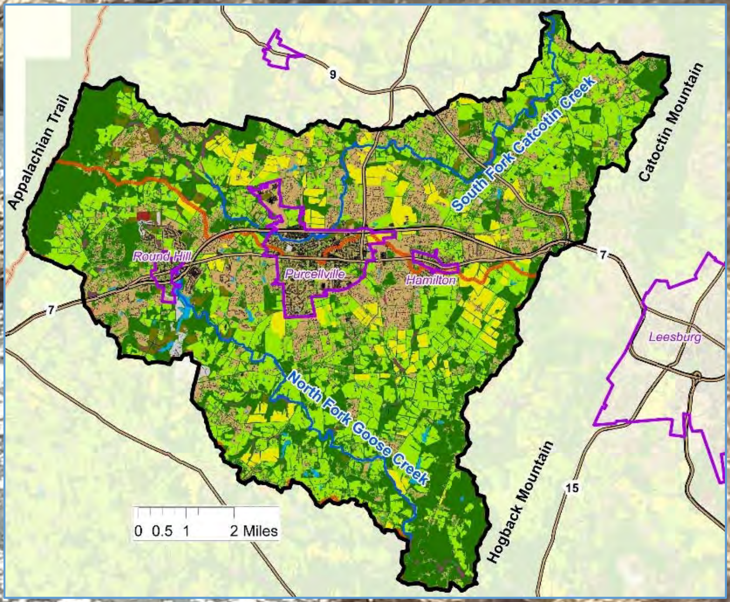
# WESTERN HILLS WATERSHED MANAGEMENT PLAN





**Prepared Jointly by**

**Loudoun County**
**Department of**
**Building and Development**
**1 Harrison St.**
**Leesburg, VA 20175**

**and**

**Tetra Tech, Inc.**
**10711 Red Run Blvd., Suite 105**
**Owings Mills, MD 21117**


**May 12, 2020**

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Prepared Jointly by:

Loudoun County
Department of Building and Development
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Leesburg, VA 20175

and

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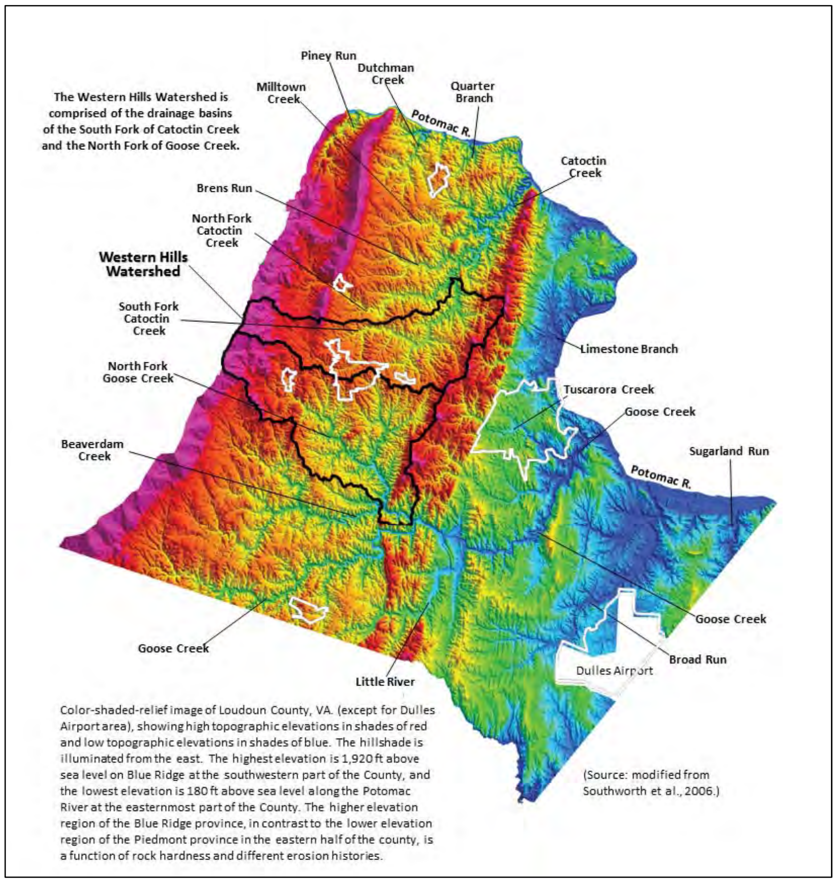
# EXECUTIVE SUMMARY

The Western Hills Watershed Management Plan was developed in 2018-2019 to fulfill several objectives as approved by Loudoun County's Water Resources Technical Advisory Committee (WRTAC). The objectives of the project include:

- Build upon previous watershed assessment and planning activities and take the next logical step in the County's on-going watershed management program.
- Leverage lessons learned in the first watershed plan for Upper Broad Run (2014) and have County staff perform select task elements in collaboration with the Contractor.
- Provide a basis for cost-effective watershed management plans on a countywide basis.
- Provide a long-term plan to protect and improve watershed conditions in this area, which has many types of planned land uses and significant projected future development.
- Provide a list of recommended projects and best management practices (BMPs) to address observed and potential water quality and quantity problems within the watershed.
- Develop pollutant load scenarios based on current and expected future conditions with and without implementing the management plan. These scenarios will provide the County with quantitative pollutant estimates to use in long-term planning and to meet current and future water quality regulatory requirements.



Color-shaded-relief image of Loudoun County, VA. (except for Dulles Airport area), showing high topographic elevations in shades of red and low topographic elevations in shades of blue. The hillshade is illuminated from the east. The highest elevation is 1,920 ft above sea level on Blue Ridge at the southwestern part of the County, and the lowest elevation is 180 ft above sea level along the Potomac River at the easternmost part of the County. The higher elevation region of the Blue Ridge province, in contrast to the lower elevation region of the Piedmont province in the eastern half of the county, is a function of rock hardness and different erosion histories.

- Include cost estimates for implementing various Best Management Practices (BMPs) and management recommendations that will be useful for forecasting the costs to implement watershed management plans elsewhere in the County.

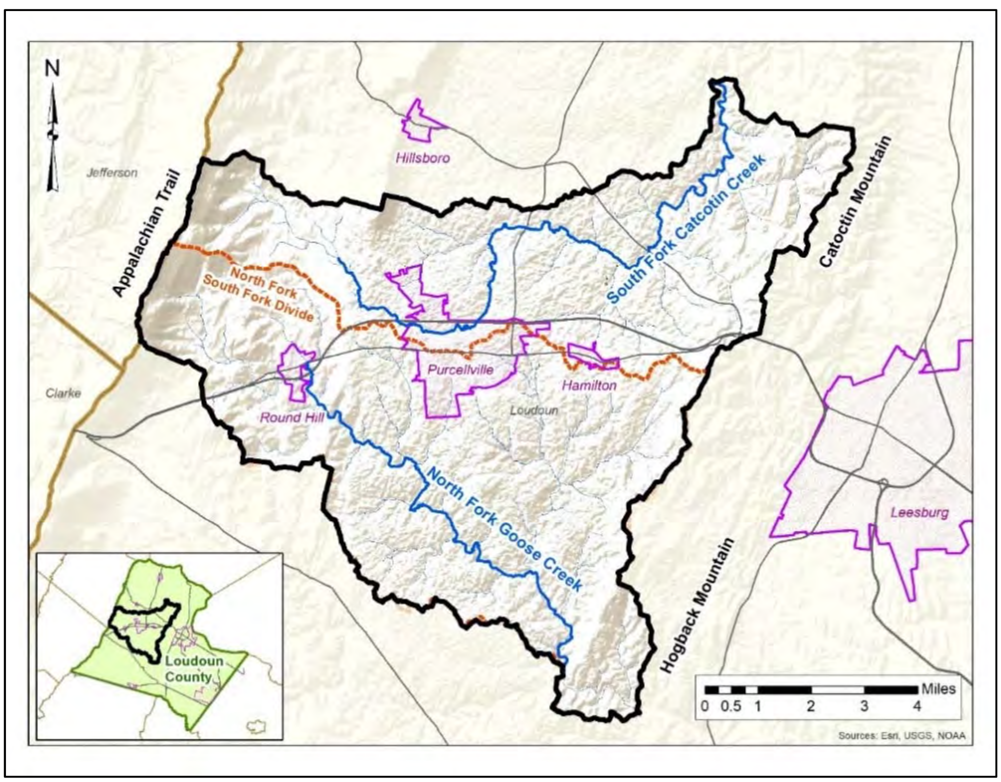
Watershed management planning is intended to protect, preserve, and restore the water resources of Loudoun County. The overall scope and location of the Western Hills Watershed Management

Plan Project was developed by County staff with concurrence of the WRTAC. The plan is similar in scope and is a follow up to the 2014 Upper Broad Run Watershed Pilot Project. Experience gained during the Pilot Project allowed for greater County staff participation in the development of selected tasks in the Western Hills Watershed Management Plan.

This Watershed Management Plan Report summarizes the current conditions and proposes watershed management recommendations and strategies for the Western Hills Watershed. Current conditions were evaluated through analyses of spatial data by Loudoun County Staff and through field assessments and modeling conducted by the County's consultant, Tetra Tech. Restoration options and recommendations presented within this report, including expected pollutant reductions and estimated costs, provide a basis for future management of the Western Hills Watershed. The scope of the plan per WRTAC specifically included groundwater-related issues due to the relative importance of this natural resource in western Loudoun County.

**Western Hills Watershed Overview**

The Western Hills Watershed is within the Blue Ridge physiographic region of Virginia, located west of the Town of Leesburg and east of the County border along the Appalachian Trail. The watershed designation originated with County staff wherein portions of the Goose Creek and Catoctin Creek watershed were selected, specifically with the intent to focus on the three western Towns that lie on the watershed boundary shared by the North Fork Goose Creek and South Fork Catoctin Creek. The 49,558 acres (approximately 77 square miles) of the Western Hills Watershed are completely contained within Loudoun County and include the towns of Purcellville, Round Hill, and Hamilton.



## Watershed Management Plan Goals

Five goals were identified for restoring the Western Hills Watershed based on the vision statement and input gathered from both the Watershed Partnership Workgroup and community meetings. These goals are:

Goal 1: Improve local watershed/stream conditions to meet Clean Water Act goals such as supporting aquatic life use and contact recreation.

*Objectives:* Make recommendations for actions that will help the County meet the Phase III WIP "Pollution Diet" targets for reducing nitrogen, phosphorus, and sediment. Identify locations and opportunities for stormwater retrofits.

Goal 2: Prevent further degradation of stream habitat, physical integrity, and water quality as watershed lands are developed.

*Objectives*: Select areas for protection as well as restoration. Mimic pre-development hydrologic condition through the use of appropriate stormwater management. Minimize impervious surfaces on new development.

Goal 3: Promote access to streams and streamside areas for recreation.

*Objectives:* Improve public access to Western Hills streams and tributaries.

Goal 4: Educate local businesses and watershed residents about watershed stewardship.

*Objectives:* Conduct educational outreach to schools, residents, and business communities throughout the watershed to encourage and support actions that reduce pollutant loads to local waterways. Use community-based grants to construct and maintain BMPs. Encourage community stewardship through watershed restoration and cleanup activities. Coordinate with STEM (Science, Technology, Engineering and Math) programs. Educate and train agricultural and equestrian community.

Goal 5: Incorporate groundwater in the watershed management planning process.

*Objectives:* Enhance groundwater quality monitoring through limited well water testing. Assess groundwater use and availability.

## Public Involvement

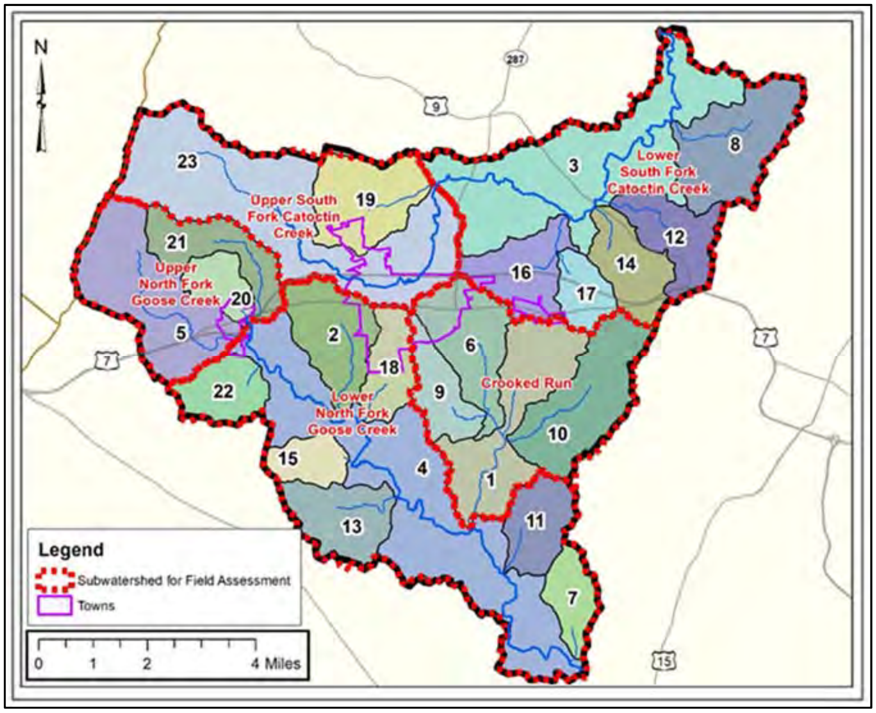

**Photo provided by Patrick Szabo Loudoun Now 9-28-2018**

Effective implementation of watershed restoration strategies requires the coordination of diverse watershed partners and the participation of many stakeholders. For the Western Hills Watershed Project, public involvement components included conducting local community meetings, providing updates via Loudoun County's website and social media sites, and forming a Watershed Partnership Workgroup (WPW). The community meetings help to engage residents through presentations and interactions regarding the watershed planning process, some of the key existing conditions and characteristics of the Western Hills Watershed, proposed goals of the plan, and strategies that may be used to meet those goals. Public input includes: resident's concerns about what major water-related issues, what locations they would recommend for targeted field visits, and what they believed is needed to implement an effective watershed management plan. Outreach methods included project updates (including presentations from community and workgroup meetings) on the County's webpage (http://www.loudoun.gov/westernhills), press releases, and updates on the Loudoun County Facebook and Twitter pages. The Watershed Partnership Workgroup (WPW) met twice and consisted of local landowners, residents, businesses, community organizations, government, stormwater management, water supply experts, environmental specialists, and other community members who have collaborated with project staff to address current and future water quality issues.

## Desktop Assessment of Current Conditions

Baseline conditions through desktop activities involved numerous GIS layers, both those maintained by the County as well as other government and non-government sources. For the desktop assessment, the Western Hills Watershed was divided into 23 smaller drainage areas called subwatersheds.

**Desktop Assessment**
Number of Maps and Figures – 60
Number of Tables - 21




This assessment task included descriptions of current conditions in the Western Hills Watershed, including natural landscape characteristics, development activities, existing water quality monitoring efforts, and local water quality impairments.

Natural landscape related parameters such as geology and topography strongly influence the formation of drainage patterns and the baseline quality of the water that they transport.

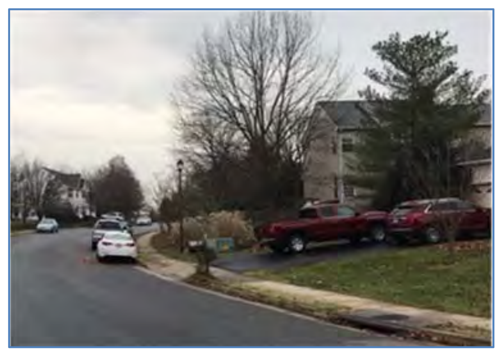
Human-modified landscape parameters such as impervious cover and land use strongly influence the quantity and quality of watershed runoff.

| Land | Water/Wastewater | Streams | Wells |
|---|---|---|---|
| Topography | Stormwater Management | Stream Impairments | Residential Well Yield and Depth |
| Geology, Soil and Forest | Water Supplies | Water Quality Monitoring | Public Groundwater Withdrawals |
| Land Use/Land Cover | Waste Discharge Permits | Stream Characteristics | Transmissivity and Storativity |
| Historical Imagery | Petroleum Tanks | Stream Buffer | Groundwater Chemistry |
| Population | Residential Septic Systems | Regulated Dams | Spring and Dug Wells |
| Potential Housing Buildout | Wastewater Outfalls | | |

**Field Assessment**

Field assessments were conducted in the Western Hills Watershed to evaluate current stream and upland conditions and aid in the development of recommendations for the watershed management plan. Designed to complement existing data, both stream walks and upland assessment were conducted by field crews who recorded data on habitat conditions, ratings of bank erosion hazard potential, and many other observations. Field work included over 80 person days during winter 2018-2019.

*Stream Corridor Assessments* (SCAs) were conducted for a subset of stream reaches using standardized protocols, developed to provide a method for the rapid assessment and documentation of environmental problems occurring within stream corridors.



*Upland Assessments* were assessed according to the Unified Subwatershed and Site Reconnaissance (USSR) Manual and the Urban Watershed Forestry Manual to identify potential pollution sources influencing water quality and to identify restoration project opportunities.

*Neighborhood Source Assessments* (NSAs) describe pollution source areas, stewardship behaviors, and restoration opportunities within individual neighborhoods. Each neighborhood has unique characteristics that are to be considered in deciding if it is possible and/or necessary to implement restoration projects, source controls, and stewardship practices. Findings from 15 sites: Downspout disconnection at 3 neighborhoods; Fertilizer reduction/education at 10; Sustainable landscaping at 13; Storm drain marking at 5; and Open space tree planting at 6 neighborhoods.

*Hotspot Site Investigations* (HSI) typically entail stormwater hotspots or areas that have the potential to generate higher concentrations of stormwater pollutants than are typically found in urban runoff because they run higher risk of spills, leaks, or illicit discharges due to the nature of their operations. The purpose of hotspot investigations is to evaluate pollution potential from operations and to identify restoration practices that may be necessary to remove, control, or otherwise mitigate the potential pollution source. The project scope included 52 parcels selected from the desktop analysis. Findings from 11 commercial sites where observations were made regarding six categories to evaluate pollution potential (vehicle operations, outdoor materials, waste management, physical plant, turf/landscaping and stormwater infrastructure).

*Institutional Site Investigations* (ISI) protocols were adapted/modified to investigating institutional and municipal sites. Findings included: Tree planting at 6 sites (over 7,000 trees to be planted); Storm drain marking at 15 locations; Downspout disconnection at 4 facilities; New stormwater treatment at 8 sites, 21 new BMPs; Education with 8 opportunities; Impervious cover removal/replacement at 4 sites; Stream buffer improvement at 2 sites; Develop a Pollution Prevention Plans at 3 sites; and trash management at 1 site.

*Urban Reforestation Site Assessments* (URSA) were conducted in open spaces to identify and evaluate sites within the Western Hills Watershed with potential for tree planting or other revegetation. A total of 11 potential reforestation sites were assessed within the Western Hills Watershed, with potential planting areas totaling 35.4 acres.

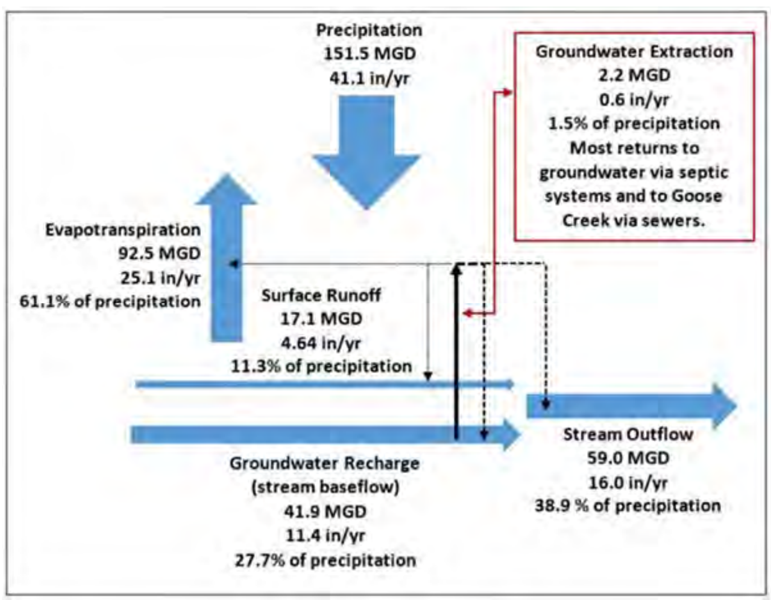
*Retrofit Reconnaissance Investigations* (RRI) methods were used primarily to investigate existing stormwater management ponds, both private and public, as candidates for conversion to designs with increased pollutant removal efficiencies. The watershed contains 91 stormwater ponds. Twenty-six are wet ponds and 65 are dry ponds. Sixty-two ponds are county-maintained, 28 are privately maintained and the remaining pond is maintained by the Town of Purcellville. Site selection began with 117 BMP sites of which 26 sites were selected and prioritized for field investigation.

**Groundwater Resources**

Groundwater pumped from public and private wells drilled in fractured crystalline bedrock provides approximately 90% of potable water supplied to approximately 25,000 residents in the Western Hills Watershed. The presence, movement, and availability of groundwater depends on watershed hydrogeology and variations in precipitation, evapotranspiration, surface runoff, streamflow, and groundwater pumping over time and space. Stream baseflow is sustained by groundwater discharge, which also affects stream water quality.

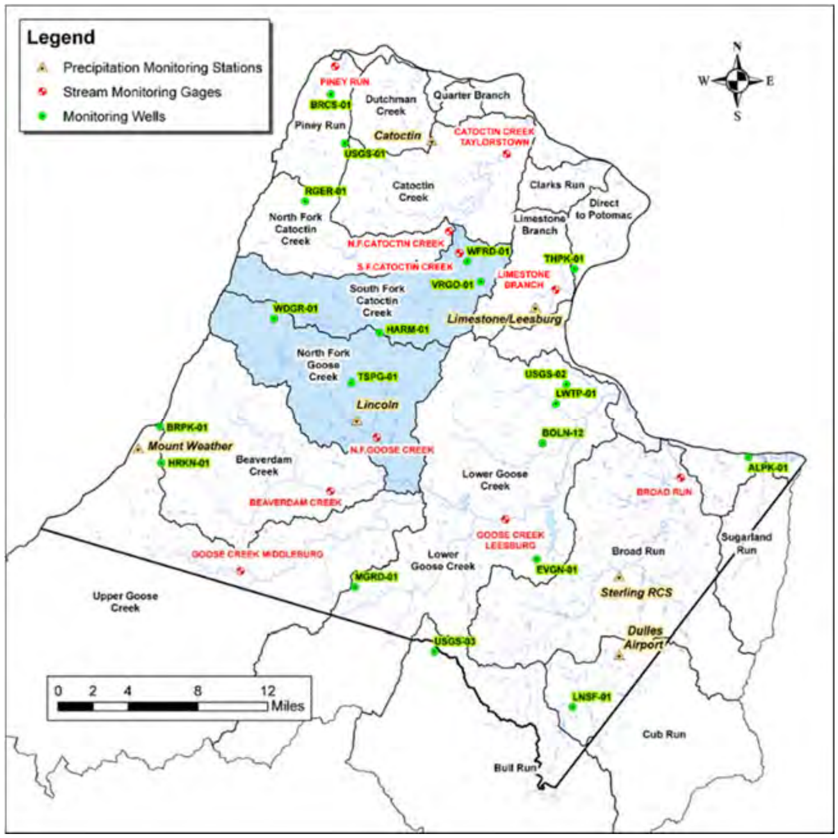
**Water Balance Analysis**

A water balance for the watershed was developed for average conditions. The balance accounts for the inflows (precipitation and stream leakage to groundwater) and outflows (pumpage, evapotranspiration and stream outflow from the watershed).



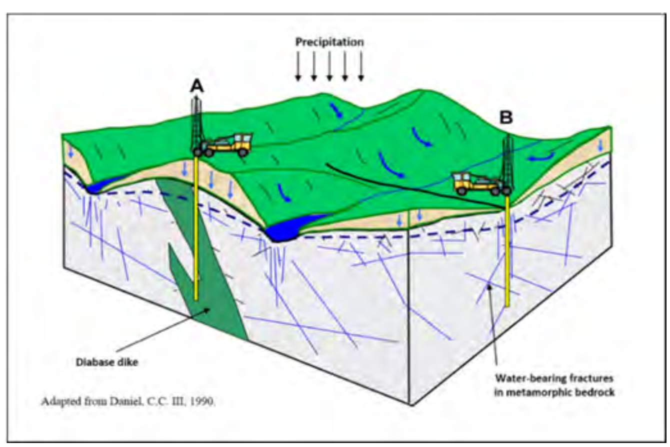
## Streamflow and Precipitation

Infiltrating precipitation recharges groundwater causing the water table to rise above stream bottom drainage elevation. Drawdown from groundwater pumping can reduce or eliminate groundwater discharge to streams and induce leakage of surface water to underlying geologic media. Of the ten stream gaging stations in Loudoun County, the North Fork Goose Creek and South Fork Catoctin Creek gaging stations in the Western Hills Watershed provide real-time flow rates since 2002 on five-minute interval. These data demonstrate that groundwater discharge sustains substantial flows in these creeks except during periods of drought.

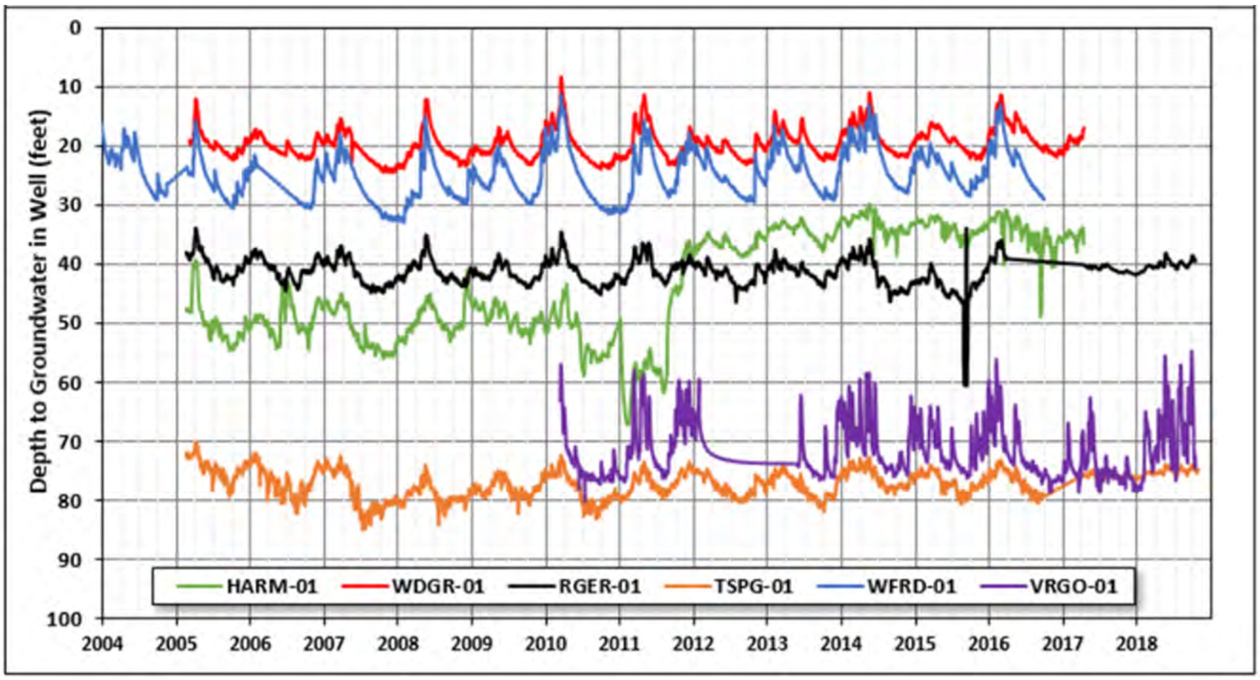



## Groundwater

Groundwater levels are measured daily in dedicated monitoring wells using datalogging devices as part of long-term monitoring programs conducted by the US Geologic Survey (USGS) and the Loudoun County Department of Building and Development. Information includes well construction, monitoring history, and groundwater levels for the 16 wells monitored by the County and three wells monitored by the USGS.

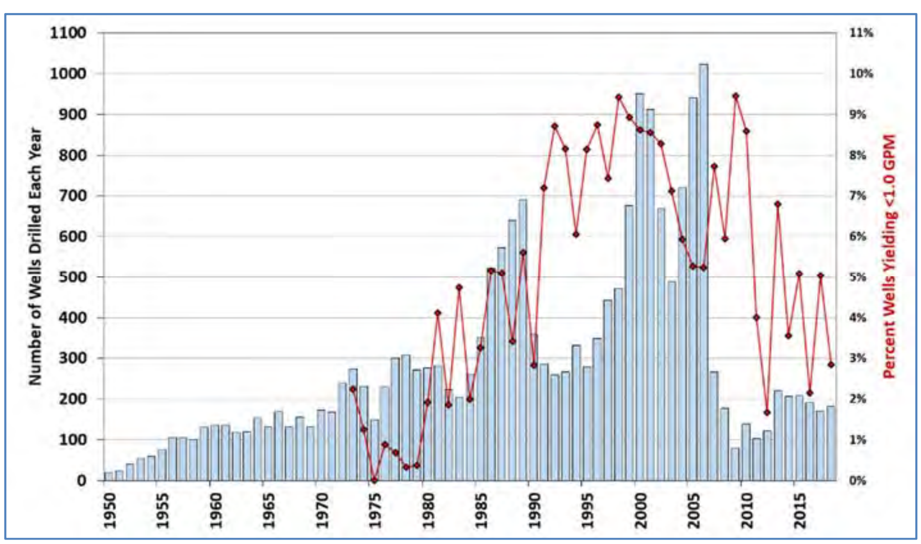



Groundwater elevation (hydraulic head) and depth-to-water values measured between 2004 and 2018 in the five monitoring wells in the Western Hills Watershed, and well RGER-01 in the western portion of the North Fork Catoctin Creek drainage basin. The data are similar to measurements and trends observed elsewhere in the County and indicate that: (1) groundwater levels tend to rise in the late fall through early spring (and during heavy precipitation events at other times) and decline in the late spring through early fall due to the annual evapotranspiration cycle; (2) the magnitude of seasonal well water level change is typically 5 to 10 feet; (3) the depth-to-water in the monitoring wells ranges from 10 to 80 feet below ground surface; and (4) no significant decline or rise in groundwater levels occurred in the monitoring wells between 2004 and 2018, except at well HARM-01 where the groundwater level rose by approximately 15 feet on August 23, 2011 due to the 5.8 magnitude earthquake centered in Mineral, VA.

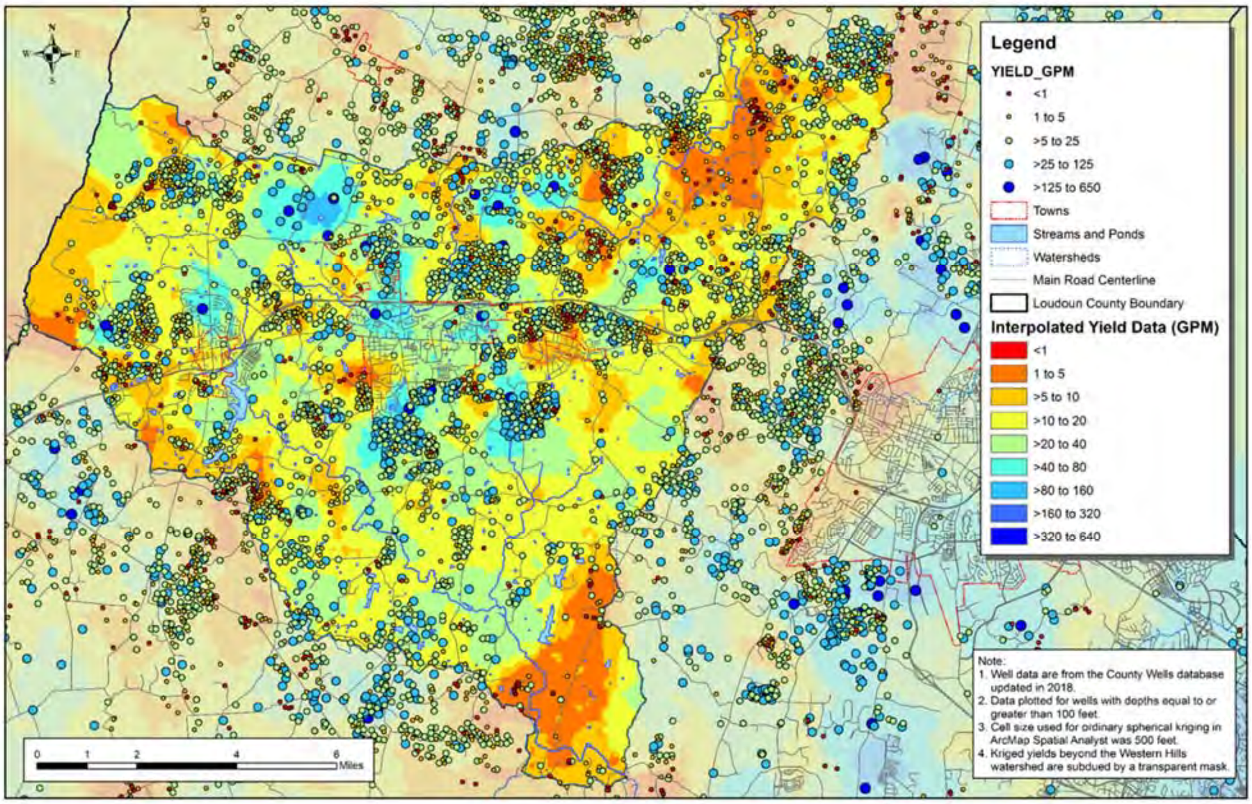



## Groundwater Well Yield and Depth

Health Department regulations require that public and private potable water-supply wells be cased to at least 100 feet and 50 feet below ground surface, respectively. As such, nearly all wells in the Western Hills Watershed are drilled into and open to bedrock at greater



depths. Well yield and depth are related to the distribution of water-bearing fractures encountered in bedrock. Low yielding wells or dry holes may result from drilling at a location where water-bearing fractures are not encountered and that a higher yielding well can and will result from drilling through multiple fracture zones. The County Well database contains 5,418 wells in the Western Hills Watershed. Detailed information on well characteristics and groundwater conditions documented by hydrogeologic studies available from the County Health Department.




Since the 1950s, the number of wells drilled annually is affected by economic conditions, population growth, real estate development, zoning changes, and other factors. Since the 1970s, the percentage of all wells drilled that yield less than 1.0 gpm in a given year has ranged from 0% to 9.5%. Between 1975 and 2000 the average depth increased from 250 to 450 feet and remained constant to present day. The average annual well depths in Western Hills Watershed are similar to the county average.

**Projected Water Use and Availability**

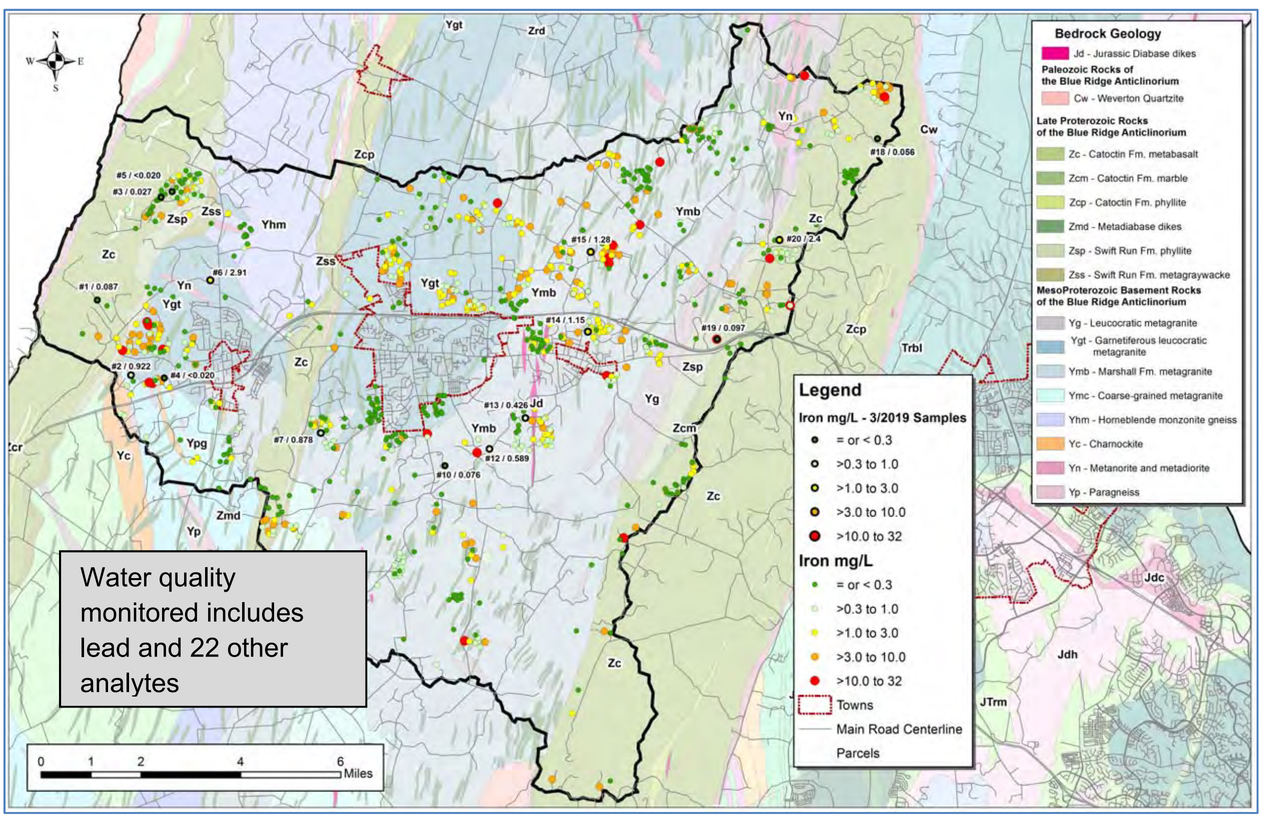
Water use is reported to the Virginia Department of Environmental Quality (DEQ) by Purcellville, Round Hill, and Hamilton for their public water-supply systems and by golf courses for irrigation. Combined monthly water use by these entities increased from approximately 0.9 MGD in 2010 to 1.1 MGD in 2017. Water use peaks during the growing season (late spring to early fall) due to golf course and lawn irrigation demand.

The population of the Western Hills Watershed is projected by the Traffic Analysis Zones (TAZ) analysis to increase from approximately 24,593 in 2015 to 33,043 in 2045. The current number of residential housing units in the Watershed is 19,630 and the potential number of future units at current zoning is 25,944, which is a 32% increase. Projected daily groundwater extraction rates based on TAZ population estimates in 2015 and 2045 assuming a groundwater use rate of 100 GPD (with no surface water contribution) are compared to groundwater recharge rates during normal and drought conditions in the Western Hills Watershed. Projected groundwater usage for the total build-out based on current zoning of 7.78 MGD assumes 300 GPD use from 25,944 housing units (or 100 GPD by 77,799 persons). Most extracted groundwater is returned to streams and the water table via sewers and septic systems; a lesser fraction contributes to evapotranspiration and surface runoff components of the water balance.

## Groundwater Quality

Groundwater quality in Loudoun County varies due to complex geologic history, soil and rock minerology, geochemical conditions, and anthropogenic activities.

During this study, twenty samples of raw groundwater collected prior to treatment at homes in the Western Hills Watershed in March 2019 were analyzed for a suite of inorganic parameters. Overall, the recent analyses are consistent with data in the Loudoun County water quality database.



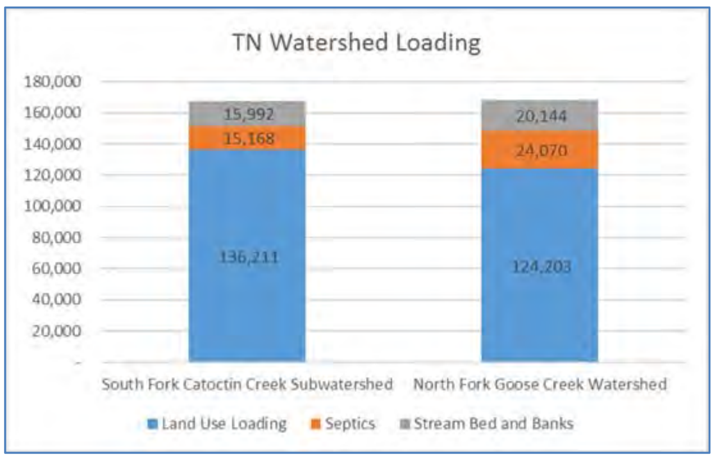
### Stormwater Control Measures (SCM) for Urban/Suburban Areas

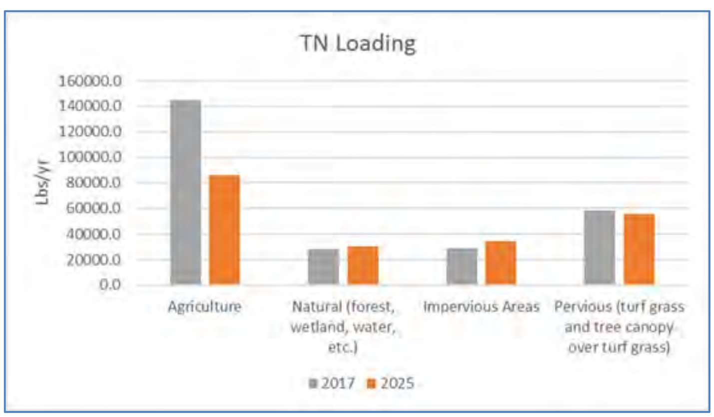
Stormwater and watershed management practices considered in this plan provide the strategies to address the effects of urban/suburban development. Each has the potential to yield quantifiable benefits in stormwater quality and in quantity control for channel protection and flooding. In more rural areas agricultural Best Management Practices (BMPs), provide benefits in reduction of nitrogen, phosphorus, and sediment inputs to local waterways.

| **Stormwater Control Measures and Watershed Practices** |
|---|
| Urban nutrient management |
| Conversion of dry detention ponds to extended detention dry ponds |
| Addition of pretreatment or post treatment SCMs within existing dry or wet pond boundaries |
| New SCMs retrofits outside of existing dry or wet pond boundaries, but which would drain into an existing pond or capture and treat stormwater just outside of the existing pond |
| Reforestation of stream buffers and upland areas |
| Stream restoration for erosion control and nutrient processing |
| New Micro-SCMs such as bioretention, bioswales, urban filtration practices, etc. not associated with an existing dry or wet pond |
| Downspout disconnection and impervious cover removal |

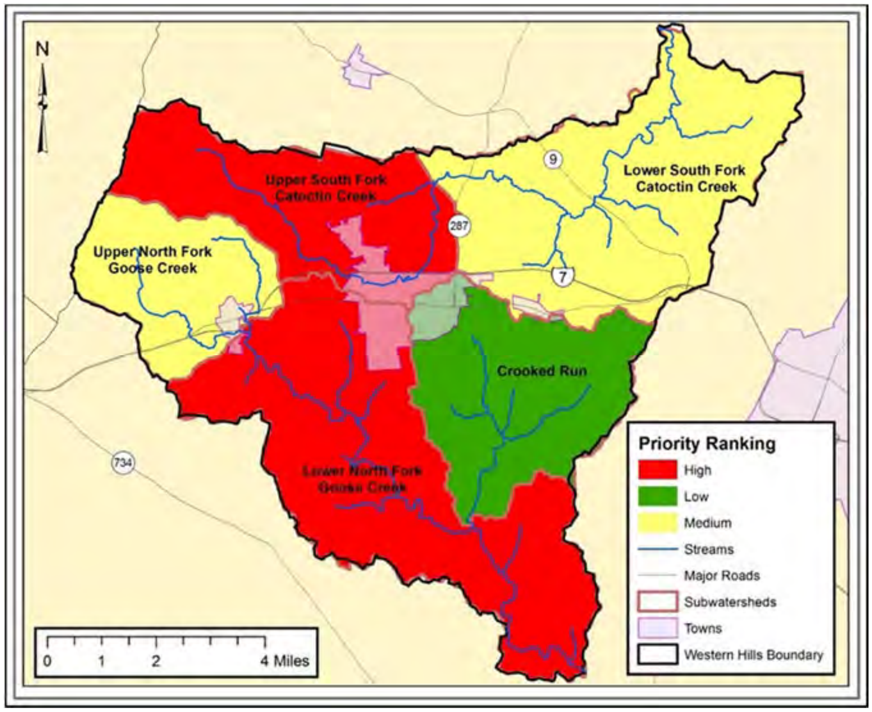
### Modeling Current and Future Conditions

Land use pollutant loading, septic loading, and stream bed and bank loading calculations were made for 2017 (current conditions) and 2025 (future conditions) based on the land uses and use changes as well as the BMPs currently implemented and those projected to be implemented in the future. The Chesapeake Assessment and Scenario Tool (CAST) was used to calculate loading rates from land uses. The model estimates nutrient (nitrogen and phosphorus) and sediment loading to the Chesapeake Bay from agricultural, developed (houses, buildings, etc.) and natural land uses, as well as septic systems and point source loads from wastewater treatment plants.



**Watershed Restoration**

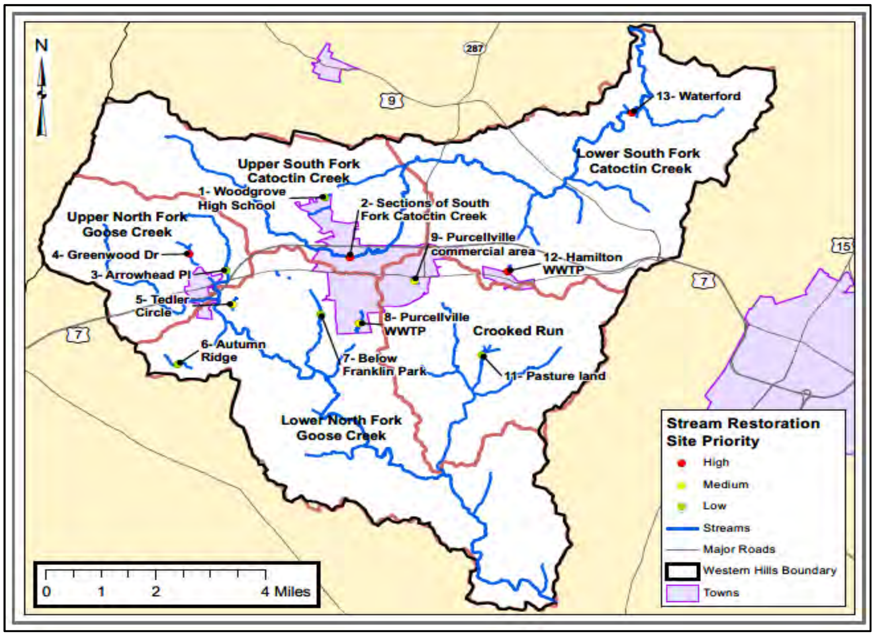



Priority ranking for five major subwatersheds in the Western Hills Watershed were based on drainage area, stream length, population, land use/land cover, impervious cover, soils, and extent of treatment by stormwater control measures (SCMs). Assessment results for neighborhoods, hotspots, institutions, tree planting opportunities, stream corridors (including potential stream restoration), stormwater conversions, and potential new stormwater control facilities are also summarized for each subwatershed. A subwatershed management strategy included recommended community and municipal followed by the individual subwatershed summaries and rankings of the five subwatersheds.

**Watershed Improvement Actions**

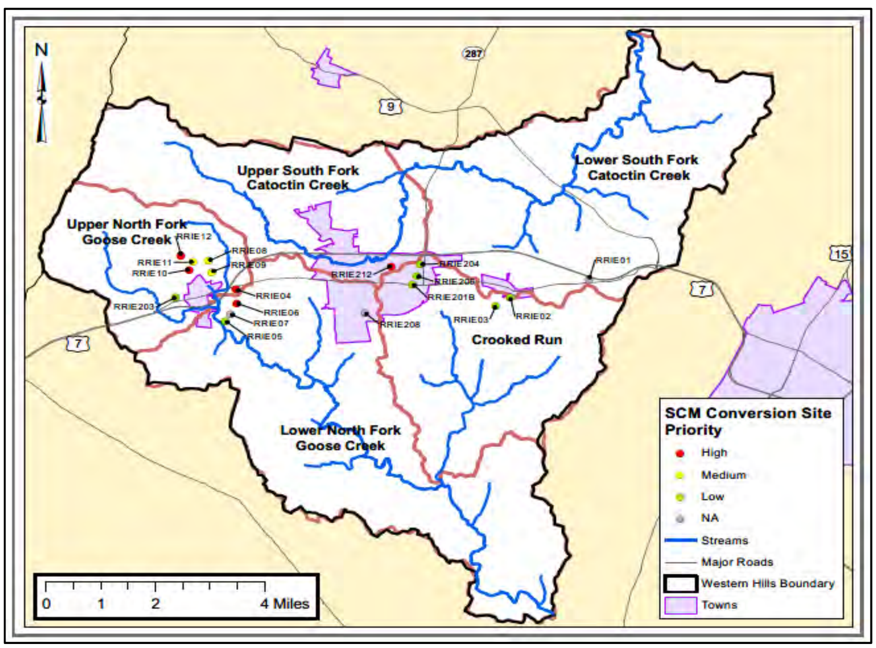
Stream Restoration
Riparian Tree Planting
Conversion of Existing Stormwater Control Measures
New Stormwater Control Measures
Watershed Programmatic Enhancement

### Stream Restoration Sites



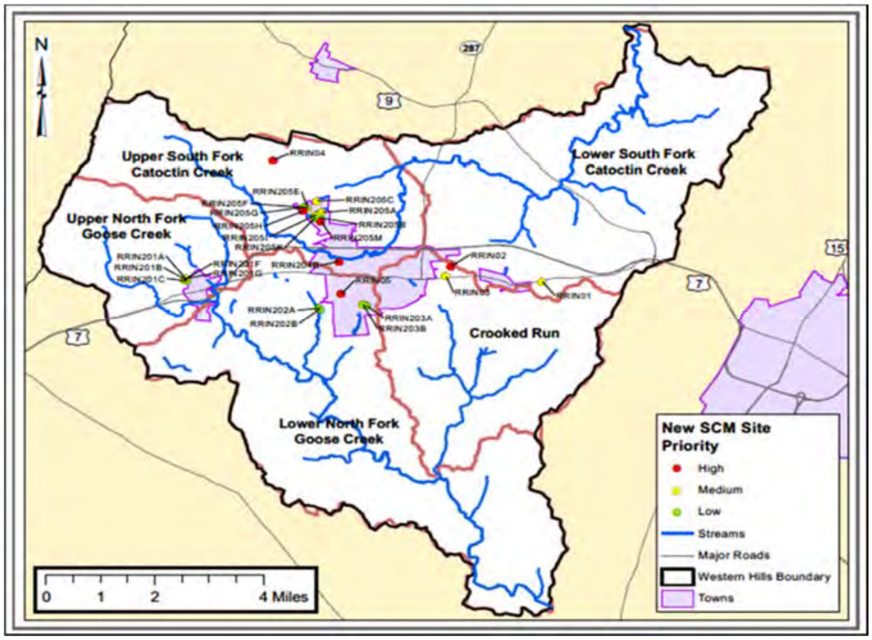

A total of 12 candidate stream restoration sites were identified based on the findings of stream surveys conducted during the field assessments. Over 10 miles of stream were walked, field crews identified erosion, inadequate buffer vegetation, and other detrimental conditions. Also noted were particular opportunities for improvements through stream restoration.

### Stormwater Conversion Sites




A total of 18 candidate SCM conversion sites were visited during Retrofit Reconnaissance Investigations (RRI) field assessments. A representative subset of the County's dry pond inventory was selected for the RRI field investigations. Of the 18 sites visited, 15 have the potential to be upgraded to a SCM with higher pollutant removal efficiencies. The 15 upgradable SCM conversion sites were assigned a priority rating of High, Medium or Low, which primarily depended upon the existing pond designation (and pollutant removal efficiency), engineering feasibility of an upgrade, and how much additional reduction was possible under the SCM efficiencies as determined by the Chesapeake Bay Program and used in CAST.

## New Stormwater Opportunity Sites




A total of 20 candidate new SCM opportunity sites were visited during Institutional Site Investigations (ISI) and new RRI field assessments. A representative subset of publicly-owned sites and churches in the watershed were selected for the field investigations. Of the 20 sites visited, 10 have the potential to treat stormwater runoff using new SCM with pollutant removal efficiencies. A total of 26 opportunities for new SCM construction were identified at these sites. Several different SCMs, including bioswales, bioretention systems, green roofs, and cisterns were considered as appropriate for each selected location on the site.

## Cost Benefit Analysis

| Stormwater Unit Costs (per acre treated): | |
|---|---|
| Bioretention: | $12,180 |
| Bioswale: | $9,912 |
| Stormwater Runoff Reduction: | $18,352 |

In addition to existing practices, several new practices are recommended for the Western Hills watershed. Some of these practices have similar or identical costs and pollutant removal efficiencies (e.g., NSA Tree Plantings and Stream Buffer Reforestation), but in other cases, costs and removal efficiencies differ among the recommended practices, which suggests that certain practices may be more cost effective when trying to meet watershed specific pollutant reduction goals. BMP recommendation costs and cost effectiveness are presented in terms the cost per pound of Total Nitrogen (TN), Total Phosphorus (TP), and Sediment removed as defined in units of cost per pound (lb) of pollutant per year.

**Summary of BMP Recommendation Costs**

| | Stream Restoration | SCM Conversion | SCM New |
|---|---|---|---|
| Costs (H, M, L) | $6,205,248 | $494,427 | $646,490 |
| Costs (only High Priority) | $2,306,556 | $260,412 | $190,663 |

**Summary of BMP Recommendation Cost Effectiveness**

| | Stream Restoration | SCM Conversion | SCM New |
|---|---|---|---|
| TN Effectiveness ($/lb/yr) | $7,828 | $4,508 | $4,642 |
| TP Effectiveness ($/lb/yr) | $10,938 | $42,440 | $26,355 |
| Sediment Effectiveness ($/lb/yr) | $5.26 | $9.31 | $25.64 |

## Programatic Recommendations

In addition to the site-specific actions identified throughout this Western Hills Watershed Plan, a list of programmatic suggested recommendations is summarized that will support Loudoun County in implementing effective measures to protect and restore the watershed. Many of these suggestions will have benefits for other watersheds throughout the County. The Towns, Loudoun Soil and Water Conservation District, and Loudoun County Government, Department of General Services would be involved for many of the actions listed. In some cases, the recommendations may involve enacting of regulations, codes, or zoning ordinances by the regulatory body. In other watersheds, incorporated Towns would also be responsible for these actions within their jurisdictions. Many of the recommendations can be facilitated through cooperative partnering, grants, targeting of existing resources, or other non-regulatory means.

### Programmatic Watershed Management Recommendations

*Note: All suggested recommendations require that County funding and staff resources be authorized by the County Board of Supervisors. Actions by other parties will also require authorization. These recommendations are not intended to serve as a commitment for actions or represent obligations for funding, rather, they provide a roadmap for future programmatic decision activities.*

| Recommended Action | Description |
|---|---|
| Secure funds for stormwater improvements | Secure funds for stormwater pond conversions as identified in this report. Currently only stormwater infrastructure maintenance funding through the County Department of General Services are authorized by County Board in support of the County Stormwater MS4 Permit and Chesapeake Bay WIP TMDL Action Plans. While most of the Western Hills Watershed is outside of the MS4 Permit area, partial nutrient load reduction credit can be claimed for actions within Western Hills. |
| Cluster implementation of stormwater improvements | Cluster the early implementation of recommended new SCMs and pond conversions so that positive results can help to build public support. |
| Stormwater management on future development | Require that all new development meet the VSMP stormwater regulations and encourage development which mimics predevelopment hydrology to the extent possible and provides sufficient water quality treatment. |
| Stormwater management at public schools | Coordinate with Loudoun County Public Schools to encourage ESD approaches, seeking to incorporate more advanced stormwater management into new designs and at existing facilities. |
| Stream restoration | Improve stormwater management controls upstream of potential stream restoration sites before initiating stream restoration projects. It is often necessary to delay large-scale restoration of stream morphology until stream flows in the upstream catchment have been stabilized. Stream restoration projects can then be designed to accommodate long-term flows. |

| | |
|---|---|
| Forest conservation | Preserve existing forest to the greatest extent possible. Strictly enforce forest conservation requirements. |
| Conservation easements | Encourage the use of permanent conservation easements for open space areas (e.g., naturally vegetated lands and agricultural land with healthy riparian buffers). |
| Encourage green infra-structure network | Encourage a green infrastructure network for preservation through easements on high quality areas. |
| Nominate high quality streams | Consider nominating selected streams for special protection areas for high quality waters, such as the VA Dept of Environmental Quality program for Exceptional State Waters (Tier III). |
| Develop public outreach strategy | Involve the community by developing a coordinated public outreach strategy for enhancing resident awareness and motivation to take actions that improve the watershed. The strategy would identify key messages, target audiences, intended outcomes, delivery techniques, and measures of success. |
| Identify partnership opportunities with local agencies and organizations | Along with Loudoun County Government, partners such as Loudoun County Public Schools, Loudoun Water, Loudoun Soil and Water Conservation District, Virginia Department of Transportation, Loudoun Chamber of Commerce and other business contacts, Master Gardeners, homeowner associations (HOAs), and many others can make valuable contributions to carrying out plan recommendations, including tree plantings, new SCMs, better housekeeping practices, and other recommendations. |
| Urban nutrient man-agement education | Encourage reduced use of fertilizers and pesticides on both residential and commercial properties. |
| Watershed education and activities through coordination with Loudoun Soil and Water Conservation District, Master Gardeners, HOAs, and other organizations | Develop and promote educational programs that encourage residents to take actions and encourage communities to implement recommended practices on community lands. Specific community involvement activities could include the following:<br>• Implementation of a watershed stewards training program<br>• Include stewardship training in recreation programs curriculum (e.g., community classes on how to create a rain garden)<br>• Regular offerings of community stewardship events (e.g., tree plantings, invasive plant removal on community property, stream clean-ups, rain garden/rain barrel workshops, and storm drain marking).<br>• Distribute free trees (seedlings) to all residents with streams on their property (through events such as Arbor Day and Nature Stewardship Day events).<br>• Awards program for outstanding stewardship projects. |
| Better housekeeping practices at commercial/ industrial facilities | Educate local business owners and employees about improving housekeeping practices to eliminate potential pollution hotspots. Conduct training workshops. |
| Public outreach materials | Engage with local conservation/environmental organizations to target public outreach efforts to the watershed’s neighborhoods, businesses, and schools. Use examples of successful watershed outreach materials that can be used or adapted for Loudoun County. |
| Other watershed education and activities at businesses | Educate business owners and employees about ways to better manage stormwater runoff and improve water quality, through projects such as tree plantings, rain gardens/rain barrels and other downspout disconnection techniques, and storm drain marking. |
| Develop volunteer opportunities | Develop or enhance volunteer programs for (1) stream monitoring, (2) raingarden planting design (through Master Gardeners and other local experts), and (3) education and outreach. |
| Promote watershed education at local schools, through coordination with Loudoun County Public Schools | Develop core watershed education materials that can be used throughout the County. Within Western Hills, promote watershed education through local schools, including elementary middle, and high schools. Identify key points of contact who can promote watershed educational experiences, including hands-on stewardship activities. |
| Agricultural BMPs | Loudoun Soil and Water Conservation District will continue to promote fencing of livestock (e.g., cattle, horses) out of streams and encourage other BMPs on agricultural lands. |
| Coordinate plan implementation | Coordinate County staff time to spearhead plan implementation and coordinate with other governmental and non-governmental organizations, for example:<br>• Loudoun County Departments of Building and Development, General Services, Planning and Zoning, and others<br>• Loudoun County Public Schools<br>• Metropolitan Washington Council of Governments |

| | |
|---|---|
| | • Northern Virginia Regional Commission<br>• Loudoun Soil and Water Conservation District<br>• Virginia Extension / Master Gardeners<br>• Loudoun Water<br>• Virginia Departments of Transportation, Forestry, Environmental Quality, and Conservation and Recreation.<br>• Home Owners Associations<br>• Loudoun Wildlife Conservancy, Goose Creek Association, and others |
| Watershed Partnership Workgroup | Continue to coordinate with the Western Hills WPW to foster community and organizational involvement in plan implementation. Begin with an invitation to current WPW members to extend their involvement and consider adding other interested members of the community (e.g., additional HOAs). |
| Interagency coordination | Form interagency committee with quarterly meetings to foster better coordination among county, state, and regional agencies to facilitate implementation of recommended actions. |
| Secure funding | Identify and apply for available grants and other funding sources. |
| Evaluate plan implementation | Re-evaluate pollutant load model and load reductions at regular intervals, as land is developed and watershed recommendations are implemented. An adaptive management approach can be taken so that the effectiveness of implemented actions can be evaluated and the plan adjusted to address changing conditions and opportunities. |
| Monitor for results | Monitoring for results. It is important that the County's watershed management efforts include continuing monitoring to demonstrate improvements and support adaptive management. An overall strategy for tracking and monitoring restoration of Loudoun County watersheds should include one or more of the following indicators:<br>• Reduction in amount of nutrient and sediment loading downstream in pounds per year<br>• Improvement or maintenance of biological condition of streams as measured by biological indicator (i.e., Virginia Stream Condition Index) scores or the number of stream miles with desired VSCI scores<br>• Increase in the acres of impervious surface with enhanced stormwater control<br>• Linear feet of eroding stream that have been stabilized<br>• Increase or conservation of forest acres |

## Summary

The Western Hills Watershed Management Plan provides both specific actions at field-identified locations (stream restoration, tree planting and stormwater management conversions) and calculated pollutant load reductions to Loudoun County waterways and ultimately the Chesapeake Bay. The pollution model analysis and planning level costs may be used justification for future grant funding and provide comparative technical support for future management decisions. Furthermore, many programmatic recommends are presented to further improve water quality in western Loudoun County.

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# CHAPTER 1: INTRODUCTION

## 1.1 Purpose

Watershed management planning is intended to protect, preserve, and restore the water resources of Loudoun County. The development of the Western Hills Watershed Management Plan Project was selected by Loudoun County's Water Resources Technical Advisory Committee (WRTAC), as described in a Board of Supervisors Business Meeting Action Item, dated February 7, 2017. The Western Hills Watershed Management Plan is similar in scope and is in follow up to the 2014 Upper Broad Run Watershed Pilot Project. Findings of the Pilot Project have been a valuable asset for identification of water quality improvement projects and meeting pollution reduction requirements and goals.

This Watershed Management Plan Report summarizes the current conditions and proposes watershed management recommendations and strategies for the Western Hills Watershed. Current conditions were evaluated through analyses of spatial data provided by Loudoun County and field assessments conducted by the County's Consultant, Tetra Tech. Restoration options and recommendations presented within this report, including expected pollutant reductions and estimated costs, will provide a basis for future management of the Western Hills Watershed.

## 1.2 Background

Following the completion of the Loudoun County Comprehensive Watershed Management Plan (CH2MHill, 2008b), the WRTAC recommended that a watershed management plan project was the next logical step to achieving Loudoun County's goal of effective management of the County's water resources. A watershed management plan identifies strategies to bring a watershed into compliance with water quality standards and to meet other watershed management goals developed by stakeholders. Strategies typically include a combination of government capital projects, actions in partnership with local organizations (such as watershed associations), educational outreach, and volunteer activities. The watershed plan follows a systematic and detailed approach as was recommended in the Loudoun County Strategic Watershed Management Solutions (Loudoun County Government, 2006). In 2006, the Loudoun County government, along with a diverse group of stakeholders and watershed experts, conducted a series of meetings to develop a shared vision for watershed management planning strategies for Loudoun County. This effort was the Strategic Watershed Management Solutions (SWMS) project and was funded by the County of Loudoun and grants from the National Fish and Wildlife Foundation and the U.S. Environmental Protection Agency.

The Loudoun County 2019 Comprehensive Plan (Loudoun County 2019e) supports the development of watershed management plans with specific policies that include:

- Develop and implement a watershed management plan for each watershed, establishing development guidelines and performance standards to protect water quality.
- Continue to perform watershed management plans to determine appropriate water quality and quality controls.

This report on Western Hills Watershed is the second local watershed management plan prepared for Loudoun County. It is based on the first plan developed in 2014 for the Upper Broad Run Watershed (Roth et al. 2014) which serves as a pilot or template for other plans.

The watershed management planning process is intended to address the many mandates that the County must meet in each individual watershed. These include the requirements of the National Pollutant Discharge Elimination System (NPDES), Municipal Separate Storm Sewer System (MS4) permit, watershed-specific Total Maximum Daily Loads (TMDLs) and the Chesapeake Bay TMDL. The watershed management plan for the Western Hills Watershed will help meet the water quality goals mandated through the Bay TMDL and will prepare for meeting future TMDL goals that are expected to be developed for the watershed's local benthic macroinvertebrate, bacteria, and other impairments (Section 3.4.1).

## 1.3 Public Involvement

Effective implementation of watershed restoration strategies requires the coordination of diverse watershed partners and the participation of many stakeholders. For the Western Hills Watershed Project, public involvement components included conducting a local community meeting, providing updates via Loudoun County's website and social media sites, and forming a Watershed Partnership Workgroup (WPW).

### 1.3.1 Community Outreach

Community Meeting

The Western Hills Watershed Project was introduced to the community during a public meeting that was held in the Carver Center in Purcellville on September 26, 2018. Project team staff gave a presentation about the watershed planning process, some of the key existing conditions and characteristics of the Western Hills Watershed, proposed goals of the plan, and strategies that may be used to meet those goals. After the presentation the attendees divided into groups to discuss and document their vision for the Western Hills Watershed, what major water-related issues they were aware of and would like to see addressed, what locations they would recommend for targeted field visits, and what they believed is needed to implement an effective watershed management plan. Participants were invited to mark specific areas of concern on a project map.

Ongoing Community Outreach

Multiple methods were used to notify the public of the Western Hills Watershed Project meetings and to keep the public updated on the project's progress. These methods included project updates (including presentations from community and workgroup meetings) on the County's webpage (http://www.loudoun.gov/westernhills), press releases, and updates on the Loudoun County Facebook and Twitter pages. A color handout was developed by Loudoun County's Public Affairs and Communications staff to promote and publicize the development of the Western Hills Watershed Management Plan. A local newspaper covered the event.

### 1.3.2 Watershed Partnership Workgroup

A knowledgeable and engaged group of stakeholders is an essential part of a successful watershed management plan. The Watershed Partnership Workgroup (WPW) consists of local landowners, residents, businesses, community organizations, government, stormwater management and water supply experts, environmental specialists, and other community members who have collaborated with project staff to address current and future water quality issues that occur within the Western Hills Watershed. The Western Hills WPW met both during the watershed plan development process and at the end in conjunction with Water Resources Technical Advisory Committee (WRTAC). The Western Hills WPW member invitees include:

- Loudoun County Department of Building and Development
  - David Ward
  - Maggie Auer
  - Bill Cain
  - Gerard Sossong

- Tetra Tech Contractor
  - Nancy Roth

- Loudoun County Parks and Recreation
  - Mark Novak

- Virginia Department of Forestry
  - Joe Rosetti
  - Kinner Ingram

- Virginia Department of Environmental Quality
  - Sarah Sivers

- Loudoun County Public Schools
  - Gary Van Alstyne

- Loudoun Water
  - Mark Peterson
  - Pam Kenel

- Loudoun Soil and Water Conservation District
  - Chris Van Vlack
  - Pat McIlvaine
  - Jay Frankenfield

- Master Gardeners
  - Alta Jones

- Meadows of Purcellville Home Owners Association
  - Maura Walsh-Copeland

- Goose Creek Scenic Advisory Committee
  - Steven Hall

- Catoctin Creek Scenic Advisory Committee
  - Bruce Johnson

- Piedmont Environmental Council
  - Tracy Lind

- Loudoun Wildlife Conservancy
  - Sarah Ali
  - Joe Coleman

- Town of Purcellville
  - Stacey Alter
  - Amie Ware

- Interested Citizens
  - Vivek Bedekar
  - Phil Daley
  - Ned Douglas
  - Andy Stoddard
  - Steve Earson

WPW Meeting (September 12, 2018; 22 attendees)

County Staff and the Contractor gave a PowerPoint presentation that included the definition of a watershed, an overview of the watershed planning process, and an overview of conditions in the Western Hills Watershed. The Contractor also reviewed the role of the WPW and presented a general project schedule. Discussions that occurred during the meeting included proposed goals of the watershed plan, issues/concerns, existing initiatives/suggested strategies, and specific locations of concern within the watershed.

WPW Meeting (May 29, 2019; 15 attendees)

In a joint meeting with the Water Resources Technical Advisory Committee (WRTAC) County staff and the Contractor gave a PowerPoint presentation which included a brief introduction and summary of the Desktop Assessment, Field Assessment (Upland and Stream) and Assessment of Groundwater. The presentation included pollutant load modeling tables and charts using the Chesapeake Assessment and Scenario Tool (CAST) for scenarios predicting pollutant loads for 2017 and 2025, with strategies to achieve water quality improvements via updating stormwater control measures, stream restoration, and other BMPs. The presentation included a breakdown by watershed and BMP type of the pollutant (nitrogen, phosphorus and sediment) load reductions based on suggested BMPs as identified in the field assessment.

### 1.3.3 Water Resources Technical Advisory Committee

The Loudoun County Water Resources Technical Advisory Committee (WRTAC) provided guidance and direction in the scope of the project and provided technical review of the project.

Appointed by the Board of Supervisors, the Committee is composed of 11 members with expertise in water resources. The details of activities are available in the meeting summaries as posted at www.loudoun.gov/wrtac. Below are some of the highlights of these meetings.

WRTAC 11/14/2016: Confirmed that staff will present to Transportation and Land Use Committee on 12/16/2016. The cost estimates for Western Hills and Middle Goose Creek were discussed and with the addition of $40,000 for groundwater sampling in Western Hills the Committee votes to recommend Western Hills Watershed.

WRTAC 3/31/2017: Discussion on actions of proposed watershed management planning per Transportation Land Use Committee on 12/16/2016 and Board of Supervisors meeting 2/7/2017. Both TLUC and BOS voted to direct WRTAC to develop a scope of work and implement watershed management planning. The Transportation and Land Use Committee recommended that the Board consider that funding in the amount of $190,000 be considered as part of the Fiscal Year 2018 budget deliberations.

WRTAC 11/13/2017: Members provided suggestions on improvements to Draft Request for Proposals.

WRTAC 4/24/2019: Interim findings of the Western Hills Watershed Management Plan were presented to the Committee. The presentation included a brief introduction and summary of the Desktop Assessment by County Staff followed by an overview of the Field Assessment and Assessment of Groundwater by the Contractor. The presentation included highlights of the assessment work which will be presented in full in the final report. Discussion included questions and answers about the stream habitat metrics, the overall groundwater quality, details on radiological analyses of groundwater, and the impacts of floodplain regulations on practical aspects of riparian buffer tree planting.

WRTAC 5/29/2019: Joint meeting with the WPW (see summary above).

WRTAC 9/11/2019: Discussed review comments from Committee members.

WRTAC 11/12/2019: WRTAC endorsed the Western Hills Watershed Management Plan Report as it conforms to the expectations of the Scope of Work issued in the 2018 Request for Proposal (RFQ 2751). Furthermore, WRTAC concured with the report's implementation recommendations subject to final revisions by County Staff. WRTAC requested an "Executive Summary" be prepared as a preface to the report and entrusts County Staff to fulfill the final report revisions that will be consistent with the WRTAC meeting discussions.

## 1.4 Western Hills Watershed Overview

The Western Hills Watershed is within the Blue Ridge physiographic region of Virginia, located west of the Town of Leesburg and east of the County border along the Appalachian Trail. (Figure 1-1). The watershed designation originated with County staff wherein portions of the Goose Creek and Catoctin Creek watershed were selected, specifically with the intent to focus on the three western Towns that lie on the watershed boundary shared by the North Fork Goose Creek and South Fork Catoctin Creek. The 49,558 acres (approximately 77 square miles) of the Western Hills Watershed are completely contained within Loudoun County and include the towns of Purcellville, Round Hill, and Hamilton. Table 1-1 summarizes the key watershed characteristics of Western Hills. Table 1-2 summarizes soil characteristics.

While characterizing the baseline conditions of the entire watershed is necessary for creating a watershed management plan, a thorough evaluation of potential pollution sources and restoration strategies within smaller drainages is also critical. For the desktop assessment, the Western Hills Watershed was divided into 23 smaller drainage areas called subwatersheds as detailed in Chapter 3 (Figure 1-2). Further information regarding the characteristics of the Western Hills Watershed and its 23 subwatersheds is provided in Chapter 3.

**Table 1-1: Key Characteristics of Western Hills Watershed**

| | | |
|---|---|---|
| Drainage Area | 49,558 acres (77 sq. mi.) | |
| Stream Length | 138 miles (perennial) | |
| Subwatersheds | 23 | |
| Jurisdictions | Loudoun County, VA | |
| Land Use/Land Cover | Forest: | 37.6% |

**Table 1-1: Key Characteristics of Western Hills Watershed**

| | | |
|---|---|---|
| | Pasture: | 27.6% |
| | Turf Grass | 19.9% |
| | Cropland: | 6.1% |
| | Impervious: | 6.4% |
| | Wetlands: | 1.3% |
| | Water: | 0.7% |
| | Barren: | 0.4% |
| | Other: | 0.8% |
| Impervious Cover | 3,214 acres (6.4% of watershed) | |

**Table 1-2: Key Characteristics of Soils in Western Hills Watershed**

| | | |
|---|---|---|
| Soils* | A Soils (low runoff potential): | 1.1% |
| | B Soils: | 38.6% |
| | C Soils: | 32.3% |
| | D Soils (high runoff potential): | 7.7% |
| | #B/D Soils: | 18.7% |
| | #C/D Soils: | 0.6% |

*There is no classification for 1% of soils.
#Dual Hydrologic Soil Group. See Chapter 3 for further detail.

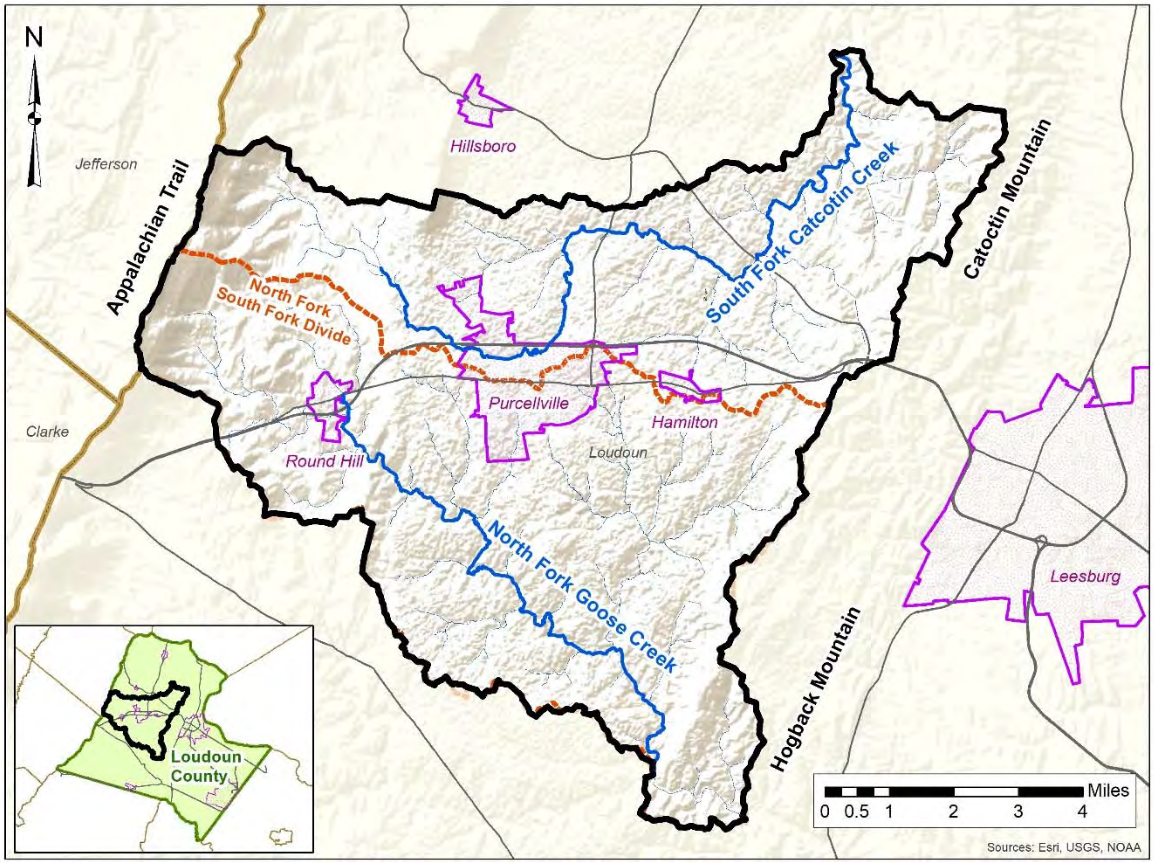


**Figure 1-1: Western Hills Watershed**

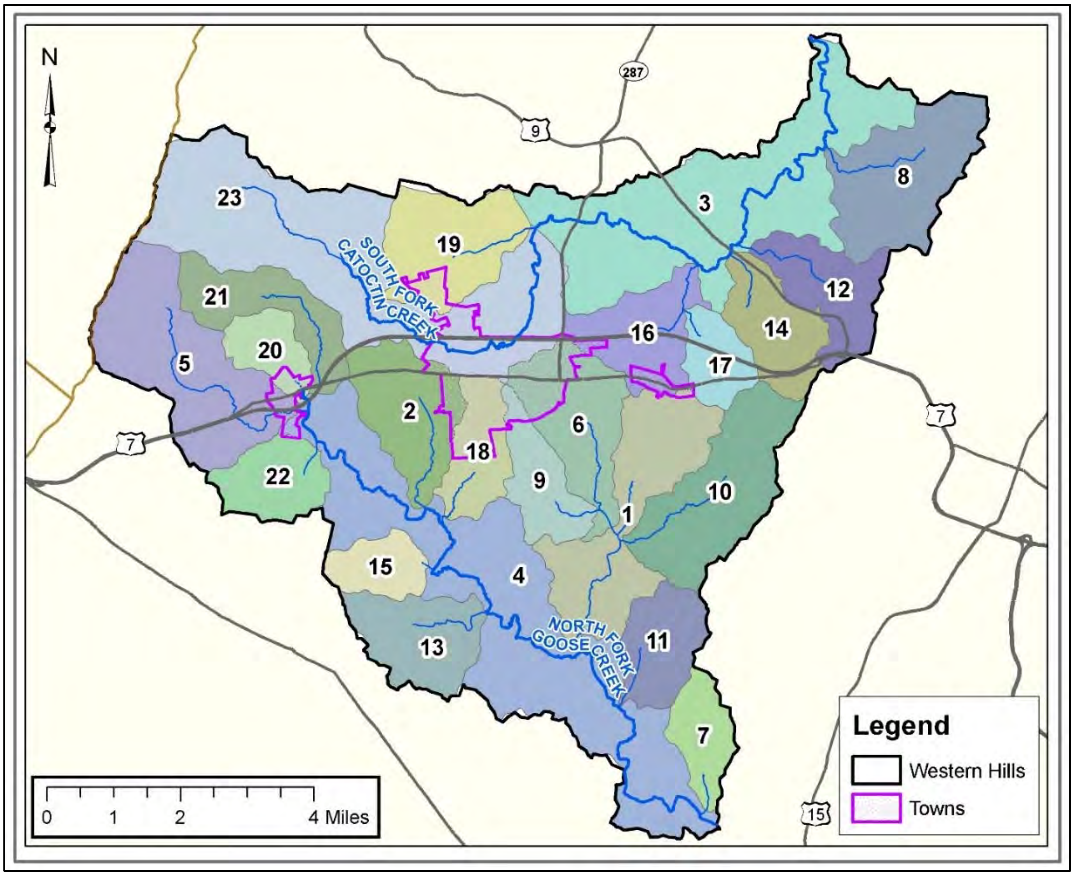


**Figure 1-2: Western Hills Subwatersheds**

## 1.5 Report Organization

This report is organized into the following 11 chapters:

Chapter 1 explains the purpose of this report, provides background on the initiation of the Western Hills Watershed Project, summarizes the public's involvement in the project, and gives an overview of the report and project area.

Chapter 2 covers the vision, goals, and objectives of the Western Hills Watershed Management Plan agreed upon by the WPW and members of the community.

Chapter 3 summarizes the watershed characteristics obtained from GIS analyses. This includes information about the natural landscape features such as geology, topography, soils, forest cover, and streams, as well as information pertaining to the human modified landscape such as population, impervious cover, stormwater structures, water distribution, discharge permits, and zoning. This chapter also summarizes the water quality data that are available for the watershed, including the locations and types of surface water quality impairments.

Chapter 4 summarizes the field work completed for the watershed plan. Field work was completed to identify pollutant sources and restoration opportunities in selected stream reaches, neighborhoods, hotspots, institutions, open pervious areas, and existing stormwater management facilities.

Chapter 5 includes discussion of groundwater and includes the results on groundwater data collection conducted as part of this watershed management plan.

Chapter 6 presents descriptions of restoration strategies that are applicable to the Western Hills Watershed and are designed to reduce pollutant loading within the watershed.

Chapter 7 explains the modeling approach used in the watershed management plan. This includes an estimate of existing and future pollutant loads using the Chesapeake Assessment Scenario Tool (CAST).

Chapter 8 gives a detailed summary of the restoration strategies proposed for each subwatershed. This chapter also explains the methods used to calculate scores for criteria that evaluate the restoration potential within each subwatershed. The chapter provides a final subwatershed ranking based on the scores calculated for the evaluation criteria.

Chapter 9 provides lists of potential opportunities for stream restoration, stormwater pond conversion, and new stormwater practices that were identified as part of developing the watershed plan. Also included are estimates of pollutant load reductions expected for these opportunities, along with planning-level cost estimates. The potential pollutant reductions of other strategies identified are also presented.

Chapter 10 discusses considerations for plan implementation, including a proposed timeframe, programmatic recommendations, and recommendations for public involvement.

Chapter 11 includes a list of reference citations.

# CHAPTER 2: VISION, GOALS, AND OBJECTIVES

## 2.1 Vision Statement

This plan proposes the following vision statement to serve as a guide in the development of management recommendations and strategies for the Western Hills Watershed. This statement was created based on input from the Watershed Partnership Workgroup and from community members who participated in a Western Hills Watershed management planning community meeting:

> *Our vision for the future is that Western Hills Watershed becomes a noticeable asset to the community and is seen as a natural resource to be enjoyed and preserved in healthy condition. We envision a watershed that sustains streams with good water quality that is free of contamination or excessive erosion, allowing for recreation in areas in and adjacent to South Fork Catoctin Creek and North Fork Goose Creek and their tributaries. We envision a watershed where forest cover is protected and where development is conducted in a manner that minimizes adverse impacts to streams and supports a sustainable clean and abundant groundwater supply.*

## 2.2 Western Hills Goals & Objectives

Five goals were identified for restoring the Western Hills Watershed based on the vision statement and input gathered from both the Watershed Partnership Workgroup and community meetings. These goals are:

- **Improve local watershed/stream conditions** to meet Clean Water Act goals of supporting aquatic life use and contact recreation.
- **Prevent further degradation** of stream habitat, physical integrity, and water quality as watershed lands are developed.
- **Promote access** to streams and streamside areas for recreation.
- **Educate** local businesses and watershed residents about watershed stewardship.
- **Incorporate groundwater conditions** as an integral component of the watershed management planning process for Loudoun County.

The following sections discuss each of the five goals for restoring the Western Hills watershed. For each goal, a series of objectives was developed to facilitate progress toward the goal. Action strategies describe the method that will be used to achieve each objective and ultimately, the watershed goal. The action strategies developed to achieve these objectives and goals will be summarized in the final watershed management plan.

The general types of restoration strategies proposed for the Western Hills Watershed are discussed further in Chapters 6, 8, and 9. An adaptive management approach will be emphasized as the watershed management plan is implemented. This approach includes evaluating the success of plan implementation over time and modifying action strategies based on community acceptance and availability of funding.

### 2.2.1 Goal 1: Improve local watershed/stream conditions to meet Clean Water Act goals such as supporting aquatic life use and contact recreation

The Clean Water Act requires that waters meet standards set by Virginia, such as for aquatic life use, which are generally measured by sampling the streams' macroinvertebrate community and comparing the organisms present to similar, healthy streams within the same region and stream type. Contact recreation depends on having streams free of unhealthy levels of bacteria and other pathogens.

- **Objective 1A. Make recommendations for actions that will help the County meet the Phase III WIP "Pollution Diet" targets for reducing nitrogen, phosphorus, and sediment.** While there are currently no local TMDLs for nutrients and sediment in Western Hills, the entire watershed is subject to the Chesapeake Bay TMDL. Watershed Implementation Plans (WIPs) have been developed by the Commonwealth of Virginia to provide a roadmap for achieving the nutrient and sediment reductions necessary to implement the Bay TMDL. Meeting these TMDL goals will go a long way toward improving overall water quality in the Western Hills and achieving the community's vision for the watershed. Local bacteria TMDLs and TMDL Implementation Plans have also been developed for areas including the South Fork Catoctin Creek and North Fork Goose Creek, as discussed in Section 3.4.2 of this report.
- **Objective 1B. Identify locations and opportunities for stormwater retrofits.** To further reduce pollutant loads from existing developed areas, the County should identify opportunities to upgrade or enhance existing stormwater management facilities. In addition, stormwater runoff from impervious areas not currently controlled can be treated by implementing new stormwater treatment methods. While most of the watershed is outside of the County's MS4 permit area, these actions will contribute to overall improvements in watershed and stream condition. This objective includes promoting the development of rain gardens and other distributed practices that focus on controlling stormwater "on-site".

### 2.2.2 Goal 2: Prevent further degradation of stream habitat, physical integrity, and water quality as watershed lands are developed

Planned urban/suburban development is a major factor in the future of the Western Hills Watershed. Rapid population growth, road development, commercial areas, and residential neighborhoods are all planned for the Western Hills Watershed. Careful planning prior to development can identify the highest quality stream and riparian habitats for preservation and help to put in place appropriate protections for maintaining water quality and stream channel integrity throughout the watershed.

- **Objective 2A. Select areas for protection as well as restoration**. “Saving the pieces” is a well-known refrain in ecology. It is often far less expensive and more successful to maintain healthy ecosystem components in good condition than to attempt to restore or re-create that condition after ecosystems become degraded. To be most effective, vegetated stream buffers should be 50 to 100 feet wide and should be protected. Enhancing riparian buffers can be accomplished through restoration projects, including partnering with local organizations, such as the Loudoun Wildlife Conservancy. Riparian buffers and other natural areas should be managed to support native plants and control invasive species.
- **Objective 2B. Mimic pre-development hydrologic condition, through the use of appropriate stormwater management.** Future development will need to adhere to the latest regulatory requirements for stormwater management, which focus on employing Environmental Site Design (ESD) approaches to achieve post-development hydrologic conditions similar to pre-development. In addition, ground and surface water withdrawals should be monitored and assessed in order to ensure that appropriate environmental flow rates are maintained.
- **Objective 2C. Minimize impervious surfaces on new development.** To protect water quality in the future, there is a need to minimize impervious surfaces and to employ highly effective stormwater treatment practices. There is a need to develop incentive programs to encourage residents and businesses to install and maintain BMPs that will increased rainwater infiltration and manage surface water runoff from developed areas.

### 2.2.3 Goal 3: Promote access to streams and streamside areas for recreation

- **Objective 3A. Improve public access to Western Hills streams and tributaries.** There is no substitute for engaged and involved citizens participating in the protection of their local watersheds. A good first step to engaging citizens is making them aware of their connections to the South Fork Catoctin Creek and North Fork Goose Creek, their tributaries, and the issues particular to this watershed. In a modern, suburban landscape, it is easy to become disconnected from the natural environment, because few people have a stream running through their backyard. By raising awareness about the issues facing a nearby stream, residents can act on a local scale, where they are more likely to see the positive effects of their actions, and thus continue their efforts. Recreational opportunities and access via parks and other open space areas should be promoted, so that residents have opportunities to appreciate the natural environment of their local streams. When people have hiked along a trail or paddled a stream or river, and seen firsthand the impact of trash and pollution, they are usually more motivated to participate in clean-ups and advocate for the health of the watershed.

### 2.2.4 Goal 4: Educate local businesses and watershed residents about watershed stewardship

- **Objective 4A. Conduct educational outreach to schools, residents, and business communities throughout the watershed to encourage and support actions that reduce pollutant loads to local waterways.** Providing information can encourage both residents and businesses to implement practices that benefit the natural environment (e.g., water conservation, recycling, using environmentally friendly car-washing and landscaping practices). Empower and encourage the community to understand "water matters."

- **Objective 4B. Use community-based grants to construct and maintain BMPs.** For example, the Town of Purcellville applied for and received a "Trees for Clean Water" grant from the Virginia Department of Forestry. They are working with HOAs on "NeighborWoods" tree plantings where neighborhood residents participate in volunteer-focused community tree plantings.

- **Objective 4C. Encourage community stewardship through watershed restoration and cleanup activities**. There are many ways for people to develop a connection to the local streams that feed Western Hills. People are empowered when they can physically make a difference and improve their community. Clean-ups, tree plantings, and other restoration projects are great opportunities for education and involvement. Students, families, and community groups (civic, corporate, religious, etc.) are readily available labor sources.

- **Objective 4D. Coordinate with STEM (Science, Technology, Engineering and Math) programs.** Many families move to Loudoun County for the STEM programs offered. Future watershed management efforts should make use of these educational programs to educate students and parents in the County. If children get involved, parents will likely also learn and get involved. Engaging with school groups and environmental groups is a good way to expand educational outreach about watershed issues and actions.

- **Objective 4E. Educate and train farmers.** Across the region, farms contribute to nutrient pollution, but implementing better management practices can reduce this impact. Farmers can install and maintain conservation measures, such as livestock exclusion fencing along waterways, to control nutrient loads. There is a need to educate and incentivize farmers to install and maintain conservation measures. The community should use experienced farms to educate and mentor other farmers in the County to install and maintain conservation measures.

### 2.2.5 Goal 5: Incorporate groundwater in the watershed management planning process in Loudoun County

Western Hills Watershed was selected for watershed plan development by the Water Resources Technical Advisory Committee. During meeting discussions, the Committee ultimately voted to recommend Western Hills Watershed over Goose Creek subwatersheds. The intent was to include investigation into groundwater issues and to explicitly include groundwater sampling at selected residential wells to enhance the County database and knowledge of groundwater conditions. Issues associated with groundwater quality and quantity include:

a. Amount of well water.
b. How many wells can the aquifer support?
c. Healthy quality of water from wells.
d. Sustaining groundwater recharge and stream flow, especially with increasing impervious surface area.
e. Consider need to limit groundwater use.
f. Assess need for well-head protection program.
g. Evaluate further needs for area-wide study.

The investigation in this report addresses many of the issues, however there are still many topics that could be explored further and/or are applicable to the entire County. Those topics include: emerging chemicals of concern (microplastics, PFAS, etc.), additional requirements for well water quality testing and importance of radiological chemical testing of groundwater.

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# CHAPTER 3: DESKTOP ASSESSMENT OF CURRENT CONDITIONS

This chapter describes the current conditions in the Western Hills Watershed, including natural landscape characteristics, development activities, existing water quality monitoring efforts, and local water quality impairments.

Natural landscape related parameters such as geology and topography strongly influence the formation of drainage patterns and the baseline quality of the water that they transport. For example, streams located within a watershed containing carbonate bedrock, such as limestone, are more likely to have higher pH values than streams in a watershed containing igneous bedrock, such as granite.

Human-modified landscape parameters such as impervious cover and land use strongly influence the quantity and quality of watershed runoff. For example, the amount and rate at which precipitation will be absorbed by the ground surface depends on the infiltration capacity of a soil for pervious areas; impervious surfaces (e.g., paved areas and rooftops) impede rainfall infiltration which can result in greater runoff rates and volumes, along with a decrease in groundwater supply. In addition, the type and extent of pollutants carried by stormwater is affected by land use characteristics.

The information presented in this chapter provides the quantitative perspective needed to characterize the entire Western Hills Watershed and its 23 subwatersheds, so that the appropriate restoration recommendations and strategies can be developed. In Table 3-1 a summary of the area and percent of the Western Hills Watershed contained in each of the 23 subwatersheds is presented. The Index is displayed in Figure 3-1.

**Table 3-1: Western Hills Subwatershed Summary**

| Index | Subwatershed | Area (Acres) | Percent |
|---|---|---|---|
| 1 | CROOKED RUN | 2,693 | 5.4 |
| 2 | JACKS RUN | 1,734 | 3.5 |
| 3 | LOWER SOUTH FORK CATOCTIN | 5,770 | 11.6 |
| 4 | NORTH FORK GOOSE CREEK | 6,716 | 13.6 |
| 5 | SIMPSONS CREEK | 3,213 | 6.5 |
| 6 | TRIB 1 TO CROOKED RUN | 1,831 | 3.7 |
| 7 | TRIB 1 TO NORTH FORK GOOSE CREEK | 871 | 1.8 |
| 8 | TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 2,348 | 4.7 |
| 9 | TRIB 1A TO TRIB 1 TO CROOKED RUN | 1,054 | 2.1 |
| 10 | TRIB 2 TO CROOKED RUN | 2,525 | 5.1 |
| 11 | TRIB 2 TO NORTH FORK GOOSE CREEK | 1,183 | 2.4 |
| 12 | TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 1,388 | 2.8 |
| 13 | TRIB 3 TO NORTH FORK GOOSE CREEK | 1,540 | 3.1 |
| 14 | TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 1,301 | 2.6 |
| 15 | TRIB 4 TO NORTH FORK GOOSE CREEK | 750 | 1.5 |
| 16 | TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 1,469 | 3.0 |

**Table 3-1: Western Hills Subwatershed Summary**

| Index | Subwatershed | Area (Acres) | Percent |
|---|---|---|---|
| 17 | TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 769 | 1.6 |
| 18 | TRIB 5 TO NORTH FORK GOOSE CREEK | 1,059 | 2.1 |
| 19 | TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 1,909 | 3.9 |
| 20 | TRIB 6 TO NORTH FORK GOOSE CREEK | 745 | 1.5 |
| 21 | TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 1,416 | 2.9 |
| 22 | TRIB 7 TO NORTH FORK GOOSE CREEK | 1,083 | 2.2 |
| 23 | UPPER SOUTH FORK CATOCTIN CREEK | 6,189 | 12.5 |
| | TOTAL | 49,558 | |

## 3.1 Natural Landscape

Natural climate and land surface characteristics relevant to watershed properties and processes are described in the following sections.

### 3.1.1 Climate

Climate is an important consideration since it can influence soil and erosion processes, stream flow patterns, and topography. In addition, climate affects vegetative growth and determines the species composition of the terrestrial and aquatic life of a region.

The average annual temperature at Washington Dulles International Airport is 55.3º F; based on 30 years of data (1981-2010) (NOAA 2019). The monthly averages range from 33.2º F in January to 76.7º F in July. The average annual rainfall at Washington Dulles International Airport is 41.54 inches, and monthly average rainfall is 3.5 inches, based on the same 30-year data set. Rainfall is fairly uniformly distributed through the year, with monthly averages ranging from 2.68 inches in January to 4.55 inches in May. Most snowfall occurs in December, January, February, and March; an average annual snowfall of 19.6 inches is based on 38 years of data (1981-2018).

### 3.1.2 Watershed Delineation

A watershed-based approach for evaluating water quality conditions and improvement potential involves determining the drainage area that contributes runoff and groundwater to a specific water body. Drainage areas vary greatly depending on the scale of the stream system of interest. Drainage areas for large river, estuary, and lake systems are typically on the order of several thousand square miles, and are usually referred to as basins. For example, the Potomac River basin covers over 14,000 square miles and includes portions of four different states. Basins consist of subbasins, which are on the order of several hundred square miles and may consist of one or more major stream networks. Virginia has 50 subbasins, including the Middle Potomac-Catoctin subbasin. These units are then further subdivided into watersheds and subwatersheds, which are a practical size for watershed assessment, management, and restoration planning.

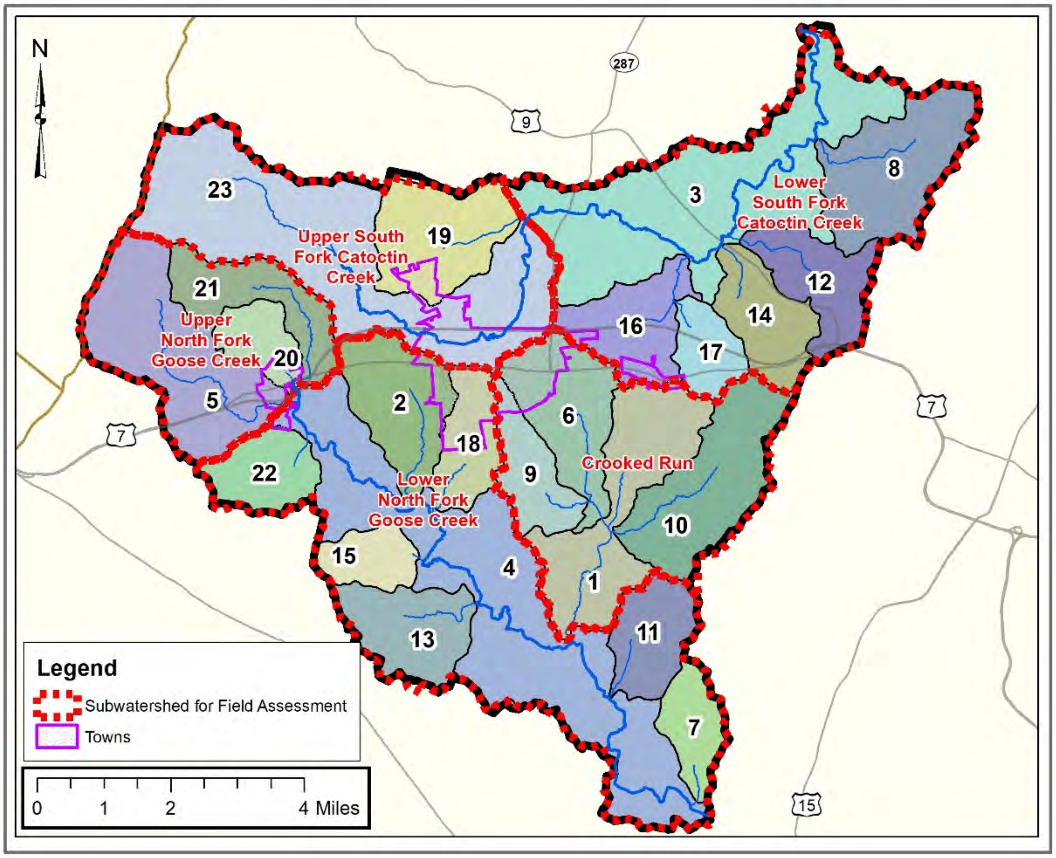


**Figure 3-1: Subwatersheds of the Western Hills Watershed**

The Western Hills Watershed covers approximately 77 square miles in western Loudoun County. To facilitate watershed management planning, maps and topographic data were used to divide the Western Hills Watershed into 23 subwatersheds, ranging in size from 750 to over 6,000 acres (Table 3-1, Figure 3-1) for the desktop assessment and groups these into 5 subwatersheds for the field assessment (Table 4-1, Figure 4-1).

### 3.1.3 Geology

The Western Hills Watershed lies completely within the Blue Ridge physiographic province. Western Loudoun is underlain by metamorphic rocks derived from both sedimentary and igneous parent material. Bedrock in the county is covered by regolith (unconsolidated sediments and soils) that is commonly between 20 and 50 feet thick, but ranges from 0 to more than 90 feet thick. Soils are generally less permeable in eastern Loudoun compared to western Loudoun. Simplified geologic formations of the Western Hills Watershed are shown in Figure 3-2, and a complete breakdown of most bedrock type percentages by subwatershed is given in Table 3-2, representing almost 90 percent of the bedrock types. The table excludes smaller percentages of Coarse metagranite, Leucocratic metagranite, and Porphyroblastic metagranite. The data are derived from

Southworth et al. (2006). Note that some thermally altered metamorphic rocks likely border most of the diabase intrusions, but are not shown at this scale.

The geology of the Western Hills Watershed has a strong influence on many of the other characteristics of the watershed, including the distribution of different slope classifications and the physical and chemical properties of soils.

**Table 3-2: Geologic Composition by Subwatershed (Percent of Total Watershed Area)**

| Watershed | Biotitic Marshall metagranite | Garnetiferous leucocratic metagranite | Hornblende monzonite gneiss | Meta-basalt | Metadiabase dike | Phyllite | Schist metasandstone |
|---|---|---|---|---|---|---|---|
| CROOKED RUN | 4.7 | 0.0 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 |
| JACKS RUN | 0.6 | 1.7 | 0.0 | 0.6 | 0.4 | 0.0 | 0.2 |
| LOWER SOUTH FORK CATOCTIN | 7.7 | 1.3 | 0.0 | 0.1 | 1.6 | 0.0 | 0.0 |
| NORTH FORK GOOSE CREEK | 8.2 | 0.5 | 0.0 | 3.0 | 1.1 | 0.1 | 0.2 |
| SIMPSONS CREEK | 0.2 | 1.4 | 0.0 | 2.9 | 0.1 | 0.3 | 0.0 |
| TRIB 1 TO CROOKED RUN | 2.6 | 0.8 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 0.4 | 0.0 | 0.0 | 3.2 | 0.3 | 0.2 | 0.0 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 1.7 | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| TRIB 2 TO CROOKED RUN | 1.4 | 0.0 | 0.0 | 1.8 | 0.1 | 0.7 | 0.0 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 1.5 | 0.0 | 0.0 | 0.8 | 0.0 | 0.0 | 0.0 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 0.7 | 0.0 | 0.0 | 1.4 | 0.1 | 0.3 | 0.0 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 1.7 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 0.9 | 0.0 | 0.0 | 0.4 | 0.2 | 0.7 | 0.0 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 0.4 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 0.1 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 2.5 | 0.2 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 1.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |

**Table 3-2: Geologic Composition by Subwatershed (Percent of Total Watershed Area)**

| Watershed | Biotitic Marshall metagranite | Garnetiferous leucocratic metagranite | Hornblende monzonite gneiss | Meta-basalt | Metadiabase dike | Phyllite | Schist metasandstone |
|---|---|---|---|---|---|---|---|
| TRIB 5 TO NORTH FORK GOOSE CREEK | 1.0 | 1.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 2.9 | 0.0 | 0.6 | 0.1 | 0.0 | 0.2 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 0.0 | 1.6 | 0.5 | 0.3 | 0.1 | 0.3 | 0.0 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 0.5 | 0.0 | 0.0 | 0.1 | 0.3 | 0.0 | 0.0 |
| UPPER SOUTH FORK CATOCTIN CREEK | 0.0 | 4.0 | 3.6 | 2.8 | 0.4 | 0.9 | 0.5 |
| TOTAL | 38.0 | 17.1 | 4.2 | 19.8 | 5.9 | 3.5 | 1.1 |

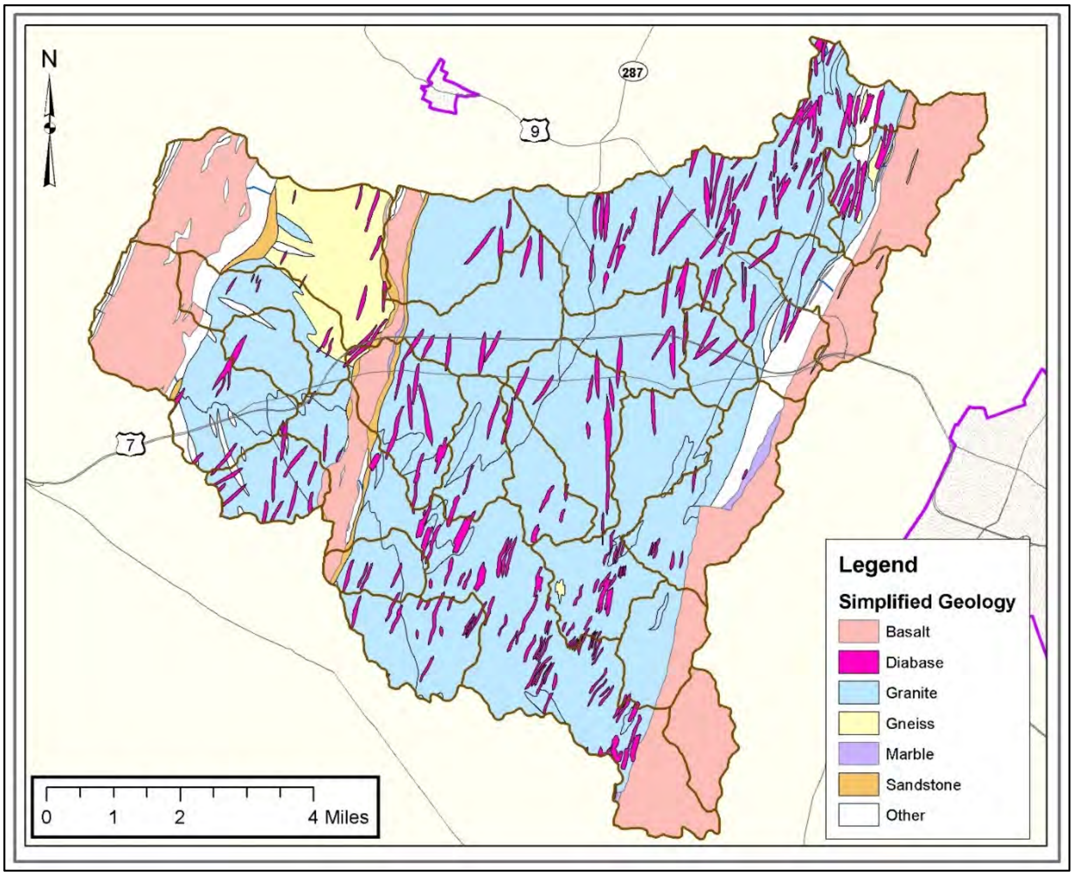


**Figure 3-2: Western Hills Watershed Geology**

### 3.1.4 Topography

The topography of a region describes the relative elevations of surface features, such as ridges and valleys. Land surface shape, including slope shape and steepness, is important as it affects the flow of surface water, soil erosion patterns, and suitability for development. For example, steep slopes are more prone to overland flow and soil erosion than flatter slopes, and thus have a greater potential for generating pollutants. Steep slopes are some of the basis used in the zoning ordinance referred to as the Mountainside Overlay District which provides regulations on development. Slopes were based on Loudoun County's GIS Steep Slope data and divided into two categories, derived through a modeling process based on recent topography produced from aerial photography:

- 15-25 percent slopes and
- > 25 percent slopes.

Table 3-3 summarizes the percent breakdown of each steep slope category by subwatershed. The distribution of these slope categories within the Western Hills Watershed is depicted in Figure 3-3.

Only 13.5 percent of the watershed area has greater than 15 percent slopes. Only a few small areas scattered throughout the watershed have very steep slopes that are categorized as greater than 25 percent, and would be more prone to erosion, depending on development and land use.

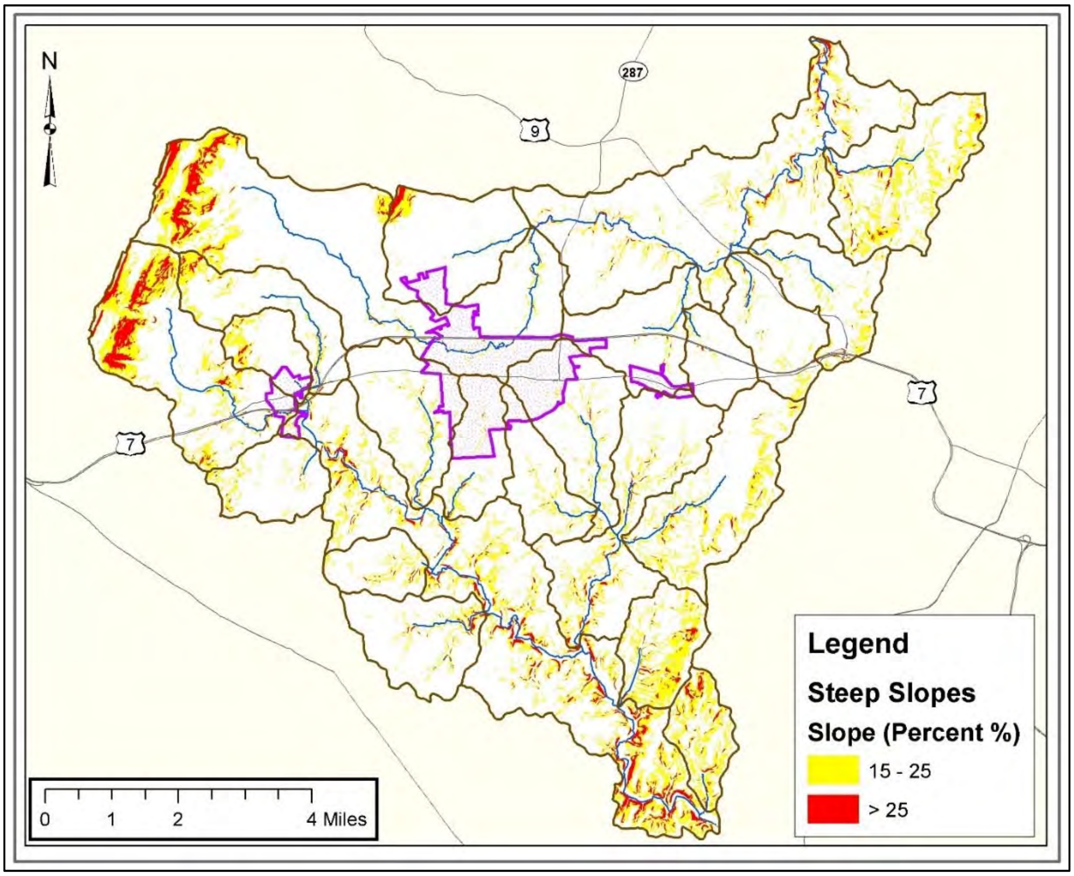


**Figure 3-3: Western Hills Watershed Topography Based on Steep Slopes**

**Table 3-3: Western Hills Watershed Steep Slope Categorization (Percent)**

| Subwatershed | 15 to 25 Percent Slope | Greater than 25 Percent Slope |
|---|---|---|
| CROOKED RUN | 9.4 | 1.4 |
| JACKS RUN | 5.2 | 0.3 |
| LOWER SOUTH FORK CATOCTIN | 6.3 | 1.3 |
| NORTH FORK GOOSE CREEK | 17.0 | 5.5 |
| SIMPSONS CREEK | 19.1 | 8.9 |
| TRIB 1 TO CROOKED RUN | 4.3 | 0.2 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 33.3 | 5.1 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 18.9 | 1.5 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 5.9 | 0.2 |
| TRIB 2 TO CROOKED RUN | 13.3 | 1.0 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 29.5 | 3.2 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 7.6 | 0.5 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 5.9 | 1.2 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 5.1 | 0.4 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 9.4 | 0.8 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 2.4 | 0.2 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 1.7 | 0.2 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 3.9 | 0.3 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 3.4 | 1.6 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 11.0 | 1.3 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 10.0 | 1.4 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 7.0 | 0.5 |
| UPPER SOUTH FORK CATOCTIN CREEK | 10.0 | 4.0 |
| TOTAL | 10.9 | 2.6 |

### 3.1.5 Soils

Soil conditions are important when evaluating how a watershed affects water quantity and quality in streams and rivers. Soil type and moisture conditions, for example, influence land use and an area's potential for supporting vegetation and habitat. Soils are an important consideration for projects aimed at improving water quality and/or habitat. The Loudoun County GIS soils layer was used for the soils data analysis and is a representation of the Loudoun County Soil Survey and the Interpretive Guide to the Use of Soils Maps, Loudoun County, VA, 2000.

#### 3.1.5.1 Hydrologic Soil Groups

The Natural Resources Conservation Service (NRCS) classifies soils into four hydrologic soil groups (HSG) based on runoff potential. Runoff potential is the inverse of infiltration capacity (ability for the soil to absorb precipitation). Soils with high infiltration capacity will have low runoff potential, and vice versa. Infiltration rates are highly variable among soil types and are also influenced by disturbances to the soil profile (e.g., land development activities). For example, urbanization in watersheds with high infiltration rates (e.g., sands and gravels) will have a greater impact than urbanization in watersheds consisting mostly of silts and clays, which have low infiltration rates. Factors that affect infiltration rate include soil permeability, slope, degree of soil saturation, percentage of leaf litter cover and other factors. The four hydrologic soil groups are A, B, C, and D, where group A soils generally have the lowest runoff potential and Group D soils have the greatest. Some soils are classified as group D because of a high water table that creates a drainage problem, but can be placed in another soil group if effectively drained. These types of soils are assigned to a dual hydrologic soil group (A/D, B/D, or C/D), where the first letter corresponds to the drained condition, and the second to the undrained condition.

Brief descriptions of each hydrologic soil group are provided below. Further explanation of each can be found in the U.S. Department of Agriculture (USDA)/NRCS publication, *Urban Hydrology for Small Watersheds*, also called Technical Release 55 (USDA 1986).

- **Group A** soils include sand, loamy sand, or sandy loam types. These soils have a high infiltration rate and low runoff potential even when thoroughly wet. These consist mainly of deep, well to excessively drained sands or gravel. These soils have a high rate of water transmission.
- **Group B** soils include silt load or loam types. They have a moderate infiltration rate when thoroughly wet. These soils mainly consist of somewhat deep to deep, moderately well to well drained soils with moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
- **Group C** soils are sandy clay loam. These soils have a low infiltration rate when thoroughly wet. These types of soils typically have a layer that hinders downward movement of water and soils with moderately fine or fine texture. These soils have a low rate of water transmission.
- **Group D** soils include clay loam, silty clay loam, sandy clay, silty clay, or clay types. These soils have a very low infiltration rate and high runoff potential when thoroughly wet. These consist mainly of clays with high swell potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission.

As shown in Table 3-4 and Figure 3-4, the majority of soils in the Western Hills Watershed are soil groups with higher runoff potential.

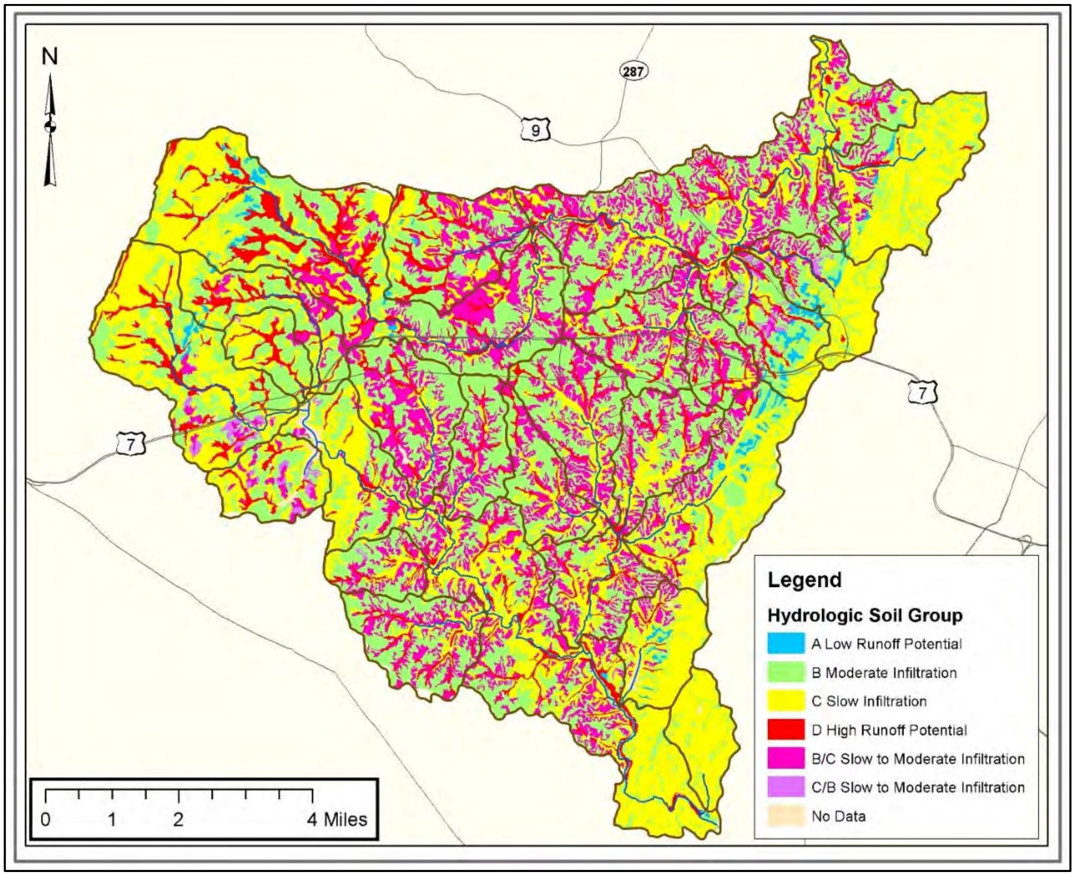


**Figure 3-4: Western Hills Watershed Hydrologic Soil Groups**

**Table 3-4: Western Hills Watershed Hydrologic Soil Groups**

| Subwatershed | Soil Hydrologic Group (Percent) | | | | | |
|---|---|---|---|---|---|---|
| | A | B | C | D | B/C | C/B |
| CROOKED RUN | 0.0 | 42.5 | 23.9 | 6.2 | 26.5 | 0.0 |
| JACKS RUN | 0.2 | 44.7 | 12.9 | 5.6 | 34.8 | 0.1 |
| LOWER SOUTH FORK CATOCTIN | 0.2 | 44.4 | 19.0 | 6.2 | 29.1 | 0.2 |
| NORTH FORK GOOSE CREEK | 0.2 | 30.7 | 44.5 | 5.9 | 16.3 | 0.3 |
| SIMPSONS CREEK | 1.0 | 30.6 | 50.4 | 11.3 | 2.8 | 3.1 |
| TRIB 1 TO CROOKED RUN | 0.0 | 48.2 | 15.4 | 5.5 | 30.3 | 0.0 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 0.0 | 14.7 | 84.4 | 0.0 | 0.0 | 0.0 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 1.4 | 28.4 | 61.4 | 1.6 | 6.9 | 0.0 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 0.0 | 49.1 | 16.3 | 5.5 | 28.6 | 0.0 |
| TRIB 2 TO CROOKED RUN | 3.4 | 34.4 | 46.1 | 3.0 | 12.5 | 0.0 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 3.2 | 18.7 | 63.2 | 1.8 | 9.7 | 0.1 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 3.6 | 34.4 | 46.2 | 4.7 | 8.4 | 2.3 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 0.0 | 52.5 | 11.8 | 6.1 | 29.1 | 0.0 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 9.6 | 46.8 | 20.2 | 8.2 | 9.6 | 4.9 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 0.0 | 49.6 | 18.5 | 5.3 | 25.4 | 0.9 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 50.3 | 13.2 | 5.6 | 30.6 | 0.0 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 48.5 | 11.0 | 9.0 | 30.8 | 0.0 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 0.0 | 59.0 | 7.1 | 4.3 | 29.1 | 0.0 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 0.8 | 38.0 | 19.1 | 14.6 | 26.4 | 0.2 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 0.0 | 47.4 | 35.6 | 14.0 | 2.2 | 0.9 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 1.2 | 42.8 | 30.2 | 15.0 | 9.8 | 0.2 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 0.0 | 36.1 | 35.6 | 7.6 | 9.7 | 6.2 |
| UPPER SOUTH FORK CATOCTIN CREEK | 1.6 | 36.5 | 30.4 | 15.2 | 15.8 | 0.0 |
| TOTAL | 1.1 | 38.6 | 32.3 | 7.7 | 18.7 | 0.6 |

#### 3.1.5.2 Septic Drainfield Potential

The Interpretive Guide to the Use of Soils Maps of Loudoun County (Loudoun County 2000) offers numerous "views" for development, agricultural and other suitability. One view is the classification by mapping unit for onsite sewage disposal or drainfield potential. Factors considered include:

- Depth to water table or natural drainage
- Whether the area receives seepage or runoff water
- Whether the area is subject to flooding
- Soil texture and structure
- Amount and type of clay
- Thickness of the surface soil and thickness of subsoil or depth to friable, weathered parent material
- Nature of the parent material
- General depth to hard rock or restricting layer

- Past percolation test of the soil and performance of septic drainage fields on the soil, and
- Steepness of slopes (installation problem)

The classes are defined as:

***CLASS I – Good Potential***

These mapping units have a combination of soil and landscape properties that are most suitable for the broadly defined use. The potential for finding suitable sites within these mapping units is good.

***CLASS II – Fair Potential***

These mapping units have some favorable and some unfavorable soil and landscape properties, or questionable soil properties. Variability of conditions affecting use as drainfield sites is high and predictability is low. Often these mapping units have soils which require percolation tests as one consideration to permit action.

***CLASS III – Poor Potential***

Those mapping units have questionable and unfavorable soil and landscape features and/or unfavorable soil properties. Predictability within mapping units is fairly accurate, although a site may be found on mapping unit inclusions (soils outside of the norm described for the unit). The majority of these mapping units are moderately deep soils over siltstones or crystalline rock, or are moderately well to somewhat poorly drained soils on nearly-level ridgetops and mountain colluvial positions.

***CLASS IV – Very Poor Potential***

These mapping units have highly accurate predictability relative to landscape and drainage features and properties. They have soil and/or landscape features that are generally considered unsuited for satisfactory drainfield use. These mapping units include somewhat poorly to poorly drained colluvial soils (in swales and depressions), flood plains, soils with high shrink-swell (expanding clay) subsoils, soils with prolonged high seasonal water tables and soils on greater than 25 percent slopes or very shallow to rock.

In Figure 3-5 the better drainfield potential areas are shown as generally being outside of the floodplain and away from steep slope on the outskirts of the subwatersheds. Percentages by watershed are listed in Table 3-5.

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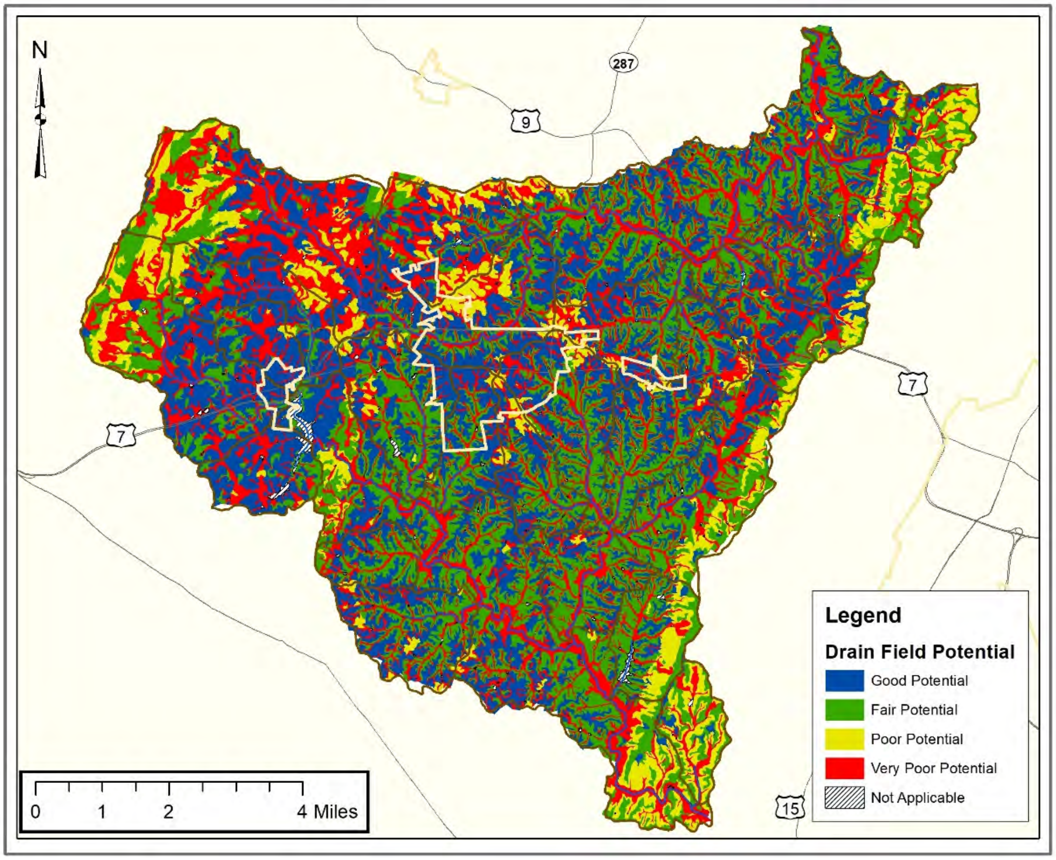


**Figure 3-5: Western Hills Watershed Septic Drainfield Potential**

**Table 3-5: Western Hills Watershed Septic Drainfield Potential (Percent of Subwatershed Area)**

| Subwatershed | Good Potential | Fair Potential | Poor Potential | Very Poor Potential | Not Applicable |
|---|---|---|---|---|---|
| CROOKED RUN | 32.7 | 42.6 | 1.6 | 22.3 | 0.8 |
| JACKS RUN | 37.8 | 36.7 | 5.6 | 18.3 | 1.6 |
| LOWER SOUTH FORK CATOCTIN | 31.8 | 37.4 | 3.2 | 26.7 | 0.9 |
| NORTH FORK GOOSE CREEK | 25.8 | 36.6 | 9.3 | 26.1 | 2.1 |
| SIMPSONS CREEK | 32.3 | 25.1 | 12.8 | 29.0 | 0.8 |
| TRIB 1 TO CROOKED RUN | 37.1 | 33.8 | 5.4 | 23.3 | 0.5 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 6.2 | 34.6 | 39.2 | 19.2 | 0.8 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 14.1 | 38.1 | 24.6 | 22.9 | 0.2 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 41.2 | 30.5 | 7.4 | 20.4 | 0.5 |
| TRIB 2 TO CROOKED RUN | 19.4 | 42.0 | 14.2 | 23.8 | 0.6 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 14.9 | 45.2 | 21.0 | 15.5 | 3.3 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 36.1 | 28.3 | 10.7 | 24.5 | 0.4 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 41.8 | 30.6 | 5.5 | 21.7 | 0.5 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 40.5 | 29.8 | 4.3 | 24.7 | 0.8 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 36.6 | 40.5 | 1.7 | 20.9 | 0.3 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 38.6 | 27.2 | 7.3 | 26.4 | 0.4 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 37.3 | 27.3 | 6.2 | 28.5 | 0.7 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 49.0 | 30.3 | 2.7 | 17.5 | 0.5 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 32.7 | 14.8 | 17.2 | 34.2 | 1.0 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 60.2 | 11.5 | 2.1 | 26.2 | 0.1 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 46.1 | 13.1 | 11.6 | 28.5 | 0.7 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 55.2 | 13.6 | 1.5 | 24.9 | 4.8 |
| UPPER SOUTH FORK CATOCTIN CREEK | 30.0 | 16.3 | 17.0 | 36.1 | 0.6 |

#### 3.1.5.3 Erodibility

Erodibility is the susceptibility of soil to erosion. It is quantified by the K factor, which is part of the Revised Universal Soil Loss Equation (RUSLE) developed by USDA's Agricultural Research Service to estimate rate of erosion and soil loss for a particular site. Low K factor values indicate low erodibility or high resistance to detachment and high K factors represent high erodibility potential. Erodibility is based on the physical and chemical properties of the soil, which determine how strongly soil particles cohere with one another. For example, clay soils are cohesive or resistant to detachment and have low K values on the order of 0.05 to 0.15 (Jones et al. 1996).

Soil erodibility was divided into the following four categories, based on Loudoun County soils data:

- Low Erodibility (K factor < 0.2);

- Medium Erodibility (0.2 ≤ K factor ≤ 0.4);
- High Erodibility (0.4 ≤ K factor ≤ 0.65 and
- Very High Erodibility (K factor > 0.65).

Figure 3-6 shows the distribution of soil erodibility in the Western Hills Watershed based on these categories and a summary by subwatershed is shown in Table 3-6.

Subwatersheds with the largest fractions of highly erodible soils present the greatest potential for addressing soil conservation issues via best management practices (BMPs) such as minimizing bare soil and keeping topsoil in place. Soil erodibility data are also useful in combination with other information such as location of cropland, slope steepness, and distance to streams to determine where retirement of highly erodible land, another BMP, may be appropriate. High K factor values can also serve as a warning for urban activities planned near streams such as road construction or utility placements. As shown in Table 3-6 and Figure 3-6, very high and high erodibility categories represent over 37 percent of the soil erodibility distribution in the Western Hills Watershed. These areas should be considered when prioritizing areas for maintaining the remaining protective land cover such as forested area or extra requirements for development.

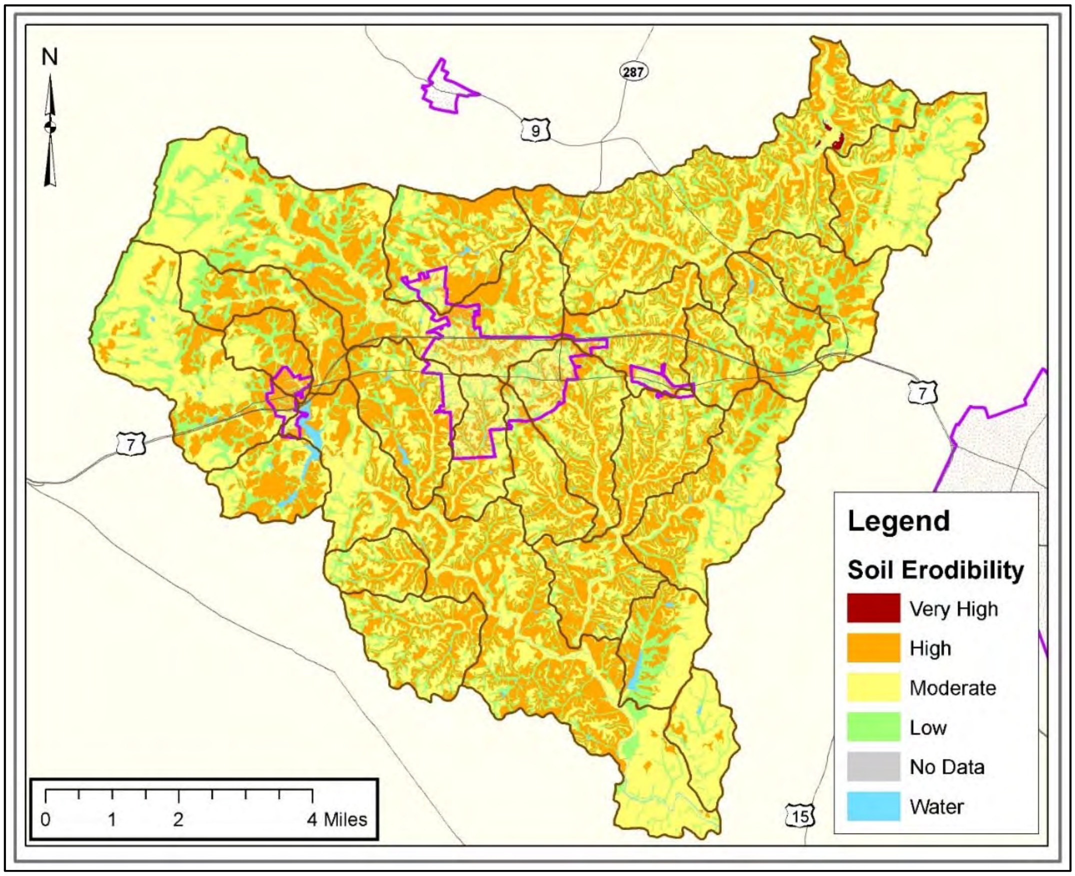


**Figure 3-6: Western Hills Watershed Septic Drainfield Potential**

**Table 3-6: Western Hills Watershed Soil Erodibility Categorization (Percent of Area)**

| Subwatershed | Very High | High | Moderate | Low | Water | No Data |
|---|---|---|---|---|---|---|
| CROOKED RUN | 0.0 | 45.34 | 38.51 | 15.39 | 0.75 | 0.00 |
| JACKS RUN | 0.0 | 48.16 | 36.55 | 13.65 | 1.64 | 0.01 |
| LOWER SOUTH FORK CATOCTIN | 0.4 | 41.31 | 41.28 | 16.13 | 0.87 | 0.00 |
| NORTH FORK GOOSE CREEK | 0.0 | 38.42 | 46.72 | 12.74 | 2.11 | 0.01 |
| SIMPSONS CREEK | 0.0 | 24.30 | 55.24 | 19.65 | 0.79 | 0.02 |
| TRIB 1 TO CROOKED RUN | 0.0 | 40.30 | 42.56 | 16.67 | 0.47 | 0.00 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 0.0 | 6.41 | 83.50 | 9.25 | 0.85 | 0.00 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 20.55 | 63.14 | 16.07 | 0.24 | 0.00 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 0.0 | 40.39 | 43.39 | 15.75 | 0.47 | 0.00 |
| TRIB 2 TO CROOKED RUN | 0.0 | 32.25 | 48.42 | 18.74 | 0.59 | 0.00 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 0.0 | 30.68 | 44.03 | 21.94 | 3.28 | 0.06 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 38.58 | 37.96 | 23.03 | 0.43 | 0.00 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 0.0 | 39.35 | 43.02 | 17.15 | 0.48 | 0.01 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 38.30 | 36.79 | 24.14 | 0.76 | 0.00 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 0.0 | 37.82 | 44.58 | 17.31 | 0.30 | 0.00 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 41.00 | 41.13 | 17.46 | 0.41 | 0.00 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 40.39 | 38.11 | 20.81 | 0.69 | 0.00 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 0.0 | 33.45 | 51.70 | 14.32 | 0.53 | 0.00 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 0.0 | 43.42 | 35.39 | 20.17 | 1.00 | 0.02 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 0.0 | 57.73 | 24.96 | 17.23 | 0.08 | 0.00 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 0.0 | 50.78 | 25.68 | 22.80 | 0.73 | 0.00 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 0.0 | 45.90 | 33.68 | 15.64 | 4.78 | 0.00 |
| UPPER SOUTH FORK CATOCTIN CREEK | 0.0 | 32.12 | 44.80 | 22.51 | 0.57 | 0.00 |
| AVERAGE | 0.05 | 37.00 | 44.32 | 17.61 | 1.02 | 0.01 |

### 3.1.6 Forest Cover

Forest provides the greatest protection among land cover types for water and soil quality. In pristine systems, forest and soils co-evolve, shaping the hydrologic cycle; these systems operate within a natural range of variability, assuring healthy habitat and water quality. The entire Potomac River basin, including the Western Hills Watershed, consisted overwhelmingly of old-growth forest at the time of European settlement. In human-impacted systems, forest cover can still provide many benefits and protect water quality if judiciously planned and conserved.

Although now above historic deforestation levels, the forested area has been greatly reduced in the Western Hills Watershed since European settlement, some subwatersheds have maintained a relatively high percentage of forest cover (e.g., Upper South Fork Catoctin, Simpsons Creek, and North Fork Goose Creek) compared to more developed watersheds in the region.

**Figure 3-7: Western Hills Watershed Forest Cover**

Figure 3-7 shows the distribution of forest cover within the Western Hills Watershed based on Loudoun County's generalized GIS Forest layer.

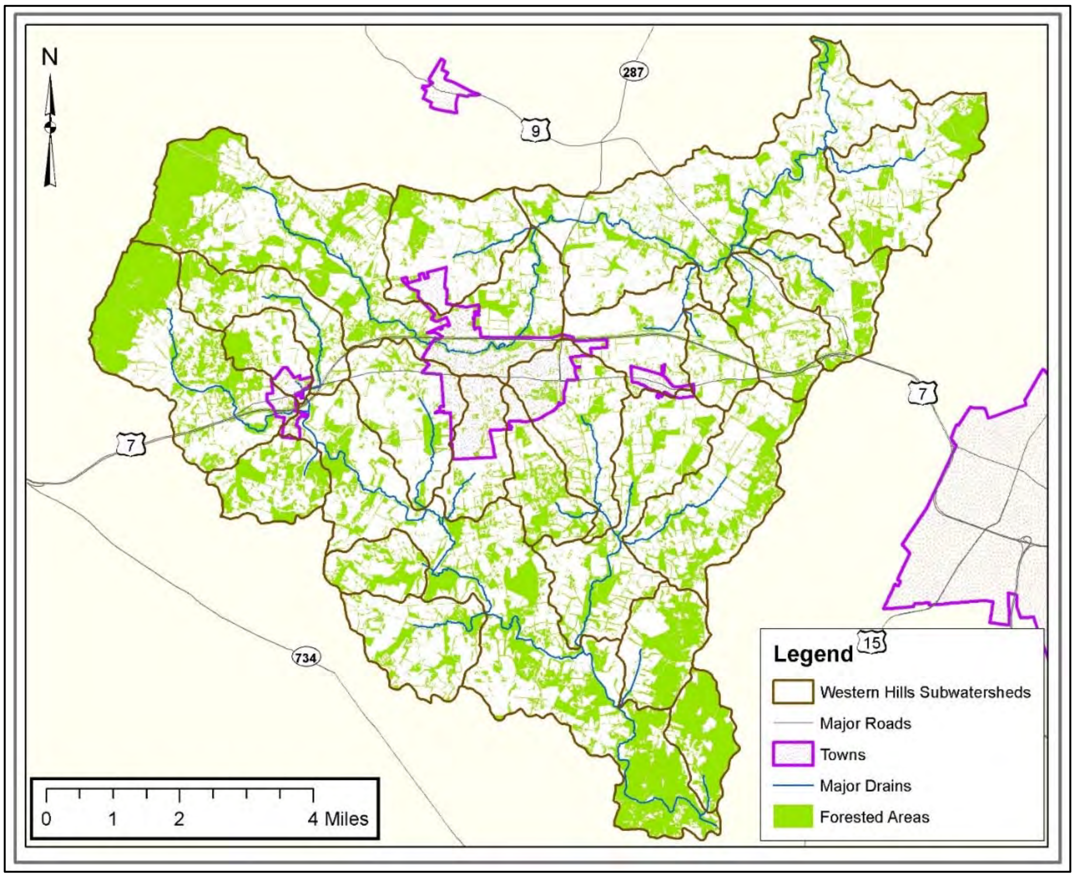


**Figure 3-7: Western Hills Watershed Forest Cover**

Table 3-7 shows that the Western Hills Watershed has approximately 15,625 acres of forested area, which is approximately 31.5 percent of the total watershed area. Substantial areas of forest cover occur within the western and eastern portions of the watershed along the Blue Ridge and Catoctin Ridge mountains.

**Table 3-7: Western Hills Watershed Forest Cover Distribution**

| Subwatershed | Forested Area (Acres) | Subwatershed Area (Acres) | Percent Forested |
|---|---|---|---|
| CROOKED RUN | 684 | 2,693 | 25.4 |
| JACKS RUN | 316 | 1,734 | 18.2 |
| LOWER SOUTH FORK CATOCTIN | 1,104 | 5,770 | 19.1 |
| NORTH FORK GOOSE CREEK | 2,731 | 6,716 | 40.7 |
| SIMPSONS CREEK | 1,547 | 3,213 | 48.1 |
| TRIB 1 TO CROOKED RUN | 324 | 1,831 | 17.7 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 647 | 871 | 74.3 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 688 | 2,348 | 29.3 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 351 | 1,054 | 33.3 |
| TRIB 2 TO CROOKED RUN | 798 | 2,525 | 31.6 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 579 | 1,183 | 49.0 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 451 | 1,388 | 32.4 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 381 | 1,540 | 24.8 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 356 | 1,301 | 27.4 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 251 | 750 | 33.5 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 166 | 1,469 | 11.3 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 142 | 769 | 18.4 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 136 | 1,059 | 12.8 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 401 | 1,909 | 21.0 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 209 | 745 | 28.1 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 456 | 1,416 | 32.2 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 464 | 1,083 | 42.9 |
| UPPER SOUTH FORK CATOCTIN CREEK | 2,443 | 6,189 | 39.5 |
| TOTAL | 15,625 | 49,558 | 31.5 |

### 3.1.7 Stream Systems

Streams are the flowing surface waters; and while they are distinct from groundwater and standing surface water such as lakes, they are closely connected to both. The stream system is an intrinsic part of the landscape and closely reflects conditions on the land. Streams are a fundamental natural resource with numerous benefits for plants, animals, and humans.

#### 3.1.7.1 Stream System Characteristics

The Western Hills Watershed is one of several watersheds found within the Middle Potomac-Catoctin subbasin, which is part of the Potomac River basin. This watershed is subdivided into 23 subwatersheds, and contains more than 100 miles of perennial streams. These streams are divided between the South Fork Catoctin Creek and North Fork Goose Creek watersheds. Figure 3-8 shows the streams and the 23 subwatersheds that make up the Western Hills Watershed. In 2009 Loudoun County estimated that the total length of perennial stream miles is significantly greater than USGS previously estimated. The National Hydrology Data (NHD) includes perennial and ephemeral streams at two scales (1:24K and 1:100K). Loudoun County basemap drainage is mapped at 1:2,400 scale and includes roadside ditches.

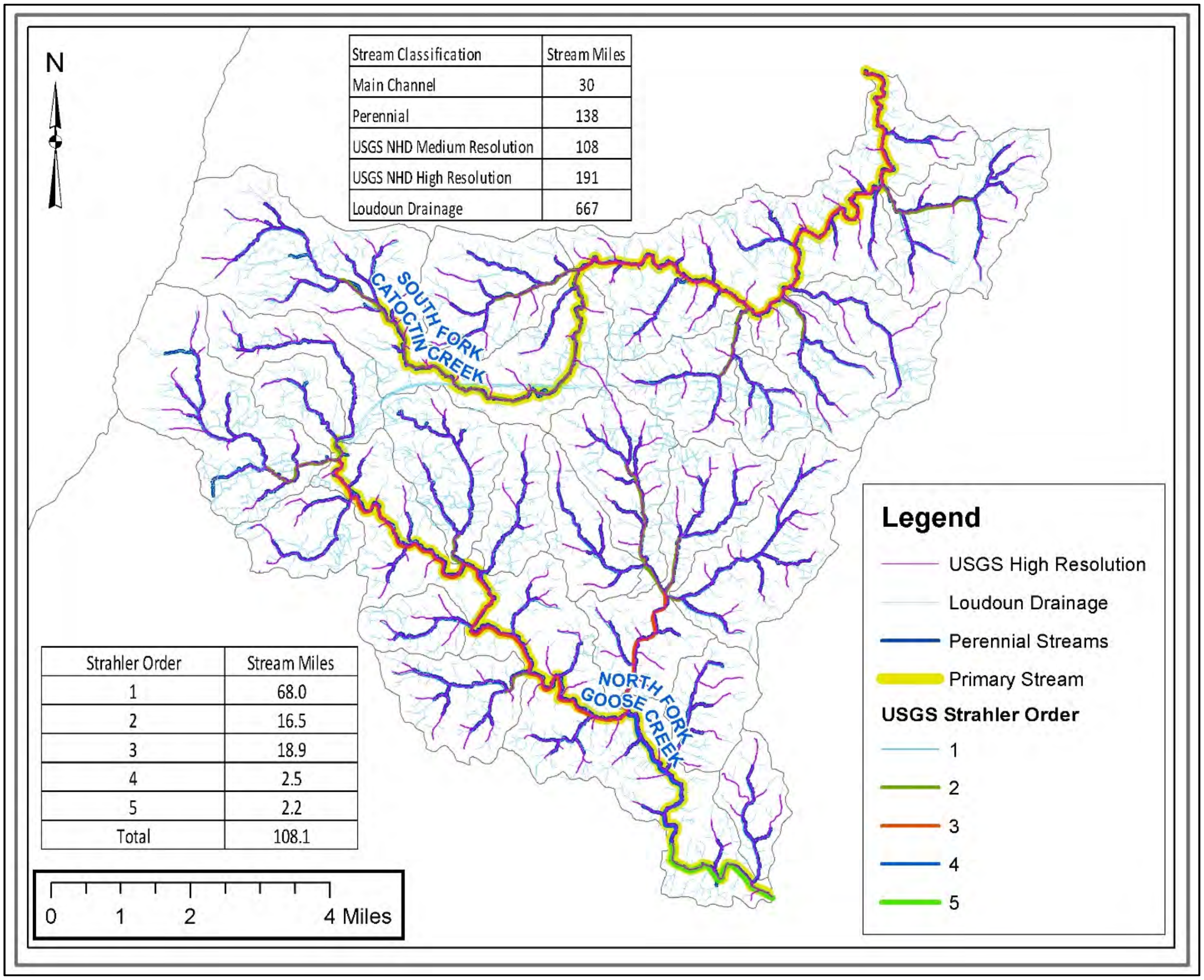


**Figure 3-8: Western Hills Watershed Stream Characteristics**

#### 3.1.7.2 Stream Riparian Buffers

Riparian buffers are the vegetated areas adjacent to streams that protect water bodies from toxins and excessive nutrients, while also providing bank stabilization and habitat. Forested buffer areas along streams play a crucial role in improving water quality and flood mitigation because they can reduce surface runoff, stabilize stream banks, trap sediment, and provide habitat for various types of terrestrial and aquatic life including fish. Tree roots, for example, capture and remove pollutants including excess nutrients (e.g., nitrogen) from shallow flowing water (Penn State Extension 2010); the tree root structure also impedes erosion and water flow, which in turn reduces sediment load and the risk of flooding. Tree canopy provides shading and results in cooler water temperatures required by a variety of stream biota, particularly cold-water species like trout. In smaller streams such as the ones surveyed, terrestrial plant material falling into the stream is the primary source of food for stream fauna. Trees provide seasonal food in the form of leaves and plant parts for stream life at the base of the food chain, while fallen tree branches and trunks provide a more consistent, slow-release food source throughout the year. Tree roots and snags offer habitat for fish and other aquatic species. Maintaining healthy, forested buffers are important for reducing nutrient and sediment loadings to the local creeks and then to the Potomac River. When stream riparian buffers are converted from forest to agriculture or urban land uses (e.g., residential), many of these benefits are lost and stream health declines. Riparian buffer zones can be reestablished or preserved as a best management practice (BMP) to reduce land use impacts by intercepting and controlling the pollutants entering a water body.

The vegetative condition of the riparian buffer was analyzed based on a 100-foot buffer on either side of the stream system. Three conditions were used to classify stream buffer conditions: forest, open pervious, and impervious. Impervious areas were determined by overlaying the Loudoun County Impervious GIS layer over the 100-foot stream buffer layer. Similarly, the forested areas were determined by overlaying the Loudoun County Forest layer over the 100-foot stream buffer layer. Remaining areas were classified as open pervious areas. The “buffer” is a broader reflection of the stream corridor and extends beyond traditional BMP cost-share width of 35 feet. The distribution of the 100-ft stream buffer classification scheme is shown in Figure 3-9. Stream buffer conditions are summarized by subwatershed in terms of acres and percentages in Table 3-8.

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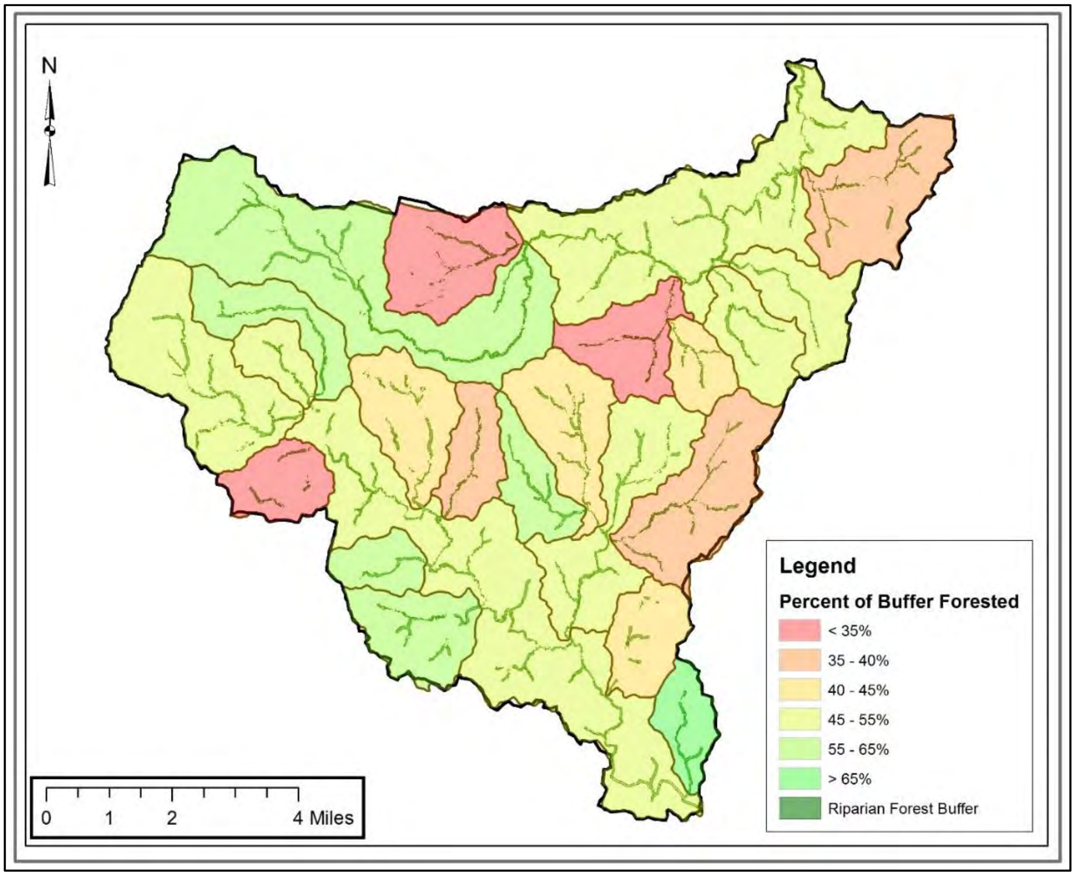


**Figure 3-9: Western Hills Watershed 100-foot Stream Buffer Condition**

**Table 3-8: Western Hills Watershed 100-foot Stream Buffer Condition**

| Subwatershed | Forested (Acres) | Riparian Buffer (Acres) | Watershed Area (Acres) | Percent of Buffer Forested |
|---|---|---|---|---|
| CROOKED RUN | 98.2 | 190.1 | 2,693 | 51.6 |
| JACKS RUN | 53.1 | 130.5 | 1,734 | 40.7 |
| LOWER SOUTH FORK CATOCTIN | 204.2 | 418.1 | 5,770 | 48.8 |
| NORTH FORK GOOSE CREEK | 253.0 | 519.9 | 6,716 | 48.6 |
| SIMPSONS CREEK | 102.4 | 195.3 | 3,213 | 52.4 |
| TRIB 1 TO CROOKED RUN | 52.5 | 130.0 | 1,831 | 40.4 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 43.2 | 55.4 | 871 | 77.8 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 55.4 | 148.5 | 2,348 | 37.2 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 49.1 | 77.9 | 1,054 | 63.0 |
| TRIB 2 TO CROOKED RUN | 60.1 | 152.3 | 2,525 | 39.4 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 27.8 | 64.2 | 1,183 | 43.3 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 27.8 | 60.4 | 1,388 | 46.1 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 57.6 | 98.1 | 1,540 | 58.7 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 40.1 | 77.3 | 1,301 | 51.8 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 23.0 | 36.1 | 750 | 63.6 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 24.4 | 81.9 | 1,469 | 29.7 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 22.2 | 53.4 | 769 | 41.6 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 21.7 | 56.3 | 1,059 | 38.5 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 39.8 | 118.4 | 1,909 | 33.6 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 22.6 | 41.7 | 745 | 54.2 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 51.3 | 85.3 | 1,416 | 60.1 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 22.7 | 64.1 | 1,083 | 35.4 |
| UPPER SOUTH FORK CATOCTIN CREEK | 208.9 | 357.6 | 6,189 | 58.4 |
| TOTAL | 1,561.3 | 3,212.8 | 49,558 | 48.6 |

## 3.2 Human Modified Landscape

The natural landscape has been modified for human use over time. The intensity of development activities has increased, starting with the colonization of Virginia in the 1600s. This modification has resulted in environmental impacts to both terrestrial and aquatic ecosystems. This section describes the characteristics of the human-modified landscape and how human uses are associated with impacts to the natural ecosystem. This includes a general description of land use and land cover and more specific issues such as population, impervious cover, stormwater management, drinking water and wastewater, discharge permits, and zoning.

### 3.2.1 Land Use and Land Cover

Land use has pronounced impacts on water quality and habitat. Different land uses generate different types and amounts of pollutants. A forested watershed has the capacity to absorb pollutants such as sediment and nutrients and reduce the flow rate of water into streams. Developed areas with impervious surfaces, such as road, parking lots, and roofs, block the natural seepage of precipitation into the ground. Unlike most natural surfaces, impervious surfaces tend to concentrate stormwater runoff, accelerate flow rates, and direct stormwater to the nearest stream. This can cause bank erosion and destruction of in-stream and riparian habitat. Undeveloped watersheds and those with small amounts of impervious surfaces tend to have better water quality in local streams than developed watersheds with larger amounts of impervious surfaces. In addition, agricultural land uses can contribute to increases in nutrients and coliform bacteria in streams, if not properly managed.

The Western Hills Watershed land use analysis was developed to represent "current" conditions, for use in mapping and in watershed modeling. The analysis was performed using 1-meter resolution data derived from the Chesapeake Bay High-Resolution Land Cover Project, one of the nation's largest, high-resolution land cover datasets, completed in 2016. The dataset was created for the Chesapeake Bay Program—a regional partnership of EPA, other federal, state, and local agencies and governments, nonprofits, and academic institutions that leads and directs Bay restoration efforts—which was looking to improve its data related to the Chesapeake Bay watershed landscape. Among other uses, the land use data support Bay-wide modeling of nutrient and sediment loads (see Shenk and Linker 2013). For the Western Hills Watershed, a summary of land use/land cover percentages by subwatershed is provided in Table 3-9. A map of land use/land cover according to the data described above is shown in Figure 3-10.

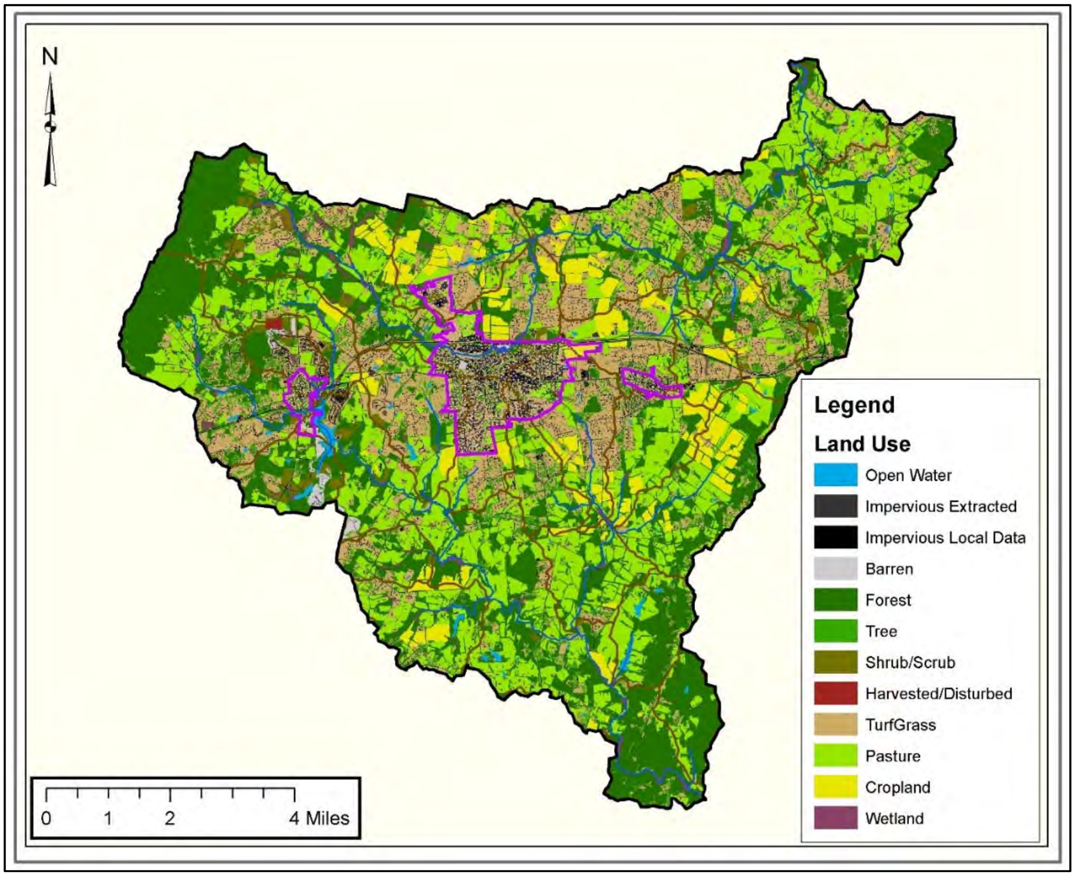


**Figure 3-10: Western Hills Watershed Land Use/Land Cover**

**Table 3-9: Western Hills Watershed Land Use Classification (Acres in Each Class)**

| | Open Water | Impervious Extracted | Impervious Local Datasets | Barren | Forest | Tree | Shrub/Scrub | Harvested/ Disturbed | Turf Grass | Pasture | Cropland | NWI/Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Class Number** | 11 | 21 | 22 | 31 | 41 | 42 | 51 | 61 | 71 | 81 | 82 | 91 | |
| CROOKED RUN | 10 | 47 | 61 | 0 | 648 | 149 | 3 | 0 | 309 | 1,221 | 229 | 16 | 2,693 |
| JACKS RUN | 29 | 96 | 68 | 0 | 195 | 174 | 33 | 0 | 720 | 309 | 102 | 9 | 1,734 |
| LOWER SOUTH FORK CATOCTIN | 24 | 180 | 113 | 6 | 1,033 | 519 | 51 | 0 | 1,366 | 2,025 | 352 | 100 | 5,770 |
| NORTH FORK GOOSE CREEK | 101 | 130 | 111 | 56 | 2,537 | 509 | 66 | 0 | 659 | 2,289 | 162 | 96 | 6,716 |
| SIMPSONS CREEK | 16 | 122 | 93 | 0 | 1,297 | 394 | 13 | 0 | 741 | 506 | 0 | 31 | 3,213 |
| TRIB 1 TO CROOKED RUN | 4 | 185 | 109 | 0 | 148 | 170 | 0 | 0 | 787 | 219 | 181 | 27 | 1,831 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 4 | 5 | 3 | 0 | 658 | 25 | 0 | 0 | 25 | 147 | 5 | 0 | 871 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 8 | 47 | 39 | 0 | 722 | 157 | 16 | 0 | 275 | 1,065 | 15 | 5 | 2,348 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 0 | 43 | 44 | 0 | 207 | 148 | 0 | 0 | 231 | 308 | 69 | 5 | 1,054 |
| TRIB 2 TO CROOKED RUN | 8 | 25 | 35 | 0 | 819 | 171 | 4 | 0 | 156 | 920 | 384 | 2 | 2,525 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 49 | 14 | 13 | 0 | 575 | 74 | 0 | 0 | 57 | 396 | 5 | 1 | 1,183 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 1 | 56 | 42 | 0 | 383 | 173 | 23 | 0 | 317 | 369 | 15 | 9 | 1,388 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 19 | 30 | 34 | 0 | 375 | 122 | 0 | 0 | 164 | 616 | 156 | 25 | 1,540 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 12 | 49 | 52 | 0 | 212 | 217 | 11 | 0 | 409 | 204 | 124 | 12 | 1,301 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 1 | 22 | 16 | 0 | 234 | 71 | 7 | 0 | 138 | 221 | 29 | 12 | 750 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 3 | 91 | 81 | 0 | 70 | 175 | 20 | 0 | 586 | 233 | 207 | 4 | 1,469 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 0 | 50 | 36 | 0 | 89 | 63 | 1 | 0 | 219 | 154 | 147 | 10 | 769 |

## Table 3-9: Western Hills Watershed Land Use Classification (Acres in Each Class)

| | Open Water | Impervious Extracted | Impervious Local Datasets | Barren | Forest | Tree | Shrub/Scrub | Harvested/ Disturbed | Turf Grass | Pasture | Cropland | NWI/Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Class Number** | 11 | 21 | 22 | 31 | 41 | 42 | 51 | 61 | 71 | 81 | 82 | 91 | |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 1 | 115 | 81 | 0 | 37 | 119 | 0 | 0 | 444 | 196 | 66 | 0 | 1,059 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 14 | 80 | 40 | 0 | 320 | 150 | 20 | 0 | 515 | 427 | 324 | 19 | 1,909 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 0 | 67 | 58 | 29 | 181 | 73 | 46 | 25 | 186 | 65 | 0 | 17 | 745 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 3 | 47 | 45 | 0 | 398 | 107 | 16 | 4 | 237 | 481 | 58 | 20 | 1,416 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 50 | 21 | 19 | 88 | 403 | 70 | 127 | 0 | 124 | 166 | 0 | 14 | 1,083 |
| UPPER SOUTH FORK CATOCTIN CREEK | 9 | 274 | 180 | 12 | 2,141 | 402 | 250 | 0 | 1,179 | 1,138 | 384 | 219 | 6,189 |
| TOTAL | 376 | 1,817 | 1,397 | 223 | 13,724 | 4,273 | 755 | 90 | 9,913 | 13,756 | 3,093 | 745 | 49,557 |

### 3.2.2 Land Use and Land Cover in Western Hills Watershed

The Western Hills Watershed encompasses approximately 49,558 acres (77.4 square miles) of land. The primary land uses in the watershed are Pasture (28 percent) and Forest and Trees (36 percent), which are spread throughout the entire watershed. Larger concentrations of Forest occur along the Blue Ridge and Catoctin Ridge mountains. Turf Grass and Cropland (26 percent) is also spread throughout the entire watershed. Illustrating one example of land use change over time, Figure 3-11 shows residential developments and two schools (Harmony Middle School and Kenneth W. Culbert Elementary School) in the vicinity of Business Route 7, east of the Town of Purcellville, including the western portion of the Town of Hamilton, which once was dominated by croplands for several decades. Similar changes in land use are likely to occur in the many parts of the watershed in the coming decades, at densities as outlined in county zoning or as amended.

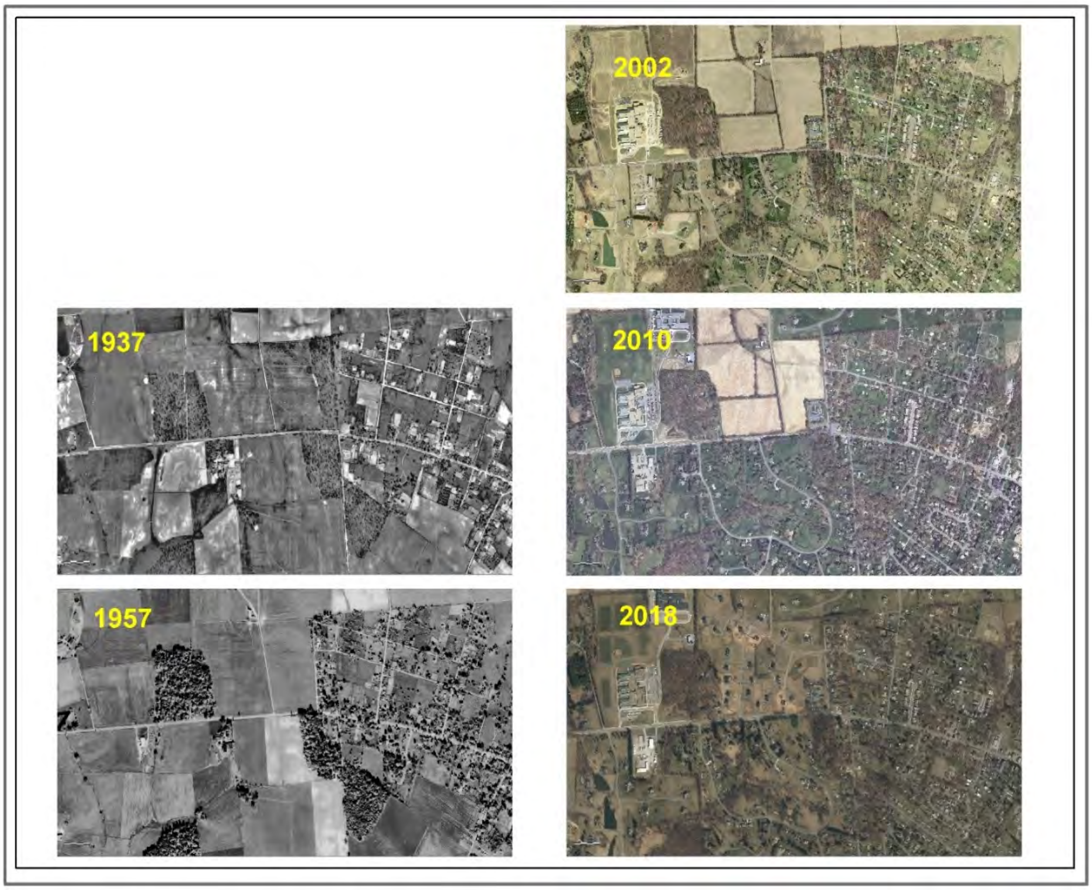


**Figure 3-11: Historical Imagery for the Vicinity of Business Route 7, between Purcellville and Hamilton in the Western Hills Watershed. (Imagery Courtesy of the Commonwealth of Virginia and the County of Loudoun.)**

### 3.2.3 Population

Population data provides another way to evaluate the intensity of human influence on the landscape. Much of the impact of residential and commercial land uses (where population is mainly concentrated) is related to the extent of impervious cover and also conversion of land uses such as forest that protect water resources. A higher population density (persons per acre) represents a more intense use of the land and greater potential for environmental degradation. The majority of the development within the Western Hills Watershed has occurred during the past three to four decades.

Population patterns in the Western Hills Watershed were examined based on 2015 Traffic Analysis Zone (TAZ) data. The population distribution for the watershed is shown in Figure 3-12. As of 2015, higher densities are located in the Town of Purcellville and on the north side of Route 7, west of the Town of Round Hill. Based on the TAZ 2045 projection, the majority of the subwatersheds are expected to experience growth in population over the next several decades as development continues (Figure 3-13).

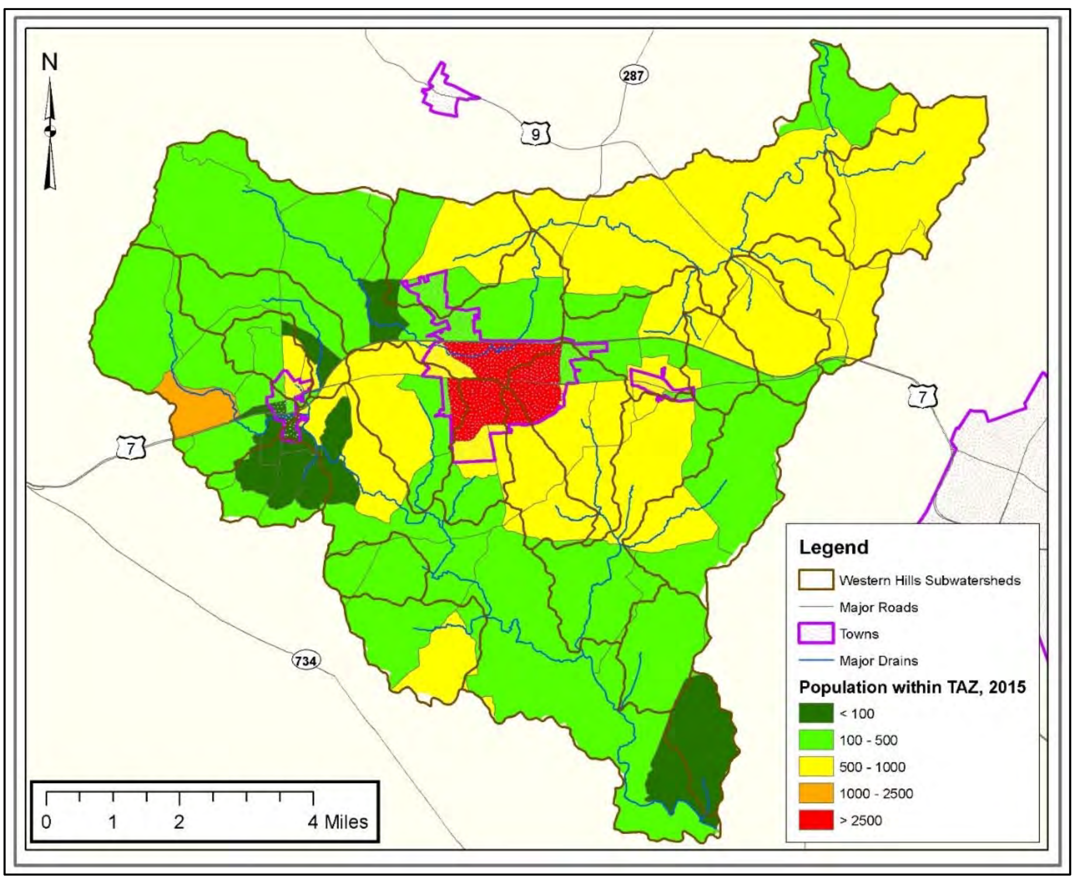


**Figure 3-12: Western Hills Watershed Population 2015**

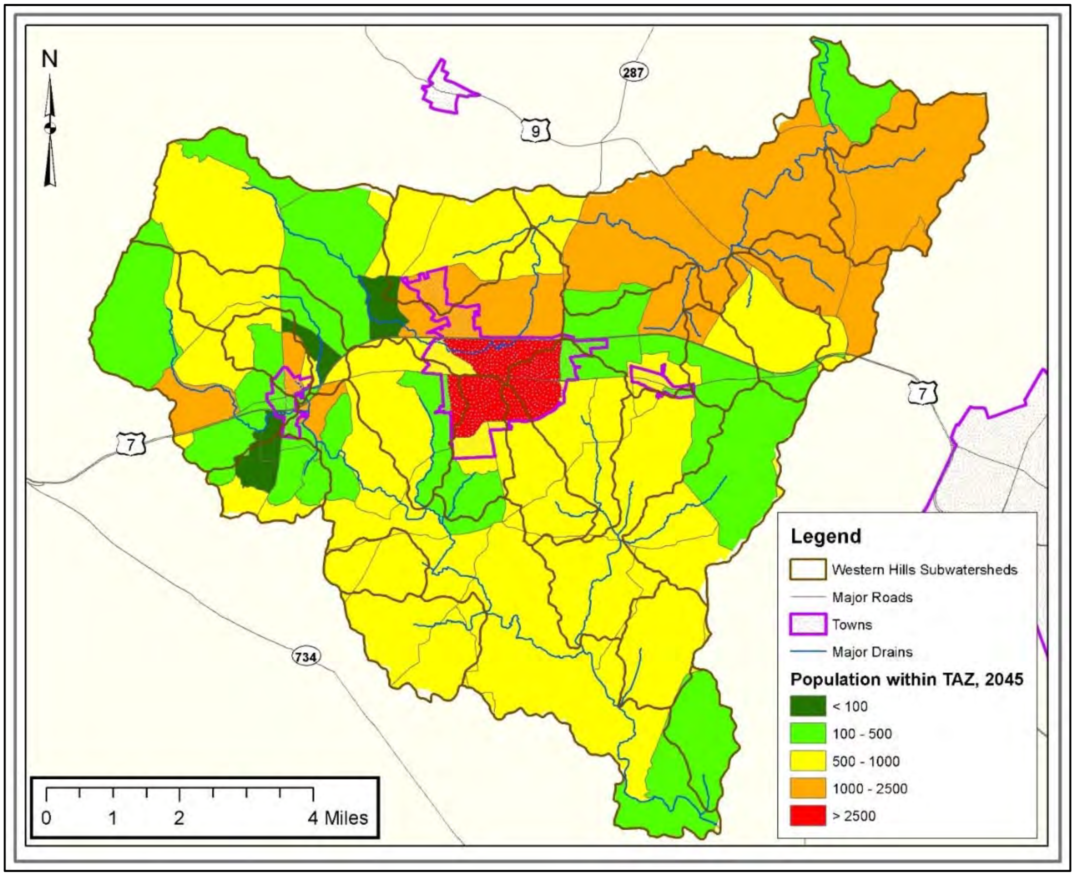


**Figure 3-13: Western Hills Watershed Projected Population 2045**

### 3.2.4 Future Growth

The population and construction development in the Western Hills Watershed is anticipated to increase over time. The population projections were developed by Metropolitan Washington Council of Government (MWCOG, see Loudoun County 2018b). For Western Hills, population estimates and projections for 2015 and 2045 are shown in Table 3-10. Between 2015 and 2045, the number of persons living in Western Hills Watershed is projected to increase by 8,450 which is a 34 percent increase.

**Table 3-10: Western Hills Watershed Summary Table of Projected Population**

| Year | Population | |
|---|---|---|
| **2015** | 24,593 | |
| **2045** | 33,043 | |
| **Increase** | 8,450 | Persons |
| **Increase** | 34.4 | Percent |

### 3.2.5 Potential Residential Buildout

Using the projected residential buildout on a parcel basis, statistics for the watershed were evaluated. The projections are developed by the Loudoun County Department of Planning & Zoning (Loudoun County 2018a), which refers to this as the Existing and Potential Development (EPD) map. The map can be used for land use, capital facilities, and transportation planning purposes as well as fiscal, demographic, and market analysis per https://www.loudoun.gov/3905/Existing-Potential-Development-Tool-EPD. The analysis is based on information from:

- Existing use of structures
- Existing use of parcels
- Location and existing number of housing units within residential projects that are completed and approved (not started or partially built)
- The remaining residential development potential of vacant or under-developed parcels and approved projects (not started or partially built)
- Location of completed and approved non-residential projects

The data reflect land use conditions as of July 1, 2017. Tabular data were geoprocessed and categorized with the 23 subwatersheds for existing residential housing units (Figure 3-14), residential housing units remaining to be constructed (Figure 3-15) and the percent of land that could be developed (Figure 3-16).

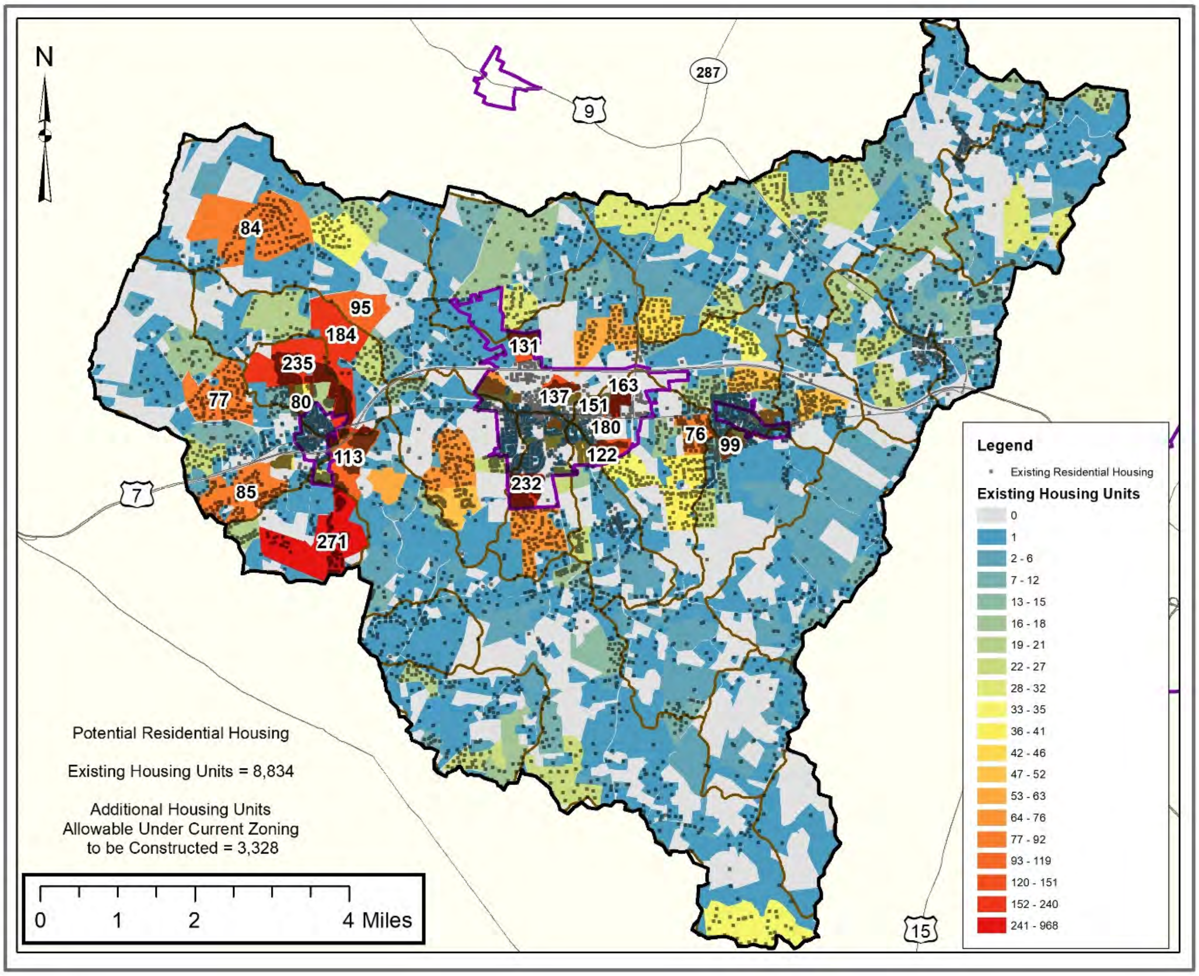


**Figure 3-14: Western Hills Watershed Existing Residential Housing Units**

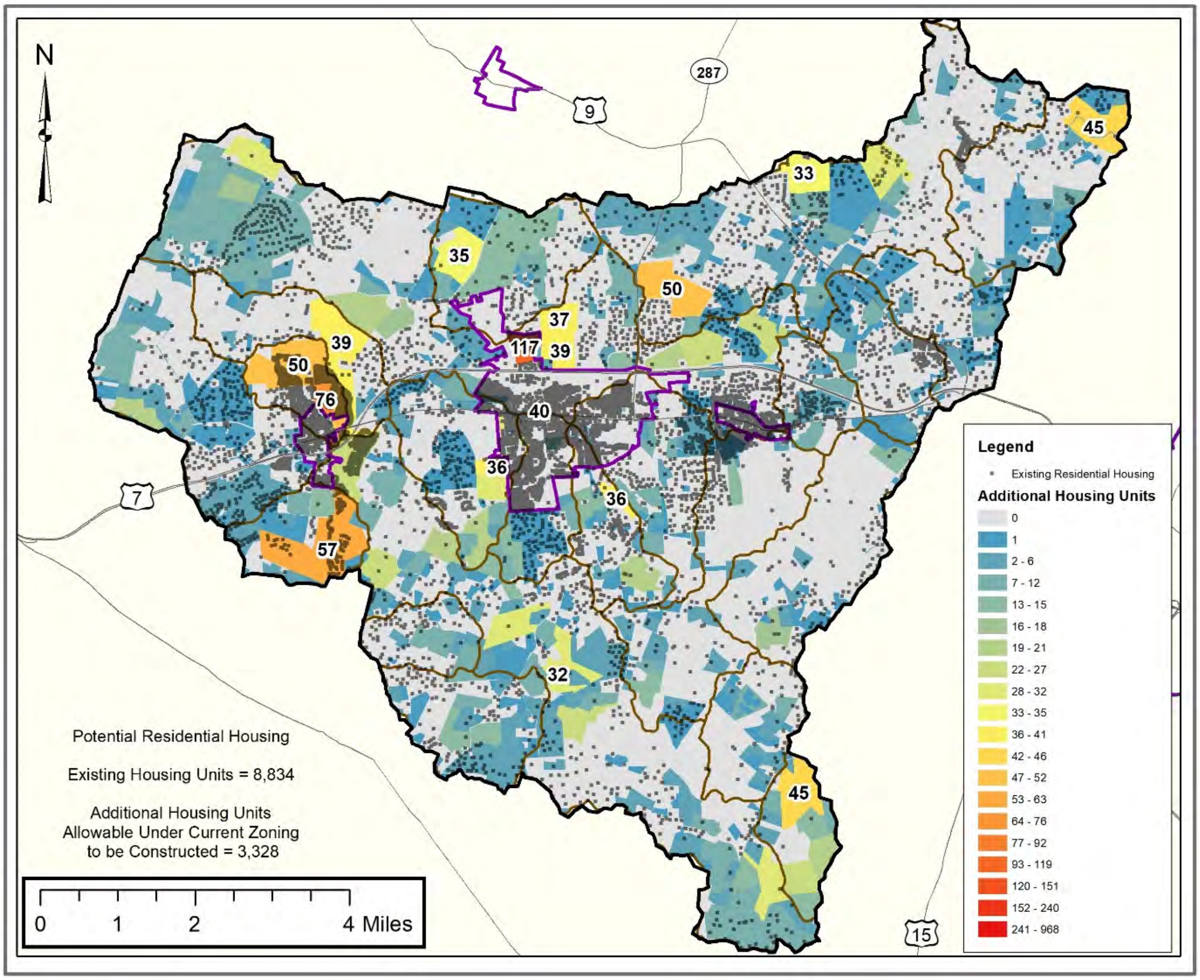


**Figure 3-15: Western Hill Watershed Potential Residential Housing Units Remaining to be Constructed**

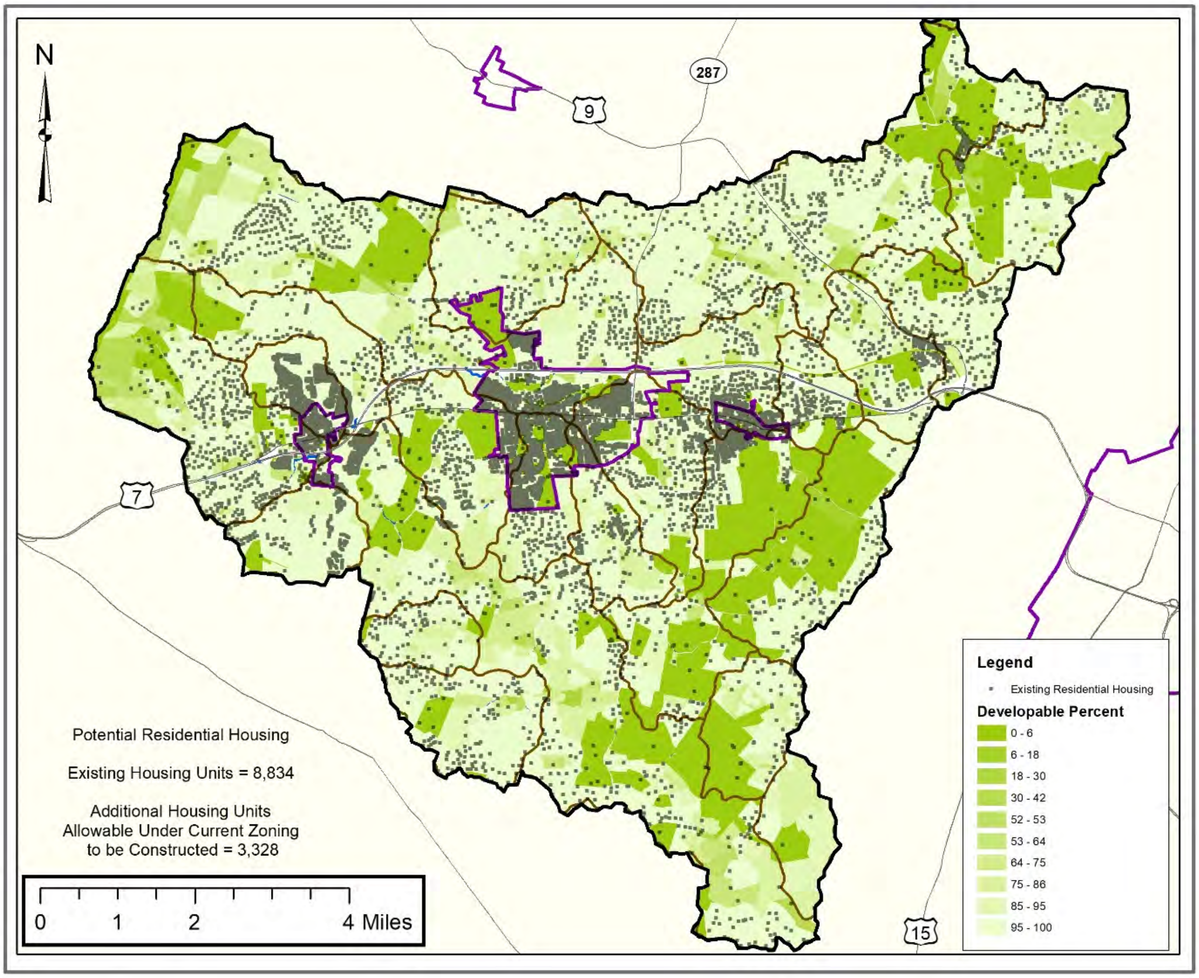


**Figure 3-16: Western Hill Watershed Potential Developable Land**

The current number of residential housing units is 8,834 and the potential number of future units at current zoning is 12,162 which is a 37.7 percent increase. Across the 23 subwatersheds, there are an estimated 3,328 additional housing units which could be constructed (Table 3-11). The average percent developable is the percent of land upon which constructions is possible. Assumptions for developable exclude the following environmentally constrained areas of a parcel: steep slopes, major and minor floodplain, mountainside overlay district highly sensitive areas, LDN 65 noise contour, conservation easements, and karst/sensitive environmental feature setback areas. The assumptions for developable also exclude the following ownership and used based criteria: Public owned parcels, HOA parcels, Cemetery parcels, Significant road covered parcels (40 percent and more coverage), and MWAA owned parcels. Further details are available in the Data Dictionary (https://www.loudoun.gov/DocumentCenter/View/123607/Land-Development-GIS-Layers-and-EPD-Tool---Data-Dictionary?bidId=).

**Table 3-11: Western Hills Watershed Summary of Residential Potential Buildout**

| Subwatershed | Existing Housing Units | Units to be Constructed | Total Units at Buildout | Average Percent Developable |
|---|---|---|---|---|
| CROOKED RUN | 347 | 98 | 445 | 81.2 |
| JACKS RUN | 443 | 196 | 638 | 94.0 |
| LOWER SOUTH FORK CATOCTIN | 565 | 269 | 835 | 70.2 |
| NORTH FORK GOOSE CREEK | 584 | 490 | 1,073 | 80.4 |
| SIMPSONS CREEK | 487 | 159 | 646 | 76.4 |
| TRIB 1 TO CROOKED RUN | 961 | 134 | 1,095 | 88.6 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 9 | 140 | 149 | 75.2 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 172 | 111 | 283 | 63.6 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 314 | 132 | 446 | 93.6 |
| TRIB 2 TO CROOKED RUN | 130 | 74 | 204 | 84.0 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 49 | 59 | 108 | 82.0 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 155 | 51 | 206 | 89.7 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 154 | 99 | 253 | 91.9 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 222 | 57 | 279 | 91.7 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 79 | 48 | 127 | 93.6 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 563 | 98 | 661 | 91.2 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 142 | 44 | 186 | 86.2 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 832 | 86 | 918 | 92.7 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 132 | 106 | 237 | 86.2 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 527 | 138 | 666 | 95.8 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 283 | 60 | 343 | 86.7 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 318 | 114 | 432 | 92.5 |
| UPPER SOUTH FORK CATOCTIN CREEK | 1,367 | 567 | 1,933 | 83.9 |
| TOTAL | 8,834 | 3,328 | 12,162 | 85.4 |

### 3.2.6 Impervious Surfaces

Various studies have shown a correlation between the amount of impervious surface within a watershed and declines in stream quality (e.g., Giddings et al. 2009; Schueler et al. 2009). Impervious surfaces, including roads, parking areas, roofs, and other paved surfaces, prevent precipitation from naturally infiltrating the ground. This prohibits the natural filtration of pollutants and conveys concentrated, accelerated stormwater runoff directly to the stream system. Consequently, stormwater runoff from impervious surfaces can cause stream erosion and habitat degradation from the high energy flow. Furthermore, such runoff is likely more polluted than runoff generated from pervious areas. Undeveloped watersheds with small amounts of impervious cover are more likely to have better water quality in local streams than urbanized watersheds with greater amounts of impervious cover.

Percent impervious cover is the most commonly used single measure of urban impacts to streams. Schueler (2008) defines the following general categories, in this latest version of the Impervious Cover Model (Figure 3-17):

- Sensitive Streams: 2 – 10 percent impervious cover
- Impacted Streams: 10 – 24 percent
- Damaged (Non-Supporting) Streams: 25 – 59 percent
- Severely Damaged (Urban Drainage) Streams: 60 percent or more

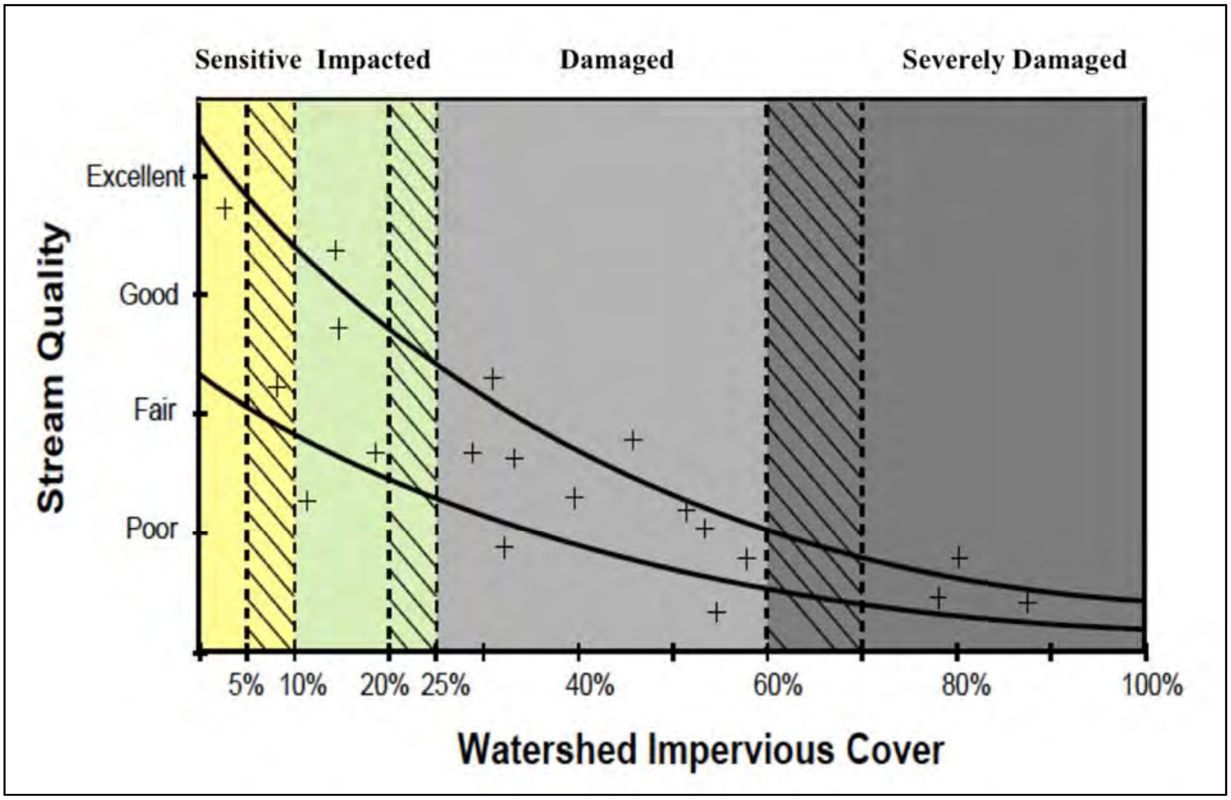


**Figure 3-17: Impervious Cover Model (adapted from Schueler et al. 2009)**

The impervious cover model also designates transitions between these four categories, e.g., 5 to 10 percent impervious cover for the transition from sensitive to impacted, and 20 to 25 percent impervious cover for the transition from impacted to non-supporting.

Studies used to develop the Impervious Cover Model measured stream quality based on a variety of indicators such as the number of aquatic insect species, stream temperature, channel stability, aquatic habitat, wetland plant density, and fish communities. Based on the research compiled, the model describes four general categories to classify and predict stream quality in terms of impervious cover. Watersheds with less than 10 percent impervious cover are referred to as sensitive and typically have high quality streams with stable channels, good habitat conditions, and good to high water quality; sensitive watersheds are susceptible to environmental degradation with urbanization and increases in impervious cover. Between 10 and 25 percent impervious cover, watersheds tend to become impacted and typically show clear signs of degradation such as erosion, channel widening, and a decline in stream habitat quality. There is a possibility to restore streams to a somewhat natural functioning system within this category. When a watershed has more than 25 percent impervious cover, streams are classified as damaged or non-supporting. These streams are characterized by fair to poor water quality, unstable channels, severe erosion, and inability to support aquatic life and provide habitat; many streams in this category are typically piped or channelized. When impervious cover exceeds 60 percent, a watershed is classified as severely damaged or urban drainage, meaning that many of the natural stream features are gone. Management of damaged and severely damaged streams may focus on decreasing pollutant loads to downstream receiving waters (e.g., installing stormwater controls) but the ability to restore natural functions, such as habitat, is unlikely. Restoration efforts may also focus on making the remaining stream systems stable, aesthetically pleasing, and an amenity to the community.

It should be noted that although it is based on research, the impervious cover model is a simplified approach for classifying the quality of urban streams. While impervious cover is a relevant and significant indicator of watershed condition, it is only one of many different factors affecting stream health and contributing to the cumulative impacts of development on water quality. For example, current and historical agricultural land uses contribute sediment and nutrient loads to receiving waters depending on management practices. Also, the ability of Stormwater Control Measures (SCMs) to offset adverse impacts from urbanized areas is not specifically accounted for in this model.

Loudoun County's impervious cover GIS data layer was used to derive impervious cover within the Western Hills Watershed (Figure 3-18). Table 3-12 provides a summary of the area of buildings, recreational courts, driveways, parking lots, roads, pools, ruins or construction in progress, sidewalks or paved trails, and percent impervious area for each subwatershed and the entire watershed. Overall, impervious cover represents about 6 percent of the watershed. Subwatershed impervious cover estimates and ratings according to the impervious cover model are shown in Figure 3-19. Currently, 20 subwatersheds are classified as sensitive (0-10 percent impervious cover) and three are classified as impacted (10-25 percent impervious). TRIBUTARY 5 TO NORTH FORK GOOSE CREEK, TRIBUTARY 6 TO NORTH FORK GOOSE CREEK, and TRIBUTARY 1 TO CROOKED RUN watersheds have the greatest percent impervious area, at 14.5 percent, 13.1 percent, and 12.9 percent, respectively.

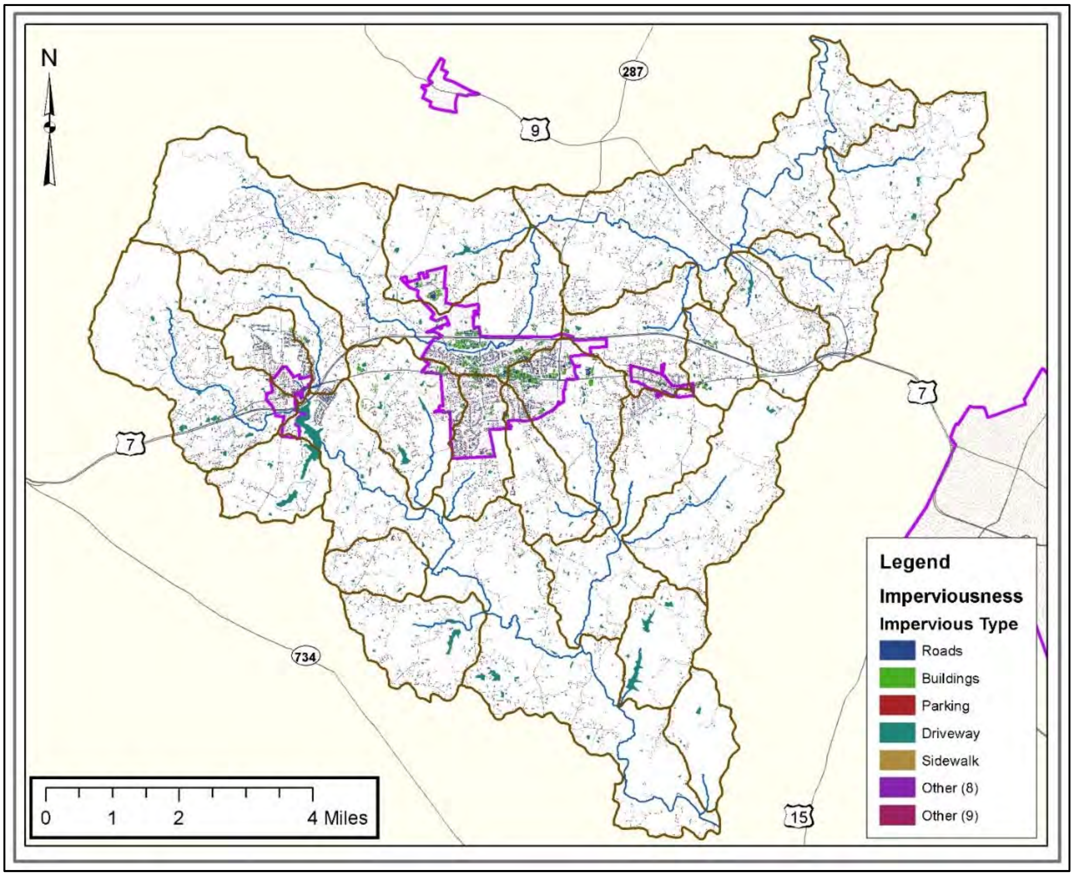


**Figure 3-18: Western Hills Watershed Impervious Types**

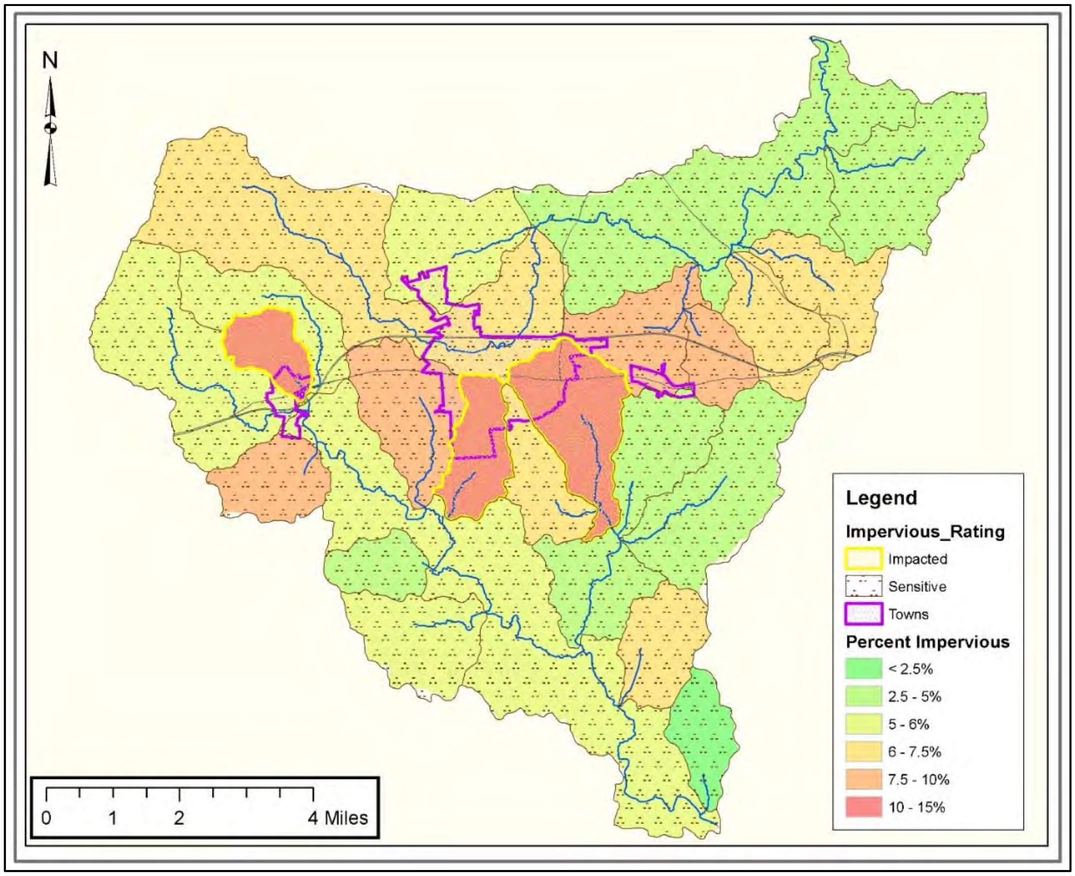


**Figure 3-19: Western Hills Watershed Impervious Rating and Percentage by Subwatershed**

**Table 3-12: Western Hills Watershed Impervious Cover Area (Acres)**

| Subwatershed | Roads | Buildings | Parking | Driveways | Sidewalks | Total Acres | Percent | Rating |
|---|---|---|---|---|---|---|---|---|
| CROOKED RUN | 70 | 1 | 24 | 12 | 0 | 108 | 4.0 | Sensitive |
| JACKS RUN | 74 | 21 | 29 | 34 | 13 | 170 | 9.8 | Sensitive |
| LOWER SOUTH FORK CATOCTIN | 173 | 6 | 75 | 32 | 0 | 287 | 5.0 | Sensitive |
| NORTH FORK GOOSE CREEK | 182 | 4 | 60 | 116 | 4 | 366 | 5.4 | Sensitive |
| SIMPSONS CREEK | 102 | 7 | 45 | 32 | 5 | 191 | 5.9 | Sensitive |
| TRIB 1 TO CROOKED RUN | 132 | 48 | 35 | 10 | 10 | 236 | 12.9 | Impacted |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 4 | 0 | 2 | 5 | 0 | 12 | 1.3 | Sensitive |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 40 | 1 | 26 | 11 | 0 | 78 | 3.3 | Sensitive |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 45 | 4 | 17 | 4 | 2 | 71 | 6.7 | Sensitive |
| TRIB 2 TO CROOKED RUN | 37 | 0 | 17 | 15 | 0 | 70 | 2.8 | Sensitive |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 13 | 0 | 9 | 53 | 0 | 75 | 6.4 | Sensitive |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 52 | 4 | 22 | 4 | 1 | 84 | 6.0 | Sensitive |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 32 | 0 | 19 | 29 | 0 | 80 | 5.2 | Sensitive |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 51 | 4 | 24 | 14 | 2 | 97 | 7.5 | Sensitive |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 18 | 0 | 10 | 5 | 0 | 34 | 4.5 | Sensitive |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 83 | 9 | 32 | 6 | 5 | 137 | 9.3 | Sensitive |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 35 | 11 | 12 | 5 | 2 | 67 | 8.7 | Sensitive |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 97 | 13 | 30 | 5 | 8 | 153 | 14.5 | Impacted |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 46 | 12 | 18 | 24 | 3 | 102 | 5.4 | Sensitive |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 69 | 3 | 19 | 2 | 4 | 98 | 13.1 | Impacted |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 50 | 3 | 15 | 9 | 2 | 80 | 5.7 | Sensitive |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 28 | 0 | 7 | 55 | 1 | 91 | 8.4 | Sensitive |
| UPPER SOUTH FORK CATOCTIN CREEK | 223 | 67 | 66 | 27 | 9 | 394 | 6.4 | Sensitive |
| TOTAL | 1,656 | 220 | 611 | 509 | 72 | 3,082 | 6.2 | Sensitive |

### 3.2.7 Stormwater

Stormwater is water generated by rainfall and snow melt events. Precipitation and snow melt that does not seep into the ground becomes stormwater runoff and flows into stormwater control facilities or directly to receiving water bodies. The amount and characteristics of stormwater runoff is affected by rainfall amount and intensity, soil properties, slope, and land use/land cover. Concerns associated with stormwater include water quantity (the rate and volume of runoff) as well as water quality.

Stormwater runoff can carry nutrients, sediment, and various contaminants depending on land use characteristics and human activities. Pollutants deposited on impervious surfaces from daily human activities are often carried by stormwater to stream systems. For example, common constituents in urban runoff include sediment, metals, bacteria, nutrients, and petroleum. Pollutants such as these build up over time from various sources such as maintenance activities (de-icing, roadside fertilizer use), vehicles (exhaust, leaks), and accidents/spills, and are washed off during storm events. Rural runoff also includes sediment, bacteria, nutrients, and other pollutants, including fertilizers and pesticides applied to lawns and agricultural fields.

#### 3.2.7.1 Stormwater Management Facilities

There are many types of Stormwater Control Measures (SCMs) available for managing stormwater runoff and providing stormwater quality treatment. Stormwater management can target specific objectives depending on the SCM type such as stormwater quality, soil erosion control, and stormwater flow control. In addition, different SCM facilities have different pollutant removal capabilities. For example, basic dry pond designs for stormwater management typically have low pollutant removal efficiency compared to practices that filter the stormwater or allow it to infiltrate into the ground or through plant roots. Several considerations are taken into account when selecting appropriate stormwater treatment measures such as space requirements, maintenance, cost, and community acceptance.

As of July 1, 2014, Loudoun County became established as a VA Stormwater Management Program (VSMP) Authority, as required by the Virginia Stormwater Management Act and the attendant regulations. Local regulations were adopted in Chapter 1096 of the Loudoun County Codified Ordinances and Chapter 5 of the Facilities Standards Manual (FSM). (https://www.loudoun.gov/3287/VA-Stormwater-Management-Program-VSMP)

Table 3-13 provides a summary of the different SCM facilities located within the Western Hills Watershed including dry and wet ponds, bioretention, level spreaders, and other types.

**Table 3-13: Summary of Existing Stormwater Management Facilities in Western Hills Watershed, by Type**

| Type | Count |
|---|---|
| Dry Pond | 57 |
| Wet Pond | 34 |
| Bioretention | 14 |
| Level Spreader | 5 |
| Commercial | 3 |
| Other | 4 |

The distribution of SCM facilities throughout the watershed is illustrated in Figure 3-20. Dry ponds and wet ponds are the most common types of SCMs within the watershed, both in number and in treatment area. The dry pond facilities represent the best opportunity for conversion to SCMs with higher pollutant removal capabilities. TRIB 1 TO NORTH FORK GOOSE CREEK is the only subwatershed that does not contain any SCMs. This is due to the fact that this subwatershed's land use/land cover is mostly cropland, pasture, and forest.

The total area treated by SCM by subwatershed is summarized in Table 3-14. This table shows that approximately 13 percent of the watershed is treated by SCMs. There may be opportunities to implement additional stormwater in existing developed areas where no practices are currently in place or to convert existing facilities to provide additional treatment before stormwater reaches the stream system.

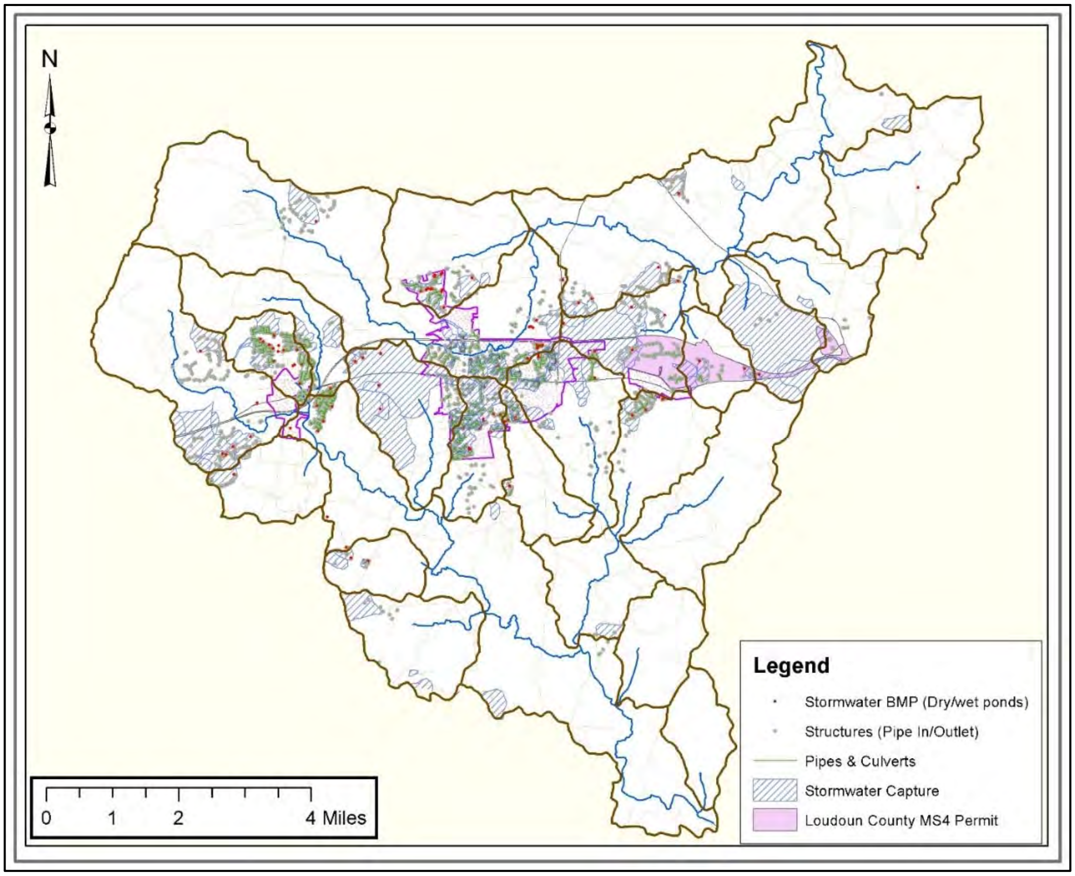


**Figure 3-20: Western Hills Watershed Stormwater Management Facilities**

**Table 3-14: Western Hills Watershed Area Treated by Stormwater Management Facilities**

| Subwatershed | Total of Stormwater Drainage Areas (Acres) | Watershed Area (Acres) | Percent |
|---|---|---|---|
| CROOKED RUN | 120.2 | 2,692.6 | 4.5 |
| JACKS RUN | 1,081.1 | 1,734.5 | 62.3 |
| LOWER SOUTH FORK CATOCTIN | 333.8 | 5,769.9 | 5.8 |
| NORTH FORK GOOSE CREEK | 152.6 | 6,715.8 | 2.3 |
| SIMPSONS CREEK | 599.9 | 3,213.5 | 18.7 |
| TRIB 1 TO CROOKED RUN | 353.2 | 1,830.9 | 19.3 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | 0.0 | 870.9 | 0.0 |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | 5.8 | 2,347.9 | 0.2 |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | 81.2 | 1,054.4 | 7.7 |
| TRIB 2 TO CROOKED RUN | 14.5 | 2,524.6 | 0.6 |
| TRIB 2 TO NORTH FORK GOOSE CREEK | 2.1 | 1,183.1 | 0.2 |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | 66.0 | 1,388.3 | 4.8 |
| TRIB 3 TO NORTH FORK GOOSE CREEK | 167.9 | 1,540.2 | 10.9 |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | 1,089.1 | 1,301.2 | 83.7 |
| TRIB 4 TO NORTH FORK GOOSE CREEK | 62.6 | 749.9 | 8.4 |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 651.2 | 1,469.0 | 44.3 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 99.4 | 769.4 | 12.9 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 348.5 | 1,059.0 | 32.9 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 162.4 | 1,909.2 | 8.5 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 202.5 | 745.2 | 27.2 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 162.6 | 1,416.1 | 11.5 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 72.6 | 1,083.5 | 6.7 |
| UPPER SOUTH FORK CATOCTIN CREEK | 383.7 | 6,188.8 | 6.2 |
| TOTAL | 6,212.7 | 49,557.6 | 12.5 |

### 3.2.8 Drinking Water and Wastewater

Most of the drinking water in the Western Hills Watershed is provided from groundwater through both the town water supplies and individual groundwater wells (Figure 3-21).

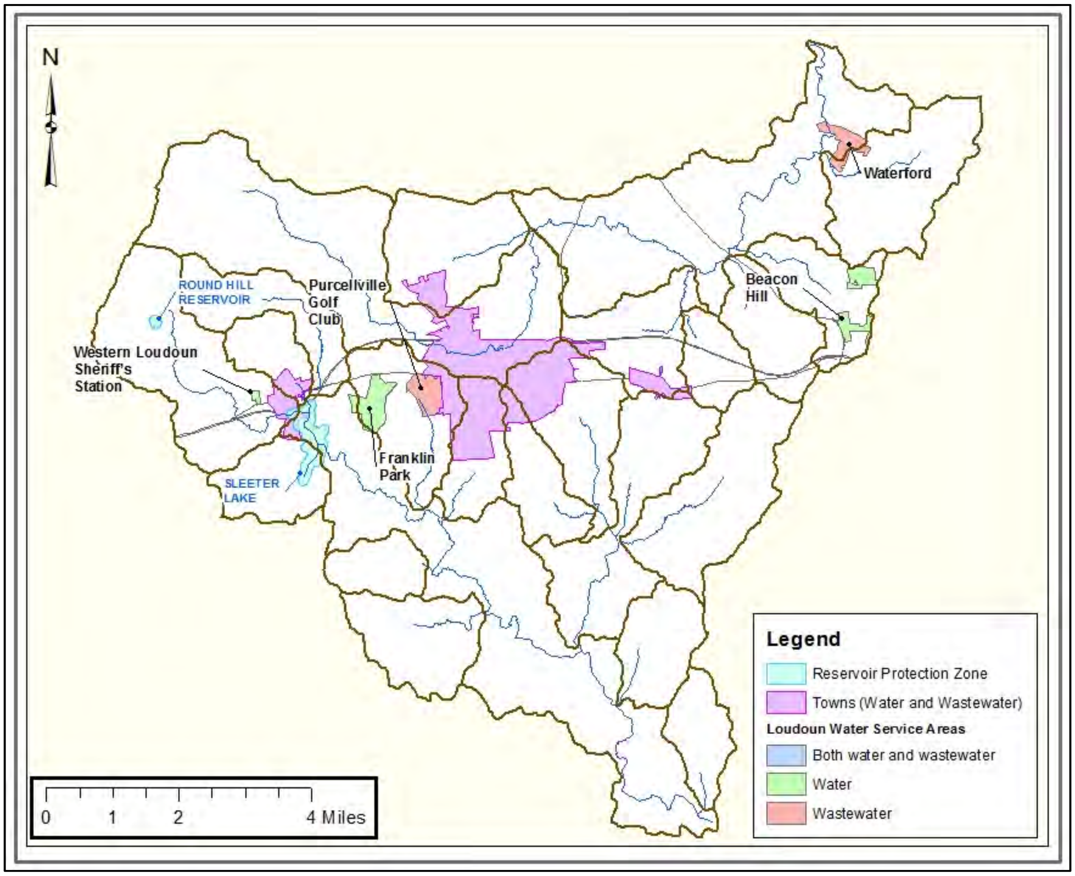


**Figure 3-21: Western Hills Watershed Water Supplies**

### 3.2.9 VPDES Discharge Permits

Virginia facilities that discharge municipal or industrial wastewater or conduct activities that can contribute pollutants to a waterway are required to obtain a Virginia Pollutant Discharge Elimination System (VPDES) permit. As of January 2018, there are several facilities within the Western Hills Watershed that have a VPDES individual and general permits (Figure 3-22). There are individual permits for the town wastewater discharge facilities. Each of these VPDES general permits are for facilities that possess a domestic sewage treatment system with a design flow of less than or equal to 1,000 gallons per day on a monthly average basis, also known as a Single-Family Home general permit.

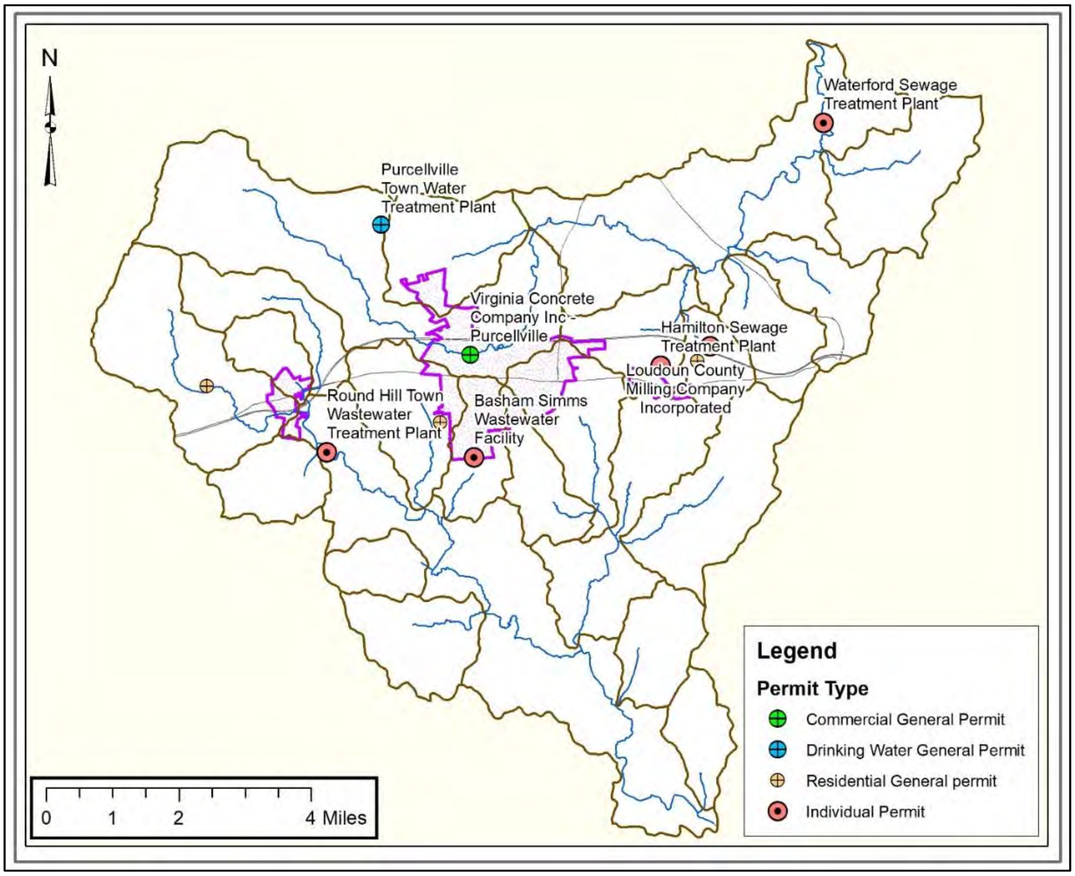


**Figure 3-22: Western Hills Watershed VPDES Discharge Permits**

Virginia Department of Environmental Quality (DEQ) maintains a list of petroleum tanks and releases. There are currently 40 petroleum tanks registered within the Western Hills Watershed, and 164 documented petroleum releases were recorded between 1980 and 2017. The location of the registered petroleum tanks and documented releases is illustrated in Figure 3-23.

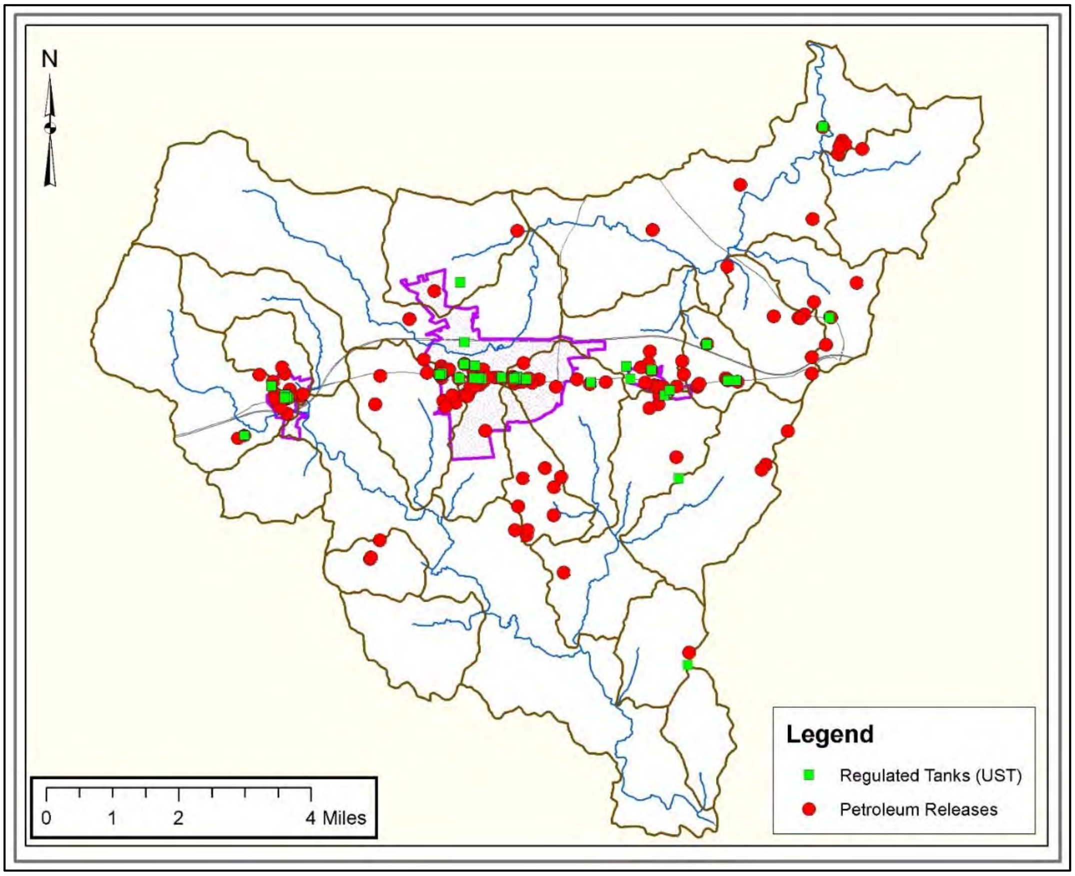


**Figure 3-23: Western Hills Watershed Petroleum Tank and Releases. Regulated Tanks Refers to Underground Storage Tanks (UST)**

### 3.2.10 Zoning

The current zoning for the Western Hills Watershed is shown in Figure 3-24. Table 3-15 provides the zoning category name for each of the abbreviations. As shown in the figure, a variety of zoning categories are represented in the watershed, with Agricultural Rural-1 ("AR-1") being the dominant category.

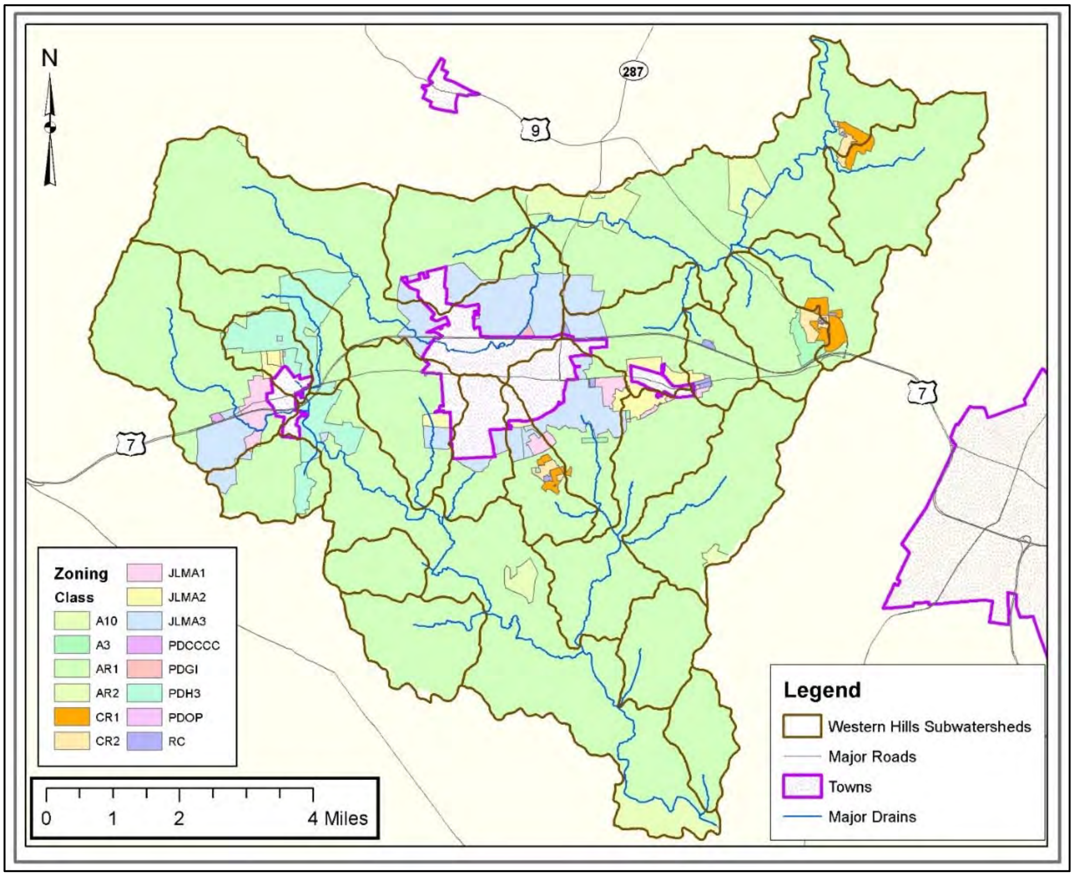


**Figure 3-24: Western Hills Watershed Zoning**

The key zoning classes present in Western Hills Watershed range from agricultural (A), to Commercial (C) to Planned (P) as listed in Table 3-15.

**Table 3-15: Western Hills Watershed Zoning Class Definition**

| Code | Definition |
|---|---|
| A10 | Agriculture: Agriculture and low density residential development with a maximum density of one unit per 10 acres. Cluster and hamlet options. |
| A3 | Agricultural/Residential: Agriculture and low density residential development with a maximum density of one unit per 3 acres with a predominantly agricultural character. Cluster and hamlet options. |
| AR1 | Agricultural Rural - 1: Rural business and residential uses: 1.0 du per 20-acres/; 1.0 du per 10 clustered |
| AR2 | Agricultural Rural - 2: Rural business and residential uses: 1.0 du per 40-acres/; 1.0 du per 20 clustered |
| CR1 | Countryside Residential-1: Residential development with a maximum density of 1 unit per acre. Not served by public water and sewer. Cluster and hamlet options. |
| CR2 | Countryside Residential-2: Residential development with a maximum density of 2 units per acre. Not served by public water and sewer. Cluster option with public water and/or sewer. |
| JLMA1 | Joint Land Management Area-1: Residential uses, cluster and traditional town subdivision design; 1.0 du/40,000 sq. ft. |
| JLMA2 | Joint Land Management Area-2: Residential uses, cluster and traditional town subdivision design; 1.0 du/20,000 sq. ft. |
| JLMA3 | Joint Land Management Area-3: Residential uses, cluster and traditional town subdivision design; 1.0 du per 3 acres |
| PDCCCC | Planned Development-Commercial Center (Community Center): Serves retail shopping needs of surrounding community. Minimum of 6 acres, max of 20 acres. |
| PDGI | Planned Development-General Industrial: Medium intensity industrial uses with public nuisance potential. |
| PDH3 | Planned Development Housing-3: Mixed use residential communities including single family and multifamily housing. Maximum residential density of 3 units per acre. |
| PDOP | Planned Development-Office Park: Office park established primarily for administrative, business, and professional offices designed in a parklike environment. |
| RC | Rural Commercial: Commercial properties predominantly located in rural Loudoun. Uses are compatible with scale and character of existing villages. Minimum lot size of 10,000 square feet. |
| TOWNS | Incorporated Towns: Districts zoned by the incorporated town and administered by the town. |

## 3.3 Surface Water Quality Monitoring

Surface water quality monitoring includes assessment of biological conditions, stream habitat and chemicals (analytes) in the water. There are numerous surface water quality sampling stations throughout the county maintained through Virginia DEQ, Loudoun Watershed Watch citizen scientist volunteers (Loudoun Wildlife Conservancy and Goose Creek Association), Loudoun Water, Natural Resources Conservation Service (NRCS) and the Metropolitan Washington Council of Governments. Countywide monitoring data are summarized by Loudoun County (2019a).

### 3.3.1 Biological Monitoring

Virginia DEQ staff conducts statewide biological monitoring at fixed (permanent), targeted, and probabilistic (randomly selected) stations each year (Figure 3-25). Benthic macroinvertebrate samples are collected from fixed stations to represent communities found in natural stream reaches with no to minimal impairments. Virginia Stream Condition Index (VSCI) scores for benthic macroinvertebrate samples collected from the targeted and probabilistic stations are compared to those collected at the fixed stations. Where sufficient data are available, stream segments with low VSCI scores are placed on the 303(d) list of impaired waters as not supporting aquatic life use. In Virginia DEQ's Draft 2018 305(b)/303(d) Water Quality Assessment Integrated Report (DEQ 2018), three segments within Western Hills Watershed are listed as impaired based on benthic macroinvertebrate data. See Section 3.4.1 for information on these aquatic life use impairments.

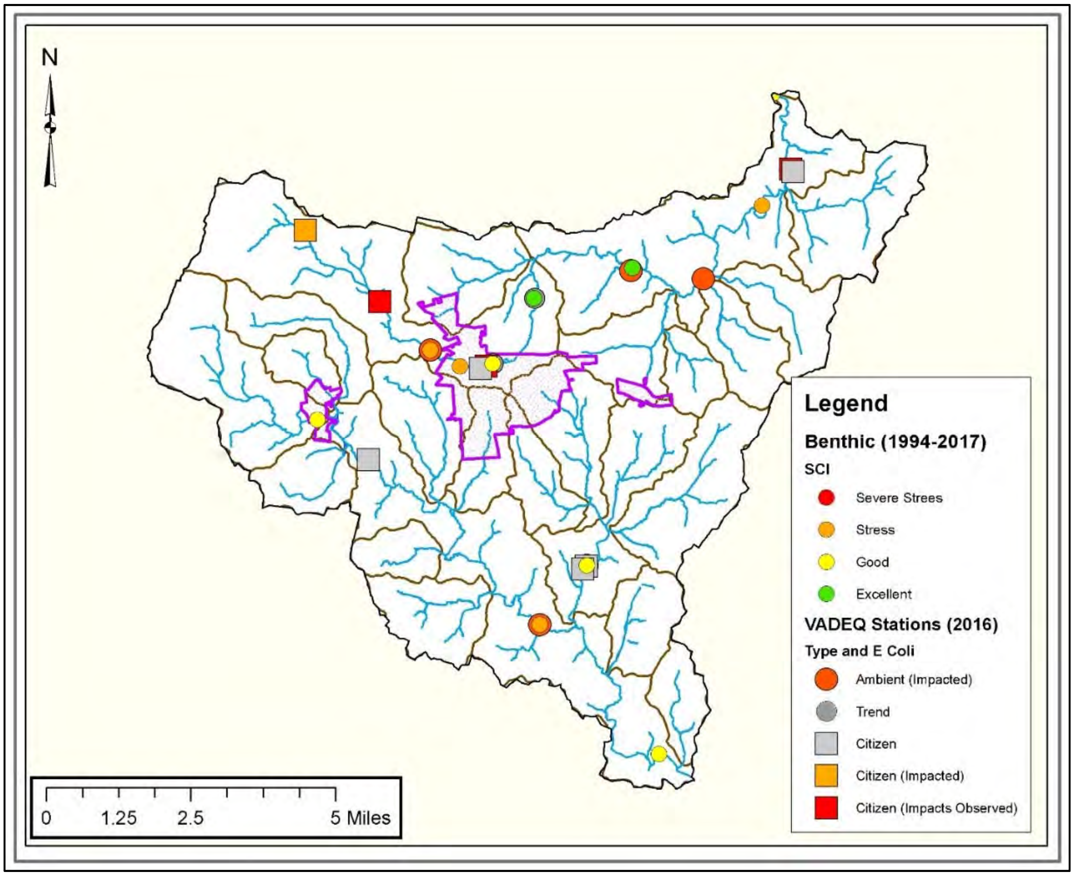


**Figure 3-25: Western Hills Watershed Virginia DEQ Water Quality Monitoring**

In addition to statewide biological sampling, Loudoun County conducted a countywide stream assessment in 2009. The countywide assessment resulted in the collection of benthic macroinvertebrate samples from a total of 200 sites; 177 randomly selected sites and 23 of Virginia DEQ's pre-existing sites. Of the 200 countywide samples collected in 2009, 32 were collected within the Western Hills Watershed (Figure 3-26). VSCI scores at the 32 benthic macroinvertebrate sites spanned a range that included all the assessment categories (Excellent, Good, Stress, and Severe Stress). Figure 3-26 shows ratings for individual sites and mean scores by subwatershed.

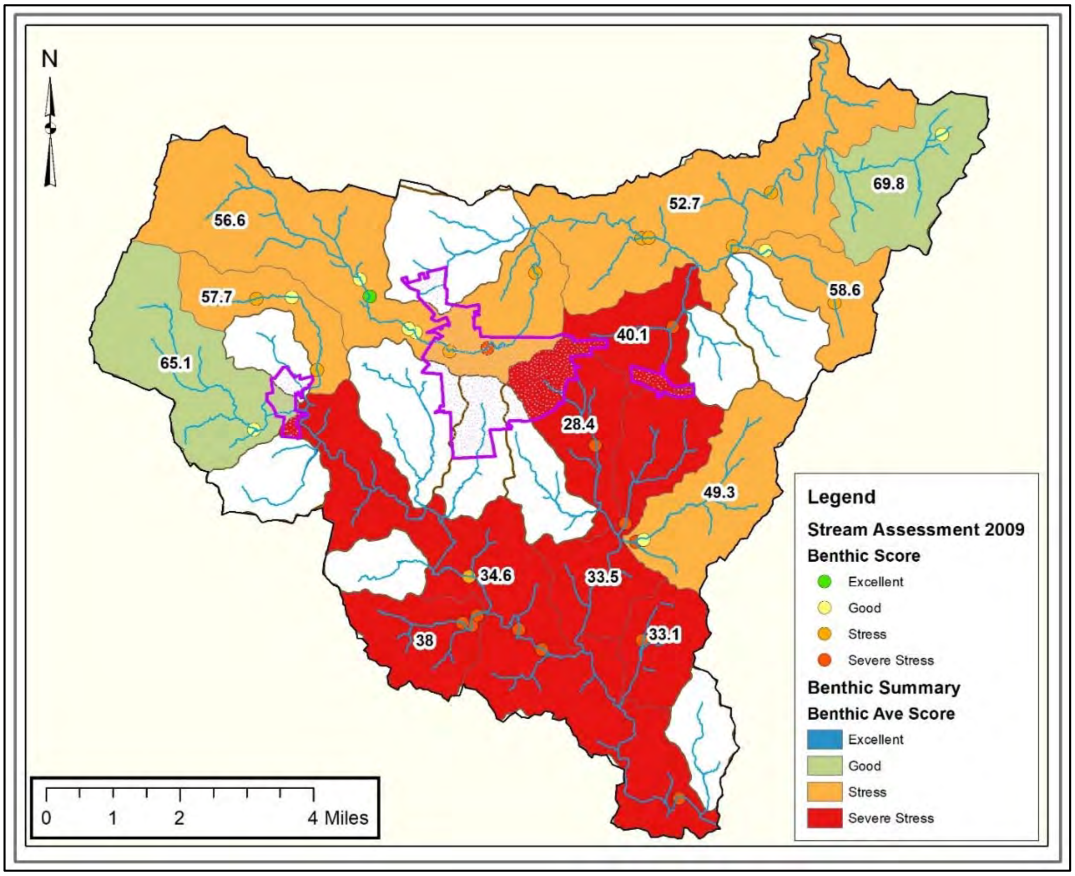


**Figure 3-26: Western Hills Watershed 2009 Benthic Assessment Results**

There were seven monitoring stations in the 2003 Goose Creek Source Water Protection program (Loudoun County Sanitation Authority 2003) as shown in Figure 3-27. The aquatic life habitat conditions ranged from good to poor.

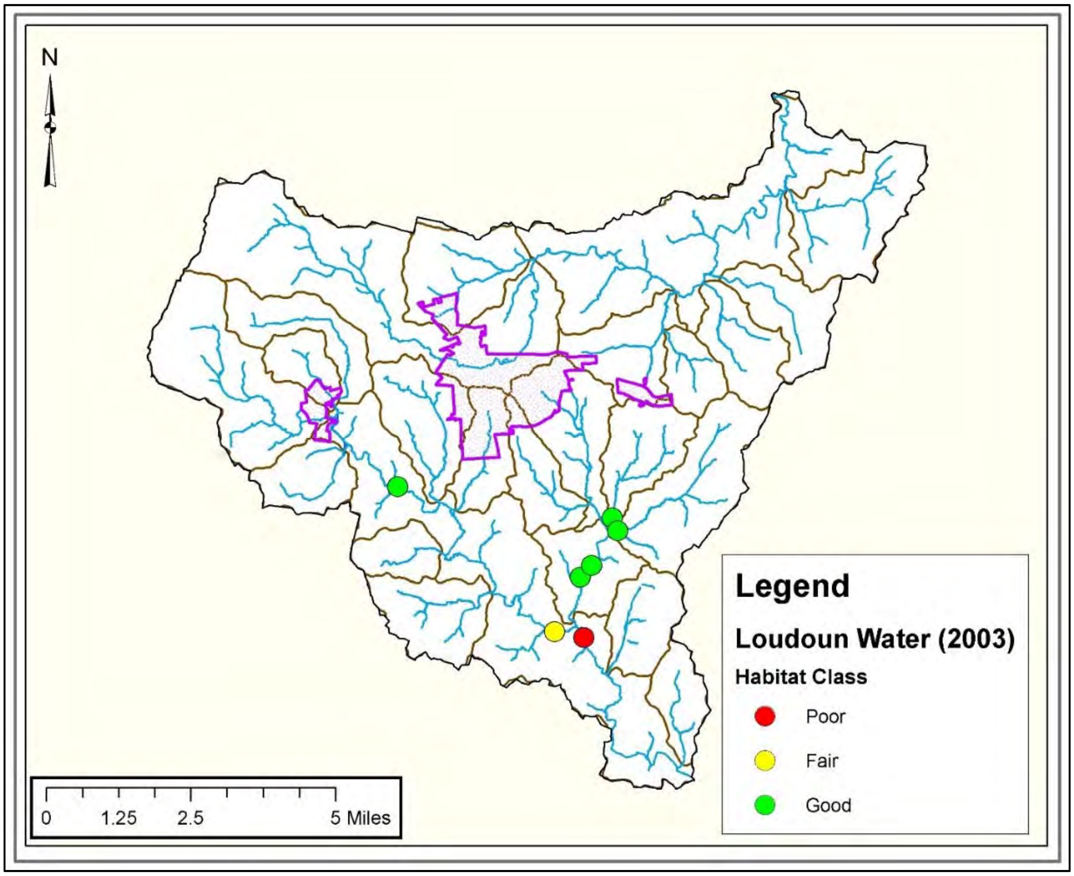


**Figure 3-27: Western Hills Watershed Loudoun Water Aquatic Life Monitoring Stations**

The Metropolitan Washington Council of Governments (MWCOG 2006) previously monitored seven monitoring stations in the early 2000s in which stream benthic conditions ranged in quality from fair to good (Figure 3-28).

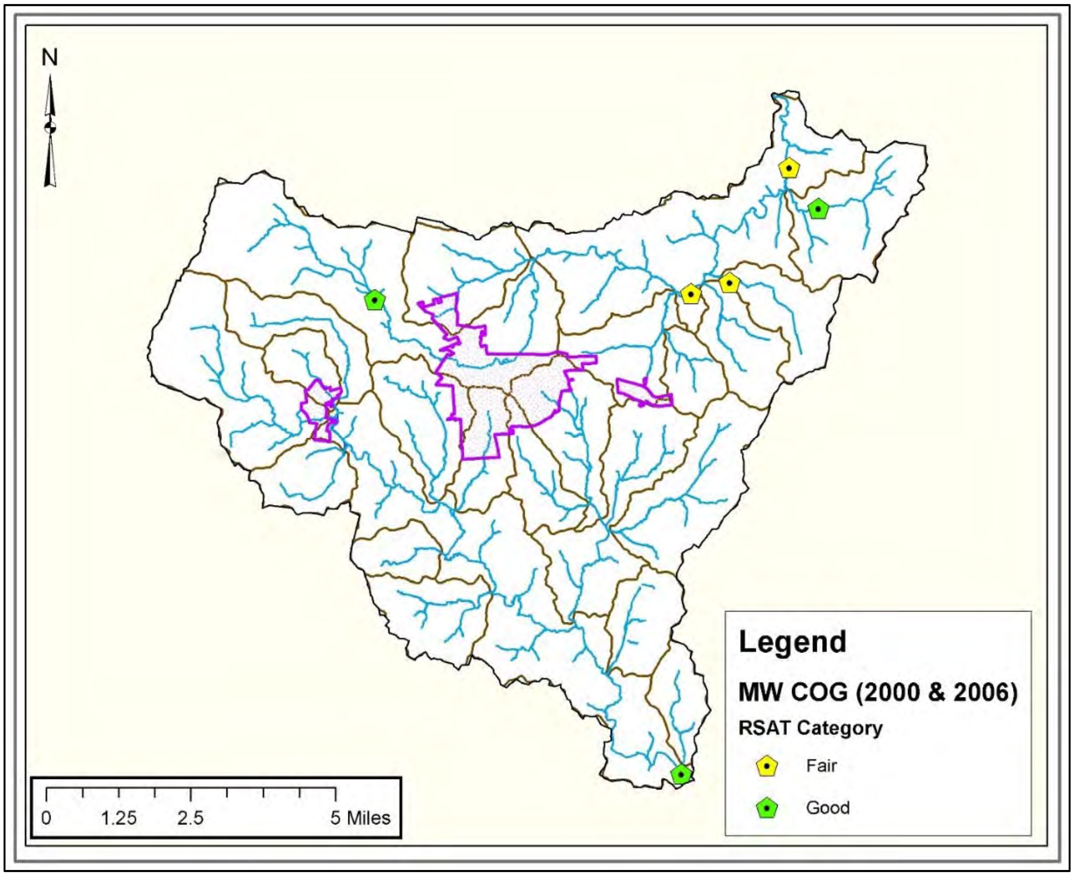


**Figure 3-28: Western Hills Watershed MWCOG Surface Water Monitoring Stations**

The Natural Resources Conservation Service (NRCS 2005) conducted fish surveys in the Goose Creek Watershed and found biological conditions ranging from very poor to fair (Figure 3-29).

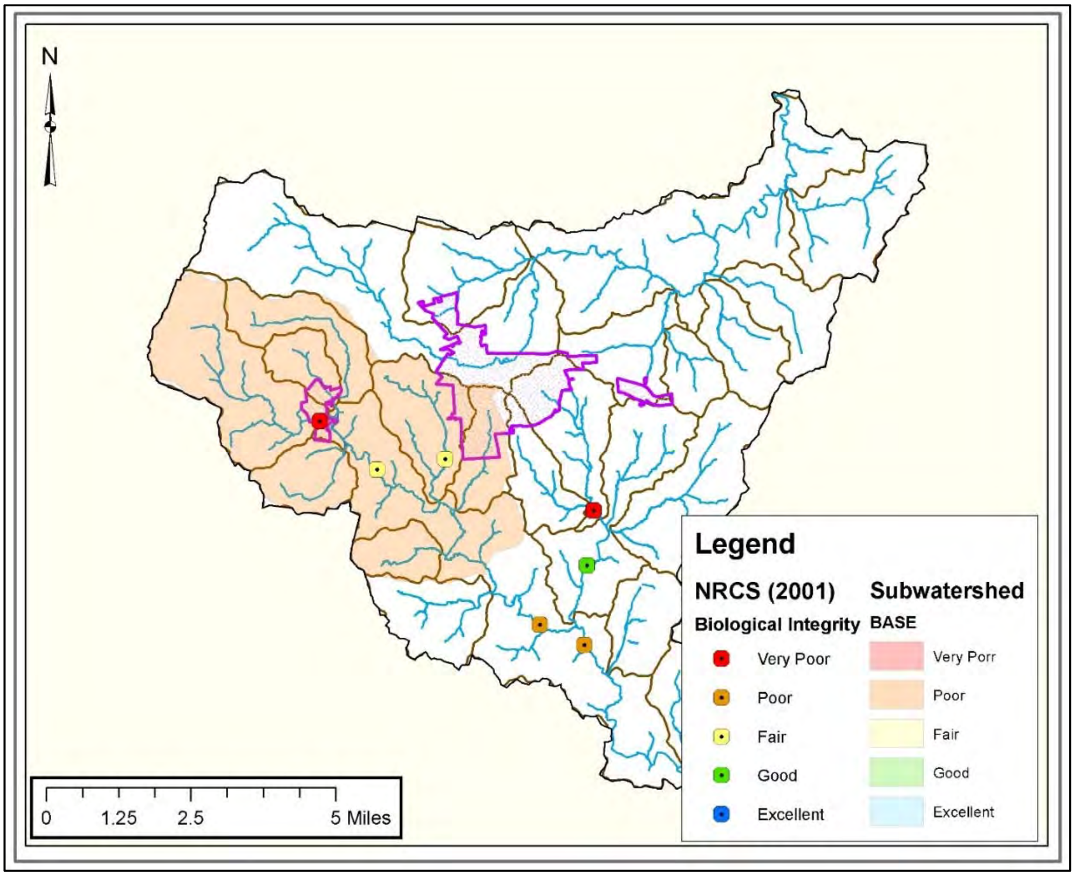


**Figure 3-29: Western Hills Watershed Biological Monitoring by Natural Resources Conservation Service (NRCS)**

### 3.3.2 Chemical Monitoring

Surface water quality stations maintained by Virginia DEQ include ambient monitoring and program-specific stations, including Chesapeake Bay Program stations. In addition, Virginia DEQ provides funding for further monitoring to citizen and non-agency groups through their Citizen Monitoring Grant Program. Sampled stream segments that have water quality parameter concentrations that exceed applicable water quality standards are placed on the 303(d) list of impaired water bodies.

There are 15 Virginia DEQ surface water monitoring stations located within the Western Hills Watershed that have either currently or previously been used to collect surface water quality samples. Of these 15 stations, 6 are collocated at citizen monitoring stations and 3 are ambient monitoring stations.

### 3.3.3 Illicit Discharge Monitoring at MS4 Stormwater Outfalls

Loudoun County is required to develop, implement, and enforce a program to detect and eliminate illicit discharges into its regulated municipal separate storm sewer system (MS4). As part of this program, each year Loudoun County screens a portion of the over 1,000 originally-defined outfalls that discharge within its MS4 permit area. These outfalls are predominantly outside of the Western Hills Watershed. (https://www.loudoun.gov/DocumentCenter/View/466/Annual-Report)

## 3.4 Stream Impairments

Section 303(d) of the Federal Clean Water Act requires states to develop (and periodically update) a list of impaired waters that fail to meet applicable state water quality standards associated with waterbodies' designated uses. States must also establish priority rankings and develop Total Maximum Daily Loads (TMDLs) for waters on the 303(d) list. According to EPA, a TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet state water quality standards. Virginia Department of Environmental Quality is responsible for development of TMDL reports (https://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment.aspx) TMDLs can be developed for a single pollutant or group of pollutants of concern, which generally include sediment, metals, bacteria, nutrients, and pesticides. The Western Hills Watershed includes segments that have been listed as impaired in the Virginia 303(d) list of impaired waters for the following causes: Aquatic Life Use (benthic macroinvertebrate) impairment and Recreational/Swimming Use (bacteria) impairment. These impairments are established through water quality assessments conducted by Virginia Department of Environmental Quality (https://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments.aspx)

While there are currently no local nutrient or sediment TMDLs for the Western Hills Watershed, the entire watershed is subject to the Chesapeake Bay TMDL for nutrients and sediment. EPA established the Chesapeake Bay TMDL in 2010, a historic and comprehensive "pollution diet" with rigorous accountability measures to initiate sweeping actions to restore clean water in the Chesapeake Bay and the region's streams, creeks, and rivers. Concurrent with the development of the Bay TMDL, EPA charged the Bay watershed states and the District of Columbia with developing watershed implementation plans (WIPs) to provide adequate "reasonable assurance" that the jurisdictions can and will achieve the nutrient and sediment reductions necessary to implement the TMDL within their respective boundaries. Virginia's Phase I WIP established an overall strategy to address Bay TMDL goals. In 2012, the Phase II WIP included local involvement in developing strategies to help meet statewide pollutant reduction targets. More recently, Virginia has made progress in drafting its Phase III WIP, which is expected to be approved during summer 2019.

### 3.4.1 Aquatic Life Use Impairment

Virginia DEQ regularly collects benthic macroinvertebrate data at stream sites statewide. Where sufficient data are available indicating an impairment to the benthic community, they are used to make a determination that stream segments do not meet the appropriate aquatic life use water quality standard. Virginia DEQ's Draft 2018 Integrated 305(b)/303(d) report (DEQ 2018) identifies the following three benthic impairments in the Western Hills Watershed:

- South Fork Catoctin Creek, 6.33 miles
- North Fork Goose Creek, 4.69 miles
- Jacks Run, 3.18 miles

Virginia DEQ is preparing a TMDL report and implementation plan for the benthic macroinvertebrate impairment in North Fork Catoctin Creek in 2019. (https://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLDevelopment/DocumentationforSelectTMDLs.aspx#NFCC)

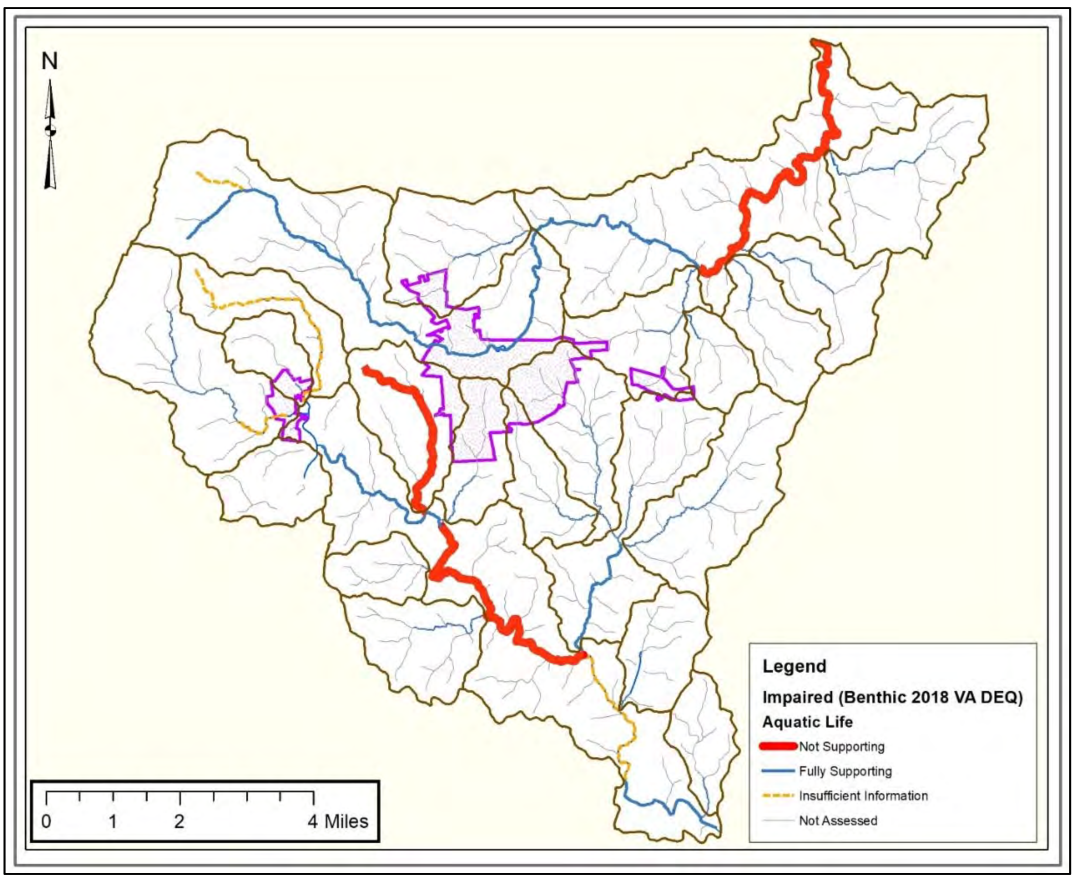


**Figure 3-30: Western Hills Watershed Benthic (Aquatic Life) Impairments**

### 3.4.2 Recreational/Swimming Use Impairment

Virginia DEQ regularly collects data on bacteria (*E. coli*) at stream sites statewide. When sufficient data are available indicating elevated bacteria, they are used to make a determination that stream segments do not meet the appropriate recreational/ swimming use water quality standards. Virginia DEQ's 2018 Integrated 305(b)/303(d) report (DEQ 2018) identifies the following four bacteria impairments in the Western Hills Watershed:

- South Fork Catoctin Creek, 18.49 miles total (4 individual segments of 6.33, 3.23, 3.59, and 5.34 miles)
- North Fork Goose Creek, 7.65 miles total (2 individual segments of 4.69 and 2.96 miles)
- Crooked Run, 2.16 miles
- Jack's Run, 3.18 miles

Figure 3-31 shows the location of the bacteria impairments within the Western Hills Watershed.

A bacteria TMDL for Catoctin Creek (including South Fork Catoctin Creek) was approved in 2004 and a TMDL Implementation plan has been completed and approved for Catoctin Creek (January 2005). The three areas of North Fork Goose Creek are covered by prior TMDLs approved in the early 2000s. A TMDL implementation plan has been completed and approved for Goose Creek (April 2018). The TMDL implementation plans are referenced by DEQ at https://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/TMDL/TMDLImplementation/TMDLImplementationPlans.aspx. The status of TMDLs for these impaired segments is documented in the fact sheets for impaired waters accompanying the 2018 Integrated Report at:

https://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterQualityAssessments/IntegratedReport/2018/ir18_Appendix5_Category4or5_FactSheets_Detailed-PotShen.pdf.

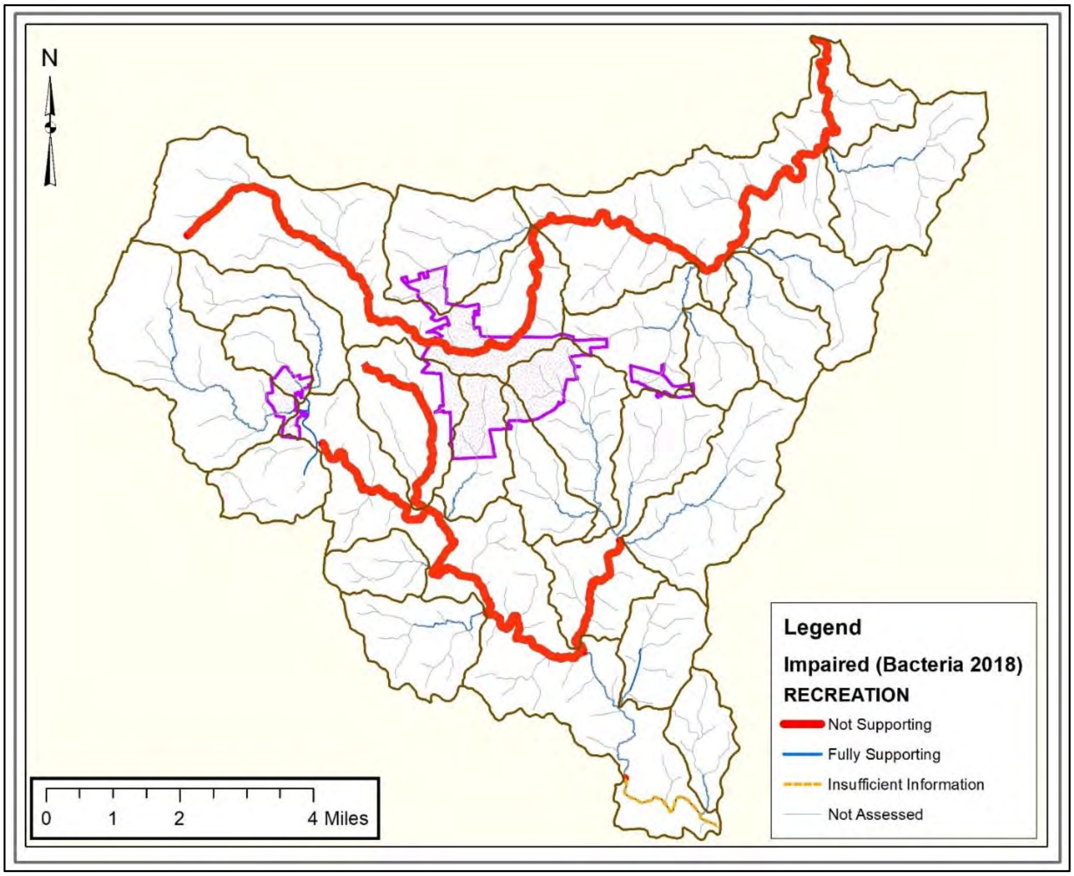


**Figure 3-31: Western Hills Watershed Bacteria (Recreational Use) Impairments**

## 3.5 Water Supply

The primary water supply in the Western Hills Watershed is groundwater. Wells are used by the towns in their drinking water systems and by several thousand private residential wells. There is one reservoir which augments drinking water for the Town of Purcellville, the J. T. Hirst Reservoir.

## 3.6 Groundwater Wells

The abundance of groundwater wells serving the population of Western Hills Watershed make groundwater a key topic for consideration in watershed management planning. This section provides an overview of background information on groundwater wells in the watershed. Further details and analyses of groundwater quantity and quality in Western Hills Watershed are found in Chapter 5 of this report.

The majority of wells in Western Hills Watershed are for drinking water. There are a small number of wells for geothermal heating, typically as a closed system. There are a few wells used for irrigation. The withdrawal rates generally fall below the requirements for a submission of a hydrostudy to Loudoun County or reporting withdrawal amounts to Virginia DEQ. The County requires a hydrostudy for proposed agricultural developments potentially withdrawing more than one million (1,000,000) gallons during any 30-day period (Facilities Standards Manual, Section 6.240). Virginia requires withdrawal amount reporting for crop production (including, but not limited to nurseries and sod farms) where withdrawals exceed one million (1,000,000) gallons in a single month or all other purposes (including, but not limited to, livestock production, mining operations, public water supplies, manufacturing, power production, and golf courses) where withdrawals exceed 10,000 gallons per day. Most of the irrigation wells in Loudoun County are associated with golf courses. There are also a few permitted surface water withdrawals for golf courses.

### 3.6.1 Residential Water Wells

There are approximately 5,557 residential wells as shown in Figure 3-32. The highest density of wells is in the lower subwatershed of North Fork Catoctin Creek. Additionally, there are 66 community wells and springs.

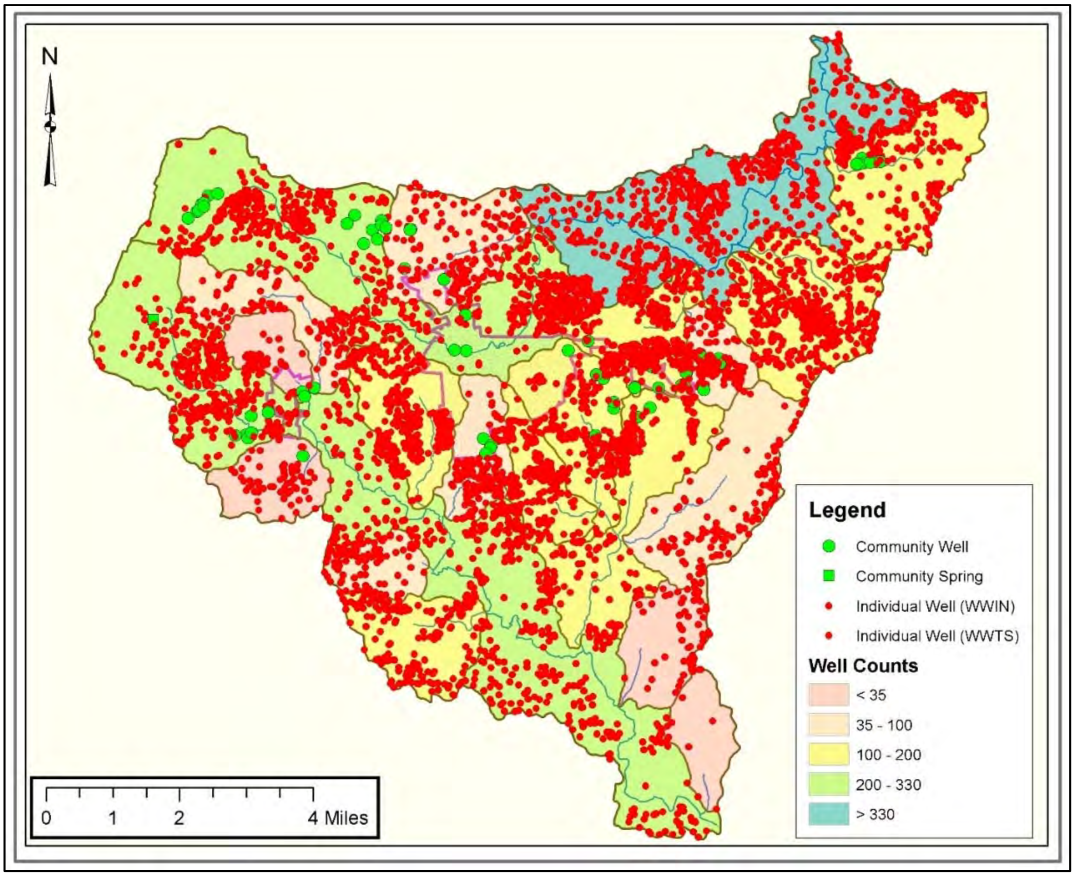


**Figure 3-32: Western Hills Watershed Residential Water Wells**

Based on the year in which a well was constructed, the percentage of wells drilled in Western Hills relative to the entire county has averaged 27.5% annually with a standard deviation of 10%. This suggests that distribution of residential development inside and outside of the watershed has remained relatively constant over time. In Figure 3-33 there were greater number of wells drilled in the late 1980's and early 2000's. The "Percent" as shown is the number of wells within Western Hills Watershed relative to the total number of wells drilled in Loudoun County for any given year.

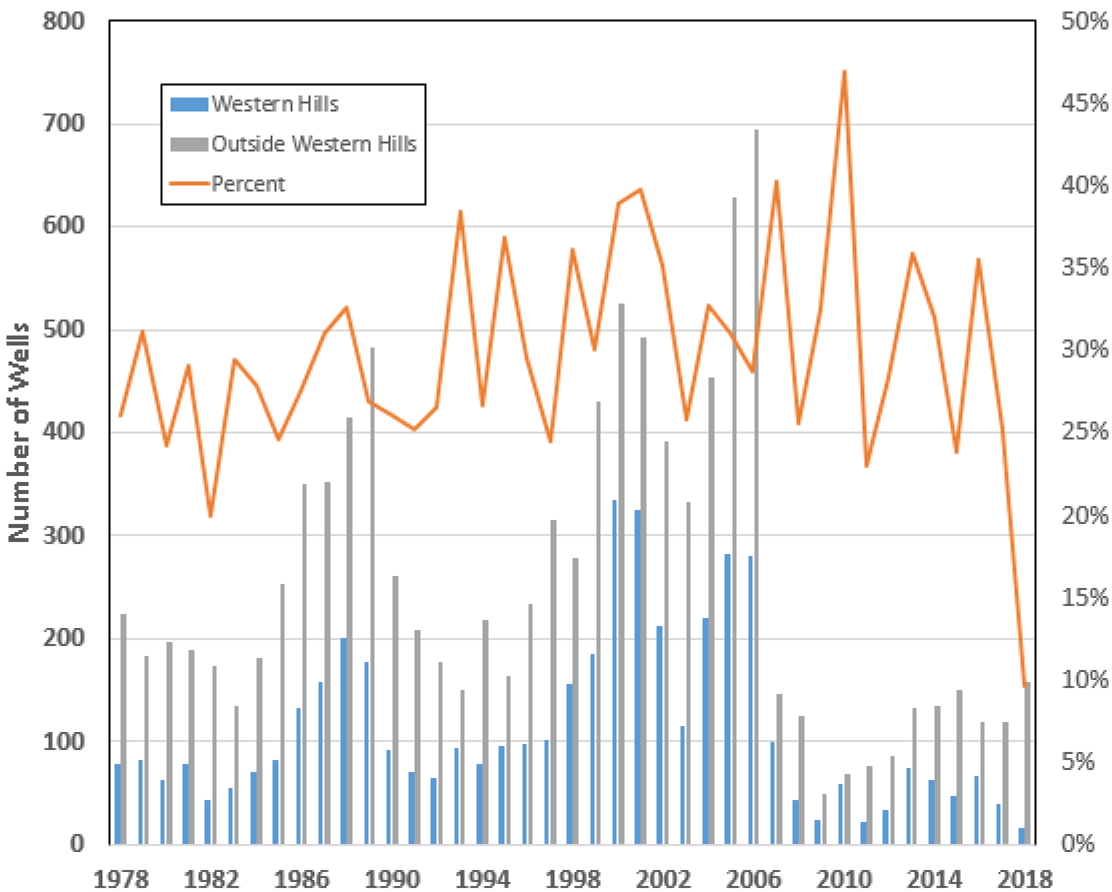


**Figure 3-33: Western Hills Watershed Annual Water Well Construction**

#### 3.6.1.1 Residential Well Yield

The residential wells are testing at the time of completion and an air-lift yield is reported. This is an estimate provided by the well driller and is not a true well test, but does provide a reasonable measure of the well capacity. Values are aggregated by subwatershed and results suggest higher field primarily along the higher-order stream subwatersheds (Figure 3-34).

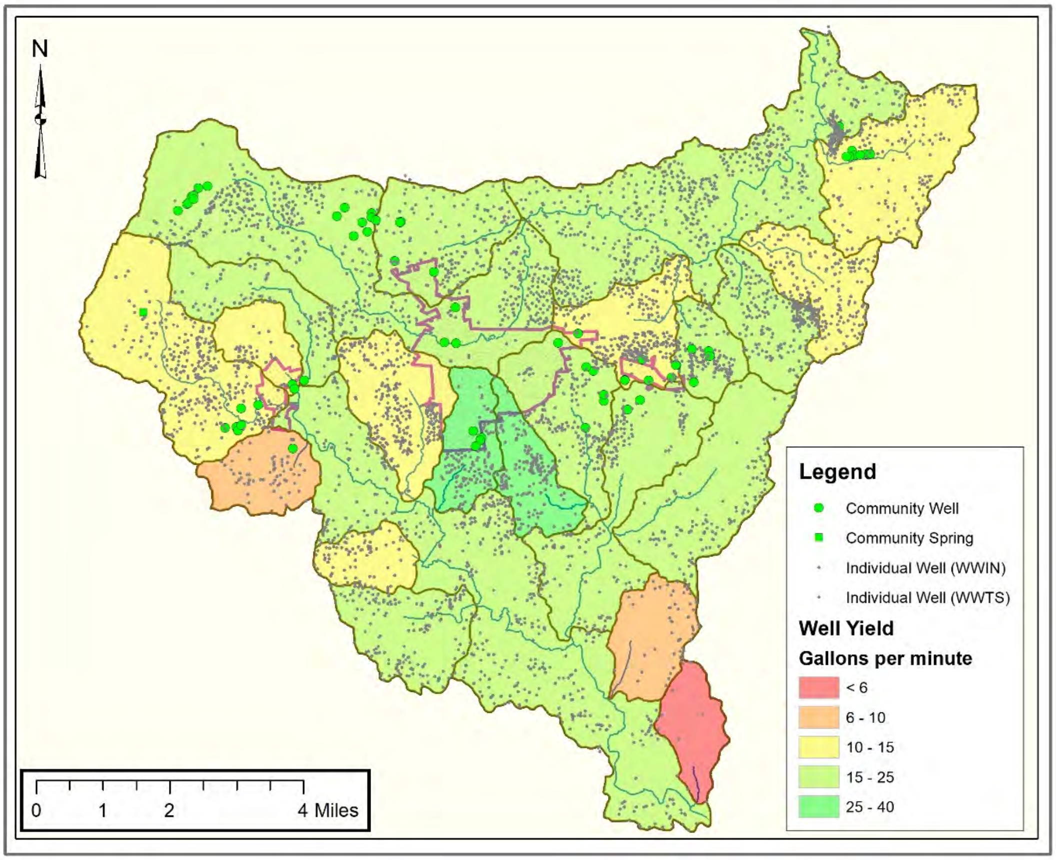


**Figure 3-34: Western Hills Watershed Residential Well Yield**

The yield values range from zero to over 500 gallons per minute (GPM) with mid-range values often between 10 to 20 GPM (Figure 3-35). Note however, that non-zero values are available for only 48 percent of the wells. For each well yield bin, the percentage in Western Hills Watershed relative to the County is relatively uniform for the midrange of wells.

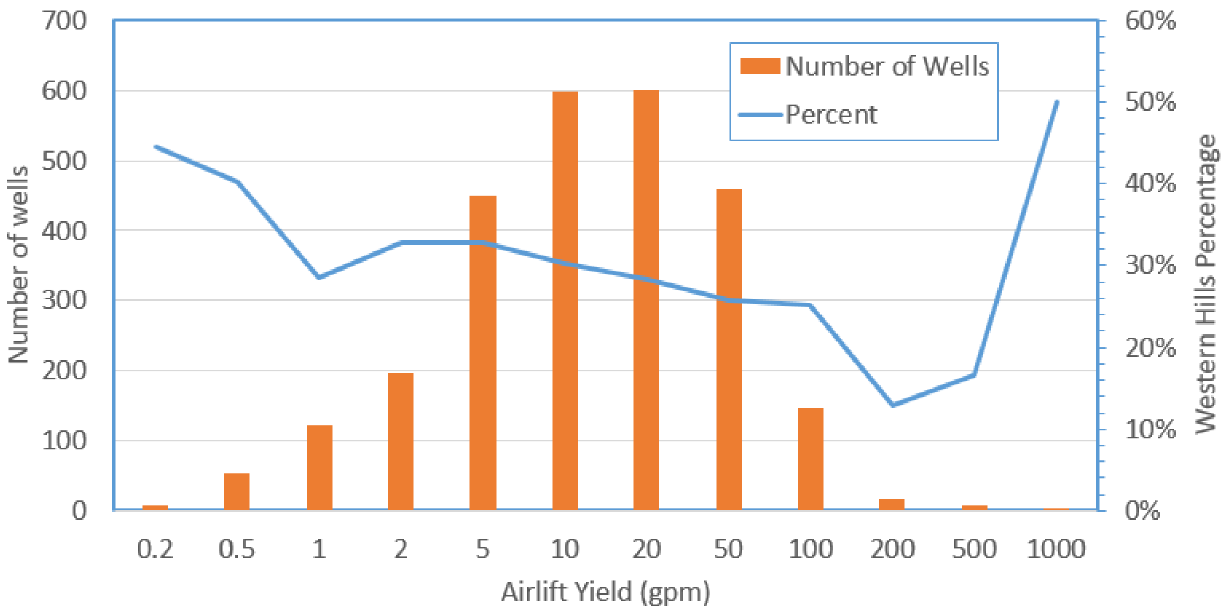


**Figure 3-35: Western Hills Watershed Residential Well Yield Distribution**

### 3.6.1.2 Residential Well Depth

The median depth of wells drilled in Loudoun County has increased from 150 feet during 1960 to 1970 to 420 feet since 2000 (Figure 3-36). The increase in drilling depth has been possible because of advances in drilling technology, allowing wells to be drilled cheaper, quicker, and deeper to provide increased water storage. Additionally, over time, increased lot restrictions have encouraged continued drilling as the same location. In the Western Hills Watershed the deepest wells are generally associated with higher elevation perimeter subwatersheds. The well depths tend to be more shallow in the interior subwatersheds along higher-order streams. Typical depths are 300 to 600 feet (Figure 3-37). For each well depth bin, the percentage in Western Hills Watershed relative to the County is relatively uniform for the midrange of wells.

Additional information on well depth and yields are presented in Section 5.5

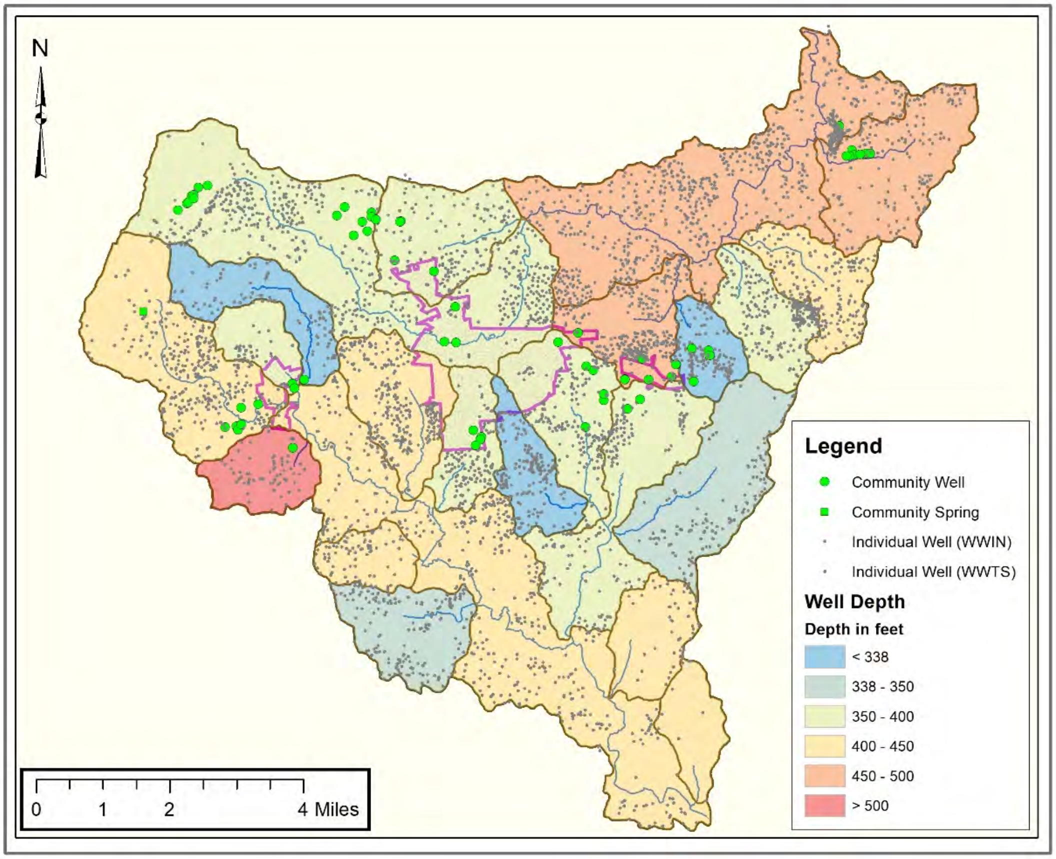


**Figure 3-36: Western Hills Watershed Residential Well Depth**

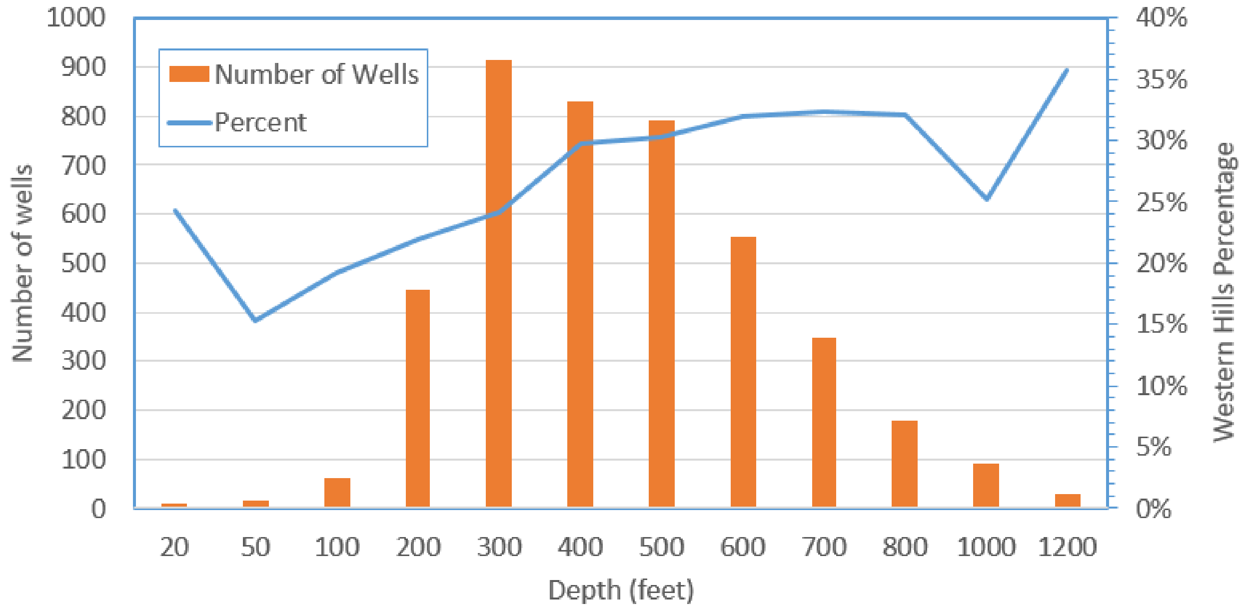


**Figure 3-37: Western Hills Watershed Residential Well Depth Distribution**

### 3.6.2 Dry Holes

The Department of Health tracks what is referred to as “dry holes”. These are the 220 wells which were drilled and tagged as “Dry Hole”, but failed to provide adequate useable yield or were abandoned after use, typically replaced by another water source. The number of dry holes was greatest around 2000 when approximately 5.2 percent of the wells were “dry”.

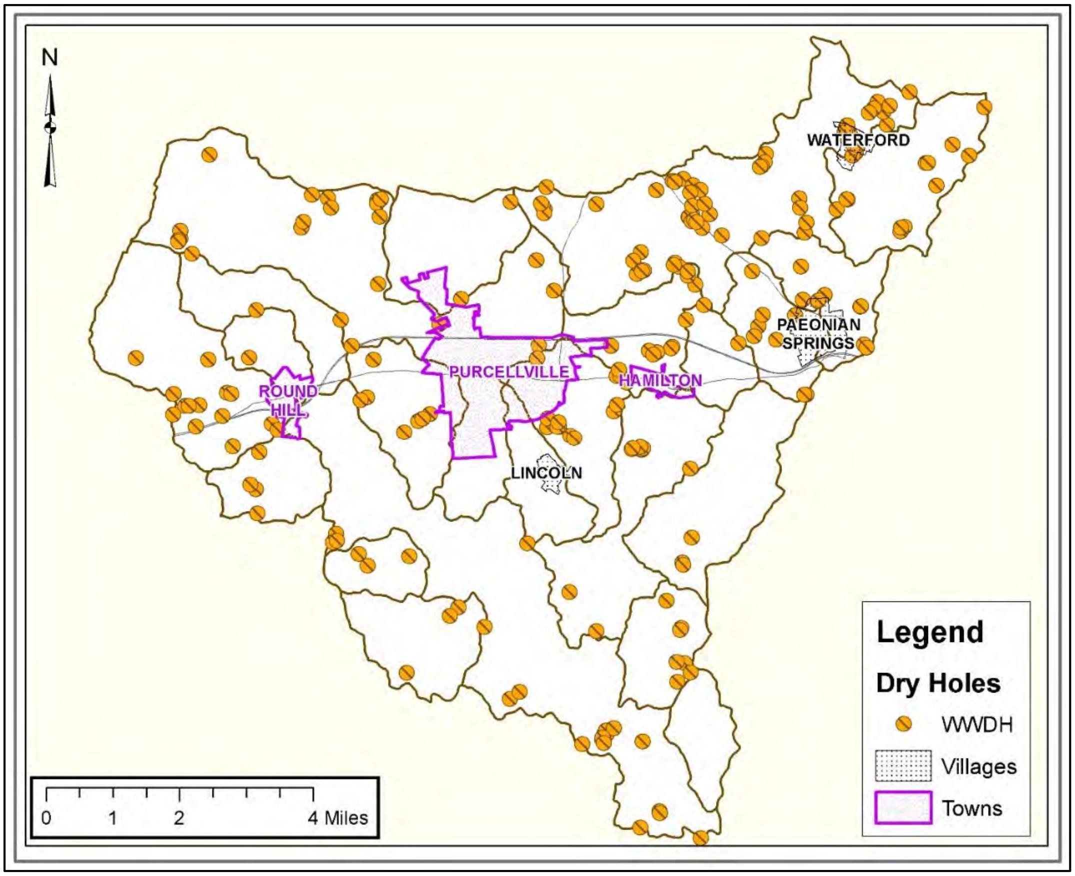


**Figure 3-38: Western Hills Watershed Dry Holes**

The “Dry Hole” designation in the data may not reflect actual drilling conditions encountered. Sometime wells are hydraulically fracked using pressure to provide sufficient useable yield. The data are included to provide some insight into the drilling history in the county (Figure 3-39).

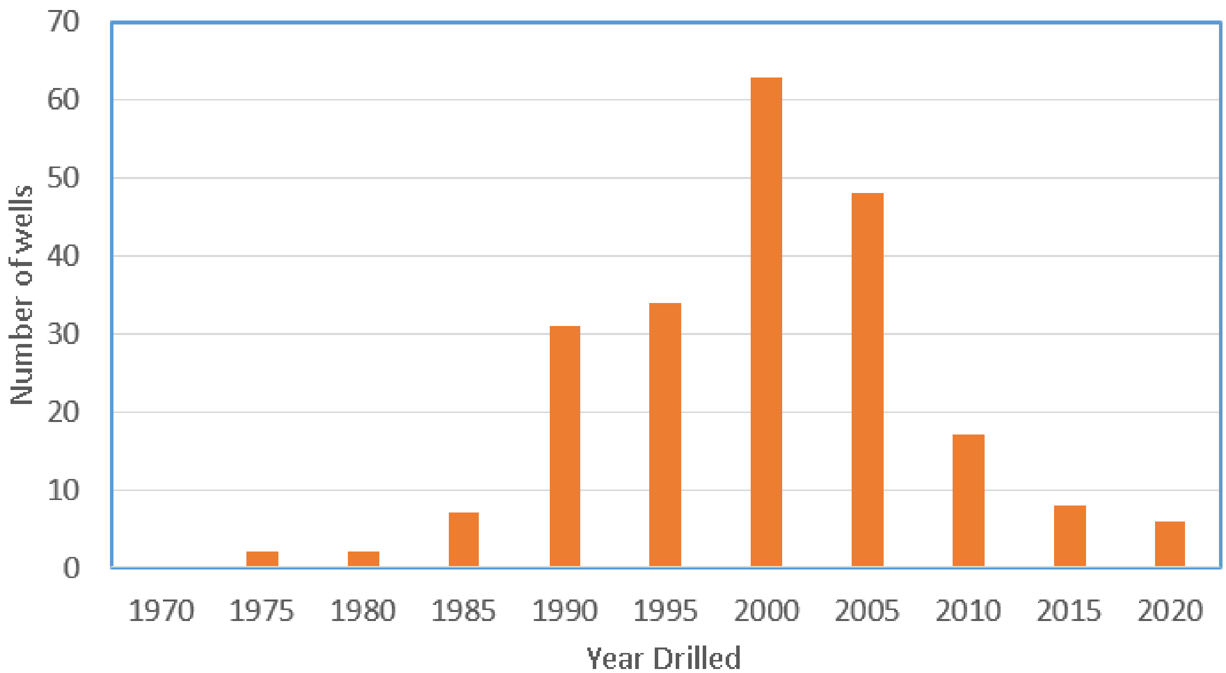


**Figure 3-39: Western Hills Watershed Time Period of Dry Hole Drilling**

### 3.6.3 Springs and Dug Wells

There are 158 springs currently mapped in Western Hills Watershed (Figure 3-40). Some springs are still used for residential water supply, however over time most have been replaced by conventional drilled wells. The Department of Health only allows springs as water supplies if the property owner owns the entire spring watershed, and the water is treated before use.

Additionally, there are 114 “dug” wells. These are typically located in rural villages such as Waterford and Paeonian Springs.

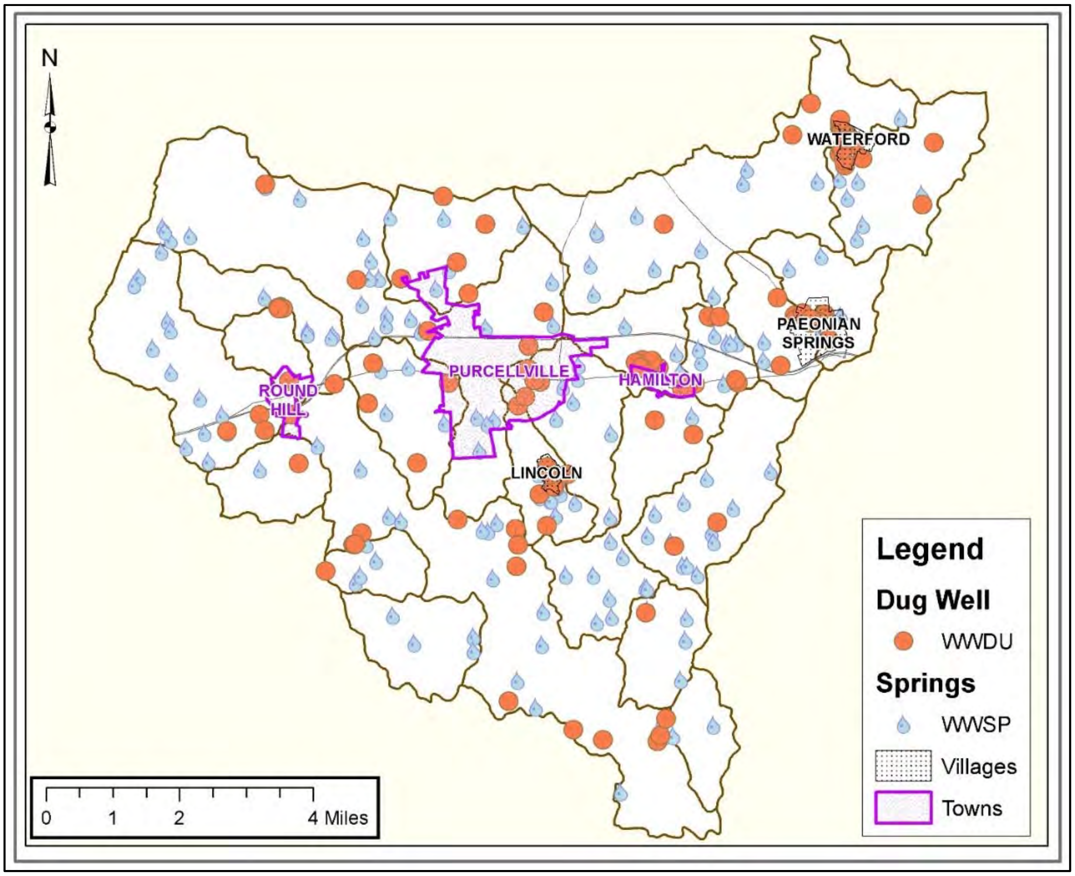


**Figure 3-40: Western Hills Watershed Spring and Dug Wells**

## 3.7 Public Water Supply

The towns of Purcellville, Hamilton, and Round Hill use groundwater wells to provide public water supply. Recent annual withdrawals were compiled and aggregated by subwatershed. While not intending to be a complete water use analysis, the percentage of total town withdrawals were mapped (Figure 3-41). For the most part, groundwater withdrawals do not cause deviation between surface subwatershed boundaries and groundwater sub-basins. This allows the data to be aggregated and percentages of total withdrawal displayed in the form of percent as allocated by watershed. More details on the overall water budget are provided in Section 5.3

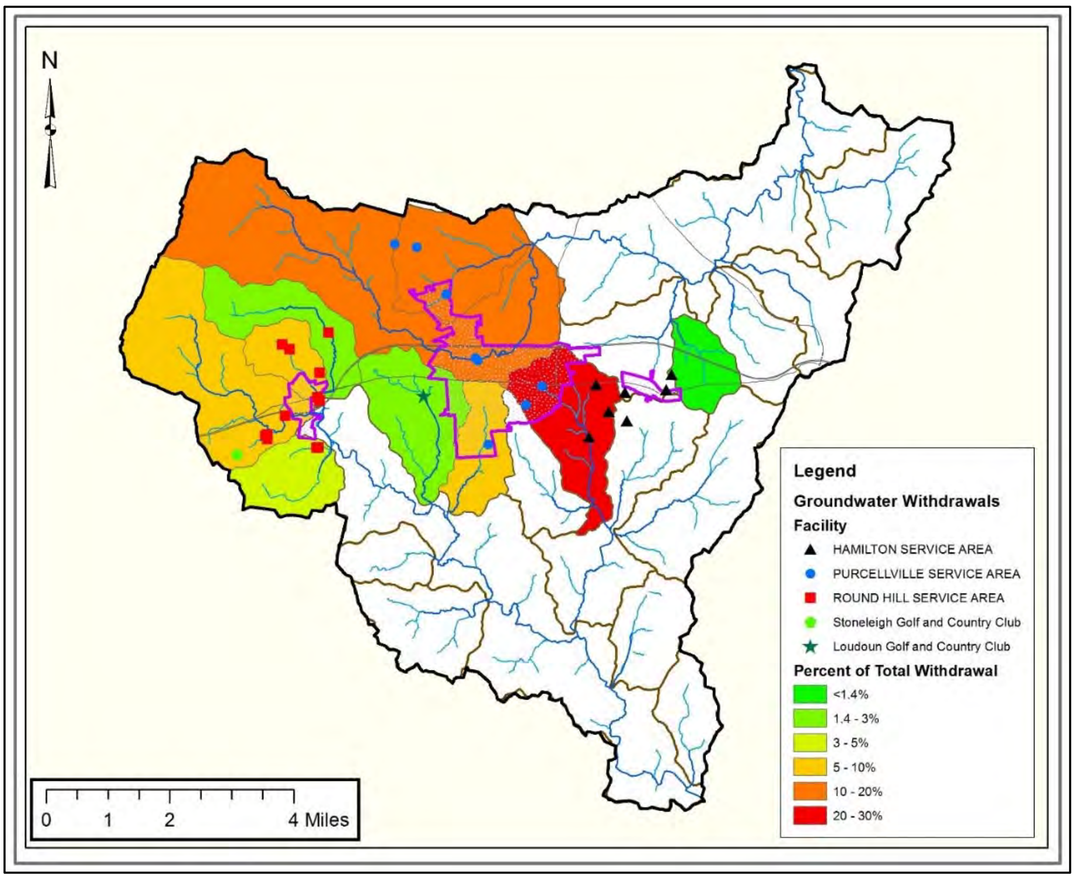


**Figure 3-41: Western Hills Watershed Water Supply Groundwater Withdrawals**

The withdrawals for public water supplies is generally localized to those subwatersheds near the towns (Table 3-16).

**Table 3-16: Western Hills Watershed Monthly Water Supply Groundwater Withdrawals**

| Subwatershed | Average withdrawal in million gallons per month for 2012 thru 2017 | Subwatershed Area (Acres) | Percent of Total Withdrawal |
|---|---|---|---|
| CROOKED RUN | | 2,693 | |
| JACKS RUN | 9.6 | 1,734 | 2.6 |
| LOWER SOUTH FORK CATOCTIN | | 5,770 | |
| NORTH FORK GOOSE CREEK | | 6,716 | |
| SIMPSONS CREEK | 32.3 | 3,213 | 8.8 |
| TRIB 1 TO CROOKED RUN | 104.1 | 1,831 | 28.3 |
| TRIB 1 TO NORTH FORK GOOSE CREEK | | 871 | |
| TRIB 1 TO SOUTH FORK CATOCTIN CREEK | | 2,348 | |
| TRIB 1A TO TRIB 1 TO CROOKED RUN | | 1,054 | |
| TRIB 2 TO CROOKED RUN | | 2,525 | |
| TRIB 2 TO NORTH FORK GOOSE CREEK | | 1,183 | |
| TRIB 2 TO SOUTH FORK CATOCTIN CREEK | | 1,388 | |
| TRIB 3 TO NORTH FORK GOOSE CREEK | | 1,540 | |
| TRIB 3 TO SOUTH FORK CATOCTIN CREEK | | 1,301 | |
| TRIB 4 TO NORTH FORK GOOSE CREEK | | 750 | |
| TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 3.3 | 1,469 | 0.9 |
| TRIB 4A TO TRIB 4 TO SOUTH FORK CATOCTIN CREEK | 4.9 | 769 | 1.3 |
| TRIB 5 TO NORTH FORK GOOSE CREEK | 19.8 | 1,059 | 5.4 |
| TRIB 5 TO SOUTH FORK CATOCTIN CREEK | 71.3 | 1,909 | 19.4 |
| TRIB 6 TO NORTH FORK GOOSE CREEK | 30.3 | 745 | 8.2 |
| TRIB 6A TO TRIB 6 TO NORTH FORK GOOSE CREEK | 10.5 | 1,416 | 2.9 |
| TRIB 7 TO NORTH FORK GOOSE CREEK | 12.3 | 1,083 | 3.3 |
| UPPER SOUTH FORK CATOCTIN CREEK | 69.8 | 6,189 | 19.0 |
| TOTAL | 368.1 | 49,558 | |

The pattern of withdrawal is seasonal, specifically for two irrigation wells at local golf courses, as shown in Figure 3-42. Further information on water use and projection of future water use are presented in Section 5.6.

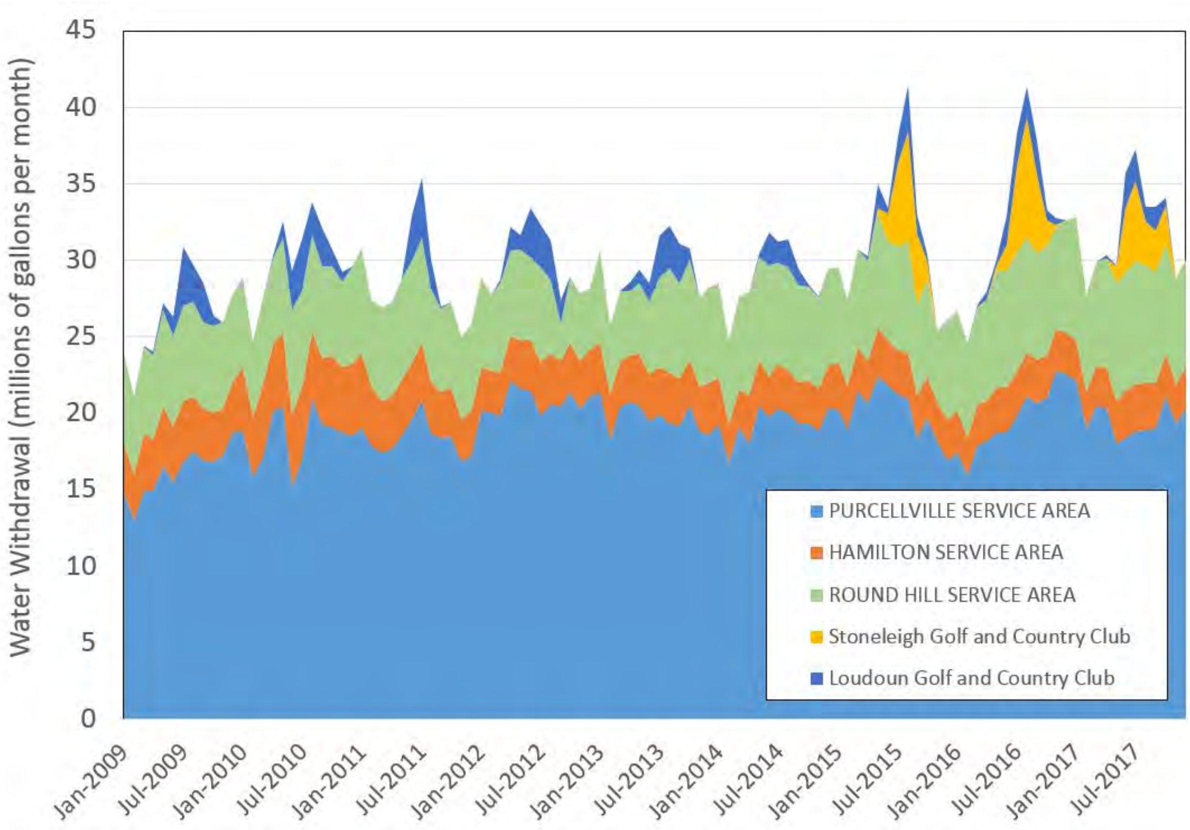


**Figure 3-42: Western Hills Watershed Monthly Water Supply Groundwater Withdrawals**

### 3.8 Hydrogeological Studies

In support of residential development, there have been many hydrogeological study reports completed in which wells for many of the proposed lots are drilled and tested and aquifer analysis is performed. As described in the Loudoun County 2019 Facility Standards Manual (Loudoun County 2019b) Chapter 6, the hydrogeological study includes a series of wells for 1/3 to 1/2 of the proposed residential development of more than ten lots. The wells are drilled and then a pump test is conducted. The pump test is typically 8 hours and the wells are then analyzed for aquifer transmissivity, T (ability to transmit water) and storativity, S (ability to store and release water). Data from hydrogeological study report has been compiled up through 2007. More recent data has not been extracted from the hydrogeological study reports. The values of transmissivity range to over 500 square feet/day (Figure 3-43).

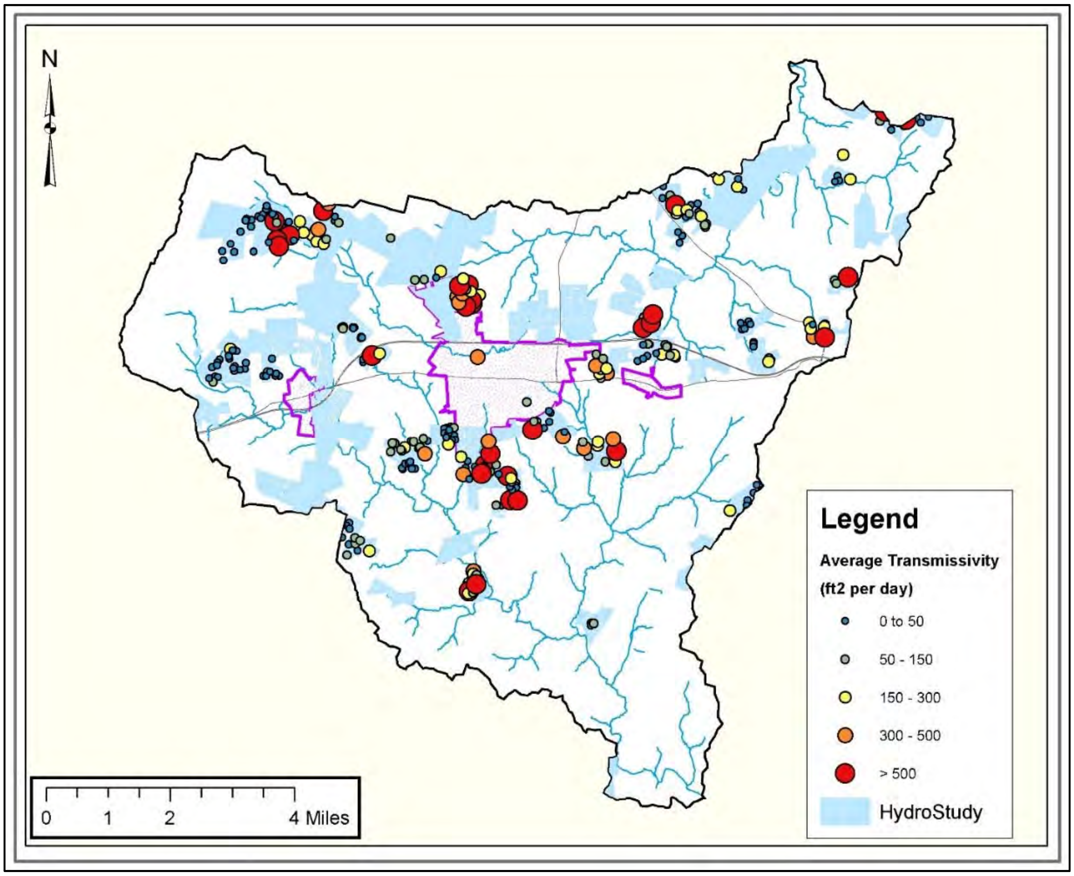


**Figure 3-43: Western Hills Watershed Transmissivity Determinations from Hydrostudies**

The storativity, S, is a dimensionless indicator of sustainability which is important during periods of excessive drought. In Western Hills Watershed, storativity measurements reflect a combination of the capacity of rocks to store water, but as is evident in the hydrogeological study reports, the results can be masked or impacted by groundwater replenishment from losing streams and creeks (Figure 3-44). In the hydrogeological study report, different methods of aquifer analysis were used over the years (unconfined, leaky, etc.) therefore one must be cautious in aggregating data. The Waterford Creek area along Old Stage Place was analyzed in 1999 included a large range of S values (Table 3-17). These suggest that various techniques were used covering confined and unconfined aquifer conditions.

**Table 3-17: Range of Storativity Values in Waterford Creek**

| $S_{min}$ | $S_{max}$ | $S_{avg}$ |
|---|---|---|
| 0.19 | 0.19 | 0.19 |
| 0.000012 | 0.34 | 0.170006 |
| 0.000078 | 0.26 | 0.130039 |
| 0.00001 | 0.21 | 0.070035 |
| 0.00012 | 0.015 | 0.005873 |
| 0.00014 | 0.013 | 0.004713 |
| 0.002 | 0.002 | 0.002 |
| 0.00071 | 0.00074 | 0.000725 |

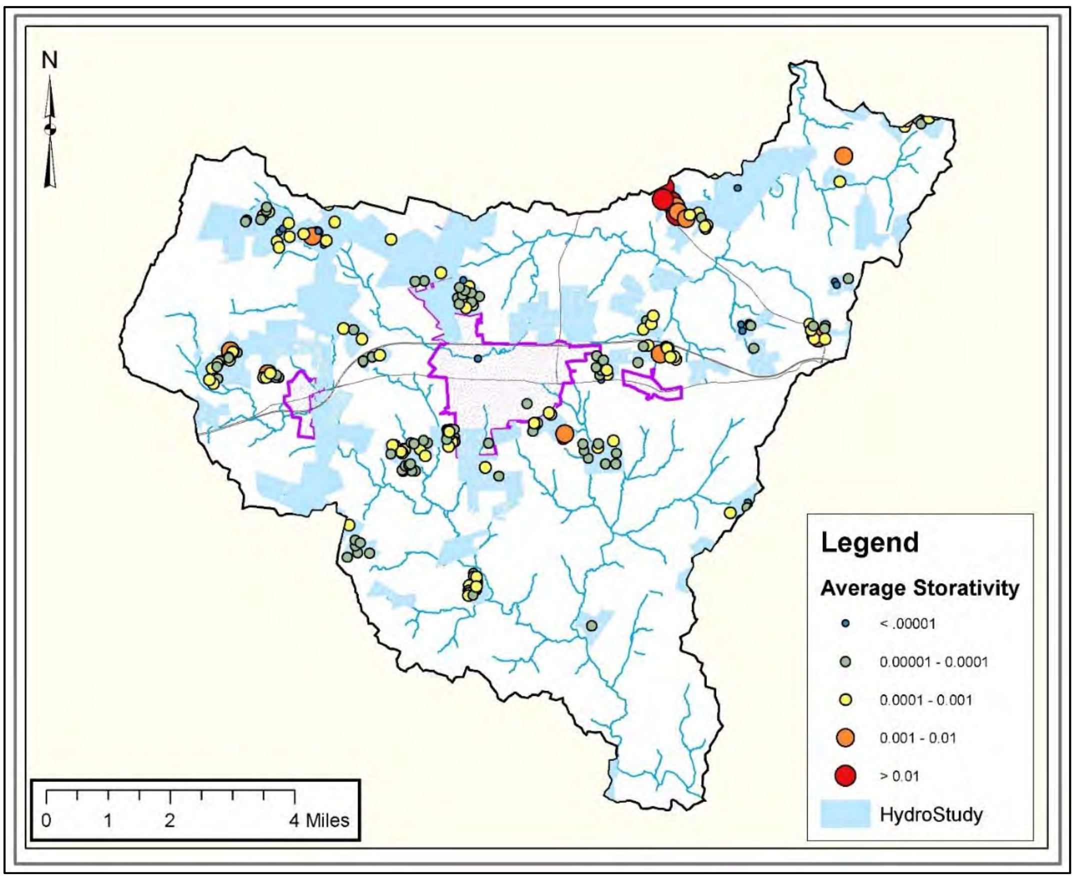


**Figure 3-44: Western Hills Watershed Storativity Determinations from Hydrostudies**

## 3.9 Groundwater Water Quality

At the time of well construction, water samples are collected and analyzed for basic water quality parameters including nitrogen, phosphorus, iron, manganese, magnesium, total dissolved solids, and bacteria. These data are reviewed by the County's Health Department prior to issuance of a permit.

There are more than 2,000 samples recorded, which represent less than half of the wells in the Western Hills Watershed. Only a few hundred wells have been sampled subsequent to residential use. Most of these tests have been through the Loudoun County Water Well Clinic available through the Virginia Extension Office and individual results are not available.

In 2009 Loudoun County conducted a countywide sampling of selected targeted and probabilistic sampling at several dozen wells. The overall probabilistic results indicated that, in the short-term, current land-use practices are not adversely affecting the quality of groundwater withdrawn from wells. A few wells did exhibit elevated levels of nitrate; however, this occurred in areas where past agricultural practices, such as fertilizer application, may still be having a negative impact on groundwater quality. From the targeted sampling, the wells ranged in age from 4 to 21 years. Among the 48 samples, there was natural variation in the results, but overall, the current groundwater quality was relatively consistent with the initial hydrogeological study results and the overall groundwater quality remains excellent. Additional details of the results appear in the 2009 Annual Water Resources Monitoring Data report.

Maps in Figures 3-45 to 3-53 display available groundwater data for several analytes. Where appropriate, the symbology of the maps includes the EPA Maximum Concentration Level (MCL). While the overall water quality is good, there are elevated occurrences of iron, manganese and other compounds indicative of "hard water" conditions.

**Summary of Types of Analyses in Loudoun County Groundwater Database**

Approximately 2,000 samples for:

Corrosivity, Sodium, Total Dissolved Solids, Iron, Alkalinity (Total as CaCO3), Manganese, pH (Standard Units), Turbidity (Turbidity Units), Hardness (as CaCO3), Magnesium, Calcium, Sulfate

Approximately 200 samples for:

Chloride, Zinc, Aluminum, Copper, Nitrate as N, Lead, Toluene, Fluoride, Styrene, Barium, Total THMs, Chloroform, Chromium, Arsenic, Foaming Agents, Nickel, Bromodichloromethane, Nitrite as N, Benzene, Ethylbenzene, Acetone, Alachlor, Atrazine, Bromobenzene, Bromomethane, Cadmium, Hardness, Mercury, Selenium, Silver, Total Coliform, Turbidity, Vinyl Chloride, pH, and several dozen other volatile organic and pesticide parameters.

Selected analytes are presented in the following maps. Text for the descriptions of each analyte are taken with fact sheets prepared by the Virginia Household Water Quality Program described at https://www.wellwater.bse.vt.edu/resources.php.

### 3.9.1 Manganese

Manganese in groundwater usually originates from certain rock formations, and does not present a health risk in drinking water. If present in amounts greater than 0.05 mg/l, it may give water a bitter taste and produce black stains on laundry, cooking utensils, or plumbing fixtures. Elevated level of manganese are widespread throughout Western Hills Watershed.

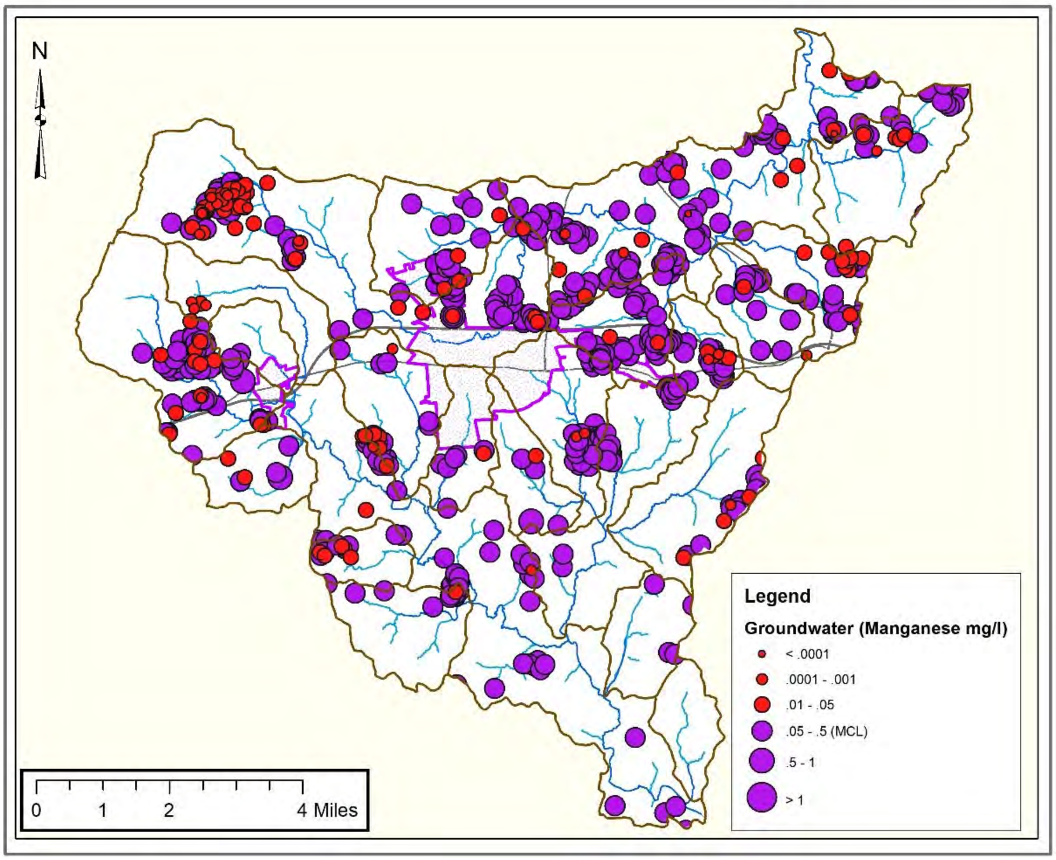


**Figure 3-45: Western Hills Watershed Distribution of Manganese in Groundwater Wells**

### 3.9.2 Lead

Lead rarely occurs naturally in water; it usually is leached into household water from plumbing or pipe materials. Lead can cause irreversible damage to the brain, kidneys, nervous system, and blood cells. It is a cumulative poison, meaning that it will accumulate in the body until it reaches toxic levels. Young children are most susceptible: mental and physical development can be irreversibly stunted by lead poisoning. Lead may be found in household drinking water in homes built prior to 1986 with lead solder, or in new homes with "lead-free" brass components, which could contain up to 8 percent lead until January 2014. There is no safe level of exposure to lead. The MCL goal is 0 mg/L, and the Health Action Level (HAL) (https://www.epa.gov/lead) is 0.015 mg/L. If lead is present in drinking water, addressing the corrosiveness (acidity) of the water by installing an acid neutralizing filter may help the problem. Alternatively, one may consider installing an activated carbon filtration or reverse osmosis unit designed to remove lead at the faucet where drinking and cooking water is obtained. If lead in the flushed sample decreases significantly, another option is to flush pipes for at least 1 minute to remove water with higher lead concentrations before drinking or cooking, and always drink and cook with cold water.

Because of the challenges associate with lead and other metals within household systems, VA Extension conducts separate sampling methods as presented in Section 3.9.1.1.

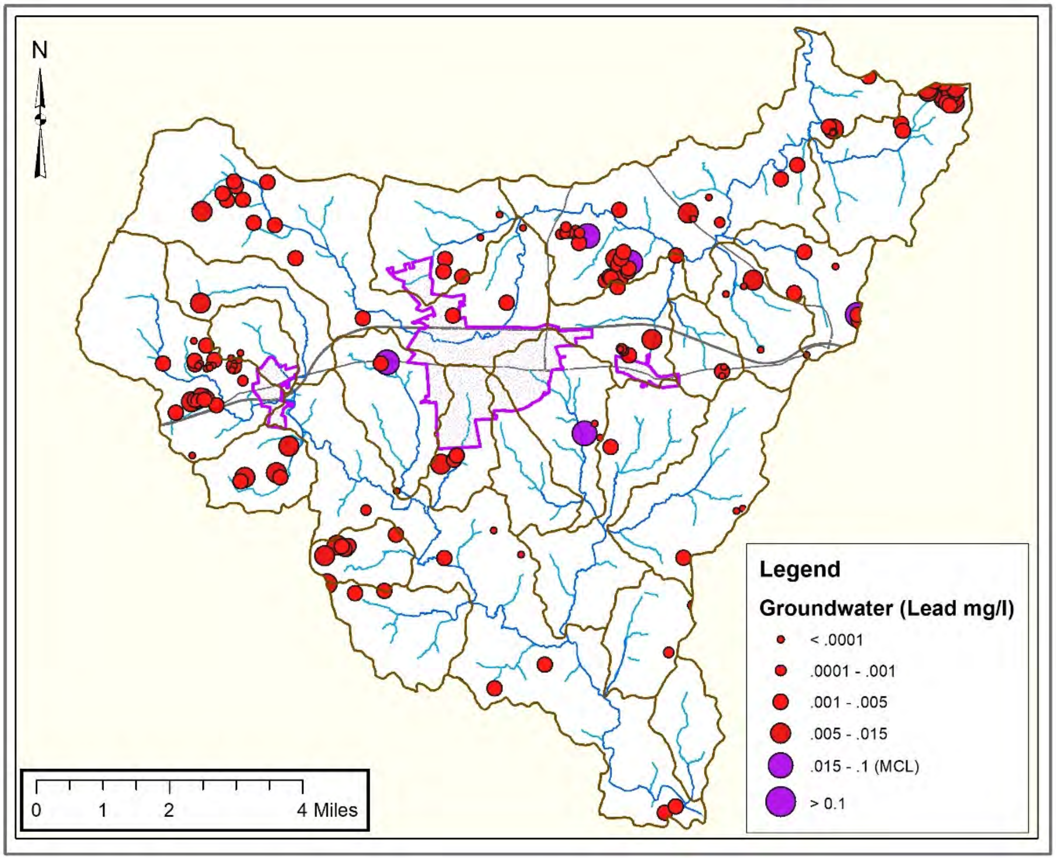


**Figure 3-46: Western Hills Watershed Distribution of Lead in Groundwater Wells**

### 3.9.3 Chloride

Chloride is not regulated as primary (health-related) contaminants in public water systems by the EPA. High levels of chloride in drinking water can cause water to have a salty taste. In addition, high levels may accelerate corrosion of pipes, pumps, hot water heaters, and plumbing fixtures. To avoid these problems, the EPA recommends limiting sodium concentrations in drinking water to below 20 mg/L, and chloride concentrations to 250 mg/L or less.

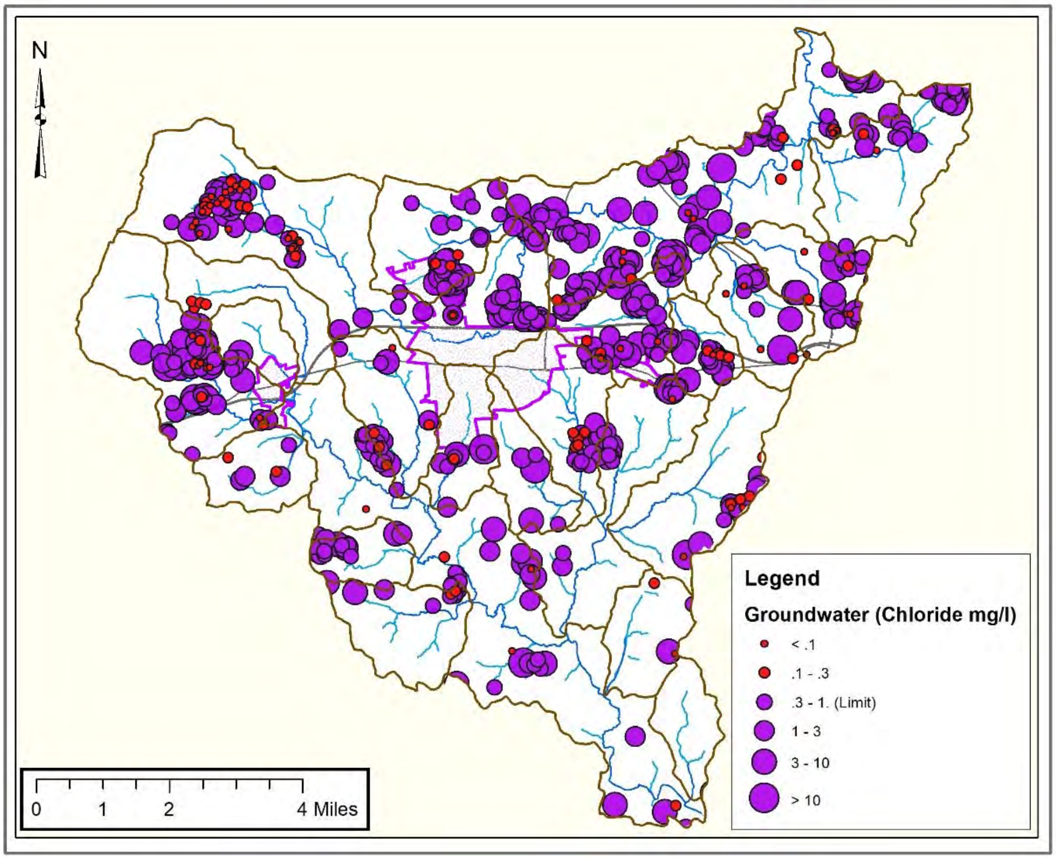


**Figure 3-47: Western Hills Watershed Distribution of Chloride in Groundwater Wells**

### 3.9.4 Iron

Iron in groundwater usually originates from certain rock formations, and does not usually present a health risk. It can, however, be objectionable if present in amounts greater than 0.3 mg/l. Excessive iron levels can leave red-orange-brown stains on plumbing fixtures and laundry. It may give water and beverages a bitter, metallic taste and discolor beverages. Iron bacteria, which are harmless to human health, may be present in water with iron, and create a reddish-brown slime by-product anywhere water stands (e.g. toilet tanks). The occurrence of iron in Western Hills Watershed is widespread.

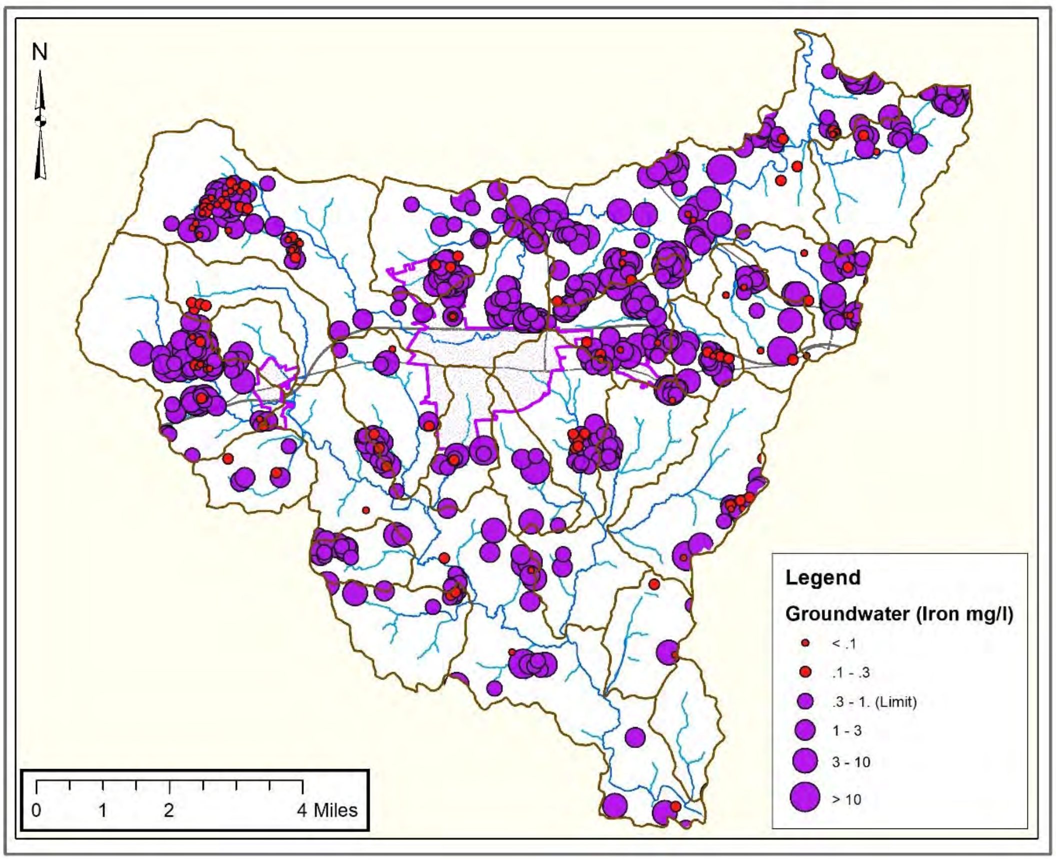


**Figure 3-48: Western Hills Watershed Distribution of Iron in Groundwater Wells**

### 3.9.5 Benzene

Benzene is a volatile organic compound made mostly from petroleum. It evaporates into the air quickly and dissolves slightly in water. Although it can be formed naturally, most benzene exposure results from human activities. Benzene can be released into water, soil and air through automobile emissions, industrial discharges, improper disposal of products containing benzene and from gasoline leaks from underground storage tanks. Benzene breaks down slowly in water and soil, and easily passes through the soil into ground water sources.

For this desktop assessment benzene and toluene were examined. These are two of the volatile hydrocarbon compounds often referred to at BTEX (benzene, toluene, ethylbenzene, and xylene).

In Western Hills Watershed there are few occurrences of benzene in the well construction database; however, there was an issue with a related compound in 1998. At that time water samples from wells in Round Hill, Hamilton and Purcellville were found to have quantities of a gasoline additive known as MTBE, or methyl tertiary butyl ether, a suspected carcinogen.

In 1998 Virginia Health Department found that the contaminants in all three towns posed no immediate health risks, but it required that persistent contamination be corrected with filters or other devices.

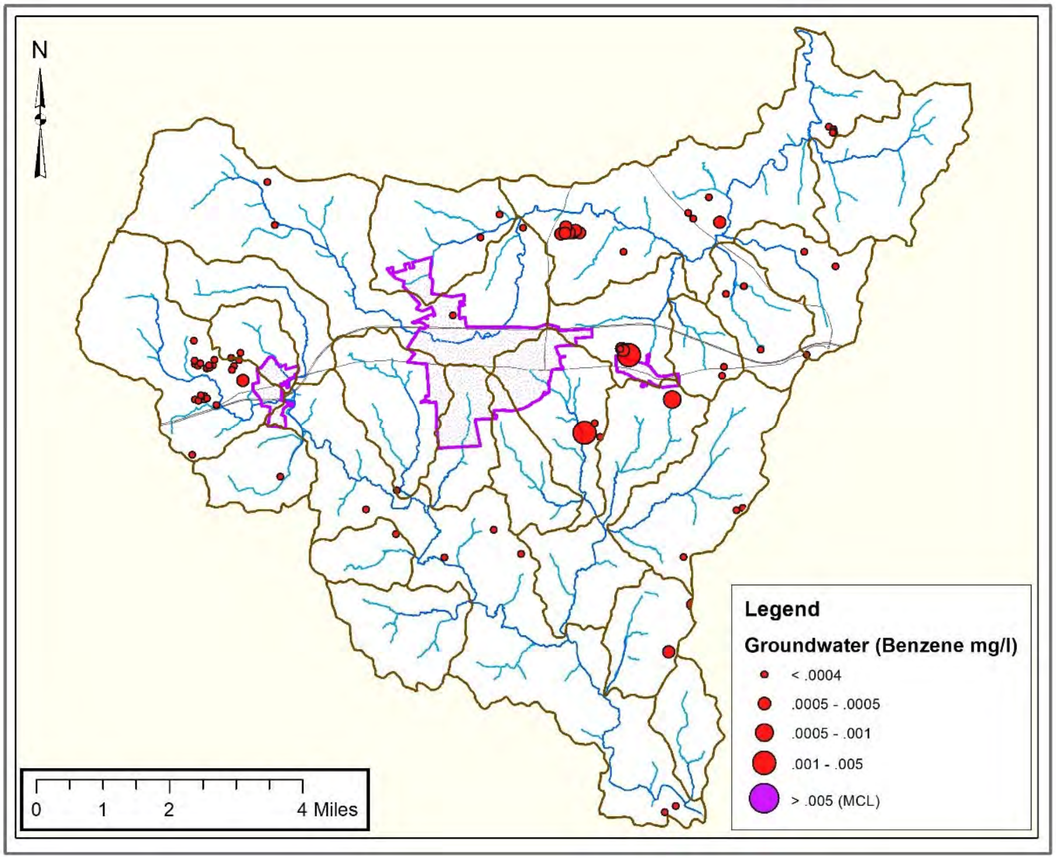


**Figure 3-49: Western Hills Watershed Distribution of Benzene in Groundwater Wells**

### 3.9.6 Toluene

Toluene is another volatile organic compound that has been observed some wells in the Western Hills Watershed. There were no detections above the MCL limit.

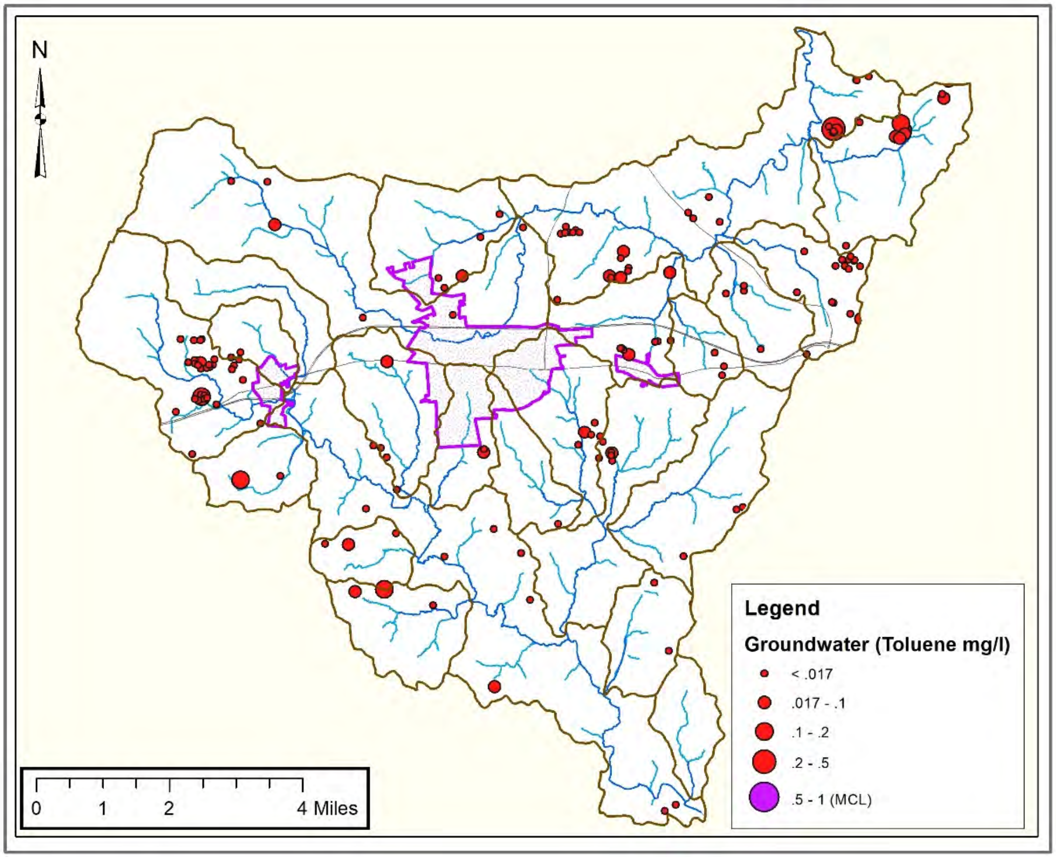


**Figure 3-50: Western Hills Watershed Distribution of Toluene in Groundwater Wells**

### 3.9.7 Arsenic

Arsenic is an odorless, tasteless, semi-metal that occurs naturally in some areas. It is used in wood preservatives, paints, dyes, drugs, and certain fertilizers and herbicides. Naturally occurring arsenic is often the source of contamination in groundwater supplies. Arsenic has been linked to many types of cancer, including cancer of the bladder, lungs, skin, and kidneys. It is also associated with stomach pain, nausea, numbness of hands and feet, blindness, and partial paralysis. The EPA standard for arsenic in public drinking water supplies is 0.010 mg/L.

While found in low levels throughout the entire watershed, there may be an isolated higher occurrence in the western area (known as) the Highlands. As discussed below, this area also has (or had at one time) elevated nitrate levels, which may have been the result of former agricultural operations.

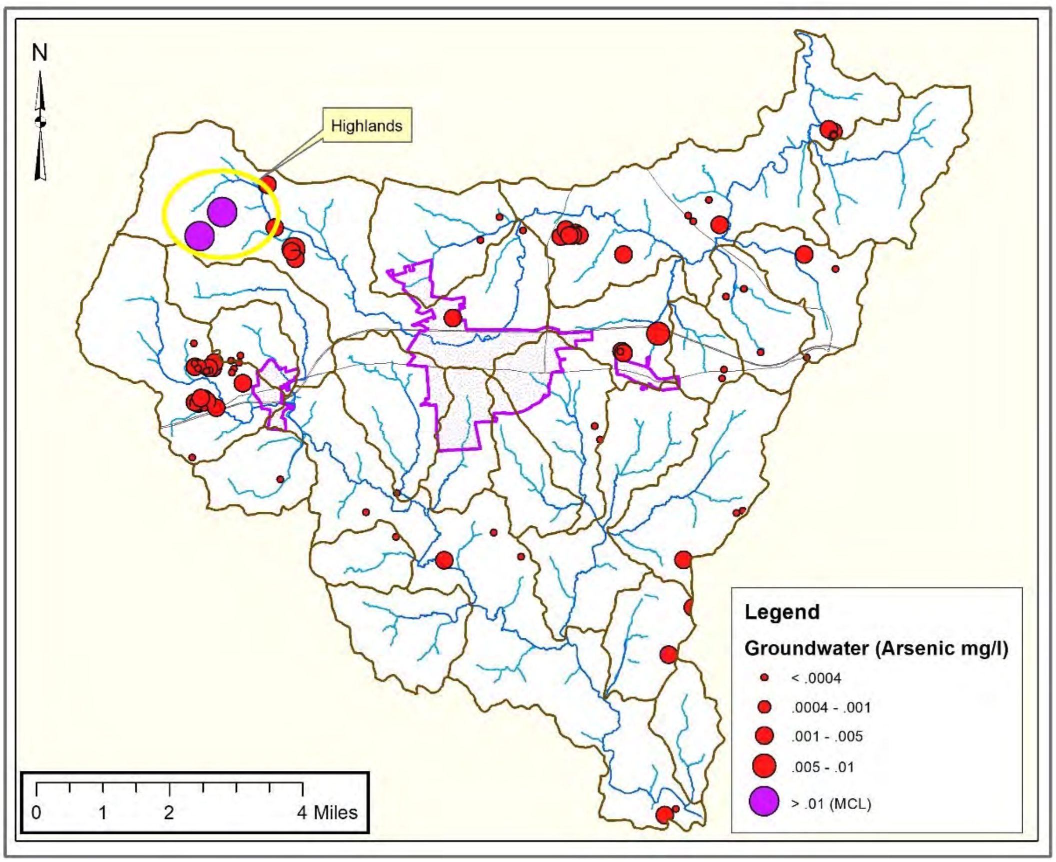


**Figure 3-51: Western Hills Watershed Distribution of Arsenic in Groundwater Wells**

### 3.9.8 Nitrate

Nitrate comes from animal manure, septic systems, and fertilizer. High levels of nitrate may cause methemoglobinemia or "blue-baby" disease in infants. EPA has set a Maximum Contaminant Level for nitrate-nitrogen of 10 mg/l for public water systems, and suggests that water with greater than 1 mg/l not be used for feeding infants. Levels of higher than 3 mg/l may indicate excessive contamination by fertilizers or organic wastes. Boiling is not recommended for treating nitrate-contaminated water. Reverse osmosis or distillation units should be used to treat.

Note that there is a cluster of elevated nitrate in the Highlands, a former intensive agricultural operation, from previous sampling. Current day concentrations in this region are not known.

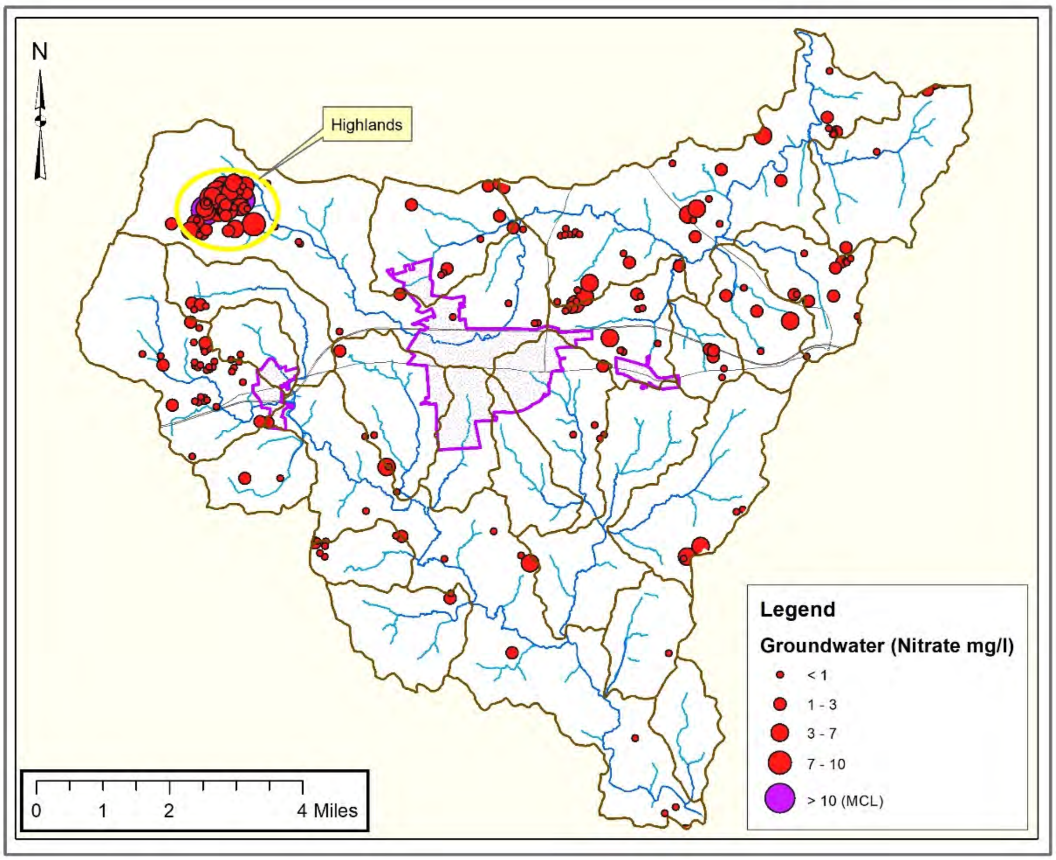


**Figure 3-52: Western Hills Watershed Distribution of Nitrate in Groundwater Wells**

### 3.9.9 Sulfate

High sulfate concentrations may result in adverse taste, and may have a laxative effect on those who are unaccustomed to drinking the water. The Secondary Maximum Concentration Level (SMCL - https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals) for sulfate is 250 mg/l. Sulfate may be linked to other sulfur-related problems, such as hydrogen sulfide gas, which gives water a "rotten-egg" odor or taste. Hydrogen sulfide gas occurs naturally as a byproduct of sulfur-reducing bacteria. These bacteria feed on small amounts of sulfur in water and thrive in low oxygen environments common in groundwater wells. These bacteria may cause an unpleasant taste or odor, but they do not present a health threat to humans. While it is difficult to test for hydrogen sulfide gas in water, it is easily detected by smell, especially in hot water. Water containing this gas may corrode metals in the water system and stain plumbing and cooking utensils.

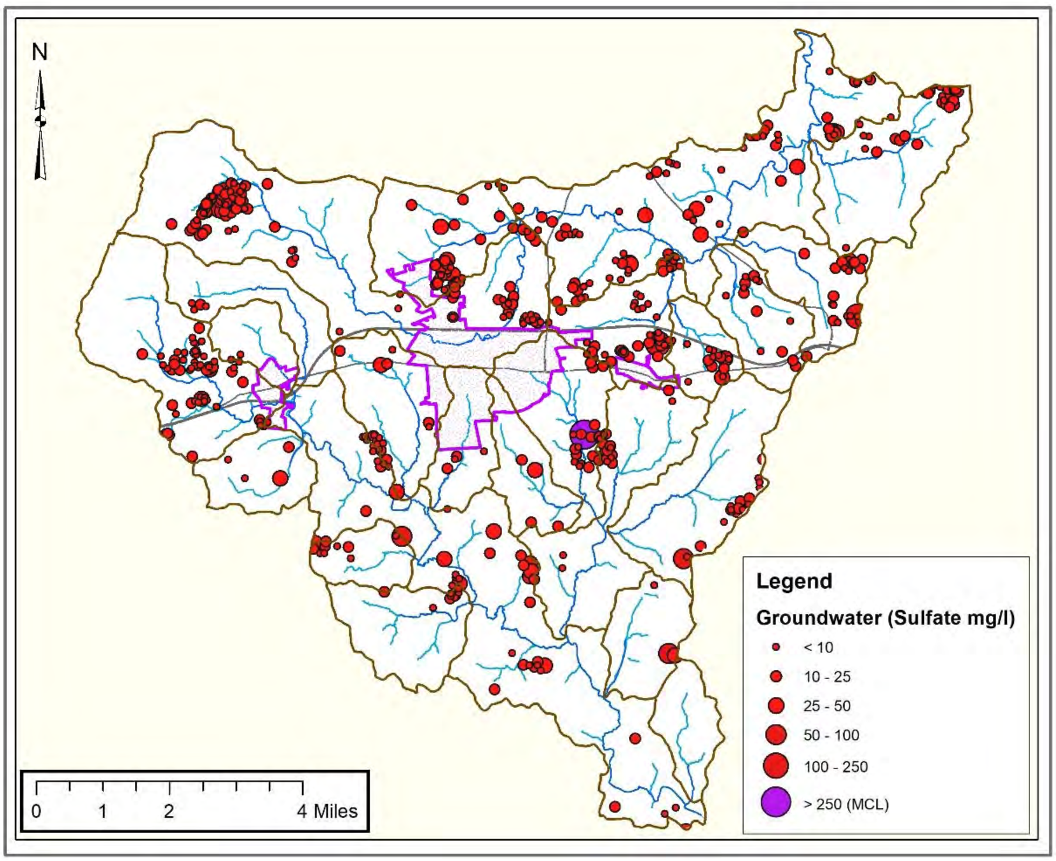


**Figure 3-53: Western Hills Watershed Distribution of Sulfate in Groundwater Wells**

### 3.9.10 Bacteria

While the Virginia Health Department requires tests for bacteria (Coliform and *E. coli*), the sampling results are not presented in this report. The tests are often repeated after the contamination issues has been resolved.

### 3.9.11 Water Well Clinic

According to the 2017 Annual Report for the Virginia Household Water Quality Program (https://www.wellwater.bse.vt.edu/files/2017-VAHWQP-Annual-Report-Final.pdf) from Virginia Tech, about 1.7 million Virginians or 22 percent of the state's population get their household water from a private well. Municipal water supplies are regulated and regularly tested under the EPA's Safe Drinking Water Act. Private wells are the responsibility of the well owner. Over 2,000 households have their water tested each year through the Virginia Household Water Quality Program.

While open to the entire county, many residents who take advantage of the water well clinics are in the Western Hills Watershed. Results are reported in aggregate, though individual results are sent confidentially to the residents. The analyses include primary and *secondary* EPA water quality standards as listed in Table 3-18.

**Table 3-18: Water Well Clinic Analytes and EPA Water Quality Standards (Italics indicate secondary water quality standard)**

| Analyte | EPA MCL or *SMCL* (mg/l) |
|---|---|
| *Iron* | *0.3* |
| *Manganese* | *0.05* |
| Hardness | 180 |
| Sulfate | 250 |
| Floride | 2 or 4 |
| *Total Dissolved Solids* | *500* |
| Copper | 1 or 3 |
| Sodium | 20 |
| Nitrate-N | 10 |
| Total Coliform | Absent |
| *E. Coli* | Absent |

Between 2010 and 2018, there were 573 water wells sampled countywide as presented in Figure 3-54. The results show a large number of wells with elevated levels of constituents. In the clinics residents are counseled on ways to address contaminants. While the study included distinction between first draw and flush samples for copper and lead, the chart is limited to draw samples which may include the effects associated with plumbing systems.

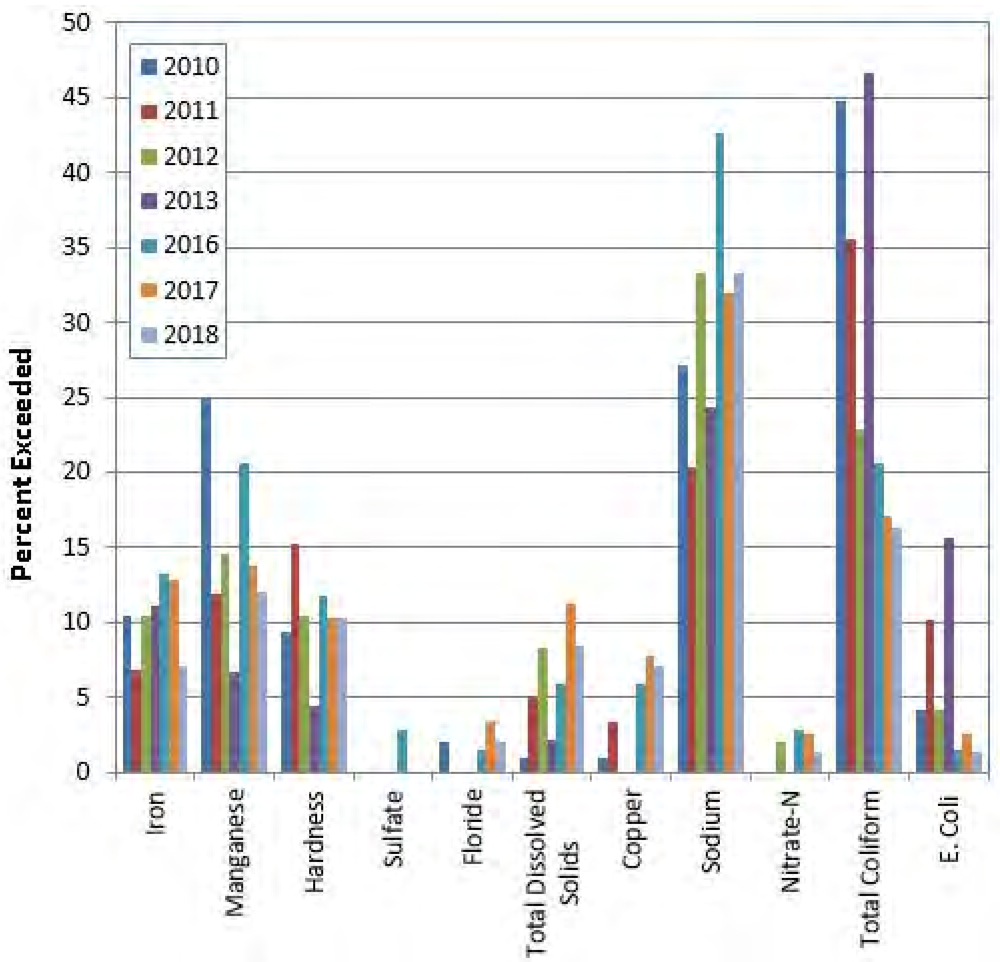


**Figure 3-54: Water Well Clinic Samples Exceeding EPA Water Quality Standards**

## 3.10 Wastewater

In the Western Hills Watershed, wastewater is typically handled within the three town limits by the Towns of Purcellville, Hamilton, and Round Hill. Loudoun Water owns and operates a wastewater facility for the Village of Waterford. Outside of the towns, wastewater is most commonly handled through individual private septic system.

### 3.10.1 Residential Septic Systems

There are over 5,010 residential septic systems for residents out of the town central services areas. Most systems (3,711) are conventional with a gravity or pump-up design (Figure 3-55). In recent years there has been an increased proportion of Alternative Onsite Systems (533) constructed. For various reasons, there are pump-and-haul and a few pit privy locations as permitted by the Health Department. When properly operated, these pose no threat to surface or groundwater pollution.

The subwatersheds with the greatest number of septic systems tends along the primary stream channels.

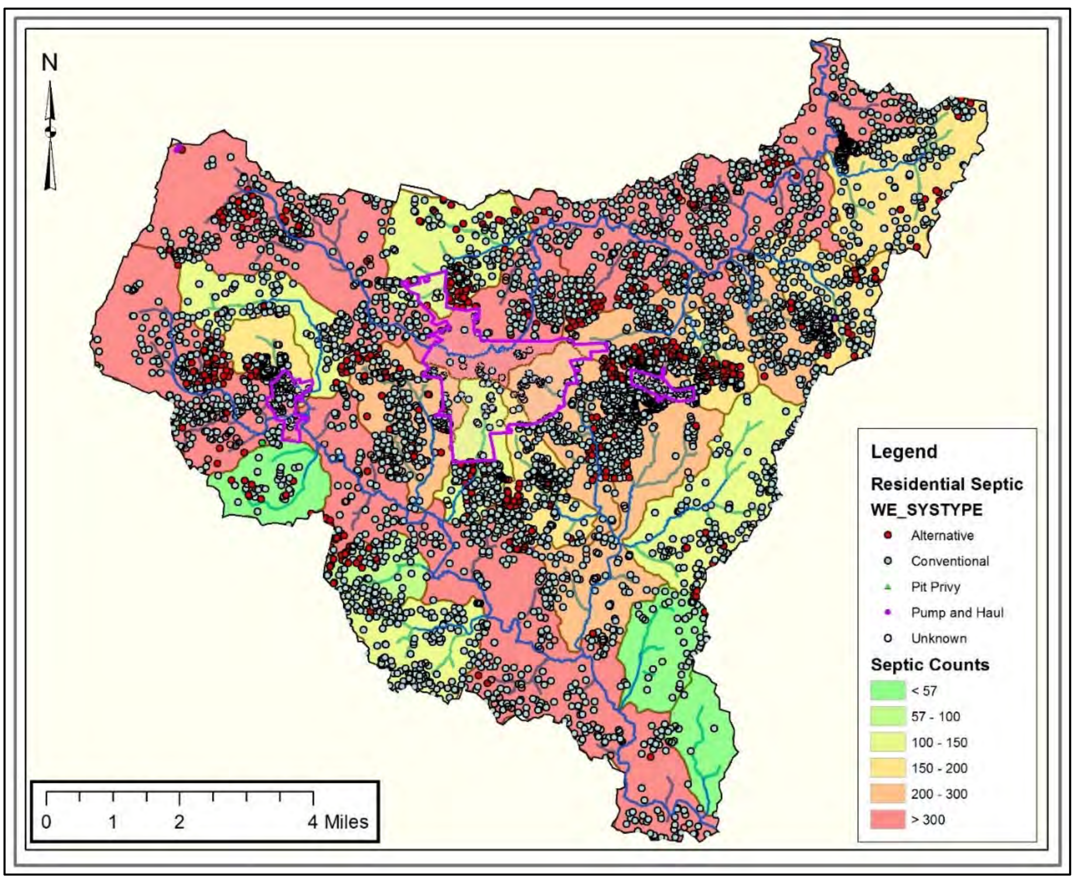


**Figure 3-55: Western Hills Watershed Residential Septic Systems**

The growth in the number of residential systems (Figure 3-56) since the 1980s is consistent with population increases. The percentage of alternative systems has significantly increased since 2006.

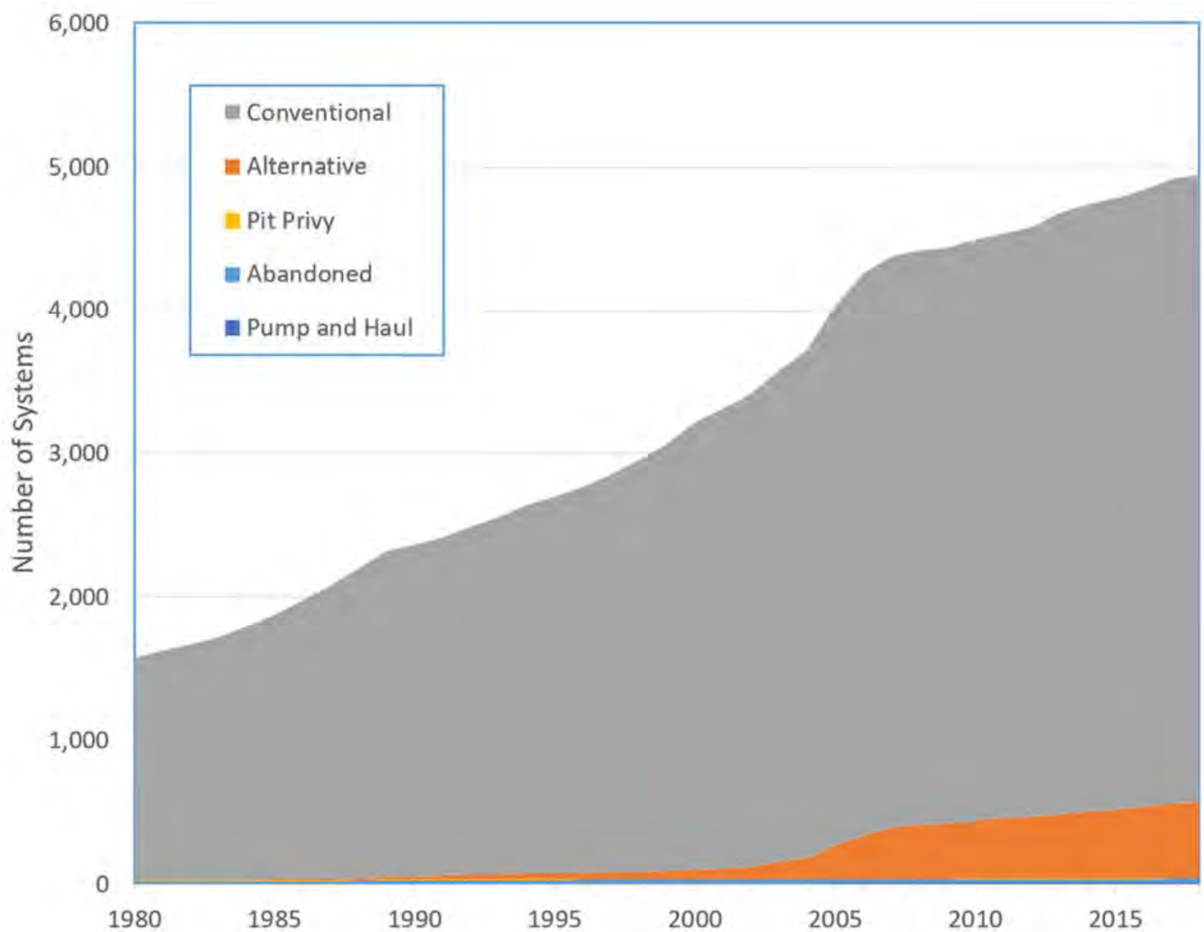


**Figure 3-56: Annual Distribution of Residential Septic Systems in Western Hills Watershed**

### 3.10.2 Wastewater Treatment Facilities

The towns (Purcellville, Hamilton, and Round Hill) as well as the Village of Waterford have permitted waste water discharges from treatment facilities (Figure 3-57). Other, non-sewer discharges include the Purcellville water treatment plant, a concrete facility and several other sites with discharges covered by Virginia Pollutant Discharge Elimination System (VPDES) permits.

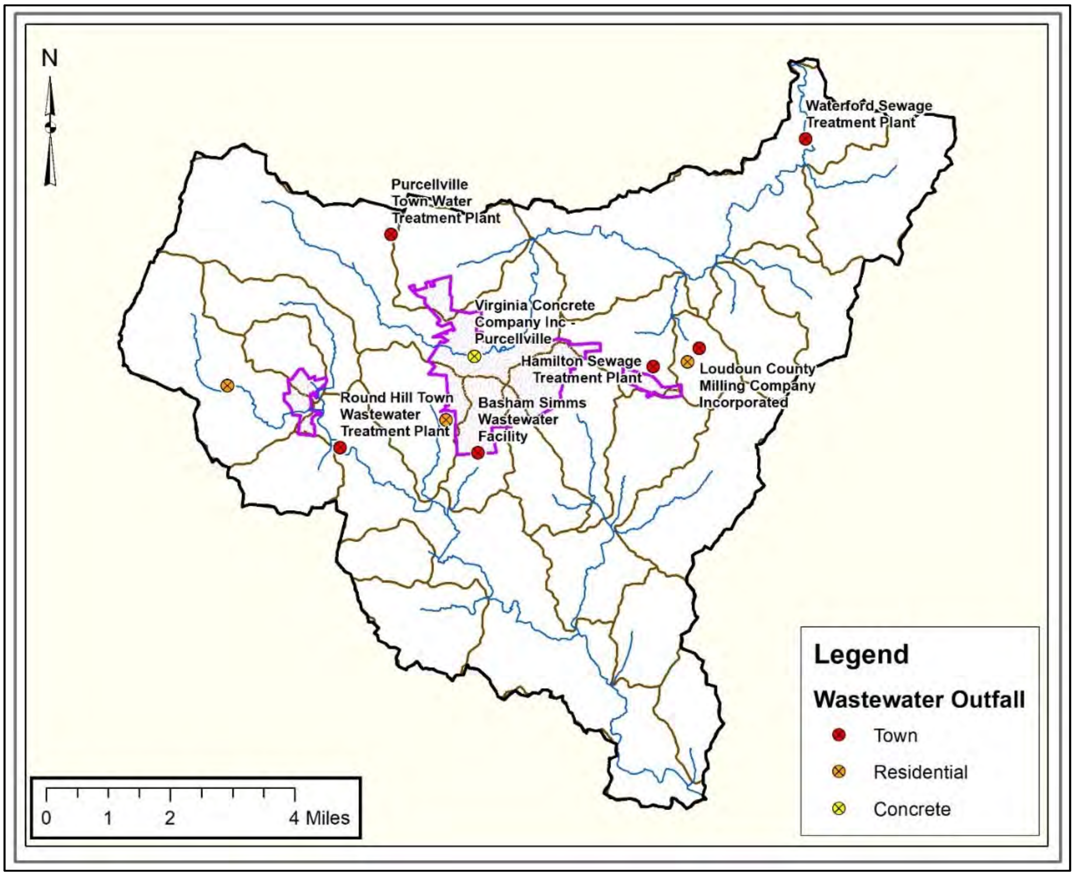


**Figure 3-57: Western Hills Watershed Permitted Wastewater Outfalls**

## 3.11 Other Watershed Features

Other watershed-specific features include regulated dams, agricultural best management practices and tree planting projects.

### 3.11.1 Regulated Dams

There are 20 surface water ponds with dams that are regulated by Virginia Department of Conservation and Recreation (Figure 3-58). Most dams are in line with perennial streams. The exception is the water supply dam for the Town of Purcellville's J. T. Hirst Reservoir, located outside of Western Hills Watershed

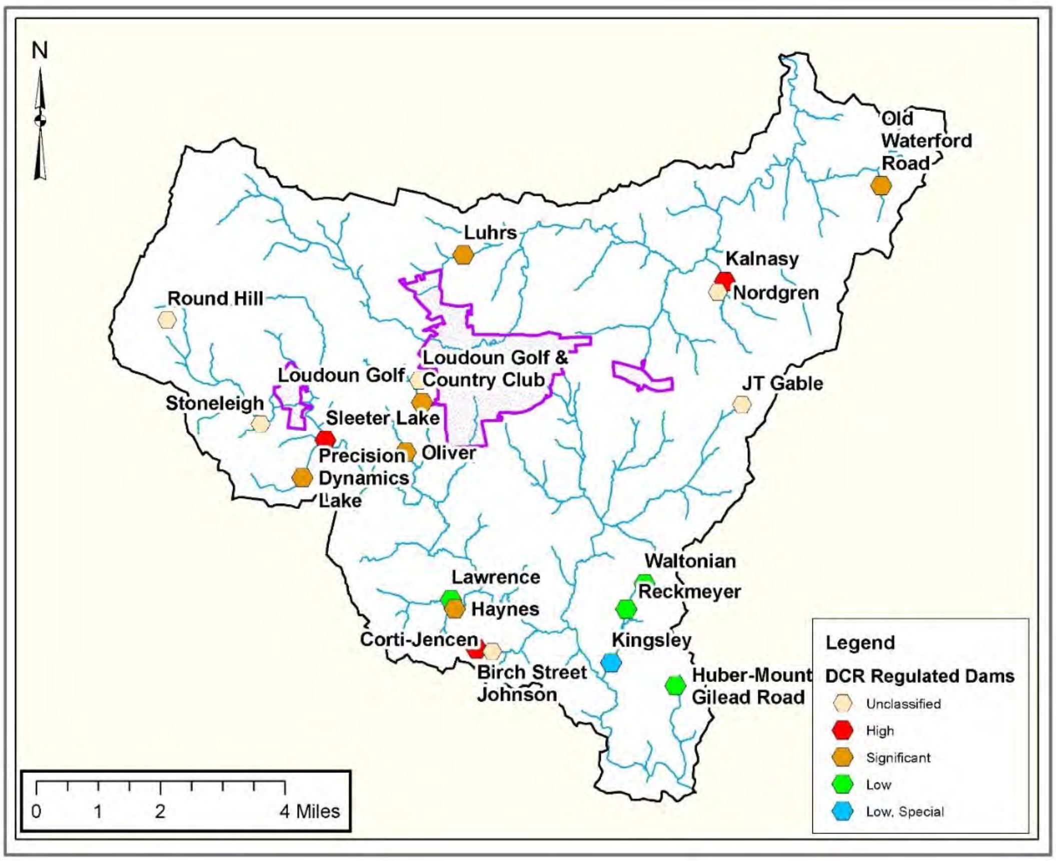


**Figure 3-58: Western Hills Watershed Regulated Dams**

Many of the dams were constructed in the 1960's with dam heights ranging between 19 and 55 feet (Table 3-19).

**Table 3-19: Western Hills Watershed Regulated Dams**

| Name | Owner | Classification | Height | Year |
|---|---|---|---|---|
| Kingsley Dam | Richard A. Rogers | Low, Special | 44.0 | 1962 |
| Huber-Mount Gilead Road Dam | Huber, George & Peggy R/S | Low | 28.0 | 1960 |
| Loudoun Golf & Country Club Dam | Loudoun Golf & Country Club | Significant | 20.0 | 1985 |
| Lawrence Dam | Martin Lawrence Family Trust | Low | 19.3 | 1980 |
| Waltonian Dam | Loudoun Waltonian Club, Inc. | Low | 37.1 | 1965 |
| Sleeter Lake Dam | Round Hill Owners Association | High | 55.0 | 1966 |
| Precision Dynamics Lake Dam | Round Hill Owners Association | Significant | 36.0 | 1967 |
| Kalnasy Dam | Johnson, Cedric & Cynthia Holgate | High | 26.1 | 1964 |
| Oliver Dam | Woodmar Farm Conservancy | Significant | 43.8 | 1968 |
| Luhrs Dam | Tsui's Grass Roots Farm, Inc. | Significant | 23.5 | |
| Haynes Dam | Martin Lawrence Family Trust | Significant | 41.0 | 1980 |
| Reckmeyer Dam | Dr. William J. Reckmeyer | Low | 39.0 | 1990 |
| Old Waterford Road Dam | Nichols, Neal C | Significant | 28.0 | |
| Birch Street Johnson Dam | 19712 Greggsville A LLC | High | 26.0 | |
| Corti-Jencen Dam | Birch Street LLC | Unknown | 25.0 | |
| JT Gable Dam | J T Gable Properties LLC | | 28.0 | |
| Loudoun Golf Dam | Loudoun Golf & Country Club | | 24.0 | |
| Nordgren Dam | Donald H. & Melody L. Nordgren | | 24.0 | |
| Round Hill Dam | Town of Round Hill | | 28.0 | |
| Stoneleigh Dam | Stoneleigh Gulf Club LC | | 24.0 | |

### 3.11.2 Agricultural Best Management Practices

For over 20 years, the Loudoun Soil and Water Conservation District and U.S. Department of Agriculture have support implementation of best management practices through cost-share programs. The practices include: riparian buffer tree planting, livestock exclusion fencing, and hardened stream crossings for livestock.

As shown in Figure 3-59, there are 315 projects from Loudoun Soil and Water Conservation District with over 38 miles of stream fencing and almost 5,000 acres of riparian buffer and cover crop planting (Loudoun Soil and Water Conservation District 2018). Additionally, the map includes parcels with Conservation Plans developed by Loudoun Soil and Water Conservation District and residential septic projects implemented through the Loudoun County Health Department.

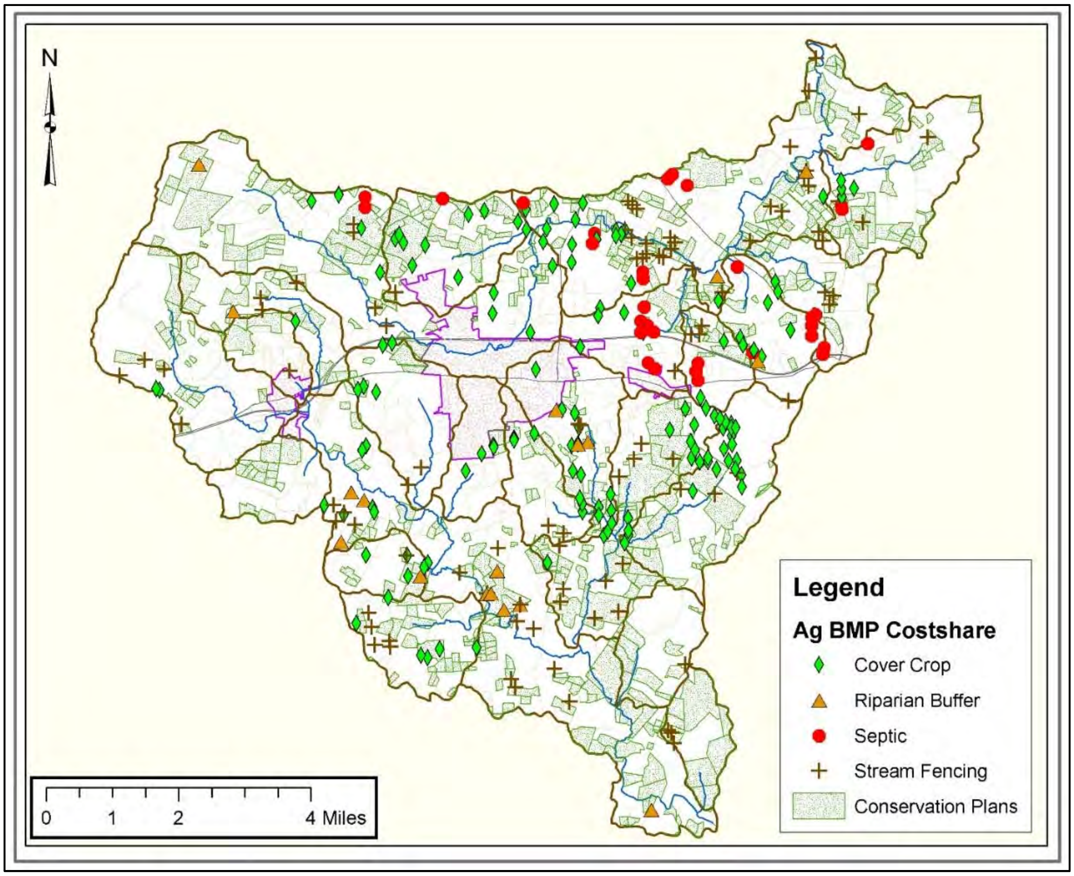


**Figure 3-59: Western Hills Watershed Agricultural Best Management Practices**

### 3.11.3 Tree Planting

Tree planting projects in the Western Hills Watershed have been funded through Loudoun County and Virginia Department of Forestry (VDOF) programs to improve riparian buffers (Figure 3-60).

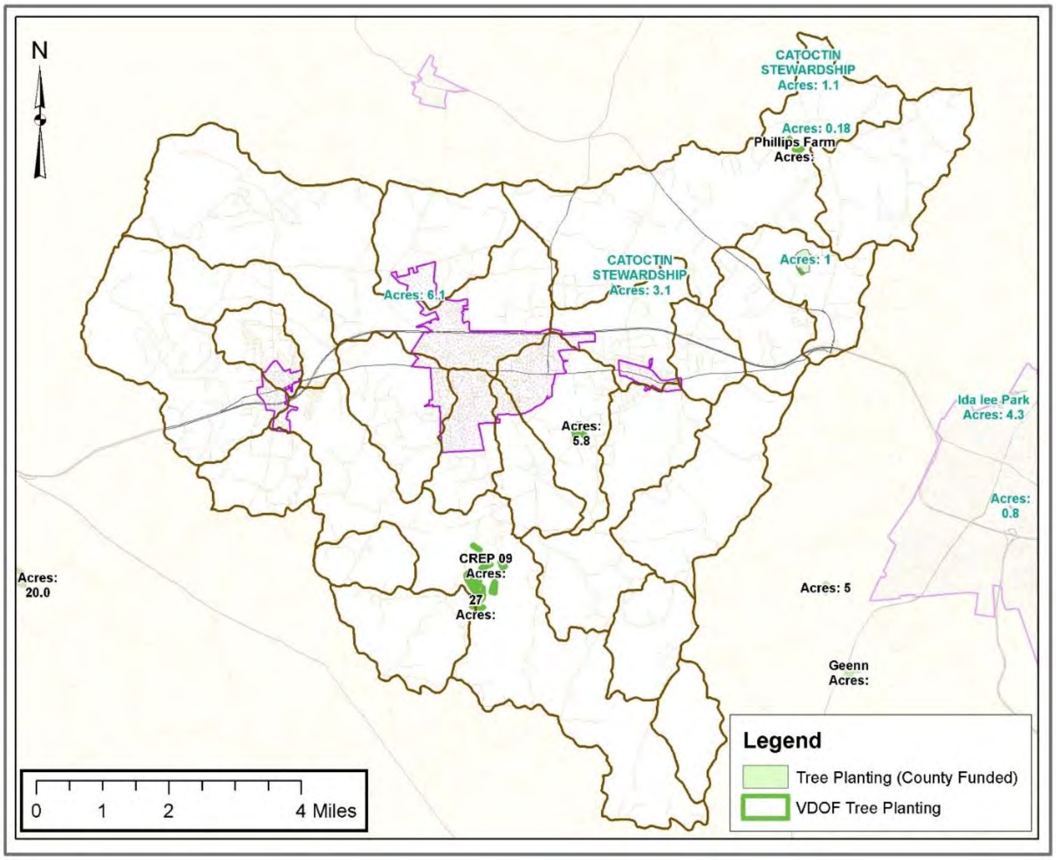


**Figure 3-60: Western Hills Watershed Tree Planting**

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# CHAPTER 4: FIELD ASSESSMENT

Field assessments were conducted in the Western Hills Watershed to evaluate current stream and upland conditions and to inform the development of recommendations for the watershed management plan. This chapter summarizes findings from these stream and upland assessments and provides an overview of some recommended types of restoration actions. Further information about specific recommendations is found in Chapter 8, Subwatershed Restoration Strategies.

## 4.1 Stream Corridor Assessment

Stream corridor assessments (SCAs) were conducted for a subset of stream reaches within the Western Hills Watershed. The stream reaches were assessed according to the SCA Survey Protocols manual, which was developed to provide a method for the rapid assessment and documentation of environmental problems occurring within stream corridors (Yetman 2001). This method helps identify areas in need of more detailed monitoring, management, or conservation efforts on the watershed and subwatershed scale. Background information provided in this section is in part adapted from Loudoun County's Upper Broad Run Watershed Management Plan (Roth et al. 2014).

### 4.1.1 Site Selection

A set of candidate streams were selected for stream and riparian buffer assessment by applying the following process and criteria to select a target of approximately 10 stream miles:

- Publicly owned parcels, along with parcels owned by Homeowner Associations (HOAs) or those with conservation easements, were identified.
- Streams flowing through public, HOA, or conservation easement parcels were initially selected for desktop review. In some locations, connecting stream segments on other privately owned parcels were added to increase connectivity, bringing the total set of initial candidate streams to 33 miles.
- These streams were reviewed using aerial imagery and other data to identify assessment reaches that would be representative of watershed conditions and that would be likely to provide restoration opportunities. Stream reaches were categorized into three groups (Priority 1, Priority 2, and other) based on their location in the watershed and parcel ownership. Proximity to known erosion points or degraded stream habitat conditions (from 2009 Loudoun County Stream Assessment data), position downstream of urbanized areas, and proximity to other assessment types were also considered in assigning priorities. Priority 1 streams were on public, HOA, or conservation easement lands. Priority 2 streams included mostly connecting streams and other reaches on private land, located on properties including residential, agricultural, golf course, and other private ownership. The total length of Priority 1 and 2 streams was approximately 16 miles.

Loudoun County staff mailed permission letters to the owners of each property that intersected a stream segment that was selected for the stream surveys. After the County received responses and made some follow-up contacts, permission was granted for nearly all of the Priority 1 streams and a sufficient number of Priority 2 streams.

### 4.1.2 Assessment Protocol

The SCA method is used to quickly assess physical conditions and identify common environmental problems in a stream corridor. A custom geodatabase and electronic data forms for the various assessment components were created to allow field crews to collect all stream assessment data using a mobile GIS application, Collector for ArcGIS. During December 2018 through February 2019, two-person field crews walked the wadeable streams in Western Hills and recorded data on habitat conditions, ratings of bank erosion hazard potential, and observations on the following nine environmental problems:

- Erosion
- Inadequate Buffers
- In or Near Stream Construction
- Fish Migration Barriers
- Channel Alterations
- Trash Dumping
- Pipe Outfalls
- Exposed Pipes
- Other Unusual Conditions or Comments

The field survey teams walked along streams and the selected stream corridors, electronically recording data for each type of assessment and capturing site coordinates using a Global Positioning System (GPS) unit. At least one photograph was taken at each site to document the conditions observed. Each site was assigned a unique identification (ID) number. After returning from the field, all data were subjected to a quality assurance review.

The field survey teams scored each problem site on a scale of one to five for severity. A score of five denotes a minor problem, or one that is easily fixed, and a score of one is the worst problem observed in a problem category. The criterion for scoring problem severity is dependent on the problem type and is described in detail in the SCA manual (Yetman 2001). The severity rating is a measure of how bad a problem site is compared to other problems in the same category; the most severe problems are those with a direct and wide impact on stream resources. These scores can also help prioritize potential restoration opportunities.

### 4.1.3 Summary of Sites Investigated

Stream assessment surveys were conducted within all five of the major subwatersheds within the Western Hills Watershed Management Area. These five subwatersheds are aggregations of the smaller 23 subwatersheds used in the desktop analysis (Chapter 3) and are used here as organizing units for presenting field results. They represent major subdivisions of the two watersheds, South

Fork Catoctin Creek and North Fork Goose Creek that make up the Western Hills Watershed Management Area. A summary of the length of stream assessed within each subwatershed is presented in Table 4-1. A map showing the location of each assessed stream reach is presented in Figure 4-1. The Upper North Fork Catoctin Creek subwatershed had the largest number of assessed stream miles. The Lower North Fork Goose Creek had the second largest amount of assessed stream miles.

A summary of the number and location of habitat assessment sites and documented environmental problems is presented in Table 4-2. Erosion and inadequate buffers were among the most common problems observed during the SCA surveys. Many of the other environmental problems documented during SCA surveys (e.g., channel alteration, exposed pipes) are more common in areas that have been urbanized for several decades, and thus were not observed in the majority of the assessed stream segments in Western Hills. Detailed descriptions of habitat and environmental problem data collected during the field assessments are discussed in Section 4.1.4.

**Table 4-1: Miles of Stream Assessed by Subwatershed**

| Subwatersheds | Stream Miles Surveyed | Total Stream Miles | Percent of Total Stream Miles Surveyed |
|---|---|---|---|
| Upper South Fork Catoctin Creek | 2.61 | 20.60 | 12.7 |
| Lower South Fork Catoctin Creek | 1.98 | 36.38 | 5.4 |
| Upper North Fork Goose Creek | 1.51 | 13.62 | 11.1 |
| Lower North Fork Goose Creek | 2.47 | 43.75 | 5.6 |
| Crooked Run | 1.26 | 23.99 | 5.3 |
| Totals | 9.83 | 138.34 | 7.1 |

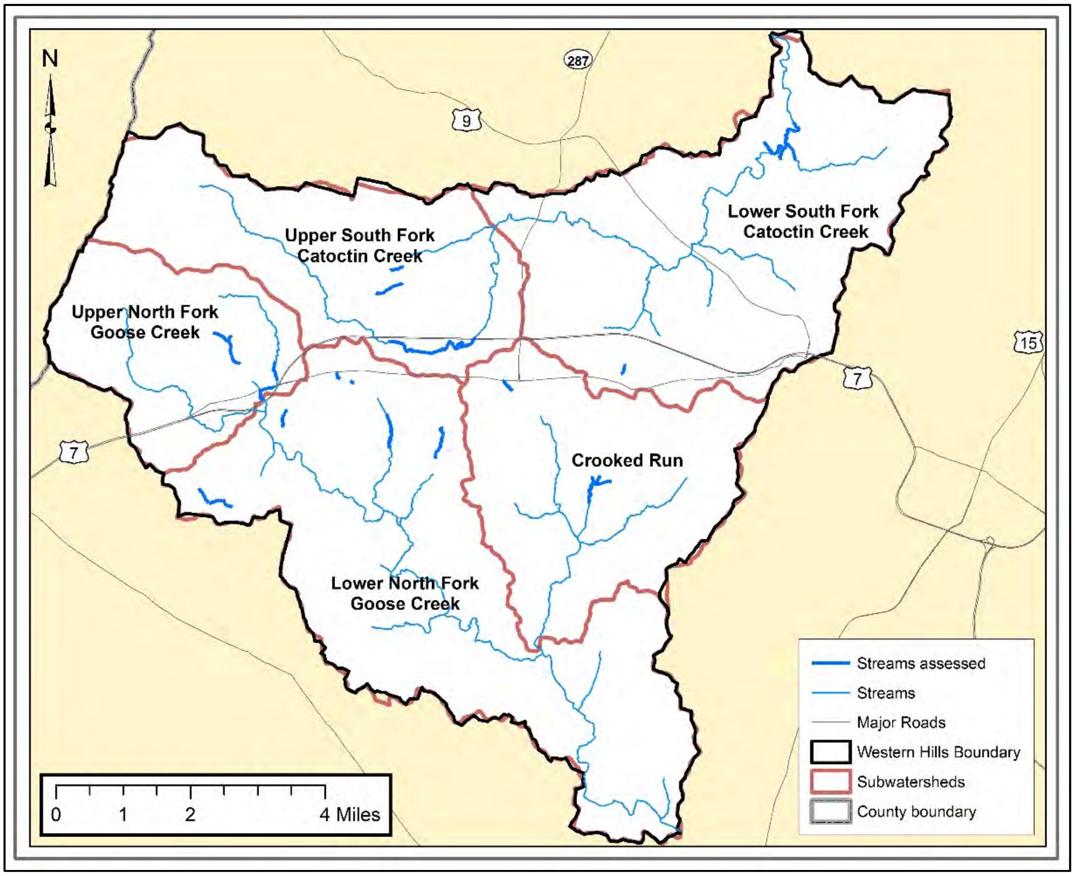


**Figure 4-1: Locations of Stream Corridor Assessments Conducted in Western Hills Watershed**

**Table 4-2: Western Hills SCA Survey Results – Habitat Assessments and Environmental Problem Totals**

| Subwatersheds | Number of Habitat Assessments | Channel Alterations | Erosion | Exposed Pipe | Fish Barrier | In or Near Stream Construction | Inadequate Buffer | Pipe Outfall | Trash Dumping | Unusual Condition or Comment |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper South Fork Catoctin Creek | 16 | 2 | 17 | 0 | 3 | 1 | 2 | 1 | 0 | 4 |
| Lower South Fork Catoctin Creek | 7 | 1 | 36 | 1 | 2 | 0 | 3 | 6 | 2 | 1 |
| Upper North Fork Goose Creek | 14 | 3 | 14 | 0 | 1 | 0 | 4 | 7 | 0 | 4 |
| Lower North Fork Goose Creek | 13 | 2 | 27 | 0 | 3 | 0 | 1 | 3 | 0 | 3 |
| Crooked Run | 6 | 0 | 11 | 0 | 0 | 0 | 4 | 0 | 0 | 2 |
| Totals | 56 | 8 | 105 | 1 | 9 | 1 | 14 | 17 | 2 | 14 |

### 4.1.4 General Findings

#### 4.1.4.1 Habitat Assessments

Representative habitat assessment sites were selected in the field and were used to characterize the Western Hills instream habitat and adjacent stream corridor conditions. Field crews walked each assigned stream and conducted assessments that represented the habitat conditions observed. Where stream character differed, for example related to a transition in surrounding land use, position above and below a road crossing, gradient change, or other variation in physical condition, a new habitat assessment segment was established. Habitat assessments were conducted using methods of Virginia DEQ (2008), which are based on EPA's Rapid Bioassessment Protocol (RBP, Barbour et al. 1999). The high gradient stream methodology was used to qualitatively rate 10 habitat parameters at each representative site as optimal, suboptimal, marginal, or poor based on observed conditions relative to a reference (healthy) stream. Once the field team selected a representative section of stream, they evaluated the 10 habitat parameters that are briefly described below.

- ***Epifaunal Substrate/Available Cover:*** Optimal substrate/cover conditions are those stream bottoms with more than 50 percent of favorable cover characteristics such as mix of snags, undercut banks or other stable habitat. Poor substrate would provide less than 10 percent stable habitat for epifaunal (benthic organisms) and fish colonies.
- ***Embeddedness*****:** The embeddedness evaluation characterizes the extent to which rocks, gravel, cobble, and/or boulders in riffles are covered or sunken into the silt, sand, or mud of the stream bottom. The embeddedness parameter evaluates how much of the substrate present at a site is actually available to the fish and benthic macroinvertebrates in a stream. Excess sediment settled around cobble and gravel can choke stream organisms and fill in the spaces they would otherwise be able to occupy and use for shelter and defense.
- ***Velocity/Depth Regime:*** If there was a balance of fast-shallow, fast-deep, slow-shallow, and slow-deep in a representative stream section, it was rated as optimal for depth regime. Sites where there was little variability in depth regime or where the stream was mostly slow-deep or slow-shallow were rated as marginal or poor.
- ***Sediment Deposition:*** Optimal sediment deposition conditions were those sites with little or no sand bars/islands and little impact to the bottom by sediment deposition. Sites where there were heavy deposits of fine material and indications of a frequently changing bottom were rated as poor.
- ***Channel Flow Status:*** Optimal channel flow status was those sites where there was sufficient flow such that minimal substrate was exposed. Poor channel flow was the opposite, where very little flow was in the channel and water was present as standing pools.
- ***Channel Alteration:*** An optimal rating for channel alteration was assigned to representative sites with a natural stream pattern and little or no evidence of channelization or dredging. A poor rating was given to sites where more than 80 percent of the stream was channelized (concrete, gabions, etc.) and disrupted with little or no in-stream habitat.

- ***Frequency of Riffles (or bends):*** Optimal channel sinuosity is where bends in the stream increase the length by about 3 or 4 times longer than if it were straight. Sites were rated as poor if the channel section was straight or channelized for a long distance, with no riffles.
- ***Bank Stability:*** Representative sites with stable banks and little or no potential for erosion or failure were rated as optimal for bank stability. Poor ratings were assigned to unstable channels with significant erosion along banks.
- ***Vegetative Protection:*** Optimal bank vegetative protection were those sites with more than 90 percent of bank surfaces covered by native vegetation including trees. Sites were rated as poor for this parameter if less than 50 percent of bank surfaces were covered by vegetation.
- ***Riparian Vegetative Zone Width:*** Representative sites with a minimum riparian buffer of 50 to 60 feet and where human activities/development have not impacted the buffer were rated as optimal. Sites with less than 20 feet of riparian buffer zone and where there was little or no vegetation due to human activities were considered as poor for this category.

A total of 56 representative habitat sites were assessed during the Western Hills SCA, including 16 sites in Upper South Fork Catoctin Creek, 7 sites in Lower South Fork Catoctin Creek, 14 sites in Upper North Fork Goose Creek,13 sites in Lower North Fork Goose Creek, and 6 sites along Crooked Run (Table 4-2). Table 4-3 presents the collective number of habitat sites rated as optimal, suboptimal, marginal, or poor for each habitat parameter assessed.

As shown in Table 4-3, most habitat sites were rated as suboptimal or marginal for epifaunal substrate and available cover conditions, embeddedness, and sediment deposition. Riparian vegetation zone width conditions received mostly optimal and sub-optimal ratings. While most of these sites consisted of woody vegetation, herbaceous vegetation was occasionally observed rather than wooded buffers. Forested areas generally provide the best riparian buffers because they provide shading, organic material inputs, and other functions that improve water quality and conditions for wildlife, in addition to serving as a filter to intercept pollutants before they are washed into streams. Potential stream restoration efforts are best focused on parameters with less than optimal ratings (particularly important are vegetative protection and riparian vegetative zone width). Channel flow status was most often recorded as good, with a rating of either optimal or suboptimal. Similarly, channel alteration conditions were most often rated as suboptimal or optimal. Relatively few poor designations were given during the habitat assessment portion of the stream survey.

Locations and overall habitat score ratings for the 2018-2019 SCA representative habitat assessment sites, are shown in Figure 4-2. Figure 4-3 shows these scores, along with habitat assessment ratings from the 2009 Loudoun County Stream Assessment (Roth et al. 2009). Figure 4-4 depicts three example habitat sites with different ratings for overall habitat score.

**Table 4-3: Western Hills SCA Survey Results -
Distribution of Habitat Ratings Collectively by Parameter**

| Parameter | Optimal | Suboptimal | Marginal | Poor |
|---|---|---|---|---|
| Epifaunal Substrate/ Available Cover | 12 | 26 | 13 | 5 |
| Embeddedness | 11 | 22 | 16 | 7 |
| Velocity/Depth Regime | 8 | 24 | 24 | 0 |
| Sediment Deposition | 7 | 16 | 28 | 5 |
| Channel Flow Status | 21 | 27 | 7 | 1 |
| Channel Alteration | 42 | 9 | 3 | 2 |
| Frequency of Riffles (or bends) | 21 | 21 | 11 | 3 |
| Bank Stability | 18 | 16 | 17 | 5 |
| Vegetative Protection | 8 | 9 | 33 | 6 |
| Riparian Vegetative Zone Width | 39 | 10 | 6 | 1 |
| **PERCENT OF TOTAL** | 33.3 | 32.2 | 28.2 | 6.3 |

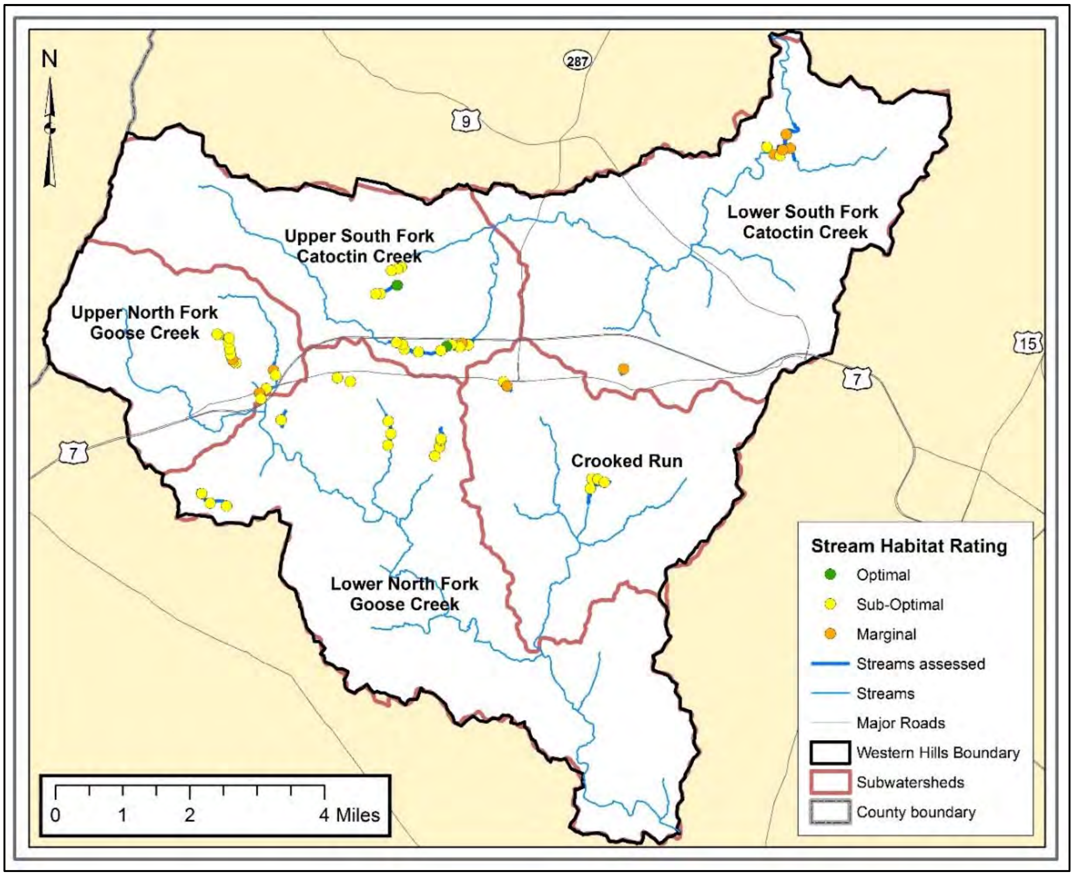


**Figure 4-2: Western Hills Stream Habitat Assessment Ratings, 2018-2019 surveys**

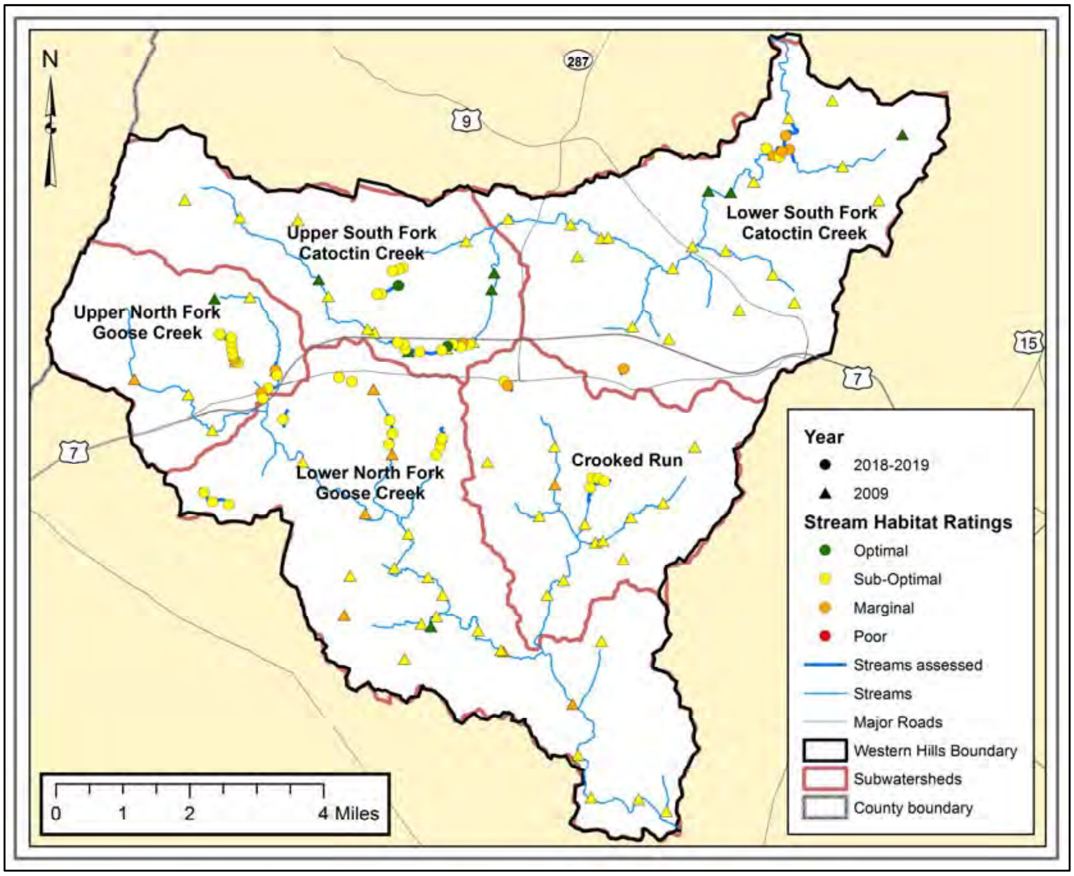


**Figure 4-3: Western Hills Stream Habitat Assessment Ratings, 2009 and 2018-2019 surveys**

Stream reach with an optimal habitat rating

Stream reach with a suboptimal habitat rating

Stream reach with a marginal habitat rating

**Figure 4-4: Three Western Hills Habitat Sites with Three Different Habitat Ratings**

#### 4.1.4.2 Erosion Sites

Stream bank erosion is a natural fluvial process, but anthropogenic changes to a stream's hydrology or sediment supply often accelerate this process. The most common cause of stream bank erosion in urbanized areas is an increase in shear stress applied to the banks from enhanced overland flows due to a high degree of impervious cover in the upstream drainage area. Many watersheds with recent urban/suburban development, such as Western Hills, have a surplus of sediment that has been stored in valley bottoms because of the historic presence of mill dams, coupled with erosion from uplands after land was cleared for farming. This legacy sediment can be mobilized by the increase in stream power associated with the increase in stormwater runoff that occurs during urbanization, ultimately leading to higher sediment loads (Miller et al. 2019). It is important to document the occurrence of erosion so the appropriate Stormwater Control Measures (SCMs) can be recommended for areas that are contributing to the high flows that are causing erosion and so sites can be targeted for stream restoration projects. Locations of erosion sites are shown in Figure 4-5.

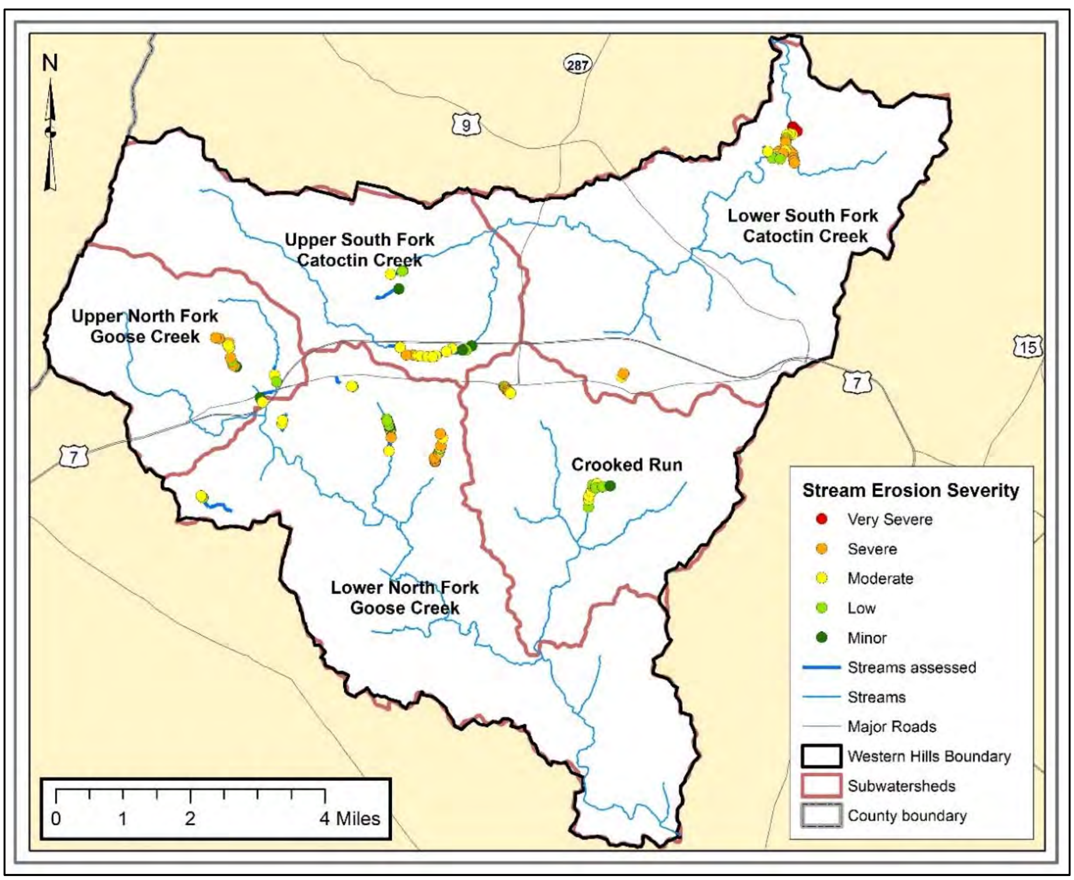


**Figure 4-5: Location of Western Hills SCA Erosion Sites**

Table 4-4 summarizes the length and severity of erosion documented within each subwatershed. A total of 105 erosion sites were documented within the Western Hills Watershed. The total length of erosion identified within the watershed was estimated at 16,618 feet, or approximately 16 percent of the streambank length along assessed streams. Of the assessed stream reaches, the Lower South Fork Catoctin Creek subwatershed had the highest number of documented erosion sites and longest stream length affected by erosion, but the Upper North Fork Goose Creek Watershed had the highest percentage of surveyed stream miles exhibiting erosion, although it was the smallest of the five subwatersheds surveyed.

**Table 4-4: Western Hills SCA Survey Results – Erosion Sites**

| Subwatershed | Severity Rating Inventory | | | | | | Stream Length Exhibiting Erosion | | Percent of Total Stream Length Surveyed Exhibiting Erosion |
|---|---|---|---|---|---|---|---|---|---|
| | Very Severe | Severe | Moderate | Low Severity | Minor | Total | Feet | Miles | |
| Upper South Fork Catoctin Creek | 0 | 2 | 9 | 2 | 4 | 17 | 2,939 | 0.56 | 10.7 |
| Lower South Fork Catoctin Creek | 4 | 16 | 10 | 6 | 0 | 36 | 4,960 | 0.94 | 23.7 |
| Upper North Fork Goose Creek | 0 | 5 | 5 | 2 | 2 | 14 | 4,247 | 0.80 | 26.5 |
| Lower North Fork Goose Creek | 1 | 7 | 9 | 9 | 1 | 27 | 2,752 | 0.52 | 10.5 |
| Crooked Run | 0 | 1 | 4 | 5 | 1 | 11 | 1,720 | 0.33 | 13.1 |
| Totals | 5 | 31 | 37 | 24 | 8 | 105 | 16,618 | 3.15 | 16.0 |

Approximately 66 percent of the documented erosion sites were rated as either moderate, low, or minor severity. Overall, 5 sites were rated as exhibiting very severe erosion and 31 were rated as severe erosion. Lower South Fork Catoctin Creek had the greatest proportion of erosion sites rated as very severe to severe. Figure 4-6 depicts examples of erosion sites documented within the watershed that were assigned a rating of severe.

**Figure 4-6: Examples of Sites with Severe Erosion, ES031 and ES033**

Another method for evaluating bank erosion is the Bank Erosion Hazard Index (BEHI), which evaluates several features of the bank indicative of erosion potential, including bank angle, density and depth of roots, and vegetative protection of the bank (Rosgen 2001, West Virginia DEP 2015). This information, combined with a qualitative assessment of near-bank stress (Rosgen 2006, as cited in Starr et al. 2015), can be useful in assessing sites for restoration opportunities. Of the 105 erosion sites noted in Western Hills, 8 had a BEHI rating indicating the greatest potential for erosion (Extreme to Very High), 30 were rated as High, 43 rated Moderate, 7 rated Low, and 17 rated Very Low (Table 4-5). Qualitative near-bank stress ratings ranged from Extreme to Low.

**Table 4-5: Western Hills SCA Survey Results – Bank Erosion Hazard Index**

| Subwatershed | BEHI Rating Inventory | | | | | | |
|---|---|---|---|---|---|---|---|
| | Extreme | Very High | High | Moderate | Low | Very Low | Total |
| Upper South Fork Catoctin Creek | 0 | 0 | 5 | 6 | 2 | 4 | 17 |
| Lower South Fork Catoctin Creek | 0 | 1 | 8 | 12 | 5 | 10 | 36 |
| Upper North Fork Goose Creek | 0 | 2 | 5 | 7 | 0 | 0 | 14 |
| Lower North Fork Goose Creek | 0 | 2 | 7 | 15 | 0 | 3 | 27 |
| Crooked Run | 1 | 2 | 5 | 3 | 0 | 0 | 11 |
| Totals | 1 | 7 | 30 | 43 | 7 | 17 | 105 |

#### 4.1.4.3 Inadequate Stream Buffers

Forested buffer areas along streams are important for improving water quality and flood mitigation because they can reduce surface runoff, stabilize stream banks (with root systems), shade streams, remove pollutants such as nutrients and sediment from runoff and provide habitat. For the SCA, a stream buffer was considered inadequate if it was less than about 50 feet wide from the edge of the stream. Inadequate stream buffers were observed at various sites in the Western Hills SCA survey area; most of these sites were associated with pastures or lawns. The field team identified a total of 14 inadequate buffer sites in the surveyed area, corresponding to a total length of about 15,491 linear feet, with 8,635 linear feet on the left bank, and 6,856 linear feet on the right bank. These data indicate that approximately 14.9 percent of the total streambank surveyed was considered as having an inadequate stream buffer.

The severity of inadequate stream buffers was rated according to length and width. Figure 4-7 depicts one typical site that was rated as possessing a severe inadequate buffer. A few sites represented potential opportunities for stream buffer reforestation, but these were in some cases limited because of the presence of the County sewer line Right-of-Way (ROW) within the stream corridor.

**Figure 4-7: Example of Inadequate Buffer Site Rated as Severe, IB204**

Table 4-6 summarizes the number of inadequate buffer sites associated with each severity rating and the length of inadequate buffer observed by stream. This table also presents the proportion of the total stream miles surveyed considered to have inadequate stream buffer.

**Table 4-6: Western Hills SCA Survey Results – Inadequate Stream Buffers**

| Subwatershed | Severity Rating Inventory | | | | | | Stream Length with Inadequate Buffer | | Percent of Total Stream Length Surveyed with Inadequate Buffer |
|---|---|---|---|---|---|---|---|---|---|
| | Very Severe | Severe | Moderate | Low Severity | Minor | Total | Feet | Miles | |
| Upper South Fork Catoctin Creek | 0 | 0 | 1 | 1 | 0 | 2 | 410 | 0.08 | 1.5 |
| Lower South Fork Catoctin Creek | 0 | 2 | 1 | 0 | 0 | 3 | 2,300 | 0.44 | 11.1 |
| Upper North Fork Goose Creek | 1 | 0 | 1 | 1 | 1 | 4 | 2,751 | 0.52 | 17.2 |
| Lower North Fork Goose Creek | 1 | 0 | 0 | 0 | 0 | 1 | 200 | 0.04 | 0.8 |
| Crooked Run | 0 | 0 | 4 | 0 | 0 | 4 | 9,830 | 1.86 | 73.8 |
| Totals | 2 | 2 | 7 | 2 | 1 | 14 | 15,491 | 2.94 | 14.9 |

The number of inadequate buffer sites were unevenly distributed among the five subwatersheds. Crooked Run had the greatest total length of inadequate stream buffer. About three-quarters of the length of the miles surveyed in Crooked Run had inadequate buffers, mostly due to surrounding pasture. Most of the inadequate buffer sites observed were rated as moderate in severity. Four out of the 10 total sites identified as lacking riparian buffer were considered severe to very severely inadequate, which could be a priority for stream buffer restoration. The distribution of inadequate stream buffer locations in the surveyed subwatersheds and their severity ratings are shown in Figure 4-9.

### 4.1.4.4 In or Near Stream Construction

There was only a single site (Upper South Fork Catoctin Creek) where construction was observed in or near the stream (Figure 4-8). The field team noted the presence of sediment control measures (silt fence and grading) and looked for possible signs of construction-related pollution, particularly sediment, but none were observed. This site was rated as Minor in severity and impacted zero feet of stream.

**Figure 4-8: Near Stream Construction with Super Silt Fence**

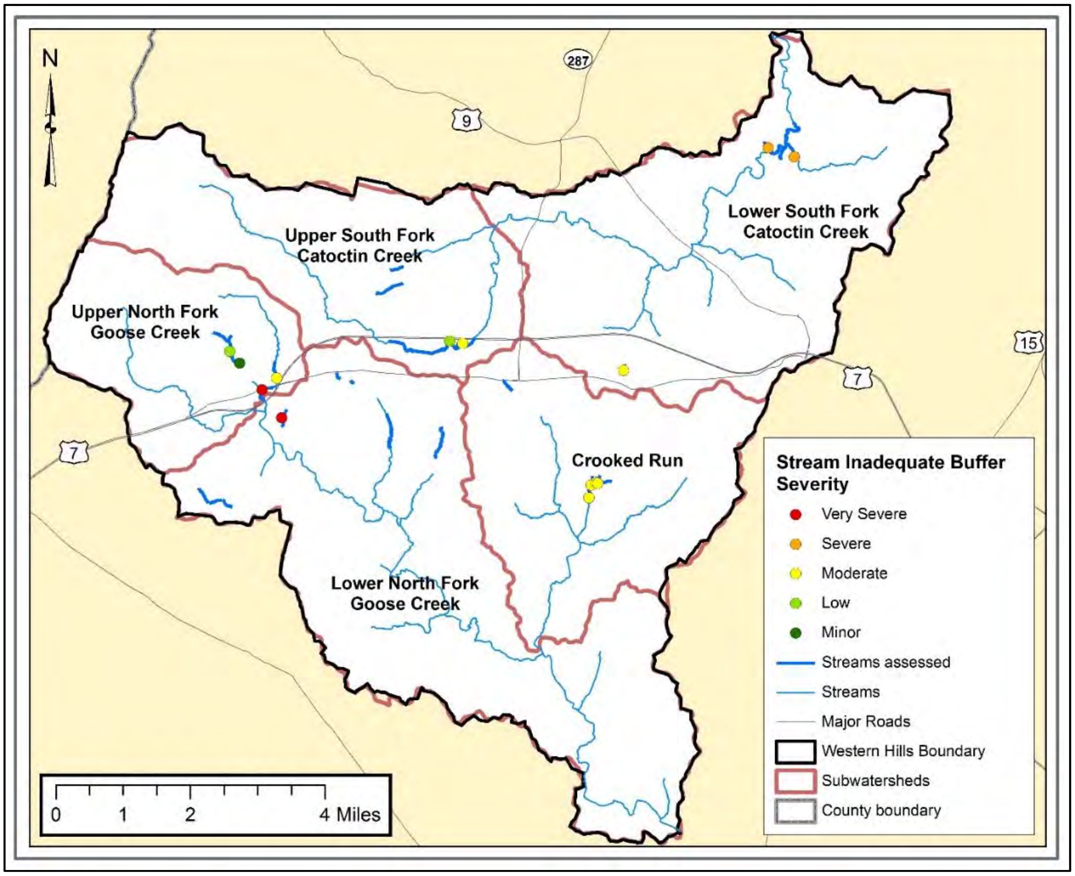


**Figure 4-9: Map of Inadequate Stream Buffers Observed in the Western Hills Watershed**

#### 4.1.4.5 Fish Migration Barriers

A fish migration barrier denotes any structure within the stream channel that significantly interferes with the upstream movement of fish. Unimpeded upstream movement is important for various species that migrate throughout a stream system during different parts of their life cycles (e.g., spawning run). Significant disruptions in migration can lead to a decrease in fish populations and diversity.

Structures can be man-made (e.g., dams or road culverts) or natural (e.g., head cuts, debris jams or beaver dams). Barriers documented within the Western Hills Watershed included debris jams, beaver dams, natural falls, and road crossings (culvert drop). The severity rating of the barriers was primarily based on the drop-in water level and the percent of the stream channel that was blocked. Figure 4-10 shows the locations of fish migration barriers noted during SCA surveys. Table 4-7 summarizes the number of fish migration barrier sites associated with each severity rating.

**Table 4-7: Western Hills SCA Survey Results – Fish Migration Barriers**

| Subwatershed | Severity Rating Inventory | | | | | | Totals |
|---|---|---|---|---|---|---|---|
| | Very Severe | Severe | Moderate | Low Severity | Minor | Unknown | |
| Upper South Fork Catoctin Creek | 0 | 1 | 0 | 0 | 1 | 1 | 3 |
| Lower South Fork Catoctin Creek | 0 | 1 | 0 | 0 | 1 | 0 | 2 |
| Upper North Fork Goose Creek | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Lower North Fork Goose Creek | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crooked Run | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Totals | 3 | 2 | 0 | 0 | 2 | 2 | 0 |

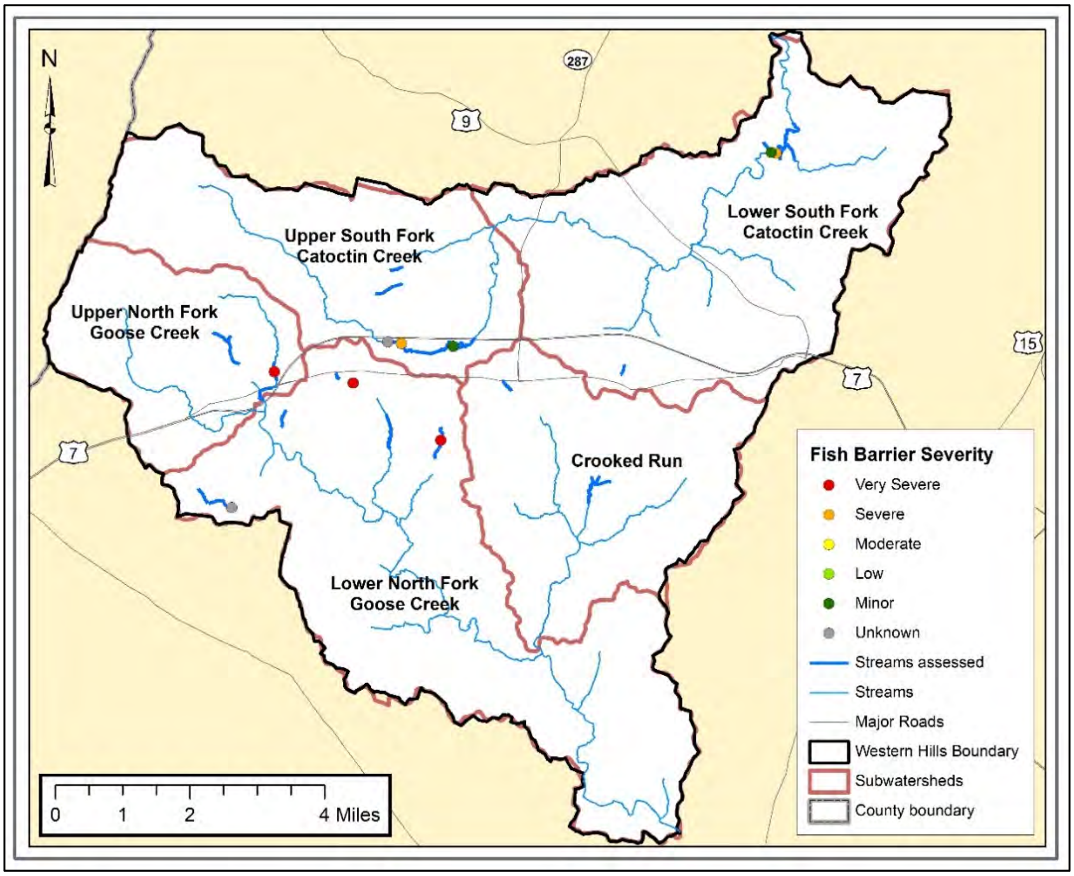


**Figure 4-10: Location of Western Hills Fish Migration Barriers**

### 4.1.4.6 Channel Alterations

Channel alteration refers to stream sections where the banks or channel have been significantly modified from their natural condition. This includes channelized stream sections where the channel has been dredged, widened, straightened, and/or covered with concrete. Channelized streams are typically intended to convey higher flows while preventing flooding and stream instability, but often create adverse environmental impacts such as impaired habitat and increased water temperature. A total of 8 sites with altered channels were documented within the Western Hills Watershed (Figure 4-11). Only one channel alteration site was greater than 300 feet in length, and nearly every alteration was due to road crossing, with one site (Upper North Fork Goose Creek) consisting of 1000 feet of concrete retaining wall. None of these sites posed significant risks to stream fauna.

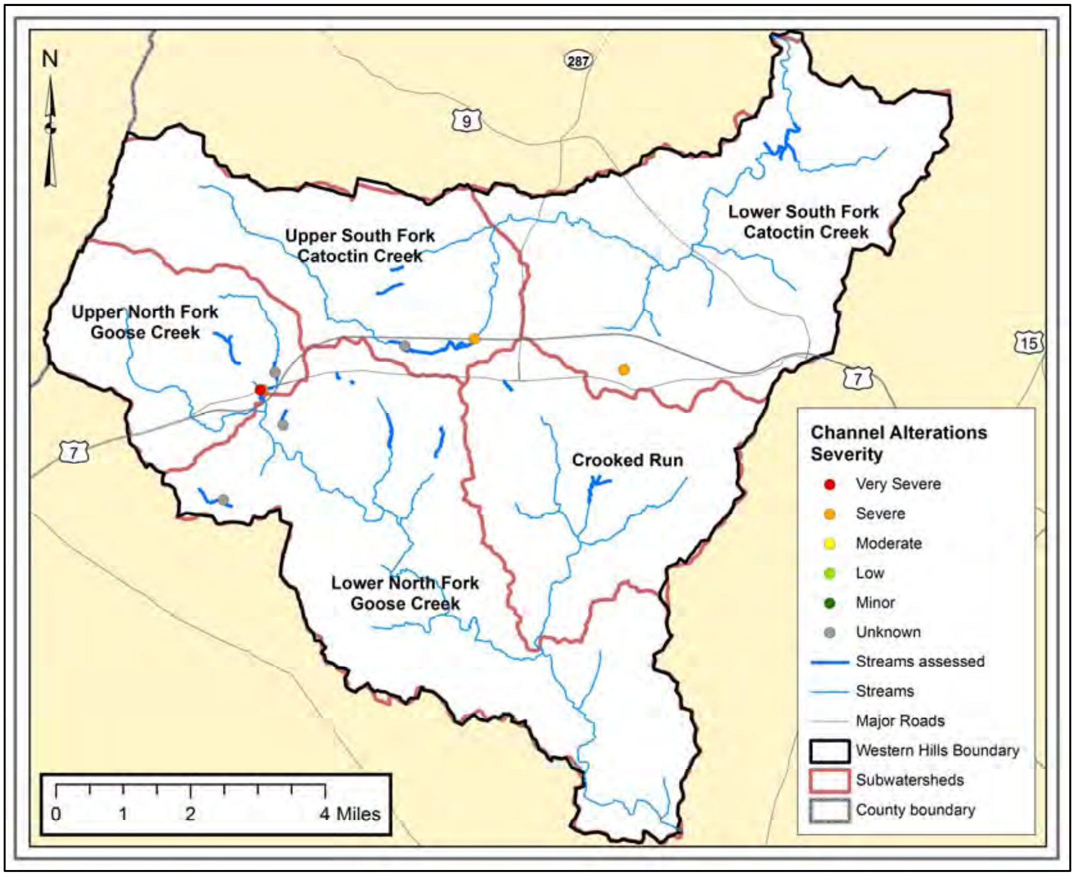


**Figure 4-11: Location of Western Hills Channel Alteration Sites**

#### 4.1.4.7 Trash Dumping

Trash dumping sites are places where large amounts of trash have been dumped or have accumulated inside the stream corridor. Identifying trash dumping sites serves two main purposes. One is to limit access to the areas of the stream corridor, where feasible, where trash dumping and accumulation is a problem. The second is to identify locations suitable for and to encourage volunteer stream clean-ups. These sites often represent a chance to engage the community to take action and to see the condition of their local streams.

A total of only two trash dumping sites were documented as part of the Western Hills SCA survey, both within the Upper North Fork Goose Creek subwatershed (Figure 4-12 and Figure 4-13). The severity of both these trash dumping sites was rated low, according to the amount and type of trash present, their location, and whether cleaning up the trash would present problems (access and safety). Both trash sites were classified as construction debris. Low severity and minor trash dumping sites are those with easy access and typically where there is potential for a volunteer cleanup. The amount of trash was estimated in terms of number of pick-up truck loads for completely clearing the site. Both sites were estimated to contain a single pick-up truck load of material. One trash pile consisted of PVC piping, and the other site consisted of steel pipes and a manhole cover. Both of these sites were considered as possible volunteer projects.

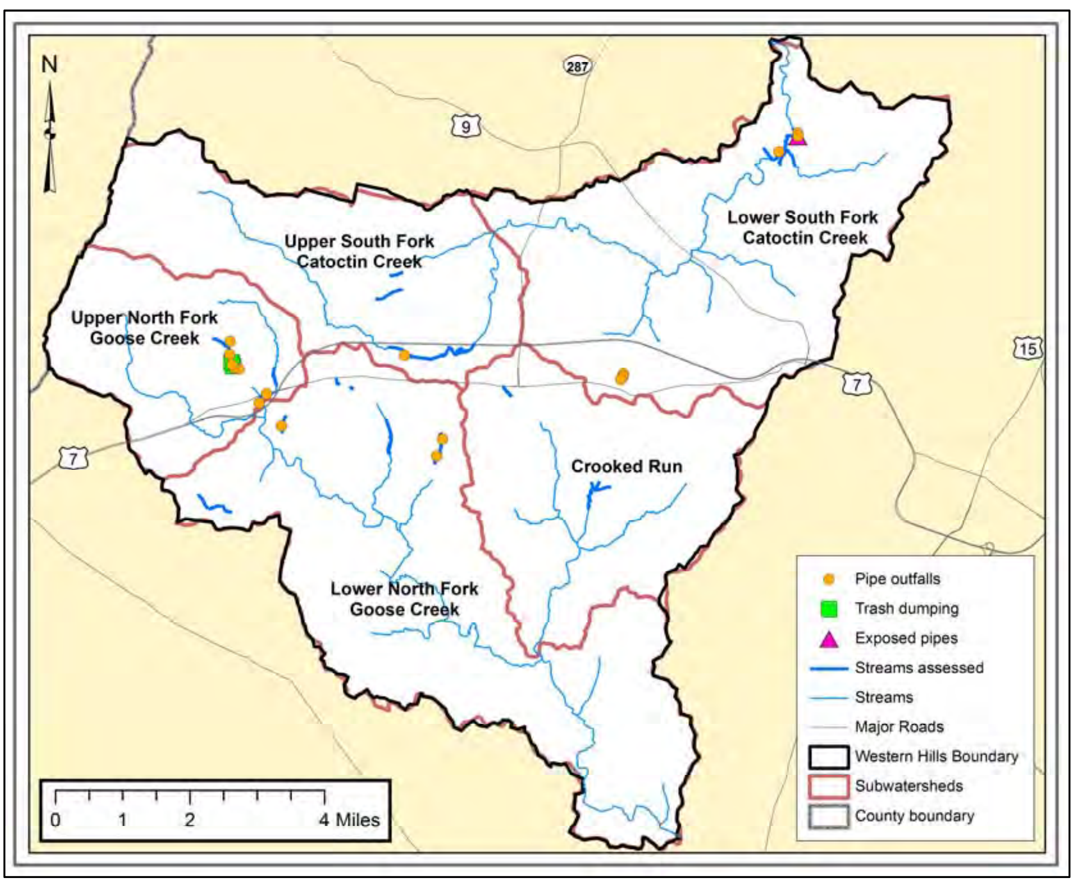

**Figure 4-12: Western Hills Trash Dumping, Pipe Outfall, and Exposed Pipe Locations**

**Figure 4-13: Examples of Two Low Severity Trash Dumping Sites**

### 4.1.4.8 Pipe Outfalls

Pipe outfalls include pipes or small manmade channels that discharge into the stream. These are considered a potential environmental problem because they can carry untreated runoff and pollutants to a stream system. Of particular interest were outfalls that were discharging at the time of the survey for which color and odor of discharge were noted. The pipe material type and size were also recorded. A pipe outfall that had a strong discharge relative to the normal stream flow, a distinct color and/or odor, and where discharge was causing significant impacts downstream would receive the most severe rating. Minor severity ratings were assigned to outfalls intended to carry storm water that did not have dry weather discharge and did not cause erosion problems. The severity rating for a pipe outfall was primarily based on the discharge including whether discharge was present, color, odor, amount, and downstream impacts.

A total of seventeen pipe outfalls were identified during the Western Hills SCA survey. Of these, most were stormwater outfalls. One non-stormwater pipe (Lower South Fork Catoctin Creek) appeared to be sewage and was rated at moderate severity. No outfalls were noted in the Crooked Run portion of the survey. Access and correctability were rated as best for both of the minor outfalls, and correctability was rated best at the sewage pipe outfall. Figure 4-12 shows the location of outfalls noted during SCA surveys. Figure 4-14 depicts the moderate severity Pipe Outfall site that drains to a tributary of the Lower South Fork Catoctin Creek.

**Figure 4-14: Photo of a Moderate Severity Pipe Outfall Site**

#### 4.1.4.9 Exposed Pipes

The severity rating for exposed pipes was based on the amount of pipe exposed, location with respect to the stream, whether structural stability of pipe is affected by erosion, and whether the pipe is leaking. A very severe rating represents any pipe that is leaking or immediate threat of failure such as one likely to collapse, a pipe that runs under the stream bed where part is suspended, a long section along the stream edge that is mostly exposed, or a manhole stack in the center of the stream with evidence of cracks. A moderate rating would be assigned to relatively long sections of exposed pipes with no immediate threat of failure. Minor exposed pipe problems are small sections of exposed pipe adjacent to stable stream banks. These sites can represent a potential threat to water quality and to public health. Consequently, they would be recommended for follow-up inspection.

A total of only one exposed pipe site, rated as moderate severity, was identified during the Western Hills SCA survey. It consisted of a 4-inch PVC pipe of unknown function. It was a 7 foot long exposure in Lower South Fork Catoctin Creek. Correctability was listed as unknown, primarily because the function of the pipe was indeterminate. However, access was rated as best and could be considered for action. Figure 4-12 shows the location of the exposed pipe. Figure 4-15 depicts the exposed pipe within the streambed.

**Figure 4-15: Exposed Pipe within the Stream, within Lower South Fork Catoctin Creek**

#### 4.1.4.10 Unusual Conditions or Comments

The unusual conditions form was used to document problems that did not fit into another category, or to provide additional comments on a specific problem. Unusual conditions typically include an unusual odor or water color, excessive algae, the presence of oil, or a man-made structure within the stream channel that would not fall into the Fish Migration Barrier category. Unusual conditions were ranked as severe if the potential problem was considered to have a direct and wide-reaching impact on the stream's aquatic resources. A site was rated as minor if it was considered to have no significant impact on the stream's aquatic resources. Figure 4-16 shows the locations of the unusual conditions documented within the Western Hills Watershed, and Table 4-8 summarizes the number and severity of unusual conditions recorded within each subwatershed.

**Table 4-8: Western Hills SCA Survey Results – Unusual Conditions**

| Subwatershed | Severity Rating Inventory | | | | | Totals |
|---|---|---|---|---|---|---|
| | Very Severe | Severe | Moderate | Low Severity | Minor | |
| Upper South Fork Catoctin Creek | 1 | 1 | 1 | 0 | 1 | 4 |
| Lower South Fork Catoctin Creek | 0 | 1 | 0 | 0 | 0 | 1 |
| Upper North Fork Goose Creek | 1 | 0 | 0 | 2 | 1 | 4 |
| Lower North Fork Goose Creek | 1 | 0 | 0 | 0 | 2 | 3 |
| Crooked Run | 0 | 1 | 0 | 1 | 0 | 2 |
| Totals | 3 | 3 | 1 | 3 | 4 | 14 |

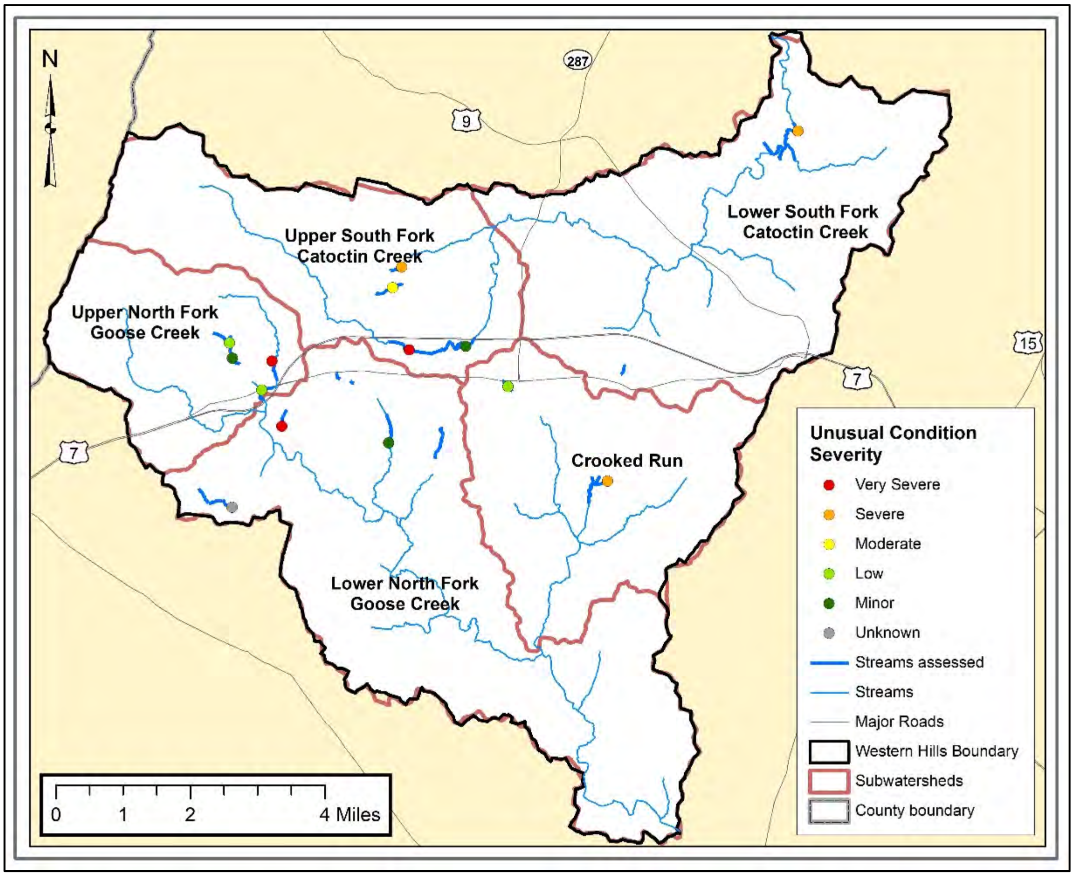


**Figure 4-16: Location of Western Hills Unusual Condition/Comment Sites**

Three unusual conditions documented within the Western Hills Watershed were ranked as very severe, one in each Upper South Fork Catoctin, Upper North Fork Goose Creek, and Lower North Fork Goose Creek. The very severe site in the Upper South Fork Catoctin consisted of a culvert discharging water onto riprap that outfalls 10ft from stream bank causing extreme erosion of stream bank and floodplain area. The very severe condition in Lower North Fork Goose Creek consisted of a collapsed road culvert and eroding bank. The very severe condition in Upper North Fork Goose Creek consisted of a severely eroded pipe outfall channel just outside of the surveyed reach. See examples in Figure 4-17.

**Figure 4-17: Examples of Unusual Conditions Encountered During SCA Surveys.**

## 4.2 Upland Assessments

Upland areas were assessed according to the Unified Subwatershed and Site Reconnaissance (USSR) Manual and the Urban Watershed Forestry Manual developed by the Center for Watershed Protection (Wright et al. 2005, Cappiella et al. 2006) to identify potential pollution sources influencing water quality and to identify restoration project opportunities. The USSR manual is the final manual in a series of 11 regarding techniques for restoring urban watersheds. It provides detailed guidance for field survey techniques and was developed to help watershed groups, municipal staff, and consultants to quickly identify major stormwater pollution sources and to assess subwatershed restoration potential for source controls and improved practices such as education, retrofits, street sweeping, and open space management. The Urban Watershed Forestry Manual includes methods for evaluating urban reforestation opportunities. Background information provided in this section is in part adapted from Loudoun County's Upper Broad Run Watershed Management Plan (Roth et al. 2014).

The field survey of upland areas in the Western Hills Watershed included five major components:

- Neighborhood Source Assessments (NSAs),
- Hotspot Site Investigations (HSIs),
- Institutional Site Investigations (ISIs),
- Urban Reforestation Site Assessments (URSAs), and
- Retrofit Reconnaissance Investigations (RRI)

Each of these components is described in detail in the following sections.

### 4.2.1 Neighborhood Source Assessments (NSA)

NSAs describe pollution source areas, stewardship behaviors, and restoration opportunities within individual neighborhoods. Each neighborhood has unique characteristics that are to be considered in deciding if it is possible and/or necessary to implement restoration projects, source controls, and stewardship practices. The sections below describe the methods used to delineate and assess individual neighborhoods in the Western Hills Watershed.

#### 4.2.1.1 Assessment Protocol

Prior to conducting NSAs in the field, neighborhoods were chosen and delineated by Loudoun County using a subdivision GIS layer. Subdivisions that contained only a few homes or lots subdivided for future development were removed from the pool of neighborhoods considered for assessment. Remaining neighborhoods were selected and delineated based on a subdivision containing a group of homes with similar characteristics including lot sizes, set-backs, year built, and type (condominium complex, townhomes, single family detached, etc.). It was decided that a mix of neighborhood ages and types would be selected for the field assessments.

Field investigations were conducted in November and December 2018, using the NSA protocol documented in the USSR (Wright et al. 2005). The field team drove through every street in a defined neighborhood to identify potential pollution sources and restoration opportunities. To standardize the NSA process and to help prioritize potential restoration efforts, data were collected in each neighborhood for four main source areas: yards and lawns; driveways, sidewalks, and curbs; rooftop runoff; and common areas. These are each described briefly below. Opportunities for tree planting were also noted.

***Yards and Lawns***

Yards and lawns typically represent a significant portion of the pervious cover in an urban sub-watershed and therefore can be a major source of nutrients, pesticides, sediment, and runoff. Maintenance behaviors tend to be similar within individual neighborhoods and certain activities can impact subwatershed quality such as fertilization, pesticide use, watering, landscaping, and waste. Potential pollution sources evaluated under this source category include grass cover and management status (fertilization and irrigation methods), bare soil, outdoor swimming pools, and uncontained junk or trash. The amount of existing shade tree cover and landscaping in neighborhoods were also evaluated, and locations for possible new plantings were noted. These plantings would provide water quality benefits through interception and filtration of stormwater runoff.

***Driveways, Sidewalks, and Curbs***

Driveways, sidewalks, and curbs are common in many urban subwatersheds and link neighborhood runoff to the storm drain system. Activities such as car washing, deicing, and improper chemical storage can contribute pollutants such as nutrients, oil, sediment, and chlorides into the storm drain system. Data were collected for potential pollution sources that might include stained/dirty driveways, sidewalks covered with lawn clippings/leaves or receiving non-target irrigation (source of nutrients and sediment), pet waste (bacteria), long-term car parking (unused old cars with potential to leak chemicals, oil, and/or grease) and the amount of sediment, organic matter, and/or trash present along curbs. Potential for street tree planting and street sweeping was also evaluated based on some of these factors.

***Rooftops***

Rooftop runoff is another contributor to stormwater runoff and pollutants in neighborhoods. Downspout retrofits can help reduce runoff and pollutants introduced to local streams. The field crews identified whether downspouts discharged rooftop runoff to pervious areas, rain barrels, impervious surfaces (driveways, street), and/or directly to the storm drain system, and the proportion of each within a neighborhood. The potential for disconnecting and redirecting downspouts from impervious surfaces or the storm drain system was also evaluated.

***Common Areas***

Common areas such as community parks, parking lots and alleys are good opportunities to see the effects of practices such as pet waste disposal, storm water management, storm drain marking, and how natural areas or buffers are managed. Good upkeep of these areas indicates that residents or a homeowner’s association are active and may represent opportunities for restoration projects. Data was collected on the condition of storm drain inlets (whether they were clean or filled with debris) and presence of pet waste or dumping in common areas to identify potential pollution sources in a neighborhood. The potential for storm drain marking, storm water management practices, and stream buffer planting was also evaluated.

Basic neighborhood information collected to help rate restoration potential included lot size and house types. After inspecting an entire neighborhood and recording basic information and data on the major pollution sources, any major pollutants that were potentially being generated by the neighborhood were noted, including nutrients, oil and grease, trash/litter, bacteria, and sediment. For example, if a neighborhood had several stained driveways and/or several long-term parked vehicles/boats, oil and grease would be flagged as a potential major pollutant being generated in that neighborhood. The presence of trash in several yards or dumping in common areas would be a significant indicator for trash/litter generated in a neighborhood. Sediment was flagged as a major pollutant source if several areas of erosion or bare soil were observed, significant amount of remodeling/ redevelopment was occurring, and/or a considerable portion of the curb and gutters were covered with sediment.

After evaluating an entire neighborhood, field staff were able to recommend specific actions for neighborhoods in the Western Hills Watershed including:

- Downspout disconnection, rain barrels, and rain gardens;
- Fertilizer reduction/education;
- Sustainable landscaping;
- Storm drain marking;
- Stream buffer improvements;
- Open space tree planting; and
- Open space bioretention and rain garden Stormwater Control Measures SCMs.

The last step of the NSA involved rating the overall neighborhood pollution severity and restoration potential. The severity of pollution generated by a neighborhood was denoted by the Pollution Severity Index (PSI) based on benchmarks and scoring system in the USSR manual (Wright et al. 2005). An NSA PSI was rated as severe, high, moderate, or none. A neighborhood's potential for residential restoration projects was rated as high, moderate, or low according to the Restoration Opportunity Index (ROI). The USSR provides benchmarks and guidelines to establish NSA ROI ratings.

#### 4.2.1.2 Summary of Site Investigated

A total of 15 neighborhoods were assessed throughout the Western Hills Watershed (Figure 4-18). The number of neighborhoods assessed within each subwatershed is summarized in Table 4-9. Several of the assessed neighborhoods were located within the town limits of Purcellville, which touches four of the five subwatersheds and has the highest population density and amount of impervious cover in the Western Hills Watershed. Note that a neighborhood may extend into more than one subwatershed; in these cases, the neighborhood was assigned to the subwatershed containing the largest portion of the neighborhood. Of the 15 neighborhoods assessed, none of the neighborhoods were rated as having a severe PSI, three had a high PSI, twelve were assigned a moderate PSI, and zero were assigned a low PSI (Figure 4-19). Four neighborhoods were considered to have a high ROI, ten had a moderate ROI, and one had a low ROI (Figure 4-20). The distribution of PSI ratings is shown in Figure 4-19, and ROI ratings in Figure 4-20.

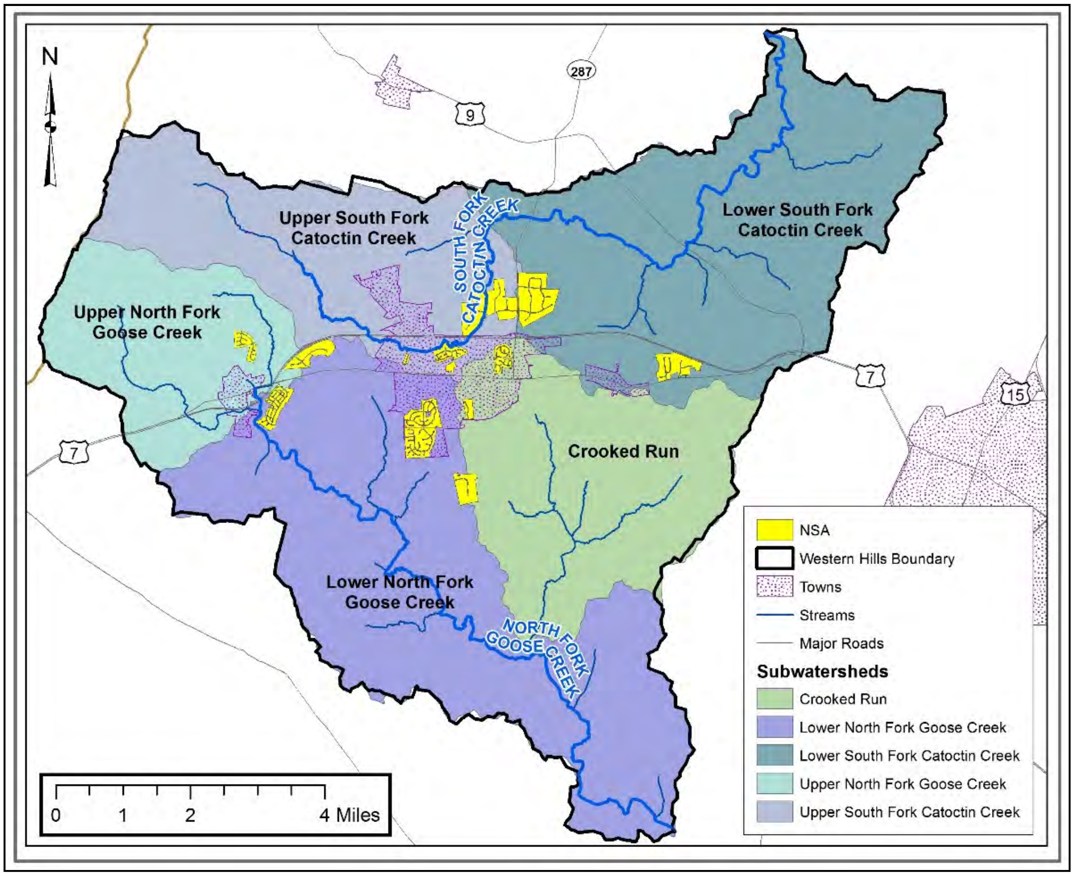


**Figure 4-18: Location of Neighborhood Source Assessments Conducted in Western Hills Watershed**

**Table 4-9: Neighborhoods Surveyed, by Subwatershed**

| Subwatershed | # of NSAs |
|---|---|
| Upper South Fork Catoctin Creek | 4 |
| Lower South Fork Catoctin Creek | 2 |
| Upper North Fork Goose Creek | 1 |
| Lower North Fork Goose Creek | 4 |
| Crooked Run | 4 |
| Total | 15 |

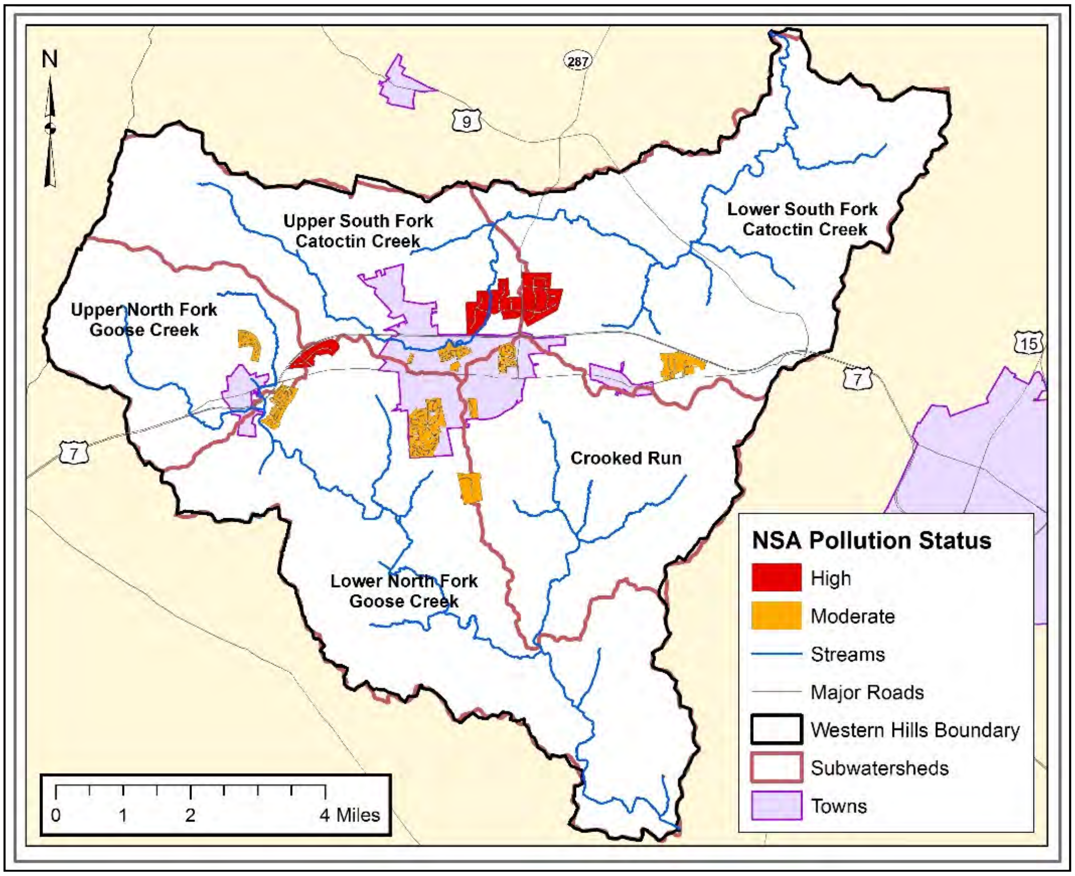


**Figure 4-19: Western Hills NSA Pollution Severity Index (PSI) Ratings**

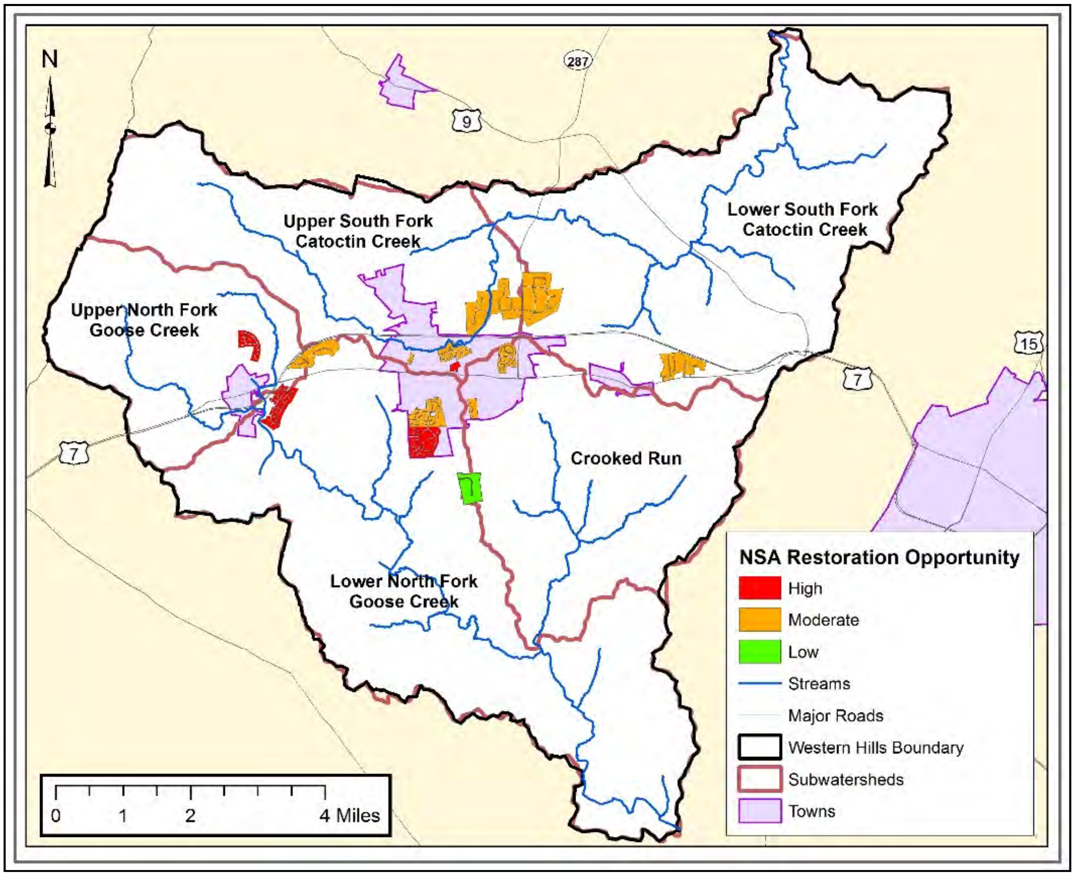


**Figure 4-20: Western Hills NSA Restoration Opportunity Index (ROI) Rating**

#### 4.2.1.3 General Findings

The following subsections describe the actions recommended based on the NSAs. This includes an explanation of the methodologies and criteria used to evaluate the potential for recommended actions and results expected if these actions were applied. Figures showing general locations of neighborhoods recommended for certain actions are included in each subsection.

##### 4.2.1.3.1 Downspout Retrofits: Disconnection, Rain Barrels, and Rain Gardens

Rooftop runoff is managed via downspouts which are considered as either connected or disconnected to the storm drain system. Directly connected downspouts extend underground, discharging runoff directly to the storm drain system without treatment. Indirectly connected downspouts drain to impervious surfaces such as paved driveways, sidewalk, or curb and gutter system with little or no treatment. Retrofitting may involve redirecting connected downspouts from impervious areas or the storm drain system onto pervious areas such as yards and lawns. Infiltration of rooftop runoff requires at least 15 linear feet of pervious area down gradient from the downspout. Under certain conditions, rain barrels and rain gardens are also retrofit options and may be recommended in lieu of redirection. Rain barrels, for example, may be used to store rooftop runoff for irrigation if there is limited pervious area available for downspout redirection, which is most often seen in condominium and townhouse neighborhoods. Rain gardens are the most desirable option in terms of water quality because they consist of amended soils and native plants that capture and treat runoff; this is a potential option for disconnection if the typical neighborhood has several hundred square feet of lawn area available down gradient from the downspout, which is most often seen in single family detached lots.

Downspout redirection is recommended for neighborhoods where at least 25 percent of the downspouts are connected to impervious area or directly to the storm drain system and where the average lot has at least 15 feet of pervious area available down gradient from the connected downspout for redirection. Table 4-10 includes a summary of the number of neighborhoods recommended for downspout disconnection and the acres of rooftop that would be addressed if downspout disconnection was implemented. Neighborhoods specifically recommended for rain gardens and/or rain barrels are also noted in the table.

Figures 4-21, 4-22, and 4-23 show the location of neighborhoods recommended for disconnection, rain barrels, and rain gardens. Out of the 15 neighborhoods assessed, three had the potential for downspout disconnection through redirection, rain barrels, or rain gardens. One was specifically recommended for rain barrels, and two were specifically recommended for rain gardens. NSAs listed below were considered highest priority, but rain garden and rain barrel education was recommended for all neighborhoods. Because lot sizes and circumstances vary, a limited number of homes may actually be suitable for such downspout disconnection practices. While this report offers recommendations for rain barrels, rain gardens, and other residential stormwater approaches, implementation of specific projects will need to consider what is allowed by local HOAs.

**Table 4-10: Downspout Disconnection Recommendations**

| Subwatershed | # of NSAs Recommended for Downspout Disconnection | Rooftop Acres Addressed | # of NSAs Recommended for Rain Barrels | # of NSAs Recommended for Rain Gardens |
|---|---|---|---|---|
| Upper South Fork Catoctin Creek | 1 | 12.3 | 1 | 0 |
| Lower South Fork Catoctin Creek | 0 | 0 | 0 | 0 |
| Upper North Fork Goose Creek | 0 | 0 | 0 | 0 |
| Lower North Fork Goose Creek | 2 | 33.6 | 0 | 2 |
| Crooked Run | 0 | 0 | 0 | 0 |
| Total | 3 | 45.9 | 1 | 2 |

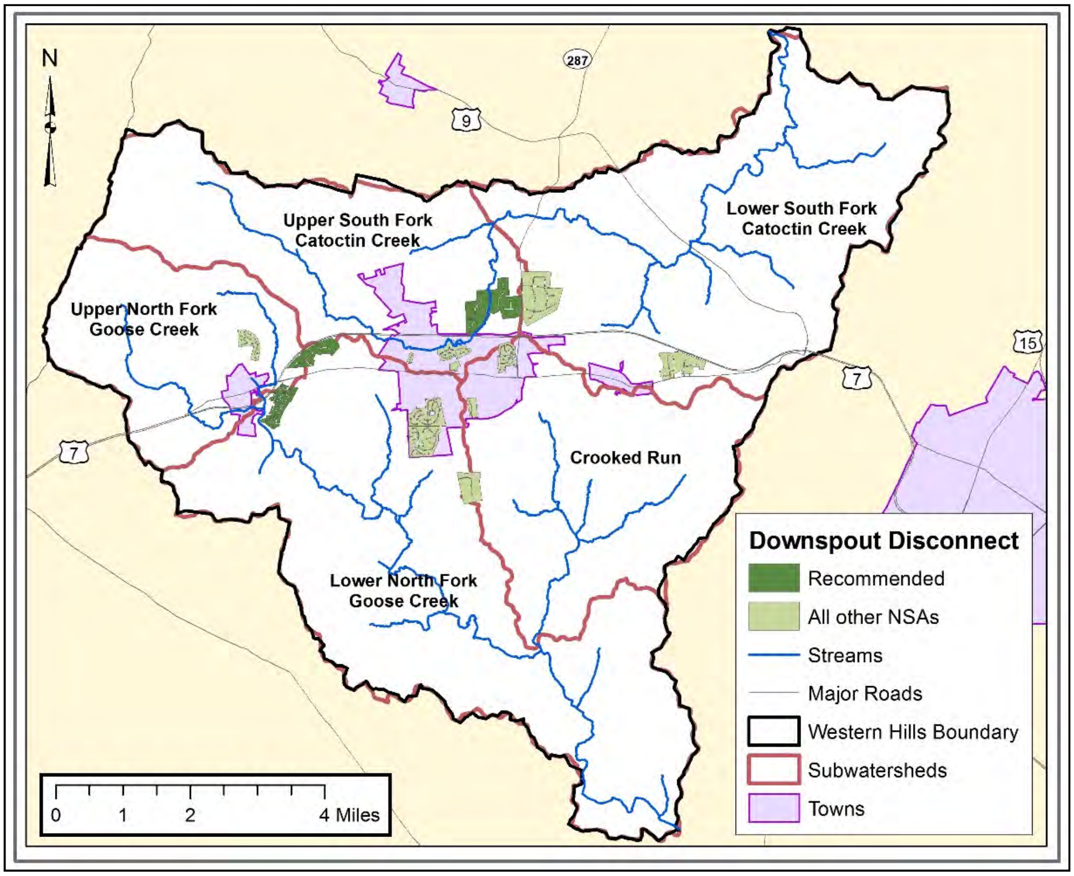


**Figure 4-21: Western Hills Neighborhoods Recommended for Downspout Disconnection**

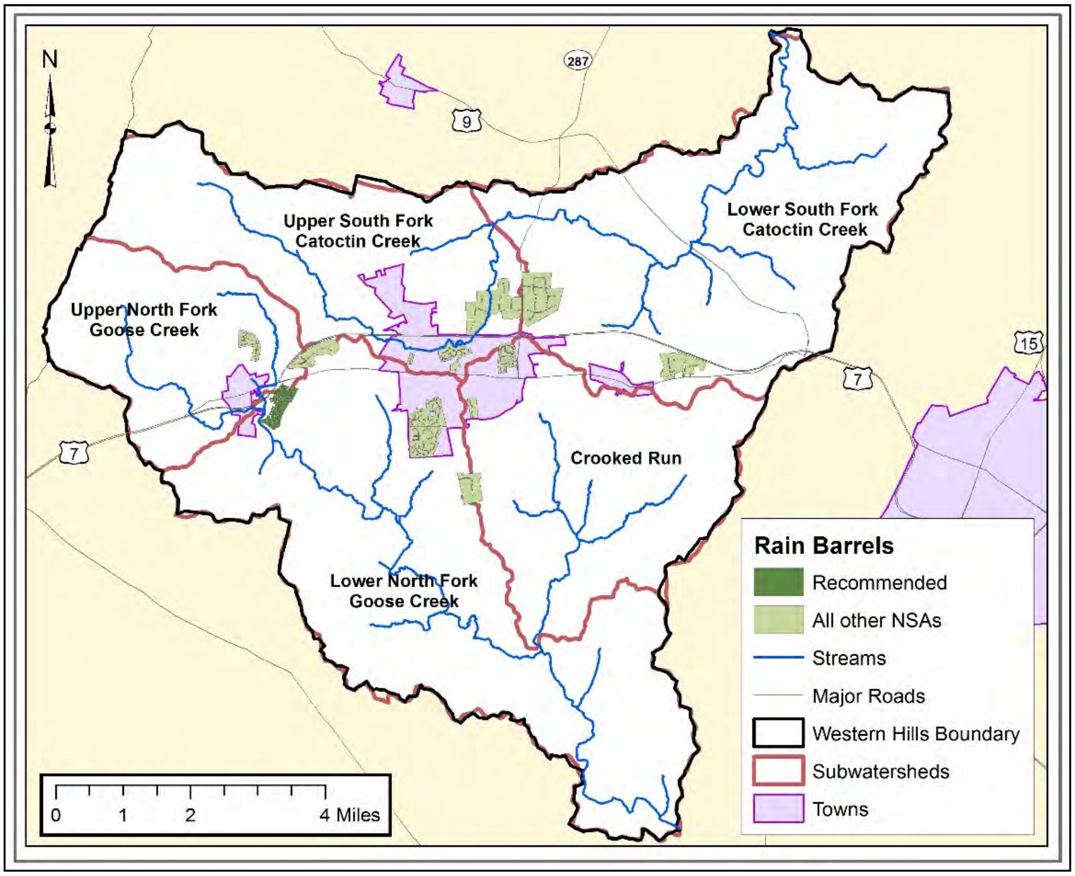


**Figure 4-22: Western Hills Neighborhoods Recommended for Rain Barrels**

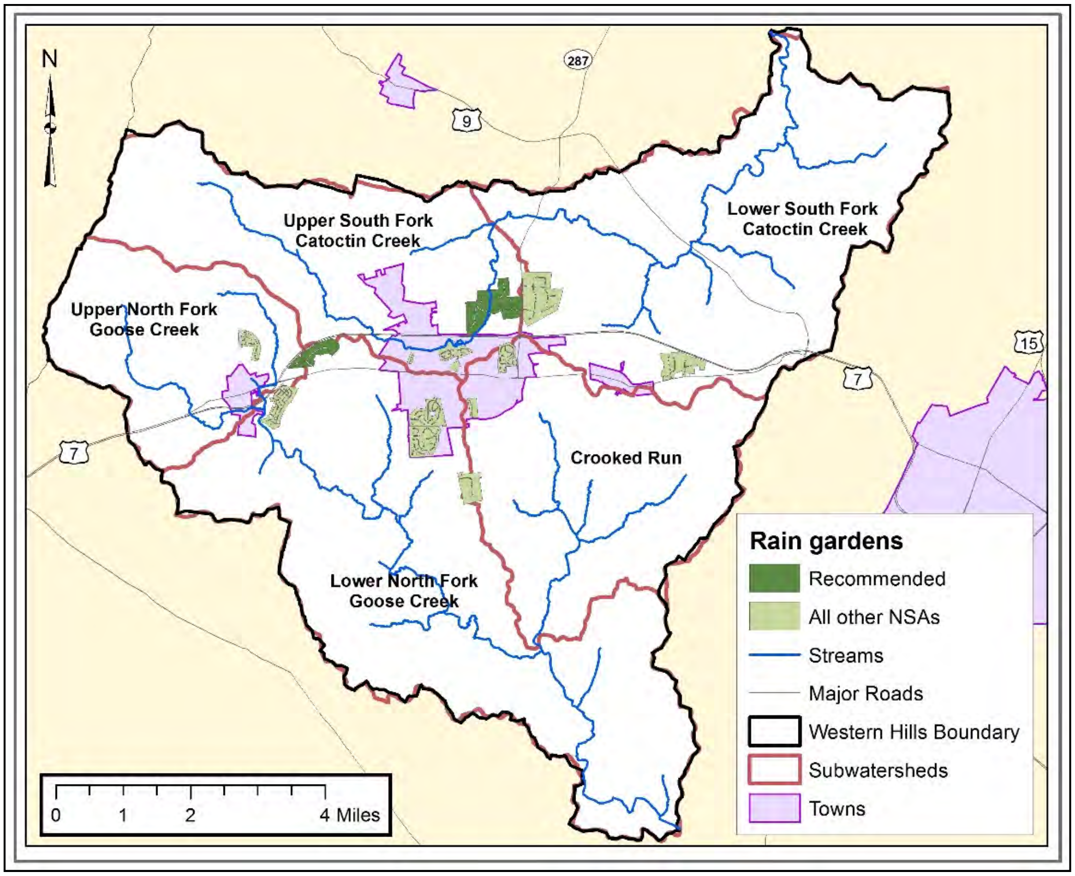


**Figure 4-23: Western Hills Neighborhoods Recommended for Rain Gardens**

#### 4.2.1.3.2 Fertilizer Reduction/Education

A well-maintained lawn can be beneficial to the watershed. However, lawn maintenance activities often involve over-fertilization, poor pest management, and over-watering resulting in polluted stormwater runoff to local streams. Lawns with a dense, uniform grass cover, signs warning of the presence of lawn care chemicals, or sprinkler systems indicate high lawn maintenance activities. Neighborhoods where 20 percent or more of the homes appeared to employ high lawn maintenance practices were recommended for fertilizer reduction/education. Table 4-11 includes a summary of the number of neighborhoods recommended for fertilizer reduction/education and the acres of lawn addressed if implemented. Figure 4-24 shows the location of neighborhoods recommended for fertilizer reduction/education (any neighborhood with 20 – 100 E high maintenance lawns). Ten neighborhoods were recommended for fertilizer reduction/education.

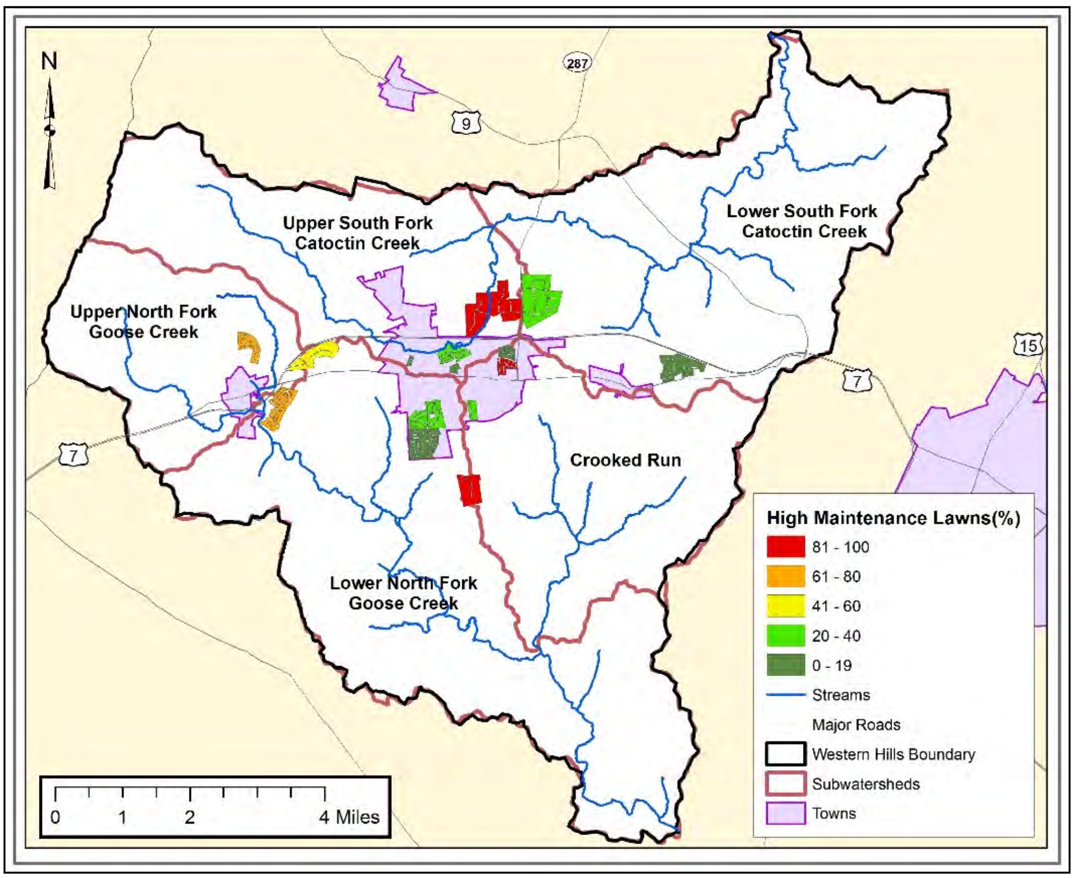


**Figure 4-24: Western Hills Neighborhoods by Percentage of High Maintenance Lawns**

**Table 4-11: Fertilizer Reduction Recommendations**

| Subwatershed | # of NSAs Recommended for Fertilizer Reduction | Acres of Lawn Addressed |
|---|---|---|
| Upper South Fork Catoctin Creek | 2 | 183.6 |
| Lower South Fork Catoctin Creek | 1 | 184.8 |
| Upper North Fork Goose Creek | 1 | 36.9 |
| Lower North Fork Goose Creek | 3 | 156.2 |
| Crooked Run | 3 | 53.1 |
| Total | 10 | 614.6 |

#### 4.2.1.3.3 Sustainable Landscaping

Sustainable landscaping refers to the use of plants native to the local watershed for landscaping. Because they are native to the region, these plants require less irrigation, fertilizers, and pesticides to maintain as compared to non-native or exotic plants (Croson 2017). This means less stormwater pollution and lawn maintenance requirements. Sustainable landscaping is also beneficial to wildlife.

All neighborhoods could use more sustainable landscaping; however, the benefits and feasibility of this action are limited by several factors. Sustainable landscaping was recommended in neighborhoods where the typical lot was at least ¼ acre in size, was less than 25 percent landscaped, and where there was sufficient grass area available (i.e., where impervious cover on the lot would not inhibit improvement of this percentage). Table 4-12 includes a summary of the number of neighborhoods recommended for sustainable landscaping and the acres of land addressed if implemented. Figure 4-25 illustrates the location of neighborhoods recommended for sustainable landscaping. Out of the 15 neighborhoods assessed, thirteen met the criteria and were recommended for sustainable landscaping.

**Table 4-12: Sustainable Landscaping Recommendations**

| Subwatershed | # of NSAs Recommended for Sustainable Landscaping | Acres of Land Addressed |
|---|---|---|
| Upper South Fork Catoctin Creek | 2 | 183.6 |
| Lower South Fork Catoctin Creek | 2 | 267.8 |
| Upper North Fork Goose Creek | 1 | 36.9 |
| Lower North Fork Goose Creek | 4 | 226.1 |
| Crooked Run | 4 | 72.0 |
| Total | 13 | 786.4 |

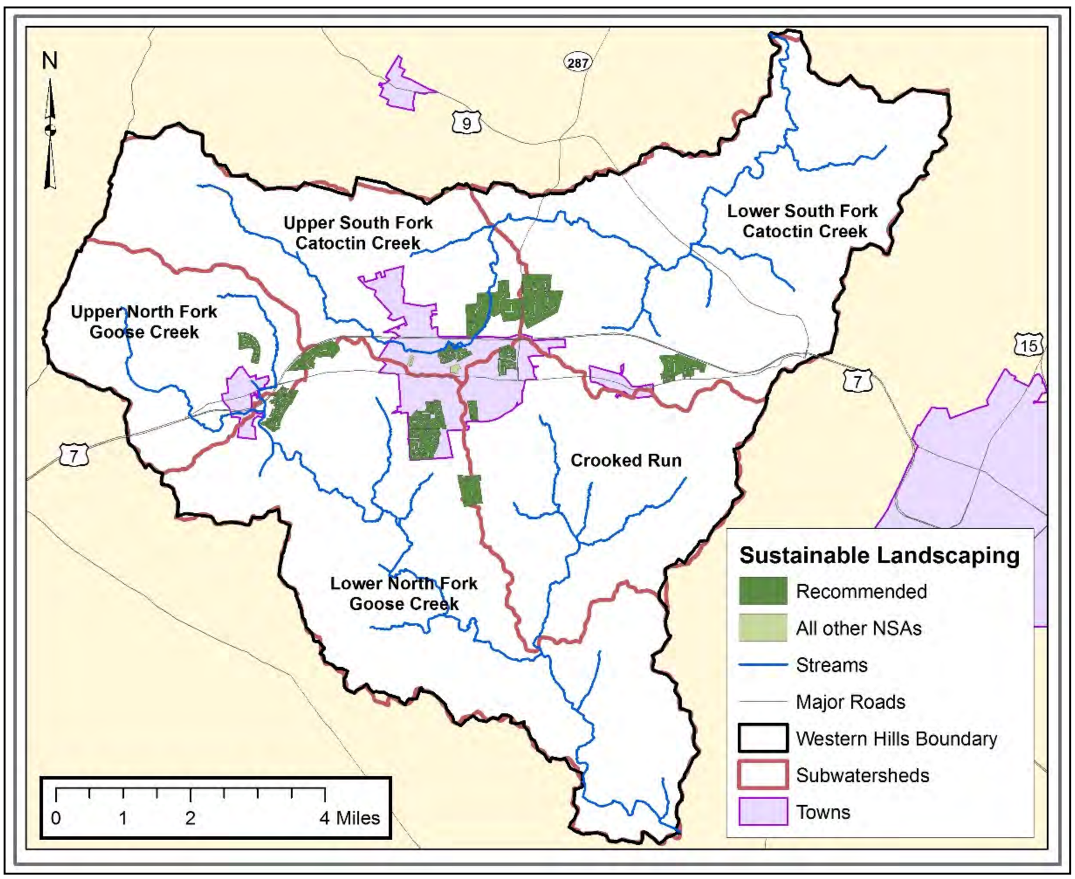


**Figure 4-25: Western Hills Neighborhoods Recommended for Sustainable Landscaping**

#### 4.2.1.3.4 Storm Drain Marking

Neighborhoods assessed in the Western Hills Watershed either consist of curb and gutter systems, or roadside ditches. These systems include storm drain inlets that convey stormwater runoff quickly and directly either to the stormwater control system or to the stream system and ultimately into North Fork Goose Creek or South Fork Catoctin Creek and the Potomac River. Marking these inlets is an excellent way to educate the public about the connection between their storm drain inlets and the river and local streams. Knowing this helps them to understand that anything building up along the curbs and gutters, such as trash and lawn clippings (potential for nutrient pollution), will be washed away after a storm event and end up in Goose Creek or Catoctin Creek and the Potomac River. Many neighborhoods had only a few inlets with markings or no markings at all. Particularly in areas with little or no infiltration of stormwater, there is more potential for pollutants to be carried to the stream system.

Neighborhoods recommended for storm drain marking had curb and gutter systems, or roadside ditches with inlets appropriate for marking and where less than 10 percent of the existing inlets were already marked (and legible). Table 4-13 includes a summary of the number of neighborhoods recommended for storm drain marking. Figure 4-26 illustrates the location of neighborhoods recommended for storm drain marking. Out of the 15 neighborhoods assessed, five met the criteria and were recommended for storm drain marking. Loudoun County keeps track of storm drain markings and reports the location of marked inlets in their MS4 Annual Report.

**Table 4-13: Storm Drain Marking Recommendations**

| Subwatershed | # of NSAs Recommended for Storm Drain Marking |
|---|---|
| Upper South Fork Catoctin Creek | 2 |
| Lower South Fork Catoctin Creek | 0 |
| Upper North Fork Goose Creek | 1 |
| Lower North Fork Goose Creek | 2 |
| Crooked Run | 0 |
| Total | 5 |

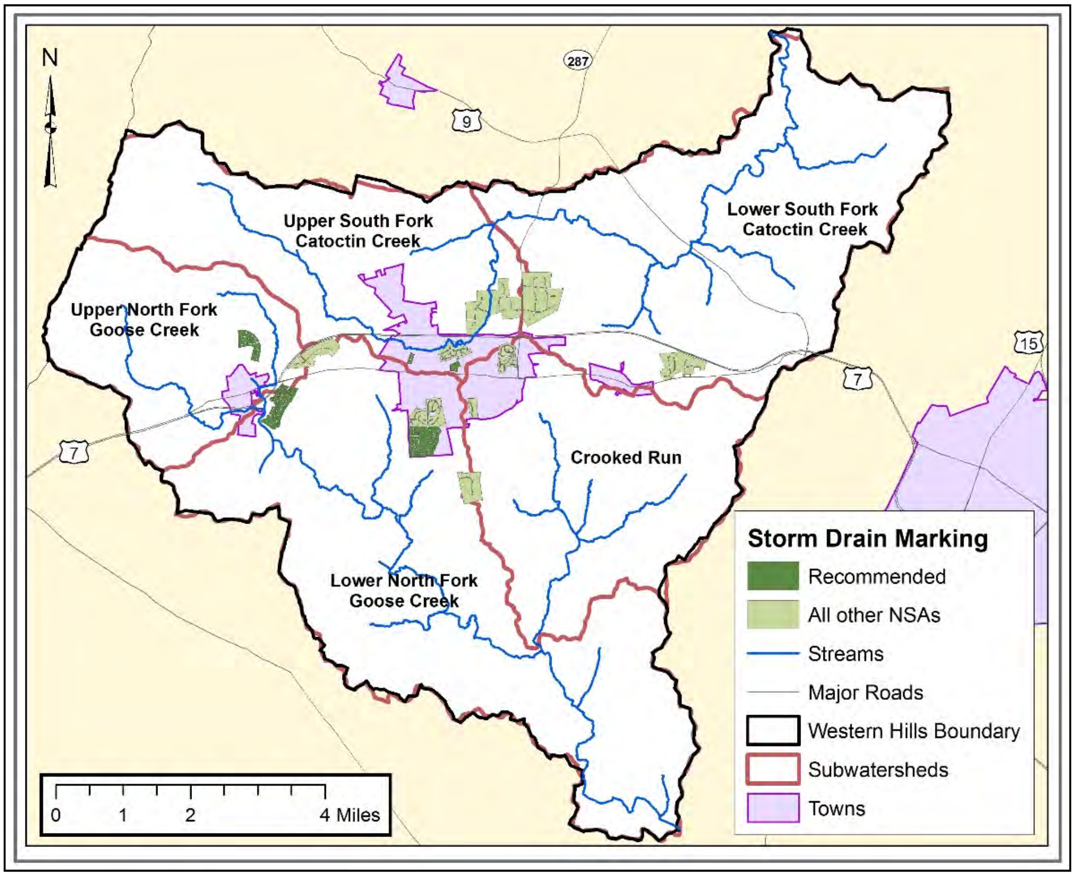


**Figure 4-26: Western Hills NSAs Recommended for Storm Drain Marking**

### 4.2.1.3.5 Tree Planting Opportunities

Trees are an asset to a neighborhood aesthetically, and they also improve air and water quality as they intercept precipitation with their leaves and can absorb precipitation and nutrients through their root systems. Interception of precipitation with the leaves or infiltration through the root systems slows stormwater runoff and provides some treatment before it reaches the stream system.

Open space trees were recommended for neighborhoods where there were open pervious areas that were not being used by the community for other purposes. The recommended planting density on open space land was calculated at 200 trees per acre, or a spacing of approximately 14 to 15 feet between trees. Up to 20 feet of spacing is recommended in planting trees for wildlife use, to encourage crown development and seed production (Penn State Extension 2014). Another source recommends 10-foot spacing of trees (NVRC 2019). Coder (2017) provides good reference tables for converting any desired tree spacing to the number of trees per acre.

Street trees are typically recommended for neighborhoods where at least 25 percent of the streets have a minimum of 6 feet of greenspace between the sidewalk and curb and less than 75 percent of the suitable areas had trees planted. None of the assessed neighborhoods met these criteria, thus street tree plantings were not recommended for the Western Hills Watershed. Neighborhoods were not recommended for street trees because they either did not have sidewalks and a curb-and-gutter system, had insufficient greenspace between the sidewalk and curb, or lawn trees already provided shade for the street.

Table 4-14 includes a summary of the number of neighborhoods recommended for open space trees proposed per subwatershed. Figure 4-27 illustrates the location of neighborhoods where open space trees could be planted. Out of the 15 neighborhoods assessed, 6 met the criteria and were recommended for tree planting. There is potential for planting 10,356 open space trees in these neighborhoods across the watershed.

**Table 4-14: Tree Planting Potential by Subwatershed**

| Subwatershed | # of NSAs Recommended for Tree Planting | # of Potential Open Space Trees |
|---|---|---|
| Upper South Fork Catoctin Creek | 1 | 3,882 |
| Lower South Fork Catoctin Creek | 0 | 0 |
| Upper North Fork Goose Creek | 0 | 0 |
| Lower North Fork Goose Creek | 3 | 4,912 |
| Crooked Run | 2 | 1,562 |
| Total | 6 | 10,356 |

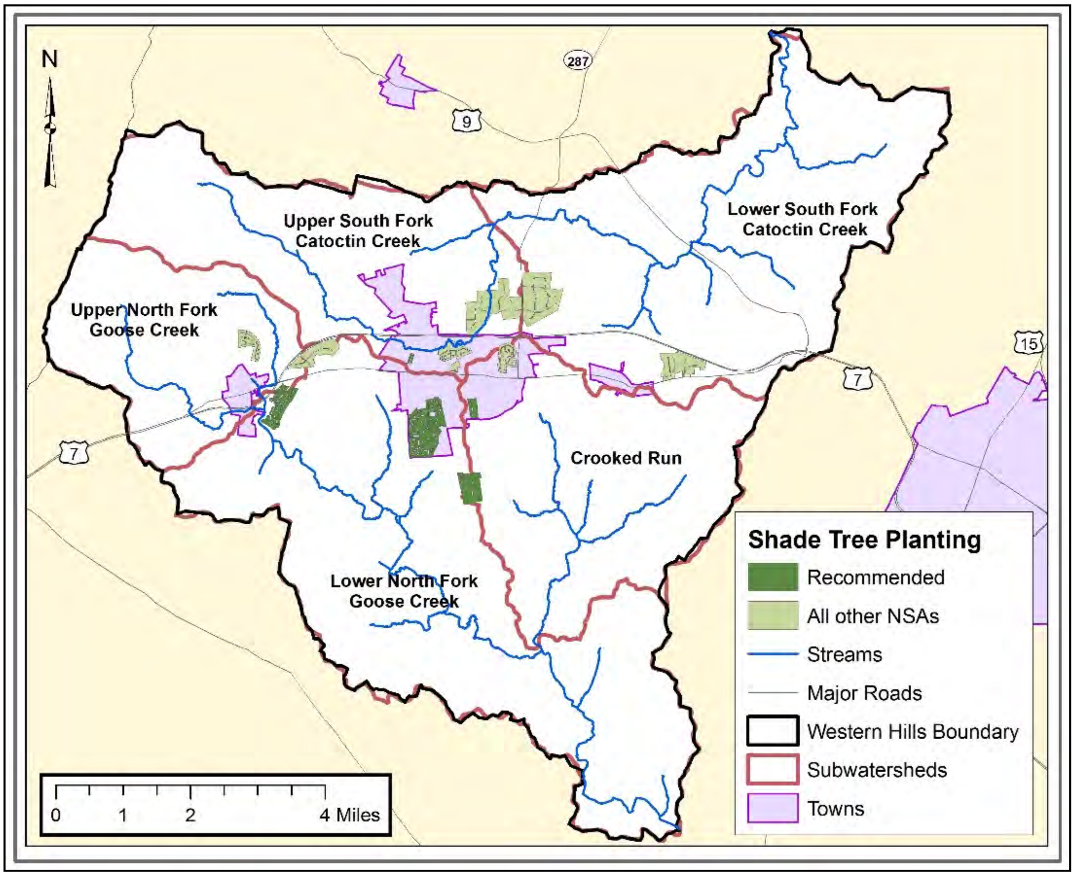


**Figure 4-27: Western Hills Neighborhoods Recommended for Tree Planting**

#### 4.2.1.3.6 Street Sweeping

Neighborhoods where 20 percent or more of the curbs and gutters are covered with excessive trash, sediment, and/or organic matter are typically recommended for street sweeping. No neighborhoods assessed within the Western Hills Watershed met these criteria, and thus no new street sweeping was recommended.

#### 4.2.1.3.7 Neighborhood Trash Management

Trash is one of the many types of pollution that may affect a watershed. Neighborhoods where junk or trash was observed in at least 25 percent of yards would be recommended for trash management initiatives. The Western Hills NSA survey revealed that there were no neighborhoods where trash management was an issue. Efforts such as community cleanups, trash management education, and working with the County's Department of General Services (DGS) to manage any bulk trash pick-up programs should be considered in order to prevent the occurrence of trash pollution in the future. VDOT roadside pickup programs can also reduce trash along roadways, with the added benefit of reducing the likelihood of trash being washed into local streams.

#### 4.2.1.3.8 New Stormwater Control Measures SCMs

Neighborhoods that have minimally used open common areas or alleys that are down gradient of rooftop downspouts, walkways, and parking lots could be good candidates for the installation of new Stormwater Control Measures (SCMs) to address runoff from impervious surfaces. This type of opportunity can address a large area of impervious cover within a single design plan. As discussed in Chapter 5, infiltration/filtration practices such as bioretention areas with native plantings could be used to capture and treat storm water runoff from impervious parking lots while requiring minimal maintenance.

The presence of wet or dry storm water ponds in all NSAs in the Western Hills Watershed gave sufficient evidence that additional SCMs were not generally needed. It was recommended that the County continue its active engagement in stormwater infrastructure maintenance.

### 4.2.2 Hotspot Site Investigations (HSI)

Stormwater hotspots are areas that have the potential to generate higher concentrations of stormwater pollutants than typically found in urban runoff because they run higher risk of spills, leaks, or illicit discharges due to the nature of their operations (Wright et al. 2005). The purpose of hotspot investigations is to evaluate pollution potential from operations and to identify restoration practices that may be necessary to remove, control, or otherwise mitigate the potential pollution source. In general, operations that may pose a higher risk of polluting stormwater runoff can be classified into commercial, industrial, or transport-related and can be regulated or un-regulated. In the Western Hills Watershed, commercial areas were the predominant type of site assessed.

***Commercial hotspots*** include private businesses whose operations include maintenance, storage, or repair of any kind of equipment, merchandise, or fleet. Maintenance and repair may generate waste, which also must be managed and can be a source of pollution. Common commercial hotspots include auto repair shops, car dealerships, car washes, parking facilities, gas stations, marinas, garden centers, construction equipment and building material lots, swimming pools, and restaurants.

***Industrial operations*** are large-scale manufacturing or processing operations that may utilize, generate, handle, and/or store pollutants that can be washed off with stormwater, spilled, or mistakenly discharged into the storm drain system. Many industrial hotspots are regulated under NPDES industrial discharge permits and include various manufacturing operations such as metal production, chemical manufacturing, and food processing.

***Transport-related hotspots*** normally include large areas of impervious cover and extensive storm drain systems to support transportation activities such as airports, ports, highway construction, and trucking centers.

Regulated hotspots are known sources of pollution that are subject to applicable federal or state laws. U.S. EPA requires that all stormwater associated with industrial activity be regulated by either individual or general discharge permits, which have rigorous self-inspection requirements. A permit is required if there is an opportunity for waterways to be exposed to pollutants from the industrial facility. If there is any potential for exposure, a permit is required.

Unregulated hotspots, such as retail and wholesale establishments, and to a lesser degree, lawns, employee/customer parking, or roofs of administrative buildings, are not regulated, but the nature of their operations makes them likely to be potential pollutant sources. Stormwater pollutants generated as a result of hotspot operations depend on the specific activities or materials used but typically include nutrients, hydrocarbons, metals, chloride, pesticides, bacteria, and trash. The hotspot investigations described in this watershed plan were targeted toward unregulated hotspots.

#### 4.2.2.1 Site Selection Protocol

Site selection began with a desktop review of 176 commercial candidate sites using Loudoun County-provided data, with the goal to visit 10 sites for HSI assessments. The type of commercial space was characterized by ownership and aerial imagery information into the following categories: Office Space, Work Yard, Automotive, Storefront, and Equipment Rental. Of these 176 commercial candidate sites, only 12 and 18 sites were located in Hamilton and Round Hill respectively. Initial selection analysis was conducted to select parcels with the largest area (top 20 percent), resulting in 35 commercial sites, 33 of which were within Purcellville. Due to the large number of sites concentrated around Purcellville, the 30 sites for Hamilton and Round Hill were reviewed separately to obtain a better spread of the sites across the towns and the watershed. The

Hamilton and Round Hill sites that were greater than 0.5 acres in size were selected, for a total of eight sites. In all, a total of 42 sites were identified as candidates for HSI visits.

The selected commercial sites were categorized into three priority groups for purposes of maintaining a manageable number to contact and obtain permissions for access. Sites were prioritized to ensure that a wide range of HSI categories were contacted for permission. Priority 1 sites were selected as the number of sites to visit if all permissions were received. Priority 2 sites were selected with the understanding that not all Priority 1 sites would receive permission for field crews to visit the property. Sites were prioritized higher if they had more than one type of upland assessment that could be performed at one location. Twenty-two sites were prioritized as 1 or 2 based on their subwatershed location and assigned category to ensure a wide range of spatial distribution and site types. Property owners for Priority 1 and 2 sites were contacted by Loudoun County in November 2018, with letters requesting permission to access the properties. The remaining sites selected were prioritized as Priority 3 and were contacted in early January 2019 with a second round of letters. In all, of the 42 sites for which letters were sent, 13 sites received permission for field teams to visit their property and 11 were visited. Of these 11, two were within Hamilton, seven were within Purcellville, and the remaining two were outside of the town boundaries. The limited spread was due to a lack of received permissions in Round Hill and Hamilton.

#### 4.2.2.2 Assessment Protocol

Field teams conducted site visits to 11 commercial areas within the Western Hills Watershed. At each site, the teams examined site conditions using HSI protocols developed by Wright et al. (2005) to obtain an overall assessment of hotspot status. A standard HSI field form, also developed by Wright et al. (2005), was used to guide staff activities, and was also digitized in ArcGIS Online so that observations could be recorded using a tablet while in the field.

Following the HSI protocol, each hotspot investigation consisted of an evaluation of six common hotspot operations: vehicle operations, outdoor materials, waste management, physical plant, turf/landscaping, and stormwater infrastructure. Field teams conducted "windshield" surveys and/or physically walked the geographic extent of the site to document potential or confirmed pollution sources in the six broad categories. Field teams recorded their observations on the standard form and took photographs of site conditions. The six broad categories of hotspot operations are described briefly below.

***Vehicle Operations***

Vehicle operations include activities such as maintenance, repair, recycling, fueling, washing or long-term parking. The presence of fleet vehicles at large businesses is an early indicator that a vehicle operations hotspot may exist. Activities taking place outdoors without cover from which there is runoff to the storm drain system without the implementation of secondary containment or onsite stormwater treatment can be a source of significant pollution from metals and hydrocarbons.

### *Outdoor Materials*

The storage of materials, supplies, and inventory outdoors without cover can be a source of pollution to storm drain systems. Problems may also result from loading and unloading activities at loading docks. Poor labeling, storage of material on impervious surfaces, poor condition of containers, and presence of stains are indicators of poor housekeeping practices related to materials storage. Special attention was paid to the impact of material storage areas on nearby stormwater infrastructure.

### *Waste Management*

Waste management encompasses both the nature of the waste generated and the manner that it is stored. Waste management hotspots may occur when waste is stored or placed carelessly. Especially when located near storm drain inlets, this can provide a direct route for pollutants to enter the system. Field staff examined the condition of dumpsters (open, damaged, leaking) and the general area around the premises for accumulations of discarded material. The presence of hazardous or construction materials and their manner of storage were also noted.

### *Physical Plant*

Physical plant assessments include examining the condition of specific areas of the physical property, such as the building and parking lot condition, cleaning practices, whether downspout disconnection can occur, and whether excess impervious cover can be removed. The parking lot may become a source of sediment if it is in poor condition. Impervious cover that is non-utilized or under-utilized could be removed to improve infiltration of stormwater. Stormwater could also be diverted from downspouts to treatment areas provided that adequate space and slope exists for rain garden placement. Maintenance practices such cleaning and washing may introduce non-stormwater, polluted flows to storm drains.

### *Turf/Landscaping*

The condition of turf was examined to determine whether maintenance activities could become a source of polluted runoff. High maintenance turf on which much fertilizer, pesticides, and irrigation is applied may become a source of pollution. Neglected turf areas may likewise become an erosion source if bare areas develop. Beneficial tree canopy, expanses of bare ground, turf grass area, and areas devoted to landscaping were calculated to determine hotspot status due to undesirable coverage. Areas of more than 20 percent of bare soil in turf/landscaped areas were flagged as a sediment pollution source.

### *Stormwater Infrastructure*

Presence or lack of stormwater treatment practices were noted on the field data sheet. A lack of stormwater controls indicates that a site may be a potential pollution source. Field staff examined catch basins and noted those with noticeable accumulations of sediment, organics, and/or trash.

For each broad category listed on the HSI field form, there are observed pollution source indices and potential pollution source indices which can be checked off and summed to calculate a "Hotspot status" grade based on severity for the site. Finally, one or more of the follow-up actions listed below could be recommended based on initial field observations:

- Refer for immediate enforcement
- Follow-up on-site inspection
- Test for illicit discharge
- Future education effort
- On-site non-residential retrofit
- Review for storm water pollution prevention (SWPP) plan
- Pervious area restoration

#### 4.2.2.3 Summary of Hotspot Assessments

Field investigations were conducted in December 2018 through February 2019. Table 4-15 shows the locations of the 11 sites visited by watershed. Figure 4-28 shows the location of each candidate hotspot investigated within the watershed.

**Table 4-15: Potential Hotspot Sites Assessed by Subwatershed**

| Subwatershed | Number Assessed |
|---|---|
| Upper South Fork Catoctin Creek | 5 |
| Lower South Fork Catoctin Creek | 2 |
| Upper North Fork Goose Creek | 1 |
| Lower North Fork Goose Creek | 0 |
| Crooked Run | 3 |

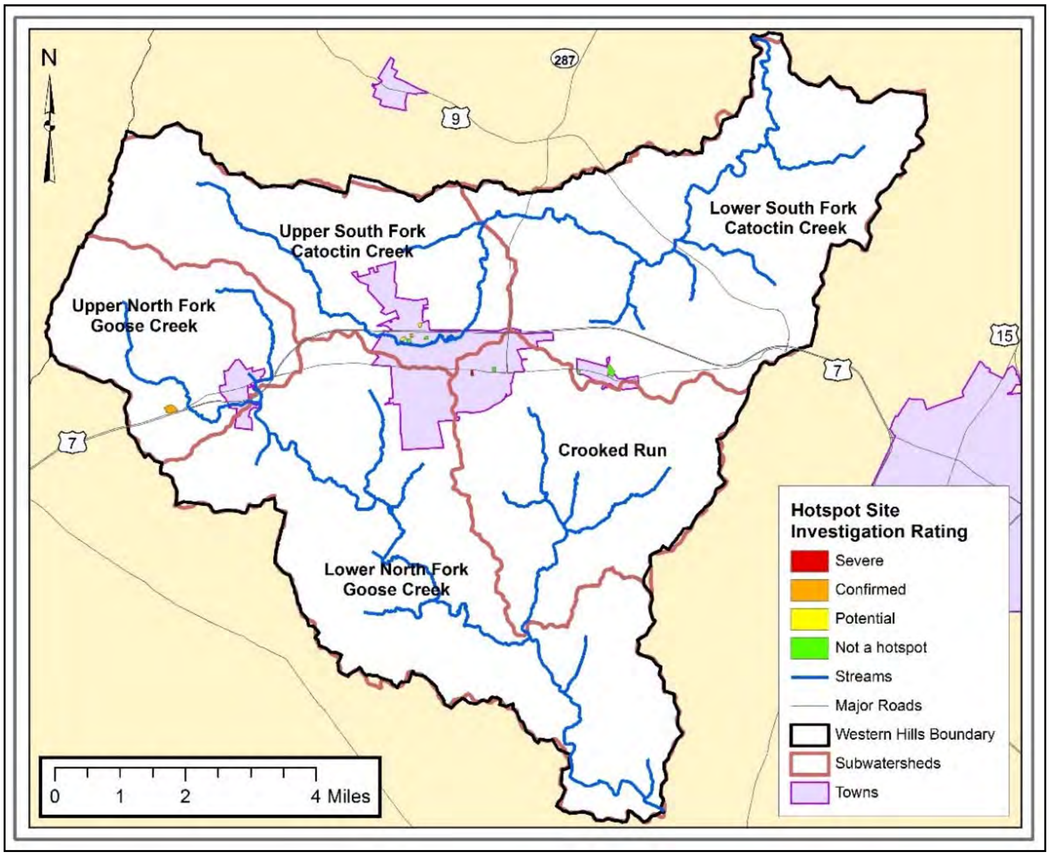


**Figure 4-28: HSI Locations in the Western Hills Watershed**

#### 4.2.2.4 Results of Assessments

A summary of hotspot findings by individual business or grouping is presented in Table 4-16. Selected photographs of commercial HSIs with examples of issues encountered are included below (Figures 4-29 through 4-33).

**Table 4-16: HSI Recommended Actions by Subwatershed**

| Subwatershed | Active Pollution Observed | | | Recommended Follow-up Action | | | |
|---|---|---|---|---|---|---|---|
| | Vehicle Operations | Outdoor Materials | Physical Plants | Refer for Enforcement | Follow up Inspection | Review SWPP | Include in Future Education |
| Upper South Fork Catoctin Creek | 4 | 4 | 0 | 0 | 0 | 2 | 0 |
| Lower South Fork Catoctin Creek | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Upper North Fork Goose Creek | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| Crooked Run | 2 | 2 | 1 | 0 | 0 | 2 | 2 |
| **Total** | **6** | **7** | **1** | **0** | **0** | **5** | **2** |

***Outdoor Vehicle Activity***

Outdoor vehicle activities such as maintenance, fueling, and washing, without benefit of canopy cover or garaging, were found at four of the sites investigated. Outdoor vehicle activities were found at two commercial businesses dedicated to automotive maintenance, for example an auto body shop where outdoor washing was observed (Figure 4-29). The other two sites were municipal facilities, for example a recycling, maintenance, and bus yard where outdoor fueling was observed (Figure 4-30) and maintenance occurs regularly.

**Figure 4-29: Outside Maintenance of a Vehicle at HSI08**

**Figure 4-30: Uncovered Fueling Station at HSI01.**

***Outside Materials***

Materials were found stored outside and uncovered at seven locations. If uncovered, such material can leach pollutants or suspended solids to the storm drain system and eventually make its way to surface waters. Material stored outside was mostly found on impervious areas (i.e., concrete or asphalt), such as a maintenance yard. At a maintenance yard, barrels labeled gas and oil were found without secondary containment (Figure 4-31). Other bulk material storage included construction materials, junked equipment parts, and merchandise. In some instances, material was found near storm drain inlets, providing a direct pathway for pollutants to be transferred to surface streams via stormwater runoff. Uncovered loading/unloading operations were found at five locations.

**Figure 4-31: Outside storage of liquid materials without an overhead cover or secondary containment at HSI10.**

### *Waste Management*

Uncovered and overflowing dumpsters were found at six businesses. Open dumpsters were the most frequently found potential pollution source during hotspot investigations. (Figure 4-32). At one auto body business, discarded car engine parts were placed on the gravel parking area near the dumpster, presumably awaiting disposal.

**Figure 4-32: Overflowing Dumpster at HSI10.**

### *Parking Lot Condition*

Poor parking lot conditions were observed at four commercial sites investigated. This was seen at all types of commercial businesses where there was a lot of car travel for maintenance work or where construction was occurring on site, for example a parking lot for a storefront where construction had been occurring recently (Figure 4-33).

**Figure 4-33: Pavement breaking up at HSI07.**

### 4.2.3 Institutional Site Investigations (ISI)

For this watershed plan, the hotspot investigation (HSI) protocols were adapted/modified to investigating institutional and municipal sites. Institutions may include the following types of facilities: churches and other religious institutions, hospitals/care centers, public schools, colleges/research centers, municipal facilities (e.g., public libraries), and other public, civic organizations. Not all operations found at commercial and industrial establishments directly correlate to operations commonly found at institutions. Additionally, problems found onsite can often be administratively addressed and corrected, whereas commercial and industrial hotspot problems may require a different method of outreach or enforcement.

Additionally, the institutional site investigation (ISI) protocol includes determination of areas for expansion of green infrastructure, a greater focus on SCM opportunities, and attention to stream buffers if streams are present on an institutional parcel. Because institutional parcels (e.g., schools) can cover a large area that is more likely to impact streams and on which trees and SCMs can be readily added, these elements were included in the ISI protocol and field data sheet. The following subsections describe the methods used to identify and evaluate pollution sources and restoration potential at institutional facilities.

#### 4.2.3.1 Site Selection Protocol

Site selection began by reviewing 52 parcels owned by religious organizations and 96 public parcels from Loudoun County-provided data, with the goal of visiting 5 religious institutions and 15 public sites. The religious institution sites were analyzed spatially using ArcMap, Google Earth, and Street View. Parcels representing the same religious institution and location were combined, resulting in 31 separate religious institutions. An area filter was used to select religious institution sites whose total acreage was between 1 acre and 10 acres to obtain a good analytical set for evaluating potential new upland BMPs and tree planting opportunities while completing the ISI. The area filter provided 15 religious institution sites.

The public sites were analyzed spatially using ArcMap, Google Earth, and Street View. Parcels representing the same location were combined, resulting in 53 separate public properties. These sites were used to select candidate locations for ISI review.

The selected institutional (religious and public) sites were prioritized into three priority groups for purposes of maintaining a manageable number to contact and obtain permissions for access. Sites were prioritized to ensure that a wide range of institutional property types were contacted for permission. Priority 1 sites were selected as the number of sites to visit if all permissions were received. Priority 2 sites were selected with the understanding that not all Priority 1 sites would receive permission for field crews to visit the property. Sites were prioritized higher if they had more than one type of upland assessment that could be performed at one location. Twenty-eight sites were prioritized as 1 or 2 based on their subwatershed and assigned category to ensure a wide range of spatial distribution and site types. For publicly-owned sites, appropriate Town, County, or Loudoun County Public Schools staff were contacted to coordinate permissions as needed. For sites without public access, property owners for Priority 1 and 2 sites were contacted by Loudoun County in November 2018, with letters requesting permission to access the properties. Landowners for the remaining Priority 3 sites were contacted in January 2019. Of the 68 sites that were contacted, 56 received permission for field teams to visit their property and 20 were visited (3 religious and 17 public institutions).

#### 4.2.3.2 Assessment Protocol

In the Western Hills Watershed, ISIs were performed at public schools, municipal facilities, and religious institutions. At each site, the entire property of an institutional site was walked by the field team to collect necessary data and to take photographs. Prior to arrival at public schools, prior arrangement was made with the school system administration to explain the purpose of the investigations, and field teams checked in at each school office upon arrival.

The ISI field form includes the same broad categories (e.g., vehicle operations, waste management) of operations as the HSI form, but differ in some specific elements within the categories. Some of the types of recommended restoration actions from the NSAs and URSAs are also incorporated into the ISI protocol. A main focus of ISIs is to identify potential restoration opportunities, educate the community, and provide water quality benefits. The information collected by field teams for each of the pollution source and restoration categories is briefly described below.

***Tree Planting***

Potential tree planting locations at an ISI site were marked on aerial photographs while walking the property. Areas targeted for recommended tree planting included existing green space with small numbers of trees already planted, borders of athletic fields, centers of bus turnarounds, or otherwise underutilized turf areas with no apparent infrastructure constraints. Field maps were digitized to obtain total areal coverage of tree planting areas, and the total number of trees that could be planted at the site was estimated based on an estimate of 200 trees per acre.

***Exterior***

The condition of the building and parking lot were noted. Stained, dirty, and damaged/breaking up building and parking surfaces were noted as potential pollution sources. The absence of stormwater management for impervious parking areas was also considered as a potential pollution source. Storm drain inlets were inspected for evidence (e.g., presence of mop threads, staining) of maintenance or wash water dumping. Exterior building downspouts that were directly connected to the storm drain system or indirectly connected via discharge to impervious surfaces were also recorded as potential pollution sources. Potential restoration opportunities in the exterior category included downspout disconnection.

### *Waste Management*

Waste management at institutions typically encompasses collection of material into dumpsters in designated areas. The field team noted the type of waste generated (e.g., hazardous, garbage, etc.) and the condition and location of the dumpsters in relation to storm drain inlets. Dumpsters with no cover or open lids, with leaks, damaged/in poor condition, and/or overflowing were noted as potential pollution sources. The field team also noted whether loose trash was present that could leave the site with wind or rain. Dumpster stalls that doubled as storage areas for bulk waste, liquid drums, or other discarded material were also flagged as potential pollution sources.

### *Vehicle Operations*

Vehicle operations are typically not conducted at schools but are often found at municipal sites. The category of vehicle operations includes maintenance, repair, recycling, fueling, washing, or long-term parking of fleet vehicles. The presence of any of these activities, especially when conducted outdoors without suitable cover, was noted for each site because they can be a source of metals, oil and grease, and hydrocarbons. Overnight parking of buses can sometimes be associated with oil stains, but this condition was not observed at any of the schools where buses could be parked overnight.

### *Outdoor Materials*

Materials such as mulch piles, storage drums, and de-icing salt are sometimes stored on institution grounds in staging areas. Locations where materials were loaded or unloaded, and methods of storage were examined to determine if areas were uncovered and draining toward a storm drain inlet.

### *Turf/Landscaping*

As in the HSI, the condition of turf was examined to determine whether maintenance activities could become a source of polluted runoff. High maintenance turf on which large amounts of fertilizer, pesticides, and irrigation are applied may become a source of pollution. Neglected turf areas may likewise become an erosion source. Non-target irrigation on impervious surfaces was also noted. Beneficial tree canopy, expanses of bare ground, turf grass area, and areas devoted to landscaping were calculated to determine hotspot status due to undesirable coverage. Areas of more than 20 percent of bare soil in turf/landscaped areas were flagged as a sediment pollution source. Impacts of landscaped areas on impervious surfaces and the storm drain system were noted. Stream buffer encroachment and opportunities for buffer expansion to minimally accepted widths of 100 feet on each bank were evaluated in this section.

### *Stormwater Infrastructure*

The field team checked whether storm drains were marked and whether stormwater treatment practices were present. The locations and types of SCMs or treatment upgrades were marked on field maps. After conducting the field portion of the ISI, one or more of the follow-up actions listed below were recommended based on the initial field assessment.

- Tree planting
- Storm drain marking
- Downspout disconnection
- New RRI
- Education
- Impervious cover removal
- Stream buffer improvement
- Develop a Pollution Prevention Plan
- Trash management

#### 4.2.3.3 Summary of Institutional Site Assessments

A total of twenty institutions were assessed throughout the Western Hills Watershed (Figure 4-34). The number and type of institutions assessed within each subwatershed is summarized in Table 4-17.

**Table 4-17: Types of Institutions Assessed by Subwatershed**

| Subwatershed | Public School | Municipal Facility | Religious Institution | TOTAL |
|---|---|---|---|---|
| Upper South Fork Catoctin Creek | 2 | 2 | 0 | **4** |
| Lower South Fork Catoctin Creek | 1 | 3 | 0 | **4** |
| Upper North Fork Goose Creek | 1 | 1 | 1 | **3** |
| Lower North Fork Goose Creek | 0 | 3 | 2 | **5** |
| Crooked Run | 2 | 2 | 0 | **4** |
| **Total** | **6** | **11** | **3** | **20** |

#### 4.2.3.4 Results of Assessments

The number of the different types of recommended actions for ISIs is summarized in Table 4-18 by subwatershed. Tree totals were estimated using a density of 200 trees per acre.

**Table 4-18: ISI Recommended Actions by Subwatershed**

| Subwatershed | # of Trees | Storm Drain Marking | Downspout Disconnect | New Stormwater Treatment (Number of BMPs) | Future Education | Buffer Improvement | Pollution Prevention Plan | Trash Management | Impervious Cover Removal |
|---|---|---|---|---|---|---|---|---|---|
| Upper South Fork Catoctin Creek | 6,216 | 2 | 0 | 3 (12) | 1 | 1 | 0 | 0 | 0 |
| Lower South Fork Catoctin Creek | 194 | 4 | 1 | 2 (2) | 1 | 0 | 1 | 1 | 1 |
| Upper North Fork Goose Creek | 422 | 2 | 0 | 1 (5) | 0 | 0 | 0 | 0 | 1 |
| Lower North Fork Goose Creek | 238 | 4 | 2 | 1 (1) | 4 | 0 | 1 | 0 | 0 |
| Crooked Run | 0 | 3 | 1 | 1 (1) | 2 | 1 | 1 | 0 | 2 |
| **Total** | **7,070** | **15** | **4** | **8 (21)** | **8** | **2** | **3** | **1** | **4** |

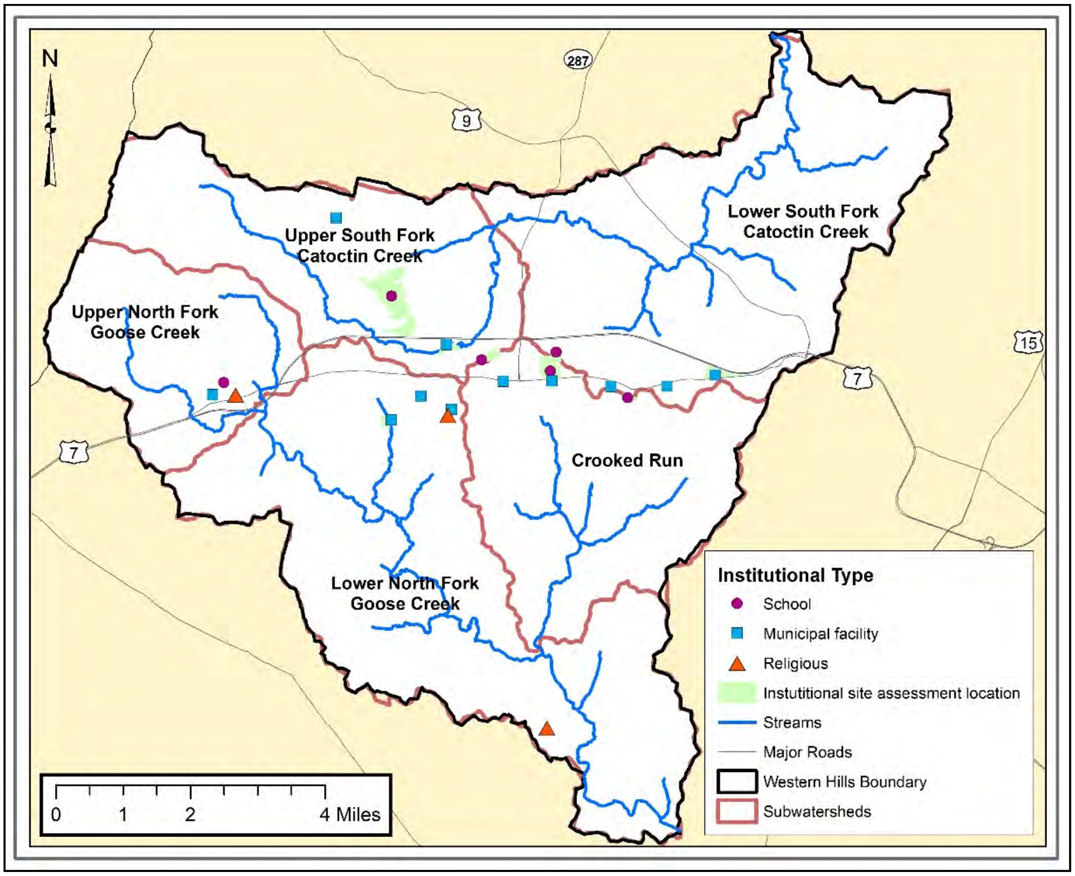


**Figure 4-34: ISI Locations in Western Hills Watershed**

***Tree Planting***

An estimated 7,070 trees were recommended to be planted at institutions within the Western Hills Watershed. Trees were recommended for seven institutions assessed. During field assessments, tree planting areas were identified in the field and drawn on field maps. Small quantities of trees (i.e., less than 10) were recommended for smaller-acreage institutions such as the Loudoun Valley Community Center while a greater number of trees were noted as appropriate for public schools, which tend to have larger available acreage in which to plant. For example, at Culbert Elementary School, a sloping area behind the baseball field that drains to the dry pond on site is currently maintained turf. The slope could be planted in forest cover to help slow overland flow to the facility and improve water quality. In another example, at Mountain View Elementary School, the maintained turf bus circle could be planted with additional trees. These examples are shown in Figure 4-35.

For planning purposes, the number of trees was estimated based on a density of 200 trees per acre, as noted above. Planning-level estimates presented in Table 4-18 can be refined during follow-up site evaluations.

Shade trees provide air and water quality improvement while providing stability to the surrounding terrain. Root systems intercept, treat, and absorb stormwater, thereby reducing excess overland runoff contributions to stream networks.

**Figure 4-35: Potential Tree Planting Areas at ISI04 (left) and at ISI17 (right)**

***Stormwater Management Improvements***

Stormwater management improvements were recommended for eight of the institutions that were investigated. Downspout disconnection was recommended for just four sites where external downspouts were evident and sufficient pervious area down-slope of the roof leader was available to redirect rooftop runoff.

Bioretention treatment utilizes grasses, trees, and shrubs in a planted area to capture, treat, and infiltrate stormwater runoff. At the several public schools that field staff visited, opportunities were found to augment existing stormwater controls. For example, at Culbert Elementary School, an existing grassy swale south of the bus circle could be converted to bioretention to improve stormwater treatment prior to entry into the storm sewer system (Figure 4-36). At Woodgrove High School, installation of bioretention would improve stormwater treatment prior to entry into the storm sewer system. These actions also present an opportunity to educate students and the community at large about the connection between the schools' storm drain systems and the downstream water bodies they flow into.

**Figure 4-36: Opportunities for Bioretention at ISI04 (left) and at ISI17 (right)**

***Impervious Cover Removal***

Impervious surfaces create a barrier between precipitation and natural recharge of groundwater aquifers. Additionally, impervious surfaces accumulate pollutants which then collect in stormwater runoff and concentrate during precipitation events. The excess volume and energy of runoff from impervious areas contributes to stream erosion, degradation of stream habitat, and general pollution at points farther downstream. Removing unused or underutilized impervious surfaces can help increase pervious area and improve the watershed’s capacity for infiltrating and treating stormwater runoff.

The potential for impervious cover removal was noted at four of the twenty institutions investigated, all at Loudoun County Public School owned sites. Two examples include impervious play areas at Hamilton Elementary School and Culbert Elementary School (Figure 4-37). The removal and replacement of these impervious surfaces was recommended, to be replaced with pervious pavement.

**Figure 4-37: Play Area Impervious Cover at ISI10 (left) and ISI04 (right)**

***Buffer Improvement***

Forested and native vegetation zones along streams provide both stream stability and water quality improvement benefits. Root systems of trees stabilize banks and the cumulative effect of native grasses, shrubs, and trees planted in the buffer serve to treat and slow down stormwater runoff from the drainage area. Trees are also critical for moderating stream temperature with consequent benefits to aquatic life. Restoring natural vegetation along streams can involve a variety of practices including planting of trees, seeding or planting native vegetation, putting up stream fencing to reduce access by livestock, allowing natural succession of plant growth, establishing "no mow" areas, or a combination of these approaches. In Loudoun County, tree plantings in the major floodplain require floodplain studies prior to implementation.

Streams were noted on five of the institutions and two were found to lacking adequate buffers. Field teams noted two buffer improvement opportunities. In one case, buffer encroachment has occurred as a result of sanitary sewer installation in stream valleys in order to accommodate new residential and commercial construction in the watershed. Field teams noted that efforts had been made to replant buffers along some streams. An ideal buffer has at least 100 feet of native vegetation along each bank and some previous efforts did not meet this threshold; therefore, opportunities exist at the following areas to improve the buffers: Purcellville Well Head and South Fork Catoctin Creek Conservation Easement. In addition, near the South Fork Catoctin Creek Conservation Easement (Figure 4-38), both banks of a stream near a sanitary sewer right of way would benefit from buffer augmentation.

**Figure 4-38: Potential Stream Buffer Restoration at ISI16 (left) and ISI11 (right)**

***Trash and Other Waste Management***

All institutions generate waste, but proper management can remove potential sources of chemical pollution to waterways and minimize washing of litter into streams. Improvements to waste management were recommended for six of the twenty institutional sites visited in the Western Hills Watershed. Waste management is often improved through education and outreach efforts. Current waste management problems, such as leaking dumpsters, open or uncovered dumpsters where trash can leave the site or rainfall can pick up pollutants, and dumpster placement near storm drain inlets or streams, as well as signs of past problems such as stains or rust on impervious surfaces near dumpster areas were noted during the field investigations (Figure 4-39).

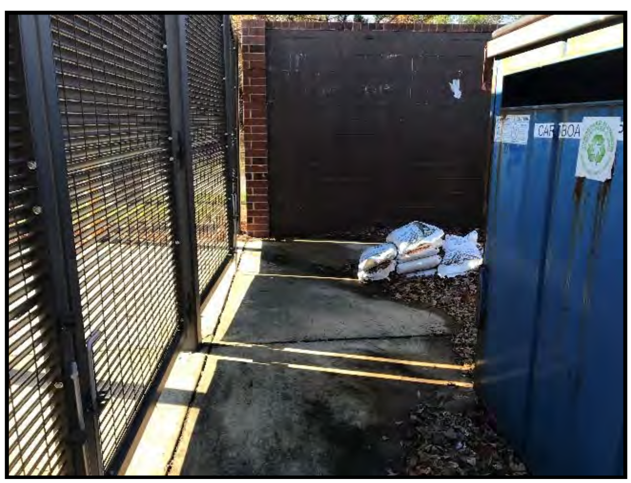

**Figure 4-39: Trash Management Opportunity at ISI04**

Nearly all dumpsters were found in good condition and with lids properly placed except for at one municipal facility and one religious institution. Dumpsters were found with evidence of past leakage at three sites. Inappropriate storage of material outdoors in dumpster stalls (mulch) was found at one elementary school. These trash management problems may be addressed through various measures such as waste management education.

#### 4.2.4 Urban Reforestation Site Assessment (URSA)

Urban Reforestation Site Assessments (URSA, Cappiella et al. 2006) were conducted in open spaces to identify and evaluate sites within the Western Hills Watershed with potential for tree planting or other revegetation. Field investigations took place from December 2018 through February 2019. The following subsections describe the methods used to identify and evaluate the restoration potential of these open space areas.

##### 4.2.4.1 Site Selection Protocol

Large parcels of open land associated with ISI assessments throughout the watershed were identified in the office prior to conducting the field assessment. Upon visiting ISI parcels identified in the office, an URSA was conducted if the field team verified the site as having sufficient space and potential for restoration. In some cases, additional sites were identified for URSA while performing other upland assessments. The Center for Watershed Protection (Wright et al. 2005) generally recommends assessing publicly-owned open space areas greater than two acres and privately-owned areas greater than five acres.

##### 4.2.4.2 Assessment Protocol

The entire property of each URSA site was walked by the field team to collect necessary data and take photographs. Basic information was filled out first, including site accessibility, ownership, current management, and whether the site was connected to other pervious areas. The area of the site proposed to be planted was determined in the field using GIS tax parcel information and aerial photographs available on the tablets.

Access to a site is important when considering its restoration potential. The field team determined in the field whether the URSA site could be accessed by foot, vehicle, and/or heavy equipment. A site that can only be accessed by foot may have less potential for restoration if it requires greater disturbance or costs to restore (e.g., constructing an access road). Ownership is also important because different approaches may be used to coordinate with private versus public institutions. Current management describes the current use of the land. The presence and type of connected pervious area is also relevant to the restoration potential of a pervious area. For example, if a site connects existing forested areas, reforesting the site would help to continue the forested corridor for wildlife habitat or stream buffer purposes. If a site is connected to an existing wetland area, it could be reforested to protect the wetland or re-vegetated to extend the wetland area. The other data categories assessed are briefly described below.

***Current Vegetative Cover***

The current vegetative cover was assessed including the proportion of the site covered by maintained turf, herbaceous, shrubs, trees, or bare soil. The presence of invasive species was noted including percent of site with invasive species and type.

***Reforestation Constraints***

Information regarding factors that may impede reforestation efforts was collected. The type of sun exposure was recorded as full sun, partial sun, or shade. The field team noted whether there was a nearby water source for supplemental water if necessary.

Other constraints related to tree planting that were noted include overhead wires, underground utilities, pavement, and buildings. Private ownership was noted as a potential constraint.

#### 4.2.4.3 Summary of Reforestation Assessments

A total of 11 reforestation assessment sites were assessed within the Western Hills Watershed, with potential planting areas totaling 35.41 acres. Figure 4-40 shows the location and size of URSAs within the Western Hills Watershed. URSAs were conducted at Blue Ridge Baptist Church, Culbert Elementary School, Loudoun County Sheriff's Office, Loudoun Valley Community Center, Purcellville Water Treatment Plant, South Fork Catoctin Creek Conservation Assessment, and Woodgrove High School / Mountain View Elementary School. Totals of potential planting areas at the sites ranged from 0.32-acre to 11.83 acres (Table 4-19). The sites surveyed were a mixture of pervious areas with trees, shrubs, and turf.

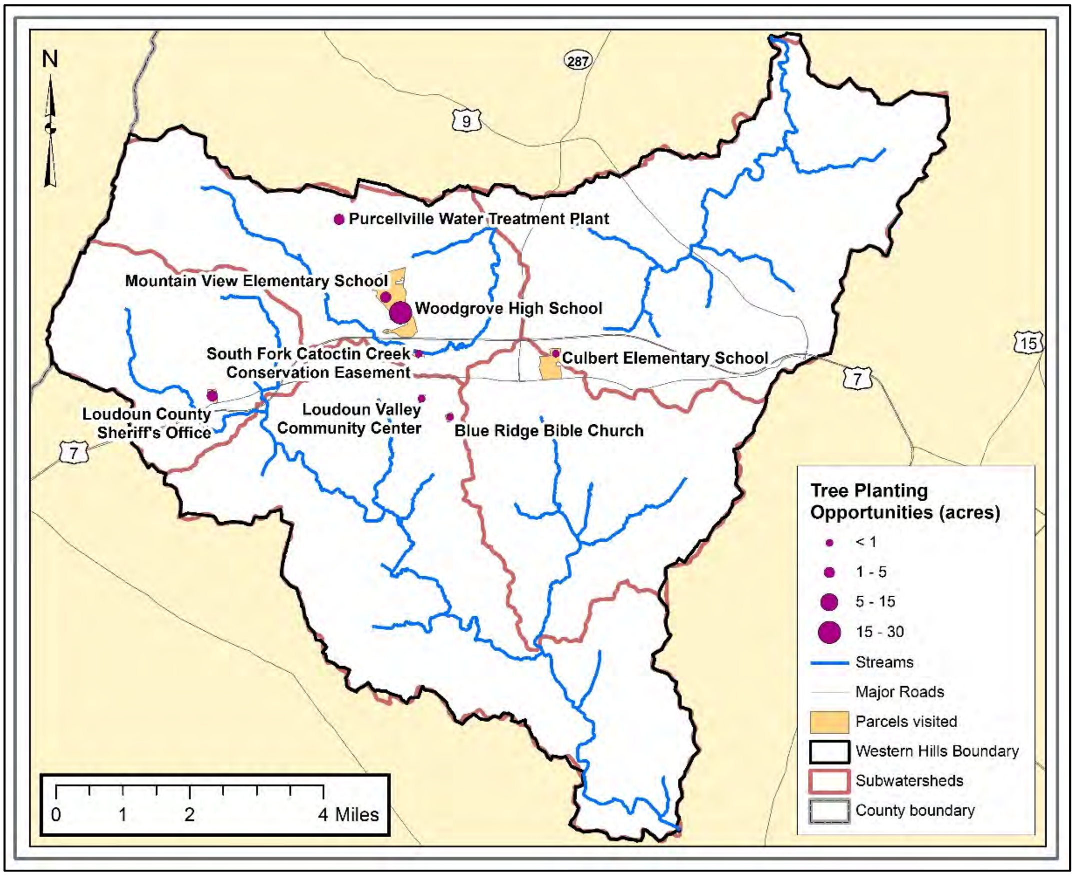


**Figure 4-40: URSA Locations in the Western Hills Watershed**

#### 4.2.4.4 Results of Assessments

A summary of URSA results including parcel size, potential planting area, ownership, management, percent-maintained turf cover, and site preparation that would be required for the sites assessed is provided in Table 4-19.

**Table 4-19: Summary of Western Hills URSA Results**

| Name | Total Parcel Size (acres) | Total of Potential Planting Areas (acres) | Ownership | Management | Turf % | Site Preparation Needed |
|---|---|---|---|---|---|---|
| Woodgrove High School (1) | 223.14 (combined Woodgrove High School and Mountain View Elementary) | 11.83 | Public | School | 100 | Minimal |
| Woodgrove High School (2) | | 3.97 | Public | School | 70 | Minimal |
| Woodgrove High School (3) | | 11.20 | Public | School | 100 | Minimal |
| Mountain View Elementary School | | 1.90 | Public | School | 95 | Moderate |
| Culbert Elementary School | 31.08 | 0.97 | Public | School | 100 | Minimal |
| Purcellville Water Treatment Plant Northeast | 4.46 (combined Northeast and Northwest) | 1.03 | Public | Municipal | 100 | Minimal |
| Purcellville Water Treatment Plant Northwest | | 0.48 | Public | Municipal | 0 | Minimal |
| Loudoun Valley Community Center | 4.73 | 0.32 | Public | Municipal | 95 | Minimal |
| Blue Ridge Bible Church | 7.10 | 0.87 | Private | Religious Institution | 100 | Minimal |
| South Fork Catoctin Creek Conservation Easement | 13.16 | 0.72 | Public | Conservation Easement | 0 | Moderate |
| Loudoun County Sheriff's Office | 14.18 | 2.12 | Public | Municipal | 80 | Minimal |
| **Total** | | **35.41** | | | | |

### *Ownership*

The most likely candidates for successful pervious area restoration efforts are those on public lands with minimal site preparation required. Public sites often provide good opportunities for volunteer or community projects. Of the 11 sites surveyed, ten are under public ownership and most were considered to require minimal site preparation. All 11 of the sites assessed are briefly described below.

**Woodgrove High School (1)**

The first Woodgrove High School site is located off Allder School Road (Figure 4-41). It is owned and maintained by Loudoun County Public Schools, and the site is easily accessible by foot, vehicle, or heavy equipment. The entire parcel includes two school buildings and many sports fields. The first site is south of Woodgrove High School, is fully covered by maintained turf (100 percent), and it receives full sun exposure. The location identified for tree planting is a large, flat open area that appears ideal for planting. Planting of this site, however, requires verification that it would not interfere with the current school uses of the site, future planning needs, and school safety concerns, and that the tree planting could be a potential community project.

**Figure 4-41: Photo of Woodgrove High School (1) potential site for tree planting**

**Woodgrove High School (2)**

The second Woodgrove High School site is located off Allder School Road (Figure 4-42). It is owned and maintained by Loudoun County Public Schools, and the site is easily accessible by foot, vehicle, or heavy equipment. The second site is southeast of Woodgrove High School, is covered primarily by maintained turf (70 percent), and it receives partial sun exposure. The location identified for tree planting is a low-lying area next to a small pond that connects to a stream on the edge of the woods and appears ideal for streamside planting. Tree planting could be a potential community project.

**Figure 4-42: Photo of Woodgrove High School (2) potential site for tree planting**

### Woodgrove High School (3)

The third Woodgrove High School site is located off Allder School Road (Figure 4-43). It is owned and maintained by Loudoun County Public Schools and the site is easily accessible by foot, vehicle, or heavy equipment. The third site is at the far south end of the parcel, fully covered by maintained turf (100 percent), and it receives full sun exposure. Planting of the site, however, will require verification that it would not interfere with the current planned uses of the site and that tree planting could be a potential community project.

**Figure 4-43: Photos of Woodgrove High School (3) potential site for tree planting**

**Mountain View Elementary School**

The Mountain View Elementary School site is located off Allder School Road on the same parcel as Woodgrove High School (Figure 4-44). It is owned and maintained by Loudoun County Public Schools, and the site is easily accessible by foot, vehicle, or heavy equipment. It is a grassed bus circle; it is mostly covered by maintained turf (95 percent) and receives full sun exposure. The bus circle identified for tree planting is sloping to the west, with two street lamps present and two catch basins. Planting of this site, however, requires verification that it would not interfere with the current school uses of the site, future planning, needs, and that tree planting could be a potential community project. This site has also been marked as a potential site for a new stormwater treatment BMP.

**Figure 4-44: Photos of Mountain View Elementary School potential site for tree planting**

**Culbert Elementary School**

The Culbert Elementary School site is located north of West Colonial Highway (Figure 4-45). It is owned and maintained by Loudoun County Public Schools and the site is easily accessible by foot, vehicle, or heavy equipment. The site selected for tree planting is currently covered by maintained turf (100 percent) and it receives full sun exposure. Opportunities for tree planting at this site are located between the baseball field and a County owned dry pond. This will help slow overland flow to the dry pond and improve water quality. Tree planting could be a potential community project.

**Figure 4-45: Photos of Culbert Elementary School potential site for tree planting**

**Purcellville Water Treatment Plant Northeast**

The Purcellville Water Treatment Plant – Northeast site is located immediately southwest of Short Hill Road (Figure 4-46). It is owned and maintained by the Town of Purcellville and is easily accessible by foot, vehicle, or heavy equipment. The site selected for potential tree planting is fully covered by maintained turf (100 percent) and it receives full sun exposure. Opportunities for tree planting at this site are located directly east of the fence around the water treatment plant, along the hill.

**Figure 4-46: Photos of Purcellville Water Treatment Plant – Northeast potential site for tree planting**

**Purcellville Water Treatment Plant Northwest**

The Purcellville Water Treatment Plant – Northwest site is located immediately southwest of Short Hill Road (Figure 4-47). It is owned and maintained by the Town of Purcellville and is easily accessible by foot, vehicle, or heavy equipment. It is currently uncovered dirt (0 percent turf cover) because of maintenance occurring on site and it receives full sun exposure. An area of opportunity for tree planting at this site is located directly west of the fence around the water treatment plant. The area has been recently disturbed and would be easy to reintroduce trees to the site. Although the entire area is marked as a site for future expansion of the plant, an established forested buffer could be incorporated within the planning of the expansion.

**Figure 4-47: Photos of Purcellville Water Treatment Plant – Northwest potential site for tree planting beyond settling ponds and fence**

**Loudoun Valley Community Center**

The Loudoun Valley Community Center site is located off West School Street, at the intersection of South Nursery Street (Figure 4-48). It is owned and maintained by Loudoun County and all parts of the site are easily accessible by foot, vehicle, or heavy equipment. About ninety-five percent (95 percent) of the area to be reforested is covered by maintained turf and it receives full sun exposure. There is a path along South Nursery Street that would benefit from plantings along the whole path. The tree planting could be a potential community project.

**Figure 4-48: Photos of Loudoun Valley Community Center potential site for tree planting**

### Blue Ridge Bible Church

The Blue Ridge Bible Church site is located off South 20th Street, north of East A Street (Figure 4-49). It is privately owned and maintained, and all parts of the site are easily accessible by foot, vehicle, or heavy equipment. The location for tree planting is fully covered by maintained turf (100 percent) and it receives full sun exposure. It is recommended that trees be added to the buffer already in place on the eastern stormwater conveyance leading to the dry pond and along the western conveyance also. Planting these areas would help to slow overland stormwater flows to the dry pond on site. Planting of this site, however, requires verification that it would not interfere with the current church uses of the site and future planning needs.

**Figure 4-49: Photos of Blue Ridge Bible Church potential site for tree planting**

**South Fork Catoctin Creek Conservation Easement**

The South Fork Catoctin Creek Conservation Easement site is located off North 21st Street, at the entrance to the martial arts building (Figure 4-50). It is owned and maintained by the Town of Purcellville and all parts of the site are easily accessible by foot, vehicle, or heavy equipment. About forty percent (40 percent) of the site is covered by trees or shrubs and sixty percent (60 percent) other herbaceous plants and it receives full sun exposure. The location would add a stream buffer to a recommended regenerative stormwater conveyance. Upland locations are potentially available for planting as well. Planting trees in these areas after completing the retrofit would help to slow overland stormwater flows to the local tributaries. Planting of this site, however, requires verification that it would not interfere with the neighboring utility easement.

**Figure 4-50: Photos of South Fork Catoctin Creek Conservation Easement potential site for tree planting**

**Loudoun County Sheriff's Office**

The Loudoun County Sheriff's Office site is located off Michelle Way, north of West Loudoun Street (Figure 4-51). It is owned and maintained by Loudoun County and all parts of the site are easily accessible by foot, vehicle, or heavy equipment. About eighty percent (80 percent) of the site is covered by maintained turf and it receives full sun exposure. The large open upland fields behind the building appear to be ideal for tree planting. Tree planting could be a potential community project.

**Figure 4-51: Photos of Loudoun County Sheriff's Office potential site for tree planting**

### 4.2.5 Retrofit Reconnaissance Investigations (RRI)

For this watershed plan, retrofit reconnaissance investigation (RRI) methods were used primarily to investigate existing stormwater management ponds, both private and public, as candidates for conversion to designs with increased pollutant removal efficiencies.

The Western Hills Watershed contains 91 known stormwater ponds. Twenty-six are wet ponds and 65 are dry ponds; there is one wetland. Sixty-two ponds are county-maintained, 28 are privately maintained and the remaining pond is maintained by the Town of Purcellville.

#### 4.2.5.1 Site Selection Protocol

Site selection began with 117 BMP points from Loudoun County-provided data, with the goal to visit twenty sites for RRI assessments. The BMP type and subtype was used to narrow down the list first to 65 dry ponds and further to 55 dry ponds without enhanced or extended treatment. The 55 sites were analyzed spatially using ArcMap, Google Earth, and Street View. BMPs were narrowed down to 43 based on location and review of aerial imagery. There are some HOA properties that have multiple existing BMPs within the same neighborhood spread over multiple parcels. In these cases, one site was selected to represent all the BMPs on a HOA's property, for a total of 26 individual selected sites. Field teams planned to perform a visual assessment of all the BMPs associated with the HOA property and then were able select either all facilities or an appropriate subset for RRI.

The 26 selected sites were prioritized to maintain a manageable number to contact for permissions. Priority 1 BMPs were selected if they were public sites, had another planned type of upland assessment prioritized as 1, or were located near another high priority location. Priority 1 sites were selected as the number of sites to visit if all permissions were received. Priority 2 sites were selected with the understanding that not all Priority 1 sites would receive permission for field crews to visit the property. Thirteen BMPs were assigned Priority 1, four were assigned Priority 2, and the remaining sites were assigned Priority 3. For several sites, Loudoun County Department of General Services (DGS) already had access for inspections and maintenance; access for these sites was granted by the County to the Western Hills field teams. For sites without public or County access, property owners for Priority 1 and 2 sites were contacted by Loudoun County in November 2018 with letters requesting permission to access the properties. Of the 26 sites for which landowners were contacted, nine sites received permission for field teams to visit their property. Of those with permission, four of them had more than one BMP on their property. A total of 18 BMP sites were visited.

#### 4.2.5.2 Assessment Protocol

Field teams conducted site visits to 18 BMPs within the Western Hills Watershed. At each site, investigators examined site conditions using RRI protocols developed by CWP (Schueler et al. 2007) to obtain an overall assessment of the BMP. A standard RRI form, also developed by Schueler et al. (2007), was used to guide staff activities, and was also digitized in ArcGIS Online so that observations could be recorded using a tablet while in the field.

The RRI field visit protocol also includes consideration of the downstream condition, both the pond outfall and its channel and that of the receiving stream. Outfall channels or receiving streams showing signs of erosion or incision were noted as such. Field visits also considered whether the pond was draining a headwater and whether the pond was in line with a perennial stream. Inline stormwater management ponds are barriers to fish passage and create an artificial impoundment which prevents normal stream flow. Headwaters are the most sensitive of waterways to erosive forces and they have a disproportionately important impact on downstream biology and as such were noted on field forms.

#### 4.2.5.3 Summary of Retrofit Assessments

Field investigations were conducted in December 2018 through February 2019. Table 4-21 summarizes findings for the 18 existing BMP sites visited. Figure 4-52 shows all the existing stormwater control facilities in the watershed and those which were visited as candidates for conversion or for some manner of upgrade.

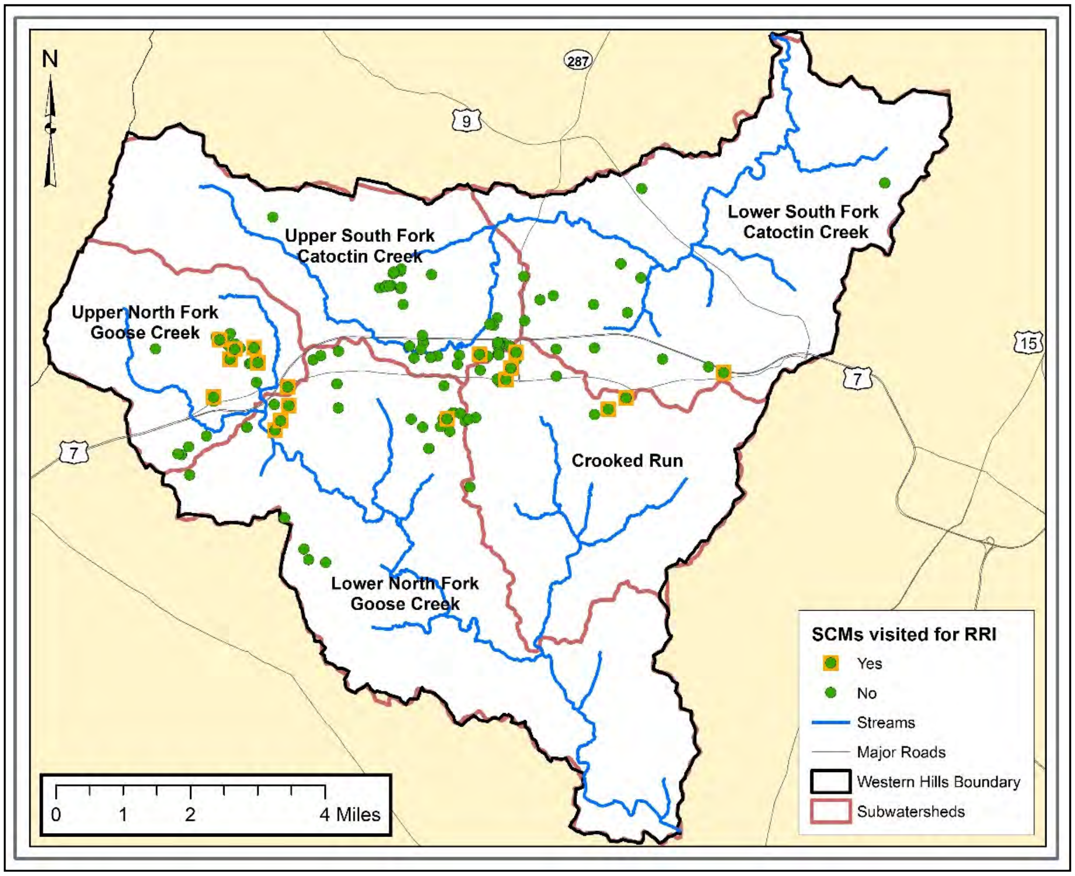


**Figure 4-52: Location map of stormwater management facilities and those facilities visited as candidates for upgrade or conversion**

Field observations guiding the viability of upgrading existing SCMs included undocumented in-field retrofits, primary debris type and amount, invert elevation (if visible), available space for expansion, potential presence of a shallow ground water table, soil type as indicated on soil maps, room for additional control measures within the existing pond basin, prominence of the pond relative to homes nearby and the need to consider aesthetics in the final design, and other considerations. Note that design or as-built plans were not available for review.

Existing SCM upgrades were also given a Priority Designation of Low, Medium, High, or Not Upgradable, depending primarily upon the existing pond designation (and pollutant removal efficiency), engineering feasibility of an upgrade and on how much additional reduction was possible under the SCM efficiencies designated by the Chesapeake Assessment and Scenario Tool (CAST). The SCM efficiencies found in CAST represent SCM efficiencies approved by the Environmental Protection Agency (EPA) Chesapeake Bay Program for meeting nutrient (nitrogen and phosphorus) and sediment reductions required by the Bay TMDL.

Existing dry ponds treating larger drainage areas would have priority because of the larger water quality benefits in pollutant load reduction. Aesthetic and community acceptability concerns were also considered. Ponds at which undocumented in-field retrofits were observed were given higher priority to include any missing elements and to check the modification in hydraulic characteristics due to the retrofit. Ponds were not prioritized by ownership.

#### 4.2.5.4 Results of Assessments

Available options for upgrades of existing SCMs and their effectiveness in the Piedmont Crystalline Hydro Geomorphic Region were focused on those options listed on the *CAST Source Data* spreadsheet (see Table 4-20).

**Table 4-20: Pollutant Removal Efficiencies of Select BMPs as Provided by CAST February 2019**

| Select BMPs from CAST** | Nitrogen Effectiveness (%) | Phosphorus Effectiveness (%) | Sediment Effectiveness (%) |
|---|---|---|---|
| Dry Detention Ponds and Hydrodynamic Structures | 5 | 10 | 10 |
| Dry Extended Detention Ponds | 20 | 20 | 60 |
| Wet Ponds and Wetlands | 20 | 45 | 60 |
| Bioretention/rain gardens - C/D soils, underdrain | 25 | 45 | 55 |
| Bioswale | 70 | 75 | 80 |

**Table 4-20: Pollutant Removal Efficiencies of Select BMPs as Provided by CAST February 2019**

| Select BMPs from CAST** | Nitrogen Effectiveness (%) | Phosphorus Effectiveness (%) | Sediment Effectiveness (%) |
|---|---|---|---|
| Bioretention/rain gardens - A/B soils, underdrain | 70 | 75 | 80 |
| Bioretention/rain gardens - A/B soils, no underdrain | 80 | 85 | 90 |

***From **CAST Source Data** spreadsheet, version CAST-2017d, dated February 5, 2019 (Chesapeake Bay Program 2019, https://cast.chesapeakebay.net/Home/SourceData). Color coded by similar BMP type. Sorted by pollutant removal efficiency.*

The results of field reconnaissance are summarized in Table 4-21. Out of 18 ponds visited, all but three were judged to be candidates for either conversion of the entire pond or addition of some additional treatment within the pond boundary or both to increase pollutant removal efficiency.

Pond type designations were initially based on County-provided data, but in some cases were modified based on field observations. Our final designations of Pond Type are listed in Table 4-21.

**Table 4-21: Stormwater Pond Retrofit Reconnaissance Summary**

| Structure ID | Nearby Landmark | Owner-ship | Subwatershed | Pond Type | Proposed Redesign (s) | Priority Designation | Drainage Area (acres) |
|---|---|---|---|---|---|---|---|
| KS0410 | Scott Jenkins Memorial Park | County | Lower South Fork Catoctin Creek | ED | N/A | Not Upgradable | 5.26 |
| DD106 | Hamilton Elementary School | School System | Crooked Run | - | Bioretention/Infiltration Swale | Low (maintenance needed) | 0.88 |
| BC44 | Tillett Way | Private[b] | Crooked Run | DP | ED/Bioswale | Low | 1.88 |
| JC7334 | Tedler Circle (Northern) | Private[b] | Upper North Fork Goose Creek | DP | ED | High | 17.93 |
| JC7435 | Sleeter Lake | Private[b] | Lower North Fork Goose Creek | DP | ED | Low | 7.32 |
| JC7335 | Tedler Circle (Middle) | Private[b] | Lower North Fork Goose Creek | DP | ED | High | 16.43 |
| JC7434 | Tedler Circle (Southern) | Private[b] | Lower North Fork Goose Creek | DP | N/A | Not Upgradable | 17.2 |
| JC7170 | Park Heights Circle | Private[b] | Upper North Fork Goose Creek | DP[a] | Confirm ED elements added are appropriately credited, add missing ED elements | Medium | 7 |
| JC7169 | Magic Mountain Drive | Private[b] | Upper North Fork Goose Creek | DP[a] | Confirm ED elements added are appropriately credited, add missing ED elements | Medium | 11.92 |

**Table 4-21: Stormwater Pond Retrofit Reconnaissance Summary**

| Structure ID | Nearby Landmark | Owner-ship | Subwatershed | Pond Type | Proposed Redesign (s) | Priority Designation | Drainage Area (acres) |
|---|---|---|---|---|---|---|---|
| JC6966 | Greenwood Drive (Southern) | Private[b] | Upper North Fork Goose Creek | ED | Add ED elements and improve low flow design | High | 37.81 |
| DP0033 | Kedleston Court | Private[b] | Upper North Fork Goose Creek | DP[a] | Confirm ED elements added are appropriately credited, add missing ED elements | Medium | 2.20 |
| JC50025 | Greenwood Drive (Northern) | Private[b] | Upper North Fork Goose Creek | DP | ED | High | 14.79 |
| SWM32 | Loudoun Valley Medical Center | Private[b] | Crooked Run | DP | ED | Low | 8.4 |
| DP0030 | Loudoun County Sheriff's Office | County | Upper North Fork Goose Creek | DP[a] | Confirm ED elements are appropriately credited, add drawdown device to forebay | Low | 4.93 |
| SWM38 | Pickwick Drive | Private[b] | Crooked Run | DP | ED | Low | 4.34 |
| SWM40 | Wexford Place | Private[b] | Crooked Run | DP | ED | Low | 7.42 |
| Unknown | Blue Ridge Bible Church | Private | Lower North Fork Goose Creek | ED | N/A | Not Upgradable | 5.30 |
| SWM24 | Across from Loudoun Valley High School | County | Upper South Fork Catoctin | DP | ED | High | 12.51 |

DP = Dry Pond, ED = Extended Detention

[a] Undocumented in-field retrofit.

[b] Privately owned, County maintained.

In all, five High Priority conversion opportunities were identified (at four ponds and one bioretention). Another three Medium Priority opportunities were identified (at three ponds).

The most common conversion suggestion in the watershed is conversion of existing dry ponds to extended detention dry ponds; nine instances in total. Extended detention (ED) ponds are well suited for small to medium urban watersheds which do not generate consistent baseflow for development of wet ponds or wetlands benches. Retrofit features considered during the field observations included extended/meandering flow path, sediment forebays, energy dissipation, outflow structure modifications, and outfall improvement. The extended detention retrofits will provide improved sediment capture without the substantially increased effort attributed to maintaining diverse and healthy wetland systems as a part of enhanced treatment. In most of the cases, any retrofit will have to be preceded by a substantial maintenance effort to remove sediment accumulated over time and establishing the original pond floor elevations per the design plans. Extended detention was also selected for sites where partial retrofit of the outflow structure using a gravel filter with a perforated drain was constructed in the field. In these cases, any elements of the ED design that were missing were noted to be added to complete the retrofit. In a small number of cases, addition of enhanced treatment features can be considered during the design phase for the projects if baseflow conditions are deemed adequate for establishing of enhanced treatment systems.

It is important to note that the options in Table 4-21 require additional vetting, including review of as-built plans to better estimate constructability. This would be followed by cost estimations for design, construction, and permitting which would allow for further prioritization based upon costs per pound of nutrient removed under the new design scenarios.

Based on the field assessment, the Western Hills Watershed appears to offer some good pond conversion opportunities if the County and the neighbors living near the existing ponds are willing to consider extended detention dry ponds in lieu of dry ponds.

**Example Upgrade: Park Heights Circle**

Dry pond JC7170 (Figure 4-53) drains a residential section of the Oak Hill neighborhood. It is an offline pond that has been modified with extended detention elements. The low flow has been designed as a perforated drain pipe and gravel filter connecting to the existing low flow orifice. The existing outflow structure with grate provides conveyance and flow control (Figure 4-54). It is unknown if the additional extended detention elements added to the pond are appropriately credited. The western side of the dam wall is considerably lower and could cause overflow into neighbors' yard during intense rains (Figure 4-55). It is recommended that in addition to the extended detention elements already in place, more be added to help with the erosion seen along the outfall (Figure 4-56). A sediment forebay is recommended at the inlet, and flow diversions as needed to direct flow to the eastern side of the pond to use all available space and reduce deposition of finer settleable and suspended fractions on the gravel filter. In addition to these upgrades, the pond needs regular maintenance to prevent pond floor sedimentation and clogging of the gravel filter. Alternate designs for low flow and/or incorporating real-time control can provide improved sediment recovery.

**Figure 4-53: Dry Pond JC7170**

**Figure 4-54: Perforated stack pipe, gravel filter, and grated outflow with low flow orifice in Dry Pond JC7170**

**Figure 4-55: Low point along Western side of Dry Pond JC7170**

**Figure 4-56: Erosion along outfall swale**

**Example Upgrade: North Maple Drive**

Dry pond SWM24 (Figure 4-57) drains Loudoun Valley High School and portions of North Maple Drive. The pond was designed as an educational opportunity for the high school with a pollinator garden (Figure 4-58) but the pollinator species appear to have died out because of the pond holding water beyond the designed detention time which has caused continuous inundation (Figure 4-59). It is recommended that extended detention elements be added to the pond to improve the capacity. The flow path can be extended to fully use the space available in the pond by adding a berm. Currently, it appears the low flow orifice is experiencing sedimentation. Sediment forebays could be utilized at both inlets to prevent this sedimentation (Figure 4-60). The regular maintenance of the pond will ensure that wetland species do not crowd out the local and pollinator species and will ensure that this continues to be an educational opportunity for the high school.

**Figure 4-57: Dry Pond SWM24**


**Figure 4-58: Sign at Dry Pond SWM24 indicating pollinator garden and educational opportunity**

**Figure 4-59: Continuous ponding at Dry Pond SWM24**

**Figure 4-60: Outflow with standing water, assumed sedimentation within the low flow orifice**

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# CHAPTER 5: ASSESSMENT OF GROUNDWATER RESOURCES

## 5.1 Introduction

Groundwater pumped from public and private wells drilled in fractured crystalline bedrock provides approximately 90% of potable water supplied to approximately 25,000 residents in the Western Hills Watershed. The presence, movement, and availability of groundwater depends on watershed hydrogeology and variations in precipitation, evapotranspiration, surface runoff, streamflow, and groundwater pumping over time and space. Stream baseflow is sustained by groundwater discharge, which also affects stream water quality. Water resource studies required for land and water-supply development, as well as investigations and monitoring of hydrologic conditions by the U.S. Geological Survey (USGS) and County agencies, have substantially increased knowledge of groundwater in the Western Hills Watershed since the 1980s. The purpose of this chapter is to provide an overview of watershed hydrogeology, water balance components, well characteristics, capacity of groundwater to meet future demands, and groundwater quality. Additional relevant information is provided by the references cited herein.

## 5.2 Watershed Geology

The Western Hills Watershed consists of drainage basins of the South Fork Catoctin Creek and the North Fork Goose Creek as shown on the topographic relief map in Figure 5-1. It includes the towns of Round Hill, Purcellville, and Hamilton. Most of western Loudoun County occupies a broad valley bounded by north-northeast-trending physiographic features, including Catoctin Mountain to the east and the Blue Ridge to the west. Short Hill Mountain, which rises steeply from Hillsboro, bisects the northern portion of the valley before dropping sharply to the Potomac River. The valley floor has low relief characterized by gently rolling hills and eastward-draining stream valleys.

Bedrock units and faults mapped by the USGS (Burton et al. 1992; McDowell and Milton 1992; Southworth 1995; Southworth et al. 1999 and 2006) in the Western Hills Watershed are shown in Figure 5-2. The Watershed is underlain by Mesoproterozoic to Early Cambrian age rocks, which are part of the Blue Ridge anticlinorium, a large allochthonous fold apparently formed during the Alleghenian orogeny[1]. The anticlinorium is cored by weakly to strongly foliated high-grade Mesoproterozoic metagranites (e.g., Ymb, Ygt, Yg, and Yhm) and non-granitic gneisses (e.g., Yp, and Yn), which were emplaced, deformed, and metamorphosed during the Grenville orogeny approximately 1.0 to 1.1 billion years ago. A cover sequence of Late Proterozoic (approximately 600 million years old) to Early Cambrian (approximately 325 million years old) metavolcanic and metasedimentary rocks unconformably overlies the basement gneisses along ridges where these

[1] An anticlinorium is a large anticline on which minor folds are imposed. An anticline is a fold of geologic structure that has an arch-like shape with its oldest beds at its core. An allochthonous fold indicates that the rocks of the anticlinorium were formed elsewhere and were moved to their current location (apparently by compressional forces pushing rocks over a fault surface). The Alleghenian orogeny occurred approximately 325 million to 260 million years ago and was caused by Africa colliding with North America.

cover rocks have not been eroded. The metavolcanic rocks (primarily Catoctin Formation

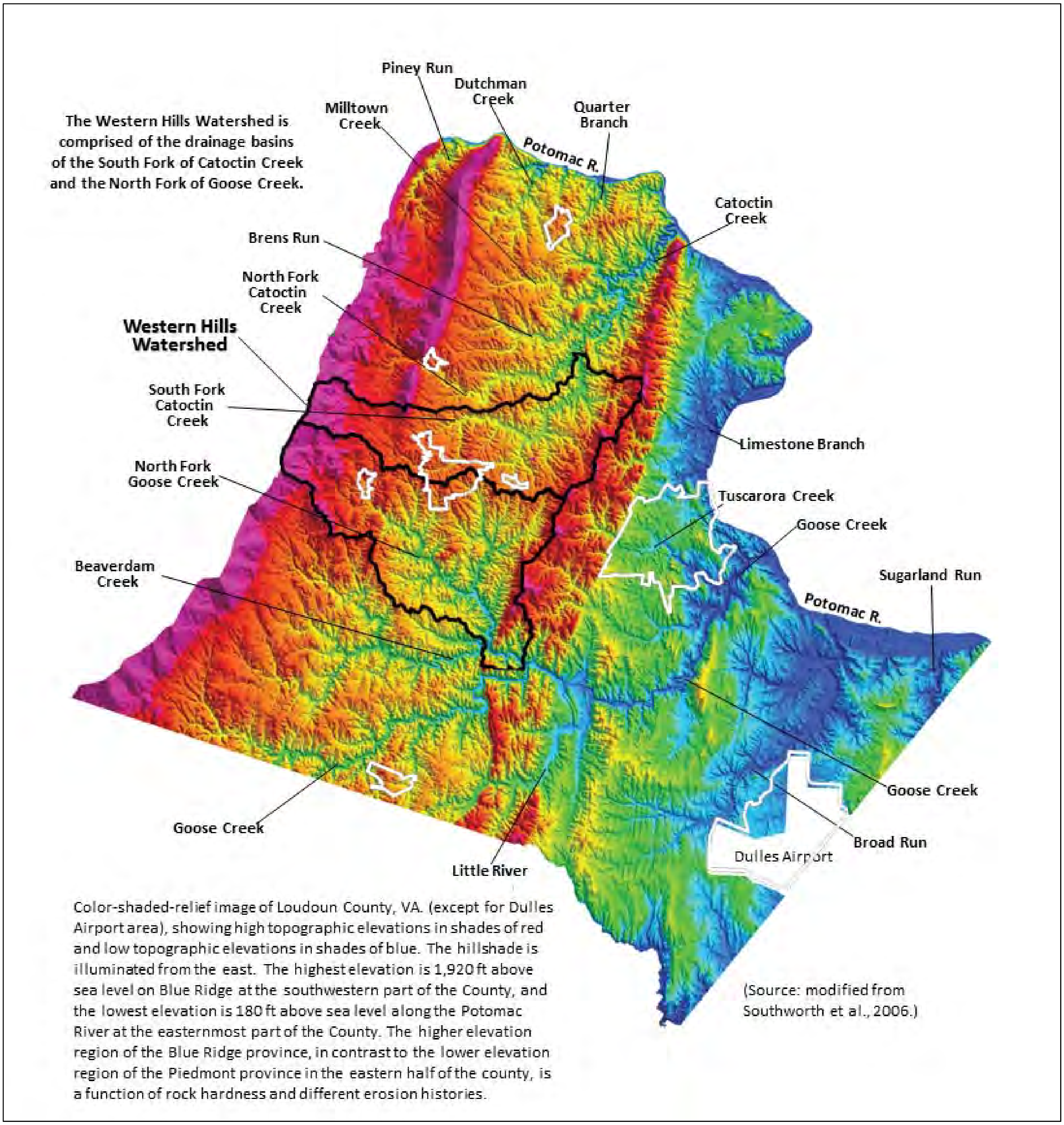


**Figure 5-1: Topographic relief map of Loudoun County showing the Western Hills Watershed**

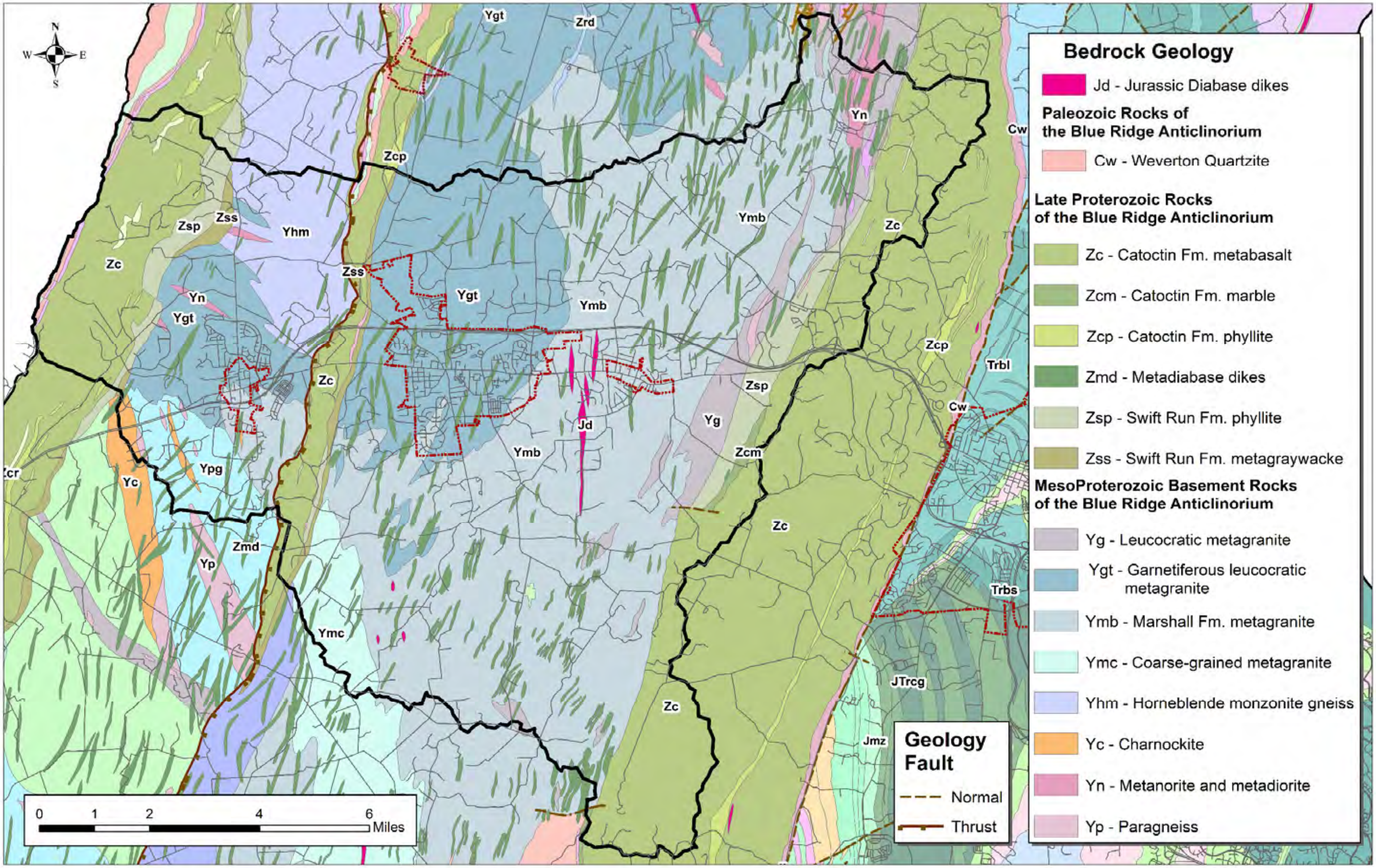


**Figure 5-2: Geologic map of the Western Hills Watershed (modified from Southworth et al. 2006).**

metabasalt) were fed by a northeast-trending swarm of tabular late Proterozoic metadiabase dikes that intruded the basement rocks during sea-floor spreading of continental plates. The cover rocks were later deformed and metamorphosed to greenschist facies during the Alleghenian orogeny.

A block diagram showing the general distribution of soil, saprolite (chemically-weathered unconsolidated material showing relic structure of its source rock), weathered bedrock, and unweathered bedrock is provided in Figure 5-3.

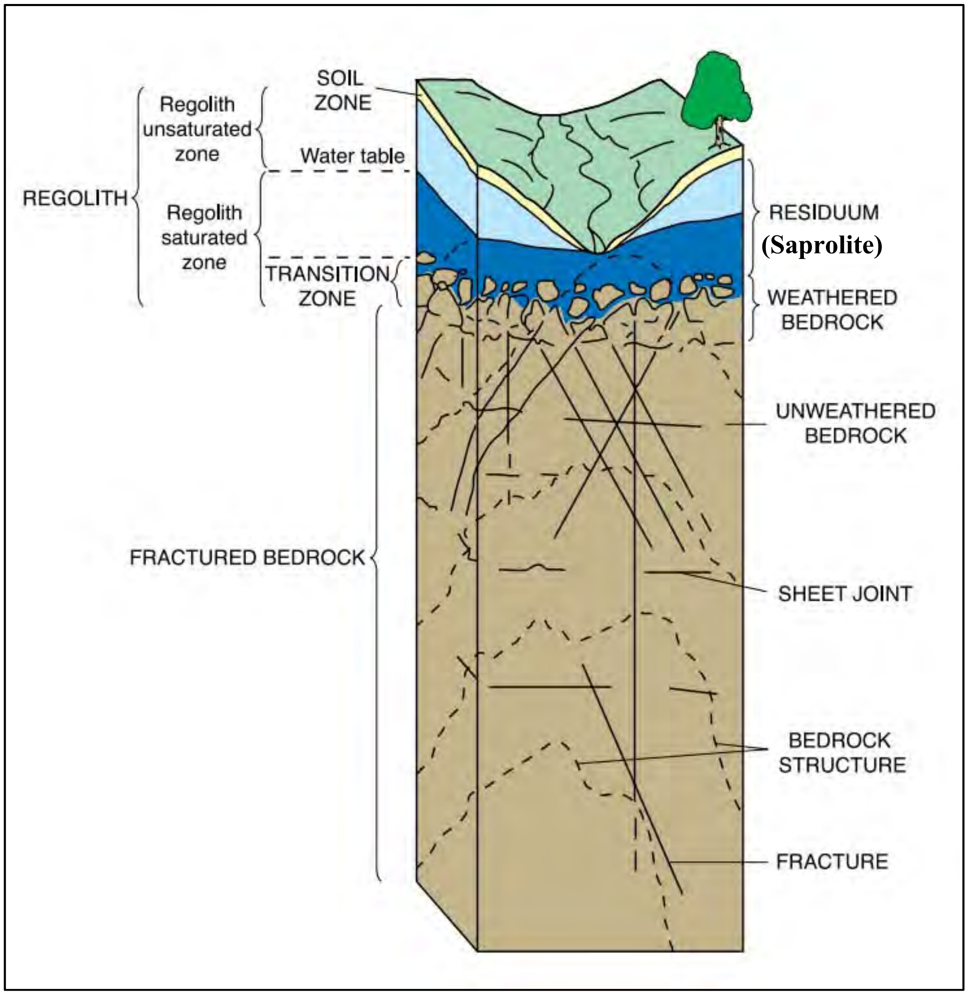


**Figure 5-3: Principal hydrogeologic components of regolith and bedrock in the Blue Ridge physiographic province (from Swain et al. 2004 and Daniel et al. 1997).**

Crystalline metamorphic bedrock in the study area has essentially no primarily porosity. As such, its capacity to store and transmit groundwater is highly dependent on the density and interconnectivity of secondary void spaces (primarily open fractures) present in the rock. The presence, distribution, and orientation of fractures in local bedrock are controlled by brittle deformation fabrics such as joints, faults, and folds. The development of bedrock fractures depends on rock lithology and the nature of stresses imposed on the rock mass over geologic time. The most dominant and pervasive fracture fabric features, which may influence groundwater flow, are: (1) the northeast-striking, moderately to steeply dipping (generally to the southeast) metadiabase dikes that intrude the older gneiss, and (2) subparallel northeast-trending Paleozoic cleavage (schistosity). Northwest-trending foliation in the Middle Proterozoic basement rock, which was overprinted by dike intrusion and Paleozoic cleavage, is also observed in much of western Loudoun County.

Unconsolidated geologic deposits that overlie bedrock in the study area include alluvium, soil, and saprolite, and typically range from 10 to 50 feet thick based on well drilling records. Usually, only a thin cover of unconsolidated material is present below ridges, hilltops, and steep slopes due to limited bedrock weathering and increased erosion in these areas. Narrow valleys, most upland flats, and gentle slopes have greater thicknesses of unconsolidated deposits.

## 5.3 Water Balance Analysis

A water balance for the watershed, not accounting for changes in water storage over time, can be characterized as:

$$P - Q_s/A + U_i/A = ET_{vz} + ET_{rp} + U_o/A$$

where P is the average rate of precipitation (L/t); $Q_s$ is the average rate of streamflow out of the watershed ($L^3$/t); A is the area of the watershed ($L^2$); $ET_{vz}$ is the average rate of evapotranspiration from the soil or vadose zone in the watershed (L/t); $ET_{rp}$ is the average rate of evapotranspiration directly from groundwater near streams in riparian zones in the watershed (L/t); $U_i$ is the average rate of groundwater underflow into the watershed ($L^3$/t); $U_o$ is the average rate of groundwater underflow out of the watershed ($L^3$/t); L is the dimension of length, and t is the dimension of time.

Assuming groundwater flow into and out of the watershed is very small compared to its discharge to streams in the watershed, and combining evapotranspiration terms, results in a simplified water balance equation:

$$P - Q_s/A = ET$$

Results of water balance analysis for the Western Hills Watershed using the simplified equation and hydrologic data are provided in Figure 5-4 and Table 5-1. Given average precipitation, estimated water balance component flows over the 77.5 square mile Western Hills Watershed area include:

- Precipitation of 41.1 inches per year (in/yr), which equals 151.5 million gallons per day (MGD);
- Evapotranspiration of 25.1 in/yr (92.5 MGD and 61.1% of precipitation);
- Surface runoff of 4.6 in/yr (17.1 MGD and 11.3% of precipitation);
- Groundwater recharge, which provides stream baseflow, of 11.4 in/yr (41.9 MGD and 27.7% of precipitation);
- Stream outflow of 16.0 in/yr (59.0 MGD and 38.9% of precipitation); and

- Groundwater extraction of 0.60 in/yr (2.23 MGD and 1.5% of precipitation), which contributes to the groundwater recharge, evapotranspiration, and surface runoff components noted above.

These results are comparable to water balance component estimates calculated by the USGS (Sanford et al. 2011) for all Loudoun County and the drainage basin of Goose Creek at the gage near Middleburg (see Table 6-1).

Water balance components listed in Table 6-1 and discussed below were calculated using hydrologic monitoring data. Precipitation, streamflow, and groundwater elevation monitoring stations operated by Loudoun County, the National Weather Service, and/or the USGS are shown on Figure 5-5. Groundwater recharge in the two subwatersheds is calculated using the USGS software RORA (Rutledge 2007), which evaluates streamflow data to estimate recharge.

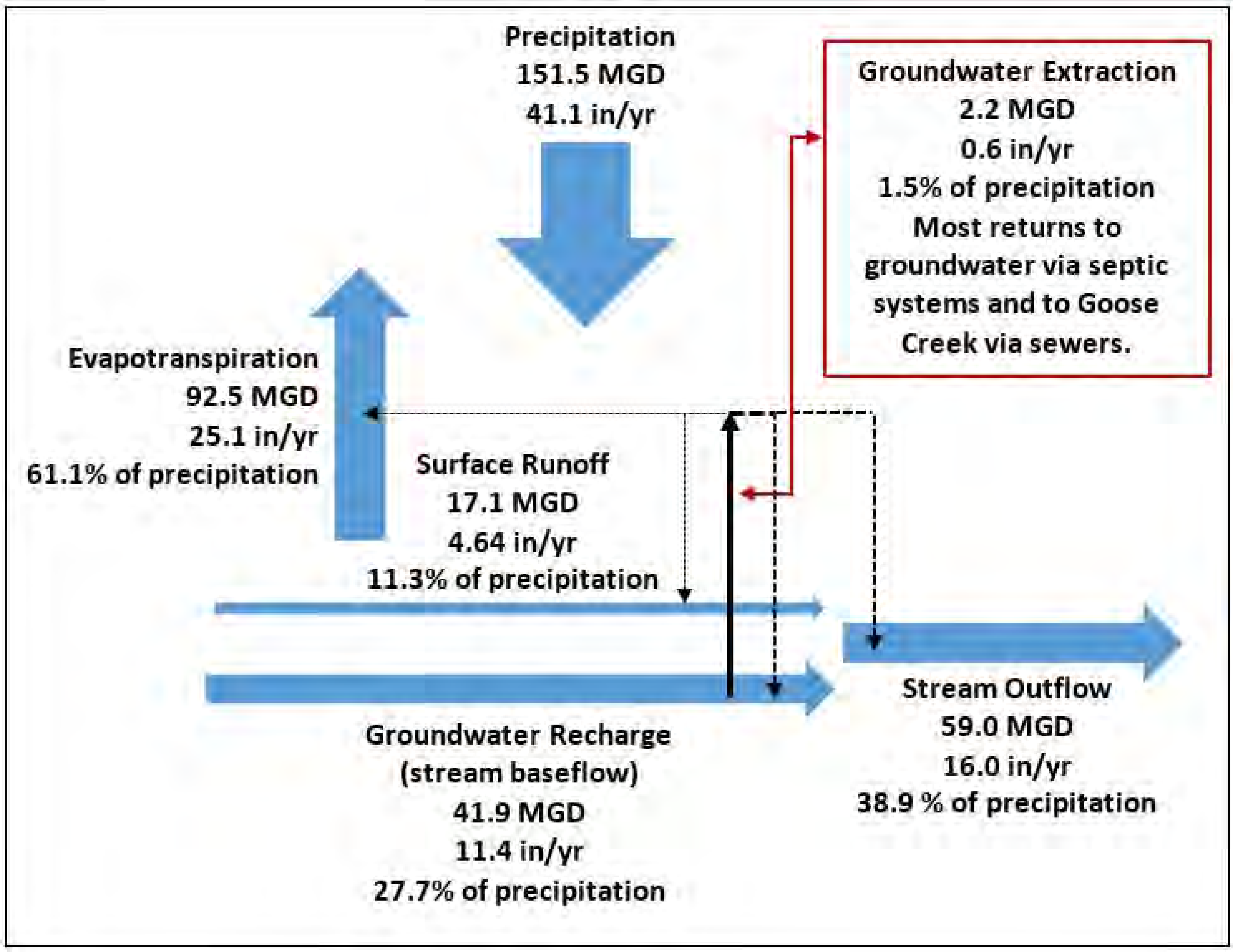


**Figure 5-4: Western Hills Watershed water balance. Arrow width is proportional to magnitude of flow component.**

**Table 5-1: Western Hills Watershed water budget analysis.**

| Units | Water Budget Component | Western Hills Watershed | | | USGS Scientific Investigations Report 2011-5198 Estimates | | |
|---|---|---|---|---|---|---|---|
| | | North Fork Goose Creek | South Fork Catoctin Creek | Basis | Goose Creek Gage near Middleburg | Loudoun County | Basis |
| Square miles | Watershed Area | 44.4 | 33.1 | Values from Loudoun County GIS. | -- | 522.1 | Values from USGS. |
| Square miles | Stream Gage Drainage Basin Area | 38.1 | 31.6 | Values from USGS. | 122.0 | -- | Values from USGS. |
| Inches per year | Annual Precipitation | 41.1 | 41.1 | Average of annual precipitation at Dulles Airport (1968-2018) and Lincoln (1966-2016) stations. | 42.3 | 42.5 | Precipitation records (1971-2000). |
| Inches per year | Annual Stream Outflow at Gage Station | 15.9 | 16.1 | Converted mean cubic feet per second (cfs) in 2002 to 2018 to in/yr in gage station drainage basin. | 15.6 | -- | Conversion of cfs to in/yr in drainage basin. |
| Inches per year | Annual Net Stream Outflow in Entire Watershed | 18.6 | 16.9 | Conversion based on ratio of entire watershed area to gage drainage area. | 16.1 | 16.1 | Calculated as precipitation minus Total ET. |
| Inches per year | Total Evapotrans-piration | 22.5 | 24.2 | Total Evapotranspiration = Precipitation - Net Outflow. | 26.7 | 26.4 | Estimated from a regression eqn relating ET to climatic characteristics & impermeable surface. |
| Inches per year | Groundwater Recharge | 11.8 | 10.8 | Based on RORA analysis of streamflow gage station records 2002-2018. | 16.0* | 12.2 | Calculated as Recharge = Precipitation - Surface Runoff - Vadose Zone ET. |
| Inches per year | Groundwater Extraction | 0.60 | | Assuming water use of 100 GPD/person, 25,000 residents, and 0.27 MGD of surface reservoir water supply. Most water supply is returned to streams or the subsurface via sewers and septic systems; a lesser portion contributes to ET and surface runoff. | | | |

## Table 5-1: Western Hills Watershed water budget analysis.

| Units | Water Budget Component | Western Hills Watershed | | | USGS Scientific Investigations Report 2011-5198 Estimates | | |
|---|---|---|---|---|---|---|---|
| | | North Fork Goose Creek | South Fork Catoctin Creek | Basis | Goose Creek Gage near Middleburg | Loudoun County | Basis |
| | **Surface Water Runoff** | 6.8 | 6.1 | Calculated as Runoff = Net Outflow - Baseflow (groundwater recharge). | 2.9 | 5.1 | Estimated from a regression eqn relating to rock type, physiography, and percent impermeable surface area. |
| Million Gallons per Day (MGD) | **Annual Precipitation in Entire Watershed** | 86.8 | 64.7 | Convert 41.1 in/yr based on watershed area and units. | 245.5 | 1055.7 | Converted from above. |
| | **Annual Stream Outflow at Gage Station** | 28.9 | 24.2 | Based on mean cfs in 2002 to 2018 at each station. | 90.5 | -- | Converted from above. |
| | **Annual Net Stream Outflow in Entire Watershed** | 33.7 | 25.4 | Conversion based on ratio of entire watershed area to gage drainage area. | 93.5 | 399.9 | Converted from above. |
| | **Total Evapotrans-piration** | 53.2 | 39.3 | Total Evapotranspiration = Precipitation - Net Outflow. | 152.1 | 655.8 | Converted from above. |
| | **Groundwater Recharge** | 24.9 | 17.0 | Based on RORA analysis of streamflow gage station records 2002-2018. | 92.9* | 303.0 | Converted from above. |
| | **Groundwater Extraction** | 2.23 | | Assuming water use of 100 GPD/person, 25,000 residents, and 0.27 MGD of surface reservoir water supply. Most water supply is returned to streams or the subsurface via sewers and septic systems; a lesser portion contributes to ET and surface runoff. | | | |
| | **Surface Water Runoff** | 8.8 | 8.4 | 8.8 | 8.4 | 8.8 | 8.4 |

* Note: The USGS calculated a groundwater recharge rate of 16.0 inches per year for the 122 square mile drainage basin of Goose Creek measured at a gage near Middleburg. This rate exceeds the rates calculated for the Western Hills Watershed basins. USGS studies by Nelms et al. 1997 and Sanford et al. 2011 both determined relatively high recharge rates in certain drainage basins in the Blue Ridge physiographic province of Virginia (see Section 5.3.4).

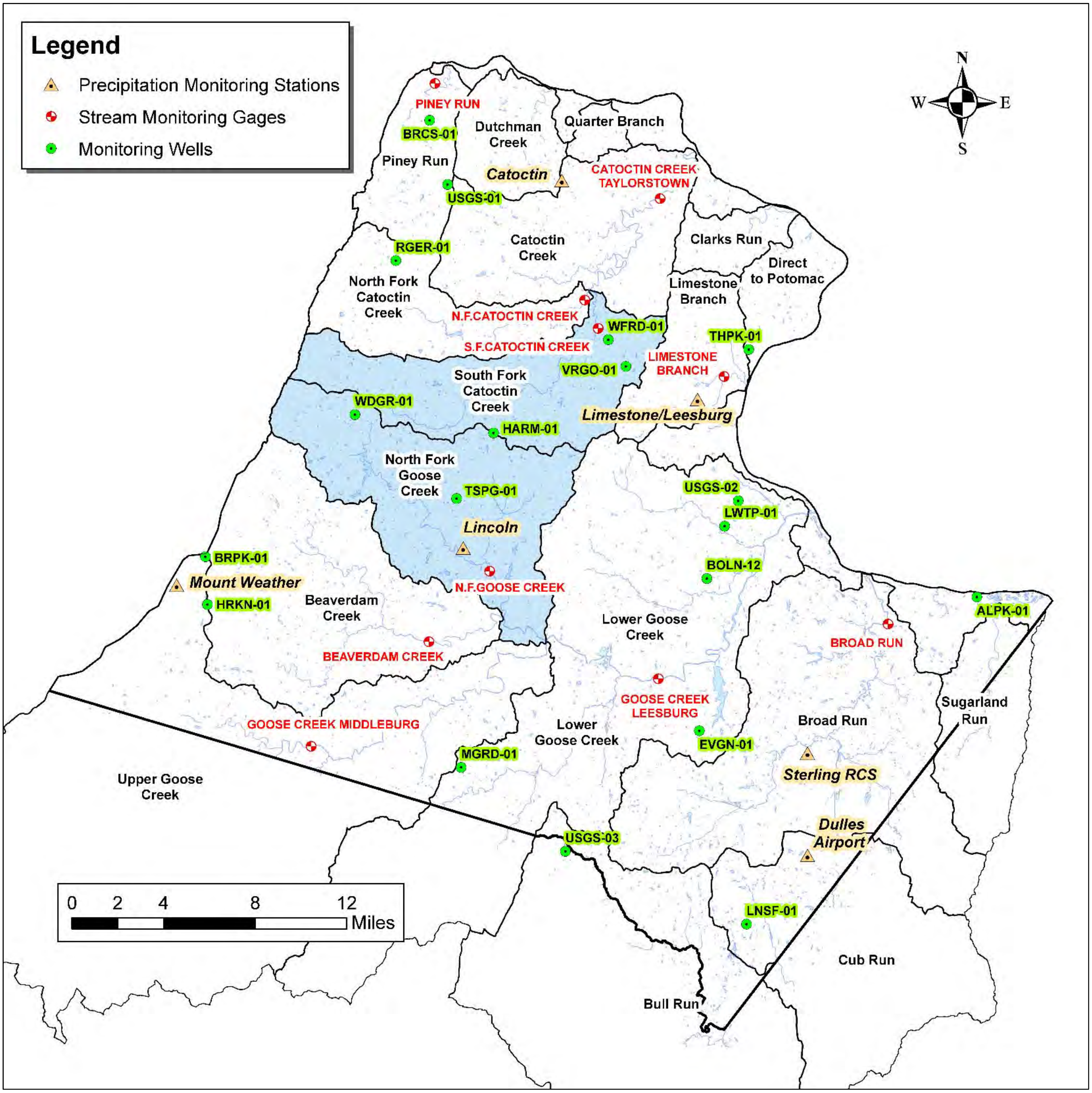


**Figure 5-5: Loudoun County hydrologic monitoring stations.**

### 5.3.1 Precipitation

Summary information regarding precipitation monitoring stations in Loudoun County are listed in Table 5-2. Annual precipitation measured at the Dulles Airport, Lincoln, Mt. Weather, and Sterling stations are plotted for the period from 1980 to 2018 on Figure 5-6. For this 38-year record, annual precipitation ranged from 27 to 67 in/yr at Dulles Airport, and from 25 to 64 in/yr at Lincoln. The combined average precipitation at Dulles Airport and Lincoln was 41.1 in/yr during this period. Average, maximum, and minimum monthly precipitation rates at Dulles Airport for 1964 to 2018 (Figure 5-7) show that higher rates of precipitation tend to fall between May and September than between October and April. Prior studies and Figure 5-6 indicate that spatial variation in precipitation between different stations in Loudoun County is small (CH2MHill 2008a). Differences in annual rates recorded at each station are typically less than 10% of the average and median annual precipitation rates.

**Table 5-2: Precipitation monitoring stations and data summary.**

| Station Name | Period of Record | Operated by | Annual Statistics in Inches for Period of Record | | | |
|---|---|---|---|---|---|---|
| | | | Minimum | Median | Maximum | Mean |
| Blue Ridge Center | 2011-2016 | Loudoun County | 31.7 | 40.7 | 50.5 | |
| Dulles Airport | 1964-2018 | NWS-COOP | 27.0 | 39.8 | 66.7 | 41.8 |
| Limestone Branch | 2003-2018 | USGS | 28.0 | 38.3 | 76.1 | |
| Lincoln | 1931-2016 | NWS-COOP | 25.0 | 41.3 | 63.5 | 40.9 |
| Lovettsville | 2003-2018 | USGS | 27.6 | 36.2 | 61.3 | |
| Mt.Weather | 1949-2018 | NWS-COOP | 24.8 | 41.2 | 71.1 | 41.8 |
| Sterling RCS | 1978-2018 | NWS-COOP | 30.3 | 43.1 | 67.7 | 43.5 |

### 5.3.2 Evapotranspiration

Evapotranspiration (ET) is the sum of evaporation and plant transpiration from land and water to the atmosphere. It can be estimated using water balance and energy balance methods. As shown in Figure 5-4, an estimated 61% of precipitation in the Western Hills Watershed returns to the atmosphere by evapotranspiration based on the water balance method, whereby ET equals precipitation minus stream outflow from the watershed. A common energy balance method, known as the Thornthwaite method, is based on monthly temperature data. Figure 5-8 illustrates that soil moisture replenishment and groundwater recharge in Loudoun County occurs primarily between October and May when evapotranspiration, greatly diminished by vegetative dormancy and lower temperatures, is less than precipitation.

### 5.3.3 Surface Runoff

Surface runoff (SRO) in the Western Hills Watershed was calculated by subtracting estimated groundwater recharge (stream baseflow) from measured stream net outflow. The estimate of surface runoff from the watershed is 17.1 MGD, which equals approximately 11.3% of precipitation.

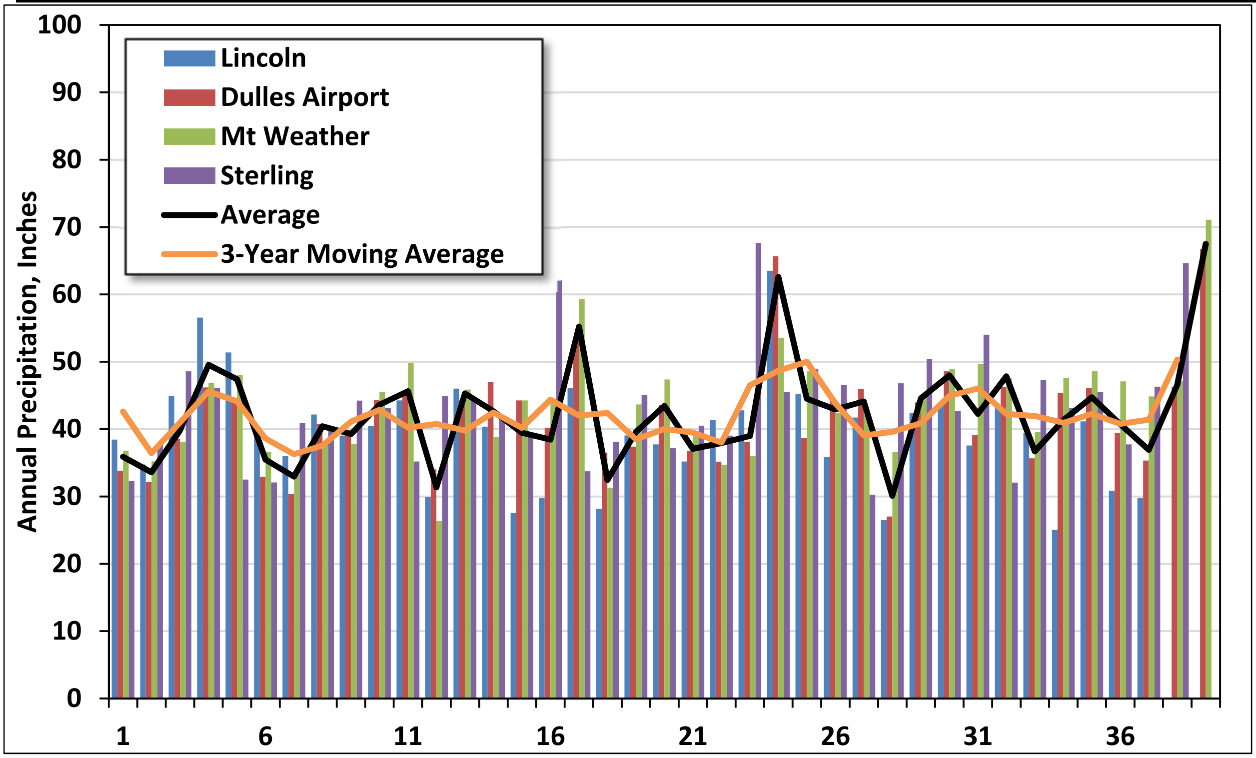


**Figure 5-6: Annual precipitation recorded at weather stations in Loudoun County.**

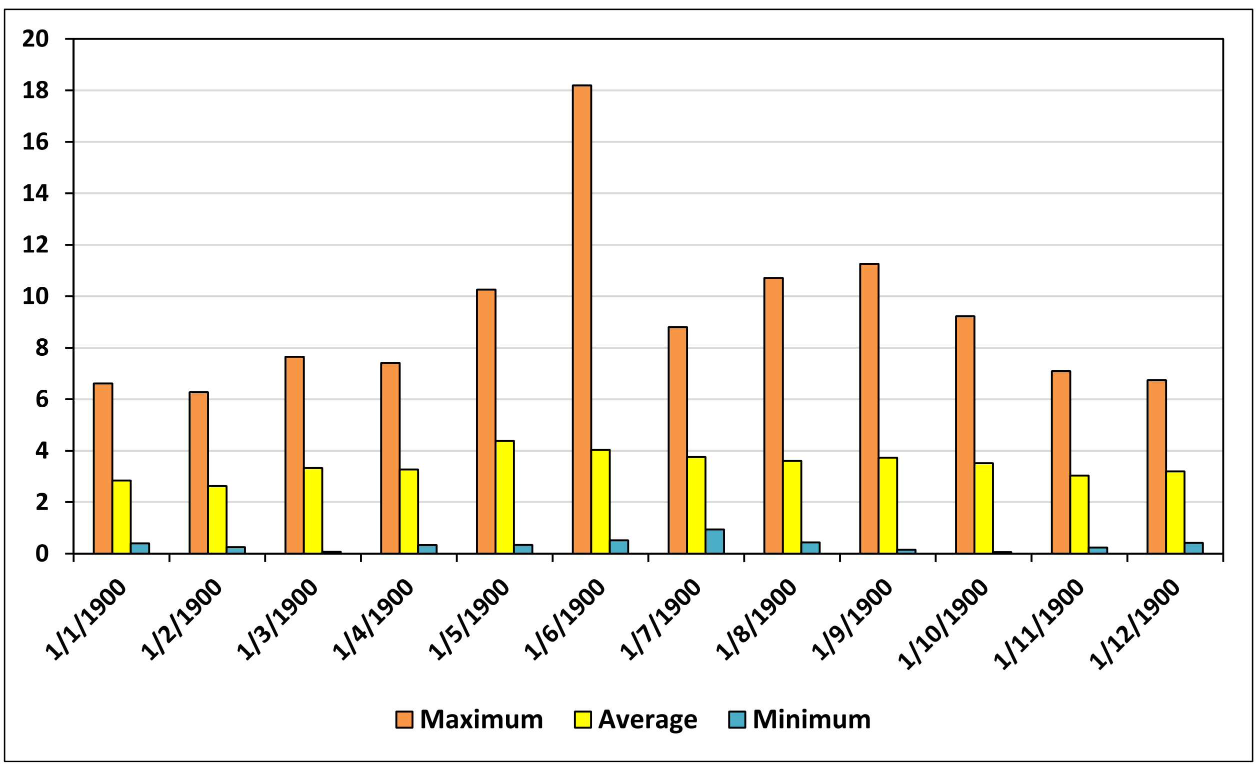


**Figure 5-7: Maximum, average, and minimum monthly precipitation rates recorded at Dulles Airport between 1964 and 2017.**

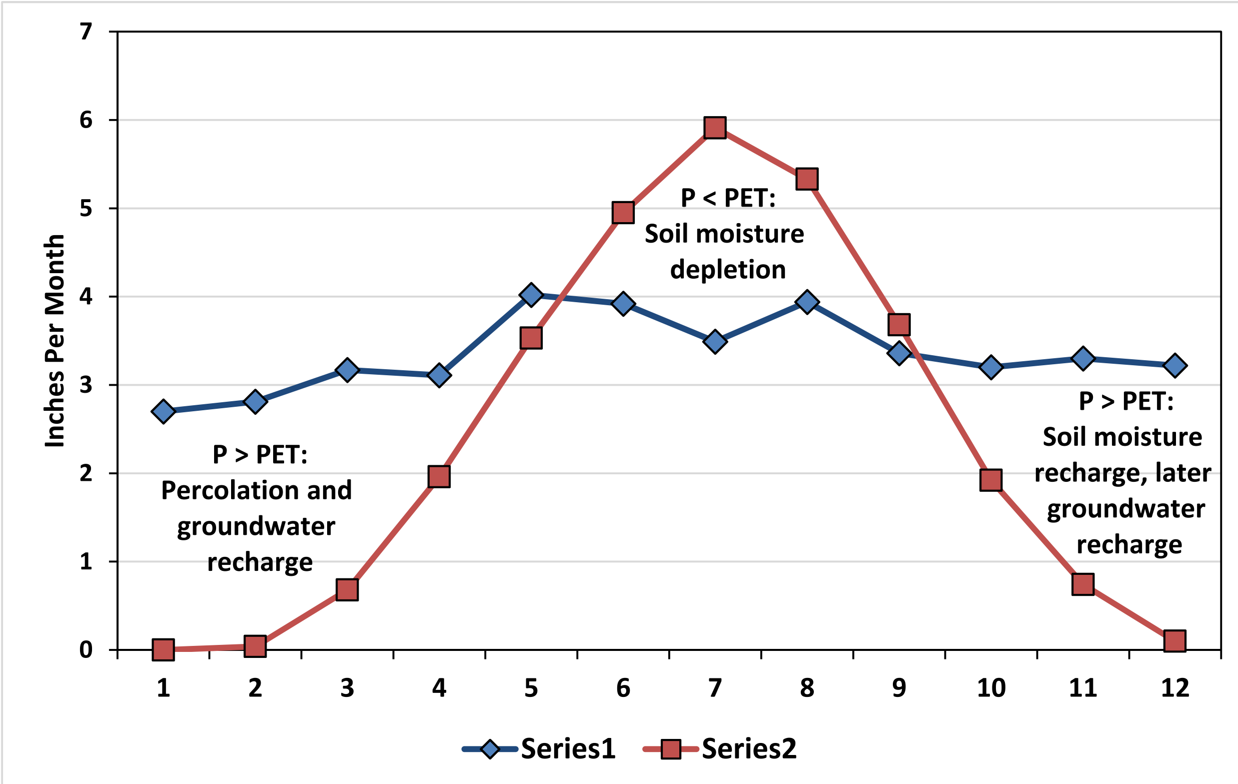


**Figure 5-8: Potential evapotranspiration calculated in Loudoun County using Dulles Airport data and the Thornthwaite method (after University of Virginia Climatology Office, http://www.climate.virginia.edu/va_pet_prec_diff.htm).**

### 5.3.4 Stream Baseflow and Groundwater Recharge

Hydrologic relationships between precipitation, groundwater flow, groundwater pumping, and streamflow are illustrated in Figure 5-9. Infiltrating precipitation recharges groundwater causing the water table to rise above stream bottom drainage elevations. Drawdown from pumping can reduce or eliminate groundwater discharge to streams and induce leakage of surface water to underlying geologic media.

Summary information on drainage areas, streamflow records, and groundwater recharge rates calculated from streamflow measurements at ten gaging stations in Loudoun County, including the North Fork Goose Creek and South Fork Catoctin Creek gaging stations in the Western Hills Watershed, are presented in Table 5-3. Monthly streamflow rate statistics for the North Fork Goose Creek and South Fork Catoctin Creek stations based on daily measurements recorded from July 1, 2001 to March 27, 2019 are shown in Figure 5-10. The data demonstrate that groundwater discharge sustains substantial flows in these creeks except during periods of drought.

Surface water from the Hirst Reservoir in the North Fork Catoctin Creek drainage basin (outside of Western Hills Watershed) is used for water supply by Town of Purcellville and conveyed after use through sanitary sewers to the Basham Simms Wastewater Facility, from which it discharges

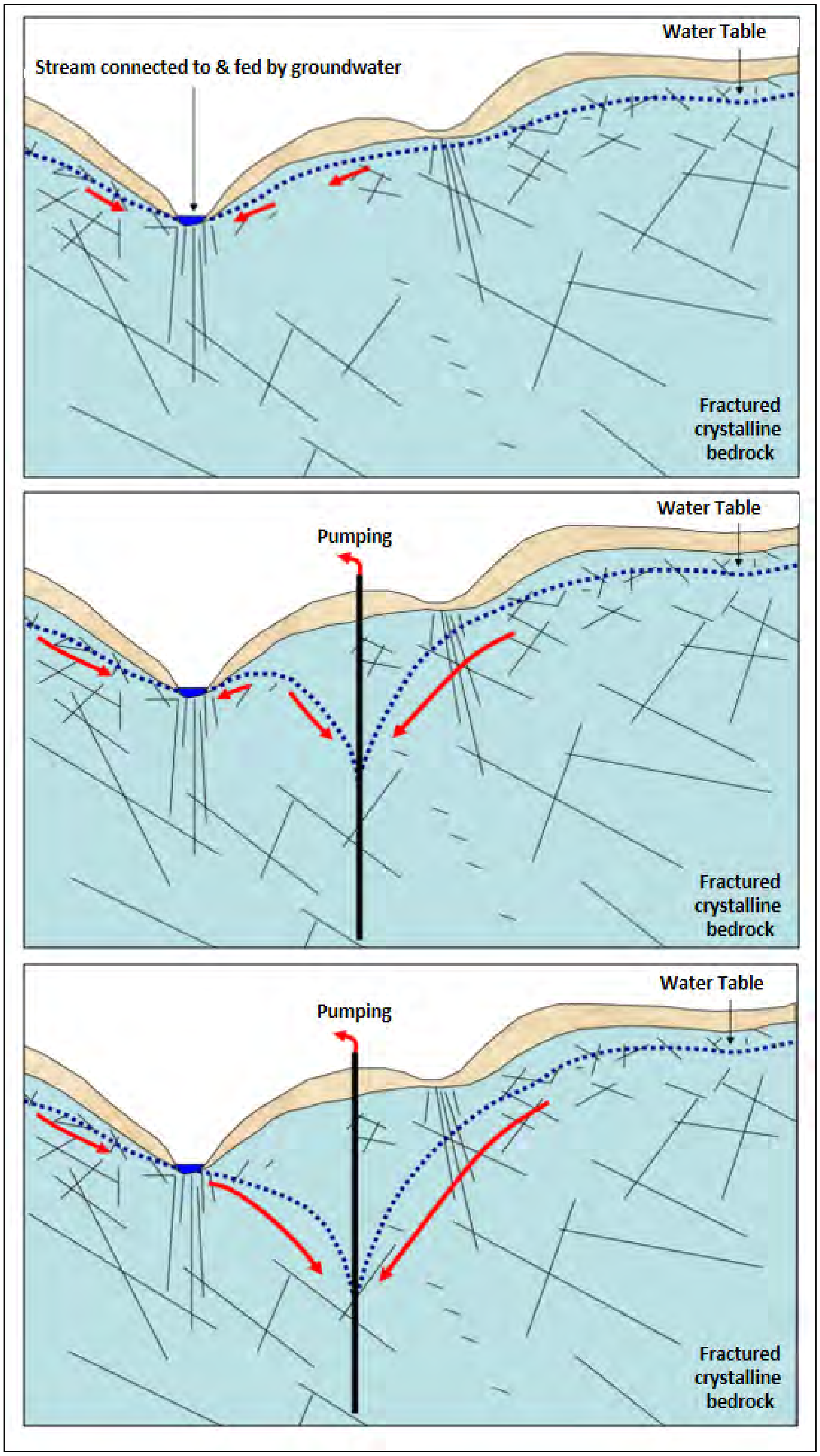


**Figure 5-9: Relations between groundwater and surface water in western Loudoun County (after Loudoun County 2019c.**

**Table 5-3: Calculated rates of groundwater recharge to watersheds in Loudoun County based on analysis of streamflow data.**

| StreamGaging Site Name and Number | Gage Drainage Area (square miles) | Start of Record | Period Analyzed | Average Annual Recharge Rate (in/yr) | Annual Recharge Rate Range (in/yr) | Average Daily Flow Rate 2002-2016 (cfs) | Lowest 7-Day Average Flow Rate 2002-2016 (cfs) | Average Annual Maximum Consecutive Days with Flow <0.2 CFS 2002-2016 |
|---|---|---|---|---|---|---|---|---|
| Beaverdam Creek at Route 734 near Mountville #01643880 | 47.2 | 7/18/2001 | 2002 - 2018 | 10.4 | 5.5 to 24.8 | 50.4 | 0.0 | 20 |
| Broad Run near Leesburg #01644280 | 76.1 | 10/1/2001 | 2002 - 2018 | 9.0 | 5.4 to 14.7 | 126.3 | 1.3 | 0 |
| Catoctin Creek at Taylorstown #01638480 | 89.5 | 10/1/1970 | 2002 - 2018 | 10.9 | 5.4 to 23.9 | 102.9 | 0.1 | 1.5 |
| Catoctin Creek at Taylorstown #01638480 | 89.5 | 10/1/1970 | 1972 - 2018 | 10.3 | 3.7 to 23.9 | 102.9 | 0.1 | 1.5 |
| Goose Creek near Leesburg #01644000 | 332.0 | 7/12/1909 | 2002 - 2018 | 10.5 | 5.4 to 24.3 | 349.6 | 1.1 | 0 |
| Goose Creek near Leesburg #01644000 | 332.0 | 7/12/1909 | 1930 - 2018 | 9.2 | 1.4 to 24.3 | 349.6 | 1.1 | 0 |
| Goose Creek near Middleburg #01643700 | 122.0 | 10/1/1965 | 2002 - 2018 | 12.2 | 4.4 to 27.3 | 134.7 | 0.0 | 4.3 |
| Limestone Branch near Leesburg, VA #01643590 | 7.9 | 8/23/2001 | 2002 - 2018 | 10.4 | 4.8 to 23.7 | 8.8 | 0.4 | 0 |
| North Fork Catoctin Creek at Route 698 near Waterford #01638420 | 23.1 | 7/20/2001 | 2002 - 2018 | 11.4 | 3.7 to 24.9 | 24.3 | 0.0 | 7.9 |
| North Fork Goose Creek at Route 729 near Lincoln# 01643805* | 38.1 | 7/1/2001 | 2002 - 2018 | 11.8 | 6.7 to 26.2 | 46.0 | 0.2 | 0 |
| Piney Branch near Lovettsville #01636690 | 13.5 | 10/1/2001 | 2002 - 2018 | 12.1 | 4.1 to 23.9 | 14.2 | 0.0 | 2.1 |
| South Fork Catoctin Creek at Route 698 near Waterford #01638350* | 31.6 | 7/1/2001 | 2002 - 2018 | 10.8 | 5.8 to 22.5 | 36.1 | 0.0 | 3.2 |

* Indicates stream gaging station that is in the Western Hills Watershed.

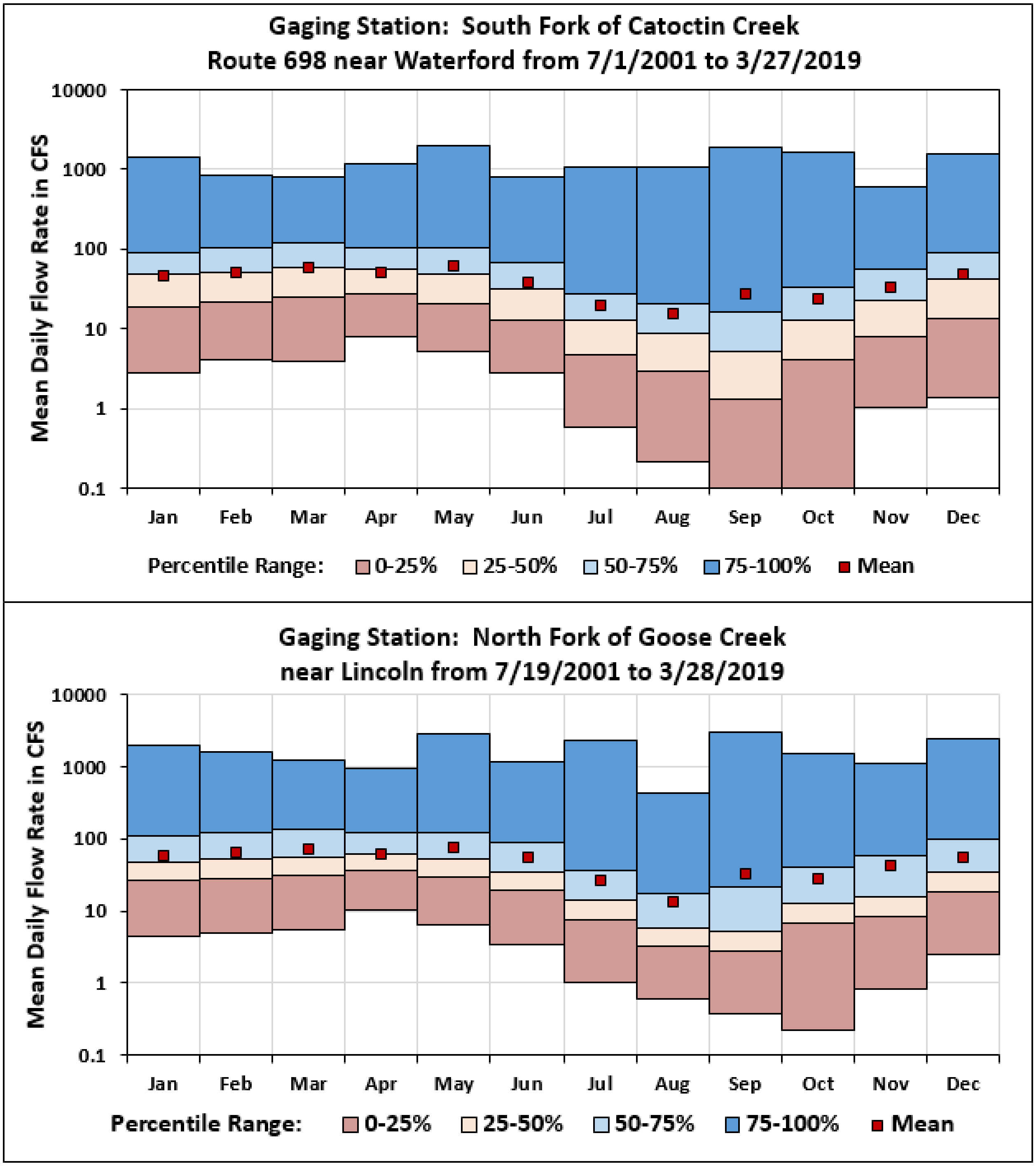


**Figure 5-10: Monthly streamflow rate statistics for gaging stations in the South Fork of Catoctin Creek and the North Fork of Goose Creek (1 CFS = 646,317 GPD).**

into North Fork Goose Creek. In 2017, Hirst Reservoir provided 84 million gallons (0.23 MGD) to the Town of Purcellville water supply. The minimal baseflow of North Fork Goose Creek in summer months is obviously enhanced by this discharge.

Groundwater recharge from infiltrating precipitation in an area can vary significantly due differences in topography, water runoff, permeability and thickness of surficial soils, vegetative cover type, local climate conditions, and the presence of impervious surfaces. Impervious area is generally associated with urban development and includes streets, roofs, driveways, and parking lots. Nearly all precipitation that falls on these areas either runs off or evaporates directly. The runoff may be routed to retention basins or other types of stormwater facilities where some portion recharges groundwater. Within the Western Hills Watershed, recharge rates are expected to be highest in areas covered by forest, cultivated fields or pastures, rural residential developments on large lots, and in areas underlain by relatively thick well-drained soils developed on bedrock. Groundwater recharge rates are expected to be lowest in more densely developed areas of the Towns and in areas underlain by hydric soils, wetlands, surface water bodies, or areas that have shallow or exposed bedrock outcrops.

The amount of water that recharges a groundwater system can be estimated by calculating a water budget for an area and/or by examining streamflow hydrographs and separating out the contribution from groundwater discharge to streamflow, which is called baseflow. With the water budget approach, the net recharge to the groundwater system is calculated as: groundwater recharge equals precipitation minus surface water runoff minus evapotranspiration (groundwater recharge = P-ET-SRO). Using the water budget approach, studies from Piedmont and Blue Ridge regions in Maryland and Virginia indicate that about 70% of the total precipitation is lost to evapotranspiration, 7% is lost as surface water runoff, and the remaining 23% recharges the groundwater system (e.g., Richardson 1982). Estimates of groundwater recharge in these studies typically range from 8 to 12 in/yr.

Calculating stream baseflow from gaging station flow records provides a more direct way of assessing groundwater recharge. For this method, it is assumed that mean baseflow in a stream equals groundwater recharge; and that estimated recharge rates represent average conditions in the entire watershed, reflecting variations in climate, geology, topography, existing land use, and land cover conditions during the period of streamflow gaging. The RORA streamflow recession-curve-displacement method implemented in the USGS Groundwater Toolbox program (Barlow et al. 2017) was used to estimate groundwater recharge in North Fork Goose Creek and South Fork Catoctin Creek drainage basins, and eight other watersheds in Loudoun County, based on stream gaging data acquired between 2002 and 2018. Using this method, groundwater recharge was estimated to be 11.8 in/yr (24.9 MGD and 28.7% of precipitation) in the North Fork Goose Creek Watershed, and 10.8 in/yr (17.0 MGD and 26.3% of precipitation) in the South Fork Catoctin Creek Watershed. The combined recharge estimate for the entire Western Hills Watershed is 11.4 in/yr (41.9 MGD and 27.7% of precipitation). Annual groundwater recharge rates estimated for the ten watersheds in Loudoun County from analysis of streamflow data using RORA are plotted in relation to annual precipitation for 1930 to 2018 in Figure 5-11. This figure shows that similar recharge rates occur in all Loudoun County watersheds and that recharge rates are well-correlated with precipitation rate over time.

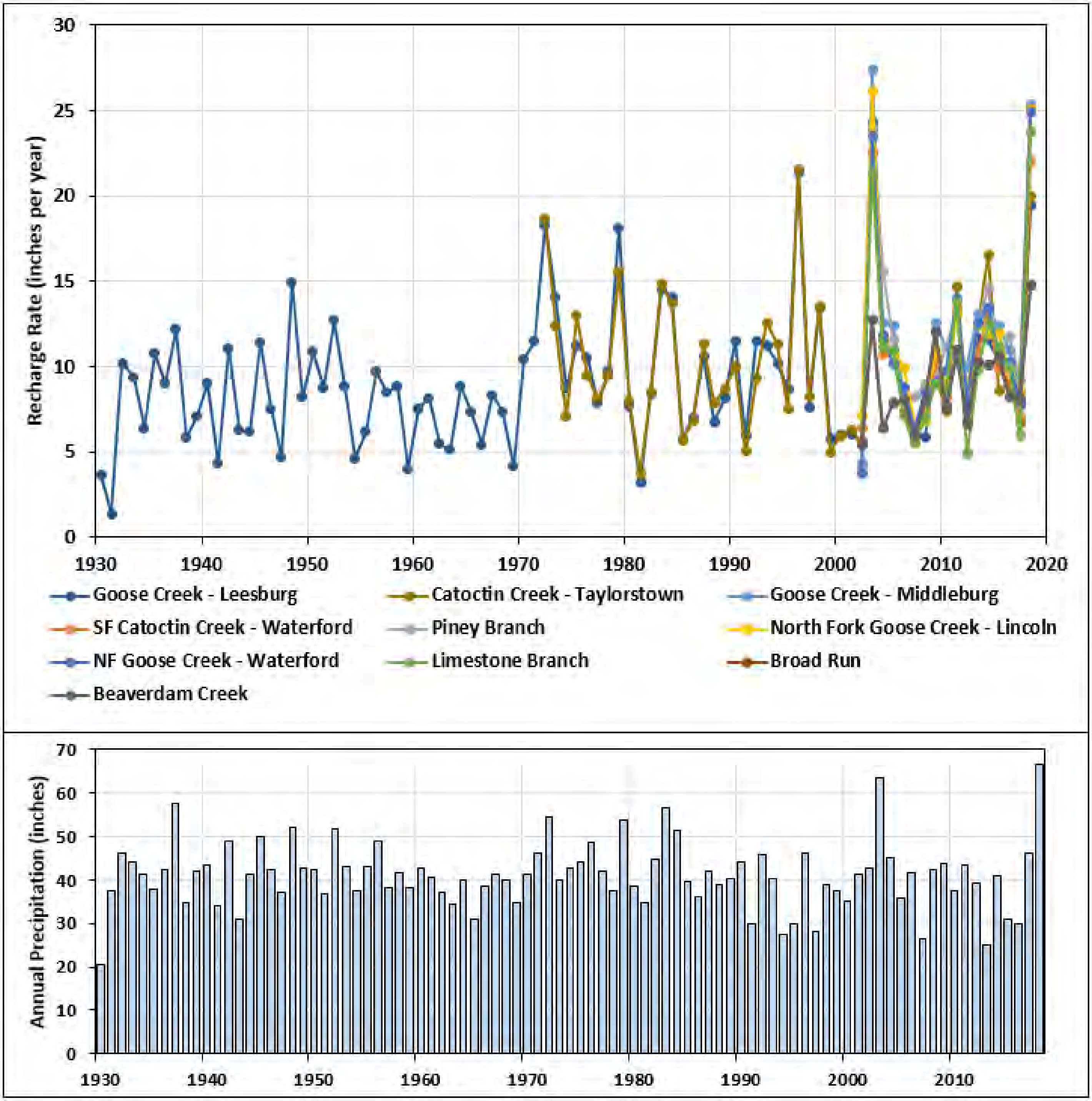


**Figure 5-11: Annual groundwater recharge rates estimated for Loudoun County watershed using RORA, a USGS streamflow recession-curve-displacement program, and their relationship to precipitation at Lincoln (1930–2016) and Dulles Airport (2017-2018).**

For comparison, groundwater recharge rates in Table 5-4 calculated from streamflow data by the USGS (Nelms et al. 1997) for 17 drainage basins in the Blue Ridge physiographic province of Virginia show rates that range from 8.40 to 16.99 in/yr for periods ending in 1984. Based on more recent data, Sanford et al. 2011 concluded that "The localities [in Virginia] with the highest recharge (15 in/yr or more) are in the Blue Ridge Province, or where precipitation is high, or where ET is relatively low (the coastal localities)."

**Table 5-4: Recharge rates estimated in drainage basins in the Blue Ridge physiographic province of Virginia (after Nelms et al. 1997).**

| USGS Stream Gaging Station | Gage Station Name | Period of Record Analyzed | Drainage Basin ($mi^2$) | Effective Recharge (in/yr) |
|---|---|---|---|---|
| 01626850 | South River near Dooms | 1976-1984 | 149 | 13.98 |
| 01638480 | Catoctin Creek at Taylorstown | 1973-1984 | 89.6 | 9.18 |
| 01643700 | Goose Creek near Middleburg | 1967-1984 | 123 | 10.72 |
| 01662800 | Battle Run near Laurel Mills | 1960-1984 | 27.6 | 9.58 |
| 01663500 | Hazel River at Rixeville | 1944-1984 | 287 | 10.94 |
| 02027000 | Tye River near Lovingston | 1940-1984 | 92.8 | 16.99 |
| 02027800 | Buffalo River near Tye River | 1962-1984 | 147 | 11.48 |
| 02028500 | Rockfish River near Greenfield | 1944-1984 | 94.6 | 14.90 |
| 02031000 | Mechums River near White Hall | 1944-1984 | 95.4 | 10.78 |
| 02032400 | Buck Mountain Creek near Free Union | 1981-1984 | 37 | 9.85 |
| 02053800 | SF Roanoke River near Shawsville | 1962-1984 | 110 | 9.55 |
| 02056650 | Black Creek near Dundee | 1976-1984 | 56.8 | 9.42 |
| 02059500 | Goose Creek near Huddleston | 1956-1984 | 188 | 8.40 |
| 02016500 | Big Otter Creek near Evington | 1938-1984 | 320 | 9.28 |
| 03167000 | Reed Creek at Grahams Forge | 1910-1984 | 247 | 10.22 |
| 03170000 | Little River at Graysontown | 1930-1984 | 300 | 11.53 |
| 03471500 | SF Holston River near Chilhowie | 1922-1984 | 76.1 | 14.98 |

## 5.4 Groundwater Elevations and Flow

GeoTrans (2007), a Tetra Tech subsidiary, developed a three-dimensional mathematical model to examine groundwater flow and pumping impacts in the Western Hills Watershed using the USGS MODFLOW finite difference model. The model incorporates three geologic layers representing overburden, shallow bedrock, and deep bedrock, recharge from precipitation, discharge to and leakage from streams and lakes, and groundwater withdrawals from public water-supply and irrigation wells. The model is used by Tetra Tech to examine potential drawdowns and groundwater flow patterns associated with groundwater development projects.

Figure 5-12 shows hydraulic head contours in bedrock circa 2007 simulated using the groundwater flow model. The water table, which is an irregular surface defining the top of saturated geologic media, is typically a subdued expression of ground surface topography. Groundwater flow occurs from areas of higher hydraulic head to lower hydraulic head; thus, as expected, simulated groundwater flow patterns reflected by hydraulic head contours in Figure 5-12 demonstrate flow from the Blue Ridge and Catoctin Mountain to streams with localized flow to pumping wells. Although hydraulic head maps are routinely prepared for hydrogeologic study reports on individual subdivision sites, no map is available for the entire Western Hills Watershed other than that provided in Figure 5-12.

Groundwater levels are measured daily in dedicated monitoring wells using automated datalogging devices as part of long-term monitoring programs conducted in Loudoun County by the USGS and the Loudoun County Department of Building and Development. Table 5-5 lists information about well construction, monitoring history, and groundwater levels for the 16 wells monitored by the County and three wells monitored by the USGS (including one well in Prince William County). Monitoring well locations are shown in Figure 5-5.

Groundwater elevation (hydraulic head) and depth-to-water values measured between 2004 and 2018 in the five monitoring wells in the Western Hills Watershed, and well RGER-01 in the western portion of the North Fork Catoctin Creek drainage basin, are plotted in Figure 5-13. The plotted data are similar to measurements and trends observed elsewhere in the County and indicate that: (1) groundwater levels tend to rise in the late fall through early spring (and during heavy precipitation events at other times) and decline in the late spring through early fall due to the annual evapotranspiration cycle; (2) the magnitude of seasonal well water level change is typically 5 to 10 feet; (3) the depth-to-water in the monitoring wells ranges from 10 to 80 feet below ground surface; and (4) no significant decline or rise in groundwater levels occurred in the monitoring wells between 2004 and 2018, except at well HARM-01 where the groundwater level rose by approximately 15 feet on August 23, 2011 due to the 5.8 magnitude earthquake centered in Mineral, Virginia. Hydrographs for the two USGS monitoring wells in Loudoun County, which are outside of the Western Hills Watershed but where monitoring began decades earlier (in 1969 at USGS-01 and 1977 in USGS-02), are shown for comparison in Figure 5-14.

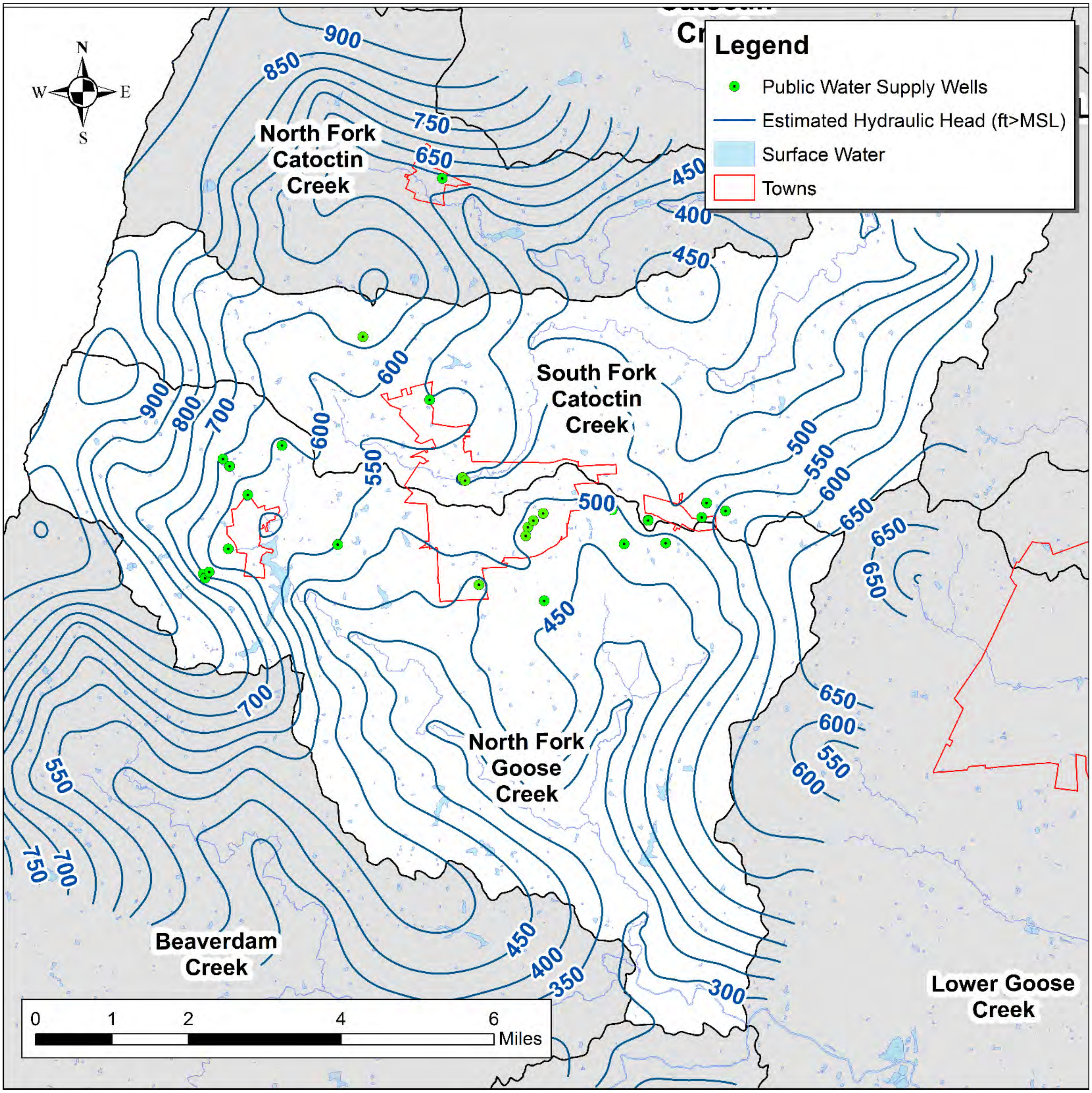


**Figure 5-12: Hydraulic heads in bedrock circa 2007 estimated by groundwater flow modeling (after GeoTrans 2007).**

**Table 5-5: Groundwater monitoring wells and groundwater level data.**

| Well ID | Moni-tored By | Well Depth (feet) | Ground Surface (feet > MSL) | Rock Type | Period of Record | Goundwater Elevation (feet > MSL) | | Depth to Water (feet) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | High | Low | Least | Most |
| HARM-01 | LC | 945 | 531 | Plutonic igneous intrusive | 2/2005 -to 4/12/2017 | 501 | 464 | 29.9 | 67.4 |
| RGER-01 | LC | 700 | 681 | Igneous intrusive | 2/2005 to present | 647 | 620 | 33.9 | 60.6 |
| TSPG-01 | LC | 360 | 505 | Plutonic igneous Intrusive | 2/2005 to present | 435 | 420 | 70.1 | 84.9 |
| VRGO-01 | LC | 300 | 585 | Igneous intrusive | 3/2009 to present | 530 | 505 | 54.8 | 80.2 |
| WDGR-01 | LC | 940 | 627 | Mafic igneous intrusive | 3/2005 to present | 618 | 602 | 8.3 | 24.5 |
| WFRD-01 | LC | 400 | 433 | Plutonic Igneous Intrusive | 11/2002 to 9/27/2016 | 422 | 400 | 11.3 | 33.1 |
| USGS-01 | USGS | 516 | 1126 | Meta-conglomerate/ metasiltstone | 8/1969 to present | 1016 | 1000 | 109.7 | 125.3 |
| USGS-02 | USGS | 535 | 389 | Fluvial, deltaic sandstone | 10/1977 to present | 365 | 342 | 24.2 | 46.8 |
| USGS-03 | USGS | 165 | 428 | Siltstone/ sandstone | 11/1968 to present | 417 | 410 | 11.5 | 18.1 |
| ALPK-01 | LC | 240 | 206 | Alluvium/ metasiltstone | 7/2009 to present | 187 | 152 | 19.3 | 54.1 |
| BOLN-12 | LC | 515 | 348 | Fluvial, deltaic sandstone | 12/2006 to 12/30/2016 | 340 | 333 | 8.0 | 15.1 |
| BRCS-01 | LC | 320 | 574 | Igneous intrusive | 12/2007 to p resent | 549 | 538 | 25.3 | 36.4 |
| BRPK-01 | LC | 680 | 1729 | Igneous intrusive | 7/2009 to present | 1669 | 1649 | 60.2 | 79.4 |
| EVGN-01 | LC | 320 | 339 | Diabase | 3/2009 to present | 322 | 313 | 16.7 | 25.6 |
| HRKN-01 | LC | 600 | 674 | Plutonic igneous intrusive | 3/2009 to present | 645 | 632 | 28.3 | 41.7 |
| LNSF-01 | LC | 322 | 317 | Hornfels | 8/2013 to present | 287 | 269 | 30.0 | 47.9 |
| LWTP-01 | LC | 250 | 262 | Metasiltstone | 3/2009 to present | 246 | 203 | 16.3 | 59.3 |
| MGRD-01 | LC | 400 | 480 | Plutonic Igneous intrusive | 12/2007 to present | 483 | 471 | -3.1 | 9.4 |
| THPK-01 | LC | 360 | 255 | Limestone conglomerate | 7/2009 to present | 222 | 188 | 32.9 | 66.9 |

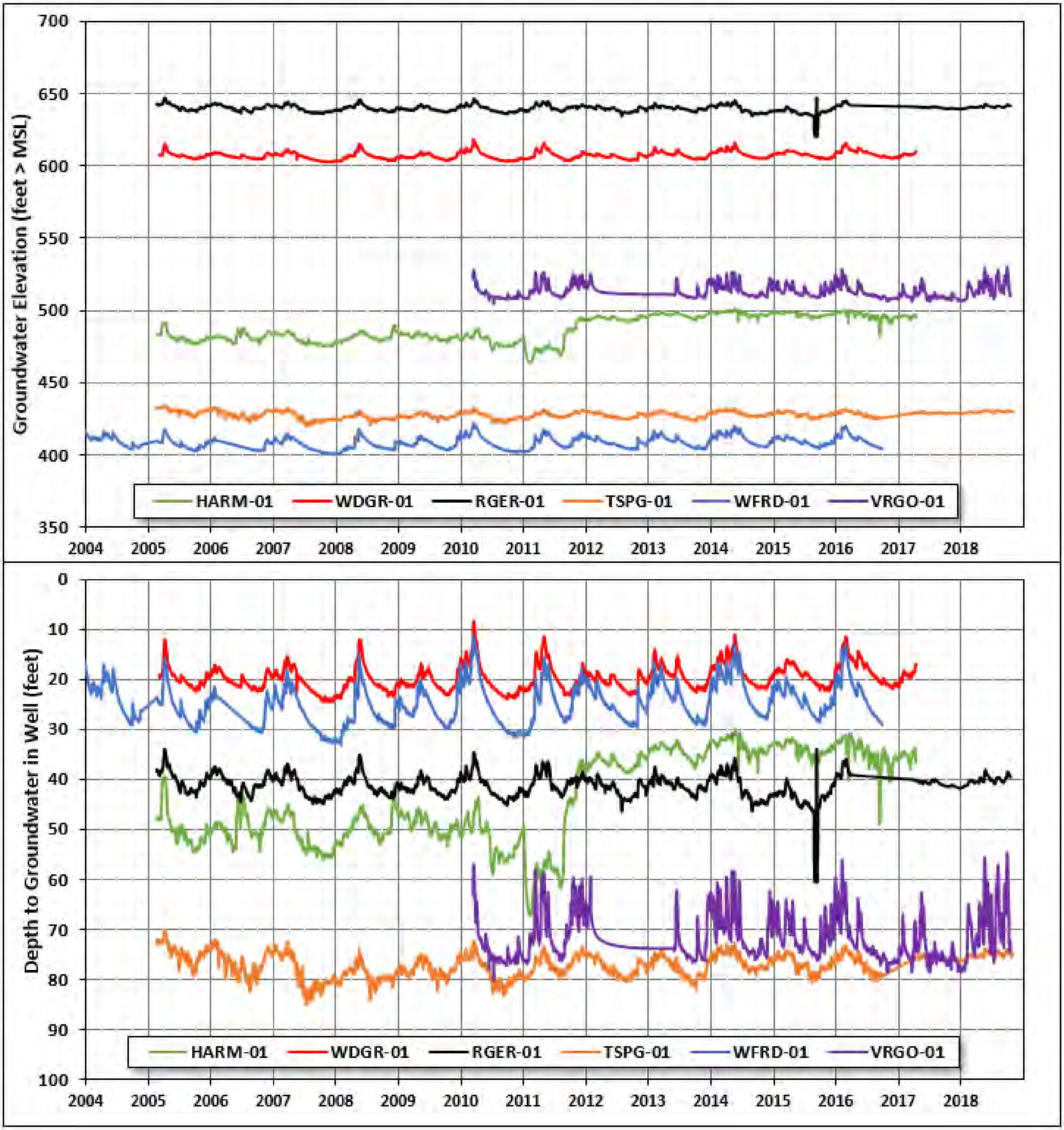


**Figure 5-13: Groundwater elevation and depth-to-water in Western Hills Watershed monitoring wells. Note that water-levels in well HARM-01, but not in other wells, rose due to the Mineral VA earthquake in August 2011.**

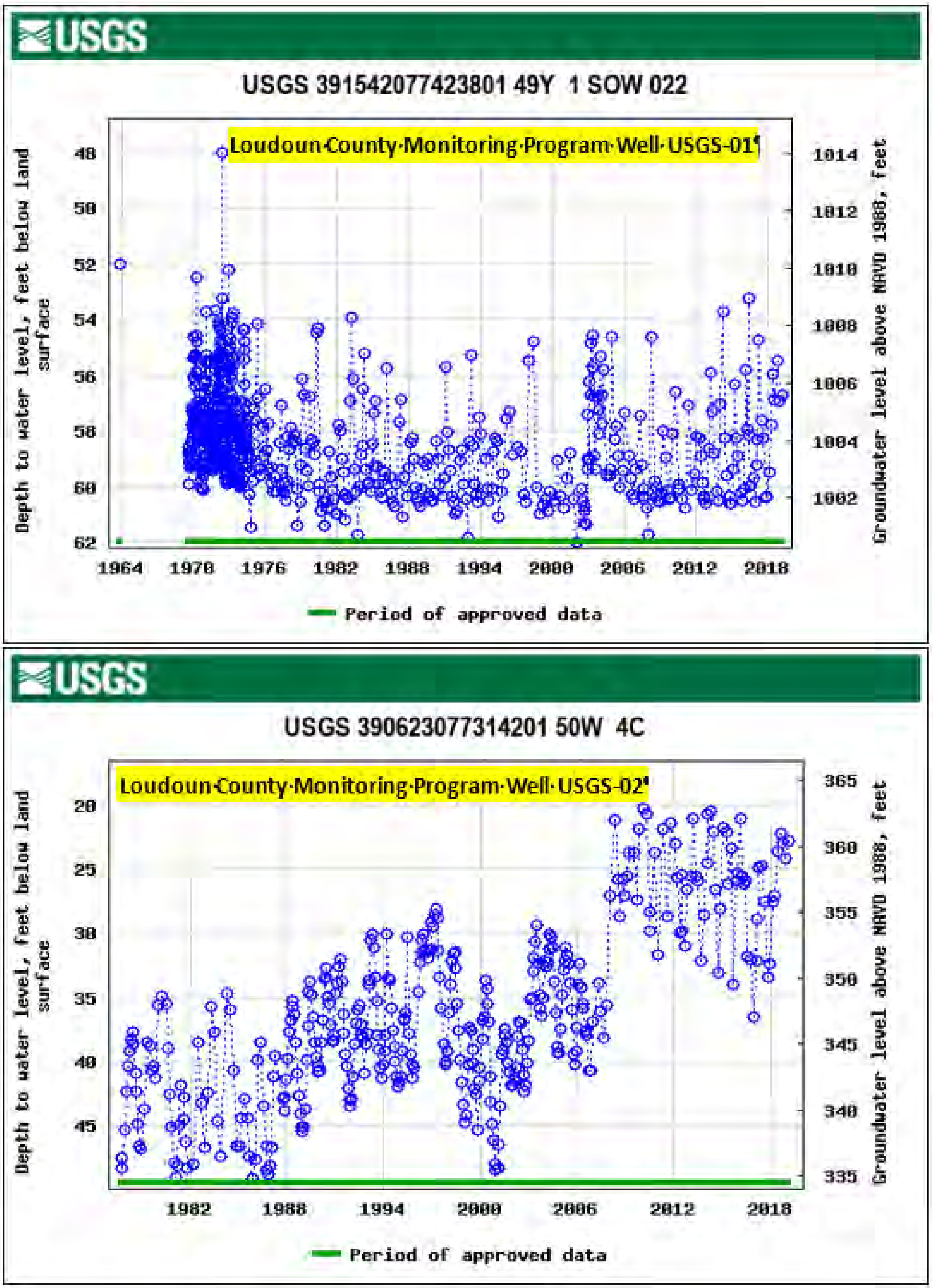


**Figure 5-14: Hydrographs of USGS monitoring wells in Loudoun County.**

## 5.5 Well Yield and Depth Data

Health Department regulations require that private and public potable water-supply wells be cased to at least 100 feet and 50 feet below ground surface, respectively. As such, nearly all wells in the Western Hills Watershed are drilled into and open to bedrock at greater depths. Well yield and depth are, therefore, related to the distribution of water-bearing fractures encountered in bedrock and the yield and storage available in a constructed well that is acceptable to the well owner. Figure 5-15 illustrates that a low yielding well or dry hole may result from drilling at a location where water-bearing fractures are not encountered and that a higher yielding well can and will result from drilling through multiple fracture zones.

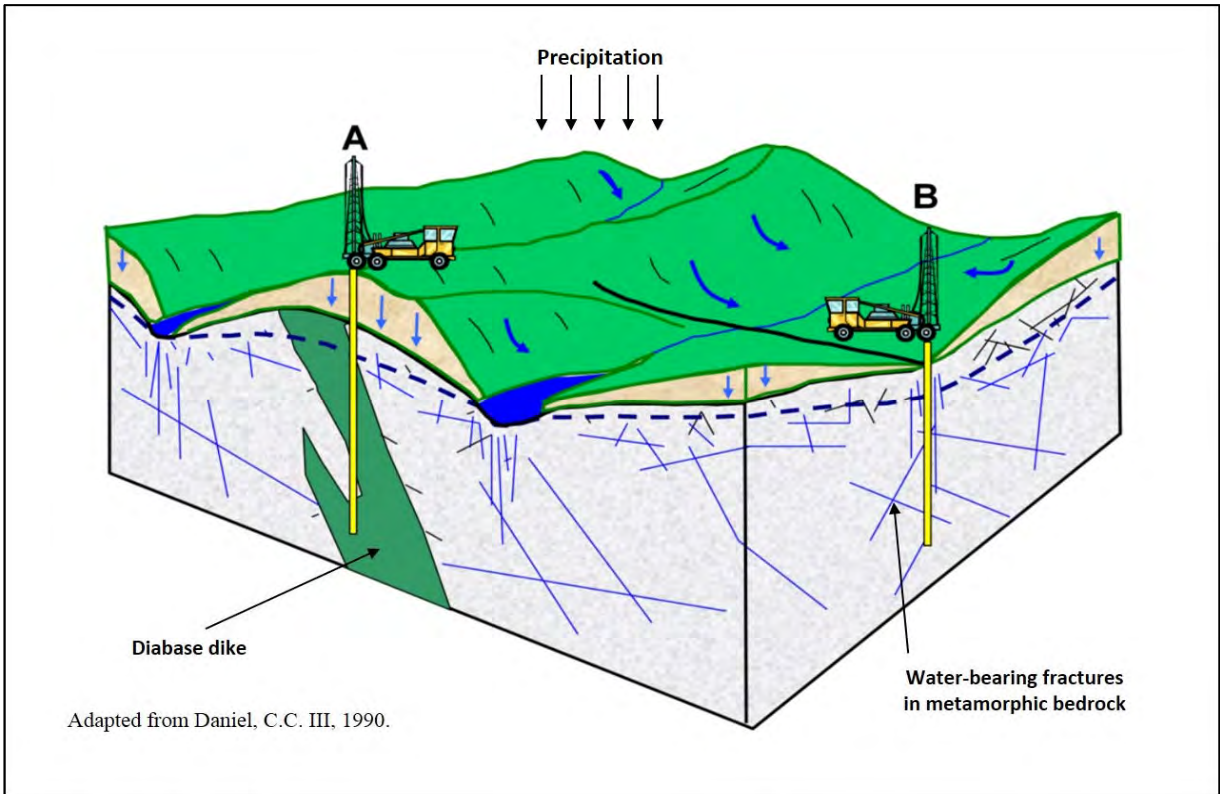


**Figure 5-15: Water-bearing fractures transmit groundwater to wells: A = dry hole, B = productive well (after Loudoun County Building and Development 2019).**

The County Wells database, updated in 2018, indicates that there are 5,418 wells in the Western Hills Watershed, including 4,176 individual water-supply wells (WWIN), 668 hydrogeologic study test wells (WWTS), 66 community public water-supply wells (WWCO and WWCS), 29 non-community public water-supply wells (WWNC), 37 irrigation wells (WWIR), 115 dug wells (WWDU), 14 monitoring wells (WWMN), 75 heat pump wells (WWHP), 221 dry holes (WWDH), and 17 unknown type wells (WWUN). Figure 5-16 identifies the locations and types of the 5,418 wells in the watershed. A subset of the WWIN and WWTS wells were drilled to meet land development requirements and are not in use. Detailed information on well characteristics and groundwater conditions documented by hydrogeologic studies performed at parcels on Figure 5-16 that are colored yellow is available from the County Health Department.

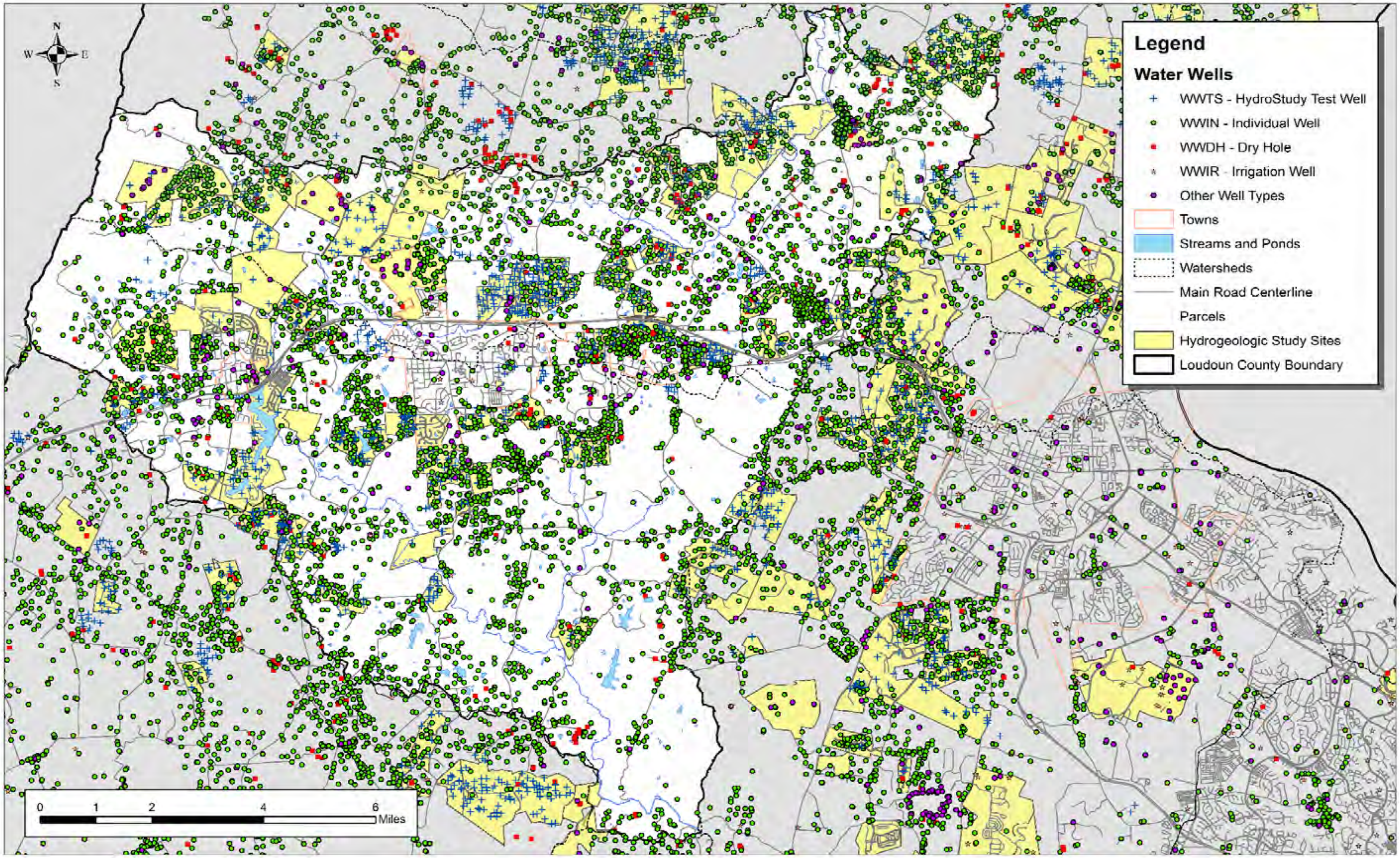


**Figure 5-16: Distribution and types of wells in the Western Hills Watershed.**

The statistical distribution of well yields (typically estimated or measured by drillers using the air-lift method of well development after drilling) and well depths associated with drilling into different rock types in Loudoun County was characterized by Cohen et al. 2007 and Sutphin et al. 2000 and 2001. These studies used geographical information system (GIS) tools to determine the rock type mapped by the USGS at each well location. Table 5-6 presents a summary of yield and depth statistics for rock units in the Western Hills Watershed based on county-wide data reported in 2007. Median well yields and depths for most rock types range from 8 to 12 gallons per minute (gpm) and 300 to 400 feet, respectively. Hydrogeologic study test well data compiled in 2008 and provided in Table 5-7 show that additional water-bearing fractures are encountered, and yield is increased, by drilling deeper, even though the mean yield per depth interval drilled declines from 4.4 gpm between 300 and 400 feet to only 1.0 gpm between 700 and 800 feet. Well depths, and to a lesser extent well yields, have generally increased over time due to the advances in drilling technology and the perceived value of deeper wells having greater water storage (Cohen et al. 2007; Loudoun County Building and Development 2019).

Figure 5-17 shows the distribution of reported well yields in the Western Hills Watershed and surrounding area based on the 2018 database. In Figure 5-18, these data are interpolated by kriging to accentuate areas having relatively low or high well yields. Well yield distribution curves (see Figure 5-19) based on county-wide data available in 2007 show similar yield results for each rock type in the watershed. The distribution of well depths in the watershed and surrounding area based on the 2018 database are plotted on Figure 5-20. Trends in the numbers of wells drilled in all of Loudoun County between 1950 and 2018 and the percentage of wells that produced less than 1.0 gpm (which is considered the minimum acceptable yield for an individual water-supply well by the County) between 1972 and 2018 are shown in Figure 5-21. The number of wells drilled annually is affected by economic conditions, population growth, real estate development, zoning changes, and other factors. The percentage of all wells drilled that yield less than 1.0 gpm in a given year has ranged from 0% to 9.5%. Between 1975 to 2000 the average depth increased from 250 to 450 feet and remained constant to present day. The average annual well depths in Western Hills Watershed are very similar to the county average.

## 5.6 Projected Water Use and Availability

In their 2008 water balance analysis, CH2MHill (2008b) determined that groundwater use in the Western Hills Watershed was approximately 3% to 5% of groundwater recharge. Calculations presented below affirm their analysis and show that estimated rates of groundwater recharge substantially exceed historic and projected groundwater withdrawal rates in the Western Hills Watershed.

Water use reported to the Virginia Department of Environmental Quality (DEQ) by Purcellville, Round Hill, and Hamilton for their public water-supply systems and by golf courses for irrigation are plotted for the period between 2009 and 2017 on Figure 5-22. Combined monthly water use by these entities increased from approximately 0.9 MGD in 2010 to 1.1 MGD in 2017. Water use peaks during the growing season (late spring to early fall) due to golf course and lawn irrigation demand. Approximately 0.30 MGD of the total Town supply derives from spring water that is piped from Purcellville's J.T. Hirst Reservoir.

The overall demand for groundwater supply is highly correlated with population. Figure 5-23 shows populations of Purcellville, Hamilton, and Round Hill between 1900 and 2020. The large

## Table 5-6: Summary of well yield and depth data from bedrock units in the Western Hills Watershed (after Cohen et al. 2007).

| Map Unit | Formation | Area ($km^2$) | Yield Data | | | | Depth Data | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | # Wells | Mean Yield (gpm) | Median Yield (gpm) | Yield Range (gpm) | # Wells | Mean Depth (feet) | Median Depth (feet) | Depth Range (feet) |
| ***Late Proterozoic*** | | | | | | | | | | |
| Zc | Catoctin Formation metabasalt | 191.0 | 1714 | 14.6 | 8 | 0-500 | 1835 | 433 | 400 | 75-1200 |
| Zcm | Catoctin Formation marble | 2.2 | 6 | 20.1 | 17.5 | 0.5-50 | 6 | 335 | 280 | 160-600 |
| Zcp | Catoctin Formation phyllite | 7.5 | 38 | 31.4 | 15 | 1-200 | 41 | 387 | 385 | 82-850 |
| Zmd | Metadiabase dikes | 50.1 | 544 | 16.7 | 9 | 0-553 | 581 | 403 | 360 | 85-1200 |
| Zsp | Swift Run Fm. marble, slate, phyllite | 9.1 | 136 | 20.4 | 10 | 0-151 | 147 | 351 | 300 | 85-865 |
| Zss | Swift Run Fm. metagraywacke | 8.4 | 90 | 22.1 | 12 | 0-246 | 100 | 329 | 300 | 75-925 |
| ***Middle Proterozoic*** | | | | | | | | | | |
| Ybg | Biotite granite gneiss | 12.1 | 175 | 15.8 | 6 | 0-200 | 194 | 448 | 420 | 100-1300 |
| Yc | Charnockite | 4.6 | 51 | 13.5 | 8 | 0-100 | 62 | 475 | 404 | 140-1000 |
| Yg | Leucocatic metagranite | 38.7 | 575 | 15.3 | 8 | 0-515 | 603 | 397 | 365 | 80-1100 |
| Ygt | Garnetiferous metagranite | 104.4 | 1499 | 17.3 | 10 | 0-650 | 1625 | 383 | 340 | 75-1200 |
| Yhm | Hornblende monzogranite gneiss | 43.7 | 473 | 16.6 | 10 | 0-230 | 531 | 368 | 300 | 79-1320 |
| Ymb | Marshall metagranite | 146.1 | 1829 | 18.3 | 10 | 0-432 | 2012 | 402 | 375 | 80-1100 |
| Ymc | Marshall metagranite coarse-grained | 20.7 | 314 | 21.0 | 12 | 0-150 | 301 | 387 | 360 | 105-1000 |
| Yn | Metanorite | 6.3 | 72 | 12.1 | 5 | 0-130 | 78 | 449 | 405 | 100-1180 |
| Yp | Paragneiss | 6.9 | 70 | 13.3 | 8.25 | 0-100 | 85 | 397 | 350 | 100-900 |
| Ypg | Porphyroblastic granite gneiss | 27.0 | 170 | 13.6 | 8 | 0-110 | 182 | 436 | 400 | 80-1040 |

1. Analysis made based on Loudoun County wells database provide in February 2007.
2. Analysis limited to water-supply wells drilled = or > 75 feet deep.
3. The following well types were excluded: WWDU (dug wells), WWSP (springs), WWQM, WWQN, and WWOB.
4. WWDH (dry hole) yields set to 0.01 if no value given
5. Other well types (WWIN, WWCO, WWIR, WWID) without yield data were removed from the yield analysis.
6. Wells were attributed to surficial bedrock unitl based using GIS. Some wells penetrate more than one unit. Middle Proterozoic metagranites are intruded by numerous Zmd dikes.

## Table 5-7: Reported yield versus depth interval in hydrogeologic study test wells.

| Drilling Interval (feed bgs) | Feed Drilled | Total Yield (GPM) | Mean Yield by Interval (GPM) |
|---|---|---|---|
| 100 to <200 | 182,950 | 5,537 | 3.03 |
| 200 to <300 | 160,032 | 6,932 | 4.33 |
| 300 to <400 | 107,997 | 4,789 | 4.43 |
| 400 to <500 | 73,663 | 2,532 | 3.44 |
| 500 to <600 | 45,050 | 872 | 1.93 |
| 600 to <700 | 24,660 | 559 | 2.27 |
| 700 to <800 | 12,059 | 123 | 1.02 |

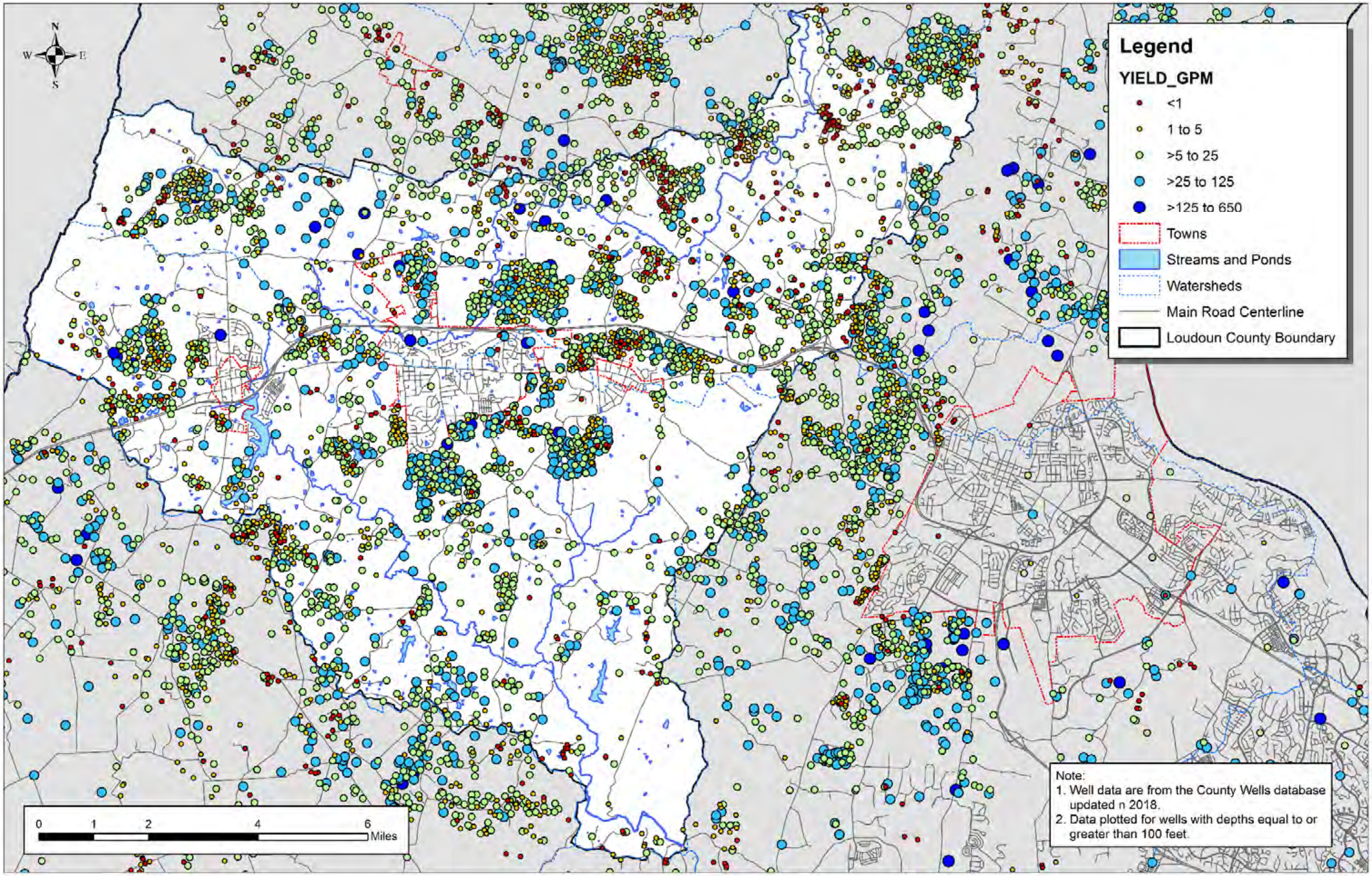


**Figure 5-17: Classified well yields (based predominantly on air-lift measurement data).**

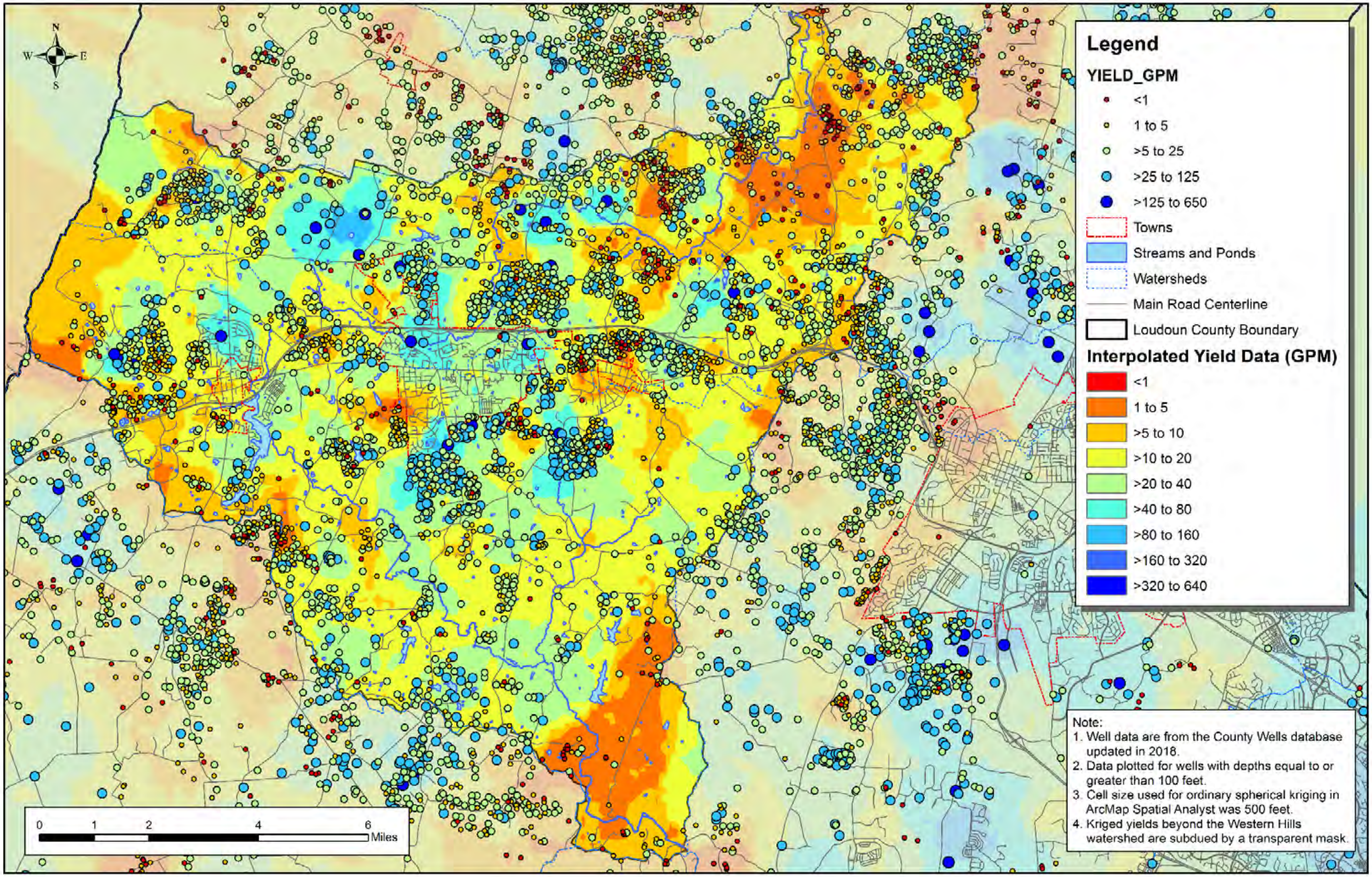


**Figure 5-18: Kriged well yield map.**

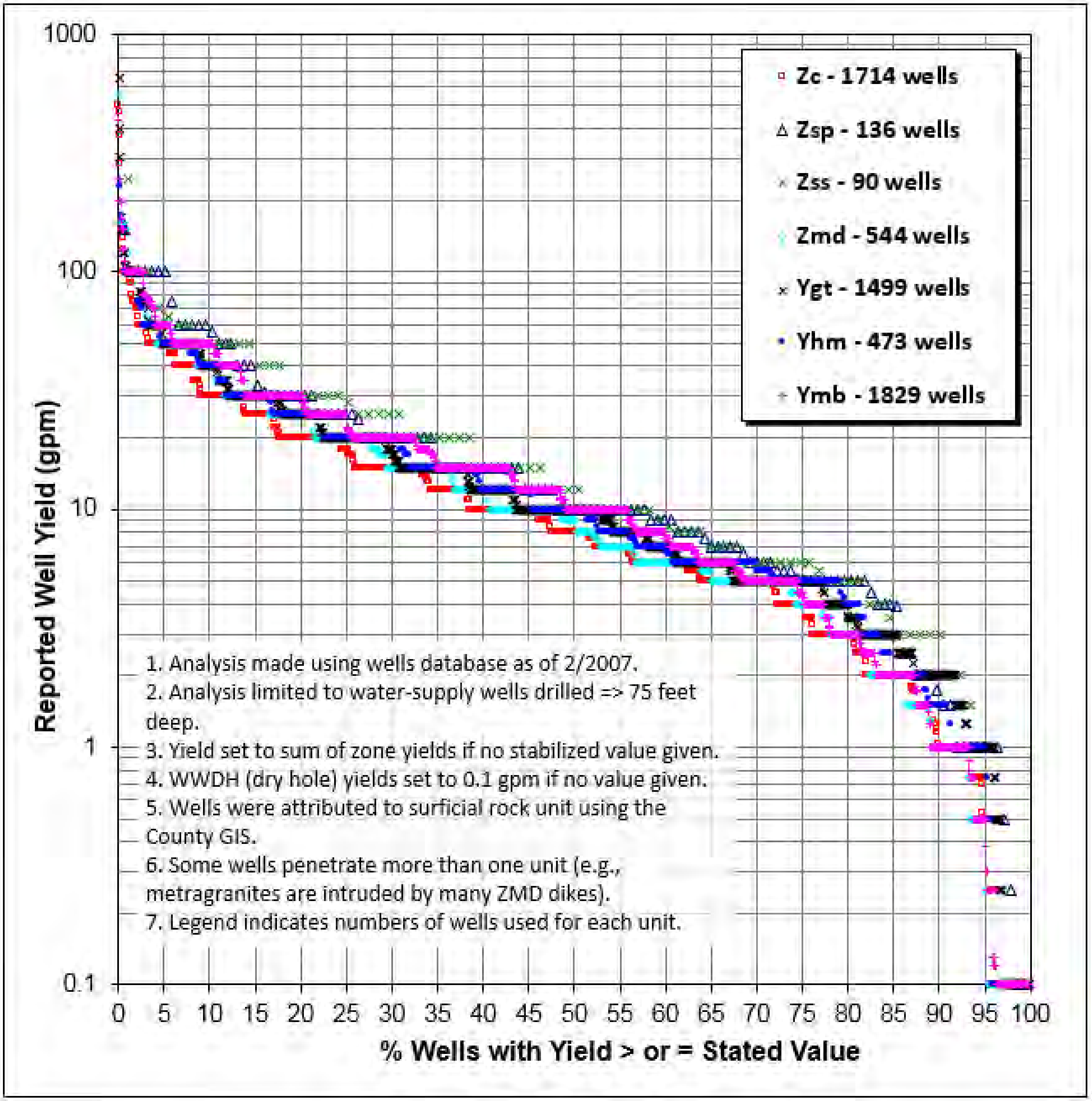


**Figure 5-19: Well yield distribution curves for rock types in the Western Hills Watershed (after Cohen et al. 2007).**

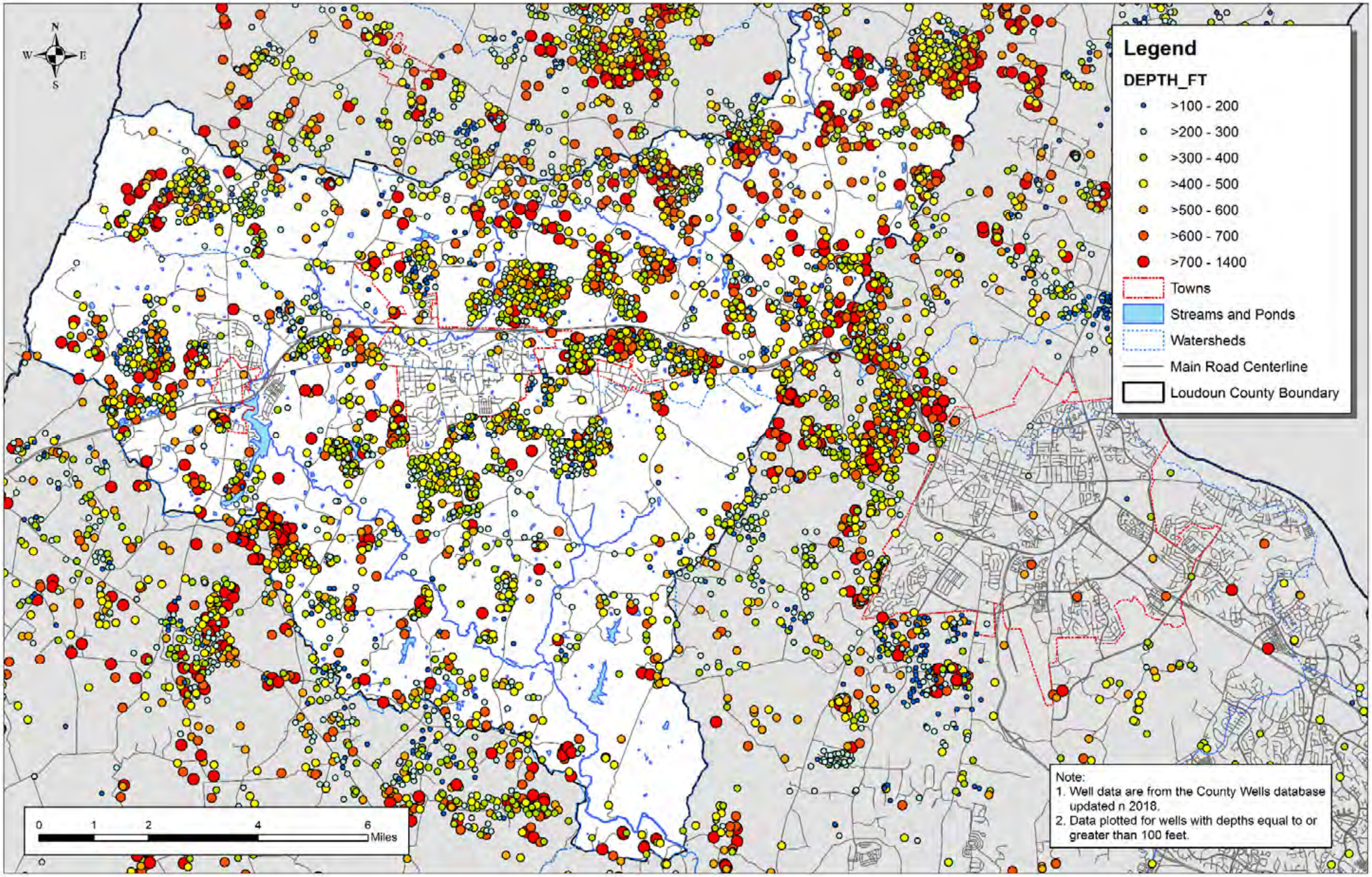


**Figure 5-20: Classified well depths**

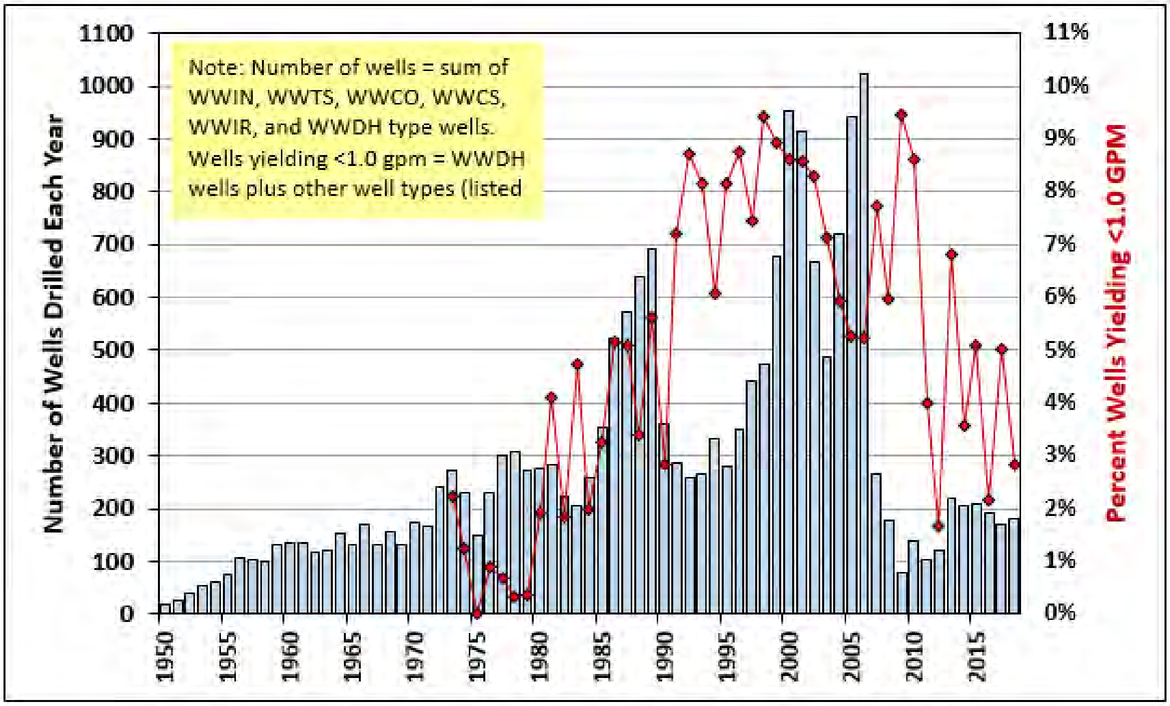


**Figure 5-21: Wells drilled by year and percent reported with yields less than 1.0 gpm.**

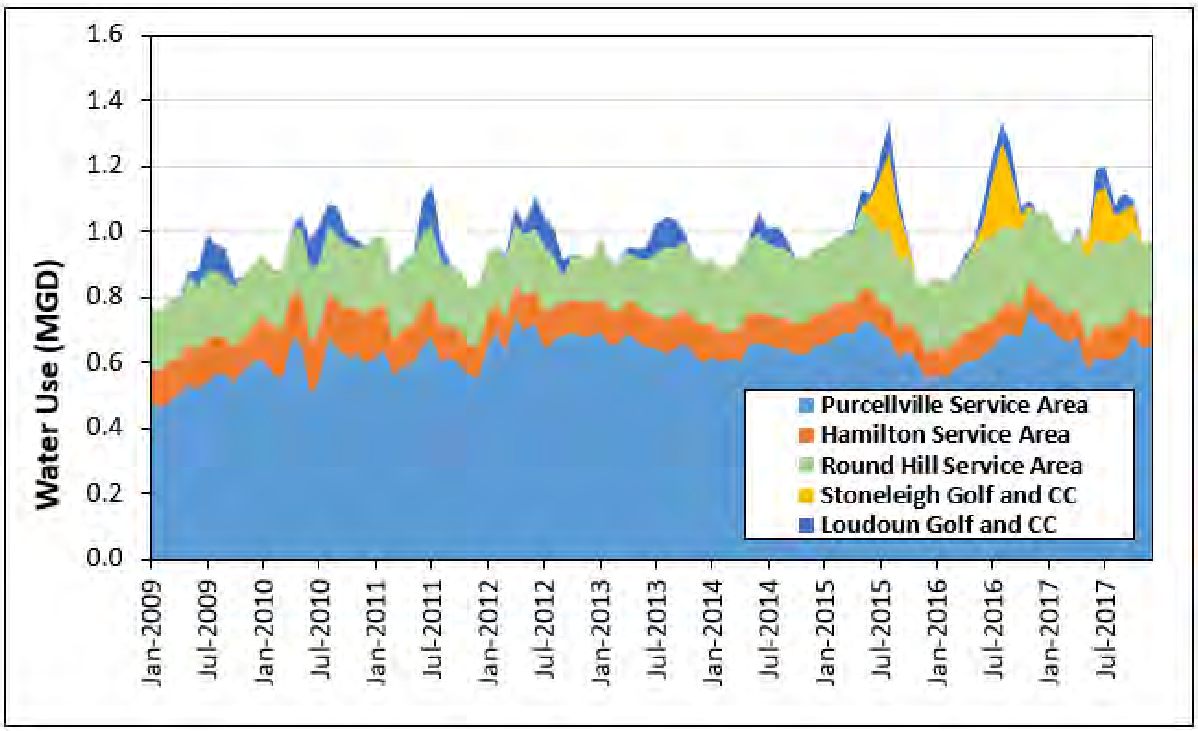


**Figure 5-22: Water use by Town Public Water Supply (PWS) systems and for golf course irrigation in the Western Hills watershed.**

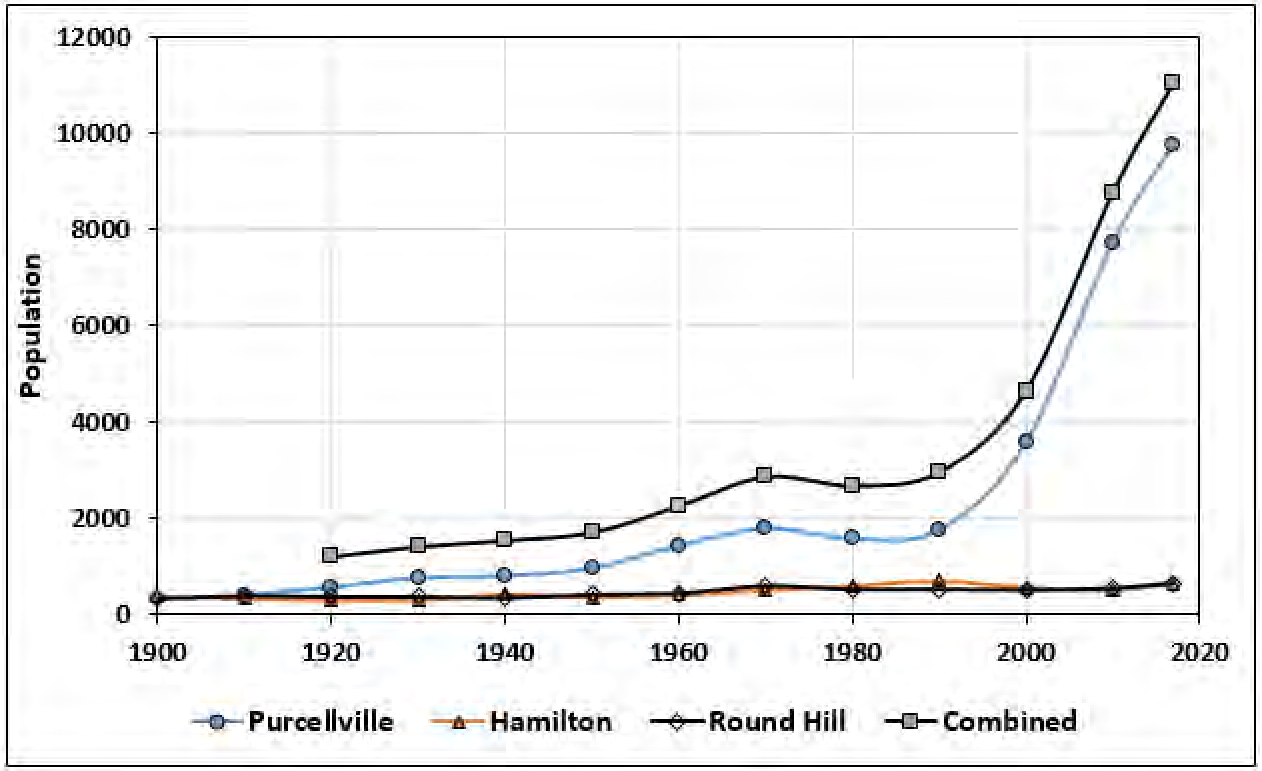


**Figure 5-23: Population trends in Purcellville, Hamilton, and Round Hill.**

increase in Purcellville's population during the past 20 years is due in part to expansion of the Town's property limits.

The Town of Purcellville currently obtains its raw water from three springs, which feed the J.T. Hirst Reservoir, and from seven bedrock wells located in and outside of town, including the Cornwell Well, Forbes Well, Main Street Village Well 1, Village Case Well, Mountain View Well, Jeffries Well, and Marsh Well. The Hirst Well, which provided about 6% of the Town's water capacity, was shut down in 2015 due to detection of fecal coliform. Purcellville is investigating treatment options so that it can resume operation. Two new wells in town adjacent to the South Fork of Catoctin Creek are under development for future use. In 2017, the average daily water supply provided by the Town was 646,280 gallons per day (GPD), of which approximately 300,000 GPD was surface water from the Hirst Reservoir. Based on a reported population of 9,771 in 2017, the average water use per person was 66 gallons per day (GPD). According to the Virginia Water and Wastewater Rates Dashboard developed by the Environmental Finance Center at the University of North Carolina (UNC 2019), in 2018, Purcellville provided water to 2,893 connections and had an average household size of 3.25, which suggests a population of 9,402 and an estimated average water use per person of 69 GPD.

Based on its website, the Town of Round Hill public water supply provides approximately 50,000 GPD from twelve bedrock wells to 270 service connections (170 within town and 100 outside of town). Including the Round Hill Elementary School, which uses about 1,500 GPD, the per connection estimated average water use rate was reported in Round Hill's 2017 Comprehensive Plan to be 185 GPD. In 2017, however, the average daily water supply value reported by Round Hill to VDEQ was only 24,080 GPD, which equates to 89 GPD per connection. Information on the Round Hill water system is not reported by UNC (2019).

Water supply data provided to VDEQ and reported on the Town's website, and by UNC (2019), indicates that, in 2017, Hamilton supplied 91,588 GPD of water from five bedrock wells to a service population (estimated in 2018) of approximately 2,240 via 699 connections. This equates to a water supply demand rates of 131 GPD per connection and 41 GPD per person.

Figure 5-24 shows estimated 2015 and 2045 population densities in persons per acre for the Traffic Analysis Zones (TAZ) in the Watershed based on Loudoun County Planning Department data and projections. The population of the Western Hills Watershed is projected by the TAZ analysis to increase from approximately 24,593 in 2015 to 33,043 in 2045. The current number of residential housing units in the Watershed is 19,630 and the potential number of future units at current zoning is 25,944, which is a 32% increase.

Projected daily groundwater extraction rates based on TAZ population estimates in 2015 and 2045 assuming a groundwater use rate of 100 GPD (with no surface water contribution) are compared to groundwater recharge rates during normal and drought conditions in the Western Hills Watershed in Figure 5-25. Projected groundwater usage for the total build-out condition based on current zoning of 7.78 MGD assumes 300 GPD use from 25,944 housing units (or 100 GPD by 77,799 persons). Most extracted groundwater is returned to streams and the water table via sewers and septic systems; a lesser fraction contributes to evapotranspiration and surface runoff components of the water balance.

## 5.7 Groundwater Quality

Groundwater quality in Loudoun County varies due to complex geologic history, soil and rock minerology, geochemical conditions, and anthropogenic activities. Fractions of Western Hills Watershed bedrock units composed of major and minor elements expressed as percentages and parts per million (ppm), respectively, based on chemical analysis of rock samples by the USGS are compiled in Table 5-8. Table 5-9 lists the chemical composition of common minerals found in these rocks. Minerals in rock and soil dissolve to varying extents depending on their solubility and local geochemical conditions, and thereby affect groundwater quality. Anthropogenic activities contribute inorganic and organic chemicals to the ground from point and diffuse sources such as leaking underground gasoline storage tanks and fertilizer spread on agricultural land, respectively.

In a USGS study, Chapman et al. (2013) evaluated the presence and distribution of naturally-occurring inorganic contaminants in groundwater sampled from 346 wells and springs in the eastern United States between 1994 and 2008 from Piedmont and Blue Ridge province crystalline rock aquifers (including in western Loudoun County) and Piedmont province Early Mesozoic basin siliciclastic rock aquifers (including in eastern Loudoun County). Normal probability plots in Figures 5-26 to 5-30 show the frequency of samples (including non-detects) in crystalline- or

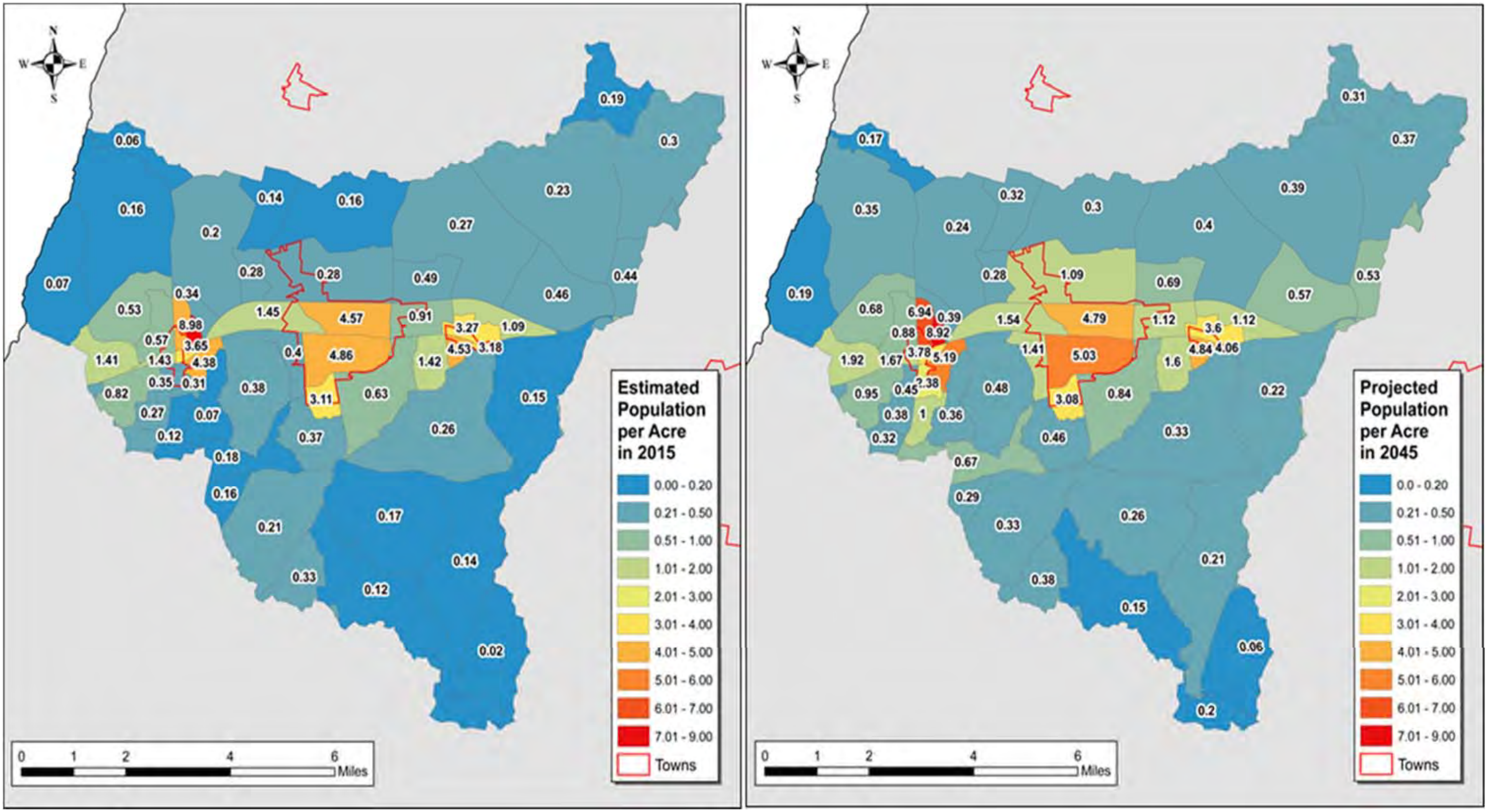


**Figure 5-24: Estimated populations densities in Western Hills Watershed traffic analysis zones (TAZ) for 2015 and 2045.**

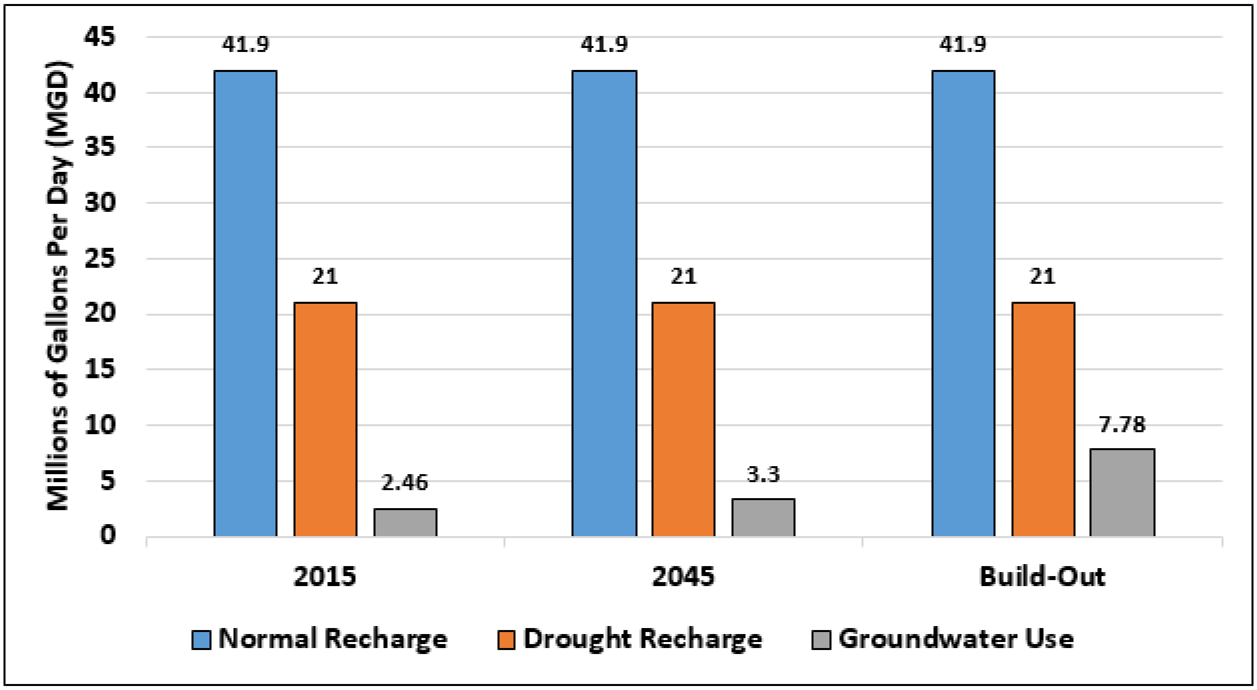


**Figure 5-25: Projected daily groundwater extraction (demand) compared to groundwater recharge rates during normal and drought conditions in the Western Hills Watershed. Groundwater use assumes no surface water supply and use of 100 GPD per person. Build-out assumes 300 GPD for 25,944 housing units (or 100 GPD for 77,799 persons). Net consumption of groundwater is greatly reduced by its return to streams and the water table via sewers and septic systems.**

siliciclastic-rock aquifers (x-axis) that exceeded constituent concentrations (y-axis).[2] Dotted horizontal lines indicate drinking water or other human health standards. Results of the USGS study are presented for comparison to chemical analyses of groundwater sampled from wells in Loudoun County. Concentrations reported by the USGS for groundwater in crystalline rock aquifers of the Piedmont and Blue Ridge provinces in the eastern United States are expected to be similar to concentrations detected in groundwater in the Western Hills Watershed.

Results of chemical analyses of thousands of groundwater samples taken from water wells between 1979 and 2018, but primarily between 2000 and 2018, are compiled in a Loudoun County database. Table 5-10 presents United States Environmental Protection Agency (EPA) Maximum Contaminant Levels (MCLs) for public water supplies, numbers of samples (having listed horizontal coordinates) analyzed throughout Loudoun County, and numbers of analyte detections

[2] The normal probability plots are scaled such that concentration frequencies look close to a straight line if the data are approximately normally distributed. Each x-axis tick mark represents 10% of the sample population. Deviations from a straight line suggest departures from normality. Concentrations below lab detection limits prevent complete determination of concentration frequency curves.

above MCLs. Except for high levels of iron and manganese (and aluminum less frequently), which may affect water taste, color, or odor, but are not considered to present a risk to human health, the

**Table 5-8: Major and minor elements detected in Western Hills Watershed rock types.**

| | **Range of Element in Late Proterozoic Metabasalt (Zc)** based on analysis of 26 samples from or near to western Loudoun County (Southworth et al. 2006). | **Range of Element in Late Proterozoic Metadiabase Dikes (Zmd)** based on analysis of 46 samples from or near to western Loudoun County (Southworth et al. 2006). | **Range of Element in Mesoproterozoic Granitic Gneiss and Metagranites (Ybg, Ym, Yml, Yg, Ygt, Yhm, Ypg, Yp, Yn)** Major elements are based on analysis of 13 samples from or near to western Loudoun County (Southworth et al. 2006). Minor elements are based on analysis of 4 samples from the Waterford quadrangle (Burton et al. 1995). |
|---|---|---|---|
| **Major Elements** | | | |
| Silica (Si) | 21.5 - 24.4% | 19.5 - 24.4 % | 23.6 - 35.3% |
| Aluminum (Al) | 5.8 - 9.2% | 6.4 - 9.2 % | 6.7 - 8.8% |
| Iron (Fe) | 3.0 - 13.8% | 1.6 - 4.6 % | 0.74 - 8.3% |
| Magnesium (Mg) | 2.1 - 4.6% | 4.8 - 9.2 % | 0.12 - 4.1% |
| Calcium (Ca) | 0.6 - 12.7% | 6.4 - 13.8 % | 0.37 - 2.6% |
| Sodium (Na) | 0.1 - 2.2% | 2.2 - 4.6 % | 1.8-2.6% |
| Potassium (K) | <0.02 - 3.1% | 4.2 - 12.7 % | 0.75 - 4.8% |
| Titanium (Ti) | <0.08 - 2.4% | 0.54 - 2.2 % | 0.1 - 1.1% |
| Phosphorus (P) | 0.04 - 0.3% | 0.1 - 3.1 % | 0.02 - 0.25% |
| Manganese (Mn) | 0.11 - 0.2% | 0.66 - 2.4 % | 0.01 - 0.13% |
| **Minor Elements** | | | |
| Arsenic (As) | <0.5 - 2.8 ppm | <0.5 - 17 ppm | <0.05 - <0.8 ppm |
| Chromium (Cr) | 8.6 - 693 ppm | 17 - 240 ppm | 8.2 - 77 ppm |
| Nickel (Ni) | <23 - 188 ppm | <25 - 130 ppm | <12 - 99 ppm |
| Zinc (Zn) | 71 - 220 ppm | 62 - 170 ppm | 16 - 92 ppm |
| Selenium (Se) | <2 - 3 ppm | <0.5 - 7 ppm | <0.7 - <2 ppm |
| Strontium (Sr) | <90 - 1050 ppm | 280 - 779 ppm | 104 - 460 ppm |
| Barium (Ba) | 40 - 505 ppm | 75 - 572 ppm | 300 - 778 ppm |
| Uranium (U) | 0.25 - 1.1 ppm | <.2 - 0.73 ppm | 0.2 - 1.2 ppm |

**Table 5-9: Presence and composition of minerals in 13 samples of Mesoproterozoic granitic gneiss and metagranites from or near to western Loudoun County (after Southworth et al. 2006).**

| Mineral | Chemical Formula | % Low | % High |
|---|---|---|---|
| Apatite | $Ca_5(PO_4)3(OH,F,Cl)$ | 0.10 | 1.40 |
| Ilmenite | $FeTiO_3$ | 0.30 | 3.50 |
| Magnetite | $Fe_3O_4$ | 0.50 | 3.10 |
| Orthoclase | $KAlSi_3O_8$ | 5.40 | 34.10 |
| Albite | $NaAlSi_3O_8$ | 21.30 | 35.80 |
| Anorthoclase | $(Na,K)AlSi_3O_8$ | 1.80 | 31.60 |
| Diopside | $MgCaSi_2O_6$ | 1.40 | 20.10 |
| Hypersthene | $(Mg,Fe)SiO_3$ | 0.50 | 17.30 |
| Corundum | $Al_2O_3$ | 0.50 | 3.90 |
| Quartz | $SiO_2$ | 6.70 | 44.80 |
| Hematite | $Fe_2O_3$ | 0.10 | 2.70 |

quality of groundwater in Loudoun County is very good. Iron and manganese are typically removed from well water using water softeners.

Table 5-11 summarizes groundwater quality analyses in the Western Hills Watershed from Loudoun County's database past samples through 2018. The data used to determine numbers of samples analyzed, mean and maximum constituent concentrations, and MCL exceedances, which are presented in Table 5-11 and Figures 5-31 to 5-49, were restricted to: (1) samples taken from wells in the Western Hills Watershed; (2) wells with listed horizontal coordinates; and (3) the most recent sample analyzed at wells that were sampled on multiple dates. The maps provided on Figures 5-31 to 5-50 and select observations regarding the distribution of constituents detected in the watershed are organized alphabetically by inorganic constituents (aluminum, arsenic, calcium, chloride, copper, fluoride, iron, lead, magnesium, manganese, nitrate-nitrogen, sodium, strontium, sulfate, total dissolved solids, uranium, and zinc) followed by organic compounds (tetrachloroethene and toluene). Review of Table 5-11 and the maps show the following:

- Aluminum was detected above its Secondary MCL of 0.2 mg/L in 104 of 869 (12.0%) groundwater samples in the watershed (Figure 5-31), which is more frequent than reported by Chapman et al. 2013 (referred to as the USGS study below). By mass, aluminum makes up approximately 5 to 10% of bedrock solids in the watershed. It is present in minerals listed in Table 5-9 and in clay minerals in soil and rock composed of hydrous aluminum phyllosilicates, sometimes with variable amounts of iron, magnesium, alkali metals, alkaline earths, and other cations. There is no obvious spatial pattern of aluminum concentrations in Western Hills Watershed groundwater.

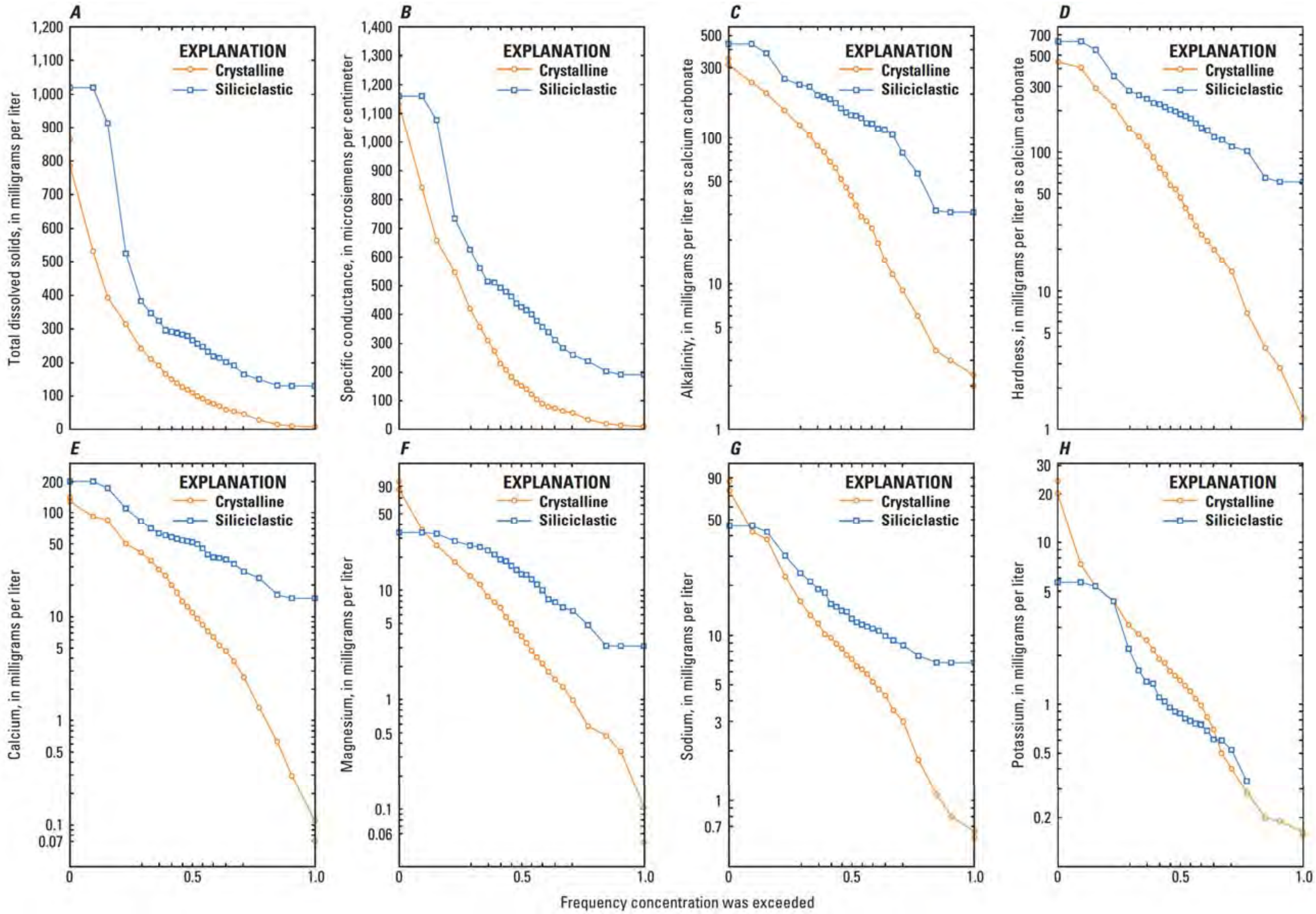


**Figure 5-26: Probability plots of groundwater quality data for siliclastic-rock and crystalline-rock aquifers in eastern U.S. Piedmont and Blue Ridge Provinces, 1994–2008: sulfate, chloride, nitrate-nitrogen, phosphate, bromide, fluoride, Si, and Al (from Chapman et al. 2013).**

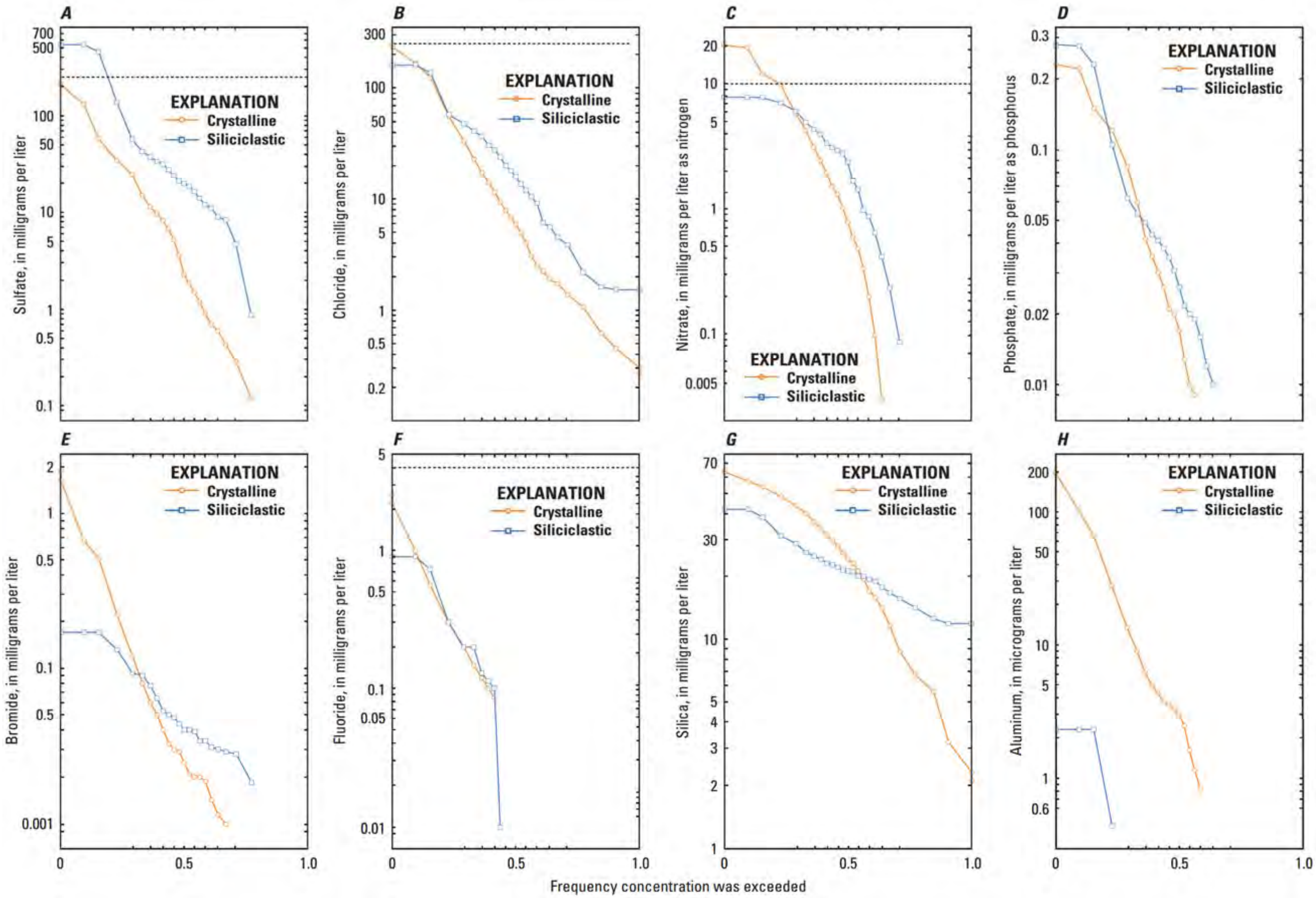


**Figure 5-27: Probability plots of groundwater quality data for siliclastic-rock and crystalline-rock aquifers in eastern U.S. Piedmont and Blue Ridge Provinces, 1994–2008: sulfate, chloride, nitrate-nitrogen, phosphate, bromide, fluoride, Si, and Al (from Chapman et al. 2013).**

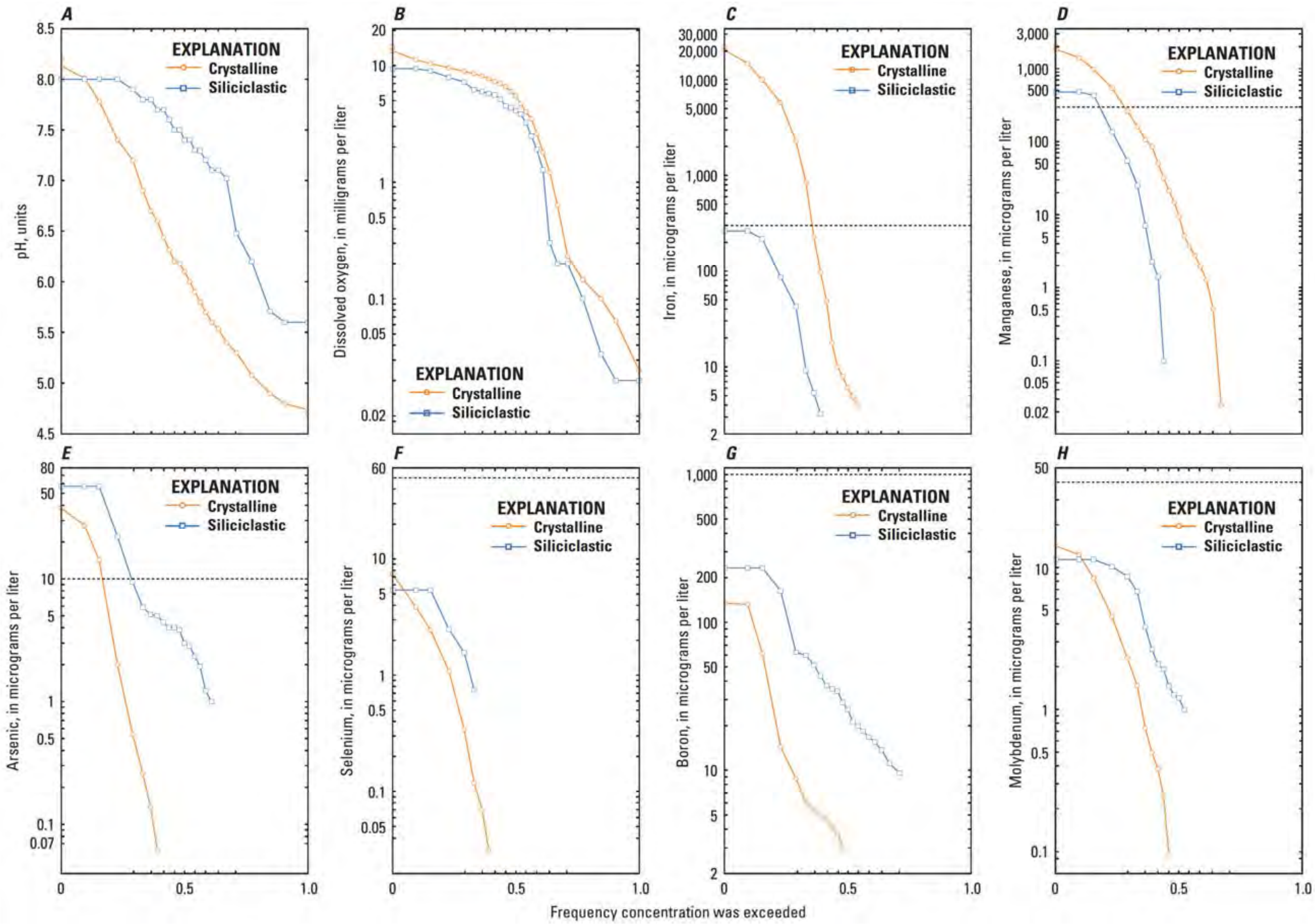


**Figure 5-28: Probability plots of groundwater quality data for siliclastic-rock and crystalline-rock aquifers in eastern U.S. Piedmont and Blue Ridge Provinces, 1994–2008: pH, DO, Fe, Mn, As, Se, B, and Mo (from Chapman et al. 2013).**

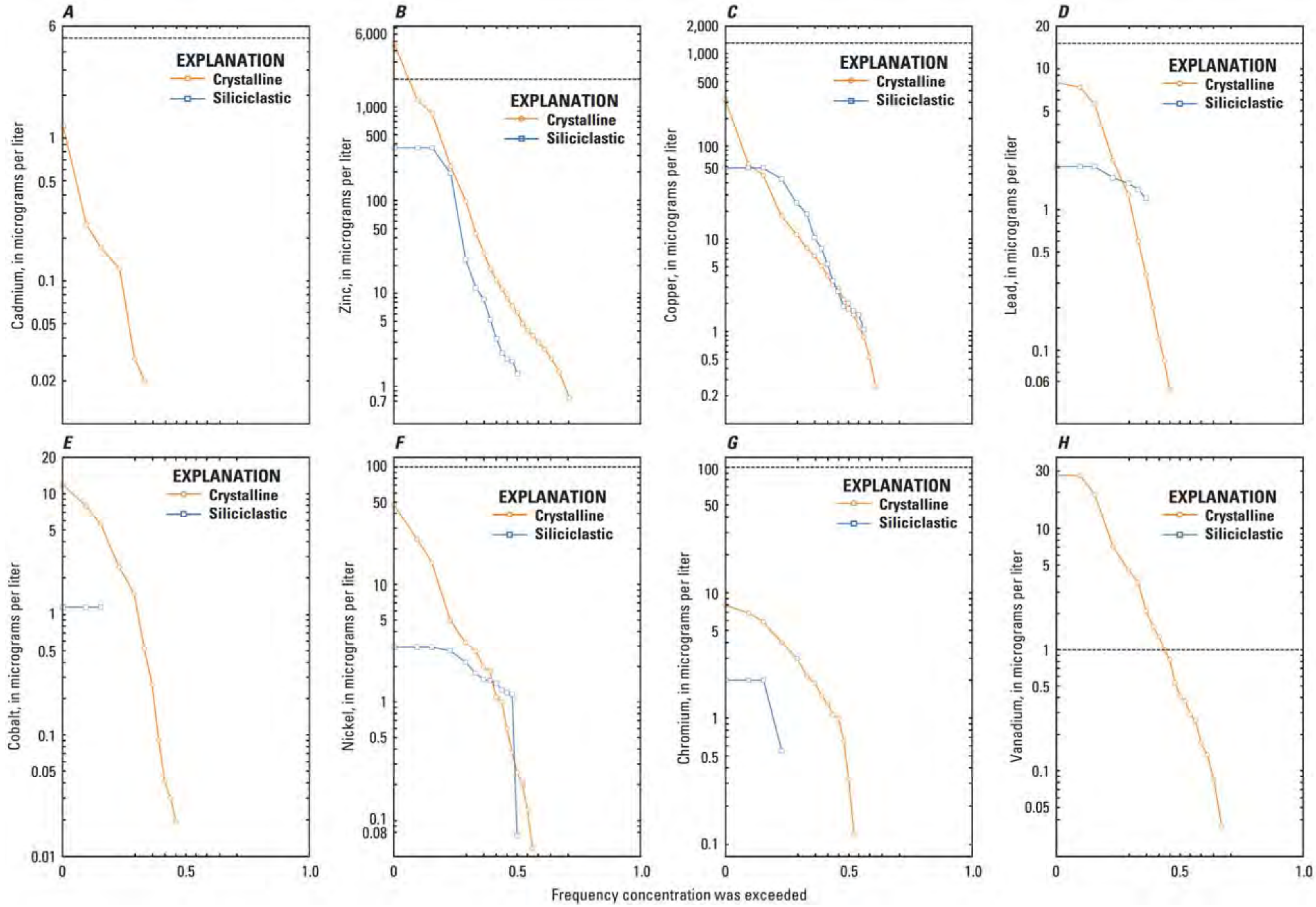


**Figure 5-29: Probability plots of groundwater quality data for siliclastic-rock and crystalline-rock aquifers in eastern U.S. Piedmont and Blue Ridge Provinces, 1994–2008: Cd, Zn, Cu, Pb, Co, Ni, Cr, and V (from Chapman et al. 2013).**

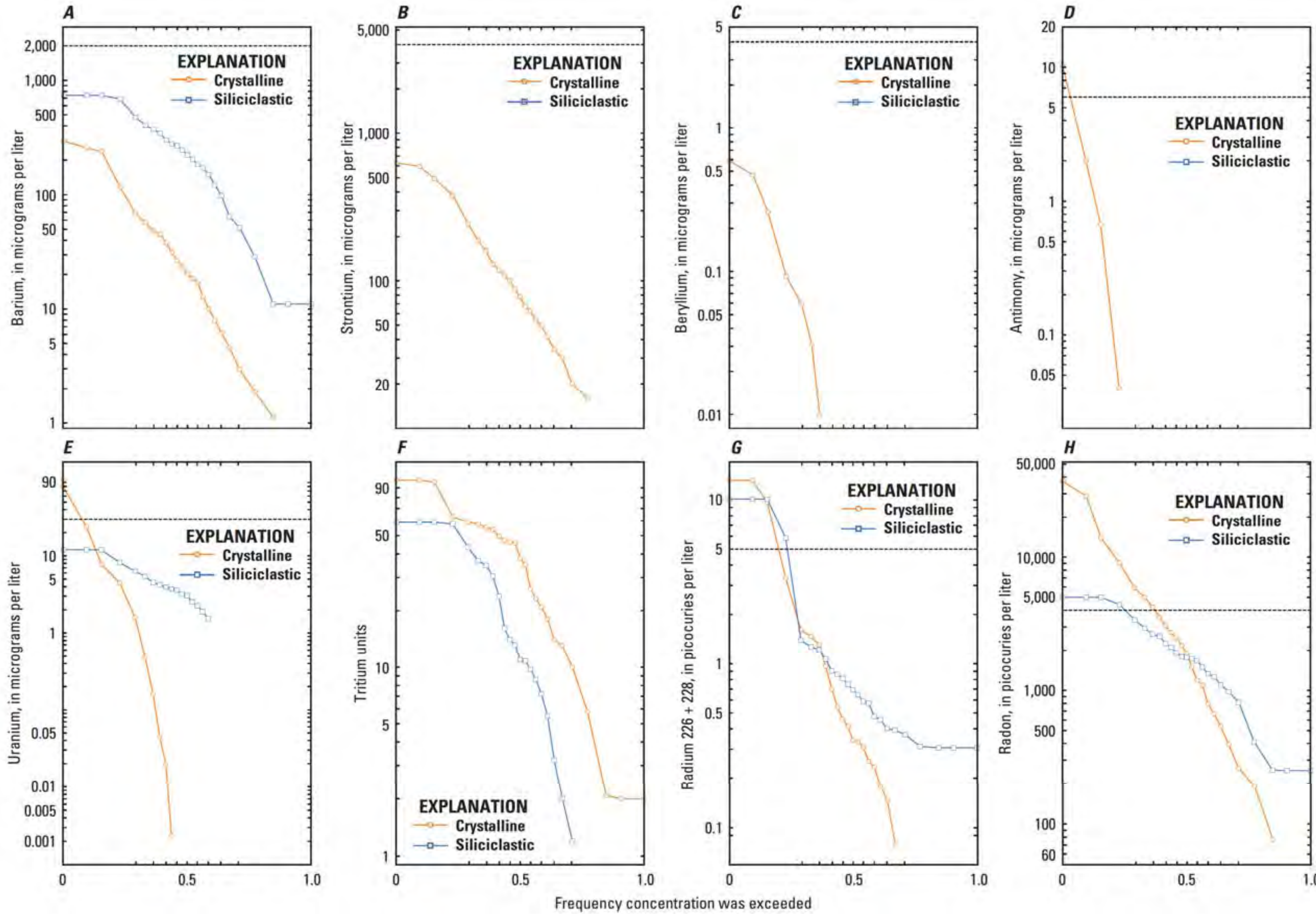


**Figure 5-30: Probability plots of groundwater quality data for siliclastic-rock and crystalline-rock aquifers in eastern U.S. Piedmont and Blue Ridge Provinces, 1994–2008: Ba, Sr, Be, Sb, U, tritium, Ra, and Rn (from Chapman et al. 2013).**

**Table 5-10: U.S. EPA public water-supply standards and chemical detections above MCLs in County-wide water well samples.**

| Analyte | Units | Primary MCL[1] or TT[2] | Secondary MCL[3] | MCL G[4] | Potential Health Threat from Long-Term Exposure Above the MCL | Noticeable Effects Above the Secondary MCL | Potential Sources of Constituent in Drinking Water | Total Number of Samples | Number of Samples Greater Than MCL | Maximum Concentration Detected (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Inorganic Analytes - Metals** | | | | | | | | | | |
| Aluminum | mg/L | | 0.2 | | | Discoloration of water. | Natural soil/rock. | 2,981 | 318 | 9.7 |
| Arsenic | mg/L | 0.01 | | zero | Skin damage or problems with circulatory systems; may have increased risk of getting cancer. | | Natural soil/rock; runoff from orchards, glass, and electronics wastes. | 2,984 | 7 | 0.036 |
| Barium | mg/L | 2 | | 2 | Increase in blood pressure. | | Natural soil/rock; discharge of drilling wastes; discharge from metal refineries. | 2,981 | 0 | 1.2 |
| Cadmium | mg/L | 0.005 | | 0.005 | Kidney damage. | | Corrosion of galvanized pipes; discharge from metal refineries; runoff from waste batteries and paints; natural soil/rock. | 2,981 | 0 | 0.002 |
| Calcium | mg/L | | | | | | Natural soil/rock. | 2,636 | No MCL; 1 value > 250 mg/L. | 630 |

**Table 5-10: U.S. EPA public water-supply standards and chemical detections above MCLs in County-wide water well samples.**

| Analyte | Units | Primary MCL[1] or TT[2] | Secondary MCL[3] | MCL G[4] | Potential Health Threat from Long-Term Exposure Above the MCL | Noticeable Effects Above the Secondary MCL | Potential Sources of Constituent in Drinking Water | Total Number of Samples | Number of Samples Greater Than MCL | Maximum Concentration Detected (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Chromium (Total) | mg/L | 0.1 | | 0.1 | Allergic dermatitis. | | Discharge from steel and pump mills; chrome plating operations; natural soil/rock. | 2,981 | 0 | 0.054 |
| Copper | mg/L | 1.3* | 1 | 1.3 | Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. | Metallic taste; blue-green staining. | Corrosion of household plumbing systems; natural soil/rock. | 2,981 | 2 | 3.3 |
| Iron | mg/L | | 0.3 | | | Rusty water color; sediment; metallic taste; reddish or orange staining. | Natural soil/rock. | 2,981 | 1,582 | 40 |
| Lead | mg/L | 0.015* | | zero | Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities. Adults: Kidney problems; high blood pressure. | | Corrosion of household plumbing systems; battery wastes; natural soil/rock. | 2,981 | 23 | 0.23 |
| Lithium | mg/L | | | | | | Natural soil/rock. | 277 | No MCL. | 0.0334 |

**Table 5-10: U.S. EPA public water-supply standards and chemical detections above MCLs in County-wide water well samples.**

| Analyte | Units | Primary MCL[1] or TT[2] | Secondary MCL[3] | MCL G[4] | Potential Health Threat from Long-Term Exposure Above the MCL | Noticeable Effects Above the Secondary MCL | Potential Sources of Constituent in Drinking Water | Total Number of Samples | Number of Samples Greater Than MCL | Maximum Concentration Detected (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Magnesium | mg/L | | | | | | Natural soil/rock. | 2,636 | No MCL. | 56 |
| Manganese | mg/L | | 0.05 | | | Black to brown color; black staining; bitter metallic taste. | Natural soil/rock. | 2,981 | 1,464 | 2 |
| Mercury | mg/L | 0.002 | | 0.002 | Kidney damage. | | Discharge from refineries and factories; runoff from landfills and croplands; natural soil/rock. | 2,981 | 0 | 0.001 DL |
| Nickel | mg/L | | | | | | Natural soil/rock. | 2,981 | No MCL. | 0.05 |
| Potassium | mg/L | | | | | | Natural soil/rock. | 451 | No MCL. | 21.3 |
| Selenium | mg/L | 0.05 | | 0.05 | Hair or fingernail loss; numbness in fingers or toes; circulatory problems. | | Discharge from petroleum refineries; natural soil/rock; discharge from mines. | 2,981 | 0 | <0.02 |
| Silica | mg/L | | | | | | Natural soil/rock. | 453 | No MCL. | 50.46 |
| Silver | mg/L | | 0.1 | | Skin discoloration; graying of the white part of the eye. | | Natural soil/rock. | 2,981 | 0 | 0.0054 |

**Table 5-10: U.S. EPA public water-supply standards and chemical detections above MCLs in County-wide water well samples.**

| Analyte | Units | Primary MCL[1] or TT[2] | Secondary MCL[3] | MCL G[4] | Potential Health Threat from Long-Term Exposure Above the MCL | Noticeable Effects Above the Secondary MCL | Potential Sources of Constituent in Drinking Water | Total Number of Samples | Number of Samples Greater Than MCL | Maximum Concentration Detected (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sodium | mg/L | | | | | | Road salt; water softener salt; natural soil/rock. | 2,981 | No MCL. | 140 |
| Strontium | mg/L | | | | | | Natural soil/rock. | 276 | No MCL. | 4.14 |
| Uranium | mg/L | 0.030 | | zero | Increased risk of cancer, kidney toxicity. | | Erosion / weathering of natural deposits. | 276 | 0 | 0.008 |
| Zinc | mg/L | | 5 | | | Metallic taste. | Natural soil/rock. | 2,990 | 1 | 5.7 |
| **Physical Factors** | | | | | | | | | | |
| Alkalinity (Total as CaCO3) | mg/L | | | | | | | 2,850 | No MCL; 26 samples >250 mg/L. | 1100 |
| Hardness as CaCO3 | mg/L | | | | | | | 1,957 | No MCL; 44 samples >250 mg/L. | 1600 |
| Total Dissolved Solids | mg/L | | 500 | | | Hardness; deposits; colored water; staining; salty taste. | | 2,709 | 12 | 1600 |
| **Inorganic Analytes - Other** | | | | | | | | | | |
| Bromide | mg/L | | | | | | | 477 | No MCL. | <0.002 |

**Table 5-10: U.S. EPA public water-supply standards and chemical detections above MCLs in County-wide water well samples.**

| Analyte | Units | Primary MCL[1] or TT[2] | Secondary MCL[3] | MCL G[4] | Potential Health Threat from Long-Term Exposure Above the MCL | Noticeable Effects Above the Secondary MCL | Potential Sources of Constituent in Drinking Water | Total Number of Samples | Number of Samples Greater Than MCL | Maximum Concentration Detected (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Chloride | mg/L | | 250 | | | Salty taste. | Road salt; water softener salt; natural soil/rock. | 2,980 | 1 | 440 |
| Fluoride | mg/L | 4.0 | 2 | 4.0 | Bone disease (paint and tenderness of the bones; children may get mottled teeth. | Tooth discoloration. | Water additive for strong teeth; natural soil/rock; discharge from fertilizer and aluminum factories. | 2,980 | 5 | 8.3 |
| Nitrate as N | mg/L | 10 | | 10 | Infants below the age of six months who drink water containing nitrate >MCL could be seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. | | Leaching of fertilizer and of animal wastes, including from septic systems; natural soil/rock. | 2,980 | 10 | 29 |
| Nitrite as N | mg/L | 1 | | 1 | Infants below six months who drink water containing nitrite >MCL could be seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. | | Leaching of fertilizer and of animal wastes, including from septic systems; natural soil/rock. | 2,980 | 2 | 1.5 |

**Table 5-10: U.S. EPA public water-supply standards and chemical detections above MCLs in County-wide water well samples.**

| Analyte | Units | Primary MCL[1] or TT[2] | Secondary MCL[3] | MCL G[4] | Potential Health Threat from Long-Term Exposure Above the MCL | Noticeable Effects Above the Secondary MCL | Potential Sources of Constituent in Drinking Water | Total Number of Samples | Number of Samples Greater Than MCL | Maximum Concentration Detected (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ortho-phosphate | mg/L | | | | | | | 348 | No MCL. | <2 |
| Sulfate | mg/L | | 250 | | | Salty taste. | Natural soil/rock. | 2,980 | 8 | 660 |
| **Relatively Common Organic Chemical Contaminants** | | | | | | | | | | |
| Benzene | mg/L | 0.005 | | zero | Anemia; decrease in blood platelets; increased cancer risk. | | Petroleum product releases, particularly gasoline; industrial discharges. | 2,982 | 3 | 0.004 |
| Carbon Tetrachloride | mg/L | 0.005 | | zero | Liver problems; increased risk of cancer. | | Past industrial releases. | 2,982 | 0 | <0.001 |
| cis-1,2-dichloro-ethene | mg/L | 0.07 | | 0.07 | Liver problems. | | Degradation of TCE and PCE; industrial discharges. | 2,982 | 0 | <0.001 |
| Chloroform | mg/L | 80 | | | Liver, kidney, or central nervous system problems; increased risk of cancer. | | Byproduct of drinking water disinfection. | 2,982 | 1 | 0.26 |
| Chlordane | mg/L | 0.002 | | zero | | | Pesticide was used for termite control. | 2,979 | 0 | <0.001 |

**Table 5-10: U.S. EPA public water-supply standards and chemical detections above MCLs in County-wide water well samples.**

| Analyte | Units | Primary MCL[1] or TT[2] | Secondary MCL[3] | MCL G[4] | Potential Health Threat from Long-Term Exposure Above the MCL | Noticeable Effects Above the Secondary MCL | Potential Sources of Constituent in Drinking Water | Total Number of Samples | Number of Samples Greater Than MCL | Maximum Concentration Detected (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ethylben-zene | mg/L | 0.7 | | 0.7 | Liver or kidney problems. | | Petroleum product releases, particularly gasoline; industrial discharges. | 2,982 | 0 | 0.007 |
| Methyl Tert Butyl Ether (MTBE) | mg/L | | | | | | Gasoline releases circa 1980 to 2005. | 1,025 | No MCL; 6 val. > 0.005 mg/L. | 0.099 |
| Toluene | mg/L | 1 | | 1 | Nervous system, kidney, or liver problems. | | Petroleum product releases; in some tape used in water wells. | 2,982 | 0; 17 values >0.010 mg/L. | 1 |
| Tetrachloro-ethene (PCE) | mg/L | 0.005 | | zero | Liver problems; increased risk of cancer. | | Discharge from factories and dry cleaners. | 2,041 | 4 | 0.033 |
| Trichloro-ethene (TCE) | mg/L | 0.005 | | zero | Liver problems; increased risk of cancer. | | Discharge from metal degreasing operations; degradation of PCE. | 1,370 | 0 | <0.001 |
| Vinyl Chloride | mg/L | 0.002 | | zero | Increased risk of cancer. | | Leaching from PVC pipes; plastic factories releases; cisDCE degradation. | 2,982 | 0 | <0.001 |

**Table 5-10: U.S. EPA public water-supply standards and chemical detections above MCLs in County-wide water well samples.**

| Analyte | Units | Primary MCL[1] or TT[2] | Secondary MCL[3] | MCLG[4] | Potential Health Threat from Long-Term Exposure Above the MCL | Noticeable Effects Above the Secondary MCL | Potential Sources of Constituent in Drinking Water | Total Number of Samples | Number of Samples Greater Than MCL | Maximum Concentration Detected (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| Xylenes (Total) | mg/L | 10 | | 10 | Nervous system damage. | | Petroleum product (gasoline) releases; industrial discharges. | 1,024 | 0 | 0.007 |

Notes:

[1] EPA has established National Primary Drinking Water Regulations that set mandatory water quality standards for drinking water contaminants. These are enforceable standards called "maximum contaminant levels" (MCLs) which are established to protect the public against consumption of drinking water contaminants that present a risk to human health. An MCL is the maximum allowable amount of a contaminant in drinking water which is delivered to the consumer.

[2] TT = EPA's Treatment Technique maximum level, which is a required process to reduce the concentration of a contaminant in drinking water.

[3] EPA has established National Secondary Drinking Water Regulations that set non-mandatory water quality standards for 15 contaminants. EPA does not enforce these "secondary maximum contaminant levels" (SMCLs). They are established as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL.

[4] MCLG = EPA's Maximum Contaminant Level Goal, which is the concentration of a contaminant in drinking water below which there is no known or expected risk to health.

Well water analyses are compiled in a Loudoun well water chemistry database. Most data are from the period between 2000 and 2018. Sample numbers shown above are calculated for wells with known horizontal coordinates.

- Arsenic was detected above its Primary MCL of 0.01 mg/L in only 1 of 869 (0.1%) groundwater samples in the watershed (Figure 5-32), which is less frequent than reported in the USGS study. Arsenic is present in bedrock solids at concentrations ranging from less than 0.05 to 17 ppm in the watershed. Arsenic concentrations in groundwater are likely related to its natural occurrence in pyrite and other minerals, but it may also be derived in part from its prior agricultural use in herbicides and pesticides. There is no obvious spatial pattern of arsenic concentrations in Western Hills Watershed groundwater.
- There is no MCL for calcium in drinking water. A concentration of greater than 500 mg/L, which was only detected in 1 of 741 (0.1%) groundwater samples (Figure 5-33), however, exceeds the Secondary MCL for total dissolved solids. The mean concentration of calcium detected in Western Hills Watershed groundwater is 25 mg/L. By mass, calcium makes up approximately 0.5 to 13% of bedrock solids in the watershed. It is present in minerals listed in Table 5-9 and in clay minerals in soil and rock. Calcium may be derived from dissolution of calcite, marble, and other natural calcium-bearing minerals as well as from agricultural and residential use of calcium carbonate to neutralize soil acidity.
- Chloride was not detected above its Secondary MCL of 250 mg/L in any of 859 groundwater samples (Figure 5-34). Chloride in Westerm Hills Watershed groundwater is likely derived from use of sodium chloride (halite) and calcium chloride for road deicing and from septic systems, which discharge chloride, including that used water softening. Two of the highest concentrations of chloride detected in the watershed are located near a Town of Purcellville road salt storage facility.
- Copper was detected above its Secondary MCL of 1 mg/L in only 1 of 869 (0.1%) groundwater samples in the Western Hills Watershed (Figure 5-35), which is comparable to findings of the USGS study (no detections above 1 mg/L). The source of copper may be from natural minerals or it may have dissolved from copper pipe (for samples taken from building taps). There is no obvious spatial pattern of copper concentrations in watershed groundwater.
- Fluoride was detected above its Secondary MCL of 2 mg/L in only 5 of 869 (0.6%) groundwater samples in the Western Hills Watershed (Figure 5-36), which is comparable to findings of the USGS study (less than 1% of samples exceeded 2 mg/L). Fluoride in groundwater samples may be from minerals (e.g., fluorite and apatite) or from phosphate fertilizers. Three of the five fluoride MCL exceedances are clustered (among wells with lower fluoride concentrations) southwest of Purcellville.
- Iron was detected above its Secondary MCL of 0.3 mg/L in 701 of 869 (81%) groundwater samples in the Western Hills Watershed (Figure 5-37), which is more frequent than reported in the USGS study (approximately 10% of samples exceeded 0.3 mg/L). By mass, iron makes up approximately 1 to 13% of bedrock solids in the watershed. The widespread presence of iron in groundwater is attributed to reductive dissolution of naturally-occurring iron oxides in aquifer zones lacking dissolved oxygen.
- Lead was detected above its Primary MCL of 0.015 mg/L in 7 of 869 (0.8%) groundwater samples in the Western Hills Watershed (Figure 5-38), which is comparable to findings of the USGS study (no samples exceeded 0.015 mg/L). Lead is present natural minerals (e.g., galena, and anglesite) and was widely used in anthropogenic products (e.g., leaded gasoline, paint, solder, and pesticides). The most common sources of lead in drinking water are lead pipes,

faucets, and fixtures. There is no obvious spatial pattern of lead concentrations in Western Hills Watershed groundwater.

- There is no MCL for magnesium in drinking water. Magnesium concentrations in Western Hills Watershed groundwater are plotted on Figure 5-39. The mean concentration of magnesium in 741 groundwater samples is 8.2 mg/L. By mass, magnesium makes up approximately 1 to 9% of bedrock solids in the watershed. It is present in minerals listed in Table 5-9 and other clay minerals.
- Manganese was detected above its Secondary MCL of 0.05 mg/L in 670 of 869 (77%) groundwater samples in the Western Hills Watershed (Figure 5-40), which is more frequent than reported in the USGS study (approximately 40% of samples exceeded 0.05 mg/L). By mass, manganese makes up approximately 0.1 to 2% of bedrock solids in the Watershed. Like iron, the widespread presence of manganese in groundwater is attributed to reductive dissolution of naturally-occurring manganese oxide and hydroxide coatings on minerals and fracture surfaces in aquifer zones lacking dissolved oxygen. There is no obvious spatial pattern of manganese concentrations in Western Hills Watershed groundwater.
- Nitrate-nitrogen was detected above its Primary MCL of 10 mg/L in 7 of 869 (0.8%) groundwater samples in the Western Hills Watershed (Figure 5-41). Nitrate-nitrogen in the watershed is derived primarily from its use as a fertilizer and presence in septic system effluent and animal manure. The high concentrations of nitrate-nitrogen clustered in the northwest portion of the Western Hills Watershed are the result of prior corn fertilizer inputs.
- There is no MCL for potassium in drinking water. Potassium concentrations in Western Hills Watershed groundwater are plotted on Figure 5-42. The mean concentration of potassium in 141 groundwater samples is 6.4 mg/L. By mass, potassium makes up approximately 0 to 12% of bedrock solids in the watershed. It is present in feldspar minerals (e.g., orthoclase and anorthoclase) and clay minerals.
- There is no MCL for sodium in drinking water. Sodium concentrations in Western Hills Watershed groundwater are plotted on Figure 5-43. The mean concentration of sodium in 869 groundwater samples is 12 mg/L. By mass, sodium makes up approximately 0.1 to 2.6% of bedrock solids in the watershed. It is present in plagioclase feldspar minerals (albite and anorthoclase) and clay minerals. High sodium concentrations are clustered in a few locations in the watershed. The high sodium concentrations detected in groundwater at the south end of Purcellville are associated with the high chloride concentrations detected near a road salt storage facility.
- There is no MCL for strontium in drinking water. Strontium concentrations in Western Hills Watershed groundwater are plotted on Figure 5-44. The mean concentration of strontium in 85 groundwater samples is 0.12 mg/L. Strontium is present in watershed rock unit solids at concentrations ranging from approximately 100 to 1000 ppm.
- Sulfate was detected above its Secondary MCL of 250 mg/L in only 1 of 869 (0.1%) groundwater samples in the Western Hills Watershed (Figure 5-45), which is comparable to findings of the USGS study (no samples exceeded 250 mg/L). Sulfate in groundwater may be derived from oxidation of sulfide minerals, dissolution of gypsum ($CaSO_4$), decomposition of natural organic matter, and atmospheric fallout of sulfur (released in part by combustion of

fossil fuels). There is no obvious spatial pattern of sulfate concentrations in watershed groundwater.

- Total Dissolved Solids (TDS) were detected above its Secondary MCL of 500 mg/L in only 2 of 869 (0.2%) groundwater samples in the Western Hills Watershed (Figure 5-46). There is no obvious spatial pattern of TDS concentrations in watershed groundwater.
- Uranium was not detected above its Primary MCL of 0.03 mg/L in any of 85 groundwater samples in the Western Hills Watershed (Figure 5-47), which is comparable to findings of the USGS study. The mean concentration of uranium in the 85 Western Hills Watershed groundwater samples is less than 0.001 mg/L. Uranium is present at approximately less than 0.2 to 1.2 ppm in watershed rock units. There is no obvious spatial pattern of uranium concentrations in Western Hills Watershed groundwater. Through radioactive decay, uranium is the parent of other radioactive elements including radium and radon, which may occur above MCLs or proposed health standards locally but whose distributions in groundwater are ill-defined due to the dearth of analyses.
- Zinc was not detected above its Secondary MCL of 5 mg/L in any of 869 wells in the Western Hills Watershed (Figure 5-48), which is comparable to findings of the USGS study. The mean concentration of zinc in the 869 watershed groundwater samples is 0.016 mg/L. Zinc was detected in watershed rocks in concentrations ranging from 16 to 220 ppm. There is no obvious spatial pattern of zinc concentrations in Western Hills Watershed groundwater.
- Tetrachloroethene (also known as PCE, perc, perchloroethylene, and tetrachloroethylene) has been widely used as a dry-cleaning and metal degreasing solvent since the 1940s. It was detected above its Primary MCL of 0.005 mg/L in only 2 of 869 (0.2%) groundwater samples in the Western Hills Watershed (Figure 5-49). The presence of tetrachloroethene in groundwater is typically due to historic releases to the ground at dry cleaning operations, auto repair shops, manufacturing buildings, and disposal sites. Its use for metal degreasing and dry cleaning has been greatly reduced in recent decades due to health concerns and regulations.
- Toluene was not detected above its Primary MCL of 1 mg/L in any of 908 groundwater samples in the Western Hills Watershed (Figure 5-50). The presence of toluene in some adhesive tapes that are used to secure electric power cable to well pump drop pipe may be responsible for the detection of trace toluene concentrations in some wells drilled in the watershed. Toluene concentrations in well water that are eluted from down-hole tape likely decrease with time.

During this study, twenty samples of raw groundwater collected prior to treatment at homes in the Western Hills Watershed in March 2019 were analyzed by National Testing Laboratories, Inc. of Ypsilanti, Michigan for a suite of inorganic parameters. Sample locations are shown in Figure 5-51 and analytical results are presented in Table 5-12. Overall, the recent analyses are consistent with data in the Loudoun County water quality database as shown on Figures 5-31 to 5-50.

**Table 5-11: Summary of groundwater quality analyses in the Western Hills Watershed.**

| Constituent | Number of Tested Wells | Mean Concentration (mg/L) | USEPA Maximum Contaminant Level (MCL) (mg/L) | USEPA MCL Type | Number of Wells with Concentration Above MCL | Percent of Wells with Concentration Above MCL | Maximum Concentration Detected (mg/L) | Lab Method Detection Limit |
|---|---|---|---|---|---|---|---|---|
| Aluminum | 869 | 0.14 | 0.2 | Secondary | 104 | 12.0% | 5.8 | 0.1 |
| Arsenic | 869 | <0.005 | 0.01 | Primary | 1 | 0.1% | 0.014 | 0.005 |
| Barium | 868 | <0.3 | 2 | Primary | 0 | 0.0% | 0.41 | 0.3 |
| Bromide | 134 | <0.5 | NA | NA | NA | NA | <0.5 | 0.5 |
| Cadmium | 869 | <0.002 | 0.1 | Primary | 0 | 0.0% | <0.002 | 0.002 |
| Calcium | 741 | 25 | NA | NA | NA | NA | 630 | 2 |
| Chloride | 859 | 9.1 | 250 | Secondary | 0 | 0.0% | 210 | 5 |
| Chromium, Total | 868 | <0.01 | 0.1 | Primary | 0 | 0.0% | <0.01 | 0.01 |
| Copper | 869 | 0.01 | 1 | Secondary | 1 | 0.0% | 3.0 | 0.004 |
| Fluoride | 869 | 0.35 | 2 | Secondary | 5 | 0.6% | 3.0 | 0.5 |
| Hardness as CaCO3 | 592 | 91 | NA | NA | NA | NA | 1600 | 10 |
| Iron | 869 | 2.6 | 0.3 | Secondary | 701 | 80.7% | 39 | 0.02 |
| Lead | 869 | 0.0017 | 0.015 | Primary | 8 | 0.9% | 0.079 | 0.002 |
| Lithium | 86 | 0.0057 | NA | NA | NA | NA | 0.013 | 0.001 |
| Magnesium | 741 | 8.2 | NA | NA | NA | NA | 48 | 0.1 |
| Manganese | 869 | 0.15 | 0.05 | Secondary | 670 | 77.1% | 0.97 | 0.004 |
| Mercury | 869 | <0.001 | 0.002 | Primary | 0 | 0.0% | <0.001 | 0.001 |
| Nickel | 869 | 0.010 | NA | NA | NA | NA | 0.050 | 0.02 |
| Nitrate as N | 869 | 0.78 | 10 | Primary | 7 | 0.8% | 18 | 0.5 |
| Nitrite as N | 869 | 0.25 | 1 | Primary | 1 | 0.1% | 1.5 | 0.5 |
| Orthophosphate | 87 | <2 | NA | NA | NA | NA | <2 | 2 |
| Potassium | 122 | 6.4 | NA | NA | NA | NA | 21 | 1 |
| Selenium | 869 | <0.02 | 0.05 | Primary | 0 | 0.0% | <0.02 | 0.02 |

**Table 5-11: Summary of groundwater quality analyses in the Western Hills Watershed.**

| Constituent | Number of Tested Wells | Mean Concentration (mg/L) | USEPA Maximum Contaminant Level (MCL) (mg/L) | USEPA MCL Type | Number of Wells with Concentration Above MCL | Percent of Wells with Concentration Above MCL | Maximum Concentration Detected (mg/L) | Lab Method Detection Limit |
|---|---|---|---|---|---|---|---|---|
| Silica | 122 | 23 | None | NA | NA | NA | 122 | 0.1 |
| Silver | 869 | <0.002 | 0.1 | Secondary | 0 | 0.0% | <0.002 | 0.002 |
| Sodium | 869 | 10.20 | NA | NA | NA | NA | 98 | 1 |
| Strontium | 85 | 0.12 | NA | NA | NA | NA | 1.6 | 0.001 |
| Sulfate | 869 | 12 | 250 | Secondary | 1 | 0.1% | 260 | 5 |
| Total Dissolved Solids | 869 | 124 | 500 | Secondary | 2 | 0.2% | 1600 | 20 |
| Uranium | 85 | <0.001 | 0.03 | Primary | 0 | 0.0% | 0.0034 | 0.001 |
| Zinc | 869 | 0.016 | 5 | Secondary | 0 | 0.0% | 3.3 | 0.004 |
| Benzene | 869 | <0.001 | 0.005 | Primary | 0 | 0.0% | 0.003 | 0.001 |
| MTBE | 292 | <0.004 | NA | NA | NA | NA | <0.004 | 0.004 |
| Toluene | 908 | 0.0035 | 1 | Primary | 0 | 0.0% | 0.43 | 0.001 |
| Tetrachloro-ethene | 869 | <0.002 | 0.005 | Primary | 2 | 0.2% | 0.012 | 0.002 |

Notes:
(1) Data used to calculate constituent concentration summaries are from the Loudoun County groundwater quality database.
(2) Groundwater samples were collected and analyzed between 1979 and 2018, but primarily between 2000 and 2018.
(3) Only chemical analyses performed on wells located in the Western Hills Watershed are included in this summary.
(2) Where more than one sample was analyzed at the same well, only the most recent sample result is included in this summary.
(3) Only wells with listed horizontal coordinates are included in this summary.
(4) NA indicates 'Not Applicable' because no MCL value has been promulgated by U.S. EPA for the constituent.

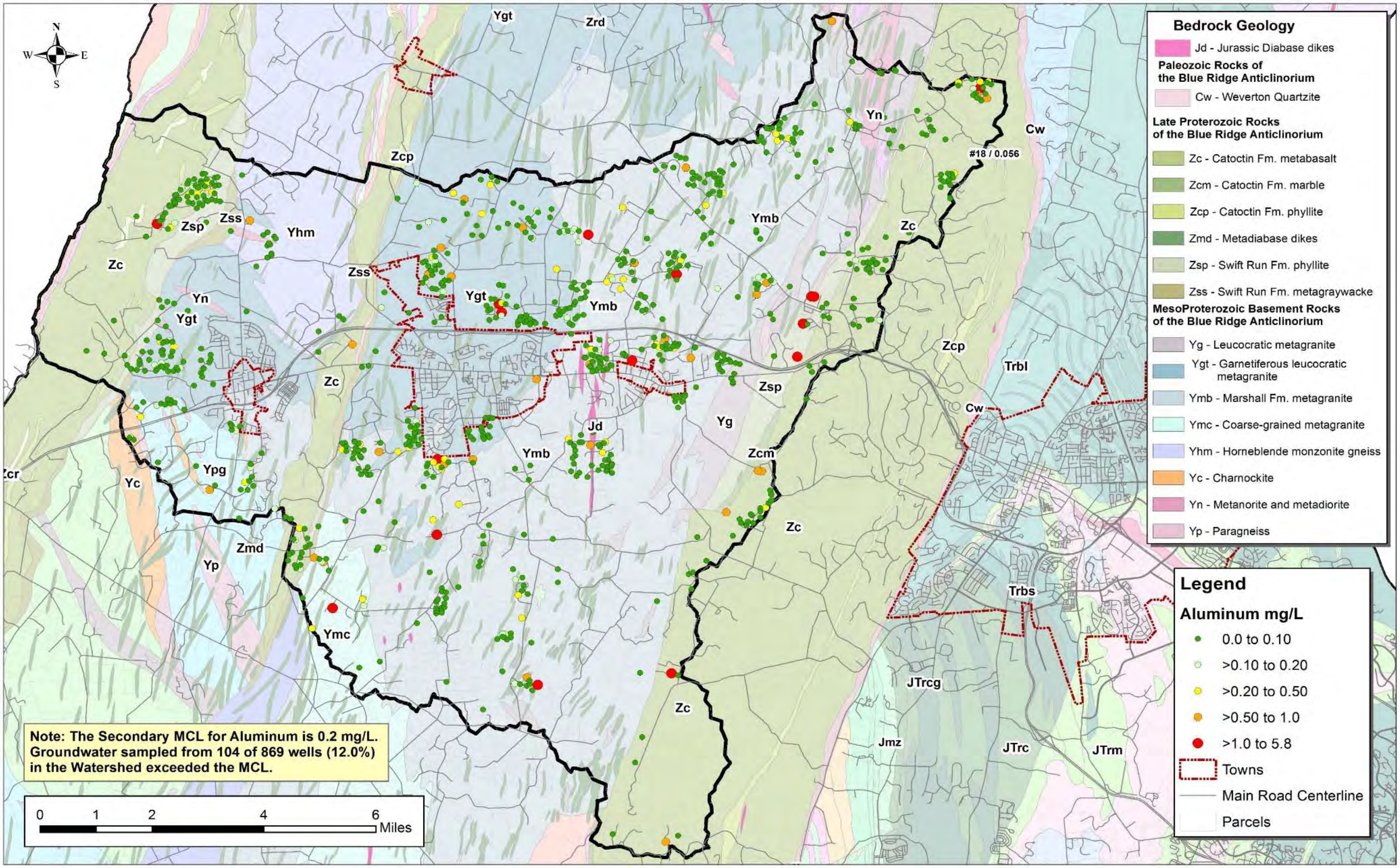


**Figure 5-31: Aluminum in groundwater in the Western Hills Watershed.**

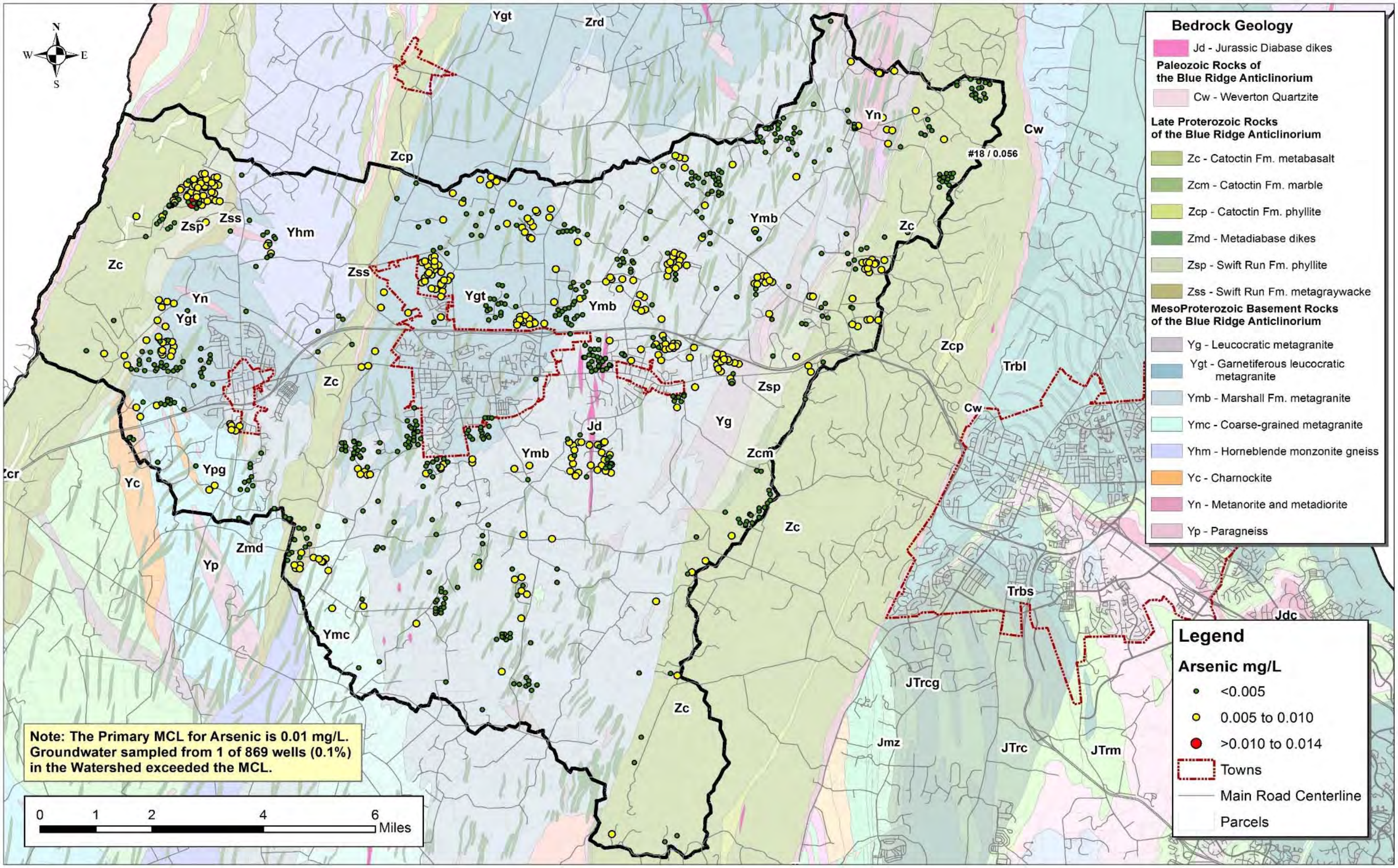


Figure 5-32: Arsenic in groundwater in the Western Hills Watershed.

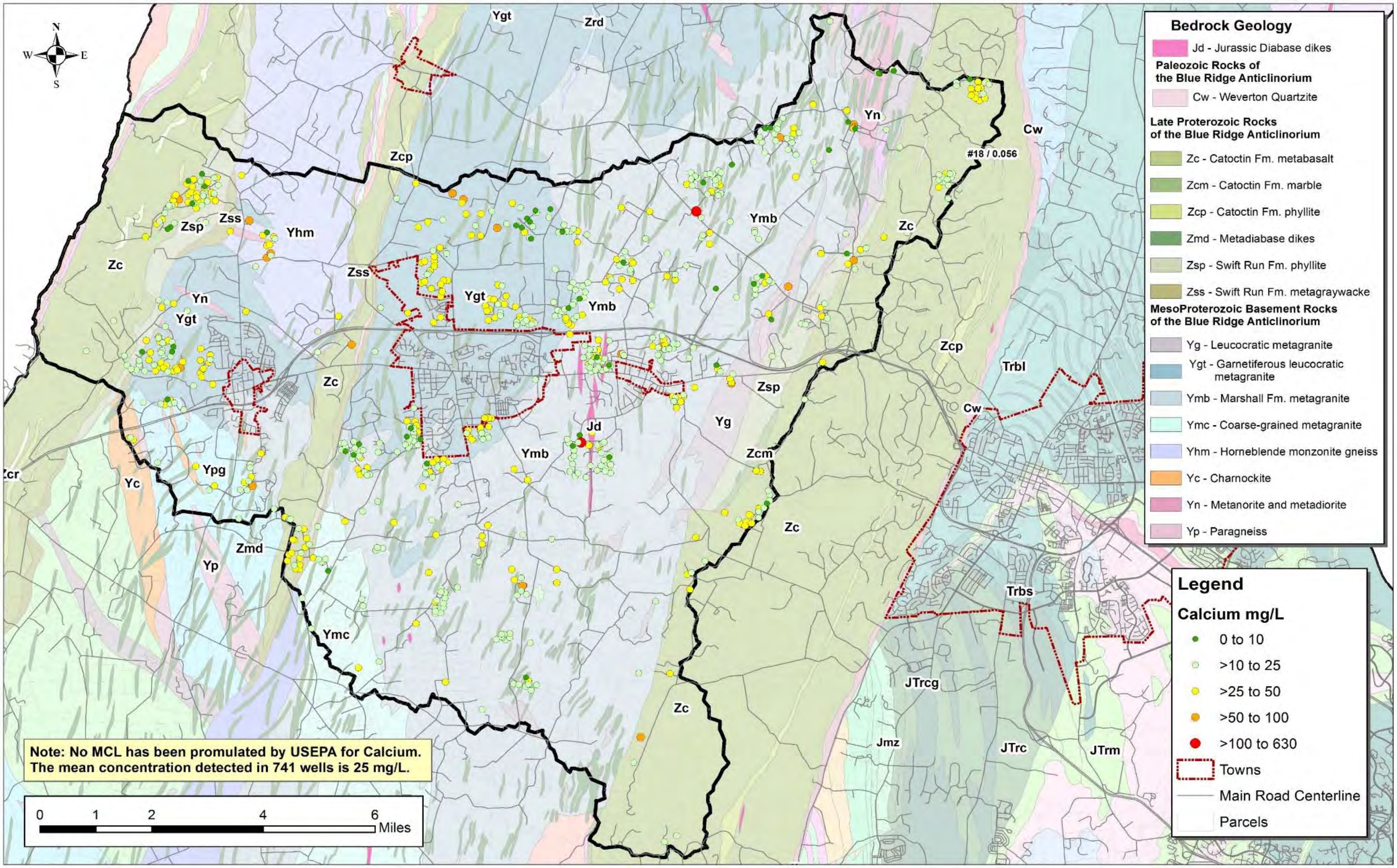


**Figure 5-33: Calcium in groundwater in the Western Hills Watershed.**

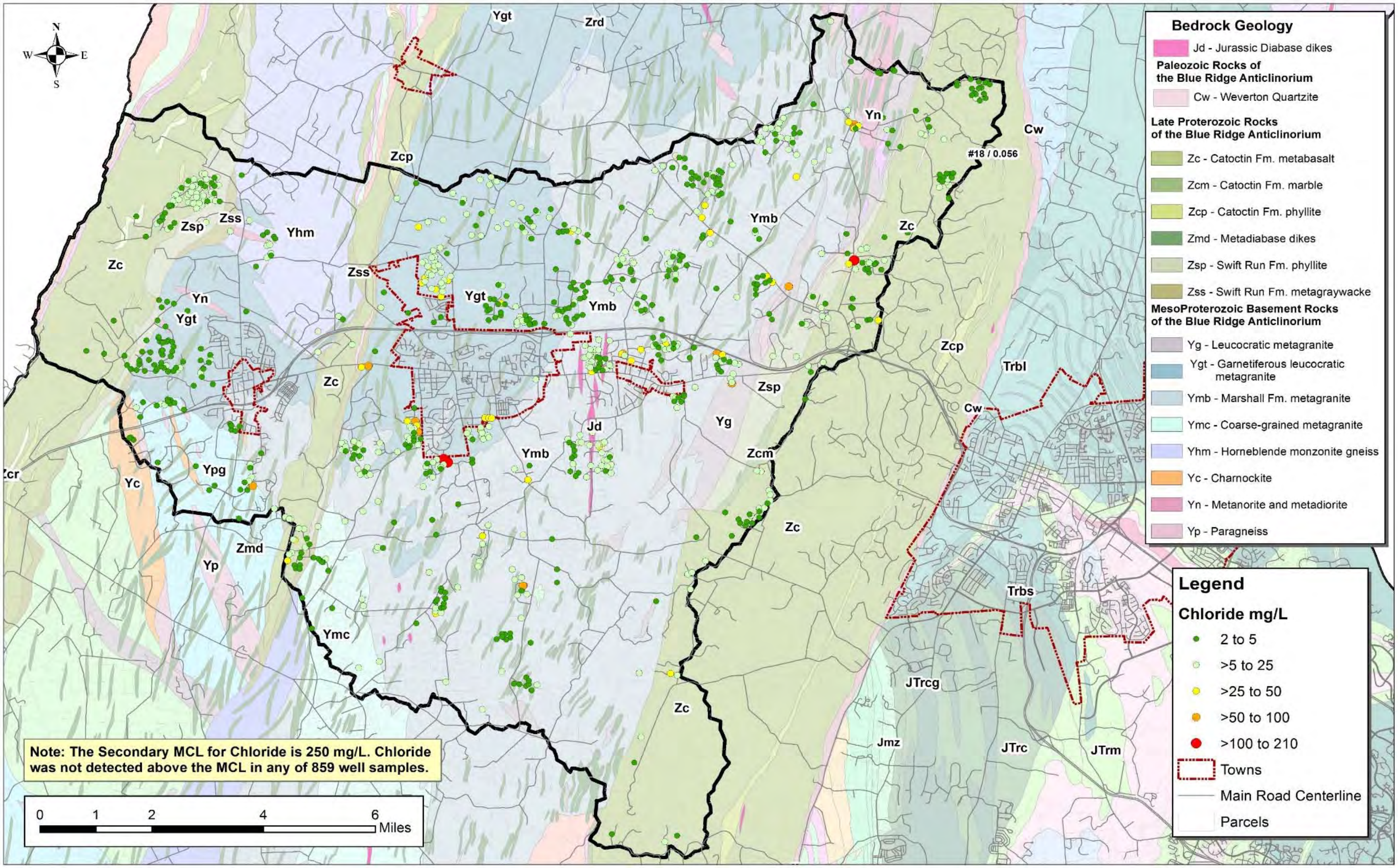


**Figure 5-34: Chloride in groundwater in the Western Hills Watershed.**

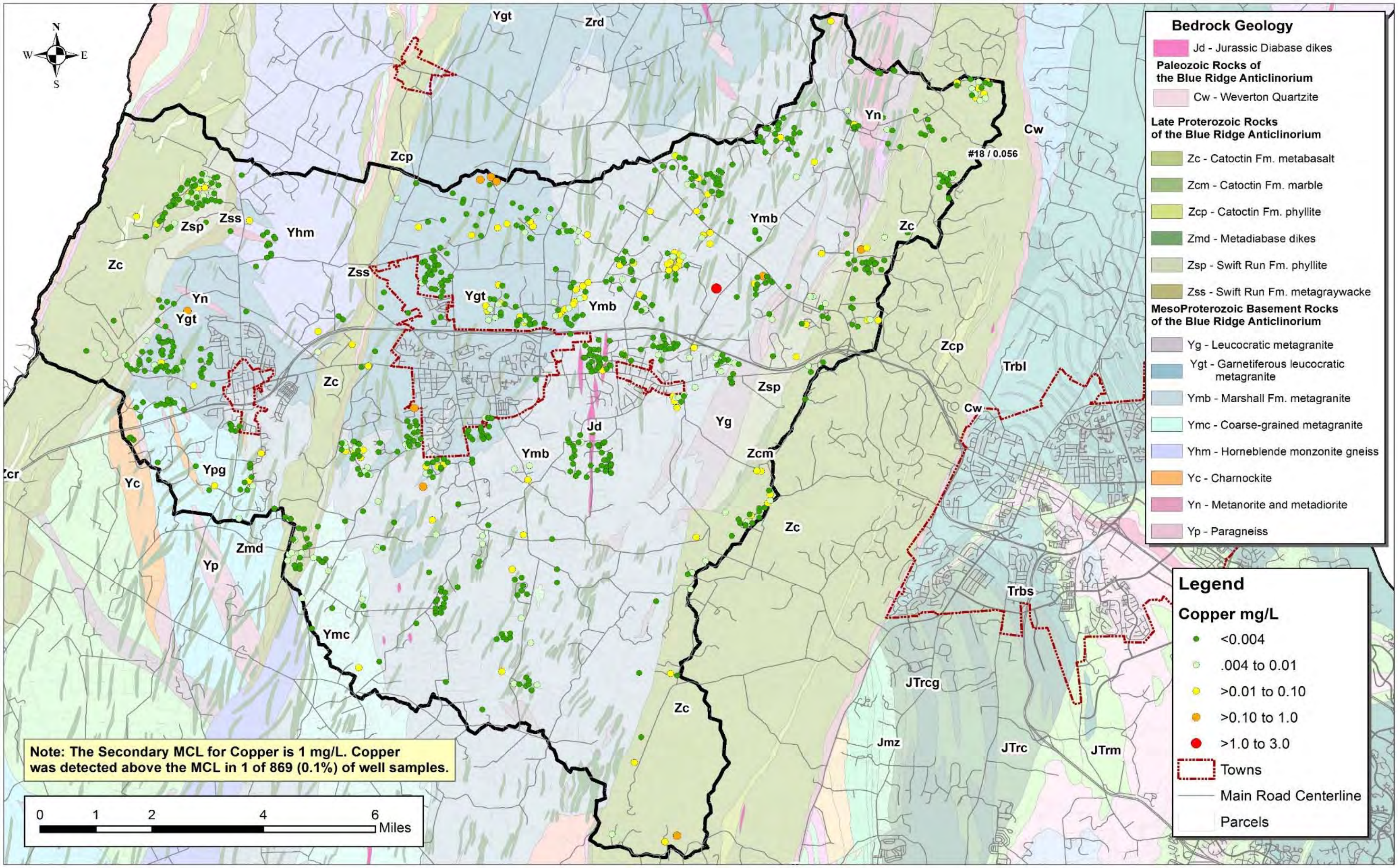


**Figure 5-35: Copper in groundwater in the Western Hills Watershed.**

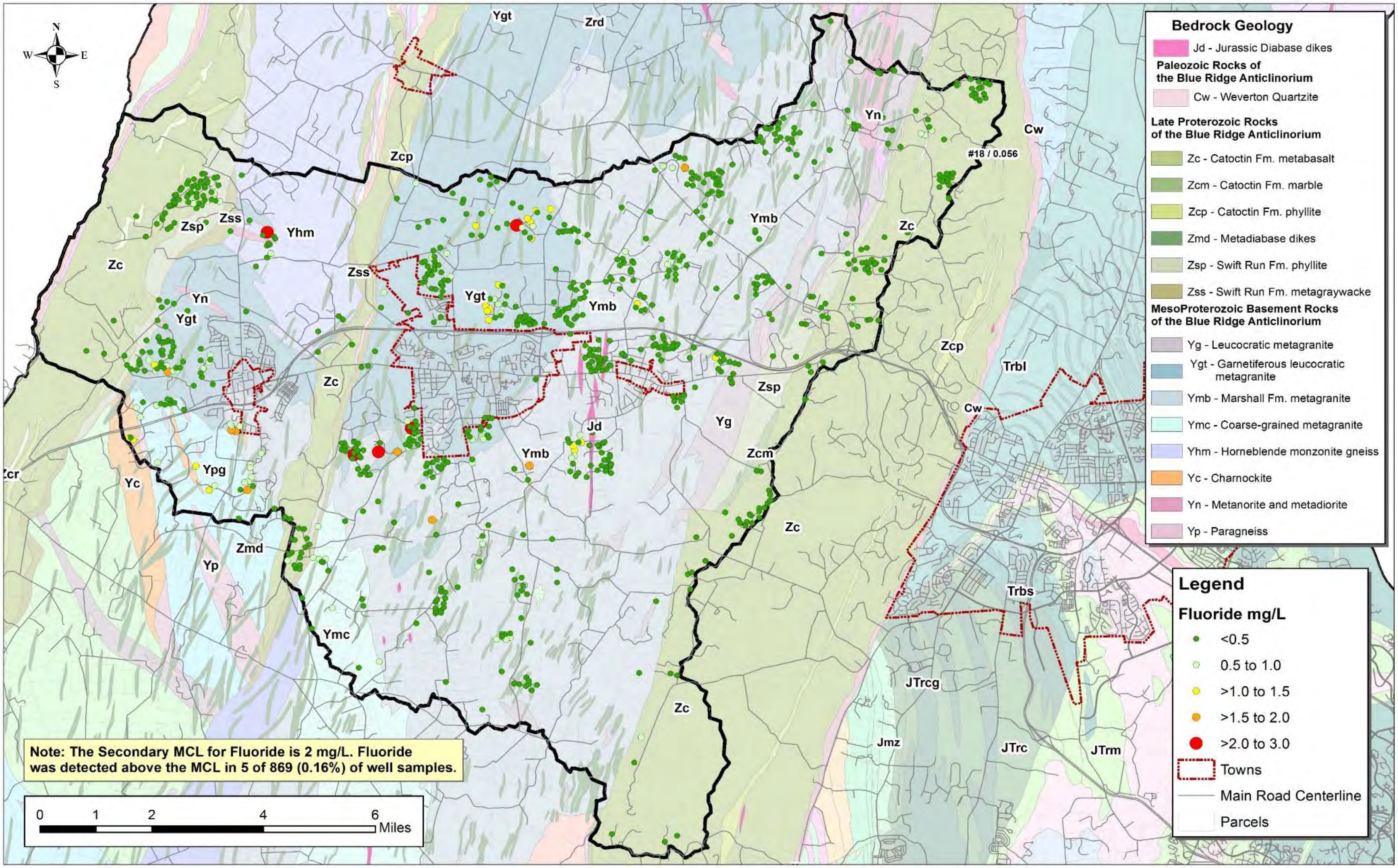


**Figure 5-36: Fluoride in groundwater in the Western Hills Watershed.**

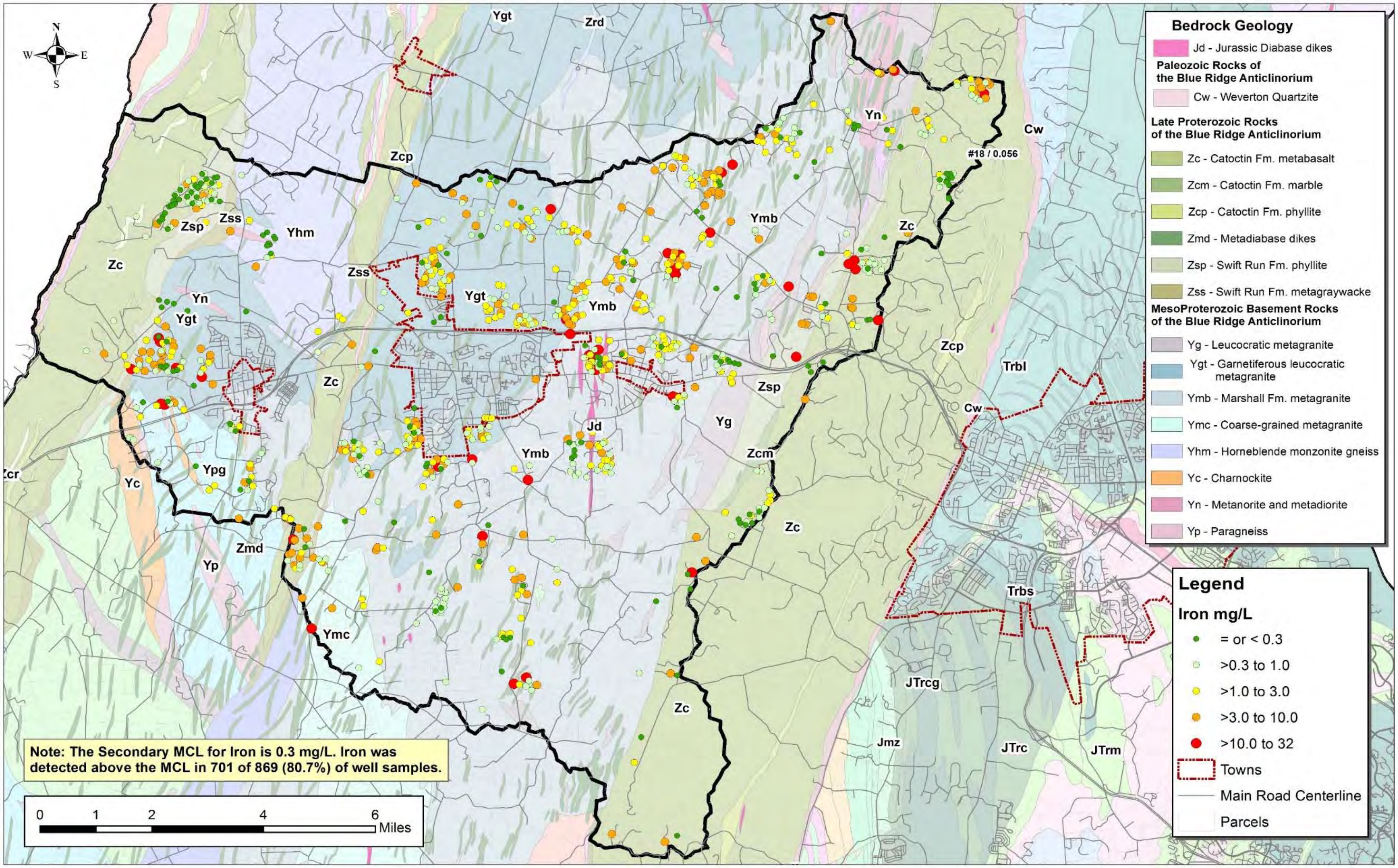


**Figure 5-37: Iron in groundwater in the Western Hills Watershed.**

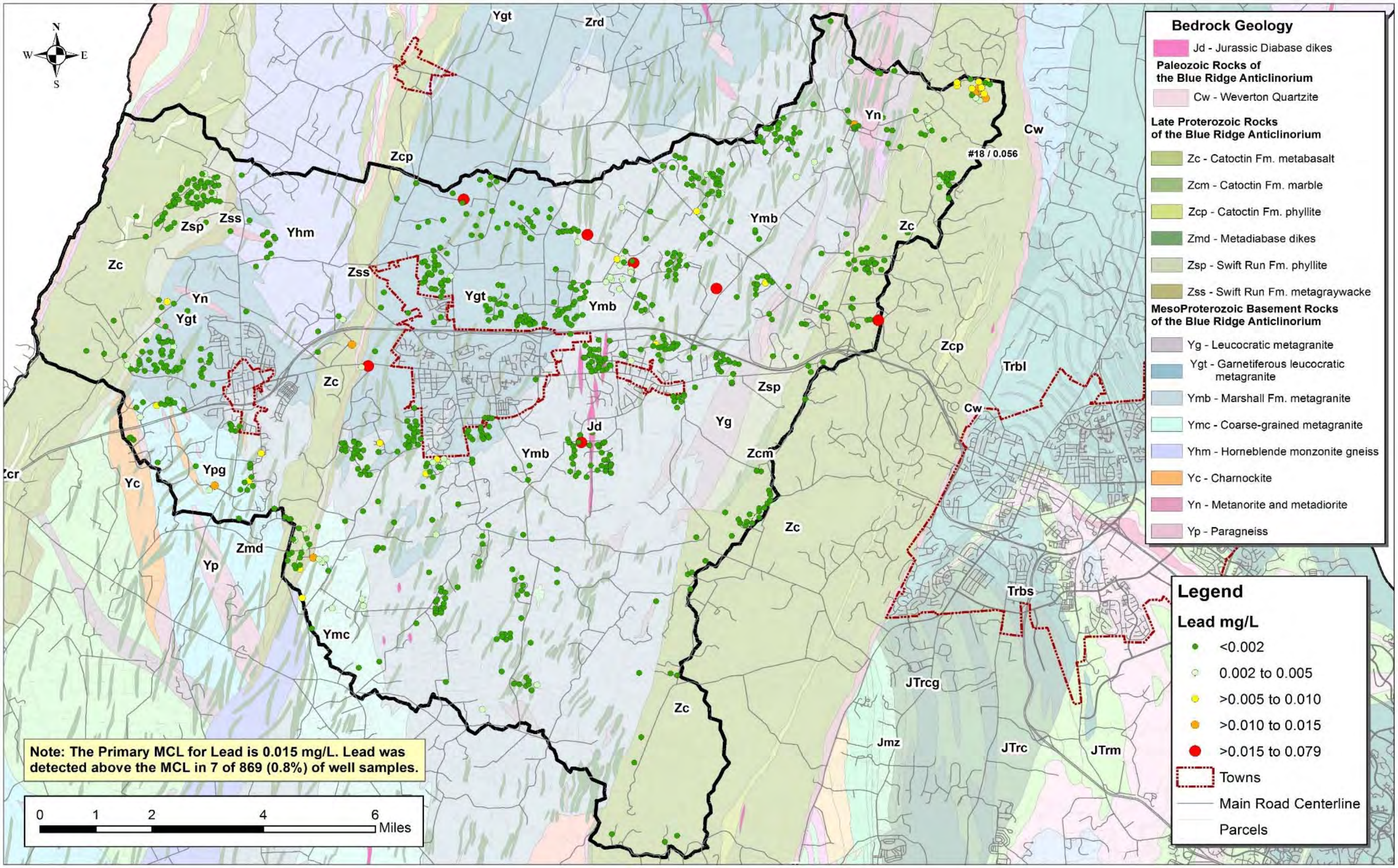


**Figure 5-38: Lead in groundwater in the Western Hills Watershed.**

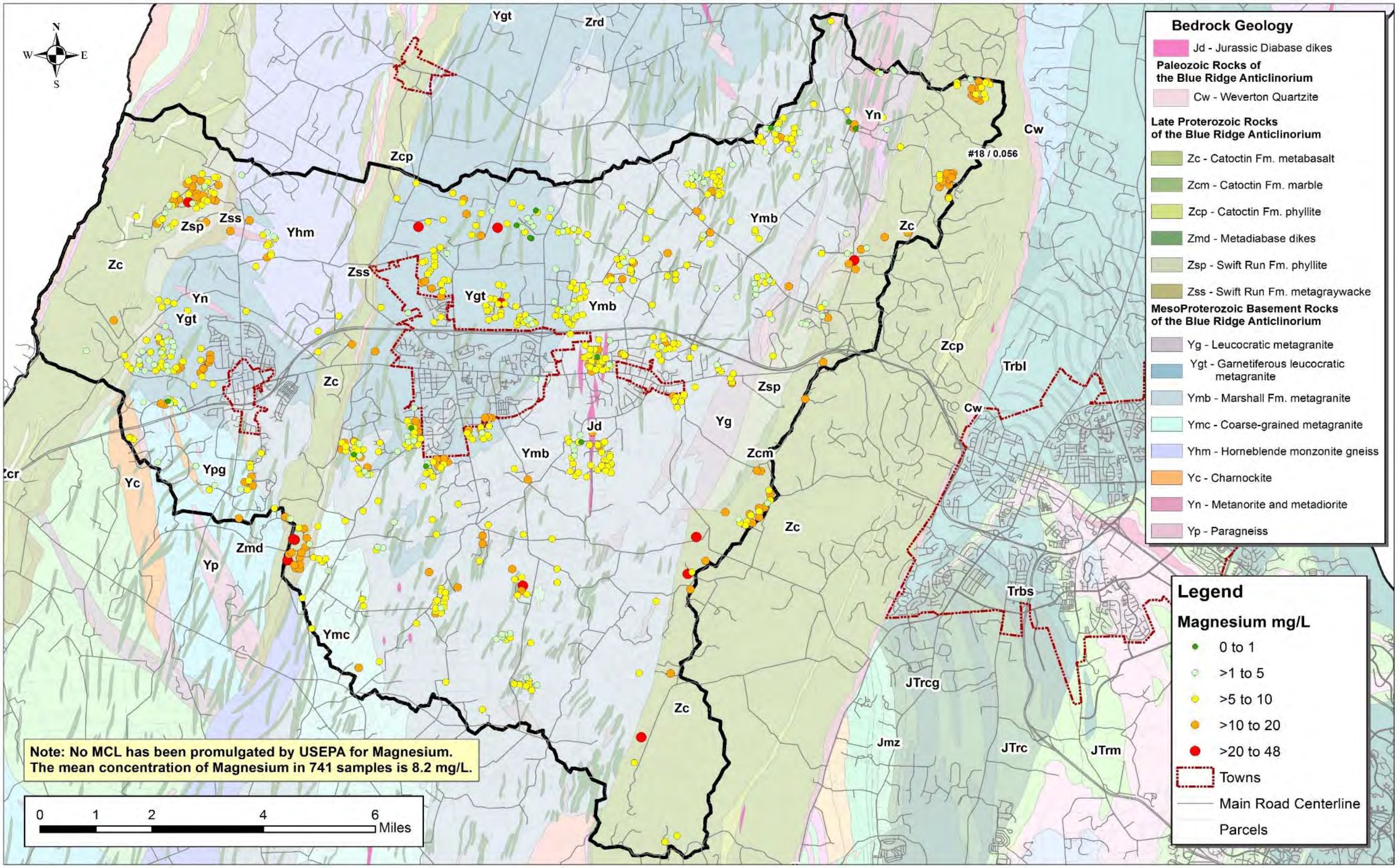


**Figure 5-39: Magnesium in groundwater in the Western Hills Watershed.**

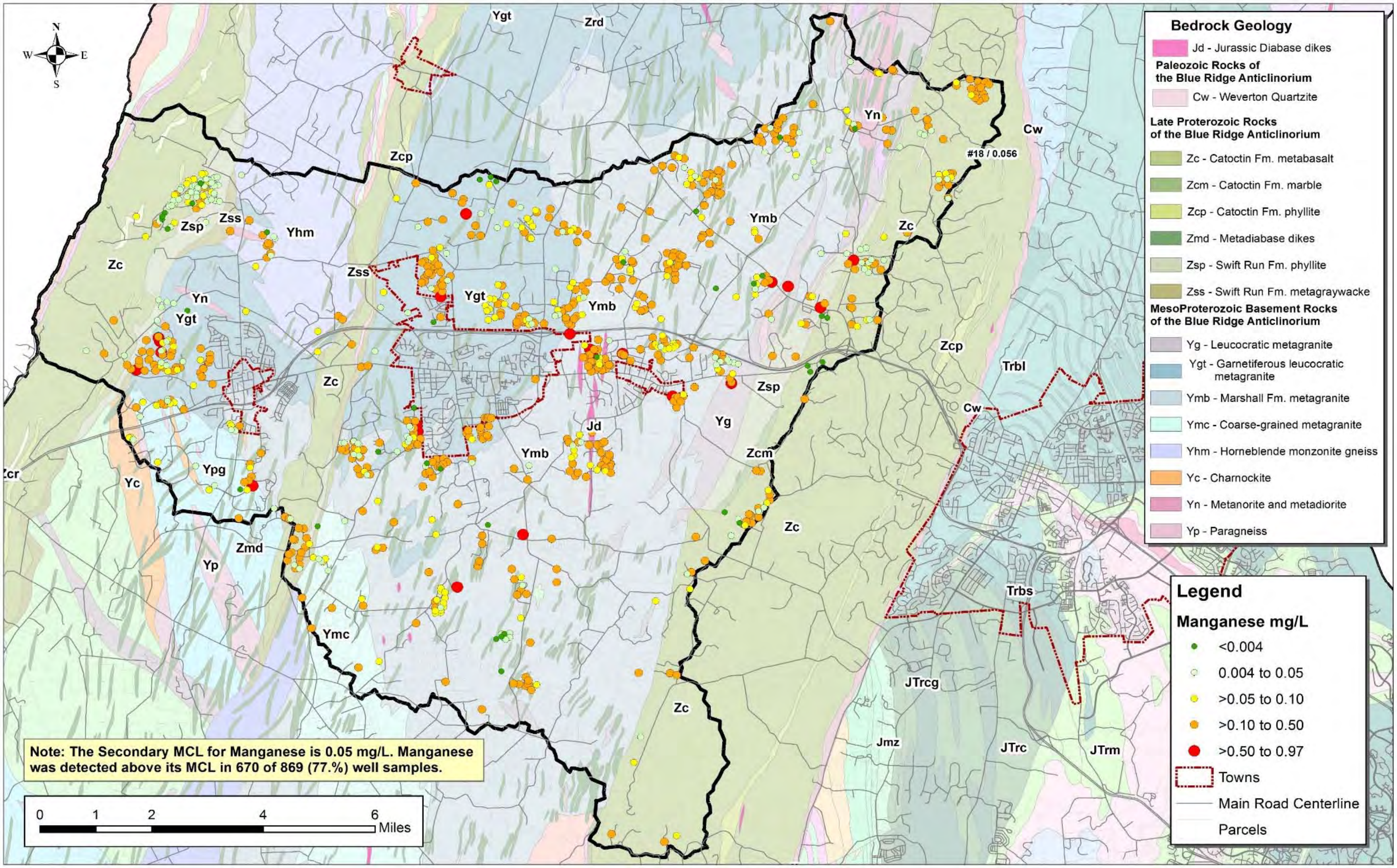


**Figure 5-40: Manganese in groundwater in the Western Hills Watershed.**

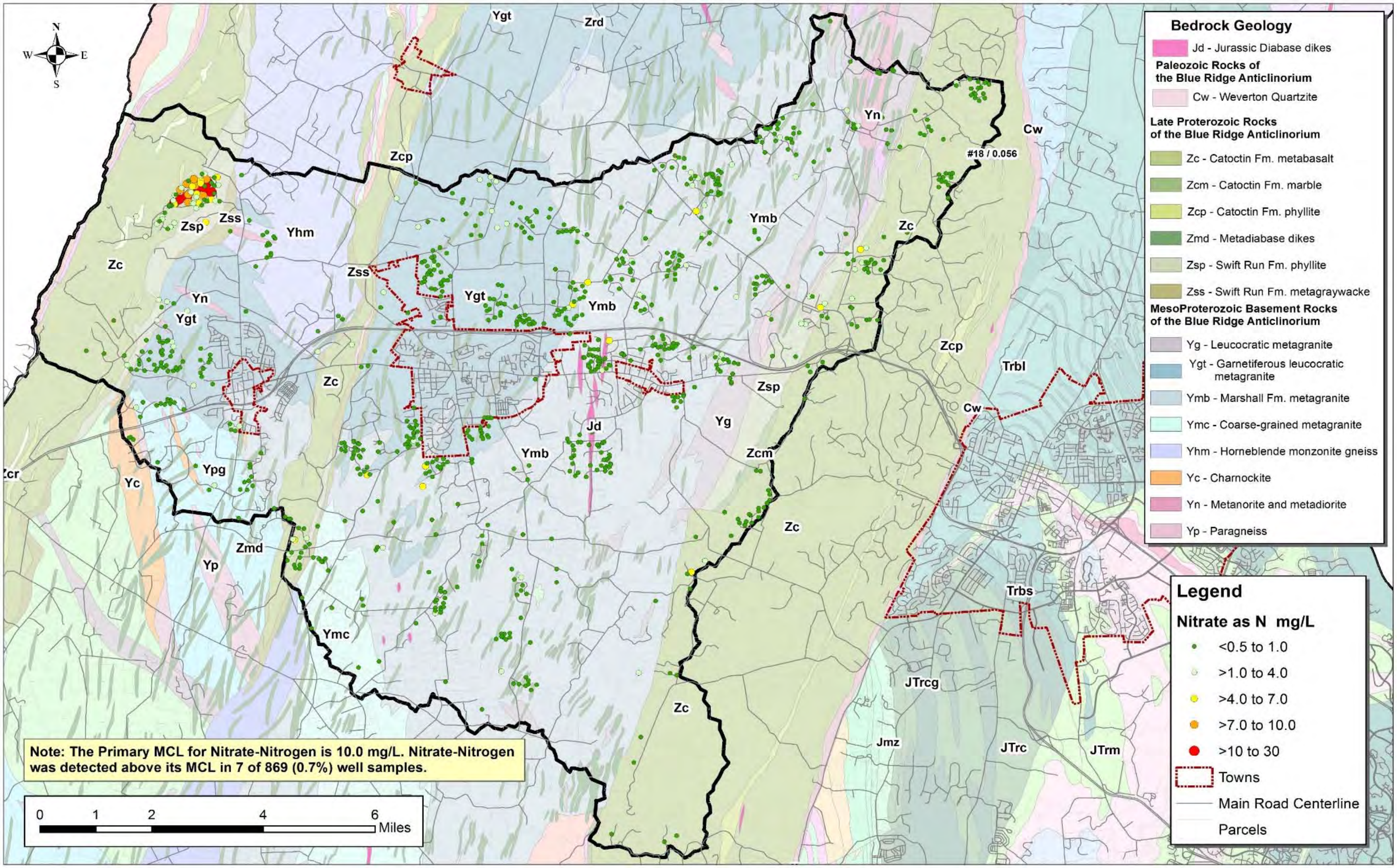


**Figure 5-41: Nitrate-nitrogen in groundwater in the Western Hills Watershed.**

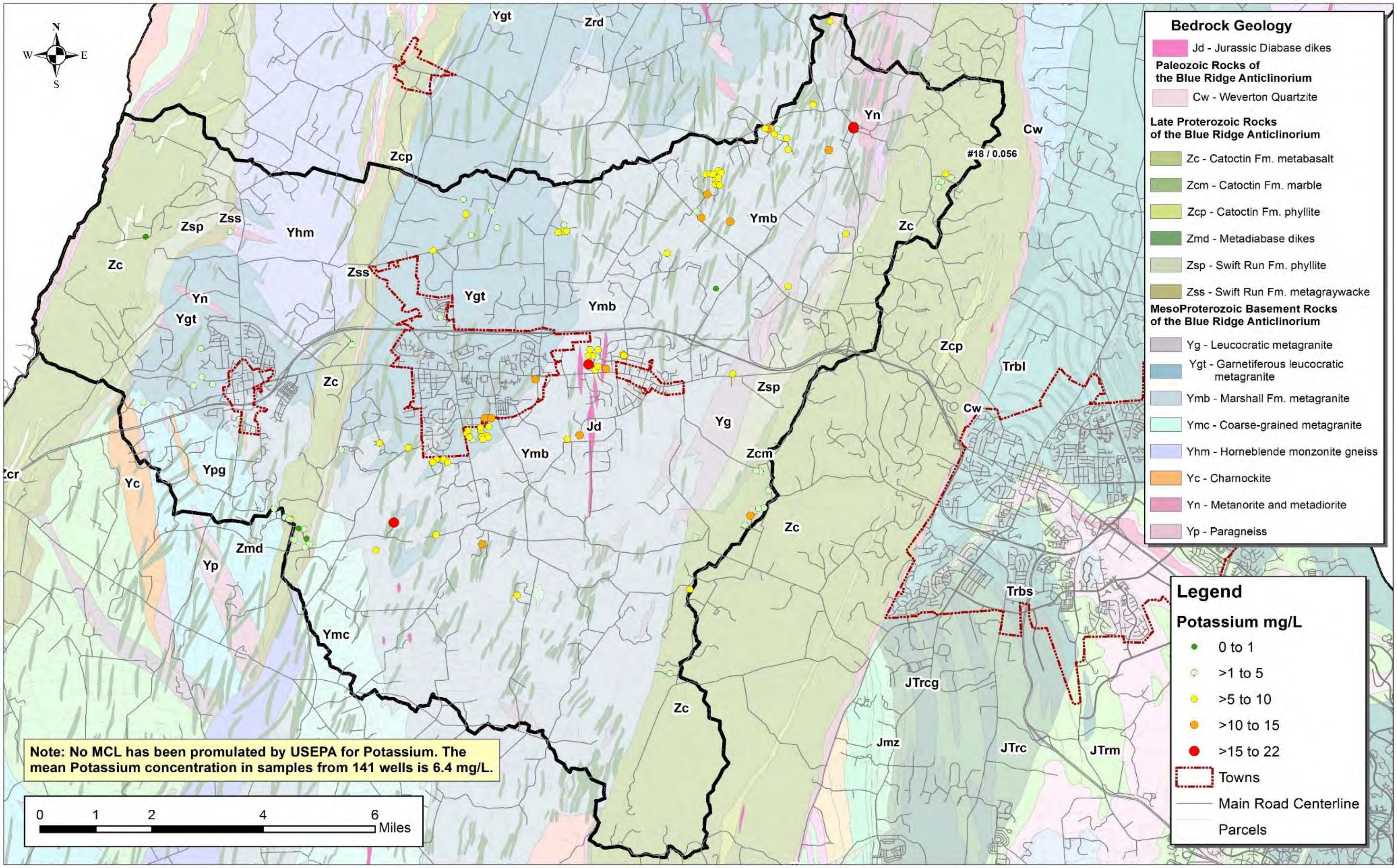


**Figure 5-42: Potassium in groundwater in the Western Hills Watershed.**

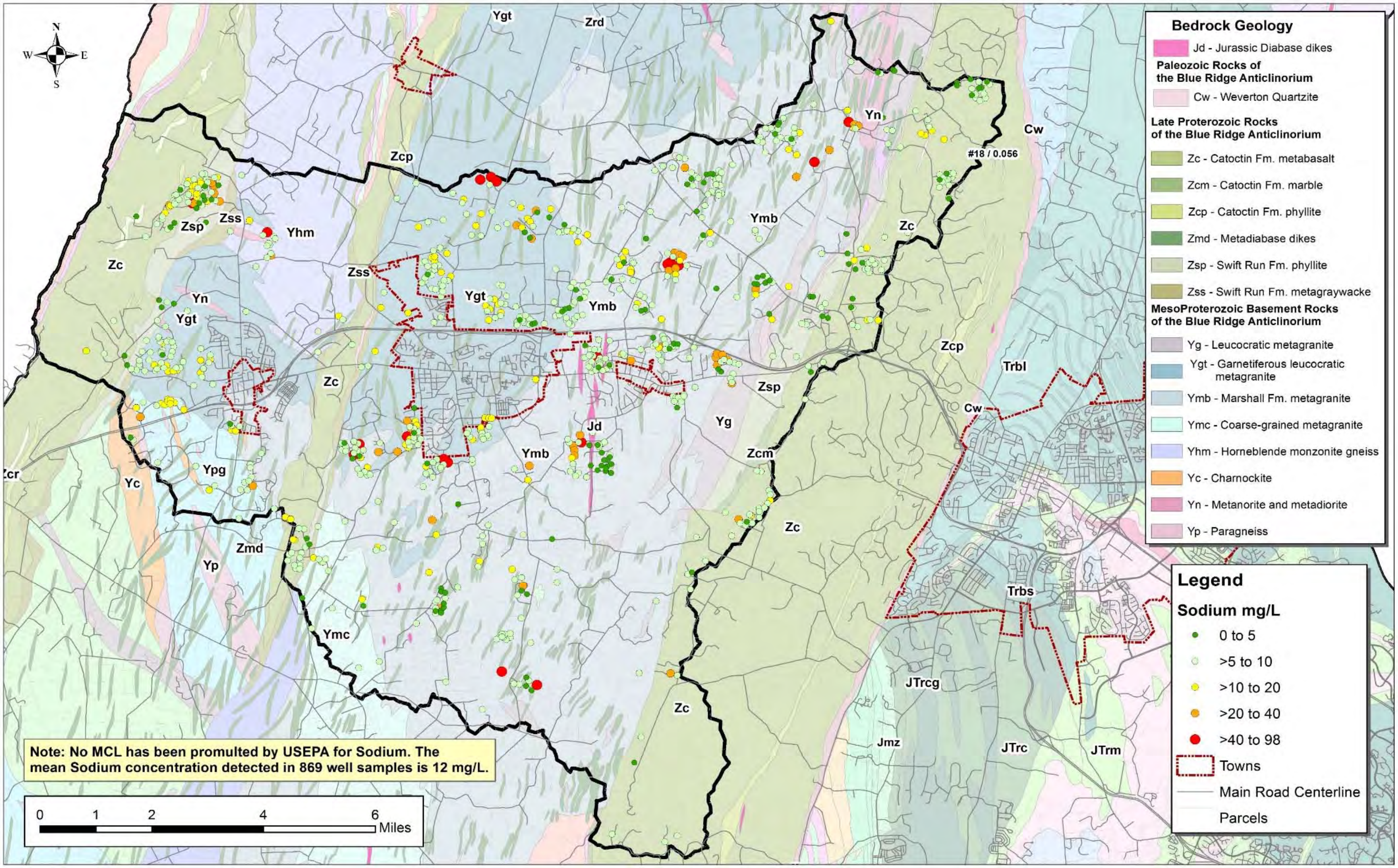


**Figure 5-43: Sodium in groundwater in the Western Hills Watershed.**

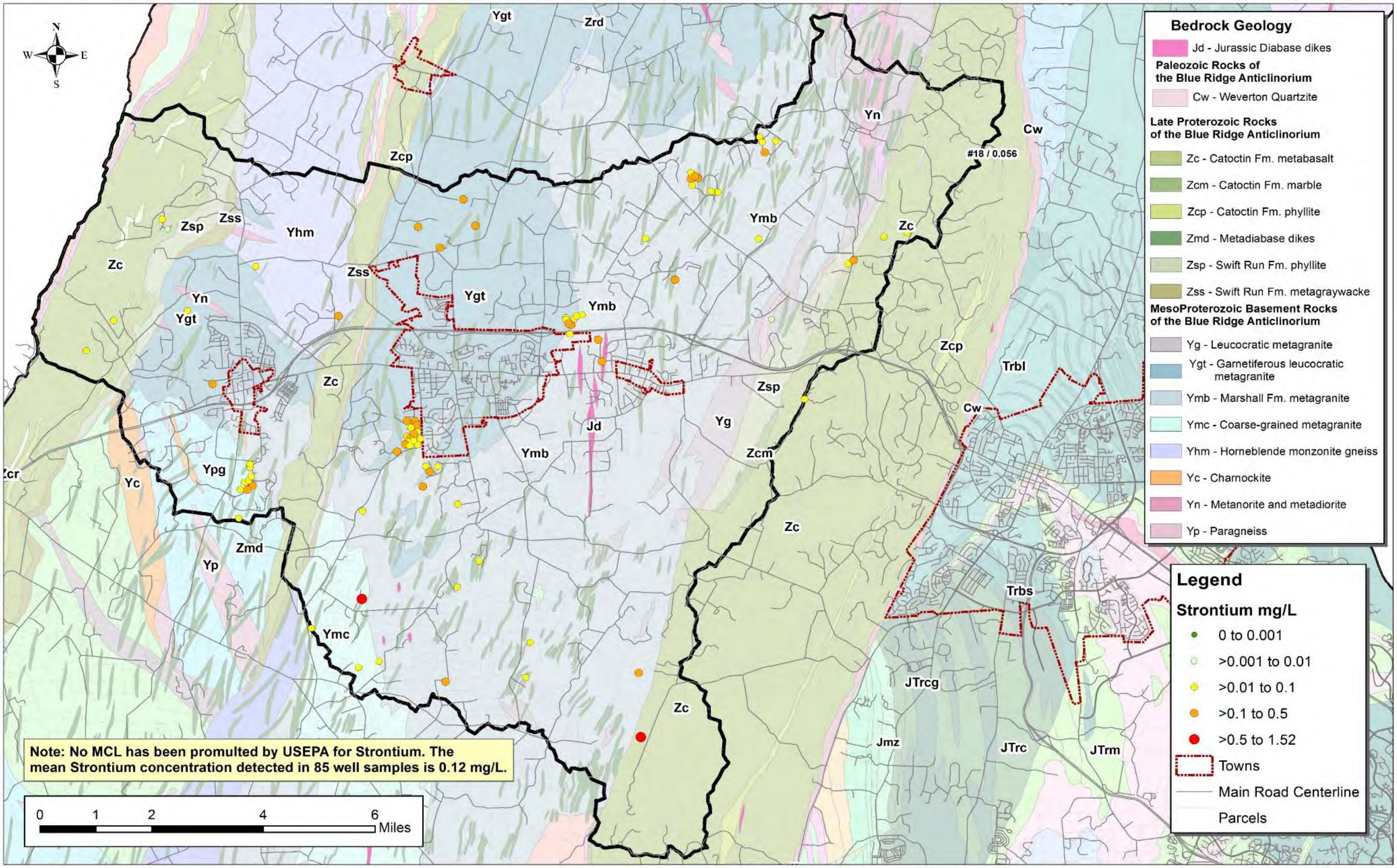


**Figure 5-44: Strontium in groundwater in the Western Hills Watershed.**

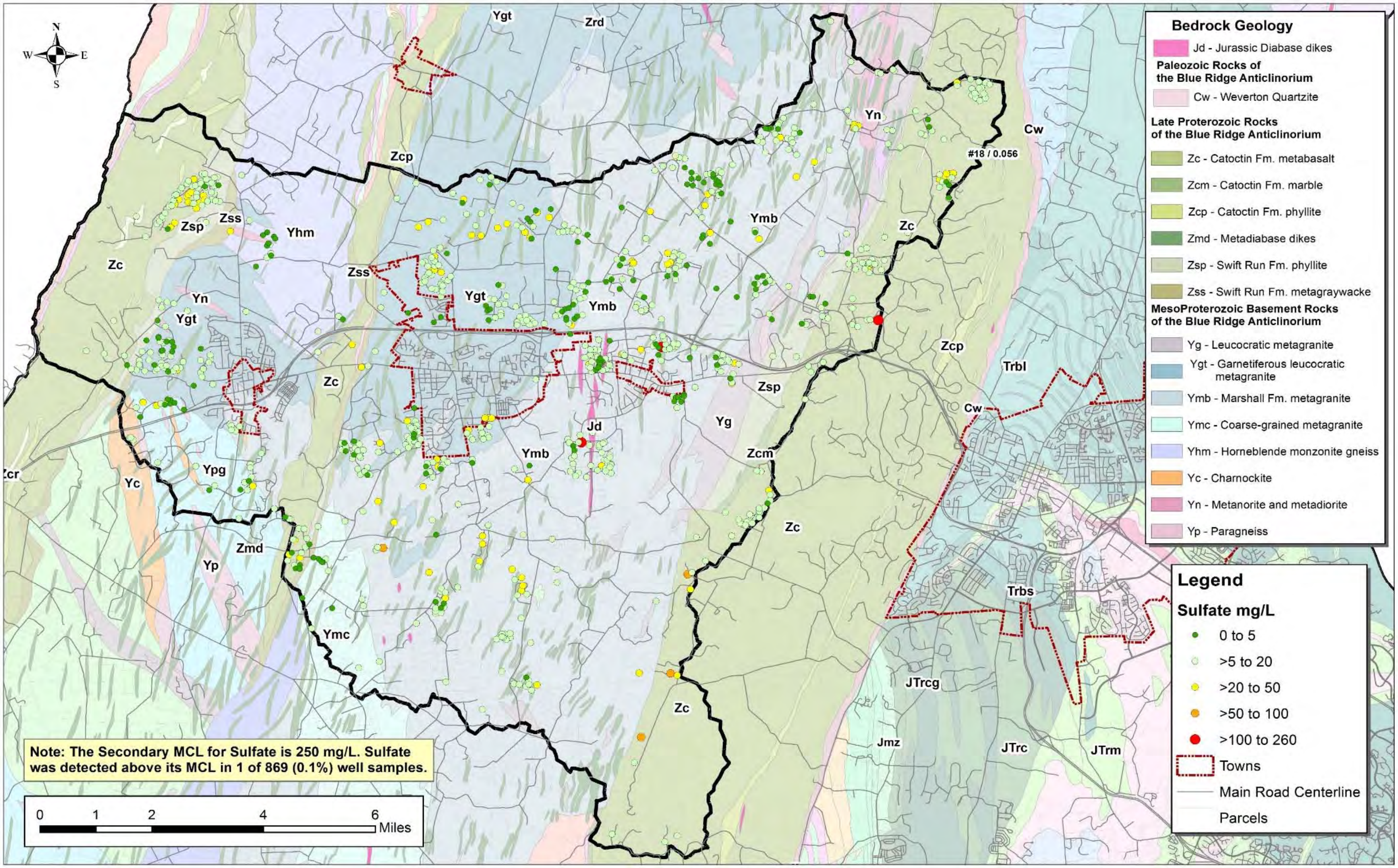


**Figure 5-45: Sulfate in groundwater in the Western Hills Watershed.**

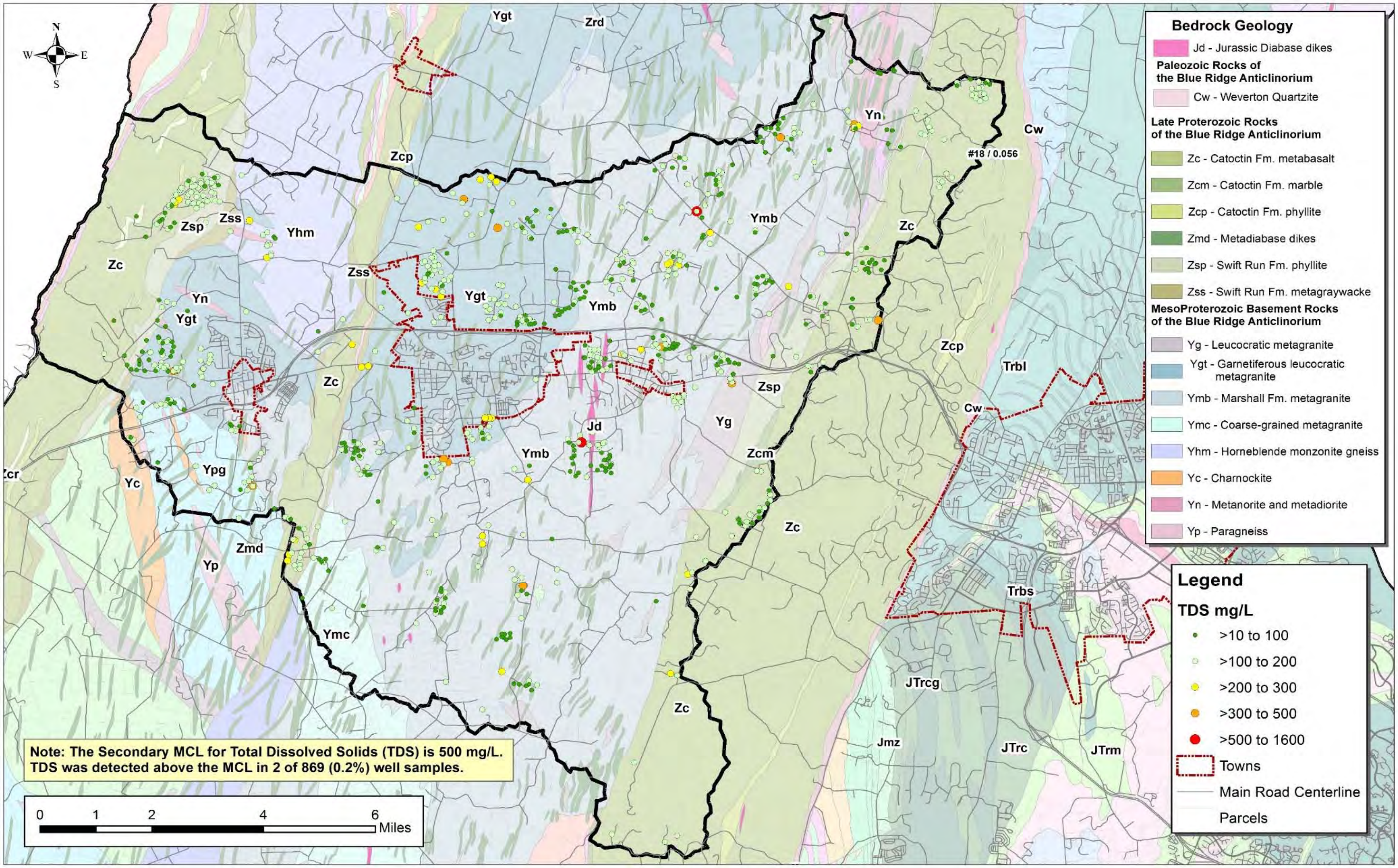


**Figure 5-46: Total Dissolved Solids (TDS) in groundwater in the Western Hills Watershed.**

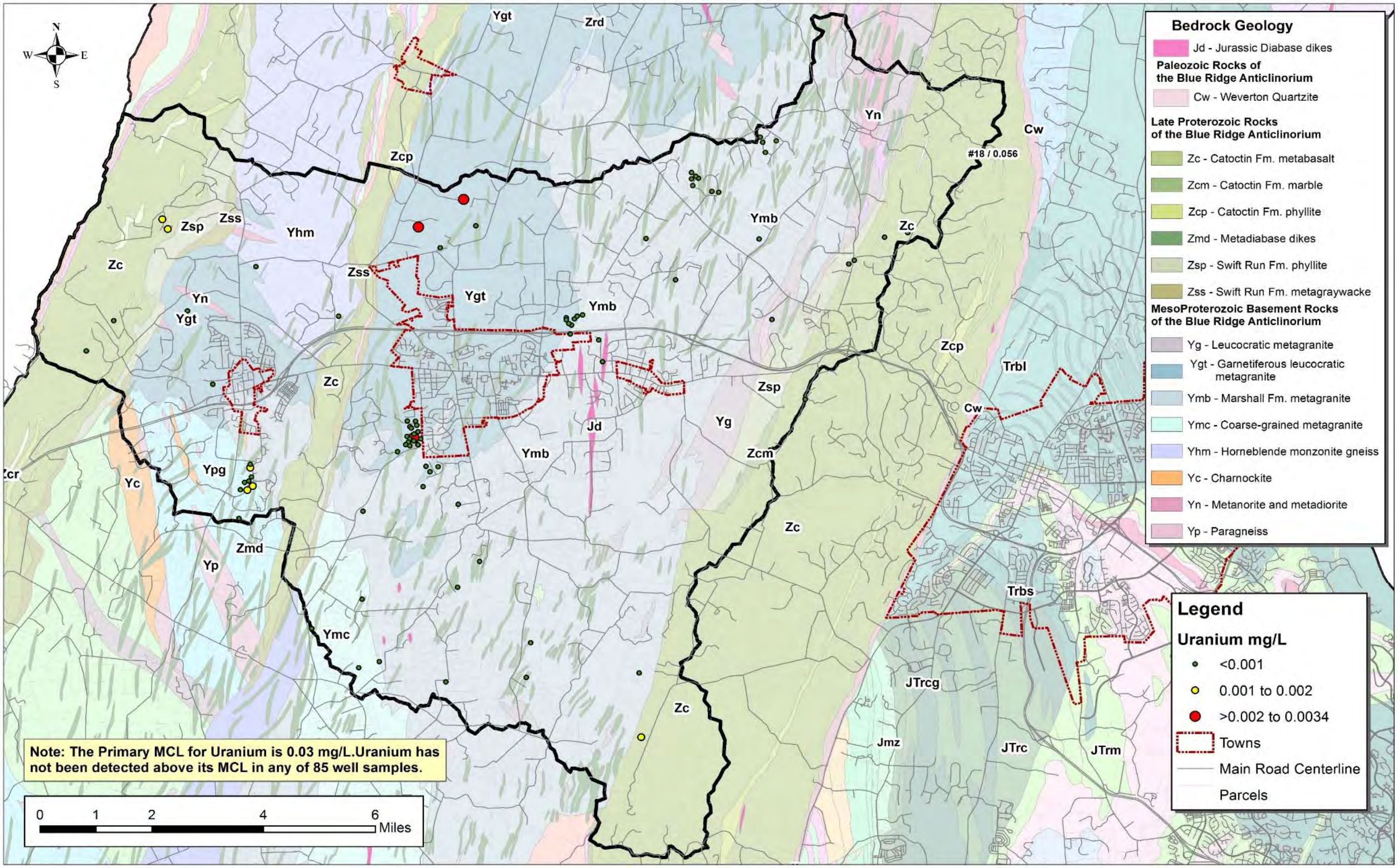


**Figure 5-47: Uranium in groundwater in the Western Hills Watershed.**

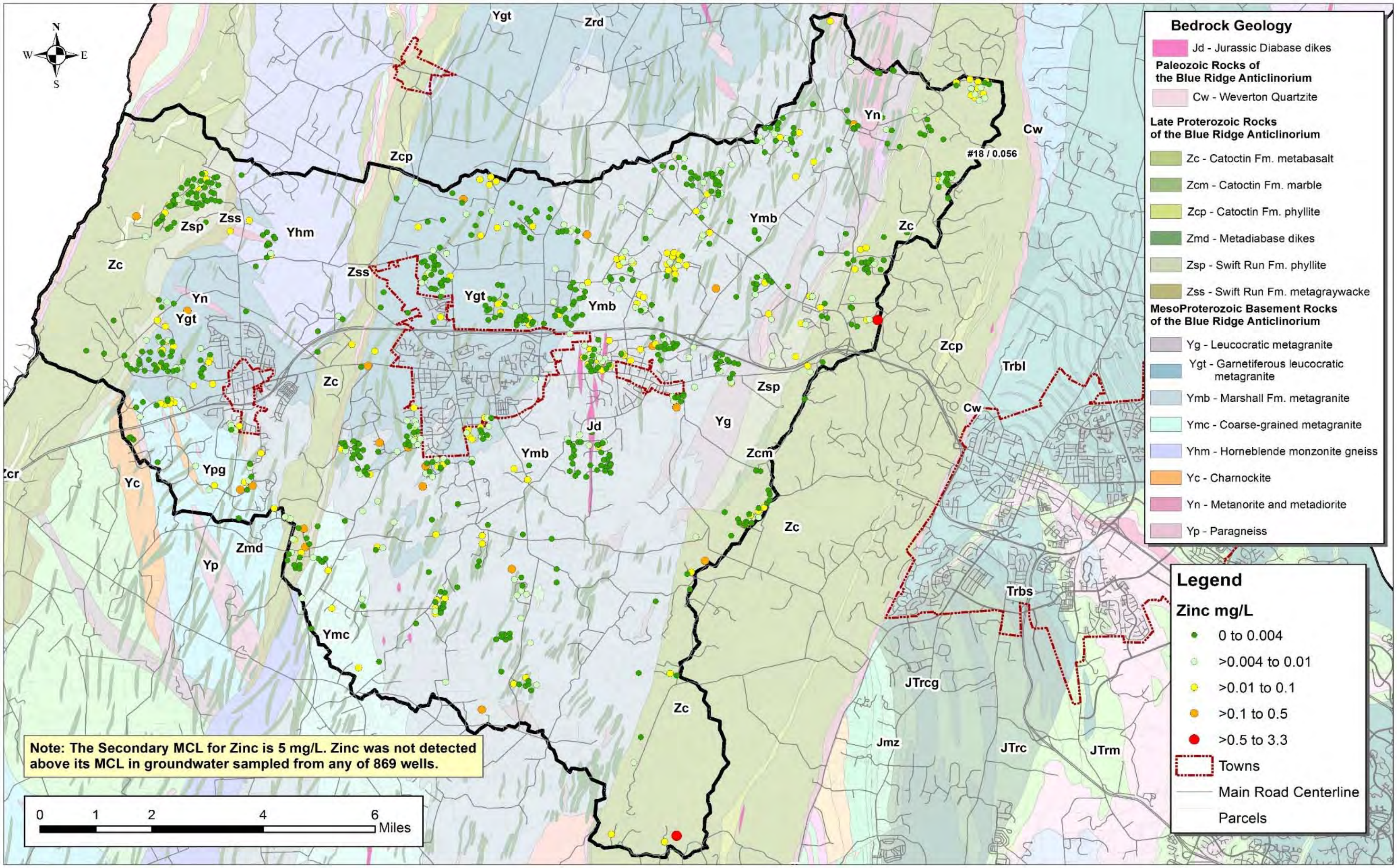


**Figure 5-48: Zinc in groundwater in the Western Hills Watershed.**

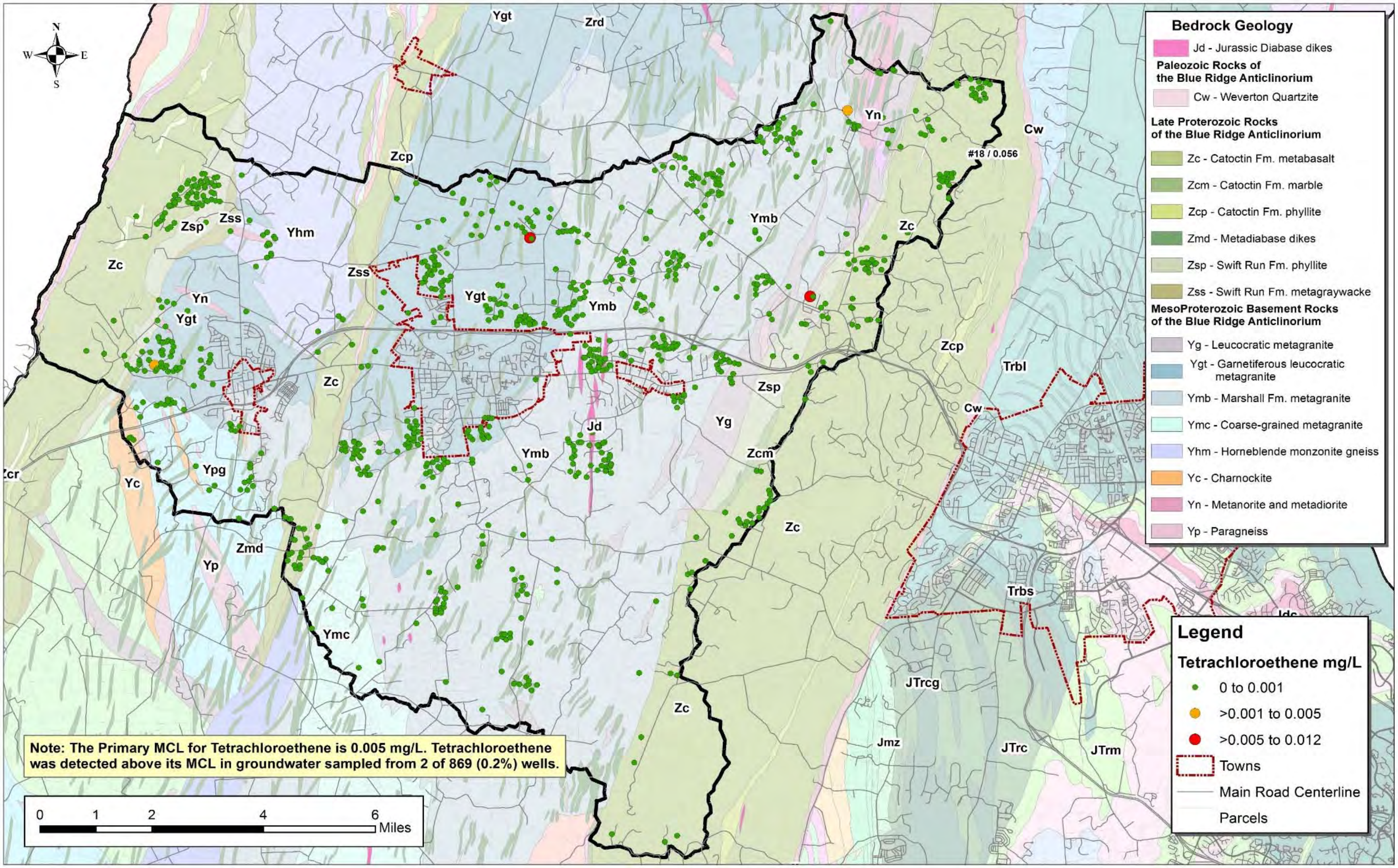


**Figure 5-49: Tetrachloroethene in groundwater in the Western Hills Watershed.**

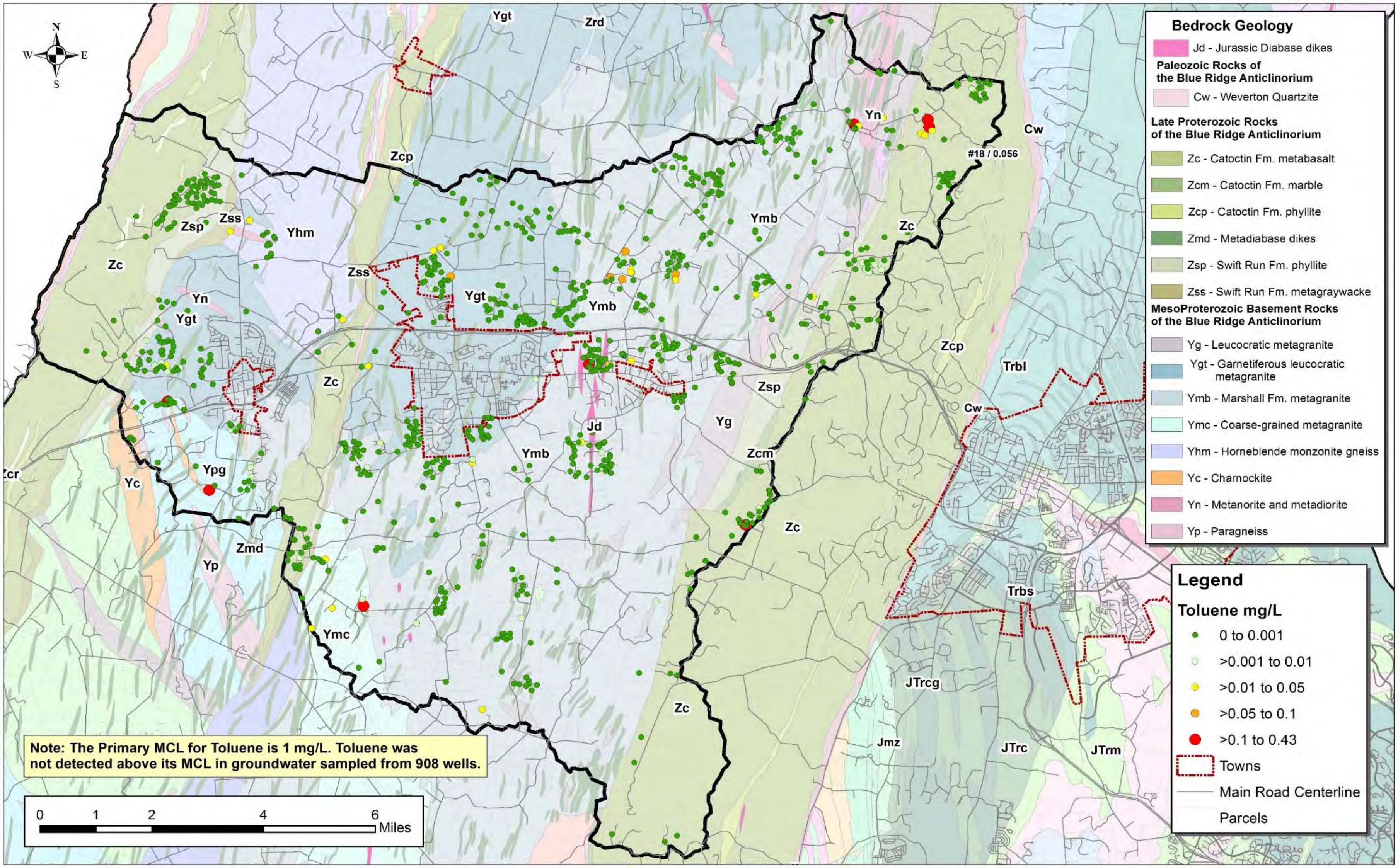


**Figure 5-50: Toluene in groundwater in the Western Hills Watershed.**

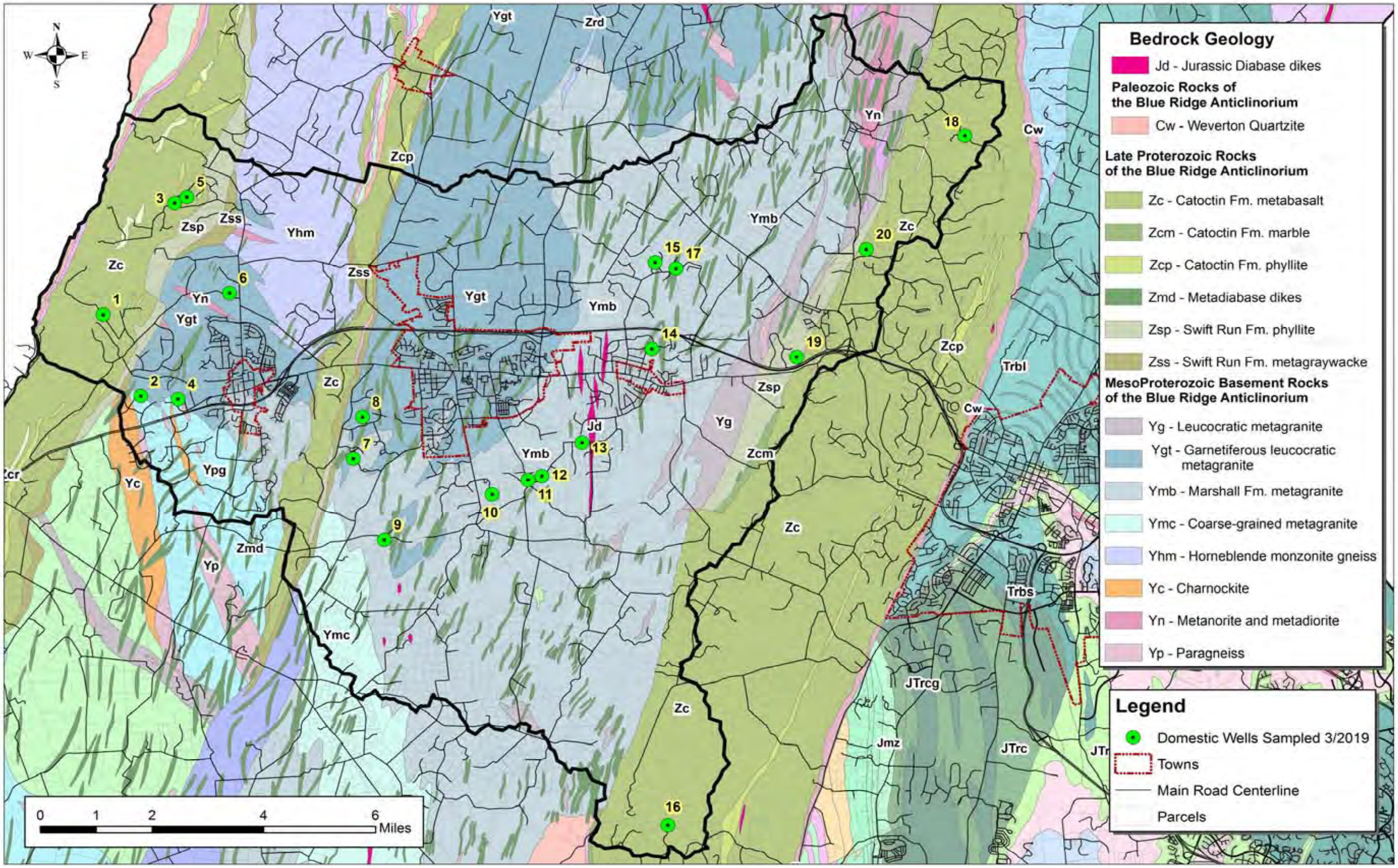


**Figure 5-51: Locations where raw water from domestic wells was sampled in March 2019.**

**Table 5-12: Inorganic chemical concentrations (mg/L) detected in untreated well water samples collected in the Western Hills Watershed in March 2019. Analytes not detected in any sample (not listed below) include arsenic, barium, cadmium, chromium, mercury, nickel, selenium, silver, bromide, nitrite-nitrogen, and orthophosphate.**

| Sample Map ID and Street | Aluminum | Calcium | Copper | Iron | Lead | Lithium | Magnesium | Manganese | Potassium | Silica | Sodium | Strontium | Uranium | Zinc | Alkalinity as CaCO3 | Hardness | pH (pH units) | TDS | Turbidity (NTU) | Chloride | Fluoride | Nitrate-N | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Primary MCL | | | | | 0.015 | | | | | | | | 0.03 | | | | | | | | 4 | 10 | |
| Secondary MCL | 0.2 | | | 0.3 | | | | 0.05 | | | | | | 5 | | | | 500 | | 250 | 2 | | 250 |
| EPA Action Level | | | 1.3 | | | | | | | | | | | | | | | | | | | | |
| Minimum Detection Limit | 0.1 | 2.0 | 0.004 | 0.020 | 0.002 | 0.001 | 0.10 | 0.004 | 1.0 | 0.1 | 1 | 0.001 | 0.001 | 0.004 | 20 | 10 | | 20 | 0.1 | 5.0 | 0.5 | 0.5 | 5.0 |
| 1 - Wilsons Gap Road | ND | 41.4 | ND | 0.087 | ND | ND | 9.49 | ND | ND | 30.4 | 8 | 0.052 | ND | 0.013 | 120 | 140 | 7.0 | 170 | 0.4 | ND | ND | ND | 10.0 |
| 2 - Scotland Heights Road | ND | 14.6 | 0.143 | 0.922 | 0.009 | ND | 6.16 | 0.007 | 1.1 | 24.8 | 6 | 0.086 | ND | 0.075 | 28 | 62 | 5.8 | 92 | 10.0 | ND | ND | 3.7 | 18.0 |
| 3 - Greyfriar Drive | ND | 72.0 | 0.018 | 0.027 | ND | ND | 31.00 | ND | 1.0 | 42.0 | 48 | 0.160 | ND | 0.007 | 98 | 310 | 6.9 | 290 | 0.2 | 21.0 | ND | 2.8 | 18.0 |
| 4 - Sweetwood Court | ND | 44.3 | 0.008 | ND | ND | 0.008 | 7.03 | ND | ND | 29.0 | 16 | 0.371 | 0.003 | 0.031 | 120 | 140 | 7.9 | 180 | 0.1 | ND | 1.4 | ND | 13.0 |
| 5 - Greyfriar Drive | ND | 59.7 | 1.280 | ND | ND | 0.002 | 18.60 | ND | 1.8 | 21.0 | 45 | 0.084 | ND | 0.195 | 130 | 230 | 7.5 | 280 | 0.1 | 22.0 | ND | 6.3 | 30.0 |
| 6 - Williams Gap Road | ND | 12.0 | 1.060 | 2.910 | 0.023 | 0.004 | 4.60 | 0.015 | 1.5 | 28.5 | 6 | 0.023 | ND | 0.044 | 38 | 49 | 6.2 | 95 | 4.1 | 5.3 | ND | 1.0 | 10.0 |
| 7 - South Shore Drive | ND | 26.4 | 0.010 | 0.878 | ND | 0.005 | 9.66 | 0.187 | 4.2 | 43.0 | 8 | 0.102 | ND | 0.008 | 90 | 110 | 7.3 | 160 | 9.4 | 6.6 | ND | ND | 11.0 |
| 8 - Lakewood Court | ND | 32.0 | ND | ND | 0.019 | 0.003 | 13.00 | ND | 1.6 | 2.6 | 11 | 0.130 | ND | ND | 46 | 130 | 6.4 | 100 | 1.5 | ND | ND | 0.7 | 11.0 |
| 9 - Paxson Road | ND | 7.4 | 0.018 | ND | ND | 0.006 | 1.40 | 0.006 | 2.2 | 34.0 | 56 | 0.190 | ND | 0.049 | 82 | 24 | 8.6 | 150 | 0.1 | ND | 1.0 | ND | ND |
| 10 -Oak Ridge Hamlet Place | ND | 12.0 | 0.021 | 0.076 | ND | 0.004 | 4.90 | .610 | 3.6 | 78.0 | 150 | 0.022 | ND | 0.054 | 120 | 50 | 6.9 | 320 | 0.2 | ND | ND | ND | ND |
| 11 - Lincoln Road | ND | 7.4 | 0.090 | 0.059 | ND | ND | 2.30 | 0.006 | ND | 3.3 | 16 | 0.026 | ND | 0.009 | 110 | 28 | 7.0 | 230 | 3.2 | 100.0 | ND | ND | 32.0 |

**Table 5-12: Inorganic chemical concentrations (mg/L) detected in untreated well water samples collected in the Western Hills Watershed in March 2019. Analytes not detected in any sample (not listed below) include arsenic, barium, cadmium, chromium, mercury, nickel, selenium, silver, bromide, nitrite-nitrogen, and orthophosphate.**

| Sample Map ID and Street | Aluminum | Calcium | Copper | Iron | Lead | Lithium | Magnesium | Manganese | Potassium | Silica | Sodium | Strontium | Uranium | Zinc | Alkalinity as CaCO3 | Hardness | pH (pH units) | TDS | Turbidity (NTU) | Chloride | Fluoride | Nitrate-N | Sulfate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 - Sands Road | ND | 32.8 | 0.007 | 0.589 | ND | 0.009 | 14.70 | 0.623 | 9.6 | 44.7 | 10 | 0.076 | ND | 0.086 | 100 | 140 | 6.6 | 210 | 4.3 | 12.0 | ND | ND | 28.0 |
| 13 - Alfalfa Court | ND | 55.2 | 0.013 | 0.426 | 0.005 | 0.005 | 13.60 | 0.246 | 7.6 | 32.2 | 13 | 0.272 | ND | 0.070 | 120 | 190 | 7.5 | 260 | 2.1 | 32.0 | ND | ND | 33.0 |
| 14 - Bettis Drive | ND | 63.8 | 0.058 | 1.150 | 0.009 | 0.006 | 21.30 | 0.294 | 8.6 | 50.0 | 16 | 0.907 | ND | 0.117 | 130 | 250 | 7.4 | 340 | 11.0 | 78.0 | ND | ND | 18.0 |
| 15 - Mosswood Drive | ND | 22.8 | 0.035 | 1.280 | 0.006 | 0.003 | 6.96 | 0.142 | 5.8 | 34.5 | 6 | 0.064 | ND | 0.058 | 66 | 85 | 7.3 | 140 | 4.1 | 5.3 | ND | ND | 15.0 |
| 16 - Old Hickory Lane | ND | ND | ND | ND | 0.009 | ND | ND | ND | ND | ND | 2 | ND | ND | ND | 160 | ND | 7.4 | 150 | 3.3 | 28.0 | ND | ND | 28.0 |
| 17 - Lance Trail Court | ND | ND | .027 | .026 | .002 | ND | ND | ND | ND | 35.7 | 56 | ND | ND | .004 | 110 | ND | 7.9 | 160 | .3 | ND | ND | ND | ND |
| 18 - Browns Lane | ND | 23.3 | 0.197 | 0.056 | 0.008 | ND | 12.60 | ND | 1.2 | 25.8 | 6 | 0.042 | ND | 0.266 | 70 | 110 | 6.9 | 140 | 0.7 | 13.0 | ND | ND | 12.0 |
| 19 - Meadowlark Drive | 0.2 | 22.7 | 0.102 | 0.097 | 0.002 | ND | 7.90 | ND | 3.6 | 25.5 | 4 | 0.046 | ND | 0.036 | 68 | 89 | 7.2 | 120 | 0.5 | ND | ND | 1.3 | 14.0 |
| 20 - Clarkes Gap Road | ND | 38.7 | 0.092 | 2.400 | 0.008 | ND | 17.00 | 0.010 | ND | 27.1 | 8 | 0.066 | ND | 0.048 | 90 | 170 | 6.9 | 200 | 16.0 | 34.0 | ND | 1.9 | 13.0 |
| Minimum | <0.1 | 7.4 | <0.004 | <0.020 | <0.002 | <0.001 | 1.40 | <0.004 | <1.0 | <0.1 | 4 | 0.022 | <0.001 | 0.007 | 28 | 24 | 5.8 | 92 | 0.1 | <5.0 | <0.5 | <0.5 | 10.0 |
| Maximum | 0.2 | 72.0 | 1.280 | 2.910 | 0.023 | 0.009 | 31.00 | 0.623 | 9.6 | 78.0 | 150 | 0.907 | <0.001 | 0.266 | 130 | 310 | 8.6 | 340 | 16.0 | 100.0 | 1.4 | 6.3 | 33.0 |
| Average (for ND = 0.0) | 0.01 | 39.2 | 0.21 | 0.73 | 0.01 | 0.00 | 13.48 | 0.102 | 3.6 | 38.4 | 29.00 | 0.181 | 0.000 | 0.078 | 119 | 154 | 7.1 | 242 | 4.8 | 23.8 | 0.2 | 1.1 | 20.9 |
| # Samples > MCL | 0 | No MCL | 0 | 8 | 1 | No MCL | No MCL | 6 | No MCL | No MCL | No MCL | No MCL | 0 | 0 | No MCL | No MCL | No MCL | 0 | No MCL | 0 | 0 | 0 | 0 |

# CHAPTER 6: STORMWATER MANAGEMENT AND OTHER WATERSHED MANAGEMENT PRACTICES

Loudoun County has implemented stormwater control measures (SCMs) and other watershed management practices since the 1980s. The initial focus of stormwater management was detention of large flows to reduce flooding. Subsequent urban stormwater designs addressed water quality treatment and stream channel protection. Most recently, "green" SCMs known as Environmental Site Design (ESD) or green stormwater infrastructure are being encouraged for new development and to facilitate restoration of watersheds. In 2014 Loudoun County was established as a Virginia Stormwater Management Program (VSMP) Authority, as required by the Virginia Stormwater Management Act and the attendant regulations. These new stormwater regulations for new and re-development require that stormwater management provide for control of water quantity and quality using the latest guidelines.

## 6.1 Stormwater Control Measures for Urban/Suburban Areas

The following categories of stormwater and watershed management practices were considered in this watershed management plan as the major strategies to address the effects of urban/suburban development in Western Hills. Each has the potential to yield quantifiable benefits in stormwater quality and in quantity control for channel protection and flooding, with the exception of urban nutrient management, which affects only the former.

- Urban nutrient management
- Conversion of dry detention ponds (DP) to extended detention dry ponds (ED DP)
- Conversion of dry ponds to infiltration practices
- Addition of pretreatment or post treatment SCMs within existing dry or wet pond boundaries
- New SCMs retrofits outside of existing dry or wet pond boundaries but which would drain into an existing pond or capture and treat stormwater just outside of the existing pond
- Reforestation of stream buffers
- Reforestation of upland areas
- Stream restoration for erosion control and nutrient processing
- New Micro-SCMs or low impact development (LID) such as bioretention, bioswales, urban filtration practices, etc. not associated with an existing dry or wet pond
- Downspout disconnection
- Impervious cover removal

Note that stormwater control measure options chosen here are all recognized by the U.S. Environmental Protection Agency (EPA) Chesapeake Bay Program and the Chesapeake

Assessment Scenario Tool (CAST) and have vetted nitrogen, phosphorus and pollutant removal efficiencies.

***Urban nutrient management*** involves the reduction of fertilizer for grass lawns and other urban and suburban manicured pervious areas through efficient application. The implementation of urban nutrient management relies on public education and awareness, targeting urban and suburban residences and businesses, with an emphasis on proper application of fertilizer in order to both reduce excessive fertilizer application and to prevent fertilizer discharge into waterways via precipitation by deliberate timing of fertilizer applications. Urban nutrient management is a source reduction solution and therefore highly cost-effective, particularly in terms of phosphorus which tends to be the limiting element to algal growth in freshwaters.

***New stormwater management ponds*** involve placing new stormwater management facilities, including extended detention dry ponds, urban infiltration ponds, constructed wetlands (Figure 5-1), or wet ponds at locations that currently have no stormwater quantity or quality controls or where existing SCMs are inadequate and where space is available for a new SCM. Ponds are the traditional method of controlling stormwater flows and the opportunity to retrofit new SWM ponds is not common in the developed environment. However, the resulting benefits to flow volume, velocity control, and water quality improvement can be significant. Benefits may vary depending on the specific design features of the individual ponds.

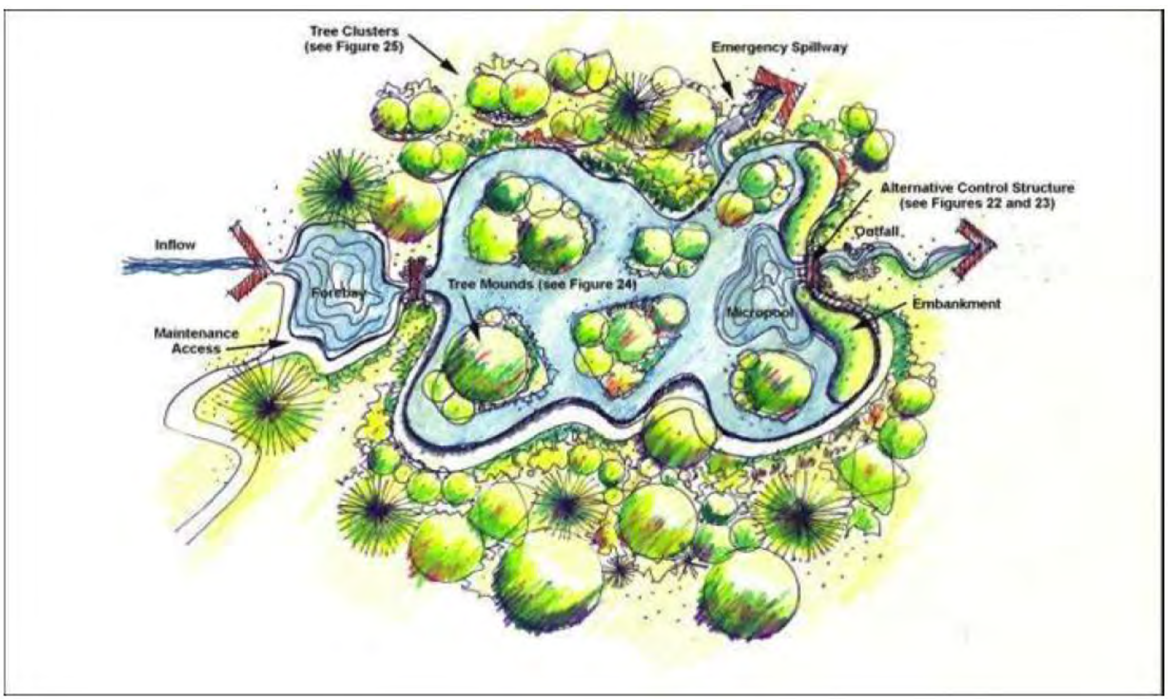


**Figure 6-1: Constructed Wetland Standard Concept Design (Virginia DEQ 2011a)**

***Stormwater pond conversions*** can include the following general options for the re-design of existing stormwater ponds to provide additional water quantity control or water quality treatment:

- Increasing storage capacity by additional excavation.
- Providing water quality treatment features at facilities that currently have only water quantity control, if the space is available. Examples include: micropools, sediment forebays, or constructed stormwater wetlands.
- Modifying or replacing existing outlet controls to reduce the discharge rate from the stormwater management facility.
- Where soil types are appropriate, adding infiltration (sometimes referred to as exfiltration) features to promote groundwater recharge and improve pollutant removal.
- Where water quality flows can be split or separated from larger events, vegetated areas with engineered soils and underdrain, referred to as bioretention, can sometimes be retrofit into an existing pond as pre-treatment or post-treatment and yield a significant increase in pollutant removal efficiency.
- Installing proprietary settling, filtering, or hydrodynamic devices in parking lots or other areas with a large percentage of impervious area to trap sediments and petroleum products before they flow into a pond. These tend to have low pollutant removal efficiencies but can be good options in the highly urban context, particularly where subterranean treatment is the only option. They have the added benefit of offering inherent quality control during construction by their manufacturers as opposed to SCMs and ponds which are custom built for each application.

Specifically, the following types of conversions are recommended.

***Conversion of Dry Stormwater Management Detention Ponds*** to extended detention dry ponds or extended detention wet pond/wetlands or conversion to ponds with infiltration capability, where soils permit. These SCMs typically treat the largest area of impervious cover because they have the largest drainage areas and were originally built as a low-cost option for flood control, channel protection and/or water quality control. Conversion of these existing devices is among the most cost effective of pollutant reduction measures because the existing ponds do not require acquisition of new property. Furthermore, the pipe infrastructure is already in place, most of the excavation is already complete, maintenance responsibilities and easements have already been established and because stormwater flows already concentrate at these devices. Pollution reduction credits may depend on specific design characteristics affecting both runoff time and treatment.

Dry and Wet Extended Detention (ED) Basins are depressions that temporarily store ("detain") runoff and release it at a prescribed rate via surface flow or groundwater infiltration following storms. Dry ED basins are designed to dry out between storm events, in contrast with wet ED ponds, which contain standing water permanently. As such, they (ED type) are similar in construction and function to simple dry or wet detention basins which are primarily for flood control or channel protection, except that the duration of detention of stormwater is designed to be longer, theoretically improving treatment effectiveness by increasing residence time of pollutants which encourages settling of sediments and allows more time for biological and physical processing of nutrients.

Urban Infiltration Practices are depressions created to allow the collection and infiltration of stormwater in order to trap sediments and nutrients in soil media and simultaneously recharge groundwater aquifers (Figures Figure 6-2 and Figure 6-3). No underdrains are associated with infiltration basins and trenches, because by definition these systems provide complete infiltration. Infiltration basins and trenches cannot be constructed on poor soils, such as C and D soil types. These urban infiltration practices may include vegetation and sand which increases the removal of phosphorus by 5 percent on average compared to infiltration practices without sand or vegetation.

**Figure 6-2: Residential Infiltration Trench (Virginia DEQ 2011b)**

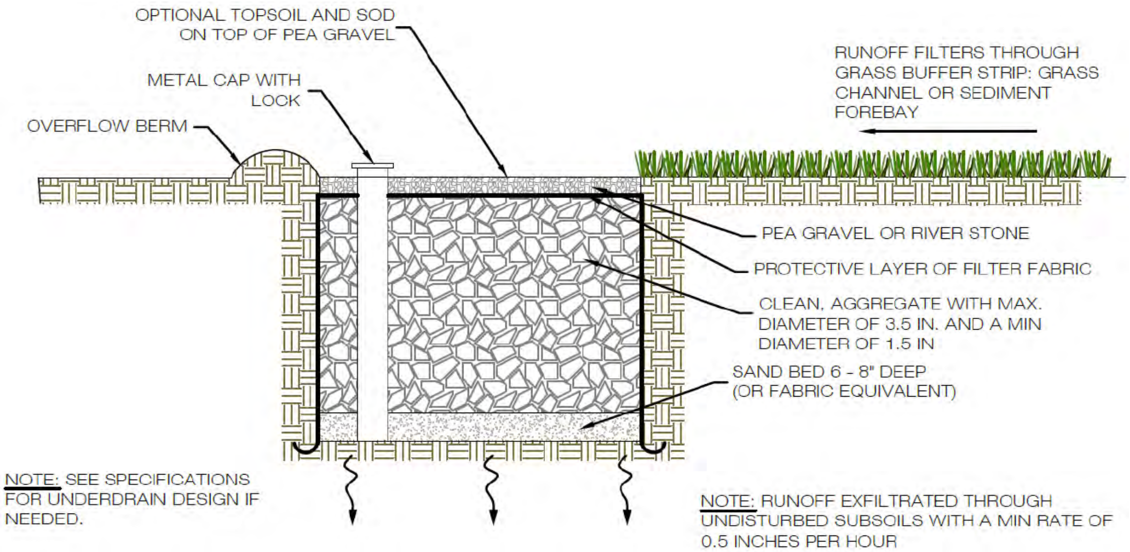


**Figure 6-3: Standard Section for Infiltration Trench (Virginia DEQ 2011b)**

***Reforestation*** consists of the following two types of tree planting, both of which provide ancillary benefits of enhancing wildlife and amenity values. Planting trees reduces runoff through interception and uptake/transpiration of precipitation, while also providing soil stability, heat island reduction and wildlife habitat benefits.

- Riparian Forest Buffers are areas of trees, shrubs, and other vegetation adjacent to a body of water. The riparian area, which is typically at least 35 feet wide on each side of a stream, is managed to maintain the integrity of stream channels, and to reduce the impacts of upland sources of pollution by trapping, filtering, and converting sediment, nutrients, and other chemicals. Planting trees and enhancing existing streamside vegetation with native varieties of trees, shrubs, and wildflowers restores many of the water quality, wildlife, and aesthetic benefits associated with riparian buffers. Vegetation filters sediments and other pollutants from stormwater runoff, moderates water temperatures in streams, and provides shelter and food to both terrestrial and stream organisms. This SCM converts urban or agricultural land to forest land and provides a nitrogen, phosphorus, and sediment reduction benefit proportional to the amount of land converted.

- Upland Tree Planting is planting trees on currently urban or other open pervious areas at a rate that would produce a forest-like condition over time. Benefits include reductions in nutrient and sediment runoff as well as improvements in wildlife habitat and aesthetics.

***Stream restoration*** is used to improve the ecosystem condition in degraded streams by restoring the natural hydrology and landscape of a stream and by enhancing habitat and water quality. Streams damaged by erosive flows, excess sedimentation, and disruptive human activities are often not capable of re-establishing a stable form. Techniques to repair these damaged or degraded streams may be based on mimicking natural stream channels and the range of natural variability exhibited by nearby stable streams. Termed ***natural stream channel design***, such repairs focus on establishing natural stream channel shape, size, and habitat features. Restoration can range from minor repairs to restoring bank stability to complete reconstruction of the stream channel. Stream restoration also provides significant ancillary benefits through habitat enhancement and improved ecosystem services. Credits may vary depending on the type of stream restoration undertaken.

***Micro-SCMs (LID)*** include the use of innovative practices designed to mimic natural flows by reducing the volume of stormwater runoff at the source. Distributed Micro-SCMs features are a series of smaller landscape features that function as retention/detention areas integrated with developed areas. Micro-SCMs include bioretention areas and rain gardens created by excavating a depression and backfilling with engineered media, mulch, and vegetation. These planted shallow basins temporarily pond stormwater runoff, filter it through the bed components and treat it through biological and biochemical reactions within the soil matrix and root zones of the plants. Micro-SCMs are suitable for stormwater runoff control for new development and re-development projects, which strive to mimic "woods in good condition" and are often paired with ponds in order to meet flood control and channel protection objectives. Practices in this category are commonly called ***green stormwater infrastructure***, ***environmental site design practices (ESD)***, or ***low impact development (LID)***. These also include such practices as bioswales or wet swales which both treat and convey stormwater.

The suite of available ESD practices is diverse and many are advocating for a more expansive use of lower-cost vegetation and tree-based practices, especially near outfalls, within existing conveyances, adjacent to parking lots, and as green streets (Cameron et al. 2011). In general, ESD practices most conducive to residential landscapes include rain gardens (typically in front yards), permeable pavement (typically for driveways), rainbarrels or cisterns, turf conversion or sustainable landscaping, dry wells, green roofs, tree canopy, soil decompaction, and pavement removal. ESD opportunities in rights-of-way may include bioretention (in medians, cul-de-sac islands, street bump outs, adjacent open space, as well as behind curbs or sidewalks), permeable pavement (in parking or bike lanes, sidewalks), turf conversion or sustainable landscaping, street trees (including tree pits), and step-pool stormwater conveyances in roadside channels.

The following are general descriptions of common Micro-SCM techniques:

- A rain garden is a shallow depression designed to detain and treat stormwater runoff from small, frequent storms by using a conditioned planting soil bed and planting materials (Chesapeake Network 2013). Pollutants are adsorbed by the soil and plant material, improving water quality. Water slowly infiltrates through the soil bed to recharge groundwater or is used by the plants via transpiration. The term rain garden is typically used for practices without an underdrain. These are often non-engineered, non-permitted SCMs used at a residential scale and not for the purpose of meeting regulatory standards for quantity or quality control.
- Bioretention is a common term for a shallow depression designed to detain and treat storm-water runoff from small, frequent storms by using a conditioned planting soil bed and planting

materials (Figures Figure 6-4 and Figure 6-5). As with rain gardens, pollutants are adsorbed by the soil and plant material, improving water quality. Water slowly infiltrates through the soil bed to recharge groundwater or is used by the plants for transpiration. Unlike rain gardens, bioretention areas typically include an underdrain system to carry treated water draining through the system and, even more importantly, overflows from heavier events, to an existing stormdrain network. In this way, bioretention can be implemented in situations with less infiltration or higher flows than can be accommodated by rain gardens. Bioretention areas are usually only used to treat the water quality event and not for flood control or channel protection.

**Figure 6-4: Photo of Bioretention Draining a Rooftop at a Commercial Facility (Virginia DEQ 2011c)**

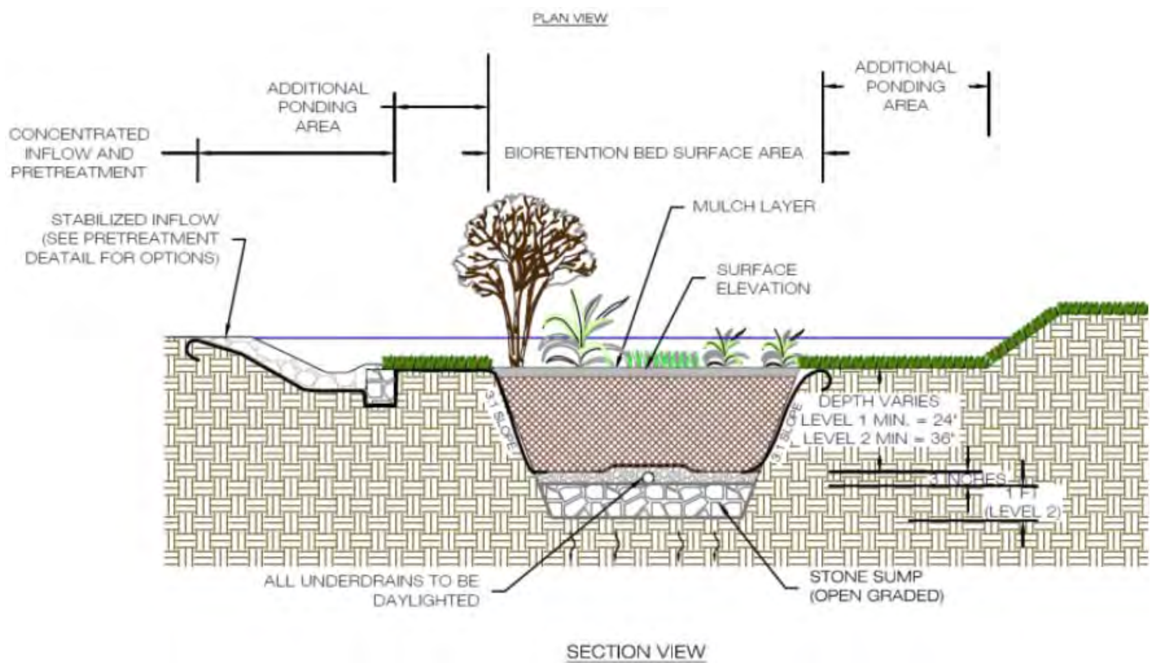


**Figure 6-5: Typical Bioretention Detail with Additional Surface Ponding (Virginia DEQ 2011c)**

- Dry and wet swales (Figures Figure 6-6 and Figure 6-7) allow for treatment and conveyance simultaneously and can be used as effective enhancement for existing ponds, both as pretreatment or post treatment, when site topography allows it or as stand along new retrofits anywhere were stormwater is conveyed on the surface. Wet swales require the interception of shallow groundwater in order to remain wet at all times. Both are excellent water quality retrofits.
- Rain barrels are low-cost, effective, and easily maintainable detention or retention devices that can be used in residential, commercial and industrial sites. They are connected to downspouts to retain or detain rooftop runoff (Figure 6-8). Rain barrels can be used to store runoff for later use in lawn and garden watering or can discharge into dry wells. The Loudoun County Soil and Water Conservation District actively educates local residents about the many benefits of rain barrels during several rain barrel workshops each year (Loudoun SWCD 2018).
- Rainwater harvesting uses larger rainwater storage via cisterns placed either above or below ground (Figure 6-8 and Figure 6-9). The water they capture is suitable for non-potable uses including flushing of toilets and urinals inside buildings (with proper cross-connection prohibition), landscape irrigation, exterior washing (e.g., car washes, building facades, sidewalks, street sweepers, fire trucks, etc.), fire suppression (sprinkler) systems, supply for chilled water cooling towers, replenishing and operation of water features and water fountains, and laundry, if approved by the local authority. Rainwater harvesting via cisterns can be combined with a secondary (down-gradient) runoff reduction practice to enhance runoff volume reduction rates and/or provide treatment of overflow from the rainwater harvesting

system. Runoff reduction volumes are defined by the size of the cistern and contributing drainage area.

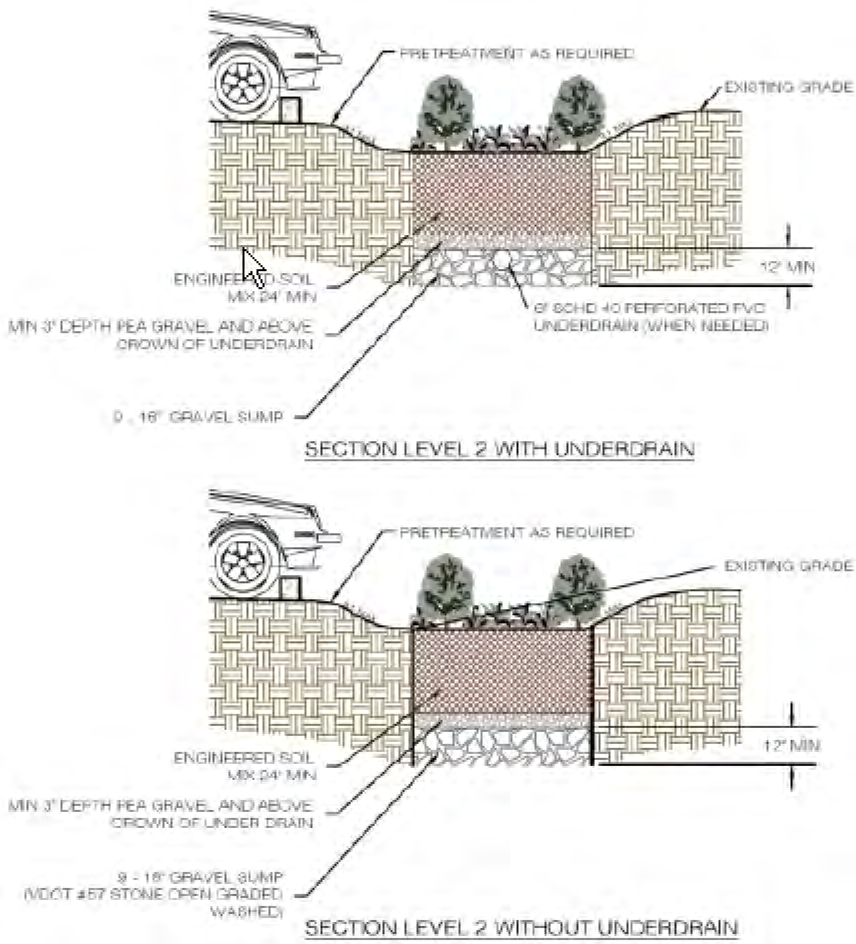


**Figure 6-6: Standard Section for a Dry Swale (Virginia DEQ 2011d)**

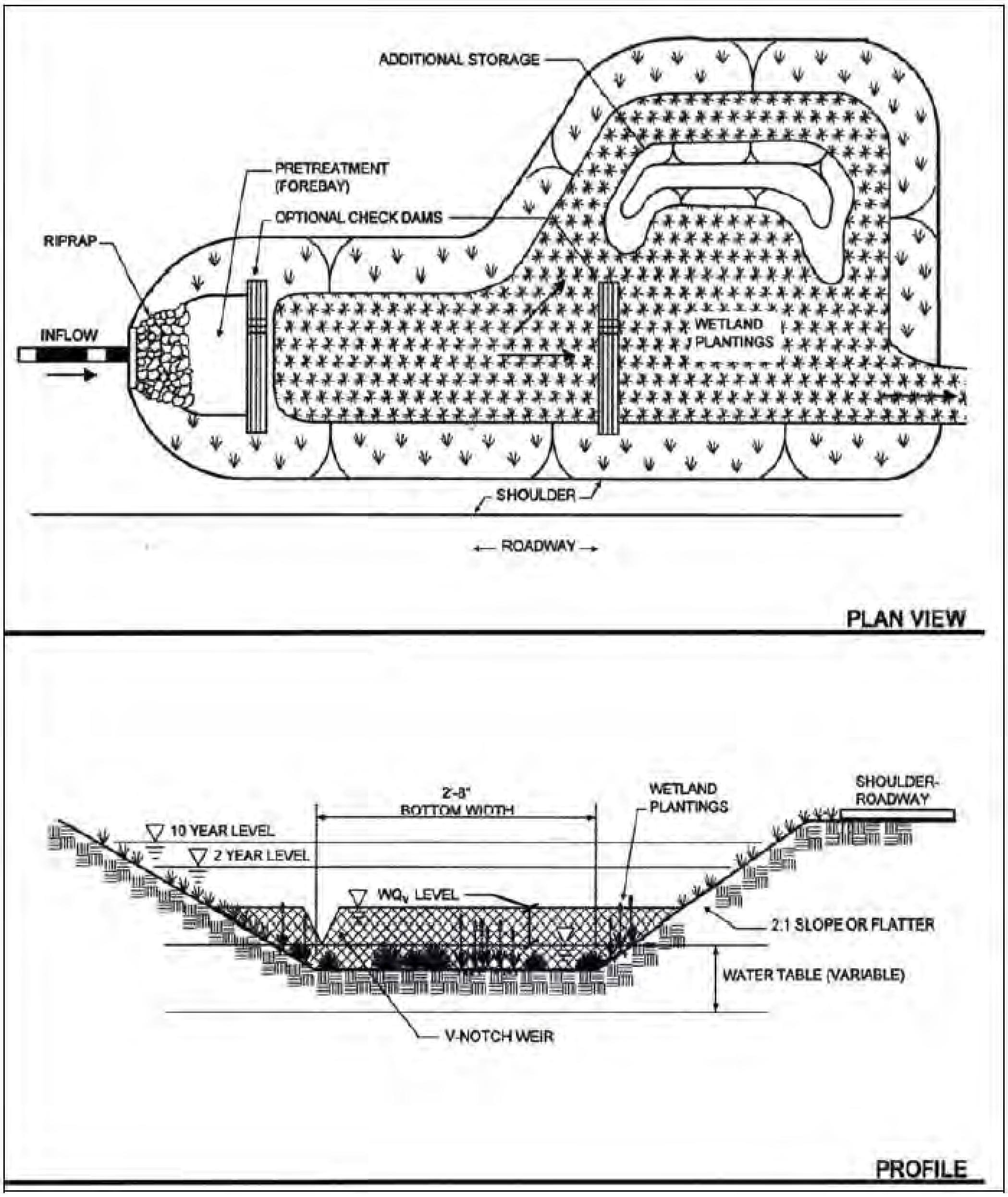


**Figure 6-7: Standard Section and Profile for a Wet Swale (Virginia DEQ 2011e)**

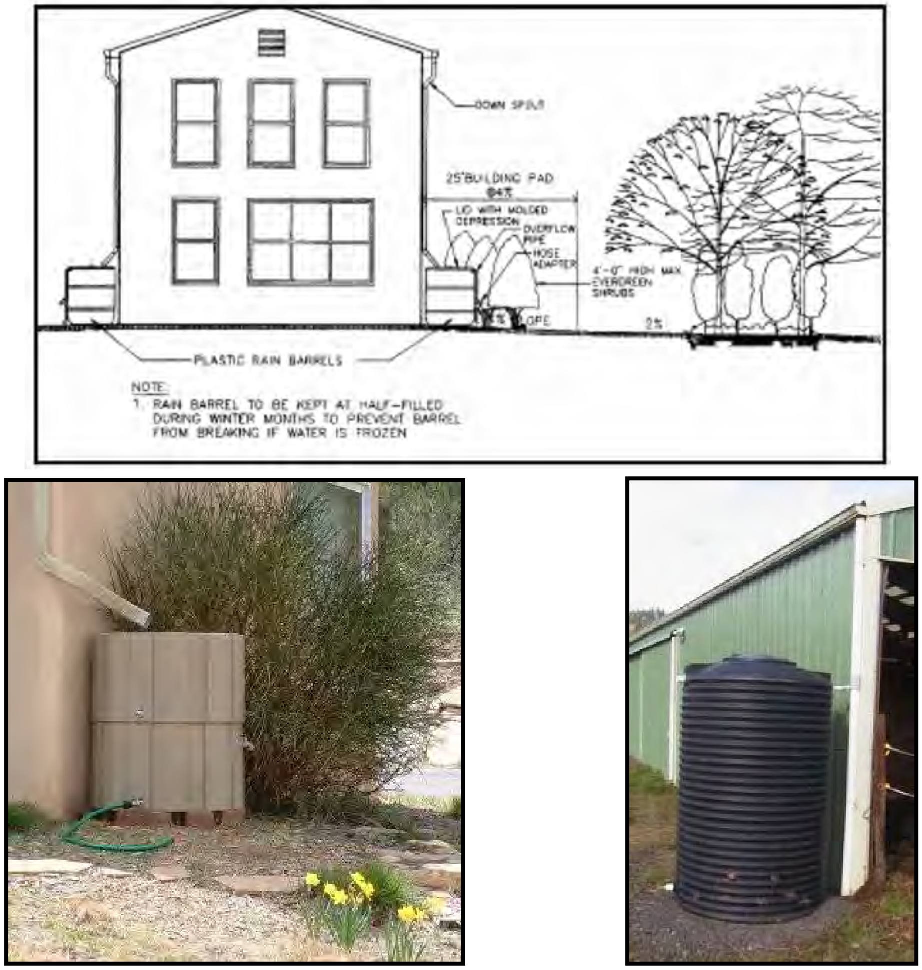


**Figure 6-8: Rain Barrel Standard Section and Photos of Rain Barrel and Above-ground Cistern (Sources: Prince George's County 1999; www.aridsolutions.com; and www.plastmo.com)**

**Figure 6-9: Subterranean Cistern (Virginia DEQ 2011f)**

***Downspout disconnection*** can capture stormwater runoff from rooftops that would otherwise be directed to the local storm drain system. Some downspouts are connected to the storm drain system through underground pipes, while others flow onto driveways and sidewalks, which then flow to street inlets. Downspout disconnection refers to practices that capture or treat rooftop runoff through either (1) simple disconnection that allows runoff to spread across pervious areas, such as a lawn, where it infiltrates into the ground, (2) a rain barrel that captures runoff for later use in watering gardens, or (3) a rain garden that infiltrates the runoff.

***Impervious cover removal*** may be an option in areas where existing parking surfaces or other paved surface are not currently needed. In some cases, large parking surfaces were previously built in commercial and institutional developments for events that occur very infrequently. Potentially, these areas could be converted to turf, thus reducing overall impervious cover and thereby reducing runoff. Pervious concrete or asphalt surfaces are another option that can be employed where appropriate.

Additional stormwater control can be achieved through restoration actions not included in the SCMs above, such as street sweeping and public education/outreach efforts (e.g., pet waste, trash, and recycling campaigns). These types of actions are not included in the pollutant removal analysis currently, because they require site-specific analyses or reductions efficiencies are difficult to estimate.

***Street sweeping*** removes floatable trash, sediment, heavy metals and nutrients associated with sediment particles, petroleum associated with sediment, and organic matter such as leaves and twigs from the curb and gutter system, preventing them from entering storm drains and nearby streams. Loudoun County does not currently plan to sweep streets in Western Hills.

An effective approach to ***trash and litter reduction*** may be multi-faceted, including public outreach (through targeted public service advertisements), clean-ups, and enforcement. Stream and roadside clean-ups can be targeted to groups such as recreation councils, scout troops, businesses, and religious organizations. Enforcement actions, when needed, usually address businesses or apartments with consistent litter problems, overflowing dumpsters, and dumping.

An ***Illicit Discharge Detection and Elimination*** (IDDE) program has been implemented by Loudoun County to find and stop discharges into streams that are harmful to aquatic life and water quality or that cause erosion/sedimentation problems. Program activities are described in the County's Annual Municipal Separate Storm Sewer System (MS4) Stormwater report (www.Loudoun.gov/stormwater). Note however that most of Western Hills Watershed is outside of the MS4 permit area.

Several programmatic practices, such as illicit discharge detection and elimination, pollutant hotspot improvements, and enhanced sediment and erosion control, are being considered for SCM credit by EPA expert panels. In the future, other innovative SCMs such as floating wetlands may be approved for credit.

A full suite of SCM options will be considered for the watershed management plan, but only the major types described above were used in the pollutant reduction analysis presented in Chapter 7 of this report. Site-specific recommendations are detailed in the subwatershed summaries in Chapter 8 and in Chapter 9.

## 6.2 Best Management Practices for Agricultural Areas

There are a large number of agricultural practices that are used by farmers to reduce soil loss, trap nutrients, and minimize the amounts of nutrients and pesticides used on the land. For many of these agricultural Best Management Practices (BMPs), there are clear benefits in reductions of nitrogen, phosphorus, and sediment inputs to local waterways.

A ***soil conservation and water quality plan*** is a comprehensive plan that addresses natural resource management on agricultural lands and describes BMPs which will be used to control erosion and sediment loss and manage runoff. Plans include management practices such as crop rotations and structural practices such as grassed waterways and water troughs. The Soil and Water Conservation District can provide assistance to determine the group of practices needed to address specific runoff concerns on a farm. The practices are designed to control erosion within acceptable levels and to be compatible with management and cropping systems. Also included in a plan are recommendations concerning forestry management, wildlife habitat and plantings, and other natural resource management practices. Agricultural BMPs are also discussed in Section 3.11, where a map of current agricultural BMPs in Western Hills Watershed is presented. The Loudoun

County Soil and Water Conservation District has aided in the development of conservation plans for 2,407 farms throughout the County as of Fiscal Year 2018 (Loudoun SWCD 2018) as shown in Section 6.4 below.

***Streamside forest buffers*** are wooded areas along rivers and streams that help filter nutrients, sediments, and other pollutants from runoff, as well as removing nutrients from groundwater and slowing erosion. Riparian forest buffers also enhance terrestrial and aquatic habitat.

***Streamside grass buffers*** are strips of grass or other non-woody vegetation maintained between the edge of fields and streams, rivers, or tidal waters. These grass strips help filter nutrients, sediment and other pollutants from runoff, as well as removing nutrients from groundwater.

***Tree planting*** on non-riparian agricultural lands can be targeted to lands that are highly erodible or identified as critical resource areas.

***Cover crops*** are small grains such as wheat, barley, or rye that are planted in the fall after the harvest of corn, soybeans, or vegetables to absorb unused nutrients that may remain in the soil. During the winter, nutrients, particularly nitrate, are subject to leaching to groundwater. In addition, the plants and roots of cover crops help anchor the soil to decrease erosion and reduce phosphorus loss, and add organic matter to soil. By timing the springtime cover crop burn or plowdown, the trapped nitrogen can be released and used by the following crop.

***Conservation tillage*** involves planting and growing crops with minimal disturbance of the surface soil. Conservation tillage requires two components: a minimum 30 percent residue coverage at the time of planting and a non-inversion tillage method. No-till farming is a form of conservation tillage in which the crop is seeded directly into vegetative cover or crop residue, with little disturbance of the surface soil. Minimum tillage farming involves some disturbance of the soil, but uses tillage equipment that leaves much of the vegetation cover or crop residue on the surface. The overall benefit is the reduction of surface soil erosion.

***Continuous no-till*** is a crop planting and management practice in which soil disturbance by plows, disk or other tillage equipment is eliminated. This practice involves no-till methods on all crops in a multi-crop, multi-year rotation.

***Stream protection with fencing*** is the installation of fencing along streams to exclude livestock. The fenced areas may be planted with trees or grass but are typically not wide enough to provide the full benefits of buffers. Stream fencing should be implemented so as to substantially limit livestock access to streams; however, it can allow for the use of limited hardened crossing areas, where necessary, to accommodate access to additional pastures or for livestock watering. By preventing or limiting access of livestock to streams, erosion from hooves and bacteria contamination is curtailed.

***Off-stream watering*** provides livestock an alternative drinking water source away from streams. By providing an off-stream watering source, livestock will reduce the time they spend near and in streams and stream banks. This will reduce animal waste deposition and move heavy traffic areas near streams to more upland locations. This practice works in conjunction with the practice of stream protection with fencing.

***Animal waste management*** systems are practices designed for proper handling, storage, and utilization of wastes generated from animal operations. They include a means of collecting, scraping, or washing wastes and contaminated runoff into appropriate waste storage structures.

***Runoff control systems*** on agricultural lands work to control or intercept flow in several ways. Gutters, downspouts, and other water conveyance devices prevent roof runoff from causing severe erosion or mixing with animal waste and transporting pollutants to waterways. Roof runoff systems improve water quality, reduce soil erosion, increase infiltration, and protect buildings and other structures. Diversions may be used to direct runoff flows away from a feedlot or to collect and direct water to a pond. Diversions reduce soil erosion, filter runoff improving water quality, and provide cover for wildlife. Grassed waterways use natural drainage to prevent gullies from forming and control soil erosion. Stormwater runoff flows over the grass rather than tearing soil away and forming a gully. Vegetation may act as a filter, absorbing some of the pesticides and nutrients in runoff water, and provides cover for wildlife.

***Nutrient management plans*** are comprehensive plans that describe the optimum use of nutrient inputs for crop yield to minimize loss of excess nutrients to the environment. A nutrient management plan details the type, rate, timing, and placement of nutrients for each crop. Soil, plant tissue, manure and/or sludge tests are used to assure optimal application rates. Though some of these plans are written to cover a three-year period, many are revised every year so that they incorporate management, fertility, and technology changes.

***Septic pump-out rebates*** are offered through the Loudoun Soil and Water Conservation District. The "Septic Tank Pump-Out Rebate Program" provides a $50 rebate to Loudoun landowners towards the pump-out of their septic system. Over 400 rebates were issued in FY 2018. The landowner must have an approved application form from the District, and the pump-out must be reported to Loudoun County Health Department by an approved hauler before the rebate can be issued. Septic pump-outs prior to September 21, 2017 are not eligible. (http://www.loudounsoilandwater.com/2017/09/septic-tank-rebates-available/)

## 6.3 Homeowner, Business, and Volunteer Watershed Stewardship Opportunities

Residents and businesses sometimes engage in activities that can negatively influence water quality, including over-fertilizing lawns, using excessive amounts of pesticides, poor house-keeping practices (such as inappropriate disposal of paints, household cleaners, or automotive fluids), and dumping into storm drains. Alternatively, positive behaviors such as tree planting, disconnecting downspouts, and picking up pet waste can help improve water quality. Targeted education can be used to deliver messages that promote changes in behavior. A recent survey of more than 800 people in the Baltimore metropolitan area regarding people's knowledge about stormwater concluded that even those who want to reduce the negative impacts of stormwater runoff do not often realize their role in controlling stormwater runoff and pollution (Opinion Works 2008). Local business associations, homeowner associations, schools, and other civic groups, such as the Master Gardeners, are in a position to effect positive changes using pollution prevention education and outreach to teach residents and business owners how to properly care for the watershed.

***Pet waste stations*** – Pet waste is one of the contributors of bacteria to streams and can cause human health concerns. A pet waste station is a sign reminding pet owners of the importance of proper disposal of pet waste and it usually includes a supply of bags for pet waste cleanup. Often it is located next to an existing trashcan or it includes one. Pet waste stations can help neighborhoods to reduce bacteria flowing into their local streams and help to keep their neighborhood park or school site clean. Residents can participate by monitoring the supply of bags to make sure they are continually available.

***Fertilizer reduction*** – A well-manicured and responsibly maintained lawn is often viewed as an amenity. Often, however, over-fertilization and irresponsible pest management can result in pollutant-charged runoff to local streams. Proper lawn and turf care practices can reduce excess nitrogen, phosphorus, insecticides, and herbicides from getting into local streams. Education on soil testing, fertilizer application, and pesticide use is intended to reduce the amount of these materials applied to the land. Eco-friendly lawn care may also include the use of mulching lawn mowers that reduce the need for fertilizer and decrease the amount of material handled by the yard material collection program.

***Trash and recycling***

- *Compost bins* – By composting leaves and weeds in backyard bins, the amount of material handled by the municipal yard material collection is reduced. Use of compost is an environmentally friendly way of improving soil and avoids the application of manufactured chemical fertilizer.

- *Stream clean-ups* – Local groups can provide assistance in planning and advertising local stream clean-up projects that involve neighborhoods, businesses, schools, or other groups. These are often an excellent way to promote watershed stewardship and encourage participation in other watershed improvement opportunities.

***Volunteer projects at community facilities*** present good opportunities for educating the public about water quality issues and opportunities for improving the health of the watershed. This can be accomplished by implementing micro-SCMs such as rain gardens and bioretention areas at these sites. In addition to environmental education, these projects have water quality and aesthetic benefits for property users. Tree plantings present great opportunities for community involvement and education, as do water quality sampling and monitoring of stormwater management.

***Training workshops*** can be held to educate watershed residents about downspout disconnection, micro-SCMs, and other practices that can be installed on individual properties.

***Conservation landscaping*** – Numerous water quality benefits are achieved from converting turf into landscaping and through increasing the area of urban tree canopy. Conservation landscaping (also known as BayScaping) uses native plants to provide habitat for local and migratory animals, improve water quality, and reduce the need for chemical pesticides and herbicides. Native plants, such as trees, shrubs and perennials, are able to make better use of rain water than typical lawn grasses, and so require less watering once established. They are also better at trapping and removing nitrogen and pollutants from rain water so that it is not released into nearby waterbodies. A BayScape is also valuable for the gardener or landowner because it offers greater visual interest than lawn; reduces the time and expense of mowing, watering, fertilizing, and treating lawn and garden areas; and can address areas with problems such as erosion, poor soils, steep slopes, or poor drainage. The removal of exotic, invasive plant species also benefits native plant and animal communities.

***Tree planting*** – Planting trees in residential yards and commercial open space can increase the tree canopy, increase evapotranspiration and interception, slow runoff, and allow greater infiltration of stormwater into the ground due to tree roots reducing soil compaction. Trees also reduce erosion by holding soil and by reducing the impact of rain to bare ground. Tree-planting programs also provide an opportunity to involve volunteers from neighborhoods, businesses, and schools to help plant trees throughout the watershed while also educating the community about the importance of trees for air and water quality.

***Conservation Newsletter*** - Conservation Education Newsletter is periodically published and posted at the website of the Loudoun County Soil and Water Conservation District. (www.LoudounSoilandWater.org)

***Stream watch volunteers*** – A stream watch program such as Loudoun Watershed Watch (www.loudounwatershedwatch.org) is intended to develop citizen stewardship through participation of volunteers who actively assume the responsibility of caring for segments of the stream network by observing changes in the system, providing stream clean-ups, and participating in planting activities. Trained volunteers can also help to identify potential restoration projects or report on potential illicit discharges. Stream sites in Western Hills Watershed are monitored by volunteers with Loudoun Wildlife Conservancy (www.loudounwildlife.org) with 18 sites in Loudoun and Goose Creek Association (https://goosecreek.org/) with 16 sites in the County, three of which are in the Western Hills Watershed.

## 6.4 Land Preservation

Land preservation complements the implementation of SCMs by insuring that land use is stabilized over time. Unlike park land, land preservation maintains certain restrictions on the land's use in perpetuity. The restrictions, in the form of conservation easements, can range from limits on development to specific resource protection, such as forest, stream buffer, or prime farmland protection.

These preservation areas may be large, multi-parcel blocks or small, individual parcels. Land preservation complements other long-term, multifaceted efforts to protect natural resources, water supplies, and local economies. The limitations on the property may vary depending on the principle of the easement program and as specifically limited by the easement.

For purposes of watershed management, an understanding of existing protected lands can provide a starting point in prioritizing potential protection and restoration activities. In many cases, protected lands may provide a better opportunity for restoration projects simply because the risk of the land being converted to development is removed, thus the investment involved in the implementation of the practice is secure.

Approximately 10,800 acres of land within the Western Hills watershed is protected by conservation easements. Loudoun County's Conservation Easement Stewardship Program (https://www.loudoun.gov/2816/Conservation-Easements-in-Loudoun-County) works with owners of properties that contain conservation easements to ensure that the terms of the easements continue to be met. Figure 6-10 shows the locations of conservation easements that exist within the Western Hills watershed. Table 6-1 shows the extent of conservation easements and other conservation practices.

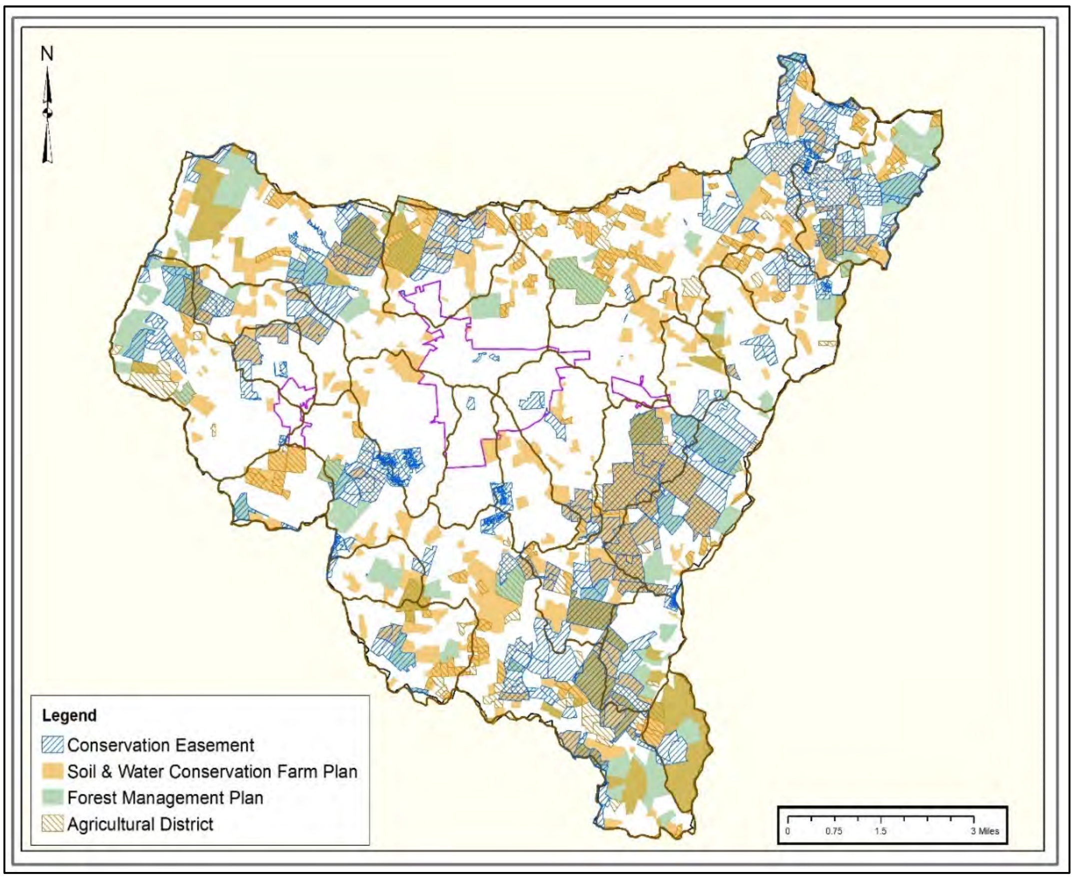


**Figure 6-10: Western Hills Watershed Conservation Easements**

**Table 6-1: Western Hills Watershed Conservation Acreage**

| Category | Acres | Percent |
|---|---|---|
| **Conservation Easements** | 10,799 | 21.8 |
| **Forest Management Plans** | 7,482 | 15.1 |
| **Soil & Water Conservation Farm Plans** | 13,008 | 26.2 |
| **Agricultural District** | 6,798 | 13.7 |
| **Total Watershed Area** | 49,558 | |

## 6.5 Public Parks

Lands in the Western Hills Watershed area include public parks owned by the Towns, Loudoun County, and the National Park Service along the Appalachian Trail.

**Woodgrove Park** consists of 30 acres for active use. Round Hill Indoor Aquatic Center is located in the park and is operated by the County https://www.loudoun.gov/Facilities/Facility/Details/Woodgrove-Park-42.

**Franklin Park** is a regional park in western Loudoun County. The 203-acre site is operated by the County https://www.loudoun.gov/1397/Franklin-Park.

The Purcellville Parks and Recreation Advisory Board provides oversight to **the Chapman Demary Trail and Nature Park** https://www.purcellvilleva.gov/171/Parks-Recreation-Advisory-Board.

The **Hamilton Community Park** consists of almost 5 acres located at 31 West Colonial Highway in Hamilton http://www.town.hamilton.va.us/general-information/hamilton-community-park.

The **National Park Service** include a 28-acre portion along the Appalachian Trail on the western border of the watershed. https://www.nps.gov/appa/learn/management/upload/AT-report-web.pdf.

A map of public parks is presented in Figure 6-11.

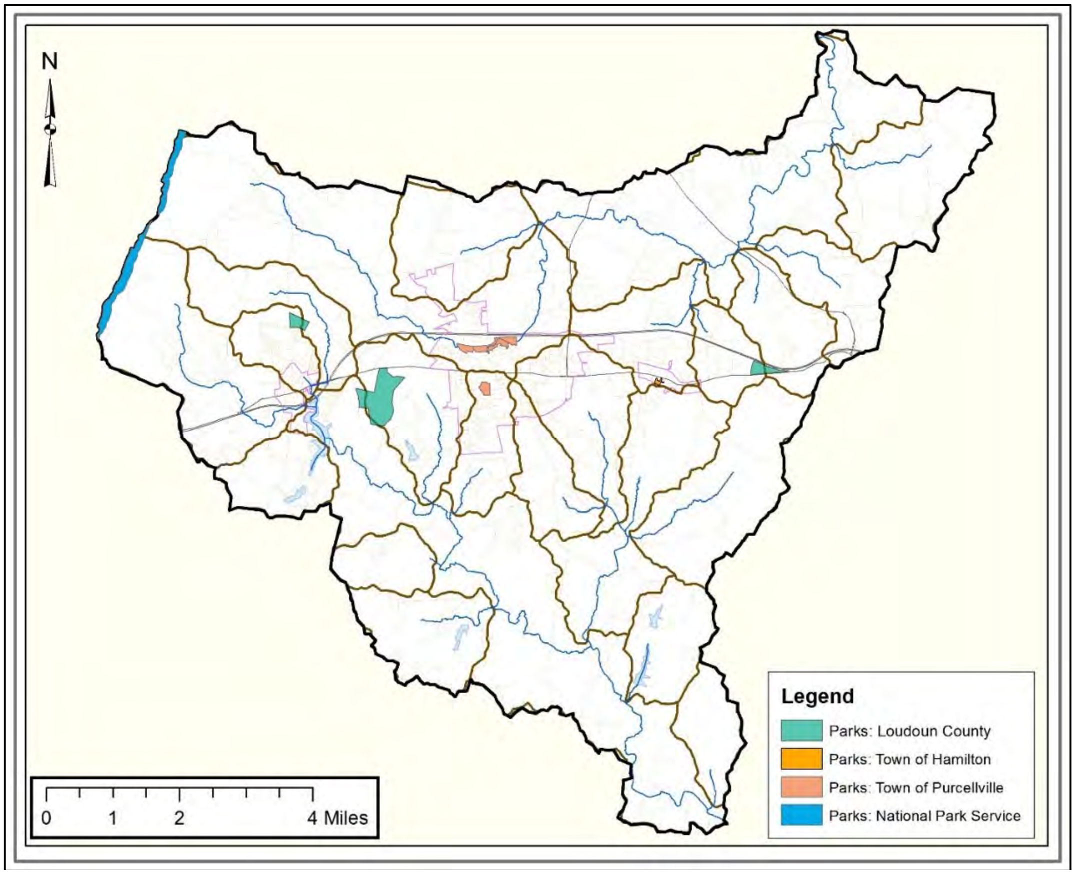


**Figure 6-11: Western Hills Watershed Public Parks**

# CHAPTER 7: MODELING CURRENT AND FUTURE CONDITIONS

## 7.1 Introduction

This chapter presents the results of analyses conducted to estimate current and future nutrient and sediment loads from the Western Hills Watershed in Loudoun County. Land use loading, septic loading, and stream bed and bank loading calculations were made for 2017 (current conditions) and 2025 (future conditions) based on the land uses and use changes as well as the BMPs currently implemented and those projected to be implemented in the future. This chapter also addresses the loading difference in 2025 if further progress is not made beyond the current level of BMP implementation and provides a general discussion of the pollutant loading implications of further land use change beyond 2025.

## 7.2 Watershed Segmentation

The Western Hills Watershed is in the central western portion of Loudoun County, and includes the towns of Purcellville, Round Hill and Hamilton. The Western Hills Watershed comprises the North Fork Goose Creek watershed and the South Fork Catoctin Creek subwatershed, see

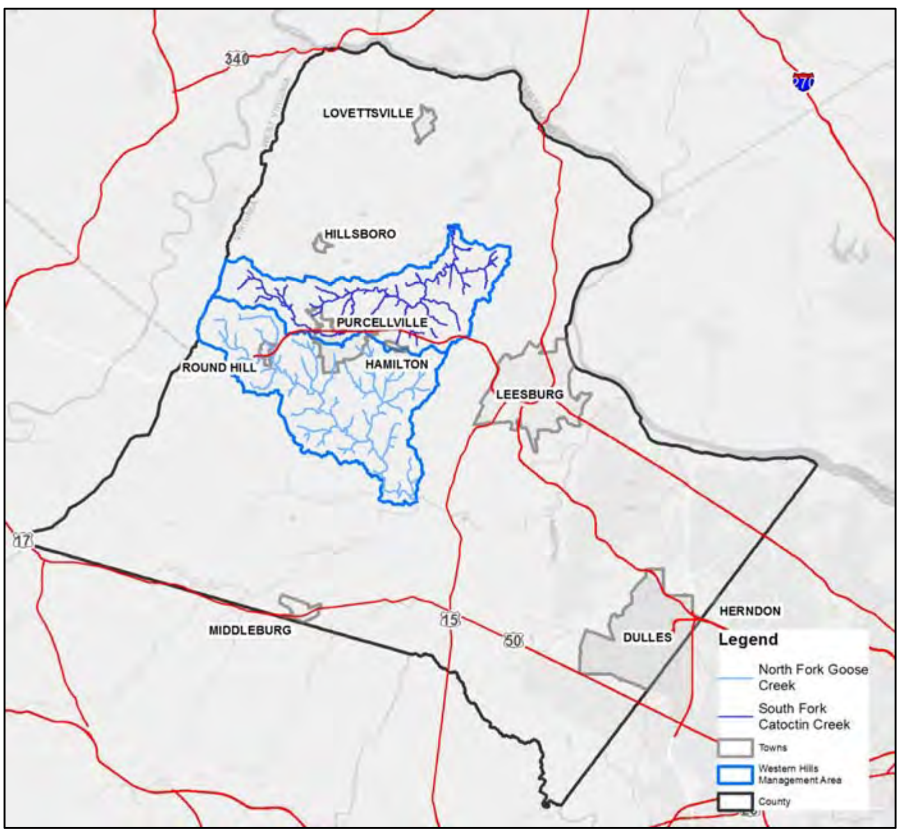


Figure 7-1. The entire North Fork Goose Creek is within the Western Hills Watershed and is defined by the USGS 12-digit hydrologic unit code (HUC) 020700080602; however, the South Fork Catoctin Creek subwatershed, while entirely within the Western Hills Watershed, is only a

portion of the USGS 12-digit HUC 020700080301, known as South Fork Catoctin Creek; see Figure 7-2.

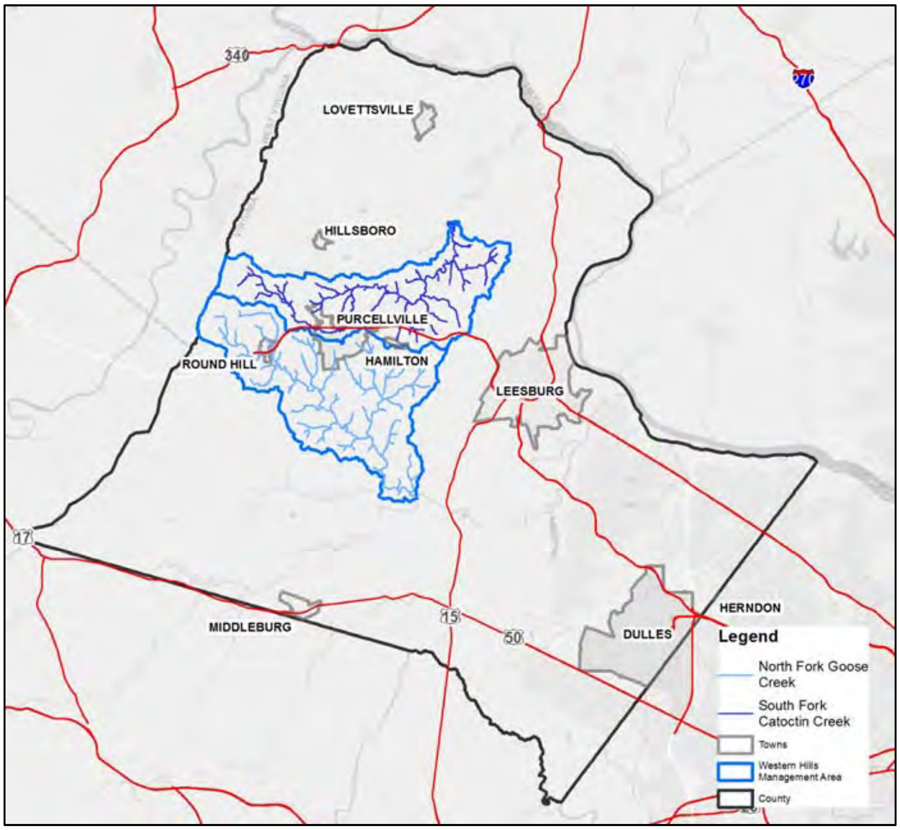


**Figure 7-1: Western Hills Watershed setting within Loudoun County, Virginia...**

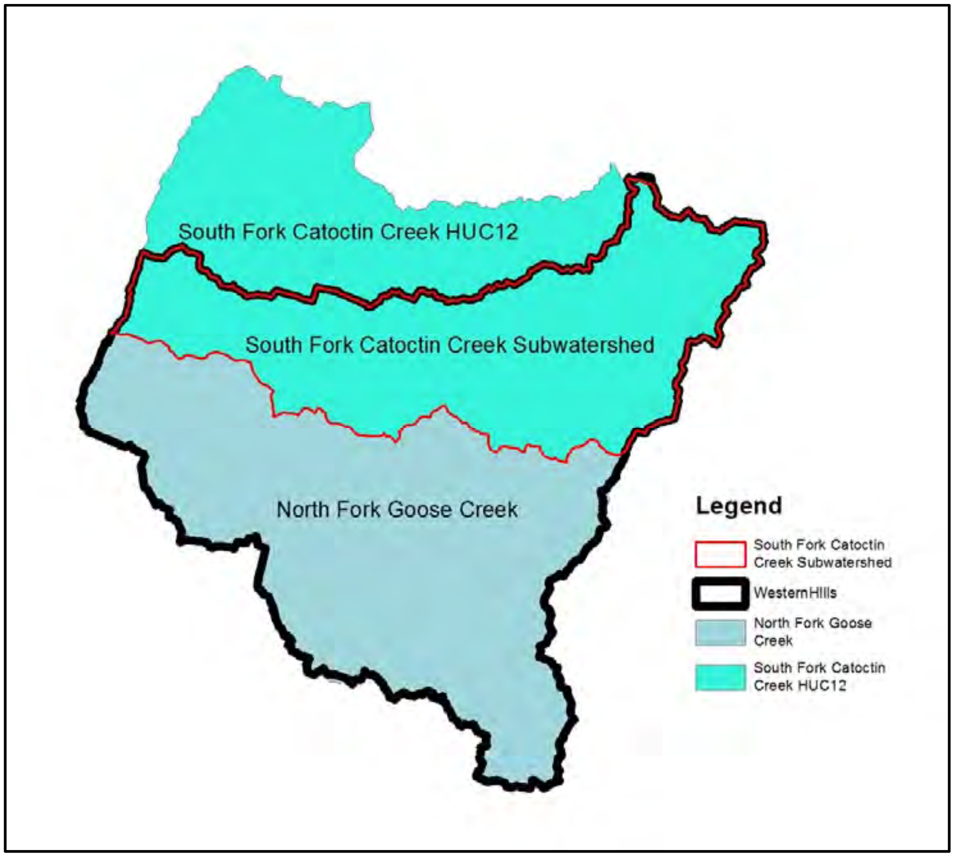


**Figure 7-2: Western Hills Watershed – North Fork Goose Creek and South Fork Catoctin Creek subwatershed, which is a portion of the South Fork Catoctin Creek HUC12**

## 7.3 Land Use

The Chesapeake Bay Total Maximum Daily Load (TMDL) is a "pollution diet" established in 2010 by the Environmental Protection Agency (EPA) that is intended to limit the amount of phosphorus, nitrogen, and sediment entering the Bay. Development of Virginia's 2012 Phase II Watershed Implementation Plan (WIP) for the Chesapeake Bay TMDL included engagement with local governments to develop strategies to help meet statewide pollutant reduction targets. As described in Loudoun County (2019d), in 2012, Loudoun County undertook a process involving community outreach to develop its Phase II WIP work plan. Note that Virginia's Phase II WIP was still in effect at the time of this Western Hills report. Virginia's Phase III WIP is scheduled to be issued in mid-2019.

To determine the nutrient and sediment loading from the Western Hills Watershed, the Chesapeake Assessment and Scenario Tool (CAST) loading rates and land uses for North Fork Goose Creek and South Fork Catoctin Creek (HUCs 020700080602 and 020700080301, respectively) were downloaded. The analysis used the most recent version of CAST (CAST-2017d, Software release 5.5.1 https://cast.chesapeakebay.net/).

CAST is the Chesapeake Bay Program's web-based watershed model. It is used to estimate nutrient (nitrogen and phosphorus) and sediment loading to the Chesapeake Bay from agricultural, developed and natural land uses, as well as septic systems and point source loads from wastewater treatment plants. CAST can also represent Best Management Practices (BMPs) that are applied to the land to reduce nutrient and sediment loads, and it provides cost estimates for each BMP. The Chesapeake Bay Program developed CAST to assist Chesapeake Bay watershed jurisdictions with their watershed implementation plan (WIP) development process. In addition to representing annual implementation progress, as submitted by each state, CAST can be used to run various "what-if" planning scenarios that can be used to compare different strategies for improving future water quality conditions in the watershed. CAST was selected for this watershed management planning analysis because it is publicly available and provides the most consistent results with the expectations for nutrient and sediment load reductions from the Chesapeake Bay Program to meet the Chesapeake Bay TMDL. It also provides a consistent platform to develop comparative scenarios to improve future water quality based on a variety of implementation strategies.

USGS 12-digit HUCs (also known as HUC12s) are the smallest individual units within CAST used to represent an area. CAST also has 10 Land-River Segments that cover Loudoun County. The Western Hills Watershed is part of the CAST Land-River Segments N51107PM3_4670_4660 (Goose Creek) and N51107PM1_4430_4200 (labelled Catoctin Creek South Fork; includes the County's North and South Fork Catoctin Creek and lower mainstem Catoctin Creek watersheds). However, these land units are larger than the USGS 12-digit HUCs, so they were not used in this analysis.

Because the entire North Fork Goose Creek watershed is within the Western Hills Watershed, the CAST land use and loading information can be used directly, without further processing. However, the South Fork Catoctin Creek HUC12 is composed of areas both within and outside of the Western Hills Watershed (Figure 7-2). Only the South Fork Catoctin Creek subwatershed is included in the Western Hills. To identify the land use for just the South Fork Catoctin Creek subwatershed, additional information is needed.

The simplest method would be to calculate the proportion of the South Fork Catoctin Creek subwatershed within the South Fork Catoctin Creek HUC12 and then apply this same proportion to each land use in the CAST output for the entire HUC12. However, this method assumes a uniform land use distribution across the watershed.

To attempt to capture land use patterns that may be present across the South Fork Catoctin Creek subwatershed, the USGS 2013 Chesapeake Bay high-resolution 1-m land use raster dataset for South Fork Catoctin Creek HUC12 was used, as shown in Figure 7-3. This dataset is the basis for the CAST land uses; however significant post-processing is done to expand the 17 land uses in the USGS dataset to the 60+ land uses in CAST. The CAST land use data are not available in a spatial format; the post-processing functions yield only tabular land use data. The source of the high-resolution land use data provided by CAST is the same source as the Bay Program land use and land cover data reported in Section 3.2.1 of this report.

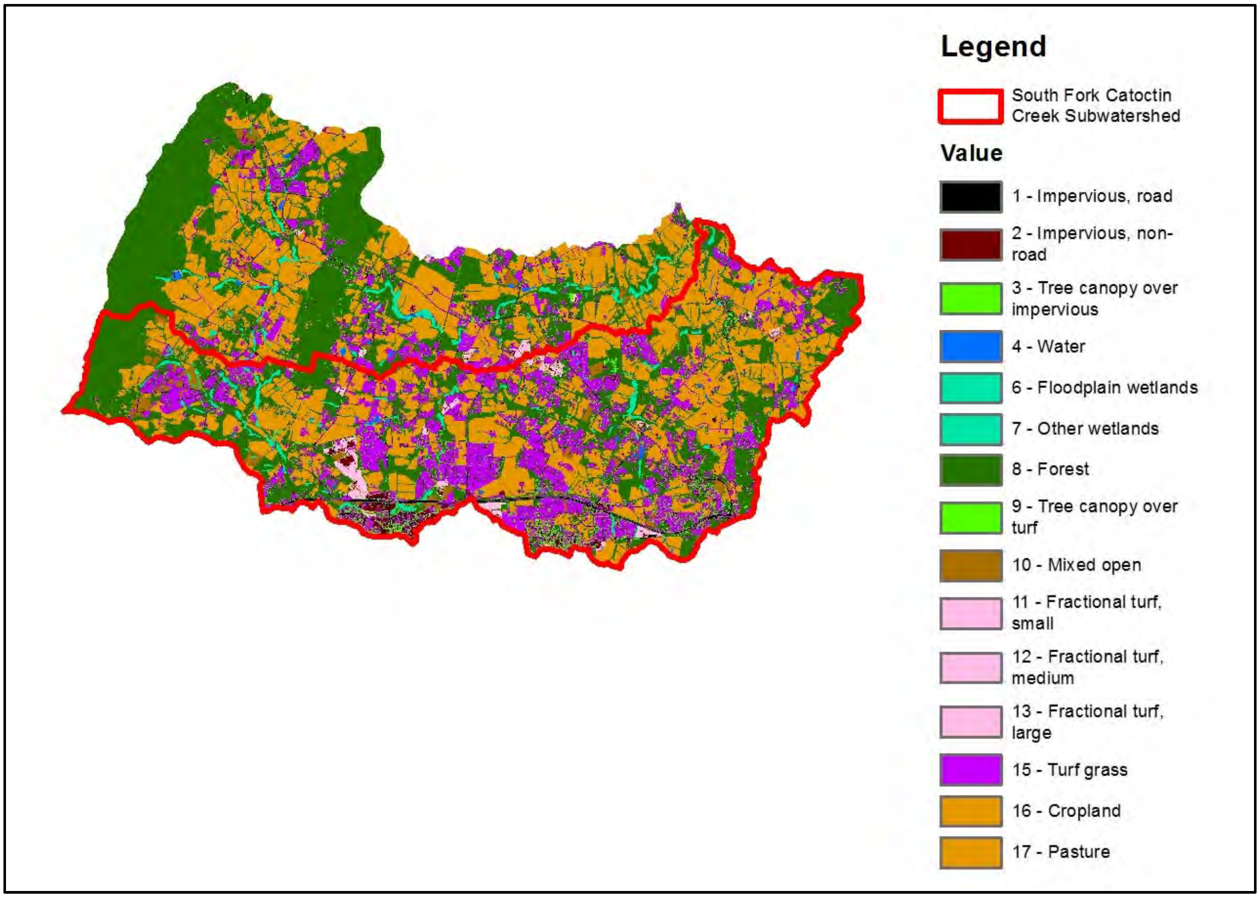


**Figure 7-3: USGS land use in South Fork Catoctin Creek HUC12**

To explore the possibility of applying the land use proportions from the USGS dataset to the CAST land uses, a crosswalk was created between the land uses from USGS and CAST and then aggregated the acreage to compare how the two datasets break out land use. The land use crosswalk is included in Appendix A. The USGS data were derived from 2013 land use information, so the USGS land uses were compared to the 2013 CAST Progress Run Scenario to see if there was reasonable agreement. The 2017 CAST Progress Run was also reviewed to evaluate whether land uses for 2013 and 2017 were substantially different. The 2017 land uses in CAST are based on the Chesapeake Bay Land Change Model v3a. While Table 7-1 shows that there are some land uses with individual acreage discrepancies between USGS and CAST, the overall proportion of each land use within the watershed stays relatively consistent between USGS and CAST. Notably, the difference from USGS for turf grass and pasture are nearly the same total acres. It is possible that one of the data sets is representing significant acres of turf as pasture or vice versa.

The results of this comparison are shown in Table 7-1 below.

**Table 7-1: Comparison of USGS Land Use and CAST Land Use for South Fork Catoctin Creek HUC12**

| USGS Land Use | USGS Acres | Percent of Total LU | CAST 2013 Acres | Difference from USGS (Acres) | Difference from USGS (%) | Percent of Total LU | CAST 2017 Acres | Difference from USGS (Acres) | Difference from USGS (%) | Percent of Total LU |
|---|---|---|---|---|---|---|---|---|---|---|
| **1 - Impervious, road** | 596.9 | 2% | 596.9 | 0.0 | 0% | 2% | 519.6 | -77.4 | -13% | 1% |
| **2 - Impervious, non road** | 915.3 | 3% | 888.4 | -26.9 | -3% | 2% | 834.6 | -80.7 | -9% | 2% |
| **3 - Tree Canopy over Impervious** | 325.0 | 1% | 307.9 | -17.0 | -5% | 1% | 332.8 | 7.9 | 2% | 1% |
| **4 - Water** | 141.6 | 0% | 358.6 | 217.0 | 153% | 1% | 358.6 | 217.0 | 153% | 1% |
| **6 - Floodplain Wetlands** | 662.2 | 2% | 537.6 | -124.5 | -19% | 1% | 536.9 | -125.3 | -19% | 1% |
| **7 - Other Wetlands** | 63.4 | 0% | 58.6 | -4.7 | -7% | 0% | 58.5 | -4.8 | -8% | 0% |
| **8 - Forest** | 13,064.1 | 36% | 13,320.4 | 256.3 | 2% | 37% | 13,298.1 | 234.0 | 2% | 37% |
| **9 - Tree Canopy over Turf** | 1,028.4 | 3% | 914.1 | -114.2 | -11% | 3% | 955.9 | -72.5 | -7% | 3% |
| **10 - Mixed Open** | 1,553.7 | 4% | 1,368.0 | -185.7 | -13% | 4% | 1,335.3 | -218.3 | -15% | 4% |
| **15 – Turf Grass** | 5,710.4 | 16% | 4,670.0 | -1,040.4 | -19% | 13% | 5,070.3 | -640.2 | -12% | 14% |
| **16 – Cropland** | 2,585.7 | 7% | 2,528.2 | -57.5 | -2% | 7% | 2,349.8 | -235.8 | -9% | 7% |
| **17 - Pasture** | 9,395.0 | 26% | 10,493.0 | 1,097.9 | 12% | 29% | 10,391.4 | 996.4 | 11% | 29% |
| **Total*** | 36,041.7 | | 36,041.7 | | | | 36,041.8 | | | |

*Total acreage is slightly different due to rounding.

Because the overall proportion of each land use within the USGS and CAST data for South Fork Catoctin Creek HUC12 is consistent, the land use proportions for the Western Hills area were calculated using the USGS data. Because these data are spatial, this analysis was able to capture the land uses specifically within the Western Hills area (South Fork Catoctin Creek subwatershed) and apply these land use proportions to the 2017 CAST Progress Run land uses to obtain an estimate of the acres of each land use in the South Fork Catoctin Creek subwatershed.

Some modifications were made to account for known differences in the land uses and post-processing from USGS to CAST. USGS contains land uses called *fractional turf*, which consist of fixed proportions of mixed open, turf grass and agricultural land uses. The proportional acres of fractional turf were reassigned to the mixed open, turf grass and agricultural land uses as appropriate and were included when calculating the proportion of each land use in the Western Hills area. In addition, the cropland and pasture were aggregated and considered one agricultural land use to be consistent with the Chesapeake Bay Program approach, which aggregates these two land uses from USGS and then apportions the land according to the USDA's Agricultural Census.

**Table 7-2: USGS Land Use Proportions for South Fork Catoctin Creek subwatershed and entire South Fork Catoctin Creek HUC12.**

| Land Use | South Fork Catoctin Creek HUC12 | South Fork Catoctin Creek Subwatershed | |
|---|---|---|---|
| | Acres | Acres | Proportion |
| **1 - Impervious, road** | 596.9 | 468.1 | 78.4% |
| **2 - Impervious, non-road** | 915.3 | 705.1 | 77.0% |
| **3 - Tree Canopy over Impervious** | 325.0 | 228.9 | 70.4% |
| **4 - Water** | 141.6 | 70.3 | 49.6% |
| **6 - Floodplain Wetlands** | 662.2 | 337.7 | 51.0% |
| **7 - Other Wetlands** | 63.4 | 41.4 | 65.4% |
| **8 - Forest** | 13,064.1 | 6,310.8 | 48.3% |
| **9 - Tree Canopy over Turf** | 1,028.4 | 809.6 | 78.7% |
| **10 - Mixed Open** | 1,424.8 | 1,012.1 | 72.0% |
| **11 – fractional turf (small)** | 417.8 | 345.7 | N/A |
| **12 – fractional turf (med)** | 5.1 | 5.1 | N/A |
| **13 – fractional turf (large)** | 1.5 | 0 | N/A |
| **15 – Turf Grass** | 5,414.9 | 4,113.1 | 76.3% |
| **16 – Cropland** | 2,585.7 | 1,465.3 | 55.2% |
| **17 - Pasture** | 9,395.0 | 5,151.5 | |
| **Total** | 36,041.7 | 21,064.5 | 58.4% |

Note: Turf is a developed land use and refers to herbaceous and barren land area within rights-of-way, residential, commercial, recreational, and other land uses, such as cemeteries, golf courses, hospitals, amusement parks, that are likely to be turf grass dominated. Pasture is an agricultural land use that includes herbaceous and barren lands not classified as turf; it also includes areas mapped as hay.

As shown in Table 7-2, the South Fork Catoctin Creek subwatershed portion is 58 percent of the South Fork Catoctin Creek HUC12. Some land uses are disproportionately located in the South Fork Catoctin Creek subwatershed area; most notably, the land uses associated with urbanization (impervious, turf and mixed open areas) are more prevalent while forests are less prevalent in the South Fork Catoctin Creek subwatershed.

Applying the proportions in Table 7-2 to the land uses in CAST yields the land use acres in the Western Hills portion of the watershed as shown in Table 7-3. Land uses are grouped into agricultural, developed and natural areas. A portion of Loudoun County is regulated by a Virginia Department of Environmental Quality municipal separate storm sewer system (MS4) permit. MS4 regulated developed land is not explicitly broken out from other developed land because the MS4 areas in CAST underrepresent the actual MS4 acreage in the Western Hills Watershed. This creates a more conservative scenario because non-regulated lands are typically not subject to as stringent stormwater management requirements. Since more stringent requirements are place on regulated areas, the loading calculations in the scenarios below are over-representing the loading in the actual MS4 areas. MS4 boundaries are likely to change following the 2020 Census, and the representation of MS4 areas can be reevaluated at that time.

Federal land is presented in aggregate in Table 7-3 and represents the Appalachian Trail, owned by the National Park Service. This area is a swath of land a few hundred feet wide, about 3.4 miles long, running along the ridgeline at the western boundary of the county.

**Table 7-3: CAST land use acres for the entire South Fork Catoctin Creek HUC12 and the Western Hills portion (South Fork Catoctin Creek subwatershed).**

| CAST Land Use | South Fork Catoctin Creek HUC12 - Total Area | South Fork Catoctin Creek Subwatershed – Area |
|---|---|---|
| | Acres | Acres |
| **Agriculture** | **12,741.3** | **7,120.0** |
| Ag Open Space | 442.8 | 247.4 |
| Double Cropped Land | 11.3 | 6.3 |
| Full Season Soybeans | 912.0 | 509.6 |
| Grain with Manure | 41.2 | 23.0 |
| Grain without Manure | 47.9 | 26.8 |
| Legume Hay | 142.0 | 79.4 |
| Non-Permitted Feeding Space | 20.3 | 11.5 |
| Other Agronomic Crops | 778.7 | 435.2 |
| Other Hay | 3,467.4 | 1,937.6 |
| Pasture | 6,339.2 | 3,542.4 |
| Small Grains and Grains | 51.1 | 28.6 |
| Specialty Crop High | 89.2 | 49.8 |

**Table 7-3: CAST land use acres for the entire South Fork Catoctin Creek HUC12 and the Western Hills portion (South Fork Catoctin Creek subwatershed).**

| CAST Land Use | South Fork Catoctin Creek HUC12 - Total Area | South Fork Catoctin Creek Subwatershed – Area |
|---|---|---|
| | Acres | Acres |
| Specialty Crop Low | 398.1 | 222.5 |
| **Developed** | **7,713.1** | **5,976.2** |
| Buildings and Other (Impervious) | 834.0 | 650.0 |
| Roads (Impervious) | 519.0 | 411.8 |
| Tree Canopy over Impervious (Impervious) | 332.8 | 237.2 |
| Tree Canopy over Turf Grass (Pervious | 955.8 | 761.3 |
| Turf Grass (Pervious) | 5,070.3 | 3,914.9 |
| Regulated Construction (Impervious and Pervious) | 1.2 | 0.9 |
| **Natural Areas** | **15,453.9** | **7,902.5** |
| Harvested Forest | 44.4 | 21.7 |
| Headwater or Isolated Wetland | 58.5 | 38.7 |
| Mixed Open | 1,333.2 | 971.0 |
| Non-tidal Floodplain Wetland | 536.9 | 277.0 |
| True Forest | 13,122.3 | 6,413.9 |
| Water | 358.6 | 180.1 |
| **Federal Lands** | **133.6** | **65.8** |
| Total | **36,058.2** | **21,064.5** |

## 7.4 Current Loading

### 7.4.1 Land Use Loading

Land use loading is the amount of a pollutant (e.g., nutrients), that is contributed by a given land use. The loading rate is the amount of pollutant in mass per area per time, for example pounds per acre per day. The land use load is the total amount of pollutant from a specific land use in mass per time, for example pounds per year. CAST provides annual loads and loading rates for Total Nitrogen (TN), Total Phosphorus (TP), and sediment.

The current loadings for TN, TP and sediment are based on CAST assumptions for each land use type and have not been verified by actual field monitoring and measurements. More information about the non-tidal monitoring in the Chesapeake Bay Watershed is presented by the US Geological Survey (https://cbrim.er.usgs.gov/index.html).

Although the land uses for the Western Hills area of the South Fork Catoctin Creek HUC12 must be broken out, the loading rates provided in CAST for the North Fork Goose Creek watershed are applicable to the Western Hills area without further processing. These are calculated as the land use load divided by the acreage of the land use. There is a land use category called riparian pasture deposition. While there are pollutant loads associated with this category, it does not have an explicit land use acreage. It represents directly excreted manure distributed based on the amount of time livestock spend along streams.

Summary annual loadings for both watersheds in the Western Hills Watershed are presented in Table 7-4. The loading attributed to land owned by federal agencies is accounted for separately, since these loads are not within the County's jurisdiction. Table 7-5 provides the land use loading rates and resulting annual loads for the South Fork Catoctin Creek subwatershed, and Table 7-6 provides the land use loading rates and annual loads for North Fork Goose Creek watershed. All loading provided here is edge of stream loading, which represents the loading to the local streams, not the Chesapeake Bay, and is most relevant to local watershed improvement.
The estimated acres of regulated construction in the South Fork Catoctin Creek subwatershed, as shown in Table 7-5, is likely an underestimate. Given the substantially higher loading rates from this land use, the loading from construction appears to be underestimated.

**Table 7-4: Summary annual land use loadings for Western Hills Watershed.**

| Watershed Area | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|
| **South Fork Catoctin Creek subwatershed** | 136,210 | 14,872 | 6,679,156 |
| **North Fork Goose Creek watershed** | 124,203 | 13,059 | 7,326,469 |
| **Total Non-Federal Load** | 260,413 | 27,931 | 14,005,626 |
| **Federal Loads*** | 109 | 7 | 3,277 |

*Not included in pie charts below (Figures 7-4 through 7-9) and include here for completeness

For purposes of sensitivity analysis, loads were also calculated assuming that the CAST land uses for the South Fork Catoctin Creek HUC12 were distributed proportionally across the entire watershed, including the South Fork Catoctin Creek subwatershed, which is 58.4 percent of the HUC12. Under this scenario, loads would be approximately 6-15 percent lower because more of the South Fork Catoctin Creek subwatershed would be characterized as agricultural and natural cover.

Ultimately, minor differences in the total loading in the Western Hills Watershed based on the land use distribution are relatively inconsequential because the load reduction calculations for the South Fork Catoctin Creek subwatershed portion of Western Hills will be calculated in CAST using the full South Fork Catoctin Creek HUC12. The relative difference in loading from any BMPs applied will be the same. For example, if one new BMP is included in the CAST scenario, the load reduction will be a fixed amount, regardless of whether the full South Fork Catoctin Creek HUC12 is evaluated or just the South Fork Catoctin Creek subwatershed is evaluated. Because the intent of this evaluation is to examine the South Fork Catoctin Creek subwatershed, the BMP reduction would be assumed to be applied to the subwatershed, rather than the entire HUC12.

As illustrated in Figures 7-4 to 7-9, developed areas (impervious and pervious) represent a substantial portion of the overall pollutant loading in the Western Hills Watershed, especially with respect to TP and sediment. The significant TP loading contribution from developed pervious areas is largely a function of both a larger land area and a higher loading rate than developed impervious areas. Agricultural land uses are the primary TN source in the Western Hills Watershed. Implementation strategies will need to focus on both agricultural and urban BMPs to fully address the pollutant loadings in the Western Hills Watershed.

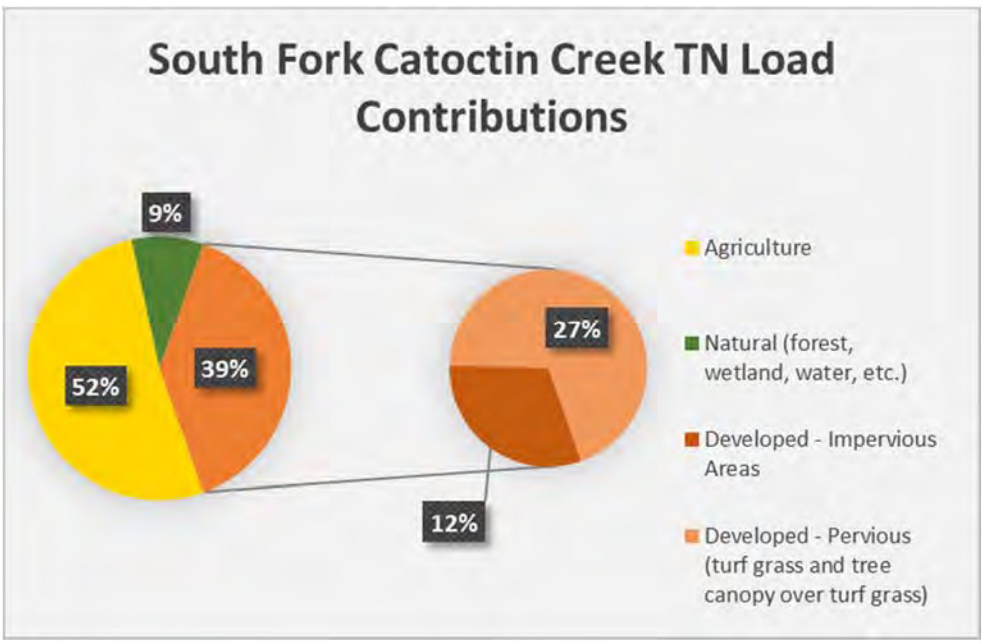


**Figure 7-4: South Fork Catoctin Creek subwatershed TN load contributions**

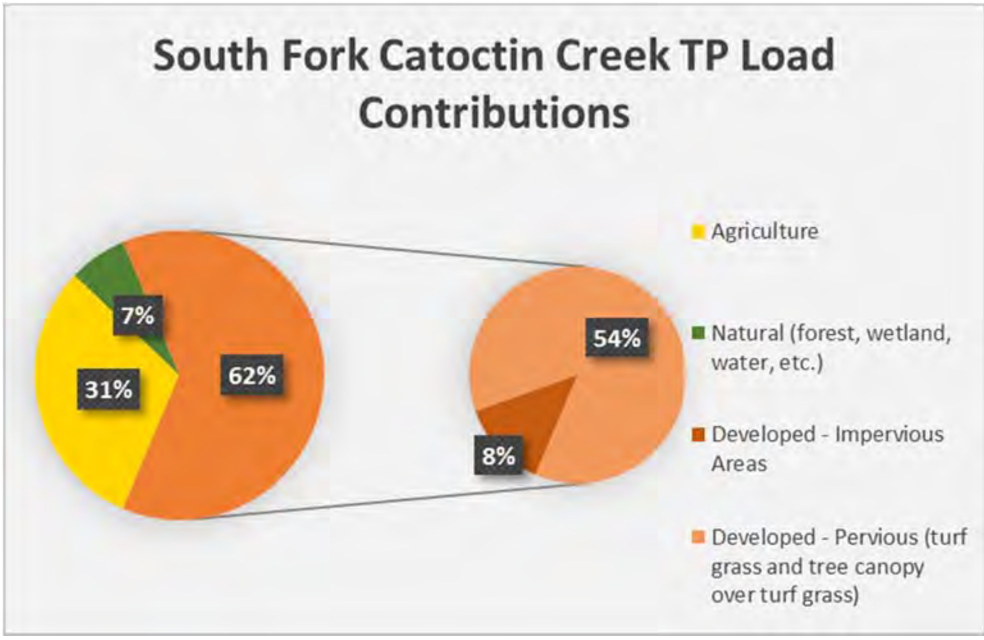


**Figure 7-5: South Fork Catoctin Creek subwatershed TP load contributions**

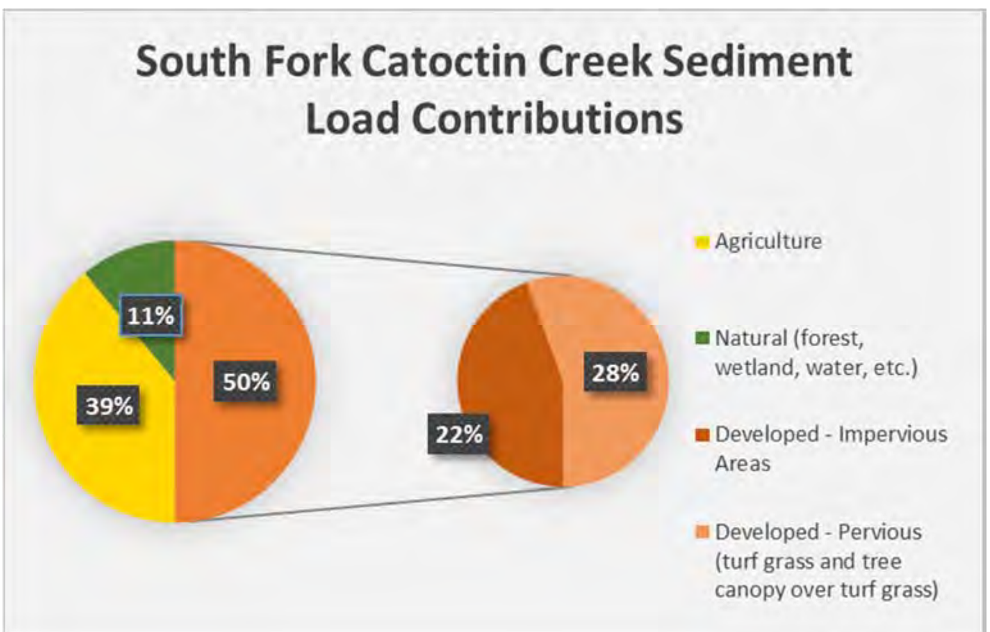


**Figure 7-6: South Fork Catoctin Creek subwatershed sediment load contributions**

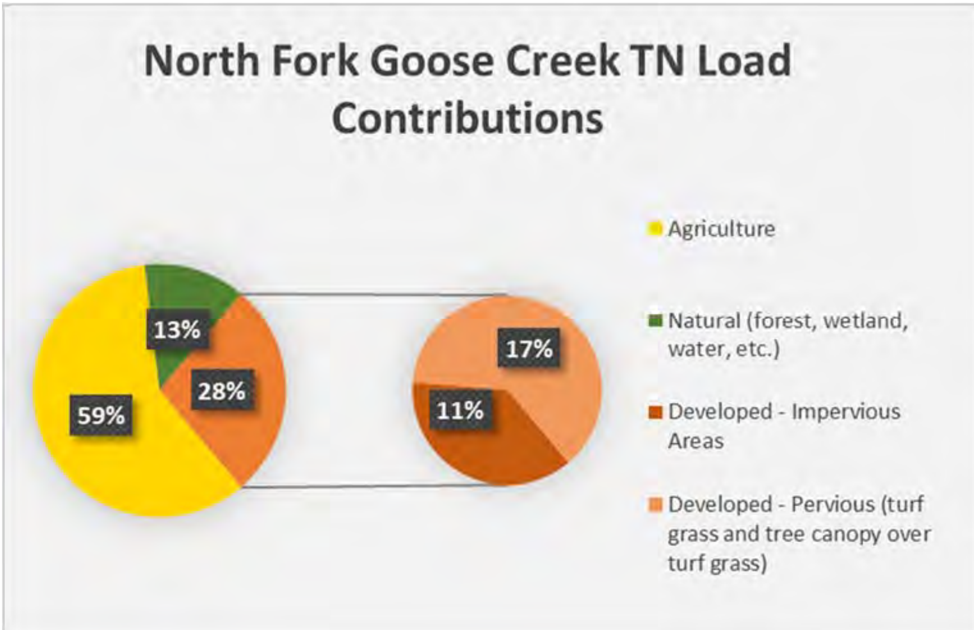


**Figure 7-7: North Fork Goose Creek watershed TN load contributions**

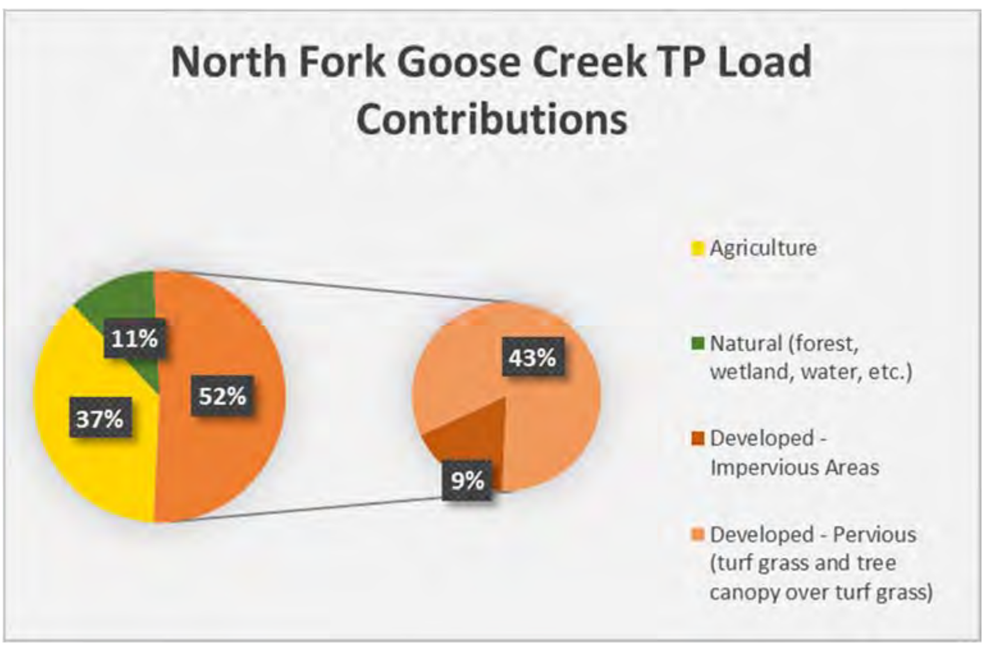


**Figure 7-8: North Fork Goose Creek watershed TP load contributions**

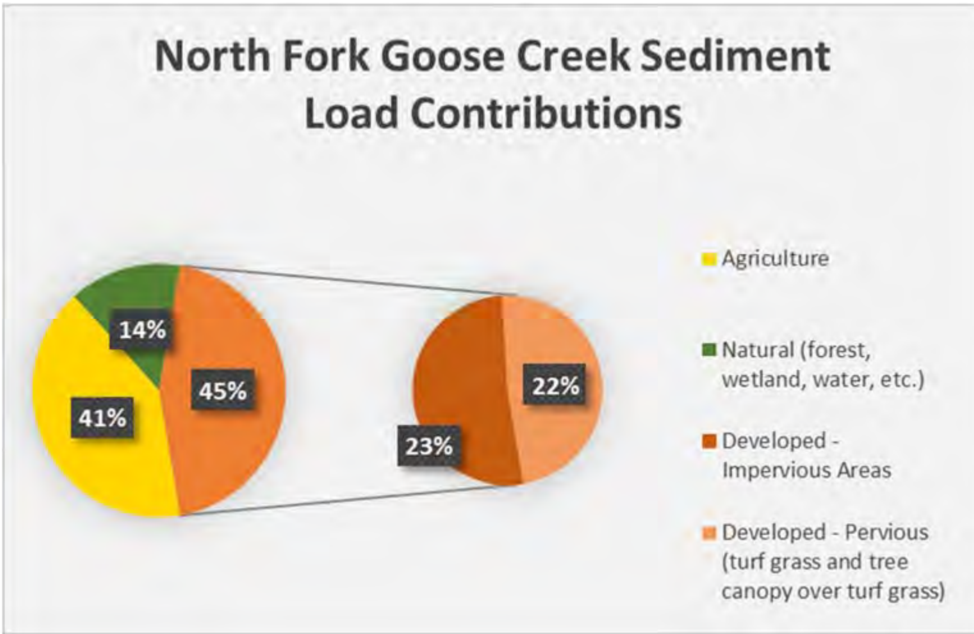


**Figure 7-9: North Fork Goose Creek watershed sediment load contributions**

**Table 7-5: South Fork Catoctin Creek Subwatershed Annual Land Use Loading Rates and Annual Loads**

| Load Source | Agency | Acres | TN lb/acre | TP lb/acre | Sediment lb/acre | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|---|---|---|---|---|
| **Agriculture** | | | | | | | | |
| **Ag Open Space** | Non-Federal | 247.4 | 3.23 | 0.944 | 34.1 | 801.1 | 233.6 | 8,443.4 |
| **Double Cropped Land** | Non-Federal | 6.3 | 20.05 | 0.133 | 362.7 | 126.7 | 0.8 | 2,292.5 |
| **Full Season Soybeans** | Non-Federal | 509.6 | 17.83 | 0.303 | 921.3 | 9,091.1 | 154.2 | 469,569.4 |
| **Grain with Manure** | Non-Federal | 23.0 | 32.92 | 0.355 | 877.7 | 757.3 | 8.2 | 201,88.8 |
| **Grain without Manure** | Non-Federal | 26.8 | 25.09 | 0.286 | 877.7 | 672.0 | 7.6 | 23,501.4 |
| **Legume Hay** | Non-Federal | 79.4 | 6.14 | 0.314 | 96.6 | 487.9 | 24.9 | 7,667.4 |
| **Non-Permitted Feeding Space** | Non-Federal | 11.4 | 30.52 | 1.235 | 3,329.7 | 347.0 | 14.0 | 37,853.6 |
| **Other Agronomic Crops** | Non-Federal | 435.2 | 12.26 | 0.604 | 1,011.2 | 5,338.7 | 262.7 | 440,040.4 |
| **Other Hay** | Non-Federal | 1,937.6 | 8.83 | 0.070 | 30.4 | 17,121.0 | 136.1 | 59,065.6 |
| **Pasture** | Non-Federal | 3,542.4 | 7.72 | 0.474 | 61.3 | 27,361.5 | 1,677.5 | 217,254.2 |
| **Riparian Pasture Deposition** | Non-Federal | 0.0 | n/a | n/a | n/a | 4,278.3 | 1,372.8 | 654,525.4 |
| **Small Grains and Grains** | Non-Federal | 28.6 | 19.12 | 0.434 | 1225.2 | 546.0 | 12.4 | 34,987.1 |
| **Specialty Crop High** | Non-Federal | 49.8 | 38.74 | 2.296 | 1,890.5 | 1,931.0 | 114.4 | 94,235.4 |
| **Specialty Crop Low** | Non-Federal | 222.5 | 8.96 | 2.518 | 2,397.0 | 1,994.5 | 560.3 | 533,265.6 |
| **Total Agriculture** | Non-Federal | 7,120.0 | | | | 70,854.1 | 4,579.6 | 2,602,890.2 |
| **Developed** | | | | | | | | |
| **Buildings and Other** | Non-Federal | 650.0 | 11.36 | 0.873 | 1,207.0 | 7,389.8 | 567.5 | 784,594.4 |
| **Roads** | Non-Federal | 411.8 | 14.38 | 1.050 | 1,207.0 | 5,922.9 | 432.4 | 497,033.3 |
| **Tree Canopy over Impervious** | Non-Federal | 237.2 | 13.11 | 0.951 | 843.0 | 3,111.8 | 225.5 | 200,001.9 |
| **Tree Canopy over Turf Grass** | Non-Federal | 761.3 | 6.25 | 1.366 | 291.1 | 4,764.1 | 1,039.9 | 221,639.3 |
| **Turf Grass** | Non-Federal | 3,914.9 | 8.21 | 1.804 | 417.1 | 32,157.1 | 7,060.8 | 1,633,010.8 |
| **Regulated Construction** | Non-Federal | 0.9 | 18.76 | 4.109 | 2,724.2 | 17.3 | 3.8 | 2,517.3 |
| **Total Developed** | Non-Federal | 5,976.2 | | | | 53,363.0 | 9,330.0 | 3,338,797.0 |

**Table 7-5: South Fork Catoctin Creek Subwatershed Annual Land Use Loading Rates and Annual Loads**

| Load Source | Agency | Acres | TN lb/acre | TP lb/acre | Sediment lb/acre | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|---|---|---|---|---|
| **Natural Areas** | | | | | | | | |
| **Harvested Forest** | Non-Federal | 21.7 | 4.79 | 0.098 | 92.3 | 104.1 | 2.1 | 2,006.0 |
| **Headwater or Isolated Wetland** | Non-Federal | 38.7 | 1.30 | 0.070 | 21.4 | 50.3 | 2.7 | 831.7 |
| **Mixed Open** | Non-Federal | 971.0 | 1.87 | 0.389 | 608.3 | 1,816.4 | 377.9 | 590,751.9 |
| **Non-tidal Floodplain Wetland** | Non-Federal | 277.0 | 1.30 | 0.070 | 21.4 | 360.1 | 19.5 | 5,939.2 |
| **True Forest** | Non-Federal | 6,413.9 | 1.30 | 0.070 | 21.5 | 8,335.9 | 451.1 | 137,940.3 |
| **Water** | Non-Federal | 180.1 | 7.36 | 0.606 | 0.0 | 1,326.7 | 109.2 | 0.0 |
| **Total Natural Areas** | | 7,902.5 | | | | 11,993.6 | 962.5 | 737,469.1 |
| **Non-Federal Land Subtotal** | | 20,998.7 | | | | 136,210.7 | 14,872.1 | 6,679,156.3 |
| **Federal Lands** | | | | | | | | |
| **All land uses** | National Park Service | 65.8 | | | | 87.0 | 5.2 | 2,351.8 |
| **Total** | | 21,064.5 | | | | 136,297.6 | 14,877.3 | 6,681,508.1 |

**Table 7-6: North Fork Goose Creek Watershed Annual Land Use Loading Rates and Annual Loads**

| Load Source | Agency | Acres | TN lb/acre | TP lb/acre | Sediment lb/acre | TN lb | TP lb | Sediment lb |
|---|---|---|---|---|---|---|---|---|
| Agriculture | | | | | | | | |
| **Ag Open Space** | Non-Federal | 431.2 | 2.52 | 0.943 | 34.9 | 1,086.5 | 406.7 | 15,063.0 |
| **Double Cropped Land** | Non-Federal | 7.5 | 17.06 | 0.133 | 498.6 | 127.9 | 1.0 | 3,735.9 |
| **Full Season Soybeans** | Non-Federal | 513.4 | 14.73 | 0.302 | 1,248.8 | 7,563.3 | 155.2 | 641,098.4 |
| **Grain with Manure** | Non-Federal | 23.6 | 27.19 | 0.355 | 1,194.3 | 642.7 | 8.4 | 28,229.4 |
| **Grain without Manure** | Non-Federal | 27.5 | 20.72 | 0.285 | 1,194.3 | 570.3 | 7.9 | 32,861.3 |
| **Legume Hay** | Non-Federal | 123.8 | 4.78 | 0.313 | 103.5 | 592.1 | 38.8 | 12,818.7 |
| **Non-Permitted Feeding Space** | Non-Federal | 16.7 | 24.67 | 1.346 | 3,408.2 | 411.1 | 22.4 | 56,781.4 |
| **Other Agronomic Crops** | Non-Federal | 438.5 | 10.13 | 0.603 | 1,382.8 | 4,442.7 | 264.5 | 606,308.2 |
| **Other Hay** | Non-Federal | 3,021.8 | 6.87 | 0.070 | 32.7 | 20,779.4 | 212.0 | 99,077.5 |
| **Pasture** | Non-Federal | 5,488.1 | 5.82 | 0.457 | 60.0 | 31,968.3 | 2,510.6 | 329,480.9 |
| **Riparian Pasture Deposition** | Non-Federal | 0.0 | n/a | n/a | n/a | 1,631.3 | 523.4 | 249,575.6 |
| **Small Grains and Grains** | Non-Federal | 29.3 | 16.27 | 0.433 | 1,685.3 | 477.5 | 12.7 | 49,454.6 |
| **Specialty Crop High** | Non-Federal | 51.2 | 31.99 | 2.294 | 2,587.5 | 1,638.3 | 117.5 | 132,506.6 |
| **Specialty Crop Low** | Non-Federal | 228.6 | 7.40 | 2.516 | 3,276.9 | 1,692.2 | 575.0 | 749,004.6 |
| **Total Agriculture** | Non-Federal | 10,401.2 | | | | 73,623.7 | 4,856.1 | 3,005,996.0 |
| Developed | | | | | | | | |
| **Buildings and Other** | Non-Federal | 539.2 | 9.55 | 0.863 | 1,494.5 | 5,150.8 | 465.6 | 805,916.4 |
| **Roads** | Non-Federal | 335.6 | 12.08 | 1.038 | 1,494.6 | 4,055.8 | 348.5 | 501,574.3 |
| **Tree Canopy over Impervious** | Non-Federal | 311.4 | 11.01 | 0.940 | 986.5 | 3,431.9 | 292.8 | 307,246.4 |
| **Tree Canopy over Turf Grass** | Non-Federal | 711.4 | 5.25 | 1.350 | 340.6 | 3,735.5 | 960.3 | 242,337.7 |
| **Turf Grass** | Non-Federal | 2,579.1 | 6.89 | 1.782 | 516.3 | 17,779.6 | 4,597.1 | 1,331,816.2 |
| **Regulated Construction** | Non-Federal | 15.7 | 15.80 | 4.111 | 5,161.7 | 247.4 | 64.3 | 80,782.1 |
| **Total Developed** | Non-Federal | 4,492.4 | | | | 34,400.9 | 6,728.6 | 3,269,673.2 |

**Table 7-6: North Fork Goose Creek Watershed Annual Land Use Loading Rates and Annual Loads**

| Load Source | Agency | Acres | TN lb/acre | TP lb/acre | Sediment lb/acre | TN lb | TP lb | Sediment lb |
|---|---|---|---|---|---|---|---|---|
| **Natural Areas** | | | | | | | | |
| **Harvested Forest** | Non-Federal | 39.8 | 3.63 | 0.098 | 118.0 | 144.8 | 3.9 | 4,697.5 |
| **Headwater or Isolated Wetland** | Non-Federal | 38.7 | 0.98 | 0.070 | 27.4 | 38.1 | 2.7 | 1,061.6 |
| **Mixed Open** | Non-Federal | 1,038.4 | 1.42 | 0.389 | 686.6 | 1,474.7 | 404.2 | 712,980.3 |
| **Non-tidal Floodplain Wetland** | Non-Federal | 330.2 | 0.98 | 0.070 | 27.4 | 325.9 | 23.2 | 9,050.4 |
| **True Forest** | Non-Federal | 11,750.2 | 0.98 | 0.070 | 27.4 | 11,591.5 | 826.3 | 323,010.2 |
| **Water** | Non-Federal | 353.5 | 7.36 | 0.606 | 0.0 | 2,603.1 | 214.2 | 0.0 |
| **Total Natural Areas** | Non-Federal | 13,550.7 | | | | 16,178.0 | 1,474.5 | 1,050,800.0 |
| **Non-Federal Land Subtotal** | | 28,444.2 | | | | 124,202.6 | 13,059.3 | 7,326,469.2 |
| **Federal Lands** | | | | | | | | |
| All Land Uses | National Park Service | 21.3 | | | | 21.6 | 1.7 | 925.2 |
| Total | | 28,465.6 | | | | 124,224.2 | 13,061.0 | 7,327,394.5 |

### 7.4.2 Septic Systems and Stream Bed and Bank Erosion Loading

Similar to the land use loading calculations, the septic and stream bed and bank erosion loadings for the North Fork Goose Creek watershed were taken directly from CAST, and the loadings for the South Fork Catoctin Creek subwatershed portion were calculated based on the proportion of septic systems and stream miles within the Western Hills area of the South Fork Catoctin Creek HUC12.

Septic systems were identified using Loudoun County's 2018 Loudoun Pollution Sources geospatial data. The South Fork Catoctin Creek subwatershed contains 63 percent of the septic systems in the South Fork Catoctin Creek HUC12. The resulting septic system counts and loading from CAST are presented in Table 7-7.

**Table 7-7: Septic counts, loading rates, and annual TN loads in Western Hills Watershed.**

| Watershed | Systems | TN lbs/system | TN lb/yr |
|---|---|---|---|
| South Fork Catoctin Creek subwatershed | 1,664 | 9.12 | 15,168.1 |
| North Fork Goose Creek watershed | 2,402 | 10.02 | 24,070.5 |
| | | **Total** | 39,238.6 |

Stream miles within the Western Hills area of the South Fork Catoctin Creek HUC12 were determined using Loudoun County's Perennial Streams geospatial data. These data were created by the county in 2009 and include approximately 1,500 miles countywide. Approximately 59 percent of the perennial streams within the South Fork Catoctin Creek HUC12 are within the South Fork Catoctin Creek subwatershed. The resulting stream bed and bank erosion loading from CAST is presented in Table 7-8.

**Table 7-8: Stream bed and bank erosion loading rates and annual loads in Western Hills Watershed**

| Watershed, Source | Miles | TN lb/mile | TP lb/mile | Sediment lb/mile | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|---|---|---|---|
| South Fork Catoctin Creek subwatershed, non-federal | 46.3 | 345.05 | 102.89 | 292,689 | 15,991.7 | 4,768.7 | 13,564,929.2 |
| North Fork Goose Creek watershed, non-federal | 57.2 | 352.38 | 84.53 | 283,405 | 20,144.1 | 4,832.2 | 16,200,815.4 |
| | | | | **Total** | 36,135.8 | 9,600.9 | 29,765,744.6 |

### 7.4.3 Total Non-Federal Watershed Pollutant Loading

As shown in Table 7-9 and Figure 7-10 through Figure 7-12, land use loading is the primary contributor to TN and TP loading in the watershed, constituting about 70-80 percent of the overall load; however, stream bed and bank erosion is the primary contributor to sediment loading, making up about 65 percent of the overall load. The strong difference in loading sources between pollutants suggests that a successful implementation plan will require a variety of strategies to address the different sources of pollutants. While urban and agricultural BMPs can help address the nutrient loading from land use sources, as well as reduce erosive flows to streams, stream restoration may be another important component to begin addressing the sediment loading in the watershed.

**Table 7-9: Summary of annual watershed pollutant loading in Western Hills Watershed**

| South Fork Catoctin Creek Subwatershed | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|
| Land Use Loading | 136,210.7 | 14,872.1 | 6,679,156 |
| Septic Systems | 15,168 | n/a | n/a |
| Stream Bed and Banks | 15,992 | 4,769 | 13,564,929 |
| Total | 167,370.5 | 19,640.8 | 20,244,086 |
| **North Fork Goose Creek Watershed** | **TN lb/yr** | **TP lb/yr** | **Sediment lb/yr** |
| Land Use Loading | 124,203 | 13,059 | 7,326,469 |
| Septic Systems | 24,071 | n/a | n/a |
| Stream Bed and Banks | 20,144 | 4,832 | 16,200,815 |
| Total | 168,417 | 17,891 | 23,527,285 |

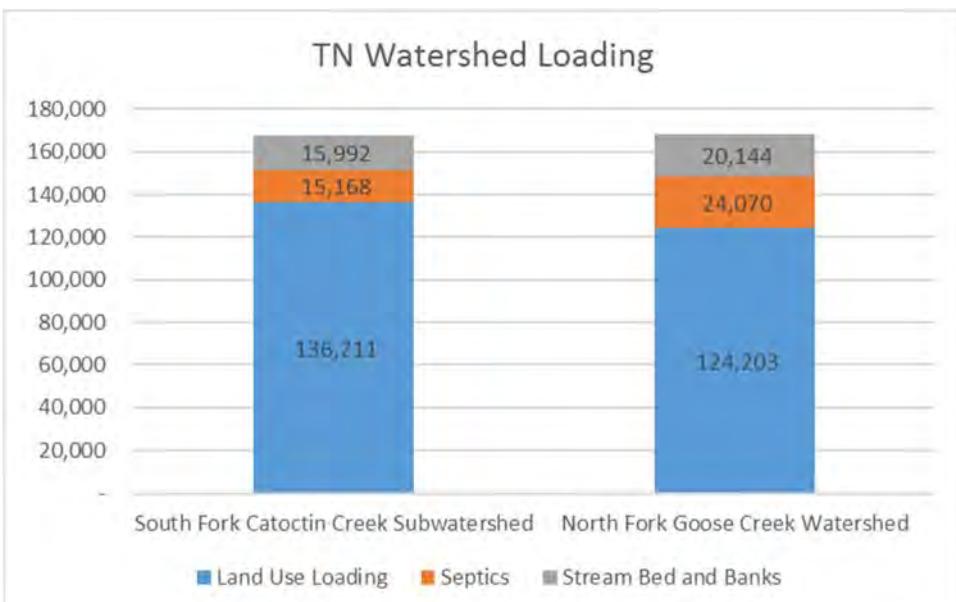


**Figure 7-10: Summary of annual TN loading (lb/yr) in Western Hills Watershed**

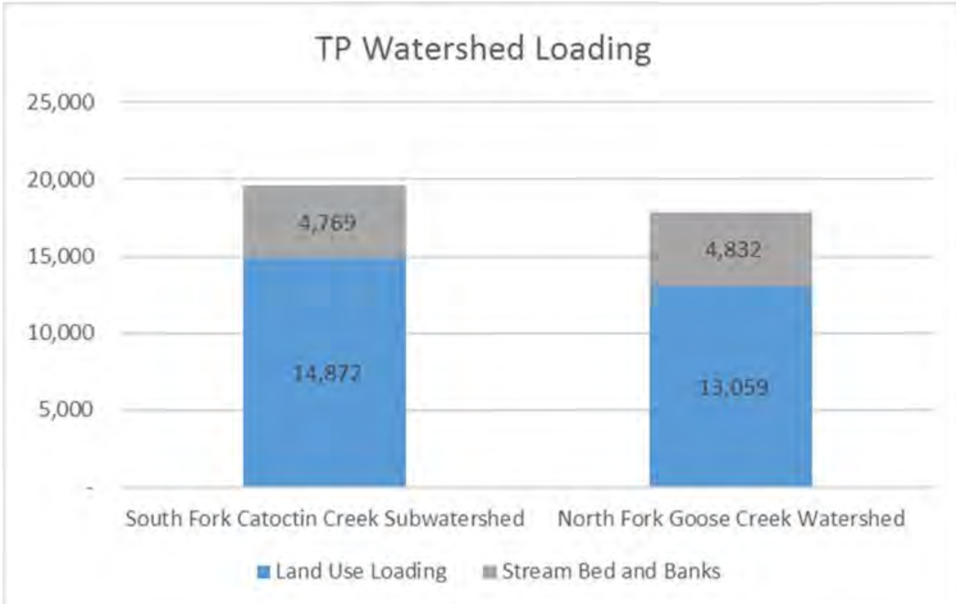


**Figure 7-11: Summary of annual TP loading (lb/yr) in Western Hills Watershed**

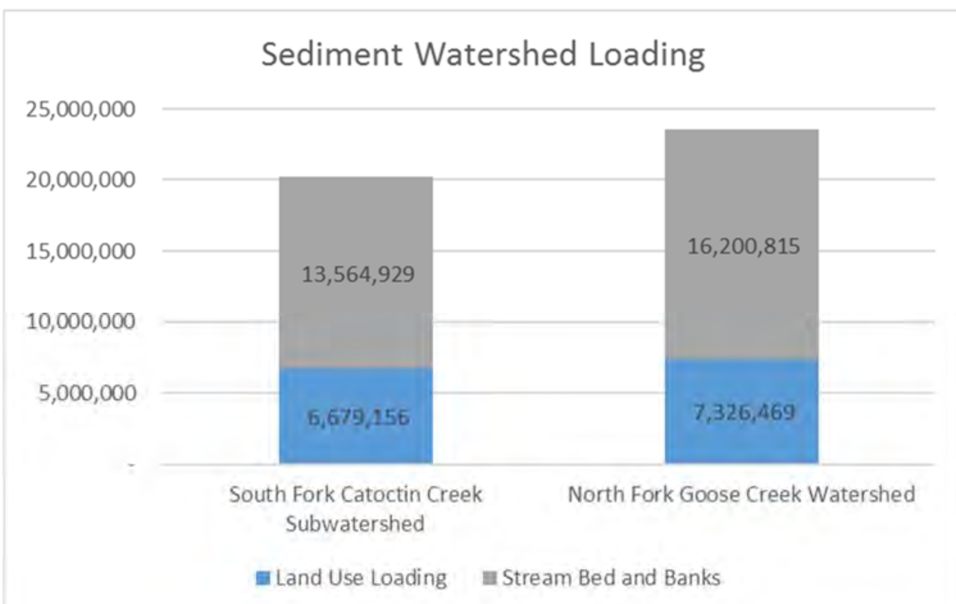


**Figure 7-12. Summary of annual sediment loading (lb/yr) in Western Hills Watershed**

## 7.5 Comparison of Western Hills to Loudoun County

The Western Hills Watershed is about 14 percent of the total acreage of Loudoun County. As shown in Figure 7-13, the Western Hills Watershed has roughly the same proportion of natural land as the rest of Loudoun County, but it is less developed and more agricultural than the county overall.

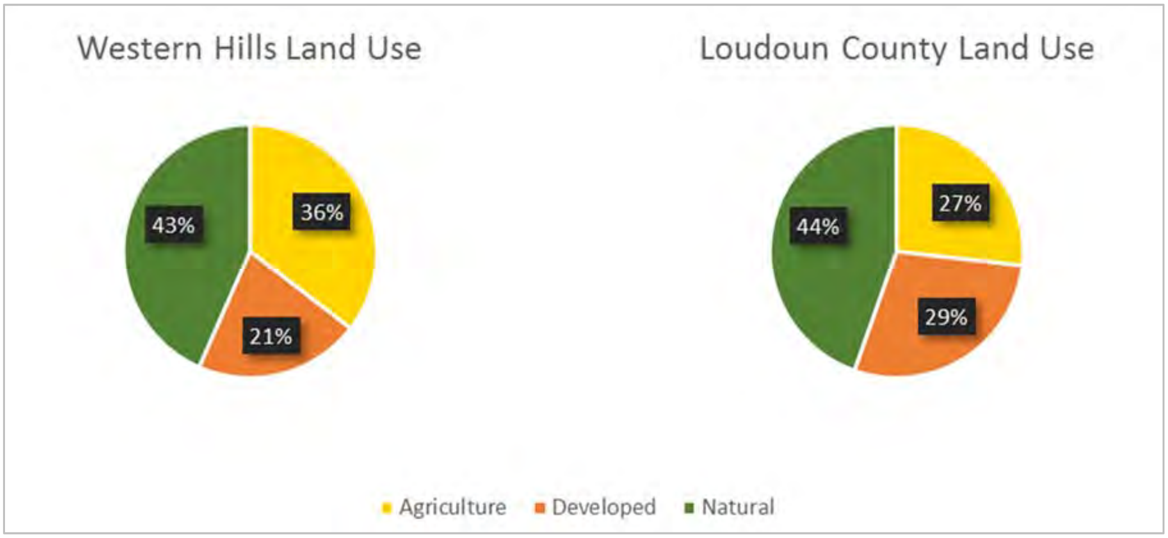


**Figure 7-13: Comparison between the Western Hills Watershed and Loudoun County land use**

Estimates of TN, TP, and sediment annual loads for the entire area of Loudoun County were derived using CAST to run a 2017 current progress scenario. Figures 14 through 16 show the relative contributions from Western Hills as a proportion of the overall Loudoun County pollutant loading. Figure 7-17 summarizes the proportional loading from the Western Hills Watershed. Because Western Hills is 15 percent of the total acreage, if all things were equal, this area would contribute 15 percent of each land use and 15 percent of each pollutant load. However, as shown, there is proportionally more agricultural land and fewer developed acres within Western Hills, with corresponding proportions of load contributions. There is also a higher prevalence of septic systems in the Western Hills Watershed. This supports the notion that Western Hills is more rural than the rest of the county. Figure 7-17 also illustrates that generally each land use is contributing pollutant loads proportional to its land use acreage (or number of systems / stream miles).

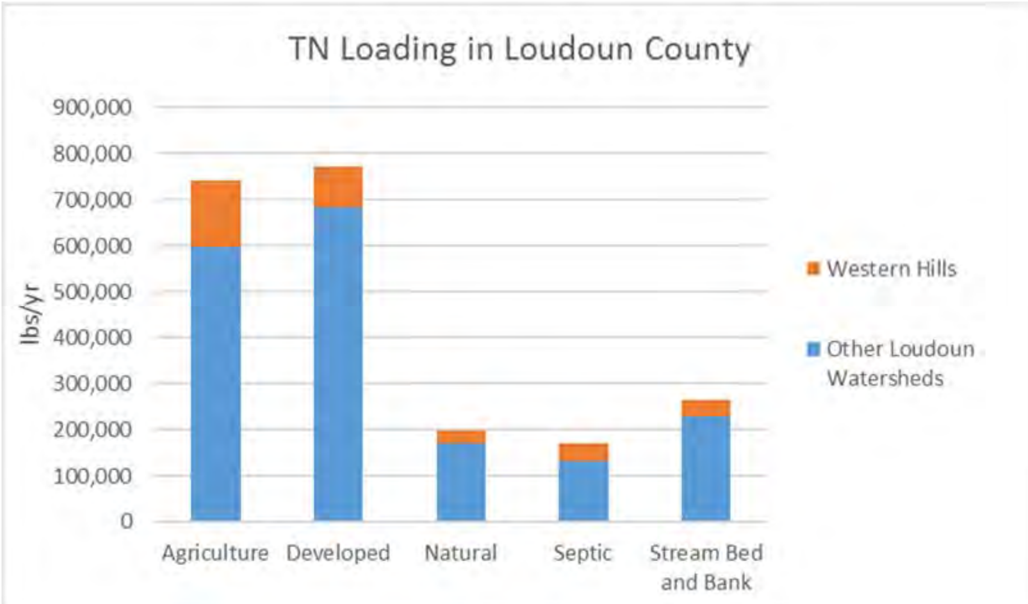


**Figure 7-14: Annual total nitrogen loading (lb/yr) in Loudoun County and the proportion of loading from the Western Hills Watershed**

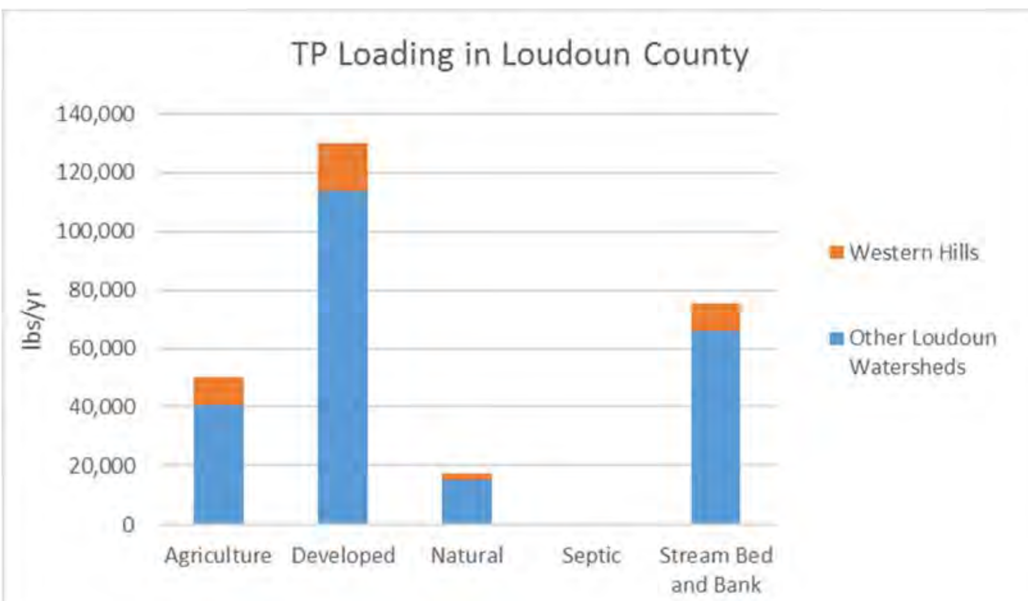


**Figure 7-15: Annual total phosphorus loading (lb/yr) in Loudoun County and the proportion of loading from the Western Hills Watershed**

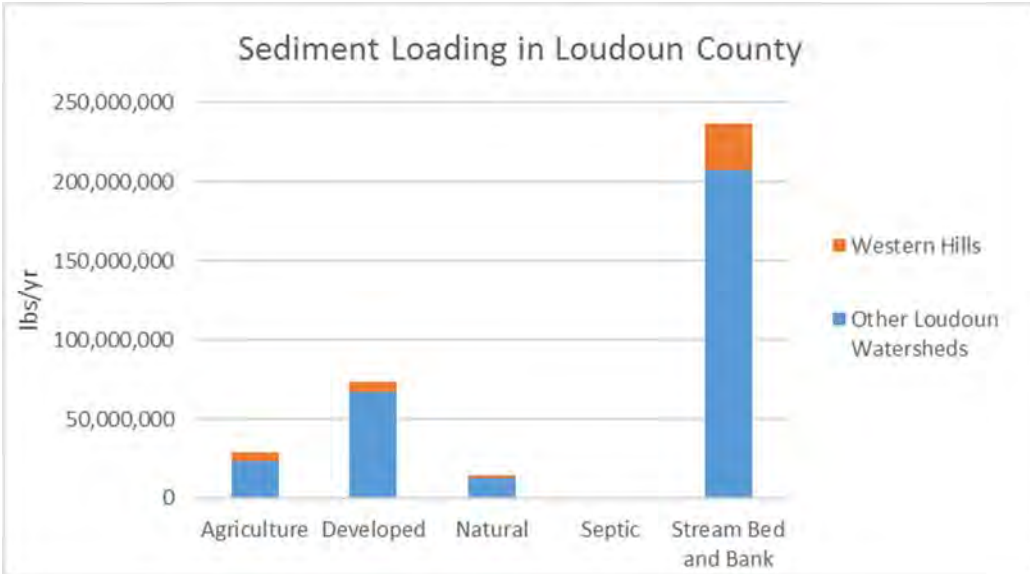


**Figure 7-16: Annual sediment loading (lb/yr) in Loudoun County and the proportion of loading from the Western Hills Watershed**

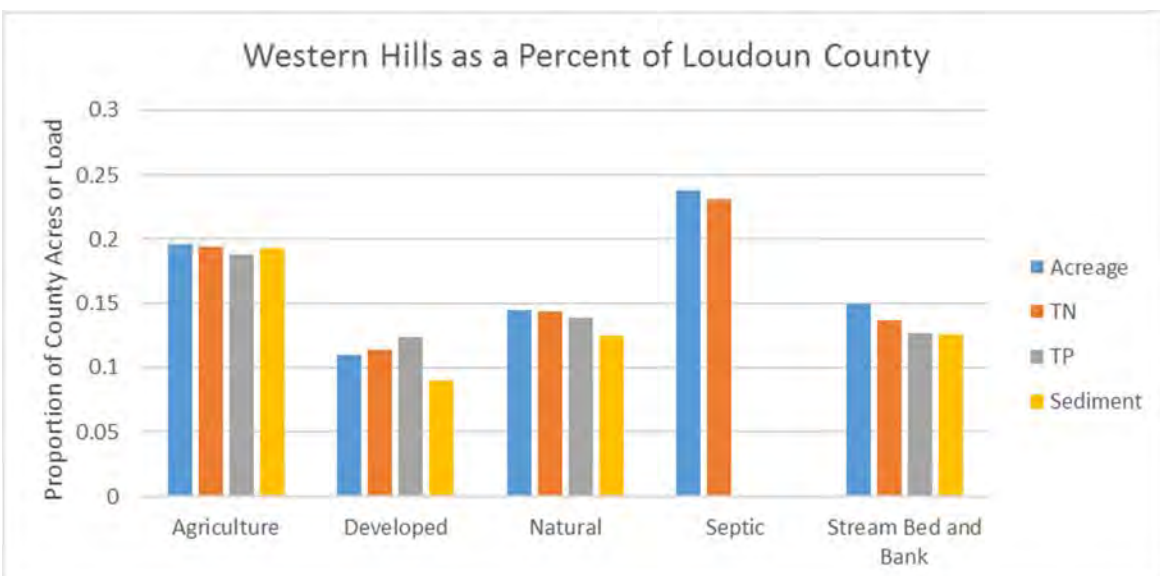


**Figure 7-17: Proportion of Loudoun County land use and loadings within the Western Hills Watershed**

## 7.6 Future Land Use and Pollutant Load Changes – 2025 WIP Scenario

In this and subsequent chapter sections, changes in land use and loadings are explored for a variety of scenarios, including the 2025 WIP Scenario, which uses the land use changes through 2025, as developed by the Chesapeake Bay Program for the Chesapeake Bay TMDL, and the BMP implementation types and levels provided by Virginia DEQ to meet the state's Chesapeake Bay TMDL targets. The other scenarios explored in this chapter include 2017 BMP implementation levels applied to the 2025 land uses. Table 7-10 summarizes the scenarios that are evaluated in this chapter.

**Table 7-10: Summary of Scenarios**

| Scenario | Projection | BMP Implementation Level | Land Use |
|---|---|---|---|
| 1 | 2017 (current conditions) | 2017 Progress | 2017 |
| 2 | 2025 | Phase II WIP | 2025 |
| 3 | 2025 | 2017 BMPs | 2025 |

### 7.6.1 Land Use Loading

CAST provides two land use scenarios for projecting land uses changes to the year 2025. These two scenarios are known as *Current Zoning* and *Historical Trends*. *Current zoning* is defined as projections of historic trends using environmentally optimistic zoning regulations. *Historical trends* is defined as a continuation of land use patterns and rates of change as occurred between 2000 and 2010. The Chesapeake Bay Program uses the current zoning projection of land uses for determining the land uses and resulting loadings in the state Watershed Implementation Plans (WIPs), WIP Milestones, and annual progress runs after 2013.

According to the CAST User Documentation[3], these land use projections are based on:

> Rates of change are dictated by the county-level population and employment projections (provided to CBPO by state agencies or state contractors). Pattern of change (e.g., infill development, proportion of growth in urban vs rural areas, and fine-scale probabilities of growth) are dictated by Census and satellite observations between 2000 and 2010. Constraints on change (e.g., zoning, employment and population densities, protected lands, already developed areas, steep slopes, wetlands, water) are dictated by regional, state, and local datasets generally representing 2011 – 2013 conditions. Shapes of change (e.g., shapes of simulated patches of new development) are dictated by a gravity surface to all roads (circa 2013) emphasizing the need for road access to all new developments.

The current zoning projection is most appropriate for estimating land use and loadings for the Western Hills Watershed in 2025. The 2025 Phase II WIP Scenario for the Western Hills

[3] https://cast.chesapeakebay.net/Documentation

Watershed is derived from the CAST output for North Fork Goose Creek HUC12 watershed and South Fork Catoctin Creek HUC12 watershed. As with the land use and loading calculations presented earlier for current conditions, the 2025 results for the North Fork Goose Creek watershed are used in their entirety, but the South Fork Catoctin Creek HUC12 area is proportionally divided between the South Fork Catoctin Creek subwatershed and the remainder of the HUC12 using the same land use ratios as provided in Table 7-2. Similarly, the same proportion of septic systems and stream miles in the South Fork Catoctin Creek subwatershed that were used in the current conditions scenario were used for the 2025 scenario. The Phase II WIP Scenario represents land use changes as well as a projection of continued BMP implementation at a rate high enough to meet Loudoun County's Phase II WIP target reductions. The results for projected 2025 loadings are presented in Table 7-11 through Table 7-12. As land is converted from agricultural or natural land uses to developed land, fewer agricultural BMPs are needed and more urban BMPs are necessary to address the loading from these new land uses.

Land use changes in the 2025 scenario are a result of two different factors. The first factor is projected land use change based on development, as described above. The second factor that affects land uses is the application of BMPs. There are some BMPs, known as load source conversion BMPs, that when applied, will change the land from one use to another. An example of this is a forest buffer. When a forest buffer is applied to agricultural land, the land use is changed to true forest. Similarly, if an agricultural land use is retired, it will be converted to pasture or agricultural open space in the model.

It should be noted that if BMP implementation is not conducted at the pace assumed in the Phase II WIP, loading rates and overall loads will be higher than shown here. Land use loading contributions are broken down in Figure 7-18 through Figure 7-23. In the South Fork Catoctin Creek subwatershed, developed land is projected to be the primary source of TN, TP and sediment in 2025, representing a shift from agriculture as the major source of TN in 2017. In the North Fork Goose Creek watershed, agriculture is projected to remain the primary source of TN and developed land is expected to remain the primary source of TP and sediment.

The timing of the draft Phase III WIP should have minimal impact on the Western Hills WMP. Virginia's first draft submission of the Phase III WIP scenario was submitted on April 12, 2019. There will likely be modifications before it is finalized. The schedule is such that there was public comment and EPA review of the draft until June 9, 2019, and the Final Phase III WIP is not due until August 2019. Giving the timing of the finalization of the Phase III WIP relative to completion of this plan, the Phase III WIP was not used in the analyses.

In addition, the Phase III WIP will only affect the loading targets and projected BMPs for 2025 needed to meet the TMDL at the state/county level. Since Loudoun County has not set a specific target load reduction for Western Hills Watershed, the Phase III implementation is not as important as the BMP recommendations in the WMP for developing a strategy to improve water quality and identify suitable practices within the WHWMA. The general BMP implementation trend between the Phase II and Phase III WIPs should be substantially similar and the general conclusions (i.e. implementation is necessary in all sectors to meet the targets) will likely remain the same.

As shown in Table 7-11 and Table 7-12, there are generally lower loading rates expected in 2025 in comparison to 2017. This is because the 2025 scenario represents the inclusion of all BMPs necessary to meet the Phase II WIP load reduction targets. The level of implementation assumed for 2025 will result in the load reduction targets being met, but only with a significant and sustained effort to implement to this level in the coming years. If implementation does not occur apace with projections, the projected 2025 loading rates and loads can be considered an underestimate of the loading in 2025. Without substantial effort, the 2025 loading will be higher than projected here.

The land uses in the 2025 scenario represent a combination of changing land uses due to development, as well as changing land uses resulting from the implementation of BMPs. The 2025 scenario shows less overall agricultural land as a result of increased urban development, but there is also a shift in the remaining agricultural land uses. For example, there is an increase in agricultural open space projected in 2025 as BMPs are applied, converting cropland acres using BMPs such as grass buffers or land retirement. There is also an increase in natural land uses as BMPs, such as forest buffers and wetland restoration, are implemented.

The grain-based land uses are no longer projected to be present in 2025, through a combination of increased development and BMPs converting the land to natural areas. The land use riparian pasture deposition is no longer projected to be present in 2025 because the land use is converted to regular pasture as exclusion fencing BMPs are added to prevent livestock access to streams.

Notably, the developed land uses projected for 2025 may underrepresent the increase in impervious acreage that is likely to occur within the Western Hills Watershed.

**Table 7-11: South Fork Catoctin Creek Subwatershed Annual Land Use Loading Rates and Annual Load Projections for 2025**

| Load Source | Agency | Acres | TN lb/acre | TP lb/acre | Sediment lb/acre | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|---|---|---|---|---|
| **Agriculture** | | | | | | | | |
| Ag Open Space | Non-Federal | 863.3 | 2.93 | 0.897 | 31.9 | 2,530.4 | 774.2 | 27,595.7 |
| Double Cropped Land | Non-Federal | 182.6 | 14.99 | 0.031 | 133.7 | 2,737.9 | 5.6 | 24,411.5 |
| Full Season Soybeans | Non-Federal | 260.8 | 13.06 | 0.156 | 428.1 | 3,407.2 | 40.6 | 111,658.7 |
| Legume Hay | Non-Federal | 8.9 | 5.40 | 0.280 | 83.9 | 48.1 | 2.5 | 748.2 |
| Non-Permitted Feeding Space | Non-Federal | 10.5 | 8.29 | 0.348 | 2,277.3 | 87.5 | 3.7 | 24,004.3 |
| Other Agronomic Crops | Non-Federal | 336.5 | 8.78 | 0.328 | 445.8 | 2,954.5 | 110.4 | 150,041.4 |
| Other Hay | Non-Federal | 1,596.0 | 7.50 | 0.063 | 26.5 | 11,977.7 | 100.1 | 42,299.2 |
| Pasture | Non-Federal | 2,685.5 | 5.47 | 0.346 | 37.4 | 14,709.8 | 928.0 | 100,463.1 |
| Specialty Crop High | Non-Federal | 46.4 | 19.71 | 1.435 | 1,110.2 | 915.3 | 66.6 | 51,550.8 |
| Specialty Crop Low | Non-Federal | 189.2 | 4.97 | 1.769 | 1,587.7 | 940.5 | 334.7 | 300,425.1 |
| Total Agriculture | | 6,179.8 | | | | 40,308.9 | 2,366.5 | 833,198.1 |
| **Developed** | | | | | | | | |
| Buildings and Other | Non-Federal | 655.5 | 10.47 | 0.776 | 1,016.4 | 6,867.8 | 508.8 | 666,272.5 |
| Roads | Non-Federal | 415.3 | 13.25 | 0.934 | 1,016.2 | 5,504.6 | 387.7 | 422,016.2 |
| Tree Canopy over Impervious | Non-Federal | 239.2 | 12.08 | 0.845 | 709.8 | 2,892.0 | 202.2 | 169,827.0 |
| Tree Canopy over Turf Grass | Non-Federal | 760.7 | 5.45 | 1.167 | 235.5 | 4,148.6 | 887.5 | 179,200.9 |
| Turf Grass | Non-Federal | 4,150.9 | 7.15 | 1.540 | 337.5 | 29,713.2 | 6,394.3 | 1,400,979.0 |
| Regulated Construction | Non-Federal | 226.9 | 18.73 | 4.111 | 1,513.9 | 4,249.9 | 932.7 | 343,515.1 |
| Total Developed | | 6,448.5 | | | | 53,376.2 | 9,313.3 | 3,181,810.7 |

**Table 7-11: South Fork Catoctin Creek Subwatershed Annual Land Use Loading Rates and Annual Load Projections for 2025**

| Load Source | Agency | Acres | TN lb/acre | TP lb/acre | Sediment lb/acre | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|---|---|---|---|---|
| **Natural Areas** | | | | | | | | |
| Harvested Forest | Non-Federal | 95.8 | 5.36 | 0.115 | 108.5 | 513.8 | 11.0 | 10,394.6 |
| Headwater or Isolated Wetland | Non-Federal | 118.8 | 1.30 | 0.070 | 21.4 | 154.4 | 8.4 | 2,552.3 |
| Mixed Open | Non-Federal | 955.7 | 1.87 | 0.389 | 608.3 | 1,787.8 | 372.0 | 581,424.8 |
| Non-tidal Floodplain Wetland | Non-Federal | 274.8 | 1.30 | 0.070 | 21.4 | 357.2 | 19.3 | 5,890.9 |
| True Forest | Non-Federal | 6,746.2 | 1.30 | 0.070 | 21.5 | 8,767.9 | 474.4 | 145,085.2 |
| Water | Non-Federal | 179.4 | 7.36 | 0.606 | 0.0 | 1,321.2 | 108.7 | 0.0 |
| Total Natural Areas | | 8,370.6 | | | | 12,902.1 | 993.8 | 745,347.9 |
| Non-Federal Land Subtotal | | 20,998.9 | | | | 106,587.2 | 12,673.5 | 4,760,356.7 |
| **Federal Lands** | | | | | | | | |
| All land uses | National Park Service | 65.6 | | | | 86.6 | 5.2 | 2,341.9 |
| Total | | 21,064.5 | | | | 106,673.8 | 12,678.7 | 4,762,698.5 |

**Table 7-12: North Fork Goose Creek Watershed Annual Land Use Loading Rates and Annual Load Projections for 2025**

| Load Source | Agency | Acres | TN lb/acre | TP lb/acre | Sediment lb/acre | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|---|---|---|---|---|
| **Agriculture** | | | | | | | | |
| Ag Open Space | Non-Federal | 1,245.1 | 2.31 | 0.901 | 32.9 | 2,875.9 | 1,121.6 | 41,051.1 |
| Ag Open Space | Non-Federal | 1,245.1 | 2.31 | 0.901 | 32.9 | 2,875.9 | 1,212.6 | 41,051.1 |
| Double Cropped Land | Non-Federal | 188.1 | 12.54 | 0.031 | 185.1 | 2,359.0 | 5.8 | 34,833.0 |
| Full Season Soybeans | Non-Federal | 270.7 | 10.92 | 0.157 | 584.7 | 2,957.9 | 42.4 | 158,324.5 |
| Legume Hay | Non-Federal | 14.0 | 4.25 | 0.282 | 90.7 | 59.5 | 3.9 | 1,267.8 |
| Non-Permitted Feeding Space | Non-Federal | 15.5 | 6.70 | 0.379 | 2,331.0 | 104.1 | 5.9 | 36,157.2 |
| Other Agronomic Crops | Non-Federal | 348.4 | 7.34 | 0.330 | 614.3 | 2,558.3 | 114.8 | 214,074.7 |
| Other Hay | Non-Federal | 2,514.0 | 5.91 | 0.063 | 28.7 | 14,867.6 | 158.4 | 72,213.6 |
| Pasture | Non-Federal | 4,236.9 | 4.32 | 0.347 | 38.5 | 18,340.8 | 1,471.9 | 163,477.8 |
| Specialty Crop High | Non-Federal | 48.0 | 16.48 | 1.441 | 1,531.2 | 790.6 | 69.1 | 73,438.7 |
| Specialty Crop Low | Non-Federal | 195.5 | 4.15 | 1.777 | 2,187.2 | 812.5 | 347.3 | 427,606.1 |
| Total Agriculture | | 9,076.3 | | | | 45,726.1 | 3,341.2 | 1,222,444.4 |
| **Developed** | | | | | | | | |
| Buildings and Other | Non-Federal | 550.6 | 8.84 | 0.776 | 1,275.7 | 4,869.6 | 427.4 | 702,421.3 |
| Roads | Non-Federal | 342.6 | 11.19 | 0.934 | 1,275.7 | 3,834.4 | 320.0 | 437,115.7 |
| Tree Canopy over Impervious | Non-Federal | 318.0 | 10.20 | 0.845 | 841.9 | 3,244.4 | 268.8 | 267,742.6 |
| Tree Canopy over Turf Grass | Non-Federal | 753.0 | 4.60 | 1.167 | 279.3 | 3,466.2 | 878.6 | 210,381.4 |
| Turf Grass | Non-Federal | 2,958.8 | 6.04 | 1.541 | 423.5 | 17,880.5 | 4,558.7 | 1,253,147.6 |
| Regulated Construction | Non-Federal | 176.8 | 15.81 | 4.111 | 1,899.7 | 2,795.3 | 726.7 | 335,861.2 |
| Total Developed | | 5,099.8 | | | | 36,090.3 | 7,180.3 | 3,206,669.8 |

**Table 7-12: North Fork Goose Creek Watershed Annual Land Use Loading Rates and Annual Load Projections for 2025**

| Load Source | Agency | Acres | TN lb/acre | TP lb/acre | Sediment lb/acre | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|---|---|---|---|---|
| **Natural Areas** | | | | | | | | |
| Harvested Forest | Non-Federal | 175.2 | 4.07 | 0.115 | 138.7 | 713.6 | 20.2 | 24,312.8 |
| Headwater or Isolated Wetland | Non-Federal | 143.7 | 0.98 | 0.070 | 27.4 | 141.8 | 10.1 | 3,948.6 |
| Mixed Open | Non-Federal | 1,016.2 | 1.42 | 0.389 | 686.5 | 1,443.1 | 395.5 | 697,727.5 |
| Non-tidal Floodplain Wetland | Non-Federal | 327.2 | 0.98 | 0.070 | 27.4 | 322.8 | 23.0 | 8,965.8 |
| True Forest | Non-Federal | 12,252.3 | 0.98 | 0.070 | 27.4 | 12,086.9 | 861.7 | 336,814.3 |
| Water | Non-Federal | 353.5 | 7.36 | 0.606 | 0.0 | 2,603.1 | 214.2 | 0.0 |
| Total Natural Areas | | 14,268.1 | | | | 17,311.5 | 1,524.7 | 1,071,769.0 |
| Non-Federal Land Subtotal | | 28,444.2 | | | | 99,127.8 | 12,046.2 | 5,500,883.2 |
| **Federal Lands** | | | | | | | | |
| All land uses | National Park Service | 21.3 | | | | 21.6 | 1.7 | 925.2 |
| Total | | 28,465.6 | | | | 99,149.4 | 12,047.9 | 5,501,808.5 |

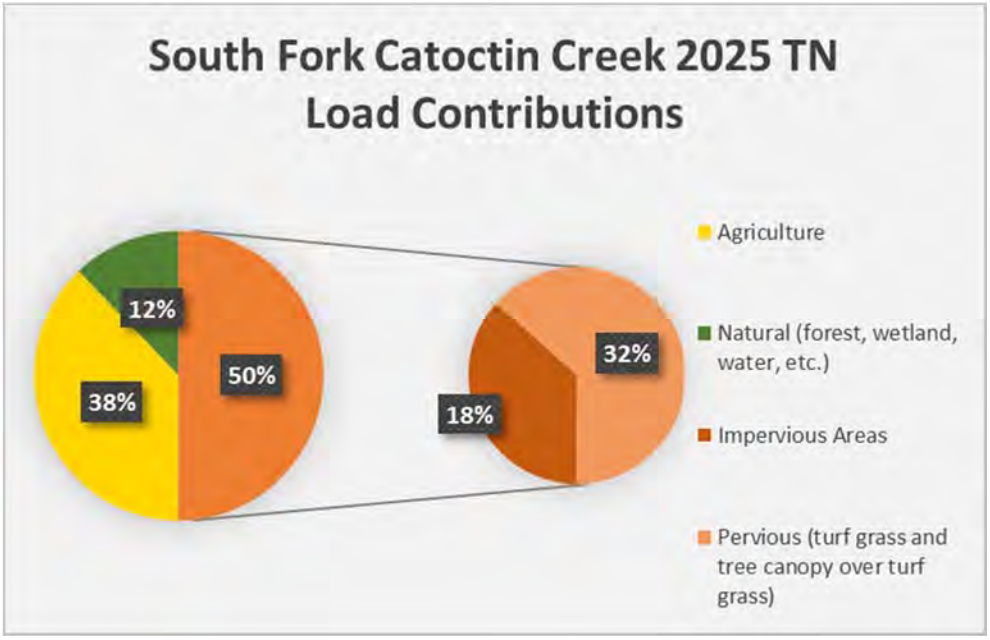


**Figure 7-18: South Fork Catoctin Creek subwatershed 2025 TN load contributions**

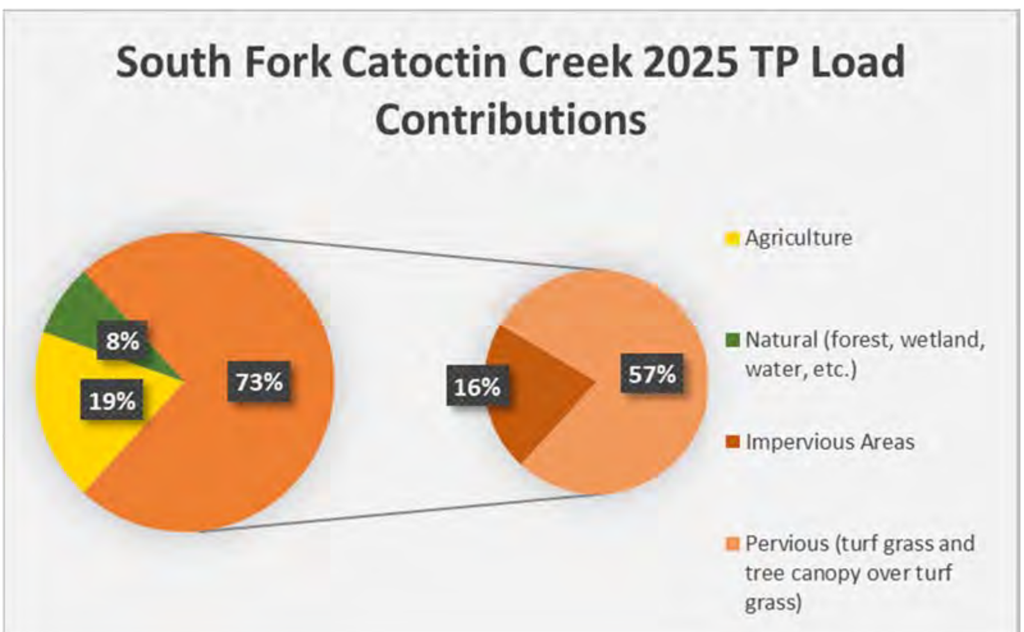


**Figure 7-19: South Fork Catoctin Creek subwatershed 2025 TP load contributions**

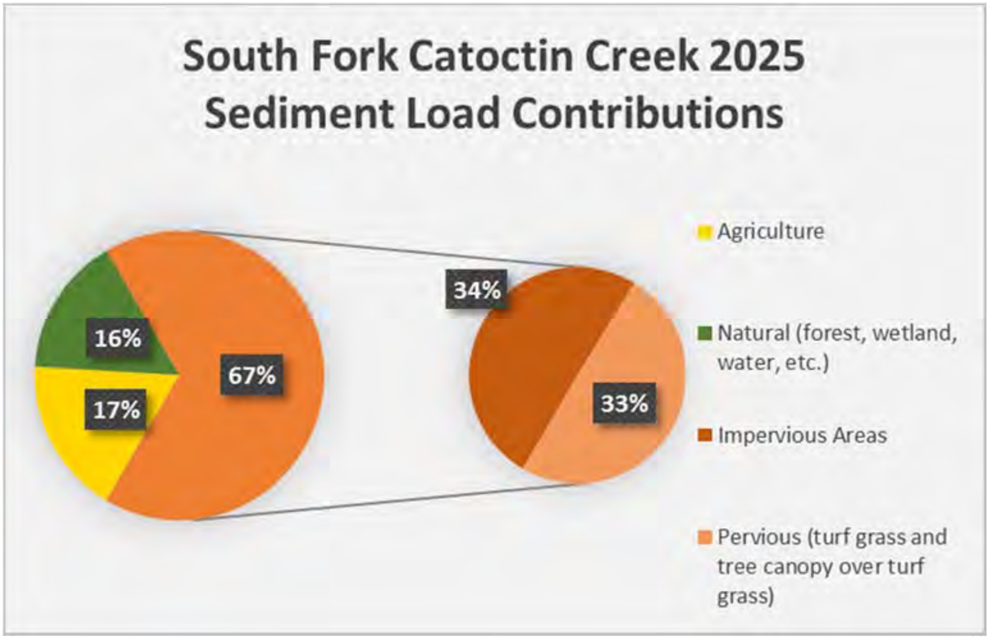


**Figure 7-20: South Fork Catoctin Creek subwatershed 2025 Sediment load contributions**

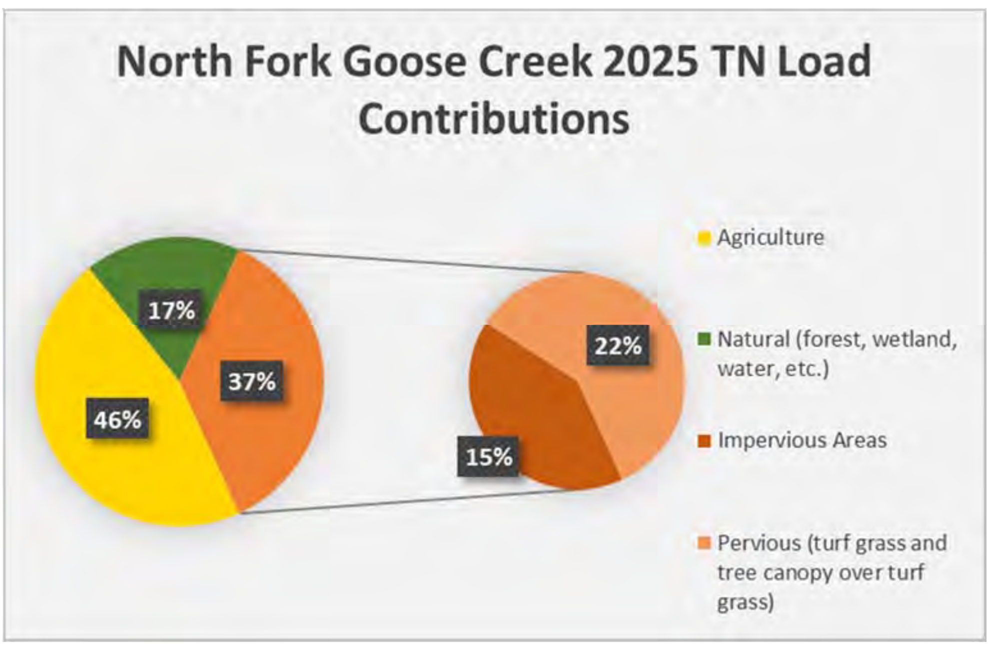


**Figure 7-21: North Fork Goose Creek watershed 2025 TN load contributions**

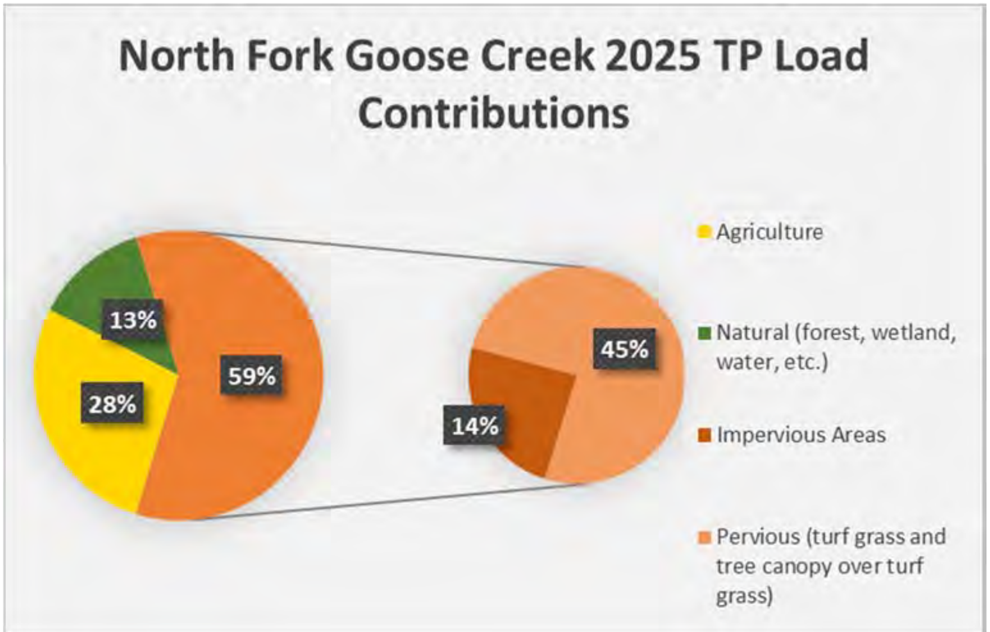


**Figure 7-22: North Fork Goose Creek watershed 2025 TP load contributions**

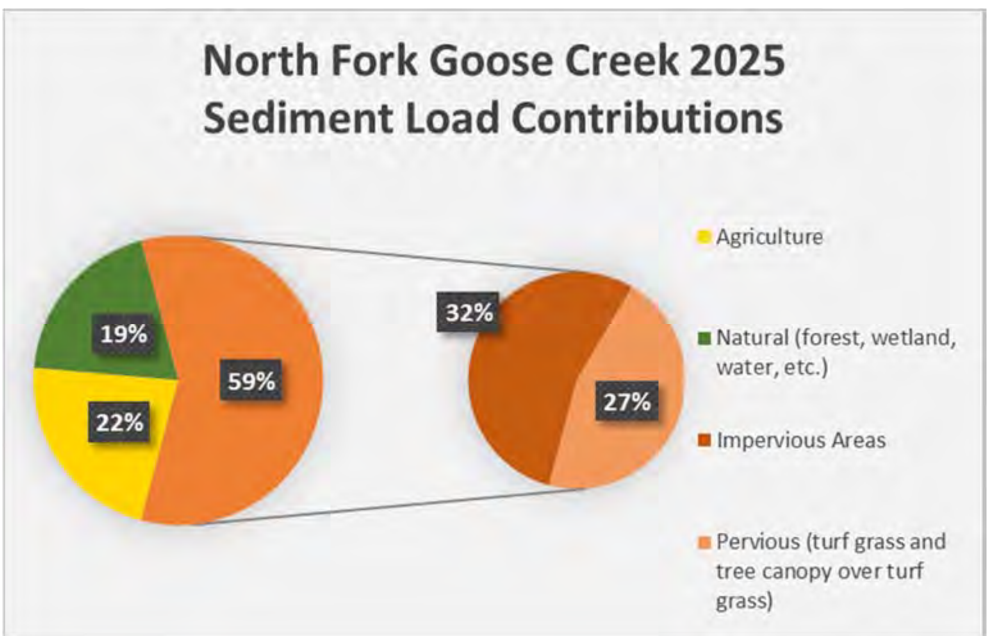


**Figure 7-23: North Fork Goose Creek watershed 2025 sediment load contributions**

**Table 7-13: Summary annual land use loading projections for Western Hills Watershed in 2025**

| Watershed Area | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|
| South Fork Catoctin Creek subwatershed | 106,587 | 12,674 | 4,760,357 |
| North Fork Goose Creek watershed | 99,128 | 12,046 | 5,500,883 |
| Total Non-Federal Load | 205,715 | 24,718 | 10,261,240 |
| Federal Loads | 109 | 7 | 3,267 |

### 7.6.2 Septic Systems and Stream Bed and Bank Erosion Loading

Since the breakdown of septic system distribution between the South Fork Catoctin Creek HUC12 and the South Fork Catoctin Creek subwatershed was not available for the 2025 projection, it was assumed that the proportion of septic systems remains the same as in the current conditions scenario (63 percent). The resulting 2025 projection of septic system counts and loading from CAST are presented in Table 7-14.

**Table 7-14: Septic counts, loading rates, and annual TN load projections for Western Hills Watershed in 2025.**

| Watershed | Systems | TN lbs/system | TN lb/yr |
|---|---|---|---|
| South Fork Catoctin Creek subwatershed | 1,765 | 8.358 | 14,745.7 |
| North Fork Goose Creek watershed | 4,325 | 9.054 | 39,154.8 |
| | | Total | 53,900.5 |

The length of stream was assumed to remain unchanged through time, so the length of streams in the current conditions scenario was applied to the 2025 scenario for the South Fork Catoctin Creek subwatershed. The length of stream in the North Fork Goose Creek watershed did not change between 2017 and 2025. The resulting 2025 projection of stream bed and bank erosion loading from CAST is presented in Table 7-15.

**Table 7-15: Stream bed and bank erosion loading rates and annual load projections for Western Hills Watershed in 2025**

| Watershed, Source | Miles | TN lb/mile | TP lb/mile | Sediment lb/mile | TN lb | TP lb | Sediment lb |
|---|---|---|---|---|---|---|---|
| South Fork Catoctin Creek subwatershed, non-federal | 46.3 | 275.5 | 87.5 | 201,858.2 | 12,768.6 | 4,053.6 | 9,355,298.1 |
| North Fork Goose Creek watershed, non-federal | 57.2 | 349.0 | 82.9 | 218,808.7 | 19,951.4 | 4,738.1 | 12,508,166.6 |
| | | | | Total | 32,720.1 | 8,791.7 | 21,863,464.73 |

### 7.6.3 Total Non-Federal Watershed Pollutant Loading

As shown in Table 7-16 and Figure **7-24** and Figure **7-26**, land use loading remains the primary contributor to TN and TP loading in the watershed, and stream bed and bank erosion is still the primary contributor to sediment loading.

**Table 7-16: Summary of annual watershed pollutant loading projections for Western Hills Watershed in 2025**

| South Fork Catoctin Creek Subwatershed | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|
| Land Use Loading | 106,587 | 12,674 | 4,760,357 |
| Septic Systems | 14,746 | 0 | 0 |
| Stream Bed and Banks | 12,769 | 4,054 | 9,355,298 |
| Total | 134,102 | 16,727 | 14,115,655 |
| **North Fork Goose Creek Watershed** | **TN lb/yr** | **TP lb/yr** | **Sediment lb/yr** |
| Land Use Loading | 99,128 | 12,046 | 5,500,883 |
| Septic Systems | 39,155 | 0 | 0 |
| Stream Bed and Banks | 19,951 | 4,738 | 12,508,167 |
| Total | 158,234 | 16,784 | 18,009,050 |

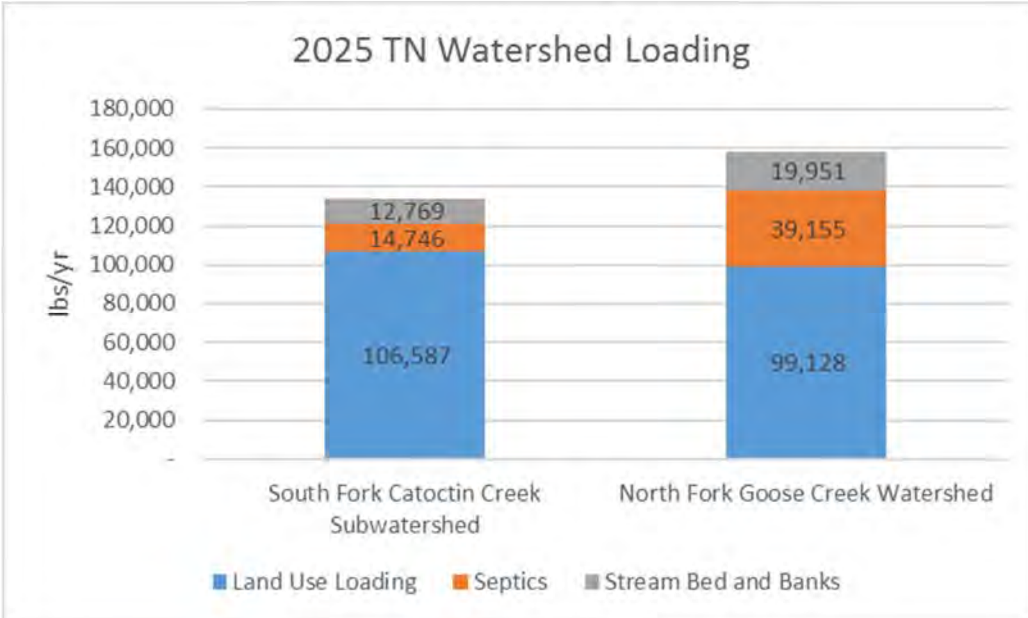


**Figure 7-24: Summary of 2025 annual TN loading (lbs/yr) in Western Hills Watershed**

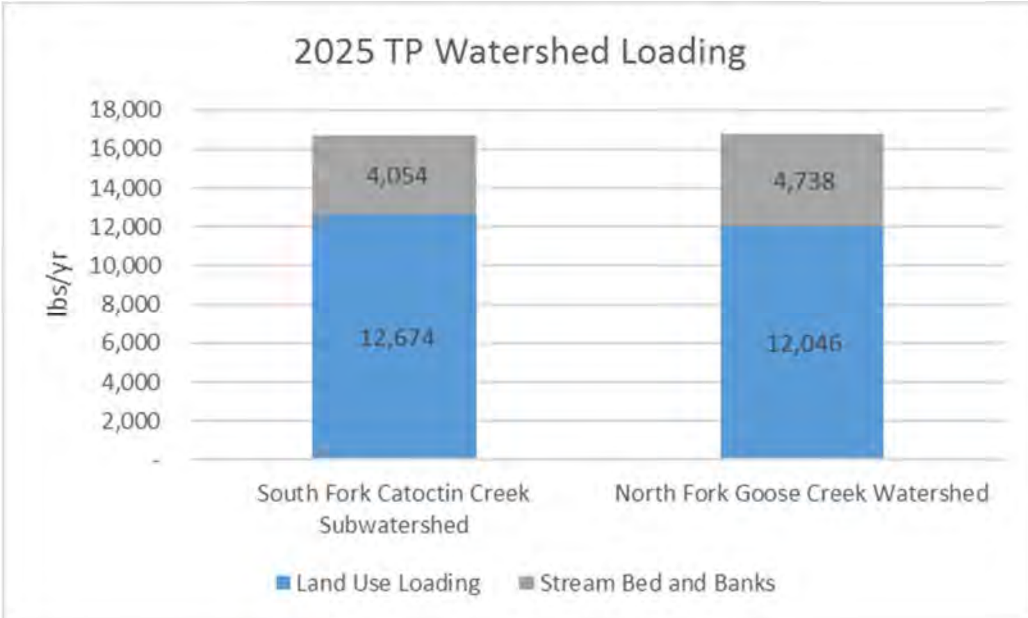


**Figure 7-25: Summary of 2025 annual TP loading (lbs/yr) in Western Hills Watershed**

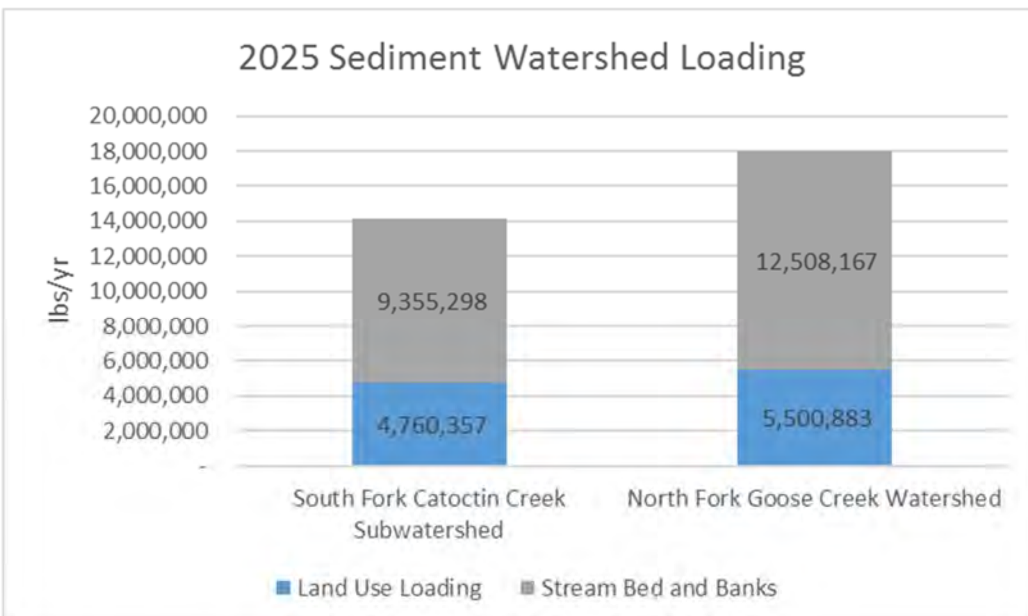


**Figure 7-26: Summary of 2025 annual sediment loading (lbs/yr) in Western Hills Watershed**

## 7.7 Comparison between 2017 and 2025 Loading and Loading Rates

### 7.7.1 Land Use Loading

It is useful to compare the land use and loading changes between the 2017 and the Phase II WIP 2025 scenarios. Agricultural land is assumed to be converted to pervious and impervious developed land as well as natural land uses. Some of the loading changes can be attributed to land use changes; however, there is also some degree of loading change that results from the additional BMPs that are assumed to be present in 2025. For example, even though agricultural land in the Western Hills Watershed is reduced by about 13 percent between 2017 and 2025, the TN load from this land use category is reduced by about 40 percent. The decreased land use loading rate is indicative of improved management of nutrients on agricultural lands. Conversely, impervious area increases by 15-18 percent but the TP load from impervious land increases by 50-65 percent. This is primarily due to a substantial projected increase in the construction land use, which has a much higher TP loading rate than other developed land uses. The CAST Phase II WIP scenario for 2025 may be misrepresenting the transition to developed land within the Western Hills Watershed, with only an additional 11 acres of impervious land in the South Fork Catoctin Creek subwatershed and 25 acres in the North Fork Goose Creek watershed predicted for the period between 2017 and 2025. Conversely, turf is predicted to increase by 235 acres and 421 acres, the South Fork Catoctin Creek subwatershed and North Fork Goose Creek watershed, respectively. Typical development patterns would suggest a higher proportion of impervious area as land is developed. Given the significant increase in regulated construction acres (226 acres and 161 acres in South Fork Catoctin Creek subwatershed and North Fork Goose Creek watershed, respectively), it may be that much of what will eventually be impervious developed land is being reflected as construction in the 2025 land use. The changes in land use and loadings are summarized in Table 7-17 and Table 7-18. Figure 7-27 through Figure 7-30 graphically illustrate the changing land uses and loadings.

**Table 7-17: South Fork Catoctin Creek subwatershed comparison of land use and loading differences, 2017 to 2025**

| South Fork Catoctin Creek Subwatershed | 2017 | 2025 | Difference | Percent Change |
|---|---|---|---|---|
| **Area (acres)** | | | | |
| Agriculture | 7,120.0 | 6,179.8 | -940.2 | -13.2% |
| Natural (forest, wetland, water, etc.) | 7,902.5 | 8,370.6 | 468.1 | 5.9% |
| Developed - Impervious Areas | 1,300.0 | 1,536.9 | 236.9 | 18.2% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 4,676.2 | 4,911.6 | 235.4 | 5.0% |
| **TN (lbs/yr)** | | | | |
| Agriculture | 70,854.1 | 40,308.9 | -30,545.2 | -43.1% |
| Natural (forest, wetland, water, etc.) | 11,993.6 | 12,902.1 | 908.5 | 7.6% |
| Developed - Impervious Areas | 16,441.8 | 19,514.3 | 3,072.6 | 18.7% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 36,921.2 | 33,861.9 | -3,059.3 | -8.3% |
| **TP (lbs/yr)** | | | | |
| Agriculture | 4,579.6 | 2,366.5 | -2,213.1 | -48.3% |
| Natural (forest, wetland, water, etc.) | 962.5 | 993.8 | 31.3 | 3.3% |
| Developed - Impervious Areas | 1,229.3 | 2,031.4 | 802.1 | 65.2% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 8,100.7 | 7,281.9 | -818.9 | -10.1% |
| **Sediment (lbs/yr)** | | | | |
| Agriculture | 2,602,890.2 | 833,198.1 | -1,769,692.1 | -68.0% |
| Natural (forest, wetland, water, etc.) | 737,469.1 | 745,347.9 | 7,878.7 | 1.1% |
| Developed - Impervious Areas | 1,484,146.9 | 1,601,630.8 | 117,483.9 | 7.9% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 1,854,650.1 | 1,580,179.9 | -274,470.2 | -14.8% |

**Table 7-18: North Fork Goose Creek watershed comparison of land use and loading differences, 2017 to 2025**

| North Fork Goose Creek Watershed | 2017 | 2025 | Difference | Percent Change |
|---|---|---|---|---|
| **Area (acres)** | | | | |
| Agriculture | 10,401.2 | 9,076.3 | -1,324.9 | -12.7% |
| Natural (forest, wetland, water, etc.) | 13,550.7 | 14,268.1 | 717.4 | 5.3% |
| Developed - Impervious Areas | 1,201.9 | 1,388.0 | 186.1 | 15.5% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 3,290.5 | 3,711.8 | 421.4 | 12.8% |
| **TN (lbs/yr)** | | | | |
| Agriculture | 73,623.7 | 45,726.1 | -27,897.6 | -37.9% |
| Natural (forest, wetland, water, etc.) | 16,178.0 | 17,311.5 | 1,133.4 | 7.0% |
| Developed - Impervious Areas | 12,885.8 | 14,743.7 | 1,857.8 | 14.4% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 21,515.1 | 21,346.6 | -168.5 | -0.8% |
| **TP (lbs/yr)** | | | | |
| Agriculture | 4,856.1 | 3,341.2 | -1,514.9 | -31.2% |
| Natural (forest, wetland, water, etc.) | 1,474.5 | 1,524.7 | 50.1 | 3.4% |
| Developed - Impervious Areas | 1,171.2 | 1,742.9 | 571.8 | 48.8% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 5,557.4 | 5,437.3 | -120.1 | -2.2% |
| **Sediment (lbs/yr)** | | | | |
| Agriculture | 3,005,996.0 | 1,222,444.4 | -1,783,551.7 | -59.3% |
| Natural (forest, wetland, water, etc.) | 1,050,800.0 | 1,071,769.0 | 20,969.1 | 2.0% |
| Developed - Impervious Areas | 1,695,519.2 | 1,743,140.9 | 47,621.6 | 2.8% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 1,574,154.0 | 1,463,529.0 | -110,625.0 | -7.0% |

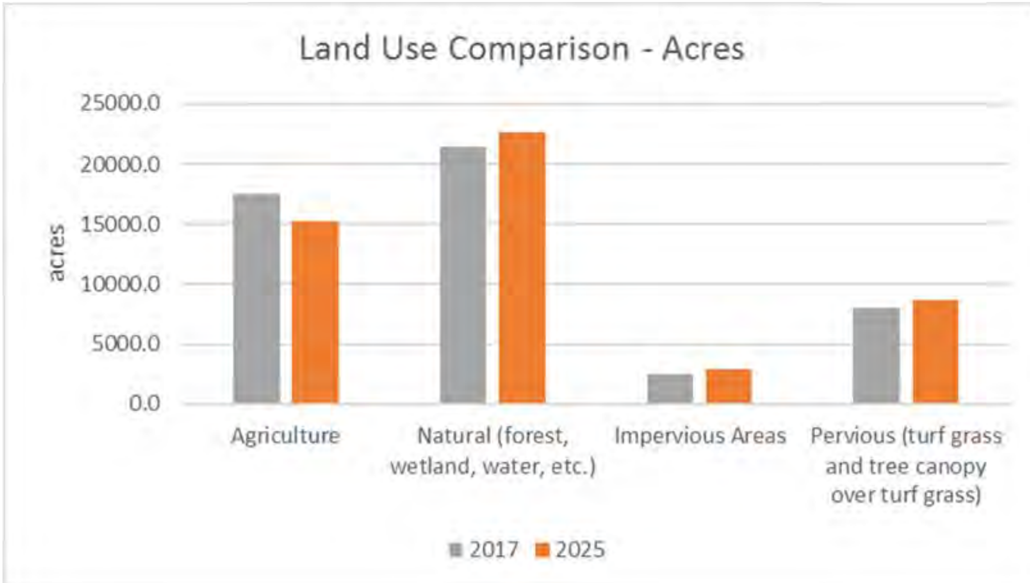


**Figure 7-27: Comparison of 2017 and projected 2025 land uses in the Western Hills Watershed**

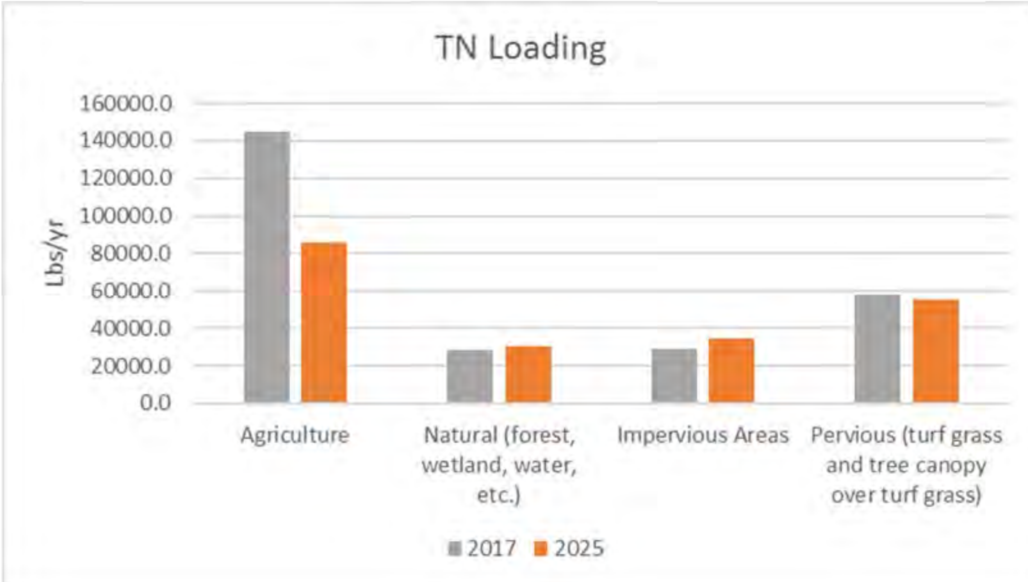


**Figure 7-28: Comparison of 2017 and 2025 projected TN (lbs/yr) land use loading in the Western Hills Watershed**

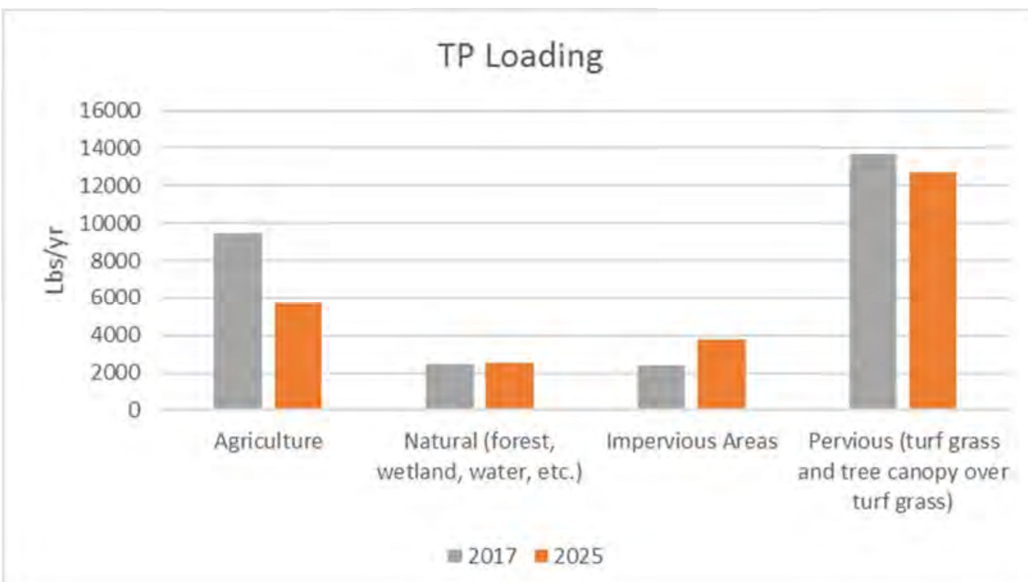


**Figure 7-29: Comparison of 2017 and 2025 projected TP (lbs/yr) land use loading in the Western Hills Watershed**

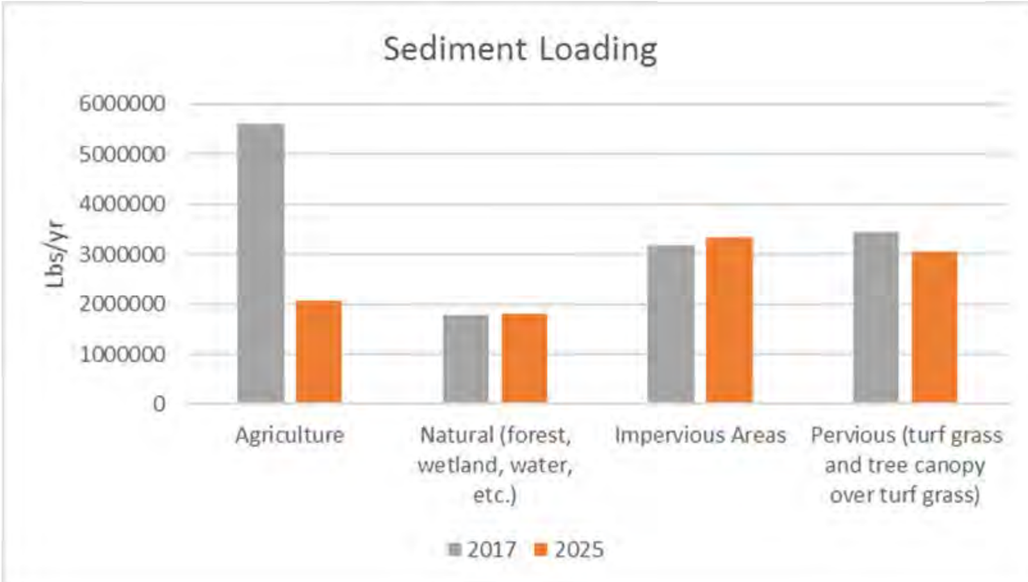


**Figure 7-30: Comparison of 2017 and 2025 projected sediment (lbs/yr) land use loading in the Western Hills Watershed**

### 7.7.2 Septic Systems and Nitrogen Loading

As shown in Table 7-19, while there is a moderate increase in septic systems projected for the South Fork Catoctin Creek subwatershed, there is a substantial increase projected for the North Fork Goose Creek watershed. In the South Fork Catoctin Creek subwatershed, the TN loading still goes down despite the increased number of systems because BMPs are anticipated to be implemented at high enough rates to significantly lower the overall contribution from these systems. In the North Fork Goose Creek watershed, lower rates of septic system BMP implementation and septic connections to sanitary sewer systems are reflected in the BMPs included in the Phase II WIP 2025 scenario, which causes the septic system loading to increase by 63 percent from 2017 to 2025. The result is that about a quarter of the TN load for the North Fork Goose Creek watershed can be attributed to septic system loading in 2025.

**Table 7-19: Summary of septic systems in 2017 and 2025 and associated loading**

| | 2017 Number of Systems | 2025 Number of Systems | Difference in Number of Systems | 2017 TN lbs/yr | 2025 TN lbs/yr | Load Difference lbs/yr |
|---|---|---|---|---|---|---|
| South Fork Catoctin Creek Subwatershed | 1,664 | 1,765 | 101 | 15,168.1 | 14,745.7 | -422.4 |
| North Fork Goose Creek Watershed | 2,402 | 4,325 | 1,922 | 24,070.5 | 39,154.8 | 15,084.3 |

### 7.7.3 Stream Beds and Bank Loading

Stream length does not change between 2017 and 2025, so loading changes can be attributed to stream restoration and impacts from upland land uses and BMPs applied to those land uses. Changes in loading between 2017 and 2025 are presented in Table 7-20.

**Table 7-20: Comparison of stream bed and bank loading between 2017 and 2025**

| | | TN lbs/yr | TP lbs/yr | Sediment lbs/yr |
|---|---|---|---|---|
| South Fork Catoctin Creek Subwatershed | 2017 | 15,991.7 | 4,768.7 | 13,564,929.2 |
| | 2025 | 12,768.6 | 4,053.6 | 9,355,298.1 |
| Difference | | -3,223.0 | -715.1 | -4,209,631.1 |
| North Fork Goose Creek Watershed | 2017 | 20,144.1 | 4,832.2 | 16,200,815.4 |
| | 2025 | 19,951.4 | 4,738.1 | 12,508,166.6 |
| Difference | | -192.7 | -94.1 | -3,692,648.8 |

## 7.8 Loading Projections Using 2017 BMP Implementation on 2025 Land Uses

### 7.8.1 Land Use Loading, 2017 BMP Implementation on 2025 Land Uses

In addition to comparing the loads between 2017 progress and 2025 Phase II WIP implementation, it can be useful to compare loads if no additional action is taken beyond current implementation. A scenario was created in CAST to apply the BMPs implemented in 2017 on the land uses projected for 2025. As shown in Table 7-21 and Table 7-22, without applying additional BMPs moving forward, loading will be significantly higher than the targets set in the Phase II WIP. Relevant BMP strategies that are missing when reviewing the loading in 2025 with only BMPs in place in 2017 include a continued effort to retrofit existing urban practices as well as implementation of new BMPs on newly developed land. In addition, some agricultural land conversion to natural land uses through wetland restoration and creation, forest buffers and tree plantings is not included in the 2017 BMP implementation on 2025 land uses scenario.

**Table 7-21: Comparison of 2025 Phase II WIP Scenario with 2025 Land Uses with 2017 BMP Implementation in South Fork Catoctin Creek subwatershed**

| South Fork Catoctin Creek Subwatershed | 2025 with 2017 BMPs | 2025 Phase II WIP | Difference | Percent Difference from 2025 WIP |
|---|---|---|---|---|
| **Area (acres)** | | | | |
| Agriculture | 6,732.4 | 6,179.8 | 552.6 | 8.9% |
| Natural (forest, wetland, water, etc.) | 7,813.7 | 8,370.6 | -557.0 | -6.7% |
| Developed - Impervious Areas | 1,583.2 | 1,536.9 | 46.3 | 3.0% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 4,869.9 | 4,911.6 | -41.7 | -0.8% |
| Total | 20,999.1 | 20,998.9 | 0.2 | |
| **TN lbs/yr** | | | | |
| Agriculture | 64,460.5 | 40,308.9 | 24,151.5 | 59.9% |
| Natural (forest, wetland, water, etc.) | 12,440.0 | 12,902.1 | -462.1 | -3.6% |
| Developed - Impervious Areas | 21,398.1 | 19,514.3 | 1,883.7 | 9.7% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 38,546.1 | 33,861.9 | 4,684.3 | 13.8% |
| Total | 136,844.7 | 106,587.2 | 30,257.4 | 30.6% |
| **TP lbs/yr** | | | | |
| Agriculture | 4,060.7 | 2,366.5 | 1,694.2 | 71.6% |
| Natural (forest, wetland, water, etc.) | 961.5 | 993.8 | -32.3 | -3.2% |
| Developed - Impervious Areas | 2,210.6 | 2,031.4 | 179.2 | 8.8% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 8,458.7 | 7,281.9 | 1,176.8 | 16.2% |
| Total | 15,691.6 | 12,673.5 | 3,018.0 | 29.9% |
| **Sediment lbs/yr** | | | | |
| Agriculture | 2,285,987.7 | 833,198.1 | 1,452,789.7 | 174.4% |
| Natural (forest, wetland, water, etc.) | 739,373.5 | 745,347.9 | -5,974.4 | -0.8% |
| Developed - Impervious Areas | 2,862,177.1 | 1,601,630.8 | 1,260,546.3 | 78.7% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 1,938,296.7 | 1,580,179.9 | 358,116.8 | 22.7% |
| Total | 7,825,835.0 | 4,760,356.7 | 3,065,478.4 | 72.1% |

**Table 7-22: Comparison of 2025 Phase II WIP Scenario with 2025 Land Uses with 2017 BMP Implementation in North Fork Goose Creek watershed**

| North Fork Catoctin Creek Subwatershed | 2025 with 2017 BMPs | 2025 Phase II WIP | Difference | % Difference from 2025 WIP |
|---|---|---|---|---|
| Area (acres) | | | | |
| Agriculture | 9,905.1 | 9,076.3 | 828.8 | -9.1% |
| Natural (forest, wetland, water, etc.) | 13,423.0 | 14,268.1 | -845.2 | 5.9% |
| Developed - Impervious Areas | 1,434.9 | 1,388.0 | 46.9 | -3.4% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 3,681.3 | 3,711.8 | -30.5 | 0.8% |
| Total | 28,444.2 | 28,444.2 | 0.0 | |
| **TN lbs/yr** | | | | |
| Agriculture | 68,155.1 | 45,726.1 | 22,429.0 | -49.1% |
| Natural (forest, wetland, water, etc.) | 16,850.0 | 17,311.5 | -461.4 | 2.7% |
| Developed - Impervious Areas | 16,210.0 | 14,743.7 | 1,466.3 | -9.9% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 24,183.2 | 21,346.6 | 2,836.6 | -13.3% |
| Total | 125,398.3 | 99,127.8 | 26,270.4 | 26.5 |
| **TP lbs/yr** | | | | |
| Agriculture | 4,230.8 | 3,341.2 | 889.5 | -26.6% |
| Natural (forest, wetland, water, etc.) | 1,480.0 | 1,524.7 | -44.7 | 2.9% |
| Developed - Impervious Areas | 1,902.5 | 1,742.9 | 159.6 | -9.2% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 6,252.2 | 5,437.3 | 814.8 | -15.0% |
| Total | 13,865.4 | 12,046.2 | 1,819.3 | 15.1 |
| **Sediment lbs/yr** | | | | |
| Agriculture | 2,672,264.2 | 1,222,444.4 | 1,449,819.8 | -118.6% |
| Natural (forest, wetland, water, etc.) | 1,066,290.2 | 1,071,769.0 | -5,478.9 | 0.5% |
| Developed - Impervious Areas | 2,922,017.3 | 1,743,140.9 | 1,178,876.5 | -67.6% |
| Developed - Pervious (turf grass and tree canopy over turf grass) | 1,775,100.3 | 1,463,529.0 | 311,571.3 | -21.3% |
| Total | 8,435,671.9 | 5,500,883.2 | 2,934,788.7 | 53.4% |

Comparison among the 2017 land use and loading, 2025 land use with 2017 BMPs, and the 2025 land use and BMPs in the Phase II WIP is presented in Figure 7-31 through Figure 7-34. As shown, without additional implementation beyond what have been completed to date, the Phase II WIP loading targets will not be achieved. In some instances, land use loading in 2025 will exceed 2017 loads if additional BMPs are not implemented, as illustrated by the developed land use loads for all three pollutants. The total acreage of developed land will increase as a result of continued development in the County, but without additional BMPs to address these changing pollutant sources, developed land loading will continue to increase.

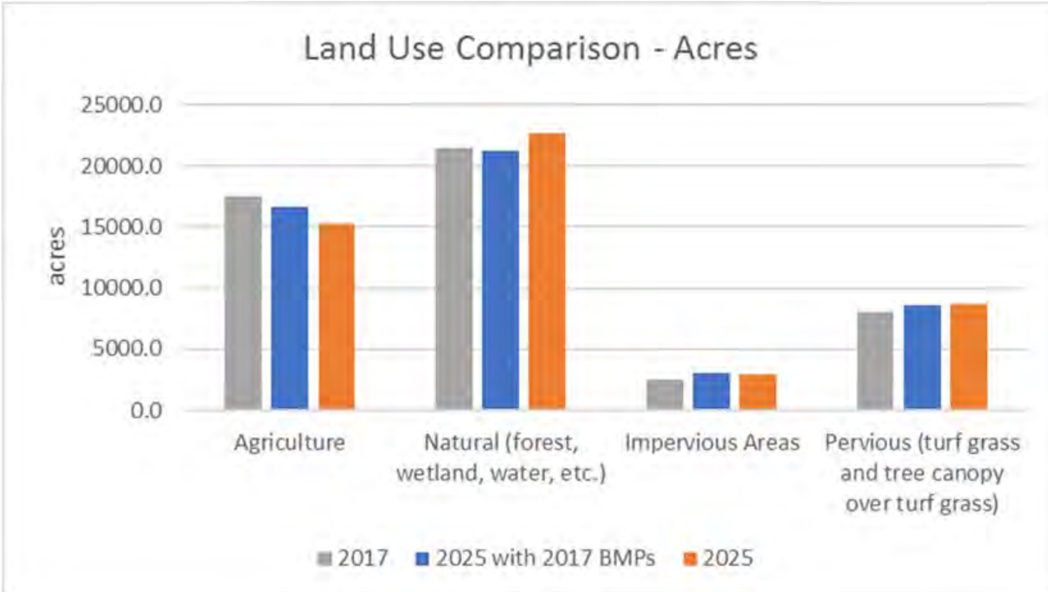


**Figure 7-31: Land use comparison across scenarios for the Western Hills Watershed**

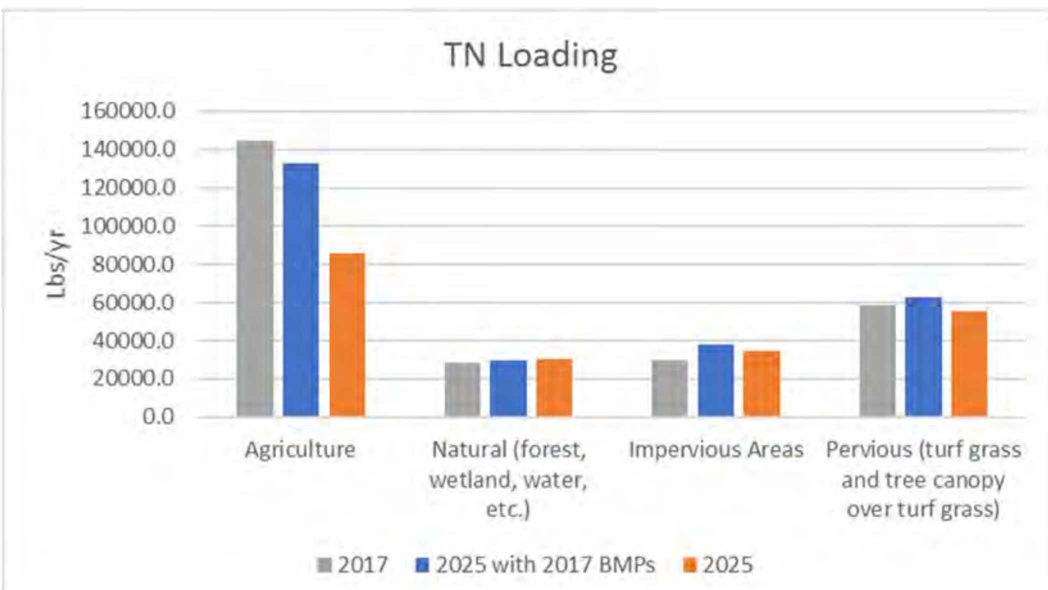


**Figure 7-32: TN loading (lb/yr) comparison across scenarios for the Western Hills Watershed**

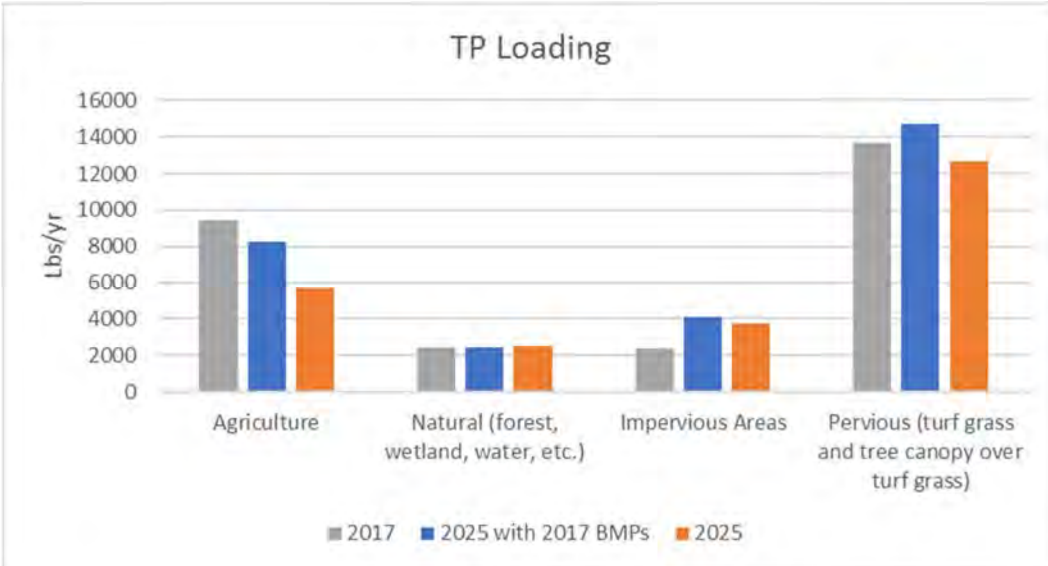


**Figure 7-33: TP loading (lb/yr) comparison across scenarios for the Western Hills Watershed**

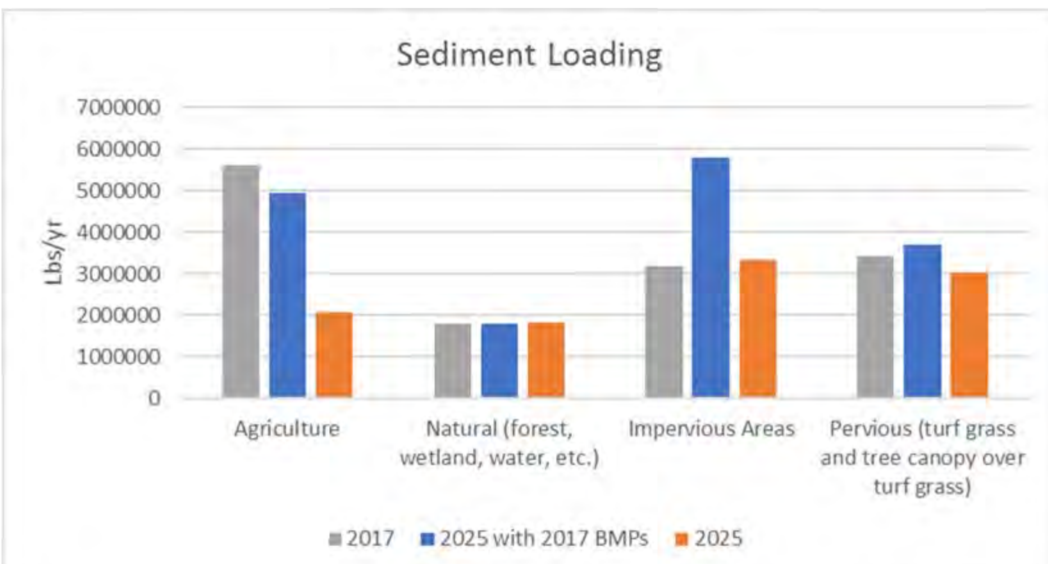


**Figure 7-34: Sediment loading (lb/yr) comparison across scenarios for the Western Hills Watershed**

### 7.8.2 Septic System and Stream Bed and Bank Loading, 2017 BMP Implementation on 2025 Land Uses

Table 7-23 and Figure 7-35 and Figure 7-36 show that without intervention to connect some existing and future systems to the sanitary sewer system, both the number of septic systems and the overall load will increase beyond 2017 levels and not meet the 2025 Phase II WIP targets. Table 7-24 and Figure 7-37 through Figure 7-40 show a similar pattern for stream bed and bank loading. Higher loads from this source result from less stream restoration and higher upland loading as a result of fewer BMPs being implemented.

**Table 7-23: Comparison of Septic System Loading between 2025 Phase II WIP Scenario with 2025 Land Uses with 2017 BMP Implementation**

| | 2025 with 2017 BMPs | 2025 systems | System Difference | 2025 with 2017 BMPs TN lbs/yr | 2025 TN lbs/yr | Load Difference lbs/yr |
|---|---|---|---|---|---|---|
| South Fork Catoctin Creek Subwatershed | 1,944 | 1,765 | 187 | 17,911.2 | 14,745.7 | 3,165.4 |
| North Fork Goose Creek Watershed | 4,765 | 4,325 | 440 | 48,000.6 | 39,154.8 | 8,845.8 |

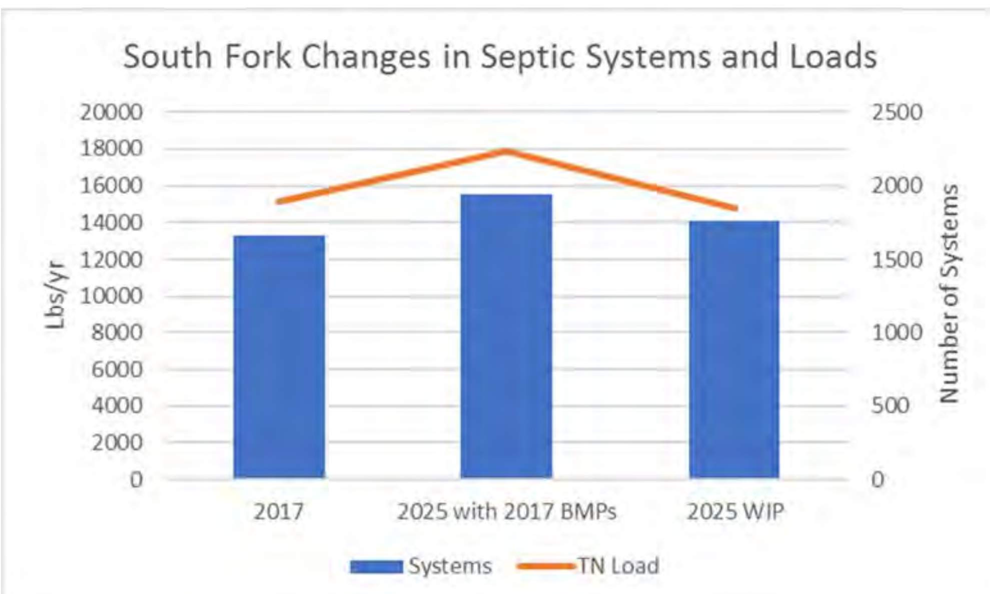


**Figure 7-35: Comparison of the number of septic systems and resulting TN loading (lb/yr) under three land use and loading scenarios in the South Fork Catoctin Creek subwatershed**

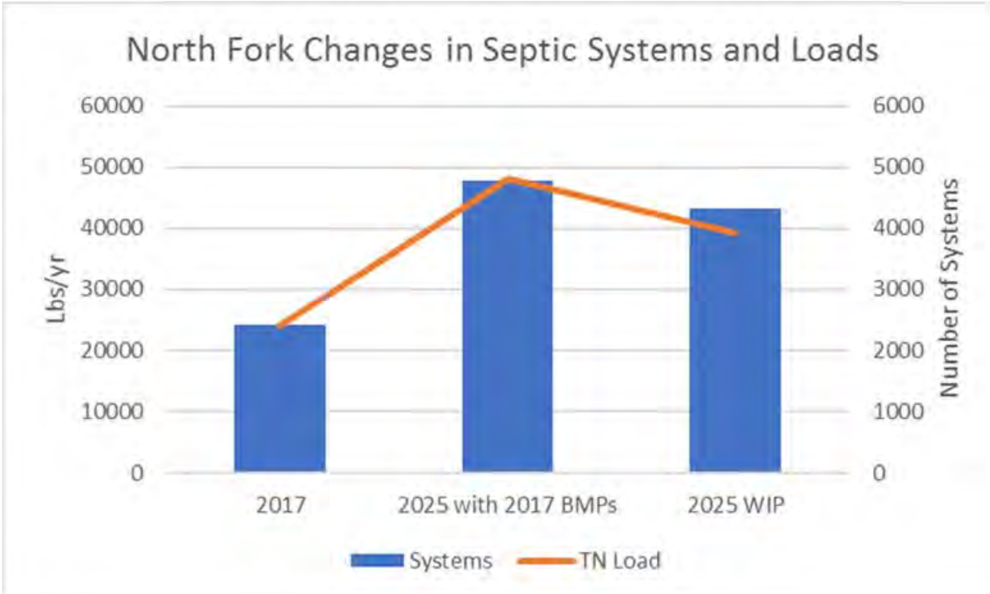


**Figure 7-36.: Comparison of the number of septic systems and resulting TP loading (lb/yr) under three land use and loading scenarios in the North Fork Goose Creek watershed**

**Table 7-24: Comparison of stream bed and bank loads between 2025 Phase II WIP Scenario with 2025 Land Uses with 2017 BMP Implementation**

| | | TN lbs/yr | TP lbs/yr | Sediment lbs/yr |
|---|---|---|---|---|
| South Fork Catoctin Creek Subwatershed | 2025 with 2017 BMPs | 16,239.4 | 4,973.0 | 15,372,974.7 |
| | 2025 | 12,768.6 | 4,053.6 | 9,355,298.1 |
| Difference | | 3,470.8 | 919.3 | 6,017,676.6 |
| North Fork Goose Creek Watershed | 2025 with 2017 BMPs | 23,464.5 | 5,120.6 | 18,541,392.1 |
| | 2025 | 19,951.4 | 4,738.1 | 12,508,166.6 |
| Difference | | 3,513.1 | 382.5 | 6,033,225.5 |

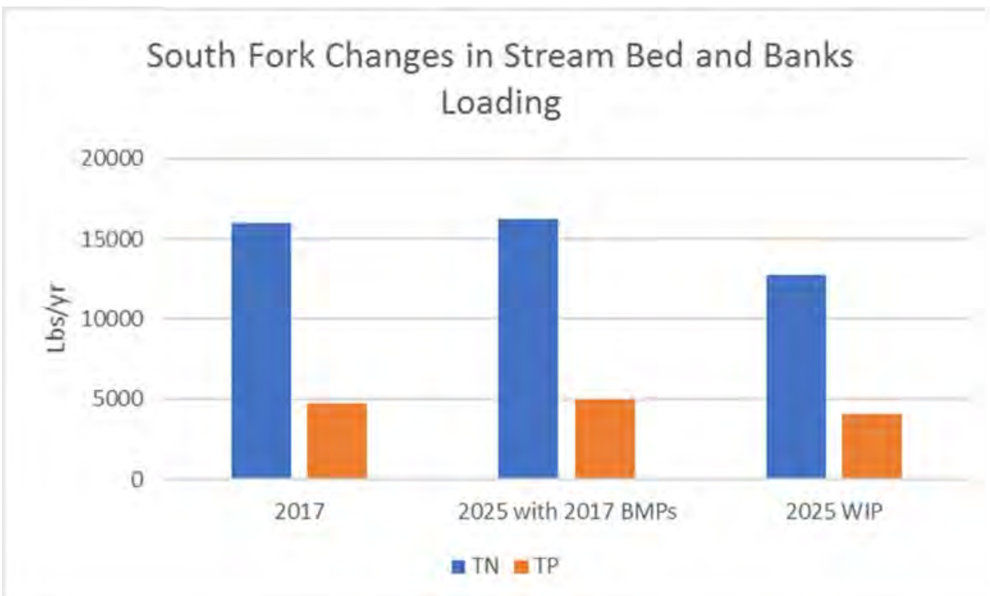


**Figure 7-37: Comparison of the stream bed and bank TN and TP loading (lb/yr) under three scenarios in the South Fork Catoctin Creek subwatershed**

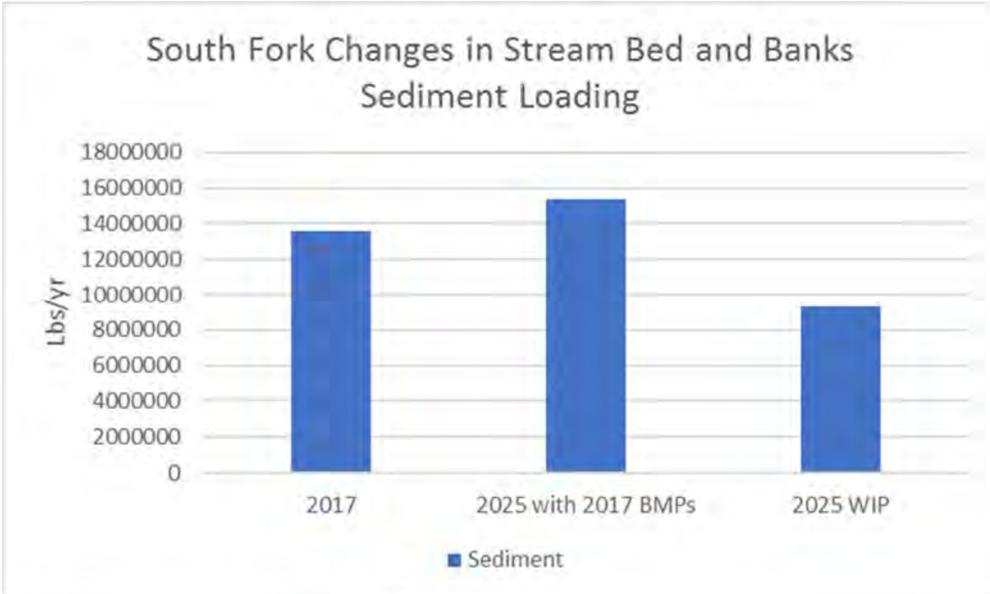


**Figure 7-38: Comparison of the stream bed and bank sediment loading (lb/yr) under three scenarios in the South Fork Catoctin Creek subwatershed**

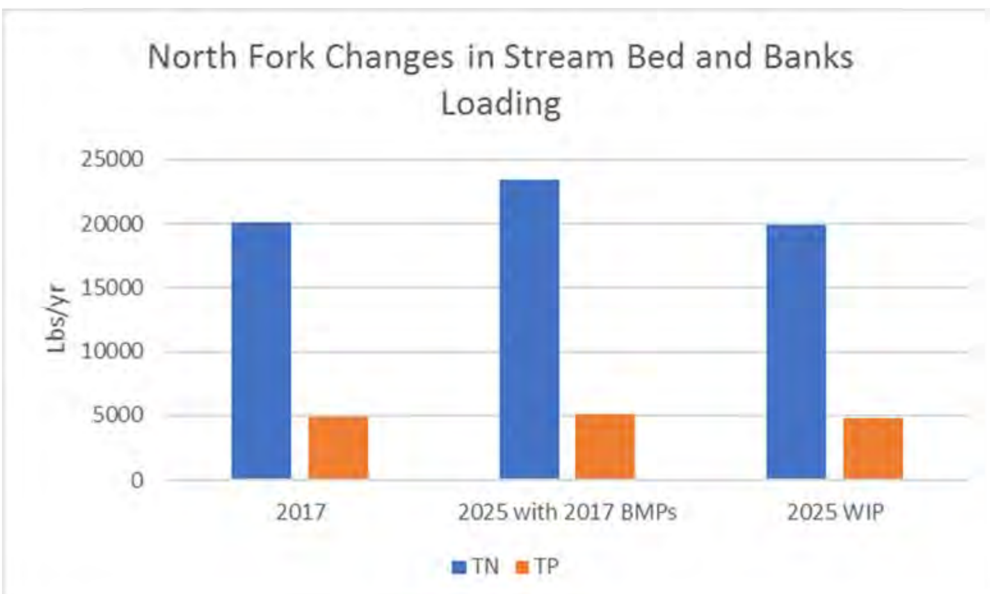


**Figure 7-39: Comparison of the stream bed and bank TN and TP loading (lb/yr) under three scenarios in the North Fork Goose Creek watershed**

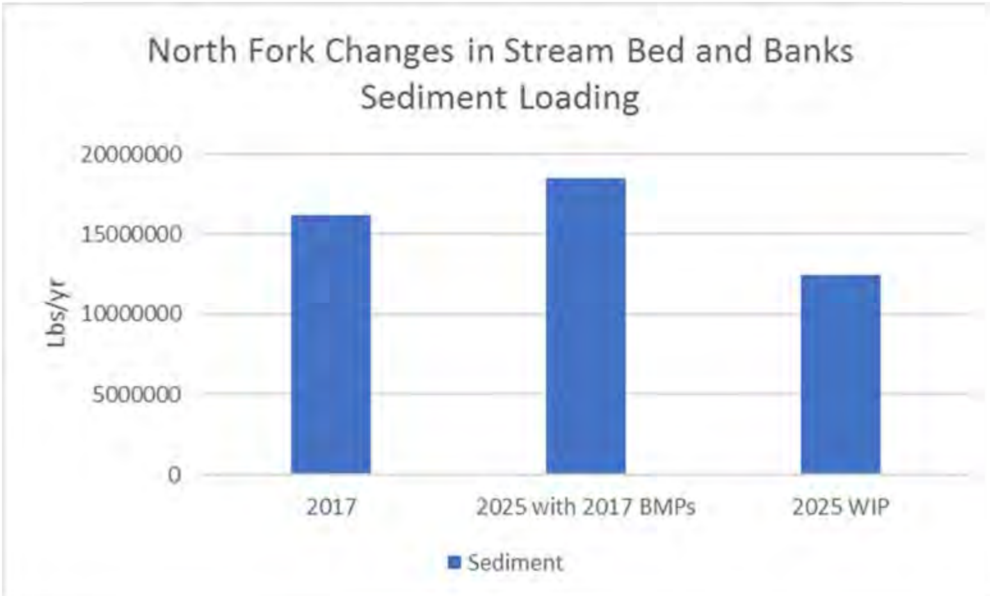


**Figure 7-40: Comparison of the stream bed and bank sediment loading (lb/yr) under three scenarios in the North Fork Goose Creek watershed**

## 7.9 Future Land Use and Pollutant Load Changes

The Western Hills Watershed is rapidly developing, transitioning from a predominantly rural area to a more suburban area with large subdivisions and commercial areas. As the area develops, pollutant loads will transition from agricultural sources to developed land sources. In addition, relatively low loading natural land uses, like forests, will be converted to higher loading developed land uses, like turf grass. On average agriculture and developed land have similar nitrogen loading rates, but developed lands have phosphorus loading that is 3 times higher than agriculture. The largest contributors to high phosphorus loading rates are turf grass and development-related construction. Sediment loading rates from impervious surfaces and construction are also higher than sediment loading rates from natural and most agricultural land uses.

While nitrogen loading may decrease slightly, if development continues with the current level of stormwater management, phosphorus loading could increase by up to 6,000 pounds per year, with a 60 percent increase in developed lands (approximately 6,000 acres) by 2045. Sediment loads could increase by over 1,800,000 pounds under this same scenario. These phosphorus and sediment increases are likely an underestimate of the pollutant load increase, as they assume that all developed land will be converted from agricultural land uses. If forests are developed, the phosphorus and sediment load increases will be substantially higher, and nitrogen loads will increase as well. From a BMP costing perspective, the average annual cost to treat a pound of nitrogen is $2,393 and the average annual cost to treat a pound of phosphorus is $23,122[4]. Moving forward, the contribution of future development to pollutant loading needs to be considered when developing strategies to address nutrients in the watershed.

[4] Devereux, O. 2018. Cost Effectiveness of BMPs. https://cast.chesapeakebay.net/Documentation/DevelopPlans

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# CHAPTER 8: SUBWATERSHED RESTORATION STRATEGIES

Restoration strategies for each of the five major subwatersheds in the Western Hills Watershed are presented in the following subsections. A description of key watershed characteristics is presented for each subwatershed including drainage area, stream length, population, land use/land cover, impervious cover, soils, and extent of treatment by stormwater control measures (SCMs). Assessment results for neighborhoods, hotspots, institutions, tree planting opportunities, stream corridors (including potential stream restoration), stormwater conversions, and potential new stormwater control facilities are also summarized for each subwatershed. A subwatershed management strategy including recommended community and municipal actions is presented at the end of each subsection. Following the individual subwatershed summaries, a ranking of the five subwatersheds based on a series of factors is presented for potential use in setting priorities for watershed management.

Some recommended practices are applicable across all subwatersheds; the first of these is related to turf grass. As seen in recent land use data, turf grass makes up a significant percentage of land use across the Western Hills Watershed and contributes considerably to pollutant loads (see Chapter 7). This contribution is likely to increase even more in the future, as residential and commercial development continues to grow. Therefore, reducing the pollutant load from mowed lawns has great potential to influence stream quality within the Western Hills Watershed. There are a number of practices that can lower the time and cost of lawn maintenance while also reducing pollution to nearby streams. Planting trees can substantially reduce nutrient and sediment runoff. Another option is to transform mowed areas into low maintenance, sustainable landscapes meant to capture and filter rainwater and impervious runoff. If sustainable landscaping is not the preferred option for a landowner, we recommend that homeowners consider lawn care practices such as the elimination of fertilizer use, mulching grass instead of bagging for curbside pickup, and adjusting mower blade settings for a taller cut to allow the development of deeper grass root systems.

Trees also provide other benefits such as providing shade that can reduce home heating and cooling costs (Nowak et al. 2017). According to the U.S. Forest Service, trees planted strategically around buildings can reduce air conditioning costs by 30 percent and can reduce heating energy requirements by 20–50 percent. In addition, the presence of healthy, mature trees can add an average of 10 percent to property values (USDA Forest Service, as cited in Arbor Day Foundation 2019).

In agricultural pastures and cropland, as well as residential areas, maintaining a vegetated buffer in the area surrounding streams is important to sustaining a healthy stream ecosystem. Streamside vegetation serves as a filter for runoff and pollutants, as well as providing shade that keeps stream temperatures cool and leaf litter inputs that feed the aquatic food web. Vegetation cover in riparian buffers can be improved through the installation of fences in pasture areas to keep livestock from wading in streams, trampling bank vegetation, and depositing manure or other nutrients that ultimately flow downstream. Planting or encouraging the growth of native vegetation to enhance buffers currently less than 50 feet wide will have a positive impact on stream health.

Maintaining the quantity and quality of groundwater resources is another example of issues that cut across subwatershed boundaries. Some of the SCM recommendations made for improving stormwater management through longer retention times and infiltration can also contribute to greater groundwater recharge. In addition, many recommended practices that can protect water quality and prevent contamination of both surface waters and groundwater. For example, the Town of Purcellville has developed and regularly updates a Source Water Protection Plan that provides recommendations to protect the quality of the Town's drinking water sources (e.g., Tetra Tech 2014). Many of that plan's recommendations for source water protection are also applicable to protecting watershed and stream health across the entire Western Hills Watershed. Examples include:

- water conservation;
- proper maintenance of private septic systems;
- avoiding petroleum spills during heating oil delivery and ensuring that oil tanks do not leak;
- avoiding excessive application of fertilizers and pesticides;
- proper handling of materials such as oils, paints, and cleaning agents to reduce the potential for these materials to be washed into local waterways in stormwater runoff; and
- proper disposal of pharmaceuticals and personal care products.

Results of the stream and upland surveys conducted in the Western Hills Watershed were used to develop the recommended strategies outlined below, with a series of potential actions organized by subwatershed. Note that in many cases, similar recommendations will likely be applicable to other areas throughout the entire watershed. Recommendations that refer to specific site locations are offered as examples of the types of practices that can be implemented, in similar situations across the Western Hills Watershed. For example, the 15 representative neighborhoods assessed using Neighborhood Source Assessment methods, as described in Chapter 4, are shown in Figure 8-1. Observations made within those specific neighborhoods were used to develop watershed management recommendations that may be of interest to local residents and community groups in those areas. However, the specific recommendations made for these example neighborhoods are also likely to apply more broadly to other, similar residential neighborhoods throughout the Western Hills Watershed. Actions such as cleaning up pet waste can be undertaken by many people and can contribute significantly to maintaining healthy streams.

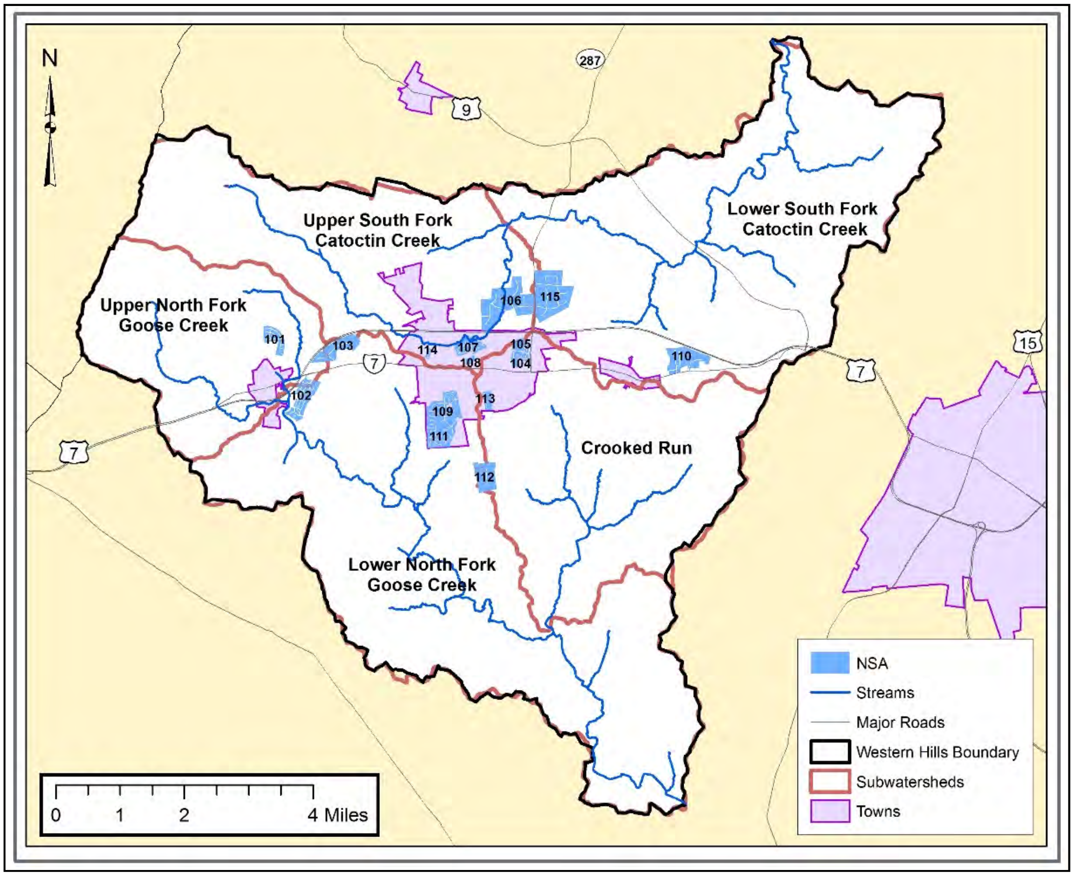


**Figure 8-1: Location and Site IDs of Neighborhood Source Assessment (NSA) Areas in Western Hills Watershed**

## 8.1 Upper South Fork Catoctin Creek

Upper South Fork Catoctin Creek is the second smallest subwatershed in the Western Hills Watershed by area. As shown in Figure 8-2, Upper South Fork Catoctin Creek subwatershed is located north of Business Route 7 and contains the northern part the Town of Purcellville, the largest population center in the watershed. Chesapeake Bay Program land use data categorizes 40.3 percent of the land use in this subwatershed as either pasture or turf grass, both of which can contribute nutrient and sediments to nearby waterways. The same data also indicate that the Upper South Fork Catoctin Creek watershed has the second highest percentage of impervious land use at 7.1 percent, with the highest density of impervious cover occurring in the vicinity of Purcellville. Figure 8-2 shows the existing conditions within the subwatershed; these and other maps in this chapter portray 2017 aerial imagery and the locations of current stormwater facilities. Table 8-1 summarizes key characteristics of Upper South Fork Catoctin Creek subwatershed.

**Table 8-1: Key Characteristics - Upper South Fork Catoctin Creek Subwatershed**

| | | |
|---|---|---|
| Drainage Area | 8,097 acres (12.7 sq. mi.) | |
| Stream Length | 20.6 miles | |
| Land Use/Land Cover | Barren: | 0.2% |
| | Cropland: | 8.7% |
| | Forest: | 30.4% |
| | Pasture: | 19.3% |
| | Harvested: | 0% |
| | Turf Grass: | 21.0% |
| | Tree: | 6.8% |
| | Shrub/Scrub: | 3.3% |
| | Water: | 0.3% |
| | NWI/Other: | 2.9% |
| | Impervious Cover: | 7.1% |
| Soils | A Soils (low runoff potential): | 1.4% |
| | B Soils: | 37.1% |
| | C Soils: | 27.9% |
| | D Soils (high runoff potential): | 15.1% |
| | *B/D Soils: | 18.4% |
| | *C/D Soils: | 0.1% |
| SCMs | 6.7% of subwatershed treated | |

*Dual Hydrologic Soil Group. See Chapter 3 for further detail.
NWI= National Wetlands Inventory

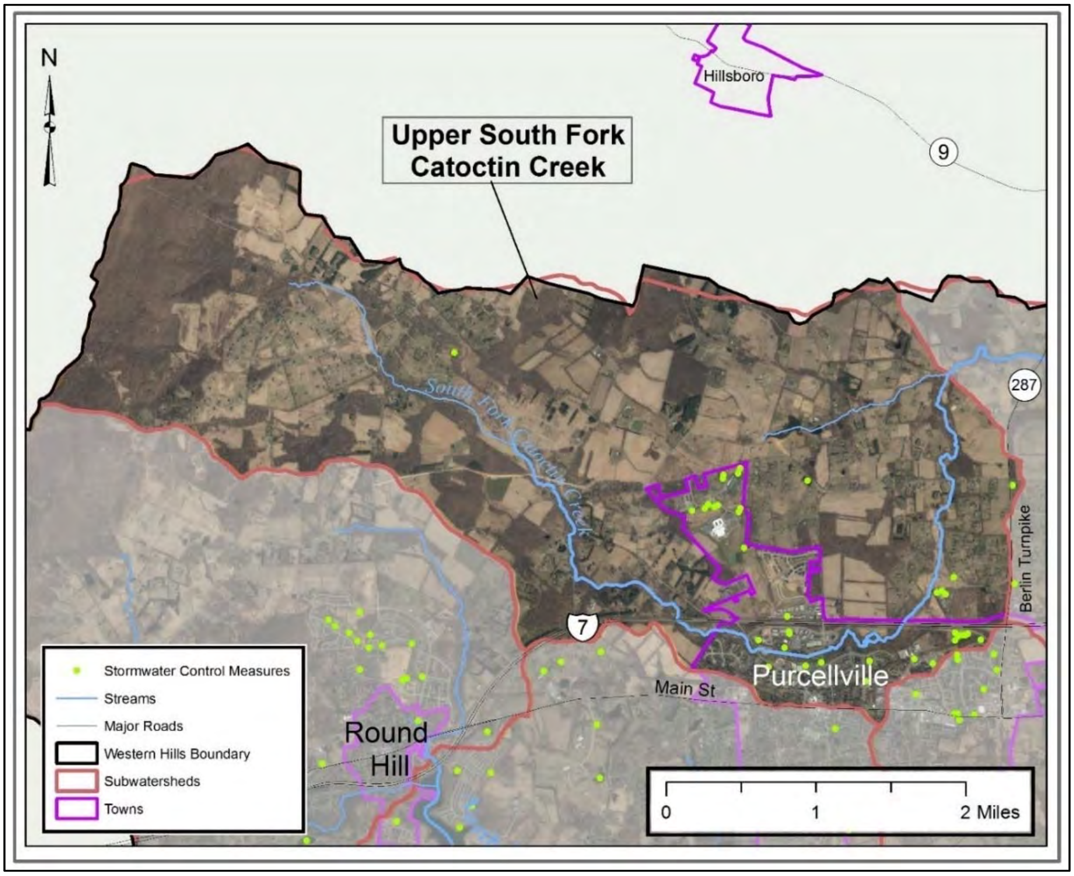


**Figure 8-2: Existing Conditions - Upper South Fork Catoctin Creek**

***Neighborhoods***

During the uplands assessment of the Western Hills Watershed, four example neighborhoods were assessed within the Upper South Fork Catoctin Creek subwatershed to characterize land management and stormwater practices that are likely to affect water quality downstream. These four neighborhoods are all within or adjacent to the Town of Purcellville city limits. Locations of each neighborhood assessed along with their Site IDs are shown in Figure 5-1. Preliminary recommendations for neighborhoods in this subwatershed included actions to reduce stormwater volume and pollutants including downspout disconnection, use of rain barrels, installation of rain gardens, sustainable landscaping, storm drain marking, fertilizer reduction, stream buffer improvements, and tree planting. A summary of recommended neighborhood actions for the Upper South Fork Catoctin subwatershed is presented in Figure 8-2.

**Table 8-2: Neighborhood Source Assessment (NSA) Recommendations – Upper South Fork Catoctin Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Lot Size (acres) | % Opportunity for Downspout Disconnection | Rain Barrels | Rain Gardens | Storm Drain Marking | Sustainable Landscaping | Increase Lot Canopy | Pet Waste Management | Fertilizer Reduction | Buffer Improvement | New SCM | # of Open Space Trees | Notes |
| NSA106 | >1 | 40% | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | 0 | Large yards provide an opportunity for planting more trees or rain gardens and educating on lawn maintenance |
| NSA107 | 1/4 | 10% | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | 0 | Open culvert near stormwater pond is safety hazard. |
| NSA108 | N/A | 0% | ✓ | | | | | | ✓ | ✓ | | 0 | Additional buffering around stormwater pond. |
| NSA114 | <1/8 | 0% | ✓ | | | | ✓ | | ✓ | | | 20 | Add pet waste disposal station near playground. Plant trees in common space between townhomes. |

All of the neighborhoods assessed within the Upper South Fork Catoctin subwatershed had opportunities for improvement. NSA areas in this subwatershed are a good representation of the different types of neighborhoods found throughout the Western Hills Watershed including apartment buildings, townhomes, tightly spaced, single family homes with yards ≤ ¼ acre, and single-family homes with yards >1 acre in size. Each neighborhood layout presents different opportunities and challenges in implementing effective stormwater management. All NSAs in this subwatershed could benefit from the addition of rain barrels and education on fertilizer reduction/low maintenance lawn care. Rain barrels serve as temporary storage of roof runoff, decreasing the volume of stormwater running off site, which is especially useful in locations like NSA108 (Figure 8-4) where there is very little pervious surfaces because of big parking lots that often accompany apartment complexes. Like many neighborhoods, NSA107 was lacking storm drain markings, a relatively easy and inexpensive action that can have a great effect by reminding residents not to dump potentially dangerous materials into the storm drain. It can also be easily paired with other education efforts, for example, with education regarding the effects of pet waste on water quality in neighborhoods where both were recommended. Neighborhoods with community open space or private yards, such as NSA106 (Figure 8-3) and NSA107 are good sites for sustainable landscaping and rain garden installation projects. Projects on this scale may encourage widespread community engagement and are ideal opportunities for children and families to become involved with their watershed in a concrete way. In addition, actions as simple as adjusting mowing practices and planting trees along stream channels and drainage ditches may help to slow down high stream flows that cause bank erosion and to intercept nutrients and other pollutants before they enter the aquatic ecosystem.

**Figure 8-3: Large yards present an opportunity to plant rain gardens in NSA106**

**Figure 8-4: Add rain barrels to apartment buildings to collect rooftop runoff from heavy rains**

### *Hotspots*

Five potential hotspot sites were inspected in the Upper South Fork Catoctin Creek subwatershed, consisting of a park and ride, a sales store, a body shop, a commercial office building, and an office building with an equipment storage yard. A summary of field findings and preliminary recommended actions is presented in Table 8-3.

**Table 8-3: Hotspot Site Investigation (HSI) Results and Recommendations – Upper South Fork Catoctin Creek Subwatershed**

| Site ID | Active Pollution Observed | | | Recommended Follow-up Actions | | | | Hotspot Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicle Operations | Outdoor Materials | Physical Plant | Refer for Enforcement | Follow Up Inspection | Review SWPP | Include in Future Education | Not | Potential | Confirmed | Severe |
| HSI02 | ✓ | | | | | | | ✓ | | | |
| HSI06 | ✓ | ✓ | | | | | | | ✓ | | |
| HSI08 | ✓ | ✓ | | | ✓ | | | | | ✓ | |
| HSI09 | | ✓ | | | | | | ✓ | | | |
| HSI11 | ✓ | ✓ | | | ✓ | | | | ✓ | | |

At the body shop, outdoor vehicle washing was observed, with washwater flowing to a storm drain. The asphalt within the vehicle storage parking lot was breaking up. Both issues are shown in Figure 8-5 (left). The equipment storage yard (Figure 8-5, right) was entirely bare soil and was used for storage of large equipment. The storage area discharged as direct runoff to a stream as well as to a storm drain system. There were signs of loading and unloading operations at the sales store.

**Figure 8-5: Washing and Parking Lot Break Up (left) at HSI08 and Large Equipment Storage (right) at HSI11**

***Institutions***

A municipal facility, two high schools, and a conservation easement were investigated in the Upper South Fork Catoctin Creek subwatershed. A summary of potential opportunities for restoration at each are presented in Table 8-4.

At ISI07, the pavement was found in poor condition and contained a lot of broken pavement areas. Downspouts were discharging directly to the impervious pavement. Due to the steep grade, shallow concentrated runoff channels were seen causing erosion. School buses are stored outside at ISI17. ISI07, ISI16, and ISI17 have opportunities for tree plantings as well as new SCMs to treat runoff generated onsite (Figure 8-6). Tree planting opportunities, as identified in the Urban Reforestation Site Assessments, are described below under Open Space Tree Planting Opportunities. Recommendations for new SCMs are described in Chapter 9.

**Table 8-4: Institutional Site Investigation (ISI) Recommendations – Upper South Fork Catoctin Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site ID** | **Storm Drain Marking** | **# Trees for Planting** | **Downspout Disconnection** | **New Stormwater Treatment** | **Future Education** | **Buffer Improvement** | **Pollution Prevention Plan** | **Trash Management** | **Impervious Cover Removal** | **Notes** |
| ISI07 | | See URSA | | ✓ | | | | | | Tree planting, Stormwater retrofit new (linear treatment system downhill from treatment facility, Storm drain marking |
| ISI15 | ✓ | | | | | | | | | Rain barrel, redirection of rain spouts, shrubbery to hold sediment in area in front of building |
| ISI16 | ✓ | See URSA | | ✓ | | ✓ | | | | *No Comments* |
| ISI17 | | See URSA | | ✓ | ✓ | | | | | Tree planting; storm drain marking; include in future education effort. Mountainview Elementary School could plant a rain garden or wetland vegetation along the muddy ditch near the playground to filter rainwater that drains from the play area. The elementary school could also stop mowing the area |

**Table 8-4: Institutional Site Investigation (ISI) Recommendations –
Upper South Fork Catoctin Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Storm Drain Marking | # Trees for Planting | Downspout Disconnection | New Stormwater Treatment | Future Education | Buffer Improvement | Pollution Prevention Plan | Trash Management | Impervious Cover Removal | Notes |
| | | | | | | | | | | inside the asphalt track on the west side of the school or potentially plant a rain garden with informative signs to educate students. Areas on the property that are currently turf grass and have no conflicting function should no longer be mowed and left to become natural meadows. |

**Figure 8-6: Tree Planting Opportunity along Slope (left) at ISI07 and Bioswale Opportunity (right) at ISI17**

***Open Space Tree Planting***

Pervious area restoration has the potential to convert areas of turf and other maintained cover to forested cover. Maintained pervious cover can potentially generate higher nutrient loads through grass clippings and fertilizer application. Forested cover with tree and understory provides runoff control through canopy interception, nutrient uptake, and shade benefits. Three pervious areas were assessed for restoration potential in the Upper South Fork Catoctin Creek subwatershed: the property including both Woodgrove High School and Mountain View Elementary School, Purcellville Water Treatment Plant, and South Fork Catoctin Creek Conservation Easement. The locations and details for each assessed site can be found in Chapter 4, Section 4.2.4.4.

A summary of these sites is provided in Table 8-5.

**Table 8-5: Urban Reforestation Site Assessment (URSA) Summaries – Upper South Fork Catoctin Creek Subwatershed**

| Site ID | Location in Subwatershed | Description | Acres | Ownership |
|---|---|---|---|---|
| Woodgrove High School (1) | Central | County School | Parcel – 223.13 (combined Woodgrove High School and Mountain View Elementary) Recommended planting – 11.83 | Public |
| Woodgrove High School (2) | Central | County School | Parcel – 223.13 (combined Woodgrove High School and Mountain View Elementary) Recommended planting – 3.97 | Public |
| Woodgrove High School (3) | South | County School | Parcel – 223.13 (combined Woodgrove High School and Mountain View Elementary) Recommended planting – 11.20 | Public |
| Mountain View Elementary School | Central | County School | Parcel – 223.13 (combined Woodgrove High School and Mountain View Elementary) Recommended planting – 1.90 | Public |
| Purcellville Water Treatment Plant Northeast | North | Municipal | Parcel – 4.46 (combined Northeast and Northwest) Recommended Planting – 1.03 | Public |
| Purcellville Water Treatment Plant Northwest | North | Municipal | Parcel – 4.46 (combined Northeast and Northwest) Recommended Planting – 0.48 | Public |
| South Fork Catoctin Creek Conservation Easement | South | Conservation Easement | Parcel – 14.18 Recommended planting – 2.12 | Public |

***Stream Corridor Assessments***

Field crews walked 2.61 miles of stream (12.7 percent of total stream miles) within the Upper South Fork Catoctin Creek subwatershed to identify potential water quality problems and restoration opportunities. Maps showing key findings of the stream corridor assessments are found in Section 4.1. A total of 26 problems were identified at stream reaches assessed in the Upper South Fork Catoctin Creek subwatershed. The predominant issues were erosion, which was generally rated moderate and with good opportunities of being corrected by stream restoration projects. Near the mainstem South Fork Catoctin Creek (Site 2) the presence of erosion is evident from drainage discharged from a culvert that outfalls 10 feet from the stream bank causing extreme erosion of the stream bank and floodplain area (Figure 8-7). At Site 1, near the football field at Woodgrove High School, a gully is being created as drainage runs off the football field. A pipe outfall observed during the stream assessment was related to runoff drainage from a neighborhood situated next to

South Fork Catoctin Creek at Site 2 (Figure 8-8). Several channel alterations have been previously implemented along South Fork Catoctin Creek in the form of riprap placed under road crossings and along the stream bank for the purpose of stabilization. Several fish barriers in the form of debris jams and beaver dams were also observed (see example in Figure 8-9).

See Chapter 9 for information on potential stream restoration projects in the Upper South Fork Catoctin Creek subwatershed.

**Figure 8-7: Erosion associated with culvert outfall.**

**Figure 8-8: Runoff from neighborhood draining into stream (left) and gully created by football field drainage (right)**

**Figure 8-9: Debris jam creating fish passage barrier at Site 2**

***Stormwater Conversions and New Stormwater Control Measures***

Existing stormwater management ponds in the Upper South Fork Catoctin Creek subwatershed were evaluated during the Retrofit Reconnaissance Investigations, to identify opportunities for facility conversions or upgrades to improve water quality. One SCM conversion opportunity was identified; see Chapter 9 for more information. Twelve opportunities for new SCMs were identified and are also described in Chapter 9.

***Subwatershed Management Strategy***

Figure 8-10 provides a visual summary of potential restoration opportunities in the Upper South Fork Catoctin Creek subwatershed.

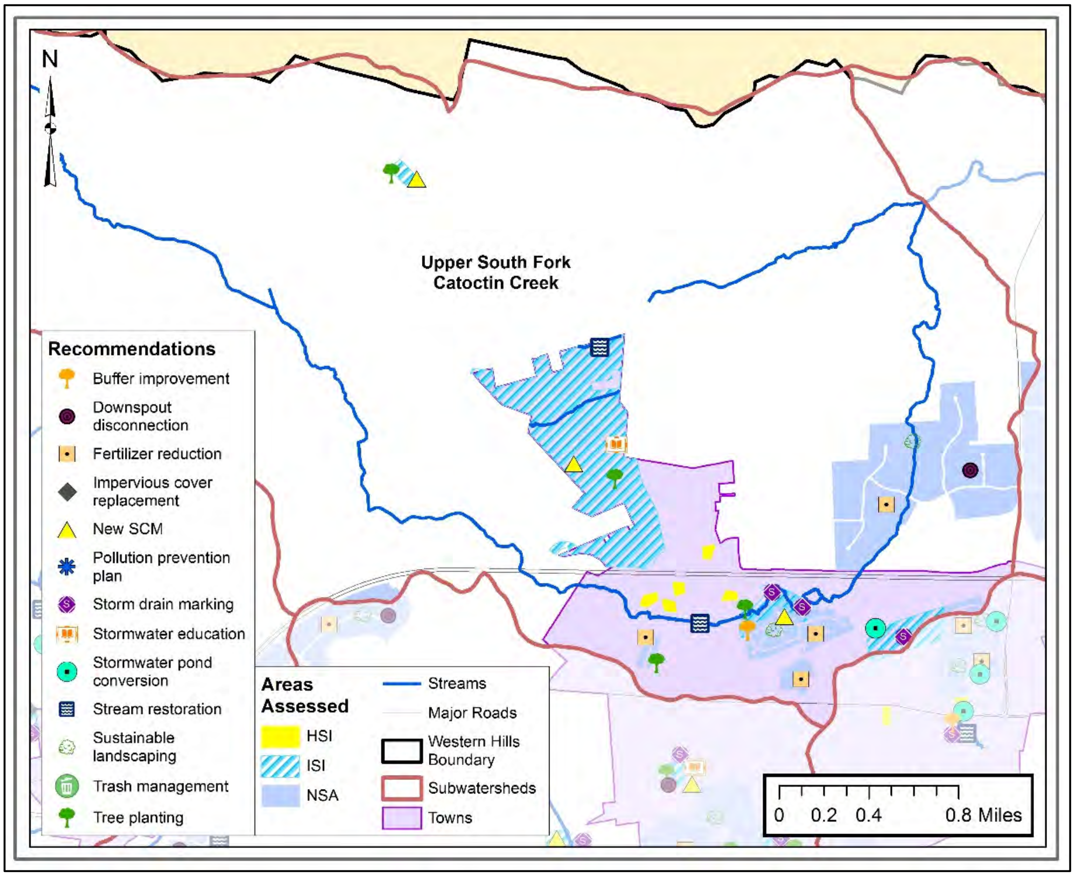


**Figure 8-10: Potential Restoration Opportunities in Upper South Fork Catoctin Creek Subwatershed**

<u>Non-Governmental Actions (residents, HOAs, public schools, other non-governmental institutions, and watershed groups, including the neighborhoods indicated above)</u>

1. Conduct appropriate downspout rain barrel and rain garden installation measures in local neighborhoods.
2. Engage residents in a storm drain marking program and conduct marking activities in local neighborhoods.
3. Educate residents about the benefits and importance of sustainable landscaping and its effects on water quality in local neighborhoods.
4. Educate property owners about improving stream buffer management, for example at the location indicated above.

5. Educate property owners about the water quality benefits of reducing fertilizer use on lawns.
6. Encourage communities to plant open space trees.
7. Engage institutional sites in storm drain marking.
8. Investigate the open space areas described above for potential tree planting.

Municipal Actions (Loudoun County and Town governments)

1. Continue to monitor conditions at the potential indicated hotspots.
2. Investigate feasibility of recommendations for stream restoration in the areas noted.
3. Assess feasibility of stormwater pond conversion for the site noted.
4. Engage with institutional sites in the planning of new SCMs as noted.

## 8.2 Lower South Fork Catoctin Creek

Lower South Fork Catoctin Creek is the second largest subwatershed in the Western Hills Watershed. The majority of this subwatershed is located north of Route 7. Most of the Town of Hamilton falls within this subwatershed. Chesapeake Bay Program land use data classifies over half (55.3 percent) of the land use type in the Lower South Fork Catoctin Creek subwatershed as pasture and turf grass. Numerous opportunities exist for increasing tree and other natural vegetation cover across the subwatershed. Figure 8-11 shows the existing conditions within the subwatershed. Table 8-6 summarizes the key subwatershed characteristics of Lower South Fork Catoctin Creek.

**Table 8-6: Key Characteristics – Lower South Fork Catoctin Creek Subwatershed**

| | | |
|---|---|---|
| Drainage Area | 13,047acres (20.39sq. mi.) | |
| Stream Length | 36.38 miles | |
| Land Use/Land Cover | Barren: | 0.1% |
| | Cropland: | 6.6% |
| | Forest: | 19.2% |
| | Pasture: | 31% |
| | Harvested: | 0% |
| | Turf Grass: | 24.3% |
| | Tree: | 10% |
| | Shrub/Scrub: | 0.9% |
| | Water: | 0.4% |
| | NWI/Other: | 1.1% |
| | Impervious Cover: | 6.4 % |
| Soils | A Soils (low runoff potential): | 1.7% |
| | B Soils: | 41.9% |
| | C Soils: | 28.7% |
| | D Soils (high runoff potential): | 5.5% |
| | *B/D Soils: | 21.4% |
| | *C/D Soils: | 0.8% |
| SCMs | 17.2% of subwatershed treated | |

*Dual Hydrologic Soil Group. See Chapter 3 for further detail.
NWI= National Wetlands Inventory

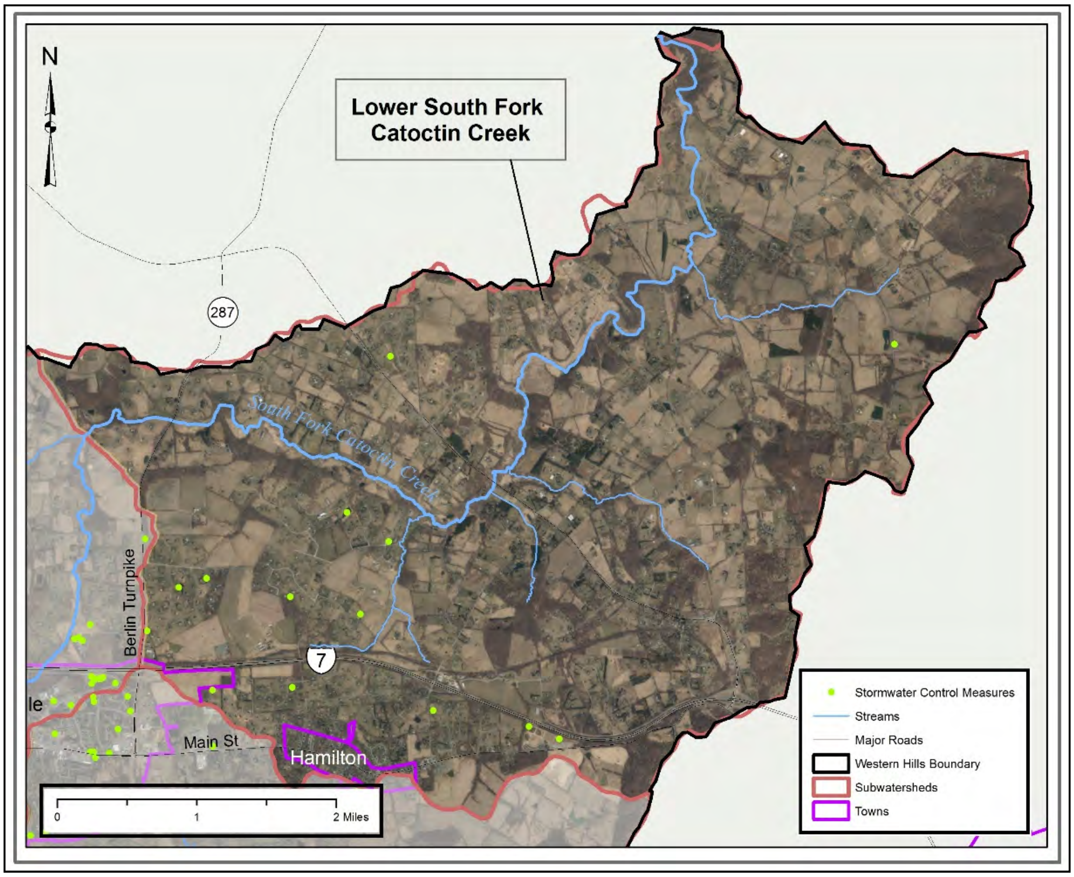


**Figure 8-11: Existing Conditions – Lower South Fork Catoctin Creek Subwatershed**

### *Neighborhoods*

Two neighborhoods were assessed within the Lower South Fork Catoctin Creek subwatershed during the uplands assessment of the Western Hills Watershed (see Figure 8-1). Preliminary recommendations for the neighborhoods in this subwatershed included actions to reduce stormwater volume and pollutants including downspout disconnection, installation of rain barrels, implementation of rain gardens, tree planting and sustainable landscaping. A summary of recommended neighborhood actions is presented in Table 8-7.

**Table 8-7: Neighborhood Source Assessment (NSA) Recommendations – Lower South Fork Catoctin Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site ID** | **Lot Size (acres)** | **% Opportunity for Downspout Disconnection** | **Rain Barrels** | **Rain Gardens** | **Storm Drain Marking** | **Sustainable Landscaping** | **Increase Lot Canopy** | **Pet Waste Management** | **Fertilizer Reduction** | **Buffer Improvement** | **New SCM** | **# of Open Space Trees** | **Notes** |
| NSA110 | >1 | 10% | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | 0 | Large yards provide an opportunity for planting more trees or rain gardens and education on lawn maintenance |
| NSA115 | >1 | 0% | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | 0 | Large yards provide an opportunity for planting more trees or rain gardens and education on lawn maintenance |

The neighborhoods assessed within the Lower South Fork Catoctin Creek subwatershed had several opportunities for improvement. Large portions of the neighborhoods covered by mowed lawns provides a great opportunity for rain garden installation (Figure 8-12) and sustainable landscaping. In addition, actions as simple as reduced fertilizer application, adjusting mowing practices, and tree plantings are recommended to slow down high flows that cause bank erosion and to intercept nutrients and other pollutants before they enter the aquatic ecosystem.

**Figure 8-12: Opportunity for rain garden in drainage ditch to stream**

### *Hotspots*

Investigations for potential hotspot sites were conducted at two residential locations in Lower South Fork Catoctin Creek subwatershed, a single-family home and a trailer park. Since these were residences, staff did not complete a traditional Hotspot Site Investigation, but noted that most of the traditional categories that are reviewed for an HSI were not applicable and both were identified as not a hotspot. Field findings and preliminary recommendations are presented in Table 8-8.

**Table 8-8: HSI Results and Recommendations – Lower South Fork Catoctin Creek Subwatershed**

| Site ID | Active Pollution Observed | | | Recommended Follow-up Actions | | | | Hotspot Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicle Operations | Outdoor Materials | Physical Plant | Refer for Enforcement | Follow Up Inspection | Review SWPP | Include in Future Education | Not | Potential | Confirmed | Severe |
| HSI03 | | | | | | | | ✓ | | | |
| HSI04 | | | | | | | | ✓ | | | |

Note: No active pollution observed or follow-up actions recommended for this subwatershed.

### *Institutions*

Two parks, a fire station, and an elementary school were investigated in Lower South Fork Catoctin Creek subwatershed. A summary of potential opportunities for restoration at each are presented in Table 8-9.

**Table 8-9: ISI Recommendations – Lower South Fork Catoctin Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Storm Drain Marking | # Trees for Planting | Downspout Disconnection | New Stormwater Treatment | Future Education | Buffer Improvement | Pollution Prevention Plan | Trash Management | Impervious Cover Removal | Notes |
| ISI01 | ✓ | | | | | | | | | Potential treatment of parking and swale (muddy) at entrance of park. If gravel ever converted to paved, add treatment. |
| ISI02 | ✓ | | | | ✓ | | | | | Include in future education efforts, suggest follow up on-site inspection (western parking lot low point and swale improvement by baseball field entrance), Invasive species removal (cattail management ) |
| ISI03 | ✓ | | | ✓ | | | ✓ | | | Stormwater retrofit (new swale at front), invasive species removal (cattails in pond), consider a water pollution prevention plan |
| ISI04 | ✓ | See URSA | ✓ | ✓ | | | | ✓ | ✓ | Tree planting, stormwater retrofit (new and existing), downspout disconnection (need to see roof drain plans to assess feasible), impervious cover removal (convert impermeable asphalt play area and walkways to porous pavement), better trash management (disconnect from drain/diversion features, include in future education effort, suggest follow up on-site inspection (check roof drain flow and potential BMP opportunity) |

ISI01 is a well-maintained park with a gravel parking lot. There is good tree coverage along the perimeter. ISI02 has two existing SCM treatment systems to treat runoff from the site. Grass swales are used to convey the runoff from upstream areas to the SCM practices. There is good perimeter planting and already existing new planting at the site. At ISI03 there is potential for a new SCM opportunity (Figure 8-13). The parking lot on some areas of the site is breaking up. Some downspouts on the site discharge directly to impervious surface. There is potential for tree planting and new SCM opportunities at ISI04 (Figure 8-13).

**Figure 8-13: Bioswale Opportunity (left) at ISI03 and Bioretention/Infiltration System Opportunity (right) at ISI04**

***Open Space Tree Planting***

Pervious area restoration has the potential to convert areas of turf and other maintained cover to forested cover. Maintained pervious cover can potentially generate higher nutrient loads through grass clippings and fertilizer application. Forested cover with tree and understory provides runoff control through canopy interception, nutrient uptake, and shade benefits. One pervious area was assessed for restoration potential in the Lower South Fork Catoctin Creek subwatershed of Western Hills Watershed, Culbert Elementary School. The locations and details for this assessed site can be found in Chapter 4, section 4.2.4.4.

Summary information for this site is provided in Table 8-10.

**Table 8-10: URSA Summary – Lower South Fork Catoctin Creek Subwatershed**

| Site ID | Location in Subwatershed | Description | Acres | Ownership |
|---|---|---|---|---|
| Culbert Elementary School | Southwest | County School | Parcel – 31.08<br>Recommended planting – 0.97 | Public |

***Stream Corridor Assessments***

Field crews walked 1.98 miles of stream (5.4 percent of the total stream miles) within the Lower South Fork Catoctin Creek subwatershed to identify potential water quality problems and restoration opportunities. This survey focused on the mainstem of South Fork Catoctin Creek and tributaries near Waterford as well as a tributary near the Town of Hamilton. A total of 49 problems were identified at these stream reaches in the Lower South Fork Catoctin Creek subwatershed. The predominant issues were moderate to severe areas of erosion, pipe outfalls, and inadequate buffers generally rated as moderate to severe. Maps showing key findings of the stream corridor assessments are found in Section 4.1.

The South Fork Catoctin Creek near Waterford had 4 pipe outfalls and 2 instances of exposed pipes. Three of the five pipes were made of terra cotta/clay material, found at various locations along the length of the stream reach surveyed. Most of these occurred where the river bends near the houses on Main Street in Waterford so it is likely that serve as yard drainage (Figure 8-14). Also occurring in this location is overland stormwater flow from the adjacent meadow, which is downhill of Main Street, directly into the creek during high flows causing severe erosion to the stream bank. Observations from the stream reach assessed near Hamilton report moderate/severe erosion downstream of channelization near the town's municipal wastewater treatment facility. Inadequate buffer was also noted as a result of the close proximity of the facility to the stream (Figure 8-15).

See Chapter 9 for information on potential stream restoration projects in the Lower South Fork Catoctin Creek subwatershed.

**Figure 8-14: Mainstem Catoctin Creek behind Main Street in Waterford: pipe outfalls behind homes (left) and overland flow from meadow into creek causing erosion of stream bank (right)**

**Figure 8-15: Town of Hamilton wastewater treatment outfall**

***Stormwater Conversions and New Stormwater Control Measures***

One existing stormwater management pond in the Lower South Fork Catoctin Creek was considered for conversion but did not present an opportunity for upgrading. One opportunity for a new SCM was identified and is described in Chapter 9.

***Subwatershed Management Strategy***

Figure 8-16 provides a visual summary of potential restoration opportunities in the Lower South Fork Catoctin Creek subwatershed.

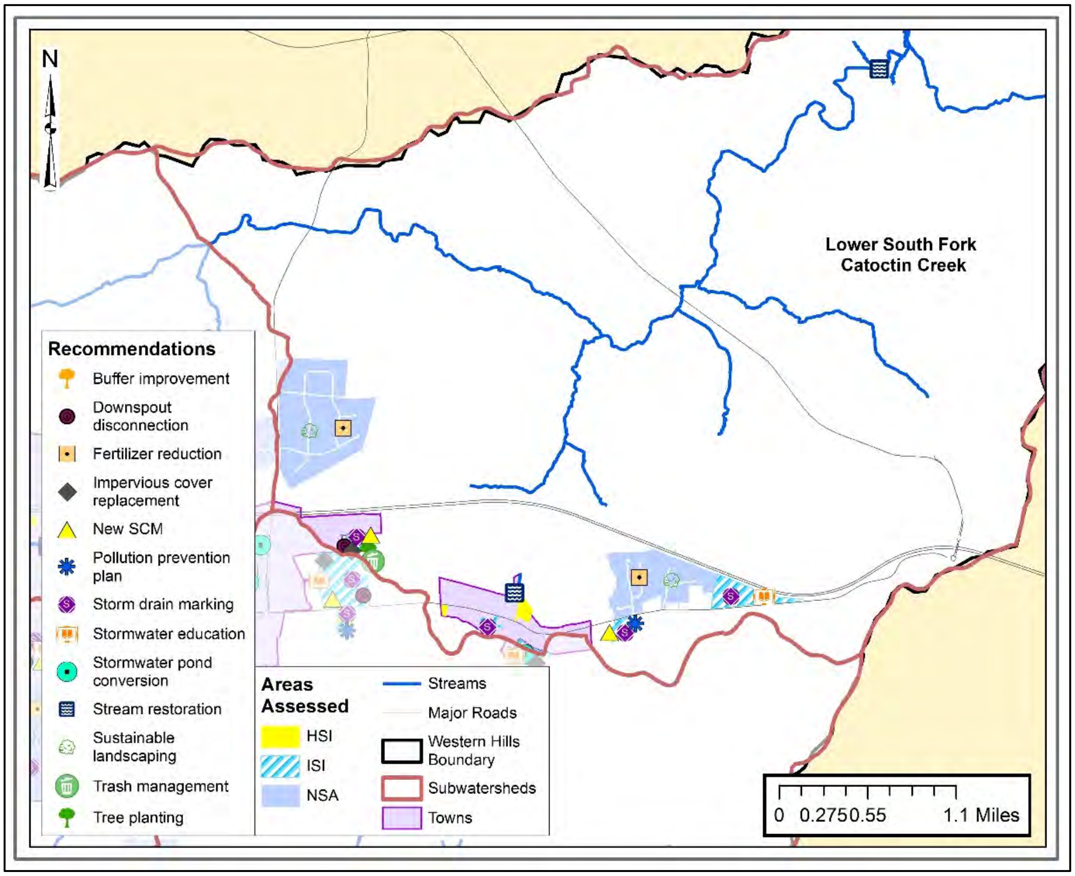


**Figure 8-16: Potential Restoration Opportunities in Lower South Fork Catoctin Creek Subwatershed**

Non-Governmental Actions (residents, HOAs, public schools, other non-governmental institutions, and watershed groups)

1. Conduct appropriate downspout rain barrel and rain garden installation measures in local neighborhoods.
2. Educate residents about the benefits and importance of sustainable landscaping and its effects on water quality in local neighborhoods.
3. Educate property owners about the water quality benefits of reducing fertilizer use on lawns.
4. Encourage residents to plant trees
5. Engage institutional sites in storm drain marking.
6. Improve trash management at one institutional site, as indicated above.
7. Consider impervious cover replacement at one institutional site.
8. Investigate the open space areas described above for potential tree planting.

Municipal Actions (Loudoun County and Town governments)

1. Investigate feasibility of recommendations for stream restoration in areas noted.
2. Engage with institutional site in the planning of new SCM as noted.

## 8.3 Upper North Fork Goose Creek

Upper North Fork Goose Creek is the smallest of the five subwatersheds in the Western Hills Watershed and has the fewest stream miles. Most of the Town of Round Hill is located within Upper North Fork Goose Creek subwatershed. Figure 8-17 shows the existing conditions within the subwatershed. Upper North Fork Goose Creek has the highest percentage of impervious surfaces (8 percent) among the major subwatersheds in the Western Hills Watershed, according to Chesapeake Bay Program land use data. Table 8-11 summarizes the key subwatershed characteristics of Upper North Fork Goose Creek.

**Table 8-11: Key Characteristics – Upper North Fork Goose Creek Subwatershed**

| | | |
|---|---|---|
| Drainage Area | 5376 acres (8.4 sq. mi.) | |
| Stream Length | 13.62 miles | |
| Land Use/Land Cover | Barren: | 0.5% |
| | Cropland: | 1.1% |
| | Forest: | 34.9% |
| | Pasture: | 19.6% |
| | Harvested: | 0.5% |
| | Turf Grass: | 21.6% |
| | Tree: | 10.7% |
| | Shrub/Scrub: | 1.4% |
| | Water: | 0.4% |
| | NWI/Other: | 1.3% |
| | Impervious Cover: | 8% |
| Soils | A Soils (low runoff potential): | 1% |
| | B Soils: | 36.4% |
| | C Soils: | 43.3% |
| | D Soils (high runoff potential): | 12.7% |
| | *B/D Soils: | 4.6% |
| | *C/D Soils: | 2% |
| SCMs | 18% of subwatershed treated | |

*Dual Hydrologic Soil Group. See Chapter 3 for further detail.
NWI= National Wetlands Inventory

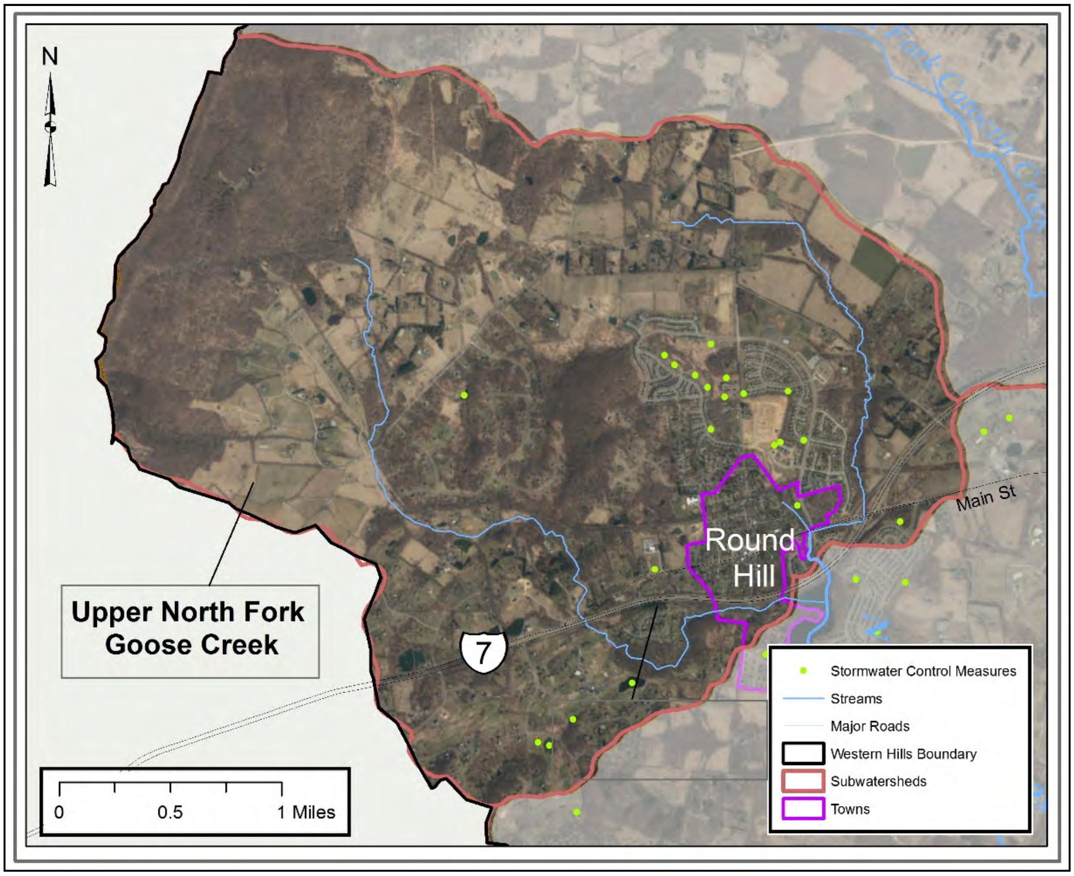


**Figure 8-17: Existing Conditions – Upper North Fork Goose Creek Subwatershed**

***Neighborhoods***

One neighborhood was assessed in the Upper North Fork Goose Creek subwatershed (see Figure 8-1). Several recommendations were made for improvements to stormwater management including the addition of rain barrels, planting of rain gardens and sustainable landscapes, storm drain marking, and fertilizer reduction. The suite of recommendations made for this neighborhood apply to many locations within the Western Hills Watershed and present a great opportunity for community engagement and education on what individual homeowners can do on their properties to improve water quality. A summary of preliminary neighborhood recommended actions for the Upper North Fork Goose Creek subwatershed is presented in Table 8-12.

**Table 8-12: Neighborhood Source Assessment (NSA) Recommendations – Upper North Fork Goose Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Lot Size (acres) | % Opportunity for Downspout Disconnection | Rain Barrels | Rain Gardens | Storm Drain Marking | Sustainable Landscaping | Increase Lot Canopy | Pet Waste Management | Fertilizer Reduction | Buffer Improvement | New SCM | # of Open Space Trees | Notes |
| NSA101 | 1/2 | 20% | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | 0 | Educate homeowners on better lawn maintenance practices. |

### *Hotspots*

An investigation was conducted at one business park within Upper North Fork Goose Creek subwatershed. Teams investigated all businesses in the business park. A summary of field results and preliminary recommendations is presented in Table 8-13.

**Table 8-13: HSI Results and Recommendations – Lower South Fork Catoctin Creek Subwatershed**

| Site ID | Active Pollution Observed | | | Recommended Follow-up Actions | | | | Hotspot Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicle Operations | Outdoor Materials | Physical Plant | Refer for Enforcement | Follow Up Inspection | Review SWPP | Include in Future Education | Not | Potential | Confirmed | Severe |
| HSI07 | | ✓ | | | ✓ | | | | | ✓ | |

There were no vehicle operations at the business park. One of the businesses appeared to be undergoing renovations and was storing a lot of equipment outdoors. Loading and unloading operations were also present and uncovered with runoff flowing to the BMP on site (Figure 8-18). Building condition was dirty and the parking lot was breaking up at multiple places (Figure 8-18).

**Figure 8-18: Uncovered Loading Operations (left) and Parking Lot Break Up (right) at HSI07**

### *Institutions*

A municipal building, a school building, and a church were investigated within the Upper North Fork Goose Creek subwatershed. A summary of potential opportunities for restoration are detailed in Table 8-14.

ISI12 has an existing SCM practice that has been identified as an SCM upgrade opportunity (Figure 8-19, left). Fleet vehicles are stored and potentially washed on the site. There are tree planting opportunities at the site. There are new SCM opportunities at ISI14 in addition to potential for impervious cover removal and wetland planting to improve the stream buffer (Figure 8-19, right). ISI19 has a cistern for stormwater reuse to water an existing garden. There is potential to add other smaller rain barrels for landscape watering needs. A trailer is stored on site.

**Table 8-14: ISI Recommendations – Upper North Fork Goose Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Storm Drain Marking | # Trees for Planting | Downspout Disconnection | New Stormwater Treatment | Future Education | Buffer Improvement | Pollution Prevention Plan | Trash Management | Impervious Cover Removal | Notes |
| ISI12 | | See URSA | | | | | | | | Potential for tree planting in available open spaces, storm drain marking, stream buffer improvement. Wetland swale could be added to prevent erosion of |

**Table 8-14: ISI Recommendations – Upper North Fork Goose Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Storm Drain Marking | # Trees for Planting | Downspout Disconnection | New Stormwater Treatment | Future Education | Buffer Improvement | Pollution Prevention Plan | Trash Management | Impervious Cover Removal | Notes |
| | | | | | | | | | | grass and gravel parking lot (inside fenced parking area in grass perimeter on west side of parking lot), widen stream buffer on north side of property beyond fence, add wetland vegetation to ditch on east side of driveway to prevent erosion of soil on slope |
| ISI14 | ✓ | | | ✓ | | | | | ✓ | Impervious cover removal; stream buffer improvement. Add wetland vegetation around stream behind outfield fence of front ballfield where there is a lot of standing water |
| ISI19 | ✓ | | | | | | | | | *No additional comments* |

**Figure 8-19: SCM Upgrade Opportunity (left) at ISI12 and Micro-bioretention Opportunity (right) at ISI14**

### *Open Space Tree Planting*

Pervious area restoration has the potential to convert areas of turf and other maintained cover to forested cover. Maintained pervious cover can potentially generate higher nutrient loads through grass clippings and fertilizer application. Forested cover with tree and understory provides runoff control through canopy interception, nutrient uptake, and shade benefits. One pervious area was assessed for restoration potential in the Upper North Fork Goose Creek subwatershed of Western Hills Watershed, at the Loudoun County Sheriff's Office. The locations and details for this assessed site can be found in Chapter 4, section 4.2.4.4.

Summary information for this site is provided in Table 8-15.

**Table 8-15: URSA Summary – Upper North Fork Goose Creek Subwatershed**

| Site ID | Location in Subwatershed | Description | Acres | Ownership |
|---|---|---|---|---|
| Loudoun County Sheriff's Office | Southeast | County Building | Parcel – 14.18<br>Recommended planting – 2.12 | Public |

### *Stream Corridor Assessments*

Field crews walked 1.51 miles of stream (11.1 percent of the total stream miles) within the Upper North Fork Goose Creek subwatershed to identify potential water quality problems and restoration opportunities. A total of 34 problems were identified in the stream reaches assessed in the Upper North Fork Goose Creek subwatershed. Maps showing key findings of the stream corridor assessments are found in Section 4.1.

The predominant issues in Upper North Fork Goose Creek streams were moderate to severe erosion, inadequate buffers, and pipe outfalls. All three reaches of stream assessed in the Upper North Fork Goose Creek subwatershed were located upstream of Sleeter Lake just north of Route 7. The most downstream reach, surrounded by Route 7, East Loudoun Street, Falls Place, and intersected by Newberry Crossing Place was noted as having inadequate riparian buffers because of the proximity of roadways (Figure 8-20). An outfall channel with substantial erosion (Figure 8-21) was noted as an opportunity for step-pool regenerative stormwater conveyance (RSC) design, particularly because of its potential to contribute sediments to the stream channel downstream, along Arrowwood Place. East of Arrowwood Place and north of Route 7 an assessed stream reach with few observed impairments lies next to a cattle pasture, where an inadequate buffer was noted. Many concerns arise when a stream intersects an active pasture including the potential for excess nutrients, lack of vegetation on banks and in riparian buffer due to grazing or trampling, and sediment disturbance if the livestock are able to walk through the stream. A culvert clogged by a debris dam was also identified as inhibiting fish passage in this reach. The longest and most impaired segment assessed in the Upper North Fork Goose Creek subwatershed was located between Greenwood Drive and Woodgrove Road. In the middle and downstream portions of this reach six stormwater outfalls, inadequate buffers related to mowing (Figure 8-20), and two head cuts (see example, Figure 8-22) were observed, which collectively led to stream restoration recommendations for this reach.

See Chapter 9 for information on potential stream restoration projects in the Upper North Fork Goose Creek subwatershed.

**Figure 8-20: Two examples of inadequate buffers in Upper North Fork Goose Creek subwatershed. Mowing too closely to stream banks (left) and roadways that run closely parallel to streams (right) reduce the opportunity for runoff to be filtered before reaching streams.**

**Figure 8-21: Outfall channel erosion presenting an opportunity for RSC design**

**Figure 8-22: Head cut stream in Upper North Fork Goose Creek subwatershed**

### *Stormwater Conversions and New Stormwater Control Measures*

Existing stormwater management ponds in the Upper North Fork Goose Creek subwatershed were evaluated during the Retrofit Reconnaissance Investigations, to identify opportunities for facility conversions or upgrades to improve water quality. Seven SCM conversion opportunities were identified; see Chapter 9 for more information. Five opportunities for new SCMs were identified and are also described in Chapter 9.

### *Subwatershed Management Strategy*

Figure 8-16 provides a visual summary of potential restoration opportunities in the Upper North Fork Goose Creek subwatershed.

<u>Non-Governmental Actions (residents, HOAs, public schools and other non-governmental institutions, and watershed groups)</u>

1. Conduct appropriate downspout rain barrel and rain garden installation measures in local neighborhoods.
2. Engage residents in a storm drain marking program and conduct marking activities in local neighborhoods.
3. Educate residents about the benefits and importance of sustainable landscaping and its effects on water quality.
4. Educate property owners about the water quality benefits of reducing fertilizer use on lawns.
5. Encourage residents to plant trees.
6. Engage institutional sites, such as those indicated above, in storm drain marking.
7. Investigate the open space areas described above for potential tree planting.
8. Consider impervious cover replacement at the institutional site noted above.

<u>Municipal Actions (Loudoun County and Town governments)</u>

1. Continue to monitor conditions at the potential hotspot indicated.
2. Investigate feasibility of recommendations for stream restoration in areas noted.
3. Assess feasibility of stormwater pond conversions for the sites noted.
4. Engage with institutional sites in the planning of new SCMs as noted.

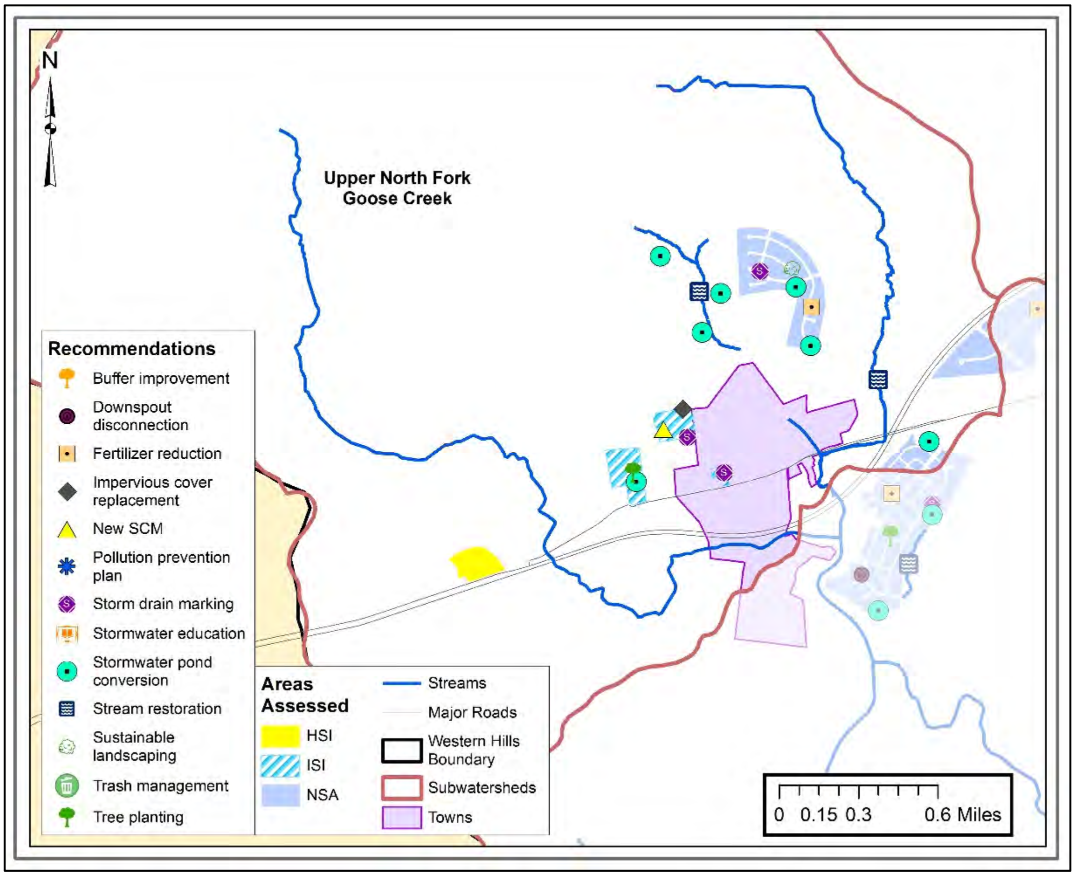


**Figure 8-23: Potential Restoration Opportunities in Upper North Fork Goose Creek Subwatershed**

## 8.4 Lower North Fork Goose Creek

Lower North Fork Goose Creek subwatershed is the largest subwatershed with the most stream miles in the Western Hills Watershed. The subwatershed is largely rural, with fairly extensive forest/tree cover (41.4 percent) along with a combination of pasture and turf grass (totaling 44.6 percent). Numerous opportunities exist across the subwatershed to increase forest and other natural vegetative cover. The Lower North Fork Goose Creek subwatershed has the lowest percentage of impervious surface even though it includes the southwestern portion of the Town of Purcellville and other residential development, including areas in and near the Town of Round Hill. Figure 8-24 shows the existing conditions within the subwatershed. Table 8-16 summarizes the key subwatershed characteristics of Lower North Fork Goose Creek.

**Table 8-16: Key Characteristics – Lower North Fork Goose Creek Subwatershed**

| | | |
|---|---|---|
| Drainage Area | 14,940 acres (23.34 sq. mi.) | |
| Stream Length | 43.75 miles | |
| Land Use/Land Cover | Barren: | 1% |
| | Cropland: | 3.5% |
| | Forest: | 33.6% |
| | Pasture: | 29.0% |
| | Harvested: | 0% |
| | Turf Grass: | 15.6% |
| | Tree: | 7.8% |
| | Shrub/Scrub: | 1.6% |
| | Water: | 1.7% |
| | NWI/Other: | 1% |
| | Impervious Cover: | 6.1% |
| Soils | A Soils (low runoff potential): | 0.4% |
| | B Soils: | 36.7% |
| | C Soils: | 37.4% |
| | D Soils (high runoff potential): | 5.3% |
| | *B/D Soils: | 19.5% |
| | *C/D Soils: | 0.7% |
| SCMs | 12.6% of subwatershed treated | |

*Dual Hydrologic Soil Group. See Chapter 3 for further detail.
NWI= National Wetlands Inventory

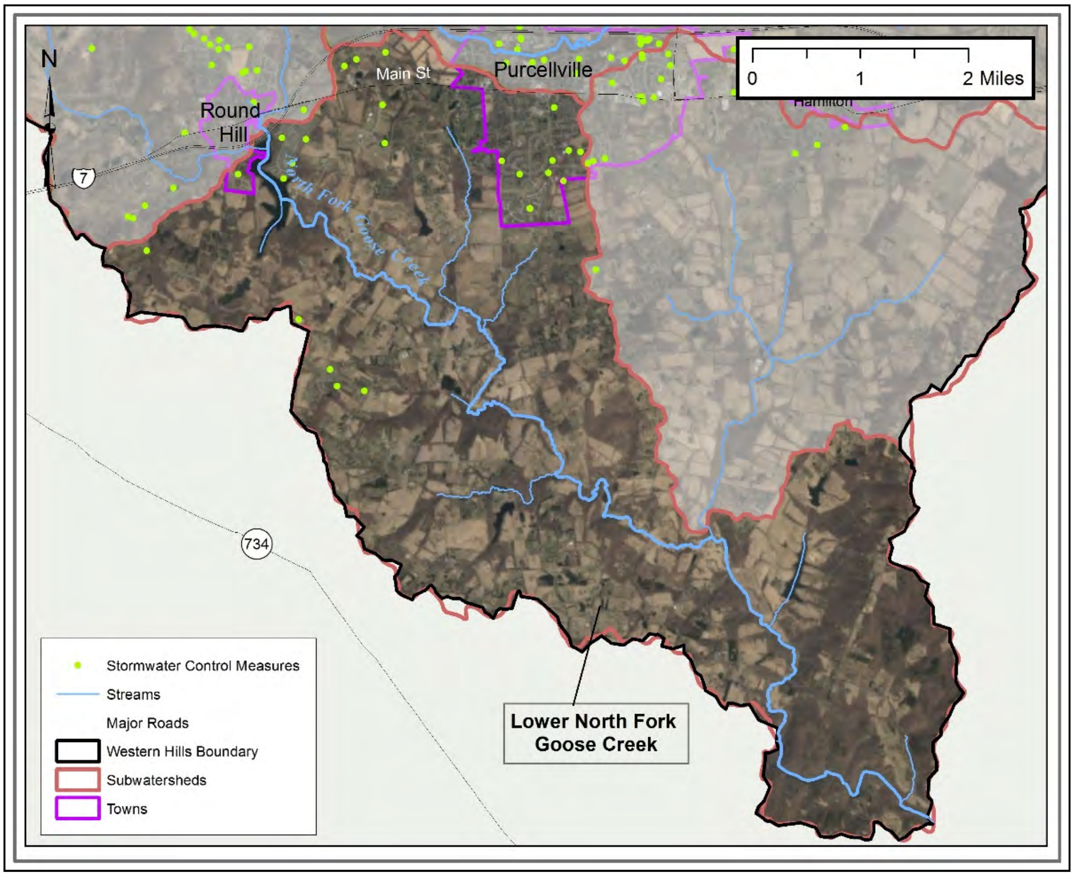


**Figure 8-24: Existing Conditions – Lower North Fork Goose Creek Subwatershed**

### *Neighborhoods*

Four neighborhoods were assessed within the Lower North Fork Goose Creek subwatershed during the uplands assessment of the Western Hills Watershed (see Figure 8-1). Preliminary recommendations for neighborhoods in this subwatershed included actions to reduce stormwater volume and pollutants including downspout disconnection, installation of rain gardens, sustainable landscaping, storm drain marking, and tree planting. A summary of recommended neighborhood actions is presented in Table 8-17.

**Table 8-17: Neighborhood Source Assessment (NSA) Recommendations – Lower North Fork Goose Creek Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Lot Size (acres) | % Opportunity for Downspout Disconnection | Rain Barrels | Rain Gardens | Storm Drain Marking | Sustainable Landscaping | Increase Lot Canopy | Pet Waste Management | Fertilizer Reduction | Buffer Improvement | New SCM | # of Open Space Trees | Notes |
| NSA102 | 1/2 | 60% | ✓ | | ✓ | | | | ✓ | | | 584 | Information regarding concern for Sleeter Lake water quality could be displayed at park on Shrewsberry Court |
| NSA103 | >1 | 40% | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | 0 | Educate homeowners on better lawn maintenance and encourage tree planting on private property |
| NSA109 | 1/4 | 10% | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | 446 | Pet waste disposal stations in common areas and lawn maintenance education are recommended. |
| NSA111 | 1/2 | 10% | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | | 3882 | Pet waste disposal stations along community trail and lawn maintenance education are recommended. |

Neighborhoods assessed within the Lower North Fork Goose Creek subwatershed had opportunities for improvement. Storm drain marking, rain gardens, sustainable landscaping, fertilizer reduction, pet waste management, and tree plantings were recommended. The neighborhood next to Sleeter Lake, NSA102, could be encouraged to engage residents in an awareness campaign focusing on the water quality in Sleeter Lake (Figure 8-25). The park at the end of Shrewsberry Court overlooking Sleeter Lake would be a great location to begin the awareness campaign with signs explaining how stormwater runoff affects the lake (Fig. 8-26). Lower North Fork Goose Creek subwatershed had good opportunities for open space tree plantings, which were recommended in NSA102, NSA109, and NSA111 (Figure 8-26). A lack of community space kept tree planting from being recommended in NSA103, but considering the large lot sizes, planting on private property would be a possibility (Figure 8-27). Small lot sizes in NSA102 and 60 percent opportunity for downspout disconnection make this neighborhood a good candidate for the installation of rain barrels and, in the case of larger lots, rain gardens or sustainable landscaping. Rain gardens and sustainable landscaping were not recorded as recommended actions during the NSA102 assessment because the majority of yards in this neighborhood were not large enough, but in other neighborhoods of similar design there may be sufficient space. Additionally, the large percentage of lots covered by mowed lawns in these neighborhoods provides a great opportunity to reduce stormwater runoff at the individual lot scale through rain garden installation and sustainable landscaping.

**Figure 8-25: NSA102 Sleeter Lake**

**Figure 8-26: NSA102 Open space tree planting opportunity (left) and Shrewsberry Park (right)**

**Figure 8-27: Large yard lots in NSA103 present an opportunity to promote tree plantings**

***Hotspots***

No hotspot site investigations were performed within the Lower North Fork Goose Creek subwatershed

***Institutions***

Two municipal buildings, a neighborhood, and two churches were investigated in the Lower North Fork Goose Creek subwatershed. A summary of potential opportunities for restoration are detailed in Table 8-17.

Fleet vehicles were stored at ISI08. There is potential for tree planting and new SCM opportunities on the site (Figure 8-28). ISI09 is well-planted with trees. The parking lot is broken and there were signs of leakage from the dumpster with stains on the ground in the vicinity. There is an existing SCM that needs maintenance. There is an existing SCM practice at ISI18. There are tree planting and new SCM opportunities at ISI18 (Figure 8-28).

## Table 8-18: ISI Recommendations – Lower North Fork Goose Creek Subwatershed

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Storm Drain Marking | # Trees for Planting | Downspout Disconnection | New Stormwater Treatment | Future Education | Buffer Improvement | Pollution Prevention Plan | Trash Management | Impervious Cover Removal | Notes |
| ISI08 | ✓ | See URSA | ✓ | ✓ | ✓ | | | | | Tree planting, stormwater retrofit potential (cisterns around building for landscape watering and garden on west side of building, swale on southern portion of parcel), Downspout disconnection, Include in future education effort |
| ISI09 | | | ✓ | | ✓ | | | | | Downspout disconnection (garden cistern and where watering is needed for landscape watering), Storm drain marking, Include in future education effort. Existing bioretention treating site, needs maintenance of BMP surface and outfall structure |
| ISI13 | ✓ | | | ✓ | ✓ | | ✓ | | | Include in future education effort; suggest follow-up on-site inspection; consider a water pollution prevention plan. After subdivision is developed a second assessment is recommended to determine where tree plantings could occur. It is recommended to build on front portion of lots to keep as much of the stream buffer in its natural state as possible since house runoff will run downhill towards stream |
| ISI18 | ✓ | See URSA | | ✓ | ✓ | | | | | Tree planting, stormwater retrofit (existing and new), Future education effort |
| ISI20 | ✓ | | | | | | | | | *No additional comments* |

**Figure 8-28: New Bioretention or Rain Garden Opportunity (left) at ISI08 and Bioswale Enhancement Opportunity (right) at ISI18**

***Open Space Tree Planting***

Pervious area restoration has the potential to convert areas of turf and other maintained cover to forested cover. Maintained pervious cover can potentially generate higher nutrient loads through grass clippings and fertilizer application. Forested cover with tree and understory provides runoff control through canopy interception, nutrient uptake, and shade benefits. Two pervious areas were assessed for restoration potential in the Lower North Fork Goose Creek subwatershed of Western Hills Watershed: Loudoun Valley Community Center and Blue Ridge Bible Church. The locations and details for each assessed site can be found in Chapter 4, section 4.2.4.4.

Summary information for these sites is provided in Table 8-19.

**Table 8-19: URSA Summaries – Lower North Fork Goose Creek Subwatershed**

| Site ID | Location in Subwatershed | Description | Acres | Ownership |
|---|---|---|---|---|
| Loudoun Valley Community Center | Northeast | County Building | Parcel – 4.73<br>Recommended planting – 0.32 | Public |
| Blue Ridge Bible Church | Northeast | Church | Parcel – 7.10<br>Recommended planting – 0.87 | Private |

***Stream Corridor Assessments***

Field crews walked 2.47 miles of stream (5.6 percent of the total stream miles) within the Lower North Fork Goose Creek subwatershed to identify potential water quality problems and restoration opportunities. A total of 37 problems were identified in stream reaches assessed in the Lower North

Fork Goose Creek subwatershed. Maps showing key findings of the stream corridor assessments are found in Section 4.1.
The predominant issues were erosion, mostly moderate in severity, which made up nearly 73 percent of the total problems recorded. Within a portion of stream assessed near a neighborhood adjacent to Sleeter Lake, field staff observed a collapsed culvert and eroding bank that poses a risk of further erosion of the nearby embankment (Figure 8-29). This same tributary was also noted as having an inadequate riparian buffer, at residences with yards near the stream channel, potentially at risk of future bank erosion. On the grounds of the Town of Purcellville wastewater and maintenance facilities, moderate/severe erosion sites (Figure 8-30), channelization, and barriers to fish passage were all reported.

See Chapter 9 for information on potential stream restoration projects in the Lower North Fork Goose Creek subwatershed.

**Figure 8-29: Collapsed culvert and eroded bank near Sleeter Lake**

**Figure 8-30: Erosion in stream reach next to Town of Purcellville wastewater and maintenance facilities**

### *Stormwater Conversions and New Stormwater Control Measures*

Existing stormwater management ponds in the Lower North Fork Goose Creek subwatershed were evaluated during the Retrofit Reconnaissance Investigations, to identify opportunities for facility conversions or upgrades to improve water quality. Two SCM conversion opportunities were identified; see Chapter 9 for more information. Six opportunities for new SCMs were identified and are also described in Chapter 9.

### *Subwatershed Management Strategy*

Figure 8-31 provides a visual summary of potential restoration opportunities in the Lower North Fork Goose Creek subwatershed.

<u>Non-Governmental Actions (residents, HOAs, public schools, other non-governmental institutions, and watershed groups)</u>

1. Conduct appropriate downspout rain barrel and rain garden installation measures in local Dneighborhoods.
2. Engage residents in a storm drain marking program and conduct marking activities in local neighborhoods.
3. Educate residents about the benefits and importance of sustainable landscaping and its effects on water quality in local neighborhoods.
4. Educate property owners about the water quality benefits of reducing fertilizer use on lawns.
5. Encourage communities to plant open space trees.
6. Engage institutional sites, such as those indicated above, in storm drain marking.
7. Investigate the open space areas described above for potential tree planting.

<u>Municipal Actions (Loudoun County and Town governments)</u>

1. Investigate feasibility of recommendations for stream restoration in areas noted.
2. Assess feasibility of stormwater pond conversion for the sites noted.
3. Engage with institutional sites in the planning of new SCMs as noted.

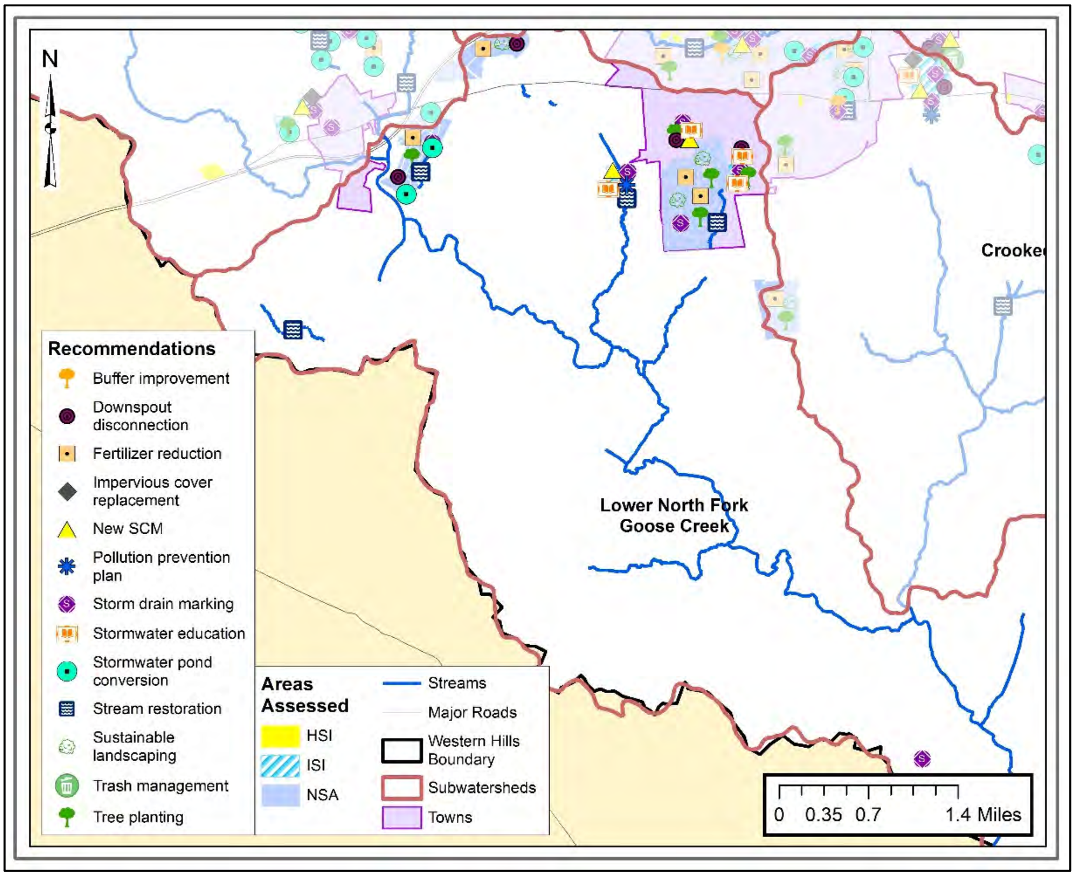


**Figure 8-31: Potential Restoration Opportunities in Lower North Fork Goose Creek Subwatershed**

## 8.5 Crooked Run

Crooked Run is the third largest subwatershed in the Western Hills Watershed. The southeast portion of the town of Purcellville falls within this subwatershed, as does a portion of the Town of Hamilton. Pasture and turf grass make up 51.2 percent of the land use in this region according to Chesapeake Bay Program data. Figure 8-32 shows the existing conditions within the subwatershed. Table 8-20 summarizes the key subwatershed characteristics of Crooked Run.

**Table 8-20: Key Characteristics – Crooked Run Subwatershed**

| | | |
|---|---|---|
| Drainage Area | 8102 acres (12.6 sq. mi.) | |
| Stream Length | 23.99 miles | |
| Land Use/Land Cover | Barren: | 0% |
| | Cropland: | 10.6% |
| | Forest: | 22.5% |
| | Pasture: | 32.9% |
| | Harvested: | 0% |
| | Turf Grass: | 18.3% |
| | Tree: | 7.9% |
| | Shrub/Scrub: | 0.1% |
| | Water: | 0.3% |
| | NWI/Other: | 0.6% |
| | Impervious Cover | 6.8% |
| Soils | A Soils (low runoff potential): | 1.1% |
| | B Soils: | 42.4% |
| | C Soils: | 28.1% |
| | D Soils (high runoff potential): | 5% |
| | *B/D Soils: | 23.4% |
| | *C/D Soils: | 0% |
| SCMs | 7% of subwatershed treated | |

*Dual Hydrologic Soil Group. See Chapter 3 for further detail.
NWI= National Wetlands Inventory

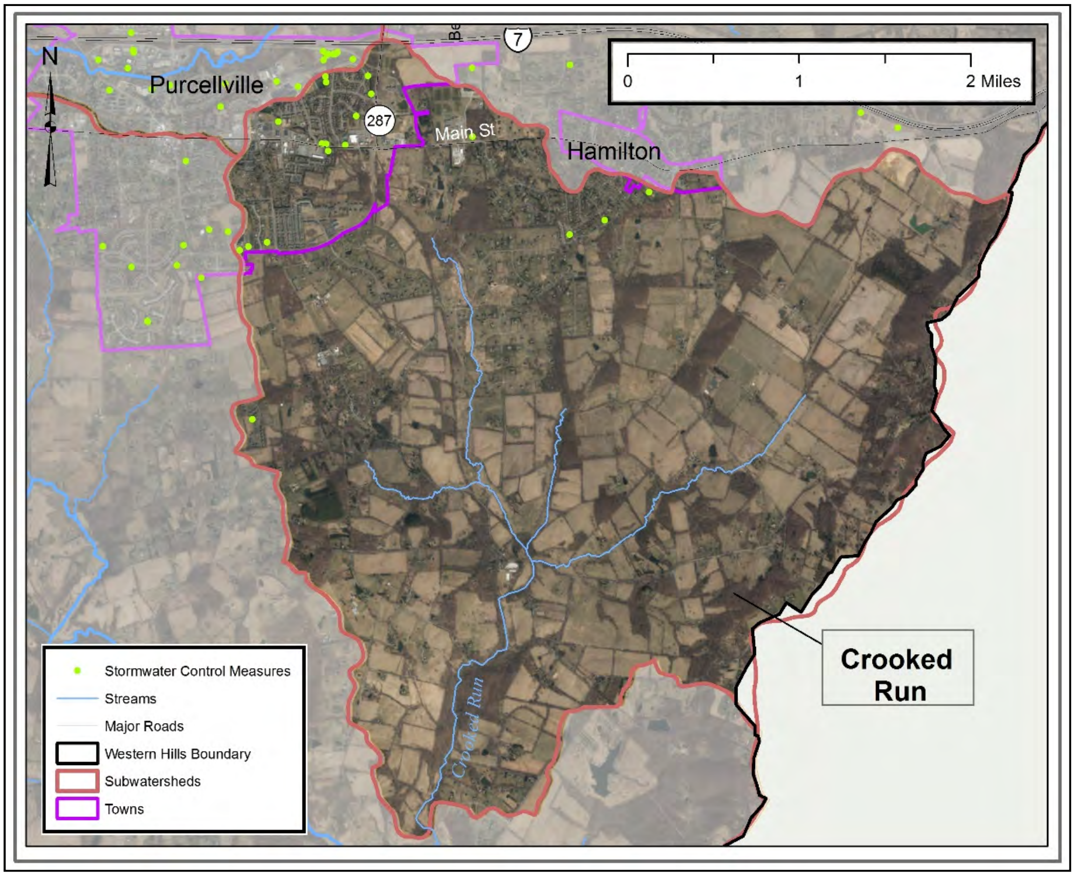


**Figure 8-32: Existing Conditions – Crooked Run Subwatershed**

### *Neighborhoods*

A total of four distinct neighborhoods were assessed within the Crooked Run subwatershed during the uplands assessment of the Western Hills Watershed (Figure 8-1). Preliminary recommendations for neighborhoods in this subwatershed included actions to reduce stormwater volume and pollutants including downspout disconnection, stream buffer improvements, installation of rain barrels, planting of rain gardens and conservation landscapes, pet waste management, and tree planting. A summary of recommended neighborhood actions is presented in Table 8-21.

**Table 8-21: Neighborhood Source Assessment (NSA) Recommendations – Crooked Run Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site ID** | **Lot Size (acres)** | **% Opportunity for Downspout Disconnection** | **Rain Barrels** | **Rain Gardens** | **Storm Drain Marking** | **Sustainable Landscaping** | **Increase Lot Canopy** | **Pet Waste Management** | **Fertilizer Reduction** | **Buffer Improvement** | **New SCM** | **# of Open Space Trees** | **Notes** |
| NSA104 | 1/4 | 10% | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | 0 | Rain garden/bioretention could be effective in common park space. Pet waste disposal stations in common areas and lawn maintenance education are recommended |
| NSA105 | 1/4 | 5% | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | 0 | Pet waste disposal stations and bioretention area for hillside next to playground are recommended |
| NSA112 | 1/4 | 10% | ✓ | | | ✓ | | ✓ | ✓ | | | 296 | Pet waste disposal stations in common areas and lawn maintenance education are recommended. Potential for rain garden in common space. |
| NSA113 | 1/2 | 10% | ✓ | | | ✓ | | ✓ | ✓ | ✓ | | 1266 | Add trees along stream banks for stabilization and pet waste disposal stations in common areas. Educate homeowners in better lawn maintenance. |

All of the neighborhoods assessed within the Crooked Run subwatershed had several opportunities for improvement. Circular roadways in NSA112 created grassy common areas where trees or rain gardens could be planted, and pet waste stations installed (Figure 8-33). The stream flowing through the common area in NSA113 could benefit from native plantings along the stream banks to assist in stabilization as well as signage educating homeowners about the purpose of the planting and what effects neighborhood runoff has on stream habitat and water quality (Figure 8-33). In NSAs 104 and 105 the large percentage of lots covered by mowed lawns provides a great opportunity to educate regarding fertilization reduction and reduce stormwater runoff on individual lots through rain barrel installation and sustainable landscaping. Additionally, the hillside next to the playground in NSA105 could provide an opportunity for bioretention.

**Figure 8-33: Opportunities for tree plantings in common area of NSA112 (left) and stream in need of bank stabilization plantings (right) at NSA113**

### *Hotspots*

Three sites were investigated within the Crooked Run subwatershed of Western Hills: a municipal building, a medical office, and a yard equipment business. A summary of field findings and preliminary recommendations at these sites is presented in Table 8-22.

The municipal building lot and the yard equipment business had a large number of vehicles/equipment storage. Uncovered fueling operations were observed at both sites. In addition, the outdoor vehicle washing area discharged directly to storm drain and adjacent stream and it was noted that materials were stored outdoors without secondary containment. In both instances, the parking lot asphalt was broken. Multiple observations at both sites are shown in Figure 8-34.

**Table 8-22: HSI Results and Recommendations – Crooked Run Subwatershed**

| Site ID | Active Pollution Observed | | | Recommended Follow-up Actions | | | | Hotspot Status | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicle Operations | Outdoor Materials | Physical Plant | Refer for Enforcement | Follow Up Inspection | Review SWPP | Include in Future Education | Not | Potential | Confirmed | Severe |
| HSI01 | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | |
| HSI05 | | | | | | | | ✓ | | | |
| HSI10 | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | ✓ |

**Figure 8-34: Uncovered Fueling Operations (left) at HSI01 and Outdoor Materials Storage, Fueling, and Vehicle Washing Operations (right) at HSI10**

### *Institutions*

In the Crooked Run subwatershed, an elementary school, middle school, and two municipal buildings were investigated by field staff. A summary of potential opportunities for restoration at those four sites are presented in Table 8-23.

**Table 8-23: ISI Recommendations – Crooked Run Subwatershed**

| PRELIMINARY RECOMMENDED ACTIONS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Storm Drain Marking | # Trees for Planting | Downspout Disconnection | New Stormwater Treatment | Future Education | Buffer Improvement | Pollution Prevention Plan | Trash Management | Impervious Cover Removal | Notes |
| ISI05 | ✓ | | ✓ | ✓ | ✓ | | | | ✓ | Stormwater retrofit (new practice), downspout disconnection, impervious cover removal (convert some walkways to porous pavement), include in future education effort |
| ISI06 | ✓ | | | | | | ✓ | | | Tree planting, consider a water pollution prevention plan. Continuously eroding gravel parking lots may pose potential high sediment load to adjacent stream |
| ISI10 | | | | | ✓ | | | | ✓ | Stormwater retrofit (existing practice), Storm drain marking, Include in future education effort. Liquid also seen stored outside. Consider replacing tennis court and blacktop with porous pavement. |
| ISI11 | ✓ | | | | | ✓ | | | | Stream buffer improvement outside of fenced area. |

At ISI05 downspouts are visible and directly discharge to impervious surface. There is potential for disconnection and discharge to pervious areas on site. A large number of vehicles are stored on the site. There is potential for new SCM opportunities to treat impervious parking areas. The parking lot at ISI06 is breaking and there is potential of discharge of large sediment load to the adjacent stream. Surface runoff including vehicle wash water also makes its way to the stream. Methods to improve physical condition of parking and contain wash water should be considered. At ISI10, an existing bioretention needs maintenance (Figure 8-35). This existing bioretention is recommended to be improved. Tennis courts and blacktop play areas may be converted to a porous concrete surface. ISI11 is a small site adjacent to an existing stream. There is some potential for stream buffer improvement at the site.

**Figure 8-35: Bioretention or Infiltration Swale Upgrade Opportunity at ISI10**

***Open Space Tree Planting***

No URSA site visits were performed within the Crooked Run subwatershed. However, opportunities may exist to increase tree cover on large parcels of private land present in this area.

***Stream Corridor Assessments***

Field crews walked 1.26 miles of stream (5.3 percent of the total stream miles) within the Crooked Run subwatershed to identify potential water quality problems and restoration opportunities. A total of 17 problems were identified in stream reaches assessed in the Crooked Run subwatershed. Maps showing key findings of the stream corridor assessments are found in Section 4.1.

Two stream reaches were assessed in the Crooked Run subwatershed. The reach located in the northern portion of the Crooked Run subwatershed area is near Route 7 which is a busy thoroughfare in the Town of Purcellville. Upstream development, impervious surfaces, upstream installation of riprap (Figure 8-36), and orchard activity surrounding the middle portion of the reach has caused widespread erosion (Figure 8-36) through this assessed area. The second reach is centrally located in the Crooked Run Watershed with more rural surroundings. Though there is less development, the surrounding area is primarily pasture and some areas of inadequate buffer zone along the reach were found (Figure 8-37). Areas of moderate erosion have also formed at many bends or constricted areas within the assessed segment.

See Chapter 9 for information on potential stream restoration projects in the Crooked Run subwatershed.

**Figure 8-36: Channelization (left) and erosion (right) in stream reach in Crooked Run subwatershed.**

**Figure 8-37: Inadequate buffer surrounding stream reach in Crooked Run subwatershed**

***Stormwater Conversions and New Stormwater Control Measures***

Existing stormwater management ponds in the Crooked Run subwatershed were evaluated during the Retrofit Reconnaissance Investigations, to identify opportunities for facility conversions or upgrades to improve water quality. Five SCM conversion opportunities were identified; see Chapter 9 for more information. Two opportunities for new SCMs were identified and are also described in Chapter 9.

***Subwatershed Management Strategy***

Figure 8-38 provides a visual summary of potential restoration opportunities in the Crooked Run subwatershed.

Non-Governmental Actions (residents, HOAs, public schools, other non-governmental institutions, and watershed groups)

1. Conduct appropriate downspout rain barrel and rain garden installation measures in local neighborhoods.
2. Educate residents about the benefits and importance of sustainable landscaping and its effects on water quality in local neighborhoods.
3. Educate property owners about improving stream buffer management, for example at the location indicated above.
4. Educate property owners about the water quality benefits of reducing fertilizer use on lawns.
5. Encourage communities to plant open space trees, for example in the neighborhoods indicated above.
6. Engage institutional sitesin storm drain marking.
7. Investigate open space areas for potential tree planting.
8. Consider impervious cover replacement at institutions indicated.

Municipal Actions (Loudoun County and Town governments)

1. Continue to monitor conditions at potential hotspots indicated.
2. Investigate feasibility of recommendations for stream restoration in areas noted.
3. Assess feasibility of stormwater pond conversion for the site noted.
4. Engage with institutional sites in the planning of new SCMs as noted.

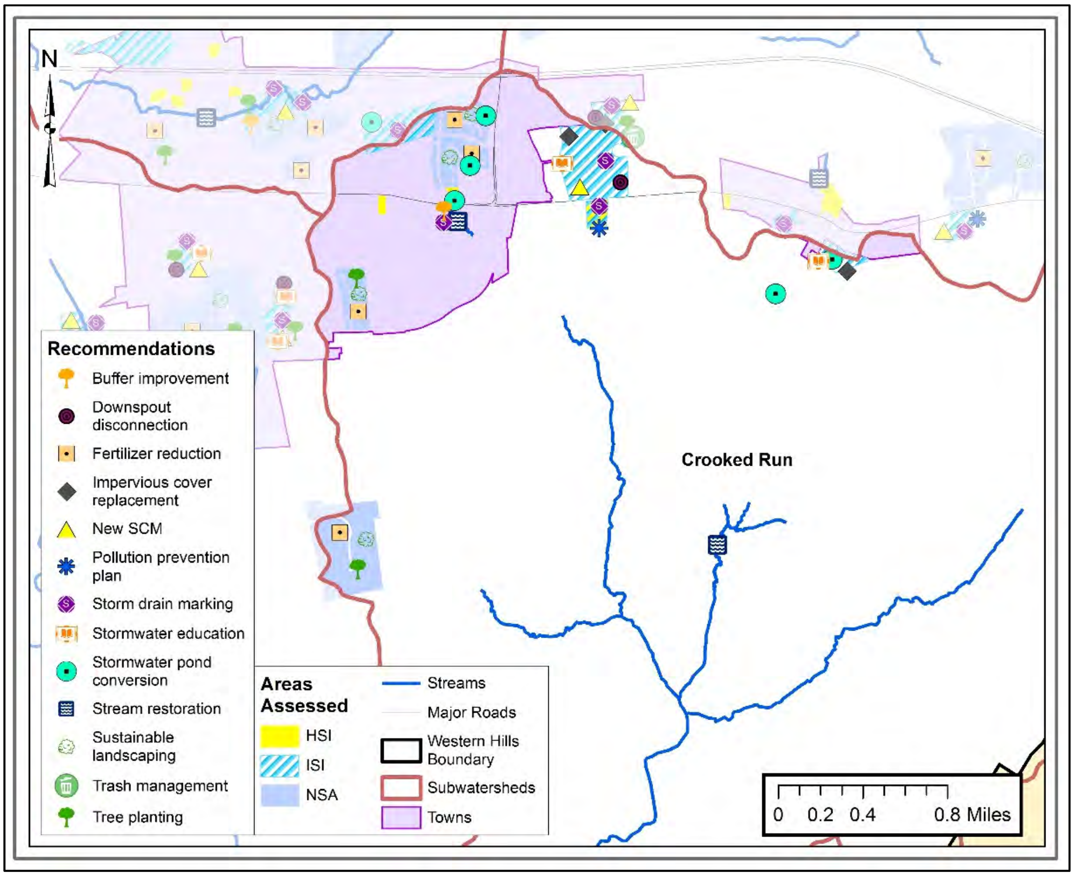


**Figure 8-38: Potential Restoration Opportunities in Crooked Run Subwatershed**

## 8.6 Subwatershed Ranking

Data from the five major Western Hills subwatersheds are useful for assessing patterns of watershed condition and for evaluating restoration potential of the different areas. As reported in previous chapters, results of the field assessments and desktop analysis provide insight into the levels of ecological conditions and stressors present within the different portions of the Western Hills Watershed, as documented by various measurements. A combined evaluation approach estimates the severity and potential for correction within each subwatershed. The extent and magnitude of stressors can be used as indicators to understand which factors are contributing to water quality degradation; combined, the suite of measures may indicate priorities for restoration efforts. The subsections below describe the criteria and methodology used to develop rankings based on indicators, as applied to the five major subwatersheds in the Western Hills Watershed. This subwatershed priority ranking method provides a tool for targeting restoration actions by location.

Criteria describing environmental stressors within a subwatershed provide information to support a priority ranking method for identifying restoration need and potential. The subwatershed restoration priorities identified with this method are based on a sum of ranking scores for a number of criteria which describe declining water quality, as well as opportunities for improving conditions. This analysis integrates results from the field surveys and desktop GIS analyses described earlier in this report. The restoration priority total score for a subwatershed is comprised of ranked conditions of the following criteria:

- Impervious surface
- Neighborhood restoration opportunity/Pollution source index
- Neighborhood downspout disconnection
- Institutional Site Investigations
- Urban Reforestation Site Assessments
- Municipal stormwater management facility conversions
- Stream buffer improvement
- Stream restoration potential

To develop a restoration priority total score, each contributing criterion receives a ranking score of 1 to 5, with higher scores representing the most severe condition or the greatest opportunity to bring about change. In general, the initial analysis approach intended to separate the evaluation results for each criterion into four classes that would result in at least one subwatershed in each ranked class. In some cases, the data distribution did not facilitate a balanced spread across the classes; for instance, a narrow range of values, clustered values, or occurrence of null values (zero) where measured conditions did not exist within the subwatershed.

The criteria combined to calculate the restoration priority total scores reflect watershed management goals and make use of information compiled during the watershed characterization and field efforts. The sections below provide descriptions and ranking levels for each of the selected criteria. These are followed by a summary of the rankings and restoration priority total scores for the subwatersheds within the Western Hills Watershed.

### 8.6.1 Impervious Surfaces

Impervious surfaces, including roads, parking lots, roofs and other paved surfaces, prevent precipitation from infiltrating into the ground as it would naturally in a forest or meadow in good condition. As a result, impervious surface runoff can result in decreased times of concentration of stormwater to receiving streams ("flashy flows") leading to erosion, flooding, habitat degradation, and increased pollutant loads to receiving water bodies. As illustrated by the Impervious Cover Model (Schueler 2008, detailed in Chapter 3), watershed areas with high proportions of impervious cover are more likely to have degraded stream systems and to be significant contributors to water quality problems than those that are less developed.

As described in the Chapter 3, data on impervious cover (including roads, buildings, driveways, and other impervious surfaces) provides the information to support estimation of percent impervious cover at the subwatershed scale. Subwatershed impervious cover percentages range from approximately 6.1 to 8 percent of area. Subwatersheds with higher percentages of impervious cover indicate higher priorities for restoration; higher scores denote greater water quality impacts and restoration needs. The following point system assigns impervious ranking scores to the five subwatersheds based on subwatershed impervious surface percentages, roughly following guidance from the Impervious Cover Model:

- 16 - 25% = 3 points
- 11 - 15% = 2 points
- 0 - 10% = 1 point

Table 8-24 presents a summary of the percent impervious cover values and corresponding ranking scores by subwatershed. All fell into the lowest category on this scale.

**Table 8-24: Percent Impervious Cover Ranking Scores by Subwatershed**

| Subwatershed | Percent Impervious Cover | Impervious Ranking Score |
|---|---|---|
| Upper South Fork Catoctin Creek | 7.1 | 1 |
| Lower South Fork Catoctin Creek | 6.4 | 1 |
| Upper North Fork Goose Creek | 8 | 1 |
| Lower South Fork Goose Creek | 6.1 | 1 |
| Crooked Run | 6.8 | 1 |

Neighborhood Restoration Opportunity/Pollution Source Indexes

As described in Chapter 3, neighborhood source assessments (NSAs) included estimations of neighborhood pollution severity and restoration potential. The Pollution Severity Index (PSI) reflects, in general, the severity of pollution generated by a neighborhood; field crews rated PSI as severe, high, moderate, or none. The Restoration Opportunity Index (ROI) reflects the neighborhood's potential for residential restoration projects; field crews rated ROI as high, moderate, or low. Out of the 15 neighborhoods assessed, seven neighborhoods received a high rating for either PSI or ROI and a moderate rating for the other index. Neighborhoods with severe or high PSI and ROI ratings represent the best areas to initially focus restoration efforts.

The subwatershed with the severe rating for PSI/ROI received the highest score (4 points), regardless of the assessments for any other neighborhood in the subwatershed. Of the remaining subwatersheds, those with a high PSI or ROI and a moderate score for the other index received a ranking score of 3 points if there were other PSI/ROI assessments in the subwatershed; 2 points if there were not. All other subwatersheds with neighborhoods received a ranking score of 1 point. The following point system summarizes PSI/ROI ranking scores assigned:

- Severe/High = 4 points
- High/Moderate or Moderate/High; other neighborhoods ranked the same or lower = 3 points
- High/Moderate or Moderate/High only = 2 points
- All other ratings = 1 point
- No NSAs performed in subwatershed = 0 points

Table 8-25 presents a summary of the number of NSAs associated with various PSI/ROI ratings and corresponding PSI/ROI ranking scores by subwatershed.

**Table 8-25: NSA PSI/ROI Ranking Scores by Subwatershed**

| Subwatershed | Number of NSAs with PSI/ROI Rating | | | | NSA PSI/ROI Ranking Score |
|---|---|---|---|---|---|
| | Severe/High | High/Moderate | Moderate/High | Other | |
| Upper South Fork Catoctin Creek | 0 | 1 | 1 | 2 | 3 |
| Lower South Fork Catoctin Creek | 0 | 1 | 0 | 1 | 3 |
| Upper North Fork Goose Creek | 0 | 0 | 1 | 0 | 2 |
| Lower North Fork Goose Creek | 0 | 1 | 2 | 1 | 3 |
| Crooked Run | 0 | 0 | 0 | 4 | 1 |

### 8.6.2 Neighborhood Downspout Disconnection

Rooftops with connected downspouts discharge runoff directly to the storm drain system or to impervious surfaces. In either case, there is little or no treatment of stormwater runoff before it reaches the stream system. Disconnected downspouts drain to pervious areas such as lawns, rain barrels, or rain gardens, and allow rooftop runoff to infiltrate the ground and enter streams through the groundwater system in a slower, more natural manner. Downspout disconnection is desirable because it decreases flow and reduces pollutant loads to streams during storm events.

Neighborhood Source Assessments recommended downspout disconnection for neighborhoods where at least 25 percent of the downspouts were directly connected to impervious surfaces or the storm drain system, and where the average lot had at least 15 feet of pervious area available down-gradient from the connected downspout for redirection.

Chapter 4 includes a summary of the NSA results regarding the acres of rooftop that would be addressed if downspout disconnection were initiated in the recommended neighborhoods. The analysis for downspout disconnection ranking included a calculation of the percentage of sub-watershed rooftop area that would be addressed; these results contribute to the estimate of restoration potential for the five subwatersheds. Subwatersheds with the highest percentages of impervious rooftop acres addressed through downspout disconnection would likely have the greatest restoration potential and therefore received the highest ranking scores. The following point system assigns downspout disconnection ranking scores to the five subwatersheds based on subwatershed rooftop acreage that could be addressed:

- > 20 acres = 4 points
- 10 - 20 acres = 3 points
- < 10 acres = 2 points
- NSA performed, but <25% of homes recommended for downspout disconnect = 1 point
- No NSAs performed in subwatershed = 0 points

Table 8-26 presents a summary of rooftop acres that would be addressed by downspout disconnection and the corresponding ranking scores by subwatershed.

**Table 8-26: Rooftop Downspout Disconnection Ranking Scores**

| Subwatershed | Rooftop Acres Addressed | Downspout Disconnection Ranking Score |
|---|---|---|
| Upper South Fork Catoctin Creek | 12.3 | 3 |
| Lower South Fork Catoctin Creek | 0 | 1 |
| Upper North Fork Goose Creek | 0 | 1 |
| Lower North Fork Goose Creek | 33.6 | 4 |
| Crooked Run | 0 | 1 |

### 8.6.3 Investigations

Institutional sites such as schools, municipal facilities, or properties owned by religious organizations offer unique opportunities for watershed restoration. Typically, institutional properties encompass considerable portions of land that contain various natural resources. In addition, they offer the opportunity to engage a wide range of citizens in restoration activities; this raises community awareness while also providing water quality improvement benefits in the watershed. Institutional Site Investigations (ISIs) in Western Hills Watershed were conducted at twenty community-based facilities (public schools, municipal facilities, and religious institutions). The focus of an ISI is to identify potential restoration opportunities, particularly those with opportunities for community education and water quality benefits.

Subwatersheds with more institutional sites present more opportunities for implementing restoration actions (e.g., tree planting, stormwater facility retrofits, community clean-ups, etc.) and encouraging citizen participation. Public institutional sites are good candidates for initial restoration efforts because there are opportunities to make use of and build upon existing partnerships, and, in many cases, incorporate student projects. The ISI criterion ranked each subwatershed based on the number of institutions considered in the assessment, according to the following point system:

- 5 ISIs = 5 points
- 4 ISIs = 4 points
- 3 ISIs = 3 points
- 2 ISIs = 2 points
- 1 ISI = 1 point
- No ISIs performed in subwatershed = 0 points

Table 8-27 presents the Institutional Site Investigation ranking scores by subwatershed.

**Table 8-27: Institutional Site Investigation Ranking Scores by Subwatershed**

| Subwatershed | Number of ISIs | ISI ranking score |
|---|---|---|
| Upper South Fork Catoctin Creek | 4 | 4 |
| Lower South Fork Catoctin Creek | 4 | 4 |
| Upper North Fork Goose Creek | 3 | 3 |
| Lower North Fork Goose Creek | 5 | 5 |
| Crooked Run | 4 | 4 |

### 8.6.4 Open Space Tree Plantings

The most likely candidates for successful tree establishment efforts are those on public lands with minimal site preparation required. Larger open parcels have greater potential for tree planting and water quality benefits than smaller areas.

Urban Reforestation Site Assessments (URSAs) recommended tree plantings in several areas throughout Western Hills Watershed (as described in Chapter 4). Subwatershed ranking for open space tree planting accounts for the acres of tree planting opportunities identified in the URSAs. Based on this calculation, the recommended areas for reforestation within the five subwatersheds range from 0.97 to 29.62 acres. The ranking scores reflect the area deemed suitable for reforestation, as follows:

- > 20 acres = 4 points
- 11 - 20 acres = 3 points
- 5 - 10 acres = 2 points
- < 5 acres = 1 point
- No URSAs performed in subwatershed = 0 points

Table 8-28 presents the open space tree planting acreages and corresponding ranking by sub-watershed.

**Table 8-28: Open Space Tree Planting Acreages and Ranking by Subwatershed**

| Subwatershed | Acres Recommended for Open Space Tree Planting | Open Space Tree Planting Ranking Score |
|---|---|---|
| Upper South Fork Catoctin Creek | 29.62 | 4 |
| Lower South Fork Catoctin Creek | 0.97 | 1 |
| Upper North Fork Goose Creek | 1.51 | 1 |
| Lower North Fork Goose Creek | 2.12 | 1 |
| Crooked Run | 1.19 | 1 |

### 8.6.5 **Stormwater Management Facility** Conversions

As part of field investigations, project staff investigated a number of existing stormwater ponds within the Western Hills Watershed for potential conversion to water quality management facilities. The assessment's main target was dry ponds because they have the greatest potential for conversion to a type of facility, such as a dry extended detention facility, that provides water quality benefits in addition to quantity control. By design, dry extended detention ponds capture and retain stormwater runoff from a storm for a minimum duration to allow sediment and pollutants to settle out while also providing flood control.

During the survey of stormwater control measures (SCMs) in Western Hills, staff assessed 18 existing ponds for their potential to be converted to increase their efficiency of treatment. Information documented at each facility included orifice, riser, ponding, debris, vegetation, adjacent land use, physical expansion capabilities, outfall, and downstream conditions. The field assessment identified five facilities with a high potential for successful conversion and three facilities with a medium potential for conversion.

The following point system assigns stormwater management facility conversion ranking scores to the five subwatersheds based on conversion potential of ponds assessed in the recent field survey:

- 2 or more ponds with high potential and at least 1 pond with medium potential = 4 points
- 1 pond with high potential = 3 points
- 1 pond with medium potential = 2 points
- 0 ponds with high or medium potential = 1 points
- No SCM assessed = 0 points

Table 8-29 presents the number of SCM facilities with significant conversion potential and the corresponding ranking scores by subwatershed.

**Table 8-29: SCM Facilities with Significant Conversion Potential and Ranking Scores by Subwatershed**

| Subwatershed | Number of SCM Facilities by Conversion Potential | | SCM Facility Conversion Ranking Score |
|---|---|---|---|
| | High | Medium | |
| Upper South Fork Catoctin Creek | 1 | 0 | 3 |
| Lower South Fork Catoctin Creek | 0 | 0 | 1 |
| Upper North Fork Goose Creek | 3 | 3 | 4 |
| Lower North Fork Goose Creek | 1 | 0 | 3 |
| Crooked Run | 0 | 0 | 1 |

### 8.6.6 Stream Buffer Improvements

Forested buffers along streams play a crucial role in improving water quality and flood mitigation. They can reduce surface runoff and pollutant loads, stabilize stream banks, trap sediment, and provide habitat for various types of terrestrial and aquatic life. Healthy forest buffers help to reduce nutrient and sediment loadings to waterways. When forested stream buffers are removed (e.g., converted to turf, cropland, pasture, or other uses), their beneficial functions are lost and stream health declines. Forested stream buffer zones can be re-established or preserved, to reduce land use impacts by intercepting and controlling pollutants entering the water body.

Chapter 3 presented the results of GIS analysis of the vegetative condition of a 100-foot buffer zone on either side of the stream system within Western Hills Watershed. The assessment classified stream buffer conditions as unforested or forested. Further analysis included calculations of acreages and percentages of the buffer by land cover type, summarized by subwatershed. Open pervious areas (e.g., turf, cropland, or pasture) represent a good opportunity for increasing forest cover in stream buffers. Subwatersheds with greater percentages of open pervious buffer areas denote the greatest potential for stream buffer improvement and received the highest ranking scores.

Open pervious stream buffer area percentages range from approximately 20.1 to 36.5 percent of the buffer zones of the five subwatersheds. The point system employed for this criterion assigned stream buffer improvement scores based on the distribution and range of open pervious buffer area percentages, as follows:

- > 40% = 4 points
- 30 - 40% = 3 points
- 25 - 30% = 2 points
- 20 - 25% = 1 point

Table 8-30 presents the percentages of open pervious stream buffer areas and corresponding ranking scores by subwatershed.

**Table 8-30: Percentages of Open Pervious Stream Buffer Areas and Ranking Scores by Subwatershed**

| Subwatershed | Open Pervious Stream Buffer (%) | Stream Buffer Ranking Score |
|---|---|---|
| Upper South Fork Catoctin Creek | 24.1 | 1 |
| Lower South Fork Catoctin Creek | 32.1 | 3 |
| Upper North Fork Goose Creek | 24.0 | 1 |
| Lower North Fork Goose Creek | 20.1 | 1 |
| Crooked Run | 36.5 | 3 |

### 8.6.7 Stream Restoration Potential

During the stream assessments conducted in Western Hills, field crews assessed the extent of stream bank erosion and evaluated the potential for correction. The stabilization of stream banks and other stream restoration techniques can provide numerous benefits including nutrient and sediment load reductions and improved habitat health for aquatic biota. Stream restoration potential ranking uses the summary of the lengths of eroded banks for each subwatershed as the basis for the ranges. Subwatersheds with a greater length of stream that would be candidates for stream restoration present a greater opportunity for restoration and pollutant load reductions and are therefore ranked higher.

The sums of erosion lengths per subwatershed range from 1,720-4,960 feet. The ranking system for stream restoration potential assigned scores to the five subwatersheds based on the range of lengths of stream in need of restoration, as determined during the stream assessments:

- > 4000 feet = 4 points
- 2000 - 4000 feet = 3 points
- 1000-2000 feet = 2 points
- <1000 feet = 1 point
- No restoration potential documented in subwatershed during stream assessments = 0 points

Table 8-31 presents the lengths of stream banks with potential for restoration as estimated during field visits and the corresponding ranking scores by subwatershed.

**Table 8-31: Lengths of Stream Banks with Potential for Restoration and Ranking Scores by Subwatershed**

| Subwatershed | Potential Stream Restoration Length (feet) | Stream Restoration Ranking Score |
|---|---|---|
| Upper South Fork Catoctin Creek | 2,939 | 3 |
| Lower South Fork Catoctin Creek | 4,960 | 4 |
| Upper North Fork Goose Creek | 4,247 | 4 |
| Lower North Fork Goose Creek | 2,752 | 3 |
| Crooked Run | 1,720 | 2 |

### 8.6.8 Summary of Subwatershed Restoration Priority Scores

The analysis for subwatershed restoration priority adds the ranked criteria scores described above to derive a total score for each of the five major subwatersheds in Western Hills Watershed. Table 8-32 summarizes the rankings by individual criteria and total scores, which illustrate the relative restoration potential. Each subwatershed was a priority category based on the following total ranking score ranges:

- ≥ 20 points = High
- 15 - 20 points = Medium
- < 15 points = Low

**Table 8-32: Subwatershed Ranking Criteria Results and Restoration Priority Categories**

| Subwatershed | Ranking Scores | | | | | | | | Total Score | Priority Category |
|---|---|---|---|---|---|---|---|---|---|---|
| | Impervious | NSA PSI/ROI | Downspout disconnection | Institutional Site Investigation | Open Space Tree Planting | SCM facility conversion | Unforested Buffer | Stream restoration | | |
| Upper South Fork Catoctin Creek | 1 | 3 | 3 | 4 | 4 | 3 | 1 | 3 | 22 | High |
| Lower South Fork Catoctin Creek | 1 | 3 | 1 | 4 | 1 | 1 | 3 | 4 | 18 | Medium |
| Upper North Fork Goose Creek | 1 | 2 | 1 | 3 | 1 | 4 | 1 | 4 | 17 | Medium |
| Lower North Fork Goose Creek | 1 | 3 | 4 | 5 | 1 | 3 | 1 | 3 | 21 | High |
| Crooked Run | 1 | 1 | 1 | 4 | 1 | 1 | 3 | 2 | 14 | Low |

Figure 8-39 illustrates the restoration priority levels for the subwatersheds in Western Hills Watershed. Upper South Fork Catoctin Creek and Lower North Fork Goose Creek subwatersheds scored in the highest priority category. Lower South Fork Catoctin Creek and Upper North Fork Goose Creek subwatersheds were rated as Medium. Crooked Run was rated as Low. While all restoration efforts will benefit the Western Hills Watershed, the priority categories presented here may help guide initial restoration efforts for the most efficient approach.

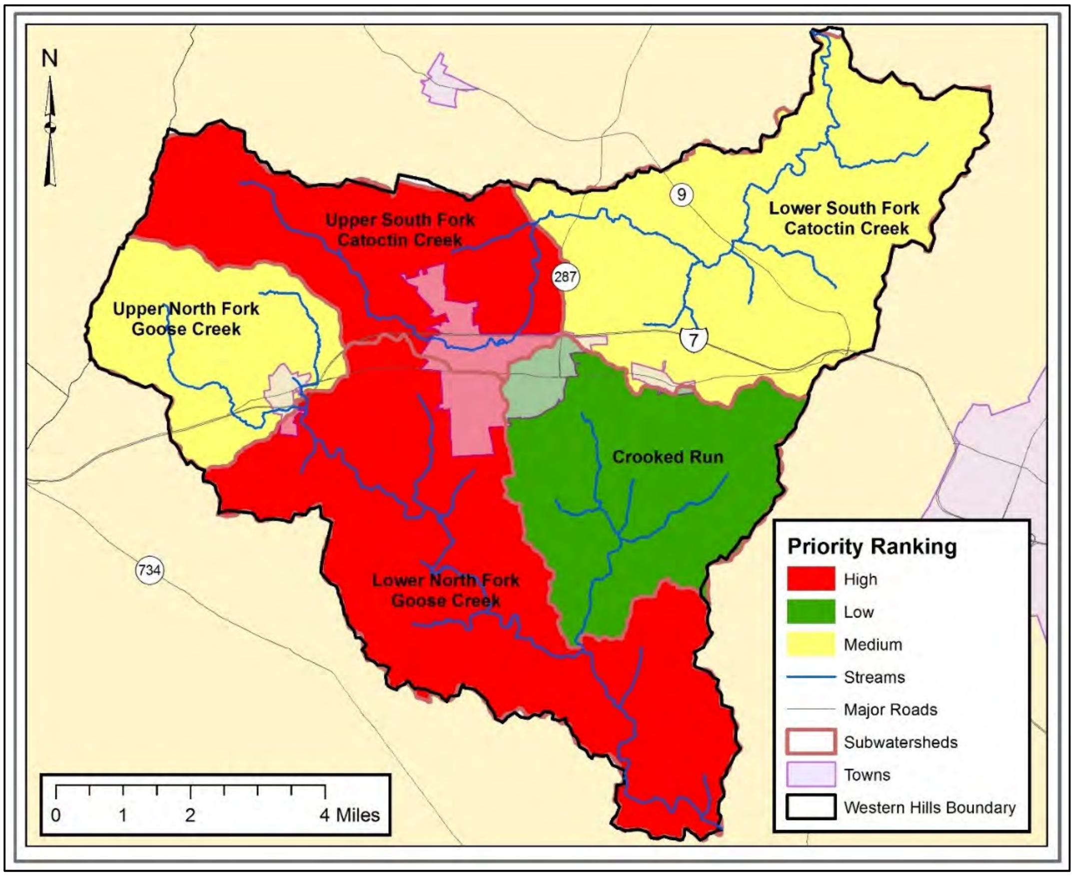


**Figure 8-39: Western Hills Subwatershed Overall Priority Rankings**

# CHAPTER 9: EXAMPLE RESTORATION PROJECTS, BENEFITS, AND COSTS

This chapter provides a summary of example stream restoration and stormwater control measure (SCM) recommendations, along with analysis of estimated nutrient and sediment loading reductions that would result from implementation of these and other types of BMPs in the Western Hills Watershed. Planning-level cost information is included for example stream restoration and SCM opportunities.

## 9.1 Stream Restoration Sites

A total of 12 candidate stream restoration sites were identified based on the findings of stream surveys conducted during the field assessments in Western Hills Watershed. As detailed in Section 4.1, over the 10 miles of stream walked, field crews identified erosion, inadequate buffer vegetation, and other detrimental conditions. Also noted were particular opportunities for improvements through stream restoration. Further review of field data, notes, maps, and photographs was conducted to identify and refine a suite of candidate stream restoration opportunities. Each of these example restoration opportunities was assigned a restoration potential rating of High, Medium, or Low, depending on the current habitat condition, severity and extent of erosion, and general feasibility of restoration. Descriptions of these potential project opportunities and ratings are shown in Table 4-1, and locations are shown in Figure 5-1. In Table 9-1, the “Length of stream with erosion observed” is the actual length of stream containing observed erosion sites, which would be considered the total length of a candidate project. In contrast, the “Overall length assessed” is the total length of stream walk conducted in the vicinity of those candidate project areas, which in a few cases may present further opportunities beyond the main restoration area, as described in the table notes.

Table 9-2 provides anticipated nutrient and sediment reductions associated with the candidate stream restoration opportunities, which are based on reduction factors in the Chesapeake Assessment and Scenario Tool (CAST). The pollutant reduction estimates presented here are intended to provide general, planning-level information. Actual nutrient reductions would need to be developed at a later stage, using specific design information and applying the Chesapeake Bay Program’s expert panel guidance for stream restoration crediting (e.g., Schueler and Stack 2014, and any subsequent CBP guidance). In addition, planning-level costs are presented in Table 9-2, as derived from unit cost information in CAST. CAST provides an estimate of $408.24 per linear foot of restored stream, which was multiplied by the proposed project length to obtain the estimated initial project cost. These cost estimates are intended to provide a relative estimate only. More detailed information will be required to determine more accurate project costs prior to moving forward with any of the candidate stream restoration projects.

**Table 9-1: Candidate stream restoration opportunities**

| Site ID | Stream Restoration Opportunity | Subwatershed | Restoration Potential Rating | Length of stream with erosion observed (ft) | Overall length assessed (ft) | Notes |
|---|---|---|---|---|---|---|
| 1 | Woodgrove High School | Upper South Fork Catoctin Creek | Low | 400 | 1150 | Behind football field. Several instances of bank erosion, some downstream of road culvert. |
| 2 | Three sections of South Fork Catoctin Creek, from Glenmeade Circle to Chapman DeMary Trail | Upper South Fork Catoctin Creek | High | 2700 | 8800 | Outfall channel with significant erosion. Along mainstem of South Fork Catoctin Creek, power poles in/near stream are a consideration. Throughout area, large upstream watershed contributes to erosion along mainstem. Near Glenmeade Circle (Catoctin Meadows HOA), there is power pole at stream edge, long continuous stretches of moderation erosion, mid-channel bars. Along Valley Industrial Park (west of Hatcher Ave), just east of N 21st Street, an outfall channel has formed large gully; mainstem has various sections of erosion but less severe. Near Chapman DeMary Trail (east of Hatcher Avenue), there are some sections of erosion. |
| 3 | Round Hill HOA, near Arrowwood Place | Upper North Fork Goose Creek | High | 900 | 900 | Outfall channel eroding; good opportunity for regenerative stormwater conveyance (RSC) design. Upper section of reach best potential. Lower section in better condition, without further opportunities. Rated high because of outfall channel erosion. |
| 4 | Round Hill HOA, near Greenwood Dr. | Upper North Fork Goose Creek | Low | 3300 | 3300 | Northeast branch is incising near wetland area. Northwest branch and mainstem have several patches of erosion that could be addressed to prevent from worsening. Area along Falls Road is wide with lots of sediment deposition, but bank erosion not very severe. Possible potential for combined opportunity with nearby BMPs. |
| 5 | Round Hill HOA, near Tedler Circle. | Lower North Fork Goose Creek | Medium | 800 | 800 | Meanders behind homes. If erosion worsens, may affect sewer line and properties. Substantial erosion at collapsed culvert in lower end of reach threatens embankment. Addressing culvert would be high priority. |

**Table 9-1: Candidate stream restoration opportunities**

| Site ID | Stream Restoration Opportunity | Subwatershed | Restoration Potential Rating | Length of stream with erosion observed (ft) | Overall length assessed (ft) | Notes |
|---|---|---|---|---|---|---|
| 6 | Round Hill HOA near Autumn Ridge Ct. | Lower North Fork Goose Creek | Low | 250 | 250 | Not good opportunity; existing beaver pond. |
| 7 | Below Franklin Park | Lower North Fork Goose Creek | Low | 2100 | 2100 | Receives flow from golf course. Sites are in wooded area but bank stability is affected by flow from upstream. |
| 8 | Purcellville WWTP | Lower North Fork Goose Creek | Medium | 600 | 1600 | Various alternating sections of bank erosion. Stream restoration could be applied along several portions, potentially more than 600 ft. |
| 9 | Purcellville, south of commercial area | Crooked Run | Medium | 400 | 1200 | Downstream of residence, shopping center, and roadway which are causing segments of erosion. Stream is surrounded by thin forest and potentially active orchard. 1200 ft assessed, restoration could potentially be applied along whole reach. |
| 11 | Pasture land in Crooked Run watershed | Crooked Run | Low | 1700 | 1700 | Potential for some riparian buffer improvements. |
| 12 | Hamilton WWTP | Lower South Fork Catoctin Creek | High | 850 | 850 | Building threatened by streambank erosion, if allowed to continue unchecked. Whole assessed reach good potential for restoration. |
| 13 | Waterford | Lower South Fork Catoctin Creek | High | 1200 | 6200 | Northwest tributary (1200 ft) presents best opportunity; entire reach was assessed and could be restored, no other upstream contributions. Southeast tributary (1350 ft) reflects large system of upstream contributions, pasture, needs fencing/buffer. South tributary (250 ft) has 4 to 5 ft banks, but restoration would also need to take into account entire buffer upstream, outside of assessed area. Mainstem has significant erosion (3400 ft total along 3 sections) but is challenging to address because of large upstream contributions to flow. |

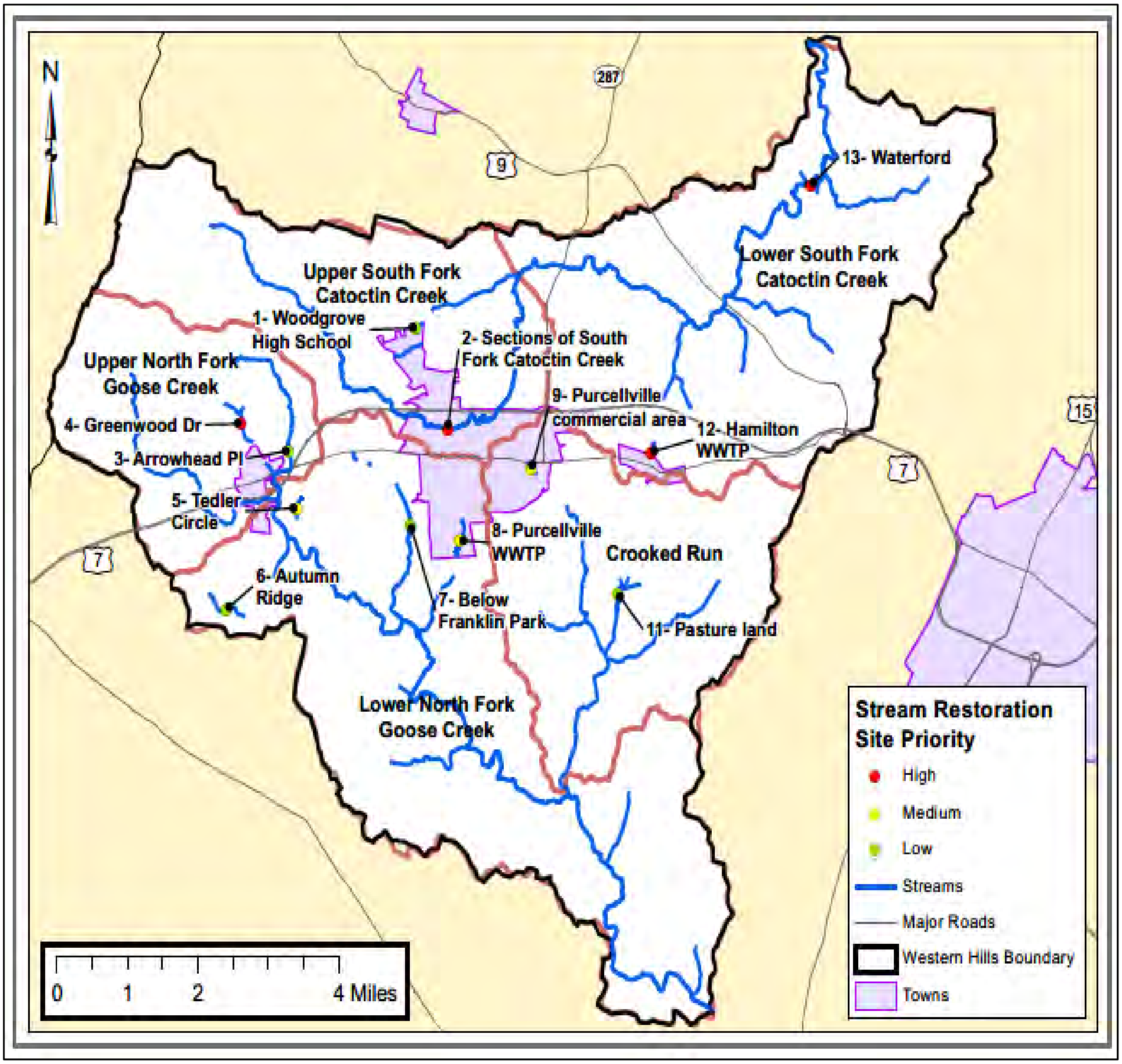


**Figure 9-1: Candidate Stream Restoration Opportunity Locations, with Priority Ratings by Restoration Potential**

**Table 9-2: Candidate Stream Restoration Opportunities, with Projected Pollutant Reductions, Restoration Potential Ratings, and Estimated Costs**

| Site ID | Stream Restoration Opportunity | Subwatershed | Project Length (LF) | Potential TN Reduction (lbs/yr)[a] | Potential TP Reduction (lbs/yr)[a] | Potential TSS Reduction (lbs/yr)[a] | Restoration Potential | Estimated Initial Project Cost |
|---|---|---|---|---|---|---|---|---|
| 1 | Woodgrove High School | Upper South Fork Catoctin Creek | 400 | 20.9 | 14.9 | 31,064.4 | Low | $163,296 |
| 2 | Three sections of South Fork Catoctin Creek, from Glenmeade Circle to Chapman DeMary Trail | Upper South Fork Catoctin Creek | 2,700 | 140.8 | 100.8 | 209,684.9 | High | $1,102,248 |
| 3 | Round Hill HOA, near Arrowwood Place | Upper North Fork Goose Creek | 900 | 46.9 | 33.6 | 69,895.0 | High | $367,416 |
| 4 | Round Hill HOA, near Greenwood Dr. | Upper North Fork Goose Creek | 3,300 | 172.1 | 123.2 | 256,281.5 | Low | $1,347,192 |
| 5 | Round Hill HOA, near Tedler Circle. | Lower North Fork Goose Creek | 800 | 41.7 | 29.9 | 62,128.8 | Medium | $326,592 |
| 6 | Round Hill HOA near Autumn Ridge Ct. | Lower North Fork Goose Creek | 250 | 13.0 | 9.3 | 19,415.3 | Low | $102,060 |
| 7 | Below Franklin Park | Lower North Fork Goose Creek | 2,100 | 109.5 | 78.4 | 163,088.2 | Low | $857,304 |
| 8 | Purcellville WWTP | Lower North Fork Goose Creek | 600 | 31.3 | 22.4 | 46,596.6 | Medium | $244,944 |
| 9 | Purcellville, south of commercial area | Crooked Run | 400 | 20.9 | 14.9 | 31,064.4 | Medium | $163,296 |
| 11 | Pasture land in Crooked Run watershed | Crooked Run | 1,700 | 88.7 | 63.4 | 132,023.8 | Low | $694,008 |
| 12 | Hamilton WWTP | Lower South Fork Catoctin Creek | 850 | 44.3 | 31.7 | 66,011.9 | High | $347,004 |
| 13 | Waterford | Lower South Fork Catoctin Creek | 1,200 | 62.6 | 44.8 | 93,193.3 | High | $489,888 |
| | | Totals: | 15,200 | 792.7 | 567.3 | 1,180,448.1 | | |

[a] Planning-level estimates of pollutant reductions were calculated using the following reduction efficiencies from CAST:

- TN: 0.05215 lb/yr per linear ft
- TP: 0.03732 lb/yr per linear ft
- TSS: 77.66106 lb/yr per linear ft

## 9.2 SCM Conversion Sites

A total of 18 candidate SCM conversion sites were visited during RRI field assessments (see Chapter 4 for more detail). A representative subset of the County's dry pond inventory was selected for the RRI field investigations. Of the 18 sites visited, 15 have the potential to be upgraded to a SCM with higher pollutant removal efficiencies. The 15 upgradable SCM conversion sites were assigned a priority rating of High, Medium or Low, which primarily depended upon the existing pond designation (and pollutant removal efficiency), engineering feasibility of an upgrade, and how much additional reduction was possible under the SCM efficiencies as determined by the Chesapeake Bay Program and used in CAST. SCM conversion project ratings and planning-level cost estimates are shown in Table 4-3, and project locations are shown in Figure 9-2. Pollutant reductions expected to result from SCM conversions are also shown in Table 4-3. Cost estimates are intended to provide a planning level estimate only, and a detailed engineering study will be required to determine more accurate project costs prior to moving forward with any of the listed candidate SCM conversion projects. The planning-level costs presented in Table 4-3 were derived from CAST. CAST documentation provides estimated unit costs for each BMP practice by county for capital costs, operations and maintenance, and opportunity costs; the capital cost for an extended detention dry pond is $4,223.36 per acre of land treated. This value was multiplied by the proposed project drainage area to obtain a rough estimate of the initial project cost for each of the proposed dry pond conversion projects. Note that the practices in Table 4-3 are proposed redesigns of existing stormwater facilities with varying levels of modifications required. These are not new facilities, so extreme caution should be used when relying on the estimated costs provided by CAST. CAST cost estimates do not consider the costs of modifying existing BMPs, which may differ significantly from that of new facilities.

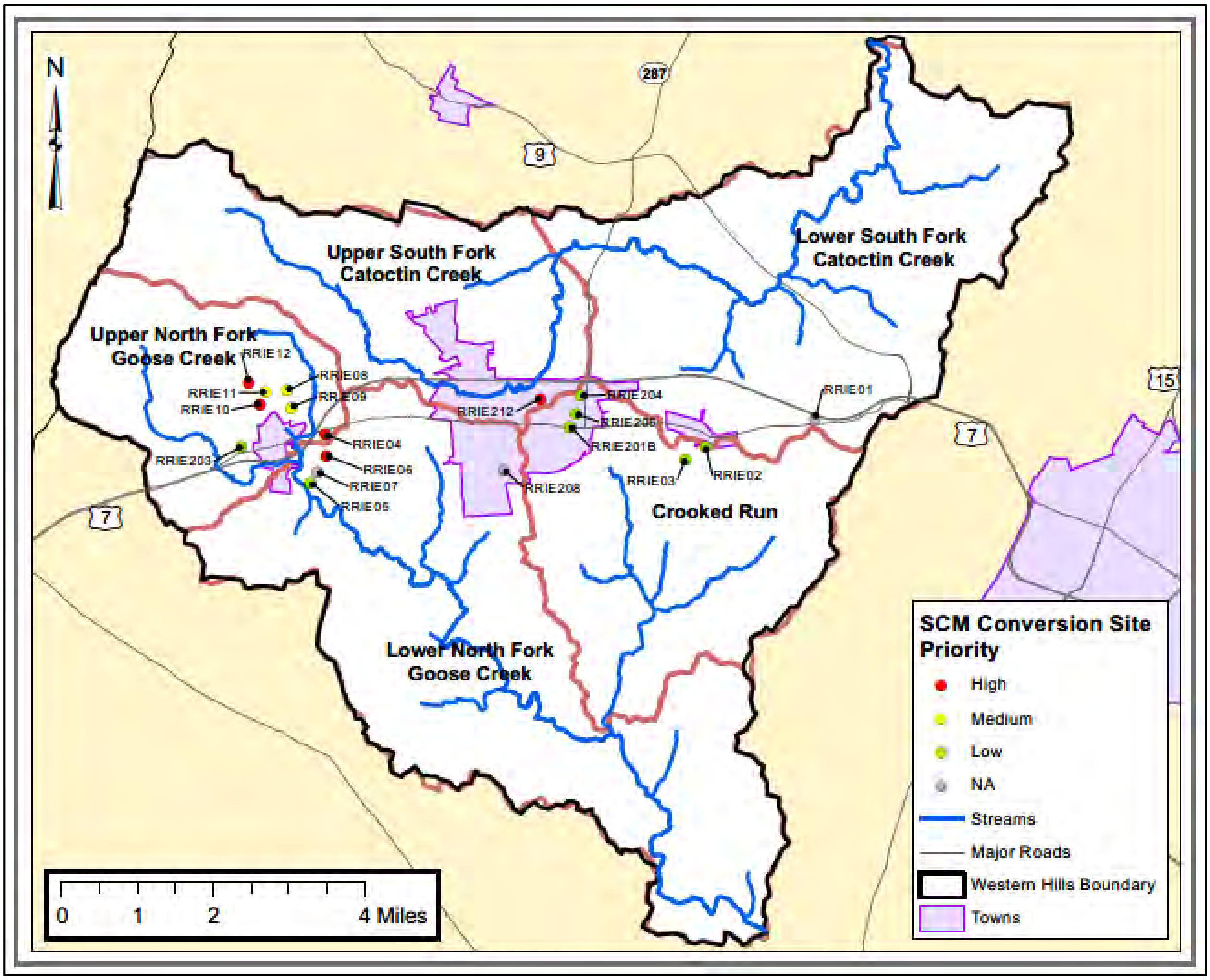


**Figure 9-2: Candidate SCM Conversion Site Locations and Priority Ratings**

## 9.3 New SCM Opportunity Sites

A total of 20 candidate new SCM opportunity sites were visited during ISI and new RRI field assessments (see Chapter 4 for more detail). A representative subset of publicly-owned sites and churches in the watershed had been selected for the field investigations. Of the 20 sites visited, 10 have the potential to treat stormwater runoff using new SCM with pollutant removal efficiencies. A total of 26 opportunities for new SCM construction were identified at these sites as some of the sites presented more than one opportunity. Several different SCMs, including bioswales, bioretention systems, green roofs, and cisterns were considered as appropriate for each selected location on the site. The 26 new SCM opportunities were each assigned a priority rating of High, Medium or Low, which primarily depended upon the engineering feasibility of the SCM opportunity at the selected location, and on how much reduction was possible under the SCM efficiencies as determined by the Chesapeake Bay Program and used in CAST. New SCM opportunity types, project ratings and planning-level cost estimates are shown in Table 9-4, and project locations are shown in Figure 9-3. Pollutant reductions expected to result from implementation of the selected SCM types are also shown in Table 9-4. Cost estimates are intended to provide a planning level estimate only, and a detailed engineering study will be required to determine more accurate project costs prior to moving forward with any of the listed candidate new SCM projects. The planning-level costs presented in Table 9-4 were derived from CAST using the following SCM unit costs:

- Bioretention: $12,180.62 per acre treated
- Bioswale: $9,912.16 per acre treated
- Stormwater Performance Standard – Runoff Reduction (green roof, cistern, regenerative stormwater conveyance): $18,352.57 per acre treated

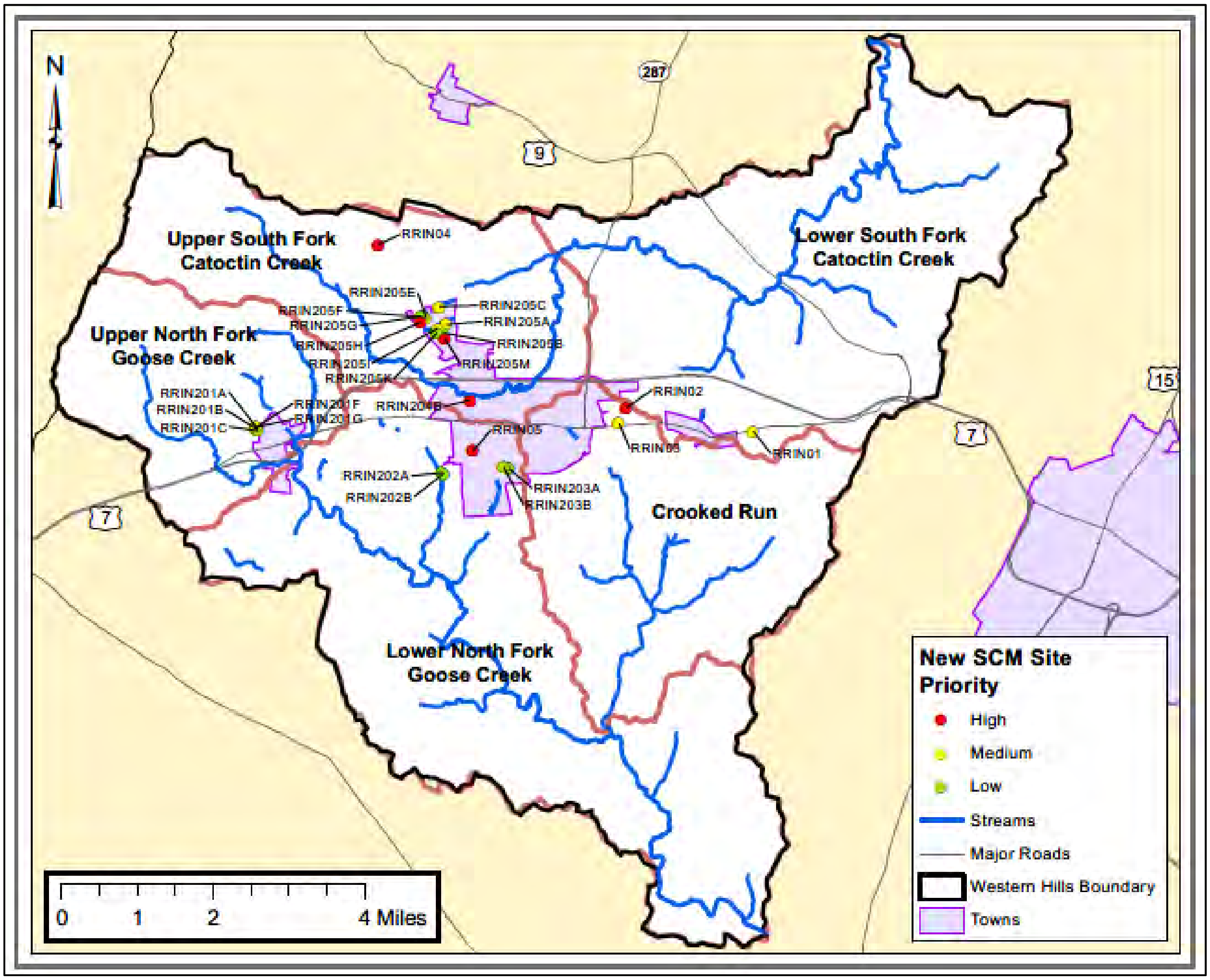


**Figure 9-3: Candidate New SCM Site Locations and Priority Ratings**

**Table 9-3: SCM Conversion Opportunities**

| Site ID | Structure ID | Subwatershed | Ownership | Owner Name | Pond Type | Proposed Redesign(s) | Priority | Drainage Area (acres) | CAST Land use | Estimated Initial Project Cost | TN Load Reduction (lbs/yr) | TP Load Reduction (lbs/yr) | TSS Load Reduction (lbs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RRIE01 | KS0410 | Lower South Fork Catoctin Creek | County | Scott Jenkins Memorial Park | ED | N/A | Not Upgradable | 5.26 | Developed, MS4 | N/A | N/A | N/A | N/A |
| RRIE02 | DD106 | Crooked Run | School System | Hamilton Elementary School | - | Bioretention/Infiltration Swale | Low (maintenance needed) | 0.88 | Developed, nonregulated | N/A | N/A | N/A | N/A |
| RRIE03 | BC44 | Crooked Run | Private[b] | Carriage Ridge Homeowners Association | DP | ED/Bioswale | Low | 1.88 | Developed, MS4 | $7,940 | 1.76 | 0.19 | 852.75 |
| RRIE04 | JC7334 | Upper North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | DP | ED | High | 17.93 | Developed, nonregulated | $75,725 | 16.80 | 1.78 | 8132.92 |
| RRIE05 | JC7435 | Lower North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | DP | ED | Low | 7.32 | Developed, nonregulated | $30,915 | 6.86 | 0.73 | 3320.30 |
| RRIE06 | JC7335 | Lower North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | DP | ED | High | 16.43 | Developed, nonregulated | $69,390 | 15.39 | 1.63 | 7452.53 |
| RRIE07 | JC7434 | Lower North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | DP | N/A | Not Upgradable | 17.2 | Developed, nonregulated | N/A | N/A | N/A | N/A |
| RRIE08 | JC7170 | Upper North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | DP[a] | Confirm ED elements added are appropriately credited, add missing ED elements | Medium | 7 | Developed, nonregulated | $29,564 | 6.56 | 0.70 | 3175.15 |
| RRIE09 | JC7169 | Upper North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | DP[a] | Confirm ED elements added are appropriately credited, add missing ED elements | Medium | 11.92 | Developed, nonregulated | $50,342 | 11.17 | 1.19 | 5406.82 |
| RRIE10 | JC6966 | Upper North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | ED | Add ED elements and improve low flow design | High | 37.81 | Developed, nonregulated | N/A | N/A | N/A | N/A |
| RRIE11 | DP0033 | Upper North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | DP[a] | Confirm ED elements added are appropriately credited, add missing ED elements | Medium | 2.20 | Developed, nonregulated | $9,291 | 2.06 | 0.22 | 997.90 |
| RRIE12 | JC50025 | Upper North Fork Goose Creek | Private[b] | Round Hill Homeowners Association | DP | ED | High | 14.79 | Developed, nonregulated | $62,463 | 13.85 | 1.47 | 6708.64 |
| RRIE201B | SWM32 | Crooked Run | Private[b] | Loudoun Valley Medical Center | DP | ED | Low | 8.4 | Developed, nonregulated | $35,476 | 7.87 | 0.84 | 3810.18 |

**Table 9-3: SCM Conversion Opportunities**

| Site ID | Structure ID | Subwatershed | Ownership | Owner Name | Pond Type | Proposed Redesign(s) | Priority | Drainage Area (acres) | CAST Land use | Estimated Initial Project Cost | TN Load Reduction (lbs/yr) | TP Load Reduction (lbs/yr) | TSS Load Reduction (lbs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RRIE203 | DP0030 | Upper North Fork Goose Creek | County | Loudoun County Sheriff's Office | DP[(a)] | Confirm ED elements are appropriately credited, add drawdown device to forebay | Low | 4.93 | Developed, nonregulated | $20,821 | 4.62 | 0.49 | 2236.21 |
| RRIE204 | SWM38 | Crooked Run | Private[(b)] | Village of Purcellville Homeowners | DP | ED | Low | 4.34 | Developed, nonregulated | $18,329 | 4.07 | 0.43 | 1968.59 |
| RRIE206 | SWM40 | Crooked Run | Private[(b)] | Village Associates of Purcellville | DP | ED | Low | 7.42 | Developed, nonregulated | $31,337 | 6.95 | 0.74 | 3365.66 |
| RRIE208 | Unknown – Blue Ridge Bible Church | Lower North Fork Goose Creek | Private | Blue Ridge Bible Church | ED | N/A | Not Upgradable | 5.30 | Developed, nonregulated | N/A | N/A | N/A | N/A |
| RRIE212 | SWM24 | Upper South Fork Catoctin | County | Across from Loudoun Valley High School | DP | ED | High | 12.51 | Developed, nonregulated | $52,834 | 11.72 | 1.24 | 5674.44 |

DP = Dry Pond, ED = Extended Detention
[(a)] Undocumented in-field retrofit.
[(b)] Privately owned, County maintained.

**Table 9-4: New SCM Opportunities**

| Site ID | Subwatershed | Ownership | Owner Name | Proposed BMP | Priority | Drainage Area (acres) | CAST Land Use | Estimated Initial Project Cost | TN Load Reduction (lbs/yr) | TP Load Reduction (lbs/yr) | TSS Load Reduction (lbs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RRIN01 | Lower South Fork Catoctin Creek | County | Hamilton Safety Center | Bioswale with subsurface gravel storage for infiltration | Medium | 1.53 | Developed, nonregulated | $15,166 | 6.73 | 1.14 | 1110.40 |
| RRIN02 | Crooked Run | School System | Culbert Elementary School | Bioretention/infiltration system | High | 3.08 | Developed, nonregulated | $37,516 | 4.89 | 1.37 | 1536.78 |
| RRIN03 | Crooked Run | School System | Harmony Middle School | Bioretentions and Microbioretentions in landscaped areas | Medium | 2.26 | Developed, nonregulated | $27,528 | 9.88 | 1.68 | 1640.19 |
| RRIN04 | Upper South Fork Catoctin Creek | County | Purcellville Water Treatment Plant | Bioretention, linear retrofit | High | 2.02 | Developed, nonregulated | $24,605 | 3.21 | 0.90 | 1007.89 |
| RRIN05A | Lower North Fork Goose Creek | County | Loudoun Valley Community Center | Bioretention or Rain Garden | High | 1.99 | Developed, nonregulated | $24,239 | 8.70 | 1.48 | 1444.24 |
| RRIN05B | Lower North Fork Goose Creek | County | Loudoun Valley Community Center | Disconnect roof drains and use cisterns for landscape watering | Low | 0.15 | Building | $2,753 | 0.19 | 0.03 | 36.43 |
| RRIN201A | Upper North Fork Goose Creek | School System | Round Hill Support Center | Microbioretention within island | Low | 0.33 | Impervious, nonregulated | $4,020 | 1.44 | 0.25 | 239.50 |
| RRIN201B | Upper North Fork Goose Creek | School System | Round Hill Support Center | Microbioretention within island | Low | 0.32 | Impervious, nonregulated | $3,898 | 1.40 | 0.24 | 232.24 |
| RRIN201C | Upper North Fork Goose Creek | School System | Round Hill Support Center | Remove excess impervious area and install Bioretention | Medium | 0.95 | Developed, nonregulated | $11,572 | 4.15 | 0.71 | 689.46 |
| RRIN201F | Upper North Fork Goose Creek | School System | Round Hill Support Center | Green Roof | Low | 0.6 | Building | $11,012 | 0.76 | 0.12 | 145.71 |
| RRIN201G | Upper North Fork Goose Creek | School System | Round Hill Support Center | Cisterns for landscape watering if Green Roof is not feasible | Medium | 0.6 | Building | $11,012 | 0.76 | 0.12 | 145.71 |
| RRIN202A | Lower North Fork Goose Creek | County | Moorcones Subdivision | Regenerative Stormwater Conveyance | Low | 3.92 | Developed, nonregulated | $71,942 | 4.98 | 0.76 | 951.98 |
| RRIN202B | Lower North Fork Goose Creek | County | Moorcones Subdivision | Bioswale | Low | 2.98 | Developed, nonregulated | $29,538 | 13.10 | 2.22 | 2162.73 |
| RRIN203A | Lower North Fork Goose Creek | Private | Blue Ridge Bible Church | Microbioretention | Low, small DA | 0.44 | Impervious, developed | $5,359 | 0.70 | 0.20 | 219.54 |
| RRIN203B | Lower North Fork Goose Creek | Private | Blue Ridge Bible Church | Bioswale to enhance linear area leading to Unknown BMP in Table 9-3 (see RRIE208) | Low | 0.30 | Impervious, developed | $2,974 | 1.32 | 0.22 | 217.72 |
| RRIN204B | Upper South Fork Catoctin Creek | Public | South Fork Catoctin Creek Conservation Easement | Regenerative Stormwater Conveyance | High | 4.19 | Developed, nonregulated | $76,897 | 5.32 | 0.81 | 1017.55 |
| RRIN205A | Upper South Fork Catoctin Creek | School System | Woodgrove High School | Bioretention | Medium | 1.42 | Impervious, nonregulated | $17,296 | 2.25 | 0.63 | 708.51 |
| RRIN205B | Upper South Fork Catoctin Creek | School System | Woodgrove High School | Green Roof | Low | 4.53 | Building | $83,137 | 5.75 | 0.88 | 1100.11 |
| RRIN205C | Upper South Fork Catoctin Creek | School System | Woodgrove High School | Bioswale with subsurface storage and check dams as required | Medium | 7.36 | Developed, nonregulated | $72,953 | 32.36 | 5.47 | 5341.52 |
| RRIN205E | Upper South Fork Catoctin Creek | School System | Mountain View Elementary School | Bioretention | Medium | 1.03 | Developed, nonregulated | $12,546 | 4.50 | 0.77 | 747.52 |
| RRIN205F | Upper South Fork Catoctin Creek | School System | Mountain View Elementary School | Green Roof | Low | 1.96 | Building | $35,971 | 2.49 | 0.38 | 475.99 |
| RRIN205G | Upper South Fork Catoctin Creek | School System | Mountain View Elementary School | Bioretention | Low | 1.06 | Developed, nonregulated | $12,911 | 4.63 | 0.79 | 769.29 |

**Table 9-4: New SCM Opportunities**

| Site ID | Subwatershed | Ownership | Owner Name | Proposed BMP | Priority | Drainage Area (acres) | CAST Land Use | Estimated Initial Project Cost | TN Load Reduction (lbs/yr) | TP Load Reduction (lbs/yr) | TSS Load Reduction (lbs/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| RRIN205H | Upper South Fork Catoctin Creek | School System | Mountain View Elementary School | Bioswale with subsurface storage and check dams along existing swale | High | 1.45 | Developed, nonregulated | $14,373 | 6.38 | 1.08 | 1052.34 |
| RRIN205I | Upper South Fork Catoctin Creek | School System | Woodgrove High School | Bioretention within islands | Medium | 0.86 | Impervious, nonregulated | $10,475 | 3.76 | 0.64 | 624.14 |
| RRIN205K | Upper South Fork Catoctin Creek | School System | Woodgrove High School | Bioretention along side slope | Low | 1.13 | Impervious, nonregulated | $13,764 | 4.94 | 0.84 | 820.10 |
| RRIN205M | Upper South Fork Catoctin Creek | School System | Woodgrove High School | Linear Bioretention | High | 1.07 | Developed, nonregulated | $13,033 | 4.68 | 0.80 | 776.55 |

## 9.4 Load Reduction Estimates for All Recommended BMP Types

Estimates of anticipated nutrient and sediment load reductions were calculated for a broad range of recommended BMP strategies, described in Chapter 8 and Sections 9.1 to 9.3 of this report. These estimates provide a basis for comparing the relative effectiveness of proposed BMPs in terms of reducing pollutant loads in the Western Hills Watershed. The estimates below are not derived directly from CAST. Instead, these estimates are based on the individual calculation of load reductions for each BMP type on a per unit basis for Loudoun County, using the Chesapeake Bay Program's BMP_LbsReducedAndCostsCounty.xlsx spreadsheet, which estimates load reductions using county-wide land use loading rates and standard BMP efficiencies. See Appendix B for a crosswalk list of Loudoun County and CAST BMP types. More detailed load reductions can be estimated in CAST as BMP recommendations are finalized for implementation. The load reductions represent the edge of tide (EOT) reductions. EOT is the metric on which the Bay TMDL targets are based.

Chapter 7 presented edge of stream (EOS) loads to best represent the local pollutant loading situation. However, EOT loads are also useful in gaging progress towards the Chesapeake Bay TMDL targets. Table 9-5 and Table 9-6 summarize the EOS and EOT loadings for the Western Hills Watershed Management Area. EOS represents the load at the local level where it runs off the land and reaches a local stream, and EOT represents the load when it reaches the tidal portion of the Chesapeake Bay drainage. EOT accounts for the effects of pollutant attenuation, soil type, and connections to groundwater, among other factors that can impact the amount of pollutant reaching the tidal waters of the Bay system. As shown, there is a significant pollutant reduction between EOS and EOT. Note that local TMDL efforts will set Load Allocations as EOS loads and that VSMP stormwater calculations are reported as EOS.

**Table 9-5: Summary of annual watershed pollutant loading in Western Hills Watershed Management Area using Edge of Stream Loading**

| South Fork Catoctin Creek Subwatershed | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|
| Land Use Loading | 136,210.7 | 14,872.1 | 6,679,156 |
| Septic Systems | 15,168 | n/a | n/a |
| Stream Bed and Banks | 15,992 | 4,769 | 13,564,929 |
| Total | 167,370.5 | 19,640.8 | 20,244,086 |
| **North Fork Goose Creek Watershed** | **TN lb/yr** | **TP lb/yr** | **Sediment lb/yr** |
| Land Use Loading | 124,203 | 13,059 | 7,326,469 |
| Septic Systems | 24,071 | n/a | n/a |
| Stream Bed and Banks | 20,144 | 4,832 | 16,200,815 |
| Total | 168,417 | 17,891 | 23,527,285 |

**Table 9-6: Summary of annual watershed pollutant loading in Western Hills Watershed Management Area using Edge of Tide loading.**

| South Fork Catoctin Creek Subwatershed | TN lb/yr | TP lb/yr | Sediment lb/yr |
|---|---|---|---|
| Land Use Loading | 88,032.7 | 8,487.4 | 2,106,377 |
| Septic Systems | 9,908.2 | n/a | n/a |
| Stream Bed and Banks | 10,445.2 | 2,731.5 | 4,344,546 |
| Total | 108,386.1 | 11,218.9 | 6,450,923 |
| **North Fork Goose Creek Watershed** | **TN lb/yr** | **TP lb/yr** | **Sediment lb/yr** |
| Land Use Loading | 84,922.9 | 6,676.2 | 2,173,266 |
| Septic Systems | 15,854.1 | n/a | n/a |
| Stream Bed and Banks | 13,268.1 | 2,395.3 | 4,646,647 |
| Total | 114,045.1 | 9,071.6 | 6,819,913 |

Table 9-7 and Table 9-8 present a summary of each BMP type proposed in this plan. In general, the individual load reductions presented below represent a good estimate of potential load reductions that can be expected from implementation, and they allow for a comparison of the relative impact of any individual BMP or type of BMP. The actual load reduction credit achieved in CAST will vary depending on the number and type of BMPs applied as well as the impacts of the "non-linear cascading effect" of applying multiple BMPs across a landscape, as described in the CAST documentation[5].

[5] http://cast.chesapeakebay.net/Documentation/DevelopPlans

**Table 9-7: Summary of BMP recommendations and estimated annual load reductions for the South Fork Catoctin Creek subwatershed.**

| BMP Type | BMP Amount | BMP Unit | TN Reduction (lbs) | TP Reduction (lbs) | TSS Reduction (lbs) |
|---|---|---|---|---|---|
| Downspout disconnection | 12.3 | acres | 15.68 | 6.59 | 6,248.72 |
| Sustainable Landscaping | 368.4 | acres | 770.82 | 95.14 | 0 |
| Impervious Cover removal and replacement with pervious pavement | 0.22 | acres | 0.27 | 0.044 | 109.77 |
| Neighborhood tree plantings | 12.83 | acres | 6.99 | 2.02 | 3129.74 |
| Open Space Plantings | 3.31 | acres | 15.02 | 3.29 | 420.03 |
| Stream Restoration | 5,150 | feet | 268.57 | 192.20 | 399,954.46 |
| Stream Buffers | 384.3 | acres | 5,379.75 | 296.98 | 73,392.73 |
| Dry pond redesigned to extended detention | 12.51 | acres | 11.72 | 1.24 | 5,674.44 |
| Bioswale* | 10.34 | acres | 45.46 | 7.69 | 7,504.25 |
| Bioretention | 8.59 | acres | 27.97 | 5.36 | 5,454.01 |
| Stormwater Performance Standard, runoff reduction* | 10.68 | acres | 13.57 | 2.07 | 2,593.65 |
| Total | | | 6,555.83 | 612.62 | 504,481.79 |

* Multiple options for BMP recommendations were proposed at 3 sites. The lowest value options are presented here.

**Table 9-8: Summary of BMP recommendations and annual load reductions for the North Fork Goose Creek subwatershed.**

| BMP Type | BMP Amount | BMP Unit | TN Reduction (lbs) | TP Reduction (lbs) | TSS Reduction (lbs) |
|---|---|---|---|---|---|
| Downspout disconnection | 33.6 | acres | 42.83 | 18.00 | 17,069.67 |
| Sustainable Landscaping | 246.2 | acres | 436.02 | 54.41 | 0 |
| Impervious Cover removal and replace with pervious pavement | 0.84 | acres | 1.05 | 0.167 | 419.12 |
| Neighborhood tree plantings | 21.4 | acres | 11.66 | 3.37 | 5,219.45 |
| Open Space Plantings | 32.1 | acres | 123.94 | 27.22 | 4,490.73 |
| Stream Restoration | 10,050 | feet | 524.11 | 375.07 | 780,493.65 |
| Stream Buffers | 483.86 | acres | 5,284.47 | 332.15 | 69,294.20 |
| Dry pond redesigned to extended detention | 159.57 | acres | 97.94 | 10.40 | 47,427.70 |
| Bioswale* | 0.3 | acres | 1.32 | 0.02 | 217.72 |
| Bioretention | 8.42 | acres | 27.00 | 5.21 | 5,312.49 |
| Stormwater Performance Standard, runoff reduction* | 4.67 | acres | 5.93 | 0.91 | 1,134.11 |
| Total | | | 6,556.27 | 826.93 | 931,078.84 |

* Multiple options for BMP recommendations were proposed at 3 sites. The lowest value options are presented here.

As simulated in CAST, stream buffers are particularly effective nutrient and sediment load reduction practices because they receive credit from a land use change (e.g. from turf or pasture to true forest) and also receive an efficiency credit for treating upland acres draining to the buffers. These upland acres are credited at a 1:1 ratio of buffer acres to upland acres when converting urban turf lands to forested buffer. In the agricultural sector, a 4:1 ratio is applied to nitrogen efficiency and a 2:1 ratio is applied to phosphorus and sediment efficiencies. In other words, for every acre of agricultural buffer, 4 upland agricultural acres receive an efficiency load reduction for nitrogen and 2 upland agricultural acres receive an efficiency load reduction for phosphorus and sediment. However, due to the way this BMP is represented, it can be challenging to estimate the load reductions outside of CAST on an individual project basis. CAST represents BMPs in a fixed sequence, so the actual loading rate on which the efficiency is applied may be different than estimated here.

In the present analysis, estimates of load reductions for retrofits were based on a generalized factor of pounds per unit treated. In addition, the retrofits to existing BMPs were calculated as the difference between the load reductions of the existing and proposed practices. Stormwater BMP enhancements (i.e., changes that may improve the water quality function of a BMP but do not convert it to another type) are not accounted for in these estimates, because the BMP types did not change. Because this is a planning-level assessment, designed runoff volume reduction for each practice cannot be determined at this stage. As retrofits of existing stormwater BMPs and new stormwater BMP enhancements are implemented, load reductions should be calculated using the runoff reduction method, which will yield more reliable reductions.

Similarly, as stream restoration projects are implemented, the protocols outlined in the Chesapeake Bay Program's report *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects* (Schueler and Stack 2014) and any subsequent CBP guidance should be followed to maximize the amount of credit received for each project. A simpler pounds per linear foot of restoration reduction estimate was used in this plan because the project-specific details of each restoration project are not available at the planning stage.

If fully implemented, the recommendations above represent a 5-13 percent reduction in nutrients and sediment in the Western Hills Management Area, varying by pollutant and subwatershed. In practical terms, the extent of implementation will depend on a number of factors such as participation by organizations and individuals, project feasibility, and available funding sources. The above estimates represent different levels of implementation. For example, the estimate of stream buffer area available for conversion to forest was developed through an analysis of unforested buffer throughout the Western Hills Watershed and therefore represents a maximum potential benefit for the stream buffer BMP. Estimates for other practices, such as sustainable landscaping or dry pond conversion were based on the sites assessed and opportunity locations identified in the field. Therefore, additional opportunities may be available in other locations, and the maximum potential benefits for these BMPs may actually be greater than the values shown.

The stream restoration load reductions presented in the tables above represent the potential load reductions from all recommended stream restorations; however, if only high priority stream restorations are undertaken, the resulting load reductions will be lower, as shown in Table 9-9.

**Table 9-9: Comparison of annual load reductions from all stream restoration recommendations and from high priority recommendations only.**

| Subwatershed | All restoration (feet) | Reduction (lbs) | | | High Priority Restoratio n (feet) | Reduction (lbs) | | |
|---|---|---|---|---|---|---|---|---|
| | | TN | TP | TSS | | TN TSS | TP | TSS |
| South Fork Catoctin Creek | 5,150 | 268.6 | 192.2 | 399,954.5 | 4,750 | 247.7 | 177.3 | 368,890.0 |
| North Fork Goose Creek | 10,050 | 524.1 | 375.1 | 780,493.7 | 900 | 46.9 | 33.6 | 69,895.0 |
| Total | 15,200 | 792.7 | 567.3 | 1,180,448.1 | 5,650 | 294.7 | 210.9 | 438,785.0 |

As a further step, CAST was used to estimate the net loading changes from the combined suite of proposed BMPs. Table 9-10 provides a summary of output from this analysis. Using CAST to calculate the combined nutrient and sediment reductions from recommended BMPs yields much larger reductions than calculating reductions from each type of BMP in isolation. The difference in reductions is a result of several factors. General, minor differences in all BMP reductions can be attributed to CAST BMP sequencing and averaged load reductions used outside of CAST. BMPs in CAST are calculated in a fixed sequence and account for the impacts of existing BMPs. This order of operations yields somewhat different land use loading rates that are not accounted for in the individual BMP reduction calculations. In addition, the individual reduction calculations used county-wide average loading rates, while CAST used the land-river segment-specific loading rates.

Beyond the minor discrepancies described above, stream restoration load reductions in CAST are much higher than using the average load reduction values to calculate reductions outside of CAST. CAST accounts for all upstream BMPs in a pre-defined order, then determines the resulting bed and bank loads and then applies the stream restoration BMPs. This sequence of calculations accounts for the difference in load reductions.

CAST also accounts for the reductions from the riparian pasture deposition load. This load does not have land use acreage explicitly associated with it, so it was not calculated in the individual BMP load reductions. Reductions from riparian pasture deposition are a result of applying stream buffers to pasture land. These pollutant reductions are specifically called out in Table 9-10, rather than being grouped with general agricultural land use reductions. CAST calculates the nitrogen and phosphorus reductions as a result of removing livestock from the stream, and then applies a ratio of nitrogen to sediment to calculate the TSS reductions (122.42 lbs sediment reduced/1 lb of N reduced). This results in a substantial load reduction by removing or reducing riparian pasture deposition.

The increased load (negative reduction) attributed to natural land uses is the result of creating increased forested acres by way of creating forested riparian buffers. While the pollutant loading rates from forested land is very low, any increase in acreage will result in an increase in the load from this land use. However, it should be noted that the increased load from forested lands is dwarfed by the decreased loads from agricultural and urban lands as a result of creating the buffers, creating an overall net pollutant load reduction.

While the load reductions from CAST differ substantially from those calculated outside of CAST, the individual BMP reductions are still useful as a way to compare across BMPs to provide a relative comparison of efficiencies and help identify the most efficient practices.

**Table 9-10: Load reductions from combined suite of recommended watershed BMP strategies, as calculated in CAST.**

| South Fork Catoctin Creek | Acres | TN lb/yr | TP lb/yr | TSS lb/yr |
|---|---|---|---|---|
| Agriculture | 263.64 | 4,275.75 | 88.46 | 16,702.60 |
| Riparian deposition | 0.00 | 3,257.21 | 916.85 | 244,416.50 |
| Developed | 123.69 | 1,741.33 | 297.55 | 36,802.95 |
| Natural | -387.32 | -320.13 | -15.19 | -2,595.58 |
| Stream Bed and Bank | 0.00 | 1,247.76 | 673.32 | 1,061,287.00 |
| Septic | 0.00 | -0.01 | 0.00 | 0.00 |
| | Total | 10,201.91 | 1,960.99 | 1,356,613.47 |
| **South Fork Catoctin Creek** | **Acres** | **TN lb/yr** | **TP lb/yr** | **TSS lb/yr** |
| Agriculture | 314.01 | 4,066.45 | 66.62 | 18,319.05 |
| Riparian Deposition | 0.00 | 3,914.33 | 944.71 | 260,608.39 |
| Developed | 196.01 | 1,723.65 | 316.97 | 69,339.98 |
| Natural | -510.03 | -346.60 | -18.60 | -4,208.23 |
| Stream Bed and Bank | 0.00 | 1,704.07 | 796.58 | 1,415,969.00 |
| Septic | 0.00 | -0.02 | 0.00 | 0.00 |
| | Total | 11,061.89 | 2,106.28 | 1,760,028.20 |

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# CHAPTER 10: IMPLEMENTATION

This chapter discusses considerations for plan implementation, including cost estimates for various plan elements, schedule considerations, a series of programmatic recommendations, and specific suggestions for involving the community and other partners in future watershed planning efforts.

## 10.1 Cost/Benefit Analysis

In addition to existing practices, several new practices are recommended for the Western Hills watershed. Some of these practices have similar or identical costs and pollutant removal efficiencies (e.g., NSA Tree Plantings and Stream Buffer Reforestation), but in other cases, costs and removal efficiencies differ among the recommended practices, which suggests that certain practices may be more cost effective when trying to meet watershed specific pollutant reduction goals. A detailed discussion of removal efficiencies, including their sources, is provided in Section 9. Table 10-1 is a summary of the costs, both for all priorities high (H), medium (M) and low (L) and high only. Table 10-2 provides a summary the cost per pound of Total Nitrogen (TN), Total Phosphorus (TP), and Sediment removed as defined in units of cost per pound (lb) of pollutant per year.

**Table 10-1: Summary of BMP Recommendation Costs**

| | Stream Restoration | SCM Conversion | SCM New |
|---|---|---|---|
| Costs (H, M, L) | $6,205,248 | $494,427 | $646,490 |
| Costs (only High Priority) | $2,306,556 | $260,412 | $190,663 |

Details of cost estimates are presented in Chapter 9.

**Table 10-2: Summary of BMP Recommendation Cost Effectiveness**

| | Stream Restoration | SCM Conversion | SCM New |
|---|---|---|---|
| TN Effectiveness ($/lb/yr) | $7,828 | $4,508 | $4,642 |
| TP Effectiveness ($/lb/yr) | $10,938 | $42,440 | $26,355 |
| Sediment Effectiveness ($/lb/yr) | $5.26 | $9.31 | $25.64 |

## 10.2 Timeframe of Potential Next Steps to be Considered

The suggested schedule for Loudoun County's implementation of specific watershed restoration projects is given below. This watershed management plan can provide a generalized scheduling. The details are logically project-dependent and the inherent staffing availability will necessitate phased approach overall. Timeframes will also depend on funding sources, either internal or external, such as grants and other agencies (Appendix C). Nonetheless, it is recognized that watershed restoration activities will evolved in a staged pattern and be dependent on future workplans and authorizations development.

The timeframe described below is relative to the authorization to proceed from the County Board of Supervisors (Board). Prior to developing an actual schedule there must be approved scope and funding authorized by the Board. Implementation of other recommendations will depend on coordination among various agencies and organizations. Authorization and notice to proceed will be required for each recommendation prior to implementation.

Suggested schedule for SCM conversions, new SCMs and stream restoration projects after approval and authorization to proceed. While the:

- SCM Conversion (Year 1 after authorized to proceed): Review site priorities for SCM conversion projects. For High and Medium priority SCM conversion opportunities, evaluate feasibility, land ownership, utilities, or other constraints. Review Low priority sites for additional opportunities.
- SCM Conversion (Years 2-3): Design phase for high priority SCM conversion projects.
- SCM Conversion (Years 4-5): Bid/construction of high priority SCM conversion projects.
- SCM Conversion (Years 6-7): Design phase for medium priority SCM conversion projects.
- SCM Conversion (Years 8-9): Bid/construction of medium priority SCM conversion projects.
- New SCM (Year 5 after authorized to proceed): Review site priorities for new SCM projects including: evaluate feasibility, land ownership, utilities, or other constraints. It is suggested that new SCM be staged or phased later, although each potential project opportunity should be assessed for best start time.
- New SCM (Years 6-7): Design phase for high priority new SCM projects.
- New SCM (Years 8-9): Bid/construction of high priority new SCM projects.
- Stream Restoration (Years 1-10 after authorized to proceed): Review site priorities for stream restoration. Stream restoration sites, or groups of sites, will likely require separate approval and authorization to proceed. For High and Medium priority stream restoration opportunities, evaluate feasibility, land ownership, utilities, or other constraints. Review Low priority sites for additional opportunities.

## 10.3 Programmatic Recommendations

In addition to the site-specific actions identified throughout this Western Hills Watershed Plan, Table 10-3 provides a list of programmatic suggested recommendations that will support Loudoun County in implementing effective measures to protect and restore the watershed. Many of these suggestions will have benefits for other watersheds throughout the County. Although developed independently, many of these recommendations are consistent with recommendations in Loudoun County's 2008 Comprehensive Watershed Management Plan (CH2MHill, 2008b).

In the Western Hills Watershed, the Towns, Loudoun Soil and Water Conservation District, and Loudoun County Government, Department of General Services would be involved for many of the actions listed in Table 10-3. In some cases, the recommendations may involve enacting of regulations, codes, or zoning ordinances by the regulatory body. In other watersheds, incorporated Towns would also be responsible for these actions within their jurisdictions. Many of the recommendations can be facilitated through cooperative partnering, grants, targeting of existing resources, or other non-regulatory means.

## 10.4 Public Involvement in Watershed Plan Development

Development of the Western Hills Watershed Management Plan included an opportunity for the community to obtain information about the planning process and to provide input to plan development (see Section 1.3), which included a public input community meeting, website updates, and a Watershed Partnership Workgroup (WPW) which met at the start of the project and near the close. Additionally, prior to contract award the overall project scope evolved over many months through the meetings discussion and recommendation of the Loudoun County Water Resources Technical Advisory Committee (WRTAC). The WPW was created with specific members of the community that were invited to be a part of the WPW based on their experience and knowledge of Loudoun County and water quality issues within the watershed.

One public community meeting was held at the beginning of the project to solicit input on problems and areas of concern. The meeting was held on a weeknight and employed a presentation and small-group discussion format. The meeting featured a large format map which captured participants' attention and recorded site-specific comments. Loudoun County's Public Affairs staff publicized the community meeting through press releases, County Board of Supervisor email lists, Twitter, Facebook, and other outlets. Meeting announcements were picked up and run as calendar items by local media (e.g., Loudoun Now). Community meeting attendance included key stakeholders: interested members of the general public, the environmental community and Loudoun Now reporting staff. A separate meeting for the WPW was held prior to the open community meeting. The WPW meeting also included a large format map so that the members could record site-specific comments and concerns.

In future watershed planning efforts, it is recommended that community meetings be held to solicit public input, but that methods for boosting attendance be explored. Tying in with another community event or a hands-on nature activity (e.g., a streamside trail hike or stream cleanup) would likely broaden participation. In addition, contacting existing organizations that already meet regularly—such as the Master Gardeners, Chamber of Commerce, or networks of local HOA managers—and asking to be part of their agenda would be an additional avenue to promote collaboration.

Throughout the project, updates and the presentations were made available through dedicated pages on the Loudoun County website (https://www.loudoun.gov/5072/Western-Hills-Watershed-Management-Plan) and WRTAC (https://www.loudoun.gov/wrtac). This was a convenient way to get information out to the public and to the WPW. Future enhancements could include: (1) more frequent, high visibility updates; (2) email and phone contact information for those interested in volunteering for watershed stewardship events; and (3) links to public outreach information on what-you-can-do to help improve water quality such as “Clean Waters Initiative” (https://www.loudoun.gov/3493/Clean-Waters-Initiative ).

### Table 10-3: Programmatic Watershed Management Recommendations

*Note: All suggested recommendations require that County funding and staff resources be authorized by the County Board of Supervisors. Actions by other parties will also require authorization. These recommendations are not intended to serve as a commitment for actions or represent obligations for funding, rather, they provide a roadmap for future programmatic decision activities.*

| Recommended Action | Description |
|---|---|
| Secure funds for stormwater improvements | Secure funds for stormwater pond conversions as identified in this report. Currently only stormwater infrastructure maintenance funding through the County Department of General Services are authorized by County Board in support of the County Stormwater MS4 Permit and Chesapeake Bay WIP TMDL Action Plans. While most of the Western Hills Watershed is outside of the MS4 Permit area, partial nutrient load reduction credit can be claimed for actions within Western Hills. |
| Cluster implementation of stormwater improvements | Cluster the early implementation of recommended new SCMs and pond conversions so that positive results can help to build public support. |
| Stormwater management on future development | Require that all new development meet the VSMP stormwater regulations and encourage development which mimics predevelopment hydrology to the extent possible and provides sufficient water quality treatment. |
| Stormwater management at public schools | Coordinate with Loudoun County Public Schools to encourage ESD approaches, seeking to incorporate more advanced stormwater management into new designs and at existing facilities. |
| Stream restoration | Improve stormwater management controls upstream of potential stream restoration sites before initiating stream restoration projects. It is often necessary to delay large-scale restoration of stream morphology until stream flows in the upstream catchment have been stabilized. Stream restoration projects can then be designed to accommodate long-term flows. |
| Forest conservation | Preserve existing forest to the greatest extent possible. Strictly enforce forest conservation requirements. |
| Conservation easements | Encourage the use of permanent conservation easements for open space areas (e.g., naturally vegetated lands and agricultural land with healthy riparian buffers). |
| Encourage green infra-structure network | Encourage a green infrastructure network for preservation through easements on high quality areas. |
| Nominate high quality streams | Consider nominating selected streams for special protection areas for high quality waters, such as the VA Dept of Environmental Quality program for Exceptional State Waters (Tier III). |
| Develop public outreach strategy | Involve the community by developing a coordinated public outreach strategy for enhancing resident awareness and motivation to take actions that improve the watershed. The strategy would identify key messages, target audiences, intended outcomes, delivery techniques, and measures of success. |
| Identify partnership opportunities with local agencies and organizations | Along with Loudoun County Government, partners such as Loudoun County Public Schools, Loudoun Water, Loudoun Soil and Water Conservation District, Virginia Department of Transportation, Loudoun Chamber of Commerce and other business contacts, Master Gardeners, homeowner associations (HOAs), and many others can make valuable contributions to carrying out plan recommendations, including tree plantings, new SCMs, better housekeeping practices, and other recommendations. |
| Urban nutrient man-agement education | Encourage reduced use of fertilizers and pesticides on both residential and commercial properties. |
| Watershed education and activities through coordination with Loudoun Soil and Water Conservation District, Master Gardeners, HOAs, and other organizations | Develop and promote educational programs that encourage residents to take actions and encourage communities to implement recommended practices on community lands. Specific community involvement activities could include the following:<br>• Implementation of a watershed stewards training program<br>• Include stewardship training in recreation programs curriculum (e.g., community classes on how to create a rain garden) |

| Recommended Action | Description |
|---|---|
| | • Regular offerings of community stewardship events (e.g., tree plantings, invasive plant removal on community property, stream clean-ups, rain garden/rain barrel workshops, and storm drain marking).<br>• Distribute free trees (seedlings) to all residents with streams on their property (through events such as Arbor Day and Nature Stewardship Day events).<br>• Awards program for outstanding stewardship projects. |
| Better housekeeping practices at commercial/ industrial facilities | Educate local business owners and employees about improving housekeeping practices to eliminate potential pollution hotspots. Conduct training workshops. |
| Public outreach materials | Engage with local conservation/environmental organizations to target public outreach efforts to the watershed's neighborhoods, businesses, and schools. Use examples of successful watershed outreach materials that can be used or adapted for Loudoun County. |
| Other watershed education and activities at businesses | Educate business owners and employees about ways to better manage stormwater runoff and improve water quality, through projects such as tree plantings, rain gardens/rain barrels and other downspout disconnection techniques, and storm drain marking. |
| Develop volunteer opportunities | Develop or enhance volunteer programs for (1) stream monitoring, (2) raingarden planting design (through Master Gardeners and other local experts), and (3) education and outreach. |
| Promote watershed education at local schools, through coordination with Loudoun County Public Schools | Develop core watershed education materials that can be used throughout the County. Within Western Hills, promote watershed education through local schools, including elementary middle, and high schools. Identify key points of contact who can promote watershed educational experiences, including hands-on stewardship activities. |
| Agricultural BMPs | Loudoun Soil and Water Conservation District will continue to promote fencing of livestock (e.g., cattle, horses) out of streams and encourage other BMPs on agricultural lands. |
| Coordinate plan implementation | Coordinate County staff time to spearhead plan implementation and coordinate with other governmental and non-governmental organizations, for example:<br>• Loudoun County Departments of Building and Development, General Services, Planning and Zoning, and others<br>• Loudoun County Public Schools<br>• Metropolitan Washington Council of Governments (MWCOG)<br>• Northern Virginia Regional Commission (NVRC)<br>• Loudoun Soil and Water Conservation District<br>• Virginia Extension / Master Gardeners<br>• Loudoun Water<br>• Natural Resource Conservation Service (NRCS)<br>• Virginia Departments of Transportation, Forestry, Environmental Quality, and Conservation and Recreation.<br>• Home Owners Associations<br>• Loudoun Wildlife Conservancy, Goose Creek Association, and others |
| Watershed Partnership Workgroup | Continue to coordinate with the Western Hills WPW to foster community and organizational involvement in plan implementation. Begin with an invitation to current WPW members to extend their involvement and consider adding other interested members of the community (e.g., additional HOAs). |
| Interagency coordination | Form interagency committee with quarterly meetings to foster better coordination among county, state, and regional agencies to facilitate implementation of recommended actions. |
| Secure funding | Identify and apply for available grants and other funding sources. |
| Evaluate plan implementation | Re-evaluate pollutant load model and load reductions at regular intervals, as land is developed and watershed recommendations are implemented. An adaptive management approach can be taken so that the effectiveness of implemented actions can be evaluated and the plan adjusted to address changing conditions and opportunities. |
| Monitor for results | Monitoring for results. It is important that the County's watershed management efforts include continuing monitoring to demonstrate improvements and support adaptive management. An overall strategy for tracking and monitoring restoration of Loudoun County watersheds should include one or more of the following indicators:<br>• Reduction in amount of nutrient and sediment loading downstream in pounds per year |

| Recommended Action | Description |
|---|---|
| | • Improvement or maintenance of biological condition of streams as measured by biological indicator (i.e., Virginia Stream Condition Index) scores or the number of stream miles with desired VSCI scores<br>• Increase in the acres of impervious surface with enhanced stormwater control<br>• Linear feet of eroding stream that have been stabilized<br>• Increase or conservation of forest acres |

## 10.5 Potential Partners, Programs, and Incentives

The draft North Fork Catoctin Creek sediment TMDL and watershed management plan (Virginia Tech 2019), currently in development, recommends many potential partners to play key roles in implementation of that plan. Because many of the issues in the Western Hills Watershed are similar to those identified in North Fork Catoctin Creek, many of these same partners may be vital to implementing the Western Hills Watershed Management Plan as well. Potential partners for the Western Hills Watershed include:

- Watershed Landowners, including farmers, homeowners, and homeowner associations (HOAs)
- Loudoun Soil and Water Conservation District (SWCD) and Natural Resource Conservation Service (NRCS)
- Loudoun County Departments of Building and Development, General Services, Planning and Zoning, Health, and others
- Loudoun County Public Schools
- Loudoun Water
- Metropolitan Washington Council of Governments (MWCOG)
- Northern Virginia Regional Commission (NVRC)
- Virginia Department of Environmental Quality (DEQ)
- Virginia Department of Conservation and Recreation (DCR)
- Virginia Department of Forestry (DOF)
- Virginia Department of Transportation (VDOT)
- Virginia Cooperative Extension
- Catoctin Creek Scenic River Advisory Committee
- Towns of Purcellville, Hamilton, and Round Hill
- Piedmont Environmental Council
- Other Potential Local Partners
    - Banshee Reeks Chapter - Virginia Master Naturalists
    - Loudoun County Master Gardeners
    - Virginia Farm Bureau
    - Virginia Outdoors Foundation
    - Loudoun Wildlife Conservancy, Goose Creek Association
    - Other environmental organizations

The availability of necessary funding and other incentives for action will be important to the successful implementation of the Western Hills Watershed Management Plan. The draft North Fork Catoctin TMDL and Watershed Plan (Virginia Tech 2019) recommends several funding sources, including those that can provide incentives for farmers, homeowners, or others to participate in watershed management actions. The annotated list from the North Fork report (included here as Appendix C) can serve as a good starting point for identifying future support and incentives for implementation of the strategies outlined in the Western Hills Watershed Management Plan.

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# APPENDIX A: Land Use Cross Walk

## Appendix A – Land Use Cross Walk

This crosswalk provides a comparison of variables used in the CAST model and the classification developed by USGS.

| CAST Land Use | USGS Land Use |
|---|---|
| **Ag Open Space** | 17 - Pasture |
| **Double Cropped Land** | 16 - Cropland |
| **Full Season Soybeans** | 16 - Cropland |
| **Grain with Manure** | 16 - Cropland |
| **Grain without Manure** | 16 - Cropland |
| **Legume Hay** | 17 - Pasture |
| **Non-Permitted Feeding Space** | 16 - Cropland |
| **Other Agronomic Crops** | 16 - Cropland |
| **Other Hay** | 17 - Pasture |
| **Pasture** | 17 - Pasture |
| **Silage with Manure** | 16 - Cropland |
| **Silage without Manure** | 16 - Cropland |
| **Small Grains and Grains** | 16 - Cropland |
| **Specialty Crop High** | 16 - Cropland |
| **Specialty Crop Low** | 16 - Cropland |
| **MS4 Buildings and Other** | 2 - Impervious, non road |
| **MS4 Roads** | 1 - Impervious, road |
| **MS4 Tree Canopy over Impervious** | 3 - Tree Canopy over Impervious |
| **MS4 Tree Canopy over Turf Grass** | 9 - Tree Canopy over Turf |
| **MS4 Turf Grass** | 15 - Turf Grass |
| **Non-Regulated Buildings and Other** | 2 - Impervious, non road |
| **Non-Regulated Roads** | 1 - Impervious, road |
| **Non-Regulated Tree Canopy over Impervious** | 3 - Tree Canopy over Impervious |
| **Non-Regulated Tree Canopy over Turf Grass** | 9 - Tree Canopy over Turf |
| **Non-Regulated Turf Grass** | 15 - Turf Grass |
| **Regulated Construction** | 50% 1 - Impervious, road / 50% 2 - Impervious, non road |
| **Harvested Forest** | 8 - Forest |
| **Headwater or Isolated Wetland** | 7 - Other Wetlands |
| **Mixed Open** | 10 - Mixed Open |
| **Non-tidal Floodplain Wetland** | 6 - Floodplain Wetlands |
| **True Forest** | 8 - Forest |
| **Water** | 4 - Water |

# APPENDIX B: Crosswalk between Loudoun County BMP types and CAST BMP Types

## Appendix B – Crosswalk between Loudoun County BMP types and CAST BMP Types.

| Loudoun County BMP Recommendation | CAST BMP Type |
|---|---|
| Downspout disconnection | Filter strip runoff reduction |
| Sustainable landscaping | Conservation landscaping practices |
| Impervious cover removal and replacement with pervious pavement | Permeable pavement, with underdrain |
| Tree Plantings | Tree planting - canopy |
| Open Space Plantings | Tree planting – forest |
| Stream Restoration | Urban stream restoration |
| Reforest stream buffer | Forest buffer/grass buffer |
| Extended detention | Dry extended detention ponds |
| Grass swale | Bioswale |
| Bioretention | Bioretention A/B soils with underdrain<br>Bioretention C/D soils with underdrain |
| Microbioretention | Bioretention A/B soils with underdrain<br>Bioretention C/D soils with underdrain |
| Disconnect roof drains and use cisterns | Stormwater performance standard, runoff reduction |
| Green roof | Stormwater performance standard, runoff reduction |
| Regenerative Stormwater conveyance | Stormwater performance standard, runoff reduction |
| Dry swale | Bioswale |

# APPENDIX C: Funding Sources and Incentives

**Appendix C – Funding Sources and Incentives**

The following list of potential founding sources and incentives that may contribute to implementation of watershed management strategies was compiled for the TMDL and Watershed Management Plan to address sediment in North Fork Catoctin Creek (Virginia Tech 2019).
(https://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/NF%20Catoctin/NFCatoctin_JTI_Sediment_Final%20319%20Approved%20Wtrshed%20Rpt_20191022.pdf?ver=2019-11-05-161257-613)

# A TMDL and Watershed Management Plan to address Sediment in North Fork Catoctin Creek Located in Loudoun County, Virginia

Submitted by:

Virginia Department of Environmental Quality

Prepared by:

Department of Biological Systems Engineering, Virginia Tech

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VT-BSE Document No. 2018-0004

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# 14 FUNDING

A list of potential funding sources available for implementation has been developed and a brief description of the programs and their requirements follows. Detailed descriptions can be obtained from the Loudoun SWCD, DCR, NRCS, and VCE.

### Environmental Protection Agency (EPA) Section 319 Grant Project Funds

Through Section 319 of the Federal CWA, Virginia is awarded grant funds to implement NPS programs. DEQ administers the money annually on a competitive grant basis to fund TMDL implementation projects, outreach and educational activities, water quality monitoring, and technical assistance for staff of local sponsor(s) coordinating implementation. In order to meet eligibility criteria established for 319 funding, all proposed project activities must be included in the TMDL implementation plan covering the project area. In addition, this plan must include the nine key elements of a watershed based plan (noted in Section 8.3.2). *For more information:* https://www.epa.gov/nps/319-grant-program-states-and-territories, accessed 4/12/2019.

### EPA/VA Clean Water State Revolving Fund

EPA awards grants to states to capitalize their Clean Water State Revolving Funds (CWSRFs). The states, through the CWSRF, make loans for high-priority water quality activities. As loan recipients make payments back into the fund, money is available for new loans to be issued to other recipients. Eligible projects include point source, nonpoint source and estuary protection projects. Point source projects typically include building wastewater treatment facilities, combined sewer overflow and sanitary sewer overflow correction, urban stormwater control, and water quality aspects of landfill projects. Nonpoint source projects include agricultural, silvicultural, rural, and some urban runoff control; on-site wastewater disposal systems (septic tanks); land conservation and riparian buffers; leaking underground storage tank remediation, etc. *For more information:* http://www.deq.virginia.gov/programs/water/cleanwaterfinancingassistance.aspx, accessed 4/12/2019.

### National Fish and Wildlife Foundation

Grant proposals for this funding are accepted throughout the year and processed during fixed signup periods. There are two decision cycles per year. Each cycle consists of a pre-proposal evaluation, a full proposal evaluation, and a Board of Directors' decision. Grants generally range between $10,000 and $150,000. Grants are awarded for the purpose of conserving fish, wildlife, plants, and their habitats. Special grant programs are listed and described on the NFWF website (http://www.nfwf.org). If the project does not fall into the criteria of any special grant programs, a proposal may be submitted as a general grant if it falls under the following guidelines: 1) it promotes fish, wildlife and habitat conservation, 2) it involves other conservation and community interests, 3) it leverages available funding, and 4) project outcomes are evaluated. *For more information:* https://www.nfwf.org/Pages/default.aspx, accessed 4/12/2019.

### USDA Agricultural Conservation Easement Program (ACEP)

The Agricultural Conservation Easement Program (ACEP) provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps American Indian tribes, state and local governments and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect and enhance enrolled wetlands. *For more information:* https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/acep/, accessed 4/12/2019.

### USDA Chesapeake Bay Watershed Initiative

This initiative was authorized in the 2008 Farm Bill for 2009-2012. It provides technical and financial assistance to producers to implement practices that reduce sediment and nutrients to help protect and restore the Chesapeake Bay. Priority has been given to the Shenandoah and Potomac River Basins and selected watersheds that have impaired streams due to high levels of nutrients and sediment. Producers who live in an NRCS high priority Chesapeake Bay watershed receive additional consideration in the funding ranking process. *For more information:* https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/initiatives/?cid=stelprdb1047323, accessed 4/18/19.

### USDA Conservation Reserve Program (CRP)

Through this program, cost-share assistance is available to establish cover of trees or herbaceous vegetation on cropland. Applications for the program are ranked, accepted and processed during fixed signup periods that are announced by the USDA Farm Service Agency (FSA). If accepted, contracts are developed for a minimum of 10 and not more than 15 years. Payments are based on a per-acre soil rental rate. To be eligible for consideration applicants must meet certain criteria set by FSA. Land must have been owned or operated by the applicant for at least 12 months prior to the close of the signup period. The payment to the participant is up to 50% of the cost for establishing ground cover. *For more information:* https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program, accessed 4/12/2019.

### USDA Conservation Reserve Enhancement Program (CREP)

This program is an "enhancement" of the existing USDA CRP Continuous Sign-up. It has been "enhanced" by increasing the cost-share rates from 50% to 75% and 100%, increasing the rental rates, and offering a flat rate incentive payment to place a permanent "riparian easement" on the enrolled area. Pasture and cropland (as defined by USDA) adjacent to streams, intermittent streams, seeps, springs, ponds and sinkholes are eligible to be enrolled. Buffers consisting of native, warm-season grasses on cropland, to mixed hardwood trees on pasture, must be established in widths ranging from the minimum of 30% of the floodplain or 35 feet, whichever is greater, to a maximum average of 300 feet. Cost-sharing (75% - 100%) is available to help pay for fencing to exclude livestock from the riparian buffer, watering facilities, hardwood tree planting, filter strip establishment, and wetland restoration. NRCS and the local SWCD determine and design appropriate conservation practices. A 40% incentive payment is offered upon project completion and an average rental rate of $70/acre on stream buffer area is provided for 10-15 years. The State of Virginia will make an additional incentive payment to place a perpetual conservation easement on the enrolled area. *For more information:* https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-enhancement/index, accessed 4/12/2019.

#### USDA Environmental Quality Incentives Program (EQIP)

This federal program was established in the 1996 Farm Bill to provide a single voluntary conservation program for farmers and landowners to address significant natural resource needs and objectives. EQIP offers one to 10-year contracts to landowners and farmers to provide cost-share assistance, tax credit, and/or incentive payments to implement conservation practices and address the priority concerns statewide or in the priority area. Eligibility is limited to persons who are engaged in livestock or agricultural production. Eligible land includes cropland, pasture, and other agricultural land in priority areas, or land that has an environmental need that matches one of the statewide concerns. *For more information:* https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/, accessed 4/23/2019.

#### USDA Regional Conservation Partnership Program (RCPP)

This federal program promotes coordination between NRCS and its partners, such as local SWCDs and non-profit organizations, to assist producers and landowners to install and maintain conservation activities on their properties. The Chesapeake Bay watershed is one of eight Critical Conservation Areas receiving funding for RCPP projects. *For more information:* https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/rcpp/, accessed 4/12/2019.

#### Virginia Agricultural Best Management Practices Cost-Share (VACS) Program

The VACS program is administered by the Virginia Soil and Water Conservation Board and Department of Conservation and Recreation, who allocate annual funding to Virginia's 47 local SWCDs. The program goal is to improve water quality in the state's streams, rivers, and the Chesapeake Bay. VACS offers cost-share assistance as an incentive to carry out construction or implementation of selected Best Management Practices (BMPs). The VACS program encourages the voluntary installation of agricultural BMPs to meet Virginia's nonpoint source pollution reduction water quality objectives. VACS objectives include special emphasis on the reduction of nutrients (nitrogen and phosphorus), and sediment delivered to the Chesapeake Bay; by preventing additional pollution from entering state waters; and meeting the criteria for Virginia's compliance with Section 319 of the Clean Water Act. *For more information:* http://www.dcr.virginia.gov/soil-and-water/costshar2, accessed 4/12/2019.

### Virginia Agricultural Best Management Practices Tax Credit Program

For all taxable years, any individual or corporation engaged in agricultural production for market, who has in place a soil conservation plan approved by the local SWCD, is allowed a credit against the tax imposed by Section 58.1-320 of an amount equaling 25% of the first $70,000 expended for agricultural best management practices by the individual. Any practice approved by the local SWCD Board must be completed within the taxable year in which the credit is claimed. The credit is only allowed for expenditures made by the taxpayer from funds of his/her own sources. The amount of the credit cannot exceed $17,500 or the total amount of the tax imposed by this program (whichever is less) in the year the project was completed. If the amount of the credit exceeds the taxpayer's liability for such taxable year, the excess may be carried over for credit against income taxes in the next five taxable years until the total amount of the tax credit has been taken. This program can be used independently or in conjunction with other cost-share programs on the stakeholder's portion of BMP costs. It is also approved for use in supplementing the cost of repairs to streamside fencing. *For more information:* http://www.dcr.virginia.gov/soil-and-water/costshar, accessed 4/12/2019.

### Virginia Conservation Assistance Program (VCAP)

This is a relatively new program that provides financial incentives and technical and educational assistance to residential/urban landowners who install stormwater BMPs in Virginia's Chesapeake Bay watershed. Cost-share is typically 75% and some practices provide a flat incentive payment. SWCDs administer the program to encourage residential and urban property owners to install BMPs on their land to reduce erosion, poor drainage, and poor vegetation that contribute to water quality problems. *For more information:* https://vaswcd.org/vcap, accessed 4/12/2019.

### Virginia Logging BMP Cost Share Program

Virginia Department of Forestry (DOF) offers cost-share assistance to timber harvest operators through a unique program offered through the utilization of funding from the Commonwealth's Water Quality Improvement Fund. This program shares the cost of the installation of forestry BMPs on timber harvest sites by harvest contractors. Contractors may receive up to 50% of direct project costs, not to exceed $2,500 per parcel for BMP installation practices involving the stream(s). If the project scope involves the purchase of a portable bridge, assistance shall be 50% of direct project costs plus the portable bridge cost, not to exceed $5,000. *For more information:* http://www.dof.virginia.gov/costshare/index.htm, accessed 4/12/2019.

### Virginia Nonpoint Source Implementation Program

Virginia's nonpoint source (NPS) implementation program is administered by DEQ through local Soil and Water Conservation Districts (SWCD), local governments, nonprofits, planning district commissions (PDC), and local health departments to improve water quality in the Commonwealth's streams and rivers and in the Chesapeake Bay. DEQ, through its partners, provides cost-share assistance to landowners, homeowners, and agricultural operators as an incentive to voluntarily install nonpoint source (NPS) best management practices (BMPs) in designated watersheds. The program uses funds from a variety of sources, including EPA 319(h) and the state-funded Water Quality Improvement Fund (WQIF) to install BMPs with the goal of ultimately meeting Virginia's NPS pollution water quality objectives. Although resource-based problems affecting water quality can occur on all land uses, this manual addresses cost-share assistance on agricultural, residential, and urban lands. The geographic extent of eligible lands is identified in grant agreements and in watershed based plans (WBPs), including TMDL IPs approved by DEQ and the United States Environmental Protection Agency (EPA). *For more information:* https://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/NonpointSourcePollutionManagement.aspx, accessed 4/12/2019.

### Virginia Riparian Forest Buffer Tax Credit Program

The primary goal of this program administered by DOF is to provide an incentive to landowners through a tax credit for preserving riparian forest buffers along waterways during a timber harvest operation. In 2000, the Virginia General Assembly enacted the Riparian Buffer Tax Credit to provide a non-refundable credit to: Individuals, S-Corporations or Partnerships. Estates and Trusts are not eligible for this tax credit, but Family Partnerships and Limited Liability Corporations are eligible. Applicants must own land that abuts a waterway on which timber is harvested. Recipients must refrain from timber harvesting on certain portions of the land for 15 consecutive years. The amount of the credit is equal to 25 percent of the value of the timber retained as a buffer up to a specified limit. The buffer must be at least 35 feet wide and no more than 300 feet and be intact for 15 years. The applicant must have a Stewardship Plan for the tract to qualify. *For more information:* http://www.dof.virginia.gov/tax/credit/riparianbuffer/index.htm, accessed 4/12/2019.

### Virginia Water Quality Improvement Fund

This is a permanent, non-reverting fund established by the Commonwealth of Virginia in order to assist local stakeholders in reducing point and nonpoint nutrient loads to surface waters. Eligible recipients include local governments, SWCDs, and individuals. Grants for both point and nonpoint source pollution remediation are administered through DEQ. *For more information:* https://www.deq.virginia.gov/Programs/Water/CleanWaterFinancingAssistance/WaterQualityImprovementFund.aspx, accessed 4/12/2019.

### Virginia Wetland and Stream Mitigation Banking

Mitigation banks are sites where aquatic resources such as wetlands, streams and streamside buffers are restored, created, enhanced, or in exceptional circumstances, preserved expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources. Mitigation banking is a commercial venture that provides compensation for aquatic resources in financially and environmentally preferable ways. Not every site or property is suitable for mitigation banking. Mitigation banks are required to be protected in perpetuity, to provide financial assurances and long term stewardship. The mitigation banking process is overseen by an Inter-Agency Review Team made up of state and federal agencies and chaired by DEQ and Army

Corps of Engineers. *For more information:* https://www.deq.virginia.gov/Programs/Water/WetlandsStreams/Mitigation.aspx, accessed 4/12/2019.

### Other Potential Funding Sources

Additional potential funding sources that have been identified in previous TMDL IPs include:

- Virginia Outdoors Foundation. *For more information:* http://www.virginiaoutdoorsfoundation.org/, accessed 4/12/2019.
- U. S. Fish and Wildlife Service (FWS) Conservation Grant Program. *For more information:* https://www.fws.gov/grants/programs.html, accessed 4/12/2019.
- Trout Unlimited. *For more information:* https://www.tu.org/conservation/, accessed 4/12/2019.
- Ducks Unlimited. *For more information:* http://www.ducks.org/, accessed 4/12/2019.
- Potomac Conservancy. *For more information:* https://potomac.org/, accessed 4/18/19.