modeling

Figures 4.8, 4.9 and 4.10 present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.14 shows the total pollutant loading to the endpoint of Lower WMA. According to the STEPL model results, the Lower Horsepen WMA contributes approximately 30 percent of the total suspended solids, 20 percent of the total nitrogen, and 20 percent of the total phosphorous annual loads to the Sugarland Watershed. Pollutant loadings normalized to the acres within the drainage area of Lower Horsepen WMA are presented in Table 4.15. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Lower Horsepen WMA as compared with unit area loads for the entire watershed.

Table 4.14 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	**Total Nitrogen (pounds/year)**	**Total Phosphorus (pounds/year)**
Lower	864.0	17,946.98	2,543.35
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.15 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	**Total Nitrogen (pounds/acre/year)**	**Total Phosphorus (pounds/acre/year)**
Lower	0.271	5.628	0.798
WS Totals	**0.205**	**6.069**	**0.894**

4.4.6 HEC-RAS Modeling

Because the Lower WMA is almost entirely located within Loudoun County, the WMA was not modeled in HEC-RAS.

4.4.7 Lower Horsepen WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 4.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. Only one subwatershed within the Lower Horsepen WMA was scored, and it was not considered to be a potential problem area. Based upon existing conditions, the condition of the remainder of the WMA is moderate.

The Lower Horsepen WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 4.13. The lowest ranking subwatersheds were identified as additional potential problem areas. One subwatershed in the WMA was scored and it was not considered to be an additional problem area.

4.5 Lower Middle Horsepen WMA

4.5.1 Lower Middle Horsepen WMA Characteristics

The Lower Middle Horsepen WMA is located in the central portion of the Horsepen Creek Watershed and bordered is on the east by Sugarland Run Watershed. Approximately one half of this WMA is located in Fairfax County and the other half is located in Loudoun County. The Lower Middle Horsepen WMA is comprised of 1,188 acres (1.9 square miles). The WMA is bordered on the south by the Dulles Access Road and bordered on the northeast by the Herndon Parkway. See Figure 4.1 for the location of the Lower Middle Sugarland WMA.

There are approximately 3.4 miles of perennial streams within the Lower Middle Horsepen WMA. The streams flow in a western direction toward the confluence with Horsepen Creek. The stream flows through a combination of low, medium and high density residential and open space areas.

4.5.2 Existing and Future Land Use

Approximately 61 percent of the Lower Middle Horsepen WMA is urbanized, consisting primarily of medium and high density residential (36 percent), commercial and industrial (4 acres), and transportation networks (21 percent) land uses, as shown in Table 4.16. This WMA is comprised of almost 30 percent open space. A portion of open space has been designated as parkland between the Dulles Access Road and Parcher Avenue.

Table 4.16 Existing and Future Land Use

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	0.5	0.3
High Density Residential	16.8	16.9
Medium Density Residential	19.4	19.4
Low Density Residential	3.9	3.9
High Intensity Commercial	1.0	2.5
Low Intensity Commercial	2.1	1.4
Industrial	1.2	1.2
Institutional	2.1	3.4
Open Space	29.9	27.8
Transportation	21.1	21.1
Water	1.9	1.9
Total	100	100

Source: Fairfax County GIS, 2008

Table 4.16 and Figure 4.3 show the expected change in land use as the Lower Middle Horsepen WMA continues to develop. A slight decrease in estate residential, low intensity commercial and open space land use, with a corresponding increase in high density residential, high intensity commercial and institutional areas is projected within the Lower Middle Horsepen WMA.

4.5.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Fairfax County portion of Lower Middle Horsepen WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Lower Middle Horsepen WMA:

1. Evaluated drainage complaints.
2. Documented new construction.
3. Evaluated projects proposed by the county.
4. Evaluated existing stormwater facilities.
5. Reviewed stream physical assessment inventory points.
6. Conducted neighborhood source assessments.
7. Conducted hot spot investigations.

The results of each of the above evaluations are briefly described in the following sections.

<u>Drainage Complaints</u>
Seventy seven (77) drainage complaints have been documented within the Lower Middle Horsepen WMA between 2001 and 2006. Of those, two representative complaints were chosen for field investigation. The complaints included erosion around a stormwater management facility and a stormwater infrastructure problem. Field reconnaissance indicated no erosion or infrastructure problems.

<u>New Construction</u>
To document areas of growth or re-growth within the watershed, new construction areas were identified for field reconnaissance. Two new single family residences were field verified, although no new construction was found.

<u>Proposed County Projects</u>
Based upon past evaluations and reports, multiple stormwater projects have been proposed within the Lower Middle Horsepen WMA. Field investigations were conducted to determine whether the projects were still viable. The projects included two culvert replacement projects under Rock Hill Road, the purchase of a flooded property and two stream restoration and stabilization projects.

<u>Existing Stormwater Facilities</u>
Four stormwater management facilities were evaluated within the Lower Middle Horsepen WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. One of the four facilities was found to not provide stormwater management functions. The remaining facilities were functioning as designed, although most presented some opportunity for retrofit.

Stream Physical Assessment (SPA) Inventory Points
Inventory points identified during the original stream physical assessment that received an impact score of five or greater were field verified. A cable utility line was identified within the streams banks. The broken utility line was still present, but was no longer functioning.

Neighborhood Source Assessment (NSA)
One representative neighborhood was chosen for a NSA to help identify potential improvement projects throughout the Lower Middle Horsepen WMA. The neighborhood consisted of single-family detached houses on lot sizes less than a quarter-acre. The neighborhood conditions, as well as the lack of stormwater management facilities, were evaluated. The NSA indicated the potential for stormwater management facilities and a need for better lawn and landscaping practices.

Hot Spot Investigation (HSI)
Four representative facilities with the potential to generate concentrated stormwater pollution were chosen within the Lower Middle Horsepen WMA for the HSI. An investigation was conducted of each facility and the corresponding property to identify sources of pollution. A convenience store, office building, school and department store were targeted for the HSI within the Lower Middle Horsepen WMA. One of the facilities was not identified a hot spot, two of the facilities were potential hot spots and one facility was a confirmed hot spot. This indicated the need for future education efforts, follow up on-site inspections, illicit discharge testing and the need for review of stormwater pollution prevention plans.

Stream Physical Assessment (SPA)
A supplemental stream physical assessment was conducted on 0.5 miles of stream within the Lower Middle Horsepen WMA. The stream was found to have fair to good habitat conditions. Multiple inventory points were identified with impact scores of five or higher including five erosion areas, two obstructions, three ditches and one utility line.

4.5.4 Lower Middle Horsepen WMA Characterization

Approximately one mile of stream was assessed within the Lower Middle Horsepen WMA to determine the overall stream conditions. As shown in Figure 4.4 the majority of the main stem has good to fair habitat conditions. All of the streams within the Fairfax County portion of Lower Middle Horsepen WMA are protected by the resource protection area, as described in Chapter 1. The stream was designated as protected in 2003. Several pipes, deficient riparian buffer areas, obstructions, stream crossings, and a utility were identified during field reconnaissance, although the majority of the problems were considered minor to moderate. One of the deficient riparian buffers was considered moderate to severe; however the restoration potential for this area was low. The surveyed channels in this WMA are in Channel Evolution Model Stage 3. This indicates an unstable channel that is experiencing significant bank erosion.

As shown in Figure 4.6, the Lower Middle Horsepen WMA contains a handful of stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network, including dry ponds, wet ponds and farm ponds. Table 4.17 provides treatment information for the portion of the Lower Middle Horsepen WMA located within Fairfax County.

Information regarding treatment within Loudoun County would be required to adequately calculate the total treatment coverage. Approximately 31 percent of the land in this WMA is impervious. More stormwater management is needed within the Lower Middle Sugarland WMA. Drainage complaints made by residents consisted of erosion and infrastructure problems.

Table 4.17 Lower Middle Horsepen WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types*			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Lower Middle Horsepen	1,186	379.7	32%	1.5*	41.9*	71.9*	1,071

* Treatment only within Fairfax County

4.5.5 STEPL Modeling

Figures 4.8, 4.9 and 4.10 present the results of the STEPL model for total suspended solids, total nitrogen, and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.18 shows the total pollutant loading to the endpoint of Lower Middle Horsepen WMA. According to the STEPL model results, the Lower Middle Horsepen WMA contributes approximately 11 percent of the total suspended solids, 12 percent of the total nitrogen, and 13 percent of the total phosphorous annual loads to the Horsepen Watershed. Pollutant loadings normalized to the acres within the drainage area of Lower Middle Horsepen WMA are presented in Table 3.19. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Lower Middle Horsepen WMA as compared with unit area loads for the entire watershed.

Table 4.18 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Lower Middle	329.0	10,617.54	1,669.08
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.19 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Lower Middle	0.277	8.937	1.405
WS Totals	**0.205**	**6.069**	**0.894**

4.5.6 HEC-RAS Modeling

The Lower Middle Horsepen WMA was not modeled in HEC-RAS because the contributing drainage area within Fairfax County was not considered substantial.

4.5.7 Lower Middle Horsepen Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 4.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. No potential problem areas were identified within the Lower Middle Horsepen WMA. Based upon existing conditions, the WMA is in a moderate condition.

The Lower Middle Horsepen WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 4.13. The lowest ranking subwatersheds were identified as additional potential problem areas. No additional subwatersheds within the Lower Middle WMA have been identified as additional problem areas. The Lower Middle Horsepen WMA was ranked as having low to moderate levels of stressors and pollutant sources.

4.6 Merrybrook WMA

4.6.1 Merrybrook WMA Characteristics

The Merrybrook WMA is located in the central portion of the Horsepen Creek Watershed and is bordered on the east by Sugarland Run Watershed. A small portion on the western side of the WMA lies within Loudoun County. The Merrybrook WMA is the third smallest WMA in the Horsepen Creek Watershed and consists of 967 acres (1.5 square miles). The WMA is bordered on the north by the Dulles Access Road and bordered on the west by Sully Road. See Figure 4.1 for the location of the Merrybrook WMA.

There are approximately two miles of perennial streams within the Merrybrook WMA. The streams flow in a western direction into Loudoun County before flowing into the main stem of Horsepen Creek. The streams flow through a combination of high density residential, low intensity commercial and open space areas. Two areas designated as parkland are located within the Merrybrook WMA, including Chandon Park.

4.6.2 Existing and Future Land Use

Approximately 77 percent of the Merrybrook WMA is urbanized, consisting primarily of medium and high density residential (24 percent), commercial (35 percent) and transportation networks (18 percent) land uses, as shown in Table 4.20. Approximately 15 percent of the area in this WMA is open space, which is primarily located around stream corridors.

Table 4.20 Existing and Future Land Use

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	4.8	0.7
High Density Residential	22.4	22.7
Medium Density Residential	1.7	1.7
Low Density Residential	0.4	1.9
High Intensity Commercial	0.9	11.7
Low Intensity Commercial	33.8	35.7
Industrial	0.7	1.3
Institutional	1.1	0.0
Open Space	14.9	5.0
Transportation	17.8	17.8
Water	1.4	1.4
Total	100	100

Source: Fairfax County GIS, 2008

Table 4.20 and Figure 4.2 show the expected change in land use as the Merrybrook WMA continues to develop. A decrease in estate residential, institutional and open space land use, with a corresponding increase in high density residential, low density residential, high and low intensity commercial and industrial areas is projected within the Merrybrook WMA.

4.6.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed in the Fairfax County portion of Merrybrook WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Merrybrook WMA:

1. Evaluated drainage complaints.
2. Documented new construction.
3. Evaluated projects proposed by the county.
4. Evaluated existing stormwater facilities.
5. Conducted neighborhood source assessments.
6. Conducted hot spot investigations.

The results of each of the above evaluations are briefly described in the following sections.

<u>Drainage Complaints</u>
Ten (10) drainage complaints have been documented within the Merrybrook WMA between 2001 and 2004. Of those, one representative complaint was chosen for field investigation. The complaint included streambank erosion along Centreville Road. Field reconnaissance indicated the streambanks have already been stabilized with geotextile matting and vegetation in this area.

New Construction
To document areas of growth or re-growth within the watershed, new construction areas were identified for field reconnaissance. Six new construction areas were field verified including commercial buildings, a townhouse complex, and apartment buildings. All of the locations were either under construction or recently finished.

Proposed County Projects
Based upon past evaluations and reports, multiple stormwater projects have been proposed within the Merrybrook WMA. Field investigations were conducted to determine whether the projects were still viable. The projects included two stream restoration and stabilization projects. Field investigation also verified the completion of a regional pond and a culvert replacement project on Woodland Park Road.

Existing Stormwater Facilities
Six stormwater management facilities were evaluated within the Merrybrook WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. One of the six facilities was found to not provide stormwater management functions. The remaining facilities were functioning as designed, although most presented some opportunity for retrofit.

Neighborhood Source Assessment (NSA)
Two representative neighborhoods were chosen for a NSA to help identify potential improvement projects throughout the Merrybrook WMA. The neighborhoods consisted of a low intensity commercial area and multi-family housing. The neighborhood conditions, as well as the stormwater management facilities, were evaluated. The NSAs indicated the potential for stormwater management facility retrofit and a need for better lawn and landscaping practices.

Hot Spot Investigation (HSI)
Three representative facilities with the potential to generate concentrated stormwater pollution were chosen within the Merrybrook WMA for the HSI. An investigation was conducted of each facility and the corresponding property to identify sources of pollution. Three varying commercial establishments were targeted for the HSI within the Merrybrook WMA. All three of the facilities were identified as potential hot spots. This indicates the need for future education efforts and the need for review of stormwater pollution prevention plans.

Stream Physical Assessment (SPA)
A supplemental stream physical assessment was conducted on 0.5 miles of stream within the Merrybrook WMA. The section was chosen for reassessment because two county stream restoration and stabilization projects were located in the WMA. The stream was found to have fair to good habitat conditions. Only one inventory point was identified with an impact score of five or higher, an obstruction of trees and sediment.

4.6.4 Merrybrook WMA Characterization

Approximately 1.2 miles of stream was assessed within the Merrybrook WMA to determine the overall stream conditions in the WMA. As shown in Figure 4.4, the entire length of the Merrybrook Branch has good to fair habitat conditions. All of the streams in the WMA are protected by the resource protection area, as described in Chapter 1. The stream was designated as protected in 1993. Several pipes, deficient riparian buffer areas, obstructions and stream crossings identified during field reconnaissance, although the problems were considered minor to moderate. The surveyed channels in this WMA are in Channel Evolution Model Stage 3. This indicates an unstable channel that is experiencing significant bank erosion.

As shown in Figure 4.6, the Merrybrook WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network, including dry ponds, wet ponds and farm ponds. A stormwater regional pond is actively being funded for construction. Table 4.21 indicates that stormwater runoff from approximately 19 percent of the area in this WMA is treated, and approximately 81 percent of the area in this WMA is not treated by any means. Stormwater runoff from the areas that do receive treatment are treated for both quantity and water quality. Approximately 41 percent of the area in this WMA is impervious. More stormwater management facilities are needed in the Upper Middle Sugarland WMA.

Table 4.21 Merrybrook WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Merrybrook	967	396.2	41%	68.4	0	115.1	783.5

4.6.5 STEPL Modeling

Figures 4.8, 4.9 and 4.10 present the results of the STEPL model for total suspended solids, total nitrogen and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.22 below shows the total pollutant loading to the endpoint of Merrybrook WMA. According to the STEPL model results, the Merrybrook WMA contributes approximately 7 percent of the total suspended solids, 10 percent of the total nitrogen, and 9 percent of the total phosphorous annual loads to the Horsepen Watershed. Pollutant loadings normalized to the acres within the drainage area of Merrybrook WMA are presented in Table 4.23. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Merrybrook WMA as compared with unit area loads for the entire watershed.

Table 4.22 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Merrybrook	213.3	8,457.03	1,191.94
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.23 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Merrybrook	0.221	8.746	1.233
WS Totals	**0.205**	**6.069**	**0.894**

4.6.6 HEC-RAS Modeling

The Merrybrook WMA was not modeled in HEC-RAS because the contributing drainage area within Fairfax County was not considered substantial.

4.6.7 Merrybrook WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 4.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. No potential problem areas were identified within the Merrybrook WMA. Based upon existing conditions, the WMA is in fair condition.

The Merrybrook WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 4.13. The lowest ranking subwatersheds were identified as additional potential problem areas. No additional subwatersheds within the Merrybrook WMA have been identified as additional problem areas. The Merrybrook WMA was ranked as having moderate levels of stressors and pollutant sources

4.7 Middle Horsepen WMA

4.7.1 Middle Horsepen WMA Characteristics

The Middle Horsepen WMA is located in the central portion of the Horsepen Creek Watershed. A small portion of the northern tip lies within Loudoun County. The Middle Horsepen WMA is the second smallest in the Horsepen Creek Watershed and consists of 953 acres (1.5 square miles). The WMA is bordered on the east by Centreville Road and traversed by Sully Road. See Figure 4.1 for the location of the Middle Horsepen WMA.

There are approximately 2.9 miles of perennial streams within the Middle Horsepen WMA. The streams in the upper portion of the WMA are in good to fair condition, and streams in the lower portion of the WMA are in poor to very poor conditions. The streams flow in a northern direction into Loudoun County and flow through a combination of land uses. A portion of the open space along Horsepen Creek has been designated as parkland within the Middle Horsepen WMA.

4.7.2 Existing and Future Land Use

Approximately 60 percent of the Middle Horsepen WMA is urbanized, consisting primarily of medium and high density residential (7 percent), commercial and industrial (46 percent) and transportation networks (5 percent) land uses, as shown in Table 4.24. Open space makes up almost 28 percent of the land use in this WMA.

Table 4.24 Existing and Future Land Use

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	7.2	0.5
High Density Residential	5.9	6.9
Medium Density Residential	0.8	0.8
Low Density Residential	9.5	10.2
High Intensity Commercial	7.2	6.9
Low Intensity Commercial	8.6	9.2
Industrial	29.7	42.3
Institutional	1.7	1.7
Open Space	27.8	15.1
Transportation	5.1	5.1
Water	1.1	1.1
Total	100	100

Source: Fairfax County GIS, 2008

Table 4.24 and Figure 4.2 show the expected change in land use as the Middle Horsepen WMA continues to develop. A decrease in estate residential, high intensity commercial and open space land use, with a corresponding increase in high density residential, low density residential, low intensity commercial and industrial areas is projected within the Middle Horsepen WMA.

4.7.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Fairfax County portion of the Middle Horsepen WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Middle Horsepen WMA:

1. Evaluated drainage complaints.
2. Documented new construction.
3. Evaluated projects proposed by the county.
4. Evaluated existing stormwater facilities.
5. Reviewed stream physical assessment inventory points.
6. Reviewed on-site septic areas.
7. Conducted neighborhood source assessments.
8. Conducted hot spot investigations.

The results of each of the above evaluations are briefly described in the following sections.

<u>Drainage Complaints</u>
Eighteen (18) drainage complaints have been documented within the Middle Horsepen WMA during 2001. Of those, one representative complaint was chosen for field investigation. The complaint sited erosion around stormwater infrastructure. Field reconnaissance indicated minor erosion around a stormwater inlet that should be monitored.

<u>New Construction</u>
To document areas of growth or re-growth within the watershed, new construction areas were identified for field reconnaissance. A new office building was field verified, and the building was still under construction.

<u>Proposed County Projects</u>
Based upon past evaluations and reports, multiple stormwater facility projects have been proposed within the Middle Horsepen WMA. Field investigations were conducted to determine whether these projects were still viable. The projects included three stream restoration and stabilization projects of Horsepen Creek and the construction of regional pond. Field investigation also verified the completion of a culvert replacement project under Sully Rd, a culvert replacement project under Frying Pan Road and a culvert replacement project under McLearen Road.

<u>Existing Stormwater Facilities</u>
Nine stormwater management facilities were evaluated within the Middle Horsepen WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facilities. Three of the six facilities did not exist and one of the facilities could not be accessed. The remaining facilities were functioning as designed, although most presented some opportunity for retrofit.

<u>Stream Physical Assessment (SPA) Inventory Points</u>
Inventory points identified during the original stream physical assessment and which received an impact score of five or greater were field verified. Six sites were verified including three tree obstructions and three areas of erosion. Two of the areas of erosion were directly connected to stormwater management facilities.

<u>On-site Septic</u>
Portions of the Horsepen Creek watershed still use on-site septic systems. Properties using on-site systems were chosen for field reconnaissance if problems were noted in the area. One on-site septic area was visited along Frying Pan Road, although no problem was noted.

<u>Neighborhood Source Assessment (NSA)</u>
Three representative neighborhoods were chosen for a NSA to help identify potential improvement projects throughout the Middle Horsepen WMA. The neighborhoods consisted of two low-intensity commercial areas and a multi-family housing complex. The neighborhood conditions, as well as the stormwater management facilities, were evaluated. The NSAs indicated

the potential for stormwater management facility retrofit and a need for better lawn and landscaping practices.

Hot Spot Investigation (HSI)
Three representative facilities with the potential to generate concentrated stormwater pollution were chosen within the Middle Horsepen WMA to for the HSI. An investigation was conducted of each facility and the corresponding property to identify sources of pollution. Two schools and a retail area were targeted for the HSI within the Middle Horsepen WMA. All three of the facilities were identified as potential hot spots. This indicated the need for future education efforts and the need for review of the stormwater pollution prevention plan.

Stream Physical Assessment (SPA)
A supplemental stream physical assessment was conducted on 0.9 miles of stream within the Middle Horsepen WMA. The section was chosen for reassessment because three county stream restoration and stabilization projects and six SPA inventory points were identified within the WMA. The stream was found to have fair to good habitat conditions. Multiple inventory point was identified with an impact score of five or higher including two erosion problems, 13 obstructions and four ditches.

4.7.4 Middle Horsepen WMA Characterization

Approximately 2 miles of stream was assessed within the Middle Horsepen WMA to determine the overall stream conditions in the WMA. As shown in Figure 4.4, the upper portion of Horsepen Creek within the Middle Horsepen WMA has good to fair habitat conditions. The lower portion of Horsepen Creek within the Middle Horsepen WMA has poor to very poor conditions. All of the streams in the WMA are protected by the resource protection area, as described in Chapter 1. The main steam was designated as protected in 1993 and one of the tributaries was added in 2003 and 2005. A pipe, several deficient riparian buffer areas, obstructions, ditches, headcuts, stream crossings and an area of erosion were identified during field reconnaissance. Most of the problems that were identified were considered minor to moderate. Several of the deficient buffer areas were considered moderate to severe; however, their restoration potential was also consider low. One ditch, four headcuts and one stream crossing were ranked moderate to severe. Several obstructions were ranked moderate to severe, and two obstructions ranked severe to extreme. The surveyed channel within the Middle Horsepen WMA is in Channel Evolution Model (CEM) Stage 3. This indicates an unstable channel that is experiencing significant bank erosion. All of the SPA inventory points indicate that Horsepen Creek is unstable throughout the Middle Sugarland WMA.

As shown in Figure 4.6, the Middle Horsepen WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network, including dry ponds, wet ponds and farm ponds. A stormwater regional pond is actively being funded for construction at the end of Cedar Run Lane. Table 4.25 indicates that stormwater runoff from approximately 14 percent of the area in this WMA is treated, and approximately 86 percent of the area in this WMA is not treated by any means. Stormwater runoff from the areas that do receive treatment are mainly treated for quantity and not water quality. Approximately 23 percent of the area in this WMA is impervious. More stormwater management facilities are needed in the Upper Middle Sugarland WMA. Drainage complaints made by residents consisted of erosion around stormwater infrastructure.

Table 4.25 Middle Horsepen WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/ Quality (acres)	None (acres)
Middle Horsepen	953	215.1	23%	102.2	18.7	9.2	822.9

4.7.5 STEPL Modeling

Figures 4.8, 4.9 and 4.10 present the results of the STEPL model for total suspended solids, total nitrogen and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.26 below shows the total pollutant loading to the endpoint of Middle Horsepen WMA. According to the STEPL model results, the Middle Horsepen WMA contributes approximately 6 percent of the total suspended solids, 6 percent of the total nitrogen, and 6 percent of the total phosphorous annual loads to the Horsepen Watershed. Pollutant loadings normalized to the acres within the drainage area of Middle Horsepen WMA are presented in Table 4.27. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Middle Horsepen WMA as compared with unit area loads for the entire watershed.

Table 4.26 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Middle Horsepen	180.1	5,679.34	739.50
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.27 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Middle Horsepen	0.189	5.959	0.776
WS Totals	**0.205**	**6.069**	**0.894**

4.7.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Middle Horsepen WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 4.11, a 100-year storm in the Middle Horsepen WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

One bridge and two culverts are located within the Middle Horsepen WMA. This bridge and culverts were modeled to determine if the 100-year storm exceeded their capacity to carry the flow. The modeling shows that the bridge does not carry the 100-year stormflow and the water may possibly overtop the bridge structure. One culvert cannot carry the 100-year stormflow and will overtop. The second culvert will carry the 100-year stormflow.

4.7.7 Middle Horsepen WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 4.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. Two subwatersheds within the Middle Horsepen WMA have been identified as a potential problem area. Based upon existing conditions, the Middle Horsepen WMA is in poor to very poor conditions condition.

The Middle Horsepen WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 4.13. The lowest ranking subwatersheds were identified as additional potential problem areas. No additional subwatersheds within the Middle Horsepen WMA have been identified as additional problem areas. The southern portion of the WMA was ranked as having moderate levels of stressors and pollutant sources. The northern portion of the WMA was ranked as having low to moderate levels of stressors and pollutant sources.

4.8 Stallion WMA

4.8.1 Stallion WMA Characteristics

The Stallion WMA is located in the western portion of the Horsepen Creek Watershed. The WMA lies entirely within Loudoun County. The Stallion WMA is the second largest in the Horsepen Creek Watershed and is comprised of 2,394 acres (3.7 square miles). See Figure 4.1 (WMA Map) for the location of the Stallion WMA.

There are approximately 3.2 miles of perennial streams within the Stallion WMA. The streams flow in a northern direction into the Lower Horsepen WMA. The streams flow primarily through open space areas.

4.8.2 Existing and Future Land Use

Approximately 16 percent the Stallion WMA is urbanized, consisting primarily of residential (2 percent) and industrial (14 percent) land uses, as shown in Table 4.28. The industrial area is comprised of the Dulles International Airport which covers a portion of the WMA. The land use in over 80 percent of this WMA is open space.

Table 4.28 Existing and Future Land Use

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	0.0	0.0
High Density Residential	0.1	0.1
Medium Density Residential	0.4	0.4
Low Density Residential	1.5	1.5
High Intensity Commercial	0.0	0.0
Low Intensity Commercial	0.0	0.0
Industrial	14.2	14.2
Institutional	0.0	0.0
Open Space	81.3	81.3
Transportation	0.0	0.0
Water	2.5	2.5
Total	100	100

Source: Fairfax County GIS, 2008

Table 4.28 and Figure 4.3 indicate no change in land use within the Stallion WMA is expected.

4.8.3 Field Reconnaissance and Stream Physical Assessment

No field reconnaissance was completed for the Stallion WMA since it is located completely in Loudoun County.

4.8.4 Stallion WMA Characterization

No stream condition information is available or has been collected for the Stallion WMA since it is located completely in Loudoun County.

The current stormwater treatment types for the Stallion WMA are unknown and unmapped, as all of this WMA is located in Loudoun County. Approximately 8 percent of this WMA is impervious, and no information is known about the stormwater treatment facilities in this WMA.

4.8.5 STEPL Modeling

Figures 4.8, 4.9 and 4.10 present the results of the STEPL model for total suspended solids, total nitrogen and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.29 shows the total pollutant loading to the endpoint of Stallion WMA. According to the STEPL model results, the Stallion WMA contributes approximately 13 percent of the total suspended solids, 8 percent of the total nitrogen, and 8 percent of the total phosphorous annual loads to the Horsepen Watershed. Pollutant loadings normalized to the acres within the drainage area of Stallion WMA are presented in Table 4.30. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Stallion WMA as compared with unit area loads for the entire watershed.

Table 4.29 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	**Total Nitrogen (pounds/year)**	**Total Phosphorus (pounds/year)**
Stallion	378.6	6,796.83	1,052.83
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.30 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	**Total Nitrogen (pounds/acre/year)**	**Total Phosphorus (pounds/acre/year)**
Stallion	0.158	2.839	0.440
WS Totals	**0.205**	**6.069**	**0.894**

4.8.6 HEC-RAS Modeling

Because the Stallion WMA is located completely in Loudoun County, HEC-RAS modeling was not completed.

4.8.7 Stallion WMA Subwatershed Ranking

No subwatershed ranking was completed for the Stallion WMA since it is located completely in Loudoun County.

4.9 Upper Horsepen WMA

4.9.1 Upper Horsepen WMA Characteristics

The Upper Horsepen WMA is located in the southern tip of the Horsepen Creek Watershed. The Upper Horsepen WMA is the fourth largest in the Horsepen Creek Watershed and it is comprised of 1,929 acres (3 square miles). The WMA is bordered on the east by the Reston Parkway, Lawyers Road and West Ox Road, and it is bordered on the west by Centreville Road. See Figure 4.1 for the location of the Upper Horsepen WMA.

There are approximately 7.3 miles of perennial streams within the Upper Horsepen WMA. The majority of streams are in good to fair condition, although there are some small portions in poor to very poor condition. The streams flow in a northwest direction into the Middle Horsepen WMA. The stream travels through primarily medium density residential and open space areas. A portion of the open space along Horsepen Creek has been designated as parkland within the Upper Horsepen WMA.

4.9.2 Existing and Future Land Use

Approximately 76 percent of the Upper Horsepen WMA is urbanized, consisting primarily of high and medium density residential (52 percent), commercial and industrial (4 percent), institutional (3 percent) and transportation networks (17 percent) land uses, as shown in Table 4.31. The open space land use is primarily located around the stream corridors.

Table 4.31 and Figure 4.2 show the expected change in land use as the Upper Horsepen WMA continues to develop. A decrease in estate residential, low intensity commercial and open space land uses, with a corresponding increase in medium and low density residential, high intensity commercial and industrial areas is projected within the Upper Horsepen WMA.

Table 4.31 Existing and Future Land Use for Upper Horsepen WMA

Land Use Type	Existing Percent (%)	Future Percent (%)
Estate Residential	1.0	0.3
High Density Residential	2.2	2.2
Medium Density Residential	50.2	50.9
Low Density Residential	3.7	4.2
High Intensity Commercial	2.2	2.5
Low Intensity Commercial	1.6	1.4
Industrial	0.4	0.8
Institutional	3.0	3.0
Open Space	18.1	17.1
Transportation	16.9	16.9
Water	0.9	0.9
Total	100	100

Source: Fairfax County GIS, 2008

4.9.3 Field Reconnaissance and Stream Physical Assessment

Field reconnaissance was completed within the Upper Horsepen WMA to evaluate projects proposed by the county, to identify problems areas and to identify potential improvement projects. The following tasks were completed during the field reconnaissance surveys of the Upper Horsepen WMA:

1. Evaluated drainage complaints.
2. Documented new construction.
3. Evaluated projects proposed by the county.
4. Evaluated existing stormwater facilities.
5. Reviewed stream physical assessment inventory points.
6. Reviewed on-site septic areas.
7. Conducted neighborhood source assessments.
8. Conducted hot spot investigations.

The results of each of the above evaluations are briefly described in the following sections.

Drainage Complaints

Two hundred and fifty nine (259) drainage complaints have been documented within the Upper Horsepen WMA between 2001 and 2006. Of those, 26 representative complaints were chosen for field investigation. The complaints sited erosion around stormwater infrastructure and management facilities, odor from stormwater infrastructure and streambank erosion. Field reconnaissance indicated minor erosion around several stormwater inlets, no foul odors and some minor streambank erosion.

New Construction

To document areas of growth or re-growth within the watershed, new construction areas were identified for field reconnaissance. A new office building was field verified and the building was still under construction.

Proposed County Projects

Based upon past evaluations and reports, multiple stormwater projects have been proposed within the Upper Horsepen WMA. Field investigations were conducted to determine whether these projects were still viable. The projects included two stream restoration and stabilization projects on Horsepen Creek, a culvert replacement project under Viking Drive, a regional pond near the Fairfax County Parkway and a culvert replacement project under West Ox Road. Field investigation also verified the completion of a culvert replacement project under Centreville Road and a regional pond constructed near West Ox Road.

Existing Stormwater Facilities

Eighteen (18) stormwater management facilities were evaluated within the Upper Horsepen WMA to determine the need for repair or the potential for retrofit to increase the benefit of the facility. Four of the 18 facilities were not providing stormwater management. The remaining facilities were functioning as designed, although most presented some opportunity for retrofit.

Stream Physical Assessment (SPA) Inventory Points

Inventory points identified during the original stream physical assessment and which received an impact score of five or greater were field verified. Fourteen (14) sites were verified including a stream crossing, two tree obstructions, a utility, seven areas of erosion, and two pipes. Two of the inventory points, an area of erosion and a pipe, were unable to be found, and therefore were not verified.

On-site Septic

Portions of the Horsepen Creek watershed still use on-site septic systems. Properties using on-site systems were chosen for field reconnaissance if problems were noted in the area. Three on-site septic areas were field verified, but no problems were noted. One of the sites was being re-developed and it is expected that it will not longer use an on-site septic system.

Neighborhood Source Assessment (NSA)

Five representative neighborhoods were chosen for a NSA to help identify potential improvement projects throughout the Upper Horsepen WMA. The neighborhoods consisted of a low intensity commercial area and four single family developments. The single- family detached housing was located on one-quarter to half-acre lots. The neighborhood conditions, as well as the stormwater management facilities, were evaluated. The NSAs indicated the potential for stormwater management facility retrofit and a need for better lawn and landscaping practices.

Hot Spot Investigation (HSI)

Four representative facilities with the potential to generate concentrated stormwater pollution were chosen within the Upper Horsepen WMA for the HSI. An investigation was conducted of each facility and the corresponding property to identify sources of pollution. Two schools and a convenience store/gas station were targeted for the HSI within the Upper Horsepen WMA. A dry cleaning establishment was also targeted, but it was no longer in business. All three of the facilities were identified as potential hot spots. This indicated the need for future education efforts and the need for review of the stormwater pollution prevention plan.

Stream Physical Assessment (SPA)

A supplemental stream physical assessment was conducted on 1.1 miles of stream within the Upper Sugarland WMA. The section was chosen for reassessment because two county stream restoration and stabilization projects, 10 SPA inventory points, and an erosion drainage complaint were identified within the WMA. The stream was found to have fair to good habitat conditions. Multiple inventory point was identified with an impact score of five or higher including 20 erosion problems and three obstructions.

4.9.4 Upper Horsepen WMA Characterization

Approximately seven miles of stream was assessed within the Upper Horsepen WMA to determine the overall stream conditions. As can be seen from Figure 4.4, the main stem of Horsepen Creek within the Upper Horsepen WMA has good to fair habitat conditions. A few of the tributaries have poor to very poor conditions. All of the streams in the WMA are protected by the resource protection area, as described in Chapter 1. The main steam was designated as protected in 1993, whereas the tributaries and headwaters were added in 2003 and 2005. Pipes, deficient riparian buffer areas, obstructions, ditches, headcuts, utilities, dumps, stream crossings and areas of erosion were identified during field reconnaissance, although most of the problems were considered minor to moderate. Some of the points were ranked severe to extreme including a headcut of 2.5 feet, a tree obstruction on a tributary and a pipe causing major erosion. Based on the stream length that was surveyed within the Upper Horsepen WMA, the entire channel is in Channel Evolution Model Stage 3. This indicates an unstable channel that is experiencing significant bank erosion. All of the SPA inventory points support the instability rating of Horsepen Creek through the Upper Horsepen WMA.

As shown in Figure 4.6, the Upper Horsepen WMA contains multiple stormwater management facilities that collect and treat stormwater runoff before it reaches the stream network, including dry ponds, wet ponds and farm ponds. A stormwater regional pond has been constructed near West Ox Road and one is planned for construction near the Fairfax County Parkway. Based on Table 4.25, stormwater runoff from approximately 32 percent of the area in this WMA is treated, and stormwater runoff from approximately 68 percent of the area in this WMA is not treated by any means. Stormwater runoff from the areas that do receive treatment is treated for both quantity and water quality. Approximately 29 percent of the area in this WMA is impervious. More stormwater management facilities are needed in the Upper Middle Sugarland WMA. Drainage complaints made by residents consisted of erosion around stormwater infrastructure and facilities, streambank erosion, and foul odors.

Table 4.32 Upper Horsepen WMA Summary

WMA Name	Total Area (acres)	Impervious Current Condition (acres)	Percent Impervious	Current Treatment Types			
				Quantity (acres)	Quality (acres)	Quantity/Quality (acres)	None (acres)
Upper Horsepen	1,929	556.4	29%	373.3	56.9	188.4	1,310.4

4.9.5 STEPL Modeling

Figures 4.8, 4.9 and 4.10. present the results of the STEPL model for total suspended solids, total nitrogen and total phosphorus, respectively, which were used to estimate the pollutant loadings in each subwatershed and WMA. Table 4.33 shows the total pollutant loading to the endpoint of Upper Horsepen WMA. According to the STEPL model results, the Upper Horsepen WMA contributes approximately 12 percent of the total suspended solids, 17 percent of the total nitrogen, and 18 percent of the total phosphorous annual loads to the Horsepen Watershed. Pollutant loadings normalized to the acres within the drainage area of Upper Horsepen WMA are presented in Table 3.33. The values in this table indicate the total nutrient and sediment load that results from stormwater runoff over one acre of Upper Horsepen WMA as compared with unit area loads for the entire watershed.

Table 4.33 Summary of Pollutant Loadings

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/year)	Total Nitrogen (pounds/year)	Total Phosphorus (pounds/year)
Upper Horsepen	364.7	15,343.90	2,289.32
WS Totals	**2,992.98**	**88,606.20**	**13,047.25**

Table 4.34 Summary of Pollutant Loadings Normalized by Drainage Area

WMA Name	Pollutant Loadings		
	Total Suspended Solids (tons/acre/year)	Total Nitrogen (pounds/acre/year)	Total Phosphorus (pounds/acre/year)
Upper Horsepen	0.189	7.954	1.187
WS Totals	**0.205**	**6.069**	**0.894**

4.9.6 HEC-RAS Modeling

HEC-RAS hydraulic modeling was completed for a 100-year storm event in the Upper Horsepen WMA. Channel flow capacity was analyzed to determine if the 100-year storm event would overflow the channel and flood onto the floodplain. Additionally, the elevation of the flow was determined with reference to the topographic elevations in the stream valley.

As shown in Figure 4.11, a 100-year storm in the Upper Horsepen WMA resulted in an overflow event with flooding onto the floodplain. The modeling showed that the 100-year stormflow elevation covered the entire floodplain and reached up the valley slope.

Three culverts and a paired weir and culvert are located within the Upper Horsepen WMA. The culverts and the paired weir and culvert were modeled to determine if the 100-year storm exceeded their capacity to carry the flow. The modeling shows that three culverts carry the 100- year stormflow. The modeling for the paired weir and culvert shows that the weir is overtopped and the culvert outlet does not carry the 100-year stormflow.

4.9.7 Upper Horsepen WMA Subwatershed Ranking

As indicated in Section 2.6, two indicator categories – watershed impact and source indicators - were used for ranking overall stream conditions in the subwatersheds. Figure 4.12 illustrates the results obtained for subwatershed ranking of the watershed impacts. The lowest scoring subwatersheds were identified as potential problem areas. Two subwatersheds within the Upper Horsepen WMA have been identified as potential problem areas. The existing conditions within the WMA have been ranked as moderate.

The Upper Horsepen WMA was also evaluated using source indicators to identify potential WMA stressors or pollutant sources as shown in Figure 4.13. The lowest ranking subwatersheds were identified as additional potential problem areas. Two additional subwatersheds within the Upper Horsepen WMA have been identified as additional problem areas. The remainder of the Upper Horsepen WMA was ranked as having moderate to high levels of stressors and pollutant sources.

4.10 SWMM Modeling for Horsepen Creek Watershed

The Stormwater Management Model (SWMM) was used to determine the peak rate (maximum volume of water per second) of stormwater flows in stream channels during a storm. The 2-year and 10-year storm flows were modeled; these are the storm flows that, on average, occur once every 2 or 10 years. Figure 4.14 shows peak rates of flow for the 2-year storm across the watershed. As shown in Figure 4.14, within each WMA, peak flows tend to increase downstream as more drainage area contributes more stormwater runoff to the stream channel. In a similar manner, an upstream, contributing WMA augments the flow in a downstream, receiving WMA. Because stormwater runoff flow carries pollutants, pollutant loadings also increase downstream within a WMA and from one WMA to the next.

Table 4.35 shows peak flows for the 2-year and 10-year storms in the WMAs in the Horsepen Creek watershed. The SWMM model shows that peak flows are increasing from the upstream, contributing WMAs to the downstream WMAs. The Lower Horsepen WMA has the highest cumulative peak flows because it is the receiving WMA for all the stormwater runoff in the watershed. Peak flows for the 10-year storm are approximately twice as large as the flows for the 2-year storm.

Table 4.35 Summary of SWMM and STEPL Results

		Stormwater Runoff Peak Flow Values		Pollutant Loadings		
WMA Name[1]	**Contributing WMA(s) [2]**	**2-yr storm (cubic ft/sec)**	**10-yr storm (cubic ft/sec)**	**Total Suspended Solids (tons/yr)**	**Total Nitrogen (pounds/yr)**	**Total Phosphorus (pounds/yr)**
HC-Upper	Cedar, Upper	822.01	1622.37	526.69	21,314.45	3,197.37
HC-Middle	Upper, Frying Pan, Merrybrook, Middle	1587.46	3147.43	1,128.62	43,935.13	6,375.56
HC-Lower Middle	Middle, Lower Middle	1827.85	3764.58	1,457.57	54,552.68	8,044.65
HC-Lower	Lower Middle, Stallion, Indian, Lower	2456.98	5521.38	2,992.98	88,606.20	13,047.25
WS Totals		**2456.98**	**5521.38**	**2,992.98**	**88,606.20**	**13,047.25**

1. The "WMA Name" is the WMA for which there is a modeled cumulative peak flow (2 and 10 year) for the entire upstream drainage area.
2. The "Contributing WMA(s)" are the upstream WMAs for which there is nomodeled cumulative peak flows (2 and 10 year) for the entire upstream drainage area. Example: The "Upper" WMA includes all the stormwater draining from the Cedar WMA and the Upper WMA.

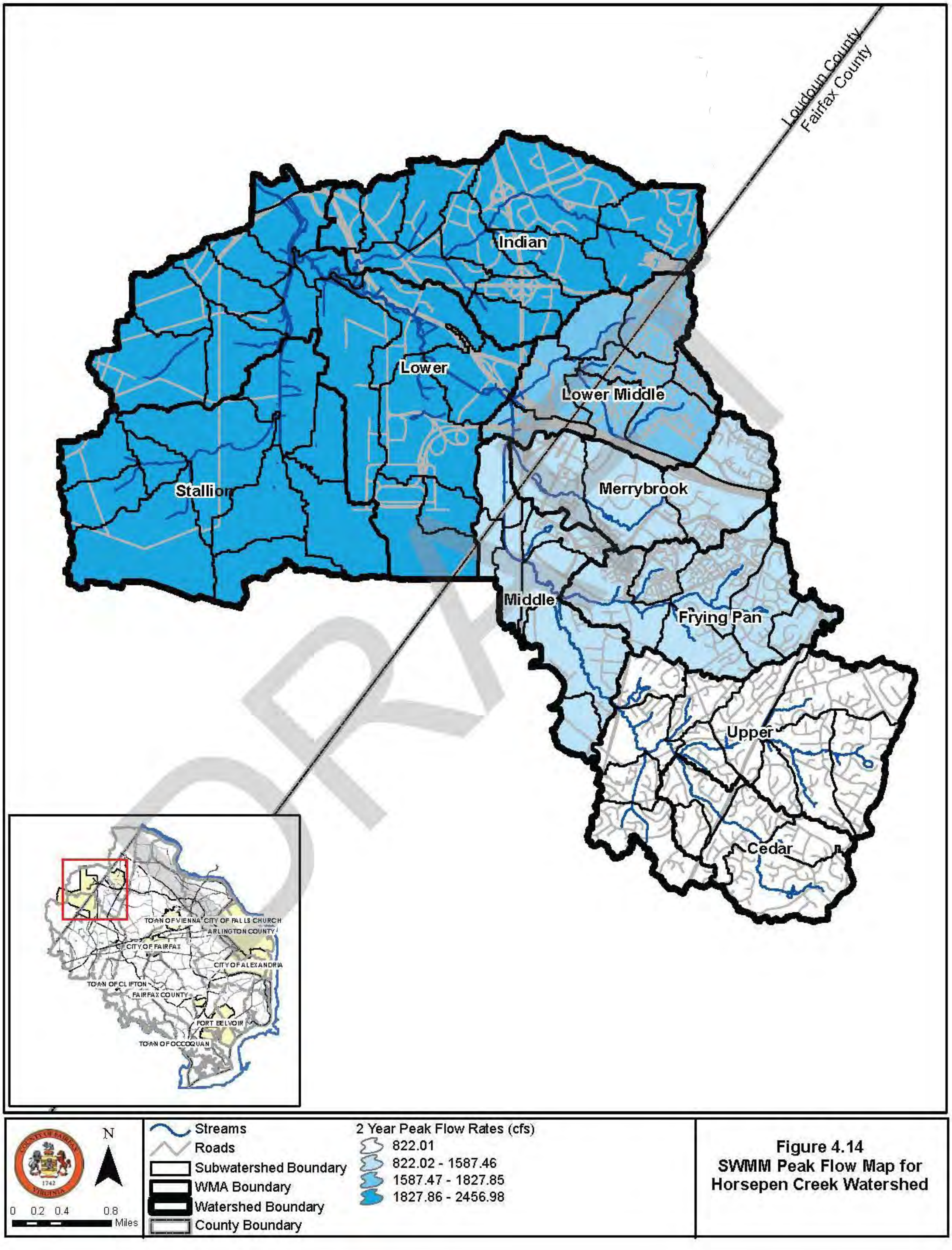

Figure 4.14
SWMM Peak Flow Map for Horsepen Creek Watershed

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To determine which WMA contributes the greatest flows, the peak flows in Table 4.35 were recalculated based on WMA drainage area. Table 4.36 shows these flows normalized by WMA drainage area. Upper Horsepen WMA contributes the most stormwater runoff during the 2-year storm and Lower Horsepen WMA contributes the least. During the 10-year storm, the Upper Horsepen WMA contributes the most cumulative stormwater runoff per drainage area and the Lower Horsepen WMA the least.

The STEPL model was used to estimate the pollutant loadings for total suspended solids (sediments), total nitrogen, and total phosphorus for each WMA and the results are shown in Table 4.35. As stormwater flows accumulate downstream, so do the pollutant loadings carried by the flows. For instance, Table 4.35 shows the Upper, Frying Pan, Merrybrook and Middle WMAs contributing flows and pollutants to the Middle WMA. Pollutant loads increase from the upstream, contributing WMAs to downstream WMAs. The Lower Horsepen WMA contributes the greatest cumulative pollutant loading and the Upper WMA the least.

To determine if the pollutant loadings shown in Table 4.35 are increasing or decreasing with downstream flow, the pollutant loadings in Table 4.35 were recalculated based on WMA drainage area. Table 4.36 shows pollutant loadings normalized by the contributing drainage area. Pollutant loadings in the Horsepen Watershed decrease with downstream flow, indicating that the increase in flow is relatively greater than the increase in added pollutants.

Table 4.36 Summary of SWMM and STEPL Results Normalized by Drainage Area

			Stormwater Runoff Peak Flow Values		Pollutant Loadings		
WMA Name[1]	**Contributing WMA(s) [2]**	**Drainage Area (acres)**	**2-yr storm (cubic ft/sec)**	**10-yr storm (cubic ft/sec)**	**Total Suspended Solids (tons/yr)**	**Total Nitrogen (pounds/yr)**	**Total Phosphorus (pounds/yr)**
HC-Upper	Cedar, Upper	2,712	0.303	0.598	0.194	7.859	1.179
HC-Middle	Upper, Frying Pan, Merrybrook, Middle	5,763	0.275	0.546	0.196	7.624	1.106
HC-Lower Middle	Middle, Lower Middle	6,951	0.263	0.542	0.210	7.848	1.157
HC-Lower	Lower Middle, Stallion, Indian, Lower	14,600	0.168	0.378	0.205	6.069	0.894
WS Totals		14,600	**0.168**	**0.378**	**0.205**	**6.069**	**0.894**

3. The "WMA Name" is the WMA for which there is a modeled cumulative peak flow (2 and 10 year) for the entire upstream drainage area.
4. The "Contributing WMA(s)" are the upstream WMAs for which there is nomodeled cumulative peak flows (2 and 10 year) for the entire upstream drainage area. Example: The "Upper" WMA includes all the stormwater draining from the Cedar WMA and the Upper WMA.

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5.0 Glossary of Terms

Acre – A measure of land equating to 43,560 square feet.

Aquatic Habitat – The wetlands, streams, lakes, ponds, estuaries, and streamside (riparian) environments where aquatic organisms (e.g., fish, benthic macroinvertebrates) live and reproduce; includes the water, soils, vegetation, and other physical substrate (rocks, sediment) upon and within which the organisms occur.

Benthic Macroinvertebrate – An aquatic animal lacking a backbone and generally visible to the unaided eye.

Best Management Practice (BMP) – A structural or nonstructural practice that is designed to minimize the impacts of changes in land use on surface and groundwater systems. Structural best management practices refer to basins or facilities engineered for the purpose of reducing the pollutant load in stormwater runoff, such as bioretention, constructed stormwater wetlands, etc. Nonstructural best management practices refer to land use or development practices that are determined to be effective in minimizing the impact on receiving stream systems such as the preservation of open space and stream buffers, disconnection of impervious surfaces, etc.

Bioengineering – Combines biological (live plants) and engineering (structural) methods to provide a streambank stabilization method that performs natural stream functions without habitat destruction.

Channel Evolution Model (CEM) – The geomorphologic assessment of the incised stream channels developed by Schumm et. al.

Channel – A natural or manmade waterway.

Confluence – The joining point where two or more stream create a combined, larger stream. Design

Storm – A selected rainfall hyetograph of specified amount, intensity, duration, and frequency that is used as a basin for design.

Detention – The temporary impoundment or holding of stormwater runoff.

Ecosystem – All the component organisms of a community and their environment that together form an interacting system.

Erosion - is the natural process by which a stream channel adjusts to changes within its watershed. Increased development within a watershed can accelerate the erosion process, resulting in the loss of residential yards, threatened infrastructure, siltation of aquatic habitat, and decreased water quality.

Floodplain - Area of land on each side of a stream channel that is inundated periodically by flood waters; important zone for dissipating the energy of peak storm flow discharges and for storing waters that otherwise might damage in-stream habitat and/or cause downstream flood damage; typically includes high-quality riparian habitat (if undisturbed); waters flowing in incised (down-cut) streams may not be able to access the adjacent floodplain area to dissipate the volume and energy of higher storm flow events.

Geographic Information System (GIS) – A method of overlaying spatial land and land use data of different kinds. The data are referenced to a set of geographical coordinates and encoded in a computer software system. GIS is used by many localities to map utilities and sewer lines and to delineate zoning areas.

Geomorphology – A science that deals with the land and submarine relief features of the earth's surface.

Headcut – The geomorphologic incision of the stream due to the hydraulic effect of a channel from head forces. One example is the accelerated cutting of a stream due to a manmade or natural constriction where water velocities are increased substantially. Another example is the outlet of a dam, where extreme velocities can occur due to the high static head forces created by the build-up of water from the dam structure.

Headwater – The source of a stream or watershed.

Hot Spot – A problem area that may contain significant stressors or pollutant sources that can affect watershed conditions within the immediate subwatershed and may be having an impact on downstream areas.

Hydraulics – The physical science and technology of the static and dynamic behavior of fluids.

Hydrograph – A plot showing the rate of discharge, depth, or velocity of flow versus time for a given point on a stream or drainage system.

Hydrology – The science of dealing with the distribution and movement of water.

Hyetograph – A graph of time distribution of rainfall over a watershed.

Impervious Surface – A surface composed of any material that significantly impedes or prevents natural infiltration of water into the soil. Impervious surfaces include, but are not limited to, roofs, buildings, streets, parking areas, any concrete, asphalt, or compacted gravel surface.

Modeling - Use of conceptual and/or computer models to simulate the response (e.g., pollutant loading to streams) of a natural system (e.g., watershed) to various management scenarios; useful in assessing which types of watershed protection techniques will yield the greatest benefit to water quality, habitat, or flooding conditions, and in determining which locations within the watershed are optimal for such practices or project sites.

Open Space – The area within the boundaries of a lot that is intended to provide light and air, and is designed for either scenic or recreational purposes. Open space shall, in general, be available for entry and use by residents or occupants of the development. Open space may include, but is not limited to, lawns, decorative planting, walkways, recreation areas, playgrounds, undisturbed natural areas and wooded areas.

Peak Discharge – The maximum rate of flow at an associated point within a given rainfall event or channel condition.

Perennial Stream – A body of water that normally flows year-round in a defined channel or bed, and is capable, in the absence of pollution or other manmade stream disturbances, of supporting bottom-dwelling aquatic animals.

Pipes - carry water from various sources to a stream. Because of this, the discharge may contain pollutants such as oil from roadway runoff, sewage, nutrients from lawn fertilization, etc. The high volume and flow delivered to the stream, particularly during storm events, can result in erosion of the stream channel and banks.

Redevelopment – The substantial alteration, rehabilitation, or rebuilding of a property for residential, commercial, industrial, or other purposes.

Resource Protection Area (RPA) – Vegetated riparian buffer areas, which include land within a major floodplain and land within 100 feet of a water body. These buffer areas are important in the reduction of sediments, nutrients, as well as the other adverse effects of human activities, which could potentially degrade these systems and those downstream.

Restoration - The re-establishment of wetlands or stream hydrology and wetlands vegetation into an area where wetland conditions (or stable streambank and stream channel conditions) have been lost.

Retention – The permanent storage of stormwater.

Retrofit – The modification of stormwater management systems through the construction and/or enhancement of wet ponds, wetland plantings, or other best management practices designed to improve water quality.

Return Period – The average length of time between events having the same volume and duration. If a storm has a one percent chance of occurring in any given year, then it has a return period of 100 years.

Riparian Buffer - An area adjacent to a stream, wetland, or shoreline where development activities (e.g., buildings, logging) are typically restricted or prohibited; may be managed as streamside (riparian) zones where undisturbed vegetation and soils act as filters of pollutants in stormwater runoff; buffer zone widths vary depending on state and local rules, but are typically a minimum of 25 to 50 feet on each side of perennial streams.

Road Crossing - are structures that span the width of a stream, usually road or foot bridges. The structures constrict the flow within a stream which can result in detrimental effects including erosion, flooding, and decreased water quality. In addition, structures may block fish and wildlife passage preventing migration to feeding/spawning areas.

Runoff – The portion of precipitation, snow melt, or irrigation water that runs off the land into surface waters.

Stormwater - Precipitation that is often routed into drain systems in order to prevent flooding.

Stormwater Management Facility – A device that controls stormwater runoff and changes the characteristics of that runoff including, but not limited to, the quantity and quality, the period of release or the velocity of flow.

Stream Restoration – The reestablishment of the general structure, function, and dynamic, but self-sustaining, behavior of the ecosystem.

Subwatershed – A subdivision of a watershed used for planning and management purposes, usually ranges in size from 100 to 300 acres.

Tree Cover – The area directly beneath the crown and within the dripline of a tree.

Watercourse – A stream with incised channel (bed and banks) over which water are conveyed.

Watershed – A defined land area drained by a river, stream, or drainage way, or system of connecting rivers, streams, or drainage ways such that all surface water within the area flows through a single outlet.

Watershed Management Area (WMA) – A subdivision of a watershed used for planning and management purposes, usually four square miles in size.

Watershed Planning - The development of basin wide Watershed Restoration Plans; planning typically includes (1) an assessment of watershed conditions and functional impacts at progressively smaller scales of study, and (2) the development of land use management strategies and optimal watershed restoration, enhancement and protection/preservation projects designed to address the identified watershed needs & opportunities.

Wetland - Habitats where the influence of surface water or groundwater has resulted in the development of plant or animal communities adapted to aquatic or intermittently wet conditions. Wetlands include tidal flats, shallow sub-tidal areas, swamps, marshes, wet meadows, bogs, and similar areas.