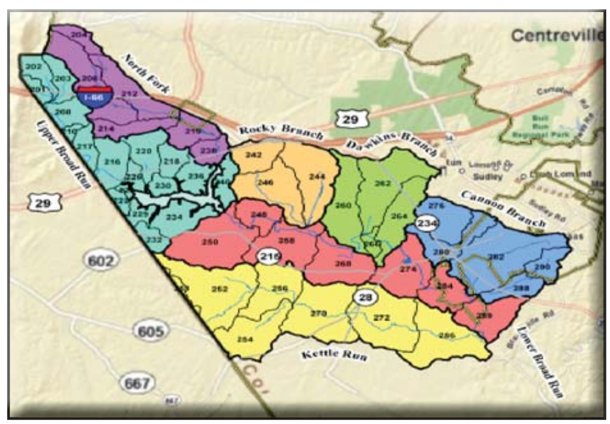
PRINCE WILLIAM COUNTY, VA
DEPARTMENT OF PUBLIC WORKS

Broad Run Watershed

an Assessment of Stream Corridors and Stormwater BMPs in Five Representative Subwatersheds



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September 2012

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An Assessment of Stream Corridors and Stormwater BMPs

in Five Representative Subwatersheds

Prepared for:

Watershed Management Branch
Environmental Services Division,
Public Works Department,
Prince William County

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DISCLAIMER

This watershed study is a management tool for use in planning and prioritizing potential Capital Improvement Projects. While the information is based on actual observation in the field and believed to be accurate, all conceptual projects are subject to staff evaluation and prioritization based on multiple constraints such as time, resources, regulatory changes, and funding. This study is not designed, intended, or to be construed in any way, as a complete listing or comprehensive evaluation of all issues or needs within the area studied. This study does address many of the elements of the PWC Comprehensive Plan, Chapter 7, "Environment". However, this study was not conducted to meet any regulatory requirement and is not a "Watershed Management Plan" in the regulatory sense. Cost estimates included are "order of magnitude" estimates based on the consultant's expertise, experience, and judgment.

ACKNOWLEGEMENTS

We like to acknowledge the following professionals for their dedication and assistance in completing the many tasks in this study:

Prince William County Personnel:

Marc Aveni (Environmental Services Division Chief)
Charles Williamson (Stream Protection Manager)
Tom Dombrowski (Environmental Engineer)
Clay Morris (Environmental Engineer)

Whitman, Requardt and Associates LLP.:

Robert Siegfried (Restoration Practice Leader)
David Kwasniewski (Environmental Scientist)
Glenn Wilson (Environmental Scientist)
Aaron Hofberg (Design Engineer)

List of Acronyms and Abbreviations Used in Report

BMP	Best Management Practice, often referring to a water quality stormwater facility
CDA	Contributing Drainage Area
CIP	Capital Improvement Projects
CMP	Corrugated Metal Pipe
CPv	Channel Protection Volume
CSWMP	County Maintained Stormwater Management Pond
CWP	Center for Watershed Protection
DCR	Virginia Department of Conservation & Recreation
DEQ	Virginia Department of Environmental Quality
ED	Extended Detention
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographical Information System
GPIN	Geographic Parcel Index Number
GPS	Geographic Positioning Satellites
HOA	Home Owner Association
IC Model	Impervious Cover Model
IDDE	Illicit Discharge Detection and Elimination
LID	Low Impact Development
MAGIC	Management and Government Information Center
MS4	The stormwater permit issued to County by EPA
N (or TN)	Total Nitrogen, measured as mg/l
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
OWML	Occoquan Watershed Monitoring Lab
P (or TP)	Total Phosphorus, measured as mg/l
RCP	Reinforced Concrete Pipe
RPA	Resource Protection Area
RSAT	Rapid Stream Assessment Technique
SCI	Stream Condition Index, used by DEQ to measure stream health
SWM	Stormwater Management
SWMP	Stormwater management pond, privately maintained
TMDL	Total Maximum Daily Load
USA	Unified Stream Assessment method
VaSOS	Virginia Save Our Stream benthic sampling protocol
VDOT	Virginia Department of Transportation
VPDES	Virginia Pollution Discharge Elimination System
WIP	Watershed Improvement Plan
WQv	Water Quality Volume
WWTP	Wastewater Treatment Plant

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I. EXECUTIVE SUMMARY

The Prince William County Public Works Department, Environmental Services Division, Watershed Management Branch conducted a watershed study for the Broad Run watershed within the County. The investigation included an evaluation of watershed conditions based on existing Geographic Information System (GIS) data, the assessment of condition of stream channels and stormwater management facilities within representative subwatersheds of the Broad Run Watershed, and identification of potential watershed management Capital Improvement Projects (CIP).

Broad Run flows southeast from its headwaters in Fauquier County and discharges into the Occoquan River draining approximately 120 square miles. Approximately 73 square miles of the Broad Run watershed are located within the boundaries of Prince William County including the Cities of Manassas and Haymarket. The Broad Run watershed comprises approximately 20% of the total surface area of the County.

Public Outreach & Information

A public information meeting was conduct on August 9th, 2011 at the Sudley North community room. The meeting was advertised in the Prince William Section of the Washington Post and in InsideNOVA. Meeting announcements were sent to environmental groups in the County, as well as provided to the Magisterial District Supervisors offices for distribution. The presentation summarized the purpose of the study and the proposed the methods. Attendance at the meeting was light with no specific comments at that time on the proposed study or methods. On August 14th, 2012, a second public meeting was held to present the results of the watershed assessment. This meeting was advertised in the same media as the first meeting. Attendance was similar to the first meeting, and generated a few general questions about who is responsible for maintenance and inspection of stormwater facilities, how can the public become more involved in watershed issues, and how land ownership effect stream restoration projects.

The public can review the full text and graphics included in this report through the County website under watershed studies or by clicking on the following link
http://www.pwcgov.org/government/dept/publicworks/environment/Pages/Watershed-Studies.aspx

The County GIS mapper is being modified to incorporate GIS data generated during this study. Hard copies of the report are available for reference at the Management and Government Information Center (MAGIC) at the Chinn Library (13065 Chinn Park Drive).

Watershed Assessment Process

In the Broad Run watershed there are 50 subwatersheds, over 73 square miles with 185 miles of streams and over 333 stormwater facilities. Evaluation of all of the streams and stormwater facilities within the entire watershed would be time consuming and expensive. This study used a four stage screening process to narrow the study:

- Using land use information to select five representative subwatersheds.

- Using desktop analysis to select stream and stormwater facilities for detailed field inspections.
- Using results from the field inspections to identify those streams and stormwater facilities that may require maintenance, repair or retrofitting.
- Using ranking and prioritization to identify which streams or stormwater facilities where suitable for the development of conceptual plans.

The five selected subwatersheds were:

- Tributary to Rocky Branch (subwatershed 244);
- Rocky Branch (subwatershed 246);
- Dawkins Branch (subwatershed 262);
- Broad Run Mainstem downstream of Lake Manassas (subwatershed 250); and
- Kettle Run (subwatershed 272).

Watershed Characterization with Existing GIS Data

The major subwatersheds in the Broad Run watershed were characterized based on the resources listed in the 2008 Comprehensive Plan, Environmental Chapter – Action Strategy EN7.1, using available GIS information. For each data set used in the watershed characterization, a set of recommendations were made to improve the functionality of the existing County GIS data, to add new data to the County GIS system or to otherwise improve the County's ability to characterize watersheds based on existing data. The recommendations detailed in Chapter 3 are summarized below:

- **Improvements to Existing County Base Mapping** – Update and revise existing subwatershed mapping prior to each watershed study, compile a new layer for "Major Subwatersheds" that represent continuous stream systems, and revise/update the existing stream network within the watersheds.
- **Improve Ability to Characterize Watersheds**– Improve the existing GIS data for impervious surface, wetlands, wells and septic systems, and forest cover.
- **Add Existing Data from Other Sources to the County GIS System** – Incorporate National Wetlands Inventory (NWI) wetlands mapping, National Resources Conservation Service (NRCS) soils databases, and Virginia Department of Environmental Quality (DEQ) data (hazardous materials, water quality monitoring stations, etc.) into County GIS.
- **Improve GIS functionality with other County Programs** – Develop a process for revising and updating stormwater GIS data based on inspections, watershed studies, and other data.

Stormwater Facilities Condition and Recommendations

A Stormwater Facilities Reconnaissance Inventory was conducted of the 33 sites identified during a desktop screening analysis. The field inventory included an inspection of existing stormwater facilities and documentation of any problems which were observed. The retrofit potential of the existing facility was assessed, and any existing constraints identified. The following summarizes the results of the field inspections identified:

- Fourteen out of thirty-three (41%) of the facilities were in good condition.
- One facility had a broken fence around a wet pond. The Park Authority was advised of the problem and safety concerns.
- Paint was observed in one facility which was removed prior to a follow up inspection by the county.
- Four dry basins are good candidates for retrofitting to improve water quality treatment. Retrofitting dry basins could be used to meet the Environmental Protection Agency (EPA) Chesapeake Bay Total Maximum Daily Load (TMDL) goals for nutrient removal.
- The bioretention facilities in one neighborhood should be studied to determine if they are functional.
- Six facilities would benefit from minor improvements such as cleaning out forebays can be addressed as part of routine maintenance.
- Six facilities would benefit from major improvements such as sediment removal from the basin or adding forebays. Two sites appear to have been filled-in by adjacent parking lots and may require significant reconstruction.

The estimated design, construction, and contingency costs for the ten proposed improvements, repairs and water quality retrofits would cost an estimated $900,000. The four water quality retrofit projects would cost approximately $600,000 and improve water quality treatment for over 100 acres.

Stream Channel Condition and Recommendations

The desktop site selection analysis identified 22 stream reaches to be assessed in the field. Three of these reaches were reference condition sites and the rest were potential stream restoration sites. The stream reaches that were assessed represent a total of 19,387 linear feet of stream channel, out of an estimated total of 258,069 linear feet of channel within the five subwatersheds, or approximately 8% of the total.

Due to the presence of Resource Protection Area buffers and effective stormwater management, there were few degraded streams reaches in the subwatersheds that were studied. Only three stream and riparian buffer projects are recommended out of 22 stream reaches assessed. The recommended projects would address deficiencies and degradation along approximately 900 linear feet of stream channel at an estimated cost of $220,000. Costs per linear foot range from $100 to $320 depending on the complexity of the project.

Outfall Retrofits Recommendations

In the Broad Run Watershed very few potential stormwater outfall retrofit sites were identify during this study. Most stormwater outfalls are already treated by a stormwater facility or are small outfalls that discharged into a wooded riparian buffer not suitable for an outfall retrofit. This is in contrast with older developed watersheds, such as Bull Run, where stormwater outfalls are often not treated, and stormwater outfall retrofit opportunities are relatively common. The lack of stormwater outfall retrofit opportunities in the Broad Run watershed is a positive sign that most stormwater is already being treated prior to discharging to local streams.

Existing Water Quality Data and TMDLs

Water quality monitoring data from DEQ and from the Occoquan Watershed Monitoring Lab both indicate that Broad Run and Kettle Run have nitrogen concentrations only slightly elevated over reference conditions but are stressed by high phosphorus concentrations. DEQ developed a TMDL for stream segments in the Broad Run watershed which are not meeting current water quality standards for fecal bacteria. A second TMDL was developed for a section of South Run upstream of Lake Manassas which is benthically impaired due to high phosphorus concentrations. The only point source in the watershed, the Vint Hill Wastewater Treatment Plant (WWTP), is scheduled to be diverted to Kettle Run. This would improve the benthic impairment in South Run but increase degraded conditions in Kettle Run.

Recommendations for Watershed Management and Planning

The following recommendations are based on the lessons learned after completion of the Bull Run and Broad Run watershed studies, and our understanding of upcoming regulatory requirements. The following recommendations would enhance the ability of the County to manage its watersheds and to respond effectively to increasing federal and state regulatory requirements:

- **Continue Watershed Studies** – The County should continue to conduct watershed studies in order to assess the condition of the County's streams and stormwater facilities. These studies provide the county the baseline information to respond to upcoming regulatory requirements to increase pollutant removal.

- **Stormwater Inspections and Maintenance** – This process could be improved through strengthen the three major steps. Step 1: Strengthen the GIS/database system to help track compliance with inspections and maintenance. Step 2: Integrate inspections into both GIS/database and maintenance program. Step 3: Make maintenance driven by inspection results, and tracked through GIS/database system.
- **Resource Protection Areas (RPA)** – The RPA program resulted in the protection of riparian buffers throughout the Broad Run watershed and the County should continue to support this program.

- **Strengthen Illicit Discharge Detection and Elimination Program (IDDE)** – The County should consider strengthening its IDDE program since correction of these discharges are often much more cost effective than Stormwater Management Best Management Practice (SWM BMP) retrofits or other standard watershed load reduction methods.
- **Implement Water Quality Monitoring** – The County should consider implementation of a water quality monitoring program that helps address the most pressing watershed management issues and that complements other existing water quality monitoring programs conducted by DEQ and Occoquan Watershed Monitoring Lab (OWML). A water quality monitoring program could be used to meet MS4 stormwater permit requirements, identify sources of pollution, and track improvements in watershed conditions.
- **Implement Benthic Monitoring** – The County should consider establishment of a benthic (i.e. stream invertebrate) monitoring program targeted at meeting future MS4 permit requirements and tracking down streams with significant pollution issues. The additional biological information could help the County track improvements in stream conditions due to management actions, and to more effectively target where watershed management actions would be the most effective.

II. PROJECT DESCRIPTION

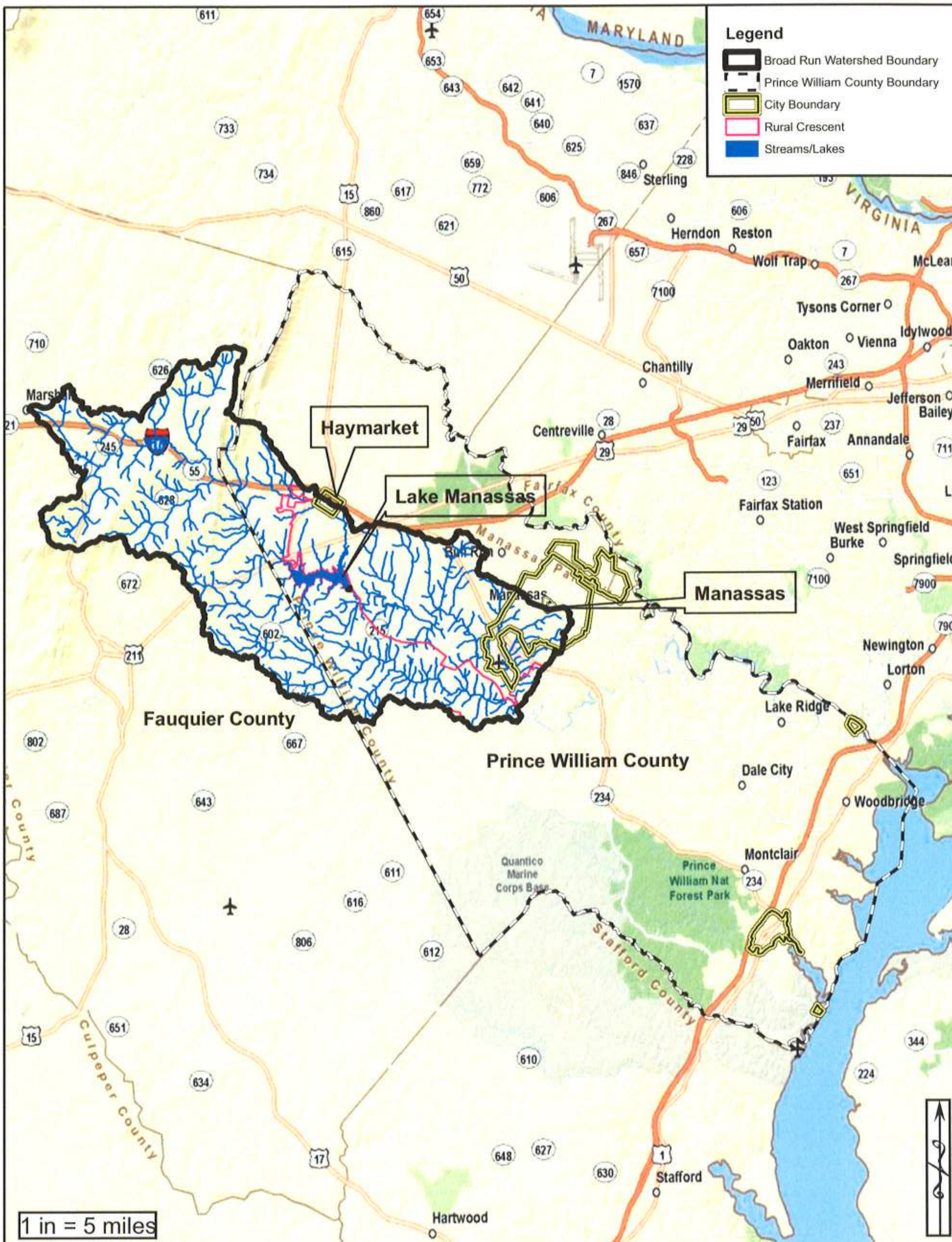
The Prince William County, Public Works Department, Environmental Services Division, Watershed Management Branch conducted a study of the Broad Run watershed within the County. The investigation included an evaluation of watershed conditions based on existing Geographical Information System (GIS) data, the assessment of the condition of stream channels and stormwater management facilities within representative subwatersheds of the Broad Run watershed, and identification of potential watershed management Capital Improvement Projects (CIP).

Broad Run flows southeast from its headwaters in Fauquier County and discharges into the Occoquan River, draining approximately 120 square miles (**Figure 1**). Approximately 73 square miles of the Broad Run watershed are located within the boundaries of Prince William County including the Cities of Manassas and Haymarket. Lake Manassas, a 677 acre public drinking water supply holding 5.1 billion gallons of water, was formed by impounding Broad Run. The artificial impoundment is geographically centered within the Broad Run watershed. The Broad Run watershed comprises approximately 20% of the total surface area of the County.

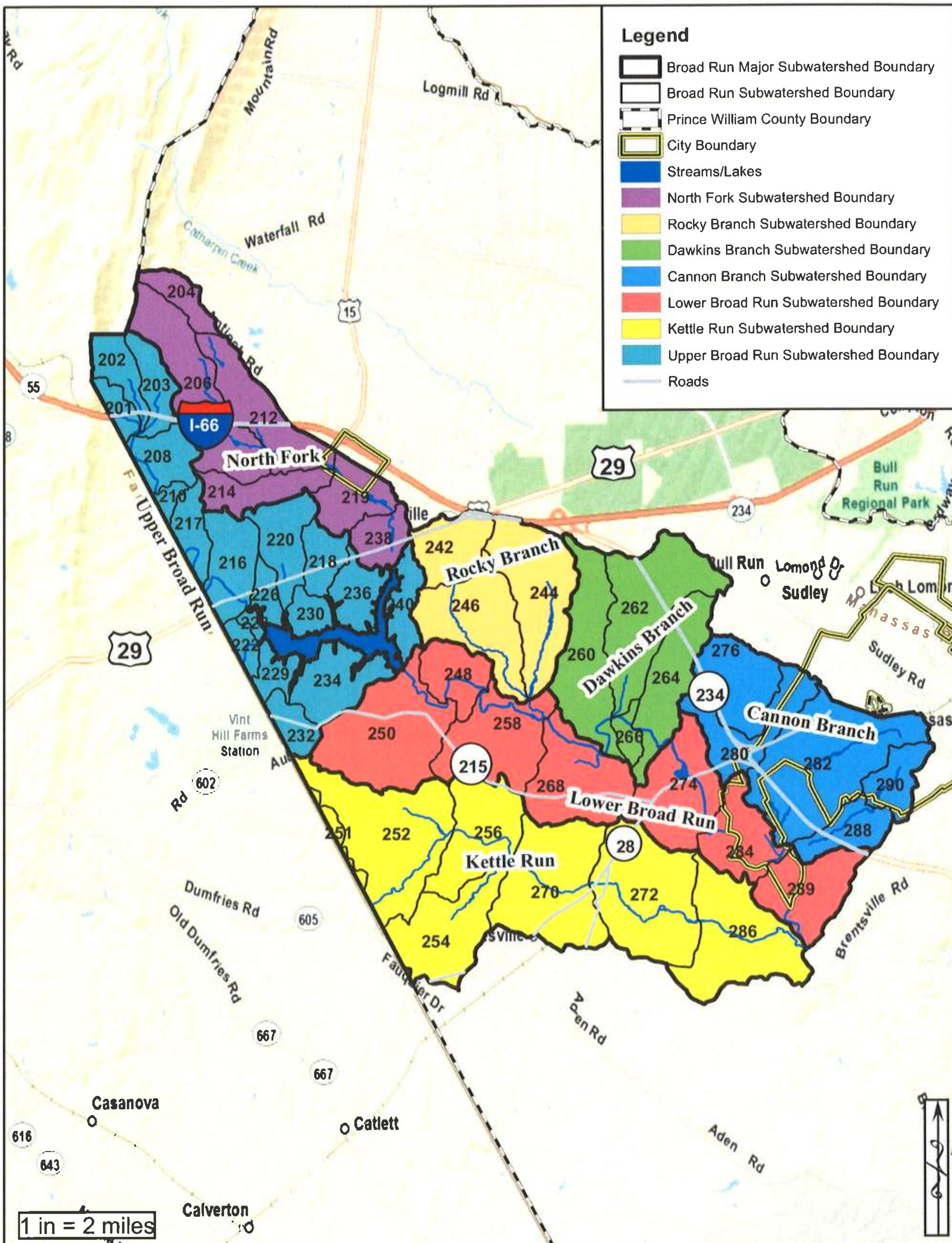
Broad Run is one of ten watersheds within Prince William County. Each watershed contains a large number of subwatersheds. In the Broad Run watershed there are 50 subwatersheds or catchments. The county has assigned an ID number to each subwatershed. To facilitate the analysis of existing GIS data and the characterization of the Broad Run watershed, the 50 subwatersheds were combined to form seven Major Subwatersheds (**Figure 2**). The subwatersheds which comprise the Major Subwatersheds of Broad Run include:

- Upper Broad Run upstream of Lake Manassas: (subwatersheds 201, 202, 203, 208, 210, 216, 217, 218, 220, 222, 226, 228, 229, 230, 232, 234, 236, and 240)
- North Fork: (subwatersheds 204, 206, 212, 214, 219, and 238)
- Rocky Branch: (subwatersheds 242, 244, and 246)
- Dawkins Branch: (subwatersheds 260, 262, 264, and 266)
- Cannon Branch: (subwatersheds 276, 280, 282, 288, and 290).
- Broad Run Mainstem downstream of Lake Manassas: (subwatersheds 248, 250, 258, 268, 274, 284, and 289)
- Kettle Run: (subwatersheds 250, 252, 254, 256, 270, 272, and 286)

This watershed study identifies opportunities to address sources of sediment, other pollutants and stream degradation that may be contributing to the listing of the Broad Run as impaired. Based on the results of the study, potential watershed management CIPs were identified. This initial inventory will lead, in future phases, to more detailed studies or surveys of each potential watershed management project, and eventually to final design and construction of individual projects.



Source:	Title:	Figure:
Prince William County GIS, Esri World Street Map	**Broad Run Watershed Map**	1



Source:	Title:	Figure:
Prince William County GIS, Esri World Street Map	**Broad Run Major Subwatershed Map**	2

The first phase of this watershed study was to compile and evaluate existing GIS data for the Broad Run watershed within the County. Data was compiled from the County and other sources to characterize the watershed following the guidance in the 2008 Comprehensive Plan, Environmental Chapter –Action Strategy EN7.1. The results of this characterization are presented in Section III of this report.

The second phase of this watershed study involved inspecting existing stormwater facilities, assessing the condition of stream channels, inventorying problem areas along stream channels, and identifying opportunities to retrofit stormwater management where it is currently lacking. Due to the large size of the Broad Run watershed within Prince William County, this study was narrowed to five major subwatersheds which are representative of conditions found throughout the Broad Run watershed. The subwatersheds selected for detail study are identified in Section III of this report.

Even though the scope of the study was narrowed to five major subwatersheds, there are extensive amounts of stream channel, stormwater facilities, and outfalls included in these subwatersheds. For both the stormwater inventory and the stream assessment, additional steps were taken to screen the existing facilities and stream channels to identify those sites where degradation was most likely and where a watershed improvement project would be compatible with the existing land use and ownership.

Based on the results of the stream assessments and stormwater inventory, the sites were prioritized and ranked within each subwatershed and across the entire study area. Based on the prioritization and ranking, specific projects were carried forward into conceptual design. Design narratives and cost estimates were developed for each project.

The steps in the study process are detailed in the following chapters and supported by detailed data provided in the Appendices.

III. WATERSHED CHARACTERIZATION

As part of the Broad Run Watershed Study, the major subwatersheds in the Broad Run watershed were characterized based on the resources listed in the 2008 Comprehensive Plan, Environmental Chapter–Action Strategy EN7.1. The goals of this task were three fold:

- To provide a description of the condition of Broad Run watershed based on existing data sources,
- To evaluate the utility of the existing County data sources, and identify data gaps or limitations, and
- To make recommendations to improve the County's ability to characterize watersheds.

Methods

The data included in **Table 1** was collected from County and other sources, from which maps and tables were generated to characterize the Broad Run watershed and its major subwatersheds.

Table 1:
Watershed Planning Data and Sources

Data as listed in EN7.1	Sources
Existing Impervious Surface	Data from County GIS
Stormwater Management Facilities	Data from County GIS and database
Water Quality Stations	Data from DEQ
Forest Cover/Tree Cover	Data from County GIS
Topography	County, but of limited usefulness at watershed scale
Soils and Geology	Data from County GIS and NRCS database
Floodplains	Data from County GIS
Hazardous Waste Sites	Data from DEQ and EPA
Wells	Well Data is not available in digital format
Land Ownership	Data from County property assessment
Subwatershed Area	Data from County GIS
Land Use from Zoning	Data from County GIS

The additional data listed in **Table 2** was included in the analysis. This data is typically used for watershed planning but not included in the Action Strategy EN7.1:

Table 2:
Additional Watershed Planning Data and Sources

Additional Data	Sources
Wetlands	National Wetlands Inventory
Hydropolygons	County GIS
Streams	County GIS

A detailed memorandum was generated highlighting the data sources used to generate mapping and tabular data, how the data can be used for watershed planning, where there are limitations or gaps in the available data, and recommendations to improve the usefulness of existing data. The following is a summary of the detailed memorandum. Watershed characterization maps are included in **Appendix A**.

Results

The available GIS and related data were plotted and evaluated to determine its usefulness in watershed planning, and to characterize the Broad Run Watershed.

Zoning

The County's zoning GIS data was used to characterize the existing land use within the watershed (**Appendix A, Figure A-1**). Land use within a watershed can have profound impacts on water quality and stream condition. Zoning may not reflect actual land use, or may not differentiate between land uses that have significantly different impacts on a watershed but which fall under the same zoning.

The zoning data provides an understanding of intended land uses within the Major Subwatersheds (**Table 3**). Dawkins Branch and Cannon Branch have the greatest levels of high density zoning while Kettle Run has the lowest level of zoning supporting development. Dawkins Branch contains the highest percentage of industrial zoning, which often results in high levels of impervious surface.

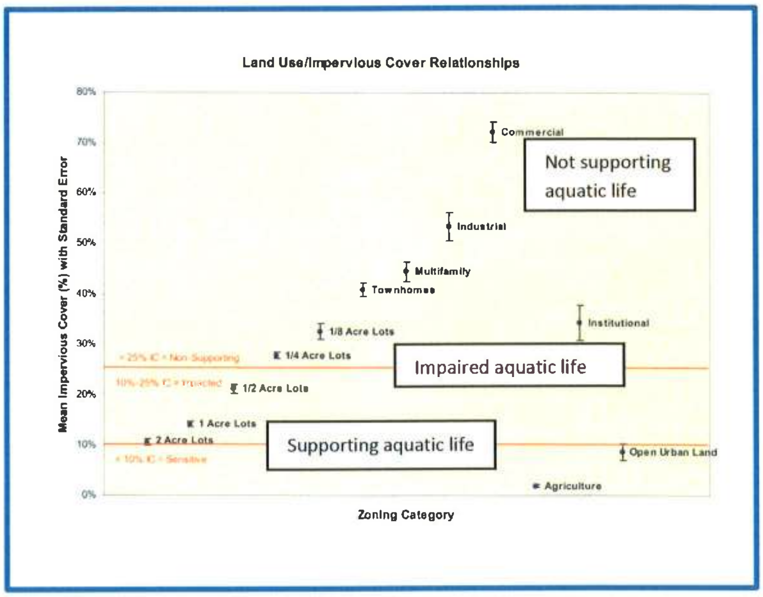
Table 3:
Zoning by Major Watershed

Zoning Percent of Each Major Subwatershed								
Major Subwatersheds	Business	Residential	Industrial	Mixed	Agricultural	Office	(City of Manassas/ Haymarket)	Percent excluding Agricultural
Cannon Branch	1%	10%	16%	14%	11%	-	48%	89%
Dawkins Branch	1%	29%	39%	14%	17%	1%	-	83%
Kettle Run	0%	0%	0%	1%	98%	-	-	2%
Lower Broad Run	1%	8%	5%	27%	51%	1%	8%	49%
North Fork	3%	13%	4%	4%	72%	1%	4%	28%
Rocky Branch	7%	19%	28%	14%	31%	1%	-	69%
Upper Broad Run	0%	7%	0%	16%	77%	-	-	23%
Broad Run Watershed	1%	10%	10%	13%	59%	0%	8%	33%

From a watershed planning perspective, actual land use/land cover data is more useful in watershed management than zoning data. For example, agricultural zones may be used for either row crops or pastures which have significantly different impacts on adjacent streams and water quality. Land use/land cover data would be more useful in a watershed planning context, while zoning can be valuable in predicting future land use. Land use / land cover data is being used in the Environmental Protection Agency (EPA) Chesapeake Bay model to allocate pollution loads.

Impervious Surface

Impervious surface is a significant contributor to watershed degradation (**Appendix A, Figure A-2**). It is a surrogate measure of how much the watershed hydrology has been disrupted by development. The Impervious Cover Model (IC Model) proposes that if impervious cover is less than 10%, a watershed is relatively un-impacted (i.e. "Supporting" the biological community). From 10 to 25% impervious cover, there is an increasing level of degradation but the conditions can be rehabilitated (i.e. stream is "Impaired"). Between 25 and 40% impervious cover, the watershed is considered seriously impaired (i.e. "Non-Supporting" of aquatic life). Above 40% impervious cover, the watershed is considered "urban drainage". Each of these categories can have different watershed management goals and strategies.



However, not all impervious cover is effectively connected to the stream system. Some roof tops drain into pervious lawns, and runoff does not flow directly into a stream. Small buildings and other structures may also be "dis-connected" impervious cover.

Equally as important in characterizing watershed health and potential stream condition is the use of the pervious cover or any land that is not considered impervious. Forests tend to be protective of watershed conditions, while agricultural lands tend to contribute sediment and pollutants. Lawns tend to behave as nearly impervious, with high runoff rates, as well as high exports of nutrients. Just considering Impervious Cover may not provide a very accurate prediction of watershed health.

The County has very good data on roads, commercial/industrial buildings, parking lots and residential homes which are the major contributors to impervious cover. The amount of impervious surface ranges from 2 to 21% among the major subwatersheds (**Table 4**). The majority of the impervious surface is contributed by roads and parking lots (70% of total). Residential and commercial buildings represent only 30% of the impervious surfaces in the watershed.

**Table 4:
Impervious Cover by Major Subwatershed**

Major Subwatershed	Percent Impervious Surface	Impervious Cover Model Classification
Cannon Branch	21%	Impaired
Dawkins Branch	21%	Impaired
Kettle Run	2%	Supporting
Lower Broad Run	8%	Supporting
North Fork	7%	Supporting
Rocky Branch	18%	Impaired
Upper Broad Run	4%	Supporting
Watershed Total	10%	Supporting/Impaired

Kettle Run and Upper Broad Run are within the Rural Crescent and have a low percentage of impervious surface. The IC model would predict these watersheds to have relatively healthy streams. But the streams in these watersheds may be impacted by past and present agricultural land use.

Lower Broad Run and North Fork have impervious cover less than 10%, but significantly higher than Kettle Run or Upper Broad Run. Based on the IC model, the streams in these watersheds may show some signs of degradation, but should still support a relatively healthy biological community.

Cannon Branch, Dawkins Branch, and Rocky Branch have impervious cover exceeding 10% but below 25%. The IC model would classify these watersheds as "impaired". With proper stormwater management and stream restoration, the streams in these watersheds may be rehabilitated to provide improved biological conditions.

The ability of the IC model to predict stream condition solely on watershed impervious cover is limited. Watersheds can have much poorer biological communities than the IC model would predict due to water quality impacts from other types of human activities such as agriculture, or pollution discharges. However, the biological condition of a stream is rarely better than is predicted by the IC model.

Forest Cover

Forest cover in a watershed is a good predictor of overall stream health or biological condition. Forests provide many protective functions to stream, such as shading, low runoff rates, and low nutrient loading. Portions of a watershed that have large forest tracts will tend to have higher quality streams than developed portions of the watershed. Forested watersheds also tend to have better quality streams than agricultural watersheds.

The analysis of forest cover for the Broad Run watershed was hampered somewhat by the configuration of the existing County GIS data. All trees, whether individual trees, tree lines or forest tracts, are lumped into the same data layer. Lumping individual trees, particularly landscape trees in residential and commercial areas, into the same data as extensive forest tracts, inflates the actual area of the watershed that is benefiting from a forested condition.

Forest cover ranged from a low of 19% in Cannon Branch to a high of 59% in Upper Broad Run (**Appendix A, Figure A-3**). Kettle Run, which is only 2% impervious cover (i.e. developed), is only 39% forested, reflecting that a majority of Kettle Run is open land (i.e. pastures, crop lands, large lots, golf courses). Rocky Branch which has one of the highest percent impervious cover (18%) also has the second highest forest cover (47%). The average forest cover across the entire watershed is 41%.

Another measure of the protective functions of forests is to consider the amount of Resource Protection Areas (RPA) within the watershed. Among the Major Subwatersheds, the RPAs generally account for 6-9% of the total area. The North Fork, with its many perennial streams and wetlands, had the highest level of RPA (13.6%). Resource Protection Areas contribute significantly to the protection of forest cover in a watershed.

Wetlands

Wetlands provide numerous functions within a watershed, including water quality filtering, flood storage, wildlife habitat, and groundwater recharge. A watershed with a relatively high percentage of wetlands will more likely have healthy, intact stream systems and good water quality.

The extent of wetlands in the watershed was estimated based on National Wetland Inventory (NWI) GIS mapping (**Appendix A, Figure A-4**). Within Broad Run watershed, the major subwatersheds generally contain 5 to 10% wetlands, except for the North Fork major subwatershed which has an estimated 22% wetlands. The majority of the wetlands are forested and occur primarily along streams and floodplains. Across the entire watershed within the County the wetland mapping indicates over 700 acres of emergent wetlands and 3,200 acres of forested wetlands, which represents approximately 8.5% of the entire watershed.

Hydric Soils

Hydric soils are saturated for long periods of time, and often occur within wetlands. Most wetland mapping, like the NWI mapping, is incomplete and only identifies a limited number of the most obvious wetlands in a watershed. Hydric soil maps can be used to identify areas that are not indicated as a wetland on the NWI mapping but which could potentially be a wetland. In Broad Run, there are two distinct types of hydric soils:

- **Floodplain Hydric Soils** – These hydric soils are occasionally flooded by adjacent streams, and tend to have a sandy texture. These soils tend to occur along the floodplains of larger streams. In Broad Run there are two floodplain hydric soils. Aden soils flood occasionally, and Hatboro soils flood frequently. Both of these soils also have a shallow water table.
- **Non-Floodplain Hydric Soils** – These hydric soils are found in uplands between stream channels, along headwater streams, or in areas of red parent material soils which have a high clay content which restricts water infiltration. Water perches or ponds on top of the soil, sometimes for long durations. The mapping of these soils often includes areas along small stream floodplains. There are three non-floodplain hydric soils in Broad Run: Baile soils have a water

table within 0.0–0.5 feet of the surface. Albano soils have a water table within 0–1.5 feet of surface. Waxpool soils have a water table within 0–1.0 feet of the surface. None of these soils are recorded as flooding.

Hydric soils were mapped for the watershed based on data from the Natural Resources Conservation Service (NRCS) (**Appendix A, Figure A-5**). Across the entire watershed, approximately 13% of the soils are hydric. The Upper Broad Run major subwatershed is only 7% hydric soils, while Rocky Branch and North Fork major subwatersheds are over 20% hydric soils. Compared to the existing NWI wetland mapping, there are three times more acreage of hydric soils than wetlands. This discrepancy is a good indication that many wetlands are not currently mapped by the NWI.

Permeable Soils

Watershed planning should strive to protect soils with high infiltration rates. Mapping areas of permeable soils helps to meet the following watershed planning goals:

- Protecting groundwater recharge areas which will maintain stream baseflows and reduce surface runoff.
- Identifying areas where bioretention and other infiltration practices should be encouraged.
- Identifying areas where increased impervious surfaces would generate the greatest increases in surface runoff.

When reviewing soils data, it's important to consider the permeability of the majority of the soil profile. Some soils are shallow and sit on bedrock, and thus are not permeable. Other soils have a tight clay layer in the profile that inhibits infiltration. For this study soils were selected that had greater than 0.5 inches per hour hydraulic conductivity (vertical infiltration) through at least the upper 40 inches of the soil profile. Some highly permeable soils are found on floodplains (i.e. sandy deposits), and others are found in upland areas. Some hydric soils have high infiltration rates, but would not be suitable for infiltration practices due to high groundwater. Based on a review of the soils data from NRCS, the following soils have permeable conditions: Bermudian, Cordorus, Comus, Elsinboro, Legore Oakhill, Manassas, Meadowville, and Neabsco Quantico.

Combining the County's soils mapping and the NRCS database allowed the permeable soils identified above to be mapped (**Appendix A, Figure A-6**). The Broad Run watershed within the County has approximately 13% permeable soils. Generally, the major subwatersheds have 10-20% permeable soils. Rocky Branch subwatershed which has soils with high clay content has the lowest percentage of permeable soils (3.4%). This subwatershed may be less suitable for stormwater infiltration practices than other subwatersheds.

Hydrologic Soils Groups

This soil classification reflects the runoff production potential of the soil under saturated conditions. The Broad Run watershed has the following Hydrologic Soil Groups:

- B – Moderate low runoff potential
- C – Moderately high runoff potential and
- D – High runoff potential.

Runoff potential is a combined result of the clay content, water transmission, and the elevation of the water table. Areas with B soils should be reserved for open space, Low Impact Development (LID), and infiltration practices, allowing higher density development to be focused in areas with C and D soils. These soils already have relatively high runoff rates and are less suitable for infiltration practices.

Overall, the Broad Run watershed has 19% B, 44% C, and 37% D soils (**Appendix A, Figure A-7**). Rocky Branch has very little B soils (6%) and a very high percentage of D soils (77%). Rocky Branch also has the highest percentage of hydric soils, and lowest percentage of permeable soils, so infiltration practices may be of limited use in this major subwatershed. Upper Broad Run has a much higher percentage of C soils and lower percentage of D soils than the other subwatersheds. The management of the Upper Broad Run major subwatershed should stress preservation of highly permeable soils and the use of infiltration practices.

Floodplains

Floodplains are an important component of a watershed and its streams. Undeveloped floodplains often contain wetlands, forests and other features that provide benefits to the stream ecosystem. Developed watersheds often lack natural floodplains along streams, which can lead to increased pollutant loads, increased damage during floods and increased erosion/scour within the stream channel. Protection of undeveloped floodplains should be a goal of a watershed management program.

Federal Emergency Management Agency (FEMA) floodplain mapping was used to estimate how much floodplain is located throughout the Broad Run watershed (**Appendix A, Figure A-8**). Generally, the major subwatersheds are composed of 6-9% FEMA floodplain. The lower Broad Run watershed has significantly larger floodplains which account for up to

What is a Floodplain?

Every stream has a floodplain, even streams that only flow during part of the year. To a scientist, a natural floodplain is the area adjacent to a stream that floods very frequently.

To an engineer, the floodplain is often the portion of the stream valley that is regulated by the Federal Emergency Management Agency (FEMA). Building in or filling the FEMA floodplain is regulated in order to protect the public from flooding. The FEMA floodplain is typically the area of the stream valley that is flooded during the 100 year storm. FEMA may not study smaller streams, those with little potential for development, or with low flood hazards. So not all streams have a regulatory FEMA floodplain, but all streams have a natural floodplain.

18% of the total subwatershed area. Averaged across the watershed, 10% of the watershed is FEMA floodplain.

Water Quality Data and Discharges Permits
A key set of data for any watershed management program is water quality data. Currently, there are limited water quality data available for Broad Run. The Virginia Department of Environmental Quality (DEQ) has monitoring stations scattered widely across the state. Each watershed may only have a few monitoring stations, and few are long-term stations. Within the Broad Run watershed in Prince William County there are seven DEQ monitoring stations, and only one station has recent water quality data (**Appendix A, Figure A-9**). The DEQ does not have a benthic monitoring station within the watershed. The Occoquan Watershed Monitoring Lab (OWML) has long-term water quality monitoring stations within the Broad Run watershed. There is one station (ST70) upstream of Lake Manassas and one station (ST30) near Linton Hall Road. These stations are sampled multiple times per month, including both baseflow and storm event samples.

Another set of data that a watershed management program should consider is the location of all industries permitted to discharge waste to the watershed's streams. Permit holders are allowed to discharge pollutants to state waters through the Virginia Pollution Discharge Elimination System (VPDES) program managed by DEQ. Depending on the type of facility and volume of discharge, these facilities may create a pollution problem downstream of the discharge. There are only three VPDES permit holders in Broad Run watershed (**Appendix A, Figure A-9**).

Hazardous Materials
An understanding of the location of permanent storage facilities and spills of hazardous materials can help watershed managers identify potential pollution hotspots within a watershed (**Appendix A, Figure A-10**). Data of petroleum releases and petroleum storage facilities were obtained from DEQ. GIS data of hazardous materials sites were collected from EPA. There are 135 recorded petroleum storage facilities in Broad Run watershed within the County. EPA reports 13 additional facilities which storage potentially hazardous materials. The storage facilities are generally located along the main roadways such as Lee Highway (US-29/15). The location of these facilities can be used to define stormwater "Hotspots" where there is a greater likelihood of contaminated runoff and higher potential for spills. The County can also use this data to assist in targeting outfalls for screening under their Inappropriate/Illicit Discharge Detection and Elimination (IDDE) program, a component of the County's MS4 permit.

Within the Broad Run watershed, DEQ data indicates there have been 173 reported petroleum releases. Although the petroleum spills are concentrated along major roads, the spills are also fairly well distributed across all of the subwatersheds. Petroleum spills can have very significant impacts to the ecology of streams and wetlands.

GIS Recommendations to Improve Watershed Management

For each data set used in the watershed characterization, a set of recommendations were made to improve the functionality of the existing County GIS data, to add new data to the County GIS system or to otherwise improve the County's ability to characterize watersheds based on existing data.

Improvements to Existing County Base Mapping (subwatersheds boundaries, streams, etc.):

- Use the EPA catchment data set, county contour mapping, drainage system mapping, and aerial photography to update and revise existing subwatershed mapping prior to each watershed study.
- To facilitate data summarization, subwatersheds could be compiled into a new layer of "Major Subwatersheds" that represent continuous stream systems.
- Code the County's hydropoly file to separate out the large lakes, small ponds, and stormwater facilities. Consider not including stormwater facilities or marshes in this layer since these can be covered in other data files.
- Use a combination of topographic mapping, existing stream files, and aerial photography to generate an updated stream layer that is a consistent representation of the existing stream network within the watersheds.

Improve Ability to Characterize Watersheds as part of a Watershed Study

- Compile a Land Use/Land cover GIS layer that indicates current uses of the land, which may be different than zoning. Land Use data should differentiate between various agricultural land uses such as cropland, pasture, and concentrated livestock. This data can be used to help County meet its requirements under the EPA Chesapeake Bay Total Maximum Daily Load (TMDL).
- Impervious surface estimates can be improved by converting driveways from a line to a polygon, and limiting driveway coding to only residential property. Some parking areas and entrance roads in commercial properties are currently coded as driveways. These areas should be re-coded as roadways and parking lots, or coded separately from residential driveways.
- The estimate of forest cover within the watersheds could be improved by creating separate shapefiles for individual trees, treelines/fencerows, and forested tracts. Currently these types of data are all contained within the same GIS files. In addition, giving each forested tract a unique identifier will allow watershed planners to identify individual large tracts for protection or evaluation. An additional step which would improve watershed characterization would be to identify non-forested vegetation outside of forest polygons, such as pastures, marshes, etc, in order to identify large, vegetated but non-forested parcels.
- The ability of the County to predict the presence of wetlands could be improved by combining existing data for wetlands, hydric soils, and floodplains to generate a "Potential Wetland" GIS layer. This compiled layer could be further refined by reviewing the results against aerial photography and topography. The resulting "Potential Wetland" layer could be used by planning and watershed divisions to anticipate where wetlands exist that may warrant additional protection or require permits if disturbed.

Add Existing Data from Other Sources to the County GIS System

- Incorporate NWI wetlands mapping into the County GIS to improve ability to avoid or minimize impacts to these resources during land use planning. Identify wetland mitigation banks, and individual wetland mitigation sites, and include in County GIS. The US. Army Corps of Engineers RIBITS site can be used to find all mitigation banks in the county. Individual wetland mitigation site may be identified based upon approved development plans.
- Attach the NRCS soils databases to the soil GIS files to allow for more detailed use of existing soils mapping. Include hydric soils as a standard attribute in the soils GIS files.
- County should periodically download DEQ data (hazardous materials, water quality monitoring stations, etc.), and incorporate into County GIS.
- Work with the Health Department to incorporate private wells and septic systems into the County GIS.

Improve GIS functionality with other County Programs

- Link the County GIS data of stormwater facilities to the database of stormwater facility attributes maintained by the Watershed Division to improve interaction between these two sets of information. Develop a process for revising and updating both sets of data based on inspections, watershed studies and other data.
- Use GIS to help manage field inspections of stormwater facilities, including scheduling of inspections and reporting of results.
- Include all stormwater facilities in the County in the GIS mapping, regardless of ownership. Currently, only those stormwater facilities that are owned by the county or for which there is a maintenance agreement with the county are included. Facilities owned by Virginia Department of Transportation (VDOT) or other agencies are not included in the GIS or database.

Selecting Subwatersheds for Detailed Study

Due to the large size of the Broad Run watershed within Prince William County, this study was narrowed to five primary subwatersheds based on predominant land use / zoning data (**Figure 3**). Each subwatershed selected for detailed study is representative of a predominant land use such as residential, commercial or agricultural (**Table 5**). This subset of subwatersheds covers 13.9 square miles or approximately 19.3% of the watershed within the County. The character of each subwatershed can be summarized as follows:

- **Tributary to Rocky Branch (244)** subwatershed includes the Jiffy Lube Pavilion, a super fund site, a significantly large forested area, and substantial floodplain and "upland" wetlands. This subwatershed is zoned for future development. This subwatershed provides an opportunity to consider watershed planning issues surrounding the development of the large forested track within the subwatershed. This subwatershed drains 1,610 acres, contains 25 stormwater facilities, and 48,489 linear feet (lf) of streams.
- **Rocky Branch (246)** subwatershed is primarily residential with a large number of relatively recently built stormwater management facilities. This subwatershed provides the opportunity to

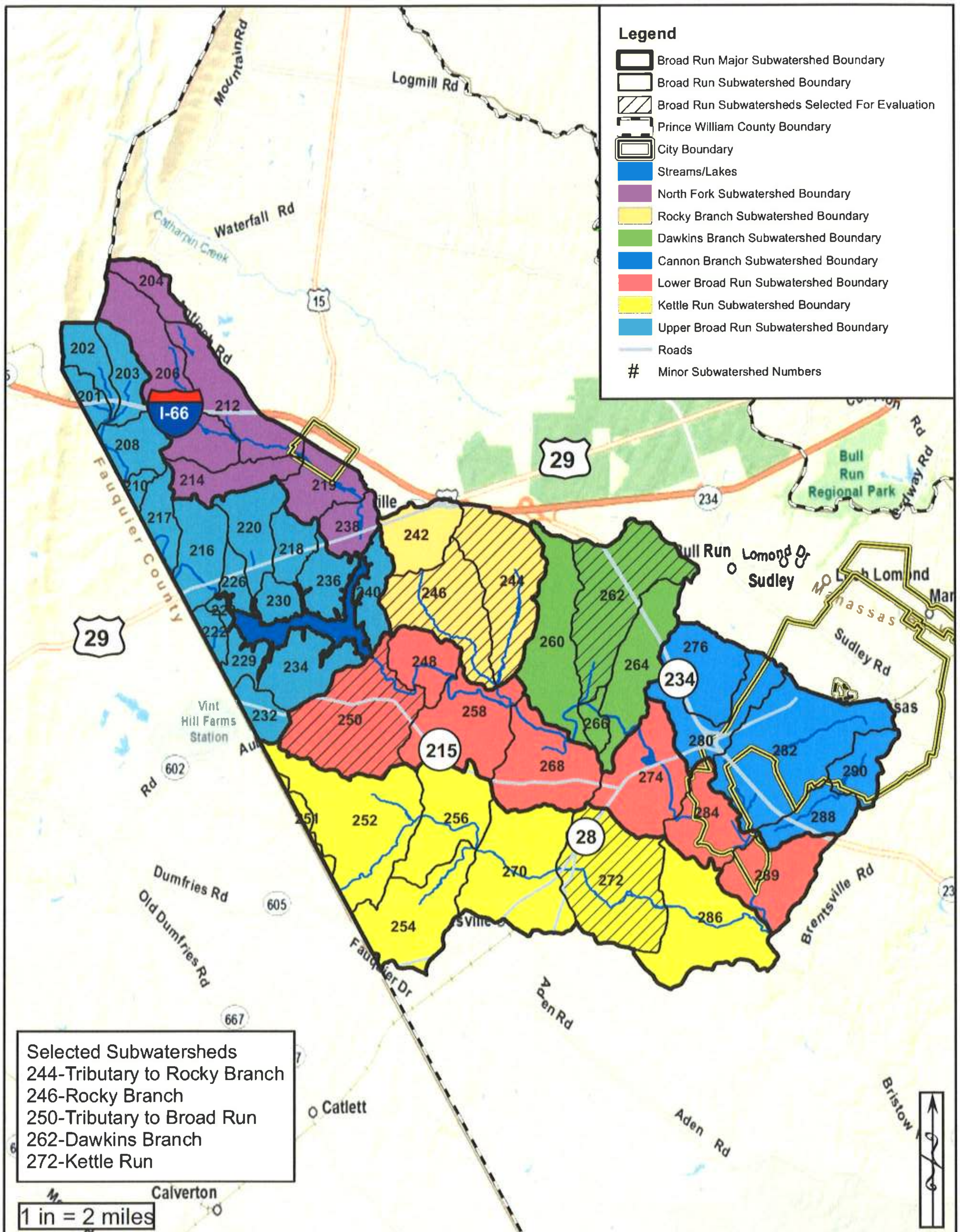
evaluate the condition and function of a large number of relatively new stormwater facilities, including a significant number of bioretention sites. This subwatershed drains 1,449 acres, contains 46 stormwater facilities, and 32,880 lf of streams.

- **Tributary to Broad Run (250)** is composed of agricultural lands, a park, a golf course, and low density residential development within the rural crescent. There are no recorded stormwater facilities in this subwatershed. This watershed was selected to allow for evaluation of streams in the rural crescent that may be impacted by agriculture or other low density land uses. This subwatershed drains 1,975 acres and 78,442 lf of streams.
- **Dawkins Branch (262)** subwatershed has experienced significant levels of development. Much of the development is commercial with many small stormwater facilities. This subwatershed also contains a significant amount of residential development. This subwatershed was selected because it has the highest rate of commercial development in the watershed. It drains 1,838 acres, contains 50 stormwater facilities, and 43,090 lf of streams.
- **Kettle Run (272)** subwatershed is dominated by a large forested parcel, rural and suburban residential land, and a county park within the rural crescent. It has several headwater streams which may be minimally impacted by current land use. It provides an opportunity to consider these streams as reference sites for comparison to headwater streams in developed subwatersheds. It drains 2,001 acres, contains 6 potential stormwater facilities, and 55,168 lf of streams.

Table 5:
Characteristics of Five Selected Subwatersheds

Major Subwatershed	Acres	Streams (l.f.)	Stormwater Facilities	Percent Impervious Surface	Subwatershed Characteristics
Tributary to Rocky Branch (244)	1,610	48,489	25	13%	Contains a large undeveloped forested parcel surrounded by residential and commercial development
Rocky Branch (246)	1,449	32,880	46	16%	Primarily residential with large number of stormwater facilities
Tributary to Broad Run (250)	1,975	78,442	0	3%	Rural residential, golf course and agricultural
Dawkins Branch (262)	1,838	43,090	50	26%	High percentage of commercial land use with many small stormwater facilities
Kettle Run (272)	2,001	55,168	6	3%	Predominately agriculture, but includes some residential and a park
TOTAL	**8,873**	**258,069**	**127**		

Number of stormwater facilitates (dry basins, wet ponds, bioretention) includes potential facilities identified from aerial photography



Source: Prince William County GIS, Esri World Street Map

Title: Broad Run Selected Subwatershed Map

Figure: 3

IV. STORMWATER INVENTORY APPROACH AND RESULTS

To help guide the stormwater portion of this study, the first five steps in an eight step process described in the *Manual 3: Urban Stormwater Retrofit Practices Manual (Center of Watershed Protection)* were completed. Traditionally, this process focuses on identification of stormwater retrofit opportunities. However, this study included consideration of existing stormwater facility condition and any need for repairs to address existing deficiencies as well as addressing the potential for water quality retrofits. The five steps in evaluating stormwater facilities were:

1. **Stormwater Scoping –** The study approach was refined to meet local watershed objectives and stormwater management requirements.
2. **Desktop Analysis** – Existing stormwater facilities were screened using existing county GIS data and aerial photography.
3. **Stormwater Facility Reconnaissance Investigation –** Each stormwater facility identified in the desktop analysis was evaluated in the field, noting the existing condition, deficiencies, and retrofit feasibility.
4. **Stormwater Facility Evaluation and Ranking** – Each facility was prioritized (i.e., high, moderate, or low) and assigned a numerical ranking. The high and moderate priority sites were selected to carry forward into conceptual design development.
5. **Development of Conceptual Design** – For each stormwater site, conceptual designs were developed to address the identified deficiencies or to improve water quality treatment.

Completion of these steps will allow the County to progress into the later phases of watershed management, including subwatershed treatment analysis, final design, and construction.

4.1. Stormwater Scoping Process

In order to clearly articulate the goals of the stormwater inventory and the development of proposed repair and retrofit projects, the following guiding principles were defined:

- Core Stormwater Objectives
- Minimum Performance Criteria
- Preferred Retrofit Treatment Options
- Maintenance and Repairs

Core Stormwater Objectives – The projects identified in this watershed study focused on addressing sources of watershed impairments such as stream sedimentation, channel erosion, nutrient enrichment, toxic pollutants, and disrupted watershed hydrology. However, the projects addressed other objectives as well, including:

- Correcting safety issues
- Insuring that stormwater facilities are functioning as intended
- Improving water quality function of existing facilities (i.e., retrofit for water quality)
- Improving protection of downstream channels

- Improving ease of maintenance

Minimum Performance Criteria – The two primary performance criteria of concern in this study were to provide control of the water quality volume and the channel protection volume where practicable when considering retrofits or repairs. The two performance criteria were:

- **Water Quality Volume (WQv)**: Target the rainfall events that generate the majority of stormwater pollutants in a year by providing 100% control of the first one inch of runoff from impervious surface.
- **Channel Protection Volume (CPv)**: Target storms generating bankfull or sub-bankfull floods that cause stream channel erosion, which would typically require 60% control of the 1 year, 24-hour storm event (2.4 inch event).

Preferred Retrofit Treatment Options – The study focused on improvements that could be made at the subwatershed scale to address water quality and channel protection. The treatment options most applicable to a subwatershed scale are storage retrofits. Storage retrofits are more cost effective than on-site retrofits due to the economies of scale. Storage retrofit projects usually treat 1 to 500 acres, are generally constructed on public lands, and typically rely on extended detention, wet ponds, and constructed wetlands to meet water quality and channel protection criteria.

On-site retrofits typically target individual rooftops, parking lots, streets, stormwater hotspots, and other small projects. While on-site projects may cumulatively contribute to improvements in water quality and quantity, the potential sites within this large watershed are too numerous to address at the subwatershed scale and were not addressed in this study. On-site retrofits are typically addressed in a catchment or neighborhood scale study.

The initial watershed management strategies for storage retrofit opportunities included:

- **Retrofit of existing extended detention (ED) dry ponds** – Conversion to constructed wetlands to improve water quality efficiencies.
- **Retrofit of existing wet ponds** – Add or increase water quality volume storage, add wetlands, or modify detention.
- **Adding new storage below existing outfalls** – Limited to outfalls less than 36 inches, this option includes creation of off line bioretention basins or wetlands within open land between the outfall and the receiving stream.

Maintenance and Repairs – In addition to considering each facility for its water quality retrofit potential, the field assessments also addressed the existing condition of the facility. Typical repairs that might be noted during the field investigations would be replacing or adding a trash rack to a riser, addressing erosion at a riser or headwall, or replacing a broken low flow outlet structure. A number of dry basins contained wetland vegetation due to groundwater or shallow ponding. These sites were not flagged as needing vegetation maintenance unless the wetland vegetation was clogging inlets or outlets. The presence of the wetland vegetation was considered a water quality improvement over mowed grass.

If there was unmaintained upland vegetation within a dry basin, the facility was flagged as needing maintenance, particularly if woody vegetation was limiting the inspection of the inlets or riser structure.

4.2. Desktop Analysis

The desktop analysis consisted of compiling existing county GIS mapping layers, databases, and aerial photography. Each subwatershed was screened for stormwater facilities suitable for evaluation in the field. The following screening criteria were used to narrow the selection of stormwater facilities to individual sites to carry forward into the stormwater facilities reconnaissance inventory:

- Dry basins, wet basins, and bioretention facilities were included in the screening, but underground facilities and trenches were not considered.
- Dry basins were preferred over other types of stormwater facilities because they are typically good candidates for water quality retrofitting. Most ED dry basins in Broad Run are designed to provide both quantity and quality control (i.e. Stormwater Management Pond/Best Management Practice (SWMP/BMP)). However, the conversion of these facilities to constructed wetlands would increase their pollutant removal efficiencies.
- Sites located on public lands, home owner associations (HOAs), and institutional land (i.e., churches, schools, etc.) are preferred over private residential or commercial property.
- Typically sites treating greater than 1 acre but less than 500 acres were targeted for field inspection.

The initial stormwater database review identified 87 existing dry basins, wet basins, and bioretention facilities within the study's five selected subwatersheds. Each of the 87 facilities are provided in **Table 6**.

During the desktop analysis 28 additional facilities were identified which may be stormwater facilities but were not listed in the county stormwater database. There are a number of valid reasons why these facilities may not have been included in the County's database:

- Recently built facilities are not added to the inventory until as-built surveys are approved and bonds are released.
- A facility may belong to another jurisdiction (VDOT, City, etc.) and is not part of the County system.
- A facility may not be intended to treat stormwater (i.e., farm ponds, irrigation ponds, etc.).
- A facility may not be accepted into the County system due to deficiencies, or other issues.

Site IDs were reassigned to all of the facilities targeted for field inspection using the Subwatershed code (i.e., 246) and the Facility ID number (i.e., 246-5199, etc.). For facilities that were not on the County inventory, the subwatershed code and sequential numbers were used for site IDs (i.e., 246-1, 246-2).

Table 6:
Stormwater Management Facilities – Desktop Screening Results

Subwatershed Name and ID	Facility ID (from GIS)	Type of Facility	Facility Description	Condition based on Aerial Photography	Land Use Type	Included in Field Inventory
Tributary to Rocky Branch (244)	219	SWMP/BMP	D	dry	residential	
	239	SWMP/BMP	D	dry	residential	
	323	SWMP/BMP	D	dry	residential	
	324	SWMP/BMP	D	dry, possible short circuiting	residential	Y
	660	SWMP/BMP	D	minimal ponding	residential	Y
	688	SWMP/BMP	D	dry with LFC	industrial	Y
	689	SWMP/BMP	D	ponding	industrial	Y
	5095	CSWMP/BMP	D	wet	commercial	Y
	5102	CSWMP/BMP	D	dry	commercial	
	5102	CSWMP/BMP	D	dry	commercial	
	5102	CSWMP/BMP	D	dry	commercial	
	5199	CSWMP/BMP	D	dry	industrial	Y
	5369	CSWMP	D	wet?	commercial	Y
	5596	CSWMP/BMP	W	wet	commercial	
	244-1*	Unknown	W	wet	ROW	
	244-2*	Unknown	W	wet	commercial	
	244-3*	Unknown	W	wet	commercial	
	244-4*	Unknown	W	wet	commercial	
	244-5*	Unknown	D	dry	commercial	
Rocky Branch (246)	204	BMP	B	veg	residential	
	205	BMP	B	veg	residential	
	213	SWMP/BMP	D	dry with some veg	residential	
	215	SWMP/BMP	D	dry with some veg	residential	
	221	BMP	B	veg	residential	
	222	BMP	B	veg	residential	
	240	SWMP/BMP	D	dry with some veg	residential	
	241	BMP	B	little veg	residential	
	242	BMP	B	partial veg	residential	
	243	BMP	B	min ponding & some veg	residential	Y
	244	BMP	B	min veg	residential	Y
	247	BMP	B	veg	residential	
	248	BMP	B	ponding	residential	
	249	BMP	B	some veg	residential	
	250	BMP	B	min veg	residential	
	296	SWMP/BMP	D	dry, possible short circuiting	residential	
	364	BMP	B	min ponding & veg	residential	Y
	365	BMP	B	min ponding & veg	residential	Y
	366	BMP	B	min veg	residential	
	367	BMP	B	some veg	residential	

Table 6: Stormwater Management Facilities – Desktop Screening Results

Subwatershed Name and ID	Facility ID (from GIS)	Type of Facility	Facility Description	Condition based on Aerial Photography	Land Use Type	Included in Field Inventory
Rocky Branch (246) (cont.)	395	BMP	W	slightly wet	residential	Y
	398	SWMP/BMP	D	minimal ponding	residential	
	400	BMP	B	min veg	residential	
	431	SWMP/BMP	D	minimal ponding	residential	
	451	SWMP/BMP	W	wet	residential	
	508	SWMP/BMP	D	dry w/ paved LFC	residential	
	509	SWMP/BMP	D	dry w/ veg	residential	
	576	SWMP/BMP	D	dry w/ paved LFC	residential	Y
	577	SWMP/BMP	D	minimal ponding	residential	Y
	578	SWMP/BMP	D	dry with veg	residential	Y
	579	SWMP/BMP	D	dry with veg	residential	
	581	SWMP/BMP	D	dry	residential	
	582	SWMP/BMP	D	minimal ponding	church	Y
	648	SWMP/BMP	D	dry	residential	
	668	SWMP/BMP	W	wet	residential	
	671	SWMP/BMP	D	dry	commercial	
	5050	CSWMP/BMP	D	wet	commercial	Y
	5472	CSWMP/BMP	D	dry, possible short circuiting	residential	
	5492	CSWMP/BMP	D	dry	commercial	
	5589	CSWMP/BMP	W	wet	commercial	
	246-1*	Unknown	W	wet	residential	
	246-2*	Unknown	D	dry with veg	residential	
	246-3*	Unknown	W	wet	industrial	
	246-4*	Unknown	D	ponding possible short circuiting	ROW	
Dawkins Branch (262)	210	SWMP/BMP	D	dry	industrial	Y
	281	SWMP/BMP	D	appear to be filled in	industrial	Y
	435	SWMP/BMP	D	appear to be filled in	industrial	Y
	493	SWMP	W		residential	
	494	SWMP	D	dry w/ paved LFC	residential	Y
	548	SWMP/BMP	D	dry, possible short circuiting	residential	
	605	SWMP/BMP	W	wet	residential	
	618	SWMP/BMP	W	wet with growth	residential	
	657	SWMP/BMP	D	dry	industrial	Y
	665	SWMP/BMP	D	dry	commercial	Y
	666	SWMP/BMP	D	dry	commercial	Y
	682	SWMP/BMP	D	dry	industrial	Y
	5018	CSWMP/BMP	D	dry	industrial	Y
	5082	CSWMP/BMP	B	dry with some veg	commercial	
	5087	CSWMP/BMP	B	dry with some veg	commercial	
	5188	CSWMP/BMP	D	dry	industrial	
	5239	CSWMP/BMP	D	dry w/ some veg	commercial	Y

Table 6:
Stormwater Management Facilities – Desktop Screening Results

Subwatershed Name and ID	Facility ID (from GIS)	Type of Facility	Facility Description	Condition based on Aerial Photography	Land Use Type	Included in Field Inventory
Dawkins Branch (262) (cont.)	5244	CSWMP/BMP	W	wet	industrial	
	5263	CSWMP/BMP	W	wet	industrial	
	5335	CSWMP/BMP	W	wet	residential	
	5340	CSWMP/BMP	D	dry	industrial	
	5361	CSWMP/BMP	D	dry	industrial	Y
	5383	CSWMP/BMP	D	Not Present	industrial	
	5428	CSWMP/BMP	W	wet	commercial	
	5439	SSWMP	D	minimal ponding	ROW	
	5441	SSWMP	D	dry	ROW	
	5442	SSWMP	D	minimal ponding	ROW	
	5487	CSWMP/BMP	W	wet	residential	
	5488	CSWMP/BMP	D	dry	industrial	
	5632	CSWMP/BMP	D	dry	industrial	Y
	5644	CSWMP/BMP	D	dry	residential	
	262-1*	Unknown	W	wet	commercial	
	262-2*	Unknown	D	dry	commercial	
	262-3*	Unknown	D	dry	industrial	
	262-4*	Unknown	D	dry	commercial	
	262-5*	Unknown	W	wet	industrial	
	262-6*	Unknown	D	dry	industrial	
	262-7*	Unknown	W	wet	commercial	
	262-8*	Unknown	W	wet		
	262-9*	Unknown	W	wet		
	262-10*	Unknown	D	dry	commercial	Y
	262-11*	Unknown	D	dry w/ paved LFC	industrial	Y
	262-12*	Unknown	W	wet	residential	
	262-13*	Unknown	D	dry	industrial	Y
	262-14*	Unknown	D	dry	residential	
Kettle Run (272)	13	SWMP	D	dry	ROW	
	14	SWMP	D	dry	ROW	
	272-1*	Unknown	W	wet	residential	
	272-2*	Unknown	W	wet	residential	
	272-3*	Unknown	W	wet	park	
	272-4*	Unknown	D	dry	park	
	272-5*	Unknown	W	wet	park	Y
Facility ID based on County GIS, if not on the GIS, then a study ID was assigned *.						
Facility Description D = dry basin; W = wet basin; B = bioretention						

A total of 115 stormwater facilities were identified during the desktop screening, the majority were found in Rocky Branch and Dawkins Branch subwatersheds (**Table 7**). A total of 33 facilities were selected for inspection, representing 29% of the total facilities in the subwatersheds. The majority of the facilities selected for inspection are dry basins (**Table 8**). The results of the desktop screening are presented in **Table 8**, which identifies the individual facilities selected for field inspection.

**Table 7:
Stormwater Management Facilities – Desktop Screening**

Subwatershed Name and ID	Number of Facilities in County Inventory	Number of Additional Facilities Identified	Total Number of Facilities in Subwatershed	Total Number Selected for Assessment # / (%)
Tributary to Rocky Branch (244)	14	5	19	7 (36%)
Rocky Branch (246)	40	4	44	10 (23%)
Dawkins Branch (262)	31	14	45	15 (35%)
Kettle Run (272)	2	5	7	1 (14%)
Subwatershed Total	**87**	**28**	**115**	**33 (29%)**

**Table 8:
Stormwater Management Facilities –
Summary of Facilities within Subwatersheds**

Subwatershed Name and ID	Dry	Wet	Bioretention
Tributary to Rocky Branch (244)	14	5	0
Rocky Branch (246)	21	6	17
Dawkins Branch (262)	29	14	2
Kettle Run (272)	3	4	0
Subwatershed Total	**67**	**29**	**19**
Selected for Inspection (Percentage Inspected of Each Type of Facility)	**27 (39%)**	**2 (7%)**	**4 (21%)**
Broad Run Watershed Totals Based on GIS	**167**	**56**	**32**

Totals include those within County records and additional facilities identified through desktop screening.

The engineering data for each of the stormwater facilities that were selected for field inspection was retrieved from the stormwater database and is presented in **Table 9**.

Table 9:
Stormwater Facility Database – Engineering Data for All Facilities that were Inspected

Facility ID	Facility Type	Facility Description	Riser Present	Riser Diameter	Type of Outlet Pipe	Invert In	Invert Out	Spillway Present	Dam Height	Drainage Area	Date Added to Inventory	Maintained By	COMMENTS	SubDivision
Tributary to Rocky Branch Subwatershed (244)														
324	SWMP/BMP	D	Y	72	RCP	219.74	219.69	N	12	0.00	12/1/2000	Private		FOXBOROUGH SECTION 1 PHASE 1
660	SWMP/BMP	D	Y	72	RCP	224.27	223.47	N	9	27.63	4/14/2009	Private	2.5" bmp orifice at ew, 2 risers	Catholics for housing public improvement plan
688	SWMP/BMP	D	Y	84	CMP	339.49	339.65	Y	9	41.00	3/1/2010	Private	4" bmp orifice at riser	Piney branch industrial park lot 1a rev
689	SWMP/BMP	D	Y	84	CMP	324.92	324.83	Y	11	104.00	3/1/2010	Private	4" bmp orifice at riser	Piney branch industrial park lot 5a-1 rev
5369	CSWMP	D	Y	42	RCP	280.69	281.25	Y	9	44.00	3/1/2003	County		ATLANTIC COMMERCE CENTER
Rocky Branch Subwatershed (246)														
243	BMP	B	N	0	RCP	243.35	242.49	N	0	0.00	12/1/1999	Private	Bioretention facility	Kingsbrooke phase 2 section 6
244	BMP	B	N	0	RCP	243.35	243.00	N	0	0.00	12/1/1999	Private	Bioretention facility	Kingsbrooke phase 2 section 6
364	BMP	B	N	0		0.00	0.00	N	1	0.00	2/1/2002	Private	Bioretention facility	Kingsbrooke section 7 phase 2
365	BMP	B	N	0		0.00	0.00	N	1	0.00	2/1/2002	Private	Bioretention facility	Kingsbrooke section 7 phase 2
395	BMP	W (D)	Y (N)	72 (0)	RCP	272.83	0.00	N	4	0.00	7/1/2002	Private	Pwse = 272.83 c/o w/ ea of 4 pvc pipes	Kingsbrooke section 15 a phase 2
576	SWMP/BMP	D	Y	74	RCP	321.32	321.28	N	9	21.78	4/1/2007	Private	With low flow dewatering pipe	Broad run oaks sierra sunset lane and pond 2
577	SWMP/BMP	D	Y	60	RCP	306.98	306.90	Y	11	31.02	4/1/2007	Private		BROAD RUN OAKS SECTION 1
578	SWMP/BMP	D	N	0	RCP	315.69	315.51	Y	7	58.29	4/1/2007	Private	Modified ew riser w/ grates	Broad run oaks frontage improvements
582	SWMP/BMP	D	Y	54	RCP	309.85	309.10	N	9	3.06	4/1/2007	Private	4'x4' riser weir slot wing wall bmp plate	Apostolic faith united Pentecostal church
5050	CSWMP/BMP	D	Y	48	RCP	310.05	308.26	N	5	19.00	7/1/2002	County		ATLANTIC RESEARCH GAINESVILLE TECHNOLOGY CTR
Dawkins Branch Subwatershed (262)														
210	SWMP/BMP	D	Y	24	RCP	230.91	230.44	Y	5	0.00	2/1/1998	Private		VIRGINIA MEADOWS LOT 7 B
281	SWMP/BMP	D	N	0	RCP	238.92	238.78	Y	3	2.00	5/1/2000	Private	County maintenance per plat	Virginia meadows ind pk potomac concrete 8 b
435	SWMP/BMP	D	Y	48	RCP	233.19	230.47	Y	7	0.00	5/1/2003	Private		VIRGINIA MEADOWS IND PK L 8 CASTLE CONCRETE
494	SWMP	D	N (Y)	0 (54)	RCP	295.50	295.11	N	7	0.00	7/1/2000	Private		PARADISE SWM/BMP
657	SWMP/BMP	D	Y	48	RCP	221.94	221.67	Y	6	3.54	3/18/2009	Private	3" bmp orifice at ew	Virginia meadows lot 3
665	SWMP/BMP	D	Y	48	RCP	239.56	239.45	N	6	2.39	5/19/2009	Private	3" bmp orifice at riser	Virginia meadows industrial park lot 10
666	SWMP/BMP	D	Y	48	RCP	242.95	242.74	N	4	2.30	5/19/2009	Private	3" bmp orifice at riser, receives 2 rd	Virginia meadows industrial park lot 10
682	SWMP/BMP	D	Y	60	RCP	222.90	222.39	N	7	2.55	8/5/2009	Private	3" bmp orifice at ew	Virginia meadows ind pk lot 2-a-2
5018	CSWMP/BMP	D	Y	42	RCP	234.16	233.99	Y	6	5.00	11/1/1992	County		VIRGINIA MEADOWS IND PK LOT 14A UTZ FOOD
5239	CSWMP/BMP	D	N	0	RCP	233.50	233.25	Y	5	2.70	9/1/2005	County	Bioretention forebay serves as bmp	Robert louis investment partnership
5361	CSWMP/BMP	D	Y	48	RCP	234.53	234.16	N	4	5.00	1/1/2003	County	Riser w/ bmp opening 3 storage pipes	Virginia meadows lot 11c
5632	CSWMP/BMP	D	Y	30	RCP	238.00	236.82	N	8	1.58	1/6/2010	County	.75" bmp orifice at riser	Virginia meadows industrial park lot 11b

Facilities carried forward into conceptual design
Data does not fit field conditions (Field Data)
Note: W = Wet Pond; D = Dry Pond; B = Bioretention; N = No, Y = Yes; -- = no data

4.3. Stormwater Facilities Reconnaissance Inventory

A stormwater facilities reconnaissance inventory was conducted of the sites identified in the desktop analysis. Field data sheets were completed and Global Positioning System (GPS)-located photographs were taken for each site inspected. The field inventory included an inspection of existing stormwater facilities. The retrofit potential of the existing facility was assessed, and potential retrofit sites were evaluated to determine appropriateness of a retrofit and to identify any existing constraints. The location of the evaluated stormwater facilities in each subwatershed are presented in **Figures 4 through 7**.

Approximately 70% of the stormwater facilities are privately maintained and 30% maintained by the County. The timing and type of maintenance required varies by facility type, and inspections can be somewhat subjective as to when maintenance or a repair is required.

Stormwater Maintenance

Stormwater management facilities require periodic inspection and maintenance in order to continue to function effectively. The County's program focuses on maintaining the function of each stormwater facility. The aesthetic appearance of the facility is the responsibility of the land owner. The type of functional maintenance varies depending on the type of facility. The example below is the typical maintenance for a dry basin:

Aesthetic Maintenance

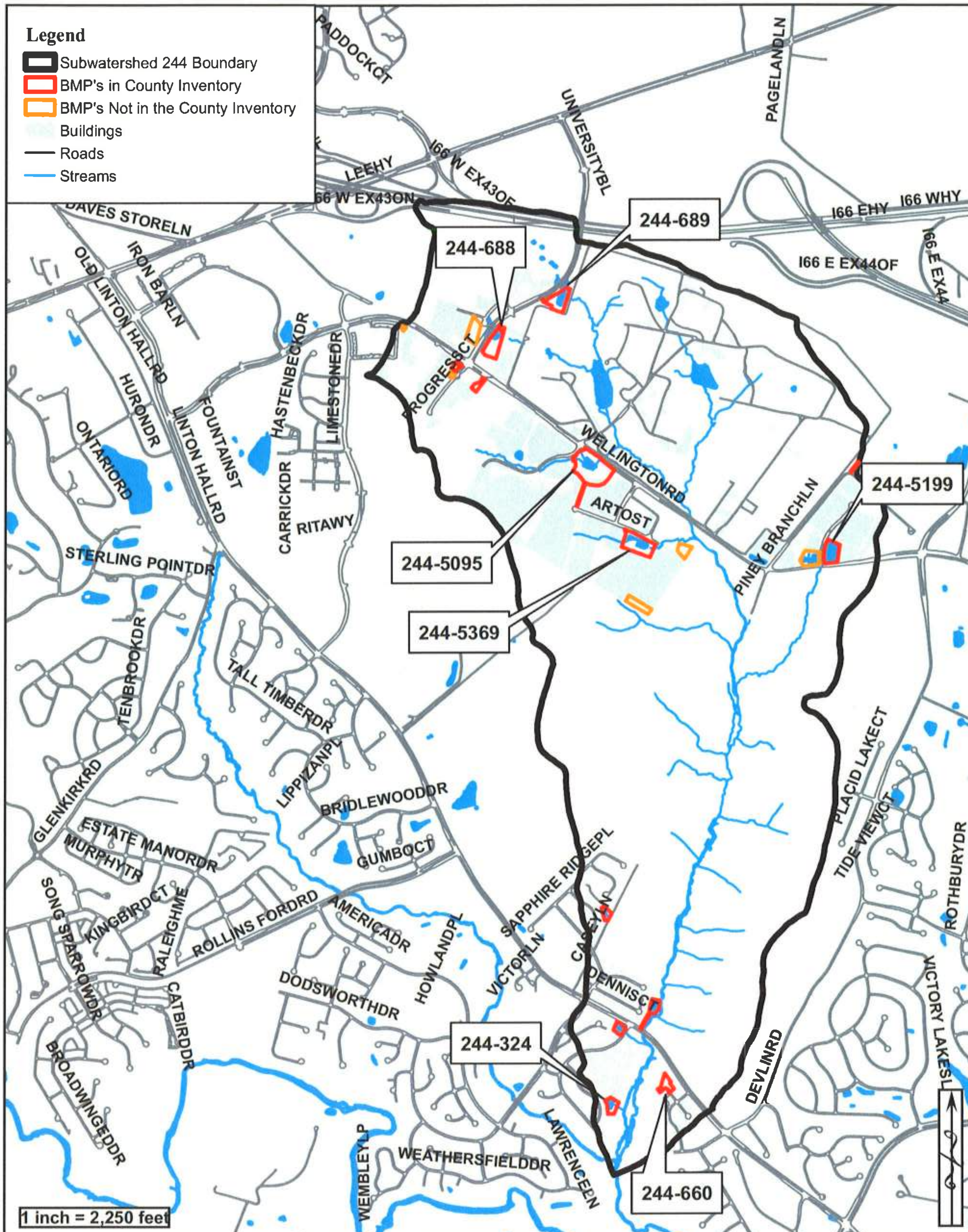
- Mowing
- Remove litter and debris throughout basin

Functional Maintenance

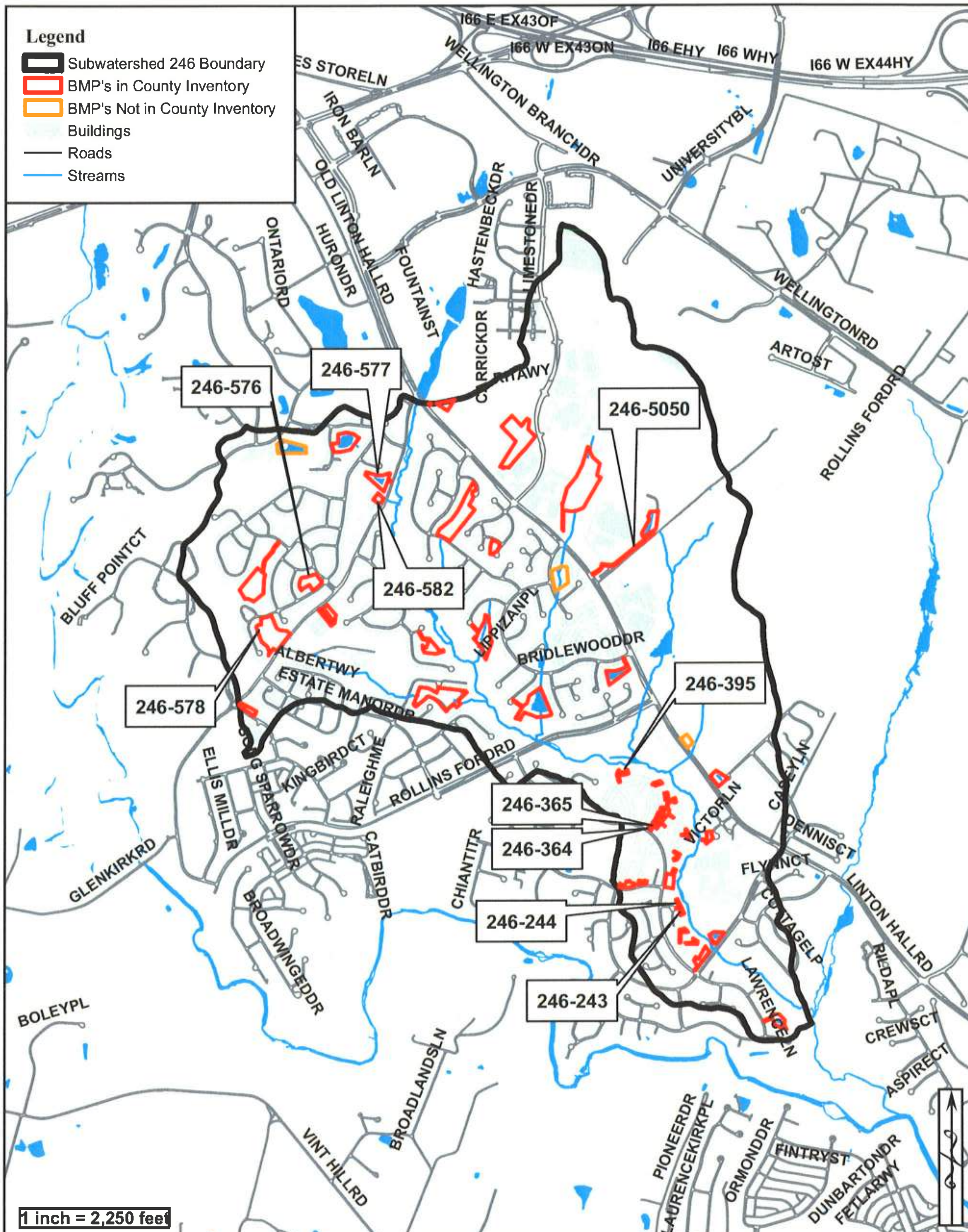
- Repair fencing or locks, or address other safety issues
- Clear debris from low flow orifice
- Remove woody vegetation from spillway, around risers or inlets
- Repair eroded, bare or undercut areas at inlets, on side slopes, on the berm or bottom of the basin.
- Remove sediment from the forebay
- Repair pipes or risers
- Replace or repair pipes or riser, if required

The results of the field inspections are provided in **Table 10** and summarized below:

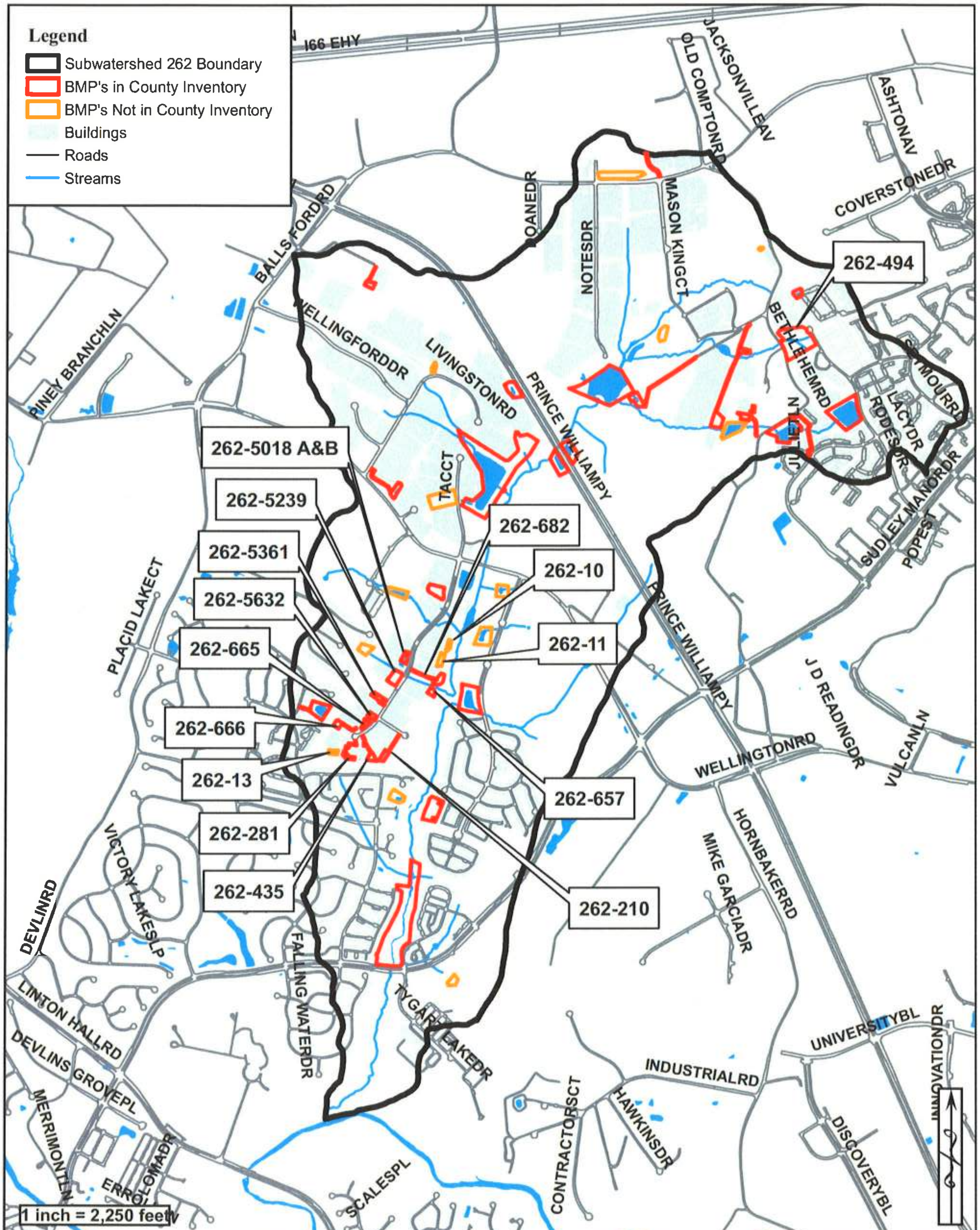
- Fourteen out of thirty-three (41%) of the facilities were in good condition.
- One facility had a broken fence around a wet pond. The Park Authority was advised of the problem and safety concerns.
- Paint was observed in one facility which was removed prior to a follow up inspection by the county.
- Four dry basins are good candidates for retrofitting to improve water quality treatment. Retrofitting dry basins could be used to meet the EPA Chesapeake Bay TMDL goals for nutrient removal.
- The bioretention facilities in one neighborhood should be studied to determine if they are functional.
- Six facilities would benefit from minor improvements such as cleaning out forebays can be addressed as part of routine maintenance.
- Six facilities would benefit from major improvements such as sediment removal from the basin or adding forebays. Two sites appear to have been filled-in by adjacent parking lots and may require significant reconstruction.



Source:	Title:	Figure:
Prince William County GIS	Stormwater Facility Reconnaissance Inventory Tributary to Rocky Branch (244) Subwatershed	4



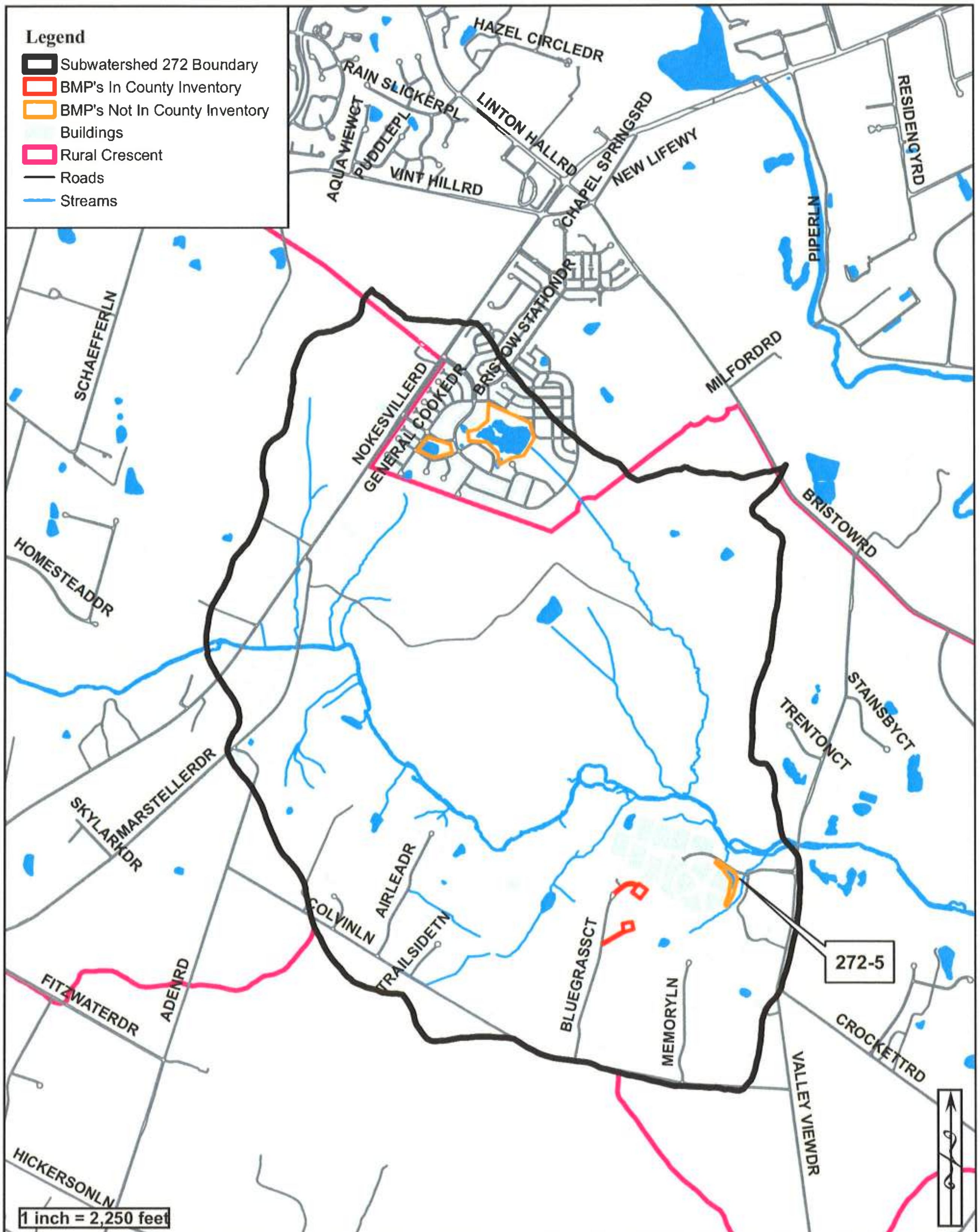
Source:	Title:	Figure:
Prince William County GIS	Stormwater Facility Reconnaissance Inventory Rocky Branch (246) Subwatershed	5



Source: Prince William County GIS

Title: **Stormwater Facility Reconnaissance Inventory Dawkins Branch (262) Subwatershed**

Figure: 6



	Source:	Title:	Figure:
	Prince William County GIS	**Stormwater Facility Reconnaissance Inventory Kettle Run (272) Subwatershed**	7

Table 10:
Stormwater Management Facilities – Inspection Results

Subwatershed Name and ID	Study ID	Facility Type (per PWC GIS)	Drainage Condition	Safety Issues	Site Conditions	Maintenance	Improvements	Investigation / Retrofit
Tributary to Rock Branch (244)	244-324	Dry	Dry	No	Well Maintained, Low Flow Riser Is PVC Pipe Prone To Clogging	None	Replace Low Flow Riser And Upgrade Trash Rack	None
	244-660	Dry	Minor Ponding	No	Forebay With Cattails	Clean Out Forebay	None	None
	244-688	Dry	Minor Ponding	No	Dry Basin With Minor Ponding And Short Circuiting. Wetland Across Basin	None	None	WQ Wetland Retrofit
	244-689	Dry	Ponded	No	Heavy Sediment Load From Quarry, Full Of Sediment	Remove Sediment	None	Add Forebay
	244-5095	Dry	Ponded	No	Sediment In Facility And Minor Erosion Behind Headwall; Appears To Be A Wet Pond	Remove Sediment	Repair Erosion At Headwall	Determine Original Design
	244-5369	Dry	Ponded	No Fence	Permanently Ponded, Covered With Cattails, Minor Erosion At One Inlet, Trees In Basin	Remove Sediment, Vegetation And Clean Out Low Flow Orifice	None	None
	244-5199	Dry	Minor Ponding	No Fence	Minor Ponding; Vegetation In The Bottom Of Entire Basin Inflow Channels Blocked With Veg And Sediment	Remove Veg. And Sediment At Inlets And Outlets	None	None
Rocky Branch (246)	246-243, 244, 364, 365	Bio.	Dry	No	Sites May Not Be Functional Bioretention Facilities	None	None	Investigate Original Design
	246-395	Wet	Dry With Wet Forebay	No	Forebay Filled With Sediment And Cattails, Basin Is A Filtration Basin	Clean Out Forebay	None	Retrofit Infiltration Basin To Bioretention
	246-576	Dry	Dry	No	Unusual LF Pipes, Well Maintained	None	None	None

**Table 10:
Stormwater Management Facilities – Inspection Results**

Subwatershed Name and ID	Study ID	Facility Type (per PWC GIS)	Drainage Condition	Safety Issues	Site Conditions	Maintenance	Improvements	Investigation / Retrofit
Rocky Branch (246) (cont.)	246-577	Dry	Minor Ponding	Fence Not Locked	Needs Maintenance	Remove Veg. And Sediment	None	None
	246-578	Dry	Dry	No	Large Box Weir ; Flooding And Trees Dying	Screen LF Orifice, Drain Box, Remove Dead Trees	None	None
	246-582	Dry	Dry	No	Functional Site	None	None	None
	246-5050	Dry	Ponding	No Fence	Basin Is Full Of Sediment And Permanently Ponded	Remove Sediment, Clean Orifice	None	Wetland WQ Retrofit
Dawkins Branch (262)	262-10*	Dry	Dry	No	Well Maintained	None	None	None
	262-11*	Dry	Dry	No	Mowed, Blocked Orifice, Erosion, LF Channel Concrete	Remove Blockage	Fix Erosion	Remove LF Channel
	262-13*	Dry	Dry	No	Broken LF Inlet, Riprap Berm, Sediment, Vegetation	Remove Veg., Berm, And Sediment	Repair LF Inlet	None
	262-210	Dry	Dry	No	Well Maintained, No Trash Rack, Some Sediment	Minor Inflow Channel Cleanout	Install Trash Rack	None
	262-281	Dry	Wet	No	No Longer Functional Due To Filling, Design Did Not Include Riser	None	Re-Construction	Determine Original Design, Address Filling
	262-435	Dry	Dry	No	Poorly Maintained, Not Functional, Possibly Filled, Orifice Broken	Remove Veg.	Repair Orifice	Determine Original Design And Determine If Major Reconstruction Is Required
	262-494	Dry	Ponded, Wetland	Trail Through BMP	Large Facility With Up To 2 Feet Of Ponding, And Wetland Fringe Around Pond	Low Flow Orifice Clogged, Sediment Accumulated	None	Retrofit For Constructed Wetland

Table 10:
Stormwater Management Facilities – Inspection Results

Subwatershed Name and ID	Study ID	Facility Type (per PWC GIS)	Drainage Condition	Safety Issues	Site Conditions	Maintenance	Improvements	Investigation / Retrofit
Dawkins Branch (262 (cont.)	262-657	Dry	Minor Ponding	No	Paint And Paint Supplies In Facility	Remove Vegetation And Paint Supplies	None	Investigate Source Of Paint Supplies
	262-665	Dry	Dry	No	Functional With Minor Erosion, Berm Prevents Short Cutting	None	None	None
	262-666	Dry	Minor Ponding	No	Some Cattails, Landscaped In Areas	None	None	None
	262-682	Dry	Dry	No	Well Maintained,	None	None	None
	262-5018a	Dry	Dry	No	Paved Low Flow Channel, No Screen On The Orifice, Possible Short Circuiting, Recently Clogged But Cleaned Out	None	Screen Orifice	Remove LF Channel
	262-5018b	Na	Dry	No	Box Weir, Well Mowed,	None	None	None
	262-5239	Dry	Minor Ponding	No	Site Appears Functional But Design Unconventional, Forebay Is Bioretention For BMP, Basin Has Only Culvert, No Riser For Volume Storage	None		WQ Retrofit
	262-5361	Dry	Dry	No	Outlet Pipe Settling, Riser Rusting, Constrictor Plate Has No Hole, Sediment	Remove Sediment	Repair Riser/Outlet Pipe	None
	262-5632	Dry	Dry	No	Fenced, Well Maintained	None	None	None
Kettle Run (272)	272-5	Wet	Wet	Broken Fence	Wet Pond In Park With Broken Fence	Remove Baseballs	Fix Fence	None

4.4. Stormwater Repair and Retrofit Prioritization and Ranking

The stormwater facilities inspected in the reconnaissance inventory were assigned a priority based on how well the site was functioning, and the potential to improve function with water quality retrofits. Priorities were assigned based on the guidance in **Table 11**:

Table 11:
Stormwater Facilities Priority Guidance

Priority	Reasons
High	Safety issues or site completely failing to perform as designed
Moderate	Site is functional, but may not be fully performing as designed; or where a retrofit could improve functions, such as adding water quality control
Low	Site is functional, with only minor repairs or maintenance required, which can be addressed during routine maintenance.
None	Well maintained sites, fully functional

The priorities assigned to each of the facilities inspected in the field are listed in **Table 12**. There are 6 high priority sites, 11 moderate priority sites, and 17 sites with low or no priority. Within each subwatershed, the individual sites with a priority of high or moderate were ranked to facilitate the selection of projects to move forward into implementation.

4.5. Stormwater Outfall Retrofit Recommendations

In a developed watershed which lacks stormwater management one of the preferred stormwater retrofit options is to add new BMPs at untreated existing stormwater outfalls. These retrofits typically are bioretention basins which capture and treat a portion of the first flush, thereby providing water quality improvements, and some limited water quantity controls. Retrofitting an existing outfall to provide water quality treatment is a space efficient approach to improving stormwater treatment in a developed watershed.

In the Broad Run Watershed very few potential outfall retrofit sites were identified during the stormwater desktop analysis. Most stormwater outfalls are already treated by a stormwater facility. Small outfalls often discharge into a wooded riparian buffer not suitable for an outfall retrofit. Because of the existing stormwater management and riparian buffer protection typical of these subwatersheds there are fewer opportunities to add new stormwater facilities. This is in contrast with older developed watersheds where outfalls are often not treated, riparian buffers are often cleared of vegetation, and stormwater retrofit opportunities are relatively common.

Table 12:
Stormwater Management Facility Repair and Retrofit Recommendations

Subwatershed Name and ID	Site ID	Priority	Type of Project	Recommendations
Tributary to Rocky Branch (244)	244-324	Low	Minor Repair	Replace PVC Pipe And Trash Rack
	244-660	Low	Minor Repair	Clean Out Forebay
	244-688	Moderate	WQ Retrofit	Expand Wetland And Add Berm To Prevent Short Circuiting
	244-689	High	Major Repair	Remove Sediment And Add Forebay
	244-5095	Low	Maintenance	Cleanout Sediment And Repair Minor Erosion
	244-5369	Low	Maintenance	Remove Sediment And Vegetation
	244-5199	Low	Maintenance	Maintenance Of Inlets
Rocky Branch (246)	246-243, 246-244, 246-364, 246-365	Moderate	Invest./Study	Investigate Original Design For Possible Modification, include all 17 bioretention sites within the same neighborhood.
	246-395	Moderate	WQ Retrofit	Clean Out Forebay And Retrofit Infiltration Basin Into Bioretention
	246-576	None	None	None
	246-577	Low	Maintenance	Remove Vegetation And Debris
	246-578	Low	Maintenance	Maintenance (Install Screen, Remove Dead Trees)
	246-582	None	None	None
	246-5050	Moderate	WQ Retrofit	Convert Into Constructed Wetland With Forebays and berms
Dawkins Branch (262)	262-10	None	None	None
	262-11	Low	Minor Repair	Minor Repairs And Removal Of LF Channel
	262-13	Moderate	Major Repair	Repairs And Maintenance
	262-210	Low	Minor Repair	Install Trash Rack
	262-281	High	Major Repair	Possible Reconstruction
	262-435	High	Major Repair	Major Maintenance And Repair Orifice, Possible Reconstruction
	262-494	Moderate	WQ Retrofit	Convert To Constructed Wetland
	262-657	High	Maintenance	Site Contained Paint Supplies, Follow Up Inspection Indicated that Site Has Been Cleaned
	262-665	Low	None	None
	262-666	Low	None	None
	262-682	Low	None	None
	262-5018a	Low	Minor Repair	Screen Orifice, Remove LF Channel
	262-5018b	None	None	None
	262-5239	Moderate	Major Repair	Renovate Bioretention Area, Add Forebay, Improve Detention in Basin
	262-5361	Moderate	Major Repair	Repair Riser And Outlet Pipe, Remove Minor Amount of Sediment
	262-5632	None	None	None
Kettle Run (272)	272-5	High	Minor Repair	Repair Broken Fence In Park To Address Safety Issue

Five potential outfall retrofit sites were briefly evaluated in the field, but were determined to be unsuitable due to existing forest buffers. One site was identified during the stream field assessments as an outfall with perennial flow but lacking stormwater management. This outfall retrofit project is discussed under the stream section of the report.

4.6. Stormwater Conceptual Design Projects

A conceptual design was developed for most sites assigned a high or moderate priority, resulting in the 11 projects summarized in **Table 13**. A full description of each project is presented in the conceptual design narrative included in **Appendixes B–E**, organized by subwatershed. Each appendix includes a map indicating the location of each project. Each design narrative includes the location, problem description, project description, potential benefits, design considerations, and a summary of cost estimate. Each design narrative also includes a location map with ADC map page references, ground level photos of existing conditions, and aerial photos of either existing conditions or the proposed conceptual plan. Each project is identified by subwatershed, site ID, County facility ID if available, Geographical Parcel Index Number (GPIN) Ownership, and GPS coordinates. The proposed projects would include the following:

- One stormwater study to evaluate the effectives of 17 bioretention facilities in a single neighborhood.
- Two projects address BMPs which appear to be filled or partially filled by adjacent landowners and may require full re-construction of the facilities.
- Four potential water quality retrofits, converting ED dry basins into constructed wetland facilities. Site 262-494 is the best potential site, based on size and likelihood of success.
- Repairs or improvements to three sites which would address existing functional issues.

Several sites were ranked high priority, but due to the nature of the issues did not warrant a conceptual narrative. Site 272-5, which was ranked high due to a broken fence, should be repaired to prevent unauthorized access to the wet pond. Site 262-657 contained paint and painting supplies during the initial site visit. The County conducted a follow up inspection at which time the BMP had been cleaned up.

Table 13:
Stormwater Management Facility Ranking and Prioritization

Subwatershed Name and ID	Site ID	Priority	Ranking within Subwatershed	Study Ranking	Type of Project	Reasoning For Ranking
Tributary To Rocky Branch (244)	244-688	Moderate	2	--	WQ Retrofit	Good WQ Retrofit Site, Basin Functional
	244-689	High	1	2	Major Repair	Very High Sediment Load From Quarry Degrading Functions
Rocky Branch (246)	246-243, 246-244, 246-364, 246-365	Moderate	3	--	Invest./Study	Listed As Bioretention But Not Design To Current Standards; Appears To Be Landscaped Areas, No Erosion, but Sites May Not Be Providing Water Quality Improvements.
	246-395	Moderate	2	--	WQ Retrofit	Basin Undersized, Forebay Ponded, Infiltration Basin Clogged
	246-5050	Moderate	1	--	WQ Retrofit	Good WQ Retrofit Site
Dawkins Branch (262)	262-13	Moderate	6	--	Major Repair	Facility Functions Degraded
	262-281	High	1	3	Major Repair	No Longer Functional Due To Filling, Lack Of Maintenance
	262-435	High	2	4	Major Repair	Basin No Long Present Due to Filling- Reconstruction Required
	262-494	Moderate	4	--	WQ Retrofit	Excellent WQ Retrofit Site
	262-5239	Moderate	5	--	Major Repair	Bioretention Forebay Plants Are Dying, And Soils May Be Clogged.
	262-5361	Moderate	3	5	Major Repair	Soil Is Piping Into Outlet Pipe, Restrictor Plate May Be Too Small Causing Deep Ponding
Kettle Run (272)	272-5	High	1	1	Minor Repair	Safety Issue – Broken Fence in Public Park

Shading Indicates Sites for which Conceptual Narratives where Developed and be found in Appendix B-E

4.7. Stormwater Pollutant Removal Efficiencies

This study considered two ratings for Pollutant Removal Efficiencies (**Table 14**). The current Virginia Stormwater Regulations addresses phosphorus and nitrogen. These regulations were passed in 2011 and give localities 2 years to implement these regulations at the local level. These regulations address both phosphorous and nitrogen reduction efficiencies. These regulations consider pollutant load reductions based on both the reduction in the volume of runoff that a BMP can provide, as well as the reduction in pollutant concentration.

Table 14:
Stormwater Pollutant Removal Efficiencies

Stormwater Load Removal Efficiencies (%)	Ext Detention Pond		Bioretention		Constructed Wetland	
	DCR	EPA	DCR	EPA	DCR	EPA
Total Phos. Load	15% (31%)	20%	55% (90%)	45-85%	50% (75%)	45%
Total Nitrogen Load	10% (24%)	20%	60% (90%)	25-80%	25% (50%)	20%
Sediment Load	--	60%	--	55-90%	--	60%

- Virginia Department of Conservation and Recreation (DCR) Efficiencies per 2011 DCR regulations Level I (Level II)
- EPA Efficiencies per Chesapeake Bay TMDL Model

EPA has established removal efficiencies for phosphorus (P), nitrogen (N), and sediment as part of the Chesapeake Bay TMDL Model. The EPA efficiencies are comparable to the DCR Level I removal efficiencies for Extended Detention and Constructed Wetland. The DCR regulations allow for higher removal rates with the more stringent Level II design. The DCR Level I and Level II removal efficiencies for Bioretention are similar to EPA removal efficiencies. Unfortunately, the discrepancies between these two sets of pollutant removal efficiencies may require the County to use both sets of efficiencies for different reporting purposes.

Under the current DCR standards, extended detection (ED) dry basins are considered to provide the lowest possible pollutant removal rate of any stormwater management treatment (**Table 15**). Under the current DCR standards, ED should be combined with a wet pond (retention), or a constructed wetland. Most of the existing ED dry basins in the Broad Run watershed do not meet the current DCR standards for ED, which includes a forebay, a long flow path, a micropool and no pilot channels. As such, most existing ED dry basins probably are not providing Level I efficiencies. Compared to past regulations, the new regulations provide greater removal efficiencies for bioretention and created wetlands compared to extended dry detention. This change in efficiencies makes it feasible to convert an extended dry detention basin to a created wetland, resulting in an increase in BMP removal efficiency.

Table 15:
DCR Stormwater Pollutant Removal Efficiencies (% Load Reduction)

	Extended Detention Pond		Constructed Wetland		Bioretention	
	Level 1	**Level 2**	**Level 1**	**Level 2**	**Level 1**	**Level 2**
Previous DCR P Removal	35%	--	20%	--	50%	--
2011 DCR Efficiencies						
Runoff Reduction	0%	15%	0%	0%	40%	80%
Phos. Removal	15%	15%	50%	75%	25%	50%
Total Phos. Load Reduction	15%	31%	50%	75%	55%	90%
Nitrogen Removal	10%	10%	25%	50%	40%	60%
Total Nitrogen Reduction	10%	24%	25%	50%	60%	90%

Converting an existing ED dry basin to a Level I constructed wetland results in the following increases in pollutant removal efficiencies:

- Phosphorus removal increased to 50%, or a 3+ fold increase over the existing facility (15%)
- Nitrogen removal increased to 25%, or a 2.5 fold increase over the existing facility (10%).

Being able to retrofit an existing ED Dry basin to a Level II constructed wetland would result in the following:

- Phosphorus removal increased to 75%, or a 4.5 fold increase over the existing facility (15%)
- Nitrogen removal increased to 50%, or a 5 fold increase over the existing facility (10%).

Conversion of an ED dry basin to bioretention is typically much less likely due to engineering constraints, but this type of retrofit would increase pollutant removal efficiencies by up to 9 fold.

4.8. Retrofit Design Assumptions

When evaluating the retrofitting of existing stormwater BMPs from an ED dry basin to a constructed wetland, the design standards from the current DCR regulations (**Table 16**) were compared to the basin characteristics to determine the feasibility of a retrofit meeting the current DCR requirements.

Table 16:
Stormwater Design Standards (2011 DCR)

	Ext Detention Pond		Constructed Wetland	
	Level 1	**Level 2**	**Level 1**	**Level 2**
Treatment Volume (Inches)	1.0"	1.25"	1.0"	1.5"
Required Design Features	Forebay and Micropool	Forebay & Micropool with Wetland or Wet Pond	Single Cell with Forebay	Multi-Cell, with Forebay
Extended Detention (ED)	24 hours, > 4 Feet Deep	36 hours, < 4 Feet Deep	ED for 24 hours, no more than 1 foot	No ED
Design Depth	15% of Tv in the Permanent Pool	40% of the Tv in the Permanent Pool	Uniform, mean depth > 1 foot	Variable Depth, < 1 foot
Size of Contributing Drainage Area (CDA) OR Basin Size compared to CDA	< 10 acres	> 10 acres	< 3% of CDA	> 3% of CDA
Length to Width Ratio	2:1	3:1	2:1	3:1
Length of Shortest Flow Path Ratio	0.4+	0.7+	0.5+	0.8+
Type of Plantings	Turf	Trees and Wetlands	Emergent Wetland	Mixed Wetland Design

V. STREAM INVENTORY APPROACH AND RESULTS

Due to the large amount of stream within the Broad Run watershed, this study evaluated streams through a multi-step process. The initial step was to compile a complete and accurate map of the perennial and intermittent streams within the subwatersheds. Then a desktop site selection analysis was conducted to identify potential stream and riparian restoration opportunities from existing data and mapping. Third, a stream reconnaissance inventory was conducted in the field to evaluate the initially identified stream or buffer restoration sites. Fourth, conceptual narratives were developed for those sites with the greatest restoration opportunities. The individual stream projects were prioritized and ranked to aid in the selection of projects to move forward into implementation.

5.1. Developing a GIS Stream Layer

A basic requirement of this study is a well-defined stream GIS layer. The existing County GIS stream layer did not completely identify all perennial and intermittent open channels within the study area. A revised GIS stream layer was developed using the County's existing GIS stream layer, aerial photography, and topographic layers to identify all open channels. One continuous layer was generated illustrating the open channel network to be studied. The initial identification of open stream channels was verified in the field and the GIS stream layer was updated. Based on the revised GIS stream layer, the selected subwatersheds in this study contain the following length of stream channels:

Tributary to Rocky Branch (244) Subwatershed	9.2 miles
Rocky Branch (246) Subwatershed	6.2 miles
Tributary to Broad Run (250) Subwatershed	14.9 miles
Dawkins Branch (262) Subwatershed	8.2 miles
Kettle Run (272) Subwatershed	10.4 miles
Total	**48.9 miles**

5.2. Desktop Site Selection Analysis

The desktop site selection analysis consisted of compiling existing GIS mapping layers and photography, and searching each subwatershed for potential stream or riparian buffer restoration sites. The County's stream assessment data were used to assist in the location of potential projects. A set of screening criteria was developed to focus field efforts on those stream reaches which had characteristics most compatible with restoration (**Table 17**).

**Table 17:
Restoration Site Screening Criteria**

Screening Criteria	Most Preferred	Least Preferred
Drainage Area	> 500 acres	< 50 acres
Length of Channel	> 1,000 lf	< 300 lf
Riparian Buffer	No forested buffer	Forested buffer > 50 feet wide
Adjacent Land Uses	Undeveloped, lawn	Developed, commercial, or industrial
Ownership	County, HOAs, Institutional	Private residential or business

Across the five subwatersheds included in this study, 18 stream reaches were selected for evaluation as stream or buffer restoration sites. Stream reach identification numbers were assigned based on subwatershed ID numbers (i.e., 244), and then a sequential number assigned to a particular reach during the desktop analysis (i.e., 244-1). If during the field investigations a stream reach warranted division into several separate reaches due to highly variable field conditions, then an alphabetic subscript was added to the initial reach ID (i.e., 244-1A). The start and end of a reach was identified by a physical stream characteristic such as a tributary or a road crossing.

In addition to the restoration sites identified during the desktop analysis, a limited number of reference conditions sites were also identified at which to perform the stream assessments. Reference condition sites consisted of streams within large forested parcels or other areas which appeared to be minimally impacted by surrounding land use. The following four reference condition sites were selected:

- Forested headwater Tributary to Rocky Branch (244-3)
- Forested main channel of the Tributary to Rocky Branch (244-2)
- Main channel of Kettle Run (272-1)
- Forested headwater tributary to Kettle Run (272-4)

Sites 244-3 and 272-4 are headwater tributary streams surrounded by undeveloped forest. Sites 244-2 and 272-1 are located along main stream channels surrounded by a forested buffer greater than 100 feet wide. The selected restoration and reference stream sites include a wide range of watershed conditions and channel size, and include both impaired streams as well as relatively non-impaired streams. One goal of this wide range of sampling stations is to allow a comparison between the watershed condition, the stream condition and the benthic/biological condition.

5.3. Stream Reconnaissance Inventory

Each site identified by the desktop site selection analysis was evaluated in the field. Streamside infrastructure was identified, problem areas assessed, geomorphic and habitat assessments completed, and potential restoration projects considered. Within each reach, GPS located photographs were taken of representative stream conditions and of each infrastructure element identified.

Stream Assessment Methods

A review of at least 40 various stream assessment protocols and methods as reported in "*Physical Stream Assessment: A Review of Selected Protocols for Use in the Clean Water Act Section 404 Program (March 2004)*", came to the following conclusions:

> *"Stream assessments undertaken to prioritize watersheds or stream reaches for management or aid the design of stream enhancement or restoration projects should be based on fluvial geomorphic principles".*

The Rapid Stream Assessment Technique (RSAT) was selected as the stream assessment protocol for this watershed study because it specifically focused on stream geomorphology and the identification of stream restoration projects as part of a watershed management program. RSAT was developed by the Washington Metropolitan Council of Governments for assessment of stream conditions in Northern Virginia, D.C., and Maryland, specifically to identify stream reaches suitable for restoration. It has a strong geomorphology emphasis, as well as water quality and benthic macroinvertebrate evaluations. RSAT provides the flexibility to generate subscores for bank stability, channel stability, riparian buffer condition, water quality, and benthos. RSAT provides the data most suitable for targeting restoration projects. The standard RSAT scoring matrix was modified to further increase its sensitivity to fluvial geomorphic conditions. RSAT is also less affected than other methods by seasonal and flow variability. RSAT generates a score for a wide range of metrics, allowing watershed managers to more specifically compare reaches to determine the types of degradation present and suitability for restoration.

The Modified RSAT evaluation categories and parameters are summarized in **Table 18** and the complete data sheets are included in **Appendix G**.

Table 18:
Modified Rapid Stream Assessment Technique

Evaluation Category	Parameters
Channel Stability	Shape, incision, deposition, exposed utilities
Bank Stability	Slumping, height, angle, material, tree falls, vegetation
Riparian Habitat	Buffer width, type of vegetation, shading
Water Quality	Benthic diversity, pollution sensitive benthos, litter, fouling, odors
Aquatic Habitat	Channel modifications, riffle substrate, embeddeness, pool depth, fish cover

Within each category, there are 3 to 6 specific parameters which are scored individually. These scores are averaged to produce a score for each evaluation category. The total of the score for each of the five evaluation categories provides an overall stream condition score.

Channel stability is given twice the weight of the other variables to reflect the importance of channel stability, particularly incision, in the selection of stream restoration projects (**Table 19**). Bank stability, riparian buffer, and water quality are equally weighted. Aquatic habitat is given a lower weighting due to the difficultly in visually assessing aquatic habitat accurately.

**Table 19:
Rapid Stream Assessment Technique Rating Table**

Evaluation Category	Excellent	Good	Fair	Poor
Channel Stability	18-20	12-16	6-10	0-4
Bank Stability	9-10	6-8	3-5	0-2
Riparian Habitat	9-10	6-8	3-5	0-2
Water Quality	9-10	6-8	3-5	0-2
Aquatic Habitat	7-8	5-6	3-4	0-1
Reach Scoring Ranges	52-58	35-46	18-29	< 11

Note: Some sites may fall between the scoring ranges. In these cases, the site can be assigned a narrative descriptor indicating a border line condition (i.e. good/fair for a score of 31).

Inventory of Streamside Infrastructure and Assessment of Problem Areas

The inventorying of streamside infrastructure and the assessment of potential problem areas is a critical element of a stream assessment conducted for restoration purposes. This type of data tends to be related to a specific point along the stream instead of representing an entire reach. For this study, the Unified Stream Assessment (USA) method was used to identify problem areas. This method was developed by the Center for Watershed Protection to inventory streamside infrastructure and assess problem areas in urban streams. The USA method datasheets rely on check boxes instead of codes for recording observations. For this study, field data forms were designed based on the USA method, which includes evaluation of access and restoration potential. Scoring of the problem areas is compatible with the existing county database (i.e. CH2MHill method). Each streamside infrastructure element was located with GPS located photographs, and documented on a field data form. The field protocols identify the following types of infrastructure/problem areas:

- Pipe Outfall / Ditch
- Exposed Utility
- Fish Barrier / Obstruction / Head cuts
- Dump Sites
- Culvert Crossings
- Unusual conditions

All streamside infrastructure elements identified in the field were assigned an ID based on the reach ID (i.e., 246-1), the type of infrastructure, and the number of each infrastructure elements assessed (i.e., 246-1-O1). The abbreviations for each of the infrastructure types are as follows:

- Pipe or Culvert Outfall = P
- Ditch Outfall = D
- Exposed Utility = U
- Fish Barrier = B
- Obstruction = O
- Head cuts = H

- Dump / Trash Sites = T

Benthic Macroinvertebrate Sampling

A limited number of the stream reaches identified in the desktop analysis were sampled for their benthic macroinvertebrate community (**Table 20**). Benthic macroinvertebrates are good indicators of stream health, and a benthic monitoring program can be a helpful tool within a watershed management program. The stream reaches sampled ranged from reference sites in forested tracts to stream reaches with highly developed drainage areas. This limited effort at benthic sampling was intended to evaluate its ability to provide additional information when conducting a watershed study.

Table 20:
List of Benthic Sampling Stations

Subwatershed Name and ID	Site -ID	Stream Condition
Tributary to Rocky Branch (244)	244-2	Large forested parcel along Tributary to Rocky Branch. This reach had areas of bedrock. The riffles are short and contain gravel material. The pools are greater than 12 inches and are long. This reach contains emergent/shrub wetlands in the floodplain.
	244-3	Headwater tributary stream surrounded by undeveloped forest. Well defined stream banks are undercut. Riffles contain fine gravel. Wetlands are located in the floodplain of this reach .
	244-4	Tributary to Rocky Branch. The riffle substrate contains gravel and larger material. Large amounts of organic matter were present in the substrate. Wetlands exist in the floodplain. BMP's are located upstream of the reach and receives parking lot drainage from Jiffy Lube Live and superfund site.
Rocky Branch (246)	246-1A	Residential watershed with greater than 100 feet of riparian buffer. Substrate material contains gravel and fines. Emergent/shrub wetlands are located upstream of this reach.
Dawkins Branch (262)	262-3	Watershed dominated by commercial land use. Dawkins Branch dominated by shrub wetlands. A sanitary utility parallels the stream in the floodplain. One BMP discharges into this reach.
Kettle Run (272)	272-1	Main channel of Kettle Run with wide forested riparian buffer. Site may show impacts of upstream agricultural land use.

Field sampling was based on standard benthic macroinvertebrate sampling methods. A D-frame kick net was used to sample productive habitats such as riffles, undercut banks, and woody debris. The material collected was preserved in alcohol and returned to the office for processing. The benthic invertebrates were picked from each sample, and identified to Order or Family taxonomic level.

Since the majority of the sites were gravel bed streams, the benthic data was analyzed based on the Virginia Save Our Stream (VaSOS) Multi-metric Index. This method uses order/family level data to gauge the ecological condition of a stream's benthic community. One goal of the benthic sampling was to test a fairly simple benthic index such as the VaSOS index to determine if the method was sufficiently sensitive to identify differences in stream condition within a range of streams typical of the Broad Run watershed. The key parameters in the VaSOS index are:

- Percent Mayflies, Stoneflies and Caddisflies (not including net spinning caddisflies)
- Percent Net Spinning Caddisflies (hydropsychidae).
- Percent Lunged Snails
- Percent Beetles
- Percent Tolerant Taxa
- Percent Non-Insects

The VaSOS index groups ecological condition score into three levels (**Table 21**). This method was evaluated because it is fairly rapid and cost efficient compared to other more detailed sampling methods.

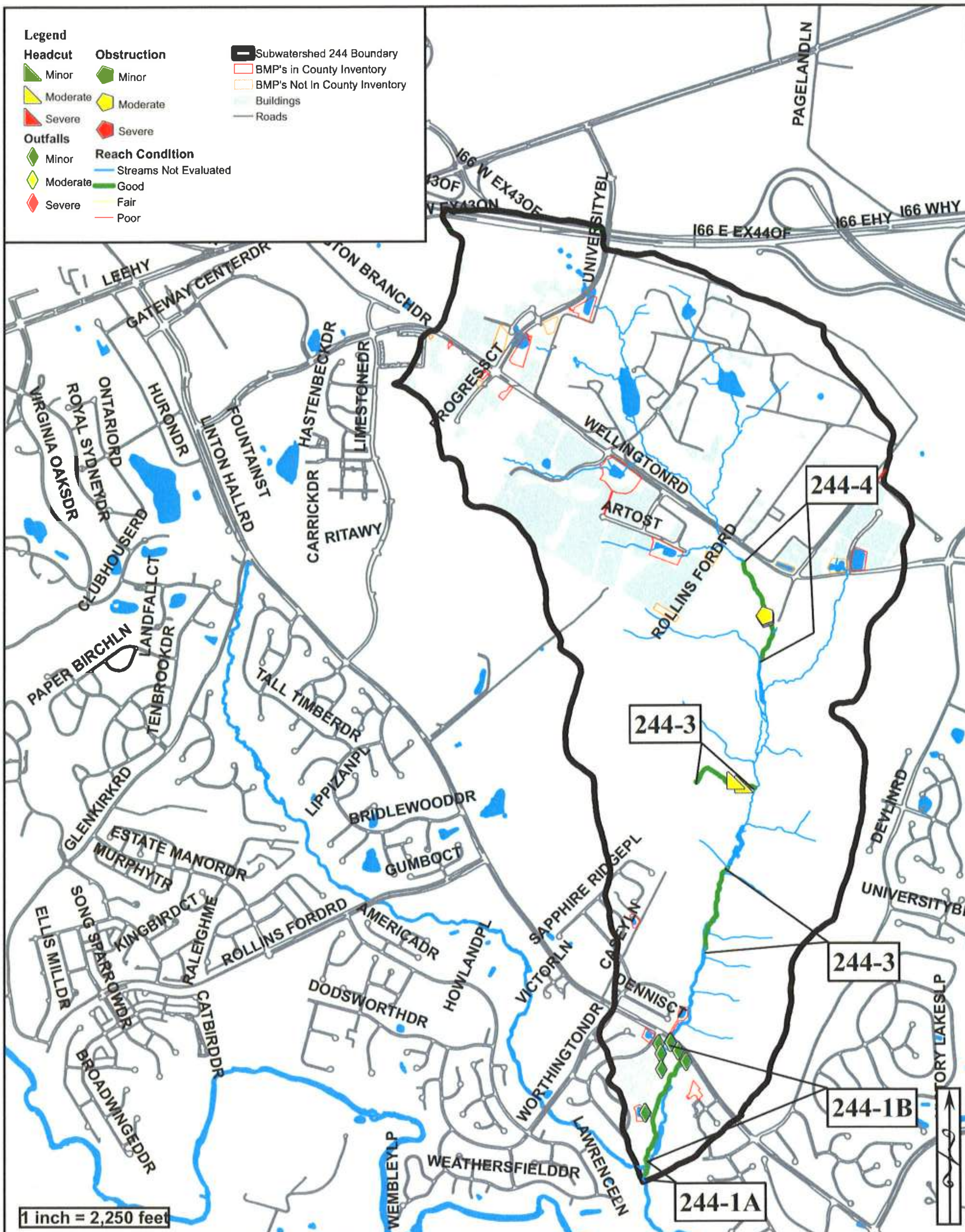
Table 21: Ecological Condition Score

Ecological Condition	Score
Acceptable	9-12
Undetermined	8
Unacceptable	0-7

5.4. Stream Assessments Results

The desktop site selection analysis identified 22 stream reaches to be assessed in the field. Three of these reaches are reference condition sites and the rest are potential stream restoration sites. During the field assessments, two reaches (250-2 and 272-3) lacked defined stream channels but did contain headwater wetlands. However, since neither site contained a defined stream channel they were not assessed with the RSAT method. The GIS stream layer was revised to reflect these field results.

The 18 stream reaches that were assessed represent a total of 19,387 linear feet of stream channel, out of an estimated total of 258,069 linear feet of channel within the five subwatersheds, or approximately 8% of the total. The location of each stream reach within its subwatershed is presented in **Figures 8 through 12**. The overall condition score is indicated by color coding each stream reach.



Source:

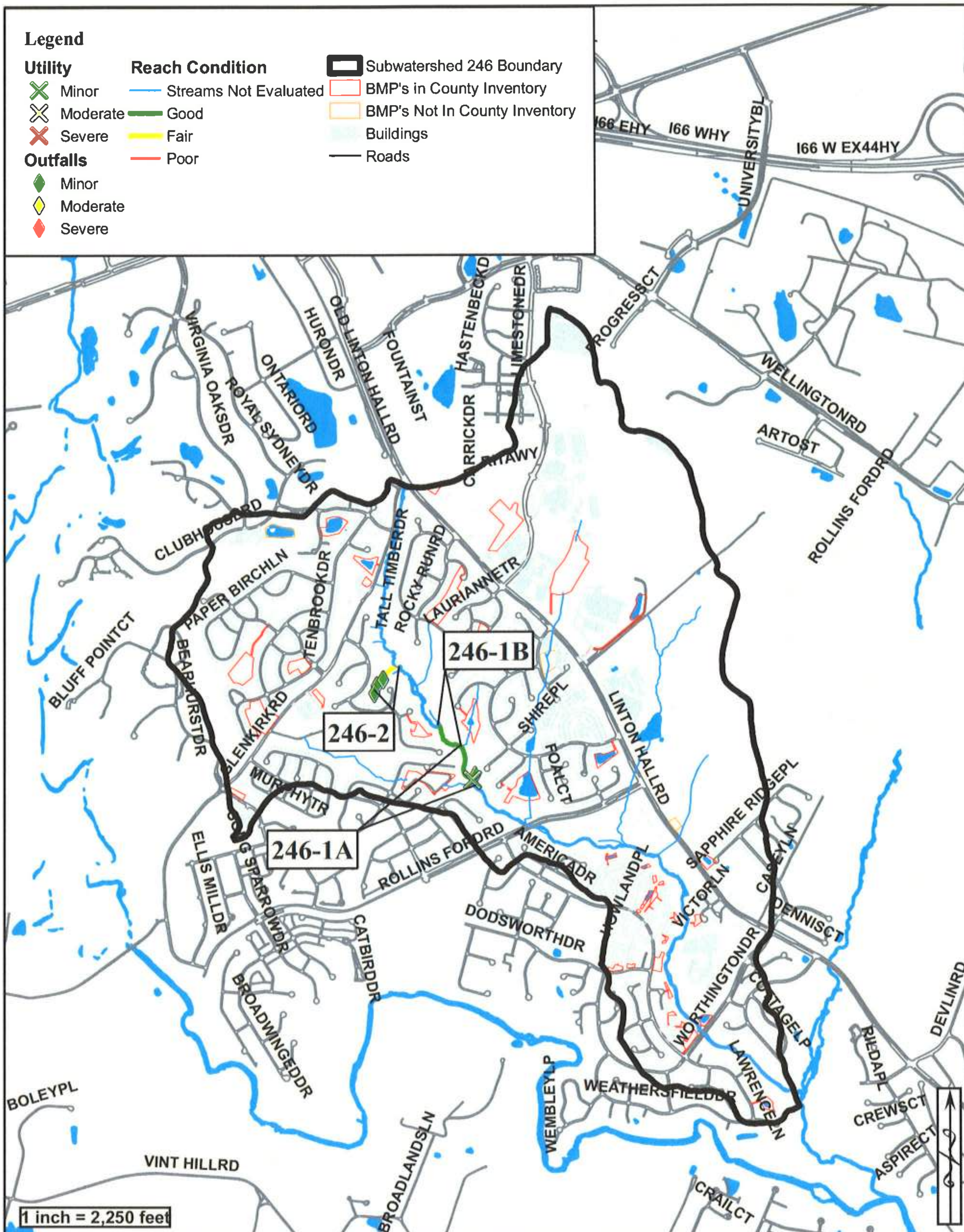
Prince William County GIS

Title:

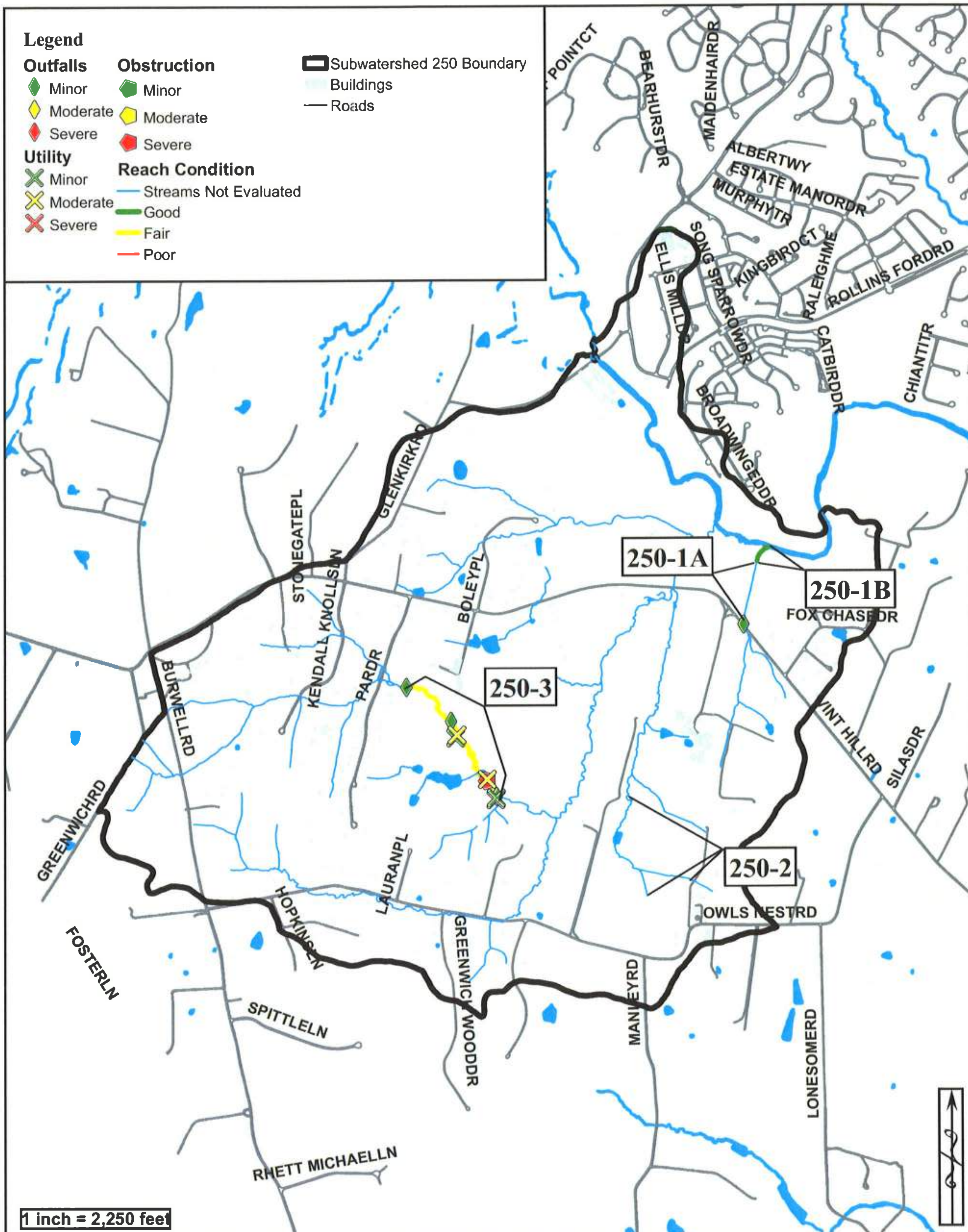
Stream Assessment Tributary to Rocky Branch (244) Subwatershed

Figure:

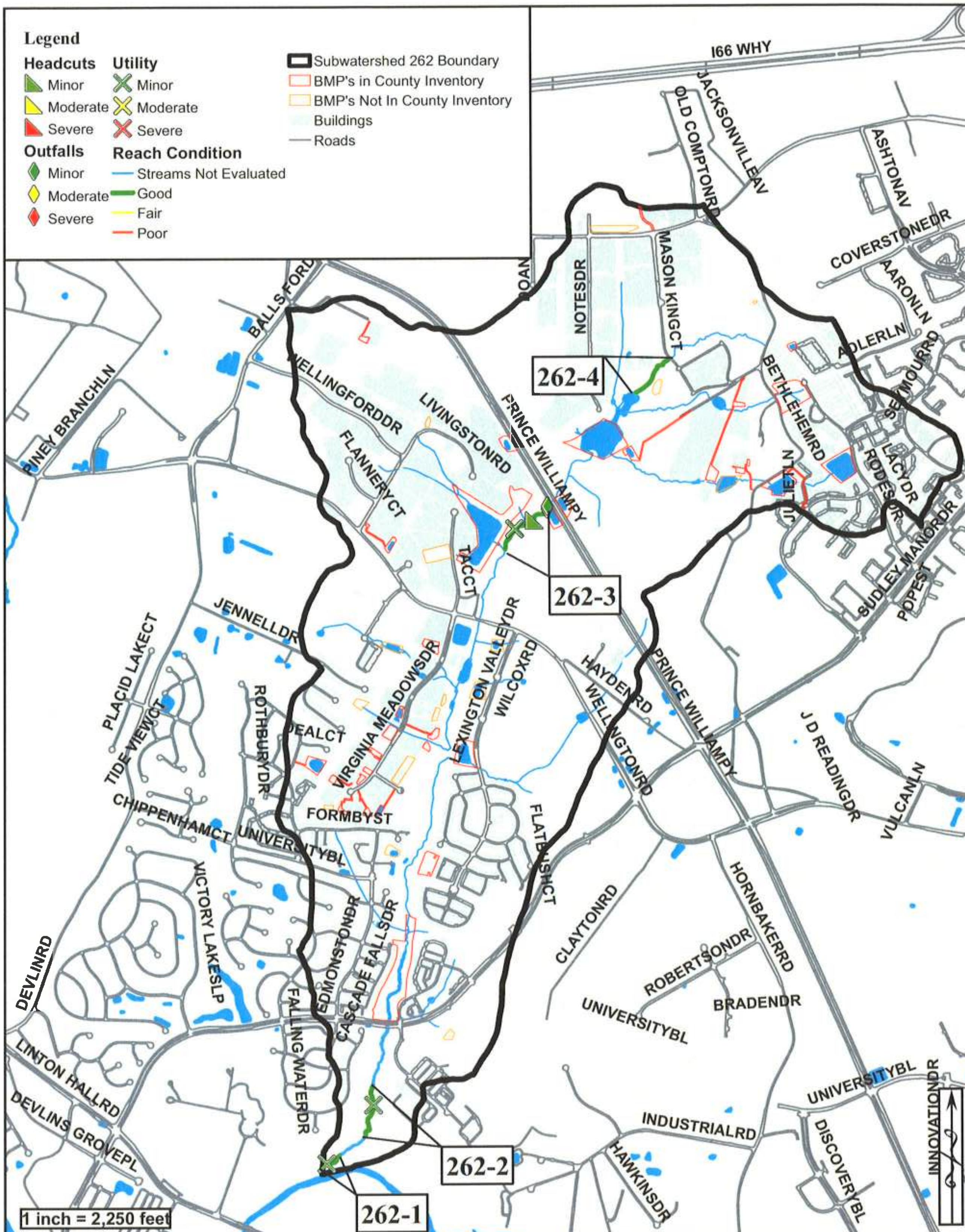
8



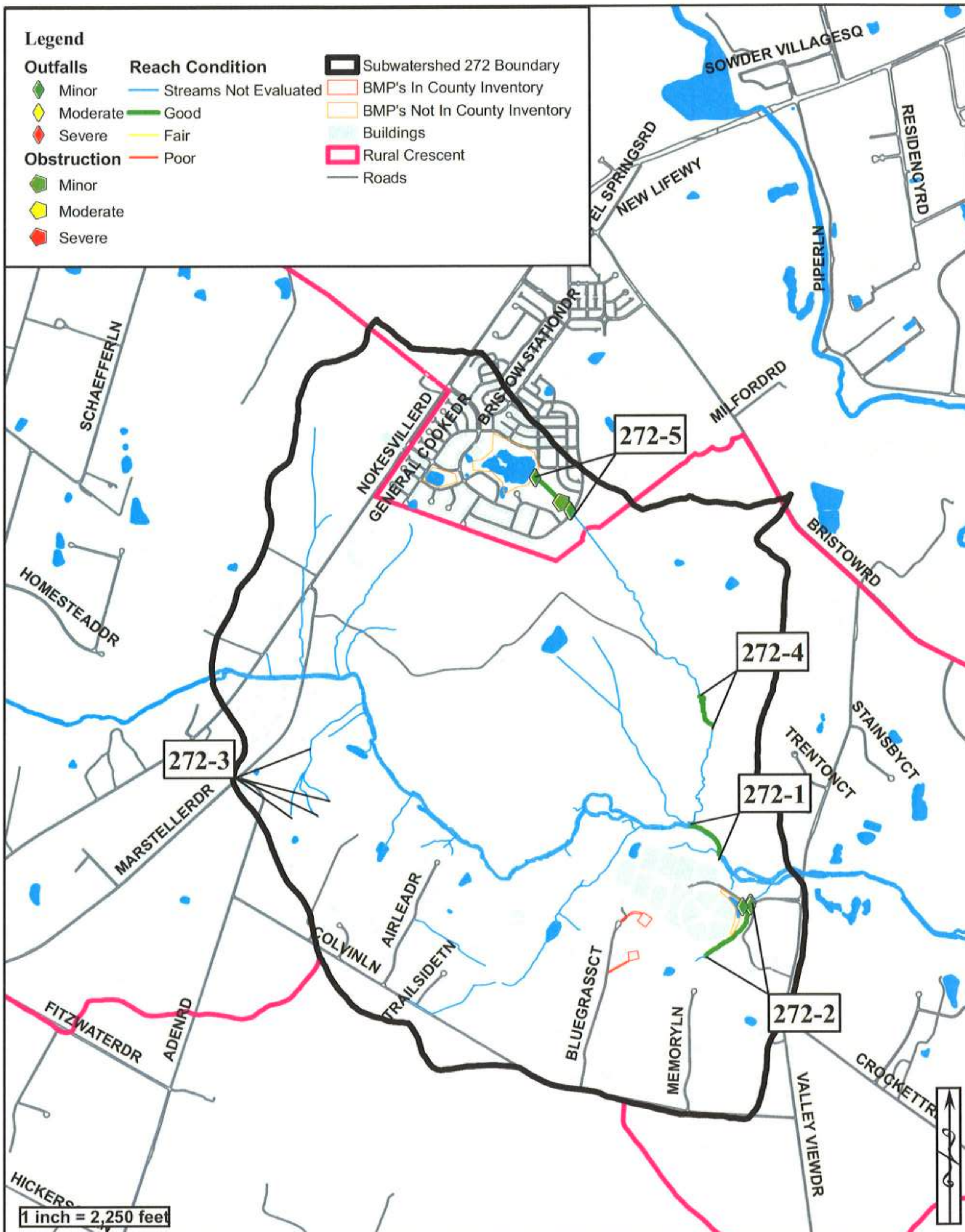
Source:	Title:	Figure:
Prince William County GIS	Stream Assessment Rocky Branch (246) Subwatershed	9



	Source:	Title:	Figure:
WR&A	Prince William County GIS	**Stream Assessment Tribuary to Broad Run (250) Subwatershed**	10



	Source:	Title:	Figure:
WR&A	Prince William County GIS	**Stream Assessment Dawkins Branch (262) Subwatershed**	11



Source:	Title:	Figure:
Prince William County GIS	Stream Assessment Kettle Run (272) Subwatershed	12

The majority of the streams scored good condition overall (**Table 22 and 23**). Water quality and aquatic habitat tended to score fair over most of the streams. General observations of the results of the stream assessment include:

- The majority of reaches scored good for channel stability.
- The majority of reaches scored good or better for bank stability.
- Most scores for riparian habitat were good or excellent.
- Scores were evenly split between good and fair for water quality.
- In contrast to the scores of good for channel stability and bank stability, the majority of streams scored fair for aquatic habitat.
- The streams in this study appear to be relatively stable, but have degraded water quality and habitat.
- Two reference conditions sites scored the highest (46 and 47), at the upper end of the good range.

Channel stability, bank stability, and riparian habitat tended to score good across the majority of the stream reaches. Water quality and aquatic habitat appeared to be in a more degraded condition than the riparian buffers or the stability of the channels.

Table 22:
Numerical Stream Condition Scores

Subwatershed Name and ID	Site ID	Channel Stability	Bank Stability	Riparian Habitat	Water Quality	Aquatic Habitat	Numerical Score	Narrative Score
Tributary to Rocky Branch (244)	244-1A	17.00	8.17	7.33	7.33	4.40	44.23	Good
	244-1B	14.50	4.67	9.67	6.83	3.60	39.27	Good
	244-2	16.50	7.83	6.33	8.00	4.80	43.47	Good
	244-3	17.00	8.33	9.67	8.33	4.00	47.33	Good
	244-4	18.50	5.83	8.67	7.67	5.60	46.27	Good
Rocky Branch (246)	246-1A	15.00	6.33	8.67	6.83	5.00	41.83	Good
	246-1B	16.50	7.67	8.00	5.50	4.20	41.87	Good
	246-2	15.50	7.67	5.00	3.67	1.80	33.63	Fair
Tributary to Broad Run (250)	250-1	15.00	4.00	8.33	5.00	3.60	35.93	Good
	250-3	11.00	3.83	7.33	4.33	3.60	30.10	Fair
Dawkins Branch (262)	262-1	16.50	6.00	8.00	6.83	3.80	41.47	Good
	262-2	15.50	7.00	8.33	4.17	3.60	38.60	Good
	262-3	15.00	7.33	7.67	6.83	4.33	41.17	Good
	262-4	17.50	7.83	6.67	3.67	3.40	39.07	Good
Kettle Run (272)	272-1	16.00	5.17	9.67	5.83	5.00	41.67	Good
	272-2	18.00	7.50	7.67	5.00	4.00	42.17	Good
	272-4	15.00	5.67	9.67	4.50	4.00	38.83	Good
	272-5	18.50	7.67	8.67	4.33	3.80	42.97	Good

Note: Reaches 250-2 and 272-3 were wetlands and did not contain stream channels

Table 23: Narrative Stream Condition Scores

Subwatershed Name and ID	Site ID	Channel Stability	Bank Stability	Riparian Habitat	Water Quality	Aquatic Habitat	Numerical Score	Narrative Score
Tributary to Rocky Branch (244)	244-1A	Good	Good	Good	Good	Fair	44	Good
	244-1B	Good	Fair	Excellent	Good	Fair	39	Good
	244-2	Good	Good	Good	Good	Fair	43	Good
	244-3	Good	Good	Excellent	Good	Fair	47	Good
	244-4	Excellent	Fair	Good	Good	Good	46	Good
Rocky Branch (246)	246-1A	Good	Good	Good	Good	Good	42	Good
	246-1B	Good	Good	Good	Fair	Fair	42	Good
	246-2	Good	Good	Fair	Fair	Poor	34	Fair
Tributary to Broad Run (250)	250-1	Good	Fair	Good	Fair	Fair	36	Good
	250-3	Fair	Fair	Good	Fair	Fair	30	Fair
Dawkins Branch (262)	262-1	Good	Good	Good	Good	Fair	41	Good
	262-2	Good	Good	Good	Fair	Fair	39	Good
	262-3	Good	Good	Good	Good	Fair	41	Good
	262-4	Good	Good	Good	Fair	Fair	39	Good
Kettle Run (272)	272-1	Good	Fair	Excellent	Fair	Good	42	Good
	272-2	Excellent	Good	Good	Fair	Fair	42	Good
	272-4	Good	Good	Excellent	Fair	Fair	39	Good
	272-5	Excellent	Good	Good	Fair	Fair	43	Good

Note: Reaches 250-2 and 272-3 showed wetland characteristics during field assessments and did not represent stream characteristics

Of the stream reaches investigated, 16 scored good and 2 scored fair (**Table 24**). None of the stream reaches scored poor. When stream length is considered, the vast majority of the stream length was rated as good (**Table 25**).

Table 24: Summary of Channel Condition by Number of Reaches

Evaluation Category	Excellent	Good	Fair	Poor
Channel Stability	3	14	1	0
Bank Stability	0	13	5	0
Riparian Habitat	4	13	1	0
Water Quality	0	8	10	0
Aquatic Habitat	0	3	14	1
Narrative Score	**0**	**16**	**2**	**0**

Sites with mixed narrative scoring were rounded down (i.e. Good/Fair counted as Fair)

**Table 25:
Summary of Channel Condition by Length
(Linear Feet)**

Condition	Tributary to Rocky Branch	Rocky Branch	Tributary to Broad Run	Kettle Run	Dawkins Branch	Total Length	Percentage of Total Streams Surveyed
Excellent	0	0	0	0	0	0	0%
Good	6,877	1,275	2,927	3,146	3,334	17,559	91%
Fair	0	476	1,352	0	0	1,828	9%
Poor	0	0	0	0	0	0	0%
Total	**6,877**	**1,751**	**4,279**	**3,146**	**3,334**	**19,387**	

5.5. Problem Area Identification (Infrastructure Inventory)

During field assessments of stream conditions, the field crew identified any "problem areas" that may have an impact on the condition of the stream channel or buffer. Problem area identification is essentially an inventory of streamside infrastructure such as outfalls, road crossings, utility crossings, as well as reach issues such as debris dumps, head cuts or fish blockages. During the stream assessments, a relatively low number of potential problem areas were identified and evaluated (**Table 26**). The general location of the problem areas are illustrated in **Figures 8-12**, for each of the subwatersheds. Due to the large number of points, individual labeling was not included in the report graphics. However, this information is available in the GIS data provided to the County. In addition, the detailed summary tables give specific site identification numbers in order to retrieve the data from the GIS.

**Table 26:
Summary of Problem Area Inventory**

Problem Area	Total Recorded	Total Moderate Condition	Total Severe Condition
Debris Dumps	0	0	0
Exposed Utilities	10	2	0
Outfalls	23	0	0
Head Cut, Obstruction, Fish Barrier	7	3	2

Debris Dumps/Trash

All stream reaches were surveyed for trash dumping areas in the stream or the adjacent floodplain. No significant trash dumping areas were identified along any of the stream reaches. Minor trash was found to some degree along some of the stream reaches. These areas generally consisted of automotive tires or plastic bags.

Utilities Crossings

Only ten utility stream crossings were catalogued during stream field assessments (**Table 27**). The majority of the utility crossings appear to be buried well below the streambed. Two utility crossings were considered moderately exposed and none were severely exposed. A majority of the exposed utilities were irrigation pipes within a County golf course.

**Table 27:
Utility Summary Table**

Subwatershed Name and ID	Site ID	General Description	Severity	Recommendations
Rocky Branch (246)	246-1-U1	Sewer pipe embedded in substrate	0	None
Tributary to Broad Run (250)	250-3-U1	Exposed irrigation pipe along stream bed	3	None
	250-3-U2	Exposed irrigation pipe above stream bed	3	None
	250-3-U3	Exposed irrigation pipe above stream bed	7	Relocate irrigation pipe
	250-3-U4	Exposed irrigation pipe above stream bed	3	Relocate irrigation pipe
	250-3-U5	Exposed irrigation pipe along left bank (Aerial)	7	Relocate irrigation pipe
Dawkins Branch (262)	262-1-U1	Gas pipe buried below streambed	0	None
	262-1-U2	Sewer pipe buried below streambed	0	None
	262-2-U1	Gas pipe buried below streambed	0	None
	262-3-U1	Gas pipe buried below streambed	0	None

Outfalls (pipes, ditches, and culverts)

No stormwater outfalls or ditches were in poor or failing condition (**Table 28**). The majority of the stormwater outfalls are structurally and functionally stable. Seven stream crossings (i.e. road culverts) were also examined during stream assessments and none had significant issues.

Table 28:
Outfall Summary Table

Subwatershed Name and ID	Site ID	General Description	Severity	Recommendations
Tributary to Rocky Branch (244)	244-1B-P1	Stormwater	0	None
	244-1B-P2	Stormwater	2	None
	244-1B-P3	Stormwater	0	None
	244-1B-P4	Stormwater	0	None
	244-1B-P5	Stormwater	2	None
	244-1B-P6	Stormwater	0	None
	244-1B-P7	Stormwater	0	None
	244-1B-P8	Stream Crossing	0	None
Rocky Branch (246)	246-1A-P1	Stormwater	0	None
	246-2-P1	Stormwater	0	None
	246-2-P2	Stormwater	0	None
	246-2-P3	Stormwater	0	None
Tributary to Broad Run (250)	250-1A-P1	Stormwater	0	None
	250-3-P1	Stream Crossing	2	None
	250-3-P2	Stream Crossing	0	None
	250-3-P3	Stream Crossing	0	None
Dawkins Branch (262)	262-3-P1	Stormwater	2	None
	262-3-P2	Stream Crossing	0	None
Kettle Run (272)	272-2-P1	Stream Crossing	0	None
	272-2-P2	Stormwater	0	None
	272-2-P3	Stormwater	0	None
	272-5-P1	Stormwater	0	None
	272-5-P2	Stream Crossing	0	None

Head cuts, Fish Barriers, and Flow Obstructions

Head cuts (i.e., areas of vertical bed erosion), fish barriers, or obstructions that restrict stream discharge were evaluated and assigned a score of minor, moderate, or severe (**Table 29**). A total of three headcuts were found during the evaluation. No severe headcuts were documented during our evaluation. Four obstructions were identified; most were old culvert crossings left in the stream channel. Two were creating a significant blockage of the channel.

Table 29: Obstruction / Fish Barrier / Head Cut Summary Table

Subwatershed Name and ID	Site ID	General Description	Severity	Recommendations
Tributary to Rocky Branch (244)	244-3-H1	Head cut	5	None
	244-3-H2	Head cut	5	None
	244-4-O1	Obstruction	10	Remove Pipe
	244-4-O2	Obstruction	5	Remove Pipe
Tributary to Broad Run (250)	250-3-O1	Obstruction	10	Potentially remove pipe
Dawkins Branch (262)	262-3-H1	Head cut	3	None
Kettle Run (272)	272-5-O1	Obstruction	3	Potentially remove pipe

5.6 Benthic Monitoring

A limited number of the stream reaches identified in the desktop analysis were sampled for their benthic macroinvertebrate community. These stream reaches ranged from reference sites in forested tracts to stream reaches with highly developed drainage areas. One reference station (272-4) was not flowing, so it was not sampled.

The individual number of each taxa and percent of total taxa in the samples are presented in **Table 30** and **31**, respectively. There are obvious distinct differences between the benthic sampling stations. For example, Dawkins Branch (262-3) is dominated by midge larvae, a reliable indicator of poor stream health. Station 244-4 is dominated by netspinner caddisflies, a reliable indicator of organic or nutrient pollution. The netspinners are common below lakes and ponds where they use their nets to capture algae suspended in the water column. The headwater stream (244-3) is dominated by caddisflies, and non-insects which is common for headwater streams.

Table 30:
Benthic Macroinvertebrate Results (individuals per taxa)

Macroinvertebrates	Site ID (Station)					
	244-2	244-3	244-4	246-1	262-3	272-1
Worms	1	1			2	
Flat Worms						
Leeches	3		3	4	3	3
Crayfish		11				
Sowbugs		6				
Scuds	75	19		1		111
Stoneflies						
Mayflies	3		7	1	1	9
Mother Damselflies and Dragon Flies		8		1	2	
Gomphidae Dragonfly	1					3
Hellgramites	1		1			1
Common Netspinner		15	390	29	2	32
Most Caddisflies	10	25	13	5		25
Most Beetles	15	1	11	58	17	6
Waterpennies (Beetles)	12		20			20
Midges			8	3	48	3
Blackflies	4					
Most true flies			3	7	1	1
Gilled Snail		1	1			
Lunged Snail		1	4	5	1	22
Clams	2	1	1	21	1	5
Total Number of Organisms	**127**	**89**	**462**	**135**	**78**	**241**

Shading indicates the dominant taxa at each station

Table 31: Benthic Macroinvertebrate Results (% per taxa)

Macroinvertebrates	Site ID (Station)					
	244-2	244-3	244-4	246-1	262-3	272-1
Worms	0.8%	1.1%			2.6%	
Flat Worms						
Leeches	2.4%			3.0%	3.8%	1.2%
Crayfish		12.4%				
Sowbugs		6.7%				
Scuds	59.1%	21.3%		0.7%		46.1%
Stoneflies						
Mayflies	2.4%		1.5%	0.7%	1.3%	3.7%
Mother Damselflies and Dragon Flies		9.0%		0.7%	2.6%	
Gomphidae Dragonfly	0.8%	0.0%		0.0%	0.0%	1.2%
Hellgramites	0.8%		0.2%			0.4%
Common Netspinner		16.9%	84.4%	21.5%	2.6%	13.3%
Most Caddisflies	7.9%	28.1%	2.8%	3.7%		10.4%
Most Beetles	11.8%	1.1%	2.4%	43.0%	21.8%	2.5%
Waterpennies(Beetles)	9.4%		4.3%		0.0%	8.3%
Midges			1.7%	2.2%	61.5%	1.2%
Blackflies	3.1%					
Most true flies			0.6%	5.2%	1.3%	0.4%
Gilled Snail		1.1%	0.2%			
Lunged Snail		1.1%	0.9%	3.7%	1.3%	9.1%
Clams	1.6%	1.1%	0.2%	15.6%	1.3%	2.1%

Shading indicates the most dominant and second most dominant taxa at each station

Net spinning caddisflies require stable substrate (gravel or cobble) to set nets, and feed on suspended organic matter (algae, fine organic material). They often indicate nutrient enrichment in an urban watershed. Net spinners are typically not present if substrate is covered in sand, or if flashy flows constantly disturb the substrate.

Beetles were more abundant across all stations than typically seen in urban watersheds. Waterpennies in particular which were present at three streams are generally considered pollution sensitive, and are indicators of good water quality. They are rarely found in urban watersheds. They require diatom covered rocks, instead of the filamentous algae common to most urban streams.

Scuds were dominant or co-dominant at three streams, and tend to occur where there are large quantities of course organic matter to feed on. Highly urbanized streams tend to not retain organic material like leaves, which the scuds feed on. Sites 244-2 and 272-1 have wetlands upstream of the sampling station supplying decaying leaf material, which may help explain the presence of the scuds.

Midges dominate Dawkins Branch (262-3), the most developed of the benthic sampling sites, a reliable indicator of a stressed stream. This station is clearly different from the other stations based on the percent of midge larvae.

The change in benthos between 244-4 and 244-2 is interesting. The upstream station (244-4) is dominated by net spinning Caddisflies which feed on suspended organic matter, particularly algae. This reach is downstream of several stormwater wet ponds which could be the source of organic food. The downstream station (244-2) had no net spinning caddisflies but it has an increased number of Ephemeroptera, Plecoptera, and Trichopteras (i.e. stoneflies, mayflies, and caddisflies, all sensitive to pollution) and beetles, both considered signs of improved water quality. This station included the water penny beetle, which is a diatom scraper requiring low nutrient concentrations and relatively clean gravel/cobble. The high number of scuds at this station may reflect the 13 acres of wetlands along this reach which may convert nutrients in the water into plant biomass, which in turn the scuds feed upon.

Results with Virginia SOS Modified Method

None of the streams sampled, even the reference sites, scored in an acceptable range using the Virginia SOS modified method. This method is intended for use with gravel bed streams. The VaSOS index is designed to compare a specific station to reference conditions for streams not impacted by development. As such, it may not have sufficient ability to separate stations of different quality within an urban watershed. The VaSOS method tends to clump all of the sampled stations together in a category of "unacceptable" (**Table 32**). Compared to a pristine, undeveloped watershed without urban or agricultural impacts, that may be an accurate assessment. However, within a developed watershed where there are known urban and agricultural impacts, the VaSOS method makes it difficult to separate the least impacted streams from the most impacted streams.

Most stations (5 out of 6) score acceptable on the percent beetle metric, which was surprising since beetles tend to be rare or absent in many urban watersheds (**Table 32**). Four sites scored acceptable for percent net spinner caddisflies. Station 244-4 exceeded the acceptable score for percent net spinner caddisflies and had a very high abundance (390 in the sample).

Only 1 out of 6 stations scored acceptable for percent non-insects (i.e. scuds, sowbugs, crayfish, worms, leeches, snail, and clams). Percent non-insects was dominated by the presence of scuds at 3 out of 6 station. Freshwater clams were dominant at one station. The forested headwater stream had a significant number of non-insects (crayfish, scuds, and sowbugs) which is typical for headwater streams where flows are more variable seasonally, and there is a high input of organic matter such as leaves.

**Table 32:
Benthic Macroinvertebrate Results – VaSOS Index**

Virginia Save Our Stream Modified Rocky Bottom Method							
Scoring Parameters	Percent Mayflies, Stoneflies, and Most Caddisflies	Percent Common Netspinners	Percent Lunged Snails	Percent Beetles	Percent Tolerant	Percent Non-Insect	Score
Unacceptable	< 16	> 34.5	> 1.5	< 3.2	> 61.5	> 20.8	0-7
Gray Zone	16.1-32.2	19.7-34.5	0.3-1.5	3.2-6.4	46.7-61.5	5.4-20.8	8
Acceptable	> 32.2	< 19.7	< 0.3	> 6.4	< 46.7	< 5.4	9-12
Station							
244-2	10.2	0	0	21.3	67.7	63.8	6
244-3	28	16.9	1.1	1.1	40.4	44.9	6
244-4	4.3	84.4	0.86	6.7	3.5	1.9	7
246-1A	4.4	21.5	3.7	43	26	23	5
262-3	1.3	2.6	1.3	21.8	73	8.9	6
272-1	14.1	13.3	9.1	10.8	61	58.5	5

Shading indicates whether the parameter meets the scoring parameter criteria for unacceptable, gray zone, or acceptable.

The results of the limited benthic sampling conducted in Broad Run are summarized in **Table 33**. The benthic data clearly shows significant differences between developed watersheds (i.e. Dawkins Branch, 262-3) and "reference" conditions (i.e. 244-2). When the benthic data is compiled into the VaSOS index, a method based on Order/family level taxonomy, the important differences between streams are no longer apparent. The VaSOS index does not appear to be able to identify important biological differences between streams in a developed watershed. The VaSOS index identifies all of the sampled streams as impaired, which, compared to pristine streams, is probably true. However, in order to be useful for watershed management and planning in a developed/developing locality, the index needs to be able to differentiate between streams with different levels of degradation or stress.

The following recommendations are based on this limited assessment of benthic sampling:

- Raw benthic data can identify biological differences between stream reaches
- The VaSOS index is not sensitive enough for use in the County's developed watersheds
- A genus/species benthic index such as the DEQ Stream Condition Index (SCI) method should be evaluated for future benthic sampling

Table 33:
Benthic Macroinvertebrate Results – Summary

Subwatershed Name and Site ID	# of Organisms (# of Scud)	Rocky Bottom VaSOS Score	Watershed Land Use	Comments on Benthic Data
Tributary to Rocky Branch (244-2)	127 (75)	6	Forested Main Channel	Scuds and beetle dominant, no netspinners. Beetles were waterpennies. Presence of large wetlands upstream may have supported large scud population.
Tributary to Rocky Branch (244-3)	89 (19)	6	Headwater Forested	Headwater stream often have limited sample size due to low productivity. Mostly non-insects (crayfish, scuds and sowbugs).
Tributary to Rocky Branch (244-4)	462 (0)	7	Developed Upstream Drainage Area	Dominated by 390 net-spinners, 31 beetles. Upstream of Station 244-2.
Rocky Branch (246-1A)	135 (1)	5	Residential	Dominated by Netspinners and beetles and clams.
Dawkins Branch (262-3)	78 (0)	6	Developed	Dominated by midges and beetles. Low sample size.
Kettle Run (272-1)	241 (111)	5	Rural, Agriculture Main Channel	Dominated by scuds and caddisflies and netspinners and beetles.

Note: All VaSOS scores fall into the "unacceptable" range of 0-7

5.7. Stream and Buffer Prioritization and Ranking

The stream reaches assessed in the reconnaissance inventory were assigned a priority based on the following characteristics:

- Low RSAT Scores, particular for channel and bank stability;
- Lack of woody riparian buffer;
- Sufficient length to make a project warranted;
- Ownership and land use that is compatible with project;
- Ease of construction access;
- Presence of head cuts, exposed utilities, or failing outfalls; and
- Reach's impact on downstream stormwater facilities.

The assigned priorities are listed in **Table 34**. There were no high priority sites; three assigned moderate priority, and most were no priority. Only three sites were selected to develop a conceptual narrative. The relatively low number of sites suitable for stream restoration or other improvements is due to a lack of degraded, unstable stream channel, or poor riparian buffers. The lack of high priority sites and limited number of conceptual designs actually reflects the good condition of the watershed's streams and riparian buffers.

Table 34:
Ranking and Prioritization of Stream Reaches with Recommendations

Subwatershed Name and ID	Site ID	RSAT	Stream Length	Priority	Study Ranking	Ownership	Buffer and Channel Recommendations
Tributary to Rocky Branch (244)	244-1A	Good	2,197	Low	--	HOA	None
	244-1B	Good	209	Low	--	HOA	None
	244-2	Good	1,441	Low	--	Private	None
	244-3	Good	1,248	Low	--	Private	None
	244-4	Good	1,782	Low	--	Private	None
Rocky Branch (246)	246-1A	Good	744	Low	--	Park Authority, HOA, Community Assoc., and Private	
	246-1B	Good	531	Low	--	Park Authority, HOA, Community Assoc., and Private	
	246-2	Fair	476	Moderate	Outfall Retrofit	HOA	
Tributary to Broad Run (250)	250-1B	Good	1,352		--		Private
	250-2	NA	NA	Moderate	2	Headwater Wetland Preservation	Private
	250-3	Fair	2,927	Moderate	1	Pond and Buffer Restoration	PWC Park Authority
Dawkins Branch (262)	262-1	Good	365	Low	--	Private	None
	262-2	Good	860	Low	--	Private	None
	262-3	Good	1,126	Low	--	Private	None
	262-4	Good	794	Low	--	Commonwealth of Virginia	None
Kettle Run (272)	272-1	Good	737	Low	--	PWC Park Authority and Private	
	272-2	Good	1,190	Low	--	PWC Park Authority	
	272-3	NA	NA	Moderate	2	Private	Headwater Wetland and Stream Preservation
	272-4	Good	616	Reference	na	Private	
	272-5	Good	790	Low	--	Private	

5.8. Conceptual Design for Stream and Buffer Projects

The type of potential stream and riparian buffer restoration projects that were considered included:

- **Riparian Zone Restoration or Enhancement** – Riparian buffer projects were limited to sites where a relatively stable channel would benefit from increased buffer protection and the buffer would be compatible with the existing land use.
- **Stream Restoration / Enhancement / Stabilization** - Projects considered ranged from partial stabilization where infrastructure is being threatened, to larger functional restoration, to strategic stabilization of individual head cuts.

The Broad Run watershed had relatively few stream reaches in fair condition and none in poor condition. Most stream reaches had intact wooded riparian buffers and the stream channels were not incised or significantly eroded. The primary problem observed was reduced water quality and habitat which is better addressed with stormwater management improvements than stream or buffer restoration. Only three projects were identified based on the stream assessment and are summarized in **Table 35**. A full description of each project is presented in the conceptual design narrative included in the Appendices, organized by subwatershed.

Each appendix includes a map with the location of each project. Each design narrative includes the location, problem description, project description, potential benefits, design considerations, and a summary of cost estimate. Each design narrative also includes a location map with ADC map page references, ground level photos of existing conditions, and aerial photos of either existing conditions or proposed conceptual plan. Each project is identified by subwatershed, site ID, County facility ID if available, GPIN Ownership, and GPS coordinates.

Table 35:
Summary of Proposed Stream Projects

Site ID	Stream Length (linear feet)	Proposed Stream and Buffer Projects	Justification
250-1, 250-2, & 272-3	NA	Headwater Wetland and Stream Protection	The primary impact in the rural portions of Broad Run Watershed is runoff from agricultural cropland and a lack of water quality buffers between wetlands/streams and actively farmed croplands. This project would help identify and protect headwater wetlands and streams
250-3	2,927	Pond and Buffer Restoration, Bank Stabilization, Address Exposed Utilities	A large stream reach in public (Park) property with eroding banks, lack of buffer in some areas, and dysfunctional pond. This project would repair erosion, lack of buffer, and restore the pond. Restoration would include management plan to reduce impacts of golf course on stream corridor.
246-2	476	Channel Improvements	Manicured stormwater outfall channel with perennial flow. This project would address landowner concerns over pests and provide improved water quality functions

VI. COST ESTIMATES

The costs for construction and design of the proposed projects were estimated several different ways to provide to the County a range of possible costs. By reviewing the range of costs, the County can develop a list of funding priorities, and an estimated capitol cost to address those projects selected for funding. The cost is summarized in the conceptual design narratives in **Appendices B-F**, and the detailed cost estimates are provided in **Appendix F**. The methods used to estimate costs included the following:

Costs based on Center for Watershed Protection (CWP) Studies

The CWP has developed a range of planning level construction costs for different types of stormwater facility construction, based on the acres of impervious surface treated (**Table 36**). These costs would not include the site specific factors identified in this study which may affect costs. The cost estimates for new facilities are significantly lower than retrofitting existing facilities. These costs are only for construction and do not include design or contingency costs.

**Table 36:
Construction Costs
(Per Impervious Acre Treated)**

Type of BMP	Low Cost	Median Cost	High Cost
New Wetland Construction	$2,000	$2,900	$9,600
New Extended Detention	$2,200	$3,800	$7,500
Pond Water Quality Retrofit	$3,600	$11,100	$37,100
Bioretention Retrofit	$19,900	$25,400	$41,750

Generalized Construction and Design Costs

Generalized unit construction costs were developed for created wetlands and bioretention facilities (**Table 37**). These estimates do not take into account factors that might increase or decrease costs at a specific site. Design costs were assumed to be 30% of the estimated construction costs, and an additional 20% contingency was added to the design and construction costs.

**Table 37:
Generalized Costs Per 1,000 sf of Facility**

Type of BMP	Construction Cost	Design (30%)	Contingency (20%)	Total Cost
Created Wetland	$5,687	$1,706	$1,137	$8,530
Bioretention	$14,171	$4,251	$2,834	$22,106

The generalized construction costs for bioretention matched well with the low range estimated from the CWP studies. A 1,500 sf bioretention basin ponding to 1 foot deep would be required to treat one acre of imperious surface (based on capture of 0.5 inch), resulting in an estimated construction cost of $20,500 per acre of impervious surface treated. Costs would be doubled to capture 1.0 inch of runoff.

The generalized construction estimate for a created wetland was similar to the high estimate from the CWP studies. A 1,800 sf constructed wetland ponding to 1 foot deep (Level I) would be required to treat one acre of imperious surface (based on capture of 0.5 inch), resulting in an estimated construction cost of $10,250 per acre of impervious surface treated.

Site Specific Costs

Based on the proposed conceptual design narratives, assumed unit costs, and an initial rough estimate of quantities, this study developed planning level construction costs that are specific to each of the proposed projects. These estimates take into account factors that might increase or decrease costs at a specific site. Individual cost estimates for each project are available in **Appendix F**. Design costs were assumed to be 30% of the estimated construction costs. An additional 20% contingency was applied to the construction and design costs resulting in the total costs. The site specific costs are summarized below:

Stormwater Facility Repair and Retrofit Cost Estimates – For the eleven proposed stormwater facility repairs and retrofits, the estimates of total construction costs are approximately $571,000 (**Table 38**). The total costs including design, construction, and contingency, is approximately $915,000 for the eleven proposed stormwater repair and retrofit projects. Of those totals, approximately $600,000 would be for four retrofit projects, while the remaining $300,000 would be for major repairs.

**Table 38:
Site Specific Cost Estimate for Each Facility**

Subwatershed Name and ID	Site ID	Construction Cost	Design Cost (30%)	Contingency (20%)	Total	$/Imp. Acre
Trib. to Rocky Branch (244)	244-688	$89,013	$26,704	$23,144	$138,861	$10,911
	244-689	$74,097	$22,229	$19,265	$115,592	na
Rocky Branch (246)	246-243	na	$25,000	na	$25,000	na
	246-395	$22,120	$6,636	$5,751	$34,507	$8,458
	246-5050	$61,035	$18,310	$15,869	$95,214	$8,376
Dawkins Branch (262)	262-13	$9,607	$2,882	$2,498	$14,988	$9,222
	262-281	$20,436	$6,131	$5,313	$31,879	$36,330
	262-435	$22,880	$6,864	$5,949	$35,693	$23,802
	262-494	$223,982	$67,195	$58,235	$349,412	$19,942
	262-5239	$35,876	$10,763	$9,328	$55,966	$43,184
	262-5361	$11,917	$3,575	$3,098	$18,590	$7,377
	Total	**$570,963**	**$196,289**	**$148,450**	**$915,702**	

Stream and Buffer Enhancement and Stabilization Cost Estimates – For stream and buffer projects, the estimated total cost is approximately $225,000 for the two proposed sites, including design, construction, and contingency (**Table 39**). This cost estimate results in an average cost of $204 per linear foot. This estimated cost is well within the typical planning range of costs of $200-300 per linear foot for stream stabilization. Full stream restoration in urban watersheds typically would cost upward of $400 per linear foot, depending on the design approach.

Table 39:
Total Cost Estimates for Each Proposed Stream or Buffer Project

Subwatershed Name and ID	Site ID	Const. Cost	Design Cost (30%)	Contingency (20%)	Total Cost	Cost Per Linear Foot
246	246-2	$20,148	$6,000	$5,239	$31,431	$104
250	250-3	$123,965	$37,189	$32,231	$193,385	$322
	Total	**$144,113**	**$43,189**	**$37,470**	**$224,816**	**$204 (avg.)**

Cost Summary

Based on the individual cost estimates prepared for each concept design narrative, the total program cost to implement the projects identified within this study would be $1.1M (**Table 40**). The prioritization and ranking provides the County with the ability to limit the implementation of projects to those that are most needed, or the most cost effective.

Table 40:
Summary of Costs for Proposed Projects

	Construction	Design	Contingency	Total
Stormwater Improvements and Retrofits	**$570,963**	**$196,289**	**$148,450**	**$915,702**
Stream Stabilization and Buffer Enhancements	**$144,113**	**$43,189**	**$37,470**	**$224,816**
Totals	**$715,000**	**$239,478**	**$182,920**	**$1,140,518**

This study did not identify all possible projects or all high priority projects which may exist in the Broad Run watershed. This study evaluated only five subwatersheds out of 50 total subwatersheds within the Broad Run watershed, representing approximately 19% of the total area of Broad Run watershed in the county.

The stream assessments screened all streams within the study subwatersheds but only field evaluated 13% of the total length of streams within the five subwatersheds. Those reaches which were assessed in the field were those reaches where the potential for problems were the highest, and the compatibility of restoration with adjacent land use and ownership were the greatest. The two step approach to identification of stream projects (i.e., screening and field assessments) should result in the majority of existing stream problems being identified within these subwatersheds. The stream conditions in the other subwatersheds may vary from those found in the subwatersheds in this study.

The stormwater inventory provides a subsampling of existing conditions which could be used to project costs across the entire Broad Run watershed within the County. Based on the results of the stormwater facility inventory conducted for this study, the following assumptions could be made:

- Based on the results of this study, approximately 18% of the facilities in the County's inventory may require major repairs or modifications to address existing deficiencies. Based on the total of

255 bioretention basins, dry ponds, and wet ponds reported to be in the Broad Run watershed within the county, potentially an additional 40 facilities may require repairs to correct existing deficiencies. Based on an average repair cost as determined in this study (approximately $45,000 each facility), there may be up to $1,800,000 in major repairs within the entire Broad Run watershed.

- Out of 67 dry ponds screened in this study, 27 were selected for field inspection. Of those, four dry ponds were determined to be suitable for water quality retrofits. Based on a total of 167 dry ponds in the Broad Run watershed, a total of 10 dry basins, or 6 additional sites within the watershed, may make good candidates for water quality retrofits. The average cost to retrofit a dry basin in this study is $150,000. A projected total cost to retrofit a total of 10 facilities in the entire watershed would be $1,500,000.
- In this study, an additional 27 potential stormwater facilities not included in the County database were identified during the desktop analysis. These facilities represent a 31% increase over the 88 facilities in the database within the five study subwatersheds. Based on a total of 255 wet ponds, dry ponds and bioretention sites reported within the entire Broad Run watershed in the County, there may be 40-50 facilities not currently included in the County inventory. These facilities would be located in those subwatersheds not included in this study. Not all of the potential facilities identified during the desktop screening are actual stormwater facilities. Facilities not included in the County inventory may not be routinely inspected or maintained and may require additional maintenance or repair to address existing deficiencies.
- This study identified relatively little need for stream restoration, or buffer enhancement within the five subwatersheds reviewed, despite evaluating approximately 20,000 linear feet of streams. A gross estimate of the amount of stream related work within the watershed would be $1M.
- For the entire Broad Run Watershed, the total costs to address stormwater repairs, water quality retrofits, buffer enhancements and stream restoration may approach $5M. However, this projection is based on a limited sampling of only 5 of the 50 subwatersheds within the Broad Run watershed. Continuing watershed studies that investigate additional subwatersheds would help to refine the total costs for the entire watershed.

VII. WATERSHED PLANNING RECOMMENDATIONS

7.1 Introduction

A watershed management or planning program typically relies on three tools to understand the condition of a watershed, to manage potential impacts to the watershed and to gauge the success of management policies:

- Monitoring Data
- Land Use / Land Cover Data
- Modeling

Each of these approaches has its benefits and challenges. A robust watershed planning program will use all three approaches to most effectively understand the County's watersheds and determine appropriate management programs and policies.

Monitoring Data – Measurements of stream condition, water quality, benthic macro-invertebrates, fish, habitat, and/or flow are the best methods of assessing the actual health of the streams within a watershed. Monitoring is the most direct approach to determining existing conditions and documenting trends within a watershed's streams. Many of these parameters, particularly water quality, vary considerably daily, seasonally, and annually, which can make detection of trends difficult. Collecting reliable monitoring data requires standardize protocols, trained personnel, and frequent sampling such that an accurate evaluation of the stream condition can be made. Trend detection requires a long-term data set of high quality data in order to factor out much of the variability in the data.

Despite these difficulties, monitoring data is the only way to directly measure the impacts of development on a watershed and the efficacy of watershed management programs. Reliance solely on indirect methods of evaluating stream health based on land use or modeling can misrepresent a stream's actual condition.

Land Use/Land Cover Data – Land use/cover data can be used as a measure of the condition of the watershed that provides the flows and runoff to the watershed's streams. This data includes aerial photography, zoning, wetlands, and many other types of data about how the land is used and its condition. A lot of information can be inferred from the land use/cover of a watershed, based on our understanding of the general impacts of changes in land use on water quality and streams. The change in hydrology, the potential pollution loads, and the potential for toxic discharges can be somewhat predicted through the use of land use/land cover data.

However, the predictive power of land use/cover data is limited by our understanding of how different land uses impact streams. In addition, historical land uses may have long-term impacts on stream health which are not obvious when reviewing current land use data. An example of this issue is the impact that historical dams have on stream stability for decades or centuries, even though the dam may no longer be recognizable from land use data.

Modeling – Modeling of land use, stormwater runoff, stream discharge and water quality is an important tool to help understand existing conditions, and to predict how future conditions could change under different management policies. However, modeling should always be viewed cautiously since models are sensitive to the data and assumptions they are based upon. Models should always be validated against measured data from the field to ensure that the model is reliable.

Models can help policy makers understand the relative contribution of different pollution sources to the degradation of a watershed, thus helping to target corrective actions where they will be most effective. Models can help guide policy by predicting changes due to management actions, but models cannot be used to measure actual changes due to management actions.

7.2 A Review of Existing Monitoring Data, Land Cover Data and Modeling

Existing DEQ Water Quality Data

There is a limited supply of historical water quality for the Broad Run watershed. DEQ has conducted water quality monitoring in the Broad Run watershed, but the number of stations and consistency of sampling have varied widely over the years. The data is not consistent enough in time or space to allow the detection of trends for any particular station. For this analysis the data from all stations and years were compiled and analyzed to characterize the data that is available.

DEQ considers streams with a total nitrogen (TN) concentration below 1 mg/l to represent reference conditions, while streams with concentrations >2.0 mg/l TN are considered stressed. Streams with concentrations below 0.02 mg/l Total Phosphorus (TP) and over 0.05 mg/l TP are considered reference condition and stressed, respectively. By comparing the available data from the DEQ monitoring programs to these benchmarks, some assessment of the water quality conditions of the streams in the Broad Run and Kettle Run watersheds can be made.

Broad Run

A total of 9 stations have been monitored in Broad Run over a period of 9 years (**Table 41**). The average TN for Broad Run is 1.09 mg/l TN, a level slightly above reference conditions. Of the 49 samples, 49% were greater than 1.0 mg/l TN. Only two of the 49 samples were above the threshold to be considered stressed (i.e. > 2 mg/l TN).

**Table 41:
Broad Run DEQ Data
(9 stations sampled between 2000-2008)**

	pH	DO	NH3+NH4-N mg/l N	NO2 and NO3 N mg/l N	NO3-N mg/l N	TOT KJEL N mg/l N	TOTAL N mg/l N	Diss. P mg/l P	Total Phos. mg/l P
Number of Samples	110	112	61	20	41	43	49	43	87
Average	7.44	10.13	0.08	0.74	0.36	0.58	1.09	0.02	0.06
Median	7.4	9.71	0.04	0.62	0.35	0.50	0.99	0.02	0.04
Min.	6.44	4.77	0.04	0.32	0.04	0.2	0.41	0.01	0.01
Max.	8.9	16.09	1.32	1.48	0.83	1.9	2.71	0.06	0.28

Most ammonia (NH4) data is below the detection limit, except for three very high readings, two of which were at a single station in the same year. From 2006 onward nitrate data is consistently higher than prior to 2006, which is a pattern typical of a change in analytical methods.

The phosphorus data shows a few highly elevated samples, probably as a result of storm events. The average concentration of 0.06 mg/l TP is considered stressed while the median concentration of 0.04 mg/l TP is considered suboptimal. Forty (40%) of the samples are ≥ 0.05 mg/l TP, or considered stressed.

Broad Run appears to have elevated nitrogen levels but below what is considered "stressed". However these streams appear to have phosphorus levels that are considered "stressed".

Kettle Run

A total of 4 stations have been monitored in Kettle Run over a period of 4 years (**Table 42**). The average TN for Kettle Run is 1.01 mg/l TN, a level slightly above reference conditions. Of the 19 samples, only 16% were greater than 1.0 mg/l TN. Two of the 19 samples were above the threshold to be considered stressed. Kettle Run appears to have lower TN concentrations than Broad Run.

The average and median concentrations for Kettle Run watershed were 0.07 and 0.06 mg/l TP, respectively, and would be considered stressed. Eleven out of 19 samples (57%) ≥ 0.05 mg/l TP, and would be considered stressed. Phosphorus levels in Kettle Run are higher than in Broad Run, based on available data.

The latest sample date for Kettle Run is from 2004, compared to 2008 for Broad Run. Some of the differences between the two data sets could be attributed solely to the different monitoring years and number of samples. The lack of consistent water quality monitoring limits its usefulness in targeting subwatersheds with higher pollutant concentration for watershed management actions.

Based on the DEQ data, neither Kettle Run nor Broad Run appears stressed by high nitrogen concentrations. Kettle Run is stressed by high phosphorus concentrations. Broad Run is borderline stressed by high phosphorus levels. The high phosphorus levels might be attributed to high suspended sediment loads, but there is insufficient data to confirm this possibility.

**Table 42:
Kettle Run DEQ Data
(4 stations sampled between 2000-2004)**

	pH	DO	NH3+NH4-N mg/l N	NO3-N mg/l N	TOT KJEL N mg/l N	Total N mg/l N	PHOS-T ORTHO mg/l P	PHOS-TOT mg/l P
Number of Samples	31	33	19	19	19	19	19	19
Average	7.38	9.42	0.06	0.65	0.71	1.01	0.04	0.07
Median	7.37	9.11	0.04	0.14	0.6	0.72	0.03	0.06
Min.	6.61	3.56	0.04	0.04	0.1	0.24	0.01	0.02
Max.	8.03	15.01	0.31	7.6*	2.7	3.43	0.13	0.24

*7.6 is probably an error

Review of Data from Occoquan Watershed Monitoring Lab

The Occoquan Watershed Monitoring Lab (OWML) has long-term water quality monitoring stations within the Broad Run watershed. There is one station (ST70) upstream of Lake Manassas and one station (ST30) near Linton Hall Road. These stations are sampled multiple times per month, including both baseflow and storm event samples. The dataset from 2000 to 2011 contains in excess of 700 samples, a very robust and consistent dataset in contrast to the DEQ dataset. Station ST30 is centrally located and the best representative of the Broad Run water quality in Prince William County.

The average TN for station ST30 is 1.07 mg/l TN, which slightly exceeds reference conditions and is very similar to the DEQ data (**Table 43**). The median TN concentration is 0.98 mg/l which is considered a reference condition. The nitrate/nitrite concentrations average 0.50 mg/l N, and the ammonia concentrations averaged 0.06 mg/l N. The nitrate level is low and the ammonia level may be somewhat elevated compared to reference conditions. This data set includes stormflows, which show elevated TN concentrations of 1.36 mg/l N, with the increase mostly consisting of particulate organic N. When the storm event samples are removed from the dataset, the average TN level drops to 0.92 mg/l N, well within what is considered to be a reference condition.

Based on the existing water quality, it may be difficult to reduce existing N concentrations as part of a TMDL program since the existing concentrations are not considered significantly elevated. Additional monitoring could be used to help pinpoint if any of the tributaries are experiencing elevated N levels. The nitrogen data from station ST70 upstream of Lake Manassas is very similar to station ST30.

**Table 43:
Broad Run OWML Data
(Station ST30 sampled between 2000-2011)**

	pH	DO	NH3+NH4-N mg/l N	NO2 and NO3 N mg/l N	TOT KJEL N mg/l N	TOTAL N mg/l N	Dissolved P mg/l P	Total Phos. mg/l P
Number of Samples	495	540	697	740	325	740	412	738
Average	6.1	8.97	0.06	0.51	0.62	1.07	0.04	0.08
Median	7.03	8.44	0.04	0.47	0.52	0.98	0.02	0.04
Min.	6.1	4.40	0.01	0.01	0.04	0.27	0.01	0.01
Max.	7.8	16.7	1.19	3.6	3.7	3.7	2.9	0.90

The average concentration of 0.08 mg/l TP is considered a stressed condition while the median concentration of 0.04 mg/l TP is considered a suboptimal condition. The average concentration of TP exceeds 0.05 mg/l P which is the cut off for being considered a stressed condition. The data set contains both storm events and baseflows. When these two types of samples are analyzed separately, the baseflow average TP concentration of 0.04 mg/l P is considered a suboptimal condition – impacted but not yet stressed. The storm event samples have a higher average TP concentration of 0.16 mg/l P, which appears to be driven primarily by particulate phosphorus such as sediment, algae and organic matter. The phosphorus data from station ST70 upstream of Lake Manassas is higher than station ST30. Some of the phosphorus may be trapped within the lake, reducing downstream export.

Review of Existing Modeling - Total Maximum Daily Loads (TMDL)
The DEQ has identified stream segments in the Broad Run watershed which are not meeting current water quality standards (**Figure 13**). The DEQ and EPA have developed two TMDLs to address the stream reaches that do not meet water quality standards. The identification of the stream reaches that are not meeting current water quality standards is based on the limited monitoring conducted by DEQ. Each TMDL is summarized below:

Fecal Bacteria TMDL for Broad Run, Kettle Run, and South Run
A TMDL was developed in 2006 for the Occoquan Watershed, which includes stream reaches in Broad Run, Kettle Run, and South Run not meeting water quality standards for fecal bacteria. This TMDL also includes Pope's Head Creek, Bull Run, Little Bull Run, and the Occoquan River above the Occoquan Reservoir.

Three segments of Broad Run were identified in DEQ's 2004 305(b) water quality assessment integrated report as impaired. A total of 10.6 miles of the main stem of Broad Run is listed as impaired. The first segment is a 7.3 mile reach (VAN-A19R-01) between Rocky Branch and Cannon Branch. Four out of 19 samples collected at DEQ station ABRU0007.58 exceeded fecal bacteria standards. The second segment (VAN-A19R-02) is a 1.5 mile reach located immediately upstream of Lake Manassas, where 7 out of 18 samples exceeded fecal bacteria standards. The third segment extends from Mill Run downstream to

Trapp Run (VAN-A19R-05). Two out of five samples at DEQ station (AABRU026.40) exceeded fecal bacteria standards.
The impaired segment of Kettle Run (VAN-A19R-03) begins 0.08 miles upstream of Route 708 and continues downstream to its confluence with Broad Run. Between 1998 and 2002, 8 out of 20 samples from DEQ station (1AKET0008.00) exceeded the fecal bacteria standard.

The impaired segment of South Run (VAN-A19R-04) begins on South Run downstream of Lake Brittle and continues downstream to its confluence with Lake Manassas. Between 1998 and 2002, 5 out of 18 samples from DEQ station (1ASOT001.44) exceeded the fecal bacteria standard.

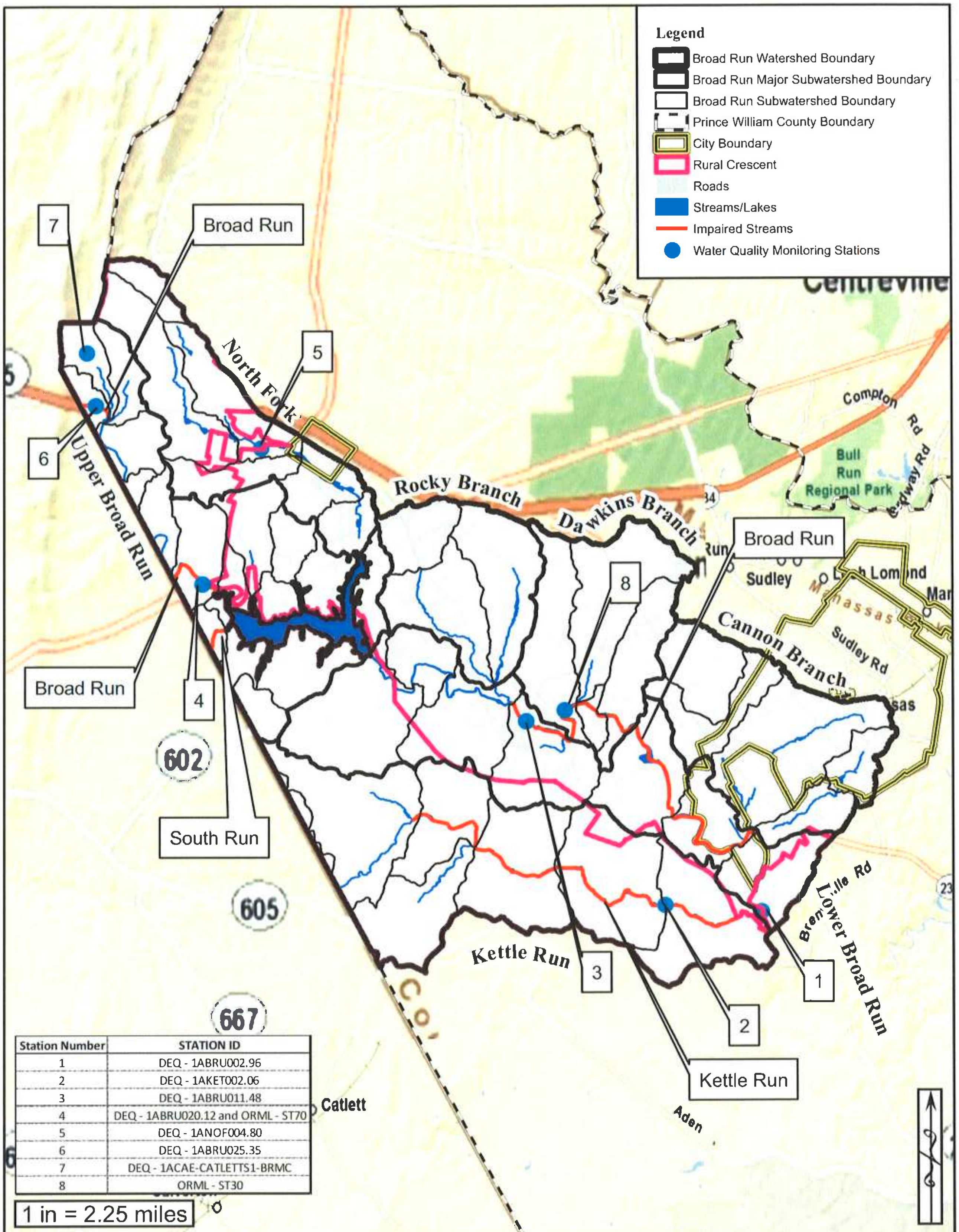
The TMDL identifies a need for up to 94% reduction in bacteria loads to meet water quality standards within the impaired reaches. DEQ identified failing septic systems, cattle access to streams, and urban runoff are identified as key sources which would have to be controlled 95-100% in order to meet the TMDL goal.

Benthic Impairment TMDL for South Run

South Run drains approximately 4,400 acres into Lake Manassas, and is listed as benthic impaired. The impaired reach is located between Lake Brittle and Lake Manassas, and is 2.3 miles long (VAN-A19R_SOT01A00). Only a small portion of this reach is located in Prince William County. The monitoring data indicates that the benthos is moderately to slightly impaired based on monitoring data from 1994 to 2005. A TMDL was completed in June, 2006, which evaluated the potential stressors causing the benthic impairment. Based on the available data, nutrient enrichment was identified as the primary stressor, specifically phosphorus. Potential toxic stressors were noted in sampling (arsenic and silver) and by in-stream toxicity testing, but were not considered to be the primary stressor. Phosphorus measurements taken from the stream typically exceed the 75^{th} percentile for reference conditions in this region. Other signs of nutrient enrichment are present such as high algal concentrations. The TMDL identified the need for a 33% load reduction in phosphorus. However, the only point source in the watershed, the Vint Hill WWTP, is proposed to relocate its outfall to the Kettle Run watershed. As a result, the phosphorus load in South Run would be reduced below the TMDL required end point. The Vint Hill WWTP has not been relocated as of the date of this report.

Chesapeake Bay TMDL

The Broad Run watershed is part of the much larger Chesapeake Bay watershed for which there is a TMDL addressing excessive loads of nitrogen, phosphorus, and sediment. Prince William County as part of a Watershed Improvement Plan (WIP) will be tasked to reduce loads of all three pollutants. A portion of the pollutant load reduction may come from the Broad Run watershed. The following are some observations concerning meeting the Chesapeake Bay TMDL based on the findings of this study:



Station Number	STATION ID
1	DEQ - 1ABRU002.96
2	DEQ - 1AKET002.06
3	DEQ - 1ABRU011.48
4	DEQ - 1ABRU020.12 and ORML - ST70
5	DEQ - 1ANOF004.80
6	DEQ - 1ABRU025.35
7	DEQ - 1ACAE-CATLETTS1-BRMC
8	ORML - ST30

	Source:	Title:	Figure:
WR&A	Prince William County GIS, DEQ, Esri, World Street Map	Broad Run Watershed TMDL Map	13

Developed Portions of Broad Run

- Most streams are in good condition with stable channels, so stream restoration will not be an widespread approach to reducing sediment loads in this watershed.
- Most development already drains to existing SWM BMPs, thus there is little opportunity to construct new SWM BMPs to treat existing impervious surface.
- The limited benthic data generated in this study do not show impacts from a high suspended sediment load, additionally confirming the stream assessments that sediment load may not be high in much of this watershed.
- The pollutant removal efficiency of some existing SWM BMPs could be improved by conversion from dry extended detention basins to constructed wetlands or other more efficient BMPs.
- Current monitoring data from OWML shows only slightly elevated concentrations of nitrogen above reference conditions. Relatively low N concentrations make meaningful reductions in N difficult to achieve.
- Current monitoring does indicate elevated P concentrations. The source of existing elevated levels of phosphorus in Lower Broad Run should be identified through a targeted water quality monitoring program. Once the source of elevated phosphorus levels is identified, corrective actions to reduce the loads can be developed.

Rural Portions of Broad Run and Kettle Run

- There is relatively little impervious surface to treat with stormwater management facilities. There is also little opportunity to improve the few existing SWM BMPs or treat currently untreated impervious pavement.
- Current monitoring data show only slightly elevated nitrogen concentrations, but current monitoring data do not include storm event monitoring or flow weighted sampling.
- Many headwater streams and wetlands may be impacted by agricultural practices and often lack riparian buffers or filter strips. Increased use of agricultural BMPs may help reduce loads of sediment, phosphorus and nitrogen.
- The source of existing high levels of phosphorus in Kettle Run should be identified through a targeted water quality monitoring program. Once the source of elevated phosphorus levels is identified, corrective actions to reduce the loads can be developed.

Review of Existing Land Cover/Land Use Data

The impervious cover model suggests that stream health declines as the percentage of impervious surface in a watershed increases. Below 10% impervious cover, streams are considered "supporting" of aquatic life. Between 10 and 25%, degradation is apparent ("impaired"), and above 25%, the streams are considered to be "non-supportive" of aquatic life. Based on existing GIS data, the potential condition of streams within the Broad Run watershed can be projected (**Table 44**).

**Table 44:
Existing Land Use Data and Related Water Quality Data**

Major Subwatershed	Percent Impervious Cover	Percent Forested	Classification Based on Impervious Surface	Nitrogen and Phosphorus	TMDL
Cannon Branch	21%	19%	Impaired	No Information	None
Dawkins Branch	21%	34%	Impaired	No Information	None
Kettle Run	2%	40%	Supporting	Stressed by High P	Fecal Bacteria
Lower Broad Run	8%	35%	Supporting	Stressed by High P	Fecal Bacteria
North Fork	7%	58%	Supporting	No Information	None
Rocky Branch	18%	47%	Impaired	No Information	None
Upper Broad Run	4%	59%	Supporting	Stressed by High P	Fecal Bacteria; Benthic Impairment
Study Average	**10%**	**41%**	**Supporting / Impaired**		

Cannon Branch, Dawkins Branch, and Rocky Branch exceed the 10% threshold of impervious surface to be considered impaired. However, none of these streams have documented water quality problems or a TMDL, primarily due to a lack of monitoring data. The existing land cover/land use date would suggest that these streams are degraded. However there is no DEQ data to verify this prediction. In this study, a single benthic sample from Dawkins Branch does indicate a significantly degraded benthic community. In Rocky Branch, a single benthic sample from this study indicates a moderately degraded benthic community.

Kettle Run and Lower Broad Run are considered "supporting" with less than 10% impervious cover. However, these two of the least developed major subwatersheds in Broad Run have elevated levels of phosphorus and a fecal bacteria TMDL. Both of these subwatersheds highlight the limitation of using land cover/land use to predict stream condition. Despite land cover/land use data that would suggest minimal impact, both of these subwatersheds have elevated phosphorus levels based on existing water quality monitoring data. The water quality impacts of agriculture in Kettle Run are not reflected in the percentage of impervious surface. In Lower Broad Run major subwatershed, the source of elevated phosphorus may be from the other heavily developed subwatersheds which drain into Lower Broad Run, such as Dawkins Branch. The elevated P concentration may also be due to point sources upstream of the County. This simple evaluation illustrates the limitation of only using land use to predict stream health.

7.3 Recommendations for Watershed Management and Planning

The following recommendations are based on lessons learned from watershed studies of Broad Run and Bull Run, and our understanding of upcoming regulatory requirements. The following recommendations would enhance the ability of the County to manage its watersheds and to respond effectively to increasing federal and state regulatory requirements:

- **Revise/Update GIS Data** – Improved GIS data will allow for better watershed planning and modeling efforts. During master planning and site planning processes, the following information could be used to improve the County's ability to meet watershed management goals:
    - Presence of wetlands, streams, hydric soils, large forest tracts, and floodplains which should be preserved during master planning and site development.
    - Presence of highly permeable soils suitable for stormwater infiltration where low impact development methods would be most effective.
- **Update Stormwater Management GIS and Database** – The County currently has a well-developed GIS, which includes stormwater management facilities and the stormwater drainage network. The EPA Chesapeake Bay TMDL requires an accurate determination of the number, type and location of all stormwater BMPs in the County. During this watershed assessment and others, BMPs were identified which are not included in the County's GIS database. Including these facilities in the County's database would allow these facilities to be counted toward meeting the Bay TMDL requirements.
- **Continue Watershed Studies** – The County should continue to conduct watershed studies in order to identify the condition of the County's streams and stormwater facilities. These studies provide the county the baseline information to understand watershed condition, as well as to respond to upcoming regulatory requirements to increase pollutant removal.
- **Continue Resource Protection Areas (RPA)** – The RPA program resulted in the protection of riparian buffers throughout the Broad Run watershed. Few streams in the Broad Run watershed lack a riparian buffer, unlike older watersheds such as Bull Run which were developed prior to the RPA program. The preservation of the RPAs contributes significantly to protecting stream quality. This program is an important component of the watershed management program, preserving healthy existing riparian buffers.
- **Strengthen Stormwater Inspection and Maintenance Program** – This program could be improved through strengthen the three major steps.
    - Use the stormwater GIS/database system to help track inspections and maintenance.
    - Integrate inspection results into stormwater GIS/database.
    - Use inspection results to guide maintenance activities.
- **Strengthen Illicit Discharge Detection and Elimination Program (IDDE)** – The MS4 permit program requires an IDDE program to detect non-stormwater discharges from stormwater systems. These discharges can contribute nitrogen, phosphorus and fecal bacteria from sanitary sewer discharges. A wide range of toxic chemicals can be discharged from industrial, commercial, and recreational facilities. A strong IDDE program can address requirements of TMDLs to reduce loadings of nitrogen, phosphorus and fecal bacteria. Recent research has shown that in many developed watersheds, small illicit discharges can represent a significant source of pollutant load. Identification and correction of these discharges is often much more cost effective than SWM BMP retrofits or other watershed load reduction methods.
- **Implement Benthic Macro-invertebrate Monitoring** – There is no benthic data available from DEQ for streams in this watershed, or for much of the County. EPA has stated that the next round of MS4 permit renewals will require benthic sampling. The County should consider

establishment of a benthic monitoring program targeted at meeting MS4 requirements and identifying streams with significant pollution issues. Benthic data can be used to confirm streams which are suspected of having poor conditions. Benthic data can also be used to screen for unexpected water quality problems. Benthic monitoring can be followed up with water quality monitoring to track down pollutant sources for correction. Long-term benthic monitoring can help judge the success of watershed management policies and programs.

- **Implement Water Quality Monitoring** – The existing water quality data for the County's streams is limited to data collected by DEQ and the OWML. The OWML data is very complete and provides a long-term data set, however it has relatively few stations. The DEQ data is not a long-term data set, but does include more stations than the OWML program. TMDLs and other regulatory requirements are predicated upon the DEQ data, despite its limitations. The County should consider a water quality monitoring program that compliments the long-term OWML program, and which helps address the most pressing watershed management issues. It should be a targeted program to clarify the location and sources of the most significant pollution sources in the County. Long-term water quality monitoring can help judge the success of watershed management policies and programs. In some cases where limited data was used to establish a stream specific TMDL, such as the benthic impairment TMDL for Bull Run, a targeted water quality monitoring program could provide help to reduce or eliminate the need for a TMDL.

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