Blue Ridge Mountain Communities Area Watershed Plan

Engineering Report

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AGENCY / ORGANIZATION ABBREVIATIONS

USEPA	United States Environmental Protection Agency
WVDEP	West Virginia Department of Environmental Protection
WVU	West Virginia University

TERMS

Best Management Practice (BMP)	A technique, process, activity, or structure used to reduce water pollution; although this is a type of water pollution control for many pollution sources, this report focuses on stormwater discharge
Evapotranspiration	Uptake of water by plants, and release of water back to the atmosphere
Geographic Information System (GIS)	A system that stores and displays statistical and demographic information linked to a map of the land area that it describes
Impervious cover	Surfaces that decrease the ecosystem's ability to infiltrate stormwater, resulting in greater runoff Examples of these surfaces include rooftops, roads, overly compacted areas, sidewalks, and other hard surfaces
Site design	The comprehensive planning of a site, including but not limited to layout, grading, utilities, and stormwater management
Stakeholder	Any person or individual with a vested interest
Tributary	A stream or river that flows into a main river
Vision	A document that describes a picture for the future, created with input from Blue Ridge Mountain citizens, which will guide Jefferson County in creating a small area plan for the Mountain
Watershed	An area of land that drains into a river, lake, or bay

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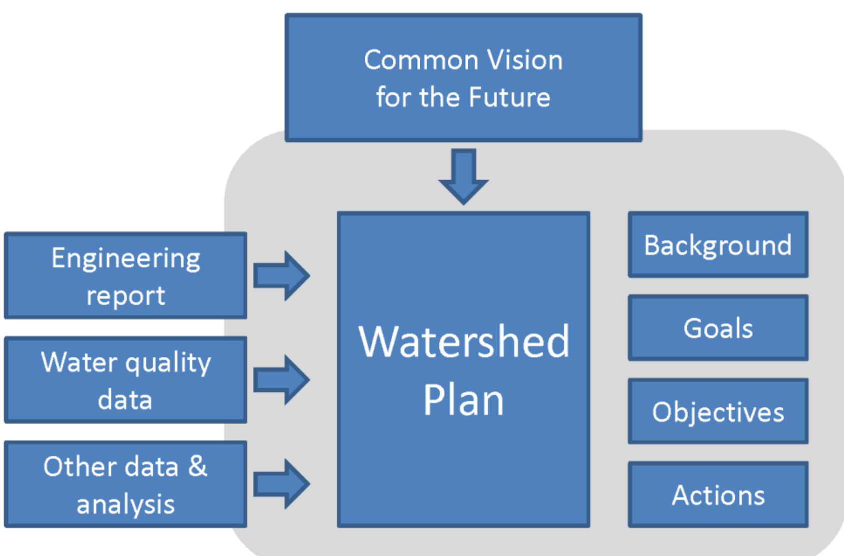
1. BACKGROUND

The Blue Ridge Mountain Communities Area in Jefferson County, West Virginia, referred to as "the Mountain," lies within the Shenandoah River watershed. The Mountain area is bordered by the Shenandoah River to the west, the Appalachian Trail and Virginia line to the east, the confluence of the Potomac and Shenandoah Rivers to the north, and the Clark County, Virginia line to the south. Not only does the Shenandoah River serve as the community's western border, it also serves as a major tributary that affects the water quality of the Chesapeake Bay.

In 2009, President Obama signed an executive order mandating improved water quality for the greater Chesapeake Bay watershed, which includes six states and the District of Columbia. As the Shenandoah is part of the Chesapeake Bay watershed, the National Fish and Wildlife Foundation awarded Jefferson County a grant to develop a locally supported vision document and to create engineering recommendations, to guide the preparation of a locally supported watershed management plan for the Shenandoah River watershed in Jefferson County. Through the Blue Ridge Mountain Communities Area Watershed Plan (BRMCAWP) effort, Jefferson County seeks to take a positive step toward protecting such a culturally significant area of the County and meeting the presidentially mandated order.

The goal is to create a watershed management plan that allows future development and improvement to the area, while maintaining or improving the water quality of the watershed. The visioning process serves to both guide preparation of a watershed management plan to improve the water quality of the Shenandoah River, and also to incorporate the thoughts of Mountain residents and other stakeholders regarding the future. Beyond the vision document, relevant data, analysis, and resources will serve to ground the watershed plan; information presented in this engineering report will serve as a key component in the watershed plan (Figure 1). The information in this report also served to communicate engineering information during the stakeholder visioning process.

Figure 1: Components of the watershed plan



Downstream Strategies, in coordination with Harbor Engineering, Inc. (HEI), provides the following engineering report detailing landscape engineering recommendations, including a case study of a similar community, as well as the following components:

- Best management practices for steep slope watershed management;
- Recommendations for impervious surface cover limits based on slope and subwatershed; and
- Recommendations regarding improved road access and future transportation connections.

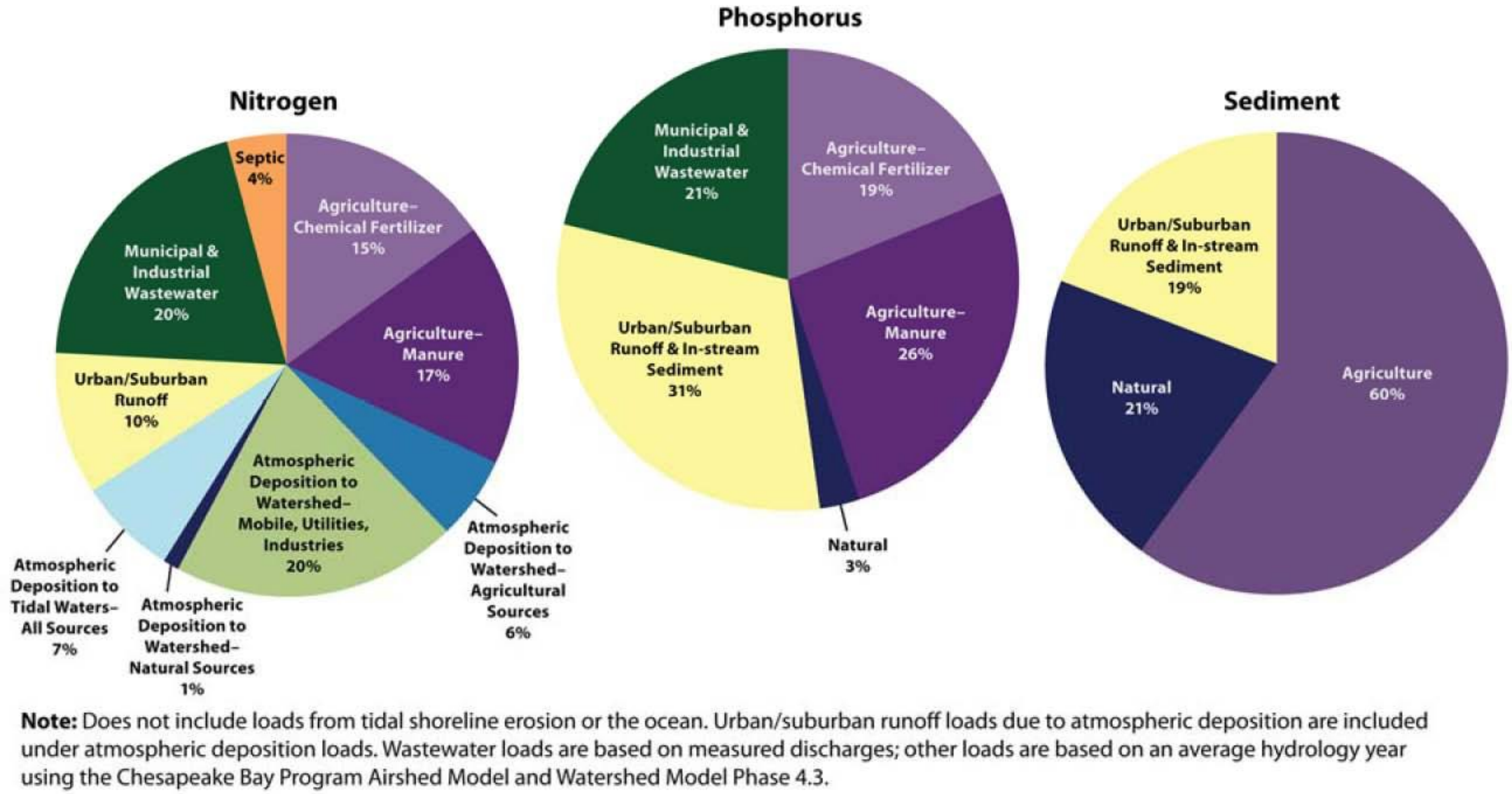
1.1 Chesapeake Bay Watershed

According to the United States Environmental Protection Agency (USEPA)'s Chesapeake Bay Compliance and Enforcement Strategy (2010a), West Virginia and other basin states are required to address downstream pollution to the Chesapeake Bay by reducing the flow of nutrients and sediment into the Bay using maximum amounts, known as Cap Load Allocations, for each jurisdiction. The greatest pollution threats to the Bay include nitrogen, phosphorus, and sediment. These pollutants come from sources such as agricultural operations, wastewater treatment facilities, and stormwater runoff. Agricultural sources contribute the largest amount of nutrient and sediment pollution in the watershed, accounting for about 38% of the nitrogen, 45% of the phosphorus, and 60% of the sediment. Stormwater runoff accounts for about 10% of the nitrogen, 31% of the phosphorous, and 19% of the sediment (Figure 2). Population growth and development have caused a rapid increase in the amount of impervious surfaces, and the associated concern with stormwater pollution (USEPA, 2010a).

Of the Chesapeake Bay watershed jurisdictions, Pennsylvania and Virginia contain the most land area in the Chesapeake Bay watershed and contribute the highest nutrient loadings. Out of the total nutrient and sediment load into the Bay, West Virginia contributes 3% of all nitrogen and 4% of all phosphorous (USEPA, 2010a); agriculture is the source for about 65% of the nitrogen and 60% of the phosphorous loads (Jefferson County Department of Planning and Zoning, 2010a). Urban development and stormwater runoff are two contributors to excess nitrogen and phosphorous that may concern Jefferson County (Jefferson County Department of Planning and Zoning, 2010a). While the amount of nitrogen contributed from septics is relatively small, development pressures and aging septics could increase the contribution of nitrogen from this source. The Shenandoah Valley in Virginia and West Virginia, as well as south-central Pennsylvania, are two of the three areas with the greatest contributions of manure-based agricultural nutrient loads to the Bay; densely populated animal agriculture operations in these areas cause the highest agricultural nutrient loads to the Bay in comparison to other areas (USEPA, 2010a).

The Chesapeake Bay watershed includes Jefferson County and the Shenandoah River. The type and amount of contaminants entering the Shenandoah from the Mountain, however, are unclear. Water quality is currently being monitored on the Mountain to determine the total contribution of pollutants relevant to the Chesapeake Bay, namely, nitrogen, phosphorous, and sediment.

Figure 2: Relative responsibility of pollutant loading to the Chesapeake Bay



Source: Copied from USEPA (2010a).

1.2 Blue Ridge Mountain Communities Area

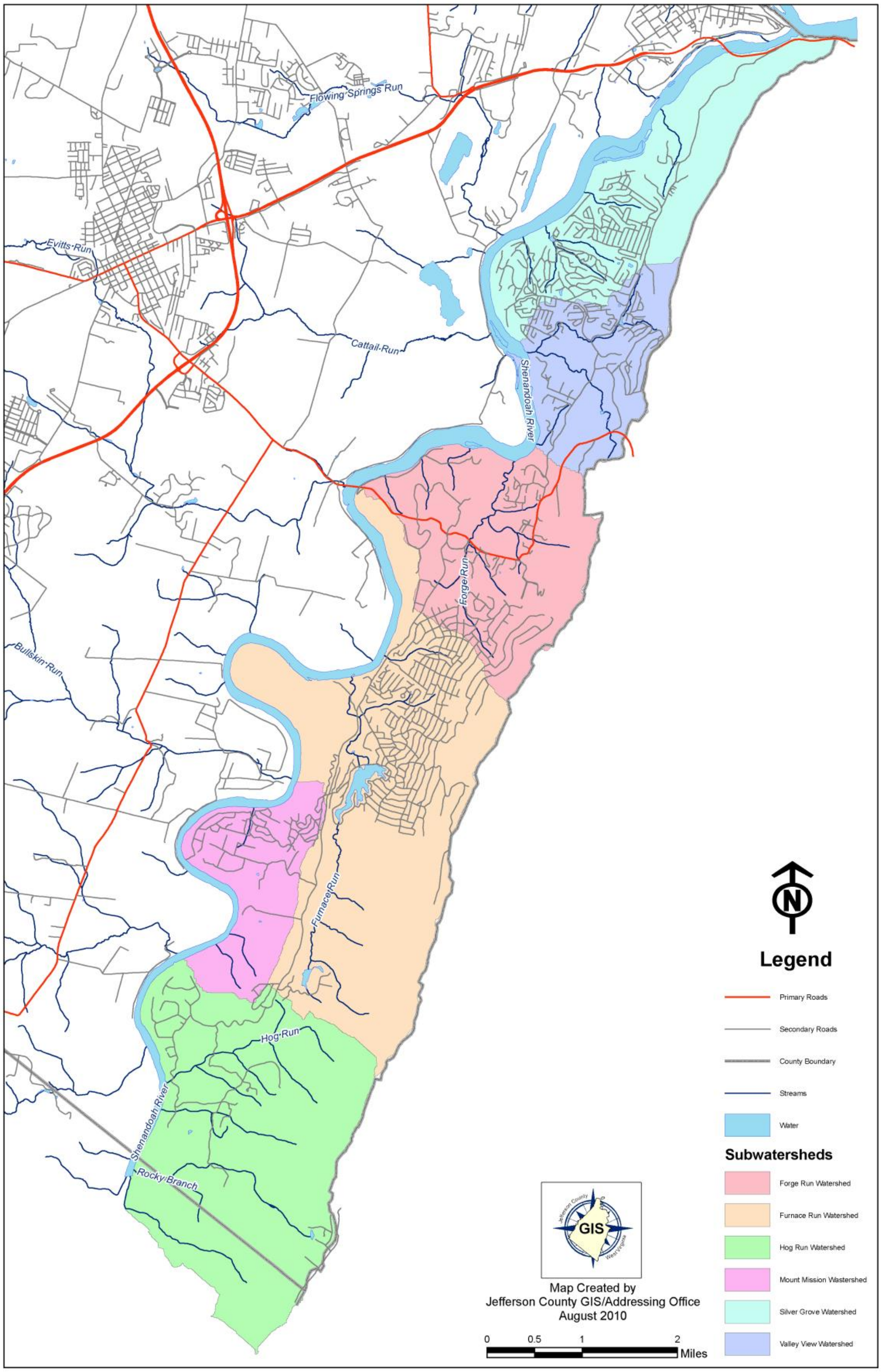
The Mountain watershed, a physical area of land east of the Shenandoah River in Jefferson County, is approximately 24 square miles, which makes up 11% of Jefferson County. This land area includes federal-, state-, county-, and privately-owned land. The land use is mixed; much of the northern portion is residential, largely located in areas called Shannondale and Keyes Ferry Acres. The southern part of the Mountain is largely open space, managed as wildlife management area (Jefferson County Department of Planning and Zoning, 2010b).

A watershed can be defined as an area of land where all precipitation falling within that boundary drains to a single point (USEPA, 2010b). Smaller areas that drain into a single point, such as those within the Shenandoah watershed, are called subwatersheds. In the Mountain's area, Jefferson County has identified six subwatersheds for this project, including the following (named north to south): Silver Grove, Valley View, Forge Run, Furnace Run, Mount Mission, and Hog Run (Figure 3). These subwatersheds can be useful boundaries in watershed planning and monitoring efforts.

Several subdivisions on the Blue Ridge Mountain were planned and approved from 1940 through the 1970s, before subdivision regulations first came into effect in Jefferson County in 1972; these communities also pre-date additional County land development regulations and ordinances that guide development with standards for lot size, water supply, wastewater treatment, road construction, and stormwater management (Jefferson County Department of Planning and Zoning, 2010c).

Current and future development on the Mountain can impact the Shenandoah watershed. Without guidance such as education, standards, or regulations, future development could threaten the environment and existing quality of life. Recommendations in this report can be implemented—on a subwatershed basis when appropriate—to reduce environmental impacts on the Mountain and downstream and to improve the overall quality of life for Mountain residents.

Figure 3: Subwatersheds of the Blue Ridge Mountain Community



Source: Copied from Jefferson County GIS Office (2010a).

2. EXISTING CONDITIONS

2.1 Slope

The elevation of the Mountain ranges from 250 feet at the junction of the Shenandoah and Potomac Rivers to 1,700 feet, which accounts for a 1,450-foot change in elevation. Jefferson County identified and mapped the slope of the land on the Mountain in a 2009 slope stability project (Shirley, 2009); slope ranges are classified based on the Jefferson County Subdivision and Land Use Regulations as of August 19, 2010 (Table 1; Figure 4). Approximately 55% of the Mountain consists of steep slope, defined as a 15% or greater incline (Maryland Department of Natural Resources, 2010).

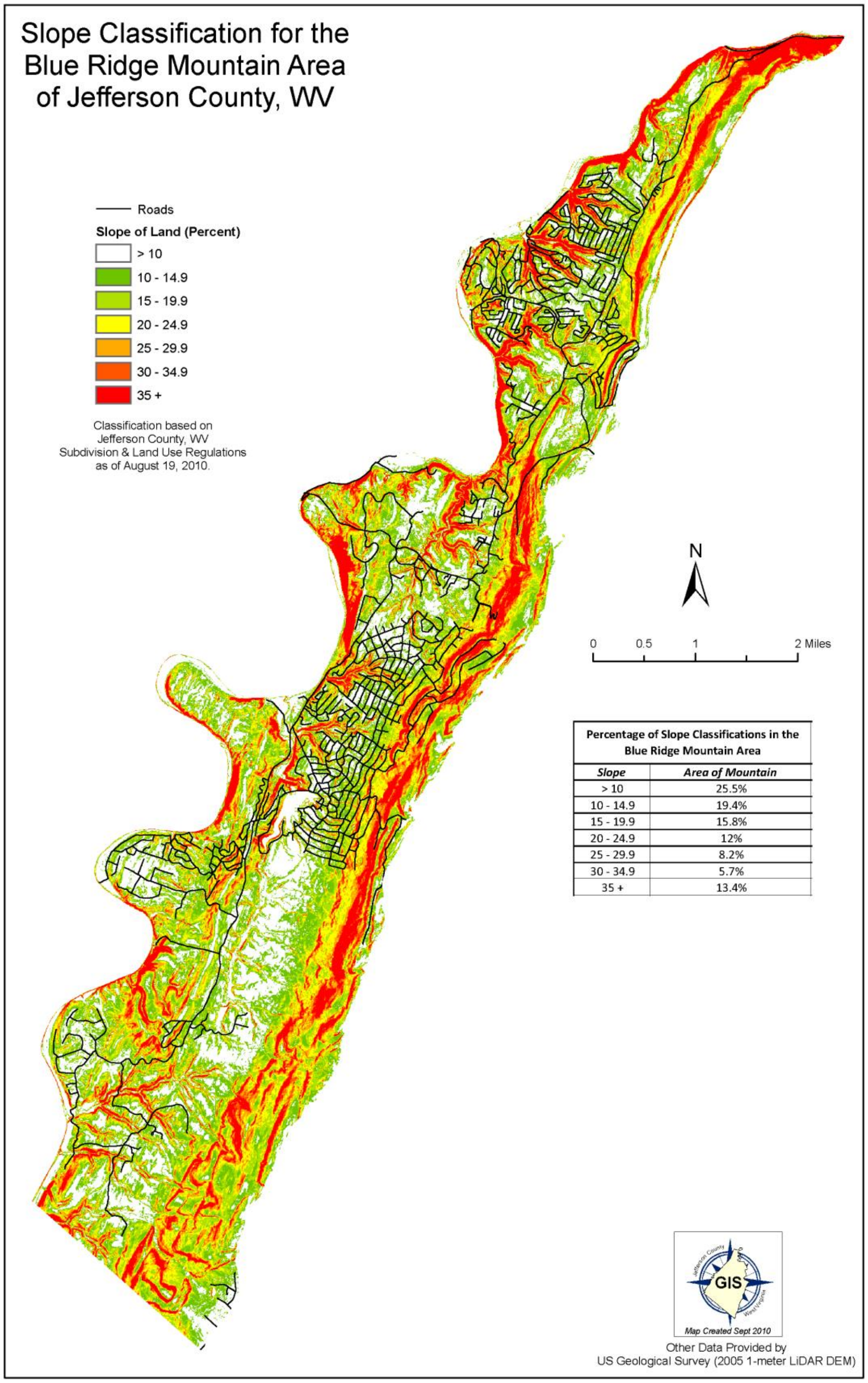
Table 1: Area of the Mountain by slope category

Slope	Percent of Mountain area
<10%	25.5%
10-14.9%	19.4%
15-19.9%	15.8%
20-24.9%	12.0%
25-29.9%	8.2%
30-34.9%	5.7%
35+%	13.4%

Source: Jefferson County GIS Office (2010b).

The Jefferson County Planning and Zoning Department has worked with the GIS Office to map these slope data to analyze both developed and developable lands. This analysis can serve to create or refine recommendations and, where appropriate, regulations.

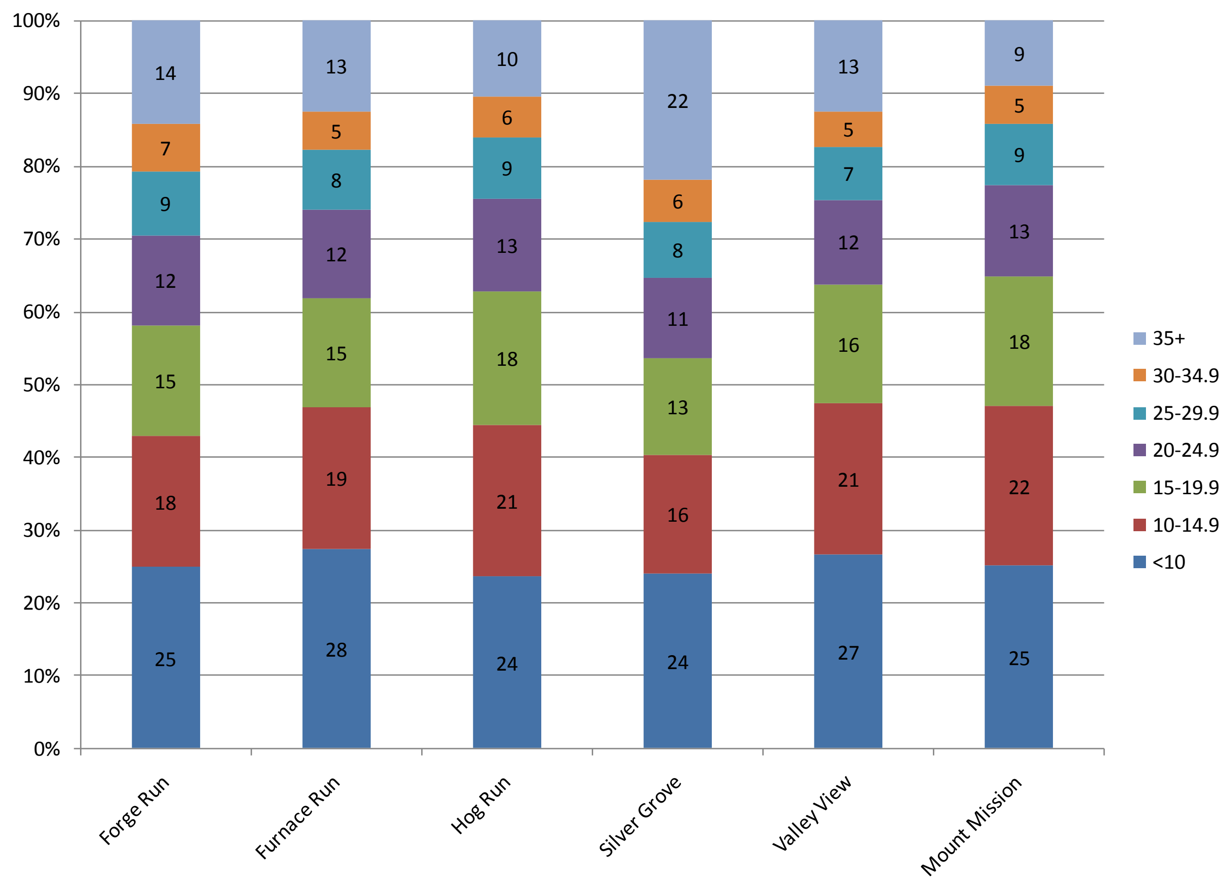
Figure 4: Slope on the Blue Ridge Mountain Area, Jefferson County



Source: Copied from Jefferson County GIS Office (2010b).

Examining slope by subwatershed, each of the subwatersheds on the Mountain contains relatively similar proportions of land area in each slope category (Figure 5). Silver Grove subwatershed contains the highest proportion of land with greater than 35% slope at 22%; in addition, nearly 60% of the land in the Silver Grove subwatershed is considered steep slope (greater than 15%). Three subwatersheds have a cumulative percent of steep slope that is over the Mountain average of 55%, including the following: Silver Grove (60%), Forge Run (57%), and Hog Run (56%).

Figure 5: Percent of land in slope categories by subwatershed



Source: Jefferson County GIS Office (2010b).

2.2 Land ownership and state of development

The Mountain area contains a total of 15,567 acres of land; of these total acres, about 4,392 acres of land are undeveloped, accounting for about 28% of the area, as listed in Table 2 (Jefferson County Department of Planning and Zoning, 2010a).

Table 2: Proportion of land ownership on the Mountain

Land type	Percent of Mountain area
Developed land	37%
Federal, state, county, private easements, and educational facilities	35%
Undeveloped land	28%

Source: Jefferson County Department of Planning and Zoning (2010a).

Potential future growth on the Mountain can be determined by subtracting existing houses from tax parcels and platted lots: 4,249 tax parcels remain unimproved, and 7,143 lots remain undeveloped (Table 3). Of the total platted lots on the Mountain, roughly one-third are developed.

Table 3: Houses, tax parcels, and platted lots on the Mountain as of August 2010

	North of Route 9	South of Route 9	Total
Houses	1,313	1,878	3,191
Tax parcels	3,005	4,435	7,440
Unimproved parcels	1,692	2,557	4,249
Platted lots	4,301	6,033	10,334
Undeveloped lots	2,988	4,155	7,143

Source: Jefferson County Department of Planning and Zoning (2010a). Note: Numbers of houses were subtracted from tax parcels to get unimproved parcels; numbers of houses were subtracted from platted lots to get undeveloped lots.

Although numbers of unimproved parcels and undeveloped lots help estimate maximum possible future growth, a tax parcel or platted lot does not indicate the ability to build upon the property. Because much of the Mountain originally was laid out as individual campsites, some of the lot sizes are unusually small. The smallest lot size on the Mountain, for example, is about 10 feet by 150 feet. The vast majority of these smaller lots, however, have contiguous ownership; although these lots are not legally merged for planning and zoning, they are merged for tax assessment. Many platted lots are inadequate to support private wells and septic systems due to small size, steep slopes, or limited road access; these constraints limit opportunities to for building on some existing platted lots. The number of existing platted lots, however, demonstrates future development possibilities (Jefferson County Department of Planning and Zoning, 2010c).

2.3 Septic

2.3.1 *Permit applications*

To provide perspective regarding development on the Blue Ridge Mountain, the Jefferson County Board of Health has issued a total of 5,604 drainfield permits , of which 5,177 have been built, as shown in Table 4 (Jefferson County Department of Planning and Zoning, 2010a).

Table 4: Septic drainfield permits issued by Jefferson County Board of Heath

	North of Route 9	South of Route 9	Total
Drainfield permits	1,720	3,884	5,604
Built	1,609	3,568	5,177
Not built	111	316	427

Source: Jefferson County Department of Planning and Zoning (2010a).

2.3.2 *Septic regulations*

State septic rules are enforced at the county level. Additional standards and regulations may be present at the county or subdivision levels, but do not currently exist in Jefferson County. According to state rules, the general area required for installation of an individual septic system must be at least 10,000 square feet. Where pubic water is not available, the required area is doubled to 20,000 square feet. This regulation serves to protect drinking water supplies, assuming that without a public water supply system, wells or springs serve as drinking water sources (State of West Virginia, 1998).

The design standards for an individual sewage system regulate where septic tanks and drainfields can be located, and include area required, as well as both horizontal and vertical setbacks. A few other considerations encompass the general requirements for septic installation in West Virginia. According to the State of West Virginia (2003), general site requirements for an individual sewage system include the following:

- 10 foot setback from building or property line
- 25 foot setback from public water supply, 10 feet from private
- 50 foot setback from private water well or groundwater supply in any direction (in Jefferson County, it is a 100 foot setback)

In addition to horizontal setbacks, vertical limits for an individual sewage system include a minimum distance of three feet between the drainfield and the seasonal groundwater bedrock or any impermeable soil layer. These vertical conditions may be problematic in karst regions or areas with high groundwater tables. In these areas, elevated mound systems may be required, which are expensive due to the costs of engineered sand and its transport (State of West Virginia, 2003).

Beyond the necessary area and setbacks, drainfields must have a maximum depth of 36 inches, and a minimum depth of 18 inches. Other site considerations for the size of drainfields include the nature of the soil and the size of the house. In West Virginia, a percolation ("perc") test is used to determine soil characteristics. In other states, soil texture is used to determine loading rate, a more specific measure of the nature of soil than a perc test. Pool soils may necessitate the development of a larger drain field; no septic can be installed where perc test results show an average percolation time of less than five minutes per inch (State of West Virginia, 2003). In addition, the tank capacities are based on the number of bedrooms in a house; a four bedroom house requires 1,000 gallon capacity, and each additional bedroom requires 250 gallons (State of West Virginia, 2003).

In other parts of the country, factors such as nearby sensitive areas are relevant in permitting septic use. Minnesota, for example, has higher levels of protection in the northern part of state due to the proximity to the Great Lakes. Other examples of septic restrictions in sensitive areas include the Pine Barrens area in New Jersey to protect drinking water quality, and Puget Sound in Washington State to protect the ecology and connected tourism industry. In Maryland, regulations address the excess nitrogen flowing into the Chesapeake Bay. Although the contribution of nitrogen to the Chesapeake Bay from septics (4%) is far less than the contribution from agriculture (32%) (USEPA, 2010a), Maryland Department of the Environment began offering free septic upgrades to residents via the Maryland Bay Restoration Fund to remove nitrogen from the systems' wastewater (USEPA, 2009). The Fund is supported by fees from users of Maryland's wastewater facilities, onsite sewage disposal systems, and holding tanks.

In Pennsylvania, areas of known high nitrates require that a preliminary hydrogeology study be performed prior to the permitting of an on-lot septic system. The study takes into account the nitrate levels of the subject and nearby properties to determine the appropriate recharge area required for a new on-lot system. The determined recharge area is exclusive of impervious surface, and is the minimum area required for the septic system to avoid negative impacts on the drinking water supply. In the case of nitrate levels that are too high (above 10 parts per million nitrogen), traditional on-lot septic systems may be prohibited. Higher levels of nitrates (below the 10 parts per million threshold) often require larger lot sizes. It should be noted that these requirements are for proposed lots to be subdivided, and not for existing lots of record.

Steep slopes offer unique challenges for septic systems, which are designed to evenly spread out wastewater. Perc tests assume an even distribution, and are conducted on a square foot basis. A drainfield can become overloaded if wastewater is delivered to only a portion of the field. Currently, there are no slope restrictions for septics in West Virginia; the accepted guideline is to restrict septic drainfields on slopes over 25% (State of West Virginia, 1998). Although costly, methods such as serial distribution, or trellising, can be used when a drainfield is installed on a hillside.

2.4 Public water supply

Three neighborhoods on the Mountain—Keys Ferry Acres, Harper's Ferry Camp Sites, and West Ridge Hills—are served by a small public water system; this system consists of a series of sheds with water tanks and pumps that pump water to individual homes. This system serves about 300 customers in the northern part of the Mountain and is run by Jefferson Utilities, Inc. (JUI). The remaining 90% of the Mountain's residents use private wells and springs for water supply (Jefferson County Department of Planning and Zoning, 2010c).

The Jefferson County Public Service District estimates the total cost of providing public water and sewer to all Mountain residents would be $109,286,000, as shown in Table 5 (Jefferson County Department of Planning and Zoning, 2010a). During the visioning process, citizens of the Mountain expressed strong concern regarding public water and sewer systems.

Table 5: Estimated costs of proving public services on the Mountain (millions)

Service	North of Route 9	South of Route 9	Total
Sewer	$24.7	$41.7	$66.4
Water	$20.4	$22.4	$42.8
Total			**$109.3**

Source: Jefferson County Department of Planning and Zoning (2010a).

2.5 Recommendations

To protect water quality, and to prevent potential issues from worsening, we recommend Jefferson County foster a water quality monitoring program on the Mountain that collects and analyzes water quality data that serves as a foundation for decision making. Monitoring for nitrogen, for example, can help understand existing septic systems; other parameters such as fecal coliform, a parameter used by the West Virginia Department of Environmental Protection (WVDEP), and E. coli, a parameter used by the USEPA, are also informative. Caution should be used in interpretation of the latter two parameters, which can be present at high concentrations where animals frequent, such as deer or cows. Monitoring for sediment concentrations, as well as phosphorus is also recommended, especially considering the Mountain's connection to the Chesapeake Bay. The WVDEP's Watershed Assessment Section (WAS) systematically measures water quality and the biological health of West Virginia's rivers and streams using a five-year rotating basin plan. The Shenandoah-Jefferson County watershed, of which the Mountain is a part, was monitored in 2006, and is scheduled again for 2011. These data can be used in conjunction with additional monitoring efforts to collect baseline data to understand impacts of development on the Mountain, as well as the Mountain's contribution to Chesapeake Bay water quality.

Participants in the vision process had the most consensus and passion about the need for more water quality data. Some participants expressed, for example, that this data collection was long overdue. Participants agreed that baseline water quality data must be collected and analyzed before and during the watershed planning processes to identify water quality problems (if any), as well as its type and source. More specifically, participants also would like to identify pollution from connected watersheds (e.g., to identify what is coming into the Shenandoah from upstream in Virginia). Participants also supported ongoing stream monitoring efforts to comply with USEPA's strategy for the Chesapeake Bay.

3. BEST MANAGEMENT PRACTICES FOR STEEP SLOPE WATERSHED MANAGEMENT

Best management practices (BMPs) are techniques, processes, activities, or structures used to reduce water pollution; although BMPs are used for a wide variety of types of pollution, this report focuses mainly on stormwater discharge. More specifically, we are focused on BMPs that are the tools for steep slope watershed management.

The goals of these practices are to mimic natural flows, to prevent erosion and sedimentation, and to minimize pollution discharges into streams. In designing a site, these goals can be met by reducing impervious cover and utilizing pervious or otherwise natural areas for addressing stormwater runoff. These BMPs also help reduce the pollutants relevant to concerns with the Chesapeake Bay, including phosphorous, nitrogen, and sediment.

BMPs are typically organized into two categories: (1) structural, or built structures, and (2) non-structural, which include processes or techniques such as preservation or planning. The following BMPs could be encouraged or incentivized; for new development especially, these BMPs can be mandated. We suggest that Jefferson County think about property rights if considering mandating BMPs; throughout the visioning process, citizens of the Mountain expressed concern regarding individual lot regulations that affect their property rights.

3.1 Structural BMPs

Structural BMPs such as green roofs, grassy swales, and rain gardens are being used more and more across the country to mimic natural processes such as infiltration and evapotranspiration, and also to capture and reuse stormwater. In addition to water quality improvements, structural BMPs typically provide many side benefits such as flood prevention and aesthetic appeal.

The degree of stormwater volume and pollutant reduction achieved by these practices varies based on design, precipitation patterns, slope, and other factors. However, these techniques have been successfully implemented throughout a variety of climates and terrains in US cities of various sizes.

3.1.1 *Seepage pits*

Seepage pits are constructed sub-surface pits filled with clean stone and designed to infiltrate stormwater from a contributing drainage area. Common uses for seepage pits include capturing and infiltrating stormwater from rooftops, parking lots, driveways, and lawns. When designing seepage pits, it is important to verify that the sub-surface soil will percolate adequately, and the bottom of the pit must be sufficiently clear of any limiting zones or hazards, including bedrock or a high water table. Seepage pits are typically designed with sufficient storage volume to store the contributing stormwater runoff until it has an opportunity to infiltrate.

3.1.2 *Rain gardens*

Rain gardens, also known as bioretention cells, are a more decorative means of increasing infiltration. They often use engineered soils and carefully chosen plants to infiltrate up to 30% more rainfall than typical turf lawns (Wisconsin Department of Natural Resources (WDNR), 2003). Rain gardens are also graded to create a shallow depressed area so that rainwater can collect and pool in the area before infiltrating. As with all infiltration facilities, it is important to verify that there are no hazards or limiting zones that would not allow the facility to function as designed.

Figure 6: Rain Garden at Habitat for Humanity in Charleston, West Virginia

Photo: Sherry Wilkins., WVDEP.

3.1.3 *Bioswales*

Vegetated conveyances called bioswales help filter contaminants from stormwater runoff, and may also allow for biological uptake of pollutants (USEPA, 2007). Bioswales are not retention facilities; they are designed to infiltrate or drain within 12 to 24 hours. Bioswales differ from traditional vegetated stormwater conveyance; the plants and engineered soils are specially chosen to increase infiltration and filter pollutants from the runoff. Bioswales are widely used in parking lots and along roadways.

Photo: USEPA.

3.1.4 *Terraced planter systems*

Terracing steep slopes allows for the management of stormwater runoff by slowing or preventing it. The upper-most terrace detains stormwater until it reaches capacity; additional runoff will overflow to the next level below. This system slows stormwater runoff to reduce the possibility of erosion, and allows for ground infiltration and plant uptake.

Figure 7: Terraced rain gardens at the Sidwell Friends School, Washington DC

Photo: USEPA.

3.1.5 *Green roofs*

Green roofs are separated from the ground surface and incorporate an impermeable lining in order to protect the building from leaks. Thus, much of the water captured by a green roof evaporates or transpires through plants. Even when larger storm events exceed the retention capacity of green roofs, the volume of runoff to storm drains is reduced, allowing local sewer systems and streams to recover from the initial storm surge before processing the runoff.

3.1.6 *Rain barrels and cisterns*

These storage systems are often connected to downspouts to harvest runoff from roofs. Collecting and reusing runoff from roofs can result in substantial savings for property owners and stormwater management departments alike. Nearly 80% of domestic water use is for landscaping or indoor non-potable use including flushing toilets and washing clothes (USEPA, 2008). Runoff from a 40 foot by 30 foot roof will generate 75 gallons of water for every 0.1 inch of rainfall. Capturing and reusing runoff can keep thousands of gallons of water out of the sewer system while saving money on water use.

Figure 8: Rain barrels and cisterns

Photos: USEPA.

3.1.7 _Traffic islands, curb extensions, and sidewalk landscaping_

Curb extensions are vegetated areas that capture runoff from impervious surfaces such as roads. Besides adding aesthetic appeal, curb extensions have the added benefits of slowing traffic on residential streets, as well as reducing or eliminating basement flooding. Creating vegetated roadside channels where practical can provide water quality benefits and reduce erosion created by roadside stormwater runoff.

Photo: USEPA.

3.1.8 _Pervious pavement_

Pervious pavement has been available for decades, but is now gaining in popularity as a stormwater control measure. Pervious asphalt and concrete are poured over an aggregate base that provides structural support and runoff storage; this base also filters pollutants. Pervious asphalt and concrete are ideal for parking lots, low-traffic streets, and basketball courts. Other pervious pavement technologies include interlocking pavers and plastic grid paving, which can both be planted with grass or filled with gravel to promote infiltration; these can be used for parking lots, sidewalks, and driveways.

Figure 9: Examples of standard pavement alongside pervious pavement

Photo: Harbor Engineering. Note: Standard, impervious pavement is shown on left side of photo under the pooling water. Pervious pavement is shown on right side of photo, where water has absorbed into the pavement. Also note the medians designed to assist with stormwater runoff.

3.2 Non-structural best management practices

Non-structural BMPs use existing resources such as open space and natural systems to manage stormwater. These BMPs focus more on planning and policy to minimize disturbance and reduce the amount of impervious area.

3.2.1 *Planned development*

In addition to preserving open space at the site scale, neighborhoods and municipalities can take steps to encourage cluster development and redevelopment of previously developed sites. Integrating the design of the stormwater management facilities into the initial site design can also influence the layout of a project. Reduced impervious coverage achieved through clustered design can reduce impervious surfaces and also reduce the need for stormwater management facilities. In addition, focusing new development in areas that are already densely developed and redeveloping sites that are no longer in use allow for the preservation of open space or vegetated buffers that might otherwise be developed to accommodate urban growth.

3.2.2 *Preservation of open space during construction*

During construction, greenspace, even when an integral part of final site design, is often compacted, stripped of topsoil, and reduced in area more than necessary. Conservation design promotes careful planning to preserve open space, including, for example, sighting buildings away from wetlands and other ecologically important areas, and clearing the minimum amount of land necessary to accommodate the construction. Conservation design can also curb construction costs by reducing the need for traditional stormwater management, as well as the required amount of pavement and infrastructure.

3.2.3 *Shared, reduced width, and two-track driveways*

Planning to reduce road widths can help preserve open space and reduce impervious surfaces. Shared driveways, reduced driveway widths, and two-track driveways are all ways to preserve some degree of open space, without compromising the functionality of driveways.

3.2.4 *Infill development*

Concentrating new development in urban areas rather than expanding into surrounding undeveloped areas reduces the need for additional road and sewer systems, saving municipalities money and preserving open space for recreation and agriculture. Fewer roads mean less stormwater runoff.

3.2.5 *Preservation of existing trees and vegetation*

Preserving existing trees is a low-cost way to reduce stormwater runoff and provide water quality benefits. In addition to air quality benefits, trees provide shade and release moisture, reducing the direct solar radiation and providing energy savings. A common concern of street-side trees is the damage caused to hardscapes by tree roots. These concerns are being addressed through more careful assessment of soil volume requirements and by new technologies that support heavy loads while making larger volumes of soil available to the trees.

The tree canopy catches some precipitation as it falls, a first step in reducing stormwater runoff. Even if trees, shrubs, or wildflowers are disconnected from the natural soil, runoff directed into planters will be taken up by the plants and released into the atmosphere.

Re-vegetating disturbed areas with native plants can also reduce stormwater runoff, as well as reduce the amount of area that would otherwise be left as a traditional lawn, which requires continuous maintenance and often receives fertilizer inputs.

3.2.6 *Education and outreach*

Education and outreach efforts by the county or homeowners associations can include, but are not limited to the following:

- Encourage tree and vegetation plantings as a means to stabilize eroded slopes and channels.
- Encourage the use of cisterns to collect and reuse stormwater runoff from dwelling roof areas.
- Encourage rain gardens and natural areas, as well as the naturalization of existing lawn areas.
- Provide free guidelines for rain garden and cistern design and installation.
- Provide a natural plantings plant list at no charge to homeowners.
- Discourage the use of lawn fertilizers to reduce the amount of nitrogen and phosphorous runoff into the watershed.

3.3 Septic system maintenance

Although not directly related to stormwater, routine inspection and maintenance of existing septic systems could help minimize pollution discharges into streams. Through inspection and replacement of failing systems, a septic system maintenance program could help reduce the pollutants relevant to concerns with the Chesapeake Bay, including nitrogen and phosphorous. Existing programs in West Virginia offer technical and financial assistance for residents with failing septics. Education and outreach efforts can also be specifically focused on septic maintenance and assistance opportunities.

Model Development Principles

Model development principles have been adapted from a series of nationally-endorsed principles developed by the Site Planning Roundtable, a national cross-section of planning, environmental, home builder, fire, safety, public works, and local government personnel. These principles outline areas for consideration to change the standard approach to site design. It is acknowledged that some of the practices below do not apply to the Mountain.

Residential streets and parking lots.

1. Reduce residential street width
2. Reduce residential street length
3. Reduce residential street right-of-way widths
4. Minimize cul-de-sacs
5. Use vegetated open channels
6. Lower required parking ratios
7. Reduce parking ratios for mass transit or shared parking
8. Reduce parking lot imperviousness
9. Provide meaningful incentives to encourage structured and shared parking
10. Provide stormwater treatment for parking lot runoff

Lot development.

1. Advocate open space development (or cluster design)
2. Relax setbacks and frontages
3. Promote more flexible sidewalk standards
4. Promote alternative driveway surfaces and shared driveways
5. Specify management of open space
6. Direct rooftop runoff to pervious areas

Conservation of natural areas.

1. Create aquatic buffers along all perennial streams
2. Maintain buffers over time, through all stages of development
3. Minimize clearing and grading of native vegetation
4. Conserve and promote trees and other native vegetation
5. Encourage conservation incentives and flexibility
6. Provide stormwater management

A handbook developed by the Center for Watershed Protection provides additional tools: "this handbook details the technical support for the 22 Model Development Principles and outlines current and recommended practices along with research data on the economic, market, legal, safety, and social benefits of better site designs." Also featured is a worksheet designed to help communities target the development rules most in need of change in their localities.

Source: Center for Watershed Protection (1998, 2004).

4. IMPERVIOUS SURFACE COVER LIMITS

4.1 Impervious surfaces indices

Impervious surfaces convey stormwater runoff directly to local streams because they prevent or limit the infiltration of water into the soil. Examples of these surfaces include rooftops, roads, overly compacted areas, sidewalks, and other hard surfaces. Imperviousness is an important indicator of water quality, and the quantification of imperviousness threshold levels directly assists in understanding the negative effects of urban runoff on in-stream water quality (Arnold and Gibbons, 1996; Brabec et al., 2002).

Generally, research indicates that streams in catchments or drainage areas with greater than 10% imperviousness have a higher likelihood of experiencing water quality degradation. Common thresholds include catchments that are protected (less than 10%), impacted (10-30%), and degraded (greater than 30%) (Arnold et al., 1996; Brabec et al., 2002). These thresholds are still being refined; a more recent educational tool, for example, describes streams with catchments at 8-10% imperviousness as stable but with erosion apparent. This tool also notes a threshold of 20%, at which stream substrate quality decreases and erosion is active (Center for Watershed Protection, 2004).

Impervious surface cover limits can help to retain pervious surfaces that serve to reduce the negative impacts caused by development such as increased stormwater runoff. These cover limits can include, for example, limitations on the percent impervious of a lot. Cover limits can also include required components such as associated stormwater management facilities to mitigate increased runoff as a result of impervious coverage.

4.2 Existing regulations

Existing planning regulations in Jefferson County require the retention of a certain percentage of land in hillside development in its natural, pervious condition. The Jefferson County Subdivision and Land Use Regulations, as of August 19, 2010, specifically include slope delineations, as well as regulations on residential and non-residential site grading, land retention in hillside development by slope, and riparian buffers. The percent of land to be maintained in natural condition is shown in Table 6. These regulations, for example, restrict development on land with a weighted average slope greater than 35% by requiring that 100% of the land area in that parcel be maintained in natural condition.

Table 6: Current requirements for retention of land in natural condition

Weighted average slope of land	Percent of land to be maintained in natural condition
<10%	n/a
10-14.9%	25%
15-19.9%	40%
20-24.9%	55%
25-29.9%	70%
30-34.9%	85%
>35%	100%

Source: Jefferson County Department of Planning and Zoning (2010b).

4.3 Recommendations

We recognize and support the County requirements for retention of land in natural condition in hillside development; these requirements serve as a step towards potential further impervious surface cover limits, should they be required. In addition to the disturbance requirements, we further suggest setting reasonable impervious coverage limits by parcel. For example, current regulations do not contain any impervious coverage limits on sites with less than 10% average slopes; the only limitation to development is associated with the construction of on-lot sanitary sewers. Setting impervious coverage requirements could become more critical in the unlikely event of a public sewer becoming available on the Mountain, beyond the three existing public water supply systems, as the on-lot septic space requirements would no longer be applicable and minimum lot size would decrease. Current requirements have some limitations.

We suggest Jefferson County first inventory existing conditions. Stormwater runoff is influenced by a number of factors including percent impervious surface, soil permeability, and percent slope. Slope can have a considerable impact on the potential infiltration of stormwater and wastewater into the soil. Slope can be a complicated metric to calculate at the subwatershed scale. One method can use mean percent slope for each catchment to get a general idea of how steep a given catchment is and how that may affect stormwater infiltration. Using GIS, the percent imperviousness can be calculated by subwatershed and prioritized according to thresholds such as the following: 5%, 10%, 20%, and 30% (Hansen et al., 2010). This process should also include the spatial identification, using GIS, of all remaining contiguous wooded areas in relation to available lots. This should be done in the context of steep slopes and existing springs and water bodies. Jefferson County's existing GIS work with tree cover inventory can help assess cover type. A wooded area, for example, would generally be associated with less stormwater runoff than a lawn or cultivated area on similar slopes, even though all three cover types are considered pervious. This information can help to establish impervious surface cover limits that apply to individual parcels; the rules would impact different parcels in different ways, depending on the specific characteristics of each parcel.

For all lots, or at least those over a certain size such as one acre, more restrictive criteria may be used to determine the maximum allowable impervious coverage. Slope thresholds, for example, may be used to determine impervious coverage or woodland buffer requirements, such as discussed in Section 2.1; the quantity and quality of existing vegetation can also be used to determine lot impervious coverage requirements. Additional regulations could include offsetting additional impervious coverage with wooded areas rather than traditional lawns; these wooded areas can serve to reduce erosion and stormwater runoff. To support impervious surface cover limits, the County can also establish woodland buffer requirements for all lots to ensure contiguous tree canopy and understory where practical.

Additionally, we suggest the County Planning and Zoning Department work with the County Health Department to establish a minimum lot size based on sanitary sewer requirements due to the large variation in available lot sizes. This minimum lot size can serve as a baseline for a reasonable impervious coverage for a single-family dwelling, driveway, and associated impervious surface.

Limiting development is an alternative way to preserve water quality. Zoning large contiguous sections of wooded and steeply sloped areas as "Conservation Areas" is an approach to minimizing the allowable developable areas, and keeping lot coverage to a minimum. These areas are typically associated with limited development rights, large minimum lot sizes (i.e., 10 acres), and low impervious coverage limits (i.e., less than 5%).

In Jefferson County, conservation easements provide another option to preserve water quality by minimizing development in certain areas. The Land Trust of the Eastern Panhandle provides conservations easements to properties larger than 20 acres. If a single landowner does not have the necessary acres alone, residents with development rights or development potential could work with contiguous landowners to meet the 20 acre minimum threshold.

In addition to recommendations outlined for existing development, we suggest that Jefferson County consider property rights when assessing land use regulations on individual lots; throughout the visioning process, citizens of the Mountain expressed concern regarding individual lot regulations that affect their property rights.

4.4 Recommendations for future development

Site-specific slope data from the Mountain can be used to generate potential limits on future development. Other relevant documentation may include, for example, evidence that erosion generally occurs in areas developed on slopes over a certain percentage, or that landslides may be a concern in the area (Wieczorek et al., 2004; 2006). The actual predictors for erosive conditions depend on many factors such as soil type, vegetation, and contributing upslope drainage area. In the case of the Mountain, the slope data may help to determine a more site-specific slope percentage where erosion is generally observed, assuming similar slope and cover types. Using this information, future development on slopes over a certain grade could be prohibited. Alternately, development on slopes over a specified limit could be allowed with stipulations. These development stipulations could include, for example, requirement of a special exception or some other ordinance mechanism with site-specific requirements obtained from a steep slope evaluation performed by an engineer or other qualified professional. This evaluation would need to identify plans for structural integrity of buildings, stormwater facilities, and erosion prevention that would be approved by the county engineer and commissioners.

Jefferson County should also strengthen existing or, where necessary, create new stormwater management guidelines for future development. There are many approaches that can be used to ensure that post-development runoff is clean and that the volume does not increase after development occurs. One approach could include the requirement that all roof water from proposed dwellings be taken into cisterns, rain gardens, or stone seepage pits, or a combination of all three. This requirement would promote groundwater recharge and reuse, which could have a positive impact on potable water concerns on the Mountain. Water systems could be required to be sized anywhere from the first one inch of rainfall or to completely retain a 100-year storm event.

A second approach would be to mimic the post-construction requirements in West Virginia's general construction stormwater permit. For land disturbances of more than one acre, this permit requires descriptions of measures to be installed to control pollutants after the project is completed; it also requires that stormwater is conveyed from a site in a manner that protects the site and the receiving stream from post-construction erosion (WVDEP, 2007, Section G.4.e.2.B; 2010). In addition, this permit requires Stormwater Pollution Prevention Plans, commonly referred to as erosion and sedimentation control plans. Given the unique challenges associated with steep slope development, Jefferson County should consider requiring erosion and sedimentation control plans for all earth disturbances over 5,000 square feet. The contents of the plan could be the same as the requirements of the general construction stormwater permit and could include, for example, measures to stabilize exposed earth during construction, to trap sediment, and to keep sediment off of roadways and out of watercourses.

A third approach would be to mimic the requirements in West Virginia's general municipal separate storm sewer system (MS4) permit (WVDEP, 2009a; 2009b), even though this permit does not now apply to the Mountain. This permit includes requirements for controlling runoff from new development and redevelopment, and includes numerous elements related to watershed protection and site and neighborhood design. For example, it requires that all new and redevelopment projects implement management measures that keep and manage the first inch of rainfall from 24-hour storms that are preceded by 48 hours of no measurable precipitation.

Combinations of approaches for addressing post-development runoff may be most desirable. We suggest that Jefferson County closely analyze its county requirements as well as these two general permits to choose the best mix of approaches. We also suggest that Jefferson County consider property rights when assessing land use regulations on individual lots; throughout the visioning process, citizens of the Mountain expressed concern regarding individual lot regulations that affect their property rights.

5. IMPROVED ROAD ACCESS

Roads are important to provide access for residents, as well as emergency vehicles. Roads that are poorly designed, constructed, or maintained can prevent access and cause damage to vehicles. Because they intercept surface and subsurface water, roads lead to impacts both on- and off-site, including sedimentation in waterways and damage to vehicles. Properly designed, constructed, and maintained road systems, however, can minimize these impacts (Spong, 2006).

5.1 Current conditions and standards

Most of the subdivision road systems on the Mountain predate engineering specifications; many roads would not be approved under current regulations due to steep slope. In addition, most of these roads do not incorporate stormwater management. These factors contribute to erosion, which causes ruts and gulleys. In turn, water quality is degraded and the roads are almost impassable at times for residents (Jefferson County Department of Planning and Zoning, 2010c).

The Mountain area contains almost 150 miles of roads (Jefferson County GIS Office, 2010a). The primary road to access the Mountain area is Route 9, which is owned and maintained by the State of West Virginia. This east/west road splits the Mountain into northern and southern units. An additional state road, the new Route 9, is currently under construction. In the southern section of the Mountain, Mission Road provides the primary north-south access. Chestnut Hill provides the primary north-south access in the northern portion of the Mountain. Several of the largest communities dissolved their homeowners associations many years ago, and left many roads unmaintained. In 1998, the West Virginia Legislature declared the social and economic importance of roads, establishing a program run by the West Virginia Division of Highways for the identification, acquisition, and maintenance of orphan roads and bridges (State of West Virginia, 2007). The orphan roads program addressed the issues on the Mountain, creating a network of roads that are now considered “orphan” by the West Virginia Division of Highways and that receive only minimal maintenance (Jefferson County Department of Planning and Zoning, 2010c). Many of these orphan roads remain minimally maintained. Residents can apply for a permit from the state Division of Highways to repair a section of road. Others are inappropriate for vehicular travel in their current condition (Figure 10).

Figure 10: An orphaned road on Mountain that travels to platted lots

Photo: Evan Hansen.

Questions about slope stability, structure design, and culvert specifications may require professional advice. Deciding between paved versus gravel roads, for example, involves multiple site-specific factors such as existing and anticipated traffic volumes, slope, contributing drainage areas, soil stability, and maintenance responsibilities. A well-maintained gravel road may generate less stormwater runoff than a paved surface, but could contribute more sediment runoff and dust than a paved surface. A gravel road on a steep slope would also require more consistent maintenance than a paved road to prevent scouring and loss of surface material during rain events.

5.2 Improved road access and future road development

Improved road access and future road development begins with an inventory of existing conditions, as well as an understanding of those conditions' impacts. To understand conditions and minimize impacts, Jefferson County should develop a road maintenance plan that starts with an inventory of the current road system that includes roads, culverts, stream crossings, wet areas, and steep slopes. In this inventory, Jefferson County should evaluate existing drainage features to serve as outlets for stormwater conveyance piping and inlets along existing and proposed roadways, as well as analyze specific drainage and erosion problems.

More specifically, future road corridors should be evaluated with existing houses to help identify, for example, through-routes, as well as density criteria for smaller roads. Roads under a certain density could become privately owned lanes, with homeowners entering into agreements for maintenance. The road plan should determine the roads' purposes; it should address how to respond to emergency situations, as well as road maintenance activities such as the following:

- Road surface, including proper grading and any chemical application;
- Drainage structures, including cleaning and repairs of ditches, culverts, and bridges;
- Road sides, including addressing slumps and slides, erosion control, and vegetation control; and
- Access control such as traffic barriers and road closures (Spong, 2006).

This road plan should also include a comprehensive stormwater management system with cost estimates. Stormwater management design should include water quality inlets and vegetated roadside swales to reduce pollutants before entering natural waterways. Because these facilities will require routine maintenance by the county, homeowners associations, or the state, the plan should also identify resources and partners.

In these efforts, Jefferson County Planning and Zoning Department should work with state and emergency services providers to establish minimum roadway construction guidelines, including material, width, slope, horizontal and vertical curve requirements, and stormwater conveyance.

For future development, impact fees could be considered for lot construction that can be applied towards a road maintenance and stormwater planning. Future development can also include restrictions on private driveways that include provisions on maximum slope approach, roadside conveyance at street line, and management of stormwater flows from driveways onto the roadway.

Finally, any new roads must adhere to the state standards according to the West Virginia Department of Transportation. The state requires, for example, about 30 feet beyond the construction limits for the construction and maintenance of slopes, ditches, culverts, and fencing (State of West Virginia, 2006, pp.DD-301).

Additional state design directives include the following on lane widths:

- Local street lane width should be 12 feet for a single lane, and eight feet each for two lanes;
- Arterial roads should be 10-12 feet wide per lane, adding an additional 1-12 feet if heavy truck traffic is anticipated; and
- Parking lanes for local streets should be seven feet wide in residential areas, and eight feet wide in commercial areas (State of West Virginia, 2006, pp.DD-610).

5.3 Recommendations from residents and other stakeholders

The Blue Ridge Mountain Communities planning process presents a unique opportunity for Jefferson County to involve many different stakeholders. The creation of a common vision served as a cooperative, stakeholder-driven community process; residents and other stakeholders identified and built on their assets by stimulating community involvement and developing a stakeholder-driven vision to address watershed issues and concerns. The following statement about roads was included in the separate vision document: Participants envision the maintenance and improvement of the Mountain's roads so they provide reliable access and minimize their environmental impacts. To accomplish this vision, residents and other stakeholders agree to the following actions:

- Identify and explore using Green Infrastructure techniques and BMPs for steep slope development and maintenance
- Study stormwater management for roads and prioritization of improvements
    - Identify and document problem areas during storms and provide information to the Division of Highways
- Involve the Department of Transportation in establishing stormwater BMPs for the Mountain
- Contact Allegheny Power regarding unsafe utility poles and lines
- Redesign and reconstruct base asphalt roads
- Establish standards for better road maintenance, including proper grading and gravel placement
- Remediate the effects of steep slope development by incorporating rain gardens or terracing, which have been used for thousands of years to decrease erosion from the fast flow of water
- Recycle/reuse of equipment and materials involved in road repair and maintenance
- Explore alternative(s) to the orphan road program

Residents and stakeholders participating in this process made the following suggestions to be considered when developing the watershed plan for the Mountain:

- Current problems on existing roads such as surface runoff and stormwater flowing from gravel roads and large trails
- Address impacts of new Route 9 (e.g., blasting effects on land and water, sediment pollution)
- Financial opportunities for road maintenance
- Road and culvert design and maintenance, ownership
- Infrastructure improvements (e.g., fire protection, roadways, emergency services)
- Mission Road is essentially a long cul-de-sac and needs an emergency exit to Virginia, as voiced often by Mountain residents. Options provided by residents include the following:
    - Shannondale Lane past Eagles Nest Lane to provide eastern access
    - An alternative access to the south
- Consider trained Mountain residents as a means to maintain roads
- Consider tax credits or help with equipment that qualified neighbors or homeowners associations could use to help properly maintain roads

5.4 Resources

The West Virginia University (WVU) Extension Service Environment and Natural Resources Forest Stewardship Program conducts site visits and offers technical assistance. Additionally, the Center for Dirt and Gravel Road Studies has created a reference manual for the maintenance of dirt and gravel roads that contains information and materials related to this topic:

http://www.epa.gov/owow/NPS/sensitive/EnvironmentallySensitiveMaintenance_DirtGravelRoads.pdf

6. CASE STUDY: LANCASTER COUNTY, PENNSYLVANIA

Several municipalities within Lancaster County, Pennsylvania have established subdivision and land development ordinances that specifically address development on steep slopes. For example, some ordinances require a steep slope report to accompany any development proposed on slopes exceeding 15%; this report must be prepared by a professional engineer with expertise in soil, geology, and construction. In addition, the report must provide a detailed description of the methods proposed to accomplish the following:

- protect and stabilize areas with high erosion potential;
- accommodate stormwater runoff;
- assume structural safety and minimize harm to the environment;
- assure adequate foundations for buildings; and
- protect and preserve valuable natural wildlife, plant habitat, and water quality.

Many municipalities in Lancaster County also require that a stormwater management plan be prepared for any earth disturbance exceeding 5,000 square feet. This often requires that stormwater management plans be prepared for the construction of a single family home on an existing lot of record. By adhering to the stormwater management regulations, even the construction of single homes must provide stormwater management facilities that result in no post-development peak flow rate increases after construction. Many ordinances also have provisions for water quality and groundwater recharge objectives that must be met within the stormwater management facilities. Where the site geology and soils permit, these requirements are often met with infiltration facilities such as sub-surface seepage pits, above-ground rain gardens, or capture and re-use cisterns.

Zoning large contiguous sections of wooded and steeply sloped areas as "Conservation Areas" is another approach that has been used by municipalities in Lancaster County and central Pennsylvania. These areas are associated with limited development rights and are typically associated with large minimum lot sizes (i.e., 10 acres) and low impervious coverage limits (i.e., less than 5%). The limited development is an alternative way to preserve water quality by minimizing the allowable areas on which to develop, keeping lot coverage to a minimum

6.1 Example project, Harbor Engineering

Harbor Engineering completed a project in 2010 in Lancaster County that serves as a more site-specific example. This project involved the construction of a single-family dwelling on an existing lot of record (±2 acres). The lot is on an existing slope averaging approximately 25%, and was in a completely wooded condition. Public water and sewer were available to serve the site.

The first step in developing the property was to evaluate the pre-development stormwater runoff conditions. Because the area was in a wooded condition, its pre-development rate of runoff was low. The next step was to site the house and driveway, and prepare a site grading plan to minimize slope impacts. This stage required the design of appropriate stormwater management facilities to mitigate the increased runoff from clearing some of the woodland areas and adding impervious surfaces to the site.

In a desire to keep the visual and spatial impacts of the stormwater facilities to a minimum, sub-surface stone seepage pits were designed to collect the roof water from the proposed house and driveway and infiltrate it back into the ground. Qualified professionals dug deep probes and performed percolation tests, as well as conducted a geological evaluation to ascertain the site's suitability to accommodate the proposed facilities. Because of the steep slopes and soil limiting zones found during testing, multiple seepage pits were placed along the hillside rather than one large facility.

In addition to the stormwater plans, erosion and sedimentation control plans were submitted to the County Conservation District to ensure that no sediment-laden runoff would leave the site and pollute adjoining properties and waterways during construction. See Appendix A for plan.

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APPENDIX A: CASE STUDY CONCEPTUAL DRAWING